THE ECONOMIC VALUE OF

KING GEORGE WHITING AND SNAPPER

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PREFACE

The purpose of this study was to investigate the values of the Whiting and Snapper catches made by South Australian commercial and recreational fishers and to consider the policy implications of this kind of information.. A policy issue of particular interest is the question of how the total catch might best be allocated between the commercial and recreational sectors.

Parts of this study are necessarily of a quite technical nature. Some description of the state-of-art research methodology and statistical techniques used is clearly required to satisfy both normal professional standards and the referencing process that is part of this project. However, policy analysis is also of a complex nature and cannot be sensibly undertaken without some understanding of some key concepts.

There are at least two such concepts which are central to the alternative measures of 'value', such as *market value, value to consumers*, *added-value* and *economic value*, must be understood. The second concept is the *marginal principle* which underlies the fundamental rule that allocations between alternative uses cannot be determined on the basis of total 'values' but require measures of the 'value' of an additional unit (or fish) for each different type of catch of fish.

These principles of optimal allocation are highly complex, but so central are they to policy considerations that an expository, but still somewhat technical, discussion of these issues has been included as the first major section of the study.

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Note: This study, while embodying the best efforts of the investigators, is but an expression of the issues considered most relevant, and neither the Centre, the investigators, the Executive Committee, nor the Universities can be held responsible for any consequences that ensue from the use of the information in this paper.

EXECUTIVE SUMMARY

Introduction

The objectives of fisheries management are to protect the fish stock, achieve optimum utilisation of the resource and provide an equitable distribution of the resource between various interest groups. The effective management of the fishing resource requires measures of the economic values of those resources, both in terms of the economic benefits to user groups and the associated costs of bringing the resource to these users.

In Australia, there is currently an acute lack of information on the relative economic values and costs of commercial and recreational fishing. Accordingly, policy prescriptions involving the allocation of fisheries management between commercial and recreational sectors remains unclear.

The South Australian King George Whiting (KGW) and Snapper fisheries are two of the few fisheries where quantitative data on commercial and recreational catch and effort are available. In broad terms, this study represents a methodological foundation for estimating the economic value of these two species of fish to recreational and commercial anglers. From this foundation further research can be undertaken, on a sound basis, to formulate options for the management of fishery resources.

The methodology contained in this report has general application to all fisheries, both in Australia and overseas, and this is an important reason for the Fisheries Research and Development Corporation (FRDC) supporting this project.

In developing the methodological framework, the report identifies important related topics in fisheries economics research. PIRSA understand and accept that the foundation for these topics needs to be laid before the research objectives specified in items (ii) and (iii) of the terms of reference can be fulfilled. The related research topics are:

- optimal catch levels cannot be determined without knowledge of current stock levels and of the nature of population dynamics;
- resolution of resource-sharing conflicts, which are seen to depend upon marginal rather total valuation measures, requires data on total, and marginal external costs associated with competing harvesting methods (especially between line and net fishing) ; and
- even if data on external costs were available the current best practice in empirical analysis may not be able to deliver useful measures of the marginal benefits and costs critical to policy considerations.

Value and Policy

Section 2 of the report discusses several matters of economic principle that need to be understood to interpret economic values for the purpose of formulating fisheries management policy. The principles are summarised below and illustrated in Box 1.

The total value of a fish resource must distinguish between *value in consumption*, which takes no account of the resource costs of making that consumption available, and *economic value* (which takes such into account).

Value in consumption, which is related to *willingness to pay* and *willingness to accept* measures, exceeds actual expenditure by the amount purchasers would have been prepared to pay over and above the actual purchase price. This amount is known as consumer surplus.

The total economic value of a resource has no policy implications other than to indicate whether the resource should be harvested or not. Harvesting management decisions should be based upon marginal economic value which is the difference between marginal value in consumption (often given by price) and marginal social cost.

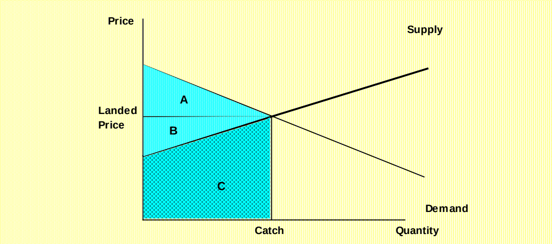
Social cost measurements must include externality effects, including both those associated with overuse of a common resource and those due to environmental impacts for which there is no financial accountability.

Optimal resource allocation requires that the difference between marginal valuation in consumption and marginal social cost should either be zero or equal in all markets. Marginal external cost data must therefore be obtained for all harvest methods.

Providing commercial fishing is competitive, there are no general grounds for discriminating between commercial and recreational fishers except where fishing technology (e.g., net *versus* line fishing) brings about differences in external costs.

BOX 1
ECONOMIC VALUE

A simplified discussion is as follows. Value in consumption is the amount a consumer is willing to pay for a given catch of fish, and is illustrated by the sum of the blue areas under the demand curve. This value does not take into account the resource cost of catching the fish, the cost of being Area C under the supply curve. Economic value is the difference between the amount a consumer is willing to pay and the resource cost for a given catch. The economic value, illustrated by the light blue area, can be partitioned into two components: consumer surplus which is the difference between the amount a consumer is willing to pay and the amount actually paid (Area A) and producer surplus which is the difference between the price received and the resource cost of the catch (Area B). Gross production value is commonly known as the commercial value which is the landed price times the quantity of fish caught (Area B+C). There is no reason to expect (except under special and somewhat unrealistic assumptions) that economic and commercial value to be equal — as can be seen from the diagram only the producers' surplus (Area B) is common to both values.



Results

Sections 3 to 7 of this report employ complex econometric estimation procedures, contingent value and travel cost survey methods to derive results. These sections are, by necessity, very technical in nature. The details of this are left to the interested reader. General valuation results for commercial and recreational fishers are stated and interpreted below.

Although the terms of reference were framed to consider only two species, namely KGW and Snapper, results are also provided for the value of Garfish in the commercial sector because data was readily available and Garfish is an important substitute for KGW in South Australia.

Empirical Results for Commercial Fishers

The own-price elasticity of demand for a fish measures the decrease (increase) in the quantity demanded in response to an increase (decrease) in the price of that fish. The results of the regression analysis lead to a consistent overall view that the own-price (wholesale) demand elasticities for KGW, Snapper and Garfish are substantial and in the order of -5. This figure indicates that demand is very sensitive to price.

Overall the evidence tends to support the view that the scalefish considered are substitutes for each other.

While estimated equations appear to satisfy normal benchmark statistical criteria and track the data well within sample, a significant component of the variations in prices and quantities is explained by seasonal factors rather than by economic factors.

Two sets of economic values are presented for KGW and Snapper, namely, value in consumption and economic value, and contrasted with gross production value. These values are explained (in Box 1).

Estimates of the annual values in consumption, measured in 1996 dollars, are presented in the Table 1. The table shows that the value in consumption of KGW and Snapper is $6.51 million and $2.12 million respectively.

Estimates of the annual economic values are presented in the Table 2. The table shos that the economic value of KGW and Snapper is in the range of $0.88 million to $1.42 million and $0.29 million and $0.46 million respectively.

TABLE 1
COMMERCIAL SECTOR
VALUE IN CONSUMPTION

Fish	Sample Mean Quantity[1] ($m p.a.)	1996 Quantity ($m p.a.)
KGW	6.51	5.61
Snapper	2.12	1.77
Garfish	2.27	2.50

TABLE 2
COMMERCIAL SECTOR
ECONOMIC VALUE

Fish	Sample Mean Quantity ($m p.a.)	1996 Quantity ($m p.a.)
KGW	0.88 to 1.42	0.77 to 1.22
Snapper	0.29 to 0.46	0.24 to 0.39
Garfish	0.31 to 0.50	0.34 to 0.55

Note: [1] The column "1996 Quantity" reflects estimates based on 1996 harvest and price data. However, 1996 is thought to be an uncharacteristic year, and accordingly the column "Sample Mean Quantity" is more reliable, reflecting harvest and price data from 1984 to 1996.

The values of the catch based on economic criteria are contrasted with the values based on commercial criteria (Table 3). The table shows that the landed value of the commercial catch of KGW and Snapper is $5.01 million and $1.62 million. As predicted by the areas under the demand curve (Box 1), gross production value is larger than economic value and smaller than the value in consumption, although what is more interesting is that the gross production value is close to the value in consumption. The implication being that the consumer surplus is small and reflects that these fish have close substitutes.

TABLE 3
COMMERCIAL SECTOR
GROSS PRODUCTION VALUE (1995-96)

Fish	Catch (Kg)	Unit Value ($)	Gross Production Value ($m)
KGW	534,000	9.38	5.01
Snapper	306,000	5.28	1.62

Because Whiting, Snapper and Garfish appear to be substitutes for each other, estimates of their annual economic values based upon the possibility of consumers having to go without all three scalefish are up to 11.7 per cent greater for Whiting, 13.3 per cent for Snapper and 33.3 per cent for Garfish.

All of the above estimates are based solely on wholesale market data. Allowing for the additional profits and rents obtained by processors, retailers and restaurateurs could increase both of the above economic value estimates by as much as 40 per cent.

Reliable estimates of marginal economic values could not easily be obtained but, ignoring externality effects, economic theory would suggest that for all recreational and commercial fishers not subject to quota the expected marginal values should be approximately zero.

Empirical Results for Recreational Fishers

There is no observed market data for fish caught by recreational anglers, in essence, because the catches are not sold. For this study a survey technique known as contingent valuation was conducted each for KGW and Snapper to elicit an estimate of the marginal willingness of anglers to pay for catching the species. The techniques reflect many of the standards of such studies required by the U.S. courts in determining environment damages. The results are summarised in Table 4 below.

The derivation of the recreational value of KGW is based on surveys conducted by the Centre totalling approximately 800 questionnaires of which 753 responses were used for this study. The surveys were conducted at metropolitan ramps, Cape Jervis, Yorke Peninsula, Spencer Gulf and Coffin Bay.

TABLE 4
RECREATIONAL SECTOR
ECONOMIC VALUE

Fish	aWTP $ per Kg	mWTP $ per Kg	Economic Value ($m)
KGW	65.75	3.62	0.977
Snapper	86.06	28.75	1.380

The study reveals that the marginal willingness to pay (mWTP) of KGW is $0.724 per fish or $3.62 per Kg and that the average willingness to pay (aWTP) is $13.15 per fish or $65.75 per Kg.

The large difference between the marginal and average willingness to pay reflects the unequal distribution of the catch. A small number of KGW fishers tend to catch a large proportion of the total KGW catch, therefore a downward bias results in the marginal willingness to pay. The estimate of the economic value of the recreational sector is therefore a lower bound of the true value.

The economic value of the recreational sector is estimated by multiplying the marginal willingness to pay by the total amount of recreational KGW catch. The SARDI creel survey in 1996-97 estimated that the boat catch of KGW was 270 tonnes. Other surveys (Jones and Retallick, 1989-90) have estimated that the share of KGW catch is approximately half of the commercial share (586 tonnes in 1996-97). Therefore, on the basis that the total recreational catch of KGW is between 270-300 tonnes, the lower bound estimate of the recreational economic value of KGW is $0.977 million.

The derivation of the recreational value of Snapper is based on a sample size of 91 observations. The majority of the observations were taken at a snapper fishing tournament, but results have adjusted using standard techniques to reflect a more general non-tournament setting.

Overall the marginal willingness to pay for Snapper is found to be considerably higher than that of KGW. This indicates that Snapper is more highly priced by the specialist anglers who expend considerably greater resources in its pursuit. The average amount actually spent by a typical recreational fisher who neither targeted not caught Snapper was $30.50, while the average amount actually spent by the Snapper fishers interviewed for this study was $86.06.

The SARDI creel survey estimated that 48 tonnes of snapper were caught recreationally in 1995-96, representing 16 per cent of the commercial catch. At the marginal willingness to pay of $28.75 the recreational value of the catch is estimated to be $1.380 million.

Policy Directions

In order to formulate recommendations about the management of recreational fishing stocks information is needed about several important aspects: stock levels and population dynamics, the externalities of overharvesting, the externalities associated with certain harvesting techniques (e.g., netting) and the broader benefits of recreational and sport fishing such as indirect tourism. The terms of reference for this report were quite explicit is not seeking this information and, consequently, the only results that can be presented are those that do not take these other economic factors into account.

Notwithstanding the missing economic factors above, some general observations are as follows.

- the marginal recreational value of KGW of $3.62 per Kg is lower than the retail price, suggesting that the motivation of recreational fishers for catching KGW is a cheap means of catching fish for eating;

- the commercial economic value of KGW ranges between $0.88 million to $1.42 million in 1995-96 prices. The estimate of the recreational value of KGW is in the same order of magnitude as the value for the commercial sector. As the recreational value represents a lower bound, it is safe to assume that recreational economic value of KGW is ***at least*** as large as the commercial economic value;
- the marginal recreational value of Snapper of $28.75 per Kg is considerably greater than the approximate retail price of $11.60 per Kg. This finding is consistent with the interpretation that Snapper is pursued for the recreational benefits that it confers, rather than a cheap means of acquiring fish; and
- the economic value of commercial Snapper fishing ranges from $0.29 million to $0.46 million in 1995-96 prices. The recreational economic value of snapper is at least 3 times greater than these figures, indicating that the value of South Australian recreational Snapper fishing is significantly higher than the benefits derived from commercial Snapper fishing in South Australia.

Broadly, the above observations suggest that the recreational fishing sectors for both KGW and Snapper are important, and are at least as important as the commercial sectors. Accordingly, for fisheries management there is a prima facie case for suggesting that effort in policy design and implementation to improve fisheries resource allocation should be just as strong in the recreational sectors as in the commercial sectors, the specific design and implementation of policies to be the subject of further research as identified.

1. INTRODUCTION

Pressure on the fish resources of South Australia is increasing from all sectors, whether it be from the greater fishing power of commercial operations, or the increasing demand for recreational fishing. Most of the principal scalefish species are considered to be fully exploited and in some areas have declined to unsatisfactory levels due to over fishing. In many coastal waters of South Australia, both the recreational and commercial fishing sectors fish the same ground for the same species. This has led to continuing and increasing conflict over resource allocation.

The objectives of fisheries are to protect the fish stock, achieve optimum utilisation of the resource and provide an equitable distribution of the resource between various interest groups. Effective management of a fishery not only requires constant monitoring of fish stocks, but also information on the fishing activity of all sectors utilising the resource, and an analytical framework to assess the impact of policy decisions on the user groups.

The allocation of a scarce resource, however, requires measures of the economic values that user groups derive from the resource which in turn depends upon the willingness-to-pay (WTP) of these users as well as on the associated costs of bringing the resource to these users. Greatest benefits, or economic optimum utilisation, is achieved by allocating on the available fish stock across markets on the basis of marginal WTP's and costs in these markets. Consequently, fisheries managers need to have measures of these marginal values and costs of fish in recreational fishing to compare with that in the commercial sector.

In Australia, there is currently an acute lack of information on the relative economic values and costs of commercial and recreational fishing. The South Australian King George Whiting and Snapper fisheries are two of the few fisheries where quantitative data on commercial and recreational catch and effort are available. A current FRDC funded project aims to improve the completeness and accuracy of recreational catch estimates. This information, however, needs to be supplemented with information on the relative economic values and costs of King George Whiting and Snapper to commercial and recreational fishers so that more objective management decisions can be made with regard to optimal exploitation and sharing of the resource.

While recognising the need to have economic information relevant to all fish species, King George Whiting and Snapper are selected as case studies as they represent fish resources that are important to both the recreational and commercial sector in South Australia. These two species can be considered as being quite different economic resources. King George Whiting is a common fish to most inshore waters of the State and is easily caught. Snapper is regarded more as a trophy fish.

In order to address these issues Primary Industries South Australia commissioned the South Australian Centre for Economic Studies to prepare a report on the economic value of King George Whiting and Snapper to recreational anglers and commercial fishers.

The objectives of the project are to:

- quantify the economic values (and costs) of King George Whiting and Snapper to both the recreational fishers and commercial operators in different regions of South Australia;
- use the information gained above with quantitative catch and effort data on these species to resolve resource sharing conflicts, and implement equitable and economically rational management decisions; and
- establish a mechanism for undertaking large-scale surveys using the contingent valuation methodology.

The specific terms of reference for the study are:

- determine the current and potential value of the King George Whiting and Snapper fishery resource in South Australia;
- estimate the optimal catch for both commercial and recreational fishers; and
- develop options for improved resource use and the means for achieving economically efficient outcomes.

To this end, empirical analysis of characteristics of these industries is a central part of this report. If empirical analysis is to be useful, however, it must be based upon a thorough understanding of what questions needs to be asked and why.

To this end the report opens with a discussion of the concept of value, and of how policy-prescriptions are necessarily tied in with this concept. The essential need for information about both demand and costs, including external costs, is clearly identified. This is followed in Section 3 by a review of the existing literature bearing on the South Australian scalefish industry. Particularly with regard to King George Whiting, there is much useful information, especially with regard to costs. For this reason, the major emphasis in the new empirical analysis of commercial scalefish activity undertaken for this study, and reported in Sections 4 and 5, is in using an appropriate econometric methodology to obtain estimates of the parameters of the commercial demand relationships the King George Whiting, Snapper and Garfish. Section 6 discusses the measures of value that can be derived from demand and cost estimates.

Sections 7 and 8 per cent the results of data collected by survey on the recreational values of King George Whiting and Snapper. Section 9, the final section, identifies the policy implications arising from the respective commercial and recreational values of these species of fish, and problems and issues requiring further analysis.

2. VALUE AND POLICY

Discussions of value, its role in benefit-cost analysis and the associated policy implications make up a substantial and often technically difficult literature that extends over a period in excess of 150 years. A series of papers written in 1970's, including Burns (1973, 1977) and Willig (1976), clarified most of the ambiguities and difficulties associated with the measurement of value and an excellent synthesis and critique of this volumous literature is to be found in the text by Just, Hueth and Schmitz (1982).

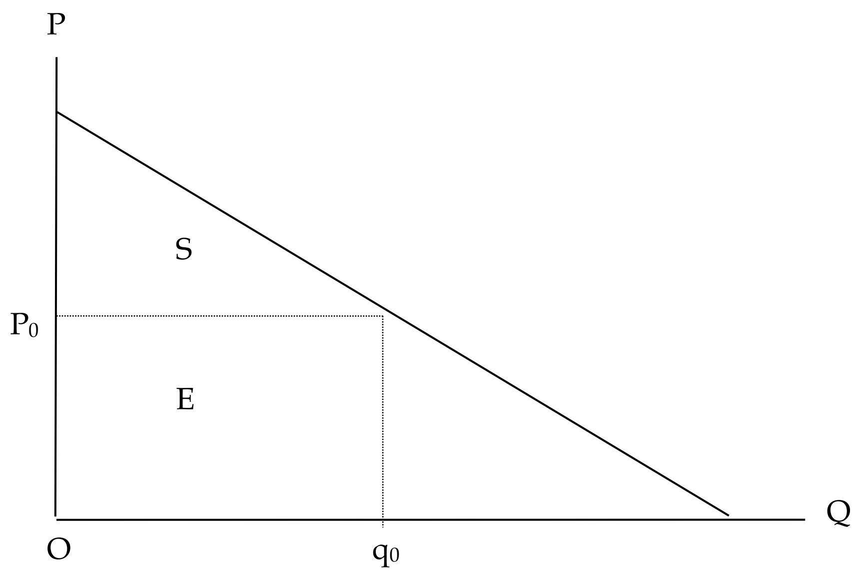
What follows is a much simplified review of some of the key issues from this literature, especially those issues that bear directly on the central concerns of this report. Many of these key issues had been identified, but not discussed in any detail, in the Green Paper published by the SA Department of Fisheries (1990). Readers wanting more details should consult Just, Hueth and Schmitz or the original material cited in their work.

2.1 Value in Consumption: The Individual Consumer

The amount individuals are willing to pay for a given quantity of a good or service, which may be called *value in consumption*, clearly does not reflect value to society (economic value) in any meaningful sense since it takes no account of resources that must be used up in making the good or service available for consumption. Nor should value in consumption be confused with the simple measure of what individuals actually pay in practice.

The most common measures of value in consumption are those associated with the use of consumer's surplus. The simplest of these, shown in Figure 2.1, suggest that the *ceteris paribus* value of q_0 units of a good or service may be measured by the sum of the expenditure associated with the purchase of these q_0 units at a price of P_0 (area E) and the consumer surplus area to the left of the (Marshallian) demand curve. In addition to its simplicity this measure has the advantage, in a market where all consumers pay the same price, that the aggregate of value in consumption will be obtainable directly from the market demand curve.

FIGURE 2.1 MARSHALLIAN CONSUMER'S SURPLUS

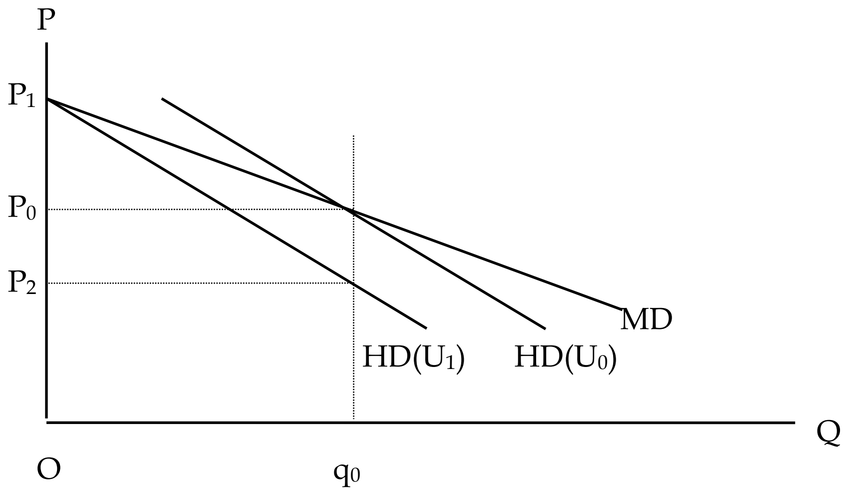


2.2 Consumer's Surplus and Willingness to Pay

Readers who are not concerned with the details of the relationship between consumer's surplus areas and willingness-to-pay measures may proceed directly to Section 2.3. To understand this relationship it is necessary to be aware of the properties of Hicksian (constant utility or constant real income) demand curves as opposed to the standard Marshallian demand curves.. The latter show the relationship between price and quantity with all other prices and income held constant. Utility therefore must increase as price falls and the consumer moves down the Marshallian demand curve.

