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Estimating values for recreational fishing at freshwater dams in Queensland*

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In this paper, estimates of value for recreational fishing are reported for three major freshwater impoundments in Queensland, Australia, using both travel cost and contingent valuation methods. Policy analysts often require estimates of value when analysing the importance of recreation against other uses of impoundments, or when considering the potential for further investments, such as with fish stocking programs. Different forms of the travel cost method are used to estimate separate consumer surpluses associated with two key subgroups of recreational anglers: frequent and occasional anglers. A contingent valuation study is used to estimate the marginal values associated with a potential improvement in fishing experience. The results of the travel cost analysis provide strong evidence that recreational values vary between different groups of anglers and across sites, while the contingent valuation estimates provide values for additional marginal benefits of recreational angling.

Key words: consumer surplus, contingent valuation method, recreational fishing, travel cost method.

1. Introduction

There are a limited, but growing number of studies evaluating the benefits of recreational fishing. Economists focus on methods that estimate consumer surplus (CS), because this provides estimates of benefits that are consistent with welfare measures (Willig 1976; Shrestha *et al*. 2002). Rosenberger and Loomis (2001) provide a review of non-market valuation studies conducted between 1967 and 1998 that estimate economic use values for recreational activities. They identify 39 studies involving fishing activities, all focused on North American case studies. In Australia and New Zealand, there are many fewer published studies. A revealed preference technique was used by Swait *et al*. (2004) to estimate values for recreational fishing in Western Australia, while Wheeler and Damania (2001) used the contingent valuation method (CVM) to estimate the recreational values of fishing in New Zealand.

There are three broad methodological approaches to estimate the value of recreational fishing activities (Haab and McConnell 2002). These include

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single-site demand models, site choice models and stated preference techniques. In the application of a single-site model, analysts use expenditure and other data revealed by angler activities to estimate a travel cost model, and hence, calculate estimates of CS. With a site-choice model, analysts use a random utility model (RUM) to identify how anglers make choices between several substitute sites. They can then generate utility models for the recreational site of interest. A third approach is to use stated preference techniques such as the CVM or the choice modelling (CM) technique to develop a relationship between a monetary tradeoff, site characteristics and the likelihood that an angler will state their preference for a particular site. Within each of these methodological groups, a choice of functional forms and modelling approaches is available to the analyst searching to understand or predict demand behaviour.

In this paper, estimates of value for recreational fishing are reported for three major freshwater impoundments in Queensland, Australia. There are several reasons why value information may be important to policy analysts. Many impoundments are constructed for agricultural and industry uses, and the value of consequential recreational benefits are rarely assessed, even though these may be an important component of total values. In some cases there may be tradeoffs between recreation outcomes and water extractions for industry, leading to information requirements about best-value use. Value information may also be required to justify investment in fish stocking programs and recreation facilities. A potential benefit of performing valuation studies is that results can be potentially transferred to other similar sites (Loomis 1992; Rosenberger and Loomis 2001).

The objectives of the study reported in this paper were to:

- estimate the average value of recreational fishing at each of the three dams in Queensland;
- specify these values across different user groups of recreational anglers: those who were repeat anglers at a dam and those who were single visitors (tourists); and
- estimate the marginal value of an improvement in catch rates at each of the three dams.

In the study, the travel cost method (TCM) was used to estimate separate consumer surpluses associated with the two groups of recreational anglers, and CVM was used to estimate the marginal values associated with a potential improvement in fishing experience. The TCM was chosen for this study because of its simplicity, the ease of data collection for the types of anglers involved, and the requirements to value individual sites rather than substitute sites. A RUM would have been harder to apply because a large proportion of the samples involved once-off visits, and there were problems in identifying substitute activities between different groups of visitors, especially tourists. The CVM was chosen as the stated preference technique because of the need to minimise survey complexity and the focus on simple tradeoffs between fish catch rates and price.

Heterogeneity among anglers can make model estimation more complex. It is normal to analyse the demand patterns of recreational users as a single group (Haab and McConnell 2002), but there have been studies that divide the sample into specific groups to generate more accurate models. Beal (1995) used one form of the TCM to estimate separately the demand for two groups of visitors to a national park in Australia, while Lupi *et al.* (1998) used RUMs to estimate demand for two subgroups of recreational anglers in Michigan. In a similar approach, Schuhmann and Schwabe (2004) use RUMs to estimate recreational fishing values for two separate groups of anglers in North Carolina: 'catch and release' anglers and 'catch and keep' anglers.

There are some recreational amenities that attract use from very different groups. An example in recreational fishing might be where one group comprises regular, repeat visitors, while another group are tourists with very different travel and recreational patterns. Where such a clear distinction between groups can be made, application of a standard TCM may be problematic, and it may be appropriate to model recreation demands specifically for each group. This issue is explored further in this paper using two different forms of the TCM.

There are a limited number of studies that use stated preference techniques to estimate marginal values for recreational fishing.[1] In the study by Wheeler and Damania (2001), anglers were asked whether they would still have gone fishing if their costs had been higher. Their results indicated that the average value of snapper (one of the fish species reported in the survey) was $30.85NZ per fish, while the marginal value was $5.73NZ per fish. Huang *et al.* (1997) used both TCM and CVM to estimate recreational values (including fishing), associated with improvements in environmental quality in the Pamlico Sound area in North Carolina. Azevedo *et al.* (2003) combined data from revealed preference and stated preference sources to estimate values for recreation demands for Iowa wetlands, including those associated with fishing. The advantage of using stated preference techniques is that the value of a potential change in condition can be assessed.

