Bioeconomic Analysis of the Queensland Beam Trawl Fishery

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Non-Technical Summary

94/035 Bioeconomic Analysis of the Queensland Beam Trawl Fishery

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Objectives

1. To provide a comprehensive description of the beam trawl fishery, including fleet composition, species composition of the catch, catch and effort time series, destination and value of the catch, economics of production and value to the local economy.

2. To estimate the costs imposed by beam trawlers on recreational fishers and other commercial operators harvesting the resource.

3. To estimate the net economic benefits or costs to the competing sectors and the broader community of altering the level of beam trawl activity in each river system.

4. To assess management options currently under consideration, including possible levels of compensation.

Non-technical Summary

The study estimates the benefits and costs of the beam trawl fishery to the Queensland economy in each of four study areas. Benefits are values of catches and costs include catching costs and costs imposed on the recreational and otter trawl fisheries, through by-catch, congestion and habitat disturbance in the case of the recreational fishery, and through competition for prawn stocks in the case of the otter trawl fishery. Chapter 2 of the study provides a comprehensive review of the beam trawl fishery. Chapters 3 and 4 deal with the interactions between the beam trawl fishery and the recreational fishery. Chapter 5 models these interactions together with the interaction with the otter trawl fishery. Chapter 6 summarises the study and presents the conclusions.

Three surveys were conducted of the beam trawl and related fisheries: a survey of the recreational boat and shore fishery in areas nominated by the Project Steering Committee; a beam trawl by-catch survey; and an income, costs and returns survey of beam and otter trawl vessels. Using the results of these surveys, together with those of previous surveys, information about the prawn fisheries available in published articles and reports, and vessel logbook data, a simulation model of the beam trawl fishery and its interactions with the recreational and otter trawl fisheries was constructed. The model was used to estimate the net contribution of the beam trawl fishery to the economy in each of four study areas: Area 1 between 27°S and the NSW border, and Areas 2, 3 and 5. The net contribution is measured as prawn revenues less all variable, annual and capital costs, and less the costs imposed by beam trawling on the recreational and otter trawl fisheries.

The model results indicated that, at current levels of effort, the returns from the fishery between 27°S and the NSW border in Area 1 are more than sufficient to cover the costs involved in beam trawl operations - including the costs imposed on the recreational and otter trawl fisheries - and justify the continuation in the long term of the current level of investment in the fishery. For the other areas it appears that the returns are sufficient in Areas 3 and 5 and not quite sufficient in Area 2 to justify the long term continuation of the current level of investment in the fishery. Given this and the sensitivity of the results to the variable and parameter values used, there appears to be little to gain economically from the closure of the beam trawl fishery, particularly when adjustment costs may need to be incurred as resources from the fishery are reallocated to other sectors within the economy.

If management options included reducing but not eliminating the level of beam trawl effort on an area by area basis, then relatively small economic gains could be had by reducing effort to around half of the current levels except in Area 3. The gains from this policy would be small and unlikely to justify the additional management costs.

If beam trawl vessels are excluded from the fishery their owners may experience costs. A range of costs is calculated for active beam trawlers in each of the four study areas under different assumptions about the alternative activities available to the excluded vessels. Costs range from zero to almost $60,000 in Area 1.

Keywords: Queensland beam trawl fishery, social costs, benefits

Background

Prawn production is Queensland’s single most valuable fishing activity. In 1995-96 the value of production of prawns from Queensland’s waters was estimated to be around $84 million (ABARE 1996a). Prawns are harvested by a number of different sectors and at various stages in their life cycles. Beam trawlers operate mostly in estuaries and rivers harvesting juvenile and adult prawns for the bait and food markets. Otter board trawlers operate in deeper waters, predominantly harvesting adult prawns for the food market.

The beam trawl fishery is divided into 5 areas along Queensland’s east coast. Catches from the fishery can be divided into three broad categories. In the northern part of the fishery (Areas 2 to 5) the catch consists primarily of banana prawns with greasyback and other prawns taken in smaller numbers. In the part of Area 1 lying south of 27°S to the NSW border (including Moreton Bay) the catch consists predominantly of greasyback prawns, with school, banana and other prawns being taken in smaller numbers. In the northern section of Area 1 (from Double Island point (just north of 26°S) to 27°S) the fishery is based predominantly on the catch of school prawns with minor catches of greasyback, king and banana prawns being taken.

The Queensland east coast beam trawl fishery has attracted some criticism in recent years. This criticism is based on concerns that the beam trawlers take fish species as by-catch which contributes little if any value to their operations but which are of value to recreational fishers, and that their catch of juvenile prawns adversely affects catches of the more valuable adult prawns offshore. The view has also been expressed that beam trawling disturbs estuarine habitats and hence adversely affects fish and prawn stocks.

Recreational fishers benefit from the beam trawlers’ supply of bait prawns, which would otherwise need to be met from some other source, such as imports or substitute products. Nevertheless recreational fishers have at times criticised the beam trawl method. A Queensland state government inquiry into recreational fishing (the Burns Inquiry) recommended that river/inshore beam trawling operations be phased out with immediate attention given to the Burnett, Mary and Burrum Rivers, Great Sandy Strait and the rivers of Moreton Bay (Recreational Fishing Consultative Committee (1993)).

In response to the recommendations of this report, and the lack of information about the beam trawl fishery, the Queensland Commercial Fisheries Organisation (QCFO) commissioned WBM Oceanics to conduct a survey of commercial beam trawl operators to estimate the contribution of the fishery to the local economy and the likely impacts of closing the fishery. While this study provides a useful survey of the fishery it does not attempt to quantify the extent to which the value of the recreational or offshore commercial fisheries would be increased by phasing out the beam trawl fleet. The main purpose of the present study is to fill that gap.

In Chapter 1 various aspects of the Queensland beam trawl fishery are reviewed and discussed. These include management arrangements, catch rates, levels and values, fleet size and composition, and the interactions with the recreational and offshore otter trawl fisheries. Chapter 2 examines the value of various fish species to the recreational fishery. A sample survey of recreational shore and boat fishers operating in the five areas nominated by the Project Steering Committee - the Logan, Pine, Mary and Burnett rivers and Repulse Bay - was carried out to determine information about fishers and fishing days. Using this information, together with techniques of demand analysis and contingent valuation, various estimates of the contribution of factors such as fish catches and congestion to the value of a recreational fishing day were obtained. In Chapter 3 the impact of beam trawling on the factors which contribute to the value of a recreational fishing day is analysed and quantified. The analysis draws on the results of the recreational fishing survey and of a beam trawl by-catch survey conducted on the Logan, Mary and Burnett rivers and Repulse Bay, as well as on previous studies. On the basis of the analysis reported in Chapters 2 and 3 it is possible to estimate the cost to the recreational fishery - in terms of reduced value of recreational fishing days - imposed per unit of beam trawl effort.

The main focus of Chapter 4 is the interaction between the beam and otter trawl fleets. The analysis is based on regional models of the banana and greasy back prawn fisheries. These models consist of biological models taking account of prawn stocks, mortality, recruitment, growth and migration, as well as economic models of costs and returns, based partly on a survey of beam and otter trawl operators. The extent to which the beam trawlers impose a cost on the otter trawl fishery, through their catches of juvenile prawns, is determined by estimating and comparing the returns to the otter trawl fishery from the prawn stock with and without beam trawl effort. The results of this comparison are used to determine the cost imposed on the otter trawl fishery of any given level of beam trawl effort.

Chapter 4 also incorporates the results obtained from the recreational fishery into the analysis. The profits earned by the beam trawl fleet are reported for four regions within the fishery: the greasyback prawn fishery in Area 1, and the banana prawn fisheries in Areas 2, 3 and 5. The net benefit of the beam trawl fishery to the economy is calculated as the profits earned by the beam trawl fleet less the costs it imposes on the recreational and otter trawl fisheries. When these costs are subtracted from the profits of the beam trawl fleet the net value of the fishery to the economy is obtained.

The results of the study are discussed in Chapter 5. It was found that even accounting for the costs it imposes on the recreational and otter trawl fisheries, beam trawling in Area 1 makes a positive contribution to the economy. The benefits of beam trawling in Areas 2, 3 and 5 at current levels of effort appear to be just sufficient to cover all the costs associated with exploiting the prawn resource in these fisheries.

Need

Following the Burns Inquiry, a White Paper released by the Queensland Government (1993) on the future on the future of fisheries in Queensland recommended that beam trawl operations be phased out in Pumicestone Passage and Burnett River, followed by reductions elsewhere. However there has been insufficient information available on the current value of the beam trawl fishery to enable managers and industry to determine the appropriate allocation of the resource between the competing users. There is no adequate description of the beam trawl fishery in terms of fleet composition, species composition of the catch, catch and effort time series, destination and value of the catch, economics of production and value to the local economy. Most importantly, there is no information available on the interactions among the three sectors (beam trawlers, otter trawlers, and recreational fishers) and on the potential benefits (if any) of reducing beam trawl effort. If buy-back arrangements are to be instigated the above information is essential to ensure that the maximum benefit is achieved.

Objectives

1. To provide a comprehensive description of the beam trawl fishery, including fleet composition, species composition of the catch, catch and effort time series, destination and value of the catch, economics of production and value to the local economy.

2. To estimate the costs imposed by beam trawlers on recreational fishers and other commercial operators harvesting the resource.

3. To estimate the net economic benefits or costs to the competing sectors and the broader community of altering the level of beam trawl activity in each river system.

4. To assess management options currently under consideration, including possible levels of compensation.

Methods

State-of-the-art methods of bioeconomic modeling were used to answer three central questions. First, what is the value of additional catches in the recreational fishery? Second, to what extent do the operations of the beam trawl fishery affect catches in the recreational fishery? Third, how do the operations of the beam trawl fishery affect the otter trawl fishery? The answers to these questions were then combined in a bioeconomic model which provided estimates of the combined value of the three fisheries under different levels of beam trawl effort.

The methods used to answer the first question were those of recreational demand analysis and contingent valuation, based on a sample survey of recreational boat and shore fishers. The demand analysis employed the total direct cost method, while the contingent valuation study used a double bounded dichotomous choice model in order to minimize the effect of possible sources of bias.

The second question was answered by means of a literature review supplemented by a by-catch survey conducted in key river systems.

Virtual population analyses of the various prawn stocks, together with assumptions about spawning and migration patterns, were used to construct a model of the interaction between the beam and otter trawl fisheries.

The above studies were the basis of a simulation model, assembled on a spreadsheet, which was used to calculate the combined contribution of the three fisheries to the economy under different levels of beam trawl effort, allowing for consequent changes in otter trawl and recreational fishing effort.

While the methods used are now standard in the theoretical literature and in advanced applications, this is probably the first study which combines them in a bioeconomic analysis of the production and consumption externalities imposed by a commercial fishery. For this reason the study is likely to be used as a model for approaching similar problems in other fisheries. The results of the recreational fishing study are likely to be cited in less detailed studies as measures of the value of additional catch of various finfish species.

Discussion and Results

1. Description of the Beam Trawl Fishery

Queensland fisheries regulations allow for three forms of beam trawling in state managed waters. These are off-shore, inshore, and river beam trawling. Offshore beam trawlers, of which there are none currently operating, are managed as part of the Queensland east coast otter trawl fishery. River and inshore beam trawlers are managed as a separate fishery known as the Queensland beam trawl fishery, and operate in creeks, rivers and inshore areas over much of the Queensland east coast. It is this fishery that is the central focus of this study.

The resources/grounds exploited by beam trawl operators are also used by other groups within the community. As such, management decisions relating to the beam trawl fishery also impact on these other stakeholders. Representatives of several community groups have expressed concerns in the past about the management of the beam trawl fishery, including those from the recreational fishing sector and the otter trawl fishery. The objective of this chapter is to provide an overview of the beam trawl fishery and its management and interactions with the recreational and otter trawl fisheries, so as to establish the context within which the analysis presented later in this study is conducted.

To do this it is first important to define the various components of the fishery in a clear and succinct manner. The following terminology will be employed throughout this report when alluding to the various areas and sectors of the fishery. First, the various sectors involved, either directly or indirectly, in the fishery are referred to as stakeholders. Second, the fishery as a whole, including all stakeholders and the area encompassed by the Queensland beam trawl fishery will be referred to as the river/inshore fishery. Finally, the terms beam trawl fishery, recreational fishery, and otter trawl fishery will refer specifically to these fisheries, with the latter also being referred to as the offshore fishery. The Moreton Bay trawl fishery is also referred to as the bay trawl fishery, and refers to the otter trawl fishery in Moreton Bay.

The Queensland beam trawl fishery

Beam trawling in Queensland originated in the river systems of Moreton Bay, preceding the development of the otter trawl fishery. Up into the mid-1970s, the beam trawl fishery operated on an artisanal basis, with displacement hull vessels operating in estuaries, mainly in south Queensland, targeting greasy, school and banana prawns on a seasonal basis. After this time the fishery expanded with the introduction of more efficient technology and more operators into the fishery (QFMA 1996).

In 1983 limited licensing was introduced into the river and inshore beam trawl fishery. In particular, limited licensing was applied to river systems in Moreton Bay and Pumiceston Passage and to the Noosa and Burnett River systems. By the end of

1984 the beam trawl fishery had been zoned into five areas along the east coast of Queensland and was prohibited in the waters of the Gulf of Carpentaria under Northern Prawn Fishery management arrangements.

The expansion of the fishery has lead to criticisms of the fishery by a range of interest groups, including conservationists and recreational fishing interests, and some sections of the commercial fishing industry. These interests have expressed concerns about:

- environmental damage induced by beam trawlers;
- the taking of juvenile prawns (particularly banana prawns) before their movement offshore and their availability to otter trawlers, thereby reducing the value of the resource; and
- the incidental capture of important angling species such as bream and flathead and other marine species (QFMA 1996).

In 1992 the Queensland State Government conducted an inquiry (the Burns Inquiry) into recreational fishing which recommended

- That river/inshore beam trawling operations be phased out with immediate attention to the Burnett, Mary and Burrum Rivers, Great Sandy Strait and the rivers of Moreton Bay except the Brisbane River upstream of Luggage Point to the Victoria Bridge; and
- That all river/inshore beam trawling endorsements be made non-transferable (Recreational Fishing Consultative Committee (1993)).

Management arrangements

The Queensland beam trawl fishery is sub-divided into five areas, with operators needing an endorsement for each specific area, and is primarily regulated through a combination of limited licensing and gear restrictions. Table 1.1 shows the boundaries of, and vessel and net restrictions enforced in, the respective areas.

The restrictions on the beam length results in operations always being on a small scale. The minimum mesh size of 25 mm (1 inch) in many areas often causes conflict between the beam trawl fishery and the otter trawl fishery, where the minimum mesh size is set at 38 mm (1 1/2 inches). The smaller net mesh size for the beam trawl is set to suit the fishery as, particularly in the southeast of the state, it is based on capturing school and greasy back prawns for the bait market. Banana prawns for human consumption become a larger and more important component of the catch the further north the area fished. As well as gear restrictions, seasonal, weekend, area and river closures are used as tools to manage the fishery. The exact regulations depend upon the area fished and are similar to those that apply to net fishing in the particular area.

1.1 Beam trawl area specification and vessel and trawl net restriction

<u>Vessel length restrictions</u>	
All areas	Maximum length 9 metres
<u>General trawl net specifications</u>	
Area 1: Waters south of Double Island Point to NSW border	Beam length up to 5m - Minimum mesh 25mm (Brisbane River and mouth and other rivers and creeks) Beam length up to 5m - 38-60 mm mesh (Moreton Bay) Beam length up to 5m - Minimum mesh 28mm (Noosa River and Lakes)
Area 2: Waters between Double Island Point and Burrum River	Beam length up to 5m - Minimum mesh 25mm (Great Sandy Straits and rivers and creeks) Beam length up to 10m - 38-60 mm mesh (Hervey Bay)
Area 3: Waters between Burrum River and Richards Point (Rodds Peninsula)	Beam length up to 5m - Minimum mesh 25mm (Rivers and creeks)
Area 4: Waters between Richards Point (Rodds Peninsula) and Reef Point (south of Townsville Island)	Beam length up to 5m - Minimum mesh 25mm (Rivers and creeks) Beam length up to 10m - 38-60 mm mesh (Part of Keppel Bay and near Facing Island) Beam length up to 5m - Minimum mesh 25mm (Fitzroy River)
Area 5: Waters between Reef Point (south of Townsville Island) and Cape York Peninsula	Beam length up to 5m - Minimum mesh 25mm (Rivers and creeks) Beam length up to 10m - 38-60 mm mesh (Llewellyn Bay, Repulse Bay, Sinclair Bay and Cleveland Bay)

Source: QFMA 1996

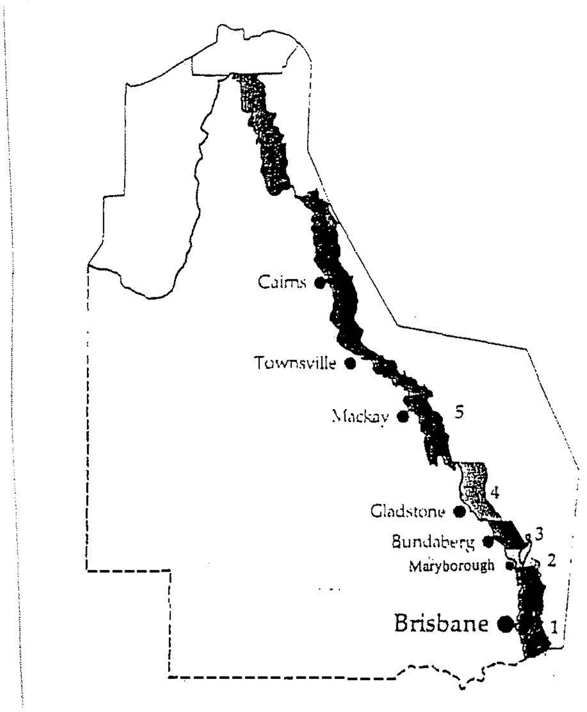


Figure 1I: Map of beam trawl fishery by area (QFMA (1996))

In 1998 QFMA released a paper detailing proposed management arrangements for the Queensland trawl fishery, of which the beam trawl fishery is a part. In this paper the following management interventions were proposed for the beam trawl fishery.

- Increase the minimum mesh size for beam trawl nets from 25 to 28 mm
- Implement the compulsory use of trawl bycatch reduction devices (BRDs) for all bream trawlers
- Implement a voluntary buyback scheme for the beam trawl fishery which provides the opportunity to surrender a beam trawl endorsement attached to a licence for $5000. The surrender must occur by June 30 1998 (QFMA (1998)).

The prawn resource

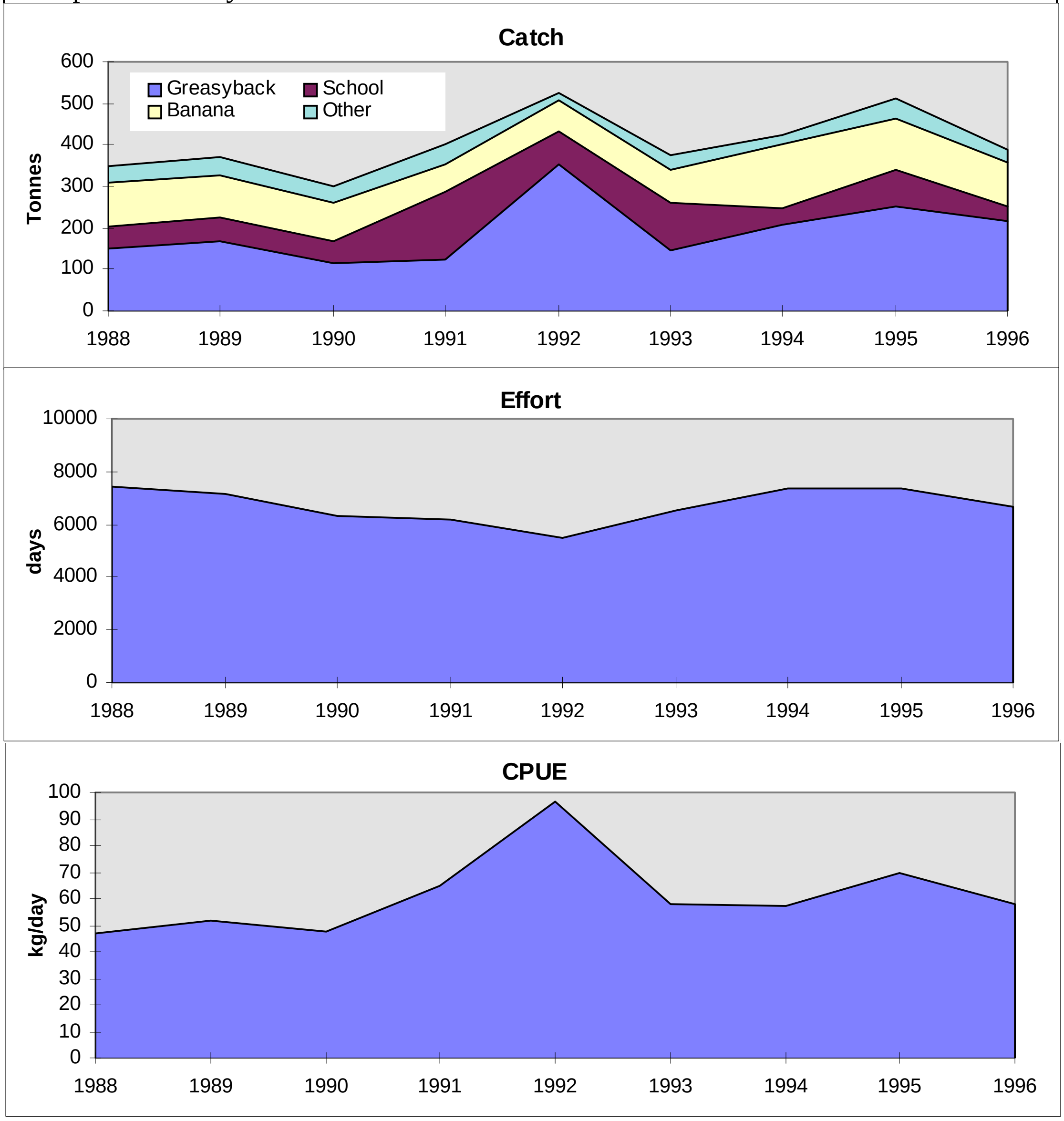
The value of the prawn catch from the beam trawl fishery in 1996 was estimated to be about $2.4 million. The catch consists primarily of greasyback (or bay) (*metapenaeus bennettae*), school (*metapenaeus macleayi*) and banana (*penaeus merguiensis*) prawns. These three species make up around 90 per cent of the total prawn catch.

The estimated total prawn catch in 1996 was 387 tonnes, slightly lower than the estimated annual average total prawn catch over the period 1988-1996 of 405 tonnes. These figures and other catch and effort data presented in this chapter are derived from logbook data collected by QFMA. However, several things in relation to this data source should be noted. First, between 1988 and 1991 beam trawl logbook data collected by QFMA were entered into a mixed fishery data base. As such, these data include prawn catches landed by operators using stripe (set pocket) nets, of which there are 10 operating in a restricted number of estuaries, particularly the Mary River. These stripe netters catch about 30 tonnes of banana prawns annually, however as this species is noted for its response to climatic conditions catches may vary dramatically between seasons (QFMA 1996). From 1992 onwards beam trawl returns were entered into the trawl logbook data base, however, as some operators still used mixed logbooks, some data from these operations were entered into the mixed logbook data base. Also, it is not possible to readily distinguish prawn catches from the otter trawl and beam trawl fisheries where a licence package includes both endorsements (some 27 of the 222 beam trawl endorsement holders also hold an east coast otter trawl endorsement). Further, to obtain the beam trawl data from the trawl data base it is necessary to identify vessels holding beam trawl endorsements and then to extract the information relating to this group of vessels. As it is not possible to relate data to a specific boat or operator (due to the confidentiality of the data) it is only possible to track catch and effort over time through a vessel sequence number. When a package is sold it is assigned a new vessel sequence number. Consequently, the data obtained were for those packages which existed in 1996, and as such only covers a portion of the beam trawl fleet in prior years (that is, for those operators who held endorsement in both 1996 and the relevant year). It is from these data that the estimates presented were derived.

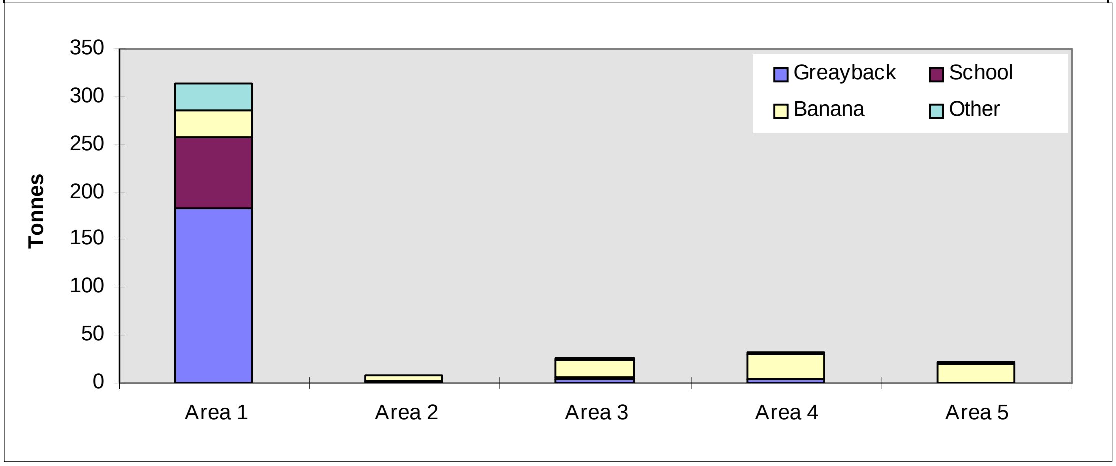
From Graph 1A it can be seen that while there has been some variation in total catch and effort levels over the last decade, no contractionary or expansionary trend is evident. Further, catch per unit effort (CPUE) in the fishery has not declined over this period and, hence, the fishery does not appear to be suffering from recruitment overfishing.

The majority of the total catch is taken in Area 1, with almost the entire greasyback and school prawn catch being landed in this area and only banana prawns being taken in substantial numbers in the other areas (Graph 1B). In Graph 1C, the seasonal variation in catch levels of the various species can be seen. The difference in fishing patterns between areas is also reflected in this figure with the season in Area 1 starting in October/November (reflected in the greasyback and school prawn catch) with the main season in northern areas not commencing for another few months, as reflected by the higher banana prawn catch at that time.

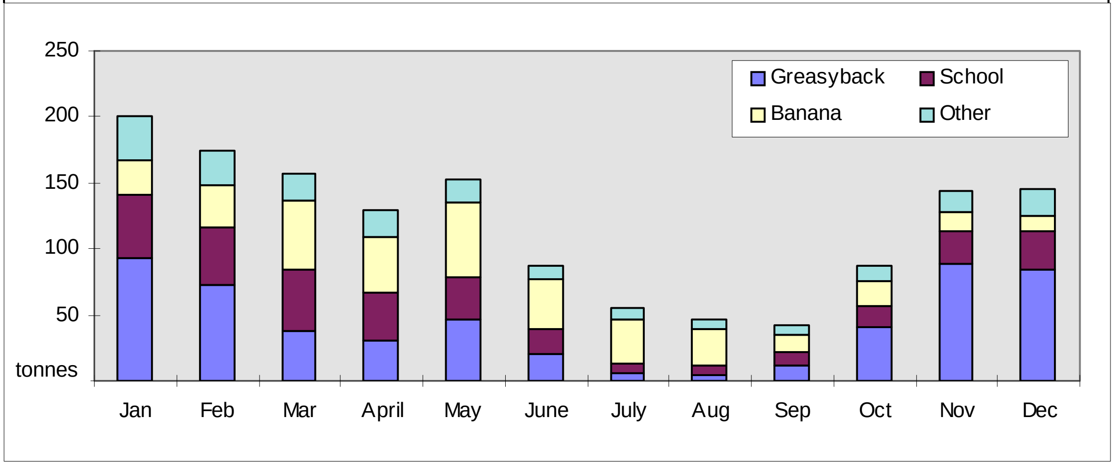
1A Estimated catch, effort and catch per unit effort in the Queensland beam trawl prawn fishery 1988 –1996



1B Composition of average annual catch by zone 1988-1996



1C Composition of average monthly catch 1988-1991



Fleet structure and fishing pattern

Some 222 vessels were endorsed to fish in the Queensland beam trawl fishery as at June 1996. Of these vessels 110 participated in the fishery during 1996 with participation rates in the fishery varying from around 70 per cent in areas 1 and 3 to around 30 per cent in areas 2 and 5 (Table 1.2). As can be seen in Graph 1D holders of beam trawl endorsements also hold a range of other licences, as is the case for most Queensland fisheries with few operators holding endorsements for a single fishery. This pattern of endorsements means that the fishing pattern and number of vessels operating in the fishery at any given time is determined not only by the beam trawl fishery management regulations and profitability, but also by the management regulations and the relative profitability of the other fisheries for which operators hold endorsements. Also, the fleet is highly mobile, in that it can enter and exit the fishery at short notice. Further, given the large number of endorsed vessels not participating in the fishery the level of latent effort (that is, the additional effort that could be applied to the fishery) is high. These factors have several consequences for the management of the fishery.

- First, the mobility and multiendorsed nature of the fleet may help to protect the fishery from overfishing as it allows for the dispersion of effort from the fishery where and when prawn catches are relatively low.

- Second, difficulties may arise in trying to reduce actual effort levels due to the high level of latent effort in the fishery.

- Third, any successful attempt to reduce effort in the beam trawl fishery may have consequences for other fisheries that beam trawl operators may be endorsed for, in that operators may compensate for any reduction in effort in the beam trawl fishery with an increase in effort in the other fisheries.

1.2 Endorsed and active beam trawl vessels in 1996 by zone

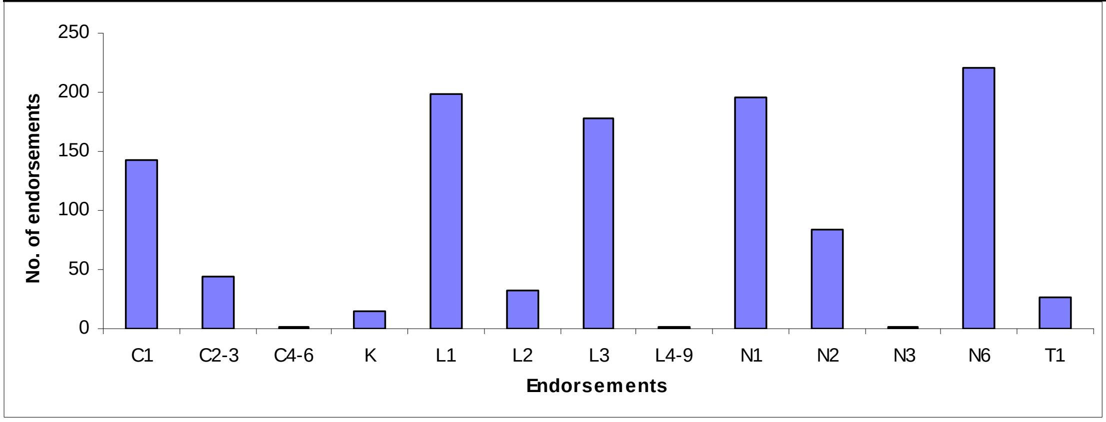
	Number of endorsed vessels	Trawled for prawns in 1996	
		Number	% of total
Area 1	76	52	68.42
Area 2	26	8	30.77
Area 3	11	8	72.73
Area 4	44	24	54.55
Area 5	64	18	28.13
Total	221	110	49.77

1.3 Value of prawn and other fishing catch taken by active beam trawl operators[a]: 1996

	Prawns		Other		Total value	% of total income from prawns
	Weight	Value	Weight	Value		
Area 1	298,985	1,672,018	497,342	1,617,716	3,289,734	50.83
Area 2	19,006	165,459	161,312	762,046	927,505	17.84
Area 3	28,779	232,863	66,773	243,321	476,184	48.90
Area 4	37,015	338,284	302,602	1,867,823	2,206,107	15.33
Area 5	43,011	435,540	487,756	2,615,209	3,050,749	14.28
Total	426,796	2,844,164	1,515,785	7,106,115	9,950,279	28.58

a Prawn catch includes catches taken by otter trawl endorsed operators in both the beam trawl and otter trawl fisheries.

1D Fishing endorsements held by Queensland beam trawl operators (at June 1996)



The fishing method

Beam trawling is a fishing technique applied in a range of fisheries throughout the world. A beam trawl differs from the more prevalent otter trawl in that the mouth of the net is held open by a rigid frame or beam rather than by the action of water shearing forces against otter boards as in otter trawls. A basic diagrammatic representation of the components of a beam trawl are shown in Figure 1II.

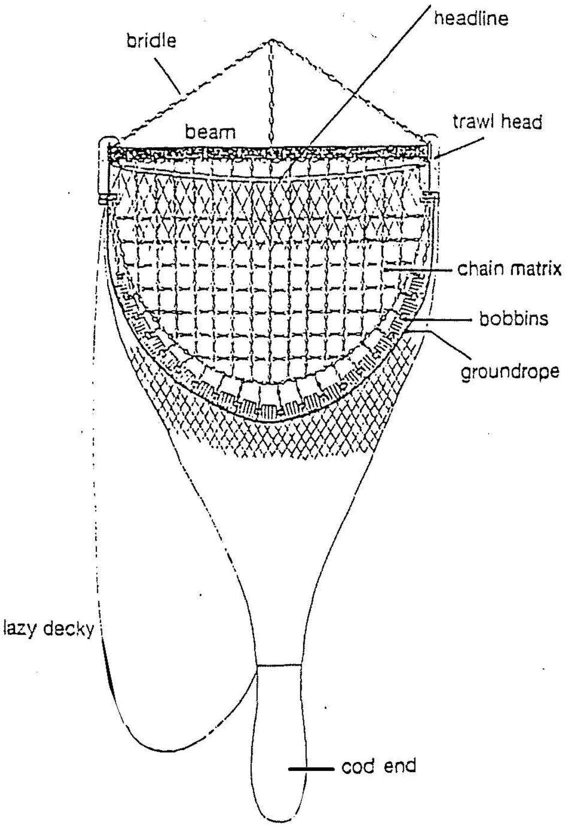


Figure 1II: Commercial beam trawl apparatus (Kaiser and Spencer (1995))

Fishing vessels operating in the beam trawl fishery are restricted to a maximum of 9m in length, with the length of many vessels being less than 7m. Consequently beam trawling operations are on a small scale, with, in most situations, the boat being worked by a single individual, usually the owner. Shots vary in length depending on the nature of the operation and the number of crew on board, but are usually of a short duration of between 15 and 30 minutes (Hyland and Gilmour (1988)). Many beam trawl operators work alone and time must be spent sorting the catch between shots. This compares with the larger offshore trawlers where the nets are shot away immediately after they are retrieved and emptied onto sorting trays so that trawling is more or less continuous.

Market structure

Prawns from the beam trawl fishery are primarily destined for two markets, with greasyback and school prawns usually being as sold as bait prawns, and banana prawns being sold as prawns for human consumption. Operators usually sell product to processors who then onsell the product to retailers, although some operators sell their product directly to retailers and/or consumers. Product from the beam trawl fishery is sold to local, intra and interstate markets.

The South-East Queensland Bait Processors Association estimate that Queensland processors supplied 90 per cent of the Australian bait prawn market (WBM Oceanics 1994). Given that most greasyback and school prawns are caught in area 1 (the southernmost fishing area) it can be seen that this area is the major supplier of the Australian bait prawn market.

Prior to November 1996 imported bait prawns also supplied the domestic market, however after this date all further importation of bait prawns was banned by the Australian Quarantine Inspection Service, and as a result the bait prawn market is now solely dependent on domestic suppliers.

A survey of processors conducted by WBM Oceanics indicated that over the 1992/93 financial year processors paid (beam trawl operators received) on average $4.40 per kilogram for bait prawns and $8.27 per kilogram for food prawns, and sold the respective products for $7.70 and $11.38 per kilogram. Anecdotal evidence suggested that prices remained at around this level through to the 1996 season, with operators receiving $4 and $5 per kilo for bait prawns and around $9 per kilo for food prawns.

Interactions with the otter trawl fishery

The two primary concerns of representatives of the otter trawl fishery with the beam trawl fishery is the taking of juvenile prawns and the environmental damage induced by beam trawlers to nursery areas. The main concern with beam trawlers taking juvenile prawns is that by doing so the value of the resource is less than that which may otherwise be achieved. It is argued that by waiting for the prawns to migrate to offshore waters the value of the resource will be increased due to the increase in the size of the prawns and the higher prices paid for larger prawns. The concern with the possible environmental damage induced by beam trawlers is that the areas worked by beam trawlers are nursery areas for some of the species caught by the otter trawl fishery and any damage to these areas may adversely affect recruitment to the otter trawl fishery.

The primary concern with the capture of juvenile prawns by beam trawl operators in rivers and inshore areas is with banana prawns. As can be seen in Graph 1B this species constitutes most of the catch landed in each of the beam trawl areas, with the exception of area 1. The interaction between the beam and otter trawl fishery in area 1 is somewhat more complex. For example, in the Moreton Bay region three geographically distinct prawn fisheries exist with exploitation in the rivers, in adjoining Moreton Bay and offshore. Three species, greasyback, banana and school prawns form the basis of the river fishery, with king, tiger and greasyback prawns being the major species of the Moreton Bay fishery. King prawns are also the main species of the offshore trawl fishery (Hyland 1988). Hence, there may be some interaction between the beam trawl and Moreton Bay fishery in regard to the greasyback prawn catch.

The principal management regulations for the otter trawl fishery are listed in Table 1.4. The fishing pattern of otter trawl vessel varies depending on the nature of the ground being worked. In shallower waters, such as Moreton Bay, shots are generally one half to one hour in duration, with an average of 50 minutes in Moreton Bay being reported by Hyland and Gilmour (1988). In deeper offshore waters the duration of setting and hauling times precludes the use of short shots so trawl duration is typically 3 hour, although some operators may trawl continuously for up to 6 hours (Hyland and Gilmour (1988)).

1.4 Otter trawl vessel and trawl net restriction

<u>Vessel length restrictions</u>	
Moreton Bay	Maximum length 14 metres
Otter trawl fishery except Moreton Bay area	Maximum length 20 metres
<u>General trawl net specifications</u>	
Inshore otter trawl	Length up to 32.5 metres - Mesh 38 to 60mm (Moreton Bay, Hervey Bay, Fitzroy River mouth, Cleveland Bay)
Offshore otter trawl	Length up to 88 metres - Mesh 38 to 60mm
Deep water otter trawl	Length up to 184 metres - Mesh 38 to 60mm

Source: QFMA 1996

Interactions with the recreational fishery

As previously mentioned, representatives of the recreational fishing sector have raised concerns about the impact of the beam trawl fishery on the recreational fishery. The main areas of concern are the incidental capture of important angling species such as bream and flathead and the environmental damage induced by beam trawlers. The presence of beam trawlers on fishing grounds may also impact upon the level of enjoyment recreational fishers derive from a fishing day. As a result of the latter of these concerns beam trawling is prohibited on weekends when recreational fishers are most numerous.

Recreational fishery regulations

Recreational fishers in south east Queensland are subjected to a range of regulations enforced by the Queensland Fisheries Management Authority. The principle regulations relate to bag limits (the maximum number of a given fish species that an individual may have in their possession at a given time) and minimum size limits. In Table 1.5 bag and minimum size limits for a range fish caught in estuarine, inshore and beach waters are reported.

Managing interactions between stakeholders

In examining the river/inshore fishery as a whole, the following conclusions can be drawn. The prawn catch is managed through the use of inputs controls, however, it is also clear that there is a large amount of latent effort in the fishery, and that the effort applied in the fishery is to a degree self regulated as operators move in and out of the fishery as catch rates fluctuate. The recreational fish catch component is however, almost completely unregulated with only length restrictions on most of the major estuarine species taken by recreational fishers, and there are essentially no restrictions on incidental catches of these species by beam trawlers.

From the above discussion it can be seen that there is very little in the way of managing the interactions between the various groups with the exception of restricting inputs into the beam trawl fishery.

1.5 Bag and minimum size limits of a range of recreational fish species

Common name	Bag limit (whole fish)	Minimum size (cm)
Barramundi	5	Min 58 Max 120
Bass		
Australian	2	30
Bream		
Pikey	N/A	23
Yellow fin	N/A	23
Cod		
Mary River	1	50
Murray	5	50
Dolphin Fish	N/A	45
Emperor		
Grass Sweetlip	N/A	30
Flathead		
Bar-tailed	N/A	30
Mud	N/A	30
Sand	N/A	30
Hussar	N/A	25
Javelin-fish		
Small-spotted	N/A	30
Spotted	N/A	30
Jew Fish		
Silver	N/A	45
Luderick	N/A	23
Mackerel		
Sharkey	N/A	50
Mangrove Jack	N/A	35
Mullet		
Sea	N/A	30
Perch		
Golden	10	30
Moses	N/A	25
Pearl	10	30
Silver	10	30
Saratoga	1	35
Stripey	N/A	25
Tailor	N/A	30
Tarwhine	N/A	23
Teraglin		
Silver	N/A	30
Salmon		
Burnett	N/A	40
Cooktown	N/A	40
Whiting		
Gold-lined	N/A	23
Sand	N/A	23

Source: Queensland Transport 1996

2. Value of the Recreational Fishery

Recreational fishers derive benefits from their activities, although markets which reflect this value may not exist. Benefits from recreational fishing may be derived through many sources, including the anticipation of and the actual capture of fish, and the relaxation and enjoyment of being outdoors. These benefits may be impacted upon by the activities of others, such as commercial fishing operators, through their impacts on fish stocks and hence recreational fish catches, or through their mere presence on the fishing grounds.

Recreational fisheries can be contrasted with commercial fisheries, for which economic value is reflected in the market price of the fish landed and in the value of commercial fishing licences (Cameron and James (1986)). Market prices for fish reflect the amount that consumers are willing to pay for an additional quantity of a particular fish species. The value of commercial licences reflects the stream of future profits expected from a given fishing operation. While licence fees are levied in some recreational fisheries, this is generally not considered a price for recreational fishing, as the fees are unrelated to the number of fishing trips undertaken or the number of fish caught (Cameron and James (1986)). Nor are market prices for fish considered to reflect this value, as the number of fish caught is only one component of the recreational fishing experience (Lal, Holland and Power (1992)).

The objective of this and the next chapter is to estimate the impact of beam trawl effort on the benefits derived by fishers in the recreational fishery. The primary concern of the recreational sector in relation to beam trawl activities is the impact of incidental catches of important angling species such as bream and flathead on these fish stocks (QFMA (1996)). Beam trawl operations are confined to rivers, creeks and inshore areas of the eastern Queensland coast, and since the main focus of the study is on southern Queensland the recreational fishery is defined to consist of anglers (or line fishers) fishing in rivers, creeks or inshore areas south of Shute Harbour on the Queensland east coast.

The measure of the recreational experience to be used is a recreational fishing day. This measure is frequently used for recreational experience in general, and recreational fishing, in particular (see, for example, Vaughan and Russell (1982), Cameron and James (1986) and Staniford and Siggins (1992)). There are two types of inputs likely to be used in the production of recreational fishing days. These are the inputs over which the fisher has direct control, such as bait and equipment, and inputs over which the fisher has no control such as the weather and site congestion. It is difficult to assess accurately the time frame over which consumption plans are made. Two assumptions are made in this study: that fishers plan their recreational experience over a period of one month and over one year respectively.

The determinants of the demand for recreational fishing days are assumed to be a vector of fishing quality variables, a vector of the characteristics and tastes of the fisher, the inputs into the day's fishing trip controlled by the fisher, and the price of a day's admission to a fishing site. The inputs into the day's fishing trip include inputs associated with both monetary and time expenditures.

As the price of a day's admission to a fishing site is not observable, non-market valuation techniques must be employed to obtain a measure of the value of the recreational experience. There is a range of such techniques that may be employed which fall into two broad categories; the expressed preference approach, and the revealed preference approach.

In the expressed preference approach respondents are asked through various survey constructs to express their preferences in relation to the valuing of a specified good. One of these approaches, the contingent valuation method, uses a questionnaire to construct a hypothetical market in which the respondent has an opportunity to purchase or sell the good in question.

In the revealed preference approach, user behaviour in consuming goods and services involved in the production of the recreational fishing experience is analysed. There are several techniques that can be utilised to derive these estimates. These include, the 'travel cost method' and 'hedonic pricing'. The travel cost method obtains a proxy for the price of the recreational fishing day through an analysis of travel costs to a recreation site. These may also include the opportunity cost of the time associated with the travel. There are several other approaches using costs associated with a recreational experience that can be used to obtain a price proxy, including the use of entrance fees and permits, opportunity cost of recreation time at the site, total direct costs, and the fixed costs involved in participating in a recreational experience. A combination of these costs may also be used.

There is a range of other techniques such as benefit transfer, conjoint analysis and choice modeling that can also be used to value the recreational fishery. However, as the primary purpose of this study was to obtain a valuation of the recreational fishery and the contingent valuation and travel cost methodologies have been the most extensively used and developed for this type of application these methodologies have been employed in this study. The reader is referred to DEST, DoF and RAC (1995) and Bateman and Turner (1993) for a comprehensive examination of non-market valuation techniques. The costs analysed under the expressed preference approach are those associated with traveling to the site and all other costs of undertaking the day's fishing. This approach is known as the total direct costs approach (Walsh (1986)). To employ these methodologies it was necessary to conduct a survey of the fishery. In the next section issues relating to the design of the survey used in the present study are addressed.

A survey of the recreational fishery

The survey was designed to allow for the estimation of the value, and determinants of value, of a recreational fishing day using the contingent valuation and direct cost methodologies.

The survey form was designed for surveying boat fishers with slight variations made to the form used for shore fishers. A copy of the survey forms is presented in the Appendix to this Chapter. The survey can be regarded as consisting of three distinct sections; the contingent valuation section, the direct cost section, and the attributes (of the fisher and the fishing day) section. A description of the information sought, and related issues, for each of these sections is provided next.

Contingent valuation method (CVM)

The contingent valuation method is a technique used to estimate the monetary value of a given set of goods or amenities for which no market exists. It circumvents the absence of markets for the particular good through the use of a questionnaire that constructs a hypothetical market in which the respondent has an opportunity to purchase or sell the good in question. Because the elicited values are contingent upon the hypothetical market constructed, this approach came to be called the contingent valuation method (Mitchell and Carson (1989)).

If information is also elicited on the attributes of the good that influence consumer demand, the data can be used to obtain estimates of consumers' willingness to pay for a particular good and the relationship between this and the good's attributes.

