



BENEFITS AND COSTS OF

# FISHERIES *research*

IN AUSTRALIA



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Evaluating fisheries research  
and development projects

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## *Foreword*

This study is the latest in a series of studies conducted by ABARE into the application of benefit–cost analysis to the economic evaluation of research into agricultural and resource industries. By investigating the merits of various research activities and undertaking research into methods of evaluating research proposals, ABARE aims to assist decision making and priority setting for the allocation of future research funds.

With the establishment of the Fisheries Research and Development Corporation in 1991-92, the Commonwealth has indicated that it will continue to fund fisheries research in Australia. The focus in this study is the benefits that may arise from funding alternative types of applied fisheries research and the potential role of benefit–cost techniques for evaluating and selecting project proposals.

This research report complements the operational handbooks, *Setting Research Priorities: A Step By Step Procedure* and *Fisheries Research Evaluation and the Selection of a Research Portfolio: A Step By Step Procedure*, prepared by ABARE for the Fisheries Research and Development Corporation in 1993.

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BRIAN FISHER  
*Executive Director, ABARE*

March 1994

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# *Glossary*

(For phrases used in this document)

## **Attractiveness of research**

The maximum possible benefits expected from research. This may be measured quantitatively (in dollars), qualitatively (descriptively) or subjectively, on the basis of the assessor's experience and perceptions.

## **Benefit–cost ratio**

The returns to the investment of funds in research, as measured by the proportions of benefits expected in relation to the costs of undertaking the research and implementing its findings.

## **Benefit–research cost ratio**

The returns to the investment of funds in research, as measured by the proportion of benefits expected in relation to the costs of undertaking the research. This will not give a true representation of the returns to investment in research because there is no account made in this ratio for the costs of implementing the research findings (which may be large in proportion to the expected benefits).

## **Expected net benefits**

This is the average net benefits expected from research. Where stochastic analysis is performed, this will be assessed by calculating the likely net benefits from research in all possible outcomes, weighted by the likelihood of each of those benefit outcomes occurring. The value of all the possible benefits are then summed, and the average value of benefits is estimated.

## **Feasibility of research**

This refers to the potential for realising possible research benefits. It is based on the likelihood of research success, the rate of research adoption and the rate of benefit dissipation. These factors are particularly hard to evaluate quantitatively because of a lack of information. Often, there will be a need for the funding agency to make subjective judgments about the feasibility of research, on the grounds of experience and understanding of the field.

## **Adoption and implementation costs**

These are the costs of applying the findings of research. For example, it may be the costs of introducing and enforcing new management techniques

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identified in fisheries management research, in which case, adoption of research results occurs through fisheries managers. Alternatively the implementation costs may involve purchasing new fishing gear identified in cost reducing research, in which case, costs are borne by fishing operators.

### **Property rights**

This refers to a bundle of entitlements defining the rights, privileges and limitations on the use of a resource by individuals (Tietenberg 1988). In fisheries, the type of property rights which individuals have over resources will determine the size of benefits which arise from research and the length of time over which they will be maintained. Broadly speaking, property rights structures in fisheries fall into one of three categories:

- ***Poorly defined property rights***

In fisheries, these tend to be characterised by regulations which guarantee operators access to the stock (for example, licences) but do not guarantee them a share of the catch (the catch may still be harvested first by another operator). Fisheries where poorly defined property rights exist are often characterised by limited entry or input restrictions.

- ***Weakly defined property rights***

In fisheries, these are characterised by regulations which guarantee operators access to the stock and a designated share of the catch, as is the case with individual catch quotas, but where some restrictions apply — for example, an inability to freely transfer catch rights to other operators.

- ***Well defined property rights***

In fisheries, these are characterised by regulations which guarantee operators access to the stock, a designated share of the catch and the rights to trade those catch rights, if they wish. In Australia, these are best illustrated in fisheries by individual transferable quotas.

### **Private research benefits**

These are the increases in welfare received by private individuals actively involved in the fishery (see box 1).

### **Social research benefits**

These are the increases in welfare received by all of society as a result of changes arising from research (see box 1). They include private benefits, such as benefits to the commercial fishing industry, plus any benefits to other users, such as to the recreational fishing sector, or the public.

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## *Summary*

There is increasing pressure on funding agencies to account for their allocation of funds to projects and the selection of their research portfolios. In its 1989 policy statement on fisheries management, the Commonwealth government noted that fisheries research funds should be directed toward research areas that were likely to provide the highest benefits, net of costs. The government also identified benefit–cost analysis as providing the most rigorous means of assessing the likely economic benefits of particular research proposals.

*Benefit–cost  
analysis is  
appropriate for  
assessing research  
proposals*

The potential role of benefit–cost techniques in the evaluation of project proposals and the selection of a fisheries research portfolio is examined in this report. Lack of information about the value of all the benefits and costs expected from fisheries research means that a precise benefit–cost assessment of fisheries research proposals is unlikely to be possible. It is concluded that in any evaluation of research, a range of types of assessments may be necessary, depending on the information available.

*. . . but a range of  
assessments may  
be needed*

The focus in this report is on the practicalities of quantifying the expected benefits and costs of proposed research. The simplifications and approximation that may be needed to estimate expected payoffs of proposed research are identified. Six case studies are used as illustrations.

*Case studies  
provide  
illustrations*

The factors which affect the expected benefits and costs of fisheries research may be considered to fall into two categories:

*Attractiveness  
and feasibility of  
research need to  
be assessed*

- those that determine the maximum possible size and value of the expected benefits and costs to

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society from a research project (termed the ‘attractiveness’ of the research); and

- those that determine the likelihood of those research benefits being realised and maintained (termed the ‘feasibility’ of the research).

*Attractiveness is assessed by assuming complete feasibility and that each proposal contributes 100 per cent of potential research benefits*

To assist in maintaining consistency in assessment, research attractiveness could first be estimated by assuming complete research feasibility and that each research proposal contributes 100 per cent of the expected research benefits (as opposed to contributing less than 100 per cent when a project constitutes only one part of many research projects necessary to achieve the expected benefits).

*Complete feasibility assumes full and successful application of results . . .*

Complete research feasibility assumes total research success, total adoption of results, a management structure which allows the resource rents and/or conservation benefits to be maximised, and the absence of international competition so that benefits are not leaked. Subsequently judgments about the likelihood of these factors could then be used to temper those expectations, depending on how realistic these assumptions for feasibility are.

*. . . tempered subsequently*

*Qualitative assessments may be needed*

Research may need to be qualitatively assessed due to lack of complete fisheries data. Project evaluation thus remains subjective to some extent. While the benefit–cost approach to evaluating research proposals may need to be significantly modified to deal with such gaps, it provides funding agencies with a systematic framework for scrutinising and evaluating research proposals.

*Benefit–cost analyses provide a framework for assessing proposals*

At best, benefit–cost analysis could be used to provide an indication of the net returns to fisheries projects; at worst it could provide a basis for formalising the process of research assessment, ensuring that the factors likely to affect the benefits and costs of research proposals are explicitly considered.

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However, choosing a research portfolio is likely to be difficult when a variety of market measures, non-market measures and judgments have been used in evaluating different projects. The comparison of research projects is also likely to be difficult where different assumptions and simplifications have been used to evaluate different proposals.

*Comparing projects is difficult when different methods of assessment are used*

In this report, a scoring system is discussed for comparing and ranking projects in such cases.

*A scoring system is discussed here*

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## *Introduction*

Constraints on public funding have led to calls from governments for greater accountability in research expenditures, and hence a need for systematic evaluation of the economic benefits of research. In its 1989 policy statement, *New Directions for Commonwealth Fisheries Management in the 1990s*, the Commonwealth government called for fisheries expenditure to be directed toward areas likely to provide the highest level of benefits (Commonwealth of Australia 1989).

The total funds invested in fisheries research and development in 1992-93 by state and Commonwealth governments and industry are estimated to have been around \$48 million (FRDC 1992). This is about 3.5 per cent of the estimated gross value of fisheries production.

The industry in any one year may contribute up to 0.25 per cent of the gross value of fisheries production to the Fisheries Research and Development Corporation (FRDC), with the Commonwealth government matching the industry contribution. In addition, the Commonwealth contributes to the FRDC an unmatched amount set at 0.5 per cent of the gross value of Australian fisheries production. The fisheries research budget of the FRDC from the various sources is thus 1 per cent of the total gross value of fisheries production, or about \$12 million for the year 1991 (ABARE 1991).

Additional fisheries research money equivalent to 0.25 per cent of the gross value of production in fisheries is provided by the Commonwealth through the Fisheries Resource Research Fund (FRRF). Additional funds are employed in fisheries research from direct appropriation by CSIRO, the Bureau of Resource Sciences and ABARE. Thus, fisheries research in Australia is predominantly publicly funded.

Until recently, evaluation and selection of fisheries research proposals have largely been made on the basis of expert opinion rather than through systematic economic appraisals — a situation similar to that in many other industries (see, for example, OECD 1987; Islei, Cox and Stratford 1989). At its simplest, this process has involved some form of review of potential projects by a funding committee, with selection by voting or consensus. In some cases, it has been made more rigorous by drawing on assessments by

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internal or external referees, although the use of this approach tends not to focus on the benefits that the research is likely to have.

In order to identify cost effective fisheries research and to fund the research portfolio which produces the greatest benefits, funding agencies need to be able to identify those research proposals with the highest expected payoffs. To evaluate research and compare projects, funding agencies need to assess both the maximum possible magnitude of benefits likely relative to the costs (which can be termed the *attractiveness* of the research) and the likelihood of realising and maintaining those benefits (the research *feasibility*).

In the evaluation and comparison of research projects, some degree of subjectivity will inevitably remain due to the lack of complete information. However, it is important to reduce the degree of subjectivity, to provide as far as possible a systematic and consistent comparison between research proposals. The Commonwealth government has identified benefit–cost analysis as providing the most rigorous means of evaluating fisheries research projects (Commonwealth of Australia 1989).

In this study, the methods that are conventional in evaluating fisheries research (for example, Lindner 1989; Bosch and Shabman 1990; Fearn and Davis 1991) are adapted into a system that can be used to evaluate fisheries research proposals while being flexible enough to allow for the lack of, or imprecision inherent in, some fisheries relationships.

The focus in this report is the potential role of benefit–cost analysis in providing a consistent framework for assessing and selecting research proposals, taking into account the risk associated with each research project. More specifically, the objectives in the study are:

- to examine the issues that may need to be addressed when assessing fisheries research proposals using benefit–cost analysis; and
- to identify criteria other than standard benefit–cost ratios that could be used to compare and select research proposals where considerable uncertainty surrounds the expected benefits or where only qualitative information is available.

The types of fisheries research benefits are examined in chapter 2, together with their dynamics and the effect that fisheries management can have on achieving those benefits in reality. The factors that need to be considered



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when assessing the benefits of fisheries research using benefit–cost analysis are broadly identified. A benefit–cost model for assessing the net benefits of research projects is set out in chapter 3.

The problems and practicalities involved in assessing the benefits of fisheries research using benefit–cost analysis are discussed in chapter 4. Because of the problems in estimating the benefits from fisheries research, funding agencies may not be able to evaluate research proposals accurately, and may have to use simplified measurement approaches which can give only a broad indication of the magnitude of the benefits. These approaches are explained.

Once the benefits and costs of individual research projects (or programs) have been assessed, projects would have to be compared and selected, so that a research funding portfolio can be composed. In chapter 5, a procedure is outlined for comparing projects on the grounds of their net benefits. A scoring model is suggested for this purpose. The assessment and comparison of fisheries research projects using a benefit–cost approach are presented in chapter 6.

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## *The dynamics of fisheries research benefits*

Fisheries research is usually designed to generate information about the factors that affect the production or consumption of fisheries products and the use of the marine resource. The objective, in any case, is to generate information which enables the net benefits derived from the fisheries resources to be increased. The benefits of interest may be those obtained by private individuals or by society as a whole (see box 1). Both market and non-market benefits may be included.

Because the government has required funding agencies to increase their accountability for the projects they fund, these agencies require methods of identifying the research portfolio that will give the greatest net return to research dollars. Agencies need to be able to compare the benefits, relative to the research and implementation costs, that each research project is likely to contribute over time. However, arriving at a clear appreciation of the benefits that fisheries research projects may generate, and quantifying these benefits, is often difficult.

To assess the benefits to be expected from a research project, a funding agency would need to identify and assess a number of factors. First, the different types of benefit obtainable from the research are considered, together with the economic terms in which they may be evaluated. Second, the need for discounting is introduced — that is, the need to bring the costs and benefits that are spread over a period to a common viewpoint in time.

### Box 1: Social benefits of research

In many business investment decisions, including decisions on research, the benefits and costs to the investor are the only considerations taken into account. However, in the case of government funded research, it is the benefits that the community as a whole can derive from the research that are relevant, and not just the returns to the commercial sector.

For example, research which leads to an improvement in the quality of fish may increase the prices that fishing operators can charge for their catch, but the improvement in quality may also be of benefit to consumers. The benefits accruing to both the producers and the consumers should be included when assessing the expected economic value of proposed government funded research.

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Third, the uncertainties inherent in research and its application are considered, showing how they can be taken into account. Finally, attention is drawn to the influence of the fishery management regime on the benefits obtainable.

## Fisheries research benefits

Fisheries research covers a diverse range of issues and may produce any of a number of different kinds of output. Research may concern, for example:

- fish stocks and life cycles
- marketing the products of a fishery
- fish diseases and post-harvest technology
- ways of regulating a fishery to ensure long term survival of the stock
- efficiency in fish harvesting.

However, research alone produces only information. It is only by implementing research results (using the results to make changes) that benefits can be created. In the commercial harvesting and marketing of fish, the benefits of research are any additional profit to the industry, together with any benefits to consumers in terms of quality or price. The benefit to the harvesting sector of the industry can be determined from the total revenue less the costs of the operation (including a return to capital and management) — this is commonly known as the *resource rent*. The net benefit to consumers is the difference between the maximum they would be willing to offer for the amount of fish they buy and what they actually pay — commonly known as the *consumer surplus*.

Research may also lead to non-market benefits, particularly in the recreational sector. For example, the net non-market benefit from a fishery obtained by recreational anglers can be defined as the total willingness to pay for the additional quantity or quality of fish caught over and above the costs of recreational fishing. Another type of non-market benefit may be derived when the results of research are used to prevent a fish species from becoming extinct, and members of the public value the existence of the species as such (irrespective of any use made of it).

However, fisheries research — if it is successful and its results are implemented — confers its measurable benefits largely through its effect on the

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factors that determine resource rent and consumer surplus. Any non-market benefits must be considered separately. The development of new fisheries can also conveniently be considered as a separate category of benefit. In this case, all the above types of benefit may be involved, but measurement of these benefits may be difficult because of a lack of prior cost, production and market information.

The impact of applied fisheries research on social welfare can be categorised into:

- changes in product prices
- changes in costs
- changes in fish catches arising from changes in sustainable stocks
- changes in non-market benefits
- development of new fisheries.

These are all categories of expected impact on fisheries — that is, of the way in which the research could contribute to change. However, it should be noted that not all research is aimed directly at bringing about such changes. Some research is performed to seek out general information about fisheries — for example, to gain an understanding of stock behaviour. Pure (baseline) research may not address an already identified problem but may, through a better understanding a fishery, be useful in determining what issues may become important at a later stage. Evaluation of such research is more difficult than for research whose application can be expected to have a direct impact, as in the categories above. Therefore, in this report, it is not suggested that pure research be compared with directly applicable research for funding purposes.

### *Changes in product prices*

The aim in some research is to affect the quality of products sold or quantity demanded, and hence to affect market prices. Research which leads to increases in the demand for certain products (either specific products or seafood in general), and thereby raises the price of those products, would increase industry profits. For example, socioeconomic research in an overseas market which results in Australian producers being able to establish brand superiority in their products would be likely to cause the price obtainable for the products to rise. Biological research may result in

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higher quality fish, thus increasing consumer demand, and hence prices, for the fish. An example of such biological research is the study of the protective mechanisms in fish for ciguatera poisoning funded by the then Fishing Industries Research and Development Council (FIRDC 1990).

### *Changes in costs*

Research may lead to technological developments which (depending on how the fishery is managed) can reduce fishing costs and thus increase industry profits. Management related research may lead to more cost efficient monitoring and enforcement, which can be used to reduce long run fishing industry costs.

### *Changes in fish catches (and sustainable stocks)*

Much biological research is targeted at increasing allowable catch levels (or avoiding a reduction in catch levels) while maintaining fish stocks. (Such research may also indirectly influence industry costs.) For example, research has been targeted at assessing the strength of the relationship between the extent of seagrass dominated habitats and the size of the commercial fish stocks that depend on them. In the absence of such research, the size of a seagrass dependent fish stock might be expected to decrease if seagrass beds are eroded. This would cause the sustainable harvest to decrease as the carrying capacity (the maximum fish population which can be supported) of the area decreases. Through research based changes to the management of seagrass beds, decreases in the fish stock might be prevented, which in turn would prevent a decrease in the harvest.

The economic benefit of such biological research is the resource rent that, in its absence, would have been lost. (In addition, the depletion of ecologically related non-commercial fish species may also be prevented.)

### *Changes in non-market benefits*

The activities which may be affected by the application of fisheries research range from the harvesting of fish for commercial markets to recreational fishing for private consumption and other recreational experiences such as boating and snorkelling. For example, research may indicate that fish habitats can be protected by a change in the type of commercial fishing gear employed. While the benefits of sustained or increased fish stocks to the commercial sector should be considered, any non-commercial benefits from

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increased catch prospects or an improved natural environment should also be taken into account.

Some of these benefits are ‘non-market’ only in the sense that they are outside the commercial fish market. They may enter into other markets, like tourism. Other benefits from fisheries research may not be reflected in changes in any market quantities, costs or prices. Non-market benefits include the ‘conservation values’ obtained when application of the results of research prevents a fish species from becoming extinct. In that case, the research may prevent a loss in terms of the values that society places on knowing that the species exists (existence value) and on the ability to pass the genetic pool of that species on to future generations (bequest or quasi-option value).

Thus, for example, research which allows fisheries managers to successfully define the efficient total allowable catch for a fishery may, by preventing the fish species from becoming extinct, confer on society conservation benefits in addition to the financial gains.

An indirect valuation of non-market benefits may be done using techniques such as ‘contingent valuation’ and the ‘travel cost’ method. Such techniques can be costly to employ and results may not yield value estimates which can be compared with other financial and economic measures. For discussions on how to value non-market benefits, see Mitchell and Carson (1989), Rose (1990) and Lal, Holland and Power (1992).

### *New fisheries*

In some cases, research may facilitate the creation of a new commercial fishery. For example, in the absence of the research, production and harvest costs may be too high for a commercially viable fishery to develop. With research created reductions in costs, however, producers may be able to make use of the fishery.

## Timing and time value of research benefits

Adjustment to research innovations may take considerable time. At the same time the fishery may be adjusting to past overexploitation of the fish stock, overcapitalisation of fleets or management changes. In addition, fish populations and ‘catchability’ will vary over time due to environmental factors (such fluctuations are generally greater for short lived species such

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as prawns). The responses of fisheries or of industry supply to research innovations will therefore change over time, in ways that may be difficult to predict.

Generally, the benefits from fisheries research tend to be generated slowly to start with, because there are likely to be lags in both biological and industry responses to research innovations. For example, it may take time for the use of a technical innovation to spread through the industry, for a fish stock to increase, or for a new management system to take effect. Similarly, there are likely to be lags in deriving the benefits from marketing changes which promote demand, as market intermediaries and consumers take time to respond to changes in the choices available.

In contrast, the costs associated with the project are mainly incurred during the research phase and the period when research findings are disseminated to the users. In some instances there may be a lag between the dissemination stage and when any benefits are first realised. There will generally be a further lag before maximum benefits are realised. Therefore, when assessing the expected value of any proposed research, it is important to consider both the time lag before the results are adopted and the likely rate of change, as well as the maximum benefits that may be produced.

Moreover, after the benefits from the research have reached a maximum, they may diminish. Some types of innovation are subject to obsolescence, for example; others may come to be of less value to Australia as they are adopted overseas. (A further reason why benefits may be short lived — inappropriate fishery management methods — is discussed in the last section of this chapter.)

When the benefits of the research will be realised, and how long the benefits will last, will influence the value of the research at the time a funding decision must be made. In particular, those projects from which benefits can be expected sooner will be valued more highly than those which offer equal benefits at a later date. To compare the net benefits from competing projects, their values must be discounted to a common time, to obtain their 'net present value' (see box 2).

## Realisation of benefits

Whether the desired benefits of research are realised will depend on a range of factors including:

- whether the research is appropriately designed to produce information which could lead to benefits;
- whether it is in fact successful in producing such information;
- whether the results are adopted and implemented successfully.

Thus, there are a number of possible research outcomes, as shown in figure A.

### Box 2: Net present value of research benefits and costs

The value assigned, at any given time, to future benefits depends on the time when the benefits will be received. The same is true of costs. This dependence of value on time is partly due to the fact that assets can be invested to yield a positive return over time, and partly due to subjective 'time preference', which varies between individuals.