This paper is organised in the following way. The scope of the study and a brief overview of the data collection process are provided in the next section. The application and analysis of the TCM are outlined in section 3, while the results of the CVM study are reported in section 4. Discussion and conclusions are reported in the final section.

2. Scope of the study

Three large artificial water impoundments in Queensland were chosen for this study. They are the Boondooma Dam and the Bjelke-Petersen Dam in South-east Queensland, and the Fairbairn Dam in Central Queensland. The Boondooma Dam and the Bjelke-Petersen Dam are in the South Burnett region

[1] There are a larger number of studies that use stated preference techniques to estimate non-use values associated with fish populations, for example, Hanemann *et al.* (1991) and Loomis (1996).

(Wondai and Murgon shires, respectively), while the Fairbairn Dam is in the Central Highlands region (Emerald shire). The Fairbairn and the Bjelke-Petersen Dams largely service the agricultural sector, while the Boondooma Dam provides water to the Tarong Power Station. All of the dams are on or near major highways, meaning that access is not a limiting factor.

The three dams are useful case studies because each is associated with high levels of recreational fishing. Estimation of recreation values at these sites may allow benefit transfer to other fished impoundments in the state. There is no commercial fishing at the dams, although eels have been commercially fished at the Bjelke-Petersen and Boondooma Dams in the past. The dams are located away from major population centres, making it easier to identify visitor numbers. There are accommodation, service or tourist facilities at each dam, which help to service the recreational fishing industry, as well as other recreation activities.

There are also some differences between the dams, which may impact on recreational fishing levels. The Boondooma and Bjelke-Petersen Dams are closer to the major population centres of South-east Queensland, while the Fairbairn Dam is close to Emerald – an affluent regional centre. The Fairbairn Dam is also close to major inland highways (Gregory and Capricorn highways), and may be more accessible to passing visitors and tourists. Redclaw are a key fishing target at Fairbairn, while the other two dams are stocked almost exclusively with popular native fish. The Boondooma and Bjelke-Petersen Dams may possibly be viewed by anglers as substitutes, while the Fairbairn Dam has no comparable substitutes within several hundred kilometres.

There was little data available for the three dams about visitation rates or the economic values associated with recreational fishing. This meant that primary data had to be collected for the study. The data were collected by surveys at each of the dams over a one year period from November 2002 to November 2003. The sample of respondents for the surveys was selected from the actual anglers to the dams, by surveying available anglers within a 2 h time block selected randomly within regular periods. Surveys were collected on two days each week or fortnight, a weekday and a weekend day, but the actual day of collection and the daylight time block of collection were randomised. It was normal to survey angler groups who were shore fishing and those who returned to the boat ramp during the survey time period.

The survey that was collected had a limited number of questions so that it could be administered in a face-to-face setting without generating complexity or fatigue issues. The total number of surveys collected during the 12-month period was 264 at the Bjelke-Petersen Dam, 250 at the Boondooma Dam and 182 at the Fairbairn Dam. Data were collected from each visitor group on a number of variables[2] including:

[2] Data on individual respondent characteristics such as age, education and income were not collected because pre-tests showed that: it was difficult to collect in a group setting, it made the survey longer and more complex to administer and it reduced the willingness of anglers to participate.

- the number of people in the group,
- hours spent fishing on that day,
- place of residence (city and postcode),
- approximate distance travelled one-way,
- travel time in hours,
- trip cost for the entire group (travel costs, fishing costs for this trip, annual boat expenses),
- mode of travel,
- number of days planning to fish this trip,
- length of the total trip, and
- number of fishing trips to the dam and other places in a year.

Table 1 Summary statistics for all three dams

	Dam		
Statistics	Bjelke-Petersen	Boondooma	Fairbairn
Total number of surveys	264	250	182
Average group size	2.56	2.78	3.8
Average one-way distance travelled to reach dam (km)	239.56	239.55	701.28
Average time spent travelling (hours)	3.05	4.16	10.09
Average trip cost/group ($)	390.23	397.63	1252.8
Average fishing costs/group ($)	60.52	32.77	102.87
Average spending on boat/year ($)	201.43	278.27	301.97
Average number of days spent fishing at dam this trip (days)	6.52	7.03	8.55
Average length of the entire holiday (days)	10.06	7.4	53.22
Average number of visits to dam/year	5.23	6.51	3.14
Average number of total fishing trips/year	26.88	15.4	23.92

A CVM question was also included in the survey, where anglers were asked if they would be prepared to pay an additional fishing license fee for an improvement in catch rate. A summary of the trip and respondent data provided by anglers is shown in Table 1.

The average size of the groups that visited the dams was largest for Fairbairn (3.8 people) followed by Boondooma and Bjelke-Petersen. The average distance travelled one-way by anglers was the same for both the Bjelke-Petersen and Boondooma, while it was about three times greater for anglers to the Fairbairn Dam. Anglers visiting the Fairbairn also had greater trip, fishing and boating costs than anglers visiting the other two dams. Anglers at the Fairbairn Dam spent only 16 per cent of their total holiday fishing at the dam, while anglers visiting the Bjelke-Petersen and Boondooma Dams spent 65 per cent and 95 per cent of their holiday, respectively, fishing at the dams.