As we are seeking to estimate the surplus value of a recreational fishing day the contingent valuation section of the survey was designed to elicit information on a fisher's willingness to pay an extra amount over and above the input costs of a recreational fishing day. This approached follows that employed in other recreational fishery contingent valuation studies (Cameron and James (1986), Collins (1991), and Staniford and Siggins (1992)).

In the next part of this section some background information on the contingent valuation method is supplied. Following this, issues relating to the survey design with respect to the contingent valuation section are presented.

Background

The key role in the development of the CVM was undertaken by Robert K. Davis in the early 1960s through his development of a bidding game to estimate the benefits of outdoor recreation in a Maine backwoods area (Mitchell and Carson (1989)), although the use of the *direct interview method* had been suggested as a tool to measure the value of a natural resource several years earlier by Ciriacy Wantrup (1947).

Since this early development the use of CVM has gained acceptance, particularly in the United States where some 104 CVM studies were conducted between 1963 and 1986 (Mitchell and Carson (1989)). The US has been the primary developer of environmental benefit estimation techniques (Pearce and Markandya (1989)) and appears to be the only country where the CVM is formally applied in policy and legislation (Imber, Stevenson and Wilks (1991)).

The use of CVM in Australia has grown in recent years and several major CVM studies have been undertaken including those by the Resource Assessment Commission for the Kakadu Conservation Zone inquiry (Imber *et al* (1991)), and by the Institute of Applied Environmental Research (IAER) to assist the Commission of inquiry into the conservation, management and use of Fraser Island and the Great

Sandy Region (IAER (1990)). However, the acceptance of the results produced by these studies has not been universal. The Kakadu Conservation Zone CV, in particular attracted criticism from several sources including ABARE (1991), Moran (1991) and Brunton (1991). The criticisms of this report, including amenity mis-specification and strategic bias, and the presence of hypothetical and embedding effects, are similar to those generally raised as objections to CVM results. These and other criticisms, as well as possible methods of overcoming them, are discussed later in this section.

However, before these specific potential problems in CVM survey design are addressed, the questions relevant to the CV in this study need to be addressed. These are what is to be valued, how it is to be valued and how is the information to be elicited?

What is to be valued?

There is more than one type of non-market good, and often different types of benefits that arise from the provision of a good may need to be valued. Mitchell and Carson (1989) divide non-marketed goods into two categories, that of a public good and a quasi-private good. Quasi-private goods are those that can potentially be provided to consumers for a price, such as access to parks or permits to fish, in other words where user values predominate and the imposition of a fee is feasible. Public goods are defined, as in general economic literature, as those goods that are non-rivalrous and non-excludable.

There is a wide range of benefits that may arise from the public provision of a non-market good. These include both use and non-use values. Use values, as the name implies, reflect the value of benefits arising from all the current direct and indirect ways in which the good can be physically utilised (Mitchell and Carson (1989)). Non-use, or existence, values reflect the value people gain from a good for various reasons other than their expected personal use. For example, people may derive satisfaction, and hence gain utility, from the knowledge that an endangered species is protected, or that a particular environment is preserved in its pristine state even though they expect to have no personal contact with the species or environment.

The objective of the present CVM study is to estimate the surplus value, and the determinants of surplus value, of a recreational fishing day in the defined fishery. That is, the good to be examined is, as defined by Mitchell and Carson (1989), a quasi-private good. As such, the benefits that may arise from the provision of an extra unit of the good, that is a day’s fishing, are purely those related to the use of the resource. This is not to say that non-use benefits relating to the fishery, such as the preservation of fish stocks for future generations, do not exist, but merely that it is not necessary to determine these values when allocating portions of the total resource access rights between the commercial and recreational sectors. Non-use values need to be addressed when the question of what is the appropriate total level of resource exploitation in the fishery is raised.

How is the good to be valued?

There are two ways that goods can be valued using the CVM. These are through eliciting a respondent's willingness to pay (WTP) for a change in the level of provision of a good or their willingness to accept compensation (WTA) for the proposed change. In theory WTP should be less than WTA in the case of a proposed reduction in provision of the good, but the difference between the two measures should be small because it is caused by the difference in the income effect of the change in question, and the good in question generally makes a small contribution to total utility (Wilks (1990)). However, empirical evidence shows that WTP is consistently and significantly smaller than the WTA value for the same good (Mitchell and Carson (1989), Pearce and Markandya (1989), Knetsch (1990) and (1994)). In the Knetsch (1990) paper which examined this disparity, he concludes, in part:

> "A wide range of experimental designs have now been used to test the equivalence assumption and the persistence of observed disparities (between WTP and WTA). This and other evidence indicates that contrary to conventional assertions losses are more valued than gains, the differences are pervasive and large, the disparities are not attributable to wealth effects, they are likely to persist over repeated valuations, and they are not the result of transaction costs or strategic behaviour."

This finding has implications for the question of which measure should be used. If, as this evidence suggests, individuals value significantly more highly goods that they already possess than the acquisition of additional quantities then, when endeavouring to measure the effect of a decline in the provision of the good, or the quality of the good, it could be argued that using the WTA measure is the more appropriate approach. Whereas, if the effect to be measured is an increase in the provision or quality of a good then the WTP measure is more appropriate. Of course, if this is true then it alters a basic conclusion of neo-classical economics that WTA and WTP should be the same except for small income effects, given perfect knowledge in relation to the good. However, in another analysis of this question Mitchell and Carson (1989) propose an approach, in which they argue that the WTP format is the correct format for 'valuing decreases in the level of provision of a large class of goods that were previously thought to require a WTA approach'.

As the policy issue considered in the present study is the possible reduction of effort in the beam trawl fishery and the benefits that may accrue to recreational fishers as a result of an increase in the quality of a recreational fishing day, WTP was viewed as the most appropriate measure. However, a WTA question was also posed to allow for comparison of these two measures. The WTA question was posed in terms of a hypothetical loss of fishing opportunities over a period of one month. This approach was taken as the objective was to measure the value of lost fishing opportunities and it was felt that by posing the question in terms of the next fishing trip substitution for the hypothesised lost day could easily take place. That is, respondents could accept the offered compensation and undertake an additional fishing trip at another time, whereas if a month's fishing days were forgone substitution was less likely to occur. This approach is similar to that adopted by Cameron and James (1986).

In relation to the willingness to pay model, questions have been raised as to the theoretical correctness of the WTP question. These queries relate to the appropriateness of eliciting willingness to pay extra for a marginal day. The question is usually structured in terms of the day on which the interview was conducted, that is, by asking

> *You estimated that the cost for today's fishing trip was $_____(total from previous question). Given constraints on your disposable income, if this trip had cost you $_____ more would you still have gone fishing?*

That is, it measures the value a fisher associates with one extra day added to his total fishing bundle. On the basis of economic theory, and given undistorted markets, it would be expected that a fisher's willingness to pay would be equal to the marginal cost of the day. In other words, they would not be willing to pay any additional amount over and above the cost of the fishing day for the extra day. Otherwise, the question arises as to why they do not take more trips. However many markets, including labour markets, are distorted resulting in individuals not being able to choose the exact amount and pattern of leisure which maximizes their welfare. In these circumstances it is not surprising to get positive responses to the WTP question.

The elicitation method, and the private goods and political market models

There are three methods that are generally employed in CVM studies to elicit the value that a respondent attaches to a particular good. These approaches are; *open ended*, where the respondent is simply asked to nominate the sum; *sequential bids*, where respondents are asked whether or not they would pay or accept a specified sum with the question being repeated with a higher or lower sum being used until their response changes, dependent on the initial response and; *closed ended*, where the respondent is simply asked whether or not they would pay or accept a single specified sum. With a closed ended survey the specified sum is varied among the respondents.

Each of the aforementioned elicitation methods may result in biased outcomes, depending on the approach and structure of the questionnaire used. For example, sequential bidding has been found to be strongly biased by the initial amount quoted (starting point bias) (see, for example, Boyle, Bishop and Welsh (1985)). A detailed explanation of the various elicitation methods that can be employed in contingent valuation surveys, and their drawbacks, is given in Mitchell and Carson (1989) and Loomis (1988).

Traditionally the private goods market has been accepted as the appropriate model on which to base contingent valuation studies. However, there has been a recent shift towards the use of a particular political market model called the referendum model (see, for example, Mitchell and Carson (1989) or Wilks (1990)). This approach is primarily used for valuing public amenities that exhibit public good features, that is amenities which are non-rivalrous and non-excludable. The private goods market model is appropriate for certain types of quasi-private goods that can be potentially provided to consumers for a price (Mitchell and Carson (1989)).

All three previously mentioned elicitation methods may be employed in surveys based on private goods markets, whereas in the referendum model a take it or leave it approach, that is a closed ended approach, is used. While the use of a closed ended elicitation method under a private goods market model is similar to the referendum model, in that a take it or leave it cost to the respondent/voter is implied, the two methods are distinct (Mitchell and Carson (1989)).

As the good examined in this research project, the right to a day's fishing, is a quasi private good that may potentially be provided for a price, the contingent valuation study was based on a private goods market. Further, a closed ended approach was used, hereafter referred to as the dichotomous choice contingent valuation model (DC CVM). This approach was used as it generates a scenario similar to that which consumers face in their usual market transactions and to minimise potential sources of bias (see the next section for a discussion of potential biases). That is, consumers merely decide whether to 'take it or leave it' and are relieved of the need to determine a precise dollar value. In recent years the standard closed ended model has been developed further, and a shift toward using a follow-up has developed. That is, respondents are asked if they would pay (or accept) a follow-up bid which is dependent upon their initial response. This approach has been used in this study, and is referred to as the double bounded dichotomous choice contingent valuation model (DB DC CVM). While the use of the closed ended survey should produce unbiased results the data analysis is more complex than that required for the other methods.

In summary, the contingent valuation undertaken in the survey is based on a private goods market, utilising a double bounded contingent valuation model, and endeavours to measure both the respondent's willingness to pay for the good and their willingness to accept compensation to forgo the good. Finally, it is confined to measuring only the use values associated with the good.

In the remainder of this section the following issues are addressed. First, an overview of CV survey bias and design issues is presented. Second, the double bounded contingent valuation model and issues relating to its use are examined.

Contingent valuation survey bias and design issues

The major criticism of CV studies is that they provide hypothetical answers to hypothetical questions. To ensure that the information obtained through CV studies is valid, that is that the hypothetical responses would be matched in actual market behaviour, surveys need to be well designed. In this section three areas relating to the reliability of the CVM results are addressed. These are, the divergence in behaviour of respondents when responding to a hypothetical construct and their actual behaviour when purchasing goods and bias that may arise from this; bias that may arise as a result of the survey design; and other potential biases.

Hypothetical vs actual behaviour

A major concern relating to CV studies is whether the amount that respondents indicate they are willing to pay (or accept) actually reflect the amount that they would be willing to pay if a market for the good or amenity existed. Bishop and Heberlein (1986) state that ‘offers in CV of willingness to pay are, in psychological terms, ‘attitudes’ while actual buying and selling things is ‘behaviour’’. The divergence between the amount that a respondent claims they would spend and the actual amount they would spend is termed the hypothetical effect.

As attitudes, which reflect behavioural intention, do not always predict actual behaviour, the relationship between attitudes and behaviour becomes important in understanding how well behavioural predictions can be made from responses to a CV survey (Ajzen and Peterson (1988)). Social psychological assessments of CV have suggested two techniques which can be incorporated into CV surveys to improve the attitude-behaviour link: first, to incorporate questions about attitudes and actual behaviour in CV applications to allow for the association between intentions and behaviour to be tested directly; and, second, to design the questionnaire in such a way as to encourage respondents to offer an honest answer to the valuation question (Wilks (1990)).

The existence and extent of bias due to the hypothetical nature of the CVM, that is the hypothetical effect, is a source of conflict between researchers among in the field. Cummings *et al* (1986) for example, are part of the school that claims there is significant evidence to suggest that choices involving actual payments are substantively and significantly different from those involving hypothetical payments. Conversely, Mitchell and Carson (1989) are part of the school that claims that the findings of studies in which CV respondents were later asked to make actual payments indicate that the CV measures of WTP are valid. Further, they claim that the evidence shows that with quasi-private goods the ability of CV studies to predict spending behaviour is impressive.

To try to ensure that respondents offered honest answers to the valuation question in this study the following steps were undertaken as part of the survey. The CV scenario was kept simple and avoided use of technical jargon to ensure that the respondent understood what they were valuing. Also, given that those surveyed were undertaking or had just undertaken the activity being valued, respondents were likely to be familiar with the scenario described. Further, for the WTA question time horizons were kept specific and short, so as to ensure that time lags would not have a major impact on respondents’ answers. To ensure that the information provided to respondents was relevant and described the scenario to be valued adequately a pilot survey was undertaken**.**

Contingent valuation design

In standard CVM studies the CV survey usually sets out to accomplish three things: first to describe the good being valued: second to elicit respondents’ willingness to pay for a good and/or their willingness to accept compensation to forgo the good; and third, to ascertain respondents’ characteristics, their preferences relating to the good and their use of the good (Mitchell and Carson (1989)). The latter of these is dealt with at the end of the survey design section.

In the CV survey conducted for this report, as respondents were undertaking or had just undertaken the activity being valued and, therefore, were likely to be familiar with the scenario described, a detailed description of the good was not necessary.

The WTP question was formed in terms of an increase in costs for a day fishing. This was done in order to avoid vehicle bias. Vehicle bias is bias that arises as a result of a respondent's reaction to the hypothetical payment method that is posed in the questionnaire. For example, a payment vehicle based on charging for the right to engage in recreational fishing was felt likely to incur a strong negative reaction given the reactions that have resulted when such a proposal has been floated in the past, and the experience of Cameron and James (1986) when such a proposal was implied in their pilot survey.

Increased costs have been identified as a payment vehicle that may induce strong budget constraints and other negative reactions (Mitchell and Carson (1989)). However, as this payment vehicle has been employed in several other recreational fishing CV studies (Cameron and James (1986), Collins (1991) and Siggins and Staniford (1992)) and vehicle bias was not a major concern, it was felt that an increase in fishing costs was the least likely way to invoke an emotional response from respondents and as such was the chosen method following suggestions made by Wilks (1990). Also, if the respondent queried the dollar amount being used in the question, they could be told that this amount was being varied between each respondent which may help to allay fears of a fishing fee to a degree.

To address the possibility of embedding effects, that is the upward bias that may occur if respondents consider their WTP bids in isolation rather than in the context of it being an additional expense to be meet from their income, the WTP question include the qualification 'Given constraints on your income, ...'.

The WTA question was constructed to cover the hypothetical loss of fishing opportunities for the period of one month after the time of the interview. The interviewer multiplied the respondent's estimated fishing days in that time by a predetermined amount and then inquired whether that amount would be acceptable compensation for the loss of fishing time.

Treatment of other potential biases

There are several other potential sources of bias that may arise when a CV study is conducted. These include the incentive to misrepresent responses, the presence of implied value cues, the mis-specification of the scenario, and biases arising from the design and execution of the sample.

Incentive to misrepresent responses

Biases of this type arise when a respondent deliberately under- or over-states their WTP or WTA bid for either strategic or compliance reasons.

Strategic bias occurs when a survey respondent makes a bid in order to influence the outcome of the survey in a way preferable to them. The primary source of this bias is the free rider problem in that respondents may know or presume that they will not have to pay directly for the provision of the good and are willing to claim that the good has a higher value to them than they would be actually willing to pay in order to increase the probability that the good is provided. For example, in the survey conducted for this report a fisher may believe that if they claim they are prepared to pay a large sum to continue fishing, the relevant authorities may reduce access by commercial fisherman for the benefit of recreational fishers. Conversely, the fisher may claim that they attach a low value to recreational fishing in order to ensure that fees are not introduced, or if they are, are minimised.

While strategic bias is recognised as a potential source of bias, the use of the closed ended technique is incentive compatible, and thus no incentive exists for a respondent to give an answer that does not reflect their true position (Hoehn and Randall (1987)). Nor in this survey does the respondent have sufficient knowledge to ascertain the likely effects of their bid. Further, empirical evidence suggests that strategic bias is not a significant problem for CV studies under most conditions (Mitchell and Carson (1989) and Cummings, Brookshire and Schulze (1986)).

Another reason that respondents may deliberately misrepresent their bids is compliance bias. Compliance bias occurs when respondents (consciously or not) express responses that are based on their expectation of what the survey sponsor or interviewer expects. Given the nature of the WTP and WTA questions used in this survey it was felt that there was little possibility that this would arise. However, to ensure that it did not occur several precautions were undertaken. First, it was clearly stated that the project was being undertaken by The University of Queensland and that the study was of an independent nature. Second, a neutral position in both attitude, appearance, and in answering requests for further information was presented to all respondents.

Implied value cues

Biases in this category occur when respondents interpret information in the survey as providing detail on correct or expected bids. An example of this type of bias is starting point bias where the first bid may influence the amount of a respondent’s bid. Others types of bias resulting from implied values in surveys include range bias, relational bias, importance bias and position bias. However, as this survey used the closed ended technique in which respondents merely have a choice of accepting or refusing the bid, there is little or no chance of such biases invalidating the survey results. For a detailed discussion of these biases see Mitchell and Carson (1989) or Cummings *et al* (1986).

Inadequate bid design

While implied value biases are unlikely to arise in DC CVM surveys, problems may arise due to inadequate bid design. That is, do the bids offered provide adequate information to allow for proper estimation of the true WTP or WTA? Several papers in recent years have addressed this problem. For example, a study by Kriesel and Randall (1990) using a DC CVM survey addressing the WTP for an improvement in air quality demonstrated the pitfalls of a survey in which the bid amounts offered are too small. In the study, 60 per cent of respondents were willing to pay the highest bid offered, resulting in WTP being underestimated. As this is a major issue in relation to DC CV surveys, it is addressed more fully in the following section.

Scenario mis-specification

Scenario mis-specification bias occurs when respondents misinterpret one or more aspects of the contingent market or the good to be valued. There are several forms of mis-specification bias. These are amenity, theoretical or content mis-specification (Mitchell and Carson (1989)).

Theoretical mis-specification occurs when the researcher constructs a scenario that is contradictory to economic theory or is wrong in fact. In such a situation respondents cannot indicate their true bids even if they understand the scenario presented to them perfectly. To ensure this situation does not arise it is necessary to ensure the factual and theoretical correctness of the scenario presented. To ensure this occurred the survey utilised in this report was reviewed by both academics and industry representatives. Further, given that the structure of the survey is similar to that used in previous recreational fishing CV studies it was felt at the time the survey was constructed that the chance of such mis-specification was minimal. However, as the survey was conducted some concerns as to exactly what is being valued arose. These concerns relate to the expectation under economic theory that a fisher’s expected willingness to pay would be equal to the marginal cost of the day. However, as outlined earlier given distortions to markets positive responses to the WTP question are not surprising.

Amenity mis-specification arises when the respondent offers a bid for a good that is different from that being valued by the survey. As stated when addressing hypothetical effects earlier in this chapter, those surveyed were undertaking or had just undertaken the activity being valued and were likely to be familiar with the scenario described. As such, it is unlikely that respondents do not have a clear idea of what is being valued.

Context mis-specification occurs when respondents misinterpret a given aspect of the researcher’s contingent market. This can occur in terms of payment vehicle bias, property right bias, method of provision bias, budget constraint bias, elicitation question bias, instrument context bias and question order bias. Of the issues that may be relevant to this study (all except method of provision bias) all but instrument context and question order bias have been addressed previously in this chapter. Instrument context bias occurs when the questionnaire material that precedes the CV scenario influences the bids offered by respondents. Question order bias arises when the order of the questions, in an unintended way, influences the response patterns in the survey. However, this type of bias is only a potential problem in CV when values are elicited for several different goods or level of good provision (Mitchell and Carson 1989).

Double bounded dichotomous choice contingent valuation model

The double bounded dichotomous choice contingent valuation was first proposed by Carson, Hanemann and Mitchell in 1986, to overcome the statistical inefficiencies associated with the single bounded model, while retaining the positive aspects of this model, such as the minimisation of several forms of bias (Cameron and Quiggin (1994)). As previously outlined, under this model respondents are asked whether they would be willing to pay (accept) two amounts (bids) for a given good, with the second bid amount being determined by the response to the initial bid. That is, if the respondent is willing to pay the initial amount posed, they are then asked if they would be willing to pay a higher amount. Conversely, if the respondent is not willing to pay the initial amount, a lower amount is posed.

One of the most important aspects of any CV survey using this approach is the setting of the level of the initial and follow up bids that are to be used in the relevant questions. That is, when asked 'would you accept $t not to fish' or 'would you pay an additional $t to continue fishing' what values are assigned to t.

In recent years a range of papers have been published addressing the issue of optimal design for both single and double bounded DC CV surveys (see, for example, Cooper (1993), Duffield and Patterson (1991), and Kanninen, (1993a)). The starting point for most of the work done in this area, is research on optimal design for binary data in biological assay and fatigue experiments. Both Cooper (1993) and Kanninen (1993a) provide examples of this work. As stated by Cooper (1993) only a narrow range of CV surveys are suitable for the application of these design methods as they require a sequential procedure. That is, the data must be collected in phases. Fortunately, as the survey in the present study was conducted in person over a relatively long time frame it was feasible to conduct it in a number of phases. Kanninen (1993b) in a paper on sequential CV design conducted a Monte Carlo experiment in which she found that there was a significant decrease (13%) in the asymptotic variance between a two and three stage DBDC CV. This improvement decreased after three stages to less than 4 per cent. Given that there was no difficulty in having several phases in the survey a sequential procedure was used in this study.

Optimal bid design methods

When applying optimal design techniques to the CVM it must be assumed that the survey respondents act as 'statistical animals' (Kanninen (1993b)). That is, respondents do not indulge in strategic behaviour and answer honestly (the issue of bias resulting from strategic behaviour is addressed in the previous section). There are several different techniques for obtaining an optimal design for a given experiment or survey, the choice of which is dependent upon the objective of the survey (Aigner (1979)).

Kanninen in two papers (1993a, 1993b) provides an overview of a range of design methods developed for sequential procedures including: D-optimal design, C-optimal design, the fiducial method, the Robbins-Monro (R-M) procedure and the Dixon and Mood's up and down method. These procedures are used in contingent valuation surveys to select the opening and follow-up bids so as to maximize the value of the information obtained.

In the present study the C-optimal design method was used. The following brief outline of this design method for the double bounded survey is based on Kanninen (1993a). In the doubled bounded survey there are three bid amounts specified for each observation. Although each person is asked only two bids all three bids enter the function because *a priori*, it is not known which response any individual will give to the initial bid. The C-optimal procedure involves three simplifying assumptions: first, it is assumed that there is only one optimal bid scheme; second, the first bid is the median value; and third, the follow up bids are symmetric about the median. These restrictions reduce the problem from one of solving simultaneously for three bids, to one of solving for one only, namely, the distance between the median and the follow-up bids. Under the C-optimal design the objective is the minimisation of the asymptotic variance of the median WTP. The design places the bids at the median values with the follow-up bids conditional on the responses to the initial bid (Kanninen 1993a).

Survey bid design

To ensure that the most appropriate bid design was used the survey was conducted in phases of approximately 50 interviews, for both shore and boat fishers, with the bid design being updated after each phase.

Previous studies

As there was no data available for the first phase a review of previous recreational fishing studies was undertaken, in order to obtain an indication of WTA and WTP values associated with a recreational fishing day.

Three previous studies identifying recreational fishers marginal WTP and/or marginal WTA were examined. Table 2.1 gives a summary of these studies and the respective values obtained. From this Table it can be seen that a wide range of values was obtained. As a result during the first phase of the survey a wide range of values was used to ensure that a good indication of the underlying WTP and WTA amounts were obtained. From an examination of these studies it is difficult to ascertain where the true mean of WTA and WTP may lie. This is particularly true as the nature of the fisheries vary quite significantly, as do the nature of the participants involved in the respective fisheries. For example, the British Columbia fishery is based on salmon, and the fish targeted and caught in this fishery are significantly larger than those found in the other fisheries, including those examined in this study. A further complication was the fact that the fishery examined in this study is spread over many hundreds of kilometres and includes both shore and boat fishers.

2.1 WTP and WTA values of a recreational day derived by contingent valuation surveys in other fisheries

Source	Fishery/Fishery type	Survey design	WTP	WTA
Dragun (1991)	Port Phillip Bay & Western Bay, Victoria /All fishers	Telephone survey Open ended- WTP	$9.81[a] $9.61[b]	**na**
Siggins and Staniford (1991)	Coffin Bay, SA /Boat fishers	In person interview Open ended - with payment card WTP - additional daily expenses	$36.42	**na**
Cameron and James (1986)	Salmon fishery, British Columbia, Canada /Boat fishers	In person interview SB DC - WTP additional daily expense and WTA compensation for block of fishing days	$C41.99	$C56.84

a based on a licence fee, **b** base on a fee to buyout commercial fishers, **na** not applicable.

Before the bid design is presented it should be noted that as previously outlined the primary measure used to value a recreational fishing day is willingness to pay an extra amount. As such, the bid design outlined in the following sections is based on the results obtained from the WTP section of the questionnaires. Although it would also have been possible to obtain a separate bid design for the WTA question this was not done. As the bid design may influence the result it was felt that to allow for a comparison between the two measures identical designs should be used.

1st phase

As a result of the factors previously mentioned a range of bid values was used during the first phase. The initial bids were decided on after examining the range of values derived in other studies. The follow up bid was set at around half the initial bid where respondents indicated they were not willing to pay (or were willing to accept) the initial bid. If respondents indicated they were willing to pay (not willing to accept) the initial bid the follow up bid was set at around twice the initial bid. This method of setting the follow up bid is an accepted procedure for CV studies of this nature (Cameron and Quiggin (1994)). While it was recognised that problems, such as data truncation may arise, these problems should be overcome by the phased structure of the survey. The bid structure used and results of the 1st phase are shown in Table 2.2 below.

2.2 Bid structure and results of first phase

Initial Bid	Follow up bid	Boat fishers					Shore Fishers				
				Responses[a]					Responses		
		No.	YY	YN	NY	NN	No.	YY	YN	NY	NN
5	2,10	5	5	0	0	0	7	3	3	1	0
10	5,20	5	3	2	0	0	7	1	4	2	0
20	10,40	5	1	2	2	0	7	1	1	3	2
30	10,50	5	1	3	1	0	7	0	0	6	1
40	20,70	5	2	1	2	0	7	0	1	3	3
50	20,100	6	1	2	2	1	7	0	1	0	6
70	40,150	5	0	2	0	3	6	0	0	1	5
100	50,200	5	0	1	2	2	6	0	0	0	6
150	70,300	5	0	1	0	4	6	0	0	0	6

a Y Indicates yes response and N indicates a no response. Thus, for example, of 5 boat fishers asked if they would pay an extra $20 three responded in the affirmative and two in the negative. Of the 3 responding in the affirmative, one was willing to pay the second bid of $40 and two declined, with both those declining the initial bid indicating they would be prepared to pay the second bid offered ($10).

Second and subsequent phases

As the results from the first phase indicated that the underlying true value of willingness to pay may differ between boat and shore fishers the survey was stratified into these two groups and a bid design estimated for each group. The bid design was calculated using the C-optimal design as previously outlined. Table 2.3 shows the bid structure for the 2nd and subsequent phases. In calculating these estimates it was assumed that the underlying true value of expected WTP for the initial bids and follow up bids were identical.

2.3 Bid structure 2nd and subsequent phases

	Phase							
	2	3	4	5	6	7	8	9
Boat fishers								
Initial bid	55	45	40	40	40	40	40	40
Follow up bids	30,80	25,65	20,60	20,55	25,55	25,55	25,55	25,55
N	51	48	58	60	50	51	51	90
Shore fishers								
Initial bid	15	20	15	15	15	15	15	15
Follow up bids	10,25	10,25	10,25	10,20	10,20	10,20	10,20	10,20
N	60	48	57	73	57	106	80	130

Total direct cost method (TDCM)

The total direct cost method is a variant of the well established travel cost method (TCM) of estimating demand functions for recreational experiences. Under the TCM demand is estimated through analysing the relationship between the variation in demand for a recreational experience and the travel cost involved in participating in the experience. The total direct cost method employs the same techniques but incorporates all direct costs associated with partaking in the recreational experience. For example, the cost of undertaking a fishing trip includes the cost of travel, the opportunity cost of travel time and the cost of other inputs such as bait, ice and tackle. These costs represent the marginal cost of a fishing day for trips of one day’s duration. This approach was preferred to using travel costs alone as participants in the fishery tend to fish in their local area and greater variation was expected in total costs than in travel costs alone.

Data can be collected for the analysis at either the macro or micro level. As micro data allows for a greater range of socio-economic data to be collected and aggregation leads to a loss of information, in that variation in the data is reduced, it is usually preferable to use micro data where possible. Also the collection of micro data allows for the estimation of a general demand function for recreational fishing days as well as for site specific demand functions. Given that the collection of micro data was possible this approach was taken.

In this section, details of the information required to apply the total direct cost method are discussed, followed by an outline of possible bias that may arise from the data and model specification.

The first question that needs to be addressed relates to the observation of user behaviour. As the survey is conducted at a micro level it is possible to collect information on individual use patterns, that is the number of days a recreational fisher fishes. As stated previously, the objective of the recreational fishing survey is to allow for the estimation of the surplus value, and its determinants, of a recreational fishing day in the river/inshore fishery. Information on river/inshore fishing patterns only was sought as it is in these areas that the recreational fishing experience is likely to be affected by beam trawl operations and it was felt that it was reasonable to assume that fishing in these areas was a distinct experience compared to that of other forms of fishing such as off-shore or reef fishing.

Further, two assumptions are made in relation to the time frame over which a fisher decides on their consumption of recreational fishing days, these being, one month and one year. Information on the number of fishing days a fisher engaged over both these time frames was sought.

For information on the level of planned fishing activity over the following year two questions were asked. First, the number of days that a fisher fished over the previous year, including the day of the interview. Given the difficulties likely to be encountered by asking fishers to estimate their planned consumption of fishing days over the following twelve months fishers were simply asked whether they planned to go fishing on more, less or approximately the same number of days in the following year. Respondents were also asked both questions again in relation to the site at which the interview was conducted. For information on the level of planned fishing activity over the following month, fishers were simply asked this question directly.

The second set of data sought related to the inputs into the fishing day. For inputs involving monetary expenditure, information was sought on expenditure levels associated with these inputs. This was done as it was felt that it would be difficult to obtain accurate information on the quantity of these inputs. The other input sought was that of time. Data were collected on three categories of time inputs. These were travel time to the site, time spent fishing and total time spent on the water (or time spent at the fishing site for shore fishers).

There are two approaches that can be used to elicit this information. One method is to ask respondents their average level of expenditure (and time inputs) on fishing trips. In a study of the Coffin Bay fishery undertaken by Collins (1991) this method was applied and it was found that recall difficulties led to the data being of dubious quality. An alternative is to simply ask for expenditure on the current day and use this as a proxy for the average trip. While it is realised that expenditure may vary substantially between trips this is not as unreasonable as it may initially sound. If, for example, the true underlying level of expenditure on a fishing day for those who fish on say 20 days is less than that for those who fish twice a year, while there may be some variation between the cost of each day, given a reasonable sized sample the estimated means of the level of expenditure of the two classes of fishers will reflect this difference. Given that it was necessary to elicit information on the inputs to the current days fishing for the contingent valuation analysis, and that it was desired to keep the survey to a reasonable length and to minimise the level of recall needed, the latter approach was used for the present study.

There are several issues in using the total direct cost method that need to be addressed. These are the allocation of the costs incurred for the fishing trip, the cost of time and the omission of a substitute price variable.

The possibility that fishers engage in activities other than fishing as part of their day trip may lead to estimates being biased if all the cost of the day's outing are allocated to the fishing component of the trip. To counter this respondents were asked if the primary purpose of the trip was for recreational fishing, and the percentage of the time spent recreational fishing if it was not. The cost for the fishing day was then determined as the percentage of the time spent fishing multiplied by the total cost of the trip.

While the issue of the opportunity cost of time is a major issue in travel cost method analysis using macro data (Collins (1991)) it is not a major issue in this analysis. This is because no exogenous attempt was made to value the opportunity cost of travel or on-site time. Instead, the time inputs were entered directly into the model and from the results of the estimation procedure opportunity costs associated with each time input were derived.

The final issue to be addressed is the possible presence of omitted variable bias arising from a substitute site price variable, which is negatively correlated to the own price variable, being excluded from the specified equation (Clawson and Knetsch (1996)). This bias arises from the fact that when a hypothetical fee increases the cost of fishing for those close to the fishing site to the same amount as that faced by those distant from the fishing site, those close to the fishing site are assumed to demand the same number of trips as those distant from the site. Yet if a substitute site exists for those more distant but not for those close to the site, then at equalised costs, inhabitants close to the site will demand more trips to that site. Therefore, the omission of a substitute price variable will mean that the estimated demand curve will underestimate the demand for trips to the site by residents close to it. It is also possible that the substitute price variable is positively correlated to the own price variable causing the own price coefficient to be biased upwards (Caulkins, Bishop and Bouwes (1985)). Thus, it is not possible to specify the results as upper or lower bounds unless the nature of the correlation is known.

For the present study it is proposed to estimate two types of demand functions, one for river/inshore fishing days in general and another for the demand for these days at specific sites. Thus the substitute in the former case is other recreational activities and for the latter fishing days at other river/inshore sites. First, addressing the site demand function, as it was not possible to extend the survey to obtain information on substitute sites for the nominated areas, it was decided to use an index for the availability of substitute sites. This index was simply the proportion of the total number of river/inshore fishing trips taken at sites other than the site at which the interview was conducted. This should be a reasonable proxy to both the quality and price of substitute sites, as the higher the proportion of total trips a fisher makes to a given site the more likely it is that substitute sites are of inferior quality or that the fisher faces a higher price (or total direct cost) to access them. As previously mentioned the survey elicited information on the number of days that a fisher fished over the previous year in river/inshore areas and at the site at which the interview was conducted. The proxy could then calculated from this information. For the river/inshore model the substitute for this is most likely other recreational activities including other forms of fishing activity such as off-shore fishing. As it was not possible in the scope of the survey to obtain information on fishers' other recreational pursuits no substitute price variable was obtained for this model. This fact should be borne in mind when assessing the results from this model. In retrospect it is possible that information on the total number of fishing days of all forms could have been sought and used in a similar manner to that used in the site demand model. However, this would require further questioning of, and recall from, respondents.

Attributes of the fisher and the fishing day

The final section of the survey to be addressed is that of the attributes of a fisher and the fishing day. As for the information on the inputs into the fishing day the information sought related to the fishing day just undertaken, with these being used as a proxy for the average day in the total direct cost analysis.

Taking the attributes of the fisher first, there are several characteristics of a fisher that were hypothesised to influence their demand for recreational fishing days and information pertaining to these characteristics was elicited as follows:

- the fisher's income. In endeavouring to collect information on a fisher's income level it was noted that in several previous studies that endeavoured to elicit this information the number of respondents who refused to provide this information when the researchers were conducting the pilot stage was such that this information was not sought in the survey proper (see, for example, Cameron and James (1986) and Staniford and Siggins (1991)). As a consequence of this concern, it was decided in the preamble to the questionnaire to emphasis the anonymous nature of the survey and the fact that individual respondents would in no way be associated with their answers, and to present respondents with wide income bands, so as to make the question as innocuous as possible. In addition, as a fall-back position respondents were asked what type of car they owned. This was done with the possibility of using this information as a rough proxy for a fisher's income.
- the discretionary time available to partake in recreational fishing. For this, the fisher's employment status was used as a proxy.
- a fisher's dedication to the sport. To obtain an indication of this two proxies were used, that of their willingness to fish in adverse conditions, and whether they fished alone or in a group. To assess their willingness to fish in adverse conditions fishers were asked to rank the conditions they expected to experience during their fishing trip on a scale of 1 to 4, with 1 being excellent and 4 being poor. It was assumed that fishers who fished alone were the more dedicated fishers.
- the location of the fisher's permanent residence, obtained through asking for the relevant postcode.

- whether the fisher was a visitor to the region they were fishing in. Fishers were asked if they were staying overnight away from their permanent place of residence while undertaking their fishing trip to ascertain this.
- the type of fishing activity undertaken. Respondents were asked what fishing activities they undertook during their fishing trip.

The attributes of a fishing day that were hypothesised to influence its quality and hence a fisher's demand for a recreational fishing day, were as follows:

- the number of a given fish species caught on a given trip. As the importance of a given species to recreational fishers varies, information was sought on catch, release and what species fishers targeted.
- how enjoyable the fishing trip was. Respondents were asked to rank how enjoyable the fishing trip was on a scale of 1 to 4, with 1 being very enjoyable and 4 not at all enjoyable.
- the number of commercial vessels seen by the fisher.
- the level of congestion experienced at the fishing site. This was ranked on a scale of 1 to 4, with 1 being very congested and 4 not at all.
- the weather and fishing conditions. This was also ranked on a scale of 1 to 4 with 1 being excellent and 4 poor.
- the time of year the fisher was interviewed.
- the location of the fishing day.

Sample design

The interviews were conducted on a random basis within the stratified subgroups as outlined below. Fishing groups were approached and an individual adult was chosen at random and asked if they would participate in the survey, if they declined another member of the group was asked. If no adult was present an individual was chosen at random from amongst the group. Boat fishers were approached as they returned from their fishing trip, with shore fishers being approached as they fished. As a consequence it was anticipated that the almost all boat fishers surveyed would have completed their fishing activity for the day, whereas shore fishers were likely to continue fishing after the completion of the interview.

Five areas were nominated by the project Steering Committee for investigation, these being the Logan, Pine, Mary and Burnett Rivers and the Repulse Bay region and the surveys were undertaken at sites within these areas. For the Logan, Pine, Mary and Burnett Rivers fishers were interviewed at fishing sites/boat ramps within the river systems and at inshore areas close to the river mouth. For Repulse Bay, interviews were conducted at fishing sites/ boat ramps in rivers and inshore areas within the bay.

As it was felt that recreational fishing effort may vary between these areas stratified random sampling was used to improve the efficiency of the estimates with the survey being stratified between these areas. Further, as previous studies of recreational fishing have indicated that there is significant variation in recreational fishing effort between times of the year, days of the week, and the time of day (see, for example Hill (1986), or Staniford and Siggins (1992)) the survey was further stratified into seasonal, day type and time of day subgroups. The day type subgroups were similar to those used in Staniford and Siggins (1992), that is:

- Weekends, including all weekends except those associated with public and school holidays.
- Weekdays, including all weekdays except public and school holidays.
- Public holidays, defined as any public holiday, and in the case of long weekends the Saturday and Sunday associated with them were also classified as public holidays.
- School holidays, that is all days over the school holiday period, with the exception of those classified as public holidays.

Further, each day was broken up into four subgroups (periods). For the boat fisher survey the interviewer simply waited at a randomly selected boat ramp within one of the nominated areas for the duration of the period and approached the boating party as they landed. For the shore fisher survey the interviewer went to a fishing site at a nominated time and approached each group fishing at the site in turn. If nobody was present at the site or all present had been interviewed, the interviewer proceeded to the next site. This continued until all fishers at the last site visited were interviewed with the last site being that which the interviewer was present 90 minutes after the survey period commenced. The periods and interview times associated with each period were as follows:

- Early morning; boat fisher survey 5:15 am to 8:45 am; shore fisher survey, 60 minutes after sunrise.
- Late morning; boat fisher survey 9:15 am to 12:45 pm; shore fisher survey, 10.30 am.
- Afternoon; boat fisher survey 1:15 pm to 4:45pm; shore fisher survey, 3.30 pm.
- Early evening; boat fisher survey 5:15 pm to 8:45 pm; shore fisher survey, 60 minutes prior to sunset.

Finally, as previously outlined, the results from the first phase of interviews indicated that the underlying true value of willingness to pay may differ between boat and shore fishers, thus, the survey was further stratified between these two groups.

Pilot survey

After designing the CV survey it was reviewed by several sources who were ask to examine its structure and content. Two aspects of the proposed survey were identified that may have given rise to difficulties, namely, the length of the survey and the elicitation of income levels. Difficulties in eliciting responses in relation to income levels were noted in previous CV studies into recreational fishing (see, for example, Cameron and James (1986) and Staniford and Siggins (1991)). As a consequence of this concern, as previously mentioned, it was decided in the preamble to emphasis the anonymous nature of the survey and the fact that respondents would in no way be associated with their answers, and to present respondents with wide income bands.

A pilot survey was conducted before the main survey was carried out. The purpose of the pilot survey was to ensure the structure and content of the survey elicited the desired information. While it is standard practice to use the pilot stage to obtain data to assist in the bid design for the contingent valuation question, this was not deemed necessary, as the survey was conducted in phases as previously outlined. Instead the pilot survey was of short duration, with 43 interviews being conducted and used for structure and content checking. The 43 interviews consisted of 25 shore fishers and 18 boat fishers, conducted on a weekday at the Logan River (early morning for boat fishers and evening for shore fishers) and a weekend at the Pine River (late morning for boat fishers, and afternoon and evening for shore fishers). The pilot survey was also used to ensure that the information obtained could be easily recorded and that the questions posed did not arouse, either positively or negatively, the respondent. From the pilot survey it was found that no reluctance was displayed by respondents in giving income levels, with none of the 43 respondents declining to provide the information. It was also found that the survey was usually completed in around ten minutes and appeared to be not of too great a length as to provoke a negative reaction from respondents. Overall the survey did not appear to provoke respondents in any manner and respondents were happy to cooperate and willing to assist.

As the pilot survey indicated that there was no need for major changes to the structure or content of the survey, the 43 interviews conducted at this stage were incorporated into the first phase of the survey proper. The bid design used for the pilot survey was the same as that used for phase one of the survey as previously outlined.

Survey data

The survey data consist of 1176 responses to in-person interviews of recreational fishers conducted throughout the 1996 calendar year, in rivers/inshore areas of the east coast of Queensland. Of these responses 505 involved boat fishers and 671 involved shore fishers. Interviews were conducted in five nominated areas by two interviewers. The five areas included the Logan and Pine Rivers located respectively in the southern and northern reaches of the Greater Brisbane area, the Mary and Burnett River on the banks of which Maryborough and Bundaberg are located respectively, and the Repulse Bay area lying to the north of Mackay (see Figure 2I).

The data collected in the survey can be used to estimate characteristics of two distinct populations, these populations being that of fishing days and that of fishers. For example, in relation to catch rates both the average catch rate per fishing trip and the average catch rate per fishing group can be estimated. To illustrate this point an example is provided shortly, however, first an outlined of the derivation of the weighting variable used for each of the populations is presented.

As outlined earlier the survey was stratified over location, season, day type and period of the day. To obtain estimates of the various characteristics of the population of fishing days, given that the survey is stratified, the data needs to be weighted to account for the variation in size of the subgroups and the number of data points collected within each subgroup (see Tables 2.4, 2.5, 2.12 and 2.13). This is because the methodology of selecting the sample in itself produces a bias toward those fishers that undertake the most trips, as the probability that a fisher will be interviewed increases with the number of fishing days they undertake at the site at which the survey is conducted. Thus, there is not an equal chance that any given fisher will be interviewed. To allow for the population means to be calculated where the population is defined as the total number of individuals that engage in river/inshore fishing, the data need to be weighted to account for this bias.

Boat fishers and boat fishing days

Over the survey period occupants of boats were approached as they returned to a boat ramp with one adult chosen at random and asked if they would participate in the survey. The final data set includes the 505 respondents who spent at least a part of their fishing day in the recreational fishery, as previously defined, and who provided sufficient information in response to the survey questions.

The number of respondents entering the data set and the number of periods in which interviews were conducted by area, type of day and period, and by area and season is given in Tables 2.4 and 2.5, respectively.

2.4 Number of survey respondents by area, type of day and period: Boat fisher survey

		Time of day							
Area	Type of day	Early Morn		Late Morn		Afternoon		Early Eve	
		# periods	# inter	# periods	# inter	# periods	# inter	# periods	# inter
Logan River	Public holiday	1	8	2	13	2	6	2	4
(total number of	School holiday	1	1	2	8	1	6	1	4
Interviews 114)	Weekend	3	7	3	22	3	17	1	6
	Weekday	2	2	2	3	2	2	3	5
Pine River	Public holiday	1	2	1	5	2	6	1	3
(total number of	School holiday	1	0	1	11	1	2	1	4
Interviews 106)	Weekend	2	3	3	31	3	13	3	10
	Weekday	2	2	2	7	1	3	2	4
Mary River	Public holiday	1	2	2	8	1	6	1	0
(total number of	School holiday	1	1	1	12	2	5	2	3
Interviews 80)	Weekend	2	4	3	14	4	15	3	3
	Weekday	3	1	2	4	1	2	2	0
Burnett River	Public holiday	0	0	0	0	0	0	0	0
(total number of	School holiday	1	0	1	12	1	7	1	0
Interviews 131)	Weekend	2	3	4	42	5	14	3	7
	Weekday	3	3	2	20	3	14	3	9
Repulse Bay	Public holiday	0	0	0	0	0	0	0	0
(total number of	School holiday	2	6	1	9	1	6	1	5
Interviews 76)	Weekend	1	5	2	5	2	8	1	3
	Weekday	3	5	3	9	2	6	3	7
All areas	Public holiday	3	12	5	21	5	18	4	7
(total number of	School holiday	6	8	6	52	6	26	6	16
Interviews 505)	Weekend	10	22	15	114	17	67	11	29
	Weekday	13	13	11	41	9	27	13	25

2.5 Number of survey respondents by area and season: Boat fisher survey

	Summer		Autumn		Winter		Spring		Total	
	# periods	# inter	# periods	# inter	# periods	# inter	# periods	# inter	# periods	# inter
:Logan	11	42	6	26	8	27	6	19	31	114
:Pine	6	35	7	33	6	23	8	15	27	106
:Mary	0	0	18	43	6	16	7	21	31	80
:Burnett	0	0	14	69	10	35	5	27	29	131
:Repulse	21	71	1	3	0	0	0	0	22	74
All areas	38	148	46	174	30	101	26	82	140	505

Catch, catch rates and targeting behaviour

The species most often targeted by boat fishers in the river/inshore fishery are bream, whiting and flathead. In Table 2.6 the targeting behaviour per fishing trip is reported. That is, for example, for every 100 trips undertaken in the Logan River bream is the targeted species on 23 of these trips. These were also the species which tended to be kept after capture. In the survey respondents were asked for both the number of fish caught and the number of fish released. However, as many of the respondents only provided a vague response for the number of fish released it was not possible to obtain an accurate estimate of total catch rates. As such, only catch rates relating to the number of fish caught and kept by fishers could be estimated. In Table 2.7, average catch rates per trip for the three main target species and other species are provided for each of the survey areas, with the standard deviation for each sample provided in brackets. Catch rates are provided in terms of total boat catch and catch per hour fished, where the number of hours fished was obtained by the product of the number of adult fishers (that is, fishers over 16) in a boat and the number of hours spent fishing. Following this average catch rates per boat group and average trip catch rates per season are given in Tables 2.8 and 2.9, respectively. Although in general the average per trip catch rates are higher than the average boat catch rates, only for bream and whiting catches in the Burnett River was the difference found to be significant (at the 10 per cent level). The average bream catch per hour fished was found to be significantly lower (at the 1 per cent level) in summer than during each of the other seasons, with the catch rate during winter also being significantly higher than during autumn and spring (at the 1 and 5 per cent level respectively). Whiting catch rates were not significantly different at the 5 per cent level between each of the other seasons. This is interesting to note given that the recreational whiting fishery is primarily for summer and yellow fin whiting (Pollock (1980) and Hyland (1988)). However, while summer is the best time for summer whiting (The Great Outdoors 1996) these species are available all year round (Queensland Transport 1996) and it is possible that the decline in catch rates in winter and spring of summer whiting is offset by winter whiting catches. Flathead catch rates were significantly higher (at the 5 per cent level) in spring and summer compared to catch rates during winter.

