AN APPLICATION OF THE CHOICE EXPERIMENT METHOD TO ESTIMATE WILLINGNESS-TO-PAY FOR AND GUIDE MANAGEMENT ON ESTUARINE RECREATIONAL SERVICES

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EXECUTIVE SUMMARY

Among the world's ecosystems, estuaries have the highest total economic value per hectare. They are dynamic coastal biomes that provide a host of different goods and services to the surrounding terrestrial and aquatic environments and the people who utilise them. These goods and services include, *inter alia*, nursery areas for marine organisms, harvested natural resources (such as fish, shell-fish, bait organisms, reeds and mangroves), flood attenuation, water purification, nutrient and sediment sinks, waste disposal, transport, aesthetic beauty and areas for swimming, boating and fishing.

Assessing the condition of estuaries is difficult as their state can change depending on what is being measured. Assessments have been carried out on the health of estuaries in South Africa with the results of these studies being used as inputs to the process of assessing the minimum water supply requirements for each estuary (ecological reserve) in order to maintain or improve its functionality. These ecological reserve requirements are assigned using Resource Directed Measures (RDM). These measures, however, have been criticised for being highly complex and too costly to implement for all South African estuaries within a reasonable time period. Another concern is that the levels of demand for recreational goods and services provided by the estuary are not taken into account when assessing estuarine value. It is important to understand that the use of estuaries for recreational purposes is inextricably linked to their health and sound ecological functioning. Although South African estuaries have been quite well buffered from impacts until only very recently, their use and pressures have escalated faster than what conservation authorities and policy makers have been prepared for over the last couple of decades. There is thus mounting pressure on estuaries as recreational outlets, which, in turn, has led to their functional deterioration as well as deterioration in the quality of the recreational experience as a whole. One implication for management is that more and more trade-offs have to be made in an attempt to balance the conservation and recreational use of estuaries.

From a South African perspective, a number of estuarine recreational use trade-offs require policy guidance. One is between the short-run and long-run (sustainable) human recreational predation demands for fish and bait in the estuary (both recreational and subsistence). Another is between demand for public spending on improvements in the recreational appeal of an estuary, for example, providing public (open) access to the estuary and its various attractions, and demand for public spending on other services, for example housing and health. Yet another is between the demand for access to an estuary area by the population of boat owners and the demand for this same area by other categories of users, for example, shore-based fishers and owners of other craft.

Two South African estuarine systems currently facing recreational demand pressures are the Sundays River and the Kromme River. Over time, the lower reaches of the Sundays River Estuary have been significantly developed for residential purposes. These developments, coupled with the popularity of the estuary as a fishing destination, have resulted in the over-exploitation of fish stocks and high boat use during peak holiday seasons. Recreational over-fishing is threatening the future availability of estuarine fish species, particularly the dusky kob, white steenbras and spotted grunter. In addition to over-fishing and boat congestion, the estuary's overall recreational appeal as a tourist destination is also negatively affected due to a lack of public access.

The Kromme River Estuary is starved of freshwater. The expansion of a canal system, as well as the construction of two major dams on the Kromme River, have restricted the water flow into and through the estuary and resulted in increased sedimentation. This sedimentation has reduced navigability. Growth in both resident and visitor populations have also resulted in higher levels of boat congestion. In addition to navigability and congestion issues, there has also been an on-going dispute among recreational users over the potential use of personal jet-propelled water craft on the estuary, for example jet skis and wet bikes.

One way of guiding management of the Sundays River and Kromme River Estuaries for recreational purposes, is to compare the values users attach to the different recreational attributes of each estuary. The choice experiment (CE) approach has the potential to enable such a comparison because it allows for the estimation of the values of an environmental resource's constituent parts in a single application. The trade-offs between these parts (attributes) indicates the relative importance that individuals place on each part of the composite good (the estuary). Can this potential be realised in practice?

The primary objective of this thesis is to demonstrate that it can by improving the knowledge of the willingness-to-pay (WTP) process for improvements to problems associated with recreational demand at estuaries in South Africa. This primary objective will be achieved by estimating WTP values of estuarine recreational services in a single application of the CE. It is envisaged that these WTP values can be used to guide policy makers on appropriate demand management strategies. Four sub-objectives were pursued during this process, i.e.:

- the development of focus groups of stakeholders, including municipalities, conservation authorities, ratepayers and estuarine experts, to determine and select estuary management strategies for society, thereby identifying and defining possible estuary management options;
- the selection of an appropriate valuation technique to value recreational users' preferences for various management options;
- the administration of a questionnaire survey, based on the selected estuary management options, and the subsequent estimation of the recreational values that form part of the identified set of strategies; and
- the drawing of conclusions on the strengths of the chosen valuation technique for addressing multi-faceted estuary demand management challenges in South Africa.

This study forms part of a broader research initiative under the auspices of the Water Research Commission (WRC) of South Africa. The research initiative is entitled "The application of choice modelling techniques to guide the management of estuaries in South Africa – case studies of the Kromme, Nahoon, Sundays and Gonubie Estuaries" and is linked to the WRC Key Strategic Area (KSA) of water-centred knowledge (WRC Project No. KSA5/1924).

In order to determine and choose potential management strategies for the estuaries in question, focus group discussions were held. Estuary experts and users of the Sundays River Estuary (Sundays River Joint River Forum, and Sundays River Ratepayers Association) revealed that the following recreational use issues (attributes) deserved immediate attention as far as management of the estuary is concerned: the physical size of the fish stocks, the level of boat congestion and the level of public access. Discussions with estuary experts and users of the Kromme River Estuary (Kromme River Trust, Kromme River Riparian Homeowners Association, and Kromme River Joint River Forum) revealed that the following recreational use issues (attributes) deserved immediate attention as far as management of the estuary is concerned: reduced navigability on the estuary due to sedimentation, the level of boat congestion and the potential use of jet skis and wet bikes on the estuary.

In the light of information supplied by the Sundays River Estuary focus group, the following management options were investigated – increasing the existing license fee structure in order to decrease fishing level efforts, the imposition of a supplementary tariff during times of peak demand (the price rationing instrument) to discourage congestion, and improving public access at the Sundays River Estuary through the development of a nature trail along the banks of the estuary.

In the light of information supplied by the Kromme River Estuary focus group, the following two management options were incorporated in the CE design for improving navigability in the estuary – increasing freshwater inflows and dredging. Also incorporated into the CE were alternative management arrangements for (1) reducing boat congestion during peak periods, and (2) the use of jet skis and wet bikes on the Kromme River Estuary.

For all the above-mentioned options (specific to each estuary) marginal WTP values were calculated. The CE method offers a way of determining these marginal changes through one survey (for each estuary) by measuring the amount of income that an individual is willing to pay for an improvement in a part of that composite recreational good or service.

Three different choice model specifications were estimated for the Sundays River and Kromme River Estuaries: a conditional logit (CL) model, a heteroskedastic extreme value (HEV) model and a random parameters logit (RPL) model.

In the case of the Sundays River Estuary, the results from the CL, HEV and RPL models revealed that recreational users were willing to pay more for an estuary management strategy:

- the higher the physical size of the fish stock;
- the lower the amount of boat congestion; and
- the higher the amount of public access available.

Allowing preferences for recreational attributes to vary across respondents, through the application of the RPL model, showed that there was very little unexplained heterogeneity in respondent preferences. The implicit prices indicated that respondents valued most highly increasing the physical size of fish stocks. The differences in WTP values among the three models were small and showed overlapping confidence intervals.

In the case of the Kromme River Estuary, the results from the CL, HEV and RPL models revealed that recreational users were willing to pay more for an estuary management strategy:

- the higher the level of navigability;
- the lower the amount of boat congestion; and
- the lower the amount of jet ski and wet bike access.

The RPL model indicated the presence of unobserved heterogeneity, but failed to explain the sources of the heterogeneity. In this case, complete reliance was placed on the fixed mean and standard deviation of the parameter estimates. The latter represented all sources of preference heterogeneity around the mean. The implicit prices indicated that respondents valued most highly improved navigability. The differences in the WTP estimates among the four models were small, except for the WTP figures in the second RPL model. The CL and RPL models indicated overlapping confidence intervals, but the CL model gave a narrower range.

The thesis concludes that the rich data on estuary users' preferences – collected as part of the CE - can be used to improve the knowledge of WTP through the generation of statistically robust models of choice. This allows for the estimation of WTP values for estuarine recreational attributes. These values can be used in practice by policy makers to guide management on recreational demand challenges, for instance, in guiding license fees.

RECOMMENDATIONS

The thesis makes recommendations regarding estuary management and the use of the CE method to guide estuary management in the future.

Estuary management

Based on the results of this study, the following recommendations are made with respect to the management of the Sundays River and Kromme River Estuaries for recreational purposes.

- It is recommended that license fee adjustments be accepted as an appropriate option for managing demand at South Africa's estuaries.
- In order to decrease fishing effort, it is recommended that the boat license fee for the Sundays River Estuary be increased by R150 per annum.

- An increased effort must be made to enforce fishing regulations, and this enforcement should be funded through increased license fee collection.
- More public awareness should be created around the sustainability of the Sundays River Estuary fishery. This awareness campaign should be funded through increased license fee collection.
- In addition to the standard boat license fee, a once-off per annum peak period supplementary tariff should be implemented in order to discourage congestion. This tariff should be payable by peak period boat users, and cover the months of November to February. The recommended tariffs for immediate imposition are R33 and R302, respectively, for the Sundays River and Kromme River Estuaries.
- In order to improve the recreational appeal of the banks of the Sundays River Estuary, a nature trail along the banks of the estuary has been proposed. It could not be determined whether this investment was efficient as the required cost information was not collected. It is recommended that a cost-benefit analysis be conducted on the feasibility of this project.
- In order to improve navigability, the main channel of the Kromme River Estuary should be dredged. It is recommended that this dredging operation be funded through an annual additional boat levy of R437.
- Both historical rights and WTP should be taken into account with respect to the allocation of water between recreational (environmental), consumption, agricultural and industrial uses.
- The prevailing management strategy for the use of jet skis and wet bikes on the Kromme River Estuary should be kept in place.

Using the results of the CE experiment, policy makers can develop specific management ‘packages’ that include all the preferred management options of the attributes. When the marginal WTP values are added together, the overall additional levies recommended for each estuary are:

- R183 per annum for boat users of the Sundays River Estuary, taking the relevant boat license fee up from R94 to R277 (2010 price levels).

- R739 per annum for boat users of the Kromme River Estuary, taking the relevant boat license fee up from R169 to R908 (2010 price levels).

Future use of the CE method to guide estuary management

The application of the CE method to value natural resources, more specifically, estuarine attributes in South Africa, is a new development. There are examples of applying the CE method to value estuarine attributes, for example Oliver (2010), but they have design and estimation limitations. This thesis sought to address these limitations. It strongly recommends the CE approach be integrated into management practice at all estuaries in South Africa that are major recreational attractions, and at which there is demand conflict. This method forces the recreational user to make trade-offs among estuarine attributes, and reveal which of these are most important. This information is vital in the context of resource management decision making, where scarce resources need to be allocated between competing recreational demands. The proper application of this method yields meaningful insight into recreational demand, and objective scientific information that can be of direct use in managing the estuaries. A further argument in favour of integrating the CE method into management practices at South African estuaries is its ability to "generate multiple value estimates from a single application". These results would be difficult to provide through other non-market valuation techniques, for example the contingent valuation method (CVM), where only one environmental service input can be valued at a time.

Keywords: Estuary, demand management, recreational attributes, stated preference, random utility model, choice experiment, willingness-to-pay, conditional logit model, heterogeneity.

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CHAPTER ONE: SOUTH AFRICAN ESTUARIES –AN OVERVIEW AND PERSPECTIVE ON RECREATIONAL MANAGEMENT CHALLENGES

1.1 AN OVERVIEW OF SOUTH AFRICAN ESTUARIES

"Throughout history, estuaries and coastal seas have played a critical role in human development as a source of ocean life, a habitat for most of our commercial fish catch, a resource for our economy and a buffer against natural disasters" (Lotze, Lenihan, Bourque, Bradbury, Cooke, Kay, Kidwell, Kirby, Peterson & Jackson, 2006). As such, estuaries form an integral part of the total economic value of the planet. Costanza, d'Arge, de Groot, Farber, Grasso, Hannon, Limburg, Naeem, O'Neill, Paruelo, Raskin, Sutton and van den Belt (1997) estimated the economic value of estuaries within the entire natural coastal environment. Globally, 17 ecosystem services for 16 biomes were valued. It was found that the value of natural coastal environments, particularly those in estuarine systems, were among the most valuable on earth (Costanza *et al*. 1997).

South Africa's coastline, which stretches for about 3000 kilometres (km) from north of Richards Bay on the East Coast to Alexander Bay on the West Coast, is blessed with a large number[1] of estuaries, which cover an area of about 600km^2 (Baird, 2002). Not unlike estuaries worldwide, many in South Africa have also been a focal point of human settlement, resource use and waste disposal (Hay, Hosking & McKenzie, 2008; Hosking, 2008).

A few attempts have been made to estimate the value of South African estuaries' marine resources. For example, in a study by Lamberth and Turpie (2003), the value of estuaries to the South African fishing community was estimated at approximately R1.162 billion in

[1] Some claim that these estuaries total 289 (Hattingh, Whitfield, Van Driel, Archibald, Hay, Bate & Schumann, 2002), while others argue that there are in fact 465 along this stretch (Baird, 2002).

2001. This value comprised of estuary fisheries as well as estuary dependent businesses within the marine environment. The bulk of this value was generated from recreational fishing (Lamberth & Turpie, 2003). It is not only the fishing community that derives value from estuaries, but other sectors of society benefit as well. For example, it was estimated that the economic value of the mangroves in the Mngazana Estuary is R3.4 million per year (Hay *et al.* 2008). The mangroves are primarily used as building material. In addition, the mangroves constitute an important nursery area for fish, and form the focal point for commercial canoe trails. The tourism sector also profits greatly from the aesthetic appeal of estuarine systems, as a large number of people from diverse backgrounds make use of the estuary for recreational purposes.

1.2 PROBLEM STATEMENT AND RELEVANCE OF THE STUDY

Due to the public good problem of open access there has emerged growing doubt as to whether the recreational value of estuaries is being optimised (Hosking, 2011). The natural beauty, easy access, and range of environmental services provided by estuaries have attracted recreational, commercial and industrial activities (Day, 1980; Forbes, 1998). These activities have led to a partial loss of the environmental service flows supplied by estuaries. These losses first became a concern in the 1970's, when it was revealed that only a minor number of estuaries remained in their natural state (Heydorn, 1972). Assessing the condition of estuaries is problematic, because their state can change depending on what is being measured (Turpie, 2004). Assessments have been carried out on the health of estuaries in South Africa from ichthyofaunal diversity, water quality and aesthetics perspectives (Coetzee, Adams & Bate, 1997; Harrison, Cooper & Ramm, 2000; Colloty, 2000; Harrison & Whitfield, 2006) and from a conservation significance perspective (Turpie, Adams, Joubert, Harrison, Colloty, Maree, Whitfield, Wooldridge, Lamberth, Taljaard & Van Niekerk, 2002; Turpie & Clarke, 2007; Department of Water Affairs (DWA), 2010). These studies have been used as inputs to the process of assessing the minimum water supply requirements for each estuary (ecological reserve) in order to maintain or improve its functionality. These ecological reserve requirements were assigned through the use of Resource Directed Measures (RDM). This approach has, however, been criticised for being highly complex and too costly to implement for all South African estuaries within a reasonable time period (DWA, 2010). Another concern with regards to the RDM approach is that it does not take the demand for estuarine goods and services into account. Most of the large open estuaries in South Africa tend to be the most popular for recreational use. The use of these estuaries for recreational purposes is inextricably linked to their health and sound ecological functioning. Although South African estuaries have been quite well buffered from impacts until only very recently, their use and pressures have escalated faster than what conservation authorities and policy makers have been prepared for over the last couple of decades (Turpie & Clarke, 2007).

The discord between the conservation of the environmental service flows provided by estuaries, and their development and use has never been more apparent (Hay *et al.* 2008; Hosking, 2011). Decision makers and other stakeholders have also become more aware of the complexity of this discord and the trade-offs that it implies; there have emerged trade-offs (Hay *et al.* 2008):

- between short-run and long-run human recreational predation demand for fish, bait and mangroves in the estuary (both recreational and subsistence), also known as sustainability;
- between demand for abstraction of river inflows into estuaries and the human demand to maintain ecologically functional estuary habitats for bait, fish, birds and mangroves;
- between the demand for access to the estuary space among the population of boat owners and also the demand for use of the estuary space by other categories of users (shore based fishers, residents and owners of other craft);
- between demand for public spending on service provision enhancement of the recreational appeal of the estuary (providing public (open) access to estuary and its attractions, changing and ablution facilities and safety in and out of the water)

and demand for public spending on other services (housing, health, roads and so on);

- between the demand by residents for exclusive access rights to the estuary and its banks and the demand by visitors for open access; and
- between the demand to dump human effluent and other chemicals into water that ends up in the area defined to make up the estuary and demand to use the estuary for recreation (Hosking, 2011).

These demand trade-offs require policy guidance given the public good problem of open access. The primary objective of this thesis is to improve the knowledge of the willingness-to-pay (WTP) process for improvements to problems associated with recreational demand at estuaries in South Africa. This primary objective will be achieved by demonstrating that estimated WTP values of estuarine recreational services, through the application of a choice experiment (CE), can be used to guide policy makers on appropriate demand management strategies. It aims to provide policy makers and other stakeholders with useful information on the values that current and potential recreational users attach to the recreational attributes of two selected South African estuaries. This study forms part of a bigger research initiative under the auspices of the Water Research Commission (WRC) of South Africa. The research initiative is entitled "The application of choice modelling (CM) techniques to guide the management of estuaries in South Africa – case studies of the Kromme, Nahoon, Sundays and Gonubie Estuaries" (WRC Project No. KSA5/1924).

The pursuit of this primary objective entailed:

1. The setting up of focus groups of stakeholders (municipalities, conservation authorities, ratepayers and estuarine experts) to determine and choose estuary management strategies on behalf of society, thereby identifying and defining feasible choices for estuary management;
2. The selection of an appropriate valuation technique to guide on what prioritises recreational value;

3. The administration of a questionnaire survey based on the choices defined in (1) and from this information the estimation of the alternative recreational value of the identified set of strategies; and
4. Providing conclusions of the merits of the selected valuation technique for addressing multi-faceted estuary management challenges in South Africa.

1.3 THE DIFFERENT TYPES OF ESTUARIES

Initially estuaries were thought of as “a semi-enclosed coastal body of water, which has a free connection with the open sea, and within which seawater is measurably diluted with fresh water derived from land drainage” (Pritchard, 1967). Later, the requirement for a connection with the sea was relaxed, allowing for periodic closure. The National Water Act (Act 36 of 1998) defines an estuary as “a partially or fully enclosed body of water: (a) which is open to the sea permanently or periodically; and (b) within which the sea water can be diluted, to an extent that is measurable, with freshwater drained from inland”. The latter definition has economic implications if the estuary is partially or fully enclosed, as it can no longer be viewed as a pure public good. For example, excludability could be feasible.

Both Harrison *et al’s* (2000) geomorphological classification of estuaries and Whitfield’s (1992) estuarine classification system are useful ways of distinguishing estuaries into different types, but the latter is the more widely accepted of the two (Turpie, 2004). Physiographic features refer to the size of the tidal prism, hydrographic features refer to the fresh- and seawater mixing process, and salinity features refer to the mean salinity measured in parts per thousand. The five types of estuary are described in Table 1.1.

Table 1.1: Types of estuaries based on Whitfield's (1992) classification

Type	Tidal Prism	Mixing Process	Mean Salinity[1]
Estuarine Bay	Large (>10 x $10^6 m^3$)	Tidal	20 – 35
Permanently Open	Moderate (1 – 10 x $10^6 m^3$)	Tidal/Riverine	10 - >35
River Mouth	Small (<1 x $10^6 m^3$)	Riverine	<10
Estuarine Lake	Negligible (<0.1 x $10^6 m^3$)	Wind	1 - >35
Temporarily Open	Absent	Wind	1 - >35

(1) Total amount of dissolved solids in water in parts per thousand by weight (seawater = ~35).

The majority of South African estuaries (70 percent) are temporarily closed for some period of each year (Breen & McKenzie, 2001). The closure of estuaries is caused by numerous contributing factors: climate changes, upstream water abstraction and urban development (Allanson & Baird, 1999; Hosking, Wooldridge, Dimopoulos, Mlangeni, Lin, Sale & Du Preez, 2004).

1.3.1 ESTUARINE BAYS

The water area of an estuarine bay exceeds 1 200 hectares (ha). They have a large tidal prism with strong tidal exchange. As a result, these estuaries have continuously open mouths i.e. they are permanently linked to the sea (DWA, 2010). High salinity levels are found in their lower reaches and, in the event of low freshwater inflows, near-marine conditions can extend into their upper reaches (Allanson & Baird, 1999; Breen & McKenzie, 2001; Hosking *et al.* 2004). The replacement of seawater in the lower and middle reaches takes place on a regular basis. The influence of the sea dominates that of the river as far as estuarine bay water temperatures are concerned. The primary mixing process is tidal. Estuarine bays are dominated by marine and estuarine organisms (Whitfield, 1992). Examples of these types of estuaries include Richards Bay, Durban Bay and the Knysna Estuarine Bay (Breen & McKenzie, 2001). Figure 1.1 below shows the Knysna Estuarine Bay.

Figure 1.1: The Knysna Estuarine Bay (CMS13)
Source: Whitfield, Bate, Colloty & Taylor (2011)

1.3.2 PERMANENTLY OPEN ESTUARIES

In most cases permanently open estuaries are relatively large systems with perennial rivers flowing into them and/or strong tidal exchanges with the sea (Allanson & Baird, 1999; Breen & McKenzie, 2001). During times of low river inflow conditions, the tidal exchange keeps the mouth open. Salinity values normally vary between 5 and 35 parts per thousand, but hyper saline conditions (> 35) occur during periods of high evaporation and low or no river inflow. A large number of these estuaries have catchment areas that exceed 500km^2 and some exceed 1 000km^2. Wetlands often exist in these estuaries and are vegetated with salt marshes in more temperate areas and mangroves in tropical areas. Eelgrass may be present sub-tidally, especially in the middle to lower reaches of these estuaries. Examples of these types of estuaries include the Breede, Mlalazi and Swartkops

Permanently Open Estuaries (Breen & McKenzie, 2001). Figure 1.2 below shows the Swartkops Permanently Open Estuary.

Figure 1.2: The Swartkops Permanently Open Estuary (CSE3)
Source: Whitfield, Bate, Colloty & Taylor (2011)

1.3.3 RIVER MOUTHS

A river mouth exists for all rivers flowing into the ocean (Allanson & Baird, 1999; Breen & McKenzie, 2001), but an estuary classified as a river mouth displays additional characteristics to the mere presence of a mouth. River mouth estuaries are permanently open to the ocean, and typically have small tidal prisms (Whitfield, 1992). The physical processes that take place in these estuaries are dominated by river processes, and as a result, salinity values approach oligohaline (salinity < 5 parts per thousand) (Hosking *et al*. 2004). Seawater intrusion into the upper reaches of these estuaries is limited by river flow. Moreover, in some estuaries intrusion may even be limited to the lower reaches for most of the year (Breen & McKenzie, 2001). During strong flood conditions the sea salinity can be affected by the outflow being pushed offshore. The catchment areas of river mouth estuaries are normally large and the rivers usually transport a high silt load. As a result, the mouths are normally shallow (< 2 metres (m)) (Hosking *et al*. 2004). The surface water temperatures in river mouth estuaries are strongly influenced by river inflow, whereas bottom water temperatures are influenced by the sea. Examples of these types of estuaries include the Orange, Mzimvubu and Thukela River Mouths (Breen & McKenzie, 2001). Figure 1.3 below shows the Mzimvubu River Mouth Estuary.

Figure 1.3: The Mzimvubu River Mouth Estuary (TS63)

Source: Whitfield, Bate, Colloty & Taylor (2011)

1.3.4 ESTUARINE LAKES

The water area of an estuarine lake exceeds 1 200ha. These systems are created by inundated river valleys that are filled in by modified sediments and are mostly detached from the ocean by vegetated sand dune systems. These systems are linked to the ocean via a channel of fluctuating width and length (Allanson & Baird, 1999; Breen & McKenzie, 2001). This link can be either permanently open or temporarily open. In some cases the dune system has completely isolated the lake resulting in its loss of estuarine characteristics. Highly variable salinity levels are found in these lakes due to the extent of freshwater inflows, the levels of evaporation and the relative size of the marine link (Breen & McKenzie, 2001). Salinity levels can range from oligohaline (salinity < 5 parts per thousand) to hyper saline (> 35 parts per thousand) depending on freshwater inputs (Hosking *et al*. 2004). Prevailing salinity conditions determine the nature of the estuarine, marine and freshwater organisms found in these systems (Whitfield, 1992). Water temperatures are mainly governed by solar heating and radiation. Since these systems are large and shallow, marine and river inputs play a small part in influencing temperatures. Examples of these types of estuaries include the Kosi, Swartvlei and St Lucia Estuarine Lakes (Breen & McKenzie, 2001). Figure 1.4 below shows the St Lucia Estuarine Lake.

Figure 1.4: The St Lucia Estuarine Lake (NN19)

Source: Whitfield, Bate, Colloty & Taylor (2011)

1.3.5 TEMPORARILY CLOSED/OPEN ESTUARIES

Temporarily closed/open estuaries close off from the ocean, often for periods of many months per year, and sometimes in excess of a year (Allanson & Baird, 1999). This closure is due to sandbar formation at the mouth (Hosking *et al*. 2004) and happens during periods of longshore sand movement in the marine nearshore, coupled with low or non-existent freshwater inputs. Small catchment areas (< $500km^2$) characterise these systems and only limited penetration of seawater takes place when the estuary mouth is open. The mouths of these systems usually open after periods of flooding. Hydrographic conditions are subject to frequent changes and substantial amounts of sediment are removed during flooding episodes. Gradually rising water levels may occur during times of mouth closure which ultimately overtop the sandbar at the mouth. Water levels normally recede rapidly which tends to expose previously flooded areas that sustained a high biomass of animal and plant life (Hosking *et al*. 2004). Hyper saline conditions dominate the temporarily closed/open estuary during drought periods. Both tidal and riverine inputs govern the water temperature when the mouth is open. Depending on the state of the mouth, both marine and freshwater organisms can be found in these systems (Whitfield, 1992). Approximately 75 percent of South Africa’s estuaries fall into this category with examples including the Mhlanga, Great Brak and Van Stadens Temporarily Open/Closed Estuaries (Breen & McKenzie, 2001). Figure 1.5 below shows the Van Stadens Temporarily Open/Closed Estuary.

Figure 1.5: The Van Stadens Temporarily Open/Closed Estuary (CMS49)

Source: Whitfield, Bate, Colloty & Taylor (2011)

Although Whitfield's (1992) classification of estuarine systems is comprehensive in terms of its approach to classifying estuarine characteristics, it is important to recognise that estuaries are still unique ecosystems with different processes occurring in each. For example, estuaries could show large differences in biotic and abiotic characteristics, yet be classified in the same category (DWA, 2010). A more robust approach to valuing and classifying estuaries is therefore required in order to assess the current state of each estuary, and to determine alternative management strategies for each that can be used to maintain or improve individual functionality.

1.4 CONSERVATION POLICIES GOVERNING ESTUARIES IN SOUTH AFRICA

South African policies for wetland management and conservation are considered in the National Water Act (NWA), and, more specifically, the National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008). The main objective of the NWA is to sustainably and equitably protect, use, develop, conserve and manage South Africa's water resources. This objective promotes the principles of (1) recognising basic human needs, (2) protecting and conserving the water resources within our country, and (3) developing the socio-economic aspects of South Africa through the use of water. In order to achieve its main objective, the NWA laid down a series of measures designed to protect all water resources in South Africa. The implementation of these measures would occur within different phases of the complex protection process. This process was divided into three stages, namely (1) the development of a management classification system for water resources, (2) the classification of water resources whilst meeting resource quality objectives, and (3) the determination of an ecological reserve based on this classification. The RDM approach was implemented in order to classify each water resource into its respective management class. This facilitates the setting of the ecological reserve, i.e. the minimum freshwater level required to maintain natural levels of functionality of that specific resource system (Department of Water and Environmental Affairs (WEA), 2012).

The National Environmental Management: Integrated Coastal Management Act (ICMA), which was promulgated in December of 2009, requires coordinated and efficient management of estuaries in South Africa (National Environmental Management: Integrated Coastal Management Act (ICMA), 2008). It is the ICMA that guides the management of individual estuarine systems through their respective allocation into management classes i.e. (I), (II), or (III). This process is guided by a National Estuarine Management Protocol (NEMP) as gazetted by the WEA in May of 2012 (WEA, 2012). It is envisaged that this protocol will take the allocated management class into account when prioritising estuarine protection. Allocating water resources into their respective classes is a complex issue. A National Water Resources Classification System (NWRCS) was developed by Dollar, Brown, Turpie, Joubert, Nicolson & Manyaka (2006) to provide structure to this comprehensive process. This process consists of seven steps broken down into three main procedures and, for the purposes of this study, applied specifically to estuaries.

Firstly, a conservation importance index (CID) for each estuary must be determined. The variables selected for inclusion in the CID include estuary size, link with freshwater and marine environments, rarity of estuary type based on geographical position, habitat diversity and biodiversity importance (Turpie *et al.* 2002). Secondly, a preliminary management category must be assigned to each estuary based on their calculated CID and other socio-economic criteria. These management categories include (A) Unmodified or close to natural condition, (B) Largely natural with few modifications, (C) Moderately modified, (D) Largely modified, (E) Seriously modified, and (F) Critically modified. Categories (E) and (F) are not within the desired ecological range (DWA, 2010). The assigned preliminary management category will be based on current estuarine conditions relative to the status quo or stable baseline condition, and will range from category's (A) to (F). The final ecological management category is assigned taking into account the desired level of protection and management for that particular estuary into the future. Once the final ecological management category is assigned, the equivalent management class is determined through stakeholder evaluation and finalised by the Minister of Water and Environmental Affairs or his/her designated authority (DWA, 2010). These management classes represent (I) water resources in a condition minimally altered from their pre-development state, i.e. 'minimally used', (II) water resources in a condition moderately altered from their pre-development state, i.e. 'moderately used', and (III) water resources in a condition significantly altered from their pre-development state, i.e. 'heavily used'. Following this management classification, resource quality objectives are determined and the ecological reserve level is assigned. This reserve refers to the minimum freshwater supply required by the estuary in order to maintain its ecological functionality (Turpie *et al.* 2002).

1.5 THE CLASSIFICATION OF ESTUARIES IN SOUTH AFRICA

Estuaries are widely recognised as very important entities contributing to the coastal geomorphology of South Africa (Hosking *et al.* 2004). They hold an intermediary position between land and ocean, and, as such, are affected by many variations in the processes that occur in each. South African estuaries have been divided into three distinct biogeographic areas that characterise the coastline. There are the cool-temperate regions that stretch from the Gariep Estuary to Cape Agulhas, the warm-temperate regions that stretch from Cape Agulhas to the Mdumbi Estuary, and the subtropical region that spans from Mdumbi Estuary to Kosi Bay (Harrison *et al.* 2000). Consumptive and non-consumptive demand pressures affect a significant number of these estuaries. Consumptive use entails the removal of a good from an estuary. This use decreases other users' potential for consuming that good, for example, fishing, so the good is a rival good. Non-consumptive use refers to estuary activities that do not decrease the possibility for other estuary users to partake in that same activity, for example, bird watching. Whitfield (2000) assessed the condition of estuaries in South Africa by defining four categories of overall estuarine health. These categories are 'Excellent', 'Good', 'Fair' and 'Poor'. 'Excellent' refers to estuaries that are unpolluted and in their natural state, i.e. nearly perfect conditions; 'Good' refers to estuaries where the catchment is not greatly affected in terms of sources of organic toxic wastes, erosion, and river regulations; 'Fair' refers to estuary conditions where there is a degree of noticeable ecological degradation as a result of environmental changes in areas that are close to the estuary; and 'Poor' refers to estuaries where there is major ecological degradation due to a combination of anthropogenic influences. The geographic distribution of estuaries, rated according to Whitfield's (2000) health classification, is shown in Figure 1.6.

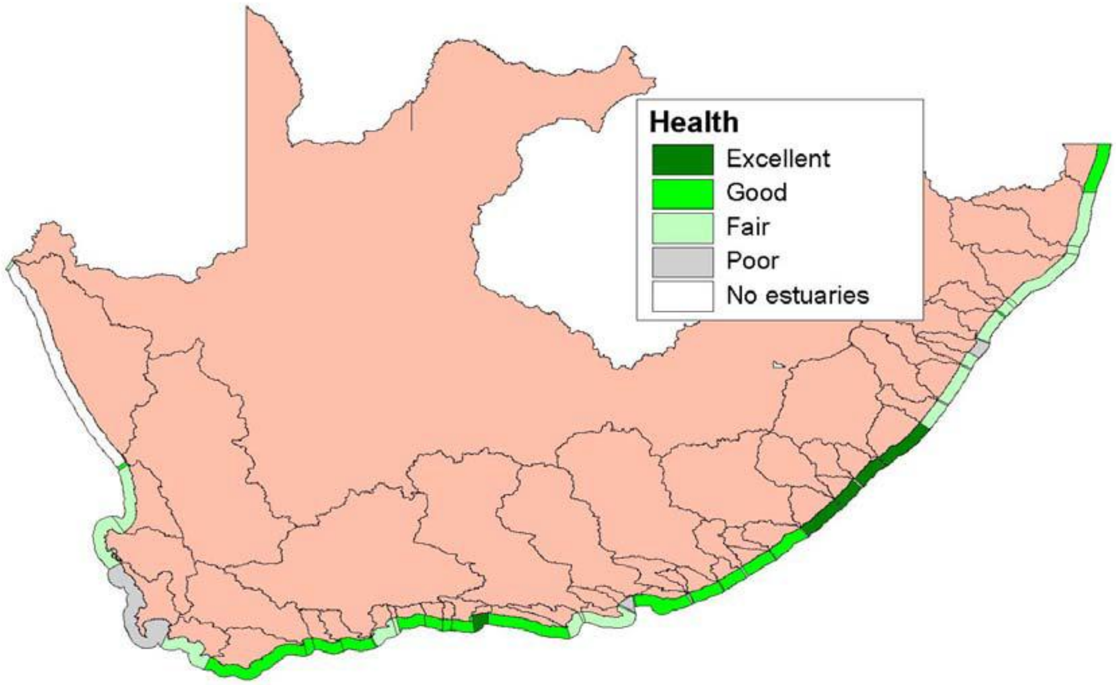

Figure 1.6: The geographical distribution of estuaries by Whitfield's (2000) health classification

Source: Turpie (2004)

In temperate regions, approximately 28 percent of estuaries were categorised as being in an excellent condition, 44 percent were classified as being in a good condition, 21 percent were classified as being in a fair condition, while 16 percent of estuaries were classified as being in a poor condition (Whitfield, 2000). An attempt to maintain high levels of functionality across all estuaries is not feasible due to budgetary constraints. For this reason, a prioritisation of estuaries has been favoured (Turpie *et al.* 2002). This prioritisation is achieved by applying methodologies that indicate each estuaries importance by considering current levels of protection and current socio-economic pressures. Turpie *et al.* (2002) estimates the recommended ecological reserve for each estuary by applying the RDM approach (Turpie *et al.* 2002). This method of estuarine prioritisation is in line with objectives as set out by the NWA (NWA, 1998).

1.5.1 ESTIMATION OF THE CID

Measures used to record and monitor the health status of estuaries are referred to as indices. Indices provide a framework for the collecting and disseminating of information by estuary so that it can be easily understood and used for comparative purposes (Breen & McKenzie, 2001). These indices allow complex information to be simplified into various measurements of estuary health. Studies have been carried out to assess the quality of estuaries using different indices, namely fish indices (Harrison & Whitfield, 2006), estuarine health indices (Cooper, Ramm & Harrison, 1994; Harrison *et al.* 2000) and conservation indices (Turpie *et al.* 2002). Turpie *et al.'s* (2002) study, in particular, defined a CID by measuring various factors that are important to ecological diversity and functioning of the estuary. These factors were weighted during the index construction process. Conservation importance scores were derived for all South African estuaries. The interpretation of these scores is as follows: a '0 – 60' score implies average importance, a '61 – 80' score implies an above average importance, while a '81 – 100' score implies a high level of importance. The highest ranked estuaries were found to be mostly large systems, for example the Knysna Estuary and the Berg Estuary. The scores for the variables included in the index were re-estimated and updated by Turpie and Clarke (2007). Table 1.2 shows the conservation importance scores for selected estuaries in South Africa (Turpie *et al.* 2002; Turpie & Clarke, 2007).

Table 1.2: Conservation importance scores for selected estuaries in South Africa

Estuary (West to East)	**Conservation Importance Score *(Turpie et al. (2002) in brackets)***	**Conservation Ranking out of 250 functioning estuaries**
Berg (Groot)	98.4 *(97.5)*	3 *(2)*
Klein	97.0 *(95.3)*	5 *(9)*
Heuningnes	83.1 *(82.4)*	24 *(25)*
Knysna	100.0 *(99.8)*	1 *(1)*
Kromme	88.4 *(86.4)*	17 *(17)*
Sundays	77.8 *(77.4)*	42 *(39)*
Richard's Bay	69.3 *(81.8)*	67 *(26)*
St Lucia	96.6 *(96.6)*	9 *(5)*

Source: Turpie & Clarke (2007), updated from Turpie et al. (2002)

Most of the updated importance scores have increased, except for Richard's Bay, where the estuary has dropped in conservation importance. Its ranking dropped from 26th to 67th out of 250 estuaries. The Knysna Estuary remains the most important in terms of conservation status.

Once these scores have been estimated, factors comprising the CID, for example, habitat diversity and biodiversity importance, are then used to derive the Estuary Health Index (EHI). This index estimates the degree to which the estuary's current conservation status compares with those features representing the reference condition. The reference condition of an estuary refers to its pre-settlement and pre-development state (DWA, 2010). Once the EHI has been calculated, estuaries can then be assigned into their present ecological status (PES) categories. These categories cover six broad states of estuarine health (see Table 1.3).

Table 1.3: The classification of estuaries into their PES categories

EHI Score	PES	Description
100 – 91	A	Unmodified, natural
76 – 90	B	Largely natural, with few modifications
61 – 75	C	Moderately modified
41 – 60	D	Largely modified
21 – 40	E	Highly degraded
0 – 20	F	Critically degraded

Source: Taken from DWA (2010)

1.5.2 ESTIMATING THE RECOMMENDED ECOLOGICAL STATUS FOR EACH ESTUARY

An estuary's recommended ecological status (RES) can only be determined once the PES, conservation importance score, and estuarine health score have been estimated. Recommended ecological categories are largely based on conservation importance scores, whilst taking the estuary's PES into account. An estuary's present condition can be represented by any category, but the recommended category for an estuary cannot be lower than ‘D’, as it is not considered feasible to manage an estuary that has high to critically high levels of degradation (DWA, 2010). Table 1.4 provides the link between an estuary’s PES, its RES (based on health and conservation importance scores), and its corresponding management class (MC). This MC will be assessed and finalised by the Minister of Water and Environmental Affairs.

Table 1.4: Link between an estuary’s PES, RES and MC

<table>
<tr><th>EHI Score</th><th>PES</th><th>RES</th><th>Assigned MC</th></tr>
<tr><td>100 – 91</td><td>A</td><td>A</td><td>Minimally used</td></tr>
<tr><td>76 – 90</td><td>B</td><td>B</td><td>Moderately used</td></tr>
<tr><td>61 – 75</td><td>C</td><td>C</td><td rowspan="2">Heavily used</td></tr>
<tr><td>41 – 60</td><td>D</td><td>D</td></tr>
<tr><td>21 – 40</td><td>E</td><td rowspan="2">Not less than D</td><td rowspan="2">Assigned relevant class</td></tr>
<tr><td>0 – 20</td><td>F</td></tr>
</table>

Source: Adapted from DWA (2010)

Table 1.5 provides recommended ecological categories for all the estuaries selected in Table 1.2 above.

Table 1.5: Selected estuaries with RES and assigned MC

Estuary (West to East)	Present Ecological Category	Recommended Ecological Category	MC (I, II, or III)*
Berg (Groot)	D	C	III
Klein	C	B	II
Heuningnes	D	A or next best	I
Knysna	B	B	II
Kromme	D	C	III
Sundays	C	A or next best	I
Richard’s Bay	C	A or next best	I
St Lucia	D	A	I

Source: DWA (2010)

* *The allocated MC will determine the assigned ecological reserve*

Once the recommended ecological category has been determined, a MC can be assigned. This MC determines the quantity and quality of water that should be allocated to each estuary in order to maintain that estuary's functionality, i.e. the ecological reserve. In terms of the RDM approach, the amount of water is calculated that management should supply to each estuary to allow either the maintenance of its current health status, or the implementation of measures to improve its health status into the future.

The RDM approach is perhaps well suited to guiding supply side management, for example, the supply of water to estuaries. This approach is not, however, the only way to ensure the productivity and sustainability of estuaries into the long-run, and it fails (by definition) to guide demand side management.

1.6 MANAGEMENT CHALLENGES FACING SOUTH AFRICAN ESTUARIES

It is widely accepted that there has been a drastic and accelerated decline in the condition of the world's estuaries and coastal seas, most notably during the past 150 to 300 years (Lotze *et al*. 2006). The decline in coastal vegetation, due to human exploitation and habitat destruction, has caused a substantial loss in the number of nursery areas found within estuarine systems. In order to diminish the negative impacts on estuaries, it is essential that effective management and marine conservation strategies are put in place. The ICMA is in the process of developing a NEMP which will be responsible for the development of individual estuarine management plans (ICMA, 2008). It is envisaged that these management plans will provide balance between the demand for physical processes within the estuary and the demand for recreational use of the estuary (WEA, 2012). The NWA has set out four regulating activities to ensure optimal and balanced use of South Africa's water resources (NWA, 1998). The use of RDM defines a minimum reserve requirement (water supply) for each estuary, thus setting flows and defining quality objectives. In order to accomplish these objectives demand side management is required in the form of registration fees, permits, levies and/or fees, and before such management is implemented, it must be informed by demand side analysis. The latter has a different focus of attention. While RDM aims to limit the use of the resource in order to maintain the required level of functionality, demand side analysis aims for the optimal use of the resource.

1.7 RESEARCH DESIGN AND METHODOLOGY

The development of adequate and cost effective methods to value trade-offs, such as those that occur with respect to estuary use, has been one of the major advances in Environmental and Resource Economics. The estimation of Rand values for the recreational and environmental attributes of estuaries is a complex task since these attributes are not traded in markets. Examples of valuation studies applied to South African estuaries abound (Hosking *et al.* 2004; Sale, 2007; Van der Westhuizen, 2007; Dikgang, 2007; Akoto, 2008; Chege, 2009; Nyaboga, 2011). All of these studies employed the contingent valuation method (CVM). The CVM has been widely applied to value environmental resources over the last 30 years (Adamowicz, Boxall, Williams & Louviere, 1998; Adamowicz & Boxall, 2001; Bateman, Carson, Day, Hanemann, Hanley, Hett, Jones-Lee, Loomes, Mourato, Özdemiroglu, Pearce, Sugden & Swanson, 2002). It is a direct approach whereby the consumer is asked to make a hypothetical WTP bid for a defined good or service (Kahnemann & Knetsch, 1992). A set of general guidelines has been developed for the proper application of CVMs (see Arrow, Solow, Portney, Leamer, Radner & Schuman, 1993). Although the CVM is accepted as a non-market valuation technique, it suffers from several shortcomings. One of the most important shortcomings of the CVM is that it is incapable of "generating multiple value estimates from a single application" (Bennett & Blamey, 2001). The examples of South African estuary valuation studies listed above suffer from this shortcoming as they only valued one estuarine environmental service flow, namely freshwater inflow. This analysis is too narrow. A more comprehensive type of analysis is required for composite goods like estuaries to capture the broad range of factors that influence recreational choice and experience.

Conjoint analysis, also known as the CM approach, is a technique capable of handling the analysis of composite goods. Four different types of CM studies can be conducted. First, individuals may be presented with a series of alternatives and asked to state their most preferred option (CE), second, individuals may be asked to rank the alternatives in order of preference (contingent ranking), third, individuals may be asked to choose the preferred alternative out of a set of two choices (paired comparisons), and lastly, individuals may be asked to rate the alternative on a cardinal scale (contingent rating) (Garrod & Willis, 1998; Foster & Mourato, 1999; Foster & Mourato, 2000; Haab & McConnell, 2002).

The CE is the preferred method if the *relative* values of characteristics (referred to as attributes) of a public good are to be analysed and valued. In addition, the method is also applicable in cases where the characteristics of the environmental good or service are somewhat unlike those possessed by traditional consumer goods, because the choice scenario employed in the method more closely resembles real-life market conditions. Despite this technique's apparent relevance and usefulness for the valuation of the attributes of composite goods, such as estuaries, there is a paucity of published studies on South African wetlands that apply this technique, but there are unpublished studies, for example, Oliver (2010).

The CE is a survey-based method that models preferences for goods and services, represented in terms of different levels of attributes. The CE approach to valuation was first proposed by Louviere and Hensher (1983). It shares a theoretical framework with dichotomous choice valuation in random utility models (McFadden, 1974) and utilises the empirical framework of limited dependent variable statistical models (Greene, 1997). The CE technique was initially developed for the analysis of markets and transportation studies (Green & Srinivasan, 1978; Hensher & Johnson, 1981; Green, 1984; McFadden, 1986; Louviere, 1988; Batsell & Louviere, 1992; Gan & Luzar, 1993; Holmes & Adamowicz, 2003), but further development allowed for the increased use of this technique to value non-market goods (Adamowicz, 1995; Boxall, Adamowicz, Swait, Williams & Louviere, 1996; Hanley, Macmillan, Wright, Bullock, Simpson, Parrison & Crabtree, 1998a; Hanley, Wright & Adamowicz, 1998b; Hanley, Mourato & Wright, 2001; Macmillan, Duff & Elston, 2001; Nunes & van den Bergh, 2001). The conceptual roots of this technique can be traced to Lancaster's (1966) characteristics theory of value. In this utility maximising theory of choice, utility from consuming goods is decomposed into utilities from the attributes of the good. Applied to the modelling of choice, target populations are presented with alternative packages of attributes expressed by levels and asked to make a choice between these alternative packages. Their choices subtly reveal the trade-offs they make between the attributes.

For the purpose of estuarine recreational management, a CE is appropriate because the decision issues are typically multidimensional and inter-dependent. These types of decisions include, but are not limited to, the following: access to infrastructure, recreation activity management, and bank development. The composite good that results is the recreational experience of the user. By including cost as an attribute of the management set of options, recreational marginal value for the specific management interventions can be deduced, and utilised to assist to help prioritise management effort.

1.8 DATA COLLECTION

For this thesis, data will be obtained using both primary and secondary sources. Primary data will be gathered by means of an empirical study. Personal interviews will be conducted at each estuary by means of a pre-coded questionnaire to determine the recreational preferences of each estuary user. This questionnaire will also include questions relating to key socio-economic variables, for example, income.

One of the key steps needed for the collection of primary data is sample design. The first aspect of sample design is the determination of the target population. The target population for the data collection process was defined as all the recreational users of each of the estuaries being studied. The choice of the target population was relatively straightforward as it was governed by the primary objective of the study – the valuation of the recreational attributes of both estuaries. Drawing a representative sample from the target population should ideally be preceded by a process of clarification that entails the compilation of a sampling frame. It is defined as a complete but finite list of all units of analysis. The importance of a properly specified sampling frame lies in its usefulness in judging the representativeness of the sample – the sample selected should be representative of the sampling frame and of sufficient size to enable significant estimates of parameters. Two approaches to the determination of sample size in choice modelling exercises are often proposed (Hensher, Rose & Greene, 2005): the use of probability sampling and *rule of thumb*. The former is very often abandoned in favour of the latter due to practical considerations (budget and time constraints).

1.9 ORGANISATION OF THE THESIS

Chapter One introduces selected recreational management challenges facing South African estuaries. Chapter Two describes the features of the two estuaries selected for this case study, i.e. the Sundays River and Kromme River Estuaries, and the recreational challenges facing each of them. Chapter Three provides a policy perspective on managing recreational demand at these estuaries. Chapter Four presents an overview of the CE method, and discusses its suitability for valuing the attributes (parts) of a composite good (estuary). Chapter Five discusses the design and implementation of the CEs for the selected estuaries. Chapter Six determines predictive models for the selected estuaries using maximum likelihood estimation (MLE) and presents the results for the recreational attributes of interest. Lastly, conclusions are drawn and recommendations made in Chapter Seven.

1.10 CONCLUSION

South Africa's many and varied estuaries are facing a demand induced crisis. *Inter alia*, freshwater demand upstream is depriving them of freshwater inflow, they are being polluted, the immediate environments are being increasingly and often recklessly imposed upon by human demand for services, and an ever increasing number of people are using them. In the face of this demand, local government support service and conservation are often woefully inadequate. The result is increasing conflict in recreational demand.

While the Resource Directed Measures approach does provide a method for determining a minimum water requirement for an estuary, it does not take into account, or control for, the level of estuarine recreational demand. In order to manage estuaries in a holistic manner, demand-side factors should also provide input to the management decision-making process. Management alternatives should thus be investigated that can control use of the estuary, from a recreational perspective, by decreasing recreational demand at the estuary to levels that ensure its sustainability into the long-run. It is evident that the relevant authorities face an enormous challenge in managing these demand problems. But what information are they to use to meet this challenge? This thesis will argue that the choice experiment has the potential to yield some of the demand information needed. Two choice experiment analyses will be reported – one among the Sundays River Estuary users and another among the Kromme River Estuary users, and it will be shown how the results of these analyses can guide management of recreational demand for the services of estuaries.

