USING MULTIPLE DISCIPLINES TO INVESTIGATE COASTAL STORMS IN THE UK: CONSIDERING ENVIRONMENTAL RECORDS AND SOCIAL PERCEPTIONS

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Abstract

Global climate change poses risks to the environment and to society. These effects are pertinent on the coast, where projected increases in storm frequency and magnitude threaten low-lying ecosystems and communities. Numerous benefits are derived from coastal ecosystems, which are important to wellbeing, including flood protection, food provision and recreation. Storm effects on coastal ecosystems are highly variable and potential impacts on the non-monetary values and psychological benefits (e.g. restoration) derived from spending time on the coast are little understood. This research considers methods from environmental science and environmental psychology to evaluate storm effects on saltmarshes and how these storms can shape the psychological benefits derived from the coast. Saltmarsh sedimentary analyses alongside quantitative, qualitative and spatial analysis of survey data were employed in two UK coastal areas; Spurn Point (Humber Estuary) and Silverdale (Morecambe Bay). Potential storm records were identified in the saltmarsh stratigraphies, although not all documented events were present. Perceived risk from such storms was significantly predicted by location, with greatest perceived risk at Spurn. Storm experience at home did not translate to perceived coastal storm risk, emphasising the role of contextual factors in risk perception. Both study coasts were perceived to offer restorative potential and climate change risk perception did not significantly predict this restorativeness. Whilst environmental values significantly predicted saltmarsh importance to wellbeing on the coast, saltmarsh was considered least important to area enjoyment, relative to sand dunes and mudflats/sandflats. Aesthetics and place attachment were central to coastal protection acceptability, with soft-engineering measures significantly most acceptable. Negative spatial correlation between perceived value and risk, and between perceived and expert-assessed risk, suggests a need to raise storm- and flood-risk awareness at the study sites. This research highlights the importance of cross-disciplinary approaches to facilitate a holistic understanding and long-term perspective for effective and democratic coastal management.

List of Contents

List of Tables

CHAPTER 4

List of Figures

CHAPTER 2

CHAPTER 3

CHAPTER 4

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Declaration

I declare that the work contained within this thesis is my own and has not been submitted for any other degree or award at this, or any other, University. The contributions of co-authors to papers submitted or prepared for submission are detailed in the preface to their respective chapters. All sources are acknowledged as References.

Chapter 1. Introduction

Global climate change poses risks to both the natural environment and to society. These effects are particularly pertinent in the coastal zone, with its low-lying ecosystems, densely-populated urban infrastructure and pressure from multiple uses. Whilst consensus on the trends of increasing storminess (the frequency and magnitude of storm events) is not complete (Spencer et al., 2015), these low-lying ecosystems and coastal communities are predicted to become increasingly subjected to the effects of high-energy storm events, such as flooding and erosion (O'Riordan et al., 2014; UNEP, 2006).

The diverse effects of storms in the coastal landscape are principally governed by ecosystem setting and extent (Spencer et al., 2014). In saltmarsh ecosystems, these effects can be erosive, which may exacerbate marsh vulnerability (e.g. Adam, 2000), or depositional, which can promote marsh resilience to increasing rates of sea-level rise (e.g. de Groot et al., 2011). Whilst numerous studies suggest catastrophic losses of saltmarsh as a result of increased rate of sea-level rise and storminess, widespread ecosystem loss and degradation is not inevitable provided sediment supply to marshes is maintained and not altered through human activity (e.g. Kirwan et al. 2016). Saltmarsh sediment records can offer a detailed insight into the mesoscale (decadal- to century-scale), dynamic effects of storms in the coastal zone (e.g. Dyer et al., 2002; Kortekaas and Dawson, 2007; Tsompanoglou et al., 2010).

Society depends upon low-lying coastal ecosystems, such as saltmarshes, as they provide numerous benefits, or ecosystem services, which are integral to human wellbeing. These benefits range from the key provisioning service of coastal protection, through wave energy reduction, to regulatory services such as water purification, and the cultural service of recreation value, the latter of which contributes substantially to the economy of island nations such as the UK (DCLG, 2016; MEA, 2005; Summers et al., 2012). Cultural value ascribed to the coast has been characterised in art and literature and the coast has been promoted as a destination for physiological restoration since the Nineteenth Century. From a psychological perspective, the benefits of the coast as "blue space" have received increasing attention, for example through perceived restorativeness (e.g. White et al., 2010; c.f. Attention Restoration Theory; Kaplan and Kaplan, 1989). The impacts of environmental conditions (e.g. tidal state and marine litter) on perceived restorativeness in the coastal zone have been explored empirically (e.g. Wyles et al., 2016) and perceived restorativeness of waterscapes has been shown to be negatively affected by inclement weather conditions (White et al., 2014).

Whilst such coastal values and their loss through climate change have traditionally been studied economically, far less research has investigated the psychological impacts; individual responses to environmental risks will be determined by how these risks are perceived. The importance of previous experience and place attachment in flood risk awareness and perception is consistently demonstrated (e.g. Burningham et al., 2008; Tapsell and Tunstall, 2008). Risk management on the coast necessitates effective communication of expert-assessed risk. Failures in the effectiveness of climate change risk communication on the coast have been reported by a number of studies, and it is suggested that this is partly due to such strategies being based on limited understanding of individual risk perceptions on the coast (e.g. Smith et al., 2016). Work on climate change risk perceptions has been identified as fundamental to informing robust policy and decision-making (Pidgeon, 2012). An "expert-lay divide" regarding risk perception is often cited, yet the spatial dimensions of perceived value and risk in the landscape and between expert-assessment and lay risk perception have not been fully researched. The need to understand the risks posed to the coast by climate change and also how such risk is perceived by the public is integral to inform effective, democratic management policy in the coastal zone.

In order to implement effective adaptation strategies, a long-term perspective and individual/ community engagement are required (Clayton et al., 2015; Raaijmakers et al., 2008). This is consistent with the principles of Integrated Coastal Zone Management (ICZM), which emphasise the need for a long-term, holistic perspective that considers the interdependency and divergence between society and the coastal environment (McKenna et al., 2008). Mixed-methods, interdisciplinary approaches, which incorporate a psychological perspective to understanding global climate change effects have much to offer in this regard (Clayton et al., 2015). Such approaches can facilitate a broader contextual understanding of the social-environmental effects of climate change and extreme events on the coast.

1.1. Research aims and objectives

This research aimed to consider perspectives from environmental science and environmental psychology to evaluate storm effects on low-lying coastal environments and the psychological implications of storm risk for the benefits that society derives from those environments.

The specific objectives this research set out to determine were to:

1. Evaluate the utility of saltmarshes as archives of storm records to inform a long-term approach to coastal management
2. Examine the restorative benefits of living on, or visiting the coast and the effects of storms and coastal floods on these benefits
3. Investigate perceptions of value, change and risk from storms and flooding on the coast

and their determinants

4. Explore attitudes towards, and relationships with, the coastal landscape through quantitative, qualitative and spatial approaches

1.2. Study areas

Study sites were located at Spurn Point (Humber Estuary) and the Silverdale coast (Morecambe Bay), on the east and west coasts of the UK, respectively. These sites were chosen as they both exhibit saltmarsh environments, with coastal communities living in close proximity. These areas have experienced the effects of storms, erosion and coastal flooding, notably in recent years the 5 December 2013 storm surge, which had substantial and highly diverse effects at both locations.

1.3. Overview of methodologies

Environmental science methodologies used in this research included the collection of saltmarsh sediment cores, followed by stratigraphic analysis in the laboratory to identify potential evidence of storm records at both sites. These analyses included laser particle size analysis and loss-on-ignition techniques to determine grain size and organic matter content. Sediment geochemistry was analysed through ITRAX core scanning at the National Oceanography Centre, University of Southampton. Horizons in the core stratigraphy were dated using ^{210}Pb/ ^{137}Cs. Correlations between documented storms and potential storm record indicators in the stratigraphy were drawn. The results of these approaches are discussed in Chapter Two.

Environmental psychology approaches included the design and implementation of a pilot study, through in-depth semi-structured interviews, with 14 participants who lived in and/ or worked at the study sites. These informed the design of the Coastal Experience Survey (N = 211) which was conducted on the coasts at Spurn Point and Silverdale (April to December 2015). The survey comprised ten pages of qualitative and quantitative questions, which considered benefits and values, including saltmarsh importance to wellbeing and perceived restorativeness, changes experienced, risk perception from storms and coastal floods and demographics. Within this survey, two participatory mapping exercises were included to spatially consider the relationships between perceptions of value and risk at the study sites. The results of the Coastal Experience Survey are presented in Chapter Three and the results of the participatory mapping exercises from the survey are explored in Chapter Four.

1.4. Outline of chapters

In Chapter Two, techniques including the analysis of sediment core stratigraphy, geochemistry and geochronology were employed to investigate the effects of storms in saltmarsh environments at Spurn Point and Warton Marsh, near Silverdale in Morecambe Bay. In order to address the first research objective, potential storm signatures were identified in the sediment record. These archives were then considered in the context of documented historical storm events, the wider saltmarsh environment and discussed in terms of the numerous drivers of change that can contribute to variation in storm effects in these low-lying coastal ecosystems. This chapter identifies the important need to establish a baseline of evidence, which is required to evaluate historical saltmarsh storm effects with certainty and considers the implications of this approach for informing a long-term perspective to management of these ecosystems that promotes resilience to future changes in climate and storminess.

Chapter Three considers the psychological benefits derived from the coast and the effect of storms on these benefits and on risk perception. Research objectives two to four are addressed through the use of a survey, which was conducted with residents of, and visitors to, the two coastal study sites (N = 211). The chapter explores perceptions of value ascribed to the coast, with a specific focus on saltmarshes. The predictors of perceived restorativeness are discussed, along with the perception of risk from coastal storms and flooding and an evaluation of the acceptability of coastal protection measures. The implications of this research for management to safeguard and promote the restorative benefits from the environment are discussed, alongside approaches to management and means to inform the design of future coastal protection strategies in a manner, which is acceptable to the public and stakeholder organisations.

Chapter Four further explores survey data from the Spurn and Silverdale coasts with the aim to identify the spatial distribution and correlation of perceived value and risk in the coastal landscape; this addresses research objectives three and four. Spatial and qualitative analyses were undertaken using data from mapping exercises and open response questions from the survey discussed in Chapter Three. This chapter examines the spatial relationship between perceptions of value and of risk from storms and coastal floods. Correlations between expert flood risk assessment and lay risk perception, and of the perceptions of residents and visitors to the study areas are investigated. The results are discussed with reference to public support for coastal zone management strategies and the implications for effective communication of risks from climate change.

Chapter Five integrates discussion of the environmental science and environmental psychology techniques employed in this study. Storms can have significant implications for low-lying coastal ecosystems and thus for the numerous benefits that society gains from these ecosystems economically, physiologically and psychologically. This research applies a novel approach spanning the disciplines of environmental science and environmental psychology, in order to allow a greater depth of understanding, which can guide holistic management in the coastal zone. The importance of considering perception, and of participation in democratic policy design is worthy of emphasis, as it will likely increase public support for coastal zone management. Insights from the sediment record, not only provide long term context to the variable effects of storms on saltmarsh ecosystems, but can inform modelling of their future effects on the coast and increasing flood-risk preparedness. The multi-disciplinary approach highlights important theoretical and policy implications through the breadth of understanding of the social and environmental effects of coastal storms.

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Chapter 2. Interpreting storm effects from saltmarsh geochemical signatures

2.1. Preface

There is ambiguity in the evidence for long-term change in storminess attributable to climate change, yet storms may threaten low-lying coastal ecosystems, such as saltmarshes, from which society can gain numerous benefits (Spencer et al., 2015). Storms can have erosional and depositional effects in saltmarsh environments; these effects can be heterogeneous at multiple spatial scales (de Groot et al., 2011; Nikitina et al., 2014). Sedimentation during storm events increases saltmarsh surface elevation and, in so doing, can serve to promote ecosystem resilience to rising sea levels (Reed, 1989). This variability can be dependent upon numerous factors and can have implications for management of these important, yet threatened ecosystems.

Storm records can be identified in saltmarsh sediment stratigraphies through geochemical methods and techniques, which were employed in the following chapter. These records can substantially further understanding of saltmarsh development and the effects of coastal storms on these ecosystems; valuable knowledge for coastal managers to aid design of appropriate conservation and management strategies.

This chapter evaluates the utility of saltmarshes as archives of storm records, to inform a long-term approach to coastal management. Two macro-tidal estuarine saltmarshes were studied on the UK east and west coasts at Spurn Point, Humber Estuary and Warton Marsh, near Silverdale in Morecambe Bay. The methodology employed comprised analyses of core stratigraphy, geochemistry and geochronology. These allowed evaluation of the presence of significant documented storms within the sediment record. To aid understanding as to why certain storms were present or absent from the sediment record, the contextual forcing factors of storm impacts in the saltmarsh environment are considered.

This paper was written in the style of Progress in Physical Geography, to which it was submitted and is currently in review. Figures and tables are presented close to their first point of reference in the text, rather than as separate files, as were submitted to the publishers.

AUTHOR CONTRIBUTIONS

I declare that the work submitted is my own. The contributions by co-authors were as follows:

Katherine Selby: Primary supervision, research design, substantial review and editing

Colin Brown and Lorraine Whitmarsh: Co-supervision, review and editing

Ian Croudace: Review, editing and assistance with ITRAX data interpretation

Graeme Swindles: Review and editing

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Interpreting storm effects from saltmarsh geochemical signatures

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ABSTRACT

Whilst evidence for long-term change in storm frequency and magnitude is somewhat ambiguous, predicted increased storminess may significantly affect low-lying coastal ecosystems such as saltmarshes. Storms can cause diverse erosional or depositional impacts, with the latter potentially integral to saltmarsh resilience to increased rates of sea-level rise. Erosional or depositional saltmarsh storm records can be discontinuous at multiple spatial scales. Consequently, associations with documented storms are often cautious.

Sediment coring and application of high-resolution grain-size and geochronological analyses, alongside X-ray fluorescence core scanning can yield insights into saltmarsh development. However, storm record preservation is key to interpretation. Considering the sediment record in isolation could under- or over-estimate mesoscale response to storms, if extrapolated to the marsh scale, with significant management implications.

Stratigraphies of two macrotidal estuarine saltmarshes at Spurn Point (Humber Estuary) and Warton Marsh (Morecambe Bay), UK are presented. Sediment coring and grain-size, geochemical and geochronological analyses have facilitated potential saltmarsh storm record interpretation. These are evaluated through consideration of documented storm characteristics. Potential storm records, evident as heavy mineral sand deposits, include those of September 1969, November 1977, January 1978 and February 1997 at Spurn Point and March 1968, November 1977 and February 2002 at Warton Marsh. Documented events are clearly not all recorded in the stratigraphy, raising questions regarding the number of lines of evidence required to determine saltmarsh storm signatures with certainty. Consideration of contextual forcing factors is essential, including storm meteorology, marsh orientation and bathymetry, sediment sources and availability and coastal management.

Keywords: Storm; saltmarsh; geochemistry; geochronology; saltmarsh storm records; North Sea; Irish Sea; UK;

1. Introduction

Low-lying coastal ecosystems are predicted to become increasingly subjected to the effects of high-energy storm events due to elevated storm frequency and magnitude (storminess) (Brown et al., 2010; Dyer et al., 2002; Orme et al., 2015). The evidence for long-term changes in storminess is, however, ambiguous (Spencer et al., 2015). Consideration of the mesoscale (decadal- to century-scale) geomorphological impacts of such high-energy events is essential to inform sustainable coastal zone management (Clarke et al., 2014; French and Burningham, 2009). The dynamic relationship between saltmarshes and storms makes them pertinent, yet challenging environments in which to study storm effects. High-energy events can exacerbate marsh erosion rates (Adam, 2000; Cooper et al., 2001), yet they are also integral to marsh resilience as significant sediment loads deposited on the marsh surface allow accretion rates to keep pace with rising sea levels (de Groot et al., 2011; Reed, 1989). The rate of sea-level rise is a key factor in the importance of storm sediment delivery to the marsh, as increased rate of sea-level rise may require increased sediment delivery. The highly variable effects of storms on saltmarshes are evidenced in numerous UK and international studies, including remote sensing approaches (Pringle, 1995), ground-truthing with photographic records (Dawson et al., 2007; Spencer et al., 2015) and interpretation of saltmarsh sedimentary records through borehole data (Dyer et al., 2002; Kortekaas and Dawson, 2007; Tsompanoglou et al., 2010).

Storm records in saltmarsh sedimentary sequences can be erosional or depositional and are inherently discontinuous at a range of spatial scales, from within a 1 m^2 plot (de Groot et al., 2011) to several kilometres (Nikitina et al., 2014). Variation in the character and preservation of storm stratigraphical signatures may be determined by storm duration and coincidence of peak high water with strong onshore winds, sediment source proximity, bathymetry and marsh morpho- and hydro-dynamics (de Groot et al., 2011; Friedrichs and Perry, 2001; Spencer et al., 2015). Differential accumulation rates occur, for example, due to patchiness in vegetation coverage (Ehlers et al., 1993) and the presence of tidal creeks, alongside which the highest accumulation rates have been observed (Tsompanoglou et al., 2010). Erosion can occur during the storm event itself and may be followed by rapid accumulation to infill newly-created accommodation space. Conversely, erosion may also occur retrospectively, instigated by vegetation removal during a storm (Nikitina et al., 2014). The identification of a site with well-preserved storm deposits that have not been subjected to tidal reworking is important (Zong and Tooley, 1999), yet presents a significant challenge in dynamic saltmarsh environments. Whilst correlations have been drawn between erosive contacts across marshes spanning several kilometres, such erosion hinders conclusive attribution of individual horizons to specific storm events (Nikitina et al., 2014). Consequently, proposed links between the sediment record and documented storms are often tentative.

High-resolution grain-size analysis enables mesoscale environmental changes to be determined. Insights into the conditions under which sediments were deposited may be obtained through analysis of the contacts between sand lenses and finer sediment horizons. In a Californian back-barrier marsh system, low-frequency, high-energy event layers that were characterised by very coarse silt and sand and followed by phases of recovery were proposed to represent an inherent, yet time-dependent resilience in the system (Clarke et al., 2014). The effectiveness of a biostratigraphical approach in storm surge signature identification was highlighted by Zong and Tooley (1999), though they also noted that developments in geochemistry were essential to support high-resolution stratigraphic interpretation.

Advances in the application of high-resolution X-ray fluorescence (core scanning) techniques (Rothwell and Croudace, 2015) alongside grain-size analysis have allowed detailed insights into fluctuations in saltmarsh geochemistry. Tsompanoglou et al. (2010) applied these techniques to saltmarsh sediment cores from The Wash, Norfolk, UK. Using ^{137}Cs and ^{210}Pb dating, coarser, heavy mineral-rich silty-sand layers were attributed to the significant storm surges of 31st January – 1st February 1953 and 11th January 1978. These proposed storm signatures were not uniformly represented across the marsh due to differential accumulation rates and sediment reworking. Further north in the macrotidal Humber Estuary, Lee and Cundy (2001) proposed a time-integrated archive of heavy metal pollutants in cores from Skeffling Marsh. Two shell horizons in the stratigraphy were postulated to represent storm deposition.

