Evaluation of Fisheries Research: An Application to Support International Decision Making

Murray Fearn and Jeff Davis

Australian Nation l University/
Australian Centre for International Agricultural Research

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1. Introduction

In many countries, the fisheries sector is an important component of the economy. The importance of this sector can be viewed through its contribution to gross domestic product, the level of foreign exchange earnings, domestic nutrition, domestic employment and linkages to other industries and services. Artisinal fisheries are also an important component of the subsistence economies of many developing countries, and provide a major source of animal protein. For an international aid organisation such as the Australian Centre for International Agricultural Research (ACIAR), it is part of its mandate to consider the fisheries sector of developing countries in the funding of collaborative research projects.

As part of the decision making process for the allocation of research funds, ACIAR is developing a set of procedures for quantifying, in a systematic manner, the potential economic welfare effects of research. The analysis of 24 agricultural commodities is outlined in Davis and Ryan (1988) and a similar analysis for forestry products has been completed by Davis, McKenney and Turnbull (1989). The evaluation of potential gains from fisheries research using existing economic surplus methodologies such as that applied in the agricultural and forestry analyses, has received little attention in the literature. As a result, there has been little analytical information available to assist decisions regarding the emphasis that should be given to fishery research on a commodity and regional emphasis. The main focus of this paper is to develop an analytically based information system to assist decision makers in their choice of which fishery commodities should receive research attention.

With the fisheries sector gaining attention internationally and an increased focus on fisheries research by national and international organisations, it seems important to develop some systematic information to assist in this research decision making process. This paper has two objectives. The first is to apply an existing research evaluation methodolgy to selected commodities of the fisheries sector. The second objective is to generate information to support decision making choices between geographic regions, and between commodities within the fisheries sector. The generated information provides some insights as to the desirable fishery commodity research focus. An important influence on the choice of commodities is the research objective of an organisation. The impact of this on the commodity choices is illustrated.

The first section of the paper will have a brief overview of world fisheries. Included is a summary of some recent literature on determining fishery evaluation and priority setting. Section 3 will outline the methodology used and the information required. Some preliminary results are presented in section 4, emphasising the potential regional and Australian benefits from fisheries research. This information is summarised in a suitable form for use as one input in the decision making process for choosing between research options. Some concluding observations are presented in section 5.

2. World Fisheries and Fishery Research Evaluation.

2.1 An Overview of Fishery Catches and Processed Products

World fishery catches in 1988 totalled 98.0 million metric tonnes, of which 71.1% was used for human consumption (FAO 1990a, 1990b). Of this, exports of processed products exceeded 35.7 million tonnes or 36.5% of total catches. Table 1 summarises world catches and processed product exports from 1979. The contribution of catches from the marine and inland water environments is also presented. Aquaculture production data, which is included in total world catches, has been recorded from 1984.

Total world fishery growth from 1978 to 1988 was 3.1% annually, though it had been as high as 5% prior to 1970 and below 1% annually for the decade from 1970. The rapid growth of inland fishery production in the same period has been due primarily to the growth of aquaculture. This is becoming an increasingly important area of fishery development.

Of the total world catch, 78% is processed further in some fashion, whether by freezing, curing or canning for human consumption; or reduction for industrial and other purposes.

In developing fisheries, there are few unexploited stocks of abundant species which can be readily caught and marketed by conventional methods. Future catch growth must come from increases in aquaculture production and unused resources such as krill and mesopelagic fish (Lawson 1984, p.28). In conjunction, one of the challenges of fishery development will be the design and implementation of management schemes designed to conserve current resources. Research planners, in order to achieve the greatest impact, would benefit from a systematic evaluation of the potential gains resulting from fishery research. Such a system would assist decision making where currently limited information is available. The next section will summarise some recent information and studies relating to the evaluation of fishery research before an analysis of the evaluation of fishery commodities is presented.

2.2 Previous Fishery Research Evaluation Studies

There are few studies explicitly dealing with the economic evaluation of fisheries and priority setting. A paper by Linder (1989) proposed a fisheries priority-setting framework in which he identified key variables. These include the ratio of potential gross annual benefits to average annual research cost, the estimated probability that gross annual benefits will be realised, the duration of the research project and the time lag to adoption. A quantitative measure incorporating this information was presented. The 'social surplus' approach was proposed as the method to quantitatively estimate gross annual research benefits, though an application of the framework is not included in the paper.

A study by Bosch and Shabman (1990) developed a simulation model which was applied at the commodity level to determine a set of research priorities for oyster production research. A model of oyster production under uncertainty, including growth, disease and economic components was used to aid priority setting. This was achieved by estimating the impact that different types of

1.

Table 1: Summary of Total World Fishery Catches, Aquaculture and Trade.

		1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	Percentage Increase 1979-88	Annual Increase
World Catch 2.	mill. mt	70.9	72.2	74.8	76.7	77.4	83.8	86.3	92.6	93.4	98.0	31.7	3.3
Inland Fisheries	mill. mt	7.2	7.6	8.1	8.5	9.2	10.0	10.7	11.8	12.7	13.4	76.4	6.4
Marine Fisheries	mill. mt	63.7	64.4	66.5	68.4	68.2	73.8	75.6	80.8	80.7	84.6	26.7	2.9
Aquaculture 3.	mill. mt	na	na	na	na	na	10.5	11.5	12.5	13.2	na	25.7	5.9
	% World Catch	-	-	-	-	-	12.5	13.3	13.5	14.1	-		
Total International Trade (exports)													
Percentage of world catch		33.2	33.3	31.5	34.0	32.5	32.9	36.1	35.9	36.6	36.5		

1. Nominal catch is measured in live-weight of landed fish (referred to as whole fresh equivalents).
2. Total world catch of fisheries excludes whales, seals, other aquatic mammals and aquatic plants. Aquatic production is included in total world catches of fisheries (including the breakdown to inland and marine fisheries).
3. Only 1984-87 available for aquaculture data

na not available

research information has on returns from a representative oyster planting enterprise.

In other studies, the economic benefits accruing from fishery rationalisation programs have been analysed. Staniford (1988) developed a partial equilibrium model for estimating the annual gross benefits from economic improvement programs that rationalise fisheries, testing the sensitivity to differing supply and demand elasticites. Generally, these studies have not considered the impact of new technologies on fisheries which could potentially provide the same level of benefits. Bolade (1988) discusses the issues and analysis of technological innovations for fisheries development but does not apply any framework to assess their impact.

Internationally, there has been increasing attention focused on developing strategies for fisheries research. This has enhanced the need for more systematic procedures to generate information as an input into this decision making process. International organisations such as the International Centre for Living Aquatic Resource Managemen (ICLARM) are actively involved in developing research strategies for fisheries. This need has increased with their recent admittance to the Consultive Group on International Agricultural Research (CGIAR) who, through the Technical Advisory Committee Secretariat (TAC), have also been considering how to assess research priorities. Other organisations such as The World Bank, The Commission of European Communities, United Nations Development Program (UNDP) and FAO jointly sponsored a 'Study of International Fisheries Research' which commenced in May, 1989. Part of the study involves developing an approach and a framework for assessing fisheries research needs in developing countries (World Bank 1989). Australian institutions have also been involved with developing priorities and research strategies. A recent workshop organised by the Bureau of Rural Resources (BRR 1989) discussed the future needs of Australian fisheries research, part of which involved the research priority setting process. While no formalised procedure was developed, participants expressed strong interest in greater involvement in research priority setting.

While fishery research has been recognised as having the greatest potential for the future development of fisheries, there is little information on the potential economic benefits of research to assist in any decision making regarding the potential research emphasis to follow. Through this study, it is hoped that the information generated from the framework's application will be of use to decision makers to assist in the development of fishery research strategies.

3. Methodology and Data Assembly

3.1 Introduction

Davis, Oram and Ryan (1987) summarise the categories of information required to apply a partial equilibrium multi-regional traded good model to evaluate the potential benefits from research for a particular commodity. Before outlining the information requirements, the methodology used in the analysis is briefly outlined followed by the definition of fishery commodities used for the study.

