Using a choice experiment to manage the excess demand challenges facing the Sundays River Estuary recreational fishery in South Africa

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Abstract

The Sundays River Estuary, situated in the Eastern Cape, South Africa, has excess recreational demand for estuarine services, specifically recreational fishing. The estuary has been over-fished, putting its sustainability at risk. Various management interventions may be required in order to save it, but how is this to be done without reducing welfare. This paper reports the application of a choice experiment to guide this very issue. It is found that the physical size of fish stocks is a very important predictor of recreational choice at the Sundays River Estuary, and it is recommended that demand be curtailed through an increase in the boat license fee for using the estuary of R174 per annum.

Keywords: Estuary, demand management, recreational attributes, recreational fishery, choice experiment

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1 Introduction

The Sundays River Estuary, situated on the east coast of South Africa, is a dynamic ecosystem that provides a host of services, particularly recreational, but excess demand for some of these services has disturbed the balance within the system (Hosking 2011). Nowhere is this more apparent, than with respect to the fish stocks (Wooldridge, 2010). Three main species are targeted in the Sundays River estuary: the spotted grunter (*Pomadasys commersonnii*), the dusky kob (*Argyrosomus japonicas*), and the white steenbras (*Lithognathus lithognathus*). These fish populations have declined radically during the last decade due to the popularity of the Sundays River Estuary for recreational fishing. The drop in the fish stock population numbers makes these three species particularly vulnerable, jeopardising the sustainability of their populations in the long-run[1].

In order to restore the targeted fish species to a level where harvesting is equal to maximum sustainable yield, management has to be aware of the choices that recreational users make when visiting this estuary (Hay et al. 2008). The Sundays River fishery faces a trade-off between the short-run (current) human recreational predation demands for targeted fish in the estuary, and the need for sustainability of the fishery into the long-run. Management intervention, through the use of an appropriate mechanism, is required in order to manage recreational demand, and allow the fishery to replenish.

Herein lies the research challenge addressed by this paper – how to inform this intervention so that recreational value is not lost. More specifically, the challenge is to advise on a license fee increase that satisfies these criteria. The aim of this paper is to contribute to this management intervention by reporting the value that recreational users place on the Sundays River Estuary fishery and recommending this value be used as a control measure to limit fishing effort. It is envisaged that this control measure will take the form of a fishing license fee adjustment, which will address the excess demand for fishing, while at the same time, not reduce welfare.

2 The Sundays River Estuary

The Sundays River Estuary (33 ° 43'S, 25 ° 25'E) is situated in the Eastern Cape, South Africa, approximately 40 kilometers (km) northeast of Port Elizabeth (see Figure 1 below). The estuary is approximately 20km long, permanently open, and discharges at Algoa Bay, into the Indian Ocean (MacKay and Schumann 1990).

The Sundays River Estuary contains two types of microalgae, namely phytoplankton and benthic microalgae. Phytoplankton forms the base of the food chain in the estuary (Integrated Environmental and Coastal Management (IECM)

[1] The stock status of the dusky kob and white steenbras is believed to be collapsed, while the stock status of the spotted grunter is considered over-exploited (Cowley et al. 2009). The most recent research available on the adult dusky kob population suggests that it is between 1 and 4.5 percent of the non-impacted (original) population, a level that could be below the recovery threshold for this species (Griffiths 1997).

2010). The most dominant vegetation types found in this estuary are reeds and sedges, which cover an area of 29 hectares (ha) (IECM 2010). Extensive salt marshes are precluded because of the narrow channel-like morphology of this estuary. The salt marsh covers an area of 21.7ha (IECM 2010). Submerged macrophytes include pondweed in the upper reaches and eelgrass in the lower reaches of the estuary. Twenty zooplankton species can be found in the Sundays River Estuary. Ichthyoplankton (fish larvae) also forms part of the zooplankton and 17 species from 11 families can be found in this estuary (IECM 2010). Despite the limited area of mudflat available in the estuary, mud prawn (an example of invertebrate macrofauna) can attain high densities in localised areas (IECM 2010). The Sundays River Estuary has high fish species richness – 51 species representing 27 families of fish have been recorded (Cowley et al. 2009). Fifty three percent of the total numbers of species are marine migrants, 25 percent are estuarine residents and 18 percent are marine stragglers. An abundance of bird species makes the Sundays River Estuary a popular location for bird watching – between 27 and 166 species have been recorded (IECM 2010). Up to 59 aquatic species have been sited (IECM 2010).