To compare the relative merits of alternative project proposals, all the benefits and costs over time of each proposal must therefore be viewed to accumulate at a single point in time. This can be done using some agreed discount rate (see below).

The formula which is usually used to discount future benefits and costs is as follows:

$$NPV = \sum_{t=1}^n \frac{1}{(1+r)^t} [B - C]_t$$

Where  $NPV$  is the net present value at some agreed 'present' date (year 0);  $t$  is the year;  $n$  is the period during which costs are incurred and benefits are gained;  $r$  is the discount rate;  $B$  is the benefits obtained in year  $t$ , valued in that year; and  $C$  is the costs incurred in year  $t$ , valued in that year.

#### **Choice of discount rate**

The appropriate discount rate for evaluating projects is subject to considerable debate, which will not be entered into here. A principle commonly adopted is that the discount rate should reflect the rate of return that society would expect to receive if the funds employed were used elsewhere in the economy. This rate of return, termed the opportunity cost of capital, depends on a number of factors, including current interest rates and inflation. For more detail, see for example Mishan (1976).

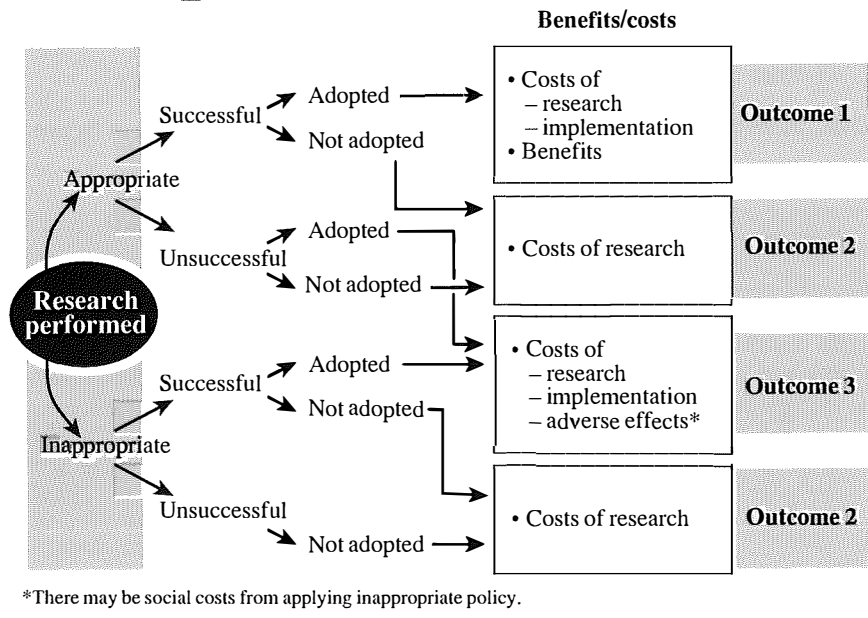
The Department of Finance (1991, ch. 5) has suggested the use of discount rates between 6 and 10 per cent in benefit-cost analysis, with the most likely discount rate being 8 per cent.

It should be noted that the choice of discount rate may affect the relative sizes of the net present values of alternative project proposals. The use of a high discount rate favours research expected to produce benefits sooner relative to research which is expected to produce benefits later.



## A Possible research outcomes

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The least desirable outcome would be for the results of an inappropriate or unsuccessful project being adopted (outcome 3), since this generates the highest costs without producing any benefits, and may even produce adverse effects. For example, suppose that profits in one fishery were relatively low compared with other fisheries. Research might be proposed to produce cheaper harvesting gear so that profits could increase. However, if the lower profits occur as a result of ineffective management, undertaking the gear research would be inappropriate, as any profits would eventually be competed away (see below). The implementation of research findings then incurs implementation costs, in addition to the research costs, but would not generate any long term benefits.

The 'expected' benefits from a research project will depend on the size of the benefits and costs associated with each of these possible outcomes (relative to what would happen in the absence of the research), together with the probabilities of each outcome. To assess the expected net benefits of a project, the net benefits from all possible outcomes are estimated, the net benefit of each project is multiplied by its estimated probability, and the results are summed. The expected value of net benefits is thus an average of all possible net benefits, weighted by their probabilities.

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## The importance of management

Realising and maintaining benefits from the application of fisheries research (whether its direct effects are on costs, prices, catch, non-market benefits or the development of new fisheries) will be affected by the form of management structure existing in the fishery. That is, they will depend on the property rights structure governing the ownership or use of the resource.

In many Australian fisheries, the limited entry licensing system has been the traditional management approach. This system provides operators with clearly defined rights of *access* to fishery resources — for example, a licence clearly permits operators to fish — but it does not provide operators with clearly defined individual property rights; that is, it does not ensure a share of the catch. In a fishery without clearly defined individual property rights, any income in excess of normal profits (resource rent) will attract increased fishing effort and will therefore lead to an increase in unit fishing costs. In the long run, therefore, any resource rent that might be obtainable will be competed away. It follows that unit industry supply costs in fisheries without well defined individual property rights are likely to be higher than in an equivalent fishery which has well defined property rights. Furthermore, in the absence of well defined individual property rights, competition may result in excessive pressure on fish stocks. Thus, a fishery will usually be economically, and possibly biologically, overexploited, in the absence of clearly defined individual property rights.

A lack of individual well defined property rights to the resources — or the absence of management to correct this shortcoming — could strongly affect the extent to which any research benefits realised in a fishery are maintained over time. This is because any increase in resource rent made possible by more abundant stocks or cheaper fishing methods may be dissipated through competition. The result is that the benefits expected from some kinds of fisheries research may not be maintained in the long run.

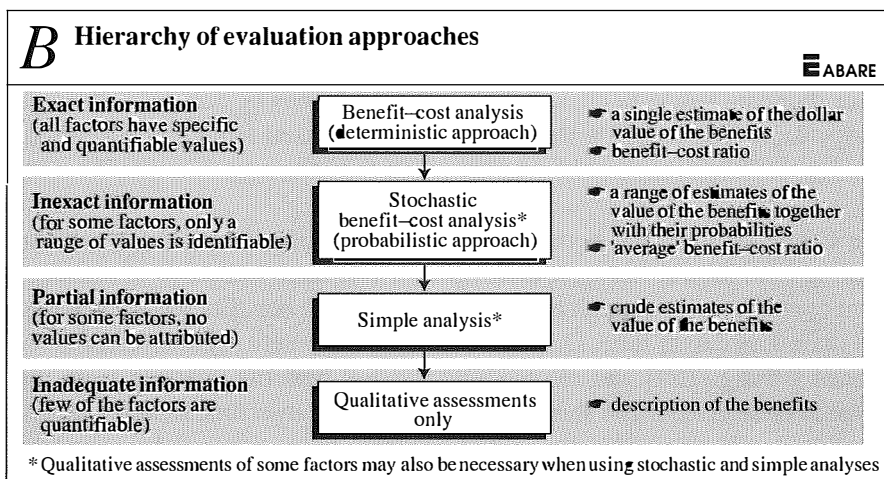
The extent of research benefits will therefore depend critically on the existing (and future) management regimes. The mere existence of management controls is not enough to ensure that research benefits will be realised and maintained over time. Only where the management regimes effectively control fishing effort and catches will the full benefits possible from the research be realised in the short run and maintained over time. Funding agencies thus need to consider the kind of property rights likely to be operating in the fishery when assessing expected benefits from research proposals.

## *Benefit–cost analysis and fisheries research evaluation*

Benefit–cost analysis is the principal method used to compare proposed development projects. It has the potential to provide a systematic and rigorous means of assessing and comparing fisheries research project proposals.

Benefit–cost analysis could be performed on a single research project by estimating the benefits (such as resource rents) that are currently generated in the absence of the research, and comparing them with those likely to be generated if the research were performed (discounting future values, and summing across all possible outcomes, as was explained in chapter 2). The expected net benefits from the project would be the difference in expected benefits in these two cases, less the expected costs of undertaking the research and implementing the results, both valued at some specific point in time. Projects could be compared on the basis of the resulting ‘expected net present value’.

In this chapter, the types of benefit–cost tools appropriate for assessing research proposals in situations of differing availability of information in a fishery are outlined. A hierarchy of evaluation approaches is shown in figure B. In general terms, the scarcer the information available is, the less accurate (simpler or more qualitative) the assessment is likely to be.



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A further factor which may influence the type of analysis undertaken is the cost of evaluation (since undertaking benefit–cost analysis of projects itself involves a cost). This cost might in some cases depend on the accuracy of estimates required.

It is often the case in fisheries research that the cumulative efforts of many research projects (simultaneous or sequential) are needed to provide sufficient information to achieve the desired benefits. It may thus be more practical to assess the benefits of a suite of research projects, rather than evaluating individual projects in isolation.

For example, the economically optimal level of catch in a fishery is determined by the interaction of a complex set of biological and economic factors. Any one research project could provide information about only one or a few of these factors. As a result, a proposed research project may provide only partial information, contributing to, but not on its own sufficient to make possible, a change in resource use which would produce benefits for society. If there is a critical dependence between each segment of the research proposed, the total program of research should be considered. The probability of research success is the product of the individual probabilities from each segment of research.

## Benefit–cost analysis in ideal circumstances

Under ideal circumstances, benefit–cost analysis could be used to calculate exactly the present value of the benefits over time from the proposed research relative to its cost. In a pure benefit–cost analysis, all the factors which affect the size of the benefits to all users would have identifiable and quantifiable values. That is, a monetary (quantitative) value could be put on them so that a value for the research could be estimated in dollars. The costs would be the costs of undertaking the research, plus any costs associated with implementing the resulting recommendations.

If the research budget were sufficiently large, all research projects which offered a positive return in excess of research and implementation costs (that is, net benefits greater than zero) could be funded. However, as research funds are often constrained, funding agencies will generally need to make a selection between such proposals.

A common means of comparing the benefits and costs of alternative projects is to compare their ratios of expected benefit to cost. The expected

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benefit–cost ratio for a research project is the discounted value of the stream of benefits expected to accrue, divided by the discounted value of the costs (see box 3). This criterion is useful for comparing projects because it provides a measure of the return which investors achieve on their investment. In the simplest use of this criterion, a project with a higher benefit–cost ratio would be preferred over a project with a lower benefit–cost ratio. More generally, given a number of proposed projects, a portfolio of projects with high benefit–cost ratios would be selected.

The use of this criterion alone would imply an assumption either that all benefits can be valued, or that other considerations (which might include non-market benefits) can be neglected. For details of a proposed research portfolio selection method, see chapter 5.

### Box 3: Benefit–cost ratios

A commonly used criterion for comparing alternative projects is the ratio of the present values of benefits and costs. The benefit–cost ratio is the discounted expected gross benefits divided by the discounted costs of the research and of implementing the results. Benefit–cost ratios are independent of the scale of the research project, implementation costs and benefits. The ratio may be interpreted as a rate of return to research, comparable to alternative commercial investments.

For example, suppose the present values of the benefits and costs involved in a research project are as follows:

Present value of research costs	\$100 000
Present value of implementation costs	\$300 000
Present value of total costs	\$400 000
Present value of gross benefits	\$500 000
Net present value	\$100 000

In that case, the benefit–cost ratio is  $\$500\,000/\$400\,000 = 1.25$

This ratio can be termed the social benefit–cost ratio, since all costs and benefits have been counted regardless of who incurs or obtains them. An alternative, and often easier to calculate, ratio is the rate of return to research funding alone. This would be  $\$500\,000/\$100\,000 = 5$  in the above example. However, in many cases, implementation costs may be considerable, in relation to research costs, so funding agencies need to be cautious when using a benefit–research cost ratio for assessing research proposals. Its use should occur only if absolutely no reliable information about implementation costs can be found. As well, the social goal is the relevant perspective to adopt when comparing relative payoffs to society from alternative research proposals, when society as a whole is the main contributor of research funds.

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## Modifications to the benefit–cost approach

In practice, there are likely to be difficulties in estimating benefits. To assess the benefits from a research project, it is essential to be able to predict, and then value, the effects that the application of the results will have on factors that determine industry profits and benefits to consumers — that is, on catch, price or costs — and non-market benefits. However, information on the impact of research based innovations on catches, costs and prices in fisheries is not always available or may be costly to obtain.

For example, an innovation which prevents fish stocks from declining would be expected to have benefits in cost savings to fishing operators, because they would not need to go further afield to catch the same amount of fish (other factors remaining constant). To estimate the value of such a benefit, however, analysts would need to be able to estimate the effect of a change in stock size on harvesting costs, and the relationship between stock size and harvesting costs may not be known, or may be known only very approximately.

Similarly, information may be scarce on a host of other factors that are needed to estimate the expected benefits from research; for example:

- fundamental data on stock dynamics (size of stock, breeding and migration patterns, and their relationship with and dependence on numerous environmental variables);
- cost of production;
- supply response (the change in quantity of fish likely to be harvested by operators in response to a given increase in price or decrease in costs);
- product demand.

In addition, it is necessary to evaluate the other factors, referred to in chapter 2, which affect the realisation of research benefits (the likelihood of the research being successful, the rate of adoption of the results and the rate of benefit realisation) and also to estimate the duration of the intended benefits — for example, how quickly they might be lost to foreign competitors or through poor fishery management.

There may also be difficulties in estimating the likely costs of implementing the research results — for example, of developing and introducing new management rules and regulations in a fishery.

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#### Box 4: Risk and uncertainty

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A situation of ‘uncertainty’ is defined as one in which the likelihood of an event, or of a particular value for a parameter, is unknown. There are two forms of uncertainty — that where the uncertainty about a parameter is quantifiable, so that some degree of probability can be attached to the parameter; and that where the uncertainty about a parameter is unquantifiable, so that a probable value or probable range of values could not even be assumed for the parameter.

Risk is the product of making an investment when either the costs or the returns are uncertain. That is, when a liability or opportunity cost relative to some alternative investment may eventuate.

To the extent that the necessary information is scarce or unavailable, modifications to benefit–cost analysis methods are required. The type of modification necessary depends on how much information is available and on whether, in relation to factors that are not known exactly, a range of values can be assigned to them together with the probabilities of those values (see box 4).

#### *Probabilities known: stochastic benefit–cost analysis*

Where there is enough information to be able to assign specific probabilities to the possible values for all of the factors affecting the size and value of research benefits, the possible benefits and their probabilities may be estimated through the use of *stochastic* benefit–cost analysis. Stochastic benefit–cost analysis can be viewed as a form of sensitivity analysis — that is, estimating the sensitivity of an outcome to changes in some determining factor — where a number of factors are varied simultaneously.

The technique follows the stochastic approaches to investment analysis and gross margin analysis used and discussed by Fairly and Jacoby (1975), Treadwell and Woffenden (1984) and Treadwell, McKelvie, and Maguire (1991). In stochastic analysis, the range of possible benefits is calculated with the values for all the unknown factors varying simultaneously. The technique involves the use of ‘Monte Carlo’ simulations of returns and costs. The benefits are calculated repeatedly, using different values of the factors, selected randomly in accordance with their assumed probabilities of occurrence (see Tulpulé, Johnston and Foster 1992, pp. 21–2).

For each run of the model, a random value is selected for each uncertain factor from its specified distribution, and the resulting benefit–cost ratio is

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estimated. This process is repeated a large number of times to generate a set of possible payoffs. From the set taken together, the *expected* benefit–cost ratio can be calculated (by multiplying each possible ratio by its probability), as well the probabilities associated with other possible benefit–cost ratios.

A funding agency could focus on maximising the expected payoffs from the projects in its research portfolio using the expected benefit–cost ratio. A project with a higher expected benefit–cost ratio would be chosen over a project with a lower expected ratio. For the practical aspects of using stochastic benefit–cost analysis to evaluate the expected payoffs of fisheries research, see chapter 4.

### *Values and probabilities unknown: simple analyses and qualitative assessments*

In some cases, researchers may not be able to identify meaningful ranges of values and probabilities of occurrence for factors affecting the size of research benefits. The effects of an envisaged innovation on certain fisheries parameters may not be predictable; or users of the fisheries resource may derive non-market benefits which the funding agency wishes to take into account, but which cannot easily be measured. For example, a change in the size and quality of the recreational fishing catch could be of considerable public interest, but its value could be hard to estimate in monetary terms.

In situations such as these, the stochastic estimation of expected benefit–cost ratios may not be possible. Instead, projects could be assessed on the basis of the minimum value of benefits necessary for the project to break even. The funding agency could reject proposals for which the total expected benefits did not appear likely to exceed some breakeven value, and then select the preferred projects from the remaining proposals. (See chapter 5 for more information on portfolio selection.)

In some cases, it may be possible to assess the cost effectiveness of the project only in qualitative rather than quantitative terms. That is, it may be possible only to list, and describe the nature of, the benefits and then make a subjective judgment about the value of these benefits in relation to the cost.

For some projects, it may be possible to quantify some of the benefits but not others. For example, if a management innovation increases catch, the



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economic benefits to the commercial sector might be measurable but not those to the recreational sector. As a result, both quantitative and qualitative assessments of the likely value of the research would be necessary. Ways of combining these kinds of assessments are suggested in chapter 5.

## Risk aversion and benefit–cost analysis

Some funding agencies may be risk averse — that is, they may be willing to fund a portfolio of projects with lower net payoffs where the probability of achieving them is high, rather than a portfolio of projects with potentially higher payoffs where the probability of achieving them is low.<sup>1</sup> Such a strategy may serve the longer term interests of the agency to the extent that it represents industry clients who are collectively risk averse.

Risk averse funding agencies need to explicitly consider the degree of risk associated with any expected payoff. The use of expected net benefit or benefit–cost ratio alone as a criterion, as proposed above, is appropriate only if the decision maker is risk neutral.

For example, consider two projects, A and B. For each project, there are several possible outcomes, the likelihood of which is as shown below.

<b>Project A</b>		<b>Project B</b>	
Probability	Benefit–cost ratio	Probability	Benefit–cost ratio
0.25	–8	0.1	–20
0.5	16	0.6	0
0.25	24	0.3	50
Average	12	Average	13

The expected (probability average) benefit–cost ratio for project A would be 12, while that for project B would be 13. A funding agency which had no preferences as to risk would prefer project B to project A. For a risk averse agency, this would not necessarily be the case. A risk averse agency would be likely to rank a project which has a narrow range of possible payoffs above a project which is expected to produce the same returns, but where the spread of possible outcomes is greater. Thus, it would be likely

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1. Given a choice between two net benefits, one twice as large as the other but half as probable, a risk averse decision maker will choose the more probable, while a ‘risk neutral’ decision maker will be indifferent between them because their expected values are the same. See Hinchy and Fisher (1991) for a fuller explanation of risk aversion.

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to prefer project A, in the above example, to project B. (In ‘expected utility’ theory there is an exact criterion for such choices which is generally referred to as the Markowitz expected return–variance rule: see Levy and Sarnat 1990, p. 214.)

The usual measure of the risk associated with a research proposal is the spread of the likely returns about the mean (the standard deviation of the probability distribution of the returns). In addition to using this information, it would also be useful to know whether the probability distribution has a longer tail rightward or leftward (the skewness) as this indicates the chances of extreme benefits being derived. For example, a typical lottery has a negative expected return but also a small probability of a very large return. This skewness of the payoff distribution attracts some investors despite the negative expected return.

With the help of information on the risks associated with the estimates of the expected payoffs, a funding agency could assemble a research portfolio comprising some desired balance of high risk projects with high expected returns and low risk projects with lower expected returns. The selection of a portfolio of research projects is discussed in chapter 5 (box 9).

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## *Practical considerations*

In this chapter the evaluation of research proposals in the various ‘impact categories’ (chapter 2) will be illustrated with reference to a number of actual proposals. The evaluations are set out in detail in the appendix. It was seen in chapter 2 that the total benefits from a fisheries research project are determined by a number of factors. These include:

- the values of the impacts on the commercial fishing sectors;
- the values of the impacts on other sectors;
- whether research is successful (that is, provides the information sought);
- whether the results are adopted, and if so, at what speed;
- the extent to which the initial benefits are maintained (or the rate of benefit dissipation), as determined by any overseas competition and by the management structure in the fishery.

### Separating ‘attractiveness’ and ‘feasibility’ factors

It may be appropriate to assess the value of parameters whose values are in general most easily identified separately from those which are generally harder to measure. In this research, it was found useful to separate factors into two groups:

- Factors affecting the *attractiveness* of a project — attractiveness being broadly defined as the maximum possible expected benefits that could be obtained from the research (after allowing for uncertainties that can be taken into account by stochastic analysis). The factors in this group are summarised in box 5.
- Factors affecting the *feasibility* of a project — feasibility being broadly defined as whether or not the above benefits could be achieved in reality, and if so, to what extent. The factors in this group include: the chance of research success; the rate of adoption; and the chances of the envisaged benefits being realised and maintained. They are summarised in box 6.