3.2 Methodology

A framework to evaluate the potential gains from research is developed by Davis, Oram and Ryan (1987), incorporating international, regional and national perspectives in a single commodity, partial equilibrium, multi- regional traded good model. The model uses the concepts of economic surplus to derive *ex ante* measures of the relative economic benefits of alternative commodity and regional research portfolios and the distribution of these benefits among consumers, producers, importers and exporters (Davis and Ryan 1987a).

The framework is an extension of the Edwards and Freebairn (1981, 1982, 1984) model from a two-country to a multi-country basis. This allows the likely spillover effects of research to similar production environments to be incorporated and is an important distinguishing feature from the Edwards and Freebairn model.

The details of the model are documented in Davis, Oram and Ryan (1987) and are only briefly summarised here following Davis and Ryan (1987a, 1987b). Figure 1 illustrates a simple two-country situation for a single time period. In evaluating any benefits, the model assumes that research on a commodity generates benefits through lowering the costs of production of the commodity, represented by k_{aa} in Figure 1(a). This causes the supply curve to shift down to the right from S_a to S_a'. This supply curve is assumed to be linear with a parallel shift due to research. If the research has relevance in an importing country (B), it can be expected to also lower production costs in that country after a suitable lag period by k_{ba} in Figure 1(c). The shaded area indicates the benefits from research that are measured using the framework. The commodity research is assumed to have no impact on other commodity prices or services, or any macro- economic variables. World price effects on the commodity being researched are accommodated through the demand curves which are assumed to be linear. The model also assumes static demand, although this can easily be relaxed.

The model also incorporates the strength of individual countries' research systems, the ceiling level of adoption of research results, lags in the adoption of the research results, and the impact of the commodity being traded or not.

3.3 Fishery Commodity Classification

The methodology employed to evaluate the potential economic benefits from research in fisheries requires information to be commodity based. The most comprehensive world-wide information source of fishery catches and processed product statisitcs is from the United Nation's Food and Agricultural Organisation's "Yearbook of Fishery Statistics" series (eg. FAO (1990a, 1990b)). Within these sources, information is presented in a wide range of formats. Fearn (1990) provides a comprehensive review of the FAO fishery data sources. From this it is noted there is no formalised commodity structure linking the catches and landings data with the processed products information since each data source is based on different classification systems. It is necessary to establish a clear understanding of the basis for the definition of fishery commodities used in the analysis.

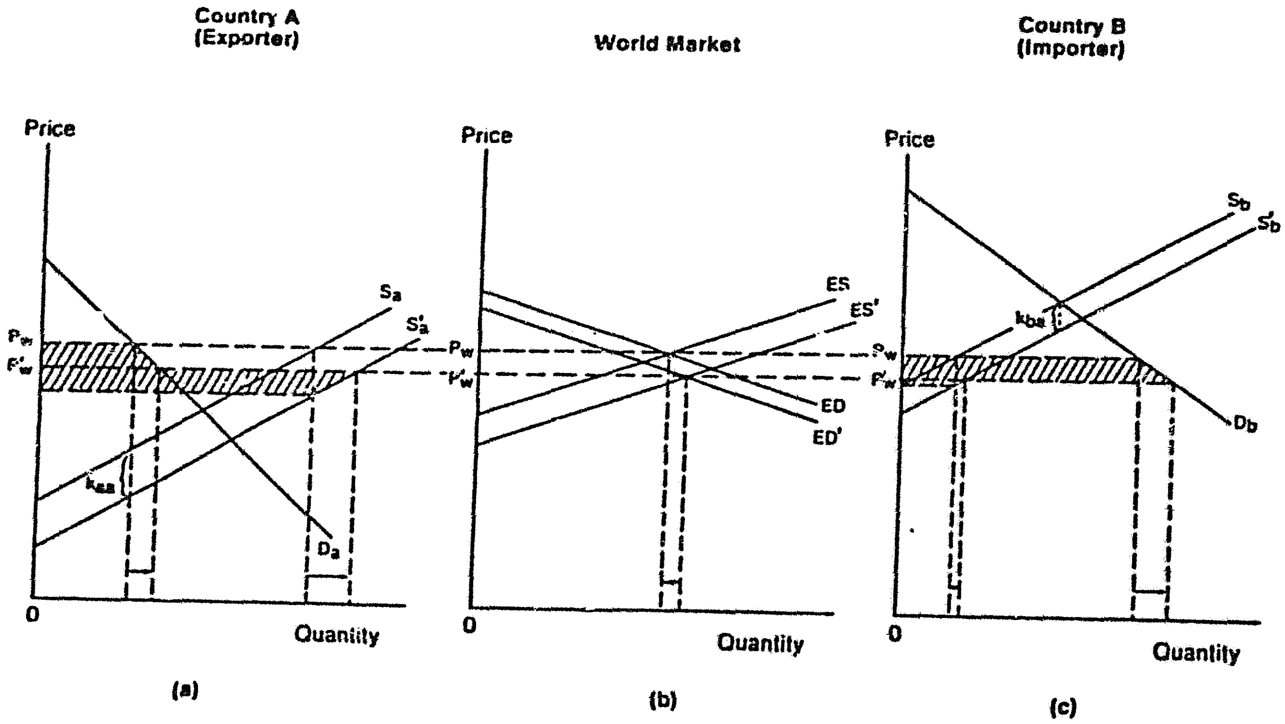

Figure 1: Two Country Diagrammatical Representation of the Model
(Source: Davis and Ryan 1987a)

The definition of fishery commodities is based on the format used by FAO to record the catches and landings information. FAO provides catches information on 840 individual species. Each of the species items is arranged into fifty-one groups of species that constitute the nine divisions of the FAO 'International Standard Statistical Classification of Aquatic Animals and Plants' or ISSCAAP (FAO 1990a, p.7). Each of the 51 ISSCAAP sub-groups is represented by a 2-digit code.

From the ISSCAAP system, the 2-digit level is used as the basis for determining fishery 'commodities'. The 2-digit ISSCAAP groupings provide a logical aggregation of similar species. As a result, each of the 2-digit groupings are refered to as separate commodities. It is assumed each represent reasonably homogenous 'fisheries' in production (ie. captures and landings) and relatively homogenous products in consumption. The logic for determining the individual fishery commodities has been supported by fishery technical experts.

Figures 2 to 4 illustrate the ISSCAAP commodity classification system for the three fishery production environments of marine, freshwater and brackishwater. Catches and landings production levels for 1988 are also shown. The boxed commodity groupings indicate those commodities selected for analysis.

The definition of the commodities has been orientated towards that of the primary product at the captures level rather than the processed products. This is consistent with the nature of fishery research projects funded by ACIAR and the emphasis of these projects on the development of fishery resources in developing countries. Other influencing factors in commodity definition have been the availability of production and price data at this level. Also, it is important for production data to include fishery output captured or cultured for subsistence purposes.

Within the three fishery environments of marine, brackishwater and freshwater, the twelve commodities selected for analysis include:

- Carps, barbels and other cyprinids (11)
- Tilapias and other cichlids (12)
- Miscellaneous diadromous fishes (25)
- Demersal and pelagic fishery (31-34)
- Herrings, sardines, anchovies (35)
- Tunas, bonitos, billfishes (36)
- Mackerals, snoeks, cutlassfishes (37)
- Lobsters, spiny-rock lobsters (43)
- Shrimps, prawns (45)
- Oysters (53)
- Mussels (54)
- Clams, cockles, arkshells (56)

The number in brackets indicates the 2-digit ISSCAAP grouping. Catches and landings production from the selected commodities account for 72% of total world fisheries production (FAO 1990a). One commodity, the Demersal and pelagic fishery, is an aggregation of four 2-digit ISSCAAP groupings[1].

