# Fishing Industry Research and Development Council, (FIRDC).

**Project 90/98, final report, part one.**

**July 1992.**

**A Cost and Income Survey of the East Coast Tuna Longline Fishery.**


**By H.F. Campbell[*] and A.McIlgorm[**].**

**Cooperating Institutions:**

**[*]The Department of Economics, University of Tasmania and**

**[**]The School of Fisheries, Australian Maritime College.**

## Ammendments to the final report.

Please be aware of the following points of clarification:

- Tables 2, 3 and 4 are Japanese data

- The Northern and Southern Japanese fisheries in Table 4 are North and South of 25 degrees South.

- In tables 5, 6, and 7 for the domestic fishery the Northern area is from 25 degrees South to 34 degrees South and the Southern area is the domestic fishery South of 34 degrees. (The domestic fishery North of 25 degrees S is not considered in the report.)

- Table 9 refers to the area shown in Figure 5 between 25 and 34 degrees South

Thankyou ,

Alistair McIlgorm.

## Preface

This is the first of two reports of the Fishing Industry Research and Development Council (FIRDC) project No: 90/98 (1990-1992):

*" An economic analysis of the management options for tuna fishery development in the east coast tuna longline fishery of the Australian Fishing Zone".*

Project participants: Professor H.F. Campbell, Dr A.D McDonald and Mr A.McIlgorm.
Co operating Institutions: The Department of Economics, University of Tasmania and the School of Fisheries, Australian Maritime College.

The objective of the research project is to provide economic analysis that will assist in future management of tuna in the eastern Australian Fishing Zone, with particular reference to the area north of Barrenjoey point. The original project proposal stated the following objectives. To establish :

*" i) The costs and returns of the Australian vessels in the domestic fishery*
*ii) The benefits to Australia from licensing the Japanese fleet compared to other arrangements and*
*iii) The interactions between the inshore and offshore fisheries ".*

FIRDC project 90/98 proposal 1990.

The results of the research are presented in two reports of which this is the first part. The second report addresses production, rent and policy issues for the fishery and will be published in late 1992. (Campbell and McIlgorm, forthcoming). The present study draws on parts of McIlgorm (forthcoming).

**Project Contact Officer:** Alistair McIlgorm, School of Fisheries, Australian Maritime College.Tel. (003) 834404 Fax (003) 834766

### Acknowledgements

We wish to thank the Fishing Industry Research and Development Council for funding of project No: 90/98. *" An economic analysis of the management options for tuna fishery development in the east coast tuna longline fishery of the Australian Fishing Zone"*

We would also like to thank the Australian Fisheries Service for access to licensing, catch and market price data and Mr Thim Skousen, of the tuna section AFMA, for his advice on vessel identification. We would also like to thank Mr Rob Nicholl for his comments on an early draft of this report and Carol Scott for assistance with illustrations and Mr Ken Baulch and Mr Steve Bolton, A.M.C for their assistance with telephoning fishermen.

The Project Officer, Mr Alistair McIlgorm would like to thank Dr J.H Wallace, Head of School of Fisheries for his support in this project and the Australian Maritime College Staff Development Fund and Research Committee for supporting cooperative research with the University of Tasmania, Department of Economics.

Finally we would like to thank all the fishermen who took the time to assist us with the survey.

## Executive Summary

A cost and income survey of 102 vessels active in the fishery in the 1989-90 financial year was undertaken and had 22 survey respondents. Four vessel classes were identified: planing longliners, multi-purpose vessels, trawlers and purpose built longliner/dropliners. The first three of these classes contributed to the survey.

Variation between fishing activity for all methods led to the results being weighted, by days fished as a fraction of total days fished in the fishery. Tuna fishing activity was found to be diverse and not the main fishery for most operators.

The survey and accounting analysis over all fishing methods revealed all three classes to be earning accounting losses varying from -1% to -13%. More importantly, estimated economic returns per vessel over all fishing activities, were also negative, varying from -10 to -16%.

The variable and fixed costs were calculated for both tuna and non-tuna fishing activities. Planing longliners had a higher proportion of fixed costs than other vessels types. Whilst economic returns are low, the total revenue exceeded total variable costs for the average vessel. There was variation in the results across vessel classes, six vessels approaching a shut down decision at the time of the survey. Some have subsequently left the fishery.

The derivation of variable and fixed costs for tuna and non-tuna fishing enabled the total economic cost of tuna and non-tuna fishing to be calculated. Subtracting economic costs of tuna and non-tuna fishing, from tuna and non-tuna income, revealed economic returns to days spent tuna fishing. Multi-purpose vessels earned high rates of return for days tuna fishing, 35.7%. Trawlers fishing tuna earned a negative economic rate of return of -7.6%, whilst planing longliners showed a negative rate of return from tuna of -11.5%. Alternatively economic rates of return to non-tuna activity were poor, -17% for multi-purpose vessels, -10% for planing longliners, and -10.8% for trawlers.

Daily tuna income was similar for planing longliners and multi-purpose vessels but was lower for trawlers. The variable and fixed costs of a day tuna fishing varied substantially. Planing longliners had higher variable and much higher fixed costs per day operated than other vessel groups. The contribution margin was estimated as the difference between total income per day and variable cost per day. This revealed high daily margins for multi-purpose vessels fishing tuna and low daily margins for non-tuna activities. Trawlers had poorer tuna margins than other classes, but had better non-tuna results than multi-purpose vessels.

It is suggested that tuna fishing on a daily basis is more rewarding for multi-purpose vessels at the margin, but only for a limited time when tuna appear. Trawlers and planing longliners depending on tuna had poorer results for the period. Caution is urged in the interpretation of the daily results due to possible small sample bias and effort discrepancies in data base and survey replies.

Marketing and exporting arrangements were compared for each vessel class and revealed that planing longliners received higher net of marketing cost prices and exported a greater proportion of their catch than other vessel classes. Trawlers marketing all tuna to the domestic market have lowest product prices. These results should be treated with caution.

However, the results are believed to capture what was happening during the period. The major question remaining is whether the 1989-90 tax year period was a poor year for tuna fishing?. Many fishermen interviewed suggested it was not a good year. In this report it was not possible to establish this. The production of the domestic fishery will be addressed in Part II of the project final report (Campbell and McIlgorm, forthcoming).

**Table of Contents**

**The Domestic East Coast Tuna Fishery Cost and Income Survey.**

## 1.0 Introduction

Tuna fisheries in the eastern Australian Fishing Zone extend along the Australian east coast from Cape York in the north, to Tasmania in the south. Of this area this study concentrates on the area shown in Figure 1 from Mooloolaba in the North to Eden in the South. The catch from Japanese offshore activity in the Eastern Australian Fishing Zone (AFZ) totalled approximately 6000 tonnes of all tuna and billfish species in 1989 whilst the domestic longline fishery landed approximately 800 -900 tonnes of tunas of various species. The tuna fisheries in this area are multi-species, with catches of yellowfin, albacore, bigeye, and billfishes, (black, blue and striped marlin and swordfish).

The total tuna catch value in the eastern AFZ fishery had a value of approximately 20 million Australian dollars (mA$), in 1989. This is smaller than Australia's largest tuna fishery, Southern Bluefin Tuna, (SBT) which was worth A$72.2 m in 1989 (Geen, 1990 ).

During the early 1980's smaller domestic vessels entered the developing inshore tuna fishery. The domestic vessels aim at supplying the lucrative fresh Japanese sashimi market. The domestic fishermen annually catch approximately 600 tonnes of yellowfin tuna with a by catch of other species. In 1990 the domestic tuna fishery was worth approximately A$6.5 m at point of first sale. A review of recent management issues can be seen in Jackson (1990).

## 1.1 The cost and income survey of the domestic fishery

The domestic tuna longline fishery extends from Cape York in Northern Australia to the Victorian State border in the south with most fishing activity in the innermost fifty nautical miles from shore. The area of the fishery with the main ports is shown in Figure 1.

A cost survey was developed for the domestic tuna longline fishery so as to establish capital and recurrent costs as well as income from tuna fishing. Economic cost surveys provide information on the cost of effort and the results may be used to guide government policy decisions. Costs also form an important input for economic modelling of future management. This cost survey was the first to be conducted on the East coast domestic tuna longline fleet.

Previous tuna industry cost surveys in Australia have been undertaken by the Australian Bureau for Agricultural and Resource Economics (ABARE), formerly the Bureau of Agricultural Economics (BAE). They have all been concerned with the Southern Bluefin Tuna fishery (BAE, 1983, 1984 and 1986).

Recent ABARE cost surveys of non-tuna Australian fisheries have been the Northern Prawn survey (Collins and Kloessing, 1988), the South East Trawl fishery (Geen et al.,1989) and the Southern Shark Fishery (Battagalene and Campbell, 1991).

## 1.2 The Survey

The survey of the fishery was divided into three geographic areas indicated in Figure 1. These were:

a) Northern Area / Queensland- Tweedheads to Brisbane to Cairns / Cape York.
b) Northern NSW -Sydney to Tweedheads and
c) Southern NSW - Eden to Sydney.

The zones were used to facilitate the survey undertaken in three stages.

Examination of fishing activity showed that most vessels operated along the coastline south of Sydney. The Northern New South Wales area was less active than the south coast. There was little fishing activity in the northern area. The significant ports for domestic tuna vessels can be seen in Figure 1.

Within the domestic fishery four categories of vessels were identified by physical and operational criteria (Anon, 1990). The four categories were:

i) Planing longliners - These are typical planing hulled longliners, also involved in tuna poling, droplining or trapping.
ii) Multi-purpose vessels - These vessels participate in a number of fisheries throughout the year.
iii) Trawlers - In the south trawlers catch fish and in the north prawns, turning to tuna only in the off season.
iv) Deep sea purpose built longliners/dropliners - These boats work offshore droplining and are also involved in offshore tuna fisheries.

## 1.3. The Survey form

The survey format was adapted from the ABARE cost survey of the South East trawl fishery (Geen et al.,1989) for the peculiarities of a longline fishery, for example the use of bait which is not used in trawl fisheries. Income was also adjusted so as to separate income from tuna as opposed to other species and alternative boat income sources. The survey format enabled cost and revenue data to be transferred from a fishing vessel's tax return with minimum inconvenience for fisherman. This, in turn, promoted the reliability of data obtained.

The definitions of each cost and income category were included so that the participant could sum costs into their appropriate categories. A copy of the survey is included in Appendix One.

The domestic tuna longline fishery has a variety of fishing vessels. The differing modes of operation require more comprehensive operational data and vessel details. A form called 'Fishing Record' was developed to gain additional information on vessels and fishing patterns. The Fishing Record form is shown in Appendix Two.

### 1.4 Method

At the outset it was apparent that getting the co-operation of the fishermen would be critical to the success of the survey. Alternative sampling procedures were discussed and current government methods reviewed.

Licensing information was sought for the vessels in the fishery, but was not available in sufficient detail to enable selection of vessels by clustering techniques (Geen et al., 1989).

As response rate was anticipated to be the main constraint, all fishermen active in the fishery were personally contacted to take part in the survey and the respondents' results were assessed for bias when returned.

A list of endorsement holders was obtained from the tuna management section of the Australian Fisheries Service. The domestic east coast tuna longline fishery had approximately 170 endorsed fishing vessels in the July 1989 - June 1990 period. All fishermen who were known to have fished in the 1989/90 tax year were identified from data base records.

Each fisherman was initially contacted by letter indicating that the Fishing Industry Research and Development Council (FIRDC) had funded project 90/89 into the economics of future development of the fishery. It was also made clear the the survey was supported by the East Coast Tuna Management Advisory Committee (ECTUNAMAC). It was stated that the project officer would be attempting to contact all fishermen in order to obtain cost and income data and to listen to fishermens' opinions of economic issues in the future development of the fishery. The letter was followed by a phone call arranging times and places for meetings.

Most fishermen were interested in the project, but could not guarantee an interview, as fishermen must put to sea when the opportunity presents itself. The survey meetings were timed so as to be with the fishermen at low or marginal times of the season, rather than at periods of peak activity. This was expected to increase the response rate.

On receiving the form many fishermen, or their wives as book keepers, were reluctant to spend time in filling out "yet another form". To counter this the project officer discussed the survey and Fishing Record and tried to partially or fully complete the survey during the interview. This minimised the remaining paperwork to be completed by the fisherman thereby increasing the survey response rate. Full completion of the form at interview was often not possible as accounting source records were with the accountant having a tax assessment prepared.

A significant number of fishermen were not conversant with accounting records and in the light of this it was recommended that the most accurate survey results could be obtained by the fishermen either by;

a) getting his accountant to complete the form

or

b) forwarding a copy of the vessel's Profit and Loss and Balance sheet to the project officer.

Fishermen were reminded about the survey by telephone several weeks after being visited. Subsequently letters were forwarded with a closing date for the survey being stated. At the final deadline a significant number of fishermen were re-telephoned in an attempt to obtain survey returns. Survey retirns were slow, primarily due to delays in getting accounting records from accountants after year-end tax calculations.

### 1.5 Discussion of Response rate.

The response details for the survey are reported in Table I. There were 68 endorsed vessels that did not fish for tuna in the 1989-90 financial year. Some of these vessels may be involved in other major fisheries, but many are not. From limited contact with inactive fishermen it seemed that many licencees were holding the tuna fishing endorsement as an investment, hoping for capital gain. Having so many inactive licensed vessels may lead to more effort entering the fishery in the future if conditions prove attractive. On the other hand, many of the non fishing licence holders had little apparent tuna fishing experience.

Of the 102 active tuna fishing vessels, 29 when initially contacted were unable to supply figures for the period. The reasons given were:

i) Low level of activity

The fishermen, had fished very few days for tuna in the survey year;

ii) Vessels leaving the fishery

During the survey period some vessels left the fishery due to financial difficulty, change in partnerships and vessel crewing arrangements halting fishing for the season. Several active fishermen had become financially insolvent in or after the survey period and had to leave the fishery;

iii) Vessels that had entered the fishery.

Some vessels had entered the fishery during the year and had fished for less than six months in the survey period;

iv) Confidentiality

Assurances of confidentiality were accepted by most fishermen. Only two fishermen explicitly refused to co-operate with the survey on the basis that their business details were personal. The fishermen were assured that personal identification would not be possible in the survey results;

v) Ill health

Changes in personal health curtailed the fishing activity of several fishermen contacted;

vi) Major vessel breakdown

Several vessels had been laid up due to serious mechanical breakdown or structural damage; and

vii) Other reasons

Others evaded the survey giving many varied and colourful reasons for not being able to cooperate with the survey.

A survey form was distributed to the remaining 73 fishermen. Most were given directly to fishermen at interview. Where contact was not possible the survey was sent by post. In the course of the six months after the survey 22 responses were collected or received. Of these, one was filled out incorrectly and was unusable. The response rate can be estimated as approximately 20% (21/102) of those fishing in the period.

The difference between surveys distributed (73) and returned (21) was 51 non respondents. Their reasons for not compiling were similar to the reasons previously stated above. Invariably, many fishermen were "too busy" and saw little point in completing the form. Several responses were prompt, but many other responses only came after significant follow-up.

### 1.6 The Sample and vessel activity.

In the tax year in question only 102 fishermen took part in the fishery. The number of tuna trips in the tax year was calculated from the AFS domestic logbook data. The number of days the fishermen fished in fisheries other than tuna was obtained from the Fishing Record.

The mean number of days fished in all fisheries for all vessel classes was 84 days per vessel. Of this 57 days were spent on non-tuna activities and 27 on tuna. The ratio of days tuna fishing to non tuna fishing can be seen in Figure 2. This is a plot for the 21 vessels that responded to the survey showing days spent tuna fishing as opposed to other fishing activities. Vessel numbered 1-11 are planing longliners, 12-18 are multi-purpose vessels and 19-21 are trawlers. The non-tuna fishing activity is diverse and not all of it is in fisheries with logbook recording systems. The the non-tuna days estimate was from fishermen's estimates or personal records and may be subject to error. Where all other fishing activity was recorded in log books, the fisherman was asked to refer to records for the period.

For the tuna activity that was recorded on the database, Figure 3 shows a frequency plot of the number of vessels, against the number of tuna trips undertaken by vessels in the 1989-90 tax year. This gives an indication of tuna fishing activity across the fleet. The repondents to the survey, that will be referred to as the "sampled" vessels, are reported in Figure 3.

Figure 3 shows that the distribution of vessel activity in the tuna fishery is skewed to the left. The mean tuna trips per vessel per year is 27 trips (s.d. =22). About 64% of vessels fish tuna for less than 20 days a year. This observation is reinforced by a median of 22 trips. The highest number of days fished was 98. Levels of fishing activity in the fishery exhibit a high degree of variability. Only 21.5% of fishermen fished more than 30 days per year for tuna and 10% fished for tuna for over 40 days per year.

Some respondents may see it as being to their advantage to reply to the survey. For instance, fishermen who possibly were in financial difficulty may complete a return in the hope of Government assistance. If this was the case, it was not evident in contact with the fishermen. To try and check on the quality of the sample of tuna fishing activity data, the survey respondents' tuna fishing activity was compared to the tuna activity in the rest of the fleet. A visual comparison can be made from Figure 3 by comparing activity levels of the sampled and non sampled vessels.

The sample covered most levels of fishing activity in the fishery. This may be some indication of the sample's validity. On discussion with fishermen many said the number of trips per year was a measure of "who the real fishermen were", but contradicted this by indicating that many newcomers to the fishery did too many trips as they were inexperienced. While vessel activity indicates the most active vessels, the less efficient operators are not readily determined. The sample can be examined for the coverage of activity for the various classes of vessel. This is reported in Table II.

The information from Table II shows that while sample coverage by vessel number was 21%, the sample had 26% coverage of all tuna fishing trips. This would indicate that, all else being equal, the sampled boats were more active tuna fishers than the non-sampled vessels. The sample coverage for effort and catch, at 24% and 23% respectively, confirm the contribution made to the fishery by the surveyed vessels. Although the survey attempted to cover each class of vessel, none of the purpose-built dropliners/longliners responded. However, there are few of these vessels in the fishery.

In Table II the 'other vessels' were vessels unable to be identified for class type and also includes several non responding purpose-built longliner/dropliners. Although the unidentified vessels were 36% (37/102) of vessel numbers they accounted for less than 25% of the effort, trips and total catch. The following results are expressed as a percentage of vessels identified in each vessel class. By vessel numbers 30%-40% of each of the three classes were sampled. When trips and catch were used to assess sample coverage, 61% of trips, 71% of effort and 67% total tuna catch by trawlers were covered. While these numbers should be interpreted with some care this could be indicative of the efficiency of the operators sampled.

From the database of catch and effort records it was also possible to examine the surveyed vessels' contribution to effort in the previous tax years. These confirmed the reported results with all of the vessels surveyed in the 1989-90 tax year fishing in the 1988-89 tax year. Again they constituted approximately 20% of the active vessels and 28% of the tuna effort in that year. In the 1987-88 year the surveyed vessels still contributed 20 % of the declared tuna vessel activity in that period.

Interpreting surveys of fishing activity is difficult due to posible inaccuracies. There can often can be an inherent mistrust on the part of the fisherman of the system and motives of management. In this case the sample obtained from respondents' returns was held to be reasonably representative of the fishery. The contribution made by the sampled vessels to effort, catch and trips over several seasons was in proportion to the number of vessels sampled. The vessels sampled in 1989-90 were not newcomers to the fishery having had several seasons of activity validated by logbook records. The responses to this survey are proposed as being reasonably representative of the tuna fishing activity in each of the vessel classes.

## 1.7 The Fishing Record

In order to gain more precise information on the vessels in the fishery the Fishing Record form requested details of the vessel name, class, age and length. The vessel name was used for identification on the domestic data base. Other information was sought on endorsements as an indicator to involvement in other fisheries as was the number of days fishing for tuna and days spent in other fisheries in the survey period.

Other details such as type and cost of bait and fuel consumption per day were obtained as a cross check on stated fishing activity. Information about targeting on the various species in the fishery was also sought. This involved fishermen ranking targeted species. Yellowfin was the most targeted species..The record concluded by requesting details on the marketing of tuna from the fishery. Data on tuna exports and domestic supply, by weight, were also requested. The Fishing Record aimed to try and gain as much additional information as possible, without overwhelming the fisherman with paperwork and thus lowering response rate. The Fishing Record responses were compiled for the returned surveys and are shown in Table III.

Planing hull vessels were between 11 and 16.5 metres and are generally longer than multi-purpose vessels. Planing longliners were also the youngest vessel class, averaging 8 years, with some of the vessels just two years old. This contrasts with the older multi-purpose vessels, 17 years, and trawlers which were the oldest vessels at over 23 years of age.

Days spent tuna longlining were retrieved from logbook data and the Fishing Record. Planing longliners fished for tuna on more occasions than the other two vessels classes. The ratio of tuna to other fishing days was calculated from the Fishing Record. For the three vessel classes planing longliners were the most dependent on the tuna fishery, fishing an average of 31 days per year for tuna. Within this group three vessels fished less than ten days per year and two vessels fished over 40 days per year.

Multi-purpose vessels and trawlers were less dependent on tuna than planing hulled vessels, fishing fewer days, 23 and 21 respectively. The ratio of other fishing to tuna fishing days was higher for the trawlers and multi-purpose vessels. On average, trawlers and multi-purpose vessels fished more days per year than planing hulled vessels. Overall, planing longliners directed 42% of their fishing effort towards catching tuna. While this was more than for the other classes, only one vessel directed all activity towards tuna in the period surveyed and several fished more than 60% of their time for tuna. Few fishermen targeted exclusively on tuna with droplining, trapping, trawling and abalone diving being alternative fisheries. In most cases tuna fishing was regarded as the alternative or second fishery. This view is supported by days fishing other species exceeding those spent fishing tuna for all vessel classes.

The Fishing Record proved to be very useful. Given the lack of detailed data on the vessels in this fishery the information proved essential for the interpretation of accounting data and assessment of economic performance.

The Fishing Record was popular with fishermen, as they could fill it in relatively easily and knew it was essential due to the complexity of this fishery. Some problems were experienced in the interpretation of the vessel class terminology. Some fishermen rated their vessel class by current fishing behaviour, rather than by fundamental physical characteristics. For example a fisherman who used a planing hull vessel to go droplining and trapping may have regarded his vessel as multi-purpose. The assistance of the former Department of Agriculture for New South Wales fisheries research log book coordinator, who was familiar with the vessels, helped to clarify this issue.

Replies within the Fishing Record on the number of days fished for tuna often differed from computerised log book records. On following this up with fishermen the logbook figures usually were correct, except where there was a delay in logbook sheets being returned to the coordinator in Canberra. Unless fishermen had counted the logbook daily entries for the period they tended to over-emphasise the number of days they fished. The nature of the fishery has something to do with this. Fishermen spend considerable time ashore in this seasonal fishery due to high winds and unfavourable currents, water temperatures and tides. At short notice they must utilise changes in weather patterns to pursue the tuna whilst they are there. Seasonality and downtime partially explain why days fished tended to be low compared to a typical trawl fishery where 130-150 fishing days per year is not uncommon.

The Fishing Record could have been improved by the addition of an additional question.on crewing of the vessels, with part time and full time crew. The crew numbers were requested from fishermen to assist in the calculation of the opportunity cost of labour, the respondents being contacted by telephone to provide this information.

## 2.0 Results of the cost and income survey

The costs and returns of the accounting survey source data returned by fishermen were entered on to a computer spreadsheet. The data were used to calculate accounting and economic profit.

The diversity in the vessel activity in the fishery necessitated the weighting of results.[1]

## 2.1 Accounting results

Accounting profit, was calculated for each vessel by subtracting operating costs, including interest and depreciation, from income. Income, net of marketing costs was used, and hence marketing costs were not included in costs. Accounting return to capital, a measure of accounting profitability, was also calculated by vessel class and can be seen in Table IV.

Generally, few vessels were involved with short term chartering and thus income from this source was low at less than 2% of income for planing longliners and multi-purpose vessels. Trawlers had less than 5% of total net receipts from chartering.

Overall costs showed planing hulled vessels to exceed other vessels in annual operating cost. Individual costs as a percentage of total cost were calculated for each vessel class and can be seen on the right hand side of Table IV.

Repairs and maintenance as a proportion of total costs were greater for trawlers than for other vessels. This reflects more slipping and maintenance due to older hull types. Gear repairs and maintenance are slightly higher as a percentage of total cost for multi-purpose vessels. There is no apparent reason for this. Fuel is noted to be higher by percentage of total costs for the planing longliners and trawlers. This may reflect the large engines often used to power these vessels and the amount of "travelling" often done by planing longliners. Trawlers tended to use more fuel and oil in their trawling operations and less when longlining.

---

[1] Due to the diversity in annual fishing activity, evident from fishing record and logbook data, the results were summed by a weighted average to reflect disparate levels of fishing activity. The formula used was:

$$WAACF_i = \sum_{j=1}^{n} C_{ij} \cdot \frac{d_{ij}}{\sum_j d_{ij}}$$

where $WAACF_i$= Weighted Average Annual Cost of Fishing, i= the ith vessel class j=the jth vessel C = annual cost per vessel n=number of vessels and d=days fished.

This weighted averaging method weights an individual vessels' results by the days fished as a proportion of the total days fished in each vessel class of the fishery. Income was also apportioned by this method. This meant vessels that fished more days per year had greater weighting in the mean results. A simple average could be used only where all vessels have similar levels of operation. A simple average would have tended to lead to less active boats being given over emphasis in the accounting results.

Payments to crew as a proportion of costs vary between fishing methods with trawler crew costs being a greater proportion of total costs than for other vessels types. In absolute terms wage costs were higher on planing longliners. Labour costs for crew, including the skipper, were thought to be low given that all vessels have a skipper with at least one reasonably competent deckhand and possibly a part-time deckhand, family member or youth assisting. This may be related to the poor results in the year surveyed or, may show a reluctance to state wage levels in the survey. Wage levels varied noticeably between individual survey forms.

