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When the Tide is High: Estimating the Welfare Impact of Coastal Erosion Management

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Abstract:

A choice experiment was undertaken at Buffalo beach, Whitianga, in order to investigate beach visitors' preferences for various coastal erosion management options. Constructing rock seawalls is a common response to coastal erosion but seawalls can negatively affect visual amenity, biodiversity and recreational values. The choice experiment results from this study show that the average visitor would be willing to pay $20 per year to remove an existing rock wall at either end of Buffalo beach. Visitors place high value on useable sandy beaches and reserve areas behind the beach. A latent class analysis reveals there are distinct sub-groups with varying preferences for beach characteristics. This paper presents a model with separate classes for residents and visitors and the compensating variation estimates to calculate the overall welfare effect for three coastal management scenarios.

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1. Background and purpose

This paper reports the results of a pilot study which tested the application of choice modelling at Buffalo beach. The purpose of the wider research project is to quantify the change in consumer welfare resulting from different coastal management strategies on the Coromandel peninsula. The information gained will help inform Waikato regional policy and coastal strategies.

Buffalo Beach, named after a vessel wrecked on the beach in 1840, is a medium-fine sand beach three kilometres long and located at the head of Mercury Bay. It is the main beach for Whitianga, the second largest township on the Eastern Coromandel. Mercury Bay is a popular coastal destination in the Coromandel peninsula.

Buffalo beach is a natural asset which provides a range of services including recreation opportunities, landscape amenity, natural character, food provision, public access and wildlife habitat. A beach user survey (Thomson, 2003) previously identified that what people value most about Waikato beaches are the appearance of the beach, safe swimming conditions, the amount of dry beach at high tide, the presence of sand dunes, easy access and naturalness of the beach. Property owners also value the security and safety of their property. Many of these values are threatened or reduced by beach erosion and erosion control structures.

Buffalo beach was chosen as a case study to test a non-market valuation methodology for Waikato Regional Council because it is a popular beach for visitors and has already been subject to several different erosion management strategies.

1.1 Erosion and flood risk at Buffalo Beach

Coromandel beaches typically undergo major shoreline movements over periods of decades, with the largest changes usually seen near estuaries and river entrances. Some fluctuations are not permanent. Mercury bay in particular is subject to significant wave and storm surge effects. Waves commonly overtop back beach areas during coastal storms. The south end of Buffalo Beach has experienced periodic erosion problems since the 1960s, requiring the placement of rock armour to protect the state highway. The central and northern areas of the beach have experienced periodic storm cut erosion and recovery over time, but a period of very serious erosion and shoreline retreat commenced in this area in 1995 (Beca Carter & Hollings, 2004). Future sea level rise and changing weather patterns accompanying predicted global warming may alter the dynamics of many beaches and lead to widespread permanent erosion. Permanent erosion at beaches along the eastern Coromandel peninsula could exceed 15-20 metres over the next century, given present best estimates of sea level rise(Dahm & Munro, 2006). There are 80 properties and 56 dwellings on the foreshore of Buffalo Beach which are expected to be affected by erosion in the absence of shoreline protection. These properties have a combined capital value of around $70 million.

1.2 Statutory requirements for Waikato Regional Council

Coastal development and erosion management is relevant to the statutory functions of both regional and local authorities in New Zealand. There is potentially some overlap, although regional councils cannot control subdivision and local authorities cannot control existing uses of land (Turbott, 2006). Section 62 of the Resource Management Act (1992) states that primary responsibility for managing natural hazards defaults to the regional council unless the regional policy statement specifies otherwise. The RMA does not provide explicit direction as to how coastal erosion hazards should be managed, other than the overall goal of sustainable management.

Regional policy statements and plans are also required to give effect to the New Zealand Coastal Policy Statement (NZCPS). The objectives of NZCPS are to:

1. safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land;
2. preserve the natural character of the coastal environment and protect natural features and landscape;
3. take account of the principles of the Treaty of Waitangi, recognise the role of tangata whenua as kaitiaki and provide for tangata whenua involvement in management of the coastal environment;
4. maintain and enhance the public open space qualities and recreation opportunities of the coastal environment;
5. ensure that coastal hazard risks taking account of climate change, are managed;
6. enable people and communities to provide for their social, economic, and cultural wellbeing and their health and safety, through subdivision, use, and development;
7. ensure that management of the coastal environment recognises and provides for New Zealand's international obligations regarding the coastal environment, including the coastal marine area.

In deciding how to achieve these objectives, Waikato Regional Council must take account of local issues and priorities and balance the competing economic, cultural, and environmental interests. It is desirable to have long-term coastal management strategies in place so that response to coastal erosion is consistent and appropriate.

1.3 Erosion management options

The feasibility of several erosion management options have previously been investigated for Buffalo beach by Beca Carter and Hollings Ltd. (2004) and Turbott (2006). These options comprise of frontal seawalls, backstop walls, dune restoration and planting, managed retreat, and nourishment.

Frontal seawalls are constructed parallel to the coastline. The primary purpose of a seawall is to protect the land behind from wave and current action. They maintain the coastline in a fixed position, similar to a headland. The seawall is typically constructed of rock or concrete and requires on-going maintenance. While seawalls protect the land behind them, the sandy beach in front of them is often lost. There is also increased erosion at either end of the wall.