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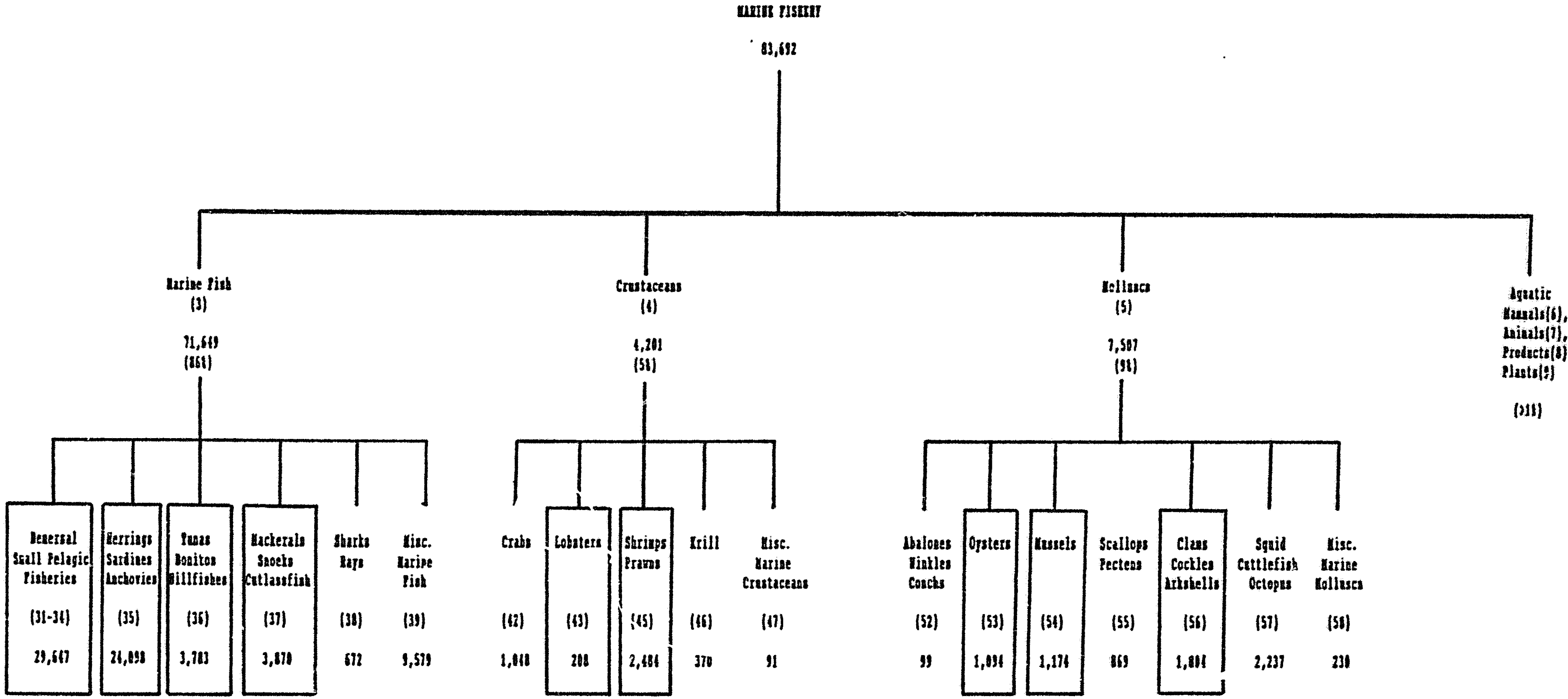
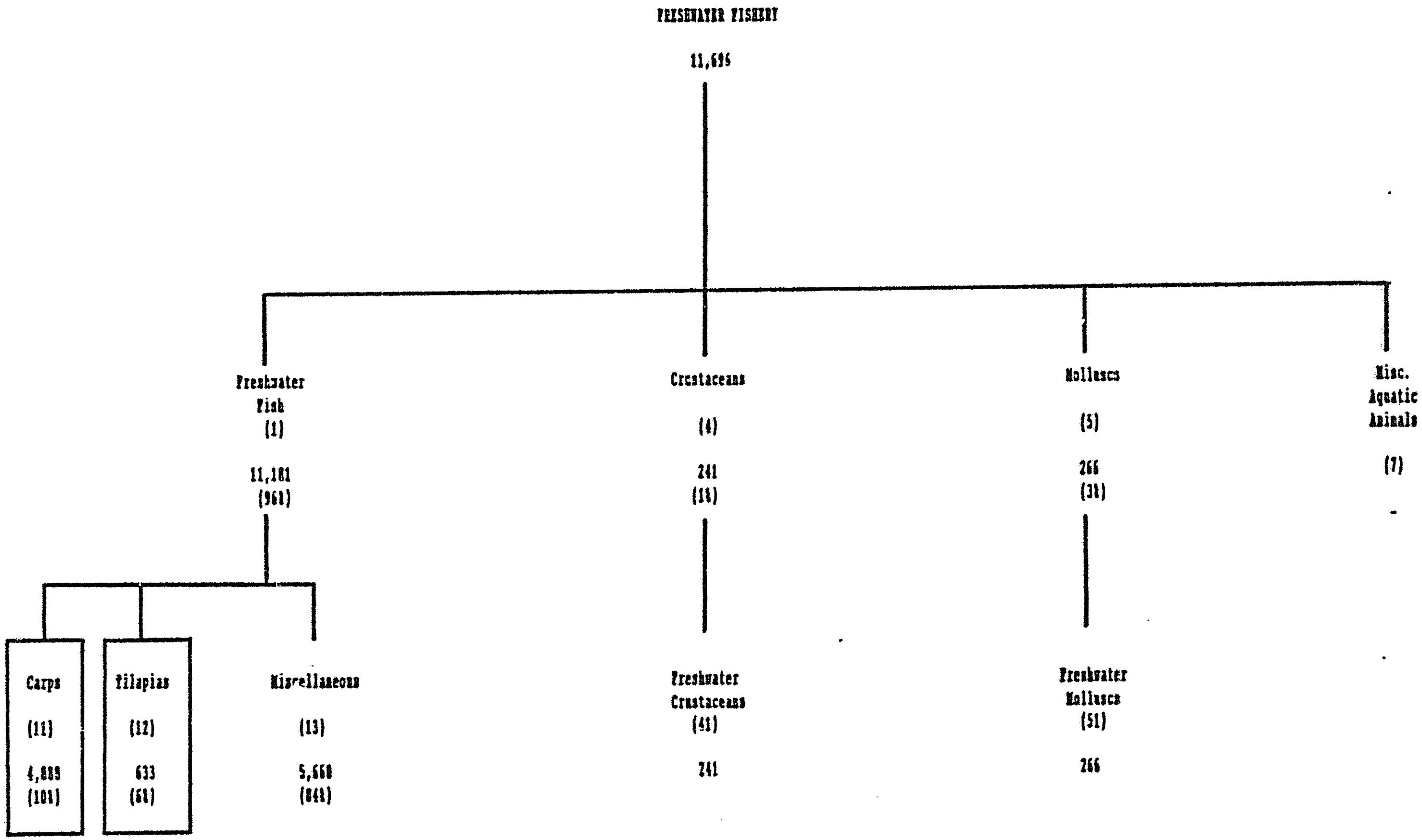
1. These groupings include: Flounders, halibuts, soles (31); Cods, hakes, haddocks (32); Redfishes, basses, congers (33); and Jacks, mullets, sauries (34).

Figure 2: The Breakdown of the Marine Fishery into Commodity Groupings with 1988 Production ('000 mt).