2.6 Species targeted per fishing trip: Boat fishers

	Species targeted				
	None %	Bream %	Whiting %	Flathead %	Other %
Logan River	53	23	14	15	2
Pine River	45	27	12	18	4
Mary River	32	38	7	19	22
Burnett River	26	58	11	21	5
Repulse Bay	34	29	8	14	25

2.7 Average trip catch rates by species and area: Boat fishers

	Bream		Whiting		Flathead		Other	
	Boat catch	*No./hr fished*	*Boat catch*	*No./hr fished*	*Boat catch*	*No./hr fished*	*Boat catch*	*No./hr fished*
Logan River	3.84 (4.60)	0.42 (0.67)	1.93 (3.38)	0.25 (0.52)	0.95 (1.48)	0.09 (0.20)	1.31 (3.29)	0.16 (0.49)
Pine River	3.38 (3.85)	0.50 (0.76)	2.36 (4.74)	0.28 (0.63)	0.79 (1.69)	0.10 (0.24)	0.85 (1.96)	0.09 (0.28)
Mary River	6.44 (5.35)	0.97 (1.08)	5.18 (6.11)	0.71 (0.90)	2.59 (4.45)	0.28 (0.47)	3.80 (6.62)	0.45 (0.75)
Burnett River	5.87 (4.48)	0.82 (0.90)	2.22 (3.30)	0.30 (0.55)	1.32 (2.37)	0.15 (0.28)	2.22 (3.58)	0.35 (0.73)
Repulse Bay	6.65 (5.57)	0.60 (0.55)	1.82 (3.52)	0.21 (0.44)	1.21 (1.62)	0.13 (0.25)	5.08 (5.49)	0.49 (0.65)
All areas	4.71 (4.62)	0.63 (0.81)	2.57 (4.47)	0.34 (0.64)	1.27 (2.46)	0.15 (0.30)	2.44 (4.42)	0.32 (0.65)

2.8 Average group catch rates by species and area: Boat fishers

	Bream		Whiting		Flathead		Other	
	Boat catch	*No./hr fished*	*Boat catch*	*No./hr fished*	*Boat catch*	*No./hr fished*	*Boat catch*	*No./hr fished*
Logan River	3.08 (3.97)	0.35 (0.60)	1.4 (2.57)	0.15 (0.42)	0.77 (1.18)	0.09 (0.21)	1.79 (3.65)	0.19 (0.39)
Pine River	2.86 (2.86)	0.44 (0.66)	1.80 (4.00)	0.24 (0.57)	0.58 (1.43)	0.08 (0.22)	0.86 (2.19)	0.11 (0.37)
Mary River	6.49 (5.24)	1.05 (1.07)	3.89 (4.82)	0.66 (0.91)	1.93 (3.19)	0.26 (0.41)	2.67 (5.02)	0.41 (0.78)
Burnett River	4.41 (4.20)	0.59 (0.74)	1.37 (2.79)	0.18 (0.43)	1.30 (2.03)	0.17 (0.29)	2.01 (2.79)	0.27 (0.47)
Repulse Bay	5.74 (5.96)	0.55 (0.66)	1.54 (3.27)	0.18 (0.39)	0.95 (1.31)	0.09 (0.16)	4.83 (5.46)	0.47 (0.65)
All areas	3.83 (4.25)	0.53 (0.73)	1.84 (3.79)	0.26 (0.59)	0.95 (1.88)	0.12 (0.27)	2.13 (3.79)	0.27 (0.53)

2.9 Average trip catch rates for target species by season: Boat fishers

	Bream		Whiting		Flathead		Other	
	Boat catch	*No./hr fished*	*Boat catch*	*No./hr fished*	*Boat catch*	*No./hr fished*	*Boat catch*	*No./hr fished*
:Summer	2.40 (3.15)	0.31 (0.56)	2.22 (3.53)	0.26 (0.46)	1.30 (2.57)	0.14 (0.27)	2.37 (4.44)	0.29 (0.57)
:Autumn	4.72 (4.44)	0.64 (0.81)	2.28 (4.62)	0.25 (0.52)	1.00 (2.01)	0.12 (0.25)	2.57 (4.03)	0.30 (0.62)
:Winter	6.31 (4.65)	0.97 (1.10)	2.60 (3.69)	0.41 (0.75)	0.78 (1.68)	0.09 (0.23)	2.78 (6.11)	0.37 (0.84)
:Spring	5.22 (4.69)	0.68 (0.84)	2.82 (4.47)	0.36 (0.67)	1.42 (2.54)	0.15 (0.30)	1.52 (2.87)	0.20 (0.43)

In Tables 2.10 and 2.11 the mean (and standard deviation) of the characteristics of a fishing trip and of fishers is provided. The difference between the two relates to the sample weights used. In Table 2.10 the data is weighted such that the figures reflect the average fishing trip, whereas in Table 2.11 the data is weighted to reflect the average fisher. For example, the average time spent traveling to a fishing site at the Logan River per trip is around 29 minutes, however the average fisher travels for around 39 minutes. This difference reflects the fact that those who are closest to the site fish at the site most often.

A t-test was carried out and the mean of the total number of days fished over the previous year using the weighting factor for fishing trips was found to be significantly different from the total number of days fished over the previous year using the weighting factor for fishers at at least the 5 per level in all areas. For the annual number of days fished at the interview site the means of the two measures were found to be significantly different at the 1 per level in all areas. For the number of days expected to be fished in the following month the trip means were significantly different at at least the 10 per cent level for all areas expect for Repulse Bay. This indicates that it is important that where appropriate the data be weighted to ensure that the bias toward those who fish, or fish at a given site, the most often is accounted for.

2.10 Characteristics of fishing trip: Boat fishers

		Logan River	Pine River	Mary River	Burnett River	Repulse Bay	All areas
Days fished in rivers/inshore areas in previous year		22.83	17.18	32.41	34.96	25.08	28.57
		(27.45)	(18.90)	(32.50)	(37.18)	(28.37)	(32.30)
Days fished at site in previous year		13.33	8.52	13.62	14.53	9.90	12.25
		(21.46)	(11.32)	(15.06)	(17.98)	(12.18)	(15.89)
Days expected to fish in following month		2.75	2.40	4.64	4.69	3.89	4.07
		(2.61)	(2.09)	(4.05)	(3.59)	(3.82)	(3.74)
Number of commercial vessels seen by fishers		0.43	0.45	0.80	1.18	0.15	0.71
		(0.81)	(0.81)	(1.29)	(1.63)	(0.48)	(1.21)
Number of fishers in boat		2.71	2.75	2.42	2.38	2.84	2.57
		(1.10)	(1.36)	(1.25)	(1.20)	(1.10)	(1.23)
Number of fishers in boat over 16		2.42	2.29	2.06	2.03	2.30	2.21
		(1.09)	(1.12)	(1.00)	(1.10)	(0.88)	(1.08)
Time taken to travel to fishing site	*min*	29.07	23.67	21.14	15.63	12.65	20.40
		(30.32)	(14.02)	(12.72)	(8.81)	(9.87)	(14.05)
Total time spent on water	*hrs*	5.06	5.19	5.56	6.24	5.58	5.49
		(1.89)	(1.66)	(1.67)	(2.32)	(1.83)	(1.99)
Time spent fishing	*hrs*	5.06	4.68	4.95	5.63	5.01	4.92
		(1.68)	(1.43)	(1.48)	(2.18)	(1.80)	(1.88)
Expenditure by group on day’s fishing trip	*$*	23.48	19.38	15.72	15.31	17.60	17.98
		(16.38)	(8.50)	(9.42)	(8.77)	(9.07)	(10.99)
Average expenditure per adult over 16 on day’s fishing trip	*$*	11.50	10.46	9.91	8.91	8.78	9.76
		(9.04)	(7.07)	(8.66)	(6.29)	(5.25)	(7.26)
Income levels							
:$0-15 000	*%*	24.66	35.40	25.52	26.79	22.95	31.07
:$15 000-30 000		42.80	28.97	26.26	20.82	46.30	29.71
:$30 000-45 000		18.11	22.37	30.27	24.68	24.67	22.40
:$45 000+		14.43	13.27	17.94	27.71	6.08	16.83
Employment Status							
:Full-time	*%*	69.98	62.77	63.67	60.43	67.65	58.14
:Other		30.02	37.33	36.33	39.57	32.35	41.86
Fishing activity							
:Line only	*%*	78.28	74.16	82.56	75.90	52.71	75.54
:Line plus other		21.72	25.84	17.44	24.10	47.29	24.46
Congestion ranking							
1 or 2		20.79	17.50	4.40	8.56	3.63	10.34
3 or 4		79.21	82.50	95.60	91.44	96.37	89.66
Enjoyment ranking							
1 or 2		90.82	95.85	94.10	88.36	98.01	92.89
3 or 4		9.18	4.15	5.90	11.64	1.99	7.11
Expected weather conditions ranking							
1 or 2		59.36	48.32	54.41	58.17	66.43	59.05
3 or 4		40.64	51.68	45.69	41.83	33.57	40.95
Weather and fishing conditions[c]							
1 or 2		61.35	51.14	57.19	60.41	64.80	59.13
3 or 4		38.65	48.96	42.81	39.59	35.20	40.87
Visitor to region	*%*	1.65	2.82	9.80	13.17	12.86	11.33
Type of bait used[a]							
:Prawns	*%*	36.28	41.29	36.68	51.24	33.95	42.60
:Mullet gut		21.25	17.74	20.93	30.63	14.11	29.47
:Pilchard		25.99	26.35	48.99	21.81	59.35	32.89
:Yabbies		25.03	34.49	21.95	8.94	8.64	18.51
:Other		48.46	53.56	38.17	45.15	53.65	24.28

a Figures will not add up to one hundred as many fishers use more than one bait type on a given day.

2.11 Characteristics of fisher: Boat fishers

		Logan River	Pine River	Mary River	Burnett River	Repulse Bay	All areas
Days fished in rivers/inshore areas in previous year		11.32 (15.78)	8.79 (11.99)	18.24 (4.52)	21.03 (30.37)	17.16 (5.32)	15.92 (22.97)
Days fished at site in previous year		3.32 (5.79)	3.15 (4.13)	4.52 (6.45)	4.58 (6.78)	5.32 (4.97)	4.08 (5.78)
Days expected to fish in following month		1.63 (1.89)	1.61 (1.83)	3.47 (4.34)	3.62 (3.40)	3.35 (4.03)	2.89 (3.48)
Number of commercial vessels seen by fishers		0.40 (0.92)	0.44 (0.83)	0.70 (1.20)	0.80 (1.34)	0.17 (0.54)	0.61 (1.09)
Number of fishers in boat		2.71 (1.20)	2.96 (1.49)	1.92 (1.26)	2.73 (1.47)	2.83 (1.21)	2.64 (1.35)
Number of fishers in boat over 16		2.40 (1.10)	2.37 (1.22)	1.76 (1.12)	2.25 (1.18)	2.23 (0.93)	2.21 (1.14)
Time taken to travel to fishing site	*min*	38.87 (22.12)	24.21 (12.70)	23.33 (13.59)	17.89 (10.71)	14.09 (12.28)	24.92 (16.87)
Total time spent on water	*hrs*	5.50 (1.99)	5.13 (1.54)	5.16 (1.30)	5.84 (2.32)	5.50 (1.90)	5.33 (1.92)
Time spent fishing	*hrs*	5.09 (1.87)	4.59 (1.49)	4.67 (1.13)	5.35 (2.20)	4.78 (1.90)	4.80 (1.85)
Expenditure by group on day's fishing trip	*$*	29.60 (18.68)	21.08 (8.18)	18.32 (9.12)	17.36 (8.41)	20.82 (12.26)	21.47 (12.77)
Average expenditure per adult over 16 on day's fishing trip	*$*	14.09 (9.27)	11.48 (7.90)	13.71 (9.69)	9.53 (6.54)	10.72 (6.24)	11.74 (8.13)
Income levels							
:$0-15 000	*%*	23.85	40.02	26.74	27.73	27.12	33.71
:$15 000-30 000		39.94	26.72	34.07	14.80	40.94	29.48
:$30 000-45 000		19.46	24.04	15.13	25.82	22.49	20.50
:$45 000+		16.77	9.22	24.06	31.63	9.45	16.31
Employment Status							
:Full-time	*%*	72.87	64.58	69.21	63.84	66.74	61.48
:Other		27.13	35.42	30.79	36.16	33.26	48.71
Fishing activity							
:Line only	*%*	76.99	71.38	83.10	88.63	45.39	80.43
:Line plus other		23.01	29.62	6.90	11.37	54.61	19.57
Congestion[b]							
1 or 2		18.71	16.84	3.46	17.53	3.87	12.37
3 or 4		81.29	83.16	96.54	82.47	93.44	87.63
Enjoyment ranking							
1 or 2		94.52	95.27	85.62	89.37	94.99	92.43
3 or 4		5.48	4.73	14.38	10.63	5.01	7.57
Expected weather conditions ranking							
1 or 2		64.91	49.82	57.27	57.72	69.51	58.08
3 or 4		35.09	50.08	43.73	42.28	30.49	41.92
Weather and fishing conditions[c]							
1 or 2		61.77	48.15	58.84	58.78	63.87	56.68
3 or 4		38.23	51.85	41.16	41.22	36.13	43.32
Visitor to region	*%*	2.74	2.94	15.40	20.67	25.19	15.01

Shore fishers and shore fishing days

Six hundred and seventy one respondents provided sufficient information in response to the survey questions to enter the final data set. Before presenting the results there are two main areas differentiating the shore fisher survey from that of the boat fisher survey that need to be outlined. First, in the boat fisher survey, all fishers had completed their days fishing at the time of the survey whereas in the shore fisher survey a substantial majority of fishers continued to fish after the survey was completed. Thus, the catch rates provided are for the proportion of the days fishing that had been undertaken at the time of the survey. Second, in the boat fisher survey in all cases there was at least one adult over the age of 16 amongst the fishing group, this was not always the case in the shore fisher survey. As such where previously hourly catch rates were based on the number of adults in the party, for the shore fisher data, where no adults are among the fishing group, the number of persons in the group is used. Where an adult is present the calculation is as for the boat fisher data.

The number of respondents entering the data set and the number of days on which interviews were conducted by area and survey strata and by area and season is given in Tables 2.12 and 2.13, respectively.

2.12 Number of survey respondents by area, type of day and period: Shore fisher survey

		Time of day							
	Type of day	Early Morn		Late Morn		Afternoon		Early Eve	
		# days	# inter	# days	# inter	# days	# inter	# days	# inter
Logan River (total number of Interviews 168)	Public holiday	0	0	1	6	3	9	2	23
	School holiday	1	6	1	8	1	4	0	0
	Weekend	2	10	3	28	2	14	2	22
	Weekday	0	0	1	2	2	19	3	17
Pine River (total number of Interviews 165)	Public holiday	1	6	1	19	1	11	0	0
	School holiday	1	10	1	6	1	3	0	0
	Weekend	2	24	3	34	3	24	2	18
	Weekday	1	1	1	2	1	4	1	3
Mary River (total number of Interviews 72)	Public holiday	0	0	0	0	0	0	1	4
	School holiday	1	4	1	9	1	2	1	6
	Weekend	0	0	1	6	1	9	1	16
	Weekday	1	1	1	6	1	0	1	9
Burnett River (total number of Interviews 189)	Public holiday	0	0	0	0	0	0	0	0
	School holiday	0	0	0	0	1	12	1	17
	Weekend	3	34	3	11	3	23	2	12
	Weekday	3	21	3	29	2	13	2	17
Repulse Bay (total number of Interviews 77)	Public holiday	0	0	0	0	0	0	0	0
	School holiday	1	9	1	5	1	6	1	9
	Weekend	0	0	1	5	0	0	1	2
	Weekday	3	10	2	6	3	9	2	16
All areas (total number of Interviews 671)	Public holiday	1	6	2	25	4	20	3	27
	School holiday	4	29	4	28	5	27	3	32
	Weekend	7	68	11	84	9	70	8	70
	Weekday	8	33	8	45	9	45	9	62

2.13 Number of survey respondents by area and season: Shore fisher survey

	Summer		Autumn		Winter		Spring		Total	
	# periods	# inter	# periods	# inter	# periods	# inter	# periods	# inter	# periods	# inter
:Logan	5	48	10	62	6	39	3	19	24	168
:Pine	6	41	3	22	6	49	5	53	20	165
:Mary	0	0	4	23	4	18	4	31	12	72
:Burnett	0	0	13	87	5	57	5	45	23	189
:Repulse	14	72	2	5	0	0	0	0	16	77
All areas	25	161	32	199	21	163	17	148	95	671

Catch, catch rates and targeting behaviour

The majority of shore fishers did not nominate any specific target species. Of those who did the species most often targeted by far was bream. As reported in Table 2.14, a range of other species were also targeted including whiting, flathead, trevally, and mackerel although by a much smaller number of fishers. These were also the species which tended to be kept after capture. As the predominant species sought and kept was bream the results for this species are presented separately, with the data on the other fish species kept being provided under the one category. As for the boat fisher survey, only catch rates relating to the number of fish caught and kept by fishers are provided. Further, the catch data per group relates to the number of fish caught by fishers at the time of the interview. As such, the average time already spent fishing at the time of interview is also provided for each area (Tables 2.16 and 2.17), and hourly catch rates calculated on this portion. Also as previously outlined, where no adults are among the fishing group, the number of persons in the group is used to calculate catch rates, and where an adult is present the calculation is as for the boat fisher data.

2.14 Species targeted per fishing trip: Shore fishers

	Species targeted		
	None %	Bream %	Other %
Logan River	71	21	13
Pine River	76	21	9
Mary River	58	28	26
Burnett River	54	33	16
Repulse Bay	44	18	46

2.15 Average trip catch rates by species and area: Shore fishers

	Average time spent fishing before interview (*mins*)	Bream		Other	
		No./hr fished	*Trip catch*	*No./hr fished*	*Trip catch*
Logan River	109	0.41	0.84	0.40	1.04
		(0.86)	(1.44)	(0.68)	(1.48)
Pine River	132	0.30	0.71	0.35	1.14
		(0.76)	(0.41)	(0.60)	(1.94)
Mary River	89	0.98	2.34	0.86	1.63
		(1.47)	(3.35)	(1.55)	(2.79)
Burnett River	125	0.77	2.27	0.29	0.64
		(0.29)	(1.65)	(0.68)	(1.26)
Repulse Bay	129	0.17	0.52	1.62	4.54
		(0.45)	(1.31)	(1.52)	(3.51)
All areas	111	0.63	1.64	0.66	1.66
		(1.20)	(3.06)	(1.23)	(2.72)

2.16 Average group catch rates by species and area: Shore fishers

	Average time spent fishing before interview (*mins*)	Bream		Other	
		No./hr fished	*Group catch*	*No./hr fished*	*Group catch*
Logan River	107	0.54	1.03	0.39	1.04
		(1.14)	(1.63)	(0.68)	(1.47)
Pine River	127	0.38	0.73	0.33	0.79
		(0.94)	(1.62)	(0.59)	(1.47)
Mary River	78	0.89	1.64	0.64	0.87
		(1.75)	(2.69)	(1.61)	(1.83)
Burnett River	123	0.68	1.96	0.24	0.60
		(1.19)	(3.23)	(0.52)	(1.21)
Repulse Bay	113	0.25	0.59	1.48	3.66
		(0.50)	(1.39)	(1.36)	(3.17)
All areas	107	0.70	1.36	0.51	1.24
		(1.50)	(2.32)	(0.96)	(2.14)

2.17 Average trip catch rates for target species by season: Boat fishers

	Bream		Other	
	Group catch	*No./hr fished*	*Group catch*	*No./hr fished*
:Summer	0.84	0.31	2.26	0.87
	(1.63)	(0.60)	(3.24)	(1.49)
:Autumn	0.86	0.29	1.14	0.49
	(1.69)	(0.63)	(1.92)	(0.99)
:Winter	2.11	0.89	1.09	0.41
	(3.33)	(1.48)	(2.09)	(0.81)
:Spring	1.71	0.71	1.25	0.51
	(3.07)	(1.28)	(1.95)	(0.88)

2.18 Characteristics of fishing trip: Shore fishers

		Logan River	Pine River	Mary River	Burnett River	Repulse Bay	All areas
Days fished in rivers/inshore areas in previous year		17.53	15.48	25.11	26.98	47.72	25.15
		20.45	18.09	30.53	32.80	39.84	31.36
Days fished at site in previous year		11.49	9.89	16.76	14.48	19.31	14.06
		13.93	13.31	25.71	16.36	16.67	17.88
Days expected to fish in following month		2.23	1.82	3.30	3.81	4.85	3.31
		2.07	1.81	3.23	3.61	3.17	3.27
Number of commercial vessels seen by fishers		0.11	0.20	0.08	0.11	0.08	0.13
		0.32	0.40	0.27	0.32	0.27	0.33
Number of fishers in group		2.02	2.08	1.98	2.16	2.07	2.08
		1.44	1.14	0.95	1.35	0.81	1.16
Number of fishers in group over 16		1.63	1.60	1.54	1.64	1.29	1.69
		0.78	0.94	0.90	1.14	1.02	1.02
Time taken to travel to fishing site	*min*	23.35	25.47	16.93	12.53	12.56	17.94
		11.11	9.98	6.86	5.42	5.90	9.48
Time spent fishing before interview	*min*	108.86	132.48	89.03	125.20	129.20	110.51
		55.89	68.70	53.76	67.71	57.86	63.18
Expected extra fishing time	*min*	62.22	38.15	73.08	58.38	42.16	61.55
		58.66	48.53	56.59	58.20	51.40	61.46
Expenditure by group on day's fishing trip	*$*	14.81	11.43	5.91	7.72	9.80	9.52
		11.13	8.28	4.28	4.10	5.71	7.29
Average expenditure on day's fishing trip	*$*	9.92	7.39	4.45	5.34	7.92	6.30
		7.05	6.16	3.66	3.42	5.41	5.34
Income levels							
:$0-15 000	%	36.77	45.64	53.87	45.71	76.96	46.42
:$15 000-30 000		18.82	11.37	29.37	29.48	12.72	26.03
:$30 000-45 000		20.06	31.70	10.59	11.89	5.85	16.05
:$45 000+		24.35	11.29	6.17	12.92	4.47	11.50
Employment Status							
:Full-time	%	67.79	65.68	42.57	52.40	23.81	54.96
:Other		32.21	34.32	57.43	47.60	76.19	45.04
Congestion ranking							
1 or 2	%	11.58	12.88	0	4.00	0	5.68
3 or 4		88.42	77.12	100	96.00	100	94.32
Enjoyment ranking							
1 or 2	%	79.38	82.73	89.69	80.52	76.09	81.75
3 or 4		20.62	17.33	10.31	19.48	24.91	18.25
Expected weather conditions ranking							
1 or 2	%	76.68	87.09	73.42	77.21	41.76	74.72
3 or 4		23.32	12.91	44.49	22.79	58.24	25.28
Weather and fishing conditions[c]							
1 or 2	%	65.56	68.69	63.64	63.02	49.37	65.26
3 or 4		47.66	46.52	36.34	48.40	51.63	34.74
Visitor to region	%	0.24	1.11	12.44	12.74	9.13	10.20
Type of bait used[a]							
:Prawns	%	24.40	29.09	20.83	32.80	25.97	27.71
:Mullet gut		7.14	3.03	13.89	11.64	9.09	8.35
:Pilchard		31.55	37.58	55.56	44.44	64.94	43.07
:Yabbies		13.69	7.27	4.17	7.94	11.69	9.24
:Other		58.33	55.76	48.61	44.44	45.45	51.27

a Figures will not add up to one hundred as many fishers use more than one bait type on a given day.

2.19 Characteristics of fisher: Shore fishers

		Logan River	Pine River	Mary River	Burnett River	Repulse Bay	All areas
Days fished in rivers/inshore areas in previous year		5.71 8.66	4.36 7.85	6.49 1.47	8.79 15.58	18.41 27.83	7.14 13.38
Days fished at site in previous year		3.43 5.27	2.73 4.44	3.74 7.03	4.50 6.72	8.04 9.58	3.99 6.34
Days expected to fish in following month		1.20 1.24	0.77 1.10	1.47 1.94	2.07 2.13	2.75 2.51	1.56 1.91
Number of commercial vessels seen by fishers		0.05 0.23	0.11 0.31	0.02 0.15	0.07 0.26	0.08 0.28	0.08 0.27
Number of fishers in boat		2.06 1.38	2.10 1.23	1.84 1.03	2.01 1.09	2.07 0.81	1.99 1.10
Number of fishers in boat over 16		1.61 0.75	1.64 0.96	1.35 0.60	1.35 0.97	1.56 0.95	1.57 0.91
Time taken to travel to fishing site	*min*	24.27 10.30	27.48 9.94	17.38 5.93	13.66 5.55	13.23 5.46	20.12 10.37
Time spent fishing before interview	*min*	107.34 55.87	126.80 61.43	78.08 55.68	123.35 66.49	113.28 59.23	107.01 62.83
Expected extra fishing time	*min*	69.02 63.86	38.80 46.00	66.92 50.94	56.72 53.97	45.60 58.73	60.14 59.43
Expenditure by group on day's fishing trip	*$*	15.86 11.25	13.40 8.16	7.33 4.79	8.05 4.06	9.12 5.37	10.89 7.84
Average expenditure on day's fishing trip	*$*	10.65 7.41	9.08 6.68	5.61 3.74	6.23 3.51	6.60 4.26	7.62 6.13
Income levels							
:$0-15 000	*%*	23.75	41.81	36.90	41.53	72.28	38.38
:$15 000-30 000		34.78	14.81	42.49	35.79	12.85	30.58
:$30 000-45 000		22.66	26.06	15.91	11.20	6.50	18.65
:$45 000+		18.81	17.33	4.70	11.50	8.37	12.39
Employment Status							
:Full-time	*%*	79.76	78.35	51.13	62.70	32.85	65.33
:Other		20.24	21.65	48.97	37.30	68.15	34.67
Congestion[b]							
1 or 2	*%*	15.27	11.61	0	8.53	0	7.17
3 or 4		84.73	88.39	100	91.47	100	92.83
Enjoyment ranking							
1 or 2	*%*	69.43	82.74	92.91	83.00	75.83	77.05
3 or 4		31.57	17.26	7.09	17.00	24.17	22.95
Expected weather conditions ranking							
1 or 2	*%*	86.70	93.98	82.02	89.82	66.55	86.22
3 or 4		13.30	23.86	17.98	10.18	33.45	13.78
Weather and fishing conditions[c]							
1 or 2	*%*	70.09	70.60	74.44	60.17	70.86	70.16
3 or 4		29.91	29.40	25.56	39.83	29.14	29.84
Visitor to region	*%*	0.35	0.67	19.04	21.59	16.99	13.49

Other studies

There have been several other studies conducted into various aspects of recreational fishing in river and inshore areas in Queensland with the majority of the information relating to catch rates. In the next chapter a comparison of catch rates between studies is provided in an attempt to examine changes in recreational fish catch rates over recent years. The reader is referred to this chapter for this comparison and discussion. There is also some socioeconomic and fishing pattern data available from a survey conducted by the QDPI in the Pine River (Phil Pond, Fisheries, QDPI, pers com.) and an ABS survey of Queensland recreational fishing (ABS (1986)) and these are presented in Table 2.20. While it is difficult to make direct comparisons between the studies as there is some discrepancy as to the nature of the questions asked to elicit responses the following observations can be made.

The major difference in these studies from the results obtained in the present study is the percentage of fishers who are visitors to the region in which they are fishing, with the ABS survey showing a much higher percentage of visitors. Also the number of days fished is somewhat different, with the ABS study indicating that around 50 per cent of fishers fished 4 days or fewer per year, a much larger percentage than in the current study.

2.20 Socioeconomic and fishing pattern data: other studies

		Pine River[a]	Brisbane[b]	Wide Bay-Burnett[b]	MacKay-Fitzroy[b]
Employment status					
Employed	%		69	70	70
Unemployed	%		6	7	10
Not in labour force	%		24	23	20
Visitor to region	%	10	18	60	59
Number of days fished per annum					
1-2	%		35	32	30
3-4	%		19	23	15
5-9	%		20	19	25
10-19	%		15	14	15
20+	%		11	12	15
Percentage of fishing conducted in area					
<25%	%	35			
>50%	%	49			
100%	%	16			
Bait type used (%)					
Worms	%	21			
Prawns	%	28			
Lures	%	2			
Mullet gut	%	8			
Squid	%	8			
Yabbies	%	3			
Fish	%	27			
Other	%	3			

a Pers. com. Phil Pond, Fisheries, QDPI. **b** ABS (1986).

Analysis and results

In this section the survey data are analysed to estimate the value, and the determinants of value, of a recreational fishing day, where value is defined as net economic benefit. As previously stated the survey was divided between recreational boat and recreational shore fishers. In the first part of this section the data from the boat fisher survey are analysed and the results presented. Following this the results of the estimation procedures are presented for the shore fisher component of the survey. Finally a discussion of the results obtained from both surveys is presented.

Boat fishers and boat fishing days

In the analysis that follows the value, and determinants of value, of an river/inshore recreational boat fishing day are estimated through five different approaches. These approaches are:

- the estimation of boat fisher demand and willingness to pay functions for a year's river/inshore recreational fishing days through a total direct cost analysis (TDC AD).
- the estimation of boat fisher demand and willingness to pay functions for a month's river/inshore recreational fishing days through a total direct cost analysis (TDC MD).
- the estimation of boat fisher demand and willingness to pay functions for a year's recreational fishing days at a given site through a total direct cost analysis (TDC ASD).
- the estimation of willingness to pay for a marginal boat fishing day function through a contingent valuation analysis (CVM WTP).
- the estimation of willingness to accept compensation to forgo a marginal block of boat fishing days function through a contingent valuation analysis (CVM WTA).

As the total direct cost functions relate to the population of fishers, and the contingent valuation functions relate to the population of fishing days, in estimating the respective functions the sample data are weighted by the fisher weighting variable under the former analysis, and by the fishing day weighting variable under the latter.

The purpose of the question relating to whether a fisher had been interviewed before was to allow for the elimination of repeat respondents from the total direct cost analysis. However, given that of those who had been interviewed before further post survey discussion often revealed that the previous interview was for a different survey; only a small proportion of the sample claimed to have been interviewed before (some 4.7 per cent), possibly due to the fact that those who had participated in previous surveys were the most likely to decline and to the large area and portion of the day covered in the survey; and that the season was a rolling one; all responses were entered into the data set.

A vector of explanatory variables was obtained from the survey data for each of the analyses. The variables correspond to the hypothesised influences on the demand for recreational fishing days. Some variables are included only in some of the estimation procedures as they are not appropriate proxies in all cases. For example, the weather conditions on the day of the survey is a good proxy for the weather experience on that day, and as such is included in the WTP analysis. However, it is not a good proxy of the average weather conditions a fisher experienced over an extended period and, as such, is not used in any of the other models. Two additional dummy variables in relation to beam trawl and commercial fishing activity were also used. Beam trawl activity is seasonal, with the majority of effort being expended between November and May in Area 1 and between February and July in Areas 2 to 5. As such, for analysis including seasonal factors a dummy variable was used to indicate if the fishing day(s) lay in this period. Second, there is a weekend closure enforced in the beam trawl and many other commercial fisheries. As such, a dummy variable was used to indicate these times. The variables included, and their use, in each of the analyses are listed in Table 2.21.

2.21 List of variables used in boat fisher analysis

Description	Variable name	TDC AD	TDC MD	TDC ASD	CVM WTP	CVM WTA
t: Bid amount offered						
Willingness to pay	WTP	-	-	-	D	-
Willingness to accept	WTA	-	-	-	-	D
T_f: Fishing days demanded						
Total days fished previous year	AD	D	-	-	E	E
Days anticipated to fish in next month	MD	-	D	-	-	E
Site days fished previous year	ASD	-	-	D	-	-
X: Inputs into fishing day						
Individual's expenditure on day's trip[c]	FEXP	E	E	E	E	-
Total travel time[d]	TRAV	E	E	E	E	-
Time spent fishing	TFSH	E	E	E	E	-
Time spent on site not fishing	TNFSH	E	E	E	E	-
F: Attributes of fisher						
Income $15 - 30 000	INC15	E	E	E	E	E
Income $30 - 45 000	INC30	E	E	E	E	E
Income $45 000+	INC45	E	E	E	E	E
Full time employed (1= yes)	FTEMP	E	E	E	E	E
Expected weather and boating conditions (1= rank of 1 or 2)	ECON	E	E	E	E	E
Fished alone (1= yes)	SOLO	E	E	E	E	E
Visiting region (1= yes)	VIST	E	E	E	E	E
Fished line plus other method (1= yes)	FSHLO	E	E	E	E	E
Q: Attributes of the fishing day						
Number of bream per fisher kept[d]	NBRE	E	E	E	E	E
Number of whiting per fisher kept[d]	NWHI	E	E	E	E	E
Number of flathead per fisher kept[d]	NFLA	E	E	E	E	E
Number of other fish per fisher kept[d]	NOTH	E	E	E	E	E
Number of crabs per fisher kept[d]	NCRAB	E	E	E	E	E
Weight of prawns per fisher kept[d]	WPRA	E	E	E	E	E
Enjoyed trip (1= ranking of 1 or 2)	ENJ	E	E	E	E	E
Commercial vessels seen (1= yes)	SCOM	E	E	E	E	E
Beam trawl season (1= yes)	BTS	-	E	-	E	E
Weekend closure (1= yes)	WCL	E	E	E	E	E
Site congested (1= rank of 1 or 2)	CONG	E	E	E	E	E
Weather and boating conditions on day of interview (1= rank 1 or 2)	COND	-	-	-	E	-
Time of year (by season):						
Summer	AUT	-	E	-	E	E
Winter	WIN	-	E	-	E	E
Spring	SPR	-	E	-	E	E
Site:						
Pine River	PINE	E	E	-	E	E
Mary River	MARY	E	E	-	E	E
Burnett River	BUR	E	E	-	E	E
Repulse Bay	REP	E	E	-	E	E
A: Substitute site availability index	A	-	-	E	-	-

a D denotes the dependent variable in the respective analysis. **b** E denotes the variable was used as an explanatory variable in the respective analysis. **c** Obtained by dividing the total group expenditure by the number of adults over 16 in the group. **d** Obtained by multiplying time taken to travel to site by 2. **e** Obtained by dividing the boat catch by the number of adults fishing over 16.

Total direct cost method model

Under the total direct cost method demand for recreational fishing days is estimated as a function of the explanatory variables as given in Table 5V. From this a willingness to pay function is derived, with price being imputed from the total direct cost borne by the consumer for the fishing day.

Demand for Queensland river/inshore recreational fishing days model

In this section a demand function for recreational fishing days in the defined recreational fishery is reported. Full details of the estimation procedure are described in Reid (forthcoming). The dependent variable is the number of fishing days, and the explanatory variables are listed in Tables 2.22 and 2.23 Table 2.22 describes the annual demand, and Table 2.23 describes the monthly demand.

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2.22 Annual demand for recreational fishing days model: Boat fishers

Model specification		Model results	
Log T_f = x 'B		Average number of trips demand per month (standard deviation)	13.47 (8.10)
Lambda (λ) (t-ratio)	0.29623 (14.661)	Average cost of trip (including opportunity cost of travel time ($\delta WTP/\delta T_f$)	$16.92 (9.40)

Vector	Variable[a]	β_i	t-ratio	Level of significance at which H_A accepted	$\delta T_f/\delta x_i$	
					Mean	St Dev.
	constant	1.9761	6.313	1		
X: Inputs	FEXP	-0.0244	-3.374	1	-0.329	0.198
	TRAV	-0.0025	-1.395	-	-0.034	0.021
	TFSH	0.0241	0.875	-	0.325	0.195
	TNFSH	0.0288	0.379	-	0.388	0.233
F: Attributes of the fisher	INC15	0.4060	2.289	5	5.469	3.291
	INC30	0.6498	3.218	1	8.753	5.267
	INC45	0.6077	2.849	1	8.185	4.925
	FTEMP	-0.5841	-3.383	1	-7.868	4.734
	ECON	-0.2436	2.342	5	-3.281	1.974
	SOLO	-0.0879	-0.609	-	-1.184	0.712
	VIST	-0.1864	-1.112	-	-2.511	1.511
	FSHLO	0.0097	0.068	-	0.130	0.078
Q: Attributes of the fishing day	NBRE	00.339	3.067	1	0.457	0.275
	NWHI	0.0359	2.000	5	0.484	0.291
	NFLA	0.0812	2.706	1	1.094	0.658
	NOTH	0.0566	3.044	1	0.762	0.458
	NCRAB	0.1615	2.879	1	2.176	1.309
	WPRAW	0.0778	0.725	-	1.049	0.631
	ENJ	0.3861	2.043	5	5.200	3.129
	SCOM	0.2806	1.948	10	3.780	2.274
	WCL	0.1648	1.022	-	2.220	1.336
	CONG	-0.0101	-0.067	-	-0.134	0.082
	PINE	-0.0316	-0.202	-	-0.426	0.256
	MARY	0.1836	1.029	-	2.473	1.488
	BUR	0.2735	1.612	-	3.683	2.216
	REP	0.5104	2.555	1	6.874	4.136

a FEXP, Expenditure on day's trip per fisher over 16. TRAV, Total travel time. TFSH, Time spent fishing. TNFSH , Time spent on site not fishing. INC15, Income $15 - 30 000. INC30, Income $30 - 45 000. INC45, Income $45 000+. FTEMP, Full time employed. ECON, Expected condition (1= rank of 1 or 2). SOLO, Fished alone. VIST, Visiting region. FSHLO, Fished line plus other method. NBRE, Number of bream per fisher kept. NWHI, Number of whiting per fisher kept. NFLA, Number of flathead per fisher kept. NOTH, Number of other fish per fisher kept. NCRAB, Number of crabs per fisher kept. WPRAW, Weight of prawns per fisher kept. ENJ, Enjoyed trip (1 = rank of 1 or 2). SCOM, Commercial vessel(s) seen. BTS, Beam trawl season. WCL, Weekend closure of commercial fisheries. CONG, Site congested (1 = rank of 1 or 2). AUT, Autumn. WIN, Winter. SPR, Spring. PINE, Pine River. MARY, Mary River. BUR, Burnett River. REP, Repulse Bay.

2.23 Monthly demand for recreational fishing days model: Boat fishers

Model specification		Model results	
$\left(T_f^{\lambda}-1\right)/\lambda = x'\beta$		Average number of trips demand per month (standard deviation)	3.29 (2.29)
Lambda (λ) (t-ratio)	0.29623 (14.661)	Average cost of trip (including opportunity cost of travel time ($\delta WTP/\delta T_f$)	$27.56 (14.73)

Vector	Variable[a]	β_i	t-ratio	Level of significance at which H_A accepted	$\delta T_f/\delta x_i$ Mean	St Dev.
	constant	0.0872	0.202	-		
X: Inputs	FEXP	-0.0624	-5.100	1	-0.138	0.067
	TRAV	-0.0076	-3.961	1	-0.017	0.008
	TFSH	0.0378	0.874	-	0.083	0.041
	TNFSH	0.0028	0.028	-	0.006	0.003
F: Attributes of the fisher	INC15	0.4777	1.619	-	1.054	0.515
	INC30	0.4546	1.566	-	1.003	0.490
	INC45	0.2917	0.859	-	0.644	0.314
	FTEMP	-0.6613	-2.943	1	-1.459	0.712
	ECON	0.0329	0.251	-	0.073	0.035
	SOLO	0.6119	2.843	1	1.351	0.659
	VIST	0.7904	1.859	10	1.744	0.851
	FSHLO	-0.0260	0.160	-	-0.057	0.028
Q: Attributes of the fishing day	NBRE	0.0078	0.277	-	0.017	0.008
	NWHI	0.0536	1.778	10	0.118	0.058
	NFLA	0.0859	1.500	-	0.190	0.093
	NOTH	0.0394	1.156	-	0.087	0.042
	NCRAB	0.2407	3.744	1	0.531	0.259
	WPRAW	0.1712	0.993	-	0.378	0.184
	ENJ	0.6460	2.633	1	1.426	0.696
	SCOM	0.2093	0.981	-	0.462	0.225
	BTS	0.0789	0.237	-	0.174	0.085
	WCL	0.4584	1.409	-	1.012	0.494
	CONG	0.2442	1.568	-	0.539	0.263
	AUT	0.2645	1.327	-	0.584	0.285
	WIN	0.8902	2.204	5	1.965	0.959
	SPR	0.7979	2.891	1	1.761	0.859
	PINE	-0.0421	-0.205	-	-0.093	0.045
	MARY	0.0440	0.163	-	0.097	0.047
	BUR	0.2589	1.115	-	0.571	0.2789
	REP	1.0809	2.614	1	2.386	1.164

a FEXP, Expenditure on day's trip per fisher over 16. TRAV, Total travel time. TFSH, Time spent fishing. TNFSH , Time spent on site not fishing. INC15, Income $15 - 30 000. INC30, Income $30 - 45 000. INC45, Income $45 000+. FTEMP, Full time employed. ECON, Expected condition (1= rank of 1 or 2). SOLO, Fished alone. VIST, Visiting region. FSHLO, Fished line plus other method. NBRE, Number of bream per fisher kept. NWHI, Number of whiting per fisher kept. NFLA, Number of flathead per fisher kept. NOTH, Number of other fish per fisher kept. NCRAB, Number of crabs per fisher kept. WPRAW, Weight of prawns per fisher kept. ENJ, Enjoyed trip (1 = rank of 1 or 2). SCOM, Commercial vessel(s) seen. BTS, Beam trawl season. WCL, Weekend closure of commercial fisheries. CONG, Site congested (1 = rank of 1 or 2). AUT, Autumn. WIN, Winter. SPR, Spring. PINE, Pine River. MARY, Mary River. BUR, Burnett River. REP, Repulse Bay.

As a check on the reasonableness of the models a comparison between the results of the models and that which economic theory would predict follows.

From economic theory it would be expected that the coefficients of the inputs that reflect a cost to the fisher of undertaking a fishing trip would be negative, that is as these costs increase the quantity demanded would decrease. *A priori* it was assumed that the day's fishing cost and the time taken to travel to the site would be regarded as costs and as such the variables would have negative coefficients. There was no *a priori* position in respect to the coefficients of the other time input variables as it was felt that either of two hypotheses may be valid. The first being that the more dedicated the fisher, and hence the more days demanded, the longer they would spend on the water on a given trip. The second, that those who have less opportunity to fish, and hence demand fewer fishing days in total, would seek to maximise their fishing time on the trips they undertake.

In the annual model only the coefficient of the fishing days expenses variable is significant at at least the 10 per cent level, being significant at the 1 per cent level. In the monthly model both the coefficients of the fishing days expenses variable and the travel time variable are significant at the 1 percent level. The signs of the coefficient of the expenditure and travel time variables in both models are negative, as expected. The coefficient of the travel time variable is interesting in that from the monthly model it appears that travel time is, as expected, viewed as a cost by fishers, whereas in the annual model the coefficient is not statistically significant at the 10 per cent level. As the travel time specified in the models is that to the site the fisher was interviewed at, and not the average time they take to travel to a fishing site over the relevant time frame, it is possible that this travel time more accurately reflects the time that a fisher expects to expend on future trips over the following month, than that spent on fishing trips over the previous year. However, in the analysis carried out in the next section, on demand for fishing days at a given site, at two of the four sites the travel time coefficient is not significant, perhaps indicating that, overall, the opportunity cost of travel time does not have a significant impact on the demand for fishing days as indicated by the annual model. The coefficients of the fishing time variable and non-fishing time in boat variable are not significant in either model. This indicates that there is no significant relationship between the fishing time on a given day and the number of trips taken over either time frame.

The signs of the coefficients of the variable representing the attributes of the fisher were also as expected. The coefficients of the income variables in the annual model are all statistically significant at the 5 per cent level and indicate that as income increases to the $30 000 to $45 000 bracket the demand for fishing days over a year rises, holding all other variables constant, and then declines slightly for those on incomes above $45 000. In the monthly model none of the coefficients of the income bracket dummy variables are significant at the 10 per cent level. This indicates that while a fisher's income influences the number of fishing days they demand over a year, it does not appear to have a significant influence on the number of fishing days demanded over a month. This could be for several reason including the possibility that those in the sample earning higher income are doing so through working longer hours and have less flexibility in regard to when they fish. That is, while those in the higher income brackets may fish more often over a year their fishing pattern may be restricted to a certain number of times a week or month while those on lower incomes may fish relatively often at certain times of the year, while not fishing at all during other times of the year. While the full time dummy variable will allow to some extent for changes in the level of discretionary time available to fishers it is not a perfect proxy. As noted by O'Neill and Davis (1991) it may be desirable to ascertain the source of fishers' income as higher income generated through higher work time may negate the effect of increased income on demand. This appears to be the case over the shorter time frame of a month, although not over the longer time frame of a year. A better alternative to the employment status proxy used in the present study may be to ask respondents the average number of hours of work a week they have worked over a certain period. Another possibility is that over a period of a month as incomes increase fishers substitute fishing days for other activities.

