# Valuing a managed realignment scheme: what are the drivers of public willingness to pay?

Dr. Katherine Needham[1,a]

Professor Nick Hanley [1,2,3]

[1]Economics Division, University of Stirling, Stirling, FK9 4LA

[2] Department of Geography and Sustainable Development, University of St. Andrews

[3] Institute of Biodiversity Animal Health and Comparative Medicine, University of Glasgow, Glasgow.

[a] The research was undertaken at the University of Stirling. The corresponding author, Katherine Needham is currently based at the University of Glasgow. Institute of Biodiversity Animal Health and Comparative Medicine, University of Glasgow, Glasgow.

Email address: katherine.needham@glasgow.ac.uk

**Abstract**

Offering several advantages over traditional "hold the line" flood defences, including increases in the supply of ecosystem services such as carbon sequestration and habitat provision, managed realignment is increasingly being used as a flood defence option. This paper seeks to add to the growing literature on public perceptions of the benefits of managed realignment by examining local resident's knowledge of estuarine management issues and identifying their willingness to pay towards a new managed realignment scheme on the Tay Estuary, Scotland. Results showed that the majority of respondents were not aware of flood risk issues on the estuary or of different flood defence options. Household mean willingness to pay for a specific managed realignment scheme was calculated at £43 per annum. Significant drivers of willingness to pay included respondents perceived flood risk and worries about the state of existing flood defences. There was also spatial heterogeneity with those living closest to the scheme being willing to pay the most. Prior knowledge of flood risk issues were found not to significantly influence willingness to pay.

**Keywords:** Flooding; Flood control; Wetlands; Economic analysis; Contingent valuation; Ecosystem Services.

## Highlights

- We estimate the public willingness to pay for a new flood defence scheme.
- A contingent valuation survey is used to explore public preferences for this.
- Household mean willingness to pay was calculated at £43 per annum.
- Significant drivers were respondents perceived flood risk and worry about current flood defences.
- Many respondents had a limited understanding of current flood risk and flood defence options.

## 1. Introduction

Global sea level is rising between 3 and 4 mm per year, partly as a result of climate change (Vitousek et al., 2017). This threatens coastal settlements, infrastructure and ecosystems with future coastal erosion projections for Europe predicting a loss of between 3700 $km^2$ and 5800 $km^2$ by 2050 (Kopp et al., 2014; Roebeling et al., 2011). As a result, coastal planners are increasingly recognising the need for alternative forms of flood defence (French, 2006), as the traditional 'hold the line' approach is no longer viewed as the best-choice option that it once was (Garbutt et al., 2006; Turner et al., 2007). Whilst hard engineered defences will need to be maintained for many towns and industrial areas, it is rarely economically justified to maintain hard defences along dynamic, open coasts. For example, in the UK, expenditure on hard defences is predicted to increase to £200 million per annum by 2030, a 60% increase on current spending levels (Committee on Climate Change, 2013). Moreover, hard defences are unsustainable as they contribute to coastal squeeze. Hard defences restrict the natural migration of intertidal habitats inland, reducing these habitats to narrow strips along the coast (Doody, 2004).

In the United Kingdom, there has been a gradual move towards Natural Flood Management as part of the UK Governments Flood Risk Management Strategy (SEPA, 2012; Ledoux et al., 2005). Natural flood management works with natural hydro-geological and morphological processes to manage the sources and pathways of flood waters and involves the alteration, enhancement or restoration of natural features and characteristics (Lane, 2017). Managed realignment is one natural flood management option at the coast. This involves breaching existing coastal defences, allowing previously reclaimed land to be subjected to tidal flooding, and allowing the natural processes of inundation, erosion and accretion to take place (French, 2006). Managed realignment reduces the costs of hard defences by making use of the storm buffering capacity of intertidal habitats such as mudflats and saltmarshes (King and Lester, 1995; Ledoux et al., 2005; Moller et al., 1999). Managed re-alignment is now considered one of the most cost-effective options for strengthening coastal defences: it is estimated that allowing managed realignment to take place on 10% of the English coastline will save between £180 and £380 million in reduced maintenance and avoided construction costs compared to hold the line approaches (Committee on Climate Change 2013). To date, managed realignment has been used at several sites along the east coast of England including the Blackwater Estuary (Essex), Freiston Shore and Brancaster West Marsh (Norfolk) and the Humber Estuary (Yorkshire) (Luisetti et al., 2011; Myatt et al., 2003a, b, c). In Scotland, one managed realignment scheme has been undertaken at Nigg Bay on the Cromarty Firth (Tinch and Ledoux 2006).

Whilst the main policy driver for managed realignment has been flood defence, it also offers the opportunity to restore wetland habitats which have been lost through coastal squeeze and other anthropogenic stressors such as land reclamation (McLusky et al., 2004). Many intertidal areas are now protected under the UK Biodiversity Action Plan and the EU Habitats and Wildbirds Directives (Council Directive 92/43/EEC, Council Directive 2009/147/EC) and managed realignment is viewed as an important technique in restoring these wetland areas (Garbutt et al., 2006). Restoration also offers additional ecosystem service benefits including enhanced carbon sequestration, new nursery and spawning grounds for fisheries and recreational activities, as well as a contribution to biodiversity through the provision of roosting and foraging sites for internationally protected waterbirds (Luisetti et al., 2011).

A challenge for policy makers is valuing the additional non-market benefits which arise from managed realignment (NEA, 2013). A meta-analysis of 190 wetland valuation studies found the majority of studies valuing flood defence used market-based approaches such as replacement cost, thus excluding the wider, non-market benefits noted above (Brander et al., 2006). Several studies have used benefits transfer approaches. Roebeling et al., (2011) consider non-market ecosystem services losses due to coastal erosion across several European Member states: losses were valued between €20.1 and €19.4 billion per year by 2050. A similar benefits transfer approach was applied in the Ovar-Marinha region of Portugal (Alves et al., 2009). Non-market ecosystem services were valued at €193 million per year (present day) with losses from coastal erosion equating to over €45 million per year by 2058. The authors emphasise that this value is a best estimate and that errors due to extrapolation between sites, scale and methodological differences between the underlying valuation studies exist. Whilst using benefits transfer can provide an initial indicative figure for losses in the coastal zone, there is a limited range of valuation studies which hamper the quality of benefits transfer. Instead, there are calls for more primary, high-quality valuation studies which in turn will improve the applicability of benefits transfer for valuation in the coastal zone (Torres and Hanley, 2017).

The number of primary valuation studies for natural flood defence options is increasing, For example, in Italy, ecosystem services provided by beach nourishment have been identified and their values explored (Martino and Amos, 2015). It was estimated that the damage cost avoided by the beach nourishment ranged from € 9.1 to € 15.5 million, depending on the project lifespan. Recreational benefit from beach nourishment was €3.1 million per year. However, only those ecosystem services providing a direct value to beach business and beach users were evaluated for the study. Alexandrakis et al., (2015) combine economic and environmental data to estimate the vulnerability of a tourist beach to sea level rise in Crete. Hedonic pricing was used to value 38 sectors of the beach, with the highest value sector that containing six five star hotels (€60 euros per $m^2$ per day). Combining these values with sea level rise scenarios allows a revenue loss of €48,700 per $m^2$ per year to be calculated. The authors recommend increasing beach front rental values within the study area to fund a beach nourishment programme.

In England, several studies have been undertaken to value the additional benefits of managed realignment. Turner et al., (2007) undertook a cost-benefit analysis for a variety of managed realignment scenarios for the Humber Estuary. Benefits valued included carbon sequestration and habitat creation, whilst costs included capital costs of realignment and forgone agricultural incomes. Habitats were valued using the results generated by the meta-analyses of Brander et al., (2006) and Woodward and Wui, (2001). Turner et al., (2007) concluded that managed realignment would be more economically efficient than hold the line over longer timescales (greater than 25 years) but also urged that greater stakeholder inclusion is needed when planning sites with complex trade-offs. Related to this was the work of Andrews et al., (2006) who analysed the biogeochemical value of managed realignment in the Humber Estuary in terms of increased carbon sequestration and reduced metal contamination. Results showed that sediment burial at the site resulted in a saving of £1000 per annum in avoided clean-up costs for copper contamination. Luisetti et al., (2011) extended this work by considering the recreational and fish nursery benefits of managed realignment for the Humber and Blackwater estuaries. Using a choice experiment the recreational value of saltmarsh at the Blackwater Estuary was estimated to be worth between £4,429,000 and £6,430,000 per annum. Similar to the finding of Turner et al., (2007), Luisetti et al., concluded that valuation plays a small but important role in the planning of new managed realignment schemes.

A further challenge for coastal planners is communicating the flood defence and ecosystem service benefits of managed realignment to the general public and, particularly, to local stakeholders (SEPA, 2012). Historically, coastal protection has been achieved via hard engineered structures which have helped form the view of the general public that the boundary between land and see is fixed rather than dynamic. This has led to local residents being opposed to managed realignment schemes which appear to "give land to the sea" (Coates et al., 2001; French, 2002). Consequently, there is an increasing need to engage with local residents throughout the planning process and study public perceptions of managed realignment schemes (Ledoux et al., 2005). The move towards integrated flood risk management globally has led to a wider range of stakeholders being involved in decision making (Begg et al., 2017) and this is now taking place both in developed and developing countries.