Sediment record analysis and interpretation can substantially further our understanding of saltmarsh development. Storm record interpretation, however, is highly dependent upon preservation potential within the marsh. The presence or absence of depositional or erosional storm records in the sampling area could be misleading if the sediment record is interpreted in isolation. This could lead to under- or over-estimation of storm geomorphological impacts across the wider saltmarsh environment, with significant implications for coastal zone management. This paper examines 20th-Century storm records within two UK macro-tidal estuarine saltmarshes on the east and west coasts of the UK. Through analysis of core stratigraphy, geochemistry and geochronology, the presence/absence of significant documented storm events are evaluated. The results are placed in the wider context of saltmarsh storm record research and key drivers to consider in addition to the sediment record, along with associated secondary datasets.

2. Site descriptions

2.1. Spurn Point, Humber Estuary

The saltmarsh at Kilnsea Clays (BNG 541690, 415010) is situated in the lee of Spurn Point, a 5.5 km ridge of sand and gravel at the mouth of the Humber Estuary on the east coast of the UK (**Figure 1(a) and (b)**). The rapidly eroding Holderness coast is a significant source of sediment delivery to Spurn. Basal till underlies the peninsula and this, coupled with historical management (Crowther, 2010), has enabled Spurn to maintain a relatively constant position, despite the rapid retreat of the Holderness coast (Humber Estuary Coastal Authorities Group, 2009) and macro-tidal conditions of the Humber Estuary (maximum range 7.2 m) (Cave et al., 2003). Saltmarsh extent in the Humber Estuary is "uncharacteristically low for an English Estuary" (Morris et al., 2004: 789), having reduced significantly since the mid-Holocene to <7% of the intertidal area alongside substantial land reclamation (Townend et al., 2007). Estuarine saltmarsh coverage decreased from 1826 ha in 1824 to 1148 ha in 1977 (Pethick, 1994 cited in English Nature, 2006). A net gain in marsh area between 1976 and 1995 was reported for the Humber Flats, Marshes and Coast Special Protection Area, although this masks a 1.26 ha a^{-1} decrease in the outer estuary (English Nature, 2006).

Several hypotheses have been proposed to explain Spurn's development. De Boer (1969) suggested an approximate 250-year cycle of breach and renewal over the last millennium. Sea-level variations were proposed to be responsible for its morphological change during the 13th and 17th centuries (Pethick, 1991 cited in Crowther, 2010). A slightly more random development has since been proposed, governed instead by sequences of large storms. Vulnerability to storm breach is heightened by Spurn's continued growth and rotation (Humber Estuary Coastal Authorities Group, 2009). This site was selected as Spurn has been subjected to numerous breaches due to northern North Sea storms (Crowther, 2010; de Boer, 1969), yet surprisingly, the saltmarsh at Kilnsea Clays has remained unstudied with respect to storm records. A significant storm surge that occurred on 5-6th December 2013 during the study period, had major social, economic and environmental implications for the Humber Estuary and Spurn Point was severely breached.

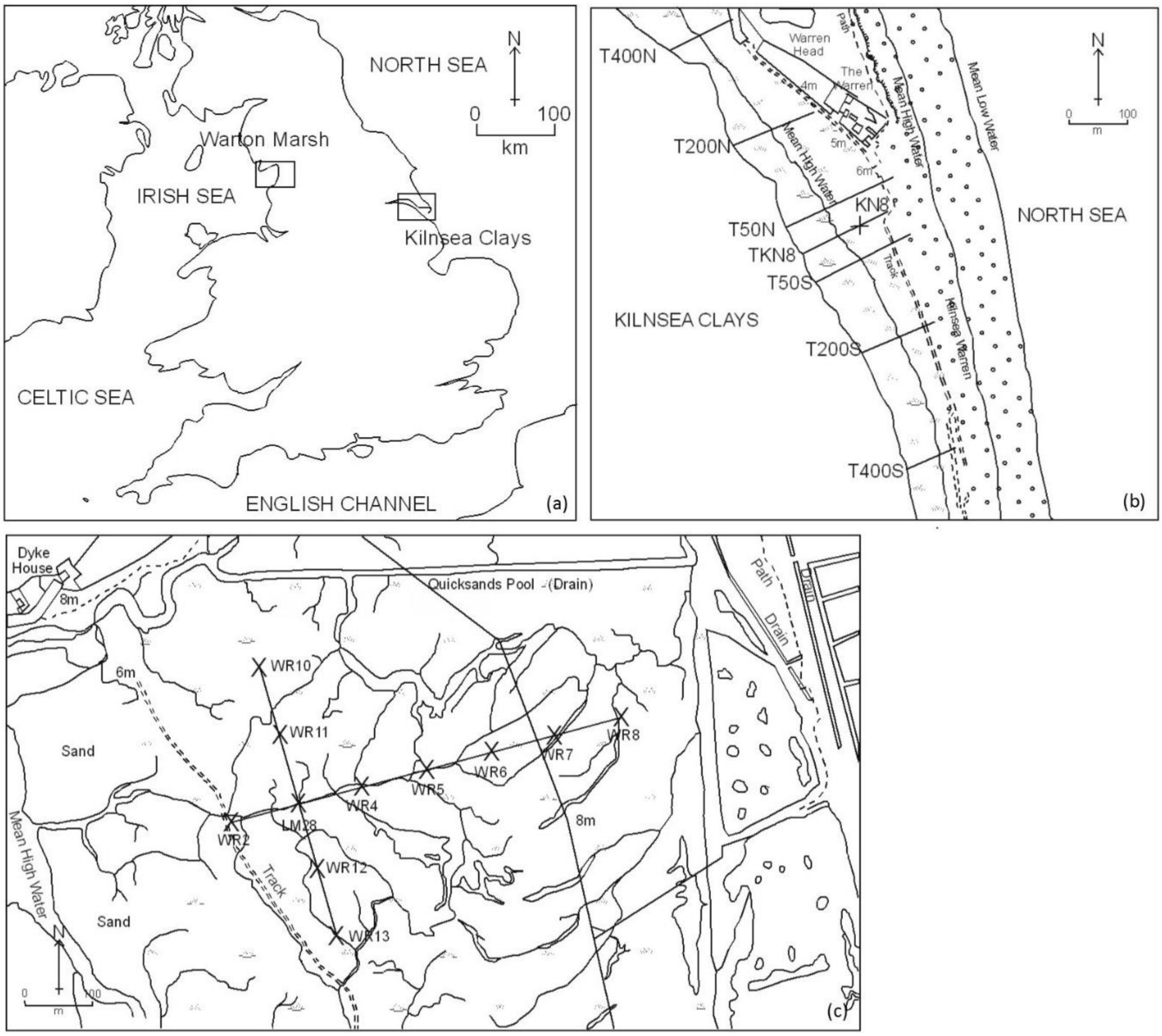


Figure 1. (a) Map of the UK showing the two study sites at Kilnsea Clays, Spurn Point, Humber Estuary and Warton Marsh, Morecambe Bay; **(b)** map of Kilnsea Clays, showing the coring site at KN8 and borehole transects at 50 m, 200 m and 400 m north and south of KN8; **(c)** map of Warton Marsh, showing the coring site at LM28 and borehole transects. WR8 is located in the high marsh and WR2 is close to the marsh cliff.

2.2. Warton Marsh, Morecambe Bay

Warton Marsh (BNG 347190, 472914) is located within Morecambe Bay, a large, macrotidal (spring tidal range 9 m) estuarine system in northwest England (**Figure 1(a) and (c)**) that is characterised by cyclic saltmarsh development (Pringle, 1995). The pattern of erosion and deposition is primarily determined by river channel movements. Whilst there was a trend of increasing saltmarsh area in Morecambe Bay from 557 ha in 1845 to 1485 ha in 1967 (Gray, 1972), there have since been extensive losses at Silverdale and Warton Marsh. This erosion has been attributed to the movement of the River Kent channel. The most significant marsh cliff erosion occurs due to storm waves when high overmarsh tides correspond with strong onshore winds (Adam, 2000). This area is pertinent to study, given the increased frequency of extreme high water levels reported in the eastern Irish Sea since the 1990s (Brown et al., 2010). Significant quantities of sand deposited on Silverdale Marsh were clearly visible from aerial photography following a major surge on 9th February 1988 (see Pringle, 1995). Such sand layers have also been recorded at Storth marsh (e.g. in 1994) in the River Kent estuary (Adam, 2000; Pringle, 1995).

3. Methods

3.1. Spurn Point

Sediment cores were obtained from the mid-marsh at Kilnsea Clays (**Figure 1(b)**) in November 2012. Field stratigraphy was described according to Troels-Smith (1955). A Russian auger was used to reach a depth of 50.8 cm at sampling site KN8 (N 53° 36. 619', E 000° 08. 739') with altitude of the coring site measured using differential GPS (DGPS). Additional gouge transects were sampled in October 2014 at 50, 200 and 400 m north and south of the coring transect (**Figure 1(b)**) to provide broader stratigraphical context.

3.2. Warton Marsh

Gouge samples were taken in March 2015 at every 100 m along transects from the high marsh towards the sandflats and also parallel to the marsh cliff through the coring site at LM28 (SD 46903 BNG 73212) (**Figure 1(c)**). Larger sampling intervals were adopted at Warton Marsh due to the marsh size. Altitude data for each sample location were obtained using a DGPS. Sediment cores of 82 cm were collected for laboratory analysis using a Russian auger in November 2013. Gouge coring at LM28 reached a depth of 300 cm. As this site was located in a relict creek system it was possible to core deeper beyond the dense silty-sand, which hindered sampling using a Russian auger elsewhere in the marsh. Cores were frozen on return to the laboratory for preservation prior to analysis.

3.3. Sediment characterisation

Laser particle-size analysis was undertaken to determine sedimentation processes at Spurn Point and Warton Marsh, particularly focusing on coarser, sandy deposits as potential storm signatures (Tsompanoglou et al., 2010). The Spurn core was subsampled contiguously at 0.5 cm resolution and the Warton Marsh core at every 2 cm. The reduced sampling resolution was adopted for Warton Marsh for greater analytical efficiency. Samples were pretreated with 30% H_2O_2 to remove organic matter (Lawson, 2001; Vaasma, 2008).

The Spurn sediment was analysed using a Coulter LS 230 laser granulometer with a small volume module. To ensure data reliability and consistency, the instrument was calibrated with reference material *LS Control G15* (a garnet grain of 15 μm). Three replicate subsamples of each sediment sample were run for 90 seconds, with each subsample run in triplicate. The Fraunhofer optical model was applied to produce curves of particle size (μm) against volume (%). These data were grouped using the Wentworth scale (Wentworth, 1922) and mean values of the replicate subsamples were calculated to determine the relative percentage volume of the sand, silt and clay fractions. The Warton Marsh sediment was analysed using a Malvern Mastersizer 2000 laser granulometer, which was calibrated using reference sand of known particle diameter. Once grouped into the Wentworth sub-fractions, the particle-size data were plotted using Excel for comparison with the sediment core profiles and geochemical data.

3.4. Loss on ignition

Loss on ignition (LOI) was undertaken at 550°C and 950°C following Heiri et al. (2001) to determine organic matter and carbonate content respectively in the sediment. LOI is expressed as the percentage weight lost following moisture content determination and assumes a constant ratio of organic matter to organic carbon. The LOI data were also used to determine the overlap between subsections of the Warton Marsh core.

3.5. Sediment geochemistry

To obtain a comprehensive insight into geochemical changes, ITRAX X-ray fluorescence core scanning was undertaken at the National Oceanography Centre in Southampton, using Mo and Cr X-ray tubes (Croudace et al., 2006). Elemental data profiles were compiled using ItraxPlot software (Croudace and Rothwell, 2015). The peak area intervals are "nominally proportional to concentrations of major and minor elements within the sediment" (Rothwell et al., 2006: 82).

3.6. ^{210}Pb and ^{137}Cs dating

^{210}Pb and ^{137}Cs isotope dating is commonly used to develop chronologies for marshes that have accumulated over the last century. Samples were prepared and analysed to determine ^{210}Pb content and ^{137}Cs activity following standard procedures (Tsompanoglou et al., 2010). Calculation of the sediment accretion rate (cm a^{-1}) assumes that no radionuclide migration occurs within the sediment profile following deposition (Dyer et al., 2002). However, the post-depositional mobility of the radionuclides and sedimentation phases should be considered during interpretation. The application of ^{210}Pb and ^{137}Cs dating in coarse-grained sediments could also be hindered by the lower sorption capacity of quartz particles. (Tsompanoglou et al., 2010).

4. Results

4.1. Spurn

4.1.1. ^{210}Pb/ ^{137}Cs chronology

^{137}Cs and ^{210}Pb dating suggests that the 50.8 cm KN8 core spans at least the last 70 years, with 41.5 cm depth representing sediment deposition in 1942 (**Figure 2**). A spike in ^{137}Cs at 29 cm represents nuclear weapons testing in 1963. Whilst it has been suggested that the Humber Estuary was unlikely to receive significant fallout of ^{137}Cs from Chernobyl (Lee and Cundy, 2001) with total wet and dry deposition for the Hull and Barton-upon-Humber area estimated at 100 Bq m^{-2} (Watt Committee on Energy, 1991), the ^{137}Cs signature from 1986 is evident at 15.5 cm depth. A sediment accumulation rate of ~0.59 cm a^{-1} at Kilnsea Clays is therefore proposed, assuming a constant supply rate.

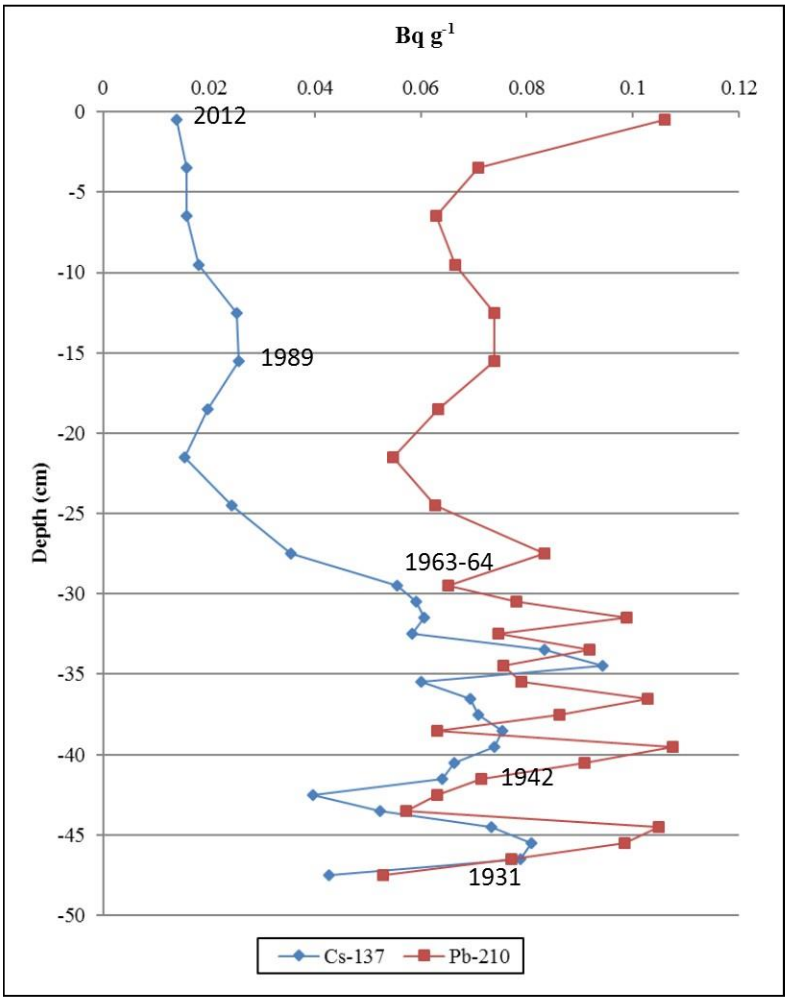


Figure 2. ^{210}Pb and ^{137}Cs concentrations in the saltmarsh sediment at Kilnsea Clays, Spurn Point, plotted against depth. The proposed chronology for the saltmarsh sediment is also presented.

4.1.2. Particle size and geochemistry

The stratigraphy of core KN8 is presented in **Figure 3.** The sediment primarily comprises olive, grey-brown silt. Very fine to medium silt (6—20 µm) is the predominant sediment type represented in the particle-size data (**Figure 4**). Peaks in the medium to coarse silt fraction correspond with increased percentages of sand (63—250 µm). The sand fraction is presented in greater detail in **Figure 3**, where it is plotted with organic matter content (%) and the element profiles of Zr, Ti, Ca and Si. Further particle-size and geochemistry trends are presented in **Table 1**.

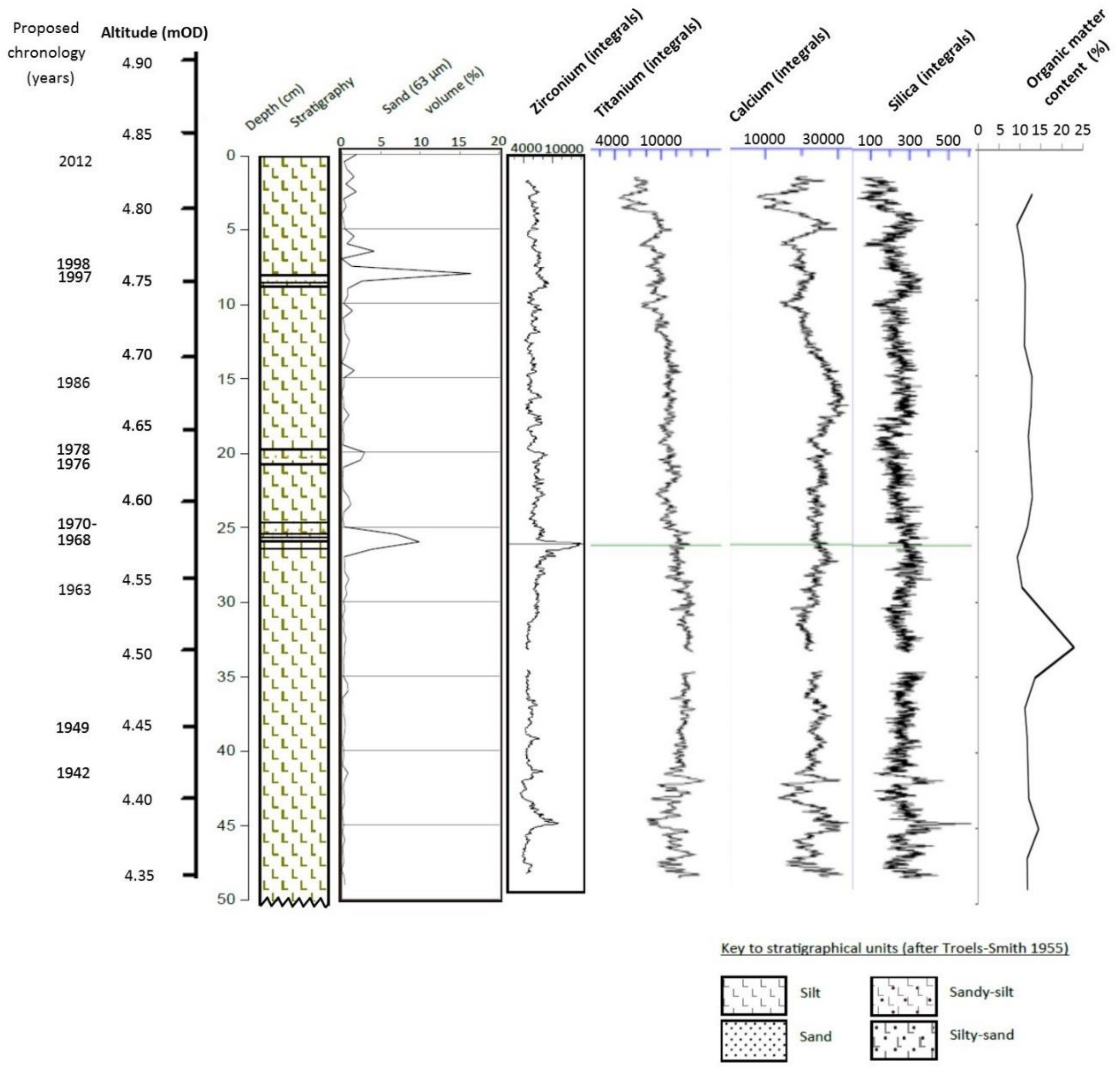


Figure 3. Stratigraphy of core KN8 from Kilnsea Clays, Spurn Point. Particle size data reveal some correlation between sand layers and peaks in zirconium, which is associated with heavy mineral sand deposition in saltmarsh sediments (Tsompanoglou et al. 2010). Organic matter content, determined through loss-on-ignition, is also plotted for comparison with the core stratigraphy.