CHAPTER TWO: THE STUDY SITES AND RECREATIONAL CHALLENGES FACED AT THESE SITES

2.1 INTRODUCTION AND STUDY SITE SELECTION

Two Eastern Cape (EC) estuaries were selected for the purposes of this study. The EC Province lies on the south eastern seaboard of South Africa. It is a large province covering approximately 13.9 percent of South Africa's land mass. It has a total of 213 estuaries, more than half of the estuaries situated in South Africa (CSIR, 2004). They range from large permanently open systems, for example, the Swartkops River Estuary, to smaller temporarily open/closed systems, for example, the Van Stadens River Estuary. These estuaries provide both consumptive use values (like fishing) and non-consumptive use values (like swimming and picnicking). Knowledge about the condition of these estuarine systems found in the EC is analysed in Table 2.1 below.

Table 2.1: Health of EC Estuaries

State of Estuaries	Number of Estuaries	Percentage
No Information	78	36
Fair Condition	18	9
Good Condition	44	21
Excellent Condition	73	34
Total	213	100

Source: Whitfield (2000)

The selection process took this health analysis into account, and was done in consultation with members serving on the WRC Project No: K5/1924 Reference Group. The two estuaries chosen were the Sundays River and the Kromme River Estuaries. Both face direct and indirect pressures, such as habitat alteration, over-exploitation and reduction in freshwater inputs. These pressures have led to adverse economic consequences through the loss of environmental service flows. More specifically, the lower reaches of the Sundays River Estuary have been significantly developed. This estuary also experiences high boat use during peak holiday seasons. Recreational over-fishing has also been reported (Cowley, Childs & Bennett, 2009). Uncontrolled agricultural run-off in the higher reaches of the system and sewage spills along its entire course pose further threats to the health of the system.

The Kromme River Estuary is considered to be freshwater starved (Baird, 2002). A marina canal system was constructed in a marshy area at the estuary mouth. The canal system has since undergone numerous expansions in order to accommodate the construction of more houses. Numerous small dams are also situated on the tributaries of the Kromme River and these tend to restrict the water flow. The very low freshwater inflows and resultant sedimentation have reduced the surface area available for boating – this in turn has led to peak period boat congestion (Forbes, 1998).

A detailed description of each selected estuary is provided below, as well as a background to the identified recreational challenges facing each of them.

2.2 BIOTIC AND ABIOTIC FEATURES OF THE SUNDAYS RIVER AND KROMME RIVER ESTUARIES

2.2.1 THE SUNDAYS RIVER ESTUARY

2.2.1.1 Location

The Sundays River Estuary (33°43’S, 25°25’E) is situated in the EC, approximately 40km northeast of Port Elizabeth. The estuary is approximately 20km long, is permanently open and discharges into Algoa Bay, in the Indian Ocean (MacKay & Schumann, 1990). Figure 2.1 below shows an aerial photograph of the Sundays River Estuary.

Figure 2.1: An aerial photograph of the Sundays River Estuary (CSE5)

Source: Whitfield, Bate, Colloty & Taylor (2011)

The Sundays River's headwaters can be found in the catchment of the Nqweba Dam (formerly the Van Rynevelds Pass Dam) at Graaff Reinet.

2.2.1.2 Climate

In the summer rainfall area, annual rainfall fluctuates between 250 to 500 millimetres (mm) per annum. In the south, this figure lies between 400mm and 1 000mm per annum. This categorises the catchment as semi-arid. The prevailing wind in the catchment area is south westerly. In terms of temperature variations, it fluctuates from 17°C in mid-winter to 24°C in mid-summer (Scharler, Baird & Winter, 1998).

2.2.1.3 Area of river catchment and tributary information

The Sundays River has a catchment area of approximately 22 000km^2. It lies in a semi-arid region and has no tributaries (Scharler & Baird, 2003).

2.2.1.4 River length and estuary characteristics

The Sundays River Estuary is approximately 24km in length (Scharler & Baird, 2003). The estuary's average depth and width, respectively, are 2m and 50m. The overall surface area covers approximately 156ha (Scharler & Baird, 2003).

2.2.1.5 Runoff and flow records

The mean annual runoff (MAR) is approximately $186x10^6m^3$. The two dams constructed in the catchment area have a combined storage of about 140 percent of the MAR (Reddering & Esterhuysen, 1981). A significant part of the freshwater inflow for the Sundays River comes from one of the largest rivers in South Africa, the Orange River. This occurs via an inter-basin water transfer scheme which provides water for irrigation purposes for the extensive citrus farming community in the Sundays River catchment area. This inter-basin water transfer scheme provides the Sundays River Estuary with a regular inflow of freshwater, leading to an unnatural dilution of the saline balance in the estuary (Emmerson, 1989).

2.2.1.6 Land ownership, catchment uses and estuary access

Sheep farming and citrus cultivation are the main agricultural activities in the catchment area and along the entire river, which is about 310km in length. Agricultural enterprises within the Sundays River system mostly consist of commercial land and commercial irrigated activities. This portion, however, represents only 3 percent of the catchment land-cover in total. There is also a very small percentage (1 percent) of residential developments in the catchment (Afri-Coast Engineers, 2004). The main activities that occur on the estuary are recreational activities. These include high levels of fishing and lots of motorised boating during peak periods. The main town in the Sundays River system is Graaff Reinet. It is situated in the upper catchment area. Smaller towns, such as Kirkwood, Jansenville and Pearston, are located in the middle to upper catchment (Afri-Coast Engineers, 2004).

2.2.1.7 Estuary fauna and flora

The Sundays River Estuary contains two types of microalgae, namely phytoplankton and benthic microalgae. Phytoplankton forms the base of the food chain in the estuary (Integrated Environmental and Coastal Management (IECM), 2010). The most dominant vegetation types found in this estuary are reeds and sedges, which cover an area of 29ha (IECM, 2010). Extensive salt marshes are precluded because of the narrow channel-like morphology of this estuary. The salt marsh covers an area of 21.7ha (IECM, 2010). Submerged macrophytes include pondweed in the upper reaches and eelgrass in the lower reaches of the estuary.

Twenty zooplankton species can be found in the Sundays River Estuary. Ichthyoplankton (i.e. fish larvae) also forms part of the zooplankton and 17 species from 11 families can be found in this estuary (IECM, 2010). Despite the limited area of mudflat available in the estuary, mud prawn (an example of invertebrate macrofauna) can attain high densities in localised areas (IECM, 2010).

The Sundays River Estuary has high fish species richness – 51 species representing 27 families of fish have been recorded (Cowley *et al.* 2009). Fifty three percent of the total numbers of species are marine migrants, 25 percent are estuarine residents and 18 percent are marine stragglers. The most popular recreational species targeted include dusky kob, spotted grunter and white steenbras (Cowley *et al.* 2009).

An abundance of bird species makes the Sundays River Estuary a popular location for bird watching – between 27 and 166 species have been recorded (IECM, 2010). Up to 59 aquatic species have been sited (IECM, 2010).

2.2.2 THE KROMME RIVER ESTUARY

2.2.2.1 Location

The Kromme River Estuary (34°08'S, 24°5'E) is located in the EC approximately 80km west of Port Elizabeth (see Figure 2.2) (Scharler & Baird, 2003; Sale, 2007). The estuary flows into St Francis Bay, in the Indian Ocean. This estuary is considered to be one of the larger estuaries situated in the EC province and is classified as permanently open. It also lays claim to a relatively undisturbed catchment area (Heymans, 1992).

Figure 2.2: An aerial photograph of the Kromme River Estuary (CMS45)

Source: Whitfield, Bate, Colloty & Taylor (2011)

2.2.2.2 Climate

The Kromme River Estuary experiences rainfall throughout the year. Annual rainfall varies from 700mm to 1 200mm (Baird, Marais & Bate, 1992). Temperatures in the area range from 14°C in mid-winter to 24°C in mid-summer (Day, 1980). Rainfall in the catchment area occurs throughout the year, but rainfall maximums are usually recorded in autumn and spring. January and February are the months that have the lowest average rainfall (Bickerton & Pierce, 1988).

2.2.2.3 Area of river and tributary information

The catchment area of the Kromme system is between $936km^2$ (Baird *et al.* 1992) and $1085km^2$ (Day, 1980), and drains a large part of the Langkloof. This valley lies between the Tsitsikamma Mountains and the landward Kouga Range. The system's biggest tributary, the Geelhoutboom tributary, joins the river approximately 7km from the tidal head (Scharler & Baird, 2003).

2.2.2.4 River length and estuary characteristics

The Kromme River runs for approximately 95km, with the last 14km of the river regarded as estuarine (Heymans, 1992). This estuarine system has a total surface area of approximately 172ha (Colloty, 2000). The average depth at low spring tide is about 2.8m (Scharler & Baird, 2003). The estuary is a relatively narrow one, with the average width being approximately 80m.

2.2.2.5 Runoff and flow records

The MAR for the Kromme River Estuary was estimated at $105.5x10^6m^3$ by Reddering and Esterhuysen (1983). Bickerton and Pierce (1988), however, estimated it closer to $116.8x10^6m^3$. The high runoff is due to various key geomorphologic characteristics of the Kromme River catchment area, namely the high relief, rocky slopes and sparse vegetation.

2.2.2.6 Land ownership, catchment uses and estuary access

The Kromme River Estuary occurs in a relatively undisturbed area and comprises approximately $12km^2$ of pristine forest, $80km^2$ of fynbos and 1 $462km^2$ of private farmland. Farmland activities include stock farming and grain cultivation (Heymans, 1992). Recently there have been a large number of residential developments along the banks of the estuary. There is also a marina canal system which has undergone numerous expansions over the years in order to accommodate more houses with water frontage, and a bridge running over the estuary has been constructed. Dams have been constructed on the upper reaches of the estuary leading to a reduction in freshwater inflows.

2.2.2.7 Estuary fauna and flora

In the Kromme River Estuary, seaweeds (a form of algae) are not an important component of the flora present. Eelgrass can be found on 14ha of the estuary, whereas reed beds are found in brack water conditions at the mouths of freshwater tributaries (Bickerton & Pierce, 1988). Many tidally inundated salt marshes occur at the conference of streams with the estuary. These marshes fulfil an important role in the estuarine food chain and also provide a buffer against flood effects. Many of the salt marshes have, however, been disturbed by developments such as the construction of bridges and private roads (Bickerton & Pierce, 1988). Closed grassland can be found in flat areas slightly higher than salt marsh. These areas are not regularly flooded, but fall below the flood line. The following species of grass can be found in these areas, namely brakgrass, buffalo grass and kweekgras.

Twenty two species of zooplankton have been recorded in the Kromme River Estuary (Bickerton & Pierce, 1988). Fifty six species of aquatic macro-invertebrates have also been recorded. These invertebrates include mainly different species of crab, sand prawn, snails, mud prawn and bloodworm.

A total number of 45 fish species occur in the Kromme River Estuary (Bickerton & Pierce, 1988). The most abundant of these species include the leervis, and sea-catfish.

Despite its large size, the Kromme River Estuary does not support large numbers of water birds (Bickerton & Pierce, 1988). This is mainly due to the lack of sizable intertidal mud flats and salt marsh areas. In addition, human encroachment in the form of bank developments and boating has also led to low bird numbers (Forbes, 1998). A total of 35 bird species have been recorded at the Kromme River Estuary. Of this total, 20 species were waders (Bickerton & Pierce, 1988). Fourteen of the total numbers of species were migrants and six were residents.

2.3 RECREATIONAL CHALLENGES FACING THE SUNDAYS RIVER AND KROMME RIVER ESTUARIES

2.3.1 A REVIEW OF AVAILABLE LITERATURE

2.3.1.1 The Sundays River Estuary

a) The Sundays River Estuary fishery

The Sundays River Estuary fishery is a major tourist asset (Cowley *et al.* 2009). Recreational use of the fishery dominates that of subsistence. Three fish species are actively targeted by recreational fishers in the Sundays River Estuary, namely spotted grunter (*Pomadasys commersonnii*), dusky kob (*Argyrosomus japonicas*) and white steenbras (*Lithognathus lithognathus*) (Wooldridge, 2010). These fish species are not being allowed to reach their adult size, due to over-fishing and high retention rates of undersized fish. The stock status is collapsed of two of these species, namely dusky kob and white steenbras (Cowley *et al.* 2009). The stock status is over-exploited of spotted grunter. The most recent research available on the adult dusky kob population suggests that it is between 1 and 4.5 percent of the non-impacted (original) population, a level that could be below the recovery threshold for this species (Griffiths, 1997).

Cowley *et al.* (2009) have estimated the total annual catch for the Sundays Estuary to be 17 518 fish or 8.7 tons. Of the total tonnage caught, dusky kob makes up 3.5 tons, spotted grunter 2 tons, and white steenbras 310 kilograms (kg). This estimate is based on a study by Cowley *et al.* (2009), which revealed that 19 different fish species were caught during the period September 2007 to August 2008. In total, 1 497 fish were caught by recreational as well as subsistence fishers. The recreational fishers were responsible for the highest catches of all species (taking into account both number and mass).

The catch composition recorded during the Cowley *et al*. (2009) survey was dominated by five species, namely Cape stumpnose (*Rhabdosargus holubi*), spotted grunter, dusky kob, white seacatfish (*Galeichthys feliceps*), and white steenbras. The five species are caught throughout the year, with a peak during the summer months (Cowley *et al.* 2009). Catches of dusky kob and spotted grunter peak during February, whilst catches of Cape stumpnose peak during November and December. Of the targeted recreational fish species, the spotted grunter was the most commonly caught during the survey (24 percent), followed by the dusky kob (21.8 percent) and the white steenbras (7.4 percent) (Cowley *et al.* 2009).

Overall, 25 percent of all fish caught during the survey period were kept. Subsistence fishers kept a higher proportion (71 percent) than the recreational fishers (22 percent). Of the targeted species, 32.8 percent of all spotted grunter caught were kept, 33.1 percent of the dusky kob and 26.6 percent of the white steenbras.

The average lengths of spotted grunter, dusky kob and white steenbras, respectively, caught during the survey period were 31.4 centimetres (cm) (0.50kg), 35.9cm (0.95kg) and 25.0cm (0.23kg) (Cowley *et al.* 2009).

Of all those fish caught and subsequently kept, a large proportion were under the legal size limit. More specifically, 63 percent of the dusky kob were below the legal size limit, 100 percent of the white steenbras were below the legal size limit, and 30 percent of the spotted grunter were below the legal size limit (Cowley *et al.* 2009).

b) Boat congestion on the Sundays River Estuary

<u>Current recreational activities</u>

This study found that the main recreational activities for the Sundays River Estuary were: recreational shore fishing (41 percent), recreational boat fishing (41 percent), speed boating (11 percent), water skiing (1 percent), paddling (2 percent), jet skiing (1 percent), swimming (1 percent) and bird watching (1 percent). By way of comparison, the main estuary activities observed by the Cowley *et al*. (2009) study were recreational shore fishing (32 percent), recreational boat fishing (18 percent), speed boating (11 percent), water skiing (3 percent), paddling (2 percent), and jet skiing (1 percent). Both of these assessments indicate that fishing and non-fishing motorised boating activities constitute a large part of all activities that occur in the Sundays River Estuary. The number of boats registered to use the Pearson Park Resort slipway for the years 2007 and 2008 respectively, were 774 and 812. These numbers exclude the boats that made use of the public launching facilities under the new Mackay Bridge (between zones 4 and 5).

Recreational boating activities by estuary zone

The Cowley *et al.* (2009) study divided the recreational boating area of the Sundays River Estuary into six zones (see Figure 2.3). These zones stretch for 12km, starting at the mouth of the estuary and ending approximately 4.5km beyond the N2 Bridge. Various recreational activities take place on this stretch of water, but some are focused within specific zones.

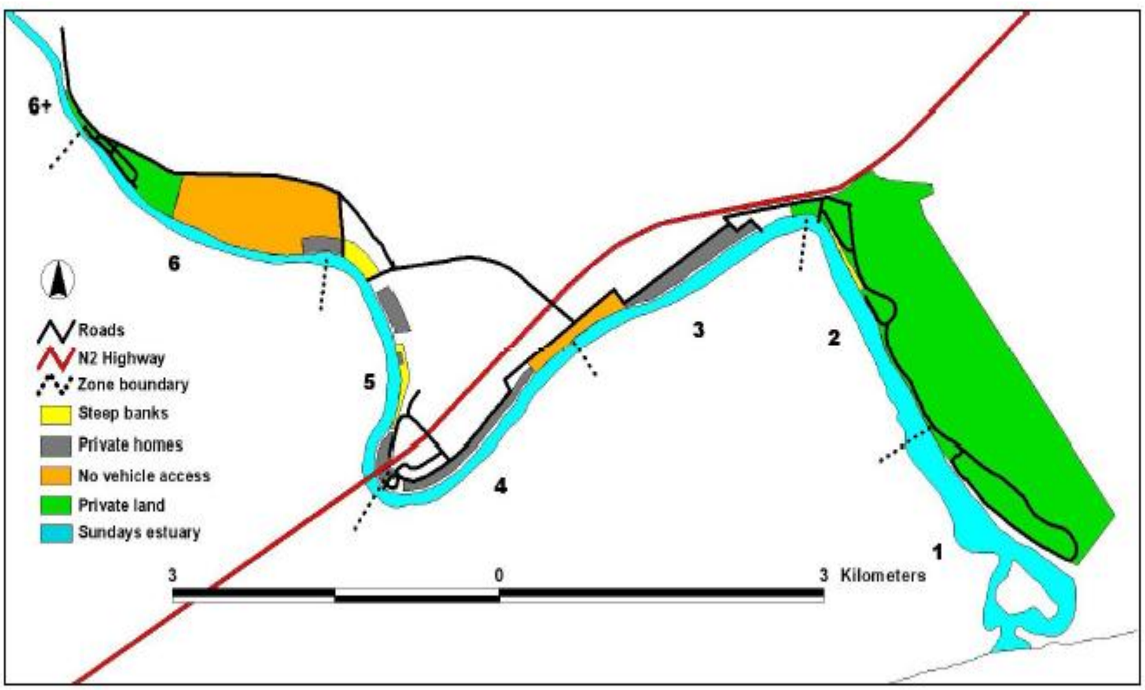

Figure 2.3: Spatial zones of the Sundays River Estuary

Source: Cowley, Childs & Bennett (2009)

Recreational boat[2] fishing is not confined to any particular part of the estuary, but is spread throughout. This type of fishing mostly takes place between 2 and 4km from the estuary mouth. Motorised boating activities, excluding fishing, but including family outings, 'booze' cruises, leisure cruises and ferry trips, take place all along the estuary. The incidence of motorised boating activity is higher within 2km on either side of each of the main two slipways (Cowley *et al.* 2009). Motorised boating activity related to water skiing, is mainly confined to the area between the two slipways.

Non-ski motorised boating activity takes place anywhere in the estuary because no boundaries exist and there are no access restrictions limiting the movements of boats (Cowley *et al.* 2009). Table 2.2 below summarises the spatial distribution of recreational motorised boating activities (as described by Cowley *et al.* 2009).

Table 2.2: Spatial distribution of recreational motorised boating activities – Sundays River Estuary

Boating Activity	**Zone**	**Zone(s) with most Activity**
Recreational Boat Angling	1 – 6	2
Other Motorised Boating*	1 – 6	2, 3, 4, 5
Water Skiing	1 – 5	3, 4
Jet Skiing	2 and 4	2 and 4

Source: Cowley, Childs & Bennett (2009)

**This type of boating includes leisure cruises, 'booze' cruises, ferry trips and family outings.*

General motorised boating activity (excluding fishing) peaks during the summer months. Cowley *et al.* (2009) found that a maximum of about 40 boats use the estuary at any one time (survey conducted between September 2007 and August 2008 – excluding jet skis and wet bikes). The summer peak is from October to January.

[2]Boats include motorised boats, canoes and kayaks.

The development of space standards for recreational water activities have been advocated by Sowman and Fuggle (1987). Their space standards are displayed in Table 2.3 below.

Table 2.3: Space standards for recreational water activities

Recreational Activity	**Crafts per Hectare (ha)**
Boat Angling	0.25
Leisure Cruising	0.83
Water Skiing and Speed Boating	0.06 – 0.13 (avg. = 0.095)
Jet Skiing	Same as Water Skiing
Hobie Cats	1 - 3 (avg. = 2)
Dinghies	1 – 3 (avg. = 2)
Canoeing	Not Defined
Windsurfing	10
Bait Collecting	Not Defined
Swimming	Not Defined
Average	2.18

Sources: Sowman & Fuggle (1987) and Forbes (1998)

If one takes the length of the Cowley *et al*. (2009) study area (12km) and an average estuary width (between 50m to 100m with an average = 75m), approximately 90ha are available for recreational activities. Based on the abovementioned space standards and the total number of hectares available, it is possible to determine the extent of the boat congestion in the Sundays River Estuary. According to the space standards defined above, the maximum number of motorised recreational angling boats using the Sundays River Estuary at any one time should not exceed 23, i.e. 90x0.25. There should also be no more than 75 leisure cruises taking place at any one time, i.e. 90x0.83, or 9 water skiers or speed boaters on the water, i.e. 90x0.095, and 9 jet skiers or wet bikers at any one time, i.e. 90x0.095. This standard assumes only one of these recreational activities is taking place at a time. The policy challenge at the Sundays River Estuary is to determine a simultaneous capacity limit covering all these activities. When this determination is done by weighting each of these boating activities proportionally[3], the capacity limit at any one time for the whole Sundays River Estuary is 55 boats.

[3]Total motorised craft per hectare equals 1.27, of which boat angling, leisure cruising, water skiing/speed boating and jet skiing represent 20 percent, 65 percent, 7.5 percent and 7.5 percent respectively. This

Within any given zone, the capacity limit is less. Recreational boat angling, for example, is focused mainly in zone 2; 2 to 4km from the mouth of the estuary (Cowley *et al.* 2009). Within this zone of approximately 15ha, only 4 fishing boats should ideally be active, or less than that, if other activities also take place in this area.

By similar calculations, the area within about 2km on either side of each of the two main slipways (approximately 60ha), no more than 50 leisure boats should be active at one time. Water skiing in the estuary is confined to zones 3 and 4 (the area situated between the two main slipways at Pearson Park Caravan Park and at the N2 New Mackay Bridge). This stretch has a surface area of approximately 22.5ha. In terms of the space standards formula of Sowman and Fuggle (1987) and the available surface area, no more than two craft should be active. The same space standard applies to jet skis and wet bikes.

The level of boat congestion on the Sundays River Estuary

The Forbes (1998) study and a status quo assessment report of the Sundays River Estuary conducted by Afri-Coast engineers in 2004 argued that the recreational users at this estuary show a lower tolerance towards motorised activities than non-motorised and shore-based activities (Forbes, 1998; Afri-Coast Engineers, 2004). A survey of recreational users showed that, with respect to motorised activities:

- the noise generated and the danger associated with the high speed of the craft, were considered problematic;
- the neglect of regulations governing motorised craft use and reckless behaviour were problematic; and
- the high number of boats was a major problem (Forbes, 1998; Afri-Coast Engineers, 2004).

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implies 4.6 angling boats, 48.75 leisure boats, 0.675 water skiers or speed boaters and 0.675 jet skiers can make use of the estuary at one point in time. This represents a capacity limit for the Sundays River Estuary of 55 motorised craft at one point in time.

Although the Cowley *et al.* (2009) study did not ask respondents about their perceptions regarding motorised boat congestion, it did enquire about respondents' opinions of other estuary users. Speed boating was one of the main activities cited as problematic by the respondents, followed by jet skiing/wet biking and water skiing. A small percentage of respondents suggested that zoning[4] the estuary for different uses was necessary and that a speed limit should be implemented for motorised craft (Cowley *et al.* 2009).

c) Public access at the Sundays River Estuary

Public access at the Sundays River Estuary is subject to a number of restrictions – some are natural barriers and others are man-made. The former includes steep, inaccessible banks. The latter includes private residential properties on land adjacent to the banks of the estuary, private ownership of land adjacent to the estuary's banks and the paucity of roads to the estuary's banks (Cowley *et al.* 2009; IECM, 2010).

Public access to the west bank of the estuary is limited by privately-owned farms (no public access save for farm staff), the N2 national highway (this permits access to pedestrians only), and the Mackay Rail Bridge, that is currently closed, permits bicycle and pedestrian access only (Cowley *et al.* 2009).

Access to the east bank of the estuary, from the mouth of the estuary up to the Pearson Park caravan park, is restricted due to the presence of privately-owned land. Estuary users can only access this bank if they are prepared to pay an access fee. Access to this bank is further hampered by the existence of a steep, rocky cliff situated at the northern end of the east bank. This makes shore access difficult and dangerous during low tide and impossible during high tide (Cowley *et al.* 2009). Vehicle access does exist on the east bank, with the exception of the area beyond the parking lot, to the south of the ablutions.

The north bank of the estuary, between the N2 Bridge and the Pearson Park caravan park, is largely residential. The estuary banks and riparian zone on this bank are frequented

[4]The estuary is currently zoned for skiing, but there is little, if any, compliance to these zoning regulations (Cowley *et al.* 2009).

mostly by residents, but the area is accessible to the general public via a wide open grass space between the residential dwellings and the estuary. Vehicle access to the estuary is restricted to two distinct points: one near the petrol station in the north-east corner of the estuary, and the other at the slipway located adjacent to the N2. Except for these two access points, there are virtually no other vehicle access points along this stretch of the estuary (Cowley *et al.* 2009).

The estuary bank to the north of the N2 highway is accessible by vehicle, but is restricted to the road that leads up to the Mackay Rail Bridge. The east bank to the north of the N2 Bridge is mainly occupied by residential properties. The estuary banks along this stretch are also steep and inaccessible (Cowley *et al.* 2009). The area to the north of the Mackay Rail Bridge is hardly accessible by road.

In the vicinity of Colchester and Cannonville private jetties have proliferated in an ad-hoc manner along the northern bank of the Sundays River Estuary. Most of these jetties have been constructed on Municipal Public Open Space without authorisation. Although most of the jetties are situated on Municipal land, access is controlled by those who erected them.

2.3.1.2 The Kromme River Estuary

a) Navigability of the Kromme River Estuary

Navigation is considered to be hazardous on the Kromme River Estuary (Thorpe, 2010). The level of navigability of the Kromme River Estuary is inextricably linked to the extent of *in-situ* sedimentation taking place. Increased levels of sedimentation lead to the constriction of the river channel, both in terms of width and depth. The constriction of the river channel makes navigation difficult, sometimes impossible, especially at low tide.

The Kromme River Estuary is considered a “natural sediment trap”. Sediment enters from the tidal head and inlet. In an unmodified system, the net long term rate of sediment buildup is relatively slow as periodic freshwater floods scour the channels and remove accumulated sediment out to sea (Reddering & Esterhuysen, 1983). This sediment balance in the Kromme River, however, has been disrupted through artificial modifications to the estuarine system. Early studies on sedimentation in the Kromme River Estuary expressed concerns at increasing levels of sediment due to reduced freshwater inflows (Reddering & Esterhuysen, 1983; Bickerton & Pierce, 1988). The construction of the Churchill Dam in 1943, and the later completion of the Mpofu Dam (previously named the CW Malan Dam) in 1982, has over time, reduced the freshwater discharge passing through the Kromme River Estuary (Reddering & Esterhuysen, 1983; Baird & Pereyra-Lago, 1992). These dams have a combined storage capacity of approximately 133 percent of MAR of the Kromme River. They supply water to both Nelson Mandela Bay and agricultural users. The effect of these dams has been to reduce the natural scouring power of periodic freshwater floods (Heymans, 1992). Shoaling (the creation of an underwater sandbank) associated with this level of sedimentation will lead to reduced navigability of the estuary (Reddering & Esterhuysen, 1983).

Another source of sediment for the Kromme River Estuary is the Sand River[5]. It begins approximately 2km upstream from the mouth and deposits a small amount of sand into the estuary on the southern bank. This deposit is spread upstream and downstream in the estuary by the tidal currents. This increased sedimentation has been exacerbated by the creation of a large 'sand spit' which provides protection to the marina from strong south easterly gales (Bickerton & Pierce, 1988).

Channel constriction due to sedimentation build-up is mainly a problem in the lower part of the estuary – an area of approximately 70.63ha or 706 300m^2, stretching from the mouth to the confluence of the Kromme River and the Geelhoutboom River (Forbes, 1998).

[5] There is some evidence suggesting that the Sand River initially opened directly into St Francis Bay. Later, it opened into the marshlands on the south bank of the river mouth. More recently, however, these original outlets have been cut off by dune stabilisation and the development of the Marina Glades (Bickerton & Pierce, 1988).

The MAR for the Kromme River has been estimated at between 105.5 million m^3 (Reddering & Esterhuysen, 1983) and 116.8 million m^3 (Bickerton & Pierce, 1988). Upstream water abstraction (damming) and resultant sedimentation buildup has reduced the actual annual freshwater inflow into the estuary to approximately 0.011 million m^3; this system is, therefore, almost totally denied freshwater input (Baird *et al.* 1992).

b) Boat congestion on the Kromme River Estuary

Current recreational activities

This study found the main recreational activities for the Kromme River Estuary to be: recreational shore fishing (38 percent), recreational boat fishing (18 percent), speed boating (13 percent), water skiing (6 percent), paddling (6 percent), jet skiing (1 percent), swimming (16 percent) and bird watching (1 percent). By way of comparison, the main estuary activities observed by Forbes (1998) were recreational fishing (34 percent), speed boating (23 percent), water skiing (23 percent), paddling (2 percent), and swimming (30 percent). Both of these assessments indicate that fishing and non-fishing motorised boating activities make up a large part of activities that occur in the Kromme River Estuary.

Recreational boating activities by estuary zone

The Forbes (1998) study divided the recreational boating area of the Kromme River Estuary into four zones as illustrated in Figure 2.4. These zones, starting from the mouth of the estuary, stretch for approximately 8km. Various recreational activities take place on this stretch of water, but some are focused within specific zones. Forbes's (1998) demarcation of these activities into the specified categories is not necessarily logical, but nevertheless represents the only available zoning information for the estuary.

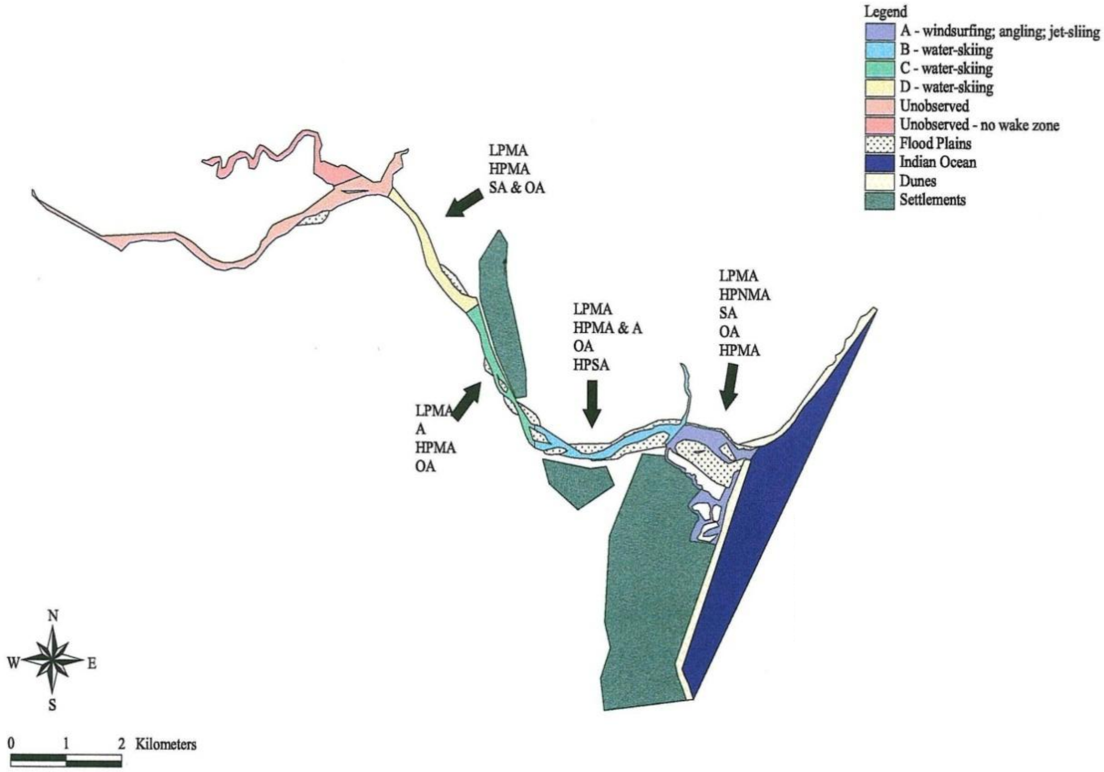

Figure 2.4: Recreational zones of the Kromme River Estuary

Source: Forbes (1998)

The different forms of boat usage identified by Forbes (1998) were:

- High powered motorised activities (HPMA) – high engine output motorised activities, for example, water skiing and jet skiing;
- High powered non-motorised activities (HPNMA) – windsurfing;
- Low powered motorised activities (LPMA) – motorised activities with low speed, for example, leisure cruising;
- Oaring activities (OA) – rowing, canoeing or paddle skiing;

- Sailing activities (SA) – non-motorised activities which use wind power, for example, sailing; and
- Recreational boat angling (A).

In zone A, the following activities were observed to take place, namely low powered motorised activities, high powered non-motorised activities, sailing activities, oaring activities, and high powered motorised activities. In zone B, low powered motorised activities, high powered motorised activities, recreational boat angling, oaring activities, and high powered non-motorised activities took place. In zone C, observed activities included low powered motorised activities, recreational boat angling, high powered motorised activities, and oaring activities. Lastly, low powered motorised activities, high powered motorised activities, sailing activities and oaring activities occurred in zone D. Motorised boating activity occurs in all the estuary zones, but is most intense in zone D.

The most popular type of motorised water craft is a cabin boat, followed by a speed boat (Forbes, 1998). The lengths of most of the boats range from 3 to 5m, and are powered by 25 – 50horse power (hp) engines (Forbes, 1998).

<u>The extent of boating on the Kromme River Estuary</u>

The Kromme River Estuary is a popular tourist destination and intensively used for recreational purposes. Recreational use is concentrated over relatively short peak holiday periods, i.e. less than 30 days. Approximately 65 percent of people using the estuary own some form of water craft and the most popular recreational activities include leisure cruising and water skiing (Forbes, 1998). During the 2009/2010 year the number of motorised water craft registered for use on the Kromme River Estuary was 1 100 boats. The boats that obtain temporary registration for water craft usage on the estuary during peak periods must be added to this number.

In 1987 it was estimated that 8 950 people visited the Kromme River Estuary (Sowman, 1987). A decade later annual visitation levels had almost doubled (Forbes, 1998). In

1998, it was estimated that 1 400 residents and 13 500 visitors made use of the estuary for recreational purposes (Forbes, 1998). Yet another decade later the resident figure had almost doubled. In 2010 approximately 4 200 households resided in the St Francis Bay area (Red Cap Investments (RCI), 2010). The number of recreational visitors to the estuary has risen exponentially since 1998. Approximately 35 000 visitors were recorded in the peak holiday month of December 2010 alone (RCI, 2010). Given these large increases in the number of residents and visitors to the estuary, as well as the problem of increased sedimentation and reduced navigability of the estuary, the occurrence of conflict between boat users of the estuary was inevitable.

Table 2.4 shows the area of each of the four zones, the average number of motorised craft using each zone according to the Forbes (1998) study, the 2010 estimate of the current number of motorised craft using each zone, and two estimates (a low and high estimate) of the recommended number of motorised craft per zone according to the Sowman and Fuggle (1987) formula (see Table 2.3). The Forbes (1998) study estimates for the number of motorised craft on the estuary were adjusted upwards by multiplying the given number by a percentage representative of the increase in motorised water-based activity since 1998 (RCI, 2010). These estimates are conservative because the growth in visitor population since 1998 was not taken into account in its calculation.

Table 2.4: Motorised activity per zone for the Kromme River Estuary*

Zone	Estimated Area (ha)[1]	Observed Motorised Activity[2]: Forbes (1998) Estimate	Motorised Activity[3]: This Study	Recommended Space Standard (RSS) (Sowman & Fuggle, 1987)[4] – Low Estimate	Recommended Space Standard (RSS) (Sowman & Fuggle, 1987)[5] – High Estimate	Excess Boat Use/ha
A	10.64	2.62	6.03	1.01	2.66	3.37
B	21.33	1.64	3.77	2.03	17.70	-
C	18.66	1.71	3.93	1.77	15.49	-
D	20.00	7.43	17.09	1.90	16.60	0.49

* *Motorised activity and Recommended Space Standards per zone measured in terms of number of motorised water craft.*

Notes:

(1) Estimated using an average estuary width of 80m (Forbes, 1998). This width is a high estimate because the levels of sedimentation have increased substantially since 1998.

(2) Motorised water craft include power boats, rubber ducks, sea boats and jet skis.

(3) This study estimate is derived by multiplying the percentage increase in the residential population (200 percent) by the percentage of recreationists that according to Forbes (1998) own motorised water craft, i.e. 65 percent. The Forbes (1998) estimate was adjusted upward by this percentage.

(4) The RSS for each zone was calculated taking into account the present zoning of activities and the activity with the most conservative RSS. In this case, zones B to D are zoned for water skiing only (RSS of 0.095/ha), while zone A is zoned for jet skiing only (RSS of 0.095/ha).

(5) The RSS for each zone was calculated taking into account the present zoning of activities and the activity with the highest RSS. In this case, zones B to D are zoned for leisure cruising only (RSS of 0.83/ha), while zone A is zoned for boat angling only (RSS of 0.25/ha).

As can be seen from Table 2.4, the estimated activity by Forbes (1998) exceeds the low estimate RSS in two zones, namely A and D. When compared to the high estimate RSS, the activity estimated by Forbes (1998) is very low in all four zones. The revised estimates of motorised activity in the current study exceed the low estimate RSS in all four zones. However, when compared to the high estimate RSS, motorised activity in only two of the zones is higher, namely A and D. It is important to note that the RSS applied above assumes only one motorised recreational activity is taking place per zone at one time. In reality, there is a mix of activities taking place at any one time in each zone. Moreover, the different activities taking place in each zone are very often conflicting ones. It is therefore necessary to determine a physical and social carrying capacity that allows different forms of motorised activity to take place in each zone at the same time. The concept of physical carrying capacity refers to activity limits that are based on the sizes of each zone, whereas the concept of social carrying capacity refers to activity limits that are based on users' perceptions of the size of each zone and potential conflicting activities therein. These issues of carrying capacity are discussed further below.

Carrying capacity[6] of the Kromme River Estuary

i) Physical carrying capacity

An initial assessment of the recreational carrying capacity of the Kromme River Estuary found that the level of recreational use of the estuary by speed boats and sailing craft did not exceed the physical capacity limit (Environmental Evaluation Unit (EEU), 1986). A later study reassessed the physical carrying capacity of the estuary, and also found that the level of water-based recreational activity did not exceed the physical carrying capacity (Forbes, 1998). Total physical carrying capacity for the studied zones in the estuary in 1998 was calculated to be 295 water craft (Forbes, 1998). This figure included both motorised and non-motorised water craft. Forbes (1998) estimated the limit for water-based recreational activity to be approximately 115 craft at any given time. In order to calculate a physical carrying capacity that relates to motorised recreational activities only, a few adjustments needed to be made to the information presented in Table 2.4 above. Table 2.5 shows the physical carrying capacity per zone for motorised activities only.

[6] It should be noted that it is no longer 'fashionable' to try and define carrying capacity – hence the modern trend for analysis of trade-offs and search for optima.

Table 2.5: Physical carrying capacity for motorised activities – Kromme River Estuary

Zone	Estimated Size (ha)	RSS (Forbes, 1998) per ha[1]	RSS (Forbes, 1998) per Zone	Current Motorised Usage per Zone
A	10.64	0.055	0.59	6.03
B	21.33	0.06	1.28	3.77
C	18.66	0.11	2.10	3.93
D	20.00	0.316	6.32	17.09
Total	70.63	0.148[2]	10.29	30.82

Notes:

(1) *These figures were the current mean estimates of physical carrying capacity for the different motorised activities occurring within the designated zones (Forbes, 1998). The motorised activities were leisure cruising, water skiing, jet skiing and boat fishing.*
(2) *This value represents a weighted total based on estimated zone size*.

The total physical carrying capacity for all zones is calculated by totalling the recommended physical carrying capacity for each zone. This calculation indicates that there should be no more than a maximum of 10.29 motorised water craft on the estuary at any given point in time. The revised estimates of motorised craft usage for the current study (see Table 2.5) indicate that the total physical carrying capacity was exceeded by approximately 20 motorised water craft in 2010. All zones indicate an exceeded physical carrying capacity, but the excess is worst in zones A and D.

ii) Social carrying capacity

There are a wide range of recreational activities that can be accommodated on the Kromme River Estuary but some of these activities interfere with the level of enjoyment of other users. A study conducted by Sowman and Fuggle (1987) considered user perceptions of various recreational activities conducted on the estuary in order to determine whether these activities could be supported without creating negative externalities for other users. The study found that approximately 73 percent of users felt that the social carrying capacity of the estuary was already exceeded, particularly over peak holiday periods (Forbes, 1998). This finding implies that the majority of the recreational users of the estuary believed that it is overcrowded and that any increase in recreational activities on the water would worsen the situation.

The level of boat congestion on the Kromme River Estuary

The Forbes (1998) study found that respondents considered motorised activities problematic in terms of the noise generated, and the danger associated with the high speed of the crafts. Also criticised, were the attitudes of water craft users'. It was felt that these users neglect boating regulations and were reckless. Respondents were also critical of the high number of motorised activities (Forbes, 1998). The majority of respondents (68 percent) felt that boat congestion constituted a serious threat to the quality of the recreational services provided by the estuary (Forbes, 1998).

c) The potential use of jet skis and wet bikes on the Kromme River Estuary

All jet skis and wet bikes that operate in the area controlled by the Kouga Municipality (St Francis Bay Marina, St Francis Bay Beach, Cape St Francis) or by the Western District Council (WDC) (Kromme River) must be registered for that recreational purpose. The registration fee is the same as that paid by owners of standard motorised water craft, namely R169 per annum (pertaining to 2009/2010). Access to the Kromme River Estuary for the purposes of jet skiing or wet biking is, however, limited. The use of jet skis and wet bikes on the Kromme River Estuary is currently banned (St Francis Bay Ratepayers Association (SFBRA), 2011), partly because these motorised vehicles are noisy, and partly because this group (jet ski/wet bike owners) have been blamed for a high proportion of irresponsible and reckless driving events in the estuary and for disturbing those swimming, fishing or water skiing. They may, however, traverse through zone A (see Forbes (1998) study) for the sole purpose of accessing the open ocean through the estuary mouth.

The current status of jet ski and wet bike access

The recreational population are divided on whether jet skis/wet bikes should have complete access to the Kromme River Estuary. The Forbes (1998) study found that recreationists on the Kromme River Estuary were not in favour of jet ski/wet bike activities. Due to the negative social impacts of high noise levels, high travelling speeds, reckless behaviour and large scale disregard for regulations, the majority of the respondents suggested that they remain in excess of 80m away from other recreational users at all times (Forbes, 1998). Statistics from the California Department of Boating and Waterways in the United States of America revealed that about half of the recreational boating accidents were caused by jet skis, whilst only accounting for 11 percent of all motorised craft registrations (Forbes, 1998). This negative sentiment towards jet skiers and wet bikers was also evident in this study, with approximately 61 percent of respondents believing that the use of jet skis/wet bikes were a threat to the quality of the recreational services provided by the estuary.

Efforts by concerned jet skiers/wet bikers to have these craft reinstated on the Kromme River Estuary have taken two forms. First, a jet ski club was formed, which is affiliated to the Port St Francis Ski Boat and Yacht Club. Second, a proposal was tabled at a Kromme River Joint River Forum meeting to reinstate the use of jet skis and wet bikes on the Kromme River Estuary (see Appendix A). They proposed that all jet ski/wet bike owners who wish to operate on the estuary must (1) be fully paid up members of the jet ski club, (2) be issued with a club identification number, and (3) be expected to adhere to the rules of conduct as set out by the jet ski club. In addition, they proposed that all jet skis and wet bikes be subject to an annual safety inspection by an accredited safety officer, and all jet-propelled craft owners must hold a valid skipper's license. Along with the rules of conduct, a disciplinary code was also developed to punish those who don't abide by the rules of conduct. At the time of writing, this proposal had yet to be accepted.

2.3.2 FOCUS GROUP ASSESSMENTS

Focus group discussions were held with Prof P Cowley, from Rhodes University, Prof TH Wooldridge, from Nelson Mandela Metropolitan University (NMMU), Prof J Adams, also from NMMU, Mr C Tunstead, the chairman of the Sundays River Ratepayers Association, and Mr J Moore, a member of the Sundays River Joint River Forum. The results of the focus groups were put before the various committees and subsequently revealed that the following recreational use issues merited immediate attention as far as management of the Sundays River Estuary was concerned: the physical size of the fish stocks, the level of boat congestion and the level of public access. Focus group discussions were held with Mr D Nel, the chairman of the St Francis Bay Riparian Association, Mr H Thorpe, the chairman of the Kromme River Trust, and Mr N Marais, the chairman of the Kromme River Joint River Forum as well as the chairman of the Kromme River Angling Club. These focus group results were presented to members of the various committees and subsequently revealed that the following recreational use issues deserved immediate attention as far as management of the Kromme River Estuary was concerned: reduced navigability on the estuary due to sedimentation, the level of boat congestion and the use of jet skis/wet bikes on the estuary.

2.4 CONCLUSION

There are a great number of recreational challenges facing South African estuaries (Chapter One), some of which are also of concern at the Sundays River and Kromme River Estuaries. In the case of the Sundays River Estuary, over-fishing, coupled with high retention rates of undersized fish has led to concerns in respect of the sustainability of fish stocks in the long-run (Cowley *et al.* 2009). The high levels of demand for use of the estuary space by motorised boat users has led to congestion costs being imposed on other estuary users, for example, yachtsmen, sailboarders and canoeists (Cowley *et al.* 2009). Public access is also limited, with a demand for investment in projects aimed at improving the recreational appeal of the estuary banks (Cowley *et al.* 2009).

In the case of the Kromme River Estuary, navigability was found to be decreasing due to, inter alia, increased sedimentation. This sedimentation balance has been disrupted through the abstraction of freshwater inflows (Scharler & Baird, 2003). This estuary also suffers from high levels of demand for use of the estuary space by motorised boat users, and similarly imposes congestion costs on other estuary users (Forbes, 1998). The use of jet skis and wet bikes on the estuary also has the potential to impose external costs on users of other types of water craft (Forbes, 1998).

These identified recreational challenges facing the Sundays River and Kromme River Estuaries need to be managed in order to alleviate the discord between the estuaries' conservation and their use. How can Economics be used to manage these challenges? Chapter Three explores the ways in which these challenges can be managed through the use of economic analysis and policy interventions.

CHAPTER THREE: SELECTING THE ECONOMIC CONTROL VARIABLE THROUGH ECONOMIC MODELLING OF WELFARE OUTCOMES

3.1 INTRODUCTION

Forbes (1998), Cowley *et al*. (2009) and this study's focus group discussions suggest that the Sundays River Estuary exhibits excess recreational demand for many estuarine services, for example, fish, boat use and public access (see Chapter Two). Similarly, at the Kromme River Estuary there is excess recreational demand for navigability, boat use and jet ski/wet bike use (see Chapter Two). Chapter Three partly addresses sub-objective one, namely identifying and defining feasible choices for estuary management. It provides the background to the policy control variable (tariff or license charge) added to the feasible choice option sets. This control variable was the primary instrument selected to manage the identified recreational demand challenges. The key management challenges covered are: exploitation of fish stocks in the Sundays River Estuary, motorised boat congestion on both the Sundays River and Kromme River Estuaries, public access at the Sundays River Estuary, navigability of the Kromme River Estuary, and the use of jet skis/wet bikes at the Kromme River Estuary.

3.2 ESTUARIES – A PROPERTY RIGHTS PERSPECTIVE

The management of most estuaries in South Africa is problematic because of their public good nature (i.e. non-rivalry and non-excludability). Defining property rights can alleviate this problem by allocating different bodies with rights, provided they fulfil various management obligations. Property rights are defined as a flow of secure benefits to the holder that will occur as long as others believe that these rights should be honoured. In other words, these rights will be supported as long as the controlling body continues to honour the right and provide protection against other claims (Turner, Pearce

& Bateman, 1993). The existence of these rights provides specific users with certain privileges regarding the use of the resource in question.

There are four types of resource management regimes that can explain the importance of rights, duties and privileges within the estuarine environment. These include the application of state property rights, private property rights, and common property rights, as well as the potential for open access privileges (Turner *et al.* 1993). In the case of state property, individuals have a duty to observe the rules and regulations that govern the use of the resource. These rules are determined by a controlling body, and can be updated by the body as required. State ownership is only effective if the state is able to institute acceptable rules of use, is able to monitor use, and is able to enforce the rules and regulations.

Private property rights are established by conferring land titles on individuals by way of legal documentation. In addition, land titles are enforced by the relevant authorities. The existence of private property rights provides individuals with a right to embark on socially acceptable uses, and a duty to desist from unacceptable uses. Individual rights also imply a duty on behalf of others to respect the rights bestowed by law.

