The Economics of Papua New Guinea's Tuna Fisheries

The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. Its mandate is to help identify agricultural problems in developing countries and to commission collaborative research between Australian and developing country researchers in fields where Australia has a special research competence.

Where trade names are used this constitutes neither endorsement of nor discrimination against any product by the Centre.

ACIAR Monograph Series

This peer-reviewed series contains the results of original research supported by ACIAR, or material deemed relevant to ACIAR's research objectives. The series is distributed internationally, with an emphasis on developing countries.

Campbell, H.F. and Owen, A.D., ed. 1994. The Economics of Papua New Guinea's Tuna Fisheries. ACIAR Monograph No. 28, 277p.

ISBN 1 86320 114 9

Technical editing, typesetting and layout by Arawang Information Bureau, Canberra, Australia.
Printed by Brown Prior Anderson Pty Ltd, Melbourne, Australia.
Cover photographs: South Pacific Commission, New Caledonia and the Department of Foreign Affairs and Trade, Australia.

The Economics of Papua New Guinea's Tuna Fisheries

Editors
Harry F. Campbell
Anthony D. Owen

ACIAR
The Australian Centre for International Agricultural Research

Canberra 1994

Authors

Harry F. Campbell
Professor of Applied Economics, The University of Queensland, Australia

Inge Y. Duchesne
Tutor in Economics, The University of Tasmania, Australia

Ronald Kuk
Senior Planning Economist, Department of Finance and Planning, Papua New Guinea

Robert B. Nicholl
Principal Research Officer, Department of Treasury, Tasmania, Australia

Harry Landu
Fishery Economist, Department of Fisheries and Marine Resources, Papua New Guinea

Inga Leaney
Graduate Student, Centre for Applied Economic Research, The University of New South Wales, Australia

Kenneth M. Menz
Research Program Coordinator (Economics and Farming Systems), Australian Centre for International Agricultural Research, Australia

Gareth W. Meyer
Research Economist, Department of Treasury, Commonwealth of Australia

Kwame Mfodwo
Lecturer in Law, Department of Accounting and Finance, The University of Waikato, New Zealand

Anthony D. Owen
Director of the Centre for Applied Economic Research, The University of New South Wales, Australia

B. Martin Tsamenyi
Professor of Law, Centre for Natural Resources Law and Policy, The University of Wollongong, Australia

David A. Troedson
Research Assistant, Centre for Applied Economic Research, The University of New South Wales, Australia

Geoffrey H. Waugh
Senior Lecturer in Economics, The University of New South Wales, Australia

Contents

Foreword

Fisheries represent an important resource for the South Pacific. In recognition of this, ACIAR held a workshop in Hobart, Tasmania, in March 1989 to explore possibilities for a collaborative research project. Representatives from research and fishery management institutions in the South Pacific region, Australia and North America attended. A report of that workshop is available in ACIAR Proceedings No 26.

The project that subsequently emerged from the workshop and follow-up discussions was one titled 'Economics of the tuna fisheries industry in Papua New Guinea'. It involved collaboration between the University of Tasmania (and later the University of Queensland following the transfer of Professor Campbell), the University of New South Wales and the Papua New Guinea Department of Fisheries and Marine Resources. This publication presents the output of that project.

ACIAR was delighted with the spirit of cooperation that prevailed during the project, and with the immediate usefulness of some of the results in policy making and negotiations regarding access fees in Papua New Guinea. Thanks are due to the researchers and administrators in all participating institutions.

While ACIAR operates in a bilateral mode through projects between Australian and developing country institutions, whenever possible we seek to extend the results of projects to other countries. The work on international market demand for tuna is already of relevance beyond Papua New Guinea. We propose to implement research on tuna fisheries management in other South Pacific countries.

Kenneth M. Menz

ACIAR Program Coordinator

Economics and Farming Systems

Part 1

Introduction and Overview

Chapter 1

Economic Issues in Tuna Fisheries Management and Development in Papua New Guinea

H.F. Campbell
K.M. Menz
A.D. Owen

Introduction

This paper provides a summary of a research program on the economics of Papua New Guinea's tuna fisheries, funded by the Australian Centre for International Agricultural Research (ACIAR Project No. 8928). The research was divided into five general areas: harvesting costs and returns; sustainability, stock management and fishery rents; fisheries law, regulations and monitoring; the processing sector; and international tuna markets. The research is described in detail in the papers in this volume. This paper gives an overview of the research undertaken and summarises some of the results.

Harvesting costs and returns

The two areas of basic research on the supply side were on the costs of harvesting tuna by purse seine, longline and pole-and-line vessels, and on the technology of harvesting tuna by purse seine and longline vessels. The former work allowed conclusions to be drawn about the profitability of Japanese distant water operations in the 1980s, while the latter made it possible to investigate a number of issues including: the ability of the purse seine fleet to target species; the level of the economic interaction between the purse seine and longline fisheries; and the relative efficiency of U.S. and Japanese purse seine search behaviour. Results from the two areas of research were combined to estimate rents from tuna fishing in Papua New Guinea and to develop a financial appraisal model for purse seine, longline, and pole-and-line fishing.

The profitability of the Japanese tuna fleets

The Japanese Ministry of Agriculture, Forestry and Fisheries publishes annual data on the costs and returns of purse seine, longline, and pole-and-line vessels in its offshore and distant water tuna fleets. A sample of cost and returns data is taken for each size class of vessel in each category and the sample averages are published. Since the published data are in the form of averages they do not necessarily reflect the economics of tuna fishing in a particular area such as Papua New Guinea's fishing zone. In particular, while fishing costs might not be expected to vary greatly between distant water locations, the returns from fishing would reflect significant differences in productivity between one area and another. Thus the data are useful in providing reasonable estimates of fishing costs in an area such as Papua New Guinea, and a general picture of overall profitability.

The Ministry of Agriculture, Forestry and Fisheries data for 1979–89 were analysed to calculate the costs and profitability of the various classes of vessel. In analysing the data, certain costs, such as licence fees or the imputed return on nonfixed assets such as goodwill, were excluded on the grounds that they represented current or capitalised fishery rent rather than fishing costs. The cost of the fixed assets was estimated on the basis of reported depreciation, and using the average required rate of return on capital in Japanese industry. Alternative required rates of return, one ignoring and one taking account of cross equity holdings, were employed but the results were similar. In calculating daily fishing costs the annual cost of owning and operating a vessel was divided by the number of days fished per annum. In this way allowance is made for time spent provisioning, travelling and unloading.

The cost estimates are average cost per fishing day for longliners in the 50–100, 100–200, and 200–500 gross registered tonne (GRT) classes; pole-and-line vessels in the 50–100, and 200–500 GRT classes; and group purse seiners in the 50–100, and 100–200 GRT classes. The published data do not include information about single purse seiners. As an example of the results obtained, Table 1.1 gives estimates of cost per day fished in 1988–89 at current prices.

Table 1.1. Cost per day fished by Japanese tuna vessels, 1988–89.

Type of vessel	Size of vessel (GRT)	Cost per day fished (¥'000)
Longliners	50–100	441
	100–200	654
	200–500	1017
Pole-and-liners	50–100	470
	200–500	1002
Group purse seiners	50–100	1865
	100–200	2990

The rate of return and economic profit and loss calculations indicated that virtually no size or type of vessel was making the required rate of return or an economic profit over the period 1979–89. It should be remembered that these results are based on sample averages and do not imply that no vessels in the fleet were making a profit in the course of a year, or in certain fishing grounds. The categories of vessels for which a zero or positive average economic profit was estimated were: medium and large longliners in 1979–80; large longliners in 1987–89; and small group purse seiners in 1979–80 and 1984–85. These results raise the question of why the fleet continued to operate over this period.

Vessels will continue to operate in the short term, even if they are making a loss, provided that they are covering their variable costs. Operating under these circumstances reduces the size of the economic loss. In the long run, however, vessels making a loss would be expected to leave the fishery. The reason the Japanese fleets continued to operate at a loss during the decade of the 1980s appears to be the subsidies paid by the government, apparently to slow down the pace of adjustment to economic and fishing conditions. The research indicated that, even if the entire Japanese offshore and distant water fleet had incurred annual losses on the scale experienced by the average vessels in the tuna fleets, the total amount of assistance provided to the industry was sufficient to more than offset these losses. This assistance made it possible for the tuna fleets to continue operating at a loss over an extended period.

Technology of purse seining and longlining

The purse seine and longline tuna fisheries are multispecies fisheries: purse seiners catch mainly skipjack and juvenile yellowfin, while longliners catch yellowfin, bigeye albacore, billfish and swordfish. Studies were undertaken to determine how much control vessels fishing in Papua New Guinea in the period 1983–86 had over the species composition of their catch. Using a revenue function framework, it was found that U.S. purse seine vessels had targeted juvenile yellowfin tuna in response to changes in the price of yellowfin relative to skipjack, whereas Japanese vessels had apparently not changed the species mix of their catch. The U.S. vessels are larger and more technologically advanced than the Japanese vessels and this may account for a difference in targeting ability.

The catch and effort data for the Japanese longline fleet operating in Papua New Guinea in the period 1979–87 were also analysed by means of the revenue function framework to determine the relationships among the species harvested. It was found that small vessels (< 100 GRT) used different technology to that of large vessels in that certain pairs of species were substitutes in production. This means that when the price of one species rises, thereby inducing an increase in effort targeting that species, the catch of the other species falls. The substitution relationships were between yellowfin and albacore, yellowfin and billfish, bigeye and albacore, and bigeye and swordfish. These relationships may be explained by the depth at which the various species are commonly found; each substitute pair tends to consist of a shallow and a deep-water species. No such relationships were detected for the large vessel sample, which accounted for 24% of the longline catch in Papua New Guinea, indicating that those vessels do not influence the species mix of the catch in response to relative price changes. This result may reflect the greater depth at which the larger vessels typically fish.

Financial appraisal model for tuna vessels

The Japanese cost estimates, together with catch and price data, are used to generate a simulation model of the financial performance of various kinds of tuna fishing. The model estimates the cash flow, payback period, return on investment, net present value, and internal rate of return for various sizes of longline, purse seine, or pole-and-line vessels operating under specified circumstances. The model can be used to conduct a sensitivity analysis of financial performance when inputs such as the number of trips per year, days fishing per trip, daily catch, and species prices are varied. It can be used by both domestic and foreign investors to plan and assess tuna fishing ventures.

As an example, the Financial Appraisal Model (FAM) is used to assess the likely performance of a small longliner (50–100 GRT) operating in Papua New Guinea's fishing zone. According to the analysis of fishery rents discussed earlier, this size of vessel was the most profitable Japanese longline operation in the 1980s. The results of the FAM are not encouraging: the payback period is 13 years and the internal rate of return 0.03% which is not high enough to justify investment by Papua New Guinea or another foreign nation. Since the FAM is based on Japanese costs and returns data it may be that some of the inputs should be adjusted to reflect the particular circumstances being considered. Japanese labour costs, for example, might be significantly higher than those in Papua New Guinea. The LOTUS 123 spreadsheet format of the model makes it easy to amend the inputs as required.

Sustainability, stock management and fishery rents

The sustainability of the current level of purse seine skipjack catch is not in question, but the purse seine yellowfin catch may impact on the longline yellowfin fishery. The question of the optimal allocation of the yellowfin stock between the two gear types was analysed within a benefit–cost framework. Another stock management issue considered was the sharing of information among purse seine vessels during the search process for schools of tuna. The different approaches of the U.S. and Japanese fleets to information sharing are analysed and the benefits of cooperation are explored. The generation of fishery rents in Papua New Guinea's purse seine, pole-and-line, and longline fisheries is also analysed.

Interaction between the purse seine and longline fisheries

Around 25% by weight of the catch of the purse seine fleet consists of juvenile yellowfin tuna, while adult yellowfin constitute around 40% by weight of the longline catch. There is clearly the potential for the purse seine fishery to have a significant impact on the longline fishery through its yellowfin catch. A benefit–cost analysis was conducted to determine whether a small decline in the purse seine yellowfin catch would generate sufficient benefits in the longline fishery to offset the costs to the purse seine fishery. The benefit to the longline fishery results from a higher yellowfin catch per unit effort. This generates higher effort levels in the longline fishery and results in changes in the catches of other species as well. The extent to which yellowfin catch per unit effort rises depends on the relative importance of growth and natural mortality among the additional juvenile yellowfin that escape the purse seine fishery, and the importance of the adult biomass in determining catch per unit effort. In addition to the biological effects, the higher price obtained for longline as compared with purse seine caught yellowfin is an important determinant of the benefit of a reduction in purse seine catch.

The extent of the cost of restraining the purse seine catch depends on whether purse seiners can target individual species. If they can target, as indicated by the analysis of U.S. purse seine data described earlier, they can substitute skipjack for yellowfin in their catch. The cost will be approximately the relatively small difference in price between yellowfin and skipjack multiplied by the reduction in juvenile yellowfin catch. If purse seiners are unable to target, as indicated by the analysis of the Japanese data, purse seine effort will need to be restrained to secure a reduction in yellowfin catch. This will also cause a reduction in skipjack catch, thereby making the cost of the policy higher than in the targeting case. The benefit–cost ratio of a policy involving a 1% decline in the purse seine juvenile yellowfin catch in Papua New Guinea's fishing zone was approximately 9 in the no-targeting case and around 30 in the targeting case. These ratios are subject to substantial error because they are based on estimated variables, but even taking account of the standard errors involved there seems to be a case for considering a reduction in the purse seine yellowfin catch. The present value of the net benefit of reducing the purse seine yellowfin catch in Papua New Guinea waters by 1% was estimated to be around $3 million. It should be noted that these results are based on the level of activity and the prices and costs experienced in the 1980s.

Search behaviour of purse seine tuna vessels

It has been suggested that the Japanese purse seine fleet adopts a cooperative approach to locating schools of tuna, whereas U.S. vessels behave in a competitive manner. Information sharing would be expected to increase the efficiency of the search process, thereby improving the returns to tuna fishing and the potential returns to the host nation. A sample of Japanese and U.S. purse seine vessels fishing in Papua New Guinea's fishing zone in the period 1983–86 was used to investigate this issue. It was found that, at any particular time, the Japanese fleet tended to be more concentrated by area than the U.S. fleet, suggesting a more cooperative approach to fishing. Japanese vessels also had a greater tendency to shift location when higher catch rates were being achieved elsewhere than did U.S. vessels. Statistical tests supported the hypothesis that Japanese vessels, unlike U.S. vessels, were moving in response to information on catch rates in other parts of the fishing zone. Since the analysis tends to support the hypothesis of greater information sharing by the Japanese, there should be objective evidence of greater efficiency of the Japanese search process. An analysis of the proportion of trip time consisting of days on which sets were made revealed that Japanese vessels made sets on between 90 and 95% of days as compared with 77–84% for the U.S. fleet. At least some of the difference could be attributed to the efficiency of the search process.

Fishery rents in Papua New Guinea's exclusive economic zone

The cost estimates for the Japanese fleet can be combined with the catch data for Japanese vessels operating in Papua New Guinea's fishing zone to obtain an estimate of the rents which were generated in the tuna fishery. In view of the evidence presented above on the profitability of the Japanese offshore and distant water tuna fleets it is not surprising that the rent estimates for some categories of vessels fishing in Papua New Guinea are negative in some years. Positive rents, expressed as a percentage of the gross value of the catch, were observed for small longliners (50–100 GRT) in the following years: 1983 (30.3%), 1984 (15.4%), 1985 (33.7%) and 1986 (5.2%); medium sized longliners (100–200 GRT) earned positive rents in 1983 (13.2%) and broke even in 1986; and large longliners (200–500 GRT), pole-and-line vessels and group purse seiners made consistent and substantial losses in Papua New Guinea in the period covered by the analysis. This performance may explain why the Japanese withdrew from the Papua New Guinea tuna fisheries after 1987. The rent estimates also provide a guide to Papua New Guinea as to the appropriate level of access fees as a percentage of expected catch. Clearly, small and medium longliners could have paid access fees of more than 6% of gross revenue in the period studied.

Rent generation and sustainable yield

The decision on how best to develop and manage a nation's tuna resource is difficult to make, since it embraces a range of social, political and biological factors. In this study, the question of management is analysed on the basis of fishery rent and the level of effort applied to the fishery. Controlling the level of effort in order to maximise rent from the fishery is assumed to be the operative goal of management.

Simple yield and rent models were constructed and applied to the Papua New Guinea pole-and-line skipjack fishery, with the results being compared with empirical fishery statistics from the 1970s and early 1980s when the fishery was in operation. The comparison revealed that the model predictions were reasonably close to the empirical averages. For a range of prices, the level of effort which maximised rent was determined. Not surprisingly, optimal effort, and hence optimal rent, was found to be very sensitive to fluctuations in tuna prices. This alone suggests that tuna marketing research is critical to good management. For the pole-and-line fishery, the results indicate that fishers should target the Japanese market for fresh and frozen tuna.

Fisheries law, monitoring and enforcement

Two areas of research on legal and enforcement issues were the International Law of the Sea together with the national and international legal frameworks within which Papua New Guinea operates, and the problem of obtaining accurate catch data from distant water fishing fleets.

Law of the Sea: a southern Pacific fisheries perspective

A study was undertaken of a number of aspects of the modern law of the sea and their impacts on south Pacific state fisheries and economies. The economic survival of many small states depends largely on the exploitation of the living resources of their territorial seas and exclusive economic zones. A general goal of this work is to draw attention to the impact treaty provisions may have on international law and the domestic legal systems of individual countries. Particularly, the provisions of an international agreement may restate pre-existing customary law, may crystallise emergent rule, or may precipitate an action which may eventually become generally accepted practice.

The nature of south Pacific state practice and direction in managing their fishery resources and the problems they have or could have in the future, are discussed in general terms. Specific developments within the western Pacific fisheries are discussed to highlight these issues, and the acceptance and adoption of the Law of the Sea Convention provisions by various south Pacific states are examined.

The feasibility, relevance and adequacy of the various regional agreements are assessed, particularly the 1982 Nauru Agreement and the 1992 Arrangement for the Management of the Western Pacific Purse Seine Fleet Fishery. The enforceability of these enactments is also examined, in the context of both international and domestic law, pre and post- ratification, and comparing convention signatories, ratifiers and nonparties. Also considered is the issue of what problems could arise in the face of foreign resistance. In other words, how much power is really conveyed to south Pacific states via the various legal instruments?

Marine fisheries law and regulations in Papua New Guinea

A detailed study was undertaken of the enforcement of fisheries law and regulations, with specific reference to Papua New Guinea. The study reviews the relevant provisions of the United Nations Law of the Sea Convention, and discusses in detail the array of practical measures and procedures that lie at the core of most fisheries law enforcement systems. It then examines Papua New Guinea's enforcement framework in detail. Discussion of this framework is divided into three sections: the national regime, the bilateral regime operating in the Torres Strait and involving close cooperation with Australia, and the regional regime operating under the aegis of the Forum Fisheries Agency.

Monitoring reported catch rates

Pacific Island nations such as Papua New Guinea have the objective of obtaining as access fees a specified proportion (currently 6%) of the value of the tuna catches in their exclusive economic zones or fishing zones. In order to achieve this objective, and to manage their fish stocks efficiently, these countries need accurate information about catches. Since access fees are normally set as a percentage of the expected value of the catch per trip, individual vessels do not have an incentive to under report; foreign fleets, on the other hand, do have an incentive to under report since it is the aggregate catch which is being used to determine expected catch per vessel per trip. It is believed that the

U.S. vessels were providing reasonably accurate information on their recent catches. The Korean and Taiwanese purse seine vessels are similar to those of the U.S., although the Taiwanese vessels tend to be smaller. If Korean and Taiwanese catch rates differed significantly from that of the U.S. fleet this could indicate a difference in fishing skill or technology, or a difference in the accuracy of reporting. A sample of data on U.S., Korean and Taiwanese purse seiners operating in Papua New Guinea's fishing zone in the period 1983–88 was used to compare catch rates.

At an aggregate level the reported catch rates of the Korean and Taiwanese vessels are significantly lower than those of the United States. When the data are disaggregated to provide comparisons of catch rates in the same quarter and subzone, however, the significant differences in catch rates tend to disappear. The difference between the results of the comparison at aggregated and disaggregated levels of data could indicate that U.S. vessels were better at locating productive fishing grounds than the Korean or Taiwanese. In view of the results of the analysis of search behaviour described previously further research is required to resolve this issue. In principle, however, relative vessel catch rates can be a useful tool in monitoring the accuracy of logbook data.

The processing sector

The westward movement of the Pacific tuna-canning industry over the past decade is attributed mainly to exchange rate changes. An economic model of a tuna-canning plant is used to determine whether the establishment of a cannery would bring significant benefits to a country such as Papua New Guinea.

Exchange rates and comparative competitive advantage

A study was undertaken on the role of real (as opposed to nominal) exchange rate movements in providing Thailand with the opportunity to establish and expand its 'value-adding' canned tuna industry during the decade of the 1980s. It also considers the adverse conditions faced by Japan over the same period, and the prospects for expansion of 'new' sources such as Indonesia, Papua New Guinea and the Philippines.

By the end of the decade, on the basis of relative levels of real exchange rates, Indonesia appeared to have achieved a significant competitive advantage over the Philippines and Thailand. The question of whether this can be translated into increased market share depends on a range of other factors, but the opportunity is clearly present.

Cannery costs

This work entailed the development of a template for assessing the financial viability of new investments in tuna-canning plant located in the western Pacific. It is assumed that the project is a greenfield investment, and thus requires investment in local infrastructure as well as plant and machinery. The resulting analysis reveals that financial rates of return in the range of 15–20% can be predicted under relatively conservative assumptions but, as would be expected, these rates of return are particularly sensitive to variations in labour productivity and the price received for canned tuna.

While the development of infrastructure can be extremely beneficial to developing economies, for western Pacific nations the benefits will be highly site specific. In order to simplify the economic analysis, net external benefits were assumed to be negligible. Ignoring the impact of market distortions, the analysis indicates that economic internal rates of return within the range 10–20% are not unreasonable. Taking into account foreign exchange and labour market distortions, the analysis suggests that internal rates of return within the range 20–30% can be expected. However, these results depend, to a significant degree, on the assumption that canned tuna is exported to the European Community (E.C.) under tariff-free entry conditions.

International tuna markets

The three most important tuna markets are the United States, Japan and Europe. The features of each market are explored and the factors determining demand in each market are analysed. A forecasting model developed for the Japanese market is relatively successful at forecasting skipjack, yellowfin, bigeye and albacore prices within the sample period.

The U.S. market for canned tuna

The U.S. tuna market is primarily a market for canned product, although small markets are evolving for speciality tuna products. Traditionally, meat products have been the staple diet of Americans, and canned tuna is the only seafood product which enjoys widespread acceptance. More recently, shrimp consumption has risen to a level of demand almost equivalent to that of tuna, and it is anticipated that shrimp consumption will exceed that of tuna in the near future. However, chicken and red meat products remain the major competitors for canned tuna.

A comprehensive overview of the U.S. canned tuna market was undertaken, identifying the major factors which 'drive' the market, and deriving estimates of their relative importance. The results of a statistical analysis indicate that increases in real disposable income have been the major driving force behind increased per capita U.S. consumption of canned tuna over the past two decades. While the impact of (real) falls in the price of canned tuna has also been a significant factor, the magnitude of the impact has been relatively small.

The Japanese tuna industry and market

This study provides a detailed evaluation of the Japanese tuna market, with particular emphasis on imports, trade barriers, consumer preferences, the wholesale marketing system, market participants, purchasing patterns and price determination.

The development of the tuna industry in Japan has been characterised by significant changes over time and a lack of general stability. The structure and conduct of Japan's present tuna industry is a consequence of relatively recent developments, and the industry is continuing to change rapidly in response to a variety of factors. A knowledge of these developments and the underlying factors responsible for them is important both for exporters in the region, who are endeavouring to formulate effective tuna-marketing strategies, and for government fishery authorities in the western Pacific, who are charged with the development and implementation of effective management policies for their respective fisheries.

Over 80% of tuna consumed in Japan is eaten raw, either as sashimi or sushi. The remainder is processed into a number of forms including canned, smoked, dried and salted. Tuna is marketed primarily in carcass form at the wholesale level, although an increasing proportion is processed to fillet, chunk or blocks for direct sale to retailers.

Fresh and frozen tuna consumption has been increasing steadily in recent years, fuelled in particular by increasing imports. Over the period 1986–92, Japanese fresh and frozen tuna imports doubled, a significant portion of the increase coming from Taiwan. Current trends indicate that consumption will continue to increase in the near future.

Japanese consumption of canned tuna generally increased over the period 1981–91, although this was largely facilitated by a decline in exports. While production levels were reasonably stable during most of the period, they declined in the latter years. Imports remained low during 1981–87, then increased significantly in the following four years. The increase was supplied principally by Thailand. The increasing supply of canned tuna from Thailand may have a negative impact upon domestic production because it is significantly cheaper than the domestic product. This may be further exacerbated by the increasing use of albacore for sashimi, thereby reducing the supply of albacore for canning. If the situation in the Japanese canned tuna market continues on its current course, such trends may lead to the demise of the domestic canned-tuna industry in forthcoming decades, and the rise of Japan as a major importer of canned tuna.

The European market for tuna

The European market for canned tuna is dominated by the E.C. It is an extremely diverse market, with distinctly identifiable market structures and consumer preferences. Historically, the E.C. market has represented a considerable challenge to canned tuna exporters, due to differing standards and requirements among importing countries, and considerable nontariff barriers to trade, particularly in mature markets such as France. In recent years, that challenge has been successfully taken up by Asian canned-tuna exporters, particularly Thailand and the Philippines.

With a view to achieving uniformity across markets, uniform regulations for imports into the E.C. were introduced in January 1993. While a single, community-wide, standard was originally intended to be of considerable benefit to exporters, lobbying by French interests has resulted in the additional implementation of a community-wide import quota of 75000 tonnes for canned tuna, excluding that which is imported from certain Asian, Carribean and Pacific (ACP) nations. The major beneficiaries of this move will be canneries in ACP countries, while Thailand and, to a lesser extent, the Philippines will be the major losers. Thailand alone, the dominant supplier to the E.C., has exceeded this level annually since 1989.

This study provides a description of the European processing sector and current trends in European canned-tuna production. This is followed by an overview of the canned-tuna market, including import policies and rules of origin, current trends in consumption and imports, and individual market descriptions. Recent changes in E.C. legislation regarding canned tuna imports are also discussed.

Modelling tuna prices

Based upon monthly price data at the Yaizu market, a vector autoregressive model was constructed to provide short-term price forecasts for skipjack, yellowfin, bigeye, albacore, and southern bluefin tuna. Estimation of the model was based on data over the period 1976 to 1992 (196 observations in total), with forecasting extending to the end of 1994.

The model was able to reproduce the peaks and troughs of price movements over the period with a reasonable degree of accuracy, with the exception of southern bluefin where prices were invariably underestimated. This latter observation could be due to the effects of quotas being established and varied throughout the later part of the sample period, thereby changing the fundamental structure of the time series used for estimation.

Summary and conclusions

The main conclusions of the research described in this paper can be summarised as follows.

- The Japanese tuna fleet as a whole was making significant economic losses during the 1980s. It was able to maintain its operations because of substantial subsidies from the Japanese government.
- In spite of the overall losses, sections of the operations of the tuna fleet were profitable. In Papua New Guinea small Japanese longliners made consistent profits during the 1980s.
- The Financial Appraisal Model indicated that the rate of return to small longliners was unlikely to attract foreign investment to this activity under current price and cost conditions.
- Economic analysis of the technology of tuna purse seining and longlining revealed significant substitution and complementarity relationships among species. In purse seining, skipjack and juvenile yellowfin were found to be substitutes, while in longlining yellowfin and bigeye are substitutes in production for albacore and billfish or swordfish. These relationships have important implications for multi-species stock management.
- The net present value of Papua New Guinea's tuna fisheries could be increased by increasing the escape rate of juvenile yellowfin from the purse seine fishery to promote higher catch per unit effort in the longline fishery.
- Greater cooperation in information sharing among U.S. tuna purse seine vessels, as practised by Japanese vessels, would increase the returns to these vessels and the potential returns to the host nation.
- The provisions of some of Papua New Guinea's fisheries legislation are outmoded, and review and consolidation of the legislation is required if the country is to develop an effective fisheries enforcement policy. In particular, enforcement would be facilitated if Papua New Guinea transformed its fisheries zone into an exclusive economic zone.
- Underreporting of catches may be detected by intervessel comparisons in the same spatial and time dimension. This has reportedly been implicitly acknowledged by a distant water fishing nation agreeing to an increase in the access charge.
- Real exchange rate depreciation vis-a-vis the U.S. dollar delivered a significant competitive advantage to Thai exporters of canned tuna during the early 1980s but, more recently, Indonesia has been the major beneficiary of a depreciating real exchange rate.

- Analysis of cannery costs indicated that the most important factors which influence the financial viability of new tuna canneries located in the western Pacific are: the price received for canned tuna exported to the E.C. and plant throughput as determined by tuna yields. In the case of the former, the question of eligibility for duty-free access is of paramount importance, while low labour productivity in the region is of concern for the latter.
- The United States, the E.C. and Japan are the three major world markets for tuna and tuna products. Each of these markets has individual characteristics that differentiate it from the other two, while the E.C. market is also characterised by the heterogeneous nature of the individual markets of its member countries.
- A recurring theme is that tuna marketing research is critical to good management, and the use of time series forecasting techniques may provide management with information that will assist in determining fishing effort and potential financial returns.

Chapter

2 Economics and Politics of Tuna Fisheries in the South Pacific

G.H. Waugh

Background

The tuna resources of the south Pacific are vast, and may well be the one large fishery resource that is still biologically underexploited. The total harvest is variable, but in excess of 1 million tonnes annually, valued in excess of $US100 million. There are a number of tuna species harvested, the important species being yellowfin, bigeye, skipjack and albacore. Skipjack is the most abundant and is the major source of tuna for canneries. It is an unusual resource: the species is mobile, spawns daily, is short lived (three–four years) and is thought to be able to sustain up to a several fold increase in catch (Kearney 1981).

Economic factors and international intrigues have interacted to determine both the harvest and the distribution of that harvest. Although economic factors play the dominant role in the long term, historical and political factors have had important repercussions. The distant water fishing nations include Japan, Korea, Taiwan, Russia and the United States (for a summary of catches see Waugh 1989). Japan, to a large extent, ceased operations in 1987, being unwilling to pay the licence fees required by the south Pacific countries. However, a number of Japanese vessels still operate in various Pacific island waters. Taiwan and Korea continue to pay less than might be considered reasonable. Russia has had two shortlived agreements on fishing rights but has had numerous discussions and negotiations with a number of south Pacific countries. The United States has signed and renewed a multilateral five-year treaty with the Forum countries.

In addition, the south Pacific tuna resources have been exploited by the Pacific islanders themselves. Their activities have included small harvesting industries and in some cases extensive industries primarily based on pole-and-line vessels. In some cases canneries have been worked for considerable periods of time but, as in other parts of the world, such operations are generally marginal at best. For many of these countries, fishing is part of their history and culture. It is the intrusion of international markets and international fishing politics that has changed the course of events, and these intrusions have not always been determined by rational economic debate.

Who will exploit these resources may depend on who has the ultimate sway in the political arena, where aid money comes from, as well as other economic circumstances. Although jurisdiction may be firmly in the hands of the south Pacific peoples, history and socioeconomic conditions may influence the final outcome. Either way, it is unwise to ignore the lessons of history.

Apart from the issues of jurisdiction and development, the south Pacific tuna fishery is an extraordinarily complex one, and provides an array of difficult problems for management and policymakers. Tuna are a highly mobile (and sometimes migratory) species and thus management cannot be left to individual coastal states acting in isolation. In addition, several species of tuna are fished by a number of different nations using a variety of gear types.

Second, since the rights to harvest the resource are generally sold to the distant water fishing nations, issues arise that are analogous to more general problems of international trade. The actions of coastal states in seeking the service of distant water fishing nations can be considered in terms of the coastal state importing, harvesting and processing services. Economic factors play an important part here, and traditional societies are quickly becoming adept at dealing in these markets.

Third, since all of the coastal states in question are developing nations, problems arise as to how these states can best develop their fisheries resources to their maximum potential. The trade-off is between domestic harvesting and processing using domestic capital and labour, and selling the rights to distant water nations who process the catch overseas.This raises issues as to where the comparative advantage is likely to lie (for a summary of the issues see Brown and Waugh 1989; Waugh and Brown 1990).

Finally, all these issues are clouded by the politically charged nature of the discussions and events that have taken place. On the one hand, strong national feelings on the part of the coastal states have led to pressures for increased domestic participation in the fishery, even when economic circumstances are unfavourable. On the other, the interests of the distant water fishing nations have not always resulted in constructive negotiations for fishing rights.

Economic perspective

From an economic point of view, catching tuna is basically about the search for increased rent from the resource. Rent can be thought of in its simplest form as the difference between the gross revenue from harvesting the tuna resources and the opportunity cost of capital and labour used in harvesting the resource.

While the tuna resources remained unowned, all the distant water fishing nations were competing for that rent. With the establishment of the 200 mile exclusive economic zone, coastal nations in general, and the south Pacific countries in particular, claimed exclusive ownership of tuna resources. The rent now belonged to them.

The rationale that coastal states ought to collect the rent is similar in one respect to the rationale that mining companies should pay a royalty for the title to mineral resources. Mining companies would earn, without a royalty, profits in excess of their normal returns for operation. And that super profit rightly belongs to the owners of the resource, in this case the crown. So it is with fisheries: the fishery is an unpaid-for input in the production process and there is potential for excess profit. This profit rightly belongs to the coastal state and therefore should be paid back to them in the form of a royalty.

However, there is a further reason why the coastal state should charge a royalty or rent for the right to harvest. And that reason is concerned with economic efficiency. Unless the rent is collected there is a tendancy for fishers to overexploit the resource. The result is lower stocks and excess capital and labour invested in harvesting the resource, with the eventual dissipation of the rent.

A more difficult question is related to how uncertainty can be included in the calculation of rent. Tuna is a very risky business. There are large fluctuations in markets, catches, the environmental conditions and weather. In short, luck plays an important role. Fishers must therefore be allowed a return over and above their normal return in order to compensate for this risk. The greater the risk, and the more risk averse the fishers, the higher return required, and the lower the rent earned. Although it is not possible to do justice to the complexities here, it is important to realise that uncertainties and risk reduce the level of rents that can be collected.

That a coastal state bears considerable risk in both exploiting and processing its resource adds another dimension to the problem. A coastal state that is risk-averse and finds that it has a large abundance of tuna relative to other natural resources, can reduce its own risk by leasing to many distant water fishing nations. The reverse is also true: the smaller the fishing industry in the economy, the less critical is the risk factor, and the greater the rent from domestic development as opposed to fee fishing. Nevertheless, small economies with relatively large fisheries may achieve more rent by spreading the risk and seeking returns from fee fishing. This is generally the case in the south Pacific.

Distant water fishing nations often offer payment-in-kind rather than direct cash for the rights to fish. These payments may include: grants of goods and services, provision of scientific data, technical assistance, aid, provision of capital and infrastructure, domestic processing facilities, and access to foreign markets for locally caught fish products. These benefits may be considered 'defacto royalties' only if, in the absence of a fishing agreement, the particular in-kind payment would not have been a necessary expenditure for the distant water nation to fish. For example, the provision of much of the technical assistance to processing plants by the distant water nation under joint venture agreements cannot be considered a defacto royalty, nor can access to markets or the provision of infrastructure, where these are part of the normal requirements of operation; some of these payment-in-kind are really part of the firm's operating costs.

If a foreign government has negotiated a reduction in fee payments in return for support of domestic processing facilities, then it is possible that the perceived returns to the coastal state are largely illusionary. The foreign firm has made no substantial losses or gains if the lower fees are compensated for by higher operating costs: but the domestic government has made a substantial loss in terms of lower fee collections.

In some other circumstances there may be genuine defacto royalties. The provision of infrastructure such as wharves or port facilities, or the construction of a road, may allow other industries to grow and prosper. In general, however, provision of infrastructure does not substitute for fee payments for the right to fish; nor does the provision of more value added, more employment, and more technical assistance automatically imply that the coastal state has received any substantial benefit that would have not been forthcoming. Indeed the provision of payments-in-kind has the potential to complicate what would otherwise be a simple fee negotiation.

If we accept that the rents are there to be taken, then the western world has done this remarkably efficiently over this century, and has built a major international industry. Estimates of the size of this rent put it at in excess of $US200 million (Waugh 1987; Troedson and Waugh 1993). Japan was the first to realise this potential.

The Japanese fleet

The development of the Japanese tuna fleets began in the early part of this century, and the tuna fisheries have been directly, or indirectly, subsidised by government through the *Distant Water Fisheries Promotion Act 1897;* this act was later used to provide a vehicle for the expansion of tuna fisheries into the central western Pacific. Initially, Japanese tuna fishing was limited to nearshore fisheries around Japan. In 1914 Japan occupied some islands of the central western Pacific, and after World War I, Japan was granted trusteeship of over 14000 islands including the Marianas, Carolines and Marshall islands. Japanese tuna fisheries expanded along with this increase in territory. Based in Truk, Saipan and Ponape, the pole-and-line fisheries began their incursion into the central western Pacific waters. By the late 1920s the pole-and-line fleets were well established in Micronesia with shore facilities to service fleets. The main interest was Katsuobushi (smoked and dried skipjack) and canned skipjack - which later was used to supply the military forces. By the late 1930s nearly 8000 Japanese fishers were operating in Micronesian waters.

World War II marked the transfer of tuna vessels to military control. Japan's loss in this war meant also a loss of much of its gains in tuna fisheries. Immediately after the war, with food production a high priority, fisheries subsidies again assumed importance. Initially the tuna fleet was restricted, firstly to the 12 mile limit, and then to the so called McArthur lines (Matsuda and Ouchi 1984).

Postwar development paved the way for the Japanese fleet to continue to expand its influence in the Pacific, restricted only by Japanese fishery legislation which restricted gear types to specified areas. The McArthur lines were gradually relaxed and the tuna fleet started again its southern and eastern sweep into the central western Pacific.

Developments in the longline fishery, with improvements in vessel design and technology, coupled with government subsidies, provided added impetus to the fleet expansion. By the 1960s, bases had been established throughout the Pacific – in Fiji, Vanuatu, French Polynesia and American Samoa – supporting the longline fleets fishing for albacore.

However, the success of the Japanese fleets brought new competition. Longliners from Taiwan and Korea quickly replaced the Japanese albacore fleet which now turned to the more lucrative sashimi species, such as yellowfin (bluefin in Australian waters), bigeye and (to a lesser extent) billfish. The pole-and-line fleet at this stage was supplying fish primarily for the canned tuna market.

The Taiwanese and Korean vessels were initially all longliners. The area of operation was generally the more southerly and eastern areas – Kiribati and the Cook Islands. Here they competed with the Japanese for albacore, which is used for canning and sold principally in North America and Europe. More recently these two Asian countries have turned their attention to purse seining and to longlining for the Japanese sashimi market. There has thus been an increasing presence in the waters off Papua New Guinea.

Despite this Asian competition, Japan has had a long historical interest in the western Pacific. Although there are no multilateral agreements with Pacific islanders, Japan continues to fish under arrangements with countries such as Papua New Guinea. This long-term interest, coupled with growth in the Japanese economy, is likely to ensure continuing presence of Japanese interest in the development of the tuna industry in the south Pacific.

The United States

The world market for canned tuna continued to rise throughout the 1960s and 1970s, but pole-and-line fishing was hampered by the lack of good supplies of baitfish. Purse seining, a United States innovation of the 1970s, provided a solution. Schools of skipjack could be efficiently encircled and harvested on a large scale. Although these captures were unsuitable for sashimi, they found a ready outlet in the ever expanding market for canned tuna. Both the Japanese and the United States began an 'invasion' of the western Pacific tuna grounds.

The United States has never unambiguously accepted the 200 mile exclusive economic zone. Between 1980 and 1987 it fished almost unhindered in south Pacific waters, although there were a handful of arrests of United States vessels by the small island states (for a summary of United States involvement in the Pacific see Waugh 1987). In response, both Kirabati and Vanuatu signed one-year agreements with the Soviet Union. Subsequently in 1987 a five-year agreement was signed with the Forum countries allowing United States vessels to fish for a fee, mostly paid by the United States Treasury. The United States tuna fishers see this as foreign aid, and others see it as a market for 'not dealing with the Russians'. Subsequent events in Europe have not diminished the interests of the United States government in supporting tuna fisheries in the central western Pacific.

The United States purse seine fleet (vessel size ranging from 200 GRT to 2000 GRT) was developed and operated traditionally outside the western Pacific in the waters of the eastern tropical Pacific. Their markets were canneries on the west coast of the United States and the canned product was for home consumption. The 'invasion' from the north arose as a direct result of a number of economic and environmental effects that made their operations unprofitable at home.

During the tuna boom period of the late 1970s the United States industry overinvested in large purse seiners and became overcommitted in debt repayments. During the 1980s, oversupply in the international tuna market, brought on largely by the purse seine revolution, led to a price collapse in the tuna market. Traditional markets on the west coast of the United States closed as prices fell, exchange rates moved against vessel owners, fuel prices rose, and imports from Asia, particularly Thailand, became cheaper. Vessel owners were faced with high transshipment costs to foreign ports, higher than expected debt service payments and fuel payments, and a 30% fall in tuna prices. In 1982 and 1984 El Nino conditions prevailed, resulting in poor fishing conditions in the eastern tropical Pacific and very good conditions in the western tropical Pacific. Further, the conservation lobby was pressing the tuna vessels about the incidental catches of dolphins, a problem associated with tuna catches in the eastern pacific, but not in the western tropical Pacific (see Joseph 1991).

As a result, in the 1980s many of the large purse seiners headed to the western Pacific, in some cases attempting to get agreements with the island states at very low access fees. When that failed, in line with United States policy, they fished anyway.

The United States view at that time was that tuna did not come under exclusive jurisdiction of the coastal states beyond the 12 mile limit. Such a view developed to protect the interests of United States fishers who, as a group, have proved a powerful lobby. Despite the dispute in the Pacific having recent origins, development of United States policy has a much longer history.

The entry of the United States tuna fleet into the south Pacific was at a turbulent time for the world tuna market. The United States tuna fleet was, itself, heavily in debt, and given a long history of disputes over the 200 mile limit, strong action by the United States government in support of those tuna vessels that broke coastal state fishing regulations, and a virtually surveillance-free fishing area, the outcome was hardly surprising. The first seizure was the Danica, a 1500 tonne United States purse seiner, arrested by Papua New Guinea in 1982. This issue was quickly resolved and the American Tunaboat Association then entered into an agreement with the coastal state to pay fees for the right to fish.

Several of the island states were, however, alarmed at the continued 'illegal' fishing in their waters. One vessel (the Carol Linda) had run aground while allegedly fishing in Kiribati waters, clearly well inside the 12 mile limit. The presence of helicopters was common in Solomon Islands waters, indicating illegal tuna activities. The Solomon Islands prime minister protested formally to the United States, citing the presence of two United States purse seiners, the Lone Wolf and the Bold Adventurer; photographic evidence apparently showed clear violation of Solomon Islands fishing laws. The position of the United States government was that it was not responsible for the actions of individual vessels.

On the 20th June 1984 the United States purse seiner the Jeannette Diana was seized after a two-hour chase that ended only when the Solomon Islands patrol boat fired three shots. Despite the captain and owners of the Jeannette Diana vigorously defending the charges of illegal fishing , the defendants were found guilty by the High Court, fined a total sum of SI$72 000, and the court ordered the forfeiture of the vessel, gear and illegal catch. The Solomon Islands government sought to sell the vessel for SI$3.9 million. For its part the United States imposed a total ban on imports of fish products from Solomon Islands under the Magnuson Act, and agreed to recompense the owners and captain of the arrested vessel, adding the threat that this would be subtracted from its foreign aid to Solomon Islands. The Solomon Islands government responded by banning United States vessels from fishing in its waters and by offering an open invitation to the Soviet Union for negotiations on fishing rights, a proposal it had previously rejected.

The dispute continued for seven months, and it was not until April 1985 that an agreement was reached. The Solomon Islands sold the Jeannette Diana to its owners for SI$770000 and the embargo was lifted. Negotiations between the United States and the south Pacific nations on a fishing agreement were then able to proceed. Solomon Islands never regained the loss of its SI$10 million trade with the United States.

There were a number of other incidents. The Federated States of Micronesia threatened to have the Ocean Pearl blacklisted, thus inducing her to pay US$500000 (she had escaped after threatening to drop a small boat rigged to its boom on the boarding party). Criminal action against the Pricilla M induced her owners to pay US$400000 in an out of court settlement (she had pulled into Federated States of Micronesia to seek medical attention for an injured crew).

These events, reinforced by the presence of a Russian fleet in the south Pacific, led to a series of negotiations between the United States and the Forum countries. There were 10 meetings over a period of two and a half years. The treaty was signed in Port Moresby early in 1987. Forum countries were given approximately US$60 million over five years to grant United States access to the tuna resources; the industry only contributes about 10% to these fees. The treaty was renewed in 1992, reinforcing the view that the United States has a long-term interest in tuna in the western Pacific.

The treaty was unique from a number of points of view. First, it was the first treaty between a single nation (the United States) and a region (the Forum countries). Second, it was the first time that the United States accepted the 200 mile limit. And third, the United States agreed to pay, not only for fishing within the 200 mile exclusive economic zone, but also for fishing in the high seas pockets that are enclosed by the zone. This treaty was renewed, prompting increased, if unsuccessful, pressure on Japan to also sign a multilateral treaty. But as the Pacific islanders are finding, the hierachical nature of Japanese society is more difficult to deal with than the individualistic culture of the United States.

Other fleets in the south Pacific

In addition to the major fleets of Japan and the United States, a number of other countries have continued to show interest in the central and western Pacific. The Philippines and Indonesia have had recent agreements with Papua New Guinea and the Federated States of Micronesia for the operations of purse seiners. The Soviet Union had negotiated agreements with Kiribati and Vanuatu, although these short agreements were never renewed, primarily because the Russian vessels were less successful at harvesting tuna than their Asian and United States counterparts.

Taiwan and Korea have operated in the central western Pacific for some time. Although these nations have played a smaller role, their interest has been increasing. This has been partly a result of the rapid economic development of Asian countries. Indonesia, Taiwan and Korea have seen advantages in distant water fishing, while Thailand and Philippines and now Indonesia have exploited their industrial advantages in operating tuna canneries. Exchange rate movements are important in this regard – movements in tuna processing have coincided with changes in real exchange rates.

Drift netting became an issue in the late 1980s. One reported estimate of the length of drift nets in 1989 was that, end to end, they would stretch one-and-a-half times around the equator. Recent international alarm at the damage being caused has promoted many countries to reduce drift netting. Some estimates put the reduction at one-half of previous levels. If correct, drift nets now stretch only three-quarters of the way around the equator. France proudly proclaims that it only uses small drift nets (7 km in length – hopefully not in multiples of seven).

Domestic operations

If the interest of Asian and north American tuna industries can be understood in terms of economic rent, what of the Pacific islanders themselves? The position is not clear.

For anyone raised in a society where the accumulation of wealth is the prime mover in economic affairs, it may come as a shock to learn that in many traditional societies it is unimportant. Here, traditionally, profit does not motivate, capitalism is not the engine of production, and wealth does not pay dividends; rather it attracts considerable social costs (Johannes 1989).

The coastal states of the south Pacific have a choice in the development of their offshore fishery resources. They may, at the one extreme, leave the entire industry of harvesting and processing with the distant water fishing nations; or, at the other extreme, they may elect to seek development of the industry themselves, either with their own resources or through a joint venture arrangement (Waugh 1986, 1993).

In practice, the island states have sought to participate in the development of the tuna fishery to the fullest possible extent. The south Pacific island states are fiercely independent nations, and they have cultural and historical reasons for seeking to develop both their harvesting and processing facilities. Net economic gains do not figure prominently in their arguments.

The *Solomon Islands Development Plan 1980* (Solomon Islands 1980), for example, provides for the maximum participation of nationals in the tuna fishery; benefits are seen in terms of export earnings, employment and import substitution. The joint venture arrangement (Solomon-Taiyo Ltd) has been the vehicle through which these objectives have been pursued.

In its *Eighth Development Plan 1981*, Fiji finds that 'the major economic potential lies in the development of industrial pelagic fisheries' (Fiji 1981); the argument is that tuna fishing operations provide 'the greatest potential to increase foreign exchange earnings, to maximise value added, [and] increase the rate of import substitution'. Comparative advantage does not figure strongly in their claims.

Vanuatu, in its *First Development Plan* sought to develop a 'locally-based, industrial-scale fishery, exploiting tuna resources' and 'where appropriate tuna processing facilities'. Economic justification for these plans is missing, and by the 1990s these hopes remain largely unfulfilled. During the 1980s many of the other island states purchased tuna vessels, including Solomon Islands, Fiji, Kiribati, Papua New Guinea, and Tuvalu, and there were processing facilities in Fiji, Solomon Islands and Vanuatu.

In general, the south Pacific island governments see the need to create employment opportunities, generate foreign exchange, and increase value added; the argument used is that local participation in the tuna fishery is likely to provide these opportunities. The counter economic view is that, although there may be some room for a small domestic operation, the greatest gains are likely to come from using the services of distant water fishing nations to harvest (and process) tuna resources, and extracting the economic rent, in the form of licence fees, from those nations. This view rests on the case for trade (Munro 1984, 1985). Simply stated, the argument for trade is that welfare for both trading partners is raised if trade is allowed to flow freely. Countries can export those commodities in which they have a comparative advantage. The island states may have an advantage in the ownership of the tuna resources which pass through their exclusive economic zones, but a comparative disadvantage in the harvesting and processing of them. The struggling domestic harvesting and processing industries in the Pacific provides evidence for this view (see for example Waugh 1986).

The law of the sea

The United Nations Convention of the Law of the Sea provides the impetus for the Pacific islanders to continue their ambitions to expand harvesting facilities. Most international lawyers argue that control of tuna resources within the exclusive economic zone rests with the coastal states. The two sections of special concern are Article 62 and Article 64.

Article 62 relates to a number of issues, including the licensing of foreign vessels and the payment of fees. It gives the coastal state the right to require payment of fees for access by foreign fishing vessels to its surplus of harvestable fish stock within its 200 mile exclusive economic zone. In relation to this article, William Burke (1984:31) adds that there is 'no specific limitation or restriction on fee level, and although reasonableness is required the treaty gives ample leeway to coastal states to secure monetary benefits from its exclusive economic zone.'

Article 64 deals with highly migratory species and Annex 1 includes the tunas among its listing of highly migratory species. Article 64 requires the coastal state to cooperate with other states fishing in the region to ensure conservation and optimum utilisation of those species both within the exclusive economic zone and beyond. In the view of Burke (1984) and Tsamenyi (1986), and probably many other international lawyers, highly migratory species are subject to coastal authority in the exclusive economic zone in the same way as other species, except for this added requirement of cooperation.

Tuna are highly mobile, and some species are migratory. Fishing in one zone or in the high seas must, in time, have an impact in other zones. The Convention of the Law of the Sea requires international cooperation for highly migratory species, but firmly leaves the control of all species in any 200 mile exclusive economic zone in the hands of the domestic country.

So the south Pacific countries can confidently claim ownership of the tuna resource, at least while the tuna are in their exclusive economic zone. But the zone for each of the states is very large and there is little hope that they can enforce their claims. They rely on international cooperation and good will. There is another problem: the Convention of the Law of the Sea requires the domestic country to allow other countries to use that part of the resource which is not being harvested domestically, at least up to some undefined optimal level. While they have signed the provision of the United Nations Convention on the Law of the Sea relating to the utilisation of surplus fish stocks, the south Pacific countries appear in practice to be reluctant to relinquish control over any portion of the fish stocks in their exclusive economic zones.

There are three ways they can maintain at least partial control. First, they can define the optimal level of catch at some low level. This would require a difficult exercise in semantics.

Second, they can continue to sell the rights to fish. Here international negotiation has always been a long and difficult road. High licence fees have not been easily won, although the Forum Fisheries Agency has had a number of notable successes.

Third, they can expand their own domestic operations. There have been a number of successes and failures here. Expertise, capital and skilled labour are required, all suggesting that the comparative advantage is with the distant water fishing nations, and that selling the rights may well be the better way to go. Who really has the right to fish depends on the social context.

A cultural perspective

The western perspective then is seen as a search for rent and market efficiency. What is not so clear is whether this search has been embraced by the Pacific community. In specific terms it is not clear that the Pacific people wish to maximise their share of the rent from the resource. Nor can it be established that in an imperfect world, policy changes that move actual conditions in the direction of the assumptions of the rent collection model necessarily result in increased efficiency or mutually beneficial outcomes, especially for very small, less developed communities.

An alternative view for understanding and justifying fisheries resource development in the Pacific region recognises explicitly that the basic and fundamental forces (if there are any) are cultural and social, or at the very least not just economic. There is nothing honourable or right about particular cultural and social features: they are just there, are structured and run deep. Serious problems emerge when explanations and modes of action challenge and frustrate traditional values that on historical evidence have a strong tendency to reassert themselves, in the process often upsetting the best intentioned development plans.

Rent maximisation, especially when international competition and markets are considered, still has an important role to play, but this concern may not necessarily be the primary or dominant one. The primary concern could well be about minimising the vulnerability of Pacific ways of working the world. Here it is recognised that traditional society is valuable, and deserves the concern of those who seek to advise on resource development and markets in the island states. The imposition of markets has often failed in traditional cultures. It may be more appropriate to consider a vulnerability framework for sorting out fisheries development strategies; that is, a framework that directly represents cultural and social features (see Ruddle 1989; Brown and Waugh 1989).

From this framework, fee fishing could well emerge as the most appropriate course of action. Although this is in accord with the rent maximising outcome, the conclusion is reached by a different path, a path that recognises the vulnerability of Pacific society to the impacts of international forces.

Revenues from fee fishing may have an impact on Pacific customs. This will vary depending on how revenue is distributed, whether in accord with traditional ways of sharing, or ways driven by a value system that features individual self-interest and private ownership, features that are generally accepted as fundamental and necessary in western capitalist society, but may be lacking in traditional society.

It is clear that domestic participation in harvesting and processing, given the size of the resource and the gearing of output to international markets, takes on a different dimension in a vulnerability framework. Domestic participation necessitates a different way of working the world, a different sort of industrial organisation, a different reward system, and a different institutional framework, amongst other things. This type of enterprise cannot be isolated from traditional ways of working the world in other sectors of the community. The switch and sway of international forces, and the aspirations of foreign participants (joint-venturers and investors) would necessarily have an impact on traditional culture and custom, particularly in crisis. Foreign currency debt could deepen and widen the impact. Foreign creditors who rightly demand their 'pound of flesh' have not been, and are not likely to become, serious respecters of traditional cultural and social systems. Recent and current events in central and south America, and in Papua New Guinea, strengthen this concern.

There are also direct environmental effects to consider. Fluctuations in harvest, due to overfishing or random and temporal environmental changes, would be more strongly and widely transmitted to the Pacific community under domestic-participation outcomes. There is no guarantee in the findings on biological research, where explanation is often based on meagre and deficient data. It is important that decision-makers are not swayed by the impression of precision given by these representations, more particularly the economic models that make the sort of existence claims that biologists would not entertain.

The formal representation of sustainable yield serves to illustrate this concern. This concept is given ostension through the population yield relationship. Although biologists know and accept that this ostension does not extend to the seas and ocean, sustainable yield has been eagerly embraced by those fisheries economists who prefer to proceed along the rent maximising path. With great facility the population yield curve is converted to a total revenue curve and ostension given to the rent maximising output by the addition of a total effort or cost function. But this ostension is only in the model. The variability of international market forces and the impact of environmental effects seriously challenges, and diminishes, the importance of the rent maximising outcome. The efficacy of this outcome is only supported by the presuppositions of the model. The collapse of the tuna market at the beginning of this decade, and the closure of nearly all processing facilities on the west coast of the United States had little effect on the United States economy. It is possible to imagine the serious social effects of closures if these facilities had been located in the Pacific region.

Secondary effects of crisis arise when domestic participation strategies are upset by debt servicing problems. This has its effect on the wider community, often making necessary different ways of working the world: cash crop expansion at the expense of traditional food crops, as well as externally imposed constraints. Serious social tensions generally follow. These issues are important and have been highlighted in recent times.

The Pacific peoples may not view fee fishing as the most desirable outcome. Emerging from a global framework, fee fishing could well be viewed as a western, capitalist trick, as this mode of operation may not give the immediate impression of being development at all. It could well be taken as a locking-in strategy. For less developed small economies this framework leads to a circularity; stage of human resource development determines comparative advantage, and comparative advantage determines and fixes stage of development. There is no avenue here for domestic participation in fishery resource development, no direct employment effect, no skill enhancement, construction or infrastructure development – the very indicators that are commonly understood as measures of economic development.

Economists give considerable emphasis to secondary effects. These effects have, no doubt, been of considerable benefit in more developed and diverse economies. It is not so evident that they apply to the small Pacific economies. The revenues from fee fishing could well be dissipated in the consumption of imported goods, increasing consumer welfare, but not necessarily domestic development in the commonly accepted sense.

Whether fee fishing would be more readily accepted emerging from a vulnerability minimising framework is an open question. But at least concern is given to protecting those things that are traditional and valuable from the intrusion of different and often disagreeable world views.

Conclusion

It would appear that rent maximisation is an important driving force in international markets, both in understanding the present situation in the south Pacific and in development planning. The major distant water fishing nations, the United States and Japan in particular, have attempted to increase their returns from the tuna resources. Japan has had a long interest in the south Pacific, and is unlikely to be dissuaded by the exclusive economic zones or licence fees. There are significant gains for the Pacific people in selling fishing rights to these countries in the long term.

However, Pacific views on how they wish to develop their tuna resources may not coincide with market outcomes, or if they do their line of reasoning may be different. The Asian and European ways of working the world may be vastly different from those in Pacific countries.

Chapter

3

The Papua New Guinea Tuna Fisheries: an Overview

R. Kuk

Background

Papua New Guinea has a total land area of approximately 464 000 km^2 and, together with its exclusive economic zone, encompasses over 2 million km^2 of the western Pacific region. It is the largest country in the Pacific islands region. The country consists of the eastern archipelago, the northern islands of the Solomon group and many other smaller islands. In all there are about 600 islands of significance. Papua New Guinea shares common borders with Australia, the Federated States of Micronesia, Indonesia and the Solomon Islands (Fig. 3.1). The country has a population of over 3 million and an annual population growth rate of 2%. Of the total population of Papua New Guinea, 80% live in the interiors of the main islands and the remaining 20% inhabit the coastline of its many islands. According to the 1980 census the Papua New Guinea population density is 6.5 persons/km, which is modest by international standards.

Papua New Guinea's national economy is heavily dependent upon exports of gold and copper and, to a lesser degree, tree crops (coffee, cocoa, copra and palm oil) and forestry products (Table 3.1). In 1980, fisheries

Table 3.1 Papua New Guinea, value of exports, selected years, 1980–93 (kina million)

	1980	1983	1987	1990	1993
Minerals	500.0	425.3	714.9	757.5	1997.0
Coffee	183.8	108.0	134.7	103.5	105.4
Cocoa	72.1	47.2	56.2	29.9	37.9
Forestry products	71.0	62.4	110.9	79.6	112.8
Copra products	38.0	27.4	29.7	20.3	26.9
Palm oil	25.7	22.8	23.9	32.7	60.1
Fisheries products	52.5	10.9	11.0	8.2	18.7
Other exports	129.2	79.6	41.9	90.9	75.6
Total	1072.3	783.6	1123.2	1122.4	2434.4

Source: Papua New Guinea Bureau of Statistics.

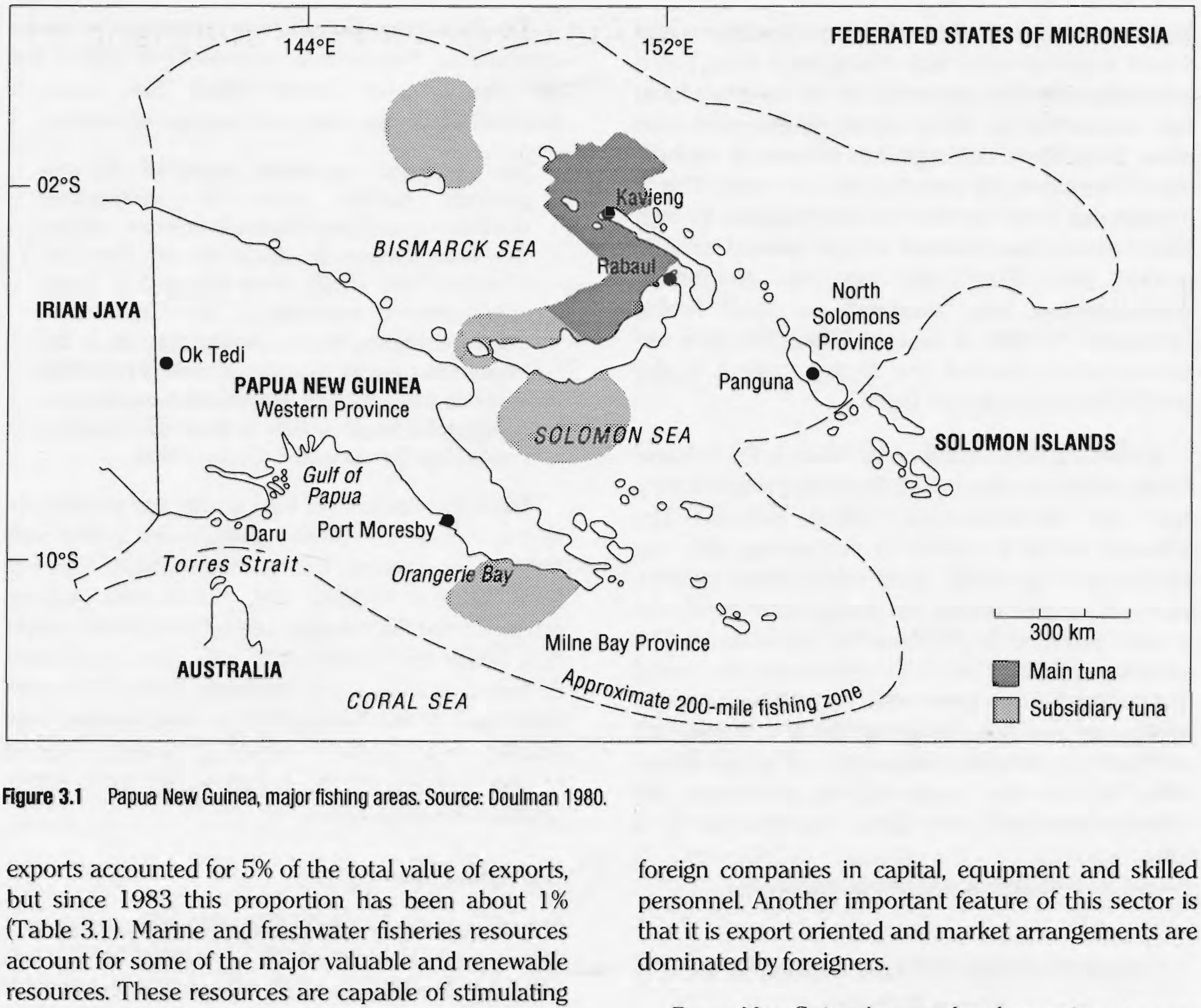

Figure 3.1 Papua New Guinea, major fishing areas. Source: Doulman 1980.

exports accounted for 5% of the total value of exports, but since 1983 this proportion has been about 1% (Table 3.1). Marine and freshwater fisheries resources account for some of the major valuable and renewable resources. These resources are capable of stimulating economic development within the 13 maritime provinces of Papua New Guinea. Fisheries resources also guarantee a protein supplement for domestic consumption and generate foreign exchange. The government promotes fisheries development because of its distinct advantage over the development of nonrenewable resources. If rationally managed, fish stocks are intergenerational assets which will continually yield harvests without overexploiting the resource.

The two components of the Papua New Guinea fishing industry are the industrial (large-scale) and the artisanal (small-scale) sectors. Catches in the industrial sector have consisted primarily of tuna, prawns, lobsters, and a small amount of barramundi. This sector has required a high level of investment from foreign companies in capital, equipment and skilled personnel. Another important feature of this sector is that it is export oriented and market arrangements are dominated by foreigners.

Papua New Guinea's coastal and oceanic waters are well stocked with an abundance of varied marine resources. However, with the exception of a very large tuna resource and smaller prawn, lobster and barramundi resources, the bulk of the species do not have an adequate total biomass to sustain an industrial fishery operation. Most of the fish species exploited are marine species, with the exception of tilapia (*Tilapia mossambica*), an introduced freshwater species, and barramundi (*Lates calcarifer*) of a native catadromous species. They have supplied the major sources of protein among the river and delta populations.

A major feature of Papua New Guinea's industrial commercial fishery is its heavy dependence on foreign skill and capital. Because of cyclical market price fluctuations, the tuna fishery has experienced ups and downs, resulting in the lack of long-term shore based establishments. The prawn fishery on the other hand has experienced a rather stable development with minor fluctuations and a gradual increase in national ownership, especially over the past few years. This is partially due to the fact that the fishery caters for high price foreign prawn markets with an upward trend in product price. There has also been government encouragement and assistance to local fishing companies. In 1984, a national fishing company was formed which acquired four fishing trawlers. It also established a subsidiary in Japan.

Coexisting with the industrial fishery is the artisanal fishery, which involves local fishers using simple fishing gear and labour-intensive fishing methods. The artisanal fishery is mainly for subsistence, with any surplus catch generally being sold in local markets, although the government has coastal fisheries stations in some provinces to purchase the surplus catch. The advantage of this fishery is its closeness to the coastal and riverine fishing communities and the use of simple fishing gear. A major constraint is the lack of adequate storage, transportation, marketing and proper fishing skills. Without the proper fishing techniques and adequate assistance, the fishery has survived as a sector catering for the domestic requirements of coastal and riverine fishing communities only.

Present status of the commercial tuna fishery

Papua New Guinea's principal commercial fisheries exploit tuna, prawn, lobster and barramundi. All these fisheries are export oriented and they meet the requirement of industrial fisheries.

> By the nature of their development, they have been dominated by foreign companies that have assembled the necessary capital equipment and key personnel, that have organised the fishing operations, and that have exploited the overseas marketing channels open to them (Copes 1982).

The most significant industrial sectors consist of the tuna and prawn fisheries which export almost all of their products.

The Papua New Guinea tuna fishery has two major components, the domestic pole-and-line fishery and the distant water fishery which has employed pole-and-line, purse seine, and longline techniques.

> For successful operation, industrial fisheries generally require access to commercially significant quantities of high value species ... Papua New Guinea waters lie astride the migration path of major South Pacific stock (Figure 3.2). These waters are very important to the skipjack tuna stocks originating from spawning grounds in the Micronesian waters. Sizeable schools of these fish at two to three years of age remain available for a considerable length of time in the surface layers of Papua New Guinea waters (Copes 1982).

Biological research of tuna stocks was undertaken by the Papua New Guinea government in the early 1970s. A recent survey from the South Pacific Commission Skipjack Tagging and Assessment Program estimated that the potential annual sustainable yield of tuna within the country's 200 mile zone significantly exceeded the quantity currently being harvested (Doulman 1987a). Skipjack is the predominant tuna species and is capable of sustaining an annual harvest of over 100000 tonnes according to South Pacific Commission assessments.

Domestic tuna fishery

The Papua New Guinea domestic commercial tuna fishery began in March 1970, after initial baitfish and tuna surveys in the late 1960s indicated the existence of bait and tuna stocks capable of sustaining commercial exploitation. Between 1970 and 1981 a number of foreign fishing companies set up bases in Papua New Guinea to harvest tuna, but by 1979 only two remained in the fishery. These companies were Star Kist (Papua New Guinea) and New Britain Fishing Industries (NBFI) Pty Ltd. The two companies operated through 1981, but as a result of deteriorating world tuna market conditions they did not fish in 1982 (Doulman and Wright 1983). The NBFI eventually announced its intention to terminate its operation in Papua New Guinea, after incurring losses in 1981 and the reorganisation of its parent company. Star Kist followed suit by terminating its Papua New Guinea operation in early 1983. The closure of the domestic tuna fishery affected 1200 Papua New Guinean nationals, and commerce in

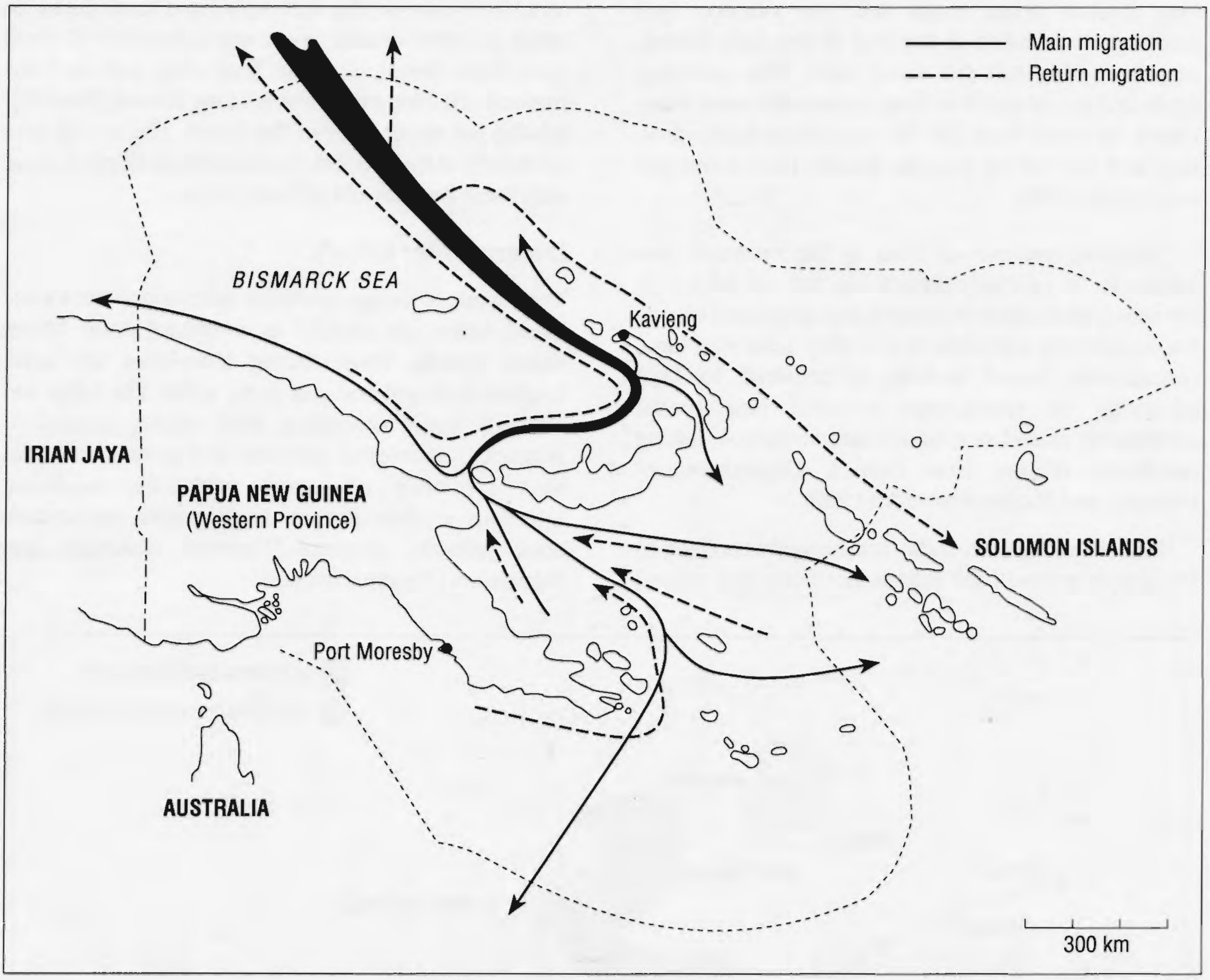

Figure 3.2 Papua New Guinea, skipjack migratory patterns. Source: Doulman 1980.

Rabaul and Kavieng, where the tuna fleets were based and provisioned, was badly affected (Doulman and Kuk 1986).

The fishing operations by the two companies were mainly pole-and-line, although NBFI operated a purse seiner in its fleet. The boats employed were of the traditional Okinawan type. Most of the pole-and-line vessels were of 59 GRT, about 12 metres in length. The main engine of these boats ranged from 350–600 horse power with a 50 to 150 horse power auxiliary power unit.

In 1980, NBFI operated with two motherships, 12 pole-and-line boats and a purse seiner, while Star Kist worked with four motherships and 36 pole-and-line boats. One-third of these boats were owned by Star Kist; the remainder were individually owned and delivered their catch to the companies under contract or on other commercial arrangements. All of the tuna catch was exported frozen in the round from motherships and shore holding facilities of the two companies. The catcher boats operating in the fishery used an anchored mothership of 1000 to 4000 GRT as a base. These vessels moored close to the baiting grounds so that catcher boats could take on supplies and discharge their catch at the end of the day's fishing, prior to taking bait the same night. The operating range of the pole-and-line boats is limited to near shore waters, no more than 100 km away from the mother-ship and the baiting grounds (Copes 1982; Doulman and Wright 1983).

Migrating patterns of tuna in the Bismarck Sea appear to be relatively predictable, but are related to the seasonal changes in current and associated events. For an efficient exploitation of surface schooling tuna, considerable vessel mobility is required to take advantage of year-to-year seasonal and spatial variation in abundance, and hence favourable fishing conditions (Papua New Guinea, Department of Fisheries and Marine Resources 1989).

As a result the pole-and-line fishery was confined to the waters around New Britain, northern New Ireland and New Hanover (Fig. 3.3). Significant tuna stocks do occur in other coastal areas and a number of them have been fished at some time. The pole-and-line method of fishing catches only young juvenile tuna that inhabit the upper layer of the ocean. The young tuna are mostly of the two and three year class skipjack tuna, with some two year old yellowfin tuna.

Distant water fishery

The vessels of foreign countries operating in the Pacific island region are referred to as distant water fishing nation vessels. Three fishing techniques are used: longline, pole-and-line and purse seine. The latter two methods target on-surface tuna stocks, particularly skipjack (*Katsuwonus pelamis*), and juvenile yellowfin tuna (*Thunnus albacares*), while the longlining technique exploits deeper dwelling tuna, particularly adult yellowfin, albacore (*Thunnus alalunga*), and bigeye tuna (*Thunnus abesus*).

Figure 3.3 Papua New Guinea, main baitfish and tuna fishing grounds. Source: Doulman 1980.

In 1984 there were 115 purse seiners from Cayman Islands, Honduras, Indonesia, Japan, Korea, Mexico, Panama, Philippines, Taiwan and the United States operating in Papua New Guinea's 200 mile exclusive economic zone. Japan accounted for 90% of all seiners and most of the longliners and pole-and-liners. The number of seiners licensed in waters fluctuates each year as some United States seiners enter and exit the Papua New Guinea waters from the eastern Pacific fishing grounds. There are 700 longliners fishing in the region (including Papua New Guinea waters). Most are Japanese and Korean owned, but there are also a number of Taiwanese owned vessels. Distant water fishing nation pole-and-line fishing has declined over the years as a result of the Japanese rationalisation program.

Most of the distant water fishing nation vessels operating in Papua New Guinea waters fish under 'access agreements' that recognise the jurisdiction of coastal states over tuna stocks and the right of the government to regulate and control access to these resources. Access agreements offer access to foreign vessels under a licence to operate on payment of a negotiated fee and compliance with specific terms and conditions. These conditions govern the crew and vessel obligations in provision of catch data and orderly exploitation of the tuna resource. Catch information is crucial to provide a basis for the biological management of the fishery. Access agreements are either bilateral or multilateral between Papua New Guinea, Pacific islands and Taiwan, Japan and the United States. They yield a small financial return to the government together with an aid component. The Papua New Guinea/Japanese fishing arrangement was terminated in 1987 after disagreement over fee calculations.

The access arrangements under which foreign vessels are licensed to fish are influenced by Papua New Guinea government policy. Government policy encourages distant water fishing nation vessels to fish in Papua New Guinea's zone because:

- the country's domestic harvesting capacity is insufficient to fully exploit its tuna resource;
- government revenue is generated through the payment of access fees and other statutory charges as provided for in the Fisheries Act; and
- the provision of Article 56 of the United Nations Convention of the Law of the Sea, relating to the utilisation of the surplus fish stocks, is acknowledged by Papua New Guinea.

The government does not discriminate in the licensing of tuna vessels on the basis of nationality or vessel type. However, access can be denied if the vessel or its owner have infringed previous licensing conditions. Access can also be denied if the vessel is not registered in the Forum Fisheries Agency Regional Register of foreign vessels or has been removed from the Register.

For the right to harvest tuna stock in the Papua New Guinea exclusive economic zone, the government levies a fee on each operating vessel. The access fee is imposed:

- to extract resource rent from the fishery;
- to foster operational efficiency in the use of the resource; and
- to provide an instrument for the government to regulate, develop and manage the fishery (Doulman 1980).

Vessels can decide not to pay access fees and fish illegally, but the ultimate financial burden payable if a vessel is apprehended greatly exceeds the cost of access compliance.

Types of fishing operation

There are three major types of tuna fishing operation currently employed in the waters of the Pacific islands region – longlining, pole-and-lining and purse seining. The distant water fishing nation longline fleets from Japan, Korea and Taiwan are registered with the Regional Register. These vessels vary in size from 20–500 GRT, and operate predominantly in Papua New Guinea, Solomon Islands and Micronesian waters. They concentrate on the exploitation of skipjack, yellowfin, albacore and bigeye.

The Japanese longline fleet consists of 500–600 vessels which are closely monitored by the Japan Fishery Agency. Korea and Taiwan also have a sizeable longline fleet operating throughout the region, exporting most of their catch to the United States canners; they are, however, gradually shifting supply to the more lucrative Japanese sashimi markets. This trend is expected to continue because the Korean and Taiwanese fishing costs are lower than Japanese fishing costs, and the Japanese trading houses frequently contract and finance Korean and Taiwanese fishing fleets (Doulman 1987a).

Distant water fishing nation pole-and-line operations in the region are undertaken by Japanese fishers only. There are 80 vessels operating out of Japan, using live bait and fishing mostly in the Micronesian and Kiribati waters, as required by the Japanese government. However, this fleet rarely fishes in Papua New Guinea waters, since Japanese government policies were formulated to minimise the interactions and conflicts between the three modes of fishing, especially between purse seiners and pole-and-liners. These two techniques of fishing concentrate on the exploitation of the same surface schooling skipjack and yellowfin stocks. The pole-and-line catch data report 94% skipjack and 6% yellowfin, while purse seine catch of skipjack and yellowfin account for 70% and 30% respectively (Papua New Guinea Department of Fisheries and Marine Resources 1989). Pole-and-line catches are usually destined more for high quality use, mainly in the sashimi market, than for canning, since the cost per unit of output is relatively higher than purse seine caught tuna. There has been a gradual decline in the pole-and-line fleet under a plan by the Japanese government to allow only additional purse seine vessels to be registered as pole-and-line licences are surrendered. The extent to which pole-and-line vessels have been scrapped has been determined by competing market requirements for varying qualities of fish. The demand for high quality skipjack and yellowfin for the fresh market required some pole-and-line vessels, whereas the need to deliver reasonably priced fish for other local processed demand required the use of purse seine gear (Matsuda and Ouchi 1984).

The distant water fishing nation purse seine fleet has experienced a rapid growth in the Pacific islands region, especially in Papua New Guinea and Micronesian waters. The Japanese operate 14 purse seiners and other countries operate the remaining seiners. The total number of seiners operating in the region peaked at 115 in 1984 but has since decreased with the departure of some of the United States fleet from the region to the eastern Pacific. However, there is still a sizeable number of United States seiners operating in the Pacific islands region, fishing under the United States/South Pacific multilateral fisheries treaty. The Regional Register of foreign vessels has a total of 145 seiners varying in size from 300–2000 GRT from 11 countries, but 64% of the fleet are United States and Japanese flagship vessels. These seiners are mobile in their operation in and out of Pacific islands waters throughout the year. The 14 Japanese seiners were the core of the foreign fleet in the region (Doulman 1987a).

The core fleet operates exclusively in Papua New Guinea, Federated States of Micronesia and Palauan waters, including the high seas pockets between the 200 mile jurisdictions of these countries. A significant proportion of the catch is transshipped or discharged in the south Pacific region, either at canning facilities or United States territory ports. In 1984, the foreign and south Pacific island national fleets landed a total of 600000 tonnes of tuna with a market value of US$662.7 million.

Biology of the fishery

The two major species of tuna being exploited in Papua New Guinea's 200 mile zone are skipjack and yellowfin tuna. The most important stock accounting for 80% of the catch is skipjack tuna (*Katsuwonus pelamis*). Skipjack tuna are fast swimming fish, inhabiting tropical and subtropical waters where temperatures range from 17°C–30°C. They are a pelagic species that have no connection at any period of their life with the sea-bed or coast (Grandperrin 1978). They inhabit the upper 200 metres of the surface of the ocean and tend to be found between 40S and 40N.

Skipjack are a heterosexual species of fish with eggs being fertilised externally. The fish commence spawning after one year of age, beginning with about 100000 eggs each spawning period and increasing with age. Skipjack tuna spawn several times in each spawning period. The eggs hatch out about four days after fertilisation. As usual with schooling species, mating is promiscuous. Biological research has found that spawning takes place throughout the year in equatorial waters. Spawning probably takes place in surface waters, consistently being observed by the fishers from their fishing vessels. Mature female skipjack probably produce between 1 and 3 million eggs in a year as the production of eggs is proportional to the body weight of the fish (Waldron 1958). The larvae of these fish are widely distributed in the Atlantic, Indian and Pacific oceans. The concentration of fry in the Pacific Ocean increases significantly from east to west, being especially heavy in the area between 10N and 10S.

The hatching skipjack larvae approach 3 mm in length and become juvenile when they are between 15 and 30 cm. After the juvenile reaches 20 cm it has the full body form and coloration of an adult skipjack (Kearney 1978). Juveniles develop in the nursery ground and disperse beyond these grounds when the young skipjack have reached 35 cm in length but their migration is horizontal and they are rarely found feeding with adult skipjack in surface water layers. It has been observed by Japanese fishers and researchers, that oceanographic conditions have considerable influence on skipjack tuna. The fish gather in commercial concentrations in latitude 40N to 40S, especially where the colour of the sea is blue or blue-green. The transparency of the water is measured with a Secchi disc to exceed 20 m and temperature in its upper layer is between 17°C and 30°C. The adult skipjack distribution in the Pacific Ocean is complex, but it would seem there are two major tuna populations.

The Papua New Guinea skipjack tuna resource is of the western Pacific stock and the relationship and interaction with other tuna stock is complicated. Additional information is required on dynamics and stock interactions to establish effective management in the region. The movement of skipjack tuna within the Papua New Guinea fishery according to Kearney (1978) has been established accurately in the Bismarck Sea and to a lesser extent in the Solomon and Coral Seas. This distribution is due to:

- the movement of freshwater from the major river systems in Papua New Guinea to north of the equator to about 4N; and
- a clockwise movement around the Bismarck Sea, spilling over into the Solomon and Coral Seas (Fig. 3.2).

Operation of the skipjack fishery based in the southern and south western Bismarck Sea has shown consistently good catches (Kearney 1978). These areas have an abundant tuna resource and good baiting grounds, essential for a sustainable pole-and-line tuna industry.

Property rights and fisheries management

Fisheries regulation

Regulation has become a crucial element of fisheries management. There have been dramatic advances in fishing technology and fishing power, and rapid development of fish processing and marketing. With this has come recognition of the threat of resource depletion, and acceptance of the urgency for government intervention to control the rate of exploitation (Pearse 1980a). Associated with this recognition has been the declaration of the 200 mile fishing limit by coastal states. This development can be interpreted as part of the effort of coastal states to protect their resources from expanded fishing by foreign fleets. It was less than a quarter of a century ago that the jurisdiction of coastal states extended to 12 miles only. In 1977 fishing jurisdiction was extended to 200 miles, and now encompasses most of the world's richest fish resources. Governments of coastal states recognise the need for fisheries regulation and a much broader responsibility for resource management.

A third major change concerns the theory and practice of fisheries regulation. In the past, regulatory organisations aimed at achieving the maximum sustainable yield level of catch for each stock. Economists have now succeeded in ensuring recognition of the alternative goal of maximising resource rents and other benefits. Coastal states acknowledge the economic desirability of restricting entry whilst complementing the effort of regulators to control fishing pressure (Pearse 1980a).

It is evident both in theory and experience that in the absence of regulation a profitable fishery is unsustainable over the long run. If access is not restricted, profit will attract new entry, resulting in the expansion of fishing power and labour and the elimination of all returns in excess of the cost of fishing. Sometimes this adjustment towards an equilibrium between revenue and cost leads to resource depletion. But even if it does not, or if the catch is carefully regulated at the desired level, the fleet will inevitably expand beyond the required capacity and all potential net yields will be dissipated (Pearse 1979).

Common property status is a primary cause of economic inefficiency in the fishing industry. Individual fishers expand their operations in response to profit opportunities. However, they neither have control over the fish resources on which they depend nor over the other fishers with whom they compete for the catch. This results in exploitation, inefficiency and waste.

Property rights and individual transferable quotas

The major characteristic of fisheries resources that distinguishes them from most other natural resources is the institutional arrangements regarding the ownership of the resources. Fisheries resources most often are unowned or under collective ownership of nations, tribes or other groups. There are three major forms of property rights over fisheries resources. First, at one extreme, is sole ownership Scott (1955), where the exclusive right of ownership is held by a single owner.

At the other extreme is open access or absence of property rights. Here the resources are unowned (*res nullius*) and no fisher can enforce rights to exploit over any other. This absence of property rights has traditionally been associated with high seas fishing. High seas constituted the bulk of the world's oceans until the 1977 declaration of the 200 mile jurisdiction by coastal states.

Between the two extremes are the group forms of ownership where the resources are common property (*res communes*). Here rights over resource exploitation are held by persons in common with others (Pearse 1980b).

There are three general forms of common property rights. Firstly, there is unrestricted access which is closest to the case in which there are no property rights. Here anyone in the group that holds the rights may use the resource, but no one has power to exclude other members of the group. The non-enforcement of property rights, in this case, has a two fold impact:

- The reluctance of individual fishers to conserve some proportion of current stock for regeneration has historically resulted in stock depletion. No fisher finds it advantageous to release or leave in the sea small fish so that they can grow to a more profitable size. The likelihood is that they are only going to end up in the nets of other fishers. Therefore, the individual has no incentive to devote resources to habitat maintenance or fish stock enhancement (Copes 1980).
- The misallocation of resources because of excess investment in capital and labour. This results in excessive fishing effort and low productivity per unit of effort.

The second general form of common property right involves access restricted to those who hold explicit rights. Access rights may be in the form of licences, heritage rights or common law privileges based on residency. Property rights holders can collectively claim rights over specific resources and have the right to exclude others. Traditional unrestricted access has been ended to pave the way for limited entry policies, involving various forms of restrictive licensing.

The third form of common property right can be regarded as a subcategory of restricted access in which the rights of an individual holder are stinted, allowing a specific quantity of the resource to be taken. This is a characteristic of the individual transferable quota scheme. The objective of the individual quota is to allocate a fixed share of the catch in advance to individual operators (Copes 1986).

The advantage of management by individual transferable quota lies in the elimination of important external diseconomies associated with open-access fisheries and with fisheries subject to limited entry licensing. When fishers are guaranteed an individual quota they can take their time to make their catch, spreading their efforts optimally and using efficient configurations of equipment and labour in the process.

The transferability of quotas further facilitates rationalisation if there is excess capacity in the fishery relative to the total allowable catch, that is there is not sufficient harvesting opportunity under the quota scheme for all existing fishing vessels to operate at full capacity throughout the season. Rent can be generated from the fishery by the withdrawal of some fishing units from the fishery and their application elsewhere. The quota rights system allows quotas to be consolidated in the hands of the most efficient operators who can fish full time and reduce unit costs of production (Copes 1986).

However, there are several disadvantages of individual transferable quotas:

- difficulty in enforcement
- the culling and discharging of surplus catch at sea
- the inapplicability to short-lived species.

Therefore this form of regulation is not suitable for all fisheries.

The 200 mile jurisdiction

Governments of coastal states have declared 200 mile jurisdictions in response to concern about overfishing by distant water fishing nations. It should be noted that the declaration of 200 mile limits by coastal states in itself does not address the common property status of fisheries, which is the cause of economic inefficiency in the fishing industry. The declaration excludes non-citizens, but citizens of the coastal states can collectively exploit their zonal fisheries resources. An unregulated collective exploitation of the fish stock by citizens of a coastal state still has the problems of an open-access fishery.

There are three major advantages of enforcing the 200 mile jurisdiction. Coastal states can control overfishing by distant water fishing nations. Where foreign fishers are allowed, they have been licensed under stringent conditions. Second, the 200 mile jurisdiction enables national fishers to increase fishing activities without competition from foreign fishers and to use fishing as a means of promoting economic development. Third, it enables coastal states to regulate fishing effort by their own nationals and prevent overexploitation of fisheries resources.

However, the implementation of the 200 mile jurisdiction has resulted also in three major disadvantages. It has generated an expansion of fishing effort on a number of valuable fish species and the underexploitation of many other fish stocks through lower levels of effort. The exclusion of distant water fishing nations from 200 mile zones has resulted in the shifting of their fishing activities to the high seas. This has generated a rapid expansion of distant water fishing nation fishing effort on the remaining high seas stocks (Copes 1981). It has also resulted in the underexploitation of certain fish resources of coastal states which do not have adequate fishing capabilities and which have not concluded agreements with distant water fishing nations to fish in their zones. Finally, it has resulted in boundary disputes between coastal states, especially over more productive fishing banks and migration channels.

Tuna management in the Pacific islands region

Tuna stocks are highly migratory and pass through the waters of many 200 mile zones and the enclaves of high seas. Regional and subregional joint fisheries management provides an important measure of control over migrating tuna stocks between respective fisheries jurisdictions. To exercise a degree of control over distant water fishing nation fleets, Pacific islands states have established a number of regional and subregional fisheries organisations to monitor, conserve and regulate the activities of distant water fishing nations and their interactions with national fishing operations. The Nauru Group, which was established in 1983 by the Federated States of Micronesia, Kiribati, Marshall Islands, Republic of Palau, Nauru, Papua New Guinea and Solomon Islands, is an example of such an organisation. Its major objective is to develop a coordinated approach to control, management and conservation of common tuna stocks. This organisation functions in line with the spirit of the U.N. convention of the Law of the Sea (Matsuda and Ouchi 1984).

The distant water fishing nation vessels licensed to fish in the waters of the Nauru Group are subject to an identical set of terms of access and other licensing requirements, to enable a coordinated approach to foreign fishing activities. The Nauru Group share common tuna stocks in the region, together with some of the best tuna intercepting zones in the south Pacific. The distant water fishing nations are obligated to pay a negotiated fee under bilateral and multilateral fishing arrangements with countries of the region for access to their waters. The distant water fishing nation fleet can avoid paying these fees by waiting to fish in the high seas or by engaging in illegal fishing. However, it is more effective and cheaper to fish migrating tuna stocks from the best interception zones, reducing the average cost per tonne of fish.

Three major reasons for the dissipation of resource rents in a common property situation are: inadequate management capabilities in the coastal states; the existence of shared stocks; and ideological and philosophical constraints. But the two major underlining reasons analysed by Munro (1979) are:

- A coastal state may lack the resources to facilitate effective stock assessment, surveillance and enforcement. The distant water nations have every incentive to discount the future returns of the resources and may lack incentives to honour their obligations.
- Tuna are highly mobile, and stocks are shared by a number of coastal states. Tuna stocks also move into the high seas adjacent to coastal state zones. This puts a premium on cooperative management programs. With uncertainty and inadequate management capabilities, and the transboundary nature of the tuna stocks, it is difficult to coordinate management policies. Distant water fishing nations have an incentive to underreport their harvest and a complementary incentive to fish heavily in the present, in fear of restrictions on fishing effort in the future.

The 1977 international fisheries regime based on the 200 mile fishing zone brought most of the world's fisheries under national jurisdictions and there was a rush to the proclamation of 200 mile limits. Article 56 of the draft U.N. Convention of the Law of the Sea assigns each coastal state 'sovereign rights for the purpose of exploring, exploiting and managing resources' in a designated fishing zone extending beyond the 12 mile territorial sea to a distance of 200 miles from a coastal baseline. However, the task of determining the total allowable catch was left to the coastal state, but 'where the coastal state does not have the capacity to harvest its entire total allowable catch it shall ... give other states access to the surplus' (Copes 1981).

The draft Convention attempts to solve the transboundary stock problem by requiring adjacent states to cooperate in the establishment of joint management arrangements. The guidelines for this type of arrangement under the draft Convention are not tight and provisions for enforcement are absent. Prospects for such arrangements are often good if they involve only two countries, thus reducing the complexity of bargaining necessary to achieve a mutually advantageous management program.

The overlapping/transboundary tuna stocks in the central and western Pacific require joint management. This is because of the:

- wide range of stock management problems
- complexity of stock composition and migration patterns
- many coastal state and distant water fishing nation participants
- many stock components.

The south Pacific tuna fisheries are complex, consisting of many overlapping stocks of several species. Managing mixed tuna stocks requires regulating fishing effort, targeting more effort on stronger and less on weaker stocks, gear regulation and area closures.

Current management policies

Most management policies introduced in the Papua New Guinea tuna industry are designed to avoid sector conflict, especially between the locally based operators and distant water fishing nations. Regulations are designed to protect local pole-and-line operations, baitfish grounds, and artisanal fishers. The major management policies that have been implemented to date include:

- area and time closures
- gear restriction
- limited entry
- baitfish management.

Area and time closure

There are restrictions on major inshore tuna and baitfish grounds, especially around Cape Lambert and Ysabel Passage. Foreign vessels are not allowed to fish or travel within a radius of 100 km of Cape Lambert and Taskul in the East New Britain and New Ireland provinces respectively. These areas are near the major inshore tuna grounds. In addition to these two areas, the 12 mile territorial waters, inland waters and a major spawning area bounded by the parallels and meridians from latitude 0.30S to latitude 3.30S and from longitude 149E to longitude 153E are also restricted to all foreign fishing activities. Fishing in these areas would adversely effect the economic viability of any future locally based pole-and-line operation, and the viability of the artisanal fishery.

The time closure was introduced to areas within the seasonal tuna fishery, especially in the southwest of New Britain islands and the eastern Papuan waters for about three months of the year.

Gear restriction

The government has introduced a restriction on purse seining in the above areas of its 200 mile zone to avoid potential damage to locally based operations. Heavy purse seining activity in Papua New Guinea waters greatly affected the catch rates of pole-and-line operations between 1984 and 1985. The restrictions were formulated to safeguard future attempts to re-establish the locally based tuna operation, while at the same time controlling the number of seiners in Papua New Guinea waters. Gear restriction is crucial for ensuring the economic viability of a locally based tuna industry.

The restriction on longlining activities within the 12 mile zone was introduced after gear conflict between artisanal fishers and foreign based longliners. Local fishers and provincial governments have long opposed the licensing of longliners within the 12 mile limit because they interfere with local shipping traffic and community based fishing activities. There have been instances where local fishers have removed longline gear and retrieved the catch. The success of any restrictions depends on the effectiveness of surveillance and enforcement. In Papua New Guinea, such services are not very effective because of a lack of adequate labour and financial and capital resources. But the actions of local fishers have been very costly to the foreign based longliners.

Limited entry

The number of vessels allowed in the two major areas mentioned above has been restricted according to the availability of resources and baitfish. The Cape Lambert area has been restricted to 10 pole-and-line vessels and one mothership, while 24 pole-and-liners and two motherships are allowed into the Ysabel Passage area. The limited entry measure was introduced after the 1984 fishing season, on the basis of experience during the period 1971 to 1981, to ensure the viability of the locally based tuna industry, and in particular to safeguard the then Papua New Guinea Tuna Fisheries Pty Ltd operation. The policy can be re-examined for future pole-and-line operations, with a view to possibly incorporating seiners into the locally based tuna industry.

Baitfish management

The baitfish fishery is a subsidiary of the pole-and-line operation. Pole-and-line vessels take on bait at the end of each day. Bait are used to feed migrating tuna to induce them to a feeding frenzy before they are caught by pole-and-line using barbless hooks. Because the fishery is heavily dependent upon baitfish it disturbs the fishing activities of artisanal fishers. The pole-and-line companies are required to compensate the local artisanal fishers for the inconvenience and loss of fishing. The fishing companies pay baitfish royalties to local owners of the baitfish resources as a condition of licence.

Refined management policies

There are certain refined management policies that could be introduced to the fishery as a means of inducing new foreign investment in the industry. These policies include the restriction of purse seining activities in Papua New Guinea waters. The new incentives would have to be consistent with policies on joint venture participation and restrictions on fishing in the archipelagic waters.

Restriction on purse seine fishing activities

Purse seine fishing activities in Papua New Guinea waters have expanded rapidly over the past five years, reflecting the government's nondiscriminatory policy. This policy specifies that distant water fishing nation fleets will not be discriminated against so long as they pay the appropriate fees and satisfy government requirements. However, it is worth noting that increasing seining activities would adversely affect catch per unit effort of the locally based tuna operators.

The greatest impact has been experienced in the yellowfin catches, where catch per unit effort has declined with increasing seining. The government needs to introduce new policies that will control growth of future seining activities. Such policies will require detailed analysis of the dynamics and interactions between overlapping tuna stocks, and their effects on the foreign and locally based purse seine, longline and pole-and-line fleets.

As the government is actively seeking foreign partners to develop the locally based tuna industry, it is timely to consider a restriction on seining. The government would also need to reconsider its current policy of nondiscriminatory licensing of foreign vessels. A restriction on seining would succeed only if all countries sharing a common stock cooperate in reducing effort. The Papua New Guinea government would need the cooperation of all Nauru Group members to restrict the number of licensed seiners. The highly migratory nature of the fishery requires joint management policies to be formulated between the host countries and the distant water fishing nations.

Incentives to the tuna industry

For the government to satisfy its objective of establishing a sustainable, competitive and integrated domestic tuna industry, it would have to provide the appropriate incentives such as infrastructure (wharves, roads, water and utilities), exemptions from import duties, reduction of export taxes and exemption of all tuna vessels from the 8.5% import duty, which is a significant 'front end' cost. Since there is no national shipbuilding industry capable of constructing tuna vessels, the domestic based companies have no option but to import their vessels. Such an exemption would not be unique. There have been precedents in a range of industries, both primary and secondary (mining, meat canning, television), that have been granted exemptions on imported equipment required to establish ventures.

The government could exempt all tuna vessels from the current fuel import duty of 2 toea per litre. Since distant water fishing nation seiners and longliners travel long distances to the major tuna grounds, fuel constitutes 25% of their operation cost. Exemption from fuel import duty would provide a stimulus for foreign vessels to base in Papua New Guinea. Fuel concessions provided to these vessels would have to be comparable with competing areas in the region if Papua New Guinea is to be successful in attracting foreign vessels. Such fuel concessions are not without precedent. The Papua New Guinea Electricity Commission was granted a reduced rate on imported diesel fuel used for electricity generation.

There is also a case for a reduction in the export tariff on round tuna exports from the current 15% to 2.5%. This reduction would be consistent with other established Papua New Guinea primary products, such as tea, coffee and copra, for which the export tariff is only 2.5%. Such a reduction would greatly reduce the operational expense of domestic based vessels, thus offering a stimulus to base in a Papua New Guinea port.

Joint venture participation

The government has long recognised the need for foreign participation to develop the domestic tuna industry. There is an urgent need to formulate a policy on joint ventures that require the government to take up equity. There has been precedent in the primary and secondary industries (mining and agriculture), where the government has taken out equity in these ventures. Government participation provides a degree of confidence in the industry and encourages new local and foreign investment.

Archipelagic waters

The government should consider restricting access to its archipelagic waters. For this policy to succeed, considerable surveillance and enforcement would be required. If some long-term benefits were to be derived from foreign vessels, then the government could introduce a differential access fee structure with locally based vessels paying a lower fee than their foreign counterparts. A very high fee on all foreign vessels would induce illegal fishing in the archipelagic waters and would influence future investment decisions. A locally based fishing fleet would generate substantial economic benefit to the local economy, through creation of employment opportunities, payment of taxes and purchases of provisions.

Conclusions

Papua New Guinea has long recognised the potential of its tuna resources for economic development. However, the locally based tuna industry has experienced fluctuations between 1971 and 1985. There were four companies in 1972, reduced to two in 1979, which then ceased operation in 1981. The cyclical nature of the tuna industry has reflected world tuna market conditions and the entry of new low cost producers to the industry. The local benefits from the industry were substantial and its closure in 1981 resulted in the laying off of 1200 nationals, which adversely affected commerce in Kavieng and Rabaul where the industry was located. Attempts to re-establish the pole-and-line fishery in 1984 were not successful because of the depressed tuna market and high operation costs. These are the two major factors hampering attempts to reactivate locally based tuna operations.

The government of Papua New Guinea has been actively seeking potential foreign partners to develop the industry, especially the pole-and-line fishing operation, with the possibility of establishing a processing facility with associated shore based establishments. The major internal constraints hindering the development of a tuna industry include the lack of adequately skilled labour, lack of infrastructure (wharves, water supplies, utilities and domestic markets), the high costs of inputs and lack of consistent government tuna policies on equity participation. The government will have to reconsider its current nondiscriminatory licensing policy if it is going to develop a locally based tuna industry. For foreign based vessels to locate in the country, incentives would have to be provided: including fuel concessions, tariff exemptions or reductions, and equity participation. There are significant long-term benefits to be gained from foreign vessels basing in the country.

The current tuna industry includes the licensing of distant water fishing nation vessels to operate in the Papua New Guinea 200 mile zone. The highly migratory nature of tuna stocks requires joint management of this transboundary stock. The joint management regime would require a coordinated approach to exploit, conserve and manage the common transboundary tuna stock. Since Papua New Guinea has no locally based tuna industry, the government can benefit significantly from its tuna resource by simply charging high licence fees to foreign fishers. However, this could encourage illegal activities. The government could induce them to base in Papua New Guinea if domestic based vessels paid a lower fee. Failure to attract these vessels could result in Papua New Guinea imposing a high licence fee and closing off archipelagic waters to foreign based vessels.

Gear selectivity, area and time closures would greatly enhance the domestic based tuna industry in the future. This policy would have to take account also of the artisanal fishers whilst avoiding intersectoral conflicts. These incentives and management policies, if effectively executed, would result in a well managed tuna industry that would generate significant benefits to the local economy.

Part II

Harvesting Costs and Returns

Chapter

4

The Economics of the Japanese Tuna Fleet; 1979–80 to 1988–89

H.F. Campbell
R.B. Nicholl

Introduction

Recognition of the rights of Pacific island nations to the tuna resources in their exclusive economic zones has given those countries the opportunity to manage their fisheries with a view to maximising their economic return. Where distant water fishing nations are involved in harvesting, Pacific island nations are concerned with ensuring that they receive access fees which reflect the full value of the resource. This has led to a desire amongst coastal states to negotiate higher payments for the exploitation of their resources by distant water fishing nations. The trend has been met with reluctance on the part of distant water fishing nations to pay the higher fees. Many distant water fishing nations, such as Japan, claim that the combination of rising operating costs with relatively minor increases in tuna prices is constraining their ability to meet demands for increased access payments. Steadily increasing labour and fuel costs are argued to be placing the greatest pressure on profitability. Access negotiations between resource owners and distant water fishing countries have, as a result, become more vigorous. Some agreements, such as the one between Papua New Guinea and Japan prior to 1987, have expired and have not been renewed. This is primarily attributable to the extent of disagreement about the ability of distant water fishing nation vessels to pay higher access fees.