4.1.3. Stratigraphical context

The surrounding borehole transects (**Figure 5**) show clear spatial variation in the frequency, thickness and altitude of sand layers across the marsh stratigraphy at Kilnsea Clays. The sandy layers identified in the KN8 stratigraphy were not present in the majority of boreholes. Sand layers which occurred at similar altitudes to the 4.79—4.78 mOD layer in KN8 were, however, evident in borehole WP16 in transect T50N and in WP6 in transect T200S. A further sand layer in WP6 occurred at a similar altitude to that of 4.67—4.66 mOD in KN8.

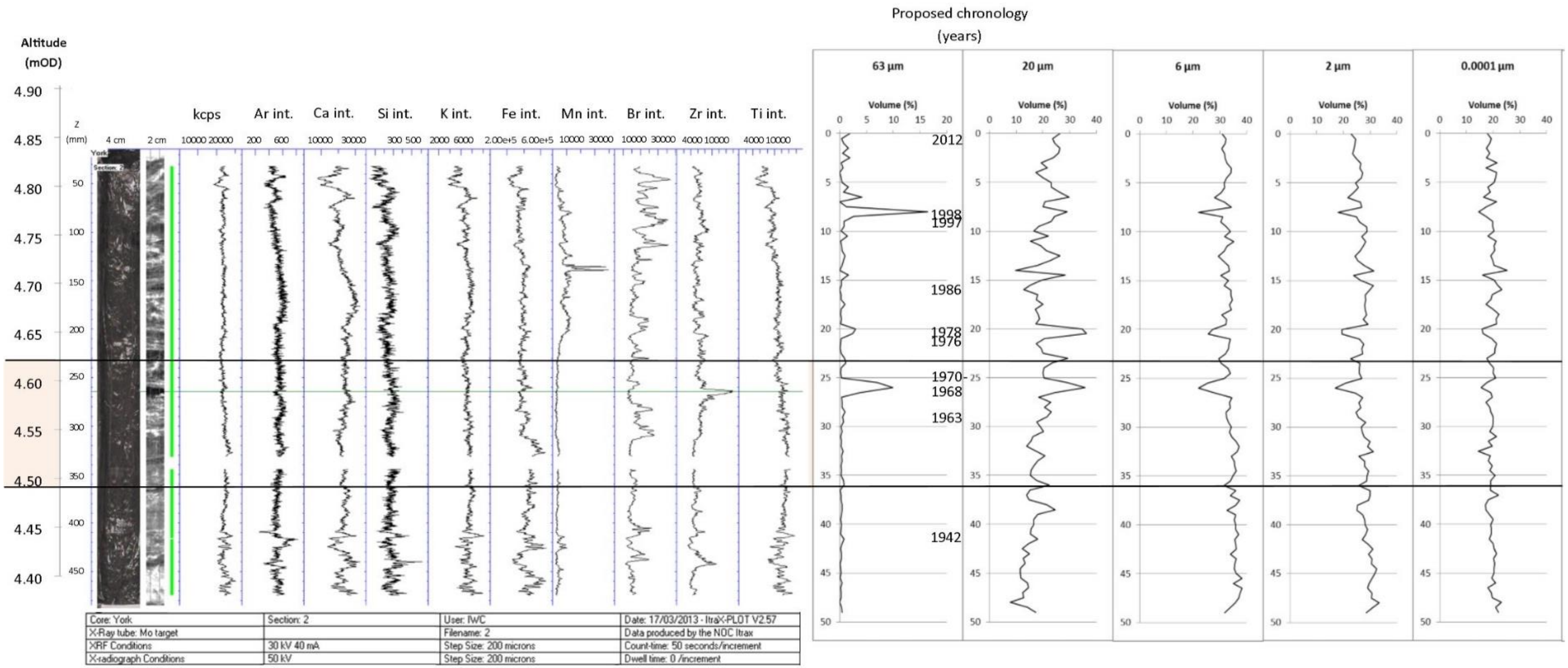
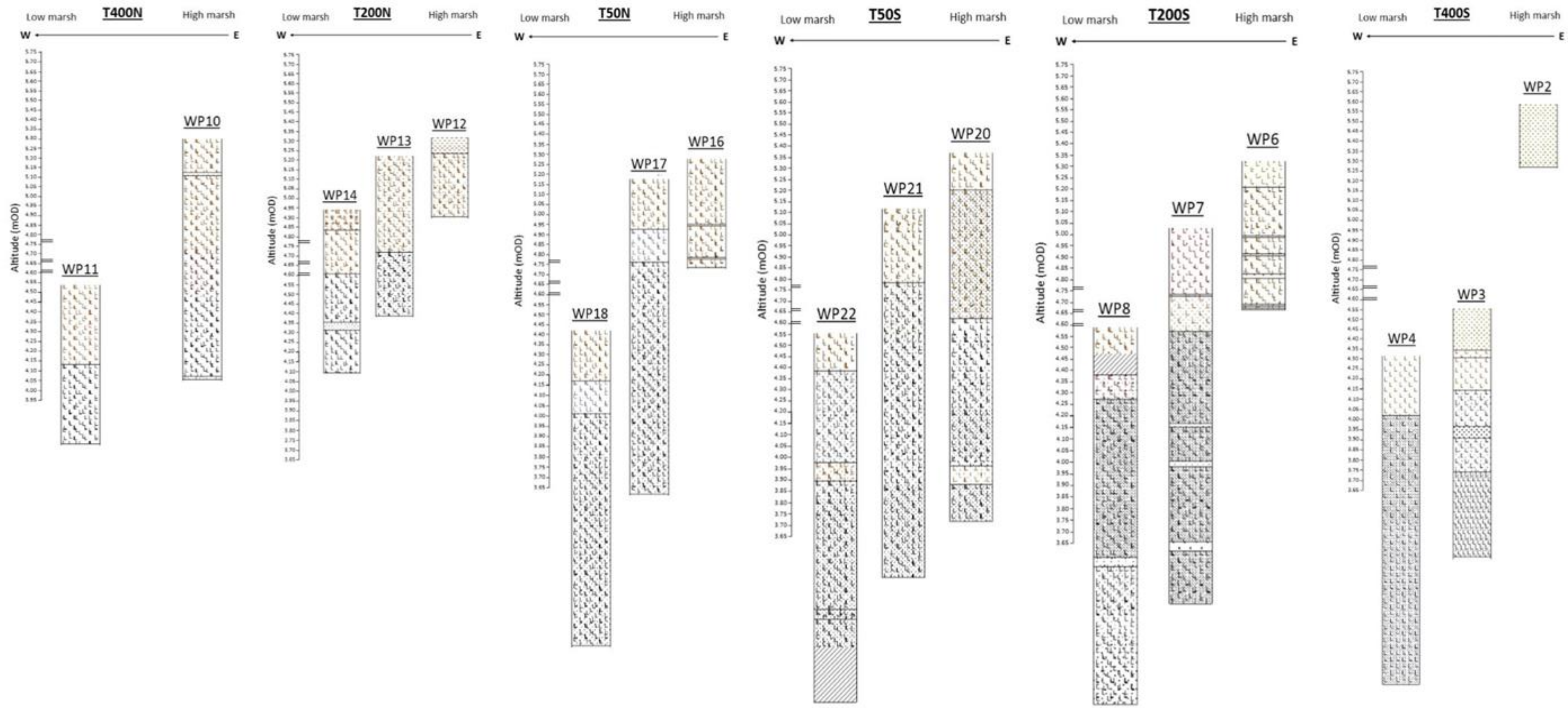


Figure 4. ITRAX geochemical profiles for Ar, Br, Ca, Fe, K, Mn, Si, Ti, and Zr obtained using a Mo X-ray tube (values presented as area integrals) for a 50 cm core from location KN8 at Kilnsea Clays. These data are plotted alongside particle size profiles to facilitate interpretation. Altitude and chronology, derived from ^{210}Pb and ^{137}Cs data, are also plotted; the shaded box between 1951 and 1973 represents the time within which the marsh at Kilnsea Clays was established, based on historic Ordnance Survey maps.

Table 1. Trends in KN8 particle size and geochemistry

<table>
<tr><th>Depth (cm)</th><th>Particle size</th><th>Geochemistry</th></tr>
<tr><td>26.00 – 24.75,
20.75 – 19.75,
8.75 – 8.00</td><td>Sand layers identified during stratigraphical description correspond with peaks in the very fine to fine sand fraction at 27.0–26.5, 26.5–26.0, 26.0–25.5, 21.0–20.5, 20.5–20.0 and 8.5– 8.0 cm.</td><td>Co-variation in Zr, Ti, Ca and Si suggests heavy mineral sands in the saltmarsh sediment record, with Zr likely to occur as zircon (Tsompanoglou et al., 2010). There is some correlation between sand layers and peaks in Zr. High-energy storm waves may be a key mechanism for transporting coarse grains onto the saltmarsh (Tsompanoglou et al., 2010).</td></tr>
<tr><td>25 – 0</td><td>Minor variability in sand (%) between principal sand peaks (Figure 3).</td><td rowspan="2">Co-variation in Ca and Si profiles. The Ti profile is generally in phase with Ca and Si, as is the profile for Zr, albeit to a lesser extent.</td></tr>
<tr><td>49 – 27</td><td>Less fluctuation is evident in sand fraction (%) from 49 – 27 cm.</td></tr>
<tr><td>33</td><td>Concurrent with reduced sand content is an increase in organic matter content, evident in a peak of 22.9% in the LOI 550 profile. Organic matter content for the rest of the core lies within the range 9.3 – 14.5%.</td><td></td></tr>
<tr><td>25.5 – 27.0,
20.0 – 21.0,
8.0 – 8.5</td><td colspan="2">There are three key phases of heavy mineral sand deposition represented in the sediment record, which may be associated with high-energy storm events. Based on the proposed sediment chronology these may represent deposition during 1968-1970, 1976-1978 and 1997-1998.</td></tr>
</table>



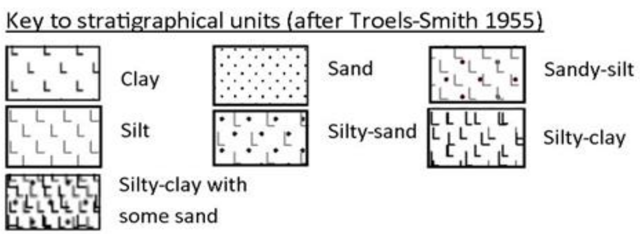


Figure 5. Stratigraphy of the saltmarsh at Kilnsea Clays (after Troels-Smith, 1955). Boreholes followed transects from the high marsh to the low marsh at 50 m, 200 m and 400 m north and south of the KN8 coring site (see **Figure 1(b)** for location). The position of sand layers in the KN8 core are highlighted on the altitude axes to facilitate comparison with the borehole stratigraphy.

4.2. Warton Marsh

4.2.1. ^{210}Pb/ ^{137}Cs chronology

Concentrations of ^{137}Cs and ^{241}Am isotopes within the Warton Marsh sediment are presented in **Figure 6**. The ^{137}Cs profile is dominated by the discharges from Sellafield nuclear waste reprocessing plant on the Cumbrian coast. Similar profiles of ^{137}Cs have been reported from other studies of intertidal Irish Sea sediments (Kershaw et al., 1990; Mackenzie and Scott, 1993). Peak discharge at Sellafield occurred around 1977 and with a 1—2-year transit time for ^{137}Cs transport to Morecambe Bay, this suggests that the ^{137}Cs peak at 32 cm depth represents sediment deposited in 1978-79.

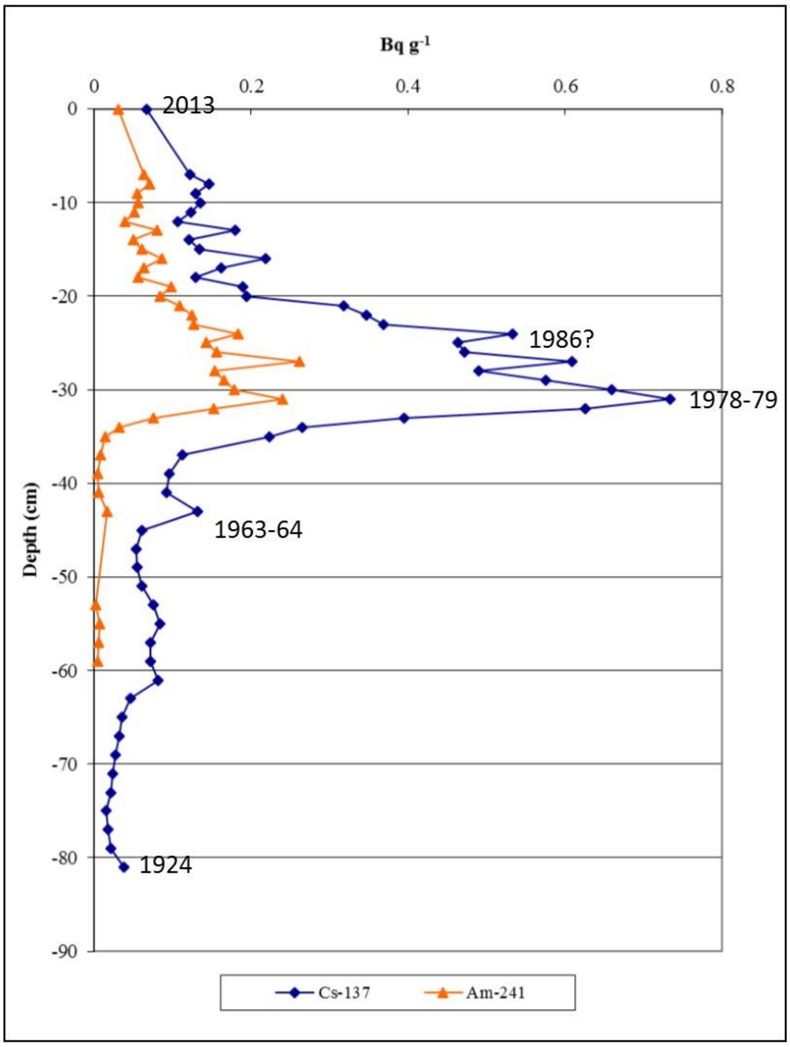


Figure 6. ^{137}Cs and ^{241}Am concentrations in the saltmarsh sediment at Warton Marsh plotted against depth. The proposed chronology for the saltmarsh sediment is also presented. ^{210}Pb concentrations have been removed due to the suppression effects of high ^{241}Am.

A spike in ^{137}Cs at 43 cm depth represents the 1963 nuclear weapons' testing. ^{137}Cs from Chernobyl may have been anticipated, owing to the estimated 10,000 Bq m^{-2} total wet and dry ^{137}Cs deposition within the area adjacent to Warton Marsh following the disaster (Watt Committee on Energy, 1991). Despite a peak in ^{137}Cs around 24 cm depth, the strength of the signal from neighbouring

Sellafield would likely mask such events. As the profile markedly reflects Sellafield discharge, it is unlikely that substantial erosion or reworking of the sediment profile occurred at LM28 over the period represented within the profile. Assuming a constant accumulation rate, estimated to be ~0.91 cm a^{-1}, the 82-cm core spans approximately 89 years to 1924. This calculation assumes that the core surface represents deposition in 2013, despite the lower elevation of the coring location relative to the surrounding marsh.

4.2.2. Particle size and geochemistry

The LM28 core stratigraphy comprises grey-brown silty clay with gritty aggregates at the base and light brown sand layers with some orange staining evident at 25.0—24.0 cm, 13.5—12.5 cm, 10.5—9.0 cm and 8.5—7.0 cm depth (**Figure 7**). Trends in the particle-size and geochemical data are summarised in **Table 2**.

4.2.3. Stratigraphical context

The stratigraphic complexity of the LM28 core when compared to the surrounding borehole transects (**Figures 9(a) and (b)**) may reflect the more dynamic creek system from which it was obtained. Extrapolating this stratigraphy across the wider marsh is therefore not advisable. The borehole transects largely comprise dense, grey-brown silty sand, which is overlain by a thin layer of sandy topsoil. Some organic peat (WR7 5.22—5.14 mOD) and silty clay horizons (WR7 5.14—5.08 mOD and WR8 5.09 mOD) are also evident. Observations generally confirm the stratigraphy reported by Gray and Bunce (1972). Thin, oxidised and black sandy-silt laminae were particularly evident in the shore-parallel transect at Warton Marsh (**Figure 9(b)**) and iron oxide deposits were also observed in the creeks. Whilst there is some correspondence between the altitude of potential storm signatures in the LM28 stratigraphy and the altitude of sand laminae across the Warton Marsh stratigraphy (e.g. around 4.77 mOD in WR6, WR10 and WR12 and around 4.85 mOD in WR12 and WR13), there is clear spatial heterogeneity in the frequency and altitude of these deposits.