Common property resources can be defined as "a class of resources for which exclusion is difficult and joint use involves substractability" (Berkes & Farrer, 1989). A common property resource can also be defined as one held by an identifiable community of interdependent users (community members). These users have a right to exclude others (non-members) from using the resource and have rights and duties with respect to the use of the resource (Fenny, Berkes, McCay & Acheson, 1998). Non-members have a duty to adhere to the exclusion.

In the case of open access resources, there are no defined users or owners, i.e. there are no property rights. As such, individuals have a privilege, but no right to use the resource, and benefit streams from the common pool resource are available to anyone (Bromley, 1991). Thus, no user has the right to preclude use by any other party – a situation that leads to the “tragedy of the commons” (Hardin, 1968).

Literature attempts to avert the “tragedy of the commons” by presenting three alternative “schools of thought” (Johnson, 1972). The first school advocates the use of private property rights to alleviate the problems of over-exploitation and common property resource degradation (Demsetz, 1967; Smith, 1981). According to the second school of thought, the over-exploitation of common property resources can only be mitigated by the implementation of a state property regime, i.e. the allocation of full authority to a government department over the resource to an external entity (Hardin, 1968). The third school of thought believes firmly in the idea of voluntary compliance. The belief of this school is that the “tragedy of the commons” can be avoided through the collective management by users of these common property resources (Wade, 1987; Chopra, Kadekodi & Murthy, 1989).

The open access nature of estuaries means that there are no formal property rights over the resource in an *in situ* condition. Thus, a physical unit of the resource (like fish stocks) cannot be associated with a particular owner unlike under a private property regime where an *in situ* resource can be said to belong to a particular real or legal person.

In South Africa, specifically, common property resources, for example estuaries, are largely controlled through state property regimes, where various government authorities are tasked with mitigating the problem of over-exploitation. These control measures can take the following forms: marine protected areas (MPAs), closed areas and national parks. These measures are governed largely by the Marine Living Resources Act (Act No. 18 of 1998). For example, in the case of MPAs, no fishing, construction work, pollution, or any form of disturbance is allowed unless written permission has been granted by the Minister. In closed areas, fishing is restricted or prohibited entirely. National parks fall under MPAs and could include marine areas, as well as estuaries. Only a handful of South African estuaries are MPAs or closed areas or national parks. All other estuaries along the South African coastline are administered by municipalities. The laws and regulations relating to estuaries are often breached by the municipalities themselves and are often poorly monitored or enforced (Cowley *et al.* 2009). This lack of administrative effort results in a situation whereby the advantage of the state ownership arrangement is lost, and the problem of open access remains unresolved.

Two examples of estuaries where the problem of open access has not been adequately resolved are the Kromme River and Sundays River Estuaries. They are not MPAs or closed areas, and do not form part of a national park. They are governed by a set of rules and regulations specifically aimed at controlling excess recreational demand. In the Sundays River Estuary, for example, recreational fishing is subject to the following set of nationally implemented regulations: (1) the fisher must acquire a recreational fishing permit, (2) the fisher may not catch, disturb, land, keep or control any prohibited fish species, (3) the fisher must adhere to the bag limit in respect of each species, (4) the fisher must adhere to the size limit in respect of each species, and (5) the fisher may never use a club, stick spear or spear gun for the purpose of landing a fish.

With respect to boating, there are also regulations governing the use of motorised craft on the Sundays River and Kromme River Estuaries. All motorised craft owners must be in possession of a valid boat license, and there are some restrictions that limit the movement of boats through the estuary, for example, jet skis.

3.3 THE EXPLOITATION OF FISH STOCKS IN THE SUNDAYS RIVER ESTUARY

Like other goods, recreational fisheries provide utility to individuals and resource owners. Unlike many other goods, however, recreational fisheries constitute common pool resources whereby one angler’s catch of fish reduces the harvest potential for other anglers (Kahn, 1998). Recreational fisheries share the open access externality problem with commercial fisheries.

3.3.1 CURRENT LEGISLATION GOVERNING THE SUNDAYS RIVER ESTUARY FISHERY

The Sundays River Estuary fishery lies within two local authorities, namely, the Nelson Mandela Bay Municipality (NMBM) and the Sundays River Municipality (SRM) (Afri-Coast Engineers, 2004). The Sundays River Estuary fishery, as with all other saltwater fisheries in South Africa, is managed through the issuing of fishing permits and the enforcement of bag and size limit regulations. The current bag and size limits for the three main species of interest are shown in Table 3.1 below.

Table 3.1: Bag and size limits for the Sundays River Estuary fishery

Recreational Fish	**Bag Limit (Number of Fish per Day)**	**Size Limit (Minimum Size in cm)**
Dusky Kob	1	60
White Steenbras	1	70
Spotted Grunter	4	40

Source: Cowley, Childs & Bennett (2009)

Of all the fish kept, 47 percent were below the legal size limit (Cowley *et al*. 2009). Of the dusky kob kept, 63 percent were below the size limit, of the white steenbras kept, 100 percent were below the size limit, and of the spotted grunter kept, 30 percent were below the size limit.

In 2009, adherence to daily bag limits per fisher outing was 2.6 percent for dusky kob, and 0.1 percent for spotted grunter. No white steenbras larger than the legal size were caught during the period monitored by Cowley *et al.* (2009).

Part of the reason for the disregard for bag and size limits is ignorance – 87 percent of respondents in the Cowley *et al.* (2009) survey did not know the regulations. Another equally important reason is lack of law enforcement effort – only 71 percent of respondents said they had acquired a fishing permit for the survey period in question, and almost 60 percent of all respondents reported that they had never before had their catches inspected. Law enforcement officers were only encountered once before by 11 percent of the respondents (Cowley *et al.* 2009). Law enforcement at the Sundays River Estuary is the responsibility of the NMBM because the estuary is located within the boundaries of the municipality. All the policing of the Sundays River Estuary is carried out by one conservation officer.

3.3.2 A THEORETICAL MODEL FOR THE RECREATIONAL FISHERY

When analysing a recreational fishery, it is important to conduct both a short run and long run analysis. The difference between the two time periods relates to the possible effects anglers may have on the fish stocks (Flaaten, 2010). In the short run, there is often a negligible effect on the fish stock, whereas in the long run there may be a sizeable effect.

3.3.2.1 Short-run analysis

The recreational fishery can be analysed using traditional microeconomic theory (demand and supply analysis). A conventional linear downward sloping demand curve is utilised as part of the analysis:

$$p = p(D,Q) = \alpha - \beta D + \gamma Q \text{, for } Q > Q^0 \qquad (3.1)$$

where:

D = the demand for fishing, measured by days of fishing (number of licenses issued daily);

p = the price of a fishing license;

Q = the quality of the fishing experience, defined as the quantity of fish caught per day of fishing (Q^0 represents the lowest level of quality that attracts anglers to this fishery);

α = the constant of the linear demand function;

β = the slope of the linear demand function representing the marginal WTP for an angler day; and

γ = the quality constant of the linear demand function representing the marginal WTP for quality (Flaaten, 2010).

Total revenue (TR) in this case can be defined as pD or $(\alpha - \beta D + \gamma Q)D$. The supply curve shows the total marginal cost of issuing and handling licenses. Total cost is defined as:

$$C(D) = cD \tag{3.2}$$

and marginal cost as

$$\frac{\partial C(D)}{\partial D} = c \tag{3.3}$$

Figure 3.1 shows the demand curves for two levels of quality, namely Q^1 and Q^2, with $Q^2 > Q^1$.

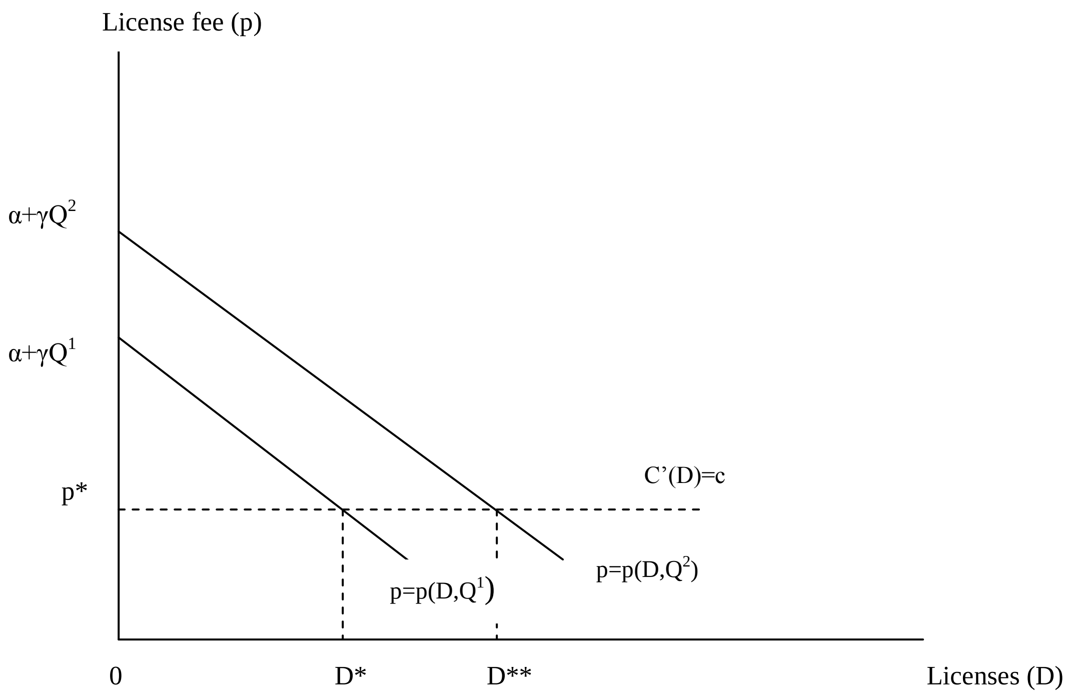

Figure 3.1: Demand and supply for daily angler licenses at two quality levels

Source: Adapted from Flaaten (2010)

In a competitive market for licenses, the equilibrium price is equal to marginal cost: p* = c (see Figure 3.1). In this case, c is a constant and so also equal to average cost.

In order to derive the equilibrium number of angler days, i.e. number of fishing licenses issued daily, MC must be set equal to marginal WTP:

$$c = \alpha - \beta D + \gamma Q \tag{3.4}$$

or

$$\beta D = \alpha + \gamma Q - c .$$

It follows that the equilibrium number of angler days purchased/sold (D**) is:

$$D^{**} = \frac{\alpha + \gamma Q - c}{\beta} \tag{3.5}$$

In order to maximise profit (and resource rent) it is necessary to maximise:

$$\begin{aligned} \pi &= TR - cD \\ \pi &= D(\alpha - \beta D + \gamma Q) - cD \\ \pi &= \alpha D - \beta D^2 + \gamma Q D - cD \end{aligned} \tag{3.6}$$

The necessary condition for maximising π with respect to *D* is:

$$\left(\frac{\partial \pi}{\partial D}\right) = \alpha - 2\beta D^M + \gamma Q - c = 0$$

or

$$c = \alpha + \gamma Q - 2\beta D^M \tag{3.7}$$

or

$$D^M = \frac{\alpha + \gamma Q - c}{2\beta} \tag{3.8}$$

Where

D^M is the profit (rent) maximising the number of angler days sold.

Figure 3.2 shows the profit maximising solution.

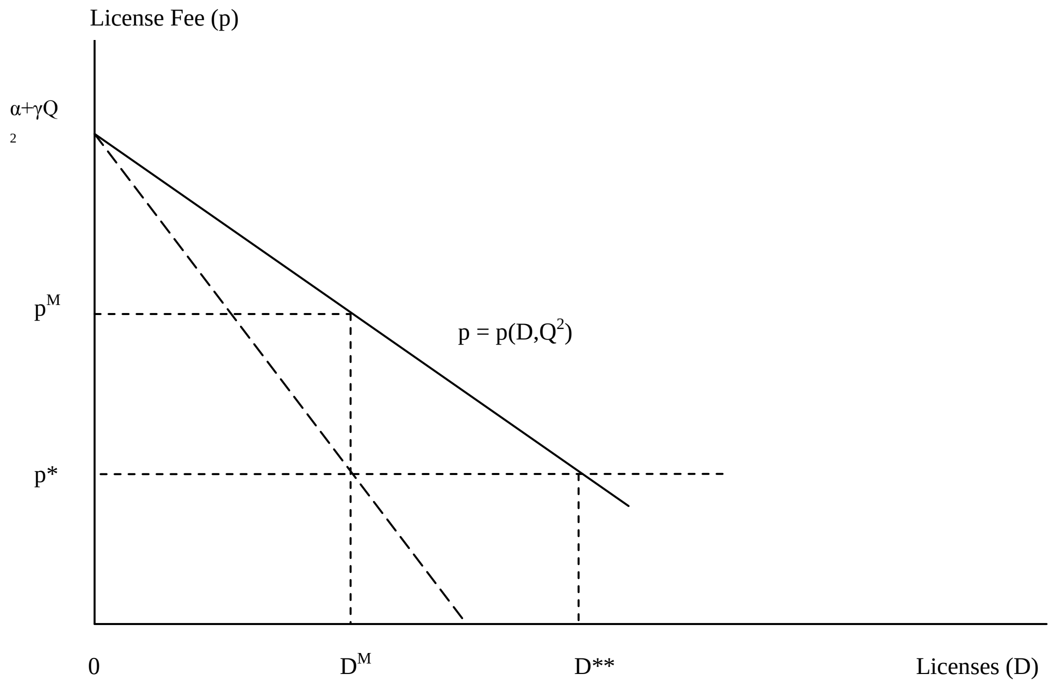

Figure 3.2: The monopolist's daily angler license model

Source: Adapted from Flaaten (2010)

The number of licenses purchased at a fixed price p*, namely D^{**}, is larger than would be issued in order to maximise profit (rent), namely D^M – double the number in this case (Flaaten, 2010).

3.3.2.2 Long-run analysis

The above analysis relates to the short-run and omits the effect anglers' fishing might have on the fish resource. Increased angling pressure can negatively affect fish stocks, reducing the quality of the fishing. To incorporate this effect into the recreational fishing model, changes in quality (Q) are included in the analysis.

Quality changes take place over the long-run. A new resource adjusted angler demand curve (the long-run demand curve) can be derived to incorporate quality changes (Flaaten, 2010). To this end, a logistic growth model and an angler harvest function must be employed.

The logistic growth model takes the following form:

$$f(X) = rX(1 - \frac{X}{K}) \tag{3.9}$$

where:

X = the fish stock level;

r = the maximum (intrinsic) growth rate; and

K = the carrying capacity for the fish stock (Field, 2001).

The angler harvest function is given by:

$$H = qDX \tag{3.10}$$

where:

H = the total catch per year; and

q = the catchability coefficient of the fishery (Field, 2001).

The long-run productivity of the fishery will vary with the number of angler days (number of licenses issued):

$$Q = Q(D) = \frac{H}{D} = qK\left(1 - \frac{qD}{r}\right) \tag{3.11}$$

Substituting for Q in Equation 3.11 into the inverse demand curve equation (3.1) yields:

$$p(D) = \alpha - \beta D + \gamma qK\left(1 - \frac{q}{r}D\right) = a - bD \tag{3.12}$$

where:

$$a = \alpha + \gamma q K ;$$

and

$$b = \beta + \frac{\frac{\gamma q K}{r}}{q}$$

Equation 3.12 is a resource adjusted demand curve. It is corrected for the negative effect fishing has on the resource stock and on catch per angler day. The resource adjusted demand curve and the short-run demand curves are illustrated in Figure 3.3 (Field, 2001; Flaaten, 2010).

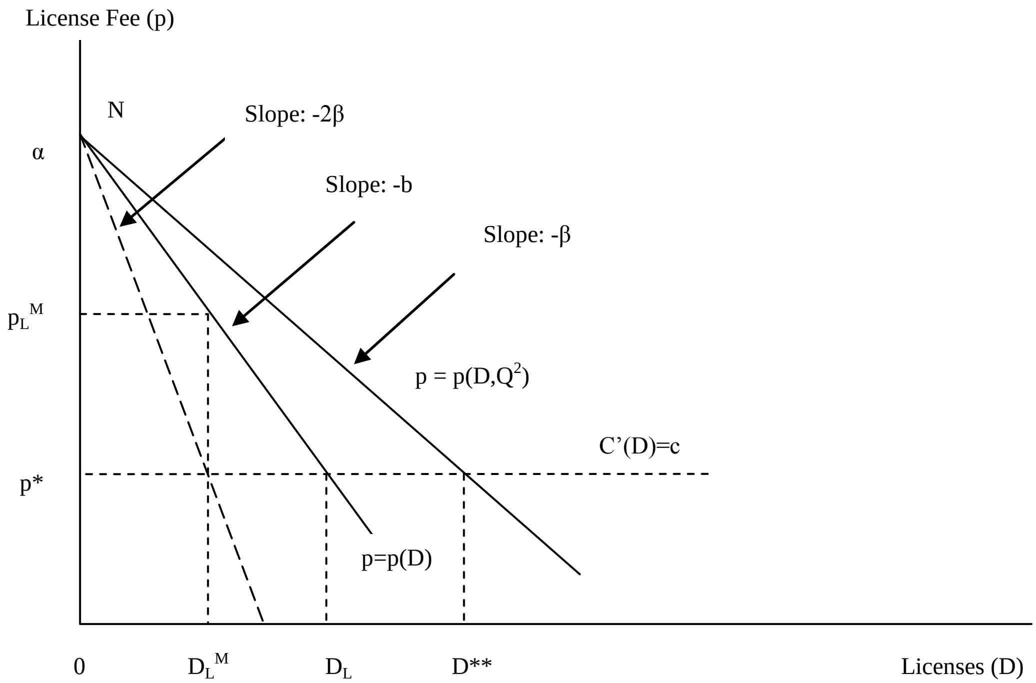

Figure 3.3: The short run demand curve and the resource adjusted demand curve

Source: Adapted from Field (2001) and Flaaten (2010)

In Figure 3.3, the short-run demand curve in a competitive environment has a slope equal to $-\beta$. The short-run demand curve adapted for sole ownership is the steepest of the three curves and has a slope equal to -2β. The resource adjusted demand curve is positioned between the two short-run curves and has a slope equal to $-b$. As anglers' WTP for fishing quality (γ) and the catchability coefficient (q) increase, the difference between the competitive demand curve slope and the resource adjusted demand curve slope increases. The resource adjusted demand curve is also affected by the biological characteristics of the fish stock (r and K in Equation 3.12). The higher r and K, i.e. the more productive the resource, the higher the WTP for an angling day (p(D)).

3.3.3 AN ALTERNATIVE APPROACH TO FISHERY MANAGEMENT

Most fishery management initiatives are aimed at controlling effort levels through the use of command-and-control restrictions, the imposition of catch limits or the implementation of transferable catch quotas (Field, 2001). These initiatives relate to the management of a commercial fishery and not a recreational one. Initiatives specifically aimed at managing a recreational fishery are limited, and thus an alternative management approach is necessary.

The recreational fishing model described above (see Figure 3.3) shows that as Q declines, so does the demand for angler days, but not in terms of the revenue yielded. Since recreational fishing appears to be driven by utility considerations and not revenue ones, a decrease in fishing quality will not necessarily drive down effort levels. The stock of fish in the Sundays River Estuary is already negatively affected by recreational over-fishing (Cowley *et al.* 2009) and thus the quality of the fishing reduced via the average catch per angler day. Falling stock levels and fishing quality, however, do not necessarily reduce the demand for fishing licenses by much as recreational fishing is not driven by revenue yield. For this reason, poor revenue yield does not curtail fishing effort by as much as it would in a commercial fishery. In order to decrease fishing effort and restore stock levels, in the absence of revenue maximising behaviour by recreational anglers, some mechanism must be implemented to force anglers to decrease their demand for licenses per day, i.e. decrease quantity demanded.

Under normal circumstances, D_L licenses would be demanded per day at a price per license of p*. In the case of an over-exploited fishery, such as the Sundays River fishery, the quantity of licenses demanded will have to drop to the profit maximising level of D_L^M issued per day in order to restore stock levels. To get quantity demanded to drop to this level thereby reducing effort, the price per license will have to increase to P_L^M to reach equilibrium and sustainability in the long-run.

The size of this price increase cannot be determined by using biological values as the population biology of this fishery is unknown, the stock-yield and effort-yield curves (both current and historical) are unknown, economic information pertaining to fishing costs and potential changes in fishing technology is not available, and biological variability in ecological variables (for example, ocean temperature and predators) are not easily accounted for.

3.4 CONGESTION AND RELATED TRADE-OFFS SPECIFIC TO THE SUNDAYS RIVER AND KROMME RIVER ESTUARIES

3.4.1 A THEORETICAL OVERVIEW OF CONGESTION EXTERNALITIES

People are often more an attraction than detraction in recreational activities, especially within the younger cohorts, because of the social element in recreation. For this reason, as a general rule, increased human recreational demand at any given estuary will not necessarily reduce the recreational appeal of that estuary. However, certain types of recreational activity are prone to negative crowding effects. One of these is motorised boat use.

In order to analyse the negative crowding effects associated with motorised boat use, a demand analysis of recreational boating is useful. This demand will be affected by changes in population, income, transportation services, as well as the existence of substitute or complementary sites in the surrounding area (see Figure 3.4).

When the costs of boat entry are non-zero because there are externally generated congestion costs, the socially optimal levels of boat entry onto the water at a specific point in time will differ from market regulated entry – it will be less (see Figure 3.4). The model shown in Figure 3.4 distinguishes two demands – a private demand (D_p) showing WTP for boat entry onto the estuary, where no externally generated congestion costs are included, and a social demand (D_s) showing the net social WTP after deduction of the externally generated congestion costs.

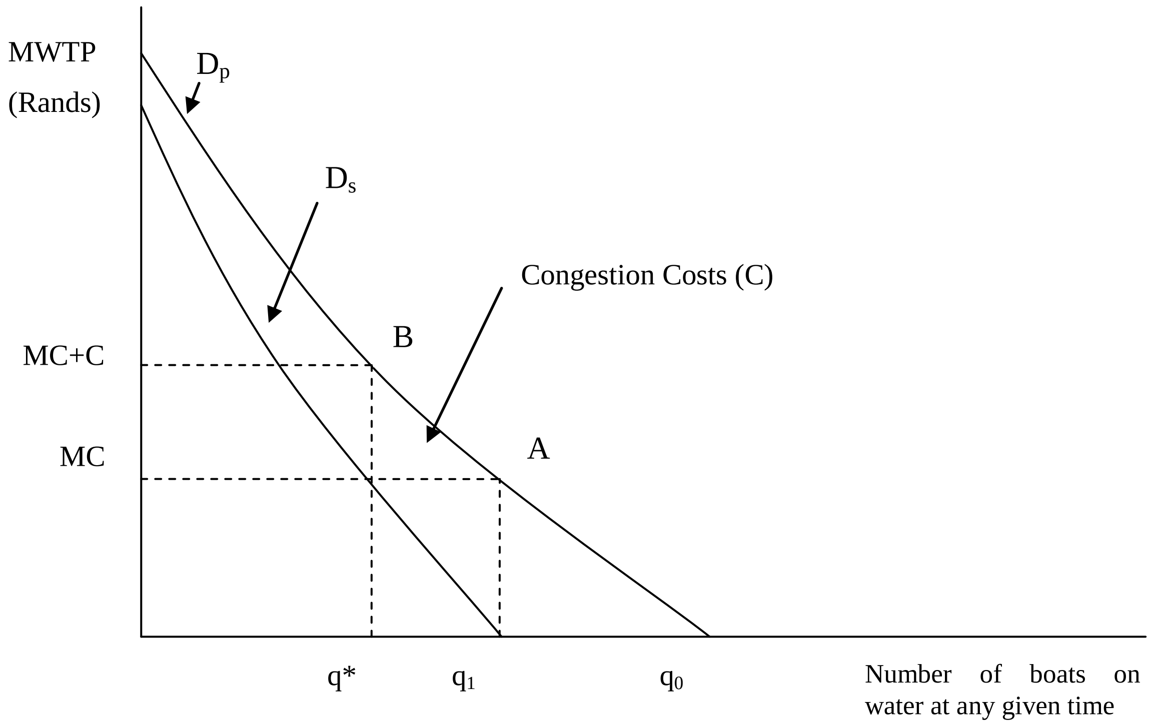

Figure 3.4: The socially efficient number of boats

Source: Field (2001)

Letting the entry fee for boating be MC, the demand for boat access is q_1, resulting in more boats (q_1- q*) on the estuary than would be socially optimal (where MC = D_s). The socially efficient number of boats is q*. In order to discourage boat entry to the optimum level a supplementary levy on boats is required of C, the vertical difference between the two demand curves and also the marginal external congestion cost (Figure 3.4).

3.4.2 THE RULES GOVERNING BOAT USE ON THE SUNDAYS RIVER AND KROMME RIVER ESTUARIES

All powered craft used within the area controlled by a Municipality or Council must be registered, and the registration decal(s) displayed on the craft at all times. The Marine Notice No. 27 of 2008, released by the South African Maritime Safety Authority (SAMSA), requires that all skippers be in possession of a Certificate of Competence (CoC) and all vessels be in possession of a Local General Safety Certificate (LGSC) (SFBRA, 2011).

The Sundays River is controlled by the SRM. The area between the Pearson Park slipway and the public slipway adjacent to the Mackay Bridge (zones 3 and 4 in Figure 2.3) is zoned for jet skiing and water skiing. Apart from this zoning regulation, there are no other access restrictions limiting the movement of boats (Cowley *et al.* 2009), and hence, motorised boating activity is widely spread throughout the Sundays River Estuary.

The Kromme River Estuary waterways are controlled by two different authorities. The canals and a section of coastline from the low-water mark to 200m offshore are controlled by the St Francis Bay Municipality. The Kromme River itself falls under the jurisdiction of the WDC. There are no access restrictions limiting the movements of boats through the Kromme River Estuary.

3.4.3 MANAGEMENT ALTERNATIVES

3.4.3.1 Formal regulation

a) Non-price rationing procedures

Open access to recreational areas has led to exploitation, congestion externalities and, in some cases, the general degradation of scarce natural resources (Field, 2001). One method of controlling use is by limiting access to these recreational areas. This limitation can be on the basis of 'first-come-first-served' or other methods. Once the limit of recreational users for that area has been reached, the entry points or permits are closed and no other user can legally gain access.

b) Price rationing procedures

A price rationing procedure is one that uses a fee to limit access to a recreational area (Field, 2001). This fee must be sufficiently high to reduce visitation to q* in Figure 3.4. This rationing mechanism not only limits the use of a scarce natural resource, but it also yields a revenue flow that can be used to manage recreation in the area. The effect of a higher fee on total revenue is dependent on the price elasticity of demand. From a revenue raising perspective, the implementation of a single access fee is sub-optimal for all users and for all periods. The external congestion cost is typically only incurred in peak demand periods. The WTP for use during a peak period is higher, and, *a priori*, the price elasticity of demand is lower (see Figure 3.5).

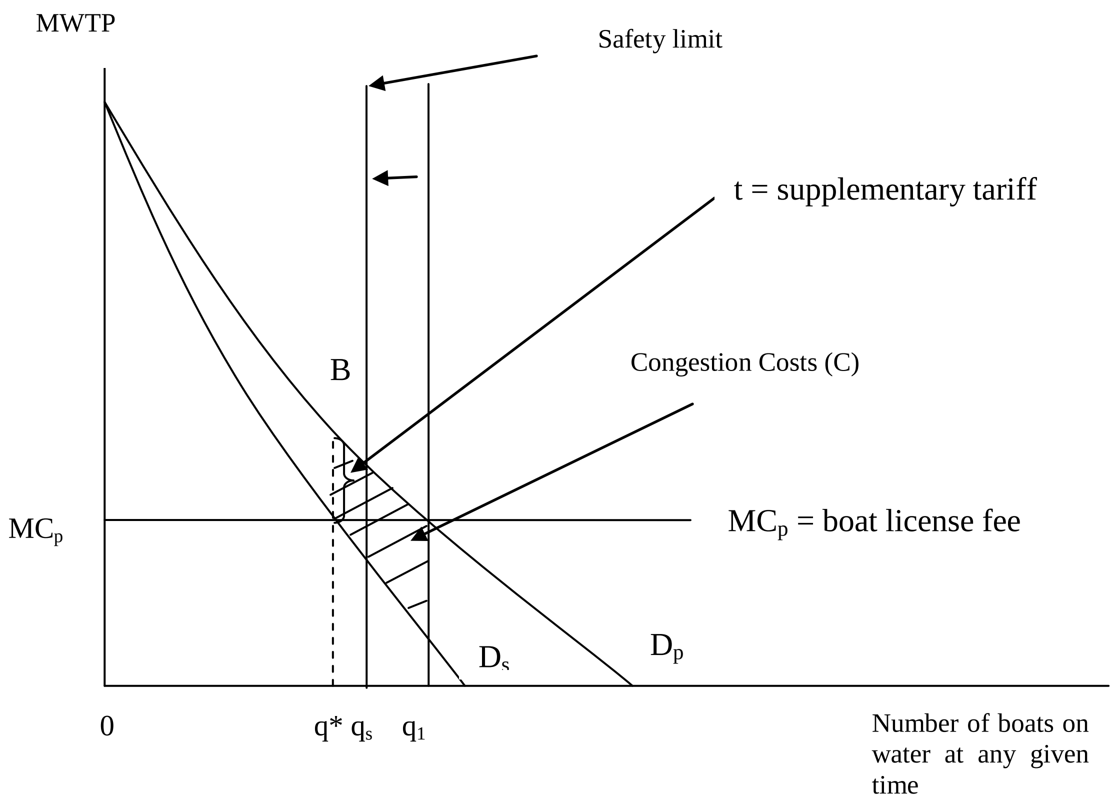

Figure 3.5: Peak period pricing for boat use

With no intervention, the boat use is q_1, where $MC_p = D_p$, but q_1 exceeds q_s, the safety limit, and also the boat users take no account of the external congestion cost (the vertical difference between the D_s and D_p curves). A welfare improvement in the situation is possible in this case by imposing a supplementary congestion cost tariff equal to the marginal congestion cost (MEC = t). As a result of this charge demand declines from D_p to D_s, the number of boats on the water is reduced to $q^* < q_s$, a welfare gain of the shaded area is achieved and additional revenue is raised of ($0q^*$ x t). The key empirical question is what the appropriate tariff supplement should be.

3.4.3.2 No Regulation

If formal regulation is not applied, it is then left to the market to resolve the issue of congestion. This approach assumes that the cost of congestion is internalised among the boat users and is not an externality in the traditional sense. The motivation for using the ‘no regulation’ option, is the belief that people use motorised craft according to their expected benefit gain, and this gain takes the presence of other boat users into account (rational expectations).

3.4.3.3 An assessment of the abovementioned management options

Rationing boat use through the implementation of a quota, or relying on self-regulation (automatic market resolution), are not generally considered as the most appropriate options for reducing boat congestion (Field, 2001; Flaaten, 2010). Quotas can be difficult to implement due to practical considerations, for example, prohibitively high costs and the need for competent physical enforcement (Field, 2001). Self-regulation will not work if one or a few of the boat users act selfishly and do not take other boat users into account. The use of peak load pricing has been effective, however, as (1) it provides users with economic incentives to use the resource during off-peak periods, and (2) it guarantees that the users that place the highest value on using this resource for boating purposes during peak periods are the individuals that are actually willing to pay for it (Van Kooten & Bulte, 2000).

Under these circumstances, the preferred management option is the use of prices to ration use. The correct price adjustment to make in this situation is to add a congestion cost (in the form of a supplementary tariff) to the existing boat license fee structure during peak use periods. This supplementary tariff is calculated as the vertical difference between the demand curves in Figure 3.5.

3.5 PUBLIC ACCESS AT THE SUNDAYS RIVER ESTUARY

3.5.1 INVESTMENT IN THE IMPROVED RECREATIONAL APPEAL OF ESTUARIES

The theory and resultant policy relating to the demand for further investment in the recreational appeal of estuaries is limited, but follows the general demand and supply framework (Field, 2001). Figure 3.6 models the demand for and supply of improved recreational quality of estuary banks.

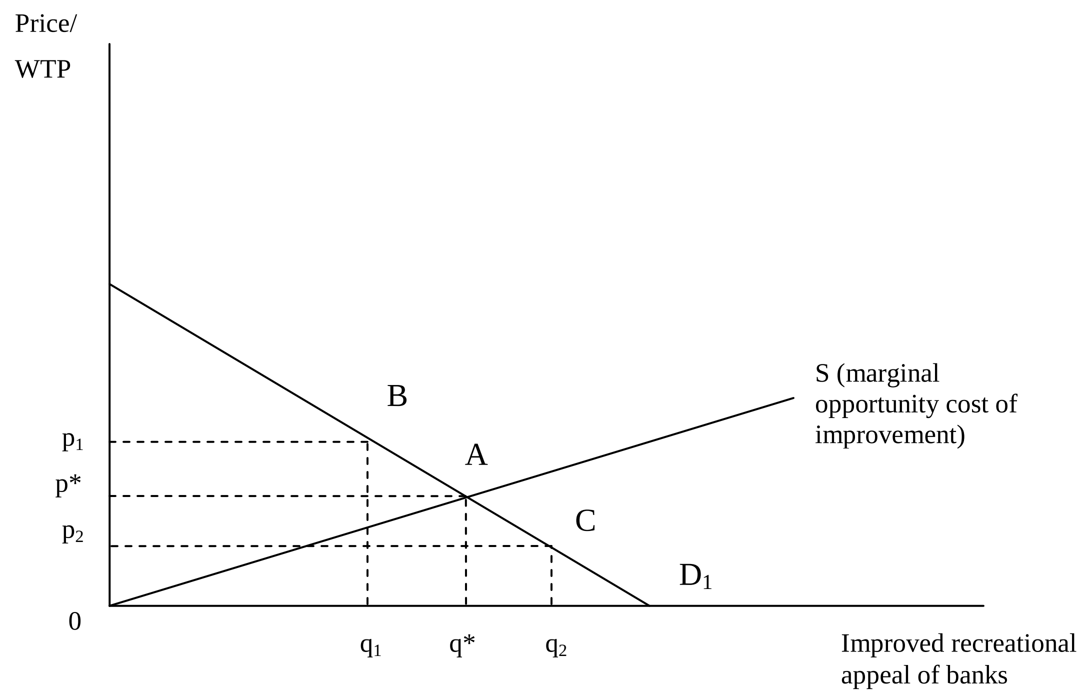

Figure 3.6: Proposed model for improved recreational appeal of estuary banks

The demand for improvement in the recreational appeal of estuary banks is given by demand curve D_1. Equilibrium is at point A in Figure 3.6, where private demand (D_1) equals the marginal opportunity cost of recreational improvements (S). Investments in improving the recreational appeal of the estuary banks are only efficient if the marginal benefit of this investment exceeds its marginal cost, such as an investment project located at point B. This project leads to improvements in banks of (q^*-q_1). For this project, the marginal benefit exceeds the marginal cost. In the case of an investment project located at point C, the recreational appeal of banks are improved from q^* to q_2. This project is inefficient because the marginal cost of this improvement exceeds its marginal benefit. The marginal WTP for a specific project can be estimated, for example, p_1 at q_1 can be estimated for a project located at point B, or p_2 at q_2 can be estimated for a project located at point C. Total WTP for a project located at point B will be equal to BAq_1q^*. This is an efficient project because total WTP exceeds TC. A project located at point C, however, will have a total WTP equal to ACq_2q^*. This is an inefficient project as TC exceeds total WTP. Without project cost information (MC) the researcher is unable to determine whether the quantity (q_1 or q_2) of a specified project is to the left (efficient) or right (inefficient) of q*.

3.5.2 POLICY GOVERNING ACCESS TO AND USE OF ESTUARIES

The NWA governs public access to estuaries in South Africa, but is limited in terms of how this public access must be managed and conserved. More specifically, it states: "A person may, subject to this Act— … (e) For recreational purposes - (i) use the water or the water surface of a water resource to which that person has lawful access; or (ii) portage any boat or canoe on any land adjacent to a watercourse…"

3.5.3 A PROJECT TO IMPROVE THE RECREATIONAL APPEAL OF THE SUNDAYS RIVER ESTUARY BANKS

In their status quo assessment report, Afri-Coast Engineers recommended that "… a continuous strip of green open space be preserved along the river banks (of the Sundays River Estuary) to form an aesthetic nature trail providing a valuable asset to the area for both local residents and tourists" (Afri-Coast Engineers, 2004). The green open space must constitute a sufficiently wide river frontage to allow for safe public access. It was further recommended that "… negotiations should be initiated with the private land owners who own private land along the river edges (of the Sundays River Estuary) to investigate a mutually beneficial partnership to conserve this ecologically valuable land" (Afri-Coast Engineers, 2004). It was also suggested that other privately-owned land be incorporated into conservancies, or bought by the NMBM, in order to conserve these areas and to incorporate them into the Nelson Mandela Metropolitan Open Space System (Afri-Coast Engineers, 2004).

The introduction of a nature trail fronting the banks of the Sundays River Estuary would improve the quality of the public land fronting the water's edge, and make it more appealing for recreational shore fishing, as well as provide further areas for other recreational activities, such as bird watching or walking. The marginal WTP at q_1 may be estimated with choice modelling methods, i.e. p_1 in Figure 3.6, but the question of whether the project is efficient must remain unresolved in the absence of cost information for the proposed nature trail.

3.6 NAVIGABILITY ON THE KROMME RIVER ESTUARY

Navigability is a function of the amount of sedimentation that takes place over a period of time in a river bed, amongst other things. Sedimentation, in turn, is a function of the volume of instream flows, amongst other things. The less instream flows, the higher the buildup of instream sedimentation, and the less the navigability. Since the level of navigability is partly a result of the protection of instream flows, this study investigates the issue surrounding navigability of the Kromme River Estuary from an instream flow protection perspective.

3.6.1 NAVIGABILITY – THE THEORY ‘IDEALLY’

River water is in high demand in South Africa for urban and rural household consumption, inputs into production processes and agriculture (Sale, 2007). The abstraction of river water, has however, led to the degradation of estuarine environments in the form of habitat losses, and reduced recreational service yield. It is widely accepted that adequate instream flows protect the ecological and aesthetic values of the estuarine environment (Kahn, 1998; Field, 2001). They also provide the basis for many outdoor recreational activities, most notably, fishing, and boating. Instream flow water rights are governed by the NWA and the mandate to manage them is allocated to catchment management agencies. No such agency has yet been created for the Kromme River and Sundays River Estuaries. The amount of water that should be appropriated from a stream is dependent on the costs and benefits associated with these instream flows (Hosking, 2008). Figure 3.7 shows the costs and benefits of instream flows. The optimum freshwater level of instream flow for an estuary is defined as the level where the positive difference between the total benefit and total cost curves is maximised (Loomis, 1998).

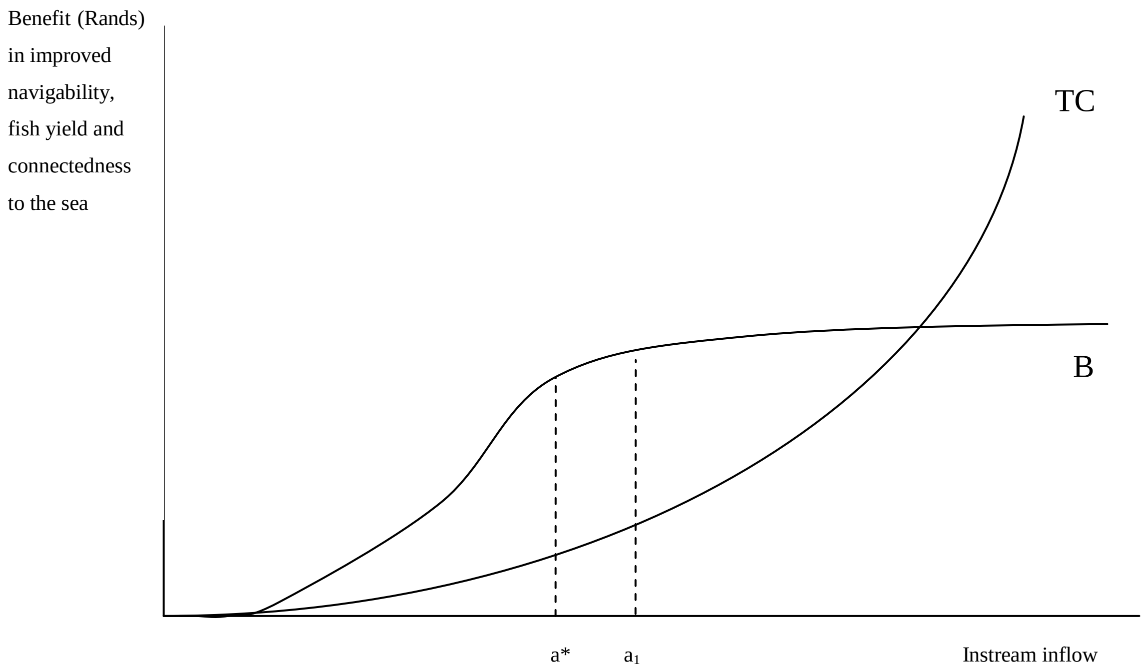

Figure 3.7: Benefits and costs of instream flows in an ideal model

Source: Field (2001)

The curve labelled B represents the total benefit curve. This curve begins on the x-axis, to the right of the origin, as a minimal amount of instream flows are required before any benefits can be accrued. In an ideal model, the benefit curve is initially steeply positive as instream flows yield substantial benefit and then levels out. The curve labelled TC is the cost curve. The slope of the curve is positive starting relatively flat and becoming steeper as instream flows increase along the x-axis. The cost of instream flows is the opportunity cost of this water not being abstracted upstream. It represents the value of the best alternative use forgone from water withdrawal. These values would depend on the purpose for which the water is withdrawn, i.e. urban consumption or irrigation for growing agricultural crops.

The instream flow that maximizes net benefits is a*. At point a*, marginal benefits are equal to marginal costs, i.e. the slopes of B and C are equal. This level of instream flows is economically efficient (net benefits are maximised).

This theory of instream flow protection is subject to a number of qualifications:
(1) The cost of instream flows will vary from estuarine system to estuarine system;
(2) Since instream flows vary substantially from day to day, it is best to apply a mean annual figure in this type of analysis; and
(3) The benefit of instream flow protection will also vary from estuarine system to estuarine system.

3.6.2 POLICY GOVERNING THE ALLOCATION OF FRESHWATER FLOWS

The Department of Water Affairs and Forestry (DWAF) (currently known as the Department of Water and Environmental Affairs (WEA)) is re-examining the foundations underlying river water allocation in South Africa, with a view of incorporating conservation demand (Hosking, 2008). South Africa's Directorate of Marine and Coastal Management, which falls under the WEA, has, along with the local authorities, actively sought to formulate policies aimed at countering the degradation of estuaries.

3.6.3 MANAGEMENT OPTIONS FOR IMPROVING NAVIGABILITY ON THE KROMME RIVER ESTUARY – AS SUGGESTED USING ACTUAL VALUE INFORMATION

3.6.3.1 Increased instream flows

In a study conducted by Sale (2007), the value of freshwater inflows into the Kromme River Estuary was estimated by means of a contingent valuation. Consultations with an estuarine expert, Prof T Wooldridge, suggested that an increase of 75.5 million m^3 per annum in freshwater inflows would lead to consequences of the following magnitudes: a

25 percent increase in angling fish that use the estuary, a 25 percent increase in the availability of mud prawn, and a 25 percent increase of foraging birds in the inter-tidal areas (Sale, 2007).

The results of the study showed that the median household WTP per annum for the suggested increase in freshwater inflows was R287. Taking into account the estimated number of households of 3 200, the total WTP amounted to R918 400 (Sale, 2007). This information can be used to generate the m^3 rand value of water flowing into the estuary. The specified change (75.5 million m^3 per annum) is divided by the total WTP figure, yielding a value of R0.012 per m^3 per annum (Sale, 2007), R0.014 per m^3 per annum at 2010 price levels.

In order to establish a formal model of instream flow protection, Sale's (2007) benefit estimates must be compared to the costs of the best alternative use of this freshwater forgone. The correct cost of the freshwater is it's *in situ* price. The most conservative estimate of this price is the one paid by agricultural users and the best current estimate of the value of this water is the one charged by the Gamtoos Irrigation Board (GIB). The board charges an annual rate per scheduled hectare of R2 200. This entitles the user to a full water quota of 8 000m^3 per ha per annum (Murray, 2011) and translates into an annual cost of R0.275 per m^3. The formal model, inclusive of actual benefit and cost estimates derived above, is shown in Figure 3.8. It is significantly different from the idealised model shown in Figure 3.7.

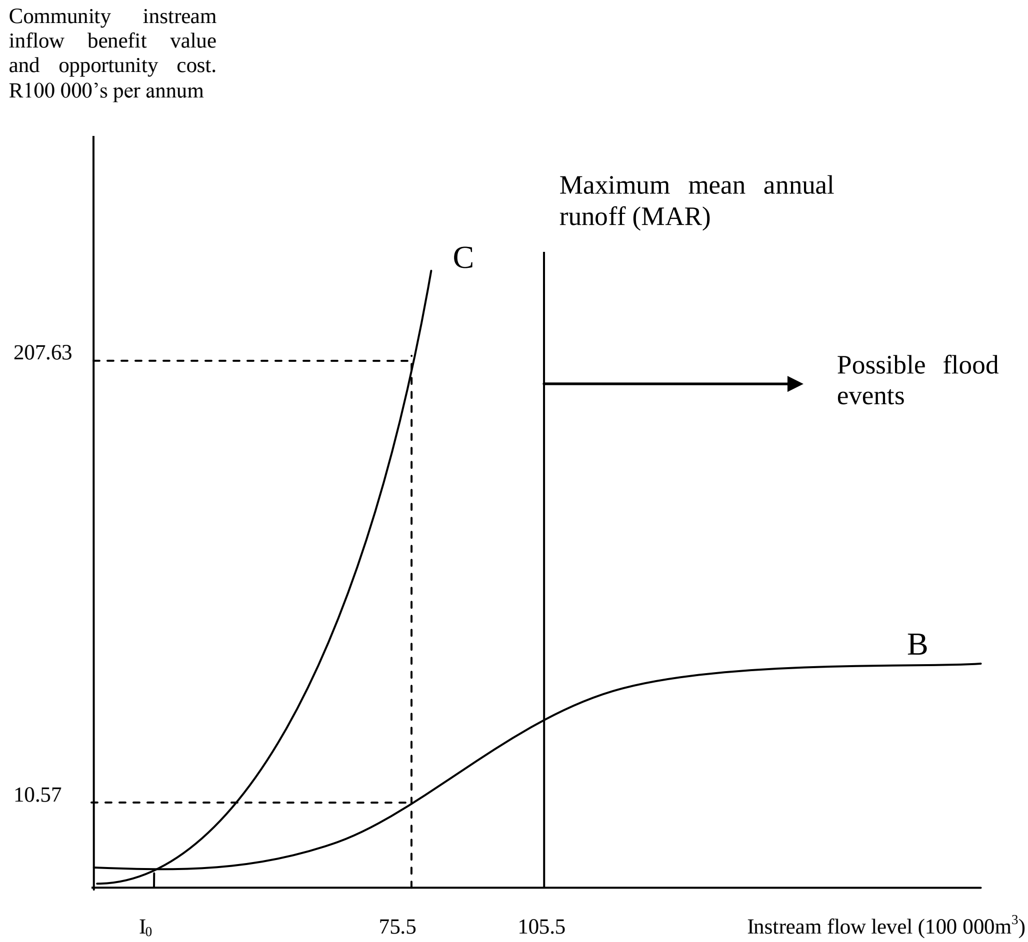

Figure 3.8: Costs and benefits of instream flow protection for the Kromme River Estuary

According to Figure 3.8, the total benefit of instream flow protection in the Kromme River Estuary is above the total cost up to instream flow level I_0. This is because there is a small amount of freshwater inflow that keeps the estuary functioning – in the case of the Kromme River Estuary this amount of inflow is equal to approximately 11 000m^3 per annum. The maximum MAR for the estuary is also indicated (105.5 million m^3). The benefit curve (B) slopes upward from the maximum MAR due to the positive effects caused by possible flood events. These positive effects are well documented in the literature (see Reddering & Esterhuysen, 1983; Heymans, 1992). Beyond I_0 the total benefit of instream flow protection is below the total cost at every instream flow level.

More specifically, the total benefit of a 75.5 million m^3 increase in freshwater inflows (to secure a 25 percent increase in fish, mud prawn and foraging birds) equals R1 057 000, whereas the total cost for an equivalent amount of water used upstream equals R20 762 500 (a net cost of R19 705 500).

The results of this study show that allocations based on marginal cost do not safeguard estuaries such as the Kromme River Estuary, because recreational demand tends not to be equivalent to (is increasing less than) urban and/or agricultural demand. An added complication to management through changing freshwater inflows is that feasible ones would have minimal effect on the estuary services provided to boaters. In other words, changing the amount of water that flows into the estuary is not a feasible option for changing the level of navigability of the estuary. Based on these cost and benefit considerations, a more economically feasible alternative to the release of freshwater to improve navigability is considered, namely dredging.

3.6.3.2 Dredging

An alternative way of improving navigability of the Kromme River Estuary is to dredge the channel bottom. Dredging involves the use of a machine equipped with a suction device which removes sand and silt from the channel bottom, deepening the waterway. Unfortunately it can come at a cost, for example, damaging prawn habitats. Currently, dredging activities are confined to the canal system in the marina. There are no immediate plans to extend the dredging to the main estuary channel (partly due to the damage it can cause). A potential source for funding this dredging activity could take the form of an additional tariff imposed on recreational boat users of the estuary. In order to ensure holistic decision making by policy makers and the relevant stakeholders, a WTP amount should be compared to the costs of dredging. Assuming an area of 10 000m^2 requires dredging, and a cost of hiring a dredging outfit of R30 per m^2 (SFBRA, 2011), the annual cost (excluding habitat damage) of dredging the main estuary channel would be R300 000. The total cost including habitat damage would be much higher.