In addition to facilitating consistency in project evaluation, there are operational advantages to this distinction for the ranking and selection of

Box 5: Factors to be considered when assessing the *attractiveness* of a research proposal

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**Determinants of potential benefits**

- size of the fishery
- effects on resource rent and consumer surplus
- effects on benefits to other users (such as recreational anglers)
- timing of benefits
- scope for wider adoption of results
- (in some cases) relative contribution to the benefits from an overall research program.

**Determinants of costs**

- research costs
- cost of implementation

**Measures of attractiveness**

- expected benefit–cost ratio  
or
- subjective comparison of benefits with a ‘breakeven’ value  
or
- subjective assessment of qualitative descriptions.

Box 6: Factors to be considered when assessing the *feasibility* of a research proposal

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**Factors to be considered**

- appropriateness of the research
- likelihood of research success
  - technical feasibility of the stated method
  - competence of the research team
- rate of adoption of research results by industry or a management agency
- prospect of capturing and maintaining benefits
  - technological feasibility
  - financial feasibility
  - extent of slack capacity within industry
  - current and future management/institutional arrangements
  - scope for leakage of benefits to international competitors
  - possibility of obsolescence.

**Measures of feasibility**

- probability estimates  
or
- qualitative assessment of chances
- qualitative (or subjective, if necessary) assessment of the ability to capture and maintain benefits.

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projects (see chapter 5). Partly for this reason, this categorisation of factors is not as clear cut in practice as may appear at first sight. Some factors have been assigned to one group or the other on the basis of procedural convenience. It is essential, however, that consistency of treatment be maintained across all projects.

## Assumptions in assessing attractiveness

### *The status of the fishery*

Ideally, research benefits could be estimated using a logical and consistent framework which incorporates the physical, biological and economic relationships which affect the fishery. For example, a bioeconomic simulation model of oyster production was used in the United States to estimate the monetary returns to alternative research areas (Bosch and Shabman 1990).

As discussed earlier, however, the necessary information about the interaction between biological, economic and institutional factors affecting fisheries is often scarce in Australia, even for the more established fisheries. Consequently, to evaluate the benefits to be expected from research projects, some assumptions about the future supply and demand of the affected fish, and the current and future management regime (property rights) in the fishery must be adopted (see box 7). Bioeconomic models, where practical and cost effective to develop, can play an important role in estimating the expected payoffs.

### *Research and implementation costs*

It is rarely possible to predict accurately the costs of implementing research results. Where such costs can be estimated within some range, stochastic benefit–cost analysis could be used to derive benefit–cost ratios.

For example, in a prawn market study (appendix evaluation A), the researchers predicted that implementation would cost at least \$1 million a year for three years to promote prawns plus approximately \$15 a tonne for changes in packaging and labelling. Such implementation costs, together with the costs of the research, gave a benefit–cost ratio of about 12, against 340 when the implementation costs were omitted. From this example, the importance of considering implementation as well as research costs is highlighted.

## Box 7: Assumptions about supply and demand in fisheries

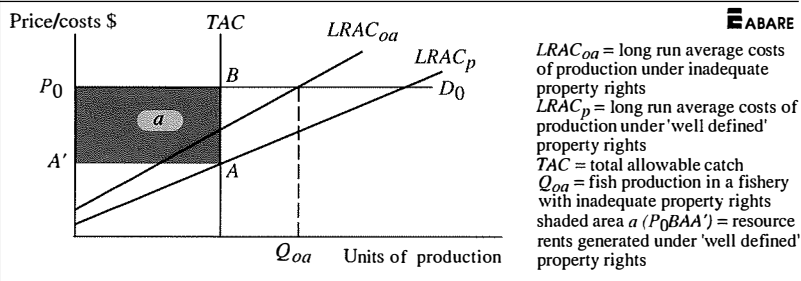
### Consumer demand

Fisheries research is generally directed at an individual fishery or target genus or species. The domestic demand for products from a specific fishery or individual species may be assumed to be highly elastic. This is a reasonable assumption if there is a large number of close substitutes available for consumption either from domestic or imported sources. This would appear to be appropriate for many Australian fisheries products that are marketed domestically (Battaglene, Geen and Simmons 1991).

Diagrammatically, such a demand is represented by the horizontal line  $D_0$  in figure C: whatever the total allowable catch (TAC), that quantity of fish will be consumed at price  $P_0$ . Because the commercial demand for fish products is assumed to be very elastic, changes in 'consumer surplus' are assumed to be negligible in response to changes in either demand or supply. (If there are consumers who would be willing to pay more than the current market price for any product, they are said to obtain a 'consumer surplus' by buying it at the market price. In that case, demand would not be perfectly elastic, as is assumed here, but would vary with price.)

When considering the demand for seafood in general or in other sectors, such as recreational fishing, demand is likely to be less elastic. In such a case, the effects on consumer surplus of the application of research findings should also be considered.

### C Demand and supply of fish products in the Australian commercial fishing industry



### Supply functions and property rights

Supply responses to changes in prices, costs and catch brought about by the application of research will be influenced by the structure of property rights in the fishery.

#### Supply with 'well defined' rights

Property rights in the fishery are initially assumed to be 'well defined': that is, it is assumed that each producer in the fishery has guaranteed access to the fishery, and is guaranteed the right to catch, market and trade some specified quantity (quota) of fish. In Australian fisheries, such property rights are most closely seen in the use of individual transferable quotas (ITQs), where a total allowable catch is shared among operators to ensure that each has a clearly defined proportion of the harvest. In this

### Box 7: Continued

case, the long run supply of the fishery will effectively be the total allowable catch, since this is the maximum allowable total harvest, and it would be expected to be fully used (figure C).

The total allowable catch in a fishery would ideally be set at the social maximum economic yield — that is, the sustainable catch level at which resource rent (the excess of social returns over social costs) is maximised. (Resource rent is maximised when the unit social cost of harvesting additional fish just equals the market price). The total allowable catch would thus be set after taking into account the population dynamics of the fish stock and the economic supply and demand characteristics of the fishery (Cunningham, Dunn and Whitmarsh 1985).

If a catch quota in a fishery has been set, and if individual property rights are clearly defined, each fishing operator can be expected to harvest his/her share of the quota at the lowest cost. In the fishery as a whole, the total supply of fish, the total allowable catch, will thus also be produced at the minimum average cost. In figure C, the industry costs at which different total allowable catches could be supplied are represented, therefore, by curve  $LRAC_p$ .

The fishery supply of fish can be assumed to be inelastic, simply equalling the total allowable catch, where used. However, allowances for an expansion or contraction in supply could be made in some instances, reflecting, for example, supply from new fishing grounds or aquaculture. In these cases, supply can be assumed to be more elastic (at least over the short to medium term) as production in aquaculture may be more readily expanded or as the accumulated biomass in a new wild fishery offers potentially high catches in the early years of exploitation.

#### *Supply without 'well defined' defined property rights*

In the absence of clearly defined individual property rights, commercial operators in fully exploited fisheries would be expected to compete for the resource up to the point where total revenue just covers total cost (that is, where average revenue equals average cost). In that case, operators will not realise any resource rents (profits in excess of normal returns to labour, management and capital).

In addition, fishing effort per unit catch will usually be greater than optimal. Often, in an attempt to prevent overexploitation input restrictions are imposed in such fisheries, with the result that the industry may not be permitted to use the most cost effective combination of inputs. Consequently, the fishery is likely to be operating at higher costs than necessary (Campbell 1985), represented by the  $LRAC_{oa}$  in figure C. This curve represents the industry supply in a fishery with 'poorly defined' rights. Note that the level of production,  $Q_{oa}$ , is unlikely to coincide with the optimal sustainable catch, total allowable catch.

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For most research, the costs of implementing the results are unknown. Often only rough estimates may be possible, and in some cases only subjective estimates. As a result, the estimation of the ratio of benefits to total costs by stochastic benefit–cost analysis is not feasible. As a second best alternative, the funding agency could calculate the ratio of social benefit to research costs, B/RC.

In all the case studies performed in this report, except appendix evaluation A, the quantitative ratio assessments are made in terms of B/RC ratios. This is because for most of the research proposals the implementation costs were not available. However, B/RC ratios cannot give a true representation of the returns to investment in research because implementation costs, which may be considerable, cannot be accounted for. They can only be used as a simple guide and must be accompanied by subjective assessments of the implementation costs in order to adjust the initial measures of attractiveness of the proposals.

Through the use of benefit–cost or B/RC ratios (and judgments of likely implementation costs), funding agencies could compare alternative research proposals taking into account all the factors that determine the magnitude of expected returns to investment, in a consistent manner.

### *Incremental research contributions*

Many fisheries research projects are incremental in nature, contributing to but not sufficient in themselves to make any measured improvement. It may happen that only the results of an entire research program produce benefits to society.

In these circumstances, it may not be possible to assign a value to the contribution of a single project. If there is a need to evaluate all research projects singly (rather than as entire programs), it is suggested that the whole program be evaluated. While it may not be possible to assign a value to each individual component of the project, each should be assessed to determine if the research is technically efficient in that the research is designed to deliver appropriate results at a minimum costs.

Furthermore, each component should be assessed for feasibility to ensure that the failure of any one aspect of the research program does not undermine the benefits derived from the program as a whole.



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## Assumptions in assessing feasibility

### *Research success and adoption*

It is likely that values for research success and adoption will not be known with any certainty and, in practice, it is likely that only subjective assessments of the factors are possible, at best.

To maintain consistency in the evaluation of all research proposals, it may therefore be relatively easier to first estimate research benefits assuming total success and complete adoption of the findings, and then to modify the expected research payoffs in the light of informed or subjective judgments about the likelihood of research success and adoption.

The importance of judgments about the probability of these factors can be seen in the case of the marketing research described in appendix evaluation A. In this case, the researchers were uncertain about the probability of the research being successful in identifying the possibility of a niche market for Australian prawns, and could only put the chance of success in the broad range of 33–66 per cent. If these values are used when evaluating this research proposal — despite the considerable reservations — the benefit–cost ratio of this research could be estimated to be around 6, as against 12 when the probability was assumed to be unity. In this way, funding agencies could have their attention drawn to the subjective assessments of the researchers on the size and credibility of the factors affecting research benefits, so that they could temper the estimated benefits.

### *Realisation and maintenance of benefits*

The presence of international competitors and the structure of fisheries management may determine whether or not research benefits are maintained over time. Dissipation of the resource rent resulting from the implementation of research results may occur through the leakage of innovations to international competitors (Lindner 1989). However, probably of greater importance for realising the benefits from research is having an appropriate fisheries management structure. Most Australian fisheries are undergoing management reform which is changing the fundamental supply characteristics of those fisheries, and hence the size and nature of benefits that a research innovation may generate. However, property rights in most Australian fisheries are currently poorly defined (see box 7), and this will lead to the dissipation of benefits generated by research.

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Whether or not research benefits are dissipated and, if they are, the speed at which they are dissipated, will depend on a number of factors, including the presence of excess harvesting capacity in the fishery as well as the effectiveness of current and future management structures. As a result, the likelihood of research benefits being maintained and the rate at which benefits are lost will be unique for each fishery. The data needed to make this assessment for each fishery would be extensive.

Therefore, the estimation of research benefits in fisheries may be more easily done in two stages: first, assuming ‘well defined’ property rights (see box 7) and no leakage of benefits to international competition; and then taking into account the prevailing property rights framework in the fishery and the state of international competition, and tempering estimates of research benefits accordingly. As little information on probable rates of benefit dissipation under actual conditions is likely to exist, a ‘best guess’ approach should probably be used. (The effects of alternative assumptions about the impact of dissipation rates on project benefits can be examined using Monte Carlo simulations, data permitting.)

Thus, to maintain consistency in assessing research proposals, the size of expected research benefits (the research attractiveness) could first be estimated assuming:

- total research success,
- total adoption of results and
- that resource rents are maximised (and/or maximum non-market benefits are realised) through appropriate management, and that the benefits are not lost to international competition.

Knowledge about, or estimates of, these factors could then be used to temper those expectations.

## Approximation methods

The amount of information available when evaluating research proposals is likely to vary between fisheries and therefore the evaluation methods applied may differ between projects. However, similar methods are likely to be applicable when estimating expected benefits of research that affect similar factors and produce similar impacts.

The benefits of fisheries research may be manifested through increased sale prices, reduced costs, increased catch or enhanced non-market benefits; or research may be directed at the development of a new fishery, thus affecting both price and cost. More than one type of impact could also be produced by research, though here the focus is the evaluation of the single most direct expected impact.

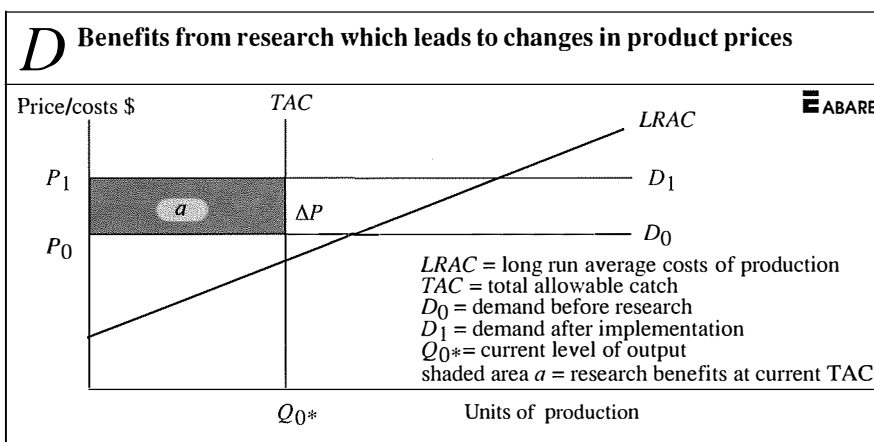
### *Changes in product prices*

Research aimed at increasing product prices does so by showing how the demand for a fisheries product can be increased, as is illustrated in figure D. Such research may be aimed at, for example, increasing the quality of fish supplied to existing markets, or identifying other markets where the retail price is higher. In these circumstances, research causes a shift in the demand curve (see Lindner 1989 for details), from  $D_0$  to  $D_1$ , with a consequent increase in price from  $P_0$  to  $P_1$ . If the industry output is limited to some total allowable catch (TAC: see box 7), then at this level of output,  $Q_0^*$ , industry profits would increase by the amount represented by area  $a$ .

Area  $a$  can be estimated by multiplying the current output by the expected increase in price,  $\Delta P (= P_1 - P_0)$ . That is, equation 1 could be used to estimate the research benefits.

Where research application leads to changes in product prices, gross benefits assuming unchanged output are given by:

$$(1) \quad \text{Benefits (area } a) = Q_0^* \cdot \Delta P.$$



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The increase in product price may in the long run also lead to an increase in the total allowable catch, since the social maximum economic yield is a function of market supply and demand characteristics as well as fish population dynamics (Cunningham, Dunn and Whitmarsh 1985). If the long run response of the optimal total allowable catch to price increases were known, the net value of the additional catch could also be measured. In practice, however, the increase in the total allowable catch that would be justified by a given change in product prices is unlikely to be known in the absence of a well specified bioeconomic model of the fishery. However, it will at least be possible to estimate the benefits of the current level of production. It should be noted, however, that the benefits achievable in principle are then likely to be underestimated.

The formula could also be used to estimate the value of a research project which may prevent a fall in demand for certain fish products (for example, research which leads to better monitoring of ciguatera poisoning). In the absence of such research, the demand for that product would decrease. This would be illustrated in figure D by a shift *downwards* of the demand curve, from  $D_1$  to  $D_0$ . In such cases, the benefits of the research would be the industry profits,  $a$ , that would have been forgone in the event of a fall in demand.

***Example 1: Prawn market research***

An example of research designed to lead to increases in product prices is described in the case study in appendix evaluation A. The primary objective in this research was to identify a niche market for Australian prawns in Japan, and to recommend possible action to exploit this niche. In this way, price premiums for Australian prawns could be generated. Over the range of possible benefits from the research, the average benefit–cost ratio for this proposal was estimated to be 12, assuming that the probability of identifying a niche market was unity and that the benefits would not be competed away.

The data on which this estimate was based were provided by the proponents of the research (the Australian Prawn Producers Association). A funding agency may of course attempt to check the parameter estimates supplied by the proponents or researchers.

As discussed earlier, when estimating the potential payoff to research proposals it is necessary to take into account the form of property rights in the fisheries concerned. In the ideal situation, where property rights to fishery resources are ‘well defined’ (see box 7), all potential research

benefits can be achieved. But more usually, property rights to fishery resources are inadequate, and this appears to be the case here.

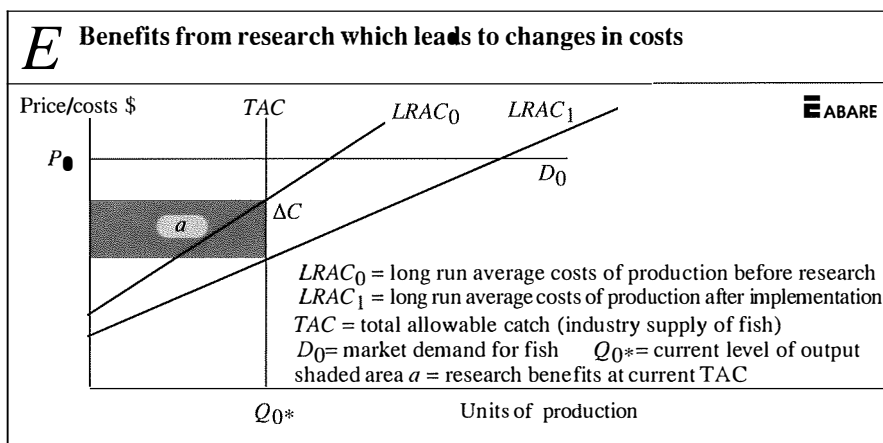
The situation is thus not that of figure D, but closer to the alternative that was shown in figure C, with resource rents tending to zero at an output  $Q_{oa}$ . Research benefits could thus be expected to be competed away and funding agencies would need to be aware of this when considering alternative project proposals.

### Changes in costs

New technology may allow the production of a given amount of fish at a lower cost. This is illustrated in figure E by a shift in the average cost curve  $LRAC_0$  to  $LRAC_1$ . Where the supply of fish is fixed at  $TAC$ , the reduction in the unit cost of production,  $\Delta C$ , results in an increase in the profitability of the industry. The benefit from the fall in industry costs is the gain in the resource rent, represented by the shaded area  $a$ .

Following the same principle as suggested earlier, it would therefore be more practical to estimate the benefits of the research at the current level of production,  $Q_0^*$ . The formula for estimating the benefits from research leading to a change in costs is to multiply the current output by the expected change in unit cost, as in equation 2.

Where research application leads to changes in costs, then gross benefits assuming an unchanged level of output are given by equation 2.



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(2)

$$\text{Benefits (area } a) = Q_0^* \cdot \Delta C.$$

The decrease in industry cost may in the long run also lead to an increase in the total allowable catch, for similar reasons to those mentioned earlier in relation to an increase in price (again, see Cunningham, Dunn and Whitmarsh 1985). Here too, the future change in the social maximum economic yield in response to a decrease in industry cost is likely to be difficult to predict, so this measure of benefits may again understate the true level of likely benefits.

### ***Cost changes due to management***

Cost may also be reduced as a result of management-related research. A broad objective of fisheries management is to promote an industry structure which enables resource rents to be maximised, given the underlying sustainable yield of the fishery and cost structure of the industry. Research which provides information on the appropriate mix of fishing effort, harvest, and the institutional means of achieving these, would provide gross benefits as shown by the area  $P_0BAA'$  in figure C, for the following reason.

As noted in box 7, in fisheries without 'well defined' property rights, fishing effort will tend to stabilise around the level giving the catch shown as  $Q_{\bullet a}$ , where the average industry cost is equal to price. Note that the supply function used here is  $LRAC_{\bullet a}$ : because of the inefficient level of activity in the fishery and use of input constraints, long run average costs in such a fishery (for any given catch) are likely to be higher than they would be in the same fishery given 'well defined' property rights.

Maximum rents could be earned in a fishery if operators could be induced to reduce their effort in such a way as to produce fish at minimum average cost. The commercial value of research that leads to the establishment of a socially optimal total allowable catch and clearly defined individual property rights within that catch would be the increase in resource rent generated. (There might also be an increase in existence and option values from protecting the species.)

If detailed information were available on the cost structures of the industry and the underlying biological production functions of the fishery, the resource rents to be expected from applying such research could be estimated. In practice, such information is seldom available. Hence, to estimate the expected benefit of management research, an approximation approach may be necessary. The approach suggested here is based on the

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proportions of the gross value of production that, from previous studies in other fisheries, it appears possible to obtain as rent through effective management.

Recent research has indicated that potential rents available in some fisheries through management could be anywhere between 20 and 60 per cent of the gross value of production (Geen and Nayar 1989; Geen 1990; Campbell and Haynes 1990). Thus, the potential benefits from fisheries management research in Australia could be substantial, given that the total gross value of production of Australia's fisheries in 1992-93 is estimated to have been \$1374 million (ABARE 1993). Current profit or rent in most Commonwealth fisheries is generally considered to be low (Campbell and Haynes 1990, p. 11).

On this basis, the potential benefits of research aimed at reducing industry costs through management change could be estimated using equation 3.