There are a range of studies which assess participatory approaches linked to flood risk management including Begg et al., (2017) who compares differences in the process between England and Germany; Campos et al., (2016) who follow community decision making process for management of coastal flood risk in Portugal; as well as Vizinho et al., (2017) and Evadzi et al., (2018) who use participatory methods to understand adaptions to flood risk management in African countries. In the African studies, it was found that individuals who were aware of sea level rise and flood risk were more willing to adapt to climate change when provided with information through education and outreach. In Europe, participatory methods have focussed more on scheme design and acceptance: in Portugal, a community-based approach brought together key stakeholders including engineers, policymakers, residents and businesses. The process showed that many of those involved had an overly simplistic view on the potential flood risk adaption solutions (Campos et al., 2016). Furthermore, policymakers and planners emphasised the importance of economic assessments to establish the costs and benefits of the proposed management solutions.

In the context of the gaps in the literature identified above, the aim of this paper is to explore public preferences for a proposed managed realignment site on the Tay Estuary, Scotland. This study contributes to the existing literature on managed realignment in two ways. First, the study explores public perceptions of flood risks, flood defence and coastal ecosystem services, by asking survey respondents a nine-question quiz about flood risk management on the Tay Estuary. Survey respondents were then asked a series of questions regarding their own perceptions of flood risk and the state of current defences. This follows similar work Myatt et al (2003 a,b,c) who explored attitudes towards managed realignment schemes on the south coast of England. Surveys for the Freiston Shore, Orplands and Brancaster managed realignment schemes sought to gain an insight into residents understanding of flooding, their perceptions of managed realignment and which issues they considered important (Myatt et al 2003 a,b.c). Results for the Brancaster project highlighted that the majority of respondents felt they were at risk from flooding, although in reality only a "few properties are vulnerable to flooding at present" and over 60% of respondents considered the "effectiveness of managed realignment" to be a very important issue. Myatt et al concluded that local residents should be involved in the discussion of managed realignment and have direct inputs into decision making.

Our work extends the research of Myatt et al by exploring public perceptions and attitudes using a stated preference (contingent valuation) exercise. This survey asks residents directly if, and how much, they are willing to pay towards a new managed realignment scheme. Drivers of willingness to pay for the scheme are explored, including prior knowledge of flood risk management, personal flood risk awareness and residential location. The remainder of the paper is structured as follows: Section 2 provides an overview of the contingent valuation method; Section 3 details the survey methodology and empirical approach; Section 4 provides the results; the discussion and conclusion are provided in Sections 6 and 7 respectively.

## 2. The contingent valuation method

Contingent valuation uses questionnaires to elicit people's preferences for changes in a good or service by asking them what they are willing to pay for an improvement (or to prevent a reduction in supply) in the good or service; or their minimum willingness to accept compensation to go without an improvement or tolerate a reduction in a desired good or service (Mitchell and Carson, 1989). Contingent valuation has its foundations in welfare economics with surveys capable of obtaining a Hicksian measure of welfare (equivalent or compensating surplus) for a discrete change in the provision of an environmental good or service (Hoyos and Mariel, 2010). Social choices can then be better made, based on the resulting estimates (Chilton, 2007). If the study is well designed and carefully pretested, responses should represent valid willingness to pay (WTP) responses. These responses can then be used to generate marginal values to estimate the aggregate welfare change.

Following the recommendations of Mitchell and Carson (1989), such surveys should consist of three key parts. Firstly, respondents are provided with a detailed description of the good being valued and how it will be made available to the respondent. The hypothetical market created should be as plausible as possible. Scenarios are constructed which offer different policy alternatives relative to a baseline which is often the current situation. The respondent is asked to state whether they would support an alternative policy option depending on what the new policy will provide, how this will be delivered and how much it will cost. Values are elicited through a question which asks the respondent what they are willing to pay for the good in question. Finally, questions about the respondent's socio-demographic characteristics are asked (age, gender and income), their attitudes towards the good being valued and their use of the good. This information is then used in regression equations to estimate the valuation function of the good. Following the survey, the WTP estimates can then be used to develop a benefit estimate.

The development of contingent valuation can be divided into three main periods; early research up until the Exxon Valdez oil spill (1989); a second period (1989-1992) which covered the debates following the use contingent valuation to estimate the damages of the Exxon Valdez oil spill and the subsequent publication of the 'NOAA Blue Ribbon Panel' report, as well as the publication of the Mitchell and Carson book '*Using Surveys to Value Public Goods'* which played a key role in defining the methodology. Finally the period from 1992 until present day where contingent valuation has been accepted as a non-market valuation method, academically and politically, but with many challenges still needing to be explored (Carson, 2012; Hoyos and Mariel, 2010). There has been a great research effort into areas such as hypothetical bias, elicitation formats, information provision and uncertainty, survey validity and scope and embedding effects, all with the aim of improving the validity and reliability of the WTP estimate (see Johnston et al., (2017) for a detailed overview of these issues and best practice guidelines for stated preference surveys).

For our study, contingent valuation allows us to compare whether respondents prefer managed realignment over maintaining existing hard flood defences; to assess the most they are willing to pay for such an investment, and to explore which factors influence their WTP for the scheme management realignment. Additionally our survey includes a nine-question flood defence “quiz” at the start of the survey, to allow us to identify what respondents already understand about flood risk, flood defence and managed realignment in the Tay Estuary, since one’s knowledge of an environmental good may affect one’s WTP for changes in this good (Czajkowski et al., 2014).

## 3. Case study

For policymakers considering implementing a new managed realignment scheme, it is helpful to understand local stakeholder's attitudes towards flood defence and flood risk, and also consider the drivers behind these attitudes. This engagement is even more crucial in Scotland where there is a requirement for SEPA (the Scottish Environment Protection Agency who are responsible for delivering flood risk management) to raise public awareness of flood risks and future investment plans for flood defence schemes (Scottish Government, 2011).

The proposed management realignment scheme considered in the present paper was at Newburgh on the Tay Estuary, Scotland (Figures 1a&b) which is one of SEPA's proposed natural flood management areas as part of the Fife Shoreline Management Plan (SEPA, 2015). For Tayport and Newburgh, the Shoreline Management Plan states "that 117 residential properties and 12 non-residential properties are at risk of flooding in this location, with potential damages of up to £12 million". In addition, the report states that "natural flood management actions can restore and enhance natural environments and create opportunities for recreation and tourism".