3 A literature review of choice analysis

The choice experiment (CE) technique was selected as the most appropriate method to analyse choice due to its extensive use to value environmental goods and services (Adamowicz 1995; Bennett and Adamowicz 2001; Hanley et al. 2001; Hensher et al. 2005). It has already been extensively applied to analyse choice and inform management in wetland settings, for instance in Vietnam (Nam Do and Bennett 2007), Sweden (Eggert and Olsson 2004), Greece (Birol et al. 2006), England, Scotland and Wales (Hanley et al. 1998; Luisetti et al. 2008), Australia and Tasmania (Kragt and Bennett, 2009) and the United States of America and Canada (Smyth et al. 2009).

Nam Do and Bennett (2007) estimated wetland biodiversity values by applying a choice model to the Mekong River Delta in Vietnam. WTP values were estimated for Tram Chim National Park, one of the many wetlands found in the Delta. The survey was conducted by means of personal interviews. In total, a sample of 917 respondents was interviewed from three main cities in the study area. The CE utilised the multinomial logit (MNL) model and RPL model to estimate implicit prices for the proposed wetland biodiversity plan. Total benefits were estimated at $3.9million. Nam Do and Bennett (2007) found that the benefits outweighed the costs of implementation, implying that social welfare would improve if more resources were allocated to the conservation of wetlands in Tram Chim.

Eggert and Olsson (2004) studied the economic benefits of improving coastal water quality in the coastal waters of the Swedish west coast. This improvement was investigated from a fishing, bathing water quality and biodiversity perspective. The sampling frame for the study was the Swedish Register of Inhabitants, and only respondents from the permanent population in the counties representing the southwest part of Sweden were randomly sampled. Questionnaires were sent out to 800 respondents via mail, of which 343 were returned, and 324 were deemed usable. The data was analysed using mixed MNL models. The calculated marginal WTP values revealed that respondents prioritised improvements in fishing stocks, and wanted increased efforts at developing a strategic management plan aimed at preventing biodiversity loss.

In Greece, a CE was applied by Birol et al. (2006) to estimate the value of changes in different social, ecological and economic functions that the Cheimaditida wetland provides to the citizens. Study results revealed that the public derived positive and significant WTP values of enjoyment from the conservation and sustainable management of this wetland.

Hanley et al. (1998) carried out a CE as well as two CV studies in order to estimate and compare values for landscape and wildlife protection in Scotland. The CE made use of special information packages which provided the respondent with predicted changes to wildlife and the surrounding landscape. The two CV studies made use of open-ended and dichotomous choice designs, respectively. Hanley et al. (1998) found that the value generated through the CE was not significantly different to the value estimated by the dichotomous choice CV study. These values, however, were much larger than that estimated through the open ended CV study.

Luisetti et al. (2004) utilised an ecosystem approach to assess managed realignment coastal policies on the east coast of England. These coastal management strategies include managed realignment projects whereby sea defences are breached and the land flooded in order to restore salt marshes in the area. The CE was used in this case, as the value of salt marshes created by different managed realignments, could be estimated in a single application. The project site was the Blackwater Estuary in Essex in the east of England. The key finding of the study was that site specific value estimates derived through the use of the CE yielded results in line with other previous managed realignment cost-benefit analyses, lending support to the use of this approach for assessing future coastal management strategies.

In north-eastern Tasmania, Kragt and Bennett (2009) applied the CE method in order to address catchment management issues in the George catchment. This report attempted to assess community preferences for different proposed management scenarios aimed at improving the quality of the catchment environment. This status quo scenario implied a slow degradation in catchment conditions, whilst the other two options represented management scenarios for improved catchment conditions. It was found that Tasmanians were willing to pay for increased protection of native riverside vegetation and rare native animal and plant species in the George catchment.

Smyth et al. (2009) investigated public preferences for alternative management scenarios for Lake Champlain, situated in Vermont and New York, but also bordering on Quebec, Canada. They found that although water quality and beach closures were important management issues, the public wanted policy measures aimed at improving the safety of fish consumption.