Figure 1 - Frontal seawall at Buffalo beach

The backstop wall option involves constructing an engineered wall located sufficiently far enough landward (approx. 10-20m) so that the wall is buried but may be exposed in storm events. The sand in front of the backstop wall provides a natural dune buffer to protect properties and maintains an exposed beach. Maintenance costs depend on the frequency and severity of wall exposure. This option would require the removal or relocation of existing properties that are too close to the beach.

Figure 2 - Backstop wall under construction in Australia

The dune restoration option involves planting dunes with native plants to trap sand, and restricting pedestrian or vehicle access. This option requires sufficient reserve land behind the beach to allow for a natural dune system. Planted dunes are not immune from severe storm events, and ideally a wide buffer would be maintained between the beach and roads or properties.

Figure 3 - A restored dune at Whangamata

Beach nourishment refers to bringing in sand from some other location and spreading it on the beach to replace sand lost in storm events. Sand was applied to Buffalo beach following a series of severe erosion events in the early 2000s. This is a temporary solution and regular replenishment is typically required to maintain the beach. Nourishment can be a cost-effective option for highly utilized beaches.

Figure 4 - Nourishment of Buffalo beach

Managed retreat is where no attempt is made to maintain the existing shoreline, but properties and infrastructure are relocated when erosion threatens. Properties may be replaced by public reserve and be accompanied by dune restoration. This option has the potential to be very expensive in developed areas.

The management options vary widely in terms of cost (both capital and maintenance), risk, and effects on beach amenity and biodiversity values. A realistic erosion management plan would most likely use a combination of different methods.

To date, the primary response of public and private property owners to coastal erosion has been the placement of various seawalls. Many of the existing structures were constructed without necessary consent and are exhibiting significant adverse effects on natural character, visual amenity and recreational values.

Coastal protection structures externalise long-term costs by reducing the amenity value to the local community and visitors The economic choices available to communities therefore need to be more clearly identified and debated at times of decision-making in order to minimise any inappropriate transfer of costs into the future.

Monetary impacts are easily identified but there is currently little quantitative information about non-market values affected by coastal management in the Coromandel. The expected value of threatened property may be appropriate as a primary decision criterion if the value of beach resource is a small portion of the total economic value associated with a site(Landry, 2008), but the total economic value of Buffalo beach has not previously been quantified. Boating, fishing, swimming, and landscape appreciation are prominent non-market uses of the beach. There are also non-use values. Without a quantitative valuation these values are either excluded from a cost-benefit analysis or are left for political debate.

2. Method

This study uses a stated preference method called choice modelling, which is well-suited to multi-facet nature of beach values and the management options under consideration. Choice modelling involves describing a good (i.e. a beach) as a bundle of features or attributes. People are presented with a set of alternatives which differ among attributes, and choose their preferred alternative.

The theoretical basis for choice modelling lies in Random Utility Theory (RUT), originally developed by Daniel McFadden (1974). RUT posits that the utility/welfare gained from making a choice is an unobservable quantity which exists in the mind of the decision-maker. By observing the choices made and with appropriate study design, researchers can decompose the factors that drive these choices and estimate partial values of each attribute which defines the alternative.

The latent utility experienced by an individual can be decomposed into an explainable or systematic component, and a random component:

$$U_{njk} = \beta_1 x_{1jk} + \ldots + \beta_M x_{Mjk} + \varepsilon_{njk}$$

This is the multinomial logit model, which has provided the foundation for the analysis of discrete choice modelling(Greene & Hensher, 2003). The probability that a randomly selected consumer will choose a particular option can be written as:

$$p_{njk} = \frac{\exp(x'_{jk}\beta)}{\sum_{i=1}^{J} \exp(x'_{ik}\beta)}$$

The standard multinomial logit has a number of limitations, one of which is the inability to model preference heterogeneity which cannot be captured by interactions with measurable socio-economic variables. Other researchers have found substantial variation among natural resource users(Breffle & Morey, 2000; Riccardo Scarpa, 2005). Failure to account for variation can also cause a bias in MNL estimates since maximum likelihood estimates are unbiased only under the correct specification (Hess & Axhausen, 2005). Mixed logit and latent class models both offer ways of modelling unobserved heterogeneity

2.1 Mixed logit models

The mixed logit model (MMNL), also known as random parameters logit, allows the parameters of the utility function to vary across individual respondents. It also avoids the "independence from irrelevant alternatives" (IIA) restriction of the standard logit model (Train, 1998). The central equation for the choice probability is

$$\text{Prob}[\text{choice } j \text{ by individual } i \text{ in choice situation } t] = \frac{\exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_i)}{\sum_{j=1}^{J_i} \exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_i)} = P_{it} \mid \boldsymbol{\beta}_i.$$

(Greene & Hensher, 2003)

RPL models have increased in popularity due to advances in computing power in the past three decades. Recent applications to environmental economics applications include renewable energy (Scarpa & Willis, 2010), protection of natural resources (Hoyos et al, 2009), and rural landscape improvements (Campbell, Hutchinson and Scarpa, 2009).

