Valuing Trout Angling Benefits of Water Quality Improvements while Accounting for Unobserved Lake Characteristics: An Application to the Rotorua Lakes

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Abstract

Trout angling is one of the most popular water-based recreational activities in the Rotorua Lakes. Despite the high demand for trout angling and other recreational purposes, water quality in some of these lakes has been declining over the past decades and initiatives to try to restore the lakes are underway. To compliment these efforts, this study uses the travel cost random utility models to explore how changes in water quality would impact upon angler’s choice of fishing destinations. The welfare impacts due to water quality changes and possible lake closures are also explored. These findings highlight the importance of discrete choice random utility models as a policy decision making tool for recreational-based natural resource managers in New Zealand. Additionally, this study represents one of the unique cases in travel cost random utility applications that accounts fully for unobserved site effects.

Keywords: Trout angling, Travel cost random utility models, inter-temporal variation in water and fishing quality, unobserved effects

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1.0 Introduction

The Rotorua Lakes offer a wide range of recreation and tourist activities including trout angling. Despite the attractiveness of these lakes, several of the Rotorua Lakes have experienced a marked decline in water quality over the past 30 years. Studies conducted indicate that point, non-point sources and internal loads from bottom sediments are the major sources of phosphorus and nitrogen nutrients (Hamilton, 2003; Burger *et al.*, 2007). Excessive nutrients from Septic tanks are considered to be the main point source of phosphorus and nitrogen nutrients to the lakes. For instance, the decline in water quality in Lake Rotorua is largely attributed to the direct input of effluents from the waste water treatment plant in the 1980s prior to the diversion of sewage inflows to land-based treatment in 1991 (Rutherford *et al.*, 1996). Non-point source nutrients to the lakes is mainly attributed to agricultural production in the catchments and to a lesser extent storm water, geothermal inputs, rainfall and erosion (PCE, 2006).

Many actions have been undertaken over the years to protect and restore water quality under a project called the Rotorua Lakes Protection and Restoration Action Programme. Some of the mitigation measures being considered and in some cases already in place include sewerage works, treatment or diversion of nutrient-rich streams, capping lake sediments to lock up nutrients, construction of wetlands, and land management changes (MFE, 2011). Over the past few years, Lakes Rotoiti and Rotorua have experienced some improvements in water quality[1]. While the costs of water quality improvements may be easy to quantify, benefits realized from such policies are more difficult to measure and require the use of non-market valuation methods.

To date studies conducted to value the non-market impact of water quality changes in these lakes have relied on the use of stated preference techniques more specifically, the contingent valuation method (e.g. Weber *et al.*, 1992; Bell & Yap, 2004). However, these valuation methods have been criticized on a number

[1] However, whether or not such improvements can be attributed to some of the stated mitigation measures is still under investigation (PCE, 2006).

of grounds including the possibility of respondents over-stating or under-stating their willingness to pay measures. As an alternative, this study employs the travel cost random utility models with a specific focus on valuing angler's preferences for better water quality. This modeling framework is a revealed preference approach that uses real data based upon observable individual behavioural patterns and therefore capable of giving more reliable value estimates. Additionally, the ability of random utility models to estimate alternative patterns of substitution across recreational sites induced by policy changes at one or more of the sites makes them the most popular modeling framework in recreational literature (Parsons & Kealy, 1992; Morey *et al.*, 1993; Phaneuf & Smith, 2004).

Travel cost random utility models have been applied in a number of studies of recreational fishing (e.g. Kaoru, 1995; Train, 1998; Jakus *et al.*, 1998; Morey *et al.*, 2002; Johnstone & Markandya, 2006; Murdock, 2006;) and other outdoor recreation activities (e.g. Coyne & Adamowicz, 1992; Needelman & Kealy, 1995; Thiene & Scarpa, 2008; Egan *et al.*, 2009). These models while widely applied elsewhere, are considered novel to New Zealand non-market valuation context and hence the motivation. Through this modeling framework, some of the factors influencing angler's choice of lake for trout fishing are identified. The study further investigates the effect of changes in water quality on the probability of fishing choice destinations and the substitution patterns across lakes induced by such changes. The value of water quality improvements to trout anglers is also explored. Findings from this study might provide policy makers with some vital information that can be integrated into the Rotorua Lakes management policy tools.

The remainder of the paper is organized as follows. The next section gives an outline of the empirical fishing site choice model employed in this study. Section 3 outlines the study area and data used in the analysis. Results and discussions are presented in section 4 and finally, conclusions and implications of the study are presented in section 5.

2.0 The multinomial logit random utility fishing site choice model

Following Thurstone (1927b) and Marshack (1960), discrete choice models are derived on the notion that given a finite set of alternatives to choose from, a decision maker chooses the alternative that gives them the highest level of utility. In the context of this application, it is assumed that on each fishing trip, an angler is faced with a choice of J possible lakes to visit. Letting n denote an angler, the utility each angler would derive from fishing at lake j is given by $U_{nj},\ j = 1,2,3,\dots,J$. The utility maximizing angler would choose lake i over j only if $U_{ni} > U_{nj},\ \ i \neq j$. While each angler knows the utility that is derived from the chosen lake i, the researcher can only conjecture part of this utility through lake attributes and social-economic characteristics of anglers. Assuming that utility is additive, and further that an angler chooses lake i over other lakes in the choice set on a particular choice occasion, the utility an angler would derive from choosing lake i can be specified as:

$$U_{ni} = V_{ni} + \varepsilon_{ni}$$

where; V_{ni} represents the systematic part of utility that can be observed by the researcher through lake attributes and social-economic characteristics of an angler. ε_{ni} is the stochastic component of utility that captures all the unobserved factors that may influence the angler's utility but not accounted for in V_{ni}. The probability that lake i will be chosen by angler n denoted as P_{ni} is given by:

$$P_{ni} = Pr\left(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj} \forall j \neq i\right)$$