Depreciation is largest in absolute terms and by percentage of total costs for planing longliners. This reflects the lower average age of purpose built planing longliners. Interest payments in absolute terms are higher for planing longliners and reflect the amount of capital invested in newer vessels. Trawlers are seen to have low interest repayments due to age. When interest is expressed as a proportion of total costs multi-purpose vessels and planing longliners have higher interest levels than trawlers. Interest levels vary between boats in any given class. Some of the newer multi-purpose vessels had debt levels as high as some of the planing hulled vessels, whilst others carried no debt at all.

Bait costs are as expected, with trawlers having the lowest cost due to being able to catch and retain bait for longlining. Other boat expenses were noticeably higher for the planing longliners probably reflecting the expenses incurred in travelling and working the boats from different ports along the coast.

Comparisons of annual costs across vessel classes are not possible due to different activity levels and different fisheries. The economic and variable cost per day fished are compared in section 4. for tuna and non-tuna fishing for each vessel class.

The three categories of vessel made an accounting loss in the 1989-90 tax year. Planing longliners had the most severe losses per vessel of $-23,077, multi-purpose and trawlers at losses per vessel of $-1054 and $-748 respectively. These are accounting rates of return to capital of -12.1%, for planing longliners, -1.2% for multi-purpose vessels and -0.5% for trawlers.

The results above are for the mean of each vessel class. There was variation within the vessel classes. Only two of eleven planing longliners and one in three trawlers were earning an accounting profit. Multi-purpose vessels had four from seven vessels earning an accounting profit. (last row, of Table IV).

### 3.0 The economic returns.

The accounting returns for the fishery are of interest to fishermen, but the economic returns for vessels are of more interest from the management viewpoint. The economic returns from tuna fishing will be be calculated in section 4.

To determine the economic returns from fishing activity there are several changes that have to be made to costs. Appendix Three details these. The economic profit and cost results of the survey are shown in Table V.

The economic returns were calculated on an all equity basis, as if the vessel been fully owned by the operator. The economic profit gives an indication of the ability of the fishing vessel owner to meet all of their costs, including depreciation and opportunity costs of capital, in the long run. The economic profit can be thought of as a measure of the capacity of the fisherman to stay in the fishery in the long run. In the long run capital stock can be changed as re-investment decisions such as decisions to leave the fishery are made.

All three vessel types showed negative per vessel economic profits in the survey year. The average economic losses were $-19,994 for planing longliners, $-14,610 for multi-purpose vessels and $-16,465 for trawlers. An economic rate of return to capital was obtained by expressing economic profit as a percentage of the average capital per vessel employed in the fishery. Rates of return to capital of -10.8% for planing longliners, -16.3% for multi-purpose vessels and -10.2 % for trawlers were obtained. (Table V).

### 3.1 Discussion of economic performance.

For the period covered by the survey the vessels made economic losses. Given the previous accounting returns, it is not particularly surprising, though the level of economic loss is quite significant. The long run viability of some vessels must be questioned.

Several questions arise:

i) What is the short run viability of the vessels ?;

ii) Are the returns indicative of the economic profits from tuna fishing or from other fishing ?;

iii) How do these results compare with those of past surveys or with results from other fisheries ?;

Issue (i) will be addressed in section (3.2) when short run viability is investigated. Issue (ii) will be addressed in section 4 when returns from both fisheries are calculated.

For issue (iii) there have been no previous surveys of this fishery for comparison. However, the results can be compared to the southern shark fishery survey of the 1988-89 financial year (Battagalene and Campbell, 1991). In the southern shark fishery the returns to full equity were from a high of 18%, to a loss in one vessel class of -2.2% (Battagalene and Campbell, 1991).

For comparison between results amendments to our calculations were made to produce estimates on the same basis as the results of Battaglene and Campbell, 1991.[2] The amended results for comparison with the southern shark fishery results are presented in Table V(b). Planing longliners had a positive rate of return to equity, 1% and trawlers, 2.5%. Multi-purpose vessels had poorer returns at -5.7%. It appears that the results across the fishery are not as good as the results for the southern shark fishery in the same period. This should be of concern to management.

### 3.2 Short run viability of the fishery - are the losses critical?

In any industry, should there be economic losses occurring due to an individual producer's Total Costs exceeding Total Revenue, it is important to examine the relationship between Total Revenue (TR) and Total Variable Costs (TVC). When an individual firm's TR is less than TVC the firm will immediately shut down production (Baumol et al., 1990). In the case of the fishery this will lead to vessels being tied up in the hope of better times. It may also lead to long run exiting of the fishery.

The variable costs were calculated for the vessels. Those costs most obviously related to fishing effort were added to variable costs (fuel, wages, bait). The overheads, administration, insurance, and depreciation were treated as fixed costs. Two cost categories were not clearly either fixed or variable. The costs of gear repairs and maintenance can be considered both fixed and variable; discussion with fishermen revealed that greater fishing activity led to more repairs and maintenance. However, some repairs were independent of the level of use. This cost category was divided equally between fixed and variable costs. Similarly itemisation of "other costs" by some fishermen led to one third of these costs being assumed to be related to the level of fishery activity. The variable and fixed costs were calculated and are shown in Table VI(a).

The survey results reported in Table VI(a) indicate that for the mean vessel, total variable costs are lower than total revenue, and hence that short run viability is not in question in any vessel class. However, in individual results, not reported due to confidentiality, three planing longliners, two multi-purpose vessels and one trawler were facing a possible shut down decision.

[2] The opportunity costs of capital were removed from the results in this study, and fees were treated as in Battaglene and Campbell,(1991).

From Table VI(a) variable costs for multi-purpose vessels and trawlers are greater than fixed costs, whereas planing longliners have fixed costs exceeding variable costs. This may be related to the relatively low level of activity by planing vessels.

## 4.0 The economic costs and returns from tuna fishing and non-tuna fishing

The accounting, economic returns and fixed and variable costs detailed previously are for running a vessel in several fisheries, not only the tuna fishery. While the primary interest in this study is the economic returns from tuna fishing, the returns from other fishing activities are also of interest.

### 4.1 Apportioning variable costs

All boats have access to several fisheries in which the variable cost for operating may be different. Variable costs, apart from bait and fuel costs, for tuna fishing and for non-tuna fishing activities were calculated by apportioning overall variable costs by the ratio of days spent tuna fishing to total numbers of days fished. Using Fishing Record results for relative fuel and bait costs per day of tuna fishing, the fuel cost per day for operating in tuna and non-tuna fisheries was obtained. The bait cost was regarded as being 80% attributable to longlining for tuna for multi-purpose and planing vessels, and 100% of bait costs for trawlers were attributed to longlining.

The total variable costs for tuna fishing and non-tuna fishing are reported in Table VI(b). In Table VI(b), the fixed costs of tuna and non-tuna fishing have been apportioned by the ratio of days spent tuna fishing to other days. The sum of total variable costs and fixed costs for tuna fishing give the total economic cost of tuna fishing.

The economic profits from tuna fishing and non-tuna fishing were given by subtracting total economic costs from total income for each category of operation. These are recorded in Table VII. The economic profit attributable to tuna fishing was calculated and also expressed as a rate of return to the capital used in catching tuna. The percentage of capital attributable to tuna fishing is determined by the ratio of days spent tuna fishing to other fishing days.

### 4.2 Tuna fishing results

From Table VII rows 3 &4 it can be seen that planing longliners record economic losses of $-8806 from tuna fishing, a rate of return of -11.6%. Trawlers refused a loss of $-2847, a rate of return for tuna fishing of -7.6%. However, multi-purpose vessels made positive economic profits from tuna fishing, $7553 and a high economic rate of return to capital invested of 35.7 %.

The planing longliners received a poorer return to capital than other vessel groups from tuna fishing. This is an interesting result as many of the longliners have been purpose built to fish tuna. Daily costs and returns will be evaluated in section 4.5.

### 4.3 Non-tuna fishing results

The right hand side of Table VII reports economic losses for all three vessel classes engaged in other fisheries. Multi-purpose vessels show lowest economic rates of return, -32.4 % followed by trawlers, -10.8.% and planing longliners at -10.6%. This shows that in comparison to tuna fishing, other fishing activities had poorer rates of return for all vessel classes.

### 4.4 Discussion of tuna and non-tuna fishing results

The economic rate of return from tuna fishing is greater for all classes than the rate of return from non-tuna fishing. In the results above, planing longliners and trawlers earned negative rates of return in both fisheries.

Many of the planing longliners are newer and have been purpose built specifically for tuna fishing. It seems that rates of return from other fishing activities by this class are approximately equal to tuna fishing. However, multi-purpose vessels earn high positive rates of return from tuna fishing and negative rates of return from their other fishing activities. The profit made tuna fishing ($ 7553) does not cover the losses of multi-purpose vessels in alternative fishing ($-22163).

### 4.5 Daily costs and returns in both fisheries.

The average number of days fished in tuna and non-tuna fisheries were obtained from data base and Fishing Record results. Obtaining this information enabled daily income, economic costs, variable costs and fixed costs to be calculated for both tuna and non-tuna fisheries (Table VII). The calculations should be treated with some caution as will discussed in section 5.0.

In Table VII, rows 5-9, income per day from tuna fishing was $1592 for planing longliners and $1455 for multi-purpose vessels. Trawlers had much lower daily revenue from tuna fishing, $989 per day. The daily income from tuna exceeds estimates of the daily income from other fishing activities. Planing longliners and trawlers had higher non-tuna income than multi-purpose vessels.

The economic cost, when allocated by days of operation, is highest for planing hull vessels at $1871/day. This is much greater than the daily cost of multi-purpose vessels and trawlers, $1125/day for both vessel types. The high economic cost for planing vessels is due to their high fixed cost component, $900/day. However, variable costs for planing hull vessels are not insignificant, $971/day, compared to multi-purpose vessels $599/day, or trawlers $528/day.

Economic costs for non-tuna fishing activities are lower than for tuna fishing. Again planing longliners exhibit high fixed and variable costs relative to other vessels, but variable costs are less than the equivalent costs for tuna fishing. Variable costs for multi-purpose vessels fishing tuna are $599 per day, but are lower when not tuna fishing, at $387 per day fished. This is probably due to higher fuel and bait consumption when tuna fishing. Trawlers have slightly higher variable costs for tuna fishing than for trawling. Whilst trawler fuel expenses are lower when longlining for tuna, all bait costs for trawlers are assumed to be for longlining. Averaged across the three trawlers in the survey the bait cost tended to offset fuel savings from not trawling.

Fixed costs for the three vessel types varied substantially. The high fixed costs for planing longliners reflects the high amount of capital invested in these vessels and hence high opportunity costs. When viewed on a daily basis, the fixed costs for planing longliners ($900) are larger than the fixed costs for trawlers ($597) and multi-purpose vessels ($526).

The days fished by each vessel class are reported in Table VII. The days per year fished by planing longliners,(74) in all fisheries was noticeably lower than other vessel classes (97 & 92). The high fixed costs per day for planing longliners could be reduced by vessels undertaking more activity. However this would only be rational if income for a marginal day exceeded daily variable cost. Thus fish availability for the high variable cost planing longliners may limit fishing.

Table VII further shows the contribution margin from a day in the various fisheries. This is the difference between daily income and variable cost per day. The margin is greatest for multi-purpose vessels fishing tuna. It is noticeable that the margin for multi-purpose vessels not tuna fishing is distinctly lower. The margin for planing longliners is similar for both kinds of fishing. Trawlers have a slightly higher margin when fishing tuna.

## 5.0 Discussion

The high daily returns from tuna fishing for multi-purpose vessels may be related to the general reluctance on the part of multi-purpose vessels to switch to tuna longlining until aggregations of tuna are known to be in the area. Whilst the daily margin would lead us to believe that more multi purpose vessel effort should be directed towards tuna, many of these vessels do not consider tuna worth pursuing over large distances and are content to fish for a limited number of days when the tuna are potentially available. Having substantial catch and hence income in these times, for relatively few days effort, gives a significant rate of return from tuna. It is not clear that spending more time tuna fishing would enhance economic performance for trawlers and multi-purpose vessels. Interviews with many of these owners noted a reluctance to actively pursue tuna with inevitable travelling and social costs.

It was not possible to establish if the year surveyed had been a bad year for tuna. Many of the fishermen interviewed believed it was a poorer than average year. Catches were apparently down and despite moving along the coast, good catches did not eventuate for most fishermen. The next report from this project (Campbell and McIlgorm, forthcoming) estimates production in the domestic fishery for the 1987-1990 period and will assist in determining variations in production in the tuna fishery.

The daily results in this study should be interpreted with caution as the sample sizes obtained for each vessel class are low and showed marked differences between operators. The daily figures also refer to days actually fished and depend on the integrity and accuracy of the log book records for the period and the estimation of involvement in other fisheries relative to tuna fishing by fishermen. Every attempt was made to establish if there was any difference between log books in the field and the data base records.

Daily costs also reflect the expenses from days when the vessel were transiting between ports, "chasing fish" without success and days lost due to vessel or gear breakdown. In all these daily figures it should be borne in mind that the costs may be high due to assumptions used in the calculation of economic cost. The opportunity cost of labour assumes that the vessel skipper, who is often the owner, is employed full time with the boat. If part time labour outside these fishing activities is undertaken by the skipper, economic cost will be over estimated.

The survey calculated income net of marketing expenses (see Appendix 4). Many fishermen noted the attraction of the Japanese market was diminishing due to high freight costs, less attractive exchange rates and poor prices for the high risk of exporting fresh product. For many, the certainty of the Sydney market or fixed price agent was preferable to the risk of exporting.

The difference between net income may be due to different marketing arrangements used by each of the three vessel types. To investigate this the data base information on the catch of each tuna species was combined with the survey returns on the income derived from tuna. Table VIII reports average prices, net of marketing costs, for yellowfin tuna and all tuna species. Table VIII also reports the export and domestic marketing behaviour for each vessel class. The table should be treated with caution due to possible errors inherent in relating the data base and the income survey data. Table VIII also reports information from the Fishing Record to obtain the exporting behaviour for each vessel class.

In Table VIII the average net price received for tuna by planing longliners exceeds multi-purpose vessels and trawlers. From Table VIII it is apparent that the percentage of tuna exported, as opposed to marketed domestically, was greatest for planing longliners than for other groups. This would suggest that net of marketing cost returns are higher for planing longliners due to exporting fish. The results for trawlers may confirm this. Two vessels, referred to as T*in table VIII sent all their tuna to the Sydney market and received net income that was less than a third trawler that was partially exporting. Again, caution is urged with the results due to the diversity in marketing arrangements. The emergence of agents buying at contract price in Sydney for export may have influenced the accuracy of the results with some fishermen recording these transactions as exported fish. The marketing area is worthy of further investigation.

### 5.1 Conclusions

In this fishery many fishermen have invested in planing longliners as the most appropriate vessel. The poor results for planing longliners fishing tuna are probably explained by the high fixed costs reflecting the capital cost incurred in owning this kind of vessel, and the variable costs of chasing the all too elusive tuna. While income on a daily basis is similar to other vessels, the concentration on tuna fishing, with the inevitable chasing and transiting between ports and areas, pushes up variable costs. High fixed and variable costs make this vessel class vulnerable to poor economic performance when income falls due to poor catch rates.

Multi-purpose vessels had good economic rates of return from tuna fishing and poorest economic rates of return from other fishing. Trawlers had negative rates of return from both fishing activities, though fishing tuna was only marginally better than trawling. Tuna lonlining would seem to be an attractive secondary fishery for multi-purpose vessels.

## References

ABARE,(1990) Commodity Statistical Bulletin 1990, Australian Bureau of Agricultural and Resource Economics, Canberra, AGPS.

Anon., (1990) Annual Report of the New South Wales Tuna Longline Logbook Programme. Tuna Section, The Australian Fisheries Service, Canberra.

Anon., (1991a) Federal Award Rates for Electricians and Plumbers. Commonwealth Department of Industrial Relations.

Anon., (1991b) State Award Rates for Builders. Tasmanian Department of Industrial Relations and Training. Hobart

Battaglene, T. and D. Campbell, (1991). Survey Reveals that Shark Fishermen are Struggling. Australian Fisheries, May. pp12-15.

Baumol, W.J., A.S Blinder, A.W. Gunther and J.R.L. Hicks (1988). Economics -Principles and Policy. Australian Ed. Harcourt Brace and Johanovich, Sydney.

Bureau of Agricultural Economics, (1983). Survey Results for the Southern Bluefin Tuna Catching Sector. Supplementary Evidence to the Industries Assistance Commission, Canberra.

Bureau of Agricultural Economics, (1984). Submission to the Industries Assistance Commission Inquiry on Southern Bluefin Tuna, Canberra.

Bureau of Agricultural Economics, (1986). Southern Bluefin Tuna Survey 1980-82, Canberra.

Campbell, H.F. and A. McIlgorm (forthcoming). An Economic Analysis of Management Options for tuna fishery Development in the East Coast Tuna Longline fishery of the AFZ. Final Report, Part 2 of the FIRDC Project 90-98.

Collins, D. and K. Kloessing, (1988). Financial Performance in the Northern Prawn Fishery - Latest Results by ABARE. Australian Fisheries, December,.pp 38-44.

Geen, G. (1990) The Value of Japanese Access to the Australian Fishing Zone- A Report to the Australian Fisheries Service. Australian Bureau of Agricultural and Resource Economics (ABARE), Canberra.

Geen, G., D.Brown and S.Pascoe, (1989) Economic Survey of the South East Trawl Fishery. Australian Fisheries, December,.pp 45-47.

Jackson, S. (1990) East Coast Tuna under Review. Australian Fisheries, October.pp 40-44.

McIlgorm, A. (forthcoming) The Management of East Australian Tuna. Ph.D. thesis in preparation, The Department of Economics, University of Tasmania.

# Figures

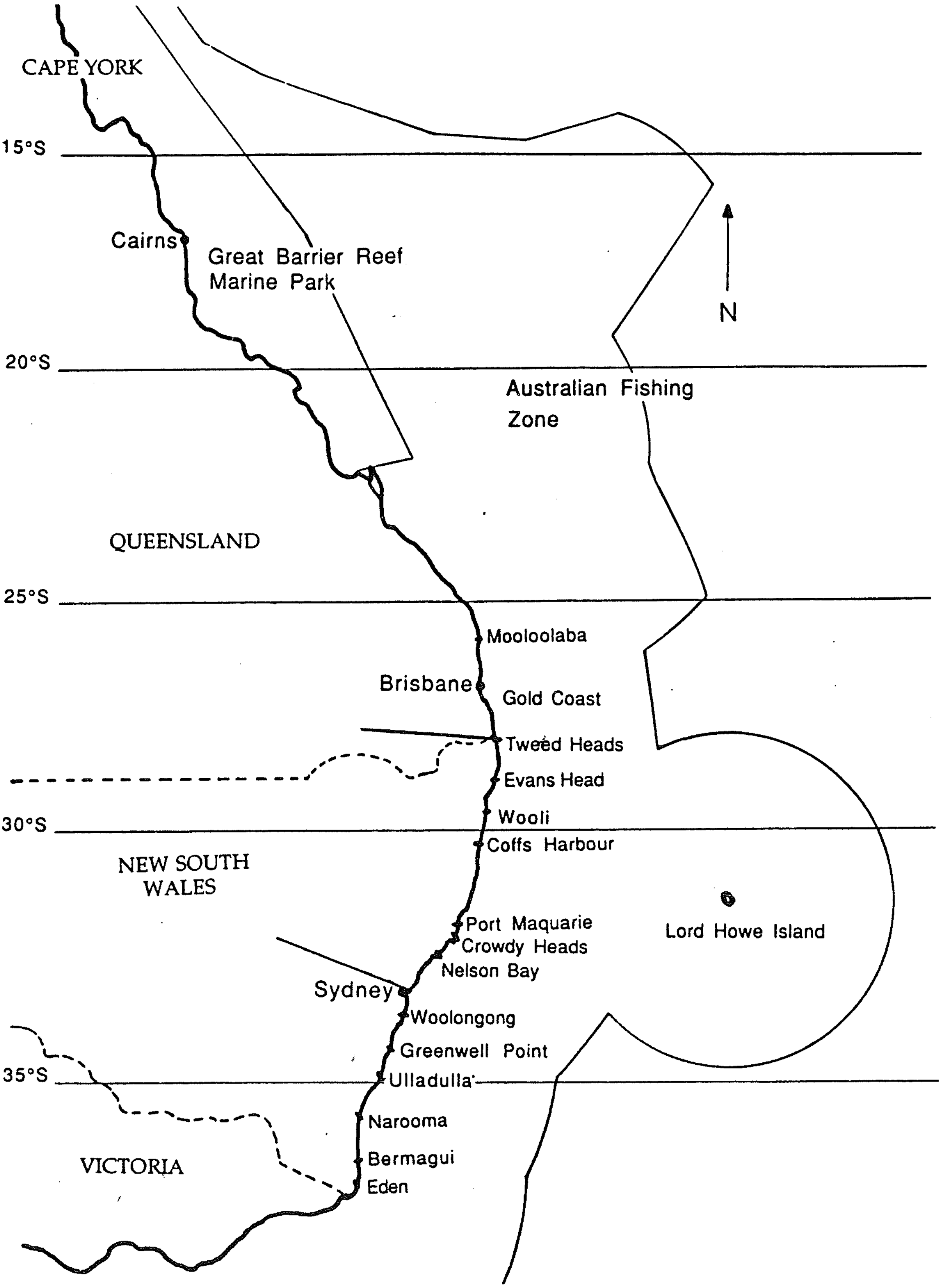


**Figure 1 :** The area of the Domestic tuna longline fishery. Ports with three or more active tuna vessels are shown. The three areas used in the domestic cost survey are shown. They are Eden to Sydney, Sydney to Tweed heads and Tweed heads to Cape York.

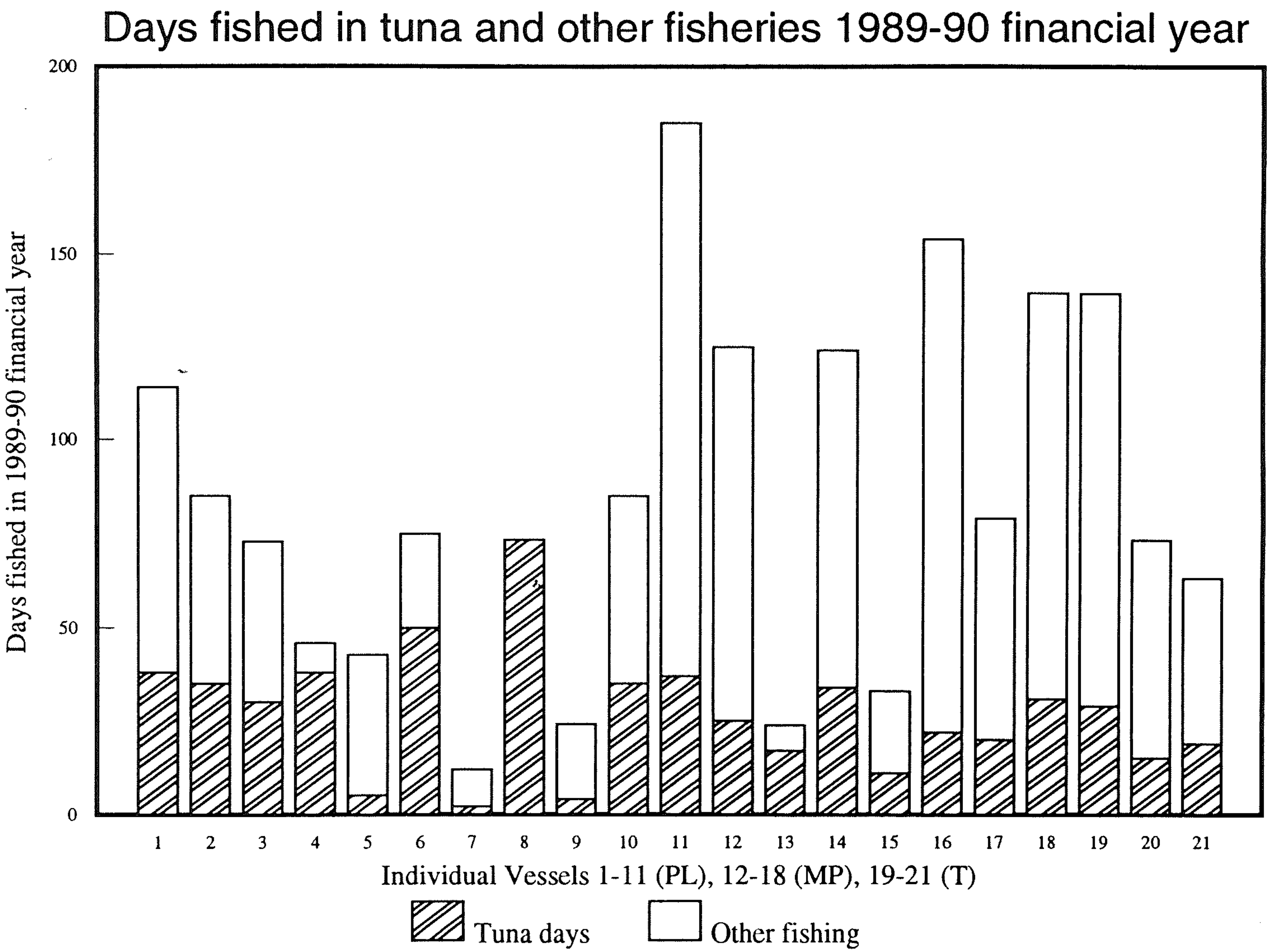


**Figure 2** :A plot of the number of days tuna fishing as opposed to other fishing activities for the domestic east coast tuna longline fishery. Source: AFS, database and Fishing Record.