In South Africa, there have also been a few attribute valuation studies reported. The WRC commissioned a study in 2008 (Project K5/1413/2) to generate information on guiding the allocation of river water to South African estuaries and to investigate the factors that explain willingness-to-pay (WTP) for river inflows into South African estuaries (Oliver, 2010). This study applied a CE to the Bushmans River Estuary in the Eastern Cape, and compared the results with those of an application of a contingent valuation (CV) done by Van Der Westhuizen (2007). Welfare measures derived from the CE study were found to be 30 percent less than those derived from the CV study (Oliver, 2010).

The conclusion drawn is that the CE method is appropriate for analysing choice to exploit the Sundays River Estuary fishery and generate values on this basis. The method has already been successfully applied in many different wetland settings and has the advantage of being able to generate multiple value estimates from a single application.

4 The choice model

In a seminal paper, Lancaster (1966) argued that it was *the attributes* of a good that determined the utility derived from the good, and therefore that utility, and hence choice, could best be explained in terms of the attributes of the good. It had previously already been recognised that choice was not a fixed determined action but rather comprised of a number of random elements (Luce 1959). The people making the choices did not have complete information and were faced with uncertainty in making their utility calculations. Following this line of thinking, the utility function has come to be thought of as the sum of two parts: an observed or measurable component, and an unobserved or random component. This model currently serves as the foundation for modelling the choices that individuals make (Howard and Sheth, 1969; Abelson and Levy, 1985; Engel et al. 1995; Bateman et al. 2002; Hensher et al. 2005).

The random utility model allows for random (error) influences in addition to identified fixed ones (McFadden 1974; 1984):

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{1}$$

where:

U_{iq} represents utility derived for consumer q from option i,

V_{iq} is an attribute vector representing the observable component of utility from option i for consumer q, and

ε_{iq} is the unobservable component of latent utility derived for consumer q from option i (Nam Do and Bennett 2007).

Assuming a linear additive form for the multidimensional deterministic attribute vector (V_{iq}):

$$Viq = \beta_{1i} f_1(s_{1iq}) + ... + \beta_{ki} f_k(s_{kiq}) \tag{2}$$

where:

$\beta_{ki}$are utility parameters for option i, and
s_{iq}represents 1 to $k$different attributes with differing levels,

Equation 3 can be expanded to:

$$U_{iq} = \beta_{1i} f_1(s_{1iq}) + ... + \beta_{ki} f_k(s_{kiq}) + \varepsilon_{iq} \tag{3}$$

This random utility model is converted into a choice model by recognising that an individual (q) will select alternative i if and only if (iff) U_{iq} is greater than the utility derived from any other alternative in the choice set. Alternative i is preferred to j iff $P\left[(V_{iq} + \varepsilon_{iq}) > (V_{jq} + \varepsilon_{jq})\right]$, and choice can be predicted by estimating the probability of individual (q) ranking alternative i higher than any other alternative j in the set of choices available (Louviere et al. 2000; Nam Do and Bennett 2007).

The probability of consumer $q$choosing option i from a choice set may be estimated by means of the maximum likelihood estimation (MLE) approach, whereby estimates are obtained through the maximisation of a probabilistic function with respect to the parameters (Louviere et al. 2000; Hensher et al. 2005; Nam Do and Bennett 2007). This estimation approach requires the random components (ε_{jq}) to be independently and identically distributed (IID) which in turn, requires the error term to be independent of irrelevant alternatives (IIA). This type of statistical distribution is referred to as the extreme value type 1 distribution (EV1). Using the EV1 distribution, the unobserved random components associated with each alternative must be converted into a workable component of the probability expression. Once this is done, the model can be simplified by integrating the random component out of the model. The resultant choice model only has unknowns relating to the utility parameters of each attribute within the observed component of the random utility expression, and is called the multinomial logit (MNL) or (more correctly) the conditional logit (CL) choice model (Hanley et al. 2001; Hanley et al. 2004). The CL model takes the following form (Louviere et al. 2000):

$$P(i|A) = \frac{1}{\sum_{j=1}^{j} \text{exp-}(V_i\text{-}V_j)} \tag{4}$$

where:

P_i is the probability of an individual choosing the i^{th} alternative over the jth in the set of choices A,

V_i is the representative utility from the i^{th} alternative, and

V_j is the representative utility from the j^{th} alternative.