Where research application leads to the changes in institutional structure gross benefits are given by:

$$(3) \quad \text{Benefits} = GVP (M - N)$$

where *GVP* is the current gross value of production; *M* is the percentage of *GVP* that could be captured as rent; and *N* is the percentage of *GVP* currently being obtained as rent.

The benefits from any changes in the price and the level of fish harvest are neglected here — though they could also be evaluated if the necessary data were available.

***Example 2: Research leading to change in fishery management***

An example of research aimed at improving the institutional structure of fisheries was a project analysing management options for the east coast longline tuna fishery (appendix evaluation B). The objective in this project is to quantify the benefits (or rent) attainable in the fishery under alternative management regimes. As noted above, it has been found that rent worth 20–60 per cent of gross revenues could be achieved in some fisheries as a result of effective restructuring. Using these findings, the potential rent achievable from the east coast tuna fishery under optimum management would be \$7–20 million a year. Rents of \$1.3 million are currently being earned from access fees charged on Japanese vessels.

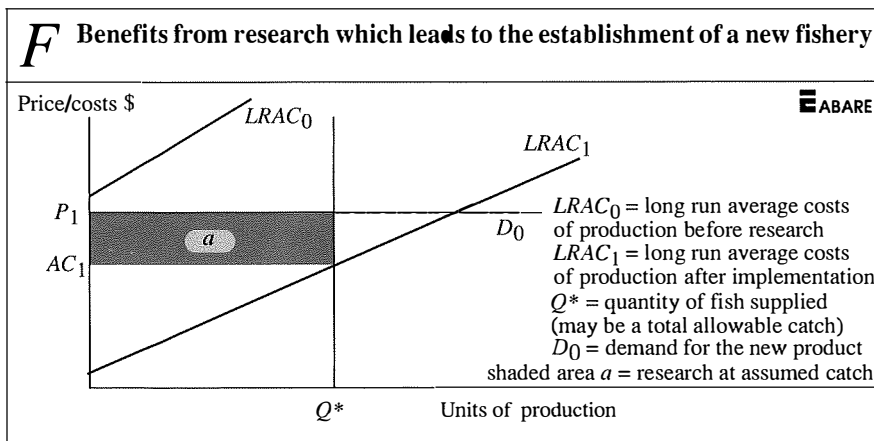
Therefore, the benefits of management related research could lie in the range \$6–19 million, if there are no associated increases in management and enforcement costs.

### *Development of a new fishery*

In some cases, cost reducing research may encourage the development of new fisheries. For example, a new fishery could result from a reduction in the cost of harvesting some species. Introduction of a new aquaculture industry or fish product may conveniently be placed in the same category, since these also often become economically viable as a result of implementing cost reducing research.

In circumstances where research enables a new fishery to develop, the total value of production, net of production costs, could be attributed to the research. The creation of benefits of this type from cost reducing research is illustrated in figure F. Before research, it is not possible to enter the market because the average production costs, represented by the curve  $LRAC_0$ , are higher than the price that consumers are willing to pay. Consumer demand for the new product is represented by curve  $D_0$ . With research, however, it may be possible to produce at or below the price consumers are willing to pay. This is illustrated by a shift in the average cost curve from  $LRAC_0$  to  $LRAC_1$ .

If property rights are ‘well defined’, only the total allowable catch will be produced (see box 7). If the total allowable catch is set at the level at which the resource rent is maximised (or, indeed, at any level yielding a resource





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rent), the benefits of research whereby a new fishery is established are the consequent long run profits, represented by the shaded area  $a$ .

In the absence of the fishery prior to the research, the information on either demand or supply needed to predict the benefits of research may not have been available. However, it may be possible to forecast the average fishing cost and the expected market clearing price at some proposed scale of operation. (It is here assumed that a rent maximising total allowable catch could not be estimated in advance of development of the fishery, but that a catch level could be chosen which would yield rent.) The benefits from research which leads to a new fishery could then be estimated using equation 4.

Where research application leads to the development of a new fishery, gross benefits in any year are given by :

$$(4) \quad \text{Benefits (area } a) = (P_1 - AC_1) Q_1$$

where  $P_1$  is the expected price of the new product in that year;  $AC_1$  is the expected average unit cost of production (operating and capital) in that year; and  $Q_1$  is the expected production in that year (total allowable catch being as yet undefined).

In figure F and equation 4, it is assumed that output can be constrained so that average cost can be held below price. In fact, in the case of a potential new fishery, a funding agency would need to take into account whether 'well defined' property rights are likely to be introduced in the fishery, since any research induced benefits would otherwise be competed away in the long run. (In the case of aquaculture, the problem of property rights in a wild resource does not arise.)

Forecasting the average values of costs, prices and quantities will not be an easy task, as it involves estimating the viability and likely development of the new fishery. In relation to new aquaculture industries, a detailed description of the problems and some possible forecasting methods can be found in Treadwell, McKelvie and Maguire (1991). Even in that case, considerable subjectivity cannot be avoided when estimating the benefits of this kind of research.

***Example 3: Research into silver perch production***

An example of research which could lead to changes in costs and, ultimately, to the development of a new 'fishery' (in this case, an aquaculture industry)

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is presented in appendix evaluation C. It concerns the development of techniques for the commercial aquaculture of silver perch. Currently, the risks of failing to obtain profits from the aquaculture production of silver perch are seen as considerable. However, if better culture technology could be developed, costs might be reduced substantially.

The objectives in this research were to determine the feasibilities of different perch culturing techniques and to determine the optimal water quality and feeding regime for this species. Effectively, findings from this research could encourage the current fledgling industry for cultured silver perch to expand, since there already exists a demand for silver perch.

It is difficult to estimate the expected benefits and costs of future silver perch farming, since there is considerable uncertainty associated with the determining factors — that is, the future size and number of farms, product price, labour costs and other operating expenses. Using projections made by the researchers and by the operator of the only existing commercial silver perch farm in Australia, a benefit–cost analysis was performed using Monte Carlo simulation.

If an appropriate technology is not identified from the research, the only likely outcome would be research costs being incurred. From the analysis, the research would appear to offer a potentially high payoff to funds invested in it. However, the results are highly sensitive to projections about the probability of research success, the adoption rate, and the number of farms which might eventually be established. In this particular case study, a large degree of uncertainty surrounds research success and other parameter estimates.

### *Changes in fish stocks and sustainable catches*

Biological research may lead to improved understanding of the population dynamics of fish. For example, projects may examine questions such as when and where particular species breed, or what are their birth rates, intrinsic growth rates, mortality and recruitment rates. Using such information, together with economic data, it may be possible to improve the management of the capture fishery. The impact of such biological research is through its effect on harvest levels (and stock sizes).

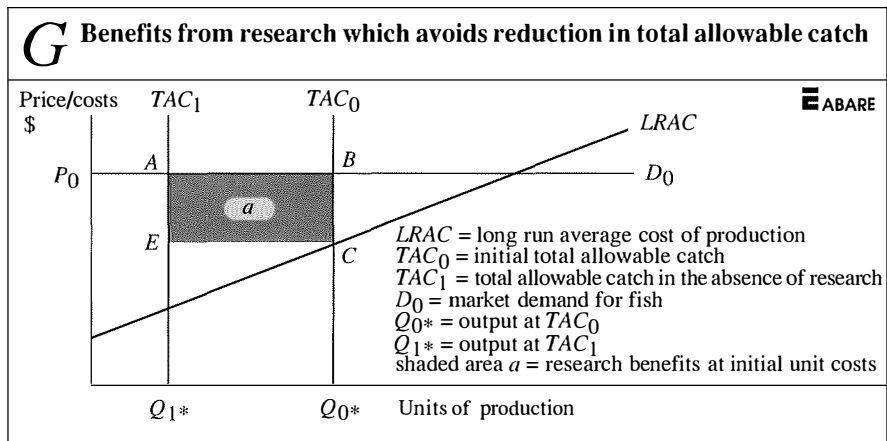
As noted in box 7, if the catch in a fishery is not effectively managed, industry output is likely to occur at the level where average cost equals price

( $Q_{oa}$  in figure C). At this point, no resource rents are generated. Information from biological research can be used to implement appropriate management so that rents may be generated, given by the shaded area  $a$  ( $P_0BAA'$ ) in figure C.

Alternatively, some research may be directed at preserving or increasing catches directly (as distinct from the indirect effect of constraining fishing effort). For example, the aim of the research might be to clarify the relationship between environmental factors and the sustainable level of fish biomass (the carrying capacity).

An example of this type of research is two projects on the consequences for coastal fisheries of the loss of seagrass caused by dredging (see appendix evaluation D). If this research demonstrates a causal link between the survival of seagrass beds and coastal fisheries and establishes the exact relationship, steps could be taken to conserve the seagrass beds and hence maintain the current rate of harvest. If a resource rent is currently being obtained from the fishery, the benefit of research which avoids a decline in the optimal sustainable catch is the amount of resource rent that would be lost if the catch continued to decline.

Research that leads to the maintenance of fish stock may also prevent the industry cost increasing. In a fishery with reduced fish stocks, the average cost of catching a given quantity of fish is likely to be increased. In that case, research that enables a reduction in the fish biomass to be avoided not only prevents the catch from falling but also may provide additional benefits in the form of cost savings.



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A simplified representation of the benefit from such research is shown in figure G. Here it is assumed that the current harvest level is the socially optimal total allowable catch, based on the biology of the fishery and industry costs and prices. Continued dredging could mean a fall in fish population and the need to reduce the total allowable catch from its present level of  $TAC_0$  to  $TAC_1$ . The total gross value of protecting existing sea grass habitats from any destruction would be the loss in resource rent avoided by maintaining the size of the fishery.

As noted above, in the absence of the research, not only would the catch fall from  $TAC_0$  to  $TAC_1$ : the unit harvesting cost for any given catch would be likely to increase, shifting upwards the supply curve  $LRAC$ . In most cases, it would not be expected that the change in fishing costs could be predicted. Therefore if it is assumed, for simplicity, that unit fishing costs remain unchanged, the loss in rent that would be avoided as a result of the application of the research results is shown as area  $a$  in figure G. (In principle, the change in unit costs of fishing which is avoided if research induced management prevents further losses in seagrass beds should be taken into account explicitly.)

A number of factors may need to be considered when assessing the benefits from research on the biological characteristics of a species (relevant to the level of fish harvests). These include:

- the gross value of production of the fishery (which provides an order of magnitude for the potential benefits);
- whether the form of management is such that measures to increase sustainable yields will lead to greater rents being obtained;
- the resource rent generated before the research;
- the likely changes in fish biomass and, thus, in sustainable economic yields;
- the sensitivity of unit harvesting costs to fish abundance;
- whether the biological sustainability of the fishery is threatened, and if so what is the likely magnitude of the existence and quasi-option values of preserving the fish species (see chapter 2).

If the effect on catch levels can be predicted, then (as in the case of seagrass research) benefits could be assessed as indicated in figure G, by estimating the losses in the industry profits which are avoided (area  $a$  in figure G). If

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it is assumed that fishing costs (and prices) will not change, it is thereby assumed that the rents earned will not change as a percentage of the gross value of production. The potential benefits of research could then be estimated by calculating the expected effect on the gross value of production, and multiplying this by the current percentage resource rent,  $N$  (equation 5).

Where research application leads to changes in stocks or sustainable catches, gross benefits are given by:

$$(5) \quad \text{Benefits (area } a) = N (Q_1 - Q_0) P$$

where  $(Q_0)P$  is  $GVP_0$ , the gross value of production in absence of research;  $(Q_1)P$  is  $GVP_1$ , the gross value of production after implementation; and  $N$  is the current percentage of gross value of production captured as rent.

The current level of resource rent in most Australian fisheries is fairly low, since in most cases there are no well defined individual property rights to the fishery resources. Agencies estimating the benefits of such research need to take into account the current and expected management situation in the fishery.

***Example 4: Research leading to changes in fish stocks — the case of seagrass research***

Research was proposed by the Victorian Institute of Marine Sciences and the University of Melbourne (Zoology Department) to investigate whether coastal fisheries were dependent on the supply of seagrass (appendix evaluation D). The benefits of maintaining seagrass dependent fisheries were estimated using the change in fish harvest predicted to occur if the seagrass were lost.

Using the GVP method of benefit estimation, and a range of resource rent of 20–60 per cent of the gross value of production, the benefit–research cost ratio was estimated to be 1.8, with a standard deviation (due to parameter uncertainties) of about 1.0. In other words, the expected benefits of research are almost twice the research costs. In view of the lack of individual property rights in the fishery, this might be an overestimate of the benefits of research to commercial fishing. However, in addition to the research costs, the value of dredging likely to be forgone through seagrass conservation would also need to be considered.

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In this analysis, only information about the commercial harvest was used. Yet others, such as anglers, also use the fish that are apparently dependent on seagrass. Baseline data for a quantitative assessment of benefits to these users were unavailable. Nevertheless, at least qualitative information on the expected benefits to the recreational sector would need to be included in the assessment of this research project, together with any existence or quasi-option values attached to the conservation of species that might be dependent on seagrass.

In general, given the current often poor state of knowledge of Australia's fisheries, estimates of likely changes in fish abundance and the impact of such changes on catch and fishing costs, and of the resulting impact on industry profitability, are likely to be highly speculative. Consequently *ex ante* project evaluations may contain a large element of subjective judgment.

An example of the need for systematic subjective consideration when evaluating research is provided by two projects performed on the Great Barrier Reef Marine Park (appendix evaluation E). This research was undertaken to provide biological information on coral trout at the reef, in the hope that a more effective minimum harvesting size could be determined to better protect stocks, and to provide biological information on other reef target fish (sweet lip emperor and snapper).

It is difficult to quantify the benefits from this research. In the case of coral trout, the change in the catch in response to a change in minimum size cannot be estimated ahead of the research, and there are conflicting views as to the effect on price. In the case of sweet lip emperor and snapper, information on catches is not available. In addition, a large but unknown proportion of reef catches are made by recreational anglers, who would therefore also benefit from improved management. Consequently, the benefits of this research can only be assessed in qualitative terms. That is, it can only be said that the research would be expected to lead to more effective management, increased revenue and improved non-market benefits to the recreational sector (see appendix evaluation E for details).

### *Changes in non-market benefits*

As indicated earlier, benefits from fisheries research may be realised in a diversity of areas other than commercial fishing, where markets may not exist or the benefits of research may not be easily quantified (as in the case

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of research induced improvements in the quality of recreational fishing grounds).

These non-market benefits could be measured either quantitatively (in dollars) or qualitatively. Ideally, the dollar worth should be measured, since it would be easier to compare research proposals using this measure. This could be done if the amounts that users of non-market goods and services were prepared to pay for them could be identified. The values of research induced changes in non-market benefits could then be estimated using approximation formulas similar to those used for benefits obtained in commercial fisheries (that is, in terms of the benefits derived from the current levels of the non-market goods and services).

If, for example, research led to an improvement in the quality of an environmental service, such that its users would be willing to pay more for each unit of service 'used' (though they do not actually pay), this would be interpreted as an increase in demand. The non-market benefits of the change could then be evaluated in the same way as those of research induced increases in demand for commercial products (figure D and equation 1).

In general, however, the amounts that society would be willing to pay for such non-market goods and services are not known. As a result, it is unlikely to be possible to quantify the value of non-market research benefits. At best, a 'breakeven' analysis may be all that can be used. Evaluation of non-market benefits, and the use of breakeven analysis, can be illustrated by the case of research that was done in producing a fisheries resources atlas.

***Example 6: Research leading to changes in non-market benefits — a resources atlas***

The Bureau of Resource Sciences (BRS) has recently produced a comprehensive atlas of Australia's fishery resources (appendix evaluation F), since it believed that the information, being widely scattered, was not readily accessible to all sections of the industry or the community at large. The availability of the fisheries atlas is expected to provide a number of non-market benefits through the improvement of databases (as a result of cross-checking), improved industry access to information, and possibly through a raised public awareness of the fishing industry.

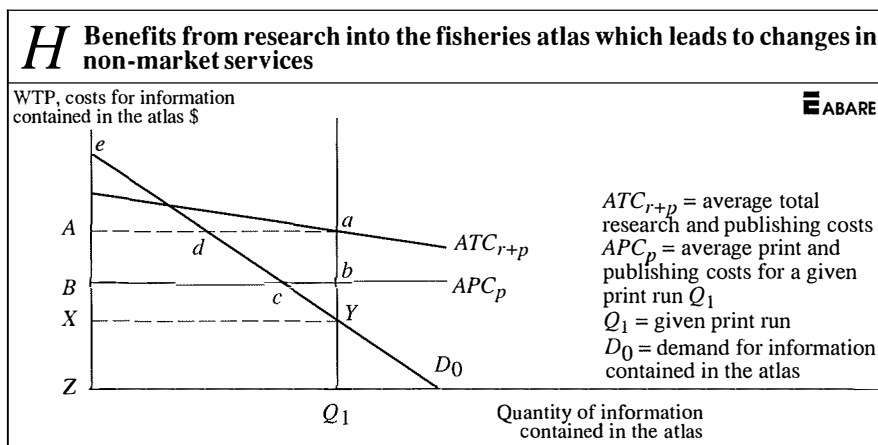
When the project was proposed, the BRS intended to market a fixed number of atlases at average publication cost. However, it is likely that in addition to the benefits accounted for by market returns there will be other benefits

from use of the atlas. This is because the atlas can provide pervasive benefits to a wide cross-section of potential users, beyond those who will pay for it. Once an atlas is purchased, it may be made available to any number of people at little extra cost — for example, in the case of a library. While these benefits cannot be recouped through the sale of the atlas, they do constitute real benefits to the industry or the nation.

Before the research, the cost of accessing the information concerned was unknown, although it could have been significant, since the information was scattered throughout the country. The information expected to be contained in the atlas is a proxy for information which could be collected from various sources, by various agents over time. Demand for the atlas is therefore a derived demand for that information which is dispersed. The amount users are willing to pay for the information in the atlas would depend on the cost savings that the users of the information could expect from accessing the required information from the atlas instead of from the original sources.

The extent of use from the atlas throughout society is not likely to change much, even if its price were reduced. This is because of the lack of similar (substitute) specialised products providing fisheries information compiled in one document.

As a result, demand for the non-market benefits of the fisheries atlas is represented in figure H by a downward sloping demand curve  $D_0$ . (It is possible to have either elastic or inelastic demand for non-market goods, depending on the availability of close substitutes). Not all information presented in the atlas may be wanted at once, if at all. More of the





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information contained in the atlas could, however, be expected to be used at some time during the life of the atlas.

Average print and publishing costs are represented by horizontal curve  $APC_p$  for given print run of  $Q_1$  because the intention of the BRS was to market the atlas to cover printing and publishing costs only for a given print run.

Average total research, printing and publishing costs for the fisheries information in the atlas (including research costs) are represented by curve  $ATC_{r+p}$ . This slopes downwards to the right to reflect economies of scale in the collection of information over a reasonable range.

The net benefits produced from research leading to the atlas are total benefits  $eYX$  less total costs of supplying the atlas of  $AaQ_1Z$ .

If information on the demand for the atlas were available (say, from market research into the sales potential and willingness to pay for the atlas), the value of the research could be estimated. In practice, however, estimating the potential demand for very specialised publications like the fisheries atlas may be difficult, since extrapolations cannot be easily made from sales data on other publications. Consequently, the research benefits may be difficult to estimate.

At best, it may be possible to obtain some assessment of the average willingness to pay, for a volume of such information, from market research, so that the minimum benefits provided by the atlas could at least be estimated using equation 4 (suggested earlier for evaluating research which could lead to the development of a new fishery). That is, the gross benefits of research application leading to changes in non-market benefits (estimated through a proxy market) are:

$$(4) \quad \text{Gross benefits} = (P_1 - AC_1) Q_1$$

where  $P_1$  is the price that consumers would be willing to pay for the atlas;  $AC_1$  is the average per unit (operating and capital) cost of production in that year; and  $Q_1$  is the amount of the good or service demanded at the market price.

If estimates of the willingness to pay for the atlas were not available, a fallback approach could be to use a breakeven analysis. This could enable the funding agency to focus on the order of magnitude of the likely benefits

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of the research that would be necessary to match the research costs. The funding agency would then attempt to assess how large the expected benefits of the research are likely to be compared with the breakeven value.

In the case of the atlas, recouping total costs would allow the project to break even financially, in respect of the costs that the BRS and the funding agency would incur through research and publication of the atlas. However, the generation of a net social benefit from the atlas study would depend on demand for the atlas. The benefits recouped at total breakeven for the  $Q_1$  level of information contained in the atlas, inclusive of research costs, would be represented by  $AaQ_1Z$ , leaving a net difference of costs  $daY$ . A funding agency would thus need to make some subjective judgment about whether any additional benefits from acquiring information from the atlas as compared with individuals collecting it separately and whether other benefits from the atlas which are not reflected in its breakeven would be sufficient to justify the project.