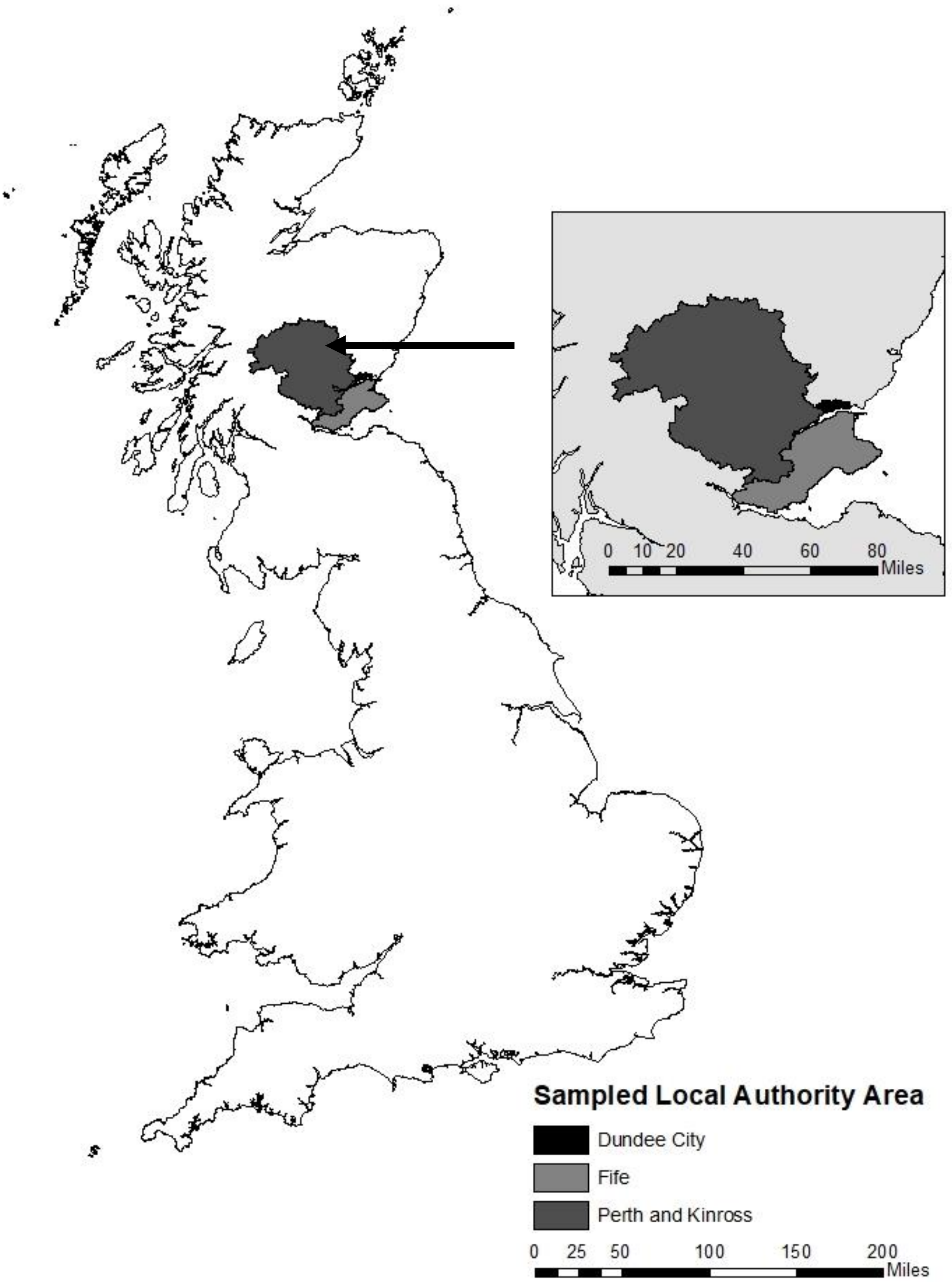


**Figure 1a: Case study region. Contains OS data © Crown copyright and database right 2018.**

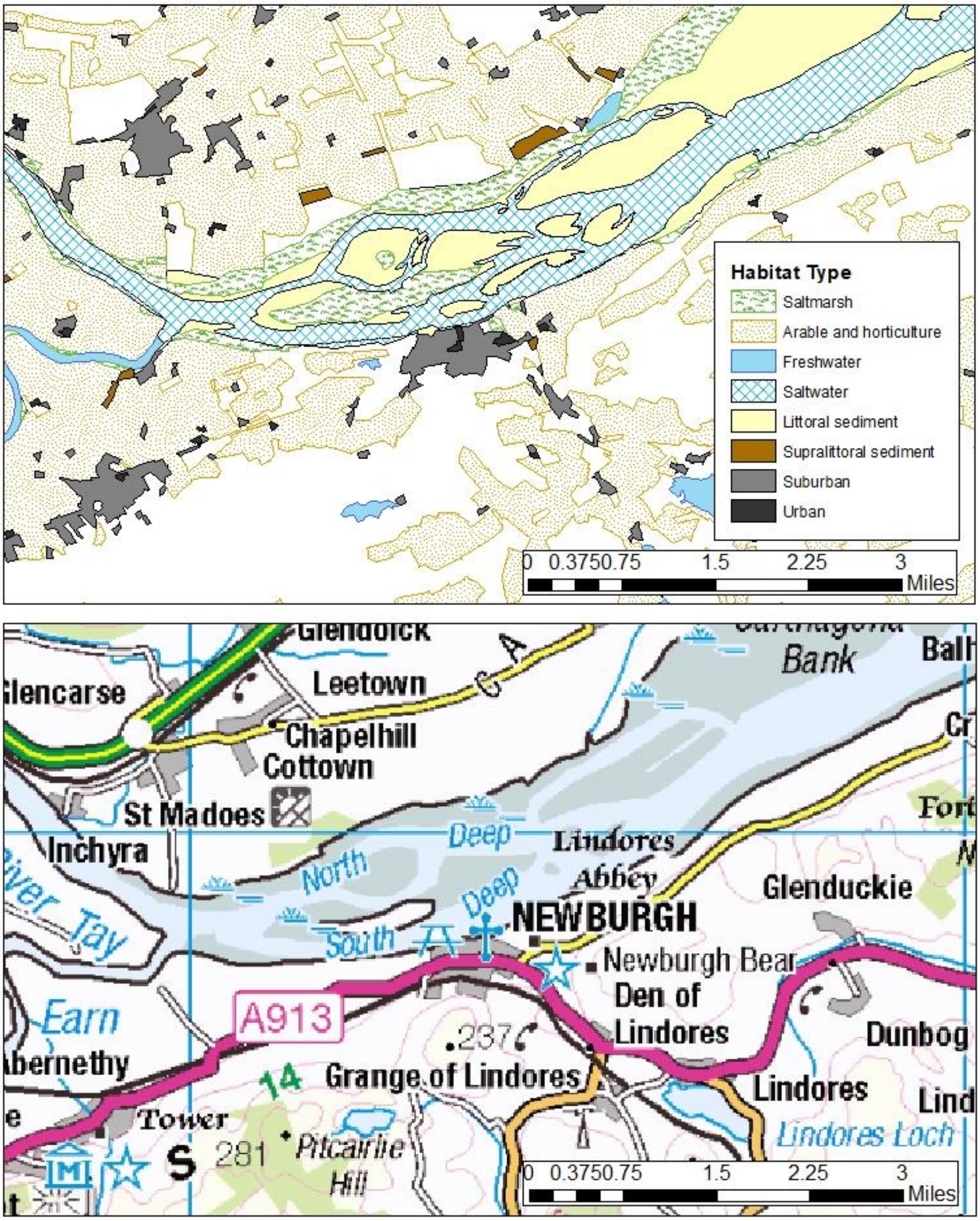


**Figure 2b: Location of proposed managed realignment scheme, Newburgh, Tay Estuary. The top panel shows selected estuarine habitats using Rowland, C.S.; Morton, R.D.; Carrasco, L.; McShane, G.; O'Neil, A.W.; Wood, C.M. (2017). Land Cover Map 2015 (25m raster, GB). NERC Environmental Information Data Centre. https://doi.org/10.5285/bb15e200-9349-403c-bda9-b430093807c7, Bottom panel shows the location of Newburgh and the surrounding areas. Contains OS data © Crown copyright and database right 2018.**

## 4. Methods

### *4.1. Survey design*

The survey was designed following the recommendations of Carson, (2000). The first stage was holding a focus group with the staff and students from the University of Stirling to review the flood risk management quiz and the valuation scenario. A pilot survey was then sent to households within the study area and 50 people responded. The final survey was conducted throughout 2013. Securing participants was a two-stage process: i) respondents received a letter on University of Stirling headed paper inviting them to take part in the online survey and were given details of the survey website (www.surveygizmo.com); ii) respondents then needed to complete the survey online. A reminder card was sent two weeks after the first contact attempt.

Survey participants were randomly selected from the Scottish Phone Directory. Only people living within the three local authorities expected to receive benefits from the proposed flood defence scheme (Perth and Kinross, Dundee City and Fife) were selected to take part. Local authorities are responsible for funding flood defence schemes in Scotland and as such council tax (as collected by the local authorities) was used as the payment vehicle for the contingent valuation scenario.

The survey was divided into three parts: knowledge of current flood risk management, the contingent valuation scenario and question, and finally follow up socio-demographic questions. Respondents first received an introductory text outlining the purposes of the survey and who would be using the results and why. In line with the recommendations of Carson and Groves, (2007) and Vossler and Watson, (2013) it was made clear that the survey results would be shared with relevant policymakers and would be taken into consideration when planning future flood prevention schemes. This "policy consequentiality" has been shown to improve the demand-revealing properties of contingent valuation, so that respondents state a WTP which is closer to their true, underlying valuation of the good. Respondents were then asked to complete a nine-question multiple choice quiz. This was used to determine what individuals already knew about existing flood defence and flood risk in the Tay Estuary, as well as the costs and benefits associated with managed realignment. The quiz was developed with researchers specialising in flood risk management at the University of Stirling to ensure that the questions were accurate and relevant to the study region. The quiz was also pre-tested on the pilot respondents to ensure that the questions were easily understood and of interest to the general public". There was a control group who did not take the first quiz.

In the valuation portion of the survey, respondents were given text and graphics to inform them of the process of managed realignment, flood risk in their local area and the possible additional ecosystem service benefits of managed realignment (the phrase ecosystem services was not used in the survey). The managed realignment scenario was then detailed, including a map of where the scheme would take place, how many homes would be protected and the length of time before the defences would be completed. The status quo scenario of continued hard defences was also included. Respondents were told that increases in council tax would fund the scheme. Council tax was a plausible payment vehicle as local authorities are responsible for funding flood defence in Scotland. Respondents were then presented with the payment card ranging from £0 to £150 and asked to tick all the amounts the household was willing to pay towards the scheme. A payment card was chosen as the valuation format to increase the statistical efficiency gains relative to the dichotomous choice format and lower the cognitive burden placed on respondents which are associated with the open-ended format (Boyle and Bishop, 1988; Mitchell and Carson, 1989). The values shown on the cards were chosen based on feedback from initial focus groups.

Following the valuation exercise, a series of debriefing questions followed, including statement questions regarding perceived flood risk, whether respondents felt flood risk was increasing and whether the current defences were adequate enough to protect their home. Finally, respondents were asked a set of socio-demographic questions. A summary of the survey is provided in Figure 32 and a full copy of the survey can be made available on request.