An important issue is the choice of population distribution for the random parameters. Inappropriate choice of distribution may lead to bias or counter-intuitive signs in the estimated parameters (Fosgerau & Bielaire, 2007). Normal and lognormal distributions are commonly used in RPL modelling. The log-normal distribution is typically used where there is an *a priori* assumption that negative values do not exist in the population. However, the lognormal distribution can cause problems with long tails. A constrained triangular distribution is useful for the price attribute because it is bounded at reasonable values (Hensher & Greene, 2003).

Hess and Axhausen (2005) state that the uniform distribution might be a more appropriate choice in the initial search for random taste variation, as it has a lower risk of misspecification than less flexible distributions. The ideal distribution mix would signal the presence of a non-zero probability of a coefficient of the wrong sign, with minimal risk of the effect being caused by the distribution itself.

2.2 Latent class models

The latent class model (LCM) is a semi-parametric variant of the MNL. The underlying theory is that individual behaviour depends on observable attributes and on unobserved variables that cause latent heterogeneity. Based on their conditional choices, individuals may be implicitly sorted into a set of classes with different preferences. The probability that individual *i* makes choice *j* in situation t is conditional on the unobserved class *q*:

$$\text{Prob}[\text{choice } j \text{ by individual } i \text{ in choice situation } t \mid \text{class } q] = \frac{\exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_q)}{\sum_{j=1}^{J_i} \exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_q)}$$

(Greene & Hensher, 2003)

Unlike the mixed logit model, LCM relaxes the requirement for specific assumptions about the distributions of parameters across individuals. Class membership can be assumed to be conditional on observed, individual-specific variables. Or individuals can be endogenously assigned to classes by estimating the probability of membership conditional on his or her choices, as in . Individual-specific conditional estimates of the marginal WTP for attributes can be derived similar to the MNL model :

$$\widehat{WTP}_n = \hat{E}\left(-\frac{\hat{\beta}_{nk}}{\hat{\beta}_n}\right) = \sum_{c=1}^{C} \hat{Q}_{nc}\left(-\frac{\hat{\beta}_{nck}}{\hat{\beta}_{nc\epsilon}}\right)$$

(R. Scarpa & Thiene, 2005)

On issue with the LCM model is that the researcher needs to decide on the correct number of classes to use. The Bayesian information criterion can be used to obtain a posterior estimate of the latent class probabilities(Greene & Hensher, 2003). A larger number of classes will decrease the significance of parameter estimates in each class, especially those with few members. The choice of number of classes should therefore take into account the significance of parameter estimates and the meaningfulness of the parameters signs(R. Scarpa & Thiene, 2005).

Both LCM and mixed logit models offer ways of modelling unobserved heterogeneity. The LCM has the advantage of not requiring the researcher to specify individual distributions, but the mixed logit offers more flexibility. Both LCM and mixed logit models were estimated using the data collected for this study.

2.3 Best-worst theory

Choice experiments typically elicit respondents' preferences by asking them to repeatedly select their most preferred alternative in a number of choice sets. Additional information can be obtained from each choice set if the respondents instead rate or rank all the alternatives in each set. This reduces the number of choice sets required per respondent. The disadvantages are that ratings are highly subjective, and the reliability of rankings decreases with every step(Boyle, 2001).

Another way to obtain more information from a choice set is to ask respondents to select their most and least preferred alternative in each. The “Best-worst” method was first proposed by Finn and Louviere (1992) and later formalized by Marley and Louviere(2005). Best-worst ranking takes advantage of the fact that it is easier for respondents to identify extreme options than rank or rate every alternative.

The joint probability of an individual choosing alternative *j* as the best and *j'* as the worst in choice set *k* is:

$$p_{BW_{kjj'}} = \frac{\exp\left((\mathbf{x}_{kj} - \mathbf{x}_{kj'})'\beta\right)}{\sum_{i=1}^{J} \sum_{i'=1, i' \neq i}^{J} \exp\left((\mathbf{x}_{ki} - \mathbf{x}_{ki'})'\beta\right)}.$$

(Vermeulen, Goos, & Vandebroek, 2010)

A best-worst choice design may decrease the D-error by 45% to 60% compared with a single-choice design(Vermeulen et al., 2010). With a 3-alternative choice set, best-worst yields the same amount of information as ranking all alternatives. This study uses the best-worst response method because it was important collect as much information as possible from each respondent in the limited time they were prepared to give.

3. Experimental design

Waikato Regional Council commissioned a study in 2003 of beach users and beach preferences (Thomson, 2003). This data helped to define a list of possible attributes for the choice experiment. Three focus groups were held in Whitianga in December 2010 to investigate perceptions of coastal erosion and preferences for various coastal management options.

The choice experiment design was ultimately restricted by the requirement that attributes should be affected by erosion management policy. Focus group participants expressed strong preferences about beach facilities and conflicts between different recreational users, but these were outside the scope of this study. The attributes used in this study are presented below (Table 1). The seawall attribute introduces a complication because it has both a direct effect on utility (e.g. visual amenity) and *indirect* effects by increasing erosion in front of, and at the ends of the wall. Blamey, Bennett, Louviere and Morrison (2002) discuss the issue of causal versus effects attributes and state that it can be unwise to combine them in one design. However, beach width can also be affected by setback and nourishment activities. It is not determined purely by the existence of a seawall so it was included as a separate attribute.