Assuming ε_{ni} is distributed as type I extreme values, the probability of lake i being chosen by angler n is given by:

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_{j=1}^{J} e^{V_{nj}}}$$

Parameters in the representative utility are obtained by maximizing the likelihood function which is derived from the choice probabilities (Ben-Akiva & Lerman, 1985; Train, 2002). Assuming independence among choices made by anglers in the sample, the log-likelihood function for all sampled individuals can be expressed as:

$$LL(\mu) = \sum_{n=1}^{N} \sum_{i}^{J(n)} y_{ni} \, lnP_{ni}$$

where; μ are the parameters to be estimated and y_{ni} denotes the observed choice made by an angler. The parameters are estimated in Nlogit 4.0.

The parameter estimates obtained can be used to assess the welfare measures of changes in site attributes. Hanemann (1982) has shown that when the unconditional indirect utility is assumed to be linear in income and the stochastic component of utility is assumed to follow type I extreme value distribution, the expected per trip welfare measure (CV) can be calculated using the log-sum formula below.

$$CV = \frac{ln\left[\sum_{j=1}^{J} e^{V_{nj}^{q1}}\right] - ln\left[\sum_{j=1}^{J} e^{V_{nj}^{q0}}\right]}{\alpha_m}$$

where; α_m is the marginal utility of income, which is equal to the travel cost coefficient. V_{nj}^{q0} and V_{nj}^{q1} are the deterministic component of utility before and after hypothesized water quality changes at some of the lakes respectively.

Similarly, the expected per trip welfare loss (CV_{j-1}) due to lake closure can be calculated using the following expression:

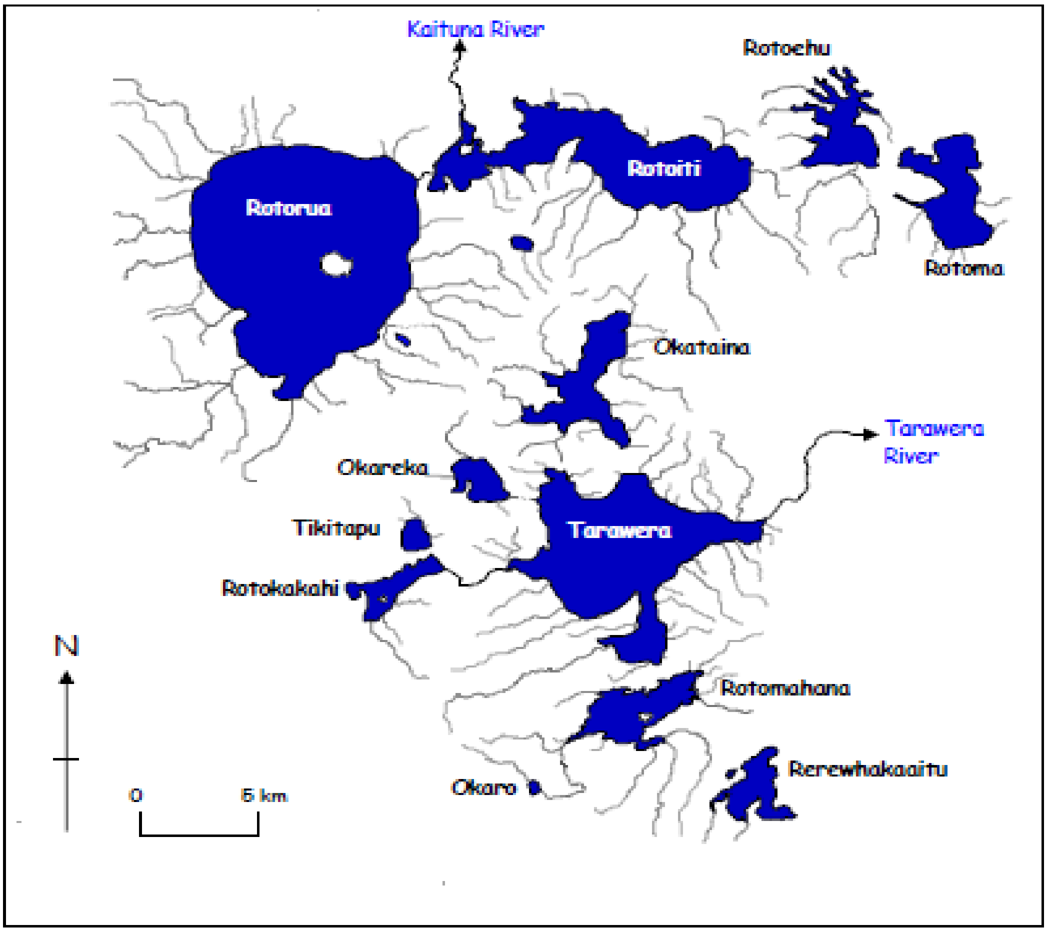
$$CV_{j-1} = \frac{ln\left[\sum_{j=1}^{J} e^{V_{nj}^{0}}\right] - ln\left[\sum_{j=1}^{J-1} e^{V_{nj}^{1}}\right]}{\alpha_m}$$

where; V_{nj}^{0} and V_{nj}^{1} are the deterministic component of utility before and after one of the lakes is closed for recreational fishing respectively.