3.7 THE POTENTIAL USE OF JET SKIS/WET BIKES ON THE KROMME RIVER ESTUARY

3.7.1 THE ECONOMICS OF JET SKI/WET BIKE ACCESS

The model used in this study applies negative externality theory to explore non-jet ski/wet bike owners/users' views and perceptions of these personal water craft and their access to the estuary in question.

Figure 3.9 below applies the negative externality theory to the jet ski/wet bike case.

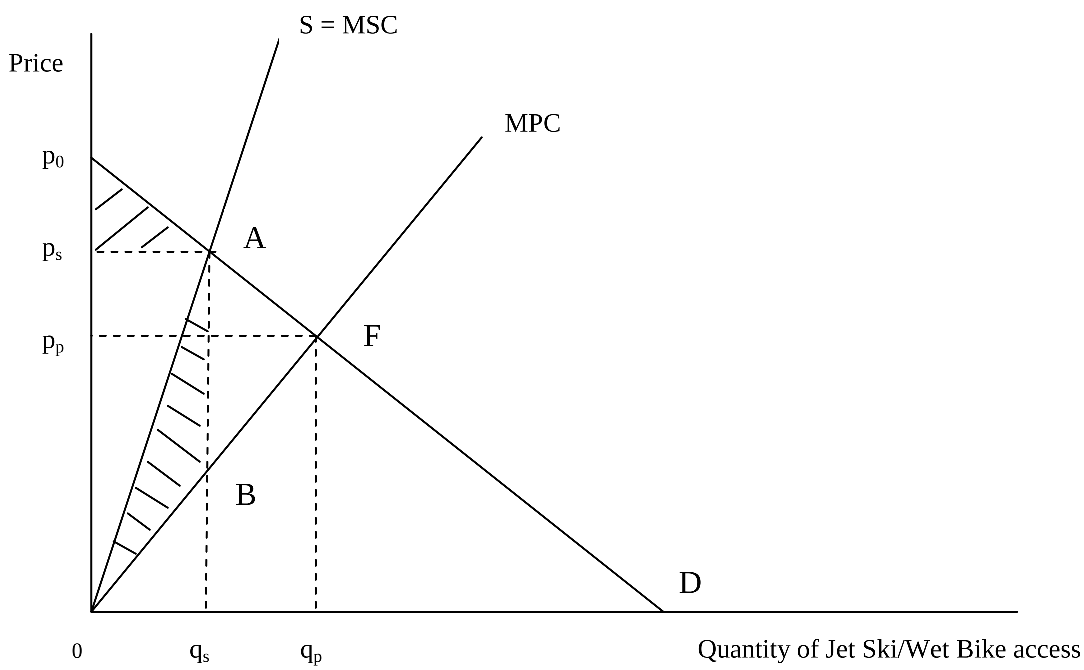

Figure 3.9: Negative externalities of jet ski/wet bike access

The socially efficient level of jet ski/wet bike access is q_s where MSC = D (point A). The right price for this access is p_s and the welfare benefit that could be gained by permitting access is the difference between the WTP for zero access (traversing allowed for accessing the sea only) and access based on social cost, namely p_sp_0A. The external cost imposed on others by this access (captured in the boat access fee) is AB0. It would be welfare improving to allow access at the access fee of p_s, but the gain accrues only to the jet skiers and wet bikers, namely shaded area p_sp_0A (WTP). The gain to jet skiers and wet bikers is also partly at an external cost to other users, namely shaded area AB0. These other users would have to be compensated (from the boat access fee collected) before this access could be considered efficient.

3.7.2 MANAGEMENT OF AND LAWS GOVERNING THE USE OF JET SKIS/WET BIKES ON THE KROMME RIVER ESTUARY

All jet skis/wet bikes that operate in the area controlled by the Kouga Municipality (St Francis Bay Marina, St Francis Bay Beach, Cape St Francis) or by the WDC (Kromme River) must be registered for that recreational purpose (SFBRA, 2011). The registration fee is the same as that paid by owners of standard motorised water craft, i.e. R169 per annum (pertaining to 2009/2010) (p_sp_p less than welfare maximising – Figure 3.9). Access to the Kromme River Estuary for the purposes of jet skiing and/or wet biking is, however, limited. Currently, these jet-propelled craft are not allowed to operate on the Kromme River Estuary. They may, however, traverse through zone A (Forbes' 1998 study) for the sole purpose of accessing the open ocean through the estuary mouth.

In the absence of compensation being made to those imposed upon by the jet skiers, the welfare case for providing them with access rests on a comparison of gain (p_0p_sA) with the uncompensated losses (0AB). This comparison is indeed something that the choice modelling method is capable of informing.

3.8 CONCLUSIONS

This chapter discussed the theory underlying, current policy/regulations/laws related to and various management options for the identified issues specific to each selected estuary (sub-objective one in Chapter One). Welfare analyses indicate that a number of different control variables (tariffs and license fees) are appropriate in the different choice experiments proposed in this study. With respect to over-fishing at the Sundays River Estuary, it was found that the only available instrument with which to control recreational fishing effort is the boat license fee structure. The piece of information that is needed to adjust the existing instrument is the increment in its size that will induce a decrease in effort levels in the fishery toward the optimum.

With respect to boat congestion on the Sundays River and Kromme River Estuaries during peak periods, the only feasible management option is the use of prices to ration use. In order to affect the correct price adjustment, information is required on the congestion cost. This cost would be in the form of a supplementary tariff, which is added to the existing boat license fee structure during peak use periods.

With respect to public access at the Sundays River Estuary, an investment project to improve access was proposed. The investment would entail the development of a nature trail fronting the banks of the estuary. To determine whether this project is efficient, information is required on users' willingness-to-pay, in the form of boat license fees, for the project, and costs involved for the projects implementation. It is conceded that control through this pricing mechanism may encounter resistance because boat owners could legitimately argue that they would not be the main beneficiaries of such an investment.

The analysis of navigability of the Kromme River Estuary based on actual information revealed that freshwater allocations based on marginal cost do not safeguard this estuary because recreational demand is not equivalent to urban and/or agricultural demand. The alternative option of dredging was explored. In order to determine the feasibility of this operation, information is required on users' willingness-to-pay, in the form of boat license fees, to implement dredging activity in the main channel of the estuary. This amount can then be compared to costs of undertaking this activity.

With respect to the use of jet skis and wet bikes on the Kromme River Estuary, a negative externality theory was applied. In order to determine whether access is welfare improving in the absence of compensation, the uncompensated external cost imposed on others by the use of jet skis and wet bikes on the estuary must be estimated. This can be estimated by how much the conventional motor boat owners were willing to pay, in the form of additional boat license fees, to deny access to jet skiers and wet bikers.

Chapter Four provides a theoretical overview of the choice experiment method in order to determine whether it has the potential to generate the information described above.

CHAPTER FOUR: THE CHOICE EXPERIMENT AS AN APPROACH TO INFORMING MANAGEMENT OF THE COMPOSITE GOOD

4.1 INTRODUCTION

Chapter Three identified information that is required to guide the management of estuaries through the application of economics-based policies. Additional license fees were advocated as an appropriate control variable for the Sundays River and Kromme River Estuaries. It revealed that information was required on the increase in the existing license fee structure to appropriately reduce the exploitation of fish in the Sundays River Estuary, on the supplementary tariff required to decrease the number of boats on the estuaries to safe levels, on users' WTP for a project that will improve the recreational appeal of the Sundays River Estuary's banks, on the additional tariff required to fund a project to improve navigability of the Kromme River Estuary, and on jet ski and wet bike users' WTP to gain access to the entire Kromme River Estuary. Chapter Four will show how the CE method, a form of conjoint analysis, is suited to the task of generating information on the scale of change required in the control variable in order to bring about the desired welfare objective. It will also provide an overview of the method, according to the second sub-objective specified in Chapter One.

4.2 A REVIEW OF SELECTED LOCAL AND INTERNATIONAL STUDIES

The CE method has been extensively used and developed for the valuation of environmental goods and services (Adamowicz, 1995; Boxall *et al.* 1996; Bennett & Adamowicz, 2001; Hanley *et al.* 2001; Hensher *et al.* 2005). Numerous international CE studies have been conducted into the valuation of wetland, estuary and river attributes in different countries, including Vietnam (Nam Do & Bennett, 2007), Sweden (Carlsson, Frykblom & Liljenstolpe, 2003; Eggert & Olsson, 2004), England and Wales (Economics for the Environment Consultancy (EFTEC)), 2002; Hanley, Adamowicz & Wright, 2002; Bateman, Cole, Georgiou & Hadley, 2005; Luisetti, Turner & Bateman, 2008), Greece (Birol, Karousakis & Koundouri, 2006a), Australia and Tasmania (Morrison & Bennett, 2004; Windle & Rolfe, 2004; Kragt, Bennett, Lloyd & Dumsday, 2007; Kragt & Bennett, 2009), and the United States of America and Canada (Opaluch, Grigalunas, Diamantides, Mazzotta & Johnston, 1999; Heberling, Shortle & Fisher, 2000; Smyth, Watzin & Manning, 2009).

Nam Do and Bennett (2007) estimated wetland biodiversity values by applying a choice model to the Mekong River Delta in Vietnam. Protection values were estimated for Tram Chim National Park, one of the many wetlands found in the Delta. The choice model employed five attributes, with four levels each, including a status quo option. The cost attribute was defined as a once-off change in the current monthly electricity bill. An orthogonal, main effects design was constructed for use in this study. The survey was conducted by means of personal interviews. In total, a sample of 917 respondents was interviewed from three main cities in the study area. The CE utilised the multinomial logit (MNL) model and random parameters logit (RPL) model to estimate implicit prices for the proposed wetland biodiversity plan. Total benefits were estimated at $3.9million. Nam Do and Bennett (2007) found that the benefits outweighed the costs of implementation, implying that social welfare would improve if more resources were allocated to the conservation of wetlands in Tram Chim.

Carlsson *et al.* (2003) conducted a CE in order to identify the characteristics of wetlands that individuals deem important. The study was conducted in a wetland area in Staffanstorp, located in southern Sweden. The majority of wetlands in this area have been eradicated due to urban and agricultural expansions. Individual WTP values were estimated in order to determine the value that individuals place on selected characteristics (attributes) of this wetland area. The choice model employed seven attributes, including a status quo option. Five attributes had two levels each and one attribute had three levels. The cost attribute had four levels and was defined as a once-off total cost per citizen falling within that specific municipality. The choice sets were created using a D-optimal design procedure. A random sample of 1 200 Staffanstorp citizens, aged between 18 and 75 years, was drawn from the Swedish census register. These citizens received the questionnaire through the mail and were sent one reminder after two weeks. In total, 468 questionnaires were used for the study. A RPL model was estimated using LIMDEP 7.0, and implicit prices were calculated for each attribute. Using these WTP values, it was found that biodiversity and walking areas were the greatest contributors to welfare, while introducing crayfish to the wetland and adding a 1m fence to the waterline would actually decrease welfare.

Eggert and Olsson (2004) studied the economic benefits of improving coastal water quality in the coastal waters of the Swedish west coast. This improvement was investigated from a fishing, bathing water quality and biodiversity perspective. These three characteristics were set as the attributes and assigned three levels each. The additional cost variable (six levels) was defined as a user fee to be collected from all working age permanent citizens in the relevant municipalities. This amount would be paid on a monthly basis for a period of one year. A fractional factorial, main effects design was used to create the choice sets. Each respondent faced four choice set questions, and every choice set presented three possible alternatives, one of which was a status quo option. The sampling frame for the study was the Swedish Register of Inhabitants, and only respondents from the permanent population in the counties representing the southwest part of Sweden were randomly sampled. Questionnaires were sent out to 800 respondents via mail, of which 343 were returned, and 324 were deemed usable. The data was analysed using mixed MNL models. The calculated marginal WTP values revealed that respondents prioritise improvements in fishing stocks, and want increased efforts aimed at preventing biodiversity loss.

EFTEC (2002) conducted a CE study on the value of benefits that could be derived from a revised bathing water quality directive in England and Wales. The objective of this study was to determine people's WTP for improvements to water quality and other defined beach characteristics that could occur from the implementation of such a directive. Focus groups identified the following beach attributes, namely water quality, an advisory note system, litter/dog mess and safety and amenities. The additional cost attribute was defined as an increase in water charges per household per year. A fractional factorial main effects design produced eight different choice sets. Each respondent answered eight choice set questions which incorporated three alternatives each. Two alternatives represented improvements, while the third represented the base case or status quo alternative. A representative sample of 809 respondents was interviewed and the data from the usable questionnaires captured. The nested logit (NL) model was used to calculate marginal WTP values for each attribute. Most respondents preferred some level of improvement to the current situation. The most preferred changes based on WTP values were to eliminate dog mess and litter, and to introduce an advisory note system on bathing water quality.

Hanley *et al.* (2002) conducted a CE to estimate the value of improvements in the ecological status of the River Wear, in Durham, England. This CE was aimed at testing whether the levels of attributes used in the experimental design affected preference and welfare estimates. The use of focus groups helped identify the attributes used in the study, namely ecology, aesthetics, and river banks. These were each set at one of two levels, i.e. ‘good’ and ‘poor’. The cost attribute was defined as higher water rates payments by households to the local water company. The choice sets were created using a fractional factorial design. Sampling occurred through a randomised quota-sampling approach and the questionnaires were then administered in-house by trained individuals. Each respondent answered eight choice questions, and each of these questions consisted of a choice between three alternatives, one of which was always the status quo. The captured data was analysed using conditional logit (CL) models. Implicit prices representing a change from a ‘poor’ status to a ‘good’ status were calculated for each attribute. It was found that people were indifferent as to which of the three attributes was improved. The difference in values between the three attributes was insignificant, indicating that all three attributes could have been viewed independently as good indicators of river health, i.e. they were almost perfect substitutes. It was also found that this CE was insensitive to the range of attributes used, once scale effects were accounted for.

Although not a CE study, Bateman *et al.* (2005) conducted a contingent valuation (CV) study and a contingent ranking (CR) study to look at the benefits of water quality improvements in the River Tame in Birmingham, England. The CR study, a choice modelling derivative, was proposed as a more appropriate alternative for the valuation of public goods. The CV study presented respondents with a single open-ended WTP question, whereas the CR study presented respondents with a choice of different combinations of attributes. The CR study employed four attributes with three levels of improvements for each. The cost attribute represented an annual increase in council taxes. Face-to-face interviews were conducted in the Birmingham area at each respondent's place of residence. This elicited a total of 675 usable questionnaires. Three water quality improvement scenarios were given, with each providing different combinations of the attributes and their levels. An ordered logit model was estimated and WTP values calculated. The most notable result with regards to the CV study was the high proportion of respondents that could not provide a WTP amount (23 percent). In the CR exercise, approximately one-third of respondents assigned rankings that were consistent with the maximisation of water quality improvements. The most interesting result was the difference in response rates between the two techniques. The CR study exhibited a 98 percent response rate whereas the CV study exhibited a 77 percent rate of response. It was suggested that the CR study was conceptually easier for respondents to answer.

Luisetti *et al.* (2004) utilised an ecosystem approach to assess managed realignment coastal policies on the east coast of England. These coastal management strategies include managed realignment projects whereby sea defences are breached and the land flooded in order to restore salt marshes in the area. The CE was used in this case, as the value of salt marshes created by different managed realignments could be estimated in a single application. The project site was the Blackwater Estuary in Essex in the east of England. The choice model employed five attributes of which one had two levels, two had four levels, and one had eight levels. The fifth attribute (with four levels) was a cost variable, defined as an increase in the respondent's annual local council tax measured in Pounds (£) per household per annum. Choice sets were created by applying a fractional factorial design. Each respondent answered eight choice questions, with each choice set presenting two possible options. One of the pre-defined options presented in every choice set was the status quo. Non-probability sampling techniques were applied and the selected sample surveyed through face-to-face interviews. This resulted in a total of 508 usable questionnaires. A random effects binomial logit model was estimated, which allowed for the calculation of marginal WTP values. For this study an aggregated WTP value for a management policy creating new salt marshes in the estuary was calculated. The key finding of the study was that site specific value estimates derived through the use of the CE had yielded results in line with other previous managed realignment cost-benefit analyses, which lent support to the use of this approach for assessing future coastal policy strategies.

In Greece, a CE was applied by Birol *et al.* (2006a) to estimate the value of changes in different social, ecological and economic functions that the Cheimaditida wetland provides to the citizens. Five attributes considered significant to this wetland were identified, namely biodiversity, open-water surface area, education and research extraction, re-training of farmers and payment. Three of the attributes had two levels each while the fourth had four levels. The cost variable had four levels and was defined as a once-off payment that would be directed to the Cheimaditida Wetland Management Fund. An orthogonal main effects design was constructed, which resulted in each respondent answering eight choice questions with three options presented in each. One of these options was always the status quo. Face-to-face interviews were conducted which resulted in 407 completed questionnaires. In order to account for preference heterogeneity, two RPL models and a latent class model were estimated. Study results revealed a high degree of preference heterogeneity across the general public. The public also derived positive and significant values of enjoyment from the conservation and sustainable management of this wetland.

Morrison and Bennett (2004) conducted a number of CE studies to value certain rivers in New South Wales for possible use in benefit transfer. They investigated whether these WTP estimates could be used through benefit transfer to value similar improvements in the health of other rivers in the same region. Five river catchments were selected for valuation. The surveys were conducted within the catchment area only. This approach assumed, however, that only those living in the catchment area would derive benefits from improved river health. In order to account for those who derived benefits from improved river health but lived outside the catchment area, two more CE studies were conducted (on two of the five inland catchments) surveying only residents outside the particular catchment area. The seven different CE's employed five attributes, of which one had three levels, and three had four levels each. The fifth attribute, with four levels, represented the cost variable which was defined as a once-off payment levy on water rates. An orthogonal design was selected, which led to a total of 25 alternatives. This resulted in there being five versions of the questionnaire presented for each catchment. The samples for each catchment were randomly drawn from the 'Australia on disk' telephone directory on the basis of postal codes for that catchment. Questionnaires were mailed to a total of 900 respondents for each of the pre-defined catchment samples. The response rates for these surveys ranged from 30.4 to 45.9 percent. CL and NL models were estimated using LIMDEP 7.0. The estimated WTP values differed across catchments when inland residents were sampled, implying that benefit transfer can only occur in this case between similar inland rivers in the same region. It was also found that the WTP values from the two catchments, where outside residents were sampled, were statistically similar, implying that benefit transfer could occur between other outside catchment surveys.

In central Queensland, a CE study was conducted by Windle and Rolfe (2004) to assess community preferences for the protection of the Fitzroy Estuary using different payment options. This CE was part of a series of CE studies assessing the trade-offs between water resource development and environmental and social impacts in the Fitzroy basin. This study employed four attributes to represent various protection scenarios, namely healthy vegetation left in the floodplain, kilometres of waterways in good health, protection of aboriginal cultural heritage sites and health of the river estuary. The fifth attribute was a monetary variable representing the payment mechanism. This mechanism was defined in three ways. The first two definitions represented an increase in annual rate payments for a

20 year period, while the third represented a once-off lump-sum payment covering the cost over the whole 20 year period. An orthogonal experimental design generated 64 choice sets blocked into groups of eight, i.e. each respondent was presented with eight choice questions. Households were randomly selected and surveyed using the drop-off/pick-up method of data collection. The survey that used the first payment mechanism yielded 151 completed questionnaires. The survey that utilised the second payment mechanism as the cost variable yielded 152 completed questionnaires, while the survey that incorporated the third payment mechanism yielded 150 completed questionnaires. The data was analysed using MNL models and marginal WTP values were calculated for each of the three surveys representing the different payment mechanisms. It was concluded that the community places a high value on improvements in the health of the Fitzroy River Estuary. It was also found that the WTP values estimated using the CE technique were not sensitive to the levels used for the cost attribute, but the timeframe for the payment needs to be carefully considered and further researched.

In Victoria, Australia, a CE was applied by Kragt *et al.* (2007) to estimate benefits associated with improved health of the Goulburn River. Individual preferences were modelled with regards to marginal changes in different environmental attributes. This study employed four river health attributes, namely native fish, healthy riverside vegetation, native birds and fauna, and water quality. The fifth attribute was a cost variable and represented a once-off compulsory payment into a trust fund by all households in Victoria. An orthogonal fractional factorial main effects design was constructed providing 54 different river management outcomes. A mail-out-mail-back survey technique was applied. Each respondent received a questionnaire where they were requested to answer five choice questions. Each choice question included two management options, and a status quo or 'no action' management option. The data was used for CL and NL model estimation. The Hausman test was applied to the results of the CL model, which indicated a violation of the 'Independence of Irrelevant Alternatives' (IIA) assumption. The CL model was therefore not appropriate in this case. A more complex NL model was then estimated. Results indicated that individuals would pay for increased protection of fish species, birds, and native water animals, and for an improvement in riverside vegetation. These NL results, however, were statistically similar to the CL results, which implied that testing for the IIA violation required a more rigorous approach.

In north-eastern Tasmania, Kragt and Bennett (2009) applied the CE method in order to address catchment management issues in the George catchment. This report attempted to assess community preferences for different proposed management scenarios aimed at improving the quality of the catchment environment. The study employed three attributes relating to overall catchment health and the condition of the Georges Bay Estuary, namely native riverside vegetation, rare native animal and plant species, and the seagrass area. The fourth attribute was a payment attribute defined as a once-off levy on rates, payable by all Tasmanian households in 2009. Choice sets were generated through the use of a Bayesian D-efficient design technique. Each questionnaire included five choice questions with three alternatives, one being the no change, status quo option. This status quo scenario implied a slow degradation in catchment conditions, whilst the other two options represented management scenarios for improved catchment conditions. Of the 1432 respondents surveyed through the use of the drop off/pick up survey technique, only 933 were returned. A CL model was estimated but the Hausman test revealed that the IIA assumption had been violated. Additional mixed logit (ML) models were also estimated. Overall results from this study revealed that Tasmanians are willing to pay for increased protection of native riverside vegetation and rare native animal and plant species in the George catchment. It was suggested that more focus be given to catchment valuation studies that investigate preference heterogeneity amongst respondents.

A survey of public preferences for improvements in the natural resources of the Peconic Estuary System situated in the East End of Long Island was conducted by Opaluch *et al.* (1999) in August of 1995. Focus group discussions, interviews and pilot studies revealed five main attributes of interest, namely farmland, undeveloped land, wetland, safe shell fishing areas, and eelgrass. The sixth attribute, a cost attribute, was defined as an annual cost to households. An orthogonal design was constructed yielding sixty different choice sets. These choice sets were divided into twelve questionnaires with five choice set questions in each. Each choice set had three alternatives, with one representing a status quo or ‘no new action’ option. A convenience intercept sampling method was used whereby fieldworkers approached random individuals and asked them if they would be willing to participate in the survey. Personal interviews were conducted with willing respondents, which yielded 968 completed questionnaires at the end of the survey period. The study utilised a CL and a NL model. Results indicated similar preferences in terms of what attributes to protect. Respondents were willing to provide support for the protection of selected resources in the following order: farmland, eelgrass, wetlands, shell fish and undeveloped land. Using a 25-year time horizon and a seven percent discount rate, the estimated dollar value of farmland was $745 000 per acre, while that of undeveloped land was lowest at $14 000 per acre.

An important issue when using stated preference methods is the potential affect that the number of choice sets could have on response rates. Heberling *et al.* (2000) explored this issue by conducting a survey on the benefits of restoring streams that have been damaged by acid mine drainage in western and central Pennsylvania. Five attributes were identified through the use of focus groups, namely water quality, miles restored, travel time from home, and easy access points. The fifth attribute was defined as household cost in the form of increased water payments for the next ten years. An orthogonal main effects design was used to generate twenty choice sets containing three alternatives, one being the status quo. To examine non-response rates, four versions of the questionnaire included five choice sets each, while two versions of the questionnaire included ten choice sets each. Three random samples were drawn from different locations within the acid mine drainage area. In total, 2 208 questionnaires were mailed and 1 171 of those were return in a usable state giving an overall response rate of 60.2 percent. A CL model was estimated for each data group – one group included those that answered ten choice sets and the other group included those that answered five choice sets. In both models, respondents were willing to pay the most for an improvement in water quality. With the difficulty of the choice task measured in terms of number of choice sets answered per respondent, results indicated that survey responses do not differ across the number of choice sets. In other words, increasing choice sets per questionnaire does not decrease response rates.

Smyth *et al.* (2009) investigated public preferences for alternative management scenarios for Lake Champlain, situated in Vermont and New York, but also bordering on Quebec, Canada. Five attributes of interest were identified, namely water clarity, public beach closures, land use change, fish consumption advisories and the spread of water chestnut – an invasive plant. An orthogonal fractional factorial design was used to create management scenarios that varied across three levels. These scenarios were then paired and blocked, resulting in five versions of the questionnaire with nine choice questions in each. An existing mailing list of approximately 7 000 addresses in the Lake Champlain watershed was used as the target population. Questionnaires were mailed to a random sample of 2 000 resident addresses drawn from this mailing list. Each respondent faced nine choice questions involving a choice between two alternatives. A 'no change' or status quo option was not included thus forcing respondents to choose one of the two management scenarios. The response rate was estimated at 41 percent which yielded 6541 responses. The study utilised a binary logit model in order to estimate preferences for different management scenarios. Results indicated that although water quality and beach closures were important management issues, the public wanted policy measures aimed at improving the safety of fish consumption.

In South Africa, there have only been a few attribute valuation studies reported. The WRC commissioned a study in 2008 (Project K5/1413/2) to generate information on guiding the allocation of river water to South African estuaries and to investigate the factors that explain WTP for river inflows into South African estuaries (Oliver, 2010). This study applied a CE to the Bushmans Estuary, in the Eastern Cape Province, and compared the results with those of an application of a CVM done by Van Der Westhuizen (2007). Welfare measures derived from the CE study were about 30 percent less than the welfare measures derived from the CVM study (Oliver, 2010). Reasons cited for this difference included different samples of users, as well as the possibility of embedding bias in the derived CVM estimates. The Oliver (2010) study suffered from several deficiencies: too many attributes were included in the experimental design, and two cost attributes (instead of one) were included in the experimental design. An auxillary regression test revealed the presence of multicollinearity, implying that the orthogonality of the design was compromised, the sample size was small by international standards, and no attempt was made to test for possible sources of heterogeneity.

4.2.1 A SUMMARY OF CE DESIGN AND ANALYSIS TRENDS

The studies described above all dealt with the valuation of wetlands, including rivers, lakes, basins and estuaries. Only a few dealt with the specific valuation of estuaries. Common themes that have emerged from this literature review do not deal with attribute identification and policy issues, specifically, but rather with general CE design and analysis trends. The majority of studies cited above employed, on average, five attributes, with three levels each. Most studies included a status quo option. The most popular experimental design was a fractional factorial one. The average sample size for these studies was in excess of 500 respondents. In most cases, each respondent was required to answer five choice set questions. The choice data was analysed in most studies by means of an RPL model, but the basic CL model was always initially presented.

4.3 THE THEORETICAL BASIS FOR THE CE METHOD

The most frequently used tool for modelling the behaviour of individual choice is the discrete choice model based on the hypothesis of random utility (Blamey, Rolfe, Bennett & Morrison, 1997; Bateman *et al.* 2002; Hensher *et al.* 2005). These models are founded in classic economic consumer theory. In this section, a brief overview of the relevant economic consumer theory is presented, discrete choice theory is discussed and the fundamentals of the random utility choice model are outlined.

Consumers are typically assumed to be rational decision makers (Howard & Sheth, 1969; Howard, 1977; Engel & Blackwell, 1982; Abelson & Levy, 1985; Howard, 1989; Engel, Blackwell & Miniard, 1995), so that when they are faced with a set of possible consumption bundles of goods, they assign preferences to each of these bundles and then select the most preferred (utility maximising) bundle from the set of affordable alternatives. Using the properties of completeness[7], transitivity[8] and continuity[9], a continuous function exists which links a real number with each possible bundle, thereby summarising and ordering the consumers preferences. This function is known as a utility function (Ben-Akiva, 1973; Louviere, Hensher & Swait, 2000). The consumer behaves in such a manner as to choose the consumption bundle that maximises their utility subject to their budget constraint. This choice optimises the consumer's utility and provides the basis for the demand function and inferences of indirect utility enjoyed. The indirect utility function shows the maximum amount of utility that a consumer can achieve, given prices and income, and plays a key role in discrete CM.

Initially, consumer theory assumed that the goods being chosen were homogeneous (one car is the same as another) simplifying the utility function to one in quantities only. Later, following a seminal paper in which Lancaster (1966) argued that it was *the attributes* of a good that determined the utility derived from the good, the utility function concept was extended to incorporate the attributes of goods that were close but not perfect substitutes (Lancaster, 1966; Rosen, 1974). This consumer theory models behaviour in a deterministic manner.

To allow for statistical estimation, this extended utility function has to include a variable to incorporate random elements (see Thurstone, 1927; Luce, 1959; Marschak, 1960). The resultant function is called a random utility function. Within a random utility theory

[7] Any two bundles can be compared i.e. *a* can be preferred to *b*, *b* can be preferred to *a*, or they can be equally preferred.

[8] If *a* is preferred to *b*, and *b* is preferred to *c*, then *a* is preferred to *c*.

[9] If *a* is preferred to *b*, and *c* is infinitely close to *a*, then *c* is also preferred to *b*.

framework a consumer's behaviour is inherently probabilistic. Even if consumers can exercise discretion when making choices, they do not have complete information and for this reason there is an element of uncertainty that must be taken into account. The random utility function may be considered as the sum of two parts. The first part is the observed or measurable component, and the second part, the unobserved or random component. The random component captures the consequence for choice of uncertainty due to incomplete information. Manski (1977) identified four sources of uncertainty contributing to the unobserved component of utility: effects of unobserved alternative attributes, effects of unobserved consumer characteristics (or taste variations), measurement errors, and the use of imperfect proxy (or instrumental) variables. The random utility approach to model estimation is adopted, that is a model that provides for random (error) influences in addition to identified fixed ones (McFadden, 1974; McFadden, 1981; McFadden, 1984). More formally, total utility can be presented as:

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{4.1}$$

where:

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

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

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

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

$$Viq = \beta_{1i} f_1(s_{1iq}) + \ldots + \beta_{ki} f_k(s_{kiq}) \tag{4.2}$$

where:

β_{ki} are utility parameters for option i, and

s_{iq} represents 1 to k different attributes with differing levels, Equation 4.1, is expanded to become:

$$U_{iq} = \beta_{1i} f_1(s_{1iq}) + ... + \beta_{ki} f_k(s_{kiq}) + \varepsilon_{iq} \tag{4.3}$$

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

The probability of consumer *q* choosing option *i* from a choice set may be estimated by means of the MLE approach, whereby estimates are obtained through the maximisation of a probabilistic function with respect to the parameters (Louviere *et al.* 2000; Hensher *et al.* 2005; Nam Do & Bennett, 2007). This estimation approach requires the random components (ε_{jq}) to be independently and identically distributed (IID) and this, in turn, requires the error term to be IIA. This type of statistical distribution is referred to as the extreme value type 1 distribution (EV1). Using the EV1 distribution, the unobserved random components associated with each alternative must be converted into a workable component of the probability expression. Once this is done, the model can be simplified whereby the random component is integrated out of the model. The resultant choice model only has unknowns relating to the utility parameters of each attribute within the observed component of the random utility expression, and is called the MNL or (more correctly) the CL choice model (for further detail see section 4.4.6). A Gumbel or Weibull distribution is an example of an EV1 (Hanley *et al.* 2001; Hanley, Bergmann & Wright, 2004).

4.4 STEPS IN APPLYING A CE

4.4.1 DEFINE STUDY AIMS

Refining the research question is often a difficult task requiring the researcher to consult public interest from a wide range of perspectives, for example, the findings of others, statements made in the mass media, contributions from focus groups and pilot studies (Louviere *et al.* 2000).

4.4.2 THE USE OF FOCUS GROUPS

Focus groups are a convenient and commonly used method for gathering qualitative information on what the key public interest issues are (Morrison, Bennett & Blamey, 1997). Five to ten individuals are drawn from the target population and asked to participate in discussions on the study's preferred focus of attention. These discussions should provide inputs to the study in respect of the most important attributes and their levels, personal characteristics that affect choice behaviour, possible reasons for differences in utility, the number of alternatives in a choice set, and also whether different decision rules are used (Louviere *et al.* 2000; Birol *et al.* 2006a; Nam Do & Bennett, 2007). Focus groups may also assist in the description of attributes used in the study - suggesting words and phrases that are generally understood by the target population.

4.4.3 SAMPLE DESIGN

As with other survey-based research, the sample design strategy for CM exercises entails four distinct steps: selecting the target (sample) population, determining who to sample (the sample frame), determining the appropriate sample size and choosing the method of respondent selection and elicitation of response technique.

4.4.3.1 Target population

The target population comprises those individuals who receive benefits from, and who are subject to costs of, the effect being studied (Bateman *et al.* 2002). For geographically well-defined areas, such as estuaries, benefits can be derived by users as well as non-users. The population that bears the cost may not be so easy to define and imperfect secondary sources of information have to be used to guide sample design (Bateman *et al.* 2002). These secondary sources may include lists like rate payers and angling club members.

The user population for a well-defined geographical area is often easy to identify (Bateman *et al.* 2002), but for an estuary, this identification is complicated by visitors for recreational purposes. Identifying the population of non-users is also problematic. The following factors should be considered when attempting to identify the user and non-user population (Bateman *et al.* 2002):

- Resources with few substitutes are considered unique and hold the potential to exhibit high non-use values. Under these circumstances the sampling process should go beyond the user population.
- The greater the distance from the resource in question, the less familiar it will be to the respondents and the less likely they will be to make use of it. It is assumed that beyond 'some' distance there will be no use or non-use values.
- A change in the quality of a resource is more likely to affect use than non-use values, but a great change may well affect both.
- Those affected by the specified payment vehicle of the resource are by definition included in the sampling frame.

4.4.3.2 Sample frame

Drawing a representative sample from the target population should ideally be preceded by a process of clarification which entails the compilation of a sampling frame. It is defined as a complete, but finite, list of the decision makers (Louviere *et al.* 2000). An ideally specified sample frame is one where the decision makers are listed only once

(Bateman *et al.* 2002). This listing allows a random sample to be selected from the sample frame without the concern for over- or under-sampling. The importance of a properly specified sampling frame is in the definition it provides of the people of interest – the sample selected should be representative of the sampling frame.

There is a trade-off involved between the representativeness of the sampling frame and the cost involved. Frequently, there are no readily available representative lists that can be used as a sampling frame. In some cases, it is not even possible to find a sample frame that lists the entire target population (Bateman *et al.* 2002). If no lists exist, a sample frame cannot be specified and sampling necessarily has to be carried out directly from the sample population. An example where this would be relevant could be the population of visitors to a specific beach. In this case, people would have to be sampled on site. This type of survey is known as an intercept survey (Bateman *et al.* 2002). The randomness of intercept surveys is questionable as the rate and nature of visitation is likely to differ during the different times of the year, and there might be numerous entrance and exit points to the beach in question. In order to improve the randomness and representativeness of this technique, sampling may be undertaken only during certain hours of the day, and during that time the n^{th} user is approached, as they arrive or leave (Bateman *et al.* 2002).

4.4.3.3 Sampling approaches and sample size determination

a) Sampling approaches

There are both probabilistic and non-probabilistic ways to determine sample size. With a probabilistic design, each unit of the population has a fixed probability of being chosen for the sample. With a non-probabilistic design, the discretion of the researcher is relied upon (Bateman *et al.* 2002).

Probability sampling techniques include simple random samples, systematic sampling and stratified random samples (Louviere *et al.* 2000; Bateman *et al.* 2002; Hensher *et al.*

2005). Simple random sampling is the most basic form of probabilistic sampling. Every unit within the sample frame is given an equal chance of being selected for the sample. Systematic sampling requires that the units within the sampling frame are numbered in a sequential manner, concluding with the last unit being equal to the size of the frame. Once the sampling fraction is calculated, i.e. the ratio of sample size to population size, a random number is selected within the sampling fraction and this forms the starting point for the sample. The sample is collected by moving sequentially through the sample frame in multiples of the random number. For stratified sampling, the target population is separated into non-overlapping strata. To ensure representivity, the proportions of the strata in the sample should be the same as in the population.

Non-probability sampling techniques include convenience sampling, judgement sampling and quota sampling (Bateman *et al.* 2002). Convenience sampling is the least preferred method of sampling. It involves choosing a sample at the convenience of the researcher rather than with reference to population representivity (Bateman *et al.* 2002). A judgment sample refers to a sample that has been judged to be representative of the target population. This judgment is subjective and non-random. Quota sampling involves a controlled selection of respondents by the interviewers, where the interviewers ensure that, within the sample, certain proportions of respondents (quotas) are included (Bateman *et al.* 2002).

b) Sample size determination

In the context of CM, sample size is often determined through the use of both probabilistic and non-probabilistic sampling techniques, known as *rule of thumb* approaches (Hensher *et al.* 2005).

A simple equation can be employed to determine the minimum acceptable sample size (n) for a simple random sample:

$$n \geq \frac{(1-p)}{pa^2}\left[\Phi^{-1}\left(1-\frac{\alpha}{2}\right)\right]^2 \qquad (4.4)$$

where:

p	is the reported choice proportion of the relevant user population, i.e. the share of the total each alternative commands,
a	is the level of allowable deviation of sample proportions from the reported population proportions, expressed as a percentage between $\hat{p}$ and *p*, and
$\Phi^{-1}\left(1-\frac{\alpha}{2}\right)$	is the inverse cumulative distribution function of a standard normal, i.e. N ~ (0, 1) taken at (1 - *α*/2), where α is the selected probability, for example, 0.90, 0.95, 0.99 (Louviere *et al.* 2000; Hensher *et al.* 2005).

Sample size increases as '*p'* decreases, '*a'* decreases and 'α' decreases. Systematic sampling is related to simple random sampling, but the population frame is in random order and every n^{th} unit is selected for the representative sample (Bateman *et al.* 2002). Stratified random sampling entails dividing the sample population into *G* mutually exclusive groups. Each of these groups represents a proportion of the total population, W_g (Hensher *et al.* 2005). This technique is based on the principle that samples are more representative and thus more accurate when the population from which they are selected is homogenous. The sample population is grouped into non-overlapping strata that are known to be more homogenous. In order to ensure the randomness of the sample, a random sample of respondents is surveyed within each stratum (Louviere *et al.* 2000; Hensher *et al.* 2005).

Equation 4.4, above can be employed to estimate the appropriate sample size for a stratified random sample. The total sample size can be estimated using Equation 4.4, and then partitioned into the *G* group. Alternatively, the sample size for each stratum can be estimated using Equation 4.4, and these can be summed to calculate the total sample size (Hensher *et al.* 2005).

Probabilistic sample size approaches are very often abandoned in favour of '*rule of thumb'* approaches due to practical considerations – budget and time constraints often supersede theoretical preference (Hensher *et al.* 2005). These approaches identify the minimum sample size that is required in order to estimate the model of choice (Hensher *et al.* 2005). Researchers commonly determine the minimum sample size as the number of observations needed to estimate “robust models” (Hensher *et al.* 2005). Since the standard CL model applied in this study uses only the recreational use attributes and their levels (as contained in the experimental design), and not the socio-economic characteristics of decision makers (non-design attributes), the variability of the data is less of an issue (Hensher *et al.* 2005). The variability of the collected data is even less important if the alternatives contained in the choice sets are unlabelled, since all parameters are generic across all alternatives (Hensher *et al.* 2005). A *rule of thumb*[10] that can be employed in the case where only design attributes are included in the analysis and only unlabelled alternatives are used, is that a sample size be selected of at least 50 respondents and each respondent be presented with 16 choice sets (Hensher *et al.* 2005).

4.4.4 INSTRUMENT DESIGN

In most cases the design of a stated preference survey instrument includes the following four steps (Hasler, Lundhede, Martinsen, Neye & Schou, 2005):

(1) Provide introductory information for the study, as well as an explanation of the environmental issue being analysed. The institutional bodies charged with managing the environmental issue in question can also be identified.

(2) Set out the CE. This is done by providing detailed descriptions of the payment vehicle as well as the attributes of interest and their levels.

(3) Provide follow-up questions, which will allow for reliability and validity testing.

(4) Collect socio-demographic information about the respondent.

[10] There are two other rules-of-thumb approaches that are frequently used: a sample size is selected whereby each alternative is given at least 30 times in the sample, and every choice set is presented to a minimum of 50 respondents (Bennet & Adamowicz, 2001).

4.4.4.1 Introductory information and introductory questions – attitudes, opinions, knowledge and use

a) Introductory information and questions

Survey instruments begin with an introductory section which familiarises the respondent with the study good in question. These take the form of introductory questions, whereby the respondent is encouraged to critically think about the topic of interest and the study. In doing this the respondent is provided with necessary information, and discouraged from providing strategic rather than truthful answers (Bateman *et al.* 2002).

Providing introductory information is important if the respondent is unfamiliar with the good in question, but the amount provided should not be so great that it leads to respondent boredom and irritation. The amount of information required is less for choices the consumer is typically very familiar with, for example, water utilities (Centre for International Economics (CIE), 2001).

When providing a description of the good, neutral wording must be used. In other words, an understandable and unambiguous description of the good to be valued must be provided so that all respondents have the same level of basic information.

In the context of a CE survey, this introductory information should be followed by additional questions. These questions attempt to elicit respondents' attitudes to and their opinions of the good to be chosen. Questions relating to the general use of the good are also incorporated in this section.

b) Introductory questions - attitudes, opinions, knowledge and use

The questions in the CE questionnaire are placed at the beginning for three reasons: firstly, to 'warm up' the respondent to the task at hand, secondly, to allow the respondent time to think about the various important aspects of the choice problem, and thirdly, to provide the researcher with information which can be used to check for consistency and validity of later answers.

Included in the aspects the respondent needs to think about are the trade-offs between environmental policies and programmes (Hasler *et al.* 2005).

4.4.4.2 Setting up a CE

a) The choice of a reliable payment vehicle

In a CE the respondents indirectly reveal their WTP by making choices, i.e. in the trade-offs they implicitly make between various alternatives. These alternatives comprise different attributes, as well as a price attribute. The inclusion of a price attribute allows for marginal WTP to be estimated, and thereby for welfare measures to be calculated. These measures are compensated and equivalent surplus, as measured by the amount taken from the consumer in order to hold their level of utility constant.

The choice of a payment vehicle needs to have a connection to the good being valued (Garrod & Willis, 1999). A payment vehicle can be coercive or voluntary in nature. Examples of coercive payment vehicles are an additional tax levied on the consumer and an annual sum added to a consumer's existing service statements. An example of a voluntary payment vehicle is a once-off voluntary donation to an environmental body tasked with the improvement of the environment. A coercive payment is preferred, as respondents have the incentive to free-ride if the payment is voluntary (Whitehead, 2006; Birol, Karousakis & Koundouri, 2006b). Whatever format the payment vehicle takes, it must be seen as being realistic, fair and equitable to all respondents.

b) The budget constraint and the concept of "cheap talk"

Once the payment vehicle has been selected, it is important that respondents understand its meaning and that they are aware of their households' budget constraints and substitution possibilities (Boxall *et al.* 1996). In order to make sure that the respondent is aware of their budgetary commitments, some CE studies include "cheap talk" (see for example, Abou-Ali & Carlsson, 2004; Birol *et al.* 2006b; Nam Do & Bennett, 2007). "Cheap talk" as defined in the literature, is "an attempt to eliminate hypothetical bias by including an explicit discussion of the problem" (Cummings & Taylor, 1999). The inclusion of "cheap talk" is said to induce valid and reliable responses from respondents, and also reduce the incidence of strategic behaviour (Cummings & Taylor, 1999; List, 2001).

The effect of various "cheap talk" designs has been investigated under different stated preference contexts, and the results have been mixed in respect of CVM (Boxall *et al.* 1996; Poe, Clark, Rondeau & Schulze, 2002; Aadland & Caplan, 2003) and CM (Carlsson, Frykblom & Lagerkvist, 2004; List, Sinha & Taylor, 2006). The inclusion of "cheap talk" was found to have a positive effect by Cummings and Taylor (1999), List (2001), Murphy, Stevens and Weatherhead (2003) and Carlsson *et al*. (2004), but others found that the inclusion of "cheap talk" induced internal inconsistencies regarding respondents' preferences in stated preference valuations (Samnaliev, Stevens & More, 2003; Carlsson & Martinsson, 2006).

Even though the net-benefit of "cheap talk" is inconclusive, it is considered acceptable to include a short section within the survey instrument (Nam Do & Bennett, 2007). The "cheap talk" section should (1) inform respondents of their budgetary constraints, (2) specify that all consumers will be contributing in an equitable fashion (thus discouraging free-riding), and (3) stipulate the amounts that will be paid in addition to any current payments, whatever the good or service may be (Nam Do & Bennett, 2007).

c) Composition of the choice sets

<u>Selection of attributes and their levels</u>

In the CE survey, each alternative presented to the respondent corresponds to a different policy proposal concerning the future management of the resource in question. Each of these alternatives is characterised by differing levels of attributes (Boccara, 1989). In selecting the attributes and levels to include, the findings of other similar studies, policy relevance (Alpizar, Carlsson & Martinsson, 2001), as well as focus group discussions are useful (Louviere *et al.* 2000; Bateman *et al.* 2002; Birol *et al.* 2006a; Nam Do & Bennett, 2007). Minimum and maximum levels for each attribute should be established through focus group discussions. All attributes must pass the 'independence test', i.e. they must be able to be estimated independently from each other (Eggert & Olsson, 2004). The inclusion of a monetary attribute is usually relevant and has the added advantage of making it feasible to calculate monetary value trade-offs against non-money attributes.

<u>The number of alternatives</u>

The number of alternatives in a CE should be chosen once task complexity has been evaluated. Task complexity is determined by factors such as (1) the number of choice sets per respondent, (2) the number of alternatives per choice set, (3) the number of attributes in each alternative, and (4) the number of levels representing each of the attributes (Alpizar *et al.* 2001). Task complexity can negatively affect respondent decisions by increasing the amount of effort needed to make trade-offs between different alternatives. If the test is too complex, respondents could become 'fatigued' and pay less attention to the process of choice selection (Hanley, Wright & Koop, 2002). For this reason, most environmental valuation studies using CE designs, adopt only two to three alternatives per choice set (Hanley *et al.* 1998b; Adamowicz & Boxall, 2001; Bateman *et al.* 2002).

<u>The inclusion of a 'status quo' or 'opt-out' option</u>

A matter of special importance when calculating welfare measures is whether or not to include a base case (status quo) or 'opt-out' alternative (Alpizar *et al.* 2001). The generally accepted format for CE designs is to include a status quo alternative or an 'opt-out' alternative (see, for example, Adamowicz *et al.* 1998; Mallawaarachchi, Blamey, Morrison, Johnson & Bennett, 2001; Abou-Ali & Carlsson, 2004; Morrison & Bennett, 2004; Birol *et al.* 2006a; Nam Do & Bennett, 2007; Kragt & Bennett, 2008). If the option of status quo or 'opt-out' is not allowed as an alternative, this can distort (bias) the welfare measure for non-marginal changes (Kontoleon & Yabe, 2003; Birol *et al.* 2006a), because respondents are forced to choose an alternative which they might not necessarily desire (Banzhaf, Johnson & Mathews, 2001; Dhar & Simonson, 2001; Bateman *et al.* 2002).

The inclusion of a status quo or ‘opt-out’ alternative is not without problems. It is included largely to eliminate bias caused by forcing respondents to make choices that they otherwise would not have made, but it can create another bias whereby respondents continually select the status quo or ‘opt-out’ alternative. Possible reasons why this could happen include respondent boredom and respondent fatigue (Adamowicz *et al.* 1998; Scarpa, Willis, Acutt & Ferrini, 2004). Another issue to consider when deciding whether to include a status quo or ‘opt-out’ alternative is whether or not the current scenario or non-participation are relevant or feasible alternatives (Alpizar *et al.* 2001; Terawaki, Kuriyama & Yoshida, 2003).

<u>Number of choice sets per respondent</u>

There are no definitive rules that specify the number of choice sets that may be presented to each respondent. Task complexity must be taken into account (Bateman *et al.* 2002). When choices are complex, respondents may answer by applying a simplified decision rule (DeShazo & Fermo, 2002) such as ‘yea’ saying or ‘nay’ saying with respect to one attribute, for example, the most environmentally friendly alternative. This problem is also referred to as ‘compliance bias’ as respondents try and ‘comply’ by overstating their WTP values (Boxall *et al.* 1996). They do not want to appear as if they are voting against the environment. Another factor to consider, apart from task complexity, is the potential learning and fatigue effects that the CE can cause. This general problem is known as ‘respondent fatigue’.

d) The experimental choice design

<u>Introduction</u>

One of the most important parts of carrying out a CE study is to identify an appropriate experimental design. Experimental design creates choice sets in the most efficient way possible. It combines attribute levels into alternatives, and alternatives into choice sets (Alpizar *et al.* 2001). The practice of experimental design is a complex process (Huber & Zwerina, 1996; Hensher *et al.* 2005). The accuracy of the results obtained from a CE study are dependent on the properties of the experimental design that was used to elicit respondents' preferences for the good being valued. Ideally, experimental designs should be generated from first principles, but for practical reasons most choice modellers rely on computer software to generate workable statistical designs (Hensher *et al.* 2005).

This section outlines the steps taken to develop an experimental design using computer software, namely SPSS[11].

