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A SURVEY OF RECREATIONAL FISHING ACTIVITY IN COFFIN BAY; JANUARY TO JUNE 1990[1]

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ABSTRACT

Recreational boat fishing is an important activity in Coffin Bay. Recreational fishers using the Coffin Bay boat ramp between January and June 1990 were interviewed to obtain information on their fishing activities. The majority of fishers targeted King George whiting (Sillaginodes punctata), which accounted for over half the total catch. The average catch rate of King George whiting per angler hour was 1.25 fish. Information was also obtained on the value fishers place on recreational fishing. These data were included in a simple model of the fishery to evaluate the economic benefits of changing the current allocation of fish between commercial and recreational fishers. The analysis indicates that it may be desirable to reduce recreational fishing and increase commercial fishing in Coffin Bay. Further research is required to verify this finding.

[1] Further details on this study will be provided in Staniford AJ and Siggins SK 1992, Allocation of fish between commercial and recreational fishers, Fisheries Research Paper 24, SA Department of Fisheries.

INTRODUCTION

Fish stocks are frequently exploited by both commercial and recreational fishers. Effective management of such fisheries requires information on the fishing activity of participants, and an analytical framework to assess the impact of policy decisions on the user groups. Many fisheries management agencies have information available on the commercial fishery (obtained from fishers' catch and effort returns). However, there is often little information available on the recreational fishery, and even less information available on an analytical framework to assess policy impacts.

This project was initiated as a pilot study to collect information on recreational fishers in the South Australian Marine Scalefish Fishery at Coffin Bay and to develop a framework for analysing interactions between commercial and recreational fishers.

The specific objectives of the project were:

1. to collect data on recreational fishing activity in the Coffin Bay area.

2. to elicit information on the value of fish in commercial and recreational uses.

3. to develop an analytical framework to estimate the benefits to commercial and recreational fishers from implementing policies to change the share of catch between the two sectors.

METHODS

Area Description

Coffin Bay is a renowned fishing area for both commercial and recreational fishers. The area is well known for its catches of King George whiting (Sillaginodes punctata).

Recreational fishing from boats and the shore is popular. The waters in the bay are sheltered and the Coffin Bay "Ledge" provides shore fishers with access to waters in which King George whiting can be regularly taken. Boat ramps are located at Coffin Bay and Farm Beach (see Figure 1).

Closures apply to commercial and recreational net fishers with part of the Bay permanently closed to netting (see Figure 1). There is also a seasonal netting closure on a larger portion of the bay between November 1 and May 1 (see Figure 1). At the opening of the netting season in May, a large number of itinerant commercial net fishers travel to Coffin Bay in the belief that the build-up of numbers of fish during the closed season improves the viability of fishing.

Commercial and recreational line fishers are permitted to fish all waters at any time during the year.

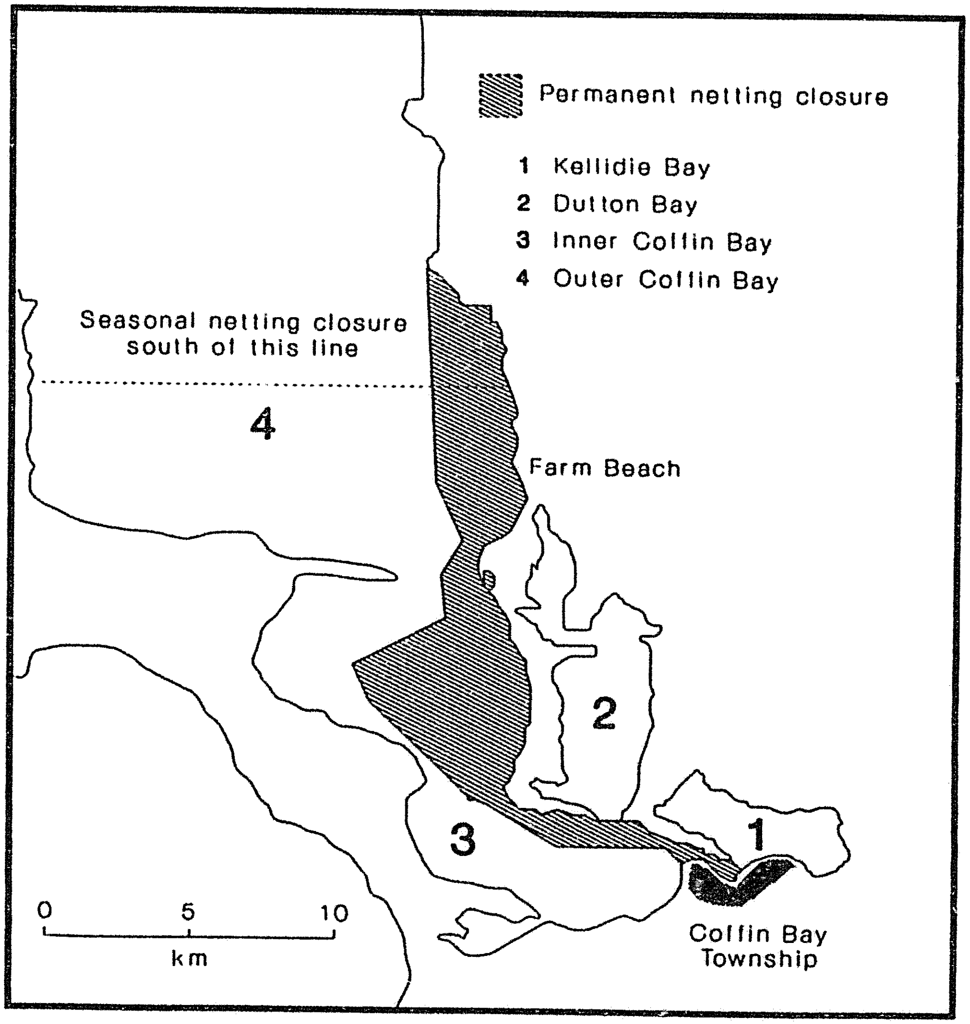

Figure 1. Map of Coffin Bay showin netting closures and fishing areas

Sampling Frame

The sampling frame for the study was defined as all recreational boat fishers using the Coffin Bay boat ramp between the hours of 0630 and 1830 during the period January 1 to June 30 1990, excluding the Easter period.

