Economic valuation of recreational fishing in Western Australia

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23 February 2010
Working Paper 1001
School of Agricultural and Resource Economics
http://www.are.uwa.edu.au

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Citation: Raguragavan, J., Hailu, A. and Burton, M. (2010) *Economic valuation of recreational fishing in Western Australia*, Working Paper 1001, School of Agricultural and Resource Economics, University of Western Australia, Crawley, Australia. *Contact authors for a revised version of the paper.*

Abstract
Allocation of fish resource is a controversial subject. Decision making is partly made difficult by the lack of knowledge on recreational fishing preferences and the value of fishing opportunities. This study investigates fishing site choices in Western Australia. Recreational fishing data covering the eight major fishing regions and fourty eight fishing sites in the State are used. The data are used to estimate a random utility model (RUM) of site choice behaviour with a supporting negative binomial econometric model of angler- and fish-specific expected catch rates. We provide value estimates for different fish types, fishing site attribute changes as well as site access values. It is argued that sound economic value estimates can be starkly different from ad hoc recreational estimates that are commonly cited or presented.

Key words: non-market valuation, recreational fishing, random utility models, fisheries management, marine environment management.

1. Introduction

Management of marine resources involves difficult decisions. One of the most difficult elements in this process is the management of recreational fishing. In the case of Western Australia, for example, the State government has recently introduced changes to recreational license fees, penalty levels and seasonal limits for some fishing regions. The controversy that accompanied these changes highlights the degree to which sensible decision making is hampered by the lack of information about the value of recreational fishing[1]. Different groups will provide estimates of values but these values tend to be estimates based on some direct but inappropriate monetary transactions values (e.g. angler expenditures). What is lacking, however, is information on the economic surplus generated by recreational fishing opportunities.

Unlike for commercial fishing, the benefits (or economic surplus) from recreational fishing cannot be directly observed in market transactions. The benefits are non-market values. These values represent the value that anglers attach to recreational fishing opportunities or the fishing experience. In other words, these values are indications of the economic surplus that anglers derive from the experience of fishing over and above the costs they incur in undertaking the activity. As a result, these values can only be estimated indirectly using econometrically estimated recreational demand models.

Recreation demand models serve two main purposes. First, they predict demand for recreational activities and recreational site choices. For example, recreational fishing

[1] See The Sunday Times, 11 October 2009.

models focus on an angler's demand for fishing trips and determinants of fishing site choices. Specifically, the models relate an angler's decisions to the characteristics of available sites (e.g. availability of fish, distance, etc.), personal characteristics of the angler (e.g. experience, age, gender, income etc.), and, possibly, other influences (e.g. weather). Second, the models provide a basis for estimating the utility of fish and site attributes and, therefore, the basis for working out the value (or willingness to pay) for these resources. Willingness to pay estimates can be generated for individual or combinations of site attributes as well as for site access opportunities. In sum, these empirical models provide a wealth of information that resource managers rarely have but is information that is vital to improving decision making.

Recreational fishing in WA is a major social activity involving about 34 per cent of the population, and contributes more than $500 million per annum to the economy of Western Australia (Recfishwest 2008; Fisheries Western Australia 2000). The importance of recreational fishing in the State started to become clearer only after 1997 when the Department of Fisheries WA began collecting information on fishing effort and catches through surveys. The recent rapid increase in recreational fishing demand together with the noticeable depletion of some species highlight the need for managing the impact of recreational fishing along with those from commercial fishing. However, while the economic value and management strategies of commercial fishing are well established, little information is available about the value of recreational fishing in the State. Currently, the precautionary approach (Fisheries Western Australia 2000) is used to manage recreational fishing. However, this approach can no longer cope with the increased demand. Non-market valuation studies are needed to estimate values on recreational fishing enabling resource managers to consider trade-off in fish allocation and make better decisions.

To date, there have been very few recreational fishing studies focusing on Western Australia (Swait *et al*. 2004; Zhang, 2003; van Bueren 1999). Further, previous studies have focused on a limited number of fishing sites. There have been no studies that take into account the variability in fishing opportunities across the State. Most of the published recreational fishing literature has focused on the US or Europe (Lew and Larson 2005; Navrud 1999; Adamowicz 1994; Morey *et al.* 1991; Walsh *et al*. 1992; Wegge *et al*. 1986). These studies clearly show that site values vary greatly, depending on location as well as site and angler characteristics. Per trip recreational fishing value estimates provided by previous studies vary greatly, ranging from as little as US$0.20 to US$146 per trip.

This study is the first investigation into recreational fishing covering all the major fishing regions in Western Australia. Eight major fishing regions and 48 fishing sub-regions, stretching along the coast from Esperance in the south to the Kimberley in the north, are included. Data from the 2000/2001 National Survey of Recreation Fishing (NSRF) (Fisheries Western Australia 2002; Henry 2001) is used to econometrically estimate a random utility model (RUM) that enables us to predict fishing choice behaviour and the economic welfare impacts of management changes.

The paper is organized as follows. Section 2 presents a brief review of the literature on the valuation of recreational fishing. This is followed by a discussion of the modelling framework used in this study. This framework includes a negative binomial fish catch rate model and a random utility model of site choice. The RUM model includes as one of its variables the expected catch rates predicted by the negative binomial model. Section 4 describes the data and their sources. The econometric estimation results are presented in Section 5. Welfare measures of site attribute and site access changes are also presented in the section. The paper is summarized and some management implications drawn in Section 6.