3.0 Study area and data used

The Rotorua Lakes refers to twelve main lakes all located in the Rotorua District as shown in Figure 1 below. The popularity of these lakes for trout angling and proximity of these lakes to each other make them the most appropriate choice set for investigation destination fishing choices using random utility models of recreation.

FIGURE 1: THE ROTORUA LAKES



Source: Edwards & Clayton (2009)

Lake Rotokakahi is privately owned and is not open to the public, reducing the fishing choice set to 11 lakes. The lakes differ in many aspects including water quality. In terms of the eutrophication status, the lakes range from supertrophic (very poor water quality), eutrophic (poor water quality), mesotrophic (average water quality) and oligotrophic (good water quality). Presently, Lake Okaro is supertrophic, Lakes Rotorua and Rotoehu are eutrophic, Lakes Rotoiti, Rotomahana, Rerewhakaaitu and Okareka are mesotrophic and Lakes Tikitapu, Okataina, Tarawera and Rotoma are oligotrophic. Table 1 below presents the summary statictics for some of the lake attributes employed in this study. Besides water quality, the lakes differ in a number of other attributes including the size of the lakes, number of key access points, number of boat ramps, amount of forested land and depth. Later in this paper we provide a detailed description of how these attributes are measured.

TABLE 1: SUMMARY STATISTICS OF LAKE ATTRIBUTES

Variable	**Mean**	**St.dev**	**Min**	**Max**
Secchi depth (Yearly average)	6.4	3.5	2.3	13.3
Weight of fish (yearly average)	1.6	0.2	1.3	2.0
Lake size	18.7	24.4	0.3	80.6
Lake access[2]	2.4	2.2	0	7
Boat ramp	2.3	2.1	1	7
Urban development (percentage)	1.4	2.4	0.0	8.1
Forested land (Percentage)	56.6	28.1	6.0	94.0
Lake depth	29.3	20.6	7.0	60.0

Furthermore, in addition to the variability of water quality across lakes, often times spatial variability in water quality do exist even within the same lake (Allan *et al.*, 2007). The lakes are also characterized by seasonal variations in water quality across the year with summer months generally experiencing poorer water quality with algal blooms than winter months[3].

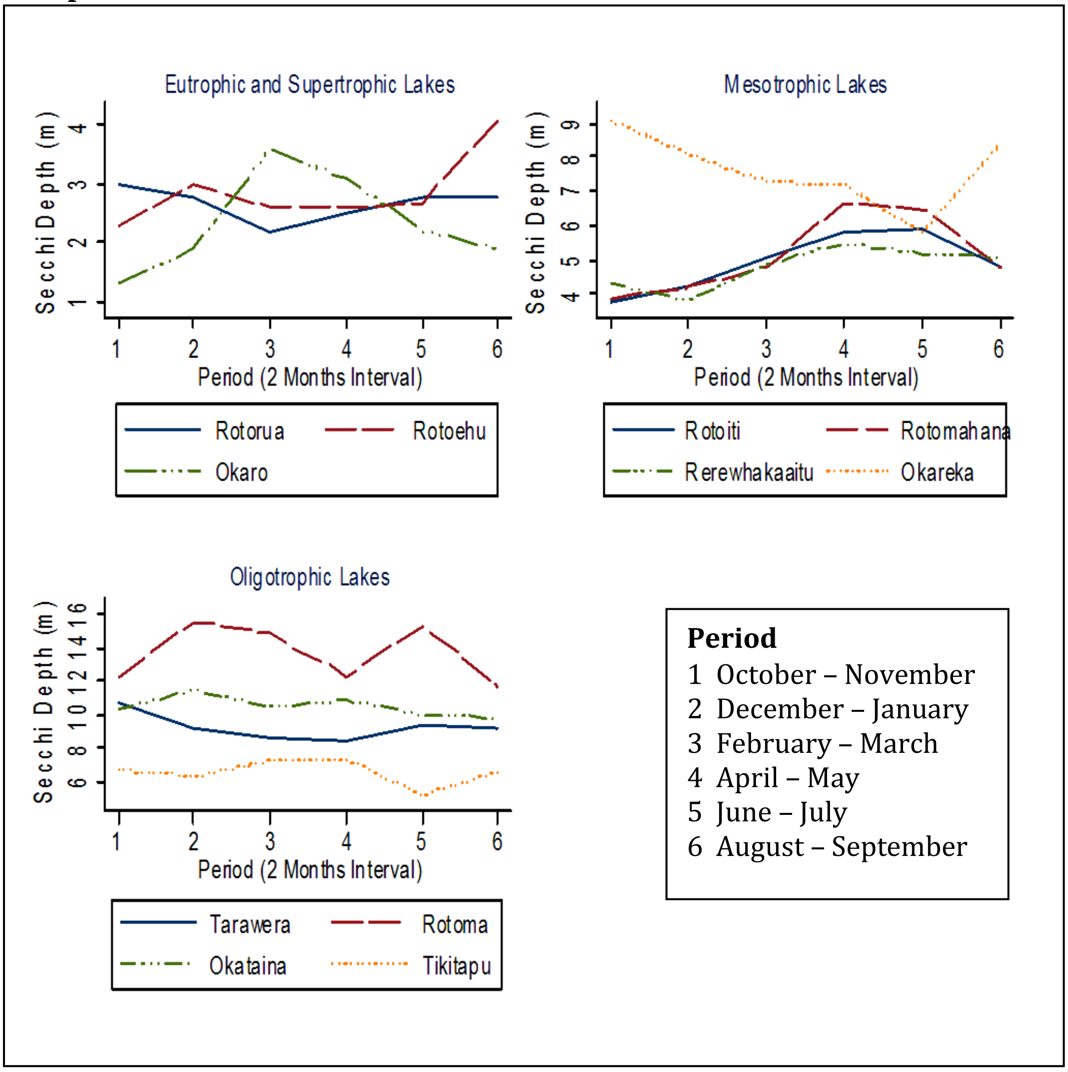
In Figure 2 below, we explore the seasonal variability in water quality for the 2007/08 fishing season under consideration in this study. In New Zealand the fishing season spans from October to September each year. Two monthly averages of water clarity measured by secchi depth in metres corresponding to the

