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Techniques for Evaluating Community Preferences for Managing Coastal Ecosystems

Auckland region stormwater case study discrete choice model estimation

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Techniques for Evaluating Community Preferences for Managing Coastal Ecosystems

Auckland region stormwater case study discrete choice model estimation

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1 Executive summary

Auckland's coastal environments are subject to development effects that have an impact on its beaches and coastal ecosystems. A range of ecological and human factors affect the coast and to understand this complex issue, appreciation of these aspects is needed. While much research has been undertaken in the area of ecology, little is understood of human preferences for coastal management in the Auckland region. What do people actually value in the coastal environment? How much money should be spent reducing urban effects and upgrading infrastructure to mitigate these effects? To answer these questions, the Auckland Regional Council commissioned Cawthron Institute to design a way to estimate the benefits to Auckland of a healthy marine environment.

This project addresses the social dimension of planning mitigation processes for managing the Auckland coastal environment. Identifying priorities for mitigation expenditure requires an understanding of the ecological and social systems. In the context of a storm water case study, the aims of this project are:

- To develop environmental evaluation techniques for the coastal marine environment that capture human use values around ecological goods and services provided by a healthy ecosystem. The techniques go broader than a focus on water quality and clarity and include coastal zone substrate (underfoot conditions), as well the notion of ecological health.
- To investigate how people respond to, and understand, the concepts of ecological goods and services and ecosystem health, and the values they place on these. These values are reflected in willingness to pay estimates for different locations of Auckland's coastline and the attributes of storm water effects relevant to coastal use at those locations.

In previous reports, we reviewed existing research work about valuing coastal environments. The environmental economics literature pointed to recent developments in environmental valuation as a means to provide a structured and statistically robust way to understand community preferences. The method, known as a choice experiment, asks survey respondents to choose which alternative future scenario they would prefer, from each of several "choice sets". In the process of developing the choice experiment, we found that the attributes of most importance to people were water clarity, the quality of underfoot conditions and ecological health. A financial variable was included in the study, which enabled us to derive estimates of monetary values that decision-makers can use to maximise benefits from new policies and engineering measures.

The focus of this project is on assessing the benefits associated with remediation of storm water through the application of a choice experiment. This experiment consists of two parts. First, the data collection vehicle, a choice experiment, was developed. Second, the associated analytical vehicle, a Discrete Choice Model (DCM), was applied. The choice experiment and DCM were developed and pre-tested in a prior project (2008–2009) to design a vehicle to understand Aucklanders' coastal preferences and the economic benefits that flow from mitigation expenditure. Under the current project, data was collected for the choice model estimation and a number of model specifications were estimated.

A Latent Class Model, with five classes, was selected for its fit to the data. Model fits to the data are moderate, with a high proportion of benefit estimates proving statistically significant at the 99% confidence level. The model is able to assess the rate at which respondents make trade-offs between coastal marine environmental attributes and to derive money value estimates for environmental changes.

Three environmental quality attributes at three broad coastal categories were specified in the model: ecological health, water clarity, and underfoot conditions; and the coastal locations are upper harbour, middle harbour and outer coastal zones. Respondents show a strong preference for outer coastal beach locations over middle and upper harbour locations. Water quality leads ecological health, then underfoot conditions in importance at beach locations.

The study estimates money values for changes in the three environmental quality attributes at three categories of the coast. For example, the lump sum money value of a decline in ecosystem quality understood in terms of species diversity at beach locations from medium to low level is of the order of $1.15 billion. An alternative interpretation is that this represents the lump sum value of remediation works and policy changes that would improve outer zone ecological health from low to medium.

This project differs from previous benefit estimation work in Auckland's coastal environmental management. The current work moves from assessing a specific technology's net benefits, to providing estimates of benefit change related to a number of environmental qualities, independent of the policy and engineering interventions necessary to achieve them. An application is discussed in which a hypothetical project consisting of policy and engineering components delivers changes in water quality and underfoot conditions in the upper harbour areas of the Auckland region, but no discernable change to other locations. A 95% confidence estimate of the money value of that change ranges from $783 million to $1.122 billion.

This project provides a methodology to collect data on community preferences for environmental quality across differing coastal location types. The approach's strengths lie in:

- a statistically robust method for data collection and analysis,
- data collection theory and practice is well developed and supported in the literature,
- the capacity for model outcomes to include monetised assessments of project benefits,
- an assessment and estimation of benefits, rather than a focus on issue and solution,

- application to a wide variety of coastal environmental management and engineering projects in the benefit estimation area.

2 Introduction

This project is intended to inform policy development for the management of the Auckland coastal environment. To reduce complexity, a case study approach was adopted. The focus is on assessing the benefits associated with remediating storm water through applying a discrete choice modelling format.

Two earlier Cawthron projects in this area have:

- reviewed a prior assessment (Ward & Scrimgeour 1991) of the net benefits of storm water remediation engineering and recommended a direction for the assessment of the economic benefits associated with storm water remediation on coastal environments, and
- established a choice experiment format (Batstone 2009) to derive estimates of individual willingness to pay for changes in key attributes attached to community values associated with coastal marine environments in the Auckland region.

Work to date has highlighted the complexities of Auckland's coastal environment. The available knowledge was unable to inform comprehensive coverage of the region in terms of understanding the values associated with differing storm water engineering strategies. The initial question was around determining the value placed by the community on the coastal environment and how that might change as a result of storm water management options. Aspects of Phases 1 and 2 of the Cawthron projects identified problems in answering this question directly for the whole Auckland region and in linking environmental outcomes to particular storm water management options.

This storm water case study narrows the focus of the enquiry away from a broad assessment of the value associated with the region's coast. Instead, the case study assesses the value placed by the community on key storm water effects on ecosystem health and, in turn, the services that people derive from Auckland coastal ecosystems.

This report is structured as follows: the second section describes the methods, the third and fourth sections present the results and discussion, and then concluding remarks complete the report.

3 Methodology

In the context of a storm water case study, the aims of the project are:

- To develop environmental evaluation techniques for applying in the coastal marine area that capture human use values around the ecological goods and services (provided by a healthy ecosystem). The techniques go broader than a focus on water quality/clarity to include coastal zone substrate (underfoot conditions) and the notion of ecological health.
- To investigate how people respond to, and understand, the concepts of ecological goods and services and ecosystem health and the values they place on these. These values are reflected in willingness to pay estimates for combinations of broad geographic descriptions of Auckland's coastline and the attributes of storm water effects relevant to coastal use at those locations.

3.1 Model

The methodology used in this the project was developed in prior work that took storm water's effects on coastal marine environments as its context. That work recognised a choice experiment as a fruitful direction for further enquiry and resolved design and technical issues (Hensher *et al.* 2003) to produce the method presented here (Batstone *et al.* 2008; Batstone 2009).

To address the aims of the study, the choice experiment format offered respondents three options that reflected aspects of coastal use experience impacted by the constituents of storm water: water quality, underfoot conditions, and ecological health. Each of these options were differentiated at three broad location categories: outer harbour (beaches), middle harbour and upper harbour environments. For each location/environmental quality combination, three levels were specified: low, medium and high. In the estimation process, the model base case is low levels of each of the environmental quality attributes. The model coefficients are interpreted as the change in utility associated with a change in environmental quality from low to medium or from low to high, depending on the variable label.

A payment vehicle was developed to derive willingness to pay (WTP) estimates for each of three quality attributes at the three locations. The payment vehicle was motivated by local governments' capacity in New Zealand to levy additional property rates for environmental management, for example storm water remediation costs, with flow-on effects for both owners and those who rent homes. The levels of the payment vehicle were obtained in preparatory focus groups: $0, $25, $50, $75 and $150. The payment vehicle enters the model description below as the variable "cost."

Model attributes are coded using upper case notation. The first sequence of letters in each of the nine location/quality combinations represents the geography: Upper harbour, Middle harbour, Outer harbour. For example:

- OT = Outer
- M = Middle
- UP = Upper

The middle letter aligns with the environmental quality attribute: Ecological health, Water quality, Underfoot conditions. The last letter of the string represents the level of the environmental quality attribute in terms of: L for low, M for medium, and H for high.

- OTEH = Outer Ecological health High
- MWM = Middle Water quality Medium
- UPUH = Upper Underfoot High

In utility specification form, the model estimated was:

$$U(X) = con + b1*OTEM + b2*OTEH + b3*OTWM + b4*OTWH + b5*OTUM + b6*OTUH + b7*MEM$$
$$....+ b8*MEH + b9*MWM + b10*MWH + b11*MUM + b12*MUH + b13*UPEM + b14*UPEH$$
$$.....+ b15*UPWM + b16*UPWH + b17*UPUM + b18*UPUH + b19*Cost$$

Where:

U (X) = Utility of option X

OTEM = Outer Ecological Health (Medium)

OTEH = Outer Ecological Health (High)

OTWM = Outer Water Quality (Medium)

OTWH = Outer Water Quality (High)

OTUM = Outer Underfoot Conditions (Medium)

OTUH = Outer Underfoot Conditions (High)

MEM = Middle Ecological Health (Medium)

MEH = Middle Ecological Health (High)

MWM = Middle Water Quality (Medium)

MWH = Middle Water Quality (High)

MUM = Middle Underfoot Conditions (Medium)

MUH = Middle Underfoot Conditions (High)

UPEM = Upper Ecological Health (Medium)

UPEH = Upper Ecological Health (High)

UPWM = Upper Water Quality (Medium)

UPWH = Upper Water Quality (High)

UPUM = Upper Underfoot Conditions (Medium)

UPUH = Upper Underfoot Conditions (High)

Cost = Additional annual household cost

Con = Model constant, (Base=1, Otherwise =0) and,

b_i = Estimated model coefficients

In the context of the case study, the estimation of the Discrete Choice Model produces mathematical expressions that summarise how human welfare changes when environmental quality attributes are altered.

The willingness to pay relative to the model base case is derived by the expression:

$$WTP_i = -\frac{Attribute\ coefficent_i}{Cost\ coefficent_i}$$

A key to interpreting the model is recognising that the coefficients represent the change in utility that correspond to a change in an environmental quality attribute from low (the model base case), to medium or high depending on the attribute coding. Accordingly, there are no variables coded for "low" in the utility expression since that is the model base case.