In using breakeven analysis in this case, judgments on project merits would have to take account of both project costs and the opportunity costs of not having the atlas. In the case of the atlas project, research costs are high, in excess of \$1 million. The opportunity cost — that is, the cost to users of not having access to such an atlas — may not be demonstrably as high. In this circumstance research may actually result in a cost or deficit rather than producing a net benefit. If research costs were also to be recouped, depending on the number of copies printed, the atlas users would have to value it on average by between \$275 and \$650 an atlas (depending on printing costs), for the project to break even. A subjective judgment would then need to be made about whether the users of the atlas are likely to place such a high value on the information compiled in the atlas. This would also have to take into account the cost savings to individual users of the atlas of not having to access the information they need in the absence of the atlas.

### ***Qualitative assessment of non-market research benefits***

In some cases, adequate information may not be available even for breakeven analysis to enable a meaningful comparison of project merits. This is particularly true of projects which provide baseline information relevant to activities from which non-market benefits are derived.

For example, research which leads to increases in the overall demand for recreational fishing (through increased information about sites and clean waters) would shift the recreational demand curve upwards and generate

benefits similar to those represented earlier in figure E. The magnitude of those benefits would depend on the significance of those factors which are changed by its application. For example, consider research whose application could lead to some improvement in the quality of the environment which in turn would be likely to improve the quality of experience in a recreational fishery. If the value of the recreational fishing is influenced by the quality of the environment, implementing the results of this research could result in significant gains to this sector. If, however, the most important factor for anglers was not the environment but, say, the number of fish caught, the implementation of the research might be of little social value to the anglers. To estimate the expected benefits of this kind of research to anglers 'with and without' estimates of the current and future willingness to pay for recreational fishing would be necessary.

However, such estimates of willingness to pay for non-market benefits are usually expensive to obtain and there are seldom any comparable activities from which proxy estimates could be derived. In cases where research leads

**Box 8: Approximation formulas for estimating the value of the benefits of fisheries research**

The biological and economic production functions of fisheries are not usually known, but it may nevertheless be possible to estimate the changes in prices, costs and/or catches likely to result from the application of research results. Given such estimates, the following approximation methods could be used for estimating benefits, depending on the type of direct effect that application of the results is expected to produce, and the amount of information available.

<b>Impact category</b>	<b>Evaluation guide</b>
Changes in <i>product prices</i>	<ul style="list-style-type: none"> <li>• benefits are most easily estimated assuming unchanged output (<math>Q_0</math>) and estimating the price change (<math>\Delta P</math>):</li> <li>(1) Gross benefit = <math>Q_0 \Delta P</math></li> <li>• In addition, any non-market values could be considered qualitatively.</li> </ul>
Changes in <i>production costs</i>	<ul style="list-style-type: none"> <li>• Benefits are most easily estimated assuming unchanged output (<math>Q_0</math>) and estimating the cost change <math>\Delta C</math>):</li> <li>(2) Gross benefit = <math>Q_0 \Delta C</math></li> <li>• In addition, any non-market values could be considered qualitatively.</li> </ul>

## Box 8: Continued

*Multicategory*: institutional change (affecting more than one parameter – price, cost and/or catch)

- Probable changes in the level of resource rents in the fishery could be used, assuming a constant gross value of production ( $GVP$ ). Assuming that a fraction  $N$  of the  $GVP_0$  is currently being earned as rent, and that the institutional change would increase this fraction to  $M$ :

$$(3) \text{ Gross benefits} = GVP_0(M - N)$$

- Failing this, the evaluation must remain qualitative.

Development of a *new fishery*

- Estimates of both output and market price are required. Average fishing costs ( $AC_1$ ) at the projected market price ( $P_1$ ) and quantity ( $Q_1$ ) can then be forecast from the estimated total cost of production of that quantity.

$$(4) \text{ Gross benefit} = (P_1 - AC_1)Q_1$$

Changes in *fish stocks* and hence sustainable catches

- Benefits are most easily estimated assuming unchanged price ( $P_0$ ) and also assuming that some unchanged proportion  $N$  of the gross value of production ( $GVP$ ) is captured as resource rent. Given an estimate of the change in the total allowable catches ( $Q_1 - Q_0$ ):

$$(5a) \text{ Gross benefit} = N(Q_1 - Q_0)P_0$$

or assuming some projected increase in GVP to  $GVP_1$ :

$$(5b) \text{ Gross benefit} = N(GVP_1 - GVP_0)$$

- If any of the above variables cannot be estimated, the evaluation must remain qualitative.

Changes in *non-market* benefits – for example, from recreational fishing

- If possible, identify measures of cost or value that can be imputed to the good, so that benefits may be estimated from the research led changes in these measures using equation 1 or 2.
- Use breakeven analysis (see appendix evaluation F).
- Failing this, the evaluation must remain qualitative.

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to unquantifiable non-market benefits, and where only limited information is available for a breakeven analysis, the estimation of research benefits may have to remain qualitative. The focus is then on likely changes in the factors affecting non-market benefits. The key factors will be those affecting fish production and the costs of, and willingness to pay for, non-market services relevant to the fishery. For example, in recreational fisheries, costs will largely be borne by fishers, and the size of the 'industry' will be determined by the number of anglers and quantity of fish taken by each angler. In many cases such information, as well as the value placed on the recreational experience, may not be available. Indeed, many currently funded projects are being undertaken to provide baseline data to provide information on fisheries in general.

To assess the relative importance of proposals which provide some baseline information, research and funding agencies may have to rely on a subjective assessment of such indicators as the probability of research being successful, the likely future importance of the information resulting from the research, and on this basis whether future benefits are likely to exceed the current costs. Often these factors are used intuitively to assess projects the market benefits of which are unquantifiable (for example, the research in the Great Barrier Reef line fishery discussed in appendix evaluation E).

The different approximation methods discussed in this chapter are summarised in box 8.

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## *Comparison of research proposals and the selection of a research portfolio*

It has been shown that, provided that quantitative estimates of the expected benefits and costs of alternative research proposals are available, proposals can be compared on the basis of their benefit–cost ratios (possibly subject to other considerations such as their relative risk). However, it has also been noted that in many cases quantitative analysis may not be possible, and qualitative or subjective assessments may be necessary. Portfolio selection will be more difficult where projects evaluated by different methods have to be compared, because of the lack of a common basis for comparison. There is no single procedure for comparing and selecting projects which allow quantitative information and qualitative and subjective assessments to be consistently combined. However, a consistent approach may lead to the best comparative ranking of proposals.

### Scoring systems

One way to encompass all the qualitative, quantitative and subjective assessments of the different aspects of research proposals is through a ‘scoring’ system. In a scoring system, each proposal is assigned numerical scores on each of a number of factors.

The scores are used to place the proposals in order of preference. The resulting ranking is comparative (ordinal) only, and has no absolute significance, although at least some of the constituent scores on particular factors may be measured objectively. Despite the inherent difficulties in using scoring methods (notably the choice of procedure for combining the scores), such methods have been used widely in the past in the administration of research funds (see Fox 1987).

### Factors to be considered

The factors to be considered when scoring research proposals are all those which, under ideal circumstances, would have been included in the estimation of the expected benefit–cost ratio. In chapter 4, these factors were grouped into two broad categories: first, the ‘attractiveness’ of the research proposal — the maximum possible value of its expected benefits (taking into account the uncertainty in their estimates); and, second, the ‘feasibility’

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of achieving those benefits — that is, the likelihood of the research being successful, its results being applied and the desired effects being achieved.

There are advantages to calculating scores separately for attractiveness and feasibility. To start with, when different levels of subjective assessment cannot be avoided, separation of factors would be preferable to a single composite merit score, as a single project is not likely to contain enough information for discriminating between the alternative proposals.

In addition, a type of ‘double counting’ may be avoided (CSIRO 1991). For example, the benefits of a research project which is likely to lead to changes in catch may be ‘marked down’ if it is known that the most appropriate management strategy is politically unpopular. When the probability of that project being successful is then considered, it would be likely to be marked down a second time for the same reason. This can be avoided by ensuring that no factor enters into both groups.

Separate scoring for attractiveness and feasibility may also draw attention to possibilities for refining proposals. A project may be judged to be highly attractive (with high payoffs) but with low feasibility. In that case, the funding agency might ask the proponents of the research to revise their proposal and resubmit it at a later date. Alternatively, a project may be considered to be highly feasible but have a wide range of possible returns. It might be that the uncertainty could be reduced if more baseline information were available. A funding agency might then wish to first fund a preliminary study which would firm up some of the parameter estimates so that the level of uncertainty could be reduced. In this way, the funding agency could spend a relatively smaller sum of money in the first instance to obtain further information that it could use when deciding whether or not to fund the entire research project in the future.

## Selection of the research portfolio

Because of the different levels of uncertainty and different expected benefits associated with projects, a funding agency is likely to choose some combination of research projects with a variety of levels of attractiveness and feasibility. An agency may trade off the attractiveness of some proposals against the feasibility of others. In addition, in evaluating attractiveness, a risk averse agency will be likely to trade off expected benefits against risks (see box 9). For empirical studies on portfolio selection and spreading of risk, see Evans and Archer (1968) and Johnson and Shannon (1974).

## Box 9: Risk spreading and portfolio selection

A risk averse funding agency is likely to take into account the riskiness of alternative projects when selecting its portfolio. The simplest measure of risk is the standard deviation of the probability function that describes the range of possible payoffs. As an example, suppose there are three research proposals, A, B and C, with expected returns, standard deviations and costs as given below.

### Returns and risks for three hypothetical projects

	Project A	Project B	Project C
Expected benefit–cost ratio	10	20	30
Standard deviation	10	50	40
Cost (\$)	1 000	2 000	1 000

Suppose that the funding agency has a budget of \$2000, and therefore has to choose between funding project B alone or both projects A and C. To choose between these options, the agency would need to determine the average expected return from projects A and C together with their combined risk. The average total benefit–cost ratio of projects A and C is given by dividing the total expected benefits by the total cost:

$$[(10 \times 1000) + (30 \times 1000)]/2000 = 20$$

The combined risk is given by the combined standard deviation, which is the square root of the sum of the squares of the individual standard deviations (assuming that the distributions of the uncertain parameter estimates are independent):

$$\sqrt{(100 + 1600)} = 41.2$$

Thus, projects A and C offer the same average expected returns (\$20 for every research dollar spent) as project B. However, the risk associated with projects A and C together is lower (a standard deviation of 41) than that associated with B (standard deviation of 50). A risk averse agency would invest in the bundle of two projects rather than the single project (other things being equal) — a risk neutral agency would be indifferent between the two options.

If the expected return from project B were higher than the combined expected returns from projects A and C, with the variances still as above, a risk neutral agency would choose project B, but a risk averse agency would require some decision rule for choosing between the two options. One such rule was mentioned in chapter 3 — the Markowitz rule.

Difficulties arise when quantitative and qualitative assessments of expected returns and risks have to be combined. In these circumstances, subjective assessments of the combined risks and average expected returns of alternative bundles of research projects must be used.



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Projects which would affect similar factors in a fishery (costs, prices, stocks, or non-market benefits — see chapter 2) are likely to have similar amounts of quantifiable data available for them. Therefore, to minimise subjectivity when assessing alternative projects, projects which fall into the same ‘impact’ category could initially be compared with each other.

This is particularly relevant to proposals which are evaluated using similar modifications to benefit–cost analysis (see figure B). For example, it would be easier to compare the expected benefits of all proposed projects that may affect product prices, for which good quantitative estimates are likely to be available, than to compare them with projects that affect, say, catch levels.

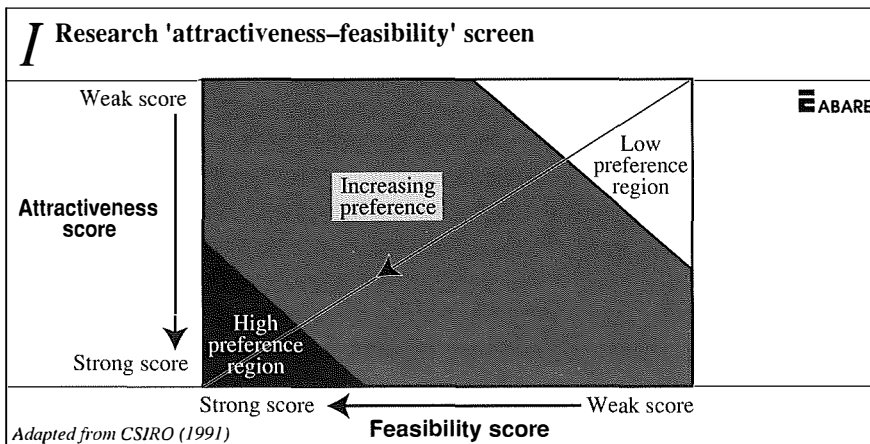
Thus, the first step would be to sort proposals into impact categories. Each proposal could then be assessed, and projects within each category could be compared on the basis of their attractiveness and feasibility before attempting to compare projects in different categories.

### *Comparison within impact categories*

The merits of proposals would be considered by the members of the evaluating group (possibly the board of the funding agency), each of whom would assign to each proposals two scores (say, from 1 to 10) for attractiveness and feasibility respectively.

For each proposal, the individual members’ scores would be combined into collective scores (still keeping attractiveness and feasibility separate). There are a number of ways of doing this: for example, preliminary discussion of minority scorings, followed by averaging. The collective scores for all the proposals in a given output category could then be collated by plotting them on an ‘attractiveness–feasibility screen’ (figure I). On such a display, the tradeoff between attractiveness and feasibility can be made explicit, and a ranking may be eased.

However, between the extremes of highly desirable and highly undesirable proposals, it is likely to be difficult to decide beforehand which project would be preferable to another. Trading off the attractiveness of some proposals against the feasibility of others would no doubt require further subjective judgments. To ease the ranking of projects in the middle region, it may be useful to recall the initial scoring of the attributes, examine the factors that may have contributed to the lower scores, and make a judgment focusing on the major differences.



The system outlined above, though employing subjective judgments, would enable the funding agency to systematically consider all the factors — with their quantitative estimates, wherever possible — that influence the returns per investment dollar, to derive an internally consistent ranking of proposed projects within an impact category.

A hypothetical example of the ranking of projects within categories is given in the following section of this chapter.

### *Comparison across impact categories*

When composing a research portfolio, research proposals in different impact categories will need to be compared. In principle, the same scoring procedure as outlined above could be used for ranking project proposals between research categories. Members of a funding agency would select projects on the basis of their collective judgment, drawing on their past experience, their knowledge and understanding of the fisheries, and taking into account issues such as urgency and regional considerations. However, a greater degree of subjectivity is inevitable when comparing across the research categories.

Selection between categories might be facilitated if project proposals could be considered in the light of research priorities already identified by the funding agency. For example, the agency might consider its priority to be the protection of profits through research into sustaining the fish stock.

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## Example of the research portfolio selection process

Assume that the agency has received proposals for research projects in the following areas:

- **Proposal A** Improving current fishing gear technology in the shark fishery
- **Proposal B** Improving the marketing of squid
- **Proposal C** New harvesting techniques for silver perch
- **Proposal D** Improving the quality of blue pincher crabs sold on the domestic market
- **Proposal E** Effect of restricted entry on operating costs in the prawn fishery
- **Proposal F** Identifying export markets for the redclaw crab
- **Proposal G** Developing less costly packaging for crab
- **Proposal H** Preventing ciguatera poisoning from fish

(These are hypothetical examples.) Assume further that the agency's secretariat has verified that these projects are appropriate for the issues they are intended to address and that none of the proposals needs to be revised to provide fuller or more accurate information.

The secretariat groups these proposals into impact categories. In this imaginary case, all of them fall into just two categories — cost reduction and the enhancement of price, as shown in table 1.

The secretariat performs benefit–cost analyses on each research proposal in each impact category (tables 2 and 3).

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### **I** Hypothetical research proposals sorted into impact categories

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<b>Cost reduction</b>		<b>Price enhancement</b>	
<b>Proposal A</b>	Gear technology for shark	<b>Proposal B</b>	Squid marketing
<b>Proposal C</b>	Harvesting techniques for perch	<b>Proposal D</b>	Quality of pincher crabs
<b>Proposal E</b>	Restricted entry for prawn	<b>Proposal F</b>	Markets for redclaw
<b>Proposal G</b>	New packaging for crab	<b>Proposal H</b>	Preventing ciguatera

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## 2 Results of benefit–cost analyses on hypothetical research proposals in the cost reduction category

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<b>Proposal</b>	<b>B/C analysis</b>
<b>Proposal A</b> Gear technology for shark	<p><i>Attractiveness</i> B/C ratio = 4 Standard deviation (degree of risk) = 3</p> <p><i>Feasibility</i> Likelihood of research success and adoption — high Prospect of maintaining benefits — low (due to inappropriate fishery management)</p>
<b>Proposal C</b> Harvesting techniques for perch	<p><i>Attractiveness</i> B/RC ratio = 10<sup>a</sup> Standard deviation (degree of risk) = 5</p> <p><i>Feasibility</i> Likelihood of research success — high Likelihood of adoption — high Prospect of maintaining benefits — high</p>
<b>Proposal E</b> Restricted entry for prawn	<p><i>Attractiveness</i> Highly attractive, at \$10 million savings (possibly up to 25 per cent of current gross value of production) Degree of risk — low</p> <p><i>Feasibility</i> Likelihood of research success — high Likelihood of adoption — low Prospect of maintaining benefits — low</p>
<b>Proposal G</b> New packaging for crab	<p><i>Attractiveness</i> Highly attractive for future net earnings, but initial costs high Degree of risk — high</p> <p><i>Feasibility</i> Likelihood of research success — high Likelihood of adoption — low Prospect of maintaining benefits — moderately low</p>

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<sup>a</sup> B/RC = benefit–research cost ratio. In this case it is supposed to be impossible to estimate the implementation cost with sufficient accuracy to generate an overall benefit–cost ratio.

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### 3 Results of benefit–cost analyses on hypothetical research proposals in the price enhancement category

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<b>Proposal</b>	<b>B/C analysis</b>
<i>Proposal B</i> Squid marketing	<p><i>Attractiveness</i> B/C ratio = 8 Standard deviation (degree of risk) = 3</p> <p><i>Feasibility</i> Likelihood of research success — medium Likelihood of adoption — medium Prospect of maintaining benefits — medium (due to competition from overseas)</p>
<i>Proposal D</i> Quality of pincher crabs	<p><i>Attractiveness</i> B/RC ratio = 10<sup>a</sup> Standard deviation (degree of risk) = 5</p> <p><i>Feasibility</i> Likelihood of research success — high Likelihood of adoption — high Prospect of maintaining benefits — low (due to competition from overseas)</p>
<i>Proposal F</i> Markets for redclaw	<p><i>Attractiveness</i> High, although this is only one of many projects likely to be necessary to achieve the goal Degree of risk — high</p> <p><i>Feasibility</i> Likelihood of research success — medium Likelihood of adoption — high Prospect of maintaining benefits — medium</p>
<i>Proposal H</i> Preventing ciguatera	<p><i>Attractiveness</i> Very attractive, but unquantifiable, and this is only one of many projects likely to be necessary to achieve the goal Degree of risk — medium</p> <p><i>Feasibility</i> Likelihood of research success — medium Likelihood of adoption — medium Prospect of maintaining benefits — relatively high</p>

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<sup>a</sup> B/RC = benefit–research cost ratio. In this case it is supposed to be impossible to estimate the implementation cost with sufficient accuracy to generate an overall benefit–cost ratio.

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### *Comparison and selection assuming risk neutrality*

Individual members of the board compare and rank the attractiveness and feasibility of each proposal within each impact category.

Suppose, for simplicity, that the agency is risk neutral. Thus, when ranking projects on attractiveness, the members are concerned only with the expected payoff from each, not with the range of possible payoffs.

The lowest possible rank within a category at this stage is simply the number of proposals within that category — four, in this case. The initial ranks are rescaled in the range 1–10 to give scores for each project, either by using a constant factor or by assigning the same score to more than one proposal. In this case, number 1 is the highest ranking and number 10 the lowest.

Suppose that there are only two members and that their scaled scores are as shown in table 4. For example, in the *cost reduction* category, member A assesses that the research into new harvesting techniques for perch (proposal C) is likely to offer the highest returns and that the lowest returns are offered by the research into gear technology for shark (proposal A), while member B determines that the highest returns are offered by the research into the cost effects of restricted entry for prawn (proposal E) and the lowest by the research into packaging for crab (proposal G).