Sample Design

Previous studies of recreational fishing (e.g. Hill 1986) have shown that there is considerable variation in the number of boats using the ramp each day. A stratified survey design was used to improve the precision of estimates.

The days within the survey period were stratified into four groups:

1. Weekends

   This stratum included all weekends excluding those associated with public holidays (long weekends) and school holidays.

2. Weekdays

   The weekdays stratum included all weekdays except public and school holidays.

3. Public Holidays

   Public holidays were defined as any public holiday, and in the case of long weekends, the Saturday and Sunday of the weekend were also classified as public holidays.

4. School holidays

   School holidays included all weekdays and weekends during the school holiday periods.

Catch rates and participation rates were expected to vary throughout the sampling period. Thus the sampling period was further stratified into 6 time periods (corresponding to months).

Random sampling was used to define sampling periods. In any sampling period, individual respondents were approached at random as they returned from their fishing trip, and asked if they would participate in the survey. A spokesperson for each boat completed the questionnaire. Data collected related to the boat trip undertaken on the day of the interview.

Method of Collecting Data

A personal interview questionnaire was used to collect the data. Respondents were interviewed after they had retrieved their boat from the water.

Observations on the number of empty boat trailers at the Coffin Bay boat ramp were made on the hour between 0700 and 1800 hours.

Estimation of Stratum Totals for Fishing Effort, Catch and Catch Rate

Total Fishing Effort

Let b_{ijk} denote the number of boat trailers at the ith count time on day j in stratum k

t_i denote the time between the i-1 and the ith count times

n_{ik} denotes the n number of counts conducted at time i in stratum k.

The average number of boat trailers counted at time i in stratum k is

$$\bar{b}_{ik} = \sum_j b_{ijk} / n_{ik}$$

The estimated daily boat effort (DBE) in stratum k is

$$DBE = \sum_i (\bar{b}_{ik} * t_i)$$

Total boat effort in stratum k (E_k) is

$$E_k = DBE * \text{Number of days in stratum } k$$

Total boat effort during the sampling period (E) is

$$E = \sum_k E_k$$

As outlined in Hill (1986), total boat effort includes commercial and non-fishing boat effort as well as recreational boat fishing effort. Therefore

Recreational Boat Fishing Effort = Total Boat Effort

- Commercial Fishing Effort

- Non-Fishing Boat Effort.

Commercial fishing effort was estimated from data collected on the number of commercial fishers returning to the boat ramp each day. Recreational fishers interviewed were asked to estimate the proportion of time they had spent fishing. These data were used to adjust the estimates of total boat effort for non-fishing effort.

Catch Rate

Let CR_k denote catch rate specified as fish caught per hour fished in stratum k;

c_{sijk} denote the catch of species s by the ith fisher on day j in stratum k.

e_{ijk} denote the hours fished by the ith fisher on day j in stratum k.

Average catch rate of species s in stratum k is

$$CR_{sk} = \sum_{i}\sum_{j} c_{sijk} / \sum_{i}\sum_{j} e_{ijk}$$

Total Catch

Total catch of species s was estimated using

$$TC = \sum_{k} \left[\begin{array}{l} \text{Total recreational} \\ \text{boat fishing effort} \\ \text{in stratum k (hrs)} \end{array} * \begin{array}{l} \text{Catch of species s per unit} \\ \text{effort in stratum k (number of} \\ \text{fish per hour)} \end{array} \right]$$

RESULTS

Sample Size

During the survey period, 629 boats were selected and one person from each boat was interviewed. Professional fishers were approached on 49 occasions (7.7% of the sample). The number of recreational boaters using their boat for activities other than fishing was 71 (11.3%). The remaining 509 respondents (81.0%) undertook some fishing during their boat trip. The data presented below relate to these 509 fishers, 28 of which indicated that fishing was not the primary purpose of their boat trip.

The number of recreational boat fishers interviewed by survey strata, along with the number of days on which interviews were held in each strata, is provided in Table 1. The average number of interviews per day was highest in January (11.8) and lowest in June (3.0).

Multiple Sampling

Many anglers fished in the Coffin Bay area regularly, or were staying for an extended period, and were interviewed on more than one occasion. During the survey period, 213 interviews (41.8% of the total) were conducted with people who had been previously interviewed.

Total Fishing Effort

Total recreational fishing effort during the survey period was estimated to be 15 145 hours. Recreational fishing effort was highest in January (4 945 hours) declining to 326 hours in June.

Catch Rate

The average catch rate for all species was 5.7 fish per boat hour. A two way analysis of variance indicated that there were significant variations in catch rate between months and survey period ($P<.01$ and $P<.001$). (The interaction effect was not siginificant, implying that the means for different months and survey periods can be compared, Underwood 1981.) Catch rate varied throughout the survey period, increasing from January through to May. Catch rates during weekdays were always higher than those on weekends or in holiday periods.