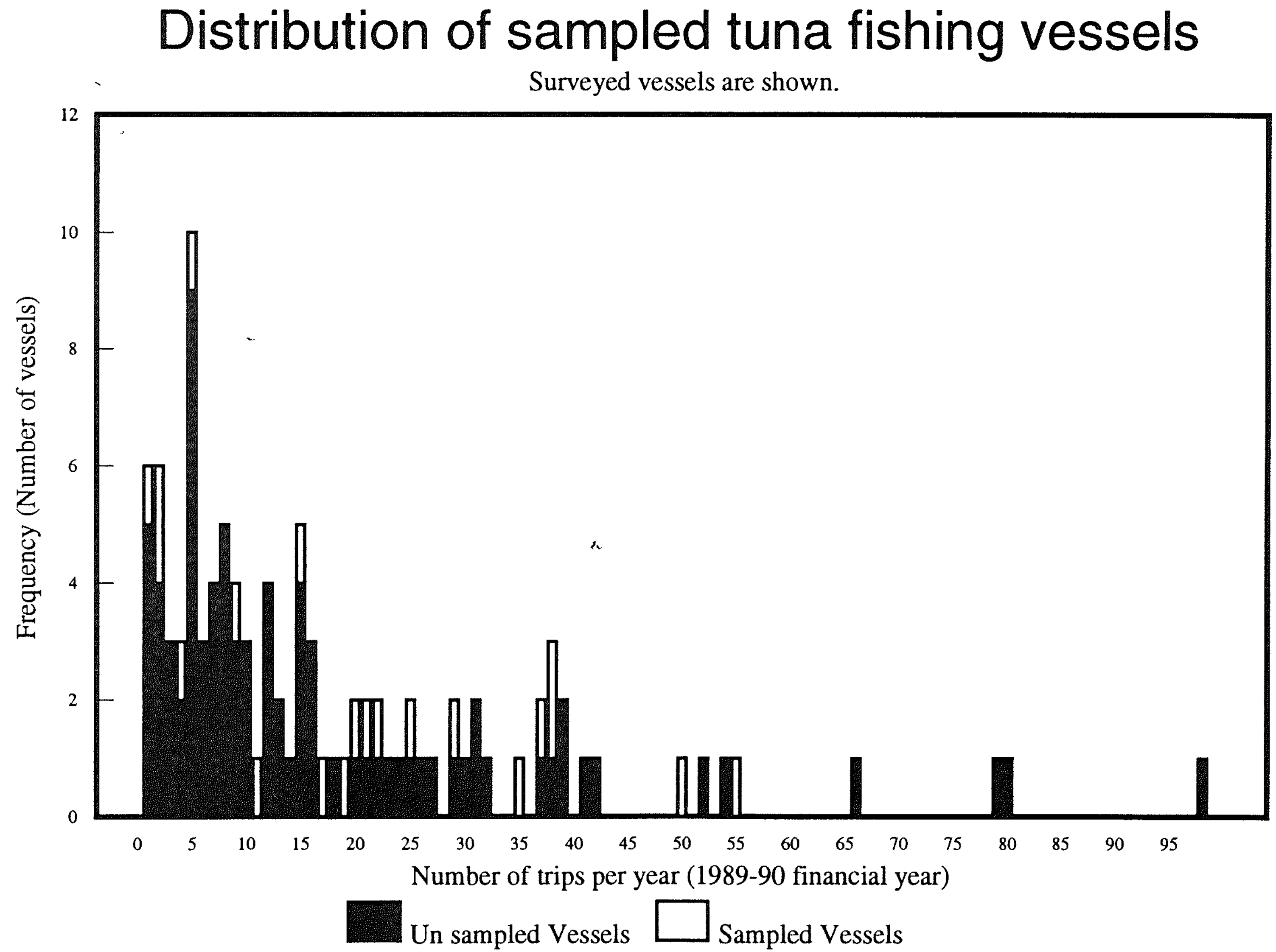


**Figure 3**: A frequency plot showing number of vessels and their trips per year in the 1989-90 tax year, with the sampled vessels shown. The distribution of the sampled vessels is evident.

# Tables

| | Northern area/ Queensland | New South Wales North | South | Total |
|---|---|---|---|---|
| Number of endorsed Vessels | 42 | 34 | 89 | 170 |
| Number of active vessels in 1989/1990 tax year | 5 | 33 | 64 | 102 |
| Fishermen contacted | 5 | 33 | 64 | 102 |
| Surveys sent | 4 | 22 | 47 | 73 |
| Surveys returned | 0 | 9 | 13 | 22 |

**Table I:** The returns of the survey of the East coast Tuna longline fishery.

| YEAR 1989-90 | Planing Longliners (PL) | Multi Purpose (MP) | Trawlers (T) | Others | Totals |
|---|---|---|---|---|---|
| Sample by vessel numbers | | | | | |
| No of Vessels | 35 | 17 | 8 | 37 | 102 |
| No. Surveyed | 11 | 7 | 3 | 0 | 21 |
| % Coverage of class** | 31 | 41 | 38 | 0 | |
| Coverage as % of total | 11 | 7 | 3 | 0 | 21 |
| Sample by trips | | | | | |
| Trips per vessel | 1026 | 247 | 104 | 417 | 1893 |
| Surveyed trips | 320 | 101 | 63 | 0 | 484 |
| % Coverage of class** | 31 | 41 | 61 | 0 | |
| Coverage as % of total | 17 | 5 | 3 | 0 | 26 |
| Sample by effort in '00 hooks | | | | | |
| Vessels '00 hooks | 3288 | 647 | 234 | 1208 | 5801 |
| Surveyed '00 hooks | 936 | 285 | 166 | 0 | 1387 |
| % Coverage of class** | 28 | 44 | 71 | 0 | |
| Coverage as % of total | 16 | 5 | 3 | 0 | 24 |
| Sample by Total Catch (tonnes) | | | | | |
| Weight,all species | 261 | 50 | 21 | 110 | 464 |
| Surveyed all species | 71 | 24 | 14 | 0 | 109 |
| % Coverage of class** | 27 | 48 | 67 | 0 | |
| Coverage as % of total | 15 | 5 | 3 | 0 | 23 |

**Table II :** The survey coverage of different vessel classes in the domestic fishery. Source: Derived from the domestic logbook database, AFS.

** It was not possible to establish to which group the 'other 'vessels belonged.

| Vessel Type | Planing Longliner | Multi Purpose | Trawler |
|---|---|---|---|
| Number of Vessels | 11 | 7 | 3 |
| Length | 13.8 | 11.5 | 15.9 |
| Age | 8.5 | 17.3 | 23.7 |
| Days tuna longlining | 31.6 | 22.9 | 21 |
| Days other | 42.5 | 74.1 | 71 |
| Total days fished | 74.1 | 96.9 | 92 |
| Ratio of tuna non-tuna fishing days | 1: 1.3 | 1: 3.1 | 1: 3.3 |
| Tuna days as a % of total days fished | 43 | 24 | 23 |

**Table III**: The surveyed results for fishing activity in the domestic fishery by vessel class.

| Table IV Vessel Type | Planing Longliners (PL) | Multi Purpose (MP) | Trawlers (T) | Costs as % of Total Costs (PL) | (MP) | (T) |
|---|---|---|---|---|---|---|
| Number of vessels n= | 11 | 7 | 3 | | | |
| RECEIPTS | | | | | | |
| Total net receipts ($) | 111852 | 78724 | 85229 | | | |
| BOAT EXPENSES ($) | | | | | | |
| Administration | 3657 | 2118 | 4208 | 3 | 3 | 5 |
| Repairs and Maintenance | 11017 | 5080 | 11641 | 8 | 6 | 14 |
| Gear replacement and repair | 6996 | 7216 | 4539 | 5 | 9 | 5 |
| Fuel,oil and grease | 14520 | 6958 | 11571 | 11 | 9 | 13 |
| Payment to crew (inc skipper) | 36364 | 26449 | 30175 | 27 | 33 | 35 |
| Insurance | 3871 | 2429 | 2195 | 3 | 3 | 3 |
| Depreciation | 20166 | 8685 | 10321 | 15 | 11 | 12 |
| Interest | 11950 | 7542 | 2143 | 9 | 9 | 2 |
| Licence fees,rates and taxes | 5170 | 4065 | 4439 | 4 | 5 | 5 |
| Bait | 5501 | 3379 | 1836 | 4 | 4 | 2 |
| Marketing expenses * | | | | | | |
| Other boat expenses | 15716 | 5857 | 2911 | 12 | 7 | 3 |
| Annual cost (cash+int+ dep ) ($) | 134929 | 79778 | 85978 | 100 | 100 | 100 |
| Accounting Profit (loss) ($) | -23077 | -1054 | -748 | | | |
| Capital value of boat ($) | 183636 | 89633 | 163333 | | | |
| Accounting return to capital (%) | -12.6 | -1.2 | -0.5 | | | |
| Vessels earning positive accounting profit | 2/11 | 4/7 | 1/3 | | | |

**Table IV:** Accounting profit results of the Australian East coast tuna longline fishery survey for the 1989-90 financial year. Results are weighted means for each vessel class. The right hand side of the table records costs as a percentage of total costs for each vessel class.

Table V (a)

| Vessel Type | Planing Longliners | Multi Purpose | Trawlers |
|---|---|---|---|
| Total net receipts ($) | 111852 | 78724 | 85229 |
| Annual cost less interest | | | |
| Annual cost less interest and fees | 120479 | 69736 | 81335 |
| Opportunity Cost of Capital and labour | 25488 | 26235 | 25136 |
| Adjustment to depreciation | -14121 | -3572 | -5338 |
| Total economic cost | 131846 | 93334 | 101694 |
| Economic Profit ($) | -19994 | -14610 | -16465 |
| Economic rate of return (%) | -10.8 | -16.3 | -10.1 |

**Table V(a):** The economic costs and profits for each of the three vessel classes.

Table V (b)
(Calculated for comparison with Battaglene and Campbell, 1991)

| | | | |
|---|---|---|---|
| Return to full equity ($) | 1808.94 | -5098.63 | 3919.54 |
| Return to full equity as (%) | 1.0 | -5.7 | 2.4 |

**Table V(b):** The return to equity - calculated for comparison with Battagalene and Campbell, (1991).

Table VI a

| Variable cost of fishing<br>Units in dollars ($) | Planing Longliner (PL) | Multi Purpose (MP) | Trawlers (T) |
|---|---|---|---|
| Total Revenue net | 111852 | 78724 | 85229 |
| Variable Costs | | | |
| Gear replacement and repair | 3498 | 3608 | 2269 |
| Fuel,oil and grease | 14520 | 6958 | 11571 |
| Payment to crew (inc skipper) | 36364 | 26449 | 30175 |
| Bait | 5501 | 3379 | 1836 |
| Other boat expenses | 5238 | 1952 | 970 |
| Total Variable Costs (TVC) | 65122 | 42346 | 46822 |
| TVC as % of Total Costs | 49 | 45 | 46 |
| Total Fixed Costs (TFC) | 66724 | 50988 | 54873 |
| TFC as % of Total Costs | 51 | 55 | 54 |

**Table VIa:** The variable and fixed costs of fishing.

Table VI b

| Units in dollars ($) | TUNA (PL) | (MP) | (T) | NON TUNA (PL) | (MP) | (T) |
|---|---|---|---|---|---|---|
| Gear replacement and repair | 1491 | 851 | 518 | 2007 | 2757 | 1751 |
| Fuel,oil and grease | 7031 | 3440 | 1626 | 7489 | 3518 | 9945 |
| Payment to crew (inc skipper) | 15497 | 6237 | 6888 | 20867 | 20213 | 23287 |
| Bait | 4401 | 2703 | 1836 | 1100 | 676 | 0 |
| Other boat expenses | 2232 | 460 | 221 | 3006 | 1492 | 749 |
| Variable cost of tuna fishing | 30652 | 13691 | 11089 | 34470 | 28656 | 35733 |
| Fixed cost of tuna fishing | | | | | | |
| Economic cost of tuna fishing | 59087 | 25714 | 23615 | 72759 | 67620 | 78079 |

**Table VIb:** The variable and fixed costs of tuna and non-tuna fishing.

Table VII

| | TUNA FISHING | | | NON TUNA FISHING | | |
|---|---|---|---|---|---|---|
| | Planing Longliners | Multi Purpose | Trawlers | Planing Longliners | Multi Purpose | Trawlers |
| ANNUAL RESULTS | (PL) | (MP) | (T) | (PL) | (MP) | (T) |
| Income ($) | 50281 | 33267 | 20768 | 61571 | 45457 | 64462 |
| Economic cost ($) | 59087 | 25714 | 23615 | 72759 | 67620 | 78079 |
| Economic profit ($) | -8806 | 7553 | -2847 | -11188 | -22163 | -13618 |
| Economic rate of return(%) | -11.3 | 35.7 | -7.6 | -10.6 | -32.4 | -10.8 |
| DAILY RESULTS ($) | (PL) | (MP) | (T) | (PL) | (MP) | (T) |
| Tuna income per day | 1592 | 1455 | 989 | 1448 | 614 | 908 |
| Economic cost per day | 1871 | 1125 | 1125 | 1711 | 913 | 1100 |
| Variable cost per day | 971 | 599 | 528 | 811 | 387 | 503 |
| Fixed cost per day | 900 | 526 | 597 | 900 | 526 | 597 |
| Margin per day | 622 | 856 | 461 | 637 | 227 | 405 |
| FISHING DAYS | | | | | | |
| Days fished | 32 | 23 | 21 | 43 | 74 | 71 |
| Total days for class | 74 | 97 | 92 | 74 | 97 | 92 |
| Days fished as % of Total days | 43 | 24 | 23 | 57 | 76 | 77 |
| Capital attributable to fishing method ($) | 78258 | 21136 | 37284 | 105378 | 68497 | 126049 |

**Table VII :** The economic, variable cost and income for a day tuna fishing and non tuna fishing.

| Vessel Type | Planing Longliners | Multi Purpose | Trawlers | T* |
|---|---|---|---|---|
| Yellowfin tuna | $ 7.35 | $ 5.54 | $ 5.28 | $ 4.20 |
| All tuna species | $ 6.48 | $ 5.36 | $ 4.65 | $ 3.38 |
| Ratio of tuna sales Domestic:Export | 70:30 | 75:25 | 90:10 | 100:0 |
| Vessels sampled | 5/11 | 6/7 | 3/3 | 2/3 |
| Marketing costs as % of economic cost | 13.3 | 21.3 | 16.1 | 12.0 |

T * is for two trawlers marketing catch domestically

**Table VIII:** The estimated average price of tuna for each vessel class. The ratio of domestic to export sales and the approximate marketing costs as a percentage of economic costs are also shown (see Appendix Four).

# Appendices

## Appendix One

The domestic cost survey form used to survey fishermen in the east coast tuna longline fishery (Adapted from Geen et al., 1989).

FIRDC Project 90/98. Economics of the East coast tuna longline fishery.

---

**SURVEY OF THE EAST COAST TUNA LONGLINE FISHERY**

**Financial year 1989-90**

---

Vessel name. ______________________________

### Boat receipts

| | |
|---|---|
| Income from tuna sales | $ ...................... |
| Income from other fish sales | $ ...................... |
| Other vessel income | $ ...................... |
| **Total boat income** | $ __________ |

### Boat expenses

| | |
|---|---|
| Administration | $ ...................... |
| Boat repairs and maintenance | $ ...................... |
| Gear replacements and repairs | $ ...................... |
| Fuel, oil and grease | $ ...................... |
| Payments to crew (including skipper) | $ ...................... |
| Insurance | $ ...................... |
| Depreciation | $ ...................... |
| Interest | $ ...................... |
| Licence fees, rates and taxes | $ ...................... |
| Bait | $ ...................... |
| Marketing expenses | $ ...................... |
| Other boat expenses | $ ...................... |
| **Total boat expenses** | $ __________ |

### Market value of boat $ __________

---

Please return to
Mr Alistair McIlgorm, East Coast Tuna Longline Project,
Australian Maritime College, P.O.Box 21, BEACONSFIELD, TASMANIA 7277.
--- use the attached Stamp Addressed Envelope for convenience.--

No................

# East Coast Tuna Longline Survey Definitions

## BOAT RECEIPTS

**Income from tuna sales**

The total returns from the sale of tuna caught during the financial year prior to the deduction of marketing charges. (TUNA includes Yellowfin, Bigeye, Albacore, Billfish and skipjack.)

**Income from other fish sales**

The total returns from the sale of "non tuna" fish caught during the financial year prior to the deduction of marketing charges.

**Other vessel income**

Refers to all boat income not directly derived from the sale of fish. Such income may have been derived from charter fees, profits from the sale of capital items connected the business and rebates, refunds or discount relevant to the fishing activity - for example, payments by fishing co-operatives.

## BOAT EXPENSES

**Administration**

These costs comprise charges for:

- accountancy
- banking and legal
- electricity
- stationery
- subscriptions
- telephone
- other

**Boat repairs and maintenance**

These costs include:

- boat and equipment
- slipping charges
- other

**Gear replacements and repairs**

**Fuel, oil and grease**

**Payments to crew (including skipper)**

**Insurance**

These include charges for:

- boat insurance
- other capital items
- workers compensation

**Depreciation**

**Interest**

**Licence fees, rates and taxes**

- boat - Commonwealth and State
- wharfage
- radio
- management levies (membership to fisherman's association)

**Bait**

**Marketing expenses**

- boxes and other packing materials, packing costs
- commissions, agents fees, export fees and selling costs / tariffs
- freight, Air freight and cartage
- cool storage
- ice

**Other boat expenses**

These costs include all those not stated elsewhere which are incurred in the operation of the business unit.

- bad debts
- rations
- investment allowance
- lease payments - onboard equipment
- motor vehicle expenses
- protective clothing
- rent
- travelling expenses
- wages (excluding share payments)
- loss on capital items sold
- other

MARKET VALUE OF BOAT

Is the insured value of the boat including the hull, engine, radio, sonar, etc. but excluding endorsements. (or boat units if applicable)

## Appendix Two

The domestic Fishing Record form used to survey fishermen in the east coast tuna longline fishery about aspects of their fishing operation.

FIRDC Project 90/98. Economics of the East coast tuna longline fishery.

**EAST COAST TUNA LONGLINE**
**Fishing record**

### VESSEL

VESSEL NAME: ______________________ OWNER'S NAME: ______________

LENGTH O.A = ______________________ AGE OF VESSEL: ______________

VESSEL TYPE:

(a) Planing longliner (c) Trawler

(b) Multi-purpose vessel (d) Deep sea purpose built longliner/dropliner

What endorsements does the boat have? ______________________________

### FISHING

(i) If you fish in other fisheries, estimate your involvement in tuna fishing in days per year as accurately as possible for the July 1989/June 1990 period?.

ie.- other fishing method: ________days - longlining for tuna: ______days

(ii) What length is your normal tuna trip? ______________

(iii) Estimate your cost of fuel/trip? ______________________

(iv) BAIT Bait types used? ______________________________

______________________________

Estimate your Bait cost/trip? ______________________

(v) What species do you most regularly target ? (Rank in order 1-6 )

Yellowfin Bigeye Albacore Bill fish Blue Fin Skipjack

### MARKETING

(a)Where did you market most of your fish in the 1989/90 financial year (Estimate % by weight)

| DOMESTIC | EXPORT |
|---|---|
| Sydney Fish Market ____________ | Last year to Japan ____________ |
| Melbourne /Brisbane ____________ | Last year to U.S. ________ |
| Cannery ____________ | Last year to other destinations __ |

(b) Do you have a detailed records of all your marketing ? YES / NO

Who is your normal Agent/exporter for the Japanese market ______________

--Thankyou for your co-operation.--

Please return with the cost survey to
Mr Alistair McIlgorm,East Coast Tuna Longline Project,
Australian Maritime College,P.O.Box 21, BEACONSFIELD,TASMANIA 7277.
--- use the attached S.A.E.for convenience.--

## Appendix Three Adjustments for economic costs.

Economic costs vary from accounting costs in several ways as forgone alternatives must be costed. These are the opportunity costs capital and labour used in the fishing process.

### The Cost of Capital

The opportunity cost of capital was taken to be 13.4 %, the long term (15 year) government bond rate for the period (ABARE, 1990). The rate was applied to the capital value of the vessel as stated in the survey. This essentially is a riskless return to capital and thus is a conservative view and may understate the opportunity cost of capital.

### Opportunity cost of labour

Opportunity costs to labour are included in economic costs to reflect opportunities for employment forgone in alternative industries. It was decided to impute an opportunity cost of labour for the calculation of economic returns. Crewing details were obtained by telephone survey requesting full time and part time crew members. The survey data for crew wages included the wages of the skipper, who often was the owner as well. As an owner / operator, wages should be included in the opportunity cost of labour at a return similar to that paid to non-owner skippers in the fishery.

The skill level of the skipper was assessed to be similar to that of a qualified tradesman such as an electrician or plumber. Thus an independent measure of opportunity cost could be given by the minimum weekly wage for qualified electrician as stated in government pay award statistics. In the 1989-90 period this was $499.30 per week (Anon,1991a)

The skill level of a crewman was assessed as being equal to an unskilled labourer in the building trade. The 1989-90 minimum award wages levels were obtained at State level, as no federal award for this classification exists (Anon, 1991b). Opportunity costs of labour for full time fishermen were imputed at an annual wage rate, whereas part time fishermen were imputed on a per day fished basis.

### Other Adjustments

Several other adjustments were made to satisfy theoretical requirements for economic profit.

### Fees and Licences

Fees and licences can be interpreted as returns to the management of the fishery as a form of rent (Campbell and Nicholl,1991). As such the portion reflecting management cost should be removed as should other statutory and licences fees. This came to approximately $2500 of the cost category licences, rates and fees.

**Economic depreciation**

Economic depreciation is different from accounting depreciation, which is influenced by the tax system. The economic depreciation is the proportion of the capital value consumed in one year. It was assumed that vessels would have a remaining lifespan over which time the vessel would fully depreciate. The remaining lifespan was calculated for each vessel class. (i.e. the expected working life span of a vessel less it's age to date, available from the Fishing Record). The expected working lifespan was assumed to be 25 years for all vessel types.

A real rate of interest of 6 % was assumed for the lifespan of the asset. This was obtained from ABARE,(1990) and is the difference between the long term government bond rate and the rate of inflation in the 1989-90 period. This assumes that the expected rate of inflation over the remaining life of the asset will remain at 1989-90 levels. In the light of economic changes in 1991 and 1992, this rate may be high, but was chosen as the expectation at the time of the survey.Given real interest rates in the previous ten years it is assumed to be a reasonable long term rate.

Over the remaining life span of the asset the entire value of the asset in real terms will be consumed. This usually yields smaller results than accounting methods and is given by the formulas below:

$$S X = C$$

Where S = adjusting real interest factor, X = economic depreciation and C = value of the asset. given that

$$S = \frac{(1+r)[(1+r)^n-1]}{r}$$

where r = the real rate of interest and n = the lifespan of the asset

Depreciation was calculated for each vessel and class and an adjustment was made to the depreciation recorded in the accounting survey when calculating economic cost.

## Appendix Four Marketing costs

In the survey results used to obtain economic profit income was net of marketing costs. Most fishermen recorded income gross and stated marketing costs as an expense as per the survey recommendations. In other surveys actual marketing expenses were not stated.

### Domestic and export marketing

Tuna in the East coast fishery are sold domestically and in Japan. In the Fishing Record the fishermen surveyed were asked to estimate the percentage of tuna (by weight) exported or sold domestically. Table VIII was calculated using the Fishing Record and cost survey data .

In this table it can be seen that the ratio of domestic to exported tuna was high. Planing longliners and multi-purpose vessels sold 70% and 75% of tuna on the domestic market and exported 30% and 25% to Japan. For the trawlers surveyed, two of the three vessels sent all tuna to the domestic market.

Marketing cost as a percentage of economic costs was calculated for vessels that had recorded marketing costs. From Table VII it can be seen that trawlers spent 16.1% of economic cost on marketing all of their tunas in the domestic market.

This cost figure includes a market commission, usually between 9-11%, cooperative costs such as packing and transport by road as well as ice costs. This figure varied with distance of the fishing operation from market.

Fishermen in the multi-purpose and planing longliners sent fish to domestic and export markets. The figure of 13.3 % for marketing costs for planing longliners is almost certainly too low. However the figure of 21.3% for multi-purpose vessels is more likely to be closer to the expected costs. Personal contact with fishermen revealed that marketing, commission, transport and agency costs can be 40% or even 50% of gross sale revenue for fish exported to Japan. Obviously this is price dependent.

The erroneous figure for planing longliners can be explained as 6 of the 11 surveyed fishermen sent results net of marketing costs. Of the gross results that were sent, 3 of the 5 were below 10%. As market commission in Sydney is 9-12 % of gross revenue, and overall some 70% of tuna is marketed domestically, there is error here.

There are several reasons apparent.

i) Many fishermen obtain the bulk of their income from fish cooperative sales, often receiving revenue net of marketing costs. For fishermen to back calculate for the survey was too burdensome or not possible.

ii) With exported fish the paperwork states gross revenue less freight and commissions. For the survey, domestic sales net of marketing cost may have been added to export revenues with export costs being recorded as marketing costs. Thus marketing costs would be under represented.

iii) During contact with fishermen some fishermen indicated that export houses were offering a cash price in Sydney. Many fishermen used this to avoid uncertainty and inconvenience in personal shipments to Japan. Thus fish would have been recorded as exported in this survey and a net of marketing cost income received.

**Estimated costs of marketing**

A detailed quantitative marketing study of the variables associated with tuna marketing in this fishery was beyond the scope and resources of the present study. However an estimate of true export costs may be reflected in the result for multi-purpose vessels in Table VIII. Overall marketing costs as a percentage of economic cost were calculated to be 21.3%. This would imply that if domestic costs are 16.6% that export costs are approximately 33.4% of total cost[3]

The cost of a days tuna fishing previously calculated without marketing and freight costs and commissions could be thought of as the cost of a tuna landing on shore. This cost could be adjusted to Sydney market equivalent by the addition of at least 12% of economic cost. Similarly shore price plus 33% of economic costs would be an average cost to market in Japan. These results should be treated with caution. Marketing arrangements in this fishery are complex and costs can vary considerably.