The underlying assumptions of the model are (Louviere et al. 2000):

- that scale parameters have constant variance (typically equal to 1 (Ben-Akiva and Lerman 1985)),
- that random components do not exhibit serial correlation (IIA assumption),

- that utility parameters are set, and
- that there is no heterogeneity between individual preferences.

If the first of these assumptions is relaxed, the scale parameter (λ) will not have constant variance, and will become an additional multiple of each of the alternatives in the model and influence choice. The CL model can then be adapted to allow for variance of a scale parameter (λ) by dividing the respective representative utilities defining the probability of choice by it (scale parameter):

$$P_{iq} = \frac{\exp(V_{iq}/\lambda_i)}{\sum_{j=1}^{j} \exp(V_{jq}/\lambda_j)} \tag{5}$$

However, a problem of bias occurs if the IIA assumption is violated, because then the observed $\left(\frac{V_i}{\lambda_I}\right)$ and unobserved $\left(\frac{\varepsilon_i}{\lambda_I}\right)$ components of utility are dependent on one another and the error terms exhibit serial correlation (Nam Do and Bennett 2007). A more flexible model that relaxes the IIA assumption is the heteroskedastic extreme value (HEV) model. This model, initially developed and applied by Bhat (1995), allows the variance of the error term to differ across alternatives within a choice set. It models the probability that an individual (q) will choose the ith alternative in a choice set (A), but relaxes the assumption of independence among the random components. Substituting z in place of $(\varepsilon_i/\lambda_i)$ in the choice model, the HEV specification is:

$$P_i = \int_{z=-\infty}^{z=+\infty} \prod_{j\in C, j\neq 1} F\left[\frac{V_i - V_j + \lambda_i z}{\lambda_j}\right] f(z)dz \tag{6}$$

A problem with both the CL and HEV models is that they assume that the coefficients of variables that enter the model are the same for all consumers, i.e. that there is homogeneity in preferences across respondents, which implies that consumers have the same socioeconomic characteristics, for instance, it assumes that people with the same level of income will equally value the good in question (MacDonald et al. 2005). A model that relaxes the assumption of homogeneity of preference (allowing for heterogeneity) is the random parameter logit (RPL) model.

The RPL model is a generalisation of the standard MNL logit model[2]. The advantages of this model are that (1) the alternatives are not independent because the model does not rely on the IIA assumption, and (2) the existence of unobserved heterogeneity can be investigated (Ben-Akiva et al. 1999; Hensher and Greene, 2002; Carlsson et al. 2003). As a result, the RPL model has been found to have advantages over the CL model in terms of fit and overall welfare

[2] Increases in estimation capabilities through advancements in computational power have led to the RPL method becoming the most popular method of choice during the previous two decades (Hensher et al. 2005; Nam Do & Bennett 2007).

estimation (Gopinath 1995; Bhat 1997; Revelt and Train 1998; McFadden and Train 2000; Carlsson et al.2003; MacDonald et al. 2005; Kragt and Bennett, 2008). A generalised version of the RPL choice model is (Louviere et al. 2000):

$$P(j|\mu_i) = \frac{\exp(\alpha_{ji} + \theta_j \mathbf{z}_i + \delta_j \mathbf{f}_{ji} + \beta_{ji}\mathbf{x}_{ji})}{\sum_{j=1}^{J} \exp(\alpha_{ji} + \theta_j \mathbf{z}_i + \delta_j \mathbf{f}_{ji} + \beta_{ji}\mathbf{x}_{ji})} \quad (7)$$

where:

α_{ji} is a fixed or random alternative specific constant (ASC) with $j = 1,....,J$ alternatives and $i = 1,...,I$ individuals; and $\alpha_j = 0$,

δ_j is a vector of non-random parameters,

β_{ji} is a parameter vector that is randomly distributed across individuals,

μ_i is a component of the β_{ji} vector,

z_i is a vector of individual-specific characteristics, for example, income,

f_{ji} is a vector of individual-specific and alternative-specific attributes,

x_{ji} is a vector of individual-specific and alternative-specific attributes, and

μ_i is the individual-specific random disturbance of unobserved heterogeneity.