In contrast, the Hicksian demand curve shows the relation between price and quantity with utility (or real income) and all other prices held constant. Income is not held constant, however, but is varied simultaneously with price so as to maintain utility at a constant level. When price is increased, therefore, income is also increased to compensate the price effect. This means that for a normal good, compared to the Marshallian demand curve MD, and starting at a given price P_0 and utility level U_0 , as price increases the Hicksian demand curve $HD(U_0)$ will lie to the right, as shown in Figure 2.2. For an individual, the exact answer to question "how much extra would the individual be *willing to pay* to keep a price of P_0 rather than have one of P_1?" is given by the area above the P_0 price line and underneath this Hicksian demand curve (between q=0 and q = q_0) rather than that beneath the Marshallian curve. The total value of q_0 units of the good to this individual according to the *willingness-to-pay* criterion is therefore given by the area underneath $HD(U_0)$ between q=0 and q=q_0.

FIGURE 2.2: HICKSIAN AND MARSHALLIAN DEMANDS



It is useful to turn this illustration around, starting instead at a price P_1 on the Marshallian demand curve, where none of the good would be consumed and utility, now U_1, must be lower than U_0 in the earlier scenario. We can draw a Hicksian demand curve associated with this utility level U_1, noting that as price falls reductions in income will be needed to maintain a constant utility level so that, for a normal good, this Hicksian curve, $HD(U_1)$, will now to the left of the original Marshallian curve. For the individual initially at utility level U_1 the area above the P_2 price line and beneath $HD(U_1)$, between q=0 and q=q_0, measures how much that consumer would be *willing to accept* in order to remain with a price of P_0 instead of face a price of P_2. The total value of

q_0 units to this individual according to the *willingness-to-accept* criterion would therefore be the area under HD(U1) between q=0 and q=q_0.
A number of observations can be made:

(a) (Marshallian) consumer's surplus, willingness-to-pay and willingness-to-accept measures of the value in consumption of a given quantity of a good or service all differ in magnitude (except where the income elasticity of demand is zero);

(b) all measures exceed the expenditure on the good, the Marshallian measure lying between the other two measures; and

(c) for a normal good, willingness-to-pay will be greater, and willingness-to-accept less than the Marshallian measure of the value of a given quantity of that good.

The Hicksian measures are in fact not readily observable but the Marshallian measure will in most circumstances be a good approximation to the willingness-to-pay/accept measures. In addition, as noted by Burns and Willig, it will usually be possible to calculate a range within which the three measures are likely to lie. For simplicity, we shall ignore differences between the measures and focus upon the Marshallian demand curve and the associated measure of value in consumption. A more formal explanation of these concepts and of difficulties with their identification is provided in Appendix A.

2.3 Value to Society

Within the framework described above the value in consumption of the marginal unit will always be given by the height of the demand curve at the relevant output level. In general this will also be true in quantity-rationed situations. That is, suppose an individual was given q* units of a good at zero price and was not allowed to obtain additional units. The marginal value in consumption would not be zero unless that was the height of the demand curve at q=q*.

In turning our attention now to the question of value to society rather than to an individual we will first focus on a single market, but introduce industry cost information to supplement demand consideration. For simplicity it is assumed that there are no taxes, but the broad thrust of what follows can easily be shown to carry through to a situation incorporating all forms of government intervention. The need for costs to be taken into account is transparent. Making a good or service available for consumption will use up valued resources. If the value of resources used up in the process of supply exceeds the value in consumption achieved, in net terms society is clearly worse off.

The simple partial-equilibrium optimising condition is equally transparent, that additional units of output should be produced and consumed until marginal value in consumption (marginal benefit) equals marginal (resource) cost. An interesting more general result is that within a single market the net benefits of increasing output by one unit are given by the difference between the value in consumption (price) and marginal cost at that output. This measure takes into account changes in both consumer's surplus and in producer's surplus. Changes in producer's surplus, of course, correspond to changes in economic profit.

In the absence of fixed costs and ignoring other markets, the value to society of having q_0 units of a good or service available at price P_0 rather than having none consumed (e.g., because the price is P_1 or higher) is given by the diagonally shaded area between the demand curve and the marginal cost curve as shown in Figure 2.3a. Note that the sum of the vertical strips underneath the marginal cost curve between q=0 and $q=q_0$ add up to the total variable costs associated with the supply of output q_0.

FIGURE 2.3a: MC MEASURE OF VALUE

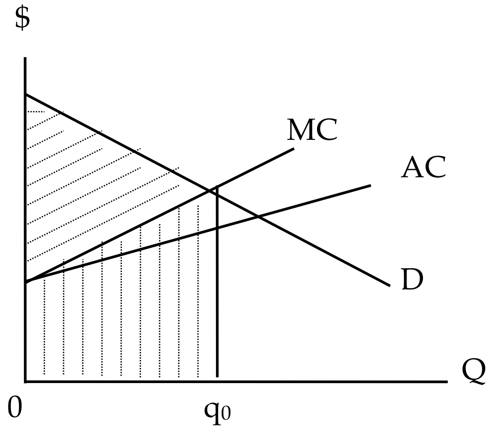
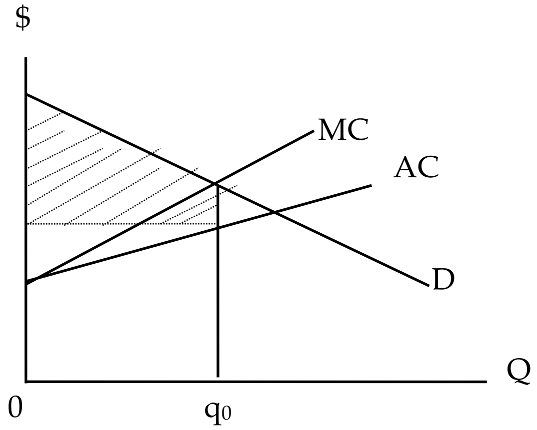


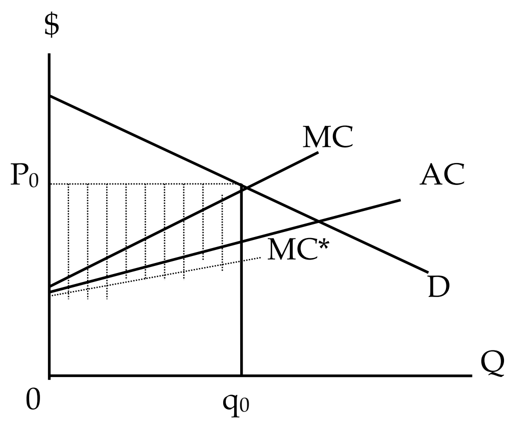
FIGURE 2.3b: AC MEASURE OF VALUE



In Figure 2.3b is shown an exactly equivalent measure of the net benefits shown in Figure 2.3a, given here by the area between the demand curve and the average variable cost curve at q_0 between q=0 and $q=q_0$. Bearing in mind that if any fixed costs relevant to this period's demand and supply had been incurred, this too would reflect a value of resources foregone. It follows that in the presence of fixed costs applying to a given time period, net benefits in that period would be given by total value in consumption less total costs. In diagrammatic terms this would simply be the area between the demand curve and the average total cost line over the relevant quantity range.

Some studies have mistakenly used the value-added contribution as a measure of the net benefit achieved by the availability of a good or service. The difference between the value-added contribution and net benefits is shown by comparing Figure 2.3a and Figure 2.4. In the latter diagram an alternative "marginal cost" curve, MC*, is shown that takes into account costs of inputs paid outside the firm. Value-added, which reflects how much value is added by labour (including management) to the inputs purchased by the 'firm', is therefore measured by the area between price and this curve, MC*. Depending upon the properties of the particular demand and cost curves, value-added may either understate or overstate the true net benefits of the good in question.

FIGURE 2.4: VALUE-ADDED



The reasons why value-added is an inappropriate measure of net benefits are quite clear. First, sales revenue takes no account of consumers' surplus and second, labour input is accorded no value. As has been discussed in the literature, however, there will be some situations where the treatment of labour inputs is more complex. One such situation considered later in the report is where there is labour input into a recreational activity, such as fishing.

All of the above is founded on the premise that the demand curve will meet the price axis at some finite price level. This, of course, need not be the case. For example, a constant elasticity demand with elasticity equal or greater in magnitude than unity will never touch the price axis. Accordingly, value in consumption as measured above would be infinite. While it is unlikely that there is no finite price at which consumption of a particular fish species would reduce to zero, there will plausibly be goods (such as water) where this is true. This realisation may well explain why welfare economists are far more comfortable about evaluating changes in well-being than attempting to put numbers on things such as the level of well-being.

2.4 Net Benefits in Multi-Market Situations

There are very few cases where it makes sense to undertake partial equilibrium analysis and consider a single market in isolation. Almost any policy-action or shock in an economic system will bring about a series of adjustments in other markets. In the context of the current study, an increased harvest restriction on one scalefish will almost certainly impact upon other scalefish markets and maybe even on certain meat markets. Where small changes in quantity are involved there is no problem in defining the aggregate change in net benefits across all n markets, dW.

$$dW = \sum_{i=1}^{n} (P_i - MC_i) dx_i \qquad (1)$$

The implications of (1) within the fish stock valuation context are easily seen. Essentially the (net) value, for example, of whiting consumption would be derived from the effects of a change in price sufficient to reduce consumption of whiting to zero. But if this happens the expenditure which had previously been allocated to whiting would now be allocated to other goods or services. This would in turn result in quantity changes in other markets, each such quantity change being valued according to the difference between price and marginal cost.

Now it might at first seem that there will be many markets where competition has resulted in price being equal to marginal cost. In any such case the value in consumption would, on the margin, be exactly equal to the value of the resources required to generate a unit increase in output. Quantity changes in such markets would then generate zero net benefits (or losses).

Unfortunately, things are not as simple as this. So far in our discussions, the possibility of taxes or subsidies has been omitted to simplify the exposition. With, for example, a per unit tax paid by the producer, the competitive price would be set equal to the marginal cost faced by the producer. But this is not the marginal cost referred to in equation (1) which refers to society's value of the resources used up in production. This latter marginal (resource) cost is less than the marginal cost faced by the producer, and hence less than price, by an amount reflecting the (marginal) tax paid by the producer.

The implication of all this is that the answer to a question such as, "how much would society be worse off if there were no whiting?", should pay some cognisance to fact that additional expenditure will take place in other markets. Insofar as there are likely to be relatively few markets where price is less than marginal cost, there is a reasonable chance that the possibility of substitute expenditures would make the end result less detrimental than implied by the initial partial equilibrium evaluation of the net loss.

2.5 Competing Uses of a Common Resource

While keeping firmly in our minds that whenever we consider disturbing an existing market situation some consideration must be given to general equilibrium or flow-on effects in other markets, for the purposes of this section our focus will return to the single market framework. The market for whiting is just one where we may identify several distinct competing demands for the good in question. For simplicity suppose there were just two sources of demand, commercial and recreational fishers. These demands, and associated cost structures are characterised in Figure 2.5 below.

FIGURE 2.5a: COMMERCIAL MARKET

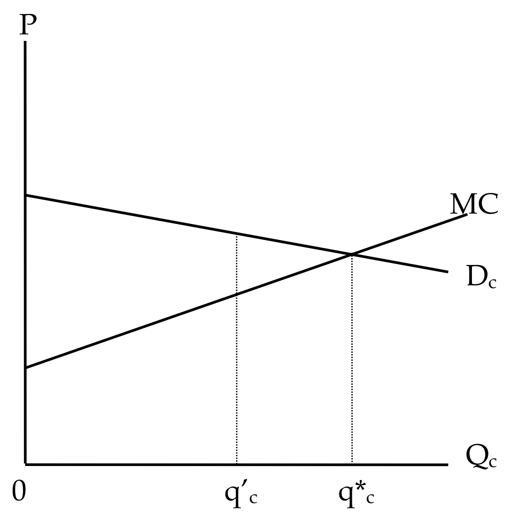
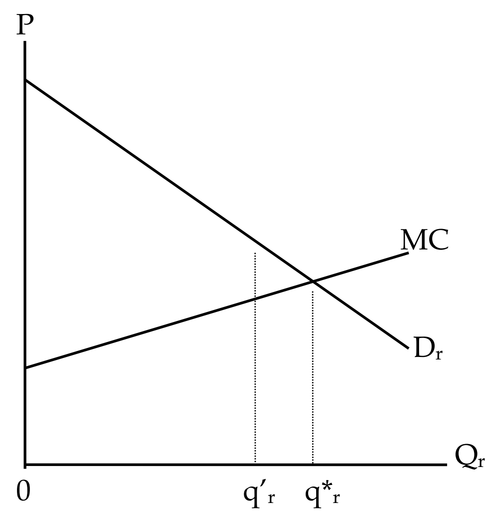


FIGURE 2.5b: RECREATIONAL MARKET



It should be noted that in this case the two demands have rather different rationale. The demand for commercially caught fish is derived from the demands of buyers in fish markets while the demand for recreationally caught fish is here assumed to be the demands of those who do the fishing. This assumption, of course, runs contrary to an interpretation of comments by Gunner (1994) which might suggest that more than half of the recreational catch is caught by persons who, in a number of respects, seem to behave more like commercial fishers than other recreational fishers. For simplicity we shall at first assume that demand parameters differ between commercial and recreational fishers but not within each category.

At this stage no allowance is made for the externality effects of increased consumption of whiting. On this basis, bearing in mind that variations in output impact upon net benefits (or losses) according to the difference between price (or marginal valuation) and marginal cost, a number of conclusions follow directly:

(i) Ignoring the dynamics relating current harvest to future stocks and costs of catching fish, the optimal solution would to have "price" equated to marginal cost in both markets, as at q_c* and q_r* in Figure 2.5. In this situation, of course, the marginal net benefit of an extra whiting would be zero in both markets.

(ii) On the assumption that there is no collusion among the 530 marine scalefish commercial licence-holders, the expectation would be for a competitive outcome with price equal to marginal cost.

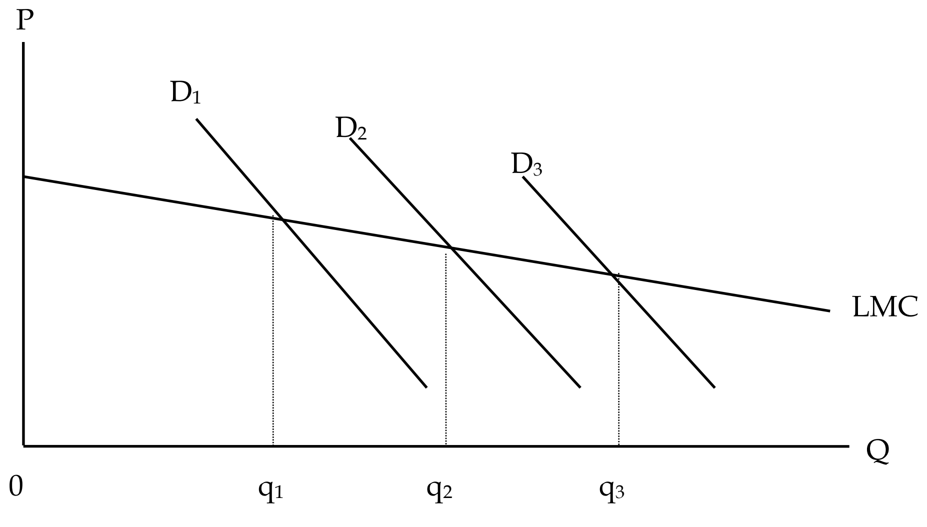
(iii) On the assumption that recreational fishers are satisfying their own demand, subject to their own costs, their optimal behaviour would be to aim for a catch level where their marginal valuation is equal to their marginal cost.

(iv) If total catch was to be less than that required for the solution in (i), the new "optimal" condition would be that the difference between price and marginal cost should be the same in both markets, as at q_c' and q_r' in Figure 2.5.

Under the assumptions described above and underlying Figures 2.5a and 2.5b, and if commercial behaviour is predicated only upon the profit motive, on average commercial fishers would be expected to have similar sized catches obtained through the use of similar equipment. The difference in demand elasticities suggested may well reflect reality but also serves to draw out the implications of (i) to (iv) above.

Gunner, as indicated above, cautions us that commercial fishers and recreational fishers differ among themselves, certainly with respect to their chosen cost characteristics and logically, therefore with respect to demand characteristics. If commercial fishers enjoy fishing, even though they are competitive, like recreational fishers their demand curves for fish could be downward-sloping. Illustrated in Figure 2.6 below is a scenario that, on this basis, could apply equally well to either commercial or recreational markets where there are demand and chosen cost differences between fishers.

FIGURE 2.6: DIFFERING DEMANDS WITH A MARKET



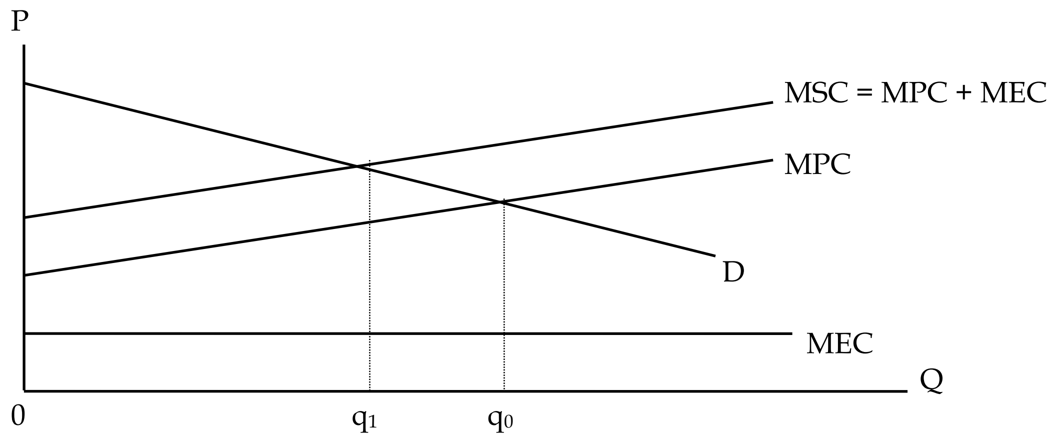
What is suggested is that within the market shown here there is only one long-run marginal cost curve but that there are different types of capital equipment (and therefore different short-run marginal cost curves) and the optimal choices therefore depend upon individual demand curves. Figure 2.6 draws attention to the particular care that must be taken in interpreting empirical analysis and making policy prescriptions. For example, total willingness-to-pay here increases with catch levels across individuals by an approximately constant amount. These increases in willingness-to-pay are not, however, the marginal willingness-to-pays of any individual (except the one with zero catch) which in general are less and fall as catch increases.

For the reasons discussed, above even the appropriately measured marginal willingness-to-pays are not indicative of benefits to be achieved through additional consumption since, as illustrated, each individual has already fished up to the point where marginal benefits equals marginal cost. These points are explained in more detail in Appendix A.

2.6 Externalities

Given the dynamics of fish populations, the catching of additional fish in the current time-period or season imposes costs upon other fishers, both in the current period and in the future. Less fish today means both that the remaining fish are harder (more costly) to catch this season, but also leads to reduced breeding capacity and reduced stocks in the future. Individual fishers only take into their marginal private costs and not the external costs imposed upon others, leading to the standard externality problem illustrated in Figure 2.7 below.

FIGURE 2.7: EXCESS HARVESTING IN THE PRESENCE OF EXTERNALITIES



Here is shown the standard marginal (private) cost and demand curve for an individual fisher. We have also shown a constant marginal external cost curve, assumed constant given the current catch levels of all other fishers, and the associated marginal social cost curve. The standard externality results follow directly. Taking into account only his/her private costs the fisher would aim to harvest catch q_0. If appropriate account had also been taken of external costs the socially optimal catch would instead have been where marginal social cost equals price, at the lower level q_1. The cost to society of over-harvesting is given in the usual fashion by the shaded deadweight loss area.

The simplifying assumption regarding constant marginal social costs leads to a useful approximation for optimality conditions across competing demands. While clearly the socially optimal outputs can only be determined from knowledge of the parameters describing demand, private and external costs, a useful policy result can be derived which is independent of the measurement of external costs. If, at a given total harvest level, it can be assumed that the increase in the total catch imposes the same external costs whoever catches this fish, then it remains optimal to equalise the divergence between price and marginal (private) costs across competing demand groups.

If a constraint is placed upon the catch of one group and not others, this will not only penalise that group relative to others, but lead to a sub-optimal division of the total catch. For example, bag or boat limits that constrain the catches of high demand recreational catches are both discriminatory and likely to be inefficient. This conclusion, of course is drawn from a much simplified characterisation of real world situations.

There are at least four further complicating factors that need to be taken into account. First, bag or boat limits are not the only form of intervention faced by commercial and recreational fishers. The net endorsements faced by the 210 licence-holders, in addition to whatever else they achieve, almost certainly affect the cost structure faced by commercial fishers. Whether reducing catch levels through such a cost-increasing mechanism is efficient or not is of interest in its own right.