[2] Lake access refers to the number of key access points to the lakes

[3] In the past decade, health warnings have been issued with respect to cynobacteria blooms in some lakes or just part of the lake (e.g Okaro, Rotoehu, Rotorua, Rotoiti).

periods: October-November, December-January, February-March, April-May, June-July and August-September are used in this investigation. Comprehensive data on water quality obtained from the Environment Bay of Plenty enabled us to compute two monthly averages of secchi depth for the stated periods.

Figure 2: Seasonal variations in secchi depth over the period October, 2007 to September, 2008.



Source: Environment Bay of Plenty.

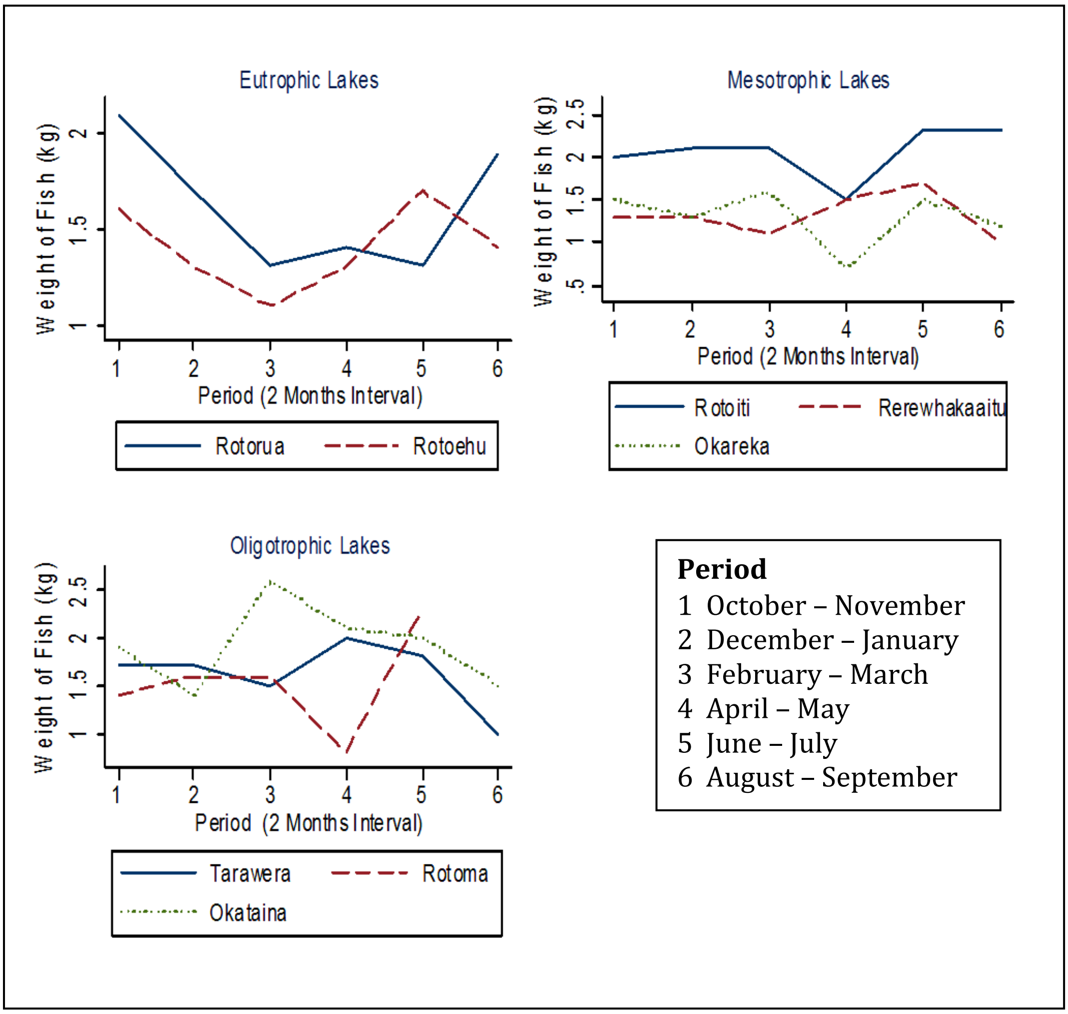
From Figure 2 above it can be seen that generally, the lakes displayed different patterns of variability in secchi depth during this period. For instance, Lake Okaro registered a minimum of about 1.2m in period 1 and 3.6m in period 3, representing a change in water clarity of about 2.4m. Lake Okareka experienced a decline in secchi depth from 9.0m in period 1 to 6.0m in period 5. Similarly, Lakes Rotoiti and Rerewhakaaitu registered a maximum change in secchi depth of about 2m between periods 1 and 4. Even lakes with good water quality did experience fluctuations in water quality over this period. Lake Rotoma registered the largest variability in secchi depth with a minimum of about 12.0m in periods 1 and 4 and a maximum of around 15.6m in periods 2 and 5. This is followed by Lake Tarawera with a decline in secchi depth from about 11.0m in period 1 to about 8.0m in period 4.