3.2 Data collection process: the choice experiment

A sample of respondents was selected to be representative of the adult Auckland population in terms of proportions defined by residential location and census demographics: age, gender, ethnic affiliation. Participants were offered an incentive of $50 to attend data collection meetings. The exact nature of the meeting subject was not disclosed, although participants were informed that the subject was Auckland's coast. Recruitment, venue hosting and incentive management were performed by a professional market research firm, Prime Research. Table 1 describes the target versus actual composition of the sample.

The recruitment sample of 336 (actual) returned 301 useable responses for analysis. Analysis sample proportions did not differ notably from the recruitment sample. Data collection was undertaken in the period 26 May to 11 June 2009.

Data were collected in three rounds of three meetings, with each meeting attended by 30–40 participants. Data collection took place at locations in the south, central, and the northern Auckland metropolitan areas, and Franklin.

Table 1. Target versus actual sample.

		Actual (count)	Actual (%)	Target (%)
Residential location *2006 Census, Census Usually Resident Population Count*	Auckland City	109	32%	31%
	Franklin	17	5%	5%
	Manukau	76	22%	25%
	North Shore	56	17%	16%
	Papakura	9	3%	3%
	Rodney	20	6%	7%
	Waitakere	49	15%	14%
Ethnicity *2006 Census, Ethnic Groups (Grouped Total Responses), for the Census Usually Resident Population Count*	European/NZ Euro	187	56%	56%
	Maori	40	12%	11%
	Pacific Island	44	13%	14%
	Asian/Other	64	19%	19%
	Unidentified	1	0%	0%
Gender *2006 Census, Sex, for the Census Usually Resident Population Count*	Male	162	48%	49%
	Female	174	52%	51%
Age *2006 Census, Age in 5 Year Groups, for the Census Usually Resident Population Count*	20-24	40	12%	11%
	25-29	35	10%	10%
	30-34	38	11%	11%
	35-39	37	11%	11%
	40-44	42	13%	12%
	45-49	32	10%	10%
	50-54	27	8%	8%
	55-59	25	7%	7%
	60-64	18	5%	6%
	65 and over	42	13%	14%

The venue formats were standardised as much as possible. Depending on the room dimensions and the anticipated numbers of participants, chairs and tables were arranged in 3–4 rows, split at the centre so that 6–8 distinct groups of forward facing, seated people resulted. Participants were offered coffee and light refreshments on arrival.

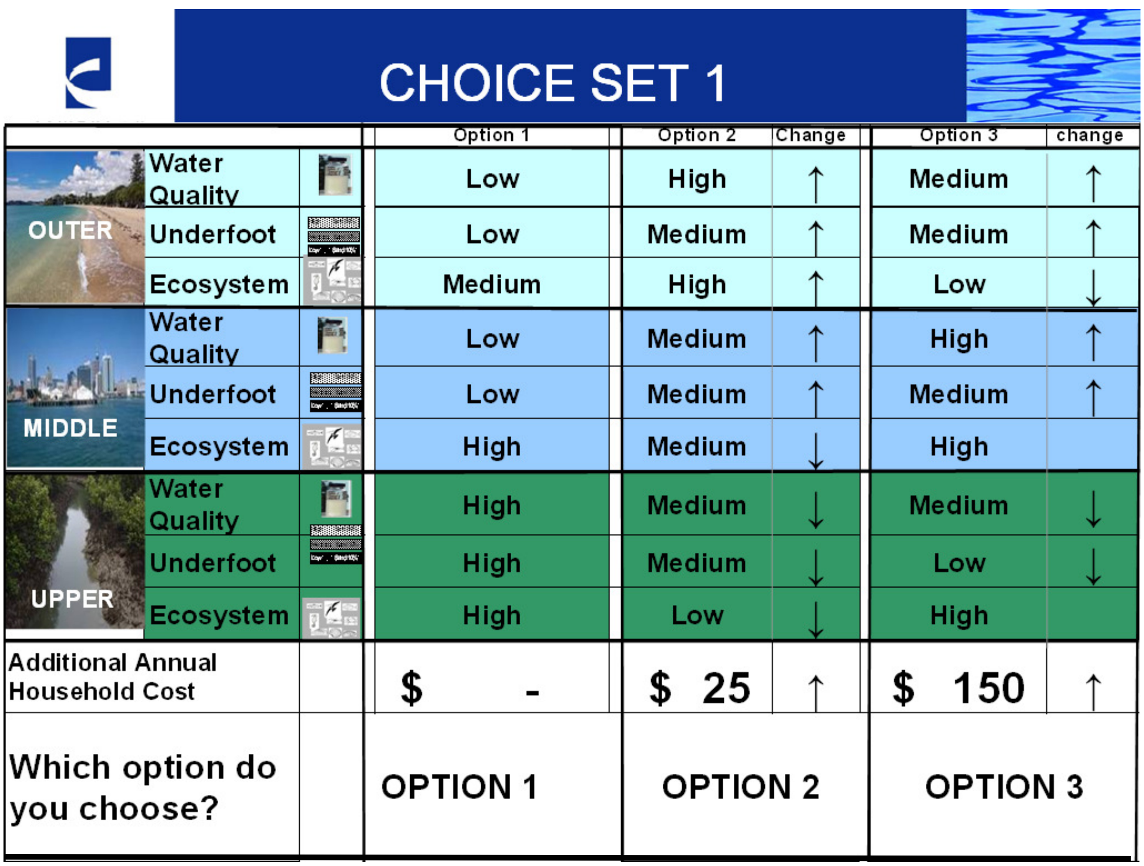
Data collection meetings consisted of:

- Presenting the context and the issue,
- Reviewing the attributes and the symbols used in the choice experiment,

- Training participants to build capability in choice selection through a ranking exercise,
- Reviewing the experiment format and how respondents make choices, and
- Outlining the data collection process.

In the data collection phase of the meeting, participants were asked to address 20 choice sets. Each choice set offered three options defined in terms of three location attributes, each in turn featuring three environmental attributes and a payment vehicle attribute. Figure 1 describes the format of the choice sets offered to participants. The choice sets were displayed by data projector onto a screen, with participants indicating choices on a data collection form. That information was transcribed to Excel spreadsheet.

Figure 1. Choice set presentation example.



The design features three unlabelled options, each option characterised by variation in a sequence of combinations of environmental quality and coastal zone across three levels, low medium and high. Additional annual household cost is the payment vehicle. The coastal zones are identified by photograph, and kept distinct in the choice set through colour differentiation. Arrows indicate the outcomes of each scenario relative to Option 1, in which the cost variable does not change across the choice sets. The other environmental quality attribute levels do change in Option 1, their change generated by the same process as for the other options. The following section describes the method used to obtain the attribute levels in the choice set design process.

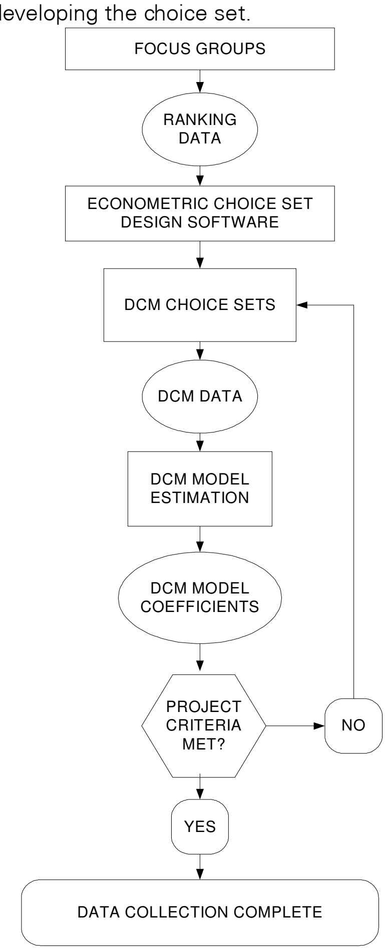
3.3 Choice set design process

An evolutionary approach to generating the choice sets was used in this project. The objective was to generate increasingly efficient combinations of choice attributes as the data collection proceeded in batches through the sample. The aim was to achieve statistical significance of the model coefficients and the derived WTP estimates ($p < 0.05$) for potential sample strata with low populations.

The choice sets were generated using Ngene econometric design software (Rose *et al.* 2009). The software allows improvement in statistical efficiency by updating choice options after each data collection meeting. It requires *a priori* estimates of model coefficients as starting values for the software's iterative search algorithm. *A priori* knowledge of the relative magnitudes of the model coefficients was derived first from ranking data generated in the final round of focus groups (Batstone *et al.* 2008). Pre-testing of the first choice set design over a small (N = 17) sample conducted in April 2009 (Batstone 2009) produced statistically significant ($p < 0.05$) estimated model coefficients that were used as starting points for further choice set design refinements in the main data collection process. Figure 2 describes the iterative process for choice set development.

Model estimation from the first data generated parameter estimates, which were put into the choice set design process to generate an efficient design. The updated design was used for subsequent data collection. This process was repeated so that each meeting used choice set design improvements obtained in the previous meeting. The choice set design criteria was C(p) efficiency (Hensher *et al.* 2008; Scarpa & Rose 2008; Kerr & Sharp 2009). This approach generated choice sets that minimised the variance of the WTP estimates derived from the choice model estimation. The efficiency criterion was defined in terms of the target minimum sample size required to establish significant WTP estimates at the 95% confidence level. The "p" portion of the C(p) descriptor indicates that the iterative selection process uses point (rather than Bayesian) estimates of model coefficients as opposed to selection from a prior distribution specified in terms of mean and variance.

Figure 2. Process for developing the choice set.



DCM = discrete choice model

The targeted sample size was N=300, intended to deliver significant WTP estimates from a representative sample of Auckland residents. The choice set design process stopped after ten iterations in total: focus group ranking data, pre-test coefficient estimates, and eight revisions prior to the final data collection meeting. The model was estimated with LIMDEP econometric software, using variations on the multinomial logit specification (Hensher *et al.* 2005).