---

[3] Note that

$$(Cd*Pd)+(Ce*Pe) = (Coa*Poa)$$

where Cd= the % cost of domestic marketing Pd= the proportion of tuna marketed domestically Ce= the % cost of export marketing Pe= the proportion of tuna exported Coa = the % cost of overall marketing Poa = the proportion of tuna marketed overall. re arranging $(Ce) =((Coa*Poa)-(Cd*Pd)) / Pe$ can be solved to give the % cost of exported tuna (33.4% for the data in Table VIII).

Fisheries Research and Development Corporation, (FRDC).

Project 90/98, final report, part two,

December, 1992.

# A Bioeconomic Analysis of the East Coast Tuna Longline Fishery.

By H.F. Campbell, Department of Economics, University of Tasmania.
and A. McIlgorm, School of Fisheries, Australian Maritime College.

**A Bioeconomic Analysis of the East Coat Tuna Longline Fishery.**

H.F. Campbell, University of Tasmania and A. McIlgorm, Australian Maritime College.

**Preface**

This is second part of the final report of the Fisheries Research and Development Corporation (FRDC) project No: 90/98 (1990-1992):*"An economic analysis of the management options for tuna fishery development in the east coast tuna longline fishery of the Australian Fishing Zone".*

Project participants: Professor H.F. Campbell, Dr A.D McDonald and Mr A.McIlgorm.
Co operating Institutions: The Department of Economics, University of Tasmania and the School of Fisheries, Australian Maritime College.

The objective of the research project is to provide economic analysis that will assist in future management of tuna in the eastern Australian Fishing Zone, with particular reference to the area north of Barrenjoey point taking account of :

*" i) The costs and returns of the Australian vessels in the domestic fishery*
*ii) The benefits to Australia from licensing the Japanese fleet compared to other arrangements and*
*iii) The interactions between the inshore and offshore fisheries ".*

FIRDC project 90/98 proposal 1990.

The results of the research are presented in this second of two reports which will be presented to ECTUNAMAC in December 1992 as a final draft of the results of the project. The present study draws on parts of McIlgorm (forthcoming).

**Project Contact Officer:** Alistair McIlgorm, School of Fisheries, Australian Maritime College.
Tel. (003) 834404 Fax (003) 834766

**Acknowledgements**

Funding for this research was provided by the Fishing Industry Research and Development Council (FIRDC), now called the Fisheries Research and Development Corporation, under Project 90/98. We wish to thank the following people for their assistance in obtaining the data required for this study: Martin Exel and Geoff Gorrie, Australian Fisheries Service; Albert Caton, Caesar Ramirez and Peter Ward, Bureau of Rural Resources; Bob Miller, New South Wales Fisheries Department; Thim Skousen, Australian Fisheries Management Authority; and Mike Rowley, Daito-Fortuna Pty Ltd. The following organizations also helped in the provision of data: the South Pacific Commission and the New South Wales Fish Marketing Authority. We wish to thank David McDonald and Rob Nicholl, Department of Economics, University of Tasmania for help in analysing and interpreting the data. We also thank Carol Scott, Australian Maritime College, for drawing the diagrams, and John Wallace, School of Fisheries, Australian Maritime College, for research support.

**Executive Summary**

This is the first study to address the bio-economics of the longline fishing activity of both the Japanese and Australian vessels operating in the Eastern AFZ. The fishing activity and data available for both nationalities are reviewed giving an overview of the fishery.

The study uses a revenue function to model the technology of production in the Japanese multi-species tuna fishery though this method was less suited to the domestic fishery which is mainly based on a single species, Yellowfin.

Tests established that there is a significantly different Northern and Southern region in the Japanese fishery around the line 25°S. A revenue function was used to assess the relationships between market price, effort and catch rates in the fishery for small and large Japanese longliners (below and above 200 GRT respectively). This method uses shift parameters to take account of annual, seasonal and regional variations in tuna stocks.

The analysis of the Japanese fishery showed significant production differences between small and large vessels. In the northern region there is little opportunity to vary species mix of the catch whereas in the southern area there is noticeable targeting of species in response to price changes. In the south Bigeye and Yellowfin are produced together as complements with an increase in the catch of one species leading to an increased catch of the other species also. Albacore and Bigeye are produced as substitutes indicating that an increase in the catch of Albacore will lead to a reduced catch of Yellowfin. The analysis for the overall fishery indicated some inter-relationships between Yellowfin and Marlin but these were not confirmed in the separate regional analyses. From the responsiveness of supply of the species to the changes in fish prices, management can determine the possible affects of implementation of species specific quotas.

Returns to effort were investigated for the Japanese vessels, and individual vessels fishing in the north, and small vessels in the south, did not experience any decrease in catch rates with increasing monthly effort. However larger vessels showed decreasing returns to effort when increasing monthly effort . Small vessels in the south were found to be applying the profit maximising level of effort though in the north the small vessels could apply more effort. The larger vessels were found to be applying to much effort in the north and the south and would be advised to fish elsewhere for maximum profit if altern tive grounds were available.

The Japanese and Australian production processes were compared in a limited area off northern New South Wales for the years 1988 and 1989. The comparison was made difficult by having many Australian vessels only catching Yellowfin tuna. Targeting for the Australian vessels that caught more than just Yellowfin was not different from the Japanese vessels, however catch per unit effort was three times higher for the Australians and could be as great as eight times higher if vessels catching only Yellowfin are included. This is probably due to the difference in the two longline operations as the

Australian vessels are more manoeuvrable and can search and set gear for small aggregations more easily than the large industrial Japanese vessels which tend to fish at greater depths.

In the analysis of domestic production the area north of 25°S was excluded from the analysis which centred on a northern area and southern area around the 34°S line of latitude. The revenue function was not used due to the predominantly single species nature of the domestic fishery and the limited price data available. A direct production approach was used relating catch to effort with a temperature proxy variable and shift variables for annual and seasonal fluctuations to account for availability of Yellowfin in the absence of direct observations on stock. The northern area was found to have significantly higher returns to effort for Yellowfin than the area south of 34°S where local aggregations of Yellowfin appear to be more quickly exhausted. Yellowfin productivity by vessel class was assessed for available data and it was found that purpose built longliners had significantly higher catch rates than other vessels types though trawlers in the northern fishery performed well in limited tuna fishing activity.

The eastern Australian area is subject to annual, seasonal and spatial fluctuations between major areas. Sub zones were constructed at 50 mile intervals from the coast and at 150 miles intervals in the outer zone (figure 2). Seasonal abundance was estimated for each species in the Japanese fishery, the seasonal patterns being more pronounced in the non tropical southern region south of 25°S. Seasonal differences were significantly different for small and large vessels, though in the comparison of large Japanese and Australian vessels there was no strong evidence of significantly different patterns of seasonal distribution. All estimations confirmed the higher availability of Yellowfin in the July to September period off the northern coast of New South Wales. In the estimations of the domestic fishery the seasonal advantages of moving fishing operations along the New South Wales north and south coast are marginally significant when Yellowfin tuna cach rates are being considered. The model indicates these area decisions are difficult and will vary from year to year.

Inter-annual fluctuations were ranked for the six years of Japanese fishing activity. Years were noted to be significantly different from one another but there were no significant patterns in the rankings. The domestic fishery estimations for the northern area found significantly higher Yellowfin catch rates in the years 1988 and 1990 than in 1987 and 1989 while 1987 had significantly lower Yellowfin catch rates than the other years in the south. Yellowfin catch rates were significantly higher in the south than the north in 1989 probably due to the influence of the east Australian current.

The zonal distribution of Japanese catch rates of all species varied between small and large vessels in the north and south differing in availability between species. Highest catch rates of Albacore and Marlin were found in the outer zones more than 200 miles from shore whereas the general trend for Yellowfin and Bigeye was for higher catch rates inside 200 miles from shore. Swordfish distribution by sub zone was highly variable.

Catch rates of Australian vessels catching Yellowfin only in the outer area 50-100 miles from shore were significantly lower than in the inner zone 12-50 miles from shore. This result was not confirmed by the direct analysis of domestic catch rates which found no significant difference in Yellowfin catch rate with distance from shore. The reason may be related to the significant temperature variable indicating that proximity to optimum temperature and location of Yellowfin is more critical than distance from the coast. Other terms responsible for some variation in catch rates in the domestic fishery were moonphase in the north of the domestic fishery where fishing on the new moon brought highest catch rates. The northern area also had significantly greater catch rates for longer soak times whereas this was not important in the south and where the patrolling of the line was found to increase catch rate by 11%.

The sustainability of the fishery was investigated by joining Fisheries Agency of Japan data and more recent logbook data to form a time series of catch rates by number of fish for the 1962-1989 period for an area wider than the AFZ. The analysis used shift variables to represent changes in log book systems which were significant structural changes in the data set. The commencement of the domestic fishery was included as avariable and there was no evidence of significant depletion in Japanese catch rates for all species in the 1983-1989 period. This result may be interpreted as there being no significant deterioration in catch rates in the East Australian area with the development of the Western Pacific fishery in the same period. The restrictive assumptions on which this analysis is based means this result should be interpreted with caution. The only significant depletion trends were for Albacore and Yellowfin though these did not appear to be threatening the future of the fishery.

Price comparisons for the years 1988 and 1989 of the Japanese frozen, chilled/fresh and Australian sashimi markets confirmed that the Japanese chilled tuna market has significantly higher prices than the Australian market and the Japanese frozen tuna market. When the Japanese chilled prices were brought back to Sydney equivalence by deduction of relevant freight costs for the period, the Yellowfin prices in the Japanese chilled market net of freight were not significantly higher than the domestic sashimi market, though there was a significant premium for Bigeye in the Japanese market. An overall comparison of prices between Australian and Japanese vessels in the AFZ revealed that Australian producers had a 40% price advantage for Yellowfin and a 30% advantage for Bigeye.

Rent in the Japanese fishery was estimated for the Years 1984-1989. This paper uses the direct approach of comparing the Total Revenue from effort with the Total Cost of effort as opposed to other less direct methods (Brown and Dann,1991). A comparison of costs of effort for the Australian and Japanese vessels reveal that the Australian cost of effort is approximately twice that of the Japanese. Only in 1985 were economic profits positive in the total Japanese fishery. The northern fishery generally returned higher rent than the southern area and small vessels had consistently higher rent than the large vessels. Seasonal fluctuations in rent were evident as were variations in rent with zones where the area inside 200 miles was generally more profitable than the outer region of the zone.

The poor performance of the Japanese fleet was investigated by two further tests. The operating profit was obtained by comparing Total Revenues from effort with the operating cost of effort. For the larger vessels in the south the operating profit was still negative indicating the vessels would apparently be better off tied up. This prompted investigation, in the light of recent experiences in the SBT fishery, of under recording of logbook catches by Japanese vessels in the 1984-1989 period. Under different assumed rates of under recording across the fleet the economic returns improved and covering operational costs looked probable. The true rate of under reporting catch is unknown though even under liberal assumed rates there are profitability problems for the larger vessels, particularly in the south of the fishery. The economic losses confirm the results of other recent studies on rent in Japanese tuna fisheries (Campbell and Nicholl, 1991). However losses in the east coast fishery may be acceptable if the Japanese have previously been fishing SBT fishery and are topping up with catch prior to returning to Japan. The nature of the inter-relationship is unknown.

The future of Japanese access is not clear given these poor results. The rent calculations do not include payment for access which has been at 6% of Total Revenue since 1989 and the long run viability of Japanese fishery must be questionable without subsidisation from Government restructuring programmes or from the vessels' other fishing activities in the SBT fishery. The analysis indicates that differential access fees for small and large vessels may be a possibility. The profitable performance of small Japanese vessels in the fishery may be a indication of the potential for the appropriate Australian vessels. Insufficient observations on larger Australian vessels did not allow comparison with the Japanese vessels in the time period covered by this study.

Rent in the domestic fishery was negative in the 1988 and 1989 period when considering revenues from Albacore, Bigeye and Yellowfin tuna only. The rent in the northern fishery was higher than the south, particularly in the July to September period in the north when positive rent was obtained in both years. Rent estimates by vessel class indicate that the positive returns obtained by multi-purpose vessels and trawlers exceeded those of planing longline vessels which had negative rent in both fisheries. This indicates the tuna fishery is profitable for given seasons and in lower cost vessels.

In conclusion the limited study of available data for the inshore area showed Australian vessels to have significantly higher catch returns to effort than the Japanese but at a cost of effort twice that of the Japanese. This indicates Australian vessels are more efficient in inshore areas, though displacement of the Japanese in areas more distant from shore could only be justified by analysis of the activity of larger Australian vessels relative to the Japanese. Also the fact that the domestic vessels are not fully exploiting the range of available species needs to be taken into consideration. Given the lack of profitability of the Japanese fleet offshore and their willingness to pay access fees it is unlikely that total exclusion of the Japanese is a justifiable option given a limited ability at present for Australian vessels to take over the fishery.

## Table of Contents

## Bioeconomic Analysis of the East Coast Tuna Longline Fishery

## 1. Introduction

The first Part of this Report dealt with the costs and returns of Australian vessels operating in the East Coast Tuna Longline Fishery. This Part presents the results of a bioeconomic analysis of the fishery and discusses some implications of the results for the management of the fishery. The purpose of the bioeconomic analysis is:

(i) to determine the production technology of the Japanese and Australian vessels which have been operating in the fishery. By production technology is meant the relationship between the catches of various species, the vessels, and the fish stocks. This information will indicate the constraints under which management is operating and will reveal whether multi-species management of the fishery is feasible;

(ii) to analyse the seasonal and inter-annual fluctuations in catches resulting from the interaction of the vessels with the fish stocks. There is insufficient information available about the biology of the tuna stocks to determine whether the current levels of exploitation are sustainable. Instead the Report determines whether there is any pattern of decline in catch rates over the period of the analysis, holding other factors constant;

(iii) to analyse the spatial pattern of harvests to determine where the highest catch rates for the various species typically are. This information will be useful for management purposes;

(iv) to compare the operations of Australian and Japanese vessels to determine whether there are any significant differences in production technology, efficiency, or product markets between the two fleets.

## 2. The Data

### (i) Data Sources

### (a) The Area and Zones

The study area is the Eastern Australian Fishing Zone (AFZ) in which the East coast tuna fishery extends from Cape York in the north to the New South Wales and Victorian border in the south. The area, along with management exclusion areas as of late 1990, is shown in Figure 1. The foreign fishing activity is exclusively Japanese, with longlining vessels in the area north of 34° South. Some Japanese vessels participate seasonally in the handline fishery in Box '171' in the north of the fishery, but this activity was excluded from the study. The foreign fishery was divided into two regions, north and south, by the line of latitude 25° South as it is believed these areas may be two distinct fisheries. The dividing line, 25° South is shown in Figure 2. Sub-zones at distances from the coast were also constructed in each area of the fishery. Figure 2 illustrates, for each region, the four inner zones, which are fifty miles in width, and the two outer zones which are 150 miles wide.

In the domestic fishery most activity is in the coastal waters of New South Wales in the area south of Sydney (approximately 34°S). While the study concentrated on the area north of Sydney, which is fished by the Japanese vessels, the domestic production south of Sydney was also investigated in the area closed to the Japanese. Southern Bluefin Tuna was not considered in either fishery.

### (b) The Catch and Effort Data

Data for both the Japanese and domestic fisheries were provided by the Australian Fisheries Service. The Japanese data set of primary interest was from the Australian Fishing Zone Information System (AFZIS) logbook TL04 records for the years 1984-1989 inclusive. AFZIS records for the 1979-1983 period and the Fisheries Agency of Japan records for the 1962-1980 period were used in assessing the longer term sustainability of the fishery.

Data on the Gross Registered Tonnage (GRT) of Japanese vessels were provided through the Bureau of Rural Resources (BRR), from the Australian Fisheries Service (AFS,now the Australian Fisheries Management Authority) and Forum Fisheries Agency licensing records.

The domestic data available were AL02 logbook records for the 1986-1990 period. The domestic data set recorded variables not available in the Japanese data set such as details on patrolling fishing lines and water temperatures observed by fishermen. Details on vessels in the domestic fishery were provided by AFS but supplementary details on the characteristics of each domestic vessels were obtained from the New South Wales Coordinator and AFS tuna section.

### (ii) The Japanese Fishing Activity in the Eastern AFZ

The Japanese catch and effort data were daily observations of fishing activity in the East Australian area. The vessels were identified and put into size classes of below and above 200 GRT. The daily effort was recorded in hooks set per day. Table 1 reports the number of each vessel class in the fishery during the 1984-89 period, the average number of hooks set per day in each year, and the number of observations available. Overall effort in terms of boats in the fishery and the number of hooks set by each vessel are seen to have risen over the study period. The daily number of hooks set by each vessel has also risen. Table 2a reports the catch and effort (in millions of hooks) in each year of the study. The catch and effort have risen during the study period with the total weight of fish reaching 7486 tonnes in 1988. From Tables 2b and 2c it can be seen that there is greater fishing activity and catch in the northern area. Table 3a reports the effort and catch of each species from the north and south as a percentage of the total catch. Over the six years 1984-89 the Japanese expended 68% of effort in the southern region and caught 80% of the total Japanese catch of Bigeye, 82% of the total catch of Swordfish, and 68% of the total catch of Striped Marlin in that region. Low percentages of the total catches of Black and Blue Marlin were taken in the southern region. Yellowfin and Albacore catch rates were higher in the northern region but the absolute size of the catches were larger in the southern region.

The gross value of the Japanese fishery is reported in Table 4a. The fishery had its highest catch value in 1988 when its nominal value was A$33.6 million. Table 4b reports the value of the northern and southern region as a percentage of total value. The overall mean percentages of revenue indicate that 62% of total revenue is obtained from the 68% of total effort applied to the southern region of the fishery. In the north Albacore,Yellowfin, Black Marlin and Blue Marlin make a greater than proportional contribution to revenue while in the south Bigeye, Swordfish, and Striped Marlin make a greater than proportionate contribution to revenue. This is indicative of the distribution of the species in the different areas.

**(iii) An Overview of the Domestic Data**

In the domestic fishery Yellowfin, Albacore and Bigeye are the most frequently caught species. Marlin are protected and few Billfish are captured, due to marketing problems. A limited amount of Southern Bluefin Tuna is captured in the southern part of the fishery but is not considered in the study. Table 5a reports the average daily catch and effort for the domestic fishery for the 1986-1990 period, as well as information on soak time, water temperature, and the total number of observations available. Table 5b reports for each year the total catch by species, total effort, and the number of observations available. The rise in reported catch and effort may be misleading as the database coverage was poorest in the 1986 period, but by 1989 was thought to be approximately 90% of activity in the study area. The data for 1990 is incomplete due to late logbook returns and figures reported here do not include joint venture vessels or large Japanese style vessels operating in the domestic fishery. Table 5c reports the percentages of total domestic catch by species and effort occurring in each year in the northern and southern regions of the fishery. The area north of 34°S has 32% of the total effort and 56% of the total Yellowfin catch. In the South 68% of the effort yields 76% of the total Albacore catch and 92% of the Bigeye catch.

Zonal distribution of the catch and effort in the fishery is reported in Table 6. The mean effort and catch of the most important species, Yellowfin, was calculated for the years 1987-1990. In the total domestic fishery 25% of the effort and 24% of the catch of Yellowfin catch occur in the innermost 12 miles. The area of prime importance is the zone 12-50 miles from shore which has 64% of the domestic effort and 67% of the domestic catch. The mean effort and catch for the northern and southern areas show the same general zonal pattern but a greater percentage of effort and catch occur in the innermost 12 miles in the southern than in the northern region.

The mean catch and effort per annum for each vessel class in the fishery was calculated and is reported in Table 7. In approximately 14% of observations the vessel class could not be identified. In the overall fishery planing longliners contributed 66% of the total effort with multipurpose vessels and trawlers generating 14% and 12% of total effort respectively. Purpose built longliners contributed 8% of the total.effort. The pattern in the north and south was not particularly different though the planing longliners contributed a greater proportion of total effort in the south and trawlers contributed a greater proportion of effort in the north. It should be noted that the purpose built category did not include the larger Japanese style vessels and some of the larger purpose built vessel whose records were not in the data set due to delays in submitting logbook returns. As can be seen from Table 7 the purpose built vessels lay a greater average number of hooks than the other vessel classes.

### (iv) The Price Data

Japanese frozen tuna market prices of all species caught by the Japanese landed at the port of Yaizu in Japan for the 1984-89 period were obtained from AFS. The observations were a monthly average price for each species. Japanese fresh market average monthly prices were obtained from the Fortuna-Daito Fishing Company for the years 1988-1989. Domestic market prices were extracted from New South Wales Fish Marketing Authority hard copy records for weeks in the 1988 and 1989 period. These were changed to monthly averages for comparison with Japanese data. The sashimi category was predominantly Yellowfin with an unknown proportion of Bigeye.

Figures 3a and 3b report a graph of the monthly average prices for tuna and billfish in the Japanese frozen Market in the 1984-89 period. Figures 4a, 4b and 4c are graphs comparing the Japanese and Australian fresh market prices for Yellowfin, Bigeye and Albacore and Billfish.

With both domestic and export marketing occurring in the domestic fishery an average price for each species caught in the domestic fishery was required for modelling purposes. The average tuna price was constructed for each species for the period in question using estimates of the proportion of each tuna species exported and marketed domestically. The domestic Yellowfin catch can be sold in the Sydney fish market as sashimi, Yellowfin gutted, Yellowfin gutted- head on, and if poor quality, can be sold for canning. Thus to establish an average price for Yellowfin in the Sydney market required construction of a weighted average price based on estimates of the amount of longlined Yellowfin sold in each category. The price index was given by the formula:

$$WAPS_{Yfn} = Q_1 *P_S + Q_2 *P_G + Q_3 *P_{HO} + Q_4 *P_C$$

where $Q_1$ is the proportion, by weight of Yellowfin sold as sashimi, $Q_2$ the proportion by weight of Yellowfin sold as gutted Yellowfin, $Q_3$ the proportion by weight of Yellowfin sold as "Yellowfin head on" and $Q_4$ the proportion by weight of Yellowfin sold to canneries, $P_S$ is the average monthly price of sashimi, $P_G$ the price of Yellowfin gutted, $P_{HO}$ the price of Yellowfin head on, and $P_C$ the cannery price for Yellowfin. The proportions were estimated from annual market data for the period. Estimated proportions are shown in Table 8b.

The overall Weighted Average Price (WAP) for Yellowfin in the domestic fishery was given by:

$$WAP_{Yfn} = (Q_e * P_e) + (Q_d * WAPS_{Yfn})$$

where $Q_e$ is the proportion of Yellowfin exported to Japan, $P_e$ is the average monthly price of Yellowfin in the Japanese fresh market (less freight and packaging from Sydney), $Q_d$ is the proportion of Yellowfin sold in Sydney market, and $WAPS_{Yfn}$ is the weighted average price of Yellowfin in the Sydney market. Table 8a gives the estimated ratios of exported and domestically marketed tuna for the period. The figures were estimated from Australian Quarantine Inspection Services (AQIS) export data.

The prices of tuna recorded in the Japanese fresh tuna market were observed prior to deduction of transportation costs, including air freight, packaging and administrative charges. For construction of the average Yellowfin price, the Japanese prices were adjusted to equivalent Sydney price by the deduction of an estimated transportation cost of 500 Yen per kilogram. This figure was obtained from discussions with fishermen who had regularly exported fish during the period.

Revenue from tuna sold in Japan is initially received in Japanese Yen and exchanged to Australian dollars. The Australian weighted average Sydney tuna prices were converted to Japanese Yen prior to formation of the weighted domestic price using the appropriate exchange rate (ABARE, 1991)

### (v) Comparison of the Japanese and Australian fisheries

Japanese and Australian production processes are compared in the 100 mile study area shown in Figure 5. The catch and effort for both the nationalities are reported in Table 9a. The zones 1 and 2, 12-50 and 50-100 miles respectively from the coast, are common to both fleets but the innermost zone, zone 0, is reserved for Australians only. Australian effort yields fewer species than the Japanese effort and Yellowfin tuna is the major species produced by the Australians. The Japanese total effort in hooks is considerably larger than the Australian effort.

The catches per unit effort are reported for all species for both nationalities in the sub-zones for the years 1988 and 1989 in Table 9b. These are compared in Table 9c where the ratios of the Australian CPUE/Japanese CPUE is reported. It can be seen that the Australian CPUE for Yellowfin is considerably higher than the Japanese CPUE by a factor of between 3 and 10 times. The relative CPUE for Albacore fluctuates between nationalities as does the CPUE for Striped Marlin. However for Bigeye and Swordfish the Japanese have a considerably higher CPUE. These observed results support the view that the Japanese fishery is multi-species and the Australian fishery is based on Yellowfin tuna.

## 3. Method of Analysis

The analysis assumes that individual fishing vessels operate independently of one another and that they have no influence over the prices received for their catch. It assumes that vessel operating costs are independent of harvesting activity: in other words, that the labour, fuel, supplies and bait costs are incurred at a fixed rate per unit of effort independent of the level and species mix of harvest. In these circumstances, the objective of a vessel at sea is to maximise the value of its catch per unit of effort. Using standard economic assumptions about the technology of production, and assuming the objective of revenue maximisation, the revenue of each vessel is described by the following Equation:

$$R(Z,P) = \Sigma_i \Sigma_j \, ß_{ij} \, (P_i \; P_j)^{1/2} \, Z + \Sigma_i \, ß_i P_i \, Z^2$$
$$+ \Sigma_i \Sigma_k \, a_{ik} \, D_k P_i Z + \Sigma_i \Sigma_m \, \mu_{im} \, Q_m P_i Z$$

where Z is effort (measured as hooks * GRT/100 per vessel per month), $P_i$ and $P_j$ are the prices of the i th and j th species, $D_k$ are the dummy variables for years (1984 is the base year), $Q_m$ are the quarterly dummies for season (January to March is the base season).