In Figure 3 below, we also explore the variability in fish growth over the same period. Fishery in the Rotorua Lakes is managed by Eastern Region Fish and Game Council (Appendix 1). The council monitors fishing quality mainly through yearly creel surveys and also the datawatch tagging programme. This provided us with a comprehensive data for exploring any possible underlying variation in fish growth over the 2007/08 fishing season. Just as with water quality, two monthly averages of the weight of fish for the periods: October-November, December-January, February-March, April-May, June-July and August-September are used in this exploration[4]. This investigation is imperative, since although no conclusive evidence exist yet, there is an indication that declining water quality in some lakes (e.g. Rotoehu) seem to impact negatively on fish growth (Pitkethley, 2008).

Generally, the variability in the average weight of fish across the 2007/08 fishing season was quite substantial for some lakes. For instance, Lake Rotorua registered a maximum of about 2.1kg in period 1 and minimum of about 1.3 in periods, 3 and 5, representing a decline in the weight of fish of about 0.8kg between the stated periods. Lake Tarawera registered a maximum of about 2kg in period 4 and a minimum of about 1kg in period 6 representing a decline of about 1kg between the two periods. Lake Rotoma registered a minimum of about 0.8kg in period 4 and a maximum of about 2.3kg in period 5, representing a change of about 1.5kg between the two periods.

[4] Monthly data on fish growth across the 2007/08 fishing season was not available for Lakes Rotomahana, Tikitapu and Okaro and hence their exclusion from this investigation.

FIGURE 3: SEASONAL VARIATIONS IN WEIGHT OF FISH OVER THE PERIOD OCTOBER, 2007 TO SEPTEMBER, 2008.



Source: Eastern Region Fish and Game Council

Figures 2 and 3 above have demonstrated that the variability in water and fishing quality during the 2007/08 fishing season was quite considerable for some lakes. Consequently, anglers may experience different levels of utilities corresponding to water and fishing quality prevailing in each lake during the time they went fishing and therefore, worth accounting for in model estimation. We account for this in estimation by ensuring that each angler faces water and fishing quality levels prevailing during the period of reported fishing. This is possible since the two monthly partitions of water and fishing quality also correspond to the partitions in the fishing choice data applied in this study. The remainder of this section outlines the fishing trip choice data and the definition of variables employed in model estimation.

The fishing trip choice data used in this study was obtained from the 2007/08 national angling survey carried out by the National Institute of Water and Atmospheric Research Ltd (NIWA) on behalf of Fish and Game New Zealand (FGNZ). This was a telephone sample survey of random samples of anglers drawn from records of fishing licence sales for the 2007/08 angling season, which spanned from October, 2007 to September, 2008. The survey was stratified by FGNZ Region, licence type and fishing season. Licence types were stratified into three strata, namely adult and family whole season licences, junior whole season licences and part-season licences. The licence dates of issue were used to partition sales into two monthly intervals from October-November, 2007 to August-September, 2008. This gave rise to six two-monthly interval strata for the whole fishing season[5].

The survey was designed with the main objective of obtaining estimates of angler usage for all rivers and lakes in New Zealand. In line with the angling survey objectives, the main focus was on the number of days an angler spent fishing on a particular water body. Consequently, anglers were asked if they had fished during the specified two months period. Only anglers who indicated to have fished were asked to report the waters they had fished from and number of days spent on each water body (Unwin, 2009).

For purposes of this study, we are interested in firstly, single day fishing trips. In line with this criteria only angler's who lived within 241-262 km from the lakes are included in our analysis for a reasonable a day trip[6]. Secondly, we are interested in individual level choice data and therefore, only adult individual fishing licence holders are included in this study. A total of 414 New Zealand resident anglers fulfilled these two criterions. For these sampled anglers each day of reported fishing is considered to be a single day fishing trip. Table 2 present a

[5] A random sample of 17, 739 anglers was drawn from a population of 97,215 fishing licence holders. Out of this total, 84,875 were New Zealand resident anglers and 12,340 were overseas anglers (Unwin, 2009).

[6] In determining which recreational sites to include in choice sets, some researcher have used the 150 miles (241 km) as benchmark for the maximum distance for a day trip (Parsons & Kealy, 1992; McConnell & Strand, 1994).

summary of trips undertaken by this group of anglers to each of the lakes in the choice set.

TABLE 2: DESCRIPTIVE STATISTICS FOR THE NUMBER OF TRIPS TO EACH LAKE

Lakes	Mean	St.dev	Min	Max	No. of trips
1. Rotorua	11.9	12.5	1	45	583
2. Rotoehu	27.4	8.5	1	30	33
3. Okaro	3.4	1.3	1	4	5
4. Rotoiti	15.6	12.2	1	44	673
5.Okareka	7.8	13.1	1	61	19
6. Rotomahana	1.0	1.0	1	1	1
7. Rerewhakaaitu	10.3	6.4	2	18	99
8. Tarawera	13.8	16.3	1	61	548
9. Okataina	12.2	17.6	1	61	95
10. Rotoma	20.6	12.0	1	36	233
11. Tikitapu	1.7	0.6	1	2	3
Total no. of trips					2,292

Altogether, the sample of 414 anglers reported a total of 2,292 fishing trips to the Rotorua Lakes for the 2007/08 fishing season. However, it is evident that the sampling procedure used to select the sample of anglers for this application is not synonymous with random sampling procedures. Due to non-random sampling procedures, the distribution of fishing trips across the lakes reported in Table 2 above is not representative of the reported distribution of angler lake usage by the national angling survey for some lakes. To account for under-sampling and over-sampling, the choice variable is re-weighted to correspond to the distribution of the angling days as reported in the 2007/08 national angling survey using procedures outlined by Hensher *et al.* (2005).