4 Results

4.1 Model specification

A number of alternate model specifications are available to take account of the diversity of tastes and preferences in a population. Technically this issue is referred to as "preference heterogeneity" and is a key consideration in understanding environmental management costs and benefits. Diversity has been accommodated in the choice experiment process through development of variations on the main effects multinomial logit (MNL) model. This project uses both the interactions model and the latent class model (LCM) variations.

The interactions model allows personal characteristics of individual respondents to enter the analysis. Individual characteristics such as age, gender, income, and coastal use avidity may influence the parameters. Variables describing these personal characteristics enter the model multiplicatively. An iterative search process is used to identify statistically significant combinations of the attribute and personal characteristic variables.

The LCM formulation takes account of the presence of preference heterogeneity in the population by a process in which respondents are sorted into a small number of "classes," each class with identical utility functions for all members. Information about class membership and class specific parameters is extracted from the data in the estimation process (Greene 2007).

Model selection from these alternatives was achieved by comparing a number of diagnostic statistics that point to relative quality of fit between model specifications. The diagnostic criteria employed were:

- Log Likelihood Function (LL),
- Akaike information criteria (AIC),
- Bayesian information criteria (BIC), and
- Adjusted $\boldsymbol{\rho}^2$.

The LL statistic is the basis for calculation of the other measures, which take account of difference in the number of parameters estimated between the specifications. Optimal model selection is a balance between selecting the model that minimises the value of AIC and BIC, while maximising the adjusted $\boldsymbol{\rho}^2$ statistic. Table describes the evaluation of six model specifications: MNL, the interactions model, and four LCM models. The LCM has class versions of two through to five. The MNL specification is the equivalent of the specification for a latent class model with one class. The comparison between diagnostic statistics selects the model with the best fit to the data, according to specific criteria.

In all of the LCM models, the coefficient on the cost attribute is constrained to be the same for each class estimated. This convenience enables direct comparison between the signs and relative magnitudes of the attribute coefficients and, in turn, WTP estimates between model classes. In making this assumption, differences in WTP estimates between model classes may be understood in terms of differing utility revealed in the model coefficients, rather than through differences sourced in both attribute and cost coefficients.

Table 2. Alternate model specification performance diagnostics.

Model	LL	AIC	BIC	Adjusted ρ^2
MNL	-6972.5110	1.9359	1.9550	0.1188
Interactions	-6951.3000	1.9350	1.9510	0.1285
MNL LCM-2	-6639.2820	1.8500	1.8635	0.1634
MNL LCM-3	-6534.7170	1.8270	1.8479	0.1766
MNL LCM-4	-6403.9740	1.7968	1.8788	0.1931
MNL LCM-5	-6348.3400	1.7875	1.8904	0.2001

In Table 2, stages of model development follow the rows down the table from MNL to MNL LCM-5. The shaded cell in each column shows the best specification according to that measure. The greatest gains in the real improvements in the adjusted ρ^2 statistic come from the use of the latent class specification (0.1188 to 0.1634). Overall the Latent Class Model with five classes performs the best. It minimises the absolute value of LL and AIC, and maximises the adjusted ρ^2 (ρ^2 = 0.2001) statistic, compared with the other model specifications. Note that this outcome is not consistent across all the measures; the BIC statistic indicates that the MNL-LCM-3 model performs best.

4.2 Base model multinomial logit outcomes

Table 3 describes the outcomes of the base MNL specification estimation. It shows the values of the estimated coefficients, with WTP estimates and the Z statistic for the WTP estimates on the far right column of the table. Z statistics were calculated using the Delta method (Hensher *et al.* 2008) to test the null hypothesis that each WTP estimate was not statistically significantly different from zero. All WTP estimates are significant at the 99.98% level. The lowest Z score is Z = 4.15, associated with the WTP estimate for Upper Ecological Health High (UPEH).

Table 3. Outcomes of discrete choice model estimation.

Model	Estimated Coefficient	WTP Estimate[1]	Z (WTP)
Constant	-0.1726	NA	
OTEM = Outer Ecological Health (Med)	0.5225	$ 135.64	8.69
OTEH = Outer Ecological Health (High)	0.6989	$ 181.45	9.15
OTWM = Outer Water Quality (Med)	0.7297	$ 189.45	9.55
OTWH = Outer Water Quality (High)	1.0591	$ 274.96	8.08
OTUM = Outer Underfoot Conditions (Med)	0.4470	$ 116.05	8.62
OTUH = Outer Underfoot Conditions (High)	0.6507	$ 168.94	6.72
MEM = Middle Ecological Health (Med)	0.3268	$ 84.83	7.42
MEH = Middle Ecological Health (High)	0.4254	$ 110.45	4.49
MWM= Middle Water Quality (Med)	0.1817	$ 47.18	6.74
MWH= Middle Water Quality (High)	0.3347	$ 86.90	5.06
MUM = Middle Underfoot Conditions (Med)	0.2166	$ 56.22	5.20
MUH = Middle Underfoot Conditions (High)	0.2234	$ 57.99	5.92
UPEM = Upper Ecological Health (Med)	0.2450	$ 63.60	6.95
UPEH = Upper Ecological Health (High)	0.3197	$ 83.00	4.15
UPWM= Upper Water Quality (Med)	0.1578	$ 40.98	7.48
UPWH= Upper Water Quality (High)	0.3819	$ 99.16	4.80
UPUM = Upper Underfoot Conditions (Med)	0.1962	$ 50.94	4.95
UPUH = Upper Underfoot Conditions (High)	0.2207	$ 57.31	8.30
Cost = Additional annual household cost	-0.0039		

[1] Calculated using the expression: $WTP_i = -\frac{Attribute\ coefficent_i}{Cost\ coefficent_i}$

All reported coefficients are significant at the 0.002% level (equivalent to Z=4.5). The reported Z statistics show the WTP estimates to be highly significant. Figure 3 contrasts the annual household WTP estimates for each of the coastal zone/environmental quality attributes, indicating that estimated WTP ranges from roughly $50 per household per year for improvements in upper harbour attributes to well over $100 per year for outer beach attributes, and in the case of Outer Water Quality (OWH) up to $275 per year. Error bars represent 95% confidence intervals for WTP estimates.

Figure 3. Multinomial Logit willingness to pay estimates.

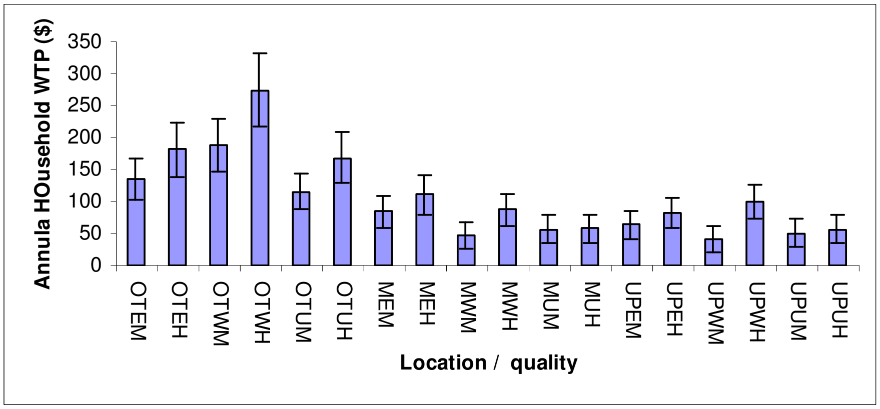


Figure 3 indicates that respondents showed higher WTP for environmental quality in the Outer Zone, consisting primarily of beach locations, than for other parts of the Auckland coast. Table 4 describes the outcomes of econometric testing (Krinsky and Robb, 1986) to identify statistical significance of differences in estimated WTP for each of the three environmental quality attributes between coastal zones. A statistically significant difference ($p < 0.01$) in WTP is evident for each of the three environmental quality attributes between Outer and Middle, and Outer and Upper coastal zones. However no significant difference was detected between Middle and Upper zones for each of those attributes at the $p < 0.05$ level of confidence (signaled by shaded cells in the table).

Table 4 Comparison of estimated WTP for environmental quality attributes between coastal zones.

Attribute	Change	Change WTP difference between zones	P value
Ecological Health (EH)	Low - medium	Outer / Middle	0.00
		Middle / Upper	0.13
		Outer / Upper	0.00
	Medium - high	Outer / Middle	0.00
		Middle / Upper	0.07
		Outer / Upper	0.00
Water Quality (WQ)	Low - medium	Outer / Middle	0.00
		Middle / Upper	0.62
		Outer / Upper	0.00
	Medium - high	Outer / Middle	0.00
		Middle / Upper	0.39
		Outer / Upper	0.00
Underfoot Conditions (UC)	Low - medium	Outer / Middle	0.00
		Middle / Upper	0.70
		Outer / Upper	0.00
	Medium - high	Outer / Middle	0.00
		Middle / Upper	0.96
		Outer / Upper	0.00

Note: For shaded comparisons, the differences are not statistically significant.

Figure 3 also indicates that respondents showed higher estimated WTP for water quality than for other environmental quality attributes in the outer zone (consisting primarily of beach locations). Table 5 describes the outcomes of econometric testing (Krinsky and Robb, 1986) to identify statistically significant differences in estimated WTP for each of the three environmental quality attributes within each of the outer and middle, and upper coastal zones.

Table 5. Comparison of estimated WTP for environmental attributes within coastal zones.