2. Review of the recreational fishing literature

In the valuation literature, the application of random utility modelling (RUM) techniques to estimate the economic value of recreational resources has become a standard approach. To save space, we will focus our review of the literature mainly on studies that use this technique. There have been numerous studies conducted in the United States, Canada as well as European countries (Lew and Larson 2005; Navrud 1999; Adamowicz 1994; Walsh *et al*. 1992). These studies are reviewed in several papers. Loomis *et al*. (1999) reviews 109 consumer surplus studies of recreation in the US that employ RUM and other models. A detailed literature review of recreational studies can be found in Raybould and Lazarow (2009), Markowski *et al.* (1997) and Freeman (1995).

Morey *et al.* (1991) is among the early studies in the US. They focus on access to coastal salmon fishing sites in Clatsop County, in the north of Oregon, and use data from the National Marine Fisheries Service intercept surveys conducted along the Pacific coast covering seven sites from north to south. Their results indicate that access values for salmon fishing in California, Oregon, and Washington are low. Their findings are notable in that they highlight the dependence of values on residence or proximity to natural resources. For example, they find that the value local residents attach to fishing sites in Clastop County are five times more than the value attached to these same sites by residents from the nearby County of Deschutes. They also estimate value changes from increases in salmon catches and conclude that an extra fish caught in a trip is worth $1.58 for a resident of Clatsop County but only $0.20 for non-local residents from the neighbouring county.

McConnell and Strand (1994) use 1987/1988 data from the Marine Recreational Fishery Statistical Survey (MRFSS/US) to evaluate values for Atlantic sports fishing. They derive different fishing benefit estimates, including: values for proportional increases in fish catch; values for extra game fish catches and the value of a fishing trip. They estimate that the value of a 50 percent increase in expected catch rates across all species to be $26.59 per fishing trip in Maryland. For Georgia, this figure ranges from $66.06 to $70.12. With regards to the value of an extra fish caught, they find that an extra half of a big game fish per day is valued at $17.56 per person in Florida but only $0.21 in Delaware. They conclude that this disparity is due to differences in the predominant big game species between Florida and Delaware.

McConnell *et al*. (1995) use a Poisson model to predict angler specific expected catch rates for sport fishing trips and then use these expected catch values as variables in a random utility model of site choice. Their empirical application combines two surveys: a household survey of recreational fishing activity and the MRFSS intercept surveys. They calculate welfare losses from policy changes such as creel limits and find that these losses range from $0.00 to $287.49, indicating the impact of angler heterogeneity on expected catches. The higher estimates suggest that the effect of a bag limit is felt most strongly by anglers who would expect to catch most of the fish.

Whitehead and Haab (2000) evaluate the impact of participation on values using marine recreational fishing data from Southeast region of the US. They also use data from the

MRFSS. A joint recreation demand model using a random effects Poisson model which accommodates heterogeneity among individuals was used to estimate catch rates. They used historical catch rate data and predicted catch rate to evaluate structural changes under different scenarios. They find that alternative choice set definitions, based on distance or fish catch, do not lead to significant changes in welfare estimates for a fishing trip. Their estimate for Florida amounts to $30.19 per trip, but only $0.82 for Alabama

A Poisson catch rate model was also used by Lipton and Hicks (2003) to study fishing values among anglers who target striped bass (*Morone saxatilis*) in Chesapeake Bay, Maryland. Their model incorporates the effects on catch rates of bottom temperature and dissolved oxygen (DO). They show angler catch rates are negatively affected by low levels of DO. Predicted angler catch rates were then used in a random utility model (RUM) along with two other variables, namely, the monetary and time costs of travel from the angler's residence to the fishing location. The results indicate that the site value estimates were small and the authors attribute this to the presence of many substitute fishing sites along the Patuxent River which is a tributary to Chesapeake Bay. Further, they conclude that limited increases in DO from current levels have a small effect on angler welfare. However, if levels are allowed to deteriorate to a very low level, the welfare effects become much larger. Under this latter scenario, the net present value of welfare losses exceed $100,000 and can be as high as $300,000 if the fishing sites become anoxic.

In contrast to the diversity of studies in the United States, there have been only a few recreational fishing studies in Western Australia (Zhang 2003; van Bueren 1999). This is despite the fact that fishing is a popular activity in the State and also despite the fact that the State is arguably home to one of the world's iconic ecosystems (Ningaloo).

Van Bueren (1999) uses a RUM model of site choice to estimate values for fish as well as access values for 13 recreational fishing sites on south west coast of WA. His results show that angler benefits range from $13.00 to $39.00 per day of fishing. Zhang (2003) uses a similar approach to evaluate shore-based recreational fishing in WA using data similar to that used in this study. However, she limits her focus to only 16 of the 48 major fishing sites in the State. Zhang grouped the fish species into five types (namely, Prize fish, Reef fish, Key sport fish, Butter fish and Table fish) shown in Table A1 in the appendix to this paper. Her estimates of the willingness to pay for an additional fish catch ranges from

\$0.53 to \$26.03 depending on fish type. The annual aggregated welfare benefit of recreational fishing is estimated assuming that a total of 10 million fishing days per year are undertaken by anglers in WA. She obtains an aggregate value of \$10 million Australian dollars for the high value fish (i.e. Prize Fish, Reef Fish and Key Sport Fish) and \$33.6 million for low value fish (i.e. Butter and Table fish).