Most of the anglers for this study sample came from home origins within the Eastern Region and Auckland/Waikato Fish and Game Councils (Appendix 1). In view of this, the appropriate study population consists of all adult New Zealand resident anglers who bought fishing licences during the 2007/08 fishing season from these two Fish and Game Councils. Thus the study population of interest is equal to 21,883 anglers (Unwin, 2009). In Table 3 below we provide a description of the variables used in estimation.

Table 3: Description of variables used in estimation

Choice	Is equal to 1 if angler n chooses lake j and zero otherwise
ASC_j	Alternative specific constants for each lake j.
COST	Cost of lake access. This included the variable cost of travel (fuel only) and the opportunity cost of travel time. The cost of fuel was estimated at NZ$0.19/km. The round-trip road distances from each angler's place of residence to each of the lakes in the choice set were estimated using the GIS software. The opportunity cost of travel time was valued at 25% of the wage rate. Median income for each region the anglers came is used as a proxy for angler's income[7].
WCLARIT	Water clarity measured by secchi depth in metres.
FWEIGHT	Weight of fish in kilograms[8]
LKSIZE	Log of lake size in square kilometres
FDVT	Facility developments around the lakes. Number of boat ramps, and key lake access points were found to be highly collinear. Therefore, the number of key lake access points is used as a proxy for facility development
URBAN	Percentage of land around the lake devoted to urban development
FOREST	Percentage of land around the lake with forest cover
DEPTH	Lake depth measured in metres

[7] Median incomes were obtained from Statistics New Zealand and are for the 2006 census.

[8] Average catch rates of fish would have been the most appropriate but were only available for five of the lakes in the choice set.

4.0 Results and Discussions

The estimated results are presented in Table 4. The parameters are estimated in Nlogit 4.0. Model 1 consists of a full set of alternative specific constants (ASCs)[9]. The seasonal variability in water and fishing quality across the fishing season presents a unique opportunity to estimate the fishing site choice model using the traditional single stage approach with a full set of ASCs. As highlighted by Murdock (2006), this modeling framework is a complete solution since the lake characteristic to be valued in this case water quality will be identified. In addition to the ASCs, the choice variable in this model is regressed against the cost of site access (COST), two monthly averages of water clarity (WCLARIT) and two monthly averages of weight of fish (FWEIGHT) variables.

Model 2 excludes all ASCs, retains the cost variable but instead uses yearly averages of water clarity and weight of fish variable. Furthermore, the impacts of five more attributes on fishing site choice including the size of lake, facility development, amount of land devoted to urban development, amount of forested land and lake depth are explored. This model is included to assess the effect of lake attributes that are only variable across lakes and therefore cannot be identified together with a full set of ASCs. All the lake attributes entered the utility specifications assuming a linear form except for the size of lake variable in which the log-linear specification was used to account for diminishing marginal utility to size.

In terms of the model fit as measured by the log-likelihood, the model which included a full set of ASCs (Model 1) performs slightly better that Model 2 by about 27 points. However, it should be highlighted that the small difference in model performance between the two models was attained by identifying the best alternative model possible (Model 2) using the model with a full set of ASCs as a benchmark.

[9] Since ASCs cannot be included for all the alternatives in the choice set because of identification problems, the ASC for Lake Okaro is normalized to zero (Hensher *et al.*, 2005).

TABLE 4: ESTIMATION RESULTS

	Model 1(ASCs)			Model 2 (NO ASCs)		
Variable	*Coefficient*	*Std Error*	*|t-value|*	*Coefficient*	*Std Error*	*|t-value|*
ASC_Rotorua	3.827***	0.244	15.67	-	-	-
ASC_Rotoiti	4.249***	0.236	18.04	-	-	-
ASC_Tarawera	3.599***	0.224	16.08	-	-	-
ASC_Okataina	1.784***	0.263	6.78	-	-	-
ASC_Rotoma	2.315***	0.330	7.01	-	-	-
ASC_Okareka	0.483	0.340	1.24	-	-	-
ASC_Rotoehu	1.629***	0.293	5.56	-	-	-
ASC_Tikitapu	-1.638***	0.613	2.67	-	-	-
ASC_Rotomahana	-2.149**	1.022	2.10	-	-	-
ASC_Rerewhakaaitu	2.857***	0.240	11.90	-	-	-
COST	-0.077***	0.007	11.27	-0.060***	0.007	9.14
WCLARIT	0.116***	0.031	3.68	0.175***	0.021	8.22
FWEIGHT	0.097	0.099	0.99	1.745***	0.351	4.97
LKSIZE	-	-	-	3.261***	0.252	12.95
FDVT	-	-	-	0.300***	0.024	12.55
URBAN	-	-	-	-0.374***	0.038	9.72
FOREST	-	-	-	0.016***	0.002	6.85
DEPTH	-	-	-	-0.064***	0.008	7.63
Summary Statistics						
Log-Likelihood	-3774.24			-3801.36		

***, **, * denotes significance at 1%, 5% and 10% respectively

Note: In Model 1 the water clarity and weight of fish variables pertains to the two monthly averages except for Lakes Rotomahana, Tikitapu and Okaro in which the yearly averages of the weight of fish is used. In Model 2 WCLARIT and FWEIGHT variables refers to the yearly averages of water clarity and weight of fish, respectively.