3. Application of the travel cost models

Recreational demand models based on the TCM have been widely used to estimate the economic use values of recreational activities (Garrod and Willis 1999; Ward and Beal 2000; Haab and McConnell 2002). The TCM involves the use of observed travel patterns and costs of travel incurred by recreational users to first derive a model of travel behaviour (the trip generation function (TGF)). In the second stage, a demand function for the recreational good is estimated by simulating from the TGF a relationship between additional entry fees and the number of estimated visits. In the third stage of analysis, the economic benefit CS associated with the travel behaviour can then be estimated from the demand function.

The TCM has two basic variants depending on the definition of the dependent variable (Ward and Beal 2000). These are the zonal travel cost model (ZTCM) and the individual travel cost model (ITCM). In the ZTCM, the dependent variable is the number of visits made from a particular zone, over a specific period of time, divided by the population of that zone. In the ITCM, the dependent variable is simply the number of visits to a site made by each visitor over a specific period of time. The ITCM is appropriate for sites that have high individual visitation rates and the ZTCM is appropriate for sites that have very low individual visitation patterns (Bateman 1993; Bennett 1996).

The application of a travel cost model involves the specification of a number of assumptions about factors such as the identification of the dependent variable, the measurement of travel costs, the specification and measurement of other independent variables, the specification of the function form for both the TGF and the demand function, and the appropriate integration procedure to calculate estimates of CS (Ward and Beal 2000; Haab and McConnell 2002). Here, some of the assumptions underlying the analysis reported in this paper are outlined in more detail.

A key issue is whether the recreation users should be analysed as a single group or split into subgroups. In this study, initial attempts to fit either an ITCM or a ZTCM model to the three data sets were unsuccessful, as robust models could not be developed. The poor model fits that resulted suggested that some confounding effects might be being caused by underlying heterogeneity. To address this, the data set for each dam was divided into two groups – frequent anglers and occasional anglers. Frequent anglers (423 in total) were those who fished at a dam more than once a year and occasional anglers (273 in total) were those who fished at a dam only once a year. It is possible that occasional anglers are part of the tourist market, and have very different visitation and expenditure patterns compared to dedicated anglers. The t-tests on the pooled data set revealed that there was a significant difference between the two angler groups by a number of variables including *travel costs* (t-statistic = 5.544 with 287 d.f.), *distance travelled* (t-statistic = 8.442 with 321 d.f.), *days spent fishing* (t-statistic = 4.267 with 448 d.f.), *length of holiday* (t-statistic = 6.241 with 314 d.f.) and *number of people in group* (t-statistic = 2.015 with 429 d.f.).

Summary statistics for each key variable that distinguished the groups are reported in Table 2. Recreation demands for the two groups of anglers were analysed separately. The frequent anglers were analysed using the ITCM because the individual anglers in this group had high visitation rates. The occasional anglers group was analysed using the ZTCM because there was no variation in individual visitation rates for anglers in this group.

Table 2 Annual visits

Variable	Type of angler Occasional	Frequent
Travel costs ($)	1116	397
One-way distance travelled (km)	578	220
Days spent fishing	9.19	5.83
Length of holiday (days)	37.14	8.56
Number of people in group	3.21	2.81

The use of ZTCM for occasional anglers leads to another issue that needs to be resolved, namely the identification of zones. It is common for the zones to be based on population groupings like postcode areas or statistical divisions (Stoeckl 1994 quoted in Driml 2002). Zones can be identified on the basis of postcode clusters which contain approximately equal populations (Lockwood and Tracy 1995). They can also be identified based on statistical divisions which could be aggregated according to their approximate distance from the site (Beal 1995). The zones for this study were identified on the basis of statistical divisions given by the Australian Bureau of Statistics (ABS), with the population for each zone calculated from the 2001 ABS census data. Since the two southern dams (Bjelke-Petersen Dam and Boondooma Dam) are close together, the zones identified for these two dams are the same, while the ZTCM for the Fairbairn Dam involves some different zones.

There are three ways in which the travel costs could be estimated (Bateman 1993; Bennett 1996). They can be estimated either by considering only petrol costs, by considering full car costs as a rate of distance travelled or by considering the perceived costs as estimated by the respondents. There is little consensus in the literature about the correct method of estimating travel costs. Bateman (1993) and Bennett (1996) argue that the most appropriate form of travel costs is to use the perceived costs as estimated by the recreation users. This is the approach adopted in this study for both the ITCM and the ZTCM components.

It is also possible to include time spent travelling as a part of the travel costs. The opportunity cost of time is the value of the next best alternative activity during the time spent travelling to and from a recreation site (Ward and Beal 2000). However, for many people the number of work hours is fixed and the traditional definition of opportunity cost of time is not as relevant. This is because individuals may travel for leisure and recreation during holidays or non-work time when there is no loss of income (Ward and Beal 2000). Following this view the opportunity cost of time for travel has been assumed to be zero in this study. The time spent on-site has also been assumed to have zero opportunity cost, on the basis that the marginal utility derived from time spent on site would be equal to that derived from alternate activities (Whitten and Bennett 2002).

For this study, the value of the travel cost (TC) variable for both the ITCM and the ZTCM models was calculated by use of the following formula, where each of the cost variables was calculated from data reported by the anglers:

$$\text{TC} = \text{trip cost} + \text{fishing cost} + \left(\frac{\text{annual boat expenses}}{\text{number of annual fishing trips}}\right). \quad (1)$$

Other methodological issues relate to incidents of multipurpose and multi-destination trips. Where a visit to a site is not the sole purpose of the trip, the costs should be allocated between the different activities undertaken along the way (Casey *et al*. 1995; Bennett 1996; Whitten and Bennett 2002). In practice, the data for this is difficult to collect. Issues relating to multipurpose and multi-destination trips were addressed by asking the anglers to rate the importance of fishing activities in their trip and to identify the number of days fishing and the total trip duration. The data collected meant that the estimates of CS could be adjusted *ex post* to apportion out some allowance for trips that were conducted for non-fishing purposes.