Second, as was made clear in the Green paper, the external costs of net fishing are sometimes argued to be greater than those of line fishing. Knowledge of this external cost differential is needed to achieve equalisation of the difference between marginal social cost and price for both types of fishing. The third additional factor that is important, however, concerns monitoring costs. With respect to Figure 2.7 above, if the administrative/monitoring costs necessary to reduce output to the appropriate level were greater than the indicated deadweight loss area then that particular regulatory regime should not be pursued.

The fourth and final complicating factor, and one that was also appropriately identified in the Green Paper, is that all of the above assumes that the demands for fish are of a straightforward nature. However in both the commercial and recreational context fish may be simply a component of a more complex consumption activity. Unravelling the value contribution of an additional fish to either a restaurant meal or to a recreational fishing trip is an extremely difficult task. The characteristics of this type of problem are discussed in more detail in Appendix A.

As is true of much policy analysis all of the above considerations have been made within a framework which assumes that individuals are certain about the quality and quantity of a good or service they will consume when they decide to participate in a particular consumption activity. While there is a vast literature dealing with decision-making under uncertainty, its introduction here would greatly complicate the exposition but, in many cases, leave the general thrust of the results unchanged. For this reason it was decided not to extend discussions of resource valuation beyond the certain quality/quantity situations considered above.

3. BACKGROUND TO THE STUDY

Since this study is concerned with both the current and potential value of the King George Whiting and Snapper fishery resource and to provide information relevant to the ongoing management of this resource, it is appropriate to briefly present some background data regarding the South Australian scalefish Fishery, the population dynamics of the species in question and the results of some earlier research into these areas.

3.1 The Marine Scalefish Fishery in South Australia

Marine scalefish include all species of fish, crustacea and molluscs in the marine waters of South Australia but not species such as prawns, rock lobster, abalone and scallops that are separately managed by either the South Australian Department of Fisheries or other State and Federal bodies.

There were 530 marine scalefish licences at 31 March 1989 (South Australian Department of Fisheries, 1990, p. 29) of which 210 had *net endorsements* **w**hich means that the licence holder has permission to use a certain type and number of nets to catch fish in specified areas at specified times of the year. There are a further 151 so-called *restricted* marine scalefish licences but the proportion of the catch due to these is small. In 1977 there was a freeze on the number of commercial marine scalefish licences. Despite this the effective commercial fishing effort (measured in fisher- boat days) increased by 16 per cent over the 12 years from 1978 to 1990 (South Australian Department of Fisheries, 1990, p. 9).

Before 1980 fishing licences were not transferable. In 1980 they became transferable to family members. In 1982 licences became transferable to anyone, except that net endorsements could only be transferred to family members. The subsequent decrease in active net endorsements was not as rapid as was expected; the number decreased from 426 on 30 June 1980 to 219 on 30 June 1988, and the average age of net licence holders correspondingly increased. As noted in the Green Papers (1990,1991) the issue regarding the environmental impact of net fishing vis-a-vis line fishing is particularly contentious and is one that must be addressed in any management plan. An assessment of the relative environmental impact of these alternative methods was not, however, part of the brief for this study.[1]

3.2 Scalefish Population Dynamics: The King George Whiting

The KGW has recently been the subject of a very thorough and wide-ranging study by Gunner (1994) and much of what follows is drawn from this work. The species spawns, matures and dies in and around the coast of South Australia. The region of study can be assumed to be closed and to be confined to the State of South Australia; there is no significant net migration of KGW across the borders of State fishing zones. Figure 3.1 shows the areas of the State in which the life-cycle of the KGW takes place.

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1 For example, in Victoria, Port Phillip Bay mussels have been declared poisonous and in South Australia fish have died in Lake Bonney in the South East. However, because of its geographical location and pattern of behaviour the KGW stock has not yet been subjected to much pollution by other industries; the main problem for the fishery is the usual free-rider tendency within.

FIGURE 3.1 HABITAT OF THE KING GEORGE WHITING

KGW is a demersal fish, which means that it feeds on plants and animals on the bottom of the sea floor, and it inhabits coastal inshore areas such as bays, harbours and the Gulf waters. It lives in and around sea grass beds and is harvested in the sandy patches near these beds. It is not a tight schooling fish and in the main the two to four year old KGW comprise the 'catchable' stock while the older fish migrate out to deeper waters where they are less vulnerable to the type of fishing gear allowed for KGW. KGW do interact biologically with other marine species, in particular snapper and garfish but the effects are thought to be small even though commercial fishers catch snapper and garfish as well as whiting.

The King George Whiting spawns only once a year, over a period of three months. The young fish are 2 years old before they are vulnerable to the lines and nets used by the commercial fishers and are 3 years old before they spawn. There is therefore a two year lag before any effect of over-harvesting may be felt. The total number of KGW in the region is not known and any biological estimate of it is subject to such error that the Department of Fisheries does not recommend its use and favours a "per recruit" method of analysis. An outline of the basic "per recruit" PRANA model is given in provided in Section 3.3.1 below.

3.3 Related Literature

Estimates of the stock level based on historic catch and effort data, a delayed recruitment biological growth model and open access economic model have been made for various fisheries. Discrete delayed recruitment models have been applied by Palsson (1991) to estimate the stock of whales in Canada, Chapman (1964) to study fur seal populations, Allen (1973) on Baleen whale populations, Campbell et al (1991) to predict the open access equilibrium for the Orange Roughy stock in Tasmania, and many others.

In the fishery economics literature many models have been developed for deep sea pelagic schooling fish such as tuna, whales and prawns (Clark and Kirkwood (1979), Haynes and Pascoe (1988), Palsson (1991) and Schaefer (1957)) and various assumptions about the biology of these types of fish have been made that do not apply to King George Whiting, Snapper, Garfish and Salmon. In many applications of economic models to fish harvesting the data necessary for the estimation of the models is not available. The stock level is a most important variable in these models and yet it is rarely possible to estimate it with any reasonable precision. The commonly used fishery models are well described in textbooks by Conrad and Clark (1987) and Clark (1985). Shrimp and prawn fisheries lend themselves to continuous stochastic differential models as described by MacDonald and Hanf (1990) because these species can be assumed to reproduce continually throughout the year.

A rather different approach to the management of fisheries model has been taken by Walters (1984). Walters advocates the implementation of extreme management policies in the form of restrictions or freedoms for limited periods of time in order that useful and unconfounded data be generated. He recommends deliberate experimentation with the management of fisheries using the "old scientific idea of replicated experimental units". He also favours the use of simple feedback policies such as closing the fishing season when the remaining stock reaches some predetermined optimal level. This latter type of policy presupposes that the level of the stock can be accurately measured during the fishing season which is not possible for the SA Marine Scalefish fishery.

The Walters model may be suitable for pelagic schooling fish that move to find new food sources but it is not suitable for KGW say, which are in the main confined to a finite area of coastal inshore sea grass beds. Other supply side models are the Ricker model (Ricker, 1968) and the Beverton Holt model (Beverton and Holt, 1957).

3.3.1 The PRANA Model

The South Australian Department of Fisheries model, PRANA, an acronym for Per Recruit ANAlysis, is yet another type of model used by fishery managers. The 'per recruit' model originated with Allen (1950), Beverton and Holt (1957) and von Bertalanffy (1957). The model summarises the relationships between fishing effort, total mortality of the stock (sometimes by age, length and gender) and the biomass (total weight) of the catch. It does this by applying appropriate multiplicative factors for survival, harvest, weight and egg production etc., to a single representative fish. The representative fish is harvested when it is at an optimum weight, having produced an optimum number of eggs.

For most of the models discussed fishing effort is standardised to one type of gear. In the PRANA model, effort is measured by the number of equivalent handline fisher-boat days; the South Australian Department of Fisheries converts days of netting effort into an equivalent number of handline days based on comparative catch rate measurements for handline and nets in selected locations throughout the South Australian KGW fishery.

Biological data and parameter values used by the Department of Fisheries are given in Appendix 3 of Gunner. So is data on the costs of fishing and the value of production, and catch and effort data for KGW, also obtained from the Department of Fisheries. Catch data was available from 1951/2 to 1995/6 but effort data was only available from 1976/7 to 1989/90 and prices from 1983/4. Gunner also obtained further data by verbal communication with the Department of Fisheries and some available in the Green Paper and Supplementary Green Paper (South Australian Department of Fisheries, 1990 and 1991).

3.3.2 The Gleeson Study

A previous unpublished study by Gleeson (1979) for the Department of Fisheries estimated single equation models for the wholesale demand for various species of fish in South Australia. It included a single equation demand functions for KGW based on the monthly sales and prices of KGW in the Adelaide wholesale fish market over the years 1974 to 1978, and similar models for Snapper and garfish. Only a proportion of the commercial harvest was sold through this market and this proportion decreased over the period of Gleeson's study so that the main problem with the Gleeson estimates is that the monthly quantities used were those sold in the Adelaide market rather than the monthly quantities sold at that price. That is, the harvest could have risen in response to a high price while the quantity sold through the Adelaide market could have fallen for the same or some other reason. This may explain some of the 'wrong signs' obtained by Gleeson. The model did include the prices of the main substitutes for KGW, snapper and garfish, and many other relevant variables. The partial own price elasticity of the demand for KGW from Gleeson's full log model was -1.3.

In a final model for KGW demand Gleeson omitted all variables except the price of garfish and produced a log model with an elasticity of -2.19 (i.e., -2.2) which incorporated the effects of all the omitted variables. The results are summarised in Table 3.1 below.

TABLE 3.1 SUMMARY OF GLEESON'S RESULTS

FISH	ELASTICITY WITH RESPECT TO PRICE OF (OR INCOME)					
	KGW	Snapper	Garfish	Silver Wh	Income	Rbarsq
KGW	-1.26	-0.33	-0.33	-0.57	-1.59	0.92
Snapper	-0.72	-1.93	0.38	0.52	2.18	0.92
Garfish	0.11	0.12	-1.18	0.34	-5.48	0.84

The review of Gleeson's methodology and results and the re-estimation of these demand parameters is one of the key objectives of the present study.

3.3.3 Information on Costs

The Green Paper (1991), as well as providing a perceptive identification of the key management issues confronting the Scale Fishery, contained a detailed and useful analysis of fishing costs in the net and line industry. As would not be surprising the data is consistent with both falling (long-run) average and marginal costs in the scalefish industry. Although this was obtained for the period 1986-87 it was sufficiently carefully derived that, adjusted for inflation, it will be used for part of the consideration of costs undertaken in the present study. The Green Paper also contains valuable information on profit margins for both line and net fishers which can be updated as a second indicator of costs in our later considerations.

4. ESTIMATION OF SCALEFISH DEMAND PARAMETERS

As is clear from the preceding sections it is appropriate for the focus of the empirical analysis to be with the determination of the parameters of the demand equations for the various marine scalefish. At least with respect to King George Whiting the study by Gunner as well as the Green Papers provide a reasonable understanding of cost and supply considerations, some of which is relevant to other scalefish. Two particular aspects of scalefish demand are of special interest, the elasticity values at normal harvest levels and, essential to the process of valuing the stocks of scalefish, the characteristics of these demand relations across the complete range down to zero quantity. As will emerge in the discussions in this section there are a variety of reasons why these tasks pose considerable difficulty and why the estimates obtained must be viewed with great caution.

4.1 Modelling Market Behaviour

There is broad agreement as to how systems of demand relations should be specified, each quantity usually being specified as being dependent upon own price, prices of complements and substitutes, the general price level and an income or wealth variable. Such a specification, of course, simplifies considerably the theoretical prescription that quantities demanded depend upon all the prices of all the goods, services and assets to which expenditures are allocated.

$$q_w = f_w\left(P_w, P_s, P_g, P_m, P, Y, \ldots.\right) \quad (4.1a)$$

$$q_s = f_s\left(P_w, P_s, P_g, P_m, P, Y, \ldots.\right) \quad (4.1b)$$

$$q_g = f_g\left(P_w, P_s, P_g, P_m, P, Y, \ldots.\right) \quad (4.1c)$$

In this simplified form here the subscripts *w, s, g*, and *m* refer to whiting, snapper, garfish and meat respectively while the variable P (no subscript) is the general price level. As is described later the variables included in the estimated equations varied slightly from the above specification, largely due to data limitations. These demand relations would be assumed to have the property of homogeneity of degree zero, that an equi-proportionate change in all prices and income would leave demands unchanged, so that (for example) equation (4.1a) would more usually be written in terms of relative prices and real income as:

$$q_w = f_w\left(\frac{P_w}{P}, \frac{P_s}{P}, \frac{P_g}{P}, \frac{P_m}{P}, \frac{Y}{P}, \ldots.\right) \quad (4.2a)$$

with similar revised forms for (4.1b and c).

Although the theory of demand derives from considerations of the individual decision maker, aggregation across individuals is usually taken to suggest that market demand equations can be written in the form of (4.1) and (4.2).

Demand equations, however, indicate only what quantities will be chosen for given values of prices and income. They do not indicate how the prices are determined. Since this determination reflects the interaction of the forces of demand and supply, a specification of the supply relations is also required. Here lies an issue that is both complicated and complicating, one that is often largely ignored. A reasonable presumption would be that the amount of effort expended in catching fish, which would be correlated with the harvest, would depend upon the expected profitability of this activity. This in turn would depend upon both the costs involved in catching fish and (at least) the relative prices included in the demand equations. Changes in the stock of fish would impact upon the costs of catching fish and, to make matters more complicated, fish population dynamics would need to be built into the model.

All of this make the matters of modelling, estimation and identification of what has actually been estimated extremely complex. One approach to circumventing many of these difficulties is to focus upon the auction dimension of fish price determination and to assume as was implicitly done by Gleeson, that the quantities supplied to and sold in the fish market on a daily basis are predetermined. While, at least in the case of King George Whiting where unsold catch are sometimes sold the following day, this is at best a good approximation, the simplifications achieved suggest this is a useful first approach.

On this basis, scalefish prices are demand-determined on a daily basis taking into account existing income and other price conditions. Given the characteristics of the fish market in Adelaide, the prudent approach would therefore appear to treat the prices of whiting, snapper and garfish as being jointly and simultaneously determined, largely conditional on the quantities of the daily catch. The empirical analysis that follows, as well as being an important update of Gleeson's study using data available in 1979, will also differ from this earlier work in the consideration of the joint determination of prices.

4.2 Methodology

The methodology adopted here has been primarily determined by four factors: problems arising from the endogenous nature of explanatory variables; role of fish; the consequences of searching for the 'most appropriate' estimated equations; consideration of the influence of fishing population dynamics on market outcomes; and, the consequences of limited variation in some of the key variables.

4.2.1 Endogeneity

Variables whose values are simultaneously and jointly determined within a system of equations are termed endogenous. If explanatory variables in an ordinary least squares (OLS) regression equation are endogenous, their values will be correlated with the stochastic (error) terms present in the model and the coefficients estimated in that equation will be biased. That is, even if the regression equation could be continually re-estimated using new data, on an average basis the parameter estimates will differ from their true values.

Some might argue that variables such as the income and price of meat are not jointly determined with fish prices in any relevant sense and could therefore be treated as exogenous or pre-determined variables. To help remedy uncertainties such as these most modern statistical packages, such as MFIT which was used in this analysis, contain statistical tests designed to shed light on whether particular explanatory variables should be treated as exogenous or endogenous. The Hausman-Wu test was used for this purpose in the regression results that are reported below.

The regression analysis used both OLS (accompanied by these exogeneity tests) and the instrumental variable (IV) approach which is specifically designed to deal with the presence of endogenous explanatory variables.

4.2.2 The Consequences of Searching

Searching is a generic name for the many and different ways in which applied economists experiment with a data set with a view to finding the 'most satisfactory' estimated equation. Searching processes go under a variety of names, from the derogatory 'data mining' to the seemingly more scientific 'pre-testing' or 'testing down'. All of these processes are well known to make invalid the use of test statistics presented with the final chosen equation.

This problem has been recognised for a considerable period of time and a survey of the key issues and relevant literature can be found in Burns (1991). Briefly, until the early 1980s, processes of data-mining, specification searching and pre-testing were common elements of applied econometric methodology. As Lovell (1983) and Denton (1985) illustrated very clearly, however, these procedures lead to significantly (downward) biased estimates of standard errors and prediction intervals. To give an example, suppose if a researcher eliminates explanatory variables from a regression equation on the basis that they seemingly contribute very little to the explanatory power of the equation. In broad terms, if a selection of K explanatory variables are finally chosen (by stepwise regression, testing-down, etc.) from an initial larger selection of nK explanatory variables, then the standard errors in the final equation will understate the true uncertainty by a factor of approximately n times.[2] In his discussions with Poirier (1990), Hendry, a key proponent of 'testing-down', clearly recognised these problems.

In an important sense the problem here is not so much with the searching, which most applied econometricians do and mainly do so in a logical and sensible manner. Indeed, one of Australia's leading econometricians, Max King (1997), has just published a further contribution to the literature seeking to define appropriate search methodologies. The real problem is that when data searching has been undertaken many researchers appear oblivious to the fact that most formal hypothesis testing is no longer appropriate.

The searching in the present paper takes a number of forms: comparison of linear and logarithmic function forms; alternative dynamic specifications; comparison of OLS and IV estimation outcomes and some limited elimination of variables in a component of the IV analysis. Many of the regression equations estimated, especially the results obtained using the preferred methodology, pass a battery of statistical tests with flying colours. As has been made clear, however, the search process invalidates the usual testing procedures. For this reason, inferences from the empirical analysis undertaken here will

2 Burns, (1991), p. 15.

be presented in a far more informal basis, but one which still points towards useful interpretations of the evidence regarding the characteristics of scalefish demand relationships.

4.2.3 Dynamics

As is clearly explained by Gunner, especially in the case of King George Whiting, population dynamics will have an important influence on the intertemporal pattern of quantity and price. Excessive harvesting of adults in one period may impact on the extent of spawning and, with a lag of two to three years, impact upon the future numbers locating in the fishing grounds.

Since this is a supply-side influence, if prices were purely demand determined and if the demand equations were correctly specified, the cyclical characteristic of the population would reveal itself in the intertemporal pattern of harvests but should not effect the regression analysis in an untoward manner.

If, however, the equation is misspecified, for example in regard to the choice of functional form, the cyclical output pattern may manifest itself with an apparent cyclical error pattern. Techniques are available to deal with such error characteristics and, where appropriate, higher-order auto-regressive correction procedures have been employed. Explorations are reported for auto-regressive structures extending up to both 8 and 12 periods, both lengths of time being significant in the whiting life cycle.

4.3 The Equations Estimated

Bearing in mind the discussions above, for purposes of completeness and also to enable comparison with earlier results, a range of regression equations were estimated. Using the whiting equation as an example, the equation that would be preferred on theoretical grounds is the inverse demand function whose basic form is:

$$\frac{P_w}{P} = \beta_o + \beta_w Q_w + \beta_s \frac{P_s}{P} + \beta_g \frac{P_g}{P} + \beta_m \frac{P_m}{P} + \frac{\gamma Y}{P} \tag{4.3}$$

The more usual textbook form with quantity functionally dependent upon relative prices and real income was also estimated. The linear form characterised in (4.3) has at least two problems, one being its general inability to fit demand data particularly well and the other being the more pedagogical objection that with the inclusion of a constant term the desired homogeneity properties are no longer present.

An alternative to (4.3) is that a linear equation involving the logarithms of the variables concerned is estimated. Such an equation has usually appeared to fit demand data better than the linear equation, satisfies the required homogeneity condition and its restricting condition that all elasticity values remain constant does not appear to have been a problem over the reduced ranges of price and quantity variables normally encountered. In addition to the linear specifications described above, the logarithmic version of (4.3) were also estimated both with price and with quantity as the dependent variable.

These four equations formed the basis of the regression analysis which was conducted using both OLS (with and without the Cochrane-Orcutt auto-regressive correction) and IV. For the instrumental variable estimation the procedure requires the specification of additional exogenous or predetermined variables. These are used to obtain estimates of endogenous explanatory variables that are then used to replace the actual endogenous variables in the estimation procedure. The procedure enables consistent estimates of the elasticity parameters to be obtained.

Two IV versions were considered, one where the additional exogenous variables specified were only price and income variables lagged at least two periods. In the second case, for IV estimation with price as the dependent variables, quantities of scalefish were also specified as additional exogenous variables.

4.4 Data

The price and quantity data for scalefish used in the analysis were quarterly variables aggregated over monthly data provided by SARDI. Household disposable income for South Australia was based upon ABS listing 5220.0, interpolating annual SA data on the basis of quarterly movements in Australian household disposable income. The consumer price index used was the Adelaide index contained in ABS listing 6401.0 under the capital cities category. There was not a single meat price index that appeared to adequately capture the desired substitution characteristics and two series were therefore used, both from the food group indices in Table 6A under the same 6401.0 listing. The series used were for poultry and for beef and veal.

5. RESULTS

Of the three scalefish, obtaining satisfactory results for whiting has proved the most difficult. Plausibly, this may be related to the population dynamics of that species. Two features of the empirical analysis emerged that were common to all species. First, determination of equation parameter values was handicapped by the limited variability of relative price and real income data. Second, the theoretically appropriate modification of estimations procedures to take account of equation dynamics and the endogeneity problem always led to increase in the magnitudes of own-price elasticity estimates.

In the results that follow it should be kept in mind that the empirical analysis was applied to wholesale market data and that the elasticities obtained therefore are applicable to this market and would only apply to 'final demand' for scalefish under fairly restrictive assumption about the relationship between wholesale and retail demand. Data and resource limitations precluded empirical analysis of behaviour in retail markets.

5.1 Whiting

Both linear and log forms of simple OLS equations performed poorly, exhibiting severe positive serial correlation in the residuals. Although serial correlation is not a source of bias in elasticity estimates, all coefficients in these equations were poorly determined even though the equation as a whole exhibited good explanatory power. In general, exogeneity of the explanatory variables could not rejected on normal Hausman-Wu criteria. Multicollinearity was not an obvious cause of large standard errors in these or other equations considered, cross-correlation coefficients between explanatory variables never exceeding 0.65 and generally being much closer to zero.