Table 1. Recreational Boat Fishers Interviewed Coffin Bay - January to June 1990

	PERIOD	NUMBER OF INTERVIEWS	NUMBER OF SURVEY DAYS	AVERAGE PER DAY
JANUARY	School Holidays	141	12	11.8
	Sub-Total	141	12	11.8
FEBRUARY	Weekdays	43	6	7.2
	Weekends	18	2	9.0
	Sub-Total	61	8	7.6
MARCH	Weekdays	47	5	9.4
	Weekends	55	5	11.0
	Sub-Total	102	10	10.2
APRIL	Weekdays	25	3	8.3
	Weekends	24	3	8.0
	School Holidays	61	5	12.2
	Sub-Total	110	11	10.0
MAY	Weekdays	33	8	4.1
	Weekends	24	3	8.0
	Public Holidays	11	3	3.7
	Sub-Total	68	14	4.9
JUNE	Weekdays	6	5	1.2
	Weekends	1	1	1.0
	Public Holidays	20	3	6.7
	Sub-Total	27	9	3.0
TOTAL	WEEKDAYS	154	27	5.7
	WEEKENDS	122	14	8.7
	PUBLIC HOLIDAYS	31	6	5.2
	SCHOOL HOLIDAYS	202	17	11.9
	TOTAL	509	64	8.0

Table 2. Catch Per Angler Effort Recreational Fishers - King George Whiting Coffin Bay - January to June 1990

	PERIOD	CATCH RATE	STANDARD DEVIATIONS
JANUARY	School Holidays	0.65	0.98
	Average	0.65	0.98
FEBRUARY	Weekdays	1.18	1.01
	Weekends	1.02	1.84
	Average	1.14	1.30
MARCH	Weekdays	1.98	1.82
	Weekends	1.25	1.59
	Average	1.58	1.73
APRIL	Weekdays	1.55	1.44
	Weekends	1.58	1.71
	School Holidays	1.06	1.34
	Average	1.29	1.46
MAY	Weekdays	2.26	2.47
	Weekends	1.85	2.19
	Public Holidays	0.81	1.10
	Average	1.88	2.23
JUNE	Weekdays	2.81	2.55
	Weekends	0.00	0.00
	Public Holidays	1.36	2.01
	Average	1.63	2.16
AVERAGE		1.25	1.61

F value for Month	3.556 **
F value for Period	5.546 ***
F value for Interaction	0.919 ns

*** significant at the .1% level
** significant at the 1% level
* significant at the 5% level
'ns' not significant

The catch rate of King George whiting per angler hour was 1.25 fish. This estimate is comparable with that of Jones (1990) for Franklin Harbour of 1.2 fish per angler hour. Catch rate per angler hour varied significantly between months (highest between March and June) and survey period (higher on weekdays, Table 2).

The species most frequently targeted by respondents in all months was King George whiting. In March, 73.5% of respondents targeted King George whiting. The proportion of respondents targeting King George whiting was lowest in January (44.0%). During this month, 22% of respondents were targeting scallops. There was also a large proportion of respondents who were not targeting any particular species (ranging from 22.5% in March to 37.7% in February).

The average number of people fishing in each boat was 2.62. The number of poeple fishing did not vary significantly between months. However, the number of persons under 16 years was significantly higher in the school holiday months of January and April.

Total Catch

Over half the fish caught (53.7%) were King George whiting (Table 3). The next most frequently caught fish were tommy ruff (18.7%), garfish (10.9%) and Australian salmon (7.7%). Data were not obtained on the size of fish taken. However, estimates of fish size were obtained from a survey conducted by Jones (1983). This survey was undertaken in March, and thus corresponded to the mid point of the current survey. The average weights for King George whiting, garfish, Australian salmon and tommy ruff were 240g, 66g, 250g and 100g, respectively. These data were used to estimate the total weight of fish caught, which is also provided in Table 3.

Table 3. Total Catch - Major Species Coffin Bay - January to June 1990

	CATCH (No. of Fish)	%	CATCH Weight (kgs)
King George whiting	46293	53.7	11110
Salmon	6615	7.7	1654
Garfish	9416	10.9	621
Tommy ruff	16163	18.7	1616
Other	7716	9.0	na
	86203	100.0	15002

King George whiting catches peaked in March at 11345 fish, before declining to 1249 in June. The main factor contributing to the decline in catch from March to June was the reduction in fishing effort rather than the reduction in catch rate. Garfish catches peaked in March and April and catches of tommy ruff were highest in January.

Fishing Area

The Coffin Bay waters were divided into 4 subregions (Figure 1) and respondents were asked to nominate the region in which they had been fishing. Most respondents fished in the inner and outer Coffin Bay regions (54.2% and 19.3% respectivley).

Fishing Method

The fishing method most frequently used by boat anglers was the rod or handline (87.7%). Diving was the next most frequently used method (9.8%).

Fishing Time

The average length of each boat trip was 4.8 hours. This did not vary significantly between months. The average amount of time spent fishing by each respondent was 3.5 hours (72.7% of the time spent out in the boat).

Employment Status

Most boat anglers were employed full-time (68.4%). Retired persons accounted for 26.1% of the sample. The proportion of retired persons was low in the school holiday period in January (6.4%).

Average Expenditure

The average daily expenditure by recreational fishers on specific fishing activities was $16.56c, with the three major costs being boat fuel ($12.01c), car fuel ($2.92c), and bait and ice ($1.50c, Table 16). All expenditure showed little variation over the six month period.

Staying Overnight

Most fishers interviewed (70.5%) obtained overnight accommodation on the day of the interview. A smaller proportion of respondents made day trips to Coffin Bay (18.3%) or were residents of Coffin Bay (11.2%).