All ASCs in Model 1 are significant except for Lake Okareka, implying that unobserved factors either had a positive or negative influence on choice probability. The COST variable is negative and highly significant in both models indicating that in general anglers preferred lakes that were closer to their place of residence. The water clarity attribute (WCLARIT) is positive and highly significant in both models indicating that largely anglers favoured lakes with better water quality. The weight of fish attribute (FWEIGHT) is positive and insignificant in Model 1 but highly significant in Model 2 indicating that generally anglers preferred lakes with bigger fish. The size of lake variable (LKSIZE) is positive as expected and highly significant indicating that generally bigger lakes were preferred by anglers. The facility development variable (FDVT) is positive as expected and significant at 1% level signifying that generally anglers preferred lakes with more facilities. Additionally, results show that in general anglers preferred lakes surrounded by more forest cover. On the other hand, the presence of urban development around the lakes, and deeper lakes had a negative effect on fishing site choice probability.

Water quality policy simulations

We hypothesize a one and three metres increase in water clarity in all lakes with poor and average water quality concurrently and individually. All water quality policy simulations are based on the model that accounts fully for unobserved lake characteristics (Model 1) to ensure more reliable welfare estimates. Of particular interest are the changes in the probability of fishing site choice and how anglers would redistribute across lakes following hypothesized changes in water clarity. In Table 5 below, we present the predicted changes site choice probabilities for a three metre rise in water clarity.

TABLE 5: PREDICTED PERCENTAGE CHANGES IN THE PROBABILITY OF SITE VISIT UNDER HYPOTHETICAL WATER QUALITY CHANGED CONDITIONS

3 metres rise in water clarity in all lakes with poor and average water quality concurrently and individually.

	All Lakes	Rotoiti	Rotorua	Rerewhakaaitu	Rotoehu	Okareka	Okaro	Rotomahana
Lakes with poor and average water quality								
Rotoiti	3.507	7.109	-2.562	-0.465	-0.168	-0.091	-0.024	-0.005
Rotorua	2.979	-2.537	6.501	-0.403	-0.130	-0.082	-0.021	-0.004
Rerewhakaaitu	0.516	-0.426	-0.358	1.532	-0.024	-0.015	-0.003	-0.001
Rotoehu	0.176	-0.151	-0.119	-0.021	0.539	-0.004	-0.001	0.000
Okareka	0.099	-0.082	-0.075	-0.014	-0.004	0.314	-0.001	0.000
Okaro	0.026	-0.022	-0.019	-0.004	-0.001	-0.001	0.083	0.000
Rotomahana	0.005	-0.004	-0.004	-0.001	0.000	0.000	0.000	0.017
Lakes with good water quality								
Tarawera	-4.573	-2.383	-2.148	-0.402	-0.123	-0.079	-0.021	-0.004
Rotoma	-1.919	-1.064	-0.832	-0.155	-0.067	-0.029	-0.008	-0.002
Okataina	-0.789	-0.426	-0.374	-0.064	-0.022	-0.013	-0.005	-0.001
Tikitapu	-0.025	-0.013	-0.012	-0.002	-0.001	0.000	0.000	0.000

Note: the dark shades denotes own probability of site visit for a 3 metres rise in water clarity in each of the lakes with poor and average water quality individually.

Considering the rise in water clarity in all lakes with poor and average water quality concurrently (Column 2), the lakes enjoying the most own probability of site choice are Rotoiti and Rotorua, with a predicted rise in the probability of site visit by 3.5% and 3.0%, respectively. On the other hand, the model predicts the least own probability of site choice of about 0.03% and 0.01%, for Lakes Okaro and Rotomahana, respectively.

For a rise in water clarity in each lake individually, the lakes enjoying the most own probability of site visit are Rotoiti and Rotorua with predicted increase in site visit by about 7.1% and 6.5%, respectively. While Lakes Okaro and Rotomahana have the least own probability of site visit of about 0.08% and 0.02%, respectively. The model further predicts most anglers redistributing their fishing effort from Lake Tarawera followed by Lake Rotoma. Presently, the two lakes are among lakes with good water quality.

The equivalent monetary value measured in terms of the compensating surplus (CS) for all hypothesized changes in water quality improvements are presented in Table 6 below. The table presents the compensating surplus per choice, per angler, for the whole sample and population for the entire 2007/08 fishing season. Considering a 3 metres increase in water clarity in all the lakes with poor and average water quality concurrently, the model predicts welfare gains of about $168.19 per angler per year. Aggregated over the target population of anglers, the total welfare gains amounting to $3,680,513.61 are predicted for this policy.

Furthermore, focusing on a 3 metres increase in water clarity in each of the lakes with poor and average water quality individually, the highest welfare gains are predicted for Lake Rotoiti of about $84.53 per angler per year. This is followed by Lake Rotorua with predicted welfare gains of about $73.63 per angler per year. The lowest welfare estimates are predicted for Lakes Rotomahana of about $0.13 per angler per year. When aggregated over the target population, the total welfare gains range from a minimum of $2,902.44 for Lake Rotomahana to $1,849,866.99 for Lake Rotoiti.