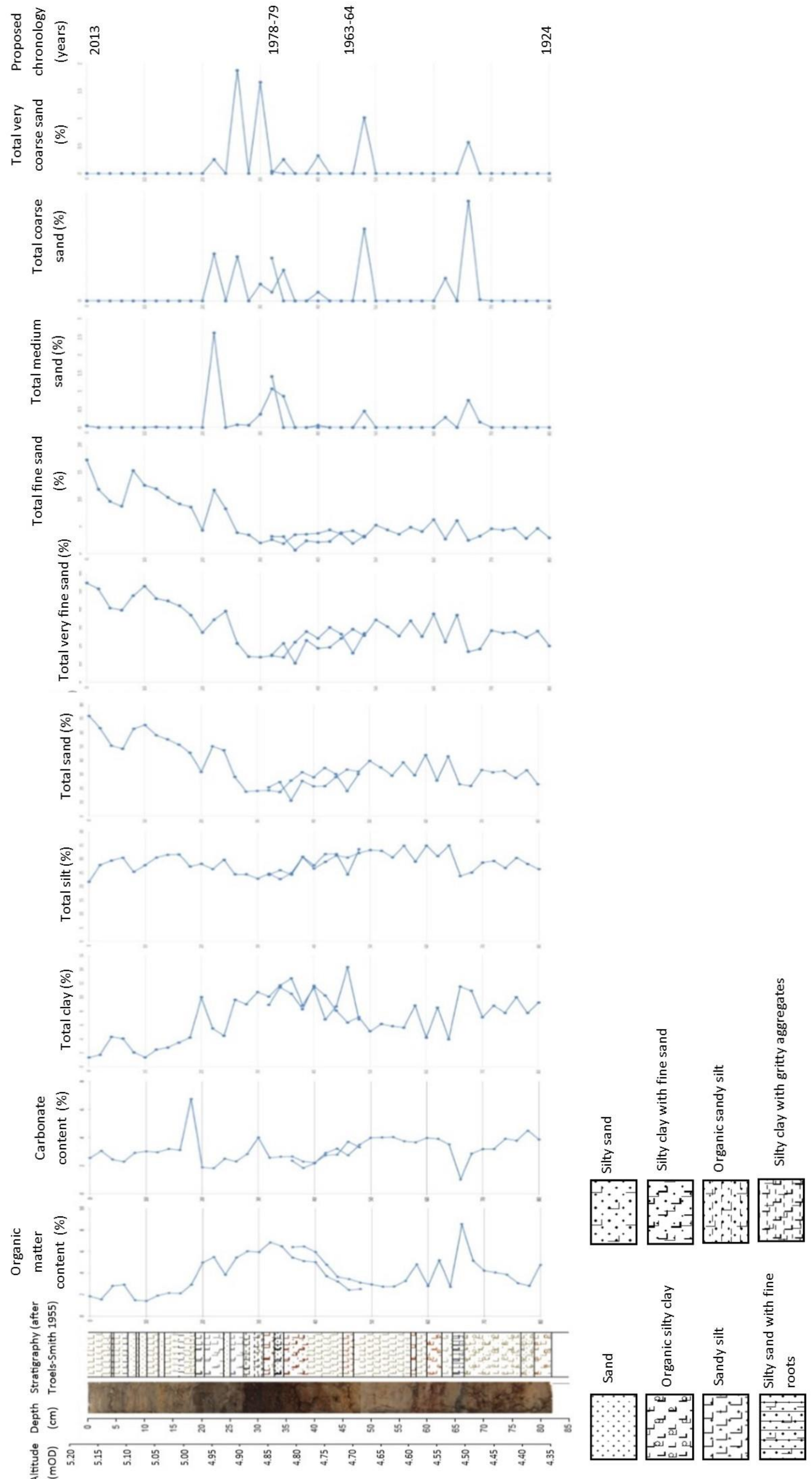


Figure 7. Stratigraphy (after Troels-Smith, 1955) of sediment core LM28, collected from Warton Marsh plotted alongside organic matter and carbonate content, determined through loss-on-ignition, and total clay, silt and sand fractions.

Table 2. Trends in LM28 particle size and geochemistry.

Depth (cm)	Particle size	Geochemistry
64, 60, 56, 50, 46, 42, 38, 24, 10	Peaks in total sand (%) **(Figure 7)**. Clear transition from silty clay at base to sandy silt is evident in the profiles.	Peaks in Pb, Si, Ti, Zr, Sr, Cr and V at 64 cm **(Figure 8)**; a spike in Ti at 42 cm coincides with increases in Zr, Ca, Si, Sr; peaks in Zr and Ti occur at 38 cm; slight spikes in Zr, Ca, Sr and Cr at 24 cm; further heavy mineral peaks at 10 cm.
64	Silt content is predominantly coarse throughout the core (>31 µm), ranging from 21.7% to a peak of 35.0% at 64 cm.	
80 – 0	Sand fraction largely comprises very fine sand (from 63 µm) and increases from 20.1% at 80 cm to 54.7% at 0 cm.	
10, 24	Notable peaks in very fine sand fraction (53.0% and 39.1%), correspond with peaks in fine sand fraction at 8 cm (15.3%) and 24 cm (8.3%)	Peak in Zr, Ti, Ca, Si at 10 cm and peak in Zr at 24 cm depth.
66	Medium, coarse and very coarse sand peaks correlate with peaks in % organic matter. This horizon was particularly organic, fibrous silty-clay. The peak of 8.5% organic material may indicate some material left in suspension, despite pre-treatment with H_2O_2.	

64, 54, 47, 33, 30, 29	Peaks in total silt, sand, very fine and fine sand at 64 cm; medium, coarse and very coarse sand at 48 and 34 cm; peaks in coarse and very coarse sand at 30 cm correspond with a peak in LOI 950 (%).	Notable peaks in Pb profile. These precede a considerable reduction to the top of the core. This reduction appears to occur in two phases (29—19 cm and 19—0 cm).
43 – 34	Sand lens not evident in particle-size data, as did not occur in the core which was used for this analysis.	Identification of heavy mineral sand deposits may be hindered by the sand-dominated stratigraphy of Morecambe Bay saltmarshes. Despite this, a large sand lens is evident from distinctive peaks in Zr, Si, Ca and Sr. A concurrent reduction in Pb is also apparent in this horizon.
34.0 – 27.5	Reduced sand content	Dark black-brown, silty-clayey peat yields a substantial decrease in Si, Ti and Ca, due to reduced sand content.
40, 32, 10	Sand peaks	Peaks in Si, Ti, Zr and Ca may indicate high-energy storm deposition, which occurred around 1969, 1977 and 2002.
17, 15, 4-6	No corresponding sand peaks	Heavy mineral element peaks

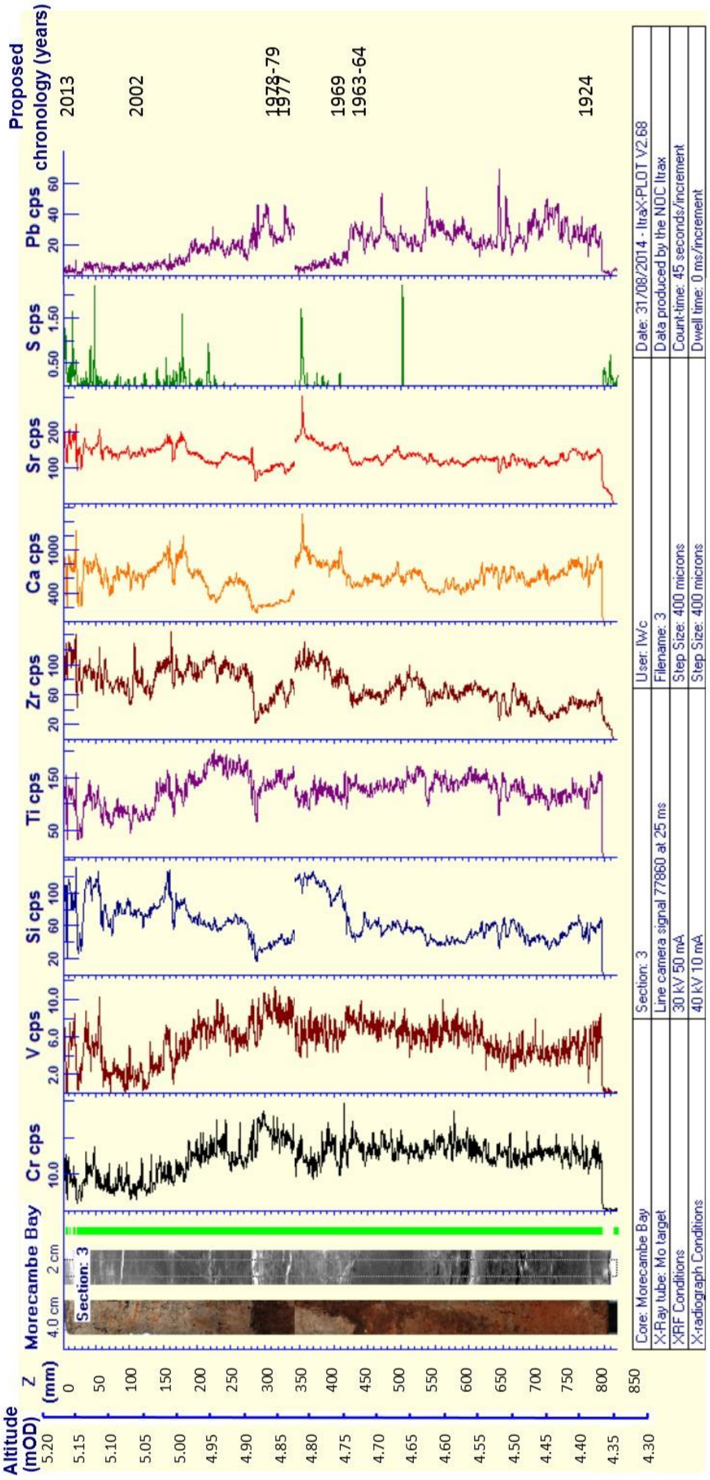


Figure 8. ITRAX geochemical profiles for LM28 core from Warton Marsh. Element profiles are displayed as area integrals (the overlap between the two core sections occurs at 34 cm depth). Estimated dates of sediment deposition, based on a constant accumulation rate of 0.91 cm a^{-1} established using ^{210}Pb/ ^{137}Cs data, are presented to the right of the element plots to facilitate interpretation.

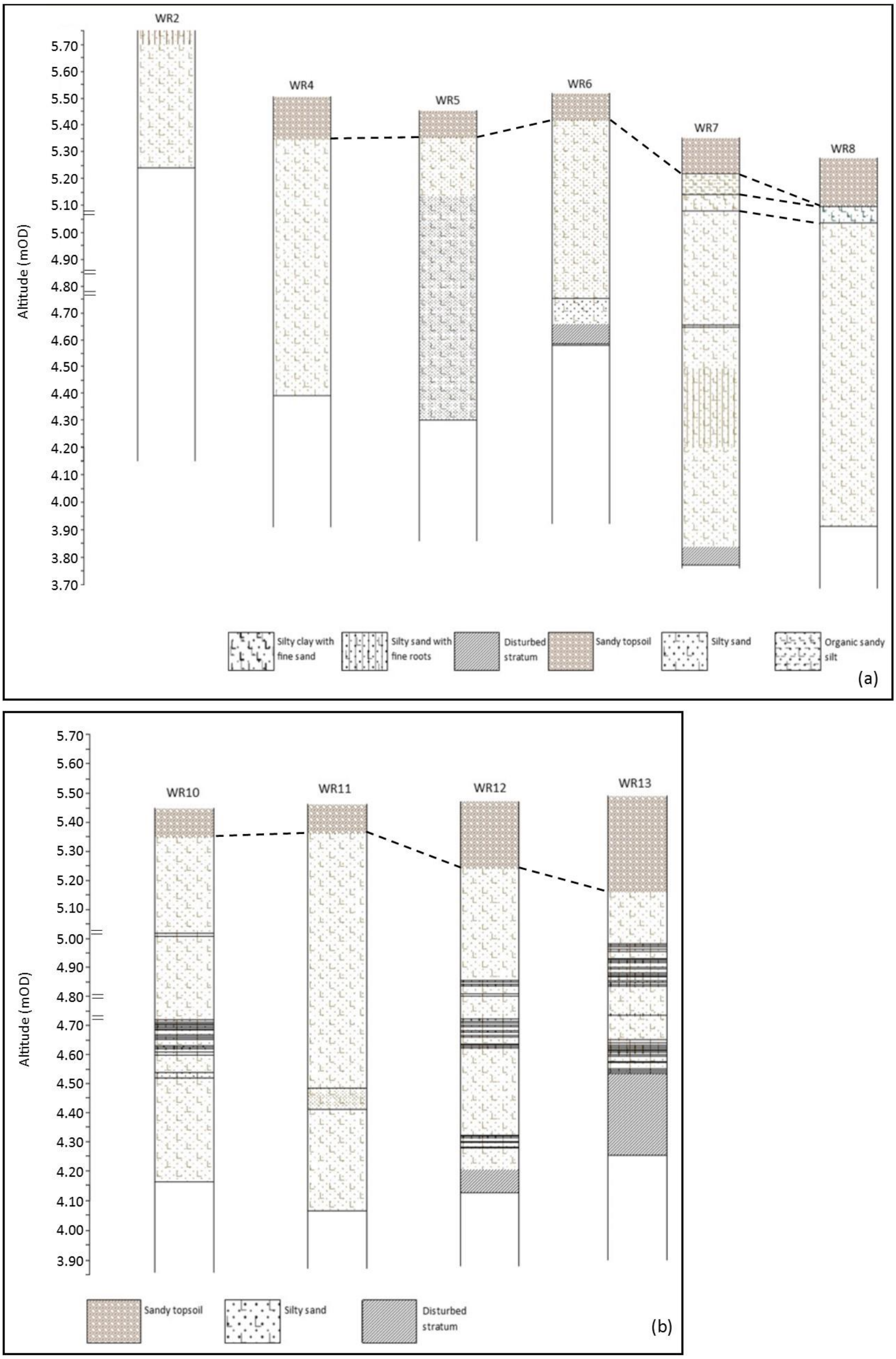


Figure 9. Stratigraphy (after Troels-Smith, 1955) of boreholes taken at every 100 m along transects from **(a)** the high marsh to the marsh cliff and **(b)** parallel to the marsh cliff at Warton Marsh. The altitudes of heavy mineral sand layers identified in the LM28 core sediment are highlighted on the axes for comparison. Transects and borehole locations are shown in **Figure 1(c).**

5. Discussion

5.1. Storm classification, attributes and stratigraphic signatures

North Sea storms were classified by Muir Wood et al. (2005) into those which are (i) southeast-tracking e.g. 31 January to 1 February 1953, (ii) east-tracking (northern North Sea) e.g. 3 January 1976, and (iii) those with a southern North Sea storm track e.g. 12 January 1978. This classification has been applied to the storms detailed in **Table 3** to consider trends amongst those proposed to be recorded in the Spurn marsh stratigraphy. Storm classifications are presented with instrumental data for still water level, tidal level, skew surge and return period from the nearest tide gauge station where available, to allow comparison of storm magnitude alongside potential stratigraphic signatures.

Haigh et al. (2015) used measures of skew surge and return period to rank storm events based on their magnitude at estuarine tide gauge stations around the UK (SurgeWatch, 2016). Skew surge is the difference between maximum observed and predicted high tide levels, irrespective of timing in relation to the tidal cycle. It is proposed as an unequivocal storm surge measure, without the errors associated with the non-tidal high water residual (Batstone et al., 2013; Haigh et al., 2015). Return period represents the probability of an event occurring in any given year, relative to an Environment Agency base mean sea level in 2008 (Batstone et al., 2013). In the Surgewatch database, these were offset to account for mean sea-level changes prior to 2008 (Haigh et al., 2015).

5.2. Potential storms in the Spurn stratigraphy

Heavy mineral sand peaks in the Spurn stratigraphy are proposed to represent deposition during the periods 1968-1970 (27.0-25.5 cm depth), 1976-1978 (21.0-20.0 cm depth) and 1997-1998 (8.5-8.0 cm depth) due to significant North Sea storm surges that are discussed in detail below.

Table 3. Documented North Sea storm events, their characteristics and potential evidence in the stratigraphy at Kilnsea Clays, Spurn Point, based on the proposed chronology. Presence (√) or absence (X) of peaks in the coarse grain fractions of the particle size data and element data are indicated. Storm event characteristics represented using data from SurgeWatch (2016), derived from tide gauges at Immingham (IM) and Grimsby (GR). Documented storms outside of the proposed core chronology are indicated with “N/A” in the stratigraphic evidence cells.

Documented		**Storm event characteristics**							**Evidence in Spurn stratigraphy**							
Date	**Time**	**Storm track**[1]	**Water level (mOD)**	**Tide (mOD)**	**Skew Surge (mOD)**	**Return Period (yrs)**	**Tide gauge**	**Ref**	**Depth (cm)**	**Altitude (mOD)**	**Sediment character**[2]	**Coarse grain peaks**	**Geochemistry**			
													Zr	**Ti**	**Ca**	**Si**
05 Dec 13	19:15	E	9.12	7.50	1.62	787	IM	3,4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12 Jan 05	19:00	E					IM	3, 5	4.1	4.80	Fibrous silt	X	√	√	√	√
09 Feb 97	19:15	E	8.33	7.73	0.60	7	IM	4	8.9	4.75	Fibrous silt	√	X	√	√	√
07 Oct 90	07:00	E	8.31	7.62	0.69	6	IM	3, 4	13.0	4.71	Fibrous silt	√	√	X	√	√
01 Feb 83	20:00	E	8.68	7.43	1.26	75	IM	4	17.2	4.67	Fibrous silt	√	√	√	X	√
11 Jan 78	20:00	Southern	8.51	7.53	0.98	27	IM	4, 6, 7,	20.1	4.64	Fibrous	√	√	X	√	√
15 Nov 77		SE						10	20.7	4.63	Fibrous sandy silt	√	√	X	√	√
13 Nov 77	07:00	E	8.29	7.56	0.73	7	IM	4	20.7	4.63						
31 Jan 76								8	21.3	4.63	Fibrous silt	√	√	X	√	√
03 Jan 76	19:00	E	8.47	7.27	1.20	21	IM	4	21.3	4.63						
29 Sept 69	07:00	E	8.56	7.34	1.22	43	IM	3, 4, 6,	25.5	4.59	Fibrous sandy silt	√	√	√	√	√
19 Feb 69								6, 7,	25.5	4.59						
15-17 Feb 62		W– NW gale force winds over North Sea						12, 13, 14, 15	29.6	4.54	Fibrous silt	X	X	√	X	√
20 - 21 Mar								13, 14	30.2	4.54	Fibrous silt	X	X	X	√	√
24 - 26 Feb								14	32.0	4.52	Fibrous silt	X	X	X	X	X
31 Jan 53	19:00	SE	8.42	6.84	1.58	21	IM	4, 7, 9,	34.9	4.49	Fibrous silt	X	X	X	X	X
08 Jan 49					1.16		GR	17	37.3	4.47	Fibrous silt with	X	X	√	√	√

[1] Muir Wood et al. (2005); [2] Troels –Smith (1955); [3]Spencer et al (2015); [4]SurgeWatch (2016); [5]Dawson et al. (2007); [6]Richards (1978); [7]Spink (1988); [8]Crowther (2010); [9]Tsompanoglou et al. (2010); [10]Heaps and Jones (1979); [11]Spink (1978); [12]Steers et al. (1979); [13]Banks (1974); [14]Heaps (1969); [15]Heaps (1983); [16]Steers (1953); [17]Corkan (1950); [18] Brown et al. (2010); [19] Zong and Tooley (2003); [20] Pringle (1995); [21] Lancaster City Council (2008); [22] Posner (2004).

5.2.1. 1968-70 (25.5 cm depth)

The east-tracking (northern North Sea) storm of 29 September 1969 caused flooding in North Norfolk (e.g. Spencer et al., 2015). The magnitude of the event in the Humber Estuary is evident in the substantial skew surge of 1.22 m and return period of 43 years at Immingham tide gauge. A documented surge prior to this event occurred on 19 February 1969, although a paucity of instrumental/ tide gauge data regarding its characteristics presents a barrier to understanding any stratigraphic signature when compared with the September 1969 event.

5.2.2. 1976-78 (20.0 cm depth)

Several North Sea storm surges occurring during 1976-78 may have contributed to the heavy mineral sand peaks at 21.0-20.0 cm depth. The east-tracking storm of 3 January 1976 had a skew surge at Immingham of 1.20 m and return period of 21 years. A further surge on 31 January 1976 stripped sand from the beach at Spurn and local flooding was the worst since 1953 (Crowther, 2010). It is unclear whether this remobilised sand was deposited on the marsh at Kilnsea Clays to produce the sand peak in particle-size data. Further storms have been documented for 13 (east-tracking) and 15 November 1977 (southeast-tracking). The former had a skew surge at Immingham of 0.73 m and return period of seven years. A surge on 11 January 1978 had a skew surge at Immingham of 0.98 m and return period of 27 years. Geomorphological responses to the 1978 surge included breaching at the neck of Spurn Point (Spink, 1988) and heavy mineral sand deposition on Wrangle saltmarsh, North Norfolk (Tsompanoglou et al., 2010).