Some recreational studies frame the payment vehicle as a cost *per trip*, or a user fee, as in Kelly et al(2007). However, when the product of trips and consumer surplus per trip is taken as an estimate of consumer surplus per year, hypothetical bias may cause significantly upwardly biased total surplus estimates(J.C. Whitehead, Dumas, Hestine, Hill, & Buerger, 2008). Other researchers frame the question as how much the respondent is willing to contribute *per year* as in Lindsay et al(1992). Considering that the present cost of Coromandel coastal policy is recovered through annual rates, an annual cost was chosen as the payment vehicle for this study. There may still be hypothetical bias, but the assumption is that respondents will take into account the availability of substitute beaches when stating their preferences. Examination of the validity of this assumption would be a useful area of further research.

Table 1 - Attributes and levels

Attribute name	Description	Levels
Hard protection	The presence and extent of hard protection structures	None Frontal seawall along 50% of the beach Frontal seawall along 100% of the beach Backstop wall along 50% of the beach Backstop wall along 100% of the beach
Beach width	Minimum width of the beach at high tide	0 metres 5 metres 10 metres
Reserve width	Width of reserve/picnic area behind the beach	0 metres 5 metres 10 metres
Beach access	Maximum distance to nearest beach access	50 metres 100 metres 200 metres
Property removals	Number of existing properties which would need to be removed in a managed retreat policy	0 10 20
Flood risk	Relative risk of flood damage to public and private property	Low (1 in 20 years) Medium (1 in 10 years) High (1 in 5 years)
Cost	Change in annual taxes	$0 to $50

3.1 Labelled versus unlabelled designs

Choice experiments can either be generic or alternative-specific. The latter option is also called a labelled experiment. An example of a labelled experiment would be one in which each alternative is a different named beach (e.g. Cooks Beach, Hahei, Buffalo beach). Or the labels may refer to a scenario such as “do nothing” or “managed retreat”.

The label itself conveys information about the option, and this means that attributes associated with the label may not need to be explicitly included in the experimental design if they are not going to change. The disadvantage of labelled experiments is that the attributes must be realistic and match the label. They can be varied only if one provides consumers with plausible reasons why they might vary (Crouch & Louviere, 2001).

The choice cards were specific to Buffalo beach. The alternative future scenarios had generic labels "A" and "B" rather than specific policy labels because the objective was to determine values of beach features which might be affected by erosion and erosion management, rather than preferences for specific policies.

The status quo situation had to match actual conditions at Buffalo beach, which presented a complication because the beach is not homogenous from one end to the other. The north and south ends of the beach have stretches of rock wall, while the middle section has a large reserve area and a more natural appearance. The choice experiment was therefore split into three designs for the North, South, and middle sections of the beach. Respondents were asked to complete 6 choice cards about just one section of the beach.

Figure 5- Aerial photograph showing the 3 beach sections

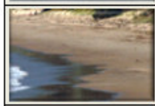
South Beach #2		Option A	Option B	Option C (Current situation)
	Erosion protection structures	**Frontal seawall** along **100%** of this section of the beach	**Backstop wall** along **100%** of this section of the beach	**Frontal seawall** along **50%** of this section of the beach
	Minimum width of beach at high tide	**0 metres** (sand underwater at high tide)	**5 metres** of dry sand at high tide	**0 metres** (sand underwater at high tide)
	Width of reserve/picnic area behind the beach	**0 metres** (no reserve area)	**10 metres** of reserve area	**0 metres** (no reserve area)
	Maximum distance to beach access	**50** metres	**100** metres	**100** metres
	Number of properties to be removed from the shore	**0** Properties removed	**20** Properties removed	**0** Properties removed
	Risk of flood damage to property	**Medium** (1 in 10 years)	**Low** (1 in 20 years)	**High** (1 in 3 years)
	Increase in taxes to pay for this option	Taxes increase by **$100** per year for your household	Taxes increase by **$80** per year for your household	No change

Figure 6 - Example of a choice card

3.2 Design optimisation

The configuration of the choice sets was optimised in order to efficiently obtain as much information as possible under a limited sample size. The criterion for efficiency used was the D-criterion, which seeks to maximise the determinant of the Fisher information matrix given *a-priori* information on the parameter vector. The performance of the design is measured by the D-error, which is defined as:

$$D\text{-error} = \det(\boldsymbol{I}_{BW}(\boldsymbol{X}, \boldsymbol{\beta}))^{-\frac{1}{q}}.$$

D-optimal designs are efficient under correct a-priori information and are also robust to some misspecifications(Ferrini & Scarpa, 2007). The best-worst choice design was optimised by randomly swapping the levels of all non-price attributes until the D-error was minimised. Then prices were included and continuously adjusted to achieve optimal probability balance as in Kanninen (2002). Only main effects were optimised. The initial parameter values were effects coded with 1 or -1. One of the alternatives was a zero-cost, status-quo option which is a common configuration(Hensher, Rose, & Greene, 2005).