In summary, RUM modelling is a well established technique for non-market valuation of recreational fishing. It treats the demand for recreational fishing as a series of discrete choices. That is, a decision is made for every trip in the form of a one-off discrete choice between multiple fishing sites (Blamey 2002). Angler site choice decisions are modelled as functions of the expected utilities of different choices (Sandefur et al. 1996). RUM techniques involve estimating the probability of an individual's choice of a site given the characteristics of the site, the characteristics of substitute sites as well as the characteristics of the angler (Sandefur et al. 1996). The ability to describe values based on individual characteristics is very useful for sharpening analysis on the distribution of the impact of management or policy changes.

3. Random utility model of fishing site choice

The model we use describes a choice occasion in which person *i* has a set of *n* alternative fishing sites to choose from. Choice is driven by the relative utility of a visit to a site. The model starts by hypothesizing that the utility V_{ij} derived by angler *i* from a trip to a fishing site *j* depends on a vector q_{ij} of distance and other attributes of the site as perceived by *i* as well as a vector of angler characteristics z_i. That is:

$$V_{ij} = V_{ij}(q_{ij}, z_{ij})$$

Angler *i* will visit site *j* if the utility of site *j* is greater than the utility of any other site *k*, where *k* = (1, 2…, *j-1*,j+1 …, *n*). However, the RUM model recognizes that the utility of a site cannot be fully observed or modelled. To obtain an empirically estimable model, one needs to recognize that utility is the sum of two components: a systematic or observable component (V_{ij}) and a random or unobservable component (ε_{ij}):

$$U_{ij} = V(q_{ij}, z_{ij}) + \varepsilon_{ij} \qquad (1)$$

Given an assumption on the distribution of the random utility component, we can obtain an econometric model that describes site selection as a probabilistic choice. The most common mathematical representation of the RUM is the multinomial logit (MNL), which assumes that the ε_{ij} terms are independent and identically distributed as type I extreme value variates. The MNL probability, $prob_{ij}$, that individual i chooses site j out of n sites can then be expressed as:

$$prob_{ij} = \frac{\exp(U_{ij})}{\sum_{j=1}^{J} \exp(U_{ij})} \qquad (2)$$

To implement this model, one needs to identify the set of site attributes to include in the specification of the systematic utility component. Cost of travel to the site is a key influence. Other key attributes are the expected catch rates for the different categories of fish. One way to estimate expected catch rates (henceforth CR's) for a site is by computing the average number of fish caught by all anglers. However, this approach to CR estimation does not specifically accommodate differences in catch rates or target species preference among anglers (Bockstael *et al*. 1991). In reality, expected catch rates for a particular fish type will be different for different anglers.

To overcome the catch rate measurement problem, many studies (e.g. Schuhmann and Schwabe 2004; McConnell *et al.* 1995) have modelled individual angler expected catch rates using Poisson models, in which the intensity variable in the Poisson model (i.e. expected catch rate) is specified as:

$$\mathrm{CR}^{\mathrm{e}}_{\mathrm{ijf}} = \exp(\beta \mathrm{x}_{\mathrm{ijf}}) \qquad (3)$$

where $\mathrm{CR}^{\mathrm{e}}_{\mathrm{ijf}}$ denotes the expected catch rate, x is a covariate vector and β is a vector of regression coefficients. However, the Poisson model has a drawback in that it assumes uniform dispersion in the Poisson random variable Y (catch rate in our case) since, for a Poisson model, the expected value and variance of the random variable are same and equal to the intensity variable, *i. e.* $\mathrm{E}[Y] = \mathrm{Var}[Y] = CR_{ijf}$. This property is too restrictive, and over dispersion is often observed in practice. One way to avoid this restrictive dispersion assumption in the Poison model is to introduce unobserved heterogeneities which lead to a negative binomial distribution form for the catch rate variable. Negative binomial models were first introduced into economics by Hausman *et al*. (1984). The negative binomial models incorporate heterogeneities by expressing the intensity variable as follows:

$$\tilde{CR}^{e}_{ijf} = CR^{e}_{ijf}.u_i \qquad (4)$$

where u is unobserved and distributed as a one parameter gamma variable $\Gamma(\theta, \theta)$ with the mean and variance as shown below:

$$E[u] = 1 \text{ and } var[u] = \theta^{-1}, \qquad (5)$$

This leads to the following negative binomial distribution for the marginal distribution of Y (Green 2008):

$$f(CR_{ijf} \mid \theta, \beta) = \frac{\Gamma(\theta + CR_{ijf})\left(\frac{\theta}{\theta + CR^{e}_{ijf}}\right)^{\theta}\left(\frac{CR^{e}_{ijf}}{\theta + CR^{e}_{ijf}}\right)^{CR_{ijf}}}{\Gamma(1 + CR_{ijf})\Gamma(\theta)} \qquad (6)$$

Taking the limit of $\theta \to \infty$ makes the negative binomial distribution converge to the Poisson distribution. Thus the negative binomial model nests (or is a generalization of) the Poisson regression model.