As is indicated in Table 5.1, however, variability of elasticity estimates according to whether price or quantity was the dependent variable suggested that errors in variables (e.g., measurement error) could be a problem. Equations embodying log variables appear to perform better across the range of diagnostic tests, including that regarding functional form. Only these log variable equations are therefore reported in Table 5.1.

Further, given the presence of serial correlation under simple OLS the only equations here are those embodying the Cochrane-Orcutt correction (denoted CO) or those using a generalised instrumental approach (GIVE) to counter any endogeneity problem. It is of interest that the use of instrumental variables in itself is associated with a reduction in the apparent serial correlation in the residuals of the estimated relations. For this and for reasons discussed below the IV results here do not use any error adjustment procedure.

Two comments should be made. Results using alternative auto-regressive error correction procedures, Cochrane-Orcutt and the exact Maximum Likelihood Methods, were initially used but the results were sufficiently similar that only the C-O procedure was used for all equations. It is those results that are reported here. Second, even though the GIVE estimates did not exhibit significant serial correlation and otherwise appeared well-specified, explorations were made with a GIVE auto-regressive model using the Gauss-Newton iterative procedure. These attempts either failed to converge, converged to an unstable solution and/or failed to improve upon the straightforward GIVE results. GIVE/AR results are therefore not included in Table 5.1.

For expositional purposes, and given that the focus here is on own-price, cross-price and income elasticities, only the major explanatory variables have been included in Tables 5.1. In the actual regressions seasonal dummy variables were always included and were generally significant. These seasonal effects are discussed in more detail below.

TABLE 5.1: SUMMARY OF WHITING EQUATION RESULTS
Quarterly Data, 1984(3) to 1996(2)

Dependent Variable	C-O Quantity	C-O Price	GIVE Quantity	GIVE Price
Price Elasticities				
Own Price	-0.35	-5.65	-0.03	-10.3
	(2.07)	(1.66)	(0.15)	(0.34)
Cross (Snapper)	-0.06	-0.15	-0.59	2.99
	(0.31)	(0.19)	(0.90)	(0.50)
Cross (Garfish)	-0.10	0.11	-0.42	0.72
	(0.72)	(0.57)	(1.7)	(2.25)
Cross (Salmon)	-0.11	-0.11	-0.11	-3.11
	(1.73)	(0.50)	(0.73)	(1.28)
Cross (Beef & Veal)	0.46	-2.37	0.43	0.05
	(0.55)	(0.48)	(0.43)	(0.04)
Cross (Poultry)	-0.13	0.00	-0.64	0.80
	(0.44)	(0.00)	(1.47)	(1.34)
Real Income	-0.06	-1.10	-1.38	2.38
	(0.19)	(0.98)	(1.24)	(1.98)
$\bar{R}^2$	0.88	0.76	0.82	0.33
DW	1.90	0.93	(1.24)	(1.98)
LM Tests				
Serial Correlation	-	-	1.94	3.64
Functional Form	-	-	1.86	2.92*
Normality	-	-	0.02	0.21
Hetroskadasticity	-	-	8.26*	1.90

Note: * Denotes significance at 90 per cent level

The disparity of the explanatory power depending upon the choice of dependent variable is somewhat misleading and is driven largely by the relative variability of these two variables. In all equations, using the F-test the hypothesis that all elasticities are zero (that the equation has zero explanatory power) is comfortably rejected. The reduced explanatory power of the GIVE equation with dependent price is readily explained by the poor performance of the instruments in predicting the values of endogenous explanatory variables.

In fact, the performance of the equations may not be as bad as it seems. In Figure 5.1 below is shown the paths of actual and predicted quantity variables on the basis of the C-O quantity equation. As has been argued above, however, on *a priori* theoretical grounds the C-O price equation is more likely to have properties consistent with use of OLS. It is this equation that is quite unambiguous in its implication that whiting is highly price elastic.

FIGURE 5.1: PLOT OF ACTUAL AND FITTED VALUES

A characteristic of all of the equations is the uncertainty surrounding the elasticity values, reflected in generally low asymptotic t-values. There is, however, a very simple explanation for this. Especially when logs of variables are considered, the relative price and real income variables vary very little over the sample. This diagram is based upon the C-O price equation, making allowance for the role of other explanatory variables in the following manner. Note that (log of) price is explained by (log of) quantity and (logs of) other variables:

$$\log \frac{P_w}{P} = \alpha \log q_w + (\text{component of } \log \frac{P_w}{P} \text{ explained by other variables}) \qquad (5.1)$$

In other words, if we wish to see how much leverage there is in the data set to obtain an estimate of α, we need to identify:

$$\log\left(\frac{P_w}{P}\right)^* = \text{component of } \log \frac{P_w}{P} \text{ whose variations are due to } \log q_w$$

$$= \log \frac{P_w}{P} - \text{component explained by other variables} \qquad (5.2)$$

Figure 5.2 overleaf shows the scatter diagram of the variables $\log\left(\frac{P_w}{P}\right)^*$ and $\log q_w$, but using the labels LRPSTAR and LWHQ respectively to describe these variables. It is immediately clear that the available data is completely inadequate for the purposes of obtaining a price estimate of α for within-sample purposes, let alone for identifying characteristics of the demand curve accurately over the range down to zero quantity.

FIGURE 5.2: SCATTER PLOT OF LRPSTAR ON LWHQ
Sample from 83Q3 to 96W2

One further attempt was made to deal with the joint problems of choice of functional form (requiring log variables to be used) and the lack of variability (exaggerated by use of log variables). This involved the iterative non-linear estimation of the equation:

$$q_w = f\left(\frac{P_s}{P}, \frac{P_g}{P}, \frac{P_m}{P}, \frac{Y}{P}, \ldots\right).\left(a + b\frac{P_w}{P}\right) \tag{5.3}$$

To give some idea of the additional leverage obtained with regard to the estimation of the own-price elasticity, in Figure 5.3 below (which should be compared with Figure 5.2) is shown the linear relationship between the "component of P_w/P whose variations are due to q_w" and the variable q_w, denoted here by ULRPSTAR and ULWHQ respectively.

FIGURE 5.3: SCATTER PLOT OF ULRPSTAR ON ULWHQ
Sample from 83Q3 to 96Q2

Such an approach actually generates well determined estimates for the slope and intercept parameters *a* and *b* which imply own-price elasticity values for whiting ranging from -2.5 to -10.0 across the sample range of whiting harvests. This is consistent with the results of the C-O price equation which suggests an "average" elasticity value of -5.65.

Undoubtedly the apparent precision of the estimates could have been increased by a process of 'testing-down' or elimination of the least significant variables. As was noted above, searching or data-mining of this form, like 'testing' alternative functional forms or dynamic error specifications, means that the resulting standard errors are biased downwards and the standard tests invalid. All the same, where there is excessive multi-collinearity some variable elimination may be appropriate. In the current situation, as noted above however, correlation between explanatory variables never exceeded 0.65 in magnitude and was usually very much less.

A further danger with the practice of 'testing-down' is that the omission of a relevant variable is likely to lead to biased parameter estimates for some or all of the remaining variables. One indicator of the presence of these problems would be significant changes in other existing parameter estimates when a variable is omitted. Such changes do occur when variables are omitted from any of the scalefish demand equations reported here. Given that the presence of all variables considered can be justified on *a priori* theoretical grounds, these are yet further reasons why the results of 'testing-down' are not considered here.

5.2 Snapper and Garfish

Equations for snapper and garfish, summarised in Tables 5.2 and 5.3 are more satisfactory than for whiting in a number of respects. Hausman-Wu tests suggests that endogeneity is not a major problem and, perhaps reflecting this, GIVE estimates are broadly consistent with OLS/C-O results. All equations fail the normality test. This failure would mean that estimates no longer retain the Maximum Likelihood property, that standard error formula will be inappropriate, but does not affect the bias and consistency properties of the elasticity estimates.

The more interesting question is whether to be guided by the quantity or the price equations, or by both. All suggest that income elasticities are negative, but the preferred price equations yield higher own-price elasticities and consistently indicate that other scale-fish (but not meats) are substitutes for snapper.

Much that has been said about the snapper equations applies to the garfish equations. Own-price elasticities are significantly higher in price equations, which also identify other scalefish as substitutes but not meat and poultry. While the overriding indication is that garfish are in an inferior good the evidence is not quite as strong as it was in the case of snapper.

Of particular interest is the tendency across all scalefish, as more preferred estimation procedures are used, for own-price elasticities to the values of the order of -5 and for cross-elasticities to suggest at least weak substitution effects. With meats, however, with the possible exception of whiting, the cross-price elasticities tend to be negative. These substitution effects are more apparent in the preferred equations using (log) price as the dependent variable.

As in Table 5.1, for expositional purposes and given that the focus here is on own-price and cross elasticities, only the major explanatory variables have been included in Tables 5.2 and 5.3. In the actual regressions seasonal dummy variables were always included and were generally significant. These seasonal effects are discussed in more detail below.

TABLE 5.2: SUMMARY OF SNAPPER EQUATION RESULTS
Quarterly Data, 1984(3) to 1996(2)

Dependent Variable	C-O Quantity	C-O Price	GIVE Quantity	GIVE Price
Price & Income Elasticities				
Own Price	-1.60	-5.26	-2.24	-4.54
	(4.26)	(4.16)	(3.17)	(4.51)
Cross (Whiting)	0.20	0.63	0.36	0.48
	(0.79)	(1.10)	(1.07)	(0.94)
Cross (Garfish)	-0.45	0.14	-0.18	0.08
	(1.91)	(0.28)	(0.43)	(0.13)
Cross (Salmon)	-0.01	0.14	0.10	0.25
	(0.04)	(0.60)	(0.98)	(0.53)
Cross (Beef & Veal)	-1.60	0.57	-0.59	-0.20
	(1.32)	(0.19)	(0.38)	(0.36)
Cross (Poultry)	0.40	-2.20	-0.32	-0.20
	(0.85)	(2.30)	(0.44)	(0.74)
Real Income	-0.74	-2.17	-1.47	-0.15
	(1.10_)	(1.94)	(0.98)	(0.25)
$\bar{R}^2$	0.81	0.68	0.80	0.64
DW	1.92	1.90	1.70	1.66
LM Tests				
Serial Correlation	-	-	2.93	2.80
Functional Form	-	-	0.34	0.00
Normality	-	-	7.38*	11.74*
Hetroskadasticity	-	-	1.29	0.57

Note: * Denotes significance at 90 per cent level.

TABLE 5.3: SUMMARY OF GARFISH EQUATION RESULTS
Quarterly Data, 1984(3) to 1996(2)

Dependent Variable	C-O Quantity	C-O Price	GIVE Quantity	GIVE Price
Price & Income Elasticities				
Own Price	-0.66	-7.14	-0.38	-6.15
	(2.73)	(2.49)	(0.86)	(1.34)
Cross (Whiting)	0.15	0.43	-0.07	1.30
	(0.60)	(0.50)	(0.17)	(1.91)
Cross (Snapper)	-0.17	2.18	0.86	2.46
	(0.48)	(1.88)	(0.74)	(0.60)
Cross (Salmon)	-0.75	0.66	-0.39	1.62
	(1.10)	(1.28)	(1.42)	(1.07)
Cross (Beef & Veal)	0.18	-6.99	-0.19	-7.63
	(0.14)	(0.81)	(0.11)	(1.21)
Cross (Poultry)	-0.31	-9.21	0.78	-2.90
	(0.64)	(2.12)	(0.81)	(0.22)
Real Income	-0.15	0.97	2.21	-5.66
	(0.22)	(0.59)	(1.11)	1.67
$\bar{R}^2$	0.82	0.80	0.76	0.55
DW	1.95	2.48	1.89	1.36
LM Tests				
Serial Correlation	-	-	7.15	5.59
Functional Form	-	-	1.62	4.09*
Normality	-	-	1.72	2.44
Hetroskadasticity	-	-	0.01	0.56

Note: * Denotes significance at 90 per cent level.

5.3 The Seasonal Factor

Seasonally unadjusted data has been used throughout the study and, as a consequence, seasonal dummy variables have been incorporated into the regression equations. They capture the combined effects of seasonal variations in tastes as well as in harvests and other supply factors. The dummy specification used corrected all other quarters to the second (or June) quarter. The results were fairly consistent across estimation methods and are summarised in Table 5.4 for the OLS/C-O equations.

TABLE 5.4: ESTIMATES OF SEASONAL DUMMY VARIABLES
Cochrane-Orcutt Estimation Method

Fish	Whiting		Snapper		Garfish	
Dependent Variable	**Quantity**	**Price**	**Quantity**	**Price**	**Quantity**	**Price**
S_1	0.21 (4.08)	0.05 (1.23)	-0.39 (3.64)	0.00 (0.03)	0.71 (6.61)	-0.04 (0.64)
S_2	0.59 (10.48)	0.06 (0.83)	-0.69 (6.59)	-0.06 (1.19)	0.80 (7.60)	-0.13 (2.01)
S_3	0.45 (7.99)	0.02 (0.26)	-0.88 (7.81)	-0.11 (1.84)	0.19 (1.70)	-0.20 (4.99)

Note: Asymptotic t-ratios in brackets.

Table 5.4 suggests some quite complicated interactions between seasonal factors across the three scalefish markets. First, with respect to quantity, after all market factors (which themselves influence fishing effort) have been taken into account, the whiting harvest is over 80 per cent higher in the December quarter than in the June quarter. Since the estimates in Table 5.4 are derived from equations expressed in natural logarithms, the values describing the seasonal impacts are not immediately easy to interpret and these have been converted to percentage changes (shown relative to June quarter figures) in Table 5.5 below.

TABLE 5.5: PERCENTAGE SEASONAL IMPACTS

Fish	Whiting		Snapper		Garfish	
Dependent Variable	**Quantity**	**Price**	**Quantity**	**Price**	**Quantity**	**Price**
June Quarter	100.00	100.00	100.00	100.00	100.00	100.00
September Quarter	123.40	105.13	67.61	100.00	135.69	96.08
December Quarter	180.30	106.18	50.16	94.17	191.55	87.81
March Quarter	156.80	102.02	41.48	89.58	120.92	81.87

What is clear from Tables 5.4 and 5.5 is that the major source of variation in harvests of scalefish is not market-driven but is captured mainly through seasonal components. More interestingly perhaps, is the seasonal variation in prices unaccounted for by market forces. Thus, in spring and summer consumers appear to be prepared to pay a premium for whiting, while for snapper and garfish summer and autumn taste switches appear to result in prices by between 5 per cent and 20 per cent less than can be explained though conventional market factors (including substitution effects). Such variations are an important reminder that average and marginal willingness-to-pay are also likely to exhibit seasonal variations of this magnitude which will need to be taken into account in computing annual or average figures for these measures.

6. ECONOMIC VALUES FOR COMMERCIAL FISHERIES

As noted above, to answer questions of the value of scalefish stock and make recommendation about the management of those stocks, information is needed about: existing stock levels; population dynamics and the associated externalities associated with overfishing, and perhaps most importantly, the external costs associated with net fishing in particular, but also any arising through other fishing activity. The terms of reference for this report were quite explicit in not seeking this information and, consequently, the only results that can be presented are those that do not take these other factors into account. Where possible, however, some qualitative allowance will be made for the likely impact of those other variables.

6.1 Partial Equilibrium Estimates of Scalefish Values

As discussed earlier, estimates of the values of the stocks of scalefish require information about the respective demand curves over the entire range down to zero quantity. As also made clear above, there are at least two reasons why such information cannot be determined with any confidence: the lack of variability in key sample data, and; the invalidity of the normal statistical testing procedure due to searching and pre-testing with the sample data set.

Notwithstanding these difficulties some useful and somewhat conservative estimates can be made. This conservative approach is built on two assumptions: first, taking elasticity values at the sample mean to be of the order -5 for each of the scalefish concerned; second, assuming a linear (partial) relationship between quantity and own-price even though there is some suggestion of convexity in the demand relationships. If the true demand curve were less elastic and/or convex then the consumer surplus value would be greater than those presented.

If the own price elasticity of a linear demand curve at the sample mean is -5 then some very simple results follow directly. Consumer's surplus would be 10 per cent of expenditure at the sample mean while prices would need to rise 20 per cent (all other prices constant) for demand to fall to zero. In Table 6.1, two estimates for the annual values in consumption measured in 1996 dollars are presented.

TABLE 6.1: ANNUAL CONSUMPTION VALUES OF SCALEFISH
$ millions in 1995-96 prices

Fish	Sample Mean Quantity	1996 Quantity
Whiting	$6.51m	$5.61m
Snapper	$2.12m	$1.77m
Garfish	$2.27m	$2.50m

Here the column headed "Sample Mean Quantity" allows for the divergence of the 1996 harvest from the sample average harvest, and for associated price changes implied by the estimated elasticity values. These values, of course, take no account of the resource costs associated with obtaining the harvests in question.

Based upon the cost information contained in the Green Paper, adjusted for price changes since 'that time', sensitivity analysis is suggested using profit margins of 5 per cent, 10 per cent and 15 per cent. Adding these percentages to the consumer surplus percentage of 10 per cent suggests an annual economic value for each of the scalefish stocks between 15 per cent and 25 per cent of sales revenue as shown in Table 6.2 below.

TABLE 6.2: ANNUAL ECONOMIC VALUES OF SCALEFISH CONSUMPTION
$ millions in 1995-96 prices

Fish	**Sample Mean Quantity**		**1996 Quantity**	
Profit margins	5%	15%	5%	15%
Whiting	$0.88m	$1.42m	$0.77m	$1.22m
Snapper	$0.29m	$0.46m	$0.24m	$0.39m
Garfish	$0.31m	$0.50m	$0.34m	$0.55m

6.2 Taking Final Demand into Account

This approach ignores the fact most fish is further processed after sale at the market while a proportion of this is then even further processed to become part of a joint consumption activity in restaurants. As each point further surplus or rents are created and as far as possible these should be factored into the estimates of economic value.

The possibility of use a contingent valuation (CV) approach for trying to identify the value contribution of just to restaurant meals was considered but not pursued for two main reasons: first, as identified in the study of recreational fishing in this report, the proper conduct of survey methods to support a CV approach would have involved a resource cost for beyond the scope of this section of the report; second, for the reasons explained in Appendix A, even using current best practice there remains considerable uncertainty as to whether this approach can actually yield the critical information on individual marginal evaluation essential for policy analysis.

An alternative simplistic approach is to posit a straightforward relationship between the derived demand relationships that apply in the fish market and the final demand as well as between the 'consumer surplus' associated with these derived demand relationships and the profits of the processors, retailers and restaurateurs. One way of doing this is to assume that for any given quantity the price indicated by final demand is a constant proportion higher that indicated by the estimated derived demand curve for wholefish.

To give an example, when whiting are sold for around $7.00 per kg wholefish this generates about 0.5 kg filleted fish worth around $10.00 to final consumers. The consumers surplus associated with final demand curve would now be 40 per cent greater than previously suggested (and would now be around 14 per cent of wholesale fish market sales value if elasticity is -5). If a profit margin of between 5 per cent and 15 per cent of the 40% added to the wholesale market value is assumed to accrue to processors, retailers or restaurateurs, then the economic values of scalefish shown in Table 6.2 would also simply increase by 40 per cent.

6.3 A General Equilibrium Approach

The values presented so far apply for individual scalefish under the assumption that the prices of other scalefish remain unchanged. This is implausible on at least two grounds: first, the evidence suggests (weak) substitution effects between scalefish; second, at least some of the factors leading to a reduction in harvest for one scalefish will similarly affect other scalefish.

To take an extreme example, although a 20 per cent (*ceteris paribus*) increases in price of one of the scalefish considered might reduce the quantity demanded to zero, if the prices of all these scalefish were simultaneously to increase, substitution effects of the type estimated (e.g., under Cochrane-Orcutt, price dependent variable equations) would cause all three demand curves to simultaneously shift outwards. This in turn would suggest high "consumer surplus" values.

In fact the prices of whiting, snapper and garfish would need to increase by around 23.5 per cent, 24 per cent and 30 per cent respectively for demands to reduce to zero on this basis. Instead of the associated "consumer surpluses" being 10 per cent of fish market sales expenditures the figures for whiting, snapper and garfish would now be approximately 11.75 per cent, 12 per cent and 15 per cent respectively. On this basis the new "general equilibrium" wholesale market economic values of annual scalefish consumption would be as shown in Table 6.3 below.

TABLE 6.3: ANNUAL 'GENERAL EQUILIBRIUM' ECONOMIC VALUES OF SCALEFISH CONSUMPTION
$ millions in 1995-96 prices

Fish	Sample Mean Quantity		1996 Quantity	
Profit margins	5%	15%	5%	15%
Whiting	$0.98m	$1.52m	$0.86m	$1.31m
Snapper	$0.33m	$0.50m	$0.27m	$0.42m
Garfish	$0.41m	$0.60m	$0.45m	$0.66m

As in the single price change case detailed in Table 6.2, these figure are based solely on wholesale market values and take no account of the additional rents accruing to processors, retailers and restaurateurs. If the same kind of simplifying assumptions were made as above, estimates of economic value taking into account these rents would simply be 40% greater than the figures shown here in Table 6.3.

6.4 Marginal Economic Values and Policy Implications

Reliable estimates of marginal economic values could not easily be obtained but, ignoring externality effects, economic theory could suggest that for all recreational and commercial fishers not subject to quota the expected marginal values should be approximately zero. As discussed earlier, in the absence of data on stock levels, population dynamics and externality effects there are no policy implications other than those general propositions outlined in Section 2 above.