5.2.3. 1997-98 (8.0 cm depth)

Deposition from the east-tracking surge of 9 February 1997 (skew surge 0.60 m, return period seven years) may be recorded at 8.9 cm depth. It appears that primarily east-tracking storms may be represented in the Spurn sediment record (**Table 3)**. Storms which may be associated with heavy mineral sand deposits around 21-20 cm depth, however, exhibit greater storm track variability, with the 15 November 1977 storm following a southeasterly track. It could be postulated that the greater magnitude east-tracking events of 1976 and 1978 have a higher likelihood of being recorded in the stratigraphy. Brooks et al. (2016), however, advise caution when drawing correlations between hydrodynamic forcing and geomorphological responses in the coastal landscape. They reported that meso-scale barrier island dynamics at Scolt Head Island on the North Norfolk coast were not clearly attributable to storm frequency. Shoreline morphological response can vary considerably, as determined by still water level and wave height, and the duration and timing of the interaction between them (Brooks et al., 2016).

5.3. Potential storms in the Warton Marsh stratigraphy

In the Warton Marsh stratigraphy, heavy mineral sand layers at 41 cm, 33 cm and 10 cm depth are proposed to represent deposition around 1969, 1977 and 2002. These may be attributable to documented Irish Sea storm surges in March 1968, November 1977 and February 2002 (**Table 4**).

5.3.1. 1969 (41.0 cm depth)

Heavy mineral sand peaks around 41 cm depth may represent the March 1968 surge. This event damaged coastal protection in Morecambe and eroded dunes along the Sefton coast (Brown et al., 2010).

5.3.2. 1977 (33.0 cm depth)

Morecambe sea walls were breached due to a storm in November 1977, which may be associated with heavy mineral sand in the Warton Marsh stratigraphy around 33 cm depth. This sediment signature may be attributable to the east-tracking surge, which was recorded at Immingham on 13 November 1977, and could also be evident in the Spurn marsh stratigraphy. Whilst this was not deemed a significant surge at Heysham tide gauge (SurgeWatch, 2016), substantial dune erosion occurred along the Sefton Coast (Brown et al., 2010) and significant flooding occurred on 11 November 1977 in Morecambe and Fleetwood (Posner, 2004).

5.3.3. 2002 (10.0 cm depth)

With a skew surge of 1.08 m at Heysham tide gauge and return period of 28 years, the noteworthy 1 February 2002 surge may be represented in heavy mineral sand deposits at 10.0 cm depth.

Additional documented storms may be attributable to coarse-grain heavy mineral deposits in the Warton Marsh stratigraphy, which occur at 79.2 cm (19 February/ 30 December 1926), 78.4 cm (28 October 1927), 63.8 cm (February 1943), 33.7 cm (January 1976) and 27.3 cm depth (January 1983). These events damaged coastal protection structures and caused flooding in Morecambe and Heysham. A major surge on 1 February 1983 appears to be recorded in the heavy mineral sand peak at 27.3 cm. This was an extreme event with skew surge of 1.74 m and return period of 100 years, the largest values reported for Heysham during the study period. Heavy mineral sand peaks at 22.8 cm depth may represent the significant surge of 9 February 1988 that produced overmarsh tides at neighbouring Silverdale Marsh, to the north of Warton Marsh. Wave action removed and disaggregated turf blocks and the composite sediment was deposited upon the marsh. Aerial photography from May 1988 reveals substantial, yet patchy winter storm surge sedimentation that was partly attributed to the 9 February event (Pringle, 1995).

Table 4. Documented Irish Sea storm events, their characteristics and potential evidence in the stratigraphy at Warton Marsh, Morecambe Bay, based on the proposed chronology. Presence (√) or absence (X) of peaks in the coarse grain fractions of the particle size data and element data are indicated. Storm event characteristics are presented using data from SurgeWatch (2016), derived from the tide gauge at Heysham (HE). Documented storms outside of the proposed core chronology are indicated with "N/A" in the stratigraphic evidence cells.

Documented storms in region		Storm event characteristics							Evidence in Warton stratigraphy							
Date	Time	Wind / wave direction	Water level (mOD)	Tide (mOD)	Skew Surge (mOD)	Return Period (yrs)	Tide gauge	Ref	Depth (cm)	Altitude (mOD)	Sediment character[2]	Coarse grain peaks	Geochemistry			
													Zr	Ti	Ca	Si
03 Jan 14	12:15		11.18	10.47	0.71	9	HE	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
03 Dec 06								18	6.3	5.11	Sandy silt	X	√	√	√	√
01 Feb 02	13:45		11.35	10.28	1.08	28	HE	4	10.0	5.07	Sandy	√	√	√	√	√
10 Feb 97	13:15		11.29	10.45	0.84	19	HE	4	14.6	5.02	Sandy silt	X	√	√	In phase	
02 Jan 91								19	20.1	4.97	Silty clay	X	X	X	√	√
01 Feb 90		W from SW						18	21.0	4.96	Silty clay	√	X	X	X	√
9th Feb 88		W			>1.5		HE	20	22.8	4.94	Silty clay	√	√	√	√	√
01 Feb 83	01:00		11.56	9.82	1.74	100	HE	4, 19	27.3	4.90	Silty clay	√	√	√	√	√
Jan 83								21	27.3	4.90						
Nov 77		W from SW						18, 21, 22	32.8	4.84	Black, sandier	√ medium sand	√	√	X	√
Jan 76								21	33.7	4.83	Black, sandier	√	√	√	√	√
Mar 68								18, 21	41.0	4.76	Silty sand	√	√	X	√	√
Nov 60								21	48.2	4.69	Organic, silty-clay beneath sandy-silt	√	X	X	X	X
Aug 57								21	51.1	4.66	Silty clay, fine sand	X	√	√	√	√
Mar 45								21	62.0	4.55	Sandy silt	√	X	X	√	√
Feb 43								21	63.8	4.53	Sandy silt	√ v fine/ fine sand	√	√	√	√
Nov 38								21	68.3	4.49	Silty clay, gritty aggregates	X	√	√	√	√
28 Oct 28								19	77.5	4.40	"	√ v fine/ fine sand	X	√	In phase, increase towards 76 cm	
Oct 27								19, 21	78.4	4.39	"	√ v fine/ fine sand	√	√	√	√
Dec 26									79.2	4.38	"	√ v fine/ fine sand	√	√	√	√
19 Feb 26								19								
1925								19	80.2	4.37	"	X	√	√	√	√
27 Dec 24								19	81.2	4.36	"	N/A	N/A	N/A	N/A	N/A

5.4. Documented storms that are absent at Spurn

Whilst some of the aforementioned documented storms appear to be recorded in the Spurn and Warton Marsh stratigraphies, it is clear from **Tables 3 and 4**, that certain storms are not evident in the sediment record. The following discussion considers the characteristics of these storms.

In terms of loss of life, the southeast-tracking surge of 31 January to 1 February 1953 was the most devastating storm to affect north-western Europe in the last century (Brooks et al., 2016; Gerritsen, 2005). A substantial skew surge of 1.58 m was recorded at Immingham, with a return period of 21 years. Heavy mineral-rich silty-sands in the marsh stratigraphy at Wrangle, North Norfolk, were attributed to the 1953 surge (Tsompanoglou et al., 2010). The Spurn stratigraphy does not, however, record such deposits at 34.9 cm depth. This may suggest that the marsh was insufficiently established to record such deposition, as distinct erosional sequences are not apparent. It may be inferred from historic Ordnance Survey maps that the marsh established between 1951 and 1973. Distinct patchiness in depositional and erosional impacts was observed at Spurn in the immediate aftermath of the 5-6th December 2013 storm surge. The KN8 coring location may therefore have received insignificant coarse sediment during the 1953 event, particularly considering the contradictory observational evidence of geomorphological impacts (Spink, 1988; Steers, 1953).

Maximum disturbance at high water from the 8 January 1949 surge was calculated to be 1.16 mOD for the Humber Estuary based on records from Grimsby (Corkan, 1950). This event would be anticipated in the stratigraphy at a depth of 37.3 cm. Whilst peaks in Ti, Ca and Si are evident, these do not correspond with sand peaks in the particle-size data.

Evidence of the southern North Sea ("Hamburg") surge of 15-17 February 1962 would be anticipated at 29.6 cm. The surge was partly attributable to external forcing due to westerly winds against the northern coast of Scotland and propagation into the western and southern North Sea. A maximum surge of ~2.13 m was recorded at Southend-on-Sea on the Essex coast (Heaps, 1969). However, only peaks in Ti and Si are evident in the Spurn stratigraphy and these do not correspond with sand peaks.

Sand peaks appear to correspond with peaks in Zr, Ca and Si at 17.2 cm, which may represent deposition during the east-tracking storm of 1 February 1983; however, this does not correspond with sand lenses identified during stratigraphical description of the core. The 1983 storm may be evident in the Warton Marsh stratigraphy, where a skew surge of 1.74 m and return period of 100 years were recorded at 01:00 on 1 February 1983 at Heysham tide gauge and substantial dune erosion occurred on the Sefton Coast (Brown et al., 2010). Following this surge in the Irish Sea, the storm tracked east across the UK, with a smaller, yet noteworthy skew surge of 1.26 m and return period of 75 years recorded 19 hours later at Immingham.

A further coarse-grain peak at 13.0 cm, where evidence of the east-tracking storm of 7 October 1990 would be anticipated, corresponds with peaks in Zr, Ca and Si, despite being characterised by fibrous silt. This event was far smaller than that of 1 February 1983, with a skew surge of 0.69 m and 6-year return period at Immingham. The apparent discrepancy between initial sediment characterisation, grain size and geochemistry may be attributed to undertaking these analyses on separate cores, despite being taken within 0.5 m^2. This suggests variability in these sand layers at small spatial scales and supports observations by de Groot et al. (2011) for Dutch and Danish barrier island marshes.

Despite significant geomorphological impacts in the Scottish Outer Hebrides following the 12 January 2005 surge, no saltmarsh change occurred (Dawson et al., 2007). Whilst the Spurn stratigraphy at 4.1 cm shows heavy mineral peaks in Zr, Ti, Ca and Si, no corresponding sand peaks are evident.

5.5. Documented storms that are absent at Warton Marsh

As with Spurn, numerous storms are not apparent in the Warton Marsh stratigraphy (**Table 4**). Flooding was documented at Morecambe, Pilling, Knott End, Bolton-le-Sands and Cockerham Sands (Zong and Tooley, 2003) following a storm in 1925 (80.2 cm). Whilst there are peaks in Zr, Ti, Ca and a slight peak in Si, there are no coarse-grain peaks in the particle-size data. This horizon occurs at the base of the core and should be interpreted with caution, due to a high risk of compaction or contamination. The storms of November 1938 (68.3 cm), March 1945 (62.0 cm), August 1957 (51.1 cm), November 1960 (48.2 cm) and 1 February 1990 (21.0 cm) all caused flooding and infrastructural damage in Morecambe and the latter eroded dunes on the Sefton coast (Brown et al., 2010). The Warton Marsh stratigraphy does not, however, show consistent sediment character and geochemistry where these records are expected. Flooding occurred at Grange-over-Sands, situated northwest of Warton Marsh, due to the 28 October 1928 storm. Small peaks in very fine and fine sand at 77.5 cm correspond with a peak in Ti. Ca and Si are in phase, as would be expected with sand deposition, and the elements increase towards 76.0 cm depth, although no corresponding peaks are evident in the Zr profile.

The storm event of 10 February 1997 had a skew surge of 0.84 m with a return period of 19 years at Heysham tide gauge (SurgeWatch, 2016) and 3 December 2006 had a peak tide-surge residual of 1.57 m. Although the geochemical profiles indicate heavy mineral sands at 14.6 cm and 6.4 cm, no distinct coarse-grain peaks are evident. Interpretation of the sediment record in isolation could clearly lead to under- or over-representation of storm impacts if trends are extrapolated to the landscape scale. It is imperative to consider other factors which may determine the effects of storms on the saltmarsh.

5.6. Storm event meteorological characteristics

As previously discussed, east-tracking storms can result in surges in both the Irish Sea and, subsequently, the North Sea. The Scandinavian high-pressure system can block the eastward track of storms across the UK and determine their passage over the North Sea. Alternatively, storms may be diverted across the Norwegian Sea, or the Bay of Biscay and English Channel, through which they may become amplified (Zong and Tooley, 2003). Lennon (1963) reported surprisingly consistent weather conditions associated with major storm surges on the west coast of the UK. Direction and velocity of the depression relative to the ports considered in the study were fundamental; however, minor surges may not satisfy all proposed criteria but could still yield appreciable effects. The concurrence of extreme wave heights (>4 m) with extreme surge events (>1.5 m) is rare in the eastern Irish Sea. Such coincidence was concluded to occur only with west-southwesterly and westerly winds (Brown et al., 2010).

Concurrence of still water level and wave height at the shore and the magnitude, timing and duration of their interaction can determine geomorphological responses ranging from no observable effects to significant change (Brooks et al., 2016). At Scolt Head Island on the North Norfolk coast, the dune-breaching capacity was not exceeded during the December 2013 storm surge, as low wave heights corresponded with maximum still water level. A change in wind direction was partly responsible for a significant reduction in the landscape effects of the December 2013 surge on the southeast coast of England when compared to the effects of the 1953 event (Spencer et al., 2015).

5.7. Marsh orientation and bathymetric variability

Saltmarsh orientation is a key determinant of exposure to tides and onshore winds. Whilst the marsh at Kilnsea Clays is relatively sheltered in the lee of Spurn Point, Warton Marsh faces southeast towards the mouth of Morecambe Bay and is therefore more exposed to onshore winds and wave run-up and consequently at greater potential risk of erosion, particularly during storm events (Adam, 2000). During the 5 December 2013 surge, Morecambe received the full force of the waves, whilst east-facing Grange-over-Sands was comparatively sheltered from westerly winds and waves (Morecambe Bay Partnership, 2013). Direct wave action at the saltmarsh-mudflat interface was proposed as a significant driver of saltmarsh erosion in Essex, southeast England, where a 25% reduction in saltmarsh area occurred between 1973 and 1998 (Cooper et al., 2001). Despite a propensity for erosion, the Warton Marsh geochronology records discrete deposition events as evidenced in the ^{137}Cs profile. Nikitina et al. (2014) interpreted abrupt contacts between saltmarsh peat and mud sequences as rapid infill following storm erosion at Sea Breeze marsh, Delaware Bay, New Jersey. Whilst the organic horizon in the Warton Marsh stratigraphy could be interpreted in this manner, the time-integrated record of Sellafield ^{137}Cs discharge suggests that the sediment profile has not been subjected to significant erosion or reworking.

In contrast to earlier research, Olbert and Hartnett (2010) found that bathymetry outweighed local wind influence in determining Irish Sea surge characteristics; external surge propagation through the north and south channels was of greater importance. Nearshore bathymetry, in terms of river channels and sandbank proximity, can account for differential erosion or deposition during high-energy events, as was evident at Silverdale Marsh, Morecambe Bay (Pringle, 1995). Sandbank and tidal channel mobility in Morecambe Bay, through progressive lateral migration or sudden shifts over several kilometres, can yield distinct variability in saltmarsh geomorphological response to a storm. Westerly storms and peak spring tides can cause significant tidal channel and sandbank shifts, particularly in the inner Bay (Zong, 1993). The current proximity of the River Kent channel to Warton Marsh enhances such erosion risk. Sandbanks may protect the marsh during storm events through increased bottom friction and concurrent wave energy reduction (Zong, 1993) and also function as a sediment source.

5.8. Sediment sources and availability

As both sediment sources and sinks (Montreuil and Bullard, 2012), sandbanks, and their proximity and movements within Morecambe Bay, determine sediment availability and delivery to saltmarshes (Zong, 1993). At Spurn Point, eroded material from the Holderness Cliffs is an important sediment source that is transported south through longshore drift and also stored in offshore sandbanks prior to redistribution by onshore waves. Montreuil and Bullard (2012) proposed that approximately 29% of eroded sediment from the Holderness cliffs is redistributed to the Lincolnshire coast. Sediment delivery under storm conditions is highly dependent upon storm direction and wave heights. It is predicted that sediment transport into Morecambe Bay will increase in response to sea-level rise and increased surges (Wyre Borough Council, 2013).

In addition to drivers of sediment input to the marsh, within-marsh redistribution and local hydrogeo-morphodynamics yield characteristically patchy spatial distribution of sand across the marsh. Preferential sediment deposition occurs around creek networks and may be evident in the LM28 core at Warton Marsh. Vegetation coverage can trap sediment or accelerate erosion through movement of exposed roots in the marsh cliff (Feagin et al., 2009; Möller et al., 2014). Möller (2006) observed that seasonal changes in sward height and density had a greater effect on wave attenuation and subsequent erosion or deposition than variations in canopy roughness at Tillingham Marsh, Essex, UK. These effects may be overridden by hydrodynamic controls, such as the wave height:water depth ratio, with wave energy dissipation due to bed erosion and sediment resuspension (Möller, 2006).

Sources of sand deposited around the marsh edge can be inferred based on spatial distribution in core samples, whether from the creek bed, tidal flats and dunes or beach (de Groot et al., 2011). Determining the sources of sand deposited within the inner marsh presents an even greater challenge, as evident in the cores from Spurn Point and Warton Marsh. Conclusions regarding the conditions under which sediment has been deposited or eroded in the past cannot be drawn with certainty from present day marsh morphology because of the inherently dynamic nature of saltmarsh topography during its development (de Groot et al., 2011). Storms and associated surges were found to be key determinants of sediment deposition rate in the Elbe Estuary, particularly for marshes at higher elevations. It is proposed that high marshes, in particular, may benefit from increased storminess and associated propensity for tidal flat erosion and deposition of suspended sediment in the marshes (Butzeck et al., 2015). These effects are also vegetation-dependent, however, as marsh edge erosion and vegetation damage may exacerbate vulnerability to erosion and instigate regressive succession (Butzeck et al., 2016).

5.9. Management in the coastal zone

Coastal zone management can influence sediment availability and redistribution. Dredging operations to maintain shipping lanes in the Humber Estuary and off the Holderness coast determine estuarine bathymetry and will undoubtedly govern the availability and character of sediment deposited at Kilnsea Clays. Approximately 242 x 10^6 m^2 sediment was dredged and redistributed within the estuary between 1960 and 1994 (Townend and Whitehead, 2003). Whilst the entire estuarine dredged output is returned to the estuary to allow saltmarshes to keep pace with rising sea levels (Morris et al., 2004), offshore dredging may influence sediment input to the estuary (Environment Agency, 2000). Dyer et al. (2002) attributed increases in marsh sediment accumulation rate in the Westerschelde Estuary, southwest Netherlands, to shipping channel maintenance and associated increases in estuarine mean high water level. It is postulated that dredging and consequent increased flow velocity would enhance the effects of increased storminess, through increased marsh cliff erosion.

Coastal protection measures at Spurn, primarily wooden groynes and former concrete anti-tank blocks, were maintained until Spurn transferred from military ownership to management as a nature reserve in 1959 (Crowther, 2010). With management favouring accumulation to maintain Spurn in a static position, this would have significantly altered sediment transport around the Point. Maintenance of vehicular access along the peninsula requires sand redistribution to infill areas which have been repeatedly breached and will likely influence sediment supply to the saltmarsh at Kilnsea Clays. Anthropogenic forcing was a key influence on sand distribution across Dutch and Danish barrier island saltmarshes (de Groot et al., 2011).