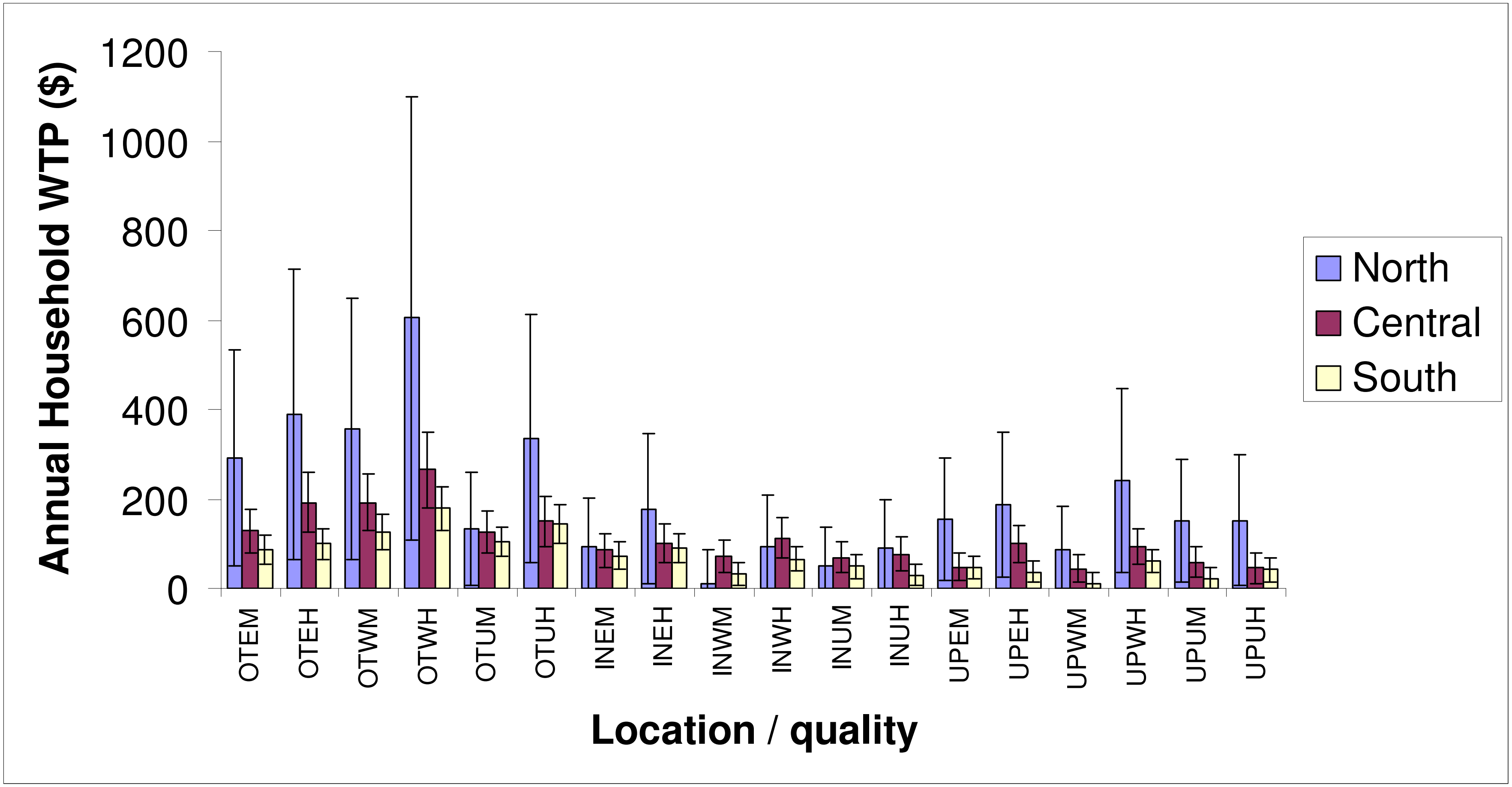
		WTP difference	
Outer Coastal Zone	Low - medium	WQ - EH	0.00
		EH - UC	0.15
		WQ - UC	0.00
	Medium - high	WQ - EH	0.00
		EH - UC	0.37
		WQ - UF	0.00
Middle Coastal Zone	Low - medium	WQ - EH	0.00
		EH - UC	0.06
		WQ - UC	0.51
	Medium - high	WQ - EH	0.09
		EH - UF	0.00
		WQ - UF	0.05
Upper Coastal Zone	Low - medium	WQ - EH	0.08
		EH - UC	0.37
		WQ - UC	0.44
	Medium - high	WQ - EH	0.22
		EH - UC	0.06
		WQ - UC	0.01

Note: For shaded comparisons, the differences are not statistically significant.

On the basis of the statistically significant differences in estimated WTP reported in Tables Four and Five it is possible to infer Aucklanders' preference for outer zone locations over those in middle and upper zones. There are no clear indications of preferences between middle and upper zones in the data however. Similarly, there are indications of Aucklanders' relative preference for water quality over environmental health and underfoot conditions in the outer zone. This pattern is not repeated consistently in the middle and upper zones, although relaxing statistical confidence levels allows water quality to take priority in some cases. These features in the patterns of respondents' estimated WTP may in turn reflect the location and nature of Aucklanders' use and experience of Auckland's coast and the values they hold in respect of the coast. Section 3.4 explores this in the context of five distinct classes identified in the sample in the course of estimation of LCM formulation of the model. It presents visual comparisons of respondents' coastal use and WTP patterns.

The socio-economic profiles of the areas covered by the three data collection venues differ considerably. Figure shows estimated WTP in south, central and northern parts of Auckland. The error bars represent 95% confidence intervals for the WTP estimates from each location. Figure shows that, although there are some apparent differences in WTP estimates arising from data collection locations, these are not statistically significant. WTP estimates in this report are generated from data pooled from the three data collection locations. The high variability in WTP estimates generated from the northern data may be explained by two factors. First, while North Shore City has a higher income profile in comparison with other Auckland residential locations, it also has a considerable population of low to medium income residents. Second, respondents attending the northern data collection meetings were drawn from residential locations with lower income profiles in Waitakere City as well as from North Shore City. The combination of these two effects is likely to explain the higher variability.

Figure 4. Willingness to pay estimates by data collection location.



4.3 Accounting for preference heterogeneity: model outcomes

4.3.1 Interactions Model

Main effects models include only information that varies across the choices made by respondents. Personal characteristics data does not vary across choices such as age, gender, income, avidity, but may contain information about influences on choices made. These data are introduced into the model by "interacting" personal characteristics variables with environmental quality variables. A discussion of this interaction process in DCM is found in Hensher *et al.* (2003).

Two personal characteristics proved statistically significant when interacted with environmental quality/location variables: income and broad residential location. Age, gender, and coastal use avidity interactions with environmental quality attributes did not prove statistically significant.

Table 4 contrasts the coefficient estimates for the two alternate model specifications: MNL and interaction specifications. The highest income category (*i.e.* with household incomes greater than $100,000 per year) interacted with outer zone water quality variables proved statistically significant ($p < 0.05$). The positive signs on the coefficients indicate a higher utility from water quality in the outer zone by high income households than those in other income categories. Respondents from two Auckland local body areas, Rodney (ROD) and Waitakere City (WAK), showed statistically significant ($p < 0.05$) lower utility from middle coastal zone underfoot conditions than residents of other local bodies. Positive signs on these coefficients imply lower willingness to pay and negative signs higher willingness to pay in contrast with everyone else.

Table 6. Comparison of coefficient estimates: MNL and interactions model specifications.

Attribute	Base MNL	Interactions Model
CONSTANT	-0.1755	-0.1766
OTEM	0.5214	0.5186
OTEH	0.6975	0.6941
OTWM	0.7293	0.6719
OTWH	1.0552	1.0108
OTUM	0.4494	0.4495
OTUH	0.6495	0.6555
MEM	0.3263	0.3298
MEH	0.4235	0.4257
MWM	0.1809	0.1815
MWH	0.3307	0.3349
MUM	0.2118	0.2379
MUH	0.2190	0.2721
UPEM	0.2457	0.2445
UPEH	0.3182	0.3183
UPWM	0.1579	0.1615
UPWH	0.3824	0.3888
UPUM	0.1951	0.1978
UPUH	0.2175	0.2161
COST	-0.0039	-0.0039
IE*OTWM		0.4313
IE*OTWH		0.4847
ROD*MUM		-0.3918
ROD*MUH		-0.4371
WAK*MUH		-0.1921

All Interactions Model main effects coefficients are significant at the $p < 0.01$ level. The interaction terms (shaded) are significant at the $p < 0.05$ level.

4.3.2 Latent Class Model

Table 2 showed that the five class LCM performed better than the other class specifications in terms of model diagnostics (excepting the BIC criteria). Table 5 shows the WTP estimates for five separate classes. In the estimation process the cost coefficients are constrained to be the same for all classes. This simplifies comparison between WTP estimates.

Table 7. Household willingness to pay estimates contrast between MNL and LCM specifications.

		Annual Household WTP Estimate				
Attribute	MNL	Class 1	Class 2	Class 3	Class 4	Class 5
OTEM	$135.64	$194.51	$237.06	$102.59	$52.87	$29.54
OTEH	$181.45	$244.40	$315.43	$48.45	$88.24	$31.93
OTWM	$189.45	$517.77	$194.21	$165.34	-$16.92 **	$69.62
OTWH	$274.96	$703.03	$225.15	$288.38	$49.32	$122.96
OTUM	$116.05	$295.25	$142.05	$28.32	$12.71	$49.61
OTUH	$168.94	$407.80	$164.93	$75.56	$34.09	$97.47
MEM	$84.83	$104.46	$153.08	-$32.10	$28.64	$69.21
MEH	$110.45	$124.33	$231.54	-$26.99	$17.18	$84.57
MWM	$47.18	$92.79	$129.57	-$18.82	-$30.15 **	$54.22
MWH	$86.90	$142.98	$192.05	$125.36	-$66.71 **	$106.64
MUM	$56.22	$79.21	$99.75	$136.84	-$15.09 **	$52.14
MUH	$57.99	$83.54	$118.83	$139.89	-$49.54 **	$47.44
UPEM	$63.60	$49.72	$151.48	-$14.08 **	$22.28	$9.91
UPEH	$83.00	$63.43	$214.14	-$46.14	-$5.13	$70.22
UPWM	$40.98	$52.89	$83.28	$48.13	-$11.13	$28.52
UPWH	$99.16	$118.29	$177.89	$110.88	-$6.22	$85.92
UPUM	$50.94	$89.82	$78.84	$71.14	$46.39	$43.18
UPUH	$57.31	$75.80	$76.33	$41.12	$38.34	$111.52
Class Proportion of Population		32%	30%	5%	20%	13%

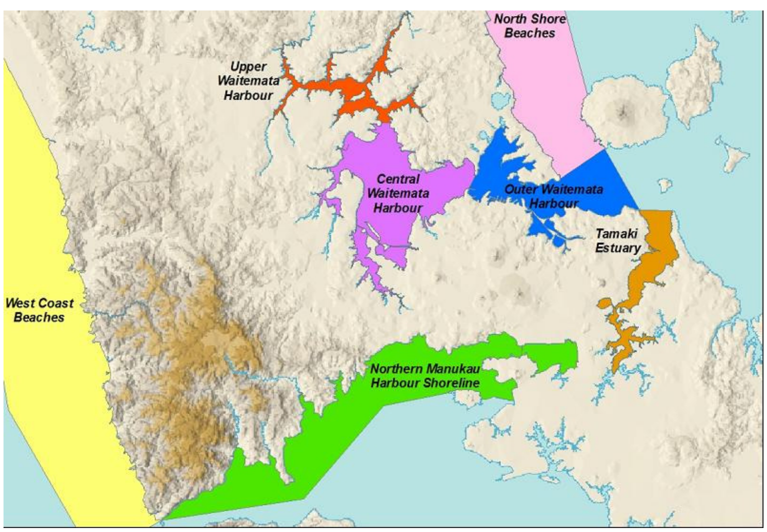
The estimated coefficients in the shaded cells in Table 5 are not significantly different from zero at $p < 0.15$. All other WTP estimates are significant at the $p < 0.01$ level. The coefficients in the cells marked with ** have negative signs and are statistically significantly different from zero. An interpretation of this outcome is that class three and four members are negatively impacted by changes in environmental quality in middle and upper zones.