This form of the revenue function has been used in the analysis of other multi-species fisheries (see Squires and Kirkley (1991)). The supply equation for each species corresponding to the revenue function is given by:

$$\frac{dR(Z;P)}{dP_i} = Y_i(Z;P) = ß_{ii} Z + ß_i Z^2 + \Sigma_k \, a_{ik} \, D_k \, Z + \Sigma_m \, \mu_{im} \, Q_m Z + $$
$$+ \Sigma_j \, ß_{ij} (P_j / P_i)^{1/2} Z$$

When the individual vessel data are fitted to the revenue function the technology of the fishery and the form of the individual species supply equations can be ascertained from the results. For example, if the estimated values of the coefficients Bij i neq j are not significantly different from zero the supply of each species takes the form:

$$\frac{dR(Z;P)}{dP_i} = Y_i(Z;P) = ß_{ii} Z + ß_i Z^2 + \Sigma_k \, a_{ik} \, D_k \, Z + \Sigma_m \, \mu_{im} \, Q_m Z$$

which indicates that the supply of each species depends only on the level of fishing effort and not on the species prices. If, on the other hand, the Bij i neq j coefficients are non-zero then relative prices affect the catch mix. This implies that vessels are able to vary the species mix of their catch, by targeting species, in response to price changes. Pairs of species may be complements in the sense that they tend to be caught together so that an increase in the market price of one species will tend to increase the catch of the other; or they may be substitutes in the sense that vessels can target one at the expense of the other, and an increase in the price of one species will reduce the catch of the other. The existence of relationships of this kind is a result of the interaction between the gear and behaviour of the fishing vessels and the behaviour of the stock. A production process which has inter-relationships of this kind is termed **a joint production process** and the revenue function will reveal this characteristic if it exists.

The revenue function will also indicate whether individual catch rates vary with the amount of effort used. If the estimated coefficients, $\beta_i$, are not significantly different from zero there are no local stock depletion or gear saturation effects as a result of a vessel's fishing activity. If this is the case, then the species mix of the vessel's catch is independent of the level of effort it expends. In that case the production process has **input-output separability**. If the production process is non-joint and separable the various species in the catch can be aggregated for management purposes.

The revenue function described above takes no account of the behaviour of the fish stocks. Ideally the fish stocks should be included in the estimation of the production technology. However, this information is not available and alternative ways of taking account of stock fluctuations and trends have to be devised. Seasonal and inter-annual fluctuations can be incorporated into the estimation of the revenue function by means of shift variables which adjust the catch upwards or downwards for the seasonal and annual patterns contained in the data. Differences in production conditions in various parts of the Zone can be accommodated in a similar same way by allowing revenue to shift upwards or downwards as indicated by the data for the various sub-zones.

The absence of estimates of levels of fish stocks is an unavoidable limitation of the analysis. An attempt has been made to check the results of the revenue analysis by conducting an alternative form of production analysis, based on a production function. This method assumes that catch is determined by effort and stock according to the following relationship:

$$h = A \quad E^{\alpha} \quad X^{\beta}$$

where h is harvest, A, $\alpha$ and $\beta$ are constants, E is vessel fishing effort, and X is fish stock. Since fish stock data are not available a proxy variable for stock is used in the estimation of the above equation. Biological research and industry experience have revealed that the distribution of tuna stocks is partly determined by water temperature. This means that a vessel which is fishing an area of "ideal" temperature is likely to have access to a larger portion of the tuna stock than a vessel fishing elsewhere. Thus water temperature can be used as a proxy for the local availability of fish stocks to vessels. Since water temperature observations were available for the domestic vessels only the use of this approach was confined to the analysis of the Australian data. The disadvantage of this approach to production analysis is that it is not able to deal with the multi-species nature of the fishery.

The analysis is carried out in several stages:

(i) the Japanese price, catch and effort data are used to fit the revenue function and the technology of the Japanese vessels, together with seasonal, inter-annual and sub-zonal variations are estimated;

(ii) the Australian price, catch and effort data are used to fit the revenue function and similar information is derived for the Australian vessels fishing in sub-regions of the Zone as for the Japanese vessels;

(iii) the technology of the Japanese and Australian vessels is compared by fitting the revenue function to the data for vessels of both nationalities operating in a sub-region of the Zone; and the technology of different types of Australian vessels is also compared;

(iv) the Australian catch, effort and water temperature data are fitted to the production function and the results compared with those obtained from the revenue function analysis;

(v) the Japanese catch data are analysed to determine whether there is evidence of stock depletion;

(vi) the level of prices received for the various species by Australian and Japanese vessels is compared by analysis of average prices;

(vii) the rent or profit generated by various classes is estimated for Japanese and Australian vessels in the fishery.

## 4. Results

The results of the analyses are summarized in this Section of the Report. Detailed statistical information is not reported here, but will be reported in A. McIlgorm An Economic Analysis of the Australian East Coast Tuna Longline Fishery. Ph.D. Thesis in preparation, Department of Economics, University of Tasmania.

### (i) The Production Technology of Japanese Vessels

The revenue function was first estimated for the fishery as a whole and then for the Northern and Southern Regions separately. Statistical tests indicated that technology differed between the Northern and Southern Regions. The revenue function was then estimated separately for large (>200 GRT) and small (<200 GRT) vessels operating in each of the Regions. Tests indicated that the technology of large and small vessels was different. Consequently results are reported for each Region and each class of vessel.

### (a) Jointness

Tests indicate that the production process in the Southern Region is joint and the process in the North is generally non-joint. For large vessels operating in the Northern Region there is little opportunity to influence species mix. The only significant relationship is between Bigeye and Swordfish which are substitutes: in other words, if a vessel attempts to increase its Bigeye catch it will catch fewer Swordfish. For small vessels operating in the Northern Region there is no opportunity to influence species mix. Thus the species mix of the catch in the Northern Region is largely technically determined and there is little opportunity for vessels to increase their revenue by targeting high priced species or for management to control harvests of individual species. The analysis of the data for the overall fishery indicated that Marlin and Yellowfin were complements and Marlin and Swordfish were substitutes. However this result was not confirmed in the separate analysis of the Northern Region.

Production in the Southern Region was found to be joint, with vessels having the opportunity to vary the species mix of the catch in a number of ways. For both sizes of vessels Bigeye and Yellowfin were complements, Bigeye and Swordfish were substitutes, and for larger vessels Albacore and Bigeye were substitutes.

### (b) Separability

Input-output separability was found for both sizes of vessels in the Northern Region of the fishery, and for small vessels operating in the Southern Region. This means that the catch per unit effort does not vary with the level of effort at the vessel level, and that the species mix of catch does not vary with the level of fishing effort, although it may vary with relative product prices where species are complements or substitutes. Large vessels operating in the Southern Region are subject to input-output separability and experience decreasing catches per unit effort as the level of effort increases.

### (c) Individual Vessel Level of Effort

Tests were conducted to determine whether individual vessels were applying the levels of effort to the fishery which maximized profit. Since the optimal level of effort varies from Quarter to Quarter and from Year to Year, and since conditions in the fishery also vary it is not expected that a particular class of vessels has consistently been applying the profit maximizing level of effort over the period of study 1984-89. However the following general results were obtained:

- small vessels (< 200 GRT) in the Northern Region of the fishery were generally applying less than the optimal level of effort, whereas in the Southern Region they were generally applying the optimal levels;

-large vessels (> 200 GRT) were generally applying more effort in both Regions of the fishery than the level consistent with individual vessel long-run profit maximization. It would pay these vessels to shift some of their effort to a suitable alternative fishery if one were available.

### (d) Supply Response to Relative Price Changes

Where production is joint in nature, as in the Southern Region, a change in relative species prices will result in a change in the species mix of the catch, with reductions in catches of some species and increases in catches of others for the same level of vessel effort. These changes in catches are described by elasticities which report the percentage change in the quantity of a species supplied in response to a 1% increase in the price of that species or another species. The supply response elasticities quantify the substitute/complement relationships already reported in Section 4 (i) (a) above on jointness in production. Since the Northern Region of the fishery was generally non-joint in production the supply of species in that Region will depend on price only indirectly through the effect of prices on the level of effort. In the Southern Region the species mix of the catch responds to changes in relative prices, with the level of vessel effort held constant.

The significant supply responses in the Southern Region are summarized as follows:

*Small Vessels (< 200 GRT)*

A 1% rise in the price of Yellowfin results in a 0.9% rise in the catch of Bigeye;
A 1% rise in the price of Bigeye results in a 0.5% rise in the catch of Yellowfin.

*Large Vessels (> 200 GRT)*

A 1% rise in the price of Bigeye results in a 0.4% decline in the catch of Albacore;
A 1% rise in the price of Albacore results in a 0.3% decline in the catch of Bigeye;
A 1% rise in the price of Bigeye results in a 0.3% rise in the catch of Yellowfin;
A 1% rise in the price of Yellowfin results in a 0.6% rise in the catch of Bigeye.

There are also changes in the supply of some species in response to changes in their own price. The significant result is for Large Vessels catching Albacore in the Southern Region:

A 1% rise in the price of Albacore results in a 0.8% rise in the catch of Albacore.

These elasticity estimates can be used by fishery managers to gauge the effect of species specific royalty or catch quota policies on the species mix of catch. Assuming that such policies could be enforced the species mix of the catch could be influenced to some extent by the management authority. For example, in the Southern Region a quota on Bigeye would also reduce the harvest of Yellowfin, but would result in an increase in the harvest of Albacore.

### (e) Seasonal Patterns

Statistical tests indicated that seasonal patterns differed between the Northern and Southern Regions, and between large and small vessels. The latter result is likely due to the different areas fished by large and small vessels. The seasons are described by Quarters with the first Quarter being defined as January-March. The results for each species for the overall fishery are summarized, and then any significant regional or vessel size differences are noted. The Quarters are listed in declining order of catch rates:

| | |
|---|---|
| Albacore: | 1,2,3,4 |
| Bigeye: | 2,3,1,4 |
| Yellowfin: | 1,4,3,2 |
| Swordfish: | 2,3,4,1 |
| Marlin: | 4,1,3,2 |

The seasonal patterns were more pronounced in the Southern Region of the fishery, and more pronounced in this Region for large vessels. Significant variations in the Southern Region from the overall seasonal pattern include: the Swordfish fishery peaks in Quarter 4; the Yellowfin fishery peaks in Quarter 2; and the Albacore fishery peaks in Quarter 2.

### (f) Inter-annual Fluctuations

The years of study 1984-1989 are designated years 1-6 and are listed in declining order of catch rates by species for the overall fishery:

| | |
|---|---|
| Albacore: | 1,4,6,3,2,5 |
| Bigeye: | 3,2,4,5,1,6 |
| Yellowfin: | 4,5,2,3,6,1 |
| Swordfish: | 6,5,1,2,3,4 |
| Marlin: | 4,5,3,2,1,6 |

If a fish stock was consistently declining over the period of the analysis the years would be ranked in the order 1-6 with a perfect correlation between the rank and the year number. Albacore and Bigeye have positive correlations between the rank and the year number and the remaining species have negative correlations. However none of the correlations is significant enough to provide evidence of a change in stock availability over the six years considered. A longer study period would be required to assess the significance of any trends in catchability. This issue is addressed in Section (v) below.

### (g) Production in the Sub-Zones

With the exception of Swordfish, sub-zones were defined for the Northern and Southern Regions of the fishery. Sub-zones 1-4 represent the first four 50 mile sub-zones from the coast, and sub-zones 5 and 6 represent the 200-350 and the 350-500 mile bands associated with Lord Howe Island. These sub-zones are illustrated in Figure 2. Because there were too few recorded catches of Swordfish in sub-zone 1 for the purposes of statistical analysis, no information is reported for that species in that sub-zone. The sub-zones are ranked in terms of their catch per unit effort for each species having accounted for price effects. The ranks are reported for both small and large vessels operating in the Northern and Southern Regions.

Northern Region, Small Vessels (< 200 GRT)

| | |
|---|---|
| Albacore | 6,5,4,3,2,1 |
| Bigeye | 1,2,3,5,4,6 |
| Yellowfin | 2,3,5,4,1,6 |
| Swordfish | 2,3,5,4,6 |
| Marlin | 5,4,3,1,2,6 |

Northern Region, Large Vessels (> 200 GRT)

| | |
|---|---|
| Albacore | 6,5,4,3,2,1 |
| Bigeye | 2,1,3,4,5,6 |
| Yellowfin | 1,2,3,4,5,6 |
| Swordfish | 3,4,5,2,6 |
| Marlin | 5,4,1,3,2,6 |

Southern Region, Small Vessels (< 200 GRT)

| | |
|---|---|
| Albacore | 6,5,4,3,1,2 |
| Bigeye | 2,3,4,5,6,1 |
| Yellowfin | 3,2,4,5,6,1 |
| Swordfish | 2,6,4,5,3 |
| Marlin | 5,6,4,1,3,2 |

Southern Region, Large Vessels (> 200 GRT)

| | |
|---|---|
| Albacore | 5,4,6,3,2,1 |
| Bigeye | 2,3,4,5,6,1 |
| Yellowfin | 2,3,4,1,5,6 |
| Swordfish | 6,4,3,2,5 |
| Marlin | 1,6,4,5,3,2 |

### (ii) A Multi-species Analysis of the Australian Fishery

The Australian fishery is based mainly on Yellowfin and is not predominantly a multi-species fishery. For this reason a production function approach to analysing technology may be more appropriate than a revenue function approach. The production function approach is used in Section (iv) to analyse the data for the Australian vessels. A disadvantage of applying the production function approach to the Australian data is that the results are not directly comparable with the results obtained for the Japanese vessels using the revenue function approach. Since it will be useful to compare the activities of the two fleets, the revenue function approach is applied to the Australian data in the area north of 34°S for the years 1988 and 1989 when price data were available and the results reported in this Section.

Section (iii) reports the results of the comparison with the Japanese vessels. In the present Section the results of the revenue function approach regarding technology and the availability of fish to Australian vessels on an inter-annual, seasonal, and sub-zonal basis are reported.

Since, as demonstrated in Section (vi) below, the Australian and Japanese vessels receive different prices for their catches, a separate price series must be generated for the Australian vessels in order to apply the revenue function approach. Australian vessels market around 35-40% of their catch in Japanese fresh tuna markets, with the balance being sold in the Sydney fish market as sashimi, Yellowfin gutted, Bigeye and Yellowfin gutted-head on, poorer quality Yellowfin for canning, Albacore (none of which is exported) and billfish. A weighted average price was calculated for the fish sold in the Sydney market and converted to Yen for the purposes of comparison with prices in the Japanese market. Observed prices of Yellowfin and Bigeye in the Japanese fresh tuna markets were reduced by 500 Yen per kilogram to reflect the transportation costs between Sydney and Japan incurred by the Australian exporters. An overall weighted average price series was calculated for the Australian vessels and used in the estimation of the revenue function. This price series is also used in Section (vi) below in a comparison with the frozen tuna prices received by the Japanese vessels operating in the AFZ.

The species composition of the catch of the two fleets is different as the Japanese vessels produce seven species whereas the domestic fishery is primarily based on Yellowfin tuna with the occasional catch of another tuna species. Since many of the monthly catch records of Australian vessels record zero observations for catches of species other than Yellowfin it was not possible to compare the two fisheries on a seven-species basis. A compromise designed to maintain the multi-species nature of the analysis was to aggregate all species other than Yellowfin caught by each fleet into a single category. The aggregation was performed by establishing for each fleet a price index of species other than Yellowfin - Marlin, Swordfish, Albacore and Bigeye - and then dividing the revenue obtained from sales of these species by the price index to obtain a quantity index of "other species" for each fleet. The revenue function approach is then applied to the price and quantity data for Yellowfin and the "other species".

There were 409 monthly observations on Australian vessel catches in the period 1988-89 which was chosen for the comparison of the Japanese and Australian technology as described in Section 4 (iii) below. Of these observations, 211 recorded a zero catch of species other than Yellowfin. These vessels can be regarded as targeting a single species and their performance is better analysed using the production function approach of Section 4 (iv) below. The remaining Australian observations were used to estimate a revenue function. Three sub-zones were identified - 0-12, 12-50, and 50-100 miles (see Figure 5) and the productivity of the fishery in each sub-zone was analysed.

The only significant result regarding technology is that Australian vessels which fish more than one species appear to be able to target species in response to relative price changes. The supply responsiveness of Yellowfin to a 1% increase in the price index for the "other species" is 0.03%, and the responsiveness of supply of "other species" to a 1% increase in the price of Yellowfin is 0.4%. The results regarding annual and seasonal stock fluctuations are that the two years of the sample are not significantly different with respect to stock levels, and that the third Quarter of the year (July-September) is significantly better than the other three. The 0-12 mile sub-zone, from which the Japanese are excluded, had significantly higher catch rates than the other two for both Yellowfin and "other species". The 12-50 mile sub-zone provided a significantly higher Yellowfin catch per unit effort than the 50-100 mile sub-zone.

### (iii) A Comparison of Japanese and Australian Technology

In order to compare Japanese and Australian technology a common method of analysis has to be applied to a sample of Australian and Japanese vessels operating in similar areas at the same time. As explained in Section (ii), the revenue function approach was chosen for the comparison because of the multi-species nature of the Japanese fishery. In addition to the problem, discussed in Section (ii) above, of the different range of species fished by the two fleets, there are several spatial factors which have to be taken into account in establishing comparable data samples for the two fleets. There is only a small range of latitudes in which the two fisheries overlap, since the Japanese are excluded from the area south of 34°S and the Australian data had poor coverage north of 25°S (See Figure 5). Even where they do fish the same latitude the Japanese fleets were denied access to the twelve mile area adjacent to the coast and in the years of the available domestic price data, 1988-89 were also subject to seasonal closures of the innermost fifty miles. This means that the comparison will be of vessels operating in the region 25°-34°S, and in the band from 12-100 miles from the coast which will be divided into two sub-zones - 12-50, and 50-100 miles - for analysis. This area includes 83% of the effort expended by the domestic fleet in the area north of 34°S. In the 88 mile wide study area there were 379 monthly observations on Japanese vessels, and 285 monthly observations on domestic vessels in the 1988-89 study period. Of the 285 domestic observations, many record zero catches for species other than Yellowfin because of the tendency of domestic vessels to focus on that species. The analysis was conducted both with and without these zero observations which numbered 144, to check for any bias in the comparison. Only those results from the complete sample which remain unchanged when the zero observations are dropped are reported.

The sample information for the two fleets was analysed and it was found that there is a significant difference between the production technologies of the two fleets. The revenue function model was then used to address the following questions:

(a) do the two fleets experience similar inter-annual and seasonal fluctuations in stock availability?

(b) do the two fleets experience similar patterns of stock availability in the sub-zones of the fishery?

(c) are the two fleets equally productive?

**(a) Inter-Annual and Seasonal Fluctuations**

Although some minor differences in annual and seasonal availability of stocks to the two fleets was found, there was no strong evidence that they experience significantly different patterns of inter-annual and seasonal fluctuations. These patterns have already been described in Sections 4 (i) (e) and (f) above.

**(b) Stock Availability in the Sub-Zones**

Despite some evidence from the sample which excluded the zero observations that stock availability to the two fleets differed within the individual sub-zones, it was concluded that the experience of the two fleets in terms of relative availability of stock in the two sub-zones was not significantly different. When zero observations were included the Australian catch per unit effort in the outer zone was significantly worse than in the inner zone. This may be due to the fact that this sub-sample consists mainly of specialist Yellowfin vessels which concentrate on stocks relatively close to the coast. However this result conflicts with the results of the production function approach described in Section 4 (iv) below.

**(c) Productivity**

The ability to target species was found not to differ significantly between the two fleets. Since targeting can be observed only for those vessels which are catching more than one species, the observations which report a zero catch of the "other species" are dropped from the sample. It is then found that for those vessels which do catch species additional to Yellowfin there is some response of the species mix of the catch to relative price changes. The response is a substitution response, as expected in a two species production relationship. For both fleets it was found that a 1% rise in the price index of "other species" resulted in a 0.03% fall in the quantity of Yellowfin, and a 1% rise in the price of Yellowfin resulted in a 0.4% fall in the quantity of "other species" harvested by Australians. No significant cross species supply responses were detected for the Japanese vessels in this sample.

The Yellowfin catch per unit effort was found to be significantly higher for the Australian fleet whereas catch per unit effort of the "other species" was the same for the two fleets. Based on the sample which excludes zero observations of catch of the "other species", the advantage of the Australian fleet in Yellowfin catch per unit effort was around three-fold. When zero observations were taken into account the advantage of the Australian vessels was around eight fold. Also the decline in Yellowfin catch per unit effort as vessel effort increased was smaller for the Australian than for the Japanese fleet, whereas the results for the "other species" were the same for the two fleets. The results for Yellowfin may reflect the greater manoeuvrability of the Australian vessels which typically set 250-300 hooks (see Table 7) as compared with the approximately 3000 set by the Japanese vessels (see Table 1). This may allow them to chase and locate fish aggregations, including fish in relatively shallow water. The results may also reflect the fact that the Japanese vessels typically set deeper lines and may be targeting species other than yellowfin, inparticular, bigeye.

The average and marginal returns to effort were compared with the unit cost of effort. The Australian cost data were obtained from Volume 1 of this Report and the Japanese data from Campbell and Nicholl (1990) as explained in Section 4 (i) above. Marginal and average revenue are obtained from the estimated revenue functions for the vessels of the two fleets. It was found that, in general, individual Australian vessels are equating their marginal returns with unit cost, indicating that there is no advantage to expanding individual vessel effort. The principal exception is in the 12-50 mile zone in the July-September Quarter when there is scope to increase per vessel profit by applying more effort. When average return is compared with unit cost it is found that a significant profit is earned in the July-September Quarter by the Australian vessels.

A similar comparison of average and marginal returns with unit cost was performed for the Japanese vessels in the sub-sample. According to the reported data these vessels are consistently applying effort beyond the profit maximizing level, and are consistently making a long-run economic loss. This does not imply irrational behaviour as they may be covering their variable costs and making an operating profit. Since, however, the vessels are not recouping their capital costs there will be little incentive for them to remain in the fishery unless their performance is significantly better in other areas.

### (iv) The Technology of the Australian Fishery

This Section reports the results of an analysis of the activities of the Australian vessels using a production function approach. The distribution of the domestic vessels in the fishery is different from that of the Japanese. Only a very small proportion of the domestic catch is recorded as coming from north of 25°S, which is the Northern Region of the Japanese fishery. Around 32% of domestic catch comes from the area between 25°S and 34°S, which is the Southern Region of the Japanese fishery, and the balance is from south of 34°S, which is an area from which the Japanese vessels are excluded (see Table 5c). In this Section the terms Northern and Southern fishery will be used to denote the domestic fisheries from 25-34°S and south of 34°S respectively. For the purposes of the analysis the domestic fishery is divided into four sub-zones which are defined by the bands 0-12, 12-50, 50-100, and over 100 miles from the coast.

The Australian fishery is primarily a single species fishery. Around 90% by weight of the catch consists of Yellowfin, and around 60% of the logbook entries report no species other than Yellowfin in the catch. In the analysis of this Section catches of species other than Yellowfin will be regarded as incidental and omitted from the harvest data. This could result in bias if some of the 40% of vessels which report catches of other species are targeting those species. The revenue function approach was used in the analysis of the multi-species Japanese fishery, and in the analysis of the domestic fishery reported in Section 4(ii) above to provide a basis for comparison with the Japanese fleets. However the revenue function approach has no advantages over the production function approach when applied to a single species fishery. The more direct production function approach will be used in this Section.

As mentioned in Section 3, one of the problems of analysing production in a fishery is the absence of direct observations on fish stock, which is a critical input to the production process. Annual, seasonal and lunar fluctuations in stock can be taken into account by means of shift variables in the production function. Local variations in stock availability can be accounted for by including water temperature as a variable. Diplock and Watkins (1988) note that the mean temperature at which Yellowfin occur in the New South Wales area is between 21° and 22°C. The assumption that a vessel which is fishing water at this temperature will encounter more fish than a vessel fishing water of different temperature can be built into the model and tested. Table 5a reports the average and the standard deviation of the temperatures recorded for each catch observation.

The data used in the analysis consisted of 4500 daily observations of fishing activity by individual vessels in the years 1987-1990. Daily catch is recorded as weight of Yellowfin and fishing effort is recorded as the number of hooks fished. Information on the type of vessel, the area fished, and water temperature was also available, and well as details of soak time and whether the longline was patrolled.

The objective of the analysis is to answer the following questions:

(a) what is the overall productivity of the Yellowfin fishery and is there a significant difference between the Northern and Southern fisheries? (North and South of 34°S).

(b) are there significant differences in productivity between the various sub-zones of the Yellowfin fishery?

(c) are there significant seasonal variations in the Yellowfin fishery?

(d) are there significant inter-annual fluctuations in the period of analysis?

(e) does the phase of the moon affect Yellowfin productivity?

(f) does water temperature affect Yellowfin catch rate?

(g) do patrolling and soak time affect Yellowfin productivity?

(h) are there significant differences between the performance of the four classes of vessels - planing longliners, multi-purpose vessels, trawlers, and purpose-built longliners - when fishing Yellowfin?

### (a) Technology of the Fishery in the North and South

The technology of the fishery was found to be significantly different between the North and South in the following respects: seasonal variations; inter-annual fluctuations; the influence of Moonphase; the effect of water temperature on catch rates; the effect of patrolling and soak time on catch rates; and the relative performance of the classes of vessels. The overall productivity of the two regions can be compared by considering the constant term in the production function and the coefficient on effort. The constant term is the catchability coefficient which determines the harvest which can be obtained from a particular input configuration. The coefficient on effort indicates how the level of harvest changes as the number of hooks fished by the vessels increases. The catchability coefficient was found not to vary significantly between the two regions, but there is a significant difference between the coefficients on effort. In the North a 1% increase in effort produces a 0.79% increase in harvest, whereas in the South the increase in harvest is 0.56%. This suggests that local aggregations of Yellowfin are more quickly exhausted by vessels operating in the South than in the North.