Warton Marsh does not require sediment redistribution in order to maintain access. It is managed through livestock grazing to create optimal habitat for breeding birds. Historically, areas of Warton Marsh have been utilised for commercial turf cutting. This would remove vegetation and sediment from the marsh system. Loss of sediment stability following vegetation and sediment removal could have caused localised erosion. Turf cutting is not thought to have occurred in the borehole sampling areas of the present study. Additionally, the deposition to the south of Warton Marsh of blast furnace slag, an industrial by-product from local iron production, provides protection from strong onshore wind and waves at the southern limits of the marsh.

5.10. Spatial scale and management implications

Significant stratigraphical variation has been demonstrated across a range of spatial scales in macrotidal saltmarshes, which are characterised by different sediment types. These observations support those of de Groot et al. (2011) who reported variation in the number and thickness of sand layers at sampling points within a 1 m^2 plot for the Dutch barrier island of Schiermonnikoog. The frequency and depth of sand layers attributable to storms decreased with increasing marsh elevation, such that sand layers tapered and were rarely observed in the high marsh (de Groot et al., 2011; Kortekaas and Dawson, 2007). Due to the inherent spatial variability evident in saltmarsh storm responses, caution is advisable in the extrapolation of borehole sediment geochronology across the wider marsh. Such data must be interpreted in the context of the fundamental drivers of storm impacts on saltmarshes. Modelling projections suggest increased sediment input to Morecambe Bay under future scenarios of sea-level rise and surge. Whether this results in net accretion at Warton Marsh will likely be determined by more localised forcing factors, such as sandbank and tidal channel proximity to the marsh. At Spurn, anthropogenic forcing through dredging and redistribution of sediment will undoubtedly be a key driver.

6. Conclusions and recommendations

This study presented data from two macrotidal estuarine saltmarshes in the UK that were previously unstudied with regard to sedimentary storm records. In corroboration with other European and US studies, potential storm records at Kilnsea Clays and Warton Marsh are strongly influenced by geomorphology and the setting and extent of the ecosystem. Inherent stratigraphic variability evident at a range of spatial scales means that whilst some storm events may be apparent in the stratigraphy they are clearly not all recorded consistently across the marsh. Such variability raises important questions regarding the number of lines of evidence required to determine saltmarsh storm responses with certainty. Considering the variability in geomorphological response, it is advisable that borehole sediment stratigraphies are not simply extrapolated across the marsh and instead are considered holistically alongside high-resolution field analyses and in the context of internal and external forcing factors.

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Chapter 3. Psychological benefits from coastal environments and perceived risk from climate change

3.1. Preface

The effects of storms in low-lying coastal ecosystems, through flooding, erosion, and sediment deposition, can be highly variable, as was evident in Chapter Two. Storms may also threaten the social and psychological benefits gained from these environments, which are integral to wellbeing. The benefits derived from the coastal environment, through restorative potential, have been shown by a number of studies (e.g. Wheeler et al., 2012; White et al., 2010, 2013). The potential association of climate change with the psychological benefits derived from these environments, however, has yet to be fully explored. Individuals' responses to environmental risks will be governed by their perceptions of risk.

This chapter contributes to understanding of coastal restoration and climate change risk perception. A survey was conducted with residents and visitors on the coasts at Spurn and Silverdale. Through use of quantitative and qualitative methodologies, the social and psychological benefits ascribed to living on and visiting the coast are explored, through focusing particularly on perceptions of saltmarsh value. The predictors of perceived restorativeness are examined, particularly considering the role of storms and coastal flooding. Perceptions of change and risk from storms and coastal flooding are also examined. Acceptability of coastal protection measures is also explored, through a photo preference task, along with the predictors of acceptability.

This paper was written in the style of the Journal of Environmental Psychology, to which it was submitted for review. Figures and tables are presented close to their first point of reference in the text, as they were submitted to the publishers.

AUTHOR CONTRIBUTIONS

I declare that the work submitted is my own. The contributions by co-authors were as follows:

Lorraine Whitmarsh: Supervision, support in research design, substantial review and editing

Katherine Selby and Colin Brown: Supervision, review and editing

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Psychological benefits from coastal environments and perceived risks from climate change

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ABSTRACT

The environmental and societal effects of climate change are particularly apparent on the coast, where high population density and important, low-lying ecosystems such as saltmarshes are threatened by sea-level rise and increased storm frequency and magnitude. These risks may also threaten important social and psychological functions of coastal ecosystems. Yet how psychological benefits (e.g., restoration) from spending time on the coast are experienced and might be threatened (or even enhanced) by climate change is little understood. This study discusses novel, empirical insights into coastal experience and perceptions of change and risk. A survey and photo preference task was administered to residents and visitors at two UK coastal sites between March and December 2015 (N = 211), to ascertain values ascribed to the coast, particularly saltmarshes, predictors of perceived restorativeness, perceived storm and flood risk, and acceptability of coastal protection measures. Saltmarsh was least important to area enjoyment relative to mudflats/sandflats and sand dunes, although more important for those with strong pro-environmental values. Location significantly predicted current perceived storm and flood risk, with significantly greater risk perceived on the east coast site. Contextual factors in risk perception were also notable, as storm experience at home did not translate to perceived risk on the coast. Whilst both sites were considered restorative, none of the variables significantly predicted perceived restorativeness. Aesthetics may be important for acceptability of coastal protection measures, with soft-engineering rated as significantly more acceptable. Length of residency/ area familiarity, perhaps indicating place attachment, predicted acceptability. Our findings suggest a need to enhance understanding and support for future management strategies amongst local communities and the wider public.

Keywords: Restorative environments; coasts; storms; floods; risk perception; saltmarsh;

1. Introduction

Global climate change poses risks to both the natural environment and to society. These effects are particularly evident in the dynamic coastal environment which is densely populated and threatened by projected sea-level rise and increased frequency and magnitude of extreme weather events, particularly storms (O'Riordan et al., 2014; UNEP, 2006). The landscape effects of coastal storms are principally experienced through erosion and flooding, which may negatively affect the vulnerability and wellbeing of coastal communities both indirectly, due to a loss in ecosystem service provision, or through direct infrastructural impacts (Marshall et al., 2013).

The effects of storms and extreme events can have significant cultural and psychological impacts. The mechanisms through which climate change can impact upon health and wellbeing include effects on mental, physical and community health, such as trauma and anxiety associated with extreme weather and loss of identity and place attachment through disruption to the fabric of social systems and infrastructures (Devine-Wright and Howes, 2010; Tapsell and Tunstall, 2008). In addition, storms, erosion and sea-level rise are likely to impair the capacity of coastal environments to provide a range of ecosystem services such as food provision and recreation (MEA, 2005). While the value of these services, and their loss through climate change, has been examined using economic methods (UNEP, 2011), far less attention has been given to understanding these impacts from a psychological perspective. Yet, individuals' response to coastal environmental risks will be highly dependent upon how these risks are perceived, which in turn is shaped by various psychological and social factors. Similarly, how psychological benefits (e.g., restoration) from spending time on the coast are experienced and might be threatened (or even enhanced) by climate change is little understood. This paper provides novel empirical insights from a study of two UK coastal regions into coastal experiences and how these are perceived to be changing or at risk. These insights are valuable for building scientific understanding of restoration and risk perception amongst coastal communities and visitors, as well as informing effective, democratic and socially robust design of policy to mitigate and adapt to climate change on the coast (e.g. National Research Council, 2008).

2. Literature review

2.1. Cultural values and use of the coast

The coast is culturally important, often represented as iconic and revered in art and literature, particularly in island nations like the UK (Geoghegan and Leyshon, 2014; White et al., 2010). The associated coastal ecosystem services (benefits obtained from nature) include aesthetic, recreational, educational and spiritual services, all of which are integral to human wellbeing (MEA, 2005). Coastal saltmarshes, for example, provide a water purification role, regulate climate through sequestration of carbon, and also mitigate against climate change effects through protection of coastal communities against increases in sea-level rise and the frequency and magnitude of storm surges (MEA, 2005). Furthermore, coastal tourism is estimated to be worth £4 billion to the UK economy (DCLG, 2016).

The Nineteenth Century saw a distinct transition from perception of the coast as a dangerous, inhospitable unknown to promotion as an area of wellness and rejuvenation for urban dwellers through the development of Victorian coastal spa resorts. This association between the coast and health/ restorativeness continues into the twentieth century and there is now a considerable body of evidence to support this link (e.g. White et al., 2010).

2.2. Psychological benefits of the coast

The psychological benefits of the coast, as "blue space", have received increasing attention in the restorativeness literature (White et al., 2010; Wyles et al., 2016). Coastal areas are frequently cited as "favourite places" and nostalgia and family connections can play a prominent role in the selection of favourite coastal areas (White et al., 2014). The mechanisms through which restorative benefits are derived from the natural environment are proposed in psycho-evolutionary theory (Ulrich et al., 1991) and attention restoration theory (ART; Kaplan and Kaplan, 1989). ART states that restorative environments are those which allow fatigued attention to be restored by offering a change of scene ('being away'), features requiring effortless attention (e.g., clouds, trees; 'soft fascination'), scope to feel immersed ('extent'), and a place where individuals want to spend time ('compatibility'), which together form central constructs in the Perceived Restorativeness Scale (PRS; e.g. Hartig et al., 1997). Ulrich's (1983) psycho-evolutionary theory contrasts with the Kaplans' (1989) cognitive approach. It considers preference as important, but as one of a broad suite of emotions in the initial response to the natural environment. It was proposed that initial, unconscious emotional response is central to subsequent attention and conscious processing, physiological and behavioural responses (Ulrich et al., 1991).

There is mixed evidence for demographic effects in perceived restorativeness (e.g. Scopelliti and Vittoria Giuliani, 2004; von Lindern et al., 2013; Wyles et al., 2016). Wyles et al. (2016) found no significant age or gender effects on coastal perceived restorativeness, under different tidal conditions and in littered and non-littered environments. An effect of age, and associated available leisure and restoration time, and potential for socialising, was found by Scopelliti and Vittoria Giuliani (2004). "Being away" was a more important component of perceived restorativeness to young people and adults than to the elderly, whereas the built environment was perceived to offer more socialising opportunities amongst the elderly.

Photo preference studies have shown the presence of water, in both natural and built environments, to yield greater preference, positive affect, through valence and arousal (Russell, 1980), and perceived restorativeness (White et al., 2010; Wyles et al., 2016). In the inherently dynamic coastal environment, the influences of changing weather and tides can have a profound effect on an individual's experience and, consequently, the perceived restorativeness derived from this environment (Wyles et al., 2016). Different light patterns in a waterscape and restorative sounds, such as breaking waves, and the associated potential for reduction in both psychological and physiological stress have also been proposed as sensory elements which may be integral to coastal restorativeness (White et al., 2010).

2.3. Risks to psychological benefits of the coast

Storms may pose a risk to the restorative benefits of the coast; yet, the emotional and symbolic effects of climate change on the coast have been given much less attention than the physical effects. Perceived restorativeness experienced from waterscapes was shown by White et al. (2014) to be significantly lower under conditions of inclement weather than in "pleasant" weather conditions. Waterscapes were the most negatively affected landscape type when compared with preferences for and perceived restorativeness of rural/ green and urban landscapes (White et al., 2014). Ulrich (1983) similarly found participants least preferred paintings of stormy seas and flooding, compared to calmer scenes.

The relationship between climate change, extreme weather and flooding is largely recognised by the public, particularly in the UK where flooding is amongst the most serious risks posed by climate change (Jenkins et al., 2009). Yet, while awareness of climate change and its associated risks has grown steadily, concern has lagged behind and several studies have shown that climate change is not a pressing issue for the public in most developed countries with many uncertain or doubtful about its reality or severity (Capstick et al., 2015). Other, more "immediate" social and economic changes and risks in the coastal zone are likely to be prioritised as environmental risks are usually perceived as less salient and more psychologically distant than others (Lorenzoni et al., 2007). This can be explained by construal-level theory (Trope and Liberman, 2010) which states that objects or issues are understood in more concrete ways and more likely to result in practical decision-making if they are geographically, temporally, socially and hypothetically proximal; yet, climate change is distant along all these dimensions for most people and consequently less tangible or likely to influence action (Gifford, 2011). Even those who have experienced flooding directly are not necessarily more concerned about climate change, although evidence on this point is mixed (Clayton et al., 2015).

Research has highlighted a range of factors that determine risk perception (e.g., Slovic, 2000). As noted, flooding is a key risk for coastal ecosystems and studies consistently demonstrate the importance of “place” and experience in awareness and perception of flood risk (Tapsell and Tunstall, 2008). Flood risk perception is principally determined by length of residency in the study area and by the extent of previous flooding experience (e.g., Burningham et al., 2008). Areas which are subjected to frequent episodes of flooding, or where flooding has occurred recently can result in higher perception of risk and a higher degree of preparedness at the individual or community level (Tapsell and Tunstall, 2008). Perception of risk can also be heightened through extensive media coverage, which enables such events and associated risk to be recalled with ease (Whitmarsh, 2008). On the other hand, there is often significant heterogeneity within flooded regions due to topographical, geological, and structural reasons, such that a flooded property may be surrounded by unaffected homes. Similarly, psychological and social factors mean that responses to floods may vary from one household to another (Whitmarsh, 2008). Besides residence and experience, other factors that have been shown to affect responses to floods and related risks include environmental values (e.g. Whitmarsh, 2008), gender (Kahan et al., 2007; Whitmarsh, 2011), age, education, political standpoint (Whitmarsh, 2011) and social or institutional support (Höppner et al., 2012). In respect of climate change, political standpoint has been shown to be of greater importance than knowledge, although knowledge can enhance views (Kahan et al., 2012). The relative importance of these various factors in determining perceived risks to the coast has yet to be explored.

2.4. Preferences for coastal management options

A perceived need for “physical” action to remediate flood risk has been demonstrated in flooded communities in England (Tapsell and Tunstall, 2008) and the Netherlands (Schmidt et al., 2014). In order to alleviate risk from storms and coastal flooding, coastal zone management in the UK comprises traditional “hard-engineering” through such measures as sea walls, beach groynes and earth and rock embankments. Such structures interfere with coastal processes and sediment movement and can offer a “false sense of security,” such that development occurs in the immediate hinterland (Andrews et al., 2006: 20). A change in strategy over the last two decades has become increasingly evident, which includes “soft-engineering” protection measures, such as managed realignment, and supplementing natural coastal protection through beach nourishment, dune stabilisation and the restoration and conservation of saltmarsh (e.g. Myatt-Bell et al., 2002). The importance of understanding stakeholder perceptions of coastal management and incorporating this into coastal planning is becoming increasingly recognised (Tompkins et al., 2008). Not only does this increase the quality of decision-making, but it can also increase confidence in governing bodies and management decisions; this, in turn, has been shown to influence acceptance of protection schemes (Myatt et al., 2003). Other factors that are integral to perception and acceptance of protection schemes include the extent of personal experience, availability of information, aesthetics and the influence of the media (Myatt-Bell et al., 2002). On account of the numerous drivers and site-specific nature of perception, Myatt-Bell et al. (2002) advocate a case study approach to investigate perception of such coastal protection schemes.

Landscape preferences, public perception and uses of the natural and restored Odiel Marshes neighbouring the Spanish city of Huelva, were examined through a survey by Curado et al. (2014). They adopted a "case study" approach, highlighting the importance of local participation and perceptions in decision-making. Sampling was conducted at a single city centre location on working days in October 2010, as they aimed to reach a broad cross-section of the local population; residents of the city, who were of or greater than 20 years of age. A mixed sampling approach was adopted, comprising non-probability quota sampling of sex and estimated age and random selection, and systematic selection with random sampling**.** A response rate of 22.2 % was achieved (394 completed surveys). Their survey comprised multiple choice questions and a photo preference task. The extent to which respondents recognised saltmarsh ecological service provision was examined. Whilst this was described as a quantitative survey, the thematic dimensions of public perception and marsh utility were explored qualitatively. The items elicited value perception and "physical" perception of saltmarshes. As the study focused on local perceptions towards natural and restored marshes, a photo preference task examined landscape preferences for the native saltmarsh vegetation. Respondents' usage of the marsh, including visit frequency and activities undertaken whilst there, and the "beliefs and behaviour" of the local population were also ceonsidered.

Three-way Analysis of Variance (ANOVA) was used to determine difference between sex, age and level of education. Saltmarshes were considered beneficial by 75% of survey respondents. Education level was found to positively influence perceptions of saltmarsh environments, and to reduce negative associations. Respondents in the high education level more frequently answered that saltmarshes were beneficial and less frequently mentioned perceived negative aspects of saltmarshes. Only around half of respondents recognised the ecological service provision of saltmarshes. Sex was only concluded to influence marsh use, as more male than female respondents used the marsh for fishing. "Perceived naturalness" appeared to be a key influence on photo preferences for saltmarsh vegetation.

The installation of interpretation boards was recommended, as a means to increase awareness and knowledge of saltmarsh benefits. The authors highlight the importance of directing education at school-aged residents, through incorporation in curricula. Curado et al. (2014) contrasted the results of their study with those of even 20 years prior to its publication, in order to demonstrate a perceptual shift towards wetland, from negative associations to more positive perceptions.

2.5. Study aims and hypotheses

Owing to the cultural significance of the UK coast for an "island nation" (Geoghegan and Leyshon, 2014) and the social-environmental risks posed to the coast by climate change, this paper focuses on the value ascribed to saltmarshes due to their coastal protection and ecosystem value at two study sites on the east and west coasts of the UK. Through a survey conducted with coastal communities and visitors the following research questions are addressed and (where relevant) hypotheses proposed based on previous research:

1) *What are the social and psychological values attached to the coast and coastal saltmarshes?*

   We expect the coast to be valued for a range of functions (e.g., recreation), including restoration (cf. White et al., 2010; UNEP, 2011).

2) *What predicts perceived restorativeness of the coast in particular; and to what extent is this perceived to be impacted by climate change?*

   While we expect the coast to offer restoration, it is anticipated that storms and coastal floods will have a negative impact on restoration (cf. White et al., 2014).

3) *What changes do people perceive on the coast and what predicts perceived risk from storms and coastal floods?*

   It is expected that environmental changes (e.g., climate change) will be less commonly identified than social changes. It is also predicted that women, those with higher education, longer residency, direct experience and higher environmental values will have higher perception of risk to storms and coastal floods.

4) *What measures aimed at protecting the coast from storms are accepted, and what predicts their acceptability?*

   Experience, knowledge and aesthetics are expected to be relevant factors, with soft-engineering options generally more likely to be preferred than hard-engineering measures.

3. Materials and Methods

3.1. Study areas

This paper focuses on two UK sites situated on the east and west coasts of England (**Figure 1**). Spurn Point is a 5.5 km sand and shingle spit located at the mouth of the Humber Estuary, on the Holderness Coast. It is considered to be the most rapidly eroding coastline in Europe, at a rate of 1-2 m^{-a} (Elliott et al., 2014). The area received widespread media attention following a significant storm surge on 5/6 December 2013 (e.g. BBC, 2013). On the northwest coast of England, the Silverdale coast is situated at the northeast of Morecambe Bay. In this paper, the area referred to as the “Silverdale coast” is shown in **Figure 1** and encompasses the Arnside and Silverdale Area of Outstanding Natural Beauty.