The design was also subject to several constraints to restrict unrealistic combinations of scenarios. For example, frontal seawalls could not be combined with a wider beach, and reserve area could not be created without removing at least some properties. Despite these constraints, the D-error of the design was a very reasonable 9%. The final design had 3 blocks for each of the 3 beach sections, 6 cards per block, and 3 alternatives per card.

4. Results

The data used in this study were collected by interviewing people on Buffalo beach between 7am and 8pm on a weekend in January 2011. These beach users were asked to fill in a survey about beach visits and activities and then were shown 6 choice cards and asked to rank the 3 alternatives on each card from best to worst. A large proportion of beach users were on the beach with a group of other people, typically families. Only one adult from each group was interviewed. There were 119 completed surveys.

For a best-worst ranking experiment the data is analysed as a nested structure where the best is selected from n alternatives and then the next selection is from n-1 alternatives. There are therefore 12 selections for the 6 choice cards.

4.1 Multinomial logit model

The estimated standard multinomial logit model is presented in Table 2, below. The pseudo r-squared, or measure of overall model fit, is relatively low at 0.005 and only a few coefficients are statistically significant.

The frontal seawall attributes have a strong negative effect on utility, as expected from previous qualitative research by Thomson (2003) and Beca Carter & Hollings Ltd. (2004). The coefficients for a backstop wall are not significantly different from zero. There is currently no backstop wall at Buffalo beach, and respondents may not have seen one before. Future research will include a comparison with respondents at Cooks Beach where there is a backstop wall.

Willingness to pay (WTP) for or avoid an attribute, holding all else constant, is calculated by dividing the parameter coefficient by the cost coefficient. The average respondent would pay $65 per year not to have a full-length seawall.

The coefficients for beach width and reserve width were both positive, as expected. An extra 5 metres of dry sandy beach at high tide has a part-worth of $14 per year, and an extra 5 metres of reserve (along the whole section of the beach) is worth $48. There is not enough data to determine whether the preferences are non-linear and what the optimal beach or reserve width actually is. But the results indicate that respondents would be willing to pay for an extra 5-10 metres at least. The distance to beach access is negative, and reducing the distance by 50 metres has a part-worth of $48 per year.

Property removal, required for managed retreat and dune restoration, has a small negative WTP of $7 per property. Presumably so long as it is not the respondent's own property. A reduction in flood risk has a part-worth of $23 for both medium and low risk but the coefficients are not statistically significant. As will be explained further on, there are classes in which respondents have positive WTP for property removals and different signs on other attributes.

The status quo parameter is significant and positive. This is not surprising since all the respondents chose to visit Buffalo beach and most also had visited previously, so must be reasonably satisfied with the current situation. However, when results from the middle beach section (with the natural dunes) are excluded, the status quo effect is negligible.

Table 2 – Multinomial logit results

	Coefficient	Sig.	WTP
Cost	-0.006		
Frontal seawall 50%	-0.126		-$19.67
Frontal seawall 100%	-0.420	***	-$65.34
Backstop wall 50%	-0.070		-$10.95
Backstop wall 100%	-0.000		-$0.01
Beach width per m	0.023	***	$3.54
Reserve width per m	0.018	**	$2.87
Distance to access per m	-0.003	***	-$0.48
Removal of 1 property	-0.046	***	-$7.10
Medium risk	0.151	***	$23.47
Low risk	0.145	***	$22.56
Status quo	0.361	***	$56.15
Log-likelihood			-1066.42
Psuedo-R2			0.0045

***, **, * ==> Significance at 1%, 5%, 10% level.

Interaction effects for each attribute for several individual-specific variables were tested. Most of them were statistically insignificant. The significant interactions were high income * frontal seawall (64% higher WTA) and status quo for the middle section of the beach (six times higher than the status quo for the North and South sections).

4.2 *Mixed logit model*

A panel mixed logit model is estimated with uniform distributions on all parameters except for cost, which is assumed to be lognormal. A constrained triangular distribution was also tested for cost but it resulted in a significantly worse model fit.

The mixed logit model, presented in Table 3, fits significantly better than the standard MNL model. The pseudo r-squared is 0.097 compared with 0.005 for the MNL. The parameters for backstop wall are still insignificant. The beach width, access and removal attributes have a statistically significant mean and standard deviation. The risk dummy variables have statistically significant means but not standard deviations so these could be modelled as fixed parameters instead. The status quo parameter has a relatively large standard error, indicating varying levels of satisfaction with the current situation at Buffalo beach.

Table 3 - Random parameters logit results

Attribute	$\hat{\mu}$	Sig.	$\hat{\sigma}$	Sig.
Negative cost	4.873	***	1.009	**
Frontal seawall 50%	-0.190		0.762	**
Frontal seawall 100%	-0.888	***	0.616	
Backstop wall 50%	-0.086		0.468	
Backstop wall 100%	0.072		0.720	
Beach width per m	0.085	***	0.160	***
Reserve width per m	0.047	*	0.046	
Distance to access per m	-0.002	**	0.006	***
Removal of 1 property	-0.034	***	0.067	***
Medium risk	0.528	***	0.095	
Low risk	1.098	***	0.576	
Status quo	0.596	**	2.027	***
Log-likelihood				-1237
Psuedo-R2				0.0969

The table below shows the mean, median, and 25th/75th percentiles of individual WTP for each attribute. The median part-worth for a full-length frontal seawall is -$92, lower than the -$65 reported for the MNL model. A full-length backstop wall has a positive part-worth for two-thirds of respondents and a small negative part-worth for the remainder. The median WTP for beach and reserve width are a few dollars high than in the MNL model. The part-worths for risk reduction are significantly higher than the MNL model, $117 versus $23. These results highlight how failure to account for preference variation can bias results.