### (b) Productivity of Sub-Zones

No significant differences in productivity were found between the sub-zones in either region of the fishery. This means that the distance from the shore - 0-12, 12-50, 50-100, and over 100 miles - does not affect the catch of Yellowfin for the Australian vessels, holding all other variables constant. As noted in Section 4 (iii) (b) above this result is different from the result obtained from the multi-species revenue function approach. It is possible that the temperature variable in the production function analysis is picking up the differences in catchability among sub-zones.

### (c) Seasonal Variations

The seasonal nature of the fishery is different as between the Northern and Southern fisheries. In the North Quarter 3 (July-September) has significantly higher catches, other things being equal, than the rest of the year. This is probably related to the Tasman Front being in the North at this time. In the South the seasonal pattern is less distinct with the first Quarter (January-March) having significantly lower catch rates than the rest of the year. There are no significant differences in Yellowfin catch rates among the last three Quarters of the year in the South, although the estimated April-June coefficient is higher than the others.

In comparing seasonably between the North and the South, the important question for most fishermen is whether the availability of Yellowfin is greater in the North than in the South for the July-September Quarter. The evidence suggests Yellowfin availability is marginally greater in the North but the difference is not highly significant. Northern fishermen are also interested in whether they should move south in the April-June Quarter prior to the peak July- September season, and whether they should follow the fish south in the October-November Quarter as the east Australian current moves south. The model indicates how difficult these decisions are when considering Yellowfin as the differences between the North and South fisheries in these Quarters are only marginally significant on average. However, is some years one or other area may have a decided advantage, as, for example, in the case of the Southern Region in 1989.

The seasonal patterns revealed by the analysis agree with much of the anecdotal evidence about the fishery. Both regions are known to be poor for Yellowfin in the first Quarter of the year. The Southern Yellowfin fishery improves in April-June as the Tasman Front recedes northwards. Producers in the Southern fishery then have to decide whether stay where the fishing is moderately good, or to move north of Sydney where Yellowfin fishing is marginally better in the July-September period. The advantage of the Coffs Harbour area relative to other areas in the Quarter may not be as great as many fishermen believe. In the last Quarter of the year the fishing improves in the South as the Tasman Front moves south.

### (d) Inter-Annual Fluctuations

In the Northern fishery 1988 and 1990 were significantly better years than 1987 and 1989. In the South 1988-90 were all significantly better than 1987. These inter-annual fluctuations are probably caused by environmental conditions, mainly the strength and progression of the East Australia current which varies from year to year (Nilsson and Creswell , 1981).

### (e) Moonphase

Anon (1990) has suggested that Moonphase may have an influence on Yellowfin catches, presumably because of lighting conditions or tidal movements. No significant influence of Moonphase was detected by the analysis of the Southern fishery. In the Northern fishery there was some evidence that Moonphase does affect Yellowfin catch rates, being significantly higher in the New Moon Phase than in the Full Moon and First Quarter. The Last Quarter is ranked second after the New Moon, but its advantage over the remaining two Phases is not significant.

### (f) Water Temperature

A water temperature variable was included in the analysis to represent changes in local availability of fish due to movements of stocks. The form of the variable was - Exp(1/ABS), where ABS is the absolute difference between the temperature of the water fished and the "ideal" temperature of 21.5°C. As temperature of water fished diverges from this "ideal" temperature the value of the variable declines exponentially to reflect the distribution of fish stocks. The effect of this temperature variable was found to be significant in the North but not in the South. The reason for this may be that the Tasman Front is more stable in the North than in the Southern area where the East Australian current forms eddies (Nilsson and Creswell, 1981).

### (g) Patrolling and Soak Time

The individual vessel records indicated whether the vessel patrolled the longline and the length of the soak time. Patrolling involves moving along the set line and removing fish which are indicated by the activity of the floats. This may increase catch per unit effort since the hook can be rebaited and resume fishing. Soak time is the length of time the bait is in the water. Soak time observations are widely distributed, probably because of the occurrence of bad weather preventing the retrieval of gear when planned.

It was found that patrolling makes a significant contribution to Yellowfin catch per unit effort in the Southern fishery but not in the North. In the South, current patrolling practice increases Yellowfin catch per unit effort by 11.8%, with other factors held constant.

It was found that soak time was a significant variable in the North but not in the South. In the North, Yellowfin catch per unit effort rises as soak time increases. Holding other factors constant, a 1% increase in soak time over its current level increases catch per unit effort by 1.6%.

### (h) Vessel Performance

There are significant differences between the Northern and Southern fisheries in the relative performance of the four classes of vessels catching Yellowfin only. In the South the purpose built longliners had significantly higher Yellowfin catch per unit effort than the other three classes. The sample of purpose built vessels operating in the South does not include some of the larger purpose built vessels or larger Japanese-style vessels for which records were not available. In the North the purpose built longliners significantly out-performed the multi-purpose vessels and planing longliners, but were only marginally more successful than the trawlers. This latter result may be explained by trawler owners in the North fishing for Yellowfin only when significant stocks are known to be in the area. The trawlers tend not to pursue Yellowfin along the coast.

### (v) Analysis of Japanese Data for Evidence of Stock Depletion

In the analysis of the relationship between Australian production and water temperature the following production relationship was assumed:

$$h = A \quad E^{\alpha} \quad X^{\beta}$$

where h represents harvest, E is fishing effort, X is fish stock, and A, $\alpha$ and $\beta$ are constants. Water temperature was used as a proxy for the local abundance of fish stock in the empirical analysis. If alpha and beta can be set equal to unity the catch per unit effort, h/E, is an index of fish stock. Changes in CPUE over time represent changes in the levels of fish stocks provided that catchability, represented by the coefficient A in the production relationship, remains constant.

The Japanese Fishery Agency (JFA) catch and effort data for the period 1962-1980 were combined with the data obtained from the AFZIS for the 1979-1989 period. The JFA data are for an area larger than the AFZ (see Figure 6) whereas the AFZIS data are for the Australian Fishing Zone only. The JFA data and the AFZIS data for the period 1979-83 record numbers of fish while the post-1983 records are of weights. Effort is measured as hooks set per year.

When the above data are used to determine trends in CPUE as an indicator of changes in stocks it is implicitly assumed that the average weight of fish of each species caught has not changed. Weight data are available for the period 1984-89. Monthly weight data for this period were analysed to determine whether there were any trends in monthly average weight of each species caught. Declines in the average weights of Swordfish and Marlin were detected, with no observed trends for the other species.

There were two significant changes to the logbook systems in the period 1962-89. The shift from JFA to AFZIS records occurred in 1979, and the shift from AFZIS TL01 to TL04 records occurred in 1984. These changes will be taken into account in the analysis.

The Australian domestic fishery commenced in 1984 and expanded from that date until the end of the study period. The data will be analysed to determine whether the Australian fishery had any impact on stocks as measured by the trend of Japanese CPUE over time.

The 1962-1989 data for all seven species (Albacore, Yellowfin, Bigeye, Swordfish, Black, Blue and Striped Marlin) were fitted to the following equation:

$$(h/E) = \alpha + D_1 + D_2 + \beta T + D_3 T$$

where T represents time, $D_1$ and $D_2$ represent the changes in reporting systems in 1979 and 1984, and $D_3$ represents the start of the Australian fishery in 1983 (Diplock and Watkins, 1990). The results indicated that the changes in reporting systems had significant effects on reported CPUE, but that the start of the Australian fishery had no significant effect on the trend of CPUE over time. A significant downward trend in CPUE was found for all species except Striped Marlin and Swordfish. The most significant declines were for Albacore and Yellowfin which did not appear to be threatening.

### (vi) A Comparison of Tuna Prices for the Japanese and Australian Fleets

Japanese vessels fishing in the eastern AFZ sell their catch in the Japanese frozen sashimi market. Domestic vessels export 35-40% of their catch for sale in the Japanese fresh sashimi market. The balance of the catch is normally sold in the New South Wales Fish Marketing Authority markets in Sydney. longlined Yellowfin is graded in this market into sashimi fish and inferior qualities. The purpose of this Section is to compare the level of prices in the above three markets, and then to compare the price, net of freight charges, received by the domestic vessels with the price received by Japanese vessels.

Monthly average prices for species sold as frozen sashimi were obtained for the Japanese port of Yaizu (1984-1989, figure 3a and 3b source: AFS). Monthly average prices for species sold as fresh (chilled) sashimi were also obtained for this market from Fortuna-Daito Pty Ltd. for the years 1988 and 1989. Domestic monthly average prices were obtained from the NSWFMA (1988-1989). For purposes of comparison, Australian prices were converted to Japanese Yen using the appropriate exchange rate (ABARE, 1991). The level of the sample prices is compared by first checking that the samples do not have significantly different variances, and then comparing the sample means.

The results of the price comparisons indicate that the Japanese fresh market prices for Yellowfin and Bigeye are significantly higher than both the Australian fresh sashimi prices and the Japanese frozen prices. Australian fresh sashimi prices are higher than Japanese frozen prices for Yellowfin but the reverse is true for Bigeye. Complete price data for other species is limited but Albacore prices in the domestic fresh market were significantly less than Japanese frozen market prices, while domestic fresh Swordfish prices were significantly higher than the Japanese frozen prices.

Australian vessels export 35-40% of their Yellowfin and Bigeye catch to the Japanese fresh sashimi markets. The average freight cost from Sydney in the 1988-89 period was around 500 Yen per kilo, although this cost has since risen. Using the 500 Yen freight rate the net of freight price to Australian vessels for Yellowfin and Bigeye sold in the Japanese fresh sashimi market can be compared with the domestic prices. This comparison shows that the net of freight prices of Bigeye sold in the Japanese fresh sashimi markets are higher than the domestic prices. The net of freight Yellowfin prices were not significantly different between Japan and Australia. If the comparison is conducted on the basis of a 600 Yen per kilo freight cost, to reflect the recent trend in freight costs, the results are not changed. The net Bigeye price in Japan still has a premium over the domestic price under both freight costs tested.

An overall comparison of the prices received by Australian and Japanese vessels can be made by comparing the average prices of Yellowfin and Bigeye assuming that 35-40% of the Australian catch is sold in the Japanese fresh sashimi market, with the balance being sold in Sydney, and that the Japanese catch is sold in the frozen sashimi market. The result of this comparison is that the Australian vessels receive a significantly higher price overall: the price advantage is in the order of 40% in the case of Yellowfin, and 30% in the case of Bigeye.

### (vii) Estimates of Rent

This Section reports estimates of the rent earned by Japanese vessels operating in the fishery in the 1984-89 period. Estimates of the costs and incomes of Australian vessels are reported in Volume 1 of this Report and rent estimates are calculated for these vessels. Rent is estimated as the difference between the value of the catch and the cost of fishing. An alternative measure of rent has been used in recent papers by Geen (1990) and Brown and Dann (1991) on the value of tuna fisheries in the AFZ. This approach measures rent as the difference between the value of the catch in the AFZ and the estimated value of catch in the next best alternative fishery at the time. This method has the advantage of not requiring cost information but the disadvantage of being sensitive to the conditions obtaining in the assumed alternative fishery. The two approaches are discussed in Campbell and Nicholl (1992).

Revenue estimates are obtained from the reported catch and the price data for the Japanese fleet. Cost information is available from studies by Campbell and Nicholl (1990,1992). The cost estimates reported in the latter studies are obtained from annual Japanese MAFF estimates. They report estimates for both small (< 200 GRT) and large (>200 GRT) vessels. The rent calculated as the difference between total revenue and total cost may be an under-estimate or over-estimate of fishery rent. The main factors possibly contributing to an under-estimate is lack of competition in product markets resulting in artificially low fish prices, and under-reporting of catches. The main factor contributing to an over-estimate is the inclusion of other kinds of rents, such as the higher profits of high-liners, in the calculation of rent.

Since rent is the difference between revenue and the sum of all costs, including capital costs, a negative rent indicates that the return on capital is not high enough to justify building a new vessel to enter the fishery, assuming that all other fishing grouhds are comparable to the AFZ. A vessel which is earning a negative rent will usually be obtaining sufficient revenue to cover it's operating costs, and operating profit is reported as a proportion of revenue to confirm this. Operating costs are defined as those costs which can be avoided by tying the vessel up. Sometimes vessels operate even though they are not earning sufficient revenue to cover their operating costs. This can be explained by unanticipated poor fishing conditions, or by the fact the vessel at sea has virtually no avoidable costs. In the course of a fishing trip the vessel's objective, as suggested in Section 3, may be to maximise it's revenue irrespective of costs.

Estimates of rent are reported as a percentage of revenue. Annual estimates are presented for the whole fleet, for the Northern and Southern Regions, for large and small vessels, for different seasons, and for different sub-zones. The results are as follows:

**(a) Rent as a Percentage of Revenue 1984-1989**

| Year | Total Fishery | Northern Region | | | Southern Region | | |
|---|---|---|---|---|---|---|---|
| | | All | Small | Large | All | Small | Large |
| 1984 | -55 | -43 | 34 | -53 | -63 | -28 | -71 |
| 1985 | 6 | 17 | 45 | 15 | -1 | 20 | -7 |
| 1986 | -27 | -26 | 25 | -29 | -28 | 4 | -36 |
| 1987 | -7 | 18 | 28 | 17 | -22 | 8 | -34 |
| 1988 | -14 | 5 | 27 | -1 | -29 | 6 | -46 |
| 1989 | -11 | 1 | 24 | -3 | -24 | 12 | -30 |
| Average | -14 | 1 | 28 | -4 | -24 | 7 | -34 |

**(b) Rent as a Percentage of Average Revenue by Season 1984-1989**

| Quarter | Total Fishery | Northern Region | | | Southern Region | | |
|---|---|---|---|---|---|---|---|
| | | All | Small | Large | All | Small | Large |
| 1 | -3 | 4 | 35 | -1 | -49 | 6 | -60 |
| 2 | -32 | 11 | 46 | -29 | -34 | 0 | -48 |
| 3 | -17 | -6 | 28 | -12 | -21 | 6 | -29 |
| 4 | 6 | 8 | 26 | 4 | -8 | 21 | -21 |

**(c) Rent as a Percentage of Average Revenue by Sub-Zone 1984-1989.**

| Sub-Zone | Northern Region | | | Southern Region | | |
|---|---|---|---|---|---|---|
| | All | Small | Large | All | Small | Large |
| 1 | -7 | 8 | -10 | 4 | 35 | -28 |
| 2 | 8 | 34 | 4 | -20 | 11 | -27 |
| 3 | 4 | 37 | -1 | -23 | 1 | -29 |
| 4 | -7 | 28 | -12 | -30 | 6 | -42 |
| 5 | -3 | 28 | -7 | -27 | 3 | -38 |
| 6 | 16 | 39 | -66 | -18 | 13 | -33 |

In view of the substantial losses calculated for some types of vessels fishing at various times and places, operating profit estimates were calculated. Operating profit exceeds rent by the amount of the capital cost. If operating profit is negative there is no incentive for the vessels to plan to fish in the Zone, even if there are no alternative fisheries available. This appears to be the case for the large vessels operating in the south.

### (d) Operating Profit as a Percentage of Revenue 1984-1989

| Year | Total Fishery | Northern Region | | | Southern Region | | |
|---|---|---|---|---|---|---|---|
| | | All | Small | Large | All | Small | Large |
| 1984 | -39 | -31 | 58 | -42 | -45 | 18 | -59 |
| 1985 | 13 | 24 | 51 | 21 | 7 | 28 | 1 |
| 1986 | -18 | -17 | 31 | -19 | -18 | 12 | -27 |
| 1987 | 5 | 28 | 36 | 26 | -8 | 19 | -19 |
| 1988 | -1 | 16 | 36 | 11 | -14 | 18 | -29 |
| 1989 | 2 | 13 | 35 | 8 | -5 | 25 | -16 |
| Average | -3 | 11 | 38 | 6 | -11 | 20 | -22 |

In view of the possibility catch catches are under-reported the rent estimates were also calculated on the assumption that catch may be under reported by up to 40%. In the SBT fishery in 1990 the vessels Koyo Maru No.1 and Shoun Maru No. 21 were apprehended for under reporting by approximately 50% and 30% respectively (Rigney,1990). The price incentive to under report is not as great in the Yellowfin fishery but the implications of different rates of under reporting can be seen below. This can also be interpreted as rent estimates should there be transfer pricing taking place within the Japanese tuna market.

### (e) Average Rent as a Percentage of Adjusted Revenue 1984-1989

| Adjustment | Total Fishery | Northern Region | | | Southern Region | | |
|---|---|---|---|---|---|---|---|
| | | All | Small | Large | All | Small | Large |
| + 0% | -14 | 1 | 28 | -4 | -24 | 7 | -34 |
| +10% | -4 | 10 | 34 | 6 | -12 | 16 | -22 |
| +20% | 5 | 17 | 39 | 13 | -3 | 22 | -12 |
| +30% | 12 | 23 | 43 | 20 | 5 | 28 | -3 |
| +40% | 18 | 29 | 47 | 26 | 12 | 33 | 4 |

The rent estimates calculated here do not include the 6% of Total Revenue access fees. These results show poor profitability for large Japanese vessels engaged in the east coast fishery. Their operations probably only feasible in conjunction with their SBT activity or by under recording of catch. Both these areas are worthy of further investigation.

### (f) Rent in the domestic fishery.

The rent for the domestic fishery was calculated by the same method as for the Japanese by comparing the Total Revenue and Total Cost of effort the costs being obtained from the Part 1 of this report. The costs were for the financial year 1989-90 but were used to obtain estimates of rent in 1988 by deducting 5% from 1989 estimates. Rent estimates are expressed as a percentage of Total Revenue for the years 1988 and 1989.

| Year | Qtr | Rent % TR Overall fishery | | North | | South | |
|---|---|---|---|---|---|---|---|
| 1988 | 1 | -52 | (18) | n/a | (0) | -52 | (24) |
| 1988 | 2 | -65 | (25) | -57 | (4) | -66 | (31) |
| 1988 | 3 | 49 | (34) | 73 | (65) | -75 | (24) |
| 1988 | 4 | -19 | (23) | 14 | (31) | -45 | (21) |
| 1989 | 1 | -60 | (14) | -27 | (5) | -65 | (17) |
| 1989 | 2 | -3 | (35) | -3 | (9) | -2 | (43) |
| 1989 | 3 | 0 | (27) | 16 | (67) | -41 | (14) |
| 1989 | 4 | -37 | (24) | -27 | (18) | -39 | (26) |

Figures in parenthesis are effort in a given quarter as a percentage of the total effort for the year. There is generally more fishing effort in profitable quarters.

### (g) Rent for different vessels classes

Rent was also estimated for the differing vessel classes in the year 1989 as a percentage of Total Revenue.

| 1989 | Overall fishery | North | South |
|---|---|---|---|
| Planing Longliners | -35 | -18 | -42 |
| Multi-Purpose | 24 | 28 | 23 |
| Trawlers | 33 | 49 | 1 |

The Total Revenue is for three species - *Albacore, Bigeye and Yellowfin only*. The results concur with the cost and income survey results as planing longliners have poorer returns than multipurpose vessels and trawlers. However in this analysis trawlers outperform multi-purpose vessels whereas in the income report the returns of the three sampled trawlers were less than those of multi-purpose vessels. No cost data for Purpose built vessels was available.

## 5. References


ABARE, (1991) Commodity Statistical Bulletin, Australian Bureau of Agricultural and Resource Economics, AGPS, Canberra.

Anon. (1990) New South Wales Logbook Coordinator's Report. Unpublished Document, Australian Fisheries Service

Brown, D and T. Dann (1991) Japanese Access to the Australian Fishing Zone. Australian Bureau of Agricultural and Resource Economics (ABARE), Canberra.

Campbell, H.F. and A. McIlgorm (1992). Economic Cost and Income Survey of the Domestic East Coast Tuna Longline Fishery. Final Report, Part 1 of the FIRDC Project 90-98. June.

Campbell, H.F. and R.B. Nicholl (1991) The Cost of Fishing Effort and the Profitability for the Japanese Tuna Fleet: 1979 to 1989. ACIAR Project Report No. 8298. The Department of Economics, University of Tasmania.

Campbell, H.F. and R.B. Nicholl (1992) The Cost of Fishing Effort and the Profitability for the Japanese Tuna Fleet. Supplement for the years 1984 and 1985. ACIAR Project Report No. 8298. The Department of Economics, University of Tasmania.

Campbell, H.F. and R.B. Nicholl (1992) Tuna Fishery Rents in Papua New Guinea: The Cost and Returns of the Japanese Fleets- 1983-1987. ACIAR Project Report No. 8928. The Department of Economics, University of Tasmania, May.

Diplock, J. and D. Watkins, (1990). "The New South Wales Tuna Fishery". Report of the Fisheries Research Institute, Cronulla, NSW.

Geen, G. (1990) The Value of Japanese Access to the Australian Fishing Zone- A Report to the Australian Fisheries Service. Australian Bureau of Agricultural and Resource Economics (ABARE), Canberra.

McIlgorm, A. (forthcoming) An Economic Analysis of the East Australian Tuna Longline Fishery. Ph.D. thesis in preparation, The Department of Economics, University of Tasmania.

Nilsson, C.S. and G.R. Cresswell (1981) The Formation and Evolution of East Australian Current Warm Core Eddies. Prog. Oceanog. Vol 9, pp 133-183.

Rigney, H. (1990) Japanese Fishermen Banned after Under Reporting Catch. Australian Fisheries, October.

Squires, D. and J. Kirkley (1991). Production Quota in Multiproduct Pacific Fisheries. Journal of Environmental Economics and Management. 21, pp109-126.

## 6. Figures

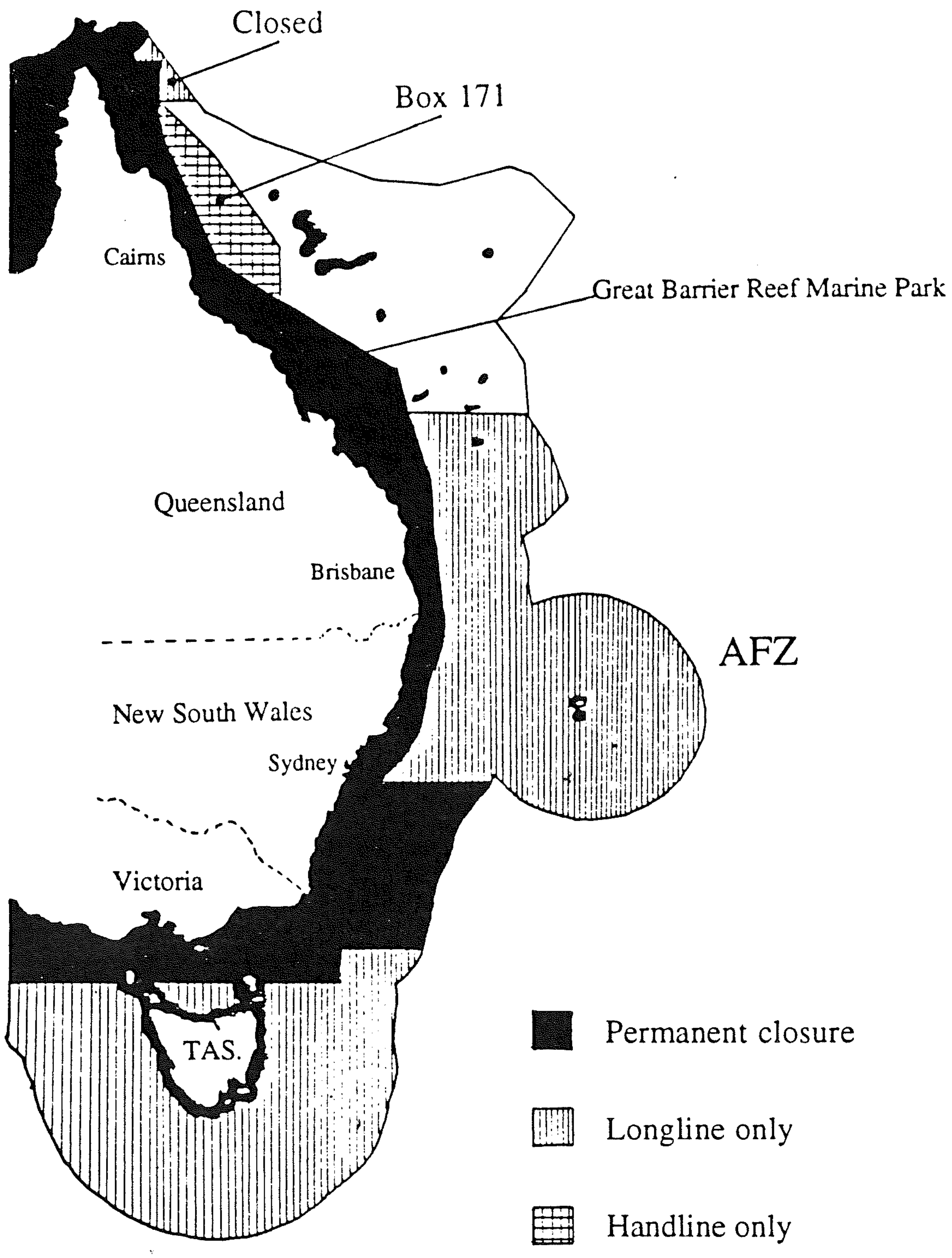


**Figure 1:** The Australian East coast tuna longline fishery with management area as of late 1990.

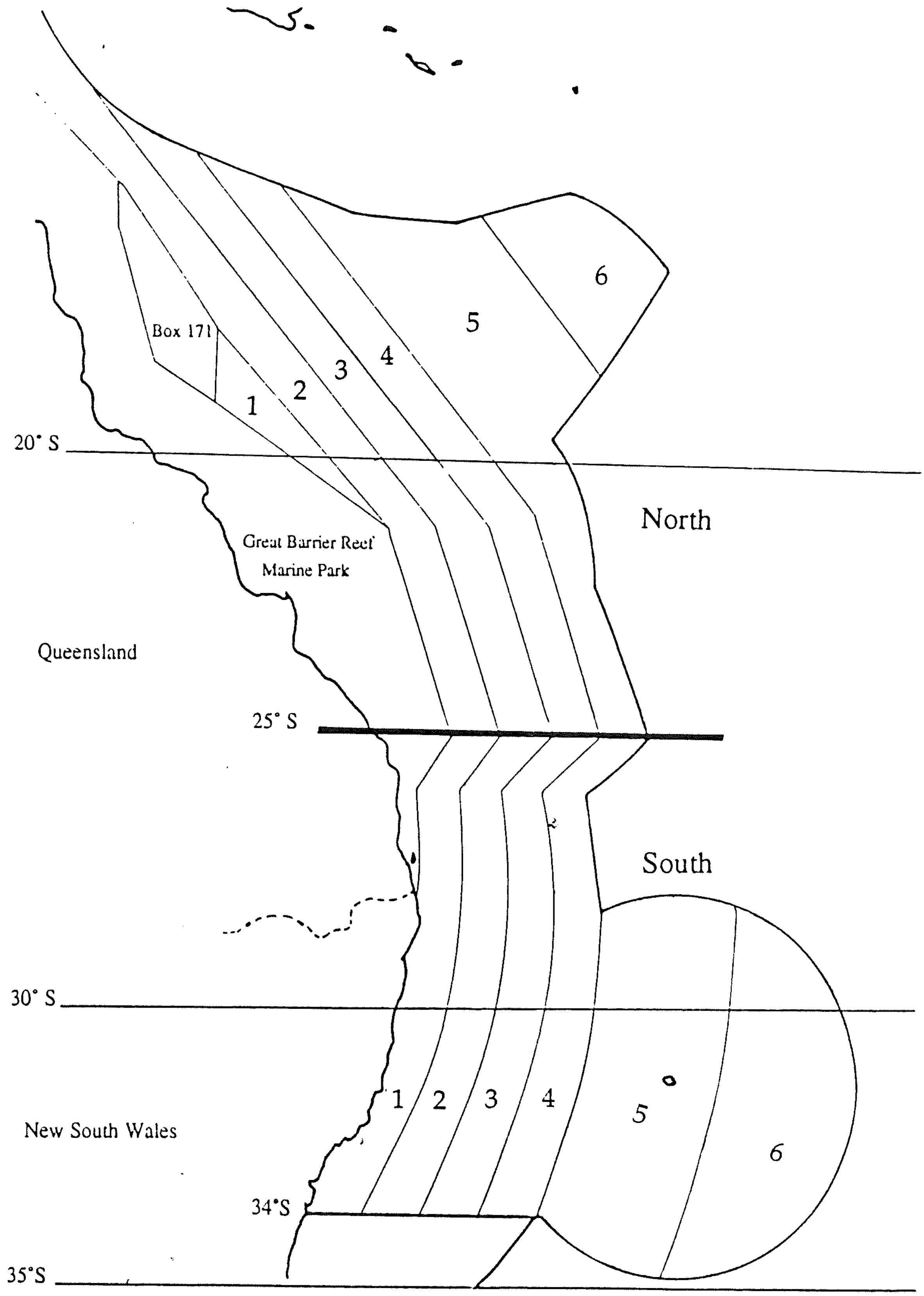


**Figure 2:** The northern and southern areas for the Japanese fishery around 25°S. The sub-zonal areas are also shown and in both cases sub-zones 1-4 are fifty miles wide and sub-zones 5 and 6 are 150 miles wide.