7. RECREATIONAL VALUE OF KING GEORGE WHITING

7.1 Introductory Comments and Qualifications

- It should also be noted that for expositional purposes statistical and methodological matters have not been discussed here in detail these matters relegated to a technical appendix;
- The contingent valuation method (CVM) has been used to provide estimates for the value placed on King George whiting (kgw) and snapper by recreational fishers in South Australia.
- The techniques used in this study reflect many of the standards for CVM studies required by the US courts in determining environmental damages;
- The study reveals that the marginal willingness to pay for kgw is 0.724 per fish or $3.62 per kg and that the average willingness to pay is 13.15 per fish or $65.75 per kg. It is demonstrated that low marginal willingness to pay is a consequence of the highly skewed distribution of the kgw recreational catch. It is shown that a more equal distribution of the catch would raise that marginal willingness to pay and may lower the gap between the average and the marginal willingness to pay for kgw.

7.2 The Data Set

A contingent valuation survey was conducted to determine the value of King George whiting (kgw) to recreational fishers in South Australia. Several variants of the survey were tested on a pilot sample of 124 fishers mainly in the Adelaide metropolitan area. Details of the pilot survey are relegated to Appendix A The final version of the questionnaire is in Appendix D. The survey was conducted at: metropolitan ramps in Adelaide (O'Sullivan, Glenelg, N Haven, St Kilda), Cape Jervis, Yorke Peninsula, Spencer Gulf and Coffin Bay. Preliminary investigations revealed that the bulk of kgw are caught by boat fishers rather than land based fishers.[3] Hence, the survey has focused mainly (though not exclusively) on boat fishers. On most occasions the author was present on site and actively involved in the surveying process.[4] The surveys at Coffin Bay and Spencer Gulf were conducted independently by members of PISA.

Approximately 800 surveys were conducted in total. In a number of cases respondents either refused to answer a question or provided, incomplete or inconsistent answers. These surveys were excluded from the data set. Problems typically arose with the last two questions where respondents were asked to report their occupation and to nominate a range for their gross income. Where reported incomes differed substantially from the expected income of an occupational group, the answer was deemed to be inconsistent and the questionnaire was excluded from the sample. Similarly, refusal to answer any question also let to exclusion from the data set.

The results outlined in this paper are based on a final sample of 753 fishers. The sampling strategy and sample size was largely determined by resource constraints. In an attempt to maximise the sample size with the meagre funds allocated for survey

[3] This has also been confirmed in conversation with members of the SARDI survey on recreational fishing.

[4] The exceptions being the Coffin Bay and Spencer Gulf survey and the surveys conducted in Adelaide during the Easter 1996 holidays.

work, most of the interviews were conducted during the more popular fishing periods. This typically involved surveying on Fridays, weekends and school holidays. Accessibility to ramps was another factor which determined the location chosen to conduct surveys. The final geographical distribution is as follows: 55 per cent of the sample (416 observations) are from surveys conducted at the Adelaide metropolitan boat ramps; 25 per cent (187 observations) from ramps in the Yorke Peninsula (ramps from Ardrossan to Marion Bay); 11 per cent (86 observations) from Spencer Gulf (mainly Whyalla, Pt Hughes and Pt Broughton); 4 per cent (38 observations) from Coffin Bay; and the remaining from other locations (Cape Jervis, Turton, Hardwicke Bay).

The fishers were approached at boat ramps on completion of a fishing trip and asked a series of questions designed to elicit the following information: (a) the importance of fishing as a recreational activity; (b) characteristics of the fishing trip (e.g., duration, catch etc.); (c) socio-economic characteristics of the fisher (e.g., income, sex, membership of fishing club); (d) fishing equipment used (e.g., own boat, type of echo sounder, etc.); (e) willingness to pay (wtp) for the days fishing. A copy of the questionnaire is in Appendix D.

Central to the study is the elicitation question which seeks to determine the respondents' wtp for the fishing trip. For this question, the initial pilot survey played a critical role in ensuring that the amounts covered the full range of values that people are willing to pay to go fishing. Having discovered the range over which the wtp lies, it was then necessary to ascertain the distribution of wtp in the sample of fishers. This involved the usual statistical and graphical tests on the pilot survey data. This information was finally employed to determine bid amounts and the sample size corresponding to each bid using the algorithm developed by Cooper (1994). This algorithm has the advantage of being able to deal with highly asymmetric distributions as encountered in this study.[5]

7.3 The Results

All the information collected in the survey was initially included in a general regression model to determine the wtp for kgw. The variables listed in Table 7.1 were arrived at through sequential statistical tests in which statistically insignificant variables were omitted. This procedure of "testing down", which was pioneered by Hendry (1980), is widely employed in econometric research.

The coefficients and standard errors reported in Table 7.1a are calculated from a Probit regression using the well known method of Cameron and James (1986). The coefficients (summarised in column 2 of the Table) provide a measure of the contribution of each variable to wtp, holding all other variables at given levels.

Consider the first explanatory variable. This is defined as the number of kgw from the catch which the respondent keeps (takes home). The coefficient of 0.724 indicates that an additional kgw adds $0.724 to the wtp for a fishing trip. That is the marginal value of a kgw, excluding the impact of all other variables in the model, is $0.724. The second term is the number of other fish from the days catch which the respondent keeps. The

[5] This procedure is the most recent published techniques and represents an advance over previous work in which the amounts are determined by simple rules of thumb. In contrast, the wtp amounts in this study are determined to satisfy minimisation of the mean square error of the distribution.

marginal value of other fish is 0 0.804. The coefficient of Log(income) indicates that an increase in income leads to an increase in wtp.[6] The fourth term is a dummy variable which is given a value of 1 for a male fisher and 0 for a female fisher. The result suggests that that female fishers, have a substantially greater wtp than do male fishers. The next term Nonmetro is also a dummy variable and reveals that those fishers who fish from (and travel to) non-metropolitan ramps have a greater wtp than there metropolitan counterparts. Finally, the positive coefficient on the term Recreational Importance indicates that respondents who regard fishing as an important recreational activity also have a higher wtp.

The signs and sizes of these coefficients all appear to be reasonable. The results inform us that those with higher incomes, who regard fishing as an important recreational pursuit and who travel to non-metropolitan ramps have a higher willingness to pay than do other fishers.

TABLE 7.1A: THE MOST PREFERRED MODEL

Variable	**Coefficient**	**Asymptotic t - Ratio**
Number of KGW kept by respondent	0.724	2.611
Number of Other Fish kept by respondent	0.804	2.015
Log(income)	2.16	1.902
Sex	-16.4	-3.847
Nonmetro Dummy	6.2	2.95
Recreational Importance	6.035	1.709

Table 7.1B describes the prediction success of the Probit model prior to the implementation of the Cameron-James procedure. To interpret this Table note that a 0 indicates that a person is not wtp the offer amount to go fishing (i.e., a "No" response), while a 1 indicates that a person is wtp the offer amount (i.e., a "Yes" response). The Table summarises the number of "Yes" and "No" responses that have been predicted by the model. Clearly, the greater the number of correct predictions, the better the model. The figures suggest that this model correctly predicts 236 out of 355 (i.e., 66 per cent) "No" responses and 293 out of 397 (i.e., 74 per cent) of the "Yes" responses correctly.

TABLE 7.1B: PREDICTION SUCCESS OF THE MODEL

		Actual	
		0	1
Predicted	0	236	104
	1	119	293
	Total	355	397

For policy purpose the average values of these variables may well be of some interest and these are presented in Table 7.2 below.

6 The coefficient indicates that recreational fishing is an income elastic good. This means that as incomes rise, demand for fishing rises at a more rapid rate.

TABLE 7.2: AVERAGE VALUES OF SOME KEY VARIABLES

Variable	Mean	Dispersion
Total kgw catch	5.1	min=0,max=71,sd=8.7,skew=4.2
Number of kgw kept	3.9	min=0,max=48,sd=5.2,skew=3.4
Number of other fish kept	3.4	min=0,max = 62, sd=6.1,skew=4.2
Willingness to pay	51.29	min= 0, max = 190, sd=34, skew = 1.03

Where: min = minimum; max = maximum; sd = standard deviation, skew = skewness.

The Table indicates that average wtp for a fishing trip is $51.3 and that each fisher kept on average 3.9 kgw. This suggests that the average value of kgw is: (51.3/3.9) = $13.15.[7] If we assume that the average weight of a kgw is 0.2 Kg[8]; this implies an average wtp of 1/.2x 13.15= $65.75 per Kg of fish caught. From Table 7.1 we know that the marginal wtp for kgw is 0.724. Thus, the marginal wtp in terms of weight is given by: 1/.2x0.724 = $3.62 per Kg.

A large difference between the average and the marginal wtp has also been reported in other studies of the recreational value of kgw in South Australia.[9] It is clearly important that this issue is explored in further detail in an effort to explain why the average value differs so substantially from the marginal value.

A low marginal value for kgw may well arise from "strategic bias". Stated simply this implies that respondents consistently provide misleading answers. In the present context respondents may have an incentive to register "protest votes" if they believe that this study is a precursor to a tax, license fee or charge on fishing. A significant number of respondents did in fact forcefully express such a view, and on some occasions declined to be interviewed. The reliability testing for such strategic bias is reported in more detail below. At this stage we merely note that this is indeed a potentially severe problem which is likely to lead to a DOWNWARD bias in our estimates.

However, strategic bias does not explain why the average wtp is found to be consistently and significantly higher than the marginal wtp in all studies of kgw undertaken thus far in South Australia. Strategic bias merely implies that both the average and the marginal wtp will be lower (or higher) than the true wtp. The reason for the large difference between the marginal and average wtp appears to lie in a fundamental and widely encountered phenomenon in economics termed the "principle of diminishing marginal utility". This principle asserts that as more of a good is consumed the satisfaction (utility) obtained from consumption of each additional unit of the good declines.

The wtp for kgw may be viewed as an indicator of the utility or satisfaction that recreational fishers obtain from catching kgw. Thus, the high average wtp for kgw suggests that on average fishers obtain substantially greater utility from fishing than they do from simply purchasing kgw from a shop. Similarly, diminishing marginal utility implies that as the number of fish caught increases, the satisfaction obtained from

7 That is wtp/(number of kgw kept) =51.3/3.9=13.15.

8 This may be regarded as an upper bound for kgw since many fishers have suggested that the average kgw caught in 1996 is smaller than in previous years.

9 See Collins (1991), and Staniford and Siggins (1992).

fishing declines. Stated differently, the first kgw caught yields greater satisfaction (or utility) than the second, which in turn yields greater utility than the third and so on.

The majority of fishers in the sample (i.e., 55 per cent) caught no kgw. Approximately 10 per cent caught between 1 and 12 kgw and less than 4 per cent of fishers reached their bag limits.[10] Overall, 15 per cent of fishers in the sample accounted for 70 per cent of the total catch of kgw. The data strongly suggests that the distribution is very highly skewed. In particular, a small proportion of fishers catch the bulk of the fish.

Since a small number of fishers catch a large number of fish, the principle of diminishing marginal utility suggests that the value which they place on the last fish caught is considerably lower than the value that would be placed if the same fish were caught by another fisher with a **lower** overall catch. The following stylised example may help to illustrate the argument.

Suppose that there are only 2 fishers A and B who have identical preferences and tastes for all things, including kgw. Assume that if one fish is caught the willingness to pay (wtp) is $6 for the first fish, if a second fish is caught the wtp is $3 for this second fish, for the third fish caught wtp is $1, and for the fourth fish wtp is $0.5. Now suppose that person A catches all four fish. The marginal wtp is then $0.5. In contrast, if both A and B caught two fish each, the marginal wtp would be $3. Thus, the low marginal value probably reflects the unequal distribution of the catch in the recreational fishery. This interpretation further suggests that a more equal distribution of the kgw catch in the fishery could raise the marginal value of a kgw.[11]

It is possible to provide a heuristic statistical test of this proposition. Suppose that the sample of fishers is divided in to two (arbitrary) categories: those with a catch of 10 or less kgw and those with a catch of greater than 10 kgw. The principle of diminishing marginal utility implies that, other things being equal, the former group (with a smaller catch) should have a higher marginal WTP than the later group. Table 7.3 provides estimates of marginal WTP in these two categories. Observe that the marginal WTP is considerably lower for the group who catch over 10 kgw on a trip.[12] Specifically, those with a catch of 10 or less kgw have a marginal wtp of 1.004 and those with a catch of greater than 10 kgw have a wtp of 0.271. This result therefore appears to confirm our explanation for the low marginal wtp.

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10 In several of these cases the bag limits were exceeded.

11 Moreover, observe that in the former case when A catches all the fish the total wtp for all four fish is (6+3+1+0.5) = $10.5 and the average wtp is 10.5/4 = $2.625. The difference between the average and marginal wtp is thus:2.625 - 0.5 = $2.125. In the latter case the total wtp of each person is (6+3) = $9 and the average wtp is $4.5. The difference between the average and marginal wtp is now $1.5. This example illustrates that a more equal distribution could lower the difference between the average and the marginal wtp.

12 The Sex dummy does not appear in the latter regression as no females caught > 10 fish in our sample.

TABLE 7.3: FISHERS WITH ≤ 10 KGW AND > 10 KGW

Variable	Coefficient Fishers ≤ 10 KGW	Coefficient Fishers > 10 KGW
Number of KGW kept by respondent	1.004	0.271
Number of Other Fish kept by respondent	0.409	0.202
Log (income)	5.072	10.3
Sex	-17.34	
Nonmetro Dummy	6.4	4.2
Recreation Importance	8.4	26.31

An immediate implication of this result is that a more equal division of the catch would raise the marginal wtp. Furthermore in the Appendix we provide a formal argument which demonstrates with greater accuracy the conditions under which a more equally distributed catch narrows the gap between the average and the marginal wtp. This therefore suggests that the unequal distribution of the kgw catch is potentially responsible for the large discrepancy between the average and marginal wtp.

As noted earlier the results outlined in Table 7.1A may be biased if individuals respond strategically, rather than truthfully. The bias is likely to arise in this case as a result of the widely held view that this study was designed as a precursor to a tax or levy on fishing. An attempt was made to test for the existence of strategic bias by determining: (a) whether respondents believe that a fishing license is likely to be introduced and (b) whether individuals who believe a tax/levy is imminent have a lower wtp than others. Thus at the end of the survey a subset of fishers were asked:

"Do you think that the government is going to introduce a licence fee or charge on fishing within the next 1 or 2 years?" Yes / No/ Don't Know.

Strategic bias would exist, if those who answer "Yes" reveal a lower wtp than others.
This question was tested on 57 respondents at metropolitan boat ramps over the Christmas holidays. All respondents answered "Yes" to the question. This, of course, makes it impossible to test whether these individuals have a lower wtp than others. However, the exercise does suggest that there is a widespread view that a license fee is likely to be introduced and this in turn implies that individuals **have a strong incentive to understate** their true wtp. Thus, the estimates provided in this section should be treated as a conservative lower bound of the true recreational value of fishing for kgw.

7.4 A Comparison with Previous Studies of the KGW Recreational Fishery in South Australia

In order to evaluate our findings we now compare these results with previous studies on the recreational value of fishing in South Australia. There have been two earlier studies and these have been undertaken by Collins (1991) and Staniford and Siggins (1992). We begin by outlining the Collins study which is closest in its approach to the current work.

The Collins Study

Collins undertook a CVM study of the kgw recreational fishery in Coffin Bay and metropolitan Adelaide. The Cameron and James (*op cit*) procedure was used and Collins' regression results are summarised in Table 7.4 below.

TABLE 7.4: COLLINS' MOST PREFERRED MODEL

Variable	Coefficient	Asymptotic t-ratio
KGW	0.3653	2.1913
Retired	-12.917	-5.3490
Income	0.0002	2.0284
Constant	15.3214	2.1443

Note: That Retired is a dummy variable with value of 1 for a retired person.

The results reveal the marginal value of a kgw is $0.3653. The Collins estimate is thus significantly lower than that obtained in this study, where the marginal value of a kgw is found to be $0.72. Since the difference is significant it would clearly seem useful to seek to either explain or reconcile the diverging results.

One simple and unenlightening explanation would be to assert that in the 6 years since the Collins study the recreational value of kgw has risen either because of a decline in fish stocks and/or because of an increase in demand.[13] Such an assertion is, of course, impossible to either empirically refute or validate because there is no historical data on either the recreational demand or supply of kgw.[14] We therefore seek a more detailed explanation for the diverging estimates by exploring the statistical properties of the models.

A number of features of the Collins model seem worth noting at this stage. First, no account is taken of the value of other fish in determining wtp. Statistically this may lead to the usual omitted variable bias.

Second, and more importantly, kgw is defined in this study as the **TOTAL number of fish caught by ALL members** on a particular boat. However, wtp is determined by asking a randomly chosen individual from a boat whether she/he is willing to pay a given amount of money to fish. When the boat crew contains individuals from more than one household, the individual being interviewed usually takes home only a fraction of the total catch. If acquiring fish is an important reason for fishing, and the total catch is shared amongst other crew members, then using total catch as an explanatory variable will result in an *underestimate* of the true marginal value of a kgw. This, suggests that a more appropriate measure of an individual's catch is given by the number of fish accruing to the respondent. It can be shown that when we define the catch in this manner the discrepancy between the Collins model and our results disappear. That is both models yield identical estimates of the marginal wtp.

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13 Fundamental economic reasoning suggests that when either supply of a resource declines or demand rises then the value of the resource will rise.

14 It may of course be possible to draw some inferences about the recreational catch from commercial fishery data.

To see this consider our most preferred model with the explanatory variables kgw and Other Fish defined as the total number of fish caught on the trip, as in the Collins study.[15] The results are reported in Table 7.5. Remarkably, the coefficient on KGW now falls to 0.41. Recall that the coefficient reported by Collins is 0.3653. The difference between the estimates is thus considerably smaller. That two different data sets should yield such close results serves to confirm the notion that the difference in estimates is a consequence of the manner in which the kgw catch is defined in the studies.

TABLE 7.5: KGW DEFINED AS TOTAL NO. CAUGHT IN REGRESSION MODEL OF TABLE 7.1

Variable	Coefficient	Asymptotic t - Ratio
Total No. of KGW	0.4103	1.9
Total No. of Other Fish	0.681	1.3
Log(income)	5.7	2.99
Sex	-27.01	-4.22
Nonmetro Dummy	5.3	1.98
Recreational Importance	8.04	2.7

This point is further reinforced when we regress a variant of Collins' model on our data set. The results are reported in the table below.

TABLE 7.6: COLLINS MODEL ON CURRENT DATA SET

Variable	Coefficient
Total KGW	0.4705
Income	-0.001
Pensioner	-6.91
Constant	25.08

Note: Retired is substituted for Pensioner which includes the young unemployed.[16]

Once again we find that kgw has a similar marginal value to that obtained by Collins in his data set. Note, however, that in the current data set this model appears to suffer from misspecification bias. Economic theory suggests that as income levels rise then, other things being equal, wtp should increase.[17] This requires that the coefficient of Income should be positive and statistically significant. Table 7.6 reveals that, contrary to economic theory, the income variable is virtually negligible in its impact, is of the wrong sign (i.e., negative) and is statistically insignificant.

15 Rather than : (proportion of catch accruing to respondent) x (total number of fish caught on trip) as in this study.

16 While it is possible to obtain an approximate estimate of the number of retirees in our sample, this question was not directly asked. Hence we use pensioners as a substitute. The argument here is illustrative so that this should not drastically alter the main thrust of the conclusion.

17 Assuming that the goods are normal.

These findings therefore suggest that when total catch is used as an explanatory variable there is no substantial difference in the wtp estimates. This, however, does not resolve the issue as to whether ***total catch*** is the appropriate explanatory variable or ***the number of fish accruing to the respondent*** is the relevant variable.

If fishers care mainly (or only) about their own share of the total boat catch then ***the number of fish accruing to the respondent*** provides a more accurate measure. On the other hand, if fishers value both their share of the total boat catch and that of others, then ***total catch*** would be the appropriate measure. This is ultimately an empirical issue which is best resolved through statistical tests. In Table 7.7 below we report a regression of our preferred model with the total catch divided between: that number of fish kept by the respondent (denoted KGWkept; OTHERkept), and the number of fish given to others on the boat (denoted KGWgiven, OTHERgiven).

TABLE 7.7: TEST OF APPROPRIATE MEASURE OF KGW IN REGRESSIONS

Variable	Coefficient	Asymptotic t-test
KGWkept	1.104	2.31
OTHERkept	0.97	3.57
KGWgiven	-0.43	-1.709
OTHERgiven	0.01	1.41
Log(income)	2.1	2.3
Sex	-14.8	1.89
Nonmetro Dummy	7.002	1.31
Recreational Importance	9.055	1.04

The results reveal that each kgw which is given away to others on the boat lowers a persons wtp by $0.43, but that any other fish which is given away raises wtp by a negligible amount of $0.01.[18] On the other hand, those fish which are kept by the respondent raise wtp by approximately $0.9. A simple t-test can be used to determine which of these variables has a statistically significant impact on wtp. Observe that the reported asymptotic t-ratios for KGWgiven, OTHERgiven **are both statistically INSIGNIFICANT** at the 1 per cent level. On the other hand, those of KGWkept; OTHERkept **are both statistically SIGNIFICANT**. This implies that fish given to others on the boat has no statistically significant effect on wtp. A Wald test of the hypothesis that KGWgiven and OTHERgiven have no impact on wtp also confirms this finding.

We therefore conclude that the empirical evidence suggests **that fishers care mainly about their own share of the total kgw catch** and that KGWkept and OTHERkept are the relevant measures to be used in the regression analysis. This suggests that the true recreational value of kgw is provided by the estimates presented in Table 7.1. That is, the marginal value is closer to $0.7 as reported in this study, rather than $0.35 as suggested by Collins.

18 Formally, in the parlance of game theory this suggests that kgw given away and other fish given away are strategic substitutes. That is a person would rather give away another fish than a kgw since kgw is presumably more highly valued.

Staniford and Siggins Study

We now compare our results to those of Staniford and Siggins (1992). Staniford and Siggins conducted a CVM study of recreational fishing in Coffin Bay. There results are summarised in Table 7.8 below.