4.4 Understanding the model classes in terms of use of the coast

Choice experiment respondents contributed information on their coastal use patterns in terms of visit frequency in the past twelve months to the following coastal areas:

- Northern Manukau Harbour Shoreline (NMHS),
- Upper Waitemata Harbour (UWH),
- Central Waitemata Harbour (CWH),
- Outer Waitemata Harbour (OWH),
- Tamaki Estuary (TAM),
- North Shore beaches (NS),
- West coast beaches (WC),
- Other (OTH), and
- None (no use of the coast in the prior 12 months).

Figure 5 Coastal locations visited by survey respondents.



A data set (N = 301) was created that included variables describing class membership and coastal use frequency. A variable representing respondent coastal use avidity (TOTNUM) was developed as the sum of visits to each coastal location in the prior 12 months. To understand how class membership in the five class LCM model relates to use (or non-use) of the coast by respondents, exploratory data analysis using correlation analysis of class membership and coastal use frequency was undertaken. The resulting linear correlations were typically low ($r < 0.2$). This may be attributable to the high potential for substitutability and complementarities between location/attribute combinations.

Tornado graphs are used to help visually distinguish the pattern of relationships between coastal use frequency and class membership.

The following sequence of figures (Figure 6 – Figure 15) should be considered in pairs. In each pair the first figure describes the point estimates of WTP for coastal zone and environmental quality combinations described in Table 5. The second figure shows the correlations between class membership and coastal visits. Environmental quality is described in terms of ecological health (EH), water quality (WQ), and underfoot conditions (UC).

Class one respondents (Figures 6 and 7) constitute 32% of the sample. The strongest positive correlations for members of this class are with use of the West Coast and North Shore beaches. There is a positive correlation with non-use of the coastal environment. The strongest negative correlations are with use of other locations and avidity.

Class two respondents (Figures 8 and 9) constitute 30% of the sample. The strongest correlations for members of this class are with use of the coast (TOTNUM), excepting North Shore and Tamaki estuary areas.

Class three (Figures 10 and 11) respondents constitute 5% of the sample. The strongest correlations for members of this class are positive with use of North Shore and out of Auckland coast, and negative for the avidity measure TOTNUM. These respondents tended to visit the coast only infrequently. Members of this class show negative WTP for a number of attribute / location combinations at locations inconsistent with their use pattern (North Shore and Other).

Class four respondents (Figures 12 and 13) constitute 20% of the sample. The strongest positive correlation for members of this class is with non-use of the coast. Members of this class show negative WTP for a number of attribute/location combinations.

Class five respondents (Figures 14 and 15) constitute 13% of the sample. The strongest correlations for members of this class are with non-use of the coast, and the use of Tamaki Estuary and Outer and Middle Waitemata Harbour areas.

Figure 6. Class one WTP estimate distribution by coastal zone and environmental quality.

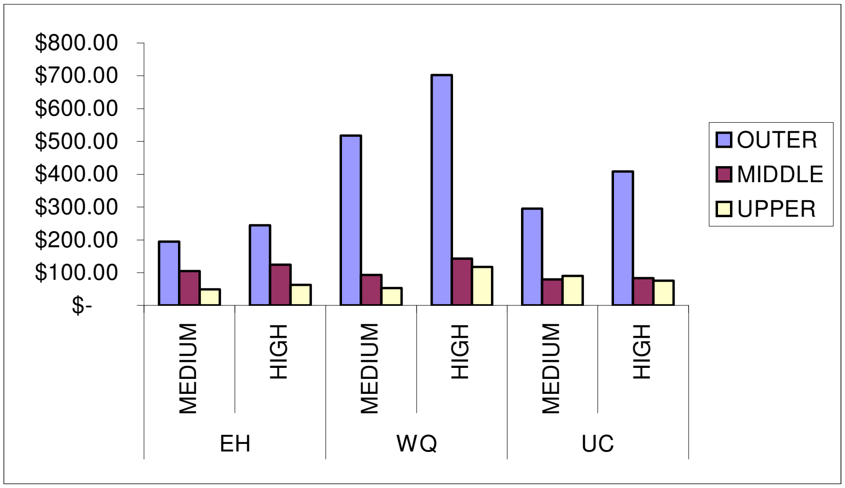


Figure 7 Class one correlations between membership of class and coastal use.

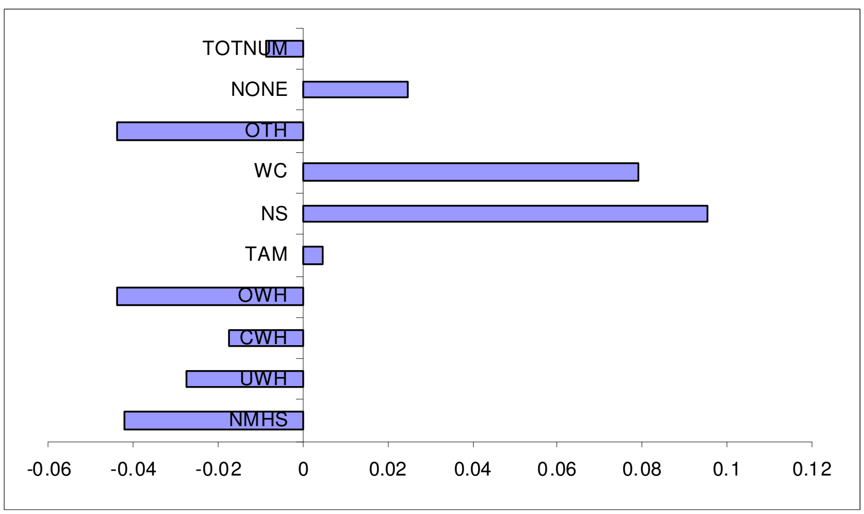


Figure 1. Class two WTP estimate distribution by coastal zone and environmental quality.

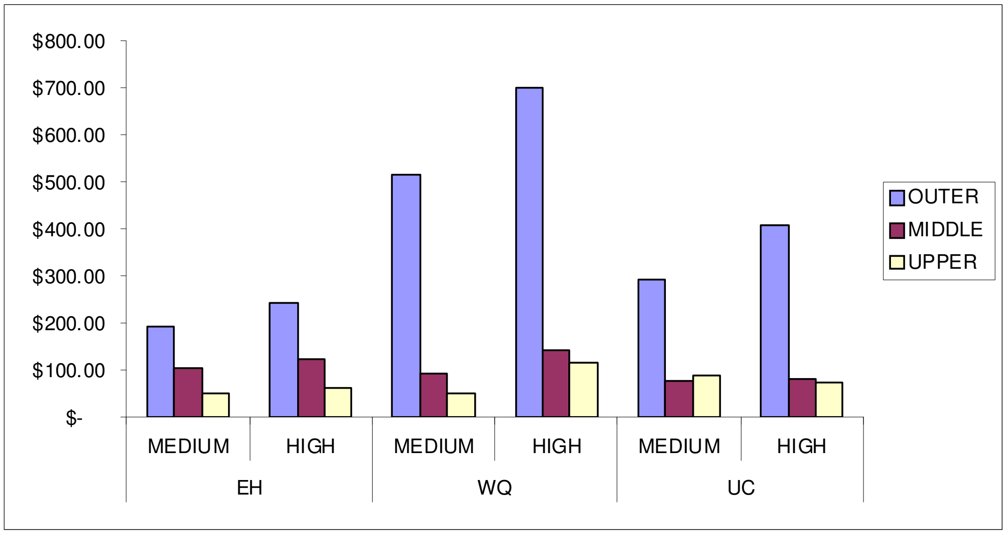


Figure 2. Class two correlations between membership of class and coastal use.

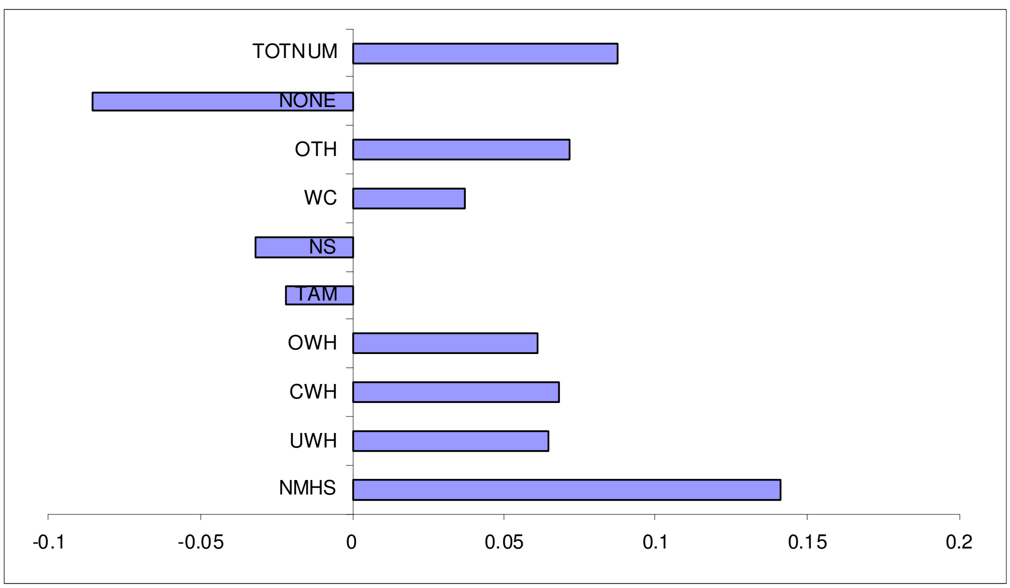


Figure 3. Class three WTP estimate distribution by coastal zone and environmental quality.