The purpose of this chapter is to compile and analyse revenue and cost profiles of Japanese offshore and distant water tuna fishing operations. The cost profiles are based on estimated economic costs of fishing, which have been calculated using accounting information from end-of-year financial statements, together with available data on Japanese capital costs. Tuna vessels have been categorised by gear type and size (based on gross registered tonnage). Annual profit or loss, annual rate of return on invested capital, and the cost per fishing day for each category of vessel for the period 1979–80 to 1988–89 is calculated. This information may help to resolve some of the disputes about the appropriate level of access fees.

Background

Prior to the early 1980s, tuna and skipjack fishing in the western Pacific had been dominated by Japanese pole-and-line, longline and, more recently, purse seine vessels. Throughout the 1980s, there was a steady increase in the number of United States, Taiwanese, Korean, Filipino and Indonesian purse seine vessels fishing in the region. The number of longline vessels operated by the latter four nations also increased. Purse seine activity is now dominated by Japanese and United States vessels, while pole-and-line fishing is still undertaken almost exclusively by Japanese vessels.

The expansion of distant water tuna fishing has been accompanied by rising costs, particularly of fuel oil and labour. Together, these costs account for between 45% and 60% of Japanese vessel operating costs for the three gear types (Japan, Ministry of Agriculture Forestry and Fisheries various years). Significant increases in fuel costs followed the world oil price shocks of 1973 and 1979. The most affected fleets were the distant water fleets, which travel long distances and operate large freezer storage capacity. The effect of rising fuel cost has been compounded by the need for the fishing industry to pay higher wages to attract labour from other more attractive employment. Younger generations of Japanese workers continue to view employment opportunities in primary industries as less desirable than those in tertiary industries.

In general, the fishing industry has been unable to translate rising fishing costs into higher market prices, further compounding the rising cost pressures faced by the fishing fleets. Although seafood prices in general rose steadily throughout the 1970s and 1980s, tuna and skipjack prices did not (ABARE 1988:276). Of tunas, only bluefin prices followed an increasing trend between 1976 and 1989. The price of bigeye rose steadily from 1976 to 1982, then fluctuated around a relatively stable trend to 1989. Yellowfin and skipjack prices were relatively constant between 1976 and 1982, but went into gradual decline thereafter. The price of albacore has remained relatively constant.[1]

Of the many distant water fishing nation fleets operating in the western Pacific, Japanese and United States vessel designs and equipment (fish finding, freezer, net handling etc.) form the basis of the two major technology streams employed. Many of the Korean, Taiwanese and Filipino purse seiners are ex-United States vessels (Doulman 1987a) or vessels built in Asia to American specifications. Technically or mechanically related operating costs are likely to be similar for vessels employing like technology. However, even for similar vessels the labour component of costs may differ due to the different wage structures which prevail in those nations which provide labour for the tuna fishing industries. The wages for Japanese and American crew continue to be significantly higher than those of their Asian, Melanesian and Micronesian counterparts.

[1] Based on average Japanese market per kg prices for frozen tuna and skipjack: 1976 to 1982 from Matsuda and Ouchi (1984); and 1983–1989 calculated from monthly Globefish prices (FAO various years).

United States vessels enjoy considerable freedom in choosing home ports, nationality of registration and sources of labour. To some degree they have been able to contain wage and fuel costs by basing their operations in American Samoa and Guam, and hiring islanders as crew. The Japanese government on the other hand exercises a considerable amount of control over the operations of Japanese vessels. It continues to restrict Japanese vessels fishing in the western Pacific to 'home ports' in Japan, using Japanese crew. Exceptions to the use of Japanese crew occur in cases where access agreements with coastal states cover the use of islanders as crew members. The required employment of Japanese crew has meant that vessel owners have had little or no scope for reducing the labour component of operating costs.[2]

Data

Financial data for the Japanese tuna industry for the fiscal years (April to March) 1979–80 to 1988–89 were obtained from Japan, *Statistical Yearbook of the Ministry of Agriculture, Forestry and Fisheries*, Volumes 56–65. The data provided in these yearbooks are averages derived from surveys of fishing vessel owners. The data state the financial positions of average vessels of particular types at the end of the financial year. They are reported as: gross revenue from fishing activities; expenditures incurred for fishing activities; depreciation; capital assets (fixed and nonfixed); and operational data such as number of workers, days worked and days fished during the year. Interest payments on debt to banks, cooperative financial institutions and government related financial institutions are not reported as part of per vessel fishing activity statements.

[2] Although data on wages of Japanese deckhands are not available to compare with other nationalities, an indication of the wage differential between Japanese and Taiwanese can be gained from the following example. In 1989, a small longline vessel (20 tonne) faced wages of US$43000 and US$57000 for a Japanese boatswain and chief engineer respectively and US$9600 and US$14400 for the Taiwanese equivalents (Thoulaug and Kawai 1989).

There are two categories of owner: small-scale owners with capital assets of less than ¥100 million and large-scale fishing companies with capital assets of greater than ¥100 million. A weighted sample of owners based on the number of vessels fishing in all areas by the Japanese is taken, each year, to cover small owner vessels, whereas all available data for large-scale fishing companies is used.

Assets are reported at depreciated historical cost. These are fixed assets (shore based facilities and vessel) and nonfixed assets (capital value of fishing licences, goodwill and establishment costs). Fixed assets are depreciated on a declining balance basis over 12 years with a 10% initial historical cost as scrap value. Depreciation of nonfixed assets is by any amount, at will.

Unfortunately, the data reported for purse seine vessels are for group seining operations only, which makes it somewhat difficult to judge how single seining operations are faring. Group purse seine operations may involve up to four vessels per group: two net vessels (one of which may act as an anchor vessel) and two carriers. Data on single purse seine vessel operations would have been more useful in investigating the viability of tuna purse seining in the western Pacific because most Japanese purse seining activity in that region is undertaken by single vessel operations.

Method of analysis

The cost of fishing in foreign exclusive economic zones has three components: capital costs; variable costs (in the form of fuel, bait, wages, maintenance etc.); and the cost of gaining access, via a negotiated agreement, to the fishing zone. As this chapter forms the basis of an analysis of Japanese vessel ability to pay for access to Papua New Guinea's fishing zone, the cost of effort for Japanese tuna vessels is considered exclusive of access fees.

The data for this investigation are available only in the form of averages derived from aggregated survey information and therefore it is not possible to compare actual vessel costs. Thus, representative cost profiles for an 'average vessel' of the three gear types and sizes of vessels are determined. Determining average cost profiles implies that all vessels in a particular gear type and size class are treated as identical with respect to operating and capital costs. The role any variation in skipper skills could play in determining vessel operating costs is also ignored. Furthermore, as the available data derives from surveys covering vessels which most likely fished in a wide variety of geographic regions, any potential variations in costs faced by vessels due to this factor is ignored.

By using the revenue data from Ministry of Agriculture, Forestry and Fisheries end-of-year statements to estimate profits, it is assumed that prices used to determine revenues accurately reflect the true value of tunas and skipjack. Observed prices may not reflect true prices if Japanese tuna markets are imperfect, or involve vertically integrated firms able to shift actual returns to different sectors of their operations by adjusting prices within the firm for tuna to the different sectors. This behaviour is referred to as 'transfer pricing'. For firms involved in tuna and skipjack harvesting and processing, one objective of transfer pricing could be to distort the true ability of vessels to pay access fees for fishing in foreign exclusive economic zones by understating ex-vessel prices.

We now turn to the procedure for calculating economic profit. It is widely accepted that accounting measures of profit differ from economic measures of profit. Put simply, economic profit is defined as income in excess of total costs incurred. In the case of tuna harvesting, total costs include explicit costs (such as wages, fuel, bait etc.) and the implicit cost of using capital for fishing when it could be invested in its next best alternative use.[3] Economic profit is calculated in the following way: the residual of total revenue less operating costs gives operating profit; depreciation and the opportunity cost of capital is then deducted to give economic profit (or loss). The rate of return on invested capital can be calculated by dividing operating profit less depreciation by the value of capital employed.

A difficulty with this approach is in measuring both the economic cost of capital and the stock of capital to apply it to. Much of the available financial data report

[3] The cost of capital is its 'opportunity cost' or the return that capital could earn if it was employed in its next best alternative use (ie. the risk adjusted, expected return if the capital had been invested in the next best alternative activity to the activity it is currently invested in).

capital stock as a depreciated historical book value. This typically represents an undervaluation of capital stock, the most appropriate measure being one based on the market value of the capital stock. However, such estimates of capital stock are difficult to obtain.

The available Ministry of Agriculture, Forestry and Fisheries data report capital stock (invested capital) of fishing units as (a) fixed capital (which includes vessels, fishing gear, buildings and other fixed assets); and (b) nonfixed capital (which includes such assets as goodwill, fishing licences and establishment costs of the operation). Both are reported at depreciated historical book value. The distinction between fixed and nonfixed capital is important for the purpose of measuring the cost of fishing effort because nonfixed capital costs should be excluded from costs in calculating economic profit from fishing since they probably represent capitalised rents from fishery resources. The use of depreciated historical book estimates of fixed capital stock also avoids the potential inclusion of any rents which can be capitalised into vessel (and other fixed gear) values, inflating fixed capital costs. It is not clear, however, whether this outweighs the disadvantage of using information which may represent an undervaluation of the true market value of fixed capital.

In addition to the above considerations regarding the cost of capital is the issue of how to treat interest paid on outstanding debt. There are basically two ways for a firm to finance capital investment. One is to use internal or equity financing; the other is to borrow from a bank or similar institution (debt financing). The cost of debt financing, in expenditure terms, is the interest payable on the loan. The cost of equity financing is the rate of return foregone from investing in the firm's next best alternative investment opportunity. In order to measure the total cost of capital, both equity and debt costs need to be considered. There are two ways of taking debt costs into account. One is to calculate the interest payable on the debt component of capital by multiplying the debt by the market rate of interest. The other way is to treat the actual reported interest payments as a cost to the firm. The former approach is incorporated in the weighted-average-cost-of-capital method which applies an average cost of debt and equity finance to the entire capital base of the firm. In the latter approach the total capital cost is calculated as the sum of actual interest payments plus the cost of equity financing multiplied by the amount of equity capital. In this paper estimates based on the weighted-average-cost-of-capital method are used.

Since all the necessary data to calculate the opportunity cost of capital for the Japanese fishing industry are not available, estimates of average capital costs in Japanese industry as reported in Ando and Auerbach (1990) are used. This study provides estimates of Japanese capital costs which cover the period 1979–80 to 1988–89. It also adjusts the series of capital cost measures to account for a variety of effects. One which may be relevant to this analysis is a correction to the basic rate of return to account for cross-holdings of equity amongst Japanese firms.

The basic method of estimating the cost of capital used by Ando and Auerbach involves using observed debt-equity ratios from a cross-section of Japanese firms as weights to calculate an 'overall' return to capital. This method assumes (at least over the long term) that firms' rates of return on capital will equal the rate required by the holders of their securities. The primary source of data is the Needs Nikkei Financial Tapes. This method is referred to as *Return to Capital (A)*, and the estimates of required rate of return are reported in Ando and Auerbach (1990) Table 1, column (3).

An adjustment for cross-equity holdings is made to account for the fact that only dividends, rather than a total return (which includes capital gains) from unconsolidated holdings amongst firms, are reported in Japanese financial statements. Therefore the returns to companies with subsidiary holdings will be understated and their capital costs will be underestimated. Although not all Japanese tuna vessels which operate in the western Pacific are owned by large companies with significant subsidiary holdings, it is common in Japan for small to medium sized firms to have a financial stake in other companies. To account for this possibility amongst tuna fishing operations, separate calculations of economic profitability based on the above adjusted method of estimating the cost of capital have been made. We refer to this method as *Return to Capital (B)*, and the estimates of required rate of return are reported in Ando and Auerbach (1990) Table 6, column (2).[4]

The results of the analysis are reported in three forms. First, estimates of economic profitability as revenue less the total costs of effort (operation and capital costs and depreciation) are shown. If tuna fleets are not, on average, earning fishery rents from harvesting, this figure will be zero. Second, profit estimates as a rate of return to invested capital are reported. Actual rates of return are calculated by subtracting operating costs and depreciation from revenue and expressing the resulting value as a proportion of invested capital. As nonfixed assets include goodwill and the capitalised value of fishing licences, the reported fixed capital stock (historical value) only is used for calculating rates of return. This is based on the view that the value of goodwill and fishery licences represent capitalised rents or quasi-rents and are not part of the opportunity cost of capital used to produce fishing effort. These actual rates of return to capital are then compared with the required rates of return reported by Ando and Auerbach (1990). Third, given the cost estimates, the information reported in the Ministry of Agriculture, Forestry and Fisheries volumes on average vessel operations is used to estimate the cost of a fishing day for the different vessel categories.

[4] There are two separate issues to consider here. One involves accounting for the cost of capital owned by parent companies in subsidiaries (subsidiary consolidation), while the other involves accounting for the cost of capital in nonsubsidiary cross-holdings. The overall effect of excluding these considerations from a measure of the cost of capital is that the returns to the firm will be underestimated and therefore, so too will the cost of capital to the firm.

Ando and Auerbach account for the absence of returns to companies from subsidiaries in their measurement of the return to capital via *Method (A)* as follows. Data on both unadjusted earnings and earnings adjusted for subsidiary cross-holdings are available for the latter part of their sample period. They assume that the observed difference is a rough estimate of the difference in the earlier period when unadjusted data only are available. They then compute a series of adjusted earnings estimates of the whole sample period.

A correction for nonsubsidiary cross-holdings was carried out by calculating an adjusted earnings-price ratio for a particular firm by subtracting the dividends from cross-held shares from earnings and subtracting the total (book) value of these shares from the equity of the company according to;

$(E/P)_i = [(E/P)_i - fd]/(1-f)$ for company i;

where E/P is the earnings-price ratio, d is the dividend yield of equity (total dividends divided by the total value of equity, summed over all firms) and f is the ratio of the market value of a company's cross-held equity to the market value of the company's own equity.

The above adjustments are then combined to give a measure of returns to capital reported as *Return to Capital (B)*.

Analysis of economic profits and rates of return to Japanese tuna vessels

Table 4.1 contains estimates of the annual economic profit for an average vessel of each of the three different gear types and the various categories of vessel size for the period 1979-80 to 1988-89. The estimates are based on data reported in Campbell and Nicholl (1990 and 1992a: Appendix A). Table 4.1 summarises profit calculations for both estimates of required rate of return to capital (*Return to Capital A*, and *Return to Capital B*).

The profit calculations shown in Table 4.1 indicate that Japanese offshore and distant water tuna fishing ventures have tended to operate at an economic loss. Even using the lower cost of capital estimates (*Return to Capital (A)*), which could underestimate the true cost of capital by ignoring the effect of cross-holdings on company returns, by far the majority of years covered show economic losses for all gear types and vessel class sizes. In fact, the only vessels to record an economic profit for the period covered by the analysis are large longliners (of the 100-200 tonne and 200-500 tonne classes) for the years 1979-80 and 1987-88 through 1988-89 (200-500 tonne class); and one-net boat purse seine operations of the 50-100 tonne class for the years 1979-80 and 1984-85. For the remainder of the period, gear types and size classes, economic losses fluctuate quite significantly from year to year.

It should be remembered that these results represent the economic situation for the 'average' vessel of each gear type and size class and that any individual vessel could in fact be making economic profits, or alternatively greater economic losses, than those reported. There is considerable variety amongst the size and types of vessels within the classifications used, and the types of operation and areas in which vessels in any class operate are as varied as the range of vessels themselves. Therefore, the following results represent an overview of total fleet operations and do

Table 4.1 Average annual per vessel economic profit (loss), Japanese Tuna Fleet 1979–80 to 1988–89 (current values, ¥'000).

Year	Longline vessels Size (GRT)			Pole-and-line vessels Size (GRT)		Group purse seine vessels Size (GRT)		
						One-net boat		Two-net boats
	50–100	100–200	200–500	50–100[a]	200–500	50–100	100–200	10–30
				Rate of return (A)				
1979–80	(14357)	2371	20513	(12057)	(45614)	614	(16847)	(228)
1980–81	(29421)	(34190)	(33307)	(82888)	(29244)	(4976)	(14679)	(891)
1981–82	(28842)	(53338)	(52729)	(21790)	(54510)	(7511)	(12454)	(2381)
1982–83	(22347)	(40889)	(33948)	(24044)	(64093)	(2451)	(6091)	(2567)
1983–84	(20170)	(38925)	(32027)	(25780)	(42807)	(2927)	(8313)	(2609)
1984–85	(14637)	(36921)	(11937)	(20407)	(33172)	921	(24117)	(3774)
1985–86	(13366)	(5436)	(23713)	(9014)	(37864)	(17684)	(17790)	(2844)
1986–87	(17431)	(7516)	(1895)	(9106)	(46548)	(9676)	(32825)	(2840)
1987–88	(9132)	(316)	7011	(3261)	(15648)	(7926)	(25391)	(980)
1988–89	(2951)	(18735)	13329	(5784)	(18933)	(2487)	(10747)	(627)
				Rate of return (B)				
1979–80	(14830)	1618	19671	(12656)	(47180)	267	(17530)	(286)
1980–81	(30312)	(35538)	(34764)	(9022)	(31361)	(5442)	(15710)	(980)
1981–82	(30107)	(54995)	(54593)	(22685)	(56876)	(8247)	(13484)	(2514)
1982–83	(23666)	(42910)	(35890)	(25112)	(66626)	(3333)	(7653)	(2771)
1983–84	(21460)	(40830)	(34156)	(26719)	(44783)	(3894)	(9654)	(2735)
1984–85	(16407)	(39304)	(14734)	(21455)	(35429)	(63)	(25670)	(3907)
1985–86	(15312)	(7498)	(26540)	(9945)	(40565)	(11932)	(9577)	(2235)
1986–87	(19086)	(9088)	(276)	(9876)	(49160)	(10715)	(34256)	(2950)
1987–88	(10794)	(2054)	4440	(3940)	(18761)	(8844)	(26836)	(1087)
1988–89	(3795)	(14811)	(11881)	(6114)	(21120)	(3041)	(11640)	(698)

[a]Average of full and part-time boats.

not hold for all specific circumstances. On the whole though, these results suggest that even before the cost of access is taken into account, the costs of tuna fishing for Japanese vessels outweighs the benefits, at least from an economic perspective.

The largest consistent losses recorded are for large vessel size (200–500 tonne), pole-and-line operations. These losses fluctuate between a low of ¥15.6 million for the year 1987–88 to a high of ¥64.1 million for the financial year 1982–83. There is a dramatic decrease in losses for these operations in the late 1980s. The smallest consistent losses recorded are for 10–30 tonne purse seine operations. These losses fluctuate between ¥0.2 million in 1979–80 and ¥3.8 million in 1984–85. In general, the purse seine operations have recorded consistently lower losses per vessel than either longline or pole-and-line operations.

Both the large (200–500 tonne) and small (50–100 tonne) full time pole-and-line operations fail to record an economic profit throughout the period covered by this investigation. The losses experienced by both groups increased throughout the years 1980–81 to

1982–83, but then began steadily to improve for the remainder of the period to 1989. Both groups experienced decreasing losses prior to the onset of the decline in profitability experienced during the early 1980s.

All of the longline vessel groups experienced a similar, though somewhat more pronounced, decline in profitability in the early 1980s compared with the declines experienced by the pole-and-line fleets. The onset of this deterioration in profitability for longline vessels, however, came a year earlier than for the pole-and-line fleet, but so too did the recovery in profitability. Nevertheless, economic profit remained below (economic) break-even throughout the 1980s.

Table 4.2 compares actual rates of return on invested capital for all vessel profiles with required rates of return over the period. These comparisons are based on required *Return to Capital* (*A*); the results based on required *Return to Capital (B)* were very similar to those of *Return to Capital* (*A*). As reported capital stocks are valued at depreciated historical cost, calculated actual rates of return will overstate the true rates of return to the extent that historical values understate market values of capital stock. Once again the results indicate that, in general, capital invested in offshore and distant water tuna fishing failed to yield returns consistent with market expectations.

The worst performances for the period were from the various pole-and-line fleets; none of the vessel classes covered by this analysis managed a positive rate of return. The trends in calculated rates of return were similar for the three classes of pole-and-line vessels: increasing to 1980–81 then decreasing significantly to 1982–83, followed by a steady increase to 1987–88.

For longliners, capital invested in the larger vessels of the fleet (of the 200–500 tonne class) earned rates of return in excess of the required rate for four years, 1979–80 and 1986–87 to 1988–89. Capital invested in the 100–200 tonne vessels earned returns in excess of the required rate in 1979–80 and then marginally below (0.2%) the required rate in 1987–88. The lowest return on capital for all gear types was recorded for this 100–200 tonne class of vessel in 1981–82 (-30.4%). Rates of return for all three longline vessel classes improved from lows in 1981–82 to 1988–89, except for the 100–200 tonne class which experienced a further decline in returns after 1987–88.

The rates of return to capital calculated for group purse seine operations vary widely across the different classes. Actual rates were greater than required rates for 50-100 tonne single net boat operations in two years, 1979-80 and 1984-85. Rates of return went into decline for several years after 1982-83 before recovering in the late 1980s. Both 100-200 tonne single and 10-30 tonne two-net boat operations failed to earn positive rates of return to invested capital except for one year each, 1979-80 (10-30 tonne) and 1982-83 (100-200 tonne).

Interpretation of rate of return results

Rates of return on invested capital

Estimated actual rates of return on fixed capital assets for the period 1979-89 have not only been consistently below required rates of return, but in most cases negative. Of all operations for the period covered, the larger vessel longline operations (of the 200-500 tonne class) are the only Japanese tuna fleets which have shown any promise with respect to profitability. Returns to capital invested in these vessels improved steadily throughout the 1980s, exceeding the required rate in 1986-87 and thereafter to the end of the period. However, from an efficiency perspective it would appear that there has been overcapitalisation in Japanese offshore and distant water tuna fleets. Much of the capital tied up in the industry could earn higher rates of return in alternative uses.

Rising labour and fuel costs have been cited as reasons for low rates of return to fishing industry capital in the 1980s. Using the Ministry of Agriculture, Forestry and Fisheries data and *Return to Capital (A)* these costs can be calculated as a proportion of total cost. While the proportions fluctuate from year to year, the fluctuations are moderate. In general, labour costs as a proportion of total costs fell slightly in the early 1980s then began to increase from 1982-83 to the end of the period. For all gear types and size classes they are in the range of 30-45% of total cost. On the other hand, fuel costs as a proportion of total costs tended to increase in the early 1980s and then

Table 4.2 Average annual rates of return[a], Japanese tuna vessels, 1979–80 to 1988–89.

	Actual rate of return (%)			RRoR[b]
Average longline vessel	50–100 t	100–200 t	200–500 t	
1979–80	(15.5)	8.0	22.9	5.8
1980–81	(26.3)	(18.7)	(16.2)	6.7
1981–82	(19.2)	(30.4)	(25.8)	8.2
1982–83	(12.7)	(16.7)	(13.4)	7.6
1983–84	(9.6)	(14.9)	(8.9)	7.6
1984–85	(4.0)	(13.3)	1.2	6.8
1985–86	(2.7)	3.2	(4.8)	6.9
1986–87	(7.2)	(0.3)	6.4	5.4
1987–88	(2.6)	4.3	8.0	4.5
1988–89	1.8	(9.1)	12.0	4.6
Average pole-and-line vessel	Average of full and part time	Full time 50–100 t	Full time 200–500 t	
1979–80	(8.3)	(8.0)	(14.6)	5.8
1980–81	(4.6)	(3.9)	(7.1)	6.7
1981–82	(21.0)	(22.9)	(19.4)	8.2
1982–83	(19.4)	(15.8)	(22.8)	7.6
1983–84	(22.6)	(22.5)	(16.2)	7.6
1984–85	(18.5)	(17.2)	(12.3)	6.8
1985–86	(6.7)	(10.1)	(12.7)	6.9
1986–87	(8.8)	(8.0)	(16.0)	5.4
1987–88	(1.7)	0.4	(2.0)	4.5
1988–89	(9.4)	(8.4)	(2.3)	4.6
Average group purse seine vessel	One boat[c] 50–100 t	One boat 100–200 t	Two boats 10–30 t	
1979–80	7.0	(11.5)	3.0	5.8
1980–81	(4.0)	(7.5)	(3.2)	6.7
1981–82	(4.1)	(6.3)	(13.2)	8.2
1982–83	4.3	2.9	(7.5)	7.6
1983–84	(3.3)	(6.8)	(22.8)	7.6
1984–85	8.0	(13.4)	(30.3)	6.8
1985–86	(21.2)	(14.9)	(32.2)	6.9
1986–87	(5.8)	(22.1)	(25.8)	5.4
1987–88	(6.7)	(18.3)	(7.3)	4.5
1988–89	1.0	(5.0)	(2.4)	4.6

[a]The figures report the calculated rates of return to fixed capital compared with the required rates of return to capital (from Ando and Auerbach 1990) for the three gear types. Return to capital (A) is used.
[b]RRoR = required rate of return.
[c]One boat = single-net boat group purse seining; Two boats = two-net boat group purse seining.

decrease from about 1982–83 to the end of the period. They have ranged from between 4 and 30% of total costs. Purse seine vessels have faced the lowest fuel costs as a proportion of total costs, ranging between 4.2 and 20.1%.

The Japanese government together with the fishing industry have, since the world oil price shocks of 1973 and 1979, devoted significant effort and research resources towards alleviating the burden to fishing fleets of rising fuel prices. The development of more fuel efficient vessel designs which incorporate reduced vessel drag in the water, larger propellers which turn at lower revolutions and energy saving freezer technology are among some of the strategies which have been adopted by the industry in an effort to deal with the oil price shocks (Matsuda and Ouchi 1984). The results of the present paper suggest that these efforts have had some success.

Other studies have also found low rates of return to Japanese fishing industry capital. Matsuda and Ouchi (1984) have estimated negative rates of return for skipjack pole-and-line and longline vessels for the years 1979–1982 (they omit purse seine vessels). They also calculate a positive rate of return for 200–500 tonne longline vessels in 1979. Furthermore, a report by the Australian Bureau of Agricultural and Resource Economics (ABARE 1988: 284) found that, for a high proportion of Japanese fishery establishments (46% in 1982), fishery expenditure has exceeded fishery receipts since the late 1970s. The results of this current investigation concur with both of these studies.

Government assistance to fishing

From whichever perspective the above results are viewed, either from that of economic profitability or the measured return to capital, it is clear that, on the whole, Japanese tuna fleets have not been viable. These results raise two important questions: why do these fleets continue to operate over the longer term at a loss?; and by what financial means can they continue to do so? Both of these questions lead to the issue of government involvement in the tuna fishing industry.

If infrequent and short-lived losses were observed for several vessel categories over the period covered, it would be tempting to conclude that an occasional poor season is not sufficient to drive vessels out of a fishery which yields prosperous long-term returns. Seasons of poor profitability resulting from any one, or a combination of circumstances such as low catches due to poor stock recruitment, or the failure of fishers to locate tuna migratory patterns, would be carried by seasons of above average returns. Our results, however, cannot be explained in such a manner.

While the major causes of these poor profitability performances are not the major concern of this chapter, explanations as to why and how these situations have persisted are needed. The answer to the first question lies, most probably, in either stated or unstated government policies which relate to two somewhat conflicting objectives. One is that of food security, which has figured significantly in Japanese agricultural and fisheries policies since the end of World War II. In fact, the extent and speed of the expansion of the Japanese distant water fishing fleets throughout the 1950s and 1960s is almost entirely attributable to the objectives of food and export commodity production (Matsuda and Ouchi 1984).

The other main objective of Japanese fishery policy has been to maintain fisheries industries (ABARE 1988). There are likely to have been a variety of considerations underlying this objective, ranging from employment aims to political pressure from cooperatives and prefectures representing communities heavily dependent on fishing for their livelihoods (Stokke 1990). Another relevant, but secondary, concern is likely to have been a desire by the Japanese to maintain a presence in what have been traditional Japanese fishing grounds, prior to the declaration of 200 mile exclusive economic zones. The Japanese government and fisheries management agencies have been acutely aware that any redeployment of distant water vessels to offshore and coastal fishing grounds would lead to competition and a possible deterioration in the viability of these operations.[5] Furthermore, domestic substitutes for high value species, such as those supplied by skipjack pole-and-line and longline fleets are not readily available (ABARE 1988: 278). Rising incomes and changes in consumer preferences have resulted in

[5] Claims by the Japanese that the introduction of 200 mile exclusive economic zones has significantly affected the profitability of their distant water fleets are well documented (see for example; Matsuda and Ouchi 1984 and Stokke 1990).

a relative increase in the demand for high quality and high value fish which would otherwise be supplied through increased imports from countries such as Taiwan and Korea.

It follows from the above discussion that if the government has played a large role in encouraging vessels to remain in distant water fishing grounds, it also must have been providing financial support to those operations which have experienced losses. There is in fact a variety of schemes through which the Japanese government has been extending at various times throughout the past several decades, financial assistance to the fishing industry in general . They have taken the form of price support schemes, favourable credit status and soft loans, insurance assistance and subsidies, to name but a few of such assistance mechanisms.

Financial assistance to skipjack and tuna fleets has been necessary throughout the 1970s and 1980s to facilitate rationalisation of the industry in response to fluctuating economic conditions and increasingly restricted access to foreign fishing grounds. Much of the assistance has been aimed at reducing the amount of effort in the distant water fisheries; the construction of new vessels to form a more fuel efficient fleet; and continuing support to remaining vessels.[6] In 1976 the government embarked on a program of vessel replacement which, effected via the *Fisheries Special Reconstruction and Adjustment Act (1 June, 1976)*, sought the replacement of pole-and-line by purse seine vessels. Under this program, vessels were paid up to ¥163 million each as compensation to retire from the skipjack fishery (Matsuda and Ouchi 1984). Assistance in the form of government subsidised low interest loans of between 3.5% and 5.7% amounting to ¥ 53.9 billion were also made available to tuna fleets between 1976 and 1980. These loans were introduced partly in response to vessels experiencing difficulties as a result of the world oil price shock (Matsuda and Ouchi 1984).

More recently, the Japanese Fisheries Agency of the Ministry of Agriculture, Forestry and Fisheries has been providing substantial assistance to the industry through a range of subsidy schemes aimed at promoting consumption of fisheries products, price stabilisation, rationalisation of processing and distribution facilities and industry structural adjustment schemes. In 1987, over ¥345 billion was allocated from the Japanese Fisheries Agency budget to fund these schemes. Of this total, 21.4% (¥60 billion) was provided as special low interest loans for the withdrawal of vessels, 28.6% (¥80 billion) was provided for the 'rehabilitation' of distant water operations affected by foreign access restrictions and 44.6% (¥125 billion) was provided for fishing gear and equipment modernisation.

It is possible, at least in principle, for these assistance packages to have offset the losses incurred by the various tuna fleets. For simplicity it is assumed that the losses incurred by the tuna fleets reflect the performance of offshore and distant water fleets in general. In the case of 1987, ¥269 billion in subsidies was provided in the form of industry 'adjustment schemes' aimed at the harvesting sector. These schemes covered the promotion of structural adjustment, loans for boat scrapping, the 'rehabilitation' of distant water operations, and funds for modernisation of industry. If the entire offshore and distant water fleet had incurred losses consistent with those experienced by the tuna fleet in general for that year, the ¥269 billion in subsidies would have more than compensated the industry for that loss. We arrive at this conclusion in the following manner:

Average loss per tuna vessel (regardless of size) across the three gear types for 1987[7]	¥6.4 million
Estimated total number of offshore and distant water vessels in the Japanese fleet for 1987[8]	18 040
Estimated loss for tuna fleets for 1987	¥115.5 billion
Japan Fisheries Association assistance package	¥269.0 billion
Japan Fisheries Association financial assistance net of total tuna fleet losses for the year	¥153.5 billion

[7] Calculated from Table 4.1.

[8] Calculated as 4.2% of the total number of fishing boats in Japan in 1987, which was 429541. The proportion of powered vessels which are 10–100 tonne was 3.4% and that for powered vessels 100 tonne and over was 0.8% (Ministry of Agriculture, Forestry and Fisheries 1988). As not all of these vessels are likely to have engaged in tuna fishing, our estimate of the total economic loss for the entire tuna fleet will be overstated.

[6] Matsuda and Ouchi (1984) report that according to the Japanese Federation of Tuna and Skipjack Fisheries Cooperatives' plan, 164 of 887 longliners and 55 of 157 distant water pole and line vessels were withdrawn during 1980-82 alone.

More detailed accounts as to how these forms of financial assistance are actually matched with vessel needs are not available. There will be many cases where individual operations were not suffering the financial difficulties experienced by the fleets in general and therefore did not require assistance. Conversely, there were most likely cases in which the amount of assistance available from various agencies was not sufficient to cover the needs of fishing establishments. However, from a broader perspective, it appears that the sums of government assistance are adequate to compensate the harvesting sector of the industry for operating losses.

The cost of fishing effort for the Japanese tuna fleet

The results of this investigation have shown that for the period 1979–80 to 1988–89 the economic costs incurred by Japanese tuna vessels have, on average, exceeded the revenues received from harvesting activities. This conclusion is consistent with previous work undertaken for periods both prior to, and overlapping with, the period investigated. It is also consistent with concerns expressed by the Ministry of Agriculture, Forestry and Fisheries (1988) regarding the financial difficulties faced by the industry (see also Japan Fisheries Association 1987). Although no detailed attempt to analyse the causes of these poor profitability performances has been made, the evidence suggests that the observed losses have been financed by government subsidies. It is difficult to believe the industry could have continued without such assistance.

Having determined overall profitability on an annual basis, costs of fishing effort on a per unit basis can be estimated. Once again, measures will be in the form of averages. Operational profiles for the vessels vary both between and within gear types and size classes. Smaller vessels tend to operate closer to Japan, making frequent, short trips to and from fishing grounds. Larger vessels on the other hand venture much farther afield, some 'campaigns' taking vessels on fishing trips for up to a year or more. Each campaign entails a routine which is essentially specific to the type and scale of operation characteristic of the vessel type. First, there is predeparture preparation involving acquisition of supplies, maintenance etc. This is followed by travel to the fishing ground during which time the crew may undertake basic gear and vessel maintenance while the fishing director, through past experience and contact with peers, gathers and assesses information on current fishing conditions. Days at the fishing ground (other than those subject to breakdowns), involve fishing effort in the form of searching and catching. Together, search and catch constitute what we take to be 'fishing effort', and the basic unit of fishing effort is a day fished. The campaign is completed once the vessel has filled its storage capacity (unless of course it transships at sea), and returns to port and unloads. The beginning of the next campaign is marked by the preparation for another voyage.

In order to measure detailed costs for each segment of a campaign or component of fishing effort (for example the cost of steaming, or search time, or making a 'set'), comprehensive data on operational profiles and technical parameters associated with different vessel types would be required. The aim here is not to provide a detailed breakdown of costs for specific areas of vessel operations. Rather, the aim is to provide information which coastal nations can use to assess the expected costs of operation faced by the different Japanese vessel types fishing in their exclusive economic zones. As much of the interest surrounding the harvesting capacity of distant water fishing nation vessels concerns their activity measured in 'zone days', we have calculated average total costs per day fished (which translates to cost per zone-day) for the different gear types of tuna vessels. Based on the assumption that campaign routines are relatively fixed for the different classes of vessel, the average total cost per fishing day (*ACFD*) is calculated as follows:

$$ACFD_i = (ATC_i/DY)/(DF_i/DY)$$
$$= (ATC_i/DY)x(DY/DF_i) \quad (1)$$

where ATC_i is the average total cost per year of owning and operating vessel type *i*, *DY* is the number of days in the fiscal year (365), DF_i is the average number of fishing days of the year for vessel type *i* and (DY/DF_i) is a ratio greater than one which reflects the fact that vessels do not fish 365 days in the year because a day fished involves associated periods of land based preparation and unloading, and steaming time to and from regular fishing grounds.

The average cost per fishing day has been calculated by taking the average total cost of operating the average vessel for one year and dividing it by the reported average number of fishing days for that year.[9] The cost of each fishing day will implicitly incorporate the associated steaming, maintenance and port related costs required to support that day fished. The cost of owning and operating a vessel per day (not day fished) has also been calculated. These estimates, for each gear type and size of vessel, are reported in Tables 4.3–4.5. Costs have been calculated in nominal (current value) terms and those reported here are based on *Return to Capital* (*A*); calculations based on *Return to Capital (B)* give similar results. Further detail is available in Campbell and Nicholl (1990 and 1992a, Appendices A and D).

The general trend of cost per fishing day for all vessel types has been an increase to the mid-1980s, then a decline to the end of the study period. For the longline vessels, the largest increase in cost per fishing day is observed for the 200–500 tonne vessels, 58% between 1979 and 1986. The 100–200 tonne vessels faced a similar rise in cost of 50%, and 22% for the smaller class of longliners. During this period fuel as a proportion of total cost was rising while labour cost as a proportion offset this rise by falling. The cost per fishing day declined steadily after 1986 for all longliners to levels experienced around 1981–82.

Although the cost per fishing day faced by owners of 50–100 tonne pole-and-line vessels was about the same at the end of the period as it was at the start of the period, costs did fluctuate significantly from year to year on an almost cyclical basis. On the other hand, the trend of costs of operation for the large (200–500 tonne) pole-and-line vessels was one of steady increase to 1981–82 (of around 30%), stabilising until 1986, then declining for the remainder of the period. For purse seine vessels, both the 50–100 tonne and 100–200 tonne classes increased steadily to 1984–85, then decreased moderately (by 15% and 14% respectively) to the end of the period.

[9]For the case of the larger longliners, the Ministry of Agriculture, Forestry and Fisheries statistics report operation data on the basis of a trip rather than a year. In most instances the trip lengths for these vessels exceed a fiscal year and therefore we have divided the annual cost of operation by 365 rather than the number of fishing days to reflect the fact that 365 is the absolute maximum number of fishing days possible for any given fiscal year.

Conclusion

There has been widespread discussion about the viability of Japanese offshore and distant water fishing activities. The common view held by the Japanese is that the introduction of exclusive economic zones, restricting their access to traditional foreign fishing waters, together with steady upward pressures on operating costs resulting from the two oil price shocks and higher wages, has resulted in financial difficulties. Our investigation suggests that the proportion of total costs contributed by fuel has fallen from the mid-1980s to the end of the period. This trend, however, has been offset by a rising proportion of labour costs, resulting in these two cost components together constituting a relatively constant proportion of total cost of fishing effort over the period.

Although the cost per fishing day for most vessels appears to have declined throughout the latter half of the 1980s, this analysis has explicitly ignored the cost of fishing licences and access to foreign fishing waters, both of which have been on the increase. Access fees, while not forming part of the economic cost of fishing effort as defined in this paper, are still, however, a financial cost which must be borne by vessel owners.

Estimates of economic profitability for the Japanese tuna fleets for the years 1979–80 to 1988–89 show that, in general, concerns regarding the viability of the various fleets are reasonably well founded. Economic losses are consistently recorded over the period for the three gear types and their corresponding size classes. In fact, of the three gear types used to harvest tuna in offshore and distant water operations, the larger longline vessels are the only ventures which have returned anything like what approaches the return to capital required by market expectations. For most of the period, however, negative rates of return are observed for most types of vessel.

In relation to the question of how the industry has continued to operate while incurring significant losses over the long term, there is evidence to suggest that the Japanese government has, at least in principle, been able to offset these losses using subsidy programs. There are two primary reasons why the government may have continued to provide assistance to an industry which has such a poor economic record. One

Table 4.3 Average cost of owning and operating a Japanese longliner[a], 1979–80 to 1988–89 (current value, ¥'000)

	Size of vessel (GRT)					
	50–100		100–200		200–500	
	Cost per day	Cost per day fished	Cost per day	Cost per day fished	Cost per day	Cost per day fished
1979–80	365	419	535	618	830	830
1980–81	405	476	609	640	913	913
1981–82	400	488	613	739	1030	1030
1982–83	417	477	692	787	1078	1078
1983–84	355	456	698	698	1153	1153
1984–85	422	509	932	932	1312	1312
1985–86	414	457	727	727	1044	1044
1986–87	445	473	624	684	1109	1109
1987–88	392	454	633	670	997	997
1988–89	390	441	557	654	1017	1017

[a]Based on Rate of Return (A), see text.

Table 4.4 Average cost of owning and operating a Japanese pole-and-liner[a], 1979–80 to 1988–89 (current values, ¥'000)

	Size of vessel (GRT)					
	50–100 (Average)		50–100 (Full-time only)		200–500	
	Cost per day	Cost per day fished	Cost per day	Cost per day fished	Cost per day	Cost per day fished
1979–80	344	470	387	467	725	789
1980–81	379	554	440	542	911	972
1981–82	403	558	436	553	928	1032
1982–83	461	607	493	592	917	1037
1983–84	426	533	436	526	993	1060
1984–85	445	541	455	537	1001	1082
1985–86	457	588	463	565	1040	1179
1986–87	423	503	438	495	904	985
1987–88	410	505	428	500	893	993
1988–89	398	472	400	470	941	1002

[a]Based on Rate of Return (A), see text.

Table 4.5 Average cost of owning and operating a Japanese group purse seine vessel[a], 1979–80 to 1988–89 (current values, ¥'000)

	Size of vessel (GRT)					
	50–100		100–200		Two boats–10–30	
	Cost per day	Cost per day fished	Cost per day	Cost per day fished	Cost per day	Cost per day fished
1979–80	224	1411	403	2534	56	435
1980–81	239	1671	500	3148	60	476
1981–82	309	1926	489	3213	69	531
1982–83	357	2078	556	3351	75	542
1983–84	413	2271	624	3989	83	718
1984–85	339	2198	552	3466	80	600
1985–86	341	2020	533	3567	69	550
1986–87	350	2003	480	3160	74	562
1987–88	315	1813	437	2906	75	576
1988–89	312	1865	452	2990	68	597

[a]Based on Rate of Return (A), see text.

relates to the basic issue of food security. Japan has a post World War II history with respect to agricultural policy, of striving for maximum output of its food producing sectors. This has been with a view to securing its own food supply, and to earning export revenue. Second, there has been a desire, for a variety of reasons, to maintain existing fishing industries. A strong desire to maintain a presence in what have been traditional (foreign) fishing waters, political pressure from prefectures heavily reliant on fishing as a source of income and employment, and attempts to cushion the impacts of industry rationalisation resulting from restricted access to foreign fishing grounds and the subsequent over-capitalisation of fishing fleets which expanded rapidly throughout the 1960s and 1970s, are but a few of the possible motivations for government assistance to the industry.

Japan's reluctance (like other distant water fishing nations) to pay higher access fees to south Pacific island nations for access rights to tuna resources has been based on the inability of the industry to meet these demands. While the overall economic picture for the viability of Japanese tuna fleets has not been one of excess profits, it appears this situation may be changing. Rates of return to invested capital for most fleets, while remaining below the required rates and in many cases below zero, have been improving since around the mid-1980s. It is difficult to predict, however, whether this trend will continue.

Finally, the results reported in this chapter are averages for the various types of vessels investigated. There is a wide variety of vessels within these categories, some of which could be earning high returns. The same may also hold for the returns from the different fishing grounds in which they operate throughout the year. While the productivity of some fishing grounds may be very poor, yielding little or no return to effort, the opposite may be the case for others. That is to say, although the general economic status of the Japanese tuna fleets appears rather bleak, there may well be specific times of the year and fishing grounds in which returns to effort are well in excess of the costs. It is this type of case by case analysis which should be of primary concern to the island nation looking to sell access rights to distant water fishing nations to fish in its waters.

Chapter

5

An Economic Model of Tuna Purse Seine Fishing

H.F. Campbell
R.B. Nicholl

Introduction

The western Pacific purse seine tuna fishery has expanded considerably since it was initiated by a small Japanese fleet in the late 1970s. Fleets from the United States, Taiwan, Korea, Philippines, Indonesia and other nations have since joined Japanese vessels in the fishery, steadily increasing the purse seine harvest relative to longline and pole-and-line catches. By the mid-1980s the purse seine catch amounted to over 60% of the total tuna catch in the Pacific islands region, and purse seine catches of yellowfin tuna were over 66% of the yellowfin catch of all gear types (Doulman 1986b). The purse seine fishery is essentially a two-species fishery with around 70% of the catch consisting of skipjack and the balance juvenile yellowfin, although there is a small by-catch of juvenile bigeye tuna. The purpose of this chapter is to determine the technology of the fishery by analysing the catch returns of Japanese and United States purse seiners operating in Papua New Guinea's exclusive economic zone in the 1980s.

An understanding of technological aspects of the fishery, such as the extent of the ability to harvest selectively, is important for determining appropriate fishery management policies. If the species composition of the catch is technically determined then the only management measure available to the policymaker is control over the level of fishing effort. This can be accomplished by access fees or by limitations on numbers of vessels, or on seasons or areas fished. If, on the other hand, vessels have some control over the species mix of their catch, it is possible, in principle, to manage the two fish stocks independently through individual species quotas or differential royalties. In addition, information about technology, together with price and cost information, can be used to determine the amount of fishing effort in the exclusive economic zone which maximises individual vessel returns.

Data

Catch and effort data for Japanese and United States registered purse seine vessels fishing in Papua New Guinea waters were obtained from the South Pacific Commission data base. These catch and effort data are compiled from vessel log sheets submitted as a requirement of the conditions for access to Papua New Guinea's exclusive economic zone. The data are daily catch records for the period 1979 to 1989 and give vessel identification, nationality, date, position, time of set, type of set, catch of yellowfin and skipjack (in tonnes), average weight of fish of each species per catch and trip length. The period covered by the analysis is 1983–86 (Japanese) and 1984–86 (United States), because there are only records for one United States purse seiner for one month in Papua New Guinea prior to 1984, and Japanese fishing in Papua New Guinea ceased in March 1987. The daily observations on fishing activity have been aggregated to monthly observations on fishing effort, skipjack catch and yellowfin catch for individual vessels, consistent with the form of available price data.

Not all vessels which fished in Papua New Guinea's exclusive economic zone for the above period did so on a continual basis. Many fished some months of various years and at no time in other years, resulting in an uneven number of observations across months and years for the period of the data sample. For the period 1983–86, the data cover a total of 49 Japanese and 27 United States registered vessels which fished for part of at least one month of the four year period. Calendar months for any vessel which report completely unsuccessful fishing effort (i.e. all sets resulting in zero catch of either species) are not included in model estimations. There were 43 observations of this nature out of a total of 1155 monthly vessel observations.

Yellowfin and skipjack prices for the Japanese fleet models were obtained from the FAO Globefish data base. These are average monthly ex-vessel prices for the Japanese port of Yaizu. Port prices used for United States purse seine catches are American Tuna Sellers Association prices for tuna delivered to canneries in American Samoa. These prices are reported in Campbell and Nicholl (1992).

Purse seine caught yellowfin and skipjack supply functions

Throughout this analysis it is assumed that the purse seine fishery in Papua New Guinea waters produces only two products; skipjack and yellowfin, both for canning, although it is believed that up to 15% of the catch reported as yellowfin is actually juvenile bigeye tuna. The following model is a representation of how price information, fishing effort and seasonal influences combine to determine harvest levels from the fishery. Of particular interest is the degree to which purse seine skippers are able to choose their mix of output, if at all. The extent of this ability is examined by conducting various statistical tests based on the economic model of purse seining outlined below.

Kirkley and Strand (1988) point out that there is no widely accepted theory of the decision-making behaviour of fishers. Most likely, fishers combine and determine the levels of inputs to fulfil one or more various objectives. Such objectives may include maximising profit, maximising revenue and minimising costs, and will depend on whether short or long-term considerations dominate. Squires and Kirkley (1991) suggest that the overall long-term objective pursued by fishers is profit maximisation, accomplished in two stages. The first stage involves revenue maximisation over a time horizon where vessel size and characteristics are essentially fixed. The second stage, or profit maximisation stage, involves selecting a vessel design and size, gear, and equipment which minimises fishing effort costs and trip duration for the optimal vessel capacity. The capital investment (second stage) decision is made over a much longer time horizon.

The following model describes the behaviour of vessels in the revenue maximisation (first) stage. Distant water fishing nation vessels which operate in Papua New Guinea and other western Pacific waters are based in ports which lie some distance from Papua New Guinea. Japanese vessels have been based primarily in Japan (although they have at various times throughout the past 40 years operated out of western Pacific ports) and the majority of United States vessels are based in Pago Pago (exceptions being those vessels operating out of Guam). Due to the distances involved between ports and fishing grounds, and the costs (both in terms of fuel and time) of steaming, vessels remain at sea until cumulative catch meets the storage capacity of the vessel.[1] Given that most vessels can spend anywhere between 30 to 140 days and more at sea on any particular fishing trip, vessel characteristics and crew numbers are essentially fixed while fishing. This implies that for any particular day a vessel is fishing in the Papua New Guinea zone, fishing costs are fixed and the most likely economic strategy which underlies fishing activity is that of daily revenue maximisation, given the (fixed) cost of fishing, current price information and fishing conditions.

All vessels supply the processing sector with canning material for which prices are competitively determined

[1] It is now common practice for vessels to eliminate costly transit between port and fishing ground by transshipping, either at sea or at a suitable port in the region of the fishing grounds.

by the combined buying activities of the major processing plants in the international tuna market. Hence, individual vessels take port prices as given. Prices are communicated to vessels through radio communications or are known prior to departure on any trip.

Following Kirkley and Strand (1988), the revenue maximising behaviour of purse seine vessels can be described using a generalised Leontief revenue function:

$$R = \sum_i \sum_j \beta_{ij}\left(P_i P_j\right)^{1/2} E + \sum_i \alpha_i P_i E^2 + \sum_i \sum_k \delta_{ik} D_k P_i E + \sum_i \sum_r \gamma_{ir} Y_r P_i E \quad (1)$$

where E is a measure of the single fixed input capital (used as a proxy for fishing effort); P_i is the price of tuna for i=S skipjack and i=Y yellowfin; D_k is one of three dummy variables for the quarters September–November, December–February and March–May; and Y_r is one of three dummy variables for the years 1984, 1985 and 1986 included to capture any possible stock availability fluctuations over the period of the analysis.[2] Symmetry is imposed by setting $\beta_{ij}=\beta_{ji}$, $i \neq j$. An input-compensated supply function for species i can be obtained from this revenue function by differentiating with respect to price, P_i (McFadden 1978). Estimation of the supply functions will yield elasticities of supply for each of the two tuna species. Variation in the species mix of tuna catches which result from relative price changes between the two species is one indication that purse seine vessels are able to target species.

The supply functions Q_i $(P_i E)$ will adequately represent the supply behaviour of individual vessels if the assumptions of revenue maximisation hold. Two key assumptions for the following analysis are that vessels operate independently of each other and cannot individually influence the prices they receive for their catch; and that the marginal cost of fishing effort for all vessels is fixed for the duration of any particular fishing trip. Furthermore, it should be borne in mind that this model describes the short-run economic behaviour of fishing vessels, that is their behaviour for any particular fishing trip. The vessel-level supply functions obtained from equation (1) are given by:

$$\partial R / \partial P_i = Q_i\left(P_i E\right) = \sum_{j \neq i} \beta_{ij}\left(P_j / P_i\right)^{1/2} E \quad \beta_{ii} E + \alpha_i E^2 + \sum_k \delta_{ik} D_k E + \sum_r \gamma_{ir} Y_r E \quad (2)$$

From the results of estimating the models in (2), we can observe whether purse seine vessels of either fleet can target either yellowfin or skipjack (that is whether fishing directors or skippers can control the species mix of catches) from the magnitude and sign of the relative price coefficient β_{ij}. If skippers can target, it would be expected that a rise in the price of one species would result in an increase in the catch of that species and a reduction in the catch of the other species, holding the level of fishing effort constant. In terms of the coefficients of the supply equation, the ability to target would imply:

$$\partial Q_i / \partial P_i = -1/2 \sum_{j \neq i} \beta_{ij}\left(P_j\right)^{1/2}\left(P_i\right)^{-3/2} E \rangle 0$$
$$\partial Q_i / \partial P_j = 1/2 \beta_{ij}\left(P_j P_i\right)^{-1/2} E \langle 0 \quad (3)$$

In the absence of targeting, the signs of the two expressions in (3) would have a zero value as the coefficient β_{ij} would be zero. In terms of the own and cross-price elasticities of supply, targeting implies a positive own-price input-compensated elasticity of supply and a negative cross-price elasticity. The supply elasticities are obtained by multiplying equation (3) by (P_i/Q_i) and (P_j/Q_i) respectively to give:

$$\varepsilon_{ii} = 1/2 \sum_{j \neq i} \beta_{ij}\left(P_j / P_i\right)^{1/2}\left(E / Q_i\right)$$
$$\varepsilon_{ij} = 1/2 \beta_{ij}\left(P_j / P_i\right)^{1/2}\left(E / Q_i\right) \quad (4)$$

For the case of just two species, the elasticities are equal and of opposite sign. The reason for this is that for a given level of effort the relative quantities of yellowfin and skipjack harvested depends only on the relative price. Thus a 1% rise in the price of both species should have no effect on the harvest of either species, holding the level of effort constant.

The supply functions (2) for yellowfin and skipjack were estimated for each of the Japanese and American purse seine fleets using monthly catches for individual vessels for the periods 1983–86 for the Japanese fleet and 1984–86 for the United States fleet. Daily catch

[2]The dummy variables included to account for changes in stock availability are intended to pick up charges in the catchability of tuna due to variations in migratory patterns, depth of thermocline, recruitment and other environmental aspects of the fishery which could affect catch per unit effort.

records for vessels of each fleet from the South Pacific Commission data base were aggregated to monthly catches giving a series of cross-sections of observations. There were 981 monthly vessel observations for the Japanese fleet and 131 for the United States fleet. The observations for each fleet were pooled and supply functions estimated using all observations. The relative prices used were (average) monthly ex-vessel prices for the Japanese port of Yaizu and the American Samoan port of Pago Pago. Three price categories for yellowfin (<7.5 lb, 7.5 lb–20 lb, >20 lb) are available for the port of Pago Pago; we use the mid-range price series for yellowfin, 7.5 to 20 lb (3.4–9 kg).[3]

Fishing effort can be defined as a composite input related to the capital stock of a vessel. Gross registered tonnage (GRT) is used as a proxy for capital stock, and adjusted by a factor to reflect the intensity with which capital stock has been used in any month. This means that fishing effort per month for a given vessel is measured as E=GRT × number of sets × scaling factor of 0.1.

Estimation and results

In many instances, vessels record zero catches of either yellowfin or skipjack. Estimating the supply functions with zero catches, where catch is the dependent variable, would present a statistical problem commonly referred to as a limited dependent variable problem (see Kirkley and Strand 1988). In order to overcome this statistical problem, zero catches of either species were assigned the arbitrarily small value of 0.1 tonnes.

The input-compensated supply functions from (2) were initially estimated separately by ordinary least squares and tested for heteroskedasticity. Prior expectation was that heteroskedasticity would be introduced via the square of the composite input variable E^2 (see Squires and Kirkley 1991).[4] Heteroskedasdicity of the form discussed by Parks (1970) was found in three of the four supply functions. All supply equations were then divided through by the effort variable (E) and yellowfin and skipjack supply per unit effort equations for each fleet were estimated using Zellner's seemingly unrelated regression method and iterating to convergence. The procedure used to test for the final structural form of the supply functions was first to test for symmetry and then to test for the inclusion of the quarterly and yearly dummy variables both sequentially and as a group using a likelihood ratio test, $-2[ln\mathcal{L}_R - ln\mathcal{L}_U]$, which is χ^2 distributed. The results of these tests are reported in Table 5.1.

The symmetry condition $\beta_{ij}=\beta_{ji}$, $i \neq j$ cannot be rejected for either the Japanese or United States sample. The restriction of zero coefficients on the quarterly dummy variables cannot be rejected for the Japanese fleet; whereas the restriction of zero coefficients on the yearly dummies can be rejected at the 5% level of significance. Restricting the model to exclude both quarterly and yearly dummy variables as a group for the Japanese fleet, however, is rejected. For the United States fleet model, restrictions to exclude quarterly and yearly dummy variables both separately and as a group cannot be rejected.

For both the Japanese and United States fleets, the hypothesis of input-output separability of purse seine technology is tested by means of the restriction $\alpha_i=0$ for i=Y,S. The restriction is rejected implying that effort interacts differently with each of the outputs of harvest activity and that the entire catch (combining both yellowfin and skipjack) cannot be treated as one composite output (see Squires and Kirkley 1991). The results of these tests suggest that the appropriate structural form for the Japanese fleet includes both seasonal and yearly dummy variables, while that of the United States fleet does not include any dummy variables.

The results of the final model for the Japanese fleet are presented in Table 5.2 and those for the United States fleet in Table 5.3. Results of models estimated both with and without the dummy variables are reported for both fleets although the final model in each case has been determined by the test results reported in Table 5.1. Prior to corrections being made to the models for heteroskedasticity, generalised R^2s

[3]The average size of a purse seine caught yellowfin is 5 kg.

[4]The Breush-Pagan test for heteroskedasticity was carried out at the 5% level of significance; it has chi-squared distribution. For the Japanese fleet supply functions, the critical value with 8 d.f. is $\chi^{2*(8)}$ = 21.955: the test statistic for yellowfin supply was $\chi^{2(8)}$ = 219.759, therefore reject the null hypothesis of homoskedasticity; and for skipjack supply $\chi^{2(8)}$ = 57.670, therefore reject the null hypothesis also. For the United States fleet supply functions, the critical value with 7 d.f. is $\chi^{2*(7)}$ = 20.278: the test statistic for yellowfin supply was $\chi^{2(7)}$ = 53.622, therefore reject the null hypothesis of homoskedasticity; and for skipjack supply $\chi^{2(7)}$ = 9.248, therefore cannot reject the null hypothesis.

Table 5.1 Tests for model structure and technology, Japanese and United States tuna purse seine fishing

Test	No. of restrictions	Critical $\chi 2$	Test $\chi 2$	Reject restriction?
Japan fleet				
Symmetry	1	7.879	1.622	No
Qtr dummies	6	18.548	12.159	No
Yr dummies	6	18.548	41.528	Yes
Qtr & Yr dummies	12	28.300	54.219	Yes
Input-output separability	2	10.597	81.304	Yes
United States fleet				
Symmetry	1	7.879	0.788	No
Qtr dummies	6	18.548	2.645	No
Yr dummies	4	14.860	5.340	No
Qtr & Yr dummies	10	25.597	6.529	No
Input-output separability	2	10.597	16.072	Yes

[a]All likelihood ratio tests performed at the 5% level of significance.

Table 5.2 Parameter estimates of Japanese purse seine fleet supply per unit effort functions

Variable	Model with dummies		Model without dummies	
	Estimated coefficient	t-ratio	Estimated coefficient	t-ratio
Yellowfin supply				
Effort	-0.4198E-04[a]	-3.7658	-0.4090E-04[a]	-3.8296
P_S/P_Y	0.2159E-01	0.5241	0.2811E-01	0.8519
2nd Qtr dummy	0.2099E-01	1.5824		
3rd Qtr dummy	0.2728E-01[a]	2.0295		
4th Qtr dummy	0.2441E-01	1.5119		
1984 dummy	0.2691E-01[a]	2.2143		
1985 dummy	0.1119E-01	0.8988		
1986 dummy	0.3781E-01[a]	2.8817		
Constant	0.8042E-01[a]	2.7540	0.1117[a]	4.2389
Skipjack supply				
Effort	-01801E-03	-8.0547	-0.1967E-03[a]	-9.0986
P_Y/P_S	0.2159E-01	0.5241	0.2811E-01	0.8519
2nd Qtr dummy	0.2437E-01	0.9141		
3rd Qtr dummy	0.4142E-01	1.5493		
4th Qtr dummy	0.7097E-01[a]	2.1896		
1984 dummy	-0.5882E-01[a]	-2.4199		
1985 dummy	-0.3925E-01	-1.5933		
1986 dummy	0.7601E-01[a]	2.9147		
Constant	0.3826[a]	5.4389	0.40777[a]	8.6041

[a]Significant at the 5% level for a two-tail test.
$\ln \mathcal{L} = 476.827$ with dummy variables; $\ln \mathcal{L} = 449.718$ without dummy variables.

Table 5.3 Parameter estimates of United States purse seine fleet supply per unit effort functions

Variable	Model with dummies		Model without dummies	
	Estimated coefficient	T-ratio	Estimated coefficient	t-ratio
Yellowfin supply:				
Effort	-0.1995E-04[a]	-2.9377	-0.2036E-04[a]	-2.9768
P_S/P_Y	-0.6620[b]	-1.8923	0.76691	0.6819
Constant	0.7613[a]	2.2256	-0.5823	-0.5468
2nd Qtr dummy			0.1754E-01	0.6001
3rd Qtr dummy			0.1565E-01	0.5081
4th Qtr dummy			-0.6908E-02	-0.2249
1985 dummy			-0.8214E-01	-1.5814
1986 dummy			-0.5076E-01	-0.9435
Skipjack supply				
Effort	-0.2145E-04[a]	-2.6051	-0.2396E-04[a]	-2.9051
P_Y/P_S	-0.6620[b]	-1.8923	0.7669	0.68187
Constant	0.8790[a]	2.4491	-0.6385	--0.5370
2nd Qtr dummy			0.2091E-01	0.5970
3rd Qtr dummy			-0.1995E-02	-0.0538
4th Qtr dummy			-0.1524E-01	-0.4111
1985 dummy			0.6516E-01	1.1347
1986 dummy			0.7879E-01	1.3039

[a]Significant at the 5% level for a two-tail test; [b]Significant at the 5% level for a one-tail test.
$\ln \mathcal{L}$ = -192.8794 without the dummy variables; $\ln \mathcal{L}$ = -196.1439 with the dummy variables.

for the Japanese and United States fleet supply systems were estimated.[5] They were 0.505 and 0.504 respectively. The key parameter estimate for this analysis is the estimated coefficient, β_{ij}, for the relative price variable, which will by symmetry have the same value in both the yellowfin and skipjack supply functions within the models for each fleet.

The results reported in Table 5.2 show that for the Japanese fleet, the coefficient β_{ij}, $i \neq j$, is not statistically different from zero. This indicates that there is no evidence to support the hypothesis that Japanese purse seine vessels control the output mix of species in response to relative price changes, thus Japanese fishing directors have not been targeting yellowfin.

The coefficients reported in Table 5.2 for the quarterly dummies indicate that yellowfin catch is significantly higher in the third quarter (December–February) than in the default quarter (June–August), and that skipjack catch is significantly higher in the fourth quarter (March–May) than in the default quarter. The coefficients reported for the annual dummies suggest that 1984 and 1986 were significantly better years for yellowfin catches than 1983, and that 1984 was a bad year and 1986 was a good year for skipjack harvests. The time frame of the analysis is too short to provide evidence of stock depletion of either species.

The results reported in Table 5.3 for the United States fleet show that the estimated relative price coefficient, β_{ij}, is statistically significant and negative.

[5]The generalised R^2 is calculated as $1-\exp[2(\ln\mathcal{L}_R-\ln\mathcal{L}_u)/N]$, where $\ln\mathcal{L}_R$ is the log-likelihood when all slope coefficients are constrained to equal zero; $\ln\mathcal{L}_u$ is the log-likelihood of the unconstrained model. Log-likelihoods are from models with all dummy variables included.

This result suggests that United States purse seine skippers can, and do, change the species mix of their catches in response to changes in the relative price of yellowfin to skipjack. As the price of yellowfin relative to skipjack has increased, United States vessels have targeted and caught more yellowfin. The results of the tests for structural form from Table 5.1 indicate that the supply of yellowfin and skipjack from the United States purse seine fleet has not been subjected to any significant seasonal influences, nor is there any evidence of significant annual variations in catch per unit effort.

While the preferred model, which on the basis of the model specification tests omits the season and year dummies, suggests the ability to target on the part of the United States fleet, there is no evidence of targeting behaviour by the Japanese fleet. In view of the low t-ratios for most coefficients in the full model the targeting result cannot be regarded as conclusive. As the low t-ratios could be caused by correlations between the (American Tuna Sellers Association) relative price of tuna variable and other variables, it was decided to determine the extent and effect, if any, of such correlations by means of several statistical methods.

The relationship between the relative price variable and the dummy variables in the United States sample was first investigated by computing a set of pairwise correlation coefficients between the relative price variable and each dummy, but no strong association was detected at the pairwise level.[6] The relative price variable was then regressed on the dummy variables (and a constant) by ordinary least squares to get the following relation (with t-ratios) and $R^2 = 0.907$:

$$\begin{array}{lllllll} (P_S/P_y) = c & + \alpha_1 Q_1 & + \alpha_2 Q_2 & + \alpha_3 Q_3 & + \alpha_4 Y_1 & + \alpha_5 Y_2 \\ = 0.945 & - 0.786E-02 & - 0.371E-02 & + 0.745E-02 & + 0.418E-01 & + 0.396E-01 \\ (688.4) & (-4.784) & (-2.064) & (0.411) & (31.633) & (22.005) \end{array} \quad (5)$$

The high R^2 indicates that the dummy variables appear to explain much of the variation in relative price, suggesting a strong correlation between relative price and the two groups of dummies. Furthermore, the year dummies are highly significant in predicting movements in the relative price variable. The period of the study (1984–86) was one of falling tuna prices, but of little change in the relative price of yellowfin to skipjack (Campbell and Nicholl 1992b). The sample mean and the standard error for the relative price variable in the United States sample are 0.971 and 0.02, giving a relatively low coefficient of variation of 0.02. Thus, it may be that the significant downward annual trend in tuna prices over the period of the sample has made it difficult to establish the effect of monthly relative price changes on harvest.

The dummy variables were included in the original econometric model to pick up any seasonal or yearly fluctuations in availability of tuna stocks to the fleet. However, it appears that the year dummies are correlated with changes in the relative price variable (P_S/P_Y) because of market trends in the early to mid-1980s. While the statistical tests indicate that the dummy variables should be dropped from the United States model, an alternative approach is to look for an instrumental variable which will measure year to year changes in stock availability if they are significant. Under certain conditions, stock availability is reflected in catch per unit effort. Mean catch per unit effort for the United States fleet sample for the years 1984–86 for yellowfin were 0.10, 0.06 and 0.09; and for skipjack 0.13, 0.16 and 0.17. Tests to determine whether mean catch per unit effort (of skipjack and yellowfin) had changed throughout the sample period revealed that they were not significantly different from each other except for the case of yellowfin catch per unit effort in 1985.[7] Mean catch per unit effort of yellowfin was not significantly different in 1985 from the base year (1983), but was significantly different in 1984 (lower) and 1986 (higher); therefore there does not seem to be a consistent pattern of yellowfin stock fluctuation across the Japanese and American sectors of the fishery.

---

[6] The coefficients were as follows: P_{YS} and Q_1 = 0.260; P_{YS} and Q_2 = −0.115; P_{YS} and Q_3 = −0.300; P_{YS} and Y_1 = −0.601; P_{YS} and Y_2 = −0.300.

[7] Changes in catch per unit effort for yellowfin and skipjack over the three years were tested by regressing catch per unit effort for each species separately on a constant and the dummy variables for 1985 and 1986. In the case of yellowfin, catch per unit effort was found to be significantly different from the base year (1984) in 1985 (t-ratio=−1.969 on its coefficient) but not statistically different from the base year in 1986 (t-ratio=−0.460). For skipjack, catch per unit effort was not found to be statistically different from the base year in 1985 or 1986 (t-ratios of 1.299 and 1.269).

Total catch (yellowfin and skipjack) per unit effort was calculated for each month of the United States fleet sample and included in each vessel supply equation as an index of stock availability. The results are reported in Table 5.4. It can be seen that the coefficient on total catch per unit effort is significant in both the yellowfin and skipjack supply equations. The coefficients on the relative price variable (P_s/P_y) in yellowfin supply is significant at the 5% confidence level, using a one-tail test. Thus the introduction of the alternative stock availability variable tends to confirm the presence of targeting.

Table 5.4 Parameter estimates of United States fleet supply with catch per unit effort

Variable	Estimated coefficient	t-ratio
Yellowfin supply		
Effort	–0.1871E–04[a]	–2.7872
P_S/P_Y	–0.6580[b]	–1.8800
Constant	0.6878[a]	2.0061
Total catch per unit effort	3.4057[a]	2.0412
Skipjack supply		
Effort	–0.1949E–04[a]	–2.4238
P_Y/P_S	–0.6580[b]	–1.8800
Constant	0.7633[a]	2.1067
Total catch per unit effort	5.4675[a]	2.7309

[a]Significant at 5% level.
[b]Significant at 5% level for a one-tail test.

An alternative instrumental variable approach to using total catch per unit effort is to consider a substitute relative price variable. It was noted that there is little variation in the American Tuna Sellers Association series of relative price (P_s/P_y). The Yaizu relative price received by the Japanese fleet is weakly correlated with the Tuna Sellers relative price (the correlation coefficient for the sample is 0.20) but the Yaizu price exhibits more variation, with a coefficient of variation of 0.137 as compared with 0.02 for the American Tuna Sellers Association price series. When the Yaizu determined relative price is used in the estimation of the United States fleet supply equations, the estimated coefficient (and standard error) for the relative price variable β_{ij} is –0.097 (0.046) which also tends to confirm the hypothesis of targeting.

In summary, the balance of evidence tends to support the hypothesis that United States vessels are targeting yellowfin tuna. The statistical tests on the original model incorporating the seasonal and yearly dummies indicated that these variables should be excluded from the model specification. The resulting model reported in Table 5.3, had a significant coefficient on the relative price variable, as well as more plausible coefficient estimates for the constant and the effort variable in the supply per unit effort equations. The regression of relative price on the dummy variables suggested that a correlation between price and the yearly dummies is responsible for the lack of significance of the β_{ij} coefficient in the original model. This conclusion was supported by the fact that omitting the year, but retaining the season dummies produced a model with a significant β_{ij}. Alternative instrumental variable approaches were adopted to deal with the correlation between the relative price variable and the year dummies. One approach was to use total catch per unit as a measure of stock availability, and the other was to use Japanese tuna prices, which exhibit more variability than the American Tuna Sellers Association prices, to compute relative price (P_s/P_y). Both approaches tended to support the hypothesis of targeting. In conclusion, the available evidence tends to support the results reported in Table 5.3 for the model based on the preferred specification which excludes the dummy variables.

Using the results reported in Table 5.3, the estimated input-compensated supply elasticities for United States vessels are evaluated at mean sample values of price and quantity using equation (3), and reported in Table 5.5 as percentage changes in quantity supplied in response to a 1% increase in the indicated variable. As noted earlier, the non-zero values of these input-compensated price elasticities indicate that skipjack and yellowfin are substitutes in production, implying that the product transformation curve is

Table 5.5 Input-compensated elasticities of yellowfin and skipjack supply: United States fleet

Variable	Price of yellowfin	Price of skipjack
Price of yellowfin	ε_{YY}= 5.248[a]	ε_{YS}= –2.577[a]
Price of skipjack	ε_{SY}= –5.248[a]	ε_{SS}= 2.577[a]

[a]Significantly different from zero at the 5% level.

convex from above. If there is no targeting, these elasticities take zero values.

A further piece of information about purse seine technology which can be obtained from the results concerns product specific returns to scale. The sign of the coefficient on the square of effort coefficient, α_i, in the supply equation (the square of effort in the supply per unit effort equation) indicates the extent of increasing or decreasing returns to scale. The results for both the Japanese and United States fleets reveal significant decreasing returns to scale. This can be interpreted as indicating local stock depletion effects as monthly effort levels increase. The product specific scale elasticities can be calculated for product *i* from the supply equations (2) as:

$$\varepsilon_{iE} = 1 + \alpha_i E^2 / \begin{bmatrix} \sum_{j \neq i} \beta_{ij} \left(P_j / P_i \right)^{1/2} E + \\ \beta_{ii} E + \alpha_i E^2 \end{bmatrix} \qquad (6)$$

When these are evaluated for United States vessels at mean sample values of price and effort the estimates (and standard errors) ε_{YE} = 0.491 (0.183) and ε_{SE} = 0.720 (0.109) are obtained.[8]

Finally, we test the hypothesis that the average vessel in the United States sample was contributing the long-run equilibrium level of effort. Long-run equilibrium is where the marginal return per unit of effort equals the opportunity cost of effort, c. The hypothesis is given by equation (7) which is derived by differentiating the revenue function (1) with respect to effort and equating the derivative to the opportunity cost of effort:

$$\partial R / \partial E = c = \sum_i \sum_j \beta_{ij} \left(P_j P_i \right)^{1/2} + 2 \sum_i \alpha_i P_i E \qquad (7)$$

The estimated value of the marginal return to effort for the average United States Pacific class purse seiner in the sample is US$106.27 with a standard error of 18.24.

We can compare the estimated value of the marginal return to effort with an estimate of cost calculated from Waugh. Based on a 1985 survey carried out by the United States Marine Fisheries Service, Waugh estimates the annual costs of a 1100 tonne purse seine vessel (Table 5.6). The total annual cost is US$2674 million, or US$222815 per month. We use this figure as an estimate of the monthly cost of operating the average sized vessel in our sample, which was 1228 tonnes. The average monthly effort (measured as GRT × number of sets × 0.1) for the sample was 2007.2. Based on Waugh's estimate of monthly vessel cost, the average total cost per unit of effort was US$111.01. An estimate of average variable cost is obtained in a similar manner, using the annual total general expenses estimate of US$2211 million. The estimate of average variable cost is US$91.79.

[8]Asymptotic t-ratios are t_y = 2.678 and t_s = 6.590 indicating that product specific scale elasticities are significantly different from zero at the 5% level.

Table 5.6 Estimated annual cost of a 1110 tonne United States purse seiner, 1985

Operating expenses	US$
Fuel	696524
Galley	77446
Labour	675855
Other	140986
Total operating expenses	1590811
General expenses	
Repair and maintenance	210000
Insurance	320000
Professional	30000
Dues, licences	30000
Other	30000
Total general expenses	620000
Total variable costs	2210811
Capital costs	
Interest and depreciation (at 6% real over 15 years)	463000
Total cost	2673811

Source: Waugh 1987: Table 9.

The estimate of a marginal return to effort for the average United States purse seine vessel of US$106.27, with standard error 18.240, is not significantly different at the 5% level (t-ratio=-0.260) from the estimate of average total cost of $111.01 derived from Waugh's analysis of costs. This suggests that United States vessels are contributing their long-run equilibrium level of effort to the Papua New Guinea fishery.

Conclusion

This study has used a revenue maximising framework to analyse the technology of Japanese and United States purse seine tuna vessels operating in Papua New Guinea's exclusive economic zone in the 1980s. A significant difference between the technologies of the two fleets is detected: United States vessels, unlike those of Japan, exhibit the ability to target juvenile yellowfin tuna. Targeting ability probably depends on both technical characteristics of vessels and the type of fishing strategy adopted. As far as technology is concerned, the United States purse seiners are larger and faster than the Japanese, and capable of deeper sets of the net. Fishing strategies are examined in Campbell and Nicholl (1992b) where it is suggested that free-school sets may offer a higher proportion of yellowfin than log sets. The study also found that United States vessels, which continue to operate in Papua New Guinea's exclusive economic zone, were in long-run equilibrium in the sense that they were contributing the profit maximising level of effort to the fishery.

Chapter

6

The Ability of Tuna Purse Seiners to Vary the Species Composition of the Catch

H.F. Campbell
R.B. Nicholl

Introduction

Purse seine vessels tuna fishing in the western Pacific catch mainly skipjack and juvenile yellowfin tuna. The average proportion of yellowfin catch by weight is around 25–30%, but individual vessels report proportions varying from below 20% to higher than 50%. Juvenile yellowfin fetch a higher price than skipjack, and those that survive are recruited into the adult yellowfin stock which is a major species in the tuna longline fishery. From the viewpoint of fishery management, it is important to know whether vessels can exert some control over the proportion of yellowfin they harvest through choice of fishing practices, or whether variations in the harvest proportion are exogenous as far as vessels are concerned.

If purse seiners can target juvenile yellowfin, a management regime which allows access to both stocks under the same terms will result in the dissipation of fishery rent through relatively too much effort being directed at yellowfin stocks. The fishery management regime currently employed by most Pacific island states bases access fees on the assumption that the proportion by weight of yellowfin to skipjack harvested is 30%. There is no additional charge imposed on vessels which exceed this proportion and no rebate for vessels which fail to achieve it. Targeting may lead to added pressure on western Pacific yellowfin stocks over and above the pressures already resulting from steadily increasing levels of purse seine activity.

The ability to target juvenile yellowfin depends on the ability of vessels to vary the proportion of yellowfin in the catch by choice of fishing practices. The next section of this chapter describes the fishery and discusses vessel operation and fishing practices. It is possible that one kind of set of the net is likely to result in a higher proportion of yellowfin than another, and that certain vessels are more likely to choose this type of set. It can be argued that the basic consideration of the fishing director is the value of the catch and that the price of yellowfin relative to skipjack will influence the choice of fishing technique. A sample of catch and effort data for the Japanese and United States purse seine tuna fleets operating in Papua New Guinea waters during the period 1983–86 is used to examine the various hypotheses which have been put forward. The data sample is described in the third section, and is used in section four to analyse the choice of fishing practices. The fifth section reports the results of an assessment of the influence of the price of yellowfin relative to skipjack on the species composition of the catch.

Background

The most intensive areas of purse seine effort are the exclusive economic zones of Papua New Guinea and Federated States of Micronesia, and the high seas region which lies between them, although fleets have become active in recent years as far east as Kiribati.

Purse seine catches of skipjack and yellowfin have led to a significant increase in total harvests of these species in the central and western Pacific and the rapid expansion of purse seine activity has recently sparked concerns regarding the sustainable level of yellowfin exploitation in the region.

Purse seine operations

Purse seining involves placing a net around a school of fish and closing the net at the base. Tuna purse seiners fish two types of schools–those which are concentrated under some floating object and those which appear to have no focal point. In the eastern Pacific tuna are found in association with dolphins, whereas in the central and western pacific association is with floating objects such as logs. The reason for these associations is not fully understood at present. Schools which appear to have no focal point may be migrating between regions. Purse seine operations can be broadly classified as those which involve log sets (associated) or free-school sets (unassociated). It is believed that catches from free-school sets are more likely to be monospecific than from log sets, and that where free-school sets yield mixed species they offer a higher proportion of yellowfin than do log sets (South Pacific Commission 1990a; Suzuki 1988). Furthermore, yellowfin harvested with free-school sets are typically larger than those from log sets. Most yellowfin caught from log sets are less than 80 cm, while sets on unassociated aggregations often yield yellowfin up to 150 cm (Forum Fisheries Committee 1990; Suzuki 1988). Suzuki reports that yellowfin from sets on free swimming schools are dominated by the 100 cm to 150 cm size range.

Before a set is made, the skipper must determine whether the aggregation is of sufficient size, containing predominantly larger fish, or of an acceptable species mix to warrant the cost and effort of making a set. On the large United States vessels spotters observe free-school characteristics from helicopters and crow's nests, relaying this information to the skipper. Japanese vessels have yet to use helicopters but have crew watching from a crow's nest and other vantage points on the vessel. When log sets are considered, both the United States and Japanese vessels use sonar to determine aggregation size and the average size of fish. The Japanese are believed to have developed the use of sonar detection to the point where they can now differentiate between yellowfin and skipjack on the basis of sonar signature.

Early attempts by the Japanese to establish a purse seine fishery in the central and western Pacific experienced mixed success. Initial purse seine fishing strategies centred on free-school sets (Hutton 1984). However, the oceanic conditions of the region (clear water and a relatively deep thermocline of around 200 m) proved somewhat challenging to vessels unable to set and purse at sufficient speeds, and which used nets shallower than the depth of the thermocline (Hutton 1984; Suzuki 1988). Log sets made prior to dawn, pursing slowly so as not to disturb feeding tuna and also maintaining net depth proved a more successful and reliable practice.

When the United States fleet entered the central and western Pacific it brought vessels which differed significantly from Japanese seiners. In an attempt to increase total catches and the value of these catches, United States vessels introduced the use of deeper, lighter weight nets and more powerful hauling equipment, significantly increasing the speed at which free-school sets could be made. The result has been an increase in the success rate of free-school sets. While all vessels employ both fishing practices, United States fishers are generally credited with refinement of free-school set techniques (skills they have brought with them from the eastern Pacific), whereas the development of log set techniques are generally credited to Japanese fishers.

Regardless of the type of aggregation exploited, fishing effort can be broadly defined as a two step procedure: searching; and making a set. The search for both types of aggregation is based largely on past experience and knowledge of oceanic conditions for the particular region. The search for tuna is also enhanced by exchange of information regarding current fishing conditions between vessels, typically of the same nationality or related flag of convenience.

The technical details of purse seine gear and how sets are made are well documented (see for example Hutton 1984; Doulman 1987c; Medley 1989). Vessels will not typically set on any aggregation. Often no attempt will be made to catch small aggregations if the potential returns to a successful set are less than the cost of making the set.[1] On the other hand, potentially large catches may also be avoided as they can result in burst nets and jammed gear. Time is also a critical factor in making a set. At one extreme is the possibility that the escape rate from a particular set is very high, in which case the net must be hauled in and then reset as quickly as possible in order to try and catch the same fish. At the other extreme is the situation where a very large catch can involve a lengthy brailing operation in which case much of the catch can spoil in the net. The time to harvest located aggregations is also presumably minimised to allow the greatest daylight search time.

In summary, although skippers are unable to change vessel size, gear, or crew while on any given fishing trip, they can vary fishing strategies in order to affect the economic outcome of any trip. Modern vessels are equipped with a wide array of instruments which allow them continual contact with ports, satellites and other vessels. This provides for a constant flow of information both to and from the vessel regarding current fishing and market conditions. Communications regarding fishing conditions increase the effective search area of cooperating groups of vessels, while current price information may influence the dominant fishing strategy for a given trip. Improved search efficiency together with technological developments which have increased set speed and vessel capacity, have resulted in purse seiners becoming very efficient tuna fleets.

Yellowfin and skipjack prices

Although there is no single world price for tuna, Yaizu ex-vessel prices are widely considered to represent a benchmark for world tuna prices. Prices offered for canning material in other parts of the world, such as Thailand, American Samoa, Puerto Rico and Taiwan, follow trends similar to those of Yaizu prices, but are generally at levels below Yaizu prices. Yaizu is the major destination of Japanese purse seine caught yellowfin and skipjack. This is demonstrated by the fact that between 1984 and March 1987 the distribution of purse seine landings for the Japanese fleet was Yaizu 90%; Shimizu 9%; and other 1% (Forum Fisheries Committee 1990).

Campbell and Nicholl (1992b) report average yellowfin and skipjack prices for the ports of Yaizu and Pago Pago for the years 1983–1986. The reported prices indicate the existence of a clear price differential between yellowfin and skipjack at Yaizu and a smaller, more consistent differential between yellowfin and skipjack prices for tuna landed in American Samoa. A price differential between yellowfin and skipjack does not typically apply to all sizes of fish. The same price is most often paid for fish of both species up to 7.5 lb (3.4 kg) and a premium is paid on yellowfin over that size. According to the prices reported in Campbell and Nicholl (1992b), there has been a smaller premium paid by American canners for larger yellowfin than has been the case at Yaizu.

Since juvenile yellowfin command a premium over the price of skipjack there may be an incentive for purse seine skippers to increase their revenue per fishing trip by increasing the proportion of yellowfin in their total catch. Vessels would do this by expending effort on searching for aggregations with a relatively high proportion of yellowfin. This has been suggested by Medley (1989) with specific reference to the United States purse seine fleet. The price incentive would, however, seem to have been stronger for the Japanese fleet.

Purse seine access fees for Papua New Guinea

Papua New Guinea has not had a domestic tuna fishery since 1984, and since that time has relied on the access fees paid by distant water fishing nations to obtain returns to its tuna resources. Access fees consist of three components: boat licence, fisher licence and operation fee. Of these three components, the operation fee is the primary instrument of fishery rent collection and is determined by a combination of (1) vessel type and size; (2) estimated catch rates; (3) duration of fishing trip and time spent in Papua New Guinea waters; (4) Japanese (3 month moving average) market prices adjusted for transport costs (fishing ground to port); and (5) estimated species composition of catch. It is the last of these fee determinants which is of direct relevance to this analysis.

[1] The cost of making a set is generally considered in terms of wear and tear on gear and net, but there is also an opportunity cost measured by the value of fishing an alternative school. The success of previous fishing days seems to be an important determinant as to what constitutes the minimum acceptable catch per set.

As Papua New Guinea authorities cannot verify the exact catch composition of any vessel, they rely on estimates of anticipated catch compositions when setting fee levels. This means that the operation fee paid by an individual vessel is independent of the species composition of its catch. Estimates of the proportion of total catch by purse seiners of yellowfin are around 25%–30%. Although species mix for purse seine catches on the whole has been treated by Papua New Guinea authorities as fixed, there is a great variation in the actual species mix of individual vessels. To give an example of the variation of species mix from purse seine catches, a United States vessel spending 44 days fishing in Papua New Guinea waters between late November 1985 and late January 1986 caught 49% yellowfin. The same vessel made a subsequent 39 day trip between the beginning of February 1986 and mid-March, as a result of which 20% of its total catch was yellowfin (FFA 1989a). Japanese (single) purse seine operations in Papua New Guinea waters from 1979–1987 made catches which varied, on average across all vessels of the fleet, between 19% yellowfin in 1980 to 42% yellowfin in 1987.

Data

Catch and effort data for Japanese and United States registered purse seine vessels fishing in Papua New Guinea waters were obtained from the South Pacific Commission data base. These catch and effort data are compiled from vessel log sheets submitted as a requirement of the conditions for access to Papua New Guinea's exclusive economic zone. The data are daily catch records for the period 1979–1989 and give vessel identification, nationality, date, position, time of set, type of set, catch of yellowfin and skipjack (in tonnes), average weight of each species of fish per catch and trip length. The period covered by the analysis of yellowfin proportion in the total catch is 1983–87, and for the analysis of fishing practice it is 1983–86 (Japanese) and 1984–86 (United States), because there are records for only one United States purse seiner for one month in Papua New Guinea prior to 1984, and Japanese fishing in Papua New Guinea ceased in March 1987. Daily observations of set type (log or free-school) at the vessel level across both the United States and Japanese fleets are used.

Not all vessels which fished in Papua New Guinea's exclusive economic zone for the above period did so on a continual basis. Many fished some months of various years and at no time in other years, resulting in an uneven number of observations across months and years for the period of the data sample. For the period 1983-86, the data cover a total of 51 Japanese and 26 United States registered vessels (which fished for part of at least one month of the four year period).

Yellowfin and skipjack prices for the Japanese fleet models were obtained from the FAO Globefish data base. These are average monthly ex-vessel prices for the Japanese port of Yaizu. Port prices used for United States purse seine catches are American Tuna Sellers Association prices for tuna delivered to canneries in American Samoa. These prices are reported in Campbell and Nicholl (1992b).

Model of purse seine tactics/behaviour

Although successfully setting on unassociated aggregations has proved more challenging to the purse seine fishing director, the return to effort may be greater if it yields a higher proportion of large juvenile yellowfin, the more valuable catch. Measures adopted by United States fishers to overcome difficulties relating to sets on unassociated aggregations (clear water and deep thermocline) have raised the likelihood that United States vessels will fish this type of aggregation. Furthermore, the Japanese may also be attempting to target yellowfin by honing their skills on log sets.

The approach of the analysis in this part of the paper is first to see whether there is any evidence that sets on unassociated aggregations yield, on average, a higher proportion of yellowfin than skipjack. Second, a probit model is used to investigate whether there is a greater probability of United States or Japanese vessels making sets on associated or unassociated aggregations. Third, we look for evidence that individual vessels within a fleet harvest greater proportions of yellowfin than the fleet average; and fourth whether the location fished within Papua New Guinea's exclusive economic zone has any influence on the proportion of yellowfin caught. The results of the revenue-maximising framework described in Campbell and Nicholl

(1992b) are used in a discussion of whether the relative price of yellowfin to skipjack plays a significant role in the behaviour of purse seine vessels.

The proportion of yellowfin in different aggregation types

For the purposes of the following analyses the total catch of a purse seine set is treated as the total weight in tonnes of yellowfin and skipjack (ignoring any possible by-catch such as juvenile bigeye tuna). Reference has been made to the difference in the proportion of catch of yellowfin between log and free-school sets. It is therefore reasonable to expect that there may be some conditions under which purse seine vessels are able to target yellowfin. If this were not so, encountering aggregations yielding more yellowfin would always be a random event and no search tactic or measure could be employed by fishers in order to deliberately increase yellowfin catches.

It can be hypothesised that free-school sets (unassociated aggregations) offer the opportunity for higher yellowfin catches as sets made on them yield a consistently higher proportion of yellowfin. This hypothesis is tested by calculating the mean proportion of yellowfin per set for log sets and free-school sets, then testing whether there is any difference between them. The proportion of yellowfin for any set is defined as the weight of yellowfin divided by the combined weight of skipjack and yellowfin caught for that set. Sets are defined as log sets, 'Type 0' and free-school sets, 'Type 1'. Individual set records indicating the type of set and yellowfin and skipjack catch for the Papua New Guinea exclusive economic zone for the years 1983-1987 were used to find total catch per set and proportion of yellowfin per set. There are 13 197 individual set records for vessels across the Japanese and United States fleets for the period. Of the total records, 2885 were for free-school sets and 10 312 log sets. All recorded sets, whether successful or not, were included in the analysis. The mean proportion of yellowfin per set was then determined for each set type and the hypothesis that the mean proportion of yellowfin from Type 1 sets was greater than that of Type 0 sets was tested. The mean proportion of yellowfin per Type 1 set (0.388) was found to be significantly greater than that of Type 0 sets (0.329).[2] Furthermore, it was concluded that at the 95% confidence level the proportion of yellowfin from free-school sets was between 3.8% and 7.8% greater than the proportion of yellowfin from log sets.[3]

In deciding to target juvenile yellowfin by increasing the number of school sets relative to log sets, a skipper would need to take account of the lower success rate for school sets. Table 6.1 shows the proportion of successful sets of each fleet, together with the number of observed sets.

The hypotheses that the success rates are the same for both types of sets is tested and rejected at the 5% level. It can be seen from Table 6.1 that the United States fleet seems to experience a higher success rate for both types of sets. The hypotheses that the success rates of the two fleets were the same was tested and rejected for both log sets ($t=-3.8068$) and free-school sets ($t=-4.1480$).

A probit model to describe the choice of fishing practice

For the years 1983–87, the average ex-vessel price of purse seine caught yellowfin has been consistently greater than that of skipjack. Catch data for Japanese and American purse seine fleets for the same period indicate the mean proportion of yellowfin caught from unassociated aggregations is between 3.8% and 7.8% greater than the mean proportion caught from associated schools. Furthermore, Hutton (1984) and Suzuki (1988) have discussed why United States skippers are more likely to pursue a fishing strategy which favours the search and capture of unassociated aggregations: larger and faster vessels with more powerful gear and the ability to set on free-schools at high speed will presumably engage more frequently in this strategy. It is not suggested that Japanese skippers will fish only associated aggregations or United States skippers unassociated aggregations, but rather that there may be a dominant strategy for each.

Each time a vessel encounters an aggregation, the skipper or fishing director must decide whether to make a set on that aggregation. What we are interested in specifically, is determining what influences the

---

[2]The t-statistic was −5.905.

[3]The 95% confidence intervals for both mean proportions were also calculated: they were $0.3203<P_0<0.3385$; and $0.3700 <P_1 <0.4056$–where P_i = mean proportion of yellowfin for $i=0$ (associated aggregation sets) and 1 (unassociated aggregation sets).

Table 6.1 Proportions of successful sets for Japanese and United States fleets

	Log sets	School sets	t-statistic
Japanese fleet	0.8955	0.4459	52.42
No. of sets	7208	4306	
United States fleet	0.9332	0.5293	
No. of sets	1084	716	15.85
Pr (t>1.645): 0.05			

probability that a skipper will decide to make a Type 1 (free-school) set. It can be hypothesised that a higher price for yellowfin together with the ability to make successful free-school sets and the knowledge that these type of sets are likely to yield a higher proportion of yellowfin, will lead United States skippers to choose Type 1 sets as a dominant fishing strategy.

This behaviour can be modelled using a simple probit analysis where the decision to adopt a particular fishing strategy is dependent on skipper nationality, vessel size and the relative price of yellowfin to skipjack. Although we cannot observe the actual decision to adopt either strategy, we can observe the outcome of that decision by the type of set made. The decision outcome can be represented by a dummy variable defined as: $y = 1$ for a Type 1 set (free-school); and $y = 0$ for a Type 0 set (log). The model is represented mathematically as;

$$y = \alpha + \beta_K K + \beta_N N + \beta_P P \qquad (1)$$

where K is a dummy variable taking the value 0 for GRT ≤ 499 and 1 for GRT >499; N is a dummy variable which takes the value 1 for a United States vessel and 0 for a Japanese vessel; and P is the relative monthly (Yaizu) price of yellowfin to skipjack (P_Y/P_S). The model is estimated by adding an error term to equation (1) and using pooled cross-section data for the years 1983–87.

Time is accounted for by the inclusion of three quarterly dummy variables. As the beginning of the fishing year in Papua New Guinea waters is around the start of June, the base quarter for which there is no dummy variable is June, July, August. The dummy variables could enter the model in two ways. One way is through a seasonal influence on price, implying that seasonality is accounted for in the above behavioural function as interaction terms with the relative price of yellowfin to skipjack, P. The inclusion of seasonal/relative price interaction terms changes equation (1) to:

$$y = \alpha + \beta_K K + \beta_N N + \beta_P P + \delta_1 Q_1 P + \delta_2 Q_2 P + \delta_3 Q_3 P \qquad (2)$$

Another way for the quarterly variables to enter into the model is as intercept shifts, implying stock effects from season to season throughout the fishing year. Intercept shift variables would be incorporated by dropping the price variable from the seasonal dummies in equation (2). However, it is not clear what, if any, effect changes in the underlying stocks would have on the decision to choose set Type 1 or Type 0. In the absence of strong a priori expectation on how these variables should be treated in the model, both types of dummy variables are tested as restrictions to the original model in (1). The restrictions involving the inclusion of the price interaction variables from (2) are tested using a likelihood ratio test, $-2[\ln\mathcal{L}_R - \ln\mathcal{L}_U]$, which is χ^2 distributed with degrees of freedom equal to the number of restrictions. The inclusion of the intercept dummy variables is then tested as an additional set of restrictions using the same procedure. Finally, no account is taken of the year, or of where fishing activity takes place, or whether some fishing grounds within Papua New Guinea waters yield aggregations with higher proportions of yellowfin than do others.

The above restrictions were tested sequentially and then together as a group; the results of these tests are reported in Table 6.2.

The restrictions were all rejected at the 5% level of significance and the form of the model to be reported is therefore:

$$y = \alpha + \beta_K K + \beta_N N + \beta_P P + \delta_1 Q_1 P + \delta_2 Q_2 P + \delta_3 Q_3 P + \gamma_1 Q_1 + \gamma_2 Q_2 + \gamma_3 Q_3 \qquad (3)$$

The results from estimating equation (3) are reported in Table 6.3. From these results the general opinion that United States vessels are more likely to make free-school sets is supported by the positive and significant coefficient on the nationality variable N. However, no significant effect of the relative price of yellowfin alone can be detected apart from its seasonal interaction, which is measured by positive and significant coefficients for the second (September–

Table 6.2 Tests for probit model structure describing choice of fishing practice.

Test	No. of restrictions	Critical χ^2	Test χ^2	Reject restriction?
Interaction dummies	3	7.82	244.8	Yes
Intercept dummies	3	7.82	227.8	Yes
All dummies	6	12.59	306.8	Yes

Table 6.3 Parameter estimates for probit model describing choice of fishing practice.

Variable name	Number of observations	Estimated coefficient	t–ratio
y_i=1	4902		
y_i=0	7899		
Constant		0.6641[a]	–4.314
K	12801	–0.0257	–1.073
N	12801	0.0672[a]	1.948
P	12801	0.0097	0.159
Q_1P	4135	0.4292[a]	5.550
Q_2P	5068	–0.0262	–0.368
Q_3P	1606	0.5281[a]	4.429
Q_1	4135	–0.4580[a]	–2.520
Q_2	5068	0.4074[a]	2.429
Q_3	1606	–0.3349[a]	–1.422

Log of likelihood function: –8364.4
Log of likelihood function (constant only): –8518.9
P (t >1.645): 0.05
χ^2 9 d.f.: 309.0
[a] Significant at the 5% level

November) and last (March–May) quarters of the fishing year. The size of vessel appears from these results to have no significant effect on the decision to make a log or school set, casting doubt on the claim that larger and faster vessels are those most likely to fish unassociated aggregations.[4] Finally, the significant coefficients on the second and third quarter intercept shift terms suggest that relative to the first quarter of the fishing year, free-school sets are less likely to be made by either nationality in the second quarter, and more likely in the third.

[4]This does not imply that larger and faster vessels are not relatively more successful at making school sets.

Variation in targeting ability across vessels

The above results report that there was a greater proportion of yellowfin on average from free-school sets than from log sets, and the results of the probit analysis indicate that United States vessel skippers were more likely to make free-school sets than their Japanese counterparts. Additionally, the suggestion is made that United States vessels were more successful at making free-school sets as they were larger, faster and equipped with more powerful gear, enabling them to reduce free-school set time and therefore increase the success rate of these sets.

This line of analysis is taken one step further to examine whether any of the United States vessels consistently achieved proportions of yellowfin higher than the fleet average. This is done by calculating the mean proportion of yellowfin for free-school sets for the United States fleet, and then for each United States vessel, for the period of the sample (1984–1986), and testing whether the highest and lowest proportions recorded by individual vessels are statistically different from the fleet mean.

The mean proportion of yellowfin from free-school sets (standard error, number of observations) for the fleet was 0.3808 (0.3306, 104). The highest vessel level mean proportion was 0.5532 (0.5084, 3). At the 5% level of significance this is not statistically different from the fleet average (t-ratio = 0.8835).[5] The lowest vessel level mean proportion was 0.1029, which at the 5% level is significantly less than the fleet average proportion (t-ratio = 2.3557). The fleet average was also calculated for each year of the sample periods and then compared with the overall sample average. The year with the highest fleet average proportion of yellowfin from free-school sets was 1986 (0.4791) and the lowest 1985 (0.3262), both of which are not statistically different from the sample mean at the 5% level (t-ratios = 1.4057, 0.9602). The 95% confidence interval for the fleet sample mean is $0.3166 < \mu < 0.4450$; 60% of the vessel level averages fall within this confidence interval.

This simple analysis does not provide any evidence to suggest that any particular vessels in the United States fleet are more successful at catching higher

[5]Vessel level mean proportions are considered only for vessels with more than one monthly observation.

proportions of yellowfin than other vessels of the fleet, or that there was any particularly good or bad years over the sample period for the United States fleet.

Catch rates of yellowfin and skipjack by zone

The preceding sections provide some support for the hypothesis that purse seine vessels can target yellowfin. There is statistical evidence to suggest yellowfin form a greater proportion of purse seine catches when free-school sets are fished, and that United States skippers are, on the whole, more likely to fish free-school sets. There is no strong evidence, however, to indicate that some United States vessels are more successful at harvesting larger proportions of yellowfin than other United States vessels. Whether there is any regional influence on the proportion of yellowfin in purse seine catches is now considered. This is done by dividing Papua New Guinea's exclusive economic zone into seven zones and calculating the mean catch of yellowfin and skipjack from purse seine sets for combined United States and Japanese fleet activity over the period 1983 to 1986 (inclusive). The mean proportion of yellowfin from sets where at least one of the species skipjack or yellowfin was caught is also calculated. Figure 6.1 shows Papua New Guinea's exclusive economic zone and its breakdown into seven zones. Two analyses were carried out: one for log sets and another for free-school sets. In both analyses, the data were grouped by quarter as well as zone with quarter 1 defined as June to August. The results, together with the level of fishing activity measured in terms of the number of sets in a zone for a quarter, are reported in Table 6.4 (log sets) and Table 6.5 (free-school sets).

The mean catch per unit effort (CPUE) figures, where a unit of effort is measured as a set, for both Tables 6.4 and 6.5 indicate there are consistently higher catches of skipjack per set than there are for yellowfin, both across zones and quarters. The greatest

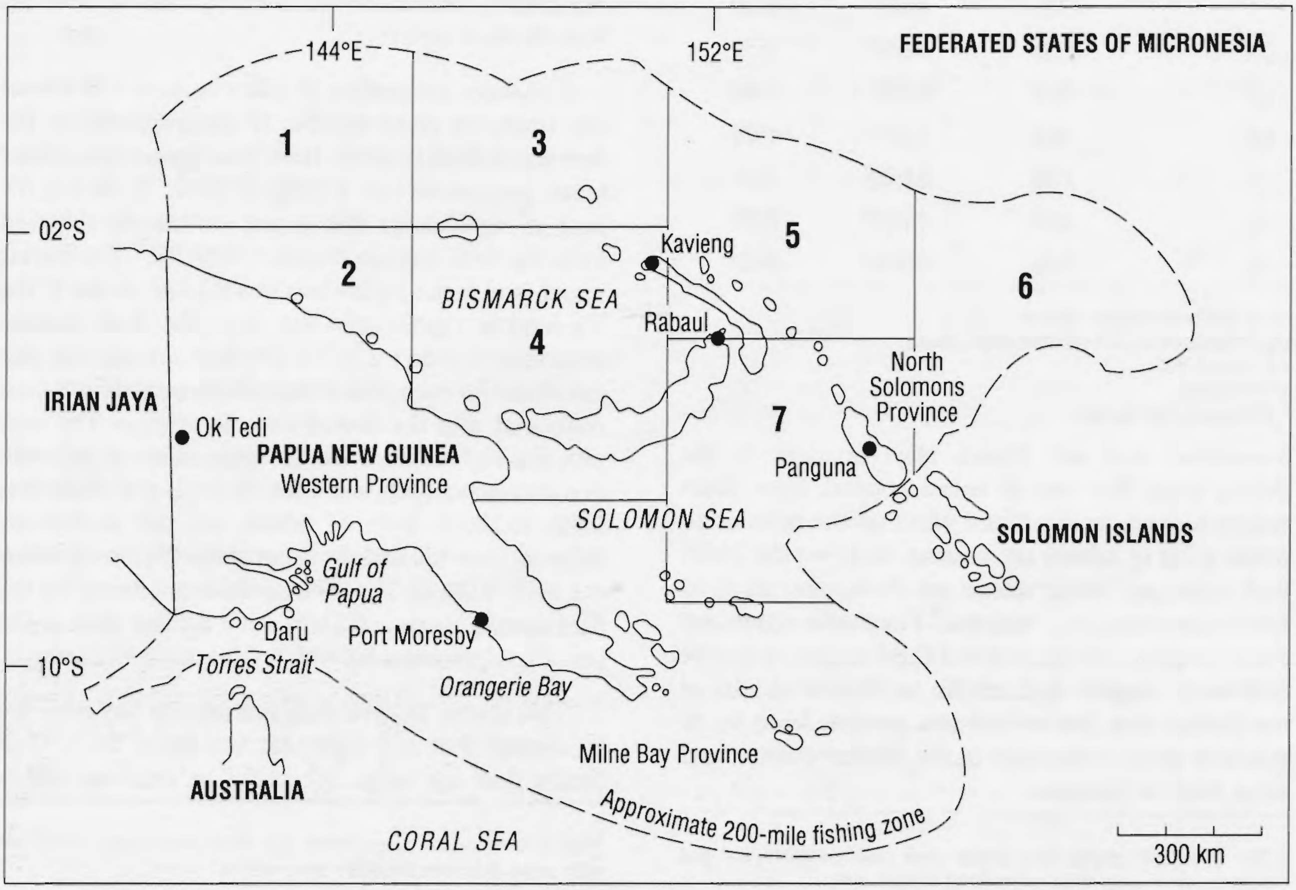

Figure 6.1 Papua New Guinea's exclusive economic zone, by fishing zone.