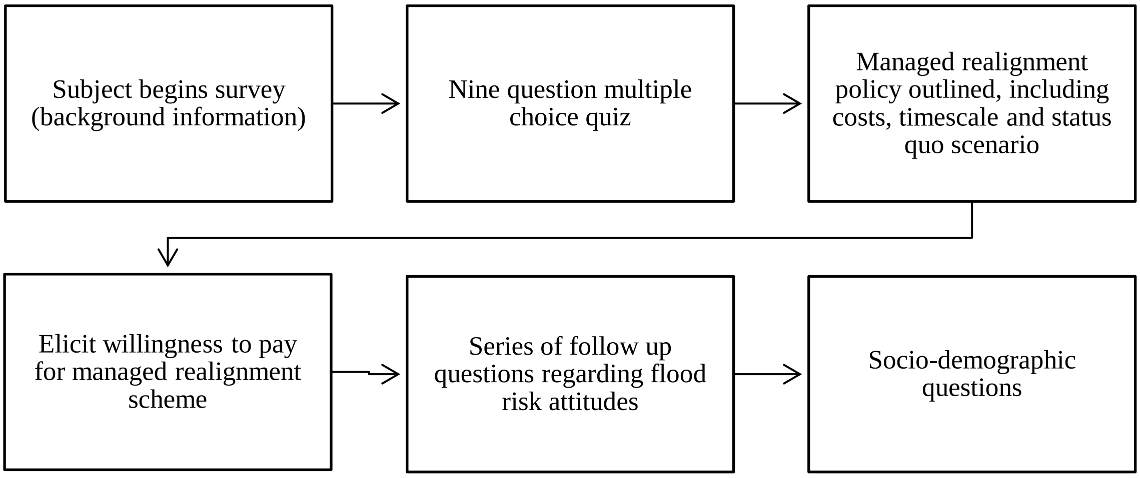


**Figure 3: Survey summary**

*4.2. Statistical analysis*

The statistical analysis was conducted in STATA (Version 14). There are a variety of estimation procedures available for estimating WTP from payment card data, two of which were used and compared in this paper. The Tobit model, or censored regression model, is designed to estimate linear relationships between variables when there is either left or right censoring in the dependent variable (Long, 1997). For WTP surveys left-hand censoring is appropriate as it takes into account respondents zero bid respondents i.e. those, not willing to pay. However, for payment card data, the researcher will observe an interval (with a lower bound and upper bound) where the respondent's true WTP lies. As a result for Tobit regression, the researcher must decide on one discrete value to be used as the dependent variable in the analysis: either the lower or upper bound of the payment card or the mid-point between the two. This can result in a biased evaluation with either the estimate being too conservative (when the lower bound is used) or too large (when the upper bound is used). Cameron and Huppert, (1989) stress the importance of sensitivity analysis if a proxy is used for the true value of the dependent variable. Interval regression can overcome this issue by using the lower and upper bounds of the value chosen on the payment card as the dependent variable in the regression analysis (Haab and McConnell, 2002). For this survey, respondents were asked to tick the highest value they were prepared to pay towards the scheme. However, their true value may lie between the highest bid they chose and the next highest amount. For example, suppose a respondent ticked £100 and the next highest was £150. In this case, their true value may lie between £100 and £150 and these bounds can be used in the interval regression estimation. Theoretically, there are $K$ payments, $t_1 \dots., t_k$ arranged in ascending order so that $t_k > t_{k-1}$. When a respondent chooses payment $t_k$, the probability that WTP lies between $t_k$ and $t_{k+1}$: $\Pr(choose\ t_k) = \Pr(t_k \leq wtp < t_{k+1}$. Responses to the payment card can be treated by specifying WTP as $WTP = \mu + \mathcal{E}$. If we let $\mathcal{E} \sim N(0, \sigma^2)$, $\Pr(choose\ t_k) = \phi\left(\frac{(t_{k+1} - \mu)}{\sigma}\right) - \phi\left(\frac{(t_k - \mu)}{\sigma}\right)$ where $\phi\left(\frac{(t_{k+1} - \mu)}{\sigma}\right)$ is the standard normal CDF evaluated at $\phi\left(\frac{(t_{k+1} - \mu)}{\sigma}\right)$. The log likelihood function on for the responses can then be formed: $\ln L = \sum_{i=1}^{T} \ln(\phi\left(\frac{(t_{k+1}(i) - \mu)}{\sigma}\right) - \phi\left(\frac{(t_k(i) - \mu)}{\sigma}\right)$ where individual $i$ chooses payment $t_k(i)$. This is a form of an interval model in which every individual picks some payment (Haab and McConnell, 2002).

In this paper, both the Tobit and Interval model have been applied to the analysis and the different models compared. For the Tobit model, the lower bound value of the payment card was used for the analysis. Several covariates were used in the analysis to explore the WTP distribution and also the reliability of the survey estimates (Carson and Hanemann, 2005) (Equation 1, Table 1).

$$WTP_I = b_0 + b_1 INCOME + b_2 GENDER + b_3 EDUCATION + b_4 ENV + b_5 AGE + b_6 OWNER + b_7 DISTANCE + b_8 HOMEFLOOD + b_9 FLOODRISK + b_{11} WORRY * PERCEIVED\ FLOOD\ RISK + \varepsilon_I \quad (1)$$

**Table 1: Explanatory variables used in the estimation process**

| | |
|---|---|
| INCOME | Household income ranging from under £15,000 to over £100,000 per annum (six categories, midpoint of each category used in the estimation process ) |
| GENDER | Gender (female=0, male=1) |
| EDUCATION | Respondent has a university degree (0-no, 1=yes) |
| ENV | Member of an environmental group (0=no, 1=yes) |
| AGE | Age ranging from 18-19 through to 65 and over |
| OWNER | Whether the respondent owns their property or not (0=no, 1=yes) |
| DISTANCE | Distance from the proposed flood defence scheme: 0=at site, 1=1-10 miles, 2=11-20 miles 3=over 20 miles |
| HOMEFLOOD | Home has been flooded (0=no, 1=yes) |
| FLOODRISK | Statement questions response "My property is at risk from flooding" (0= strongly disagree, disagree or unsure no, 1=strongly agree or agree) |
| WORRIED | Statement questions response "I am worried the current flood defences are not adequate enough to protect my home" " (0= strongly disagree, disagree or unsure no, 1=strongly agree or agree) |

In contingent valuation surveys, there is an expectation that respondent's experiences with the good in question, personal motivations, their socioeconomic status and the distance they live from the site can all affect WTP (Cameron and Englin, 1997; Kniivilä, 2006; LaRiviere et al., 2014). Socio-demographic variables used in the analysis include income, age, gender, home ownership and being a member of an environmental group. There is an expectation in contingent valuation surveys that income will be a statistically significant driver of WTP with those on the highest incomes being prepared to pay the most (Barbier, Hanley and Czajkowski, 2017).

Instead of using actual flood risk, as determined by whether the respondent lived in a floodplain, experience of flooding and perceptions of flood risk were included in the regression analysis. There is an expectation that those who had previously been flooded would be more inclined to fund the scheme to improve the level of flood defences, either for themselves or others at risk. Dummy variables for whether a respondent had been flooded (yes=1, no=0), whether the respondent believed they were at risk from flooding (yes=1, no=0) and whether they worried about existing flood defences (yes=1, no=0) were included. Additionally, the variables perceived risk and worry were interacted. There was an expectation that those respondents who feel they were at risk from flooding and were most worried about current flood defences would be prepared to pay the most towards the scheme.

To explore geographical differences in WTP residents were grouped into four distances bands depending on how far they lived from the proposed flood defence. There was an expectation that residents of Newburgh would be willing to pay the most towards the scheme as they would receive direct flood defence benefits (since this is the closest town to the proposed scheme). Distance bands were included instead of a dummy variable for Local Authority area.

# 5. Results

## *5.1. Sample Characteristics*

In total 4000 households were contacted by mail and invited to take part in an online survey. A reminder card was sent two weeks after the first contact attempt. Of 4000 people contacted, 749 people completed or partially completed the online survey with 593 responses completed in sufficient detail to be used in the analysis: a response rate of 15%.

Self-reported socio-demographic characteristics were compared with Scottish Neighbourhood Statistics for the Fife, Dundee and Perth & Kinross local authorities (Table 2). 60% of responses were from the Fife local authority, with 26% from Dundee and 13% from Perth & Kinross. Analysis revealed that the sample was not fully representative of the local population. The oldest age groups (50 - 64 years and 65 and over) were well represented in the survey whilst the youngest age group (18 - 29) was underrepresented (9% of the sample compared to 22% in population). Males were also over-represented in the survey (58% compared to 47% in the overall population). The modal income group was £20,000 - £39,000 which was similar to the median income of the local authorities (£26,000). Over 80% of the sample owned their own homes compared to the Fife average of 64%.

**Table 2: Socio-demographic characteristics of the respondents**

| | **Percentage of Sample** |
|---|---|
| **Income** | |
| Under £15,000 | 13.57 |
| £15,000 - £19,999 | 12.32 |
| £20,000 - £39,999 | 32.99 |
| £40,000 - £69,999 | 25.68 |
| £70,000 - £99,999 | 9.60 |
| Over £100,000 | 5.85 |
| **Gender** | |
| Male | 58.25 |
| Female | 41.75 |
| **Education** | |
| Higher education: no | 44.79 |
| Higher education: yes | 55.21 |
| **Member of environmental group** | 33.40 |
| **Local Authority** | |
| Fife | 60.13 |
| Perth & Kinross | 13.44 |
| Dundee | 26.43 |
| **Age** | |
| 18 - 29 | 9.39 |
| 30 - 49 | 33.86 |
| 50 - 64 | 34.05 |
| 65 and over | 22.70 |
| **Property status** | |
| Property owner | 82.32 |
| Other | 17.68 |
| **Distance from site** | |
| At site | 16.52 |
| 1 - 10 miles | 2.86 |
| 10 - 20 miles | 32.60 |
| over 20 miles | 48.02 |

### 5.2. *Respondent familiarity with flood risk management issues*

The majority of respondents appeared to be relatively un-informed about flood risk management issues and the mean quiz score was 3.05 (*SE*=0.08) (Figure 3). Respondents knew the least about estuarine flood risk and government flood defence spending (Q1 and Q2) although appeared to be familiar with historical flood protection measures (Q3). As expected, fewer respondents were aware that managed realignment could deliver a greater level of flood protection compared to traditional defences (Q4). 26% of respondents were aware that wetlands provided an important food source for wildlife (Q5) and over 50% of respondents knew wetlands were important spawning grounds for fish (Q6). 45% thought brownfield land would be used for the managed realignment site, compared with 21% who correctly knew that in most cases agricultural land is used (Q7). Almost 50% were aware that erosion was the main cause of decline for waterbird populations (Q8) and finally respondents were relatively unfamiliar with the legal obligations regarding wetland protection (Q9).