The RPL can take on a number of different functional forms and incorporate a number of underlying distribution assumptions. The most popular assumptions are normal, triangular, uniform and log-normal distributions (Bhat 2000; 2001). The log-normal distribution is applied if the response parameter needs to be a specific sign (Louviere et al. 2000; Carlsson et al. 2003). Where dummy variables are used, a uniform distribution with a (0, 1) bound is appropriate. It can be difficult to determine which variables to distribute and which distributions to choose. Some applications only randomise the cost variable, others choose to randomise all non-price variables and leave cost as non-random (Layton, 2000; Anderson, 2003). The latter choice is favoured for two reasons: firstly, the distribution of the marginal WTP for an attribute is simply the distribution of that attribute's parameter estimate, and secondly, it allows the cost variable to be restricted to be non-positive for all individuals (Carlsson et al. 2003).

5 Choice methodology

5.1 *Choice experiment design*

The attributes of interest and the specification of levels for each attribute were chosen through focus group discussions, expert interviews and telephonic communications as recommended in the literature (Ryan et al. 2001; Hensher et al. 2005; Yacob and Shuib, 2009). The selected attributes were (1) population size of fish stocks, (2) the level of boat congestion, (3) the level of public access to the estuary, and (3) price. The levels identified as relevant to these attributes are shown in Table 1.

A status quo (or opt out) option was not included in this study, as it can lead to status quo bias and the need to increase sample size (Bateman et al.

2002). The cost variable (price) was expressed by four different Rand values and was based on the added expense of an additional conservation officer (per annum remuneration). This additional conservation officer would allow more policing on the estuary to make sure that legal requirements are adhered to. The written description of the monetary attribute, or cost variable, was:

"It is assumed that the cost of providing these recreational use alternatives is ***partly*** *covered by the Sundays River Estuary's fishing and boat license holders. SANPARKS will cover the rest of the costs. We ask you to imagine that all fishing and boat license holders will contribute equally by means of a fixed annual sum added to the existing license structure. This annual sum will then be directed back to the Sundays River Estuary. This annual sum can take four different values, namely R0 (current situation), R45, R90 and R120".*

In order to try and reduce respondent fatigue and cognitive burden, two alternatives per choice set were provided. A full factorial design (2 x 2 x 2 x 4 = 32) was generated using SPSS, yielding 32 different alternatives. These alternatives were randomly allocated to 32 different questionnaires. Each questionnaire contained four choice sets, and within each choice set, the respondent had to make a choice (trade-off) between two alternatives. An example of a choice set is provided in Table 2.

Once the choice sets had been randomly allocated between questionnaires, the other sections of the questionnaire were developed. This design process followed the steps recommended by Hasler et al. (2005). These steps include (1) the collecting of introductory information from the respondent through the use of an introductory section, (2) the setting out of the CE with relevant descriptions of the attributes and levels, (3) the provision of follow-up questions, which allow for reliability and validity checks, and (3) the collection of socio-demographic information from the respondent. A pilot study was conducted in order to 'fine tune' the questionnaire.

5.2 *Sample design*

It was intended that the sample design for this study entail investigating the target (sample) population, determining from who to sample (the sample frame), calculating the sample size and devising a selection of sample strategy. The target population for the data collection process was defined as all the recreational users of the Sundays River Estuary. Drawing a representative sample from the target population should ideally be preceded by a process of clarification that entails the compilation of a sampling frame. It is defined as a complete but finite list of all units of analysis. The importance of a properly specified sampling frame lies in its usefulness in judging the representativeness of the sample – the sample selected should be representative of the sampling frame and of sufficient size to enable significant estimates of parameters.

Devising such a sample frame proved to be an unrealisable goal in this instance. The Sundays River Estuary sample frame should be a list of all the users and potential users of the recreational services provided by the estuary. The only list that existed, however, was one for the holders of boat licenses.