Table 4 - Distribution of individual WTP

Attribute	Mean	Stdev	Median	25th %tile	75th %tile
Frontal seawall 50%	-$21.94	$28.65	-$17.95	-$36.19	-$4.84
Frontal seawall 100%	-$99.61	$49.06	-$92.46	-$131.98	-$67.56
Backstop wall 50%	-$9.55	$14.11	-$8.83	-$16.84	-$2.58
Backstop wall 100%	$9.68	$23.84	$8.90	-$3.31	$21.02

Beach width per m	$10.48	$9.07	$9.53	$3.17	$15.78
Reserve width per m	$5.30	$2.57	$4.80	$3.47	$6.78
Distance to access per m	-$0.26	$0.26	-$0.25	-$0.37	$0.10
Removal of 1 property	-$3.43	$2.66	-$2.99	-$5.25	-$1.48
Medium risk	$58.90	$25.41	$56.33	$42.26	$74.59
Low risk	$124.75	$58.13	$116.98	$83.12	$163.66
Status quo	$60.93	$106.53	$54.51	-$10.43	$144.38

4.3 Latent class model

A series of models were estimated before deciding on the preferred three-class model presented in Table 5, below. Four and five-class models were estimated and had statistically significant class probabilities but the membership numbers were too small for the parameter estimates to be statistically significant. In the three-class model the majority of parameters are statistically significant, and the expected sign. The LCM offers better overall model fit than the MNL and mixed logit models, with a pseudo r-square of 0.1.

Table 5 - LCM estimation of parameters

	Class 1		Class 2		Class 3	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
Class probability	0.43	***	0.21	***	0.36	***
Cost	-0.051	**	-1.446	**	-0.167	***
Frontal seawall 50%	-5.208	**	-46.825	**	-3.849	***
Frontal seawall 100%	-6.053	***	-62.293	**	-1.981	**
Backstop wall 50%	9.410	*	-24.707	**	0.243	
Backstop wall 100%	10.673	**	-37.582		-1.537	*
Beach width per m	0.246		7.383	*	0.216	*
Reserve width per m	1.012	**	12.732	**	0.693	***
Distance to access per m	-0.066	**	-0.224		-0.040	***
Removal of 1 property	-0.281		2.477		-0.006	
Medium risk	1.238	***	37.585		0.374	***
Low risk	5.966	***	13.820		0.380	
Status quo	-5.137	*	43.649	***	2.877	***
Log-likelihood						-958.79
Psuedo-R2						0.1001

A range of socio-economic covariates were used during the specification search for the membership equation, including income, residency and familiarity with the beach. Only high income was found to be statistically significant, and this was only at the 10% level so it was not used. A larger sample size and the inclusion of attitudinal questions may allow the determination of membership to be examined in more detail.

The parameter estimates reveal significant inter-class differences in both the scale and sign of parameters. The WTP results are presented in Table 6. Class 1 members exhibit large negative part-worths for frontal seawalls and large positive values for backstop walls. They also have the largest absolute values for reserve area, access, and risk reduction. Due to the higher willingness to pay, this class is dubbed “high involvement”. It can be inferred that the members of this class prefer to protect the existing shoreline. They also place high value on beach amenity value and want reserves and dunes rather than frontal seawalls. This is somewhat at odds with the preference not to remove existing properties and policy options would have to be carefully considered to determine whether there would be an overall welfare gain or loss to this class. The “high involvement” class has a large negative status quo, perhaps because of the existing seawalls or because they have personal experience of flooding or erosion.

The second class has negative part-worths for both types of seawall, and this class is dubbed “pro-natural beaches. They prefer wide beaches, large reserve areas and the removal of existing properties, and are also willing to pay to reduce the risk of flood damage. This class has a positive status quo value, perhaps a reflection of the natural appearance of the middle section of the beach.

The third class has the lowest part-worths for most variables, and it therefore dubbed “low involvement”. There are relatively few Whitianga residents or frequent visitors in this class. They prefer no sea walls, but the part-worths are not as large as the other two classes. They are willing to pay a few dollars for a sandy beach, reserve area, and lower flood risk, and have a small positive preference for the status quo.