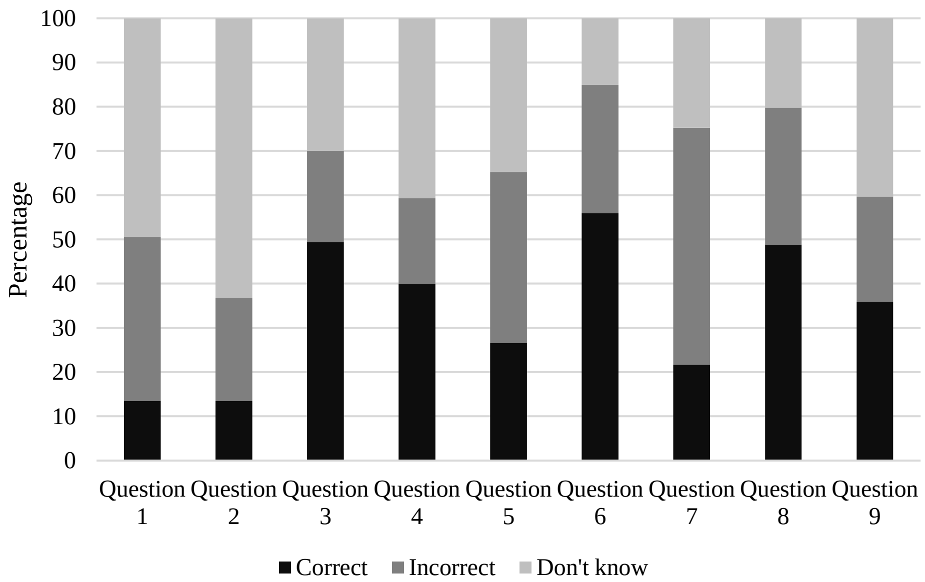


**Figure 4: Estuarine management quiz results**

The survey follow up questions revealed that approximately 18% of respondents felt they were at risk from flooding, 29% felt that flood risk was increasing and 23% were worried that the current flood defences were not adequate enough to protect their home. Over 67% of respondents felt that it was the council's responsibility to maintain and fund flood defences (Table 3). Respondent's postcodes were compared to SEPA Flood Risk Maps in ArcGIS to determine whether the resident lived on a coastal or fluvial floodplain. Overall, 26% of respondents lived on a floodplain, 8 percentage points higher than the fraction of respondents who stated that they were at risk of flooding. This suggests that some respondents were unaware of the actual flood risks they face. Additionally, 55% of those who were mapped as living on the floodplain either disagreed, strongly disagreed or were unsure that they were at risk from flooding. Despite this lack of flood risk awareness, 68% of the sample had some level of privately-purchased insurance against flooding.

**Table 3: Responses to the flood risk statement questions**

| | Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| My property is at risk from flooding | 52.08% | 24.43% | 4.73% | 12.31% | 6.44% |
| Flood risk in the area is increasing | 39.05% | 28.00% | 4.19% | 21.71% | 7.05% |
| I am worried that the current defences are not adequate enough to protect my home | 41.49% | 30.59% | 5.35% | 15.30% | 7.27% |
| It is the council's responsibility to fund flood defence, not mine | 9.75% | 17.59% | 5.54% | 41.30% | 25.81% |

### *5.3. Public WTP for the managed realignment scheme*

The majority of respondents (82%) were prepared to pay towards the managed realignment scheme (Figure 4). The main reasons for not being prepared to pay were not being able to afford to contribute (26%) and believing it is the Scottish Government's responsibility to fund flood defence (27%). The mean WTP across all respondents was £43.03 per household per annum (*SE*=1.88) (Table 4).

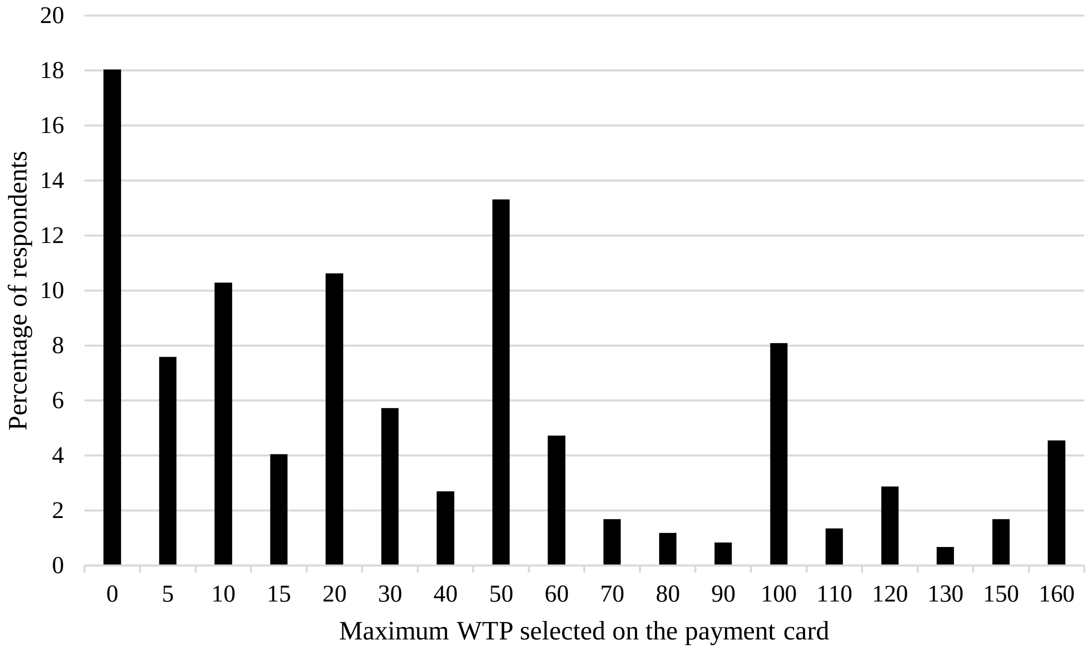


**Figure 5: Frequency of WTP by payment card amounts selected**

Responses from the flood risk quiz were grouped into two bands: below average score (0-2 correct) and above average score (3 or more correct). Table 4 presents the mean WTP of respondents grouped by their knowledge type. A Mann-Whitney test showed there were no significant differences in mean WTP between these a priori information types ($H(2)= 0.83$, $p= 0.40$. Neither was there a statistical difference in the number of zero bids ($H(2)= 0.23$, $p= 0.82$) between high and low information groups. Overall the results suggest that what respondents knew about flooding and flood defences prior to the survey, as measured by the quiz, did not affect their WTP.

**Table 4: WTP for the managed realignment scheme**

| | All respondents | Quiz score | |
|---|---|---|---|
| | | Below average | Above average |
| Mean WTP | 43.03 | 46.04 | 42.88 |
| SE | 1.88 | 2.76 | 3.07 |
| 95% CI | 39.34-46.71 | 40.62-51.47 | 36.82-48.91 |
| Number of zero bids | 107 | 53 | 30 |
| N | 593 | 301 | 203 |
| Mann Whitney Z (*p<*): zero bids | | 0.23 (p= 0.82) | |
| Mann Whitney Z (p<): mean WTP | | 0.83 (p= 0.40) | |

Note: All respondents includes those who did not take the first quiz (control group n=89). Analysis not included in this paper shows that there were no significant differences in WTP between those who took the first quiz and those who did not. There was also no significant differences in respondent characteristics between those who did and did not take the first quiz. As such all respondents are pooled together for the remainder of the analysis.

Table 5 compares the coefficient estimates for three different regression models which considered which variables influenced household WTP for managed realignment. Coefficient estimates were higher for the Tobit model (Model 1) compared to the Interval model (Model 2). Comparing the AIC, BIC and Log likelihood values shows that the Interval regression model had a better fit, so these coefficient estimates will be discussed for the remainder of the paper.

The interaction between perceived flood risk and worry about existing coastal defences had the strongest effect on WTP. Respondents who felt most at risk from flooding and were more worried about existing defences were willing to pay £32.66 more per household per annum (Model 3) compared to those respondents who were not worried and felt they were not at risk from flooding. However, there was no significant difference in WTP between respondents who had been flooded previously and those who had not.