For the other attributes of the fisher variables the coefficient of the full time employment variable is significant at the 1 per cent level and negative in both models, indicating that, holding all other variables constant, those in full time employment fish less than those not in full time employment. This was expected on the basis that it is likely that the full time employed have less discretionary time available in which to undertake fishing trips. Two dummy variables were used as a proxy for the dedication of a fisher, these being that for a fisher fishing alone and that for the conditions the fisher expected. In the monthly model, the coefficient of the solo fisher dummy variable was significant at the 1 per cent level and positive as expected. However, the coefficient of the expected conditions dummy variable was not significant at the ten per cent level. In the annual model the coefficient of the expected conditions dummy variable was significant at the 5 per cent level and negative as expected. That is, those who went fishing expecting fishing conditions to be excellent or good on average fished less than those who expected average or poor conditions. No *a priori* assumptions were made in relation to the visitor and fishing method dummy variables.

However, it can be seen that in the monthly model the coefficient of the visitor dummy variable is significant at the 10 per cent level. This indicates that visitors expect to undertake more fishing days over the following month than fishers residing in the local area. Given that visitors were typically holiday makers this is not an unreasonable finding.

The relationship between the demand for fishing days and the quality variables is ambiguous. As described by Cameron and James (1986), intuitively it would be expected that an increase in fishing quality would increase the number of days demanded at any price, however, the possibility that quality may be substituted for quantity must be taken into account. As such, no *a priori* assumptions were made in relation to the vector of quality attributes.

However, it can be seen from the model that the coefficients of all the catch variables are positive. In the annual model all the fish catch and the crab catch coefficients are significant at the 5 per cent level, with the whiting and crab coefficients being significant at at least the 10 per cent level in the monthly model. This indicates that as the size of the catch of the respective species increases there is a significant increase in number of fishing days demanded over the given time frame. Given that it is reasonable to assume that an increase in catch reflects an increase in the quality of the fishing day it follows that an increase in the quality of the day leads to increase in the number of days demanded.

In the monthly model only the coefficients of the whiting and crab catch variables are significant. It is somewhat of a surprise that the coefficient of the bream catch variable in the monthly model is not significant as this is the main target species. This may be because fishers' expectations of bream catch and, hence, their demand for fishing days over the following month, are based on the season rather than their catch on a given day. The survey data indicate that bream catches in winter and spring are significantly higher at the 5 per cent level than catch rates in summer, and both coefficients for the respective season dummy variables are significant at the 5 per cent level and positive, giving some support to this proposition. Alternatively, it may be simply that bream catch rates do not affect consumption decisions over the shorter time frame but do over the longer term, which is also not an unreasonable proposition. For example, a lower catch rate may not have an impact on a fishers demand for fishing days in the short term but over the longer term may do so, and vice-versa.

With the exception of the coefficients of some of the location and season dummy variables, for which no *a priori* assumptions were made, of the other quality variables only the coefficient of the enjoyment dummy variable was significant at at least the 10 per cent level in both models. This indicates that, as expected, those who enjoyed the fishing day more (that is, ranked it very or reasonably enjoyable) demand more fishing days over the respective time frame, holding all other variables constant.

Of the variables relating to commercial and beam trawl fishing activity, that is the weekend closure and commercial vessels seen dummy variables in the annual model and these plus the beam trawl season dummy variable in the monthly model, only the coefficient of the commercial vessels seen dummy variable in the annual model was significant at the 10 per cent level. This indicates that the presence of commercial vessels as currently experienced has little impact on the demand for recreational fishing days. The commercial vessels seen dummy variable in the annual model was positive which is not as expected. It was expected that the presence of commercial vessels in areas fished by recreational fishers would reduce demand for fishing days. However, the coefficient indicates that as the number of commercial vessels seen increases demand increases. One possibility for this is that experienced fishers, who tend to demand more fishing days, take more note of the activities and presence of commercial fishers, and indeed other recreational fishers, or more readily identify commercial fishing activities from a distance. If this is true it would lead to a bias in the number of commercial vessels seen variable and explain the sign obtained in the model results.

For the location dummy variables, no *a priori* assumptions were made but it can be seen that the coefficient of the Repulse Bay dummy variable is significant at the 1 per cent level. This indicates that, holding all other variables constant, fishers in this area demand significantly more fishing days than those fishing in Logan River.

Willingness to pay and net economic benefit

The mean (and standard deviation) of the derived maximum willingness to pay for each individual, including the imputed cost of the time involved in traveling to and from the site, are $762 (464) and $138 (99) for a year and a month's fishing respectively, with the average demand being 13.47 and 3.29 days over the respective periods. The net economic benefit (*NEB*) derived from undertaking the fishing trips is given by:

$$NEB = WTP - PT_f$$

where P is the price or cost per fishing trip, including both the direct monetary costs of a fishing day and the opportunity cost of the time involved in travel to and from the site, and T_t is the number of the trips. The average estimated total cost each individual faces for the fishing trip is $16.92 (9.40) under the annual model and $27.56 (14.73) under the monthly model. Thus, it is estimated that the net economic benefit associated with the average annual demand of 13.5 trips, is $552 (332) per year, and $63 (57) for the 3.3 trips demanded over a month.

The determinants of total willingness to pay and net economic benefit

There are two aspects associated with a change to any of the determinants, or explanatory variables x_i, these are, the change in a fisher's willingness to pay for their current demand for fishing days and the change in the total number of fishing days demanded. For example, an increase in a fisher's bream catch may result in a fisher being willing to pay more for each day that they currently go fishing and also may result in a fisher going fishing on more days. As outlined earlier net economic benefit is given by the amount that a fisher is willing to pay less the cost of undertaking the activity. Thus, the change in the level of expenditure resulting from a change in a given determinant must be taken into consideration when addressing changes to net economic benefit.

As it is the impact of beam trawling on the recreational fish catch that concerns us, the mean and standard deviation of the derived estimates for each individual of the effect of a unit change in each of the fish catch variables on the gross benefit (*WTP*) and net economic benefit (*NEB*) for fishing trips over a year is given below in Table 2.24. Since the catch rates are in terms of catch per fisher per trip, the figures shown represent the value of a unit increase in catch for each of the given species on each fishing trip undertaken over the whole year or month. Finally, as the coefficients of the variables that were used to examine the impact of the presence or possible presence of commercial vessels were not significant it follows that their impact on fishers willingness to pay is not significant and hence no values associated with these variables are shown.

2.24 Change in annual and monthly willingness to pay and net economic benefit associated with a one unit change in catch of specified species: Boat fishers

Variable	Annual model				Monthly model			
(x_I)	$\delta WTP/\delta x_j$		$\delta NEB/\delta x_j$		$\delta WTP/\delta x_j$		$\delta NEB/\delta x_j$	
	Mean ($)	St. Dev.	Mean ($)	St. Dev.	Mean ($)	St. Dev.	Mean ($)	St. Dev.
NBRE	25.84	15.75	18.72	11.26	0.85	0.42	0.45	0.29
NWHI	27.37	16.68	19.83	11.93	5.67	2.96	2.83	1.97
NFLA	61.86	37.70	44.82	26.97	9.45	4.65	4.96	3.19
NOTH	43.09	26.26	31.22	18.79	4.33	2.13	2.29	1.47

The determinants of marginal willingness to pay

The effect of a change in the value of an explanatory variable on the willingness to pay for an additional fishing day can derived. The results for both models are presented in Table 2.25.

2.25 Change in net economic benefit per trip associated with a one unit change in catch of each species: Boat fishers

Variable (x_i)	Annual model ($)	Monthly model ($)
NBRE	1.39	0.12
NWHI	1.47	0.86
NFLA	3.33	1.38
NOTH	2.32	0.63

Site demand model

In the previous section a demand model was estimated for river/inshore recreational fishing days. In this section a series of functions are reported for the demand for fishing days at specific sites. In this analysis it is assumed that a fishing day at the given site is viewed as a separate and distinct good from that of a fishing day at another river or inshore fishing site. The analysis is carried out for each of the sites with the exception of the Repulse Bay site, as Repulse Bay extends over a large area containing many sites and it is not realistic to describe it as single site. The other areas are single river systems and, as such, it is reasonable to describe each as an individual site although they may have multiple entry points.

The results of the annual site demand models are reported in Tables 2.26 and 2.27. A comparison of the estimated demand model parameters for each of the sites with *a priori* expectations indicates that the parameters are generally in accordance with these expectations. However, the signs of some coefficients are not as expected. This is particularly true for the Pine River model, in which the substitute site index variable, income, full time employment, expected conditions, fished alone, commercial vessel(s) seen and weekend closure dummy variable coefficients were significant and had signs which *a priori* were not expected. Given the high number of coefficients not meeting *a priori* expectations in the Pine River model extra caution is advocated in interpreting the results generated from this model.

The coefficient of the substitute site availability index is significant at the one per cent level in the Pine, Mary and Burnett River models and not significant at the 10 per cent level in the Logan River model. However, the sign of the coefficient is positive in the Pine River model and negative in the Mary and Burnett models. The negative coefficients indicate the higher the component of a fisher’s total river/inshore fishing days spent fishing at other sites, the lower the number of days demanded at the Mary River and the Burnett River. That is, that days at other sites are substitutes for fishing days at these sites, as was expected *a priori*. The positive coefficient in the Pine River model indicates that other sites days are complements to fishing days at this site.

The coefficient of the solo dummy variable is significant and negative in the Logan, Pine and Mary River models. As this variable was used as a proxy for fisher dedication to the sport and was significant and positive in the monthly model this was a surprise. One possibility is that these fishers tend only to fish at these sites, which are in sheltered waters, when they are alone and if accompanied fish in more open inshore waters.

The commercial vessel(s) seen dummy variable was significant and positive in both the Logan and Pine River models as it was in the annual demand model. As previously stated it may be that experienced fishers, who tend to demand more fishing days, take more note of the activities and presence of commercial fishers, or more readily identify commercial fishing activities from a distance, and hence the estimated coefficient of this variable is biased.

The coefficient of the fished on weekends when restriction on commercial activities were in place dummy variable was negative for the Logan, Pine and Mary River models, although only in the Pine River model was the coefficient significant at the 10 per cent level. The negative sign indicates that those fishing over the weekend when commercial fishing activities are prohibited demand fewer days at the site over the year, given all other variables are constant. As the model contains a discretionary time and a congestion dummy variable it was assumed that fishers who could fish at a given site during times when restrictions on commercial activities were in place would fish more at that site. The model indicates this is not the case. One possible explanation is that the full time dummy variable does not adequately reflect the discretionary time available to fishers to undertake fishing trips, and this is, in part, captured by the weekend closure dummy variable.

The coefficient of the congestion dummy variable in the Burnett River model was found to be positive and significant, against *a priori* expectations.

The coefficient of the expenditure variable in each of models is negative and significant at the 10 per cent level. However, the travel time coefficient is not significant at the 10 per cent level in the Pine River and Burnett River models indicating that no opportunity cost is associated with the time spent traveling by fishers to these sites.

2.26 Annual site demand models: Boat fishers

	Variable	Logan River		Pine River		Mary River		Burnett River	
		β_ι (t ratio)	$\delta T_f/\delta x_j$ (stdev)	β_ι (t ratio)	$\delta T_f/\delta x_j$ (stdev)	β_ι (t ratio)	$\delta T_f/\delta x_j$ (stdev)	β_ι (t ratio)	$\delta T_f/\delta x_j$ (stdev)
	constant	2.660		0.152		1.779		1.739	
		(4.827)		(0.366)		(3.040)		(4.818)	
	A	0.027	0.097	0.091	0.330	-0.059	-0.409	-0.032	-0.207
		(0.687)	(0.088)	(4.164)	(0.254)	(-3.119)	(0.368)	(-3.345)	(0.142)
X_s	FEXP	-0.033	-0.115	-0.035	-0.126	-0.035	-0.245	-0.055	-0.354
		(-3.349)	(0.105)	(-4.285)	(0.097)	(-2.502)	(0.220)	(-5.245)	(0.244)
	TRAV	-0.010	-0.036	-0.002	-0.006	-0.009	-0.064	-0.000	-0.003
		(-3.814)	(0.033)	(-0.848)	(0.005)	(-2.594)	(0.058)	(-0.097)	(0.002)
	TFSH	-0.080	-0.284	0.249	0.902	0.030	0.205	0.017	0.109
		(-1.858)	(0.259)	(7.947)	(0.693)	(0.499)	(0.185)	(0.598)	(0.075)
	TNFSH	-0.016	-0.055	-0.291	-1.053	0.080	0.551	0.075	0.484
		(-0.128)	(0.051)	(-2.611)	(0.809)	(0.482	(0.495)	(0.834)	(0.333)
F_s	INC15	0.174	0.616	-0.376	-1.361	0.590	4.074	0.438	2.833
		(0.603)	(0.562)	(-2.226)	(1.045	(1.370)	(3.664)	(1.815)	(1.950)
	INC30	0.221	0.782	-0.371	-1.341	1.081	7.460	0.470	3.042
		(0.649)	(0.713)	(-1.710)	(1.030)	(2.311)	(6.701)	(1.652)	(2.094)
	INC45	-0.093	-0.329	-0.287	-1.038	0.934	6.446	0.326	2.108
		(-0.280)	(0.300)	(-1.257)	(0.797)	(1.798)	(5.798)	(1.055)	(1.451)
	FTEMP	0.037	0.131	0.388	1.405	-1.082	-7.468	-0.252	-1.633
		(0.121)	(0.120)	(3.299)	(1.079)	(-2.602)	(6.717)	(-1.090)	(1.124)
	ECON	-0.468	-1.654	0.585	2.179	0.206	1.424	-0.079	-0.509
		(-2.763)	(1.508)	(4.800)	(1.627	(1.082)	(1.281)	(-0.551)	(0.350)
	SOLO	-0.569	-2.011	-0.549	-2.040	-0.707	-4.879	-0.132	-0.855
		(-2.430)	(1.834)	(-3.553)	(1.611)	(-2.168)	(4.389)	(-0.783)	(0.588)
	VIST	-0.709	-2.506	-1.126	-4.075	-0.498	-3.439	-0.690	-4.468
		(-1.699)	(2.285)	(-3.374)	(3.130)	(-1.790)	(3.093)	(-3.080)	(3.075)
	FSHLO	-0.273	-0.964	-0.453	-1.640	0.269	1.855	0.481	3.110
		(-1.345)	(0.879)	(-3.386)	(1.259)	(0.889)	(1.668)	(1.884)	(2.140)
Q_s	NBRE	0.081	0.287	0.053	0.193	0.040	0.275	0.029	0.185
		(3.276)	(0.262)	(4.785)	(0.148	(1.370)	(0.248)	(1.719)	(0.127)
	NWHI	0.102	0.359	0.074	0.268	0.040	0.276	0.038	0.247
		(3.623)	(0.328)	(3.552)	(0.206	(1.438)	(0.248)	(1.335)	(0.169)
	NFLA	-0.054	-0.190	0.083	0.300	0.039	0.266	0.093	0.604
		(-0.523)	(0.173)	(2.704)	(0.230)	(0.823)	(0.240)	(3.184)	(0.416)
	NOTH	0.018	0.065	0.019	0.069	0.064	0.444	0.072	0.464
		(0.425)	(0.059)	(0.630)	(0.053	(2.050)	(0.399)	(3.075)	(0.320)
	NCRAB	0.303	1.071	0.410	1.523	0.192	1.327	0.158	1.022
		(1.399)	(0.977)	(5.596)	(1.203)	(3.092)	(1.193)	(2.304)	(0.704)
	WPRA	-0.062	-0.220	2.647	9.580	0.214	1.476	0.086	0.559
		(-0.291)	(0.200)	(1.299)	(7.358)	(0.718)	(1.328)	(0.538)	(0.385)
	ENJ	0.416	1.469	0.240	0.870	0.478	3.300	0.298	1.927
		(1.121)	(1.339)	(0.904)	(0.668)	(1.294)	(2.968)	(1.116)	(1.326)
	SCOM	0.751	2.656	0.378	1.368	0.042	0.288	-0.245	-1.586
		(2.090)	(2.328)	(2.691)	(1.051)	(0.175)	(0.260)	(-0.976)	(1.091)
	WCL	-0.533	-1.885	-0.360	-1.304	0.270	1.865	-0.103	-0.668
		(-1.401)	(1.719)	(-2.022)	(1.002)	(0.682)	(1.677)	(-0.419)	(0.459)
	CONG	-0.058	-0.206	-0.068	-0.246	-0.143	-0.985	0.846	5.475
		(-0.346)	(0.188)	(-0.564)	(1.002)	(-0.372)	(0.886)	(3.135)	(3.768)

2.27 Results from annual site demand models: Boat fishers

		Logan River		Pine River		Mary River		Burnett River	
		mean	st dev	mean	st dev	mean	st dev	mean	st dev
Average annual site demand for fishing days		3.53	3.22	3.62	2.78	6.90	6.21	6.47	4.45
WTP for days demanded	$	223.85	178.87	146.25	97.91	342.31	266.16	175.62	134.02
NEB from days demanded	$	108.30	98.75	103.84	79.75	194.54	174.99	118.30	81.41
WTP for marginal day (price of a fishing day)	$	38.72	18.46	13.95	8.06	25.94	10.89	9.78	6.56
$\delta WTP/\delta x_i$									
:NBRE	$	18.17	14.52	7.79	5.22	21.74	16.90	5.02	3.83
:NWHI	$	22.77	18.19	10.83	7.25	21.77	16.35	9.74	10.50
:NFLA	$	-13.55	9.25	12.10	8.10	21.05	16.35	16.40	12.52
:NOTHE	$	4.63	3.16	3.06	1.94	22.02	17.19	12.62	9.63
$\delta NEB/\delta x_i$									
:NBRE	$	8.79	8.02	7.69	5.90	13.39	11.15	4.97	4.41
:NWHI	$	11.01	10.04	8.59	6.60	13.46	11.16	6.62	5.88
:NFLA	$	-7.50	5.98	1.99	1.53	12.95	10.78	11.05	7.60
:NOTHE	$	2.56	2.04	2.17	.54	12.51	11.25	8.50	5.85
$\delta MWTP/\delta x_i$									
:NBRE	$	2.49		1.53		1.12		0.52	
:NWHI	$	3.12		2.12		1.13		0.70	
:NFLA	$	-1.65		2.37		1.09		1.71	
:NOTHE	$	0.56		0.54		1.81		1.31	

Contingent valuation methodology

As outlined earlier the contingent valuation question used in the survey is based on the dichotomous choice model. That is, yes/no responses are elicited from respondents to a hypothetical question in relation to their willingness to pay an extra amount for a fishing day and their willingness to accept compensation not to fish. The responses are then analysed to estimate a fisher's willingness to pay for an additional recreational day. It should be noted that WTP corresponds to their willingness to pay an additional amount to the cost already incurred to undertake the day's fishing, and as such is a measure of the net economic benefit derived from the fishing day. For example, it can be seen from Table 2.28 that the average increase in fisher willingness to pay for an additional fishing day resulting from a one unit increase in the bream catch rate is $1.04.

Following Table 2.28 a summary of the goodness of fit of the model in terms of the frequency of the actual and predicted outcomes is given (Table 2.29). As outlined in the bid design section in the doubled bounded survey there are three bid amounts specified for each observation, and although each person is asked only two bids all three bids enter the estimated function as *a priori*, it is not known which response any individual will give to the initial bid. From Table 2.31 it can be seen that the model correctly predicts a negative response 80 per cent of the time and a positive response 74 per cent of time, and overall predicts the correct outcome 77 per cent of the time.

2.28 Willingness to pay an extra amount for a recreational fishing day model: Boat fishers

<u>Model specification</u>
$\log t = x'\beta$

<u>Model results</u>
Average willingness to pay $40.47 (13.15)

Vector	Variable[a]	β_j	t-ratio	Level of significance at which H_0 rejected	$\delta WTP/\delta x_j$	
					Mean	St dev.
	constant	3.0094	19.198	1		
T_f	AD	0.0007	1.133	-	0.029	0.010
Inputs (X)	FEXP	0.0025	0.846	-	0.101	0.033
	TRAV	0.0001	0.126	-	0.004	0.001
	TFSH	0.0195	1.856	10	0.789	0.257
	TNFSH	0.0349	1.199	-	1.411	0.459
Attributes of	INC15	0.0757	1.259	-	3.062	0.995
Fisher (F)	INC30	0.0995	1.423	-	4.025	1.308
	INC45	0.3517	4.665	1	14.231	4.626
	FTEMP	0.0681	1.143	-	2.755	0.895
	ECON	-0.1215	-1.774	10	-4.916	1.598
	SOLO	-0.2699	-4.779	1	-10.922	3.550
	VIST	0.2149	3.368	1	8.698	2.827
	FSHLO	-0.0268	-0.526	-	-1.085	0.353
Attributes of	NBRE	0.0258	4.212	1	1.043	0.339
Fishing day (Q)	NWHI	0.0157	2.237	5	0.636	0.207
	NFLA	0.0165	1.262	-	0.669	0.218
	NOTH	0.0111	1.676	10	0.450	0.146
	NCRAB	0.0481	1.725	10	1.945	0.632
	WPRAW	0.1553	3.680	1	6.286	2.043
	ENJ	0.3161	4.043	1	12.790	4.157
	SCOM	-0.1297	-2.662	1	-5.249	1.706
	BTS	0.1871	2.315	5	7.570	2.461
	WCL	-0.1465	-2.804	1	-5.930	1.928
	CONG	-0.0759	-1.181	-	3.072	0.999
	COND	0.2747	3.930	1	11.116	3.613
	AUT	-0.2610	-3.283	1	-10.560	3.433
	WIN	0.0920	0.948	-	3.725	1.211
	SPR	-0.0838	-1.071	-	-3.389	1.102
	PINE	0.0312	0.505	-	1.263	0.410
	MARY	0.0289	0.357	-	1.169	0.380
	BUR	-0.1514	-2.122	5	-6.125	1.991
	REP	-0.1954	-1.788	10	-7.906	2.570

a AD, Total days fished previous year. FEXP, Expenditure on day's trip per fisher over 16. TRAV, Total travel time. TFSH, Time spent fishing. TNFSH , Time spent on site not fishing. INC15, Income $15 - 30 000. INC30, Income $30 - 45 000. INC45, Income $45 000+. FTEMP, Full time employed. ECON, Expected conditions (1= rank of 1 or 2). SOLO, Fished alone. VIST, Visiting region. FSHLO, Fished line plus other method. NBRE, Number of bream per fisher kept. NWHI, Number of whiting per fisher kept. NFLA, Number of flathead per fisher kept. NOTH, Number of other fish per fisher kept. NCRAB, Number of crabs per fisher kept. WPRAW, Weight of prawns per fisher kept. ENJ, Enjoyed trip (1 = rank of 1 or 2). SCOM, Commercial vessel(s) seen. BTS, Beam trawl season. WCL, Weekend closure of commercial fisheries. CONG, Site congested (1 = rank of 1 or 2). COND, Fishing and boating conditions (1= rank of 1 or 2) AUT, Autumn. WIN, Winter. SPR, Spring. PINE, Pine River. MARY, Mary River. BUR, Burnett River. REP, Repulse Bay.

2.29 Summary of goodness of fit of WTP model: Boat fishers

Frequency of actual and predicted outcomes

	Predicted outcomes		
Actual outcomes	0	1	Total
0	626	156	782
1	189	544	733
Total	815	700	1515

As a check on the reasonableness of the model a comparison between the results of the model and those which economic theory would predict can be made.

It was expected *a priori* that the coefficients of the attributes of the fishing day would reflect an increase in willingness to pay an additional amount where there was an increase in the quality of the fishing day. The signs of the majority of the coefficients of the variables in the attributes of the fishing day vector (excluding the location and season dummy variables for which no *a priori* assumptions were made) that are significant reflect this. These being the coefficients of the bream, whiting, crab and prawn catch variables and the enjoyment, weather and boating conditions, and commercial vessel(s) seen dummy variables.

The derived marginal willingness to pay for an additional unit of catch indicates that on average boat fishers would be willing to pay an extra $1.04 for the day’s fishing if the average number of bream caught per fisher increased by one. Similarly they would pay an extra $0.64 for the same increase in the whiting catch. These results are lower than the amounts calculated under the annual model in the direct cost analysis but higher than that obtained in the CV studies conducted by Collins (1991) and Staniford and Siggins (1992) for King George whiting in the Coffin Bay fishery.

The coefficient of the commercial vessel(s) seen dummy variable is negative, indicating that if all other variables are held constant willingness to pay is less when commercial vessels are seen during the fishing day. This reduction is calculated to be around $5.25. Further, the coefficients of the weekend commercial closure and beam trawl season dummy variables are both significant. However, as for the total direct cost analysis the sign of the each of these coefficients is not as expected. The negative sign of the weekend commercial closure dummy variable coefficient indicates that fishing days taken over the weekend when commercial fishing activities are prohibited are valued less ($5.93) than fishing days during the week when commercial activity is allowed. Also the beam trawl season dummy variable coefficient indicates that fishing days during the period when beam trawl operators are most active are more higher valued ($7.57) than at other times of the year.

For the attributes of the fisher vector the signs of coefficients that were significant were as expected, with the exception of the fished alone dummy variable. The solo dummy variable was significant at the 1 per cent level and negative, indicating that a fisher fishing in a group was willing to pay a higher amount ($5.73) than those fishing alone. This indicates that while a solo fisher may be more dedicated to the sport there is on average a significant increase in the willingness to pay when a fisher has companions on their trip, that is a fisher would prefer to fish with companions than alone, which is not an unreasonable finding. The coefficient of the expected conditions dummy variable was significant at the 10 per cent level and negative. This was as expected as it indicates that those who go fishing when they expected poorer conditions are willing to pay more for a day's fishing trip. As expected those in the $45 000+ income bracket were willing to pay more than those on lower incomes, holding all other variables constant. It was, however, somewhat of a surprise that the coefficients of the other income bracket dummy variables were not significant. Finally, although no *a priori* assumption was made in relation to the coefficient of the visitor dummy variable, from the model results it can be seen that a visitor was willing to pay a higher amount for a fishing day than a local resident.

No *a priori* assumptions were made in relation to the signs of the coefficients of the variables in the vector of inputs as it was not known if these inputs were complements or substitutes to the recreational fishing day. In the model results the coefficient of the fishing time variable was significant and positive indicating that this input is a complement to the fishing day. This is similar to the finding by Cameron and James (1986). Of the other inputs none of the coefficients were found to be significant at the 10 percent level and as such there appears to be little relationship between the these inputs and a fisher's willingness to pay an additional amount.

The final variable used in the model was that of the number of days fished in the previous year. In other studies this variable has *a priori* been expected to have both a positive coefficient (Cameron and James (1986)) and a negative coefficient (Staniford and Siggins (1992)), with both obtaining statistically significant coefficients with the sign as expected. The positive coefficient was expected on the grounds that the variable indicates a greater dedication to, or experience of, the sport as the number of days increased, and the negative coefficient on the grounds of diminishing marginal returns. As it was felt that it was not reasonable to assume that a fisher who fishes frequently would necessarily value a given day's fishing more or less highly than one who rarely fishes, holding all other variables constant, no *a priori* assumption was made in relation to the sign of the coefficient of this dummy variable. The t-ratio generated from the model indicates that there is no significant relationship between the number of days fished over a year and willingness to pay for a given fishing day.

Willingness to accept compensation model

The willingness to accept compensation question in the survey attempts to elicit a different value than that addressed by the willingness to pay question. In the willingness to pay question respondents were asked whether, if the cost of the fishing trip they had just undertaken was $t higher, they would have still undertaken the trip. That is, this question addresses the value of the last fishing day they undertook, or the value of a marginal fishing day. Further, respondents know with absolute certainty the characteristics of the fishing day. This differs from the WTA question in that respondents are asked about a block of future fishing days of which the exact characteristics are unknown. As such, the value of future fishing days will be influenced by those characteristics that influenced the value of the last fishing day, except that these characteristics are anticipated rather than known.

In the survey conducted in the present study, as previously outlined, respondents were asked for the number of days they expect to fish over the following month (represented by the variable *MD* in Table 2.21) and in this analysis this represents the block of fishing days that is to be forgone.

As in the study undertaken by Cameron and James (1986) there are no data on the number of fishing days that the fisher expects to undertake over the remainder of the fishing season. However, we do have some information relating to this from the question relating to whether respondents anticipated they would fish on fewer, more or the same number of days in the following year as they had in the previous year. Some 78 per cent of respondents claimed that they would undertake approximately the same number of fishing days as they had in the previous year. As such, it was felt that it would be reasonable to use the number of days fished in the previous year as a proxy for the number of days to be fished in the following year. Further, as there is no clearly defined fishing season in the defined fishery, as conditions are suitable for fishing throughout the year, the fishing season was simply viewed as the year following the interview time. Thus, the number of days fished in the previous year (*AD*) was used as a proxy for the number of fishing days that the fisher expects to undertake over the remainder of the fishing season.

As outlined by Cameron and James (1986) if the standard economic assumption that the commodity is homogeneous is adopted and the relevant flow time period is interpreted as the fishing season, then the data can be viewed as evidence regarding the valuation of a block of marginal fishing days. Given this, the average compensation demanded (that is, the total compensation demanded for the marginal block of fishing days divided by the total number of fishing days in the block) can be considered as an approximation of the marginal compensation demanded at the midpoint of the interval from the number of days fished in the previous year less the number of days in the block, and the number of days fished in the previous year. This can be illustrated by an example. Say a fisher fished on 20 days over the year preceding the time at which they were interviewed and intended to go fishing on 3 days in the following month and would forgo these fishing days if they received $150, or in average terms, $50 for each day forgone. Then, as an approximation, it can be said that the marginal value of the 19th fishing day (the midpoint of the interval to be forgone) would be approximately $50.

In constructing the model of the fisher's willingness to accept for giving up the block of fishing days (*WTA*), it is assumed that the number of planned future fishing days is the optimal number of days for each fisher, given prices and income. It is assumed that respondents realise that should they forgo fishing in the future they will avoid incurring expenses associated with fishing. In other words, WTA should be net of normal per-day fishing expenses (Cameron and James (1986)).

The estimated parameters and associated t-ratios for the model are provided in Table 2.30. The estimation procedure was undertaken using the data set consisting of those fishers that planned to undertake a fishing day within a month following the survey, thus excluding the 60 respondents who planned no fishing days over this period. In the final two columns of Table 2.30 the mean and standard deviation of the exogenously weighted individual incremental contributions of each explanatory variable to the marginal willingness to accept compensation for a fishing day are provided.

Following Table 2.30 a summary of the goodness of fit of the model in terms of the frequency of the actual and predicted outcomes is given (Table 2.31). From this it can be seen the model correctly predicts a negative response 84 per cent of the time and a positive response 58 cent of the time, with an overall successful prediction rate of 75 per cent.

For consistency with economic theory it would be expected that *MWTA* would decrease as the number of days within the block (*MD*) increased and it can be ascertained that this holds true for the estimated model.

The only significant difference in the results compared to that of the willingness to pay model is that in the WTA model the coefficients of the full time employment and winter dummy variables are significant and that of the expected conditions dummy variable is not. The sign of the full time dummy variable is positive as expected. The winter dummy variable is of interest in that when the fisher knows the catch associated with a day, as in the WTP model, they do not attach a significantly higher value to the day regardless of the season, whereas when catch rates are not known with certainty, as in the WTA model, they attach a higher value to days taken during winter, the peak of the bream season. This may indicate that fishers attach the higher value to days fished in winter as they anticipate higher catch rates than at other times of the year. This is similar to the results found in the monthly demand model under the total direct cost analysis.

As discussed in the overview of the contingent valuation method, in contingent valuation studies WTP has consistently been found to be significantly smaller than the WTA value for the same good. The results from this study are no exception with the estimated willingness to accept compensation for a marginal fishing day being significantly higher, at the one per cent level, than the estimated willingness to pay. While the difference between these values is significant it is not as great as that found in many other studies with estimates for WTA frequently being more than double those for WTP for the same good (Knetsch (1990 and 1994)).

2.30 Willingness to accept compensation for a block of recreational fishing days model: Boat fishers

Model specification	Model Results	
$\log t = x'\beta$	Willingness to accept compensation for a block of fishing days	\$240.25 (254.72)
	Willingness to accept compensation for the marginal fishing day	\$47.89 (22.72)

Vector	Variable[a]	β_j	t-ratio	Level of significance at which H_0 rejected	δMWTA/δx_j Mean	St. dev.
	constant	3.4507	10.345	1		
T_f	logMD	0.8976	9.810	1		
	logAD	0.0021	0.054	-		
Attributes of Fisher (*F*)	INC15	0.0063	0.091	-	0.302	0.143
	INC30	0.0236	0.268	-	1.130	0.536
	INC45	0.4008	3.863	1	19.197	9.106
	FTEMP	0.2771	3.758	1	13.272	6.296
	ECON	0.0377	0.741	-	1.806	0.857
	SOLO	-0.2312	-3.423	1	-11.074	5.253
	VIST	0.3191	3.313	1	15.284	7.250
	FSHLO	0.0200	0.300	-	0.958	0.454
Attributes of Fishing day (*Q*)	NBRE	0.0527	5.856	1	2.524	1.197
	NWHI	0.0381	3.730	1	1.825	0.866
	NFLA	0.0261	1.566	-	1.250	0.593
	NOTH	0.0139	1.456	-	0.666	0.316
	NCRAB	0.1187	2.537	5	5.686	2.697
	WPRAW	-0.0068	-0.128	-	-0.326	0.154
	ENJ	0.1708	1.723	10	8.181	3.881
	SCOM	-0.2373	-3.806	1	-11.366	5.391
	BTS	0.2824	2.702	5	13.526	6.416
	WCL	-0.3338	-4.939	1	-15.988	7.584
	CONG	-0.0919	-1.053	-	-4.402	2.088
	AUT	-0.1826	-1.636	-	-8.746	4.149
	WIN	0.2977	2.121	5	14.259	6.764
	SPR	0.1098	0.930	-	5.259	2.495
	PINE	0.1172	1.300	-	5.614	2.663
	MARY	0.0579	0.529	-	2.773	1.315
	BUR	-0.0173	-0.181	-	-0.829	0.393
	REP	0.1800	1.166	-	8.622	4.090

a AD, Total days fished previous year. MD Days expected to fish in following month. INC15, Income \$15 - 30 000. INC30, Income \$30 - 45 000. INC45, Income \$45 000+. FTEMP, Full time employed. ECON, Expected condition ranked 3 or 4. SOLO, Fished alone. VIST, Visiting region. FSHLO, Fished line plus other method. NBRE, Number of bream kept per fisher. NWHI, Number of whiting kept per fisher. NFLA, Number of flathead kept per fisher. NOTH, Number of other fish kept per fisher. NCRAB, Number of crabs kept per fisher. WPRAW, Weight of prawns kept per fisher. ENJ, Enjoyed trip (ranking of 1 or 2). SCOM, Commercial vessel(s) seen. BTS, Beam trawl season (November to May). WCL, Weekend closure. CONG, Site congested (ranking of 1 or 2). COND, Conditions on day of interviewed good or better (rank 1 or 2). SUM, Summer. WIN, Winter. SPR, Spring. PINE, Pine River. MARY, Mary River. BUR, Burnett River. REP, Repulse Bay.

2.31 Summary of goodness of fit of WTA model: Boat fishers

Frequency of actual and predicted outcomes

	Predicted outcomes		
Actual outcomes	0	1	Total
0	724	137	861
1	201	273	474
Total	925	410	1335

Shore fishers and shore fishing days

As for the analysis in the boat fisher section a series of demand and willingness to pay functions were estimated from the data collected in the shore fisher survey. Table 2.32 corresponds to Table 2.21 in the boat fisher analysis and provides a description of the set of variables used in each of the analysis. Following this the results of the analysis are presented.

However, first, as outlined in the data presentation section, there are two main areas differentiating the shore fisher survey. First, a substantial majority of shore fishers continued to fish after the survey was completed. As such, the catch variable relates only to the number of fish caught up to the time of the interview. Second, some shore fishing groups contained no persons over 16. Where previously expenditure and catch rates were calculated using the number of adults in the party, for the shore fisher data, when no adults were among the fishing group, the number of persons in the group was used. When an adult was present the calculation is as for the boat fisher data. Finally, as bream was the only species targeted by a substantial number of fishers in most areas catch was simply divided into two categories, that of bream and other species.

2.32 List of variables used in shore fisher analysis

Description	Variable name	TDC AD	TDC MD	TDC ASD	CVM WTP	CVM WTA
t: Bid amount offered						
Willingness to pay	WTP	-	-	-	D	-
Willingness to accept	WTA	-	-	-	-	D
T_f: Fishing days demanded						
Total days fished previous year	AD	D	-	-	E	E
Days anticipated to fish in next month	MD	-	D	-	-	E
Site days fished previous year	ASD	-	-	D	-	-
X: Inputs into fishing day						
Total expenditure on day's trip	FEXP	E	E	E	E	-
Total travel time[c]	TRAV	E	E	E	E	-
Time spent fishing	TFSH	E	E	E	E	-
Anticipated extra fishing time	EXTF	E	E	E	E	-
F: Attributes of fisher						
Income $15 - 30 000	INC15	E	E	E	E	E
Income $30 - 45 000	INC30	E	E	E	E	E
Income $45 000+	INC45	E	E	E	E	E
Full time employed (1= yes)	FTEMP	E	E	E	E	E
Expected weather and fishing conditions (1= rank of 1 or 2)	ECON	E	E	E	E	E
Fished alone (1= yes)	SOLO	E	E	E	E	E
Visiting region (1= yes)	VIST	E	E	E	E	E
No adults in party (1= yes)	NOAD	E	E	E	E	E
Q: Attributes of the fishing day						
Number of bream per fisher kept	NBRE	E	E	E	E	E
Number of other fish per fisher kept	NOTH	E	E	E	E	E
Enjoyed trip (1= ranking of 1 or 2)	ENJ	E	E	E	E	E
Commercial vessel(s) seen (1= yes)	SCOM	E	E	E	E	E
Beam trawl season (1= yes)	BTS	-	E	-	E	E
Weekend closure (1= yes)	WCL	E	E	E	E	E
Site congested (1= rank of 1 or 2)	CONG	E	E	E	E	E
Weather and fishing conditions on day of interview (1= rank 1 or 2)	COND	-	-	-	E	-
Time of year (by season):						
Summer	AUT	-	E	-	E	E
Winter	WIN	-	E	-	E	E
Spring	SPR	-	E	-	E	E
Site:						
Pine River	PINE	E	E	-	E	E
Mary River	MARY	E	E	-	E	E
Burnett River	BUR	E	E	-	E	E
Repulse Bay	REP	E	E	-	E	E

a D denotes the dependent variable in the respective analysis. **b** E denotes the variable was used as an explanatory variable in the respective analysis. **c** Obtained by multiplying time taken to travel to site by 2. **d** Given by the sum of the time spent fishing before the interview and the expected time to be spent fishing after the interview.

Total direct cost method model

Demand for Queensland river/inshore shore based recreational fishing days model

The parameters and results from the shore fisher annual and monthly demand models are presented in Table 2.33, 2.34 and 2.35, and details of the estimation procedure are available in Reid (forthcoming). The results of the shore fisher annual site demand models follow. It is not proposed to examine in detail each of the parameters and the *a priori* expectations associated with them as these expectations are similar to those outlined in the boat fisher models. However, some comments are warranted. First, the coefficient of the travel time variable is significant and negative in all models. This indicates that travel time does have a significant impact on the demand for shore fishing days. Second, with the exception of the Mary River annual site model, none of the coefficients of the income bracket dummy variables are significant. This seems to indicate that the demand for shore fishing days is unaffected by a fisher’s income. Finally, the dummy variables indicating the presence or possible presence of commercial fishing vessels are not significant, except for the commercial vessel(s) seen dummy variable in the Pine River site demand model, which is positive (the reader is referred to the discussion of the annual boat fisher model under which the same results occurred). This indicates that as for the boat fisher model the presence or possible presence of commercial fishing activity appears to have little effect on the demand for fishing days.

2.33 Annual demand for recreational fishing days model: Shore fishers

Model specification	Model results	
$\log T_f = x'\beta$	Average number of trips demand per year (standard deviation)	9.08 (5.85)
	Average cost of trip (including opportunity cost of travel time ($\delta WTP/\delta T_f$)	15.64 (8.38)

Vector	Variable^a	β_j	t-ratio	Level of significance at which H_A accepted	$\delta T_f/\delta x_j$	
					Mean	St Dev.
	constant	3.0436	12.007	1		
X: Inputs	FEXP	-0.0342	-3.925	1	-0.310	0.200
	TRAV	-0.0068	-2.438	5	-0.062	0.039
	TFSH	0.0005	0.612	-	0.004	0.003
	EXTF	0.0009	1.054		0.008	0.005
F: Attributes of	INC15	0.0365	0.207	-	0.331	0.213
The fisher	INC30	0.1654	0.835	-	1.502	0.967
	INC45	0.2267	1.101	-	2.509	1.326
	FTEMP	-0.5489	-3.200	1	-4.985	3.211
	ECON	-0.7568	-6.973	1	-6.873	4.428
	SOLO	-0.0538	-0.518	-	-0.489	0.315
	VIST	-0.0885	-0.493	-	-0.803	0.518
	NOAD	-0.1764	-0.767	-	-1.602	1.032
Q: Attributes of	NBRE	0.0791	2.957	1	0.719	0.463
The fishing day	NOTH	0.0910	3.047	1	0.826	0.532
	ENJ	0.2819	2.312	5	2.560	1.649
	SCOM	0.0647	0.340	-	0.587	0.378
	WCL	0.1289	1.116	-	1.170	0.754
	CONG	0.1031	0.620	-	0.936	0.603
	PIN	0.1182	0.829	-	1.074	0.692
	MAR	0.0067	0.035	-	0.061	0.039
	BUR	0.0882	0.567	-	0.801	0.516
	REP	0.2319	1.196	-	2.106	1.357

a FEXP, Expenditure on day's trip per fisher over 16. TRAV, Total travel time. TFSH, Time spent fishing. TNFSH , Time spent on site not fishing. INC15, Income \$15 - 30 000. INC30, Income \$30 - 45 000. INC45, Income \$45 000+. FTEMP, Full time employed. ECON, Expected condition ranked 3 or 4. SOLO, Fished alone. VIST, Visiting region. FSHLO, Fished line plus other method. NBRE, Number of bream kept. NWHI, Number of whiting kept. NFLA, Number of flathead kept. NOTH, Number of other fish kept. NCRAB, Number of crabs kept. WPRAW, Weight of prawns kept. ENJ, Enjoyed trip (ranking of 1 or 2). SCOM, Commercial vessel(s) seen. WCL, Weekend closure of commercial fisheries. CONG, Site congested (ranking of 1 or 2).. PINE, Pine River. MARY, Mary River. BUR, Burnett River. REP, Repulse Bay.

2.34 Monthly demand for recreational fishing days model: Shore fishers

Model specification		Model results	
$\left(T_f^{\lambda}-1\right)/\lambda = x'\beta$		Average number of trips demand per month (standard deviation)	2.38 (1.84)
Lambda (λ) (t-ratio)	0.2630 (15.073)	Average cost of trip (including opportunity cost of travel time) ($\delta WTP/\delta T_f$)	20.09 (10.16)

Vector	Variable[a]	β_j	t-ratio	Level of significance at which H_A accepted	$\delta T_f/\delta x_j$	
					Mean	St Dev.
	constant	2.5170	5.633	1		
X: Inputs	FEXP	-0.0352	-3.911	1	-0.064	0.036
	TRAV	-0.0109	-3.279	1	-0.019	0.011
	TFSH	-0.0005	-0.494		-0.001	0.001
	EXTF	0.0014	1.126	-	0.003	0.001
F: Attributes of The fisher	INC15	0.2747	1.229	-	0.495	0.279
	INC30	0.1176	0.465	-	0.212	0.119
	INC45	0.0946	0.340	-	0.170	0.096
	FTEMP	-0.8675	-3.881	1	-1.563	0.880
	ECON	-1.1600	-9.324	1	-2.090	1.176
	SOLO	-0.0062	-0.051	-	-0.011	0.006
	VIST	0.9548	2.034	5	1.720	0.968
	NOAD	-0.3028	-1.016	-	-0.545	0.307
Q: Attributes of The fishing day	NBRE	0.1077	2.058	5	0.194	0.109
	NOTH	0.0476	0.951	-	0.086	0.048
	ENJ	0.7205	3.675	1	1.298	0.731
	SCOM	-0.0291	-0.092	-	-0.053	0.030
	BTS	-0.4821	-1.514	-	-0.866	0.488
	WCL	-0.2069	-1.304	-	-0.373	0.210
	CONG	0.1463	0.787	-	0.264	0.148
	AUT	-0.0725	-0.438	-	-0.131	0.074
	WIN	-0.0105	-0.028	-	-0.019	0.011
	SPR	-0.0564	-0.251	-	-0.102	0.057
	PIN	0.3309	1.798	10	0.596	0.336
	MAR	-0.1420	-0.459	-	-0.256	0.144
	BUR	-0.1758	-0.916	-	-0.317	0.178
	REP	-0.0122	-0.027	-	-0.022	0.012

a FEXP, Total expenditure on day's trip. TRAV, Total travel time. TFSH, Time spent fishing. TNFSH , Time spent on site not fishing. INC15, Income $15 - 30 000. INC30, Income $30 - 45 000. INC45, Income $45 000+. FTEMP, Full time employed. ECON, Expected conditions. SOLO, Fished alone. VIST, Visiting region. FSHLO, Fished line plus other method. NBRE, Number of bream kept. NWHI, Number of whiting kept. NFLA, Number of flathead kept. NOTH, Number of other fish kept. NCRAB, Number of crabs kept. WPRAW, Weight of prawns kept. ENJ, Enjoyed trip. SCOM, Commercial vessel(s) seen. BTS, Beam trawl season (November to May). WCL, Weekend closure. CONG, Site congestion. AUT, Autumn. WIN, Winter. SPR, Spring. PINE, Pine River. MARY, Mary River. BUR, Burnett River. REP, Repulse Bay.