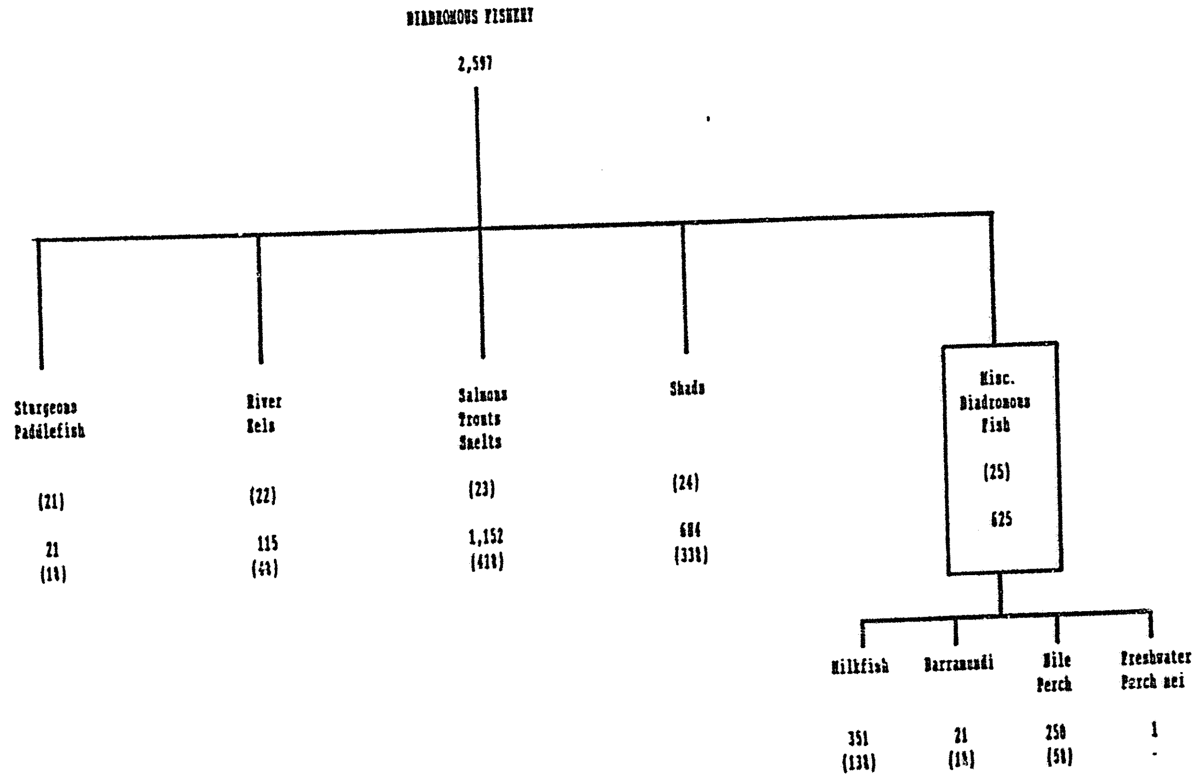
Source: FAO 1990a

Figure 3: The Breakdown of the Freshwater Fishery into ISSCAAP Commodity Groupings with 1988 Production ('000 mt).



Source: FAO 1990a

Figure 4: The Breakdown of the Diadromous Fishery into ISSCAAP Commodity Groupings with 1997 Production ('000 mt).



Source: FAO 1999a

These groupings were aggregated because of their similar production environments and technologies, based on the opinion of several fishery technical experts with a broad knowlegde of international fisheries.

The next section will outline the commodity data requirements for the evaluation of fishery research benefits.

3.4 Information Requirements

This section of the paper will discuss the information requirements and sources of this information as well as any procedures used to adapt it for use in the fisheries analysis. The information requirements include: production and consumption information; supply and demand elasticities; potential spillover effects of research; assessments of the relative strength of different research systems and ceiling levels of research adoption for each country/region; and assessments of research and adoption lags.

3.4.1 Production and Consumption

Production data is obtained from FAO computer tapes for fishery catches and landings. The catches and landings of each commodity represented by the 2-digit ISSCAAP classification grouping is recorded in metric tonnes of whole fresh equivalents (WFE).

Consumption data is more difficult to obtain by the defined commodities and in equivalent units to production. Information is available from FAO data tapes for processed fishery products. This is stored by processed product category and does not fully correlate with the format of the catches and landings data. Also, this information is in units (ie. metric tonnes) of processed product when the requirement was for consumption data to be in equivalent units to production, represented by WFE. As a result, it was necessary to convert processed product information for each commodity to WFE using FAO conversion factors, also refered to as extraction rates. This procedure is fully documented in Fearn (1990).

To simplify this procedure, commodities were assumed to be either traded or non-traded. Traded commodities included Herrings; Tunas; Mackerals; Lobsters; Shrimps/prawns; Oysters; Mussels and Clams. These commodities were subject to the procedure for conversion to whole fresh equivalents. The remaining commodities were assumed to be non-traded. These included Carps; Tilapias; Miscellaneous diadromous fish and the Demersal/pelagic fisheries. In these cases, it was assumed catches and landings production (already in WFE) equalled consumption, negating the need for any conversion procedure to be used.

3.4.2 Fishery Commodity Prices

A composite fishery 'commodity' price is required for the analysis. It would be desirable to have 'at-the-wharf' commodity prices for each individual country. However, this is obviously a difficult task given the variety of prices for individual species within each commodity and the fact that many reported values of production are for processed products. Price information for different species was obtained from Copland and Lucas (1988), ABARE (1988), Campbell et al (1989), SEAFDEC (1989) and FAO (1990b) and used to estimate commodity prices. It is envisaged that a more objective procedure to aggregate individual species price information for each commodity will be employed as the analysis develops further.

Table 2 lists the prices currently being used and the sources of information.

3.4.3 Supply and Demand Elasticities

There is limited information available on elasticity estimates for fishery commodities, especially supply elasticities. Anderson (1973) estimated demand elasticities in the USA for a range of fishery products. A later study by Cheng and Capps (1988) estimated demand elasticities for a similar range of commodities, also for the US market. Kingston, Smith and Beare (1990) studied the demand for seafood in Japan, disaggregating the analysis to home and away-from-home consumption. However, this study considered more general seafood classifications (eg. crustaceans) that where broader than that desired for this study. With studies that compare the demand for alternative forms of meat (eg. beef, chicken etc), seafood is usually included as a broad food category rather than as individual commodities. Table 3 provides a summary of demand elasticities taken from previous studies. The studies concentrate on the dominant US and Japanese markets for seafood products. Table 4 lists the elasticities currently used in the analysis. Supply elasticities are guestimates at this stage and require further input considering the variation of production techniques between commodities and countries. However, the importance of elasticites for the purpose of the results reported in this paper is not significant. Elasticity estimates are important when considering the distribution of estimated benefits between producers and consumers. More attention needs to be focused on this area when an analysis of the distribution of benefits is made.

3.4.4 Spillover estimates

(i) Background

An innovative aspect of the Davis, Oram and Ryan (1987) research evaluation framework is the inclusion of potential spillover benefits from research conducted in one region to other regions of similar agro-ecological characteristics. Davis, Oram and Ryan (1987) outline the preliminary procedures used to determine homogenous agro-climatic zones and estimate potential spillovers. Spillover estimates were based on the notion that research undertaken for a commodity in one set of agro-climatic conditions were potentially applicable to production in other similar agroclimatic regions. Likewise, regions which are dissimilar would recieve few, if any, spillover benefits of the research.

The original geographical region to region spillovers used by Davis, Oram and Ryan (1987) were subjectively estimated. Davis, McKenney and Turnbull (1989) and Davis (1991) have suggested a procedure which replaces some of the subjective spillover estimation with a more systematic procedure. This should

Table 2 : Price Information Used in the Analysis[1]

Commodity	Price[2] ($US/mt)
Carps	1,200
Tilapias	1,400
Misc. diadromous	1,000
Demersal/pelagic	1,000
Herrings	650
Tunas	1,100
Mackerals	400
Lobsters	11,000
Shrimps/prawns	5,000
Oysters	2,500
Mussels	450
Clams	3,000