TABLE 7.8: THE STANIFORD-SIGGINS MODEL

Variable	Coefficient
Constant	1.99
Total Catch	0.3
Quality	0.4
Fishing Days	-0.7
Rented House	0.21
Friends	0.87
January	0.52

Staniford and Siggins (*op cit*) obtained a marginal wtp for a fish of $0.29. This result is, however, somewhat more difficult to compare with either that of Collins or the current study.

First, there are methodological differences between the studies. The Staniford and Siggins study employs a variant of the "Open Ended" elicitation method to determine wtp. Specifically respondents were asked:

> "By how much would costs have to increase to stop you from going fishing today?"

This approach has the advantage of statistical simplicity since wtp estimates can be obtained with greater ease by employing conventional OLS regression techniques. In recent years there has been much research and debate on the manner in which wtp questions should be framed. The "Open Ended" elicitation question and its variants, have been subjected to considerable criticism (see Mitchell and Carsons (1990)). Critics argue that in real world markets people decide whether or not to buy a good at a GIVEN posted price. They are not required to decide how high the price would have to be before they choose not to purchase a good. Since CVM studies seek to emulate conventional markets, it is argued that respondents should be asked whether or not they would buy a good (e.g., fish today) at a given price, rather than asking how high the price would have to be before they refrained from purchasing the good (e.g., not fishing today). Accordingly, use of the Discrete Choice approach is often recommended by these critics. However, a disadvantage of the Discrete Choice method is that it generates discrete (i.e., non-continuous) data and thus necessitates the use of either Probit or Logit regression techniques which are technically more demanding and less amenable to comprehensive diagnostic testing.

In the Staniford Siggins study the contribution of kgw to wtp is measured through a composite variable termed "Total Catch". This is defined as "the total number of kgw, garfish, salmon tommy ruff and other finfish caught during the fishing trip" (Staniford and Siggins (*op cit)*). It is not clear from the report whether this measure relates to the total number of fish caught by all fishers on a boat or merely that proportion of the catch which the individual being interviewed expects to take home. Clearly if the former measure is used, then as noted above this will lead to a downward bias in the estimated coefficient.[19]

The second explanatory variable in the study is the "Quality of Fishing" measure. It is argued that as the proportion of kgw in the catch increases the quality of the fishing trip rises, so that wtp should increase. "Quality of Fishing" is thus measured as the proportion of kgw in the catch. The notion that wtp should rise with the quality of fishing is widely accepted in the literature. However, it would appear that the measure used in this study may have resulted in some statistical bias. In particular, observe that kgw is used **twice** as an explanatory variable in this model: once as a component of the Catch term and again in the numerator of the "Quality of Fishing" term. Duplication of terms raises the possibility of multicollinearity between the variables, which in turn may bias the estimates.[20]

In an effort to quantify the extent of bias (if any) Tables 6.9 and 6.10 below seek to replicate the Staniford and Siggins regression on the current data set. It should be noted that the results are not directly comparable since (a) the data sets and methodology differ and (b) the estimates in this study are obtained using Probit regressions due to the discrete nature of the data, whereas Staniford and Siggins use an OLS estimator.[21]

TABLE 7.9: REPLICATION OF THE STANIFORD-SIGGINS MODEL

Variable	Coefficient
Constant	2.7
Total Catch	0.545
Quality	4.063
Fishing Days	0.008
December Dummy	2.14

In Table 7.9 Total Catch is measured as the total number of finfish caught (rather than the number of fish the interviewee takes home); Quality of Fishing is measured as KGW/Total Catch; Fishing Days is defined as the number of times the respondent fished in the past 12 months, the remaining term represents a time dummy. All the variables are therefore defined as in Staniford and Siggins. Observe that the marginal value of the Total Catch is found to be $0.545.

Consider next the regression results in Table 7.10. The only variable that has been altered is the Quality of Fishing term which has now been replaced by a term called TargKGW. TargKGW is a dummy variable which represents those fishers who: (a) targeted kgw and (b) caught kgw on the trip. It is hypothesised that, if a fisher targeting

19 It is worth noting parenthetically that the authors were unable to obtain data on income which is an important determinant of WTP. This raises the usual spectre of omitted variable bias in the estimates.

20 An approximate measure of the degree of multicollinearity can be obtained by measuring the correlation between variables. In our data set the correlation coefficient between Total Catch and "Quality of Fishing is: 0.61.

21 As noted by Greene (1990), amongst others, there are significant differences between OLS and Probit regression results.

kgw catches the targeted species this should raise the quality of the fishing experience and hence wtp. Arguably, this provides a more direct measure of the role of kgw in determining quality of the fishing trip.[22] Of greater significance is that this measure involves no duplication of explanatory variables and there is therefore no direct collinearity between Total Catch and Quality of Fishing.

TABLE 7.10: STANIFORD-SIGGINS MODEL WITH NEW MEASURE FOR QUALITY OF FISHING DAY

Variable	Coefficient
Constant	2.24
Total Catch	0.658
TargKGW (quality)	10.03
Fishing Days	0.9
December Dummy	2.46

Observe that in this case the marginal value of the Total Catch now rises to \$0.66. This finding suggests that: (a) the quality of fishing term has led to downward bias in the estimates (at least in the current sample) and that (b) when the kgw term is not duplicated and quality of fishing is measured more directly the estimated marginal value of the Total Catch rises to \$0.66. Note that this finding is closer to that presented in Table 7.1A of this study and suggests that the marginal value of fishing is closer to that presented in this study.

7.5 Conclusions

The statistical tests reported in this paper suggest that while the results presented in this study differ from previous estimates, they are consistent with these estimates. A widely accepted criterion for validating and comparing estimates from different studies is that of "encompassing" introduced by Hendry (*op cit*). This requires that new estimates should be capable of explaining and encompassing previous estimates. In this paper it has been demonstrated that the model presented in Table 7.1A clearly satisfies this criterion. The differences that exist between our estimates and previous work have been explained and shown to be a consequence of either using an inappropriate measure of the catch or due to possible multicollinearity.

With the catch appropriately defined it is found that the marginal wtp for kgw is approximately 0.724 per fish or \$3.62 per kg. This value is considerably lower than the average wtp. It has also been demonstrated that the marginal wtp can be substantially increased with a more equal distribution of the catch. This, of course, presents difficult and challenging policy problems for managers of the kgw recreational fishery. Finally, it should be noted that owing to the prevalence of strategic bias these figures should be treated as a lower bound of the true recreational value of kgw.

[22] This measure was not found to be significant in the preferred model reported in Table 1a. Instead Recreational Importance was found to perform better.

8. THE RECREATIONAL VALUE OF SNAPPER

8.1 Introduction

Snapper (*Chrysophrys auratus*) is regarded as a trophy fish which is highly prized by recreational fishers. Unlike the commonly targeted kgw which frequents shallower coastal waters, snapper fishing often necessitates travel over greater distances and hence a larger investment in time and equipment. The pursuit of snapper is thus a more expensive and time consuming recreational activity than fishing for kgw. It is generally acknowledged that relatively few recreational fishers target snapper and even fewer succeed in catching snapper.[23] In addition, snapper fishers launch their boats over a widely dispersed geographic area with unpredictable and sporadic arrival times. This has rendered the data collection process difficult and time consuming.

PISA Fisheries provided considerable assistance in collecting data on snapper fishers for this study.[24] Fish Care Volunteers conducted interviews at various boat ramps across the State. This, however, resulted in only twenty two individuals who had succeeded in catching snapper being interviewed. The difficulty and expense involved in gathering data on snapper fishers made it necessary to augment the data set with interviews conducted with participants at the snapper fishing tournament held in Whyalla.[25] Sixty-nine useable surveys were obtained from the tournament participants.

A single estimate of the wtp is provided on the combined sample of (69 +22) = 91 observations. Since the majority of respondents in the sample were interviewed during a competition this immediately raises the possibility that the estimate may be biased if the behaviour and willingness to pay of individuals in a tournament differs substantially from that of snapper fishers in a more general non-competition setting. However, an attempt has been made to partly control for the impact of the tournament by including a dummy variable in the regression.

8.2 Results

The Cameron-James method described in the Appendix is used to determine the wtp for snapper. The most preferred model is reported in Table 8.1a.

The first explanatory variable termed SNAPPER in the Table measures the number of snapper caught. The regression reveals that a snapper caught, irrespective of whether it is kept by the respondent or given away to other crew members, adds $61.526 to the wtp for a fishing trip. The second term ALLKEPT is defined as the total number of all other fish (i.e., non-snapper) kept (i.e., taken home) by the respondent. Each additional fish in this category raises wtp for the trip by $1.57. The next term TIME is defined as the hours spent on the day's fishing trip. It reveals that those individuals who spend longer hours on the fishing trip have a higher wtp. Presumably, this reflects the fact that those who are willing to devote long hours in the pursuit of snapper, value their sport more highly. Similarly, the coefficient of INCOME reveals that, other things being equal, the richer the respondent the greater her/his willingness to pay for the trip. In contrast, the coefficient

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23 By way of example from March to November 1996 over 600 individuals were interviewed at various ramps across the State for this study. Only 5 snapper were caught by this sample of fishers.

24 In particular Jon Presser and Ben Diggles of PISA both provided invaluable help and support.

25 Most of these interviews were conducted by Ben Diggles, the Manager of Recreational Fishing.

on AGE implies that the older the respondent the lower the wtp. This somewhat surprising result suggests that the younger snapper fishers value their sport more highly than their older counterparts. The term ECHO is a discrete variable which captures the kind of echo sounder used on a boat. A boat with no echo sounder is given a value of 0, a vessel with a paper display echo sounder is given a value of 1, a liquid crystal display a value of 2 and a colour video display a value of 3. The coefficient of ECHO reveals that those individuals in boats with more sophisticated echo sounders have a higher wtp. This finding may reflect the fact that those who value snapper fishing more highly also invest in more sophisticated and expensive equipment. Finally, the term TOURNAMENT is a dummy variable with a value of 1 if the interview was conducted at the snapper fishing tournament and a value of 0 otherwise. The coefficient on TOURNAMENT reveals that, other things being equal, a typical participant in the snapper competition is willing to pay $27.09 more for a fishing trip.

TABLE 8.1A: REGRESSION RESULTS FOR SNAPPER

Variable	Coefficient	Asymptotic t-Ratio
Snapper	61.527	2.846
All Kept	1.5701	1.915
Time	7.05	5.711
Income	5.47	3.222
Age	-22.2	-2.367
Echo	24.3	7.025
Tournament	27.09	4.038

The final column in Table 8.1a reveals that all the explanatory variables in the model are statistically significant at conventional levels. Table 8.1b reports the prediction success of the probit model. It indicates the number of responses to question 11 of the survey (i.e., the value elicitation question) which the model can correctly predict. Observe that the model forecasts the majority of responses correctly, but appears better able to predict a “Yes” response to question 11 than a “No” response to this question. Specifically, 15 out of 27 “No” responses (i.e., 55 per cent) are correctly predicted and 53 out of 64 “Yes” responses are correctly predicted (i.e., 82 per cent)

TABLE 8.1B: PREDICTION SUCCESS

		Actual	
Predicted		0	1
	0	15	11
	1	12	53
Total		**27**	**64**

Note: 0 indicates a “No” response and a 1 indicates a “Yes” response.

Table 8.2 below reports the average values and other statistics of some of the key explanatory variables in the model.

TABLE 8.2: STATISTICS FOR KEY VARIABLES

Variable	Mean	Dispersion
Snapper	2.12	Min=1Max=36, sd =8.6, skew=1.7
Allkept	2.26	Min=0,Max=25, sd=4.9, skew= 3
WTP	123	Min =20Max=400, sd=7.3,skew=1.4
Time	10.65	Min=3.1Max=28.5,sd=4.6,skew=1.1

The table reveals that the mean wtp is $123 and that the mean snapper catch in the sample is 2.12. This suggests an average wtp for snapper of $123/2.12 = $58.02. In contrast from Table 8.1a the marginal wtp is found to be $61.53. If the average snapper caught by a recreational fisher is assumed to weigh 2.14 kg (McGlennan, pers. comm.)[26], this implies a marginal wtp of $61.53/2.14 = $28.752 per kg and an average wtp of $58.02/2.14 = $27.112 per kg.

8.3 Discussion of Results

The regression results reveal that younger fishers who spend longer hours on a trip, with higher incomes and more expensive equipment have a higher willingness to pay than others. Moreover, the snapper fishing tournament was found to increase the wtp for a fishing trip by approximately $27. These findings appear to be intuitively plausible with reasonable parameter estimates.

It is perhaps also of interest to note that the explanatory variable used to measure the wtp for snapper is defined as the total snapper catch of the boat. This measure therefore includes both the number of snapper kept by the respondent and that proportion of the snapper catch given to other crew members. This suggests that snapper fishing is valued mainly for the recreational benefits that it confers, rather than as an alternative means of acquiring snapper for consumption. In contrast, the term ALLKEPT is defined as the number of all other fish kept by the respondent. The proportion of the non-snapper catch given to other members of the crew was found to have no statistically significant impact on wtp. This implies, that unlike snapper, other fish seem to be valued at least partly for purposes of consumption. This appears to suggest that snapper is targeted primarily as a sporting trophy fish.

Overall the marginal wtp for snapper is found to be considerably higher than that of a kgw. This indicates that snapper is more highly prized by the specialist anglers who expend considerably greater resources in its pursuit. For instance the average amount **actually spent** by the typical recreational fisher who neither targeted nor caught snapper was $30.5 , while the average amount **actually spent** by the snapper fishers interviewed for this study was $86.06.[27] Similarly, Table 8.2 reveals that snapper fishers spent on average 10.65 hours on a fishing trip. In contrast, the data used in Section 2 suggests that the non-snapper fishers spent on average 3.58 hours on a fishing trip. This once more confirms the fact that snapper fishers devote considerably greater amounts of time and resources and are therefore more likely to have a higher wtp than other anglers.

26 This estimate was obtained from David McGlennan of SARDI. The figure is based on the average snapper caught by a recreational fisher from April, 1995 to March 1996 in the N Spencer Gulf. It is of interest to note that the average length of a snapper in the region during this period was found to be 44.9cm.

27 Note that these figures refer to average amounts ACTUALLY spent and NOT wtp.

Finally, it is worth noting that the marginal recreational value of snapper is considerably greater than the approximate retail price of $11.6 per kg.[28] This is once more consistent with the interpretation that snapper is pursued more for the recreational benefits that it confers, rather than as a cheap or easy means of acquiring fish.[29]

28 This figure is based on the average retail price of a gilled and gutted snapper in 9 retail outlets in Adelaide in February 1997.

29 It is perhaps worth bearing in mind that these estimates are more likely to be biased downwards because of the tacit and widespread assumption held by respondents that the survey is part of a government plan to introduce a license fee on fishing.

9. CONCLUSIONS, POLICY IMPLICATIONS AND ISSUES

In this study use has been made of sophisticated statistical techniques and current research methodology to obtain information bearing on the economic values of the South Australian commercial and recreational scalefish harvests. This research has proved useful in a number of respects.

With regard to the commercial Whiting and Snapper fisheries new evidence has been obtained suggesting that the demand elasticities are much greater than had previously been thought. In addition, stronger evidence than obtained previously supporting the presence of strong contribution effects between the different scalefish considered with respect to the recreational fishers, a methodology has been established in South Australia for obtaining resource evaluation survey data which is in accord with best international practice.

Deriving policy implications, however, is a complex matter when allocation of a natural resource is concerned, the more so when it is a renewable source and there are important external effects associated with the harvesting of the resource. For this reason, the expository discussions of different measures of value, and of the marginal concepts fundamental to policy analysis, are a key contribution of the report towards the development of improved fisheries stock management.

It cannot be emphasised too strongly that meaningful contribution to the management debate must be built upon clear understanding of the differences between the various commonly used measure of worth: market value; value in consumption (or willingness-to-pay); value added, and most importantly, economic value. It is no less fundamental for there to be understanding that optimal allocation of a scarce resource must be based consideration of marginal economic values in alternative uses of the resource. The fact that total economic value of the commercial scale fisheries might be either much greater or much less than that of the recreational scale fisheries would have absolutely no implications at all as to where there should be a redistribution of some of the harvest form one sector to another.

More detailed analysis presented in an Appendix to the report even further discusses the serious limitations to the usefulness of contingent valuation methodology as it is currently practiced. The differences here mainly relate to the usefulness of the body of information collected rather than the method of information elicitation. Certainly the kind of cost data collected is likely to significantly understate the true resource costs of fishing activity. More important, however, are the problems inherent in the approach which preclude the satisfactory revelation of the vital marginal willingness-to-pay and marginal cost information.

Once understood, the discussions of value and policy in the report have important implications for the directions future research must take if useful information for fisheries management is to be obtained. Economic insights confirms that if there is competition throughout the chain of scale fish harvesting, processing and consumption, and also if there are no significant external effects flowing from any part of this chain, then the marginal economic value of these scalefish is likely to insignificantly different from zero in all situations. In other words, there would be no need for interventionist management policy. The role for such policy arises solely from the presence of externalities and associated market failure.

Both the extensive background literature surveyed for this study and the discussions with experts and practitioners in the industry supported the analysis presented suggest that there are at least three areas where externalities and market failure are likely to be present. Research into these possibilities would both confirm a role for a prescribe the form of interventionist management.

First, and well understood, relates to the likely over-exploitation of a common resource. For overfishing to be identified as a problem, and for appropriate policy measures to be developed, information about stock levels and population dynamics must be obtained.

Second, there is some argument that different forms of harvesting may have different environmental impacts and that, for example, net fishing may be more damaging than line fishing, both in regard to overfishing and undersized catch, as well as in causing more damage to the actual marine environment. Research here would aim to obtain measures of the marginal external costs associated with alternative harvesting methods.

Finally, and especially important in the South Australian context, would be the differential flow-on effects of commercial and recreational fishing upon the population at large. These flow-on effects might have an important local focus or they may simply have a dispersed impact across the State as a whole. The research needed here would need to address matters such as the multiplier effects of general expenditures by recreational fishers, especially if these fishers come from out-of-state. It is only through data pertaining to market failures of these types that implications for resource reallocation within the scalefish industry could be sensibly derived.

Benefits

The South Australian marine scalefish fishery is the primary beneficiary of this study. The provision of estimates of the economic values of two important fish species targeted by commercial and recreational fishers compliment the quantitative data collected on catch from these sectors. This provides a sound base from which informed management decisions can be made on the allocation of fish resources to achieve greatest economic value to the community of South Australia.

It is anticipated that the many issues of conflict relating to the management of fishing effort and the allocation of the fishery resource between the commercial and recreational sectors can be resolved more readily and equitably through informed debate.

This research will provide a sound foundation and an authoritative reference for similar studies in other fisheries and other states. The methodologies used in this project has general application to all fisheries where different sectors compete for the resource, and will contribute to further research in this area.

Intellectual Property

The intellectual property developed in this project was a comprehensive understanding of the use of sophisticated econometric and survey techniques and research methodology to obtain information bearing on the economic values of recreational and commercial fishing.

Further Development

In developing the methodological framework in determining optimal allocation of fish resources between competing sectors, the report identified some important related topics in fisheries biology and economics research. These included the need to have a comprehensive understanding of current fish stock levels and the nature of population dynamics, and data on total and marginal external costs associated with competing fishing methods.

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APPENDIX A: FURTHER NOTES ON RESOURCE VALUATION

A. INTRODUCTION

There are a number of difficulties that arise in undertaking empirical analysis to assist in the valuation of the stock of a resource, such as a scalefish, and in determining the relevant marginal measures essential for policy prescription. In Section A1 the logical basis for valuation of a fixed quantity of a resource is reviewed. A by-product of this review is that some specification requirements are identified for empirical functions used in this form of analysis.

In Section A2 the case where resources contribute to composite consumption activities is considered. Further specification issues are identified and the problems arising from the (likely) occurrence of omitted variables are examined, both for the cases where the omitted variables are uncorrelated with other explanatory variables and where such correlation exists. In Section A3 attention is drawn to a further and major identification problem that arises when valuation data obtained by questionnaire is used to attempt to elicit individual marginal willingness-to-pay information.

A.1 Valuing the Fixed Quantity of a Resource

The logical basis for measures such as consumer's surplus, *willingness-to-pay* and *willingness-to-accept* (or the related *compensating* and *equivalent variation* measures) has often been illustrated within a simplified indifference curve framework[30]. The analysis is usually conducted in terms of two goods, the good whose quantities are to be valued and a composite good alternatively described as "all other goods at constant prices" or simply "income". In what follows the standard and well-known presentation has been varied slightly so that attention is focussed upon alternative measures of the value of a fixed quantity of a resource. The connection between measures shown in the standard demand framework and those identified using indifference curve analysis are shown in Figure A1 below.