2.35 Results from annual and monthly models: Shore fishers

Variable (x_j)	Annual model		Monthly model	
	Mean ($)	St. Dev.	Mean ($)	St. Dev.
WTP	386.11	224.20	113.26	96.56
NEB	265.89	171.30	73.19	72.55
$\delta WTP/\delta x_j$				
NBRE	30.56	17.74	10.70	6.94
NOTH	35.12	20.40	5.35	3.37
$\delta NEB/\delta x_j$				
NBRE	21.04	13.56	7.29	5.62
NOTH	24.19	15.58	3.71	2.75
$\delta MWTP/\delta x_j$				
NBRE	2.32		3.06	
NOTH	2.66		1.35	

2.36 Annual site demand models: Shore fishers

	Variable	Logan River		Pine River		Mary River		Burnett River	
		β_j	$\delta T_f/\delta x_j$	β_j	$\delta T_f/\delta x_j$	β_j	$\delta T_f/\delta x_j$	β_j	$\delta T_f/\delta x_j$
		(t ratio)	(stdev)	(t ratio)	(stdev)	(t ratio)	(stdev)	(t ratio)	(stdev)
	constant	1.863		2.042		2.205		2.541	
		(5.587)		(4.991)		(4.465)		(7.144)	
	A	0.298	0.954	0.454	1.363	0.057	0.259	0.075	0.440
		(3.297)	(0.469)	(4.765)	(0.821)	(0.529)	(0.193)	(1.323)	(0.267)
X_s	FEXP	-0.032	-0.102	-0.039	-0.117	-0.047	-0.210	-0.067	-0.390
		(-3.535)	(0.050)	(-3.936)	(0.072)	(-1.432)	(0.157)	(-3.194)	(0.237)
	TRAV	-0.005	-0.015	-0.007	-0.022	-0.016	-0.072	-0.009	-0.051
		(-1.681)	(0.075)	(-2.221)	(0.013)	(-2.027)	(0.054)	(-1.838)	(0.031)
	TFSH	0.001	0.004	0.000	0.001	-0.001	-0.003	0.001	0.003
		(1.019)	(0.002)	(0.265)	(0.001)	(-0.269)	(0.002)	(0.532)	(0.002)
	EXTF	0.000	0.001	-0.001	-0.002	0.002	0.009	-0.001	-0.005
		(0.322)	(0.001)	(-0.416)	(0.001)	(0.953)	(0.007)	(-0.650)	(0.003)
F_s	INC15	-0.283	-0.905	0.195	0.584	-0.995	-4.488	0.115	0.673
		(-1.098)	(0.445)	(0.638)	(0.356)	(-2.605)	(3.355)	(0.476)	(0.409)
	INC30	0.347	1.111	0.166	0.499	-1.465	-6.607	0.430	2.504
		(1.339)	(0.546)	(0.585)	(0.305)	(-3.077)	(4.939)	(1.263)	(1.521)
	INC45	0.287	0.917	0.059	0.176	-0.443	-1.999	0.400	2.332
		(1.141)	(0.451)	(0.191)	(0.108)	(-0.832)	(1.495)	(1.277)	(1.416)
	FTEMP	-0.496	-1.587	-0.483	-1.449	0.452	2.037	-0.609	-3.548
		(-2.119)	(0.780)	(-1.652)	(0.884)	(1.191)	(1.523)	(-2.509)	(2.155)
	ECON	-0.388	-1.241	-0.380	-1.140	-0.225	-1.013	-0.571	-3.326
		(-2.345)	(0.610)	(-1.641)	(0.696)	(-0.942)	(0.757)	(-3.576)	(2.202)
	SOLO	0.204	0.653	-0.104	-0.312	-0.083	-0.374	-0.085	-0.496
		(1.462)	(0.321)	(-0.684)	(0.191)	(-0.337)	(0.280)	(-0.572)	(0.301)
	VIST	-0.840	-2.688	0.226	0.678	-0.552	-2.489	-0.510	-2.971
		(-1.639)	(1.321)	(0.487)	(0.414)	(-2.232)	(1.860)	(-2.030)	(1.804)
	NOAD	-0.664	-2.124	0.393	1.180	-0.369	-1.665	-0.524	-3.052
		(-2.115)	(1.044)	(1.085)	(0.720)	(-0.840)	(1.245)	(-1.408)	(1.854)
Q_s	NBRE	-0.011	-0.034	0.040	0.120	0.128	0.577	0.071	0.411
		(-0.182)	(0.017)	(0.664)	(0.073)	(2.375)	(0.432)	(2.578)	(0.250)
	NOTH	0.053	0.167	0.082	0.247	0.187	0.845	0.015	0.088
		(0.801)	(0.083)	(1.783)	(0.151)	(2.961)	(0.631)	(0.266)	(0.053)
	ENJ	0.298	0.955	0.250	0.750	0.258	1.164	0.609	3.549
		(1.898)	(0.469)	(1.381)	(0.457)	(0.822)	(0.870)	(3.061)	(2.156)
	SCOM	-0.030	-0.097	0.804	2.412	0.629	2.837	-0.315	-1.838
		(-0.117)	(0.048)	(1.841)	(1.472)	(1.476)	(2.121)	(-1.129)	(1.116)
	WCL	-0.087	-0.278	-0.316	-0.948	0.014	0.064	0.171	0.997
		(-0.585)	(0.136)	(-1.166)	(0.579)	(0.061)	(0.048)	(1.021)	(0.606)
	CONG	-0.118	-0.376	-0.061	-0.181			0.171	0.997
		(-0.595)	(0.185)	(-0.322)	(0.111)			(0.487)	(5.254)

a AD, Total days fished previous year. FEXP, Total expenditure on day's trip. TRAV, Total travel time. TFSH, Time spent fishing. TNFSH , Time spent on site not fishing. INC15, Income $15 - 30 000. INC30, Income $30 - 45 000. INC45, Income $45 000+. FTEMP, Full time employed. ECON, Expected condition ranked 3 or 4. SOLO, Fished alone. VIST, Visiting region. NOAD, No adults in fishing group. NBRE, Number of bream pre fisher kept. NOTH, Number of other fish per fisher kept. ENJ, Enjoyed trip (1 = rank of 1 or 2). SCOM, Commercial vessel(s) seen. BTS, Beam trawl season. WCL, Weekend closure. CONG, Site congested (1 = rank of 1 or 2).

2.37Results from annual site demand models: Shore fishers

		Logan River		Pine River		Mary River		Burnett River	
		mean	st dev	mean	st dev	mean	st dev	mean	st dev
Average annual site demand for fishing days		3.20	1.57	3.00	1.83	4.51	3.37	5.83	3.54
WTP for days demanded	$	155.12	70.83	127.63	61.90	169.86	112.32	137.21	74.51
NEB from days demanded	$	100.91	49.60	76.65	46.77	96.95	72.47	87.15	52.93
WTP for marginal day (price of a fishing day)	$	18.14	8.68	20.24	9.33	17.46	5.31	9.55	3.78
δWTP/δx$_i$									
:NBRE	$	-1.98	0.82	6.22	2.76	21.74	14.37	9.68	5.25
:NOTHE	$	9.80	4.07	10.52	5.10	31.81	21.03	7.37	1.58
δNEB/δx$_i$									
:NBRE	$	-1.32	0.62	3.80	2.07	12.41	9.27	6.15	3.73
:NOTHE	$	6.57	3.08	6.32	3.85	18.15	13.57	5.56	1.18
δMWTP/δx$_i$									
:NBRE	$	-0.34		1.02		2.75		1.05	
:NOTHE	$	1.66		2.11		4.02		0.22	

Contingent valuation analysis

The results of contingent valuation analysis for the shore fisher data set are given in Table 2.38 through to Table 2.41.

2.38 Willingness to pay an extra amount for a recreational fishing day model: Shore fishers

Model specification	Model results	
$\log t = x'\beta$	Willingness to pay an extra amount	\$15.14 (3.23)

Vector	Variable[a]	β_j	t-ratio	Level of significance at which H_A accepted	$\delta WTP/\delta x_j$	
					Mean	St dev.
	constant	2.5260	15.005	1		
T_f	AD	0.0002	0.491	-	0.003	0.001
Inputs (X)	FEXP	-0.0059	-2.044	5	-0.089	0.019
	TRAV	-0.0022	-2.526	5	-0.033	0.007
	TFSH	-0.0002	-0.721	-	-0.003	0.001
	EXTF	-0.0001	-0.546	-	-0.002	0.000
Attributes of	INC15	0.0542	1.131	-	0.821	0.175
Fisher (F)	INC30	-0.0302	-0.532	-	-0.458	0.098
	INC45	-0.0806	-1.332	-	-1.220	0.260
	FTEMP	0.1259	2.592	1	1.905	0.406
	ECON	-0.0606	-2.066	5	1.311	0.279
	SOLO	-0.0174	-0.574	-	-0.264	0.056
	VIST	0.0881	1.946	10	1.333	0.284
	NOAD	-0.0887	-1.286	-	-1.342	0.286
Attributes of	NBRE	0.0407	4.972	1	0.616	0.131
Fishing day (Q)	NOTHE	0.0163	2.114	5	0.247	0.053
	ENJ	0.2192	6.221	1	3.318	0.707
	SCOM	-0.0840	-1.689	10	-1.271	0.271
	BTS	0.2140	3.953	1	3.239	0.690
	WCL	-0.0118	-0.376	-	-0.179	0.038
	CONG	-0.0537	-0.876	-	-0.813	0.173
	COND	0.0866	2.583	1	-0.917	0.195
	AUT	-0.3120	-4.497	1	-4.723	1.007
	WIN	0.1903	2.511	5	2.881	0.614
	SPR	-0.0786	-1.152	-	-1.190	0.254
	PIN	-0.0194	-0.379	-	-0.294	0.063
	MAR	-0.0573	-1.030	-	-0.868	0.185
	BUR	-0.0751	-1.426	-	-1.136	0.242
	REP	0.0119	0.148	-	0.179	0.038

a AD, Total days fished previous year. FEXP, Total expenditure on day's trip. TRAV, Total travel time. TFSH, Time spent fishing. TNFSH , Time spent on site not fishing. INC15, Income \$15 - 30 000. INC30, Income \$30 - 45 000. INC45, Income \$45 000+. FTEMP, Full time employed. ECON, Expected condition ranked 3 or 4. SOLO, Fished alone. VIST, Visiting region. NOAD, No adults in fishing group. NBRE, Number of bream pre fisher kept. NOTH, Number of other fish per fisher kept. ENJ, Enjoyed trip (1 = rank of 1 or 2). SCOM, Commercial vessel(s) seen. BTS, Beam trawl season. WCL, Weekend closure. CONG, Site congested (1 = rank of 1 or 2).. COND, Conditions on day of interviewed good or better (1 = rank of 1 or 2). SUM, Summer. WIN, Winter. SPR, Spring. PINE, Pine River. MARY, Mary River. BUR, Burnett River. REP, Repulse Bay.

2.39 Summary of goodness of fit of WTP model: Shore fishers

Frequency of actual and predicted outcomes

	Predicted outcomes		
Actual outcomes	0	1	Total
0	808	226	1034
1	233	746	979
Total	1041	972	2013

2.40 Willingness to accept compensation for a recreational fishing day model: Shore fishers

Model specification	Model Results	
$\log t = x'\beta$	Willingness to accept compensation for a block of fishing days	\$84.65 (70.20)
	Willingness to accept compensation for marginal fishing day	\$18.43 (5.01)

Vector	Variable[a]	β_i	t-ratio	Level of significance at which H_A accepted	$\delta MWTA/\delta x_j$	
	constant	2.9960	13.399	1		
T_f	logMD	0.8250	10.374	1		
	logAD	0.0504	1.901	10		
Attributes of Fisher (*F*)	INC15	-0.0942	-1.288	-	-1.736	0.472
	INC30	-0.0716	-0.798	-	-1.321	0.359
	INC45	-0.0553	-0.596	-	-1.019	0.277
	FTEMP	-0.0410	-0.555	-	-0.756	0.206
	ECON	0.0077	0.168	-	0.141	0.038
	SOLO	-0.0231	-0.511	-	-0.425	0.116
	VIST	0.3163	4.152	1	5.830	1.586
	NOAD	-0.3501	-3.714	1	-6.453	1.756
Attributes of Fishing day (*Q*)	NBRE	0.0407	3.557	1	0.750	0.204
	NOTH	0.0184	1.661	10	0.339	0.092
	ENJ	0.1531	2.999	1	2.822	0.768
	SCOM	0.0440	0.717	-	0.812	0.221
	BTS	0.2995	3.380	1	5.520	1.502
	WCL	0.1213	2.639	1	2.236	0.608
	CONG	0.0618	0.627	-	1.139	0.310
	AUT	-0.5815	-6.259	1	-10.718	2.916
	WIN	0.0507	0.844	-	0.945	0.254
	SPR	0.0174	0.160	-	0.321	0.087
	PINE	-0.0272	-0.335	-	-0.501	0.136
	MARY	-0.2775	-3.493	1	-5.115	1.392
	BUR	-0.1844	-2.618	1	-3.398	0.925
	REP	-0.0646	-0.544	-	-1.191	0.324

a AD, Total days fished previous year. INC15, Income \$15 - 30 000. INC30, Income \$30 - 45 000. INC45, Income \$45 000+. FTEMP, Full time employed. ECON, Expected condition ranked 3 or 4. SOLO, Fished alone. VIST, Visiting region. FSHLO, Fished line plus other method. NBRE, Number of bream kept. NWHI, Number of whiting kept. NFLA, Number of flathead kept. NOTH, Number of other fish kept. NCRAB, Number of crabs kept. WPRAW, Weight of prawns kept. ENJ, Enjoyed trip (1 = rank 1 or 2). SCOM, Commercial vessel(s) seen. BTS, Beam trawl season (November to May). WCL, Weekend closure. CONG, Site congested (1= rank of 1 or 2). COND, Conditions on day of interviewed good or better (1 = rank 1 or 2). SUM, Summer. WIN, Winter. SPR, Spring. PINE, Pine River. MARY, Mary River. BUR, Burnett River. REP, Repulse Bay.

2.41 Summary of goodness of fit of WTA model: Shore fishers

Frequency of actual and predicted outcomes

	Predicted outcomes		
Actual outcomes	0	1	Total
0	978	140	1118
1	264	292	556
Total	1242	432	1674

Discussion of results

From the analysis it can be seen that recreational fishers derive benefits from their activities, and that these benefits are substantial. The Total Direct Cost analysis indicated that boat fishers derive on average (with standard deviations in brackets) $552 (332) net benefit per year and $63 (57) net benefit per month from their sport. Similarly shore fishers derive on average an annual net benefit of $266 (171) and an average monthly benefit of $73 (73). While the standard deviations of these estimates are relatively high in some cases they do suggest that the recreational fishery generates significant economic benefits. The Contingent Valuation analysis confirms the importance of the fishery with boat fishers being willing to pay on average $40.47 (13.15) for an additional recreational day, and shore fishers willing to pay an average of $15.14 (3.23).

The results of the study are ambiguous about the effect of the presence *per se*, or possible presence, of commercial fishing operators on the benefits derived by recreational fishers. On the one hand, the Contingent Valuation analysis suggests that the presence of commercial vessels reduces the willingness to pay for an additional fishing day. This result is most marked in the case of boat fishers whose willingness to pay is $5.25 (1.71), or around 12 per cent of average willingness to pay, less if a commercial vessel is sighted. On the other hand, the results of the Total Direct Cost model suggest that demand for recreational fishing days increases as the number of commercial vessels sighted increases. Given the ambiguity of these results we focus our attention on the impact of the commercial vessels on the value of the recreational fishery through their effect on catch rates.

The survey results can be used to estimate the change in the benefit derived from a recreational fishing day as a result of a change in catch of a given species. The Total Direct Cost model predicts the extra amount a fisher would be willing to pay to catch an additional fish on a given fishing day. For example, it can be seen from Table 3.42 that under the annual demand model it is estimated that on average fishers would be willing to pay an additional $1.39 if they caught an extra bream on a given day. Under the monthly demand model, however, additional fish are generally valued much less than predicted by the annual model. In the annual model fishers were asked how many days they fished in the previous year, and were then asked about their plans for the following year. By relating planned fishing to actual fishing it was expected that reasonably accurate responses would be received. However because of the seasonal nature of the fishery it was not thought advisable to link fishing planned for the following month to actual fishing in the current month. Fishers generally reported more planned fishing days for the following month than were consistent with their reported plans for the following year. If those who fished the least and tended to have lower catch rates consistently over-estimated their number of fishing days in the following month the impact of catch rates on monthly demand for fishing days would tend to be under-estimated. For this reason the results of the annual demand model are considered to provide a more reliable guide to the value of additional catches per day fished.

In the Contingent Valuation analysis the estimates measure the extra value of a marginal fishing day given an increase in catch of a given species. For example, it is estimated that on average boat fishers would be willing to pay (WTP) an extra $1.04 for a fishing day if the bream catch of that day increased by one (Table 2.42). Boat fishers would be willing to accept (WTA) an extra $2.52 to forgo a day's fishing for which the catch rate was increased by one bream. As predicted by economic theory the WTP measure is less than the WTA measure, and, in common with all other studies of which we are aware, the difference is larger than expected. In the present study, which is concerned with the allocation of additional fish stock to the recreational sector, the WTP measure is the appropriate one.

A comparison of the annual and monthly demand models with the willingness to pay model within and between fisher types provides some interesting observations (Table 2.42). The shore fisher total direct cost models indicate that shore fishers would gain a higher value from an increase in catch than boat fishers, whereas the WTP model tends to indicate the opposite. Also the estimates in the shore fisher annual total direct cost model are much greater than that found under the WTP model, whereas the differences between the results of these models for boat fishers are relatively much smaller. As to which measure should be used, both methodologies yield results that appear to be reasonable.

2.42 Value of an additional fish caught per trip

		Total direct cost models						Contingent valuation models	
		Annual demand	Monthly demand	Annual site models				WTP	WTA
				Logan	Pine	Mary	Burnett		
Boat fishers									
Bream	$	1.39	0.12	2.49	1.53	1.12	0.52	1.04	2.52
Whiting	$	1.47	0.86	3.12	2.12	1.13	0.70	0.64	1.83
Flathead	$	3.33	1.38	-1.65	2.37	1.09	1.71	0.67	1.25
Other	$	2.32	0.63	0.56	0.54	1.71	1.31	0.45	0.67
Shore fishers									
Bream	$	2.32	3.06	0.34	1.02	2.75	1.05	0.62	0.75
Other	$	2.66	1.35	1.66	2.11	4.02	0.22	0.25	0.34

Conclusions

From the analysis it appears that the mere presence, or possible presence, of commercial operators has little impact on recreational fishing activities and the value of these activities in the defined fishery. However, the analysis indicates that increased catch levels will have a significant and positive impact on the benefits accruing to recreational fishers and the value of the fishery. A range of estimates of this impact have been derived in this chapter. In the next chapter the impact of beam trawl activities on recreational fish stocks will be examined and, in conjunction with the estimates derived from this chapter, the impact of beam trawl effort on the benefits derived by fishers in the recreational fishery will be estimated.

Appendix to Chapter 2

Survey of Recreational Boat Fishers

Questionnaire number: _______________
Date: _______________
Time started _______________
Time finished _______________
Interview site _______________
Weather conditions _______________

Hello my name is ________. I am undertaking some research for the University of Queensland. As part of this research I am conducting a survey on recreational fishing in this area. I would like to ask you a series of questions which will take about 10-15 minutes. Are you able to participate.

This is an independent survey I am conducting as part of our research. I am going to ask you a series of questions. There are no right or wrong answers. This interview is completely confidential. Your name is not required and, hence, you will not be associated with your answers in any form.

Questions

1. Was recreational fishing the primary purpose of your boat trip YES ☐ NO ☐

1(a) What percentage of your time was spent fishing
(If zero discounting interview) ☐ %

2. How many people in your boat were actually fishing today? ___________

3. Of the people who fished, how many are under 16? ___________

4. For how many hours have you been out in your boat today? ___________

5. Of this time, for how many hours did <u>you</u> have fishing gear in the water today? ___________

6. Of the time you spent fishing today, what percent of it was spent on

line fishing .... _______ %
net fishing .... _______ %
hoop nets .... _______ %
diving .... _______ %
other (specify) .... _______ %
other (specify) .... _______ %

7. What type of bait did you use today?

7a. Did you buy the bait or catch it?

7b. (If bait purchased) How much was spent on each bait type?

	Bait	Purchased/Caught	Cost
1			
2			
3			

8. During the time you fished today, were you targeting a particular species of fish?

NO ☐ YES ☐ 8(a) What species were you targeting?

1 ____________________
2 ____________________
3 ____________________
4 ____________________

9. What type and how many fish did your boat/group catch today?

	Species	Number
1		
2		
3		
4		
5		
6		
7		
8		

10. Of this catch did your group release any fish?

NO ☐ YES ☐

10(a) What type and how many fish did your boat/group release?

	Species	Number
1		
2		
3		
4		

11. Have you completed your fishing for today?

YES☐ NO ☐

11(a) How much additional time do you expect to have gear in the water (to the nearest 1/2 hour) ? ________

12. How long did it take you to drive from your permanent residence to this location?

☐

13. What is the postcode of your permanent home? _________

14. Are you staying away from home overnight on this fishing trip?

NO☐ YES☐

14(a) How many nights and where will you be staying on this trip?

hotel/motel .... _______
caravan park .... _______
rented house or cabin .... _______
with friends .... _______
other (specify) .... _______

14 (b). How many fishing trips do you intend to undertake during your visit to this area? _______

14 (c) How long did it take you to drive from your accommodation to this location? _______

15. On how many days did you go fishing at any location in rivers or inshore areas over the last year, including today? _______

16. How often do you intend to go fishing in these areas over the next year?

Less often than last year. ☐
The same as last year. ☐
More often than last year. ☐

17. On how many days did you go fishing at this site over the last year, including today? _______

18. How often do you intend to go fishing at this site over the next year?

Less often than last year. ☐
The same as last year. ☐
More often than last year. ☐

19. On how many days do you intend to go fishing over the next month? _______

20. Suppose you were offered (______ (days) x _____ =) $_____ to give up fishing over the next month. Would you accept the offer?

YES ☐

20a. Would you accept (______(days) x _____=) $ _______.

YES ☐ NO ☐

NO ☐

20b. Would you accept (______(days) x _____=) $ _______.

YES ☐ NO ☐

21. How much did your group spend on today's fishing trip? _______

21a. Of this approximately how much was spent on the following items.

boat fuel.._______
car fuel.._______
fishing tackle ...._______
bait .... _______
other... _______

22. You estimated that the cost for today's fishing trip was $_____(total from previous question). Given constraints on your disposable income, if this trip had cost <u>you</u> $_____ more would you still have gone fishing?

YES ☐

22a. If it had cost <u>you</u> $ _______ more would you still have gone fishing?

YES ☐ NO ☐

NO ☐

22a. If it had cost <u>you</u> $ _______ more would you still have gone fishing?

YES ☐ NO ☐

23. What were the weather and boating conditions like while you were fishing today?

1)Excellent 2)Good 3)Average 4)Poor

24. What did you expect the weather and boating conditions to be like?

1)Excellent 2)Good 3)Average 4)Poor

25. How congested was the area where you fished?

1) Very 2)Reasonably 3)Somewhat 4)Not at all

26. What is your employment status?

Full-time .... _______
Part-time.......... .... _______
Retired .... _______
Home maker .... _______
Student .... _______
Unemployed .... _______
Other .... _______

27. What make and model car do you own? _____________________

28. In which range does your gross annual income fall?
$0 -15,000 .... _______
$15,000 - 30,000 .... _______
$30,000 - 45,000 .... _______
$45,000+........... .... _______

29. Did you see or notice any commercial fishing activity today?

YES ☐ NO ☐

26a. How many commercial vessels did you see? _________

30. How enjoyable was today's fishing outing?

1) Very 2)Reasonably 3)Somewhat 4)Not at all

31. Have you previously been interviewed for this survey?

YES ☐ NO ☐

Survey of Recreational Shore Fishers

Questionnaire number ________________
Date: ________________
Time started ________________
Time finished ________________
Interview site ________________
Weather conditions ________________

Hello my name is ________. I am undertaking some research for the University of Queensland. As part of this research I am conducting a survey on recreational fishing in this area. I would like to ask you a series of questions which will take about 10-15 minutes. Are you able to participate?

This is an independent survey I am conducting as part of our research. I am going to ask you a series of questions. There are no right or wrong answers. This interview is completely confidential. Your name is not required and, hence, you will not be associated with your answers in any form.

Questions

1. How many people are in your fishing group? ____________

2. Of these, how many are under 16?

____

3. How many hours have you been here today? ____________

4. Of this time, for how many hours did you have fishing gear in the water today?

____

5. Of the time you spent fishing today, what percent of it was spent on

line fishing .... ________ %
net fishing .... ________ %
hoop nets .... ________ %
diving .... ________ %
other (specify) .... ________ %
other (specify) .... ________ %

6. What type of bait did you use today?

6a. Did you buy the bait or catch it?

6b. (If bait purchased) How much did you spend on each bait type?

	Bait	Purchased/Caught	Cost
1			
2			
3			

7. During the time you fished today, were you targeting a particular species of fish?

NO ☐ YES ☐ 7(a) What species were you targeting?

1 ________________________________
2 ________________________________
3 ________________________________
4 ________________________________

8. What type and how many fish did your group catch today?

Species Number

1 ____
2 ____
3 ____
4 ____
5 ____
6 ____
7 ____
8 ____

9. Of this catch did your group release any fish

NO ☐ YES ☐

9(a) What type and how many fish did your boat/group release?

Species Number

1 ____
2 ____
3 ____
4 ____
5 ____

10. Have you completed your fishing for today

YES ☐ NO ☐

10(a) How much additional time do you expect to have gear in the water (to the nearest 1/2 hour) ? ________

11. How long did it take you to drive from your permanent residence to this location.

☐ hrs

12. What is the postcode of your permanent home? __________

13. Are you staying away from home overnight on this fishing trip?

NO ☐ YES ☐

13(a) How many nights and where will you be staying on this trip?

hotel/motel .... _______
caravan park .... _______
rented house or cabin .... _______
with friends .... _______
other (specify) .... _______

13 (b). How many fishing trips do you intend to undertake during your visit to this area? _______

13 (c) How long did it take you to drive from your accommodation to this location? _______

14. On how many days did you go fishing at any location in rivers or inshore areas over the last year, including today? _______

15. How often do you intend to go fishing in these areas over the next year?

Less often than last year. ☐
The same as last year. ☐
More often than last year. ☐

16. On how many days did you go fishing at this site over the last year, including today? _______

17. How often do you intend to go fishing at this site over the next year?

Less often than last year. ☐
The same as last year. ☐
More often than last year. ☐

18. How many days do you intend to go fishing over the next month? _______

19. Suppose you were offered (______ (days) x _____ =) $_____ to give up fishing over the next month. Would you accept the offer?

YES ☐

19a. Would you accept (______(days) x _____=) $ _______.

YES ☐ NO ☐

NO ☐

19b. Would you accept (______(days) x _____=) $ _______

YES ☐ NO ☐

20. How much did your group spend on today’s fishing trip? _______

20a. Of this, approximately how much did was spent on the following items.

car fuel..._______
fishing tackle .... _______
bait .... _______
other.. _______

21. You estimated that the cost for today fishing trip was $_____(total from previous question). Given constraints on your disposable income, if this trip had cost <u>you</u> $_____ more would you still have gone fishing?

YES ☐

21a. If it had cost <u>you</u> $ _______ more would you still have gone fishing?

YES ☐ NO ☐

NO ☐

21b. If it had cost <u>you</u> $ _______ more would you still have gone fishing?

YES ☐ NO ☐

22. What were the weather and fishing conditions like while you were fishing today?

1)Excellent 2)Good 3)Average 4)Poor

23. What did you expect the weather and fishing conditions to be like?

1)Excellent 2)Good 3)Average 4)Poor

24. How congested was the area where you fished?

1) Very 2)Reasonably 3)Somewhat 4)Not at all

25. What is employment status?

Full-time .... _______
Part-time.......... .... _______
Retired .... _______
Home maker .... _______
Student .... _______
Unemployed .... _______
Other .... _______

26. What make and model car do you own? ____________________

27. In which range does your gross annual income fall?

$0 -15,000 .... _______
$15,000 - 30,000 .... _______
$30,000 - 45,000 .... _______
$45,000+............ .... _______

28. Did you see or notice any commercial fishing activity today?

YES ☐ NO ☐

28a. How many commercial vessels did you see? _________

29. How enjoyable was today's fishing outing?

1) Very 2)Reasonably 3)Somewhat 4)Not at all

30. Have you previously been interviewed for this survey?

YES ☐ NO ☐

3. Interaction between the Beam Trawl and Recreational Fisheries

The beam trawl and recreational fisheries interact in several ways. Beam trawlers may affect the stock of fish targeted by recreational fishers, and hence recreational fish catches, through the incidental catch of recreational species and through environmental degradation. Beam trawlers may also impact on recreational fishing experiences through their mere presence on the fishing grounds. The beam trawl fishery also provides benefits for recreational fishers through the supply of bait prawns. The net benefit derived by recreational fishers from the provision of bait prawns is equal to the amount that they would be willing to pay for bait prawns from the beam trawl fishery over and above the price actually incurred, that is the consumer surplus associated with the supply of bait prawns from the beam trawl fishery.

In Chapter 4 the net economic benefits derived from beam trawling are estimated. The objective of the present chapter is to estimate the economic cost (or benefit) that beam trawl operations impose on the recreational fishery, so as to incorporate these costs (benefits) in the analysis to be carried out in Chapter 4.

Beam trawling and the recreational fish stock

The results of the analysis in Chapter 2 indicated that recreational fishers may be willing to pay an additional amount for their fishing day if they were to catch a greater number of fish. That is, the benefits they derive from a recreational fishing day would increase if they were to catch more fish on a given trip. Estimates of the size of this increase in benefit obtained in Chapter 2 varied depending on the methodology and assumptions used, whether a fisher fished from a boat or the shore, and the species of fish caught. For example, it was estimated under the total direct cost annual demand model that on average shore (boat) fishers were willing to pay an extra $2.32 ($1.39) for the day’s fishing trip if they caught an extra bream, while under the contingent valuation willingness to pay model shore fishers were estimated to be willing to pay an extra $0.62 ($1.04 for boat fishers). Given this, if beam trawling impacts on recreational fish stocks in such a way as to reduce catches by recreational fishers then beam trawling imposes a negative externality (or cost through a reduction in benefits) on the recreational fishery.

As in all fisheries there are two issues in relation to the exploitation of the stock of fish targeted by recreational fishers (this stock is referred to in this report as the recreational fish stock, although the relevant species are also targeted by commercial fishers). These are, the optimal level at which the stock should be exploited and the optimal allocation of the rights to exploit the stock between competing users. The aim of this section is to investigate the effect of beam trawl effort on the recreational fishery and as such it is the allocation question that is to be addressed, albeit indirectly. It is simply assumed that the current level at which the recreational fish stock is exploited is sustainable. Also, while it is understood that beam trawlers do not target the recreational species and gain no benefits from their capture (the overwhelming majority of recreational fish taken are juveniles with no commercial value), the granting of a beam trawl endorsement implicitly contains a right to land these species as bycatch. Thus, they are allocated a right to exploit the recreational fish stock, albeit a restricted one, through their beam trawl endorsement.

There are two concerns in relation to beam trawling and the recreational fish stock. These are the number of fish targeted by recreational fishers taken as bycatch and the impact of environmental degradation resulting from beam trawling on these species. It would be ideal if these impacts on recreational fish stocks could be estimated and from this an estimate of the impact on recreational fish catches derived. However, due to the variety of factors influencing stock abundance such as spawning stock condition, recruitment success, predation levels and food supply and the impact on these factors of the construction of barrages, dredging, incursion on waterfront vegetation as a result of both agriculture and urban land use practices, this is not possible. As such the approach taken in this study is to estimate the number of the recreational species killed by beam trawlers per hour trawled that otherwise would have been caught by a recreational fisher. This estimate is then used with the estimates of the marginal value of a fish to a recreational fisher derived in the previous chapter to derive an estimate of the externality each hour of beam trawling imposes on the recreational fishery.

As previously stated, beam trawling may impact on recreational fish stocks directly, through the taking of bycatch, or indirectly through environmental degradation. It is possible to derive an estimate of the externality imposed by beam trawling through the landing of bycatch, and this is done later in the chapter. However, it is not possible to derive an estimate of the externality imposed by beam trawling caused through environmental degradation. Although no estimate can be derived, some general conclusions as to the effect of this environmental degradation on the recreational fish stock can be drawn.

Beam trawling, environmental degradation and recreational fish stocks

There are two main ways in which the environmental impact of beam trawling may affect fish stocks. These are through damaging the macrobenthos (bottom dwelling organisms) that some estuarine fish are dependent on as a food source (Hyland (1988)) or through the removal of fallen mangrove timber from trawl grounds which reduces the habitat available for fish which aggregate around such snags (Dredge (1983)).

Beam trawling has been shown to disturb the macrobenthos and the bottom of an estuarine environment as the beam and tickler chains, not always present, scrape along the substrate disturbing and dislodging the habitat structure (Butcher, Mathews, Glaister and Hamer (1981) and Kaiser and Spencer (1995)). River beam trawls in Moreton Bay are generally not fitted with tickler chains but have either a drop chain hung from the lead (bottom) line or a very thick rope-wrapped ‘mud-rope’ as the lead line (Hyland (1988)), and this also appears to be the case in other areas of the fishery.

As part of a study in the Burnett River undertaken by Dredge (1983), field observations of physical disturbances induced by beam trawling were made over a fifteen month period and a series of photographs of disturbances induced by trawling on intertidal flats at high tide were taken as the tide fell. From these observation it was concluded that physical disturbances induced over the mud flats trawled was minimal, and that the effect of light scuffing on the mud flats and their biota was unlikely to have observable effects given the major environmental changes occurring as a result of other activity within the estuary. Dredge (1983) did however raise concerns that beam trawling may influence the estuarine environment through the practice of removing fallen mangrove timber from trawl grounds, as this reduces the habitat available for fish which aggregate around such snags. The importance of dead timber and other such snags to estuarine fish populations is, however, unknown.

In another study Gibbs, Collins and Collet (1980) investigated the effect of otter prawn trawling in a New South Wales estuary used by both recreational fishers and commercial prawn trawl operators. As part of this study areas within the estuary were sampled prior to the opening of the commercial prawning season and again at the end of the season. The authors concluded that otter prawn trawling (without tickler chains) did not cause any detectable changes in the macrobenthos on the trawl grounds.

Hyland (1988) in an examination of the beam trawl fishery in the Brisbane, Pine, Logan and Caboolture Rivers concluded that while beam trawling caused some physical disturbance of the estuarine substrates it was ‘certainly not the only or the major cause of such disturbances’ with a number of other factors such as flooding, dredging and catchment modification providing the major impact on the rivers of the region. Similarly, a study of the Noosa River by Coles and Greenwood (1986) indicated that beam trawl operations are unlikely to result in significant environmental damage to the estuary as a whole due to the limited nature of both fishing effort and the fishing grounds within the river system.

Finally, if environmental disturbances have had a major impact on recreational fish catches then it would be expected that there would have been a significant and consistent deterioration in these catch rates over time. There have been several studies in recent years that have addressed the issue of recreational catch rates (Dredge (1983), Pollock and Williams (1983), Pollock (1986), Thwaites and Williams (1994) and Copes (1997)).

In a study by Dredge (1983) of the beam trawl fishery in the Bundaberg region, two sets of data are presented: catch rates of bream, whiting and flathead by the club champion of the Bundaberg Boat Angling Club in estuaries of the Bundaberg district over the period 1977-83 as shown in Table 3.1; and average bream catch rates of anglers participating in the ‘Bluewater Club’ bream contest for the years 1980-1983. Given that there was a major transformation and expansion of the beam trawl fishery in the region after 1976, if beam trawl effort impacted on recreational fish catch rates it would be expected that catch rates would deteriorate after this time (Dredge 1983). Dredge states that while the catch rates for the club champion show considerable variation from year to year ‘at this stage (they) show no evidence of a long-run down turn in anglers’ catch from the area.’ The data from the ‘Bluewater

Club' bream contest showed fairly consistent catch rates for the years 1980-1982, but a reduction of around two-thirds in 1983. However, caution was urged in interpreting the data as a late wet season in 1983 may have disturbed the annual bream spawning migration at the time the contest was held (Dredge (1983)).

There are obvious difficulties in comparing these catch rates with those obtained in the present study (see Tables 2.8, 2.9, 2.16 and 2.17) particularly for the 'Bluewater Club' contest data which relates to catch rates during the winter bream spawning run. For the club champion data problems arise as the average skill of those surveyed is likely to be less than that of the club champion and the Dredge data relate to the Baffle and Kolan estuaries as well as that of the Burnett. However, some observations can be made in relation to these data. The catch rate from bream in the survey period seems to indicate that there has not been a major deterioration of bream and flathead catch rates since the early 1980's, with the survey average being similar to that averaged by the club champion over the period 1980 to 1983 for bream, and higher for flathead. This is somewhat surprising given the expected higher skill level of the club champion and the growth in recreational effort over this period. The higher flathead catch rate may in part be due to the fact that within the study fishers specifically targeting this species accounted for the great majority of the catch, whereas the targeting behaviour of the Club Champion is not known. The catch rate for whiting obtained in the survey is less than that obtained by the club champion. Thus, although the conclusion can only be drawn tentatively, there does not appear to have been a significant or consistent reduction in catch rates in the Burnett River since the early 1980's.

3.1 Catch rates by Club Champion of Bundaberg Angling Club, in estuaries of the Bundaberg District (Dredge 1983)

	Bream		Whiting		Flathead		Other	
	#/day	#/hour	#/day	#/hour	#/day	#/hour	#/day	#/hour
1977-78	7.13	1.02	6.94	0.99	0.38	0.05	0.75	0.11
1978-79	14.29	2.04	3.82	0.55	0.12	0.02	0.29	0.04
1979-80	17.13	2.45	12.20	1.74	0.60	0.09	1.93	0.28
1980-81	4.29	0.61	21.82	3.12	0.12	0.02	0.29	0.04
1981-82	4.18	0.60	20.00	2.86	0.29	0.04	0.29	0.04
1982-83	5.80	0.83	5.93	0.85	0.53	0.08	0.53	0.08
Average		1.26		1.68		0.05		0.10

In a paper by Pollock and Williams (1983) angling club data for summer whiting catches off Bribie and Moreton Island between 1959 and 1980 were analysed and it was concluded that there was no evidence of a decline in the abundance of summer whiting, although the mean size of fish caught off Bribie Island had decreased over time. The catch rates recorded in the Pollock and Williams study are substantially higher than those obtained from the survey conducted for this study. However, given that Bribie and Moreton Islands are spawning areas, and hence the most productive fishing grounds, and the data relate only to members of angling clubs and to the main summer whiting season (August to February) it is difficult to draw conclusion from a comparison of the catch rates recorded in the respective studies.

Pollock (1986) examines angling club catch rates for yellowfin bream at two spawning grounds within Moreton Bay, these being Jumpinpin and Caloundra, and over the bay as a whole between 1946 and 1980. As would be expected catch rates at the spawning grounds during the winter spawning run are much higher than those found at other times of the year and that found for the bay as a whole. It was concluded that catch per unit effort (CPUE) at the spawning grounds during the spawning run increased between 1945 and 1975 and then declined. However, CPUE for the bay as a whole had remained constant over the period. The catch rates for boat fishers obtained in the survey conducted for the present study are substantially less than those obtained at the spawning grounds during the spawning season but are similar to the figures for the Bay as a whole. Given that the fishers were surveyed throughout the year in the present study, and are most likely to have fished in estuarine/river areas, and that these areas are bream feeding grounds rather than spawning grounds (Pollock (1986)), it would appear that the figures presented by Pollock (1986) for the Bay as a whole are most compatible with those obtained in the survey. As such it does not appear that catch rates have changed substantially since 1980.

In a review of the summer whiting fishery in south east Queensland Thwaites *et al* (1994) assessed the summer whiting catch from 12 recreational fishing clubs and the whiting catch (all species) of the commercial fishery between Caloundra and Southport. Catch rates from five popular summer whiting fishing locations (Inskip Point, Bribie Island, Moreton Island, Jumpinpin and Southport Broadwater) between 1959 and 1991 were examined. Yearly means for the catch per angler-day rate were found to have increased at all sites except Inskip Point from 1959 to the early 1970s. After this period the catch per angler-day rate was steady at Moreton Island, Jumpinpin and Southport, with a decline being observe at Bribie Island and no trend being discernible at Inskip point.

According to Kerby and Brown (1994), Thwaites and Williams also conducted an assessment of the yellowfin bream fishery in south Queensland, examining catch rates from four popular recreational fishing locations (Caloundra, Moreton Bay, Jumpinpin and Southport Broadwater) between 1923 and 1991. Catch rates from each area with the exception of Caloundra were found not to have shown any decrease over this time period, although a decline was observed in catch rates at Caloundra.

Finally, Copes (1997) in a study of the Pine River and Hayes Inlet waterways prepared for Sunfish Queensland concluded that ‘catch rates changed little on average over the 68 year period (to 1991)’ in regard to recreational catch rates in this area.

Overall, it appears the that beam trawl fishery is not a major cause of environmental disturbances within the estuarine system in which it takes place, nor do the environmental disturbances that may be attributable to it appear to have had a significant impact on recreational fish stocks.

Beam trawl bycatch and the recreational fishery

One of the major concerns raised about beam trawl operations is the incidental capture (or bycatch) of juvenile fish, particularly of those species targeted by recreational fishers (QFMA (1996)). The objective of this section is to derive an estimate of the externality (or cost) imposed on the recreational fishery by beam trawl operators through the incidental capture of recreational species. This externality is defined as the value to recreational fishers of the beam trawl bycatch.

In estimating this value the method that is to be used to measure the externality first needs to be established. The few other studies attempting to examining conflicts between commercial and recreational fisheries known to the author relate to the conflicts arising from the allocation of species targeted by, and hence of direct value to, both sectors. In these studies the externality imposed by the commercial fishery on the recreational sector by landing an additional unit of catch is the value that the recreational sector attaches to the unit of catch, and the optimal catch allocation is that which occurs when the value of an additional unit of catch is equal in each of the sectors. This assumes that the fishery is fully exploited and an increase (decrease) in the catch allocation of one sector will result in a decrease (increase) by the corresponding amount in the catch of the other sector. In this study the problem is more complex in that the recreational fish: are of themselves no value to commercial operators and as such are discarded and often survive upon return to the water; tend to be juveniles at the time of capture; only become of value to the recreational sector upon recruitment to the fishery, that is when they reach the minimum legal length required to allow recreational fishers to keep them upon capture; and it is unrealistic to assume that an increase in the number of fish entering the recreational fishery as a result of a reduction in beam trawl effort will result in a corresponding increase in the number of fish caught by recreational fishers. Thus, the externality imposed by beam trawlers is dependent upon not only the number of fish taken as bycatch and the value of these fish to the recreational sector, but also, the number that survive upon being discarded, the natural mortality rate suffered by juveniles before entering the recreational fishery and the proportion of fish recruited to the fishery caught by recreational fishers. Thus, in deriving an estimate of the externality imposed by beam trawlers on the recreational sector it is necessary to take all these factors into consideration, as the assumption that a reduction in bycatch from beam trawlers results in a corresponding increase in catch in the recreational fishery is demonstrably unrealistic.

As previously stated the externality imposed by beam trawling per unit of effort is defined as the value to recreational fishers of the beam trawl bycatch taken per unit of effort. Given the relationship between the beam trawl bycatch and the recreational catch as outlined above, then the externality imposed by beam trawl per unit of effort, *EPUE*, depends on the number of fish taken per unit of beam trawl effort, *RFCPUE*, the mortality rate of fish caught by beam trawlers, *BTM*, the natural mortality rate over the period between encountering the beam trawl and recruitment to the recreational fishery, *NM*, the proportion of fish recruited to the fishery caught by recreational fishers, *RC*, and the value of the fish to recreational fishers, *V*, that is:

$$EPUE = \sum_{s} RFCPUE_s * BTM_s * NM_s * RC_s * V_s + \varepsilon_s \qquad (3.1)$$

where the subscript *s* is an index relating to each of the fish species and ε is the error term.

In the following sections a discussion of the various parameters given in equation 4.1 is presented. As can be seen from this presentation there is a degree of uncertainty relating to the estimated values of the parameters. Given this, the use of point estimates is likely to be uninformative and highly speculative. As such, a stochastic estimation approached is employed. This approach has been used in other studies in which uncertainty about parameter estimates exists (see, for example, Treadwell, McKelvie and MacGuire (1991), and McKelvie, Reid and Haque (1994)). Under this approach a range of values for the uncertain parameters is employed to derive a range of results with their corresponding probability of occurrence. At the end of each section relating to the various parameters the range of values employed for each of the parameters is given. Following the last of these sections the results of the stochastic estimation procedure are presented.

Bycatch of recreational species per unit of beam trawl effort (RFCPUE)

In recent years two surveys involving bycatch from the Queensland beam trawl have been carried out. In 1983 Dredge conducted a fishery-independent study (that is, the trawl activity survey was undertaken by the researchers and not commercial operators) in the Burnett River aimed at determining: environmental damage by beam trawling; the life cycle and population dynamics of banana prawns; geographical and seasonal abundance of fish species caught as bycatch; and the correlation of mesh size and the size of prawns taken. Hyland (1988) conducted a study in the Moreton Bay region aimed at determining: the effect of the Moreton Bay river trawl fishery on juvenile fish populations, by comparing bycatch from commercial operations in the Logan, Brisbane, Pine and Caboolture Rivers; and the effect of the river beam trawl fishery on the Bay otter trawl fishery.

In addition to these studies Liggins and Kennelly (1996) conducted a bycatch study from prawn trawling in the Clarence River in northern New South Wales. This study took place over a period of three years and is the most comprehensive study of commercial bycatch in estuarine waters found. While the composition of the bycatch will vary across areas in the Queensland beam trawl fishery some results of this study are relevant. One finding was that the bycatch to prawn catch ratio was much less (with a range between 0.13:1 and 0.45:1 estimated) than that often quoted in the literature for offshore prawn fisheries, for which a ratio of 5:1 for temperate regions and 10:1 for the tropics is often cited (Liggins and Kennelly (1996)). While no measure of this is available for the Queensland fishery, from observation during a survey conducted as part of the present study it appears that the bycatch rates are not dissimilar to those observed by Liggins and Kennelly and prawn catches in most cases dominated the total trawl catch. Another observation was the variation in bycatch rates at different locations and at different times of the year.

The results of the Hyland and Dredge studies, in terms of the number of individuals of each recreational species caught per hour trawled, are provided in

Table 3.2. The results for the Hyland (1988) study relate to data collected from samples of commercial beam trawl catches in the Logan, Brisbane, Caboolture and Pine Rivers. In his study Hyland provides catch per hour trawl rates for yellowfin bream, winter whiting and river perch. The results for the other species are calculated from other results in the study. For the Dredge study the results relate to data collected as part of a standardised beam trawl sampling program conducted in the Burnett River. The configuration of the beam trawl used being a 7.3m head rope, Yankee Doodle design trawl made with a 28 mm mesh body and a 25 mm mesh cod, spread by a 5m beam. The reader is referred to the Dredge paper for detailed information on the sampling procedure used in this study. The results presented in Table 3.2 are derived from data collected for this study supplied by the Queensland Department of Primary Industries, and based on total catches divided by the total number of trawl hours involved in the survey, given as approximately 50 hours.

As these studies did not cover all areas nominated for investigation a bycatch survey was conducted as part of the present study. In addition it was felt that a new survey would allow for some comparison of bycatch rates over time and allow for data on beam trawl mortality rates to be collected. As for the recreational survey the bycatch catch survey was carried out in the areas nominated by the project's steering committee, with the exception of the Pine River which was not included in the study due to difficulties in making suitable arrangements with commercial operators.