Respondents were separated into four distance bands ranging from “at the site” to “over 20 miles from the site”. It was found that those respondents who lived at Newburgh (where the scheme was proposed) were willing to pay £21.97 more per household per annum compared to those who lived 11-20 miles from the site and £21.22 more per household per annum compared to those who lived over 20 miles from the site. The mchange command in Stata was used to compare WTP between the distance bands for the Interval regression model (Table 6) (for more information on “mchange” see Long and Freese, 2014). Results showed there were no significant differences in WTP between distance bands above 10 miles from the site. In line with many stated preference surveys, income was a significant determinant of WTP. Respondents in the highest income bands (over £100,000) were prepared to pay on average £35.94 more per household per annum compared to the lowest income band of below £15,000 per annum. In addition, being a member of an environmental group significantly increased WTP with those respondents being prepared to pay £15.28 more per household per annum compared to those who were not members of an environmental group.

**Table 5: Comparison of the Tobit and Interval regression models exploring willingness to pay for the managed realignment scheme**

| VARIABLES | Tobit Model | | Interval Model | |
|---|---|---|---|---|
| Household income: between £15,000 -£19,999 | 17.98** | (8.34) | 12.15* | (7.10) |
| Household income: between £20,000 - £39,999 | 22.54*** | (7.17) | 18.09*** | (6.07) |
| Household income: between £40,000 - £69,999 | 17.89** | (7.83) | 13.31** | (6.69) |
| Household income: between £70,000 - £99,999 | 29.16*** | (10.06) | 26.29*** | (8.67) |
| Household income: over £100,000 | 37.45*** | (11.85) | 35.94*** | (10.23) |
| Gender = Male | 12.22*** | (4.42) | 11.20*** | (3.80) |
| Higher education: yes | 4.58 | (4.60) | 0.84 | (3.96) |
| Environmental group: yes | 15.28*** | (4.94) | 12.89*** | (4.30) |
| Age: 30 - 49 | -5.74 | (8.74) | -6.53 | (7.53) |
| Age: 50 - 64 | -1.84 | (8.88) | -3.19 | (7.65) |
| Age: 65 and over | -2.65 | (9.65) | -2.24 | (8.32) |
| Home ownership: yes | -1.97 | (6.41) | -1.47 | (5.51) |
| Distance from site: 1 - 10 miles | -13.04 | (13.23) | -13.74 | (11.48) |
| Distance from site: 10 - 20 miles | -23.44*** | (6.67) | -21.97*** | (5.78) |
| Distance from site: over 20 miles | -21.15*** | (6.44) | -21.22*** | (5.60) |
| My home is at risk from flooding | -5.14 | (12.83) | -4.21 | (11.06) |
| I am worried the current defences are not adequate enough to protect my home | 14.39* | (8.47) | 10.46 | (7.40) |
| Interaction: risk (0) and worried (0) | 0.00 | (0.00) | 0.00 | (0.00) |
| Interaction: risk(1) and worried (1) | 33.89** | (15.95) | 32.66** | (13.86) |
| My home has been flooded | 6.61 | (8.83) | 6.03 | (7.67) |
| Constant | 17.70 | (11.25) | 42.37*** | (1.64) |
| Predicted WTP estimates | 34.52 | (1.17) | 42.91 | (1.06) |
| Observations | 435 | | 435 | |
| AIC | 3870.58 | | | 2863.11 |
| BIC | 3956.16 | | | 2948.70 |
| Log Likelihood | -1914.29 | | | -1410.56 |

**Table 6: Comparison of WTP by distance from the site (Interval model)**

| | | |
|---|---|---|
| Distance from site: 1 - 10 miles | vs at site | -13.74 |
| Distance from site: 10 - 20 miles | vs at site | -21.968*** |
| Distance from site: over 20 miles | vs at site | -21.219*** |
| Distance from site: 10 - 20 miles | vs distance from site: 1 - 10 miles | -8.228 |
| Distance from site: over 20 miles | vs distance from site: 1 - 10 miles | -7.479 |
| Distance from site: over 20 miles | vs distance from site: 10 - 20 miles | 0.749 |

Notes: calculated using the “mchange” command in Stata. For details on margins, see Long and Freese (2014)/
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Following the regression analysis the Stata post-estimation command "predict" was used to estimate WTP based on the Interval regression. Mean, median and the standard deviation of WTP were calculated for the whole sample and across various restrictions (Table 7). The unrestricted predicted mean WTP was £42.91 per household per annum (*CI*= 40.83–44.99). Restricting this to Newburgh residents only increased the mean WTP to £69.02 household per annum (*CI*= 63.86-74.19).

The next question is what extent of the market should be used in the aggregation? Bateman et al., (2006) offers insights into this; should the aggregation of benefits be confined to those living in the close vicinity of the good, or extended across the region, country or even further afield? This will have implications on the appropriate level of government financing and provision. It was decided to compare aggregate WTP across three spatial scales: Newburgh residents only; the population of Fife; and those living closest to the Tay Estuary.

Initially, aggregate WTP was derived for Newburgh respondents only and scaled up to the Newburgh population (Table 8). This population was chosen as Newburgh residents would directly benefit the most from the flood defence scheme. Aggregate household WTP varied between £72,350 and £84,056. Secondly, aggregate WTP was derived respondents from the Fife Local Authority only and aggregate WTP was scaled across the Fife population. This aggregation was chosen as the council tax increase to fund the scheme would take place across the whole local authority area. Predicted means from the Newburgh residents were not included and instead, the conservative predicted household means from the remainder of the Fife local authority respondents were used. It was felt the using responses from Newburgh residents would significantly over-estimate the aggregate WTP as these residents only make up a very small percentage of the Fife population. Aggregate household WTP varied between £5,966,785 and £6,826,164. Finally, aggregate WTP was calculated for households situated in census output areas adjacent to the Tay Estuary covering the Fife, Perth & Kinross and Dundee local authorities. There is potential that these properties may experience flood reduction benefits as a result of the scheme. Aggregate household WTP varied between £10,621,427 and £11,734,477.

**Table 7: Predicted WTP across varying restrictions for the Interval regression model (Model 2)**

| Restrictions | Mean | Confidence Interval | | SD | 25 %ile | 50 %ile | 75 %ile | Obs |
|---|---|---|---|---|---|---|---|---|
| Full sample | 42.91 | 40.83 | 44.99 | 22.08 | 28.39 | 37.99 | 51.20 | 435 |
| Newburgh residents only | 69.02 | 63.86 | 74.19 | 21.67 | 50.36 | 67.47 | 87.98 | 70 |
| Fife residents only (excluding Newburgh) | 37.22 | 34.72 | 39.71 | 17.24 | 26.15 | 36.23 | 45.55 | 185 |
| Residents from elsewhere | 37.90 | 36.01 | 39.79 | 18.33 | 26.15 | 35.01 | 46.21 | 365 |

**Table 8: Aggregate annual household WTP across varying populations (Model 2)**

| Area | Number of Households | Annual Aggregate WTP (mean) | Annual Aggregate WTP (lower) | Annual Aggregate WTP (upper) |
|---|---|---|---|---|
| Newburgh | 1133 | £78,203 | £72,350 | £84,056 |
| Fife residents only (excluding Newburgh) | 171861 | £6,396,474 | £5,966,785 | £6,826,164 |
| Residents from elsewhere | 294922 | £11,177,951 | £10,621,427 | £11,734,477 |

## 6. Discussion

This paper explores two questions: firstly, to what extent are local residents familiar with flood risk, flood defence and estuarine ecosystem services? Second, are residents willing to pay towards a new managed realignment scheme, and if so, which factors influence this?

With regard to the first question, the results of the quiz highlight that respondents were relatively poorly informed about current flood risk management in their area. Whilst the majority of respondents recognised the main type of coastal defence as being hard defences, far fewer were aware of the percentage of homes at risk from flooding or of current flood defence expenditures. Respondents also knew very little about the additional costs and benefits of managed realignment. This highlights the importance of providing information about managed realignment prior to undertaking a valuation exercise, as the full costs and benefits may not be readily understood or known by the general public (Needham et al, 2018). Our research overcomes this problem by controlling for each person's ex ante level of knowledge of the good, but this by no means always done in stated preference studies. Encouragingly, the quiz revealed that over 40% of respondents felt that managed realignment had the potential to deliver a greater level of protection than traditional coastal defences. This is in contrast to previous findings where it is widely discussed that the general public has negative feelings towards managed realignment and do not see it as an adequate form of flood protection (French, 2006). Overall, the results of the quiz demonstrate the need for policymakers to communicate their flood risk management policy more effectively as people are currently poorly informed about the issue.

Secondly, the results highlighted a mismatch between perceived flood risk and actual flood risk in the study area. Some 116 respondents were mapped as being at risk from either coastal or fluvial flooding; however, 64 of these did not believe they were at risk from flooding. From a flood risk management perspective, this is concerning as people may not be taking appropriate steps to protect their home, such as paying for private insurance. This has been a common finding in previous UK flood risk surveys (Environment Agency, 2004; Harries, 2008). Encouragingly, in the case of the Tay survey, 69% of respondents who lived on the flood plain did have some level of insurance against flood damages. Previous surveys have shown the main driver behind flood risk perceptions is the respondents' own experiences of flooding. Burningham et al., (2008) found that, for the UK, those who had previous flood experience, had lived in the area for longer and were in a higher social class, were all predictors of flood risk awareness. Similar results were reported by Bradford et al., (2012) where flood risk awareness was strongly correlated with flood risk experience in an EU-wide study. The results of this survey showed that respondents who had already been flooded were more likely to feel at risk from flooding. This reinforces findings from previous surveys that direct flood experience raises the perception of flood risk, as does worry about this risk.