Assuming that the board does not wish to modify the relative scores, the scores are aggregated. This may be done by averaging or summing the scores, or through consensus. Board scores for attractiveness and feasibility are thus determined for each proposal in each impact category (table 5). The

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## **4** Individual scores assigned by hypothetical board members

Member A's scores					Member B's scores				
<b>Cost reduction category</b>									
<i>Proposal</i>	<i>A</i>	<i>C</i>	<i>E</i>	<i>G</i>	<i>Proposal</i>	<i>A</i>	<i>C</i>	<i>E</i>	<i>G</i>
Attractiveness	10	3	5	8	Attractiveness	5	8	3	10
Feasibility	8	3	10	5	Feasibility	5	3	8	10
<b>Price enhancement category</b>									
<i>Proposal</i>	<i>B</i>	<i>D</i>	<i>F</i>	<i>H</i>	<i>Proposal</i>	<i>B</i>	<i>D</i>	<i>F</i>	<i>H</i>
Attractiveness	8	3	5	10	Attractiveness	3	5	8	10
Feasibility	8	10	3	5	Feasibility	5	10	8	3

## 5 Hypothetical (aggregate) board scores

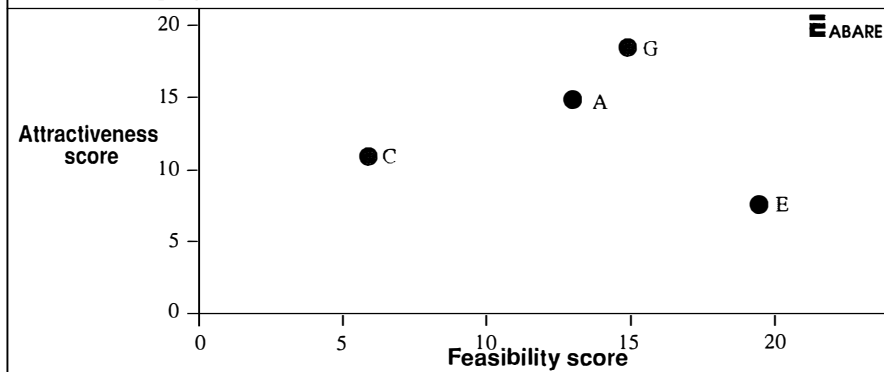
### Cost reduction

<i>Proposal</i>	<i>A</i>	<i>C</i>	<i>E</i>	<i>G</i>
Attractiveness	15	11	8	18
Feasibility	13	6	18	15

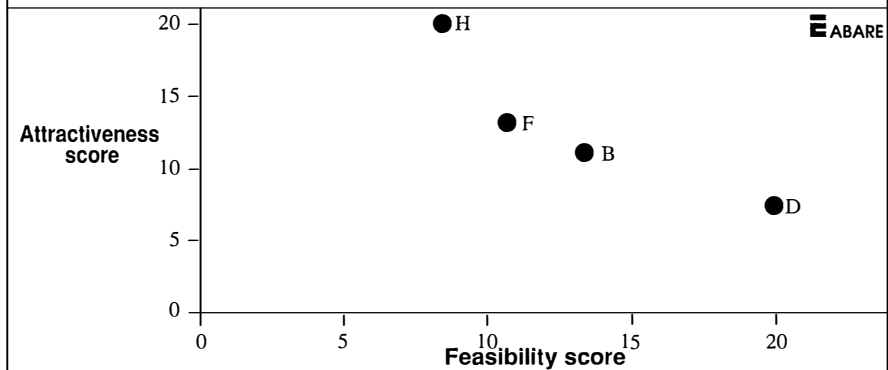
### Price enhancement

<i>Proposal</i>	<i>B</i>	<i>D</i>	<i>F</i>	<i>H</i>
Attractiveness	11	8	13	20
Feasibility	13	20	11	8

**J** Alternativeness–feasibility map of hypothetical research projects in the category of cost reduction



**K** Alternativeness–feasibility map of hypothetical research proposals in the category of price enhancement



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scores are then plotted on an attractiveness–feasibility map for each category, as in figures J and K.

The board may then sort the research proposals in each impact category in order of preference, and may identify any tradeoffs it is prepared to make between the attractiveness and feasibility of projects in each category. For instance, in this example, proposal D is more attractive than proposal H. However, the board may choose to trade off the high attractiveness of proposal D in favour of the greater feasibility of H.



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## *Concluding remarks*

In this study, the potential for applying benefit–cost analysis to the evaluation of fisheries research and the selection of an optimal research portfolio has been explored. Although rigorous quantitative evaluation and comparison of research proposals is not always possible, the use of a benefit–cost framework may greatly assist funding agencies by encouraging them to consistently and explicitly consider all the factors that are ultimately likely to influence research payoffs.

Because much of the information needed to obtain exact, single valued benefit–cost figures for research proposals may not be available, a practical assessment of proposals is likely to involve a number of modifications to the benefit–cost approach. Depending on the amount of information available, funding bodies may elect to use stochastic benefit–cost analysis, simple forms of quantitative analysis, or qualitative assessments, or some combination of these. In general, the less information that is available, the more subjective and less accurate the assessment of a proposal will be.

Since a number of evaluation approaches may be used within the same agency to assess different research proposals and different aspects of the benefits of the same proposal, comparison and selection among them, to arrive at a portfolio of projects, may not be straightforward. Use of a scoring mechanism is suggested as a procedure which can be applied to both quantitative and qualitative information.

## *Case study evaluations*

Evaluations of six fisheries research projects are documented in this appendix. The evaluations were undertaken to illustrate *methods* of evaluating fisheries research proposals, rather than to assess the merits of the projects. It must be emphasised that all of these case studies are presented as examples of evaluations carried out before the projects were undertaken. Hence, the evaluations were made on the basis of the information available at the commencement of the research, and not with the benefit of hindsight. (For example, it is clear that the values of some sea caught Australian prawns in Japan have been falling, contrary to expectations at the time when the research described in evaluation A was proposed; as a result, some of the data used in the evaluation of this project may have been overoptimistic.)

It is also important to note that the main sources of data for evaluating these research projects have been the researchers actually involved in the projects, and that not all the data provided by them has been checked. It could be argued, therefore, that in many cases the benefit estimates are likely to be optimistic. However, data from other sources have been used where researchers have not been able to provide estimates of required parameters, or where they believed other sources would provide more accurate estimates.

Where parameters were uncertain, researchers were asked to provide a range of possible estimates, corresponding to low, high and most likely possibilities. Nevertheless, researchers may generally have been optimistic about the likely success of and benefits from their research. Clearly, the validation of data provided by the proponent researchers would need to be an integral part of any evaluation system adopted by research administrators who use researchers as a primary data source. This is a situation probably currently faced by fishery research funding agencies. The use of a benefit–cost framework would help such agencies to identify all the kinds of information they need when choosing between research projects.

To ensure some degree of consistency of treatment between projects, the ‘attractiveness’ and ‘feasibility’ of projects are assessed separately, as described in chapter 4. First the attractiveness is determined, by evaluating the expected benefits to Australian society under the assumption that all the

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desired impacts could be achieved; that is, it is assumed that the research is successful, that the results are adopted, and the benefits will not be lost to foreign competitors, and that the fishery concerned is operating under conditions of 'well defined' property rights (see box 7).

A quantitative analysis is undertaken using a benefit–cost framework. Where the information required for a quantitative stochastic analysis is not available, benefits are discussed qualitatively. A maximum benefit period of twenty years is allowed in all cases. (In some cases, benefits may be expected to have been dissipated by this time, but this will not affect the accuracy of the benefit estimates.)

The second step (feasibility) in assessing research proposals is to temper the expected benefits, given whatever judgments can be made (in the light of available information) about the chances of the research being successful and of the results being adopted, and about the likely effects of overseas competition and of the current and future management of the fishery. Again, quantitative assessment of the relevant factors is attempted where possible.



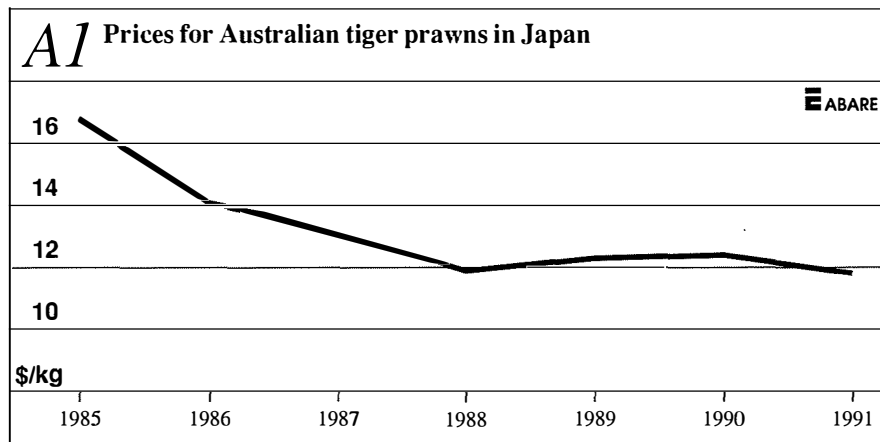
## *Market and trade perception study of Australian sea caught prawns in Japan*

**Key issues:** research which leads to price enhancement; stochastic analysis of research benefits; subjective (quantitative) assessment of factors that influence the likelihood of research success.

### Introduction

At the time this project was proposed, the prices of Australian prawns in Japan had fallen (figure A1). This was largely due to an increase in the production of farmed prawns in South East Asia and their export to Japan. In particular, developments in feeding and breeding technologies have enabled an increase in the supply of larger size prawns from aquaculture producers, resulting in greater competition for the larger 'wild caught' prawns such as those from Australia. These factors have undermined the price premiums previously captured in this market segment (Smith, Kingston and Battaglene 1990).

From figure A1, it can be seen that the price of Australian caught tiger prawns sold in Japan showed a downward trend in the late 1980s. The prices of Australian banana prawns in Japan showed a similar trend. Because the growth in production of farmed prawns was forecast to continue to exceed the growth in demand, prices for frozen prawns on the Japanese market were expected to continue to fall in real terms in coming years (ABARE 1990a).



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This prompted the Australian Prawn Producers Association (APPA) to attempt to identify a niche market for Australian prawns. It had been suggested that Australian prawns, caught and frozen at sea, could be differentiated on the basis of quality and marketed as ‘wild’ prawns from unpolluted waters.

The APPA proposed a research project with the following specific objectives:

- to investigate why prices received by Australian exporters have declined in recent years;
- to identify appropriate market niches for Australian wild prawns; and
- to recommend possible action to improve the selling price of Australian wild prawns.

### *Research costs*

The total cost of the research is \$87 000. APPA engaged a Japanese research company to undertake an analysis of the Japanese prawn market at a cost of \$77 000, funded by a 1990-91 grant from the (then) Fishing Industry Research and Development Council (FIRDC). APPA provided administration and coordination support at an estimated cost of \$10 000.

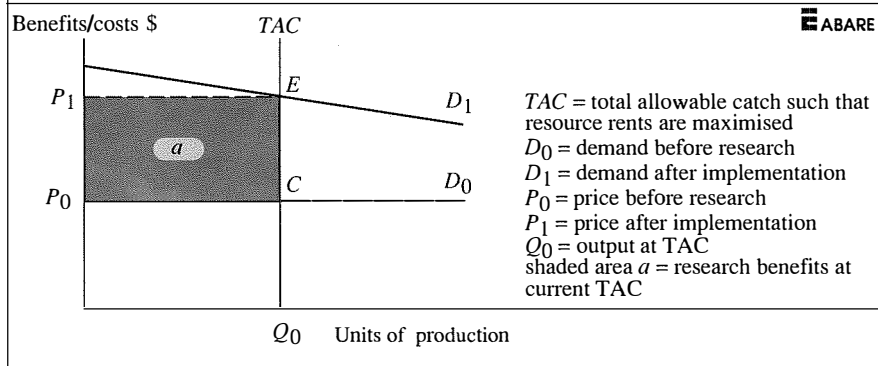
## Benefit evaluation

### *Attractiveness*

The most easily identifiable component of the benefits that could, ideally, be obtained from this research are illustrated in figure A2. Currently, Australian suppliers are price takers on the Japanese market and demand for Australian prawns is therefore represented by the horizontal demand curve,  $D_0$ . In the light of research, Australian producers might, by differentiating their product (for example, by branding and packaging), create a ‘niche’ market for their prawns, in which they would be less easily substituted for by other products. The new demand for Australian prawns could then be as represented by the downward sloping curve,  $D_1$ .

Australian producers would be able to benefit from higher prices ( $P_1$  instead of  $P_0$ ). (In addition, Japanese consumers might benefit from a perceived improvement in quality in prawns, and if the demand curve were downward sloping as shown, some of them would gain a ‘consumer surplus’ not

## A2 Expected benefits from the Australian prawn study



previously enjoyed. However, this is not relevant to Australian investment in fisheries research and development.)

It is assumed that, in the absence of the research, prawn prices would remain at the 1989 level, and that prawn promotion to establish a niche market would not be undertaken. The benefits to Australia of trading prawns to Japan would therefore remain as in 1989, but no additional promotional or packaging costs would be incurred.

At this stage of the analysis, management of the fishery is assumed to be ideal: that is, there is a total allowable catch (TAC), set to maximise the resource rent obtained at a given market price, and fishing costs are assumed to be minimised as a result of 'well defined' property rights.

All prawns caught in Australia (the TAC) are assumed to be supplied to the Japanese market. At a constant catch level, Australian suppliers would be expected to gain from the research through the capture of additional rent, given by the area  $P_1ECP_0$ . In addition, because of the increase in benefits possible from the fishery, the economically efficient total allowable catch could probably be increased, to maximise social welfare from this resource (see box 7).

To estimate the maximum possible benefits of the research to Australia, information on the current TAC, price and costs, as well as the future TAC, prices and costs would, ideally, be necessary. The increase in the TAC in response to higher prices is unlikely to be known, but the additional resource rent which could be captured by the suppliers at the current TAC could be

approximated. This could be calculated using equation 1, as discussed in chapter 4. That is:

$$\text{Gross benefits} = Q_0 \times \Delta P$$

where  $\Delta P$  is the expected price premium for product differentiation ( $P_1 - P_0$ ).

A price premium of up to 10 per cent of the 1989-90 price was suggested as possible by the researchers (Goodrick, B., International Food Institute of Queensland, personal communication, April 1991). When considering potential projects, agencies will often have only the researchers' estimates of parameter values, and have to decide on the credibility of these estimates. Even at the time when it was made, the above estimate of the price premium might be considered to be optimistic. Therefore, the present evaluation of the benefits from this research project was done assuming a more conservative range of price premiums: from 1 per cent (minimum value), 2.5 per cent (most likely) and 5 per cent (maximum).

It is assumed that there is a one year delay between the initiation of action based on the research, in 1992-93, and the realisation of any benefits. In addition, the researchers believe that full benefits could be realised only after a three year promotional campaign costing about \$1 million a year, and that packaging would cost \$15 a tonne. Because of uncertainties in the values of two of the parameters, stochastic analysis was employed. The assumptions and the data used are given in table A1.

## **A1** Assumptions and data used in the stochastic benefit–cost analysis of the prawn study

Variable	Unit	Minimum	Most likely	Maximum
Adoption lag	years	1		
Adoption rate	%/yr	33		
Quantity	t	6 744		
Original price $P_0$	\$/t		16 794	
Price premium	%	1.0	2.5	5.0
New price $P_1$	\$/t	16 962	17 214	17 634
Period of maximum benefits	yr	1		
Total benefit period	yr	20		
Discount rate	%	6	8	10
Packaging and branding costs	\$/t	14.8		
Annual cost of prawn promotion (three years)	\$		1 million	

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For the assumptions given, the expected net present value of the benefits is about \$26 million, and the expected benefit–cost ratio is 12. The results indicate that the project offers potentially high returns despite the uncertainties surrounding the expected price premium. Any small increase in price would lead to high benefits (under the ideal assumptions given above) because of the large quantity of prawns exported. In addition, changes to the assumptions concerning packaging and promotional expenditures did not significantly alter the apparent attractiveness of this project.

### *Feasibility*

The benefits to Australia from the research project will depend on whether Australian prawns, of specified types, can be successfully promoted in Japan, so that the returns to Australian producers outweigh the research, promotion and packaging expenses. Despite the rather attractive expected returns, it is not certain that a niche could be identified by the study, nor whether any price premiums could be obtained if a niche was found, or that Australian producers would benefit if they were.

A number of factors could influence whether price premiums can be captured through selling to a niche market, and can be maintained under current management arrangements.

First, it must be questioned whether or not Australia really does have, or is perceived to have, less polluted waters than in Japanese prawn producing areas, so that product differentiation on that basis is possible. It is important also to consider whether Japanese consumers are able to differentiate the Australian product and are willing to pay for its special characteristics. Williams (1991) notes the difficulty in establishing new brands in international markets unless the product is extremely distinctive. He notes the uncertainty in achieving such distinction for frozen prawns.

Second, product differentiation carries the danger that consumers would be able to associate undesirable as well as desirable product qualities with the product, and this potential cost should be considered if tight quality control from the point of capture to consumer cannot be maintained (Peterson 1991). In fact, for this reason product differentiation might be an inappropriate course of action for Australian prawn producers.

Third, it must be considered to what extent price premiums, if realised, would be passed on to Australian producers, rather than being captured by



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marketing intermediaries. For example, if the suppliers of marketing inputs have strong market power, then research benefits will not be wholly passed back to suppliers. This may well be the case for Australian prawns in Japan, where price premiums to prawn producers are usually lower than those gained by retailers or wholesalers (Williams 1991).

Fourth, it must be considered whether it is possible for other producers to reposition their product into any market niche created by Australian exporters. For example, could aquaculture producers develop an ‘ultrahygienic’ product? The benefits would then be eroded as other suppliers enter the market niche.

On the domestic front too, the problem of the erosion of benefits may occur, in the absence of ‘well defined’ access rights. In that case, any increase in rent arising from capturing price premiums in the Japanese market is likely to increase competition for catches in the fishery and raise production costs, thus cancelling any benefits from prawn promotion.

The likelihood of the research being successful — that is, of its producing factually correct results — is difficult to estimate. If the research were unsuccessful in the sense of indicating the existence of a niche market that did not exist in reality, and as a result an unsound policy recommendation were adopted, the costs would be at least the research and implementation costs, plus, possibly, additional costs imposed on Australian producers by worsening the situation. For example, by attaching a negative image to Australian products, product differentiation justified on the basis of the research might result in less prawns being exported to Japan. While it may be possible only to assess the magnitude of this impact on Australian producers subjectively, it is possible that the impact would be considerable.

At the current catch level, the costs to Australia of undertaking and applying such unsuccessful research would be as indicated in table A2, assuming that the industry would learn within the three years that a niche market could

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## **A2** Costs of applying incorrect results from prawn research

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Research costs	\$87 000 (in the first year only)
Promotion cost	\$1 million a year for three years
Packaging and branding costs	\$14.8/tonne
Total (present value)	\$3.5 million
Costs of any adverse effects	?

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not be created. (It has been assumed above that niche marketing would not be attempted in the absence of this research.)

Thus, the costs of applying incorrect results could be at least \$3.5 million, and perhaps well in excess of this.

Alternatively, the research recommendations might not be adopted. In that case, regardless of whether the research was successful, the cost to the Australian community (via the funding bodies) would simply be the research costs — that is, \$87 000.

Assuming that the research were successful and the results adopted, the research benefits calculated in the stochastic analysis (attractiveness) might still not be fully realised. APPA has estimated a 33–66 per cent likelihood of identifying a niche market for Australian prawns and of Australian suppliers being able to capture the predicted premium. In addition, once benefits are realised, they could be expected to be eroded by 5–15 per cent a year as overseas suppliers enter the market niche.

When these estimates are included in the stochastic analysis, the present value of the expected benefits reduces by almost half or to about \$13 million. The expected benefit–cost ratio reduces to 5.8 or less than half of the original ratio (table A3). The expected ratio also has a slightly larger degree of risk

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## A3 Merit assessment of the prawn study

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### Attractiveness

Present value of benefits	\$26.4 million
Benefit–cost ratio	12
Standard deviation	4.8
Benefit–research cost ratio	340

### Feasibility

Probability of R&D success	33–66 per cent
Expected rate of benefit dissipation due to foreign competition	5–15 per cent a year
Chances of benefits being dissipated locally due to lack of appropriate management	medium to high

If these factors are incorporated in the stochastic analysis:

Benefit–cost ratio	5.8
Standard deviation	2.5

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associated with it (as measured by the standard deviation as a proportion of the expected ratio).

From the analysis presented here, it can be seen that funding agencies need to take explicit consideration of factors such as the chance of the research being successful and whether the benefits, once realised, would encourage other suppliers to enter the market.

Consequently, long term net returns to the fishery from prawn promotion may be too small to justify this research funding, despite potentially attractive short run increases in revenues, while inefficient management systems prevail in the fishery.

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## *Economic analysis of management options for the east coast tuna longline fishery*

**Key issues:** research leading to changes in institutional structure and hence industry cost; use of gross value of production to estimate net benefits of research.

### Introduction

The east coast tuna fishery extends from the Victorian border to Cape York within the Australian fishing zone. The principal species caught are yellowfin, bigeye and albacore. Over 8500 tonnes of tuna were caught in 1989 (ABARE 1990b, 1991) of which over 2800 tonnes were caught by Australian operators (ABARE 1991). Large Japanese longliners on global tuna fishing trips account for approximately 66 per cent of the catch. Japanese access to the Australian fishing zone is negotiated annually, and a fee is charged based on the gross value of catch in previous seasons.