FIGURE A1(A)

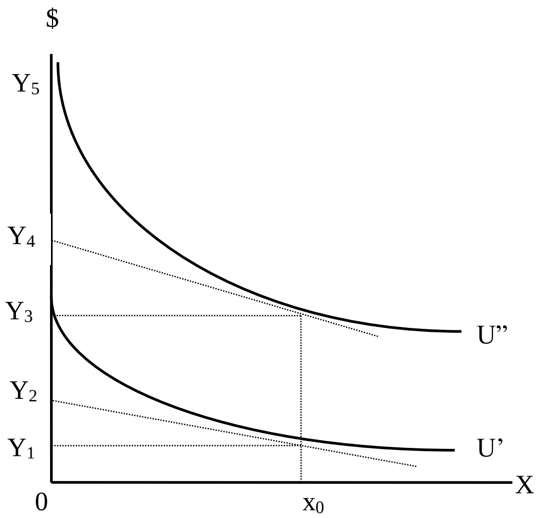
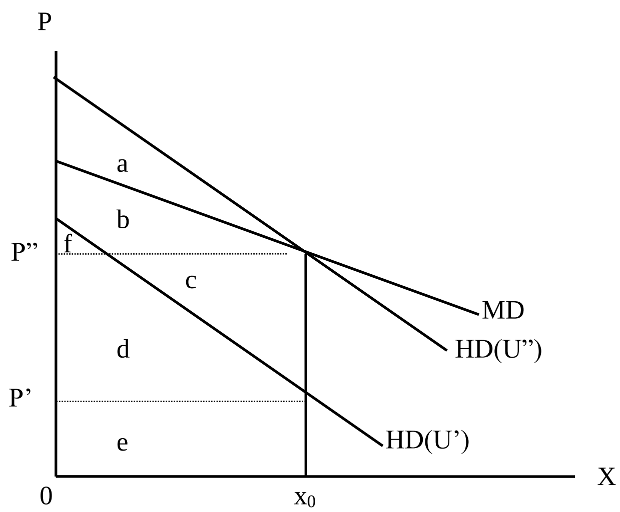


FIGURE A1(B)



30 See Burns (1973) or any standard microeconomics text such as Gravelle and Rees (1981).

Here, in Figure A1(a), two indifference curves, U′ and U′′, are drawn meeting the vertical axis at Y_3 and Y_5 respectively. They are constructed with reference to a particular quantity of good X, x_0 , so that the individual is indifferent between having an income Y_5 with zero quantities of X and having the bundle (Y_3 ,x_0).

If, independently of any price considerations, the individual was initially endowed with the bundle (Y_3 ,x_0), then they would be willing to pay an amount of income up to (Y_3 - Y_1) rather than face zero consumption of X and income of Y_3.

Also shown in Figure A1(a) is a tangent to the indifference curve U′, touching that curve where quantity of X is x_0 and meeting the vertical axis at Y_2. Let the price of X reflected in this tangency be P′. A similar tangency to the indifference curve, U″ meets the axis in Figure A1(a) at income level Y_4. Assuming the X is a normal good the price reflected in this second tangency must be greater than P′ and is designated P″.

In Figure A1(b) the two Hicksian (constant utility) demand curves associated with the indifference curves in Figure A1(a) are shown by HD(U′) and HD(U″). For expositional purposes only one Marshallian demand, MD, is shown in Figure A1(b) and, from Figure A1(a) it is clear that the income level associated with MD must be Y_4. Also, consistent with Figure A1(A), HD(U′) has been drawn to have a price intercept greater than P″.

Also shown in Figure A1(b) are various areas, a-e. These areas relate to alternative indicators of the value (in consumption) of x_0 units of good X in a straightforward manner[31]. For the individual with the initial bundle (Y_3 ,x_0), one approach to obtain a value of x_0 is to determine how much the individual would need to be paid to go without these units of X. This amount is given by the answer to the question "how much would the individual have been willing to accept in cash to have the bundle (Y_3 ,0) rather than (Y_3 ,x_0)?" and is the amount (Y_5-Y_3) shown in Figure A1(a) or, equivalently, the area (a+b+c+d+e+f) in Figure A1(b).

Alternatively for the same initial bundle (Y_3 ,x_0), we could seek the answer to the question "how much would the individual have been willing to pay to remain at (Y_3 ,x_0) rather than have only (Y_3 ,0)?". This would be (Y_3-Y_1) in Figure A1(a) or, equivalently, the area (d+e+f) in Figure A1(b).

If the original bundle (Y_3 ,x_0) had been chosen by an individual with income Y_4 facing a price of X equal to P″, and if the associated Marshallian demand MD was known, to purchase x_0 the individual would have paid out the amount (Y_4-Y_3) in Figure A1(a), which is equivalent to the area (c+d+e) in Figure A1(b). The individual would also have accrued a Marshallian (consumer's) surplus given by area (b+f) in Figure A1(a) giving a total value of (b+c+d+e+f). In general, the exact equivalent of this Marshallian measure cannot be identified in Figure A1(a), although it clearly lies between Y_5-Y_3 and Y_3-Y_1.

As noted in Section 2 of the main report, in the case where *X* has a zero income elasticity indifference curves are vertically parallel and the Marshallian and Hicksian

31 These results derive from the well-known property that the derivative of the (constant utility) expenditure function with respect to price is the Hicksian demand function.

demand curves coincide so that there is no difference between Marshallian "value" and the willingness-to-pay/accept measures. A number of observations follow directly:

(i) convexity of indifference curves guarantees that as the quantity of X increases, *ceteris paribus*, the marginal (and average) willingness to pay/accept of X falls.

(ii) convexity of indifference curves plus the normality of X together guarantees that for given X, marginal willingness to pay/accept must increase as income increases.

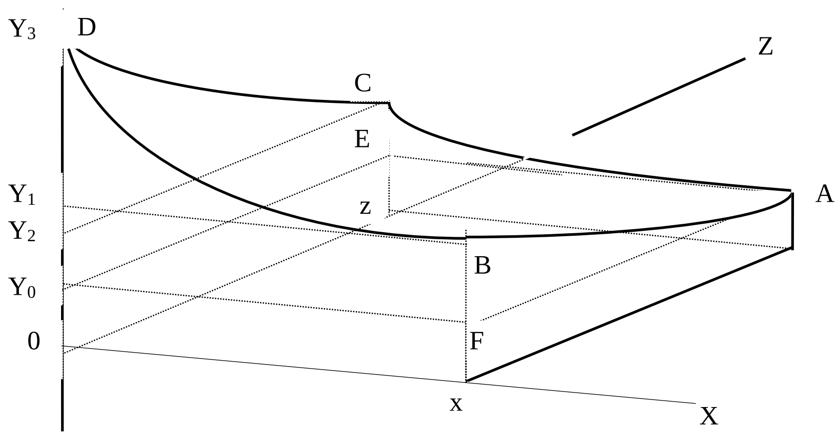
Clearly both (i) and (ii) bear directly upon the specification of willingness to pay/accept functions employed in empirical analysis. These properties derive from characteristics of the indifference curves and, since these curves are unchanged by monotonic transformations of the utility function, they must also be independent of whether marginal utilities are decreasing, increasing or constant.[32]

A.2 Composite Consumption Activities

In many cases policy-makers are concerned with the value of a composite consumption activity, such as a meal in a restaurant or a leisure activity such as a fishing trip, or with determining the value of a good or service which is sometimes consumed jointly with other goods or services.

The above analysis can be used to yield insight into various dimensions of this value measurement problem. Initially it will be assumed that the activity only yields utility through non-zero consumption of X and/or Z. For expositional purposes, discussion will focus on the willingness to pay (WTP) measure of value and its application in the case of a consumption activity involving two goods X and Z. Further, it will be assumed that the individual can choose with certainty the combination (x,z) that is actually consumed. This choice would have been made taking into account a cost function $C(x,z)$ which, again for expositional purposes, is not included in the initial discussions. Both X and Z are assumed to be normal goods and the situation is illustrated in Figure A2 below.

FIGURE A2



[32] Even in an ordinal world, however, we may sign changes in the marginal utility of income when compensated price changes are made along an indifference curve. See Burns (1977).

Here the individual is initially assumed to be at *A*, consuming the bundle (Y_o, x, z). The indifference surface containing this bundle meets the axis at *D*, the bundle $(Y_3, 0, 0)$, so that the WTP for $A(Y_o, x, z)$ rather than have zero quantities of X and *Z*, the bundle $F(Y_0, 0, 0)$, will be given by $(Y_3 - Y_o)$.

In order to identify the separate contributions of X and *Z* one *may* consider an estimate of the value of *Z* based upon the WTP for $A(Y_o, x, z)$ rather than having $D(Y_o, x, 0)$. This is given by $(Y_1 - Y_o)$ in Figure A2. If the value of *X* was then estimated sequentially by determining the WTP for $B(Y_1, x, 0)$ rather than $G(Y_1, 0, 0)$, an amount equal to $(Y_3 - Y_1)$ would be obtained. In this case the sum of the individual WTPs would be identical to the WTP obtained for the joint consumption activity. There is, however, an important issue regarding the path of integration here.[33] The implications may be illustrated as follows. Had we instead changed the order of evaluation and considered first a value of X based upon the WTP of having $A(Y_o, x, z)$ rather than $E(Y_0, 0, z)$ and then obtained a value of *Z* based upon the WTP of having $C(Y_2, 0, z)$ rather than $H(Y_2, 0, 0)$, then:

(i) the sum of the individual WTPs so obtained, $(Y_2 - Y_o)$ and $(Y_3 - Y_2)$ would still be identical to WTP for the joint consumption activity, $(Y_3 - Y_1)$; but

(ii) the individual values of *X* and *Z* so obtained will not, in general, be the same as the values of *X* and *Z* obtained when these individuals WTPs are derived from an alternative sequence of evaluation such as that described above; and

(iii) similarly, an evaluation of *X* conditional on current levels of *Z* added to an evaluation of *Z* conditional on current levels of *X*, $(Y_2 - Y_o)$ and $(Y_1 - Y_o)$ respectively, will not in general correctly determine the value of the joint consumption activity $(Y_3 - Y_o)$.

The conditions for the values of *X* and *Z* to be independent of the sequence (or path) of evaluation are quire restrictive, requiring the separability of *X* and *Z* in the utility function. This in turn clearly has implications regarding the specification of WTP functions used in empirical analysis.

The above analysis also provides a straightforward illustration of the need for caution in discussing marginal and average WTP's for individual components of joint consumption activities. While it is unambiguous that the declining marginal WTP's must yield (declining) average WTP's greater than the marginal value, the average WTP of a component of a joint consumption activity must clearly be based upon the total WTP for that component only and not for the total WTP for the joint consumption activity.

All of the above has assumed that the individual components of the joint consumption activity are known and identifiable. In practice, however, identification of all of the contributory factors to a joint consumption activity may not be straightforward. Utility yielded simply through time spent in company or in aesthetically attractive

33 See Burns (1973,1977).

surroundings, on either a restaurant or on a fishing trip may be unmeasurable to any useful degree. This utility need not be independent of other components of the activity.

The implication of omitting such a utility yielding factor from consideration may be identified using the framework described above and illustrated in Figure A2. Let Z now be such an unmeasurable factor and consider the consequence of its omission from empirical analysis. Even without reference to Figure A2, some insight can be derived immediately from the well-known econometric consequences of omitting a relevant variable which stress the importance of whether the omitted variable is correlated to the remaining explanatory variable(s) or not.[34]

Three possible outcomes related to alternative characteristics of the omitted variable are worth identifying and these are illustrated in Figure A3 below. Here the true indifference surface from Figure A2 is characterised in two dimensions, Y and X, by a series of curves reflecting different but unobservable levels of Z.

FIGURE A3(A)

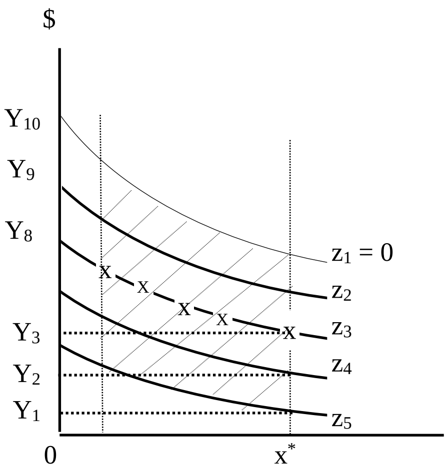
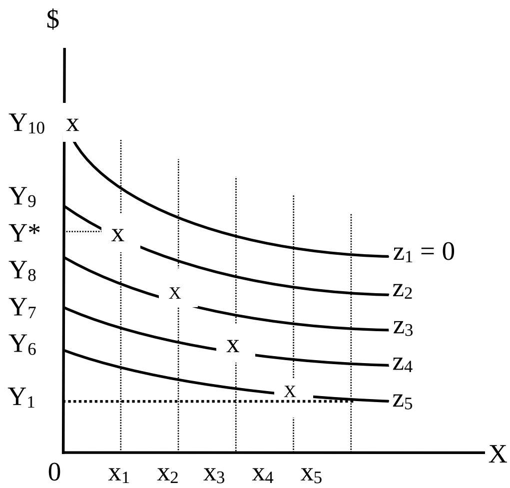


FIGURE A3(B)



In Figure A3(a), the magnitude of Z is independent of the level of X, but two possibilities are considered. Either the magnitude is fixed at Z_3 and reflected by the crosses along the Z_3 curve or it is a random variable with mean Z_3 with its impact reflected by the shaded area between curves Z_1 and Z_5.

Recall now the methods which are commonly used to obtain data in WTP studies, as detailed for example in the US Treasury Guidelines or in Cameron and James (1987). Consumers are typically asked how much extra they would have been willing-to-pay *for the composite activity.* This extra amount is then added to (an estimate of) the amount that has actually been paid to give the WTP for that individual. In our example, illustrated in Figure A3(a), the question really being asked relates to how much an individual's WTP would be, for example, to retain the bundle (Y_3 ,x^*,z_3) rather than have the bundle (Y_1,0,0), given by $\left(Y_8 - Y_1\right)$.

34 See any standard econometrics text such as Johnston (1984), p.260.

If the real concern is with the contribution of just X to WTP the danger here is that this will be taken to be $(Y_8 - Y_1)$, which measures the contribution to WTP of both X and Z, rather than a more appropriate estimate such as $(Y_8 - Y_3)$. In fact, for either of the situations (fixed Z_3 or random Z with mean Z_3) characterised in Figure A3(a), the inclusion of a constant term in a WTP function where such variables have been omitted would enable unbiased estimates of average and marginal WTP's to be derived.

In Figure A3(b), the situation characterised is one where the contribution of Z to the joint consumption activity is correlated (positively) with the quantity of X. The well known econometric result here is that estimates of parameters associated with X will now be biased. In particular the marginal MTP will be biased upwards as can easily be seen if, for example, we regard the increase in X from O *to* x_1 as being marginal. Here standard value elicitation methods are likely to associate a change in WTP of (Y_{10}-Y^*) with this (marginal) change in X whereas a more appropriate estimate would be given, for example, by the value (Y_9-Y^*) which holds Z constant and equal to z_2.

In this latter case, where unmeasurable impacts exist and are correlated with other relevant variables, nothing can be done to retrieve unbiased estimates of the required parameters or to estimate the degree of bias. It is perhaps worth noting that the inclusion of a constant term in a WTP equation would not make matters any worse but may improve them. Given that in any such equation there are likely to be some unmeasurable effects uncorrelated with identified explanatory variables, it would therefore seem worthwhile to always include a constant term which at least may reduce the bias in average and marginal WTP values associated with a particular variable. Of course, if the omitted variable is negatively correlated with an included variable the bias will be in a downward rather than upward direction.

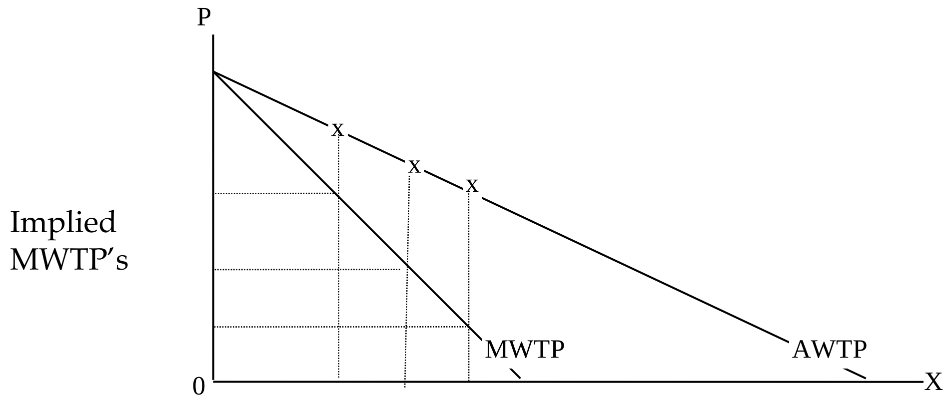
A.3 An Observational Equivalence Dilemma

Attempts to empirically determine WTP information frequently face a major problem in that while an individual's marginal WTP (along with relevant marginal cost data) is relevant for much policy analysis, the data set is likely only to have a single periods data and a single observation on WTP for each individual.

That is, for each individual undertaking a particular joint consumption activity there will be just one observation of various dimensions of the activity likely to affect the value of the activity and associated willingness-to-pay data. To illustrate the observational equivalence problem, consider the case where only the quantities of X impact upon WTP, so that for each individual there is one observation on each of quantity of X and WTP. Such a case is illustrated in Figure A4 below.

For expositional purposes the framework used here shows average willingness-to-pay for each individual plotted against their consumption level and a linear relationship has been assumed. The question is which of the various interpretations of this data that are possible is the correct one.

FIGURE A4: AVERAGE WTP DATA



One approach, which appears to be implicit in quite a lot of applied work, is that by taking into account a wide range of factors that could affect WTP one has already allowed for the factors that cause individual demand to differ. On this basis, Figure A4 can be regarded as showing a representative individual's average WTP relationship, all of these other factors held constant. There is always a one-to-one relationship between an individual's (average) WTP function and a Hicksian (compensated) demand curve, but as Friedman (1947) suggested long ago where linear functions are involved the relationship is particularly simple and well-suited to our purposes. A linear average WTP curve derives from a linear Hicksian demand curve (which is, of course, a marginal WTP curve), the latter showing half the quantity at any given price level.

There is, however, an alternative and perhaps more plausible interpretation of the observations in Figure A4. Suppose, in fact, there is at least one unaccounted for respect in which the individuals still differ, and hence, so do their demands. To make the analysis more complete, add in a falling (long run) marginal cost curve of the type that empirical evidence says may exist in activities such as fishing. Realistically this relation should be interpreted as reflecting properties of a long-run average expected total curve, which takes into account the inherent uncertainty surrounding the catch generated by a given effort level on any particular day.

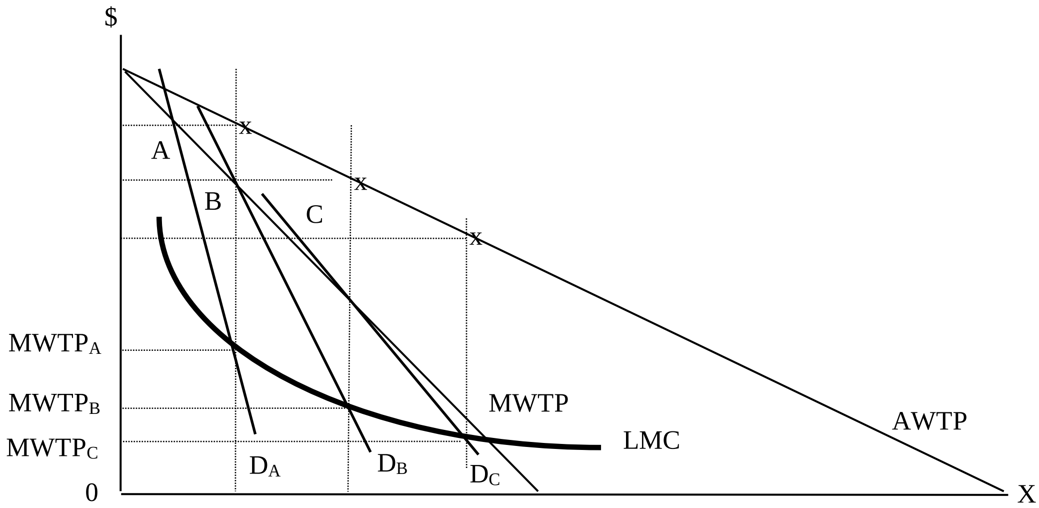
Further assume that these individuals are utility-maximising and therefore aim to consume *X* up to the point where price (which will be equal to marginal WTP) is equal to marginal cost, so that what really underlies Figure A4 is what is shown in Figure A5 below. For expositional purposes it has also been assumed that individuals are on both their short-run and long-run marginal costs.[35]

For simplicity only three individuals are shown here and they are each assumed to have linear demand curves. It follows by construction that any three individual linear demands curves passing through the points A, B and C and an associated marginal cost curve would have generated the three observations on the average WTP curve, providing they intersect the marginal cost curve at the outputs q_A, q_B and q_C respectively. Different individual demand curves would imply a different marginal cost

[35] An interesting and more complex story can be told whereby the random elements affecting the catch on a particular day are modelled as random variations in short-run marginal cost which lead to divergences from long-run marginal cost on a day-to-day basis. Since this does not alter the key points argued below these complexities have not been pursued here.

curve and, of course, there is no reason why the demand curves should have similar slopes. In other words, in the absence of any marginal cost data an infinite number of individual demand curves and associated individual marginal WTP values are consistent with data such as shown in Figure A4, and indeed with a great deal of the data collected in contingent valuation exercises.

FIGURE A5: DIFFERING DEMANDS GENERATING FIGURE A4 OBSERVATIONS



The scenario in Figure A5 is arguably more plausible than the representative individual situation suggested in Figure A4 due to its handling of costs. For the latter to be observed, fundamentally similar individuals are required to face quite different marginal cost conditions which, given competitive behaviour in the supply of fishing equipment, would be unlikely. Figure A5, however, embodies the likelihood of individuals with different demand curves, D_A, D_B and D_C, facing a fundamentally similar long-run marginal cost structure together with the strong probability that there are likely to exist some unmeasurable factors underlying demand differences.

A.4 Conclusion

If empirical research is to be directed at obtaining information about individual willingness-to-pay economic theory does make some quite clear statements about the specification of willingness-to- pay functions. It is essential that appropriate attention be paid both to functional form characteristics as well as to the probability of relevant variables being excluded. Even if these matters are attended to it is would remain impossible to identify individual marginal WTP from the standard type of data set collected in many contingent valuation studies.

But the ‘differing demand’ story which has been used to demonstrate this major identification problem contains a further ingredient which is of perhaps even greater importance in policy analysis. It reminded us that individual outcomes will be significantly related to the cost conditions faced. If as suggested, individuals tend to consume to the point where price equals marginal cost, given their differing demand schedules, then the usual efficiency conditions will have been satisfied and the absolute and relative magnitudes of their marginal WTPs are of very little interest. If for policy reasons or otherwise these marginal conditions are not to be satisfied then information on marginal private or external costs is at least as necessary as this other information.