The objective of the bycatch study was to estimate the rate of incidental capture of recreational fish species by beam trawlers in the course of their normal activities. The survey was conducted between February and May 1996 with a representative of the University of Queensland going out with commercial beam trawl operators at given times in each of the respective regions as they carried out their normal fishing operations. Beam trawling as with all methods of sampling aquatic organisms is not without bias. Factors influencing the catch of beam trawlers include: size of the gear, including mesh size; the speed at which the trawl is towed, catchability and size of the species, catch per unit effort (Warburton, (1989), Kjelson and Colby (1977)). As the study was conducted using commercial beam trawlers there were differences in gear types, boat capacity and the speed, and direction, at which the trawl was towed. In addition, trawling times varied depending on the size of the catch, the area being trawled, or incidental catches such as submerged logs, and in one case an old tyre. There was also variation between the time of the day that operators worked with some operators working at night and some during the morning. These variations in the method by which samples were collected mean that caution should be used in comparing the results between areas and with other studies. However, it should be noted that it has been determined that commercial beam trawling gear is appropriate for sampling nekto-benthic invertebrates (Stephenson, Chant and Cook (1982)).

Sites within the estuaries were chosen by the skipper and were fished in the manner they would be on a normal fishing day. These areas are defined by the commercial beam trawlers and are generally close to shore in shallow waters. A low prawn catch in one area meant a move to a different area. Substrates were not determined but in most cases muddy substrates were identified by the skipper.

Numerical abundance of all bycatch species was collated wherever possible. However, in some operations, the length of time between each shot was limited and only the recreational species in the bycatch could be identified and counted. Most identification of fish species occurred on site and fish were returned to the river, but some specimens were taken back to the laboratory and identified using Marshall (1964). This work was done by two people and some misidentifications or unreported species were inevitable, however, all data were treated as an accurate account of what was actually present in the catch. In only a few instances was any of the bycatch kept by the boat operator and in all cases this was purely for personal consumption.

In Table 3.2 average catch per hour trawled rates for each species that may contribute to recreational catches are provided. Also given is the standard deviation of the capture rates for all shots within a given area. Before an examination and comparison of the results are undertaken some comment on the survey is required. For the Repulse Bay survey the results are based on an extremely small sample. There are several reasons for this. As the fishery is highly opportunistic and the operators who agreed to take part in the survey have numerous endorsements it was difficult to know in advance when operators would be beam trawling. As it turned out these operators did little beam trawling during the survey period despite this being the peak of the season. Further, unfortunately when a suitable time was arranged and a representative sent to the region only two survey days were possible due to strong winds resulting from the presence of a cyclone off-shore. Further, on these days due to low catch rates minimal time was spent beam trawling. Similar problems were also encountered in surveying the other areas, for example, persistent heavy rains while a representative was in Maryborough meant that survey opportunities were missed as the operator stopped beam trawling as the fresh water flushed the river and prawns moved out to sea. Thus, the samples in the survey are smaller than originally desired and given the variability in bycatch between days the results of the bycatch study should be viewed with caution.

In examining the results several observations can be made. First, of the major recreational target species, as given in Chapter 2, the greatest source of possible conflict between beam trawlers and recreational fishers is the yellowfin bream catch. Although winter whiting (*sillago maculata*) catch rates are higher, summer whiting (*sillago ciliata*) and yellow fin whiting (*sillago analis*, also referred to as summer whiting) are the most important species of the recreational whiting fishery (Pollock (1980) and Hyland (1988)) and the catch rates for these species are negligible. For flathead, only in the Burnett and to a lesser degree the Mary were catch rates likely to be of any possible significance. Of the other species the source of possible conflict between the two sectors appears to be catch of: river perch in all areas; trevally and tailor in the Logan River; and, mulloway and grunters in the Burnett River.

Second, in the Logan and Burnett Rivers where such comparisons are possible, bycatch rates do not appear to be substantially lower across all species in the survey conducted for this study than for those conducted in earlier studies. For example, in the Logan River yellowfin bream catch rates were higher in the present survey with winter whiting catch rates being somewhat lower. For the Burnett River these results were reversed. This would appear to support the proposition that there has not been a substantial deterioration across the board in recreational fish stocks.

Hyland (1988) found that within the Moreton Bay area there are differences in species abundance between rivers which he attributed to the different hydrology of the systems. The results from the survey conducted for this study support this, with large variations between catch rates across the areas surveyed. This is not a surprise given the wide geographical distribution of the areas examined. Thus, in endeavouring to estimate an average rate at which a given species is caught as bycatch it is necessary to treat each area separately.

3.2 Beam trawl bycatch rates for a range of recreational species

			Logan River			Brisbane River	Pine River	Caboolture River	Mary River		Burnett River			Repulse Bay	
			Survey		Hyland	Hyland	Hyland	Hyland	Survey		Survey		Dredge	Survey	
Number of trawl hours			9.5		15.0	13.7	14.7	2.7	6.4		7.1		50.0	2.0	
Number of shots			15		56	65	52	21	23		22		**na**	9	
Common name	Genus	Species	Mean	St. dev.	Mean	Mean	Mean	Mean	Mean	St. dev.	Mean	St. dev.	Mean	Mean	St. dev.
Yellowfin bream	*acanthopragus*	*australis*	5.5	6.4	2.4	1.7	10.9	0.4	1.0	2.2	6.3	8.8	16.7	0.0	-
Whiting															
:Winter	*sillago*	*maculata*	32.8	27.4	38.0	33.0	21.3	0.7	3.7	5.7	1.8	3.8	1.1	0.5	1.41
:Summer	*sillago*	*ciliata*	0.0	-	0.1	1.1	0.0	0.0	0.0	-	0.0	-	0.0	0.0	-
:Northern	*sillago*	*sihma*	0.0	-	0.0	0.0	0.0	0.0	0.0	-	0.4	1.4	4.8	0.0	-
:Yellow fin	*sillago*	*analis*	0.0	-	0.1	0.3	0.4	0.0	3.4	7.2	0.3	0.8	1.0	0.0	-
Flathead															
:Bar tailed	*platycephalua*	*indicus*	0.0	-	0.0	0.6	0.0	0.0	0.0	-	0.0	-	0.6	0.0	-
:Mud	*platycephalua*	*fuscus*	0.9	1.4	0.4	0.4	0.3	0.0	0.6	2.5	2.0	3.6	3.3	0.0	-
River Perch	*joinieops*	*vogleri*	45.2	56.8	56.6	192.6	6.5	3.6	11.6	17.1	4.0	10.7	0.2	11.6	4.6
Tarwhine	*rhabdosargus*	*sarba*	0.2	0.6	0.1	0.4	0.1	0.0	0.0	-	0.4	1.2	0.0	0.0	-
Grunters	*pomadsys.*	*sp.*	0.0	-	0.0	0.0	0.0	0.0	0.0	-	0.0	-	18.9	0.0	-
King salmon	*polydactylus*	*sheridani*	0.0	-	0.0	0.0	0.0	0.0	0.6	1.7	0.0	-	0.0	8.6	21.3
Jew	*argyrosomus*	*hololepidotus*	0.0	-	0.0	0.0	0.0	0.0	0.0	-	0.0	-	0.4	0.5	1.8
Mulloway/Jew	*jonius*	*antarctica*	0.0	-	9.8	0.0	2.4	0.0	0.0	-	10.9	10.7	6.4	0.0	-
Tailor	*pomatomus*	*saltator*	5.1	7.6	2.4	0.5	0.2	0.0	0.0	-	0.0	-	0.0	0.0	-
Dart	*trachinotus*	*blochii*	0.0	-	0.0	0.0	0.0	0.0	0.9	2.0	0.4	1.5	0.0	0.0	-
Yellow tailed pike	*sphyraenella*	*obtusata*	1.9	2.4	4.7	0.1	0.3	0.0	0.2	0.4	0.0	-	0.0	0.0	-
Flounder	*pseudorhombus*	*arsius*	0.8	2.2	3.5	0.0	0.0	0.0	0.8	1.7	0.8	2.6	6.2	0.0	-
Trevally	*cranx*	*sp.*	2.7	3.9	4.1	0.0	0.0	0.0	1.5	3.0	0.8	1.6	0.7	1.0	2.2
Great trevally	*caranx*	*sexfasciatus*	1.26	2.9	2.4	0.0	0.0	0.0	0.0	-	0.0	-	0.0	0.5	1.8
Tiger mullet	*lisa*	*argentea*	4.1	10.6	5.9	0.0	3.3	0.0	0.0	-	0.0	-	0.0	0.0	-
Sea mullet	*mugil*	*cephalus*	0.0	-	2.5	0.1	0.1	0.4	29.7	69.3	0.0	-	1.0	10.1	8.2

Anecdotal evidence and the experience of operators indicates that there is a large variation in bycatch between shots, areas within a river system and the time of year. Unfortunately, it is not possible from the survey sample to obtain a meaningful indication of the variation in areas or the time of year. However, some indication of the variability of catch rates between shots was obtained by calculating a 95 per confidence interval for the mean rate of capture for each species (Table 3.3). Unfortunately as no data on the variance associated with the data from the other surveys is available no confidence intervals for these results can be constructed. It should be noted that as each shot is not a purely random event, as the location of each shot is in part determined by the prawn catch rates of the previous shot, and as a normal distribution is assumed, some of the lower bounds may be negative and these results are meant to be indicative only. As can be seen in Table 3.3 the ranges of the confidence intervals are quite large reflecting the variability of catch rates between shots and the small sample size.

3.3 Confidence intervals for the mean rate of capture per hour trawled of various species by beam trawlers

Species	Logan River 95 % C.I.	Mary River 95 % C.I.	Burnett River 95 % C.I.	Repulse Bay 95 % C.I.
Yellowfin bream	2.3 - 8.6	0.1 - 1.9	2.6 - 9.9	-
Whiting				
:Winter	19.4 - 46.2	1.3 - 6.0	0.2 - 3.4	-0.4 - 1.4
:Northern	-	-	-0.2 - 1.0	-
:Yellow fin	-	0.4 - 6.3	0 - 0.6	-
Mud flathead	0.2 - 1.5	-0.4 - 1.6	0.6 - 3.5	-
River Perch	17.3 - 73	4.6 - 18.6	-0.5 - 8.4	8.6 - 14.6
Tarwhine	-0.1 - 0.5	-	-0.1 - 0.9	-
King salmon	-	-0.1 - 1.3	-	-5.3 - 22.5
Jew	-	-	-	-0.7 - 1.7
Mulloway	-	-	6.5 - 15.4	-
Tailor	1.3 - 8.8	-	-	-
Dart	-	0.1 -1.7	-0.2 - 1.0	-
Yellow tailed pike	0.7 - 3.1	0 - 0.3	-	-
Flounder	-0.2 - 1.9	0 - 1.4	-0.2 - 1.9	-
Garfish	-	30.1 - 69.4	-	-
Trevally	0.8 - 4.7	0.3 -2.7	0.1 - 1.5	-0.4 - 2.4
Great trevally	-0.1 - 2.7	-	-	-0.7 - 1.7
Tiger mullet	-1.1 - 9.3	-	-	-
Sea mullet	-	1.4 -58.0	-	4.7 - 15.4

From the data presented in Tables 3.2 and 3.3 it can be seen that catch rates vary between areas and that there is high degree of variability over shots within a given area. For this reason a range of values for bycatch catch rates per unit effort are used in estimating the externality imposed by beam trawlers. The ranges used are given in Table 3.4. Rather than attempting to give a range for any particular area the approach used was to use ranges for what were designated low, medium and high catch areas for yellowfin bream and other species, and low and high catch rates for the whiting and flathead species. The ranges used were based on the catch rate data presented in Tables 3.2 and 3.3 above. For example, for yellowfin bream a low catch rate was designated as between 0 and 2 fish caught per unit of effort trawled, a medium catch rate as between 2 and 10 fish and a high catch rate set at between 10 and 20 fish.

3.4 Beam trawl capture rates per hour trawled ranges used in stochastic estimation procedure

Species	Low catch rate area	Medium catch rate area	High catch rate area
Yellowfin bream	0 - 2	2 - 10	10 - 20
Winter whiting	0 - 6	-	20 - 50
Other whiting	0 - 1	-	1 - 8
Flathead	0 - 1	-	1 - 5
Other	0 - 20	20 - 50	100 - 250

Mortality rates of fish caught in beam trawls

Fish caught in beam trawls may be damaged or killed as they pass through or get lodged in the trawl net mesh, are crushed or abraded against other species with spines or scales, or when brought aboard for sorting and exposed to the air, which causes stress and is fatal if experienced for extended periods (Kaiser and Spencer, (1995)). Fish which are discarded alive may also die later as a result of the initial capture.

Observations from surveys of beam trawl activity indicate that some species survive being caught in beam trawl nets much better than others. Hyland (1988) found yellowfin bream to be a hardy fish capable of surviving beam trawling. This observation was supported in the bycatch study undertaken as part of the current study with nearly 90 per cent of bream landed surviving the experience (Table 3.5) and most of them swimming away vigorously on release. Hyland (1988) suggests that anglers may confuse bream with silver biddy (*gerres ovatus*) a soft bodied fish which does not survive trawling well and when large quantities are discarded most will float on the surface. However, Dredge (1983) found survival rates more variable, with juvenile bream and flathead caught in small bags when water temperatures are below 22-24C normally surviving but if temperatures were above approximately 24C most fish died. As shown in Table 3.5 in the survey conducted in the present study flathead appear to survive beam trawling in most cases with those not surviving being small juveniles.

Of the other species caught in large numbers the results of the survey conducted as part of the present study indicate that river perch does not appear to survive beam trawling well (the survival rate in the survey was around 15 per cent), with the survival rate of winter whiting falling between that of river perch and yellowfin bream (Table 3.5). These results are consistent with observations made by Hyland (1988).

The percentages of the fish caught that were dead at the time when discarded are given in Table 3.5 (these results are from the survey conducted for the present study). To calculate the total beam trawl mortality rate it is also necessary to take into consideration those fish that are returned alive but die upon release as a direct consequence of having being caught by the beam trawl. No information on the rate at which this occurs is available for the species caught as bycatch in the Queensland beam trawl fishery. However, there is some information in relation to post beam trawl capture survival rates. Kaiser *et al* (1995) in a study of the North and Irish sea flatfish beam trawl fishery examined survival rates of bycatch species after capture and over periods ranging from 72 to 144 hours after capture. Of the five fish species examined post trawl survival rates (that is, the survival rate of those fish alive when brought on deck) of 50 per cent and greater were observed for 4 of the species, with one species having a survival rate of 97 per cent. As no information on survival rates is available for fish species caught as bycatch in the Queensland beam trawl fishery a range of between 0 and 50 percent post release fatality rate was used for each of the species, with the trawl kill rate being set as given in Table 3.5. From this the ranges used for the total beam trawl mortality rate are derived as given in Table 3.5

3.5 Beam trawl mortality rates

Common name	Percentage returned dead (trawl kill rate)	Beam trawl mortality rate range used in stochastic analysis
Yellowfin bream	11	11 - 56
Winter whiting	71	71 - 86
Other whiting	62	62 - 81
Flathead	23	23 - 38
Other	55	55 - 78

Recapture rates

In the previous section estimates were derived of the number of recreational fish captured per hour of beam trawling and the beam trawl mortality rate for these species. The purpose of this section is to estimate the additional number of each of the respective species that would have been caught had this kill not taken place.

If a fish is killed by beam trawling the result is a decrease in the size of the stock of the species of the given fish, reducing the number of fish available for capture by both recreational fishers and other commercial fishers targeting that species. Given that most of the beam trawl bycatch is of juveniles little immediate impact will be felt. However, over time when these juveniles would have reach a sufficient length to be targeted by recreational fishers the effect will be to reduce the size of this target stock. In addition the breeding stock may be reduced and this may affect the size of future generations of the fish stock.

Addressing the last issue first, given that it appears that the stocks targeted by recreational fishers are not currently exploited to a degree such that the spawning stock is endangered, and that the beam trawl bycatch for all of the species is much smaller than that taken by the recreational sector and other commercial fishers, the effect of beam trawl bycatch on the size of future generations of the fish stock is likely to be insignificant. Thus, the main issue is the removal of juveniles reducing the number of mature fish entering the fishery in time, and the estimation of the number of these fish killed by beam trawl operations that would have been caught by recreational fishers.

For a juvenile fish to be caught and kept by a recreational fisher at some time in the future two things have to occur. First, the fish has to survive until it reaches the minimum legal length for its species. Second it has to be caught by a recreational fisher. Thus, we need to know the natural mortality rate juveniles of each species suffer before reaching maturity and second the proportion of the adult stock taken by recreational fishers. Unfortunately very little information on these parameters is available for the species in question. However, in relation to recapture rates some rough indication may be gained from various tagging studies. In Table 4.6 results of recapture rates from various tagging studies are presented. There are several things that should be noted about these results. First, as noted by Pollock (1988) there is likely to be a number of tagged fish that are caught without the tags being returned. As such, the actual recapture rates are likely to be higher than the rates shown in Table 3.6. Second, the recapture rates relate to a specified time immediately after tagging. The recapture rates we are seeking differ from this in two regards, first we seek the recapture rate between the time of capture and the death of the fish and second there is gap between the time of being caught by a beam trawl and the fish recruiting to the recreational fishery. Estimates for the age at which yellowfin bream, for example, reach minimum legal range between 2 (Pollock (1986)) and 5 years of age (Dredge (1976)) whereas the majority of juvenile bream taken by beam trawlers would be less than a year old by Pollock's estimated growth rates and 2 years old under Dredge's. Whichever estimates are used it is apparent that the majority of bream caught by beam trawlers do not enter the recreational fishery for a significant period after their capture, whereas those in the tagging studies will be susceptible to recapture by recreational fishers immediately upon release. As natural mortality will be higher among the juveniles before they recruit to the fishery the recapture rates for the tagging studies may overstate the rate at which these fish will be caught by recreational fishers. Given all these considerations the recapture rates used in the stochastic analysis are as given in Table 3.7. (These rates include the effect of the natural mortality rate suffered by juveniles before recruitment to the recreational fishery). The reason a lower recapture rate was used for winter whiting, is that, as previously stated, the whiting fishery is primarily based on summer whiting, and recapture rates for the winter whiting tagging study cited are much lower than similar studies involving yellowfin bream and summer whiting. Finally, the recapture rate for other species is also low reflecting the lower catch rates of these species and the targeting behaviour of recreational fishers.

3.6 Fish recapture rates from various tagging studies

Reference	Study	Location	Species	Recapture rate (%)		
				Com[a]	Rec[b]	Total
Pollock (1988)	Pollock (1988)	Moreton Bay,	Yellowfin bream			
		Queensland	:Adults			6.8
			:Juveniles			3.9
	Thomson (1961)	NSW	Yellowfin Bream			
			: Peterson discs[c]			5.2
			: Monel metal straps[c]			7.0
	Henry and Vigona (1981)	Tuggerah Lakes, NSW	Yellow fin bream			7.1
McClean (1969)	McClean (1969)	Moreton Bay	Winter whiting			0.6
Morton (1982)	Morton (1982)	Moreton Bay	Summer whiting	3.0	2.5	5.5
ANSA (1997)	ANSA	Queensland	Flathead-Dusky			10.5

a Com: Recapture by commercial net fisher. **b** Recaptured by recreational line fisher. **c** Peterson discs and Monel metal straps are different types of tagging devices.

3.7 Fish recapture rates used in stochastic analysis

Common name	Recapture rates used in stochastic analysis (%)
Yellowfin bream	2 - 20
Winter whiting	1 - 5
Other whiting	2 - 20
Flathead	1 - 20
Other	2 - 5

Value of the recreational fish

The final parameter to be addressed is the value of a fish to a recreational fisher. In the previous chapter a total direct cost and a contingent valuation analysis was undertaken to estimate this value. From this analysis a range of values were estimated for the average increase in net economic benefit that a fisher would derive from catching an additional fish of a given species (Table 2.44). As previously stated the estimates of the size of this increase in benefit varied depending on the methodology and assumptions used, whether a fisher fished from a boat or the shore, and the species of fish caught. Given the different values derived in the models the upper bound used in estimating the externality was simply the highest obtained, and, as under some of the models there was no significant difference in the number of days demanded with an increase in catch rates, the lower bound was set at zero (Table 3.8).

3.8 Value of fish to recreational fishers: Ranges used in stochastic analysis

Species	Range ($)
Bream	0 - 3.06
Whiting	0 - 3.12
Flathead	0 - 3.33
Other	0 - 4.02

Estimating the externality

As previously stated given the uncertainty in relation to the parameter estimates a stochastic estimation approach is employed to derive a range of results with their corresponding probability of occurrence. Under this approach a value for each of the parameters, within its specified range, is selected at random, then using these values a result is generated. It is assumed that the probability that any given value within a specified range is equal to the true underlying value of the parameter is uniform across the range. This process was then repeated 10 000 times and a distribution of the results generated obtained.

The cost of the externality per hour of beam trawling was estimated using the ranges for the parameters as given above under several different scenarios. As the major concern with beam trawling is its effect on the main recreational species of bream, flathead and whiting the first set of scenarios included only these species (scenarios 1a-6a in Table 3.9). A second set of scenarios was then run with the catch rate for other species that may be of value to the recreational fishery included (1b-6b). The different scenarios within the two sets were based on the different ranges for the number of fish captured per unit of effort associated with the different catch levels as given in Table 3.4. Under the first scenario it was assumed that the catch rate of all species was high, with low catch rates being used for the second scenario. The third scenario was that which was felt to reflect the data on catch rates from the Logan River best. The fourth, fifth, and sixth were those reflecting the data from the Pine, Mary and Burnett Rivers respectively, with the Dredge (1983) data being the starting point for the Burnett simulation. In Table 3.9 the results corresponding to the 25, 50 and 75 per cent probability that the value of the externality is less than that shown is given. For example, under the third scenario with only the main recreational species included, the probability that the externality is less than $0.89 is 25 per cent, less than $1.50, 50 per cent and less than $2.34, 75 per cent.

3.9 Estimates of the externality imposed on the recreational sector per hour of beam trawling: Results of stochastic estimation procedure

	Beam trawl catch rates assumed					Value of the externality associated with the probability that the externality is less than:		
Scenario	Bream	Winter whiting	Other whiting	Flathead	Other	25 %	50 %	75 %
1a	High	High	High	High	-	1.77	2.65	3.72
2a	Low	Low	Low	Low	-	0.14	0.23	0.34
3a	Med	High	Low	Low	-	0.89	1.50	2.34
4a	High	High	Low	Low	-	1.21	1.99	2.97
5a	Low	Low	High	Low	-	0.35	0.59	1.00
6a	High	Low	Low	High	-	0.59	0.95	1.54
1b	High	High	High	High	High	5.49	8.61	13.03
2b	Low	Low	Low	Low	Low	0.34	0.54	0.85
3b	Med	High	Low	Low	Med	2.38	3.64	5.34
4b	High	High	Low	Low	Low	1.59	2.39	3.40
5b	Low	Low	High	Low	Med	1.66	2.72	6.33
6b	High	Low	Low	High	Med	1.89	3.06	4.67

By-catch reduction devices

Beam trawl by-catch of recreational fish species can be reduced by means of by-catch reduction devices (BRDs). Robins and Courtney (forthcoming) report that beam trawl operators have been moving towards the use of these devices during 1998. Many beam trawlers use grids, fished as both top and bottom opening devices, to exclude jellyfish and fish by-catch and these may reduce by-catch by up to 20%. There has also been limited trialing of BRDs which specifically exclude fish. Any increase in use of these devices will lead to a reduction in the cost imposed by beam trawling operations on the recreational fishery.

The presence of beam trawlers on recreational fishing grounds

In Chapter 2 the impact of the presence of commercial operators on the value of a recreational fishing day was examined through the use of a series of dummy variables to indicate the presence or possible presence of beam trawlers and other commercial fishing vessels. Two different results were apparent from these models. First, under the direct cost analysis it appeared that the seeing of commercial vessels did not have a significant effect on the number of fishing days undertaken by a fisher, indeed under the annual model for boat fishers those who saw a commercial fishing vessel actually demand significantly more fishing days (at the 10 per cent significance level). However, under the contingent valuation analysis boat fishers who saw a commercial fishing vessel were willing to pay (and accept) less to partake (forgo) in a fishing day. Shore fishers who saw a commercial vessel were also willing to pay less than those who did not. This indicates that the presence of commercial operators may adversely affect a recreational fisher’s enjoyment of their fishing day, although it does not appear to do so to such a degree that it alters their demand for fishing days. As the dummy variable relates to all commercial fishing operations it is difficult to assess the impact of beam trawling on the recreational fishery through their presence on fishing grounds.

Consumer surplus associated with bait prawns

The beam trawl fishery provides benefits to recreational fishers through the supply of bait prawns. The net benefit derived by consumers of a product is the amount that they would be willing to pay for the product over and above the price actually incurred, and is referred to in the economic literature as the consumer surplus associated with the supply of the product.

Prior to November 1996 bait prawns were imported into Australia. This situation meant that changes to the level of supply of bait prawns from the beam trawl fishery had little, if any, impact on the price of the product as more product could be imported to make up for any shortfall in local production. This was reflected in the stability of bait prawn prices received by beam trawl operators in the years preceding the import ban. Thus, there was little impact from a change in the level of prawn catches from the beam trawl fishery on recreational fishers. However, since this time the importation of bait prawns has been prohibited. Given that the Queensland beam trawl fishery is a major supplier of bait prawns to recreational fishers, changes in supply levels from this fishery are now likely to have an impact on the availability of bait prawns to recreational fishers, and hence possibly prices. However, as: the import prohibition has only recently being introduced; there are a numerous other products used for bait, such as pilchards, mullet gut and yabbies; and the degree to which a decline in bait prawn availability and any associated price increase will result in fishers substituting other types of bait for prawns is not known, it is difficult to assess the effect of changes in bait prawn supplies from the Queensland beam trawl fishery. To October 1997 there had been little change in the prices received by beam trawl operators, possibly indicating that beam trawl operators are still essentially price takers despite the import ban.

Appendix to Chapter 3

University of Queensland
Department of Economics

Beam trawl bycatch survey

Date:

Boat name:

Gear type:
-description
-length of head rope
-mesh size: body
:cod end
-mesh alignment

Boat:
-length
-engine size and type

Number of crew (including skipper):

River system:

For each shot

Date:________

Time Start:__________

Time finish:________

Location:_________________________________

Approximate Depth:__________

Type of substrata:_____________

Adjacent Vegetation:______________________

Catch	Weight	Number	No. Returned alive	Condition of returned species	Other comments
Prawns					
Banana (*penaeus merguiensis*)					
Greasyback (*Metapenaeus bennettae*)					
School (*M. macleayi*)					
Eastern King (*P. plebejus*)					
Tiger (*P. esculentus*)					
Other:					

Catch:	Weight	Number	No. Returned alive	Condition of returned species	Other comments
Crabs:					
Sand crab (portunus pelagius)					
Mud crab (scylla serrata)					
Other:					
Fish:					
River Perch (*johnieops vogleri*)					
Winter whiting (*sillago maculata*)					
Yellowfin Bream (*Acanthopagrus australis)*					
Mud flathead (*platycephalus fuscus*)					
Bar-tailed flathead (*platycephalus indicu*)					
Yellow finned whiting (*sillago analis)*					
Grunters (*pomadasys spp.*)					
Jew (*argyrosomus hololeidotus*)					

Catch: Fish (cont)	Weight	Number	No. Returned alive	Condition of returned species	Other comments
King salmon (*polydactylus sheridani*)					
Tailor *(pomatomus saltator)*					
Large toothed flounder *(pseudorhombus arsius)*					
Tarwhine *(rhabdosargus sarba)*					
Yellow tailed pike *(sphyraenella obtusata)*					
Narrow banded sole *(Aseraggodes macleyanus)*					
River garfish *(hemiramphus regularis)*					
Southern Herring *(harengula castelnaui)*					
Tiger mullet *(lisa argentea)*					
Sea mullet *(mugil cephalus)*					
Fan tail mullet *(mugil georgii)*					
Blue catfish *(Arius australis)*					

Catch: Fish (cont)	Weight	Number	No. Returned alive	Condition of returned species	Other comments
Other:					

Catch: Fish (cont)	Weight	Number	No. Returned alive	Condition of returned species	Other comments
Other:					

4. Bioeconomic Models of the Beam Trawl and Related Fisheries

The bioeconomic models described in this chapter are simulation models used to estimate the economic benefits generated from the Queensland beam trawl fishery. In the next section of this chapter the models are outlined. Following this the methodology used to incorporate the externalities arising from beam trawling into the model is discussed. Finally, an analysis of the results from the modeling procedure is undertaken. First, however, an overview of fishery management models in general and the structure of the models developed in this study is provided.

Fishery management models

The simplest approach to modeling the management of fisheries is based on the maximum sustainable yield (MSY) concept. However, this takes into consideration only the biological characteristics of the fishery and ignores economic considerations. There are several approaches that can be employed to examine the impact of management on the economic benefits generated by a fishery given its biological properties.

Many of the models that have been developed are optimisation models under which economic benefits are maximised, subject to the fishery’s biological properties. Given the management structure of the Queensland beam trawl fishery there is little prospect that effort levels can be restricted except through area closures, and hence, the objective of the model is primarily to simulate the fishery under the current management regime to examine whether the total benefit derived from areas within the beam trawl fishery under the current regulatory regime is greater than that which would be achieved if trawling was banned in the given area. An analysis of the net economic benefit derived from the beam trawl fishery under a range of effort levels in each area was also undertaken to obtain an indication of whether current effort levels are greater or less than optimal. It should be noted that in fishery the optimal level of effort in the fishery is that which maximizes economic profit (fishery rent), provided that all costs, including external costs are included. In this respect the fishery is different from other industries where efficiency is achieved at a zero level of economic profit. The reason for the difference is the absence of private property rights to the fish stock.

The model developed in the present study is a simulation model. These models have been frequently used in fisheries management analysis (see, for example, Grant and Griffin (1979) and Nance and Nichols (1987)). This approach has some advantages in that it allows for nonlinear catch-per-unit-effort or cost functions, and once parameterised, can overcome a lack of biological data by generating them (Onal, McCArl, Griffin, Matlock and Clark (1991)).

Queensland beam trawl fishery model

There are two characteristics of the beam trawl fishery that have a major influence on the structure of the models used in this study. These are the variation in the composition and size of the prawn catch between areas within the fishery and the management of the fishery.

The beam trawl fishery can be divided into three broad categories on the basis of catch. In Areas 2 to 5 (Figure 1I) of the fishery the catch consists primarily of banana prawns with greasyback and other prawns taken in smaller numbers. In the part of Area 1 lying south of 27S to the NSW border (including Moreton Bay) the catch consists predominantly of greasyback prawns, with school, banana and other prawns being taken in smaller numbers. In the northern section of Area 1 (from Double Island point (just north of 26S) to 27S) the fishery is based predominantly on the catch of school prawns with minor catches of greasyback, king and banana prawns. Of the areas nominated by the steering committee for investigation, banana prawns are the predominant species in catches from the Mary and Burnett Rivers and Repulse Bay, with the Logan and Pine Rivers lying in the southern section of Area 1 where greasyback prawns are the dominant species in the catch.

Given the variation in the composition of the catch the fishery was modeled on a regional basis. Also, as previously outlined in Chapter 1 there is a high level of latent effort in the beam trawl fishery and the fishery is opportunistic in nature. As such, the primary management tool that could effectively reduce beam trawl effort is to ban beam trawl activity within certain regions or river/estuarine systems, as was proposed by the State Government inquiry into recreational fishing. Thus, the modeling of the fishery on a regional basis best allows the management framework within the fishery to be simulated. As such, two models were developed to model the banana prawn and greasyback prawn regions in which the areas nominated by the steering committee lie:

- The banana prawn regional model; in this model it is assumed that banana prawns are the sole target species within the region, with other prawn catches being taken purely as bycatch. This model is used to simulate the northern areas of the fishery (Areas 2 to 5). It is assumed that the life cycle of the banana prawn is the same within and across these areas.
- The greasyback prawn regional model; in this model it is assumed that greasyback prawns are the target species within the region, with other prawn catches being taken as bycatch. This model is used to simulate the southern section of Area 1 south of 27S to the NSW border, where around 70 per cent of the catch is of greasyback prawn.

The biological characteristics and life cycle of each of the ‘target’ prawn species (that is, banana and greasyback) differ, as does the level of information available on each characteristic.

Banana prawns are a mixed life cycle prawn species in that they are dependent on estuaries during the post larval and juvenile stages, with sub-adults moving out of the estuary and into the marine environment where development is completed and spawning occurs. Greasyback and school prawns are shallow water estuarine species, with most development being completed within estuarine waters and spawning taking place in the deeper parts of the estuary for greasyback prawns and in adjacent marine zones for school prawns (Hyland and Gilmour (1988)).

The models developed in this chapter reflect the different life cycles and the availability of knowledge in relation to each of the species. In the remainder of this section a description of each of the components, including the mathematical specifications and the data used in the models is provided. This is presented as follows. First, the banana prawn regional model is fully outlined and specified. Following this, variations between this model and the greasyback prawn regional model are discussed.

The banana prawn regional model

The model is an annual model consisting of twelve individual monthly operations, with each month assumed to be 4.33 weeks long. The model contains a series of biological relationships of the fishery's prawn stocks that represent the fishery biomass, and economic and institutional features representing the fishery's management framework.

In the next section a description of each of the components, including the mathematical specifications and the data used in the model, is provided. Following this the procedure used to validate the model is presented.

The objective functions

The purpose of the model is to examine the profitability of beam trawl fishing in Queensland. As previously outlined in Chapter 1 most beam trawl operators are endorsed for and do participate in other fisheries. For example, in 1996 revenues from beam trawling were estimated to be around one quarter of the total annual fishing income earned by operators that were active in the beam trawl fishery. Given this, assumptions relating to the cost structure and the alternative use of the capital invested in the fishery need to be made.

The cost structure of the fishery is divided into three categories; variable and annual costs plus the cost of the capital invested in the fishery. Variable costs are those cost that vary with effort, such as, fuel and oil, and boat and gear maintenance and repairs, or with income (or catch), such as crew payments and marketing and distribution costs. Annual costs are those costs that are assumed not to vary with boat effort or income and include costs such as administration, insurance, licence fees and levies. There are two cost associated with the capital invested in the fishery, the opportunity cost of capital and depreciation. Opportunity cost is the amount that could be earned by investing the capital involved in fishing operations in an alternative investment of similar risk.

In the analysis conducted three assumptions relating to the alternative use of the capital invested in the fishery are made, and are similar to those used by Reid *et al*

(1993) in examining the Torres Strait fishery in which all operators within the fishery are also endorsed to operate in other fisheries.

Total gross margin

The first assumption used was that the capital invested in the fishery has no alternative use. This is equivalent to assuming that any reduction in beam trawl effort leads to an equivalent increase in the time that the capital is idle with their being no reduction in the annual and capital costs involved in an operator's total fishing operation. Under this situation the profitability of the fishery will be maximised when the total gross margin earned in the fishery is maximised. Total gross margin is revenue less all variable costs and is given by:

$$TGM = \sum_k GM_k \qquad (4.1)$$

where GM_k is the total gross margin for the fishery in month k and is given by:

$$GM_k = R_k - VC_k \qquad (4.2)$$

where R_k is the revenue earned from the fishery in month k and VC_k is the variable costs associated with fishing in month k.

Annual cash profit

Second, it was assumed that the capital invested in the fishery has an alternative use, and that the returns from that use cover all variable and annual costs. Under this situation the profitability of the fishery is measured by what is termed annual cash profit (ACP) and is given by:

$$ACP = \sum_k GM_k - AC \qquad (4.3)$$

where AC is the annual fixed costs incurred in the fishery.

Economic profit

The third assumption is intended to model the fishery in the long run and holds that the capital invested in the fishery is fully mobile and can be transferred cost free to an alternative use. Under this situation the profitability of the fishery is measured by what is termed economic profit. Economic profit is revenue less all economic costs incurred by the fishing operation, including capital costs, and the long run is regarded as a period of sufficient length such that all factors of production can be fully adjusted. Economic profit is given by:

$$EP = \sum_k GM_k - AC - OK \qquad (4.4)$$

where OK is the cost of the capital invested in the fishery.

Biological characteristics

The biological component of the model aims to simulate the changes to the stock of prawns that occur over time within the fishery. Simply, the model simulates the change to the biomass of the prawn stock as prawns recruit to the fishery, grow and gain weight, migrate offshore, and suffer mortality, from either natural causes or by being caught by the fishing fleet.

The prawn stock

The stock of prawns (in numerical terms) for a given region is given by:

$$S_{rik} = S_{r,i-1,k-1}\left(\exp-\left(TM_{i-1,k-1} + M_{i-1,k-1}\right)\right) + RC_{rik} \tag{4.5}$$

where S_{rik} is the number of prawns present in region r in age class i in month k; $S_{r,i\text{-}1,k\text{-}1}$ is the number of prawns in region r in age class i-1 in month k-1; $TM_{r,i\text{-}1,k\text{-}1}$ is the instantaneous total mortality rate of age class i-1 in month k-1; $M_{r,i\text{-}1,k\text{-}1}$ is the instantaneous rate at which prawns in age class i-1 migrates offshore in month k-1 and RC_{rik} is the number of new recruits entering the fishery in region r of age class i at the beginning of month k.

The average stock size (*AVS*) of prawns in region r in age i in month k is given by:

$$AVS_{rik} = \left\{S_{rik}\left[1-\exp\left(-\left(TM_{rik} + M_{rik}\right)\right)\right]\right\} \Big/ \left(TM_{rik} + M_{rik}\right) \tag{4.6}$$

Total mortality

The instantaneous total mortality rate (*TM*) in region r of age class i in month k is the sum of the instantaneous fishing mortality rate (*FM*) in region r of age class i in month k and the instantaneous natural mortality rate (*NM*) in region r of age class i in month k and is given by

$$TM_{rik} = FM_{rik} + NM_{rik} \tag{4.7}$$

Mortality rates are expressed as an instantaneous monthly (or weekly) rate at which the prawns are assumed to perish. For example, assuming there is no fishing activity during month *k-1* and no recruitment to the fishery at beginning of month k and the instantaneous natural monthly mortality rate is 0.22 then the (numerical) size of the prawn stock declines by around some 20 per cent as the prawns age by one month. That is:

$$\begin{aligned} S_{rik} &= S_{r,i-1,k-1}\left(\exp-0.22\right) \\ &= 0.803S_{r,i-1,k-1} \end{aligned}$$

Natural mortality

The natural mortality rate is the mortality rate suffered by a prawn stock, excluding that caused by fishing activity. In reviewing the literature there are several aspects of the natural mortality rate suffered by prawn stocks that need to be addressed. The first is the change in mortality rate as the prawn grows, the second is the difference in mortality rates suffered by prawns in estuarine areas and offshore areas, and the third the actual estimates of the mortality rate.

As outlined by Hyland and Gilmour (1988) penaeid prawns are subject to high mortality throughout their life cycle. Mortality during juvenile and adult life stages arises from a variety of sources including spawning stress, predation, disease and senescence, as well as from fishing activity. A range of studies have examined natural mortality rates in penaeid prawns, with it being generally concluded that juveniles suffer from a higher natural mortality rate than that of adults. Lucas (1974) estimated the instantaneous weekly natural mortality rate for juvenile king prawns in Moreton Bay to be 0.22 with the rate for adults being 0.05. Lucas, Kirkwood and Somers (1979) also estimated an instantaneous weekly natural mortality rate for banana prawns in their offshore phase of 0.05. Dann and Pascoe (1994) used this rate for this species in their study of the northern prawn fishery, however they assumed an instantaneous weekly natural mortality rate of 0.025 for grooved and brown tiger prawns.

In a paper on the Torres Strait prawn fishery by Watson, Die and Restrepo (1993) instantaneous natural mortality was calculated on a monthly basis and expressed as an exponentially decreasing function of the length of the prawn under which, for example, a prawn with a carapace length of 12mm suffers an instantaneous monthly natural mortality rate of around 0.30 falling to around 0.20 when the prawn achieves a size of 30mm.

Finally, in a study of *P. vannemi*, an estuarine prawn species found in Mexico and the southern USA, Blake and Menz (1980) estimated an instantaneous weekly natural mortality rate for the species of 0.22. This is the only known estimate for estuarine dwelling prawn species.

Given the above it was decided that two instantaneous weekly natural mortality rates would be used, 0.22 for juveniles (that is, where $CL <= 20$mm) and 0.05 for adult prawns ($CL>20$mm). This assumes that the size of the prawn is the main determinant of the natural mortality. These rates are converted to monthly rates, as the model is a monthly model, by multiplying the respective rate by 4.33 (the number of weeks assumed to be in a month).

The fishing mortality rate variable is dealt with in the economic and physical characteristics section following.

Recruitment

There are three aspects in relation to recruitment that need to be addressed, the size at which prawns recruit to the beam trawl fishery, the time of the year at which recruitment takes place and the number of individuals recruited.

There are two sequential periods of recruitment in peneaid prawn fisheries. These are the recruitment of postlarval prawns to nursery areas and the subsequent recruitment of juvenile prawns from nursery areas to deeper waters. Recruitment to most prawn fisheries involves the latter of these stages, that is the movement of juvenile prawns onto fishing grounds as subadults or adults. However, as previously outlined a significant component of the beam trawl fishery catch consists of juvenile prawns. As such, the carapace length at which recruitment to the beam trawl fishery takes place (*CLR*) was based on the approximate size at which the prawn becomes a juvenile. In Dredge (1983) post larvae banana prawns are given as 6-7 mm carapace length, and hence 9mm was used as the size which recruitment takes for these species. An examination of the size frequency data provided by Dredge (1983) of banana prawns taken using beam trawl gear (28mm mesh body and 25 mm mesh cod end) reveals that only prawns of over 8mm carapace length were taken by this gear, thereby supporting the previous proposition.

In a paper by Dredge (1984) the life cycle of the banana prawn is described. In this paper Dredge notes that near the southeastern limit of their distribution (that is, central and southern Queensland) two generations are observed per year, with spawning appearing to take place in autumn (March to June) and spring (September to December). Dredge postulates that the autumn generation, spawned both offshore and in estuaries, overwinter in estuarine waters and reach sexual maturity at approximately six months of age while still in these waters. These prawns spawn to repopulate the estuaries with juveniles throughout summer. The spring spawned juveniles then apparently migrate offshore (are recruited to the otter trawl fishery) from February to May. These banana prawns attain sexual maturity offshore during autumn, spawn and complete the two generations per year life cycle by repopulating the estuaries with postlarvae. In summary there appear to be two generations, an autumn spawned generation which remains within estuaries and a spring spawned generation that migrates offshore as juveniles before reaching sexual maturity. Hence, in the model it is assumed that recruitment to the beam trawl fishery takes place twice a year, from December to February and from May to July with one sixth of the total number of recruits entering the fishery during each of these months.

As previously outlined the life cycle of the banana prawn is assumed to be constant across the four northern areas of the fishery. Variation in catches between these areas arise in the models through differences in recruitment to the respective areas. Unfortunately, there are no known estimates of recruitment levels to the beam trawl fishery or areas within it. Hence, recruitment numbers for each of the areas were generated using an iterative process as outlined later in the model validation section. The values obtained are given in Table 4.5.

Migration

The migration rate is the rate at which prawns migrate to deeper waters (or recruit to the offshore fishery) from the beam trawl fishery. As for recruitment there are three aspects that need to be considered in addressing the migration rate, the rate itself, the carapace length and the time of year at which migration takes place.

Given the life cycle of banana prawns as previously outlined, it was assumed in the model that only the summer recruits to the beam trawl fishery migrate offshore, and that they do so before reaching sexual maturity. Tuma (1967) and Crocos and

Kerr (1983) suggested that female banana prawns commenced gonad development when in the size range 23 to 27 mm. In a study of the northern prawn fishery Dann and Pascoe (1994) assumed that banana prawns recruited to the fishery at a carapace length of 20mm in a single pulse. Dredge (1983) assumed that banana prawns recruit to the otter trawl fishery off central Queensland at a carapace length of 25mm, also in a single phase. In the model for the present study it was assumed the summer recruits to the beam trawl fishery commence migration to the offshore fishery at the beginning of February with an instantaneous monthly migration rate of 0.5 for prawns of a carapace length of greater than 20mm but less than or equal to 25mm and a rate of 1.0 for those of a carapace length greater than 25mm. The autumn spawned prawns which survive through to the following March are assumed to migrate offshore at the same rate.

Growth and weight functions

To calculate the biomass of the prawn stock two things are necessary. First, it is necessary to estimate the size of each cohort of recruits to the fishery at any given time of the year. Second, it is necessary to estimate the weight of a prawn at any given size and age.

In modeling prawn growth a frequently used approach is to assume that prawns recruit to the fishery at a given time and size and then to assume the prawns grow at a given rate from this time. The most often used growth function is that known as the von Bertalanffy growth function, for which estimates of its parameters have been made for a variety of prawn species. This approach is valid when the prawns recruit to the fishery as adults or sub adults. However, as previously stated catches of juvenile prawns are a significant component of the total prawn catch of the beam trawl fishery. As such, the growth of the prawn though its juvenile phase as well as its adult phase must be taken into account. Fortunately, a von Bertalanffy model can also be used for the juvenile growth phase (Dall, Hill, Rothlisberg and Sharples (1990)), and is done so in this study. As such the growth function is given by:

$$CL_i = \left(CL_\infty - CLR\right)\left(1 - \exp\left(-gw_i\right)\right) + CLR \qquad (4.8)$$

where CL_i is the carapace length of a prawn in age class i, CL_∞ is the asymptotic carapace length, CLR is the carapace length at which prawns recruits to the beam trawl fishery, g is the growth rate, and w is the number of weeks since a prawn in age class i recruited to the beam trawl fishery.

The asymptotic growth length (CL_∞) and the growth rate (g) used is that given by Lucas *et al* (1979) of 38mm and 0.08 per week. These parameters have been used in a number of other studies involving banana prawns, including, for example, Dredge (1983) and Dann and Pascoe (1994). As previously outlined it is assumed that banana prawns recruit to the beam trawl fishery at a carapace length of 9mm.

The weight of a prawn is a function of its carapace length and is given by:

$$W_i = aCL_i^{\,b} \qquad (4.9)$$

where W_i is the weight of a prawn (in grams) in age class i and a and b are length-weight parameters. The values of the parameters used were 0.00202 for a and 2.74 for b, obtained from Dredge (1983) and based on estimates derived from data collected from the Burnett River. A summary of the biological parameters and exogenously determined variables used in the model is given in Table 4.1.