In this study, we use the negative binomial model to predict angler specific expected catch rates for the different fish types by regressing actual catch rates on individual and site characteristics. The following log-linear form is used:

$$\ln CR^{e}_{ijf} = \beta_0 + \beta_1 stock_{jf} + \beta_2 S_i + \beta_3 X_i \qquad (7)$$

where: CR^{e}_{ijf} is expected catch per trip of angler i at site j for fish type f, $stock_{jf}$ is the stock of fish type f at site j; S_i is the vector of other site characteristics that impact on the catch rate; and, X_i represents a vector of angler attributes that influence expected catch rates.[2] The stock ($stock_{jf}$) variable is a proxy measure of the abundance at site j of fish type f which is approximated by the average catch of all anglers at that site. The set of other site attributes in the model include indicators of shore type (manmade, inshore, estuary or

[2] As discussed below, the species are grouped into the five fish categories shown in Table A1.

beach). The model also incorporates the following angler attributes: age, whether the angler fished with a group (party), target, hours spent fishing, membership in the fishing club, retirement status, and employment status. The variables are outlined in Table A2. The catch rate model in (7) was estimated separately for the five fish types by maximizing the likelihood for the negative binomial distribution.

The expected catch rate predictions from these models are then used to generate angler/site specific variables for the utility specification in the random utility model of site choice, which takes the following empirical form:

$$V_{ij} = \beta\, TC_{ij} + \sum_{f} \beta_f CR^{e}_{ijf} + \beta\, CL_{ij} \quad (8)$$

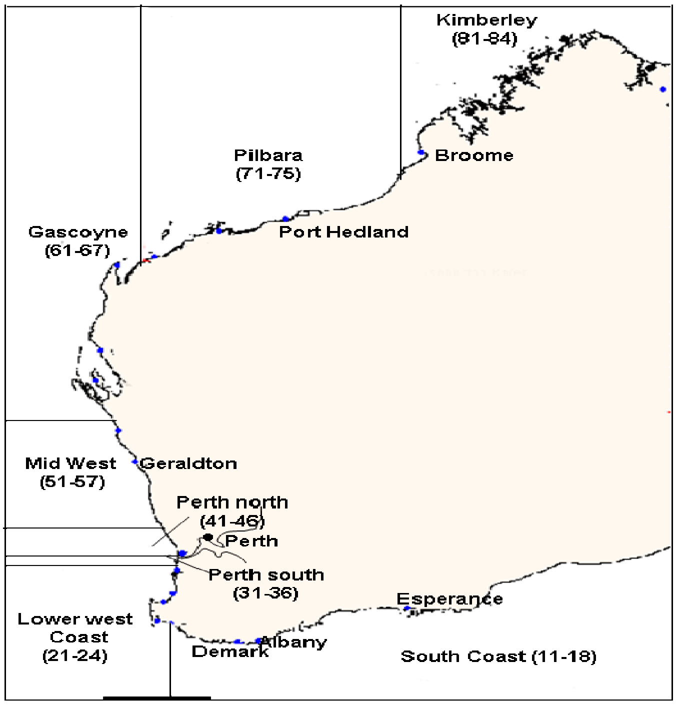
Where V_{ij} is angler i's observable utility from a visit to site j; TC_{ij} is the cost of travel to the site; CR^{e}_{ijf} represents the fish type (f) specific predicted or expected catch rate for angler i at site j*;* and CL_j represents the length of coast line (km) for the site. The coefficients of the expected catch rate variables are expected to positive.

Travel cost values are based on an estimated cost per kilometre for the distance driven to the site. Anglers reported the distances to the sites in the survey. The cost variables for sites that are actually visited are based on the actual travel distances from the angler's home town to the fishing site. Travel distances to alternative sites are calculated. Distance is converted into cost using a value of \$0.50/km, which is the estimated cost of fuel and associated vehicle wear and tear costs. For overnight or multiple day trips, distance per trip is obtained by dividing the distance from home by the number of fishing trips resulting from that particular travel. This requires getting an estimate of number of fishing days (trips) for sites that are in the angler's choice set but were not actually visited. This expected number of days was predicted using an empirical Poisson model estimated using data on actual number of trips reported in the survey and the corresponding reported distances.

4. Data

Our empirical estimation uses data from the 2000/2001 National Survey of Recreational Fishing. The NSRF was a nation-wide survey conducted by the Department of Fisheries, WA (Fisheries Western Australia 2002; Henry 2001). This survey consists of two parts, a telephone survey and a detail log book survey. We use data from the log book survey. A subset of the data, consisting of responses from 778 anglers, who made a total of 4008 fishing trips, is used in this analysis. The fishing trips cover all eight fishing regions in the State. Within these regions, 48 fishing sites were identified. These 48 sites were used as the set of available destination fishing sites in our models. The map in Figure 1 identifies the location of the eight fishing regions. The individual sites within these regions are listed in Table A3 in the appendix.

Figure 1. Major Fishing Regions of Western Australia



The survey gathered fishing trip data as well as demographic information. Trip specific data obtained through the survey include the following: date of fishing trip; fishing site for the trip; whether fishers targeted particular species; method of fishing used; size of party involved in a fishing trip; fishing mode (shore or boat fishing); fishing location type (off-shore, in-shore, estuary, river or lake); time spent fishing in the trip; number of fish kept and released; and expenditure on the fishing trip.