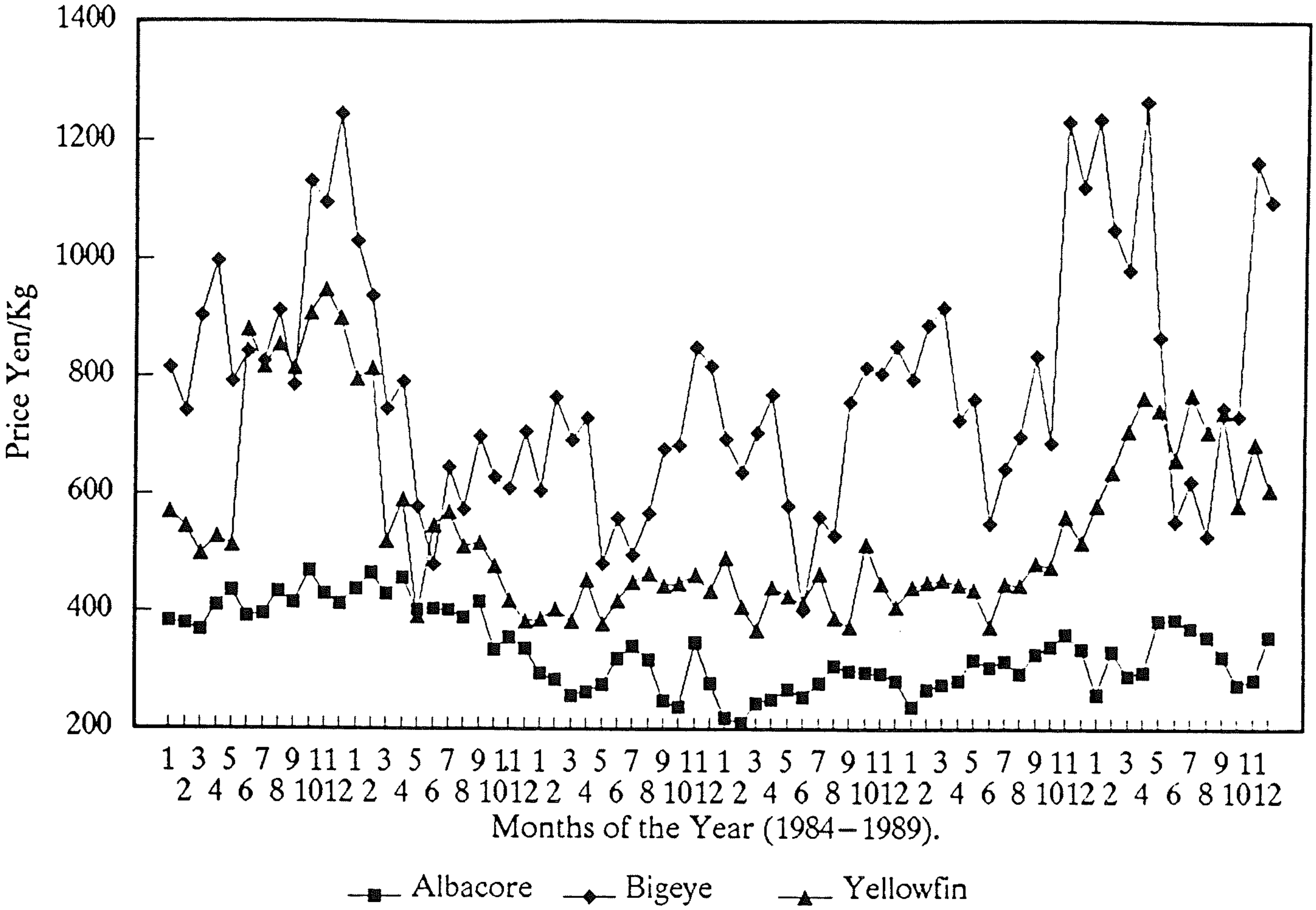


**Figure 3a:** Japanese Frozen tuna prices 1984-1989 for the port of Yaizu, Japan.

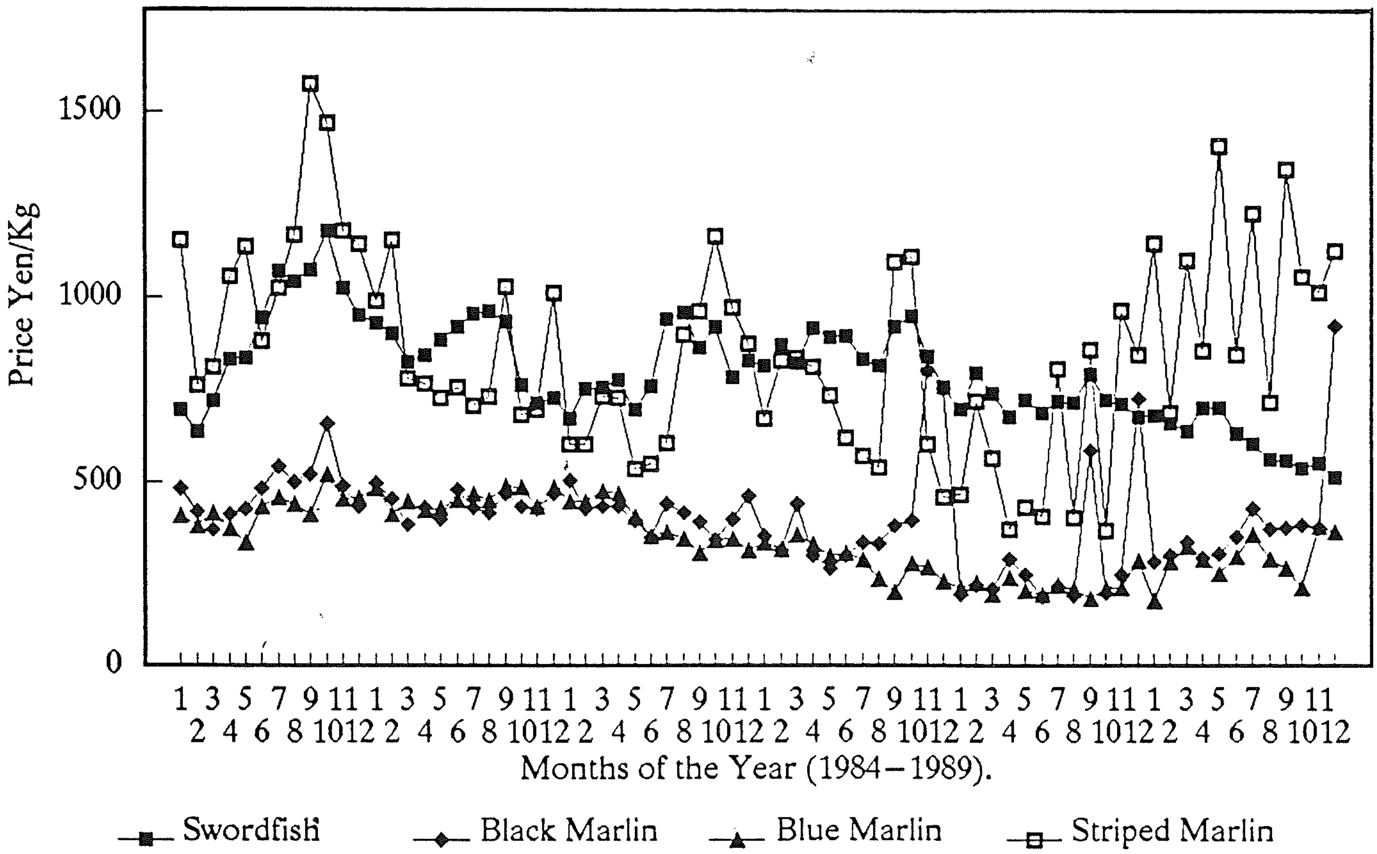


**Figure 3b:** Japanese Frozen billfish prices 1984-1989 for the port of Yaizu, Japan.

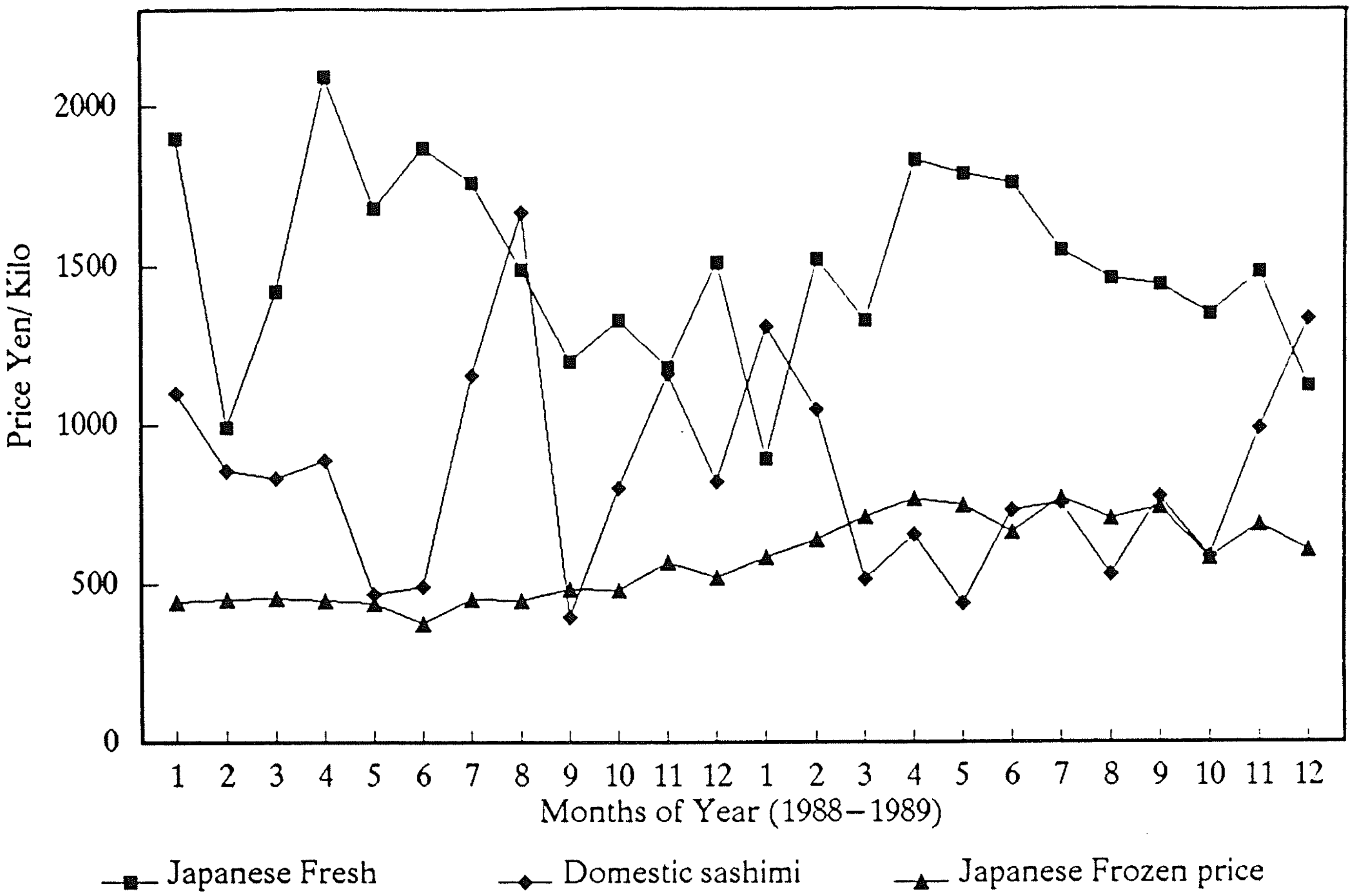


**Figure 4a:** A comparison of Yellowfin prices in Australian and Japanese markets.

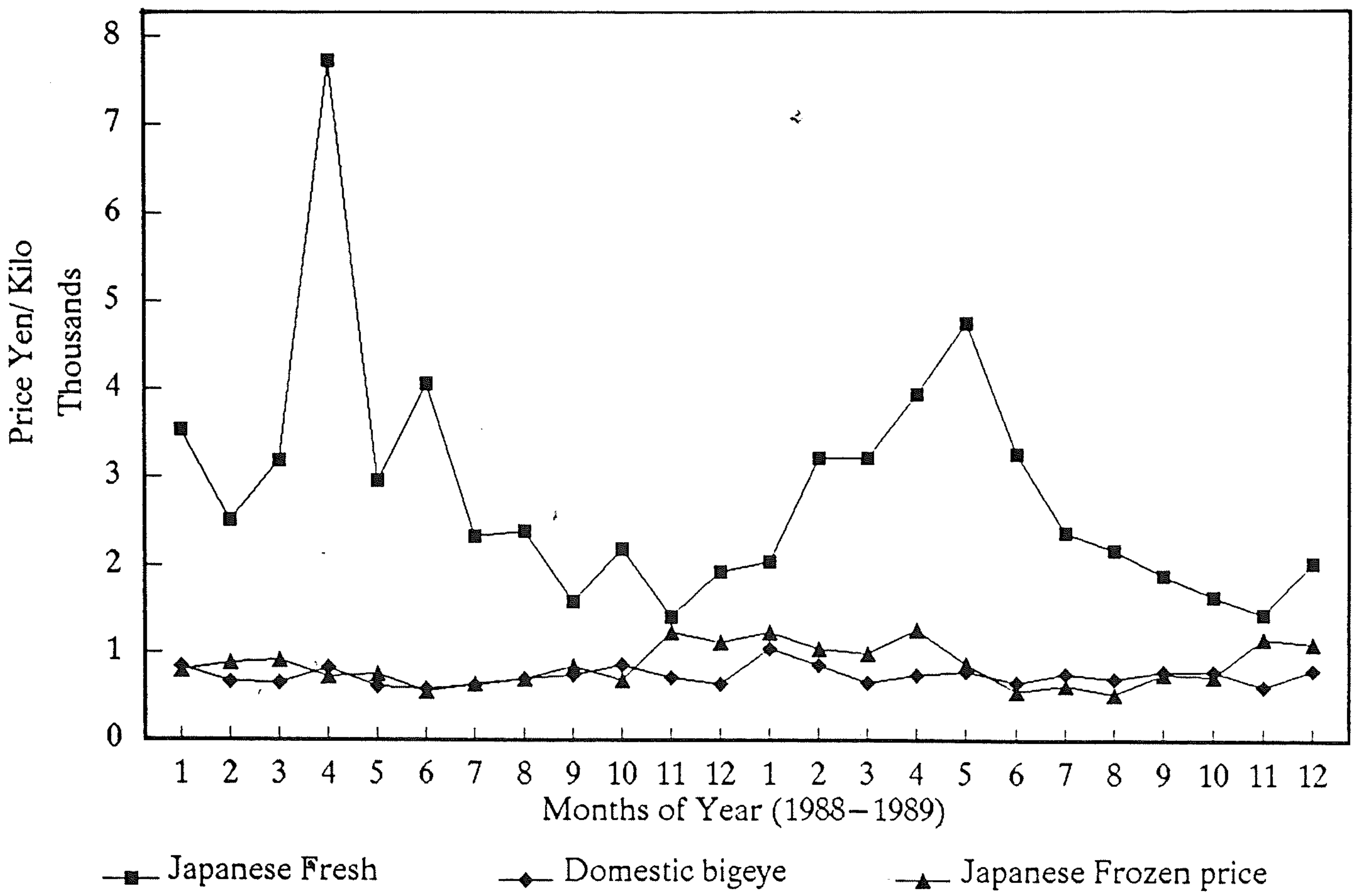


**Figure 4b:** A comparison of Bigeye prices in Australian and Japanese markets.

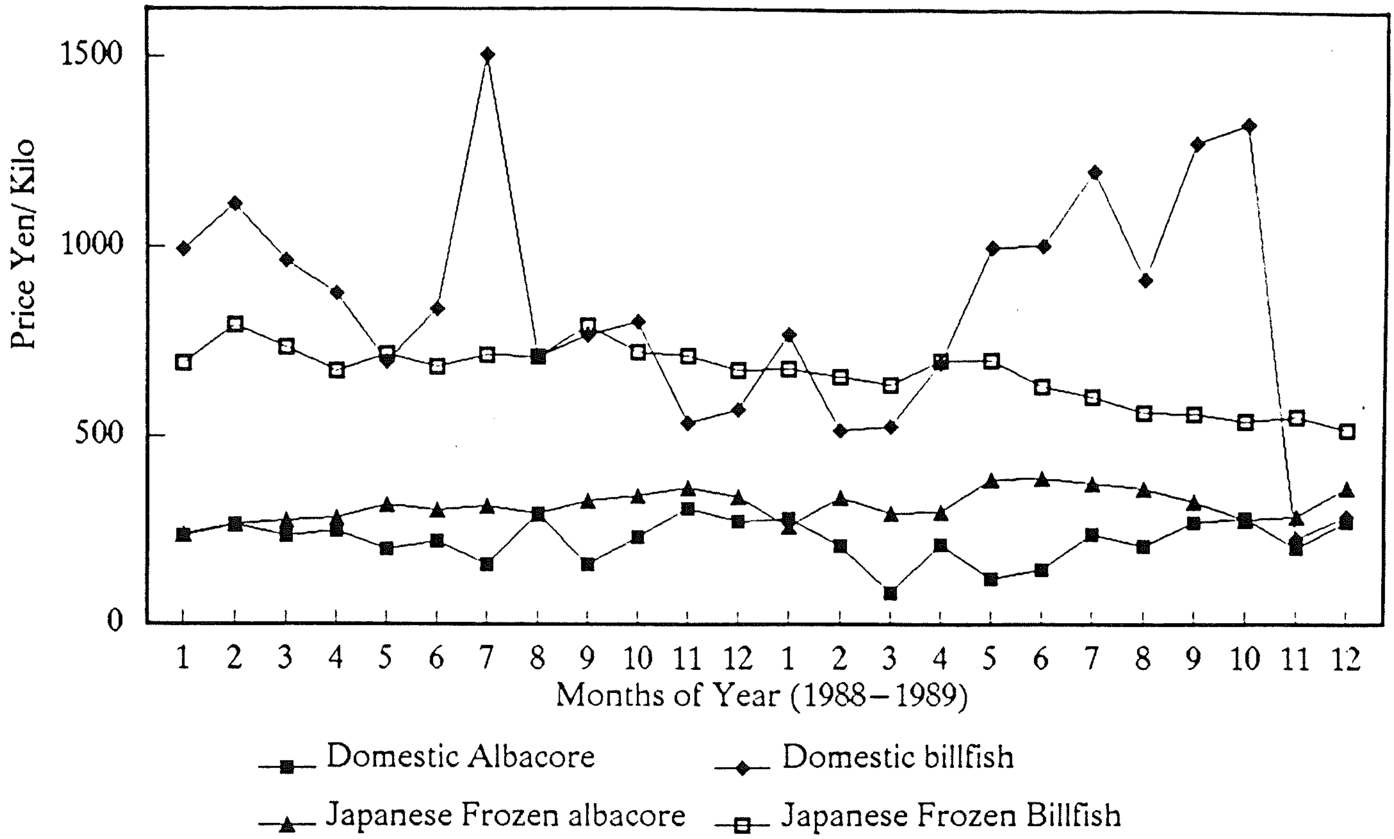


**Figure 4c:** A comparison of Albacore and billfish prices in Australian and Japanese markets.


**Figure 5:** The area used to compare production of the Australian and Japanese vessels.

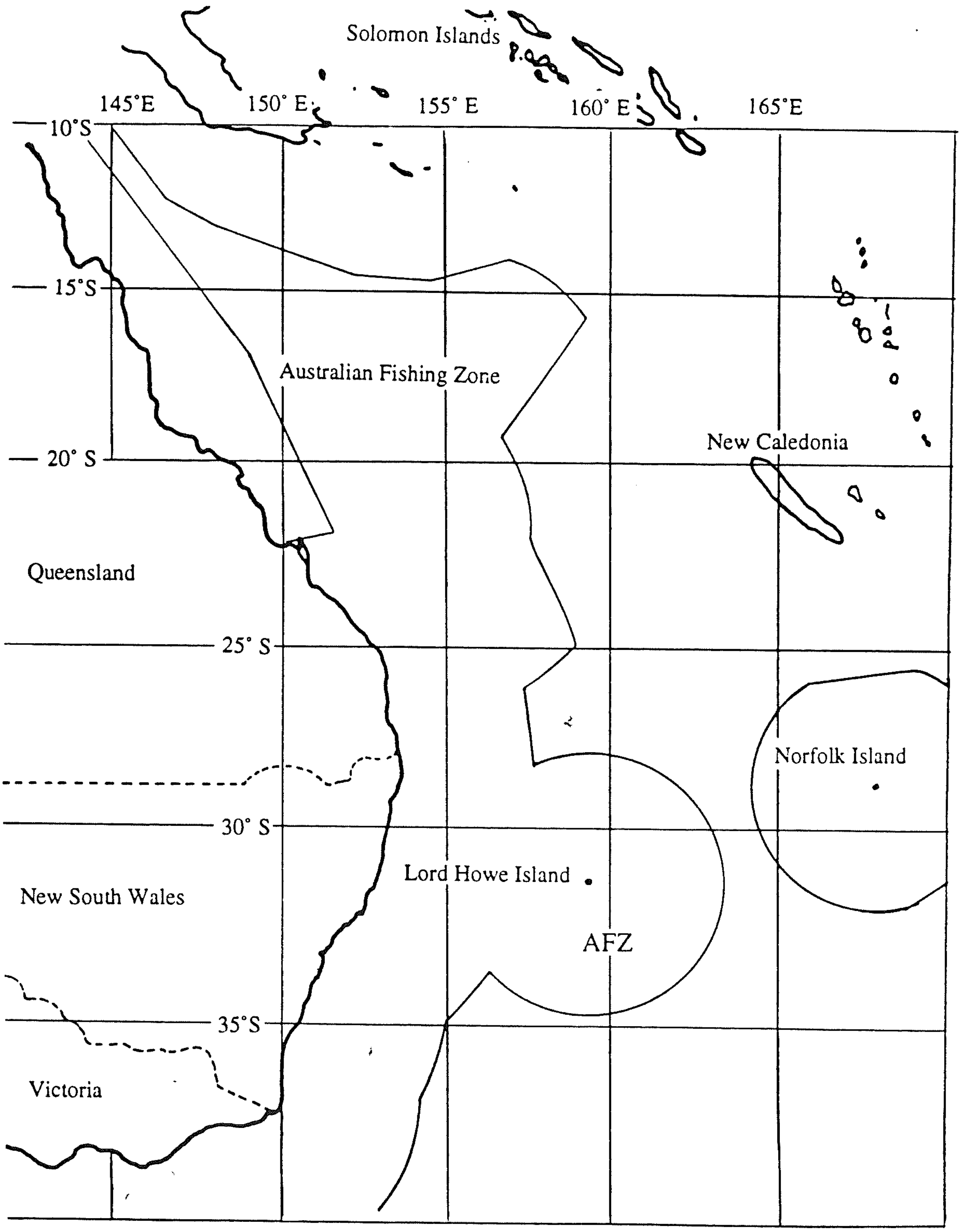


**Figure 6:** The area used to examine the sustainability of Japanese catch rates for the 1962-1989 period.

**Table 1:** The average effort per day, in hooks, and numbers of Japanese vessels in the East coast fishery in each of the years 1984-1989.

| Year | Obs. n | Tonnage (GRT) | Mean Effort/day | St.dev. | No.of Vessels |
|---|---|---|---|---|---|
| 1984 | 1803 | 100-200 | 2534.74 | 288.43 | 5 |
| | | 200-500 | 2738.75 | 180.207 | 42 |
| 1985 | 1813 | 100-200 | 2728.56 | 231.83 | 7 |
| | | 200-500 | 2832.81 | 129.70 | 42 |
| 1986 | 1763 | 100-200 | 2813.27 | 82.37 | 7 |
| | | 200-500 | 2851.85 | 126.45 | 35 |
| 1987 | 1839 | 100-200 | 2843.02 | 55.37 | 10 |
| | | 200-500 | 2887.35 | 140.36 | 38 |
| 1988 | 2784 | 100-200 | 2788.23 | 162.86 | 20 |
| | | 200-500 | 2889.45 | 165.81 | 67 |
| 1989 | 2703 | 100-200 | 2908.97 | 144.13 | 19 |
| | | 200-500 | 2952.82 | 165.78 | 78 |
| Total daily observations | ------- 12,705 | | | | |

Obs..= Number of daily observations on catch and effort for both vessels sizes in the the study area of the AFZ only.