3.1.1 Approaches to coastal zone management in the study areas

The Shoreline Management Plan sub-cell in which the Silverdale Coast is situated (sub-cell 11c of the North West England and North Wales SMP2) is said to contain 27,100 residential and 3,970 commercial properties defined as being in the long-term coastal risk area. The Lindale-in-Furness to Carnforth railway flanks the bay, as shown on the Silverdale survey map in Appendix One. The long-term plan of the SMP2 is to protect the towns and villages of Arnside and Sandside, Grange-over-Sands, and to maintain the railway line embankment. Maintenance of this embankment indirectly delivers flood protection to much of the bay frontage between Morecambe and Ulverston. Investigations are ongoing into the viability of managed realignment elsewhere in the estuaries of the rivers Kent and Leven in order to accommodate the hold-the-line approach in these areas. Where saltmarsh accretion is occurring along the shoreline at Grange-over-Sands, minimal management is anticipated in the short-term, due to the protection it offers (Halcrow Group Limited, 2012)

With regard to the SMP2 for the coast at Spurn Point, as the neighbouring Dimlington and Easington gas terminals provide 20-25 % of the UK’s gas supplies, these will remain protected, although this may ultimately have a negative impact on the landscape value and character of the area, as the size of protection measures has to be increased in line with rising sea levels. The adverse impact of maintaining these defences is also acknowledged for the along-coast area of Easington to Kilnsea and Spurn Point. Maintenance of private and Environment Agency flood defences occurs at Easington Lagoons and Kilnsea flood defences, with managed realignment considered to ensure their “sustainability.” The rest of this stretch of coastline remains undefended, in order to ensure continued supply of sediment to Spurn Point, the Humber Estuary and the Lincolnshire coast, as this sediment recharge facilitates “natural coastal protection.” The SMP acknowledges the risk posed to historic environment assets in allowing these areas to remain unprotected (Humber Estuary Coastal Authorities Group, 2009).

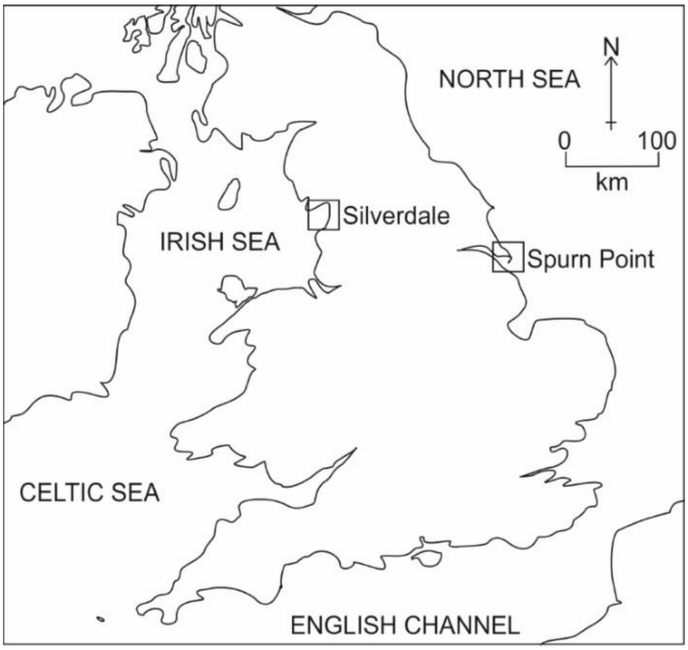

Figure 1. Map of the UK showing the two study sites at Spurn Point, Humber Estuary and the Silverdale coast, Morecambe Bay.

3.2. Participants

A total of 211 survey responses were collected from across the two study sites, with 125 from Silverdale and 86 from Spurn Point. Overall, most (60%) respondents were female, and the sample was somewhat older and more qualified than the national average: age categories 55-64 and 65-74 each accounted for 23% of the sample population; and degree or equivalent and postgrad qualifications accounted for 30% and 28% of the total sample population, respectively.

To evaluate the comparability of the samples obtained from the two study sites, normality of data distribution was, first, determined. As data were non-normally distributed median and range values are presented. Mann-Whitney U and Pearson's chi-square tests (or Fisher's exact when expected frequencies were < 5) were conducted to assess significance of difference between samples or the significance of relationship between location and a number of demographic variables.

The proportions of female and male respondents were very similar at the two study sites, with greater numbers of female than male respondents (62% female at Silverdale and 61% at Spurn). Chi-square showed no statistically significant relationship between sampling location and gender (χ^2 = .036 (1), p = .849). This gives confidence in the comparability between the two study sites.

Chi-square (Fisher's exact test) showed no statistically significant relationship between location and age (χ^2 8.91, p = .252) (*Mdn* age: 55-64, range = 7 for both Spurn and Silverdale respondents). Whilst there was a higher % respondents with postgraduate qualifications at Spurn (31%) than at Silverdale (26%), (*Mdn* = category 5 “degree or equivalent,” range = 5), no statistically significant relationship was found between location and education through chi-square (Fisher’s exact), however ($\chi^2 = 4.008$, p = .690).

Whilst the sample at Silverdale appeared to be more liberal than that at Spurn, political leaning was not found to be significantly different across the two sites through independent-samples Mann-Whitney U (Spurn *Mdn* = 4 neutral), (Silverdale *Mdn* = 3 slightly liberal), $U = 4188.5$, $p = .174$).

Environmental values, measured through wildlife organisation membership, were not significantly related to location, as evident through chi-square (*Mdn* and range of 1 “yes” for both Silverdale and Spurn) ($\chi^2 = .294$ (1), $p = .588$). Level of storm experience was not found to differ significantly between respondents at Spurn (*Mdn* = 5, range = 15) and Silverdale (*Mdn* = 4, range = 15, $U = 4976.5$, $p = .889$).

The principal differences between the two samples appear to lie in respondents’ residency on the coast and their familiarity with the study areas. Respondents at Silverdale were primarily resident in the study area, with only 30% identifying as visitors to the coast. By contrast, a greater percentage of visitors (69%) were represented amongst the Spurn respondents. Of these visitors, 55% were visiting for the first time at Spurn, compared to 31% at Silverdale. Of the visitors to Silverdale, 51% visited several times a year, compared to 21% at Spurn. Chi-square (Fisher’s exact test) showed a highly significant relationship between location and coastal residency (Silverdale *Mdn* = 1 “yes”, range 1, Spurn *Mdn* = 0 “no”, range = 1. ($\chi^2 = 32.23$, $p < .001$). A significant relationship was also evident between frequency of visits and location. From the above tests, the datasets are generally comparable across the two study sites, but it is worth considering the potential for greater study area familiarity amongst respondents at Silverdale.

3.3. Design and Methods

A pilot study was conducted through in-depth, semi-structured interviews with 14 participants who lived in and/or worked at the two study sites; the findings from which were used to inform the survey design. Interview participants were recruited through a “snowballing” approach, whereby interviewees would suggest further people to interview in the study areas. The resulting survey comprised ten pages of quantitative and qualitative questions divided into four sections, “benefits and values,” “changes” (which included perception of risk from storms and coastal floods), “the future” and “about you” (see Appendix One for the full Spurn and Silverdale Coastal Experience Surveys). The survey was piloted at Silverdale and Spurn Point in March and April 2015 (N = 18), and based on this no changes were considered necessary.

Intensive recruitment, using a variety of approaches, continued on an almost weekly basis between April and December 2015, in order to encompass temporal variation in site users. Face-to-face survey completion was undertaken along beaches and coastal paths, in local towns and villages; on the Silverdale coast these comprised Grange-over-Sands, Arnside, Silverdale and Bolton-le-Sands, whilst for Spurn Point, the villages of Easington and Kilnsea were the principal village centres. The library network was also identified as a useful platform to distribute surveys at Grange-over-Sands, Silverdale and Bolton-le-Sands, along with the Grange-over-Sands tourist information centre. Local businesses and caravan sites were visited and surveys were also conducted from the Yorkshire Wildlife Trust visitor information centre at Spurn and the RSPB Leighton Moss and Morecambe Bay nature reserves.

Random sampling of coastal users was undertaken throughout the day, from early morning to evening, in order to encompass a range of coastal users at both study sites. If respondents felt that they had insufficient time to complete surveys in-situ, they were provided with surveys in stamped addressed envelopes to maximise response rate.[1] Trained interviewers delivered the survey face-to-face. Whilst introductions did not use a standardised script, they centred on the summary at the beginning of the questionnaires themselves; "examin[ing] the benefits, values and changes you have experienced on the coast around Spurn Point [or Silverdale]." Introductions to the survey were deliberately funnel-shaped, ensuring that interviewees did not mention saltmarshes, storms or flooding, so as not to bias responses. Due to the multiple methods of questionnaire delivery adopted (e.g. face-to-face survey completion, postal responses and those administered through local businesses, visitor information centres and library networks), it is not possible to estimate response rates. No monetary incentives were provided for survey completion.

3.4. Materials and Measures

The design of the value and risk mapping survey instruments is discussed here, the results of which are discussed in Chapter Four. Please refer to Appendix One for copies of the questionnaires, which were used at Spurn and Silverdale.

3.4.1. Residence, coastal utility and saltmarsh value

Length of residence was assessed in Q1(a) "when did you first come to the coast around Silverdale/ Spurn Point?" Respondents were prompted to tick one statement from "0 = I am a visitor to the

[1] Final postal responses were received from the Silverdale coast in January 2016, following devastating pluvial flooding in Cumbria in November and December 2015. This had significant social, economic and environmental implications in the region. Undoubtedly, this will have impacted risk salience and also the frequency of responses obtained. Whilst survey uptake was very encouraging, the frequency of returns was understandably minimal in the aftermath of the flooding.

area," "1 = I moved here in the last six months," "2 = I moved here between six months and two years ago," "3 = I moved here between two and five years ago," "4 = I moved here more than five years ago" and "5 = I have lived here all my life." If respondents identified as visitors to the area, they were prompted to indicate how often they visit (Q1b), from "1 = This is my first visit," "2 = I visit once to twice a year" and "3 = I visit several times a year."

Utility and value of the coast were elicited in Q2, "why did you choose to visit/ live on the coast around Silverdale/ Spurn Point?" Respondents were prompted to tick all which applied, from a list (compiled from the pilot interviews) which included items such as "to be close to nature," "for health and wellbeing benefits," "for a family outing," "for holidays" and "for work." Space was also provided to include any additional reasons.

Spatial distribution of value in the landscape was determined through a participatory mapping exercise (Q4a), by asking respondents to "indicate with a cross on the map […], the one area which is most important to you personally (this may or may not be the place that you spend most time)." Rationales for respondents' choices were determined through a subsequent open question (Q4b), "why did you choose this area?" Ordnance Survey (OS) 1:100,000 basemaps were selected for the participatory mapping exercise, using the Edina Digimap online mapping platform (https://digimap.edina.ac.uk/os). The Silverdale map encompassed Morecambe Bay, from Morecambe to the coast near Ulverston. The Spurn map included the villages of Easington and Kilnsea (including the North Sea Gas Terminal at Easington) to the north of Spurn Point and also encompassed the Lincolnshire side of the Humber Estuary, in order to show the more densely populated urban areas of Grimsby and Cleethorpes. Further discussion of participatory mapping approaches and the results of value and risk mapping are presented in Chapter Four.

A photo preference question (Q5) was used to determine the importance of saltmarsh environments to respondents' enjoyment of the study areas relative to sandflats at Silverdale and relative to mudflat and sand dune environments at Spurn Point; "to what extent are the following types of environment important to your enjoyment of the area?" Photos were chosen to represent similar lighting conditions and seasonality with respect to vegetation, or "greenness" of the photos (e.g. Curado et al., 2014). Responses were measured on 5-point Likert scales ("1 = not at all important" and "5 = very important").

3.4.2. Perceived restorativeness

Perceived restorativeness, experienced through living on or visiting the coast, was measured using a reduced-item version of the PRS (Hartig et al., 1996) (Q3). Items were chosen to represent the four constructs of perceived restorativeness; *being away, fascination, coherence* and *compatibility*, based on the results of factor analysis by (Hartig et al., 1997). Respondents indicated on a seven-item scale, where "0 = not at all" and "6 = completely," the extent to which the statements described their experience of the coast around Spurn and Silverdale. The two coherence items were reverse-scored. PRS items included were: "it is an escape experience" and "spending time here gives me a good break from my day-to-day routine" (being away); "there is much to explore and discover here" and "I would like to spend more time looking at my surroundings" (fascination); "there is a great deal of distraction" and "it is chaotic here," (coherence); "I have a sense that I belong here" and "being here suits my personality" (compatibility). However, missing values analysis revealed noteworthy levels of non-response (27.5%) from the item "there is a great deal of distraction", which may indicate that respondents felt that certain statements were not relevant to them or were ambiguous. This item was therefore removed following reliability analysis, to improve Cronbach's Alpha from .554 to .607. Respondents who lived or worked in the study area, for instance, may have felt that "spending time here gives me a good break from my day-to-day routine" was not applicable to their experience of the coast.

3.4.3. Perceived change

In order to identify which unprompted changes were most pertinent to respondents, this section began with an open question (Q6), "what changes have you noticed in the area since you started living/ visiting here?" This question was conditional upon the respondent having visited the area more than once. The extent to which physical and biodiversity attributes have changed and the impact of these changes on enjoyment of the area were measured in the subsequent questions: (Q7a) "Please indicate the extent to which the following issues have improved or worsened in this area over the time you have known it" and (Q7b) "please indicate how these changes have affected your use or enjoyment of the area." The four-item physical changes scale comprised "erosion," "coastal flooding," "storms," and "hotter weather and droughts," and two-item biodiversity changes scale included "amount and range of wildlife" and "amount and range of plants." These were measured using seven-point Likert scales where "-3 = significantly worsened," "+3 = significantly improved" and "0 = neither worsened or improved."

3.4.4. Current and future storm risk perception

The extent of perceived risk from storms and coastal floods at Silverdale and Spurn Point was determined in Q8 "to what extent do you think the Silverdale coast [coast around Spurn Point[2]] is at risk from storms and coastal floods? (please tick one statement)." Respondents were prompted to select the most appropriate statement from "3 = a great deal," "2 = somewhat," "1 = a little," or "0 = not at all." If respondents perceived a risk from storms at the study sites, they were asked to "indicate with a cross on the map […], roughly the area which is most at risk from storms and coastal floods" (Q9a). Risk maps used OS basemaps 1:100,000, with the same extent as those used in the value-mapping exercise in Q4, as previously described in section 3.4.1. A follow-up open question

[2] Wording was tailored to each survey site.

(Q9b), “why is this area particularly at risk?” sought to establish the rationale for their selection. The item “to what extent do you think that the frequency and severity of storms will increase in this area in the future?” (Q12) sought to measure perceived future storm risk, with responses on a seven-point Likert scale, from “0 = not at all” to “6 = extremely.”

3.4.5. Acceptability of coastal protection measures

Perceived adequacy of current coastal protection was assessed through Q10, “To what extent are current levels of protection from storms and coastal floods adequate in this area?” Responses were indicated using a five-point Likert scale, with “1 = completely inadequate” and “5 = completely adequate.” Acceptability of hypothetical coastal protection measures was determined through a photo preference question (Q11): “How acceptable would you find the following coastal protection measures for this area?” A range of hard-engineering (sea wall, rock groynes, earth and rock embankment) and soft-engineering (managed realignment, beach nourishment, saltmarsh) measures was provided, along with a brief description of their functions (see Appendix One). Site-relevant photographs were used where possible. Respondents rated the acceptability of each measure on a five-point Likert scale, from “1 = completely unacceptable” to “5 = completely acceptable.”

3.4.6. Socio-demographics and political values

Demographic information included age (Q13)[3], gender (Q14), highest level of educational attainment (Q16) (from “no formal qualifications” (1) to “postgraduate qualification”(6) and political affiliation (Q17) (where 1 = “very liberal,” 4 = “neutral” and 7 = “very conservative”). Coastal residency amongst respondents was determined through Q20, “Do you live on or near the coast.”

3.4.7. Environmental values and climate change scepticism

Environmental values were measured through respondents’ membership of a wildlife organisation (Q18) and inclusion of six items from the New Environmental Paradigm (NEP) scale (Dunlap, 2008), a strong predictor of climate change attitudes (Whitmarsh, 2011), and two items from the Climate Change Scepticism scale (Whitmarsh, 2011) (Q19). Respondents were asked, “To what extent do you agree or disagree with the following statements?” NEP statements included: “Humans have the right to modify the natural environment to suit their needs,” “Humans are severely abusing the planet,” “Plants and animals have the same rights as humans to exist,” “Nature is strong enough to cope with the impact of modern industrial nations,” “Humans were meant to rule over the rest of nature,” and “The balance of nature is very delicate and easily upset.” Climate change scepticism

[3] 1 = “18-24;” 2 = “25-34;” 3 = “35-44;” 4 = “45-54;” 5 = “55-64;” 6 = “65-74;” 7 = “75-84;” 8 = “85+;” (99 = “prefer not to say” coded as missing value).

statements comprised: “There is solid evidence that the Earth is warming because of human activities” and “Climate change is just a natural fluctuation in Earth’s temperatures” (Whitmarsh, 2008). Agreement with these statements was measured using a five-point Likert scale, where “-2 = strongly disagree” and “2 = strongly agree.” Higher scores for the NEP statements are indicative of more pro-environmental values or worldview. Where higher scores are obtained for the climate change scepticism statements, this signifies greater climate change scepticism (Whitmarsh, 2011).

3.4.8. Storm experience

The degree of recent direct and indirect storm experience was measured in Q21, with the item (adapted from Capstick et al., 2013): “Specifically thinking about storm damage (e.g. flooding, erosion, wind damage), which of the following have you experienced in the last two years? (Please tick all that apply).” The seven response options were: “My home or other property has been damaged by storms;” “I have been directly affected by storms, for example through travel disruption or my ability to work;” “I experienced disruption of essential services, e.g. gas, electricity;” “Other people within two miles of where I live have experienced property damage from storms;” “My friends and/or family were directly affected by storm damage;” “I heard or saw a lot about storm damage on television, radio or in the papers;” “I have not experienced any of the above”.

3.5. Data analysis

Data were input into IBM SPSS software v22 and, later, v24, for statistical analysis of quantitative responses. Hierarchical linear regression models were run to examine the effects of selected independent variables on key outcome variables. Normality of data distribution was tested with Kolmogorov-Smirnov/ Shapiro-Wilk test. As data were non-normally distributed, non-parametric tests of difference were used. As such, median and range values are reported throughout section 4 (Results). Testing for significance of differences between responses from the two study used Independent samples Mann-Whitney U test. Related-samples Wilcoxon signed rank test and Friedman’s ANOVA were used for within-site comparisons (e.g. the importance of coastal environments to enjoyment of the area), with “Split file” used to compare results between the two sample sites.

Responses to the open question were coded using an inductive approach to identify the underlying themes and sub-themes (Braun and Clarke 2006). Analysis and results of the participatory mapping exercises in questions 4 and 9 are discussed in Chapter Four.

4. Results

4.1. What are the social and psychological values attached to the coast and coastal saltmarshes?

The coastal utility question (Q2) revealed that the principal draw for respondents was "the beautiful scenery and landscape" (68.2%), followed by "peace and tranquillity" (53.3%). Being close to nature, seeing birds and wildlife and walking were all valued by 50.7% of respondents. However, less than half the surveyed populations explicitly valued the coast for health and wellbeing (38.4%). Diversity of plant life was less frequently cited as a reason for living in/ visiting the study areas (30.3%). Only 5.2% of the sample used the study coasts for fishing. Work was cited by 23.2% of respondents as a reason for living in/ visiting the study sites.