3.1 Analysis of frequent anglers

The first step in the analysis was to estimate a TGF that related the individual visit rate against the cost of travel and other independent variables. An analysis of the data indicated that travel cost was the only independent variable with significant explanatory power in the models. The other variables (expected catch, average catch, annual boat expenses and the importance of fishing in this trip) that were tested in the model were not significant. There are a variety of potential reasons why these variables may not have been significant. One possibility is that it is the outdoors activity experience that is important rather than actually catching fish. The functional forms tested were the linear, semi log dependent, semi log independent and double log models. The double log model (Equation (2)) was the most appropriate functional form for the analysis.

$$\log(\text{visits}) = a + b \log(\text{travel cost}). \quad (2)$$

The TGF regression statistics for the frequent angler subgroup at the three dams are given below in Table 3. The *F*-test statistics indicate that each model is significant, while the R^2 statistic ranges from 0.26 to 0.46.

The TGF equations used to generate the data for the demand curve for the three dams are therefore:

$$\text{Bielke-Petersen: } \log(\text{visit rate}) = 4.471 - 0.531 \log(\text{travel cost}) \quad (3)$$

$$\text{Boondooma: } \log(\text{visit rate}) = 4.4329 - 0.477 \log(\text{travel cost}) \quad (4)$$

$$\text{Fairbairn: } \log(\text{visit rate}) = 3.578 - 0.392 \log(\text{travel cost}). \quad (5)$$

Table 3 ITCM–TGF regression statistics

Dam	Number of anglers	Coefficients: Constant (*t*-statistic)	Coefficients: Log travel costs (*t*-statistic)	Test statistics: R^2	Test statistics: *F* (*P*-value)
Bjelke-Petersen	175	4.471 (18.417)	–0.531 (–12.228)	0.46	149.529 (0.00)
Boondooma	178	4.329 (12.775)	–0.477 (–7.925)	0.26	62.805 (0.00)
Fairbairn	70	3.578 (10.966)	–0.392 (–6.621)	0.39	43.833 (0.00)

To estimate the demand functions, travel costs were increased by a hypothetical fee and sequentially added to the average cost for each group. Estimates were made of the visitation rates under these additional cost circumstances and the total expected number of visits at each travel cost computed. This comprises the data for estimation of the demand equation for visits to the three dams, where price was regressed against quantity and other explanatory variables using a variety of functional forms.

The semi log independent functional form of the demand model generated the highest R^2 values, and was chosen as the preferred functional form for demand analysis. The demand equations for the dams for frequent anglers were estimated as follows:

$$\text{Bjelke-Petersen: price} = 20\,064 - 3179.16\ \log(\text{visits}) \tag{6}$$

$$\text{Boondooma: price} = 23\,766 - 3653.82\ \log(\text{visits}) \tag{7}$$

$$\text{Fairbairn: price} = 22\,662 - 4209.38\ \log(\text{visits}). \tag{8}$$

The CS can be estimated as the area under the demand curve up to some limit. To find the CS per group for each dam, the demand curve was integrated from zero to the average number of visits per dam, following the recommendations of Garrod and Willis (1999). A convolutions approach was used to estimate 95 per cent confidence intervals (CI) for those CS amounts (the CIs estimated do not include any variance for expected visitor numbers). The total consumer surpluses of the sample, per group and per individual, together with confidence intervals, are given in Table 4. Since the confidence intervals for CS per group or per person do not overlap, the values of recreational fishing appear to be unique to each individual dam.

The expected number of groups visiting each dam on multiple trips each year can be derived from the sample data and is also shown in Table 4. This has allowed estimates to be made of the total CS available from the groups of recreational anglers making multiple visits to the dams each year.

Table 4 ITCM–consumer surplus

Dam	Bjelke-Petersen	Boondooma	Fairbairn
CS for total sample ($)†	95 088 (86 444–103 596)	170 578 (156 555–184 759)	124 341 (112 511–135 314)
No. of groups	175	178	70
CS per group ($)†	543.36 (493.97–591.98)	958.30 (879.52–1037.98)	1776.30 (1607.30–1945.30)
Average group size	2.46	2.67	4.03
CS per person ($)†	220.88 (200.8–240.64)	358.92 (329.41–388.75)	440.77 (398.83–479.67)
Expected groups/year	1666	2332	624
Total expected CS ($)†	905 237 (822 954–986 238)	2234 756 (2 051 040–2420 569)	1 108 411 (1 002 955–1213 867)

Note: CS, consumer surplus. †, 95% confidence interval.

3.2 Analysis of occasional anglers

The ZTCM model was applied to all the survey responses where participants indicated that they were only making a single trip to the dam within the 12-month period. In this case the key relationship is expected to be between the travel costs incurred and the proportion of the zonal population that is visiting the dam. It is expected that as travel costs increase, the proportion of zonal population visiting the site will decrease.