1. Average for 1983-85.
2. Units are in whole fresh equivalents.

Table 3 : Demand Elasticities for Fishery Commodities from Previous Studies

Commodity	Period	Country	Elasticity	Author
Atlantic groundfish		USA	-1.0000	Anderson (1973)
Halibut		USA	-1.0000	Anderson (1973)
Haddock	1981	USA	-0.5557	Cheng and Capps (1988)
Cod	1981	USA	-0.5258	Cheng and Capps (1988)
Cod	1967-80	USA	-0.405 (-0.460)*	Tsoa, Schrank and Roy (1982)
Flounder/sole	1981	USA	-0.4500	Cheng and Capps (1988)
Flounder/sole	1967-80	USA	-0.549 (-1.040)	Tsoa, Schrank and Roy (1982)
Perch	1981	USA	-0.7039	Cheng and Capps (1988)
Ocean perch	1967-80	USA	-0.606 (-0.702)	Tsoa, Schrank and Roy (1982)
Snapper	1981	USA	-0.9720	Cheng and Capps (1988)
Salmon		USA	-0.7066	Anderson (1973)
Sardines		USA	-0.9837	Anderson (1973)
Tuna		USA	-0.8632	Anderson (1973)
Tuna (aggregate)	1979-86	Japan	-0.45	Kingston, Smith and Beare (1990)
Tuna (household)	1979-86	Japan	-1.15	Kingston et al (1990)
Tuna (away)	1979-86	Japan	-0.35	Kingston et al (1990)
Total finfish	1981	USA	-0.6746	Cheng and Capps (1988)
Fish	1966-85	Japan	-0.55	Teal et al (1987)
Fish (aggregate)	1979-86	Japan	-0.58	Kingston et al (1990)
Fish (household)	1979-86	Japan	-0.68	Kingston et al (1990)
Fish (away)	1979-86	Japan	-0.49	Kingston et al (1990)
Total seafood	1972-74	USA	-0.465	Capps (1982)
Seafood (aggregate)	1979-86	Japan	-0.77	Kingston et al (1990)
Seafood (household)	1979-86	Japan	-0.43	Kingston et al (1990)
Seafood (away)	1979-86	Japan	-0.99	Kingston et al (1990)
Shrimp		USA	-0.3099	Anderson (1973)
Shrimp	1981	USA	-0.6956	Cheng and Capps (1988)
Shrimp	1950-68	USA	-0.63	Doll (1972)
Shrimp		USA	0.280	Cleary (1969)
Northern lobsters		USA	-0.5995	Anderson (1973)
Crabs		USA	-0.1487	Anderson (1973)
Crabs	1981	USA	-0.7713	Cheng and Capps (1988)
Crustaceans (aggregate)	1979-86	Japan	-0.39	Kingston et al (1990)
Crustaceans (household)	1979-86	Japan	-3.17	Kingston et al (1990)
Crustaceans (away)	1979-86	Japan	0.49	Kingston et al (1990)
Total shellfish	1981	USA	-0.8830	Cheng and Capps (1988)
Oysters		USA	-0.6724	Anderson (1973)
Oysters	1981	USA	-1.1320	Cheng and Capps (1988)
Clams		USA	-0.6047	Anderson (1973)
Sea scallops		USA	-0.6337	Anderson (1973)

* Numbers in brackets indicate long-run estimates

Table 4 : Summary of Fishery Commodity Elasticities Used in the Analysis

Commodity	Demand Elasticities		Supply Elasticities
	Previous studies range	Estimate used	Estimate used
Carps		-0.65	0.80
Tilapias		-0.65	0.45
Misc. diadromous		-0.65	0.80
Demersal	-0.405 - -1.0000	-0.65	0.80
Herrings	-0.9837	-0.90	0.90
Tunas	-0.35 - -1.15	-0.90	0.85
Mackerals		-0.90	0.90
Lobsters	-0.5995	-0.60	0.80
Shrimps/prawns	0.280 - -0.3099	-0.60	0.75
Oysters	-0.6724 - -1.1320	-0.70	0.30
Mussels		-0.70	0.40
Clams	-0.6047	-0.60	0.30

improve replicability and consistency of results although there is still scope for further improvement. The procedure is briefly outlined here.

With the country focus of the framework, there is often countries that have multiple production environments. The revised approach incorporates the proportion of production from each production environment within a country into the spillover estimate.

The process is represented by a simple matrix, given as:

$$S = R\ C\ F$$

Where:

S is an n x n matrix of the estimates of the potential research spillover weights on a scale of 0 to 1 among countries/regions chosen for analysis; n is the number of country/regions.

R is an n x m matrix of potential research emphasis parameters, m is the number of production environments.

C is an m x m matrix of production environment to production environment spillovers.

F is an m x n matrix of commodity production shares for each country by production environment.

The elements of S are equivalent to the potential spillovers used in Davis, Oram and Ryan (1987). Each element represents the estimated country to country research spillover. The R matrix is used to account for the multiple production environments in certain countries and assess the potential impact of focusing research to develop technologies specific to particular production environments. In this analysis, it is assumed the research focus is equivalent to the proportion of production in each of the production environments. Elements of the C matrix represent estimates of the potential spillovers due to production environment factors, ignoring the individual countries' production environment composition. Finally, elements of F represent the share of production in each production environment for each country.

(ii) Application to a Fishery Analysis - Assumptions and Information Used.

An important part of this approach is the use of production environments in the determination of spillover estimates. Davis, Oram and Ryan (1987) used the FAO AEZ classification system to define similar production environments for agricultural commodities. For the analysis of forestry commodities, Davis, McKenney and Turnbull (1989) used the agroclimatic system developed by Papadakis (1975). In order to determine the spillover effects of research for fisheries, it is necessary to identify a similar set of ecologically homogenous production environments for fishery commodities.

From the available literature, there is no uniformly accepted classification that defines ecologially homogenous aquatic environments for fisheries.

Environmental characteristics such as salinity, water temperature, water depth, currents, winds, rainfall, dissolved oxygen levels and nutrients combine to form distinct ecological areas. Even though information on some variables is available separately in varying degrees of detail, accuracy and completeness, there is no formal system combining these factors into homogenous aquatic environments. New technologies such as remote sensing and computerised fish location mapping are adding to the body of available information that could be used in developing homogenous aquatic zones.

In the absence of a formal source of homogenous aquatic production environments, other methods need to be utilised. This procedure is outlined below[2].

Each commodity consists of a group of similar species. For example, Tunas is a combination of skipjack (Katsuvonus pelamis), yellowfin (Thunnus albacares), bigeye tuna (Thunnus obesus), albacore (Thunnus alalunga), southern bluefin (Thunnus maccoyii) and other tuna and tuna-like fishes. The species that constitute each commodity are considered substitutes in consumption such that when combined, they form a homogenous product. However, each species within the commodity are biologically different and exist in differing sets of environmental conditions.

The biological differences between species within the same commodity provide the basis for determining the aqua-ecological zones. Technical experts agreed that a sufficient proxy for aqua-ecological zones is represented by individual species within a commodity. It is assumed the physical and biological characteristics of each species within the different commodities embody the environment in which they exist. Under this assumption, a certain combination of environmental conditions need be present for each individual species to occur in a particular location. Therefore, it is assumed the location of each species determines the homogenous aqua-ecological environment that represents a particular combination of environmental conditions. As the fish are sensitive to their environment and embody these characteristics in their biological makeup, it is assumed that this is the paramount indication of homogenous zones. It follows that the location of the same fish species in two aquatic areas indicates the existance of the same set of aquatic characteristics and subsequently the same aqua-ecological zone. Thus, each individual species is used to represent homogenous aqua-ecological environments.

The exception is for the commodity of Demersal and pelagic fisheries. Within this commodity there are too many individual species to consider each a separate production environment (ie. demersal/pelagic consists of 569 individual species, see Fearn (1990)). Subsequently, some form of species aggregation was required to provide a more manageable level of homogenous environments. Species were aggregated by technical experts into sub-fisheries. The sub-fishery aggregation was based firstly, on the geographic location of species production and then the biological characteristics of individual species at those geographic locations.

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2. The authors wish to acknowledge the suggestions and assistance of Dr Stephen Blaber of CSIRO Marine Laboratories, Cleveland, Qld. in developing an alternative method of defining aquatic zones for the purpose of spillover estimation.

With the homogenous production environments determined (ie. the aqua-ecological zones), potential spillover benefits of research between countries can be estimated following the procedure outlined by Davis, McKenney and Turnbull (1989) and Davis (1991). The estimation of the R, C, and F component matices is outlined below.

The C matrix indicates the potential spillovers due to environmental factors. For fishery commodities, this was a subjective estimate made by fishery technical experts of the spillovers between species. Estimates are made on the potentail spillover of the results of research done on one species to another species, based on the biological characteristics and compatability of those characteristics between the two species. In the analysis, m varies according to the number of species within a commodity, and range from m=5 to m=75.