Table 6.4 Total effort (sets), mean CPUE for yellowfin and skipjack, and ratio of $CPUE_Y/CPUE_S$ for United States and Japanese combined fleet LOG SETS, by zone, 1983–87.

Quarter	Zone 1	Zone 2	Zone 3	Zone 4 (tonnes)	Zone 5	Zone 6	Zone 7
1							
No. of sets	966	20	490	3	95	65	143
% success	93.7	95.0	94.3	66.7	96.8	98.5	99.3
$CPUE_Y$	6.15	5.40	6.55	5.67	13.80	12.32	14.57
$CPUE_S$	16.67	15.75	20.17	0.33	16.65	25.91	20.42
Propt^n Yfn	0.35	0.29	0.35	0.94	0.49	0.40	0.49
2							
No. of sets	1614	63	1496	360	188	60	63
% success	92.8	92.1	90.6	94.4	83.5	96.7	93.7
$CPUE_Y$	5.55	6.49	5.43	7.11	6.00	10.53	12.56
$CPUE_S$	17.75	10.92	18.62	23.93	21.70	27.33	21.44
Propt^n Yfn	0.31	0.44	0.31	0.30	0.33	0.36	0.51
3							
No. of sets	1533	644	1178	304	364	46	79
% success	89.1	89.9	88.5	96.4	90.9	95.7	96.2
$CPUE_Y$	6.12	7.01	6.13	7.25	8.44	6.44	6.92
$CPUE_S$	17.61	12.34	22.59	12.88	29.59	25.72	18.15
Propt^n Yfn	0.32	0.39	0.29	0.42	0.30	0.23	0.32
4							
No. of sets	597	32	304	21	79	6	10
% success	88.6	87.5	91.5	85.7	91.9	100.0	80.0
$CPUE_Y$	5.63	8.22	4.84	4.05	6.44	8.50	1.40
$CPUE_S$	19.85	12.09	28.34	24.24	21.38	40.00	3.00
Propt^n Yfn	0.29	0.56	0.23	0.28	0.39	0.10	0.32
Total sets	4710	759	3468	688	726	177	295

mean CPUE for yellowfin from log sets was 14.57 tonnes in quarter 1, zone 7; and the lowest was 1.40 tonnes for quarter 4, zone 4. For free-school sets, the highest catch per unit effort of yellowfin was 34.34 tonnes for quarter 4, zone 4; and the lowest 0 for quarter 1, zones 2, 4 and 6, and quarter 4, zones 6 and 7. In the CPUE of skipjack, the highest for log sets was 40.00 tonnes for quarter 4, zone 6; and the lowest was 0.33 tonnes for quarter 1, zone 4; while for free-school sets the highest was 139.0 (from a single set) for quarter 1, zone 6; and the lowest was zero for quarter 1, zone 4 and quarter 4, zone 7.

However, it is important to note the amount of effort which was expended (in terms of the number of sets made) in each zone when reviewing these results. Some zones record high CPUE but little cumulative fishing effort over the four year period. For example, although the highest mean CPUE of yellowfin for log sets was found to be for zone 7 (quarter 1), there was in fact very little cumulative effort for zone 7 over the

Table 6.5 Total effort (sets), mean CPUE for yellowfin and skipjack and ratio of $CPUE_Y/CPUE_S$ for United States and Japanese combined fleet FREE-SCHOOL SETS, by zone, 1983–87

Quarter	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
1							
No. of sets	376	30	281	1	25	1	14
% success	52.9	36.7	49.8	0	76.0	100.0	100.0
$CPUE_Y$	2.29	0	6.92	0	13.04	0	14.71
$CPUE_S$	13.07	6.57	14.92	0	15.68	139.0	28.23
Propt^n Yfn	0.22	0	0.30	0	0.34	0	0.42
2							
No. of sets	612	62	1004	125	191	18	31
% success	47.1	53.2	41.4	43.2	50.8	66.7	51.6
$CPUE_Y$	4.61	7.21	8.15	2.46	8.29	1.50	4.81
$CPUE_S$	11.21	15.29	8.04	8.96	15.68	32.56	28.48
Propt^n Yfn	0.35	0.36	0.55	0.27	0.33	0.03	0.17
3							
No. of sets	1037	230	610	108	161	19	31
% success	47.0	52.2	46.7	57.4	41.6	68.4	38.7
$CPUE_Y$	5.66	14.96	6.32	13.24	8.27	5.52	7.87
$CPUE_S$	12.73	8.21	11.82	7.74	7.70	11.21	7.13
Propt^n Yfn	0.36	0.58	0.42	0.59	0.41	0.39	0.46
4							
No. of sets	508	156	100	29	64	1	5
% success	42.5	43.0	41.0	72.4	51.6	100.0	0
$CPUE_Y$	3.90	8.83	6.11	34.34	3.63	0	0
$CPUE_S$	11.58	8.34	10.60	13.07	23.70	6.0	0
Propt^n Yfn	0.33	0.54	0.34	0.64	0.26	0	0
Total sets	2533	478	1995	263	441	39	81

period: 6.2% of the cumulative number of sets for zone 1 and 8.5% of those for zone 3. In fact, if we look at the zones which attracted the greatest amount of activity, then zone 1 had the most sets for log and free-school sets followed by zone 3; both significantly more intensive with respect to purse seine effort than any of the other five zones. Tables 6.4 and 6.5 also report the success rate for sets by quarter and zone. It is clear from these results that the success rate for log sets is greater than that of free-school sets, regardless of zone or quarter.

It is suggested above that calculating catch rates and species mix for different zones may offer some indication that the potential for vessels to target yellowfin exists. Tables 6.4 and 6.5 report the mean proportion of yellowfin by zone and quarter. Interpretation of these results is, however, most meaningful if the level of effort is taken into account when comparing mean yellowfin proportions from each zone. What needs to be determined, is whether at any time of the year any zone (or zones) offers higher proportions of yellowfin per set than do others. In order to determine this, the mean proportions for each quarter are

Table 6.6 Results of ANOVA analysis of proportion of yellowfin: zones 2–7 relative to zone 1

	Constant	Zone 2 Dummy	Zone 3 Dummy	Zone 4 Dummy	Zone 5 Dummy	Zone 6 Dummy	Zone 7 Dummy
Log sets							
Qtr 1	0.345[a]	–0.055	0.008	0.593[a]	0.149[a]	0.060	0.142[a]
	(35.340)	(–0.800)	(0.490)	(2.852)	(4.632)	(1.569)	(5.353)
Qtr 2	0.314[a]	0.126[a]	–0.002	–0.015	0.018	0.046	0.195[a]
	(44.919)	(3.471)	(-0.215)	(–0.932)	(0.793)	(1.278)	(5.422)
Qtr 3	0.324[a]	0.063[a]	–0.028[a]	0.096[a]	–0.020	–0.095[a]	–0.002
	(42.273)	(4.456)	(–2.401)	(5.271)	(–1.155)	(–2.176)	(–0.071)
Qtr 4	0.289[a]	0.268[a]	–0.061[a]	–0.005	0.097[a]	–0.191	0.033
	(23.673)	(4.933)	(–2.929)	(–0.068)	(2.751)	(–1.657)	(0.327)
School sets							
Qtr 1	0.220[a]	–0.219	0.079[a]	–	0.131	–0.219	0.201[a]
	(8.522)	(–1.942)	(1.973)		(1.496)	(–0.600)	(2.004)
Qtr 2	0.348[a]	0.008	0.203[a]	–0.082	–0.018	–0.314[a]	–0.178
	(13.959)	(0.102)	(6.273)	(–1.314)	(–0.360)	(–2.519)	(–1.639)
Qtr 3	0.360[a]	0.217[a]	0.056	0.230[a]	0.050	0.040	0.102
	(19.043)	(5.092)	(1.805)	(4.085)	(0.912)	(0.342)	(0.833)
Qtr 4	0.326[a]	0.214[a]	0.017	–0.069[a]	–	–	–
	(11.726)	(3.728)	(0.237)	(3.316)			

[a]Indicates significant at the 5% level.
Note: In the above regressions, the dependent variable is the proportion of yellowfin from each set recorded.

Table 6.7 Summary of ANOVA analysis results

	1st Qtr		2nd Qtr		3rd Qtr		4th Qtr	
	>Z1	<Z1	>Z1	<Z1	>Z1	<Z1	>Z1	<Z1
Log sets	4,5,7	–	2,7	–	2,4	3,6	2,5	3
School sets	3,7	–	3	6	2,4	–	2,4	–

compared using an ANOVA procedure.[6] As zone 1 attracted the most activity for both log and free-school sets, it was decided to use it as the base zone. The results of these analyses are reported in Table 6.6, with a summary in Table 6.7. The ANOVA results show the proportion of yellowfin per set for zones 2–7 relative to the base case, zone 1. The statistical differences of the proportion of yellowfin per set between zones 2–6 were also tested. The results are too numerous to report here but a summary is reported in Table 6.8, showing there is no particular zone which offers an unambiguously higher or lower proportion of yellowfin per set than other zones.

The summary results reported in Table 6.7 indicate the zones which had a proportion of yellowfin per set either greater or less than the proportion of yellowfin

[6]This is done by running ordinary least squares regressions for each quarter with the mean proportion of yellowfin as the dependent variable and dummy variables for the different zones. The base zone for which there is no dummy variable is zone 1.

Table 6.8 Summary of ANOVA analysis comparing all zones to other zones

	1st Qtr		2nd Qtr		3rd Qtr		4th Qtr	
	Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest
Log sets	4	–	–	–	2	–	2	–
No. of sets	1782		3844		4148		1049	
Successful	1686		3525		3732		939	
School sets	–	2	3	–	–	–	2,4	1,3,5
No. of sets	728		2043		2196		863	
Successful	384		916		1046		379	

per set from zone 1. Zone 2 appears to have offered a species mix with more yellowfin than zone 1 quarters 2, 3 and 4 for log sets and the quarters 3 and 4 for free-school sets. Zone 7 also offered a higher proportion of yellowfin in three cases (quarter 1, log and school sets and quarter 2, log sets). In most instances, the proportion of yellowfin per set in zones is not statistically different from that in zone 1.

The results in Table 6.8 do not show any consistent pattern, although zone 2 seems to offer a higher proportion of yellowfin per set in quarter 4 for both log and free-school sets. In most cases there is no zone (or zones) which unambiguously offers higher or lower proportions of yellowfin per set than do others within Papua New Guinea's exclusive economic zone. Finally, there is no clear indication from the above analyses that there is any opportunity for purse seiners to target yellowfin by choice of fishing ground within Papua New Guinea's exclusive economic zone. Although zones 2 and 7 appear to have offered higher proportions of yellowfin per set for the period 1983–1986, by far the bulk of the fishing effort has been directed towards zones 1 and 3.

Results from the revenue maximising model

If purse seiners are able to influence the species composition of their catch it would be expected that the effect of an increase or decrease in the price of yellowfin relative to skipjack would be to increase or decrease the proportion of yellowfin in the catch. Campbell and Nicholl (1992b) use a model in which vessels are assumed to act so as to maximise their monthly revenue to try to identify this effect if it exists. If targeting is possible then the cross-elasticities of supply in a two-species model are negative; this means, for example, that if the price of yellowfin rises, the quantity of skipjack caught falls as vessels increasingly direct their efforts towards the relatively more valuable species.

Campbell and Nicholl's results for Papua New Guinea in the period 1983–86 reveal no evidence of targeting by Japanese vessels. They conclude, however, that United States vessels have been targeting yellowfin in periods when its price has been relatively high. As noted earlier, the United States vessels are larger and more technically efficient and this may explain their targeting ability. The cross-elasticities of supply estimated by Campbell and Nicholl for United States vessels are -5.248 and -2.577; these results indicate that a 1% rise in yellowfin price will cause a 5.248% fall in skipjack catch, and a 1% rise in skipjack price will cause a 2.577% fall in yellowfin catch of the average vessel. The results provide further evidence for the hypothesis that United States vessels can vary the species composition of their catch if it is profitable to do so.

Conclusions

The analysis of the harvests from log and free-school sets indicates that the proportion of yellowfin was significantly higher in free-school sets. The analysis of vessel behaviour indicates that United States purse seiners were more likely to make free-school sets than were Japanese vessels. The results of the revenue-maximising model indicates that United States vessels were varying the proportion of yellowfin in their catch in response to changes in the ex-vessel price of yellowfin relative to skipjack. Although the revenue-maximising analysis provided no evidence that Japanese single purse seiners have been able to target yellowfin, a recent South Pacific Commission tagging study undertaken on a Japanese group purse seiner operation reports that a prevailing low price for skipjack led the fishing director to 'concentrate on making daytime sets on unassociated yellowfin schools' (South Pacific Commission 1990b:7).

Since targeting contributes to profit maximisation it can be expected that an increasing number of vessels in the fishery will adopt the technology and fishing practices that make it possible. This means that targeting ability should be taken into account in the design of future management policies. In the absence of targeting, the level of fishing effort is the only control variable available to the fishery manager. This means that if it were decided, for example, to conserve yellowfin stocks by reducing purse seine harvests, this could only be done by reducing fishing effort which would also reduce skipjack catches. The ability to target introduces another control variable, the species composition of the catch, which can, in principle, be influenced by a differential royalty or quota scheme. Under such a policy, the skipjack harvest would not be reduced to the same extent by a policy of protecting juvenile yellowfin, and the economic costs of the policy would be correspondingly lower.

Chapter

7

An Economic Model of Tuna Longlining

H.F. Campbell

R.B. Nicholl

Introduction

The future of the western Pacific tuna fisheries will ideally be characterised by stock management regimes which aim at sustainable exploitation, together with attempts to regulate conflicts between the various gear types used for tuna fishing. The complexities which arise from the multispecies nature of the fisheries involved means that a comprehensive understanding of tuna production will be required for effective management. This chapter uses a multispecies revenue function framework to estimate individual vessel supply curves for each of five species harvested by Japanese longliners fishing in Papua New Guinea's exclusive economic zone in the period 1979–1987.

The main findings of the analysis are that the Japanese longline fleet can be considered as being comprised of two distinct vessel types based on gross registered tonnage (GRT); small (GRT<100) and large (GRT>100). In the small vessel sector of the fishery the species composition of harvests of individual vessels is not independent of the level of vessel effort, or of the relative species prices. The large vessel sector, on the other hand, exhibits price inelastic supply of all species, with the species mix being technically determined, but varying with the level of vessel effort.

Data

The catch and effort data used in the following analyses were obtained from the South Pacific Commission data base. The data describe the fishing activities of Japanese longline vessels operating in Papua New Guinea's exclusive economic zone between September 1979 and March 1987. Daily log sheet information recording vessel size, identification, date, number of hooks per set, and catch of each species by number of fish and average weight are reported in the data series. The species for which catch data are recorded are yellowfin, albacore, bigeye, marlins (blue, black and striped), sailfish, swordfish, bluefin and 'other' species which include sharks. Price data for the years 1979–1989 were obtained from the Forum Fisheries Agency data base. These data record ex-vessel average monthly prices for each species for the Japanese port of Yaizu.

The vessel level catch and effort data were aggregated to give monthly observations on catch and fishing effort, consistent with the format of the price data. The resulting data set is a time series of fleet cross-sections at the vessel level. The three marlin species and sailfish were aggregated to form a category referred to as 'billfish'. The Fisher ideal index method was used to calculate quantity and price indices for billfish; this is calculated as the square root of the product of the Laspeyres and Paasche indexes. As bluefin are a temperate species, those caught by longline vessels in Papua New Guinea waters are presumed to be purely incidental and are therefore excluded from the analysis. On average, 'other' species constitute less than 1.5% of total catch for the Japanese fleet in any year and are also excluded from the analysis.

Modelling longline production technology

A revenue maximising framework

An economic theory to describe the behaviour of fishing directors and skippers will need to specify whether short or long-run considerations dominate. Profit maximisation is widely held as the long-run objective pursued by fishing firms. However, a case can be made for treating profit maximisation as a two-stage procedure. Following Squires and Kirkley (1991), fishing operations are treated as conforming to a two-stage procedure in which there are short-run (single trip) revenue maximisation and long-run profit maximisation objectives. At the individual trip level of fishing activity, a vessel remains at sea until catch meets its storage capacity. While at sea, vessel size, or capital stock, and vessel characteristics are fixed. The level of other inputs such as labour and fuel are essentially determined by vessel size and are therefore also fixed for any given fishing trip. As the costs of the inputs are fixed for the duration of any given fishing trip, then the cost per trip can also be considered to be fixed. Facing given total costs of fishing effort, the most likely behaviour of fishers for any trip is that which maximises revenue. Costs which vary with trip duration are assumed to fluctuate randomly as do trip lengths, with variable factors such as weather. Over the long-run (probably up to ten years or more) firms determine the optimal size of vessel and suitable gear and equipment types and configurations. The choice of vessel size and type is a capital investment decision and represents a part of the long-run profit maximising stage of the fishing operation.

A generalised Leontief revenue function (used by Kirkley and Strand 1988 and Squires and Kirkley 1991) can be used to model the revenue maximising short-run behaviour of fishers, and with all inputs fixed is equivalent to short-run profit maximisation (Kirkley and Strand 1988). Functions describing the supply decisions of each species can in turn be derived from the revenue function. Within this framework, revenue for species *i* is postulated to be a function of the price of species *i*, the price of species *i* relative to the prices of other species in the output mix, and the level of inputs or fishing effort. In the following analyses the number of hooks per month is used as a measure of 'fishing effort'.

Economic theory also suggests that supply is determined in part by the level of fish stocks from which harvests are taken. Stock or species abundance would appear in the supply function as a technical parameter in the production process, rather than as a choice variable. Stock level or species abundance can affect harvest rate (measured as CPUE) in essentially two ways: (1) through the general abundance of species available to be harvested; and (2) through the density of fish in any particular fishing ground. However, the lack of stock or species abundance data preclude their inclusion in this analysis. The omission of a stock variable from the supply function could mean that the model described above is mis-specified, if species abundance is truly a statistically significant determinant of supply. Whenever a relevant variable is omitted from an econometric model, there is a possibility that bias will be introduced into the estimated coefficients if there is any correlation between the omitted variable and other explanatory variables in the model (Gujarati 1988). In the case of the longline fishery, if there were a negative correlation between own-price and species abundance (price rises as a species becomes more scarce), then the potential bias in the estimated own-price coefficient would be negative. Unfortunately, the presence of bias or its extent cannot be determined empirically, but the possibility of the above bias should be borne in mind when reviewing the results of the estimations. Although the effects of stock levels on species supply cannot be incorporated directly into the model, fluctuations in the stocks available to longline fleets from season to season and year to year can be accounted for indirectly. The inclusions of dummy variables for season and year are aimed at adjusting estimated supply responses in order to account for such variability.

The longline fishery in Papua New Guinea's exclusive economic zone is essentially a sub-tropical, multi-species fishery in which Japanese vessels have been present year round. While fishing directors are believed to hold some influence over the prices they receive for their vessels' catches, this is not considered to be nearly as significant as in the temperate longline fisheries. Therefore, ex-vessel prices are treated as exogenous to the vessel.

As a primary aim of this analysis is to gain some insights into the underlying technology employed in the longline fishery, a functional form which imposes restrictions on technology would limit the scope of the analysis. The generalised Leontief approach frees model estimation of some a priori restrictions on the technology employed by the industry, and allows for technological restrictions to be tested rather than imposed. The Leontief form of a revenue function does, however, impose linear homogeneity in output (or species) prices. Linear homogeneity in output prices, or symmetry, implies that the optimal output mix remains unchanged if all output prices were to rise (fall) by the same proportion.

The mathematical form of the revenue function described above is:

$$R = \sum_i \sum_j \beta_{ij}\left(P_i P_j\right)^{1/2} E + \sum_i \alpha_i P_i E^2 + \sum_i \sum_k \delta_{ik} D_k P_i E + \sum_i \sum_r \gamma_{ir} Y_r P_i E \qquad (1)$$

where for any month of fishing activity, R is revenue, P_i is the average monthly ex-vessel price of the ith species for the Japanese port of Yaizu (for i=yellowfin, albacore, bigeye, billfish, and swordfish), E is fishing effort measured in thousands of hooks, D_k (for k=1,2,3) are dummy variables to account for seasonal variations in the fishery, and Y_r (for r=1981, 1982, 1983, 1984, 1985, 1986, 1987) are dummy variables to account for annual fluctuations in stock availability which could result from environmental factors, changes in recruitment, mortality, vessel technology etc. There were observations for the last four months of 1979 and these were pooled with the 1980 observations. Although the data describe only the activities of longline vessels within Papua New Guinea's exclusive economic zone, the behaviour of fishing directors can be assumed to be consistent across all fishing zones. Furthermore, since the data do not provide any indication as to the commencement and finishing dates of particular fishing trips, a calendar month of fishing effort is used as the level of observation. For any given month of fishing activity, fishers will be following short-run revenue maximisation objectives and it is assumed that this behaviour is consistent not only within fishing trips, but also between them.

If equation (1) is differentiated with respect to price P_i, a series of input-compensated supply equations is obtained as follows:

$$\partial R / \partial P_i = Q_i(P_i E) = \sum_{j \neq i} \beta_{ij} (P_j / P_i)^{1/2} E + \beta_{ii} E + \alpha_i E^2 + \sum_k \delta_{ik} D_k E + \sum_r \gamma_{ir} Y_r E \qquad (2)$$

for all i. The function $Q_i(P_i E)$ represents the supply of species i from a month of fishing activity and is measured in tonnes. The resulting series of n equations (for n species) can be estimated together as a system to obtain information about the structure and technology of the production process in the longline fishery. Symmetry in the model implies the following cross-equation coefficient equalities: $\beta_{ij}=\beta_{ji}$ for all $i \neq j$.

Following Squires and Kirkley (1991), the technical and economic aspects of the longline fishery which influence fishing director behaviour are discussed. It is only with the knowledge of technological structure, economic incentives and costs that suitable management regimes can be designed and implemented. There are various forms of production technology which could characterise the longline fishery. In order to test for the nature of the production technology employed in the longline fishery, log-likelihood ratio procedure which involves imposing restrictions on the model in (2) is used. The test statistic for the likelihood ratio procedure is $-2[ln\mathcal{L}_R - ln\mathcal{L}_U]$, where $ln\mathcal{L}_U$ is the log-likelihood value of the unrestricted model, and $ln\mathcal{L}_R$ is the log-likelihood value of the model when the restrictions to be tested are imposed. The test statistic is distributed as χ^2, with degrees of freedom equal to the number of restrictions.

Tests for technology

The Japanese longline fleet can be divided into two vessel size classes: GRT<100 and GRT≥100 (with vessels ranging up to 500 GRT). It is possible that the size of vessel affects the CPUE of species in the output mix, measured as the weight of fish per hook. Differences in catchability due to vessel size may arise from differences in the state of technology between larger and smaller vessels; and larger vessels may have a wider choice of fishing grounds. In order to test the hypothesis that the size of vessel affects CPUE, equation (2) can be rewritten as:

$$Q_i(P_i E) = \sum_{j \neq i} \beta_{ij} (P_j / P_i)^{1/2} E + \beta_{ii} E + \alpha_i E^2 + \sum_k \delta_{ik} D_k E + \sum_r \gamma_{ir} Y_r E + \lambda_i VE \quad (3)$$

where V is a dummy variable which takes the value 0 for vessels of GRT<100 and 1 for vessels of GRT≥100. The hypothesis that technology is the same for both vessel sizes is tested, using a likelihood ratio test, in two different ways. First by the restriction $\lambda_i=0$ for all i; and second estimating separate subsamples for small and large vessels. Rejection of the restriction suggests that technology in the fishery is vessel size dependent.

As the longline fishery is a multispecies fishery, it can be viewed as a multiproduct production process with each species treated as a separate output. The way in which inputs are combined to produce the various outputs has implications for the response fishing directors would have to a variety of regulatory measures. Inputs to the production process in the short run are fixed and can be regarded as a composite input: 'fishing effort'.[1] If there is no specific interaction between effort and the individual species, catch can be considered a single composite output and the catch of each species is determined by relative prices, independently of the level of effort. Generally, in a multi-input, multi-output production process, constraining the mix of inputs does not affect the optimal combination of species harvested by vessels, and regulating the species mix in output has no bearing on the mix of inputs combined to produce 'effort' (Squires and Kirkley 1991). The appropriate restriction to test this hypothesis is $\alpha_i=0$ for all i.

Information about the ability of vessels to target particular species or groups of species is also embodied in the technology of the fleet. By targeting, it is meant that fishing directors vary the species mix with changes in relative prices of the species in the output bundle. The various species fished will be either complements, substitutes or neutral in production. For example, the vertical distribution of yellowfin, albacore and bigeye in the water column is such that fishing the deeper swimming bigeye is likely to result in forgoing catches of yellowfin and albacore. Conversely, harvesting species of the surface fishery (yellowfin) may complement catches of other similarly distributed species (albacore). The statistical significance and signs of the estimated β_{ij}s and own and cross-price elasticities of supply indicate such relationships between the species harvested.

It is also possible for the catch of some or all species in the output mix to be technically determined and therefore independent of relative prices. Under this scenario a species, or group of species, will be nonjoint in inputs, implying that a separate production function exists for the nonjoint species or group of species. If the species mix of the catch can be altered by the fishing director and is not technically determined, then regulatory measures controlling the exploitation of a particular species can be accomplished through relative price changes or individual species harvest quotas. The econometric restriction which applies to a production process completely nonjoint in species i is $\beta_{ij}=0$ for all $j, j \neq i$; and if nonjoint in all species is $\beta_{ij}=0, i \neq j$ for all i, j.

Finally, whether the fishery is in equilibrium is also determined. If the fishery is in economic equilibrium then vessels will be expending the optimal amount of fishing effort consistent with the opportunity cost of that effort. This equilibrium will be a long-run equilibrium and requires specifically that the marginal return per unit of effort is equal to the opportunity cost of fishing effort, which we denote by c. The marginal return to effort can be calculated from the revenue function as:

$$\partial R / \partial E = \sum_i \sum_j \beta_{ij} \left(P_j P_i \right)^{1/2} + 2 \sum_i \alpha_i P_i E \quad (4)$$

[1] The implication with respect to separability for using a composite input variable in the revenue function is that inputs are assumed to be separable from outputs (Kirkley 1986). The hypothesis that outputs are separable from inputs is not assumed to hold and is tested for.

and when set equal to c gives the long-run equilibrium condition. An estimate of c is obtained from Campbell and Nicholl (1990; 1992a) in which estimates of various economic costs of fishing effort for the Japanese longline fleet are reported.

Estimations and results

Initially, the five supply functions from equation (3) were estimated as single equations and heteroskedasticity attributable to the inclusion of the square of effort as an independent variable was found to be a problem. In response to this problem each equation was divided through by effort, with the resulting supply per unit of effort equations having the dependent variable CPUE. The series of five functions was then estimated together as a system of seemingly unrelated equations using Zellner's method of SURE estimation and iterated to convergence. Symmetry in the model was tested at the 5% level of significance and rejected ($\chi^2_{(10)}$=25.0); since it is a logical requirement it was imposed in subsequent estimations via the cross-equation restrictions $\beta_{ij} = \beta_{ji}$, all $i \neq j$.

Likelihood ratio tests for the significance of vessel size and the restriction that technology is the same across both vessel size classes were performed sequentially at the 5% level of significance. The first of these tested the restrictions for the exclusion of the dummy variables V relating to the size of vessel measured by GRT; the restrictions are λ_i=0 for all i. The results indicate that the restrictions should be rejected and that these dummy variables, as a group, are statistically significant ($\chi^2_{(5)}$=221.4). Following this test, the data samples for small and large vessels were estimated separately. The sum of the log likelihood values from these models was compared with that of the combined sample estimate; the restriction that the same technology is employed across both vessel size classes is rejected ($\chi^2_{(80)}$=700.4).

Having established that the technology for small and large vessels should not be restricted to be the same, separate models based on vessel size were then estimated and tested for model structure and technological characteristics. Tests for symmetry, the inclusion of seasonal and yearly dummies separately as a group, input-output separability, and nonjointness in inputs were calculated sequentially. All tests were carried out at the 5% level of significance.

Table 7.1 Tests for model structure and technology: small vessel sample

Test	No. of restrictions	Critical χ^2	Test χ^2	Reject restriction?
Symmetry	10	18.31	24.6	Yes
Season dummies	15	24.99	110.0	Yes
Year dummies	35	43.77	2997	Yes
Season and year dummies	50	67.51	2865	Yes
Input-output separability	50	11.07	35.0	Yes
Overall nonjointness	5	31.41	142.8	Yes
Nonjointness for				
Yellowfin	8	15.51	60.2	Yes
Albacore	8	15.51	59.4	Yes
Bigeye	8	15.51	31.8	Yes
Billfish	8	15.51	58.8	Yes
Swordfish	8	15.51	38.4	Yes
Block nonjointness				
Yellowfin and albacore	16	26.30	95.6	Yes
Yellowfin, albacore and bigeye	18	28.87	141.6	Yes

The test results for the small vessel sample model (Table 7.1) indicate that symmetry is rejected and it is therefore imposed in all subsequent estimations via the appropriate cross-equation restrictions. Tests for the inclusion of dummy variables to account for seasonal and yearly fluctuations in stock availability indicate that they are statistically significant, both as separate groups and as a combined group. With the inclusion of these variables, the model was then re-estimated and tested for separability and nonjointness. Input-output separability is rejected suggesting that the small vessel longline fishery harvest should be considered as multispecies rather than as an aggregate output of 'tunas'. Overall nonjointness is rejected indicating that the five species are interdependent and that regulating harvests of any species will affect the exploitation of other species in the output mix. Similarly, individual nonjointness for each species is rejected as is block nonjointness for yellowfin and albacore and yellowfin, albacore and bigeye.

Symmetry is also rejected in the large vessel sample model (Table 7.2) and is therefore imposed throughout subsequent estimations. Restrictions to exclude the dummy variables for seasonal and yearly fluctuations in stock availability to the fleet are rejected. Input-output separability is also rejected, indicating that large vessel fleet harvest cannot be considered an aggregate output. Overall nonjointness in inputs cannot be rejected, which means that separate production functions exist for each species and fishing directors of large vessels maximise outputs of each species rather than adjust species mix with changes in relative prices in order to maximise revenue. For the case of nonjointness, the supply of each species is perfectly inelastic and therefore independent of relative prices.

The full results from the estimation of the supply systems for the small and large vessel fleets are reported in Tables 7.3 and 7.4. A discussion of the results treats the small and large vessel sample estimations separately. Throughout the following discussion, longline activity in Papua New Guinea waters is defined as the 'longline fishery' which is comprised of five sectors, in turn defined by species harvested, and is exploited by the two broadly defined fleets outlined above–small and large vessels. Statistical significance is accepted at the 5% level.

Small vessel fleet

The coefficient on E in the CPUE equations is the coefficient on E^2 in the supply equations and indicates the marginal effect on the increase in output of increasing the number of hooks fished by 1000 in a month. The law of diminishing marginal productivity implies that with a constant fish stock, as the number of hooks fished increases, the marginal increase in CPUE for each unit increase in hooks fished will be less than for the previous unit of increase. Decreasing supply per unit of effort arises largely from the fixed nature of the exploited resource. The estimated coefficients in all but the bigeye sector of the small vessel fleet are not statistically different from zero, suggesting constant marginal productivity of effort. The estimated coefficient for the bigeye sector is negative, an indication of diminishing marginal productivity. The result of constant marginal productivity of effort for most sectors suggests that profit could be increased by increasing the number of hooks fished per month and hence vessel size; however, the attractiveness of such a change could be offset by Japanese government policy on vessel licences and taxation policies which has favoured the construction of vessels under 100 GRT.

Table 7.2 Tests for model structure and technology: large vessel sample

Test	No. of restrictions	Critical χ^2	Test χ^2	Reject restriction?
Symmetry	10	18.31	81.2	Yes
Season dummies	15	24.99	103.3	Yes
Year dummies	35	43.77	1129	Yes
Season and year dummies	50	67.51	1216	Yes
Input-output separability	5	11.07	25.6	Yes
Overall nonjointness	20	31.41	24.2	No

The coefficient on the constant in each equation signifies the own-price effect on supply decisions; a positive coefficient is expected. The estimated own-price coefficients are positive for all but the billfish sector, suggesting that supply of each species (barring billfish) increases in response to rising species price independently of the prices of other species. A statistically insignificant own-price coefficient for billfish may indicate that harvests of that species are incidental.

In the yellowfin supply equation the cross-price coefficients for albacore and billfish are negative, which indicates that these species are both substitutes in production with yellowfin. The same holds by symmetry for the albacore and billfish sectors with yellowfin. This result is somewhat unexpected for albacore and yellowfin since they are believed to have a similar vertical distribution in the water column. The result could, however, be indicating a difference in the regional distribution of the two species. The cross-price coefficients for bigeye and swordfish in the yellowfin equation are not statistically different from zero. In the albacore supply equation there is a negative cross-price coefficient for bigeye (the same holding by symmetry for the bigeye sector) and this indicates that albacore and bigeye are substitutes in production for the small vessel fleet. This result is consistent with what is generally known about the vertical distribution of these species, with the deeper swimming bigeye being harvested by vessels switching from regular to deep longlining. In the bigeye equation there is a negative cross-price coefficient with swordfish (and by symmetry with bigeye in the swordfish equation) suggesting that these species are also substitutes in production. It is possible that swordfish are distributed similarly to albacore and that changes in the longline method, which target bigeye but result in lower albacore CPUE, affect swordfish catches in the same manner.

Many of the estimated coefficients for the dummy variables which were included to account for seasonality of the longline fishery are not statistically significant, indicating that CPUE for most species does not fluctuate on a quarterly basis. Recall that the base quarter for the model estimations is June–August and the dummy variables indicate changes in CPUE relative to that quarter. Yellowfin CPUE is greatest in June–August, dropping significantly in September–November, and although increasing again for the quarters December–May has remained below that for the first quarter. Albacore CPUE is greater in the March–May period than in any other quarter, and for bigeye, CPUE is greatest in the December–February quarter with no significant change between the other three quarters. There appears to be no influence by seasonal factors in the billfish and swordfish sectors of the fishery.

Changes in CPUE for each year compared to the base year (1980) for each species are interpreted from the coefficients on the yearly dummy variables. The issue of annual fluctuations in CPUE for each species is addressed in detail in Campbell and Nicholl (1992b). Yellowfin CPUE was lower in all successive years of fishing from 1981 to 1987 except for 1983 in which it was not statistically different from 1980. The largest falls in CPUE relative to 1980 occurred in 1981, 1986 and 1987. For albacore, CPUE was generally greater throughout the 1980s than it was at the beginning of the period (1981, 1983, 1984 and 1986). In 1982, 1985 and 1987 it was not significantly different from 1980. CPUE of bigeye was lower in 1981, 1982 and 1983 than it was in 1980, not significantly different from 1980 in 1984–86 and greater in 1987. For billfish CPUE there were only two years that were significantly different from the base period; 1985 and 1986 in which CPUE was greater. Swordfish CPUE was lower in 1982–84 than the base year and higher in 1985–86 than in the base year.

Large vessel sample

The large vessel sample exhibits nonjointness in inputs over all species. This implies that the cross-price terms do not appear in the equations for the large vessel sample model and that the species composition of supply is independent of all species prices. The large vessel component of the overall longline fishery can be viewed as a combination of single species stocks which are exploited by a common form of effort.

All estimated coefficients for the constant terms are positive except for that of albacore which is not significantly different from zero. This indicates that there cannot be negative fitted values for supply of any species. The yellowfin, albacore and swordfish equations all have statistically insignificant coefficients on the variable E, indicating constant marginal produc-

Table 7.3 Parameter estimates for small vessel sample: dependent variable is CPUE

Variable	Estimated coefficient	t-ratio	Variable	Estimated coefficient	t-ratio
Yellowfin			**Swordfish** (contd.)		
Constant	630.51[a]	18.105	1981	-0.6219	-1.0832
Effort	0.2550	1.0046	1982	-1.4875[a]	-3.0041
P_A/P_Y	-57.689[a]	-3.4331	1983	-1.8169[a]	-3.6338
P_E/P_Y	37.484	1.8833	1984	-1.6080[a]	-2.5293
P_B/P_Y	-2.4422[a]	-3.2212	1985	1.6088[a]	2.8482
P_W/P_Y	-0.4359	-0.1760	1986	2.6509[a]	3.7778
Season: 2nd Qtr	-97.298[a]	-7.0818	1987	1.6688	0.9697
3rd Qtr	-42.301[a]	-3.0788	1981	-0.6219	-1.0832
4th Qtr	-41.038[a]	-3.0252	**Albacore**		
1981	-225.28[a]	-14.195	Constant	122.07[a]	8.0201
1982	-180.59[a]	-11.219	Effort	0.0162	0.2282
1983	20.718	1.2315	P_Y/P_A	-57.689[a]	-3.4331
1984	-154.62[a]	-7.9617	P_E/P_A	-38.118[a]	-3.4064
1985	-135.65[a]	-7.2346	P_B/P_A	1.0818	1.1517
1986	-227.68[a]	-11.084	P_W/P_A	-0.1014	-0.0388
1987	-309.00[a]	-5.2892	Season: 2nd Qtr	-1.7220	-0.4243
Bigeye			3rd Qtr	-4.8599	-1.1509
Constant	122.36[a]	6.9478	4th Qtr	8.7765[a]	2.1225
Effort	-0.4027[a]	-5.4564	1981	26.845[a]	5.4218
P_Y/P_E	37.484	1.8833	1982	2.3451	0.4565
P_A/P_E	-38.118[a]	-3.4064	1983	29.012[a]	5.6279
P_B/P_E	0.3565	0.6819	1984	38.306[a]	5.7563
P_W/P_E	-4.2171[a]	-2.5878	1985	-5.6644	-1.0112
Season: 2nd Qtr	2.2567	0.5256	1986	13.693[a]	2.0960
3rd Qtr	21.487[a]	4.7582	1987	31.674	1.8218
4th Qtr	7.7988	1.7736	**Billfish**		
Bigeye			Constant	1.0480	1.4699
1981	-62.050[a]	-12.060	Effort	-0.0004	-0.2463
1982	-47.011[a]	-9.2407	P_Y/P_B	-2.4422[a]	-3.2212
1983	-10.288[a]	-2.0471	P_A/P_B	1.0818	1.1517
1984	-7.7821	-1.3077	P_E/P_B	0.3565	0.6819
1985	8.3626	1.4855	P_W/P_B	0.2937	0.4002
1986	-5.9938	-0.9796	Season: 2nd Qtr	0.1529	1.3719
1987	53.957[a]	3.1522	3rd Qtr	0.0759	0.5926
Swordfish			4th Qtr	0.0471	0.3895
Constant	6.3800[a]	3.0607	Billfish		
Effort	-0.0043	-0.6711	1981	0.1230	0.7561
P_Y/P_W	-u.4358	-0.1760	1982	-0.2493	-1.7365
P_A/P_W	-0.1014	-0.0388	1983	-0.1475	-1.0122
P_E/P_W	-4.2171[a]	-2.5878	1984	-0.0093	-0.0451
P_B/P_W	0.2937	0.4002	1985	0.7119[a]	4.1263
Season: 2nd Qtr	0.5992	1.5964	1986	0.6423[a]	2.9864
3rd Qtr	0.2181	0.5121	1987	0.2794	0.5410
4th Qtr	0.6572	1.6304			

[a]Indicates significant at the 5% level for two-tail test

tivity of effort in these sectors of the fishery. The bigeye and billfish equations have negative coefficients on the variable E suggesting decreasing marginal productivity for large vessels in these sectors of the fishery. This latter result implies that the species composition of the catch varies with the amount of effort used.

Seasonal effects, indicated by the coefficients on the quarterly dummy variables, are more evident for the large vessel fleet than for small vessels. Yellowfin CPUE is lower for the September–November quarter, but not significantly different in the third and fourth quarters from the first quarter (Table 7.4). For albacore, CPUE is greater in the December–February quarter than the other three quarters whereas for bigeye, CPUE is lowest in the September–November quarter as it is for yellowfin and greatest in the December–February quarter. For billfish, CPUE is marginally higher during the September–February quarter than at other times of the year, while CPUE of swordfish appears to be marginally lower throughout the December–May period than for the rest of the year. If we compare these observations with those of the small vessel fleet we find there is little similarity between them. Yellowfin CPUE, while falling from the first to second quarters for both fleets, remains lower for the small vessels while not being significantly different in the third and fourth quarters to the first for the large vessel sample. Albacore CPUE increases for one quarter relative to other quarters for both the small and large vessel samples. With respect to bigeye CPUE, both fleets experience an increase in the November–February quarter and there is a marginal seasonal effect on billfish and swordfish CPUE experienced by large vessels. There appears to be no seasonal effect on the small vessel catches of these species.

The yearly variations in supply of each species for the large vessel fleet is, on the other hand, very similar to the effects observed for the small vessel fleet. Yellowfin CPUE was lower in 1981–82 and 1984–86 than for other years. There is a similar observation for bigeye, where CPUE was lower from 1981–85 than in 1980 and not significantly different in 1986–87. Annual variation in albacore stock availability appears to have been more moderate than for yellowfin and bigeye, being slightly greater in 1981 and 1983–84 than in 1980 and not significantly different in other years. Although variations for billfish and swordfish are statistically significant, they are small compared with those associated with the main tuna species.

Long-run equilibrium

Using the expression from equation (4) we can calculate the marginal return per unit of effort for the 'average' small and large vessel of each sample. Calculated on a monthly basis and using mean values of effort and prices, and where 1000 hooks is taken as the unit measure of effort, $\partial R/\partial E$ for the average small vessel is ¥450 190 (with a mean monthly effort of 31527 hooks) and for the average large vessel it is ¥489840 (with a mean monthly effort of 34065 hooks).[2] Estimates of the opportunity cost of effort are derived from Table 1, Appendix D in Campbell and Nicholl (1992a). From these estimates it is possible to average total cost per vessel per year for the fiscal years 1979–80 to 1986–87 and convert this to a monthly estimate, which is then divided by the sample mean level of effort to give the mean long-run average total cost per thousand hooks. There is some debate about the actual magnitude of access fees paid during the 1980s. The intention of the host country was to collect 4% of gross revenue. An analysis of vessel returns by the Forum Fisheries Agency (1986) for the year 1985 suggests that on average, access fees for small and large vessels were at the intended level. Doulman (1990) on the other hand suggests that Japanese industry sources rated access fees at between 0.2% and 0.6% of operating costs. The test of long-run equilibrium in this analysis is based on the 4% of revenue fee level. The mean estimated value of the marginal product of effort for each vessel class is multiplied by 0.96 to give a net-of-access-fee figure which can then be compared with the unit cost of effort. For the large class of vessels, Campbell and Nicholl report costs for 100–200 GRT and 200–500 GRT vessels and it was decided to calculate a weighted average total cost of effort for the large vessels based on the number of observations for each size class in the sample (see footnote 2).

[2]This is a weighted average based on the number of observations in the large vessel sample which pertain to vessels of 100–200 GRT (846 observations) and 200–500 GRT (37 observations); the mean level of effort for the former size was 34 101 and for the latter it was 33253 hooks. Mean sample prices/kilogram were: yellowfin ¥582; albacore ¥440; bigeye ¥795; billfish ¥876; swordfish ¥786.

Table 7.4 Parameter estimates for large vessel samples: dependent variable is CPUE

Variable	Estimated coefficient	t-ratio	Variable	Estimated coefficient	t-ratio
Yellowfin			**Albacore**		
Constant	776.48[a]	21.085	Constant	14.189	1.0482
Effort	−1.0465[b]	−1.9006	Effort	0.0069	0.0202
Season: 2nd Qtr	−73.013[a]	−2.2701	Season: 2nd Qtr	3.3457	0.2830
3rd Qtr	0.0628	0.0022	3rd Qtr	−29.124[a]	−2.5405
4th Qtr	−49.282	−1.5778	4th Qtr	9.5112	0.8284
Year: 1981	−278.56[a]	−7.9981	Year: 1981	37.650[a]	2.9410
1982	−263.74[a]	−6.8762	1982	27.420	1.9450
1983	15.564	0.40317	1983	109.61[a]	7.7247
1984	−203.40[a]	−5.0226	1984	50.174[a]	3.3705
1985	−166.74[a]	−4.2641	1985	14.695	1.0223
1986	−283.42[a]	−5.7243	1986	26.162	1.4375
1987	−254.24	−0.7929	1987	14.666	0.1244
Bigeye			**Billfish**		
Constant	152.21[a]	15.953	Constant	0.6429[a]	5.8879
Effort	−0.5037[a]	−4.2924	Effort	−0.0037[a]	−2.2876
Season: 2nd Qtr	−15.097[a]	−2.2024	Season: 2nd Qtr	0.4274[a]	4.4819
3rd Qtr	18.235[a]	2.7433	3rd Qtr	0.3409[a]	3.6858
4th Qtr	6.6577	1.0001	4th Qtr	0.0511	0.5523
Year: 1981	−50.100[a]	−6.7494	Year: 1981	−0.2865[a]	−2.7743
1982	−47.115[a]	−5.7634	1982	−0.3202[a]	−2.8157
1983	−27.539[a]	−3.3471	1983	−0.2475[a]	−2.1620
1984	−22.520[a]	−2.6091	1984	−0.1551	−1.2913
1985	−10.992	−1.3189	1985	0.8764[a]	7.5583
1986	−9.8774	−0.9360	1986	0.7170[a]	4.8840
1987	84.680	1.2390	1987	0.4973	0.5231
Swordfish					
Constant	2.4856[a]	5.7435			
Effort	0.0033	0.5077			
Season: 2nd Qtr	−0.2881	−0.7622			
3rd Qtr	−1.1664[a]	−3.1824			
4th Qtr	−0.8378[a]	−2.2826			
Year: 1981	−0.3788	−0.9256			
1982	−0.9801[a]	−2.1745			
1983	−1.5456[a]	−3.4069			
1984	−1.4528[a]	−3.0527			
1985	2.0504[a]	4.4621			
1986	2.8446[a]	4.4888			
1987	−1.4454	−0.3836			

[a]Indicates significant at the 5% level for two-tail test; [b]for one-tail test

The estimate of c for the average small vessel is ¥398 247 and for the average large vessel it is ¥633 802. At the 5% level both estimates of c are significantly different from the respective values of $\partial R/\partial E$; ¥51 943 less for small vessels (t-statistic, 4.6444) and ¥143 960 greater for large vessels (t-statistic, −5.620). These results indicate that on average, small vessels have contributed less than the economically optimal level of effort per month for Papua New Guinea waters while the opposite was the case for the large vessels. As the Japanese government exercises considerable influence over the allocation of its distant water fishing fleets between regions, and provides subsidies to the industry which could well distort the economic decision-making process of fishing firms, a misallocation of fishing effort, from an economic perspective, is quite plausible. Furthermore, in the short run, the relationship between marginal revenue product and the opportunity cost of fishing effort can be affected by stock fluctuations and relationships with other fisheries.

Conclusion

The estimates of the production technologies of the small and large vessel fleets, together with information available about costs, can be used to draw some conclusions which are relevant to the management of the fishery. The conclusions relate mainly to management options and the efficiency of the fleet. The results suggest that large longliners lack the ability to influence the species composition of their catch. This means that a policy of conserving one or a subset of the species currently fished and concentrating on harvesting the other species is not practicable where these vessels operate. Small longliners, on the other hand, are able to respond to individual species quotas, or to incentives such as differential royalties, to some extent by targeting particular species. This means that the range of management policy measures and outcomes is broader where small vessels are operating. This information may be useful to Pacific island countries which are considering establishing their own longline fleets.

In long-run equilibrium it is expected that individual vessels will devote effort to the fishery up to the point at which the marginal revenue product of effort equals its opportunity cost. This equilibrium condition was tested for both vessel size samples. It was found that, on average, small vessels are contributing less, and large vessels more, than the long-run equilibrium level of effort. Since the differences are not substantial, and since in the short run this relationship can be affected by stock fluctuations and relationships with other fisheries, it cannot be concluded that the behaviour of individual vessels in the fleet is inefficient.

Chapter

8 The Tuna Longline Fishery in Papua New Guinea

H.F. Campbell

R.B. Nicholl

Introduction

Longline fishery has been an important part of Papua New Guinea's tuna industry, with the activities of Japanese fleets by far outweighing the activities of longline vessels from any other nation. Tunas and billfish harvested by longline vessels were, up until the early 1970s, supplied as canning material for the Japanese and other processing industries. However, since the early 1970s the more lucrative 'fresh fish' product markets of Japan have become the destination of longline catches.

Although Japanese fleet activities in Papua New Guinea waters ceased in March 1987, with the expiry of a bilateral access agreement, there remains the possibility of renewed Japanese longline activity, or of longlining by the fleets of other distant water fishing nations in Papua New Guinea's exclusive economic zone. The western Pacific region, and in particular the waters of Papua New Guinea and the Federated States of Micronesia, offer productive fishing grounds which are rich in deep water fish resources, especially tunas and tuna-like species. The re-emergence of a Papua New Guinea domestic tuna fleet, in the form of longline vessels, also remains a possibility. There has been little work undertaken to establish the economic interactions among species exploited by longliners, and between longline and other gear types. It is only on the basis of an understanding of the underlying production technology and determinants of economic behaviour in the longline fishery that the potential effects of management policies and conflicts with other gear types on longline fleet operations can be assessed.

The longline fishery in Papua New Guinea

An overview of the biology

The western Pacific offers a wide range of tunas and billfish to the industrial fishing fleets which operate in the region. The distribution of species is determined in the most part by water temperature, although ocean currents are also recognised as an important factor. In broad terms, the most significant gradations of water temperature are from the tropical waters of the equatorial region, in both northerly and southerly directions, and from the sea surface (or mixed layer) to deeper layers of the water column.

The main tuna species harvested in the tropical longline fishery of Papua New Guinea are yellowfin and bigeye, with incidental catches of albacore. Other catches are of billfishes, namely striped, blue and black marlins, together with sailfish and swordfish. In terms of catch by weight, yellowfin is the dominant species, followed by bigeye then albacore. In general, bigeye inhabit a lower region of the water column than albacore and are therefore more vulnerable to a deeper longline method of fishing. This suggests that fishing directors may be able to switch to some extent between fishing either bigeye or albacore in conjunction with yellowfin catches, although it has been suggested that targeting bigeye could mean forgoing yellowfin catches to some degree. This is because yellowfin and bigeye have different vertical distributions in the water column (SPC 1989). However, the bulk of albacore harvests from the south Pacific are taken from more southerly regions (30–40S and east of New Zealand), where they are targeted in the troll and what was previously the drift-gillnet surface fisheries (SPC 1989 and 1992b).

Although catch per unit effort (CPUE) of the various tuna species fluctuates on an annual basis, variation in stock abundance due to factors other than exploitation are believed to be minor. In cases where fluctuations are observed, they are most likely attributable to the age class structures of particular stocks. The effect of 'simple age class' structures on catches is that when a strong year class is recruited to the stock, catches of this class will be relatively higher (and dominated by this year class) for a season or two, until the class disappears resulting in a drop in CPUE (Suda 1972). However, tuna stocks in the western Pacific are not widely believed to exhibit such 'simple age class' fluctuations. Stocks of marlins in the Pacific are not believed to be susceptible to significant fluctuations either, and an observed declining trend in catch rates for blue and black marlins over the period 1974–1980 is likely to be due to longlining activities (Suzuki 1989).

History of the fishery

The longline fishery in Papua New Guinea continues to be concentrated in the northern region of the exclusive economic zone. Although there has been some Korean and Taiwanese vessels in this fishery throughout the 1980s, their activities have remained insignificant relative to the operations of the Japanese fleet, which expanded rapidly throughout the 1950s and ceased operations in Papua New Guinea in 1987. To the Japanese longline fleets, Papua New Guinea waters have represented a productive and reliable source of tropical tuna species which were originally harvested for canning material, and from the mid-1970s for high grade sashimi, katsubushi and similar products. A breakdown of longline catch for the Papua New Guinea exclusive economic zone by year and species is given in Table 8.1. Yellowfin has featured prominently in both phases of the Japanese longlining industry; together with albacore in the first phase when the bulk of tunas landed in Japan were canned or exported as canning material, and then subsequently with bigeye as the focus of activity switched to supplying the more lucrative Japanese domestic market for 'fresh fish' products. Table 8.1 shows that for the period 1980–1986, yellowfin as a proportion of total longline fleet catch in Papua New Guinea waters ranged from 72–82%.

The level of longlining activity in Papua New Guinea, although fluctuating during previous decades, peaked in 1982 before declining thereafter to cease in 1987 (SPC 1988a). CPUE for the longline fleet is reported to have decreased since 1979 in Papua New Guinea's exclusive economic zone, although it remained higher in Papua New Guinea than elsewhere in the Pacific region (SPC 1988a). Speculation about the causes of declines in CPUE for the longline fishery has ranged from changes in targeted species and accompanying changes in fishing methods, to the potential for interaction between the purse seine and longline fisheries through yellowfin stocks.

Most of the effort in the fishery has come from the smaller class of vessels, which are less than 100 GRT. Between 1984 and 1987 vessels smaller than 100 GRT caught from 77.9–91.4% of the total annual landings of tuna by Japanese longline vessels (FFA 1989b). The smaller vessels have fished in waters closer to Japan, whereas the larger vessels have made longer trips fishing the more valuable temperate species, in particular bluefin. Prior to the 1960s most longline activity was within the equatorial band 10N–10S, but during this decade attention began to turn to more intensive harvesting of billfish (primarily marlins and sailfish) which required vessels fishing beyond the equatorial zone. The move towards including billfish in longline harvests was prompted by Japanese market acceptance of them as sashimi products (Caton and Ward 1989).

After the mid-1970s, competition to Japanese longliners supplying albacore as canning material emerged from the expanding Korean and Taiwanese fleets. This led to a further shift by the Japanese longline fleets towards supplying the Japanese

Table 8.1 Papua New Guinea exclusive economic zone, longline catch by species[a], 1980–86 (tonnes)

	Yellowfin	Albacore	Bigeye	Bluefin	Marlin	Swordfish	Sailfish	Other
1980	10146	280	1768	0	216	45	33	71
	(80.8)	(2.2)	(14.1)	(0)	(1.7)	(0.4)	(0.3)	(0.6)
1981	8474	940	1264	0	156	32	40	67
	(77.2)	(8.6)	(11.5)	(0)	(1.4)	(0.3)	(0.4)	(0.6)
1982	9008	366	1449	0	82	19	13	28
	(82.1)	(3.4)	(13.2)	(0)	(0.8)	(0.2)	(0.1)	(0.3)
1983	9510	745	1485	19	101	86	40	220
	(79.9)	(6.3)	(12.5)	(0.2)	(0.9)	(0.1)	(0.1)	(0.2)
1984	5178	609	1164	17	678	56	82	275
	(64.3)	(7.6)	(14.4)	(0.2)	(8.4)	(0.7)	(1.0)	(3.4)
1985	7532	159	1761	0	366	64	13	15
	(76.0)	(1.6)	(17.8)	(0)	(3.7)	(0.7)	(0.1)	(0.2)
1986	4594	152	1271	0	266	62	10	5
	(72.2)	(2.4)	(20.0)	(0)	(4.2)	(0.1)	(0.2)	(0.07)

[a] Figures in brackets are percentages. May not add to 100 due to rounding.
Source: Compiled from South Pacific Commission catch data.

domestic sashimi market. The 1970s represented a period of significant structural change for the industry. The first of the world oil price shocks, together with emerging trends of labour shortages manifested in increasing crew costs, signalled a new era of high cost operations for longline (and other distant water) fleets. Faced with seemingly little ability to increase CPUE, supplying higher value markets was seen as a way of offsetting the effects of rising costs. These circumstances prompted a large scale modernisation of the Japanese longline fleets. The modernisation program effectively adopted two main approaches to dealing with the deteriorating economic position of these fleets. One aspect was the development of equipment and freezing techniques suitable for handling and storing sashimi grade fish. The innovation in freezing techniques served two purposes – it enabled the higher value market to be supplied, and increased campaign duration (thereby lowering costs). A second aspect was an increase in vessel size combined with increased mechanisation aimed at decreasing labour requirements and increasing fishing power (Caton and Ward 1989). In addition to the above vessel changes, fishing directors began attempting to increase catches of more valuable and deeper swimming bigeye relative to catches of albacore. They achieved this by changing their fishing technique from 'regular' to 'deep' longlining, effectively fishing a deeper segment of the water column by increasing the number of hooks per basket (Caton and Ward 1989). By the early 1980s deep longlining had all but replaced the traditional 'regular longlining' method (SPC 1988a).

Longline fishing technique

The practice of longline fishing is a well established method of catching mid and deep-layer swimming tunas and billfish, typically older and hence larger than those of the surface fisheries. Longline gear consists of a mainline (which can be up to 130 km in length) to which branchlines (or snoods) with baited hooks are attached. By attaching buoys to the mainline (usually 300–350 m spacing) a series of catenaries (also known as 'baskets') are formed, each catenary allowing a range of depths in the water column to be fished in one set of the line. Details of the search, set and retrieval techniques are given by Baron (1989) and Medley (1989).

All longline vessels employ a wide range of modern electronic equipment in the search for potential fishing grounds and the location of schools of fish. Satellite navigation and weather receiving equipment allow skippers a high degree of accuracy in mapping the location of productive fishing grounds and predicting favourable conditions for line sets and retrieval. Satellite transmissions also offer accurate information on sea surface temperature contours covering large areas. Using satellite data together with information on oceanic currents, fishing directors can carefully plan locations and orientations for line sets, significantly reducing the random component of searching for fishing sites. As Japanese fishers believe tunas and billfish swim parallel to regional currents, longline sets are typically made perpendicular to prevailing currents; this also minimises the chance that lines will tangle during a set (Medley 1989). Other devices used to help identify potential fishing sites include echo sounders for detecting fish beneath the surface, radar for detecting sea bird activity, sea water temperature sensors and radio direction finders used to locate buoy-mounted transmitters which mark the location of the end of a line set.

The depth to which a longline sinks is determined primarily by the interval between buoys and the speed at which the line is paid. Baited hooks (both fresh and frozen) are placed at intervals in a specific order across the baskets. Regular longlining uses between 5–7 hooks per basket and is more likely to result in harvests of fish which inhabit the mid- layer of the water column. In order to catch deeper swimming species (such as bigeye) the number of hooks per basket has been varied from 10–14 allowing the lower part of the line to sink farther. One of the trade-offs associated with this change in technique is that fewer billfish are likely to be caught as they are primarily surface swimmers and therefore more vulnerable to regular longline gear (Suzuki 1989). There is also a possibility that fewer yellowfin will be caught as their movements are generally restricted to the mixed layer above the thermocline; however, there is no conclusive evidence that this has been the case (SPC 1988a). As noted earlier, a general shift towards the use of deep longlining gear amongst Japanese longline vessels began in the mid-1970s; by 1983 almost all Japanese vessels were using this type of gear (SPC 1988a).

During line retrieval the vessel will slow or stop only if a valuable catch is to be landed. Tunas are processed immediately and handled in a way which minimises the stress experienced by fish; excessive stress can result in deterioration of the meat quality (often referred to as 'burning' of the flesh). Tunas are bled, gutted and tagged for identification. Billfish have the sword removed before being gilled, gutted and filleted (marlins are not filleted), weighed and frozen (Baron 1989). The overriding concern with both tunas and billfish, however, is the handling of the fish during preparation for freezing, as quality and price are highly correlated. Both types of fish can command high prices in the sashimi market. Fishing ground, season and the reputation of the fishing director are other determinants of price.

Japanese longline vessel catches have historically been sold at markets by auction at various ports around Japan. However, in recent years about 75% of the deep frozen sashimi tuna has been sold through what are known as 'whole-ship deals', where buyers negotiate the sale of an entire vessel catch while the returning vessel is in transit (Fujinami 1986b). This system is only effective when both buyers and sellers have sufficient experience with respect to the effects on quality of season, fishing ground and handling procedure.

Interaction with other fisheries

As most longline fisheries supply high quality, high value markets, they are generally accepted as being able to generate the highest returns from the exploitation of tuna and tuna-like species. Since longline catches are typically of larger fish, there are concerns regarding the delayed effect on longlining from the exploitation of smaller fish (Forum Fisheries Committee 1990; Campbell and Nicholl 1992b; Medley 1989; Suzuki 1986 and 1988), particularly the potential effects of purse seine yellowfin catches on longline harvests.

Fonteneau (1986) defined three classes of interaction (1) inter-generational whereby, for example, excessive exploitation of the adult portion of a stock leads to declining reproductive potential of the population; (2) intra-generational, where a species is exploited by different fisheries at different stages of its life cycle (the yellowfin example); and (3) intra-generational where a common stock is exploited by several fisheries and the same or similar cohorts are caught in the different fisheries.

Other fisheries which have the potential to impact on a sector of the longline fishery are the troll and drift-gillnet albacore fisheries, although activities of the latter have been reduced significantly in recent years (by international agreement). While both of these fisheries have operated mainly in the southern regions of the Pacific (south of 30S), the underlying population of albacore is possibly common to all western Pacific fishery stocks. While the question of albacore depletion through interaction with other fleets is not as important an issue with respect to longlining activities in Papua New Guinea waters as that of yellowfin depletion, any indication of an interaction between the surface fisheries and longline catches of albacore in Papua New Guinea may nonetheless be useful information.

The dynamics of potential albacore interactions are similar to those of the purse seine/longline yellowfin interaction, in that drift-gillnet and troll fleets produce surface yields of albacore and longline fleets produce deeper (mid-layer) yields. While the primary focus of concern has been on the overall sustainability of drift-gillnet albacore harvests and their impact on the troll fishery (SPC 1991 and 1992b), concerns have also been raised regarding the possibility of reduced longline yields of albacore (SPC 1989:11), not to mention widespread concern about the indiscriminate nature of drift-gillnet gear.

In both the above cases of potential interaction between longline and other fisheries, certain assumptions must be made in order to use CPUE comparisons of species, on both a spatial and temporal basis, as an indicator of declining stock due to surface yields. These assumptions are that variations in CPUE reflect changes in either local stocks or the underlying population from which stocks are recruited, and not fluctuations in catchability due to environmental causes or changes in vessel technology. However, it is often difficult to isolate the effects of environmental fluctuations and changes in vessel gear and technology when analysing CPUE trends (SPC 1988b).

Stock depletion and interaction with other fisheries

In an analysis of Papua New Guinea's longline fishery for the period 1979–1987, Campbell and Nicholl (see Chapter 7 of this volume) have incorporated annual dummy variables in each of the supply equations for the five main species caught by longliners. Although the issue of stock depletion should be addressed over a longer period and over a wider area than were considered in that analysis, the estimated values of these dummy variables offer some indication as to local stock status, or at least to stock availability to the longline fleet over the successive years of the analysis. The exclusive economic zone of Papua New Guinea represents only a portion of the total area over which the species in the longline fishery are harvested, and various substocks of tunas may interact with an underlying regional population. Details of tuna stock dynamics are yet to be determined and therefore abundance measures for any species in any given fishing ground are still to be treated with some caution in drawing conclusions about harvest sustainability. Nonetheless, the dummy variable estimates reported by Campbell and Nicholl suggest that there were significant annual changes in CPUE for at least some years for all longline species. Given the potential interactions between the longline, purse seine, drift-gillnet and troll fisheries, a closer analysis of this segment of the results has been carried out for both the small and large vessel fleets.

The supply equations are estimated in the form of catch per unit effort equations in which the constant terms measure the mean vessel CPUE in the base period 1979–80 as the level of fishing effort of the individual vessel tends to zero. As such, the constant term can be interpreted as an indicator of stock availability to the fleet prior to any local stock depletion caused by fishing effort. The yearly dummy variables in the CPUE equations represent changes relative to the base period level of CPUE over the period of the sample. As the results of the supply analysis indicate only whether CPUE for any species was different in successive years from the base period 1979–80, an ANOVA analysis was carried out for each species to determine whether there was any change in CPUE over the years 1981–1986. The year 1987 was omitted from the ANOVA analysis as the three months to March represented the transition to total withdrawal of the Japanese tuna fleets from Papua New Guinea waters. The results of the ANOVA analysis of small and large vessel base level CPUEs are reported in Tables 8.2 and 8.3. In each case, tests of the hypothesis that CPUE for the years 1981–1986 together as a group were not different from each other, and then the hypothesis that CPUE for any two of these years was not significantly different, were carried out.

The ANOVA analysis indicates that the hypothesis of a constant CPUE over the period 1981–86 can be rejected for all species. On a species by species basis, CPUE in certain pairs of years is not significantly different; for example, yellowfin CPUE in 1981 and 1986, 1982 and 1984, and 1984 and 1985 for the small vessel sample as reported in Table 8.2. The results of the pairwise comparisons of CPUEs in different years are not identical for the two classes of vessels; for example, yellowfin CPUE has been more uniform over the period for the large vessel sample, as reported in Table 8.3, than for the small vessel sample, as reported in Table 8.2.

The results indicate that there has been significant annual variation in the mean CPUE for the various species over the period of the analysis. In addition to the results presented in Tables 8.2 and 8.3, mean CPUEs for each species for each year, by vessel size, have been calculated and presented graphically in Figures 8.1 to 8.10. The first observation which can be noted from comparing the mean CPUE by species of small and large vessels as illustrated in Figures 8.1–8.5 and 8.6–8.10, is the similarities in patterns of change in CPUE between the two vessel sizes for all species but albacore; although the absolute levels of CPUE vary between vessel size and species. For example, looking at the mean CPUE for each species by vessel size (large, small) over the period 1979–1986, large vessels had higher mean CPUE (measured as kilograms per thousand hooks) over the period for yellowfin (567.1, 461.5), albacore (42.3, 18.7) and billfish (0.73, 0.60), while small vessels had higher CPUE for bigeye (90.4, 101.7) and swordfish (1.88, 2.0).

The small vessels of the fleet experienced less variation in CPUE for yellowfin and bigeye relative to the other species. Yellowfin CPUE declined from a high for the period of 727 kg/1000 hooks in 1979 to 351 kg/1000 hooks in 1980, with another high of 604 kg/1000 hooks in 1983 and then declining steadily to 291 kg/1000 hooks in 1987. For albacore, CPUE rose from a period low of 1.52 kg/100 hooks in 1979 to a period high of 38.38 kg/1000 hooks in 1981, declining dramatically in 1982 and then increasing to around 1981 levels again in 1983–84 before once again declining sharply in 1985 and remaining relatively low through to 1987. Bigeye CPUE was reasonably steady at around 110 kg/1000 hooks throughout the period, except for a drop in 1981–82 and a peak for the period of 184 kg/1000 hooks in 1987. Changes in CPUE for billfish and swordfish follow similar patterns, increasing sharply from 1979–1980 then steadily declining to 1984 followed by a very large increase (324% billfish and 741% swordfish) in 1985 and then remaining at similar levels to 1987.

For the large vessels of the fleet, yellowfin CPUE for the years 1979 and 1986 was basically at two levels; a higher level of around 700 kg/1000 hooks for 1979, 1980 and 1983, and a lower level of around 440 kg/1000 hooks for the remaining years. Albacore CPUE fluctuated around 40 kg/100 hooks for most of the period except for 1979 and 1980 which were very low levels, and 1983 which was a year of particularly high CPUE (119 kg/1000 hooks). CPUE for bigeye was consistently greater than for albacore, increasing from 1981 (61.8 kg/1000 hooks) to 1986 (100.4 kg/1000 hooks) after declining from a period high of 113.3 kg/1000 hooks in 1979. For billfish and swordfish, trends in CPUE were similar to those experienced by small vessels; there was a very large increase in 1985–1986 from much lower levels throughout the early 1980s, with highs for the earlier period in 1980 in both cases.

In summary, there appears to be a slight decline in yellowfin CPUE from 1983–1986. Furthermore, there appears to have been a gradual increase in CPUE of bigeye, the second most important species to the longline fishery, for both vessel sizes after 1981. There does not appear, from these results, to be any discernible relationship between CPUEs for albacore and bigeye. An inverse relationship between CPUE of these species would be expected if they are substitutes in production as suggested by the analysis of Campbell and Nicholl (Chapter 7 of this volume). An increasing focus on catching bigeye by longline fleets does not appear to have affected catch rates between 1983 and

Table 8.2 ANOVA for difference in CPUE between years, 1981–86: small vessel sample

Test	Yellowfin	Albacore	Bigeye	Billfish	Swordfish
All years equal[a]	47.49	14.99	53.34	77.33	64.23
$Y_{1981}=Y_{1982}$	12.10	42.63	13.47	40.84	2.274
$Y_{1981}=Y_{1983}$	243.3	0.970[b]	125.30	6.460	5.390
$Y_{1981}=Y_{1984}$	22.27	1.525[b]	114.8	15.70	6.162
$Y_{1981}=Y_{1985}$	28.55	48.76	161.1	134.4	109.0
$Y_{1981}=Y_{1986}$	0.436[b]	25.28	85.92	104.6	160.7
$Y_{1982}=Y_{1983}$	152.0	25.21	60.37	11.18	0.856
$Y_{1982}=Y_{1984}$	3.587[b]	16.24	59.61	1.439[b]	1.585
$Y_{1982}=Y_{1985}$	5.970	2.405[b]	92.30	283.6	135.7
$Y_{1982}=Y_{1986}$	3.921	0.004[b]	41.69	226.2	189.9
$Y_{1983}=Y_{1984}$	71.42	0.124[b]	0.745[b]	2.694[b]	0.181
$Y_{1983}=Y_{1985}$	67.08	32.98	6.081	171.0	139.3
$Y_{1983}=Y_{1986}$	134.3	16.07	0.002[b]	137.2	192.4
$Y_{1984}=Y_{1985}$	0.181[b]	23.77	2.052[b]	178.7	122.9
$Y_{1984}=Y_{1986}$	10.85	11.38	0.505[b]	148.3	171.7
$Y_{1985}=Y_{1986}$	14.15	1.472[b]	4.368	0.118[b]	7.686

[a]Critical value of $F_{k,\,n-1}$ is 2.10 at the 5% level of significance; all other tests have a critical F value of 3.84.
[b]Cannot reject the restriction at the 5% level of significance.

Table 8.3 ANOVA for difference in CPUE between years, 1981–86: large vessel sample.

Test	Yellowfin	Albacore	Bigeye	Billfish	Swordfish
All years equal[a]	12.99	8.013	5.834	27.16	19.56
$Y_{1981}=Y_{1982}$	0.155[b]	0.375[b]	0.409[b]	0.774[b]	2.482[b]
$Y_{1981}=Y_{1983}$	61.79	26.89	8.098	0.258[b]	6.751
$Y_{1981}=Y_{1984}$	3.704[b]	0.751[b]	12.59	0.833[b]	6.595
$Y_{1981}=Y_{1985}$	7.193	2.449[b]	16.33	99.36	31.80
$Y_{1981}=Y_{1986}$	0.147[b]	0.345[b]	14.07	38.87	30.23
$Y_{1982}=Y_{1983}$	48.60	29.07	4.294	1.620[b]	0.981[b]
$Y_{1982}=Y_{1984}$	2.128[b]	1.822[b]	7.641	2.648[b]	1.049[b]
$Y_{1982}=Y_{1985}$	4.620	0.826[b]	10.22	102.0	44.67
$Y_{1982}=Y_{1986}$	0.433[b]	0.002[b]	9.674	43.68	41.23
$Y_{1983}=Y_{1984}$	26.71	14.29	0.561[b]	0.153[b]	0.005[b]
$Y_{1983}=Y_{1985}$	21.75	37.52	1.251[b]	74.91	56.37
$Y_{1983}=Y_{1986}$	39.09	19.71	1.963[b]	30.18	50.79
$Y_{1984}=Y_{1985}$	0.381[b]	4.726	0.115[b]	63.74	0.015[b]
$Y_{1984}=Y_{1986}$	3.316[b]	1.444[b]	0.559[b]	25.44	53.70
$Y_{1985}=Y_{1986}$	5.656	0.394[b]	0.223[b]	2.762[b]	0.821[b]

[a]Critical value of $F_{k,\,n-1}$ is 2.10 at the 5% level of significance; all other tests have a critical F value of 3.84.
[b]Cannot reject the restriction at the 5% level of significance.

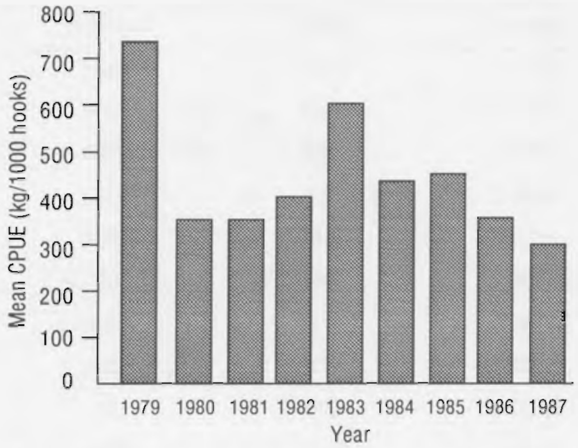

Figure 8.1. Average CPUE for yellowfin, small vessels.

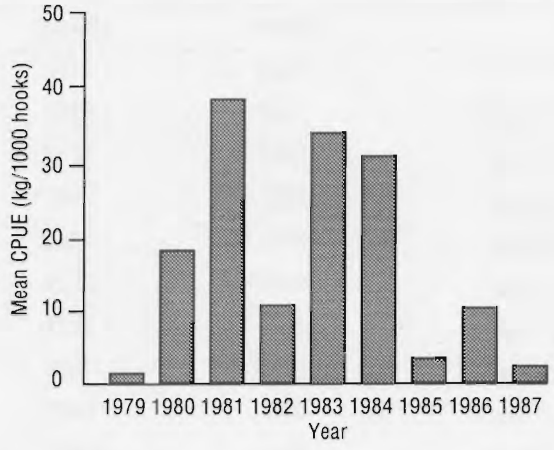

Figure 8.2 Average CPUE for albacore, small vessels.

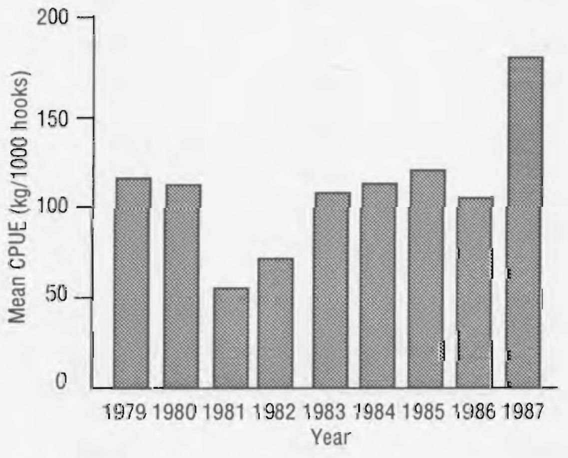

Figure 8.3 Average CPUE for bigeye, small vessels.

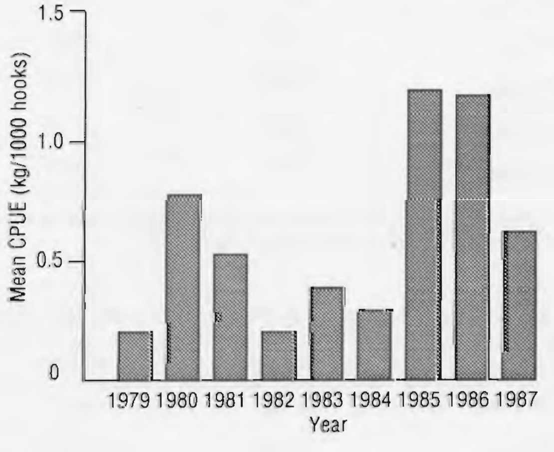

Figure 8.4 Average CPUE for billfish, small vessels.

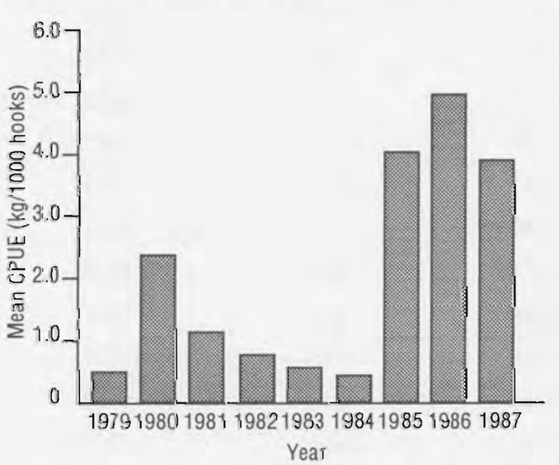

Figure 8.5 Average CPUE for swordfish, small vessels.

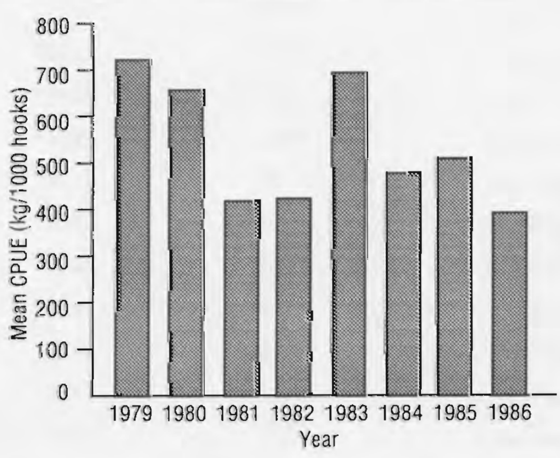

Figure 8.6 Average CPUE for yellowfin, large vessels.

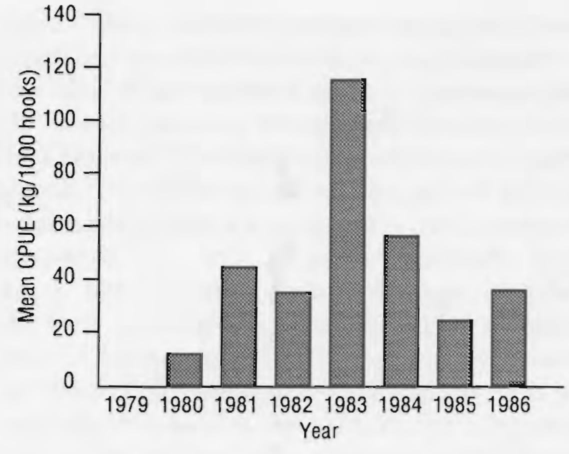

Figure 8.7 Average CPUE for albacore, large vessels.

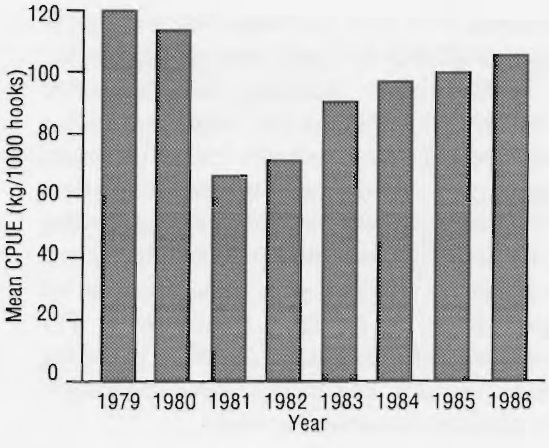

Figure 8.8 Average CPUE for bigeye, large vessels.

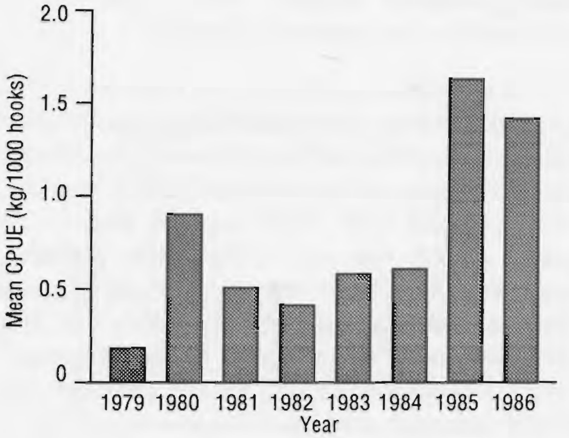

Figure 8.9 Average CPUE for billfish, large vessels.

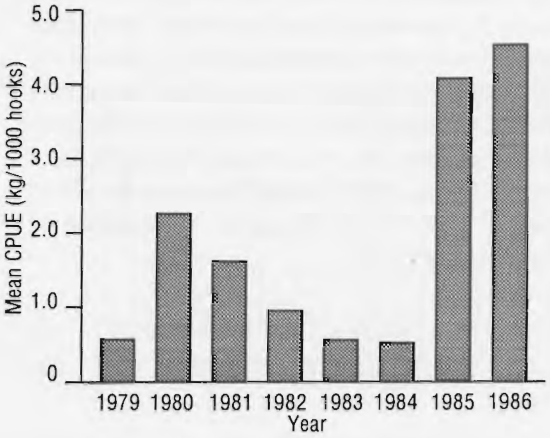

Figure 8.10 Average CPUE for swordfish, large vessels.

1986. CPUE for the fleet between these years was unchanged, but increased in the first quarter of 1987. We can conclude from these results that stock availability of bigeye has not shown signs of depletion for the period of the analysis. For albacore, a pronounced decline in CPUE occurred between 1983–1986. While this is not direct evidence of conflict between the driftgillnet albacore fishery and the longline fishery, it does offer some indirect support to the hypothesis that the gillnet fleet activities are capable of affecting longline catch rates. While it is also possible that part of this decline in albacore CPUE may be attributable to switching by Japanese fishing directors to deep longlining, we are unable to determine to what degree this may have occurred as our effort data do not provide any information on the number of hooks per basket in longline sets. By 1983 nearly all longline vessels in the Japanese fleet were using the deep longlining method. Suzuki (1989) has suggested that fewer billfish are caught with the deep longlining technique. Given that most vessels had apparently switched to deep longlining by 1983, our finding that CPUE for billfish increased markedly in 1985 and 1986 is not consistent with Suzuki's suggestion.

Supply elasticities

It is useful to know the supply responsiveness of fishing firms to changes in species prices, due either to market changes or to changes induced by regulatory measures. If relative output price changes result in variations in fishing intensity, then such variations may have implications for biological or economic management. In the absence of knowledge regarding the interaction between relative price changes and output mix, policy instruments applied to any particular species can cause unanticipated shifts in output mix, especially where species are substitutes in production. Similarly, rising prices of species which are already over-exploited and increasingly difficult to supply, may act as incentives for an increased focus on supplying those species. The result could be disproportionate amounts of fishing effort directed towards the supply of these species and increasing pressure on remaining stocks.

The ability of vessels to change output mix by substituting between species implies a degree of targeting. By targeting is meant that if the price of one species were to rise relative to other species, then more of this species would be caught and less of another (or others), for a constant level of fishing effort. Conversely, if the price of a species were to fall relative to the price of other species, then less of it would be caught for a given level of fishing effort. From the model described in Campbell and Nicholl (Chapter 7) targeting of species i is interpreted as:

$$\begin{aligned} \partial Q_i / \partial P_i &= 1/2\Sigma_{j\neq i}\beta_{ij}\left(P_j\right)^{1/2}\left(P_i\right)^{-3/2}E \rangle 0 \\ \partial Q_i / \partial P_k &= 1/2\beta_{ij}(P_j / P_i)^{1/2}E \langle 0 \end{aligned} \quad (1)$$

Input-compensated own and cross-price elasticities of supply for each of the five species can be calculated by multiplying the terms from (1) by (P_i/Q_i) and (P_j/Q_i). These elasticities measure supply response for a fixed input level and in the case of the cross-price elasticities, indicate pure substitution effects in output between pairs of species for a change in the price of one of the pair. The own (ε_{ii}) and cross-price (ε_{ij}) elasticities are:

$$\begin{aligned} \varepsilon_{ii} &= -1/2\Sigma_{j\neq i}\beta_{ij}(P_j / P_i)^{1/2}\left(E / Q_i\right) \\ \varepsilon_{ij} &= 1/2\beta_{ij}(P_jP_i)^{-1/2}\left(P_jE / Q_i\right) \\ \Sigma_j\varepsilon_{ij} &= 1/2\Sigma_{j\neq i}\beta_{ij}(P_jP_i)^{-1/2}\left(P_jE / Q_i\right) = -\varepsilon_{ii} \end{aligned} \quad (2)$$

The input-compensated price elasticities of supply for the small vessel sample analysed by Campbell and Nicholl are reported in Table 8.4. They are calculated using mean sample values of effort and quantity supplied and represent the average short-run or monthly level supply response to output price changes. For the large vessel sample, input-compensated supply of each species in the output mix appears to have been perfectly inelastic; this result is a consequence of the finding of nonjointness in inputs for all species (β_{ij}=0 for all $i \neq j$) for that sample. For the small vessel sample the expected sign of the own price input-compensated supply elasticities is ε_{ii}>0. For the cross-price elasticities, ε_{ij}>0 indicates species i and j are substitutes in production, ε_{ij}>0 indicates they are complements and ε_{ij}=0 that they are neutral. We also note from the last line of equation (2) that for any species i and a given level of effort the sum of the cross-price elasticities is equal to the negative of the own-price elasticity. This is a consequence of the property of linear homogeneity in output prices which is imposed by the generalised Leontief form of the revenue function used in the analysis in Chapter 7.

The elasticities in the first row of Table 8.4 are the calculated own-price input-compensated elasticities of small vessel supply for each of the five species. All own-price elasticities are not statistically different from zero at the 5% level. This result suggests that fishing directors do not respond to changes in individual species prices in isolation from all other output prices. As yellowfin and bigeye generally constitute over 80% of longline catches and therefore by far the greatest proportion of revenue earned for any campaign, low (although not necessarily zero) own-price elasticities of supply for these species would be expected. In other words, as the mainstay of revenue for any campaign is earned from catches of these two species, fluctuations in their prices will do nothing to change the aim of effort with respect to these species.

The last four rows of Table 8.4 show the calculated input-compensated cross-price elasticities of supply. All elasticities statistically significant at the 5% level have the expected negative sign. Those elasticities which are significantly different from zero are yellowfin/albacore (–0.0532), yellowfin/billfish (-0.0032), albacore/yellowfin (–1.2112), albacore/bigeye (–0.9236), bigeye/albacore (–0.1623), bigeye/swordfish (–0.0240), and billfish/yellowfin (–0.5895). The zero and very low cross-price elasticities for yellowfin indicate that relative to all other species in the output mix, yellowfin does not have any close substitutes in output although albacore may to a small extent serve as a substitute for

Table 8.4 Input-compensated own and cross-price elasticities of supply: small vessel sample

Y=yellowfin		A=albacore		E=bigeye		B=billfish		W=swordfish	
ε_{YY}	0.0111	ε_{AA}	0.2192	ε_{EE}	0.0511	ε_{BB}	6.5446	ε_{WW}	-0.4926
	(0.0311)		(0.6160)		(0.1436)		(18.392)		(1.0730)
ε_{YA}	-0.0532[a]	ε_{AY}	-1.2112[a]	ε_{EA}	-0.1623[a]	ε_{BA}	0.5897	ε_{WY}	0.8594
	(0.0155)		(0.3528)		(0.0476)		(0.5120)		(0.8957)
ε_{YE}	-0.0459	ε_{AE}	-0.9236[a]	ε_{EY}	0.1835	ε_{BY}	-0.5895[a]	ε_{WA}	0.9926
	(0.0244)		(0.2711)		(0.9744)		(0.4753)		(1.0366)
ε_{YB}	-0.0032[a]	ε_{AB}	0.0282	ε_{EB}	0.0022	ε_{BE}	0.2579	ε_{WE}	1.8491
	(0.0010)		(0.0245)		(0.0032)		(0.3782)		(1.9310)
ε_{YW}	-0.0054	ε_{AW}	-0.0025	ε_{EW}	-0.0240[a]	ε_{BW}	0.2140	ε_{WB}	2.0520
	(0.0031)		(0.0637)		(0.0093)		(0.5347)		(2.1429)

[a]Significant at the 5% level, for two-tail test; standard errors in brackets.

yellowfin. On the other hand, a reasonably large negative response of supply of albacore with respect to an increase in the price of yellowfin shows that yellowfin may readily be substituted for albacore. This observation is consistent with yellowfin being the more valuable of the two species. Similarly, a significant cross-price response between albacore and bigeye is expected and reinforces the view that these species can be fished as substitutes by changing longline configuration. There is a statistically significant but small supply response for bigeye to swordfish price, suggesting limited substitution possibilities, while the elasticity with respect to billfish and yellowfin also suggests possible substitution in output. Finally, all cross-price elasticities for swordfish with respect to other species are zero, indicating that swordfish supply is not responsive to changes in the prices of other species and may therefore be considered incidental to the overall harvest aims of longline fishing directors. This finding is reinforced by the observation from Table 8.1 that the proportion of swordfish in total catches between 1980 and 1986 was on average 0.55% of annual longline harvest in Papua New Guinea waters.

Conclusion

This paper has presented a summary of the development of the tuna longline fishery in Papua New Guinea during the 1980s. In addition to the general background of the fishery, the technology of small and large longline vessels, as described by input-compensated supply elasticities, was discussed, and results of the supply analysis relating to sustainability were considered.

For the large vessel fleet all elasticities of supply were not significantly different from zero, indicating that the species composition of the catch is independent of product prices. This means that the fleet's impact on individual species cannot be regulated by means of individual species quotas or royalties. If harvesting by large vessels of a particular species is to be restrained it will be necessary to reduce the total effort of the fleet; however, note that large vessel activity represented only about 24% of total longline activity in Papua New Guinea waters for the period 1979–1987. While the species composition of the catch does not vary with species prices, it does change as the level of individual vessel effort changes. This introduces a further consideration for management attempting to control the exploitation of individual species.

The small vessel fleet demonstrates an ability to target individual species in response to changes in the relative prices of species. For example, for a constant level of fishing effort, a rise in the price of yellowfin will cause falls in the catches of albacore and billfish; a rise in the price of albacore could lead to falls in the catches of yellowfin and bigeye; and a rise in the price of bigeye will cause falls in the catches of albacore and swordfish. Further results are reported in Table 8.4. The own-price elasticities of supply of the major species, yellowfin, bigeye and albacore, are low because of a heavy reliance of the fleet on these species for the bulk of revenue. The cross-price elasticities suggest that it would be possible to pursue independent management policies for certain stocks. For example, if albacore stocks were judged to be overfished, the small vessel fleet could be encouraged to replace albacore to some extent with yellowfin and bigeye. This could be achieved by an individual vessel catch quota or a royalty on albacore. The test for input-output separability indicated that, as in the case of the large vessel sample, the species composition of catch varies at the individual vessel level with the amount of effort supplied. This would need to be taken into account if policy measures were introduced which affected effort levels of vessels in the fishery.

Finally, the paper presents some slight indirect evidence about the sustainability of the fishery. Since the period of the analysis is relatively short (1979–1987), evidence of significant stock depletion would not be expected. However, in the case of the two stocks, yellowfin and albacore, which are or have been exploited by other gear types (purse seine for yellowfin, and drift-gillnet and troll for albacore), although not necessarily in the same area, there is some evidence of local depletion at least. The estimated annual stock dummy variables and the ANOVA analyses of the CPUE estimates suggested stock depletion, particularly in the case of albacore.

Chapter 9

A Financial Appraisal Model of Tuna Fishing: Purse Seine, Pole-and-Line and Longline Vessel Operations

I.Y. Duchesne

R.B. Nicholl

Introduction

There is growing interest in Papua New Guinea in the re-establishment of a domestic fleet to supply shore based facilities proposed for various ports. The integrated development of transshipment and processing facilities, together with the re-emergence of local and/or locally based fishing fleets, could mark the beginning of Papua New Guinea gaining significant economic benefits from its tuna resources.

As the economic success of a domestic fleet will depend largely on catch rates, operating costs and world tuna prices, a framework for evaluating the economic performance of vessels under various harvest and market scenarios would be valuable in making initial assessments regarding the feasibility of fishing ventures. Although any joint venture partners bringing vessels and experience into the industry would no doubt be able to make reasonable assessments of the potential viability of domestic fleet operations, it is in Papua New Guinea's interest to make independent assessments, especially if vessels are to be Papua New Guinea owned and operated.

This chapter forms the accompanying document to a spreadsheet model developed by I.Y. Duchesne and designed to aid the assessment of potential investment in domestically operated tuna vessels. Varying scenarios of harvest and market conditions are combined with vessel operating cost information to provide a financial appraisal of potential fishing ventures.

Background

Around two-thirds of total world tuna catches are caught in the Pacific Ocean (Copes 1987), with the western Pacific region representing the most important source of commercially exploited tunas within the Pacific. Within the western Pacific, Papua New Guinea has one of the largest endowments of tuna resources. Although the history of the tuna industry in Papua New Guinea is somewhat recent relative to tuna fishing in the Pacific in general, and represents only a small percentage of gross domestic product (Kuk 1991), the potential exists for a greater involvement by Papua New Guinea in world tuna markets.

Papua New Guinea's tuna fisheries have in the past been totally export orientated and composed of two sectors–a distant water sector which has formed the principal tuna fishery; and a domestic sector which has had a limited operation. Three gear types have comprised the distant water sector (to 1987): purse seine, longline and pole-and-line. Purse seine and pole-and-line have exploited (and still do in the case of purse seine) surface stocks of yellowfin and skipjack, whereas the longline fleets which have been almost exclusively Japanese, have targeted deeper swimming, larger yellowfin, bigeye and to a lesser extent albacore. Most of the single purse seine vessels continue to be in the 750 GRT to 1500 GRT size range and have typically operated some distance from the Papua New Guinea coastline. Almost all pole-and-line and longline vessels ceased operating in Papua New Guinea's exclusive economic zone following the breakdown of access negotiations between Japan and the Papua New Guinea government. As Papua New Guinea recognises and adheres to Article 62.2 of the United Nations Convention on the Law of the Sea, which requires that island nations make resources excess to their harvesting capacity (but within allowable catches) available to other fishing nations, the distant water fishing nation sectors of the fisheries will continue.

The Papua New Guinea domestic tuna fleet experience is well documented by Doulman and Wright (1983) and Kuk (1991). There were at various times throughout the 1970s and early 1980s between two and four companies operating pole-and-line boats in Papua New Guinea. These companies were either totally foreign owned or represented joint venture arrangements between the Papua New Guinea government and Japanese interests. The fishing operations of all Papua New Guinea based boats were centred around Cape Lambert in East New Britain and Kavieng in northern New Ireland, due to their proximity to both reliable baitfish grounds and good fishing grounds. Apart from the downturn in world market tuna prices in the early 1980s, the domestically based operations were impeded by the necessity to fish within about 100 km of mother ships, as fresh bait had to be taken on board each night (Doulman and Wright 1983). Shore based facilities for handling and processing catches for export were also lacking, adversely affecting the viability of the operation as a whole. It is unlikely, for the reasons of commercial convenience and technical expertise, that any future domestic fleet would involve pole-and-line fishing.

As purse seine and pole-and-line gear fish the same surface stocks of skipjack and yellowfin, there is an increasing tendency for the use of purse seining as it is a far more efficient means of harvesting tuna. The choice between the two gear types is not simple though, as efficiency of harvest must be traded off against a lower value end use. In this respect, much of the pole-and-line caught skipjack and yellowfin is sold for katsubusi and sashimi, whereas the bulk of purse seine catch is supplied as canning material. This trade-off is moderated to some extent, however, by the fact that the superior sashimi grade tunas are the larger, deeper swimming fish targeted by longline vessels. Depending upon the targeted market (or markets) for Papua New Guinea domestically supplied tuna, it seems likely that purse seine vessels would offer the most efficient means of harvesting canning grade tuna. However, purse seine vessels would most probably need to be small to medium sized vessels due to a range of factors of which capital cost would be dominant.

The Japanese sashimi market provides lucrative returns to the supply of high grade fresh and fresh--frozen tunas. Papua New Guinea is well placed geographically to establish links with Japanese markets and, using a fleet of longline vessels, could well provide the appropriate grades of tuna. Japanese longline vessels of a wide range of sizes (50–100 GRT up to 500 GRT) have had a significant presence in Papua New Guinea waters throughout the history of Papua New Guinea's tuna fisheries, a strong indication that its fishing grounds are suitable for this gear type. Studies have shown, however, that it is the smaller class of longline vessel that is more economical and better suited to the longline fishery of Papua New Guinea (Campbell and Nicholl 1992a and b).

Functions of the model

The Papua New Guinea Financial Appraisal Model (FAM) provides simulations of the operations of various types and sizes of tuna vessels. Its purpose is to help assess the viability of tuna vessel investment. The FAM reports several operational, cost and profitability characteristics based on existing data available from research undertaken by Campbell and Nicholl (1990, 1992a) into Japanese tuna operations in Papua New Guinea waters. The approach adopted in the FAM provides a benchmark against which potential domestic investors can compare their own projects. Within-model adjustment to the parameters (such as wages and unloading capacity) is possible; this allows a wide range of scenarios to be examined.

Three main tools are provided within the model to analyse investment feasibility; (1) financial measures; (2) sensitivity analysis; and (3) graphical display. The model can be used to calculate various financial measures, such as net present value and internal rate of return; it can be used to provide a sensitivity analysis of the results; and it can be used for graphical display.

Financial measures

Cash flow

The cash flow statement demonstrates calculated incoming and outgoing cash flows on a yearly basis for the expected life of the investment project (or projected economic life of the vessel). It is centred on operating cash flows, ignoring associated capital costs, such as interest repayments. Similarly, depreciation is not included since it is not a cash flow. While having some interest of its own, the cash flow table is used primarily to calculate financial indicators based on the discounted cash flow method.

Payback period

One of the simplest measures, the payback period (PP), provides a direct measure of the time it takes for the initial cash outlay of a project to be recovered from the project's net cash inflows. The PP is then compared with some maximum required PP to determine whether the financing horizon of the project is acceptable. A project with a PP greater than the maximum acceptable period will be rejected. The PP is not a measure of profitability. Furthermore, no discounting method is applied within the PP framework, thus ignoring the timing of cash flows. The PP is primarily an indicator of cash liquidity for a given project.

Return on investment

The other nondiscounted measure is the return on investment (ROI). It provides a first measure of project profitability. For the ROI, the percentage return on invested capital is calculated for a typical year of operation. This return can be compared with a minimum required rate of return.

Net present value

A net present value (NPV) calculation involves discounting cash flows taking into account both the magnitude and timing of cash flows. The NPV method is characterised by a predetermined required rate of return. All future cash flows are discounted at this rate. The resultant discounted sums are then subtracted from the initial cash outlay. The project is approved if the sum of the discounted income stream is greater that the sum of discounted expenses. The amount of a positive NPV represents the increase in the investor's wealth that will result from undertaking the investment.

Internal rate of return

The internal rate of return (IRR) is that discount rate which results in a NPV of zero. It can be considered as the maximum rate of interest that could be paid for debt financing without making a loss. The viability of the project is determined by comparing the IRR with some required rate of return. Again, a project with an IRR greater than the required rate should be accepted.

Sensitivity analysis

The calculation of financial indicators is based on a variety of input parameters, such as ex-vessel tuna prices, wages, daily catch rates and waiting days (see next secion). A useful analysis is to examine how sensitive the financial indicators are with respect to some of the key parameters. For example, tuna market prices have fluctuated significantly from month to month and year to year. It is possible with the spreadsheet model to change tuna market prices and assess the impact of such changes on profitability, as measured by NPV and IRR. In this way, the model will prove useful for scenario planning and risk assessment.

Graphical displays

The FAM has been developed within the Lotus 123 framework, which provides easy access to graphical displays of the results. This facilitates interpretation. For example, a graphical display is a useful instrument for following the evolution of a certain financial indicator throughout a sensitivity analysis. Net present value could be plotted against daily catch rate. A more detailed approach could integrate more variables in the analysis; for example, showing combinations of daily catch rates and tuna market prices that result in a NPV of zero (for example, see McIlgorm 1989).

Details of the model

The FAM, which draws on earlier work of the Forum Fisheries Agency (1985) can be applied to purse seine, longline or pole-and-line operations (McIlgorm 1989).

Using input parameters, three output statements are provided for each of the possible vessel categories. For each vessel category (type and size) there are two files – an edit file and a run file. The edit file contains all the input parameters for the output statements, for example ex-vessel tuna prices, vessel cost categories, and daily catch rates. The input parameter values can be changed at any time; this automatically alters the output statements. The run file contains the different output statements. The calculations are based on the input parameters.

An application of the model for a Japanese longliner in the size range 50–100 GRT is presented in Appendix 1.

Input parameters

The input parameters are contained in the edit files. They are divided into three categories:

[1] input parameters for the operating statement

[2] input parameters for the revenue statement

[3] input parameters for the cash flow/investment analysis statement.

The values for the input parameters are taken from Campbell and Nicholl (1990) and Forum Fisheries Agency (1985). All parameter values can be changed, allowing the user to execute a sensitivity analysis with respect to certain key input variables.

Output statement

The output statements are contained in the run files. As with the input parameters, they are divided into three categories:

[4] vessel operating statement

[5] vessel revenue statement

[6] vessel cash flow/investment analysis statement.

The model is not designed to allow the user to make changes to the structure of the output statements. The remainder of this section explains in detail the calculation of each of the statements using the example in Appendix 1.

Vessel operating statement

The vessel operating statement [4] reflects the operational practice of the vessel in an average year of operation. It provides detail of how many trips the vessel undertakes, how many days it spends waiting and unloading or actually fishing, and total catch for the vessel.

Number of trips per year is calculated by dividing days available for fishing by trip duration. Days available for fishing are obtained by subtracting the total number of days of bad weather, from 365. Trip duration is the sum of fishing time, unloading time, transit time and waiting time. Fishing time is vessel storage capacity divided by daily catch rate. Unloading time is obtained by dividing the vessel hold capacity by the unloading capacity of the port. Transit time divides the distance between port and fishing grounds by the transit speed. Waiting time is defined as the number of days waiting to unload divided by the number of trips. The complete output statement can therefore be considered as a system of equations.

Days fishing, days steaming, days waiting and provisioning and days unloading are all calculated by multiplying the respective times (as obtained above) by the number of trips.

Days other is the remainder after subtracting days fishing, days steaming, days waiting and provisioning and days unloading from 365.

Annual catch is vessel storage capacity times the number of trips.

Daily catch of the vessel is treated by species. Japanese longline vessels typically harvest five varieties of fish in Papua New Guinea waters; albacore, bigeye, yellowfin, billfish (blue marlin, black marlin, striped marlin and sailfish) and swordfish. The three tuna species make up the bulk of the catch, with yellowfin accounting for about 63% of the catch. Billfish and swordfish are incidental but together provide about 8% of the total catch on average. The division of daily catch into species is important because the market value of the different varieties can vary significantly. Over the past decade bigeye tuna has yielded the best price of the three tuna species, with a mean price that was ¥100/kg to ¥200/kg higher. The price of billfish and swordfish has been considerably higher than that of tuna.

The critical variable in the vessel operating statement is daily catch. Changes in the daily catch rates will significantly alter the financial results of the investment. Since daily catch rates are specified in terms of individual species, detailed sensitivity analysis is possible. It will show the financial implications of variability in daily catch or of variability in the composition of daily catch.