The use of this list was rejected for two reasons: firstly, boat license holders constitute a fraction of all the current users of the Sundays River Estuary; and secondly, a boat license is issued for several estuaries located in close proximity to each other. For example, a boat license issued for the Sundays River Estuary may also be used for the Swartkops Estuary and vice versa. Fishing and bait collecting permits cannot be used as a source of information as they are anonymously issued by the Post Office, and allow fishers and bait collectors to carry out their activities within a large coastal area. There is no official list of recreational fishers and bait collectors for the Sundays River Estuary. Other recreational activities also provided by the estuary, for example, picnicking and bird watching, are not subject to government regulation, and therefore not organised through club structures. Given the lack of an adequate sample frame for the Sundays River Estuary, the research team was forced to sample using "knowledge" of the target population. This form of non-list sampling is the only one feasible under the circumstances. On-site sampling was required as the users of the estuary needed to be sampled whilst they were carrying out the recreational activity (Bateman et al. 2002). An intercept survey selection strategy was adopted where every nth recreational user to the estuary was approached for participation, and the overall number guided by the proportions thought to make up the true underlying population of users.

The Sundays River Estuary questionnaire was administered on-site by four trained interviewers during August, 2010. A sample of 200 respondents is acceptable if they are offered four choice sets each (Bennett and Adamowicz, 2001).

6 Results

6.1 *The sample features*

This study only administered 175 questionnaires; below the recommended sample size but still adequate for estimating 'robust' models (Hensher et al. 2005). Not unlike the sample of respondents interviewed as part of the Cowley et al. (2009) study, most of the visitors surveyed came from areas less than 50 kilometres away from the estuary. Of these respondents, most came from Port Elizabeth (59 percent). Permanent residents of the estuary, living in Colchester and Cannonville, accounted for approximately 21 percent of the sample. The majority of recreational users surveyed were male (84 percent) and over the age of 35 (55 percent). The average annual income was R184 000. Of the respondents sampled, 35 percent had a matric qualification with university exemption. All occupational categories were well represented in the sample of respondents, with the exception of plant and machinery operators/assemblers (two percent), agricultural workers (one percent), and elementary occupations (one percent).

6.2 *Choice model specification*

Three different choice model specifications were estimated as part of the Sundays River Estuary CE: a CL model, an HEV model and an RPL model. The LIMDEP NLOGIT Version 4.0 programme was used in all the estimations. All models estimated showed the importance of choice set attributes in explaining respondents' choices across the two different options: option A and option B. Two utility functions (V_{1-2}) were derived from the models[3]. Each function represented the utility generated by one of the two options. For the two option choice sets with four attributes, the utility functions can be expressed as follows:

Option A: $V_A = \beta_1$Physsizeoffish + β_2Congestion + β_3Publicaccess + β_4Cost

Option B: $V_B = \beta_1$Physsizeoffish + β_2Congestion + β_3Publicaccess + β_4Cost

For these two utility functions, utility is determined by the levels of the four attributes in the choice sets.

7 Discussion

All the coefficients[4] in the CL model had expected signs[5], a priori, and are significantly different from zero at the 99 percent confidence level. The probability that an alternative would be chosen was reduced: the lower the physical size of the fish stock; the higher the amount of boat congestion; the lower the amount of public access available; and the higher the license fee cost.

The fishery coefficient of the CL model can be interpreted by estimating its odds ratio, i.e. by calculating the antilog[6] of the coefficient. Odds interpretation indicates how an increase (decrease) in an attribute's level would result in a change in the probability of choosing an option which includes this increase (decrease). The 'Physical size of the fish' coefficient can be interpreted as follows – an increase in the physical size of the fish stock will result in a 39.12 percent increase in the probability of a respondent choosing this option.

The HEV model relaxes the assumption of identically distributed random components, and allows for variance across all alternatives (Louviere et al. 2000). Like the CL model, the results of this HEV model estimation indicated that all the coefficients had the expected signs a priori. However, only three of the four coefficients are significantly different from zero at the 99 percent confidence level, namely the 'Physical size of the fish stock', 'Public access' and

[3] ASCs were not included in the models for two reasons: the alternatives were unlabelled and a status quo alternative was not included in the choice sets.

[4] A variable coefficient estimated by a discrete choice model reveals the relationship between the decision makers' choice and the variable of interest. A positive (negative) coefficient shows that decision makers prefer a quantitative increase (decrease) or a qualitative improvement (deterioration) of the attribute.

[5] The sign of a coefficient is used to test whether the relationship between variables correspond to a priori expectations (based on microeconomic theory).