Currently, 169 Australian boats are licensed to operate in the east coast longline tuna fishery (Industry Commission 1992); most of these boats also operate in other fisheries. In July 1988, interim management measures were introduced into the fishery to control its development and improve profitability. Key features of these measures include a limited entry regime with restricted fishing zones, and the delineation of inshore and offshore (beyond 50 nautical miles) sectors of the fishery, with overseas operators such as the Japanese fleet being excluded from the inshore area. Endorsements held by Australian operators, which generally allow wider access privileges than are granted to overseas fishers, became transferable in 1989.

While the interim arrangements are in place, a program of scientific and economic studies was undertaken to assist the East Coast Tuna Management Advisory Committee in drafting a management plan for the fishery. A number of issues were to be addressed in that plan, including the desirability of catch quotas in this fishery. There was considerable uncertainty about the biological stock structure and migration of the resource — in particular, whether the Australian resource is independent of the larger south west Pacific stock, or whether recruitment is from that stock. Efficient management of a tuna fishery in Australian waters would be very different depending on which of these relationships prevailed. If the Australian

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resource and the south west Pacific stock were not separate, management of a tuna fishery in Australian waters only would be unlikely to be very beneficial to Australia, since a management strategy which is not supported in the rest of the fishery would be unlikely to be efficient, and any benefits would also be derived by other users of the stock.

The management plan needs to cover access to the resource both by Australian operators (including long lining, purse seining, other commercial line operations and recreational fishers), and by the Japanese fleet. The study of management options examined below was relevant to this issue of access to the resource by domestic and foreign vessels. The specific objective of the project was to quantify the benefits (rent) attainable in the fishery under alternative management arrangements — in particular, comparing individual quotas with gear restrictions. The project was undertaken jointly by the University of Tasmania and the Australian Maritime College.

## Research costs

FIRDC provided \$56 296 over the period 1990–92 to fund a research officer and operating and travel expenses. The Australian Maritime College provided \$2400 (accommodation and travel) and the University of Tasmania provided research supervision (not costed) over this period. The evaluation below is as at the time of the proposal (1990).

## Benefit evaluation

### *Attractiveness*

It is assumed here that the historical catch–effort data reflect long run sustainable yields in the fishery, and that the Australian resource is independent of the south west Pacific stocks. The benefits of the research are taken to be the increase in rents generated when administrators, with the aid of the research results, introduce more efficient management measures into the fishery and reduce the fishing effort required for a given catch.

As it is the purpose of this study to provide data on what rents are achievable, it is possible at this time to forecast potential rents only in broad terms, using equation 3 as described in chapter 4. That is:

$$\text{Gross benefits} = GVP_0(M-N)$$

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where  $GVP_0$  is the current gross value of production;  $M$  is the percentage of  $GVP_0$  that could be captured as rent; and  $N$  is the percentage of  $GVP_0$  currently being captured as rent.

The gross revenue earned by commercial operators fishing in the east coast tuna fishery in 1989 was around \$33 million. Of this, the gross revenue earned by Australian operators in this fishery was an estimated \$5 million (ABARE 1991), while the returns to Japanese operators were estimated at about \$28 million (ABARE 1990b).

In the absence of management research, the present interim arrangements would be likely to continue for some time, and it can be assumed that the present rents would be maintained. However, it is uncertain what the total present level of rent is. Rents captured by Australia from the commercial exploitation of the east coast tuna resource comprise access fees received from Japanese operators and the rents earned by the Australian fleet.

In 1989, the Japanese paid \$4.6 million for access to the Australian fishing zone, principally in pursuit of southern bluefin tuna outside of the east coast zone. If this fee is apportioned between the east coast zone and other zones in accordance with the value of the catch taken in each zone, only 28 per cent, or \$1.3 million can be attributed to the east coast resource (ABARE 1990b; Industry Commission 1992).

There is little information on profits currently being earned by Australian operators in this fishery. Since the purpose of the interim arrangements in the fishery was to improve profitability and efficiency in the domestic fishery, they would presumably have led to the realisation of some rents in the fishery, but there have to date been no projects to assess these rents. However, any profits are believed to be small. This would seem to be supported by the decline in boat numbers operating in this fishery over recent years.

Research indicates that in Australian fisheries rents of around 20–60 per cent of current gross revenues would seem possible from more efficient management (Geen and Nayar 1989; Geen 1990; Campbell and Haynes 1990). Using these figures, the maximum potential rent achievable from the fishery given optimal management structures is, therefore, between \$6.6 and 19.8 million a year, while rents of about \$1.3 million (or 4 per cent of the gross value of production of all commercial operators in the fishery) are

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currently being earned from the Japanese fishing operators, plus any rents earned as a result of the interim management plan.

Costs would probably be incurred in implementing new management policies. In addition, costs may also be associated with restructuring the domestic fleet. In view of the uncertainty over future management systems and likely research recommendations, the magnitude of these costs must be speculative. However, given government interest in individual transferable quotas, management costs arising from the recommendations of this study are likely to make only a 'minimal difference' (Exel, M., Australian Fisheries, personal communication, April 1991).

Therefore, neglecting any present domestic rents and any cost of implementation, the potential annual benefits of an improvement in management can be evaluated at between \$5.3 million and 18.5 million (given the assumption of an independent Australian stock).

Not all of these expected benefits would be attributable to this research project. Research is also under way to obtain biological information on the fishery (in particular, whether the Australian fishery is independent of the south west stock), and significant information has been collected in the past leading to the establishment of earlier management arrangements. Thus, the above estimation of the possible benefits from this research would need to be tempered considerably, as discussed in chapter 4.

### *Feasibility*

The potential annual benefit is likely to be considerably less than the estimated \$5.3–18.5 million additional rents available in the fishery, for a number of reasons.

One factor is the uncertainty about stock structure and migration. The above estimation was made under the assumption that the Australian resource is independent of the south west Pacific stocks. If this assumption does not hold (and as no international tuna catch quotas exist), management measures which restrict exploitation of the resource in Australian waters will only reduce the rents that could potentially be earned in the Australian fishing zone, and might also impose additional costs.

If tuna stocks are dependent on the south west Pacific stock (unknown at the time of the management study), no research benefits would be realised.

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## ***BI*** Merit assessment of the east coast tuna fishery management study

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### **Attractiveness**

Additional potential resource rent	\$ 5.3–18.5 million
– contribution of this project to development of a management plan	– medium

### **Feasibility**

Probability of research success	medium to high
Ability to capture and maintain benefits	low to medium
– adoption of results	– medium to high
Other considerations	probability that the assumption of independent stock is correct (if not, the likely effects on management and thus resource rent could be negligible)
Research results adopted	low to medium
– appropriate actions taken (that is, the management plan is politically acceptable)	

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If the fleet were restructured, the reduction in short run fishing effort could result in lower catches and hence a loss of economic rent. There would be a loss of foreign access fees if the number of foreign vessels allowed in Australian waters were reduced. In addition, domestic operators might suffer a loss in profits resulting from reduced catches. Further domestic costs could be incurred in the fleet restructuring.

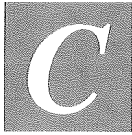
(In the longer term, rents will in any case tend to zero, regardless of any restructuring, if the stock is an international common property resource.)

Other uncertain factors affecting the probability of receiving benefits from the research, and their magnitude, include research capabilities, management response to the results of the study and continued access to the Australian fishing zone by Japanese vessels. Agencies assessing the merit of a research project such as this would need to obtain further information from applicants (or elsewhere) on the likelihood of research success and the prospects for capturing the benefits (table B1).

On the information available, this project may be considered one of high risk, despite the potentially positive payoffs.

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## ***Development of techniques for the commercial aquaculture of silver perch***

**Key issues:** research aimed at reducing cost; subjective but quantitative assessments of factors influencing research benefits; uncertainty about the adoption of research results and about future production

### **Introduction**

The Australian freshwater silver perch is considered to possess most of the characteristics needed for successful commercial aquaculture. It grows rapidly — an important determinant of aquaculture success — in both managed intensive culture ponds and unmanaged farm dams (Rowland and Barlow 1991). Both adults and juveniles readily take supplementary feeds of varying texture and flavours (Anderson 1986; Anderson and Arthington 1989). Availability of fry is not a constraint, as is often a case with cultured organisms. Hatchery technology for large scale fry production has been available for some time (Rowland and Barlow 1991).

In addition, silver perch possess favourable marketing attributes, such as attractive appearance and white flesh with few bones. Currently, silver perch commands a somewhat high price — \$10/fish (or \$20/kg) frozen and \$20/fish live (Johnson, J., Manager, Condo Fishery Pty Ltd, personal communication, January 1991). Small batches of silver perch have been sold for about \$22/kg; export markets in China and Hong Kong are thought to be possible (Lindsay 1990). However, given the new market conditions created by aquaculture supply, a realistic future price is thought to be \$10/kg, with roughly a 10 per cent chance of the price being \$5/kg or less and \$20/kg or more (Rowland, S.J., Inland Fisheries Research Station, personal communication, January 1991).

Despite rapidly growing interest in the culture of silver perch, there is a degree of caution in the light of the failure of many aquaculture projects in Australia in recent years. Examples of failures in aquaculture have involved freshwater species such as golden perch (O'Sullivan 1990) and salmon (Treadwell, McKelvie and Maguire 1991). Several of these failures have occurred either largely because appropriate technology was not identified (O'Sullivan 1990) or for institutional and financial reasons (McKinnon 1989.)

For these reasons, FIRDC funded the project, 'Development of techniques for the commercial aquaculture of fresh water silver perch'. This project was aimed at developing suitable techniques for intensive commercial culture of silver perch, specifically investigating the feasibility of using earthen ponds, cages and tanks. The researchers — at the Inland Fisheries Research Station — also hoped to identify what effects variables such as stocking density, diets and water quality may have on the growth rate of perch. Individual and interactive effects of the variables were to be examined. The effect of type of enclosure on the survival and growth rates in the nursery and the grow-out ponds were to be assessed.

## Research costs

FIRDC granted \$290 577 over three years for this project, which is about 40 per cent of the total funds required. The financial contribution by the Inland Fisheries Research Station includes wage and salaries and the cost of modifying existing ponds and a hatchery (constructed in 1984–86). The Research Station also provides the annual operation, maintenance and administration costs of the aquaculture facility, and meets the costs of breeding and supply of juveniles. The contribution of the Research Station over the three year project is \$449 876 (table C1). FIRDC's contribution covers other expenses of the experiments.

The following evaluation is as at 1990, before funding commenced.

## Benefit evaluation

An industry already exists for the commercial aquaculture of silver perch, although production is currently less than 10 tonnes a year. Even in the absence of such research, the industry would be expected to continue to grow, albeit at a lower rate. The benefits of the research would therefore be

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### **C1** Research costs for the development of techniques for silver perch culture

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	1990-91	1991-92	1992-93
	\$	\$	\$
FIRDC	112 850	87 805	89 922
Researchers	157 046	156 190	136 640
Total	269 896	243 995	226 562

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the profits gained from the commercial aquaculture of silver perch over and above what might have been made in its absence. It is difficult, however, to estimate the present rate of growth in output. Consequently, it may be possible only to make subjective judgments about the likely increases in the silver perch production without research into this area.

### *Attractiveness*

The benefits of the research would ultimately depend on how large an aquaculture industry can be established. The benefits of research which leads to the development of new fisheries, as discussed in chapter 4, depend on the market supply of and consumer demand for the new product. The supply of fish would depend on the number of farms that were established and their rate of production. The domestic price, as noted above, would be likely to fall following an increase in silver perch output.

If such information were available, the maximum expected research benefits could be approximated using equation 4. That is:

$$\text{Gross benefits} = (P_1 - AC_1) Q_1$$

where  $P_1$  is the price;  $AC_1$  is the average cost of production and marketing; and  $Q_1$  is the quantity of silver perch produced.

However, these variables cannot be projected with any degree of certainty at this stage of the silver perch industry's development. Indeed,  $AC$  depends directly on such research, and output is likely to be influenced by knowledge about viable technology for intensive culture and about the appropriate stocking density, the most economic feeding regime, and necessary water quality. To take the uncertainties into account, a stochastic benefit-cost analysis was performed.

### *Data used for estimating research benefits*

Estimates of various factors were provided by the Inland Fisheries Research Station and Condo Fishery Pty Ltd, the only known silver perch aquaculture farm operating in Australia (an experimental/commercial venture). Using an earthen pond technology, the Condo operation involves hatchery production of fry to fingerling stage followed by a grow-out phase. Fry are fed with specifically formulated high protein starter and grow-out feeds supplied by Janos Chemical Company.

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Condo currently holds about 5000 1–2 year old (averaging about 15–18 months) fish per hectare of pond, giving a production rate of about 1.2–1.25 t/ha a year. The researchers predict a maximum production figure of 2.5 t/ha a year, with about 2.3 t/ha a year as the more likely production for 2 year olds, the age at which most of the silver perch is marketed (Rowland, personal communication, December 1990). In the following analysis, assumed production is varied over the range 1.0–2.5 t/ha a year.

Condo estimates that the demand for silver perch could be as high as 5–6 tonnes a week — well in excess of the current production. The research team predicted that if the results of the proposed project are promising, about ten farms could be established by the end of 1993 — that is, immediately after the results are made available (Rowland, personal communication, December 1990). The number of farms would be expected to increase to about 50 by the year 2000. In the following evaluation, however, it is assumed that one to ten additional farms could be established within the first five years of research completion, five farms being most likely. Thereafter, the number of farms is assumed to increase to between ten and fifty. Each farm is expected to be of about 20 hectares (Rowland, personal communication, December 1990). The price range for silver perch is taken to be \$5–15/kg, with \$10/kg the most likely price.

Implementation costs are assumed to be limited to investment by the industry as new farms are developed. The production and cost estimates are derived from current figures supplied by Condo Fishery Pty Ltd. Farm labour cost for a 20 hectare farm ranges from \$60 000 to \$120 000 (depending on the number of biologists and farm hands used), with a most likely value of \$90 000 for a 20 hectare farm. The current annual operating cost varies in the range \$1800–3600 /ha with a most likely cost of \$3000/ha. The initial capital cost is \$20 000/ha. The parameters used in the Monte Carlo analysis are summarised in table C2.

Assuming that the research is successful, and that the assumed maximum of 50 farms are established by the year 2000, the present value of the expected benefits is about \$40 million. This gives a benefit–research cost ratio of 60, if all the benefits are attributed to this single project. However, since this project alone may not provide all the new information required for the perch culture industry to expand at the assumed rate, this benefit–cost ratio may be an overestimate. This ‘relative contribution’ factor may be treated, in this case, as a probability that other research will be needed.

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## **C2** Assumptions and data used in the stochastic benefit–cost analysis of silver perch research

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<b>Input data</b>	<b>Unit</b>	<b>Minimum</b>	<b>Most likely</b>	<b>Maximum</b>
Number of farms				
– for the first five years	no.	1	5	10
– thereafter	no.	10	25	50
Farm size	ha		20	
Product price	\$/kg	5	10	15
Capital cost	\$/ha		20 000	
Average operating cost				
– labour costs	\$/farm	60 000	90 000	120 000
– other operating costs	\$/farm	1 800	3 000	3 600
Time to full adoption	yr		7	
Discount rate	%	6	8	10
Adoption lag	yr		0	
Period of research	yr		3	
Period of maximum benefit	yr		20	

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If the number of farms assumed to be established by 2000 is reduced to 25, the present value of the benefits reduces to \$23.8 million and the B/RC ratio falls to about 38. While this analysis indicates that the ratio is very sensitive to the farm number estimate used, the expected net benefit nevertheless remains much greater than the research costs. However, there is a lack of information on necessary implementation costs. Funding agencies would therefore need to take account of the extent of costs likely to be necessary for operators to adopt the new technology.

### *Feasibility*

First, it must be considered whether or not the research is likely to be successful. Conceivably, the results might identify particular technology incorrectly as being suitable and economical, in which case farms adopting the identified technology could fail totally, with a loss of several million dollars. The probability of the research being unsuccessful in this way is difficult to quantify.

The possible cost to society of results wrongly implying that more operators should become involved in the market is also difficult to estimate. One small farm is already in operation and more producers might enter the market in

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## C3 Merit assessment of the silver perch aquaculture study

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Expected number of farms = 50

### Attractiveness

#### Quantitative

– net present value	\$40 million
– benefit–research cost ratio	60
– standard deviation	35

Chance that other research may be needed for the industry to establish fully	medium to high
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### Feasibility

Probability of research identifying the appropriate technology	low to medium
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Probability of industry adoption	high to very high
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the absence of the research, encouraged by the apparent success of that enterprise. Just as all the benefits from growth of the industry would not necessarily be attributed to one research project, likewise, the failure of all the farms could not be attributed solely to the unsuccessful research. The proportionate cost would be difficult to identify and value.

If the research is successful, the likelihood of the results being adopted and implemented would be high, bearing in mind the relatively high value of the product. If the research findings were not adopted, the risk of its being unsuccessful would not be of immediate consequence and the loss to society would be the cost of the research only (table C3).



## ***Research on seagrass habitat use and consequences for commercial fisheries of the loss of seagrass beds***

**Key issues:** research leading to catch maintenance; program versus project evaluation; critical role of management in realising benefits; spillover benefits.

### **Introduction**

The importance of seagrass beds as feeding and nursery habitats for many fish species is generally acknowledged (Pollard 1981, 1984). In many states, a decline in productive seagrass areas has been accompanied by changes in fauna community structures, and declines in the dependent fisheries (Pollard 1984). However, while evidence points to a causal link between the extent of seagrass beds and the level of commercial harvest, effects of losses in seagrass areas on commercial fisheries have not definitely been established. The purpose of the research evaluated here was to confirm the extent of the relationship, if any.

FIRDC funded two projects, referred to respectively as 88/91 and 89/92, on 'the consequences in commercial fisheries of the loss of seagrass beds in southern Australia', and 'patterns of utilisation of seagrass-dominated habitats as nursery areas by commercially important fish'. These two related projects were jointly initiated by the Zoology Department of the University of Melbourne and the Victorian Institute of Marine Sciences.

### **Research costs**

The total cost of the two projects, over their combined four year duration, is \$788 154, of which the FIRDC contribution is about 72 per cent (table D1). For both the projects, the Victorian Institute of Marine Sciences and the Zoology Department of the University of Melbourne have provided the balance, covering general overhead expenses, administrative/secretarial services, computer time, and so forth. The costs shown do not include similar expenses contributed by other cooperating agencies in New South Wales and Western Australia during the second and third phases of the project 88/91. The costs of these contributions are not known, and therefore costs and expected benefits outside of Victoria are not included in these analyses.

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## *DI* Research costs for two projects on the relationship between coastal fisheries and seagrass habitat

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	1988-89	1989-90	1990-91	1991-92	Total
<b>Funding source</b>	\$	\$	\$	\$	\$
FIRDC 88/91	86 840	98 325	99 477		564 874
89/92		89 725	93 250	97 257	(72%)
Victorian Institute of Marine Sciences and University of Melbourne	33 000	66 000	88 640	35 640	223 280 (28%)
<b>Total</b>	119 840	254 050	281 367	132 897	788 154

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The study areas for the second project (on the use of seagrass beds) include Swan Bay (in Port Phillip Bay) and Corner Inlet, in Victoria. On the other hand, assessment of the effects of loss in seagrass beds on commercial fisheries (the first project) is conducted in Western Port Bay (also Victoria), largely because there is a good database on the extent of seagrass beds and related commercial catch statistics in this area.

The availability of a good database is important because changes in fisheries production may have been caused by several factors, of which the loss in seagrass beds may be only one. 'Cause and effect' in changes in fauna composition and distribution, therefore, are a principal area of uncertainty.

## Benefit evaluation

### *Attractiveness*

An understanding of the dependence of the coastal fishery on the survival of the seagrass habitats is likely to result from the two research projects. From the data collected, it should be possible to estimate the marginal change in fish carrying capacity of Western Port Bay due to a marginal change in seagrass area. If a loss in seagrass area does reduce the fish carrying capacity of the coastal area, the resultant changes in the structure or size of a fish stock may affect both sustainable catch levels and the cost per unit of catch (Kahn and Kemp 1985).

Benefits would be likely to arise from a greater understanding of the nature of the relationship (if any) between seagrass and the commercial fishery. For example, the research might establish that the seagrass is necessary for feeding grounds. In the absence of such research, it is likely that dredging



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would continue and, if there is a link between seagrass and the fish harvest, commercial fishing would also continue but its value would decrease as seagrass beds were depleted. If the research established such a link, it would be necessary before taking any action to know the value of the current commercial fishing activity and the value of the dredging activity.

If the economic significance of the commercial fishery is of the same order as that of the dredging, the research may result in the recommendation that seagrass removal be decelerated, after comparing the benefits to be gained by retaining the seagrass and maintaining the fishery with those to be gained from the dredging. (Note that any such recommendation would rely on the outcome of an economic study of the commercial fishery.)

Thus, for the realisation of maximum benefits from the research, adequate measures may need to be taken to prevent further losses in seagrass beds. Ideally, protection of the seagrass would enable the current harvest to be maintained.