Vessel revenue statement

The vessel revenue statement [5] as calculated in Appendix 1, represents receipts and costs in the year 1988–1989. The values of operating cost and profit reflect the research in Campbell and Nicholl (1990). The calculation of these values has been made flexible to account for possible variation in key input parameters.

The vessel revenue statement is divided into three parts. The first part calculates gross vessel receipts, the second part tabulates the vessel operating costs and the third part combines the gross receipts and operating costs to calculate the gross and net operating profit.

The first part of the vessel revenue statement represents vessel gross receipts, and is simply the product of annual catch and ex-vessel price. Annual catch is calculated from the operating statement by multiplying daily catch by the number of trips per year. As in the operating statement, annual catch is given by species. Market value (per tonne) is the average market price of the fish (per kilogram) times one thousand. The market value by species is a mean price for each species for the period 1980 to 1987 (Japan Tuna 1992). Gross fish receipts is determined by multiplying the annual catch by market value. Again, details are provided on receipts by species.

From this calculation we can see that the profit-ability of the investment project will greatly depend on daily catch (which determines annual catch). Not only variability in daily catch, but also variability in the composition of daily catch, will affect gross fish receipts. It is equally clear that operational practice will influence gross fish receipts. More efficient unloading facilities will increase the actual days fishing, hence gross fish receipts.

The second aspect of the vessel revenue statement is operating costs. This statement lists variable and fixed operating costs per vessel in an 'average year' of operation. Wages is based on adding two potential measures of remuneration. One varies with catch and ex-vessel price, the other by catch only. The former is crew share as a percentage of gross fish receipts. The latter is crew share in thousands of Yen per tonne of fish landed multiplied by annual catch. Both calculations represent a crew effort-based type of remuneration, which reflects the general practice in the industry; although it could easily be argued that crew have no influence on price received from purse seine catches. Fishing gear, oil, ice, miscellaneous materials, cost of business, capital cost and other costs are all entered straight from the input parameter file. Bait is measured by multiplying bait cost with annual catch. Fishing boat represents vessel repair and maintenance costs. It is calculated as a proportion of the initial purchase price. Brokerage reflects the insurance costs of the vessel. It too is a proportion of the initial purchase price.

The third part of the vessel revenue statement matches vessel receipts with costs to calculate operating profit. Gross operating profit subtracts total operating cost from gross fish receipts. Subtracting capital cost from this value leaves net operating profit. These profit measures are calculated before tax liabilities are assessed.

Although the revenue statement is primarily designed to aid the calculations contained in the cash flow table and the financial indicators, it does offer relevant information in and of itself. It presents the user with the operating results (receipts, costs and profit) of an average year of operation during the life cycle of the vessel. The key parameters that will likely influence the results considerably are daily catch, operational parameters (for example days of waiting), fish market prices and wages. A sensitivity analysis on these variables is therefore appropriate.

Vessel cash flow/investment analysis statement

The cash flow/investment analysis statement [6] is composed of a cash flow table and calculations of financial indicators.

The cash flow table shows all cash inflows and out-flows for each year during the life of the vessel. The vessel economic life is a flexible input parameter and the cash flow table is set up to adjust automatically as the projected vessel life changes. Vessel cost is entered as the main cash outflow in the first year, while the vessel salvage value represents an additional inflow at the end of the economic life span. It is calculated as a percentage of the initial purchase price. Average capital cost, operating cost and revenue are entered each year from the revenue statement as average cash flows. Net cash flow subtracts the outgoing from the incoming money flows (see above for explanation of cash flow table interpretation).

The second part of this output statement is the investment analysis, which allows the user to evaluate the investment by offering four different investment measures discussed above. Return on investment shows the percentage return on the invested capital in an average year of operation. It is calculated by dividing net operating profit by the vessel cost. NPV discounts each of the annual net cash flows at a chosen discount rate; it is calculated using the Lotus 123 NPV function. IRR is that discount rate which results in a NPV of zero. It is the return on the project which would result in a break even situation. The calculation is done by the Lotus 123 IRR function. Payback period shows the number of years it would take to recoup the initial investment. It is obtained by dividing the vessel cost by the net operating profit.

An example

FAM can be used to assess potential investment in a single vessel. An extension of this exercise to a fleet of vessels is easily undertaken. The data and calculations for the following example are presented in Appendix 1.

Assume a Papua New Guinea initiative involves the establishment of a domestic tuna fishing fleet. As an initial investment, the purchase of a longline vessel of 100 GRT has been proposed. An initial assessment regarding the venture's feasibility is required. For this purpose, the FAM is specified for a Japanese longline vessel of 50–100 GRT. All prices and costs in the model are in Yen. The Japanese example is used because at present no domestically operated tuna fleet is active. The Japanese example will, however, provide some guide as to what could be expected from a Papua New Guinea based operation. In this case, the analysis would be augmented by adjusting certain variables in accordance with Papua New Guinea's specific conditions.

The following input variables are noted. The daily catch rate is expected to be 1.4 tonnes per day. The following catch composition is anticipated: 63% yellowfin; 29% albacore and bigeye; and 8% billfish and swordfish. This catch composition is quite important since the market prices of the different species can vary substantially. Of the tuna varieties, bigeye typically attracts the highest average market price at ¥416/kg. The average market price of yellowfin is ¥312/kg, while that of albacore is only ¥236/kg. Note, however, that the two residual species (billfish and swordfish) yield 480 and ¥421/kg respectively. Of these average market prices per kilogram, ¥144 goes directly to the crew as remuneration. The vessel under review is assumed to have an economic life of 12 years. The investors regard 10% as the minimum before tax rate of return they require from the project.

The operating statement indicates that the vessel can be expected to undertake five trips per year on average. The unloading facilities represent a significant constraint (30 days per year are spent loading and unloading). As stated before, the daily catch consists mainly of yellowfin. Each fishing day 882 kg of yellowfin is caught. While the market price of bigeye is higher, only 165 kg are caught per day.

From the revenue statement we determine that an average vessel year will result in a positive net operating profit of ¥13 242 000. It is yellowfin catch which represents most of the receipts; ¥86 424 000 out of some ¥141 952 000, or about 60%. Bigeye tuna is the next most important species in terms of revenue, accounting for ¥20 800 000, which is 14% of revenue. Although billfish is a residual catch, its receipts are quite substantial (¥13 440 000). On the cost side, the largest item is wages, which represents 44% of total operating cost.

From the cash flow statement we note that the first year of the project shows a very large cash outflow of ¥183 778 000, caused by the initial cash outlay for the purchase of the vessel. All subsequent years show an even net cash inflow of ¥13 242 000, except for year 12 when the salvage value of the vessel is received. This cash flow table shows the liquidity needs of the venture and also its ability to pay back possible loans. Any financial agreements burdening the project with repayments larger than the yearly cash inflow should be avoided.

The investment analysis statement shows there are problems regarding profitability of the project. Problematic is the payback period of the venture. The calculated payback period is nearly 15 years, which is longer that the economic life of the vessel at 12 years. This is also reflected in the low return on investment (6.7%). Furthermore, the NPV is negative and the IRR is very low. Given the present market and internal cost structure, the proposed project would not find financial support.

The above example is based on Japanese data. Potential Papua New Guinea investors should adjust certain key parameters, such as wages, to the domestic situation. Having done this, one can implement different scenarios (of prices, operational and cost parameters) and investigate which conditions would have to prevail in order to make the project feasible. The remaining task then is to look at the plausibility of profitable conditions and to convince potential financiers of their plausibility. Furthermore, although the project will not likely find financial support if administered as a purely private initiative, there might be grounds for government or joint private–government financial support. The wider effects on the Papua New Guinea economy of setting up a domestic tuna fishing fleet may well be considerable. The tuna fleet operations may lead to the establishment of domestic canneries and to increasing port handling volumes. Substantial spinoff effects on employment, investment, foreign reserves and facilities are to be expected. For these reasons, a wider cost–benefit approach would be appropriate and will increase the chances of the proposed investment project being undertaken.

Appendix 1

Example application of FAM to Japanese Longliner (size 50–100 GRT)

(1) Input parameters for the operating statement

Range name	Description	Value
vhc	vessel fish holding capacity (t)	90
ptof	port to fishing grounds (n miles)	800
dsr	days annual steaming allowance for refit	0
dwu	days waiting to unload/provision	2
fuc	fish unloading capacity (t/d)	12.5
ts	transit speed (miles/h)	19
dcalb	daily catch rate of albacore	0.25
dceye	daily catch rate of bigeye (t)	0.16
dcyel	daily catch rate of yellowfin (t)	0.88
dcbil	daily catch rate of billfish (t)	0.09
dcswo	daily catch rate of swordfish (t)	0.02

(2) Input parameters for the revenue statement

Range name	Description	Value
amp	average market price of tuna ('000¥/kg)	0.326
ampalb	average market price of albacore ('000¥/kg)	0.236
ampeye	average market price of bigeye ('000¥/kg)	0.416
ampyel	average market price of yellowfin ('000¥/kg)	0.312
ampbil	average market price of billfish ('000¥/kg)	0.480
ampswo	average market price of swordfish ('000¥/kg)	0.421
tcn	total crew number	20
cs%	crew share (% of gross fish receipts)	0
csy	crew share ('000 ¥ per tonne of fish landed)	144
vc	vessel cost (¥ million)	197020

(2) Input parameters for the revenue statement

Range name	Description	Value
rm%	repair and maintenance (% of vessel cost)	0.05
fgm	fishing gear maintenance (¥/year)	4652
b	bait cost (¥/ tonne)	35
ice	ice ('000¥)	248
mm	miscellaneous materials ('000¥)	2539
cob	cost of business ('000¥)	4269
i	insurance % of book value ('000¥)	0.028
oth	other costs (+ fish box) ('000¥)	13107
oil	oil ('000¥)	16214
cc	capital cost ('000¥)	4858

(3) Input parameters for the cash flow/investment analysis statement

Range name	Description	Value
vs%	vessel salvage % of initial cost	0.1
vel	vessel economic life (yrs)	12
npvd	net present value discount rate %	0.1

(4) Vessel operating statement

Range name	Description	Value
df	days fishing	314
ds	days steaming	9
dwp	days wait and provisions	2
du	days unloading	30
doth	days other	10
dtot	days total	365
dcalb	projected daily catch of albacore (t)	0.25
dceye	projected daily catch of bigeye (t)	0.16
dcyel	projected daily catch of yellowfin (t)	0.88
dcbil	projected daily catch of billfish (t)	0.09
dcswo	projected daily catch of swordfish (t)	0.02
dc	total projected daily catch (t)	1.40
nt	number of trips per year	5
ac	projected annual catch (t)	440

(5) Vessel revenue statement

Range name	Description	Value
(1) Vessel gross receipts		
acalb	annual catch of albacore (t)	79
aceye	annual catch of bigeye (t)	50
acyel	annual catch of yellowfin (t)	277
acbil	annual catch of billfish (t)	28
acswo	annual catch of swordfish (t)	6
ac	total annual catch (t)	440
mvalb	market value of albacore ('000¥/t)	236
mveye	market value of bigeye ('000¥/t)	416
mvyel	market value of yellowfin ('000¥/t)	312
mvbil	market value of billfish ('000¥/t)	480
mvswo	market value of swordfish ('000¥/t)	421
ralb	receipts of albacore catch ('000¥)	18644
reye	receipts of bigeye catch ('000¥)	20800
ryel	receipts of yellowfin catch ('000¥)	86424
rbil	receipts of billfish catch ('000¥)	13440
rswo	receipts of swordfish catch ('000¥)	2644
gfrtotal	gross fish receipts ('000¥)	141952

(5) Vessel revenue statement

Range name	Description	Value
(2) Vessel operating costs		
Variable costs		
w	wages ('000¥)	54266
fg	fishing gear ('000¥)	4652
oil	oil ('000¥)	16214
bai	bait ('000¥)	13190
ice	ice ('000¥)	248
mm	miscellaneous materials ('000¥)	2539
oth	other ('000¥)	13107
subvc	subtotal variable costs ('000¥)	104215
Fixed costs		
fib	fishing boat ('000¥)	94851
bro	brokerage ('000¥)	5517
cob	cost of business ('000¥)	4269
subfc	subtotal fixed costs ('000¥)	19637
toc	Total operating cost ('000¥)	123852
(3) Gross and net operating profit		
gop	Gross operating profit ('000¥)	18100
cc	capital cost ('000¥)	4858
nop	net operating profit ('000¥)	13242

(6) Vessel cash flow and investment analysis statement

Range name	Description	Year											
		1	2	3	4	5	6	7	8	9	10	11	12
(1) Vessel cash flow statement													
vc	vessel cost ('000¥)	197020											
vsv	vessel salvage value ('000¥)												19702
acc	average capital cost ('000¥)	4858	4858	4858	4858	4858	4858	4858	4858	4858	4858	4858	4858
tcc	total capital cost ('000¥)	201878	4858	4858	4858	4858	4858	4858	4858	4858	4858	4858	-14844
oc	operating cost ('000¥)	123852	123852	123852	123852	123852	123852	123852	123852	123852	123852	123852	123852
rev	revenue ('000¥)	141952	141952	141952	141952	141952	141952	141952	141952	141952	141952	141952	141952
ncf	net cash flow ('000¥)	183788	13242	13242	13242	13242	13242	13242	13242	13242	13242	13242	32944

(2) Investment analysis statement

Range name	Description	Value
roi	return on investment (%)	6.7
npv	net present value ('000¥)	-82 604.5
irr	internal rate of return (%)	-0.02
pb	payback period (years)	14.9

Part III

Sustainability, Stock Management and Fishery Rents

Chapter

10

Rent Generation and Sustainable Yield in Papua New Guinea's Skipjack Fishery

D.A. Troedson

G.H. Waugh

Introduction

Skipjack (*Katsuwonus pelamis*) tuna is potentially Papua New Guinea's most valuable fishery resource. At present, the skipjack fishery is under-exploited. The decision on how best to develop and manage the resource embraces a range of social, political and biological factors.

In this chapter, the question of management is analysed on the basis of fishery rent and the level of effort applied to the fishery. Controlling the level of effort in order to maximise rent from the fishery is assumed to be the operative goal of management. A simple yield model is constructed, based on the model developed by Beverton and Holt (1957). The model is applied to the Papua New Guinea pole-and-line skipjack fishery, and the results are compared with empirical fishery statistics from the 1970s and early 1980s, when the fishery was in operation. A simple rent model is then developed and applied to the fishery under a range of price scenarios. For each scenario, the level of effort which maximises rent is determined. The sensitivity of the principal economic variables to changes in the value of the model parameters is also examined.

The decision whether to invest in domestic production or to sell fishing rights needs to be assessed in terms of possible rent. The following sections address the issue of possible rent by providing an assessment of the likely rents which can be generated.

Simple yield model

For a unit stock, calculation of fishing yield can be made in terms of the yield of a single period class throughout its life. In the steady state, this will be equivalent to the yield in one period, from all period classes present in the fishery.

Typically, the period of reference chosen is one year, although for species which breed regularly throughout the year, such as skipjack, a shorter period is likely to be more appropriate. In each period, the number of fish alive, the number caught, losses from natural (non-fishery) causes, and the number remaining in the fishery at the beginning of the next period can be calculated. In addition, the yield in weight can be calculated as the product of the numbers caught and their average weight (Gulland 1969).

In order to obtain insight into the influence of various parameters upon the yield (catch in numbers), it is useful to express the yield (from a single period class throughout its lifespan) in algebraic form. The relevant terms are defined as follows:

N_t = number of skipjack remaining in the fishery at time t

R = number of recruits i.e. the number alive at time t_r (assumed to be independent of population size)

R' = number remaining in the fishery at time t_c, at which they become vulnerable to the gear in use

M = instantaneous coefficient of natural attrition (including emigration and death from natural causes)

F = instantaneous coefficient of fishing mortality

Then for $t_r<t<t_c$

$$dN_t/dt = -MN_t$$

It follows that

$$N_t = Re^{-M(t-t_r)}$$

and

$$R' = Re^{-M(t_c-t_r)}$$

and for $t>t_c$, when losses arise as a result of both fishery and natural causes

$$dN_t/dt = -(F+M)N_t$$

and

$$N_t = Re^{-M(t_c-t_r)-(F+M)(t-t_c)}$$

or

$$N_t = R'e^{-(F+M)(t-t_c)}$$

The number of fish caught in the interval (t, $t+dt$) will be $FN_t dt$, and hence the total number caught throughout the lifespan of a period class, H, will be given by the integral

$$H = \int_{t_c}^{t_L} FN_t dt$$

where t_L is the maximum age obtained.

Hence

$$H = \int_{t_c}^{t_L} FR\overline{e}^{(F+M)(t-t_c)}dt$$

or integrating

$$H = \left[R'F/(F+M)\right]\left[1-e^{-(F+M)(t_L+(t_L-t_c))}\right] \quad (1)$$

If t_L is sufficiently large the equation reduces to

$$H = FR'/(F+M) \quad (2)$$

This simplification is assumed in the following discussion.

Thus, fishing takes a proportion of the total numbers reaching the age of first capture, equal to the ratio of fishing mortality to total attrition. Equation 2 represents both the total catch of a single period class throughout its lifespan, and the total catch from the fishery (all period classes) in a single period.

If the catch is multiplied by the average weight of fish, W, an expression for yield, Y, in terms of recruiting biomass, B, is derived:

$$Y = FR'W/(F+M)$$
$$= FB/(F+M) \quad (3)$$

where $B = R'W$.

Three related measures which are often cited by fishery scientists are:

the catch per recruit

$$H/R' = F/(F+M) \quad (4)$$

the catch per unit effort

$$H/f = qR'/(F+M) \quad (5)$$

and associated yield per unit effort

$$Y/f = qB/(F+M) \quad (6)$$

where f = fishing effort, q = catchability coefficient and $qf = F$.

The ratio of fishing mortality to total attrition, termed the catch per recruit in equation 4, is also termed the harvest ratio. Analysis based on the Beverton-Holt yield per recruit model (Kleiber et al. 1983) suggests that harvest ratios in the vicinity of 0.5–0.7 would provide the maximum sustainable yield (MSY) in western Pacific skipjack fisheries. Assuming that the more conservative estimate of 0.5 is correct, an equation for the level of effort which will provide the MSY in the Papua New Guinea fishery (f_{MSY}) can be derived as follows:

$$0.5 = F/(F+M) = qf/(qf+M)$$

therefore

$$f_{MSY} = M/q \qquad (7)$$

When the fishery is exposed to a constant level of fishing effort, the size of the resource at equilibrium, i.e. the equilibrium, fishable biomass, P_e, can be derived:

$$dP/dt = -(F+M)P + B$$

At equilibrium $dP/dt = 0$, hence

$$P_e = B/(F+M) \qquad (8)$$

Thus yield (equation 3) is a function of equilibrium, fishable biomass

$$Y = FP_e \qquad (9)$$

Application of the simple yield model to the Papua New Guinea domestic pole-and-line skipjack fishery

An analysis of the Papua New Guinea domestic pole-and-line skipjack fishery was undertaken, based upon the model outlined above. Lotus 123 spreadsheet software was used for all data manipulation. The relevant parameters, their assigned values and sources are documented in Table 10.1. The values relate to the area that was fished commercially by pole-and-line vessels in 1979: principally the eastern Bismarck Sea, St George's Channel, and New Hanover-Massau.

The analysis was initially conducted over a range of effort levels, from 0 to 3578 boat-days/month (f_{MSY}),[1] in steps of 200. At each level, values for the various bioeconomic measures were calculated, and are documented in Table 10.2. Each measure is discussed briefly in the following paragraphs.

As noted, the yield model is a simple, equilibrium model. At each level of effort, there is an associated equilibrium, fishable population and hence biomass (assuming constant average weight of fish). As the level of effort rises from 0 to 3578 boat days/month, equilibrium biomass falls 50%, from 40373 t to 20186 t.

In their analysis of skipjack resources in the western Pacific, Kleiber et al. (1987) estimate the standing stock of skipjack in the Papua New Guinea pole-and-line fishery to be 35000 t, associated with an effort level of 644 boat-days/month (F=0.058 fish/month, q=0.00009 fish/boat-day). This is reasonably consistent with the present model, which estimates the biomass associated with an effort level of 600 boat-days/month to be 34574 t (Table 10.2). More precisely, the model estimates the equilibrium biomass associated with 644 boat-days/month to be 34214 t, a discrepancy of 2.2%.

The maximum obtainable age, t_L (60 months), is sufficiently large relative to the age of first capture, t_c (8 months), to validate the use of equation 2 to model catch in numbers. Monthly catch rises curvilinearly with effort to a level of 1911824 individuals when effort is 3578 boat-days/month. This is 50% of monthly recruitment, as is indicated by the corresponding catch per recruit figure.

Catch per unit effort and hence yield per unit effort decline with increasing effort, while the catch per recruit rises with increasing effort. Each individual is assumed to be 3.4 kg (the average weight), and hence yield (t/month) is catch times 0.0034.

As noted, the aim of the model is to provide insight into the influence of various parameters upon yield. It is relevant therefore to compare the model outcomes with empirical statistics (Table 10.3).

Average monthly effort during the period was 598 boat-days, while the average monthly yield was 1989 t. A comparison with Table 10.2 indicates that this is reasonably close to the model prediction; an effort level of 600 boat-days/month corresponds to a harvest of 1867 t/month. More precisely, the model predicts that 598 boat-days/month fishing effort will result in a harvest of 1862 t/month, a discrepancy of 6.4% with the empirical average.

Average yield per unit effort in the Papua New Guinea fishery during 1970–81 was 3.4 t/boat-day, associated with an average effort level of approximately 600 boat-days/month. According to the model, an effort level of 600 boat-days/month is associated with a yield per unit effort of 3.11 t/boat-day/month (Table 10.2), a discrepancy of 8.5% with the empirical average.

[1] The level of effort which will provide maximum sustainable yield (equation 7) is calculated to be approximately 3578 boat-days/month. The maximum sustainable yield is thus 6500 t/month (equation 3).

Table 10.1 Papua New Guinea skipjack yield model: parameters and assigned values

Parameter	Units	Value	Reference
R'	Fish/month	3823529	
B	t/month	13000	Derived from Kleiber et al. 1987
M	Per month	0.322	Derived from Kleiber et al. 1987
t_C	Months	8.0	Appendix 1
t_L	Months	60.0	Kearney 1989
q	Per boat-day	0.00009	Kleiber et al. 1987
f	Boat-days/month	0 to 3000	
W	t	0.0034	Appendix 2

Table 10.2 Papua New Guinea skipjack yield model: selected output.

Fishing effort (boat-days/month)	Equilibrium population (t)	Catch (fish/month)	Yield (t/month)	Catch per recruit (fraction of monthly recruitment caught)	Catch per unit effort (fish/boat-day)	Yield per unit effort (t/boat-day)
0	40373	0	0	0.000	–	–
200	38235	202422	688	0.053	1012	3.44
400	36313	384489	1307	0.101	961	3.27
600	34574	549124	1867	0.144	915	3.11
800	32995	698716	2376	0.183	873	2.97
1000	31553	835237	2840	0.218	835	2.84
1200	30233	960328	3265	0.251	800	2.72
1400	29018	1075368	3656	0.281	768	2.61
1600	27897	1181520	4017	0.309	738	2.51
1800	26860	1279776	4351	0.335	711	2.42
2000	25896	1370987	4661	0.359	685	2.33
2200	25000	1455882	4950	0.381	662	2.25
2400	24164	1535097	5219	0.401	640	2.17
2600	23381	1609183	5471	0.421	619	2.10
2800	22648	1678623	5707	0.439	600	2.04
3000	21959	1743839	5929	0.456	581	1.98
3200	21311	1805207	6138	0.472	564	1.92
3400	20701	1863057	6334	0.487	548	1.86
3578	20186	1911824	6500	0.500	534	1.82

Table 10.3 Papua New Guinea domestic pole-and-line skipjack fishery, 1970–81

	Vessel numbers	Fishing effort (boat-days)	Skipjack catch (t)	Yield per unit effort (t/boat-day)
1970	5	511	2354	4.6
1971	29	4060	16862	4.2
1972	45	4915	11718	2.4
1973	43	7719	27219	3.5
1974	47	9408	40214	4.3
1975	48	6435	15625	2.4
1976	40	7901	24358	3.1
1977	51	9736	20106	2.1
1978	48	9941	45756	4.6
1979	45	8184	23976	2.9
1980	50	9484	30976	3.3
1981	44	7861	27207	3.5
Average	41.3	7179	23870	3.4
Average monthly[a]		598	1989	

[a]Assumes effort is distributed uniformly throughout the year.

Simple rent model

A comparison of the model estimates with empirical statistics indicates that the model is not an unreasonable representation of the fishery, and in particular of the relationship between catch and effort. It is pertinent then to analyse the conditions of optimality, i.e. the optimal level of effort and subsequent yield in the fishery. In terms of economic efficiency, the optimal level of effort is that which maximises fishery rent.

In order to measure the rent generated by the fishery, two additional parameters must be included in the model: price per unit of biomass, *P*, and cost per unit of effort, *C*. More formally:

rent = revenue–cost

$= PY-Cf$

$= PFR'W/(F+M)-Cf$

$= PqfB/(qf+M)-Cf$ (10)

Rent as a percentage of revenue can therefore be expressed as follows:

rent/rev%= [(revenue–cost)/revenue]*100

$= (1\text{-}Cf/PY)*100$

$= [1\text{-}Cf/(PqfB/[qf+M])]*100$ (11)

The level of effort which maximises rent can be obtained by differentiating rent with respect to effort, and setting to zero. Hence

$$d(rent)/df = [(qf+M)(PBq)-PBqf(q)]/(qf+M)^2 - C = 0$$

The above expression simplifies to a quadratic in *f*, and the solution is f_{opt}, given by

$$f_{opt} = \frac{\left\{-2qM \pm \left[(2qM)^2 - 4q^2\left(M^2 - \{MPBq\}/C\right)\right]^{1/2}\right\}}{2q^2} \qquad (12)$$

$$f \geq 0$$

where f_{opt} is the level of effort which maximises rent.

Assuming that the parameters *q*, *M* and *B* are fixed and known, the ratio between *P* and *C* will determine the optimal level of effort. If both cost and price increase/decrease by the same proportion (leaving the ratio unchanged), the optimal level of effort will not change. The cost–price ratio also impacts upon the level of rent accruing to the fishery. If both cost and price increase/decrease by the same proportion, the absolute value of the level of rent increases/decreases by the same proportion. The break-even cost–price ratio (C/P break-even ratio), i.e. the ratio between cost and price at which rent is zero, is a function of the level of effort, and can be derived as follows:

$$\text{rent} = PY - Cf$$

When rent = 0

$$PY = Cf$$

Hence

$$\text{C/P break-even} = Y/f$$

$$= qB/(qf+M)$$

$$= \text{yield per unit effort}$$

Hence, the yield per unit effort can also be used to evaluate the cost–price ratio at which fishery rent will be zero, for a given level of effort.

If the prevailing cost–price ratio is greater than the C/P break-even ratio for the given level of effort operating in the fishery, the model predicts that losses will be made (i.e. rent will be negative). Conversely, if the prevailing cost–price ratio is less than the relevant C/P break-even ratio, the model predicts that profits will be made (i.e. rent will be positive).

For a given level of effort, the percentage difference between the market price and the break-even price is equal to the rent as a percentage of revenue. (The break-even price is equal to the cost per boat-day divided by the C/P break-even ratio). This is illustrated below.

The C/P break-even ratio corresponding to effort levels between 200 and 3578 boat-days/month is documented in Table 10.2 (under the column headed 'yield per unit effort'). As effort increases from 200 to 3578 boat-days/month, the C/P break-even ratio declines from 3.44 t/boat-day to 1.82 t/boat-day. One practical implication of this decline is that as the cost per boat-day increases relative to price per unit of biomass, the optimal level of effort declines.

Campbell and Nicholl (1990; 1992a) estimate the cost of fishing effort for Japanese, 50–100 GRT pole-and-line vessels during the period 1980–81 to 1988–89.[2] During the period, the cost per boat-day ranged from ¥466.7 thousand to ¥591.5 thousand, the average being ¥524.6 thousand.[3] At current exchange rates, this is approximately US$4142 (using the 1992 average exchange rate of ¥126.65 per US dollar; IMF 1993).

The Japanese government is currently negotiating fishery access agreements with those south Pacific governments, including Papua New Guinea, which are parties to the Nauru Agreement.[4] Should such negotiations be successful, it is conceivable that Japanese vessels will operate in Papua New Guinea waters during the current decade. Hence, the cost estimates made by Campbell and Nicholl are considered relevant, and therefore a cost level of US$4142 per boat-day is assumed in the following analysis.

Table 10.3 documents the average number of active vessels and the average monthly effort in the Papua New Guinea pole-and-line skipjack fishery during 1970–81. Using these figures, monthly fishing effort per boat is estimated to be approximately 14.5 boat-days. Assuming (for simplicity) that one full-time pole-and-line vessel operates for 15 days each month, and that the minimum operating unit in the fishery is one full-time vessel, the C/P break-even ratio can be used to determine the minimum price per tonne of skipjack for which the fishery can be operated profitably, given the cost per boat-day of fishing.

The C/P break-even ratio corresponding to the minimum level of effort required for the fishery to be in operation is 3.61837. Consequently, the minimum price for which the fishery could be operated without incurring a loss is US$1144.71/t (in this situation, one full time vessel would operate and make zero profit).

The likelihood of vessel owners receiving US$1144.71/t for skipjack depends upon the market in which it is sold and the form of processing it undergoes. In the Japanese market of Yaizu, where tuna is principally sold as sashimi, skipjack commands

[2] Most vessels operating in the fishery during 1970–85 were of this size (Wankowski 1980).

[3] Calculation of cost per boat-day involved using the method 'Return to Capital (A)', Campbell and Nicholl 1990:9.

[4] The member states include Palau, Federated States of Micronesia, Marshall Islands, Papua New Guinea, Solomon Islands, Nauru, and Kiribati.

a high price relative to other markets. Owen and Troedson (1993b) forecast the average price received for skipjack at Yaizu during 1994 to be ¥257.5/kg, which is approximately US$2033/t.[5] At this price the fishery could be operated profitably.

The optimal level of effort under such circumstances is approximately 1200 boat-days/month, or 80 full-time boats (equation 12). Total harvest is approximately 3265 t/month (Table 10.2), which is approximately 50% of MSY. Rent accruing to the fishery is US$1667581 per month (US$20 969.76/boat/month), which is approximately 25% of total revenue (equations 10 and 11). Catch per recruit is 0.25, i.e. one in every four recruits into the fishery is caught. Yield per unit effort is 2.72 t/ boat-day/month (Table 10.2). The C/P break-even ratio is hence 2.72, which, assuming that effort is optimal, means that the break-even price level is US$1522.79/t. Hence, the price can fall 25% before all rent is dissipated (assuming that only the price of skipjack changes). As noted, the percentage difference between the market and break-even prices is equal to the rent as a percentage of revenue.

If, however, skipjack is sold for canning, it commands a significantly lower price. Owen and Troedson forecast the average price paid for skipjack by canneries in American Samoa during 1994 to be US$728/t. Since this is below the minimum break-even price of US$1144.2/t, the optimal short-term decision is to cease operations in the fishery.

Should Japanese vessels operate in Papua New Guinea waters, they may have some form of purchasing agreement with wholesalers in the Japanese seafood markets. While such agreements would afford price premiums for skipjack, they may entail quantity restrictions and hence alternative markets may need to be sought. As a result, the relevant average price may fall somewhere between US$2033 and US$728/t. The simplest assumption is that the relevant price will be an unweighted average of the two, i.e. US$1380.5/t. Under this assumption the optimal level of effort is approximately 360 boat-days/month (24 full-time boats). Total monthly harvest is 1188 t (9.1% of recruitment), which is approximately 18% MSY. Rent accruing to the fishery is US$149587.1/month (US$6232.8/boat/month), which is 9.1% of revenue. Yield per unit effort is 3.3 t/ boat-day/month. The break-even price level is US$1254.64/t. Hence price can fall approximately 9.1% before all rent is dissipated.

Table 10.4 summarises the outcomes for the four skipjack prices discussed. It should be noted that the optimum effort corresponding to the price of US$1144.71/t is a constrained optimum. The true or unconstrained optimum is 7.5 boat-days/month. However, the defined minimum operating unit in the fishery is one full-time boat, which corresponds to 15 boat-days/month.

Sensitivity analysis

In the following paragraphs, the responsiveness of economic variables to changes in six parameters are analysed. Each parameter is analysed in turn, relative to the base model. The parameters under consideration are t_c, t_L, B, q, M and C. The parameter values in the base model include those documented in Table 10.2, and in addition, a fishing cost of US$4142/ boat-day, and a skipjack price of US$1380.5/t. The value of parameters B, q and M documented in Table 10.2 are point estimates derived from Kleiber et al. (1987). The range over which these parameters are varied in the sensitivity analysis is equal to their interval estimates documented in the same article.

The economic variables analysed are optimal effort, actual effort, boat numbers, rent, rent per boat, and rent/revenue. Actual effort is equal to optimal effort rounded to the nearest multiple of 15, since the minimum operating unit is defined to be one full-time boat, i.e. 15 boat-days/month.

Age of first capture (t_c) and maximum age (t_L)

The skipjack catch (H), as defined by equation 2, is a simplification of equation 1, based on the assumption that the maximum age (t_L) is sufficiently large relative to the age of first capture (t_c), to render the term $e^{-(F+M)(t_L-t_c)}$ equal to zero. This assumption holds true in the base model, where $t_L = 60$ and $t_c = 8$. The greater the difference between t_L and t_c, the nearer the term approaches zero.

[5] The 1992 January–August average price was approximately ¥272/kg, which is roughly US$2150/t.

Table 10.4 Papua New Guinea skipjack yield/rent model: output for four selected skipjack prices.

Category	Units	Value			
Skipjack price	US$/t	728	1144.71	1380.5	2033
Fishing cost	US$/boat-day	4142	4142	4142	4142
Optimum effort	Boat-days/month	0	15[a]	360	1200
Number of boats		0	1	24	80
Equilibrium population	t	40373	40204	36682	30233
Catch	Number	0	15963	349555	960328
Yield	t/month	0	54	1188	3254
Catch per recruit		0	0.0042	0.0914	0.2512
Catch per unit effort	Number of boat-days	–	1064	971	800
Yield per unit effort or C/P break-even	t/boat-day	–	3.61837	3.30135	2.72093
Revenue	$US/month	0	62130	1640707	6637981
Cost	$US/month	0	62130	1491120	4970400
Rent	$/US/month	0	0	149587	1667581
Rent per boat	$US/month	–	0	6233	20845
Rent/revenue	%	–	0	9.1	25.1

[a]Constrained optimum.

Whether variation in t_L or t_c (within reasonable limits) will impact upon the value of the economic variables under consideration depends upon the degree of variation required to make the term $e^{-(F+M)(t_L-t_c)}$ significantly impact upon the value of catch and consequently yield.

Clearly, neither an increase in the maximum age nor a decrease in the age of first capture will impact upon the value of the economic variables, since only by an increase in the age of first capture or a decrease in the maximum age will the term $e^{-(F+M)(t_L-t_c)}$ be increased. An increase in the age of first capture by one year to 20 months, or a decrease in the maximum age by one year to 48 months reduces monthly harvest by 1kg (0.00008%) at the optimum, which is not significant. Further increase in the age of first capture is likely to be beyond the scope of reasonable variation. A decline in the maximum age by 20 months reduces monthly harvest by approximately 14 kg (0.0012%). In terms of the impact upon the economic variables under consideration, this decline is not significant.

Hence, considerable variation in the maximum age of skipjack and in the age of first capture has no significant impact upon the yield, and consequently no significant impact upon the optimal level of effort in the fishery or the fishery rent. It would appear therefore, that there is no economic benefit in the targeting of skipjack schools with a higher than average mean age (if that were possible). In addition, any reasonable error in the measurement of maximum age or age of first capture should have no impact upon the results of the model.

Recruitment biomass (B)

Table 10.5 documents the responsiveness of the economic variables under consideration to a change in recruitment biomass. As recruitment biomass increases from 11000 t/month to 16000 t/month, effort increases from 45 boat-days/month (3 boats) to 795 boat-days/month (53 boats); rent increases from US$2235.3/month to US$722854.9/month; rent per boat increases from US$745.1/month to US$13638.8/month; and rent/revenue % increases from 1.2 % to 18%.

Table 10.5 Sensitivity analysis: recruitment biomass

Recruitment biomass (t/month)	Optimal effort (boat-days/month)	Actual effort (boat-days/month)	Number of boats	Rent (US$/month)	Rent per boat (US$/month)	Rent revenue (%)
11000	43.95	45	3	2235.29	745.10	1.2
11500	125.35	120	8	18158.62	2269.83	3.5
12000	205.00	210	14	48623.53	3473.11	5.3
12500	283.00	285	19	92715.14	4879.74	7.3
13000	359.46	360	24	149587.10	6232.80	9.1
13500	434.46	435	29	218522.80	7535.27	10.8
14000	508.09	510	34	298858.30	8789.95	12.4
14500	580.41	585	39	389977.40	9999.42	13.9
15000	651.49	645	43	491336.90	11426.44	15.5
15500	721.40	720	48	602491.60	12551.91	16.8
16000	790.19	795	53	722854.90	13638.77	18.0

Clearly, all variables under consideration respond significantly to the variation in recruitment biomass. From the perspective of fisheries management, the analysis indicates that an investment of funds into the determination of a more accurate measure of recruitment biomass is warranted. This may entail an analysis of the determinants of recruitment biomass and the development of forecast models based on such determinants.

Should management decisions concerning the number of vessels permitted to operate in the fishery be based on a recruitment biomass of 13000 t/month, when in actuality recruitment biomass is 14000 t/month, the analysis indicates that an investment of up to US$22883/month for the determination of an accurate recruitment figure is warranted.[6]

Catchability coefficient (q)

Table 10.6 documents the responsiveness of the economic variables under consideration to a change in the catchability coefficient. As the catchability coefficient increases from 0.00006/boat-day to 0.000144/boat-day, effort increases from zero to 870 boat-days/month (58 boats); rent increases from zero to US $1423149/month; rent per boat increases to US $24537/month; and rent/revenue % increases to 28.3%.

The percentage change in all variables under consideration is considerably greater than the percentage change in the catchability coefficient. Hence, the analysis indicates that an investment of funds into the determination of a more accurate measure of catchability is warranted.

Should management decisions be based on a catchability coefficient of 0.00009/boat-day when the true figure is 0.0001/boat-day, the analysis indicates that an investment of up to US$27835/month to determine the true value is warranted.

Instantaneous coefficient of natural attrition (M)

Table 10.7 documents the responsiveness of the economic variables under consideration to a change in the instantaneous coefficient of natural attrition. As attrition increases from 0.262/month to 0.402/month, effort declines from 645 boat-days/month (43 boats) to zero; rent declines from US$583508.7/month to zero; rent per boat declines from US$13569.97 and rent/revenue % declines from 17.9% to zero.

The magnitude of the change in the economic variables is less than occurred in response to variation in recruitment biomass and catchability coefficient,

[6] If management decisions are based on a recruitment biomass of 13000 t, effort applied to the fishery will be 360 boat-days/month and rent accruing to the fishery will be US$275975.3/month. However, optimum rent is US$298858.3/month when recruitment biomass is 14000.

Table 10.6 Sensitivity analysis: catchability coefficient

Catchability coefficient per boat-day	Optimal effort (boat-days/month)	Actual effort/month (boat-days/month)	Number of boats	Rent (US$/month)	Rent per boat (US$/month)	Rent/revenue (%)
0.00006	0	0	0	0	–	–
0.00007	0	0	0	0	–	–
0.00008	151.07	150	10	23484.43	2348.44	3.6
0.00009	359.46	360	24	149587.10	6232.80	9.1
0.00010	515.19	510	34	341391.00	10040.91	13.9
0.00011	634.09	630	42	568900.50	13545.25	17.9
0.00012	726.41	720	48	814473.00	16968.19	21.5
0.00013	799.06	795	53	1067685.00	20145.01	24.5
0.00014	856.81	855	57	1322063.00	23194.09	27.2
0.000144	876.55	870	58	1423149.00	24537.05	28.3

Table 10.7 Sensitivity analysis: natural attrition

Natural attrition/ month	Optimal effort (boat-days/month)	Actual effort (boat-days/month)	Number of boats	Rent (US$/month)	Rent per boat (US$/month)	Rent/ revenue (%)
0.262	640.41	645	43	583508.70	13569.97	17.9
0.282	551.25	555	37	401680.10	10856.22	14.9
0.302	457.45	450	30	258240.90	8608.03	12.2
0.322	359.46	360	24	149587.10	6232.80	9.1
0.342	257.67	255	17	72361.52	4256.56	6.4
0.362	152.41	150	10	23913.72	2391.37	3.7
0.382	43.96	45	3	1884.38	628.13	1.0
0.402	0	0	0	0	–	–

although still highly significant. The analysis therefore indicates that further research into the level of attrition in the Papua New Guinea fishery is warranted.

Should management decisions be based on 0.322/ month as a measure of instantaneous natural attrition, when the true measure is 0.302/month, the analysis indicates that an investment of up to US$10525.4/ month to determine the true value is warranted.

Fishing cost (C)

Table 10.8 documents the responsiveness of the economic variables under consideration to a change in the daily fishing cost. The variation in fishing cost closely approximates the range of cost estimates for the Japanese pole-and-line fleet cited by Campbell and Nicholl (1990; 1992a). As fishing cost increases from US$3600/boat-day to US$4700/boat-day, effort declines from 645 boat-days/month (43 boats) to 120 boat-days/month (8 boats); rent declines from US $419203.3/month to US$18398.4/month; rent per boat declines from US$9748.9 /month to US$2299.8/ month; and rent/revenue % declines from 15.3% to 3.2%.

The response of the economic variables to variation in cost is less than that for variation in the three previous biological parameters, but is still significant. Hence, the analysis indicates that research aimed at the development of models which forecast the various component costs of total fishing cost is warranted.

Should management decisions be based on a cost estimate of US $4142/boat-day when the actual cost is

Table 10.8 Sensitivity analysis: fishing cost

Fishing cost (US$/boat-day)	Optimal effort (boat-days/month)	Actual effort (boat-days/month)	Number of boats	Rent (US$/month)	Rent per boat (US$/month)	Rent/ revenue (%)
3600	645.46	645	43	419203.30	9748.92	15.3
3700	588.00	585	39	357542.50	9167.76	14.2
3800	532.82	540	36	301480.60	8374.46	12.8
3900	479.78	480	32	250915.70	7841.11	11.8
4000	428.74	435	29	205467.20	7085.08	10.6
4100	379.57	375	25	165084.30	6603.37	9.7
4142	359.46	360	24	149587.10	6232.80	9.1
4200	332.18	330	22	129527.60	5887.62	8.5
4300	286.45	285	19	98612.54	5190.13	7.4
4400	242.28	240	16	72185.10	4511.57	6.4
4500	199.60	195	13	50083.79	3852.60	5.4
4600	158.31	165	11	32169.73	2924.52	4.1
4700	118.36	120	8	18398.44	2299.81	3.2

US$4000/boat-day, the analysis indicates that an investment of up to US$4760/month to determine the true cost is warranted.

Conclusion

The decision to invest in domestic production or to continue the current licences with distant water fishing nations is critically determined by the licence fees that can be obtained. This is in turn dependent on the rent that can be generated. Although no decisive calculation can be made in this issue, evidence is gradually being accumulated which suggests that distant water fishing nations, with the possible exception of the United States, are paying too little for the right to fish in south Pacific waters.

Currently, the United States is paying about 12% of the value of catch, while the Japanese are paying 5%. Waugh (1987) made some rent calculations based on budget data. His findings suggest an optimal size of vessel with rent varying from 10%–27%. His calculations, based on survey data of costs, assume a given level of fishing effort in aggregate and make no attempt to calculate optimal rent.

The analysis in this chapter provides possible outcomes when fishing effort is optimised. Not surprisingly, optimal effort and hence optimal rent is sensitive to fluctuations in international tuna prices. This alone suggests that tuna market studies are critical to good management. Based on 1992 prices, rent in the range of 9–25% is not unreasonable. This is not to suggest that all rent should be appropriated by the coastal state. Waugh (1987) provides a number of reasons for this, not the least of which is the large degree of uncertainty in the industry. However, it would appear evident that foreign fee schedules could be reviewed with a view to negotiating increases where appropriate.

Appendix 1. Derivation of the age at first capture (t_c)

If the length of a fish is plotted against age, the general result is a curve which declines in slope as age increases, approaching an upper asymptote parallel to the axis on which age is plotted. The asymptote represents the theoretical average maximum length ($L\infty$). The relationship between the length at time t (l_t) and $L\infty$ is described by the von Bertalanffy curve:

$$l_t = L\infty\left[1 - e^{-K(t-t_o)}\right] \quad (1A)$$

where t_o is the theoretical age at which length equals zero and K is the instantaneous rate of change in length per period.

Sibert et al. (1983) document values of the param-eters $L\infty$ and K for skipjack in Papua New Guinea waters: $L\infty = 60.9$ cm and K (per year) = 1.55. The von Bertalanffy growth curve for skipjack in Papua New Guinea is illustrated in Figure 10.1. It is assumed that length equals zero when time equals zero.

Assuming a length at first capture of 38 cm,[7] the corresponding age of first capture (derived from equation 1A) is approximately 0.63 years i.e. 7.56 months. Rounding to the nearest whole month, the age of first capture is 8 months.

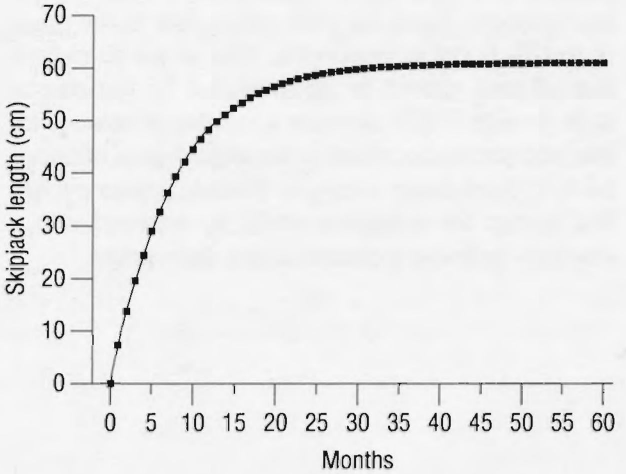

Figure 10.1 Von Bertalanffy growth curve for skipjack in Papua New Guinea

[7]Kleiber et al. (1987) estimates the length at recruitment to be between 36 cm and 40 cm.

Appendix 2. Derivation of the average weight of skipjack (W)

Figure 10.2 illustrates the relationship between length and weight for skipjack. Assuming that the average length of skipjack in Papua New Guinea waters is 55 cm,[8] the corresponding average weight is approximately 3.4 kg (Figure 10.2). Hence the value of W chosen for the analysis is 3.4 kg.

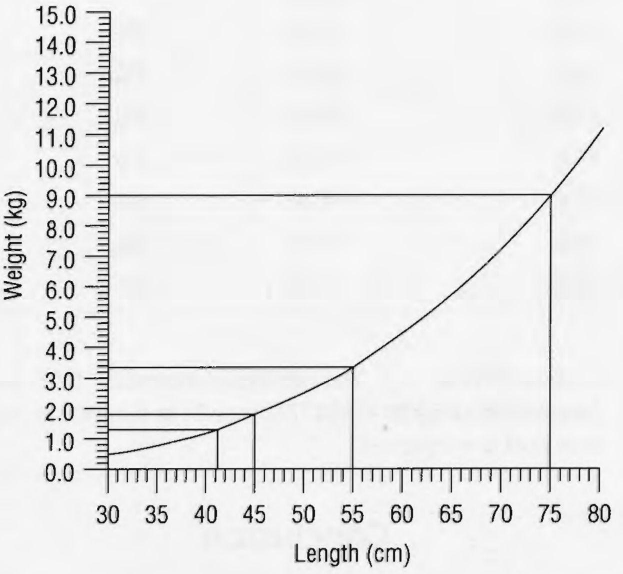

Figure 10.2 Length verses weight relationship for skipjack (Gillet 1986)

[8]The average length of skipjack sampled in Papua New Guinea waters during 1977 was 54.4 cm (Tuna Programme 1983).

Chapter

11

An Economic Analysis of the Interaction Between the Purse Seine and Longline Tuna Fleet in Papua New Guinea

H.F. Campbell
R.B. Nicholl

Introduction

In the western Pacific, yellowfin tuna are harvested as juveniles by purse seiners and as adults by longliners. Countries with extensive exclusive economic zones in the region, such as Papua New Guinea, attempt to control access by foreign vessels so as to maximise the net present value of their tuna fisheries. Extensive tagging studies are underway (South Pacific Commission 1990a); however, there is insufficient information available about yellowfin stocks to conduct a bioeconomic analysis which would indicate the optimal (i.e. net present value maximising) harvesting levels by the two gear types. Instead, the present study addresses the question of whether a marginal investment in the yellowfin stock, in the form of a 1% decline in the purse seine harvest from its current level in Papua New Guinea, would increase the net present value of the country's tuna fisheries. The approach adopted is to calculate the marginal benefit to the longline fishery and marginal cost to the purse seine fishery, in net present value terms, on the assumption that the changes in harvest are not large enough to affect world tuna prices. The analysis takes into account the multi-species nature of the purse seine and longline fisheries: in addition to yellowfin, the purse seine fishery harvests skipjack, and the longline fishery harvests bigeye, albacore, billfish and swordfish.

Background

Four major tuna species are harvested by five main gear types in the western Pacific (Table 11.1). The data in Table 11.1 are based on the fishing activities of 18 nations, with Indonesia, Japan, Korea, Philippines, Taiwan and the United States being the major participants. Three significant gear interactions appear to have been taking place amongst these fisheries: the interaction between the driftnet/troll and longline fisheries through the albacore stock; the interaction between the purse seine and pole-and-line fishery through the skipjack stock; and the interaction between the purse seine and longline fisheries through the yellowfin stock. Measures have been taken by the Pacific island nations to restrict driftnetting for albacore, and the pole-and line fishery is being phased out by distant water fishing nations as uneconomic. The present paper deals with the allocation of the yellowfin stock between the purse seine and longline fisheries.

The purse seine fishery catches juvenile yellowfin which are approximately 1 year old and average 5 kg, whereas the longline fishery catches adults averaging about 2.5 years of age and 27 kg in weight. The longline catch supplies the sashimi market whereas the purse seine catch is canned. The unit value of the longline

Table 11.1 Average catch of major tuna species by gear type, SPC statistical area 1987–91

	Species			
	Albacore	Bigeye	Skipjack	Yellowfin
Purse seine	–	–	452675	145491
Longline	16932	36224	–	35268
Pole-and-line	–	–	117981	3857
Driftnet	7278	–	–	–
Troll	5955	–	–	–

Source: South Pacific Commission (1992a). The averages are based on calendar years for purse seine, longline, and pole-and-line vessels, and fishing seasons for driftnet and trolling vessels. A proportion of the reported yellowfin catch of purse seiners consists of juvenile bigeye.

yellowfin catch is 2.6 times that of the purse seine catch.[1] In determining the appropriate distribution of the yellowfin catch between the two gear types, the following factors need to be taken into account: the delay between the escape of yellowfin from the purse seine fishery and their recruitment to the adult stock; the relatively high natural mortality rates for yellowfin in the first two to three years of life; the larger size and higher unit value of the longline harvest; and the relative catch rates and harvesting costs of the multi-species purse seine and longline fleets.

There is insufficient information available about Papua New Guinea's tuna stocks to determine an optimal harvesting plan. Instead, estimates reported in this chapter determine whether at recent harvest levels the net present value benefit to the longline fishery of a small reduction in the purse seine yellowfin catch exceeds the net present value cost to the purse seine fishery. Since both fisheries exploit more than one species, with the possibility of substitution or complementarity between species, the benefit and cost estimates presented in this paper are derived from estimated models of the multispecies production technologies of the two fisheries. While there are many nationalities involved, the Japanese longline fleet and the United States purse seine fleet are the largest in terms of the total catch by weight of their respective gear types. The analysis of benefits and costs is based on the operations of those fleets in Papua New Guinea's exclusive economic zone during the 1980s.

[1] This is an average on a monthly basis for the years 1984–85 for the Port of Yaizu.

The interaction between the purse seine and longline fleets

By catching juvenile yellowfin tuna the purse seine fleet reduces the adult stock, thereby reducing the adult yellowfin catch of the longline fleet. The size of the reduction in the adult yellowfin catch depends on a variety of factors, the most important of which are:

- the size of the purse seine yellowfin catch;
- the monthly attrition rate of yellowfin which escape the purse seine fishery;
- the time interval between escape from the purse seine fishery and recruitment to the adult yellowfin stock;
- the relationship for a given level of fishing effort, between longline yellowfin catch and yellowfin stock; and
- the level of longline fishing effort.

The present paper considers the marginal interaction between the two fisheries–the effect of a 1% change in the purse seine juvenile yellowfin catch on the longline yellowfin catch per unit effort. The interaction model can be described by means of a simple production function for longline yellowfin harvests:

$$H_t = AE_t x_t \qquad (1)$$

where H_t is longline yellowfin harvest in numbers of fish, E_t is effort in thousands of hooks, x_t is adult yellowfin stock in number of fish, and A is the catchability coefficient. Medley (1991a) has suggested the following kind of relationship between the adult yellowfin stock and the purse seine yellowfin harvest:

$$x_t = \bar{x}e^{\sum_{t=t_1}^{\infty} -q_A h_o e^{-mt}} \quad (2)$$

where $\bar{x}$ is the adult yellowfin stock in the absence of purse seining, h_0 is the purse seine catch at time zero, m is the monthly attrition rate of yellowfin which escape the purse seine fishery, t_1 is the delay between escape from the purse seine fishery and recruitment to the adult yellowfin stock, and q_A is the interaction parameter.

In the absence of purse seining, yellowfin catch per unit effort *(CPUE)* in the longline fishery is given by:

$$\overline{CPUE} = A\bar{x} \quad (3)$$

With purse seining, *CPUE* in the longline fishery becomes:

$$CPUE = \overline{CPUE}\, e^{\sum_{t=t_1}^{\infty} -q_A h_o e^{-mt}} \quad (4)$$

The elasticity of longline *CPUE* at time T in response to a marginal change in the purse seine catch at time zero can be expressed as:

$$\varepsilon\left(h_o, T\right) = \sum_{t=t_1}^{T} \left(-q_A\right) h_o e^{-mt} \quad (5)$$

When the marginal reduction in purse seine harvest is permanent and the longline fishery is allowed to adjust to a new steady-state equilibrium, the elasticity of longline *CPUE* can be expressed as:

$$\varepsilon\left(h_o\right) = -q_A h_o e^{-mt_1} / \left(1 - e^{-m}\right) \quad (6)$$

Medley (1991a) has estimated the interaction parameter q_A in a model in which m is specified as 0.133 and t_1 as 18 months. Using average weights of longline and purse seine caught yellowfin (26.5 and 5 kg respectively), the interaction elasticity can be expressed in weight of fish. Based on Medley's work, the elasticity can be calculated to be −1.68. This means that at current levels of purse seine and longline effort a 1% permanent decrease in the purse seine juvenile yellowfin catch in a 10° square of the ocean will result in a 1.68% permanent increase in longline yellowfin CPUE in that area. Since Medley notes that his estimate of the value of the interaction parameter is towards the high end of the likely range, a much lower value of the interaction elasticity will be used in the present paper: it will be assumed that $\varepsilon(h_0) = -1$.

The benefits and costs of conserving juvenile yellowfin tuna

The purse seine and longline fisheries are multi-species: the purse seine catch consists predominantly of skipjack (around 70%) and juvenile yellowfin; the longliners catch adult yellowfin, bigeye and albacore, as indicated in Table 11.1, together with small quantities of billfish and swordfish. The measurement of the costs and benefits of a 1% reduction in the purse seine yellowfin catch in Papua New Guinea's exclusive economic zone needs to take the multispecies nature of the fisheries into account. Campbell and Nicholl (1992b,c) have estimated revenue functions for longline and purse seine vessels operating in Papua New Guinea in the period 1980–86. These functions, which show for an average vessel the relationship between total revenue, species prices, and effort, can be used to estimate the per vessel benefits and costs of a policy of conservation. These per vessel benefits and costs can then be multiplied by the number of vessels in the exclusive economic zone to give an estimate of aggregate benefits and costs.

Fishing vessels maximise profit by contributing effort to a fishery up to the point at which the value of the marginal product of effort equals its marginal cost. The effect of an increase in yellowfin catchability, caused by an increase in the adult yellowfin stock, is illustrated in Figure 11.1(a): the value of the marginal product schedule shifts outwards from VMP_0 to VMP_1, and the equilibrium level of effort from E_0 to E_1. The result is an increased catch of yellowfin tuna and species, such as bigeye, that are complements in production with yellowfin. Catches of species such as albacore and billfish, which are substitutes in production for yellowfin, may also rise because of the increase in the equilibrium level of effort. The benefit to the vessel of the increase in yellowfin catchability, net of the cost of the additional fishing effort, is given by area *HDFG* which is approximately equal to area *ABDC* if the value of the marginal product schedules are nonlinear, and exactly equal in the linear case.

Two methods of inducing purse seine vessels to reduce their catch of juvenile yellowfin are considered: an *ad valorem* royalty could be levied on the yellowfin catch, or an access fee, acting as a tax on fishing effort, could be imposed. Which of these two policy instruments is appropriate depends upon the nature of purse seining technology. If purse seiners can vary the species composition of their catch in response to changes in relative species prices, then an *ad valorem* royalty will have the effect of reducing yellowfin catch and increasing skipjack catch. This would be a relatively low-cost outcome for the purse seine vessels, as well as a sustainable one given that skipjack is a relatively plentiful species (SPC 1990b). If, on the other hand, purse seiners have no control over the species composition of the catch, a reduction in purse seine effort will be required to reduce the catch of juvenile yellowfin. A reduction in effort could be achieved by an increase in the fee charged for access to the fishing grounds which would have the same effect as an increase in fishing costs.

The costs to purse seine vessels of an *ad valorem* royalty on juvenile yellowfin, or of an increase in the access fee, are illustrated in Figures 11.1(b) and (c). In Figure 11.1(b) the value of the marginal product of effort schedule shifts downwards because of the reduction in the ex-vessel price of juvenile yellowfin caused by the imposition of the royalty.

The cost of the royalty to the individual vessel is illustrated by area *FGDE* which is approximately equal to area *ABDC*. Of the latter area *ABEC* represents a benefit to the host nation in the form of royalty revenues, so that the net cost of the policy is represented by area *BDE*. The cost of an increase in the unit cost of fishing through an increase in the access fee is illustrated in Figure 11.1(c). If a rise in the access fee per unit of effort causes the unit cost of fishing effort to rise from C_1 to C_2, the profit maximising vessel reduces its effort from E_0 to E_1. The cost to the vessel is illustrated by area C_1DEC_2 in Figure 11.1(c). Of this area, only *BDE* represents a net cost of the policy since area C_1BEC_2 represents an offsetting benefit to the host nation.

In summary, the cost per purse seine vessel of a 1% decline in juvenile yellowfin catch is illustrated by Figure 11.1(b) or (c), depending upon whether the appropriate policy instrument is an *ad valorem* royalty or an increase in the access fee per unit of effort. When the per vessel cost is multiplied by the number of purse seine vessels fishing in the exclusive economic zone in the period of the analysis (the equivalent of 26 United States purse seiners), an estimate of the cost of the policy can be obtained. The benefit per longline vessel of increased yellowfin catchability is illustrated in Figure 11.1(a). When the per vessel benefit is multiplied by the number of longliners fishing in the exclusive economic zone (an average of 53 Japanese longliners) an estimate of the benefit of the policy of conservation can be obtained.

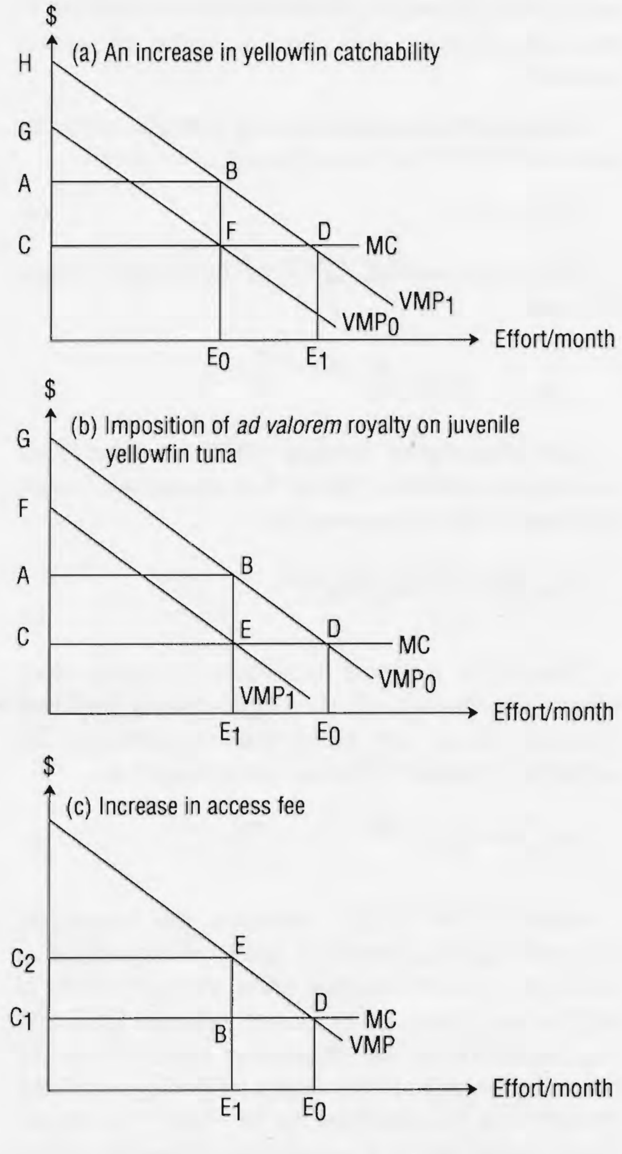

Figure 11.1 Per vessel monthly benefit and cost of conserving yellowfin tuna.

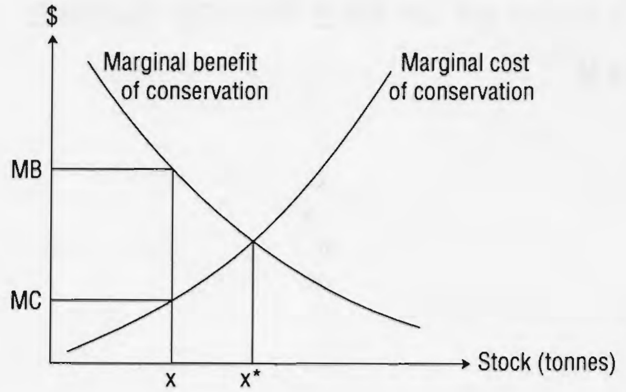

Figure 11.2 Marginal benefit and marginal cost of investing in a fish stock.

The relationship between marginal benefit and cost and optimal yellowfin stock

The optimal fish stock from an economic point of view is that stock at which the marginal benefit of conservation equals its marginal cost. This point is indicated by x^* in Figure 11.2. The marginal benefit schedule is downward sloping because, in general, harvest increases at a decreasing rate as a result of an increase in fish stock. In addition, the net value of a unit of harvest tends to fall as harvest increases because of a fall in output price and a rise in the unit cost of effort and harvest. This latter phenomenon explains why, in general, the marginal cost of conservation tends to rise as the degree of conservation rises.

The purse seine/longline interaction model described in the previous sections of the chapter is essentially a linear model which does not take account of the factors which, in general, shape the marginal benefit and cost schedules. Instead, the model simply calculates, at the current levels of exploitation, point estimates for the marginal benefit and marginal cost of conservation. These estimates are the marginal benefit to the longline fishery, and the marginal cost to the purse seine fishery, of a 1% decline in purse seine juvenile yellowfin catch. If the value of the marginal benefit exceeds that of marginal cost, and if the marginal benefit and cost schedules follow the normal pattern as illustrated in Figure 11.2, then the optimal stock of adult yellowfin, from an economic point of view, is greater than the current stock, denoted by x in the figure.

Estimates of marginal benefit and marginal cost of conservation

Campbell and Nicholl (1992d) have used the procedures outlined above to obtain estimates of the marginal benefit and marginal cost of a 1% decline in the monthly purse seine juvenile yellowfin catch in Papua New Guinea's exclusive economic zone, leading to a 1% rise in yellowfin *CPUE* in the zone. These estimates are expressed in net present value terms, using a 3% per annum real rate of interest.

The estimate of the marginal benefit of conservation is US$2.1 million while the estimate of marginal cost depends on which policy measure is used to achieve the reduction in purse seine yellowfin catch. If purse seiners have some control over the species composition of their catch then it is most efficient for them to substitute skipjack for juvenile yellowfin, and they can be induced to do this by means of the yellowfin royalty. If they are unable to target species then the reduction in juvenile yellowfin catch will require a reduction in effort, which will also reduce the skipjack catch. In the former case the estimate of marginal cost is US$0.17 million, and in the latter case it is US$0.37 million.

Under either assumption about purse seining technology the estimate of marginal benefit of conservation exceeds that of marginal cost, as illustrated in Figure 11.2. This tends to suggest that, from an economic point of view, the adult yellowfin stock is below its optimal level. Further research, incorporating a biological model of the population dynamics of the yellowfin stock, is required to test this conclusion and to determine the extent of its applicability beyond Papua New Guinea's exclusive economic zone.

Chapter 12 Search Behaviour in the Purse Seine Tuna Fishery[1]

H.F. Campbell
G.W. Meyer
R.B. Nicholl

Introduction

A purse seine vessel cruises in search of schools of tuna during daylight hours, attempting to locate fish by observing surface water disturbance, sea bird activity, or floating objects. When an appropriate size school is located the vessel attempts to capture it in the seine by setting the net around the school and closing it at the base. In the western Pacific two types of sets are made by purse seiners –'log sets' on schools which aggregate near a log or other floating object, and 'free school sets' on aggregations which have no focal point. Purse seining accounted for 60% of the tuna catch in the Pacific islands region in the 1980s, with the major species caught being skipjack and yellowfin, and the major fleets involved being those of Japan and the United States.

Doulman (1987d) has suggested a major difference between the modes of operation of the Japanese and U.S. purse seine vessels operating in the western Pacific. In particular he argues that whereas:

> Japanese vessels tend to fish as a fleet and exchange information on the fishing grounds, U.S. vessels usually operate individually and competitively. Because Japanese skippers exchange information, they can coordinate fishing without expensive aircraft support.

Doulman attributes the difference between the operations of the Japanese and U.S. fleets to differences in the structure of the two industries. Japanese vessels are usually owned by corporations or cooperatives which have more than one vessel. Vessels have sophisticated communication systems which enable them to share information with their sister vessels, thereby increasing expected value of the total catch. U.S. vessels, on the other hand, are usually owned by individuals or small companies, and they tend to operate individually and competitively, although they have been known to cooperate in small 'code groups' of three to four vessels.

The search for fish concentrations can make up a significant proportion of the cost of operations, and an efficient search process can lead to lower harvesting costs and greater returns. Information sharing of the kind attributed by Doulman to Japanese vessels can lead to efficiency benefits (Mangel and Clark 1983). A

---

[1]Reprinted with permission from Natural Resource Modeling Vol. 7, No. 1, Winter 1993.

simple example, drawn from work on labour market search by McKenna (1990), can be used to illustrate the source of these benefits. Suppose that there are 10 subzones or fishing grounds, and that the frequency distribution of the number of schools located per week in the subzones is as follows:

Number of schools located per week (N)	Frequency (number of subzones)	Relative frequency (Pr(N))
3	3	0.3
4	6	0.6
5	1	0.1

A vessel acting independently in its choice of subzone has an expected number of sets per week given by:

$$E(N)=\Sigma\left\{N_i\bullet Pr\left(N=N_i\right)\right\}=3.8 \qquad (1)$$

Two vessels which act cooperatively each obtain, in effect, two sample points from the distribution and are each able to choose the more productive subzone. The expected maximum number of sets per week when two subzones are sampled is given by:

$$E(N)=\sum_{i}^{3}\sum_{j}^{3}\left[\max\left(N_i,N_j\right)Pr\left(N=N_i\right)Pr\left(N=N_j\right)\right]=4.35 \qquad (2)$$

The purpose of this chapter is to examine the two hypotheses advanced by Doulman: that the Japanese vessels have a greater tendency to fish as a fleet than the U.S. vessels; and that they have a greater tendency to exchange information about fishing conditions.

Data

Purse seine vessels operating in Papua New Guinea's exclusive economic zone are required to submit log sheets of their daily operations as part of the conditions for access to the zone, which is approximately bounded by 134E and 174E and 3N and 9S. Most of the purse seining activity is in the area north of 5S. The data used in this study are derived from the daily catch records of Japanese and U.S. vessels in the period 1983-87. There are approximately 1000 daily observations on the U.S. fleet and 7000 daily observations on the Japanese fleet in the sample period. The Japanese fleet has ranged between 30-40 vessels over the period, while the U.S. fleet has ranged between 10-20 vessels. The catch records report vessel identification and size, position of set, type of set ('log' or 'free school'), time of set, catch by species, date, and length of fishing trip. Japanese purse seine vessels range between 200-700 GRT in size, while the U.S. vessels are typically larger, in the 900-1600 GRT range. Larger vessels tend to be faster, enabling them to move relatively quickly across the zone. Skipjack and yellowfin catches can be converted to a value using ex-vessel prices in Yaizu for the Japanese fleet and Pago Pago port prices for the U.S. vessels. Unsuccessful sets-where a school was located, a set attempted, but no fish were caught -are also recorded in the log sheets.

Spatial distribution of the fleets

Papua New Guinea's exclusive economic zone was divided into 10 subzones and an analysis of variance (ANOVA) was performed to test for preferences for particular areas of the zone by either fleet. Since the fishery is seasonal in character the ANOVA was conducted on a quarterly basis for the period 1983-87. The numbers of sets made by each fleet in this period are reported in Table 12.1, and the results of the analysis are reported in Table 12.2.

The F values reported in Table 12.2 are test statistics for the hypothesis of an equal mean number of sets across subzones, and across quarters. They indicate a clear preference for fishing in particular subzones (mainly subzones 1-4 according to Table 12.1), and, for the Japanese vessels, in particular quarters. The interactive term also suggests that the Japanese fleet has a preference for fishing in particular subzones in particular quarters. The U.S. skippers exhibit a preference for certain subzones, although this is less pronounced than for the Japanese vessels, but there is no marked seasonal preference. The F statistics reported in Table 12.2 suggest that the spatial distribution of sets by U.S. vessels may be less concentrated than that of the Japanese.

Visual inspection of set positions for the vessels in the two fleets for each quarter in the period 1984-87 supports the impression that the Japanese tend to

Table 12.1. Number of sets made, by quarter and subzone, Japanese and U.S. fleets 1983-87

Quarter	Subzone									
Japan										
Quarter	1	2	3	4	5	6	7	8	9	10
1	1218	1936	1251	398	92	104	80	10	1	1
2	785	264	72	10	19	1	4	10	1	-
3	995	826	1006	264	100	10	34	53	25	2
4	974	906	1450	1083	364	139	102	11	4	-
U.S.										
1	24	27	104	70	45	203	64	6	8	6
2	16	31	67	20	8	6	4	20	2	3
3	3	3	24	25	47	38	189	76	19	9
4	10	40	76	53	63	237	128	75	12	6

Table 12.2 Analysis of variance, mean number of sets, Japanese and U.S. fleets, 1983–87

Source	DF	Sum of squares	Mean square	F value	P>F
Japan					
Quarter	3	12038.55	40079.52	3.48[a]	0.0193
Subzone	10	1 232212.80	123221.28	10.69[a]	0.0001
Quarter	28	530260.86	18937.88	1.64[a]	0.0422
Subzone	87	1 002558.82	11523.66		
Error-corrected total	128	28852761.04			
U.S.					
Quarter	3	1118.16	372.72	0.39	0.7624
Subzone	10	19703.24	1970.32	2.05[a]	0.0432
Quarter	30	14160.17	472.00	0.49	0.9823
Subzone	61	58666.68	961.75		
Error-corrected total	104	93648.25			

[a]Significantly different from critical value at 5% significance level under an F test

cluster together as a fleet more than do the U.S. vessels. A formal test of this hypothesis is provided by a technique described by Mardia (1972) for summarising the distribution of points on the surface of a sphere. Batschelet (1981) provides a technical description of the measure of location and dispersion of such points. A heuristic description of this measure of dispersion can be developed by considering a series of points located on the circumference of a circle. In Figure 12.1 two such distributions of a series of five points are illustrated. The five points are treated as directional vectors, from the centre of the circle, and a resultant vector, of length R, is calculated for each set of points. As can be seen from Figure 12.1, the more widely distributed are the points on the circumference, as in 1(a), the shorter is the length of the resultant vector. The distribution of two sets of points can be compared by testing for a significant difference between the lengths of the resultant vectors.

Points distributed on the surface of a sphere can be treated as directional vectors relative to the centre of the sphere. The directional vector locating each point is itself a resultant vector, summarising three directional vectors from the centre as illustrated in Figure 12.2. The three directional cosines (*l, m, n*) of the point *i* (latitude θ, longitude ϕ) are represented by the vector:

$$r_i = \left(l_i = \cos\phi\cos\theta; m_i = \sin\theta\cos\theta; n_i = \sin\theta\right) \quad (3)$$

The length *R* of the resultant vector for a set of points is defined as:

$$R = \left\{\left(\sum l_i\right)^2 + \left(\sum m_i\right)^2 + \left(\sum n_i\right)^2\right\}^{1/2} \quad (4)$$

and the mean vector length is defined as: $\bar{R} = R / N$ where *N* is the number of observed locations.

The recorded set positions in each quarter for the vessels in each fleet are assumed to be a random sample from the Fisher distribution, $F\left\{\left(\lambda_i, \mu_i, v_i, k_i\right)\right\}$ with the probability density function:

$$\left\{c(k)/2\pi\right\}\exp\left\{k\left(\lambda l_i + \mu m_i + v n_i\right)\right\}, k > 0, \quad (5)$$

where $c(k) = k/2\sin k$, *k* is the concentration parameter, and λ, μ, and *v* are the directional cosines of the mean directions of the individual vessel vectors, l_i, m_i and n_i respectively. The hypothesis that the spatial distributions of the vessel positions for the two fleets are not significantly different is tested by comparing the concentration parameters for the two distributions. The test statistic is a function of the lengths of the resultant vectors R^j and R^u for the two fleets. Depending on the value of the concentration parameter, k^i, the distribution of the length of the resultant vector, R^i, can assume one of two forms: when $k^i \leq 3$ the distribution is normal, and when $k^i > 3$ the *F* distribution is appropriate. When two samples are being compared the choice of the appropriate distribution is determined by the value of the concentration parameter for the joint sample. Since the value of the concentration parameter is a function of the length of the mean vector, the mean vector length of the joint sample $\bar{R}$ can be used to determine the appropriate distribution:

$$\tilde{R} = \left\{1/\left(N^u + N^j\right)\right\}\left\{\left(\sum l_i\right)^2 + \left(\sum m_i\right)^2 + \left(\sum n_i\right)^2\right\}^{1/2}, \quad i = 1, \cdots N^u + N^j \quad (6)$$

where N^u and N^j are the numbers of observed locations in the U.S. and Japanese fleets respectively. The form of the appropriate test statistic, *U* (Mardia 1972: Ch.9) also depends on the value of the joint concentration parameter or mean vector length as illustrated in equations 7-9.

For each quarter in the sample period, except quarters 2 and 3, 1986, for which there were insufficient observations (<30), the resultant and mean vector lengths were calculated for the Japanese and U.S. fleets, and the test statistic, U_i computed as detailed in equations 7–9. The results of the tests are reported in Table 12.3. The table reports N^j, N^u, $\bar{R}^j$, $\bar{R}^u$. and the test statistic U_i, $i = 1, 2$ (in all cases $\bar{R} < 0.67$.) The Japanese concentration parameter, k^j, is significantly larger than the U.S. parameter, k^u, in six of the eleven periods considered. In no case is the U.S. parameter significantly larger than the Japanese.

In summary, the analysis presented suggests that the Japanese fleet exhibits more variation in its seasonal and spatial behaviour than the U.S. fleet, but less variation amongst individual vessels in the spatial distribution of the fleet at a given time than is evident for U.S. vessels. This can be interpreted as evidence of greater emphasis on cooperative behaviour by the Japanese skippers. The remaining sections of the chapter examine the process of information sharing associated with the spatial distribution of the vessels.

Vessel movement in response to area catch rates

Hilborn and Ledbetter (1979) consider the intra-seasonal movements of purse seine vessels in the British Columbia salmon fishery. They find a relationship between the value of catch per vessel in an area and the number of boats in that area in a subsequent period. However, there is evidence of a threshold, in the form of a significant improvement in prospective catch, before some vessels are induced to move. Clark and Kirkwood (1979) and Bockstael and Opaluch (1983) also find evidence of inertia in the response to higher returns in alternative grounds. They attribute this to the psychological costs of disregarding tradition or of fishing in remote areas, and to the monetary costs of switching grounds.

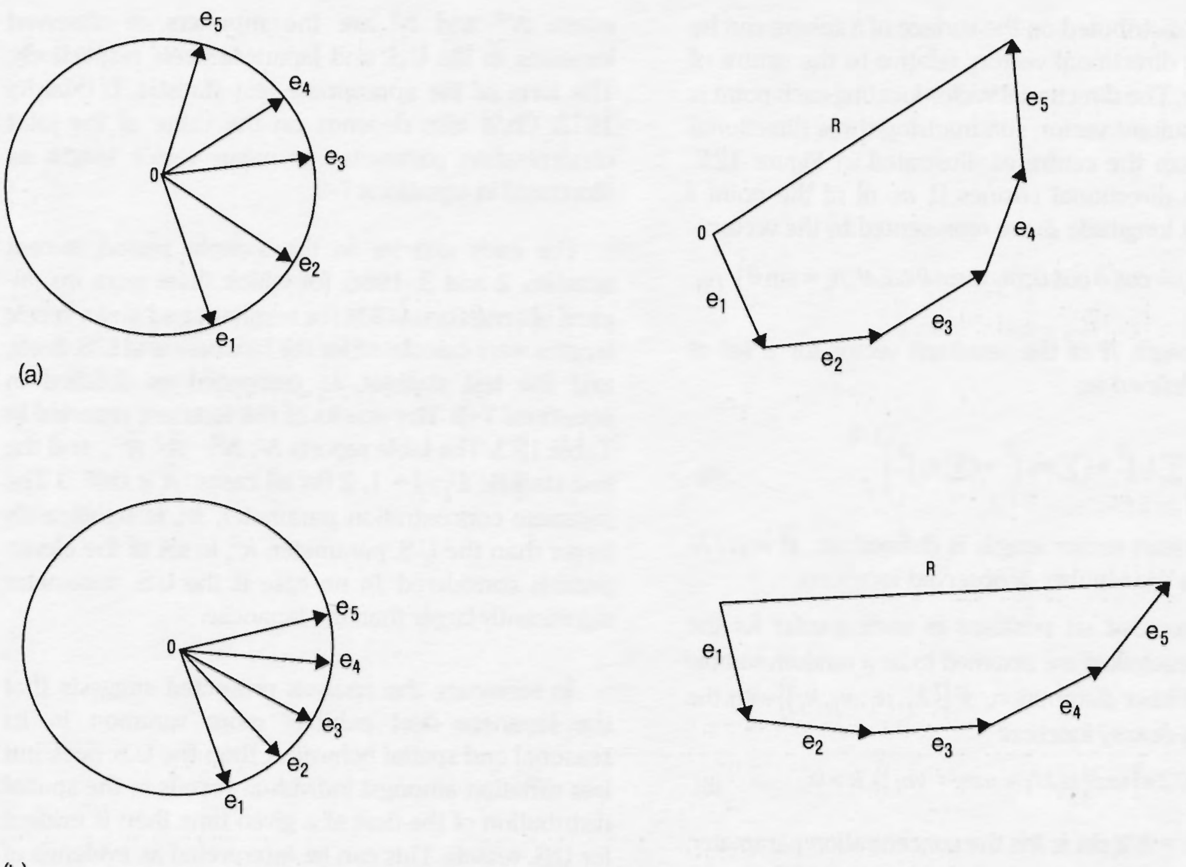

Figure 12.1 Spatial dispersion and the resultant vector: (a) widely dispersed; and (b) narrowly dispersed.

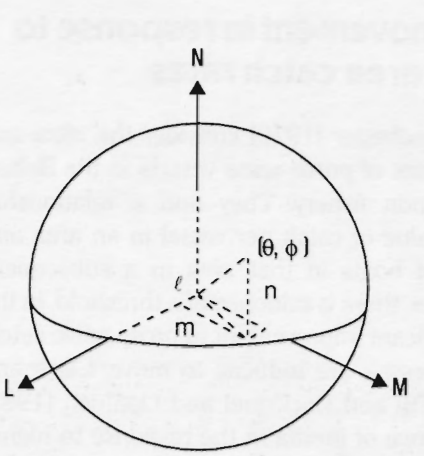

Figure 12.2 Location of points distributed on the surface of a sphere.

Case 1: $\bar{R} \le 0.44, U_1 \sim N(0,1)$

$$U_1 = \frac{(5/3)^{1/2}\left\{g_1\left(\tilde{R}^j\right) - g_1\left(\tilde{R}^u\right)\right\}}{\left\{\left(N^j-5\right)^{-1} + \left(N^u-5\right)^{-1}\right\}^{1/2}}$$

where $g_1\left(\tilde{R}^i\right) = \sin^{-1}\left(a\tilde{R}^i\right)$, $a = 1/\sqrt{5}$, $\tilde{R}^i = 3\tilde{R}^i$

and N^i = number of sample points for fleet (7)

Case 2: $0.44 \le \bar{R} \le 0.67$, $U_2 \sim N(0,1)$

$$U_2 = \frac{\left\{g_2\left(\bar{R}^j\right) - g_2\left(\bar{R}^u\right)\right\}}{c_3\left\{\left(N^j-4\right)^{-1} + \left(N^u-4\right)^{-1}\right\}^{1/2}}$$

where $g_2\left(\bar{R}^i\right) = \sin^{-1} + \left\{\frac{\left(\bar{R}^i + c_1\right)}{c_2}\right\}, c_1 = 0.17595$

$c_2 = 1.029063, c_3 = 0.62734$ (8)

Case 3: $\bar{R} \ge 0.67, U_3 \sim F\left\{2\left(N^j-1\right), 2\left(N^u-2\right)\right\}$

$$U_3 = \left\{\frac{\left(N^j - R^j\right)\left(N^u - 1\right)}{\left(N^u - R^u\right)\left(N^j - 1\right)}\right\} \quad (9)$$

Table 12.3 Two-sample test for difference of k (concentration) parameters, Japanese and U.S. fleets, 1983–87

Year	Quarter	Japan	U.S.	Test stat	Observations	
		$\bar{R}^j$	$\bar{R}^u$		N^j	N^u
1984	1	0.6041	0.3397	3.9212[a]	739	63
	2	0.2077	0.2432	0.3584	60	75
	3	0.3469	0.2207	3.8250[a]	1252	337
	4	0.5369	0.1361	6.1067[a]	1656	231
1985	1	0.3969	0.3194	1.7375	1456	72
	2	0.5825	0.1735	9.4844[a]	739	202
	3	0.5662	0.3440	5.6985[a]	490	90
	4	0.2174	0.2121	0.1617	895	210
1986	1	0.2898	0.2719	0.4563	1050	443
	4	0.5979	0.2092	6.4975[a]	933	168
1987	1	0.4471	0.5820	–1.4490	908	54

[a]Significant difference from zero at the 5% significance level under a standard normal distribution.

If revenue maximising vessels are moving in response to information about catch rates, the number of vessels in an area should be positively related to the value of catch per vessel in previous periods in that area. The nature of the relationship depends on the importance of the psychological and monetary costs of movement, and on the distribution of information about catches among vessels. The analysis of Hilborn and Ledbetter (1979) is extended in this study by applying an Almon polynomial lag model to the relationship between the number of vessels in an area and the value of catch per vessel in previous periods. The Papua New Guinea exclusive economic zone is divided into 10 subzones ranging in size from 2–3° in longitude and 6–7° in latitude. For each subzone the hypotheses to be tested can be expressed as:

$$N_t = \delta + \beta_1 v_{t-1} + \beta_2 v_{t-2} + \beta_3 v_{t-3} + \epsilon_t \quad (10)$$

where the period of time is one week, N_t is the number of vessels in a subzone, v_{t-1} is lagged average value of catch per vessel in the subzone, $\beta_i = \alpha_0 + \alpha_1(i-1)$, $\epsilon_t \sim N(O, \sigma^2)$, and $E(\epsilon_t\, \epsilon_{t-i}) = 0$, i=1,2,3. The form of the model to be estimated is:

$$N_t = \delta + \alpha_0\left(\Sigma_i\, v_{t-i}\right) + \alpha_1\left(v_{t-2} + 2v_{t-3}\right) + \epsilon_t \quad (11)$$

The model is initially estimated for each fleet in each subzone, except for both fleets in subzone 10 for which there are insufficient observations (<30). The initial results were not strong. The inclusion of the second and third lag terms are rejected on the basis of a sequential F-test (Judge et al. 1988), and the model is re-run with only one lag term and a dummy DY_t taking the value of 1 for observations in or after 1985. The coefficients of interest are those on the lagged values of catch per vessel. Estimates of these response coefficients can be biased if the total number of vessels in the fishery changes over time; for example, more vessels in a subzone could result from increased fleet size as well as from favourable catch rates. The inclusion of the dummy variable for observations on or after 1985 allows the effect of fleet size to be reflected in an adjustment to the constant term.

The observations for both fleets are pooled and the model is estimated with dummy terms, $D_t = 1$ for Japanese vessels, to compare the coefficients on the one lag term. A maximum likelihood estimator using the method of Beach and Mackinnon (1979) is used to correct for autocorrelation due to the inclusion of the lagged independent variable. The constant term reported in Table 12.4 is the estimate of the U.S. intercept, while the coefficient of D_t is added to obtain the estimate of the Japanese intercept. Similarly, the coefficient of v_{t-1} is the U.S. slope estimate of the lagged term, and the coefficient of $D_t v_{t-1}$ is added to obtain the Japanese estimate. It can be seen that the constant terms are positive and significant, supporting the hypothesis of inertia based on the psychological or monetary costs of moving from one ground to another. For the Japanese fleet the β_1 coefficients are positive and significant in three cases out of nine, suggesting that vessels do move into their preferred subzones in response to lagged catch information. For the U.S. fleet the result does not appear to be as strong, with positive and significant β_1 coefficients in one case out of nine.

The models for the United States and Japan can be compared using the dummy terms in Table 12.4. The coefficient of the dummy term $D_t v_{t-1}$, measuring the difference in fleet response to one period lagged catch per vessel, is positive and significant in three cases. In subzones 1, 2 and 4, the Japanese slope coefficient is significantly larger than the U.S. estimate. This tends to support the hypothesis that information is disseminated more quickly and completely in the Japanese fleet than among the U.S. vessels.

Success rates in encountering schools

During each week of fishing in the exclusive economic zone a vessel records the number of successful and unsuccessful sets it makes. The total number of sets per week can be regarded as a measure of its success in locating schools of tuna, and the number of sets attempted by the fleet as a whole is a measure of fleet search performance. The success rate can be affected by factors other than the characteristics of vessels or the efficiency of their search behaviour. For example, mechanical breakdowns, which are not recorded in the data, can affect the number of schools located in a week. If factors of this nature are random occurrences, however, a relationship between success rate and search behaviour can in principle be established for the sample of vessels.

The Poisson distribution is appropriate for modelling count data in the form of encounters per unit of time. The probability of encountering n schools during time t is given by:

$$Pr\left(n \text{ schools in time } t/\lambda\right) = \left(\lambda t\right)^n e^{-\lambda t} / n!$$

where λ is the average rate of encounter during time t. Uhler (1976) has applied this approach to modelling the discovery of oil reservoirs. In his model the mean rate of discovery is positively related to the amount of search effort, measured by the footage drilled. In the early stages of exploration, the mean rate of discovery per foot drilled tends to rise as information about the

Table 12.4 Maximum likelihood estimator, lag model, Japanese and U.S. Fleets, 1983-87

Subzone	Constant	D_t	V_{t-1}	D_tV_{t-1}	DY_t	$V_{t-1}+D_tV_{t-1}$	D-W	R^2	Obs
1	1.6617[a]	7.5525[a]	-0.0143	0.1964[a]	-1.2170[a]	0.1821[a]	2.02	0.22	171
	(0.3827)	(1.3230)	(0.0164)	(0.0591)	(0.3327)	(0.0554)			
2	1.4936[a]	6.1161[a]	0.0252	0.3452[a]	-0.7350[a]	0.3704[a]	1.99	0.29	191
	(0.4384)	(1.0730)	(0.0159)	(0.0651)	(0.2555)	(0.0619)			
3	3.0927[a]	6.3874[a]	0.0031	-0.0232	-0.5944[a]	-0.0200	1.93	0.07	214
	(0.9127)	(1.4560)	(0.0182)	(0.0551)	(0.3175)	(0.0520)			
4	1.8614[a]	3.4183[a]	-0.0090	0.1403[a]	-0.3171	0.1313[a]	2.02	0.11	182
	(0.6955)	(1.2120)	(0.0224)	(0.0689)	(0.2657)	(0.0629)			
5	1.3128[a]	2.2215[a]	-0.0027	-0.0659	-0.0975	-0.0687	1.92	0.03	131
	(0.3771)	(0.9029)	(0.0140)	(0.0542)	(0.2834)	(0.0515)			
6	1.4925[b]	0.2607	0.0153	-0.0094	0.4671	0.00590	1.93	0.07	130
	(0.7904)	(0.8322)	(0.0145)	(0.0295)	(0.3659)	(0.0269)			
7	2.6784[a]	0.4093	0.0081	-0.0213	-0.0780	-0.0130	1.88	0.01	102
	(0.7887)	(0.8665)	(0.0186)	(0.0461)	(0.3309)	(0.0419)			
8	1.4687[a]	0.4813	0.0303[a]	-0.0218	-0.2550	0.0085	1.89	0.14	84
	(0.4230)	(0.4434)	(0.0163)	(0.0194)	(0.3552)	(0.0121)			
9	1.7528	-0.7883	0.0348	-0.0286	-2.8811	0.0062	2.00	0.05	51
	(2.2200)	(2.2040)	(0.1373)	(0.1376)	(2.5940)	(0.0128)			

[a]Significant difference from zero at the 5% significance under a two-tail t-test.
[b]Significant difference from zero at the 5% significance level under a one-tail t-test.
(Standard errors in brackets)

area is accumulated and disseminated; in the later stages the mean rate tends to fall as the number and size of undiscovered reservoirs fall. Since resource exhaustion is not considered to be an issue in an intra-seasonal analysis of the exploitation of a migratory stock, the Poisson search model of the tuna fishery should exhibit only a rising success rate as exploratory effort increases, unless there are local stock depletion effects.

Medley (1989) applies the Poisson model to search behaviour by tuna purse seine fleets in the South Pacific Commission statistical region. He examines the influence of biological factors, as represented by time of year and fishing zone, and vessel size on the average rate of encountering schools of tuna. Medley finds that medium size vessels are the most successful, contrary to expectations, and he suggests that this may reflect familiarity with fishing grounds and information sharing.

A problem with the Poisson approach discussed by McCullagh and Nelder (1983) is the assumption that the expected value of the number of successes per unit time equals its variance across sample observations. Differences in vessel size or behaviour, or seasonal variations may lead to this assumption about the sample being violated. In particular, differences between the two fleets, such as the vessel size differences already discussed, may cause difficulties. The present analysis deals with this problem by specifying a relatively short period of search of one week, within which major differences in behaviour are unlikely to be exhibited, and by dividing the sample into a series of 10-week periods. It also incorporates dummy variables to account for differences in success rates, and changes in success rates with respect to the level of effort, between the two fleets. The model estimated is:

$$\ln \lambda_t = \beta_0 + \beta_1 D_t + \beta_2 \ln N_t + \beta_3 D_t \ln N_t \qquad (12)$$

where λ_t is the success rate of encountering fishable schools per week, N_t is the number of vessels in the fleet, and D_t is a dummy variable denoting fleet nationality, with $D_t = 1$ for the Japanese fleet.

To estimate equation (12) a set of eleven 10-week periods during 1983–87 was chosen for which there were adequate numbers of observations on vessels of each fleet. The results of the estimation are reported in Table 12.5. The constant terms are estimates of the average success rate of the U.S. fleet as the number of vessels in the fleet tends to zero. The coefficient on the dummy variable, D_t, adjusts this success rate downwards to reflect the lower average success rate of the smaller Japanese vessels. The coefficient on ln N_t is an estimate of the percentage change in the average success rate of U.S. vessels in response to a 1% increase in the size of the U.S. fleet. In all but two cases this estimate is not significantly different from zero, suggesting that success rate is independent of fleet size. In two cases success rate declines with an increase in fleet size, suggesting perhaps that local stock depletion may not be an irrelevant consideration within the 10-week period chosen for the analysis. The coefficient on $D_t \ln N_t$ is interpreted as an adjustment to the elasticity of success rate with respect to fleet size to reflect the experience of the Japanese fleet relative to that of the U.S. In eight of the eleven cases the adjusted coefficient is positive and significant, suggesting that the average success rate of Japanese vessels tends to rise as fleet size increases. In one 10-week period the estimated coefficient is significant and negative, and in the remaining two periods it is insignificant.

The results reported in Table 12.5 offer some support for the hypothesis that Japanese vessels share information to a greater extent than U.S. vessels. For most of the periods analysed, the average success rate of Japanese vessels rose as fleet size increased, whereas there was no evidence of an increase in success rate for the U.S. fleet. The results also reveal only three possible instances of stock depletion effects being strong enough to outweigh the advantages of cumulative knowledge.

Bayesian updating of information

In this analysis it is assumed that vessels enter the fishing ground with a set of prior beliefs about the success rate in their chosen and alternative fishing areas. Information obtained from the vessel's own search behaviour in the course of the week's fishing is used to update its set of beliefs about success rates in particular areas. In addition a vessel may receive information, provided either voluntarily or involuntarily by other vessels, about the success rate in its chosen area and in alternative fishing grounds. A vessel which revises downwards its beliefs about the success rate in its current ground is more likely to change its location at the end of the week. In addition, a vessel which obtains information from another ground, and revises upwards its beliefs about the success rate in that ground relative to its own ground, is more likely to choose to leave its current location.

A probit model is used to predict the decision to move or stay at the end of the week's fishing on the basis of the direction of the revision of the vessel's beliefs. As above, the mean success rate per week is assumed to be a random variable, λ, described by a Poisson distribution. Following Mangel and Clark (1983), vessel beliefs about the mean success rate are assumed to be described by a gamma distribution:

$$\gamma(\lambda, \alpha, v) = \left(\alpha^{\upsilon} \lambda^{\upsilon-1} e^{-\alpha\upsilon}\right) \Big/ \Gamma(\upsilon), \quad \lambda \geq 0 \qquad (13)$$

where the mean and standard deviation of λ are given by $\mu = \upsilon/\alpha$ and $\sigma = \sqrt{\upsilon}/\alpha$ respectively, and where α and υ are the two parameters of the gamma distribution and $\Gamma(u)$ is the gamma function. At the end of the week's fishing each vessel uses the sample information acquired during the week to update its beliefs. Specifically, a period of length t exhibiting n encounters by k vessels will cause the parameters of the gamma distribution in (13) to be updated to:

$$\upsilon^1 = \upsilon + n, \text{ and } \alpha^1 = \alpha + kt \qquad (14)$$

where in the present analysis $t = 1$ represents the standard one week unit of time per vessel. Individual vessel beliefs are defined for $k=1$, whereas the information possessed by a fleet is defined for $k = N$, where N is the number of vessels in the fleet. The revised mean and standard deviation of the beliefs about the mean encounter rate are given by $\mu^1 = \upsilon^1 / \alpha^1$ and $\sigma^1 = \sqrt{\upsilon^1} / \alpha^1$ respectively.

Table 12.5 Poisson regression of pooled Japanese and U.S. fleets, by selected periods, 1983–87

Period	Constant	lnN_t	D_t/lnN_t	D_t	$lnN_t + D_t/lnN_t$	Log-L	χ^2-stat	Obs
1984								
Weeks 20–30	1.8523[a]	−0.1260	0.2365	−0.5238	0.1105	−157.50	3.8	66
	(0.1877)	(0.1813)	(0.2226)	(0.3267)				
Weeks 40–50	2.3839[a]	−0.5777	0.5399[c]	−0.4638	-0.0378	−605.28	4.6	236
	(0.3641)	(0.3073)	(0.3413)	(0.5832)	(0.1425)			
1985								
Weeks 1–10	2.0113[a]	−0.2714	0.8867[a]	−2.0766[a]	0.6153[b]	−705.93	52.4[d]	2234
	(0.1418)	(0.2008)	(0.2217)	(0.3211)	(0.0936)			
Weeks 10–20	2.3896[a]	-0.6387[a]	0.7994[a]	−1.2264[a]	0.1607[b]	−470.43	14.5[d]	195
	(0.3725)	(0.2321)	(0.2461)	(0.4069)	(0.0817)			
Weeks 20–30	1.2264[a]	0.1589	0.1963	-0.3824	0.3552[b]	−317.29	20.1[d]	130
	(0.2414)	(0.1877)	(0.2304)	(0.4316)	(0.1337)			
Weeks 30–40	1.6112[a]	0.1703	0.3289[c]	−1.1600[a]	0.4993[b]	−295.23	29.3[d]	110
	(0.2096)	(0.1372)	(0.1908)	(0.37162)	(0.1323)			
Weeks 40–50	2.4796[a]	−0.4548[a]	0.9523[a]	−2.1582[a]	0.4975[b]	−431.65	26.2[d]	244
	(0.4222)	(0.2376)	(0.2655)	(0.5407)	(0.1186)			
1986								
Weeks 1–10	1.7039[a]	−0.0208	−0.4292	1.2537	−0.4499[a]	−539.01	7.4	281
	(0.4188)	(0.2150)	(0.2811)	(0.6396)	(0.1652)			
Weeks 10–20	1.5012[a]	0.0732	0.7966[a]	−1.7522[a]	0.8698[a]	−127.27	11.7[d]	34
	(0.3469)	(0.1784)	(0.3476)	(0.7833)	(0.2980)			
Weeks 40–50	1.4124[a]	0.2929	−0.0830	-0.3651	0.2100[b]	−451.22	11.1[d]	178
	(0.2668)	(0.2014)	(0.2248)	(0.2248)	(0.0998)			
1987								
Weeks 1–10	1.4295[a]	−0.0510	0.3921	−0.8121[c]	0.3412[b]	−465.62	30.4[d]	173
	(0.3564)	(0.3091)	(0.3197)	(0.4302)	(0.0816)			

[a]Significant difference from zero at the 5% significance level under a two tail t-test.
[b]Significant difference from zero and difference from one at the 5% significance level under a one tail t-test.
[c]Significant difference from zero at the 5% significance level under a one tail t-test.
[d]χ^2-stat exceeds critical value of $\chi^2_{(3,df)} = 7.81$ at the 5% significance level.
(Standard errors in brackets)

Bockstael and Opaluch (1983) accounted for the possibility of risk aversion in their analysis of vessel movements. In the present analysis risk aversion is not incorporated, although it might seem that the variance of the distribution of a vessel's beliefs about the mean encounter rate could be included as an explanatory variable in the model of the decision to move. A property of the gamma distribution, however, is that the expected value of the encounter rate is a linear function of its variance. This means that, in principle, the mean encounter rate and its variance, which summarise each vessel's weekly set of beliefs, are perfectly collinear and cannot both be included in the regression model. In consequence, the assumption of risk neutrality will be maintained.

One problem in applying this model to a fishery based on a migratory species is that information rapidly becomes out of date because of the movement of fish stocks. For this reason the standard time period of one week was chosen for the analysis. To ensure continuity of fishing activity in the chosen ground within the one week periods the fishing grounds had to be defined at a broader level than in previous parts of the study. The observations on sets attempted by vessels in both fleets in 1985 were divided into three fishing grounds. At the end of each week of the year a vessel choosing to leave ground *j* can move to ground *k*, the closer alternative, or ground *l*, the more distant alternative ground. Each vessel's beliefs at the start of the year are assumed to be determined by the mean value of the weekly success rate, λ, for vessels in its own fleet in the period 1983–84. This initial set of beliefs is then assumed to be updated on the basis of the information available to the vessel in the course of 1985.

The full probit model is given by:

$$Y_{ijt} = a_0 + a_1\left(\mu^1_{ijt} - \mu_{ijt}\right) + a_2\left(\mu^1_{jFt} - \mu_{jFt}\right) + a_3\left(\mu^1_{jFt} - \mu^1_{kFt}\right) + a_4\left(\mu^1_{jFt} - \mu^1_{lFt}\right) + a_5 D_i + \epsilon_{it} \qquad (15)$$

where Y_{ijt} represents the decision of vessel *i* to remain in ($Y_{ijt} = 1$) or leave ($Y_{ijt} = 0$) ground *j* at the end of week *t*; μ_{ijt} and μ^1_{ijt} represent the prior and updated beliefs respectively of vessel *i* about the mean success rate in ground *j* in week *t*, based on the vessel's own fishing experience; μ_{jFt} and μ^1_{jFt} represent the prior and up-dated beliefs about the success rate in ground j in week *t*, based on the experience of all the vessels in its fleet operating in ground *j* at time *t*; μ^1_{kFt} and μ^1_{lFt} are up-dated beliefs about the success rates in grounds *k* and *l*, based on the fleet-wide experience; and D_i is a vessel size dummy ($D_i = 1$ for large vessels, GRT › 500 for the Japanese and GRT › 1400 for the United States) reflecting the fact that the opportunity cost of changing location may be lower for the larger, faster vessels.

The full probit model is not estimated because of the high degree of collinearity between the individual vessel beliefs and the collective experience of its fleet in the same subzone at the same time. Instead, the model is fitted first to the data on the vessel's own experience in its chosen subzone to determine whether it can explain the observed vessel movements. The model is then fitted to the data on the fleet experience in the chosen subzone and alternative subzones, and a test is performed to determine which of the two specifications is preferred.

The results of the probit model applied to the individual vessels of the two fleets are reported in Table 12.6. Model I reports the results based on the vessel's own experience within its chosen ground. For both the Japanese and U.S. vessels the coefficient on the increment in the beliefs about the mean encounter rate in the subzone is positive and significant. The constant term for the Japanese vessels is also positive and significant, suggesting that there is some kind of inertia impeding the response to new information, whereas U.S. vessels exhibit no such impediment. The vessel size dummy is negative and significant for both nationalities, indicating that larger (and faster) vessels are less likely to remain in their subzone, other things being equal.