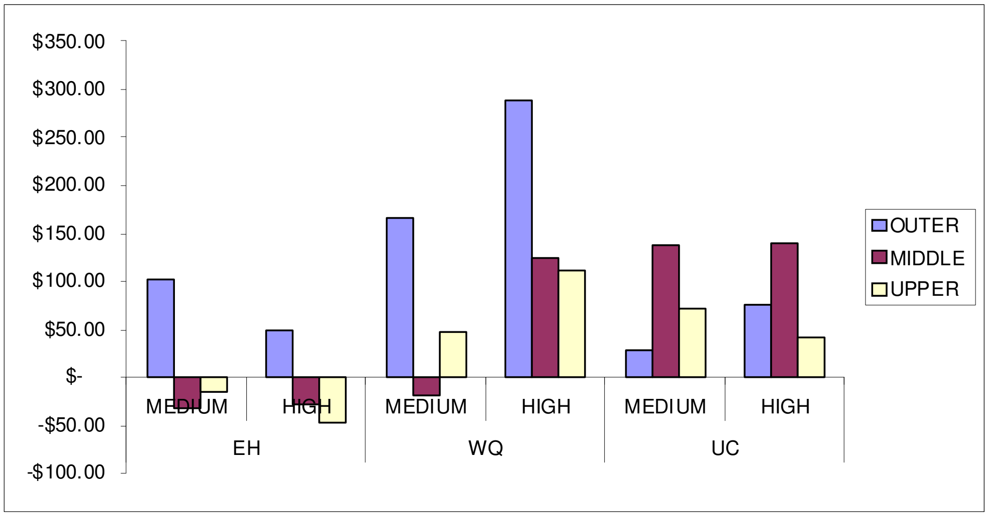


Figure 4. Class three correlations between membership of class and coastal use.

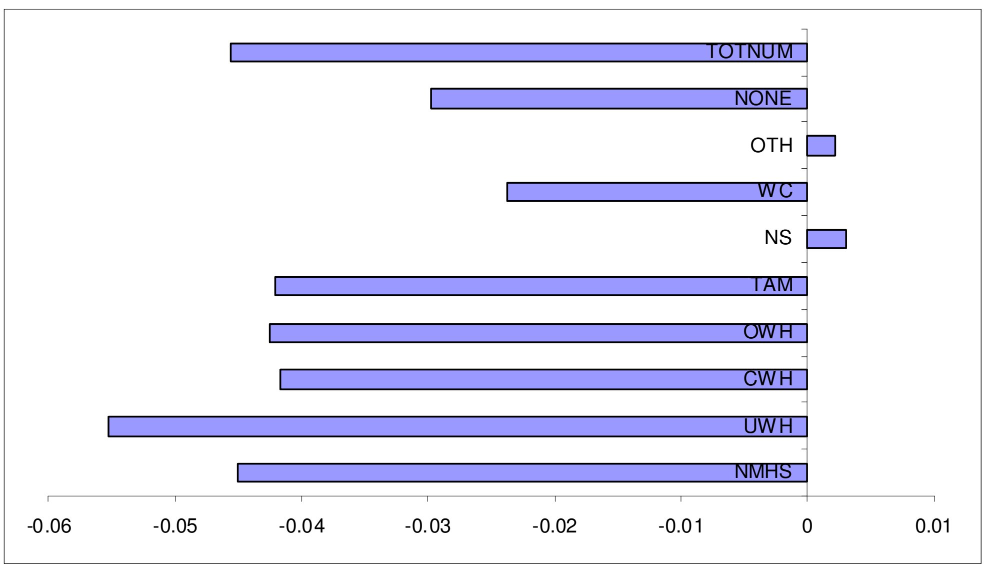


Figure 5. Class four WTP estimate distribution by coastal zone and environmental quality.

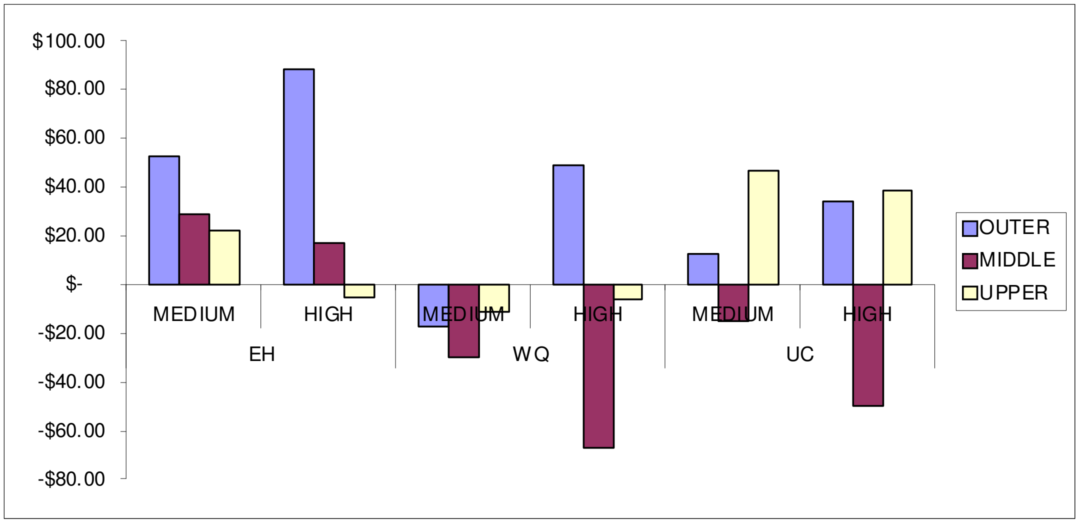


Figure 6. Class four correlations between membership of class and coastal use.

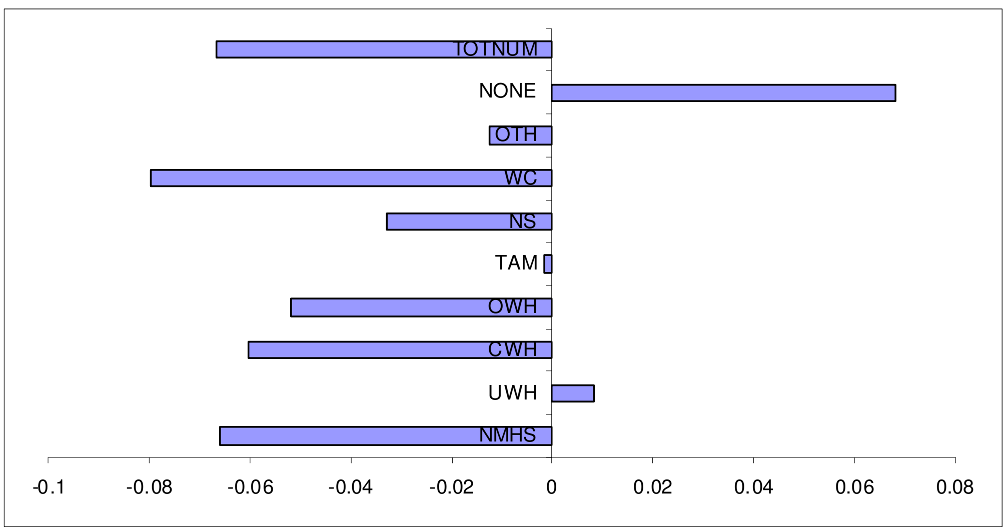


Figure 7. Class five WTP estimate distribution by coastal zone and environmental quality.

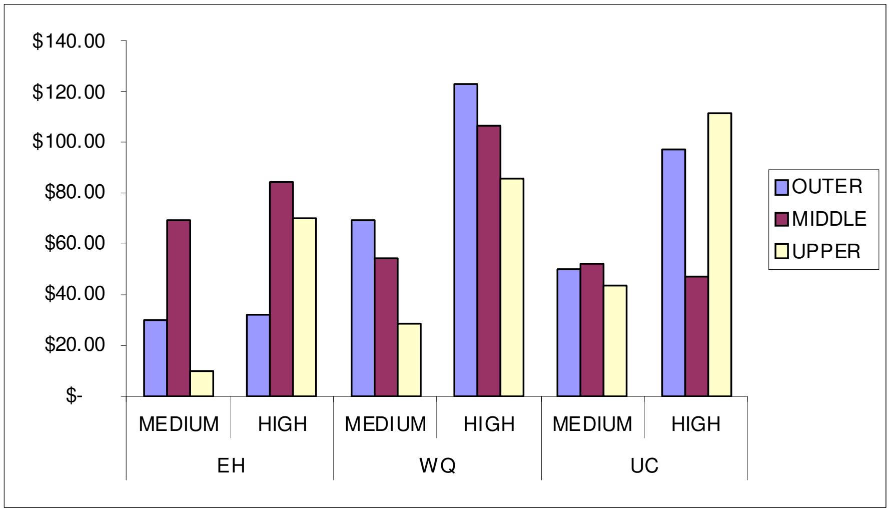
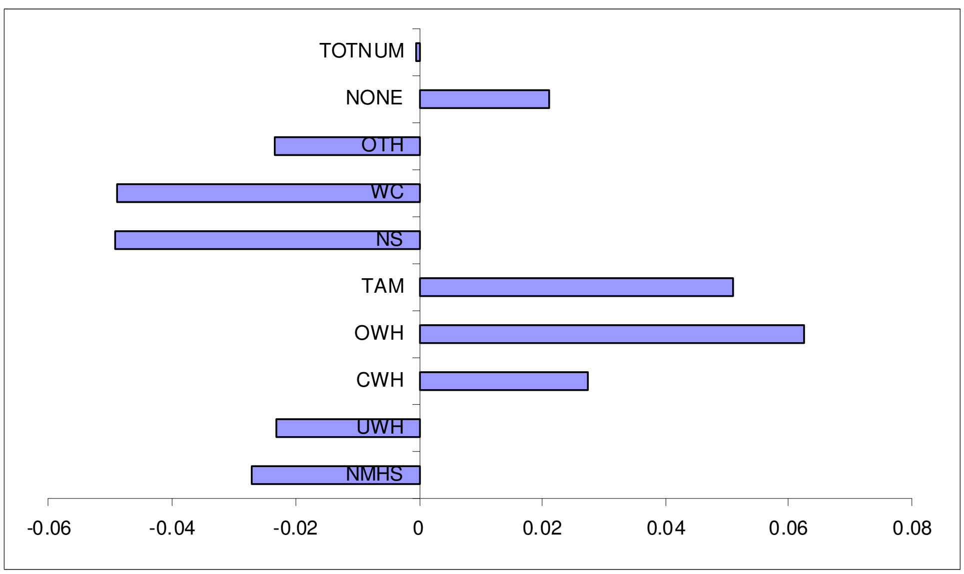


Figure 8. Class five correlations between membership of class and coastal use.