The travel costs were calculated using the formula in Equation (1) and ABS data were used to estimate populations for the relevant zones. The only other variable used in the zonal model was the average zonal weekly income, also drawn from ABS 2001 census data. A number of other variables (expected catch, average catch, and annual boat expenses and the importance of fishing in this trip) were tested but did not emerge as significant in the models. As for the ITCM, the functional forms that were tested were the linear, semi log dependent, semi log independent and double log models. The TGF for the zonal model was calculated using the double log functional form (Equation (9)), and the regression statistics are given in Table 5.

$$\log V = a + b \log(\mathrm{TC}) + c \text{ income}. \tag{9}$$

The F-test statistic indicates that each model is highly significant. The R^2 statistic indicates that a very high proportion of variation in the log of visit rate is explained by the variables. The TGF equations used to generate the data for the demand curve for the three dams are:

$$\text{Bjelke-Petersen: } \log(\text{visit rate}) = 11.391 - 2.086 \log(\text{travel cost}) - 0.013 \text{ income} \tag{10}$$

$$\text{Boondooma: } \log(\text{visit rate}) = 8.135 - 1.670 \log(\text{travel cost}) - 0.011 \text{ income} \tag{11}$$

$$\text{Fairbairn: } \log(\text{visit rate}) = -4.479 - 1.227 \log(\text{travel cost}) + 0.002 \text{ income}. \tag{12}$$

Table 5 ZTCM–TGF regression statistics

Dam	Number of respondents	Coefficients: Constant (t-statistic)	Travel cost (t-statistic)	Income (t-statistic)	Test statistics: R^2	F (P-value)
Bjelke-Petersen	89	11.391 (7.832)	–2.086 (–8.036)	–0.013 (–11.057)	0.99	120.774 (0.008)
Boondooma	72	8.135 (8.000)	–1.670 (–8.788)	–0.011 (–10.808)	0.99	163.601 (0.006)
Fairbairn†	112	–4.479 (–1.724)	–1.227 (–10.169)	0.002 (0.482)	0.98	58.488 (0.001)

Note: †Income is not significant in this model. ZTCM, zonal travel cost model; TGF, trip generation function.

Table 6 ZTCM–consumer surplus

	Dams: Bjelke-Petersen	Boondooma	Fairbairn
Sample ($)†	23 932 (12 888–34 083)	75 211 (53 748–96 886)	2 395 923 (1 400 258–2 805 482)
Group ($)†	295.46 (159.11–420.78)	1059.31 (757.01–1364.59)	21 392.17 12 502.30–25 048.95)
Person ($)†	92.04 (49.57–131.08)	366.54 (261.94–472.18)	5629.52 (3290.08–6591.83)

Note: †, 95% confidence interval. ZTCM, zonal travel cost model.

To estimate the demand function, the travel costs were increased by a hypothetical fee and sequentially added to the average cost for each person. Estimates were then made of the visitation rates under these additional cost circumstances, allowing the subsequent estimation of the demand equations for visits to the three dams. The semi log independent functional form of the demand model generated the highest R^2 values, and was chosen as the preferred functional form for demand analysis. The demand equations for the dams for occasional anglers were estimated as follows:

$$\text{Bjelke-Petersen: price} = 1755.55 - 439.08\ \log(\text{visits}) \tag{13}$$

$$\text{Boondooma: price} = 5110.57 - 1246.49\ \log(\text{visits}) \tag{14}$$

$$\text{Fairbairn: price} = 79\,762.51 - 15\,905.17\ \log(\text{visits}). \tag{15}$$

The appropriate CS amount for the ZTCM is the area under the demand function. This has been calculated for each of the dams using a simulation approach, where values are calculated for each potential catch rate over the relevant range and summed. The expected CS for the sample, average group and average angler are given in Table 6.

Table 7 ZTCM–consumer surplus after partition

Dam	Bjelke-Petersen	Boondooma	Fairbairn
Total sample	15 510.60 (8352.86–22 089.58)	71 450.45 (51 060.6–92 041.7)	384 914.35 (224 956.89–450 711.59)
Per group ($)†	191.49 (103.12–272.71)	1006.34 (719.16–1296.36)	3436.74 (2008.54–4024.21)
Per person ($)†	59.65 (32.13–84.96)	348.22 (248.85–448.57)	904.40 (528.56–1059)
Expected groups/year	847	949	998
Total ($)†	162 191.09 (87 344.09–230 986.09)	955 020.80 (682 486.05–1 230 247.51)	3 429 861.79 (2 004 526.61–4 016 162.25)

Note: †, 95% confidence interval. ZTCM, zonal travel cost model.

The CS estimates are based on the travel costs for the entire trip, so may potentially over-estimate values of recreational fishing when multipurpose and multi-destination issues are considered. This is particularly an issue for the anglers at Fairbairn, where the individual values of $5630 per trip typically involve a much longer holiday than just the day's fishing at the dam (e.g. tourists travelling around Australia). To obtain a more realistic estimate of the value of recreational fishing the CS figures can be partitioned.

It would be possible to do this in two different ways. The first is to partition values according to the purpose of the trip; this could be done with reference to answers about the *importance of fishing* to the visitors. The 'importance of fishing' variable was not significant in the models, so no attempt was made to partition values to allow for variations in trip quality. The second option is to partition according to the proportional length of the fishing trip using the ratio of the number of days spent fishing against total trip days. The second option takes into account both multipurpose and multi-destination trips and has been selected as the more appropriate method. It allows for recreational values of people on longer holidays to be apportioned in some way between the visit to the dam in question and the remainder of the holiday. In cases where the fishing section was the highlight of a holiday trip, this method of partitioning values may have resulted in over-correction.