Model II reports the results based on own-fleet experience in the chosen subzone and alternative subzones. The positive and significant coefficients on the variables which measure the change in beliefs about the relative success rates in the chosen subzone and the adjacent subzone suggest that Japanese vessels respond to fleet experience in those zones, whereas U.S. vessels respond to own-subzone information only. This latter result may be due to the correlation between individual vessel and own-fleet experience, or to voluntary or involuntary information sharing among vessels. However, unlike the Japanese

Table 12.6 Probit models of vessel movements for Japanese and U.S. fleets, 1985

	Japan		United States	
Constant	Model I	Model I (with $\hat{P}_{it}(2)$)	Model I	Model I (with $\hat{P}_{it}(2)$)
	0.5256^a	−2.1116	0.1157	-1.4750^a
	(0.0534)	(0.6573)	(0.1157)	(0.6569)
$\mu^1_{ijt} - \mu_{ijt}$	0.9063^a	-0.3587^a	3.1607^a	−0.0049
	(0.3726)	(0.4885)	(1.6417)	(2.0968)
D_i	-1.0594^a	0.4314	-0.4915^a	−0.0459
	(0.3697)	(0.5220)	(0.2581)	(0.3335)
$\hat{P}_{it}(2)$	–	3.7923^a	–	2.9257^a
		(0.9428)		(1.1346)
χ^2-stat	14.672^b	31.379^b	7.234^b	14.773^b
Count R^2	0.71	0.73	0.59	0.63
Observations	654	654	152	152
	Model II	Model II (with $\hat{P}^k_{it}(1)$)	Model II	Model II (with $\hat{P}^k_{it}(1)$)
Constant	0.5755^a	−0.9624	0.0572	−1.6226
	(0.0578)	(2.2978)	(0.1438)	(2.2482)
$\mu^1_{jFt} - \mu_{jFt}$	0.5705^a	0.6519^a	1.5149^a	−0.1497
	(0.0249)	(0.6076)	(0.6357)	(2.5044)
$\mu^1_{jFt} - \mu^1_{kFt}$	0.3385^a	0.3433^a	0.0839	0.0700
	(0.1193)	(0.1193)	(0.3257)	(0.4688)
$\mu^1_{jFt} - \mu^1_{lFt}$	−0.1214	−0.1119	0.1404	0.0607
	(0.1264)	(0.1269)	(0.2500)	(0.4095)
D_i	-1.0675^a	−1.2915	-0.5112^a	0.0994
	(0.3741)	(0.3639)	(0.2608)	(0.8209)
$\hat{P}_{it}(1)$	–	−0.5515	–	3.1676
		(3.2892)		(4.0138)
χ^2-stat	26.429^b	26.810^b	11.050^b	15.038^b
Count R^2	0.70	0.70	0.65	0.61
Observations	654	654	152	152

[a] Significant difference from zero at the 5% significance level under a two-tail t-test.
[b] χ^2-stat exceeds χ^2 (number of slope parameters) at the 5% significance level.
(Standard errors in brackets).

fleet, there is no evidence of U.S. vessels moving in response to updated information from subzones other than that chosen at the beginning of the week. The Japanese vessels do not appear to respond to information about the more distant alternative subzone, reflecting, perhaps, the cost of moving and the rapidity with which information becomes out of date. To provide a model specification test, the predicted values

$\hat{P}_{it}(1) = Pr\{Y_{it} = 1\}$ derived from Model I are included as an independent variable in Model II, and the predicted values $\hat{P}_{it}$ (2) are included in Model I. It can be seen from Table 12.6 that $\hat{P}_{it}(2)$ is significant in Model I, but $\hat{P}_{it}(1)$ is not significant in Model II. According to the Davidson and MacKinnon (1981) test, this suggests that Model II is the preferred specification. In summary, a model in which individual vessel movements are based on fleet experience is preferred for both fleets. However, only fleet experience within the chosen subzone is relevant in the case of U.S. vessels.

Conclusions

The various tests reported in the chapter tend to support two hypotheses: that Japanese purse seine vessels tend to engage in more concerted fishing behaviour than do U.S. vessels; and that the vessels in the Japanese fleet exchange information among themselves to a greater extent than do the U.S. vessels. As noted earlier, Mangel and Clark (1983) allude to the efficiency benefits of information sharing. If the Japanese vessels share information to a greater degree, this should be reflected in less time spent in searching and more in fishing. Table 12.7 reports the average proportion of trip time spent searching by the vessels of the two sample fleets in the period 1983–87. This proportion is measured as one minus the ratio of days in which fishing activity took place to total days spent in the zone. The Japanese vessels have a significantly lower average proportion of search time than the U.S. vessels for each of the three time periods considered.

Table 12.7 Proportion of trip time spent searching by vessels, average over all vessels for Japanese and U.S. fleets, 1983–87

Fleet	1983–84[a]	1985[a]	1986–87[a]
Japan	0.0476	0.0861	0.1028
	(0.1109)	(0.1623)	(0.1736)
Observations	381	237	223
United States	0.1621	(0.2564)	(0.1957)
	(0.1982)	0.2319	0.1809
Observations	22	38	36

[a]Significant difference of fleet estimates under a two-tail difference of means test
(Standard errors in brackets)

Chapter

13 Japanese Tuna Fleets and Fishery Rents in Papua New Guinea: 1983–1987

H.F. Campbell
R.B. Nicholl

Introduction

The approach to collection of resource rents taken by most, if not all, island nations in the central and western Pacific region (Papua New Guinea included) has been to negotiate access fees with the major distant water fishing nations. Access fees are presumed to reflect an 'acceptable' return to coastal nations and have typically been based on the value of catches, with little or no regard to the costs of concluding and enforcing agreements, or the level of resource rents generated from tuna fisheries. Island states bargain for the highest percentage of estimated catch values they can secure, while foreign fishing fleets bargain for the lowest payment they feel will be acceptable to the island states. The result is typically a compromise, although agreement is not always reached, as evidenced by the stand-off between Papua New Guinea and Japan since their bilateral agreement expired in early 1987. In addition to returns in the form of access payments and licensing fees, many coastal nations receive both technical assistance and financial aid, the value of both being difficult to quantify.

From an economic perspective a resource stock can be viewed as a capital asset which, if used in an efficient manner, should earn the owner a rate of return similar to that on other capital. A return from natural resource exploitation takes the form of an economic profit, defined as the total revenue received from the sale of the resource less the economic costs associated with bringing the resource to the point of sale. Returns to resource stocks arise from the fact that natural resources have inherent value as inputs to the production of consumer and capital goods. In the case of fisheries, ex-vessel harvests are valued as inputs to the production of a range of processed consumer goods. While economic profits (also known as 'super profits') may arise from a variety of activities and industries, profits which are generated from the exploitation of natural resources can be viewed as a return to the resource stock and are commonly referred to as resource rents.

This chapter reports the results of an analysis which estimates resource rents from Papua New Guinea's tuna fisheries. Rent calculations are based on the difference between revenues earned from tuna fishing activity and the estimated economic costs incurred in earning those revenues, namely the cost of fishing effort. The analysis covers Japanese pole-and-line, longline and group purse seine fleet activities between the beginning of 1983 and March 1987 (when the bilateral access agreement between the Papua New Guinea and Japanese governments expired).

Estimating fishery resource rent

Fishery rent is defined as the difference between the landed value of fish and the full economic costs of bringing a catch to port, net of any other types of rent which may be earned. It is not necessarily the case that rents arise from all fisheries exploitation, or that in cases where rents can be identified they are entirely resource rents. While fishery rent is typically associated only with stock exploitation managed in a strategic manner, this is not true for other types of rents connected with fishing industries.

The concept of rent

In the case of the fishery, a potential for rent exists because of the innate productivity of certain fishing grounds relative to others. The price of fish must be high enough to cover the costs of supply from the least productive or most remote ground. All other grounds have a potential to yield owners a higher return based on their cost advantage. In addition to this excess return, which is termed fishery rent, other factors of production may also be able to earn rents. For example, some vessels may be skippered by particularly highly skilled fishers. Such vessels, known as 'highliners', may consistently catch more fish for the same costs as other vessels. The resulting profit is a 'highliner rent'. This kind of advantage may be permanent, being based on innate ability, or temporary, being based on better information. Some vessels may be particularly suited to the fishery because of their size and the specialised gear they carry, and may enjoy a temporary advantage in costs or catch rates which manifests itself as a quasi-rent–a temporary profit in excess of the market rate of return.

An open-access or unmanaged fishery does not generate fishery rent although some of its participants may earn other kinds of rents or quasi-rents. The reason no fishery rent is generated is because the advantages of the fishery in terms of its natural productivity are offset by competitive forces resulting in over-exploitation, which in turn lowers the return to fishing effort. This is illustrated by Figure 13.1 which shows the average and marginal return to effort in a single species, single location fishery. The average return to effort is the average catch per unit effort for the fleet multiplied by the price of the harvest. The marginal return is the price of the harvest multiplied by the extra harvest which would result from an extra unit of fishing effort. The unit cost of effort is its opportunity cost, defined as the value of output which the factors of production involved in producing fishing effort could produce if they were employed in another industry. Opportunity cost is measured in a conventional way using market prices of inputs such as labour, capital, and fuel. The open-access equilibrium is at E_0 where the average return to effort equals its unit cost. At effort levels below E_0 the average return to effort is higher than its opportunity cost, indicating that additional entrants to the fishery could earn economic profits, i.e. profits in excess of the level required to generate a market rate of return on capital. At effort levels higher than E_0 the vessels in the fishery are making an economic loss, i.e. they are earning a lower rate of return than the market rate or, equivalently, they are not covering the cost of the effort they employ. Therefore, effort level E_0 is the long-run open-access equilibrium level at which there is neither the incentive to enter nor exit the fishery. At this level of effort the fishery rent is zero as total revenues for the fleet are just equal to the total costs of generating those revenues.

One objective of fishery management is to maximise the amount of rent which could be generated. This would be achieved by restricting fishing effort to the level E^* in Figure 13.1. At that level the marginal return to effort is equal to the unit opportunity cost of effort. The total economic profit, or rent, earned by the fishery is given by area *C'BDC* which represents the economic profit per unit of effort, *BD*, multiplied by the amount of effort, E^*. This rent is the resource rent, or fishery rent: it represents the return which the owner of the fish stock would receive in a perfectly competitive economy with a complete set of enforceable property rights over the resource. It is sometimes termed 'management rent' (Anderson 1988) in recognition of the fact that, given that an unmanaged fishery yields no economic rent in a purely competitive environment, with no property rights to the fish stock, a regulatory framework is required for rents to be realised.

Fishing effort can be restricted to E^* in two ways, both of which involve the collection of economic rent by the managers of the fishery. One way is to charge a royalty on the catch, reducing the average return per unit of effort until it equals unit cost at effort level E^*. The alternative is to impose a charge per unit of effort to raise the opportunity cost of effort until it equals the average return at E^*. These two methods are illustrated

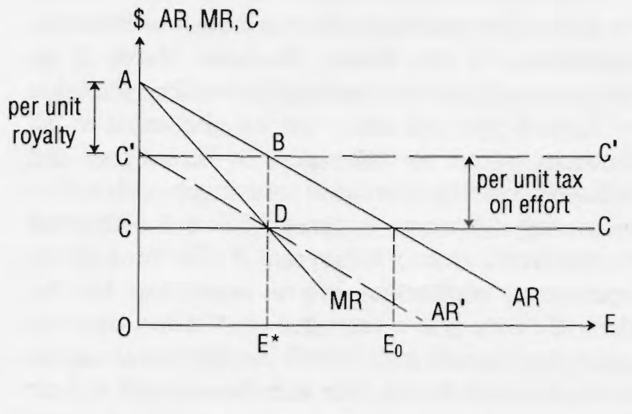

Figure 13.1 Single species fishery: managed fishery rent generation

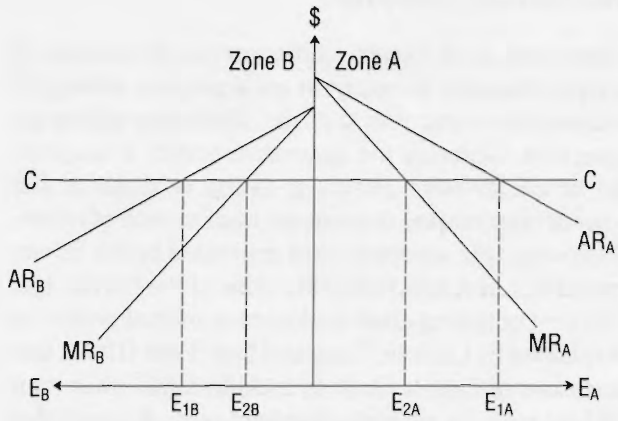

Figure 13.2 Multizone fishery: costs and returns

by the curves *C′AR′* and *C′C′* in Figure 13.1 which show the net of royalty return and the gross of access charge cost respectively. Papua New Guinea's tuna fisheries are currently managed by imposing an additional cost per unit of effort–an access fee–the level of which is intended to be equivalent to a particular level of *ad valorem* royalty on the harvest (currently 6%).

The above description of managed fishery rent generation pertains to a single species, single area fishery. In a multispecies, multilocation fishery, rent is maximised by ensuring that the optimal amount of effort is targeted on each individual species in each of the locations where the species can be harvested. Since the returns to effort will vary with the species and location fished, optimal fishery management would in principle involve a different level of royalty for each species in each area. In practice the costs of enforcing this kind of 'first-best' policy at present are likely to exceed the benefits and the imposition of an access fee per unit of effort applied to the exclusive economic zone may be a reasonable management strategy.

Even if fishing within the exclusive economic zone can be treated as a single species, single area fishery, distant water fishing nations have the choice of fishing in one of a number of exclusive economic zones, or on the high seas. At any point in time the productivity of fishing grounds, as measured by the average and marginal returns to effort, will vary from one exclusive economic zone to another. There are two models of how fleets will be allocated among exclusive economic zones: one approach, based on the concept of open-access equilibrium, argues that average returns to effort, net of access fees and transport costs, will be equalised across zones; the other approach, based on the optimal allocation of fishing effort, argues that the fleets will allocate effort to the exclusive economic zones so as to equalise the net marginal return to effort. An example of the latter approach is the management of the Japanese foreign tuna fleet in the 1950s (see Comitini and Huang 1971). Assuming that the relatively small high seas pockets can be neglected, these two approaches will coincide when the managers of the exclusive economic zones are charging the access fee *C′C* in Figure 13.1 and effort in each zone is at E^*.

In Figure 13.2 the two approaches to predicting the distribution of effort are illustrated. The figure shows the average and marginal returns to effort in two fishing zones (*A* and *B*), and the opportunity cost of effort, *CC*. Ignoring for the moment the costs of moving from one zone to the other, and the access fees which may be levied by the host countries, effort will be distributed as OE_{1A} and OE_{1B} according to the competitive open-access equilibrium, or as OE_{2A} and OE_{2B} according to the managed equilibrium. In the former equilibrium, average return per unit of effort is equalised between the two zones except for differential transport costs and access fees. In the latter equilibrium the marginal return per unit of effort, net of any marginal transport costs and access fees, is equalised.

Measuring fishery rent

Since rent is an excess return received by a factor of production over its return in an alternative activity, its measurement requires that the alternative activity be specified. Generally the alternative activity is assumed to be employment elsewhere in the economy at the competitive market determined wage or rate of return. Following this approach, rent generated by the fishery could be approximated by the value of the harvest less the cost of fishing effort evaluated at market prices. As explained by Lindner, Campbell and Bevin (1992), this measure of rent is likely to include rents other than fishery rent; for example, highliner rents. It could also exclude certain other rents, such as rents resulting from noncompetitive product markets, which may be of interest to the fishery manager (see Campbell 1989). For example, where vessel catch is sold to a cannery which either owns the vessel or has some form of financial interest in it, the revenue received by the vessel for its harvest may be lower than if the cannery and vessel were completely independent. When a processor pays a lower than market ex-vessel price for fish as a result of a financial relationship between it and vessels supplying it, this is known as transfer pricing. Under such circumstances rents which would have accrued to a vessel in a competitive product market will be passed on, at least in part, to the processor.

Recent papers by Geen (1990) and Brown and Dann (1991) have produced estimates of rents earned through tuna fishing in the Australian fishing zone based on the assumption that the opportunity cost of fishing effort is the value of the catch which could be taken in the best alternative fishing location. Using this approach these authors have estimated the net value to Japan of access to Australia's longline tuna fisheries. The advantage of the approach is that it does not require information on fishing costs for its implementation. The disadvantage is that the difference in value of catch between one zone and another may understate or overstate rent depending upon the conditions under which the fishery is operating. For example, if the returns from fishing in the best alternative location are not high enough to meet fishing costs then the approach overstates rent, and conversely if there are rents to be earned in the alternative fishery, the approach understates rent.

The basis of the alternative harvest approach can be analysed by referring to the two models of economic equilibrium in the fishery discussed above. If all fisheries are in open-access equilibrium then the value of harvest per unit effort will be the same in all locations, except for differences in access fees and transport cost. The alternative harvest approach is then measuring differences in access fees and differential location rents, and not fishery rent. If other zones are in open-access equilibrium with no access fees, but the domestic zone is in a managed equilibrium, then the alternative harvest method will measure rents earned in the domestic fishery. This rent measure will include fishery rent, highliner rent, location rent, and quasi-rents to specialised equipment and knowledge and will exclude any rents accruing to processors as a result of imperfectly competitive product markets. Finally, if all zones are in managed equilibrium the rent earned in the domestic zone could be approximated by the difference between the gross value of the domestic catch per unit of effort and the value of the catch net of royalties per unit effort in the alternative foreign zone.

It is clear from the above discussion that detailed knowledge of the royalties and access conditions in alternative fishing locations is required if the alternative harvest measure approach is to provide a good approximation to the value of fishery rent. The approach based on the difference between total revenue and total costs is likely to be more accurate and should be used when cost information is available. However, as noted above, this measure will include some rents other than fishery rent, and may exclude downstream rents which have been transfered from the fishery to the product markets because of imperfectly competitive fish markets.

Measuring rents from Papua New Guinea's tuna fisheries

In the present study rent is estimated as the difference between total revenue and total cost. First, Japanese vessels which fished in Papua New Guinea waters between the beginning of 1983 and March 1987 (when the Japanese/Papua New Guinea agreement expired) are categorised according to gear type and vessel size (in tonnage). Size classes for longline vessels are 50–100 GRT, 101–200 GRT and 201–500 GRT; for pole-and-line vessels records show that only the larger 200–500 GRT vessels were active in Papua New Guinea waters for the period of the analysis; and the group purse seine operations are all single-net boat groups where the size of the net boat is 100–200 GRT and it is assisted by a search vessel and two carrier vessels. Estimates of gross monthly revenue derived from fishing operations for all categories of vessels are then calculated by summing catches of all species for all vessels across the fleet and multiplying the fleet catches by the relevant landed (ex-vessel) price for the species. Gross revenues for each species are then summed to give total monthly (gross) revenue for each category of vessel.

The prices used to calculate revenue are average monthly prices for the Japanese port of Yaizu, where most Japanese distant water caught tuna harvests are landed. In using these prices to estimate fishery rents we assume they are competitively determined market prices which reflect the average value of fish for a given month. One problem which arises from the use of average prices is that for longline caught sashimi grade tuna there is no single price which accurately reflects the unit value of all fish delivered to market. As most tuna sold for the fresh fish market are sold at auction, prices in many instances for individual fish differ on the basis of the fishing ground in which they were caught and the reputation of the fishing director for handling the fish before they are delivered to market. There is no way around this problem as prices paid to individual vessels are not available. As the following rent estimates are only a guide to the magnitude of potential rents, the use of an average price for all species may adequately represent the value of landed harvests. The major species (by weight of total catch) harvested by longliners in Papua New Guinea's exclusive economic zone are yellowfin and bigeye; minor species and incidental catch consist of albacore, bluefin, blue, black and striped marlin, sailfish, swordfish, shark and miscellaneous species. Purse seine and pole-and-line fleets harvest mainly skipjack and yellowfin.

When interpreting the estimates of rents for the various tuna fisheries under investigation, there are important qualifications which should be borne in mind. First, since the true economic cost of fishing effort does not include any licence or access fees paid by fishers to coastal states, the following estimates exclude any consideration of the current levels of payments by the Japanese to Papua New Guinea for the rights to harvest tuna. In the concluding section of the paper the rent estimates are compared with the levels of fees paid by Japanese fleets for the periods of the various analyses. Second, while estimated rents represent economic profit accruing to vessel owners which could possibly be expropriated by Papua New Guinea, they overstate the net value of the fishery to Papua New Guinea. Implicit in any agreement between Papua New Guinea and distant water fishing nations are the costs of negotiating, administering and monitoring the agreement. Potential returns accruing to Papua New Guinea should be estimated net of these costs. Third, given that the cost of effort to the marginal or highest cost vessel in each case will not be used to determine unit harvesting costs, a portion of any rents arising from fishing will represent operator, or 'high-liner', rents. And fourth, since there is a dearth of biological information about the relationship between catch per unit effort and the level of fishing effort, the sensitivity of rents to the level of fishing effort will not be accounted for (Waugh 1987). Therefore, any estimate of potential economic profit is composed of gross fishery rent, access agreement costs, and operator rents, which together will overstate the true magnitude of fishery rents alone.

Waugh (1987) refers to the concept of 'fair costs' in a discussion of the measurement of the cost of fishing effort. 'Fair costs' are defined by Waugh as 'the costs relating to minimum expenditure on equipment, gear, wages, and other essentials that are required for the safe productive operation of the harvesting fleet in the long term.' The cost of effort used in this paper is the average total cost of a vessel-day fished for a given gear type and class size. These costs are obtained from studies by Campbell and Nicholl (1990 and 1992a) which estimated the cost of fishing effort based on surveys of Japanese fishing companies operating group purse seiners, longliners and pole-and-line vessels. The surveys report annual average levels of expenditures and capital stock. A weighted average cost of capital is applied to the capital stock to yield a cost of capital which is combined with operating costs to give total cost per year of owning and operating a distant water tuna vessel. The annual cost is then divided by the number of days fished (on average) in a particular year and adjusted upwards to reflect the support costs of a day fishing, such as transit, trip preparation and off-loading. The resulting estimate is the long-run average total cost of a day fished for a particular class of vessel. Since the measurement of capital costs is based on the average required rate of return on capital in Japanese industry, the additional cost of risk associated with tuna fishing is ignored by this method of estimating fishing costs and this introduces an upward bias to the rent estimates.

The estimates of rent reported in this chapter are based on a comparison of the average revenue obtained per day from fishing effort and the average cost. While the catch data report actual harvests in Papua New Guinea's exclusive economic zone, the prices used in calculating revenue are averages for catches landed in Japan. This means that the average revenue data are approximations to the revenues of Japanese vessels operating in Papua New Guinea's exclusive economic zone. The average cost estimates are for the operations of the Japanese tuna fleets across all zones in which they operate. The rent estimates will be accurate for vessels operating in Papua New Guinea's exclusive economic zone if their activities correspond to the relevant average operational pattern and yield catches which command average prices. Any divergence from the average, caused for example by the need for greater or less searching activity in Papua New Guinea waters, by lower or higher prices being received for Papua New Guinea caught tuna, or by operating costs being lower than or higher than those in other areas, will result in the rent estimates being over or underestimates.

Data

Three primary sources of data are used. South Pacific Commission (SPC) catch and effort data together with Food and Agricultural Organisation (FAO) tuna price information are used for the longline, single purse seine and pole-and-line fisheries. Data for the group purse seine operations were obtained from South Pacific Forum Fisheries Agency report (FFA 1989b) on Japanese fishing activities in Papua New Guinea's exclusive economic zone.

Gross revenues for the various tuna fleets are calculated using ex-vessel tuna and marlin prices for the Japanese port of Yaizu. These are average monthly prices for the different species landed and sold at Yaizu. Price data are from the FAO INFOFISH data base.

Catch and effort data for Papua New Guinea were obtained from the SPC Tuna and Billfish Assessment Programme data base. These data are daily records of catch by weight and species for all registered Japanese vessels fishing in Papua New Guinea's exclusive economic zone for the period 1983 to March 1987. Daily records have been aggregated to monthly catches and number of days fished, then summed across all vessels to give total catch and effort by gear type by month.

Cost of effort information was obtained from Campbell and Nicholl (1990; 1992a). These studies report the calculated total cost of fishing effort for an average vessel for the three different tuna gear types by various sizes of vessel. The unit of effort is a day fished and the cost estimate includes operating expenses such as fuel, wages and gear and vessel maintenance, and the capital cost of owning and operating a vessel for a fishing day. These cost estimates have been taken from Tables 1, 3 and 5 of Appendix D of Campbell and Nicholl (1990) and the same tables and Appendix of Campbell and Nicholl (1992a).

For the group purse seining operations, data on catch, effort and the landed value of catch were obtained from Forum Fisheries Agency 1989. Catch and effort information is reported by year and purse seine group. Each group made one fishing trip to Papua New Guinea for each year of the two years, and data covering the number of days fished and catch are provided for each group, for each trip. Since tuna catches are not detailed by month, Forum Fisheries Agency estimates of gross revenue for each year for all groups together are combined with the Campbell and Nicholl fishing effort cost estimates to perform the rent calculations. The per fishing day total cost was calculated by averaging the cost reported in Campbell and Nicholl (1990; 1992a) for the relevant months over which specific fishing trips took place.

Rent estimates

Longline fishery

The results indicate that the level of rent fluctuates significantly throughout the year as well as from year to year (Tables 13.1 to 13.3 and Figs. 13.3 and 13.4). The activities of the smaller vessels (50–100 GRT) generated rents in the longline fishery in all but one month between January 1983 and May 1986, after which there were five months to March 1987 in which there was no rent generated (Table 13.1). Rent, calculated as a percentage of gross revenue, from smaller vessel operations ranged from 11.6-46.2% in 1983; -4.1-38.1% in 1984; 16.5-53.0% in 1985; -23.2-47.5% in 1986; and -43.6-29.4% for the first three months of 1987. On average, rents in the longline fishery were generated for all years except the first three months of 1987 by the activities of the smaller vessels. Figure 13.5 shows that the level of smaller longline activity, measured in vessel-days fished, fluctuated from month to month throughout the period of analysis.

The activities of the 100–200 GRT class of longline vessels did not generate rent for most of the period 1983 to March 1987 (Table 13.1b). Figure 13.3b shows that rent was generated in this sector of the longline fishery from mid-1983 to early 1984, early to mid-1985, and in several months of 1986. The total costs of fishing activity appear to have outweighed the returns to effort for March to August of 1984 and most of 1986. Rent as a percentage of gross revenue ranged from -26.7-40.7% in 1983; -116.2-33.7% in 1984; -33.4-42.9% in 1985; and -102.6-55.0% in 1986. The annual average of monthly rent estimates indicate rent generated for 1983 (13.2%), 1985 (0.8%) and January of 1987 (7.0%). Figure 13.5 shows that while the level of fishing activity for this group of vessels fluctuated moderately between 1983 and 1986, there were marked declines in vessel activity in mid-1984 and mid-1986. There was no appreciable resurgence of the level of activity after the mid-1986 decline.

The operations of the larger vessel sector of the longline fishery failed to generate any rent for the few months they were active in Papua New Guinea's exclusive economic zone in 1984, 1985 and 1986 (Table 13.1c). Rent as a percentage of gross revenue ranged from -460.1% (1984) to -32.3% (1985). This larger class size of longline vessels was by far the least active in the fishery in terms of days fished, entering briefly for the last few months of 1984 and 1985 and the first three months of 1986.

Pole-and-line fishery

The vessels active in the pole-and-line fishery over the years 1983-1987 were of the larger 200-500 GRT class. They were active only for four to six months of 1983-1986 and failed to catch any skipjack or yellowfin in October 1984 and January 1987, although only two and three vessel-days of effort were recorded for these months. There were only two months out of the various months that pole-and-line vessels were active in which rent was generated in this fishery (Table 13.2). Rent as a percentage of gross revenue ranged from -271.0-70.5% in 1983; -1323.5% to -19.5% in 1984; -395.6% to -5.7% in 1985; and -150.0-22.3% in 1986. The month of greatest activity was October 1983 with 164 vessel days expended in the pole-and-line fishery resulting in a rent of ¥119.7 million being generated, representing 40.8% of gross revenue. The preceding month was the only other month in which rent was generated; ¥27.9 million or 70.5% of gross revenue.

Group purse seine fishery

Rent for the group purse seine is calculated as the total revenue for all groups combined, less the total cost based on an average of monthly per vessel per day total cost for the months in which each trip by the fleet took place (Table 13.3). There is evidence of two trips by the Japanese group seine fleet between 1983 and 1987. The first trip was in 1985 which involved seven groups and the second in 1986 involving five groups. There were no apparent positive fishery rents resulting from either trip: rent measured as a percentage of gross revenue was -146.5% for the 1985 trip and -1039.5% for the 1986 trip.

Although the level of activity of single purse seine vessels has been much higher and more consistent than that for group seine vessels, no rent estimates for this fleet could be carried out. This is because there is no cost of effort information pertaining to these vessels available to us.

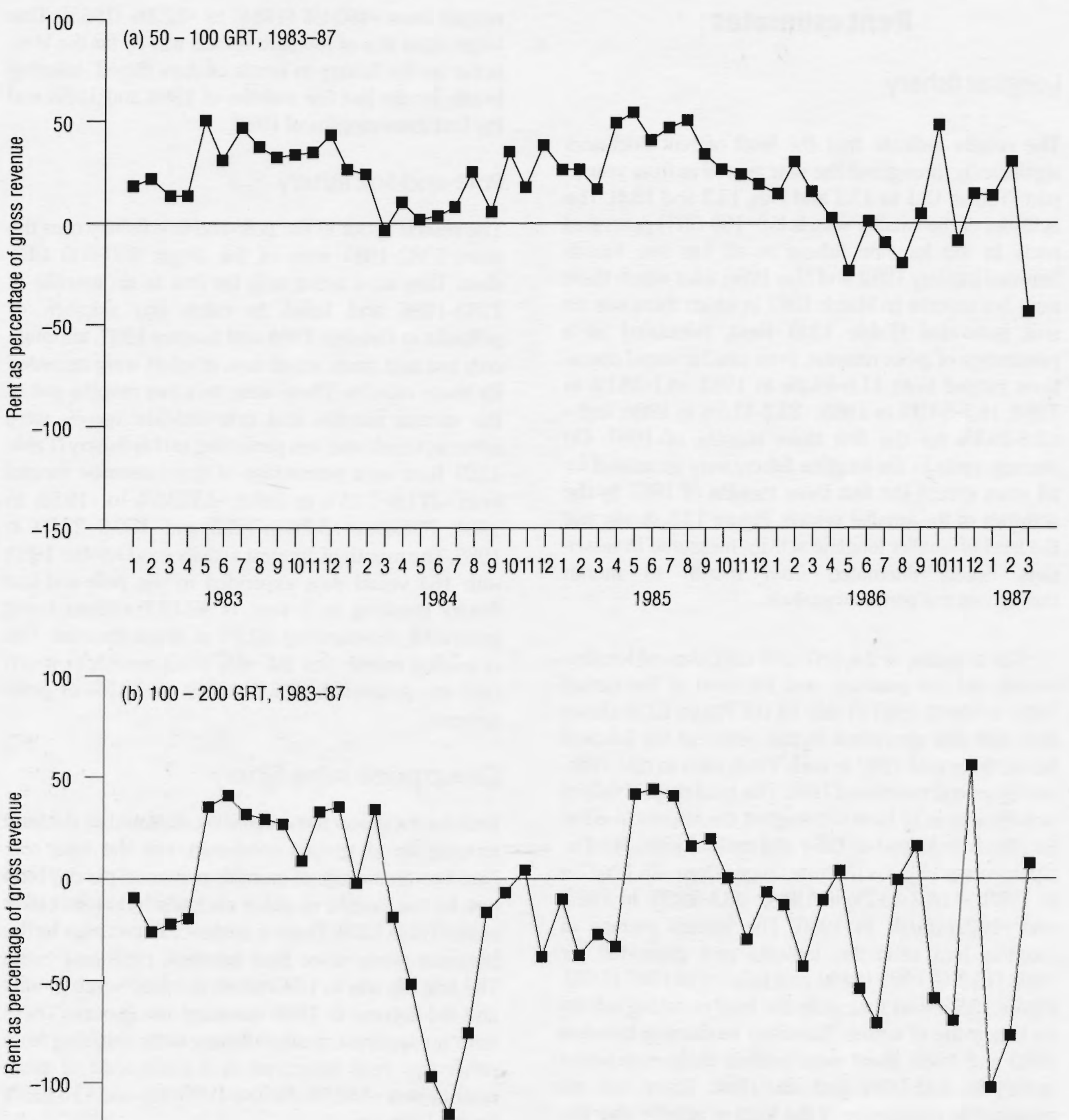

Figure 13.3 Monthly rent as a percentage of total revenue, Japanese longliners: (a) 50–100 GRT; (b) 100–200 GRT; and (c) 200–500 GRT.

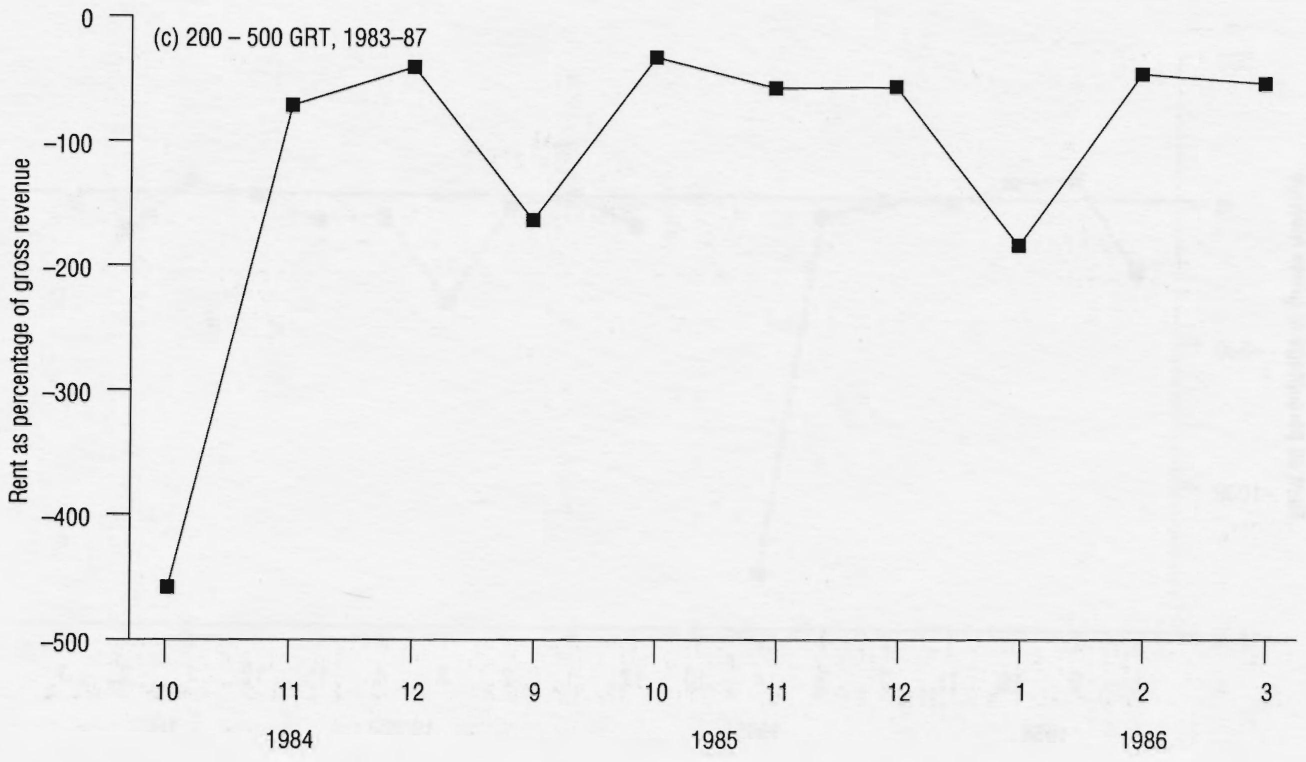

Figure 13.3 (contd) Monthly rent as a percentage of total revenue, Japanese longliners: (a) 50–100 GRT; (b) 100–200 GRT; and (c) 200–500 GRT.

Discussion

The fleet activity which generated the most consistent fishery rents, on a monthly basis, was the smaller vessel (50–100 GRT) longline fleet. Rent was greater than zero for 45 of the 52 months of recorded activity. The next best vessel class for rent generation was the fleet of 100–200 GRT longliners which recorded positive rents for 20 of the 49 months of recorded activity. The largest longline vessels were neither very active in Papua New Guinea waters between 1983 and 1987, nor capable of generating rents for any of the months they were present in Papua New Guinea waters.

If these results are considered together with the levels of activity of the various classes and profitability estimates from Campbell and Nicholl (1990; 1992a) (reproduced in Figure 13.6), some insight can be gained as to the relevant importance of Papua New Guinea as a fishing ground in the central and western Pacific region. The smaller vessels have been by far the most active in terms of vessel-days fished, and although they did not return positive profits based on their entire range of fishing operations in any given year (according to profitability estimates), they did generate revenues greater than fishing costs while in Papua New Guinea waters. Their presence was year round although there were noticeable declines in the level of activity of these vessels in mid to late 1984 and then again in 1986. This pattern of vessel-days fished was also exhibited by the 100–200 GRT class of vessels. The years 1984 and 1986 saw relatively lower rents generated in the longline fishery for both the 50–100 GRT and 100–200 GRT vessel sectors of the fishery.

The level of activity of the 100–200 GRT vessels was generally below half that of the 50–100 GRT vessels and followed a similar but less pronounced pattern as that of the smaller vessels (Figure 13.5). Their presence was also year round although slight from July 1986 on. Profitability estimates, measured as rate of return to invested capital, indicate that this mid-range size of longliners had poor general profitability performances in 1983–84 and 1984–85, but that this improved significantly

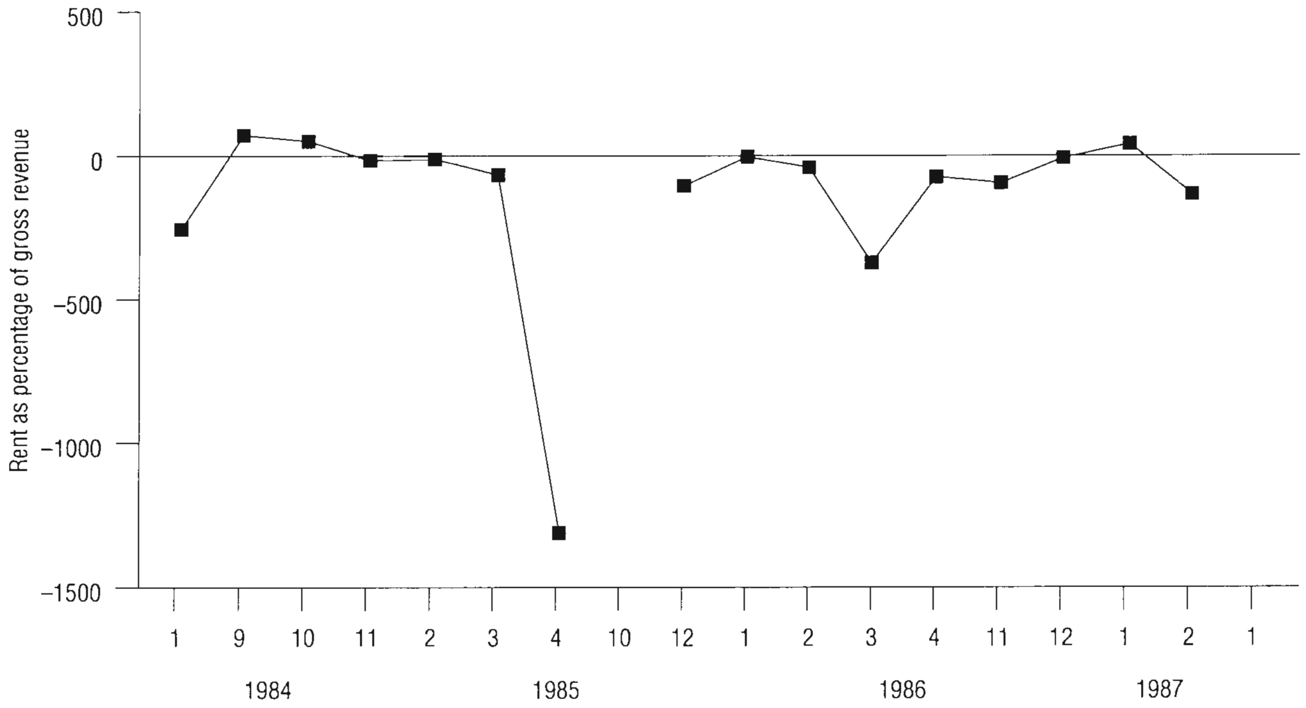

Figure 13.4 Monthly rent as a percentage of total revenue, Japanese pole-and-line, 200–500 GRT.

throughout 1985–86 (from –14% to 3%). This improvement in economic performance was also reflected in the annual average of monthly rent, moving from –33% in 1984 to 0.8% in 1985. However, it would appear that Papua New Guinea is a marginal fishing ground for these vessels as there seems to be no prospect of consistently earning returns in excess of total costs.

The largest of the longliners have not had a significant presence in Papua New Guinea. Although, according to Campbell and Nicholl (1990; 1992a), these have been the most profitable of all the Japanese longline tuna operations, their activities failed to generate positive rents for any of the recorded months of fishing in Papua New Guinea. It would seem that Papua New Guinea is not considered by fishing directors of these vessels to be of any real importance, with their fishing activity most likely representing brief attempts as they pass through in transit to some other region or back to home ports in Japan.

The pole-and-line vessels (200–500 GRT) did not have a strong presence in Papua New Guinea waters (Table 13.2). The peak levels of activity were in October 1983 and February 1985. The rent generating performance of these vessels was not good, nor have they been profitable in general (Campbell and Nicholl 1990; 1992a). The general level of activity of these vessels in Papua New Guinea suggests that other fishing grounds in the region are of more importance to their operations.

Similarly for the group purse seine operations, rent generation in Papua New Guinea was poor, as was overall profitability. Seven groups fished in Papua New Guinea in 1985, spending from between 1 and 18 days catching tunas. The following year five of the seven groups returned, fishing for between 4 and 10 days. All groups operated with one net-boat in the 100–200 GRT range. Profitability for 1985 and 1986 for these vessels was negative, remaining so throughout the 1980s.

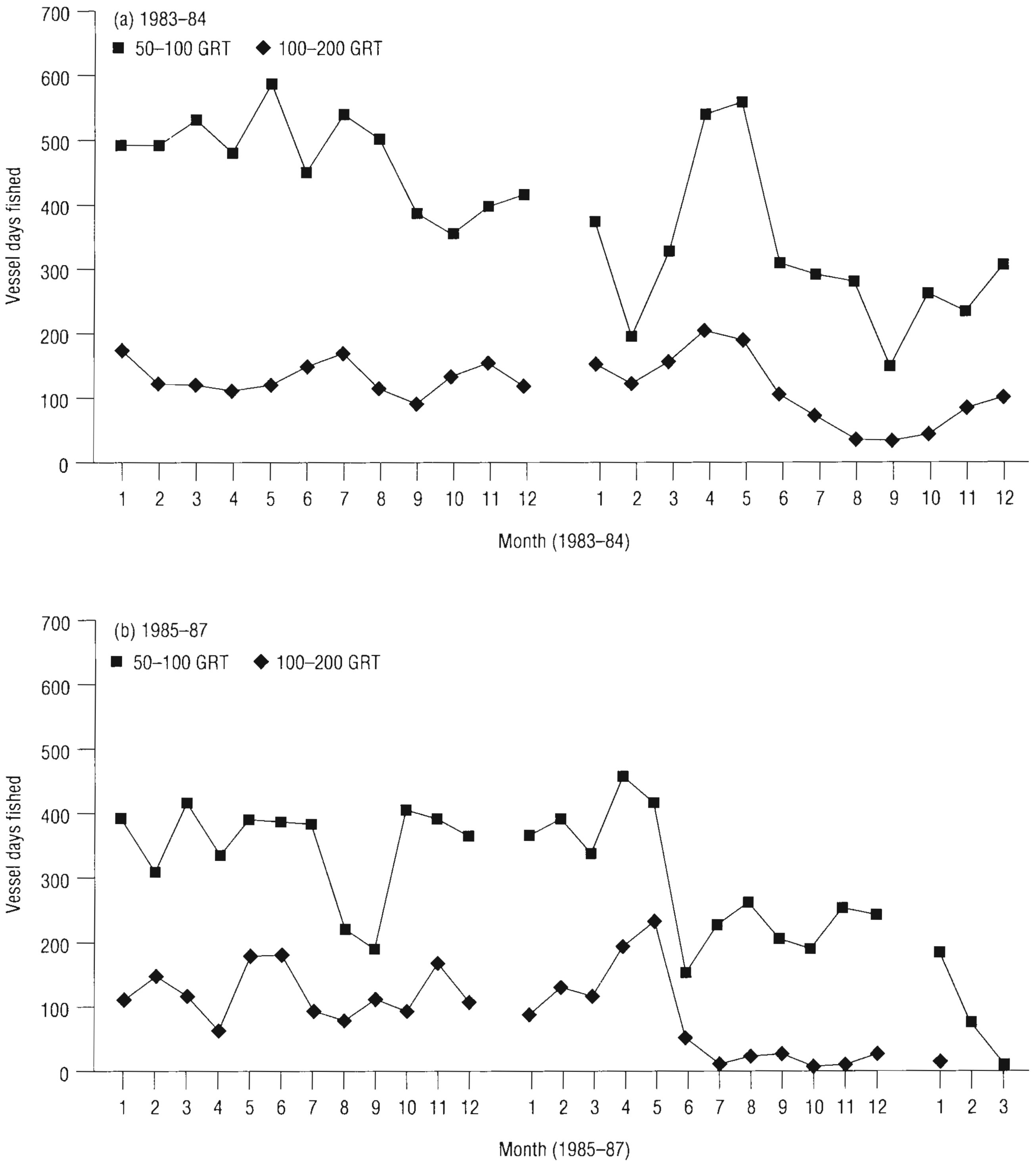

Figure 13.5 Level of longline activity: (a) 1983–84; and (b) 1985–87.

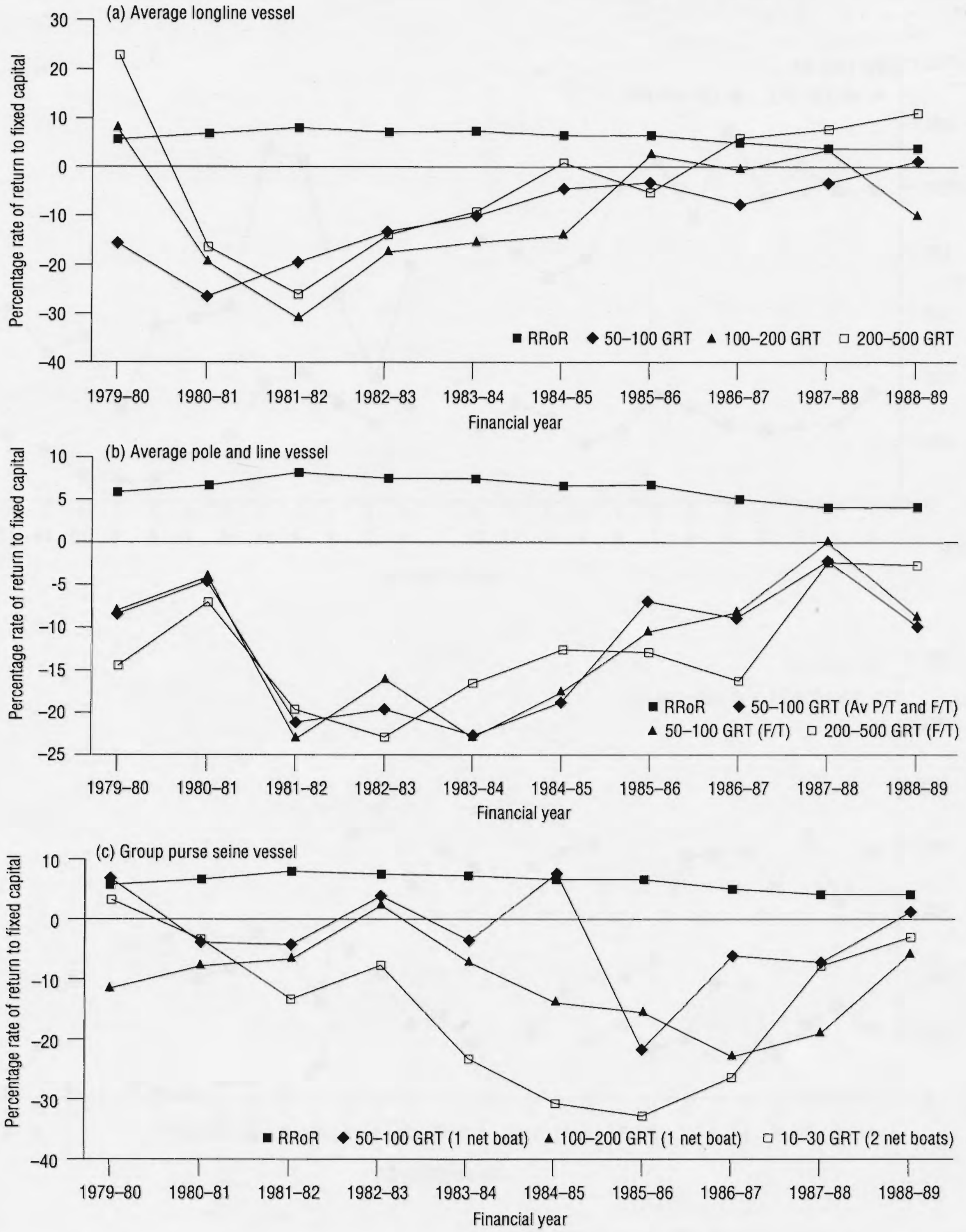

Figure 13.6 Rates of return: (a) average longline vessel; (b) average pole-and-line vessel; and (c) average group purse seine vessel. P/T = part time; F/T = full time; RRoR - Required rate of return; based on return to capital (A).

Table 13.1 Vessel-days fished and estimated rent, Japanese longline fleet, Papua New Guinea's exclusive economic zone, 1983–86, (a) 50–100 GRT

Year	Month	Vessel-days fished	Rent (¥m)	Rent as % of gross revenue monthly	Annual average
1983	1	493	50.411	17.7	
	2	496	61.741	20.7	
	3	533	36.076	12.4	
	4	483	28.909	11.6	
	5	589	261.886	49.4	
	6	451	89.951	30.5	
	7	541	211.994	46.2	
	8	503	126.680	35.6	
	9	390	79.965	31.0	
	10	357	79.846	32.9	
	11	400	91.552	33.4	
	12	418	136.888	41.8	30.3
1984	1	374	56.802	25.0	
	2	197	26.393	22.7	
	3	329	–5.963	–4.1	
	4	539	29.435	9.7	
	5	559	6.094	2.1	
	6	311	6.226	3.8	
	7	290	11.170	7.0	
	8	281	45.397	24.1	
	9	148	4.674	5.8	
	10	262	68.201	33.8	
	11	233	24.969	17.4	
	12	307	96.177	38.1	15.4
1985	1	395	71.589	26.2	
	2	310	52.892	25.1	
	3	420	42.225	16.5	
	4	337	126.076	47.8	
	5	393	180.860	53.0	
	6	390	105.009	39.8	
	7	386	137.389	46.6	
	8	221	87.575	49.3	
	9	190	38.185	33.0	
	10	408	58.123	25.9	
	11	393	48.037	23.0	
	12	366	33.548	18.3	33.7
1986	1	366	25.009	14.3	
	2	392	63.427	28.4	
	3	338	23.913	14.8	
	4	458	4.198	1.9	
	5	417	–37.180	–23.2	
	6	153	0.057	0.1	
	7	228	–10.216	–10.5	
	8	262	–20.075	–19.3	
	9	206	4.264	4.2	
	10	189	81.062	47.5	
	11	253	–10.651	–9.8	
	12	240	18.009	13.7	5.2
1987	1	181	12.792	13.0	
	2	73	14.393	29.4	
	3	9	–1.292	–43.6	–0.4

Table 13.1 (contd) Vessel-days fished and estimated rent, Japanese longline fleet, Papua New Guinea's exclusive economic zone, 1983–86, (b)100–200 GRT

Year	Month	Vessel-days fished	Rent (¥m)	Rent as % of gross revenue monthly	Annual average
1983	1	176	-11.491	-9.0	
	2	125	-20.711	-26.7	
	3	122	-17.582	-22.4	
	4	115	-13.232	-19.7	
	5	122	45.414	34.8	
	6	151	72.254	40.7	
	7	171	55.532	31.7	
	8	116	32.505	28.6	
	9	93	23.020	26.2	
	10	134	8.531	8.4	
	11	156	50.537	31.7	
	12	122	45.330	34.7	13.2
1984	1	152	-2.019	-1.9	
	2	124	44.062	33.7	
	3	156	-17.389	-19.0	
	4	204	-64.220	-51.0	
	5	191	-87.484	-96.7	
	6	104	-52.083	-116.2	
	7	69	-27.771	-76.1	
	8	34	-4.507	-16.6	
	9	32	-1.963	-7.0	
	10	41	1.393	3.5	
	11	82	-21.325	-38.7	
	12	100	-8.399	-9.9	-33.0
1985	1	111	-28.379	-37.8	
	2	150	-30.108	-27.5	
	3	117	-27.314	-33.4	
	4	64	28.564	40.2	
	5	180	89.781	42.9	
	6	182	80.590	40.0	
	7	94	12.163	16.3	
	8	80	12.199	18.7	
	9	112	0.150	0.2	
	10	94	-14.358	-29.9	
	11	168	-7.062	-6.8	
	12	107	-8.398	-13.4	0.8
1986	1	88	-17.638	-43.3	
	2	131	-8.060	-10.2	
	3	116	3.042	3.8	
	4	193	-46.356	-54.1	
	5	233	-66.059	-70.8	
	6	53	-0.499	-1.4	
	7	7	0.869	15.4	
	8	22	-5.558	-58.5	
	9	26	-7.293	-69.5	
	10	7	5.850	55.0	
	11	11	-3.811	-102.6	
	12	27	-8.059	-77.4	-34.5
1987	1	14	0.716	7.0	7.0

Table 13.1 (contd.) Vessel-days fished and estimated rent, Japanese longline fleet, Papua New Guinea's exclusive economic zone, 1984–86, (c) (200–500 GRT)

Year	Month	Vessel-days fished	Rent (¥m)	Rent as a % of gross revenue monthly	Annual average
1984	10	2	–2.156	–460.1	
	11	87	–47.407	–71.0	
	12	19	–7.385	–42.1	–191.1
1985	9	12	–6.970	–165.3	
	10	73	–16.601	–32.3	
	11	43	–14.818	–58.6	
	12	40	–13.735	–58.3	–78.6
1986	1	28	–16.930	–184.6	
	2	12	–3.572	–46.9	
	3	20	–6.653	–55.5	–95.7

Table 13.2 Vessel-days fished and estimated rent, Japanese pole-and-line fleet, Papua New Guinea's exclusive economic zone, 1983–87 (200–500 GRT)

Year	Month	Vessel-days fished	Rent (¥m)	Rent as a % of gross revenue monthly	Annual average
1983	1	8	–6.057	–271.0	
	9	11	27.915	70.5	
	10	164	119.662	40.8	
	11	15	–2.921	–22.5	–45.6
1984	2	11	–1.902	–19.5	
	3	7	–3.441	–86.5	
	4	1	–1.008	–1323.5	
	10	2	–2.168	zero revenue	
	12	20	–11.709	–117.4	–515.6
1985	1	1	–0.058	–5.7	
	2	80	–27.496	–46.4	
	3	12	–10.383	–395.6	
	4	3	–1.666	–89.0	
	11	13	–7.809	–103.8	
	12	10	–2.347	–24.9	–110.9
1986	1	14	4.743	22.3	
	2	7	–4.954	–150.0	–63.9
1987	1	3	–2.954	zero revenue	

The results indicate that the successful category of vessels (small longliners) generally earned rents in excess of the 6% of gross revenue levied as an access fee by Papua New Guinea. However, the other categories earned mostly negative rents. This raises the question of why these latter vessels continued to operate in the exclusive economic zone over the period. As long as vessels are recovering their variable costs–costs of fuel, materials, labour, vessel maintenance–fishing is a better option to owners than leaving vessels idle. Any excess of revenue over variable cost is a quasi-rent to capital–a sum in excess of that required to keep the vessel operating in the short run, but less than the sum required to cover operating costs and yield the required rate of return to capital in the long run. The required returns from operating in Papua New Guinea waters depend upon opportunities in other fishing grounds, as well as on vessel operating and capital costs. Thus the evidence presented here does not offer any clear guide to the appropriate level of the access fee, other than suggesting that access fees differentiated by vessel size and type may well be warranted.

Finally, the results presented in this paper provide some guidance to Papua New Guinea in the possible development of a domestic fishery. It appears that a fleet of small longliners (50–100 GRT) offers the best chance of operating a profitable locally based fishery, assuming that domestic operators could match the catch rates, prices and costs of the Japanese fleet.

Table 13.3 Days fished and estimated rent for Japanese group seine operations, Papua New Guinea's exclusive economic zone, 1985 and 1986

Year	Days fished	Rent (¥m)	Rent as % of gross revenue
1985	7		
	13		
	8		
	13		
	1		
	18		
	6		
Total	66	–559.596	–146.456
1986	6		
	4		
	6		
	10		
	7		
Total	165	–1902.57	–1039.47

Part IV

Fisheries Law, Regulations and Monitoring

Chapter

14

Some Aspects of the Modern Law of the Sea: a South Pacific Fisheries Perspective

I. Leaney

Introduction

The known resources of the world's seas and oceans comprise both the renewable, flow resources of fisheries, and nonrenewable stock resources such as sea-bed mineral deposits. Many people have both the desire and the technology to exploit some or all of those resources. In the context of fisheries resources, it has been traditionally assumed they were virtually inexhaustible, and accordingly, each potential participant has been granted a high degree of freedom to engage in fishing activity. Typically, the 'special interests' of individual coastal states took second place to the common interest deemed to be served by open access (Chen 1989: 131). Contemporary realities have rendered these earlier assumptions invalid.

Modern international legal instruments have attempted to address the problems posed by property rights, or more specifically, the lack thereof. In that context, the law of the sea as it applies to south Pacific states and their fisheries and economies has undergone major changes in the last 20 years. The traditional system of largely unregulated open access to fisheries resources by the inhabitants of those areas as well as distant water fishing fleets, has been replaced by a system of national and international regulation. This has taken the form of treaty and convention, statute, and the development of customary law. Multilateral treaties such as the 1982 Law of the Sea Convention are often the codification of customary law practices and come about in response to conflicting national claims and technological change. Even if conventions are not yet in force (as is the status of the Law of the Sea Convention), their current significance is in opening up awareness and incentives for individual nations and subregional groups to follow up with their own legislative instruments and changes in maritime practices. This paper will discuss some of these domestic legislative instruments, as well as two of the most significant regional agreements – the 1982 Nauru Agreement and the 1992 Arrangement for the Management of the Western Pacific Purse Seine Fishery.

These changes have had significant impacts on the distribution of access to living resources and the benefits derived from their exploitation (Kwiatkowska 1989). This is significant in light of the importance of fishery products to the economies of many south pacific states, which for the purposes of this discussion are taken to be the member states of the South Pacific Forum Fisheries Agency, namely, Australia, Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu and Western Samoa.

Law relating to fisheries

Property rights

Coastal states' common property rights in fisheries have been slow to emerge. The resources of those fisheries, namely the fish species, are commonly transitory or migratory and the development of property rights in such resources has not mirrored the development of land-based resource property rights. There has been a traditional reluctance to say that anyone could have ownership rights over something that you can't fence in. In addition, whilst law can change in a number of ways, such as the development of customary law, common law, legislative initiative and treaties, not all of these have been appropriate in fisheries law. The effective use of the courts in bringing about changes in property law has been limited as litigation and the common law rights evolving process work only when there is individual conflict or dissatisfaction with the interpretation of property rights. But when in ocean and tidal waters there was only a public right of fishing, there were no private rights to dispute. Related to that is the fact that depletion of some fish species is a relatively recent experience, and fishers have not collectively pressed for a solution, thus allowing legislators to maintain faith in the traditional scheme. Furthermore, in relation to the comparative economic and political strength of the coastal states and the distant water fishing nations, enforcement of domestic laws against foreign nations has been seen as virtually impossible, even leaving aside jurisdictional issues.

In addition, common practice can change through spontaneous and violent means. This has not, however, been a characteristic of southern Pacific fisheries development. Fishers in these waters are, understandably, less worried about the long-run implications of open-access than they are by other problems such as catching enough to provide for their own families in the immediate future.

United Nations Convention on the Law of the Sea (UNCLOS III)

Pre-UNCLOS III developments

Up until the 1970s, the majority of nations had rights of control over a 3n mile band of waters immediately off their coasts. All remaining waters were open access. From a south Pacific states perspective, pressure to lay claim to a larger area of ocean was induced by two developments. First, many small-scale fisheries are concentrated in inshore areas and with the increasing demand occasioned by growing populations and urbanisation, the impact on inshore resources had begun to become a matter of concern for governments. National policies centred on trying to induce or force a shift away from the more fragile and heavily fished reef and lagoon resources and towards the comparatively underexploited resources of the outer reef slopes and the commercially viable, highly migratory tuna and billfish species. Second was the growing concern about the technologically superior fishing fleets of other nations who were able to harvest from the same waters relied on by local inhabitants, unlicensed and to the economic detriment of the local economy.

Ironically it was the United States, one of the staunchest supporters of the 3 n mile territorial sea doctrine, that opened an era of extensive maritime claims. In 1945, United States President Truman issued a proclamation[1] creating fisheries conservation zones outside the traditional limit, thus giving the United States fishing boats exclusive rights to the fish within the newly extended U.S. waters.[2] Whilst this proclamation was carefully drafted to balance the rights of concerned states within the high seas regime, the same cannot be said for most of the bolder initiatives provoked. By the beginning of the 1970s, a number of developing countries had unilaterally extended their maritime resource jurisdiction, with the effect being to threaten the traditional law of the sea.[3]

When the first United Nations Convention on the Law of the Sea opened in 1958, it faced jurisdictional claims ranging 3-200 n miles. UNCLOS I adopted four conventions but unfortunately could not agree on territorial seas maximum breadth or the extent of states'

---

[1] That proclamation was known as the Proclamation with Respect to Coastal Fisheries in Certain Areas of the High Seas. He also made the Proclamation with Respect to the Natural Resources of the Subsoil and Seabed of the Continental Shelf.

[2] Proclamation No 2667 (The Subsoil and Sea Bed of the Continental Shelf) 10, Fed. Reg. 12, 303 (1945).

[3] Attard (1987:3-10) provides a good summary of the early claims to extended jurisdiction. Among them were Panama (1946), Nicaragua (1947), Chile (1947), Costa Rica (1948), El Salvador (1950), Honduras (1951), Norway (1951).

exclusive fishing rights.[4] There were three conflicting approaches advocated during these early negotiations. The first was one of extension of jurisdiction and the exclusion of foreign states from fishing in the new zone without coastal state permission (the 'zonal' approach) (McRae and Munro 1987; Churchill 1983). A second approach, the 'species approach', was supported by the United States and Canada. It sought to vary the extent and nature of state authority over the resource by reference to species rather than by establishing absolute authority over all species within a specified distance from the coast.

The third approach was a combination of the 'zonal' approach with the 'preferential rights' aspect of the 'species' approach, and emerged in the opinions of the two most significant distant water fishing nations, Japan and the USSR, and the judgment of the International Court of Justice in the Fisheries Jurisdiction Case.[5] The key was to be the dependence of the coastal state upon the fishery. A coastal state that was unable to demonstrate that its economic dependence on the resource required it to take all or the substantial part of the catch, could not prevent other states from having access to it. It constituted a denial of the exclusive right of the coastal state to 'ownership' of the living resources in the oceans off its coast. However, the nature of the coastal state's right would not vary species by species.

Both of these later approaches fell from favour, and the desire for the simplicity of a uniform zonal approach led to the ultimate adoption of the uniform 200 mile exclusive economic zone in UNCLOS III.

The Law of the Sea Convention: rights, duties and implications

The Law of the Sea Convention was concluded on 10 December 1982, and will come into force 12 months after the 60th acceptance. One hundred and fifty-nine nations signed the Convention, but to September 1992, only 50 had ratified it.[6] The economic importance of living resources was the main motivation behind the establishment of the exclusive economic zone, as mineral resources were already subject to exclusive control of the coastal state under the continental shelf regime.[7] Accordingly, UNCLOS III provided for broad exclusive economic zones and fisheries zones embracing most commercially exploitable fish stocks, but in a manner which allows areas of mediation between 'all-power' and 'all-freedom': territorial sea, contiguous zone, international strait, archipelagic sea, exclusive economic zone, continental shelf, deep seabed and ocean floor.

The conference proceedings of the Law of the Sea Convention sought to accommodate, in dealing with a wide range of issues, competing and conflicting demands and interests – notably between the major maritime powers and the coastal states; between coastal states and land-locked and geographically disadvantaged states; between food supply through optimum yield and conservation of living resources; between coastal fishing and distant water fishing; between states with broad and narrow continental shelves; and between developed and developing nations (Chen 1989: 133).

---

[4] Those conventions are: Territorial Sea and Contiguous Zone Convention (adopted 12 n mile Contiguous Zone); High Seas Convention (made clear by definitions that coastal states had no powers of restricting freedom of the seas which included both for coastal states and noncoastal states freedom of fishing); Continental Shelf Convention (sovereign rights over the shelf); Fisheries convention (recognised explicitly coastal state's special interest in maintenance of the productivity of the living resources in any area of the sea and the rights to initiate unilateral measures of conservation).

[5] In this case, Iceland was concerned with the quantity of the catch taken from its waters by foreign fishing vessels. To reduce this catch, Iceland announced on 1/10/72 that it would extend its fisheries zone to 50 n miles. The United Kingdom, Germany and others wanted it declared that this action had no international law basis. The Court declared that Iceland could claim preferential rights with respect to the fishery resources in question; and that the principle of reasonable regard for the interests of other states enshrined in Article 2 of the 1958 High Seas Convention required Iceland and the United Kingdom to have due regard to each other's interests, and to the interests of other states in those resources. The failure of the court to take any position on extended coastal state jurisdiction was unfortunate. Indeed, its indecision encouraged further extensive claims.

[6] Notable here is that the Convention was not signed by the United States, and has not yet been ratified by Australia, Papua New Guinea or Nauru.

[7] Kwiatkowska (1989:6) notes that exclusive economic zone rights and jurisdiction have to a significant extent evolved from the traditional doctrine of the continental shelf, which first sanctioned the extension of the coastal states' resource rights beyond the territorial sea.

Many of the provisions of the Convention repeat principles enshrined in the earlier instruments. Some provisions, virtually identical to those already codified in the Geneva Conventions and others, have since become customary rules, developed as general law by the practice of states during the 10-year period in which the Convention was sitting and partly under the influence of its drafts. Many of the 50 countries which have ratified the Convention have been active in developing domestic laws which enshrine the principles of the Convention.

The relevant provisions of the Law of the Sea Convention providing the basic framework for the exclusive economic zone are Articles 55, 3 and 57. Article 55 of the Convention defines the exclusive economic zone as the 'area beyond and adjacent to the territorial sea... under which the rights and jurisdiction of the coastal state and the rights and freedoms of other States are governed by the relevant provisions of this Convention'. Article 3 defines the breadth of the territorial sea 'up to a limit not exceeding 12 nautical miles, measured from baselines', and Article 57 states that the breadth of the exclusive economic zone 'shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured'.

The rights and freedoms of coastal and other states referred to in Article 55 are contained in Articles 56 and 58. Article 56 lists the rights, jurisdiction and duties of the coastal state in the exclusive economic zone. The coastal state has sovereign rights in the exclusive economic zone for the purpose of 'exploring and exploiting, conserving and managing' the natural resources of those waters (Article 56(1)(a)). In exercising its rights and performing its duties under this Convention in the exclusive economic zone, the coastal state shall have due regard to the rights and duties of other states (56(2)). Article 58 covers the rights and duties of other states in the exclusive economic zone. Of significance is 58(3) which provides that in exercising their rights and performing their duties under this Convention in the exclusive economic zone, states shall have due regard to the rights and duties of the coastal state and shall comply with the laws and regulations adopted by the coastal state in accordance with the provisions of this Convention and other compatible rules of international law. This has to be read in light of 58(1) which indicates that there is a presumption that all states will retain freedoms of ocean usage, such as navigation, overflight and other peaceful purposes, which are not resource-related.

Article 62 of the Convention is an important modification to the simplicity of a purely zonal approach–the coastal state must grant foreign fishing vessel access where it does not have the capacity to harvest the entire catch itself (Article 62(2)). However, under Article 61 the coastal state has the discretion and responsibility for setting the total allowable catch quantity. In the interest of obtaining maximum net benefits from the near-monopoly position over some particular species of fishery resource 'capital' coastal states have 'inherited' through the Convention provisions, the Convention exhorts them in Article 62 to promote the objective of 'optimum utilisation of the living resources' within the exclusive economic zone. However, the Convention is silent on what is to constitute optimum utilisation. In principle, a country is free to use the entire capital (i.e harvest the total allowable catch) itself. If it, however, finds that it does not have the capacity to do this, the Convention stipulates in Article 62(2) that it shall, through agreements or other arrangements, give other countries access to the surplus, having particular regard to the provisions of Articles 69 (rights of land-locked states) and 70 (rights of geographically disadvantaged states).

Foreign access depends on the availability of a surplus, on the conclusion of relevant agreements and arrangements between coastal and flag states, and is subject to detailed conditions specified in Article 62(3–5). These include: the taking into account of the significance of the living resources of the area to the economy of the coastal state concerned; the requirements of land-locked and geographically disadvantaged states and developing states in the subregion; the need to minimise economic dislocation in states whose nationals have habitually fished in the zone or which have made substantial efforts in research and identification of stocks; and compliance by nationals of other states fishing within an exclusive economic zone with the conservation measures and other terms and conditions established in the laws and regulations of the coastal state.

These obligations impose restrictions on the coastal state, but the idea of 'exclusivity' or 'sovereign rights' is not diminished by the existence of specific obligations upon the coastal state in relation to the exclusive economic zone. In practice, therefore, a state is able to manage the resources of its 200 mile zone in accordance with its own domestic policies and preferences. Provided that it does not act in a way that endangers conservation or does not arbitrarily refuse access by foreign vessels to a surplus it has declared, the coastal state would appear to be free to act as it pleases. However, the need for real cooperation between coastal states is nowhere more evident than in the context of highly migratory and transboundary fish species. Such restrictions on its courses of action are hardly inconsistent with proprietal rights, nor do they relegate the coastal state to the status of a 'steward' or 'custodian' (McRae and Munro 1987:104).

South Pacific state practice

Resources such as the various tuna species of south Pacific state fisheries are renewable, and can provide the means for island states to build a self-sustaining economy which will, over a period of time, contribute significantly to their economic well-being and self-sufficiency. The key to such success is sound management and conservation. All the south Pacific states have extended their maritime zones of jurisdiction beyond the traditional territorial sea limit. The benefits of doing so were outlined by Mr Rabbie Namaliu, Papua New Guinea Minister for Foreign Affairs and Trade, in a statement to the Final Session on UNCLOS III:

> In particular we have benefited from the relevant provisions of the Convention dealing with fisheries matters by concluding fisheries agreements with our neighbouring countries ... the general exercise of extended jurisdiction by the coastal states over certain maritime zones, the provisions dealing with protection and preservation of the marine environment, creation of the new regime of archipelagos, the recognition of coastal state's exclusive jurisdiction over economic resources in certain parts of maritime zones. (Namaliu 1983:16).

The states of the south Pacific are obviously linked by geography, and to a certain extent share the same path and level of economic and sociological development, but there is at the same time significant scope for divergence in attitudes and policies relating to their fisheries. Much of this can be traced to the differing size and richness of their exclusive economic zones, some of it comes from past experiences with foreign fishing fleets, and some of it stems from individual culture, which may attribute to fishing and a fishing-based lifestyle a greater or lesser significance.

Avenues of fisheries development and associated problems

The diversity in the economies of the countries of the south west Pacific means that the goals of development and management for similar types of fisheries in different countries could well vary greatly. Some of the variables which need to be taken into account are the availability of skilled fishers, labour, markets, capital, infrastructure for handling and processing the catches, boats and gear, fuel and back-up facilities.

Subject to the above, the following avenues of fisheries development may be identified as potentially open to south Pacific states (Kearney 1982: 7; Teiwaki 1987: 274)

- recreational or sport fisheries
- subsistence fisheries
- artisanal fisheries – surplus for sale to locals
- commercial fisheries – large-scale support facilities and marketing infrastructure
- export fisheries – local fishers fishing independently, large-scale joint ventures, or foreign enterprises fishing to supply markets outside the country
- foreign fisheries – distant water fishing nations in 200 mile exclusive economic zones with a minimum of contact with the coastal state.

Catches by foreign fleets dominate fisheries production from the region as a whole.

Very broadly, policy objectives revolve around three major concerns: the desire to develop national tuna fishing and processing industries; the wish to control and extract the maximum benefits from foreign fishing in their waters; and the need to coordinate their policies on both the exploitation of these species with other states in the region and on the cooperative relations with distant water fishing nations. Of these, the first is accorded the highest priority for the medium term. All of the island states of the region have a strong desire to increase their involvement in the fisheries around them, and the international acceptance of extended fisheries jurisdiction has undoubtedly given them new rights and powers to do so. However, increased involvement by coastal states does not necessarily imply increased participation by the nationals themselves in the fisheries. A whole range of possibilities exist, from the development of wholly owned, operated and controlled local fisheries, through numerous joint venture alternatives, to the generation of revenue from totally foreign fleets. Of course, none of these possibilities has to be pursued exclusively, and so some balance of local and foreign enterprises could be the most rewarding.

In the short term it is likely that coastal states will benefit from revenue gained through catch taxes, entry fees and licence fees from distant water fishing nation vessels, but a potential for increased participation by coastal states in future development certainly exists. Hence, the growth of domestic fisheries (in any or all stages of production) ideally sees the gradual, parallel decline of foreign control. The evidence from Fiji, Solomon Islands and Papua New Guinea suggests, however, that the considerable effort expended by island states on the development of national tuna industries has not been matched by the gains. Very few large-scale fisheries have been established to meet local demand. Most of the limited number of sizeable fisheries that do exist are export-oriented and, even though fish exports from the region are very substantial and still increasing, the quantities of fisheries products imported into the area in recent years has not decreased (Kearney 1982:6). It seems surprising at first that numerous export fisheries have been developed in the Pacific islands when it has proved difficult to provide enough fish for local consumption, but it is the very nature of the differences between export-oriented and local fisheries that emphasises the real problems of developing and managing fisheries in this region.

If the coastal states pursue the option of developing their own fisheries and processing procedures, then at least four major problems will need to be overcome: seasonal fluctuations in abundance; expensive vessels; cost and availability of fuel; and lack of economies of scale. It is the development of infrastructure necessary for the creation and maintenance of commercial scale fisheries that has proved the most common problem in coastal state fisheries development. Even though there is great diversity in the coastal fisheries resource in island states, the total harvest from them is not great. Furthermore, for the small-scale coastal fishers there are many processing and marketing problems that hinder this type of development. The remoteness of many islands normally results in abnormally high purchase, maintenance and fuel costs for all processing and refrigeration equipment.

Case study: Papua New Guinea

Papua New Guinea declared its 200 mile 'Declared Fisheries Zone' by proclamation in March 1978. This zone covers 2.3 million km^2 of the western Pacific and it is the third largest exclusive economic zone in the region.

The Papua New Guinea fisheries sector can be divided into three sectors: a domestic traditional sector with a commercially oriented subsector directed towards supplying foreign ships as well as the domestic market; a domestic nontraditional sector with an export as well as domestic orientation; and a foreign fishing sector with an enclave character and only minimal interaction with the domestic sector (Mfodwo and Tsamenyi 1992: 76).

The Papua New Guinea government has continued to encourage the operation of distant water fleets because the country's domestic harvesting capacity is insufficient to fully exploit its tuna resources, and because, through the payment of access fees and other statutory charges provided for in the legislation discussed below, government revenue is generated. The dominance of agriculture and fisheries as major economic resource bases in most of these countries means that large-scale development projects as such are often beyond their funding capacities. Locally based tuna fishing was undertaken by a number of companies from 1970–1982, but operations halted in 1982. Externally based interests which have sought access without necessarily basing their operations locally have been from Japan, since the end of World War II, and more recently, fleets from Cayman Islands, Honduras, Indonesia, Japan, Korea, Mexico, Panama, Philippines, Taiwan and the United States have joined operations.

Papua New Guinea fishing and processing operations

Papua New Guinea has generally failed to derive appropriate income from its substantial resources in this area (Connell 1989). Onshore processing and handling facilities in Papua New Guinea are limited in character and quantity. Accordingly, most marine produce for export is processed almost entirely on-board the fishing vessels equipped with processing and freezing facilities.

Papua New Guinea has been trying to attract private investors to establish shore based tuna fishing/ processing operations since the late 1970s with no success. None of the major tuna processors with extensive operations in their own countries are interested in financing the development of a new industry in another country unless very generous concessions are negotiated.[8] The Japanese and U.S. fishing interests have not been interested in investing in these areas when it is possible for them to purchase fishing licences at a nominal fee, fish in the area and process the catch in their own canneries. Under a licensing scheme with no downstream participation by islanders in fishing, processing, transporting or marketing the main beneficiaries of the tuna resources in the western Pacific are distant water fishing nations.

The major change to policy in Papua New Guinea which will have the greatest effect on foreign fishing vessels is the introduction of Article 62(4)(h) of the Law of the Sea Convention which allows the coastal state to require the landing of all or any part of the catch of foreign vessels in the ports of the coastal state.[9]

Improved management policies will enable Papua New Guinea to closely monitor the catch rate, and take appropriate action to limit the total allowable catch within their area. Similar action by the neighbouring island nations, as foreshadowed in recent times, will strengthen the region's ability to ensure the long-term sustainability of the resource. New proposed incentives for vessels landing tuna for processing in Papua New Guinea, such as exemption from export duties, together with its geographical proximity to the fishing grounds, will encourage operators to sell to domestic projects, ensuring supply. In respect of the sale of the product, some will be sold into the domestic market thereby substituting imports, but the majority will be destined for international markets, in which Papua New Guinea as a participant to the Lomé Convention has a substantial advantage as it is entitled to sell into the EEC duty free. Non-Lomé countries in contrast pay approximately 24% on the f.o.b value.

Papua New Guinea's maritime zones in domestic and international law

Papua New Guinea declared its fisheries zone under its *National Seas Act 1977*, which was part of a package of acts bringing Papua New Guinea's maritime zone jurisdiction into line with the worldwide trend towards extended jurisdiction evident in the late 1970s.[10] Papua New Guinea has signed but not ratified the Law of the Sea Convention. It is, however, debatable as to whether Papua New Guinea is relying on the Law of the Sea Convention as the basis for these extensions anyway. The reason for this is that the Law of the Sea Convention does not provide for a specific regime of a fisheries zone as such (Tsamenyi and Blay 1989: 44). By claiming an exclusive economic zone, a state acquires a fisheries zone, but a state cannot acquire an exclusive economic zone by claiming a fisheries zone. For states such as Papua New Guinea, which continue to claim only fisheries zones, the legal basis of their claims are not clear. The principal disadvantage with a fisheries zone, namely that it does not provide jurisdiction over the exploitation of nonliving resources, is, however, not relevant in Papua New Guinea's case because of the existence of additional legislation to

---

[8] Ayu (1993: 5, 29) taking a more critical view of the performance of the Papua New Guinea government, comments on the many opportunities during the 1980s for Papua New Guinea to develop its own tuna canneries, but during which time none got off the ground. Ayu believes that by 1992, Papua New Guinea could have had over five fish canneries as evidenced by the number of proposals made since 1983.

[9] A word of caution is necessary: often the words 'attract' or 'promote' will be used to describe the influence a Papua New Guinea cannery will have on foreign business and domestic development respectively–but it is important to keep in mind that frequently the wording of the legislation is such that the foreign vessels are 'forced' to use those ports.

[10] *Interpretation (Application of Laws) Act 1977*, the *Continental Shelf (Living Natural Resources) (National Sea) Act 1977*, the *Fisheries (Declared Fishing Zone) Act 1977*, *Petroleum (Submerged Lands) (National Seas) Act 1977*, the *Whaling Act* and the *Tuna Resources Management (National Seas) Act 1977* (Mfodwo and Tsamenyi 1992:80). These acts are discussed in greater detail in the following chapter.

cover this. Hence this distinction does not pose any problems for the issues currently under discussion.

The licence is the principal legal instrument authorising activity which would otherwise be prohibited. The Papua New Guinea government does not discriminate in licensing tuna vessels on the basis of flag state or type of tuna vessel. Access will only be refused if previous licensing conditions have been infringed by the vessel; the vessel owner has infringed conditions in the past for another vessel and the infringement has not been rectified; the vessel is not listed on the Forum Fisheries Agency's Register of Foreign Fishing Vessels; or the vessel has been removed from the Register (Doulman 1987a: 18). Subject to these limitations, the principal acts envisage that the relevant minister may issue licences, prohibit activities and regulate fishing methods, equipment used, areas fished, quantities caught, type of fish processing and transshipment. None of the principal acts provide any process of appeal or challenge in relation to the exercise of these powers of prohibition. In addition, the minister may cancel licences if provisions of the licensing structure are contravened.

As specified in Papua New Guinea's *Fisheries (Declared Fishing Zone) Act 1977*, access fees paid by distant water fishing vessel owners consist of three components, a Fishermen's Licensing Fee, a Boat Licensing Fee and an Operation Fee. Unlike the other two, the last is not nominal and is used to extract a financial return from the exploitation of the resource (Doulman 1987a: 20).[11] Under section 5A of the Fisheries Act, the minister shall consider the following factors in exercising his or her discretion: whether such states have cooperated with Papua New Guinea in, and made substantial contributions to, the development of the Papua New Guinea fishing industry, fishery research and the identification of fishery resources; any rights of a reciprocal nature granted to Papua New Guinea by such states; whether such states have cooperated with Papua New Guinea in enforcement and with respect to the conservation and management of fishing resources; whether, and to what extent, the fishing vessels of such states have traditionally engaged in such fishing; and such other matters that are deemed to be relevant (Mfodwo and Tsamenyi 1992: 98).

In addition to domestic considerations and requirements with respect to licensing foreign fishing vessels, Papua New Guinea is obligated to abide by certain formally agreed arrangements–without derogation of its sovereign rights. In particular, Papua New Guinea and six other countries having contiguous exclusive economic zones (the Nauru Group) have agreed to progressively harmonise terms and conditions of access for foreign fishing vessels. This point will be taken up in more depth in the following section.

Reliance on regional cooperation

A significant problem that arises in south Pacific state practice is that while a large number of developing countries assert sovereign rights in regard to 'exploration, exploitation, conservation and management', they only specify management and conservation objectives in very general terms, at the same time enforcing their right to decide who else fishes there. This reflects the lack of experience, technical and financial resources on the part of those countries in conservation, rational management and optimum utilisation of exclusive economic zones. The proposition that international cooperation is required for the effective utilisation of tuna resources has become almost universally accepted. In addition to the acceptance of the need to endorse multilateral conventions for the preservation of fisheries resources, the approach of the south Pacific states to fisheries problems is characterised also by heavy reliance on regional cooperation and the establishment of organisations such as the South Pacific Commission (SPC) and the Forum Fisheries Agency to provide, in theory at least, support to members in the negotiation of subregional, bilateral and distant water fishing nation access agreements. The need of the coastal states in the south Pacific region to have a regional organisation with the mandate to assist them to manage the tuna resource arose out of the fact that most of the states could not afford to police their vast exclusive economic zones.

The creation of regional agencies is perceived by the individual nations concerned as an integral part of the struggle for relative independence in decision-making within a still very dependent setting. One of the

[11] Unlike some Pacific island countries, Papua New Guinea does not accept aid in the form of goods or services as part payment for access to its tuna fisheries.

arguments put forward for regional cooperation is that, armed with information provided by the Forum Fisheries Agency, member states are better equipped to negotiate with distant water fishing nations.

The south Pacific state attitudes towards distant water fishing nations are often based on financial considerations. Revenue from access fees was the main criterion in Kiribati's policy of encouraging the major distant water fishing nations to fish within its extensive exclusive economic zone from 1978 to 1984.[12] Such access agreements can generally be satisfactory from the coastal state's point of view if the distant water fishing state demonstrates at least an apparent willingness to comply with the licensing terms and conditions of the coastal state. Lodge (1992: 227) comments on the increasing reluctance on the part of distant water fishing nations to accept the imposition of what are perceived as regional attempts to impose additional controls over foreign fishing activity, and a misunderstanding as to the basic nature and function of minimum terms and conditions which are accordingly imposed.

Despite the potential for good relations, or at least relations of mutual tolerance and need, to exist, the frequent disparities in negotiating power cannot always be hidden behind a mask of good will. Accordingly, the need for a collective approach to the management of exclusive economic zone fisheries resources by the South Pacific States rests on three crucial factors (Tsamenyi 1986: 31):

- The amount of ocean space under the jurisdiction of the south Pacific states, coupled with the financial burden of managing the resources in these zones is enormous. Nearly all south Pacific states have claimed exclusive economic zones in conformity with the Law of the Sea Convention. A few countries, like Papua New Guinea have not formally declared exclusive economic zones but have claimed fisheries zones of 200 miles with virtually identical rights. More than 6 million square n miles of the Pacific Ocean have come under the national jurisdictions of these countries, which are characterised by weak economies and a lack of technical expertise. To achieve maximum benefits from the exploitation of the newly acquired exclusive economic zone resources, there is a need to protect the zones against overuse.
- The significance of the fisheries stock to the south Pacific states and the highly migratory nature of the important species in relation to the size of the exclusive economic zone, makes what happens in one portion of a stock's range affect the stock throughout its entire range.[13]
- Regional cooperation is also a response of these countries to the implementation of decisions taken at UNCLOS III. Article 63 calls for cooperation. Underlying this is an assumption that an unregulated fishery must inevitably overexploit the resource. The authority to impose terms and conditions of access is found in article 62(4) of the Law of the Sea Convention which requires nationals of states fishing in the exclusive economic zone to comply with the conservation measures and other terms and conditions established in the laws and regulations of the coastal state, which must be consistent with the Convention. The Fiji Fisheries Division, for example, acknowledges that as the fisheries sector becomes increasingly developed and commercialised, fishers will become increasingly able to support their own infrastructural and capital development, whilst certain natural resources will come under greater stress. The Fisheries Division must ensure that legislative and procedural mechanisms are in place to ensure that the maximum long-term economic benefit can be gained from these resources (Fiji Fisheries Division 1991:1).

In an address to the Papua New Guinea-New Zealand Society, Auckland, on October 20, 1982, Paulias Matane, Secretary of the Papua New Guinea Department of Foreign Affairs and Trade, advocated regionalism on a broad scale to protect the south

[12] In Kiribati's case these are Japan, South Korea, United States and USSR.

[13] In contrast, however, note Hilborn and Silbert (1988) who reject the argument that most tuna species are highly migratory and argue that while individual fish occasionally move long distances, this behaviour appears to be exceptional for skipjack and yellowfin. If they are correct, then the strength of this particular argument for regional cooperation is somewhat modified.

Pacific region from being caught up in a global power play:

> While I do not question the value of the UN as a body dedicated to international peace and security, I cannot help but wonder whether individual nations loosely grouped along regional lines could not do more to help aid the UN in upholding the principles of international justice and integrity (Matane 1983: 19).

The next section of this chapter examines two specific examples of south Pacific regional agreements and their provisions, and comments on the appropriateness and effectiveness of them. The first of these is the 1982 Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest, and the second is the Arrangement for the Management of the Western Pacific Purse Seine Fishery 1992.

The Nauru Agreement 1982

Background

One of the most significant regional developments since the establishment of the Forum Fisheries Agency has been the emergence of the subregional group–the Nauru Group–and the influence of this group on regional fisheries policy. Between them, the parties exercise jurisdiction over a very large proportion of the tuna resources of the western and central Pacific.

Discussions between the original parties (Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands) began in 1981 and centred on the particular problems of the relationships with distant water fishing nations active in the area. Recognising the fact that distant water fishing nations were able to weaken coastal state negotiating positions by playing one state off against another, the group adopted and ratified the Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest in 1982.

The essence of the Nauru Agreement and the sentiments expressed by delegates is that the owners of the fisheries resources of the region, the island people, will in future drive a harder bargain when negotiating fishing rights with the major distant water fishing nations–Japan, Taiwan and the United States.

As well as the 'bargaining power' argument discussed above, the Nauru Group alliance is considered logical and sensible for several important reasons (Doulman 1987b): the Group's members have contiguous exclusive economic zones, which has significant implications for resource management and for fisheries surveillance and enforcement of distant water fishing nation agreements; research undertaken by the South Pacific Commission implies that the Nauru Group share tuna stocks, particularly skipjack; more than 75% of the tuna harvested by distant water fishing nation fleets in the exclusive economic zones of Pacific island countries is taken in the exclusive economic zones of Nauru Group countries; the region's purse seine fleets confine their operations to the Nauru Group waters; and finally, over 70% of distant water fishing nation access fee payments made under agreements in the Pacific islands go to Nauru Group countries. With few options for raising domestic revenue, Nauru Group countries must cooperate to protect this most valuable resource and to seek a fair financial return from its exploitation by distant water fishing nation fleets.

Structure and provisions

The Nauru Agreement contains the basic accepted principles for cooperation between the parties and makes provision for subordinate arrangements to be made to give effect to its intent. The first and most basic provision is that the parties shall seek to establish a coordinated approach to their fisheries management regimes. Article 1 provides as follows:

> The Parties shall seek, without any derogation of their respective sovereign rights, to coordinate and harmonise the management of fisheries with regard to common stocks within the Fisheries Zones, for the benefit of their peoples.

In this respect, it was recognised that there were some aspects of a common management regime which would be agreed upon easily and others where considerable work would need to be done before a common position could be arrived at. The Nauru Agreement requires, at a minimum, the implementation of uniform terms and conditions for the licensing of foreign fishing vessels. This is to be achieved with respect to individual licensing of vessels [Article II(b)(i)], the placement of observers on foreign fishing vessels [Article II(b)(ii)], standard log books [Article II(b)(iii)], timely entry, exit, catch and effort reports [Article II(b)(iv)] and the standardisation of identification marks [Article II(b)(v)].

The obligations of Article II(c) are softer: 'seek to establish...' rather than II(b)'s 'shall establish...' The additional minimum terms and conditions of access Article II(c) establishes are the payment of access fees [Article II(c)(i)], provision of catch and effort data and any additional information determined necessary by the parties [Articles II(c)(ii)(iii)], and flag state responsibility [Article II(c)(iv)].

There are other provisions in the Nauru Agreement which will require further discussion before subsidiary implementing arrangements may be concluded, e.g. the requirement to establish principles for the granting of preferential access to vessels of the parties to fish in the management zone over other foreign vessels [Article II(a)].

The First Implementing Arrangement

Article IX of the Nauru Agreement provides that the parties shall conclude arrangements where necessary to facilitate the implementation of the terms and to attain the objectives of the Agreement. Accordingly, pursuant to this and other Articles of the Nauru Agreement, the parties have agreed via 'An Arrangement Implementing the Nauru Agreement Setting Forth Minimum Terms and Conditions of Access to the Fisheries Zones of the Parties' (hereafter the First Implementing Arrangement) to establish and bring into operation numerous minimum terms and conditions of access.

Principal amongst these was the adoption of a 'Good Standing Register' of foreign fishing vessels to be maintained by the Forum Fisheries Agency as an enforcement tool.[14] Only vessels which are accorded good standing status on the register would be granted fishing licences in the region, in accordance with detailed arrangements to be agreed by member countries. The general intention behind it is to shift some of the responsibility for ensuring compliance to the flag state or fishing association. The First Implementing Arrangment also saw the establishment of many of the suggestions of the Nauru Agreement, notably that foreign fishing vessels be required to comply with minimum reporting conditions throughout the region regarding entry and exit, catch, effort and location log sheets and the on-board positioning of observers.

One of the most important innovations to come out of the First Implementing Arrangement discussions was the formulation of 'flag state responsibility'–flag state vessels and governments were required in access agreements to take active measures to ensure compliance by their fishing vessels with coastal state laws.

During the five-year period following the First Implementing Arrangement there was relatively little regional activity as regards the development of the minimum terms and conditions of access. However, by 1989 bilateral access agreements with Japan were in place with the following countries in the Forum Fisheries Agency region: Australia, New Zealand, Kiribati, Solomon Islands, Marshall Islands, Tuvalu, Papua New Guinea, Federated States of Micronesia, and Palau. Several countries also had access arrangements with Korea and Taiwan, both of which rapidly expanded their fishing fleets during the 1980s. Certainly the most significant development in the period 1984–1989 was the conclusion of the Multilateral Treaty on Fisheries between certain Pacific island states and the United States. The regional register procedures and minimum terms and conditions of access were incorporated in the annexes to the treaty and thus received binding legal effect as between the parties thereto.

The Second Implementing Arrangement

By 1990 it was becoming apparent that certain amendments to the First Implementing Arrangement were necessary in response to concerns expressed by Nauru Agreement countries over the substantial increases in foreign fishing activity in the region, particularly purse-seining; disparities in fee levels and methods of calculation throughout the region; as well as in response to the increased level of compliance noted on the part of the U.S. fleet following the introduction of the First Arrangement and the Treaty on Fisheries. At the request of Papua New Guinea and the Federated

[14] This was first proposed at a Workshop on the Harmonisation and Coordination of Fisheries Regimes and Access Agreements at Suva, Fiji between February 2 and March 5, 1982. The Workshop presented its report to the 7th meeting of the Forum Fisheries Committee in May 1982. These recommendations were subsequently endorsed by the South Pacific Commission.

States of Micronesia at the ninth annual meeting of the parties to the Nauru Agreement in 1990, a Second Implementing Arrangement, established a prohibition of transshipment at sea (Article I(1)); extended the duties to maintain log books to be binding on the high seas as well as in the fisheries and exclusive economic zones which the First Implementing Arrangement dealt with (Article I(2)); and established an obligation for flag states or fishers' associations to pay the full costs of having an observer on board their vessels, in addition to the First Implementing Arrangement requirements of allowing them to board, permitting them to gather information and have access to facilities, providing food, accommodation and care, assist them in carrying out their duties and so forth (Article I(3)).

It was agreed by the Nauru Group that the Second Implementing Arrangement would come into effect on January 1, 1991, but that existing access arrangements would be allowed to run their course. The latter proviso has caused some problems. Many of the existing access arrangements in the region are of the 'roll-over' type, subject to automatic extension. Given the extreme reluctance of some Nauru Group members to run the risk of a breakoff in access arrangements, only a few countries have made an effort to introduce the new arrangement, preferring to allow present arrangements to continue in force until it is seen that all other countries have successfully applied the Second Arrangement.

Law of the Sea Convention jurisdiction

The question posed in this section is whether, and to what extent, there is a justification for the minimum terms and conditions within the Law of the Sea Convention. Competence to impose conditions relating to catch and effort statistics and vessel position reports is expressly conferred by Article 62(4)(e) of the Law of the Sea Convention. [15]

[15] This section reads as follows: 62(4). Nationals of other States fishing in the exclusive economic zone shall comply with the conservation measures and with the other terms and conditions established in the laws and regulations of the coastal state. These laws and regulations shall be consistent with this Convention and may relate *inter alia* to the following: ... (e) specifying information required of fishing vessels, including the catch and effort statistics and vessel position reports.

What though of the high seas catch data obligations imposed under Article I(2) of the Second Implementing Arrangement? The high seas are prima facie beyond the reach of the exclusive economic zone powers conferred in the Convention, but there is considerable justification in law and science for requiring high seas catch data. Such data is required in order to assist the coastal state in fulfilling its obligations under the Law of the Sea Convention: to promote optimum utilisation of the living resources in the exclusive economic zone (Article 62); to conserve those resources (Article 61); and to cooperate with a view to conservation and optimum utilisation (Article 64).

The practice of transshipment at sea makes the fulfilment of the obligation for conservation and management difficult because it distorts catch data and the calculation of a 'fishing trip' which is of special concern to those countries which have adopted a per vessel per trip licensing system. In an attempt to control this practice, the Second Implementing Arrangement disallows the practice, and the revised minimum terms and conditions of access of the South Pacific Forum make similar provisions. [16] The language used in both is extremely wide and may be construed as a prohibition on transshipment anywhere on the high seas – this is indeed the construction used by Japan as an argument against accepting the provision. Such a general prohibition cannot be supported in law and it has been suggested that an attempt to support it, or even to be perceived as supporting it, would seriously undermine the credibility of Forum Fisheries Agency member states. There is an arguable case in international law for some form of restriction on transshipment in areas of high seas adjacent to exclusive economic zones, but even this has to be weighed against the practicability of enforcing such a regime.

The placement of observers is clearly one of the matters in respect of which the coastal state is empowered to make regulations under article 62(4)(g) of the Law of the Sea Convention. These requirements have not met with much resistance except regarding cost and extent of duties.

[16] An exception is made for the transfer of catch by a licensed seiner to its licensed carrier vessel, each of which holds good standing on the regional register.

Current state practice

The difficulties being encountered by Nauru Group parties with respect to the implementation of the minimum terms and conditions of access were reviewed at the 10th annual meeting of the Nauru Group parties in April 1991, at which they reaffirmed (Lodge 1992: 288):

> their total commitment to apply the minimum terms and conditions as a non-negotiable standard of access for foreign fishing vessels to the exclusive economic zones of member countries. Communication of this position of solidarity to foreign fishing industries and governments should occur at every opportunity including exchange of visits by government representatives and their attendance at access negotiations.

What then is the present status of the minimum terms and conditions of access? Having been adopted by the Forum Fisheries Agency countries and endorsed by the South Pacific Commission it is arguable that both the revised minimum terms and conditions of access and the regional register rules are binding on all countries represented by those fora. It is arguable that the agreement made by South Pacific Forum members committing themselves to making the minimum terms and conditions nonnegotiable is binding on them in international law. For example, the International Court of Justice has expressed 'no doubt' that 'declarations made by way of unilateral acts, concerning legal or factual situations may have the effect of creating legal obligations'.

The South Pacific Forum leaders, as heads of their governments, have the authority to make commitments that would bind their countries under international law. To say otherwise is to vitiate the role of the Forum and the authority its members yield as political leaders. The minimum terms and conditions that were adopted by the Forum must therefore have legal effect in international law. Whether or not the conditions have effect as part of the domestic laws of these member countries would depend on their constitution and the extent to which the courts and legislatures would apply them as part of the domestic law. It must be borne in mind that national legislation provides the basic framework for all fisheries activities in the region. In these circumstances, the incorporation of the minimum terms and conditions of access into domestic law is an important factor in ensuring the effectiveness of those conditions. Once they are part of national law they become truly nonnegotiable and can be enforced through the courts and cannot be called into question during access negotiations. Table 14.1 gives an indication of the extent to which a number of the major provisions of the Nauru Agreement and Implementing Arrangements have been incorporated through domestic legislation.

Forum Fisheries Agency member countries have met with varying degrees of success in implementing the minimum terms and conditions of access through national legislation. While it would appear that the conditions contained in the First Implementing Arrangement (licensing terms and conditions, positioning of observers, catch reporting and maintenance of log books, timely reporting of catch, entry and exit and identification of licensed vessels) were incorporated fairly quickly into national legislation in most countries, there has been no such urgency in the case of the Second Implementing Arrangement (transshipment at sea, high seas catch reporting and observer costs) and the revised minimum terms and conditions of access. The regional register and its sanctions have proven effective in enforcing compliance with the terms and conditions of distant water fishing nation access agreements with Nauru Group countries. In this way the register has helped to reduce the costs of administering agreements. The register has also reduced the incidence of illegal fishing and facilitated the collection of fines from distant water fishing nations to prevent the deregistration of their vessels for violations.

The Arrangement for the Management of the Western Pacific Purse Seine Fishery 1992

In October 1992, representatives of the governments of the Federated States of Micronesia, Republic of Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands and Tuvalu signed an agreement, 'The Arrangement for the Management of the Western Pacific Purse Seine Fishery' (hereafter the Management Arrangement) to further promote regional cooperation and coordination of fisheries policies in the light of the growth of purse seining as a particular and predominant form of fishing activity.

Table 14.1 Incorporation of Nauru Agreement provisions and Implementing Arrangements into domestic legislation, south Pacific nations

Country	Legislation	Definitions	Flag state responsibility	Observer provision	Regional register	Reporting procedure	Trans-shipping
Australia	Fisheries Management Act 1991	Yes	Terms of Access Agreements	Yes	Terms of Access Agreements	Yes	
Cook I.	Marine Resources Act 1989	Yes	Yes	Yes	Yes	No	Yes
Fiji	Marine Spaces Act & Regulations 1979	Yes	No	Yes	Yes		
Micronesia	Title 24 of the Code of the Federated States of Micronesia		No	Yes	No	Yes	No
Kiribati	Fisheries Act 1984	Yes	No	No	No	No	No
Marshall Islands	Marshall I. Marine Resources Authority Act 1988		Yes		No	Yes	
Nauru	Marine Resources Act 1978	No specific reference to any conditions, but power to set specific licence conditions					
New Zealand	NZ Fisheries Act 1983	Yes	Yes	Yes	Yes	Yes	Yes
Niue	Territorial Sea	No specific reference to any conditions, but power to set specific licence conditions					
Palau	Palau National Code		Yes	Yes	No		
Papua New Guinea	Fisheries Act	No specific reference to conditions, but power to set specific licence conditions					
Solomon Islands	Fisheries Act 1972		No	Yes	Yes	Yes	
Tonga	Fisheries Act 1989	Yes	Yes		No	No	
Tuvalu	Foreign Fishing Vessel Regulations 1983	Yes	No	Yes	No	Yes	Yes
Vanuatu	Fisheries Regulations 1983	No	No		Yes	Yes	Yes
W. Samoa	Fisheries Act 1988	Yes	Yes	No	No	No	

Source: based on information contained in Lodge 1992.

The preamble of the Management Arrangement says that particular account is taken of Articles 56(1)(a) and 61 of the Law of the Sea Convention. It is notable that while the Nauru Agreement focused on the provisions of Article 62 on the utilisation of living resources, the Management Arrangement's emphasis is on Article 61–the conservation of those resources. The preamble shows awareness of the dependence of the countries of the south Pacific upon the rational development and utilisation of the living marine resources, but is also mindful of the fact that this is dependent upon the continued abundance of the resource.

The preamble also indicates that more attention is going to be paid to the high seas. Specifically:

> recognising the responsibilities of coastal states and fishing states to cooperate with each other in the conservation and management of living marine resources of the high seas and taking into account the special interest of coastal states in highly migratory species while outside their exclusive economic zones [including fishing zones].

Effective maintenance of the ecological relationship between dependent and associated populations is recognised, as is the need to prevent any decrease in the size of harvested populations below those necessary to ensure their stable recruitment, to avoid adverse impacts upon the marine environment, and to only carry out fishing practices on the basis of ecologically sound practices. Coupled with this is the acknowledgment that an effective monitoring and enforcement system must operate.

Jurisdiction of the Management Arrangement extends over the 'Purse Seine Fisheries Management Area' (hereafter, 'the Area') which is defined in Article 1.1(a) as the exclusive economic zones or fisheries zones of the parties to this Agreement including adjacent high seas areas of the western Pacific within which purse seine vessels operate. Article 2 stipulates that the provisions of the Management Arrangement apply to all species of tuna and tuna-like species taken by purse seine vessels in the Area.

Yearly 'Management Meetings' of the parties are mandatory under Article 3.1 for the purpose of reviewing the current status of tuna stocks and to establishing necessary measures for their management and conservation. Decisions made in such meetings are to be reached through consensus and are binding on all parties (Article 4).