The point of departure in developing a statistical design in SPSS, or any other statistical software, is deciding whether a full factorial design or a fractional factorial design is desired. The former refers to a design that incorporates all possible combinations of attribute levels that make up the different alternatives (Carlsson & Martinsson, 2003; Hensher *et al.* 2005). The size of the full factorial design is determined by multiplying the levels of the attributes together. For example, if a design has three attributes with two levels each and one attribute with four levels, the full factorial design consists of (2x2x2x4 = 32) 32 alternatives (Louviere *et al.* 2000; Hensher *et al.* 2005). In contrast, a fractional factorial design only uses a subset of all possible combinations that make up the full factorial design (Louviere *et al.* 2000).

A full factorial design allows for the estimation of all main and interaction effects, whereas the fractional factorial design does not. A main effect refers to an isolated attribute effect on the probability of choice and an interaction effect is a choice caused by interactions between two or more variables (Huber & Zwerina, 1996; Kuhfeld, Tobias & Garratt, 2004).

[11] Hensher *et al*. (2005) suggested that "to describe exactly how the expert generates experimental designs would require an entire book".

Although all effects can be estimated using a full factorial design, it is considered cumbersome and impractical within a CE setting. In most cases, the fractional factorial design is adopted (Kuhfeld *et al.* 2004). The change from a full factorial to a fractional factorial design can be costly as it leads to a loss of statistical information. Moreover, certain effects may become indistinguishable from each other (Louviere *et al.* 2000; Kuhfeld *et al.* 2004; Hensher *et al.* 2005).

Even though certain interaction effects are ambiguous, the use of the fractional factorial design involves making assumptions about some of these interactions. It is assumed that two-way or higher order interactions are insignificant (Louviere *et al.* 2000; Hensher *et al.* 2005). The acceptability of this assumption is supported by evidence from several other studies (Louviere *et al.* 2000). It has been found that 'main effects' account for 70 to 90 percent of explained variances, two-way interactions account for 5 to 15 percent, and higher-order interactions usually account for the remaining variance.

<u>Generating experimental choice designs using SPSS</u>

The 'Orthogonal Design' data option is used to develop an experimental design in SPSS. The following steps are taken. First, the attributes to be included in the design are named. The analyst can choose to provide the attributes with their actual names or generic ones (Hensher *et al.* 2005). Second, once the attributes have been named, their respective levels must be assigned (the actual level names, level codes, or both can be used). Two types of coding formats are frequently applied. For an attribute with three levels, 0, 1 and 2 or -1, 0 and 1[12] can be used. Third, the analyst must decide on the number of treatment combinations required for the specific design. If SPSS is not informed about the required number of treatment combinations (alternatives in the choice sets), it will generate the smallest design available (Hensher *et al.* 2005). In most cases, this will produce a 'main effects only' design. Once these steps are completed, SPSS generates an orthogonal design[13].

[12]-1, 0 and 1 are referred to as orthogonal codes (Hensher *et al.* 2005).

[13]In an orthogonal design, the columns of the design show zero correlation. In other words, all attributes are statistically independent of one another (Hensher *et al.* 2005).

After the experimental design has been generated in SPSS, it is copied to Microsoft Excel. The required number of randomised choice set profiles is generated in Excel (using the Random Number Generator). If the analyst wishes to have 32 different questionnaires containing four choice sets each with two alternatives per set, the following information will be provided to run the Random Number Generator in Excel:

- Number of variables = 4 choice sets x 2 choices per set = 8
- Number of random variables = number of profiles generated in SPSS = 32
- Distribution = Uniform
- Parameters = 0.5 and 32.5

The relevant treatment combinations or alternatives contained in the SPSS orthogonal design are assigned to each choice set and the codes replaced by the actual attribute names and their associated levels.

4.4.4.3 Additional questions

a) Debriefing and follow-up questions

It is widely recommended that follow-up questions be included in the questionnaire. These questions are used to check several different aspects: (1) the presence of biased and illegitimate responses, (2) the respondent's comprehension and acceptance of the CE, and (3) the motives that drive the respondent's decision making (Louviere *et al.* 2000; Bateman *et al.* 2002). The inclusion of these questions allows for reliability and validity assessments.

To test for reliability, the respondent should be asked whether or not they found it difficult to make the necessary choices. If respondents found it hard to make trade-offs, this could indicate that the level of task complexity was too high for the respondent. The consequences are threefold: first, the respondent could be induced to supply less reliable answers; second, the respondent could adopt a simplified decision strategy; third, the respondent could find the completion of the choice task too time-consuming. Conversely, it may be more problematic if the respondent finds the choice task too easy. A respondent who finds it too easy to complete the choice task may adopt potentially non-compensatory decision making strategies (Watson, Phimister & Ryan, 2004).

Another relevant validity question is over the level of importance respondents attach to the different attributes when making their choices. This question can help identify whether the respondent has followed a non-compensatory decision making strategy. An important assumption when using the CE approach for non-market valuation is that individuals apply compensatory decision making strategies (Watson *et al.* 2004). It is assumed that individuals consider all attributes within the choice set when making their choices. If respondents answer that they took all the attributes into consideration when making choices, the compensatory decision making assumption has not been violated (Watson *et al.* 2004). Answers that state that choices were made with one attribute in mind does not automatically prove non-compensatory decision making strategies, but reveal the potential for these strategies to have been employed. Another explanation for the focusing on one attribute when making choices could be that certain attribute ranges have been set too narrow and resulting in the respondents not being induced to make trade-offs (Watson *et al.* 2004).

An alternative technique for detecting and correcting hypothetical bias with respect to the choice scenarios is called certainty calibration (Samnaliev *et al.* 2003). According to this technique, on completion of the choice task, respondents are asked to rate their certainty of choice by selecting a number on a scale ranging from 1 to 10, where 1 represents a low level of certainty and 10 represents a high level of certainty.

b) Socio-demographic questions

Socio-demographic questions relate to personal characteristics of the respondents. These questions are placed towards the end of the questionnaire due to their personal nature. Possible questions that could be included in this section relate to age, gender, race, household income, household size, and number of children. The answers to these questions can be useful to test for differences in WTP between certain sub-sample groups, for example, differences in WTP across income groups.

4.4.5 DATA COLLECTION

Once the sampling frame and sample size have been determined, the response selection and collection mechanisms must be established. The selection method is guided by the requirement that the sample respondents represent the sample population. The collection mechanism is largely a function of the type of respondent, the level of simplicity in identifying potential respondents, the length and complexity level of the questionnaire and the type of survey instrument implemented (Louviere *et al.* 2000). The main three survey collection modes employed are (1) mail surveys, (2) telephone interviews, and (3) face-to-face interviews. Two relatively recent additions to these modes are the Internet survey and the mixed mode survey (Dillman, Smythe & Christian, 2009).

A cost-effective method of collection is the mail survey, whereby respondents are recruited via the telephone. After this telephonic recruitment, the surveys are mailed to the respondents. These can be supported by sending reminders as well as providing incentives for timeous completion and return. The mail survey, or the 'drop-off and pick-up' option, is preferred when respondents are required to make realistic monetary trade-offs, as it allows them the freedom to spend more time thinking about their choices (Nam Do & Bennett, 2007). The mail survey method is inexpensive, but is subject to disadvantages, such as low response rates and it can be time-consuming (Bateman *et al.* 2002).

Depending on budgetary constraints, other more rigorous survey techniques are available. Personal interviewers might be required in order to conduct surveys that are more complex in nature. CE surveys can be complex, especially the selection of alternatives contained in the choice sets. Personal interviews, which allow for enhanced thoroughness in explanation, enable the respondent to have assistance in terms of understanding potentially complex matters within the CE setting (Nam Do & Bennett, 2007). These interviews can be conducted at the respondent's home, or alternatively, the respondent can be intercepted in order to fill in the questionnaire (Bateman *et al.* 2002). Face-to-face contact with the respondent allows the interviewer the best opportunity to encourage him/her to give accurate answers. Face-to-face interviews are helpful in the execution of missing data approaches (Mitchell & Carson, 1989). The ability to compensate for omitted data is important for the extrapolation of part-worth estimations from the sample to the population (Mitchell & Carson, 1989). There are also disadvantages to using this survey method. These include the potential for interviewer bias, and expense.

Mixed mode survey methods can also be used. One such method is a computerised assisted interview (Bateman *et al.* 2002). In this case, self-completion surveys are sent to the respondent on a CD or via email. The respondent mails the response back as a hard copy. Alternatively, personal interviews conducted via computer and responses are typed in real time. These computerised interview techniques have the advantage of flexibility as well as increased data quality (Louviere *et al.* 2000). In the context of developing countries, personal interviews are frequently used, as respondents frequently have little education and limited understanding of the aims of the CE study and many respondents do not have access to a computer or the Internet (Champ, 2003).

4.4.6 DATA ANALYSIS AND CHOICE MODEL ESTIMATION

Once the data is collected, it needs to be recorded in a format suitable for statistical analysis and this record checked for accuracy (Amemiya, 1985; Greene, 2000; Louviere *et al.* 2000). In the survey instrument, each respondent indicates his/her preferred alternative for each choice set provided (Bennett & Blamey, 2001). This data element must be combined with the information pertaining to the selected alternative's attribute levels and that pertaining to the attribute levels of the alternative/s not selected (Bennett & Blamey, 2001). For example, a three alternative choice set produces three lines of data, with each line showing an alternative and its attribute levels. In cases where the alternatives included in the choice sets are labelled, alternative specific constants (ASCs)[14] must also be incorporated in the rows of data. These constants reveal any variation not captured by the attributes. For a three alternative choice set, additional attributes (ASCs) must be created for two of the three alternatives (Bennett & Blamey, 2001). In cases where a status quo alternative is included in the choice sets, a status quo ASC must be incorporated in the rows of data. This constant may reveal the presence of status quo bias (in other words, there is a preference among respondents for the status quo alternative). The ASCs may also be interacted with the respondents' socio-economic characteristics in order to investigate respondent heterogeneity (Bennett & Blamey, 2001). These interactions are necessary because the socio-economic characteristics are invariant across the alternatives and drop out during the statistical model estimation process (Hessian singularities arise during the estimation process).

After a summary has been presented of the data collected, the choice models should be estimated. There are many versions – the CL model, the heteroskedastic extreme value (HEV) model and the RPL model.

4.4.6.1 Conditional Logit

The CL model has the following form (Louviere *et al.* 2000):

$$P(i \mid A) = \frac{1}{\sum_{j=1}^{j} \exp - (V_i - V_j)} \tag{4.5}$$

where:

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

V_i is the representative utility from the *i*th alternative, and

[14] It has been argued that although ASCs improve discrete choice model fit, they have no behavioural interpretation (Adamowicz *et al.* 1998).

V_j is the representative utility from the *j*th alternative.

This model is restrictive in terms of its underlying assumptions. According to Louviere *et al.* (2000), the model assumes:

- that scale parameters have constant variance (typically equal to 1 (Ben-Akiva & Lerman, 1985)),
- that random components do not exhibit serial correlation (IIA assumption),
- that utility parameters are set, and
- that there is no heterogeneity between individual preferences.

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

$$P_{iq} = \frac{\exp(V_{iq} / \lambda_i)}{\sum_{j=1}^{j} \exp(V_{jq} / \lambda_j)} \tag{4.6}$$

If the IIA assumption is violated, the observed and unobserved components of utility could be dependent on one another and the error term exhibits serial correlation leading to biased estimates (Nam Do & Bennett, 2007). A more flexible model that relaxes the IIA assumption is the HEV model. This model, initially developed and applied by Bhat (1995), allows the variance of the error term to differ across alternatives within a choice set. It models the probability that an individual (*q*) will choose the *i*th alternative in a choice set (*A*), but relaxes the assumption of independence among the random components. Substituting *z* in place of ($\varepsilon_i / \lambda_i$), the HEV specification of the choice is:

$$P_i = \int_{z=-\infty}^{z=+\infty} \prod_{j \in C, j \neq 1} F\left[\frac{V_i - V_j + \lambda_i z}{\lambda_j}\right] f(z) dz \tag{4.7}$$

4.4.6.2 Random parameters logit

A problem with both the CL and HEV models is that they assume that the coefficients of variables that enter the model are the same for all consumers, i.e. that there is homogeneity in preferences across respondents (MacDonald, Barnes, Bennett, Morrison & Young, 2005). This implies that consumers that exhibit the same socioeconomic characteristics, for example, level of income, will value the good in question in an equal manner (MacDonald *et al.* 2005). However, preferences are largely heterogeneous in nature. A model that relaxes the assumption of homogeneity is the RPL model.

The RPL model is a generalisation of the standard MNL logit model[15]. The advantages of this model are that (1) the alternatives are not independent because the model does not rely on the IIA assumption, and (2) the existence of unobserved heterogeneity can be investigated (Ben-Akiva, McFadden, Garling, Gopinath, Walker, Bolduc, Borsh-Supan, Delquie, Larichev, Morikawa, Polydoropoulou & Rao, 1999; Hensher & Greene, 2002; Carlsson *et al.* 2003). Early studies applying the RPL model in order to account for preference heterogeneity include Gopinath (1995), Bhat (1997), Revelt and Train (1998), and McFadden and Train (2000). More recent applications of the RPL model have indicated that it is superior to the CL model in terms of fit and overall welfare estimation (Carlsson *et al.* 2003; MacDonald *et al.* 2005; Kragt & Bennett, 2008).

A generalised version of the RPL choice model is (Louviere *et al.* 2000):

$$P(j \mid \mu_i) = \frac{\exp(\alpha_{ji} + \theta_j \mathbf{z}_i + \delta_j \mathbf{f}_{ji} + \beta_{ji} \mathbf{x}_{ji})}{\sum_{j=1}^{J} \exp(\alpha_{ji} + \theta_j \mathbf{z}_i + \delta_j \mathbf{f}_{ji} + \beta_{ji} \mathbf{x}_{ji})} \tag{4.8}$$

where:

[15] Increases in estimation capabilities through advancements in computational power have led to the RPL method becoming the most popular method of choice during the previous two decades.

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

δ_j is a vector of non-random parameters,

β_{ji} is a parameter vector that is randomly distributed across individuals; μ_i is a component of the β_{ji} vector,

$\mathbf{z}_i$ is a vector of individual-specific characteristics, for example, income,

$\mathbf{f}_{ji}$ is a vector of individual-specific and alternative-specific attributes,

$\mathbf{x}_{ji}$ is a vector of individual-specific and alternative-specific attributes, and

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

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

4.4.7 WELFARE CALCULATIONS

Once the appropriate model has been estimated (CL, HEV or RPL), the WTP for each attribute can be calculated. These estimates are also known as implicit prices.

4.4.7.1 Implicit price estimates

Implicit prices are point estimates of the value of a unit change in an attribute. They are calculated by determining the marginal rates of substitution between the attributes. This is done by using the coefficient for cost as the "numeraire" (Hanemann, 1984). The ratios of the attribute in question to the cost coefficient can be interpreted as the average marginal WTP for a change in each of the attribute values (Hanemann, 1984). If X = $X_1,\ldots, X_a$ attributes, then implicit prices can be derived using Equation 4.9 below:

$$IP = -\left[\frac{\beta_a}{\alpha}\right] \tag{4.9}$$

where:

IP is the implicit price,

β_a is the parameter estimate of the specific attribute X_a (Hanley, Wright & Alvarez-Farizo, 2006), and

α is the parameter estimate of the price variable.

In order for these welfare estimates to have relevance, the parameter estimates for each attribute need to be statistically significant (Hensher *et al.* 2005). It is important to provide estimates of the precision of welfare measures, i.e. standard errors and confidence intervals (Eggert & Olsson, 2004). Confidence intervals for an implicit price (a ratio parameter) can be formed by applying the delta method[16], which is based on a truncated Taylor series expansion (Cameron & Trivedi, 2005). Let $I\hat{P} = -\left[\frac{\hat{\beta}_a}{\hat{\alpha}}\right]$ be an estimate of implicit prices, where the mean parameters for the estimates, respectively, are provided by $E(\hat{\beta}_a) = \beta$ and $E(\hat{\alpha}) = \alpha$. Also, let the estimated variance-covariance matrix of the estimators $(\hat{\beta}_a, \hat{\alpha})$ be given by:

[16] The delta method can be applied in the LIMDEP NLOGIT Version 4.0 software by invoking the Wald command (Greene, 2007). Other options for forming confidence intervals include the Krinsky and Robb (1986) method and bootstrapping (Greene, 2007).

$$\begin{bmatrix} V_{11} & V_{12} \\ V_{21} & V_{22} \end{bmatrix}$$

where V_{11} and V_{22} show, respectively, the variance of $\hat{\beta}_a$ and $\hat{\alpha}$, and $V_{12} = V_{21}$ denotes the covariance between $\hat{\beta}_a$ and $\hat{\alpha}$. The variance of $I\hat{P}$ is estimated, using the delta method, by:

$$\hat{\sigma}^2 = \frac{1}{\hat{\alpha}^2}\left(V_{11} - 2I\hat{P}V_{12} + I\hat{P}^2 V_{22}\right) \qquad (4.10)$$

It can be assumed, that for a large sample size, $I\hat{P}$ has a Gaussian distribution with mean θ and variance σ^2 from which a (1 – α) percent delta method-based confidence interval may be calculated as $I\hat{P} \pm Z_{\alpha/2}\hat{\sigma}$, where $Z_{\alpha/2}$ is the (1 – α/2) percent quintile of the standard distribution (for example, for a 95 percent confidence interval α = 0.05 and $Z_{\alpha/2}$ = 1.96) and $\hat{\sigma}$ is the square root of the expression in Equation 4.10 (Cameron & Trivedi, 2005; Greene, 2007).

4.4.7.2 Compensating surplus estimates

Implicit prices provide estimates of WTP for improvements in attributes, but they do not provide estimates of WTP for a combination of attributes representing an improved management scenario (Birol *et al.* 2006a). In order to estimate the respondent's WTP for an improved management scenario, the compensating surplus (CS) needs to be calculated. The CS associated with an improvement from a specified constant base (V_C) to a change alternative (V_N) is given as:

$$CS = - (1/\alpha)(V_C - V_N) \qquad (4.11)$$

where:

α is the marginal utility of income,

V_C is the utility derived from the constant base, and

V_N is the utility derived from the change alternative.

Once implicit prices and CS estimates have been calculated and interpreted, their value must be determined by conducting validity and reliability tests.

4.4.8 VALIDITY AND RELIABILITY TESTING

Validity relates to how well a concept is defined by a measure, for example, marginal WTP, whereas reliability is concerned with the measures overall consistency (Desvousges, Johnson, Dunford, Boyle, Hudson & Wilson, 1993; Hair, Black, Babin & Anderson, 2010).

4.4.8.1 Validity

The validity of a measurement is the extent to which it accurately assesses the theoretical construct being investigated, by overcoming potential biases and the hypothetical nature of the study (Carson & Mitchell, 1993; EFTEC, 2002). In a CE context, the theoretical construct is the maximum amount of money that a consumer would pay for a combination of attributes that make up a composite good if an appropriate market existed for the good in question. This monetary amount, known as the WTP, is determined by providing the respondent with various scenarios from which a preferred alternative must be selected. More specifically, validity can be viewed as the extent to which a survey instrument overcomes bias and the hypothetical confines of the study in order to arrive at the closest approximation of the respondents' actual WTP values (Bateman *et al.* 2002). The approaches to assessing validity must make use of indirect methods. These include the implementation of content validity and construct validity tests.

a) Content validity

Content validity, also known as face validity, assesses the extent to which the content of the survey instrument is consistent with the definition of the theoretical construct (Hair *et al.* 2010). It is achieved if the survey instrument is such that the respondent feels motivated to answer it in a serious and thoughtful manner (Bateman *et al.* 2002). This occurs when the instrument is set out in a clear and understandable manner and does not suffer from biased questions or descriptions. The concept of content validity encompasses the entire CE study. It tests all the components that make up a CE application in order to persuade respondents to make informed and valid choices and reveal valid preferences. These components range from determining the sample frame and method of administering the survey instrument to checking the descriptions of the environmental quality scenarios (Bateman *et al.* 2002). The three main areas of focus when undertaking content validity testing are (1) basic design and implementation issues, (2) the good in question and its attributes, and (3) the payment description and its vehicle.

b) Construct validity

Construct validity is achieved if the measurement of interest, namely the implicit prices, are similar to implicit prices derived from other similar studies or are consistent with expectations (Bateman *et al.* 2002). If construct validity exists, it implies that the implicit prices derived from the study sample can with confidence be used to represent the actual implicit prices that exist in the population (Hair *et al.* 2010). The two types of construct validity are convergent validity and expectations-based validity.

<u>Convergent validity</u>

The convergent validity assessments compare results obtained from the CE study to (1) results obtained from other similar studies, (2) results obtained from other methods, for example, a CV study, and (3) results obtained from creating experimental simulated markets (Carson & Mitchell, 1993). Tests for convergence are often applied in environmental evaluation by comparing the study's implicit price estimates with estimates from another valuation technique, for example CV study estimates (Hanley *et* *al.* 1998a). It should be noted, however, that no method is entirely accurate. If one study produces a measure which is very similar to another, this does not automatically imply that these measures are valid, as both could be invalid (Bateman *et al.* 2002).

<u>Expectations-based validity</u>

Expectations-based validity is achieved if the measurements in question, the implicit price estimates, conform to theoretically sensible *a priori* expectations (Bateman *et al.* 2002). In other words, the implicit price estimates are consistent with economic theory. It is debatable to what extent economic theory can provide clear expectations regarding CE outcomes (Hanemann, 1996). Generally speaking, economic theory can be used to indicate the directionality of an effect, if it occurs, but it cannot be used to determine whether or not that effect will actually occur.

4.4.8.2 Reliability

An implicit price can be considered reliable if there is a high degree of consistency between responses from the individuals used to calculate the measure at two points in time (Hair *et al.* 2010). The objective of reliability testing is to ensure that choices made by respondents are not too varied over different time periods. Types of reliability testing methods include the test-retest method, the parallel testing method and the alternative form method. The test-retest method involves determining implicit price estimates for the same individuals at two different points in time. Classic test-retest experiments, however, have found WTP measurements to exhibit a variable degree of reliability (see Loomis, 1989; Teisl, Boyle, McCollum & Reiling, 1995). There could be valid reasons though for explaining differences in an individual's answers over time, for example, a change in a person's financial situation, or a change in their expenditure patterns (Bateman *et al.* 2002). The parallel testing method involves comparing the implicit price distributions from two independent, yet equivalent samples from the same population, but interviewed at different points in time. The alternative form method divides the sample into two parts and one part is re-estimated using a slightly different measurement method.

4.5 A CRITICAL ASSESSMENT OF THE CM METHOD

The CM method has, over the past two decades, evolved into a practical means of analysing peoples' preferences for environmental goods and services (Bennett & Blamey, 2001). This chapter has shown that a number of useful measures can be calculated from statistically robust estimates of choice models, namely the implicit prices of the attributes that make up a composite good and the CSs associated with varying the levels of the attributes that comprise the composite good.

The merits and demerits of the CM method are considered here by comparing it to an alternative stated preference method, namely the CVM. One of the most important shortcomings of the CVM is that it is incapable of "generating multiple value estimates from a single application" (Bennett & Blamey, 2001). This shortcoming is especially relevant when dealing with the valuation of the recreational and environmental attributes of an estuary (a composite good). The application of the CVM in this case would require the execution of separate CV studies for each recreational and environmental attribute.

Unlike the CVM, the CM approach allows for the decomposition of the values of an environmental resource's constituent parts in a single application. In a discrete choice CV study, the respondent makes a binary choice, but a CM study requires the respondent to make several choices and trade-offs between different resource use alternatives (Hanley *et al.* 2001). An extensive data set that contains a large amount of detail in terms of consumer preferences (Bennett & Blamey, 2001) is thereby created. This has advantages in terms of the amount of information available for resource use decision making, and can provide a wealth of information to policy makers.

The CVM has also been criticised for not providing respondents with the necessary 'frame' in which to consider preferences for non-marketed goods (Bennett & Blamey, 2001). Unlike the CV study, CM studies do not focus on a specific scenario, as this could make the respondent believe that this case was of specific importance. The CM method is superior to the CVM in this case, as it allows more than one specified scenario within the 'frame' of reference. A 'disguise' is offered in terms of different scenarios. All scenarios or alternatives are included in the 'frame' and receive equal weighting in the mind of the respondent. This 'frame' provides a broader context in which to value the environmental good and its characteristics (Bennett & Blamey, 2001). In CV studies, respondents are asked to explicitly and directly state their WTP for a specific bundle of goods (Hanemann, 1994). The CM method, by way of contrast, indirectly infers WTP, and by so doing, reduces the problems of protest bids and 'yea' saying (Bateman *et al.* 2002).

Another problem with CV applications is that, in many cases, they are unable to show the impact on WTP estimates of a change in the scope of the good in question (Carson & Mitchell, 1993; Bennett & Blamey, 2001; Carson, Flores & Meade, 2001). For this reason, Arrow *et al.* (1993) recommended that all CV studies carry out scope tests in order to determine whether there is 'embedding'. This adds to the cost of carrying out a CV study. The risk of 'embedding' in CM studies is greatly reduced, as internal tests of scope are automatically run when model estimation occurs. In addition, if the choice sets presented to the respondent are complete and well designed, the respondent will not mistake the "scale of the resource with something that it could be embedded in" (Birol *et al.* 2006b).

Both CV and CM studies can be subject to strategic biases, but there are certain factors that serve to decrease this bias in CM applications. Firstly, strategic bias in CM studies can be minimized as the prices of the good in question are already specified (Birol *et al.* 2006b). This makes it more difficult to construct a strategy of behaviour in a CM study in respect of the pricing mechanism. Secondly, the CM method hides the purpose of the study by providing the respondent with different attribute characteristics, as well as different price levels. This 'disguise' retards the development of any strategic behaviour on the part of the respondent.

Although it is widely acknowledged that the CM method is superior to the CVM (Adamowicz, Louviere & Williams, 1994; Adamowicz, 1995; Adamowicz *et al.* 1998;

Louviere *et al.* 2000; Adamowicz & Boxall, 2001; Bennett & Blamey, 2001; Hensher *et al.* 2005) it also has a number of weaknesses.

The CM method requires that respondents carry out a number of choice tasks (Hanley *et al.* 2001). The degree of complexity of a choice task depends on the number of alternatives per choice set, the number of attributes that make up or describe each alternative, the levels of the different attributes, and the number of repetitions made (Bennett & Blamey, 2001). This task complexity, coupled with the cognitive burden on the respondent, can lead to 'respondent fatigue', i.e. the respondent simplifying their required choices by using simple decision strategies or heuristics, rather than genuinely weighing up the alternatives before choosing (Swait & Adamowicz, 2001).

Although the CM method has an advantage over the CVM in terms of 'framing', the 'frame' can easily be incorrectly specified in the CM application. A 'framing' statement should be included that reminds respondents of their other financial commitments and budgetary constraints (Bennett & Blamey, 2001). The use of "cheap talk" can mitigate this problem (Cummings & Taylor, 1999).

A study conducted by Carson, Hanemann, Kopp, Krosnick, Mitchell, Presser, Ruud and Smith (1997) revealed that a CM study that includes more than two alternatives in each choice set adds a degree of freedom in terms of strategic behaviour. Certain management alternatives might be identified as having a low probability of being implemented and thus would not be chosen by the respondent. This could occur through the use of improper labels.

Due to the fact that the CM study is more complex in terms of its structure and focus, the contingencies it contains must also be more complex. The respondents understanding of the CM application is contingent on the questionnaire including clear descriptions of the alternative scenarios, as well as the purpose and meaning of the study.

The level of technical complexity of a CM application far exceeds that of a CV application. This difference is most noticeable in the design stage, as the CM application requires an experimental design on which to base the development of the choice sets. Many of the technical complexities of this technique still need to be explored.

The CM method is more costly than the CVM in the development of the experimental design. The latter needs to be tested through the use of focus groups and pilot surveys, which is costly and time-consuming.

Despite these weaknesses, the CM method remains a highly appropriate technique by which to value the recreational services provided by an estuary. The most compelling reason for choosing this technique over the CVM is its ability of "generating multiple value estimates from a single application" (Bennett & Blamey, 2001).

4.6 CONCLUSION

Chapter Four has shown that the choice experiment method has the potential to generate the information required for the effective management of the identified recreational challenges facing the Sundays River and Kromme River Estuaries. When the challenges are related to the recreational attributes of an estuary, each attribute can be defined with levels that represent both the challenge and a potential improvement. The inclusion of a cost attribute allows for monetary trade-offs between the identified recreational challenges for each estuary.

With respect to the Sundays River Estuary, monetary trade-offs estimated could (1) provide information regarding the size of a proposed increase in the existing license fee structure necessary to decrease fishing effort, (2) provide information regarding the size of a supplementary tariff that will decrease the number of boats to levels that are within safety regulations, and (3) provide a willingness-to-pay value for improvements in the recreational appeal of banks.

In the case of the Kromme River Estuary, monetary trade-offs estimated could (1) provide information on the size of an additional tariff that can be levied on boat users of the estuary to fund dredging operations, (2) provide information regarding the size of a supplementary tariff that will decrease the number of boats on the estuary to levels that are within safety regulations, and (3) provide information on users' willingness-to-pay to gain access to the entire estuary for the use of jet skis and wet bikes.

Chapter Five applies the various stages of the choice experiment method to the Sundays River and Kromme River Estuaries in order to estimate these trade-offs.

CHAPTER FIVE: THE DESIGN OF THE CHOICE EXPERIMENTS AS APPLIED TO THE SUNDAYS RIVER AND KROMME RIVER ESTUARIES

5.1 INTRODUCTION

Chapters Five and Six apply the CE method to assess the trade-offs users make in their recreational choices at the Sundays River and Kromme River Estuaries (sub-objective three in Chapter One). The design of the sample, the design of the CE survey instruments, the testing of them by means of a pilot survey, the administration of the improved questionnaires, and the capturing of the collected data are reported in Chapter Five. Existing literature and expert consultations were used to determine relevant policy scenarios for the valuation of the sustainability of the recreational services provided by these estuaries (Hasler *et al.* 2005). Chapter Six shows how relevant welfare measures can be calculated and Chapter Seven assesses the use of these to help policy makers prioritise alternative management actions.

5.2 RECREATIONAL CONCERNS ELICITED FROM FOCUS GROUP DISCUSSIONS

The focus group discussions are fundamentally an important stage of a CE analysis. They inform the analyst which management challenges need to be addressed. The findings of this stage were reported in Chapter Two, section 2.3.2.

5.3 SAMPLE DESIGN

The sample design of this study entailed three distinct steps, namely selecting the target population, specifying the sample frame, and calculating the sample size. The calculation of the sample size was based on a non-probability quota sampling technique. These steps are described below.

5.3.1 THE TARGET POPULATION

The populations of interest with respect to both the Sundays River and Kromme River Estuaries were all users and potential users (current non-users) of the recreational services provided by each estuary. These populations included all individuals who, at the time of the survey, made use of the estuaries for recreational purposes, as well as those individuals who had high potential to make use of the estuaries for recreational purposes in the future. It was not feasible to survey the entire target population for each estuary.

5.3.2 THE SAMPLE FRAME

A sample frame for each estuary cannot be compiled, as this population does not reveal itself until it visits the estuary. The steps taken in generating knowledge about the sample frames for each estuary are discussed below.

5.3.2.1 Sundays River Estuary

A sample frame for the Sundays River Estuary should be a list of all the users and potential users of the recreational services provided by the estuary. The only list that existed was one for the holders of boat licenses. The use of this list was rejected for two reasons: firstly, boat license holders constitute a fraction of all the current users of the Sundays River Estuary; and secondly, a boat license is issued for several estuaries located in close proximity to each other. For example, a boat license issued for the Sundays River Estuary may also be used for the Swartkops Estuary and vice versa. Fishing and bait collecting permits cannot be used as a source of information as they are anonymously issued by the Post Office, and allow fishers and bait collectors to carry out their activities within a large coastal area. There is no official list of recreational fishers and bait collectors for the Sundays River Estuary. Other recreational activities also provided by the estuary are mentioned in Table 5.2 below. These activities are not subject to government regulation, and the users who carry out these activities, most often are not organised through club structures (such as walkers and those who enjoy picnicking).

5.3.2.2 Kromme River Estuary

The Kromme River Estuary provided similar difficulties in terms of the specification of a sample frame. The use of a list that captures boat license holders could not be used from which to draw a representative sample, as this list did not capture all the users and potential future users of the recreational services provided by the estuary in question. The boat license list also included individuals who never made use of the Kromme River Estuary (only other estuaries in the area). Fishing and bait collecting permits could not be used as a source of information for this estuary, given their anonymity. The other main recreational activities provided by this estuary are not regulated.

5.3.2.3 Sampling with 'knowledge' of the sample population

As it was impossible to identify a sample frame, the closest to this objective was knowledge of the sample population and use of this knowledge to sample select. This form of non-list sampling can be used when the target population refers to visitors to a beach, or in this case, an estuary (Bateman *et al.* 2002; Dillman *et al.* 2009). Timeliness is very important when attempting to sample the recreational users of an estuary, as they ideally need to be sampled when they are actually engaged in carrying out the recreational activities. This requires on-site sampling, and is known as an intercept survey (Bateman *et al.* 2002). In the case of the Sundays River and Kromme River Estuaries, intercept surveys were a suitable technique for sample selection (Dillman *et al.* 2009). This type of survey method was also used in other estuary service valuation studies, such as the one that valued the recreation and resources of the Peconic Estuary System, United States of America (Opaluch *et al.* 1999). One of the many weaknesses of intercept surveys is that the nature of the visitors differs at different times of the year. During these surveys, every n^{th} recreational user is approached, but the sampling period was over the peak summer season.

The representativeness of intercept surveys can also be undermined by the greater readiness of some respondents to be interviewed, but this problem may also be present when a sample frame has been identified.

The knowledge of the user population was applied by alerting the interviewers to approach the estimated proportion of each population type in executing their intercept strategy.

a) The Sundays River Estuary recreational status and user groups

To identify the recreational status of the users of the Sundays River Estuary, knowledge of the sample population was derived from Forbes (1998) and, more recently, Cowley *et al.* (2009). These studies surveyed various aspects of recreational activity on the estuary with special reference to fishery resource utilisation. The Forbes (1998) study related to activities on the estuary for the period December 1995 to April 1996, while the Cowley *et al*. (2009) study entailed a survey of the fishery resource utilisation and recreational activities on the estuary for the period September 2007 to August 2008. Table 5.1 below compares these two studies and Table 5.2 details the observed activities recorded during the Cowley *et al.* (2009) survey.

Table 5.1: The recreational status of the Sundays River Estuary users (percent)

Recreational Status	**Forbes (1998)**	**Cowley *et al*. (2009)**
Resident	24.7	18.6
Visitor	75.3	81.4

Source: Forbes (1998) and Cowley, Childs & Bennett (2009)

Table 5.2: Observed activities for the Sundays River Estuary

Activity	Percentage (%)[1]
Recreational Shore Fishing	32.4
Recreational Boat Fishing	18.7
Boating	11.2
Recreational Bait Collecting	8.9
Recreational Fishing Boats Moving in Estuary	5.5
Subsistence Fishing	2.8
Water Skiing	2.5
Paddling	1.7
Subsistence Bait Collecting	1.4
Jet Skiing	0.5
Launching/Retrieving Boats	Not Specified
Walking	Not Specified
Running	Not Specified
Washing Clothes	Not Specified
Research	Not Specified
Walking the Dog	Not Specified
Swimming	Not Specified
Picniking and Relaxing	Not Specified
Fishing in the Surf	Not Specified
Boat and Jetty Maintenance	Not Specified

Source: Cowley, Childs & Bennett (2009)

Note: The total percentage of the unspecified observed activities equals 14.4 percent.

For ease of interpretation, all recreational fishing-related activities were grouped together (shore fishing, boat fishing, bait collecting, and fishing boats moving to and from fishing spots). All subsistence fishing-related activities were excluded, namely fishing and bait collecting. The recreational boating user group was defined as one that is involved with general boating activity, i.e. motorised boating activities unrelated to fishing. Other recreational user groups included those involved with skiing, paddling (rowing, canoeing and kayaking activities unrelated to fishing), jet skiing, walking, running, walking the dog, swimming, and picnicking and relaxing. Table 5.3 below shows these proportions for the Sundays River Estuary (Forbes (1998) study and Cowley *et al.* (2009) study).

Table 5.3: Composition of the user population for the Sundays River Estuary

Recreational Use	Percentage (%)	
	Forbes (1998) Study	Cowley *et al*. (2009) Study
Recreational Fishing	33.9	74
Boating	17.4	13
Water Skiing	18.9	3
Paddling	4.9	2
Jet Skiing	1.3	0.5
Walking	1.75	1.5
Running	1.75	1.5
Walking the Dog	1.75	1.5
Swimming	16.6	1.5
Picnicking and Relaxing	1.75	1.5

Source: Forbes (1998) and Cowley, Childs & Bennett (2009)

Note: In order to calculate the percentages for the unspecified observed activities, for example, walking, and running, the cumulative percentages were divided by the number of activities.

b) The Kromme River Estuary recreational status and user groups

Less information could be gained about the composition of the Kromme River Estuary user population (see Tables 5.4 and 5.5).

Table 5.4: The recreational status of the Kromme River Estuary users (percent)

Recreational Status	Percentage (%)
Resident	18.9
Visitor	81.1

Source: Forbes (1998)

Table 5.5: Observed activities for the Kromme River Estuary

Recreational Use	Percentage (%)
Recreational Fishing	22
Boating	17.9
Water Skiing	18.5
Paddling/Canoeing	6.3
Jet Skiing	1.2
Windsurfing	9.2
Swimming	24.3
Other	0.6

Source: Forbes (1998)

Forbes (1998) found swimming to be the most popular recreational pursuit, but not the most popular first choice for an activity. This choice was recreational fishing (34 percent), followed by water skiing (22.6 percent), swimming (30.2 percent) and boating (9.4 percent). The boating user group was defined as water craft usage for pleasure or leisure cruising, unrelated to recreational fishing (Forbes, 1998). Other recreational user groups included those involved with skiing, paddling (rowing, canoeing and kayaking activities unrelated to fishing), jet skiing, and windsurfing.

5.3.3 DETERMINATION OF SAMPLE SIZE

The sample populations of recreational users for the Sundays River and Kromme River Estuaries can be grouped into overlapping strata (see Table 5.3 and Table 5.5 above). In an ideal setting (a labelled experiment), with a known population and sample frame, and known market proportions, the appropriate sample size can be determined with the simple random sample equation. In this study, a definitive population and sample frame were not available, so it was impossible to define market proportions. A stratified random sampling technique was employed using the simple random sample equation (Equation 4.4, Chapter Four). Sample size was estimated using Microsoft Excel (see Table 5.6) and the information contained in Tables 5.1, 5.3, 5.4 and 5.5 was used to partition the estimated total sample size for each estuary into recreational user status groups and recreational user activity groups.

Table 5.6: Sample size estimation for the Sundays River and Kromme River Estuaries

Alternative in Choice Set (Unlabelled)	Reported Choice Proportion (p)	Allowable Deviation (a)	$1 - p$ (q)	1-α/2	$\Phi^{-1}(1 - \alpha/2)$ (Z)	Z^2	Minimum Number of Choices per Questionnaire (r)	Sample Size for One Choice Set Alternative (N)	N/r
A	0.5	0.09	0.5	0.955	1.69	2.87	4	354	88
B	0.5	0.09	0.5	0.955	1.69	2.87	4	354	88

Each choice set used in the Sundays River and Kromme River Estuary CEs employed two unlabelled alternatives (denoted by A and B in Table 5.6 above). Each respondent (decision maker) was shown four choice sets. It was assumed for the purposes of this study that the reported choice proportion (p) for each alternative in a given choice set was 50 percent. The allowable deviation (a) was set at 9 percent. The inverse cumulative normal distribution function, $\Phi^{-1}(1 - \alpha/2)$, denoted by Z in Table 5.6, was taken at (1-α/2) (Hensher *et al.* 2005).

Equation 4.4, from Chapter Four estimates the sample size if each decision maker is asked to make one choice only. If decision makers are shown more than one choice set, the minimum number of decision makers that need to be surveyed is equal to the sample size calculated for one choice set alternative (N) divided by the number of choice sets (r) per questionnaire. Thus, for each estuary, using the simple random sample formula, the minimum sample size required is 176 (= 88 + 88) respondents (decision makers). This must firstly be stratified by the recreational status of the user and then by recreational activity. The strata sample sizes calculated for the Sundays River Estuary using the overall population proportions from Table 5.1 and Table 5.3 are displayed in Table 5.7 below.

Table 5.7: Strata sample sizes for the Sundays River Estuary

Stratum 1	Sample Size		Stratum 2	Sample Size	
	Forbes (1998) Study	Cowley *et al.* (2009) Study		Forbes (1998) Study	Cowley *et al.* (2009) Study
Resident	43	33	Recreational Fishing	60	130
Visitor	133	143	Boating	31	23
			Water Skiing	33	4
			Paddling	9	3
			Jet Skiing	2	1
			Walking	3	3
			Running	3	3
			Walking the Dog	3	3
			Swimming	29	3
			Picniking and Relaxing	3	3

Source: Calculations based on percentages from Forbes (1998) and Cowley, Childs & Bennett (2009)

The strata sample sizes calculated for the Kromme River Estuary using the overall population proportions from Table 5.4 and Table 5.5 are displayed in Table 5.8.

Table 5.8: Strata sample sizes for the Kromme River Estuary

Stratum 1	Sample Size	Stratum 2	Sample Size
Resident	33	Recreational Fishing	39
Visitor	143	Boating	32
		Water Skiing	33
		Paddling/Canoeing	11
		Jet Skiing	2
		Windsurfing	15
		Swimming	43
		Other	1

Source: Calculations based on percentages from Forbes (1998)

The use of the sample size formula (Equation 4.4) gives an idea of what the sample size should be if the sample frame and market shares for each alternative are known.

A non-probabilistic sampling technique was used in this study as respondents were sampled according to the strata outlined in Tables 5.7 and 5.8 above. The total number of respondents, however, must still be determined.

A '*rule of thumb*' approach was used to calculate the minimum sample size required to estimate a model of choice using unlabelled experiments and design attributes only - a sample of 50 respondents each exposed to 16 choice sets is deemed acceptable (Bennett & Adamowicz, 2001). This translates into a sample of 200 respondents if they are offered 4 choice sets each.

5.4 DESIGNING THE SURVEY INSTRUMENT

The primary goal of the survey instruments designed for the Sundays River and Kromme River Estuaries was to value users' preferences for improvements in recreational services provided by each estuary.

5.4.1 QUESTIONNAIRE DEVELOPMENT

Questionnaire development for the Sundays River Estuary took place over the four month period from March 2010 to July 2010 (see Appendix B). The development of the Kromme River Estuary questionnaire took place over the three month period from September 2010 to November 2010 (see Appendix C). The process of questionnaire development for both estuaries included expert interviews, and the implementation of focus groups and pilot studies. One of the key elements in designing a survey instrument is to keep the format and language simple and consistent across all sections. A useful resource to aid the drafting of a questionnaire is Dillman *et al*.'s (2009) publication (Hensher *et al.* 2005). This source was consulted whilst drafting the questionnaires for this study. Different word choices were pretested in order to evaluate the ease of understanding of the various wording combinations for respondents. This pretesting is essential in a context where there might be cultural and language differences between researchers and the study participants (Mangham, Hanson & McPake, 2009). The questionnaire was also presented to the respondents in the pilot study to determine whether there was any ‘respondent fatigue’, i.e. if the questionnaire was too long. The aim of the pilot study was to develop a concise, clear and consistently written questionnaire. Specific details in respect of the development of the questionnaires were discussed separately for each estuary.

5.4.1.1 Sundays River Estuary

The development of the Sundays River Estuary questionnaire began with a meeting with two scientists from the Zoology department in the Faculty of Science at NMMU, namely Prof T Wooldridge and Prof J Adams. These interviews helped clarify the research area, and the concerns facing the various interest groups making use of the estuary for recreational purposes. An informal telephonic interview was then conducted with Prof P Cowley from the Zoology department in the Faculty of Science, Rhodes University, Grahamstown, who provided detailed information on the population of users of the Sundays River Estuary and also information regarding recreational fishing activities.

Informal interviews followed with the Chairman of the Sundays River Joint River Forum, as well as members of the Sundays River Ratepayers Association. They were asked to list their concerns regarding the recreational use of the estuary, and to rank them in order of importance. This information, together with that provided by the experts, led to the development of a pilot questionnaire. A pilot study was then conducted in order to ‘fine tune’ the questionnaire. During the pilot study a significant problem was identified - a lack of understanding of the way to answer the CE section of the questionnaire. The impression some respondents gained was that only one choice had to be made out of all four choice sets given. In order to correct this potential problem, prior to the main survey, an example choice set with a hypothetical choice already made, was included in the questionnaire.

5.4.1.2 Kromme River Estuary

The development of the Kromme River Estuary questionnaire began with two meetings in St Francis Bay. The first was with a member of the Kromme River Riparian Association. The second was with a member of the Kromme River Trust and the Chairman of the Kromme River Angling Club. After these meetings, various email communications were received, which highlighted the main concerns facing the users of the estuary. In consultation with various member organisations, these concerns were placed in order of importance. This information informed the development of a pilot questionnaire. In order to refine the wording and layout of the questionnaire a pilot study was then conducted in St Francis Bay through the use of a focus group. There were problems experienced by the members of the focus group. They included (1) not understanding the area covered by the term 'estuary', and (2) not including a specific question relating to the matter of bait collection. The first problem was rectified by defining the Kromme River Estuary as the 'tidal portion'. The second problem was dealt with by adding a question relating to users' perceptions of the severity of illegal bait collection in the area.

The development of the Sundays River Estuary and Kromme River Estuary questionnaires followed the design steps proposed by Hasler *et al.* (2005). These steps include (1) the collecting of introductory information from the respondent through the use of an introductory section, (2) the setting out of the CE with relevant descriptions of the attributes and levels, (3) the provision of follow-up questions, which allow for reliability and validity checks, and (4) the collection of socio-demographic information from the respondent. The questionnaire is discussed below.

5.4.2 INTRODUCTORY QUESTIONS

It is important to ensure that all respondents have access to the same information before attempting to make choices for a CE. The amount of detail provided to the respondent, however, must not be too extensive as this can lead to respondent boredom. It must be sufficient to provide the respondent with a clear idea of the study's main objective, and increase the respondents understanding of the constructed choice scenarios presented in the next section of the questionnaire. In this section questions were asked regarding the respondent's attitude to the estuarine environment, the recreational problems facing the estuary, the importance of flora and fauna in the area, and the role of government in protecting estuaries in a sustainable manner. One of government's main concerns when dealing with the recreational use of estuaries is whether these estuaries are being used in a sustainable manner. When establishing what policy initiatives need to be put in place, it is important for government and other stakeholders to be aware of the attitudes of estuary users.

5.4.2.1 Sundays River Estuary

The Sundays River Estuary recreational users were asked to rank their attitudes to the estuary on a 5-point Likert scale, with '1' representing 'Strongly Agree' and '5' representing 'Strongly Disagree'. There was also a 'Don't know' option that could be chosen if respondents were not sure of their answer. The questions regarding their attitudes included how they felt about:

- the responsibility of government in the protection of the estuary;
- the level of congestion on the estuary;
- recreational over-fishing;
- public access to the estuary; and
- sustainability of animal and plant life in the estuary.

Questions regarding the respondent's use of the estuary were also included in this section. More specifically, respondents were asked if they had visited the Sundays River Estuary in the past year, and if so, how many times had they visited it.

The Sundays River Estuary is frequented mostly for its residential and holiday recreational appeal. This estuary facilitates a large number of outdoor recreational activities. In consultation with various user groups, the following main recreational uses for the Sundays River Estuary were identified as:

- Recreational Shore Fishing
- Recreational Boat Fishing
- Power/Speed Boating
- Water Skiing
- Paddling
- Jet Skiing
- Swimming
- Bird Watching

The respondents were asked which of these recreational use activities they participated in when visiting the estuary. Respondents could tick off as many activities as they participated in. They were not restricted to one choice only.

This estuary has a problem with regard to the over-exploitation of certain fish species and high illegal retention of undersized fish. For this reason, a follow-up question was posed to active recreational fishing respondents, namely whether they knew what the legal requirements were in terms of size and bag limits for the fish species under threat.

Another problem facing the estuary is limited public access. There are a large number of informal jetties that have been constructed in a public area, but are treated as if privately owned. With this in mind, respondents were asked which of the following options they would prefer: (1) free public access to all jetties allowed by management, (2) the payment of a levy for the sole usage of a jetty, or (3) no payment required for sole usage of a jetty, only permission from the responsible institution.

5.4.2.2 Kromme River Estuary

The Kromme River Estuary recreational users also ranked their attitudes to the estuary on a 5-point Likert scale, using the same categories as the Sundays River Estuary questionnaire. The questions regarding the respondents' attitudes to the Kromme River Estuary included how they felt about:

- the responsibility of government in the protection of the estuary;
- the level of congestion on the estuary;
- reduced navigability due to sedimentation;
- the potential use of jet skis/wet bikes on the estuary;
- sustainability of animal and plant life in the estuary; and
- uncontrolled, commercial and illegal bait harvesting.

The next section included questions relating to the respondents status, i.e. if they were residents or visitors. Questions regarding the respondent's use of the estuary were also included in this section. More specifically, respondents were asked how many times they had visited the Kromme River Estuary in the past year. The Kromme River Estuary is very popular as a recreational destination. The following main recreational uses for the Kromme River Estuary were identified:

- Recreational Shore Fishing
- Recreational Boat Fishing
- Power/Speed Boating
- Water Skiing
- Wind/Kite Surfing
- Paddling
- Sailing
- Jet Skiing
- Swimming
- Bird Watching
- Walking

The respondents were asked which of these recreational use activities they participated in when visiting the estuary. Respondents could tick off as many activities as they participated in.