In this analysis, the potential research focus parameters, R, for each country are assumed to be the same as the proportion of each species production within the commodity concerned. Therefore, it is assumed R=F'. Elements of the F matrix consist of the share of country production contributed by each species in a commodity. These proportions are obtained from the FAO fishery computer data tapes.

3.4.5 Other parameters

(i) Relative Research Strengths and Ceiling Level of Adoption

Subjective assessments by technical experts were used to give the relative research strengths of each country/regions national research system. Estimates were based on the knowledge of national research systems and the perceived ability to complete fisheries research projects. Separate estimates were made for each commodity. For similar types of commodities such as Tunas and Mackerals, similar country estimates were assigned, indicating some consistency in this subjective parameter's estimation.

Ceiling levels of adoption were also subjectively estimated by fishery experts for each commodity by country or region. The estimates indicate the maximum proportion of producers eventually expected to adopt the new technology. It reflects the ability of producers to adopt technologies; the capacity of the extension system to provide information on new technologies; and the market environment's capacity to provide suitable means such as finance and marketing arrangements to enhance the adoption of new technologies.

(ii) Lags and Discount Rate

Davis, Oram and Ryan (1987) used a lag of 11 years for the country undertaking the research and 15 years for countries receiving spillover benefits. For the forestry analysis by Davis, McKenney and Turnbull (1989), a similar lag structure was used for fuelwood, pulpwood, charcoal and pitprop products. However, questions were raised as to the appropriate lag period for sawlogs and veneer logs.

For the preliminary results of the fishery commodities presented in this paper, a similar set of lags have been used.

The discount rate used is 12.0%. This is a real rate of interest and may be viewed as an appropriate opportunity cost of public research funds (Davis, McKenney and Turnbull 1989). Even if this rate is considered high, the relativities between the commodities should not change.

For the analysis, a 30 year planning horizon is used with a 12% discount rate. At this stage of the analysis, information on spillovers, adoption levels and research strengths have not been estimated for all commodities. It has been necessary to use default estimates of these parameters for the commodities of Carps, Misc. diadromous fishes, Oysters, Mussels and Clams. This consists of substituting 1.0 for those parameters, resulting in the potential benefit and subsequent commodity ranking being the maximum obtainable.

4. Potential Benefits from Fishery Commodity Research

4.1 Introduction

The analyses generate a considerable amount of information, of which only a small part will be dealt with in this paper. In summarising any of the available information, it is important to have the research instituitions research objectives clearly defined. The results are presented from the ACIAR veiwpoint where preliminary discussions of ACIAR's primary objectives indicate its aim is to (1) maximise regional benefits from its research funding, where a region is ACIAR's mandate regions, for example South East Asia, South Asia etc; and (2) maximise gains to Australia.

One objective of the paper is to determine the potential regional gains from fishery commodity research to support decision making choices between regions and fishery commodities. Regional benefits have been defined as direct and spillover benefits to all countries in the geographic region were the research is being undertaken (Davis, McKenney and Turnbull, 1989). For example, if research is funded in the Philippines, regional benefits include those directly accruing to the Philippines plus the spillover benefits to other countries in South East Asia. One output will summarise information focusing on the objective of maximising potential regional benefits.

Secondly, due to the collaborative nature of research projects funded by ACIAR, it is important to consider the potential Australian research benefits. Research strategies of a multi-national focus are compared to those of an Australian focus through assessing the possible congruence of commodity benefits from the alternative objectives.

4.2 Potential Regional Gains from Fisheries Research

Table 5 summarises the present values and relativities of the potential regional benefits resulting from research on the selected fishery commodities for ACIAR's five geographic mandate regions. This is based on a common unit-cost reduction of five percent of the pre-research costs for all commodities. (Initially pre-research costs are assumed to be an indicator price).

The upper half of Table 5 orders the fishery commodities according to the present value of benefits for each geographic region. No commodity appears to have any significant global domination with different commodities having the greatest estimated benefits in each region.

The bottom half of the table presents the relativities between the fishery commodities. This information has proven to be of more use to the decision maker as it abstracts from the arbitrary use of a five percent unit cost reduction. Relativities are calculated by dividing the highest present value of the expected benefits by the other values. The result indicates the multiple of the expected unit cost reduction necessary to achieve the same benefits as research on the highest ranking commodity. For example, for research on oysters in South Asia to achieve the same total benefits as clam research, it would require a unit cost reduction of 10 times that expected from clams.

The diversity of dominant commodities in each region reflects the diverse nature of the aquatic production environments between these regions. The value of regional benefits are dominanted by the potential benefits of Carp research in China. Even without the maximum parameter assumptions, benefits would still be significant because of the substantial levels of carp production in the country, especially through aquaculture activities. Prawns/shrimps and Demersal/pelagic fisheries are important in the Asian regions while Tunas are dominant in the South Pacific. The table also indicates the low potential of certain commodities in each region where unrealistic relative cost reductions are necessary to achieve comparable levels of potential research benefits. With these commodities, it is unlikely that research funding is justifiable except under special circumstances.

The information presented in Table 5 is only a small part of the information that can be obtained from the output of the analyses. In the simplified form presented, the relativites can be seen as a useful input for decision-makers determing commodity and regional research emphasises.

4.3 Priority Groupings

To further assist decision making on the the allocation of resources, information has been categorised according to priority groupings. Six groupings are formulated and allocation to each grouping depends on the commodity relativities calculated in Table 5. The cutoff levels for each grouping have been made arbitrarily and consists of the following ranges:

Table 5 : Potential Regional Benefits and Relativities from Fishery Commodity Research

SOUTH EAST ASIA		SOUTH ASIA		CHINA		SOUTH PACIFIC AND PAPUA NEW GUINEA		AFRICA		WEST ASIA NORTH AFRIC	
Commodity	Regional Benefits ($US m.)	Commodity Ranking	Regional Benefits ($US m.)	Commodity Ranking	Regional Benefits ($US m.)	Commodity Ranking	Regional Benefits ($US m.)	Commodity Ranking	Regional Benefits ($US m.)	Commodity Ranking	Regional Benefits ($US m.)
Prawns\shrimps	21.9	Clams	61.3	Carps	335.1	Tuna & others	4.4	Misc. diadr.	20.6	Herrings & others	9.5
Demersal\pelagics	12.0	Misc. diadr.	40.6	Prawns\shrimps	28.9	Demersal\pelagics	0.5	Carps	8.1	Carps	2.8
Herrings & others	6.6	Prawns\shrimps	25.9	Demersal\pelagics	7.3	Lobsters	0.2	Lobsters	4.8	Demersal\pelagics	1.6
Tilapia	2.7	Carps	23.8	Mussels	5.2	Prawns\shrimps	0.1	Tilapia	4.1	Mackerals & others	1.2
Lobsters	0.8	Demersal\pelagics	23.0	Mackerals & others	4.3	Clams	0.1	Herrings & others	1.4	Prawns\shrimps	0.6
Mackerals & others	0.8	Tilapia	9.4	Tuna & others	2.5	Misc. diadr.	0.1	Demersal\pelagics	1.0	Lobsters	0.6
Tuna & others	0.5	Oysters	6.1	Herrings & others	0.2	Tilapia	0.1	Oysters	0.3	Tuna & others	0.3
Carps	0.1	Mussels	4.9	Oysters	0.0	Carps	0.0	Tuna & others	0.2	Mussels	0.1
Misc. diadr.	0.1	Tuna & others	3.7	Tilapia	0.0	Oysters	0.0	Prawns\shrimps	0.2	Oysters	0.0
Clams	0.0	Herrings & others	3.6	Misc. diadr.	0.0	Herrings & others	0.0	Mackerals & others	0.1	Misc. diadr.	0.0
Oysters	0.0	Lobsters	3.5	Lobsters	0.0	Mackerals & others	0.0	Clams	0.0	Tilapia	0.0
Mussels	0.0	Mackerals & others	3.5	Clams	0.0	Mussels	0.0	Mussels	0.0	Clams	0.0