TABLE 6: WELFARE ESTIMATES IN 2008 NEW ZEALAND DOLLARS

	CS for Population	CS for sample	CS per angler	CS per choice
1 metre increase in water clarity in all lakes with poor and average water quality concurrently				
Lakes Rotorua, Rotoiti, Okaro, Rotoehu, Rotomahana, Okareka & Rerewhakaaitu	1,180,838.90	22,340.05	53.96	0.89
3 metres increase in water clarity in all lakes with poor and average water quality concurrently				
Lakes Rotorua, Rotoiti, Okaro, Rotoehu, Rotomahana, Okareka & Rerewhakaaitu	3,680,513.61	69,630.88	168.19	2.76
1 metre increase in water clarity in each of the lakes with poor and average water quality individually				
Lake Rotoiti	572,392.09	10,828.97	26.16	0.43
Lake Rotorua	496,698.32	9,396.93	22.70	0.37
Lake Rerewhakaaitu	85,349.88	1,614.72	3.90	0.06
Lake Rotoehu	28,513.44	539.44	1.30	0.02
Lake Okareka	16,424.66	310.73	0.75	0.01
Lake Okaro	4,323.83	81.80	0.20	0.003
Lake Rotomahana	864.87	16.36	0.04	0.001
3 metres increase in water clarity in each of the lakes with poor and average water quality individually				
Lake Rotoiti	1,849,866.99	34,997.26	84.53	1.39
Lake Rotorua	1,611,268.89	30,483.27	73.63	1.21
Lake Rerewhakaaitu	284,315.50	5,378.91	12.99	0.21
Lake Rotoehu	95,473.05	1,806.21	4.36	0.07
Lake Okareka	55,057.05	1,041.61	2.52	0.04
Lake Okaro	14,506.12	274.44	0.66	0.01
Lake Rotomahana	2,902.44	54.91	0.13	0.002

In terms of the relative rankings based on the magnitude of welfare estimates, the model ranks the lakes in the following order from highest to lowest; Rotoiti, Rotorua, Rerewhakaaitu, Rotoehu, Okareka, Okaro and Rotomahana. This ranking is consistent with the predicted trip shares in Table 5 above.

TABLE 7: WELFARE LOSS DUE TO LAKE CLOSURE IN 2008 NEW ZEALAND DOLLARS

	CS for Population	CS for Sample	CS per Angler	CS per Choice
Lake Rotoiti	-6,047,056.95	-114,403.03	-276.34	-4.54
Lake Rotorua	-5,136,467.76	-97,175.78	-234.72	-3.85
Lake Tarawera	-4,763,676.52	-90,123.02	-217.69	-3.57
Lake Rotoma	-1,884,701.45	-35,656.28	-86.13	-1.41
Lake Okataina	-771,225.75	-14,590.66	-35.24	-0.58
Lake Rerewhakaaitu	-734,402.62	-13,894.01	-33.56	-0.55
Lake Rotoehu	-251,776.39	-4,763.31	-11.51	-0.19
Lake Okareka	-144,348.16	-2,730.89	-6.60	-0.11
Lake Tikitapu	-37,866.84	-716.39	-1.73	-0.03
Lake Okaro	-22,705.17	-429.55	-1.04	-0.02
Lake Rotomahana	-7,565.05	-143.12	-0.57	-0.01

Table 7 above presents the implied welfare losses due to possible lake closure for all lakes in the choice set. Lake closure may occur for a number of reasons including deliberate management policies or environmental problems, for instance, falling water quality beyond the acceptable recreational guidelines. The highest welfare loss of are predicted for Lake Rotoiti of about $276.34 per angler per year. This is followed by Lake Rotorua, with a welfare loss of about $234.72 per angler per year. The lowest welfare loss is predicted for Lake Rotomahana of about $0.57 per angler per year. In terms of the welfare loss, the model predicts a ranking of the lakes in terms of their relative importance to anglers in the following order from the highest to the lowest; Rotoiti, Rotorua, Tarawera, Rotoma, Okataina, Rerewhakaaitu, Rotoehu, Okareka, Tikitapu, Okaro and Rotomahana.

5.0 Conclusions

Natural resource managers can be guided by the outcomes of discrete choice random utility models. Through the multinomial logit modeling framework some of the attributes which may impact positively or negatively upon anglers fishing site choice destinations are identified. The study results have revealed that anglers generally favour lakes with better water quality, bigger fish, that are relatively big in size, with more facilities and are situated in natural settings with forest cover. On the other hand, lake depth and the presence of urban developments around the lakes are major detractors for many anglers.

Furthermore, hypothesized water quality improvements in lakes with poor and average water quality illustrates that some lakes would attract most anglers (e.g. Rotoiti and Rotorua) while for others the increase would be minimal (e.g. Okaro and Rotomahana). The welfare measures associated with such water quality changes are also simulated. The highest welfare gains are predicted for Lakes Rotoiti followed by Rotorua. In addition, the study results reveal that welfare losses due to possible lake closures for the Rotorua Lakes is quite diverse ranging from as high as \$276.34 (Lake Rotoiti) to as low as \$0.57 (Lake Rotomahana) per angler per fishing season.

This study has highlighted some of the benefits that recreational-based resource managers in New Zealand can reap from discrete choice random utility models. The ability of these models to predict recreational site attributes that are most favoured by recreational users, coupled with the flexibility of these models to predict changes in the probability of site visit, and welfare gains/losses due to changes in recreational site attributes might be crucial in guiding public resource managers in coming up with better policy options that are most beneficial to society.

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Appendix 1: Fish and Game Regions

Source: FGNZ (2011)