During the focus groups, it was mentioned that the condition of the launching site and road at the bridge was inadequate to service the number of boats using the estuary. The questionnaire also sought to gauge respondents' attitudes in respect of the state of these public access facilities.

The issue of jet skis/wet bikes in the estuary was also an area of concern to various interest groups. Some focus group participants wanted the ban on jet skis/wet bikes removed, whilst others regarded the use of jet skis/wet bikes on the estuary in an unfavourable light and were against lifting the ban, even in the presence of stringent regulations on their use. There was also debate regarding the correct classification of jet boats on the estuary. In order to determine individuals' preferences with regard to the potential use of these jet-propelled craft, respondents were asked questions relating to jet boat and jet ski classifications.

The introductory questions that were included in both estuary questionnaires were aimed at 'warming up' the respondent to the task at hand. They also gave the respondents a chance to think about the important aspects of the valuation problem. The CE section of the questionnaire is covered in the next section.

5.4.3 THE CHOICE EXPERIMENT SECTION OF THE QUESTIONNAIRE

5.4.3.1 Selecting attributes and levels

The first step in the development of a discrete CE is the identification of the attributes of interest and the specification of levels for each attribute chosen (Ryan, Bate, Eastmond & Ludbrook, 2001; Hensher *et al.* 2005; Yacob & Shuib, 2009). The four attributes defined included three qualitative attributes relating to the effects of different management options in relation to the quality of estuarine services and the estuarine environment, and one quantitative attribute which specified the cost/price of the option. The qualitative attributes were used because respondents relate more confidently to these. Qualitative attributes are considered less cognitively demanding (Hasler *et al.* 2005). The different attributes and their levels were described in a 'neutral' manner. Choices are made according to the respondent's tastes and preferences and therefore any descriptions within the CE should not include phrases and/or words that were leading in nature.

The inclusion of a monetary attribute was necessary in order to facilitate the derivation of monetary values that respondents could attach to the qualitative effects of different management options. The payment vehicle selected for both estuaries was an annual environmental levy[17]. This was found to be the most understandable and least controversial option out of those discussed in the focus groups. The specific attributes and levels for each estuary are discussed below.

a) Sundays River Estuary

The attributes of the Sundays River Estuary CE are presented in Table 5.9 below. The attribute levels in Table 5.9 were derived from expert interviews and recreational user discussions.

[17] The environmental levy proposed would only apply to those who already have boat licenses or fishing permits.

Table 5.9: The Sundays River Estuary attributes and their levels

Indicator/attribute	Levels	Description of levels
Physical size of fish stocks caught	Mostly small fish now	Catch and retain whatever fish species you want 'today'
	None now but bigger and more fish next year	Keep no undersize fish now but more and bigger fish next year
Congestion	Hear and see few boats	The recreational user sees and hears a few boats
	Hear and see many boats	The recreational user sees and hears many boats
More public access	Yes	Establish a path access along the banks of the estuary
	No	Do not establish a path access along the banks of the estuary

Each of the three attributes presented in Table 5.9 assumed two different levels.

The written description of the monetary attribute, or cost variable, was:

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

This cost variable was expressed by four different Rand values in the CE. The designer considered it to be a "credible, relevant, acceptable and coercive" payment vehicle (Bateman *et al*. 2002).

b) Kromme River Estuary

The attributes of the Kromme River Estuary CE are presented in Table 5.10 below. The attribute levels in Table 5.10 were derived from informal interviews and focus group discussions.

Table 5.10: The Kromme River Estuary attributes and their levels.

Indicator/attribute	Levels	Description of levels
Level of estuary navigability	Ideal navigability	The estuary is completely navigable at any tide
	Current navigability	Parts of the estuary are not navigable at low tide. At mid to high tide, it is navigable only with detailed knowledge of fluctuating channels
Boat congestion	Hear and see few boats	The recreational user sees and hears a few boats
	Hear and see many boats	The recreational user sees and hears many boats
Potential use of jet skis/wet bikes	Unbanned, with enforced regulation	Let jet skis and wet bikes use the estuary, but in a regulated manner with very strict law enforcement
	Banned	Keep the ban on jet skis and wet bikes in place

The three attributes presented in Table 5.10, assumed two different levels. These qualitative attributes were set in order to assess the change in the level of welfare associated with the choice of one option over the other.

The written description of the monetary attribute, or cost variable, was:

"It is assumed that the cost of providing these recreational use alternatives is ***partly*** *covered by the Kromme River Estuary's boat license holders. We ask you to imagine that all boat license holders will contribute equally by means of a fixed annual sum added to the existing boat license structure, and this annual sum will then be directed back to the*

Kromme River Estuary. This annual sum can take four different values, namely R0 (current situation), R85, R169 and R507."

This cost variable was expressed by four different Rand values in the CE. The designer considered it to be "credible, relevant, acceptable and coercive" (Bateman *et al.* 2002).

5.4.3.2 Construction of the choice sets

a) The number of alternatives

As mentioned in Chapter Three, the alternatives which respondents were asked to choose from in the CE each represented different policy proposals concerning future estuarine resource management. The number of alternatives presented to each respondent in the context of environmental valuation is ideally not more than two to three per choice set (Adamowicz & Boxall, 2001). For the purposes of this study, two alternatives were adopted for each estuary. This number was considered appropriate as more than two alternatives can become demanding for the respondent in terms of cognitive burden. During focus group discussions, the users of both estuaries revealed a preference for fewer alternatives per choice set. The alternatives presented to the respondents in each choice set were left as unlabelled, so as not to distract the respondents' attention away from the attribute levels to the labels (Blamey, Bennett, Louviere, Morrison & Rolfe, 2000).

b) The inclusion of a status quo or 'opt-out' option

A large number of valuation studies advocate the inclusion of a status quo or 'opt-out' alternative. Literature suggests that if one is not included, the respondent is forced to pick a scenario that is not necessarily favoured. The inclusion of a status quo or 'opt-out' option, however, is not always recommended (Qin, 2008). It can create new biases (Scarpa *et al.* 2004). It also provides an 'easy way out' for respondents if they want to avoid the choice task (Dhar & Simonson, 2001; Kontoleon & Yabe, 2003). It might also be impossible to include a status quo alternative if the current or base scenario is not a relevant or feasible option (Adamowicz & Boxall, 2001).

For the purposes of this study, a status quo alternative was not included for either estuary. The reason for this was twofold: first, it was difficult to define a status quo option as some of the current recreational uses pertaining to both estuaries can be defined as illegal activities (for the Sundays River Estuary, bag and size limits are not adhered to; for the Kromme River Estuary, jet skis and wet bikes are often ridden in prohibited areas). Second, it was not thought necessary to include a status quo alternative if the study is assumed to guide policy-making (Hasler *et al.* 2005).

c) Number of choice sets per respondent

The number of choice sets that each respondent must face is considered to be inversely proportional to the complexity of the task at hand (Bateman *et al.* 2002). There are three qualitative attributes with two levels each, and one cost variable with four levels. This number represents a fairly low task complexity, but the effects of task complexity were not investigated in this study. Most studies recommend a maximum of six choice sets be presented to a respondent (Hasler *et al.* 2005; Bateman *et al.* 2002) in order to make the choice task manageable and not cognitively burdensome.

5.4.3.3 Experimental design

Each estuary had four attributes. Three of the attributes had two levels each, and one had four levels. A full factorial design (2x2x2x4 = 32) was generated using SPSS, yielding 32 different treatment combinations or alternatives. These alternatives were randomly allocated to 32 different questionnaires containing four choice sets each. Each choice set had two alternatives.

5.4.3.4 The budget constraint and the inclusion of "cheap talk"

Even though the effects of "cheap talk" within a CE context are inconclusive, it was decided to include a short "cheap talk" section in the design of each questionnaire. In comparison to other international studies conducted, the length of the "cheap talk" section included in the questionnaires was significantly shorter - only a couple of lines. It was felt that the inclusion of an extensive "cheap talk" section was inappropriate, since it was expected that the negative impacts of increasing the length of the questionnaire would by far exceed the potential benefits arising from the inclusion of a lengthy “cheap talk” section. Due to its brevity, it may be questioned whether the “cheap talk” section included in these questionnaires actually qualifies as “cheap talk”.

In both the questionnaires, information on the CE payment was specified so that the respondents were aware of the payment vehicle, as well as the need to consider the constraints on the household’s budget. The assumptions with respect to the payment were (1) that the costs of implementing the policy alternatives would be covered by each estuary’s recreational users, and (2) that all users would contribute equally to the implementation of the scenarios by means of a fixed annual sum per household. This sum was to be paid once a year via an environmental levy. The “cheap talk” section was phrased as follows:

“It is important to remember that this recreational use management project is only one of many such projects in South Africa. Also, be aware that spending more money on any alternative would mean that you would have less money to spend on all other goods and services, i.e. you face a budget constraint.
Please note that the choices are hypothetical, but plausible (based on advice from scientists). It is important to treat each of your four choices as if they were real, and independent from each other.”

5.4.4 ADDITIONAL QUESTIONS

As discussed in Chapter Four, a section of follow-up questions should be included after the choice task. The follow-up questions for both the Sundays River Estuary and the Kromme River Estuary questionnaires were exactly the same, except for one.

In both questionnaires, four questions were asked immediately after the choice task regarding respondents’ experiences of the choice exercise and how they made their choices.

The first of these questions (Question 4.1) asked whether the respondents found it easy or difficult to make the choices in the choice sets (Question 3). The aim of this question was to elicit feedback on the reliability of their choices.

If respondents indicated that the choice task was difficult, i.e. answered 'Yes' to Question 4.1, they were subsequently asked in Question 4.2, what had made the choice tasks difficult for them. The categories included in this question were:

- I could not relate to the questions;
- I think there was too much information to consider;
- I did not understand the questions;
- I think the alternatives were too expensive;
- It was difficult to choose as several factors were important;
- I do not believe Estuary users should pay to ensure a healthy Estuary;
- Other reason (please specify); and lastly
- Don't know.

The answers respondents provided to this question were not intended for data modelling inclusion. One of the statements included as an option, namely "It was difficult to choose as several factors were important" served to establish the validity of respondent choices, in the sense that it provided an opportunity to reveal the application of a compensatory decision making strategy.

Question 4.3 asked the respondents which of the four attributes they put greatest weight on when choosing between the different alternatives. There was also an opportunity for them to state whether it had varied from choice to choice. This question aimed to help identify if the respondent had followed a non-compensatory decision strategy, by focusing on the levels of one attribute only when making choices. If respondents answered that they took all the attributes into consideration when making choices, the compensatory decision making assumption was most likely not violated (Watson *et al.* 2004).

Question 4.4 was a policy-orientated question. It asked the respondent whether they would increase their level of estuary usage if certain recreational estuarine attribute improvements were made. This question was included as a quasi-validity test.

5.4.5 SOCIO-ECONOMIC QUESTIONS

Six questions relating to the respondent's socio-economic status were asked in both questionnaires. These questions asked about the respondent's gender, age, place of residence, occupation, household income and educational attainment.

5.5 ADMINISTERING THE SURVEY INSTRUMENTS

5.5.1 INTRODUCTION

Once the design of the survey instrument for each estuary was completed, it was administered. The steps followed in the administration of the main survey instruments are described below.

5.5.2 SELECTION OF SURVEY TECHNIQUE

The choice of a survey collection mode is vitally important in primary data generation using stated preference techniques (Mitchell & Carson, 1989; Champ, 2003; Alberini & Khan, 2006). The NOAA inquiry recommended that personal interviews be the preferred mode of collection (Portney, 1994). Web-based survey methods, however, have recently received attention as an acceptable form of data collection (Windle & Rolfe, 2009). The use of a web-based survey method for this study was considered inappropriate, however, since it was expected that some of the targeted population would not have access to the Internet. The most commonly used approach when valuing recreational sites is the face-to-face interview (Lee & Han, 2002). This personal interview method was adopted for this study. Although costly, it affords the interviewer the best opportunity to encourage the respondents to cooperate with the survey. The interviewer is also given an opportunity to explain complex information and valuation scenarios to the respondent – which is very important in the CE setting (Mitchell & Carson, 1989).

In order to prevent respondent selection bias, interviewers participated in training sessions held approximately one week prior to data collection. All the interviewers had previous household interviewing experience. The training sessions were conducted by the chief researcher, as well as estuarine use experts from each estuary. The interviewers were provided with various study materials to familiarise themselves with prior to the training sessions (Natural Resource Damage Assessment, Inc. (NRDA), 1994). Each training session began with a brief overview of the study. A demonstration interview followed whereby interviewers were shown the correct way to administer the questionnaires. After the demonstration, the interviewers formed groups of two and conducted the interviews; one being the interviewer and one playing the part of the respondent. During this training the interviewers were also informed about the undesirability of selecting respondents based on their own personal perceptions and preferences. On conclusion of the training sessions, interviewers were provided with small gifts which they were to give to the respondents to thank them for their participation. It was hoped that this would ease the interviewer's burden of approaching unknown/unfamiliar respondents.

5.5.3 DATA COLLECTION

During the process of data collection, all interviewers reported to the chief researcher. The chief researcher managed the data collection process and dealt with any logistical issues that arose. The administration of the questionnaires for each estuary is discussed below.

5.5.3.1 Sundays River Estuary

The Sundays River Estuary questionnaire was administered on-site by four trained interviewers during August, 2010. Interviewers followed the intercept sample method whereby they approached every n^{th} potential respondent and asked them if they would be willing to spend approximately 15 minutes filling in the questionnaire. In total, 175 completed questionnaires were collected. A face-to-face interview technique was adopted. The non-response rate was zero.

5.5.3.2 Kromme River Estuary

The Kromme River Estuary questionnaire was administered on-site by seven trained interviewers during December, 2010. Interviewers followed the intercept sample method whereby they approached every n^{th} potential respondent and asked them if they would be willing to spend approximately 15 minutes filling in the questionnaire. In total, 244 completed questionnaires were collected. A face-to-face interview technique was adopted. The non-response rate was zero.

Once data collection was complete, a field edit was carried out for each estuary whereby questionnaires were validated by the chief researcher in the presence of the respective interviewers (NRDA, 1994). Once complete, the questionnaires from each estuary were handed over to a qualified data processor for capturing.

5.6 CONCLUSION

The design of the choice experiments for the Sundays River and Kromme River Estuaries applied the methodology outlined in Chapter Four. The main concerns regarding the recreational services provided by each estuary were identified through focus groups. The sample design for each estuary was guided by a *rule of thumb* approach. Once the process of sample design was complete, the survey instrument was developed. The various survey instrument sections included (1) introductory questions to 'warm up' the respondent, (2) the choice experiment section where the respondent was required to make choices, (3) the follow-up section where respondents answered questions relating to why they had made certain choices, and (4) socio-economic questions.

CHAPTER SIX: RESULTS AND ANALYSIS OF THE CHOICE EXPERIMENTS

6.1 INTRODUCTION

Chapter Six reports the analysis of the choices for recreational use of the Sundays River and Kromme River Estuaries. The information collected from the respondents is summarised and used to estimate maximum likelihood models for each estuary. Implicit prices for the recreational attributes of interest are then calculated in an attempt to explain recreational user choice. These activities implement sub-objective three (as outlined in Chapter One).

The information for this analysis comes from data collected via a recreational use questionnaire survey conducted at the Sundays River and Kromme River Estuaries, during August of 2010 and December of 2010, respectively. The questionnaires were designed to elicit information on various recreational use matters, namely, (1) the respondents' attitude towards the environment, (2) their participation in and enjoyment of key recreational activities, and (3) the trade-offs they make between attributes of the estuary recreational experience. In addition to this, the surveys also included questions relating to the socio-economic characteristics of the respondents (see Appendices B and C).

6.2 THE DATA CLEANING PROCESS

6.2.1 THE SUNDAYS RIVER ESTUARY DATA

Once the data collection for the Sundays River Estuary had been completed, the data was captured into MS Excel. There were a total of 175 usable questionnaires. At this point, the data was checked for inconsistencies. A few descriptive statistics were generated in order to determine if there were any missing observations. It is important to examine these descriptive outputs carefully, as this can save the researcher valuable time and avoid any potential problems when it comes to model estimation (Hensher *et al.* 2005).

Another important aspect when checking for inconsistencies are possible correlations within the data. Severe correlations among the design attributes could lead to the problem of multicollinearity in the model. Correlations can be introduced into a model through a loss of design orthogonality. The level of orthogonal loss is reflected in correlation between the attributes, and thus multicollinearity (Hensher *et al.* 2005). A number of methods are available to the researcher to test for the existence of multicollinearity. Unfortunately, if the presence of multicollinearity is detected there is very little the researcher can do to reduce the problem at this stage. Having determined through the focus group stage that an attribute is important, it is not credible to suddenly drop one of the affected attributes (Hensher *et al.* 2005).

Two methods to test for the presence of multicollinearity are considered in this section. The first test entails the use of the method of auxiliary regressions (Amemiya, 1985; Hensher *et al.* 2005). Three steps must be carried out to administer this test. Firstly, each attribute must be regressed on the remaining attributes in the design. Secondly, the R^2 of each auxiliary regression must be calculated as well as the R_i for each regression. The R_i is calculated as follows:

$$R_i = \frac{\left[R^2_{x1x2x3\ldots xk} / (k-2)\right]}{\left[\left(1-R^2_{x1x2x3\ldots xk}\right) / (n-k+1)\right]} \tag{6.1}$$

where:

$R^2_{x1x2x3\ldots xk}$ = the coefficient of determination of the regression of attribute x_i on the remaining attributes,

k = the number of explanatory variables in the model, including the constant, and

n = the sample size, i.e. the number of observations (Hensher *et al.* 2005).

Thirdly, each R_i must be compared to a critical F-statistic with $(k - 2)$ degrees of freedom in the numerator and $(n - k + 1)$ degrees of freedom in the denominator. If the critical F-statistic is exceeded by a R_i for an auxiliary regression, the test does not reject the hypothesis that the attribute x_i is correlated with the remaining attributes and the presence of multicollinearity in model estimation (Hensher *et al.* 2005).

The results of this test for the Sundays River Estuary design are shown in Table 6.1 below.

Table 6.1: Test for multicollinearity by the method of auxiliary regressions – Sundays River Estuary

Dependent Variable in Auxiliary Regression	Regressors	Auxiliary Regression R^2	R_i	F-statistic*
Size of Fish	Congestion, Public access, Cost	0.001	0.86	3.00
Congestion	Size of fish, Public access, Cost	0.001	0.74	
Public Access	Size of fish, Congestion, Cost	0.000	0.20	
Cost	Size of fish, Congestion, Public access	0.001	1.30	

**Critical value of F-statistic at the 5 percent level of significance with 2 (4 – 2) and 1395 (1400 – 4 + 1) degrees of freedom. The F-statistic is equal to 3.00 for each test, as the degrees of freedom for each auxiliary regression do not change (Hensher, Rose & Greene, 2005).*

As can be seen from Table 6.1, none of the R_i values exceeds the critical F-statistic (3.00). It was concluded that multicollinearity was not a problem in this particular case.

The second test entails using Klein's rule (Klein, 1962) and employing the auxiliary regression's $R^{2'}$s estimated in the method above. The coefficients of determination, i.e. R^2, for the estimated auxiliary regressions above must be compared to the R^2 of the regression of the dependent variable (choice) on the attributes of the model as used in the auxiliary regression models (Hensher *et al.* 2005). If it is found that the R^2 of any of the auxiliary regression models exceeds the R^2 of the regression of choice on the design attributes of the model, multicollinearity cannot be excluded (Hensher *et al.* 2005). The results of this test are shown in Table 6.2.

Table 6.2: Multicollinearity test using Klein's rule – Sundays River Estuary

Dependent Variable in Auxiliary Regression	**Regressors**	**Auxiliary Regression R^2**	**R^2 of Regression of Dependent Variable on Attributes**
Size of Fish	Congestion, Public access, Cost	0.001	0.015
Congestion	Size of fish, Public access, Cost	0.001	
Public Access	Size of fish, Congestion, Cost	0.000	
Cost	Size of fish, Congestion, Public access	0.001	

Table 6.2 shows that none of the auxiliary regressions' R^2s exceed the R^2 of the regression of the dependent variable (choice) on the attributes of the model. This test confirms the findings of the method of auxiliary regressions carried out above - multicollinearity was not a concern in this CE.

6.2.2 THE KROMME RIVER ESTUARY DATA

Once the data from this questionnaire had been field edited, it was captured into MS Excel. There were a total of 244 usable questionnaires. Once the data was captured in MS Excel format, a few descriptive statistics were generated in order to check for any missing observations. Similar to the Sundays River Estuary analysis, the data was checked for possible correlations among attributes using the same two tests. The results of the method of auxiliary regressions test for the Kromme River Estuary design are shown in Table 6.3.

Table 6.3: Test for multicollinearity by the method of auxiliary regressions – Kromme River Estuary

Dependent Variable in Auxiliary Regression	Regressors	Auxiliary Regression R^2	R_i	F-statistic*
Navigability	Congestion, Jet Skiing, Cost	0.002	2.15	3.00
Congestion	Navigability, Jet Skiing, Cost	0.002	2.17	
Jet Skiing	Navigability, Congestion, Cost	0.002	1.83	
Cost	Navigability, Congestion, Jet Skiing	0.002	1.65	

**Critical value of F-statistic at the 5 percent level of significance with 2 (4 – 2) and 1949 (1952 – 4 + 1) degrees of freedom. The F-statistic is equal to 3.00 for each test, as the degrees of freedom for each auxiliary regression do not change (Hensher, Rose & Greene, 2005).*

As can be seen from Table 6.3, none of the R_i values exceeds the critical F-statistic (3.00). It was concluded that multicollinearity was not a problem in this case.

The results of Klein's test are shown in Table 6.4 below.

Table 6.4: Multicollinearity test using Klein's rule – Kromme River Estuary

Dependent Variable in Auxiliary Regression	Regressors	Auxiliary Regression R^2	R^2 of Regression of Dependent Variable on Attributes
Navigability	Congestion, Jet skiing, Cost	0.002	0.06
Congestion	Navigability, Jet skiing, Cost	0.002	
Jet skiing	Navigability, Congestion, Cost	0.002	
Cost	Navigability, Congestion, Jet skiing	0.002	

Table 6.4 shows that none of the auxiliary regressions' R^2s exceeds the R^2 of the regression of the dependent variable (choice) on the attributes of the model. This test confirms the findings of the method of auxiliary regressions carried out above - multicollinearity was not a concern in this CE.

6.3 SOCIO-ECONOMIC CHARACTERISTICS, ATTITUDES AND HABITS

6.3.1 THE SUNDAYS RIVER ESTUARY

6.3.1.1 Socio-economic characteristics

This section describes the data collected from the responses from the socio-economic section of the questionnaires. The only other socio-economic information available was that gathered in the Forbes (1998), and more recently, the Cowley *et al.* (2009) studies. The Forbes (1998) study captured data on the recreational users of the estuary, while the Cowley *et al.* (2009) study captured data on both recreational and subsistence users of the estuary. Comparisons with the Cowley *et al*. (2009) study are possible for the following socio-economic characteristics: residential location, age, gender and education. The Forbes (1998) study allows comparisons for residential location only. Selected, socio-economic results of this Sundays River Estuary study are summarised as follows:

- The majority (91 percent) of visitors came from areas less than 50km away from the estuary.
- The majority (55 percent) of recreational users surveyed were over the age of 35.
- The majority (84 percent) of recreational users surveyed are male.
- The average gross annual income for the sample was R184 000.
- Of the respondents sampled, 35 percent had a matric qualification with university exemption.
- All occupational categories are well represented in the sample of respondents, with the exception of plant and machinery operators/assemblers (2 percent), agricultural workers (1 percent), and elementary occupations (1 percent).

a) Residential Location

Not unlike the sample of respondents interviewed as part of the Forbes (1998) and Cowley *et al*. (2009) studies, most of the visitors surveyed came from areas less than 50km away from the estuary. Of these respondents, most came from Port Elizabeth (59 percent). Permanent residents of the Sundays River Estuary, living in Colchester and

Cannonville, accounted for approximately 21 percent of the sample. The information pertaining to respondents' zones of origin is displayed in Table 6.5 below.

Table 6.5: Percentage of respondents by place of residence – Sundays River Estuary

Place	**Percentage of Respondents**
Port Elizabeth	59
Swartkops	1
Uitenhage	6
Despatch	4
Colchester	19
Cannonville	2
Grahamstown	1
Port Alfred	1
East London	2
Jeffreys Bay	1
Humansdorp	1
Knysna	4
Kleinemond	1
Johannesburg	1
Total	**100**

A comparison of the residential location of the respondents in this study to that of the Forbes (1998) and Cowley *et al.* (2009) studies is provided in Table 6.6 below.

Table 6.6: Comparison of residential location – Sundays River Estuary

Distance	**Percentage of Respondents**		
	This Study	**Forbes (1998) Study**	**Cowley *et al.* (2009) Study**
<50km from Estuary	91	84.9	91.2
<5km from Estuary (Local Residents)	21	24.7	18.6
Between 5 and 50km	70	60.2	72.5
Between 50 and 200km	5	3.5	3.4
Between 200 and 400km	6	8.0	0.8
>400km from Estuary	1	3.6	3.5
Foreign Visitors	0	0	1.2
Total	**100**	**100**	**100**

A survey conducted by Forbes and Wooldridge (1999) showed similar trends in terms of the provincial and city/town distribution of recreational users (Afri-Coast Engineers, 2004): 94.5 percent of the recreational users visiting the Sundays River Estuary were from the Eastern Cape, and only 3.6 percent were from Gauteng. Of the recreational users that visited the Sundays River Estuary, 56.6 percent came from Port Elizabeth, 8.4 percent from Uitenhage, and 19.9 percent from Colchester and Cannonville.

b) Age

The majority of recreational users sampled were over the age of 35. The minimum age sampled was 18 years. The percentage of respondents per age category is shown in Table 6.7 below.

Table 6.7: Percentage of respondents per age category – Sundays River Estuary

Age Category	Percentage of Respondents
18 – 20	9
21 - 25	11
26 – 30	14
31 – 35	11
36 – 40	17
41 – 45	14
46 – 50	11
51 – 55	8
56 – 60	3
61 Years and Older	2
Total	**100**

A comparison of the age of the respondents of this study to that of the Cowley *et al.* (2009) study is provided in Table 6.8 below.

Table 6.8: Comparison of age profile – Sundays River Estuary

Age Category (Years)	Percentage of Respondents	
	This Study	Cowley *et al.* (2009) Study
<10	0	2.3
11 – 20	9	13.7
21 – 30	25	19.2
31 – 40	28	20.1
41 – 50	25	21.4
51 – 60	11	14.5
60+	2	8.7
Total	**100**	**100**

c) Gender

The majority of respondents were male (84 percent). Table 6.9 below shows the gender of sampled respondents.

Table 6.9: Percentage of respondents by gender – Sundays River Estuary

Gender	Percentage of Respondents
Male	84
Female	16
Total	**100**

A comparison of the gender of the respondents of this study to that of the Cowley *et al.* (2009) study is provided in Table 6.10 below.

Table 6.10: Comparison of gender profile – Sundays River Estuary

	Percentage of Respondents	
Gender	This Study	Cowley *et al.* (2009) Study
Male	84	91.8
Female	16	8.2
Total	**100**	**100**

d) Income

The percentage of respondents per income category is presented in Table 6.11 below. If respondents ticked the "Refuse to Answer" category, an income value was allocated to them based on their stated occupation. The income values for the occupational categories were obtained from the Labour Force Survey (LFS) of September 2007 (Statistics South Africa (STATSSA), 2007). In order to calculate average gross income, respondents were allocated random income values within their specified income categories. These income values were generated using a random number generator programme in the statistical package STATA Version 11.0. These values were then summed, divided by the total number of respondents, and adjusted for inflation. The average annual gross income for this sample was R184 000. A small number of very high incomes per annum captured in the upper end of the income distribution skewed the average upwards - the majority of respondents earned less than R200 000 per annum.

Table 6.11: Percentage of respondents per income category – Sundays River Estuary (gross annual total income in Rands)

Income Category	Percentage of Respondents
less than R50000	22
R50 000 - R99 999	18
R100 000 - R149 999	21
R150 000 - R199 999	15
R200 000 - R249 999	5
R250 000 - R299 999	2
R300 000 - R349 999	3
R350 000 - R399 999	3
R400 000 - R449 999	2
R450 000 - R499 999	1
R500 000 - R749 999	3
R750 000 - R999 999	3
R1 000 000 or more	1
Total	**100**

e) Education

Most of the respondents sampled had a matric qualification with university exemption. In addition to a matric qualification, 57 percent had attained at least one tertiary qualification; 27 percent held a Technikon diploma, 21 percent held a University degree and 9 percent held a post-graduate degree. The percentage of respondents per education category is shown in Table 6.12 below.

Table 6.12: Percentage of respondents per education category – Sundays River Estuary

Education Category	**Percentage of Respondents**
Secondary School Education	8
Matriculation	35
Technikon Diploma	27
University Degree	21
University Post-graduate Degree	9
Total	**100**

A cross-tabulation of the first four income categories (up to R200 000) with educational attainment was constructed. It revealed that there is a clear relationship between income earned and level of educational attainment. Of those individuals who earned less than R50 000 per annum, only 30 percent had a post matric, largely in the form of a Technikon diploma. For those who earned between R50 000 and R100 000 per annum, 48 percent had a post matric qualification. For those who earned between R100 000 and R150 000 per annum, 54 percent had a post matric, largely in the form of a degree or postgraduate degree. Lastly, for those who earned between R150 000 and R200 000, approximately 73 percent had a post matric, comprising of diplomas, degrees and postgraduate qualifications. A comparison of the educational attainment of the respondents of this study to that of the Cowley *et al.* (2009) study is provided in Table 6.13 below. It is evident that this study interviewed a more highly educated sample.

Table 6.13: Comparison of education profile – Sundays River Estuary

Education Category	Percentage of Respondents	
	This Study	**Cowley *et al.* (2009) Study**
No Education	0	0.2
Primary School Education	0	8.2
Secondary School Education	8	33.7
Matriculation	35	27.5
Technikon Diploma	27	21.8
University Degree	30	8.0
Total	**100**	**100**

f) Occupation

For the purposes of this study, occupational categories were specified in accordance with the Labour Force Survey of South Africa (LFS), currently known as the Quarterly Employment Survey (QES) – see Table 6.14 below (STATSSA, 2001). All occupational categories are well represented in the sample of respondents, with the exception of plant and machinery operators/assemblers (2 percent), agricultural workers (1 percent), and elementary occupations (1 percent). Three respondents were grouped into the unspecified category because they refused to divulge their occupation.

Table 6.14: Percentage of respondents per occupation – Sundays River Estuary

Occupation	Percentage of Respondents
Legislators, Managers & Senior Officials	14
Professionals	12
Technicians & Associate Professionals	9
Clerks	5
Service Workers & Market/Sales Workers	15
Skilled Agricultural and Fishery Worker	1
Craft & Related Trade Workers	15
Plant & Machinery Operators/Assemblers	2
Elementary Occupations	1
Self Employed	14
Student	10
Unspecified	2
Total	**100**

Given that the majority of respondents earned less than R200 000 per annum, a cross-tabulation of the first four income categories (up to R200 000) with respondent occupation was constructed. The results were largely as expected, i.e. as a respondent's occupational skill improves, so does his or her income. For example, of those individuals who earned less than R50 000 per annum, 38 percent were students, while 26 percent were service workers. Of those who earned between R50 000 and R100 000 per annum, 29 percent were craft and related trades workers (requiring a slightly higher level of skill). For those who earned between R100 000 and R150 000 per annum, 55 percent represented service workers, craft and related trades workers, as well as the self-employed. Lastly, for those who earned between R150 000 and R200 000, 59 percent were legislators, senior officials, managers, professionals and the self-employed.

6.3.1.2 Attitudes towards the environment

The respondents were asked certain questions in order to elicit information about their attitudes towards various aspects affecting the estuarine environment. The first question was whether or not the protection of the estuarine environment was considered to be one of government's most important responsibilities. The majority of respondents agreed with this statement. Respondents were split, however, when it came to the issue of boat congestion. About 32 percent of them felt that congestion on the river was a threat to the quality of the services provided by the estuary, whereas approximately 38 percent felt that it was not.

The majority of respondents (almost 70 percent) believed that recreational over-fishing was a threat to the quality of the recreational services provided by the estuary. Approximately 60 percent of respondents believed that public access to the estuary was sufficient. However, when asked specifically about access to the jetties, 40 percent of them indicated that these should be easily and freely accessible to the recreational user. Most of these jetties are currently treated as private property. The majority of respondents (63 percent) agreed with the statement that the estuary should provide a sustainable habitat for animal and plant life.

6.3.1.3 Recreational use habits

a) Number of visits

Respondents were asked the number of times they visited the Sundays River Estuary in the past year. Table 6.15 below indicates that the majority of the respondents (non-residents) had visited the estuary more than once in the past year.

Table 6.15: Number of visits by respondents – Sundays River Estuary

Number of Visits	**Percentage of Respondents**
Never Visited	1
Visited Once	13
Visited Two to Ten Times	35
Visited Eleven to Twenty Times	10
Visited More than Twenty Times	21
I live in SundaysRiver	20
Total	**100**

b) Recreational activities

Respondents were asked what the main recreational activity was that they participated in during their visits to the Sundays River Estuary. This information is summarised in Table 6.16 below. Fishing was the most popular recreational activity at this estuary; 41 percent of respondents engaged in shore fishing and also 41 percent engaged in boat fishing.

Table 6.16: Main recreational activities for the Sundays River Estuary

Recreational Activities	Percentage of Respondents
Shore Fishing	41
Boat Fishing	41
Speed Boating	11
Water Skiing	1
Paddling	2
Jet Skiing	1
Swimming	1
Bird Watching	1
Other	2
Total	**100**

If the respondents had indicated that they had participated in either boat or shore fishing, they were subsequently asked if they knew what the legal regulations were with respect to the size and bag limits of fish kept. Of the anglers, 70 percent knew the legal requirements.

A comparison of the recreational activities of the respondents of this study to that of the Cowley *et al.* (2009) study is provided in Table 6.17 below.

Table 6.17: Comparison of recreational activities profile – Sundays River Estuary

Recreational Activities	Percentage of Respondents		
	This Study	Forbes (1998) Study	Cowley *et al.* (2009) Study
Shore Fishing	41	33.9 (Shore and Boat)	32.4
Boat Fishing	41	-	18.7
Speed Boating	11	17.4	11.2
Water Skiing	1	18.9	2.5
Paddling	2	4.9	1.7
Jet Skiing	1	1.3	0.5
Swimming	1	16.6	Undefined
Bird Watching	1	1.6	Undefined

Sources: Forbes (1998) and Cowley, Childs & Bennett (2009)

The Sundays River Estuary status quo assessment report, prepared by Afri-Coast Engineers (2004), showed that 96 percent of estuary users were interested in recreational activity. Of all the recreational activities available, recreational fishing was the most popular (28.8 percent), followed by swimming (21.8 percent), leisure cruising (17.8 percent) and water skiing (14.8 percent).

6.3.2 THE KROMME RIVER ESTUARY

6.3.2.1 Socio-economic characteristics

This section describes the data collected from the responses from the last section of the questionnaires. The only other socio-economic information available was that gathered in the Forbes (1998) and, more recently, the Sale (2007) studies. Both the Forbes (1998) and Sale (2007) studies captured data on the recreational users of the Kromme River Estuary. Comparison with the Forbes (1998) data are possible for residential location and number of days visited, whilst the Sale (2007) study provided information about the average recreational user's education and income per annum. Selected, socio-economic results of this Kromme River Estuary study are summarised as follows:

- The majority (59 percent) of visitors came from areas more than 50km away from the estuary.
- The majority (64 percent) of recreational users surveyed were over the age of 35.
- The majority (65 percent) of recreational users surveyed are male.
- The average gross annual income for the sample was R447 000.
- Of the respondents sampled, 29 percent had a matric qualification with university exemption.
- All occupational categories are well represented in the sample of respondents, with the exception of plant and machinery operators/assemblers (0 percent), agricultural workers (0.4 percent), and elementary occupations (0 percent).

a) Residential Location

Unlike the sample of respondents interviewed as part of the Sundays River Estuary CE, most of the visitors to the Kromme River Estuary surveyed came from areas more than 50km away from the estuary. Of these respondents, 29 percent came from Port Elizabeth. Permanent residents of the Kromme River Estuary, living in St Francis Bay, Santareme and Kromme River, accounted for approximately 27 percent of the sample. The percentages of respondents' by place of origin are displayed in Table 6.18 below.

Table 6.18: Percentage of respondents by place of residence – Kromme River Estuary

Place	**Percentage of Respondents**
St FrancisBay	23
Cape St Francis	6
Port St Francis	1
Santareme	1
KrommeRiver	2
JeffreysBay	3
Humansdorp	3
AshtonBay	1
Port Elizabeth	29
Cape Town	4
Johannesburg	9
Pretoria	5
Durban	1
East London	2
Bloemfontein	1
Grahamstown	1
George	2
Uitenhage	1
Pietersburg	1
Uniondale	1
Tygerberg	1
United Kingdom	1
United States of America	1
Total	**100**

Table 6.18 can be summarised by using distance categories shown in Table 6.19 below. This table provides a comparison of the residential location of the respondents to that of the Forbes (1998) study, according to distance travelled.

Table 6.19: Comparison of residential location – Kromme River Estuary

Distance	Percentage of Respondents	
	This Study	Forbes (1998) Study
<50km from Estuary	40	22.6
<5km from Estuary (Local Residents)	27	18.9
Between 5 and 50km	14	5.6
Between 50 and 200km	32	20.8
Between 200 and 400km	0	3.8
>400km from Estuary	26	45.2
Foreign Visitors	1	5.7

The Forbes (1998) study captured a similar composition of residents/visitors with respect to their places of origin. The Forbes (1998) study captured a higher proportion of long-distance travellers, i.e. those travelling from cities or towns more than 400km away from the estuary. This study reflects a growth in the recreational use of the estuary of visitors from cities or towns less than 200km away.

b) Age

The majority (approximately 64 percent) of recreational users sampled were over the age of 35. The percentage of respondents per age category is shown in Table 6.20 below.

Table 6.20: Percentage of respondents per age category – Kromme River Estuary

Age Category	Percentage of Respondents
18 – 20	6
21 - 25	18
26 – 30	7
31 – 35	5
36 – 40	7
41 – 45	11
46 – 50	16
51 – 55	12
56 – 60	7
61 Years and Older	11
Total	**100**

c) Gender

The majority of respondents were male (66 percent). Table 6.21 below shows the gender of sampled respondents.

Table 6.21: Percentage of respondents by gender – Kromme River Estuary

Gender	Percentage of Respondents
Male	66
Female	34
Total	**100**

d) Income

The percentage of respondents per income category is presented in Table 6.22 below. As for the Sundays River Estuary, an income value was allocated to respondents according to their stated occupation if a respondent ticked the "Refuse to Answer" category. The average income for this sample, calculated in the same manner as for the Sundays River Estuary, was R447 000 per annum. About ten percent of the sample (34 respondents) earned incomes exceeding R1 million per annum. These respondents were managers, professionals and associate professionals. There were a few respondents earning incomes below R25 000 per annum and consisted mainly of students. A high representation of upper-income earners skewed the average upwards. The Sale (2007) study found an average gross income of approximately R257 000 per annum[18] (adjusted for inflation). This is similar to the middle-income earners' (the median respondent) gross income of R222 000 in this study.

Table 6.22: Percentage of respondents per income category – Kromme River Estuary (total gross annual income – Rands)

Income Category	**Percentage of Respondents**
less than R50000	21
R50 000 - R99 999	5
R100 000 - R149 999	24
R150 000 - R199 999	15
R200 000 - R249 999	3
R250 000 - R299 999	2
R300 000 - R349 999	2
R350 000 - R399 999	2
R400 000 - R449 999	4
R450 000 - R499 999	4
R500 000 - R749 999	3
R750 000 - R999 999	5
R1 000 000 or more	10
Total	**100**

e) Education

Most of the respondents sampled had a matric qualification with university exemption. In addition to a matric qualification, 69 percent had attained at least one tertiary qualification; 16 percent held a Technikon diploma, 35 percent held a University degree and 18 percent held a post-graduate degree. The percentage of respondents per education category is shown in Table 6.23 below.

[18] The CPI was 81.4 and 111.7 in 2004 and 2010, respectively (South African Reserve Bank (SARB), 2011). This implies that the income figure of R187 000 must be inflated by 37.2 percent.

Table 6.23: Percentage of respondents per education category – Kromme River Estuary

Education Category	Percentage of Respondents
Secondary School Education	2
Matriculation	29
Technikon Diploma	16
University Degree	35
University Post-graduate Degree	18
Total	**100**

The five most populated income categories, namely (1) < R50 000, (2) R50 000 to R99 999, (3) R100 000 to R149 999, (4) R150 000 to R199 999, and (5) > R1 million, were cross-tabulated with educational attainment. This cross-tabulation revealed a clear relationship between income earned and level of educational attainment. Of those individuals who earned less than R50 000 per annum, 35 percent had a post matric, largely in the form of a degree. For those who earned between R50 000 and R100 000 per annum, 27 percent had a post matric qualification. For those who earned between R100 000 and R150 000 per annum, 53 percent had a post matric, largely in the form of a degree or postgraduate degree. For those who earned between R150 000 and R200 000, approximately 57 percent had a post matric, comprising mostly of degrees. Lastly, for those who earned more than R1 million (10 percent of the sample), approximately 71 percent had a post matric, comprising of degrees and postgraduate qualifications.

In the Sale (2007) study, the average number of years of education was 13 years (a matriculation qualification with an additional year of study, for example, a Technikon Diploma). This study indicated an average level of completed education as being slightly more than a Technikon Diploma (13.8 years). The median respondent, however, had no less than 15 years of completed education.

f) Occupation

Not unlike the Sundays River Estuary CE, occupational categories were specified in accordance with the Labour Force Survey of South Africa (LFS), currently known as the Quarterly Employment Survey (QES) – see Table 6.24 below (STATSSA, 2001). All occupational categories are well represented in the sample of respondents, with the exception of plant and machinery operators/assemblers (0 percent), agricultural workers (0 percent), and elementary occupations (0 percent). Of the respondents, 19 percent were grouped into the “other” category because they represented students and occupational unknowns.

Table 6.24: Percentage of respondents per occupation – Kromme River Estuary

Occupation	**Percentage of Respondents**
Legislators, Managers & Senior Officials	20
Professionals	28
Technicians & Associate Professionals	24
Clerks	3
Service Workers & Market/Sales Workers	3
Skilled Agricultural and Fishery Worker	0
Craft & Related Trade Workers	3
Plant & Machinery Operators/Assemblers	0
Elementary Occupations	0
Unspecified	19
Total	**100**

Given that the majority of respondents earned less than R200 000 per annum and more than R1 million, a cross-tabulation of these five income categories with respondent occupation was constructed. The results were largely as expected, i.e. as a respondent’s required occupational skill increases, so does his or her income. For example, of those individuals who earned less than R50 000 per annum, 88 percent were service workers, craft and related trade workers, and other non-specified occupations. Of those who earned between R50 000 and R100 000 per annum, 81 percent were clerks and craft and related trades workers (these occupations require a slightly higher level of skill than service workers). For those who earned between R100 000 and R150 000 per annum, 77 percent represented professionals and technicians and associate professionals. These occupations are considered to be highly skilled by STATSSA (2007). For those who earned between R150 000 and R200 000, 37 percent were legislators, senior officials and managers, while 54 percent were professionals (37 percent of respondents exhibit the highest level of skills in this income category). Lastly, for those who earned more than R1 million per annum, 41 percent were legislators, senior officials and managers, while 45 percent were professionals (41 percent of respondents exhibit the highest level of skill in this income category).

6.3.2.2 Attitudes towards the environment

As was the case for the Sundays River Estuary CE, the respondents were asked certain questions in order to elicit information about their attitudes towards various aspects affecting the estuarine environment. The first question was whether or not the protection of the estuarine environment was considered to be one of government's most important responsibilities. Almost all of the respondents (97 percent) agreed with this statement. The majority of respondents (68 percent) felt that boat congestion constituted a serious threat to the quality of the recreational services provided by the estuary.

The vast majority of respondents (85 percent) believed that reduced navigability was a threat to the quality of the recreational services provided by the estuary. Approximately 61 percent of respondents believed that the use of jet skis and wet bikes were a threat to the quality of the recreational services provided by the estuary. The majority of respondents (97 percent) agreed with the statement that the estuary should provide a sustainable habitat for animal and plant life. Approximately 77 percent of respondents felt that uncontrolled, commercial and illegal bait harvesting was a threat to the overall quality of recreational services provided by the estuary.

6.3.2.3 Recreational use habits

a) Number of visits

Respondents were asked the number of times they visited the Kromme River Estuary in the past year. Table 6.25 below indicates that the majority of the respondents (non-residents) had visited the estuary more than once in the past year.

Table 6.25: Number of visits by respondents – Kromme River Estuary

Number of Visits	Percentage of Respondents
Never Visited	3
Visited Once	8
Visited Two to Ten Times	33
Visited Eleven to Twenty Times	6
Visited More than Twenty Times	15
I live in Close Proximity to the Kromme River Estuary*	35
Total	**100**

**This percentage exceeds the local resident percentage of 27 percent, but some individuals erroneously ticked this category as they lived in areas close to the estuary, but do not consider themselves a resident of St Francis Bay or on the Kromme River.*

b) Recreational activities

Respondents were asked what their main recreational activities were that they participated in during their visits to the Kromme River Estuary. This information is summarised in Table 6.26. Recreational shore fishing was the most popular recreational activity at this estuary - 39 percent of the respondents engaged in shore fishing. Respondents also enjoyed recreational boat fishing (18 percent), swimming (16 percent), and speed/power boating (13 percent).

Table 6.26: Main recreational activities for the Kromme River Estuary

Recreational Activities	Percentage of Respondents
Shore Fishing	39
Boat Fishing	18
Power/Speed Boating	13
Water Skiing	6
Paddling	5
Jet Skiing	1
Swimming	16
Bird Watching	1
Other	1
Total	**100**

A comparison of the four most popular recreational activities of the respondents in this study to those of the Forbes (1998) study is provided in Table 6.27 below.

Table 6.27: Comparison of recreational activities – Kromme River Estuary

Recreational Activities	Percentage of Respondents	
	This Study	Forbes (1998) Study
Shore Fishing	39	-
Angling	-	34.0
Boat Fishing	18	-
Water Skiing/Speed Boating	13	22.6
Swimming	16	30.2
Recreational Boating	-	9.4

The Sale (2007) study indicated that, of those estuary users sampled, 92 percent participated in recreational activities.

6.4 MODEL ESTIMATION RESULTS

6.4.1 THE SUNDAYS RIVER ESTUARY CHOICE EXPERIMENT

6.4.1.1 Parametric model estimation results

Three different choice model specifications were estimated as part of the Sundays River Estuary CE: a CL model, an HEV model and an RPL model. The LIMDEP NLOGIT Version 4.0 programme was used in all the estimations. All models estimated showed the importance of choice set attributes in explaining respondents' choices across the two different options: option A and option B. Two utility functions ($V_{1\text{-}2}$) were derived from the models[19]. Each function represented the utility generated by one of the two options. For the two option choice sets with four attributes, the utility functions can be expressed as follows:

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

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

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

For these two utility functions, utility is determined by the levels of the four attributes in the choice sets. The model provides an estimate of the effect of a change in any of these attributes on the probability that one of these options will be chosen.

The first model shown in Table 6.28 is the estimate of a standard CL model.

Table 6.28: Estimation results of the CE[20] - Sundays River Estuary

	CL		HEV		RPL	
Variables	**Coeff.**	**Std err.**	**Coeff.**	**Std err.**	**Coeff.**	**Std err.**
Physical Size of Fish	1.59225259**	.14157877	1.79113653**	.23779355	1.95816676**	.53555192
Congestion	-.34136177**	.13044418	-.40008933*	.15818898	-.39402824*	.15836246
Public Access	.34253510**	.12461801	.39809588**	.15093428	.38157738**	.14429206
Cost[1]	-.01033063**	.00144555	-.01192456**	.00214754	-.01126248**	.00194773
	Standard deviation of random parameters					
Physical Size of Fish					1.18863441	.97650395
Congestion					.28761409	.69802099
Public Access					.18711344	1.08321161
No. of Respondents	175		175		175	
No. of Choice Sets	700		700		700	
Pseudo R^2	.22091		.2394251		.2386784	

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

[20]The number of iterations taken to fit a model is an important aspect of interpreting LIMDEP NLOGIT Version 4.0 output (Hensher *et al.* 2005). It is argued that if more than 25 iterations have occurred in estimating a conditional logit model the researcher should question the final model produced (Hensher *et al.* 2005). In this case, the number of iterations taken for the CL, HEV and RPL, respectively were 6, 11 and 18.

All the coefficients[21] in these models have the correct signs[22], *a priori,* and are significantly different from zero at the 99 percent confidence level.

The probability that an alternative would be chosen was reduced:

- the lower the physical size of the fish stock;
- the higher the amount of boat congestion;
- the lower the amount of public access available; and
- the higher the environmental quality levy.

The significant coefficients of the CL model can be interpreted by estimating their odds ratios. This is done by calculating the antilog[23] of the various coefficients. Odds interpretation indicates how an increase (decrease) in an attribute's level would result in a change in the probability of choosing an option which includes this increase (decrease). The 'Physical size of fish' coefficient can be interpreted as follows – an increase in the physical size of the fish stock will result in an increase in the probability of a respondent choosing this option by 39 percent. An increase in boat congestion will result in a decrease in the probability of a respondent choosing this option by 2 percent. An increase in public access will result in an increase in the probability of a respondent choosing this option by 2 percent.