In the absence of adequate baseline information about the supply characteristics of the fishery, it is not possible to calculate the total benefits of the research. It may, however, be possible to estimate the approximate benefits in terms of likely changes in catch and the consequent effect on the gross value of production. In other words, benefits could be approximated using equation 5:

$$\text{Gross benefits} = N (GVP_1 - GVP_0)$$

where  $GVP_1$  is the gross value of production after implementation;  $GVP_0$  is the gross value of production in the absence of the research; and  $N$  is the percentage of the gross value of production that could be captured as rent, on the basis of studies in other fisheries.

One way to estimate the gross benefits from the research is to forecast the loss that would otherwise occur in seagrass beds, and to assume that there would be a proportionate decline in the harvest of the seagrass dependent fishery. However, the unconstrained rate of seagrass loss is uncertain. In the following calculation, the most likely decline in the area of seagrass habitat between the years 1993 and 2000 is taken to be 10 per cent (Watson, G., University of Melbourne, personal communication, November 1990). However, it is possible that the rate of loss could be more than 20 per cent by the year 2000.

Licensed commercial operators who fish inshore Victorian waters supply 1800–2800 tonnes of coastal fish to the markets. Of this catch, the seagrass habitats may have supported about 50 per cent of the catch, or 900–1400 tonnes of fish (Watson, personal communication, November 1990), with a gross value of production of \$2.7–4.2 million. The rate of reduction in gross value would then be between \$0.135 million and \$0.84 million. (This value does not include the value of gummy shark, which are caught in Bass Strait but use seagrass habitats as juvenile nursery areas.)

The proportion of the gross value of production obtained as resource rent in the seagrass fishery is not known. It is here assumed that potential resource rent is in the range 20–60 per cent of the gross value of production, with 25 per cent as the most likely figure.

The uncertainties about the decrease in seagrass areas, the gross value of production of the seagrass dependent fish and the proportion of the GVP that could be captured as resource rent are incorporated in the Monte Carlo analysis. The assumptions and the data used in the stochastic benefit–cost analysis are summarised in table D2.

The results of the analysis are in 1990 values, and indicate that the most likely net present value for the research would be about \$960 000, with an expected benefit–research cost ratio of 1.8 with a standard deviation of 1.0.

## **D2** Assumptions and data used in the stochastic benefit–cost analysis of seagrass research

	Unit	Minimum	Most likely	Maximum
Gross value of production of the seagrass dependent fisheries	\$m	2.7	3.3	4.2
Expected decline in seagrass areas by 2000 (assuming a constant rate of decline 1993–2000)	%/yr	5	10	20
Time to full adoption <sup>a</sup>	yr		7	
Discount rate	%	6	8	10
Adoption lag	yr		1	
Period of research	yr		4	
Period of maximum benefit	yr		20	
Proportion of GVP captured as rent	%	20	25	60

<sup>a</sup> While management decisions could be immediate, fish stock regeneration may take this long to occur.

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The results are sensitive to the levels of rent assumed. For example, when the rent was varied in the range 10–40 per cent, rather than 20–60 per cent, the expected ratio fell to about 0.6. That is, the expected opportunity cost (in Victoria) of not undertaking the research would be less than the cost of doing it.

In addition, the benefits to be expected from establishing the relationship between seagrass and the commercial fishery can be only partially attributed to these two projects. This is because this research follows a significant amount of research already performed into seagrass fisheries, and as noted above some economic study would also be needed before taking any action.

It should be remembered that the benefit figures estimated above are for gross benefits. The net value would be the gross value of benefits, less additional management costs associated with the protection of the seagrass beds, less the costs of restructuring the activities that would destroy the beds (such as the opportunity cost of refraining from or reducing dredging). It is possible that these implementation costs could be considerable, in which case the proposal is not very attractive at first glance.

On the other hand, it is important to note that the expected benefits were estimated using the commercial fishery data only. There are also likely to be additional benefits of seagrass conservation accruing to recreational anglers, but estimates for these benefits are unavailable. In addition, there might be non-market benefits accruing from the conservation of the seagrass (for example, the protection of the genetic pool). Furthermore, the research is likely to have large flow-on benefits in other areas, since the viability of many coastal fisheries in other states are also believed to be dependent on the sustainability of the coastal nursery and feeding grounds, such as the seagrass beds. In addition, there are also numerous similar examples of seagrass losses in these states.

Consequently, if management strategies could be developed to prevent further losses of the seagrass beds in Victoria, comparable strategies could be applied to prevent the decline of all temperate seagrass dependent fisheries in New South Wales, South Australia, Tasmania and Western Australia. Thus, these two research projects could have spillover benefits far in excess of those possible in Victoria alone. It follows that, despite the relatively low net returns of the projects to commercial fishing in Victoria, the projects may still be justifiable on the basis of expected spillover effects.

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## D3 Merit assessment of the seagrass research study

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### Attractiveness

#### Quantitative estimate

– net present value of benefits	\$960 00
– benefit–research cost ratio	1.8
– standard deviation	1.0

#### Qualitative assessment

– additional benefits to recreational anglers in Victoria	likely to be significant
– additional benefits to other state fisheries	likely to be large
– opportunity cost of preventing seagrass losses	unknown

#### Contribution to benefits

– implementation costs	medium
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### Feasibility

Probability of research success	medium to high
Chance that research results adopted	medium to high
Ability to capture and maintain benefits	low to medium

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Funding agencies would need to consider such possibilities when comparing alternative research proposals.

### *Feasibility*

Currently, the evidence of a relationship between seagrass and fisheries in Victoria is circumstantial. The main purpose of the research would be to establish whether there really is a relationship (rather than coincidence), and to identify in what ways and to what extent the fisheries are dependent on seagrass.

The research team is highly experienced in research of this nature, as reflected in the curriculum vitae included with their proposal to the FRDC. As such, the chance of research confirming a causal link between fish stocks and seagrass, if such a link exists in reality, can be considered to be relatively high. Also, with the current emphasis on ecologically sustainable development, there is a relatively strong probability that any recommendations based on such findings would be adopted.

However, it is unlikely that any benefits would be realised over a long period because of the poor property rights structure in the fisheries. As a result, the final gains from research into this area may be expected to be fairly small. The results of the assessment are summarised in table D3.



## ***Research on the Great Barrier Reef Marine Park line fishery***

**Key issues:** research leading to catch increase and maintenance; unquantifiable market and non-market benefits; qualitative assessments; subjective analysis.

### **Introduction**

The Great Barrier Reef line fishery contains commercial operators and recreational anglers targeting both demersal and pelagic fish species, such as coral trout, snappers and emperors. The fishery, which is almost entirely within the Great Barrier Reef Marine Park waters, produces an annual commercial catch of about 4000 tonnes of fish (Trainor 1991). The gear used is mainly hand line, rod and line, and troll line. The market prices for reef fish are available, but reliable economic data about production and cost structures of the commercial fishing operations are almost nonexistent (Appleton, P., Queensland Fish Management Authority, personal communication, February 1991).

Little information on the recreational fishing catch and effort applied in the reef line fishery is available (Gwynne 1990). There are over 24 000 private recreational vessels fishing in the Great Barrier Reef (Blamey and Hundloe 1991), but their fish harvest is not known (Gwynne 1990).

Current biological information is considered to be inadequate to answer many management questions, such as what should be the minimum legal harvested sizes of reef fish species. Although work has been done on growth and reproduction of redthroat (Walker 1975), coral trout and several other line species (McPherson, Squire and O'Brien 1988), researchers do not consider the information available adequate to define the minimum legal sizes that would allow these fish to grow large enough to reproduce.

In general, for effective fishery management, information on the biological, economic and social aspects of the fishery are needed. In this case, information on the distribution of fish species along the entire reef region, biology, population dynamics and stock assessment of the many fish species involved would be necessary. Estimates of economic costs and benefits (prices or willingness to pay) of fish harvesting by both commercial

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operators and recreational anglers are essential for the formulation of appropriate management strategies (see Lal, Holland and Power 1992 for more detail). In addition, an understanding of the behaviour of fishermen in the face of alternative management strategies is also needed.

In this context, two FIRDC funded projects have been undertaken on some of the dominant food fish species of the reef to provide information on: (1) times and places of spawning; (2) abundance of pelagic (pre-settlement) juveniles; (3) abundance of demersal (surface water and middle depth) post-settlement juveniles; and (4) the relationship between spawning times and abundance of pre- and post-settlement juveniles. Project 90/17 is concerned with (1) and (3), and project 90/18 with (2) and (4). The projects are jointly conducted by the Queensland Department of Primary Industries, the Australian Institute of Marine Science and James Cook University.

### *Current management strategies*

The management of fisheries in the marine park is implemented by the Queensland state government, with the exception of restrictions placed on fishing by the marine park's zoning plan, which is prepared by the Great Barrier Reef Marine Park Authority. Under this plan, certain types of commercial fishing are prohibited from specified areas in the Park.

The main emphasis of current management strategies is on input controls and area and seasonal closures. Commercial fishermen are restricted in their fishing activities, but there are few comparable restrictions on recreational catch or effort (Gwynne 1990). At the time of the research proposal the number of commercial vessels was frozen at 1963 and fishermen were restricted to using a maximum of six hooks per line. In addition, there were size limits on coral trout and snapper species, although these size limits were considered to be inappropriate (Gwynne 1990).

The level of latent fishing effort (the increase that would occur if effort constraints were removed) was considered to be large.

### **Research costs**

The total cost of the two projects was expected to be \$840 610 over the period 1990–93. Of this, FIRDC's contribution was to be 71 per cent (\$597 800) with the rest to be borne by the applicants. These figures do not include the costs of facilities and equipment which may be used in the

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surveys and laboratory analysis, or the costs which have already been incurred by other research.

## Benefit evaluation

### *Attractiveness*

The studies are specifically aimed at providing information on coral trout, snapper and sweet lip emperor. The research is expected (a) to assist fisheries managers to determine what should be the minimum legal size of coral trout when harvested, in order for an increase in juvenile recruitment to be brought about in the fishery, and (b) to collect biological information on sweet lip emperor and snapper trout caught in the reef line fishery.

It is difficult to estimate what is likely to happen to the fishery in the absence of the research. It is possible that the minimum size of coral trout is not now set at the optimum level. If the minimum size is too small, stocks may decline as few fish survive to reproduce. The coral trout is protogynous hermaphrodite (that is, it is a female first and then becomes male later in its life). If the minimum size is too small, this may mean that too few males reach sexual maturity and hence insufficient sperm is released, depressing the fertilisation rate and thus juvenile recruitment. Alternatively, if the minimum size of fish has been set too big, there will be costs to the community from an unnecessary constraint on the commercial harvest and recreational fishing benefits. These costs are, however, difficult to quantify.

Estimation of expected benefits is inherently difficult because the effect on harvest levels of an alteration in minimum size obviously cannot be known in advance of the research. In coral trout, there may also be an effect on price, but there are conflicting claims about the impact on price of changing the minimum size of fish caught.

There is increasing pressure to reduce the minimum size of coral trout from the current 35 centimetres, so that the demand for smaller 'plate size' fish can be met, and higher prices achieved. On this basis, benefits could arise from the higher price of smaller fish, if the research indicated that it is possible to reduce the minimum size without reducing the population size of the stock.

However, there are also claims that the price obtained for coral trout would be increased if the minimum size level were increased from 35 to 38 centimetres (Gwynne 1990).

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Even if the effect of size on the commercial value of coral trout were known, it would be difficult to determine that component of the benefits from this research, since the size profile of coral trout currently caught measuring 35 centimetres and above is not known. It is unknown how the quantity caught would change if the minimum size were altered in any given way.

Current information indicates that about 1230 tonnes of coral trout are caught in the commercial fishery each year (Trainor 1991), valued at an estimated \$10 million (Queensland Fisheries Management Authority and Queensland Department of Primary Industry database, quoted in project proposal to FIRDC).

However, information on fishing costs (including cost differentials for targeting, selecting and catching fish of different size minimums) is not available (Appleton, personal communication, February 1991). If estimates of such parameters were available, the commercial benefits from research led changes in management could be calculated by applying equation 4 to the present and expected situation and taking the difference.

The value to the commercial sector of the research on sweet lip emperor and snapper is also difficult to determine. This is because there is a lack of basic information about catch rates.

Furthermore, determining the benefits to the recreational fishing sector in the Great Barrier Reef is unlikely to be straightforward. This is because, generally, neither the quantity nor the value of fish caught by this sector is known. Even if some estimate could be made of the number of fish caught by this sector, it would not be acceptable to use the commercial price of the fish for a proxy for its value to anglers — fish caught in recreation have a different value from those caught commercially (see Lal et al. 1992 for a detailed discussion). Thus, the social value of the non-market benefits of the two projects is likely to remain largely unknown.

At worst, the results obtained in the research may be incorrect and the wrong recommendations may be given for minimum catch sizes. In this case, it is likely that there would be a net cost to the community, because stocks might be depleted or harvests excessively curtailed, while costs would be incurred from performing the research and implementing and enforcing it. Alternatively, regardless of the research findings, they might not be applied by management. In this case, the cost would simply be that of the research (\$840 610).



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## **E1** Merit assessment of the Great Barrier Reef line fishery study

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<b>Attractiveness</b>	
Quantitative	difficult to estimate
– size of the commercial fishery harvest	1230 tonnes
– gross value of production	\$10 million
– size of recreational fishery	unknown
– expected increase in value of the fisheries due to implementation	unknown
Cost of research	\$840 610
<b>Feasibility</b>	
Chance of research success	high
Chance of adoption	medium
Ability to capture and maintain benefits	low

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In the present state of information on the costs and extent of commercial and recreational fishing and on the economic and biological characteristics of the Great Barrier Reef, a quantitative evaluation of the project is not possible. Neither is breakeven analysis (see appendix evaluation F) likely to be useful in this case. Instead, these two projects would have to be assessed qualitatively, using such criteria as the relative importance (contribution) of the expected research output in resolving the particular management issue, and the likely management strategy to be adopted (table E1).

### *Feasibility*

The likelihood of research in this area being successful is considered to be relatively high, given the strong track record of the research team. Also, the information for setting appropriate size limits is clearly lacking, and this research would appear to be highly relevant to that problem. However, it is considered that the probability of the benefits being realised in the form of resource rents would be fairly low. This is because there is no overall catch limit in the fishery. (Despite effort controls on commercial operators, output is not regulated, and the total recreational catch is not controlled.)



## *Fisheries resources atlas of Australia*

*Key issue:* breakeven analysis.

### Introduction

The Bureau of Rural Sciences (BRS) has recently produced a comprehensive atlas of Australia's fishery resources. Such information has been widely scattered and not readily accessible to all sections of the industry, related groups and the general public. The specific objective in producing the atlas was to collate the abundant knowledge available on the range, extent and relative importance on fishery resources in Australia.

### Research costs

Research and development costs associated with the atlas were shared between four different organisations (table F1). Of the expected total expenditure of a million dollars in present value at the time of commencement (1988), FIRDC would contribute 66 per cent.

### Benefit evaluation

#### *Attractiveness*

In the absence of this project, information is likely to continue to be widely scattered and inaccessible to many groups. It is difficult to put a value on

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#### ***F1*** Fisheries resources atlas research costs

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	1988-89	1989-90	1990-91	1991-92
	\$	\$	\$	\$
<b>Organisation</b>				
FIRDC	97 370	247 214	209 633	235 000
BRS (BRR)	30 000	75 250	63 226	130 000
AUSLIG	35 000	40 250	32 340	
CSIRO	5 000	5 750	2 300	
<b>Total</b>	<b>167 370</b>	<b>368 464</b>	<b>307 499</b>	<b>365 000</b>

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the costs associated with having to continue to search through dispersed information.

The benefits from producing and marketing the fisheries atlas are expected from three sources:

- expediting access to existing fisheries resource information (by government, industry, administrators, scientists, students and the general public);
- raising public awareness and knowledge of the Australian fishing industry; and
- improving the accuracy and consistency of databases.

The third benefit, of improving databases, was not an explicit objective but results from the scrutiny to which the data are subjected in the process of collation.

Reducing information search costs is the primary benefit being sought in producing the atlas. This benefit will be reflected in consumers' willingness to pay for the atlas. If information on the demand for the atlas and its anticipated sale price were available, the value of the benefits of the information contained in the atlas could be estimated. However, demand information is not available in this case.

The benefit of greater public awareness of the fishery sector may manifest itself in greater public policy attention, research funding, investment and consumption. If this were a significant objective, the merits of the project in this respect would need to be compared with those of other types of promotion. Also, while positive benefits to the fishery sector are likely to be generated, this may be at the expense of other sectors of the economy. Consequently, net benefits to the nation from this source are extremely difficult to quantify, and are not even certain to be positive.

It is not possible to estimate the size of the third benefit — improved databases — as the costs incurred by data supplying organisations are not available, nor is the extent of improvements to databases known.

### *Supply of atlas*

In 1989 a consultant to the atlas project estimated, using limited market research, that some 5000 copies of the atlas could reasonably be expected

to be sold at a price of \$50. Using this estimate, the Bureau of Rural Resources (BRR) which later became the BRS obtained several quotes for printing and distribution (assuming publication by FIRDC/BRR). These quotes suggest an average publication cost per atlas of \$35–50. Quotes obtained from leading publishers indicated that a commercial print run would more likely be much smaller and the commercial sales price some 3–5 times greater. Retail prices for other major atlases are in the range \$75–120.

In the absence of information on the additional benefits the atlas may have beyond that benefit reflected in its sales price, even a benefit–cost analysis using a range of possible values may not serve any purpose. It is, however, useful to estimate the ‘breakeven’ benefit of the atlas — the level of benefit that would justify the costs.

The information expected to be contained in the atlas is a proxy for information which could be collected from various sources and by various agents. Demand for the atlas is therefore a derived demand for that scattered information. The intention of the BRS was to market the atlas in order to cover printing and publishing costs only for a given print run. However, such a breakeven pricing would not account for the total costs of this project, by ignoring research costs of \$1.2 million.

A breakeven analysis for the atlas study is therefore done in table F2 assuming production costs (printing) of \$35–50 per atlas and accounting for total research costs of \$1.2 million.

It can be seen that consumers would need to be willing to pay \$275–650 per atlas (depending on the number sold and rate of sale) for the project to break even financially. In addition, this assumes that all atlases would be sold

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**F2** Benefit required, per atlas sold, to break even

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Number of atlases produced	If all sold on day 1
	\$/copy
2000	635–650
3500	378–393
5000	275–290

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immediately they are available. If this is not the case (if the atlases were sold over a period of time), the present value of earnings would be less because society places a higher value on money earned today than money earned later.

However, there are additional benefits which may be associated with the atlas, but which are not accounted for in its sale. (These are presented in figure H by area *Aed*, plus benefits derived by users of library copies.) Therefore, to assess the attractiveness of this project, the benefits to all potential users of the information, rather than just to those prepared to purchase the atlas, must be taken into account.

Depending on the demand for the atlas, it is evident from the breakeven values of \$295–650 per atlas that additional benefits may need to be realised by non-buyers to justify the production of the atlas. Given its expected 10 year shelf life and its suitability as a reference document that may be widely held by education institutions, research agencies and so forth, such a level of benefit may be possible.

### *Feasibility*

The question which must be asked is whether 2000 people/organisations would, on average, place a value of \$635–650 (at a \$50 printing cost). Alternatively, it must be questioned whether some 5000 people/organisations would even realise the more modest value of \$225–240 above a \$50 printing cost.

The distribution of the journal *Australian Fisheries* was cited as influencing the estimate of likely sales potential provided by the consultant. Some 10 500 copies of this journal are distributed, at a subscription price of \$40 (including postage) for 12 issues a year. However, only a small proportion of users actually pay for this journal, since some 75 per cent are distributed free of charge (largely to Commonwealth fishing licence holders, who receive the journal without requesting it). The sale projections are highly speculative and the benefits from research uncertain.

If the research was not adopted — that is, if the atlas was not used or purchased after all — there may also be costs associated with funding this research project. The costs to the community of having funded this research would therefore be research costs (table F3), plus the costs of producing the

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### **F3** Merit assessment of the fisheries resource atlas study

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#### **Attractiveness**

##### Quantitative

– financial breakeven value at the print cost  
of \$50 for 2000 atlases \$650

#### **Feasibility**

Probability of research success high

Ability to capture benefits (chances that benefits  
to buyers – over and above the purchase price –  
plus to non-buyers would exceed above breakeven value) very low

Probability that research results 'adopted' (atlas sold) unknown

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atlas (between \$70 000 and \$250 000) depending on the number printed.  
That is a minimum total cost of \$1.4–1.5 million.

In summary, the probability of this project breaking even may be very low. However, no attempt has been made to quantify this probability due to data inadequacies, and so judgments of project merit must remain subjective. Funding agencies would therefore need to look closely at any expected non-market benefits from the production of the atlas before ranking such a research project.

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## FISHERIES RESEARCH

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With increasing emphasis being placed on maximising the benefits from research, funding bodies need a consistent approach for evaluating alternative research projects. This may be difficult because of inadequate information on many fisheries and sometimes the need to undertake a number of research projects to produce the desired output.

This report focuses on evaluating fisheries research projects and selecting a research portfolio which maximises returns to research investment.