5 Discussion

Auckland's coastal environments are subject to development effects that have an impact on beaches and coastal ecosystems. This is a complex issue with a range of ecological and human factors that lead to questions that require some measure of resolution. For example, what do people actually value in the coastal environment? And, how much money should be spent reducing urban effects and upgrading infrastructure to mitigate effects?

We have reviewed existing work about coastal environments and undertaken a literature review (Batstone *et al*. 2007) to identify potential avenues to pursue to answer these questions. Choice experiments provide a technique that offers a structured and statistically robust way to understand community preferences. The method asks survey respondents to choose which alternative future scenario they would prefer from each of several "choice sets."

In the choice experiment development process, we found that the attributes most important to people were water clarity, the quality of underfoot conditions and ecological health. Including a financial variable that reflects hypothetical household remediation costs in the study, enabled an estimation of monetary values that decision-makers can use to maximise the benefits from new policies and engineering measures.

Choice modeling is a term which embraces two aspects. First, the data collection phase, the choice experiment. Second, the method used to analyse the data, the discrete choice model (Hensher *et al*. 2003). The discrete choice model employed here is a variation of a version that has become the "workhorse" of non-market valuation. The choice task of nine attributes over three unlabelled options in twenty-four choice situations is in line with current practice. The use of an evolutionary approach to choice set design to deliver statistically significant model coefficients (Kerr & Sharp 2009) is also a feature of contemporary valuation practice.

5.1 Interpretation

Table 7 showed the WTP estimates associated with each combination of location and environmental quality that were derived from two model specifications. First, the basic MNL model, and second, the class five LCM were used to make estimates from the pooled data set from all locations.

The estimation process has been set up so that the model coefficients represent the change in utility that comes from a change in an environmental quality/location combination along a three point scale that ranges from low through medium to high. The model base case is a setting of "low" for every environmental quality/location combination. The model coefficients are either a response to a change from "low "to "medium" environmental quality with associated utility change, or the converse, a change from “medium” to “low”, in environmental quality, with associated utility change. The direction of the resulting change is signalled by the sign, positive or negative, on an attribute coefficient. The estimation process assumes symmetry, assuming that change in utility from “low to medium” is equivalent to “medium to low” except that the low to medium direction is a gain, medium to low a loss.

In Row 2 of Table 5 the MNL estimate of WTP associated with outer medium ecological health (OTEM) is $135.64. This represents the monetised annual benefits to an Auckland household for a change in the level of ecosystem health, from low to medium levels, understood in terms of species diversity at outer coastal zones (beaches). Using a discount rate of 8%, this represents a lump sum of $1695.50 lost per household if ecosystem quality declines at those sites from a medium to a low level at beach locations (annual value divided by the discount rate). Assuming a population of 1.5 million people, with 2.2 people per household, the money value of the loss to the Auckland region is $1.15 billion. This amount is the monetised value of the outcomes of remediation works and policy that would have the effect of moving the assessment of outer ecological health from low to medium.

5.2 The estimates in context

It may be useful to establish a context in the valuation literature for these estimates.

Liu & Stern (2008) undertook a meta-analysis of non-market valuation (principally contingent valuation) studies in coastal and near-shore ecosystems. While the focus of that paper is to contrast various methodologies with benefit transfer processes, their data allows a broad picture to be drawn of the likely patterns of WTP estimates. The mean annual household WTP from their sample of 39 studies, from a range of international jurisdictions, and for a range of coastal services was US$766 (expressed in 2006 US$). The authors note a skewed distribution with a long tail of higher values. Their results showed that over 75% of the variation in WTP for coastal ecosystem services between studies could be explained by differences in commodity measured, methodology applied, and a measure of study quality. Their findings limit comparison between studies to those that have similar methods and focus on similar attributes of coastal ecosystems. These findings also suggest limitations on benefit transfer – transferring estimated benefits from one study to another region – and contain a warning in making comparison across studies.

Eggert & Olsson (2003) used a choice experiment framework to understand preferences for improvements in water quality on Sweden’s west coast. In their study water quality was represented by level of fish stock, bathing water quality and biodiversity level. The levels of these attributes were characterised by the levels low, medium and high, as in this project. Water quality and biodiversity annual household WTP estimates ranged from 600 to 1400 Swedish Kroner. At the time of publication (January 2003), one Swedish Kroner bought

NZ$0.2175 (Indexmundi.com), giving a range of values, in 2003, of NZ$130.50 to $304.50. These estimates are consistent with those derived in this study. Earlier studies, employing a range of methods, provide varying estimates of the value that beach users place on water quality changes, typically ranging from NZ$4 to NZ$39 per person per year (Feenberg & Mills 1980; Bockstael *et al*. 1987; Le Goffe 1995; Choe *et al*. 1996; Georgiou *et al*. 1998).

5.3 Application of the outcomes

The model outcomes have application in scenario assessment, planning and evaluation processes. More formally, a decision support system based in the model outcomes could be developed for coastal management scenarios that involve the environmental quality attributes developed here. To illustrate an application of the outcomes of this DCM analysis, consider a potential storm water effects mitigation scenario that might represent a coastal management issue. In this hypothetical example, a project consisting of policy and engineering components delivers changes in water quality and underfoot conditions in the upper harbour areas of the Auckland region, but no discernable change to the balance of the location/quality combinations for the harbour systems. Table 8 describes the project's outcomes in terms of environmental quality. This scenario shows that the initial assessment for underfoot conditions is low and for water quality is medium. On completion of the works, at some point in the future, the outcome is a change in underfoot conditions to an assessment of medium and a change in water quality to an assessment of high.

Table 8. Storm water remediation project summary.

Environmental quality	Before project	Post project
Underfoot conditions	low	medium
Water quality	medium	high

Table 7 describes application of the WTP estimates from the choice experiment to evaluating the changes to environmental quality. It shows the calculation of total project benefits for the MNL model (unshaded column) and the five classes of the latent class model (shaded columns).

The first two rows show the annual household WTP estimates by model/class for the environmental quality changes. The figures in the columns are the attribute WTP estimates derived from DCM estimation for each attribute. In Row 1 the figures represent the annual of household WTP for the improvement in underfoot conditions. Using MNL data as an example, the changes in value are calculated in two ways. The WTP for an improvement in underfoot conditions from low to medium is $50.94 and is directly represented in the DCM estimation by the WTP for the UPUM variable. However, for water quality (Row 2), the change from medium to high is indirectly estimated from the two water quality WTP estimates shown in Table 5. For upper water quality, the high value ($99.16) less the medium upper water quality value ($40.98) is $50.18. This estimate is likely to have wide uncertainty as it is the difference between two estimated coefficients, each with a measure of uncertainty.

The values in the third row are the sums of the values in Rows 1 and 2. This is the total estimated value per year for each household of the project changes. The fourth row converts this to a lump sum per household by dividing the estimated annual value (Row 3) by the discount rate, assumed to be 8%. Rows 5 and 6 calculate the number of households by model/class assuming an Auckland region population of 1.5 million, and 2.2 persons per household. Row 7 multiplies the number of households by the estimated household lump sum values to derive estimates of the value to the Auckland region of the project changes.

For the base MNL approach, the sum of the changes in value for each attribute is $109.12 (Row 3). When this is capitalised at a discount rate of 8%, it yields a lump sum value representing a stream of benefits stretching into the far future of $1364 per Auckland household, assuming no preference heterogeneity (Row 4).

Row 8, the final row, presents the total estimated benefits from the project for each of the two model variations. This is achieved by summing over the five model classes for the latent class model, and repeating the single value of the MNL model from Row 7. In Row 8, point estimates for the MNL model and the LCM model are $930,000,000 and $1.22 billion respectively. Based on standard errors derived in the MNL model estimation process, a 95% confidence interval for the MNL estimate is from $783 million to $1.165 billion. The estimates of total benefits are not significantly different between MNL and LCM-5 specifications.

Table 9. Estimates of monetised value of change in environmental quality.

	MNL Model	Latent Class Model				
		Class 1	Class 2	Class 3	Class 4	Class 5
WTP estimate for underfoot condition change	$ 50.94	$ 89.82	$ 78.84	$ 71.14	$ 46.39	$ 43.18
WTP estimate for water quality change	$ 58.18	$ 65.40	$ 94.62	$ 62.75	$ 4.91	$ 57.40
Annual monetised household value	$ 109.12	$ 155.23	$ 173.46	$ 133.90	$ 51.30	$ 100.58
Lump sum value per household	$ 1,364.00	$ 1,940.33	$ 2,168.22	$ 1,673.70	$ 641.27	$ 1,257.20
Class as proportion of sample		32%	30%	5%	20%	14%
Number of households	681,818	617	582	95	384	262
Class lump sum value	$ 930,000,000	$ 1,197,232	$ 1,262,117	$ 159,129	$ 246,365	$ 329,318
Total of estimated benefits from project	$ 930,000,000	$1,122,405,596.40				

Table 9 shows contrasts between MNL and the five LCM classes. The LCM formulation takes account of the potential heterogeneity of preferences by developing a stratification scheme based on responses to the choice experiment. Examination of Table 5 and Table 9 shows the differences in the WTP for the environmental quality attribute and coastal zone location combinations between classes.