Thirdly, the majority of respondents were willing to pay towards the managed realignment scheme rather than maintaining the status quo of existing hard sea defences. The predicted mean WTP from the Interval regression model was £42.91 per household per annum (*CI*= 40.83 - 44.99). Restricting this to Newburgh residents only, who likely benefit most from the scheme, increased the mean WTP to £69.02 household per annum (*CI*= 63.86 - 74.19). These results are consistent with previous surveys which assessed WTP for natural flood defence schemes but lower than wetland creation values derived through meta-analysis (in a sense, what people are paying for here is wetland creation). A meta-analysis of wetland contingent valuation studies by Brouwer et al., (1999) found mean WTP for wetland regeneration was £83.65 (£131.60[1]) per household per year. English Nature, (2001) applied this value to managed realignment and derived a household WTP of £20 per household per year (£30.10[1]) for England and Wales. Further wetland values for flood defence have been calculated by Woodward and Wui, (2001) with values calculated as $159 per hectare (1990 values) and $50 per hectare (1995 values) respectively (£224 and £56.77[1]). The Environment Agency, (2004) assessed respondent's WTP to avoid health impacts associated with flooding and mean WTP values for flooded and at-risk respondents were between £150 and £200 per household per year respectively (£282 and £211.89[1]). In a more recent study Jones et al., (2015) found that residents were willing to pay £42.36 per household per year to maintain coastal sea

[1]2014 value adjusted for inflation and currency conversion

defences along the south coast of England. Overall the values estimated in this survey are more conservative than previous UK valuation studies.

As expected, respondents in Newburgh were prepared to pay the most towards the scheme as they would receive the direct benefits of reduced flood risk. Grouping respondents into four distance bands (at the site, 1 - 10 miles, 11 - 20 miles and over 20 miles) showed those living at the site were prepared to pay significantly more than those in the 11 - 20 and over 20 miles category. There was no difference in the marginal values between the 1 - 10, 11 - 20 and over 20 miles distance bands. Respondents who believed they were at risk from flooding and also felt the current defences were not adequate enough were prepared to pay the most towards the scheme. This finding is similar to that of Bradford et al., (2012), where worry was seen as important risk characteristic: an individual can be aware of a flood risk but if they are not worried about the risk it is less likely they will prepare against it. Results also showed that previous experience on flooding did not significantly influence the willingness to pay estimate. This is similar to previous flood risk surveys have shown those who have been flooded are reticent to take personal responsibility for flood protection, and instead, expect scientists and regulators to manage the problem for them (Soane et al., 2010).

It is clear that, amongst respondents living within the study area, there are varying attitudes towards flood risk and flood defences, and this is something which needs to be addressed when proposing a new scheme through information campaigns and public consultation. This is already recognised as part of Flood Risk Management planning in Scotland (Scottish Government, 2011), however, results of this survey suggest that current communication may not be effective. One drawback of this survey was that respondents were not specifically asked whether they were aware of existing flood risk campaigns in the area. As such a causal link between information provision and flood risk awareness cannot be concluded. It could be inferred that the lack of awareness of some respondents may be an indication that information campaigns may not be reaching the desired audience, or some people are unwilling to take on board the information provided to them.

## 7. Conclusion

This paper aimed to investigate preferences and willingness to pay for a proposed managed realignment scheme on the Tay Estuary, Scotland. This contributes to two strands of literature: the general public's understanding of flood risk and flood defence options; and the valuation of managed realignment schemes. This study differs from previous flood risk surveys as it employs the contingent valuation method to assess public perceptions for the alternative flood defence and their willingness to pay.

The results showed that the majority of respondents supported the scheme's development and would be prepared to pay towards the scheme. The predicted WTP from the Interval regression model was £42.91 per household per annum (*CI*= 40.83–44.99). Calculating the aggregate WTP showed that there is a great deal of variation in the welfare estimates depending on which sub-sample of residents is chosen. Annual benefits range from £78,203 for Newburgh households only to £11,177,951 if aggregated over the three local authorities. From a policy perspective, these estimates provide an initial baseline for the assessment of the benefits of a managed realignment scheme, although decisions over which if any additional flood risk mitigation schemes should be implemented will not be based on benefit-cost considerations alone.

One of the main drawbacks of this study is that values for the individual ecosystem services provided by the scheme were not estimated. Contingent valuation calculates overall WTP for the bundle of quantity and quality changes associated with the policy change. Providing respondents read and understood the information presented to them, this bundle includes the value of the flood defence good itself, as well as the additional ecosystem service provision for wildlife and fisheries. WTP for the different ecosystem service values could have been elicited using a choice experiment. For this, the managed realignment site could have been described in terms of its attributes, i.e. the different ecosystem services provided, and respondents asked to choose between different "bundles" of attributes. This would have allowed the identification of WTP for each individual ecosystem service.

A further extension would be to capture the potential recreational value of the managed realignment scheme. According to Coastal Futures, existing managed realignment sites in England offer a variety of recreational activities for local residents and visitors alike and this is something that could be potentially developed as part of the Newburgh scheme (Coastal Futures n.d). For example at Freiston Shore in Norfolk, it was estimated that the managed realignment site brings £150,000 into the local economy and attracts 57,000 visitors a year, compared to an estimated 11,000 per annum before the breach. At Alkborough Flats on the Humber Estuary, public footpaths were constructed on the site and five bird hides. Future work could estimate the potential recreational value of the Newburgh managed realignment scheme site using the travel cost model (see Haab and McConnell, 2002), as well as via stated preference approaches.

Significant drivers of WTP included flood risk attitudes, income and distance from the site. From a flood risk management perspective, a mismatch between actual and perceived flood risk was highlighted, with many respondents stating they were not at risk of flooding when they in fact were. This is potentially concerning, as respondents may not be taking adequate steps to protect their home from future flood risks and in the context of this survey may have been willing to pay less as they may not have felt they would directly benefit, when in fact the opposite may be true. From a regulator's perspective, there is a challenge of how best to communicate flood risk to those without previous experience of flooding, and best to increase respondents’ understanding of the issue. There is an expectation that increasing flood risk knowledge will increase support for the allocation of public funds towards maintaining and building new flood defences, including the wider use of managed realignment and other ecosystem-based mitigation strategies. But this depends on the translation of actual risk changes into changed risk perceptions.


## Acknowledgements

This study was part of the lead author's PhD supported by MASTS (Marine Alliance for Science and Technology for Scotland), along with Scottish Natural Heritage and the Scottish Environment Protection Agency.

## 8. Reference List


Alexandrakis, G., Manasakis, C., Kampanis, N.A., 2015. Valuating the effects of beach erosion to tourism revenue. A management perspective. Ocean & Coastal Management 111, 1-11.

Alves, F., Roebeling, P., Pinto, P., Batista, P., 2009. Valuing ecosystem service losses from coastal erosion using a benefits transfer approach: a case study for the Central Portuguese coast. Journal of Coastal Research 56, 1169-1173.

Andrews, J., Burgess, D., Cave, R., Coombes, E., Jickells, T., Parkes, D., Turner, R., 2006. Biogeochemical value of managed realignment, Humber estuary, UK. Science of the total environment 371, 19-30.

Barbier E.B., Hanley N. and Czajkowski M., 2017. “Is the income elasticity of the willingness to pay for pollution control constant?” Environmental and Resource Economics, 68: 663.

Bateman, I.J., Day, B.H., Georgiou, S., Lake, I., 2006. The aggregation of environmental benefit values: welfare measures, distance decay and total WTP. Ecological economics 60, 450-460.

Begg, C., Callsen, I., Kuhlicke, C., Kelman, I., 2017. The role of local stakeholder participation in flood defence decisions in the United Kingdom and Germany. Journal of Flood Risk Management 11, 180-190.

Boyle, K.J., Bishop, R.C., 1988. Welfare measurements using contingent valuation: a comparison of techniques. American Journal of Agricultural Economics 70, 20-28.

Bradford, R., O'Sullivan, J., Van der Craats, I., Krywkow, J., Rotko, P., Aaltonen, J., Bonaiuto, M., Dominicis, S.D., Waylen, K., Schelfaut, K., 2012. Risk perception–issues for flood management in Europe. Natural hazards and earth system sciences 12, 2299-2309.

Brander, L.M., Florax, R.J., Vermaat, J.E., 2006. The empirics of wetland valuation: a comprehensive summary and a meta-analysis of the literature. Environmental and Resource Economics 33, 223-250.

Brouwer, R., Langford, I.H., Bateman, I.J., Turner, R.K., 1999. A meta-analysis of wetland contingent valuation studies. Regional Environmental Change 1, 47-57.

Burningham, K., Fielding, J., Thrush, D., 2008. ‘It'll never happen to me’: understanding public awareness of local flood risk. Disasters 32, 216-238.

Cameron, T.A., Englin, J., 1997. Respondent experience and contingent valuation of environmental goods. Journal of Environmental Economics and management 33, 296-313.