The tasks and functions of such management meetings during such review are wide in scope. Their task is to work towards the more effective implementation of the First and Second Implementing Arrangements entered into pursuant to the Nauru Agreement (Article 3.2(d)). They must consider scientific, economic and social impact data (Article 3.2(a)), and consider management measures. This subsection, Article 3.2(b) reads as follows:

> The functions of the Management Meeting are:
>
> (b) to consider management measures, which may include, but are not limited to –
>
> (i) the regulation of fishing effort by purse seine vessels which have good standing on the Regional Register, including the number of vessels by size class, operation type, carrying capacity, fishing power and technological capability or other grouping subject to the criteria set out in Article 5.1;
>
> (ii) the allocation of licences as indicated in Annex 1 hereto for fishing access to the exclusive economic zones of parties including licence denial for those foreign fishing vessels unwilling to cooperate in these management and conservation measures by failing to provide high seas catch and effort data;
>
> (iii) the establishment of closed areas and closed seasons; and
>
> (iv) any other management measure deemed necessary from time to time.

Article 3.2(c) provides for the establishment and implementation of a system of observation and inspection 'consistent with regionally agreed initiatives', and in so doing would appear to clearly embrace Article II(2) of the First Implementing Arrangement and Article I(3) of the Second Arrangement. Surveillance and enforcement procedures consistent with regionally agreed practice are also to be developed (Article 3.2(e)). Each Party has a duty to ensure that its nationals and fishing vessels comply with any management measures adopted by management meetings (Article 3.5).

Article 8 recognises the need for, and provides for, informal consultations with other states and international organisations, a sentiment which is, of course, integral to the Nauru Agreement and Implementing Arrangements.

Articles 3.3, 5, 6 and Annex 1 set out the Management Arrangement's provisions regarding the allocation of licences. Article 3.3 provides that any allocation of licences made under 3.2(b)(ii) will take into account the strong dependence of south Pacific coastal states on fisheries resources and the special importance to them of the conservation and optimum utilisation of highly migratory species of tuna in the region. Article 5.1 provides an explicit expression of the ranking of applications for licences, providing that those vessels have good standing status on the regional register. Giving highest priority to domestic vessels acknowledges the development goals of south Pacific states discussed previously. In descending order of priority are: domestic vessels;[17] domestic vessels of another party to the Arrangement or vessels jointly operated by or on behalf of the government of the party in which the vessel is based and one or more other parties;

[17] Article 1.1 (f) 'domestic vessel' means any fishing vessel (i) wholly owned by the government of a party or by any public corporation or body established by or under any law of a party, all of the shares in which are beneficially owned by the government of the party; (ii) wholly owned and controlled by one or more natural persons who are citizens or permanent residents of the party in which the vessel is based under the relevant laws relating to nationality and citizenship of that party; and (iii) wholly owned and controlled by any company, society or other association of persons incorporated or established under the laws of the party in which the vessel is based.

locally based foreign fishing vessels;[18] foreign fishing vessels with established access arrangements over previous years and with good records of compliance with national laws and regulations, the minimum terms and conditions and reporting requirements of Parties; and new foreign fishing entrants to the fishery. There seems to be little to complain about from the point of view of developing Pacific states in this hierarchical structure. Parties which have a small or nonexistent domestic fishing fleet simply begin allocating priorities from a different starting point. However, what is curious is that there is no provision for extra-territorial agreements. For example, in the context of the Lomé Convention, it would seem that EEC vessels would be given priority over other foreign fishing vessels. It could perhaps be argued that such vessels are included under the provision for 'foreign fishing vessels with established access arrangements'.

Article 6 and Annex 1 provide the details on licence numbers and allocation criteria. Annex 1 (see box) sets a flexible ceiling on the total number of purse seine licences that may be issued (Article 6.1 and Article 6.2). Additional licences are subject to a premium of 20%. These limits may be reviewed by management meetings, and Article 6.3 says that '[i]t is further understood that the Parties will aim to reduce the number of additional licences available'.

[18] Article 1.1 (g) 'locally based foreign fishing vessel' means a foreign fishing vessel which is based in a party, lands all of its catch in that party and/or operates under a joint venture arrangement in the territory of that party which is approved by the government of that party or under arrangements whereby the operator of the vessel is participating in shore based developments or is otherwise making a substantial contribution to the development of the domestic tuna industry of the licensing party.

Reproduction of Annex 1 of the Management Arrangement
Agreed purse seine licence numbers

The maximum number of licences for purse seine vessels agreed to by the 11th Annual Meeting of the parties to the Nauru Agreement, Tarawa, Kiribati, 14–17 April, 1992, is as follows:

	Single	(Additional)	Group	(Additional)
1. Multilateral access USA (Treaty)	40	(10)[a] (5)[b]		
2. Bilateral access				
a) Forum Fisheries Agency members				
Australia	6			
b) Foreign				
Japan	32		4	(3)
Taiwan	30	(12)	2	
South Korea	32	(5)		
Philippines	6	(5)		
Indonesia	3			
Subtotal	109	(22)	6	(3)
3. Domestic and locally-based foreign vessels				
All parties	10			
Total	159	(32) (5)	6	(3)

[a]As agreed in relation to an extension of the Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America.
[b]Special licences for joint ventures/developmental licences as agreed with the United States in relation to an extension of the U.S. Treaty.

Foreign compliance is expressly stated to be the single most important factor influencing the allocation of licences. Licences to individual foreign purse seine vessels will be issued firstly on the basis of the vessel's record of compliance with the national laws and regulations and reporting requirements of parties (Article 6.4(a)) and second in chronological order of application.

Conclusion

This paper has discussed the manner in which the law and practice relating to fisheries has developed in coverage and complexity, to the current position in which many of the policies of ecological sustainability and economic control have been implemented through regional agreements such as the Nauru Agreement and Management Arrangement. The desire of south Pacific states to have greater control over the exploitation of the resources which surround their shores is understandable, but the move towards any form of 'ownership rights' must be balanced by the modern awareness of the interrelationships between ecological and environmental systems, and the political accountability for the sensible management of resources which are seen as beneficial to the 'global ecosystem'. Hence, with control, comes responsibility. This is indicated by the preferred role of regional agreements over unilateral claims which can be potentially conflicting, and accordingly diminish the power of the south Pacific states as a group. With the advent of the Law of the Sea Convention exclusive economic zone provisions, these states suddenly became the theoretical rulers of domains covering millions of square kilometers. Theoretical rulers, in the sense that it soon became apparent that there was a vast gap between the mere declaration of an exclusive economic zone and the collection of returns from such a zone in the form of solid economic development.

Chapter

15 The Legal Framework for Fisheries Management in Papua New Guinea

B. M. Tsamenyi

K. Mfodwo

Introduction

This chapter provides a broad overview of the legal framework within which fisheries exploitation is carried out in Papua New Guinea. It begins with an analysis of Papua New Guinea's fisheries jurisdiction. This is followed by a description of the jurisdictional reach of Papua New Guinea's fisheries legislation and the regulatory framework established under the legislation. Finally, the chapter examines Papua New Guinea's fisheries enforcement process from an international law and policy perspective.

The fisheries jurisdiction of Papua New Guinea

Prior to 1977 Papua New Guinea's maritime jurisdiction was regulated by three pre-independence acts and by the principles of customary international law. Drafted by Australia as the colonial power, the zones claimed under those statutes were a territorial sea of 3 n miles and under the *Fisheries Act 1974*, a further 9 n mile fishing zone, which reserved fisheries for Papua New Guinea vessels and foreign licensees. The *Continental Shelf (Living Natural Resources) Act 1974*, and the *Petroleum (Submerged Lands) Act 1975*, extended jurisdiction over the living and nonliving resources of a portion of the continental shelf of Papua New Guinea.

The situation changed in 1977 following the passage of the *National Seas Act*. Under this legislation, Papua New Guinea declared a 12 n mile territorial sea, drawn from the appropriate baselines, and an area of offshore seas (called the declared fishing zone), extending an additional 188 n miles from the outer limits of the territorial sea. In the expanded territorial sea, the customary rules of international law were stated as still applicable. The passage of the *National Seas Act* brought Papua New Guinea's maritime zone jurisdiction in line with the worldwide trend towards extended jurisdiction evident in the late 1970s.

A significant development under the *National Seas Act* was the application of the concept of 'archipelagic waters' to Papua New Guinea. Article 46 of the Law of the Sea Convention defines an 'archipelago' as a group of islands, including parts of islands, interconnecting waters and other natural features which are so closely interrelated that such islands, waters and other natural features form an intrinsic geographical, economic and political entity, or which historically have been regarded as such. Under the Law of the Sea Convention regime, archipelagic states are allowed to draw straight baselines joining the outermost points of the outermost islands and drying reefs, provided that the ratio of the area of the water enclosed by the baselines to the area of land is between 1:1 and 9:1, and that the length of the baselines does not exceed 100 miles, except that up to 3% of the baselines drawn may be up to 125 miles in length.

Under the interim delimitation of archipelagic waters, under the *National Seas Act*, a 'principal archipelago', was created consisting of the main island of New Guinea and all the fringing islands, including those of the Admiralty group, the Bismarcks, the North Solomons, the Trobriands, the Louisiades, and the D'Entrecasteaux; and the Tauu and Nukumanu Islands archipelagoes, which are located north east of Bougainville and consist of small clusters of coral reef ('low') islands. Under the Law of the Sea Convention, the waters enclosed within the archipelagic baseline are under the sovereignty of the archipelagic state, and have a status similar to the internal waters of a coastal state, except that innocent passage rights have to be accorded to foreign vessels (Article 52).

The *Continental Shelf (Living Natural Resources) (National Seas) Act 1977* and the *Petroleum (Submerged Lands) (National Seas) Act 1977* amended the respective principal acts by redefining Papua New Guinea's continental shelf jurisdiction so as to correspond with the 'offshore seas' concept embodied in the *National Seas Act*. As a result, irrespective of the actual dimensions of the continental shelf, exploitation of the living and nonliving resources of the seabed and subsoil now come under Papua New Guinea national jurisdiction, for those areas of seabed and subsoil which underlie internal waters, the territorial sea, and the offshore seas 'to a depth not exceeding 200 m, or beyond that limit, to a depth where the superjacent waters admit of the exploitation of the natural resources of that area'.[1] As a full 200 mile zone for Papua New Guinea overlaps with the territorial waters and/or exclusive economic zones/fisheries zones of Australia to the south, Micronesia to the north, and Solomon Islands to the east, delimitations are therefore necessary, and have been undertaken in relation to Australia.

The legislation

In terms of a national regime in the strict sense, Papua New Guinea regulates marine resource extraction through a number of separate acts and regulations rather than an omnibus fisheries law. The acts are (i) the *Fisheries Act* (Cap 214); (ii) the *Continental Shelf (Living Natural Resources) Act* (Cap 210); (iii) the *Whaling Act* (Cap 225); (iv) the *Tuna Resources Management Act* (Cap 224); and (v) the *Fisheries (Torres Strait Protected Zone) Act*. The relevant aspects of the legislation are described briefly below.

The Fisheries Act

This Act has territorial as well as extra-territorial application. In the territorial sense, and to the extent that the Papua New Guinea fishing zone or declared fishing zone can be regarded as a part of Papua New Guinea territory, the *Fisheries Act* applies to all persons (including foreigners) and to all boats (including foreign boats) provided that these entities are within the declared fishing zone or in internal waters (S.2). The declared fishing zone itself is determined by the Head of State, acting on advice from the relevant authorities, with its extent defined or set out in the National Gazette (S.1(2)) The declared area includes all or part of what is described as the offshore seas. With or without explicit declaration, the territorial sea itself is regarded as an integral part of the declared fishing zone (S.1 (3))

Extra-territorial application of the *Fisheries Act* is based on the notion of nationality. The Act states that all Papua New Guinea boats, in waters other than Papua New Guinea waters, are regulated by the *Fisheries Act*, as are all persons on such boats, all persons who have dealings with such boats, or have any relevant relationship to such boats, or persons dealing with them. The concept of a Papua New Guinea boat itself is defined in the following terms:

> Papua New Guinea boat means a boat the operations of which are based on a place in the country and that is wholly owned by a natural person who is a resident of, or by a company incorporated in, the country, being a boat that
>
> (a) was built in the country; or
>
> (b) has been lawfully imported into the country, otherwise than for a limited period; or
>
> (c) has been sold, or otherwise disposed of, in the country after having been forfeited or distrained under an Act or, before Independence Day, an Act of Australia (S.1).

[1] The 200 mile isobath limit and the exploitability test are drawn from the 1958 Geneva Convention on the Continental Shelf.

The *Fisheries Act*, however, does not regulate the parts of the Torres Strait regulated by the *Fisheries (Torres Strait Protected Zone) Act 1984*.

The Continental Shelf (Living Natural Resources) Act

The jurisdictional reach of this Act is determined by a combination of geographical, geological, biological, vessel nationality and resource use criteria. The Act itself at Section 1 defines continental shelf as follows:

> 'continental shelf' means the seabed and subsoil
>
> (a) underlying the waters between the high water lines and the baselines; and
>
> (b) underlying the territorial sea; and
>
> (c) adjacent to the coasts of Papua New Guinea which underlies the offshore seas to a depth not exceeding 200 m or, beyond that limit, to a depth where the superjacent waters admit the exploitation of the natural resources of that area.

As can be seen, the geographical/geological criteria for delimiting the outer extent of the shelf are a combination of the distance criterion and the exploitability criterion. Papua New Guinea has chosen this combination over the notion of natural prolongation.

The *Continental Shelf Act* applies to all persons, including foreigners, and to all ships, including foreign ships, which are in the continental shelf area. The stated geographical exception is in respect of the area governed by the *Fisheries (Torres Strait Protected Zone) Act*. The biological basis for exercising jurisdiction under the *Continental Shelf Act* is through the minister's power to declare that an organism is a sedentary organism to which the Act applies. Such an organism must be a marine organism which forms part of the living natural resources of the continental shelf, and must belong to a sedentary species. Exemptions from the status of regulated sedentary organism may be made by the minister in relation to specific kinds of organism in a specified part of the shelf area. Such notice removes the category of organism from the operation of the Act until such time as the notice expires or is revoked. To date, crustacea, molluscs, trochus and beche-de-mer have been declared to be exempted sedentary organisms, and are currently regulated by the *Fisheries Act*.

The *Continental Shelf Act* does not apply to the taking of sedentary organisms by a citizen or ordinarily resident noncitizen where the organism is taken for consumption, sport or pleasure, and is clearly not intended for sale or manufacture. Traditional fishing is also excepted from the operation of the Act. A further exemption from the Act applies where the minister is satisfied that a ship operating in an area of the shelf is being used for, or is to be used for, marine scientific research, in a context where information, or adequate information, does not already exist.

The Whaling Act

This Act has jurisdictional effect through nationality, territorial and resource use connection with Papua New Guinea. Any ship or aircraft is deemed to be under the whaling jurisdiction of Papua New Guinea if it is registered in Papua New Guinea; or if it is within the territorial limits of Papua New Guinea and is not a public ship or aircraft of a country other than Papua New Guinea that is not employed for the purposes of whaling or in other commercial operations (S.1(2)) This negatively formulated definition ensures a very wide application of the Act especially, since, in the first instance, 'ship' is defined widely to include 'every kind of vessel' (S.1) Effectively then, the only exceptions from jurisdiction under the *Whaling Act* are government owned and operated ships.

The *Whaling Act* also operates extra-territorially, applying without distinction within and outside Papua New Guinea, and to all waters, whether or not they are Papua New Guinea waters. However, the powers of control conferred on the minister by the Act are to be exercised extra-territorially (i.e. as an enforcement power over the taking or killing of whales) only to the extent that would be necessary to give effect to the *International Whaling Conventions* as if Papua New Guinea were in fact a contracting state to these Conventions. Thus, although widely formulated, the jurisdictional power under the *Whaling Act* which is likely to be exercised does not go beyond the agreed understandings of the International Whaling Conventions framework (IUCN 1982).

The Tuna Resources Management Act

This Act makes special provisions for tuna harvesting and formalises a special regime created for accredited tuna processors in 1982. The Act establishes a Tuna Resources Management Advisory Committee comprising the head of the Fisheries Department, officers appointed entirely at the discretion of the minister, and representatives appointed by the minister from any of the commercial tuna fishing companies in Papua New Guinea. The task of the Advisory Committee is to advise the minister on the following matters (S.8(11)):

- the total sustainable yield of tuna in the offshore seas;
- the proposed levels of tuna catch in the offshore seas;
- the licensing of vessels to take tuna in the offshore seas;
- any other aspects of resources management relevant to the development and efficient operation of the Papua New Guinea tuna fishing industry.

In making its recommendations, the Advisory Committee is expected to pay attention to the following matters (S.8(1)):

- the need to promote the operational efficiency of the Papua New Guinea tuna fishing industry within the broad assessment imposed by:

  the assessment of total sustainable yield of tuna from the offshore seas;
  the commitments of the country under any agreements with the state as to tuna fishing in the offshore seas.

- the past performance of applicants for licences to take tuna in the offshore seas.

Fisheries (Torres Strait Protected Zone) Act 1984

Fishing in the Torres Strait is regulated by the Torres Strait Treaty between Australia and Papua New Guinea. The Torres Strait Treaty creates the Torres Strait Protected Zone, in which each country exercises sovereign jurisdiction over swimming fish and sedentary species on the respective sides of the agreed jurisdiction lines. In so far as fisheries is concerned, Papua New Guinea implements the Torres Strait Treaty through the *Fisheries (Torres Strait Protected Zone) Act 1984* supplemented by the Fisheries (Torres Strait Protected Zone) Regulations 1987.

Two types of fisheries are envisaged within the Torres Strait Protected Zone: traditional fishing and commercial fishing which the Treaty describes as 'Protected Zone commercial fisheries'. In practice there is increasing interconnection between the two categories. Traditional fishing which can only be undertaken by traditional inhabitants falls under unilateral sovereign jurisdiction. Measures to implement Treaty obligations relating to traditional fishing are *prima facie* the preserve of each state. Under Article 22 of the Treaty, commercial fisheries fall either under joint management or unilateral management depending on the type of fishery. Those commercial fisheries which Australia and Papua New Guinea have so far agreed to jointly manage in the zone are: prawns, Spanish mackerel, pearl shell, tropical rock lobster, dugong and turtle. Papua New Guinea thus has unilateral jurisdiction over traditional fishing and all other commercial fisheries, as for example tuna fisheries, to the extent that such fisheries are commercially viable in the area.

Regulation by species, stock or resource type

An increasingly accepted approach to fisheries regulation is the regulation of a particular fishery, on the basis of species or stock type, as a discrete unit within the general regime; the Papua New Guinea regime shares elements of this approach. Thus, the legislation specifically identifies tuna fisheries (*Tuna Resources Management Act* and *Fisheries Act*), fisheries for sedentary organisms (*Continental Shelf Act*) and whaling (*Whaling Act*), and deals with each area in a specific sense and to varying extents within the general scheme. In the case of tuna, certain core species are identified. Since the legislation specifically defines the term 'tuna' to mean the specified subcategories of the genus (skipjack tuna, yellowfin tuna, albacore, bigeye tuna, mackerel tuna, or northern bluefin tuna), and nothing more, presumably no other types of tuna, or tuna-like fisheries are regulated.

Whales are also defined in a more or less specific sense (blue whale, fin whale, gray whale, humpback whale, right whale, sei whale or other baleen whale; or a sperm whale; or any other whale of a prescribed kind), suggesting that no other types of whale are intended to be regulated, unless specifically so prescribed. Presumably, these fairly specific definitions reflect the fact that these species/types are known to exist in Papua New Guinea waters and are regarded as requiring regulation for commercial or conservation reasons.

By contrast, the term 'sedentary' organisms is not given exhaustive definition in the relevant act. Rather, the authorities prescribe by regulation from time to time, which categories of organism are classified as sedentary in character for the purpose of the laws. The term 'fish' in the *Fisheries Act* also has a broad meaning, and includes turtles, dugong, crustacea, molluscs, trochus, and *bêche-de-mer*. Whales and sedentary organisms other than crustacea, molluscs, trochus, and *bêche-de-mer* are however specifically excluded from the definition of fish.

Regulation of domestic and foreign fishing

Another globally used approach to fisheries regulation is differentiating the foreign from the domestic or local sectors and having clearly demarcated legal regimes applying to the different sectors. There may also be a special regime for joint ventures, the hybrid form linking domestic and foreign interests. Within each of these sectors there may then be further specific regulation. Papua New Guinea does not as yet have a clearly specified and/or well elaborated distinctive regime governing foreign fishing, though elements of the legislative scheme in the *Fisheries Act* and the *Tuna Resources Management Act* pay particular attention to foreign fishing. As yet there is no act titled, the 'Foreign Fishing Act', or the 'Domestic Fisheries Act'.

Particular sections of a statute may deal with issues of traditional fishing,[2] or foreign fishing[3] concentrating on a particular aspect of each process and dealing with it as a specific issue, within the general legislative scheme. Foreign fishing is however not defined in any of the acts, although the *Fisheries Act* at S.1 defines 'foreign boat', identifying such boats as 'boats other than a Papua New Guinea Boat'. Also, there is as yet no specific legislation governing joint venture fishing in Papua New Guinea. Presumably, foreign boats, once they become registered as Papua New Guinea boats then become subject to the strictly domestic regime, unless specific exemptions are stated as applying to such vessels.

[2] See discussion below for a definition of traditional fishing.

[3] See for instance S. 15 of the *Continental Shelf Act* and ss. 12, 15, and 16 of the *Fisheries Act*.

A special regime for foreign tuna fishing

Because of its importance within the fisheries sector and the traditional presence of foreign interests, a special regime has been created for foreign tuna fishing. This regime can be found in (i) the *Japan/ Papua New Guinea Fisheries Arrangement* (although at the time of writing it was no longer in force); (ii) the *Tuna Resources Management Act* and (iii) in some sections of the *Fisheries Act* and the *Fisheries (Torres Strait Protected Zone) Act* dealing with capital intensive operations requiring special approval.

According to Doulman (1987c), the specific regulation of foreign fishing as a distinct activity has been achieved administratively. At least until the late 1980s, the procedure was to license all foreign fishing boats involved in the tuna industry under the same terms as were operative for Japanese tuna boats under the *Papua New Guinea/Japan Fisheries Arrangement* of 1981 (as subsequently amended). By 1986, Filipino, American, Korean, Taiwanese as well as Japanese vessels were licensed under this agreement, or had terms regulating them which were essentially based on the *Papua New Guinea/Japan Fisheries Arrangement*. The framework seemed, however, to have been applicable to tuna fishing only, not all foreign fishing.

During the period 1981-1987 the undermentioned terms formed the key elements of licensing and fisheries regulation under the Papua New Guinea/ Japan framework. Essentially there was not much difference between these terms and the broader arrangements set out in the legislation discussed above.[4]

These terms were (Doulman 1987c):

- licence applications were only allowed if the vessel was in good standing on the Forum Fisheries Agency's Regional Register;
- licence application had to be made, and had to be approved, with payment of a prescribed access fee, before a vessel could actually enter the declared fishing zone;

[4] This arrangement is no longer in force but it is unclear the extent to which it currently dominates regulation of foreign fishing in the terms suggested by Doulman (1987c).

- to protect the interests of the domestic pole-and-line fleet, foreign fishing vessels were excluded from fishing in the country's territorial seas (i.e. within 12 n miles of the coastline) and in certain other defined areas;
- all licensed foreign fishing vessels had to supply entry and exit reports to the Papua New Guinea Fisheries Division 24 hours in advance by telex, notifying the precise position and the quantity of fish on board in both exit and entry reports;
- all licensed foreign fishing vessels engaged in active operations had to report their positions each Wednesday with information on the exact quantity of fish on board;
- catch records had to be maintained on board and had to be signed and forwarded to the Papua New Guinea Director of Fisheries within 45 days of the completion of each fishing trip;
- licensed vessels were required to display their international call sign on top of their vessels, with vessel names printed in English on the bow and stern of the vessel, and Papua New Guinea registration had to be displayed on both sides of the wheelhouse;
- licensed vessels were licensed for a period of two to four months;
- foreign fishing vessel owners and companies had to establish local agents to facilitate licensing and reduce administrative costs; and
- fees paid by vessel owners were linked to prevailing tuna prices as obtained from the leading Japanese ports, and were in turn related to the estimated quantity and species of tuna harvested.

Under amending legislation passed in 1982, a special regime was created for accredited tuna processors. The species of tuna to which this section applies are skipjack tuna, yellowfin tuna, albacore tuna, bigeye tuna, mackerel tuna and northern bluefin tuna. Under this framework, a person may enter into an agreement to set up a facility for processing raw tuna. The entity may then apply for recognition as an accredited processor. This status is granted provided that the plant satisfies health and safety criteria, is capable at conception of processing up to 30 tonnes of raw tuna per day and can be expanded over a period of nine years to over 80 tonnes of raw tuna per day. It should also have appropriate storage, handling, loining, canning and quality control facilities (*Fisheries Act* S.18B(2)).

An accredited processor is granted the further right, subject to the *Tuna Resources Management Act*, to request a sufficient number and class of licences as will allow the processor to harvest the amounts of tuna appropriate to the quantity requirements of the processor's establishment. The final provision also has relevance for tuna harvesting, as an accredited processor may also be given rights to purchase raw tuna from any persons as may be prescribed by the minister.

These provisions are clearly intended to help create a domestic tuna canning industry in Papua New Guinea. They would also serve as a reasonable framework for the establishment of joint ventures. It is not clear the extent to which the needs of accredited processors would be, or have been given, priority in the allocation of licences and fishing rights in the Papua New Guinea declared fishing zone. The potential for priority allocations clearly exists however under S.18C of the *Fisheries Act*.

Regulation of traditional fishing

An increasing trend in fisheries management worldwide is the recognition of traditional fishing as a distinct form of fishing activity. This trend is reflected in Papua New Guinea legislation. The *Fisheries Act*, the *Continental Shelf Act* and the *Fisheries (Torres Strait Protected Zone) Act* all refer to traditional fishing and attempt to provide a definition of traditional fishing. The *Whaling Act* does not contain a definition of traditional fishing. At first glance, this suggests that traditional or indigenous hunting for whales is not recognised in Papua New Guinea, and/or does not have an exempt status. However, the *Fisheries (Torres Strait Protected Zone) Act* regulates the taking of dugong, a marine mammal the hunting for which is an established activity in the Torres Strait region.

Under the *Fisheries Act* and the *Continental Shelf Act*, traditional fishing is defined as fishing by natives where:

- the fish or sedentary organisms are taken in a manner that, as regards the boat, the equipment and the method used, the overall process is substantially in accordance with the traditions of the indigenous inhabitants of Papua New Guinea; and

- the catch is landed in Papua New Guinea by the boat undertaking the fishing; or alternatively
- may be transshipped to another vessel with the permission of the minister.

The *Fisheries (Torres Strait Protected Zone) Act* does not use the notion of native in its definition of traditional fishing. Instead, the focus is on 'traditional inhabitants' and traditional fishing is defined as 'the taking' of marine resources by traditional inhabitants for their own or dependants consumption or for use in the course of other traditional activities. These marine resources can be taken from the sea, seabed, estuaries and coastal tidal area, and may include dugong and turtle. Thus, in the Torres Strait Protected Zone, fishing for some marine mammals is permitted for traditional uses.

Regulation by means of prohibitions and permission

Fundamental aspects of the regulation of marine resource extraction in Papua New Guinea are the concepts of (i) activities prohibited by the responsible minister; and (ii) activities specifically permitted by the same minister, the permitted activity being a licensed activity, with the licence granted at the discretion of the minister.

Prohibited activities

All the fisheries-related acts described above envisage that the minister may prohibit a number of activities by notice in the National Gazette (*Fisheries Act, Continental Shelf Act* and *Whaling Act*). These prohibitions may relate to size, period, kind, fishing method, equipment, area, vessel, quantity, category of person, type of fish processing and type of fish transshipment process. The prohibitions may be absolute in character, or may be limited. Where there are limitations or exemptions from the prohibition, such permitted activity may be subject to conditions, which are to be specified in the relevant notice. None of the acts provide any process of appeal or challenge in relation to the exercise of these powers of prohibition. The power to prohibit a wide range of activities is thus clearly fundamental to the Papua New Guinea fisheries regime, as is the power to license otherwise prohibited activity.

Permitted activities

The licence is the principal legal instrument authorising activity which would otherwise be prohibited. All three acts envisage that the minister may grant a licence, or a class of licence to both natural and artificial persons. This permission may be for use in any area of waters, notwithstanding that notices of prohibition may in fact apply to such waters. The licensing process is entirely discretionary, and for fisheries generally, follows the procedure outlined in the Fisheries Regulations. This involves applications, the payment of a range of fees, and the provision of a range of specified information (see the Schedules to the Fisheries Regulations).

Under the Fisheries Regulations, three types of licences can be applied for. These are a fishing licence which attaches rights to the person only; a fishing boat licence; and a factory boat/ship licence. There seems to be no separate procedure for licensing aircraft under the *Fisheries Act*. Under the *Whaling Act*, licences may be granted to both ships and/or aircraft to operate as whale-catchers in Papua New Guinea waters. Additionally, licences to operate factory ships, or land factories may also be granted. The licence categories under the *Continental Shelf Act* are similar to those under the *Fisheries Act*: licences attach to persons (fishing licences, divers licences) and can also be granted to vessels or ships.

Finally, and this is of particular importance for foreign fishing interests, there are those sections of the *Fisheries Act* which establish 'special provisions for major operations' (S.7). A major operation is a venture where in the view of the minister, the capital value of the investment proposed and any associated operations exceeds, or may exceed, K250 000. In such a case, the minister is obliged to refer the matter to the country's National Executive Council before granting or refusing the application. Submission to the National Executive Council may also occur at the discretion of the minister, even though the sum is not K250 000 or above. This provision aside, the minister dominates the fisheries management and access control process entirely and exercises complete discretion, subject to the recommendations of the Advisory Committee under the *Tuna Resources Management Act*, and the requirements of S.6A and S. 20A of the *Fisheries Act*.

Endorsement of conditions on licences

Under all the acts, the minister may endorse conditions on the licence. These conditions may specify a range of restrictions or permit activity which would otherwise be prohibited under the system of general prohibitions described above. Notable permissions in this category under both the *Continental Shelf Act* (S.7(8)(b)) and the *Fisheries Act* (S.6(4)(b)) include the right for licensed nontraditional (i.e. larger commercial vessels) to haul in and receive catch acquired by 'traditional fishing' methods, a practice otherwise strictly prohibited.

Duration and transfer of licences

Licence duration may vary, ranging from three to four months to five years. The five-year licence is, however, peculiar to the *Whaling Act*. A register of licences is also envisaged under all the acts, although it is not clear the extent to which it is intended to be a public register. Licence transfer is only allowed with the permission of the minister, and may be subject to a fee. Where the minister approves licence transfer, a memorandum of the transfer is to be endorsed on the licence. There is a specified format for the licence register which is set out at Form 7 of the Fisheries Regulations.

Financial aspects of licensing

A range of fees may be required under all the acts. Under the *Fisheries Act*, these are the Fisherman's Licensing Fee, the Boat Licensing Fee and an Operational Fee. The latter involves substantial amounts, whilst the first two are relatively nominal and may be refunded if the application is refused. Securities or bonds may also be required of licensees. Although only the *Whaling Act* states this obligation in legislative terms (S.6(8)), such a requirement may also be imposed under the general powers relating to licensing conditions under the *Fisheries Act* and the *Continental Shelf Act*.

Cancellation and suspension of licences

The minister has a broad power to cancel any and all licences issued under the three principal statutes. The stated justifications for cancellation are (i) where the holder of a licence under any of the three acts contravenes a condition of the licence and/or fails to comply with a condition of the licence; and (ii) where the holder of a licence has been convicted of an offence under the relevant act. In the case of the *Fisheries Act* and the *Continental Shelf Act*, the power to cancel a licence may also be exercised where the offender has contravened the provisions of the other act.

The *Whaling Act* links the lodgment of a bond or a security to the power to cancel a licence. The minister may cancel a licence if a licensee fails to provide a satisfactory security when asked to do so. In contrast, under the *Fisheries Act* and the *Continental Shelf Act*, licences may be suspended (i) as a sanction and (ii) as a management measure. Where the suspension is undertaken as a management measure, the minister is required to write to the licensee specifying this fact and the period during which there is to be a suspension. The legislation does not state that any compensation is to be paid to a licensee during such period of inadvertent suspension. Should the issue of compensation arise, an essential matter for determination would be the extent to which the minister, the licensee or external factors are responsible for the conditions requiring suspension of the licence.

Under both the *Fisheries Act* and the *Continental Shelf Act*, suspension of licences as a sanction may be undertaken on the following grounds: (i) where the minister has reasonable grounds to suspect that there has been a contravention of, or a failure to, comply with licence conditions; and (ii) provided that the minister has not previously issued a suspension against the licensee on those specific grounds.

The procedure is that suspension notices must be in writing, and may be revoked at any time, before they expire. Suspension notices cease to have effect in two ways. First, they cease to have effect *immediately* after the completion of legal proceedings against a licensee, provided that the proceedings themselves were initiated within one month after the licence suspension. In all other cases, however, suspensions lapse *one month* after the period stated on the suspension notice, although they may, and will usually, be specifically terminated by order of the minister on the appropriate date or soon thereafter.

Licence cancellation and suspension under the *Whaling Act* involves less elaborate procedures. Essentially, there is no stated power to *suspend* a whaling licence. Cancellation of a licence may, however be effected on the grounds that a licence condition has been breached or has not been complied with, or the licensee has been convicted of an offence against the Act.

Determination of allowable level of fishing

For fisheries regulated by the *Fisheries Act*, an essential precondition for licensed foreign activity, and also presumably for determining what is to be prohibited, is the determination by the Papua New Guinea authorities, of what is to be an allowable level of fishing. The concept of allowable level of fishing is drawn from the text of the 1982 Law of the Sea Convention (Article 61). The factors the minister is required to take into account are:

- whether such states have cooperated with Papua New Guinea in, and made substantial contributions to, the development of Papua New Guinea's fishing industry, fishery research and identification of fishing resources;
- any rights of a reciprocal nature granted to Papua New Guinea nationals or boats by such states;
- whether such states have cooperated with Papua New Guinea in enforcement and with respect to the conservation and management of fishing resources;
- whether, and to what extent, the fishing vessels of such states have traditionally engaged in such fishing;
- such other matters as the minister, in consultation with the minister responsible for foreign affairs, deems appropriate.

The *Fisheries Act* also requires that the minister should have regard to a number of other factors when exercising powers under and in relation to the Act, to the extent that those powers are exercised with respect to any part of the declared fishing zone which is beyond the internal waters, archipelagic waters and territorial sea. These factors are: (i) application to the fishing process of the principle of optimum sustainable yield; and (ii) consideration of any relevant international obligations of Papua New Guinea, or applicable rules of international law, affecting or relating to the exercise of Papua New Guinea jurisdiction in any section of the zone.

Enforcement of Papua New Guinea's fisheries regime

Enforcement of fisheries laws and regulations refers to the totality of the processes by which the relevant fisheries laws and regulations are made effective. In essence, fisheries enforcement is an ensemble of activities designed to compel obedience to fisheries laws and regulations. It requires, and has come increasingly to involve, an elaborate network of institutions, rules, procedures and specialised personnel.

International law currently accepts the proposition that the right to enforce fisheries laws is a sovereign power exercisable by the coastal state. This power is an essential part of the widely accepted resource or exclusive economic jurisdiction that coastal states may exercise within the 200 n mile zone. This power can be exercised against foreign and domestic vessels and can be exercised in different ways as between these two classes of fishing interests. As far as currently operative international law is concerned, Articles 73 and 62(4)(k) of the Law of the Sea Convention provide the broad parameters within which the enforcement of fisheries sector laws and regulations is expected to proceed. Article 73 provides that:

> 1. The Coastal State may, in the exercise of its sovereign rights to explore, exploit, conserve and manage the living resources in the exclusive economic zone, take such measures, including boarding, inspection, arrest and judicial proceedings, as may be necessary to ensure compliance with the laws and regulations adopted by it in conformity with this Convention.
>
> 2. Arrested vessels and their crews shall be promptly released upon the posting of reasonable bond or other security.
>
> 3. Coastal State penalties for violations of fisheries laws and regulations in the exclusive economic zone may not include imprisonment, in the absence of agreements to the contrary by the States concerned, or any other form of corporal punishment.
>
> 4. In cases of arrest or detention of foreign vessels the Coastal State shall promptly notify the Flag State, through appropriate channels of the action taken and of any penalties subsequently imposed.

In practical terms, the core elements of a fisheries enforcement system are (Anderson 1989):

- structures and procedures for monitoring so as to identify rule breakers;
- structures and procedures to ensure prosecution of alleged rule breakers so as to ascertain innocence or guilt;
- structures and procedures for assessing and imposing penalties when guilt is proven.

The fisheries enforcement process has a number of purposes beyond rule enforcement, in the sense of rule enforcement to protect stocks and safeguard national or wider regional economic interests in the resource. The secondary functions often include serving as a feedback mechanism for evaluating management strategies and also for monitoring the internal distribution mechanisms in use by national or regional organisations. In terms of management feedback, the intelligence gathered on catch rates and on concentrations of fishing effort is also useful in at least two senses: it assists short-term decision-making on deployment of enforcement resources, but more crucially it can provide firm grounding for future management decisions. This is particularly so where the information generated by the enforcement system pays informed attention to differentiation by nationality and/or vessel/gear type.

Papua New Guinea's fisheries jurisdiction is enforced jointly by the Defence Force and the fisheries departments (Bergin 1988). The Papua New Guinea Defence Force has established a surveillance centre in Port Moresby staffed by officers from the departments of Defence, Fisheries, Customs, Transport and Civil Aviation. In practice, fisheries enforcement officials in Papua New Guinea are drawn from four sources: members of the Police Force; members of the Defence Force; officers or employees of the Public Service; and officers or employees of a Papua New Guinea statutory authority. In the case of the last two categories, there has to be written authorisation empowering the person to perform duties under the relevant act.

Authorised officers have a wide range of powers, including powers in relation to the inspection and examination of fishing vessels, and vehicles/premises used in the fishing industry, as well as those capable of use in the fishing industry, or found in the fishing zone or the shelf area.

Enforcement officers may also exercise a wide range of directive powers over directors and crews of vessels:

- Where they think an offence is in issue, they may ask the person in charge of a boat to bring the boat to a specified place in the country. (It is, however, not stated what the phrase 'a place in the country' means, and whether it refers to places on land, ports or places at sea). They may also require the person in charge to keep the boat at that place until permission to leave is given. They may detain a director and crew in this way, prior to judicial or administrative sanctioning, and during the course of such sanctioning processes.
- Where the boat is a licensed vessel, they may ask the person in charge of the vessel to produce the licence for the boat, and may take copies or extracts from the licence.
- Where the boat is a licensed vessel, they may ask the person in charge of the boat for information concerning the crew and any other person on board the boat.
- Where the boat is a vessel for which a licence is required, they may ask the name and place of abode of a person on board the boat.
- Where the boat is not licensed, or is not licensable, but is nevertheless engaged in fishing, they may ask the name and place of abode of a person on the vessel.
- Where a person is engaged in fishing, they may ask the person whether they are licensed to fish, and if so, to produce the licence.
- Where they have reason to believe a person is committing an offence, they may ask that person to state his or her name and place of abode, and may arrest that person without a warrant.

The powers in relation to direct control of vessels are also broad. Where an offence is in issue, the enforcement power also permits officials to take direct control of a boat, and remain in control of such boat, prior to judicial or administrative sanctioning procedures, or during such processes, regardless of the presence of a director or crew. Also worthy of note are the power to seize vessels, equipment and fish where an offence is in issue; the power to sell seized fish or sedentary organisms; and the right to enter and search the premises of accredited tuna processors.

In sum total, the powers given to Papua New Guinea enforcement officers are the traditional police powers of the right to board, enter, inspect, search and examine vessels, vehicles, premises or places used for fishing, or capable of being used for fishing. These powers may be exercised:

- to assess whether the *Fisheries Act* or the *Continental Shelf Act* are being complied with;
- where an authorised officer has reason to believe evidence of an offence may be found through the exercise of the power; or
- where the officer merely believes that the vessel has previously been used, is actually being used, or is intended to be used for fishing or the taking of marine organisms.

The legislation provides that these police powers may be exercised where the officer 'has reason to believe' that there is (i) the continuing performance of a prohibited act; (ii) its previous performance; (iii) its intended performance; or (iv) the threat of its performance.

The enforcement systems adopted by a coastal state must satisfy a number of criteria to be economically useful to these states. Such systems must show all or most of these characteristics:

- effectiveness in apprehending violators of relevant prescriptions;
- fairness to those affected;
- reasonableness in impact upon regulated and other activities;
- acceptability to the states and others concerned; and
- economy in resources utilised or required.

Translated into practical policy questions, coastal state policymakers have to consider the following matters in designing fisheries enforcement policy:

- the level of resources that should reasonably be devoted to the enforcement of fishing laws and management systems;
- the most appropriate enforcement philosophy to be adopted within the level of resources available;
- the relative value in terms of deterrence of (a) surveillance operations (b) sanctioning procedures;
- the best balance of effort as between air, sea and land based enforcement procedures;
- whether enforcement should be carried out by military or civilian agencies;
- whether fishing offences should be classified as a form of economic crime;
- whether fishing offences should be dealt with through administrative or judicial procedures;
- the scope available for increased international cooperation (a) with other coastal states in the region, (b) with the flag states of access-seeking fishing enterprises and (c) with and through the various marine sector international organisations;
- the balance in the enforcement process between strict legal procedure, diplomacy and relations of pure power given that international relations may often be implicated in a routine enforcement exercise;
- whether the enforcement system as a whole conforms with international law.

Conclusion

Papua New Guinea stands to gain economically from the new regime of fisheries permitted by international law. However, it is not sufficient to declare an extended zone of maritime jurisdiction or make proclamations asserting marine resource jurisdiction. To achieve maximum economic benefits from the zone a number of management policy initiatives need to be taken. One of the most significant policy questions relates to enforcement of fisheries jurisdiction. These policy questions are yet to be addressed by the authorities in Papua New Guinea. Given the growing significance of the fisheries sector in Papua New Guinea's economy, it is crucial that these policy issues are carefully considered. Papua New Guinea has also not yet ratified the

Law of the Sea Convention which is the definitive legal basis for fisheries jurisdiction at the present time. Some of the provisions of Papua New Guinea's fisheries sector legislation would appear to be contrary to the current rules permitted by international law. Papua New Guinea would need to carefully consider the question of ratification of the Law of the Sea Convention. Before that is done, a thorough evaluation of the fisheries laws in terms of compatibility with the Law of the Sea Convention regime will be required.

Chapter

16

The Use of Logbook Data in Monitoring Catch Rates: a Comparison of the U.S., Korean and Taiwanese Purse Seine Fleets in Papua New Guinea 1983–1990

H.F. Campbell

H. Landu

R.B. Nicholl

Introduction

The activities of foreign tuna purse seine fleets in Papua New Guinea's exclusive economic zone from nations other than Japan or the United States have, in the past, represented a relatively minor contribution to the overall level of tuna fishing activity. During the late 1980s, however, Korea and Taiwan showed an increased interest in Papua New Guinea waters as a source of tunas for their purse seine vessels. As vessel design and technology of these fleets parallel those of the American and Japanese fleets, it is of interest for Papua New Guinea to know how the Korean and Taiwanese fleets compare with those of the United States and Japan in terms of behaviour and catch efficiency. Access fee negotiations will be facilitated by information about whether Korean and Taiwanese vessels experience similar catch rates to vessels of like technology but operating under other flags.

Fees for access to Papua New Guinea's exclusive economic zone are levied on a per trip basis. The fee is set so as to collect 6% of the gross value of the expected catch during an average trip. Since the access fee paid by an individual vessel is not related to the actual catch of the vessel, but rather to its expected catch as determined by vessel size, there is no incentive for underreporting of catch on an individual vessel basis. There may be an incentive to underreport on a fleetwide basis, however, since Papua New Guinea uses reported catches to estimate the value of the average catch per trip.

Medley (1991b) has analysed individual vessel data in the South Pacific Commission data base for the period 1979–1990 to look for evidence of underreporting effort or catch. He bases his analysis on the proportion of a purse seiner's storage capacity which is filled at the end of a trip. He finds that most U.S. vessels report a full hold, whereas a high proportion of Korean and Taiwanese vessels report a small proportion of the hold filled. The present study looks at fleet-wide averages and compares the catches of the U.S., Korean and Taiwanese fleets at various times and in various subzones of Papua New Guinea's exclusive economic zone in the period 1983–1990.

Background

The purse seine technique of tuna harvesting was developed by U.S. fishers who used it initially in the eastern Pacific and then in the central and western Pacific. It was not until nearly 30 years later, around 1960, that the Japanese started building purse seine vessels of their own with a view to developing distant water fishing grounds in the Asia-Pacific region. The original Japanese vessels were modelled on U.S. purse seine technology (Doulman 1987a), although the Japanese have to some extent incorporated their own technological changes into their purse seine fleets. All Japanese tuna fleets have been excluded from Papua New Guinea waters since March 1987 when Japanese access arrangements lapsed due to disputes with the Papua New Guinea government concerning the level of fees to be paid for fishing rights. Other nationality fleets to increase their presence in the region since that time have included those of Taiwan, Korea and the Philippines.

The Korean fleet expanded steadily throughout the 1980s to 23 vessels at the end of 1988, to 28 in 1989 and then by a further 10 vessels during 1990 (SPC 1991a). Almost all of the Korean purse seiners are either ex-American vessels or have been built under contract in the United States. Many of the ex-American vessels were reportedly sold to Korean firms either during or after the slump in world tuna prices experienced by the industry in the early 1980s. An increase in the presence of Korean vessels in the western Pacific region has been reflected in an increase in the level of activity of these vessels in Papua New Guinea. In 1982 4 Korean flag vessels fished in Papua New Guinea waters with the number of vessels steadily increasing to 15 by 1989. The majority of these vessels are in the size range 499 to 1528 GRT.

The expansion of the Taiwanese fleet followed a similar pattern to that of the Korean fleet, growing from 3 vessels in 1980 to 32 vessels active in the SPC region in 1990 (SPC 1991a). Whereas the Korean vessels are very similar to U.S. style purse seiners, the Taiwanese vessels are reportedly close replicas of Japanese single seiners in structure, gear and fishing technique (Narasaki 1990), although they are generally larger than the average Japanese single seiner. Whereas most Japanese single seiners are of 350–500 GRT, about 70% of Taiwanese vessels are in the size range 750–1000 GRT, with 78% greater than 900 GRT. This compares with 4 out of 51 Japanese single seiners which operated in Papua New Guinea waters between 1979 and 1987 being over 900 GRT. The increase in the number of Taiwanese vessels operating in the region has been accompanied by increasing levels of their activity in Papua New Guinea's exclusive economic zone; 3 vessels were active in Papua New Guinea waters in 1983 and 17 in 1989. The peak of Taiwanese purse seine activity in Papua New Guinea for the period 1983–90 occurred in 1989, after Japanese vessels ceased to fish in the exclusive economic zone.

Fleet comparisons

As the Korean and U.S. vessels are reported to be of the same structure and employ the same type of gear, a comparison of catch rates between these two fleets can be treated as a relatively straightforward matter. Ideally, any comparison made with the Taiwanese vessels would be with the efficiency of the Japanese single seine fleet. However, as the Japanese fleet had been excluded from Papua New Guinea waters by the time their Taiwanese counterparts became most active in Papua New Guinea, and since the average size of Taiwanese purse seiners is significantly greater than Japanese seiners, it seems reasonable to compare Taiwanese vessels with the U.S. vessels. For this reason, Japanese vessels are excluded from any of the following comparisons and the U.S. fleet, which is believed to have been reporting recent catches reasonably accurately and consistently, is used as the basis for comparison.

Table 16.1 clearly demonstrates that the U.S. fleet presence in Papua New Guinea, prior to the multilateral treaty, was most prominent during the years 1984–86. The number of reported fishing trips made by U.S. purse seiners into Papua New Guinea's exclusive economic zone jumped from just 1 in 1983 to 27 in 1984 and then to 43 in 1985 before dropping back to 35 in 1986, and then to 6 for each of the two subsequent years. In comparison, fluctuations in the number of recorded trips made by Korean and Taiwanese vessels into Papua New Guinea waters have been more moderate (Table 16.2).

Excluding 1983, the number of sets per trip made on average by U.S. vessels ranged between 5 and 13–indicating that the duration of each trip (allowing for at least one set per fishing day and several days per trip to engage in search activity) to Papua New Guinea's exclusive economic zone by vessels of this fleet was probably from two to three weeks. Between 1983 and 1990, the average number of sets per trip made by Korean vessels ranged from 3 to 10 and for the Taiwanese fleet, 4 to 13 sets per trip. This observation

Table 16.1 U.S. Fleet: effort, catch, catch per trip and average catch rate, Papua New Guinea exclusive economic zone, 1983–88

Year	Trips	Sets	Yellowfin (t)	Skipjack (t)	Total catch (t)	Total catch/trip (t)	Yellowfin/ trip (t)	Skipjack/trip (t)	CPUE t/set
1983	1	5	42	576	618	618.000	42.000	576.000	123.600
1984	27	361	6927	9975	16902	626.000	256.556	369.444	46.820
1985	43	369	5881	15624	21505	500.116	136.767	363.349	58.279
1986	35	241	4956	10467	15423	440.657	141.600	299.057	63.996
1987	6	34	468	1777	2245	374.167	78.000	296.167	66.029
1988	6	48	875	2699	3574	595.667	145.833	449.833	74.458

Table 16.2 Korea and Taiwan fleets: effort, catch, catch per trip and average catch rate, Papua New Guinea exclusive economic zone, 1983–90

Year	Vessels	Trips	Sets	Yellowfin (t)	Skipjack (t)	Total catch (t)	Total catch/trip (t)	Yellowfin/ trip (t)	Skipjack/trip (t)	CPUE t/set
Korea										
1983	3	17	93	681	2330	3011	177.118	40.059	137.059	32.3763
1984	4	18	182	1010	3101	4111	228.389	56.111	172.278	22.5879
1985	4	12	36	238	873	1111	92.583	19.833	72.750	30.8611
1986	6	11	75	1083	1850	2933	266.636	98.455	168.182	39.1067
1987	11	30	186	3138	4321	7459	248.633	104.600	144.033	40.1022
1988	14	34	141	1889	3923	5812	170.941	55.559	115.382	41.2199
1989	15	44	195	3998	6875	10873	247.114	90.864	156.250	55.7590
1990	7	9	31	516	1362	1878	208.667	57.333	151.333	60.5806
Taiwan										
1983	3	6	82	652	2561	3213	535.500	108.667	426.833	39.1829
1984	6	15	59	607	1818	2425	161.667	40.467	121.200	41.1017
1985	6	30	167	1443	4186	5629	187.633	48.100	139.533	33.7066
1986	6	18	94	1124	3316	4440	246.667	62.444	184.222	47.2340
1987	9	25	176	1389	3840	5229	209.160	55.560	153.600	29.7102
1988	12	40	173	1854	5227	7081	177.025	46.350	130.675	40.9306
1989	17	42	211	1389	3408	4797	114.214	33.071	81.143	22.7346
1990	15	26	166	45	1512	2357	90.654	32.500	58.154	14.1988

suggests that Korean and Taiwanese vessels had similar duration of visits to their American counterparts.

If we consider the ratio of trips to the number of vessels, there were, as compared with the U.S. fleet, more vessels making fewer trips each from 1983 on for the case of the Korean fleet, with 3 vessels making 17 fishing trips in 1983 to 15 vessels making 44 trips in 1989 (Table 16.2). Although the increasing trend in the number of vessels fishing in Papua New Guinea over the period also holds for the Taiwanese fleet, there is no decrease in the trip to vessel ratio which averages 3.4 trips per vessel.

A comparison of the average total catch per trip for the three fleets indicates that U.S. vessels have taken significantly greater catches per trip than vessels of either of the other two fleets; the exception is Taiwanese vessels in 1983. Furthermore, the catch per unit of effort (CPUE) figures, measured as total catch per set, indicate that United States average CPUE is significantly larger than that of the Korean and Taiwanese in each year that all three nationalities have been fishing in Papua New Guinea. The sizes and gear types of vessels in all three fleets are fairly comparable and the average number of sets per trip indicates that vessels of each nationality make fishing trips into Papua New Guinea waters of similar duration. There are two possible explanations for the difference in catch rates. One possibility is that Korean and Taiwanese vessels are significantly less efficient at finding and catching fish than U.S. vessels. Another possibility is that the former fleets are underreporting catches.

The CPUEs for each of the three fleets do not exhibit any significant seasonal patterns (Tables 16.3, 16.4 and 16.5). In quarters when both U.S. and Korean, or both U.S. and Taiwanese vessels were fishing there are no instances when Korean vessels report a higher average CPUE than U.S. vessels, and five instances when Taiwanese vessels reported a higher average CPUE than U.S. vessels (1984:2, 1984:3, 1985:3, 1986:2 and 1986:4).

In order to obtain a better comparison of average catch rates, the exclusive economic zone was divided into eight fishing zones, (Figure 16.1), and quarterly catch rates and activity levels (Table 16.6) were calculated for 1985. The eight zones divide the exclusive economic zone roughly into three northern zones, an eastern zone (north of the Solomon Islands), a zone for the Bismark Sea, a zone between New Britain and Bougainville Island, a zone south of Manus and west of Madang and a southern zone incorporating waters south of 7S.

The level of purse seine activity by vessel flag and year for each zone, measured by the number of sets for the period 1983–88, are shown in Figure 16.2 with a

Table 16.3 U.S. fleet: catch and effort by year and quarter, Papua New Guinea exclusive economic zone, 1983–88

Year	Q[a]	Trips	Sets	Yellowfin (t)	Skipjack (t)	Total catch (t)	Total catch/trip (t)	Yellowfin/ trip (t)	Skipjack/trip (t)	CPUE t/set
1983	2	1	5	42	576	618	618.000	42.000	576.000	123.600
1984	1	10	180	3062	3606	6668	666.80	306.200	360.60	37.044
1984	2	10	122	3188	3522	6710	671.00	313.800	352.20	55.000
1984	3	6	47	514	1804	2318	386.33	85.667	300.67	49.319
1984	4	1	12	163	1043	1206	1206.00	163.000	1043.00	100.500
1985	1	6	53	547	2100	2647	441.17	91.167	350.00	49.943
1985	2	14	130	1681	6782	8463	604.50	120.071	484.43	65.100
1985	3	13	86	1363	3306	4669	359.15	104.846	254.31	54.291
1985	4	10	100	2290	3436	5726	572.6	229.000	343.60	57.260
1986	2	4	7	49	194	243	60.75	12.250	48.50	34.714
1986	3	22	183	4157	8010	12167	553.05	188.955	364.09	66.486
1986	4	9	51	750	2263	3013	334.78	83.333	251.44	59.078
1987	2	1	6	146	403	549	549.00	146.000	403.00	91.500
1987	3	5	28	322	1374	1696	339.20	64.400	274.80	60.571
1988	4	6	48	875	2699	3574	595.67	145.833	449.83	74.458

[a]Q-1 for June–August, Q-2 September–November, Q-3 December–February, and Q-4 March–May.

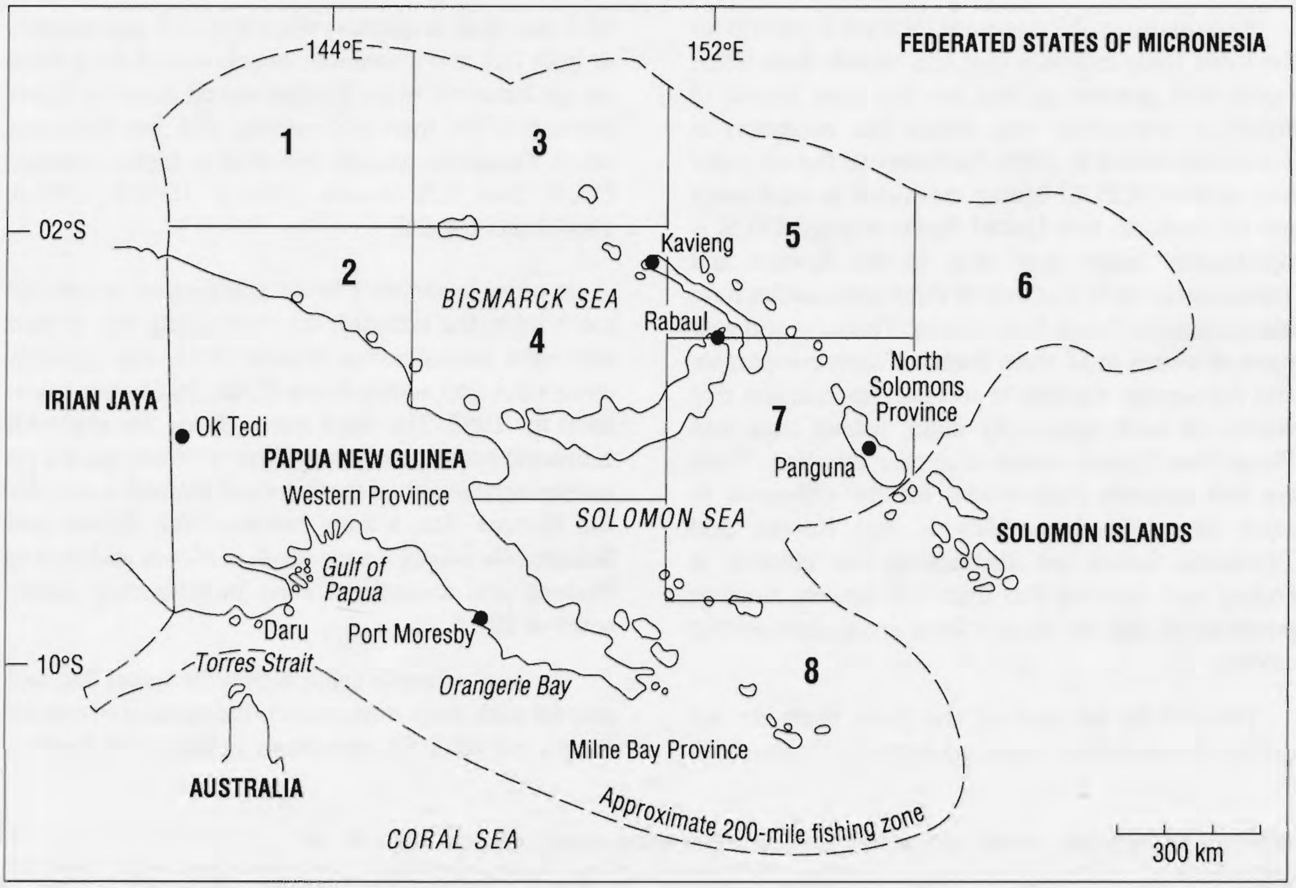

Figure 16.1 Papua New Guinea exclusive economic zone by fishing zone. Source: Doulman (1980).

summary by zone and year for the three fleets combined in Figure 16.3. From Figure 16.3 it can be seen that, in terms of the number of sets per year, zones 1, 3, 5 and 6 have attracted the most activity between 1983 and 1988. Of these, zone 5 recorded the highest level of activity with about 1000 sets of which around one-third were made in 1986; zones 1, 3 and 6 recorded cumulative sets for the period of between 500–700. Figure 16.2(e) shows that for zone 5, most of the fishing effort can be attributed to the U.S. fleet for 1986; the same holds for zone 3 in 1985 and zone 6 in 1984 (these years contributing most of the cumulative effort for these zones respectively). Zone 2 attracted the least amount of purse seine effort for the period with less than 100 sets by vessels of all three fleets.

There does not appear to be any particular pattern of activity for any particular nationality of vessel although the level of U.S. vessel activity in general seems to have been at its highest between 1984 and 1986. The only zone in which U.S. vessel effort is not on average the highest for the three fleets is zone 1, which seems to have been the preferred area for purse seining for the Taiwanese fleet. The year in which activity peaked in zone 1 for both the U.S. and Taiwanese fleets was 1985. Zones 3 and 5 appear to have been the most popular fishing grounds for Korean vessels within Papua New Guinea's exclusive economic zone. It is not apparent from the number of sets by zone for each of the Korean and Taiwanese fleets that the overall levels of fishing activity for vessels of these fleets were increasing throughout the 1980s.

Comparisons by year, species and zone for the period 1983–88 are shown for the U.S. and Korean fleets in Figure 16.4 and for the U.S. and Taiwanese fleets in Figure 16.5. In these figures each of the eight zones is identified by a number, the Korean and Taiwanese CPUE is represented by the bar corresponding to the zone number and the U.S. CPUE in

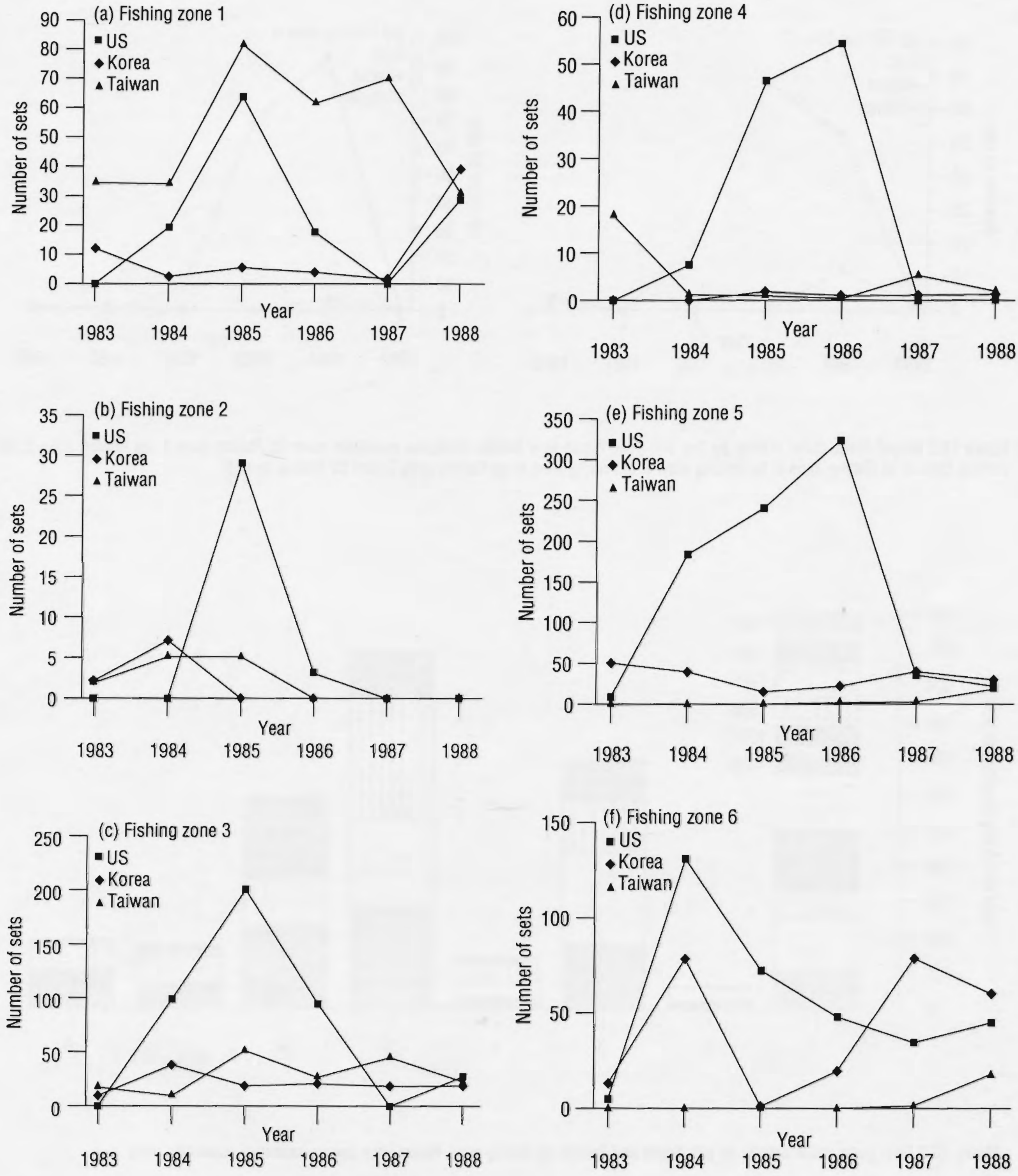

Figure 16.2 Purse seine activity by flag and year, Papua New Guinea exclusive economic zone: (a) Fishing zone 1; (b) Fishing zone 2; (c) Fishing zone 3; (d) Fishing zone 4; (e) Fishing zone 5; (f) Fishing zone 6; (g) Fishing zone 7; and (h) Fishing zone 8.

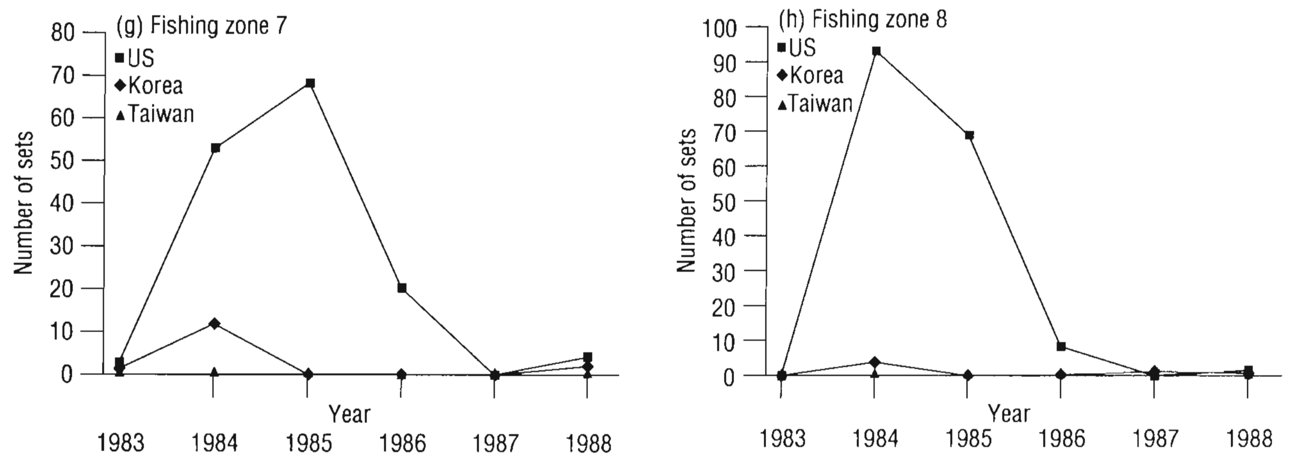

Figure 16.2 (contd) Purse seine activity by flag and year, Papua New Guinea exclusive economic zone: (a) Fishing zone 1; (b) Fishing zone 2; (c) Fishing zone 3; (d) Fishing zone 4; (e) Fishing zone 5; (f) Fishing zone 6; (g) Fishing zone 7; and (h) Fishing zone 8.

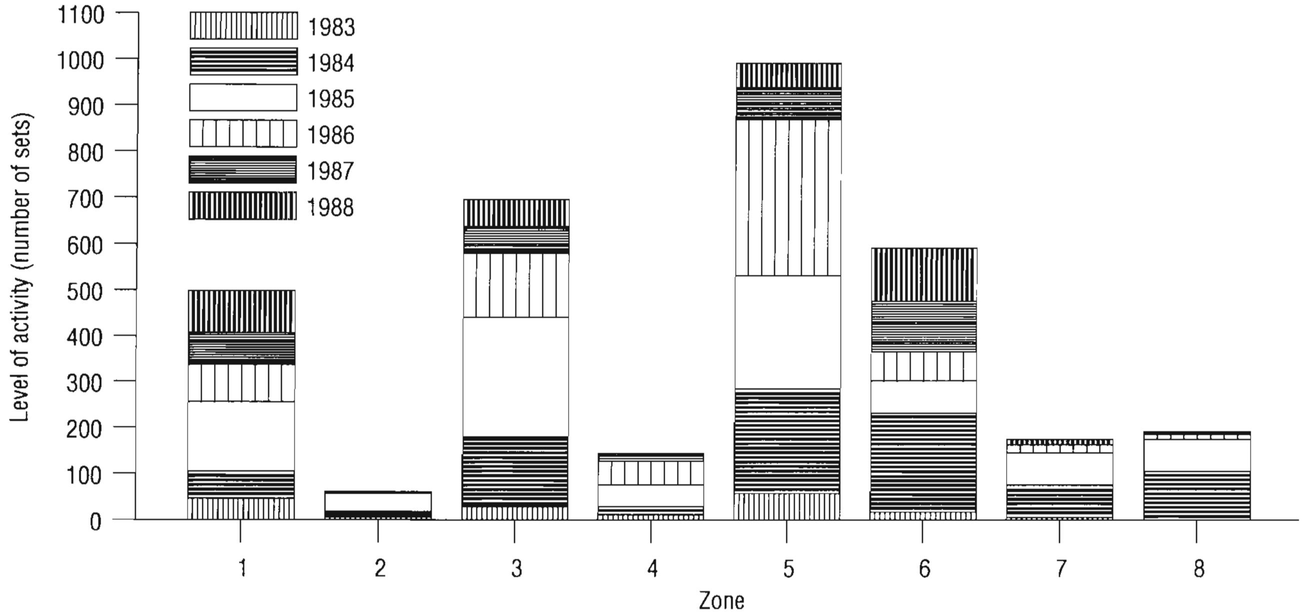

Figure 16.3 Total purse seine activity by U.S., Korea and Taiwan by fishing zone, Papua New Guinea exclusive economic zone.

Table 16.4 Korean fleet: catch and effort by year and quarter, Papua New Guinea exclusive economic zone, 1983–90

Year	Q[a]	Trips	Sets	Yellowfin (t)	Skipjack (t)	Total catch (t)	Total catch/trip (t)	Yellowfin/ trip (t)	Skipjack/trip (t)	CPUE t/set
1983	1	6	47	1673	337	1336	278.833	56.167	222.667	35.5957
1983	2	3	20	785	234	551	261.667	78.000	183.667	39.2500
1983	3	6	23	508	97	411	84.667	16.167	68.500	22.0870
1983	4	2	3	45	13	32	22.500	6.500	16.000	15.0000
1984	1	4	44	1310	359	951	327.500	89.750	237.750	29.7727
1984	2	7	80	1618	412	1206	231.143	58.857	172.286	20.2250
1984	3	6	50	982	201	781	163.667	33.500	130.167	19.6400
1984	4	1	8	201	38	163	201.000	38.000	163.000	25.1250
1985	1	5	13	488	76	412	97.600	15.200	82.400	37.5385
1985	2	2	5	75	33	42	37.500	16.500	21.000	15.0000
1985	3	1	1	20	5	15	20.000	5.000	15.000	20.0000
1985	4	4	17	528	124	404	132.000	31.000	101.000	31.0588
1986	1	3	25	758	172	586	252.667	57.333	195.333	30.3200
1986	2	4	33	1113	354	759	278.250	88.500	189.750	33.7273
1986	3	4	17	1062	557	505	265.500	139.250	126.250	62.4706
1987	1	5	16	895	395	500	179.000	79.000	100.000	55.9375
1987	2	5	47	1738	731	1007	347.600	146.200	201.400	36.9787
1987	3	10	68	2645	870	1775	264.500	87.000	177.500	38.8971
1987	4	10	55	2181	1142	1039	218.100	114.200	103.900	39.6545
1988	1	4	17	910	396	514	227.500	99.000	128.500	53.5294
1988	2	9	18	1252	508	744	139.111	56.444	82.667	69.5556
1988	3	13	60	2155	514	1641	165.769	39.538	126.231	35.9167
1988	4	8	46	1495	471	1024	186.875	58.875	128.000	32.5000
1989	1	8	42	2170	1033	1137	271.250	129.125	142.125	51.6667
1989	2	5	37	3290	1518	1772	658.000	303.600	354.400	88.9189
1989	3	13	29	2370	588	1782	182.308	45.231	137.077	81.7241
1989	4	18	87	3043	859	2184	169.056	47.722	121.333	34.9770
1990	3	7	21	1301	291	1010	185.857	41.571	144.286	61.9524
1990	4	2	10	577	225	352	288.500	112.500	176.000	57.7000

[a]Q-1 for June–August, Q-2 September–November, Q-3 December–February, and Q-4 March–May.

Table 16.5 Taiwanese fleet: catch and effort by year and quarter, Papua New Guinea exclusive economic zone, 1983–90

Year	Q[a]	Trips	Sets	Yellowfin (t)	Skipjack (t)	Total catch (t)	Total catch/trip (t)	Yellowfin/ trip (t)	Skipjack/trip (t)	CPUE t/set
1983	1	2	22	875	142	733	437.500	71.000	366.500	39.773
1983	2	2	39	1240	263	977	620.000	131.500	488.500	31.795
1983	3	2	21	1098	247	851	549.000	123.500	425.500	52.286
1984	1	3	18	263	81	182	87.667	27.000	60.667	14.611
1984	2	5	22	1372	351	1021	274.400	70.200	204.200	62.364
1984	3	5	12	623	130	493	124.600	26.000	98.600	51.917
1984	4	2	7	167	45	122	83.500	22.500	61.000	23.857
1985	1	8	50	1644	386	1258	205.500	48.250	157.250	32.880
1985	2	7	66	1538	397	1141	219.714	56.714	163.000	23.303
1985	3	9	33	1841	558	1283	204.556	62.000	142.556	55.788
1985	4	6	18	606	102	504	101.000	17.000	84.000	33.667
1986	1	2	11	430	90	340	215.000	45.000	170.000	39.091
1986	2	5	33	1885	562	1323	377.000	112.400	264.600	57.121
1986	3	9	44	1500	347	1153	166.667	38.556	128.111	34.091
1986	4	2	6	625	125	500	312.500	62.500	250.000	104.167
1987	1	1	1	20	7	13	20.000	7.000	13.000	20.000
1987	2	8	94	1996	571	1425	249.500	71.375	178.125	21.234
1987	3	12	43	1675	428	1247	139.583	35.6667	103.917	38.9535
1987	4	4	38	1538	383	1155	384.500	95.7500	288.750	40.4737
1988	1	8	45	1493	408	1085	186.625	51.0000	135.625	33.1778
1988	2	6	19	869	250	619	144.833	41.6667	103.167	45.7368
1988	3	17	69	3068	804	2264	180.471	47.2941	133.176	44.4638
1988	4	9	40	1651	392	1259	183.444	43.5556	139.889	41.2750
1989	1	5	19	670	212	458	134.000	42.4000	91.600	35.2632
1989	2	15	83	990	361	629	66.000	24.0667	41.933	11.9277
1989	3	9	45	1697	394	1303	188.556	43.7778	144.778	37.7111
1989	4	13	64	1440	422	1018	110.769	32.4615	78.308	22.5000
1990	3	15	107	1611	604	1007	107.400	40.2667	67.133	15.0561
1990	4	11	59	746	241	505	67.818	21.9091	45.909	12.6441

[a]Q=1 for June–August, Q=2 September–November, Q=3 December–February, and Q=4 March–May.

that zone is represented by the bar to the right of the zone number. Although comparisons of CPUE are shown for all eight zones, those zones of particular interest are those where there has been the greatest overlap in fishing effort.

The U.S. vessels outperformed the Korean vessels in 1984, and the Korean vessels outperformed the U.S. vessels in 1985 and 1988, in all zones in which both fleets were fishing. In other years there is no clear pattern of relative performance as measured by CPUE. There has been a great deal of variance in the CPUE of yellowfin to skipjack for both fleets, indicating that the species mix of catches has changed between years and zones and there is no evidence to suggest that one fleet is more successful at catching yellowfin than the other.

There was less overlap between the operations of the Taiwanese and U.S. fleets than was observed for the Korean and U.S. fleets. This is not suprising given the closer similarity of Korean vessels to U.S. vessels. Where the Taiwanese and U.S. fleets were fishing in the same zone in the same year, the Taiwanese vessels have generally outperformed the U.S. vessels in terms of CPUE. Similarly, there does not appear to be any pattern of consistently higher or lower catch rates for either the Taiwanese or U.S. fleets where overlap in effort between the two fleets has existed in zones. In fact, there seems to have been little overlap in the areas of fishing effort between these two fleets.

There are 12 points of comparison where the U.S. and Korean fleets were fishing in the same zone in the same quarter, and 13 such points of comparison for the U.S. and Taiwanese fleets (Table 16.6). In the U.S./Korean comparisons the Korean fleet average CPUE was roughly the same as, or higher than, that of the United States on seven occasions. In the U.S./Taiwanese comparisons the Taiwanese fleet average CPUE was roughly the same as, or better than, that of the United States on nine occasions. These comparisons suggest that when both pairs of fleets fish the same area at the same time there is no significant difference in reported catch rates.

Finally, Figures 16.6 and 16.7 show total catch by species and fleet for each year and zone for the period 1983–88. Skipjack was the dominant species in the catches of all fleets. Total catches also appear to have varied across all zones and years for the period with no particular zone or zones having dominated in terms of yielding high catches of tunas.

Conclusion

The above comparisons suggest several things. First, the increase throughout the 1980s in the number of vessels from the Korean and Taiwanese fleets fishing in the South Pacific Commission region reflects an increasing interest in Papua New Guinea as a source of purse seine caught tunas. Second, though the number of Korean vessels active in Papua New Guinea waters and the amount of fishing effort has increased throughout the 1980s, it appears that each vessel has been making fewer trips per year. It would also appear that vessels of both the Korean and Taiwanese fleets make relatively short ventures into Papua New Guinea's exclusive economic zone, usually around two to three weeks. Third, although Korean and Taiwanese vessels are of similar size and have similar trip duration to U.S. vessels, the former two fleets report somewhat lower overall total catches and catch rates. This may be a result of underreporting if it is believed that Korean and Taiwanese vessels are equally as efficient at finding and catching fish as their U.S. counterparts. Fourth, zones 3, 5 and 6, as depicted in Figure 16.1, appear to have been the fishing regions within Papua New Guinea waters which have attracted the most overlap in fishing effort between vessels of the U.S. and Korean fleets. There is no evidence presented in this analysis to suggest the catch rates in these zones are consistently more or less favourable for particular fleets, in any year. Finally, there is no evidence to suggest catch rates, as experienced by any of the three fleets, follow any particular seasonal pattern (Tables 16.3 to 16.5).

Table 16.6 U.S., Korean and Taiwanese fleets: catch, effort and CPUE by species, Papua New Guinea exclusive economic zone, 1985

Set type[a]	Q[b]	Zone[c]	Effort (Number of sets)	Yellowfin (t)	Skipjack (t)	CPUE Yellowfin (t/set)	CPUE Skipjack (t/set)
Korean fleet							
1	1	1	2	7	23	3.5000	11.5000
1	1	3	8	53	307	6.6250	38.3750
1	1	5	2	9	52	4.5000	26.0000
1	2	3	1	2	3	2.0000	3.0000
1	2	5	1	5	15	5.0000	15.0000
1	3	5	1	5	15	5.0000	15.0000
1	4	1	3	42	17	14.0000	5.6667
1	4	3	8	37	165	4.6250	20.6250
1	4	4	1	25	57	25.0000	57.0000
1	4	5	5	20	165	4.0000	33.0000
2	1	3	1	7	30	7.0000	30.0000
2	2	5	3	26	24	8.6667	8.0000
Taiwanese fleet							
1	1	1	16	107	305	6.6875	19.0625
1	1	3	16	111	249	6.9375	15.5625
1	2	1	47	293	852	6.2340	18.1277
1	2	2	1	3	2	3.0000	2.0000
1	2	3	10	44	136	4.4000	13.6000
1	2	4	1	3	1	3.0000	1.0000
1	3	1	8	116	213	14.5000	26.6250
1	3	2	1	20	40	20.0000	40.0000
1	3	3	16	184	620	11.5000	38.7500
1	4	1	7	16	341	2.2857	48.7143
1	4	3	6	69	108	11.5000	18.0000
2	3	1	3	67	85	22.3333	28.3333
2	3	2	3	120	220	40.0000	73.3333
2	3	3	1	46	40	46.0000	40.0000
U.S. fleet							
1	1	1	3	4	2	1.3333	0.6667
1	1	2	2	25	15	12.5000	7.5000
1	1	3	12	117	190	9.7500	15.8333
1	1	5	6	39	86	6.5000	14.3333
1	2	1	9	48	226	5.3333	25.1111
1	2	3	5	19	112	3.8000	22.4000
1	2	4	3	12	11	4.0000	3.6667
1	2	5	45	222	904	4.9333	20.0889
1	2	6	19	86	475	4.5263	25.0000
1	2	7	26	332	786	12.7692	30.2308
1	2	8	30	229	752	7.6333	25.0667
1	3	1	4	4	290	1.0000	72.5000
1	3	2	1	4	30	4.0000	30.0000
1	3	3	13	78	485	6.0000	37.3077

Table 16.6 (contd.) U.S., Korean and Taiwanese fleets: catch, effort and CPUE by species, Papua New Guinea exclusive economic zone, 1985

Set type[a]	Q[b]	Zone[c]	Effort (Number of sets)	Yellowfin (t)	Skipjack (t)	CPUE Yellowfin (t/set)	CPUE Skipjack (t/set)
1	3	4	1	10	0	10.0000	0.0000
1	3	5	13	58	173	4.4615	13.3077
1	3	6	5	68	27	13.6000	5.4000
1	3	7	24	182	774	7.5833	32.2500
1	3	8	12	43	335	3.5833	27.9167
1	4	1	13	6	289	0.4615	22.2308
1	4	2	7	35	59	5.0000	8.4286
1	4	3	51	221	1652	4.3333	32.3922
1	4	4	1	0	0	0.0000	0.0000
1	4	5	10	85	143	8.5000	14.3000
2	1	1	2	0	0	0.0000	0.0000
2	1	3	3	25	55	8.3333	18.3333
2	1	5	6	31	185	5.1667	30.8333
2	2	1	3	0	0	0.0000	0.0000
2	2	3	1	10	20	10.0000	20.0000
2	2	5	77	492	1197	6.3896	15.5455
2	2	6	21	145	848	6.9048	40.3810
2	2	7	1	0	0	0.0000	0.0000
2	2	8	14	27	431	1.9286	30.7857
2	3	1	11	67	139	6.0909	12.6364
2	3	2	1	2	2	2.0000	2.0000
2	3	3	48	375	236	7.8125	4.9167
2	3	4	11	321	256	29.1818	23.2727
2	3	5	5	10	15	2.0000	3.0000
2	3	6	3	0	76	0.0000	25.3333
2	3	7	6	83	77	13.8333	12.8333
2	3	8	3	10	165	3.3333	55.0000
2	4	1	5	23	22	4.6000	4.4000
2	4	2	14	187	297	13.3571	21.2143
2	4	3	20	468	262	23.4000	13.1000
2	4	4	20	921	301	46.0500	15.0500
2	4	5	3	51	225	17.0000	75.0000

[a]Set types are 1=associated or log sets and 2=unassociated or free-school sets.
[b]June-August = 1; September-November = 2; December-February = 3; March-May = 4.
[c] See Figure 16.1

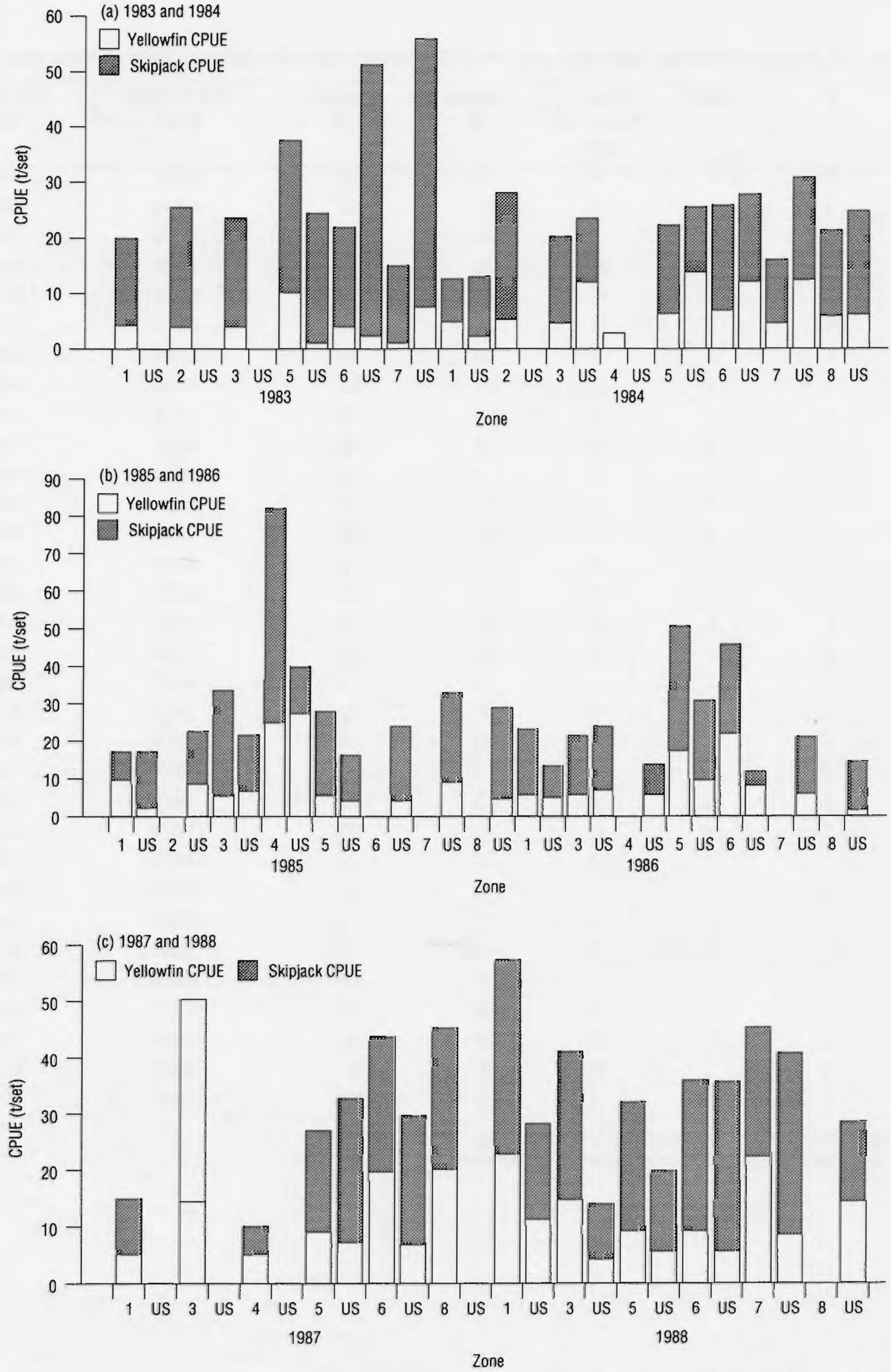

Figure 16.4 Korean and U.S. CPUE by zone, Papua New Guinea exclusive economic zone: (a) 1983 and 1984; (b) 1985 and 1986; and (c) 1987 and 1988.

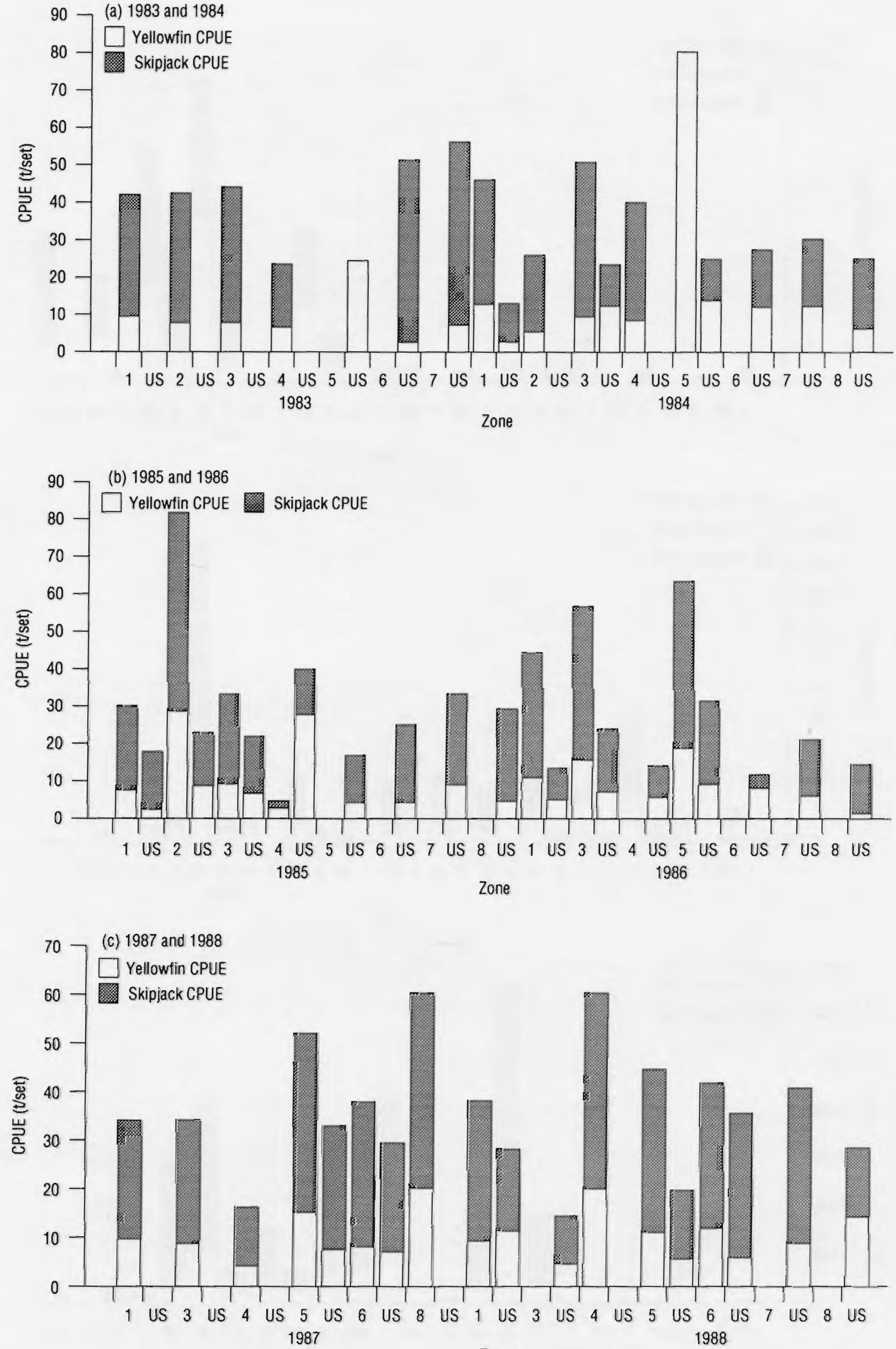

Figure 16.5 Taiwanese and U.S. CPUE by zone, Papua New Guinea exclusive economic zone: (a) 1983 and 1984; (b) 1985 and 1986; and (c) 1987 and 1988.

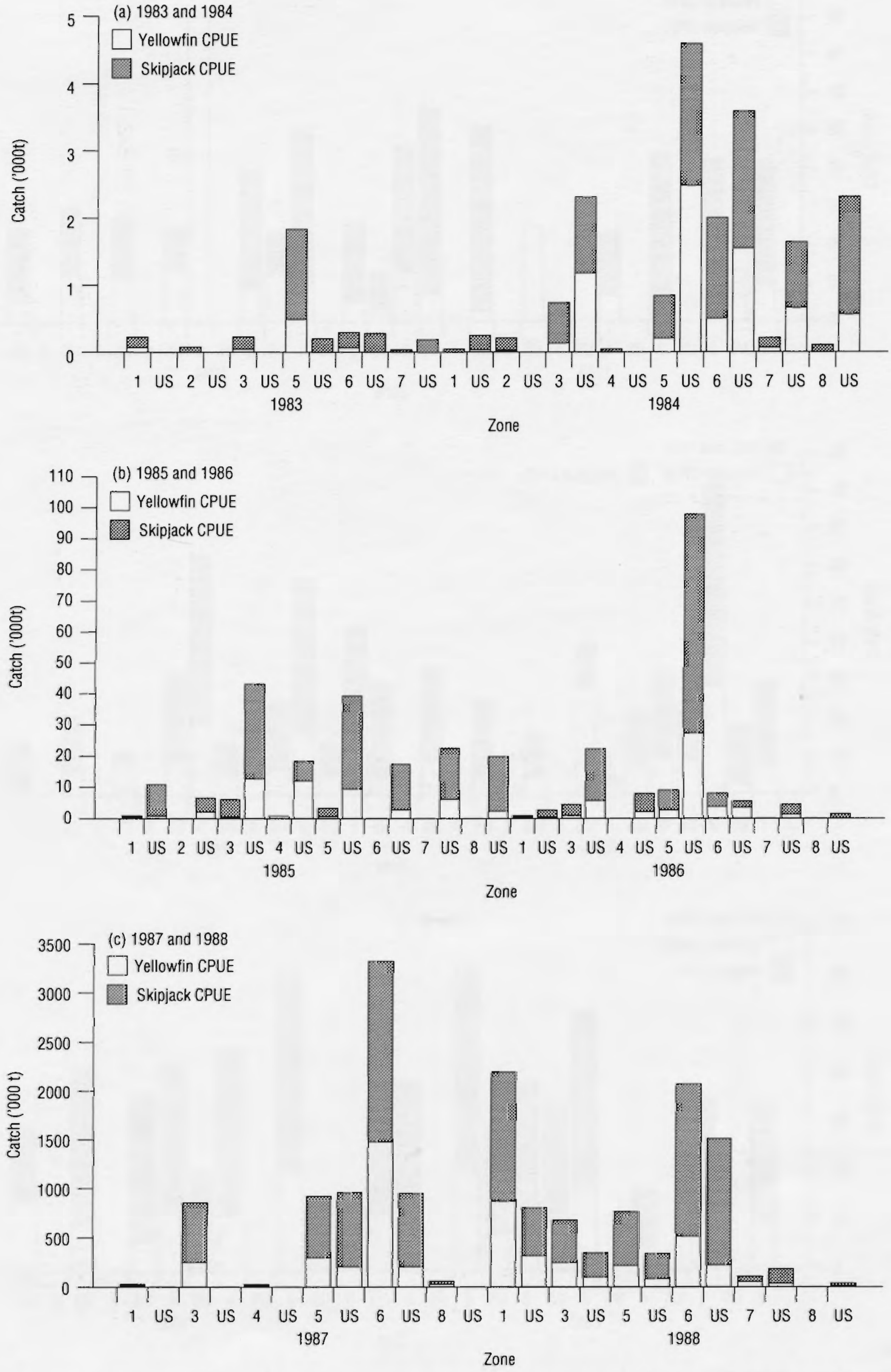

Figure 16.6 U.S. and Korean vessel catch by species and zone, Papua New Guinea exclusive economic zone: (a) 1983 and 1984; (b) 1985 and 1986; and (c) 1987 and 1988.

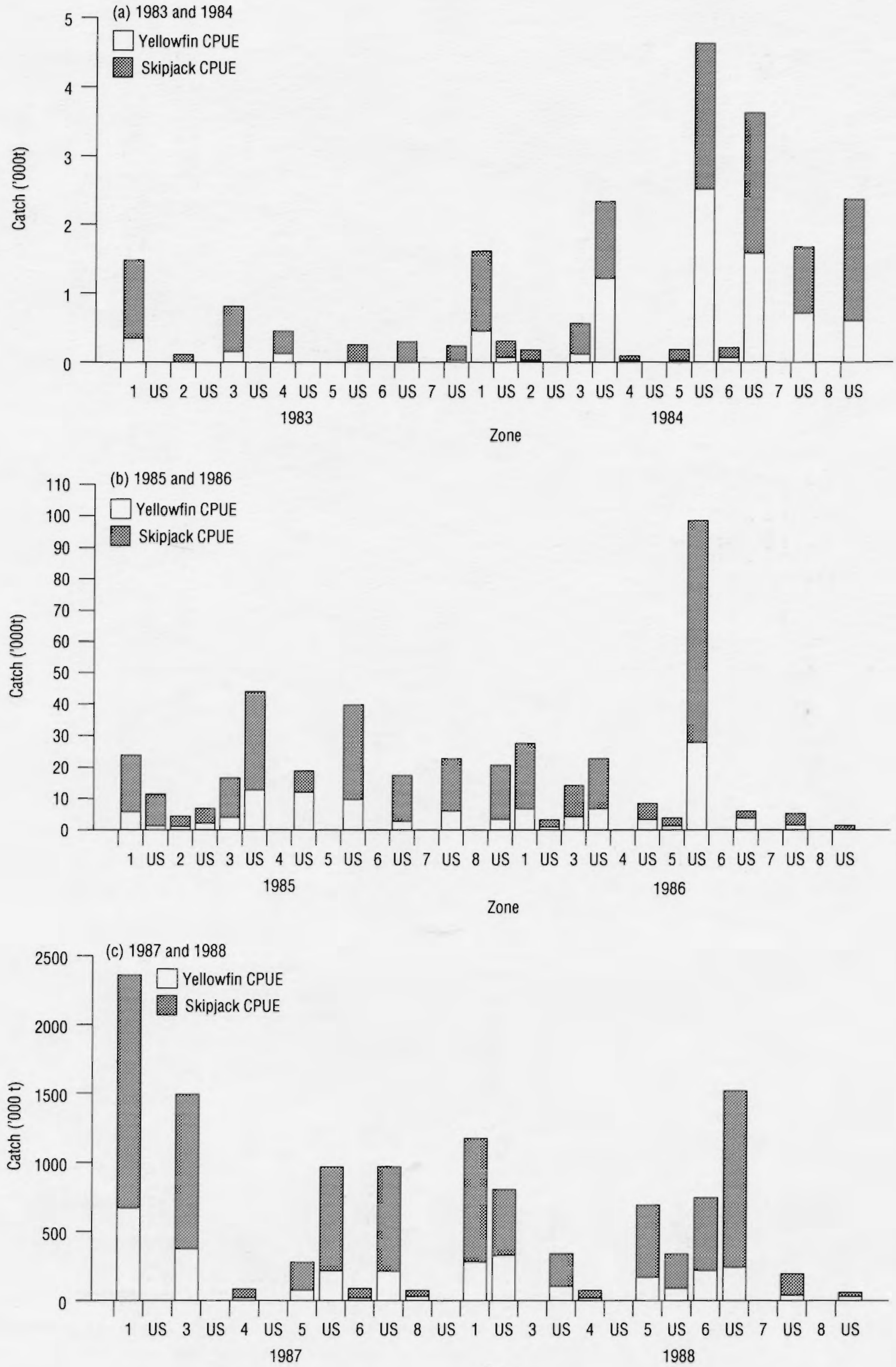

Figure 16.7 U.S. and Taiwanese vessel catch by species and zone, Papua New Guinea exclusive economic zone: (a) 1983 and 1984; (b) 1985 and 1986; and (c) 1987 and 1988.

Part V

The Processing Sector

Chapter

17

Exchange Rate Fluctuation and Comparative Competitive Advantage

A.D. Owen

Introduction

The world market for canned tuna underwent a number of substantial and fundamental changes during the 1980s (Tables 17.1–17.3). Over the decade, canned tuna production increased by about 83%, largely as the result of a rapid expansion of productive capacity in Thailand. U.S. dominance of production fell from 45% of the world total in 1980, to 28% by the end of the decade. Thailand's share of production rose from around 1% to about 20% over the same period.

However, it is in the area of international trade where the greatest changes occurred. In 1980 only about 20% of canned tuna production entered international trade. By 1989 this figure had doubled (Tables 17.2 and 17.3). Whereas Japan dominated the export scene in 1980, by the end of the decade it had been relegated to the role of a relatively insignificant market participant. In contrast, Thailand rose from the level of a virtual nonparticipant in 1980, to be the dominant export nation by 1985, a position it consolidated through the remainder of the decade. By 1989, Thailand accounted for around half of all tuna exports worldwide. Over the same period significant export growth was also experienced by the Philippines and, in later years, by Indonesia.

French ownership of canning facilities, plus France's favoured-nation trading policy with its ex-colonies, has ensured the steady growth of production in Côte d'Ivoire and the continued viability of the industry in Senegal. Most other countries are actively discouraged from exporting canned tuna to France.

Between them, the United States, United Kingdom, France and Germany (FR) accounted for the bulk of canned tuna imports over the decade. Import growth was particularly rapid (almost a fivefold increase!) in the United States and, from a smaller base, the United Kingdom.

However, the data given in Tables 17.1 to 17.3 should be treated with caution. Clearly total world exports of canned tuna (Table 17.2) should equal total imports (Table 17.3), but a substantial discrepancy is evident in the tables. This would appear to indicate an ongoing, substantial problem with errors in data collection.

This chapter analyses the effects of exchange rate movements on the growth of Thailand, the Philippines, and Indonesia in the international market, and the relatively rapid demise of Japan. Clearly this is only one of a number of factors which can enhance market competitiveness, but its long-term implications for the economic viability of many countries involved, or hoping to become involved, in the industry have been largely ignored to date.

Table 17.1 Canned tuna production by country 1979–89 ('000t)

Country	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
United States	283	275	287	246	268	275	250	295	297	271	311
Japan	95	95	111	113	126	130	121	114	112	111	104
Thailand	4	5	8	15	28	40	87	142	145	208	225
Italy	43	48	49	48	52	59	65	79	84	80	85
France	16	15	14	18	18	22	25	29	30	28	33
Spain	59	55	57	56	54	49	52	51	62	68	63
Mexico	13	15	20	13	11	22	27	13	18	23	35
Côte d'Ivoire	14	16	18	20	23	23	22	24	29	32	38
Philippines	4	11	18	19	24	23	25	26	26	37	47
Portugal	5	5	8	7	7	9	9	12	10	11	13
Fiji	5	3	7	6	8	6	7	10	11	16	15
Indonesia	5	5	6	6	11	10	6	3	6	9	21
Iran	3	2	3	3	3	5	6	4	5	10	10
Senegal	12	13	25	16	20	23	21	20	19	18	19
Taiwan	10	8	8	7	14	8	8	18	8	15	7
Venezuela	9	7	14	11	10	19	17	16	8	12	13
Others	31	24	26	16	25	56	45	56	50	55	60
World total	611	602	679	636	702	779	793	912	920	1004	1099

Source: FAO Fisheries Statistics Database

Table 17.2 Canned tuna exports by exporting country, 1980–89 ('000t)

Country	1980	1981	1982	1983	1984	1985	1986	1987	198	1989
Thailand	–	4.7	8.5	18.1	39.9	87.1	142.0	144.9	207.8	225.1
Philippines	11.2	18.0	19.4	23.5	22.6	25.5	26.4	26.1	37.1	47.5
Côte d'Ivoire	17.5	17.1	18.7	23.7	22.4	22.2	23.8	29.4	31.6	38.3
Senegal	11.5	15.2	16.2	20.1	22.7	20.6	19.6	19.0	17.8	18.9
Taiwan	16.0	13.6	11.4	15.5	13.4	15.1	19.5	17.4	15.7	12.5
Spain	8.0	11.6	2.1	4.1	4.2	4.9	4.3	6.6	11.3	9.5
Indonesia	–	0.4	0.8	2.2	2.2	1.2	1.8	4.3	8.5	20.6
Japan	38.3	34.9	35.7	36.9	45.6	34.0	29.6	15.5	8.2	5.3
Others	23.9	27.3	24.1	27.9	27.4	33.0	39.2	42.4	53.9	59.6
Total	126.4	142.8	136.9	172.0	200.4	243.6	306.2	305.6	391.9	437.3

Source: FAO, various years, Globefish highlights.