The proportion of fishers obtaining accommodation in Coffin Bay was higher in the warmer months of January (78%), February (70.5%), March (76.5%) and April (70.0%). The proportion of fishers travelling to Coffin Bay for the day increased in May (27.9%) and further increased in June (40.7%).

Accommodation

The most popular accommodation type used by survey respondents was a rented house/cabin (39.9%), their own seasonal house (32.4%) and the caravan park (22.6%). Use of the motel was negligible (.3%).

The Recreational Value of Fish Caught in Coffin Bay

A measure of the total economic value of fish to recreational fishers is the maximum they are prepared to pay for fish in lieu of spending the same amount of money on other goods and services which satisfy personal needs and wants (Edwards 1990).

Information on the maximum amount recreational fishers were prepared to pay for each fishing trip at Coffin Bay during the survey period (willingness to pay) was collected in the survey. The willingness to pay data were recorded as coded data. The coded data were converted to dollar values by setting each nominated category to the mid-point of the range.

These data refer to the total value of the recreational fishing experience. Bishop and Samples (1980) noted that the value of the recreational fishing experience includes the value placed on the opportunity to be outside, relax and enjoy the scenery etc., as well as the value placed on the fish caught. To separate the value attributed by recreational fishers to fish from the total value placed on the recreational fishing experience, it is necessary to determine the extent that the willingness to pay data are influenced by changes in the number of fish caught, taking into account other factors affecting the value of the fishing experience. This was done by estimating a willingness to pay function that relates willingness to pay to its determinants, using regression analysis (e.g. Hammack and Brown 1974, McConnell 1977, Dwyer and Bowes 1978).

The data on willingness to pay (total economic value of the recreational fishing experience) was defined as the dependent variable. Independent variables were hypothesised to be:

1. Total catch - Catch was defined as the total number of King George whiting, garfish, salmon, tommy ruff and other finfish caught during the fishing trip. A positive regression coefficient was expected, implying that as catch increased, willingness to pay would also increase.

2. Weather and sea conditions - Respondents were asked to rank weather and sea conditions on a scale from one (being poor) to five (being excellent). It was hypothesised that improved willingness to pay for the fishing trip would increase as weather and sea conditions improved.

3 Quality of fishing - A favoured target species of recreational fishers in Coffin Bay is King George whiting. It was hypothesised that as the proportion of King George whiting in the catch increased, the quality of fishing also increased, implying that the willingness to pay would increase.

4. Income - From economic theory, willingness to pay is expected to increase with increases in income. Income data were collected in a pilot questionnaire used in the Coffin Bay study. However, respondents often refused to provide the data or provided it reluctantly. The question was eventually removed from the questionnaire used in the study. Hence income was not included as an independent variable in the regression model. Difficulties in obtaining income data in willingness to pay studies have been reported by Cameron and James (1986).

5. Fishing days - Respondents were asked to estimate the number of days they had spent fishing in the last 12 months. It was hypothesised that as the number of fishing days increased, the willingness to pay for the recreational fishing experience would decline (i.e. the regression coefficient would be negative).

6. Dummy variables - Dummy variables were included as intercept shifters in the regression model to evaluate the impact of month, survey period, type of accommodation and employment status on willingness to pay. Most were statistically insignificant and were thus excluded from the model reported. The dummy variables retained were those for the month of January, accommodation in a rented house and accommodation staying with friends.

The preferred regression model is reported in Table 4, and was estimated with the willingness to pay, catch, quality, weather and fishing day variables transformed to natural logarithms. The proportion of variation explained by the model is low (R^2 is 0.24). However, this is comparable with results obtained in similar studies e.g. the R^2 obtained by Hammack and Brown (1974) and McConnell (1977) were 0.22 and 0.29 respectively. The regression model reported was estimated using ordinary least squares (OLS). Tests for heteroskedasticity were inconclusive, implying that an OLS estimator was appropriate.

The estimated coefficients for catch, quality of fishing and weather and sea conditions were highly significant ($P < .001$) and had the expected signs. From these results, it is concluded that these variables are significant determinants of the value placed by recreational fishers on the fishing trip. The coefficient for fishing days was negative as expected and significant at the 5% level, supporting the hypothesis that willingness to pay decreased as the number of fishing days increased.

Table 4. Estimated Regression Model of the Willingness to Pay Function Coffin Bay - January to June 1990

VARIABLE[a]	COEFFICIENT	STANDARD ERROR
Catch	0.30 (***)	0.05
Quality	0.18 (***)	0.05
Weather	0.40 (***)	0.11
Fishing Days	-0.07 (*)	0.04
January	0.52 (***)	0.10
Rented House	0.21 (**)	0.09
Friends	0.87	0.25
Constant	1.99 (***)	0.23
R^2	0.24	

[a] The variables Willingness to Pay, Catch, Quality, Weather and Fishing Days were transformed to natural logarithms.

*** significant at the 0.1% level
** significant at the 1% level
* significant at the 5% level

The three dummy variables had positive coefficients, implying that persons visiting Coffin Bay in January or those staying with friends or in a rented house demonstrated a higher willingness to pay than others in the sample.

The positive coefficient for January may be due to the large number of people on holidays during this month. Survey respondents during January often gave the impression that they had come to Coffin Bay to fish and that cost factors had little influence on their decision to go out fishing for the day. The positive coefficient may also reflect an income effect. As discussed above, an income variable was omitted from the estimated willingness to pay function. During January, there was a greater proportion of fishers reporting full-time employment relative to the other months, implying that average income of respondents may have been high during January relative to the other months during the survey period.