Collected demographic data include age, gender, and education. The average age of the sample participants is 46 years. Less than five per cent of the participants belong to a fishing club. More than 50 per cent of the participants are employed. On average, the size of a fishing party was two. As indicated above, demographic profile data on age, membership in fishing club, employment status, education and retirement status are used in the models to predict expected catch rates for anglers. Summary statistics on fish catches and fishing methods are reported in Table A4.

5. Results

Below, we present our estimation results for the catch rate and site choice models. This is followed by a discussion of welfare measures relating to fish values and site access values.

As indicated above, we estimate expected catch rate for different fish types as a function of site and angler characteristics. The coefficient estimates are presented in Table A5. The significance of explanatory variables differ among different catch rate functions and the results reported in the table show that four variables, namely, stock levels, fishing methods (target and bait), and the time spent fishing significantly and positively influence the expected catch rate for all the fish types. Among angler characteristics, age was found to have the expected sign and is a statistically significant influence on catch rates for prize fish and butter fish. Other site and angler attributes (inshore, beach, retire, party) that influence catch rates for some but not all fish types include fishing locating (inshore or beach), whether the angler is retired and the size of the fishing party.

The RUM estimation results are presented in Table 1 below. Coefficients indicate the impact on visitor utility of the variables listed in the table. Initially, the random utility model of recreational fishing site choice described in equation (8) above was specified as a function of a large number of variables, including interaction terms between stock and expected catch rate variables. The model was then refined by removing the variables that were statistically insignificant at the 95 per cent significance level leading to the version presented in the table. As expected, higher expected catch rates increase the attractiveness of a site. The coefficient of the catch rate variable is significant and positive for all fish types. Travel cost is also significant and has the expected negative effect on the attractiveness of a fishing site. Costal length variable also plays a significant role in site choice. The positive sign of its coefficient indicates that when the fishing site has a longer coast, the site becomes more attractive to anglers. This is to be expected because sites with longer coasts offer more choice and the availability of fish is likely to be higher on these sites. Further, longer coasts might offer isolation or less crowding, which could be valued by anglers.

Table 1. Coefficient estimates of the RUM

Variable	Five Fish Model
Travel Cost	-0.001 (-40.84)
CR_Prize fish	0.090 (15.63)
CR_Reef Fish	0.010 (6.09)
CR_Key Sports Fish	0.050 (11.24)
CR_Table Fish	0.030 (6.88)
CR_Butter Fish	0.010 (8.15)
Coastal Length	0.003 (6.03)
CR_Reef Fish * (Stock of reef fish)	0.001 (17.55)

Note: Values in the brackets are t-ratios.

These estimates link site choice to site characteristics and (through catch rate estimates) to angler characteristics. They can be used to generate part-worths for site attributes and welfare change estimates. The part-worth reflects the trade-off between influences on utility. Since a cost variable is included in the model, its coefficient reflects the marginal utility of money and can be used to derive monetary values for other attributes. In particular, we can calculate the value or part-worth for a fish type by taking the (negative of the) ratio of utility coefficient for that fish type and the travel cost coefficient. Such calculated values are reported in Table 2. These numbers represent the monetary value of a fish caught. The results indicate that the values for prize fish, reef fish and key sports fish are greater than those for table and butter fish. The relative size of these part-worth values reflect the desirability of the different fish types, e.g. prize fish are rarely caught thus anglers value these fish the most.

Table 2. Part-worth of an additional fish ($)

Fish Type	Value of Fish ($)
Prize Fish	15.94
Reef Fish	9.47
Key Sports Fish	9.40
Table Fish	4.65
Butter Fish	2.28

Calculating welfare change measures

The part-worth is a simple measure that captures the value of an attribute. The estimated model can also be used to calculate welfare values for changes in single or multiple site attributes as well as the total value of access to a fishing site. The calculation of the more general welfare measures follows the approach used in Small and Rosen (1982). The compensating variation (CV) welfare measure relating to a change in site quality vector (q) is computed as follows:

$$CV = -\frac{1}{\beta}\left[\ln\left(\sum_{j=1}^{J}\exp V_j(q^1)\right) - \ln\left(\sum_{j=1}^{J}\exp V_j(q^0)\right)\right] \quad (9)$$

Where: J denotes the number of alternative fishing sites; V_j is the utility function for site j; q^0 and q^1 represent, respectively, site attributes before and after the change; and β is the absolute value of the price coefficient in the utility function.[3]

In the case of an improvement, the compensating variation value indicates the maximum an individual is willing to pay for the change in fishing quality. The interpretation of the CV value for the reverse case would be the angler's willingness to access to endure the quality deterioration.

For example, we are able to simulate the welfare effects of a percentage increase or decrease in the expected catches. Mean CV for a 100% increase in catch rate of a fish type across all fishing sites are shown in Table 3. The CV values of the high value group fish are higher. For example, on average, anglers would be willing to pay $31.40 for a doubling in the expected catch rates for prize fish and $23 for reef fish. It may seem counterintuitive that a 100% increase in catch rates, which has an observed sample mean value close to unity in the case of prize fish, should generate such a distinctly different value when compared to the part-worth of $15.94 presented above. A proportional change in catch rates does generate a change in the probability of site choice, and hence induces two sources of change in value: the value that arises due to the increase in expected catch, plus the effect of a shift in fishing effort across sites. This is because the variation in catch rates across

[3] Note that Utility and CV value estimates are angler-specific but angler or individual subscripts have been suppressed in this equation to reduce crowding.

sites and anglers can be large. This highlights the importance of making welfare change judgements based on the mean values of the individual welfare effects, as opposed to the welfare effect on an average or representative angler.