The explanatory power of the model is measured by the Pseudo R^2. At 22 percent this is a good fit for CE-type studies – Louviere *et al.* (2000) suggested that anything between 0.2 and 0.4 can be considered very good.

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

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

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

An alternative approach to the Pseudo R^2 for determining how well a choice model explains the data is to generate a contingency table in LIMDEP NLOGIT Version 4.0 (Hensher *et al.* 2005). This table predicts choice results for the sample based on the model generated and compares these to the actual choices made. Table 6.29 below shows the contingency table results for the CL model estimated.

Table 6.29: Contingency table – CL model – Sundays River Estuary

	X1	**X2**	**Total**
X1	241	132	373
X2	115	212	327
Total	356	344	700

In Table 6.29, the rows show the number of choices made by the respondents surveyed for each alternative. The columns represent the number of times an alternative was predicted to be selected; this prediction is based on the specified choice model (Hensher *et al.* 2005).

From Table 6.29, it is possible to derive a measure of the aggregate proportion of correct predictions. This is achieved by summing across the number of correct predictions and dividing it by the total number of choices made (Hensher *et al.* 2005). The number of correct predictions is represented by the diagonal elements of the table (the number of times the choice model incorrectly predicted which alternative the respondent would select is represented by the off-diagonal elements). In this case, the model correctly predicted the alternative chosen 453 times (241 + 212) out of the total of 700 choices made. The overall proportion of correct predictions of actual choice is 453/700 = 0.647 (or 64.7 percent).

As mentioned in Chapter Four, the CL model was developed for use in market research, transportation and environmental valuation literature (Brownstone, 2001). Even though it is widely used in these areas, there is potential for bias in the estimates. The first potential for bias comes from the assumption that the utility weights for the recreational attributes are the same across all respondents. The second is the assumption of IIA. This property implies that the random components of utility are independent across alternatives and are identically distributed (Louviere *et al.* 2000). If the IIA assumption does not hold, utility parameter estimates could be biased. Finally, CL estimates assume that errors in each respondent's series of answers are uncorrelated.

In order to overcome some of the abovementioned potential sources of bias, an HEV logit may be estimated. The HEV model relaxes the assumption of identically distributed random components, and allows for variance across all alternatives (Louviere *et al.* 2000). Like the CL model, the results of this model indicate that all the coefficients have the correct *a priori* signs. However, only three of the four coefficients are significantly different from zero at the 99 percent confidence level, namely the 'Physical size of the fish stock', 'Public access' and 'Cost'. The 'Congestion' coefficient is significantly different from zero at the 95 percent confidence level.

The odds interpretation of significant coefficients may also be applied to the HEV model results. An increase in the physical size of the fish stock will result in an increase in the probability of a respondent choosing this option of 62 percent. An increase in boat congestion will result in a decrease in the probability of a respondent choosing this option of 3 percent. An increase in public access will result in an increase in the probability of a respondent choosing this option of 3 percent.

The McFadden Pseudo R^2 of the HEV model is 24 percent. As with the CL model, a contingency table was generated to compare predicted choice to the actual choices made (see Table 6.30 below).

Table 6.30: Contingency table – HEV model – Sundays River Estuary

	X1	**X2**	**Total**
X1	248	125	373
X2	120	207	327
Total	368	332	700

In this case, the model correctly predicted the alternative chosen 455 times (248 + 207) out of the total of 700 choices made; an overall proportion of correct predictions of 455/700 = 0.65 (or 65 percent).

As explained in Chapter Four, the RPL approach addresses all three potential sources of bias. Table 6.28 above reports the RPL[24]. In the RPL models, recreational attribute parameters are treated as random variables except for the 'Cost' variable. In the case of the random variables ('Physical size of fish stock', 'Congestion' and 'Public access'), each coefficient includes a systematic and a random component. The model estimates a mean and a standard deviation for each distribution. Treating the recreational attributes as random parameters allows the researcher to test for the degree of heterogeneity in preferences across respondents by examining the significance of the standard deviation (Hensher *et al.* 2005).

In this case, a normal distribution[25] was selected for all the random parameters. The 'Cost' variable was specified as fixed, and not randomly distributed, because in this case, the distribution of the marginal WTP for an attribute is simply the distribution of that attribute's coefficient.

Comparing the results from the CL, HEV and RPL models reveal that the magnitudes, signs and statistical significance of the coefficients are very similar. Allowing preferences for recreational attributes to vary across respondents, shows that there is very little unexplained heterogeneity in respondent preferences. All of the standard deviation coefficients are statistically insignificant, indicating statistically similar preferences for these attributes across respondents. The random variables specified in the RPL confirm

[24] This model was estimated with simulated maximum likelihood using Halton draws with 500 replications. Compared to standard pseudo random draws, this method (which uses low dispersion sequences) requires fewer draws to obtain robust, accurate results.

[25]Other options include a uniform distribution, a triangular distribution, and a lognormal distribution (Hensher *et al.* 2005).

preference to increase the physical size of fish stocks, for less boat congestion, and for increased public access.

As with the CL and HEV models, a contingency table was constructed for the RPL model estimates. This is shown in Table 6.31.

Table 6.31: Contingency table – RPL model – Sundays River Estuary

	X1	**X2**	**X3**
X1	241	132	373
X2	114	213	327
Total	355	345	700

In this case, the model correctly predicted the alternative chosen 454 times (241 + 213) out of the total of 700 choices made. The overall proportion of correct predictions of actual choice is 455/700 = 0.648 (or 64.8 percent).

It is not surprising that preferences for the physical size of fish stocks, boat congestion and public access do not vary much across respondents, because most of the recreational users at the Sundays River Estuary are fishers and prefer to fish from boats.

6.4.1.2 Marginal value estimates and welfare calculations

a) Implicit price estimates

Implicit prices are calculated by determining the marginal rates of substitution between the attributes, using the coefficient for cost as the "numeraire" (Hanemann, 1984). The ratios of the attribute in question to the cost coefficient can be interpreted as the marginal WTP for a change in each of the attribute values (Hanemann, 1984). More specifically, the marginal WTP value represents a change from one attribute level to another. In the case of the Sundays River Estuary, these marginal WTP values represent: a change from catching small fish now to catching bigger and more fish next year, a change from seeing and hearing few boats to seeing and hearing many boats, and a change from limited recreational appeal to an improvement in the recreational appeal of estuary banks. Table

6.32 reports the implicit prices, or marginal WTP, for each of the Sundays River Estuary's recreational attributes estimated using the Delta method (Wald procedure)[26] in LIMDEP NLOGIT Version 4.0 (Greene, 2007). For comparisons, estimates were calculated using all three models.

Table 6.32: Marginal WTP (MWTP) for attributes (Rands) and 95 percent confidence intervals (CI)* – Sundays River Estuary

Attributes	CL	HEV**	RPL
	MWTP	MWTP	MWTP
Physical Size of Fish Stock	154 (109; 200)	150	174 (95; 253)
Congestion	-33 (-60; -6)	-34	-35 (-62; -8)
Public Access	33 (8; 59)	33	34 (8; 59)

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

The differences in WTP among the three models are small, with the exception of the RPL estimate for 'Physical size of fish stock'. The respective marginal WTP value for the RPL model is R174. This is compared to the marginal WTP values of R154 and R150 for the CL and HEV models, respectively. Despite the difference in this attribute's estimates, 'Congestion' and 'Public access' show similar WTP values across models. Confidence intervals for the CL and RPL models are overlapping for all attributes, however, the CL model shows a narrower range. Given these results, the standard CL model estimates are used for calculating welfare measures and explaining sub-sample WTP differences.

b) WTP estimates: models grouped according to socio-demographic variables

The marginal WTP for the respective environmental attributes according to different socio-demographic groupings were calculated and tabulated in Table 6.33 below. The sample was grouped according to the following socio-demographic characteristics: age,

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

education, gender, income, and type of respondent. A CL model was estimated for each sub-sample. Most of the sub-sample's calculated marginal WTP estimates are significant at the 5 percent level.

Table 6.33: Implicit prices according to different socio-demographic sub-samples – Sundays River Estuary

Grouped Models	Size of Fish	Congestion	Access
Age < 36	116.8 (0.000)	-66.0 (0.000)	26.9 (0.1139)
Age ≥ 36	211.9 (0.000)	1.5 (0.9291)	42.8 (0.0248)
≤ Matric	118.1 (0.000)	-62.0 (0.000)	23.4 (0.1783)
>Matric	206.9 (0.000)	-7.0 (0.730)	44.8 (0.0164)
Female	145.6 (0.000)	0.8 (0.9732)	59.2 (0.0133)
Male	167.9 (0.000)	-47.1 (0.0029)	28.3 (0.0575)
Income ≤ R150 000	152.1 (0.000)	-61.2 (0.000)	29.0 (0.0974)
Income > R150 000	187.8 (0.000)	2.8 (0.8916)	47.5 (0.0129)
Resident	177.1 (0.000)	-5.9 (0.7974)	37.1 (0.0757)
Visitor	159.6 (0.000)	-46.9 (0.0036)	34.3 (0.0264)

Note: p-values in brackets

The line plots in Figure 6.1 illustrate the variability of each attribute with respect to marginal WTP for all the sub-samples.

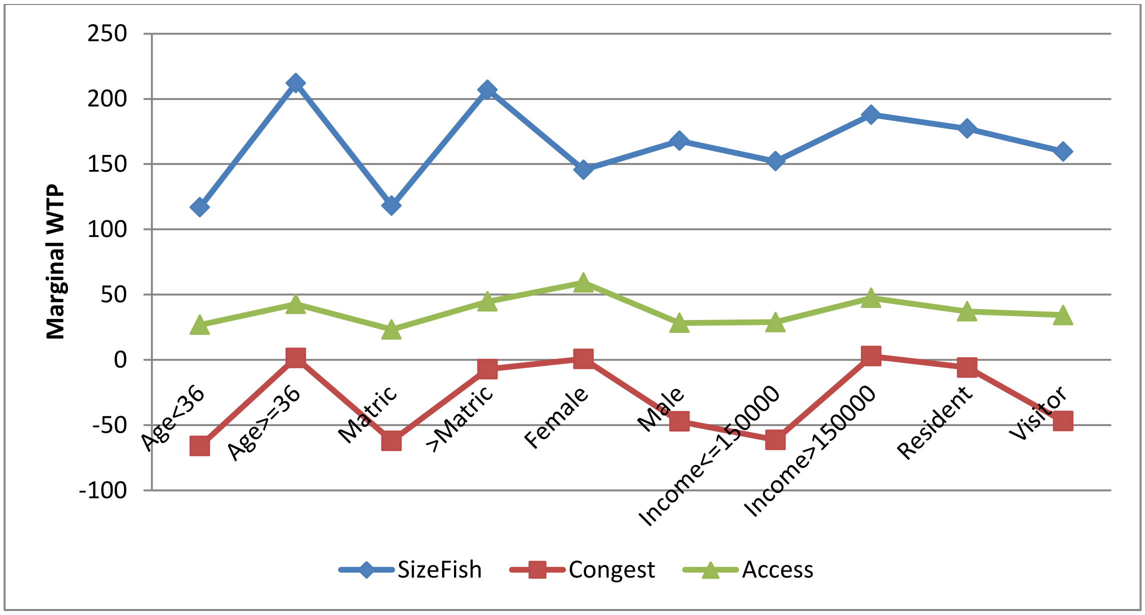

Figure 6.1: Variability of marginal WTP (Rands) of attributes for all sub-samples – Sundays River Estuary

Figure 6.1 shows that the highest marginal WTP estimates, when it comes to improving the physical size of fish stocks, are those of males, over the age of 35, with tertiary education. These individuals are also higher income earners within the sample, earning more than R150 000 per annum.

The majority of the marginal WTP estimates in Figure 6.1 are negative for boat congestion, implying that most of those sampled would pay in order to 'decrease' boat congestion on the Sundays River Estuary. The highest marginal WTP estimates for decreasing boat congestion are for males with, at most, a matriculation exemption, who earn low levels of income, i.e. less than R150 000 per annum. Visitors were willing to pay more for decreased boat congestion than residents.

Various marginal WTP estimates for improving public access to the Sundays River Estuary are also given in Figure 6.1. Residents valued public access more than visitors. Older (over 35) females earning higher incomes (over R150 000), also placed a high value on increased public access.

In the models estimated from the socio-demographically grouped sub-samples, all ‘physical size of fish’ and ‘cost’ attributes are significant. Visitors, lower income, and male categories are significant at the 10 percent level across all sub-samples.

c) CS estimates

Attribute specific CS estimates

The CS associated with an improvement in the physical size of fish stock in the Sundays River Estuary from a specified constant base (V_C) to a change alternative (V_N)) is estimated below. The constant base and the change alternative are defined as follows:

Constant base:	Catch and keep small fish now, congestion, same public access.
Change alternative:	Keep no undersize fish now but more and bigger fish next year, congestion, same public access.

The CS is calculated as follows:

$$CS = - (1/\alpha)\ (V_C - V_N) \tag{6.2}$$

where:

α = the marginal utility of income,

V_C = the utility of the constant base, and

V_N = the utility of the change alternative.

For the change to an increased physical size of fish stocks (V_N):

$$CS = 96.8x(- 1.59) = - R153.90$$

The negative sign shows that in order to maintain utility at level V_C, given an improvement in the physical size of fish stocks in the Sundays River Estuary, income must be reduced by R153.90. Another way of stating this is that the WTP per household for an improvement in the physical size of fish stocks was R153.90.

The CS associated with a decrease in the level of boat congestion in the Sundays River Estuary, from a specified constant base (V_C) to a change alternative (V_N), is estimated below. The constant base and the change alternative are defined as follows:

Constant base: Catch and keep small fish now, congestion, same public access.
Change alternative: Catch and keep small fish now, no congestion, same public access.

The CS is calculated as follows:

CS = 96.8x(- 0.34) = - R32.90

The negative sign shows that to maintain utility at level V_C, given a reduction in the level of boat congestion in the estuary, income must be reduced by R32.90.

The CS associated with an improvement of public access at the Sundays River Estuary, i.e. from a specified constant base (V_C) to a change alternative (V_N), is estimated below. The constant base and the change alternative are defined as follows:

Constant base: Catch and keep small fish now, congestion, same public access.
Change alternative: Catch and keep small fish now, congestion, more public access.

The CS is calculated as follows:

CS = 96.8x(- 0.34) = - R32.90

The negative sign shows that to maintain utility at level V_C, given an improvement in public access at the Sundays River Estuary, income must be reduced by R32.90.

Overall CS

The CS associated with an improvement from a specified constant base (V_C) to a change alternative (V_N) can also be estimated. The constant base and the change alternative are defined as follows:

Constant base: Catch and keep small fish now, congestion, same public access.

Change alternative: Keep no undersize fish now but more and bigger fish next year, no congestion, more public access.

CS = 96.8x(– 2.28) = - R220.70

The negative sign shows that to maintain utility at level V_C, given an improvement in estuary recreational services, income must be reduced by R220.70.

6.4.2 THE KROMME RIVER ESTUARY CHOICE EXPERIMENT

6.4.2.1 Parametric model estimation

Like the Sundays River Estuary, three different choice model specifications were estimated as part of the Kromme River Estuary CE: a CL model, an HEV model and an RPL model. Once again, the LIMDEP NLOGIT Version 4.0 statistical programme was used to make all the estimations. The three models estimated showed the importance of choice set attributes in explaining respondents' choices across the two different options: option A and option B[27]. For the two option choice sets, with four attributes, the utility functions were expressed as follows:

Option A: $V_A = \beta_1\text{Navigability} + \beta_2\text{Congestion} + \beta_3\text{Jetskiing} + \beta_4\text{Cost}$

Option B: $V_B = \beta_1\text{Navigability} + \beta_2\text{Congestion} + \beta_3\text{Jetskiing} + \beta_4\text{Cost}$

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

In the same way as for the Sundays River Estuary CE, the levels of the four attributes in the choice sets determine utility. The model provides an estimate of the effect of a change in any of these attributes on the probability that one of these options will be chosen.

The first model shown in Table 6.34 is the estimate of a standard CL model.

Table 6.34: Estimation results of the CE – Kromme River Estuary

Variables	CL		HEV		RPL Model 1[2]		RPL Model 2[3]	
	Coefficient	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**
Navigability	.672167**	.096057	.632440**	.09912	1.950906**	.722367	2.383288*	.965053
Congestion	-.467298**	.097580	-.424775**	.09849	-1.608222*	.693198	-1.984012*	.864568
Jet Skiing[1]	-.053177	.097113	-.044222	.08477	.122747	.182631	.1552595	.185983
Cost[1]	-.001539**	.000252	-.001405**	.00026	-.003332**	.000627	-.0034440**	.000616
	Standard Deviation of Random Parameters							
Navigability					3.356599*	1.556617	6.310501*	2.677684
Congestion					5.288879*	2.176638	9.526799*	3.695197
No. of Respondents	244		244		244		244	
No. of Choice Sets	976		976		976		976	
Pseudo R^2	.081		.085		.094		.091	

Notes: *indicates that parameter is statistically significant at the 5 percent level
** indicates significance at the 1 percent level

1. Jet skiing and Cost were specified as non-random parameters in both the RPL models.
2. The random parameters were normally distributed in Model 1.
3. The random parameters were uniformly distributed in Model 2.

All the coefficients in these models have the correct signs, *a priori*, and three of the four coefficients are significantly different from zero at the 99 percent confidence level.

The probability that an alternative would be chosen was reduced:

- the lower the level of navigability;
- the higher the amount of boat congestion;
- the higher the amount of jet skiing activity; and
- the higher the environmental quality levy.

The fact that the 'Jet Skiing' attribute's parameter is statistically insignificant is surprising, given that it was flagged as very important by the focus group participants. A possible reason for this peculiar result could be that two opposing groups of similar size were captured in the sample. Thus, the preferences of those in favour of jet ski/wet bike access were counter-balanced by the preferences of those who are against jet ski/wet bike use on the estuary. The significant coefficients of the CL model can be interpreted by estimating their odds ratios. An increase in the level of navigability will result in an increase in the probability of a respondent choosing this option by 4.7 percent. An increase in boat congestion will result in a decrease in the probability of a respondent choosing this option by 0.3 percent.

The Pseudo R^2 of this model is 8 percent. As was the case with the Sundays River CE, a contingency table was constructed for the CL model. This table is shown below (Table 6.35).

Table 6.35: Contingency table – CL model – Kromme River Estuary

	X1	**X2**	**Total**
X1	271	210	481
X2	223	272	495
Total	493	483	976

In this case, the model correctly predicted the alternative chosen 543 times (271 + 272) from the total of 976 choices made. The overall proportion of correct predictions of actual choice is 543/976 = 0.556 (or 55.6 percent).

In order to address a potential source of bias (non-identical distributed random components and constant variances) an HEV model was estimated (see Table 6.34).

Like the CL model, the results of this model indicate that all the coefficients have the correct signs *a priori*. Three of the four coefficients are significantly different from zero at the 99 percent confidence level: 'Navigability', 'Congestion' and 'Cost'. The McFadden Pseudo R^2 is 8.6 percent. The contingency table results for the HEV model are shown in Table 6.36 below.

Table 6.36: Contingency table – HEV model – Kromme River Estuary

	X1	**X2**	**Total**
X1	265	216	481
X2	216	279	495
Total	481	495	976

For this model the alternative was correctly predicted 544 times (265 + 279) from the total of 976 choices made. The overall proportion of correct predictions of actual choice is 544/976 = 0.557 (or 55.7 percent).

Table 6.34 reports the RPL results for two models. As explained for the Sundays River model estimation, the RPL addresses three potential sources of bias. Two of the recreational attributes were treated as random variables; 'Navigability' and 'Congestion'. The 'Jet Skiing' and 'Cost' variables were specified as fixed[28]. In other words, preferences relating to the use of jet skis/wet bikes and the cost were assumed to be homogenous, whereas the two variables assumed to be random represent heterogenous preferences. A normal distribution was initially selected for both the random parameters

[28] The 'Jet Skiing' variable was not made a random variable because during an initial estimation where it was specified as a random parameter its standard deviation coefficient was statistically insignificant.

specified. The contingency table results for the RPL (Model 1) are shown in Table 6.37 below.

Table 6.37: Contingency table – RPL (Model 1) – Kromme River Estuary

	X1	X2	Total
X1	273	208	481
X2	219	276	495
Total	492	484	976

The first RPL model correctly predicted the alternative chosen 549 times (273 + 276) from the total of 976 choices made. The overall proportion of correct predictions of actual choice is 549/976 = 0.563 (or 56.3 percent).

The results of the RPL model utilising a uniform distribution for the random variables are presented in Table 6.34. A contingency table (Table 6.38) was also constructed for the second RPL model.

Table 6.38: Contingency table – RPL (Model 2) – Kromme River Estuary

	X1	X2	Total
X1	272	209	481
X2	218	277	495
Total	491	485	976

The second RPL model correctly predicted the alternative chosen 549 times (272 + 277) from the total of 976 choices made. The overall proportion of correct predictions of actual choice is 549/976 = 0.563 (or 56.3 percent).

Table 6.34 also shows the standard deviations and standard errors for the random parameters of the RPL estimates. Allowing preferences for two recreational attributes (‘Navigability’ and ‘Congestion’) to vary across respondents shows that there is unexplained heterogeneity in respondent preferences. Both the standard deviation coefficients are statistically significant, indicating statistically dissimilar preferences for these attributes across respondents. In other words, the random variables specified in the

RPL indicate that respondents are divided on their views regarding the need to increase estuary navigability, and reduce boat congestion.

The RPL models indicate the presence of unobserved heterogeneity. However, they fail to explain the sources of the heterogeneity (Adamowicz & Boxall, 2001). One way to detect and account for unobserved heterogeneity is to include interactions of various respondent-specific characteristics with choice specific attributes in the utility function. This enables the RPL model to elicit preference variation, whether it is from unconditional taste heterogeneity (random) or conditional heterogeneity (individual characteristics). This can improve model fit (Revelt & Train, 1998).

In a model given in Appendix D, a series of respondent-specific control variables were included in the RPL specification[29]. These variables were: resident type, respondent type, gender, age, where the respondent lives, occupation, income and education. The inclusion of these variables did not improve the estimates. In this case, complete reliance was placed on the fixed mean and standard deviation of the parameter estimates, with the latter representing all sources of preference heterogeneity around the mean (Hensher *et al.* 2005). Comparing the results from the CL, HEV and RPL models reveals that the magnitudes, signs and statistical significance of the coefficients are very similar. Given these similarities, it was considered prudent to use the standard CL model's results when estimating welfare measures and explaining sub-sample WTP differences.

6.4.2.2 Marginal value estimates

a) Implicit price estimations

In the case of the Kromme River Estuary, the marginal WTP values represent: a change from the current level of navigability to a pre-settlement level, a change from seeing and hearing few boats to seeing and hearing many boats, and a change from no jet ski or wet

[29]These were specified in LIMDEP NLOGIT Version 4.0 as "Heterogeneity around the mean" variables. During estimation, these variables were interacted with the two random variables selected, namely Navigability and Congestion.

bike access to the potential use of jet skis and wet bikes on the estuary. Table 6.39 reports the implicit prices, or marginal WTP, for each of the Kromme River Estuary's recreational attributes estimated using the Delta method (Wald procedure)[30] in LIMDEP NLOGIT Version 4.0 (Greene, 2007). For comparisons, estimates were calculated using all four models.

Table 6.39: Marginal WTP (MWTP) for attributes (Rands)* and 95 percent confidence intervals (CI) - Kromme River Estuary**

Attributes	CL	HEV***	RPL Model 1	RPL Model 2
	MWTP	**MWTP**	**MWTP**	**MWTP**
Navigability	437 (256; 617)	450	586 (231; 940)	692 (211; 1173)
Congestion	-304 (-463; -144)	-302	-483 (-841; -124)	-576 (-1023; -129)
Jet Skiing	-35 (-161; 9)	-31	-37 (-69; 143)	45 (-59; 149)

**Please note that the estimated coefficient for the Jet Skiing attribute was statistically insignificant for all four models estimated (see Table 6.34 above). Implicit prices were calculated to inform policy analysis.*
***Confidence intervals in parentheses.*
**** Confidence intervals not calculated for HEV due to the presence of fixed parameters.*

The differences in the WTP estimates among the four models are not particularly large, except for the WTP figures reported for the second RPL model estimated. Confidence intervals for the CL and both RPL models are overlapping for all attributes however the CL model shows a narrower range.

b) WTP estimates: models grouped according to socio-demographic variables

The marginal WTP estimates for the respective attributes were also calculated according to different socio-demographic characteristics and presented in Table 6.40 below. The sample was grouped according to age, education, gender, income, respondent type and resident type. A CL model was estimated for each sub-sample. Most of the sub-samples calculated marginal WTP estimates are significant at the 5 percent level, with the exception of those for the 'Jet Skiing' variable.

[30]See Footnote 26.

Table 6.40: Implicit prices according to different socio-demographic sub-samples – Kromme River Estuary

Grouped Models	Navigability	Congestion	Jet Skiing
Age < 36	373.0 (0.000)	-307.0 (0.000)	187.5 (0.0307)
Age ≥ 36	642.0 (0.000)	-447.0 (0.000)	-242.0 (0.0437)
≤ Matric	235.3 (0.000)	-146.0 (0.0217)	96.0 (0.1145)
>Matric	650.0 (0.000)	-513.0 (0.000)	-179.0 (0.1243)
Female	670.0 (0.000)	-710.0 (0.000)	-126.0 (0.4583)
Male	319.5 (0.000)	-186.0 (0.0014)	-13.5 (0.8197)
Income ≤ R150 000	295.5 (0.000)	-169.5 (0.0146)	-23.5 (0.7324)
Income > R150 000	750.0 (0.000)	-617.0 (0.000)	-61.0 (0.6559)
Permanent	240.3 (0.000)	-172.0 (0.0047)	87.3 (0.1400)
Other	649.0 (0.000)	-492.0 (0.000)	-184.0 (0.1175)
Homeowner	295.0 (0.000)	-203.0 (0.000)	-26.0 (0.6408)
Visitor	861.0 (0.000)	-695.0 (0.000)	-74.0 (0.7028)

Note:p-values in brackets

Figure 6.2 illustrates the variability of each attribute with respect to the marginal WTP estimates for each of the socio-demographic sub-samples.

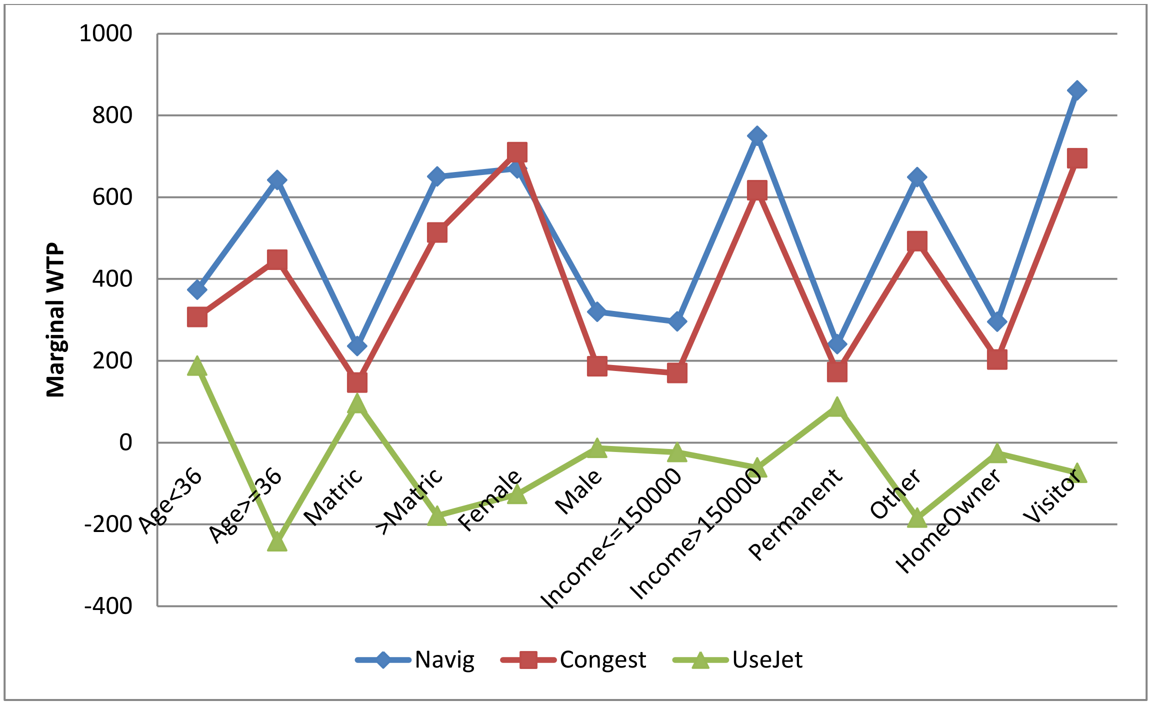

Figure 6.2: Variability of marginal WTP (Rands) of attributes for all sub-samples – Kromme River Estuary

Figure 6.2 shows that the highest marginal WTP estimates for improved navigability are those of females, over the age of 35, earning more than R150 000 per annum, with tertiary education. The visitor sub-sample has a higher marginal WTP than the permanent resident or homeowner sub-sample.

Various marginal WTP estimates for a reduction in boat congestion on the Kromme River Estuary are also illustrated in Figure 6.2. The highest marginal WTP estimates are for females, over the age of 35, earning more than R150 000 per annum, with a tertiary education. Visitors were willing to pay more for reduced boat congestion than permanent residents or homeowners.

Figure 6.2 shows marginal WTP estimates for the regulation of jet skis/wet bikes on the estuary. The majority of estimates are negative, which indicate that these categories of respondents do not want the use of jet skis or wet bikes re-instated on the estuary. Those respondents younger than 36 years of age and with less than a matric education, who are permanent residents of the estuary, are willing to pay to have jet skis/wet bikes reinstated. The estimates for this attribute are, however, insignificant.

c) CS estimates

Attribute specific CS estimates

The CS associated with an increase in the level of navigability in the Kromme River Estuary, from a specified constant base (V_C) to a change alternative (V_N), is estimated below. The constant base and the change alternative are defined as follows:

Constant base: Current navigability, congestion, jet skis/wet bikes banned.
Change alternative: Ideal navigability, congestion, jet skis/wet bikes banned.

For the change to ideal navigability, i.e. the change alternative (V_N):

CS = 649.8x(-0.67) = -R435.37

The negative sign shows that in order to maintain utility at level V_C, given an increase in the level of navigability on the Kromme River Estuary, income must be reduced by R435.37. Another way of stating this is that the WTP per household for the ideal level of navigability was R435.37.

The CS associated with a decrease in the level of boat congestion in the Kromme River Estuary, from a specified constant base (V_C) to a change alternative (V_N), is estimated below. The constant base and the change alternative are defined as follows:

Constant base: Current navigability, congestion, jet skis/wet bikes banned.
Change alternative: Current navigability, no congestion, jet skis/wet bikes banned.

For the change to no congestion (V_N):

CS = 649.8x(-0.57) = - R370.39

The negative sign shows that in order to maintain utility at level V_C, given a reduction in the level of boat congestion in the estuary, income must be reduced by R370.39.

The CS associated with the re-instatement of jet skis/wet bikes on the Kromme River Estuary, from a specified constant base (V_C) to a change alternative (V_N), is estimated below. The constant base and the change alternative are defined as follows:

Constant base:	Current navigability, congestion, jet skis/wet bikes banned.
Change alternative:	Current navigability, congestion, jet skis/wet bikes re-instated but regulated.

For the change to the re-instatement and regulation of jet skis/wet bikes on the estuary (V_N):

CS = 649.8x(-0.99) = - R643.30

The negative sign shows that in order to maintain utility at level V_C, given the re-instatement and regulation of jet skis/wet bikes on the Kromme River Estuary, income must be reduced by R643.30. The CS in this case is based on statistically insignificant coefficients.

Overall CS

The CS associated with an improvement from a specified constant base (V_C) to a change alternative (V_N) for a multiple change may also be estimated. The constant base and the change alternative are defined as follows:

Constant base: Current level of navigability, congestion, jet skis/wet bikes banned.

Change alternative: Ideal navigability, no congestion, jet skis/wet bikes re-instated but regulated.

For the change (V_N):

CS = 649.8x(-1.19) = - R773.26

The negative sign shows that to maintain utility at level V_C, given an improvement in estuary recreational services, income must be reduced by R773.26.

6.5 VALIDITY AND RELIABILITY: THEORETICAL CONSIDERATIONS

As this study was the first CE study administered at the estuaries in question, the issue of reliability cannot be tested. On the other hand, validity could be assessed. This was done for each estuary in terms of actual responses and the economic rationality of the responses, as well as an internal assessment of the theoretical adequacy of the way the questionnaires were constructed.

6.5.1 THE SUNDAYS RIVER ESTUARY

6.5.1.1 Follow-up questions: issues of reliability and validity

A set of follow-up questions were asked after completion of the CE. In the case of the Sundays River Estuary, there were four follow-up questions on the respondents' experience of the CE exercise. The inclusion of these questions aimed to allow an assessment to be made of the extent to which the respondents' decision strategies conformed to the assumptions underlying the CE approach.

In the first follow-up question (Question 4.1), respondents were asked whether they found it difficult or easy to complete the CE. Table 6.41 below shows a percentage breakdown of the responses to this question.

Table 6.41: Respondents' view of choice complexity – Sundays River Estuary

Complexity Level	Percentage
Difficult	23
Easy	77

The majority of respondents found it easy to make the necessary choices, did not need to adopt a simplified decision rule to make their choice selections easier, felt the CE was not overly complicated and was not too time-consuming.

The next question (Question 4.2) was only answered by those respondents who indicated that the choice task was difficult (in other words, those who answered 'Yes' to Question 4.1). Table 6.42 below shows the percentage breakdown of these answers.

Table 6.42: Reasons why the choice task was difficult – Sundays River Estuary

Reason	Percentage
Could not relate	12
Too much information	37
Did not understand	5
Options too expensive	5
Several factors important	29
Users should not pay	2
Other	5
Don't know	5

The responses to this question (Question 4.2) shed light on how different parts of the CE are understood. One of the assumptions underlying the use of the CE method is that individuals apply compensatory decision making strategies, that "individuals are assumed to consider all attributes, and make trade-offs between all attributes within the choice sets provided in the design" (Watson *et al.* 2004). Encouragingly, of the 'problem' respondents, 29 percent chose the "Several factors important" answer-option, indicating that they were aware of the need to adopt a compensatory decision-making strategy.

Question 4.3 asked the respondents to indicate which of the four attributes in each alternative they had put greatest weight on when choosing between the two alternatives. Two further answer categories were given as part of this question, namely "Varied between choices" and "Don't know". Table 6.43 shows the percentage breakdown of respondents' answers to this question.

Table 6.43: Respondents' attribute weights – Sundays River Estuary

Attribute	**Percentage**
Congestion	12
Physical size of fish stocks	49
Public access	11
Size of Environmental levy	15
Varied between choices	13
Don't know	1

The answers to this question serve to indicate which attributes were considered most important and thus potentially a likely focus of attention of non-compensatory decision strategies. The physical size of fish stocks was considered most important in the case of the Sundays River Estuary. This result reveals that, if there were non-compensatory decision strategies[31] adopted by respondents or lexicographic/dominant preferences, the most likely attribute linked to it was 'Physical size of fish stocks'.

Question 4.4 was a policy-orientated question, which asked the respondents whether they would increase their level of estuary usage if certain recreational estuarine attribute improvements were made. Table 6.44 below gives a percentage breakdown of the responses to this question.

[31] The dominance of a "one attribute" answer-category is by no means definitive proof of non-compensatory decision making.

Table 6.44: Potential future estuary use – Sundays River Estuary

Estuary Use	Percentage
Use the same	55
Use more often	45

6.5.1.2 Economic plausibility of responses

A test was performed to check whether demand decreases in response to increasing prices (rational respondent behaviour). The relationship between the frequency of the chosen alternative and cost size is shown below (Figure 6.3).

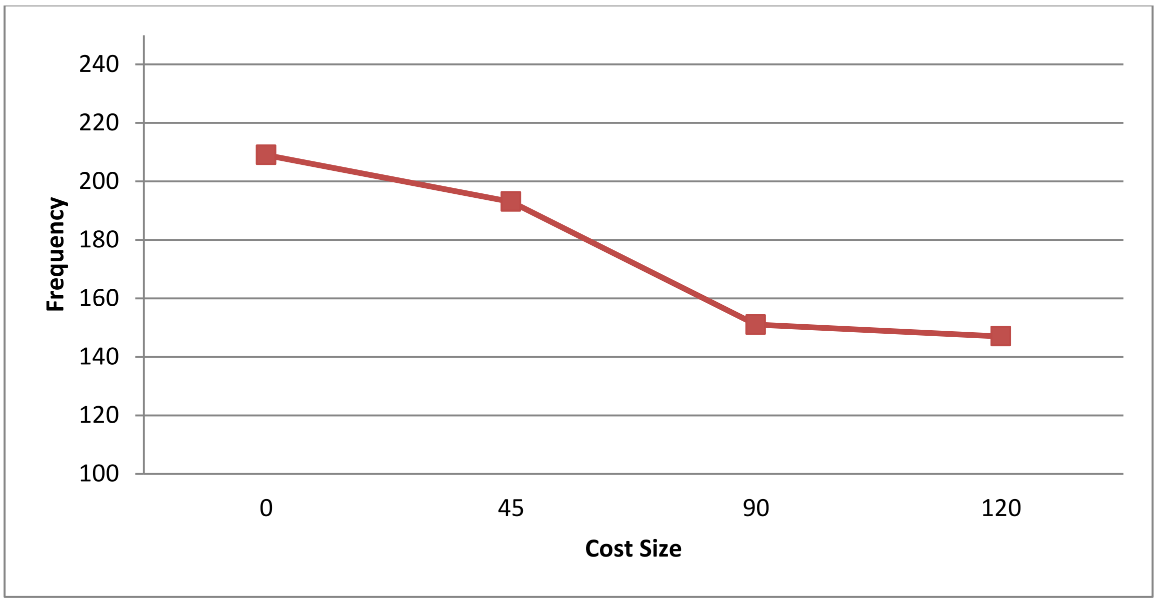

Figure 6.3: Relationship between cost size and frequency of chosen alternative – Sundays River Estuary

This figure shows that the number of chosen alternatives would drop as the cost associated with that alternative increases, which is consistent with a normal downward sloping demand curve for a normal good. For this reason the predictions of the model are consistent with economic theory and do not give rise to a query of validity on this account.

6.5.1.3 Internal assessment of content and construct validity

a) Content validity

Content validity was assessed by analysing whether the questionnaire asked the appropriate questions in a clear and understandable manner, i.e. free from ambiguity. An internal assessment of this form of validity is reported in Table 6.45 below.

Table 6.45: A Summary of Content Validity Issues – Sundays River Estuary

CONTENT VALIDITY	
Scenario Design	**Assessment**
Are the attributes and their levels described in an understandable manner?	All attributes and levels were explained to respondents prior to the completion of the questionnaire
Does the information provided to the respondent adequately explain the environmental quality issue?	The respondents were fully aware of the environmental quality issues represented in the survey and had no problem making the necessary trade-offs
Is the payment vehicle considered relevant and realistic in order for the respondent to make plausible trade-offs?	The payment vehicle was the most realistic option proposed in the focus groups. The amounts were in line with current payment scenarios for recreational use
Is there a section of "cheap talk" in the questionnaire and does it highlight budget constraints and substitutes?	This section was included in the questionnaire and interviewers highlighted its importance prior to the completion of the choice section
Elicitation Issues	**Assessment**
Is the chosen non-market valuation technique appropriate?	The CE is most appropriate as it deals with multiple scenarios in one application, whereby each scenario can represent a different policy management option
Institutional Context	**Assessment**
Does the scenario presented to the respondents give them an expectation of payment in the future?	Yes. Respondents expect to pay for the provision of the good, but were concerned about effective administration of the payment.
Do respondents feel like their input has value in the decision making process?	Yes. Respondents were happy to give their views on the environmental issues investigated and eager to participate in the study

Experimental Choice Design	Assessment
Was the experimental design efficient?	The experimental design was orthogonal and balanced. A test for multicollinearity revealed that orthogonality was maintained during the execution of the survey
Sampling	**Assessment**
Was the target population and sampling frame correctly specified?	The population and thus a sample frame could not be identified. Non-list sampling was therefore used through the n^{th} intercept survey technique
Survey Format	**Assessment**
Was the survey mode of collection appropriate?	Yes. Personal interviews are widely regarded as the most appropriate surveying technique for stated preference methods (Arrow *et al.* 1993)
Was the administration of the survey supervised and conducted in a professional manner?	Yes. Interviewers were trained and supervised during the survey. Quality checks were conducted on completed questionnaires.
Did the questionnaire design provide enough variable data for an in-depth explanation of WTP values?	Yes. WTP measures were derived for each attribute. Various socio-economic characteristics were interacted with the attributes in an attempt to reveal any source of heterogeneity.

Source: Adapted from Oliver (2010)

The judgments reported in Table 6.45 are essentially subjective. A number of questions contained in the CE questionnaire can be used to test content validity. A number of positive indicators of content validity (from the questionnaire responses) are as follows:

- Only 23 percent of the respondents found the valuation questions difficult. Of these, 3 percent could not relate to the questions and 1 percent did not understand the questions. It can thus be deduced that the questionnaire created a realistic hypothetical market (EFTEC, 2002).
- Income non-response is 27 percent of the sample. This is comparable to that found in other studies (EFTEC, 2002).
- Of the sampled respondents, 55 percent agreed that congestion is a problem (whereas 35 percent indicated that it is not a problem), 70 percent agreed that

recreational over-fishing is a problem (whereas 18 percent indicated that it is not a problem), and 73 percent indicated that current levels of access are sufficient (whereas 18 percent indicated that it is not sufficient). This lends partial support for the design of the experiment, in that two of the three attributes were also considered important by respondents.

b) Construct validity

Construct validity is divided into convergent validity and expectations-based validity. Convergent validity determines whether the welfare estimates are consistent with other comparative studies. Expectations-based validity determines whether the welfare estimates are in line with *a priori* expectations, i.e. they conform to economic theory.

Convergent validity

Convergent validity can be tested by comparing the WTP estimates from one study to those derived by a similar study at the same study site. There were no comparable valuation studies available that value one or all of the attributes included in this study, so this comparison could not be made.

Expectations-based validity

The WTP estimates for the Sundays River Estuary were adjusted to pass the expectations-based validity test if they were consistent with the study's *a priori* expectations and conform to economic theory. All parameter estimates were significant and had the expected signs, as predicted by economic theory. An increase in the cost variable was associated with a decrease in overall welfare. The estimates calculated for each attribute are also considered plausible, given that WTP is for marginal changes (EFTEC, 2002). It was concluded that the results obtained in this study pass the 'reality check' for validity.

6.5.2 THE KROMME RIVER ESTUARY

6.5.2.1 Follow-up questions: issues of reliability and validity

As in the case of the Sundays River Estuary survey, four follow-up questions were asked regarding the respondent's experience of the choice exercise. The first question (Question 4.1) asked the respondents whether they found it difficult or easy to make the necessary choices. Table 6.46 below shows the percentage breakdown of responses to this question.

Table 6.46: Respondents' view of choice complexity – Kromme River Estuary

Complexity Level	**Percentage**
Difficult	23
Easy	77

The majority of respondents found it easy to make the necessary choices, did not adopt simplified decision rules and did not find the completion of the choice task too time consuming.

The next question (Question 4.2) was only answered by those respondents who indicated that the choice task was difficult (in other words, those who answered 'Yes' to Question 4.1). Table 6.47 below displays the percentage breakdown of answer-options chosen.

Table 6.47: Reasons why the choice task was difficult – Kromme River Estuary

Reason	**Percentage**
Could not relate	13
Too much information	27
Did not understand	7
Options too expensive	13
Several factors important	38
Users should not pay	1
Don't know	1
Total	**100**

Of the 'problem' respondents, 38 percent chose the "Several factors (were) important" category, indicating that they were aware of the need to adopt a compensatory decision making strategy[32].

Question 4.3 asked the respondents to indicate which of the four attributes they had put the greatest weight on when choosing between the two alternatives. Table 6.48 shows the percentage breakdown of respondents for each category.

Table 6.48: Respondents' attribute weights – Kromme River Estuary

Attribute	**Percentage**
Navigability	18
Congestion	15
Jet Skis/Wet Bikes	39
Size of Levy	9
Varied between Choices	18
Don't know	1

The use of jet skis/wet bikes was considered most important in the case of the Kromme River Estuary.

Question 4.4 was a policy-orientated question. It asked the respondents whether they would increase their level of estuary usage if certain recreational estuarine attribute improvements were made. Table 6.49 provides a percentage breakdown of the responses to this question.

Table 6.49: Potential future estuary use – Kromme River Estuary

Estuary Use	**Percentage**
Use the same	68
Use more often	32

[32]See the discussion on compensatory decision making in the Sundays River Estuary data analysis.

6.5.2.2 Economic plausibility of responses

Figure 6.4 below illustrates the number of chosen alternatives (y-axis) against a given cost (x-axis), ignoring other influences originating from the other three attributes in a choice set.

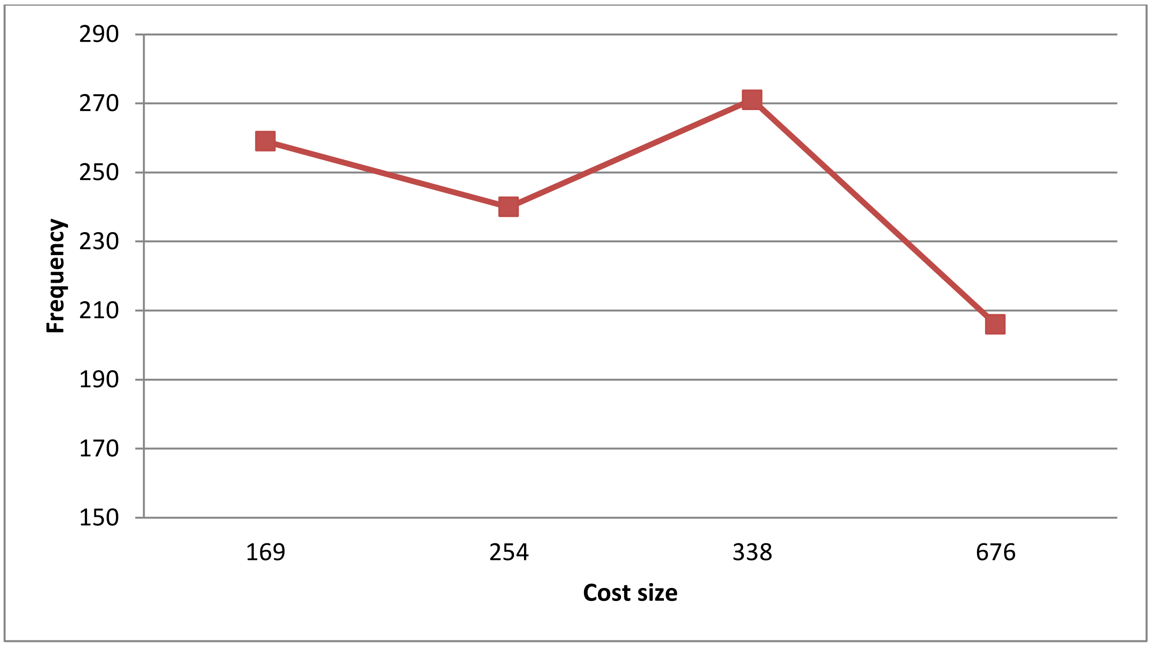

Figure 6.4: Relationship between cost size and frequency of chosen alternative – Kromme River Estuary

The relationship described in Figure 6.4 above is only partially consistent with a continuously downward-sloping demand curve, and in this sense is contrary to *a priori* expectations.

6.5.2.3 Internal assessment of content and construct validity

a) Content validity

Content validity was assessed by analysing whether the questionnaire asked the appropriate questions in a clear and understandable manner. An internal assessment is reported in Table 6.50 below.

Table 6.50: A Summary of Content Validity Issues – Kromme River Estuary

CONTENT VALIDITY	
Scenario Design	**Assessment**
Are the attributes and their levels described in an understandable manner?	All attributes and levels were explained to respondents prior to the completion of the questionnaire
Does the information provided to the respondent adequately explain the environmental quality issue?	The respondents were fully aware of the environmental quality issues represented in the survey and had no problem making the necessary trade-offs
Is the payment vehicle considered relevant and realistic in order for the respondent to make plausible trade-offs?	The payment vehicle was the most realistic option proposed in the focus groups and personal interviews. The amounts were in line with current payment scenarios for recreational use
Is there a section of "cheap talk" in the questionnaire and does it highlight budget constraints and substitutes?	This section was included in the questionnaire and interviewers highlighted its importance prior to the completion of the choice section
Elicitation Issues	**Assessment**
Is the chosen non-market valuation technique appropriate?	The CE is most appropriate as it deals with multiple scenarios in one application, whereby each scenario can represent a different policy management option
Institutional Context	**Assessment**
Does the scenario presented to the respondents give them an expectation of payment in the future?	Yes. Respondents expect to pay for the provision of the good, but were concerned about effective administration of the payment.
Do respondents feel like their input has value in the decision making process?	Yes. Respondents were happy to give their views on the environmental issues investigated and eager to participate in the study
Experimental Choice Design	**Assessment**
Was the experimental design efficient?	The experimental design was orthogonal and balanced. A test for multicollinearity revealed that orthogonality was maintained during the execution of the survey
Sampling	**Assessment**
Was the target population and sampling frame correctly specified?	The population and thus a sample frame could not be identified. Non-list sampling was therefore used through the n^{th} intercept survey technique

Survey Format	Assessment
Is the survey mode of collection appropriate?	Yes. Personal interviews are widely regarded as the most appropriate surveying technique for stated preference methods (Arrow *et al.* 1993)
Was the administration of the survey supervised and conducted in a professional manner?	Yes. Interviewers were trained and supervised during the survey. Quality checks were conducted on completed questionnaires.
Does the questionnaire design provide enough variable data for an in-depth explanation of WTP values?	Yes. WTP measures were derived for each attribute. Various socio-economic characteristics were interacted with the attributes in an attempt to reveal any source of heterogeneity.