An inverse Hicksian demand function, relating the marginal value of fish to the number of fish caught, was obtained by partially differentiating the willingness to pay function reported in Table 4 with respect to catch. A simplified model, obtained by substituting all other variables in the model at their mean values, is:

$$\partial WTP/\partial FISH = 3.073FISH^{-0.70297}.$$

where WTP denotes willingness to pay and FISH denotes the number of fish caught per boat trip.

Setting the number of fish caught per boat trip at the mean of 28.52, the marginal value of an additional fish to recreational fishers is estimated to be 29.2 cents per fish. It should be noted that this value is significantly less than the average willingness to pay per fish caught ($1.28) or the average daily trip costs per fish caught (58.1c, Table 5).

The marginal value of fish is the appropriate measure of value that should be used to compare the benefits from using fish in competing uses (e.g. commercial and recreational fishing, Bishop and Samples 1980). The variation in the alternative measures of "value" listed in Table 5 illustrates the extent to which estimates of the value of recreational fishing may be biased if inappropriate measures of value are used. It also reinforces the point that fish contribute only a portion of the value placed by fishers on the recreational fishing experience.

Table 5. Comparison of Marginal Value with the Average Willingness to Pay and Daily Trip Cost (Per Fish) Coffin Bay - January to June 1990

	c/fish
Marginal Value	29.2
Average Willingness to Pay	127.7
Average Daily Trip Costs	58.1

The catch variable used in the regression model is the sum of all finfish species caught. Thus the estimated value refers to a composite fish corresponding to the composition of species caught. The weight of this composite fish was estimated to be 175g, obtained by multiplying the percentage of catch of each species by the average weight of the species and summing. Using this estimate, the marginal value of fish to recreational fishers is estimated to be $1.67/kg[1].

An estimate of the value of the composite fish to the commercial fishery is obtained by multiplying the percentage of catch of each species taken by

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[1] 1000/175 * .292 = $1.67

recreationalists by the market price that was obtained by commercial fishers for that species in 1989/90 (data on the price of fish in the region were obtained from the Department of Fisheries catch and effort data base). The estimated marginal value to commercial fishers is \$3.86/kg.

Comparing these two estimates, it is apparent that the marginal value of fish in the commercial fishery is over twice as great as the value of the same fish in the recreational fishery. This result indicates that it may be beneficial to increase the proportion of fish taken by commercial fishers and reduce that taken by recreational fishers. However, the estimated marginal values are gross values, excluding the cost of catching fish. In the following section, a model that takes into account costs to estimate the benefits to commercial and recreational fishers from reallocating fish is developed.

Allocation of Fish Between Commercial and Recreational Fishers

A Theoretical Model

Principles for allocating fish between commercial and recreational fishers are discussed by Edwards (1990).

Consider Figure 2 which depicts supply and demand curves for the average recreational fisher and the commercial fishery. In Figure 2a, the WTP function is the Hicksian demand curve derived above, depicting the relationship between marginal willingness to pay and the quantity of fish caught per boat trip. The curve is downward sloping, implying that the marginal value of fish to recreational fishers decreases as catch increases. The costs incurred by recreational fishers are represented by the supply curve. These costs include direct costs such as fuel and bait expenses and also the opportunity cost of the fishers' time. The curve is upward sloping indicating that higher catches require increases time by fishers and increased direct costs. (It is assumed that all fishers are equally skilled). Assuming equilibrium, the supply curve for the recreational fisher will intersect the WTP function in Figure 2a at the point where marginal willingness to pay is equal to WTP_0 and catch is R_0 kgs. At this point, the marginal benefit from fishing is just equal to the marginal cost. The remainder of the supply curve is drawn as a linear function passing through the origin. A reduction in the recreational catch from R_0 to R_1 will reduce benefits to each recreational fisher by area under the demand curve between R_0 and R^1 (area R_1BAR_0). Costs will similarly be reduced by area R_1CAR_0. The net effect (benefits minus costs) is a reduction of area ABC.

The equilibrium position for the commercial fishery is depicted in Figure 2b. The demand curve for fish is assumed to be perfectly elastic at price P, implying that increases in the quantity of fish taken from Coffin Bay have no effect on the overall price of fish. The supply curve is assumed to be linear, passing through the origin and intersecting the demand curve at equilibrium price P and catch Q.

A reduction in the recreational catch will increase the quantity of fish that can be profitably taken by commercial fishers. Thus the supply curve will pivot around the origin to the right from S_0 to S_1. It is assumed that catch increases from Q to Q^*. The increase in economic benefits (producer surplus) accruing to the commercial sector is area OYZ. Note that in this model,