Cameron, T.A., Huppert, D.D., 1989. OLS versus ML estimation of non-market resource values with payment card interval data. Journal of environmental economics and management 17, 230-246.

Campos, I., Vizinho, A., Coelho, C., Alves, F., Truninger, M., Pereira, C., Santos, F.D., Penha Lopes, G., 2016. Participation, scenarios and pathways in long-term planning for climate change adaptation. Planning Theory & Practice 17, 537-556.

Carson, R., 2012. Contingent valuation: a comprehensive bibliography and history. Edward Elgar Publishing.

Carson, R.T., 2000. Contingent valuation: a user's guide. ACS Publications.

Carson, R.T., Groves, T., 2007. Incentive and informational properties of preference questions. Environmental and resource economics 37, 181-210.

Carson, R.T., Hanemann, W.M., 2005. Contingent valuation. Handbook of environmental economics 2, 821-936.

Chilton, S., 2007. Contingent valuation and social choices concerning public goods: An overview of theory, methods and issues. Revue d'économie politique 117, 655-674.

Coates, T.T., Brampton, A.H., Powell, K.A., 2001. Shingle beach recharge in the context of coastal defence: principles and problems. Ecology and geomorphology of coastal shingle, 394-402.

Committee on Climate Change. 2013. Managing the land in a changing climate – Adaptation Sub-Committee progress report 2013., London.

Czajkowski, M., Hanley, N., LaRiviere, J., 2014. The effects of experience on preferences: theory and empirics for environmental public goods. American Journal of Agricultural Economics 97, 333-351.

Doody, J.P., 2004. 'Coastal squeeze'—an historical perspective. Journal of Coastal Conservation 10, 129-138.

Environment Agency., 2004. The Appraisal of Human related Intangible Impacts of Flooding., London.

Evadzi, P.I.K., Scheffran, J., Zorita, E., Hünicke, B., 2018. Awareness of sea-level response under climate change on the coast of Ghana. Journal of Coastal Conservation 22, 183-197.

French, P.W., 2002. Coastal defences: processes, problems and solutions. Routledge.

French, P.W., 2006. Managed realignment–the developing story of a comparatively new approach to soft engineering. Estuarine, Coastal and Shelf Science 67, 409-423.

Garbutt, R., Reading, C., Wolters, M., Gray, A., Rothery, P., 2006. Monitoring the development of intertidal habitats on former agricultural land after the managed realignment of coastal defences at Tollesbury, Essex, UK. Marine Pollution Bulletin 53, 155-164.

Haab, T.C., McConnell, K.E., 2002. Valuing Environmental and Natural ResourcesThe Econometrics of Non-market Valuation.

Harries, T., 2008. Householder responses to flood risk: the consequences of the search for ontological security. Middlesex University.

Hoyos, D., Mariel, P., 2010. Contingent valuation: Past, present and future. Prague economic papers 4, 329-343.

Johnston, R.J., Boyle, K.J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T.A., Hanemann, W.M., Hanley, N., Ryan, M., Scarpa, R., 2017. Contemporary guidance for stated preference studies. Journal of the Association of Environmental and Resource Economists 4, 319-405.

Jones, N., Clark, J.R.A., Malesios, C., 2015. Social capital and willingness-to-pay for coastal defences in south-east England. Ecological Economics 119, 74-82.

King, S.E., Lester, J.N., 1995. The value of salt marsh as a sea defence. Marine pollution bulletin 30, 180-189.

Kniivilä, M., 2006. Users and non-users of conservation areas: Are there differences in WTP, motives and the validity of responses in CVM surveys? Ecological Economics 59, 530-539.

Kopp, R.E., Horton, R.M., Little, C.M., Mitrovica, J.X., Oppenheimer, M., Rasmussen, D.J., Strauss, B.H., Tebaldi, C., 2014. Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. Earth's Future 2, 383-406.

Lane, S.N., 2017. Natural flood management. Wiley Interdisciplinary Reviews: Water 4, e1211.

LaRiviere, J., Czajkowski, M., Hanley, N., Aanesen, M., Falk-Petersen, J., Tinch, D., 2014. The value of familiarity: effects of knowledge and objective signals on willingness to pay for a public good. Journal of Environmental Economics and Management 68, 376-389.

Ledoux, L., Cornell, S., O'Riordan, T., Harvey, R., Banyard, L., 2005. Towards sustainable flood and coastal management: identifying drivers of, and obstacles to, managed realignment. Land use policy 22, 129-144.

Long, J., 1997. Regression models for categorical and limited dependent variables. Advanced quantitative techniques in the social sciences 7.

Long, J.S., Freese, J., 2014. qRegression Models for Categorical Dependent Variables Using Stata, Third Edition. Stata press.

Luisetti, T., Turner, R.K., Bateman, I.J., Morse-Jones, S., Adams, C., Fonseca, L., 2011. Coastal and marine ecosystem services valuation for policy and management: Managed realignment case studies in England. Ocean & Coastal Management 54, 212-224.

Martino, S., Amos, C.L., 2015. Valuation of the ecosystem services of beach nourishment in decision-making: The case study of Tarquinia Lido, Italy. Ocean & Coastal Management 111, 82-91.

McLusky, D.S., Elliott, M., Elliott, M., 2004. The estuarine ecosystem: ecology, threats and management. Oxford University Press on Demand.

Mitchell, R.C., Carson, R.T., 1989. Using surveys to value public goods: the contingent valuation method. Washington, D.C: Resources for the Future.

Moller, I., Spencer, T., French, J., Leggett, D., Dixon, M., 1999. Wave transformation over saltmarshs a field and numerical modeling study from North Norfolk, England [J]. Estuary Coastal and Shelf Science 49, 411-426.

Myatt, L., Scrimshaw, M., Lester, J., 2003a. Public perceptions and attitudes towards a current managed realignment scheme: Brancaster West Marsh, North Norfolk, UK. Journal of Coastal Research, 278-286.

Myatt, L., Scrimshaw, M., Lester, J., 2003b. Public perceptions and attitudes towards a forthcoming managed realignment scheme: Freiston Shore, Lincolnshire, UK. Ocean & Coastal Management 46, 565-582.

Myatt, L., Scrimshaw, M., Lester, J., 2003c. Public perceptions and attitudes towards an established managed realignment scheme: Orplands, Essex, UK. Journal of Environmental Management 68, 173-181.

Nature, E., 2001. Sustainable Flood Defence: The Case for Washlands. English Nature Research Reports. English Nature, England.

NEA, 2013. The UK national ecosystem assessment: Synthesis of the key findings. Cambridge: UNEP-WCMC.

Needham, K., Czajkowski, M., Hanley, N., LaRiviere, J., 2018. What is the causal impact of information and knowledge in stated preference studies? Resource and Energy Economics 54, 69-89.

Roebeling, P., Coelho, C., Reis, E., 2011. Coastal erosion and coastal defense interventions: a cost-benefit analysis. Journal of Coastal Research, 1415.

Scottish Government., 2011. The Flood Risk Management (Scotland) Act. Delivering Sustainable Flood Risk Management – a consultation. Scottish Government, Scotland.

SEPA, 2015. Flood Risk Management in Scotland - Tayport and Newburgh Potentially Vulnerable Area, Scotland.

SEPA, 2012. Natural Flood Management Position Statement. The role of SEPA in natural flood management. SEPA, Scotland. Available: http://www.sepa.org.uk/flooding/flooding_publications.aspx.

Soane, E., Schubert, I., Challenor, P., Lunn, R., Narendran, S., Pollard, S., 2010. Flood perception and mitigation: the role of severity, agency, and experience in the purchase of flood protection, and the communication of flood information. Environment and Planning A 42, 3023-3038.

Tinch, R., Ledoux, L., Ash, J., Badley, J., Dickie, I., Dixon, M., Dodd, A., Esteban, A., Fenn, T., Miller, N., Morris, R., Murby, P., Ozdemiroglu, E., Sharpe, J., Turner, R., Watkinson, A., Watts, B., Winn, P., 2006. Economics of Managed Realignment in the UK Final Report to the Coastal Futures Project.

Torres, C., Hanley, N., 2017. Communicating research on the economic valuation of coastal and marine ecosystem services.  75, 99-107.

Turner, R.K., Burgess, D., Hadley, D., Coombes, E., Jackson, N., 2007. A cost–benefit appraisal of coastal managed realignment policy. Global Environmental Change 17, 397-407.

Vitousek, S., Barnard, P.L., Fletcher, C.H., Frazer, N., Erikson, L., Storlazzi, C.D., 2017. Doubling of coastal flooding frequency within decades due to sea-level rise. Scientific reports 7, 1399.

Vizinho, A., Campos, I., Coelho, C., Pereira, C., Roebeling, P., Alves, F., Rocha, J., Alves, M.F., Santos, F.D., Penha-Lopes, G., 2017. SWAP - Participatory planning of coastal adaptation to climate change. Journal of Integrated Coastal Zone Management 17, 99-116.

Vossler, C.A., Watson, S.B., 2013. Understanding the consequences of consequentiality: Testing the validity of stated preferences in the field. Journal of Economic Behavior & Organization 86, 137-147.

Woodward, R.T., Wui, Y.-S., 2001. The economic value of wetland services: a meta-analysis. Ecological economics 37, 257-270.