Table 3. Economic welfare estimates for catch rate increase ($/trip)

Fish type	Sample mean catch	Value of a 100% increase in catch rate
Prize Fish	1.28	31.41
Reef Fish	1.47	23.13
Key Sport Fish	1.39	21.79
Table Fish	1.97	14.88
Butter Fish	8.86	20.20

The access value of a fishing site is the welfare loss suffered by an angler if they are denied access to that site. Site closure or reducing access via increases in license fees is an important policy measure that can be used to manage fishing impacts. We calculate access values for all the fishing sites and the results are presented in Table 4. Two sets of results are presented: mean welfare losses among anglers who actually fished in the affected site and mean welfare losses suffered by all anglers as a result of the site's removal from the set of potential fishing sites.

Table 4. Access value of fishing sites

	Welfare losses ($/trip)				
Sites	**Value for anglers who fished at site**	**All Anglers**	**Sites**	**Value for anglers who fished at site**	**All Anglers**
Cape Arid	-4.77	-5.07	Lancelin	-4.42	-3.55
Esperance	-4.53	-6.01	Jurien Bay	-4.59	-3.64
Hopetoun	-8.84	-2.07	Dongara	-11.85	-9.10
Bremer Bay	-11.11	-8.17	Geraldton	-7.77	-5.45
Albany	-7.51	-5.48	Abhrolhos Islands	-4.84	-5.45
Denmark	-7.16	-5.63	Port Gregory	-8.12	-6.36
Walpole	-7.27	-4.99	Kalbarri	-5.60	-4.61
Windy Harbour	-11.64	-8.01	Shark Bay Oceanic	-1.91	-2.89
Augusta	-4.07	-3.29	Shark Bay–Western Gulf	-4.98	-2.95
Busselton	-5.30	-3.76	Shark Bay–Eastern Gulf	-3.51	-2.18
Bunbury	-7.21	-3.89	Carnarvon	-4.97	-2.09
Mandurah	-5.40	-3.84	Quobba	-3.58	-3.21
Warnbro Sound	-4.71	-3.70	Coral Bay	-14.46	-4.24
Cockburn Sound	-3.97	-3.32	Exmouth	-13.31	-6.16
West of Garden Island	-3.49	-2.83	Onslow	-2.74	-2.95
Fremantle	-3.76	-2.82	Dampier	-6.63	-2.06
Swan River	-3.59	-2.64	Point Samson	-5.70	-1.74
Rottnest Island	-3.37	-3.54	Port Hedland	-7.45	-1.88
Cottesloe	-3.23	-2.15	80 Mile Beach	-4.25	-1.36
Floreat	-3.94	-2.71	Broome	-5.62	-1.77
Hillarys	-3.46	-2.56	West Kimberley	-9.87	-5.20
Burns Beach	-2.91	-2.00	North Kimberley	-6.47	-2.70
Quinns Rocks	-2.52	-2.32	East Kimberley	-7.33	-4.04
Yanchep	-3.41	-2.67	**Mean across all sites**	**-5.61**	**-3.81**

Averaged across all sites, values of welfare losses from site closure, amount to $3.81 per trip per angler. Welfare losses from closure are almost always higher for anglers who fish at the site compared to losses incurred on average across all anglers, reflecting a consistency between modelled site utility values and actual site choices. Among the 48 sites, access values are highest for two sites in the Ningaloo region of WA, namely, Coral Bay ($14.46) and Exmouth ($13.31). The magnitude of welfare losses from site availability depend on the availability of substitute sites. For example, Dongara and Windy Harbour site access values are also high as these sites have no substitute sites (see Table 4).

Finally, these site access values could be used to generate some rough or back-of-the-envelope type estimates of the value of recreational fishing in a region or State. The aggregate annual access value for WA is $20.38 million, if one simply multiplies the average site access value reported above by the number of fishing days in the state (i.e. 5.35 million fishing days according to Fisheries Western Australia (2000)). This estimate is based on 2000/2001 data and would certainly be different if current economic and fishing data are used. However, it does highlight how different economically sound estimates can be from value figures that are provided by different groups as indications of the value of recreational fishing in the State.

6. Summary and conclusion

There has been little economic evaluation of recreational fishing in Australia compared to other countries, especially the United States and several European countries. This study is the first state-wide investigation of the value of recreational fishing in the State of Western Australia, where fishing is a highly popular activity and takes place in a large number of sites along its long coast stretching from the Esperance region in the south west to the Kimberly region in the north. The management of recreational fishing is a controversial subject in some areas because of the adverse impact of fishing on fish stocks (e.g. the Gascoyne region) and because of the ecological sensitivity of some areas (e.g. the Ningaloo coral reef ecosystems). Management decisions and public dialogue would be facilitated if claims about the value of recreational fishing are based on sound economic studies rather than on *ad hoc* estimates.