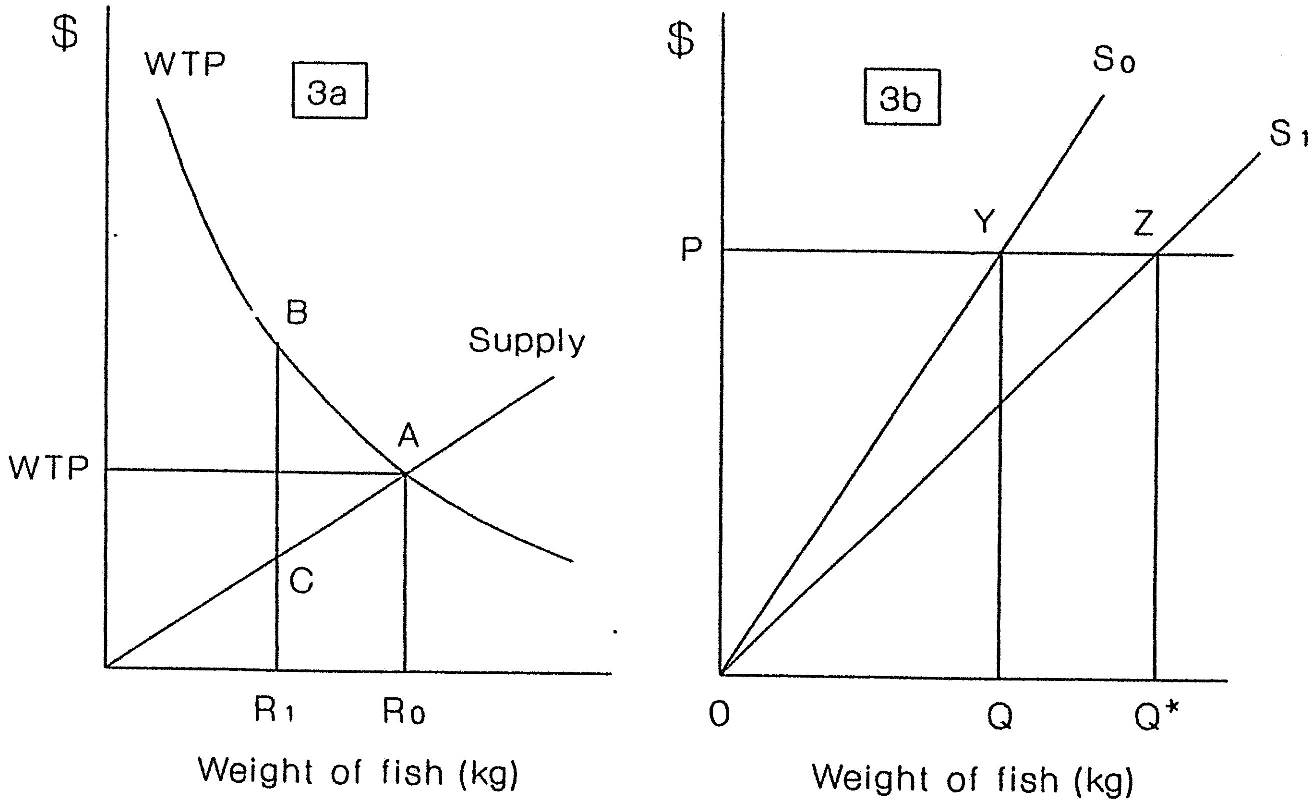

Figure 2. A conceptual model for analysing recreational and commercial fishing in Coffin Bay

consumers do not benefit from the increase in commercial catch due to the assumption of perfectly elastic demand (consumer surplus is zero). If demand for Coffin Bay fish was less than perfectly elastic, benefits would also accrue to non-fish-catching consumers.

An Empirical Model

The Hicksian demand curve for recreational fishing by individual fishers was estimated above and is of the form

$$WTP = aF^b$$

where WTP denotes marginal willingness to pay, F denotes the number of fish taken per boat trip, b is the price flexibility of demand for fish for an individual fisher and a is a model parameter.

The supply curve is defined as

$$MC = cF$$

where MC denoted marginal costs, F denotes the number of fish caught per boat trip and c is a model parameter.

Assuming equilibrium in the recreational fishery, marginal WTP is equal to MC. Thus estimates of marginal willingness to pay and fish caught can be used to calculate c:

$$c = MC/F.$$

The reduction in total benefits (RB) to an average recreational fisher per boat trip (area R_1 B A R_0 in Figure 2a) is calculated by evaluating the integral of the Hicksian demand curve between R_1 and R_0.

$$RB = a/(b+1) [R_1^{b+1} - R_0^{b+1}].$$

The reduction in costs (RC) to a recreational fisher per boat trip (area R_1 A C R_0 in Fig. 3a) is similarly calculated by integrating the supply function.

$$RC = c/2 [R_1^2 - R_0^2]$$

The net reduction in benefits per boat trip to a recreational fisher (NRB) is obtained by subtracting the change in costs from the change in benefits,

$$NRB = RB - RC.$$

The total reduction in net benefits to recreational fishers following a reduction in catch from R_0 to R_1 is calculated by multiplying the reductions in benefits per boat trip by the number of fishing trips made by recreational fishers (N)

$$RECBEN = NRB * N.$$

A reduction in the recreational catch will increase the commercial catch. The new commercial catch (Q^*), expressed in kilograms, is

$$Q^* = Q + (R_0-R_1).\ W.N.L.$$

where Q denotes the current catch, W denotes the average weight of fish caught in kilograms, N denotes the number of recreational fishing boat trips made and L denotes the percentage of fish previously caught by recreational fishers that are recaptured by commercial fishers.

The net benefit accruing to commercial fishers (CB) from the increased catch (area OYZ in Figure 2b) is

$$CB = 0.5\ P\ (Q^* - Q)$$

The overall effect of the reallocation of fish from recreational to commercial fishers on economic benefits is assessed by calculating the net economic impact (NEI)

$$NEI = CB - (RB - RC)$$

(net benefits accruing to commercial fishers minus the reduction in net benefits to recreational fishers following a reduction in the recreational catch per boat trip from R_0 to R_1).

A positive NEI implies that the reallocation of fish will increase economic benefits generated from the fishery, and is thus economically desirable.

Model Inputs

Parameters of the willingness to pay function are obtained from Table 4. The equilibrium catch per recreational fishing trip is 28 fish. The marginal value of fish to recreational fishers is 29.2 cents per fish or $1.67 per kg. The average weight of each fish is assumed to be 150 grams. The number of recreational fishing trips made is estimated to be 3155, obtained by dividing the recreational boat hours (Table 1) by the average length of each trip.