4.1 Biological data for banana prawns

Parameter/Variable	Symbol	Unit	
Natural mortality (per month)	NM	*% per month*	
:For CL <= 20mm			0.66
:For CL > 20mm			0.20
Prawn weekly growth rate	g		0.08
Asymptotic carapace length	CL_∞	*mm*	38.0
Carapace length at which recruitment to beam trawl fishery takes place	CLR	*mm*	9
Minimum carapace length at which migration from fishery commences	CLM	*mm*	20
Length-weight parameter	a		0.00202
Length-weight parameter	b		2.74
Catchability parameter	q		0.001763

Economic characteristics

The model also incorporates the economic characteristics of the fishery, including both the cost structure of the fishery and the prices received for the catch. In this section the economic component of the banana prawn regional model is outlined.

Catch

The catch of the target species (in kilograms) in month k is given by:

$$H_{rik} = FM_{rik}\,AVS_{rik}\,W_i/1000 \tag{4.10}$$

where H_{rik} is the weight of prawns harvested in region r of age class i in month k; and FM_{rik} is the fishing mortality rate in region r of age class i in month k; and is given by

$$FM_{rik} = qSEL_i\,E_{rk} \tag{4.11}$$

where q is the catchability coefficient of the target species; E_{rk} is the amount of effort expended in region r during month k; and SEL_i is the gear selectivity when applied to age class i, and is given by:

$$SEL_i = 1\Big/\left\{1+\exp\left[-\delta\left(CL_i-\lambda\right)\right]\right\} \tag{4.12}$$

where δ and λ are parameters related to gear type which are assumed to be the same across the fleet.

Fishing mortality

As given in equation 4.10 fishing mortality is a function of three variables, the catchability coefficient, the selectivity coefficient and the level of effort directed at the prawn stock. As with recruitment, there is little information on catchability for the beam trawl fishery, and an estimate of this parameter is derived along with that for recruitment in the model validation section.

The selectivity coefficient relates to the selectivity of the gear in capturing a given size of prawn. The form of the function used is taken from Reid, Collins and Battaglene (1993) with the parameters adjusted to reflect the higher retention rates of the smaller beam trawl gear. The values for the parameters used are 0.3 for δ and 12 for λ. As an indication, the retention rates for prawns of carapace length 10 and 15mm are 50 and 82 per cent respectively. The only known data relating to beam trawl gear selectivity was published by Dredge (1983) in which 75 per cent of 'small' prawns were retained by a 28mm net, and an absolute retention rate was found for the same size cod end.

Catch of other prawn species

As other species of prawns for which biological information is not incorporated into the model are also landed by commercial operators, and hence contribute to their revenue, catch of these species need to be taken into account. To do this prawn catches of other species (*OH*) were calculated using historical data, and are given by:

$$OH_{rk} = h_{rk} E_{rk} \tag{4.13}$$

where OH_{rk} is the catch of other prawns, h_{rk} is the historical average rate of capture per unit effort of other prawns in region r in month k. In Table 4.2 the monthly catch rates per unit of effort (fishing days) of prawns other than banana prawns in areas 2, 3 and 5 of the beam trawl fishery between 1988 and 1991 are presented. These figures were used directly in the model when simulating the relevant year. For the 1992-96 period the h values were calculated using the average value for the 1988-91 period and the given year's estimated other prawn catch rate. In Table 4.3 the annual values for h over the period 1988 to 1996 are shown for each of the areas modeled.

4.2 Non target prawn species catch per unit effort by month and area 1989-91

	Unit	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Area 1 (NSW Border to 27S)													
1988	*kg/day*	16.1	18.9	10.3	10.9	18.0	10.7	7.2	8.2	11.6	12.7	21.7	21.8
1989	*kg/day*	25.6	20.0	16.7	18.9	23.2	23.9	15.0	11.9	11.7	14.8	23.2	25.5
1990	*kg/day*	33.4	24.1	16.8	16.6	12.3	6.5	6.0	4.8	7.7	18.9	29.7	27.3
1991	*kg/day*	27.2	26.1	16.8	15.4	10.4	9.2	5.8	3.2	6.6	11.6	15.7	21.0
Area 2													
1988	*kg/day*	-	3.7	2.4	13.4	8.8	2.6	2.8	11.9	6.9	6.9	15.2	5.2
1989	*kg/day*	1.3	2.2	3.2	3.7	0.6	31.9	30.9	41.7	14.5	20.5	14.5	7.8
1990	*kg/day*	4.3	0.3	4.8	1.2	10.8	7.1	16.2	5.3	1.2	20.0	9.0	5.3
1991	*kg/day*	9.3	2.8	8.9	1.3	31.1	-	-	22.1	25.3	45.0	28.4	1.5
Area 3													
1988	*kg/day*	9.4	9.5	12.7	7.7	7.4	6.2	3.3	0.9	4.3	7.2	3.6	4.2
1989	*kg/day*	15.2	13.3	22.7	6.3	11.9	13.9	22.3	15.9	8.8	10.7	23.7	11.3
1990	*kg/day*	5.9	6.4	5.3	9.3	4.2	4.1	2.3	1.1	0.0	0.9	1.3	4.3
1991	*kg/day*	11.1	12.6	10.0	9.1	7.1	8.1	5.2	2.3	0.0	0.0	1.0	9.3
Area 5													
1988	*kg/day*	0.5	2.8	1.0	0.9	1.6	-	4.0	3.3	1.1	0.8	2.2	1.1
1989	*kg/day*	2.5	1.1	4.4	2.6	1.5	1.3	0.9	0.8	0.2	2.2	3.3	0.6
1990	*kg/day*	1.4	1.0	0.5	3.7	3.9	2.5	2.2	3.0	4.8	3.0	2.6	0.6
1991	*kg/day*	3.9	3.6	2.9	5.9	5.5	10.7	5.8	0.2	0.0	0.0	1.1	4.6

4.3 Non target prawn species catch per unit effort (kg/day) by year 1989-97

	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996
Area 1 (NSW Border to 27S)	*kg/day*	18.1	24.0	24.2	19.5	13.7	21.2	6.7	23.0	13.0
Area 2	*kg/day*	7.7	14.6	7.3	19.2	2.3	0.6	0.9	5.0	4.3
Area 3	*kg/day*	8.25	15.03	4.96	8.69	18.61	16.83	11.61	22.75	15.14
Area 5	*kg/day*	0.89	2.05	2.26	3.37	3.41	11.47	2.65	2.19	1.58

Total prawn catches

Total prawn landings in month *k* in region *r* are given by the sum of the total catch of the target species ($\Sigma_i H_{rsik}$) and the catch of other prawn species:

$$TH_{rk} = \sum_s \sum_i H_{rsik} + OH_{rk} \qquad (4.14)$$

Revenue

Revenue (*R*) from region *r* in month *k* is given by:

$$R_{rk} = \sum_i H_{irk} P_i + OH_{rk} PO \qquad (4.15)$$

where P_i is the price received for the target species in age class *i*, and *PO* is the average price received for catches of non target species. In the model is assumed that the price operators received is determined by the size of the prawn and given by the following relationship:

$$P_i = P_l \quad \text{where } l < 30 \text{ if } W_i < 15.2 \text{ grams} \\ \text{where } l \geq 30 \text{ if } W_i \geq 15.2 \text{ grams} \tag{4.16}$$

where *l* is the grade of prawns expressed in units of prawns per pound. The prices used in the model are given in Table 5.3.

Variable costs

The variable operating costs (*VC*) incurred in the fishery in region *r* during month *k* are given by:

$$VC_{rk} = \left(F_r + BG_r\right)E_{rk} + (c_r + m_r)R_{rk} \tag{4.17}$$

where *F* is the fuel cost incurred per fishing day, *BG* is the average daily cost incurred for maintenance and repairs, *c* is the proportion of the total revenue that is paid to the labour employed (including owner skippers) and *m* is the proportion of the total revenue that is spent on marketing and distribution.

The values of each of these parameters are assumed to be constant across each area of the fishery. Information on variable and other costs associated with beam trawl operations were obtained from a survey conducted as part of the present study and industry sources. A detailed description of the survey, the data collected and the derivation of the parameter estimates is presented in Appendix A. In Table 4.3 a breakdown of the parameter values derived from the survey is provided for Areas 2, 3 and 5.

Annual costs

AC is the annual per vessel beam trawling cost incurred in region *r* and is given by:

$$AC_r = VAC_r\left(E_r / VE_r\right) \tag{4.18}$$

where VAC_r is the annual costs incurred per vessel in region *r*, E_r is the level of beam trawl effort expended in region *r*, VE_r is the average annual fishing effort (that is, beam trawling plus all other fishing activities) of the active beam fleet in region *r*. The former is estimated from the economic survey (see Appendix A to Chapter 4) and the latter from logbook data with the parameter value used in the model given in Table 4.4.

Capital costs

The cost associated with the capital invested in the fishery (*OK*) is given by:

$$OK = \left(z + d\right)K\left(E_r / VE\right) \tag{4.19}$$

where *K* is the capital investment per vessel, *z* is the rate of return that would have been earned by an alternative investment of comparable risk to the fishing industry and *d* is the annual rate at which the capital invested in the fishery is depreciating.

In corporate finance literature the rate of return required to invest in a given industry (z_i) is given by:

$$z_i = z_f + \beta_i z_m \qquad (4.20)$$

where z_f is the rate of return on a risk free investment, z_m is the market risk premium and β_i is a measure of the relative riskiness of the investment compared to that of the investment market as a whole. For the present study it was assumed that the risk free rate was 6.5 per cent (the average available for cash management accounts as at September 4 1995 (Australian Financial Review, 4/9/95)), with the market risk premium being set at 8 per cent as calculated by Officer (1989) and a beta of 0.7 following that used by Lindner, Campbell and Bevin for the NZ fishing industry (1992). This gives a nominal required rate of return of 12.1 per cent. Adjusting this for inflation (assumed to be 3.2 per cent, the 1994-95 annual CPI rate (http\\www.abs.gov.au)) gives a required real rate of return of 8.9 per cent. If the rate of return to a private investor was being examined it would be necessary to adjust the rate of return for taxation. However, as this study examines returns from the fishery from a social view point (although the investment is made by private individuals) we are interested in total returns, regardless of whom they accumulate to. The annual depreciation rate used was 4.8 per cent with the capital invested in the fishery assuming to have a remaining productive life of 15 years.

4.4 Beam trawl cost and price data used in banana prawn model

Parameter/Variable	Symbol	Unit	Area 2	Area 3	Area 5
Price					
Under 30 grade	*P*	*$*	9	9	9
Over 30 grade	*P*	*$*	5	5	5
Other	*OP*	*$*	4.5	4.5	4.5
Variable costs	*VC*				
Fuel costs incurred per day fishing	*F*	*$/day*	20	25	20
Average daily cost incurred for maintenance and repairs	*BG*	*$/day*	30	30	30
Proportion of the total revenue that is paid to the labour employed (including owner skippers)	*c*	*%*	36	36	36
Marketing and distribution costs as a proportion of revenue	*m*	*%*	2	2	2
Annual costs	*FC*				
Annual costs per vessel	*VFC*	*$*	8 500	10 500	9 500
Total annual fishing effort per vessel	*VE*	*days*	120	150	110
Opportunity cost of capital	*OK*				
Capital per vessel	*K*	*$*	55 000	60 000	55 000
Required rate of return	*z*	*%*	8.9	8.9	8.9
Depreciation	*d*	*%*	4.8	4.8	4.8

Banana prawn model validation

The accuracy of the model was checked by analysing its ability to replicate historical data in a similar fashion to that used by Dann and Pascoe (1994) and Reid *et al* (1993).

To paraphrase Dann and Pascoe (1994), catch rates of prawn are dependent on the size of the recruitment to the fishery, the biomass of the stock, the rate of fishing mortality and the rate of natural mortality. The rate of fishing mortality is a function of the catchability of the prawns, the selectivity of the gear and the level of fishing effort. In the model the values for the key biological parameters, natural mortality and recruitment, are not known with any degree of certainty. There is also uncertainty in relation to the catchability of the prawns.

A difficulty in deriving estimates for these parameters is that they are highly interdependent. Changes in biomass are a function of both the growth rate and the mortality rate. Where stock size is unknown, it is difficult to distinguish the effects of natural mortality and fishing mortality on catch rates. As a result alternative combinations for the catchability and the natural mortality parameters could result in the same trend in catch rates.

For the present study the values for recruitment and catchability parameters were estimated employing an iterative procedure, in which all other parameter values were assumed to be known and effort was fixed at historical levels. This procedure was initially carried out for the Area 3 banana prawn regional model, the area from which much of the biological information on this species' life cycle is based. The model was initially run with the unknown parameters set at values based on available information. The solutions for variables such as catch were then compared with actual data for the period for which effort levels were fixed. The parameter value being estimated was then adjusted until the model replicated known events in a satisfactory manner. Once this occurred the catchability parameter was fixed. The model was then rerun with effort being set at that for a different period and the recruitment level adjusted such that the model replicated events for this period in a satisfactory manner.

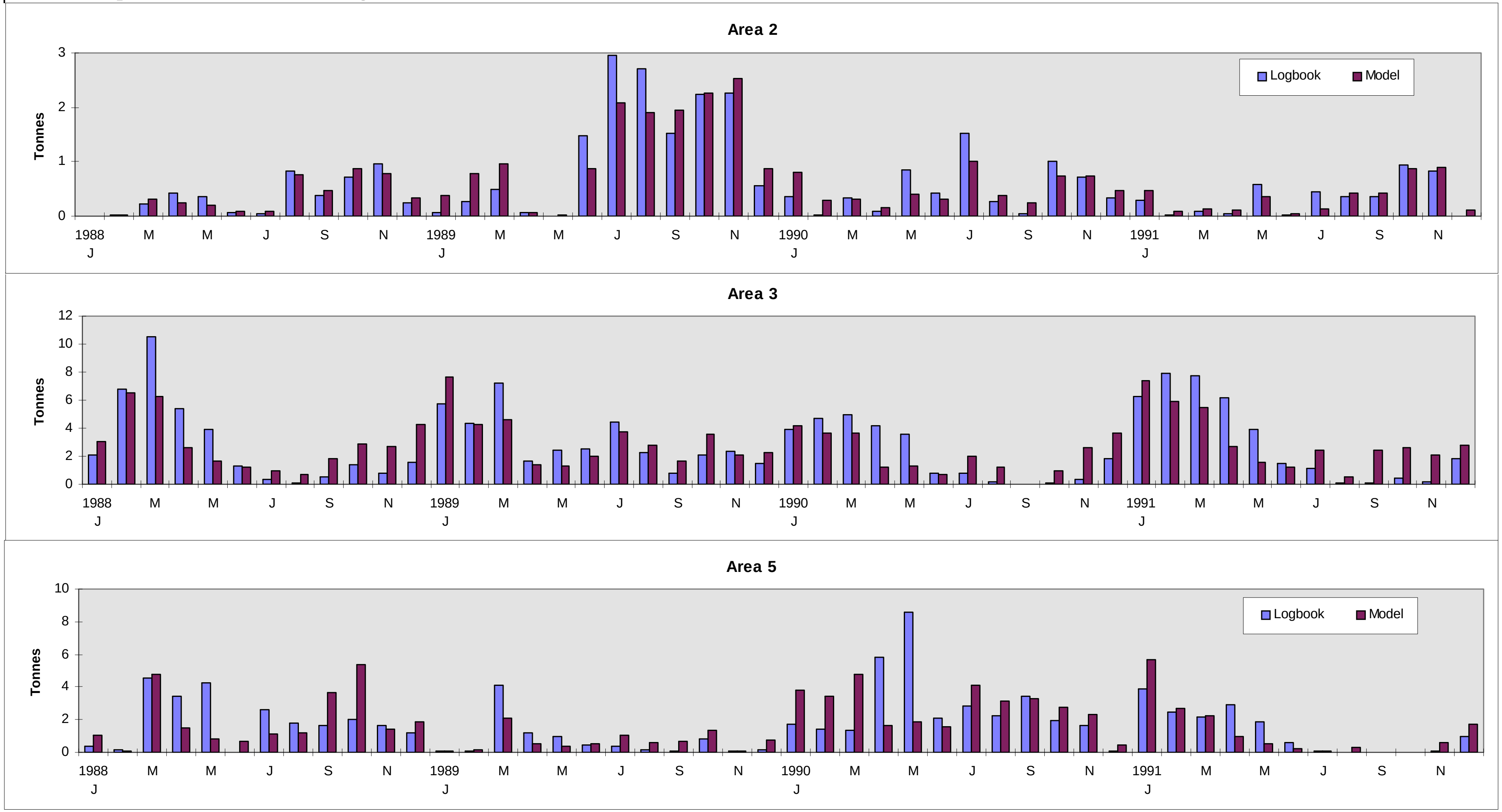
In modeling Areas 2 and 5 the catchability coefficient was assumed to be that generated for the Area 3 model with the recruitment parameter being adjusted such that historical events were replicated. The value of the catchability coefficient is given in Table 4.1 and the total annual recruitment by area and year are given in Table 4.5.

In Figures 4A, a comparison is provided of the respective model and logbook catch estimates for Areas 2, 3 and 5 for the period 1988 to 1991. The reason this period was chosen for the comparison is that, as previously outlined in Chapter 1, monthly logbook catch and effort data were only acquired for the period in which beam trawl catches were entered into the mixed fishery logbook database (that is 1988-91).

4.5 Total annual recruitment values used in validation of banana prawn model

	Model inputs		Model output	Logbook estimates
	Recruitment (*millions*)	Effort (*days*)	Total catch (*kg*)	Total catch (*kg*)
Area 2				
1988	2.7	284	4 212	4 273
1989	8.1	433	14 709	14 629
1990	4.2	332	5 855	5 951
1991	7.2	116	4 074	4 012
Area 3				
1988	17.0	1 051	35 122	35 075
1989	14.4	931	37 979	37 903
1990	19.7	693	25 327	25 272
1991	26.1	748	37 350	37 426
1992	10.7	250	12 353	12 368
Area 5				
1988	16.8	561	17 605	17 534
1989	11.1	346	7 877	7 848
1990	24.4	813	31 931	31 982
1991	18.6	293	12 161	12 217

4A Comparison of model and logbook catch estimates Areas 2, 3 and 5: 1988 to 1991



Greasyback prawn region model

As previously outlined, the specifications of each of the regional models are varied to reflect the differences in the life cycle and the biological characteristics of the region's target species. These differences are reflected in the parameters relating to recruitment, migration, natural mortality, and prawn weight and length used in the respective models.

Growth and weight-length parameters

In reviewing the literature on greasyback prawns two papers providing estimates for growth parameters for this species were found (Courtney, Masel and Die (1991), and Aziz (1979)). In both papers the growth function is specified in terms of the weight of prawn rather than in terms of its length, as was the case for the banana prawn model where the von Bertalanffy growth function was used. Hence, the growth function is specified in terms of the weight of the prawn in this model (equation 4.21).

In the work reported by Aziz (1979) the growth function of greasyback prawns up to a carapace length of 18.4 mm was estimated. Given that this species is regarded as a juvenile when it is between 5 and 15 mm long (Courtney *et al* (1991)) the results from this paper relate primarily to this phase in the life cycle of the prawn. Aziz also found that there was no significant difference in growth rates up to 18.4mm CL for males and females of the species. It should be noted that this work was based on prawns grown in captivity.

In the paper by Courtney *et al* (1991) parameter estimates of the growth function are provided separately for male and female prawns. Given that these parameters result in substantial differences between the weights of respective sexes as the prawn gets older it was decided to incorporate the growth of both sexes into the model, with ratio of male to female prawns recruiting to the beam trawl assumed to be 1:1.

The growth function specified in equation 4.21 models the growth of the prawn in two stages. The first phase is from the time the prawn recruits to the beam trawl fishery, assumed to be when its weight is equal to W_0 as given by Aziz (1979). This weight of approximately 161 milligrams corresponds to a carapace length of 5.33mm which is the approximate size of a greasyback prawn entering its juvenile stage (Courtney *et al* (1991)). Given that greasyback prawns use estuarine waters during their juvenile stage it was felt that it was reasonable to assume that the prawns recruit to the beam trawl fishery when their weight was equal to W_0. During this phase the growth function used is that given by Aziz. The second phase is the post juvenile phase of the prawn's life cycle. This was assumed to occur once the prawn reaches 2.7 months old (a weight of approximately 2.5 grams and CL of 15mm) from which time male and female prawns were assumed to grow at different rates as described by Courtney *et al* (1991). The growth function is given by:

$$\begin{aligned}
&\text{For } m_i \le 2.7\\
&\qquad W_i = \left(W_0 \exp\left(gw_i\right)\right)/1000\\
&\text{For } m_i > 2.7\\
&\qquad W_{si} = \left(W_{s\infty} - 2.5\right)\left(1 - \exp\left(-g_s\left(m_i - 2.7 - t_0\right)\right)\right) + 2.5
\end{aligned} \tag{4.21}$$

where $W_{(s)i}$ is the weight of a greasyback prawn in age class i (of sex s) in grams, W_0 is the initial weight in milligrams, $g_{(s)}$ is the growth coefficient (of sex s), w_i (m_i) is the number of weeks (months) since a prawn in age class i recruited to the beam trawl fishery and $W_{s\infty}$ is the asymptotic weight (in grams) of a prawn of sex s. The values used for the respective parameters are given in Table 4.6, and were obtained from Aziz (1979) and Courtney *et al* (1991).

The carapace length of a prawn is a function of its weight and is given by:

$$CL_i = \left(W_i / a\right)^{1/b} \tag{4.22}$$

where a and b are length-weight parameters and are taken from Aziz (1979) (Table 5.6).

Recruitment and migration parameters

As for the banana prawn model there are three aspects in relation to recruitment and migration that need to be addressed, the size at which prawns recruit to (migrate from) the beam trawl fishery, the time of year at which recruitment (migration) takes place and the number of individuals recruited (rate at which migration takes place).

It was assumed that recruitment to the beam trawl fishery takes place when prawns reach a size of 0.16 grams as outlined above. The size at which greasyback prawns were assumed to start migration from estuarine areas (and the beam trawl fishery) into the bay (and the otter trawl fishery) was 2.5 grams (CL of 15.0mm). This coincides with the size at which it was assumed that the juvenile development phase of the prawn ends and is also within the size range used for recruitment to the bay fishery in the modeling undertaken by Courtney *et al* (1991).

The time of year at which recruitment to and migration from the beam trawl fishery takes place is now considered. Coles and Greenwood (1983) provide a description of the life cycle of the greasyback prawn in the Noosa River area in which juveniles recruit to nursery areas throughout the period March to December with a distinct egress of subadults occurring in December and January. In the Courtney *et al* (1991) study it was found that recruitment to the Moreton Bay otter trawl fishery took place throughout most of the year, with a cessation of recruitment occurring over summer (December to February). In the modeling conducted in this paper it was assumed that recruitment takes place twice a year, September-October and February-March, with 70 per cent of the recruits recruiting to the fishery during the former period. In the present study it was assumed that recruitment to the beam trawl fishery occurs twice a year, August to October and January to March, with 80 per cent of recruits entering the fishery over the August to October period. Migration from the beam trawl fishery (recruitment to the otter trawl fishery) was assumed to take place throughout the year except over the period December to February. The instantaneous monthly rate of migration was assumed to be 0.5.

Natural mortality

The instantaneous weekly natural morality rates used were the same as those for banana prawn model, that is 0.22 and 0.05 for juveniles and adult prawn respectively, with an adult prawn assumed to be a prawn of a weight greater than 2.5 grams.

4.6 Biological data for greasyback prawn model

Parameter/Variable	Symbol	Unit			
			Male	Female	Combined
Natural mortality (per month)	NM	*% per month*			
:For *CL* <= 20mm					0.66
:For *CL* > 20mm					0.20
Initial weight	W_0	*milligrams*			160.8
Prawn monthly growth rate	g				
For *W* < 2.5 grams		*per week*			0.24
For *W* >= 2.5 grams		*per month*	0.29	0.20	
	t_0	*months*	-0.66	-0.73	
Asymptotic weight	W_∞	*grams*	5.85	10.20	
Length - weight parameter	a				1.91
Length - weight parameter	b				2.65
Minimum weight at which migration from fishery commences	WM	*grams*			2.5
Catchability parameter	q				0.001763

Economic characteristics

The values used for the economic parameters are shown in Table 4.7 and reflect the cost structure of the fishery in Area 1, as outlined in Appendix A to Chapter 4. The non-target prawn species catch rates for this model are given in Table 4.2 and 4.3.

4.7 Beam trawl cost and price data used in greasyback prawn model

Parameter/Variable	Symbol	Unit	
Price			
Greasyback prawns	*P*	*$*	4.5
Other	*P*	*$*	7
Variable costs	*VC*		
Fuel costs incurred per day fishing	*F*	*$ per day*	20
Average daily cost incurred for maintenance and repairs	*BG*	*$ per day*	25
Proportion of the total revenue that is paid to the labour employed (including owner skippers)	*c*	*%*	36
Marketing and distribution costs as a proportion of revenue	*m*	*%*	2
Annual costs	*FC*		
Annual costs per vessel	*VFC*	*$*	9 000
Annual vessel total fishing effort	*VE*	*days*	120
Opportunity cost of capital	*OK*		
Capital per vessel	*K*	*$*	55 000
Opportunity rate of return	*z*	*%*	8.9
Depreciation	*d*	*%*	4.6

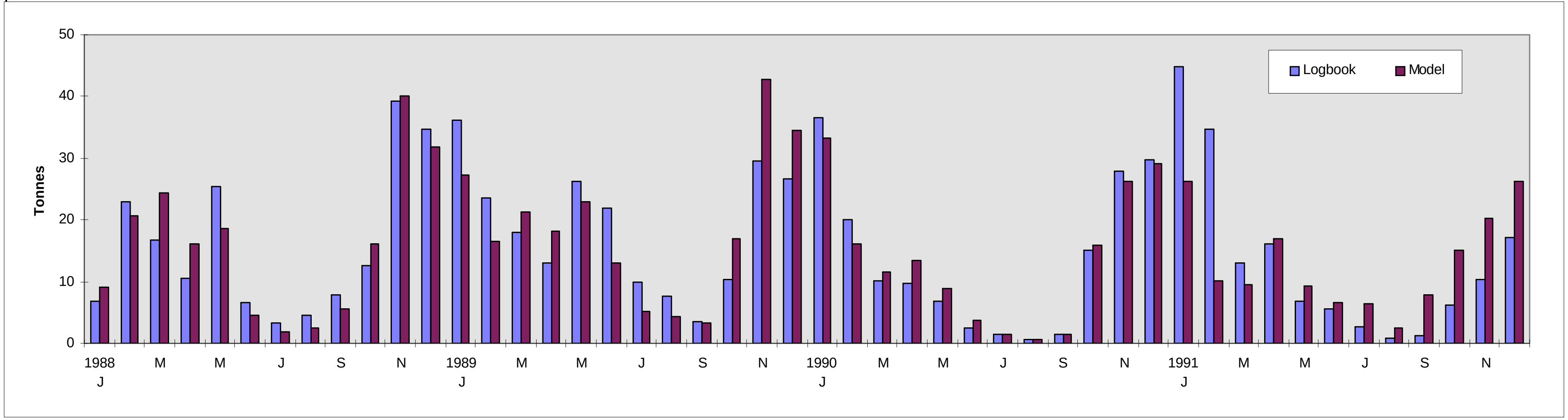
Greasyback prawn model validation

As for the banana prawn model the accuracy of the model was checked by analysing its ability to replicate historical data. However, as it was assumed that the catchability coefficient was constant across species it was only necessary to derive recruitment estimates for each of the simulated periods (Table 5.8). In Figure 5B a comparison of model and logbook catch estimates from 1988 to 1991 is shown.

4.8 Total annual recruitment values used in validation of greasyback prawn model

	Model inputs		Model output	Logbook estimates
	Recruitment (*millions*)	Effort (*days*)	Total catch (*kg*)	Total catch (*kg*)
Greasyback prawn region: Area 1, NSW border to latitude 27S				
1988	418	3 094	191 278	191 239
1989	511	3 158	226 232	226 372
1990	340	2 285	161 862	162 109
1991	459	2 474	159 473	159 554

4B Comparison of model and logbook catch estimates for the greasyback prawn region of Area 1 (latitude 27S to the NSW border) 1988 to 1991



Beam trawl externalities

In addition to the direct costs associated with beam trawling, as previously outlined, beam trawling may impose externalities on the recreational fishery and the otter trawl fishery. In this section the incorporation of these costs into the model is outlined.

Externality imposed by beam trawl operators on the recreational fishery

The issue of what cost is imposed by beam trawl effort on the recreational fishery is addressed in detail in Chapter 3 with estimates being derived under a range of scenarios (Table 3.10). This cost (that is, the externality imposed per unit of effort by beam trawlers on the recreational fishery (*XR*)) was incorporated into the model by including it as a variable cost, thus equation 4.17 becomes:

$$VC_{rk} = \left(F_r + BG_r\right)E_{rk} + (c_r + d_r)R_{rk} + XR_r E_{rk} \tag{4.23}$$

In Table 4.9 the values used in the analysis presented later in this chapter for the recreational externality are provided. These values are based on the values derived in Chapter 3 and the assumption that on an average beam trawl fishing day the time spent with trawl gear in the water is 3.5 hours. The values used from are those of the second scenario in which the catches of species other than the main recreational target species of bream, flathead and whiting are included (Table 3.9). If it is assumed that beam trawling only impacts upon recreational catches of the three main target species then the value of the externality would reflect those estimated under the first set of scenarios detailed in Table 3.9. Also an increase in the use of bycatch reduction devices as reported by Robins and Courtney (forthcoming) will mean that the externality imposed by beam trawl operations is also reduced.

4.9 Externality imposed per day by beam trawlers on the recreational fishery and values for the *XR* parameter

	Scenario	*XR* (*$/day*)
Area 1	3b, 4b (50%)	10.55
Area 2	5b (50 %)	9.52
Area 3	6b (50 %)	10.71
Area 5	6b (50 %)	10.71

Externality imposed by beam trawl operators on the otter trawl fishery

The approach taken to estimate the cost of the externality imposed by beam trawl operators on the otter trawl fishery was to compare returns from the exploitation of the beam trawl target prawn stock by otter trawlers with beam trawl effort at a given level and the returns to the otter trawl fishery when beam trawl effort is set at zero. Thus, for a given level of beam trawl effort (*E*) the externality is given by:

$$O = \pi_{E=0} - \pi_{E=E} \tag{4.24}$$

where $\pi_{E=0}$ is the return made from the otter fishery from expending effort to exploit the target prawn stock that migrated from the beam trawl fishery when no effort is applied to the beam trawl fishery, and $\pi_{E=E}$ is the return made from the otter trawl fishery from the exploitation of the same prawn stock when a given level of beam trawl effort (*E*) is applied to that stock.

The returns made by the otter trawl fishery from expending effort to exploit the target prawn stock (π) in region *r* is given by:

$$\pi_r = OR_r - OC_r \tag{4.25}$$

where OR_r is the revenue earned by the otter trawl fishery from the exploitation of the target prawn stock that migrated from the beam trawl fishery in region *r*, and OC_r is the cost of exploiting the prawn stock that migrated from region *r* incurred by the otter trawl fleet. OR_r is given by:

$$OR_r = P_i OTH_{ri} + P_{BC} BC \tag{4.26}$$

where P_i is the price received for target prawns of age class *i* and is the same as that outlined earlier for the beam trawl fishery. OTH_{ri} is the otter trawl catch of the prawns in age class *i* that migrated from region *r* of the beam trawl fishery, and is given by:

$$OTH_{ri} = \sum_k OFM\left(OAVS_{rik} W_i\right) / 1000 \tag{4.27}$$

where $OAVS_{rik}$ is the average size of the prawn stock (age class *i*) in the otter trawl fishery during month *k* that originally migrated from the beam trawl fishery in region *r*. The numerical size of the stock of individuals of age class *i* present in the otter trawl fishery at the beginning of month *k* in region *r* (OS_{rik}) is given by the sum of the number of prawns that survived in the otter trawl fishery from the previous month and the number of prawns that migrated from the beam trawl fishery at the beginning of the month.

$$\begin{aligned} OS_{rik} &= OS_{r,i-1,k-1} \exp-\left(NM_{i,k-1} + OFM_{i,k-1}\right) \\ &\quad + \left(S_{r,i-1,k-1} \exp-\left(FM_{i-1,k-1} + NM_{i-1,k-1}\right) - S_{r,i,k}\right) \end{aligned} \tag{4.28}$$

and $OAVS_{rik}$ is given by:

$$OAVS_{rik} = \left\{OS_{rik}\left[1 - \exp\left(-\left(NM_{rik} + OFM_{rik}\right)\right)\right]\right\} \Big/ \left(NM_{rik} + OFM_{rik}\right) \tag{4.29}$$

OFM is the instantaneous monthly offshore fishing mortality rate.

Dredge (1983) used an exploitation rate of 85 per cent for the banana prawn stock exploited by the otter fleet in the Bundaberg region, where the exploitation rate is the percentage of the total stock caught by the fishing fleet and is given by ($FM/(FM+NM)$). This was based on evidence that suggested that the fishery was being exploited at a higher level than that in the Gulf of Carpentaria which was estimated to be at approximately 80 per cent by Lucas, Kirkwood and Somers (1979). Dredge also noted that although there were significant temporal and spatial difference in the mean size of prawns caught in the fishery there was no trend for the mean size of prawns to increase over time, a possible explanation being that recruitment from the estuaries occurs over a prolonged period of three months or more, with prawns being taken as they left the estuaries.

In the banana prawn regional model the offshore fishing season was assumed to extend over a four month period from February to May, with the total exploitation rate assumed to be 85 per cent over the season following Dredge (1983). The corresponding monthly exploitation rate is 62 per cent per month. Given the natural mortality rate as outlined earlier the instantaneous monthly offshore fishing mortality rate corresponding to this exploitation rate is 0.57.

In an analysis carried out by Courtney et al (1991) a maximum monthly instantaneous fishing mortality rate of 0.56 was considered to represent the state of the fishery at the time of the study. Relative monthly fishing effort (RE_k), derived from logbook data for the years 1992 to 1996 are provided in Table 4.10. For the greasyback prawn model in the present study the offshore greasyback catch is given by:

$$OTH_{ri} = \sum_k OFM_k \left(OAVS_{rik} W_i\right)/1000 \qquad (4.30)$$

where

$$OFM_k = \frac{OFM_{MAX} RE_k}{RE_{MAX}} \qquad (4.31)$$

OC_r represents the costs incurred by the otter trawl fishery in exploiting the prawn stock that migrated from the beam trawl fishery in region r. As for the beam trawl fishery theses costs are divided into three categories, variable, annual and capital costs.

The variable costs incurred in exploiting the banana prawn stock from region r in month k (OVC_{rk}) is given by:

$$OVC_{rk} = \Delta OE_{rk}\left(OF_r + OBG_r\right) + \Delta OR_r\,(oc_r + om_r) \qquad (4.32)$$

where ΔOE_r and ΔOR_r are, respectively, the additional otter trawl effort and revenue resulting from the increase in recruitment due to the removal of beam trawl effort in region r. OF_r, OBG_r, oc_r and om_r are the otter trawl equivalent of F_r, BG_r, c_r and m_r outlined earlier for the beam trawl component of the model.

It is, of course, debatable as to the extent to which the presence of additional stock will result in an increase in effort as opposed to an increase in average catch rates. This depends upon how much of the additional stock would be caught by the fleet in any event and how much additional effort is required. In this analysis it is simply assumed that average catch per unit effort remain constant, thus the additional effort required in region *r* (ΔOE_r) *is* given by:

$$\Delta OE_r = OTC_r / OCPUE_r \tag{4.33}$$

where *OCPUE* is the historical banana (target species) prawn catch per unit effort rate for the otter trawl fishery in region *r* (Table 4.10).

It is also debatable as to whether any increase in effort in the otter trawl fishery resulting from the removal of beam trawl effort will be undertaken by the current offshore fleet working more days in total, the current offshore fleet substituting other fishing days for prawn trawling days or additional vessel entering the fleet. In the model it was simply assumed that the average total number of days a vessel works per year is constant. Thus, OAC_r and OOK_r, the annual and capital costs associated with the exploitation of the banana prawn stock from region *r* by the otter trawl fleet, are given by:

$$OAC_r = OVAC_r \left(OE_r / OVE_r \right) \tag{4.34}$$

where $OVAC_r$ is the annual costs incurred per otter trawl vessel, OVE_r is the average annual total vessel fishing effort (that is, otter trawling plus all other fishing activities) of the active otter trawl fleet in region *r*, and

$$OOK_r = \left(oz + od \right) K_r \left(OE_r / OVE_r \right) \tag{4.35}$$

where K_r is the capital investment per vessel in region *r*, *oz* is the expected rate of return from an alternative investment of similar risk to the otter trawl fishery and *od* is the depreciation rate. The values used for the latter two parameters is assumed to be the same as that outlined earlier for the beam trawl fishery, that is 8.9 and 4.8 per cent respectively.

P_{BC} and *BC* in equation 4.25 represent the price and volume of other prawn species landed when exploiting the beam trawl target species. The latter is given by:

$$BC_r = BCPUE_r \times \Delta OE_r \tag{4.36}$$

where $BCPUE_r$ is the other prawn catch landed per unit of effort (Table 4.10). The catch rates shown are for the peak ‘season’ for the respective species (usually February to May/June for banana prawns and November to April for greasyback prawns). Banana prawn catches on grounds off Area 2 of the beam trawl fishery are negligible and in some years no catches are recorded. Given this no otter trawl externality is calculated for Area 2 of the beam trawl fishery.

4.10 Prawn catch rates in otter trawl fishery adjacent to specified area in the beam trawl fishery

		1992	1993	1994	1995	1996
Area 1						
:Greasyback	*kg/day*	42.94	27.84	30.51	41.26	50.01
:Other	*kg/day*	29.90	26.08	26.65	27.38	31.93
Area 3						
:Banana	*kg/day*	111.25	71.85	56.20	67.44	81.20
:Other	*kg/day*	22.44	23.05	13.06	31.41	28.33
Area 5						
:Banana	*kg/day*	52.38	65.01	54.45	52.93	86.46
:Other	*kg/day*	28.92	28.76	28.48	45.75	20.59

As can be seen in Table 4.10 the otter trawl fleets' catch is only partially based on the species that are targeted by beam trawl operators. As such, it is necessary to make assumptions regarding the revenues and costs related to the catches of other prawn species. In Table 4.11, the relative values of the nominated beam trawl target species and other prawns in the catch is provided. The approach taken in this study was to simply apportion revenue and costs on the basis of the relative value of the catch. Thus, equation 4.24 is redefined to be:

$$O = \beta\left(\pi_{E=0} - \pi_{E=E}\right) \qquad (4.37)$$

where β is the value of the beam trawl target species catch relative to the total value of the catch in any region *r*.

4.11 Relative value of prawn catches in otter trawl fishery adjacent to specified area in the beam trawl fishery

		1992	1993	1994	1995	1996
Area 1						
:Greasyback	%	35	29	30	36	37
:Other	%	65	71	70	64	63
Area 3						
:Banana	%	83	76	81	68	74
:Other	%	17	24	19	32	26
Area 5						
:Banana	%	64	69	66	54	81
:Other	%	34	31	34	46	19

4.12 Cost and price data used in model for otter trawling operations

Parameter/Variable	Symbol	Unit	Banana model	Greasyback model
Price	*P*			
Banana prawns:				
Under 30 grade		*$*	9.00	
Over 30 grade		*$*	5.00	
Greasyback prawns		*$*		4.5
Other prawns		*$*	9	12
Variable costs	*OVC*			
Fuel costs incurred per day fishing	*OF*	*$ per day*	140	120
Average daily cost incurred for maintenance and repairs	*OBG*	*$ per day*	70	60
Proportion of the total revenue that is paid to the labour employed (including owner skippers)	*oc*	*%*	26	26
Marketing and distribution costs as a proportion of revenue	*om*	*%*	4	4
Fixed costs	*FC*			
Annual fixed cost per vessel	*OVFC*	*$*	48 000	34 000
Annual vessel total fishing effort	*OVE*	*days*	210	190
Opportunity cost of capital	*OK*			
Capital per vessel	*K*	*$*	205 000	150 000
Opportunity rate of return	*oz*	*%*	8.9	8.9
Depreciation	*do*	*%*	4.6	4.6

4.13 Relative monthly fishing effort in otter trawl fishery adjacent to Area 1 greasyback prawn fishery

	1992	1993	1994	1995	1996
January	0.13	0.13	0.13	0.13	0.13
February	0.12	0.12	0.12	0.11	0.11
March	0.11	0.12	0.11	0.12	0.10
April	0.09	0.07	0.08	0.09	0.09
May	0.06	0.05	0.06	0.07	0.07
June	0.05	0.05	0.03	0.03	0.04
July	0.03	0.03	0.02	0.02	0.03
August	0.04	0.04	0.03	0.03	0.03
September	0.06	0.07	0.06	0.06	0.05
October	0.09	0.09	0.10	0.10	0.09
November	0.10	0.12	0.13	0.12	0.12
December	0.12	0.12	0.12	0.12	0.13

Model application, results and analysis

The model was use to examine the profitability of the Queensland beam trawl fishery by region. The profitability of the fishery was estimated under four scenarios using three measures over a five year period.

The first scenario modeled is of the beam trawl fishery only. Under this scenario no externalities are assumed to arise from beam trawl activity. Second, the externality from beam trawl activity on the recreational fishery is incorporated into the beam trawl fishery cost structure. Third, the externality on the otter trawl fishery is incorporated into the beam trawl fishery cost structure. Finally, the externalities incurred by both sectors are incorporated.

As previously outlined total gross margin, annual cash profit and economic profit were used as measures of the profitability of the fishery. When running the simulations for each of the measures the same assumptions about the cost structure and the alternative use of capital were made in relation to both the beam and otter trawl fishery. For example, when estimating the economic profit generated by the beam trawl fishery including the otter trawl externality, it is assumed that the capital invested in both fisheries is fully mobile and can be transferred cost free to an alternative use.

The cost structure of the fishery presented above reflects the state of the fishery over the 1994-95 financial year. It would be possible to estimate the profitability of the fishery over the 1994-95 calendar years through simulating logbook catch records. However, as recruitment and hence the profitability of the fishery varies from season to season the profitability of the fishery was estimated over a five year time frame to allow for this variation. As such, it was assumed that the cost structure of the fishing fleet remains constant over the period simulated, that is any decrease or increase in effort does not change the average cost structure of the fleet. The period simulated was 1992 to 1996. Table 4.14 gives the effort and recruitment inputs used in the respective models to simulate the fishery during the respective year; also shown are the model and logbook catch estimates. As monthly data were not acquired for the 1992-96 period, monthly effort was assigned using the average distribution of effort over the 1988 to 1991 period and the total effort expended during the particular year.

4.14 Total annual recruitment values used in simulation models

	Model inputs		Model output	Logbook estimates
	Recruitment (*millions*)	Effort (*days*)	Total catch (*kg*)	Total catch (*kg*)
Greasyback prawn region: Area 1, NSW border to latitude 27S				
1992	1 145	3 488	377 086	377 153
1993	419	2 448	185 161	185 157
1994	552	4 310	216 493	216 523
1995	777	3 845	313 039	313 159
1996	605	3 931	250 982	251 002
Banana prawn region: Area 2				
1992	24.6	303	18 381	18 491
1993	3.6	142	2 197	2 174
1994	10.2	254	6 584	6 645
1995	11.7	386	12 929	12 890
1996	11.7	346	11 537	11 552
Banana prawn region: Area 3				
1992	10.7	250	12 353	12 368
1993	14.5	447	22 259	22 211
1994	21.9	438	23 716	23 773
1995	15.6	455	27 225	27 280
1996	16.7	359	18 422	18 416
Banana prawn region: Area 5				
1992	23.1	166	8 429	8 558
1993	14.4	609	23 813	24 670
1994	27.6	638	30 566	30 551
1995	31.0	502	28 198	28 123
1996	34.1	446	28 876	28 822

Base model simulation

In the base model simulation the model was run with all inputs set as previously outlined for the period 1992-96. The results of the beam trawl only simulations indicate that the fishery is returning a positive net return under all of the objective functions. This indicates that the returns are sufficient to cover all the economic costs involved in the fishery, including the opportunity cost of the invested capital.

When the externalities imposed by beam trawlers on the recreational fishery are included the returns from the fishery are still high enough such that a positive economic profit is made in each of the areas of the fishery, except Area 2, however many of the estimated values, including that of Area 2, are close to zero and given the uncertainty in relation to some of the model parameters it is unwise to draw too strong a conclusion. Similar when the otter trawl externality is included in the model economic profit is greater than zero, although only just in the case of Area 5.

Overall it appears from the modeling that the returns from the fishery are sufficient to justify the investment of resource into the fishery and while some externalities may exist in relation to the otter and recreational fisheries they are not sufficient to warrant the withdrawal of the resources invested in the fishery. Given this there appears to be little to gain from the closure of the beam trawl fishery, particularly when adjustment costs may need to be incurred as resources from the fishery are reallocated to other sectors within the economy.