APPENDIX B

THE CONTINGENT VALUATION METHOD: A SUMMARY OF SOME ISSUES

The contingent valuation method is a survey based technique used to elicit respondents wtp for an unmarketed good. The surveys have 3 components. In the first the researcher describes the change being considered. This study was commissioned to evaluate the current situation, hence this issue is not relevant to the survey. The second component involves determining a mechanism for eliciting value. This is central to the CV technique. Following a comprehensive survey of the CVM by Nobel laureates and other experts the US courts recommend use of the "Discrete Choice" approach over the "Open Ended Approach". Recent work by Cameron and Quiggin (1994) further suggests that distributional considerations warrant using the "Take or leave it" variant of the "Discrete Choice" approach over other alternatives. Thus, the elicitation question used in this study is of the "Take or leave it" variety. This is in accordance with the recommendations of US Federal Register, 1996 and circumvents the difficulties cited in Cameron and Quiggin (op cit). After much pre-testing it was discovered that a concise, comprehensible and simple question was required. The elicitation questions took the following form:

> "What did you spend on your fishing trip today on items such as bait, fuel for the boat and car, ice, food and drinks etc.? (Exclude major items such as reels, rods etc.)."

ANSWER $.................

> "Now suppose it had cost you more than this amount to go fishing today.
>
> If it had cost you an extra $x on these items would you still have gone fishing today?"

ANSWER YES / NO

The "bid amount" (i.e., $x) asked of each person were determined by the algorithm developed by Cooper (1994). This is the most recent useable technique which has been developed to minimise statistical and distributional biases in the elicitation questioning. The bid amounts satisfies an optimising criterion. If a bid is set too high it results in a wasted observation since people are unlikely to be willing to pay an excessively high amount to go fishing. A bid set too low would result in little sample information, since most people would be willing to pay this amount. The technique therefore optimises between response information received from concentrating bids in the centre of the distribution and the information received from placing bids in the tails of the distribution. Another feature of this technique is that the greater the positive (negative) skew of the data the wider is the spacing of bids to the right (left) of the median. Monte Carlo studies reveal that this technique produces more efficient surveys which maximise the information which can be extracted. Use of this method goes beyond the requirements of the US courts as outlined by the Department of the Interior.[36]

[36] Federal Register (1996)

Finally, CV surveys elicit questions on socio-economic and other characteristics of respondents. Once more trial and error and the need for brevity determined the nature and type of questions used in the survey. The most contentious question was left to the very end when respondents were asked to nominate a range for their gross incomes. The ranges were intentionally broad in order to overcome the widespread reluctance to disclose personal information. The income question was preceded by a question asking the respondent about their occupation. This provided some indication of the accuracy of the reported income. Where the discrepancy seemed large or implausible the survey was excluded from the sample.[37] Data on income are essential to the analysis. Economic reasoning strongly suggests that wtp will be highly dependent upon income levels. It is therefore necessary to standardise for differences in wtp which arise from differing income levels.

The US Department of the Interior has established a set of key guidelines for CVM studies which are summarised below. Every effort has been made to meet all of these guidelines. It should also be noted that these guidelines are designed to determine actual monetary damages payable by defendants in court cases. In contrast, where CVM studies are to be used for cost-benefit studies the Department suggests that there is little need to follow the strict guidelines outlined here. Despite the fact that this study is being used for cost-benefit purposes, these guidelines have been adhered to. It is hoped that this has yielded more reliable and conservative estimates of the recreational value of kgw.

Brief Summary of Department of the Interior Guidelines:

1. Use personal interviews not phone surveys or mail surveys.

2. Elicit willingness to pay, not willingness to accept, even though the latter is the theoretically appropriate measure.

Both these recommendations have been followed.

3. Use "discrete choice" approach and seek to emulate real world market situations in the elicitation questions.

This has been achieved by asking what would occur if the cost of goods required for a fishing trip were to rise. People purchase these goods in real markets prior to a fishing trip.

4. Hypothetical scenario change must be described comprehensively and understandably in the survey introduction.

This study has not been commissioned to assess any hypothetical changes. The Terms of Reference clearly require an evaluation of the current situation. Hence this recommendation is not relevant.

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37 By way of an extreme example a dental surgeon with a new fully equipped boat and 4 wheel drive claimed a gross income of less than $10,000 per annum. While the income level may accurately reflect the individual's circumstances it appeared to be somewhat improbable so the questionnaire was excluded from the sample.

5. Remind respondents there are many other calls on their income, so they should not inflate their wtp for the good in question.

During the pre-testing stage and through the entire surveying process this reminder when used, was found to be totally unnecessary. Typically respondents held the view that this study was part of a government plan to introduce a levy on recreational fishing. The problem confronted in this study is thus one of individuals' understating their true wtp through "protest votes". This suggests that the estimates provided here are conservative LOWER BOUNDS of the true value of kgw to recreational fishers.

6. Cross check the results for "warm glow effects".

A priori reasoning suggests that this is unlikely to be a problem because of the nature of the good being valued here.

7. Perform statistical tests to ensure that income and wtp are both statistically significant in the regressions.

The asymptotic t-tests are reported in the tables.

<u>The Pilot Survey:</u>

The pilot study was undertaken at the metropolitan ramps in Adelaide. The main aims of the survey were to determine:

1. The optimum length of the questionnaire
2. Whether the questions could be easily understood by the wide cross section of fishers with varying degrees of language fluency
3. The range over which wtp lies
4. The need for a budget constraint reminder

Boat ramp interviews are often conducted in congested, uncomfortable and inaudible[38] conditions in inclement weather. In addition, respondents were at times hostile and deeply suspicious of the motives underlying the interview. Thus, brevity was found to be a critical factor in maintaining respondents' attention and interest. Once the questionnaire was developed a test was performed to determine whether wtp varied if a budget constraint question was included prior to the elicitation question. Unsurprisingly, the reminder was found to have no impact on wtp. Thus in the interests of brevity no budget constraint reminder was included in the final questionnaire.

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38 As a result of the intermittent and piercing sound of boat motors being revved and washed.

APPENDIX C

SUMMARY OF THE CAMERON AND JAMES METHOD

This Appendix draws heavily on Cameron and James (1986). Knowledge of this material is not essential to the Report.

WTP for fishing (wtp_i) depends on a number of factors such as fishing experience, income etc., which we denote by a vector X^T. In stochastic form we have:

(1) $$wtp_i = X^Tb + \varepsilon$$

where: ε is an error term which is iid ~ $N(0, \sigma^2)$.

In the CVM take it or leave it approach individuals are asked "Would you be willing to pay $\$t_i$ to go fishing today?" The answer is either "Yes" denoted by 1, or "No" denoted by 0. Thus the probability that we get a Yes response is:

(2) $$Pr(1) = Pr(wtp_i \geq t_i)$$

Using (1) this implies:

$$= Pr(X^Tb + \varepsilon \geq t_i)$$
$$= Pr(z_i \geq (t_i - X^Tb)/\sigma)$$

where: z is the standard normal random variable. Thus:

(3) $$Pr(1) = 1 - \Omega((t_i - X^Tb)/\sigma)$$

where: Ω is the standard cdf.

To estimate the marginal wtp Cameron and James suggest first running a Probit regression with the offer amount t_i as an explanatory variable. Thus let y_i = 1, 0. The Probit regression is:

(4) $$y_i = b_i t_i + X^t b \equiv a^T Z^T$$

It is shown that the following transformation can then be used to recover the parameters of wtp and the other explanatory variables:

(5) $$(t_i, X^T)\begin{bmatrix} -1/\sigma \\ b/\sigma \end{bmatrix} = - a^T Z^T$$

The results reported in Table 1a are based on the transformation in (5). It is perhaps worth noting parenthetically that t_i is defined as the answer to question (11) of the questionnaire. It is the additional wtp for the day's fishing which is the appropriate variable used. This is in keeping with the Cameron- James procedure.

APPENDIX D

DIFFERENCE BETWEEN MARGINAL VERSUS AVERAGE WILLINGNESS TO PAY

A sufficient condition for the law of diminishing marginal utility to hold is that for each individual in the sample wtp for a kgw must be increasing and concave in the number of kgw. Writing wtp as an increasing and concave function of kgw caught and kept:

(1) $$wtp^i = f(kgw^i)$$

where: wtp^i is wtp of individual i=1,...,n, and kgw^i = number of kgw kept by i = 1,..,n

The property that the marginal wtp is increasing in its argument implies:

(2) $$mwtp^i \equiv \frac{\partial(wtp^i)}{\partial(kgw^i)} > 0$$

Concavity of a function further requires that

(3) $$\frac{\partial^2(wtp^i)}{\partial(kgw^i)^2} < 0$$

The average wtp is defined as:

(4) $$awtp \equiv \frac{\sum_{i=1}^{n} wtp^i}{\sum_{i=1}^{n} kgw^i}$$

Define the difference between the awtp and mwtp for person i as:

(5) $$\Delta^i = (awtp - mwtp^i)$$

Let $\Delta^* = \text{Max}(\Delta^i)$ (i=1,....n). By concavity of wtp the individual identified in Δ^* has the largest catch. Refer to this individual as person j.

Consider a redistribution of the catch such that Δ^* declines, holding the total catch constant. Clearly, from (2) and (4) this requires either a decrease in $\sum_{i=1}^{n} wtp^i$, or an increase in $\frac{\partial(wtp^j)}{\partial(kgw^j)}$, or both. If the catch of individual j is reduced then the mwtp of person j rises by equation (3). For $\sum_{i=1}^{n} wtp^i$ to decline we require that the decline in person j's total wtp exceed the rise in wtp of the recipients of her catch. That is:

(6) $$\sum_{r=1}^{k} wtp^{r} < wtp^{j}$$

where; r = 1, ...k (k < n) denotes recipients of j's catch

Whether or not (6) holds depends critically upon the properties of the wtp function and the extent of the distribution.[39] More generally, to reduce the gap between awtp and mwtp we simply require that following a redistribution the mwtp (i.e., $\frac{\partial(wtp^{i})}{\partial(kgw^{i})}$) rises more rapidly than aggregate total wtp (i.e., $\sum_{i=1}^{n} wtp^{i}$). Once more this depends on the functional form of wtp.

[39] For instance if the wtp function is concave in kgw, but highly skewed to the right and we redistribute from a person at the peak to individuals deep in the tail then it can be mathematically demonstrated that (6) holds. Stated differently much depends on the precise functional forms involved.

APPENDIX E

RECREATION FISHING SURVEY QUESTIONNAIRE

APPENDIX F

THE TRAVEL COST METHOD ESTIMATES OF THE RECREATIONAL VALUE OF KGW

The terms of reference for this project requires that the contingent valuation estimates of the recreational value of kgw be compared to estimates obtained from a travel cost study. Before briefly describing the travel cost method (tcm) it is worth noting that the data requirements and degree of recall required of respondents in a travel cost survey are considerably greater than for a contingent valuation study. In addition, the econometric and statistical shortcomings inherent in the procedure are also the subject of controversy. These factors appear to make the travel cost method a somewhat less useful and reliable procedure for estimating recreational values in the SA context.

The Procedure

The tcm has its genesis in the pioneering work of Clawson and Knestch (1966). The procedure is based on the obvious notion that individuals respond to costs imposed by distance in the same manner in which they react to prices. To see this consider a city located near two beaches termed A and B. Assume that beach A is located 5 km away from the city and B is 10km from the city. If travel to the more distant beach involves greater expenditure in terms of time and money, then fewer city dwellers will visit this beach. In essence, travel costs act as a proxy for entry fees. The nearer beach with the lower travel cost (i.e., entry fee) is in greater demand than the more distant site with the higher travel costs (fees). It follows that travel costs to a recreational site can be used to derive the price that people are willing to pay to visit the site. This is the simple and appealing idea underlying the tcm.

Econometrically the tcm begins by seeking to explain the number of trips a person makes to a site in a year. This is termed the participation equation, which is then used to determine recreational value. The number of trips (T) is generally seen to depend on money costs (denoted M), substitute sites (denoted S), time spent travelling (i.e., time costs denoted TI) and other things such as income, attraction of site, fish, etc (denoted by a vector X).

$$T = f(M, S, TI, X) \qquad (1)$$

There are a litany of difficulties associated with estimating such participation equations. We begin by briefly outlining a few of the more significant problems.

The information required to estimate such an equation places considerable demands upon respondents. First, not all respondents interviewed at their local metropolitan boat ramps could recall the number of trips made to the ramp in a year. Thus tcm estimates based on data from the metropolitan ramps are likely to be somewhat imprecise.

Respondents who travelled to more distant locations to fish had no difficulty in recalling the number of trips to a site. However, they were required to identify substitute sites. Failure to take account of substitute sites would result in omitted variable bias.

The tcm is also based on the assumption that the trip is undertaken for a single purpose. This assumption seldom holds in the South Australian context. A fishing trip to non-metropolitan ramps is often treated as part of a family holiday and is combined with trips to other recreational sites. This means that travel and time costs should be apportioned to these alternative destinations. Failure to do this leads to upward bias in the estimates. Once again few respondents were able to identify these alternative destinations in advance. The typical response being that the respondent was "Undecided where we go". A number of arbitrary mechanisms have been suggested to control for this problem.[40] It is, however, generally acknowledged that failure to obtain the appropriate information ultimately biases the estimates.

A further and more critical problem relates to the value which is to be given to the time spent travelling (termed time costs). It is widely recognised that tcm provides underestimates if time costs are ignored. This is a particularly troublesome issue since travel time may be valued differently from leisure time. In this study we employ the procedure outlined by McConnel and Strand (1981) to derive an estimate of time costs from the data. It should, however, be noted that this procedure is not without its shortcomings. The approach is based on the assumption that people can choose to substitute time spent travelling for work. This is, of course, true for only a subset of individuals. Most workers have limited freedom to make this exchange. Vacations of prescribed length are the norm in most labour contracts in Australia. This suggests that quantity rationing models may be more relevant. However, the data requirements of these models far exceed the resources which have been made available for this study.[41]

Even if these problems could be overcome there remains a more severe difficulty which renders the tcm of very limited use in the SA fishing context. To determine the value of a site it is necessary to obtain data on travel costs to the site from a variety of distances. If all visitors to a site travelled from the same location there would be no variation in the travel cost variable so that statistical estimation would be impossible. In South Australia, fishers at metropolitan ramps typically travel to a ramp for a short distance which involves 20-30 minutes travel from their homes. In contrast, the overwhelming majority of visitors to the more distant non-metropolitan ramps travel from Adelaide to these sites. In both cases there is therefore very little variation in travel distances and travel costs which implies that limited confidence can be placed on the tcm estimates.

Finally, it should be noted that the tcm and cvm estimates cannot be directly compared since they measure different aspects of wtp. Formally, tcm is based on Marshallian demands while cvm is based on compensated demand functions. Theoretically this means that the former estimates will invariably exceed the latter. Thus, Carson et al (1995) in a survey of studies found that tcm always generated the larger estimates.

The Results

The questionnaire used to obtain data for the tcm study is attached to this Appendix. It was deemed necessary to conduct a *separate survey* for the tcm study since a combined cvm-tcm survey would have resulted in an unreasonably long interview. Moreover, the demands placed upon respondents by the tcm questionnaire could well have jeopardised the cvm study. The tcm surveys were conducted at metropolitan ramps in Adelaide (O'Sullivan's, North Haven, St. Kilda, Glenelg) and boat ramps at Edithburg and Stansbury in the Yorke Peninsula. A total of 83 useable observations were obtained from these sites.

40 See for instance Haspel and Johnson (1982).
41 McKean et al (1996) outline one variant of the quantity rationing approach.

The procedure used is that described by McConnell and Strand (1981) which has been widely employed in tcm studies. Owing to the paucity of the results in what follows we merely outline the results of the exercise. Readers interested in the technical details are referred to McConnell and Strand (op cit). The regression yielded the following participation equation which is summarised in Table 1 below.

TABLE 1: TCM REGRESSION

Variable	Coefficient	t-ratio
Average kgw kept	0.038019	1.066
Average other fish kept	0.06896	1.72
Travel costs	-0.00035	2.029
Substitute sites	-5.613	2.106
Own boat	1.892	3.058

Note: Dependent variable is log(No. of trips to boat ramp); N = 83; R^2 = 0.249; Adjusted R^2 = 0.199; SE=2.203; DW = 2.298; Breusch - Pagan = 8.015; Ramsey-Reset = 6.891

The first two terms represents the average number of number of kgw and other fish caught and taken home after a fishing trip at the site. The next term is travel costs. The fourth variable is an index of substitute sites which was constructed using the procedure outlined by Loomis (1981). Finally, own boat is a dummy variable which indicates whether the respondent owns her/his boat.

The results reveal that trips to a site increase with the catch kept and if the respondent owns a boat. Presumably the former reflects the attractiveness of a site to a fisher while the latter indicates her/his investment in fishing as a recreational pursuit. However, trips decrease with higher travel costs and an increase in substitute sites.

The equation appears to be badly determined with a low degree of explanatory power as measured by the R^2 and there is also some evidence of misspecification. Moreover, the variables “Average kgw kept” and “Average other fish kept” are statistically insignificant at the 1 per cent level. In addition, when income was included in the regression this too was statistically insignificant and had the wrong sign. Its inclusion worsened the fit of the kgw term. These statistical problems appear to be a direct consequence of the data difficulties alluded to earlier. In particular the lack of variation in the travel cost term, and the difficulty in obtaining accurate information from participants on the average catch seem to be responsible for this badly determined equation.

The coefficient of kgw kept in table 1 provides an estimate of the total value of kgw. It can, however, be used to calculate the marginal value. This is obtained using an approximation outlined by Loomis (op cit) which has been widely employed. Applying this approximation to our data set yields a marginal value of $ 3.42 per kgw. This figure is considerably greater than the estimate obtained using the cvm, which as noted earlier, is consistent with theoretical expectations.

There have been two previous tcm studies of recreational fishing in Australia. Collins (op cit) using a similar procedure to that outlined here obtained a wtp for kgw in SA of $20.8 using the tcm and $0.36 using the contingent valuation method. In contrast, Bueren (1996) in a study of the WA fishery reports the total values obtained. A total value of $17.9 was obtained using the contingent valuation method and $60.3 using the tcm. Thus a higher contingent valuation method estimate is both a predictable and common feature. In addition, it worth noting that the tcm regression results reported in both these studies are badly determined with poor goodness of fit, insignificant explanatory variables and heteroskedastic residuals. These difficulties suggest the need for caution in using the tcm to measure the value of recreational fishing.

In conclusion, it is worth emphasising that the litany of problems associated with the tcm has rendered it a less reliable and highly questionable method for determining wtp in the SA fishery context. Perhaps the only useful and reasonable conclusion to be drawn from this tcm study is that the contingent valuation method estimates of Section 2 provide a clear lower bound to the true marginal recreational value of kgw.

TRAVEL COST METHOD QUESTIONNAIRE

Date of Interview ....

Time of Interview ....

Location of Interview...

Diurnal Temperature Range..

Rain Drizzle Cloudy Sunny

Name of Interviewer...

A. INDIVIDUAL FISHING DETAILS

1 a What time did you leave the boat ramp (to go fishing) today?

Departure Time....................

1 b What time did you arrive back at the ramp?

Arrival Time....................... Total Time..........................

2. On average how long do you stay out fishing on each trip?

...............Hrs ....Mins

3. How many times have you gone out to sea fishing in the **past 12 months?.............................. times**

4. Do you normally fish from:

1. BOAT; 2. JETTY/WHARF; 3. LAND (SHORE)

5 a Do you own your own boat? **YES**
NO (go to question 4)

5 b Does your boat have an echo sounder? **YES**
NO (go to question 4)

6. What did today's catch consist of?

SPECIES	NUMBER
SNAPPER	
KGW	
GARFISH	
BLUE CRABS	
OTHER	

7. Did the people fishing from your boat today come from MORE than one household?

YES go to question 9 **NO go to question 10**

8. What proportion of today's catch will you take home for yourself?

PERCENT/NUMBER...
(delete one)

9.a How many trips have made to this site in the past year? **.........................Trips.**

9.b On average what fish do you take home after a visit to this site?
....
....

10.a How far is this boat ramp from your home (residence)?**.........................Km/ Miles**
(delete one)

10.b What is the post code of your home?.............

11. How long does it take you to travel to this ramp?**............................**

12. How much did it cost you in fuel and travel related expenses to get to this ramp? **$...........**

13. How much did you spend today on your fishing trip on **other items** such as bait, ramp fees, ice, food etc (Exclude major items of equipment)? **$........................**

14. On average how much do you normally spend on a fishing trip?
$...

15.a What other sites do you regard as alternatives to fishing at this ramp?
SITE... Distance from Home................
SITE... Distance from Home................

15.b What other alternative sites are you planning to visit while on holiday here?
SITE... Distance from Home................
SITE... Distance from Home................

B. DEMOGRAPHIC CHARACTERISTICS

To make sure that we are interviewing a wide cross section of people I need to ask you a few more questions.

1. RECORD SEX OF PARTICIPANT: **MALE**
FEMALE

2. Which age group do you fit into?

A	**16 - 20 years**	**D**	**41 - 50 years**
B	**21 - 30 years**	**E**	**50 - 60 years**
C	**31 - 40 years**	**F**	**60 + years**

3. What is your occupation?**..**
(If unemployed end interview)

5. Do you work full time or part time? **FULL TIME** **PART TIME**

6. Could you please indicate the category of your GROSS income BEFORE TAX or anything else is taken out ?

A	**Under $ 20,000**	**B**	**20,000 - 35,000**
C	**35,000 - 50,000**	**D**	**50,000 - 65,000**
E	**More that 65,000**		

Thank you very much for the time and effort spent on this interview. Your responses will be of very great use to us in our research.