Table 6 - WTP for classes

	Class 1 “High involvement”	Class 2 “Pro-natural beaches”	Class 3 “Low involvement”
Frontal seawall 50%	-$102.92	-$32.37	-$23.00
Frontal seawall 100%	-$119.62	-$43.07	-$11.84
Backstop wall 50%	$185.96	-$17.08	$1.45
Backstop wall 100%	$210.93	-$25.98	-$9.19
Beach width per m	$4.87	$5.10	$1.29
Reserve width per m	$20.00	$8.80	$4.14
Distance to access per m	-$1.30	-$0.15	-$0.24
Removal of 1 property	-$5.56	$1.71	-$0.04
Medium risk	$24.47	$25.98	$2.24
Low risk	$117.90	$9.55	$2.27
Status quo	-$101.53	$30.18	$17.19

4.4 Two class model – residents and visitors

Differences between resident and visitor preferences are an important factor to consider in coastal policy analysis. The following table presents the average WTP for residents and visitors, ignoring the variation within each group for the moment. Due to the small number of residents surveyed (19), many of the coefficients are not statistically significant and more data needs to be collected. However, these preliminary results indicate that residents are willing to pay more not to have seawalls than visitors. Residents are also willing to pay more to reduce flood risk and preserve existing properties and are not unsatisfied with the status quo situation.

Table 7 - WTP for residents and visitors

	Class 1 Residents	Class 2 Visitor
Frontal seawall 50%	-$40.06	-$11.03
Frontal seawall 100%	-$132.20	-$99.29
Backstop wall 50%	-$14.23	-$6.76
Backstop wall 100%	-$16.43	$3.83
Beach width per m	$16.75	$13.89
Reserve width per m	$11.85	$10.39
Distance to access per m	-$0.37	-$0.15
Removal of 1 property	-$12.96	-$3.79
Medium risk	$107.90	$45.91
Low risk	$184.35	$63.62
Status quo	-$64.28	$8.38

5. State changes and welfare

The sample size of this survey is relatively small, and the WTP values will be refined with further research. However, it is still a useful exercise to see what these preliminary results would mean for the overall effect welfare effect of an environmental state change at Buffalo beach.

Compensating variation is a measure of utility change which shows how much money needs to be given to or taken away from a consumer after a price or quality change so that they are no better or worse off than before the change. If the change is an improvement, the CV is the amount of money people are willing to pay to secure the improvement. If the change is a decline in quality, it is the amount of money people would need to be compensated with. The CV measure has been shown to be consistent with random utility theory when used in a discrete choice framework (Small & Rosen, 1981).

Using the logit specification of the choice probability, the formula for the CV can be expressed as:

$$CV = \frac{1}{\lambda}\left[\ln \sum_{j=1}^{J} e^{V_j^0} - \ln \sum_{j=1}^{J} e^{V_j^1}\right]$$

Where V is the utility of alternative j before and after the change and λ is the marginal utility of income. The coefficient on the price attribute is interpreted as the marginal utility of income. We assume that the marginal utility of income is the same before and after the state change, i.e. there are no income effects. Morey and Rossmann (2008) describe a model which relaxes this assumption, but that is beyond the scope of this study.

The CV calculation is sensitive to the specification of the set of alternatives. There are plenty of alternative beaches in the Coromandel area, some of which may be considered close substitutes to Buffalo beach. Whitehead et al (2010) and Hausman, Leonard, and McFadden (1995) report that CV for environmental quality change is different when the model takes into account a change in the number of trips to the study site. However, this survey asked respondents whether they would be willing to pay a specified amount *per year* rather than *per trip* as in trip-based studies. The onus is on the respondent to decide how they would allocate trips in a given state, and respond accordingly. Some respondents may not plan to visit the beach again in the foreseeable future, and their WTP may be purely for the existence or option value. The next iteration of this survey will probe the mechanics of beach trip allocation but for now we assume respondents have taken this into account and the CV calculation collapses to one alternative, Buffalo Beach before and after the state change. This is known as a "State of the world" model (Ryan, 2004).

The overall effect on welfare also depends on the specification of the affected population. We interviewed people at Whitianga only, so the WTP values cannot be applied to the general population of ratepayers. Non-visitors may have positive non-use values for Coromandel beaches but that is also beyond the scope of this study. We therefore define the affected population as Whitianga residents plus the average number of visitors per year.

There were 3768 usual residents in Whitianga as at the 2006 census, in 1674 occupied dwellings (Statistics New Zealand, 2006). Visitors to Buffalo beach can be roughly estimated by combining Tourism data and previous beach visit surveys (Thomson, 2003). Total visitors per year can be expressed as:

$visitors_{buffalo} = p_{com}\ visitors_{buffalo} + p_{bach}\ visitors_{buffalo} + p_{day}\ visitors_{buffalo}$

where p_{com} is the proportion of visitors who stay in commercial accommodation, p_{bach} is the proportion who stay in holiday homes or other non-commercial accommodation and p_{day} is the proportion who don't stay overnight. The three probabilities add up to one and are sourced from survey data in Thomson (2003). The number of visitors who use commercial accommodation can also be expressed as:

$visitors_{com} = p_{com} \times visitors_{buffalo} = p_{buffalo} \times guestnights_{coromandel}$ / average length of stay

where $p_{buffalo}$ is the proportion of Coromandel visitors who visit Buffalo Beach (also sourced from Thomson 2010). The number of guest nights is sourced from the Commercial Accommodation Monitor (MED 2010). This assumes that average length of stay in Whitianga/Buffalo Beach is similar to the rest of the Coromandel. We can then solve for $visitors_{buffalo}$, which works out to approximately 18,500 per year. However, we want unique visitors and some people may visit Whitianga more than once in a year. We therefore arbitrarily scale this figure down by 50% to 9250, the equivalent of 5 visitor households per resident household. Future research will test and refine this assumption.