Table 17.3 Canned Tuna Imports, by importing country, 1980–89 ('000t)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
United States	28.7	26.5	28.8	48.0	58.5	74.3	106.8	97.0	110.8	152.5
France	24.6	27.7	29.8	34.0	32.5	36.9	35.6	46.9	54.8	48.0
United Kingdom	11.1	19.2	13.3	17.6	24.1	24.0	36.5	34.7	47.6	66.1
Germany FR	15.3	13.6	14.9	16.1	19.1	19.8	25.4	31.5	28.0	31.9
Canada	8.6	9.7	7.0	10.7	11.6	11.0	17.7	23.1	20.4	25.9
Others	32.6	26.8	25.6	27.0	30.4	43.2	48.0	65.3	69.7	86.7
Total	120.9	123.5	119.4	153.4	176.2	209.2	270.0	298.5	331.3	411.1

Source: FAO, various years Globefish highlights.

Exchange rates: nominal and real

International exchange rates are usually quoted as the nominal exchange rate of one currency with a numeraire currency, generally the US$. While some countries allow their currencies to 'float' against the US$, varying on a continuous basis, others prefer a 'managed float' to even out short-term fluctuations. Many other countries 'peg' their exchange rates to the US$ or a 'basket' of currencies, the 'basket' usually being comprised of the exchange rates of major trading partners weighted according to their relative importance in bilateral trade with the relevant nation.

Currently, for the countries considered in this chapter, the Philippines and Japan have floating currencies, Indonesia a managed float, and Thailand and Papua New Guinea manage their exchange rates according to the value of a basket of currencies.

The US$ is generally the currency of choice of world trade in tuna, except for French trade with certain Lomé convention countries. As a result, exchange rate fluctuations vis-a-vis the US$ can play a major role in determining the profitability of tuna canning industries worldwide.

Nominal exchange rates against a numeraire currency suffer from two problems: they make no allowance for inflation differentials between the two countries and they ignore the third country effects of independent changes in the exchange rates of other countries. The implications of the latter in the context of international trade in canned tuna will be considered later in this chapter.

Real exchange rates against the numeraire currency build in a measure of relative price movements between the domestic currency and the numeraire (US$ in this chapter). To appreciate the rationale for calculating real exchange rates, consider the following illustration. If domestic inflation, as measured by a retail prices index (RPI), in the United States is lower than that in (say) Indonesia then, assuming the nominal exchange rate remains unchanged, the real exchange rate of the rupiah with the US$ will rise thus rendering Indonesia's export industries less competitive against their U.S. counterparts. By trading in US$, such industries are price takers so their revenue in terms of rupiahs is fixed. However, the relatively high rate of domestic inflation vis-a-vis the United States will place cost pressures on such industries, leading to a squeeze on profits. Clearly, the effect can be offset by an appropriate devaluation of the rupiah against the US$, but for a number of reasons this action may be neither desirable nor possible. Conversely, if domestic U.S. inflation is higher than that of Indonesia, this would effectively produce a fall in the real price of the exported commodity, thereby increasing its competitiveness on the U.S. market and raising higher revenue through increased sales. Appreciation of the rupiah against the US$ would offset such a gain.

To summarise, real exchange rates build in a measure of relative domestic price movements in one country compared to other countries or to a numeraire currency. For the purpose of this chapter, all real exchange rates will be calculated against the US$.

The real exchange rate is calculated as:

$$\frac{CPI_t^{U.S.}}{CPI_t^*} \bullet \frac{E_t}{E_0} \qquad (1)$$

where

$CPI_t^{U.S.}$ is the level of the CPI in the United States at time t;

CPI_t^* is the level of the CPI in the country under review at time t;

E_t is the number of currency units of the country under review per US$ at time t;

E_0 is the number of currency units of the country under review per US$ in the base period.

Real exchange rates against the US$ were calculated, on a quarterly basis, for Thailand, the Philippines, Indonesia, Papua New Guinea, and Japan for the period 1980–90. For the purpose of cross-country comparisons, all nominal and real exchange rates have been expressed in index number form.

The base period for all index numbers is the first quarter of 1980.

The Thailand experience

Tuna has been harvested on a small scale by Thailand for many years, with the product exported in frozen form for canning elsewhere. A domestic canning industry was established in 1972 and, using primarily imported frozen tuna, the industry experienced rapid growth throughout the 1980s. It remains almost exclusively export-oriented.

Today, Thailand is the world's leading exporter of canned tuna and is currently the single largest source of imported canned tuna in the U.S. market. Market growth in Western Europe has been a more recent phenomenon.

World trade in tuna is generally conducted in US$. Thus for a country like Thailand, which processes imported tuna for subsequent re-export in canned form, the economic viability of the canning industry is heavily dependent upon the prevailing rate of exchange of the baht with the US$ and the domestic rate of inflation. In other words, the profitability of Thailand's tuna canning industry rests on the generation of value-added revenue expressed in US$, in addition to the interaction of other economic factors (particular prices) in world markets.

During the 1980s, the Thai baht was closely linked with the US$, although a gradual depreciation of the baht occurred over the decade (Figure 17.1). Since domestic inflation in Thailand closely followed that in the United States, the real and nominal exchange rates differed little. During the period of rapid growth of Thai canned tuna exports (1980–85), the baht was effectively devalued by almost 40% in both real and nominal terms. Thereafter, the baht experienced a gradual appreciation, but remained well below its value at the beginning of the decade.

Figure 17.2 illustrates quarterly movements in the US$ price of a carton of 48, 6 oz, cans of Thai origin canned tuna on the U.S. market over the period 1983–90. The data are also expressed in baht, calculated at the prevailing rate of exchange. Both series are in the form of index numbers (quarter 1, 1983 = 100). Prices expressed in baht exhibited considerably less volatility than U.S. prices, and were particularly strong in 1986 and 1988. These two years also witnessed considerable growth in tuna exports from Thailand (Table 17.2). In absolute terms, 1986 and 1988 saw increases in export quantities greater than for any other year in the decade.

Other exporting nations

Philippines

During the early 1980s, the peso underwent a period of rapid depreciation (in nominal terms), its value falling by 165% against the US$ between 1980 and year-end 1984 (Figure 17.3). However, this was also a period of very high domestic inflation, which served to keep the real exchange rate from depreciating as rapidly as the nominal rate.

Indonesia

The Indonesian rupiah was linked relatively closely to the US$ through the 1980s, but was subject to two major devaluations, in mid-1983 and late 1986 (Figure 17.4). As a consequence, the nominal exchange rate in

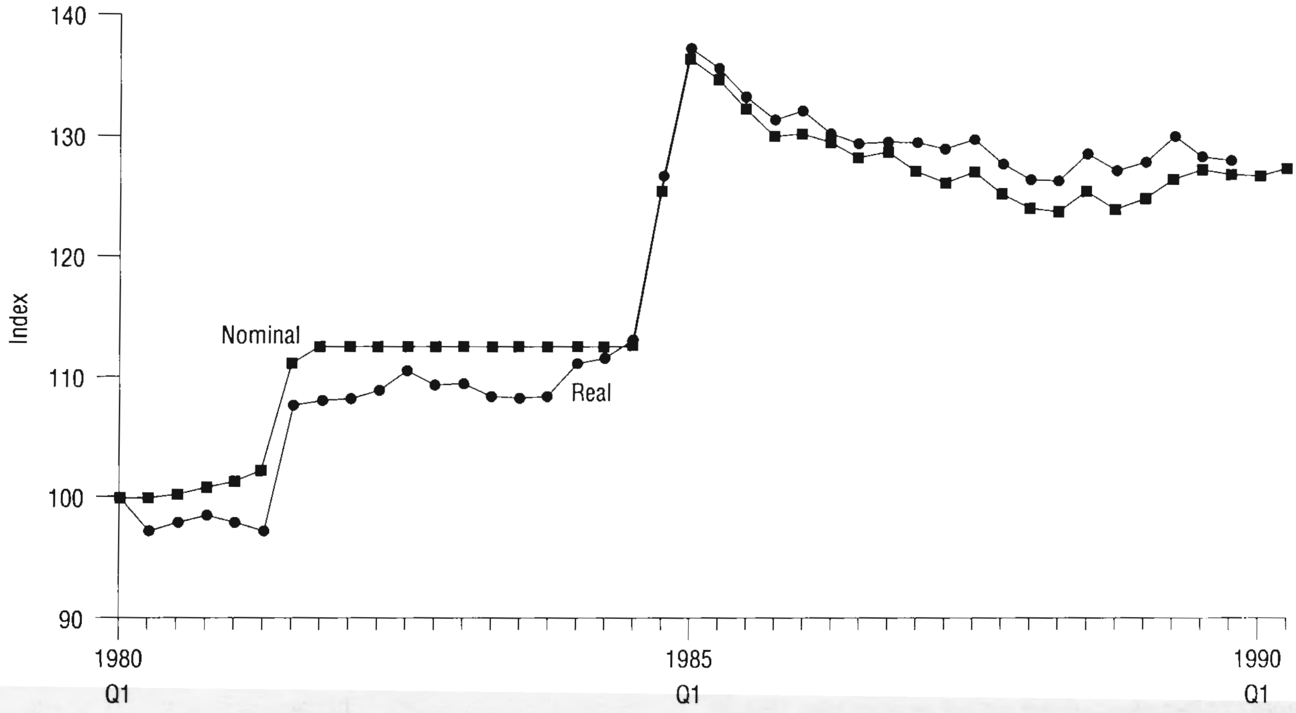

Figure 17.1 Thailand, nominal and real exchange rates, 1980–90.

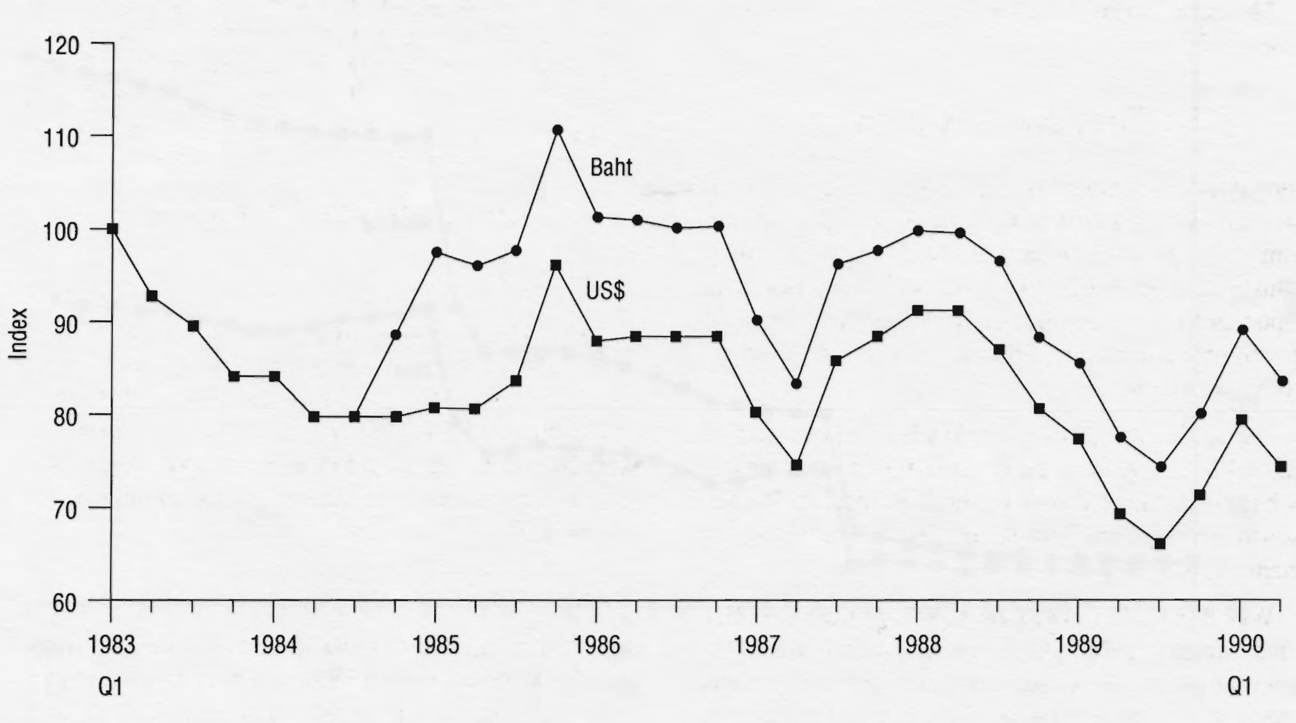

Figure 17.2 Canned tuna prices, U.S. market, 1983–90.

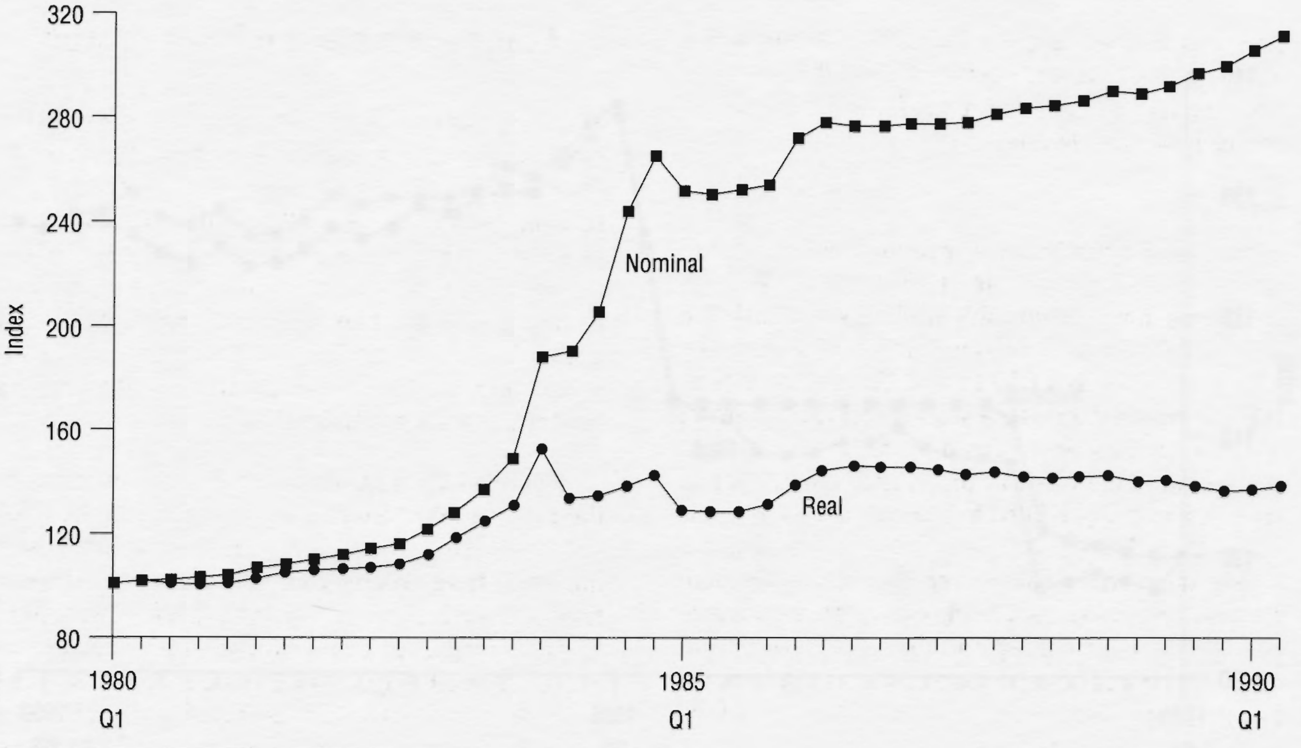

Figure 17.3 Philippines, nominal and real exchange rates, 1980–90.

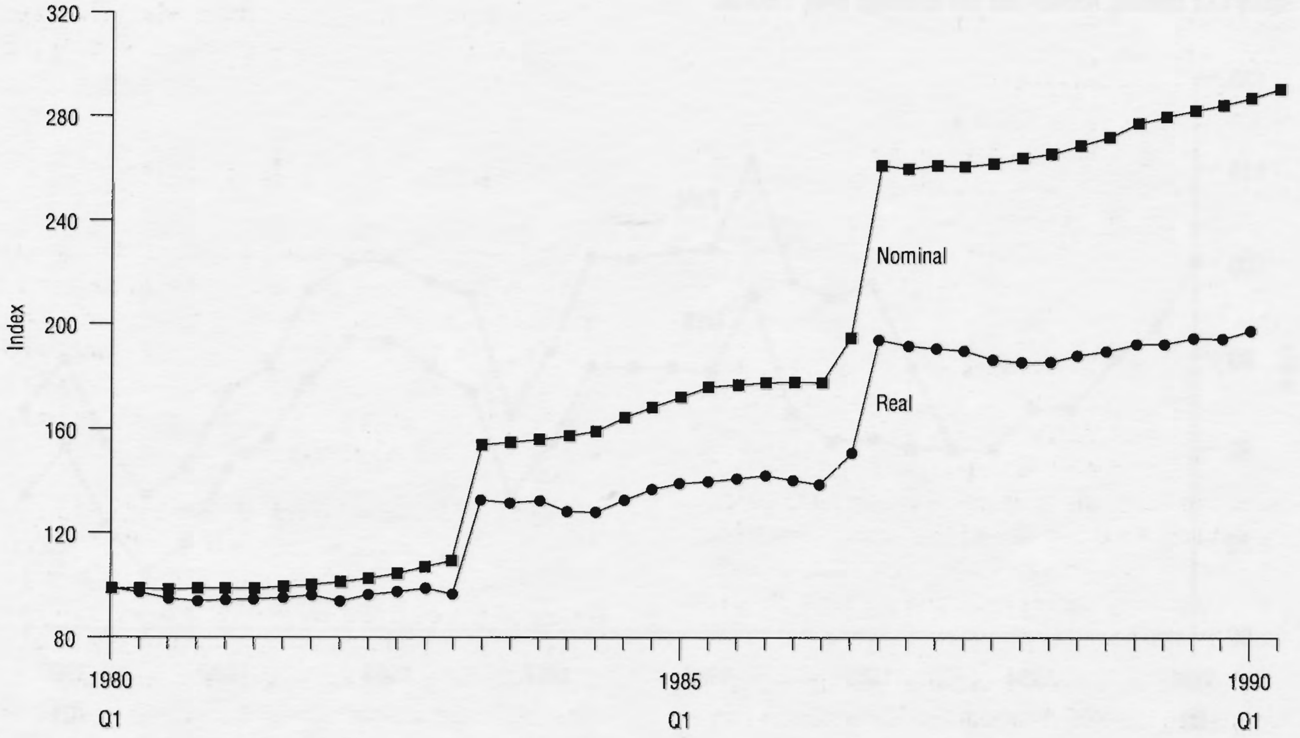

Figure 17.4 Indonesia, nominal and real exchange rates, 1980–90.

1990 was three times its level of 1980. However, with a relatively high level of domestic inflation, the rise in the real exchange rate was more moderate, although still doubling over the decade.

Japan

Japan's significance in the canned tuna export industry went into rapid decline during 1985 (Table 17.2) and the driving force behind this decline was clearly the rapid appreciation of the yen (Figure 17.5). Between the second quarter of 1985 and the first quarter of 1989, in nominal terms the yen appreciated by almost 50% against the US$. With a domestic rate of inflation considerably below that of the United States, the real exchange rate appreciated less rapidly but the rise was still substantial. Against the baht, the yen approximately doubled in value over the decade in both nominal and real terms. Clearly, exchange rate appreciation of this magnitude against the currency of a major competitor could be expected to produce a substantial loss in competitiveness for Japan in canned tuna (and many other) export markets.

Papua New Guinea

Up to now we have only considered countries which have been major participants in the international tuna canning market during the 1980s. One must assume that their presence in the market indicates that their tuna canning industries are, or were, economically viable with regard to the cost and availability of domestic capital, raw materials, and labour. Given this situation, we have considered the impact of exchange rate fluctuations on the comparative competitive advantage of such countries.

Papua New Guinea does not currently possess a tuna canning operation, although the possibility has been mooted on a number of occasions in recent years. While the current and expected level of the kina against the US$ will be of considerable importance to the industry if it is established, the industry should only be established in Papua New Guinea if it can produce an economically viable product on the basis of current domestic costs.

Figure 17.6 illustrates historical movements of the kina against the US$. A substantial depreciation occurred during the first half of the 1980s, followed by a gradual appreciation until the sharp devaluation in 1989.

Comparison of exchange rates

This study has so far ignored third country competition faced in the export market. For example, although there is only a relatively minor level of direct trade between Indonesia and Thailand, both countries export a similar range of products to the United States, one of their major trading partners. Even if there were no change in the baht/US$ real exchange rate, a change in the rupiah/US$ real exchange rate is likely to have an impact on the competitiveness of Thailand's level of exports to the United States.

Figure 17.7 compares nominal exchange rates of the five countries detailed above, relative to the US$. From a 1980 base, clearly the Philippines and Indonesia have experienced the most rapid depreciation of their currencies, particularly over the second half of the decade. However, when real exchange rates are considered (Figure 17.8) clearly Indonesia and Japan deviate, in opposite directions, from the others by a substantial margin. While Thailand, the Philippines, and Papua New Guinea have all experienced a substantial competitive advantage against Japan over the second half of the decade, Indonesia's advantage far exceeds that of these three countries when based purely on real exchange rates.

Exports to Western Europe

The Western European canned tuna market is very diverse, with individual countries having quite different requirements and favoured-nation trading concessions given by France to its ex-colonies of Côte d'Ivoire and Senegal. However, this market has been expanding rapidly over recent years and Asian producers have recently been gaining market share.

Figure 17.9 shows nominal exchange rates of France, United Kingdom, and Germany (FR) against the US$ during the 1980s. During the first half of the decade all three currencies, to varying degrees, experienced substantial effective currency depreciations as the result of a very strong dollar. An impact which was completely reversed for Germany, and largely offset for France and the United Kingdom through the remainder of the decade.

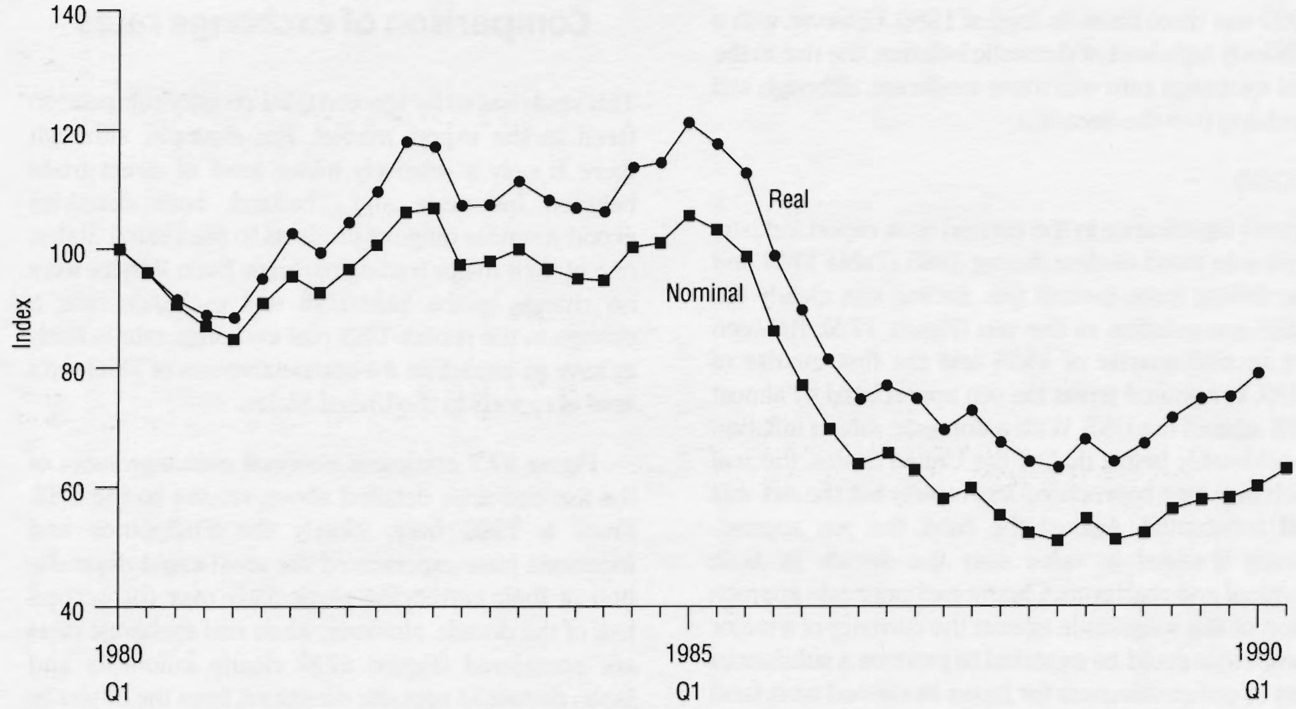

Figure 17.5 Japan, nominal and real exchange rates, 1980–90.

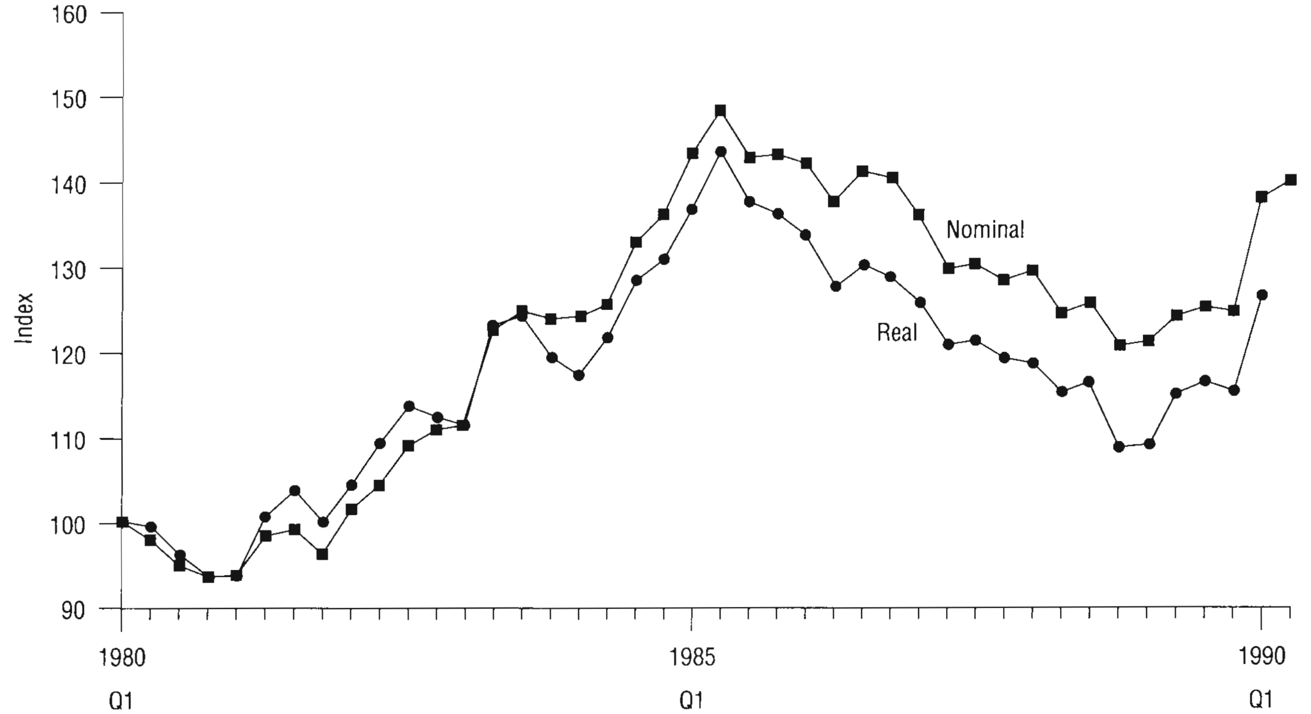

Figure 17.6 Papua New Guinea, nominal and real exchange rates, 1980–90.

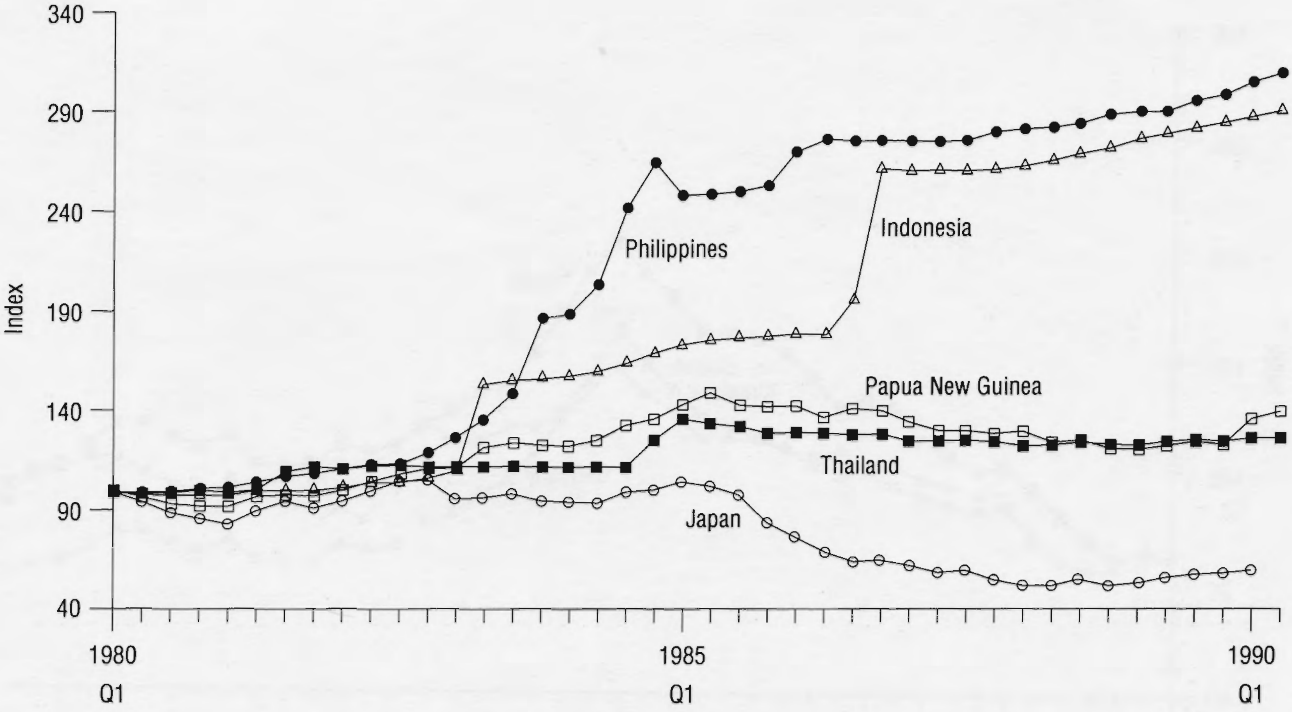

Figure 17.7 Nominal exchange rates, selected canned tuna trading countries, 1980–90.

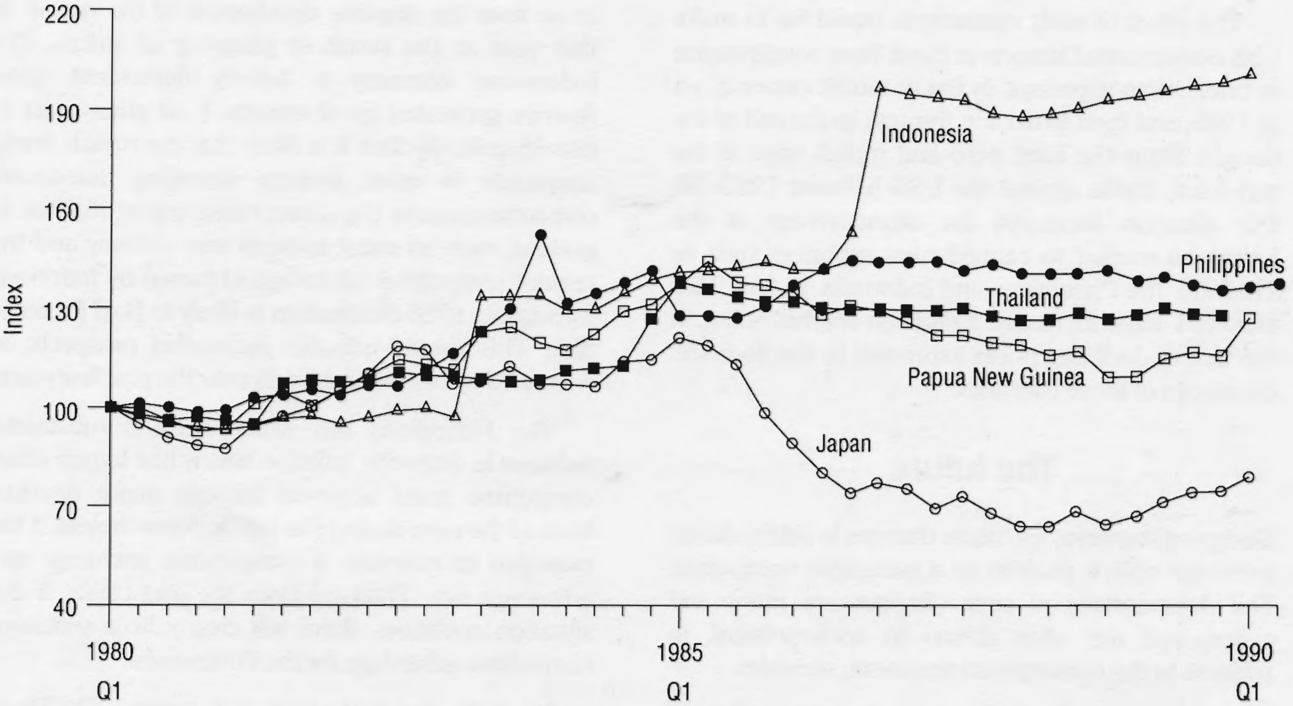

Figure 17.8 Real exchange rates, selected canned tuna trading countries, 1980–90.

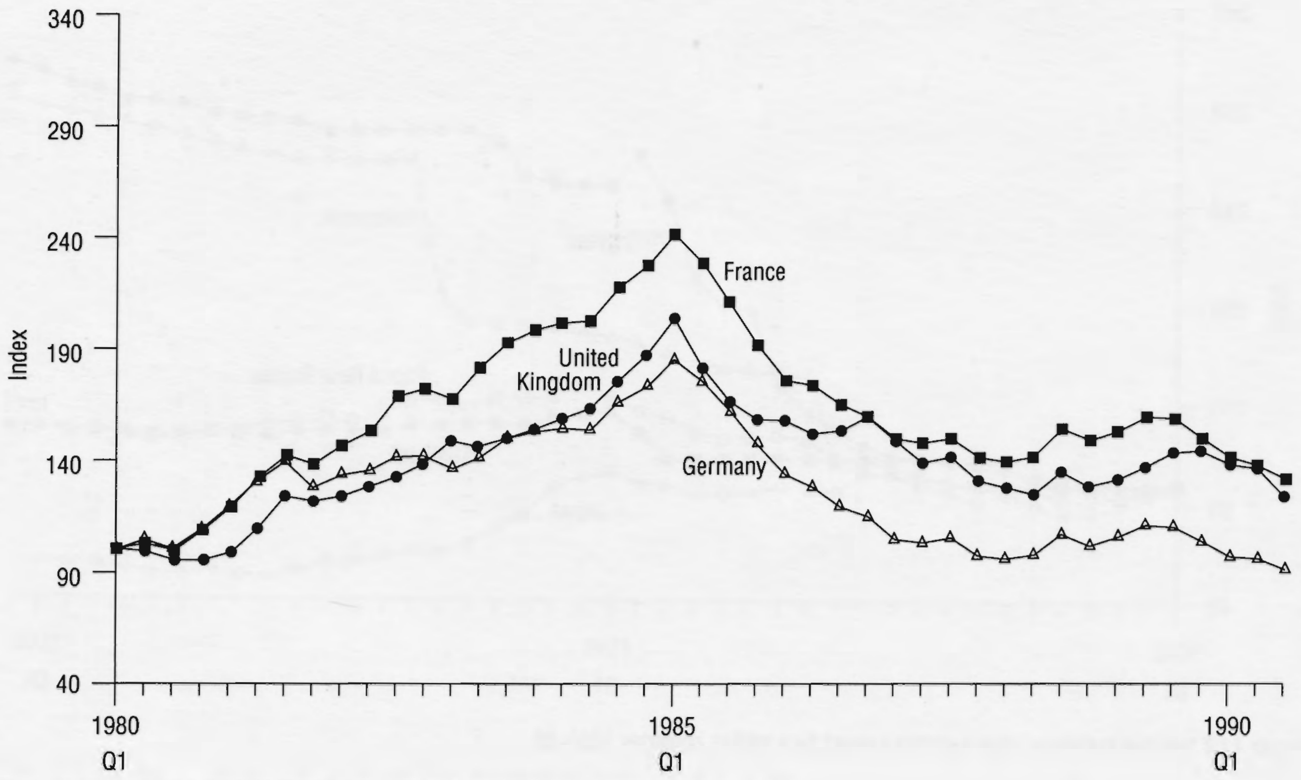

Figure 17.9 Nominal exchange rates, France, United Kingdom and Germany (FR), 1980–90.

The effect of such movements would be to make US$ denominated imports in these three countries rise in price, when expressed in the domestic currency, up to 1985, and then to decline through to the end of the decade. Since the baht, peso and rupiah were, at the very least, stable against the US$ between 1985–90, this situation increased the attractiveness of the European market to canned tuna exporters such as Thailand, the Philippines and Indonesia. In fact, Thai exporters have increased European market share in the face of declining prices expressed in the domestic currencies of those countries.

The future

Designing scenarios for future changes in international exchange rates is likely to be a precarious occupation. The determinants of such changes are many and varied, and are often driven by socio-political, in addition to the conventional economic, variables.

The comparative advantage in terms of real exchange rates enjoyed by Indonesia since 1986 largely arose from the massive devaluation of the rupiah in that year as the result of plunging oil prices. The Indonesian economy is heavily dependent upon revenue generated by oil exports. If oil prices were to rise dramatically then it is likely that the rupiah would appreciate in value, thereby damaging Indonesia's competitiveness in the canned tuna export market. At present, such an event appears very unlikely and the current competitive advantage obtained by Indonesia through its 1986 devaluation is likely to hold for some time. This should enhance its market prospects, as witnessed by increased exports over the past few years.

The Philippines has experienced a substantial increase in domestic inflation which has largely offset competitive gains achieved through major devaluations of the peso during the 1980s. Nevertheless, it has managed to maintain a comparative exchange rate advantage over Thailand since the mid-1980s. If this situation continues, there will clearly be a sustained competitive advantage for the Philippines.

In both nominal and real terms, Thailand's exchange rate has remained remarkably constant over the second half of the 1980s and scope for increasing its market share beyond its present level must be relatively limited. If total market growth for canned tuna expands rapidly then there will still be scope for Thailand to increase real exports, but a medium-term advantage may come through vertical integration in the market. The purchase of major tuna brands in the United States by Asian countries has been a relatively recent phenomenon which may well extend to many European countries. Controlling the market from the canning through to overseas distribution networks would clearly give Thai exports a considerable marketing advantage over exports from competing countries, even if the latter experienced a comparative competitive advantage through favourable exchange rate movements.

Conclusion

Exchange rates play a significant role in determining the profitability of canned tuna exports and, to a lesser extent, probably play a role in marketing decisions. However, the degree of this effect will be variable, and many other factors (such as contract arrangements and long-term market strategies) will also generally play an important role in export marketing decisions.

On the basis of relative levels of real exchange rates, Indonesia appears to have achieved a significant competitive advantage over the Philippines and Thailand. Whether this can be translated into increased market share depends on a host of other factors, but clearly the opportunities are present.

Chapter

18

Cannery Costs in the Western Pacific: a Hypothetical Model

H. Landu
D.A. Troedson
G.H. Waugh

Introduction

By world standards, island nations of the western Pacific are resource poor. In many of these island states, fisheries is a driving force to the economy generally, or at the very least, a driving force to the coastal regional economies.

Given the general resource scarcity in the western Pacific, and the potential value of the tuna fishery, the question of how best to utilise this resource in order to obtain the maximum domestic benefit is of considerable importance to island governments in the region. Currently, distant water fishing nations pay for the right to fish for tuna in the exclusive economic zones of nations in the western Pacific.

While such agreements supply the island nations with valuable foreign exchange, the major benefits from the resource accrue to foreign fishers and foreign processors.[1]

In order to address this loss of potential benefit from their tuna resources, three island governments have established domestic tuna canneries. Despite the marginal nature of the tuna canning industry, and uncertainties regarding existing canneries in Fiji, Solomon Islands and the Federated States of Micronesia, additional island governments are seeking to establish domestic canneries.

A hypothetical model of a greenfield tuna cannery situated in the western Pacific is developed, and the financial and economic viability of the cannery is analysed.

Tuna cannery model: initial assumptions

The hypothetical cannery is assumed to have the capacity to process 160 t of raw tuna per day (40000 t per year, based on an operating year of 250 days). The principal species used in the production of canned tuna are skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*). The bulk of the canned tuna produced is destined for export to the European Community, and in particular, the United Kingdom. Over the period 1982–91, European consumption of canned tuna increased dramatically, fuelled in particular by increased imports into France, the United Kingdom and Germany. During the period, canned tuna consumption in the European Community increased 119%, from 190600 t (98% of European consumption) to 418200 t (95% of European consumption). The United Kingdom is the dominant canned

[1] Troedson and Waugh (1993) and Waugh (1987), provide evidence which suggests that fees paid by distant water fishing nations are substantially less than potential rents generated by the fishery. Campbell et al. (1993) provide possible evidence that underreporting of catch by fishing vessels has been occurring in the western Pacific, resulting in a loss of revenue to western Pacific nations.

tuna importer in Europe, accounting for 26% of total European imports in 1991 (Owen and Troedson 1993a). All canned tuna exported to the European Community by the cannery is assumed to be exempt from import duties, since it is assumed to satisfy the conditions for tariff free entry into the European Community under the criteria established by the Lomé Convention.

A smaller proportion of cans comprising lower quality meat and tuna flakes is destined for the domestic market. Tuna heads, skin and viscera are processed into fishmeal.

The total project cost is US$49 million, comprising structural items including docks, buildings, and other infrastructure (22.4% of project cost); plant and equipment, consisting principally of refrigeration, canning and fishmeal equipment (33.5%); vehicles and training expenses (3.3%); and working capital, to finance initial operating losses and the cost of raw materials (40.8%) (Table 18.1).

Annual variable costs (at full production) are US$50 million, and comprise raw tuna (60% of annual variable costs); other raw materials, including cans, labels, cases and filler[2] (24%); indirect labour and freight charges (4.8%); direct labour (3%); fuel (3%); marketing and brokerage (2.7%); electricity (1.3%); and other costs (1.3%) (Table18. 2).

Annual fixed costs are US$3.635 million, and comprise a component of direct labour (41.3% of fixed costs); maintenance (31.9%); insurance fees (19.9%); management fee (5.5%); land lease fee[3] (1.4%), and other costs (5.5%) (Table 18.2).

Cannery output per tonne of raw tuna input is assumed to be 59 cases of canned tuna for export, 10 cases of canned tuna for domestic sale, and 15% (by raw weight) fishmeal (Table 18.3).

Total revenue (at full production) is US$66.64 million, and comprises canned tuna exported to the European Community (85% of total revenue); domestic canned tuna sales (10.5%); and fishmeal sales (4.5%) (Table 18.4).

[2] Including brine, hydrolysed protein etc.

[3] The lease fee is equal to the revenue generated by the previous land use, and therefore is a measure of opportunity cost.

Table 18.1 Project costs, hypothetical tuna cannery (US$ m)

Capital cost	
A. Structural items	
Deep-water dock	2.00
Wharf facilities	1.00
Buildings (canning, workshops, garages etc.)	6.00
Other (access roads, power transmission lines etc.)	2.00
Subtotal	11.00
B. Plant and equipment	
Refrigeration	3.00
Canning equipment	8.00
Fishmeal equipment	2.40
Waste water treatment[a]	1.00
Engineering	1.00
Other	1.00
Subtotal	16.40
C. Other capital costs	
Vehicles	1.50
Training	0.10
Subtotal	1.60
Total capital cost	29.00
Working capital	20.00
Total project cost	49.00

[a] Including a 500 m pipeline for deep-water liquid waste disposal.

The life of the project is expected to be 25 years, after which major replacement of plant and equipment will be required. Construction occurs during the first two years, with the capital cost of construction spread equally over both years. All finance for construction is assumed to be spent in the year that it is received. The residual value of the capital (i.e. the written down value at the end of its economic life) is US$2.61 million, which is 9% of the initial total capital value.

Production is assumed to commence at 50% of capacity in year 3, increasing to 90% of capacity in year 4, and 100% of capacity thereafter. Variable costs commence at 75% of the full-production total in year 3, increasing to 100% thereafter.

Working capital is financed on the open market at a rate of 8.5% compounded annually throughout the

Table 18.2 Annual operating costs, hypothetical tuna cannery (US$ m)

Variable costs	
Raw tuna[a]	30.000
Other raw materials (cans, labels, cases, filler)	12.000
Indirect labour and freight	2.400
Direct labour (variable)	1.500
Fuel	1.500
Marketing/brokerage[b]	1.333
Electricity[c]	0.640
Other variable costs	0.627
Total	50.000
Fixed costs	
Direct labour (fixed)	1.500
Maintenance[d]	1.160
Insurance[e]	0.725
Land lease fee	0.050
Other fixed costs	0.200
Total	3.635
Total operating cost	53.635

[a]Raw tuna price - US$750/t. Raw tuna throughput-40000 t/year.
[b]Marketing/brokerage fee-2% of gross revenue.
[c]Electricity consumption-4.0 million kW.h/year. Electricity price-US$0.16/kW.h.
[d]Maintenance cost-4% of capital cost.
[e]Insurance fee-2.5% of capital cost.

project life. Taxation commences in year 6 (i.e. it is assumed that the host government agrees to a tax holiday for the first three years of operation), at a rate of 25% of profits, where profits are equal to revenue net of operating costs and interest payments. All transactions are assumed to occur at the end of the year.

The project is financed by export credits[4] from a foreign government, since it is assumed that the western Pacific nation where the cannery will be located is unable to manufacture and construct the plant using domestic resources. The arrangement comprises two equal, US$14.5 million, 10-year loans at an interest rate of 7% compounded annually. Each loan is repaid in 10 equal yearly instalments.

[4] Export credits provide the borrower with finance at interest rates below prevailing market levels, while ensuring that the contracted builder receives payment. For example, in Australia the company contracted to build the cannery would make an application for export credit to the government owned Export Finance and Insurance Corporation.

Table 18.3 Canning yields, hypothetical tuna cannery (output/t raw tuna).

Canned tuna for export (cases)	59.0
Canned tuna for domestic sale (cases)	10.0
Fishmeal (t)	0.15

Table 18.4 Annual revenue, hypothetical tuna cannery (US$ m).

Canned tuna sales:	European Community[a]	56.64
	Domestic[b]	7.00
Fishmeal sales[c]		3.00
Total revenue		66.64

[a]Average canned tuna price - US$24/case.
[b]Domestic canned tuna price - US$17.5/case.
[c]Fishmeal price - US$500/tonne.

The rate of discount used is 12%. This value is relatively large compared to the rates commonly used to evaluate projects in industrial countries. This reflects the fact that the opportunity cost of capital and the marginal rate of time preference in the western Pacific region are relatively high compared with industrial countries.

The exchange rate in US$ per kina is assumed to equal 1.00. Hence, while all values are expressed in US$, they could equally be expressed in kina, with no change in the nominal value.

Financial analysis

Financial internal rate of return

The financial rate of return (IRR) is the rate of discount at which the present value of a project's benefits equals the present value of its costs. It represents the opportunity cost of undertaking the project as opposed to an alternative use of the funds. If the financial IRR exceeds a bench mark rate of interest (i.e. the stipulated discount rate, which represents the opportunity cost of capital), the project is deemed to be financially viable.

Financial viability of a project requires that the funds generated by the project yield a return on the investment which is at least equal to the returns which could accrue from alternative investment projects competing for the same finance, within the enterprise undertaking the project. Relevant data include all monetary flows into and out of the project. While interest payments are not included as costs,[5] a knowledge of interest payments is required for the determination of taxation payments and for calculation of the project's cash flow.

A financial analysis of the tuna cannery project was conducted under the above assumptions. The net present value (NPV) of the benefit stream is approximately US$12.18 million, while the financial IRR is approximately 15.4% (Table 18.5). Under the base assumptions of the model, and at a discount rate of 12%, the cannery project is considered to be financially viable.

Cash flow analysis

While the calculation of the financial IRR is used to determine whether a project is financially viable, this alone does not determine commercial viability. This requires an assessment of the capacity of the investor to repay all loans. The cash flow analysis provides details of project loan repayments, interest payments, revenue, costs and taxes on the project. It documents all private cost and revenue flows associated with the project. The NPV of the cash flow is used, together with the financial IRR, to determine the commercial viability of a project.

The NPV of the cash flow is approximately US$33.8 million (Table 18.6). Apart from year 2, when the first loan and interest payments are made, and year 25, when the working capital loan is repaid, the yearly cash flow is positive. Hence, it appears that there is sufficient revenue to meet ongoing costs, even in the early years. However, additional finance may need to be obtained to cover the repayments in year 2, or alternatively, the borrower may need to negotiate a delay in the first payment till the following year.

Under the base assumptions of the model it can be concluded that the cannery project is commercially viable.

[5] In the calculation of the financial IRR, costs are treated in the same manner whether funds are available from within the enterprise or from borrowing. In either case, the funds could be put to an alternative use, and hence the relevant cost is the opportunity cost of capital.

Sensitivity analysis

Project appraisal requires the estimate of costs and benefits which will accrue to a project in the future. Because future events are uncertain, undertaking a project on the basis of a positive assessment is inherently risky. Costs may be greater than anticipated, and revenues may be less. Sensitivity analysis is a crude method of accounting for this uncertainty. It analyses the impact of changes in certain key factors upon financial viability.

Two key factors which significantly impact upon the financial viability of the proposed cannery, and are also subject to a high degree of uncertainty, are the average price received for canned tuna exported to the European Community, and the plant throughput.

Canned tuna export price. It is assumed that the cannery has some degree of monopsonistic power over the price of raw tuna, but not over other inputs. An increase/decrease in the price of export canned tuna leads to an increase/decrease in the price of raw tuna, but the response is asymmetric. A 10% increase in the export price of canned tuna leads to a 4% increase in the price of raw tuna, an increase in revenue and an associated increase in marketing/brokerage costs. A 10% decrease in the export price of canned tuna leads to a 7% decrease in the price of raw tuna, a decrease in revenue and an associated decrease in marketing/-brokerage costs.

Plant throughput. It is assumed that a change in plant throughput results primarily from a change in labour productivity, not hours worked. A 10% increase in throughput leads to a 10% increase in the cost of raw tuna, a 10% increase in the cost of other raw materials, a 10% increase in indirect labour and freight costs, a 10% increase in fuel costs, a 10% increase in marketing/brokerage costs, and a 10% increase in revenue. A 10% decrease in throughput leads to a 10% decrease in the cost of raw tuna, a 10% decrease in the cost of other raw materials, a 10% decrease in indirect labour and freight costs, a 10% decrease in fuel costs, a 10% decrease in marketing/brokerage costs, and a 10% decrease in revenue.

Table 18.7 documents the responsiveness of the financial IRR to changes in the export price of canned

Table 18.5 Financial analysis, hypothetical tuna cannery (US$m).

Year	Capital costs	Working capital	Fixed costs	Variable costs	Revenue	Tax on profits	Net benefit
1	-14.5	0	0.000	0.0	0.00	0	-14.50
2	-14.5	0	0.000	0.0	0.00	0	-14.50
3	0.0	-20	-3.635	-37.5	33.32	0	-27.82
4	0.0	0	-3.635	-50.0	59.976	0	6.34
5	0.0	0	-3.635	-50.0	66.64	0	13.01
6	0.0	0	-3.635	-50.0	66.64	-2.46	10.55
7	0.0	0	-3.635	-50.0	66.64	-2.51	10.50
8	0.0	0	-3.635	-50.0	66.64	-2.56	10.45
9	0.0	0	-3.635	-50.0	66.64	-2.61	10.40
10	0.0	0	-3.635	-50.0	66.64	-2.67	10.34
11	0.0	0	-3.635	-50.0	66.64	-2.73	10.28
12	0.0	0	-3.635	-50.0	66.64	-2.79	10.21
13	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
14	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
15	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
16	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
17	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
18	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
19	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
20	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
21	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
22	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
23	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
24	0.0	0	-3.635	-50.0	66.64	-2.83	10.18
25	2.61	20	-3.635	-50.0	66.64	-2.83	32.79
			NPV (12%) 12.18		IRR(%) 15.4		

tuna and the plant throughput. In general, the financial IRR is more responsive to changes in price than to changes in throughput. A 20% decline in throughput causes the financial IRR to decline from 15.4% to 10.9%, whereas a 20% decline in price causes the financial IRR to decline from 15.4% to 6.4%. This is because, under the assumptions, changes in revenue are compensated to a greater extent by changes in costs when they are brought about by variation in throughput, rather than variation in price.[6]

[6] That is, an increase in throughput leads to an increase in revenue, and an increase in various costs, including raw tuna, other raw materials, indirect labour and freight, fuel and marketing/brokerage costs, whereas an increase in the export price of canned tuna leads to an increase in revenue, an increase in the price of raw tuna and an increase in marketing/brokerage costs.

Table 18.6 Cash flow analysis, hypothetical tuna cannery (US$m)

Year	Loan allocation	Loan drawdown	Working capital	Total costs	Total revenue	Loan repayment	Interest repayment	Interest on working capital	Tax on profit	Cash flow
1	14.5	–14.5	0	0.000	0.00	0.000	0.000	0.0	0.000	0.000
2	14.5	–14.5	0	0.000	0.00	–1.049	–1.015	0.0	0.000	–2.064
3	0.0	0.0	20	–41.135	33.32	–2.172	–1.957	0.0	0.000	8.056
4	0.0	0.0	0	–53.635	59.976	–2.324	–1.804	–1.7	0.000	0.512
5	0.0	0.0	0	–53.635	66.64	–2.487	–1.642	–1.7	0.000	7.176
6	0.0	0.0	0	–53.635	66.64	–2.661	–1.468	–1.7	–2.459	4.717
7	0.0	0.0	0	–53.635	66.64	–2.848	–1.281	–1.7	–2.506	4.670
8	0.0	0.0	0	–53.635	66.64	–3.047	–1.082	–1.7	–2.556	4.620
9	0.0	0.0	0	–53.635	66.64	–3.260	–0.869	–1.7	–2.609	4.567
10	0.0	0.0	0	–53.635	66.64	–3.488	–0.641	–1.7	–2.666	4.510
11	0.0	0.0	0	–53.635	66.64	–3.733	–0.396	–1.7	–2.727	4.449
12	0.0	0.0	0	–53.635	66.64	–1.929	–0.135	–1.7	–2.792	6.448
13	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
14	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
15	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
16	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
17	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
18	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
19	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
20	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
21	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
22	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
23	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
24	0.0	0.0	0	–53.635	66.64	0.000	0.000	–1.7	–2.826	8.479
25	0.0	2.61	–20	–53.635	66.64	0.000	0.000	–1.7	–2.826	–8.911
									NPV	33.84

As noted, the establishment of a cannery on the basis of a positive assessment of the financial return involves risk. In order to analyse this risk, it is more pertinent to consider declines in prices and throughput rather than increases. In order to be deemed financially viable, the cannery's financial IRR must be greater than 12%. As noted, a 20% decline in throughput causes the financial IRR to fall from 15.4% to 10.9%, whereas a 20% decline in price causes the financial IRR to fall from 15.4% to 6.4%. In either case, the cannery is not financially viable. If both throughput and price decline by 20%, the financial IRR declines to 3.0%. The data indicate that, beyond a 15% decline in the assumed level of throughput, or a 5% decline in the assumed levels of both price and throughput, the cannery will not be financially viable.

As is common in many commodity markets, the market price of canned tuna is subject to considerable variation. Concerning risk, it is most relevant to

Table 18.7 Sensitivity analysis: effect of changes in canned tuna prices and throughput on financial IRR, hypothetical tuna cannery

Change in throughput	Change in price of canned tuna for export								
	-20%	-15%	-10%	-5%	+0%	+5%	+10%	+15%	+20%
-20	3.0	5.1	7.1	9.1	10.9	13.3	15.5	17.8	20.0
-15	3.9	6.1	8.1	10.1	12.1	14.5	16.9	19.2	21.5
-10	4.8	7.0	9.1	11.2	13.2	15.7	18.2	20.6	23.1
-5%	5.6	7.9	10.1	12.2	14.3	16.9	19.5	22.0	24.5
0%	6.4	8.8	11.0	13.2	15.4	18.1	20.8	23.4	26.0
+5%	7.2	9.6	11.9	14.2	16.4	19.2	22.0	24.7	27.4
+10	7.9	10.4	12.8	15.2	17.5	20.4	23.2	26.0	28.9
+15	8.7	11.2	13.7	16.1	18.5	21.5	24.4	27.3	30.2
+20	9.4	12.0	14.5	17.0	19.4	22.5	25.6	28.6	31.6

consider price declines. However, it is also worthwhile to analyse the impact of price increases, since these do occur. Small increases in the export price of canned tuna can offset considerable declines in plant throughput (Table 18.7). If price increases by 5%, the cannery will be able to incur a 20% decline in throughput and still remain financially viable.

The assumed level of throughput in the base model is based upon reasonable estimates of productivity in a range of existing canneries and, as such, the inclusion of throughput increases in the analysis is not unreasonable. However, in the case of the Pacific islands, there is reason to question whether an analysis of such increases is relevant. While there is little empirical evidence available, there is considerable anecdotal evidence to suggest that levels of labour productivity in the Pacific islands region are considerably lower than those in Asian or in industrial economies. This suggests that, for practical purposes, the bottom half of Table 18.7 is less relevant than the top half. The data do indicate that, should labour productivity and thus throughput increases occur, they are capable of offsetting price declines, though not to the same extent that price increases can offset throughput declines. A throughput increase of 20% can offset a 15% decline in price to the extent that viability is just maintained. If both throughput and price increase by 20%, the financial IRR will increase to 31.6%.

Economic analysis

Economic (or cost-benefit) analysis provides a framework for the assessment of projects on the basis of the costs and benefits which accrue to the economy as a whole. It involves the identification of all project inputs and outputs and, in principle, the valuation of these in terms of incremental economic costs or benefits. On the basis of this information, the net benefit (positive or negative) to the economy can be determined. Only those costs and benefits which accrue to the economy as a whole are included. Payments such as taxes, which are included as costs in the financial analysis, are excluded from the economic analysis since they are transfers within the economy.

External economic benefits

The goal of increasing the benefits that accrue from their tuna resources is of high priority to many Pacific island governments. The establishment of a tuna cannery would increase the government's control over the utilisation of its tuna resource, and enable the government to retain some benefits from value adding in the domestic economy. In addition, the production of fishmeal could reduce imports of this product, and thus conserve foreign exchange.

Direct and indirect labour costs are assumed to equal US$5.4 million (less nonlabour freight charges) when the cannery is operating at full production. Given the importance placed on employment generation by island governments, it is likely that most of this income would accrue to nationals. Generally, in developing countries, the majority of those employed in new labour intensive industries are females, most of whom have no previous regular income. Where unemployment levels are high, the pool of potential male employees is also large. Hence it is likely that the bulk of the money received by employees is additional rather than alternative income.

Macroeconomic theory indicates that the multiplier effects of employment expenditure in an economy can be significant. However, in Pacific island economies, where most manufactured goods are imported, the benefits from employment multiplier effects may be limited, since much of the additional expenditure will 'leak' out of the economy.

During the initial two-year construction phase of the project, benefits will accrue through the purchase of locally supplied items. However, significant leakage on imports is likely to occur.

Increased purchasing power among employees and increased availability of fish products (via tuna fishing by-catch) may result in improved nutritional standards and hence improved health. Due to increased availability, the cost of fish and fish products should decline. Hence, nutritional benefits may accrue to the local community at large, and not just to those who benefit directly from employment. However, the availability of purse seine by-catch may render local artisinal fisheries uneconomic, since the marginal cost associated with such a catch is negligible.

While the employment of expatriates in management and technical positions is a cost to society, any transfer of technical and management skills to local workers is of significant benefit to the economy, particularly if these skills are transferred to other sectors of the economy over time.

The building of structural items will benefit the fishery and plantation sectors of the local economy. The building of docks and wharf facilities will improve conditions and services for local fishers, while the improvement of local roads and development of related infrastructure will benefit local plantation agriculture by facilitating the transportation of their produce to markets and export centres.

External economic costs

While the lease fee included in the operating costs is to some extent an opportunity cost, representing the benefits foregone by the cessation of current activities, it may be that the best alternative land use is development for some high-value industry such as tourism. To this extent there is an added economic cost. This cost would be increased if the establishment of the cannery deterred the development of tourist facilities in neighbouring areas.

Should conditions on the international tuna market become adverse, through a decline in canned tuna prices or the loss of tariff-free entry into the European Community, resulting in the cessation of cannery operations, extensive site rehabilitation costs may be incurred. Alternatively, the government may choose to inject funds into the cannery in order to maintain employment. Such an injection of funds would require a significant budgetary allocation, which would otherwise benefit other sectors of the economy.

Should the government offer licence fee reductions to the vessels of distant water fishing nations who supply the cannery, foreign exchange losses will accrue to the economy. In addition, some loss of payment for the transshipment of frozen tuna will occur.

The opportunity for employment and improved local conditions may result in increased migration into the area, necessitating government expenditure on housing and other amenities.

The construction of a suitably sized effluent pipe and suitable landfill are likely to limit the environmental damage associated with the project. However, oil spills and other pollution from increased purse seine traffic will incur some economic costs.

Economic internal rate of return

The economic IRR is the real rate of discount at which the present value of the benefits to the economy (or society) from the project exactly equals the present value of the costs to the economy. The stream of net benefits determined in the analysis includes private benefits (obtained from the financial analysis) and net external benefits. If the economic IRR exceeds the opportunity cost of capital, then the project is deemed economically viable. Economic viability requires that the project generate net benefits to the economy as a whole that are at least equal to those which would arise from other investment projects competing for the same financial resources.

It is difficult to determine all external benefits and costs which accrue to any given project. Those mentioned in the previous section are likely to be the most important, although the list is not exhaustive. It is also extremely difficult to quantify the external benefits and costs. While public benefits are likely to be significant in the project under consideration, so are external costs. It is possible therefore, that net external benefits will be quite small, or even negative.[7]

The economic IRR of the hypothetical cannery is analysed under two groups of assumptions.

Assumption set 1

It is assumed that yearly net external benefits are negligible. It is also assumed that all prices and therefore costs and revenues used in the financial analysis represent the true economic value, i.e. prices are determined by supply and demand. In addition, it is assumed that the dollar/kina exchange rate of 1.00 is an accurate reflection of the supply and demand for the currencies in financial markets.

In this case the only difference between the economic and financial analysis is the treatment of taxation. Since taxation is simply a transfer within the economy, it is not treated as a cost in the economic analysis. The economic IRR for the project is 18.1%, and the NPV is approximately US$23.6 million (Table 18.8). Hence, under the documented assumptions, it can be concluded that the cannery is economically viable.

As noted in the financial analysis, the economic IRR is more responsive to changes in price than to changes in throughput. A 20% decline in plant throughput causes the economic IRR to decline from 18.1% to 13.0% (Table 18.9). Hence the cannery can sustain a 20% decline in throughput and remain economically viable, given that price does not fall.

[7] While the external benefit of a road may be very large, this is highly site specific.

Table 18.8 Economic analysis of the proposed cannery, assumption set 1

Year	Total revenue	Total costs	Tax offset	Net economic benefits
1	0.00	-14.500	0.000	-14.500
2	0.00	-14.500	0.000	-14.500
3	33.32	-61.135	0.000	-27.815
4	59.976	-53.635	0.000	6.341
5	66.64	-53.635	0.000	13.005
6	66.64	-56.094	2.459	13.005
7	66.64	-56.141	2.506	13.005
8	66.64	-56.191	2.556	13.005
9	66.64	-56.244	2.609	13.005
10	66.64	-56.301	2.666	13.005
11	66.64	-56.362	2.727	13.005
12	66.64	-56.427	2.792	13.005
13	66.64	-56.461	2.826	13.005
14	66.64	-56.461	2.826	13.005
15	66.64	-56.461	2.826	13.005
16	66.64	-56.461	2.826	13.005
17	66.64	-56.461	2.826	13.005
18	66.64	-56.461	2.826	13.005
19	66.64	-56.461	2.826	13.005
20	66.64	-56.461	2.826	13.005
21	66.64	-56.461	2.826	13.005
22	66.64	-56.461	2.826	13.005
23	66.64	-56.461	2.826	13.005
24	66.64	-56.461	2.826	13.005
25	66.64	-33.851	2.826	35.615
	NPV (12%)	23.56	Economic IRR(%)	18.1

If price alone changes, the cannery can sustain a 10% decline and remain economically viable. If both price and throughput decline, the maximum changes that the cannery can sustain and remain economically viable are a 15% decline in throughput and a 5% decline in price, or a 5% decline in throughput and a 10% decline in price. Any further declines will render the cannery economically unviable.

Table 18.9 Sensitivity analysis: effect of changes in canned tuna prices and throughput on economic IRR, hypothetical tuna cannery

Changes in throughput	Change in price of canned tuna for export								
	-20%	-15%	-10%	-5%	0%	+5%	+10%	+15%	+20%
-20%	3.7	6.2	8.6	10.8	13.0	15.6	18.2	20.6	23.1
-15%	4.8	7.4	9.8	12.1	14.3	17.0	19.7	22.2	24.7
-10%	5.8	8.5	11.0	13.3	15.6	18.4	21.1	23.8	26.4
-5%	6.8	9.5	12.1	14.5	16.8	19.7	22.6	25.3	28.0
0%	7.8	10.5	13.2	15.6	18.1	21.0	23.9	26.8	29.6
+5%	8.7	11.5	14.2	16.8	19.2	22.3	25.3	28.2	31.1
+10%	9.6	12.5	15.2	17.8	20.4	23.5	26.6	29.6	32.6
+15%	10.5	13.4	16.2	18.9	21.5	24.7	27.9	31.0	34.0
+20%	11.3	14.3	17.1	20.0	22.5	25.9	29.2	32.3	35.5

If the price of canned tuna remains at the assumed level or increases, the cannery can accommodate considerable declines in throughput. As noted, with no price increase, the cannery can sustain a 20% decline in throughput and remain economically viable. Should throughput decline 20%, a price increase of 10% will result in an economic IRR of 18.2%, and hence more than compensate for the decline. Should price increase 20%, and throughput remain at the base level, the economic IRR will increase to 29.6%, which is considerably greater than the cost of capital.

If throughput increases 20%, the cannery can sustain a price decline of 15%, and remain financially viable. If both throughput and price increase 20%, the economic IRR will increase to 35.5%.

Assumption set 2

It is assumed that net external benefits are negligible. In addition, it is assumed that the exchange rate between the US$ and the kina of 1.00 is not an accurate reflection of supply and demand for those currencies. It is also assumed that not all wages paid reflect the supply and demand for labour accurately.

Specific assumptions: It is also assumed that 80% of capital costs, 90% of variable costs, the proportion of revenue which is derived from export of canned tuna, and export credits, are transacted in US$. The remainder, including working capital are transacted in kina. It is also assumed that the economic cost of direct (variable) labour is below that which is indicated by the financial cost. All other financial labour costs are assumed to be true economic costs.

In the estimation of the economic IRR, three alternative 'shadow' exchange rates in US$ per kina, and three alternative 'shadow' direct (variable) labour costs are considered.[8] Shadow labour costs are expressed in proportions, i.e. they indicate the proportion of nominal direct (variable) labour costs which are true economic costs. In both cases, the values are 1.00, 0.75 and 0.50. The value of 1.00 indicates that the nominal value equals the shadow or true economic value, while 0.75 and 0.50 indicate that the shadow value (of the kina or direct (variable) labour) is below the nominal value. The shadow labour cost is an indication of the value which the workers (assumed to be unemployed prior to their cannery employment) attributed to leisure activities which they have foregone. Since leisure is in general highly valued in the Pacific, a minimum of 0.5 has been used.[9]

As is indicated by the assumptions, the use of a shadow exchange rate has implications for both costs and benefits. The smaller the exchange rate, the larger

[8] The term 'shadow' is used to indicate that the value used is an estimate of the true economic value.

[9] For both shadow values, the nearest appropriate level is likely to be 0.5. The value of the kina is significantly less than the value of Australian dollar. The current Australian/U.S. exchange rate is approximately 0.67. With regard to labour cost, while the value of leisure is presumably high, all income is assumed to be additional, i.e. the workforce was previously unemployed.

the kina value of those goods which are traded in U.S. dollars. As the shadow exchange rate declines from 1.00 to 0.50, the economic IRR increases from 18.1% to 22.9%, indicating that the impact of the change on the present value of revenues is larger than the impact on the present value of costs (Table 18.10).

As the shadow cost of direct (variable) labour declines from 100% to 50% of the nominal value, the economic IRR increases from 18.1% to 19.2%. When shadow values are used for both exchange rate and labour cost, the impact upon economic IRR is relatively larger. As both shadow values decline from 1.00 to 0.50, the economic IRR increases from 18.1% to 23.6%.

Table 18.10 Sensitivity analysis: effect of changes in shadow prices for direct (variable) labour and the exchange rate on the economic IRR, hypothetical tuna cannery

		Shadow cost for direct variable labour (proportion of nominal direct variable labour cost)		
		1.00	0.75	0.50
Shadow exchange rate (US$./kina)	1.00	18.1	18.6	19.2
	0.75	19.6	20.0	20.5
	0.50	22.9	23.2	23.6

Hence the use of shadow values for the exchange rate and the cost of direct (variable) labour increases the estimate of economic viability.

Conclusion

Under the assumptions documented in the analysis, it has been demonstrated that the hypothetical cannery is both financially and economically viable. The two most important factors which influence financial viability are the average price received for canned tuna exported to the European Community, and the plant throughput, as determined by labour productivity. While changes in the price of canned tuna have the greater impact upon the financial IRR, declines in throughput are an equally serious concern due to the problem of low labour productivity in the Pacific islands region.

The most important factors which influence the economic viability are those which influence financial viability, i.e. price and throughput changes, and the degree to which market distortions affect the nominal monetary values which are used in the analysis. In this instance, the two most apparent distortions were those affecting the exchange rate, and hence input and output prices, and those affecting certain wage rates.

If it is assumed that market distortions are absent, the cannery can sustain a throughput decline of 20% and remain economically viable. Should price increase beyond the assumed level, the cannery could sustain an even greater decline in throughput. However, operating decisions are made not by society, but by the firm which operates the cannery. If price remains at the assumed level the cannery can sustain a 15% decline in throughput and remain financially viable. If the price declines 15% however, the cannery will not be financially viable, even in the unlikely event that throughput increases by 5%. Hence, some reservation must be placed on the conclusion that the cannery is viable.

The use of shadow values for the exchange rate and proportion of the cost of direct (variable) labour increases the estimate of economic IRR. For both, as already discussed, the most appropriate value is 0.5, which results in an economic IRR of 23.61%. In the estimation of economic IRR using shadow values, base levels for canned tuna price and cannery throughput were assumed.

Should tariff-free entry into the European Community be lost during the course of operations, the cannery would cease to be financially viable since, in order to compete with low cost producers such as Thailand, price would need to be reduced by more than 15%. In such an event, the government could choose either to subsidise operations with budgetary allocations which would otherwise be used elsewhere, or to allow operations to cease and rehabilitate the site. Either choice would entail considerable cost.

Part VI

International Tuna Markets

Chapter

19 The Japanese Tuna Industry and Market

A.D. Owen
D.A. Troedson

The Japanese tuna industry

Vessel numbers, sizes and types

Three principal vessel types are used by Japanese fishers to harvest tuna: pole-and-line; longline; and purse seine. Between 1970 and 1983, total pole-and-line vessel numbers declined from 512 to 433, peaking at 696 in the mid-1970s. The dominant class sizes were 50–100 GRT and 200–500 GRT, both of which declined in number during the early 1980s. This decline in the pole-and-line fleet resulted from financial difficulties experienced during the late 1970s, which prompted the government to organise a planned fleet reduction and conversion of vessels to the more efficient purse seiners (Williams 1987). This trend continued into the late 1980s; between 1986 and 1989, the number of pole-and-line vessels operating in distant water fisheries declined from 146 to 108 (U.S. Department of State 1990c).

Over the period 1970 to 1983, the Japanese longline fleet declined in number from 1549 to 1267, continuing a trend which began in the mid-1960s when vessel numbers reached a peak of 2135. The dominant class sizes were 50–100 GRT and 200–500 GRT, reflecting the fleet rationalisation which occurred during the *Showa Genroku* (economic boom period).[1] Between 1986 and 1989, the trend continued as the number of longline vessels operating in distant water fisheries declined from 792 to 763, while the number of longline vessels operating in adjacent water fisheries declined from 776 to 592 (U.S. Department of State 1990c).

Unlike the trends for pole-and-line and longline vessels, purse seine numbers increased during the 1970s and 1980s. In 1973, six purse seiners operated in the Pacific. By 1990, the number of overseas purse seiners in operation had increased to 36 (U.S. Department of State 1990c). The increase in vessel numbers was most marked between 1980 and 1983, reflecting government initiatives to restructure the industry. During this period, the number of purse seine vessels increased from 13 to 33 (Iizuka and Watanabe 1983; Petit 1984).

Tuna landings by form and species

During 1987–92, total Japanese tuna landings ranged between 421.8 kt and 531.7 kt. Landings of fresh tuna ranged between 84.5 kt and 132.5 kt per year, while landings of frozen tuna ranged between 324.4 kt and

[1] The prevailing trend during this period was the replacement of large tuna vessels (especially motherships) with smaller cost efficient longline vessels of approximately 240–360 GRT for distant water fishing, and smaller 50 GRT vessels for coastal and near-sea fishing (Williams 1987).

399.2 kt per year. The principal species landed were skipjack, which accounted for 58% of landings in 1992, bigeye (19%), albacore (11%), yellowfin (9%), and bluefin (3%) (FAO 1993a). Landings during January–March 1993 totalled 75.2 kt, an increase of 10% over the same period for the previous year (FAO Globefish Highlights 1993).

Japanese fresh and frozen tuna imports

In 1970, Japan imported approximately 30 kt of the main tuna species. There was little growth in the industry during 1971–73, due to the problem of mercury contamination and unfavourable rates of exchange. In 1974, imports increased to 43.1 kt, and in the following year increased substantially (112%) to 91.3 kt. During 1975–84, fresh and frozen tuna imports fluctuated yearly and ranged between 77.6 kt and 122.1 kt (Ikematsu 1984; Williams 1987).

During 1985–92, Japanese imports of fresh and frozen tuna generally increased, and ranged between 138.1 kt and 275.9 kt per year (Table 19.1). Korea and Taiwan were the two principal sources of supply. Imports from Korea fluctuated during the period reaching a peak of 67.4 kt in 1987, and subsequently

Table 19.1 Japanese imports of fresh and frozen tuna, by species 1985–92 (kt)

	1985	1986	1987	1988	1989	1990	1991	1992
Skipjack								
Korea	0.3	0.1	0.1	0.1	0.2	0.5	–	0.1
Taiwan	–	0.0	0.2	0.5	0.1	3.6	0.8	2.4
Total skipjack	6.1	2.9	3.9	3.4	3.2	25.6	29.7	29.3
Albacore								
Korea	0.7	0.8	1.2	1.3	0.8	0.7	1.2	1.5
Taiwan	0.1	–	0.1	0.1	–	0.1	1.8	5.8
Total albacore	2.6	2.4	3.0	3.1	2.9	1.8	4.2	9.4
Yellowfin								
Korea	18.1	24.1	30.2	28.6	21.3	26.0	19.3	20.5
Taiwan	17.4	20.9	32.3	32.9	31.2	48.2	43.2	68.7
Total yellowfin	75.4	66.8	98.0	120.1	110.2	134.4	115.0	133.7
Bluefin								
Korea	0.1	0.5	0.1	–	0.1	0.2	0.5	0.4
Taiwan	0.2	0.1	0.2	0.3	1.0	0.8	1.4	0.4
Total bluefin	4.8	5.2	5.1	5.8	6.8	7.0	6.5	4.9
Bigeye								
Korea	28.0	31.8	35.9	34.0	31.5	29.3	33.1	28.9
Taiwan	13.6	17.0	22.6	22.5	22.6	26.5	41.3	33.7
Total bigeye	52.2	60.8	74.7	77.4	83.3	88.7	109.9	98.6
All species								
Korea	57.2	57.4	67.4	64.0	53.9	56.7	54.1	51.4
Taiwan	31.3	38.1	55.2	56.3	54.9	79.2	88.5	111.0
Total all species	141.1	138.1	184.7	209.8	206.4	257.5	265.3	275.9

Source: Globefish Highlights, various years.

declining to 51.4 kt in 1992. Imports from Taiwan increased from 31.3 kt in 1985 to 111 kt in 1992. The principal tuna species imported were yellowfin, which accounted for 48% of imports in 1992, bigeye (36%), skipjack (11%), albacore (3%), and bluefin (2%).

Of the total Japanese tuna imports during 1992, 55 kt (20%) were imported fresh, an increase of 17% over 1991. Yellowfin is the main species imported fresh, accounting for two-thirds of fresh tuna imports (FAO 1993a). Indonesia was the main supplier of chilled yellowfin during 1992, followed by Taiwan and Malaysia. Indonesian exports of fresh/chilled tuna to Japan increased 141% during 1990–92 (Ferdouse 1993). Shipments of fresh bigeye are also increasing, and totalled 15 kt in 1992, an increase of 50% over 1991 (FAO Globefish Highlights 1993).

During January–March 1993, fresh and frozen tuna imports totalled 73.1 kt, an increase of 16% over January–March 1992. Imports of yellowfin totalled a record 41.8 kt. Japan is currently the only outlet for yellowfin tuna from the eastern Pacific, and countries which harvest this tuna, e.g. Mexico, exported more tuna to Japan in January–March of 1993 than in previous years. Much of the increase in yellowfin imports is destined for canneries, and hence the supply of canned tuna in Japan during 1993 is expected to be greater than in recent years (FAO Globefish Highlights 1993).

The most valuable tuna species on the Japanese market in terms of price paid per kilogram is bluefin. The supply of wild bluefin has declined steadily in recent decades due to over-exploitation. In response, substantial investment has gone into the raising of bluefin in captivity. Cultured bluefin from Australia arrived on the Japanese market in October 1992. Approximately 10 fish were auctioned each day, and received a price between US$16–40/kg, which exceeded the price of wild southern bluefin by US$8/kg. Cultured bluefin from Spain were also sold on the market and received a price of approximately US$58/kg (FAO 1992).

While Korea and Taiwan supply much of the imported bigeye and yellowfin (67% of yellowfin and 63% of bigeye in 1992), they do not participate significantly in the skipjack or bluefin trade. In 1992, Korea and Taiwan combined supplied 16% of bluefin imports and 9% of skipjack imports (Table 19.1). The market share of Taiwan and Korea has been significantly eroded since 1978, at which time the two countries accounted for 95.7% of the volume of imported tuna and 96.1% of the value (Japan External Trade Organisation 1984).

The decline in the market dominance of Korea and Taiwan can be attributed principally to rising costs, in particular labour and fuel, and to increasing foreign interest in the Japanese sashimi market, most notably since the late 1970s. Sashimi grade frozen tuna is currently supplied to Japan by more than 20 countries. Competitors in the frozen tuna trade include Mexico, Australia, Maldives, Panama, Indonesia and the Solomon Islands. Competition in the chilled tuna trade is provided by the Philippines, Canada, the United States, Spain, Turkey and Australia (Williams 1987).

Freezing and cold-storage

Cold storage facilities in Japan are concentrated in coastal landing ports and major cities. Land-based ultra low temperature storage capacity in Japan increased 194% during 1965–78, from 5.56 million m^3 to 16.36 million m^3. During the same period, freezing capacity (e.g. blast freezers) increased 84%, from 16 kt/day to 29.4 kt/day (Nakai 1984). During 1976–83, ultra low temperature freezer storage in tuna vessels increased dramatically (1408%), from 2.5kt to 39.1 kt (Japan External Trade Organisation 1985).

During January 1985 to March 1993, Japanese cold storage holdings of tuna fluctuated, generally increasing during 1985–91, and generally declining during 1992–93, although there was considerable month to month fluctuation. In January 1993, holdings were approximately 70kt. The principal species stored, in descending order by quantity (January 1993), were skipjack, yellowfin, bigeye and albacore (FAO Globefish Highlights 1990 and 1993).

Canned tuna: production, imports, exports, and apparent consumption

Canned tuna production increased during the first half of the 1980s, from 111kt in 1981 to 124 kt in 1984, but subsequently declined to 95.7 kt in 1991. Imports remained relatively stable during 1981–87, and then increased during 1987–91, reaching a level of 15.3 kt in the latter year. Exports increased during 1981–84, from 35 kt to 46 kt, and subsequently declined during 1985–91, to a level of 4.7 kt in the latter year. Apparent consumption of canned tuna increased during 1981–88, declined during the following two years, and then increased almost to the peak level in 1991.

Table 19.2 Japanese production, imports, exports, and apparent consumption, canned tuna, 1981–91 (t)

Year	Production	Imports	Exports	Apparent consumption
1981	111000	1000	35000	77000
1982	113000	1661	35718	78943
1983	117000	2425	36948	82477
1984	124000	1466	45635	79831
1985	114000	1566	33993	81573
1986	113744	907	29558	85093
1987	111904	1673	15452	98125
1988	110771	4049	8249	106571
1989	103793	5571	5299	104065
1990	92113	7981	3930	96164
1991	95716	15335	4699	106352

Source: FAO 1986, 1991; Ferdouse 1993; U.S. Department of State 1990c.

The increase in canned tuna imports into Japan during 1987–91 was supplied principally by Thailand. In 1987, Thailand exported 1219 t of canned tuna to Japan. By 1991, Thai exports to Japan had increased to 5700 t. In 1992, Thai canned tuna exports to Japan were a record 8700 t (FAO Globefish Highlights 1993). Due to the current problems facing the Thai tuna canning industry, i.e. the detention of product by the United State's Food and Drug Administration, and import restrictions in the European Community, it is likely that Japan will become an increasingly important target for Thai canned tuna exports.

While apparent consumption of canned tuna in Japan generally increased during 1981–92, it is difficult to forecast trends to the end of the decade. While it is likely that Japanese imports of Thai canned tuna will increase, the presence of low priced imported canned tuna on the Japanese market may reduce the viability of the domestic industry, and hence domestic production. This may be further exacerbated by the increasing use of albacore for sashimi, hence reducing the supply of albacore for canning (FAO Globefish Highlights 1993). Therefore, growth in apparent consumption may be limited. Current trends may herald the demise of the Japanese domestic canned tuna industry and the rise of Japan as a major importer of canned tuna.

Trade barriers

The Japanese tariff rate for imports of fresh, chilled and frozen tuna is 5% *ad valorem*, and for dried and canned tuna is 15% *ad valorem*. Imports of canned tuna are subject to inspection by officers in the Ministry of Health and Welfare, under the Japanese Food Sanitation Law. A permit must be issued by the Ministry before imports can pass through customs. Imported canned tuna is sampled and inspected for compliance with government regulations on food sanitation, additives and labelling. Standards required of imported tuna are the same as those required of the domestic product (USITC 1986).

In addition, industry groups may request inspection of imported tuna (for a prescribed fee), in order to ascertain whether the quality of the imported tuna is comparable with Japanese industry quality standards. Import procedures and inspection, both mandated and voluntary (as described above), have been criticised by foreign suppliers as being protectionist. The impression that significant nontariff barriers exist stems principally from the market for fresh tuna. Prices for high quality bluefin and, to a lesser extent, yellowfin are very high in the Japanese market. The price variation between high and low quality is based on the oil content and freshness of the tuna. Foreign producers of bluefin and yellowfin wishing to export to Japan have often faced rejection of the product, due to poor quality. They have suggested that this quality control is an effective nontariff barrier to entry in the Japanese fresh tuna market. Japanese industry representatives consider that such quality control is necessary to sustain sales of sashimi. A significant part of the problem is likely to be a misunderstanding of the Japanese fresh tuna marketing system, and the preferences which underlie it (USITC 1986, 1990).

Government involvement

The principal areas of government involvement in the Japanese tuna industry are licensing, financial assistance, infrastructure development, education and training, and fishers' organisations.

Licences are required to operate longline and pole-and-line vessels which are larger than 20 GRT, and purse seine vessels which are larger than 40 GRT. The licensing system also involves time and area restrictions on tuna harvesting. The Japanese government began a program to restructure the tuna fleet in 1981. The number of licences for longline and pole-and-line vessels was reduced, while the number of licences for purse seine vessels, which are generally held to be more efficient, was increased.

Financial assistance is provided primarily for vessel construction, insurance and price supports. For vessel construction, the government provides low interest (2.00 to 5.5%/p.a., as of October 1989), long-term (10 to 12 years) loans through the Agriculture, Forestry and Fisheries Finance Corporation (USITC 1986). For fiscal years (FY) 1989 and 1990, this loan parameter was ¥57500 (US$420 million in 1989 and US$383 million in 1990 due to exchange rate variations) (U.S. Department of State 1990c). Similar loans amounting to US$33 million in FY 1989 and US$67 million in FY 1990 were available to seafood processors. The Corporation also provides loans of this type for the construction of fishing ports and other infrastructure. Additional funds for the construction and repair of fishing ports are included in the operating budget of the Japanese Fishery Agency (USITC 1990).

The government provides special insurance programs for fishers (including tuna fishers) owing to the relatively high level of risk involved in their occupation which may preclude them from obtaining insurance from private sources (USITC 1986). In 1986, approximately 240000 out of a total 400000 registered vessels were insured in the government-financed scheme (Fujinami 1986b).

The Japanese Fishery Agency maintains a price stabilisation fund (US$11.5 million in FY 1990), which is used to buy and store tuna and other seafood items when market prices fall below cost. The Agency also has a fund for vessel reinsurance (USITC 1990).

There are extensive fisheries training and educational facilities in Japan, most of which are financed by the federal and local governments. In 1986 there were 60 fisheries senior high schools, two fisheries universities, and 14 general universities with major fisheries programs. In addition, the government operated eight regional fisheries research laboratories, and fisheries research was conducted by 47 local governments (Fujinami 1986b).

The Japanese government has been involved in the formation of fishers' cooperatives under the Fisheries Cooperative Association Law, which covers most fishers. In 1986, there were three cooperatives specifically related to the tuna fishery. These were composed of the crews from 400 longline and 200 pole-and-line vessels larger than 120 GRT; 300 longline and 500 pole-and-line vessels smaller than 120 GRT; and 32 small (500 GRT) purse seiners (Fujinami 1986b).

The Japanese Tuna Market

Tuna products

Three principal forms of tuna are sold in Japan: raw (chilled or frozen), canned and processed. Tuna is consumed raw, cooked, salted, dried, as fish cake (*kamaboko*), and as fish 'ham'. Over 80% of supply of the principal tuna species (bluefin, bigeye, yellowfin, and skipjack) is consumed raw.

Raw tuna is consumed either as sashimi or as sushi. Sashimi refers to slices of raw tuna served with shredded Japanese radish (*duikon*), a small amount of green paste (*wasabi*) made from horseradish, and soy sauce (*shoyu*). Sushi is served in bite-sized snacks consisting of sliced tuna served on or in small rice-balls (*sushi-meshi*), seasoned with vinegar, salt and sugar. There are numerous varieties of sushi, distinguishable by the method of preparation. The two main varieties are *makizushi* and *nigirizushi*. *Makizushi* is raw seafood or pickled vegetables combined with rice and wrapped in a sheet of double-green seaweed (*nori*). *Nigirizushi* is a rice-ball topped with raw seafood (Williams 1987).

Raw tuna is a popular dish during the summer months (June–July) and on special occasions; in particular New Year celebrations, public holidays and festivals. Consumption choices and perceived quality relate to a variety of features, which include appearance, freshness, presentation, texture and flavour (Tayama 1982).

The most common form of dried tuna is *fushi*, a product of wood-like texture which is produced by the repeated drying and smoking of tuna fillets (Williams 1987).

Tuna species, meat types and yields

Historically, the principal tuna species used in Japan to produce sashimi and sushi were northern and southern bluefin (*Thunnus maccoyi*), bigeye (*Thunnus obesus*), yellowfin (*Thunnus albacares*), and skipjack (*Katsuwonus pelamis*). A more recent trend, however, is the use of albacore (*Thunnus alalunga*) for sashimi products, in addition to those already mentioned. Japanese traders are increasingly using albacore to substitute for bluefin due to decreasing supplies of this species (FAO Globefish Highlights 1993).

In many respects tuna carcasses are similar to beef carcasses–both are graded in terms of overall quality, and different cuts of meat from the same carcass vary in quality. The two major categories of raw tuna lightmeat are *toro* (fatty meat from the belly areas of bluefin and bigeye) and *akami* (red meat). Different grades of *toro* are contained within a single bluefin or bigeye carcass, while different grades of akami are contained within all tuna carcasses. While the meat of yellowfin and skipjack does contain fat, it is not considered to be *toro* (Williams 1987).

High quality bluefin carcasses are the source of highest quality *toro*, eaten as sashimi, and are sought after by merchants specialising in the restaurant trade. *Toro* obtained from bigeye tuna is distinguishable by taste to that found in bluefin, and is eaten as sushi. Highest quality *toro* is extremely soft and lacks fibrous texture. It is distinct from other meats and as such has no direct substitute (Williams 1987).

Tuna is marketed primarily in carcass form at the wholesale level, although an increasing proportion is processed to fillet, chunk or blocks for direct sale to retailers (Tayama 1981b). Meat yields from frozen tuna carcasses are generally in the order of 70-75% (Tayama 1982). Yields from chilled carcasses are slightly higher, as cutting is done manually. Frozen carcasses are cut either with bandsaws or with chainsaws (Williams 1987).

Consumption

Total consumption

Apparent consumption of fresh and frozen tuna in Japan generally increased during 1985-91, and ranged between 554.4 kt and 611.1 kt. This was supplied by domestic production (421.8-531.7 kt) and imports (141.1-275.9 kt) (Table 19.3). Over the same period, apparent consumption of canned tuna generally increased and ranged between 81.6 kt and 106.6 kt (Table 19.2).

Table 19.3 Japanese production, imports, exports and apparent consumption, fresh and frozen tuna, 1985–92 (t)

Year	Production	Imports	Exports	Apparent consumption
1985	461400	141100	48143	554357
1986	523900	138100	69969	592031
1987	465500	184700	46993	603207
1988	531700	209800	137353	604147
1989	435700	206400	84774	557326
1990	421800	257500	69906	609394
1991	464400	265300	118639	611061
1992	428000	275900	n.a.	n.a.

n.a. not available.
Source: FAO Globefish Highlights, various years.

Consumption of tuna in Japan varies between males and females and across different age groups. With the exception of 60-64 year olds, males consume more tuna than females. This distinction is most apparent between the ages of 30 and 45 (Taya 1986). The explanation for this may relate to the use of tuna as a 'treat' for the male of the family to be enjoyed with *sake*. Women generally eat more beef, as it is considered to be nutritious for children, and the women eat generally with the children some hours before the men arrive home. As women get older (and men retire), married couples tend to eat more meals together, and in consequence women eat more tuna (Williams 1989).

Regional preferences

While tuna is consumed nationwide in Japan, consumption levels and preferences do vary by region with respect to species, size, meat colour, fat content and form (dressing style, chilled verses frozen, whole verses fillet etc.). Tuna consumption is greatest in the eastern and far southern provinces, and least in the western provinces. On the west coast, mackerels and white flesh species are preferred to tuna for use as sashimi (Williams 1989). In Tokyo, bigeye tuna is traditionally preferred to yellowfin (Shinjuku Marine Products Company 1985). The reverse is true in Osaka (Takahisa 1983).

In recent years, however, traditional regional preferences have been changing. Tuna consumption is highest in Okinawa (7 kg per family annually), Fukuoka consumes 17% of the national average, while Kanto (Tokyo region) consumes 180% of the national average. There has been an increasing trend toward the consumption of bigeye tuna in the Osaka area (where yellowfin is traditionally preferred). If the trend holds true over time it may represent an opportunity for second-grade (less oily) bigeye to be diverted from the Tokyo market (where high fat content receives a premium) to Osaka, where less oily species have been traditionally preferred (Williams 1986).

Seasonal influences on consumption

Supply of chilled tuna to the Japanese market is variable, depending upon season. Landings peak in the summer months (June, July, August) when bluefin, yellowfin and bigeye tuna migrate into coastal waters off Japan following the warm Kurushio current. During the remainder of the year, the majority of chilled tuna supplies are imported.

Supply of frozen tuna to the Japanese market is considerably less variable than the supply of chilled tuna. Tuna is landed and stored in freezer vessels virtually year round, and supplies are further smoothed by competition among major harvesting and trading companies who transfer the product from storage to the market place in accordance with their respective marketing strategies.

In addition to affecting the supply of chilled tuna on the market, seasonal variation affects the availability of tuna and nontuna species which are substitutes on the Japanese market. During spring (April–May), skipjack tuna arrive in waters off the Japanese coast on their northward migration and are considered to be in prime condition (*shun*). At this time, skipjack are preferred to yellowfin (Suzuki 1983). Yellowfin prices are also depressed by availability of local striped marlin and young bluefin (*meiji*) in October, and by the availability of yellowtail (*Seriola sp.*) in February (Tayama 1981b).

A range of factors affect the demand for tuna and tuna products in Japan. These include special days, such as public holidays, payday and the last shopping day before the weekend, and Japan's system of six monthly bonuses: *O-chugen* (midyear) and *O-seibo* (end of year). Demand for tuna and tuna substitutes peak at such times.

Price factors influencing consumption

Home consumption of tuna is influenced (in order of magnitude) by: tuna retail price; beef retail price; yellowtail price; salted salmon (mix of species) price; and bonito price (Taya 1988). The consumption function cited by Taya is: log Q = 1.229 − 1.107 log (tuna price) + 0.826 log (beef price) + 0.532 log (yellowtail price) + 0.274 log (salted salmon price) + 0.206 log (bonito price). This equation implies that consumption of tuna is price elastic in Japan.

Purchasing patterns, requirements

In general, expenditure per person on tuna in Japan is greater at specialty shops than at supermarkets. While older consumers continue to purchase tuna from specialty shops, the majority of younger consumers make their purchases at supermarkets.

Of primary consideration in the purchasing decisions of Japanese tuna consumers is the attribute of freshness (Gibson 1981, 1984; Franklin and Kitson 1982; Moret-Smith 1982; Rowly 1983). Tuna carcasses are large in comparison with other high-quality fish species (e.g. salmon), and hence must be divided into blocks and chunks for retail sale. As a result, consumers cannot assess the freshness of tuna by the simple method of inspecting the head and eyes (Lent and Johnson 1984). Instead, they rely on advice from supermarket employees, or use the attributes of meat colour and transparency as a guide. Preferences based on these attributes are important in tuna marketing as they are communicated via retailers to wholesalers (derived demand) and hence contribute to carcass characteristics desired at auction (Williams 1986).

Tuna, like beef, generally has improved flavour and tenderness with aging, although colour and transparency may deteriorate. Perhaps in consequence of this, attempts by retailers to promote 'aged' tuna on the basis of improved flavour and tenderness have proved unsuccessful.

While there is considerable differentiation of the product at the wholesale level, and a high discernment among those who purchase at this level, consumers who purchase tuna at major retail outlets are in general unaware of the species which they are purchasing. Most consumer packs are labelled with the general name for tuna (*maguro*) and not with the species name. The product may be bluefin, bigeye or yellowfin (Williams 1987).

Price formation in the markets

While frozen tuna prices tend to be smoothed over the year by storage and speculation, prices for chilled tuna vary with seasonal availability. Chilled yellowfin and bigeye prices are highest during winter (the off-season for the domestic fishery), and lowest during summer (the peak season for the domestic fishery) (Tayama 1981a, 1982). Payne (1981) documents a similar seasonal tend for bluefin tuna.

There is in general reasonable complementarity of price movements between categories of tuna species which have similar end uses. Low quality bluefin and bigeye tuna, and middle to low quality yellowfin tuna are sold in supermarkets under the general label '*maguro*' (Williams 1987).

While a knowledge of price determination in the retail sector of the market is useful, particularly for estimating long-term trends, the most important focus of attention with regard to price formation is the point of sale at the wholesale level–the auctions. At this level, prices received by foreign exporters are determined directly. While consumer preferences are transmitted to buyers at auction, buyers also take into account their own requirements (e.g. freshness–to allow for lags in distribution, and carcass meat yield). All such factors influence the formation of the bid price (Williams 1987).

Chapter

20

Modelling Tuna Prices in Japan: a Vector-Autoregressive Approach

A.D. Owen
D.A. Troedson

Introduction

This chapter contains the results of an investigation into the causal relationships between the prices of five species of tuna in a multivariate framework using monthly time series data at Yaizu market in Japan for the period 1976 (January)-1992 (August) The technique of vector autoregression (VAR) was used, to permit all possible causal influences among the variables to be taken into account.

Data restrictions decided upon the precise Yaizu price series that would be used for each species:

albacore: round weight

bigeye: gilled/gutted

skipjack (nonpurse seine): round weight

southern bluefin: gilled/gutted

yellowfin (nonpurse seine): gilled/gutted.

Prior to their use in estimation, the data were smoothed to lessen the individual impact of outliers on the analysis.

Model specification

The five variable VAR model may be specified as

$$\begin{bmatrix} P_{1t} \\ P_{2t} \\ P_{3t} \\ P_{4t} \\ P_{5t} \end{bmatrix} = \begin{bmatrix} \omega_{10} \\ \omega_{20} \\ \omega_{30} \\ \omega_{40} \\ \omega_{50} \end{bmatrix} + \begin{bmatrix} \omega_{11}(L)\omega_{12}(L)\omega_{13}(L)\omega_{14}(L)\omega_{15}(L) \\ \omega_{21}(L)\omega_{22}(L)\omega_{23}(L)\omega_{24}(L)\omega_{25}(L) \\ \omega_{31}(L)\omega_{32}(L)\omega_{33}(L)\omega_{34}(L)\omega_{35}(L) \\ \omega_{41}(L)\omega_{42}(L)\omega_{43}(L)\omega_{44}(L)\omega_{45}(L) \\ \omega_{51}(L)\omega_{52}(L)\omega_{53}(L)\omega_{54}(L)\omega_{55}(L) \end{bmatrix} \begin{bmatrix} P_{1t} \\ P_{2t} \\ P_{3t} \\ P_{4t} \\ P_{5t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix}$$

where $\omega_{ij}(L)=\sum_{\ell=1}^{mij}\omega_{ij,\ell}L^{\ell}$ g mij is the degree of the $\omega_{ij}(L)$ polynomial; L is the lag operator such that $L^k x_t = x_{t-k}; \omega_{10}$ are constants, and $[\varepsilon_{1t}\ \varepsilon_{2t}\ \varepsilon_{3t}\ \varepsilon_{4t}\ \varepsilon_{5t}]$ is a zero mean vector white noise process having $E(\varepsilon_t\varepsilon_s') = \delta_{ts}\Sigma$ where $\delta_{ts} = 1$ if $t=s$, and $\delta_{ts} = 0$ if $t \neq s$. Hence the contemporaneous correlation among the variables is reflected in the error terms of model (1).

The main difficulty in estimating model (1) is determining the appropriate lag length of each $\omega_{ij}(L)$ polynomial. By means of a likelihood ratio test adjusted by a small sample correction factor, the optimum lag length was determined to be 12 periods.

The model was estimated using unrestricted vector autoregressions for each dependent variable. Any gains in precision that could arise by utilising an iterative seemingly unrelated regression procedure were unavailable due to inadequate degrees of freedom.

Results

The specification and estimation of VAR models requires stationary series. On the basis of augmented Dickey-Fuller tests, it was concluded that all five price variables were integrated of order 1.

Using Johansen's maximum likelihood procedure for testing for cointegrating vectors, no evidence for cointegration was found at a 5% level of significance. Consequently, no cointegrating relationship was incorporated into the model.

Each equation in model (1) was estimated by least squares in what amount to, in essence, five dynamic reduced forms. Thus the meaning of the estimated coefficients is not well defined, and they are not reproduced here.

Figures 20.1 to 20.5 show the actual and fitted values for each of the five price variables. They appear to indicate a reasonably good fit, but it should be noted that this is not a dynamic simulation, i.e. the actual lagged values for all prices are used to calculate the fitted price for each period. The dynamic simulation occurs in the forecasting exercise, which extends for 28 months for each price variable (shaded areas in Figures 20.1 to 20.5).

Because of the smoothing of the data, yearly average forecast prices are presented in Table 20.1.

Table 20.1 Tuna prices, annual averages, Yaizu market (¥/kg)

Year	Albacore	Bigeye	Skipjack	Southern bluefin	Yellowfin
1990	329	811	316	5173	558
1991	264	775	199	4384	396
1992[a]	327	698	269	3759	528
1993[a]	314	664	302	4480	411
1994[a]	289	703	251	4432	453

[a]Forecast values.

Over the period of estimation, the model appears to 'reproduce' the data series with a reasonable degree of

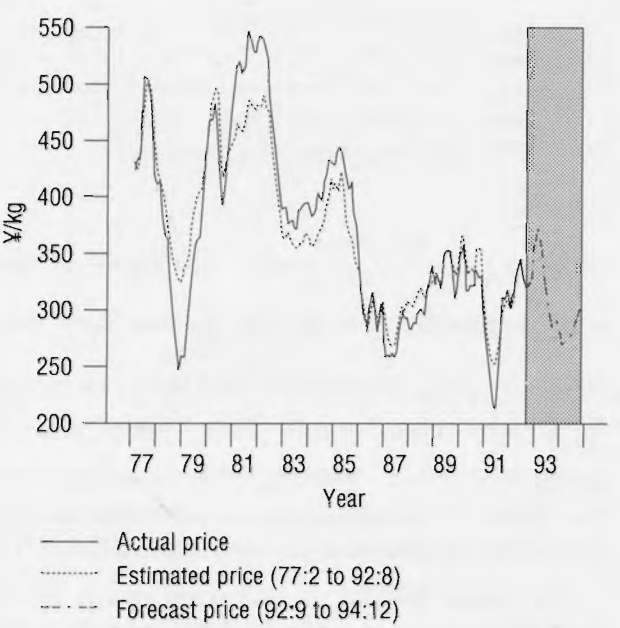

Figure 20.1 Albacore price series and forecast: Yaizu fish market.

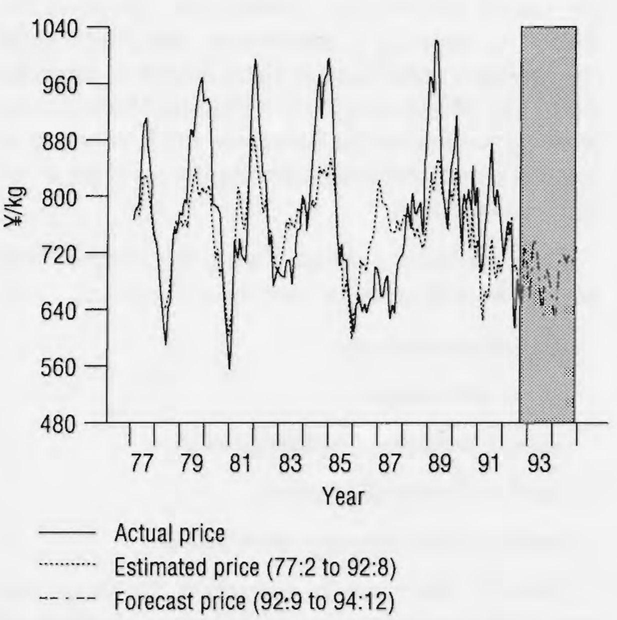

Figure 20.2 Bigeye price series and forecast: Yaizu fish market.