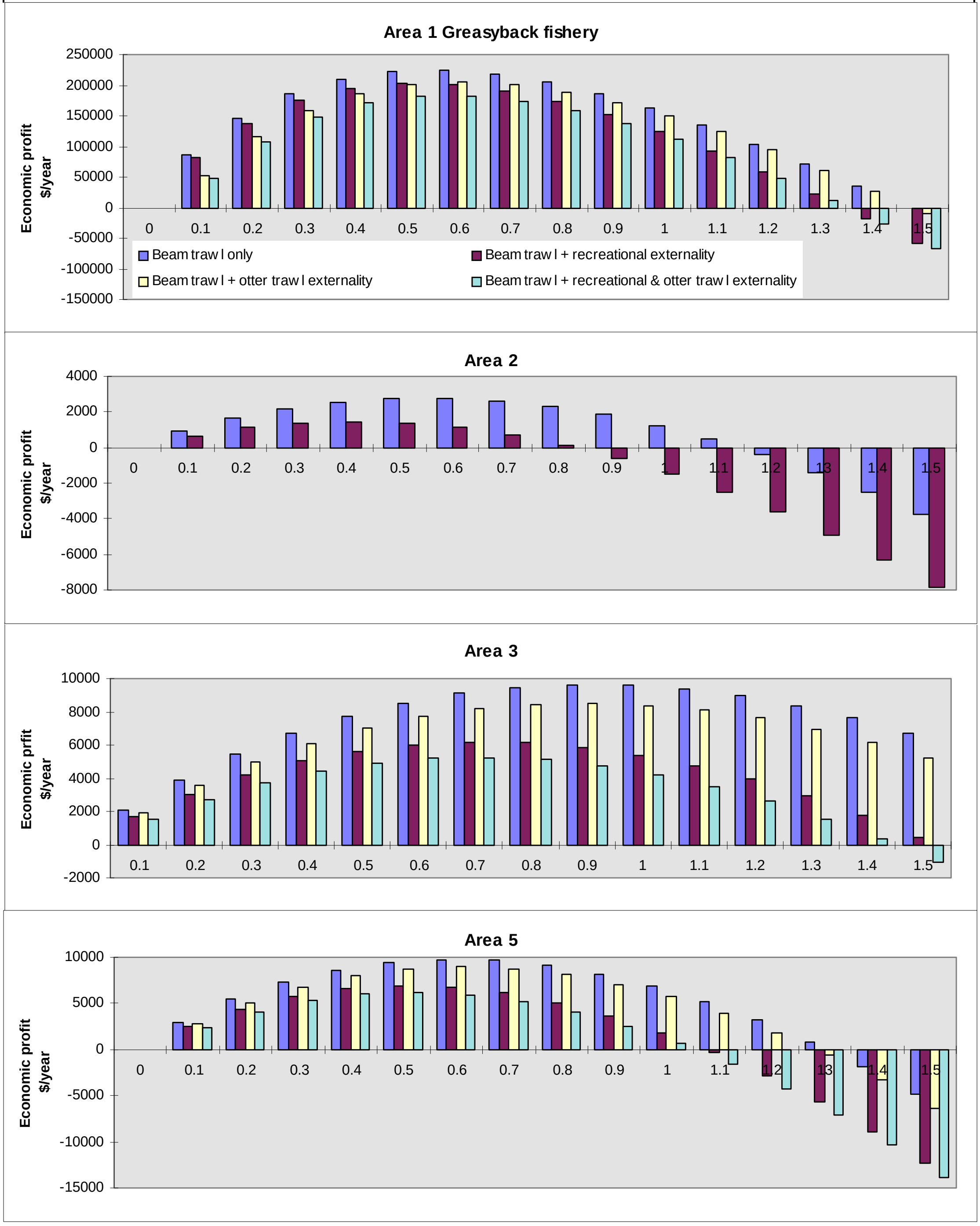
4.15 Estimated annual total and average active vessel gross margin, annual cash profit and annual economic profit by area from model simulations

	Area 1	Area 2	Area 3	Area 5
Average number of active vessels in fishery per year (1992-96)	61	8	8	16
	$	$	$	$
Area Total				
Beam trawl only				
Total gross margin	658 688	38 273	58 246	80 052
Annual cash profit	388 353	18 007	30 951	39 255
Economic profit	162 023	1 248	9 583	6 896
Beam trawl plus recreational externality				
Total gross margin	620 661	35 549	54 070	74 993
Annual cash profit	350 326	15 283	26 775	34 196
Economic profit	123 995	-1 475	5 407	1 837
Beam trawl plus otter trawl externality				
Total gross margin	100 311	-	21 600	31 806
Annual cash profit	375 999	-	16 905	20 691
Economic profit	149 669	-	8 761	5 700
Beam trawl plus otter trawl and recreational externality				
Total gross margin	62 284	-	17 424	26 746
Annual cash profit	337 972	-	12 729	15 632
Economic profit	111 642	-	4 584	641
Per active vessel				
Beam trawl only				
Total gross margin	10 798	4 784	7 281	5 003
Annual cash profit	6 366	2 251	3 869	2 453
Economic profit	2 656	156	1 198	431
Beam trawl plus recreational externality				
Total gross margin	10 175	4 444	6 759	4 687
Annual cash profit	5 743	1 910	3 347	2 137
Economic profit	2 033	-184	676	115
Beam trawl plus otter trawl externality				
Total gross margin	1 644	-	2 700	1 988
Annual cash profit	6 164	-	2 113	1 293
Economic profit	2 454	-	1 095	356
Beam trawl plus otter trawl and recreational externality				
Total gross margin	1 021	-	2 178	1 672
Annual cash profit	5 541	-	1 591	977
Economic profit	1 830	-	573	40

Varying levels of effort

In Graph 4C the estimated economic profit generated by areas within the beam trawl fishery under a range of effort levels is shown. This was obtained by multiplying the effort level expended in each year by a range of values from 0.1 to 1.5, with the distribution of effort over the year assumed to remain constant. From the graph it can be seen that, for example, in Area 5 that the economic profit from the fishery is maximised when the effort multiplier was set at 0.5 (that is, effort was set at 50 per cent of logbook estimates over the period 1992 and 1996) when both the recreational and otter trawl externalities are included in the cost structure of the beam trawl fishery. This indicates that the current effort levels may be greater than that which is economically optimal. However, it should be noted that the increase in total economic surplus resulting from restricting effort to around 50 per cent of its current levels in area 5 is estimated to be only some $5 000. Given the difficulties associated with reducing effort in the beam trawl fishery, due to the high level of latent effort in the fishery and the multiple endorsement of each vessel, it is debatable as to whether a management plan could be introduced and enforced that would allow for effort levels to be restricted and yet cost less than the benefits gained.

4C Average annual economic profit with varying beam trawl effort by area



Sensitivity analysis

The results of the analysis provided above depend on the functional relationships and data used in the model. While the best available data were used, there is a degree of uncertainty in relation to some of the key parameters. This uncertainty affects variables such as the natural mortality rate, catchability, the number of recruits, the price received for each species and the cost structure of the fisheries.

To examine the effects of changes in these parameters a sensitivity analysis was undertaken. A comparison between the values generated by the base model and that with the specified parameter increased and decreased by 10 per cent is shown in Table 4.16. As can be seen from this table the effect of a 10 per cent change in a range of parameters has a major influence on the economic profit generated by the fishery under current effort levels. For example, under a 10 per cent across the board increase in beam trawl cost the level of economic profit generated by the fishery in all areas is substantially reduced and becomes negative in three of the four areas modeled.

4.16 Economic profit by area with a 10 per cent change in specified parameter

	Greasyback prawn region	Area 2	Area 3	Area 5
Base simulation				
Economic profit with recreational and otter trawl externality included in beam trawl cost structure	111 642	-1 475	4 584	641
Sensitivity analysis				
Economic profit with recreational and otter trawl externality included in beam trawl cost structure and 10 per cent change in specified parameter.				
Recreational externality				
:10 % Increase	107 839	-1 203	4 167	135
:10 % Decrease	115 444	-1 748	5 002	1146
Prices received for target species				
:10 % Increase	149 815	2 953	5 997	5 491
:10 % Decrease	73 468	-5 904	3 172	-4 210
Beam trawl costs				
:10 % Increase	61329	-4 347	-5 174	-12 155
:10 % Decrease	161 954	1 396	14 343	13 436
Otter trawl costs				
:10 % Increase	182 882	-	11 311	9 572
:10 % Decrease	48 007	-	-2 142	-8291
Recruitment				
:10 % Increase	239 557	2 953	10 232	10 349
:10 % Decrease	-4 070	-5 904	-1 063	-9 068
Natural mortality				
:10 % Increase	16 825	-8 377	-4 023	-13 659
:10 % Decrease	226 011	6 832	14 973	17 753
Catchability (beam trawl fishery)				
:10 % Increase	131 304	2 085	9 080	8 020
:10 % Decrease	87 969	-5 177	-94	-7 098

Appendix A to Chapter 4

The economic survey

As part of the present study an economic survey of beam and otter trawl operators was carried out. The purpose of this Appendix is to provide details of this survey and other information in relation to costs and returns from the fisheries.

Other studies

WBM Oceanics (1994) conducted a mail survey of the Queensland beam trawl fishery collecting a range of information including some cost data primarily relating to the 1992-93 financial year. The Australian Bureau of Agricultural and Resource Economics conducts regular surveys of Australian fisheries and has surveyed the northern prawn and Torres Strait prawn fisheries in recent years (ABARE (1996b)) as well as other non prawn fisheries including the south east trawl, southern shark, east coast tuna and southern bluefin tuna fishery. Also, the Bureau of Agricultural Economics (BAE, ABARE's predecessor) conducted a survey of the south east prawn fishery for the 1982-83 financial year which included the Queensland otter trawl south of Sandy Cape (BAE (1985)). An economic survey of the south-east Queensland otter trawl fishery was also conducted by Moxon and Quinn (1984) covering the late 1970's and early 1980's.

The beam trawl survey

The purpose of the survey conducted for the present study was to obtain information on the costs and returns, and capital investment, for operators in the beam trawl fishery. The survey was distributed and conducted in person wherever possible although some were conducted over the phone and via mail and fax. The survey form was adapted from that used by ABARE to survey prawn fisheries and a copy of the form is presented in Appendix B to Chapter 4.

The licencing data used for the survey was that obtained from QFMA relating to the fishery during 1995. As there is a high level of turnover of operators (except for the small number of endorsement holders in area 3 where endorsements are non-transferable) information was sought primarily for the 1994-95 financial year, with some information also being collected for the 1993-94 financial year.

The survey sample

In the surveys conducted by ABARE cluster analysis using vessel operational criteria, such as type of operation, boat size and catch, are used to stratify the population of operators. A random sample of each subgroup is then undertaken.

For the beam trawl survey the fleet was simply stratified by the area the operator was endorsed to beam trawl in. Unfortunately, it was not possible to associate catch data with any given individual operator and as such the fleet could not be stratified across catch levels. However, it was possible to eliminate those endorsement holders that did not participate in the fishery over the survey period, by asking this question of operators when initial contact was made. Thus, the sample is for that of the population of beam trawl endorsement holders that was active within the fishery during the surveyed period. In Table A.1 details of the 1995 fleet and vessels in the 1994-95 survey in each area are provided. Also given is the number of beam trawl endorsed vessels that caught prawns from 1993 to 1995 in each area. This is a good proxy for the number of active beam trawl vessels during each year shown.

A.1 Physical characteristics of 1995 fleet and vessels in 1994-95 survey

	Number of vessels						Vessel characteristics					
	Fleet	Caught prawns			Surveyed		Length (*m*)		Beam length (m)		Power (kw)	
	1995	1993	1994	1995	1993-94	1994-95	Fleet[a]	Survey[b]	Fleet	Survey	Fleet	Survey
Area 1	74	57	69	66	7	15	7.28	7.42	2.68	2.59	63.89	66.14
Area 2	23	6	9	9	3	4	6.6	5.85	2.64	2.22	62.54	60.33
Area 3	12	8	8	8	3	3	7.09	7.25	2.66	2.75	64.12	68.15
Area 4	42	22	15	18	-	-	6.57	-	2.39	-	62.57	-
Area 5	64	16	16	14	3	6	6.24	6.16	2.24	2.06	64.74	60.33

a Based on 1995 fleet. **b** Based on vessel in 1994-95 survey.

Survey results

The data collected from respondents was for their entire fishing operation, of which beam trawling may be only one of several components. Estimates of prawn and other fishing receipts were usually provided separately, however separate cost data relating to the different fishing activities undertaken was not. Further, no distinction was made between prawn catches landed from beam trawling operations and those from otter trawling for operators with both endorsements. Crew payments include wages, salaries and share of receipts paid to owner operators and their families. If this labour was unpaid an estimate of the cost of the labour was obtained. It is this figure that is shown under crew payments in Table A.1.

The figures given in Table A.2 relate to the total fishing operation. The rate of return figure at the bottom of the table is a good indication of the profitability of the fishery. If as assumed in the model a rate of 8.9 per cent per annum is taken as the alternative rate of return on an investment of similar risk it can be seen that in most areas over both years an investment in the fishery on average would have outperformed the alternative investment. This indicates that the fishery's financial performance over the survey period was good.

A.2 Financial performance of active[a] Queensland beam trawl fishery boats

	Area 1		Area 2		Area 3		Area 5	
	93-94	94-95	93-94	94-95	93-94	94-95	93-94	94-95
Receipts								
Prawn receipts	24 064	39 802	5 307	8 080	48 170	38 530	25 177	20 319
Other fishing receipts	25 986	15 168	34 492	44 214	51 107	46 170	18 032	30 408
Total cash receipts	50 050	54 971	39 799	52 294	99 276	84 700	43 208	50 727
Costs								
Fuel and oil	3 477	3 958	4 772	3 947	9 568	11 713	2 760	4 420
Boat repairs and maintenance	3 963	4 190	3 133	4 896	15 517	7 133	4 237	4 282
Crew Costs	18 245	18 163	12 608	18 430	32 090	31 000	13 562	16 775
Marketing	917	1 342	470	826	2 847	2 100	573	1 190
Administration	2 882	2 704	2 157	1 167	2 158	3 323	1 447	4 257
Insurance	1 188	1 300	1 513	1 497	2 847	2 355	1 633	1 065
Interest paid	808	2 348	3 850	3 750	9 633	9 850	1 842	883
Licence fees and levies	1 100	1 147	1 450	1 413	1 417	1 450	1 057	1 297
Other costs	4 210	3 901	2 017	4 179	2 283	5 298	4 827	5 002
Total cash costs	36 789	39 052	31 970	40 104	78 360	74 223	31 937	39 170
Boat cash income	13 261	15 918	7 829	12 190	20 916	10 478	11 272	11 557
less depreciation	3 890	4 632	6 250	5 658	9 077	9 253	4 750	4 898
Boat profit	9 371	11 286	1 579	6 533	11 840	1 224	6 522	6 658
Plus interest	808	2 348	3 850	3 750	9 633	9 850	1 842	883
Profit at full equity	10 179	13 633	5 429	10 283	21 473	11 074	8 363	7 542
Capital	54 000	64 447	76 500	76 625	94 667	109 167	68 167	60 333
Rate of return	18.85	21.15	7.10	13.42	22.68	10.14	12.27	12.50

a That is operators who held a beam trawl endorsement and caught prawns during the survey period

Beam trawl component

The purpose of the economic survey was to collect information to allow for the incorporation of the cost and return structure of the beam trawl fishery into the models of the fishery. While it was not possible to disaggregate the data so to obtain cost data associated purely with beam trawling, some manipulation of the data was carried out to ensure that the data reflected this component of the total fishing operations. Given that most operators with both otter and beam trawl endorsements operate different vessel in each fishery, and that the otter trawl vessel is a larger vessel, it was felt that the overall cost structure of these operators' total operations would be greater than that for operators only working in the beam trawl fishery. As such, the cost data presented below excludes those operators with an otter trawl endorsement.

As outlined in the model description in Chapter 5 the cost structure of the fishery is divided into three components within the model, these being the variable, fixed and capital cost components. The derivation of the data used for these components is given below. Also provided is the derivation of the estimates of beam trawl revenue.

Revenue

Revenue from beam trawling is almost purely derived from the capture of prawns, as the bycatch is of little commercial value. In Table A.3 the proportion of the prawn receipts estimated to come from the beam trawl fishery for operators who caught prawns is given. In Table A.4 the prices used to derive these values are given. These prices were provided by QDPI (pers. comm., Noel Taylor Moore, Fisheries QDPI) with the exception of the average beam trawl price for banana prawns. Prices received for beam trawl caught banana prawns tend to vary with the size of the prawn. Smaller prawns sold as bait prawns often attract a lower price than larger prawns sold as food prawns. The price break up is usually around $5/kg for the bait prawns and $9/kg for the food prawns (these are the prices used in the model). Some operators however receive a flat price of around $7/kg regardless of size. As it was not possible to distinguish between catch levels this was the price used to obtain the figures given in Table A.3.

In Table A.5 the estimated revenue from beam trawling is provided from both logbook data and survey estimates. The survey estimates are based on the same proportion of the total prawn receipts derived from the beam trawl fishery as is estimated from the logbook data for the two corresponding years of the survey period. For example, for the 1994-95 survey estimates beam trawl revenue is assumed to be equal to the total prawn receipts times the average proportion of revenue derived from the beam trawl fishery during 1994 and 1995 according to the logbook estimates.

A.3 Estimated proportion of total prawn revenue from beam trawl catches from logbook data

	Area 1	Area 2	Area 3	Area 5
1993	84	100	53	24
1994	99	95	55	51
1995	89	100	72	50

A.4 Prices received by beam and otter trawl operators

	Greasyback	School	Banana	Tiger	Endeavour	King	Other
Beam trawl	4.5	5	7	12	12	10	5
Otter trawl	4.5	5	9	12	12	10	5

A.5 Estimated revenue from beam trawl operations

	Area 1	Area 2	Area 3	Area 5
Logbook				
1993	20 568	2 492	17 129	7 771
1994	24 050	5 095	19 134	13 683
1995	34 179	9 383	20 494	14 062
Survey				
1993-94	22 026	5 183	25 942	12 098
1994-95	37 448	7 891	24 294	9 713

Variable costs

Variable costs are those cost that vary with effort, such as, fuel and oil, and boat and gear maintenance and repairs, and with income (or catch), such as, crew payments and marketing and distribution costs. In Table A.6 the vessel total fishing and beam trawl effort is provided for non-otter trawl endorsed vessels. In Table A.7 expenditure on fuel and maintenance is provided in terms of dollars spent per unit effort, where for example, for 1993-94 the level of effort is taken as the average of the 1993 and 1994 logbook figures given in Table A.5. Also shown is the percentage of the total fishing receipts spent on marketing and distribution costs. The values used in the modeling procedure are given in Table 6.3. For crew payments, as there was often no allowance made for crew payments in the records collected, an estimate of the value of the labour supplied by owner operators was obtained. For the modeling it was assumed that crew payments were equal to 36 per cent of the value of the catch landed. This was based on the data collected and is similar percentage of revenue as crew costs in the danish seine fleet in the south east trawl fishery and for vessels of 5 units or less in the southern shark fishery (ABARE (1996b and 1996c)).

A.6 Vessel total fishing and beam trawl effort (days)

	Area 1	Area 2	Area 3	Area 4	Area 5
Total fishing operation					
1993	105	119	170	127	99
1994	119	124	164	127	83
1995	119	119	138	102	109
Beam trawling					
1993	47	11	48	28	16
1994	65	19	47	35	21
1995	80	26	53	33	25

A.7 Beam trawl variable costs

	Fuel and oil		Boat and gear maintenance		Marketing and distribution	
	Per unit effort (*$/day*)		Per unit effort (*$/day*)		Percent of total revenue	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
Area 1	29	22	33	26	1.8	2.4
Area 2	25	21	31	30	1.2	1.6
Area 3	29	24	27	33	2.6	2.1
Area 5	21	27	36	28	1.3	2.3

Fixed costs

Fixed costs are those costs that are assumed not to vary with boat effort or income. These costs include administration, insurance, licence fees and levies. In Table A.8 the sum of these costs for the survey periods are shown. The values used for the model are given in Table 6.3.

A.8 Beam trawl fixed costs

	1993-94	1994-95
Area 1	8 255	10 142
Area 2	6 350	8 255
Area 3	12 875	12 427
Area 5	8 963	9 730

The otter trawl survey

The purpose of the otter trawl survey conducted for the present study was to obtain information on the costs and returns, and capital investment, for operators in the otter trawl fishery. As for the beam trawl survey the survey form was distributed and conducted in person wherever possible although some were conducted over the phone and via mail and fax. The survey form used was the same as for the beam trawl survey as shown Appendix B. The vessels within the fishery were stratified by the beam trawl area in which their home port was based with vessels with home ports in Areas 1, 2, 3, and 5 of the beam trawl fishery being surveyed.

As outlined in the Chapter 2 vessels operating in Moreton Bay are restricted to a maximum length of 14m as opposed to the 20m restriction applied in other areas of the otter trawl fishery. Given this two sets of data is presented in Table A.9. That for vessels up to 14 m in length and that for all vessels surveyed. A total of 25 vessels was surveyed, of which 16 were less than 14m in length. The data for the vessels of up to 14 metres in length are used to derive the cost structure used in the offshore component of the greasyback model. For the banana prawn model the cost structure is based on all the vessel data. The parameter values used in the model are given in Table 5.10.

A.9 Financial performance of Queensland otter trawl fishery boats

	All Vessels		Length <= 14m	
	93-94	94-95	93-94	94-95
Receipts				
Prawn receipts	86 703	109 172	73 752	99 134
Other fishing receipts	48 635	60 735	41 912	48 360
Total cash receipts	135 338	169 907	115 664	147 493
Costs				
Fuel and oil	24 635	28 563	20 510	21 563
Boat repairs and maintenance	7 560	15 400	8 670	12 400
Crew Costs	34 852	46 265	28 500	38 265
Marketing	4 560	5 622	2 500	5 600
Administration	5 654	6 504	7 564	5 504
Insurance	3 852	5 526	3 852	4 526
Interest paid	9 600	10 560	10 550	9 560
Licence fees and levies	2 350	2 638	2 050	1 638
Other costs	28 650	31 560	20 550	30 750
Total cash costs	121 713	152 638	104 746	129 806
Boat cash income	13 625	17 269	10 918	17 687
less depreciation	6 350	7 650	5 880	6 953
Boat profit	7 275	9 619	5 038	10 734
Plus interest	9 600	10 560	10 550	9 560
Profit at full equity	16 875	20 179	15 588	20 294
Capital	197 500	205 000	147 250	155 650
Rate of return	8.54	9.84	10.59	13.04

Appendix B to Chapter 4

Beam Trawl Operators Economic Survey

	93/94	94/95
Fishing Income	__________	__________
Prawns	__________	__________
Fish	__________	__________
Crab	__________	__________
Other	__________	__________
Operating Costs		
Fuel, oil and gas	__________	__________
Crew payments	__________	__________
Boat repairs and maintenance	__________	__________
Gear replacement and repairs	__________	__________
Other equipment repairs/maintenance	__________	__________
Bait and ice	__________	__________
Packing, freight and carriage	__________	__________
Agent commissions	__________	__________
Administration costs	__________	__________
Interest payments on loans	__________	__________
Other	__________	__________
Asset values (estimates)		
Vessel (1)	__________	__________
Vessel (2)	__________	__________
Other vessels	__________	__________
Beam trawl gear	__________	__________
Other fishing gear	__________	__________
Licence	__________	__________
On shore equipment	__________	__________

Total asset values (estimate)
(if not willing to give estimates by item)

Otter Trawl Operators Economic Survey

	93/94	94/95
Fishing Income	__________	__________
Prawns	__________	__________
Fish	__________	__________
Crab	__________	__________
Other	__________	__________
Operating Costs		
Fuel, oil and gas	__________	__________
Crew payments	__________	__________
Boat repairs and maintenance	__________	__________
Gear replacement and repairs	__________	__________
Other equipment repairs/maintenance	__________	__________
Bait and ice	__________	__________
Packing, freight and carriage	__________	__________
Agent commissions	__________	__________
Administration costs	__________	__________
Interest payments on loans	__________	__________
Other	__________	__________
Asset values (estimates)		
Vessel (1)	__________	__________
Vessel (2)	__________	__________
Other vessels	__________	__________
Beam trawl gear	__________	__________
Other fishing gear	__________	__________
Licence	__________	__________
On shore equipment	__________	__________

Total asset values (estimate)
(if not willing to give estimates by item)

5. Summary of Discussion and Results

The Beam Trawl Fishery and the Study Area

The Queensland beam trawl fishery is a river and inshore fishery operating in five areas along the east coast of Queensland. In the south-east of the state, in the southern part of Area 1 (between 27°S and the NSW border), the fishery is based principally on greasyback prawns for the bait market with a school prawn fishery, also primarily supplying the bait market, existing in the northern section of Area 1. In Areas 2 to 5 the principal species is banana prawns supplied for both the bait market and human consumption. In 1996 there were 221 endorsed vessels of which around 50 percent were active. Half of the active vessels operated in Area 1. In Areas 1 and 3 active beam trawlers derive around half of their income from prawns, whereas in the other Areas the proportion lies between 10 and 20 percent. The gross value of the total catch is around $2.4 million, with the value net of catching costs being substantially less than that figure. In addition to gear restrictions, management measures include seasonal, weekend, area and river closures.

The Relationship between the Beam Trawl Fishery and other Fisheries

Each of the three fisheries considered by the study could impact in some way on the other two. It has been suggested that the beam trawl fishery affects the recreational finfish fishery through its by-catch, through congestion, through habitat disturbance and through the supply of bait. While the recreational fishery could also impact on the beam trawl fishery through congestion, no conclusive evidence was found of congestion being a significant problem and this issue was not pursued further. In the study it has been assumed that recreational fishers can substitute bait prawns from the beam trawl fishery with other bait products and not suffer a loss of welfare. As such, any benefits that recreational fishers do gain from the supply of bait prawns from the fishery is ignored.

While the beam trawl catch may affect offshore prawn catches, it is possible that the latter may affect beam trawl catches through a reduction in the breeding stock. Since it was felt that at current levels of exploitation the stock/recruitment relationship was not important the potential impact of otter trawling on the beam trawl fishery was ignored. It is also possible that some fisheries not included in the study may impact on the three fisheries; for example, the recreational prawn fishery may affect and be affected by the commercial prawn fisheries, particularly the beam trawl fishery. This issue was not specifically addressed by the study.

The Value of the Recreational Fishery

A survey of 671 shore fishers and 505 recreational boat fishers was conducted in the areas of the Logan, Pine, Mary and Burnett rivers and Repulse Bay in the 1996 calendar year. The survey covered the four seasons, weekends, weekdays, public and school holidays as well as early and mid-morning, afternoon and early evening fishers. Fishers were asked a range of questions about themselves - the amount of time they normally fished, income range, employment status, area of residence - about the current fishing trip - the time and costs involved, the gear and bait they used, their assessment of the day's experience in terms of weather, fishing conditions, congestion and overall enjoyment - and their catches of bream, whiting, flathead and other species.

Two general methods were used to estimate the value placed on the recreational fishery by the sample of fishers. The total direct cost method compares the daily costs incurred by different fishers with the number of days they fish. Once individual fisher characteristics, such as income and employment status, and individual trip characteristics such as catches and enjoyment rating, have been corrected for, it is expected that lower daily costs are associated with a higher number of days fished in the month or year in question. This relationship can be used to determine the gross value fishers derive from their monthly or yearly fishing activities at various sites, as well as the net benefit they derive once fishing costs have been subtracted. The analysis suggests that the net benefits derived by the sampled fishers from the recreational fishery are substantial, ranging from averages of $552 per annum and $63 per month for boat fishers to $266 per annum and $73 per month for shore fishers. As with all the figures reported, these are estimates subject to degrees of variability. The analysis also provided estimates of the value of an extra fish to the recreational fisher. These estimates also vary with the type of fishing and the site, but are all in the $0-4 range.

The contingent valuation method involves asking the fisher directly how much more they would have been willing to pay for the day's fishing, or, alternatively, how much they would have been willing to accept to have not taken the opportunity to fish. As is well known, there are many possible biases associated with this approach which have to be corrected for, such as the temptation for fishers to try to influence the results of the study. An attempt was made to correct for these potential sources of bias by asking for a series of yes/no responses to values selected by the interviewer. The results of the contingent valuation study were broadly consistent with the results reported above for the direct cost method: the sampled boat fishers placed a net value on the fishery of around $40 per day and the shore fishers around $15. Extra fish caught were valued at between $0.25 and $2.50.

The Impact of the Beam Trawl Fishery on the Recreational Fishery

As noted above, three potential sources of impact were considered - congestion, habitat disturbance and the finfish by-catch. One of the questions included in the survey of recreational fishers concerned the effect of sighting beam trawlers on the value of the recreational fishing day. There was no evidence that shore fishers were affected by the presence of commercial vessels. As far as boat fishers are concerned the evidence was mixed: the results of the direct cost models tended to suggest that the presence of beam trawlers was regarded as an advantage whereas the results of the contingent valuation model suggested that the presence of beam trawlers might reduce the value of the recreational fishing day by as much as $5.25, around a

10% reduction. On balance it cannot be concluded from the evidence available that congestion is a serious problem.

The literature suggests that there are two main ways that beam trawling could affect fish habitat - by damaging the macrobenthos (bottom dwelling organisms) that some fish depend on for food, or by removing fallen mangrove timber and other debris that fish aggregate around for shelter. If such damage had a severe and continuing effect on finfish stocks it could be expected to be reflected in recreational fish catches. A review of the available evidence, however, suggested that there was no discernible consistent decrease in recreational catch rates over the past three quarters of a century.

Studies have previously been carried out on the finfish by-catch of beam trawlers in the Moreton Bay area, as well that from prawn trawling in other regions. Since previous studies did not cover all the areas identified for investigation in the present study, a by-catch survey was conducted in the Logan, Mary and Burnett rivers and Repulse Bay. The results of the by-catch survey appeared to be consistent with those of earlier studies. The greatest source of possible conflict between the recreational and beam trawl fisheries seems to be the yellowfin bream by-catch. Other significant species found in by-catch in some areas are winter whiting, flathead, and river perch.

For beam trawl by-catch to affect catch rates in the recreational fishery, a chain of events is required to occur. First, the by-catch must be killed rather than returned to the water unharmed. By-catch mortality rates depend on a range of factors, including, for example the water temperatures and the length of the shot, but appear to be in the 10-55% range. Second, the fish killed by the beam trawl would have had to survive to reach a size at which it can be taken by a recreational fisher. Since much of the by-catch consists of juveniles, natural mortality rates are quite high. Third, the fish that survives to become part of the stock targeted by recreational fishers needs to be actually caught. Tagging studies suggest that recapture rates of tagged fish are around 5-10%. After examining the available evidence, ranges of recapture rates from 2-20% were considered to reflect the likelihood that a fish which survives being caught by a beam trawl ends up as part of the recreational fish catch.

The beam trawl by-catch rates per hour trawled can be combined with the beam trawl mortality and recapture rates to determine the numbers of fish of various species lost to the recreational fishery per unit of beam trawl effort. The numbers of bream, whiting, flathead and other species can be valued at prices ranging from $0-4 as determined from the recreational fishing survey. Since the estimates of by-catch rates and values of recreational species are site specific, it is possible to calculate estimates of the cost imposed by beam trawlers on the recreational fishery in each of the study areas. However the results across areas were very similar, ranging from $10.71 per day of beam trawling in Areas 3 and 4 to $9.52 in Area 2.

The Value of the Beam Trawl and Otter Trawl Fisheries

Simulation models of the beam and otter trawl fisheries were developed to assess their profitability under different levels of fishing effort. Two models were developed: the banana prawn regional model is used to simulate the fishery in Areas 2,3, and 5 where banana prawns are the target species; and the greasyback regional model which is used to simulate the southern section of Area 1 where greasyback prawns make up 70% of the catch. Each model incorporates information and assumptions about the size and timing of recruitment, natural mortality, migration offshore, growth in length and weight, and fishing mortality of target and non-target species. Recruitment and fishing mortality parameters were estimated by running the models with historical levels of effort and specified values of the other parameters and comparing the predicted with observed catches. The models performed reasonably well in simulating levels and trends of reported logbook monthly catches over the period 1988-91.

Surveys of beam and otter trawl operators were conducted to obtain information about costs and returns. The beam trawl survey included 28 operators who were active in the 1994-5 financial year in Areas 1, 2, 3 and 5, while the otter trawl survey covered vessels operating in this fishery in the same period. Interviews were conducted in person where possible and by phone, mail and fax otherwise. Information about prawn and other receipts, variable costs such as fuel, crew, repairs and maintenance, annual fixed costs, such as insurance and administration, and fixed costs such as interest and depreciation was obtained. The data were used to estimate real before-tax rates of return (ie. not including an inflation component) on equity which ranged from 10-21% for beam trawlers and 8-10% for otter trawlers. The highest calculated rate of return was for beam trawlers operating in Area 1. Since a target real rate of return on capital which includes the cost of risk in the fishing industry is around 9%, it can be concluded that vessels, with the exception of beam trawlers operating in Area 1, may just be breaking even, in the sense that their surplus of revenues over variable and annual fixed costs is just sufficient to meet the required rate of return on capital.

The results of the survey were compared with those of other surveys carried out by WBM Oceanics for the beam trawl fishery in the period 1993-94, and by ABARE for the Torres Strait prawn fishery and other fisheries. The information obtained on factors such as crew costs, marketing and distribution expenditures and overall rates of return were consistent with previous studies. The costs and returns survey information, together with catch data and prawn price estimates, was used to estimate the proportion of their total effort beam trawlers devote to prawn fishing, and costs were allocated to the fishery according to this proportion. For example, in 1996 revenues from beam trawling were estimated to be around one quarter of annual fishing income earned by operators who were active in the beam trawl fishery.

The impact of the beam trawl fishery on the otter trawl fishery was estimated by running the simulation models over the five year period 1992-96 with and without current levels of beam trawl effort, and comparing the returns to the otter trawl fishery in the two cases. In the absence of beam trawling, offshore prawn stocks would be higher and otter trawl catch rates would rise. However higher catch rates would also attract additional effort with a consequent increase in costs. When these two effects were taken into account it was found that eliminating the beam trawl fishery increased long-run profits in the otter trawl fishery by around $13,000 per annum in Area 1, and by around $1000 per annum in Areas 3 and 5. In terms of the cost each active beam trawler imposes on the otter trawl fishery the amounts range from $200 per vessel in Area 1 and negligible amounts in the other Areas.

Summary of Interactions among the Fisheries

The contribution of the beam trawl fishery to the economy is measured by its value added - the excess of the value of its catch over its costs. Most of the costs of the fishery are borne by the beam trawl operators - variable costs such as fuel, fixed costs such as insurance, and interest and depreciation costs of capital. When these costs are subtracted from the value of the catch a measure of the economic profitability of the fishery is obtained. The study found that the average active beam trawler was making an annual economic profit of around $3000 in the greasyback region of Area 1, around $1000 in Area 3 and less than $1000 in Areas 2 and 5.

The costs incurred by the beam trawl operators are not the only costs the fishery imposes on the economy. The by-catch of finfish by beam trawlers reduces catches in the recreational fishery and hence the value of the recreational fishery by around $10 for each day of beam trawling. This corresponds to an annual cost of around $600 per active beam trawler in Area 1 and between $300-500 in the other areas. No conclusive evidence was uncovered of other significant costs to the recreational fishery, such as congestion or habitat disturbance. The beam trawlers also impose costs on the otter trawl fishery by catching prawns which might otherwise have been recruited to the stock exploited offshore. It was found that the annual economic profit of the otter trawl fishery would be around $13,000 higher in Area 1 if the beam trawl fishery did not exist. This corresponds to a cost of around $200 per annum imposed by each active beam trawler on the otter trawl fishery. In Areas 2, 3 and 5 the costs are less than $100 per annum per active vessel.

The overall contribution of the beam trawl fishery to the economy is measured by the total value of the beam trawl catch less all the catching and other costs attributable to beam trawling. In the greasyback region of Area 1 the fishery is estimated to contribute around $110,000 dollars annually to the economy, or about $1800 per active vessel. In Areas 2,3 and 5 the net contributions per active vessel are negligible, ranging from slightly negative in Area 2 to around $600 in Area 3.

It should be borne in mind that all the values reported in the study are estimates only and subject to variability. This has been allowed for by using ranges of parameter values at various stages in the analysis. For example, in the analysis of the interaction between the beam trawl and recreational fisheries ranges of by-catch rates and values of recreational fish species were considered, and the cost of the beam trawl by-catch was varied by plus or minus 10% of the base level in the final calculation. In the beam and otter trawl interaction analysis price, cost, recruitment, mortality and catchability parameters were also varied by plus or minus 10% of base levels. As expected, the base level results are sensitive to this degree of variation. Changes in costs and in the recruitment, natural mortality and catchability parameters of this magnitude are sufficient to provide a shift of the estimate of the contribution of the beam trawl fishery from positive to negative in most Areas.

Policy Implications

On purely economic grounds there is no case for or against closing the beam trawl fishery in Areas 2, 3 and 5, whereas closing the greasyback fishery in Area 1 would involve a moderate loss of a sustained economic benefit. Any adjustment costs that may be associated in closing areas of the fishery will also represent a loss to the economy as no increase in total economic benefits will results, even in the long term.

In all Areas, except Area 3, an economic case can be made for reducing the level of beam trawl effort by up to 50% to increase the net contribution of the fishery to the economy, although the gains in net economic profit from this degree of effort reduction are not substantial and would have to be judged in the light of any additional management costs that were incurred.

Closing the beam trawl fishery or reducing the level of effort in any Area of the fishery would impose various kinds of costs - economic and otherwise - on the beam trawl operators. This analysis considers the economic costs only. Furthermore private firms frequently experience gains or losses as a result of public policy for which compensation is not always demanded or paid. This study does not address the issue of whether compensation should be paid if parts of the fishery are closed, but rather the approximate value of the current fishery to its operators. The fishery is of economic significance to other sectors of the economy, such as processors, but since the study did not conclude that the significant greasyback prawn fishery should be closed, this issue is not addressed.

A direct method of assessing the value of a beam trawl endorsement is through analysis of licence trading data. This technique has been used in the Tasmanian rock lobster fishery (Campbell (1989)) but could not be employed in the present study owing to data limitations. An indirect method is to ask what the beam trawlers would do if they were barred from beam trawling for prawns. Three scenarios can be considered, two of them involving extreme assumptions: first, it could be assumed that the beam trawl effort can divert to other areas of the regional fisheries where it can earn the operators the same level of profit; second, it could be assumed that effort can divert to other fisheries where total costs can be covered, but no surplus in the form of an economic profit can be earned; and, third, it could be assumed that there is no other productive use for the beam trawl effort over the remaining life of the vessel. Under the first assumption, the economic loss to beam trawl operators is zero. Under the second assumption, the economic loss is the present value of beam trawl economic profits which would have been sustained into the future. Under the third assumption, the annual economic loss is the excess of revenues over the variable and annual costs of the vessel over its remaining life, and there is also the long-run loss of economic profits which could have been earned from a replacement vessel.

The cost to operators under the latter two assumptions can be expressed as a present value - a sum of money which if invested in an asset with a similar amount of risk as beam trawling would yield the same annual flow of profit to its owner as would have been derived from beam trawling. These sums can be expressed as averages per active vessel operating in each of the Areas.

As noted above, active vessels as a proportion of endorsed vessels range from around 10-50%. While an inactive vessel obviously receives no current benefit from the fishery, it may have the option of participating in the future. As with any option to participate in a venture, this option is worth something, but the study did not attempt to value it.

The results reported for active beam trawl vessels (Table 4.15) can be used to obtain approximate estimates of the costs to operators of exiting from the fishery. As noted above, if exiting vessels can earn the same level of profit in alternative fisheries then there is no cost associated with exiting. If exiting vessels can just cover their annual variable, fixed and capital costs in another fishery then the cost of exiting the beam trawl fishery is the forgone economic profit which could have been earned into the future. This cost can be measured as the sum of money, invested at the appropriate rate (8.9 per cent), which would yield that same level of profit into the indefinite future. This sum is measured by the present value of the beam trawl fishery economic profit per active vessel estimates derived from Table 4.15: $29 511 for the greasyback fishery in Area 1, $1 733 in Area 2, $13 311 in Area 3, and $4 789 in Area 5. If exiting vessels are unable to cover their capital costs by participating in another fishery over the remaining economic life (assumed to be 15 years) the present value estimates are derived from the annual cash profit figure in Table 4.15 for the first 15 years and from the economic profit figures thereafter. The estimates per active vessel are $59 418 for the greasyback region in Area 1, $18 621 in Area 2, $34 842 in Area 3, and $21 089 in Area 5.

Benefits

The benefits of the research are measured by the value of the beam trawl fishery to the economy under a management regime based on the project results *less* the value of the fishery under a management regime formulated without the information made available by the project. While it can only be speculated what each of these regimes will or would have been, the following scenarios offer a guide to the potential value of the research:

1. *The beam trawl fishery in the southern part of Area 1 is phased out as suggested in the White Paper (Queensland Government, 1993)*

The Project found that this policy measure would impose an annual loss on the Queensland economy of around $112,000 per annum, with a present value of around $1.2 million. If this measure is not adopted as a result of the Project findings the benefit is $1.2 million;

2. *The beam trawl fishery in Areas 2,3, and 5 is phased out as suggested in the White Paper*

The Project found that this would involve a gain or loss to the Queensland economy as compared with the current situation. However, any adjustment costs incurred to close the fishery will effectively be a loss to the economy. This indicates that parties to either side of the debate should avoid incurring significant costs in pursuit of this policy.

3. *Beam trawl effort is permitted to remain at current levels*

The Project found that there were potential economic gains to reducing beam trawl effort in Areas 1, 2 and 5, provided that management costs were not excessive. If no action is taken to reduce beam trawl effort the magnitudes of the forgone gains to the economy range from around $50,000 per annum in Area 1 to less than $5000 per annum in Areas 2 and 5.

Further Development

A summary of the Project and its results should be published in *The Queensland Fisherman* and in *Sunfish* to provide the various stakeholders with information which can be used as an input to the policy debate. Technical papers describing the valuation of the recreational fishery and the bioeconomic models should be published in professional journals for the benefit of other researchers and consultants.

Conclusions

The first objective of the study was to provide a comprehensive description of the beam trawl fishery, including fleet composition, species composition of the catch, catch and effort data, destination and value of the catch, economics of production and value to the local economy. This information is detailed in Chapter 1 of the Discussion and Results Section.

The second objective was to estimate the cost imposed by beam trawlers on recreational fishers and other commercial operators harvesting the resource. The cost imposed by beam trawlers on recreational fisheries is described in Chapter 3 of the Discussion and Results Section, which draws on the economic analysis of the recreational fishery described in Chapter 2.

The third objective was to estimate the economic benefits or costs to the competing sectors and the broader community of altering the level of beam trawl effort in each river system. Chapter 4 of the Discussion and Results Section presents a bioeconomic analysis of this issue and concludes that on purely economic grounds there is not a strong case for or against closing the beam trawl fishery in Areas 2, 3 and 5, whereas closing the greasyback fishery in Area 1 would involve a moderate economic loss.

The final objective of the study was to assess management options, including possible levels of compensation. In all Areas, except Area 3, an economic case can be made for reducing the level of beam trawl effort by up to 50% to increase the net contribution of the fishery to the economy, although the gains in net economic profit from this degree of effort reduction are not substantial and would have to be judged in the light of any additional management costs that were incurred.

Closing the beam trawl fishery or reducing the level of effort in any Area of the fishery would impose various kinds of costs - economic and otherwise - on the beam trawl operators. This analysis considers the economic costs only. Furthermore private firms frequently experience gains or losses as a result of public policy for which compensation is not always demanded or paid. This study does not address the issue of whether compensation should be paid if parts of the fishery are closed, but rather the approximate value of the current fishery to its operators. The fishery is of economic significance to other sectors of the economy, such as processors, but since the study did not conclude that the significant greasyback prawn fishery should be closed, this issue is not addressed.

A direct method of assessing the value of a beam trawl endorsement is through analysis of licence trading data. This technique has been used in the Tasmanian rock lobster fishery (Campbell (1989)) but could not be employed in the present study owing to data limitations. An indirect method is to ask what the beam trawlers would do if they were barred from beam trawling for prawns. Three scenarios can be considered, two of them involving extreme assumptions: first, it could be assumed that the beam trawl effort can divert to other areas of the regional fisheries where it can earn the operators the same level of profit; second, it could be assumed that effort can divert to other fisheries where total costs can be covered, but no surplus in the form of an economic profit can be earned; and, third, it could be assumed that there is no other productive use for the beam trawl effort over the remaining life of the vessel. Under the first assumption, the economic loss to beam trawl operators is zero. Under the second assumption, the economic loss is the present value of beam trawl economic profits which would have been sustained into the future. Under the third assumption, the annual economic loss is the excess of revenues over the variable and annual costs of the vessel over its remaining life, and there is also the long-run loss of economic profits which could have been earned from a replacement vessel.

The cost to operators under the latter two assumptions can be expressed as a present value - a sum of money which if invested in an asset with a similar amount of risk as beam trawling would yield the same annual flow of profit to its owner as would have been derived from beam trawling. These sums can be expressed as averages per active vessel operating in each of the Areas.

As noted above, active vessels as a proportion of endorsed vessels range from around 10-50%. While an inactive vessel obviously receives no current benefit from the fishery, it may have the option of participating in the future. As with any option to participate in a venture, this option is worth something, but the study did not attempt to value it.

The results reported for active beam trawl vessels (Table 5.15) can be used to obtain approximate estimates of the costs to operators of exiting from the fishery. As noted above, if exiting vessels can earn the same level of profit in alternative fisheries then there is no cost associated with exiting. If exiting vessels can just cover their annual variable, fixed and capital costs in another fishery then the cost of exiting the beam trawl fishery is the forgone economic profit which could have been earned into the future. This cost can be measured as the sum of money, invested at the appropriate rate (8.9 per cent), which would yield that same level of profit into the indefinite future. This sum is measured by the present value of the beam trawl fishery economic profit per active vessel estimates derived from Table 5.15: $29 511 for the greasyback fishery in Area 1, $1 733 in Area 2, $13 311 in Area 3, and $4 789 in Area 5. If exiting vessels are unable to cover their capital costs by participating in another fishery over the remaining economic life (assumed to be 15 years) the present value estimates are derived from the annual cash profit figure in Table 5.15 for the first 15 years and from the economic profit figures thereafter. The estimates per active vessel are $59 418 for the greasyback region in Area 1, $18 621 in Area 2, $34 842 in Area 3, and $21 089 in Area 5.

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Appendix 1: Intellectual Property

The intellectual property arising from the research consists of the recreational fishing models which could be applied to other fisheries and the spreadsheet model of the interactions between the beam and otter trawl fisheries which could be used for further policy analysis. Valuable information generated by the research includes the value of additional catches of finfish species to the recreational fishery, which could be used as an input to other studies, and the information on the net economic benefits of the three competing fisheries which can be used in public policy formulation.

Appendix 2: Staff

FRDC Project 94/035 was undertaken by Chris Reid, University of Queensland (UQ), as principal investigator. Harry Campbell (UQ) acted as project supervisor, and John Glaister and Mike Dredge, Queensland Department of Primary Industry (QDPI) acted as associate supervisors. The general direction of the research was guided by a Steering Committee which met on 23rd February 1995 to approve the research plan, on 5th November 1997 to consider preliminary results, and on 15th May 1998, together with invited community representatives, to consider the draft report. Membership of the Steering Committee over the period of the project consisted of the project investigator and supervisors, together with David Bateman (Sunfish), Colin Bishop (QCFO), Paul Fendley (Sunfish), Darrell McFee (QCFO), Steve Morgan (Sunfish), Kylie Paulson (QCFO), Phil Pond (QFMA), and Neil Trainor (QFMA). Mike Fennessy, an Area 1 beam trawl operator, participated in the final Steering Committee Meeting. The authors would like to thank all those mentioned above for their help, together with Kylie Butler and Ian Tibbetts from the UQ School of Marine Science who assisted with the by-catch and recreational fishery surveys. We also wish to thank all the recreational fishers and commercial operators who participated in the three surveys. While acknowledging the considerable amount of assistance received from these sources, the authors remain solely responsible for the conclusions of the report.