The CS estimates calculated using these ratios are given in Table 7, and indicate that individual consumer surpluses ranges from approximately $59 per angler at the Bjelke-Petersen Dam to $904 per angler at the Fairbairn Dam. There is a significant difference in CS estimates between each of the three dams.

These CS estimates can be extrapolated over the estimated number of groups making single visits to the dams each year to calculate total CS over a one year period (Table 7). Total estimates of CS were generated by adding the estimates for the repeat anglers to the estimates of the single trip anglers (Table 8 and Figure 1). The confidence intervals for the aggregate results indicate that there is no significant difference between the CS estimates for

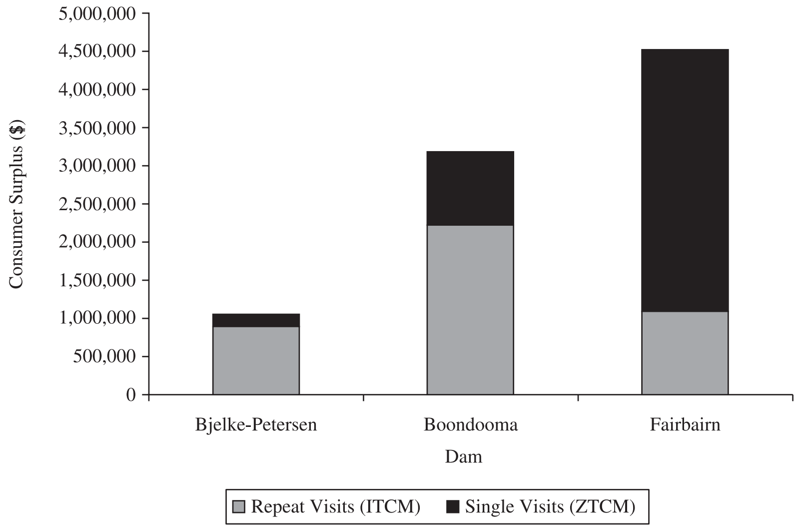

Figure 1 Total consumer surplus.

Table 8 Total consumer surplus

Expected consumer surplus†	Dam		
	Bjelke-Petersen	Boondooma	Fairbairn
Frequent anglers ($)	905 237 (822 954–986 238)	2 234 756 (2 051 040–2 420 569)	1 108 411 (1 002 955–1 213 867)
Occasional anglers ($)	162 191 (87 344–230 986)	955 020 (682 486–1 230 247)	3 429 861 (2 004 526–4 016 162)
Total ($)	1 067 428 (910 298–1 217 224)	3 189 777 (2 733 526–3 650 817)	4 538 273.00 (3 007 482–5 230 029)

Note: †, 95% confidence interval.

the Boondooma and Fairbairn Dams, but that the CS for the Bjelke-Petersen Dam was significantly lower than for the other two dams.

4. Application of the contingent valuation model

The CVM involves the presentation of hypothetical scenarios to respondents in a survey format, where the scenario involves some trade off between the amount of a recreational amenity or environmental good and a monetary attribute (Mitchell and Carson 1989; Haab and McConnell 2002). By collecting a number of responses to these tradeoffs where there is some variation in the price and/or quantities of the good involved, a demand function can be estimated. There are a variety of formats in which the tradeoffs can be presented in CVM, as well as a number of approaches in performing the statistical analysis (Mitchell and Carson 1989; Haab and McConnell 2002).

In designing a CV experiment, it is important that the tradeoffs and scenarios being presented to people are realistic, that a suitable payment vehicle is used, that the survey instrument and collection method do not cause bias, and that a representative sample is taken from the relevant population (Mitchell and Carson 1989; Hanemann 1994). The contingent valuation section of the survey was designed with these goals in mind. The CVM employed was a single bounded, dichotomous choice format. This meant that only the one CVM question was asked of each respondent at a specified price tradeoff, but several price tradeoffs were used across groups of respondents.

The survey was structured in a similar way to that employed by Wheeler and Damania (2001). Anglers were first asked about their visitation patterns, their trip details, their travel and fishing costs, and their catch rates. They were then asked if they would be prepared to pay additional fees in order to improve their fishing experience – defined as a 20 per cent increase in catch rate. This tradeoff was framed slightly differently to the approach used by Wheeler and Damania (2001). A different payment vehicle was used in this study, and the recreation benefit offered was an improvement in fishing experience rather than the existing trip.

The payment vehicle chosen for the CVM application was a fishing licence fee (Fairbairn) or increased fishing licence fees (Boondooma and Bjelke-Petersen). Throughout Queensland there are 29 dams where anglers require a fishing licence (stocked impoundment permit of \$35 annually or \$7 weekly) to fish (excluding redclaw). Anglers at both Boondooma and Bjelke-Petersen Dams require the licence whilst anglers at Fairbairn Dam do not. The permit program is administered by the Queensland Government with the majority of funds collected being returned to the associated fish stocking groups.

The scenario used in the survey was appropriate to the anglers, because many of them indicated in responses or comments to the survey collectors that they would prefer higher catch rates. The licence fee program provided an appropriate payment vehicle for use in the survey, because it was already in existence, and anglers could see a clear linkage between the payments and potential management actions such as fish stocking programs. A clear statement that the proposal was hypothetical was designed to minimise any potential for protest bids.