The price of fish to commercial fishers is $3.86 per kilogram (see above). The equilibrium commercial catch (Q) is estimated by scaling up the recreational catch according to data on the distribution of King George whiting between commercial and recreational fishers in Coffin Bay. Jones et al (1990, p.78) estimated that recreational fishers took 34.2% of total catch in Coffin Bay. Applying this factor to the total recreational catch (15 002 kg), commercial catch is estimated to be 28 865 kg.

There are no data available to estimate the proportion of fish that are recaptured by commercial fishers following a reduction in recreational catch. However, it is considered that not all of the fish would be recaptured. Some of the species caught by recreational fishers would not be targeted by commercial fishers. Professional fishers frequently target King George whiting, which accounted for approximately half of the recreational catch. It is initially assumed that 50% of the fish currently taken by recreational fishers are recaptured. Sensitivity analysis is used to determine the sensitivity of the results to variation in the proportion of fish that are recaptured by commercial fishers.

Results

The model described above was used to calculate the increase in benefits to professional fishers and the reduction in benefits to recreational fishers for varying recreational catches. The equations descrived above to calculate RECBEN (the reduction in beneftis to recreational fishers) and CB (the increase in benefits to commercial fishers) following a reallocatioin of fish from the recreational to the commercial fishersy are graphed in Figure 3. As the average recreational catch per boat trip declines from 28 fish (the sample average), benefits to professional fishers increase and those to recreational fishers are reduced. The recreational catch that maximises economic benefits is approximately 15 fish per boat trip. The curves drawn in Figure 3 intersect at this point, implying that the loss in benefits to the recreational fishery is just offset by the increase in benefits to the commercial fishery.

The position of the curves and the point where they intersect depends on the assumptions made in relation to the model inputs. As further work is required to verify these, detailed sensitivity analysis of the results is not undertaken. However, to illustrate the potential impact that changes in model inputs could have, an analysis of the impact of varying the proportion of fish recaptured by professional fishers on the optimum recreational catch per boat trip is provided in Table 6. If professional fishers recapture 70% of the catch foregone by recreational fishers (rather than 50%), the recreational catch that maximises economic benefits reduces from 15 to 10 fish per boat trip. The data in Table 6 imply that net benefits from reducing recreational catch are very sensitive to the proportion of fish that are recaptured by commercial fishers.

Table 6. Effect of Changes in % of Fish Recaptured by Commercial Fishers on the Optimal Recreational Boat Catch

% of Fish Recaptured	Optimal Recreational Catch (No. of fish caught per boat trip)
30	20
50	15
70	10
90	7

Further research is required to evaluate and verify the assumptions used in the model. Changes to policy cannot be recommended until this work is undertaken. However, to illustrate how the results obtained from the model could be used, the following interpretation of Figure 3 is provided.