	COMMODITY RELATIVITY		COMMODITY RELATIVITY		COMMODITY RELATIVITY		COMMODITY RELATIVITY		COMMODITY RELATIVITY		COMMODITY RELATIVITY
Prawns\shrimps	1.0	Clams	1.0	Carps	1.0	Tuna & others	1.0	Misc. diadr.	1.0	Herrings & others	1.0
Demersal\pelagics	1.8	Misc. diadr.	1.5	Prawns\shrimps	11.6	Demersal\pelagics	8.8	Carps	2.5	Carps	3.4
Herrings & others	3.3	Prawns\shrimps	2.4	Demersal\pelagics	45.9	Lobsters	22.0	Lobsters	4.3	Demersal\pelagics	5.9
Tilapia	8.1	Carps	2.6	Mussels	64.4	Prawns\shrimps	44.0	Tilapia	5.0	Mackerals & others	7.9
Lobsters	27.4	Demersal\pelagics	2.7	Mackerals & others	77.9	Clams	44.0	Herrings & others	14.7	Prawns\shrimps	15.8
Mackerals & others	27.4	Tilapia	6.5	Tuna & others	134.0	Misc. diadr.	44.0	Demersal\pelagics	20.6	Lobsters	15.8
Tuna & others	43.8	Oysters	10.0	Herrings & others	1675.5	Tilapia	44.0	Oysters	68.7	Tuna & others	31.7
Carps	219.0	Mussels	12.5	Oysters	0.0	Carps	0.0	Tuna & others	103.0	Mussels	95.0
Misc. diadr.	219.0	Tuna & others	16.6	Tilapia	0.0	Oysters	0.0	Prawns\shrimps	103.0	Oysters	0.0
Clams	0.0	Herrings & others	17.0	Misc. diadr.	0.0	Herrings & others	0.0	Mackerals & others	206.0	Misc. diadr.	0.0
Oysters	0.0	Lobsters	17.5	Lobsters	0.0	Mackerals & others	0.0	Clams	0.0	Tilapia	0.0
Mussels	0.0	Mackerals & others	17.5	Clams	0.0	Mussels	0.0	Mussels	0.0	Clams	0.0
Regional Relativities	15.3		5.5		1.0		76.2		15.3		35.3

PRIORITY GROUP	COMMODITY RELATIVITY RANGE
I	0 to <5
II	5 to <7
III	7 to <15
IV	15 to <25
V	25 to <40
VI	40 and above

The fishery commodities allocated to priority groupings are listed in Table 6.

The commodities in the higher priority groupings (I and II) indicate those that are likely to achieve the greatest payoffs for the research. Those commodities falling into groups III and IV warrant a greater degree of justification before research is a viable option while those in the bottom groupings are unlikely to attract funding from limited research resources.

4.4 Comparing Potential Benefits of a Regional versus Australian Objective

The analyses generates individual country information, from which the summary regional and international benefits are calculated. It is therefore possible to focus attention on individual country objectives as well as taking a regional or international perspective.

Potential collaborating Australian institutions often have a national rather than regional benefits based research objective. It is important for an international aid institution such as ACIAR to take into account the differing institutional research objectives which may result in potentially conflicting research priorities. If differing objectives lead to conflicting priorities, it is useful to assess the congruence of commodities in the resulting priority groupings as another input into the decision making process.

Table 7 summarises information on the potential benefits accruing to Australia from research done in Australia taken from the analysis discussed above. The results in column (1) of Table 7 indicate research on lobsters and prawns/shrimps provide substantially greater direct benefits to Australia than the other commodities.

The table also reports the potential spillover benefits to other regions (column (4)) other than Australia arising from this research. Total international benefits for each commodity are listed in column (5).

It is possible to highlight with this information the potential conflicts in priorities that may occur with differing research objectives. This can be illustrated using the box diagrams in Figure 5 and 6. Figure 5 compares commodities in the priority groupings resulting from a South East Asian research objective with an Australian research objective. The southwest-northeast diagonal boxes indicate a congruence of the Australian research objective with that of the regional objective. Commodities that occur in these boxes satisfy both sets of objectives. For example, Prawns/shrimps provide a

Table 6 : Fishery Priority Groupings for Regional Benefits Objective.

SOUTH EAST ASIA		SOUTH ASIA		CHINA		SOUTH PACIFIC AND PAPUA NEW GUINEA		AFRICA		WEST ASIA NORTH AFRIC	
Commodity	Regional Benefits	Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits
I Prawns\shrimps	1	I Clams	1	I Carps	1	I Tuna & others	1	I Misc. diadr.	1	I Herrings & others	1
Demersal\pelagics	2	Misc. diadr.	2	III Prawns\shrimps	12	III Demersal\pelagics	9	Carps	3	Carps	3
Herrings & others	3	Prawns\shrimps	2	VI Demersal\pelagics	46	IV Lobsters	22	Lobsters	4	II Demersal\pelagics	6
III Tilapia	8	Carps	3	Mussels	64	VI Prawns\shrimps	44	II Tilapia	5	III Mackerals & others	8
V Lobsters	27	Demersal\pelagics	3	Mackerals & others	78	Clams	44	III Herrings & others	15	IV Prawns\shrimps	16
Mackerals & others	27	II Tilapia	7	Tuna & others	134	Misc. diadr.	44	IV Demersal\pelagics	21	Lobsters	16
VI Tuna & others	44	III Oysters	10	Herrings & others	1676	Tilapia	44	VI Oysters	69	V Tuna & others	32
Carps	213	Mussels	13	Oysters	0	Carps	0	Tuna & others	103	VI Mussels	95
Misc. diadr.	219	IV Tuna & others	17	Tilapia	0	Oysters	0	Prawns\shrimps	103	Oysters	6
Clams	0	Herrings & others	17	Misc. diadr.	0	Herrings & others	0	Mackerals & others	206	Misc. diadr.	0
Oysters	0	Lobsters	18	Lobsters	0	Mackerals & others	0	Clams	0	Tilapia	0
Mussels	0	Mackerals & others	18	Clams	0	Mussels	0	Mussels	0	Clams	0

Table 7 : Potential Benefits of Fisheries Research Undertaken in Australia

Commodity	National Benefits ($US m.) (1)	Relativity (2)	Priority Grouping (3)	Spillover Benefits All Developing ($US m.) (4)	Total International Benefits ($US m.) (5)
Lobsters	20.0	1.0	I	43.4	162.9
Prawns\shrimps	10.6	1.9	I	44.4	173.8
Oysters	2.3	8.7	III	20.1	301.7
Tunas	1.4	14.3	III	4.0	28.1
Demersal\pelagic	0.7	28.7	V	17.5	37.2
Mackerals	0.1	200	VI	0.0	0.9
Misc. diadromous	0.0	-	VI	0.0	0.0
Tilapias	0.0	-	VI	0.0	0.0
Carps	0.0	-	VI	0.0	0.0
Clams	0.0	-	VI	0.0	0.0
Mussels	0.0	-	VI	11.6	48.3
Herrings	0.0	-	VI	14.9	59.4

Figure 5 : Comparison of Australian National Objective with South East Asian Regional Objective for Fishery Commodities.