[6] Finding the antilog entails calculating the value of 10 to the power of the coefficient's value.

'Cost'. The congestion coefficient is significantly different from zero at the 95 percent confidence level. The odds ratio calculation for the fishery coefficient in the HEV model indicated that an increase in the physical size of the fish stock would result in a 62 percent increase in the probability of a respondent choosing this option.

The RPL model goes one step further than the HEV model and relaxes the assumption of homogenous preferences across respondents. In the RPL model, recreational attribute parameters were treated as random variables, but not the cost variable. In this case, a normal distribution[7] was selected for all the random parameters. The cost variable was specified as fixed, and non-randomly distributed, because the distribution of the marginal WTP for an attribute is simply the distribution of that attribute's coefficient. The RPL model estimates revealed little unexplained heterogeneity in respondent preferences. All of the standard deviation coefficients were statistically insignificant, indicating statistically similar preferences for these attributes across respondents. It was deduced that the recreational users of the Sundays River Estuary were a fairly homogenous group in terms of their preferences. Most of the recreational users surveyed at the Sundays River Estuary were fishers and preferred to fish from boats.

7.1 *Estimation of WTP values*

The coefficients from the three models were also used to calculate implicit prices. Implicit prices are calculated by determining the marginal rates of substitution between the attributes, using the coefficient for cost as the "numeraire" (Hanemann 1984). The ratios of the attribute in question to the cost coefficient can be interpreted as the marginal WTP for a change in each of the attribute values (Hanemann, 1984). The marginal WTP value represents a change from one attribute level to another. In the case of the Sundays River Estuary, these marginal WTP values represent: a change from catching small fish now to catching bigger and more fish next year, a change from seeing and hearing few boats to seeing and hearing many boats, and a change from limited recreational appeal to an improvement in the recreational appeal of estuary banks. Table 4 reports the implicit prices, or marginal WTP, for each of the Sundays River Estuary's recreational attributes estimated using the Delta method (Wald procedure)[8] in LIMDEP NLOGIT Version 4.0 (Greene 2007). For comparisons, estimates were calculated using all three models.

The differences in WTP among the three models are small, with the exception of the RPL estimate for 'Physical size of fish stock'. The respective marginal WTP value for the RPL model is R173.87. This estimate is higher than those calculated for the CL and HEV models (R154.13 and R150.21, respectively).

[7] Other options include a uniform distribution, a triangular distribution, and a log-normal distribution (Hensher et al. 2005).

[8] This procedure automates the process of estimating standard errors for non-linear functions, such as marginal rates of substitution (Suh 2001).

8 Conclusions

The stocks of the fish targeted by recreational users in the Sundays River Estuary are over-exploited and face potential collapse. Most fishery management initiatives aim at controlling fishing effort levels through restricting access, implementing catch limits, and using transferable catch quotas. These initiatives relate to the management of a commercial fishery and not a recreational one. Management options are limited in the case of a recreational fishery. License fees are an obvious and arguably attractive choice for managing and limiting excess demand. The application of the CE method has revealed that the boat license fee be increased by approximately R174 (2010 price levels) without less of recreational welfare (using an RPL model as the basis to estimate the trade-off). For this reason, the following recommendation is made with respect to the management of the Sundays River fishery:

- In order to decrease fishing effort, it is recommended that the boat license fee be increased by R174 per *annum*.

In addition it would seem worthwhile to:

- Increase effort to enforce existing catch and bag limits, and
- Put more effort into improving public awareness of the serious sustainability challenges facing the Sundays River Estuary fishery.