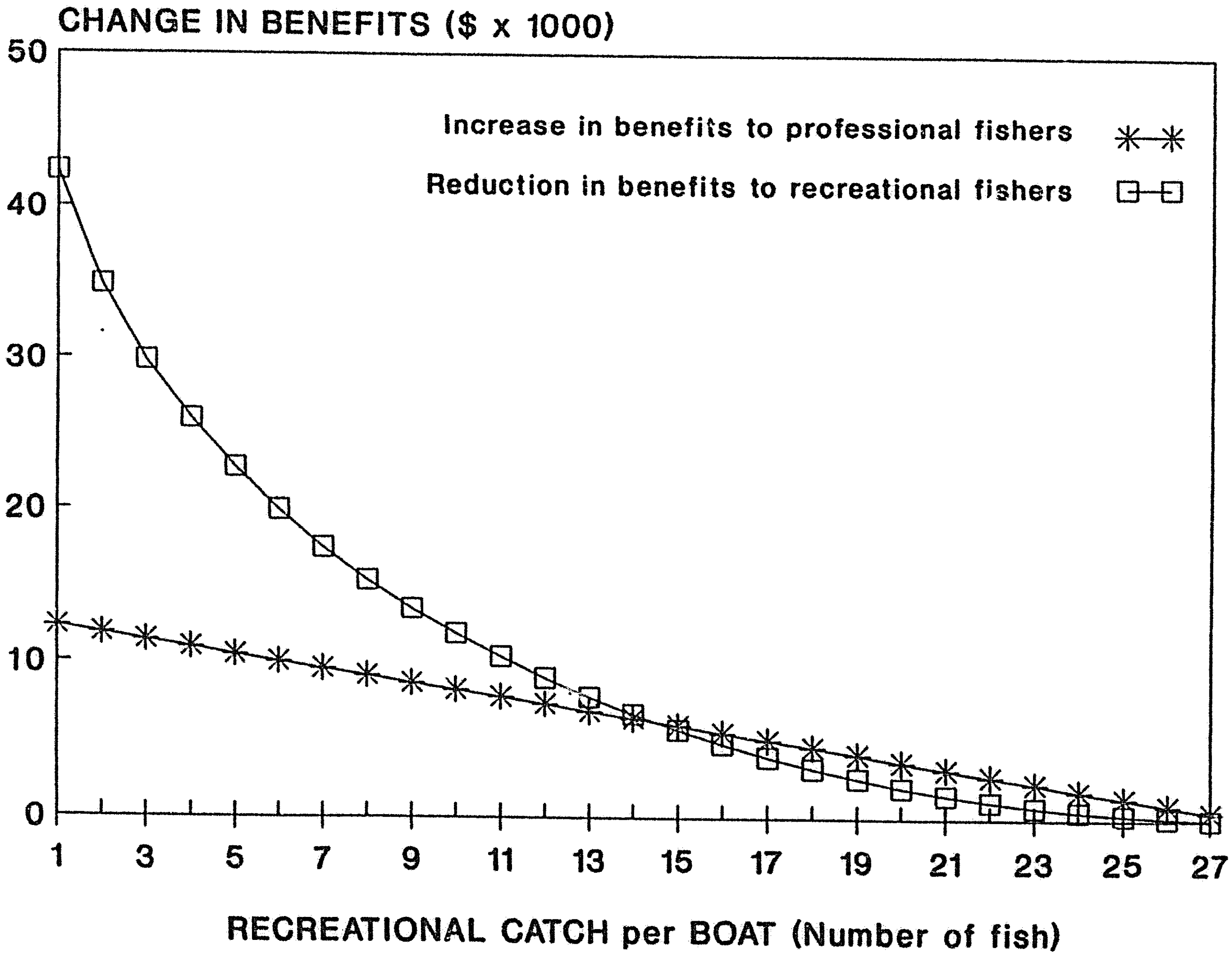

Figure 3. Impact of a reduction in the recreational catch on commercial and recreational fishers

1. The curves drawn in Figure 3 intersect, implying that both commercial and recreational fishing are necessary to maximise economic benefits from the Coffin Bay fishery.

2. The evidence obtained on the marginal value of fish in commercial and recreational fishing and from the simple economic model applied above, indicates that the current allocation of fish between the competing users is not maximising economic benefits from the fishery. The results imply that the recreational catch should be reduced and reallocated to the commercial fishery.

   According to the numerical results obtained from the model, economic benefits are maximised when the recreational catch per boat is approximately 15 fish. For catches below this level, benefits from using fish for recreational purposes exceed those that could be obtained by using the fish for commercial purposes. When catch per boat is greater than 15 fish, benefits could be increased by allocating more fish to commercial fishing. Current policy allows both commercial and recreational fishing.

3. The optimal recreational catch per boat trip is very sensitive to the assumption made on the proportion of fish foregone by recreational fishers that are recaptured by commercial fishers. More research is required to accurately quantify this parameter.

DISCUSSION

Comparisons of Results with Previous Studies

The survey results obtained in this study are in accord with those from previous studies e.g. Hill (1986) and Jones and Retallick (1990). They show that recreational fishing is an important activity in the region. Fishing was the primary purpose of the boat trip for the majority (83%) of recreational boat owners using the Coffin Bay boat ramp. The fish species most frequently targeted by recreational fishers was King George whiting (57.8% of fishers reported that they were targeting King George whiting). The recorded catch rate of King George whiting per angler hour at Coffin Bay (1.25 fish) is comparable with the estimate of Jones and Retallick (1990) in Franklin Harbour (1.2) and Hill (1986) at Port Hughes (up to 1.16). Persons fishing during the week obtained higher catch rates than those fishing on weekends or in school holidays. These people often lived locally in the area or had detailed local knowledge. This is consistent with Hill's (1986) results. Fishing in Coffin Bay is seasonal, with species composition and catch rates varying during the survey period.

Impact of Commercial Netting on the Recreational Fishery

Commercial netting in Coffin Bay is prohibited from the beginning of November to the end of April. During this period, few commercial boats were launched from the boat ramp. The incidence of commercial boats launching from the boat ramp increased markedly in May and June. However, the evidence on catch rates indicate that the increased commercial activity in the region during this period did not markedly depress catch rates in the recreational fishery (catch rates in May and June were comparable with those in March and April). Total catch taken by recreational fishers declined in May and June. However, this was due mainly to a reduction in recreational boat fishing effort, perhaps due to other factors such as deteriorating weather conditions.

Allocation of Fish Between Commercial and Recreational Fishers

A key objective of this study was to develop a method to examine the distribution of benefits between commercial and recreational fishers from policies implemented to control fishing effort in the commercial fishery. A model was successfully developed and applied to the Coffin Bay fishery. The model and data require further refinement before the results can be used to assist in policy formulation. More specifically, the model and the results obtained represent a first attempt to value fish to recreational fishers in South Australia. The analytical techniques used are simple and the method used to elicit data on willingness to pay is susceptible to various biases (see Mitchell and Carson 1989). There is scope to use more advanced analytical methods in undertaking further research. Research into the stability of the parameters of the willingness to pay function, the performance of the survey instrument and the the extent to which results can be generalised is essential before the results can be used for policy purposes.

The analysis used in this paper models the decision to go fishing on a given day, by examing the benefits and cost of the fishing trip. However, it does not take into account the decision to visit Coffin Bay. Most of the fishers interviewed (70.5%) stayed in temporary accommodation overnight. The extent to which the opportunity to fish influenced the decision to stay overnight in Coffin Bay or its adjacent areas is not known. Failure to incorporate this decision in the analysis may have biased the estimated marginal value of fish. Future research should attempt to integrate the decision to visit Coffin Bay and the decision to go fishing on a given day.

The study was restricted in its geographical coverage to Coffin Bay. Coffin Bay has unique attributes as a recreational fishing site. Also the restrictions applying to commercial netting are specific to the area. Additional research is required to determine if the results obtained for Coffin Bay are applicable in other areas before implementing policy changes.

The model developed in this paper does not contain a biological model describing the response of the fish stock to variations in commercial and recreational fishing effort. Consequently the results only relate to the conditions applying in the year in which the survey was undertaken (1990). An implicit assumption of the analysis is that the total commercial and recreational catch is sustainable. It is also assumed that a specified proportion of fish removed from the recreational fishery will be caught by commercial fishers. It is possible that variations in recreational fishing activity will not affect commercial catch rates. Under these conditions, a variation in the level of recreational fishing effort may not affect the cost curves and total catches of commercial fishers. More work is required to quantify the biological interactions between competing user groups in fisheries. Also the lack of a biological model precludes analysis of intertemporal effects, dependent on recruitment patterns and growth rates.

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