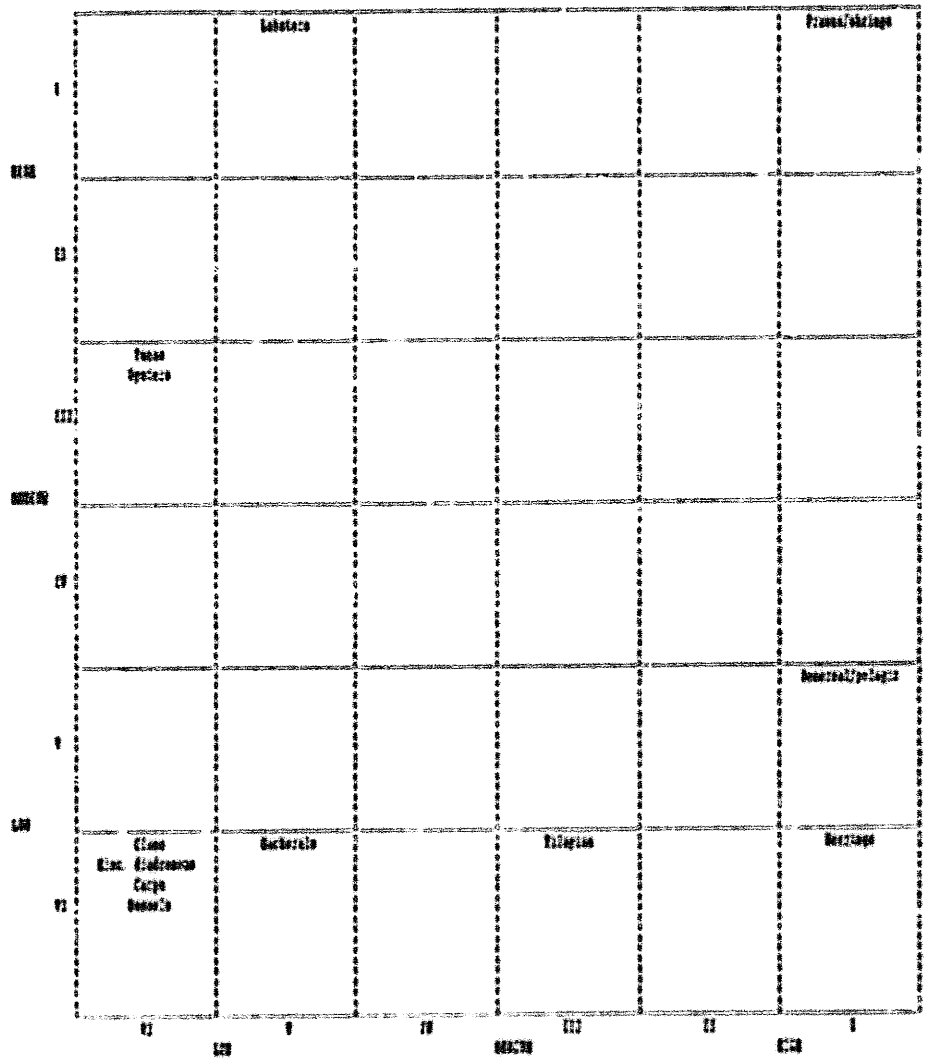
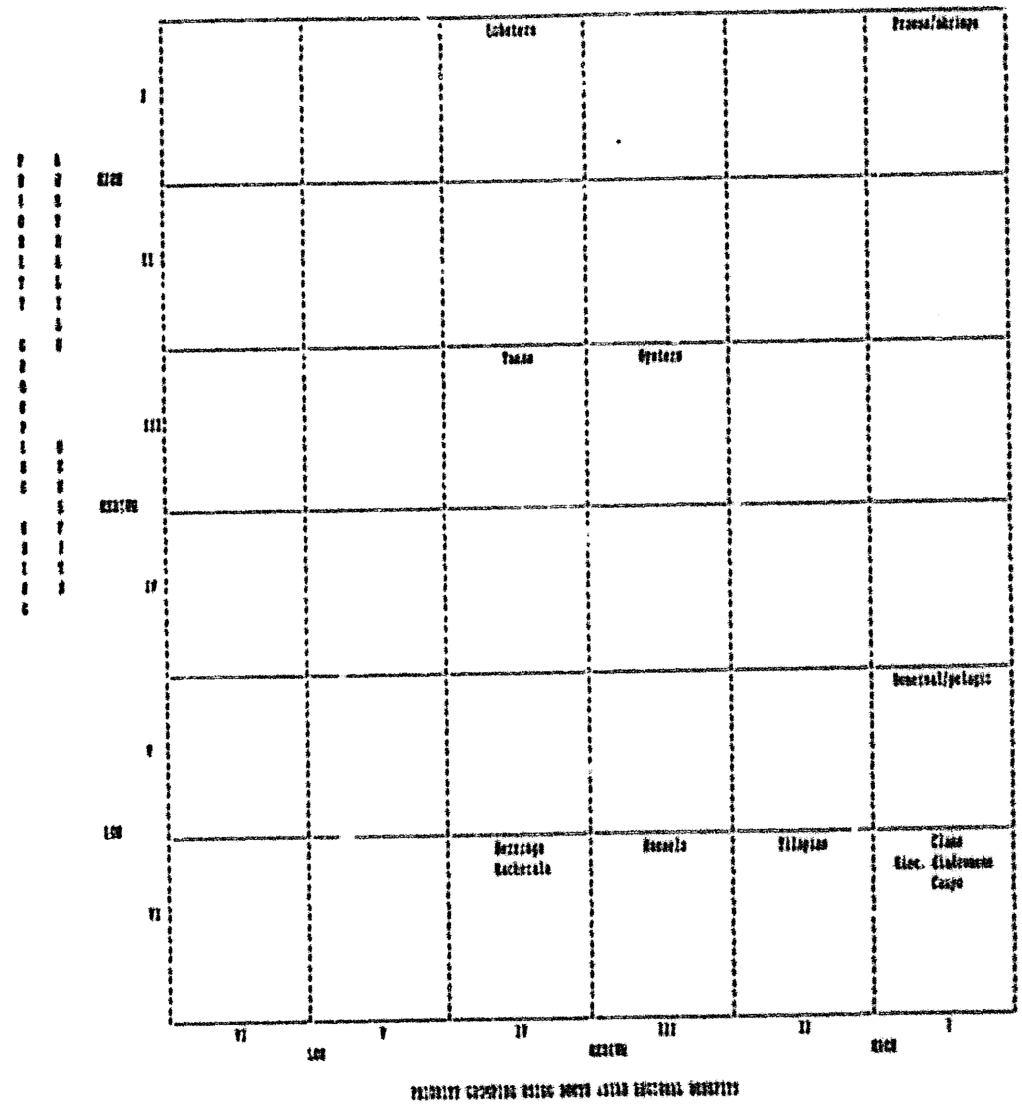


Figure 6 : Comparison of Australian National Objective with South Asian Regional Objective for Fishery Commodities.



clear match of coinciding objectives, occuring in the highest priority grouping for both objectives. Research on Prawns/shrimps would satisfy both objectives as well as achieving the greatest potential benefits. The box diagram also indicates those commodities in the lower groupings (Clams, Mussels, Carps, Misc. diadromous fish) for both objectives. Commodities that appear off the diagonal indicate importance with one objective and not the other, clearly indicating a lack of congruence. For example, Lobsters occurs in the high priority grouping for an Australian objective but not for the South East Asian objective. Conversely, Herrings is important in South East Asia but produces insignificant potential research benefits for Australia.

A similar comparison is illustated in Figure 6 for South Asia. This results in a congruence of objectives for Prawns/shrimps and Oysters, and a relatively close match with Tunas. However, the majority of commodities that fall into the higher priority grouping under a South Asian research objective have considerably less potential benefits with an Australian objective.

5. Conclusion

This paper has outlined the application of a conventional research evaluation analysis to selected fishery commodities. Information has been generated regarding the potential impact of fisheries research. This can be summarised for use as one input to the decision making process regarding research resource allocation. Several facets of the information generated have been assessed, relating primarily to the research emphasis between geographic regions and amongst fishery commodities. The importance of research objectives has also been discussed, highlighting their potential influence on the commodity ranking within the priority groupings.

Several preliminary points can be drawn from the analysis:

(i) The systematic evaluation of the gains from fishery commodity research has indicated a wide range of potential benefits resulting from research on fishery commodities. The range of benefits has allowed commodities to be categorised into high and low research priority groupings.

(ii) From the large amount of information generated, a subset can be summarised to provide information to assist decision makers in making choices amongst commodities and between geographic regions for the purpose allocating scarce research resources.

(iii) The importance of clearly defining research objectives, being national, regional or international was demonstrated. Information can be generated to facilitate the comparisons between differing and potentially conflicting objectives. The potential conflicts and trade-offs between a national and regional objective were highlighted. Useful inputs to the decision making process can be drawn from these comparisons.

(iv) A large body of information is required to conduct the analysis, some of which is subjective and relies on value judgements. It is hoped that, through creating an awareness of the application of a systematic technique to evaluate fishery research benefits, the information can be refined and verified to improve confidence in the results.

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