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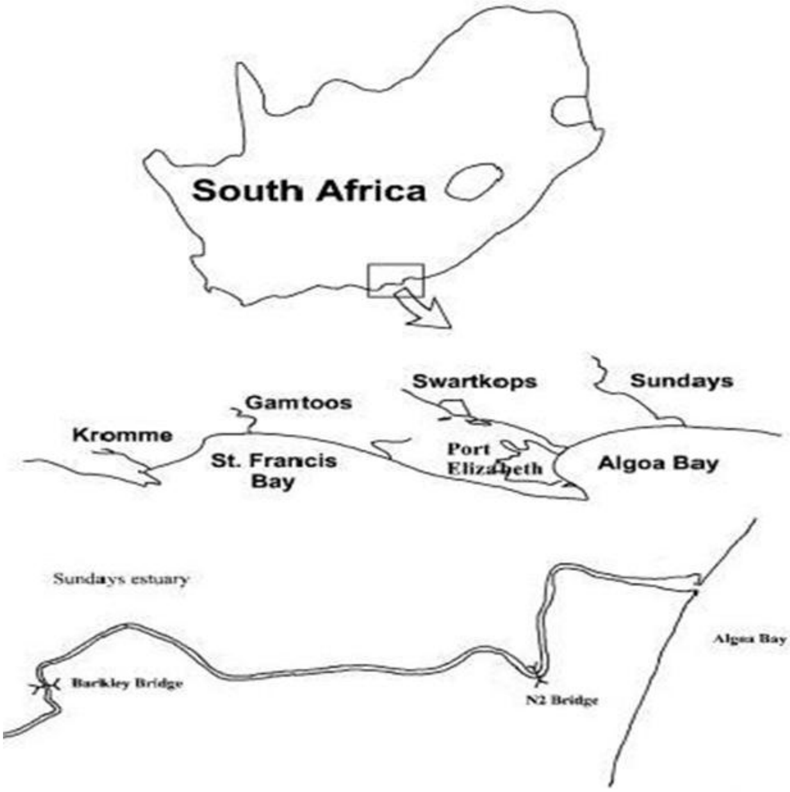
Figure 1: The Sundays River Estuary



Source: Adapted from Potgieter (2008)

Table 1 The Sundays River Estuary attributes and their levels		
Indicator/attribute	**Levels**	**Description of levels**
Physical size of fish caught	Mostly small fish now	Catch and retain whatever fish species you want 'today'
	None now but bigger and more fish next year	Keep no undersize fish now but more and bigger fish next year
Congestion	Hear and see few boats	The recreational user sees and hears a few boats
	Hear and see many boats	The recreational user sees and hears many boats
More public access	Yes	Establish a path access along the banks of the estuary
	No	Do not establish a path access along the banks of the estuary
Cost	R0	A fixed annual sum added to the existing boat license fee. This added sum will be directed back to the Sundays River fishery as a fishery quality levy
	R45	
	R90	
	R120	

Table 2 A sample choice set		
Attribute	**Option A**	**Option B**
Physical size of fish caught	Mostly small fish now	None now but bigger and more fish next year
Congestion	Hear and see few boats	Hear and see few boats
More public access	Yes	No
Cost to you (R)	R45	R0
I would choose (TICK ONE BOX ONLY):		√

Table 3 Estimation results of the CE - Sundays River Estuary						
	CL		**HEV**		**RPL**	
Variables	**Coeff.**	**Std err.**	**Coeff.**	**Std err.**	**Coeff.**	**Std err.**
Physical size of fish	1.59225**	.14157	1.79113**	.23779	1.95816**	.53555
Congestion	-.34136**	.13044	-.40008*	.15818	-.39402*	.15836
Public access	.34253**	.12461	.39809**	.15093	.38157**	.14429
Cost[1]	-.01033**	.00144	-.01192**	.00214	-.01126**	.00194
	Standard deviation of random parameters					
Physical size of fish					1.1886	.97650
Congestion					.28761	.69802
Public access					.18711	1.08321
No. of respondents	175		175		175	
No. of choice sets	700		700		700	
Pseudo R^2	.22091		.23942		.23867	

** indicates that parameter is statistically significant at the 5 percent level*
*** indicates significance at the 1 percent level*
1. Cost was specified as a non-random parameter in the RPL.

Table 4 Marginal WTP for attributes (Rands)			
Attributes	***CL***	***HEV*****	***RPL***
	MWTP	***MWTP***	***MWTP***
Physical Size of Fish Stock	*154.13*	*150.21*	*173.87*
	(109; 200)		*(95; 253)*
Congestion	*-33.04*	*-33.55*	*-34.99*
	(-60; -6)		*(-62; -8)*
Public Access	*33.16*	*33.38*	*33.88*
	(8; 59)		*(8; 59)*

** Confidence intervals in parentheses.*
*** Confidence intervals not calculated for HEV due to the presence of fixed parameters.*