This study contributes to filling the information gap by using national recreational fishing survey data to estimate a random utility model (RUM) of fishing site choice. The model links choice to site attributes and the angler characteristics. Fishing site choice is influenced by travel cost, coastal length and expected fish catch rates. Expected fish catch rate calculations are specific to an angler and fish type. Five fish categories are recognized in the study and an econometrically estimated negative binomial model used to provide a means for predicting catch rates for each fish category and for a given angler. Fish catch rates, travel cost and coastal length are statistically significant influences on fishing site choice.

The model enables the calculation of part-worths or the trade-offs between fish and cost. It also allows for the estimation of welfare gain or loss values resulting from changes in site attributes as well as the total value of access to a fishing sites or sites. The value of sites among anglers fishing in those sites as well as values among all anglers are presented and discussed. It is demonstrated that it is possible to generate estimates for the value of recreational fishing providing resource managers with the information that is based on theoretically consistent procedures and empirical data. The paper also shows that these demonstrative calculations highlight the fact that the appropriate value of recreational fishing can be vastly different from value estimates provided by different groups based on *ad hoc* calculations.

The model can be used to evaluate the distribution impact of management changes. Its recognition of heterogeneity in the angler population makes it possible for resource managers to assess the incidence of different management scenarios affecting the quality of sites or access (or conditions of access) to sites.

Finally, the value to decision making of econometric modelling can be enhanced if models of fishing site choice behaviour are linked to biophysical models that simulate the dynamics of fish stocks and marine ecosystems. The RUM model presented here can be linked to biophysical models. The RUM model would utilize information on fish stocks (and catch rates) from the biophysical model. And the biophysical model would utilize fish extraction information simulated by the RUM model. The integrated model would account for feedback effects and make it possible to evaluate outcomes under dynamic circumstances. Currently, there are no decision support systems that combine econometric models of recreational fishing behaviour and biophysical models.

Acknowledgements

We are grateful to the Department of Fisheries WA and Neil Sumner for providing the data from the National Survey of Recreational Fishing (NSRF) (2000/1).

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Appendix A

Table A1. Classification of recreational species in Western Australia

Prize Fish	Billfish Cobia, Cods, Coral trout, Dhufish WA, Mackerel, Wahoo, Spanish broad-barred, Spanish narrow-barred, Mackerel shark, Spotted and old school , Mahi Mahi, Mulloway, Northern mulloway, Queen fish, Salmon Australian, Samson fish, Sharks, Trout, brown and rainbow, Tuna Southern blue fin, Yellowtail kingfish, Barramundi*, Groper Western blue* (4 of each species, total mixed bag limit 8)
Reef Fish	Emperor red**,** Groper and tusk fish**,** Snapper pink**,** Snapper North-west**,** Snapper queen**,** Spangled emperor (Mixed bag limit 8)
Key Sport Fish	Bream black (in Swan/Canning river)**,** Bonito**,** Cobbler**,** Tailer**,** Mangrove jack**,** Fingermark bream**,** Giant threadfin salmon (Mixed bag limit 8)
Table Fish	Bream black, Northern black and yellow fin, Flathead, Flounder, Leatherjackets, Pike, Snook, Skipjack trevally, Snapper red, Tarwhine, Threadfin, Northern Gunther's and black finned salmon, Whiting king George (20 per fisher per day)
Butter Fish	garfish**,** Australian herring Blue mackerel**,** Sea and yellow eye mullet**,** Western sand school and yellow fin whiting**,** Other finfish not listed in other categories (40 per fisher per day)

Notes: *denoted special bag limits: Barramundi- possession limit 5, in lower Ord river 1; Groper, Western blue – daily bag limit 1. These bag limits are adopted from FWA (2001).

Table A2. Variables used in catch rate model

Variables	Description
Actual Catch	The total catch of fish
Stock	Annual survey mean catch of fish type *k* at site *j*
Inshore	1 if angler *i* goes fishing inshore, 0 otherwise
Estuary	1 if angler *i* goes fishing at an estuary, 0 otherwise
Beach	1 if angler *i* fishes from the beach, 0 otherwise
Manmade	1 if angler *i* fishes from a mad made structure, 0 otherwise
Lnhour	Logarithm of the number of hours angler *i* spent fishing
Party	Total number of persons included in the fishing trip with angle*r*
Target	1 if angler *i* targets fish type *k*, 0 otherwise
Bait	1 if angler *i* uses bait to catch fish type *k*
Member	1 if angler *i* is a member of a fishing club, 0 otherwise
Age	Age of angler *i*
Retire	1 if angler *i* is retire, 0 otherwise
Employ	1 if angler *i* employed, 0 otherwise

Table A3. Fishing sites and regions

Fish Site Code	Fishing Sites	Fishing Region
11	Cape arid	
12	Esperance	
13	Hopetoun	
14	Bremer Bay	South Cost
15	Albany	
16	Denmark	
17	Walpole	
18	Windy Harbour	
21	Augusta	
22	Busselton	
23	Bunbury	Lower West
24	Mandurah	
31	Warnbro Sound	
32	Cockburn Sound	
33	West of Garden Island	
34	Fremantle	Perth South
35	Swan/canning River	
36	Rottnest Island	
41	Cottesloe	
42	Floreat	
43	Hillarys	Perth North
44	Burns Beach	
45	Quinns Rock	
46	Yanchep	
51	Lancelin	
52	Jurien Bay	
53	Dongara	Mid West
54	Geraldton	
55	Abrolhos Island	
56	Port Gregory	
57	Kalbarri	
61	Shark Bay Oceanic	
62	Shark Bay – Western Gulf	
63	Shark Bay – Eastern Gulf	Gascoyne
64	Carnarvon	
65	Quobba	Ningaloo
66	Coral Bay	
67	Exmouth	
71	Onslow	
72	Dampier	
73	Point Samson	Pilbara
74	Port Hedland	
75	80 Mile Beach	
81	Broom	
82	West Kimberly	
83	North Kimberly	Kimberly
84	East Kimberly	
90	Inland	