Source: Adapted from Oliver (2010)

As was the case with the Sundays River Estuary CE, the judgments reported in Table 6.50 are essentially subjective. A number of positive indicators of content validity (from the questionnaire responses) are as follows:

- Only 23 percent of the respondents found the valuation questions difficult. Of these, 3 percent could not relate to the questions and 2 percent did not understand the questions. It can thus be deduced that the questionnaire created a realistic hypothetical market (EFTEC, 2002).
- Income non-response is 37 percent of the sample. This is comparable to that found in other studies (EFTEC, 2002).
- Of the sampled respondents, 68 percent agreed that congestion is a problem (whereas 23 percent indicated that it is not a problem), 85 percent agreed that the current level of navigability is a problem (whereas 6 percent indicated that it is not a problem), and 61 percent indicated that jet ski and wet bike access is a problem (whereas 26 percent indicated that it is not a problem). This lends support for the design of the experiment, in that all the attributes were also considered important by respondents.

b) Construct validity

Convergent and expectations-based validity are discussed below.

Convergent validity

As with the Sundays River Estuary, there were no comparable valuation studies available that value one or all of the attributes included in this study, so this comparison could not be made.

Expectations-based validity

The WTP estimates for the Kromme River Estuary were adjusted to pass the expectations-based validity test if they were consistent with the study's *a priori* expectations and conform to economic theory. The 'Navigability', 'Congestion' and 'Cost' parameter estimates were significant at the 99 percent level. All the estimates had the expected signs, as predicted by economic theory. An increase in the cost variable is associated with a decrease in overall welfare. The estimates calculated for the significant attributes are also considered plausible, given that WTP is for marginal changes (EFTEC, 2002). It can therefore be concluded that the results obtained in this study pass the 'reality check' for validity.

6.6 CONCLUSION

The results of the two case studies reported in this chapter show how a profile of an estuary's recreational attributes can be valued through a single application of the choice experiment method. The choice models generated were used to provide three estimates of value: implicit prices for the attributes that make up the recreational profiles, compensating surplus estimates that value changes in a single attribute, while holding constant all other attributes within the profile, and compensating surplus estimates for an improvement in all attributes contained in the profiles (combinations of attributes). Can these values be used to address the recreational challenges facing each estuary as discussed in Chapter Three?

The high levels of fishing effort at the Sundays River Estuary could potentially be controlled through a suggested increase in the boat license fee. The size of this increase is calculated as being R150 per user per annum.

Boat congestion on the Sundays River and Kromme River Estuaries can be managed through the implementation of a supplementary tariff during peak periods only. This tariff represents the congestion cost and is calculated as being R33 and R302 per user per annum for the Sundays River and Kromme River Estuaries, respectively.

An investment project to improve public access at the Sundays River Estuary was proposed. This project entails the development of a nature trail fronting the banks of the estuary. The calculated marginal willingness-to-pay for the implementation of this project is R33 per user per annum.

In order to improve navigability on the Kromme River Estuary, the option of dredging was explored. Users' willingness-to-pay to implement dredging operations is estimated at R437 per user per annum.

The external cost imposed on others by the use of jet skis and wet bikes on the Kromme River Estuary is estimated at R31 per user per annum. It is suggested that this cost value be compared to the welfare gains associated with the use of jet skis and wet bikes on the estuary.

Chapter Seven concludes on how these findings may be used to manage recreational demand for the identified services at each estuary.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

South African estuaries, though different in type and function, face similar pressures. Optimising functionality and reducing pressures at all estuaries is not feasible due to budgetary constraints. For this reason, estuaries have been prioritised according to favoured methodologies where estuary importance is based on various measures of estuarine health. Turpie et al (2002) estimated the recommended ecological reserve for each estuary in South Africa by applying the Resource Directed Measures (RDM) approach. While this approach does provide a method for determining a minimum water requirement for an estuary, it does not take into account, or control for, the level of estuarine recreational demand. In order to manage estuaries in a holistic manner, demand-side factors should also provide input to the management decision-making process. Management alternatives should be investigated that have the potential to control estuarine use from a recreational perspective by decreasing recreational demand at estuaries that currently face demand induced pressures. Two such estuarine systems facing demand induced pressures include the Sundays River and the Kromme River Estuaries. The lower reaches of the Sundays River Estuary have been significantly developed. This estuary experiences high boat use during peak holiday seasons, and is also the victim of recreational over-fishing, particularly the dusky kob, white steenbras and spotted grunter (Whitfield, 2008; Cowley *et al.* 2009). The lack of public access to the Sundays River Estuary affects its overall recreational appeal as a tourist destination. The Kromme River Estuary is freshwater starved (Baird, 2002). The development of two major dams on the Kromme River, as well as increased water abstraction upstream, have restricted water flows and caused increased sedimentation, and thus reduced navigability on the estuary. There has also been a significant increase in residential and visitor populations, and there has been concern expressed over whether the estuary's motorised craft carrying capacity is being exceeded. Another recreational disturbance to users of the

Kromme River Estuary is use of jet skis and wet bikes. They are noisy and threaten the safety of other users (Forbes, 1998).

Inter alia, the Sundays River and Kromme River Estuaries are defined as common property resources controlled through state property regimes. These two estuaries are not controlled by marine protected areas, closed areas or national parks implying administration by the relevant municipalities. Laws and regulations that relate specifically to these two estuaries are often breached by the municipalities themselves and are often poorly enforced (Hardin, 1968). The absence of effective administration results in a situation whereby any advantages attributable to a state ownership regime are lost. This leaves the problem of open access at the Sundays River and Kromme River Estuaries unresolved, leading to excess recreational pressures.

Discussions with estuary experts and users of the Sundays River Estuary (Sundays River Joint River Forum, and Sundays River Ratepayers Association) revealed that the following recreational use matters (attributes) deserved immediate attention as far as management of the estuary was concerned: the physical size of the fish stocks, the level of boat congestion and the level of public access. Discussions with estuary experts and users of the Kromme River Estuary (Kromme River Trust, Kromme River Riparian Homeowners Association, and Kromme River Joint River Forum) revealed that the following recreational use matters (attributes) deserved immediate attention as far as management of the estuary was concerned: reduced navigability of the estuary due to sedimentation, the level of boat congestion and the use of jet skis/wet bikes on the estuary.

The primary objective of this study was to improve the knowledge of the willingness-to-pay (WTP) process by calculating marginal WTP values relating to the recreational use issues identified for the Sundays River and Kromme River Estuaries through the application of a choice experiment (CE). These values could then be used to inform management of the problems of recreational over-fishing, boat congestion and the level of public access in the case of the Sundays River Estuary, and of reduced navigability, boat congestion and the potential use of jet skis/wet bikes with respect to the Kromme River Estuary. The primary valuation method used in this study, i.e. the CE, is a survey-based method that models preferences for goods and services, where these goods and services are decomposed into different levels of attributes. The CE facilitated a scientific assessment of the abovementioned problems - the relevant objectives were unpacked as options (levels) and economic control variables (license fees and tariffs) were identified by which to pursue welfare improving modifications to public choices.

Three different choice model specifications were estimated for both the Sundays River and Kromme River Estuaries: a conditional logit model (CL), a heteroskedastic extreme value (HEV) model and a random parameters logit (RPL) model.

In the case of the Sundays River Estuary, the results from the RPL, HEV and CL models (the magnitudes, signs and statistical significance of the coefficients) were similar. Allowing preferences for recreational attributes to vary across respondents showed that there was very little unexplained heterogeneity in respondent preferences. The random variables specified in the RPL indicated a demand to increase the physical size of fish stocks, for less boat congestion, and for increased public access. The attributes' implicit prices, or marginal WTP, for the three model specifications are shown in Table 7.1.

Table 7.1: Implicit prices (MWTP) for attributes (Rands) and 95 percent confidence intervals (CI)* – Sundays River Estuary

Attributes	**CL**	**HEV****	**RPL**
	MWTP	**MWTP**	**MWTP**
Physical Size of Fish Stock	154 (109; 200)	150	174 (95; 253)
Congestion	-33 (-60; -6)	-34	-35 (-62; -8)
Public Access	33 (8; 59)	33	34 (8; 59)

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

The implicit prices indicate that respondents valued increasing the physical size of fish stock most highly. The differences in WTP among the three models were relatively small, perhaps with the exception of that relating to increasing the physical size of fish stock. The respective marginal WTP value for the RPL model is R174, as compared to the marginal WTP values of R154 and R150 respectively, for the CL and HEV models.

For the Kromme River Estuary, the RPL models indicated the presence of unobserved heterogeneity, but they failed to explain the sources of the heterogeneity (Adamowicz & Boxall, 2001). In this case, complete reliance was placed on the fixed mean and standard deviation of the parameter estimates, with the latter representing all sources of preference heterogeneity around the mean (Hensher *et al.* 2005). The implicit prices of the attributes, or marginal WTP, are shown in Table 7.2 below.

Table 7.2: Implicit prices (MWTP) for attributes (Rands)* and 95 percent confidence intervals (CI) - Kromme River Estuary**

Attributes	**CL**	**HEV*** **	**RPL Model 1**	**RPL Model 2**
	MWTP	**MWTP**	**MWTP**	**MWTP**
Navigability	437 (256; 617)	450	586 (231; -940)	692 (211; 1173)
Congestion	-304 (-463; -144)	-302	-483 (-842; -124)	-576 (-1023; -129)
Jet Skiing	-35 (-161; 92)	-31	-37 (-69; 143)	45 (-59; 149)

**Please note that the estimated coefficient for the Jet Skiing attribute was statistically insignificant for all four models estimated. Implicit prices were calculated to inform policy analysis.*
***Confidence intervals in parentheses.*
**** Confidence intervals not calculated for HEV model due to the presence of fixed parameters.*

The price range/levels of the implicit prices indicated that respondents valued improved navigability most highly. The differences in the WTP estimates among the four models are not particularly large, except for the WTP figures reported for the second RPL model estimated. Based on these implicit prices derived from the CE applications, the following conclusions are drawn (the most conservative WTP estimates obtained from the models were used): license fees should be increased by R150 per user per annum to decrease fishing effort levels at the Sundays River Estuary, supplementary tariffs of R33 and R302 respectively, should be levied during peak periods (November to February) for boat users at the Sundays River and Kromme River Estuaries to reduce boat congestion, recreational users are willing to pay R33 per user per annum for investment in a nature trail fronting the banks of the Sundays River Estuary, recreational users are willing to pay R437 per user per annum for dredging operations to improve navigability of the Kromme River Estuary, and the external cost imposed on other users by jet ski and wet bike use on the Kromme River Estuary exceeds the welfare gain associated with their use (this is in the absence of compensation for other estuary users).

7.1.1 FISHERY RESOURCE UTILISATION ON THE SUNDAYS RIVER ESTUARY

The stocks of the fish targeted by recreational users in the Sundays River Estuary are over-exploited and face potential collapse. Most fishery management initiatives aim at controlling fishing effort levels through restricting access, implementing catch limits, and using transferable catch quotas. These initiatives relate to the management of a commercial fishery and not a recreational one. Management options are limited in the case of a recreational fishery and thus an alternative approach is proposed. In the case of an exploited recreational fishery, such as the Sundays River Estuary fishery, falling stock sizes, falling stock levels, and a decrease in overall fishing quality will not necessarily reduce the demand for angling licenses, as recreational fishing is driven by utility and not by revenue yield. In order to decrease fishing effort and restore stock levels, in the absence of revenue maximising behaviour by recreational anglers, some mechanism must be implemented to force anglers to decrease their demand for licenses per day, i.e. decrease quantity demanded. In order to get quantity demanded to drop to a point where harvest levels are at their maximum sustainable yield (MSY), the price i.e. the license fee structure will have to increase. The CE method indicates what type of increase would induce this demand trade-off (effort reduction) - the WTP for increased physical size of fish stocks was estimated to be R150 (at 2010 price levels) per annum.

7.1.2 BOAT CONGESTION ON THE SUNDAYS RIVER AND KROMME RIVER ESTUARIES

Increased human recreational demand at any estuary does not necessarily reduce the recreational appeal of that estuary, but can lead to negative crowding effects, i.e. congestion externalities. This is the case for motorised boat use. Three options for reducing these externalities include: self-regulation through the internalisation of the costs of congestion, rationing through the use of a quota system, and rationing through the use of a pricing structure. Rationing boat use through the implementation of a quota or relying on self-regulation (automatic market resolution) were not considered viable options to reduce boat congestion (Field, 2001; Flaaten, 2010). Quotas can be difficult to implement due to practical considerations, and self-regulation will not work if one or a few of the boat users act selfishly and do not take other boat users into account (Field, 2001). The management option considered most feasible was the use of prices to ration use. The option of price rationing during congested time periods was reported in Chapter Three (section 3.4.3.1(b)). The price adjustment proposed for both estuaries was to add a congestion cost (in the form of a supplementary tariff) to the existing boat license fee structure during peak use periods only.

7.1.2.1 Sundays River Estuary

In addition to the existing boat license fee, a supplementary tariff was estimated for the Sundays River Estuary through the application of a CE. The results reported in Chapter Six showed that respondents were willing to trade-off an increase in costs of between R33 and R35 per annum to decrease boat congestion (from seeing and hearing lots of boats to seeing and hearing fewer boats). Congestion on the estuary occurs during the peak demand periods of the year. These costs need to be worked into the cost structure for the peak period only. In addition to the boat license fee of R94 per annum, there is a WTP for a once-off supplemental tariff of R33 (conservative estimate) covering the months from November to February.

7.1.2.2 Kromme River Estuary

In addition to the existing boat license fee, a supplementary tariff was estimated for the Kromme River Estuary through the application of a CE. The results reported in Chapter Six showed that respondents were willing to trade-off decreased boat congestion (from seeing and hearing lots of boats to seeing and hearing fewer boats) with an increase in costs of between R302 and R576 per annum. It was deduced that, in addition to the boat license fee of R169 per annum, there is a WTP for a once-off supplementary tariff of R302 (conservative estimate) covering the months from November to February.

7.1.3 PUBLIC ACCESS AT THE SUNDAYS RIVER ESTUARY

As proposed by Afri-Coast Engineers (2004), in their status quo assessment, the introduction of a nature trail fronting the banks of the Sundays River Estuary would be an attractive complementary investment for both local residents and tourists. This investment would improve the recreational appeal of the estuary's banks and open up further areas for other recreational activities, such as bird watching and walking.

The marginal WTP for an investment in a nature trail was estimated to be R33 per user per annum. As no project cost information was available for the development of this trail, it is unknown whether this project is efficient or not.

7.1.4 NAVIGABILITY ON THE KROMME RIVER ESTUARY

The level of navigability on the Kromme River Estuary is a negative function of the level of estuary sedimentation, *inter alia*. Two management options to improve navigability are: increasing freshwater inflows and dredging the main estuary channel. If the total mean annual run-off (105.5 million m^3 per annum) was made available to the estuary it probably would be navigable at any tide. This amount of run-off could possibly restore navigability to pre-settlement levels.

However, this option is unattractive because the demand value is higher than it is for the freshwater that flows into the estuary because of water abstracted upstream from the estuary. The water abstracted is used mainly for domestic and agricultural consumption. Two big storage dams located on the Kromme River are a physical testimony to this value.

A marginal WTP value of freshwater inflows was derived from the demand response to improving the level of navigability from its current state to a pre-settlement one (Chapter Six). The marginal WTP value was estimated to be R437 per household per annum. Like the Sale (2007) study, the annual value of freshwater inflows per m^3 was estimated by dividing the product of the marginal WTP and the number of households (R437 x 3 200 = R1 398 400) by the required specified change in river water inflow (105.5 million m^3 – 11 000 m^3 = 105 489 000 per annum). It was calculated to equal R0.013 per m^3 per annum. Comparing this benefit estimate to the cost of the best alternative use of this freshwater forgone (R0.275 per m^3 charged by the Gamtoos Irrigation Board), shows that the marginal (and total) benefit of instream flow protection in the Kromme River Estuary is well below the marginal (and total) cost at every instream flow level.

These results are consistent with the findings of the Sale (2007) study, and point to a conclusion that allocations based on marginal cost probably do not safeguard estuaries; notwithstanding the advocacy of this method by Hosking (2008) because, although recreational demand is increasing, so too is urban and agricultural demand. Hosking (2008) argued that all water allocations should be based on marginal cost considerations, but this approach seems likely to prejudice the conservation of South African Estuaries.

The marginal WTP value for improving the level of navigability from its current state to one closer to pre-settlement norms was estimated to be R437 per annum. With this amount of revenue, dredging operations in the main estuary channel seem likely to be more efficient than instream purchases, providing prawn and fish habitat damage is low.

7.1.5 THE POTENTIAL USE OF JET SKIS/WET BIKES ON THE KROMME RIVER ESTUARY

There are individuals who believe that jet skis/wet bikes should have complete access to the Kromme River Estuary, yet there are others, however, who believe that these activities on the estuary should remain banned. Efforts have been made by concerned jet skiers and wet bikers to have the use of jet skis and wet bikes reinstated on the Kromme River Estuary. There is strong opposition to this course of action by individuals who believe that these jet-propelled water craft cause high levels of noise and are driven in a reckless manner that constitutes a safety hazard for other recreational users of the estuary. The CE results (Chapter Six) showed that the 'Jet Skiing' variable's coefficient was statistically insignificant and negative. This result reflects the existence of two opposing forces among the recreational users of the Kromme River Estuary - one group lobbying for jet ski and wet bike usage, and the other, lobbying to keep jet skis and wet bikes banned. Although this issue is a highly emotive one, the focus group discussions revealed that it was a major concern among recreational users, and thus warranted inclusion as an attribute in the choice experiment. Focus groups comprised different membership organisations, as well as other interested parties, and were largely representative of the resident and visitor populations. The insignificant result does not imply that the CE method is incapable of handling conflicting issues, but rather indicates that the opposing groups are similar in terms of size and thus fairly equally represented in the collected data. In effect, the two opposing user groups' preferences surrounding this issue have largely been cancelled out. The negative result could, however, indicate that recreational users have a slightly higher preference for a continued ban on all jet ski and wet bike activity on the estuary, i.e. the preferences of those opposed to jet skiing and wet biking marginally outweigh the preferences of those who wish for increased access. To this extent, the results of this study could support the theory that external costs are imposed by jet ski/wet bike users on other recreational users of the estuary.

Theoretically speaking, the negative estimated WTP implies that the external cost imposed on others (AB0 in Figure 3.13) exceeds the welfare gain ($p_s p_0 A$ in Figure 3.13). The CE estimate of this price (per capita WTP) is R31 per annum (conservative estimate). If this amount (R31) was added to the marginal private cost of motor boat access (p_p= R169), the socially efficient charge for jet ski/wet bike access would be a boat license fee of R200 (p_s in Figure 3.13). This analysis is subject to a major qualification: the WTP per user (implicit price) was derived from a statistically insignificant estimated coefficient for the jet ski/wet bike variable.

7.2 RECOMMENDATIONS

7.2.1 ESTUARY MANAGEMENT

The following recommendations are made with respect to the management of the Sundays River and Kromme River Estuaries for recreational purposes.

- It is recommended that license fee adjustments be accepted as an appropriate option for managing demand at South Africa's estuaries.
- It is recommended that the boat license fee structure for the Sundays River Estuary be increased by R150 per annum to decrease fishing efforts.
- It is recommended that there be increased efforts made to enforce fishing regulations, funded through increased license fee collection.
- It is recommended that more effort be put into increasing public awareness of the sustainability issues facing the Sundays River Estuary fishery, funded through increased license fee collection.
- It is recommended that, in addition to the standard boat license fee, a once-off per annum peak period supplementary tariff payable by peak period boat users,

covering the months of November to February, should be implemented in order to discourage congestion during this peak period. The supplementary tariffs recommended for immediate imposition are R33 and R302 respectively, for the Sundays River and Kromme River Estuaries.

- In order to improve the recreational appeal of the banks of the Sundays River Estuary, a nature trail fronting the banks of the estuary was considered in the choice modelling. Although users are willing to pay R33 per user per annum to implement such a project, it cannot be determined whether this investment is efficient as project cost information was not collected. It is recommended that a cost-benefit analysis be conducted on the feasibility of this project at a later date.
- It is recommended that the main channel of the Kromme River Estuary be dredged, funded through an annual additional boat levy of R437.
- It is recommended (preferred) that the allocation of water between recreational (environmental), consumption, agricultural and industrial demand be at least partly informed by (sensitive to) historical rights and not solely WTP.
- It is recommended that no changes be made to the current management arrangements for the use of jet skis and wet bikes on the Kromme River Estuary.

The results of the CE experiment allow policy makers to develop specific management 'packages' inclusive of all the attributes' preferred management strategies. For each estuary, when the marginal WTP values are added together, the overall additional levies recommended are:

- R183 per annum for boat users of the Sundays River Estuary, taking the levy up from R94 to R277 (2010 price levels).
- R739 per annum for boat users of the Kromme River Estuary, taking the levy up from R169 to R908 (2010 price levels).

7.2.2 FUTURE USE OF THE CE METHOD TO GUIDE ESTUARY MANAGEMENT

The application of CEs to natural resource valuation, and specifically to valuing estuarine attributes, in South Africa is a recent development. There are examples of applying the CE method to value estuarine attributes, for example Oliver (2010), but they have design and estimation limitations. This thesis sought to address these limitations. The results show that CEs can generate valuable and useful insights into preferences for estuarine management. A compelling argument in favour of using this method to value estuarine attributes is its ability to "generate multiple value estimates from a single application" (Bennett & Blamey, 2001).

The CE method, by its very nature, forces recreational users surveyed to make trade-offs among estuarine attributes, and reveal which of these are most important. This information is vital in the context of resource management decision making, where trade-offs need to be made and scarce resources allocated between competing recreational demand pressures. These estimates can be interpreted in two different ways: values of part-worths, or values for profiles or specific resource management scenarios. They provide policy makers with specific measures by which to assess various resource allocations in order to determine packages that will maximise overall benefits to society.

Although very useful, the CE method is not a panacea for resolving all estuarine management problems. Several matters need to be carefully considered when applying this method. The researcher must pay special attention to the identification and definition of the attributes and their associated levels. In this regard, focus group discussions are a cornerstone (foundation) of the method. These groups play a major role in determining the number of alternatives per choice set and the number of attributes (and levels) per alternative during the experimental choice design phase. If the design and the resultant choice tasks are too complex, respondents could experience 'respondent fatigue' (Bennett & Blamey, 2001; Hanley *et al.* 2001) and the results of the experiment will merely reflect respondents resorting to simple decision rules. The design needs to be tested through robust focus group and pilot studies. A correctly specified section on "cheap talk" should be included in order to remind respondents of their other financial commitments (a budget constraint reminder). Perhaps the biggest challenge in applying a CE to value estuarine recreational attributes is the identification of an appropriate sample population (Smyth *et al.* 2009). Ideally, a sample of current and potential users should be identified and surveyed. Unfortunately, in many cases this is impossible.

When applying the CE method, it is important to understand that, although some estuaries fall into the same management class, they may face different challenges and be used by different populations. The results of a CE valuing recreational preferences for estuarine attributes cannot completely be extrapolated to other estuaries in the surrounding area. Benefit transfer can only occur between estuaries that have the same or some similar management issues, the same or some similar attributes and statistically similar user populations. Given the costly nature of the CE method, it is suggested that more research be carried out on how the CE method can provide for the possibility of benefit transfer.

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APPENDICES

APPENDIX A: **PROPOSAL FOR THE REINSTATEMENT OF JET SKI/WET BIKE USE ON THE KROMME RIVER ESTUARY**

APPENDIX B: **CHOICE EXPERIMENT QUESTIONNAIRE – SUNDAYS RIVER ESTUARY**

APPENDIX C: **CHOICE EXPERIMENT QUESTIONNAIRE – KROMME RIVER ESTUARY**

APPENDIX D: **TESTING FOR SOURCES OF HETEROGENEITY: AN RPL MODEL FOR THE KROMME RIVER ESTUARY**

APPENDIX A: PROPOSAL FOR THE REINSTATEMENT OF JET SKI USE ON THE KROMME RIVER ESTUARY

The Secretary
P.O. Box 26
St Francis Bay, 6312 E-Mail: granitecreations1@telkomsa.net
Chairman: Chris Hattingh
Cell: 083 310 8120
Fax: 042 2940 405

Date: 18 February 2009
Dear Sir

PROPOSAL TO HAVE JETSKIS REINSTATED ON THE KROMME RIVER

A jet ski club, which is affiliated to the Port St Francis Ski Boat and Yacht Club, has been formed with its constitution and set of rules. The Port St Francis Ski Boat and Yacht Club is affiliated to the National Body SADSA who in turn is affiliated to SAMSA.

Our proposal, which needs to be confirmed with the Council, is that all jet ski owners will have to become members of this club, before they will be allowed to launch, either in the canals or in the river. All members will be issued with a club identification number and a set of rules to be signed for which will deem the member to have acknowledged receipt, understanding of and, agreement to adhere to the set of rules. All craft will have to be surveyed annually by an accredited safety officer and the skipper will need to have a valid skipper’s license. All members will be encouraged to police each other thereby easing the burden on our current law enforcement officers.

Any member who does not obey the rules will be brought before a disciplinary committee and will disciplined according to the constitution of the Ski Boat & Yacht Club which could result in either a fine being issued or suspension from the Club. This will mean that the offender would no longer be allowed to use the canals, river or sea.

Going forward the Council should only issue a jet ski permit for the canals and river if the following documents are produced:

1. Current Port St Francis Ski Boat and Yacht Club boat membership card.
2. Valid seaworthy certificate.
3. Valid skippers ticket.

The Port St Francis Ski Boat and Yacht Club will issue all these documents.

The jet ski club is also considering drawing up a roster whereby its members could be called upon to assist with lifesaving duties over the festive season.

LIST OF CONTACT DETAILS

Chris Hattingh	Chairman and Safety Surveyor	083 310 8120
Pieter Grobbelaar	Canal Manager and Law Enforcement	073 180 5529
John Robson	Vice Chairman SFBRHA	082 888 2387
Colin Beckley	Director SFBRHA	083 654 3232
Mike Beattie	Safety and Surveying Officer	082 657 5126

If you have any queries please do not hesitate in contacting John, Colin or Chris.

APPENDIX B: CHOICE EXPERIMENT QUESTIONNAIRE – SUNDAYS RIVER ESTUARY

RECREATIONAL RESOURCE MANAGEMENT IN THE SUNDAYS RIVER ESTUARY: A SURVEY OF RECREATIONAL USER ATTITUDES

Question 1: Your attitude towards the environment.

Below is a range of statements concerning the Sundays River Estuary. Please indicate how strongly you agree or disagree with each statement by making a cross [X] in the relevant box.

1.1 One of the most important responsibilities of national, provincial and local government is the protection of estuaries in a sustainable manner. This includes the protection of resources for recreational use.

Strongly disagree	☐	Don’t know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

1.2 The level of congestion, due to all forms of motorised boating, jet skiing etc. taking place on the Sundays River Estuary, poses a threat to the quality of the recreational services provided by the Estuary.

Strongly disagree	☐	Don’t know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

1.3 Recreational over-fishing, especially in nursery areas, poses a threat to the quality of the recreational services provided by the Sundays River Estuary.

Strongly disagree	☐	Don't know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

1.4 The level of public access to the Sundays River Estuary is sufficient.

Strongly disagree	☐	Don't know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

1.5 The Sundays River Estuary should provide a sustainable habitat for animal and plant life.

Strongly disagree	☐	Don't know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

Question 2: Your use of the Sundays River Estuary.

2.1 Have you visited the Sundays River Estuary in the past year?

Please indicate one choice only by making a cross [X] in the relevant box.

Never visited……………………………………………………………………………………☐
Visited only once…………………………………………………………………………………☐
Visited two to ten times…………………………………………………………………………☐
Visited eleven to twenty times…………………………………………………………………☐
Visited more than twenty times………………………………………………………………☐
I live in Colchester/Cannonville………………………………………………………………☐

2.2 When you visited the Sundays River Estuary, which of the following things did you do?

Please indicate your choice(s) by making a cross [X] in all the relevant boxes.

Recreational shore fishing……………………...☐

Recreational boat fishing…. ....☐

Power/Speed boating……………. ....☐

Water skiing………………. ....☐

Paddling (rowing, canoeing, kayaking)...☐

Jet skiing………………………….. ....☐

Swimming..………………. ....☐

Bird watching..……..…… ....☐

Other (please specify): ____

2.2.1 If you marked recreational fishing as one of the things you did, do you know what the size and bag limits are for keeping the Dusky Kob, Spotted Grunter and White Steenbras fish? ***(Please make a cross [X] in the relevant box)***

Yes ☐

No ☐

2.3 When it comes to the Sundays River Estuary, which of the following options would you prefer? ***(Please make a cross [X] in the relevant box)***

Free public access to all jetty's allowed by Management…..…………..……………………………☐

The payment of a levy for the sole usage of a jetty……..………….……………………………..☐

No payment required for sole usage of a jetty, only permission…………………………………☐

Question 3: Study of recreational use alternatives.

You will now be asked to choose among recreational use alternatives for the Sundays River Estuary. Each alternative varies with respect to:

- Physical sizes of recreational fish
- Congestion on the Estuary
- Public access to the Estuary
- The size of the recreational estuary users' environmental quality levy

Physical sizes of recreational fish:

Three main fish species are targeted by recreational fishers in the Sundays River Estuary, namely Dusky Kob, Spotted Grunter and White Steenbras. It has been documented that the stocks of these three species have declined over the past five years. It has also become apparent that the fish species mentioned above are not being allowed to reach their adult size, due to overfishing and high retention rates. Please consider the following two options when it comes to recreational fishing in the Sundays River.

Catch and keep small fish now: Catch and retain whatever fish species you want 'today'.
Keep no undersize fish now catch but more and bigger fish next year: Catch bigger and more fish in one year's time.

The level of congestion on the estuary:

For the years 2007 and 2008, a total of 774 and 812 boats, respectively, were registered to use the Pearson Park Resort slipway. At any one time, a maximum ofabout 40 boats use the estuary. Other forms of motorised activity include jet skiing. At times, especially during peak season periods, the estuary appears to be overcrowded. The following two levels of congestion are identified for the Sundays River Estuary.

Not congested: The recreational user sees and hears a few boats.
Congested: The recreational user sees and hears many boats.

The level of public access to the estuary:

Access to the estuary is limited due to steep inaccessible banks, private homes, private land, and a lack of vehicle access. It is also limited, due to the privatisation of access to the estuaryfor example, jetty's and limits to movements along the banks. In order to improve safe public access for all recreational users, the establishment of a path along the water's edge is proposed. With this in mind, the following two options for public access are identified for the Sundays River Estuary.

More public access? Yes – establish a path access along the banks of the estuary
More public access? No – do not establish a path access along the banks of the estuary

Size of recreational user's environmental quality levy:

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

<u>Selection of recreational use alternatives</u>

You will be asked to make four (4) choices in total. Within each choice set, you will be asked to choose between two (2) recreational use alternatives. In other words, you will have to choose one combination of recreational use options out of a possible two combinations of recreational use options (Option A vs. Option B). The recreational use alternatives vary according to the physical size of the recreational fish, the level of congestion, the level of public access, and the price of these recreational use options.

It is important to remember that this recreational use management project is only one of many such projects in South Africa. Also, be aware that spending more money on any alternative would mean that you would have less money to spend on all other goods and services, i.e. you face a budget constraint.

Please note that the choices are hypothetical, but plausible (based on advice from scientists). It is important to treat each of your four choices as if they were **real**, and **independent** from each other.

Please consider the example of a completed choice set given below.

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

Please continue to make your choices now - we hope you find the experience enjoyable.

Question 3.1

Attribute	Option A	Option B
Physical size of fish	None now but bigger and more fish next year	Mostly small fish now
Congestion	Hear and see few boats	Hear and see few boats
More public access	No	Yes
Cost to you(R)	R0	R120
I would choose (TICK ONE BOX ONLY):	☐	☐

Question 3.2

Attribute	Option A	Option B
Physical size of fish	None now but bigger and more fish next year	Mostly small fish now
Congestion	Hear and see many boats	Hear and see many boats
More public access	Yes	No
Cost to you(R)	R0	R120
I would choose (TICK ONE BOX ONLY):	☐	☐

Question 3.3

Attribute	Option A	Option B
Physical size of fish	Mostly small fish now	None now but bigger and more fish next year
Congestion	Hear and see many boats	Hear and see many boats
More public access	Yes	No
Cost to you(R)	R0	R120
I would choose (TICK ONE BOX ONLY):	☐	☐

Question 3.4

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

Question 4: Follow-up to question 3.

4.1 Did you find it easy or difficult to make the choices in Question 3? ***(Please make a cross [X] in the relevant box)***

Difficult ☐

Easy ☐

4.2 If you answered "Difficult" in question 4.1, what made the choices hard?

Please indicate your reason(s) by making a cross [X] in all the relevant boxes.

I could not relate to the questions ....☐

I think there was too much information to consider ....☐

I did not understand the questions ....☐

I think the alternatives were too expensive ....☐

It was difficult to choose as several factors were important..☐

I do not believe Estuary users should pay to ensure a healthy Estuary..........................☐

Other (please specify): ____

Don't know …...☐

4.3 Which item did you put greatest weight on, of your choices in Question 3?

Please indicate one item only by making a cross [X] in the relevant box.

The level of congestion…..…...☐

The population size of recreational fish stocks....……...………....................................☐

Public access………………...☐

Size of the annual environmental levy..☐

It varied from choice to choice ....☐

Don't know ....☐

4.4 If the recreational services of the Sundays River Estuary were improved, would you use the Estuary more often or would your Estuary usage remain the same? ***(Please make a cross [X] in the relevant box)***

Remain the same ☐

Use more often ☐

Section 5: Background questions.

5.1 What is your gender?

Male ☐ Female ☐

5.2 How old are you?

___Years

5.3 In which city or town do you live? ____

5.4 Please state your current, or if retired, your previous occupation *(please be as specific as possible)*.

____

5.5 What is the size of your household's total annual gross income before tax? [*Please indicate one income category only by making a cross [X] in the relevant box.*]

Less than R50 000..☐

R 50 000 – 99 999 ....☐

R 100 000 – 149 999...☐

R 150 000 – 199 999...☐

R 200 000 – 249 999...☐

R 250 000 – 299 999...☐

R 300 000 – 349 999...☐

R 350 000 – 399 999...☐

R 400 000 – 449 999...☐

R 450 000 – 499 999...☐

R 500 000 – 749 999...☐

R 750 000 – 999 999...☐

R 1 000 000 or above ....☐

Refuse to answer…………………………………………………………………………☐

5.5 What is your highest level of educational attainment? [*Please indicate one level of education only by making a cross [X] in the relevant box.*]

No education…………………………..☐

Primary school education…...☐

Secondary school education..…………...☐

Matriculation.…………………... …………………………...☐

Technikon diploma..☐

University degree...☐

University post-graduate degree..☐

The questionnaire is now completed. Thank you for your help!

APPENDIX C: CHOICE EXPERIMENT QUESTIONNAIRE – KROMME RIVER ESTUARY

RECREATIONAL RESOURCE MANAGEMENT IN THE KROMME RIVER ESTUARY: A SURVEY OF RECREATIONAL USER ATTITUDES

Question 1: Your attitude towards the environment.

Below is a range of statements concerning the Kromme River Estuary, i.e. the tidal portion. Please indicate how strongly you agree or disagree with each statement by making a cross [X] in the relevant box.

1.1 An important responsibility of national, provincial and local government is the protection of estuaries in a sustainable manner. This includes the protection of resources for recreational use.

Strongly disagree	☐	Don’t know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

1.2 The level of boat congestion, due to motorised boating (excluding jet skiing), taking place on the Kromme River Estuary during peak season, poses a threat to the quality of the recreational services provided by the Estuary.

Strongly disagree	☐	Don’t know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

1.3 Reduced navigability, due to sedimentation, poses a threat to the quality of the recreational services provided by the Kromme River Estuary.

Strongly disagree	☐	Don't know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

1.4 The potential use of jet skis/wet bikes on the Kromme River Estuary poses a threat to the quality of the recreational services provided by the Estuary.

Strongly disagree	☐	Don't know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

1.5 The Kromme River Estuary should provide a sustainable habitat for marine, animal and plant life.

Strongly disagree	☐	Don't know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

1.6 Uncontrolled, commercial and illegal bait harvesting is a threat to the quality of the recreational services provided by the Kromme River Estuary.

Strongly disagree	☐	Don't know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

Question 2: Your use of the Kromme River Estuary.

2.1 Have you visited the Kromme River Estuary in the past year?

Please indicate one choice only by making a cross [X] in the relevant box.

Never visited...☐

Visited only once ....☐

Visited two to ten times ………...☐

Visited eleven to twenty times………………………………………………………….....................☐

Visited more than twenty times...☐

I live in St. Francis Bay/on the Kromme River..☐

2.1.1 If you live in St Francis Bay/on the Kromme River or in the near surrounds, please be more specific in terms of your area of residence.

Please indicate one choice only by making a cross [X] in the relevant box.

I live on the canals..☐

I live in St Francis Village...☐

I live on the Kromme River………...☐

I live in Cape St. Francis………..…………………………………………………………….......☐

Other (please specify)____

2.2 Are you a:

Please indicate one choice only by making a cross [X] in the relevant box.

Permanent resident…………...☐

Holiday home owner……...☐

Day visitor………………..……..☐

Multiple day visitor……………….……………………….……………………………………...☐

2.3 When you visited the Kromme River Estuary, which of the following things did you do?

Please indicate your choice(s) by making a cross [X] in all the relevant boxes.

Recreational shore fishing…………………..……...☐

Recreational boat fishing…. ....☐

Power/Speed boating….………….. ....☐

Water skiing………………. ....☐

Wind/Kite surfing…………………………………………………………………..…..………☐

Paddling (rowing, canoeing, kayaking)...☐

Sailing…………………………………………………………………………………......☐

Jet skiing (access to sea only)..….. ....☐

Swimming..……………………..☐

Bird watching..……. ....☐

Walking…………………………………………………………………………………..☐

Other (please specify): ____

Please indicate how strongly you agree or disagree with the following statement by making a cross [X] in the relevant box.

2.4 The boat access facilities for the public, i.e. the condition of the launching site and road at the bridge, are adequate.

Strongly disagree	☐	Don't know	☐
Disagree	☐		
Indifferent	☐		
Agree	☐		
Strongly agree	☐		

2.5 Are you aware of the fact that JET BOATS are treated as a conventional boat and not as a jet ski/wet bike? ***(Please make a cross [X] in the relevant box)***

Yes ☐ No ☐

If you answered "Yes" to question 2.5, please proceed to question 2.5.1

2.5.1 Do you believe that all jet propelled water craft (jet boats) should be treated in the same manner (similar to jet skis/wet bikes)? ***(Please make a cross [X] in the relevant box)***

Yes ☐ No ☐

Indifferent ☐

Question 3: Study of recreational use alternatives.

You will now be asked to choose among recreational use alternatives for the Kromme River Estuary. Each alternative varies with respect to:

- The level of estuary navigability
- Boat congestion on the Estuary
- The potential use of jet skis on the Estuary
- The size of the recreational estuary users' environmental quality levy

<u>The level of estuary navigability:</u>
Navigation is considered to be hazardous on the Kromme River Estuary due to increased levels of sedimentation. Possible causes of the increased levels of sedimentation are the absence of scouring events due to river flooding, the deposition of sand from the Sand River during flood events, and sand delivered by the incoming tide. If this problem is not dealt with, it could lead to a point where the Kromme River Estuary ceases to be navigable at any tide, tidal flow is reduced to the point where the mouth closes, and the entire canal system becomes landlocked. A possible solution to this problem could entail a 20 percent regular release of water from the Mpofu Dam every 3 years in order to scour the canal system and improve navigability. Alternatively, dredging could occur on a regular basis to cope with this sedimentation issue, also improving navigability.

Current navigability: Parts of the estuary are not navigable at low tide. At mid to high tide, it is navigable only with detailed knowledge of fluctuating channels.
Ideal navigability: The estuary is completely navigable at any tide.

<u>The level of boat congestion on the estuary:</u>
For the payment year 2009/10, a total of 1 100 boats were registered to use the Kromme River Estuary. At times, especially during peak season periods, the estuary appears to be overcrowded. The following two levels of congestion are identified for the Kromme River Estuary.

Not congested: The recreational user sees and hears a few boats.
Congested: The recreational user sees and hears many boats.

<u>The potential use of jet skis on the estuary:</u>
The use of jet skis on the Kromme River Estuary is currently banned. This is partly because of the perception that these motorised vehicles are noisy, and partly because there is a high proportion of irresponsible and reckless drivers that create disturbances too close to swimming,

fishing or skiing areas. Their use can, however, be regulated in such a way as to minimise their perceived negative impact. This type of regulation, for example, could entail the application of the rules and regulations that currently govern general boat use, as well as very strict law enforcement in order to make sure that these rules and regulations are adhered to. With this in mind, the following two options for the use of jet skis and wet bikes are identified for the Kromme River Estuary.

Banned: Keep the ban on jet skis and wet bikes in place
Unbanned but regulated: Let jet skis and wet bikes use the estuary, but in a regulated manner with very strict law enforcement

<u>Size of recreational user's environmental quality levy:</u>
It is assumed that the cost of providing these recreational use alternatives is **partly** covered by the Kromme River Estuary's boat license holders. We ask you to imagine that all boat license holders will contribute equally by means of a fixed annual sum added to the existing boat license structure, and this annual sum will then be directed back to the Kromme River Estuary. This annual sum can take four different values, namely R169 (boat license payment for 2010/2011 year), R254, R338 and R676.

<u>Selection of recreational use alternatives</u>
You will be asked to make four (4) choices in total. Within each choice set, you will be asked to choose between two (2) recreational use alternatives. In other words, you will have to choose one combination of recreational use options out of a possible two combinations of recreational use options (Option A vs. Option B). The recreational use alternatives vary according to the level of estuary navigability, the level of boat congestion, the potential use of jet skis and wet bikes on the estuary, and the price of these recreational use options. **It is important to remember that this recreational use management project is only one of many such projects in South Africa. Also, be aware that spending more money on any alternative would mean that you would have less money to spend on all other goods and services, i.e. you face a budget constraint.**

Please note that the **choices are hypothetical, but plausible** (based on advice from scientists). It is important to treat each of your four choices as if they were **real**, and **independent** from each other. **Please consider the example of a completed choice set given below.**

Attribute	Option A	Option B
Level of estuary navigability	**Ideal navigability**	**Current navigability**
Boat congestion	**Hear and see few boats**	**Hear and see few boats**
Potential use of jet skis and wet bikes	**Unbanned, with enforced regulation**	**Banned**
Cost to you(R)	**R169**	**R338**
I would choose (TICK ONE BOX ONLY):	√	□

Please continue to make your choices now - we hope you find the experience enjoyable.

Question 3.1

Attribute	Option A	Option B
Level of navigability	Ideal navigability	Current navigability
Boat congestion	Hear and see few boats	Hear and see few boats
Potential use of jet skis/wet bikes	Banned	Unbanned, with enforced regulation
Cost to you(R)	R169	R676
I would choose (TICK ONE BOX ONLY):	☐	☐

Question 3.2

Attribute	Option A	Option B
Level of navigability	Ideal navigability	Current navigability
Boat congestion	Hear and see many boats	Hear and see many boats
Potential use of jet skis/wet bikes	Unbanned, but regulated	Banned
Cost to you(R)	R169	R676
I would choose (TICK ONE BOX ONLY):	☐	☐

Question 3.3

Attribute	Option A	Option B
Level of navigability	Current navigability	Ideal navigability
Boat congestion	Hear and see many boats	Hear and see many boats
Potential use of jet skis/wet bikes	Banned	Banned
Cost to you(R)	R169	R676
I would choose (TICK ONE BOX ONLY):	☐	☐

Question 3.4

Attribute	Option A	Option B
Level of navigability	Current navigability	Ideal navigability
Boat congestion	Hear and see few boats	Hear and see few boats
Potential use of jet skis/wet bikes	Unbanned, with enforced regulation	Banned
Cost to you(R)	R169	R254
I would choose (TICK ONE BOX ONLY):	☐	☐

Question 4: Follow-up to question 3.

4.1 Did you find it easy or difficult to make the choices in Question 3? ***(Please make a cross [X] in the relevant box)***

Difficult ☐

Easy ☐

4.2 If you answered "Difficult" in question 4.1, what made the choices hard?

Please indicate your reason(s) by making a cross [X] in all the relevant boxes.

I could not relate to the questions ....☐

I think there was too much information to consider ....☐

I did not understand the questions ....☐

I think the alternatives were too expensive ....☐

It was difficult to choose as several factors were important..........☐

I do not believe Estuary users should pay to ensure a healthy Estuary..........☐

Other (please specify): ____

Don't know …..........☐

4.3 Which item did you put greatest weight on, of your choices in Question 3?

Please indicate one item only by making a cross [X] in the relevant box.

The level of estuary navigability..........☐

The level of boat congestion…………………..……..………..........☐

The absence/presence of jet skis and wet bikes ....☐

Size of the annual environmental levy..........☐

It varied from choice to choice ....☐

Don't know ....☐

4.4 If the recreational services of the Kromme River Estuary were improved, would you use the Estuary more often or would your Estuary usage remain the same? ***(Please make a cross [X] in the relevant box)***

Remain the same ☐

Use more often ☐

Section 5: Background questions.

5.1 What is your gender?

Male ☐ Female ☐

5.2 How old are you?

___Years

5.3 In which city or town do you live? ____

5.4 Please state your current, or if retired, your previous occupation ***(please be as specific as possible)*****.**

____

5.5 What is the size of your household's total annual gross income? Please note: This should be income before any tax deductions.

Please indicate one income category only by making a cross [X] in the relevant box.

Less than R50 000...☐

R 50 000 – 99 999 ....☐

R 100 000 – 149 999...☐

R 150 000 – 199 999...☐

R 200 000 – 249 999...☐

R 250 000 – 299 999...☐

R 300 000 – 349 999...☐

R 350 000 – 399 999...☐

R 400 000 – 449 999...☐

R 450 000 – 499 999...☐

R 500 000 – 749 999...☐

R 750 000 – 999 999...☐

R 1 000 000 or above ....☐

Refuse to answer……………………………………………………………………………..☐

5.6 What is your highest level of educational attainment?

Please indicate one level of education only by making a cross [X] in the relevant box.

No education……………………………………..☐

Primary school education..…..☐

Secondary school education...…………...☐

Matriculation.…………………….. ……………………………...☐

Technikon diploma..☐

University degree...☐

University post-graduate degree...☐

The questionnaire is now completed. Thank you for your help!

APPENDIX D: TESTING FOR SOURCES OF HETEROGENEITY: AN RPL MODEL FOR THE KROMME RIVER ESTUARY

RANDOM PARAMETERS MODEL – ATTEMPTS TO EXPLAIN HETEROGENEITY

DEPENDENT VARIABLE: CHOICE

INDEPENDENT VARIABLES:
NAVIGABILITY (RANDOM: UNIFORM DISTRIBUTION)
CONGEST (RANDOM: UNIFORM DISTRIBUTION),
JETSKIS (NON-RANDOM)
COST (NON-RANDOM)

INDEPENDENT VARIABLES INTERACTED WITH:
RESIDENT TYPE (LIV)
GENDER (GEN)
AGE
HOMETOWN (LIV1)
OCCUPATION (OCC)
INCOME (INC)
EDUCATION (EDU)

ESTIMATION RESULTS

Variable	**Coefficient**	**Standard Error**	**b/St Er**	**P[|Z| > z]**
Random parameters in utility functions				
NAVIG	3.97614137	2.57397202	1.545	.1224
CONGEST	.32451470	2.78921517	.116	.9074
Non-random parameters in utility functions				
USEJET	.15652081	.18818384	.832	.4056
COST	-.00341745	.00061790	-5.531	.0000
Heterogeneity in mean, Parameter: Variable				
NAVI: RES	.27576904	.39603677	.696	.4862
NAVI: GEN	.00044965	.70857616	.001	.9995
NAVI: AGE	-.01091321	.02660452	-.410	.6817
NAVI: LIV	-.01041100	.06513371	-.160	.8730
NAVI: OCC	.15158140	.14208494	1.067	.2860
NAVI: INC	.14151045	.10802049	1.310	.1902

NAVI: EDU	-.51325632	.34196534	-1.501	.1334
NAVI: LIV1	-.08180610	.20451836	-.400	.6892
CONG: RES	.05468433	.53522029	.102	.9186
CONG: GEN	.37689383	.88233535	.427	.6693
CONG: AGE	-.02682220	.03324031	-.807	.4197
CONG: LIV	-.06381171	.09322796	-.684	.4937
CONG: OCC	-.21929895	.18236255	-1.203	.2292
CONG: INC	.02478229	.11753002	.211	.8330
CONG: EDU	.01895687	.39192311	.048	.9614
CONG: LIV1	-.03534087	.25030421	-.141	.8877
Derived standard deviations of parameter distributions				
UsNAVIG	6.21427085	2.84470406	2.185	.0289
UsCONGES	9.39370944	3.84989387	2.440	.0147