Given the interconnectedness of marine systems, the benefits of mitigation measures in the upper harbour catchment are likely to have flow on effects for the middle and outer harbour areas. If the degree of change in environmental quality attributes in the middle and outer areas can be estimated (e.g. low to high) through some combination of sediment transport models, expert opinion and other devices, then the potential flow on benefits to those areas from mitigation measures in the upper harbour could also be included in the estimation of benefits. Thus, in its current configuration, the example presented here is likely to understate the benefits of upstream mitigation in the coastal system. However, it shows the extent of the potential benefits for a project that addresses environmental quality in a portion of the Auckland coastal management area.

5.4 Limitations of this research

5.4.1 Sample

The data were collected from a sample created by a commercial market research firm to a quota sampling design. The criteria for the respondent list are described in Table 1. The respondents were drawn from a telephone process using commercial market research lists. The extent and nature of any biases arising are unknown.

5.4.2 Respondent task burden and evaluation

The task burden on respondents was high *i.e.* the choices presented in the survey contained a lot of information for respondents to process. No information was collected to specifically assess this aspect. The extent and nature of any biases arising are unknown.

5.4.3 Alternative estimation model specifications to account for preference heterogeneity

The DCM estimation processes used in this project relied on the MNL and latent class variations. Other estimation approaches, such as mixed logit or random parameters, may improve estimation outcomes.

5.4.4 Spatial correlation issues

The analysis employed in this project did not take into account the potential for spatial correlation issues to compromise the integrity of the estimation outcomes reported here. For example, there has been no analysis to account for potential lack of independence between the residential locations of the respondents.

5.4.5 Utility function specification assumptions

A reviewer noted that the assumption of an additive linear utility specification is a crucial one given the high potential for substitutability and complementarities between location/attribute combinations. Auckland region's location on an isthmus between the Tasman Sea and the Pacific Ocean results in benign conditions for outdoor recreation in coastal waters and a complex assemblage of geographic and ecological features in which to undertake leisure activities. These features provide choice for Aucklanders considering alternate activities and locations for a given set of prevailing conditions. This choice process may see some sites substituted for others as environmental quality and other ambient conditions change, in turn leading to a decrease in the use of one site and an increase in the use of another. Sites may also act as complements, in which an increased use of one site may be associated with an increase in the use of another site.

This aspect has been a key consideration in the design of the choice sets in that conditions changed in all three locations concurrently, so participants were forced to consider the overall implications for them of each scenario while identifying their preferred option. In the context of external influences such as climate change effecting ambient conditions in outer coastal zones, substantial increases in fuel costs, and increased environmental quality arising from mitigation measures in middle and upper zones, Aucklanders may change their patterns of coastal use in favour of geographically closer sites that under prevailing conditions would not be considered.

The decision to select a parsimonious model specification is suited to the "method development" character of the project, but may omit important components of value that lie in preferences arising from combinations of locations and environmental quality attributes. This suggests a more complex model specification. Alternate utility specifications that incorporate interaction terms between environmental quality/location combinations may improve model fit to data.

6 Conclusion

This report details the outcomes of the final phase of a three year project to investigate techniques to inform coastal management decisions. Previous reports in this series have reviewed prior research into benefit estimation for storm water remedial works (Batstone *et al*. 2008) and developed the design for a choice experiment and associated analytical discrete choice model (Batstone 2009). The aim has been to provide a vehicle to understand Aucklanders' coastal preferences and the economic benefits that flow from mitigation expenditure.

In the project described in this report, data were collected in a choice experiment, and the estimation outcomes for three model specifications are discussed. Of the three discrete choice models (main effects multinomial logit, interactions model and latent class model), the five class LCM has been shown to give the best fit to the data (Table 2).

Aucklanders show higher willingness to pay for improved quality at outer coastal beach locations compared to the middle and upper harbour locations. The water quality attribute is most important at beach locations, followed by ecological health, then underfoot conditions. The choice model was able to assess the rate at which respondents make trade-offs between coastal marine environmental attributes and enabled a derivation of money values for environmental changes associated with storm water. Estimates of money values derived in this study are consistent with those reported in the recent resource and environmental economics literature.

The point of departure for this project was a review (Batstone et al 2008) of the approach adopted by Ward and Scrimgeour (1991) to understanding the costs and benefits associated with remediation of the effects of storm water on Auckland coastal systems. That review identified substantial development in the theory and practice of non-market valuation for the estimation of the benefits of coastal system management. There is a clear difference between the choice experiment approach identified by Batstone et al (2008) to that adopted by Ward and Scrimgeour (1991) in terms of method and resulting application.

In their analysis Ward and Scrimgeour considered a specific mitigation strategy, and estimated the benefits that resulted from the anticipated environmental change. In contrast, the choice experiment approach presented in this report estimates the benefits associated with given changes in environmental quality independent of the mitigation strategy employed to achieve them. The choice experiment approach allows policy makers to consider alternate combinations of policy instruments and engineering strategies to prioritize mitigation measures in coastal management processes. Moreover, multiple benefits in one area and can be incorporated with expected flow on benefits to the wider coastal system anticipated by the ecological and coastal sciences.

While this project has focused on a stormwater mitigation case study in the coastal management domain, it should be emphasized that choice experiments have application to a broad set of problems in the environmental management area. This may include the assessment of the losses borne by communities from degraded ecosystems, and the determination of the benefits that may flow from improvement to ecological goods and services through mitigation or restoration measures.

In summary, this project provides a methodology that collects data on community preferences for three environmental qualities, in three coastal locations. The approach's strengths lie in these aspects:

- A statistically robust method for data collection and analysis,
- Data collection theory and practice is well developed and supported in the literature,
- The capacity for model outcomes to include monetised assessments of project benefits,
- An assessment and estimation of benefits, rather than a focus on an issue and a solution,
- Flexibility of application to a wide variety of coastal environmental management and engineering projects in the benefit estimation area.

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8 References

Batstone C, Roberts B, Sharp B 2008. Evaluating Coastal Receiving Environments And The Effects Of Storm water – Phase 1 Interim Report. Auckland Regional Council Working Report WR137, 95pp.

Batstone C 2009. Methods for Evaluating Coastal Receiving Environments And The Effects Of Storm Water - Report to 30 April 2009. Auckland Regional Council Internal Report IR 2010/001, 76pp.

Bockstael NE, Hanemann WM, Kling CL 1987. Estimating the value of water quality improvements in a recreational demand framework. Water Resources Research 23, 951 -960. Cited in Machadoa and Mouratob (2002).

Choe K, Whittington D, Lauria D 1996. The Economic Benefits Of Surface Water Quality Improvements N Developing Countries: A Case Study Of Davao, Philippines. Land Economics 72, 519 - 537. Cited in Machadoa and Mouratob (2002).

Eggert H, Olsson B 2003. Heterogeneous Preferences for Marine Amenities: A Choice Experiment Applied to Water Quality. Working Paper, Department of Economics, Göteborg, University, Sweden, cited in Soderqvist *et al.* 2005.

Feenberg D, Mills ES 1980. Measuring the Benefits of Water Pollution Abatement. San Diego:Academic Press, cited in Machadoa and Mouratob (2002).

Georgiou S, Langford IH, Bateman IJ, Turner RK 1998. Determinants Of Individuals' Willingness To Pay For Perceived Reductions In Environmental Health Risks: A Case Study Of Bathing Water Quality, Environment and Planning (30), 577 – 594. cited in Machadoa, and Mouratob, (2002).

Greene WH 2007. NLogit 4.0, Econometric Software Inc.

Hensher DA, Rose JR, Bliemer M 2008. Discrete Choice Modeling 2008, Executive Programmed Notes, Institute of Transport and Logistic Studies, The University of Sydney.

Hensher DA, Rose JR, Greene WH 2005. Applied Choice Analysis: A Primer, Cambridge University Press.

Indexmundi.com,2009,http://indexmundi.com/xrates/graph.aspx?c1=NZD&c2=SEK&days=1825&lastday=20080618.

Kerr G, Sharp B 2009. Efficiency Benefits Of Choice Model Experimental Design Updating: A Case Study. Paper presented to the 53rd Annual Conference of the Australian Agricultural and Resource Economics Society, Cairns, Queensland, February 10 -13 2009.

Krinsky I and L Robb 1986, On approximating the statistical properties of elasticities, Review of Economics and Statistics, 68, 4, 715 – 719.

Le Goffe P 1995. The Benefits Of Improvements In Coastal Water Quality: A Contingent Approach. Journal of Environmental Management 45, 305 - 317.

Liu S, Stern DI 2008. A Meta-Analysis of Contingent Valuation Studies in Coastal and Near-Shore Marine Ecosystems, MPRA Paper No. 11608, posted 17 November 2008, http://mpra.ub.uni-muenchen.de/11608/

Machadoa FS, Mouratob S 2002. Evaluating The Multiple Benefits Of Marine Water Quality Improvements: How Important Are Health Risk Reductions? Journal of Environmental Management 65, 239 – 250.

Rose JM, Collins AT, Bliemer MC, Hensher DA 2009. Ngene 1.0 Stated Choice Experiment Design Software, University of Sydney.

Scarpa R, Rose J 2008. Design Efficiency For Choice Modeling. Australian Journal of Agricultural and Resource Economics 52(3), 253-282.

Söderqvist T, Eggert H, Olsson B, Soutukorva A 2005. Economic Valuation for Sustainable Development in the Swedish Coastal Zone. Ambio Vol. 34, No. 2, March 2005.

Ward JT, Scrimgeuor FG 1991. Auckland Regional Storm water Project: An Economic View, Working Report No. 55. Prepared for the Environment and Planning Division, ARC.