Table A4. Summary statistics of the variables used in estimation

	Variable	Obs	Mean	Std. Dev.	Min	Max
Caught	Prize Fish	4008	1.13	3.91	0	80
	Reef Fish	4008	0.24	1.44	0	34
	Key Sports Fish	4008	1.39	4.15	0	60
	Table Fish	4008	1.98	5.47	0	88
	Butter Fish	4008	8.86	15.74	0	240
Shore Type	Inshore	4008	0.83	0.37	0	1
	Estuary	4008	0.17	0.37	0	1
	Beach	4008	0.49	0.50	0	1
	Manmade	4008	0.20	0.40	0	1
BAIT	Prize Fish	4008	0.22	0.42	0	1
	Reef Fish	4008	0.03	0.18	0	1
	Key Sport Fish	4008	0.20	0.40	0	1
	Table Fish	4008	0.19	0.39	0	1
	Butter Fish	4008	0.27	0.45	0	1
Target	Prize Fish	4008	0.14	0.35	0	1
	Reef Fish	4008	0.02	0.15	0	1
	Key Sport Fish	4008	0.20	0.40	0	1
	Table Fish	4008	0.07	0.26	0	1
	Butter Fish	4008	0.60	0.49	0	1
Demographic features	age	4008	45.70	15.21	16	85
	Member	4008	0.024	0.15	0	1
	Employ	4008	0.54	0.50	0	1
	Retire	4008	0.27	0.44	0	1
	Party	4008	1.75	1.14	1	12
	Hours	4008	0.90	0.51	-1.39	2.64
	education	4008	0.20	0.40	0	1
Other Variables	Coastal length	4008	1104.33	1113.91	10	4461
	Travel Cost	4008	141.81	118.39	0	1221.45

Table A5. Coefficient estimates for the catch rate functions by fish type

Variable	Prize fish	Reef Fish	Key Sport Fish	Table Fish	Butter Fish
Constant	-3.36 (-16.31)	-4.25 (-17.8)	-2.02 (-16.7)	-2.32 (-18.51)	-0.54 (-3.92)
Stock	0.40 (11.23)	2.21 (13.47)	0.23 (10.79)	0.24 (10.02)	0.09 (17.58)
Lnhours	0.28 (4.03)	1.01 (5.75)	0.364 (4.75)	0.94 (11.84)	0.47 (9.84)
Target	0.92 (10.77)	1.68 (5.02)	1.26 (15.61)	1.18 (9.29)	1.19 (8.73)
Bait	3.02 (40.94)	4.078 (14.5)	2.36 (31.37)	2.10 (23.18)	0.54 (10.11)
Party	0.26 (8.49)		0.21 (7.49)	0.36 (9.72)	0.28 (12.4)
Member	-1.44 (-3.92)				
Age	-0.01 (-3.32)				0.012 (4.26)
Retire				-0.20 (-2.37)	
Employ					-0.18 (-3.22)
Inshore	0.93 (8.72)		-0.82(-9.74)		
Estuary		-0.83 (-3.83)			-0.48 (-7.32)
Beach	-0.66 (-8.73)	-1.09(-4.53)		-0.43 (-5.73)	
Manmade					0.33 (5.46)
Alpha	1.63 (18.54)	7.56 (9.66)	2.27 (18.66)	3.95 (23.63	1.98 (37.00)
L likelihood	-3539.78	-1101	-4015.72	-5337.61	-8549.28

Notes: There are 4008 observations. All coefficients are significant at the 5 percent level.
The t-ratios are given in the parenthesis

Appendix B

The data was also used to estimate a trip demand model, which determines number of fishing trips as a function of different variables: (1) angler *i*'s mean inclusive value derived from the RUM model of site choice (i.e. expected utility per trip) (IV_i), (2) a measure of the angler's fishing experience ($Experience_i$), (3) age (Age_i), (4) a dummy variable indicating if an angler *i* is retired or not ($Retire_i$), (5) a dummy variable which indicates if the angler is employed or not ($Employ_i$), and (6) a dummy variable which indicates if the level of education of the angler is above Year 12 or not ($Education_i$). The coefficient estimates for the trip demand model are shown in Table B1.

Table B1. Coefficient estimates of the trip timing model.

Variable	Estimated coefficient
Constant	0.90 (9.23)
IV_i	0.05 (3.39)
$Education_i$	-0.08 (-6.28)
$Retire_i$	0.52 (8.47)
$Experience_i$	0.23 (21.35)
$Employ_i$	-0.24 (-5.54)
Age_i	0.01 (5.06)
Log likelihood	-2980.67

Notes: There are 4008 observations. All coefficients are significant at least at 5% level. The t-ratios are given in the parenthesis.