**Table 2a:** The total catch (in tonnes) for each species and for all species for the overall fishery. Effort is in millions of hooks.

| Year | Walb | Weye | Wyfn | Wswf | Wbm | Wbl | Wstm | Total Weight | Effort |
|---|---|---|---|---|---|---|---|---|---|
| 1984 | 920 | 336 | 788 | 453 | 165 | 96 | 289 | 3047 | 6.43 |
| 1985 | 1182 | 516 | 1731 | 548 | 87 | 125 | 313 | 4501 | 7.54 |
| 1986 | 880 | 513 | 958 | 520 | 22 | 58 | 216 | 3167 | 6.02 |
| 1987 | 1001 | 391 | 1931 | 619 | 167 | 145 | 216 | 4472 | 7.15 |
| 1988 | 1743 | 591 | 3339 | 877 | 195 | 398 | 343 | 7486 | 12.57 |
| 1989 | 1716 | 689 | 2497 | 601 | 83 | 301 | 465 | 6352 | 12.77 |

**Abbreviations:**

**Walb**=weight of Albacore, **Weye**-Bigeye, **Wyfn**-Yellowfin, **Wswf**-Swordfish, **Wbm**-Black marlin, **Wbl** -Blue marlin, **Wstm**-Striped marlin.

**Table 2b:** The total catch in tonnes for the northern fishery. Effort is in millions of hooks.

| Year | Walb | Weye | Wyfn | Wswf | Wbm | Wbl | Wstm | Total Weight | Effort |
|---|---|---|---|---|---|---|---|---|---|
| 1984 | 373 | 87 | 399 | 139 | 159 | 70 | 121 | 1349 | 2.45 |
| 1985 | 365 | 106 | 892 | 101 | 78 | 101 | 118 | 1761 | 2.45 |
| 1986 | 190 | 28 | 251 | 45 | 16 | 42 | 38 | 609 | 0.96 |
| 1987 | 277 | 64 | 1019 | 89 | 158 | 126 | 60 | 1793 | 1.86 |
| 1988 | 874 | 123 | 1992 | 95 | 179 | 369 | 111 | 3743 | 4.51 |
| 1989 | 829 | 194 | 1254 | 149 | 69 | 248 | 156 | 2899 | 4.65 |

**Table 2c:** The total catch in tonnes for the southern fishery. Effort is in millions of hooks.

| Year | Walb | Weye | Wyfn | Wswf | Wbm | Wbl | Wstm | Total Weight | Effort |
|---|---|---|---|---|---|---|---|---|---|
| 1984 | 546 | 249 | 390 | 314 | 6 | 26 | 168 | 1698 | 3.98 |
| 1985 | 817 | 410 | 839 | 446 | 9 | 24 | 195 | 2746 | 5.09 |
| 1986 | 690 | 486 | 707 | 475 | 7 | 16 | 178 | 2559 | 5.06 |
| 1987 | 724 | 327 | 913 | 530 | 9 | 20 | 156 | 2678 | 5.29 |
| 1988 | 869 | 468 | 1347 | 782 | 16 | 29 | 232 | 3743 | 8.07 |
| 1989 | 887 | 495 | 1243 | 452 | 14 | 53 | 309 | 3453 | 8.11 |

**Table 3a:** The total catch and effort for the northern fishery expressed as a percentage of the the total catch in the overall fishery.

| Year | Walb | Weye | Wyfn | Wswf | Wpb | Wbl | Wstm | Total Weight | Effort |
|---|---|---|---|---|---|---|---|---|---|
| 1984 | 41 | 26 | 51 | 31 | 97 | 73 | 42 | 47 | 38 |
| 1985 | 31 | 21 | 52 | 19 | 90 | 81 | 38 | 41 | 32 |
| 1986 | 22 | 5 | 26 | 9 | 69 | 72 | 17 | 20 | 16 |
| 1987 | 28 | 16 | 53 | 14 | 95 | 86 | 28 | 43 | 26 |
| 1988 | 50 | 21 | 60 | 11 | 92 | 93 | 32 | 52 | 36 |
| 1989 | 48 | 28 | 50 | 25 | 83 | 82 | 34 | 47 | 36 |
| Mean % | 37 | 20 | 48 | 18 | 88 | 81 | 32 | 42 | 31 |

**Table 3b:** The total catch and effort for the southern fishery expressed as a percentage of the the total catch in the overall fishery.

| Year | Walb | Weye | Wyfn | Wswf | Wpb | Wbl | Wstm | Total Weight | Effort |
|---|---|---|---|---|---|---|---|---|---|
| 1984 | 59 | 74 | 49 | 69 | 3 | 27 | 58 | 53 | 62 |
| 1985 | 69 | 79 | 48 | 81 | 10 | 19 | 62 | 59 | 68 |
| 1986 | 78 | 95 | 74 | 91 | 31 | 28 | 83 | 80 | 84 |
| 1987 | 72 | 84 | 47 | 86 | 5 | 14 | 72 | 57 | 74 |
| 1988 | 50 | 79 | 40 | 89 | 8 | 7 | 68 | 48 | 64 |
| 1989 | 52 | 72 | 50 | 75 | 17 | 18 | 66 | 53 | 64 |
| Mean % | 63 | 80 | 52 | 82 | 12 | 19 | 68 | 58 | 69 |

**Table 4a:** The gross value by species in the east coast tuna longline fishery (1984-1989) where total revenue is in millions of Yen (MYen)and in millions of Australian dollars (MA$). The exchange rate is from ABARE, (1991) and prices are from the frozen tuna market at Yaizu.

The Overall Fishery

| Year | Effort | Alb | Beye | Yfn | Swf | Bm | Blum | Stm | Total Revenue M.Yen | MA$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 6.4 | 364 | 274 | 423 | 344 | 73 | 42 | 271 | 1792 | 8.9 |
| 1985 | 7.5 | 483 | 455 | 1286 | 521 | 43 | 56 | 326 | 3171 | 19.1 |
| 1986 | 6.0 | 302 | 336 | 421 | 401 | 10 | 26 | 165 | 1661 | 13.8 |
| 1987 | 7.2 | 277 | 257 | 846 | 535 | 62 | 48 | 182 | 2207 | 22.3 |
| 1988 | 12.6 | 505 | 445 | 1456 | 695 | 106 | 94 | 190 | 3491 | 34.3 |
| 1989 | 12.8 | 609 | 628 | 1431 | 418 | 42 | 77 | 468 | 3672 | 33.6 |
| Mean | 8.7 | 424 | 399 | 977 | 486 | 56 | 57 | 267 | 2666 | 22.0 |

The Northern Fishery

| Year | Effort | Alb | Beye | Yfn | Swf | Bm | Blum | Stm | M.Yen | MA$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 2.5 | 148 | 71 | 214 | 106 | 71 | 31 | 113 | 754 | 3.7 |
| 1985 | 2.5 | 149 | 94 | 663 | 97 | 39 | 45 | 123 | 1209 | 7.3 |
| 1986 | 1.0 | 65 | 18 | 110 | 35 | 7 | 19 | 29 | 283 | 2.3 |
| 1987 | 1.9 | 77 | 42 | 446 | 77 | 58 | 41 | 51 | 792 | 8.0 |
| 1988 | 4.5 | 253 | 93 | 868 | 75 | 97 | 87 | 62 | 1535 | 15.1 |
| 1989 | 4.7 | 294 | 177 | 719 | 104 | 35 | 63 | 157 | 1548 | 14.2 |
| Mean | 2.8 | 164 | 82 | 503 | 82 | 51 | 48 | 89 | 1020 | 8.4 |

The Southern Fishery

| Year | Effort | Alb | Beye | Yfn | Swf | Bm | Blum | Stm | M.Yen | MA$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 4.0 | 216 | 203 | 209 | 238 | 3 | 11 | 157 | 1038 | 5.1 |
| 1985 | 5.1 | 334 | 361 | 624 | 425 | 4 | 11 | 203 | 1962 | 11.8 |
| 1986 | 5.1 | 237 | 318 | 311 | 366 | 3 | 7 | 136 | 1378 | 11.4 |
| 1987 | 5.3 | 201 | 215 | 400 | 459 | 3 | 6 | 132 | 1415 | 14.3 |
| 1988 | 8.1 | 252 | 352 | 587 | 620 | 9 | 7 | 129 | 1956 | 19.2 |
| 1989 | 8.1 | 315 | 451 | 712 | 314 | 7 | 14 | 311 | 2124 | 19.4 |
| Mean | 5.9 | 259 | 317 | 474 | 404 | 5 | 9 | 178 | 1645 | 13.5 |

**Table 4b:** The percentage of total value by species for the northern and southern region of the fishery.

| Year | Effort | Alb | Beye | Yfn | Swf | Bm | Blum | Stm | TR |
|---|---|---|---|---|---|---|---|---|---|
| North | | | | | | | | | |
| 1984 | 38 | 41 | 26 | 51 | 31 | 97 | 73 | 42 | 42 |
| 1985 | 32 | 31 | 21 | 52 | 19 | 90 | 81 | 38 | 38 |
| 1986 | 16 | 22 | 5 | 26 | 9 | 69 | 72 | 17 | 17 |
| 1987 | 26 | 28 | 16 | 53 | 14 | 95 | 86 | 28 | 36 |
| 1988 | 36 | 50 | 21 | 60 | 11 | 92 | 93 | 32 | 44 |
| 1989 | 36 | 48 | 28 | 50 | 25 | 83 | 82 | 34 | 42 |
| Mean | 32 | 39 | 21 | 52 | 17 | 91 | 84 | 33 | 38 |
| South | | | | | | | | | |
| 1984 | 62 | 59 | 74 | 49 | 69 | 3 | 27 | 58 | 58 |
| 1985 | 68 | 69 | 79 | 48 | 81 | 10 | 19 | 62 | 62 |
| 1986 | 84 | 78 | 95 | 74 | 91 | 31 | 28 | 83 | 83 |
| 1987 | 74 | 72 | 84 | 47 | 86 | 5 | 14 | 72 | 64 |
| 1988 | 64 | 50 | 79 | 40 | 89 | 8 | 7 | 68 | 56 |
| 1989 | 64 | 52 | 72 | 50 | 75 | 17 | 18 | 66 | 58 |
| Mean | 68 | 61 | 79 | 48 | 83 | 9 | 16 | 67 | 62 |

**Table 5a:** Descriptive statistics of the variables in the domestic data for the years 1986-1990 for the total, northern and southern fishery. The mean values are for individual daily fishing observations.

| | Obs. | Mean | s.d. |
|---|---|---|---|
| **Total fishery** | | | |
| Soaktime(hrs) | 4500 | 9.05 | 10.75 |
| Walb (Kg) | | 25.65 | 71.52 |
| Weye (Kg) | | 7.39 | 39.03 |
| Wyfn (Kg) | | 266.19 | 353.11 |
| Temperature (°C) | | 20.56 | 1.80 |
| Effort (Hooks) | | 319.84 | 147.71 |
| **North** | | | |
| Soaktime(hrs) | 1570 | 5.89 | 5.59 |
| Walb (Kg) | | 13.41 | 44.91 |
| Weye (Kg) | | 1.46 | 12.01 |
| Wyfn (Kg) | | 390.80 | 468.77 |
| Temperature (°C) | | 21.29 | 1.86 |
| Effort (hooks) | | 280.30 | 135.99 |
| **South** | | | |
| Soaktime(hrs) | 2930 | 10.75 | 12.35 |
| Walb (Kg) | | 32.20 | 81.57 |
| Weye (Kg) | | 10.56 | 47.26 |
| Wyfn (Kg) | | 199.41 | 247.00 |
| Temperature (°C) | | 20.17 | 1.64 |
| Effort (hooks) | | 341.03 | 149.40 |

**Table 5b:** The total catch and effort in the domestic fishery for the three main species, Yellowfin, Albacore and Bigeye. Effort is in thousand hooks. Weights are in tonnes.

| Total Fishery | Obs. | Effort | Walb | Weye | Wyfn |
|---|---|---|---|---|---|
| 1986 | 21 | 8.3 | 0.1 | 0.6 | 2.7 |
| 1987 | 852 | 278.1 | 20.2 | 11.6 | 205.2 |
| 1988 | 893 | 288.1 | 19.3 | 8.2 | 233.7 |
| 1989 | 1756 | 536.4 | 54.3 | 7.6 | 446.9 |
| 1990* | 975 | 326.8 | 21.5 | 5.3 | 309.1 |
| **Northern Fishery** | **Obs.** | **Effort** | **Walb** | **Weye** | **Wyfn** |
| 1986 | 1 | 0.8 | 0.0 | 0.0 | 0.1 |
| 1987 | 449 | 139.6 | 7.9 | 1.0 | 158.2 |
| 1988 | 258 | 67.6 | 5.1 | 0.2 | 139.7 |
| 1989 | 531 | 134.0 | 3.2 | 0.2 | 148.9 |
| 1990* | 331 | 98.1 | 4.9 | 0.9 | 166.7 |
| **Southern Fishery** | **Obs.** | **Effort** | **Walb** | **Weye** | **Wyfn** |
| 1986 | 20 | 7.5 | 0.1 | 0.6 | 2.6 |
| 1987 | 403 | 138.5 | 12.3 | 10.6 | 47.0 |
| 1988 | 635 | 220.5 | 14.2 | 8.0 | 94.1 |
| 1989 | 1225 | 402.4 | 51.1 | 7.4 | 298.0 |
| 1990* | 644 | 228.7 | 16.7 | 4.4 | 142.4 |

**n.b** catches in 1986,87,88 are low due to poorer logbook coverage. *Logbook records for 1990 are not complete due to delayed returns. Data **do not** include joint venture or Japanese style vessels.

**Table 5c:** The northern and southern catch and effort expressed as a percentage of Total Catch and Effort in each year.

| Northern Fishery | Obs. | Effort | Walb | Weye | Wyfn |
|---|---|---|---|---|---|
| 1986 | 5 | 10 | 0 | 0 | 4 |
| 1987 | 53 | 50 | 39 | 9 | 77 |
| 1988 | 29 | 23 | 26 | 2 | 60 |
| 1989 | 30 | 25 | 6 | 3 | 33 |
| 1990 | 34 | 30 | 23 | 17 | 54 |
| Mean | 36 | 32 | 23 | 8 | 56 |
| **Southern Fishery** | | | | | |
| 1986 | 95 | 90 | 100 | 100 | 96 |
| 1987 | 47 | 50 | 61 | 91 | 23 |
| 1988 | 71 | 77 | 74 | 98 | 40 |
| 1989 | 70 | 75 | 94 | 97 | 67 |
| 1990 | 66 | 70 | 77 | 83 | 46 |
| Mean | 63 | 68 | 76 | 92 | 44 |

All data in percentages

**Table 6:** The mean catch of Yellowfin and effort in each zone for the years 1987-1989 in the domestic fishery. The catch or effort as a percentage of the total catch or effort is shown in the right hand side columns. The mean values for the northern and southern fishery are also shown.

Total Fishery

| Zone | Effort | Wyfn | % of T.E. | % of $TC_{Yfn}$ |
|---|---|---|---|---|
| 0 | 72944 | 57210 | 25 | 24 |
| 1 | 183513 | 160779 | 64 | 67 |
| 2 | 28058 | 19296 | 10 | 8 |
| 3 | 3059 | 2391 | 1 | 1 |
| 4 | 857 | 467 | 0 | 0 |

North

| Zone | Effort | Wyfn | % of T.E. | % of $TC_{Yfn}$ |
|---|---|---|---|---|
| 0 | 18183 | 27781 | 17 | 18 |
| 1 | 79558 | 110006 | 74 | 73 |
| 2 | 9272 | 11502 | 9 | 8 |
| 3 | 610 | 1152 | 1 | 1 |
| 4 | 200 | 95 | 0 | 0 |

South

| Zone | Effort | Wyfn | % of T.E. | % of $TC_{Yfn}$ |
|---|---|---|---|---|
| 0 | 58398 | 34985 | 28 | 29 |
| 1 | 119867 | 72775 | 58 | 61 |
| 2 | 23483 | 9743 | 11 | 8 |
| 3 | 3265 | 1652 | 2 | 1 |
| 4 | 1185 | 654 | 1 | 1 |

where T.E. is total effort, $TC_{Yfn}$ is the total catch of Yellowfin. Zone 0 is 0-12 miles, zone 1, 12-50 miles, zone 2, 50-100 miles, zone 3, 100-150 miles and zone 4 is 150-200 miles from shore.

**n.b.** The results are means for the area specified. The % of TE or TC is the mean effort or catch as a percentage of the total mean effort or catch in the zones 0-4.

**Table 7:** The mean catch and effort of the four classes for vessel in the domestic fishery for the years 1988-1990. The average number of hooks set by each vessel class is shown and the right hand side columns show the percentage of total effort and catch of Yellowfin obtained in the fishery. (For 14% of the fishing observations the vessel could not be identified and were excluded).

**The overall fishery** (means)

| Vessel type | Class | Effort | Wyfn | Av.hooks | % of TE | % of $TC_{yfn}$ |
|---|---|---|---|---|---|---|
| Planing longliners | 1 | 240128 | 175437 | 318 | 66 | 57 |
| Multi-purpose vessels | 2 | 49806 | 39185 | 277 | 14 | 13 |
| Trawlers | 3 | 44734 | 58593 | 322 | 12 | 19 |
| Purpose Built longliners | 4 | 29749 | 33723 | 516 | 8 | 11 |

**The Northern Fishery** (means)

| | | Effort | Wyfn | Av.hooks | % of TE | % of $TC_{yfn}$ |
|---|---|---|---|---|---|---|
| Planing longliners | 1 | 64838 | 72993 | 266 | 58 | 46 |
| Multi purpose vessels | 2 | 11944 | 15073 | 264 | 11 | 10 |
| Trawlers | 3 | 25091 | 49012 | 283 | 22 | 31 |
| Purpose Built Longliners | 4 | 10521 | 21554 | 584 | 9 | 14 |

**The Southern Fishery** (means)

| | | Effort | Wyfn | Av.hooks | % of TE | % of $TC_{yfn}$ |
|---|---|---|---|---|---|---|
| Planing Longliners | 1 | 175290 | 102444 | 343 | 70 | 69 |
| Multi purpose vessels | 2 | 37863 | 24112 | 282 | 15 | 16 |
| Trawlers | 3 | 19643 | 9581 | 393 | 8 | 6 |
| Purpose Built longliners | 4 | 19228 | 12169 | 485 | 8 | 8 |

**n.b.** The data are means for three years and do not sum to the total mean results. The important part of the northern and southern results are the percentage composition of each vessel type and the average hooks set for each vessel class.

**Table 8a :** The assumed proportions of each species exported or retained on the domestic market used in calculating the Weighted average tuna price.

| Species | | | |
|---|---|---|---|
| Yellowfin | | | |
| Proportion Exported | | 0.35* | |
| Proportion sold domestically | | 0.65* | |
| Bigeye | | | |
| Proportion Exported | | 0.40* | |
| Proportion sold domestically | | 0.60* | |
| Exchange rate | 1988 | | 101.83** |
| | 1989 | | 109.41** |

*Source: AQIS and NSWFMA estimates **Source : ABARE,1991.

**Table 8b :** Assumed proportions of total catch for each species used to calculate the average NSWFMA Sydney market Weighted average price.

| Species | | | |
|---|---|---|---|
| Yellowfin | Sashimi | 0.5 | |
| | Yfn, gutted | 0.1 | |
| | Yfn, head on | 0.025 | |
| | Yfn, canning | 0.025 | |
| | | | 0.65* |
| Bigeye | Sashimi | 0.2 | |
| | Bigeye head on | 0.4 | |
| | | | 0.6 |
| Albacore | Albacore | 1.0 | |
| Billfish | Billfish | 1.0 | |

*Source: estimates from NSWFMA data.

**Table 9a:** The Australian and Japanese catches in the 100 mile wide study area. (Weights are in Kgs and effort in hooks).

Australians

| Year | Zone | Effort | Walb | Weye | Wyfn | Wswf | WBm | Wbl | WStm |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 0 | 37545 | 4122 | 169 | 44437 | 547 | 0 | 0 | 448 |
| | 1 | 64006 | 2345 | 449 | 86209 | 422 | 0 | 0 | 657 |
| | 2 | 14350 | 495 | 251 | 24555 | 348 | 0 | 0 | 120 |
| 1989 | 0 | 47436 | 1474 | 401 | 37207 | 635 | 0 | 120 | 602 |
| | 1 | 142743 | 4688 | 191 | 131050 | 953 | 0 | 61 | 992 |
| | 2 | 25030 | 1476 | 361 | 12995 | 350 | 0 | 0 | 360 |

Japanese

| Year | Zone | Effort | Walb | Weye | Wyfn | Wswf | Bm | Bl | Stm |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 1 | 280000 | 7395 | 9174 | 102641 | 0 | 0 | 2646 | 2646 |
| | 2 | 702000 | 40724 | 75332 | 116238 | 39669 | 2461 | 23281 | 3942 |
| 1989 | 1 | 76000 | 2151 | 5114 | 14414 | 0 | 0 | 2425 | 2425 |
| | 2 | 1488200 | 100863 | 143763 | 227132 | 89262 | 4398 | 16236 | 32909 |

Zone 0 is 0-12 miles from baseline, zone 1 is 12-50 miles and zone 2 is 50-100 miles.

**Table 9b:** The Catch per unit effort (CPUE) for each of the species in each zone for Australian and Japanese vessels in the study area in the 1988 and 1989 period. (CPUE, Kgs per hook)

Australians

| Year | Zone | Effort | Walb | Weye | Wyfn | Wswf | WBm | Wbl | WStm |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 0 | 37545 | 0.110 | 0.005 | 1.184 | 0.015 | 0.000 | 0.000 | 0.012 |
| | 1 | 64006 | 0.037 | 0.007 | 1.347 | 0.007 | 0.000 | 0.000 | 0.010 |
| | 2 | 14350 | 0.034 | 0.017 | 1.711 | 0.024 | 0.000 | 0.000 | 0.008 |
| 1989 | 0 | 47436 | 0.031 | 0.008 | 0.784 | 0.013 | 0.000 | 0.003 | 0.013 |
| | 1 | 142743 | 0.033 | 0.001 | 0.918 | 0.007 | 0.000 | 0.000 | 0.007 |
| | 2 | 25030 | 0.059 | 0.014 | 0.519 | 0.014 | 0.000 | 0.000 | 0.014 |

Japanese

| Year | Zone | Effort | Walb | Weye | Wyfn | Wswf | Bm | Bl | Stm |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 1 | 280000 | 0.026 | 0.033 | 0.367 | 0.000 | 0.000 | 0.009 | 0.009 |
| | 2 | 702000 | 0.058 | 0.107 | 0.166 | 0.057 | 0.004 | 0.003 | 0.020 |
| 1989 | 1 | 76000 | 0.028 | 0.067 | 0.190 | 0.000 | 0.000 | 0.032 | 0.032 |
| | 2 | 1488200 | 0.068 | 0.097 | 0.153 | 0.060 | 0.003 | 0.011 | 0.022 |

**Table 9c:** Relative catch per unit effort between Australian and Japanese vessels. The ratio is $Cpue_A/Cpue_J$. If the ratio is one the cpues are equal, if greater than one the Australian value is higher and if less than 1 the Japanese Cpue is higher.

| Year | Zone | Walb | Weye | Wyfn | Wswf | Bm | Bl | Stm |
|---|---|---|---|---|---|---|---|---|
| 1988 | 1 | 1.4 | 0.2 | 3.7 | - | - | - | 1.1 |
| | 2 | 0.6 | 0.2 | 10.3 | 0.4 | - | - | 0.4 |
| 1989 | 1 | 1.2 | 0.0 | 4.8 | - | - | - | 0.2 |
| | 2 | 0.9 | 0.1 | 3.4 | 0.2 | - | - | 0.7 |