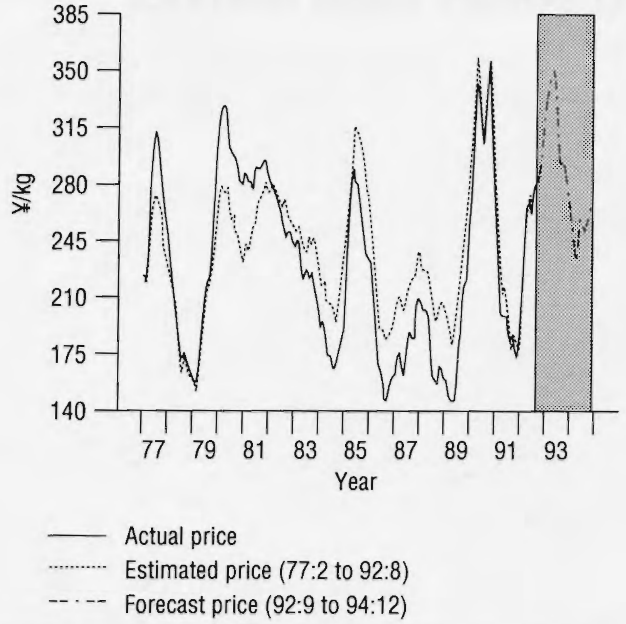

Figure 20.3 Skipjack price series and forecast: Yaizu fish market.

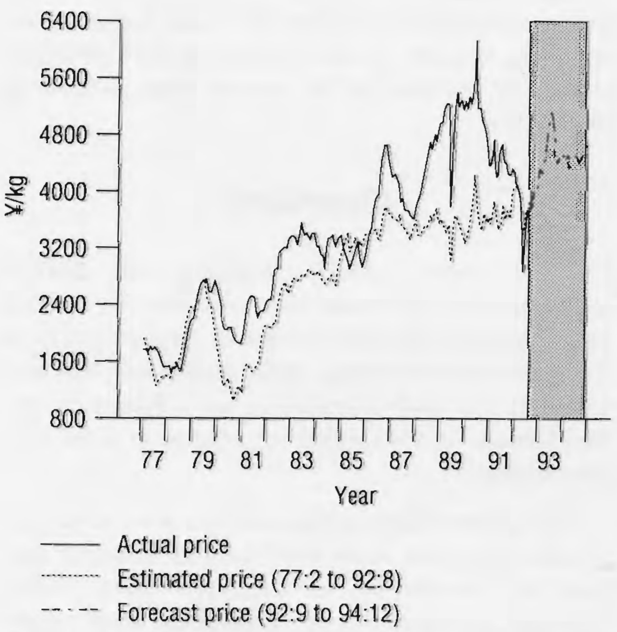

Figure 20.4 Southern bluefin price series and forecast: Yaizu fish market.

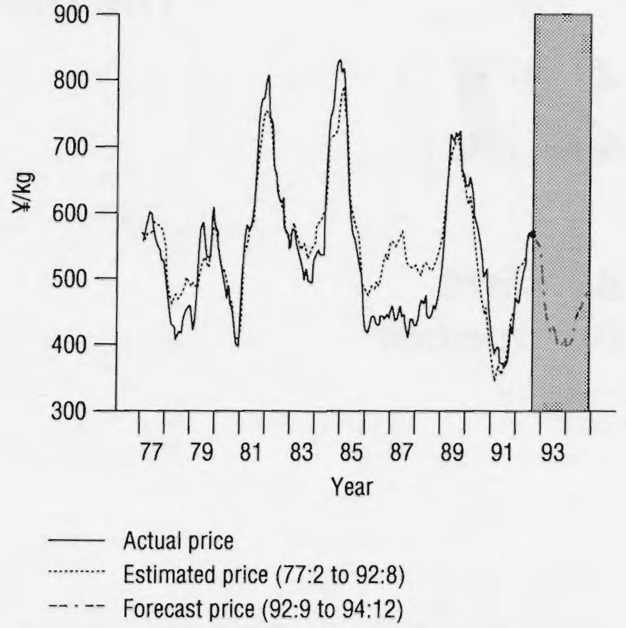

Figure 20.5 Yellowfin price series and forecast: Yaizu fish market.

precision, with the exception of southern bluefin where prices were invariably underestimated. This latter observation could be due to the effects of quotas being established and varied throughout the later part of the sample period, thereby changing the fundamental structure of the time series used for estimation.

The forecasts appear to reflect a continuation of the relatively regular price cycle experienced by the five series, although some 'dampening' is evident towards the end of the period of forecast. This is typical for a VAR, and such models tend to be useful only for short-term forecasting because of this trait.

Summary

With the exception of southern bluefish prices, the modelling process produced a reasonably precise fit to the observed data. The introduction of catch quotas has had a major impact on the price of southern bluefin tuna, and this has led to a persistent underestimation of its price in our modelling.

Chapter

21

The United States Tuna Market

A.D. Owen

D.A. Troedson

Introduction

The U.S. tuna market is primarily a market for the canned product, although small speciality markets are evolving. Traditionally, meat products have been the staple diet of Americans, and canned tuna has, for many years, been the predominant seafood product, enjoying widespread acceptance. More recently, shrimp consumption has risen to a level almost equivalent to that of tuna, and it is anticipated that shrimp will exceed tuna in the near future. However, major competitors for canned tuna remain chicken and red meat products.

The United States dominates international trade in canned tuna, with one-third of total world imports in 1991. It is also the world's second largest importer of canning quality tuna after Thailand.

While at first sight the sheer magnitude of the U.S. domestic market represents an attractive proposition for high volume canned tuna producers, it is important to recognise that distribution and marketing in the United States is generally the domain of huge food company conglomerates with established nationwide distribution and marketing networks and centralised marketing and purchasing functions reaping the benefits of economies of scale. Successful market entry by a new participant, therefore, is most likely to be in the form of a long-term contractual arrangement with an existing, established, food company.

This chapter provides a survey of the U.S. market for canned tuna, and identifies the major factors which 'drive' the industry. It also includes a brief statistical analysis of the demand for canned tuna in the U.S. market.

Overview

The U.S. tuna market comprises two distinct segments–one for frozen tuna and one for canned tuna. Almost all demand for frozen tuna comes from the producers of canned tuna, and hence the two segments are closely interrelated. The following discussion focuses on the canned tuna segment of the U.S. tuna market.

The United States is the world's largest market for canned tuna, and ranks third behind Thailand and Japan as a market for raw tuna. The United States consumes approximately one-third of the world supply of tuna (raw weight basis), and a little under two-thirds of the world supply of canned tuna (standard case basis).

United States consumption of all fish products increased from 4.8 kg/head (approximately 0.9 billion kg) in 1967, to 7.2 kg/head (approximately 1.8 billion kg) in 1989 (U.S. Department of Commerce 1990). The increase in U.S. consumption of fishery products over the period resulted from population increase, which was the primary factor, and from growth in individual demand, which is evidenced by the rise in per capita consumption. During 1967–89, U.S. consumption of canned tuna, which is the major canned seafood product in the United States, rose from 1.1 kg/head to 1.8 kg/head, an increase of 63% (U.S. Department of Commerce 1986, 1990).

Market profile

Canned tuna is consumed in approximately 85% of all U.S. households (Kitson and Hustis 1983). Most canned tuna is purchased from retail outlets and consumed in the home. Canned tuna accounts for over one-half of total retail seafood purchases in the United States, 94% of which is consumed in the home (Hu 1985).

The consumption of canned tuna in the United States varies by region. In absolute terms, consumption is concentrated in metropolitan areas along the coast, particularly in the northeast, southern California and Pacific northwest regions. In terms of frequency of consumption, canned tuna is a more prominent seafood item in the central and mid-Atlantic areas of the United States.

The U.S. canned tuna market can be divided into two broad sectors: the retail sector and the institutional sector. Over the past decade, the share of total shipments accounted for by the retail sector ranged between 86 and 96%, with the share accounted for by the institutional sector being the residual.

Within the retail and institutional sectors, there are distinct subsectors based on the type of meat (white or light), and the packing medium (water or oil). A further division in the retail sector is based on the label type (advertised brand or private label). The lightmeat sector is the principal market segment, as world supplies of albacore (used to produce whitemeat canned tuna) are relatively scarce. Over recent years, the lightmeat sector has accounted for around 80% of the U.S. canned tuna market, the residual being from the whitemeat sector (USITC 1990). With respect to regional consumption patterns, the east coast market (particularly in the northeast) has traditionally preferred whitemeat tuna, while lightmeat tuna has traditionally been preferred in the west coast market.

Over the past 15 years, there has been a marked shift in consumer preferences toward tuna canned in water, the market share of which, relative to tuna canned in oil, increased from 45% in 1979 to 82% in 1989 (USITC 1986, 1990).

Canned tuna produced in the United States dominates the advertised brand retail market, whereas imported canned tuna dominates the institutional sector and has had a growing market share in the private label retail market. In the period 1979–89, the share of the advertised brand retail market held by U.S. produced canned tuna ranged between 85% and 98%. The balance was held by canned tuna imports, a proportion of which were distributed by U.S. processors under their advertised brand labels. The share of the institutional market sector supplied by imports increased from 43% in 1979 to 70% in 1989, with a peak of 76% in 1988. The share of the private label retail market supplied by imports increased from 2% in 1979 to 24% in 1989 (USITC 1986, 1990).

Supply and demand factors

The supply of canned tuna in the U.S. market is determined by the level of domestic production and the quantity of imports. The domestic supply of canned tuna is influenced by U.S. canned tuna prices, raw material availability and production costs. The quantity of canned tuna imports into the United States is influenced by the same factors which influence domestic supply, and also by conditions in alternative markets.

The demand for canned tuna in the United States is principally determined by increases in the population, the price of canned tuna relative to competing products, real disposable income, and consumer preferences. Demand has been particularly volatile in response to concerns over dolphin mortality arising from the practices of certain tuna fishing nations.

The bulk of canned tuna supplies are marketed through retail outlets, and hence price competition with other food items is strong. Food items which compete strongly with canned tuna in the retail market include ground beef, chicken, and canned salmon.

An example of the influence of consumer preference on demand in the 1980s was the shift in demand from tuna packed in oil to tuna packed in water, as U.S. consumers became increasingly more health conscious.

Consumption

Consumption of canned tuna generally increased during the period 1981–91 and ranged between 274.8 kt and 465.9 kt (Table 21.1). The dramatic increase in imports during this period, principally from Thailand, had the most significant impact upon consumption. Although consumption of canned tuna generally increased during the decade, current problems in the industry (discussed below) suggest that consumption will decline, at least in the short term.

Table 21.1. U.S. production, imports, exports, and apparent consumption, canned tuna, 1981–91 (t)

Year	Production	Imports	Exports	Apparent consumption
1981	287000	26500	–	313500
1982	246000	28800	–	274800
1983	268000	48033	–	316033
1984	275000	58451	–	333451
1985	250000	74299	–	324299
1986	295000	84113	–	379113
1987	297000	95900	–	392900
1988	271000	110800	–	381800
1989	311000	157800	2946	465854
1990	264000	129100	4100	389000
1991	269000	159600	5130	423470

Source: Owen 1990; FAO Globefish Highlights, various years; Ferdouse 1993.

Consumption by packing media altered significantly during the period. As noted previously, the proportion of tuna packed in water increased from 45% in 1979 to 82% in 1989.

Consumption of canned tuna per capita increased significantly over the last 15 years. In 1979, per capita consumption of canned tuna totalled 1.5 kg. By 1989, consumption per capita had risen to 1.8 kg, an increase of 22% (U.S. Department of Commerce 1986, 1990). Increases in tuna consumption during the period under consideration can be attributed principally to population increase, price discounting, dietary considerations, and increases in per capita income.

Barriers to trade

Import regulations: The United States imposes strict standards on the importation of fish and fishery products. Import standards are contained in the *Food, Drug and Cosmetic Act*, and are enforced by the U.S. government. Imports must also comply with the standards established by the *Fair Packaging and Labelling Act*, and with the Food and Drug Administration (FDA) regulations.

There is concern at present in the tuna industry over an increasing number of canned tuna detentions by the FDA. Both Thai and Filipino canners have been subject to the automatic detention and rigourous inspection of their product. This has significantly reduced the level of canned tuna imports into the United States, which has resulted in extremely low inventory stocks, particularly for institutional packs. Thailand is the principal exporter of canned tuna to the United States, while the Philippines is a major supplier of catering packs. United States importers have appealed to the FDA to allow Thai canners time to come to terms with new inspection procedures (FAO Globefish Highlights 1993).

In addition to the general regulations which apply to the importation of fish and fishery products to the United States, other regulations apply specifically to tuna commodities. The United States imposes tariffs on canned tuna imports in two categories: tuna in oil and tuna not in oil. The tariffs on canned tuna were introduced in 1930, and have been revised a number of times. Current rates of duty were established on 1 January 1972.

Under tariff code 112.90, tuna prepared or preserved in oil, in airtight containers weighing 6.8 kg or less is dutiable at 35% *ad valorem* from most favoured nations, and 45% *ad valorem* from all other countries. Canned tuna not in oil is dutiable at 6% *ad valorem* from most favoured nation countries and 25% *ad valorem* from all other countries. All Pacific island countries and territories have most favoured nation status in trade with the United States.

In addition to the 6% *ad valorem* duty, a tariff-rate quota is imposed on canned tuna not in oil. The quota, which was introduced on 14 April 1956, is recalculated annually, based on 20% of domestic production in the previous year. Imports exceeding the annual quota are dutiable at a rate of 12.5% *ad valorem*.

During 1979–89, the quota declined from 57 113.2 kt to 34 821.8 kt, indicative of declining mainland domestic production, while imports over the quota increased from zero to 106 372.2 kt, indicative of rapidly increasing import levels from low-cost producers such as Thailand. While the level of imports over quota declined to approximately 68 100 kt in 1990, quota and import levels increased in 1991, exceeding all previous levels (FAO Globefish Highlights 1993).

Since 1983, canned tuna production in American Samoa has been included with domestic production in determination of the quota. In the years immediately prior to 1983, approximately one-third of the annual quota was filled by tuna processed in American Samoa, which entered the United States duty free. The inclusion of American Samoan tuna products therefore enabled foreign producers to export significantly more water-packed tuna to the United States at the 6% *ad valorem* tariff duty rate.

Embargoes: The United States has periodically imposed embargoes on the importation of tuna products. Such embargoes are imposed under the authority of two acts; the *Fisheries Conservation and Management Act 1976* and the *Marine Mammal Protection Act 1972*. In the past, embargoes on the importation of tuna products were generally imposed under the *Fisheries and Conservation Management Act* in response to the seizure of U.S. fishing vessels operating without licence in the exclusive economic zones of foreign countries. The United States did not recognise such countries' rights to jurisdiction over the harvesting of highly migratory species (namely tuna) within their exclusive economic zones.

More recently, embargoes have been imposed, under the authority of the Marine Mammal Protection Act, in response to high levels of dolphin mortality associated with the fishing practices of some foreign tuna fishers. More generally, embargoes apply when a foreign country does not effect a dolphin mortality protection plan similar to that of the United States.

In January 1992, a U.S. district court judge in California extended the previous ban on tuna imports from nations failing to effect a suitable dolphin mortality protection plan to include tuna products from countries which purchase tuna from those already embargoed. This affected over 20 countries, including Japan, Spain, Italy, France, Panama and Costa Rica, many of which purchase tuna from Mexico (which is currently under embargo) (FAO 1992).

More recently, the United States has taken further steps to legislate against the harvest of tuna that school in association with dolphin. In October 1992, President George Bush signed the 'Global Moratorium Bill', outlawing the harvesting of tuna in association with dolphin. The bill includes a five-year moratorium on purse seining, commencing March 1, 1994. The present embargo will be lifted for any nation which signs the moratorium. In addition, the bill makes it illegal for any U.S. citizen to sell, purchase or transport to the United States any canned tuna which is not 'dolphin safe' after June 1, 1994. This bill will not only impact heavily upon the Mexican and Venezuelan tuna fleets, but also the remainder of the U.S. fleet that still operates in the eastern Pacific (FAO 1992).

Distribution

Most domestically produced canned tuna is marketed via a network of brokers. The use of brokers is advantageous to domestic processors because it eliminates the need for field sales offices, and hence generally reduces marketing costs, and because it provides a source of current information on competition in regional markets. The brokers generally handle a range of food products, including tuna-based pet foods produced by U.S. tuna processors. Although brokers and processors generally have long-term relationships, most processors periodically appraise the performance of their brokers. Currently more than 200 brokers are involved in the marketing of U.S. canned tuna.

Brokers generally operate within geographically defined limits. It is a general requirement of processors that each broker handle only one brand of canned tuna, and hence an individual firm may use different brokers to market different pack types, i.e. advertised brand or private label. Brokerage fees are calculated either on a specific rate per case or on a percentage of case sales (currently 2-3%).

Although canned tuna is marketed via brokers, processors generally bill the final buyers directly. The terms of sale generally include a discount for payment within a specified time (typically 2% discount for payment within 10 days of the invoice date). In general, the buyer is responsible for freight charges.

United States-produced canned tuna is generally transported from processing plants by cargo vessel, and delivered to regional warehouses located on the mainland. The warehouses are owned by nontuna interests, and therefore space must be leased for canned tuna. Canned tuna is transported from the warehouses to the final buyer by truck, usually at the expense of the buyer, i.e. it is sold on an f.o.b. warehouse basis.

The warehouse turnover rate for canned tuna is in the order of four to six times per year, and hence a case of canned tuna remains in the warehouse (and is subject to storage charges) for about two to three months. In the mid-1980s, storage costs ranged between 50 and 60 cents per hundredweight (50.8 kg) including handling charges, which was less than 1% of average wholesale charges. Total transportation costs for domestic processors range 1–3% of the wholesale case price.

Imported canned tuna is generally marketed by the importing firm, which may also act as a broker for domestically produced canned tuna in the private label retail sector. Imported canned tuna is also marketed by institutional food brokers, as most imports are destined for this sector.

Imported canned tuna is transported via cargo vessel from the exporting country to domestic warehouses. Upon storage in domestic warehouses, imported canned tuna is subject to the same storage and transportation methods and charges as is the domestic product. In 1985, import charges for the four main exporters to the United States (which accounted for 81% of the total value of canned tuna imports), ranged between 4.7% and 8.3% of total market value.

Marketing practices

Canned tuna is marketed in the United States through retail outlets, restaurants, and other institutions, either under advertised brand labels or private labels, such as those belonging to a retail chain. Most advertised brands have nationwide distribution, although market shares held by each brand differ between regions. Various means of advertising are employed, and usually accompany other methods of promotion such as price discounting.

Individual processors do not necessarily concentrate all sales effort on their own brand. It is not uncommon for processors, on specific orders, to market tuna under the private labels of large retail chain stores. In addition, one processor may sell all or part of its output to another processor, which markets the tuna under its own advertised brand label. It has been a common practice for U.S. processors to market imported tuna under their own label.

The purpose of advertised brands is twofold: to make the consumer brand conscious (and hence to reduce the elasticity of demand); and to ensure the widest possible distribution of the product within the limits of the processor's budget. Brand differentiation forces large retailers and other distributors to carry a range of tuna brands, rather than just 'canned tuna', and hence increases individual market coverage.

Advertising methods employed by tuna processors include coupons, magazine advertisements, retailer sponsored newspaper advertisements and television commercials. Coupons (and related methods) are popular because the consumer's attention is focused on the advertised brand. In contrast, television advertisements may be remembered more for the product being advertised than the specific brand (i.e. they contain an element of generic advertising), and hence are less popular than coupons, because they boost the sale of competing brands. U.S. processors commonly let retailers advertise on their behalf through newspaper advertisements, in exchange for discounts off the wholesale prices.

In addition to advertising, competitive pricing is an important strategy employed for the retail marketing of canned tuna. While the pricing strategy for major processors is designed to capture a larger market share, i.e. price discounting in the major retail lines, for some lines of tuna it is intended to maximise profits, i.e. price premiums for specialty items.

The nature and extent of competition from imported canned tuna in the U.S. market depends upon the way in which it is marketed and the market sector in which it is sold. Significant competition with domestic brands is most likely to occur in the retail sector of the market. Due to the difficulties (cost and otherwise) of establishing a new brand in the market place, a substantial portion of the increase in canned tuna imports during the 1980s was marketed under the labels of prominent domestic processors and hence distributed through established market channels. Imports have also been distributed under retailers' own labels. Competitive pricing is the principal reason why such brands may be preferred by consumers.

Price determination mechanisms

There are three distinct levels of prices in the U.S. tuna market: the primary production level, at which frozen tuna is delivered to processors by harvesters (ex-vessel prices); the wholesale level, at which processors deliver canned tuna to distributors or directly to retailers and institutions (wholesale prices); and the final distribution level, at which retailers and institutions distribute canned tuna to the final consumer (retail prices). Imported supplies of canned tuna influence price determination at all levels. The following paragraphs outline price determination at the wholesale and retail market levels.

Wholesale prices: In the U.S. market, the wholesale price of canned tuna at any one time varies according to species (whitemeat or lightmeat), packing medium (water or oil), container size (the smaller the can the higher the unit price in general), and the brand under which the tuna is marketed. Container size (reflecting different types of customers) and brand specification are more important influences on price determination mechanisms than are species or packing medium, which have a more significant impact on price levels and trends.

Pricing at the wholesale level is closely tied to pricing at the ex-vessel and retail/institutional levels. Wholesale tuna prices are influenced by supply, seller concentration in the wholesale market, advertising methods and brand loyalty in the retail market, prices of tuna substitutes and consumer tastes. Hence processors need to balance the primary production and retail ends of the tuna market, which has resulted in a complex system of pricing and marketing at the wholesale level. Nonprice marketing mechanisms cannot be separated from price determination mechanisms at the wholesale level, because at this stage in the market, tuna is transformed from a reasonably homogeneous product into a brand-specific, differentiated product.

The base wholesale price, the list price, is used as a starting point from which the net price is determined. Promotional allowances and other adjustments generally cause the net price to be below the list price. The list price is revised periodically (about four to six times per year), depending on demand conditions in the wholesale market and the cost of raw tuna. The net price fluctuates according to promotional activity at the retail level and localised market competitive pressures.

Careful attention is paid by each processor to the pricing and marketing behaviour of competing processors, and responses to the actions of rivals are planned and executed quickly. This results in local pricing wars, which possibly serve as a means by which a firm discovers pricing policies and attitudes of its rivals in a competitive market. Price competition is the dominant form of competition, followed by nonprice promotional activity and product diversification.

Retail prices: The retail market level incorporates institutions (restaurants, schools, military establishments, hospitals etc.), in addition to supermarkets and grocery stores. Retail prices of canned tuna served in food stores are, however, conceptually different to the prices of canned tuna served through institutions. In a retail situation, consumers are faced with the choice of purchasing tuna at a known and clear price. Within institutions, the price, as understood by the consumer, is less clear. At a restaurant, the consumer is purchasing other commodities–service and side orders, along with tuna. Hence it is difficult to assess the price of the fish. The price of canned tuna is even more difficult to determine in schools, hospitals and military establishments, in which there may be no choice, and no price is paid by the consumer. Hence only price determination at retail outlets will be discussed in the following paragraphs.

Retail prices of canned tuna in the United States are set by supermarkets, chain food stores and independent grocery stores. Such establishments sell a wide array of commodities, and canned tuna is typically no more important than most other items. Were it not for promotional allowances, retailers would be unlikely in general to incur much expense for the advertisement of their canned tuna.

Tuna retail prices are in general set according to the overall marketing strategy of the retailer, and adjusted according to market conditions such as local competition, consumer tastes and incomes, and the wholesale price of tuna. Private label tuna, which is marketed only by the retailer controlling the brand name, is sold at a lower price than advertised brands. Evidence suggests that given a choice between an advertised or private label brand, a retailer will choose to market an advertised brand.

U.S. canned tuna exports

Historically, U.S. exports of canned tuna have been negligible, due principally to the fact that U.S. processors are not competitive in the major foreign markets of Japan and the European Community. Factors contributing to this lack of competitiveness in those markets include: high rates of duty (Japan 15%; E.C. 24%); high transportation costs from Puerto Rico and American Samoa; demanding product specifications which would entail increased production costs; competition from low cost Asian imports (principally in European markets); and the existence of large, well established, domestic industries in those markets.

Recently, however, U.S. canners have begun exporting small quantities of canned tuna. In 1989, U.S. canners exported 2946 t of canned tuna. By 1991, exports had increased to 5130 t (Table 21.1). The U.S. canner, Bumble Bee Seafoods was among the exhibiters at the SIAL exhibition in Paris in October, 1992. Bumble Bee is seeking to enter the competitive export market and has developed a range of new tuna products (FAO 1992).

U.S. canned tuna imports

U.S. imports of canned tuna increased dramatically during the period 1981-91, from 26.5 kt to 159.6 kt, an increase of 500% (Table 21.1). The rise in canned tuna imports resulted from a number of factors which included: strong demand for canned tuna in the U.S. market fuelled by favourable economic conditions, generally declining canned tuna prices, and shifting consumer dietary preferences; and the procurement of canned tuna supplies by U.S. processors from foreign producers, chiefly since 1984.

The contribution to total U.S. imports by source altered dramatically during 1979-89. The most significant increase in contribution came from Thailand. In 1979, Thailand contributed 9% of total canned tuna imports by quantity and 8% by value. By 1989, Thailand's contribution had risen to 71% and 69% respectively (Table 21.2).

The rapid rise in canned tuna imports from Thailand and its subsequent gain in U.S. market share occurred principally at the expense of the Japanese export industry for canned tuna. Contribution to U.S. imports of canned tuna by Japan declined from 52.8% by quantity and 57% by value in 1979, to 0.7% and 1.4% respectively in 1989 (Table 21.2).

Taiwan and the Philippines remained important and consistent sources of canned tuna over the period 1979–89, although both countries experienced a decline in market share. After the withdrawal of the U.S. military force from Subic Bay in the Philippines, it is planned to build a tuna processing centre there (FAO 1992b). Hence, the Philippine contribution to U.S. canned tuna imports may increase significantly in the future. Indonesia began exporting small quantities of canned tuna to the United States in 1984, and gradually increased its market share over subsequent years. In 1989, Indonesia contributed 6.5% of total U.S. canned tuna imports by quantity, and 5.2% by value (Table 21.2). Indonesia is expected to increase its U.S. market share significantly in the 1990s.

Canned tuna packed in water is the principal product type exported to the United States, and accounted for virtually all U.S. imports of canned tuna during 1979–89 (USITC 1986, 1990). The predominance of water-packed imports is attributable principally to the U.S. tariff structure.

Current trends indicate that canned tuna imports in 1993 will be significantly lower than levels in recent years. While in 1992, the low duty import quota was

Table 21.2 U.S. imports of canned tuna for consumption, by principal source, 1979–89

Country	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
						Quantity (kt)					
Thailand	2.199	2.908	4.683	8.475	18.128	40.717	55.690	69.143	66.706	81.240	112.719
Taiwan	5.576	7.240	7.160	4.860	8.494	8.142	10.656	12.975	11.769	10.901	12.655
Japan	12.878	11.256	9.657	12.022	9.256	12.192	10.761	4.793	2.129	1.530	1.117
Philippines	3.177	6.255	9.739	12.544	14.536	10.090	13.982	9.342	13.101	8.401	15.440
Ecuador	–	–	–	–	–	0.404	2.350	1.310	2.321	3.776	1.314
Malaysia	0.133	0.030	0.316	0.343	1.400	0.730	1.761	1.090	0.715	1.290	1.934
Indonesia	–	–	0.066	0.270	1.196	1.009	0.630	0.370	0.684	2.200	10.278
Venezuela	–	–	–	–	–	0.003	0.419	3.327	1.323	0.080	1.037
Singapore	–	0.013	0.030	0.054	0.151	0.027	0.331	0.563	0.208	0.755	0.284
Spain	0.153	0.066	0.077	0.054	0.060	0.097	0.153				
All other	0.266	1.085	0.560	1.138	2.316	0.280	0.400	1.291	0.783	0.836	1.309
Total	24.382	28.853	32.288	39.761	55.537	73.690	97.133	104.206	99.739	111.009	158.087
						Value (US$'000)					
Thailand	5135	8 875	15 400	22 711	43 259	89 253	111 852	139 561	135 368	207 538	260 996
Taiwan	14 103	23 316	24 631	14 366	22 772	22 475	29 801	34 483	34 809	41 759	44 857
Japan	37 055	42 015	36 453	38 561	24 643	29 186	28 142	14 755	7 375	6 992	5 172
Philippines	7 319	20 043	30 504	31 085	32 291	20 396	25 930	23 124	16 577	18 629	31 129
Ecuador	1	–	–	–	–	837	4 676	2 603	4 481	9 366	2 912
Malaysia	314	76	1 230	1 242	4 068	1 893	4 498	3 160	1 985	3 964	5 131
Indonesia	–	–	209	699	2 679	2 102	1 186	690	1 247	5 690	19 667
Venezuela	–	–	–	–	–	7	851	6 389	2 467	200	1 943
Singapore	–	38	91	141	386	44	671	1 140	452	1 974	768
Spain	501	367	402	300	268	376	560	n.a.	n.a.	n.a.	n.a.
All other	643	2 254	1438	4 242	6 958	701	972	3 142	2 160	2 554	3 337
Total	65 071	96 984	110 358	113347	137 324	167 270	209 139	229 047	206 921	298 666	375 912

n.a. not available.
Source: USITC 1986, 1990.

filled within minutes of opening on January 1, it was not filled until March 17 in 1993. January to March imports during 1993 (32 300 t) were the lowest in six years. While Thailand remains the dominant supplier, its exports to the United States have been curtailed by 40%. The principal cause of this decline is the growing number of detentions of Thai product by the FDA. Three Thai canners are currently under automatic detention, while a further five are understood to be under threat of similar action. In consequence, it is likely that U.S. consumption of canned tuna will be lower in 1993 than in recent years.

The share of total U.S. canned tuna supply produced by U.S. processors declined during the previous decade, particularly in the years subsequent to 1982. In consequence of the purchase of Van Camp Seafood and Bumble Bee Seafoods by Asian companies during 1988–89, this trend has continued, as both companies increased the share of their branded products supplied by imports from their home country canneries. However, with the current detention of canned tuna from Thailand and the resultant decline in imports from this country in the first half of 1993, it is possible that this trend may be reversed, if only temporarily.

Statistical analysis

An equation explaining the demand for canned tuna in the United States was estimated by least squares for the period 1967–90. The following estimated relationship was obtained:

$$D_t = -1.4725 + 0.6968\, Y_t - 0.4546\, P_t^T + 1.9218\, P_t^m$$
$$\quad (-2.5167) \quad (11.0340) \quad (-2.3616) \quad (4.3944)$$

$$R^2 = 0.91 \quad \bar{R}^2 = 0.90 \quad DW = 2.80$$
$$F(3,20) = 70.91 \quad SEE = 0.14 \qquad (2)$$

D_t is apparent tuna consumption per capita; Y_t is U.S. real disposable income per capita (in 1972 dollars); P^T is an index of the (real) wholesale price of tinned tuna (1972 = base); and P^m is an index of the (real) price of 'meat' (1972 = base).

The tuna price series was constructed as the weighted average of the price of chunk lightmeat brands. All variables had their expected signs and were well determined at the 5% level of significance (t ratios are given in parentheses). The exact Durbin-Watson (DW) probability was 0.93, indicating that the hypothesis of uncorrelated disturbances cannot be rejected at a 5% level of significance. However, the 'marginal' nature of this conclusion is very evident.

The model was therefore re-estimated using a Cochrane–Orcutt type iterative procedure (Beach and MacKinnon 1978), for estimating models in the presence of autocorrelation. The revised estimated relationship was

$$D_t = -1.8267 + 0.7172\, Y_t - 0.5684\, P_t^T + 2.3040\, P_t^m$$
$$\quad (-4.9284) \quad (18.6570) \quad (-4.7207) \quad (7.9050)$$

$$R^2 = 0.94 \quad \bar{R}^2 = 0.93 \quad DW = 2.33$$
$$F(3,20) = 95.95 \quad SEE = 0.14 \qquad (3)$$

At the point of means, price and cross-price elasticities of demand for tuna were relatively low at −0.16 and 0.72 respectively. However, the income elasticity of demand was 1.04. These results clearly indicate that increases in real disposable income per capita are the major driving force behind increased per capita U.S. consumption over the past two decades. The own price and income elasticities are very close to values obtained by King (1986) in a similar exercise based on an earlier data set. His values were −0.20 and 0.99 respectively. However, his cross price elasticity was 0.33, under half the value obtained in this study.

Chapter 22

The European Market for Tuna

A.D. Owen

D.A. Troedson

Introduction

The European market for canned tuna is dominated by the European Community. It is an extremely diverse market, with distinctly identifiable market structures and consumer preferences. Historically, the market has represented a considerable challenge to canned tuna exporters, due to differing standards and requirements among importing countries, and considerable nontariff barriers to trade, particularly in mature markets such as France. In recent years, that challenge has been successfully taken up by Asian canned tuna exporters, especially Thailand and the Philippines.

With a view to achieving uniformity across markets, uniform regulations for imports into the European Community were introduced in 1993. While a single, Community-wide standard was originally intended to be of considerable benefit to exporters, lobbying by French interests has resulted in the additional implementation of a Community-wide import quota on canned tuna, other than that which is produced in certain Asian, Caribbean and Pacific (ACP) nations. The implications of this development upon individual country markets, upon ACP exporters (including canneries in the western Pacific), and upon non-ACP exporters are of key interest in this market study.

The canned tuna processing sector

The principal European countries involved in the production of canned tuna are Italy, Spain, France, and Portugal. While Italian processors use imported raw tuna almost exclusively, Spanish, French and Portuguese processors use domestic landings as well as imported raw tuna. Over the period 1982–91, canned tuna production in these countries increased approximately 70%, from 129.7 kt to 218.2 kt (Table 22.1). In 1991, Italy accounted for 40% of the total; Spain (38%); France (15%); and Portugal (7%). While total production by French companies is comparable to production in Italy and Spain, much of this occurs in Senegal and Côte d'Ivoire.

Italy

Italian canned tuna production increased 81% during 1982–91 (Table 22.1). Processors use mostly imported fresh and frozen tuna (principally yellowfin). Fresh and frozen tuna imports increased from 77.3 kt in 1982 to 116.2 kt in 1991 (FAO 1991). In recent years, Italy (along with Spain) has been virtually the only major avenue for the marketing of yellowfin caught in the eastern Pacific, by harvesting nations such as Mexico, following boycotts by the United States. Recently, however, both Italy and Spain have joined the United

States in boycotting this tuna. No yellowfin from the eastern Pacific is presently traded in Europe. The principal suppliers of raw tuna to the Italian processing industry are Seychelles, which accounted for 16% of total frozen yellowfin imports in 1991, Mexico (12.6%), Panama (10.8%), Côte d'Ivoire (10.0%), Spain (9.0%), United States(3.7%) and France (2.8%) (FAO 1992).

Table 22.1 E.C. production of canned tuna by major country, 1982–91

Year	Italy	Spain	France	Portugal	Total
1982	48.13	56.44	18.00	7.13	129.70
1983	52.14	53.68	17.75	7.29	130.86
1984	58.65	54.65	21.96	8.91	144.17
1985	64.67	55.14	25.15	9.43	154.39
1986	84.22	59.50	29.18	12.26	185.16
1987	80.21	63.23	29.68	10.38	183.50
1988	85.22	67.31	28.20	11.40	192.13
1989	85.22	75.18	32.67	13.23	206.3
1990	86.33	75.70	31.59	14.37	207.99
1991	87.23	82.52	33.46	15.00	218.21

Sources: FAO 1991; Ferdouse 1993.

The construction of new processing facilities and the implementation of new technology have significantly increased Italian tuna canning capacity in recent years. In contrast to trends in the United States, the majority of Italian canned tuna is packed in oil. In 1989, 85% of tuna was packed in olive oil, 10% in water, and 5% in seed oils (U. S. Department of State 1990a).

Spain

Spanish production of canned tuna increased 46% during 1982–91. Spanish processors use both domestic and imported raw tuna in production. Fresh and frozen tuna imports increased from 42.7 kt in 1982 to 153.6 kt in 1991. The principal suppliers of raw tuna to the Spanish processing industry are Venezuela, Ecuador, and Côte d'Ivoire (USITC 1990).

The most preferred tuna species for canning are albacore and yellowfin, which together comprise approximately 47% of the canned product. As in the case of Italy, Spanish canneries were an important market for Mexican yellowfin, but have now boycotted all eastern Pacific yellowfin.

France

French canned tuna production increased 86% during 1982–91. Production increased annually during the period under review, with the exception of 1988 and 1990. The 1988 production decline has been attributed to increased production costs, which is the apparent reason for the closure by Starkist of two tuna processing facilities and a subsequent reduction in raw material usage (FAO 1989).

French tuna processors use both domestic and imported raw tuna for canned tuna production. While domestic landings remain the primary source, imports of fresh and frozen tuna increased 81% during 1982–90, from 20 kt to 36.2 kt. In 1991, imports declined to 19 kt (FAO 1991). The principal suppliers of imported raw tuna to the French processing industry are Senegal (landed primarily by French seiners), Spain, Venezuela, and Côte d'Ivoire (USITC 1990).

The principal species used by canned tuna processors are yellowfin, skipjack and albacore. French canners focus their production on canned tuna salads and other sophisticated products which have been gaining popularity on the French market (FAO 1992).

A number of French companies have invested in foreign tuna operations. One example is the construction of a tuna processing plant in Madagascar, at a cost of approximately ECU14.5 million. The facility comprises a can manufacturing plant, a fishmeal unit and a cold storage warehouse. A production level of approximately 10 kt was forecast for the first year of operation, increasing to 20 kt in subsequent years. The facility is owned and managed by Pêche et Froid, Océan Indien, a joint venture between Malagasy partners and the French group Pêche et Froid (the leading French seafood canner), and employs approximately 270 local people (FAO 1988). Pêche et Froid is also a major shareholder of the SAIB cannery in Dakar, Senegal, and the PFCI (Pêche et Froid de Côte d'Ivoire) cannery in Abidjan, Côte d'Ivoire (USITC 1990). In 1991, Pêche et Froid announced intentions to further invest in tuna processing in Côte d'Ivoire. Investment (through PFCI) was forecast to be US$1.5 million and was to include a 3000 t cold storage facility, a further processing line for tuna and further processing facilities (FAO 1991).

French companies are also involved in a tuna cannery joint venture in the Seychelles. The cannery, located in Fishing Port, Victoria, is owned by Armement Coopératif Finisterien (ACF) and Pêcheurs de France (30% ownership), and the Government of Seychelles (70% ownership) (U.S. Department of Commerce 1989). Armement Coopératif Finisterien also owns more than 40 seiners which are licensed to fish in Seychelles waters. An additional French company, Saupiquet, owns canneries in Senegal and Côte d'Ivoire (Seafood International 1990).

In Ghana, a tuna processing plant is under construction at the Tema port of Accra, involving investment of US$10 million. The plant will be the largest tuna processing plant in Ghana, and the second largest in West Africa. Partners in the project are International Fishing and Trading Co. Ltd (Infitco) which owns 51% of the cannery, and French Secopa (49%) (FAO Globefish Highlights 1993).

Portugal

Portuguese canned tuna production increased 110% during 1982–91. Domestic and imported tuna are used in canned tuna production. Imports of frozen tuna increased 224% during 1982–91, from 6.9 kt to 22.4 kt (FAO 1991). The principal foreign suppliers of fresh and frozen tuna to the Portuguese industry are Spain, Mexico, Brazil and Venezuela (USITC 1990).

In 1989, 15 tuna processing plants were in operation, with a total capacity of 15 kt. The packing medium used by the processors varies depending on the intended market. Canned tuna intended for export is packed in olive oil, whereas tuna produced for the domestic market is packed in vegetable oils other than olive oil (U.S. Department of State 1990a).

The canned tuna market

The European region is a major market for canned tuna and has figured prominently in the changing structure of the global tuna market. Europe, and in particular the European Community, has in recent years been one of the fastest growing markets for canned tuna. The European canned tuna market comprises three principal segments: the European Community, other western European countries, and eastern Europe.

While the European Community is collectively the world's largest importer and the second largest consumer of canned tuna after the United States, Western Europe in total (i.e. the European Community plus other western European countries) is both the world's largest importer and largest consumer of canned tuna.

The E.C. tuna market can be divided into two submarkets: countries with and countries without domestic canned tuna processing industries. In general, E.C. countries with domestic tuna industries are mature markets, while the remainder are relatively recent markets. Mature markets include France, Italy, Spain, Portugal, Greece, Belgium and Luxembourg.[1] The mature markets consume domestic and imported canned tuna, and each has reasonably distinct characteristics (USITC 1990).

Nonmature markets include the remaining E.C. countries, the most significant being the United Kingdom and West Germany. Nonmature markets depend almost entirely on imports for canned tuna supply. Much of the growth in the E.C. canned tuna market over recent decades has been accounted for by nonmature markets, and hence growth has been facilitated largely by imports.

Most eastern European markets are undergoing considerable structural change. As canned tuna is not consumed in significant quantities in these countries, the eastern European market will not be considered in the following discussion.

Import policies

Rules of origin

Under certain conditions, ACP nations are afforded preferential access to E.C. markets. The regulation and policing of these conditions is undertaken by the E.C. Commission. In effect, an ACP exporter is, under certain conditions, permitted tariff-free access to the

[1] While Belgium and Luxembourg do not have domestic tuna harvesting and/or canning industries, domestic market conditions are strongly influenced by those in France (USITC 1990).

market and thus avoids a duty of 24% which is levied on products of non-ACP origin (Elsy 1987).

Tariff-free entry into the E.C. market is granted on the condition that an ACP product meets certain criteria which are described in the rules of origin. These rules involve a range of considerations, including the value added component of the product produced in an ACP country. Such considerations require the E.C. Commission to establish workable compromises between itself, the exporting nation and E.C. member countries.

With regard to tuna and tuna products, the question of origin is determined by where the tuna was caught and by whom. Provided that tuna is caught within the 12 mile limit (territorial waters) of an ACP country, it may be caught by vessels of any flag. Beyond the 12 mile limit, tuna must be landed either by the ACP country undertaking export to the European Community, or by a vessel flying the flag of another ACP country.

If tuna is caught by non-ACP countries outside the 12 mile limit it may nevertheless be accepted tariff free into E.C. markets subject to the granting of a derogation to the rules of origin. The derogation must be applied for by the exporting ACP country through the ACP council. The ACP council submits the applications to the joint ACP/E.C. Customs Cooperation Committee.

The rules of origin were established for the protection of the European canning industry, and hence applications for derogation are of concern principally to France, Italy, Spain and Portugal (Elsy 1987).

Health and packaging regulations, tariffs and quotas

Historically, each country within the European Community had an autonomous regulatory authority which determined minimum specifications for tuna products. Most countries had reasonably complex legislation on food regulations covering a wide range of eventualities. Variations in specifications (e.g. acceptable mercury and histamine levels) were common (Elsy 1987). Such variation in requirements imposed considerable cost on exporters who were required to meet different specifications for different markets.

This situation was alleviated somewhat by the adoption of uniform regulations on January 1, 1993. When the harmonisation of existing rules was first proposed, it was believed that the change would bring considerable benefit to exporting nations. Not only would it alleviate the cost of meeting a range of specifications, but it would also prevent traditional European canned tuna producers such as France from imposing considerable nontariff barriers to trade, and thus open these markets to imports.

However, with the introduction of uniform regulations in January 1993, the European Community also imposed a quota on canned tuna imports from non-ACP countries. For 1993, the quota was initially fixed at 74 kt, and later increased to 75 kt. The quota was based on imports of 'true' tuna, i.e. excluding bonito, into each E.C. country during 1990 and 1991. For Germany, the E.C.'s third largest importer in 1991, this has meant a significant reduction in imports, since 80% were bonito.[2]

The introduction of the quota has had an extremely adverse impact upon Asian exporters such as Thailand and the Philippines. Thailand alone supplied more than 74 kt of canned tuna to the European Community in 1991. Both countries were selling at very low prices before the quota was filled earlier this year.

The major beneficiaries of this decision are the canneries in ACP countries, that is, Côte d'Ivoire and Senegal in Africa (most of which are owned and operated by French companies), Seychelles, Fiji, Solomons and Micronesia. Clearly, the quota system has been introduced to protect French interests: on the one hand the quota protects French domestic canneries from competition with cheap Asian imports, and on the other, European countries must buy tuna from French subsidiaries in Côte d'Ivoire and Senegal in order to meet domestic demand.

Recently, the European Commission has requested that Germany and other countries involved in canned bonito imports submit a new record of imports during 1992. If some bonito is reclassified as tuna, thereby requiring importers to pay 24% duty, the quota may be increased by up to 60 kt (Ferdouse 1993).

[2] While importers generally pay 24% duty for canned tuna from non-ACP countries, they pay a lower tariff for canned tuna which is labelled 'bonito'.

Imports

Over the period 1982–91, imports into the European Community increased 240%, from 68.4 kt (94% of European imports) to 232.6 kt (91% of European imports) (Table 22.2). A significant part of the increase occurred in the United Kingdom and Germany, which do not produce canned tuna. During the same period, imports into other western European countries increased 455%, from 4.2kt (6% of European imports) to 23.3 kt (9% of European imports). Total European imports increased 252% during the period, from 72.6 kt to 255.9 kt.

With the imposition of a 75 kt quota on canned tuna from non-ACP countries, it is likely that import levels in 1993 will be significantly below those in 1991. Currently, no canned tuna from non-ACP nations is being imported into the European Community.

In recent years, the main exporters of canned tuna to Europe have been Thailand, which supplied 42% of imports in 1989, Côte d'Ivoire (16%), the Philippines (10%), and Senegal (8%). In 1989, these countries supplied approximately 80% of European canned tuna imports (USITC 1990). However, with the imposition of quotas on non-ACP countries, it is likely that Thailand

Table 22.2 European imports of canned tuna, 1982–91 (kt)

Market	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
E.C.										
United Kingdom	13.3	17.6	24.0	23.8	36.5	34.7	47.6	65.3	48.8	65.3
France	29.8	34.0	32.5	36.8	35.4	46.9	54.8	44.7	52.6	63.2
Germany	14.9	16.1	19.1	19.8	25.4	31.5	28.0	32.0	39.6	46.0
Italy	2.5	3.4	3.5	5.1	6.0	9.6	9.3	10.9	11.5	21.4
Belgium/Luxembourg	4.1	4.8	5.0	5.3	6.2	7.6	7.3	8.5	14.7	13.3
Netherlands	1.4	1.4	2.2	2.0	2.9	4.9	5.7	7.4	8.3	9.1
Denmark	1.2	1.7	2.2	2.3	3.4	3.6	1.0	0.4	3.6	4.1
Spain	0.1	–	0.1	0.4	0.1	0.1	1.7	0.3	0.4	3.7
Greece	1.1	0.9	1.0	1.3	1.2	1.4	1.7	2.1	2.5	2.7
Portugal	–	–	–	–	–	–	0.1	0.1	0.2	2.4
Ireland	–	0.2	0.3	0.4	0.5	1.4	1.1	1.4	1.4	1.4
Total, E.C.	68.4	80.1	89.9	97.2	117.6	141.7	158.3	173.1	183.6	232.6
Other western Europe										
Switzerland	–	–	–	4.0	4.0	5.0	5.9	6.4	6.2	6.9
Finland	1.2	1.5	1.4	1.9	2.6	4.3	4.4	5.0	4.3	5.7
Sweden	3.0	3.2	3.5	3.3	4.3	5.4	4.4	5.3	5.0	5.6
Austria	–	–	–	2.0	2.0	4.0	3.5	4.4	4.6	5.1
Norway	n.a.	n.a.	n.a.	n.a.	1.0	1.0	1.0	1.0	n.a.	n.a.
Total, other										
Western Europe	4.2	4.7	4.9	11.2	13.9	19.7	19.2	22.1	20.1	23.3
Total, Europe	72.6	84.8	94.8	108.4	131.5	161.4	177.5	195.2	203.7	255.9

n.a. not available; – negligible.
Sources: USITC 1990; FAO Globefish Highlights various years.

and the Philippines will decline in dominance, at least in the short term, while Cote d'Ivoire, Senegal, and possibly some south Pacific nations will increase.

Consumption

European consumption of canned tuna increased dramatically during 1982–91, fuelled in particular by increased imports into France, the United Kingdom and Germany, and increased production in Italy, Spain and France, and Portugal (Table 22.3). During the period, European consumption of canned tuna increased 127%, from 198.4 kt to 441.5 kt. Consumption in the Economic Community increased 119%, from 190.6 kt (98% of European consumption) to 418.2 kt (95% of European consumption). The largest net increases in consumption occurred in Italy (55.8 kt), the United Kingdom (52 kt) and France (48.9 kt). Consumption in other western European countries increased 455%, from 4.2 kt to 23.3 kt. The largest net increases occurred in Switzerland (6.9 kt), Austria (5.1 kt) and Finland (4.5 kt).

Table 22.3 European apparent consumption of canned tuna, 1982–91 (kt)

Market	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
E.C.										
Italy	48.5	53.6	60.5	67.8	88.2	87.9	92.2	90.9	93.4	104.3
France	47.8	51.7	54.5	61.9	64.6	76.6	83.0	77.4	84.2	96.7
Spain	54.4	49.6	50.5	50.6	55.3	56.7	57.8	66.0	69.2	73.7
United Kingdom	13.3	17.6	24.0	23.8	36.5	34.7	47.6	65.3	48.8	65.3
Germany	14.3	15.4	18.6	19.0	24.2	29.7	26.7	29.5	36.9	42.2
Belgium/Luxembourg	4.1	4.8	5.0	5.3	6.2	7.6	7.3	8.5	11.9	10.7
Portugal	4.7	3.9	6.2	6.3	9.6	7.8	9.2	9.4	10.7	11.4
Netherlands	1.1	1.1	1.4	1.2	1.7	2.2	2.1	3.4	3.6	5.7
Denmark	1.2	1.7	2.2	2.3	3.4	3.6	1.0	0.4	3.6	4.1
Greece	1.1	0.9	1.0	1.3	1.2	1.4	1.7	2.1	2.5	2.7
Ireland	–	0.2	0.3	0.4	0.5	1.4	1.1	1.4	1.4	1.4
Total, E.C.	190.6	200.6	224.2	240.0	291.4	309.6	329.7	354.3	366.2	418.2
Other western Europe										
Switzerland	–	–	–	4.0	4.0	5.0	5.9	6.4	6.2	6.9
Finland	1.2	1.5	1.4	1.9	2.6	4.3	4.4	5.0	4.3	5.7
Sweden	3.0	3.2	3.5	3.3	4.3	5.4	4.4	5.3	5.0	5.6
Austria	–	–	–	2.0	2.0	4.0	3.5	4.4	4.6	5.1
Norway	n.a.	n.a.	n.a.	n.a.	1.0	1.0	1.0	1.0	n.a.	n.a.
Total, other										
Western Europe	4.2	4.7	4.9	11.2	13.9	19.7	19.2	22.1	20.1	23.3
Total, Europe	194.8	205.3	229.1	251.2	305.3	329.3	348.9	376.4	386.3	441.5

n.a. not available; – negligible.
Source: USTIC 1990; FAO Globefish Highlights various years; Ferdouse 1993.

Using the data contained in Table 22.4 and Table 22.3, estimates of European canned tuna consumption per capita have been made (Table 22.5). During 1982–91, European canned tuna consumption per capita increased 122%, from 0.55 kg to 1.22 kg. Per capita consumption in the European Community increased 112%, from 0.6 kg to 1.27 kg, while per capita consumption in other western European countries increased 454%, from 0.13 kg to 0.72 kg. Hence, canned tuna consumption increases in Europe are the result of both an increasing population of consumers, and increased consumption by individual consumers.

Market description

The European canned tuna market is as diverse as the various countries and peoples that comprise it. While harmonisation of certain import policies has occurred in the European Community, distinctly identifiable preferences and market structures still exist within each European country. In the following paragraphs, a number of individual country markets are described. While the list is not exhaustive, the descriptions provide some insight into the range and diversity within the European canned tuna market.

Table 22.4 Population of western Europe, by area and country, 1982–91 (millions)

Area and country	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
E.C.										
West Germany	61.64	61.42	61.18	61.02	61.05	61.17	61.20	61.99	63.23	64.12
United Kingdom	56.34	56.38	56.49	56.62	56.76	56.93	57.08	57.24	57.41	57.65
Italy	56.64	56.84	57.00	57.13	57.22	57.35	57.44	57.52	57.66	57.05
France	54.48	54.73	54.95	55.17	55.39	55.63	55.87	56.16	56.73	57.05
Spain	37.98	38.17	38.34	38.50	38.67	38.83	39.05	38.89	38.96	39.02
Netherlands	14.31	14.36	14.42	14.48	14.56	14.66	14.76	14.83	14.95	15.07
Greece	9.79	9.85	9.90	9.93	9.90	9.90	9.89	9.88	10.12	10.06
Portugal	9.93	10.01	10.09	10.16	10.21	10.25	10.41	10.47	9.87	9.85
Belgium	9.86	9.86	9.86	9.86	9.91	9.92	9.92	9.85	9.84	9.84
Denmark	5.12	5.11	5.11	5.11	5.12	5.13	5.13	5.13	5.14	5.15
Ireland	3.48	3.51	3.54	3.55	3.54	3.54	3.54	3.51	3.50	3.52
Luxembourg	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.38	0.38	0.38
Total, E.C.	319.94	320.61	321.25	321.90	322.70	323.68	324.66	325.85	327.79	328.76
Other western Europe										
Sweden	8.33	8.33	8.34	8.35	8.37	8.40	8.44	8.49	8.56	8.49
Austria	7.57	7.55	7.55	7.56	7.56	7.58	7.60	7.62	7.79	7.84
Switzerland	6.47	6.48	6.44	6.47	6.50	6.55	6.51	6.65	6.71	6.79
Finland	4.82	4.86	4.88	4.90	4.92	4.93	4.95	4.96	4.99	5.03
Norway	4.11	4.13	4.14	4.15	4.17	4.19	4.20	4.23	4.24	4.26
Total, other										
Western Europe	31.30	31.35	31.35	31.43	31.52	31.65	31.70	31.95	32.29	32.41
Total, Europe	351.24	351.96	352.60	353.33	354.22	355.33	356.36	357.80	360.08	361.17

Source: IMF 1993.

Table 22.5 European per capita consumption of canned tuna, 1982–91 (kg).

Year	European Community	Other western Europe	Total Europe
1982	0.60	0.13	0.55
1983	0.63	0.15	0.58
1984	0.70	0.16	0.65
1985	0.75	0.36	0.71
1986	0.90	0.44	0.86
1987	0.96	0.62	0.93
1988	1.02	0.61	0.98
1989	1.09	0.69	1.05
1990	1.12	0.62	1.07
1991	1.27	0.72	1.22

Italy

Italy is the largest European canned tuna market. It is a mature market, and is supplied by a well established domestic canning industry. As such, Italy has tended to be discounted as a target market by exporting nations in the past (USITC 1990). Over the period 1982–91, consumption of canned tuna in Italy increased 115%, from 48.5 kt to 104.3 kt (Table 22.3).

Italian consumers generally prefer yellowfin tuna in olive oil. As previously noted, 85% of Italian canned tuna is packed in olive oil. A small proportion of skipjack is also sold on the market (Elsy 1987). Canned tuna has traditionally been imported in the form of catering packs, while the retail sector has been entirely supplied by domestic processors (Elsy 1987). Although imports account for a reasonably small proportion of consumption (20.5% in 1991), Italian imports of canned tuna increased twelve fold during 1982–92. Much of the increase was accounted for by Spain and Thailand, although a range of countries contributed. In 1992, the principal sources of Italian canned tuna imports were Spain, which contributed 25% of imports, Thailand (17%), Portugal (12%), Costa Rica (4%), Senegal (4%), and Ecuador (3%) (Table 22.6).

The distribution of canned tuna from processor to retail outlet in Italy is conducted through brokers; a well established system. Regionally advertised (processors' own) brands are predominant in the market. Retail markups on canned tuna are approximately 60%, which is in line with other major European markets, although significantly higher than markup percentages in the United States. High levels of markup in Europe result in part from low product turnover (USITC 1990).

The major barrier to entry in the Italian canned tuna market has historically been the cost involved in penetrating a highly diffuse market, and strong brand loyalties, both on a national and regional level. Brand loyalties are, however, being tested by the increasing cost of domestic canning and hence the increasing price of the domestic (highly diverse) product. The retail industry is moving toward a higher degree of

Table 22.6 Italian imports of canned tuna by source, 1985-92 (kt)

Country	1985	1986	1987	1988	1989	1990	1991	1992
Spain	1.0	1.3	3.5	3.7	5.0	4.8	8.6	7.7
Thailand	–	–	0.4	0.5	0.5	1.1	2.2	5.1
Portugal	2.5	2.1	2.4	2.3	3.1	3.7	4.4	3.5
Costa Rica	–	–	–	–	–	0.1	–	1.3
Senegal	–	–	–	–	–	–	0.5	1.1
Ecuador	–	–	–	–	–	–	0.5	1.0
France	1.3	2.3	2.9	2.5	1.6	n.a.	n.a.	n.a.
Others	–	0.3	0.4	0.3	0.6	1.7	5.1	10.7
Total	5.1	6.0	9.6	9.3	10.9	11.5	21.4	30.4

– negligible; n.a. not available.
Sources: FAO Globefish Highlights various years; Ferdouse 1993.

product homogeneity and hence consumers, who have been accustomed to purchasing high quality, high priced packs, are becoming more disposed to purchase imported canned tuna. Due to the market preference for yellowfin in olive oil, the Italian market is probably not the most promising target for ACP exporters, particularly those in the western Pacific.

France

France is the second largest European canned tuna market. It is a mature European tuna market and, while earlier decades were characterised by a relatively low rate of growth, domestic consumption of canned tuna increased significantly during 1982–91, from 47.8 kt to 96.7 kt (102%) (Table 22.3). Supply patterns are reasonably stable: there is little yearly change in the balance between domestic canning and imports.

Imports of canned tuna into France increased 89% during 1985-92, from 36.8 kt to 69.6 kt (Table 22.7). The major sources of imports are Côte d'Ivoire, which supplied 42% of imports in 1992, Senegal (19%), Madagascar (10%), Seychelles (5%), and Thailand (3%). It is interesting to note that imports from Madagascar increased from zero in 1990 to 10% of total imports in 1992. Imports from Madagascar are presumably supplied by the joint venture cannery managed by Pêche et Froid, Océan Indien, which, as noted, is a joint venture between Malagasy partners and the French group Pêche et Froid.

Tuna is consumed in approximately one-half of all French households; an increasing proportion of young urban households, and also middle and upper income households are consuming canned tuna (Kitson and Hostis 1983). The principal form of tuna pack consumed is lightmeat chunk, which accounts for approximately two-thirds of the market. The flake/hors d'oeuvre pack grew in popularity during the late 1970s and currently accounts for approximately 30% of the market. Demand for whitemeat tuna has declined over recent decades and this product form accounts for approximately 5% of the market. The majority of the canned tuna market in France (over 50%) is accounted for by lightmeat tuna in brine. Tuna packed in oil accounts for less than 10% of the market (Elsy 1987).

The distribution system for canned tuna in France is well established. Tuna processors sell canned tuna to distributors, who in turn sell the product on the retail market. Canned tuna is sold by processors under their own advertised label, the distributor's label, or the house brand of a major retail outlet. Ultimately, most canned tuna is sold to consumers through supermarket outlets, and the dominant form of label is the processor's own brand. Retail markups are currently about 60% (USITC 1990). The industry as a whole provides financial support for generic advertising of canned tuna and public relations/promotional activities (Elsy 1987).

Historically, the French market has been virtually closed to imports from countries other than selected Lomé convention countries, former French colonies and countries in which domestic canneries have French equity interest (principally the Côte d'Ivoire, Senegal and the Seychelles–imports from these countries enter duty free in general).

Table 22.7 French imports of canned tuna by source, 1985–92 (kt)

	1985	1986	1987	1988	1989	1990	1991	1992
Côte d'Ivoire	20.5	18.6	27	32.2	26.3	32.7	37.6	29.3
Senegal	16.1	16.5	19.1	18.1	15.1	13.9	16	13.1
Seychelles	–	–	0.5	4.5	2.7	3.4	2.7	3.4
Thailand	–	–	–	–	–	–	–.6	2.3
Madagascar	–	–	–	–	–	–	2.6	7.2
Others	–0.2	–	–	–	–	–	–	–
Total	36.8	35.4	46.9	54.8	44.7	52.6	63.2	69.6

–negligible.
Sources: FAO Globefish Highlights various years.

While unification of import policies in 1993 was expected to remove existing barriers to trade, French lobbying has in effect extended domestic barriers to the entire European Community. Not only are imports into Europe from non-ACP countries considerably restricted, European importers must also buy tuna from canneries with French equity interest in order to avoid tariffs.

While in theory the French market is no less accessible than any other, it would be advisable for canneries in the western Pacific to focus their marketing attention elsewhere.

United Kingdom

Although a relatively new market for canned tuna, the United Kingdom has proved to be the most dynamic European tuna market in recent years. Canned tuna has become increasingly popular among younger consumers, and during the early 1980s displaced canned salmon as the preferred canned seafood item.

The U.K. canned tuna market has been characterised by a high rate of growth since the mid 1970s. All canned tuna is imported, and hence consumption and import figures are the same. Over the period 1982–92, consumption of canned tuna increased 440%, from 13.3 kt to 71.8 kt (Tables 22.3 and 22.8). The United Kingdom is currently the dominant canned tuna importer in Europe, accounting for 26% of total European canned tuna imports in 1991 (Table 22.2). The principal supplier to the U.K. market is Thailand, which contributed 51% of total imports in 1992. Other significant contributors were Philippines (10%), Mauritius (7%), Solomon Islands (7%), Maldives (7%), Fiji (5%), Indonesia (3%), and Côte d'Ivoire (3%) (Table 22.8).

Consumers in the United Kingdom historically exhibited a preference for solid, oil-packed, lightmeat tuna (principally skipjack). During the 1980s however, consumer preference shifted toward chunk style, lightmeat tuna packed in brine (USITC 1990). This shift in preferences reflects consumer responses to rising prices (solid pack to chunk pack), and increasing sensitivity to the negative health implications of high calorie foods (oil pack to brine pack) (USITC 1990).

Canned tuna has traditionally been marketed to retail outlets by distributors who own nationally recognised brands. In the past, most distributors preferred to import canned tuna through Japanese trading companies as insurance against defective and poor quality packs. However, as the U.K. market became increasingly price competitive, distributors began dealing directly with foreign suppliers, and in particular those based in Thailand. In consequence, competition between brands is increasing, with retail house brands challenging the dominance of established distributor brands (USITC 1990).

Table 22.8 U.K. imports of canned tuna, by source, 1985–92 (kt)

	1985	1986	1987	1988	1989	1990	1991	1992
Thailand	4.4	15.8	19.8	27.9	38.4	22.5	36.6	36.7
Philippines	2.9	2.4	2.1	3.4	4.6	3.8	7.0	7.1
Mauritius	3.0	3.2	2.4	3.1	3.7	2.3	4.1	5.3
Solomon Islands	n.a.	n.a.	1.4	1.0	n.a.	3.9	4.1	5.0
Maldives	–	–	0.8	1.4	3.0	3.6	4.2	4.9
Fiji	2.5	4.4	4.1	5.2	6.5	6.1	5.8	3.6
Indonesia	–	0.1	0.4	1.2	2.5	3.5	2.1	2.3
Côte d'Ivoire	3.5	3.2	2.4	3.1	2.8	0.8	1.4	2.3
Others	7.5	7.4	1.3	1.3	3.8	2.3	–	4.6
Total	23.8	36.5	34.7	47.6	65.3	48.8	65.3	71.8

n.a. not available; – negligible.

Sources: Globefish Highlights various years.

John West Foods is the acknowledged brand leader in the United Kingdom, and accounts for approximately 35% of the market. House brands, in particular Sainsbury, have assisted the development of market share, and this development is likely to continue as Sainsbury embarks on an aggressive store building program outside its traditional stronghold in the south of England (Elsy 1987). John West Foods has launched two new product ranges onto the U.K. market; tuna salads are a new addition to the fast growing value added sector of the market, while TugBoats are the first ever canned tuna-based meals for young children. The tuna salad range comprises four products which have been developed specifically for the U.K. market: tuna salad with sweetcorn, potato and peppers in yoghurt dressing; tuna salad in a Mediterranean tomato and herb dressing; tuna salad in a three bean and vinaigrette dressing; and tuna salad in a mild curry dressing.

Retail markups on canned tuna in the United Kingdom currently range between 40% and 50%, depending on the type of pack (USITC 1990).

Traditionally, the United Kingdom has been the most open European market, particularly for Pacific island tuna producers (Elsy 1987). As there are no domestic tuna harvesting or canning industries in the United Kingdom, and consumer demand for canned tuna is increasing, it seems likely that the United Kingdom will remain more accessible than most other European markets, despite the newly introduced quotas and uniform legislation.

Germany

The German canned tuna market is a nonmature market and, like the U.K. market, has experienced considerable growth in the past decade. Apparent consumption of canned tuna increased 195% during 1982–91, from 14.3 kt to 42.2 kt (Table 22.3). While there is no domestic tuna industry, a small proportion of imports are re-exported, and hence import figures (Table 22.2) are slightly larger than apparent consumption figures.

German canned tuna consumers are the most price conscious in Europe, and this characteristic has had a major impact upon the development of the market through time. German consumers do not exhibit any significant brand loyalty, and no efforts are made by distributors to develop such loyalty other than through constant downward pressure on prices. In consequence, there have been significant shifts in canned tuna sourcing over time (USITC 1990).

In 1971, Japan was the dominant source of canned tuna imports, accounting for 81% of the market. By 1980, market dominance had shifted to Taiwan, which accounted for 61% of the market. Within four years, Taiwanese dominance was superseded by Thailand, which accounted for 55% of the market, and the Philippines, which accounted for 19%. Thailand and the Philippines continue to be the principal sources of canned tuna. In 1991, Thailand accounted for 42% of imports, while the Philippines accounted for 30% (Table 22.9). Smaller quantities of canned tuna are imported from Indonesia, Belgium, Côte d'Ivoire and Maldives.

Eighty per cent of canned tuna imports are labelled bonito, tariff levels for which are lower than for tuna. Due to the introduction of quotas based on imports of 'true' tuna, there is pressure on German importers to reclassify their imports as tuna, and pressure on Thai and Filipino canners to relabel their product as skipjack.

The West German market has traditionally been dominated by flake and tuna-and-vegetable packs. These are lower in price than alternative pack types, and in the mid-1980s accounted for approximately 40% of the market (Elsy 1987). In recent years, however, the market has shifted toward solid and chunk packs, due to price declines for these packs.

House brands and brokers brands dominate the German market. As noted, brand loyalty is not a signifi-

Table 22.9 German imports of canned tuna, by source, 1989–91 (kt)

	1989	1990	1991
Thailand	14.15	17.74	19.44
Philippines	11.74	11.35	13.65
Indonesia	1.43	2.35	3.90
Belgium	0.01	2.77	2.60
Côte d'Ivoire	0.07	0.01	1.65
Maldives	0.71	0.98	0.87
Other	3.83	4.38	3.92
Total	31.94	39.58	46.04

Sources: FAO 1991; Ferdouse 1993.

cant characteristic of the West German market and, in consequence, available brands may change in relation to changing market dominance among competing exporters (USITC 1990).

Currently, retail markups on canned tuna in the West German market range between 30% and 60%, depending on the pack type (USITC 1990).

Due to the newly introduced quotas, accessibility to the German market has been severely curtailed, since bonito imports were excluded in the calculation of the quota. While this problem may be lessened by the reclassification of bonito as skipjack, this will entail a higher duty on imports and hence a higher price for canned tuna. In the short to mid-term, this may provide an excellent opportunity for ACP exporters to establish a stronger market share.

Belgium and Luxembourg

In the market description which follows, Belgium and Luxembourg are considered as one market, because of their economic union.

Volume growth in the Belgium/Luxembourg market has been below that of countries described in the previous paragraphs. During 1982–91, apparent consumption of canned tuna increased 161%, from 4.1 kt to 10.7 kt (Table 22.3). Since the late 1980s, some canned tuna imports have been re-exported to Germany, and hence import levels in these years are slightly higher than apparent consumption levels. France and Italy are the traditional suppliers of canned tuna, each accounting for between 10 and 20% of the market.

Traditionally, the Belgium/Luxembourg market has been a high value market, solid pack yellowfin being the dominant pack type. Recently however, solid pack dominance has given way to the less expensive chunk pack. Tuna packed in brine is also growing in market share for reasons of both health and price. The retail food market is highly concentrated, and consequently house brands dominate the market (Elsy 1987).

The Belgium/Luxembourg market is supplied by a wide range of countries, and as such is considered to be readily accessible. Buyers, however, maintain conservative tendencies and in general prefer to purchase high value packs from European sources. Given that suppliers maintain high quality standards in their exports, Belgium/Luxembourg buyers can be considered more consistent price takers than those elsewhere in Europe (Elsy 1987).

Other European markets

The Netherlands is a nonmature market for canned tuna, which in previous decades was characterised by instability. However, in recent years the market appears to have stabilised, and apparent consumption increased steadily during 1982-91, from 1.1 kt to 5.7 kt.

While the Netherlands canned tuna market is highly accessible in terms of structure, it is not a high value market and tends to be highly price competitive. Hence the market is likely to be most accessible to ACP exporters during the current decade.

The Swedish tuna market has in recent years traded down in terms of pack quality. During 1982–91, apparent consumption increased 87%, from 3 kt to 5.6 kt (Table 22.3). About 60% of imports in the latter part of the period originated in Thailand and the Philippines (Elsy 1987).

The market is dominated by chunk, lightmeat packs, and in recent years water packs have gained popularity over oil packs. While whitemeat accounted for approximately 20% of the market in 1980, this market share is thought to have been significantly reduced in recent years (Elsy 1987).

The Swedish canned tuna market is considered to be relatively accessible, and, due to a high level of concentration in the retail sector, relatively inexpensive to penetrate. An agency of the Swedish government (Impod), has been established to assist developing countries to introduce their produce onto the Swedish market (Elsy 1987). Hence, Sweden is probably a feasible target for ACP exporters.

Switzerland is considered to be the highest quality canned tuna market in Europe. Import levels remained reasonably stable during the early 1980s, the only major change in the market being the structure of supply: Japan was superseded by Thailand as the principal supplier. In consequence, there has been a small increase in the proportion of skipjack chunks on the market. This is not however indicative of a significant trend toward trading down in the market (Elsy 1987). During 1985-91, imports increased from 4000 t to 6900 t. The Swiss tuna market is considered to be readily accessible, provided that imports are of the highest quality (Elsy 1987).

References

ABARE 1988. Japanese Agricultural Policies–a Time of Change. Canberra, Australian Bureau of Agricultural and Resource Economics.

Anderson, David. 1989. Enforcement issues in selecting fisheries management policy. Marine Resource Economics 6, 261–277.

--1988. Conceptual Constructs for Practical ITQ Management Policies. Conference on the Scientific Foundations for Rights Based Fishing, Reyjavik, Iceland, June 27–July 1.

Ando, A. and Auerbach, A. 1990. The Cost of Capital in Japan: Recent Evidence and Further Results. NBER Working Paper No. 3371.

Attard, D.J. 1987. The Exclusive Economic Zone in International Law. Clarendon Press, Oxford.

Ayu, R. 1993. The fish cannery myth in Papua New Guinea: a story of many failures. Papua New Guinea Business, January, 5, 29.

Baron, M. 1989. Techniques Employed by the Japanese in the Longline Fishery. Canberra, Bureau of Rural Resources, Occasional Paper.

Batschelet, E. 1981. Circular statistics in biology. In: R. Gibson and J. Cohen ed., Mathematics in Biology, Academic Press, New York.

Beach, C.M. and Mackinnon, J.G. 1978. A maximum likelihood procedure for regression with autocorrelated errors. Econometrica 46, 2–9.

--1979. Maximum likelihood estimation of singular equation systems with autoregressive disturbances. International Economic Review 20(2), 459–64 .

Bergin, L. 1988. Fisheries surveillance in the south Pacific. Ocean shoreline and management 11, 467–491.

Beverton, R. and Holt, S. 1957. On the Dynamics of Exploited Fish Populations. London Ministry of Agriculture, Fisheries and Food, Fisheries Investigations Series.

Bockstael, N.E. and Opaluch, J.J. 1983. Discrete modelling of behavioural response under uncertainty: the case of the fishery. Journal of Environmental Economics and Management 10, 125–137.

Brown, D. and Dann, T. 1991. Japanese Access to the Australian Fishing Zone. Canberra, Australian Bureau of Agricultural and Resource Economics.

Brown, J. and Waugh, G. 1989. Models as modes of action: frameworks and strategies for the development of fisheries in the south Pacific. In: H. Campbell, K. Menz and G. Waugh, ed., Economics of Fisheries Management in the South Pacific Region. Canberra, Australian Centre for International Agricultural Research, 159–166.

Burke, W. 1984. 1982 Convention on the Law of the Sea: provisions on conditions of access to fisheries subject to national jurisdiction. Report of the Expert Consultation on the Conditions of Access to the Fish Resource of the Exclusive Economic Zones. Rome, FAO Fisheries Report No. 293, 174–195.

Campbell, H.F. 1989. Resource rent rivalry in the western Pacific tuna fishery: cooperative and non-cooperative solutions. Ocean and Shoreline Management 12(2), 179–187.

Campbell, H.F. and Nicholl, R.B. 1990. The Cost of Fishing Effort and Profitability for the Japanese Tuna Fleet: 1979 to 1989. Canberra, ACIAR Project 8928, Research Report 1990/1.

Campbell, H.F., Landu, H. and Nicholl, R.B. 1993. Korean and Taiwanese Purse Seine Fleet Growth in Papua New Guinea: An Analysis of Catch Rates and Levels of Fishing Effort. Kensington, Centre for Applied Economic Research, University of New South Wales, Tuna Research Programme: Research Report 1993/13.

Campbell, H.F. , Menz, K. and Waugh, G. ed., 1989. Economics of Fisheries Management in the South Pacific Region. Canberra, Australian Centre for International Agricultural Research.

--1992a. The Cost of Fishing Effort and Profitability for the Japanese Tuna Fleet (Supplement for the Fiscal Years 1983–84 and 1985–86). Canberra, ACIAR Project No. 8928, Research Report 92/5.

--1992b. The Economics of Yellowfin Tuna Targeting by Japanese and American Purse Seine Vessels. Canberra, ACIAR, Project No. 8928, Research Report 1992–96.

-- 1992c. Multispecies Longline Tuna Fishery Production in Papua New Guinea: An Economic Analysis. Canberra, ACIAR Project 8928, Report 1992/9, pp.40.

--1992d. The Purse Seine/Longline Yellowfin Tuna Interaction: An Economic Analysis for Papua New Guinea.

Canberra, ACIAR Project No. 8928, Research Report 1992/11.

--1992e. Tuna Fishery rents in Papua New Guinea; the cost and returns of the Japanese fleets–1983 to 1987, ACIAR Project No. 8928, Research Report 1992/9.

Caton, A.E. and Ward, P.J. 1989. A Brief History of Japanese Longline Activities, With Particular Reference to Restraints on Operations in Eastern Australian Waters. Canberra, Bureau of Rural Resources, Department of Primary Industries and Energy.

Chen, Lung-Chu 1989. An Introduction to Contemporary International Law: A Policy Oriented Perspective. New York, Yale University Press.

Churchill, R.R. and Lowe, A.V. 1983. The Law of the Sea, Manchester. Manchester University Press.

Clark, C.W. and Kirkwood, G. 1979. Bioeconomic model of the Gulf of Carpentaria Prawn fishery. Journal of Fisheries Research Board Canada. Vol. 36, 1304–1312.

Comitini, S. and Huang, S. 1971; Licensing and Efficiency: An Empirical Study of the Japanese Tuna Fishing Industry. Malayan Economic Review 16 (1), 76–83.

Connell, J. 1983. Papua New Guinea democracy, development and the future. Current Affairs Bulletin, August, 15–23.

Connell, J. 1989. Democracy, Development and the Future. Current Affairs Bulletin, August, 15–23.

Copes, P. 1980. Rational resource management and institutional constraints: the case of the fishery. In: J.A. Butlin ed., Economics and Resource Policy. London, England, Longman, 113–128.

--1981. The Impact of UNCLOS III on management of the world's fisheries. Marine Policy. 5(3), 217–228.

--1982. Development and Management of Papua New Guinea's Marine Fish Resources. Port Moresby, Institute of National Affairs. Republished by the Department of Primary Industry, Fisheries Division.

--1986. A critical review of the individual quota as a device in fisheries management. Land Economics 36(7), 278–291.

--1987. Tuna fisheries management in the Pacific islands region. In: D. Doulman, D., ed., Tuna Issues and Perspectives in the Pacific Islands Region, Honolulu, East–West Center, Pacific Islands Development Program, 3–26.

--1992. Development and Management of Papua New Guinea's Marine Fish Resources. Port Moresby Institute of National Affairs.

Davidson, R. and MacKinnon, J.G. 1981. Several tests for model specification in the presence of alternative hypotheses, Econometrica 49, 781–793.

Doulman, D. 1980. Development of Papua New Guinea Industrial Fisheries: What Benefits for National Fishermen? Fifth International Congress on Rural Sociology, Mexico City, 7–13 August 1980.

--1986a. Fishing for tuna: the operation of distant water fleets in the Pacific islands region. Honolulu, East-West Center, Pacific Islands Development Program.

--1986b. Licensing Distant-water Tuna Vessels: The Experience of Papua New Guinea. Honolulu, East–West Center, Pacific Islands Development Program, Multinational Corporations in the Pacific Tuna Industry Project.

--1987a. Development and expansion of the tuna purse seine fishery. In: D. Doulman ed., Tuna Issues and Perspectives in the Pacific Islands Region. Honolulu, East–West Center, Pacific Islands Development Program.

--1987b Fisheries cooperation: the case of the Nauru group. In: D. Doulman ed., Tuna Issues and Perspectives in the Pacific Islands Region. Honolulu, East-West Center, Pacific Islands Development Program.

--1987c. Licensing distant-water tuna fleets in Papua New Guinea. Marine Policy 11(1), 16–28.

--ed. 1987d. Tuna Issues and Perspectives In the Pacific Island Region. Honolulu, East-west Center, Pacific Islands Development Program.

--1990. Japanese distant water fishing in the South Pacific. Pacific Economic Bulletin, 4,2, 22-28.

Doulman, D. and Kuk, R. 1986. Papua New Guinea fisheries and their administration. Infofish Marketing Digest 6, 36–39.

Doulman, D. and Wright, A. 1983. Recent development in Papua New Guinea tuna fisheries. Marine Fisheries Review 45, 47–59.

Elsy, R. 1987. The European and Middle East tuna market: a view from the Pacific islands. In D. Doulman ed., The Development of the Tuna Industry in the Pacific Islands Region: An Analysis of Options. Honolulu, East–West Center, 91–105.

FAO (Food and Agricultural Organisation) various years. Globefish Highlights. Rome, FAO.

--1986. INFOFISH. Rome, FAO.

--1988. Tuna Factory Coming Up. Kuala Lumpur, INFOFISH. May, 9.

--1989. INFOFISH Trade News. No. 11/89. June.

--1991. FAO Fishery Statistics 1991. FAO, Rome.

--1992. EEC Markets for Value-Added Products From Developing Countries. GLOBEFISH Research Programme. Vol 16. Rome, FAO.

Ferdouse, F. 1993. A Market Update on Tuna. INFOFISH International 5/93, 15–18.

FFA (Forum Fisheries Agency) 1985. The Purse Seine financial appraisal model. Solomon Islands, FFA Report No. 85/27.

--1986. Analysis of the Japanese fishery in Papua New Guinea in 1985: the alternative fee model. Honiara, South Pacific FFA Report No. 86/36.

--1989a. Distant-Water Fishing Nations' Activities in Papua New Guinea's exclusive economic zone 1984–1988. Confidential Report to the Government of Papua New Guinea, Solomon Islands, South Pacific FFA Report No. 89/02.

--1989b. Performance of the Japanese Fleet in Papua New Guinea's exclusive economic zone 1984 to March 1987. Solomon Islands, South Pacific FFA No. 89/09.

FFC (Forum Fisheries Committee) 1990. Eighteenth Meeting. Fourth Technical Subcommittee Meeting, Honiara, April 1990.

Fiji 1981. Eighth Development Plan 1981. Suva, Bureau of Statistics.

Fiji Fisheries Division 1991. Annual Report. Suva, Ministry of Primary Industries.

Fonteneau, A. 1986. Competition Between Tuna Fisheries: A Critical Review Based on Atlantic Examples. Colombo, TWS/86/36, IPTP.

Franklin, P. and Kitson, G. 1982. Sashimi–The Japanese Market. INFOFISH Marketing Digest. (5):16-22.

Fujinami, N. 1986a. Tuna Fisheries Development in Japan. A paper presented to the INFOFISH Tuna Trade Conference, Bangkok, February 29, 1986. Cited in (USITC 1986).

--1986b. Option for the Future–Option for Distant Water Countries, Japan. Tuna Workshop on Options for Cooperation in the Development and Management of Global Tuna Fisheries, Vancouver, 29 June–3 July 1986.

Geen, G. 1990. The Value to Japan of Access to the Australian Fishing Zone. Canberra, Australian Bureau of Agricultural and Resource Economics.

Gibson, D.J.M. 1981. A Handbook on Processing Southern Bluefin Tuna for the Fresh Chilled Sashimi Market in Japan. Wellington, New Zealand Ministry of Agriculture and Fisheries.

--1984. Southern Bluefin Tuna for the Sashimi Market. Wellington, New Zealand Ministry of Agriculture and Fisheries.

Gillet R. 1986. Observations on Two Japanese Purse Seining Operations in the Equatorial Pacific. Noumea, SPC, Tuna and Billfish Assessment Programme Technical Report No. 16, New Caledonia.

Grandperrin, M. 1978. Importance of reefs to ocean production. South Pacific Fisheries Newsletter, No. 16.

Gujarati, D. 1988; Basic Econometrics (2nd edition). McGraw-Hill International Editions.

Gulland, J.A. 1969. Manual of Methods for Fish Stock Assessment. Part 1. Fish Population Analysis. Rome, FAO.

Hilborn, R. and Ledbetter, M. 1979, Analysis of the British Columbia salmon purse-seine fleet: dynamics of movement. Journal of the Fisheries Research Board of Canada 36, 384–391.

Hilborn, R. and Sibert, J. 1988. Is international management of tuna necessary? Marine Policy 12(1), 31-39.

Hu, T. 1985. Analysis of Seafood Consumption in the U.S.: 1970, 1974, 1978, 1981. NMFS. September 30. Cited in (USITC 1990).

Hutton, G. 1984. Tuna Purse Seining Technology in the Western Pacific. Workshop on National Tuna Fishing Operations (Forum Fisheries Agency). Tarawa, Kiribati, 28 May–2 June 1984.

Iizuka, M. and Watanabe, Y. 1983. Present status and problems in the southern water purse-seine fishery. In: Japan Marine Fishery Resource Centre, Tuna Fishery Research Conference February 1983. In Japanese.

Ikematsu, M. 1984. Change of distribution mechanism on tuna in Japan. In: International Institute of Fisheries Economics and Trade, Proceedings of the Second Conference of the International Institute of Fisheries Economics and Trade, Volume 1, Economic Recovery, Fisheries Economics and Seafood Trade. Christchurch, New Zealand. August 20–23, 111–25.

International Monetary Fund (IMF) 1993. International Financial Statistics Vol. XLVI, No.6. Washington D.C., IMF.

IUCN, 1982. Legal measures for the conservation of marine mammals. IUCN Environmental Policy and Law Paper No. 19.

Japan External Trade Organisation 1984. Access to Japan's Import Market–Frozen Fish. Tokyo, Japan External Trade Organisation.

--1985. Trade in Agriculture, Forestry, and Fishery Products 1985. Tokyo, Japan External Trade Organisation

Japan Fisheries Association 1987. Fisheries of Japan. Tokyo, Japan Fisheries Association.

Japan Tuna 1992. Monthly average market price of tuna at Yaizu fish market. Tokyo, Japan tuna.

Japan, Ministry of Agriculture, Forestry and Fisheries 1988. Fisheries Statistics of Japan. Tokyo, Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries.

--1989. Fishery Economy Research Report. Tokyo, Ministry of Agriculture, Forestry and Fisheries.

--various years. Statistical Yearbook of the Ministry of Agriculture, Forestry and Fisheries. Tokyo, Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries.

Johannes, R. 1989. Managing small-scale fisheries in Oceania: unusual constraints and opportunities. In.: H. Campbell, K. Menz and G. Waugh, ed., Economics of Fisheries Management in the South Pacific Region. Canberra, Australian Centre for International Agricultural Research, 85–93.

Joseph, J. 1991. The conservation ethic and its impact on tuna fisheries. In: H. de Saram, Tuna Bali: Papers of the Second World Tuna Conference. Infofish, Kuala Lumpur.

Judge, G.G., Griffiths, W.E., Hill R.C., Lutkepohl, H. and Lee T.C. 1988. Introduction to the Theory and Practice of Econometrics. Wiley, South Australia.

Kearney, R.E. 1978. Some Hypotheses on Skipjack (*Katsuwonus pelamis*) in the Pacific Ocean. Noumea, South Pacific Commission, Occasional Paper, No. 7.

Kearney, R.E. 1981. A Brief Review of the State of the Stocks of Highly Migratory Species of Fish in the Central and Western Pacific. Noumea, South Pacific Commission.

Kearney, R.E. 1982. Development management key issues in fisheries for Pacific island nations. Australian Fisheries 41(8), 6–11.

Kearney, R.E. 1989. The tuna resource base in the Pacific. In: H. Campbell, K. Menz and G. Waugh, ed., Economics of Fishery Management in the Pacific Islands Region. Canberra, ACIAR Proceedings No. 26, 37–40.

King, Denis M. 1986. The U.S. Tuna Market: A Pacific Island Perspective. Honolulu, East-west Center, Pacific Islands Development Programme.

Kirkley, J.E. 1986. The Relationship Between Management and the Technology in a Multi-Species Fishery: The New England, Georges Bank, Multi-Species Fishery. Maryland, PhD Thesis, University of Maryland.

Kirkley, J.E. and Strand, I.E. 1988. The technology and management of multi-species fisheries. Applied Economics 20, 1279–1302.

Kitson, G. and Hustis, D.L. 1983. The Tuna Market. INFOFISH Market Studies. Vol. 2. Kuala Lumpur. Cited in (USITC 1990).

Kleiber P., Argue A.W. and Kearney R.E. 1983. Assessment of Skipjack (*Katsuwonus pelamis*) Resources in the Central and Western Pacific by Estimating Standing Stock and Components of Population Turnover from Tagging Data. Noumea, SPC, Tuna and Billfish Assessment Programme, Technical Report No. 8.

Kleiber P., Argue A.W. and Kearney R.E. 1987. Assessment of Pacific skipjack tuna (*Katsuwonus pelamis*) resources by estimating standing stock and components of population turnover from tagging data. Can. J. Fish. Aquat. Sci. Vol. 44, 1122–1134.

Kuk, R. 1991. Recent Developments in the Papua New Guinea Tuna Fisheries, Canberra, ACIAR Project No. 8928, Research Report 1991/4.

Kwiatkowska, Barbara. 1989. The 200 Mile Exclusive Economic Zone in the New LOS. Netherlands, Publications on Ocean Development, Martinus Nijoff Publishers.

Lent, R.J. and Johnston, R.S. 1984. The marketing of Pacific north-west salmon. INFOFISH Marketing Digest, No. 3/84: 26–29.

Lindner, R.K., Campbell H.F. and Bevin G.F. 1992. Rent generation during the transition to a managed fishery: the case of the New Zealand ITQ system. Marine Resource Economics 7(4).

Lodge, Michael. 1992. Minimum terms and conditions of access. Marine Policy 16(3), 277–305.

Mangel, M. and Clark, C.W. 1983, Uncertainty, search and information in fisheries. J. Cons. Int. Explor. Mer, Vol. 41, 93–103.

Mardia, K.V. 1972. Statistics of Directional Data, Probability and Mathematical Statistics–a series of Monographs and Textbooks, Birnbaum, Z.W. and Lukas. E., ed. London, Academic Press.

Matane, Paulias 1983. The case for a new Pacific order. Papua New Guinea Foreign Affairs Review 3(1), 19.

Matsuda, Y. and Ouchi, K. 1984. Legal, political, and economic constraints on Japanese strategies for distant water tuna and skipjack fisheries in Southeast Asian seas and the western central Pacific. Tokyo, East-West Environmental and Policy Institute, Reprint No. 89.

McCullagh, P. and Nelder, J.A. 1983. Generalised Linear Models. London, Chapman and Hall.

McFadden, D. 1978. Cost, revenue and profit functions. In: M. Fuss and D. McFadden ed., Production Economics: A Dual Approach to Theory and Application, Vol I. Amsterdam, North-Holland.

McIlgorm, A. 1989. Australian tuna fleet in the western Pacific: implications for industry and fisheries management. In: H. Campbell, K. Menz and G. Waugh, ed., Economics of Fishery Management in the Pacific Islands Region. Canberra, ACIAR Proceedings No. 26. ACIAR, 135–147.

McKenna, C.J. 1990. The theory of search in labour markets. In: D. Sapsford and Z. Tzannatos ed., Current Issues in Labour Economics. Hong Kong, MacMillan.

McRae, Donald and Munro, Gordon 1987. Coastal state 'rights' within the 200-mile exclusive economic zone. In: Philip A. Nebe, Ragnar Arnason and Nina Mollett, ed., Rights Based Fishing. Dordrecht, Kluwer Academic Publishers.

Medley, P.A.H. 1989. Interaction Between Longline and Purse Seine in the South-West Pacific Tuna Fishery. London, PhD Thesis, Center for Environmental Technology, Imperial College of Science, Technology and Medicine.

--1991a. Estimating the Impact of Purse Seine Catches on Longline, expert Consultation on Interaction of Pacific Ocean Tuna Fisheries, FAO, October, 18.

--1991b. Western Pacific Tuna Fisheries: Economic and Resource Issues Relating to Tuna Fisheries Interactions. Solomon Islands Forum Fisheries Agency, unpublished report.

Mfodwo, Kwame and Tsamenyi, B. Martin 1992. Enforcement of Marine Fisheries Law and Regulations: A Case Study of PNS in International and Comparative Perspective. Canberra, ACIAR Project No. 8928.

Moret-Smith, E. 1982. Exporting to Japan (Part 2). Seafood America. (September/October), 16–35.

Munro, G. 1979. The optimal management of transboundary renewable resources. Canadian Journal of Economics 12(3), 355–376.

--1984. Foreign access to EEZ's and the derivation of coastal benefits: methods and techniques. Report of the Expert Consultation on the Conditions of Access to the Fish Resource of the Exclusive Economic Zones. Rome, FAO Fisheries Report No. 293, 143–151.

--1985. Coastal states, distant water fleets and EFJ: some long-run considerations. Marine Policy 9, 2–15.

Nakai, A. 1984. Consumption and distribution of tuna. In: The 7th Tokyo Fisheries College Open Lectures, 1984. Tuna–From Production to Consumption. Tokyo Fisheries College. Tokyo. (In Japanese).

Namaliu, Rabbie 1983. Papua New Guinea signs LOSC. Papua New Guinea Foreign Affairs Review 3(1), 15–16.

Narasaki, O. 1990. Structure of DFWN Purse Seine Fleets and their Production Volumes. In: R. Herr ed., The Forum Fisheries Agency–Achievements, Challenges and Prospects. Fiji, University of the South Pacific.

Owen, A.D. 1990. Exchange Rate Fluctuation and Comparative Competitive Advantage. Tuna Research Programme: Research Report 1990/2. Kensington, Centre for Applied Economic Research, University of New South Wales.

Owen, A.D. and Troedson, D.A. 1993a. The European Market for Tuna. Kensington, Centre for Applied Economic Research, University of New South Wales, Tuna Research Programme, Research Report 1993/16.

--1993b. Modelling Tuna Prices in Japan: a Vector-Autoregressive Approach. Kensington, Centre for Applied Economic Research, University of New South Wales. Tuna Research Programme: Research Report 1993/17.

Papua New Guinea, Department of Fisheries and Marine Resources 1989. Fisheries Sector Review. Port Moresby, Department of Fisheries and Marine Resources.

Parks, R. 1970. Price responsiveness of factor utilization in Swedish manufacturing. Review of Econometrics and Statistics 53, 129–139.

Payne, D.A. 1981. The Japanese Market for Chilled and Frozen Southern Bluefin Tuna. Winston Churchill Fellowship Marketing Study. Wellington, New Zealand Fishing Industry Board.

Pearse, P.H. 1979. Property Rights and Regulations of Commercial Fisheries. Vancouver, Department of Economics, University of British Columbia, Resource Paper No. 42.

--1980a. Fishing Rights, Regulations and Revenues. Paper presented for Seminar on Economic Aspects of Limited Entry and Associated Fisheries Management Measures, Melbourne, 6–8 February 1980.

--1980b. Property rights and the regulation of commercial fisheries. Journal of Business Administration 11, 185–209.

Petit, N. 1984. Fishing by tuna seiners in the tropical western Pacific. La Peche Maritime (November): 622–628. Washington D.C., South-West Fisheries Centre Translation No. 99. National Oceanic and Atmospheric Administration, United States Department of Commerce.

Rowly, M. 1983. Guide to handling chilled fresh tuna for export to Japan. Australian Fisheries 42(3) 20–22.

Ruddle, K. 1989. Traditional sole property rights and modern inshore fisheries management in the Pacific basin. In: H. Campbell, K. Menz and G. Waugh, ed., Economics of Fisheries Management in the Pacific Islands Region. Canberra, Australian Centre for International Agricultural Research, 68–77.

Scott, Anthony 1955. The fishery: the objective of sole ownership. Journal of Political Economy 63, 116–124.

Seafood International 1990. Canning Changes in France. Seafood International, September, 61.

Shinjuku Marine Products Company (*Suisansha Shinjuku*) 1985. Marine Products Yearbook. Tokyo, Shinjuku Marine Products Company. (In Japanese).

Sibert, J.R., Kearney, R.E. and Lawson, T.A. 1983. Variation in Growth Increments of Tagged Skipjack (*Katsuwonus pelamis*). Noumea, SPC, Tuna and Billfish Assessment Programme Technical Report No. 10.

Solomon Islands 1980. Solomon Islands Development Plan 1980. Honiara Statistics Office.

SPC (South Pacific Commission) 1988a. Papua New Guinea Country Report, 1987. Noumea, SPC, Tuna and Billfish Assessment Programme.

--1988b. Methods of Studying Fishery Interaction. Paper Prepared by South Pacific Commission for Twentieth Regional Technical Meeting on Fisheries. Noumea, 1–5 August 1988, SPC/Fisheries 20/Information Paper 5.

--1989. Regional Tuna Bulletin, First Quarter. Noumea, SPC, Tuna and Billfish Assessment Programme.

--1990a. Regional Tuna Bulletin, First Quarter. Noumea, SPC, Tuna and Billfish Assessment Programme.

--1990b. Stock Status of Skipjack in the Western Tropical Pacific. Noumea, SPC, Tuna and Billfish Assessment Programme, Working Paper No. 11.

--1990c. Tuna Tagging and Observations on a Japanese Group Purse Seine Vessel. Noumea, SPC, Tuna and Billfish Assessment Programme, Technical Report No. 23.

--1991a. Status of Tuna Fisheries in the SPC Area During 1990, With Annual Catches Since 1952. Noumea, SPC, Tuna and Billfish Assessment Programme, Working Paper No.3.

--1991b. Third South Pacific Albacore Research Workshop. Noumea, SPC, 9–12 October 1990.

--1992a. Regional Tuna Bulletin, First Quarter. Noumea, SPC, Tuna and Billfish Assessment Programme.

--1992b. South Pacific Albacore Observer Programme Summary Report, 1988–1991. Tuna and Billfish Assessment Programme, Technical Report No. 26.

Squires, D. and Kirkley, J. 1991. Production quota in multiproduct Pacific fisheries. Journal of Environmental Economics and Management 21, 109–126.

Stokke, O.S. 1990. Will the Sun Finally Set? Japan's Long Distance Fishing Strategy. Norway, The Fridtjof Nansen Institute.

Suda, A. 1972. Possible problems involved in the regulation of tuna longline fishery. In: OECD, Economic Aspects of Fish Production. Paris, OECD, 272–308.

Suzuki, T. 1983. Taste of Fish. Science of Seafood. Tokyo, Kyoritsu Publishing Company. (In Japanese).

Suzuki, Z. 1986. Interaction Study on Yellowfin stock Between Longline and Purse Seine Fisheries in the Western Pacific Ocean. IPTP Collective Volume of working Documents, 175-190.

--1988. Study of interaction between longline and purse seine fisheries on yellowfin tuna, *Thunnus albacares* (Bonnaterre). Bulletin of Far Seas Fisheries Research Laboratory, 25 (March).

--1989. Catch and fishing effort relationships for striped marlin, blue marlin and black marlin in the Pacific Ocean, 1952-1985. In: R.M. Stroud ed., Planning the Future of Billfishes, Research and Management in the 90's and Beyond. Savannah, Georgia. Coalition for Marine Conservation Inc. 293-311.

Takahisa, H. 1983. How to Distinguish Fish at the Market (2nd ed.). Tokyo. *Nikkan Shokuryo Shimbun-Sha.* (In Japanese). Cited in (Williams 1987).

Taya, K. 1986. How far fish and meat compete against each other. In: Forestry and Agricultural Statistics Association, The changing fish consumption, marketing, and production. Trend of Japanese Agriculture. No. 78. (In Japanese).

Taya, K. 1988. Economic Structures of the Off-Shore Tuna Fishery. Dai Nihon Suisankai. March.

Tayama, J. 1981a. The Story of Tuna. From the Fishing Grounds to the Table. Tokyo, Kyoritsu Publishing Company. (In Japanese).

Tayama, J. 1981b. Sashimi Tuna (2nd ed.). Tokyo, Japan Self--Service Association. (In Japanese).

Tayama, J. 1982. The Story of Tuna (continued). Taste and Trade. Tokyo, Kyoritsu Publishing Company. (In Japanese).

Teiwaki, Koniti. 1987. Access agreements in the south Pacific: Kiribati and the distant water fishing nations 1979-1986. Marine Policy 11(4), 273-284.

Thoulung, B. and Kawai, Y. 1989. Report on the Guam based tuna longline operation study. South Pacific Forum Fisheries Agency, Honiara, unpublished report.

Troedson, D.A. and Waugh, G. 1993. Rent Generation and Sustainable Yield in the Papua New Guinea Tuna Fishery. Canberra, ACIAR Project No. 8928. Research Report 1993/2.

Tsamenyi, B. 1986. The south Pacific States, the USA and sovereignty over highly migratory species. Marine Policy, 10. 29-41.

Tsamenyi, B. 1989. The Treaty on fisheries between the governments of certain pacific island states and the government of the USA: The final chapter in US tuna policy. Brooklyn Journal of International Law Vol XV:2, 183-221.

Tsamenyi, B. and Blay, S.K.N. 1989. Extended zones of jurisdiction over marine resources; state practice in the South Pacific region. In: H. Campbell. K. Menz and G. Waugh, ed., Economics of Fisheries Management in the South Pacific Region. Canberra, ACIAR, 159-166.

Tuna Programme 1983. An Assessment of the Skipjack and Baitfish Resources of Papua New Guinea. Noumea, SPC, Skipjack survey and assessment programme final country report No. 12. South Pacific commission, Noumea, New Caledonia.

Uhler, R.S. 1976. Costs and supply in petroleum exploration: the case of Alberta. Canadian Journal of Economics, February, 72-90.

U.S. Department of Commerce 1986. Fisheries of the United States 1985. Washington D.C., U.S. Department of Commerce.

--1989. The fisheries of the Seychelles. IFR 89/96. Washington D.C. United States Department of Commerce.

--1990. Fisheries of the United States 1989. Washington D.C., U.S. Department of Commerce.

U.S. Department of State 1990a. Report from U.S. Embassy, Lisbon. August.

--1990b. Report from U.S. Embassy, Rome. August.

--1990c. Report from US Embassy, Tokyo. U.S. Department of State. August.

USITC (United States International Trade Commission) 1984. Certain Canned Tuna Fish. Washington D.C., Report to the President on Investigation No. TA-201-53. USITC Publication No. 1558.

--1986. Competitive Conditions in the US Tuna Industry. Washington D.C. Report to the President on Investigation No. 332-224 Under Section 332 of the Tariff Act of 1930, As Amended. USITC Publication 1912.

--1990. Tuna: Competitive Conditions Affecting the U.S. and European Tuna Industries in Domestic and Foreign Markets. Washington D.C., Report to the Committee on Finance, U.S. Senate, and the Committee on Ways and Means, U.S. House of Representatives, Investigation No. 332-291 Under Section 332 of the Tariff Act of 1930. USITC Publication 2339.

Waldron, K.D. 1958. Synopsis of Biological Data on Skipjack (*Katswuonus pelamis*) (Linneaus) in the Pacific Ocean. In: FAO Proceedings of the World Scientific Meeting on the Biology of Tuna and Related Species. Rome, FAO.

Wankowski, J.W.J. 1980. Recent History and Summarised Statistics of the Industrial Fisheries for Tuna and Tuna-like Species in the Area of the Papua New Guinea Declared Fisheries Zone 1970-79. Port Moresby, Department of Primary Industries, Research Bulletin No. 24.

Waugh, G. 1986. The development of fisheries in the south Pacific region with reference to Fiji, Solomon Islands, Vanuatu, Western Samoa and Tonga. Island/Australia

Working Paper No. 86/2. Canberra, National Centre for Development Studies, Australian National University.

--1987. The Collection of Rent in the South Pacific Tuna Fishery. Island/Australia Working Paper No. 87/3. Canberra, National Centre for Development Studies, Australian National University.

--1989. Development, economics and fishing rights in the south Pacific tuna fishery. In: P. Neher et al., Rights Based Fishing. Dordrecht, Kluwer Academic Publishers, 323-348.

--1993. Strategies for the development of fisheries. In: Australian International Development Assistance Bureau, The Papua New Guinea Economy: Prospects for Sectorial Development and Broad Based Growth. Canberra, AIDAB, 124-138.

Waugh, G. and Brown, J. 1990. Strategies for the development of fishing policies in the south Pacific. In: G. McCall, ed., Sydney Talk: Australia in the South Pacific. Sydney, Centre for South Pacific, University of New South Wales Press, 30-42.

Williams, S.C. 1986. Marketing Tuna In Japan. Brisbane, Queensland Department of Primary Industries.

--1987. A Market-Oriented Management Plan For The Coral Sea Tuna Fishery. Brisbane, Ph.D. Thesis. Department of Agriculture, University of Queensland.

--1989. Japanese Tuna Markets: A case for marketing and distribution research. In: H. Campbell, K. Menz and G. Waugh ed., Economics of fishery management in the pacific islands region. Canberra, ACIAR Proceedings No. 26. 109-116.