5.1 Coastal Management Scenarios

The following future scenarios are partially based on erosion management options investigated by Beca Carter Hollings & Ferner Ltd. (2004) and do not necessarily reflect the current intentions of Waikato Regional Council or Thames-Coromandel District Council.

Scenario 1: Managed retreat at the north end of Buffalo beach

In this scenario the rock wall at the northern end of Buffalo beach is removed. The front row of 16 houses are purchased from the owners and removed. The new open space is designated as a reserve and planted to restore the natural dune. This is expected to create a dry sandy beach at least five metres wide and a reserve area also five metres wide. Beach access does not change, and relative flood risk reduces from “high” to “medium” because the removed properties are no longer at risk.

Using the two-class model for residents and visitors, the CV for the average resident is estimated to be $171 per household per year, and $109 for the average visitor household. This is the amount that would need to be *taken away* from each household to make them no better or worse off after the change. The total is $1.3 million per year across all resident and visitor households. The perpetuity value with a risk-free rate of 7% is $19 million.

A similar option is to replace the existing rock wall with a backstop wall. This would still require the removal of the front-most properties to create space for a dune in front of the wall. If this option reduced the flood risk to low (1 in 20 years) in addition to providing the same benefits as managed retreat, the total CV would be $1.4 million per year.

These CV estimates indicate there may be significant public benefit to be obtained from managed retreat or a backstop wall. However, the cost of purchasing and removing 16 beachfront properties is also significant and the payback period could be a decade or more.

Scenario 2: Extend the rock wall at the South end of Buffalo beach

The risk at the south end of Buffalo beach is to the main road and low-lying commercial area of Whitianga. In this scenario the existing rock wall is strengthened and extended the whole length of the south end of Buffalo beach including the toilet block. This would provide better protection from overtopping waves so we reduce the anticipated flood risk from high to medium (1 in 10 years).

Residents have strong preferences against rock walls, but this is partially balanced by the preference for lower flood risk. The resident CV is negative $16 for this scenario, meaning they would have to be *given* money to make them just as well off after the change. The visitor CV is much lower at negative $120 because visitors do not benefit much from reduced flood risk. The total welfare effect is negative $1 million per year. Visitors might not pay the cost of building the rock wall but they do pay the intangible cost of reduced amenity value in perpetuity.

Scenario 3: Develop the middle section of Buffalo beach

In this scenario the reserve area in the middle section of Buffalo beach is sold to developers for subdivision. This scenario is included only for interest's sake and has not been proposed as a possible future option as far as we are aware.

This scenario would remove the green reserve area and, over time, reduce the width of the beach as the natural dune system is disrupted. Both residents and visitors have significant values for beach width and reserve area so this change would have a large negative effect on welfare. The flood risk would also increase as the new properties would be at risk in future erosion events. The only positive change would be the addition of beach access points as the area is developed.

The CV estimate is -$225 for a resident household and -$134 for visitors, for a total of -$1.6 million per year. Even if residents were compensated by developers for the loss of amenity value, there would still be a negative welfare effect for future visitors to the beach.

6. Discussion and conclusion

This report has shown how stated preferences may be used to calculate the overall welfare effect from a change to beach characteristics caused by the implementation of a particular coastal management policy.

The latent class analysis showed how people may segmented into groups with similar preferences for beach characteristics. Parameter estimates vary not only in magnitude but also in sign for some attributes. For example, one class has a positive WTP for backstop walls while another has a negative value. Some people want existing beachfront properties to be removed, while others want to protect them even though it is not their property.

There was not enough information to calculate population membership for classes in the latent class analysis so another model was estimated where class membership was defined by purely residency status. This model did not fit nearly as well as the latent class model but did allow some estimation of the total welfare effect for residents and visitors. The results indicate that the public disamenity value of rock seawalls is large, even for Whitianga residents. The public benefit of implementing a managed retreat strategy is estimated to be $1.3 million per year.

Total economic value is however not the only consideration in policy analysis. Other criteria may include equity considerations, environmental standards and regional economic constraints. (Polomé, Marzetti, & van der Veen, 2005). Managed retreat may be efficient under the Kaldor-Hicks criterion that those who are better off can (in theory) compensate those who are worse off. In practice it is difficult to ring-fence everyone who would be effected by the policy. A lot of visitors are not local or regional ratepayers, or even residents of New Zealand. This does not mean that estimating total economic value is not useful for coastal policy analysis. More information about amenity values and the welfare effects for various groups can only improve decision makers ability to allocate public resources effectively.

This study was a pilot test of the application of choice modelling to the issue of coastal management on the Coromandel peninsula. The sample size was small and there are various assumptions that need to be investigated before results can be used to inform real policy decisions. The WTP estimates were very sensitive to the model form and this may be resolved with a larger sample. If not, careful consideration will need to be given to the best model to use.

Future research in this area will:

- widen the study area to include other Coromandel beaches;

- investigate the effect of beach characteristics on trip allocation;
- combine stated and revealed preference data about trips;
- investigate non-use and existence values;
- investigate issues of scope;
- collect more information to help formulate deterministic class membership equations
- and test for benefits transfer between difference beaches and communities.

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