There were two potential weaknesses with the survey format when compared to the widely accepted standards for implementation (Arrow *et al*. 1993; Portney 1994). First, there were no reminders of substitute goods and budget constraints because of limitations on space. However, because respondents had already detailed in the survey their travel and fishing costs, and annual pattern of fishing, these reminders should not have been necessary. Second, a statement was added to the CV question to make it clear that the scenario was a hypothetical one so that the nominated payment levels would not be confused with actual government policy. This is at odds with recommended CV design where the focus is on making tradeoffs as believable as possible. Given the relevance of the issue to anglers, and their location at the fishing site, it is unlikely that this clarifying statement would have induced substantial amounts of hypothetical bias. However,

Table 9 Summary of responses to contingent valuation question

	Dam						
	Bjelke-Petersen		Boondooma		Fairbairn		
Increases in fees	Yes	No	Yes	No	Yes	No	Permit only for Fairbairn Dam
$1 weekly or $5 annually	53	1	48	2	33	2	$5 weekly permit
$2 weekly or $10 annually	52	2	49	2	23	8	$10 weekly permit
$3 weekly or $15 annually	47	3	45	0	21	12	$15 weekly permit
$4 weekly or $20 annually	44	6	49	1	21	25	$20 weekly permit
$5 weekly or $25 annually	40	11	50	3	14	19	$25 weekly permit
Subtotal	236	23	241	8	112	66	
Maybe	2		0		1		
Missing	3		1		3		
Total	264		250		182		

Table 10 Logistic regression model for pooled contingent valuation method responses

Variables	B	S.E.	Wald	d.f.	Signif.
Distance in one-way trip	0.002	0.001	5.864	1	0.015
Total fish kept	–0.010	0.004	6.547	1	0.011
Bid level	–0.148	0.032	20.934	1	0.000
Boondooma	3.559	0.599	35.283	1	0.000
Fairbairn	2.223	0.423	27.653	1	0.000
Constant	2.560	0.661	15.015	1	0.000
Model statistics					
χ^2 (5 d.f.)			110.023		
–2 log likelihood			97.102		
R^2			0.230		

there remains the possibility that the combined effects of these weaknesses may have led respondents to overstate their true willingness to pay.

In the CVM dichotomous choice format, responses are ascertained for different price tradeoffs. Five different fee levels were used at random in each survey. An example of the question used from the Fairbairn survey is shown below:

> **Q20**: A fish stocking program and better monitoring could improve the amount of fish that people could catch at the dam by about 20 per cent. The program could be paid for by charging people for weekly fishing permits. (*The next question is hypothetical – there is no current intention to impose weekly permits*).
>
> If the price for a weekly permit was $5, and your catch rate improved by 20 per cent, would you still come fishing to Fairbairn Dam?
>
> YES ☐ NO ☐

A summary of the data received from the question is outlined in Table 9. To produce a useful model, the data set was pooled across the three dams and both groups of anglers, and a logistic regression equation estimated. Results are reported in Table 10. The model is significant, has strong explanatory power,

Table 11 Predictions of willingness to pay for 20% improvement in fishing experience

Dam	Bjelke-Petersen	Boondooma	Fairbairn
Mean willingness to pay ($)	19.02	43.03	36.45
Groups per year	2513	3275	1622
Average group size	2.56	2.78	3.8
Total value per year ($)	122 360.99	391 766.64	224 663.22

and several variables apart from price are significant explanators of choice. The results indicate that the willingness of anglers to pay higher fees was lower if they had caught and kept more fish. This is a similar result to the model reported by Wheeler and Damania (2001), confirming that there appears to be diminishing marginal returns associated with catching more fish.

The coefficient for 'distance' in the model indicated that anglers were more inclined to pay the higher fees if they had travelled further to reach the dam. The model also indicates that anglers at Boondooma had higher values for the fishing experience than at the other two sites, and anglers at Fairbairn had higher values than those at Bjelke-Petersen.

The model allowed the following equation to be generated.

$$\begin{aligned}\log\left[\frac{(\text{prob. of yes})}{(1-\text{prob. of yes})}\right] &= 2.56 + 0.002\times(\text{distance}) - 0.01\times(\text{no. of fish kept}) \\ &\quad - 0.148\times(\text{bid level}) + 3.559\times(1\text{ if Boondooma}) \\ &\quad + 2.223\times(1\text{ if Fairbairn}). \qquad (5.1)\end{aligned}$$

The average figures for distance and fish kept for each dam were substituted into the regression equation to generate estimates of the mean willingness to pay per angler for a 20 per cent improvement in catch. These were then multiplied by the estimated number of people fishing at each dam on an annual basis to generate the appropriate value estimates. These are reported in Table 11. The results show that the value of improving catch rates by 20 per cent per annum at each dam are estimated to be \$0.12 M for Bjelke-Petersen, \$0.39 M for Boondooma, and \$0.22 M for Fairbairn.

5. Conclusions

The research reported in this paper has involved the valuation of recreational fishing at three freshwater impoundments in Queensland, Australia. The value of existing usage has been estimated for two groups of anglers using travel cost models, while the value of potential improvements to fishing experience has been estimated with the CVM. The results allow four broad conclusions to be drawn.

First, the results of the travel cost analysis provide strong evidence that recreational values vary in these case studies between two different groups of anglers: regular visitors to the sites, and single trip visitors (tourists). Second, the results demonstrate that the value of recreational fishing varied across sites. It is possible that the lower values recorded for fishing at the Bjelke-Petersen Dam reflected a substitution effect with the nearby Boondooma Dam, while the higher values for the Fairbairn Dam reflect its major proximity to tourism traffic. Further work is needed to identify the reasons for other variations in values. These results suggest that the transfer of recreational fishing values between population groups and sites may be complex. The third conclusion to be noted is there appears to be declining marginal values associated with catching additional fish, indicating that the benefits of improving the fishing experience may be limited.

A fourth conclusion is that different non-market valuation techniques may be appropriate for different components of a valuation exercise. In this study, ZTCMs were used to assess benefits accruing to single trip anglers, ITCMs were used for multiple trip anglers, and a stated preference technique used to assess values for potential improvements in fishing experience. TCM and CVM applications can also be designed to value quality changes such as fish catch rates and recreational experiences, and to capture heterogeneity across individuals and sites. The results of this study illustrate some of the potential for these types of applications to occur.

References

Arrow, K., Solow, R., Portney, P., Leaner, E., Radner, R. and Schuman, H. (1993). Report of the NOAA Panel on contingent valuation, *Federal Register* 58, 4601–4614.

Azevedo, C.D., Herriges, J.A. and Kling, C.L. (2003). Combining revealed and stated preferences: consistency tests and their interpretations, *American Journal of Agricultural Economics* 85, 525–537.

Bateman, I.J. (1993). Valuation of the environment methods and techniques: revealed preference methods, in Turner R.K. (ed.), *Sustainable Environmental Economics and Management*. Belhaven Press, London, pp. 192–233.

Beal, D.J. (1995). A travel cost analysis of the value of carnarvon Gorge National Park for recreational use, *Review of Marketing and Agricultural Economics* 63, 292–303.

Bennett, J. (1996). Estimating the recreational use values of national parks, *Tourism Economics* 2, 303–320.

Casey, J.F., Vukina, T. and Danielson, L.E. (1995). The economic value of hiking: further on opportunity cost of time in recreational demand models, *Journal of Agricultural and Applied Economics* 27, 658–668.

Driml, S. (2002). Travel cost analysis of recreational value in the wet tropics world heritage area, *Economic Analysis and Policy* 32, 11–26.

Garrod, G. and Willis, K.G. (1999). *Economic Valuation of the Environment*. Edward Elgar, UK.

Haab, T.C. and McConnell, K.E. (2002). *Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation*. Edward Elgar, Cheltenham, UK.

Hanemann, W.M., Loomis, J. and Kanninen, B. (1991). Statistical efficiency of double bounded dichotomous choice contingent valuation, *American Journal of Agricultural Economics* 73, 1255–1263.

Hanemann, W.M. (1994). Valuing the environment through contingent valuation, *Journal of Economic Perspectives* 8, 19–43.

Huang, J., Haab, T.C. and Whitehead, J. (1997). Willingness to pay for quality improvements: should revealed and stated preference data be combined? *Journal of Environmental Economics and Management* 34, 240–255.

Lockwood, M. and Tracy, K. (1995). Nonmarket economic valuation of an urban recreation park, *Journal of Leisure Research* 27, 155.

Loomis, J. (1992). The evolution of a more rigorous approach to benefit transfer: benefit function transfer, *Water Resources Research* 28, 701–705.

Loomis, J. (1996). Measuring the economic benefits of removing dams and restoring the Elwha River: Results of a contingent valuation survey, *Water Resources Research* 32, 441–447.

Lupi, F., Hoehn, J.P., Chen, H.Z. and Tomasi, T.D. (1998). The Michigan recreational angling demand model, *Staff Paper Number 97-58*, Department of Agricultural Economics, Michigan State University.

Mitchell, R.C. and Carson, R.T. (1989). *Using Surveys to Value Public Goods: the Contingent Valuation Method*. Resources for the Future, Washington.

Portney, P.R. (1994). The contingent valuation debate: why economists should care, *Journal of Economic Perspectives* 8, 3–17.

Rosenberger, R. and Loomis, J. (2001). *Benefit Transfer of Outdoor Recreation Use Values: A Technical Document Supporting the Forest Service Strategic Plan (2000 Revision)*, General technical report, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Schuhmann, P.W. and Schwabe, K.A. (2004). An analysis of congestion measures and heterogeneous angler preferences in a random utility model of recreational fishing, *Environmental and Resource Economics* 27, 429–450.

Shrestha, R.K., Seidl, A.F. and Moraes, A.S. (2002). Value of recreational fishing in the Brazilian Pantanal: a travel cost analysis using count data models, *Ecological Economics* 42, 289–299.

Stoeckl, N. (1994). A travel cost analysis of Hinchinbrook Island National Park, *Tourism Research National Conference*, Gold Coast, Australia.

Swait, J., Adamowicz, V. and van Bueren, M. (2004). Choice and temporal welfare impacts: incorporating history into discrete choice models, *Journal of Environmental Economics and Management* 47, 94–116.

Ward, F.A. and Beal, D. (2000). *Valuing Nature with Travel Cost Models A Manual*. Edward Elgar, Cheltenham, UK.

Wheeler, S. and Damania, R. (2001). Valuing New Zealand recreational fishing and an assessment of the validity of the contingent valuation estimates, *Australian Journal of Agricultural and Resource Economics* 45, 599–621.

Whitten, S.M. and Bennett, J.W. (2002). A travel cost study of duck hunting in the upper south east of South Australia, *Australian Geographer* 33, 207–221.

Willig, R.D. (1976). Consumer surplus without apology, *American Economic Review* 66, 589–597.