For the coastal environments photo preference task (Q5), independent-samples Mann-Whitney U showed there to be no significant difference in the importance of saltmarsh to wellbeing between Spurn and Silverdale, nor significant difference in the importance ascribed to sandflats and mudflats between the two sites (**Table 1**).

At the site level, related-samples Wilcoxon signed-rank test showed no significant difference between the importance of saltmarsh and sandflats at Silverdale (T = 523.5, z = .923, p =.356, r = .08). Related-samples Friedman's two-way ANOVA for the Spurn data showed a significant difference between the importance of saltmarsh, sand dunes and mudflats to respondents' wellbeing ($\chi^2(2)$ = 17.83, p < 001). Pairwise comparison showed that sand dunes were considered significantly more important to respondents' wellbeing, than saltmarshes (T = .464, r = =.33).

The results of hierarchical linear regression analysis, which investigated the predictors of saltmarsh value (as measured through the photo preference task in Q5), are presented in **Table 2**. Environmental values, as measured through the NEP and membership of a wildlife organisation, were found to be significant predictors of saltmarsh value, when controlling for age, political affiliation, gender and education, location, familiarity and residency on the coast, which were all non-significant predictors.

Table 1. Mann-Whitney U test results comparing the importance of sandflats and saltmarsh between survey respondents at Spurn and Silverdale. Median and range values for sand dune importance are also presented for comparison, however, as they were only present on the coast at Spurn, they were not included in this between-site analysis.

Environment types	***Silverdale***				***Spurn***				***Combined***					
	Median	**Range**	**N**	**Mean rank**	**Median**	**Range**	**N**	**Mean rank**	**Total N**	**p**	**U**	**Z**	**r (effect size)** $r = Z/\sqrt{N}$	**Cohen's classification**
Sandflats/ mudflats importance	4.00	4.00	120	99.65	4.00	4.00	85	107.72	205	.315	5501.5	-1.006	.07	Small
Saltmarshes importance	4.00	4.00	121	103.23	4.00	4.00	83	101.44	204	.825	4933.5	-.221	-.02	Small
Sand dunes importance	-	-	-		4.00	4.00	-		-	-	-	-	-	-

Table 2. Hierarchical linear regression analysis of saltmarsh value, as measured through the photo-preference task in Q5 (adjusted $R^2 = .090$). A significant regression equation was found ($F(6, 130) = 2.501$, $p < .05$). Shaded cells highlight significant predictors within the models at $p < .05$ level.

Independent variables	***Saltmarsh value***			
	B	**SE**	**β**	***t (p)***
Age	.061	.055	.096	1.111 (.269)
Gender	-.247	.204	-.102	-1.214 (.227)
Education	.043	.065	.057	.656 (.513)
Political values	-.034	.065	-.047	-.522 (.603)
Membership of wildlife org.	.441	.210	.186	2.103 (.037)
NEP	.382	.152	.224	2.512 (.013)
Location	.030	.225	.013	.134 (.894)
Length of residency/ familiarity	.012	.061	.021	.202 (.841)
Coastal residency	.189	.256	.079	.736 (.463)

4.2. What predicts perceived restorativeness of the coast in particular; and to what extent is this perceived to be impacted by climate change?

Overall, the study coastlines were found to offer potential for restoration (as determined through mean of responses). Perceived restorativeness ratings did not differ significantly between the two sites (Silverdale *Mdn* = 4.43, Spurn *Mdn* = 4.43, *U* = 2005.50, *z* = -40, *p* =.690, *r* = -.03). Independent-samples Mann-Whitney U test results for between-site comparisons of the individual PRS items are shown in **Table 3**. There was a greater sense of "being away" at Spurn, than at Silverdale, with a significantly greater feeling that time spent at Spurn gave a good break from respondents' day-to-day routines. With regard to "fascination," the sense of there being "much to explore and discover" was significantly greater at Silverdale, than at Spurn, whilst no significant difference was evident in terms of the "coherence" item. A significantly greater feeling of "compatibility" through a sense of belonging was reported by respondents at Silverdale, than those at Spurn.

As shown in **Table 4**, none of the independent variables used in hierarchical linear regression were significant predictors of perceived restorativeness.

Table 3. Mann-Whitney U test results comparing perceived restorativeness ratings from respondents' coastal experience at Silverdale and Spurn. Shaded cells highlight significant predictors within the models at p < .05 level.

Perceived restorativeness items	**Silverdale**			**Spurn**			**Combined**					
	Median	**Range**	**N**	**Median**	**Range**	**N**	**Total N**	***p***	***U***	***z***	***r* (effect size)** $r = z/\sqrt{N}$	**Cohen's classification**
Being away												
It is an escape experience	4	6	94	5	6	73	167	.144	3874.5	1.46	1.46	Small
Good break from day-to-day routine	4	6	99	5	6	73	172	.035	4274.0	2.11	0.16	Small
Fascination												
Much to explore & discover	5	6	115	5	5	73	188	.011	3315.5	-2.55	-0.19	Small
Like to spend more time looking at surroundings	5	6	98	5	6	71	169	.77	3569.5	0.30	0.02	Small
Coherence												
It is chaotic here	6	5	96	6	4	65	161	.17	2824.0	-1.37	-0.11	Small
Compatibility												
I have a sense that I belong here	4	6	105	3	6	74	179	.000	2693.5	-3.55	-0.27	Small
Suits personality	5	6	111	5	6	76	187	.56	4016.0	-0.58	-0.04	Small

Table 4. Hierarchical linear regression analysis of perceived restorativeness (this was expressed as mean scores of the combined seven PRS items, which were retained for analysis from Q3) (adjusted $R^2 = -.008$). A significant regression equation was not found ($F(11, 85) = .934$, $p > .05$).

Independent variables	***Perceived restorativeness***			
	B	**SE**	**β**	***t (p)***
Age	.009	.050	.019	.174 (.862)
Gender	.199	.182	.118	1.093 (.278)
Education	.066	.068	.113	.984 (.328)
Political values	-.060	.059	-.119	-1.005 (.318)
Membership of wildlife org.	.213	.180	.131	1.184 (.240)
NEP	.113	.138	.096	.816 (.417)
Location	.045	.226	.027	.200 (.842)
Length of residency/ familiarity	-.077	.055	-.188	-1.412 (.162)
Coastal residency	.151	.227	.092	.666 (.508)
Current storm risk perception	-.064	.140	-.066	-.457 (.649)
Future storm risk perception	-.003	.074	-.006	-.046 (.964)

4.3. What changes do people perceive on the coast and what predicts perceived risk from storms and coastal floods?

All perceived change items in Q7a differed significantly across the two study sites, except for "hotter weather and droughts" (**Table 6a**). Spurn had the greatest number of lower scores for each variable, (as indicated in the mean rank scores), with the extent of erosion change, coastal flooding and storms perceived to be significantly worse at Spurn than at Silverdale. Perceived change through hotter weather and droughts was minimal and not significantly different between the two study sites, with median scores indicating that this had "neither worsened nor improved."

The effects of physical changes on enjoyment of the study areas were perceived to be significantly worse at Spurn than at Silverdale (**Table 6b**). Spurn had the greatest number of lower scores for each variable. Negative physical change corresponded with negative impact on area enjoyment.

Biodiversity changes were perceived to be minimal, but differed significantly between the study sites; whilst positive at Silverdale (wildlife biodiversity *M* = .32, SD = 1.08, plant biodiversity *M* = .24, SD = 1.00), changes were perceived to be negative at Spurn (wildlife biodiversity *M* = -.07, SD = 1.29, plant biodiversity *M* = -.19, SD = 1.20). Concurrent with perceptions of biodiversity change, effects on enjoyment differed significantly across the two study sites and were positive at Silverdale (wildlife biodiversity *M* = .31, SD = 1.12, plants biodiversity *M* = .34, SD = 1.02) and negative at Spurn (wildlife biodiversity *M* = -.34, SD = 1.16, plants biodiversity *M* = -.16, SD = .97).

Four principal themes were identified in the open responses to "what changes have you noticed in the area since you started living/ visiting here?" These divided into physical changes (N = 126), social changes (N = 92), no perceived change (N = 17) and biodiversity changes (N = 8; see Appendix Two for full list of themes).

Within the physical changes, erosion was the principal change cited. At Spurn, erosion to infrastructure and consequent impeded access along the peninsula was frequently referenced (N = 17); for example, following storm breach, *"the point is quite inaccessible."* Saltmarsh change (N = 27), primarily erosion (N = 15), was also frequently cited, almost solely at Silverdale (only one respondent at Spurn referred to *"extension of the salt marsh"*). Two respondents alluded to the effects of storms on saltmarshes in terms of erosion and deposition of debris. Some understanding of saltmarsh dynamics in Morecambe Bay was evident as one respondent alluded to the saltmarsh erosion as *"natural progression and not irreversible."* Differing perception of the saltmarsh environment in Morecambe Bay was evident in the wording of responses; apparent concern for the "*drastically*" eroded saltmarsh and "*major erosion of saltmarshes around Carnforth and Silverdale,*" contrasting with "*the grass (Spartan) that has grown on the shore at Grange-over-Sands – not pleasant."* Erosion of beaches was also a notable change (N = 3). The dynamic nature of the coastline was further alluded to in the reference to changing estuarine river channels in the Bay (N = 10). Accretional changes were alluded to (N = 2), in terms of *"silting up"* of estuarine channels and *"build up of mud flats"*. A sense of loss and a need to adapt to the dynamic nature of the coastal environment were evident at Spurn in *"erosion has taken so much away. You have to adapt to constant change.*"

In comparison to the landscape changes (N = 103), meteorological changes which may have some influence on their development, were far less frequently cited (N = 23). Increased flooding incidence (N = 3) and consequent construction of flood defences (N = 3) were noted. One respondent at

Silverdale noted*, "Climatically it feels "stormier" – but I have no scientific evidence of changes in climate/ weather."*

Biodiversity changes were only minimally cited, with one respondent at Spurn alluding to *"seasonal changes in species."* Biodiversity changes at Silverdale frequently encompassed *"increases in birdlife,"* with *"new wetland creation"* cited as the reason for this increase by one respondent.

In addition to the physical and biodiversity changes identified, social changes were a principal theme in the open responses, primarily regarding change associated with visitors and tourism. Increases in visitor numbers were the main social change identified (N = 17), although one respondent at Silverdale noted that whilst an increase was evident here, a concurrent decline in the popularity of nearby Morecambe as a seaside resort was also evident.

Changes in facilities associated with increased tourism and increased education/ promotion of the coast were noted. Increased diversity of businesses (N = 5) and consequent loss of "*local*" shops, in favour of more tourist-oriented business was also apparent (N = 4). Demographic changes in terms of increasing affluence (N = 2) and greater numbers of families in the area (N = 3) were mentioned and a concurrent increase in building development (N = 7) was noted at Silverdale. Conversely at Spurn, whilst increases in visitor numbers were cited (N = 2), a reduced sense of community was also noted (N = 2), along with *"less socialising in the area."*

Table 5. Results of independent-samples Mann-Whitney U tests, to compare differences between respondents at Spurn and Silverdale, with regard to a) the extent of perceived physical and biodiversity changes over the time that they had known the study areas, and b) the effects of these changes on their enjoyment of the areas. Shaded variables indicate significant (p< .05) differences between responses from Spurn and Silverdale.

a) Extent of change perceived	***Silverdale***				***Spurn***				***Combined***					
	Median	**Range**	**N**	**Mean rank**	**Median**	**Range**	**N**	**Mean rank**	**Total N**	***p***	***U***	***z***	***r* (effect size) $r = z/\sqrt{N}$**	**Cohen's classification**
Erosion	-1	6	97	87.73	-3	6	49	45.34	146	0	996.5	-5.99	-0.50	Large
Coastal Flooding	0	6	97	82.60	-2	6	44	45.43	141	0	1009	-5.308	-0.45	Moderate
Storms	0	4	93	75.57	-1	3	44	55.11	137	0.002	1435	-3.102	-0.27	Small
Hotter weather & drought	0	5	93	70.82	0	6	42	61.76	135	0.094	1691	-1.672	-0.14	Small
Amount & range of wildlife	0	6	97	76.95	0	5	46	61.55	143	0.024	1750.5	-2.253	-0.19	Small
Amount & range of plants	0	6	93	73.44	0	5	43		136	0.014	1540	-2.452	-0.21	Small

b) Effects of change on enjoyment of the area	***Silverdale***				***Spurn***					***Combined***				
	Median	**Range**	**N**	**Mean rank**	**Median**	**Range**	**N**	**Mean rank**	**Total N**	***p***	***U***	***z***	***r* (effect size) $r = z/\sqrt{N}$**	**Cohen's classification**
Erosion	0	6	97	86.05	-1	3	49	48.65	146	0	1159	-5.792	-0.48	Moderate
Coastal flooding	0	5	98	84.12	-1	3	47	49.81	145	0	1213	-5.365	-0.45	Moderate
Storms	0	4	93	77.73	0	3	46	54.38	139	0	1420.5	-4.142	-0.35	Moderate
Hotter weather & droughts	0	5	91	66.48	0	4	39	63.21	130	0.469	1685	-0.725	-0.06	Small
Amount & range of wildlife	0	6	95	75.53	0	5	44	58.07	139	0.007	1565	-2.685	-0.23	Small
Amount & range of plants	0	6	94	73.76	0	5	43	58.59	137	0.012	1573.5	-2.507	-0.21	Small

In survey Q8, participants indicated only a moderate degree of current risk perception, with a mean score of 2.13 (SD = .92) /*Mdn* = 2.00, range = 3) indicative that the study sites were “somewhat” at risk from storms and coastal floods. Current perceived storm risk was significantly higher at Spurn (*Mdn* = 3, range = 2) than at Silverdale (*Mdn* = 2, range = 3), $U = 8108.5$, $z = 9.253$, $p < .001$, $r = .66$. This difference in risk perception between study sites is reflected in **Table 6a**, where hierarchical linear regression analysis shows the only significant predictor of perception of current risk from storms to be location, when controlling for the effects of age, gender, educational attainment, political affiliation and environmental values. Lack of direct/ indirect storm experience, as indicated through “I have not experienced any of the above” (p = .09) and perceived adequacy of current coastal protection levels (p = .07) were found to be marginally significant predictors of perceived current storm risk.

Perceived risk of future increased storminess was also moderate overall (*M* = 3.61, SD = 1.40), although significantly greater at Spurn (*Mdn* = 4.00, range = 6) than at Silverdale (*Mdn* = 4.00, range = 6), $U = 5869.0$, $z = 3.43$, $p < .01$, $r = .25$. None of the independent variables were significant predictors of perceived future increases in storminess (**Table 6b**), although climate change scepticism was marginally significant *p* = .08)**.**

Table 6. a) Hierarchical linear regression analysis of perceived current storm and flood risk, as measured in Q8 (adjusted $R^2 = .354$). A significant regression equation was found ($F(22, 46) = 2.695$, $p < .01$). **b)** Hierarchical linear regression analysis of future storm and flood risk to the coast, as measured in Q12 (adjusted $R^2 = .200$). A significant regression equation was found ($F(22, 47) = 1.784$, $p < .05$). Shaded cells highlight significant predictors within the models *($p < .05$)*.

Independent variables	***a) Perceived current storm risk***				***b) Perceived future storm risk***			
	B	**SE**	**β**	***t (p)***	**B**	**SE**	**β**	***t (p)***
Age	-.058	.052	-.134	-1.118 (.269)	.012	.094	.017	.130 (.897)
Gender	-.010	.189	-.006	-.052 (.959)	.135	.343	.048	.393 (.696)
Education	-.069	.070	-.127	-.985 (.330)	.103	.127	.115	.811 (.422)
Political values	.020	.085	.036	.236 (.815)	-.009	.153	-.010	-.059 (.953)
Membership of wildlife org.	-.005	.219	-.003	-.024 (.981)	.505	.383	.183	1.319 (.194)
NEP	-.037	.152	-.031	-.244 (.808)	-.029	.277	-.015	-.106 (.916)

Location	.544	.240	.295	2.271 (.028)	.072	.438	.023	.163 (.871)
Length of residency/ familiarity	-.060	.057	-.146	-1.054 (.298)	- .116	.104	-.171	-1.118 (.269)
Coastal residency	-.149	.275	-.083	-.542 (.591)	- .122	.497	-.041	-.246 (.807)
"My home or other property has been damaged by storms"	-.340	.286	-.165	-1.187 (.241)	- .402	.495	-.121	-.811 (.422)
"I have been directly affected by storms, for example through travel disruption or my ability to work"	-.050	.222	-.029	-.224 (.823)	.328	.396	.117	.829 (.412)
"I experienced disruption of essential services, e.g. gas, electricity"	.067	.260	.038	.257 (.798)	.416	.454	.142	.916 (.364)
"Other people within two miles of where I live have experienced property damage from storms"	.037	.253	.023	.147 (.884)	- .260	.463	-.096	-.561 (.578)
"My friends and/or family were directly affected by storm damage"	-.036	.303	-.020	-.119 (.906)	- .194	.523	-.064	-.371 (.712)
"I heard or saw a lot about storm damage on television, radio or in the papers"	.332	.222	.180	1.492 (.142)	.031	.406	.010	.077 (.939)
"I have not experienced any of the above"	-.490	.285	-.209	-1.719 (.092)	- .470	.518	-.121	-.907 (.369)
Perceived physical changes	-.139	.196	-.124	-.706 (.484)	- .295	.352	-.160	-.837 (.407)
Perceived biodiversity changes	-.048	.194	-.053	-.250 (.803)	- .443	.341	-.308	-1.301 (.199)
Impact of perceived physical change on enjoyment	-.067	.282	-.046	-.238 (.813)	- .210	.511	-.086	-.411 (.683)
Impact of perceived biodiversity change on enjoyment	.085	.200	.097	.423 (.674)	.249	.366	.177	.680 (.500)
Climate change scepticism	.141	.114	.204	1.242 (.220)	.363	.205	.318	1.771 (.083)
Adequacy of current protection levels	-.185	.100	-.216	-1.861 (.069)	- .064	.179	-.046	-.356 (.723)

4.4. What measures aimed at protecting the coast from storms are accepted, and what predicts their acceptability?

Current levels of coastal protection were neither considered to be “completely adequate,” nor “completely inadequate” at either study site, but were perceived to be significantly less adequate at Spurn (*Mdn* = 2, range = 5) than at Silverdale (*Mdn* = 3.00, range = 5) $U = 2521.5$, $z = -4.656$, $p < .001$, $r = -.35$. Related-samples Wilcoxon signed rank test revealed soft-engineering protection options (*Mdn* = 4.00) to be significantly more acceptable than hard-engineering ones overall (*Mdn* = 3.33), $T = 1275.0$, $p < .001$, $r = .55$. This trend was also apparent when considering each site individually (Silverdale soft-engineering *Mdn* = 4.00, hard-engineering *Mdn* = 3.00, $T = 4302.00$, $p < .001$, $r = .62$ and Spurn soft-engineering *Mdn* = 4.00, hard-engineering *Mdn* = 3.33, $T = 2265.00$, $p <.001$, $r = .46$.)

Saltmarsh had the highest mean acceptability at Silverdale ($M = 4.03$, SD = 1.04), followed by managed realignment ($M = 3.97$, SD = 1.15), whilst marram grass dune stabilisation had the highest acceptability at Spurn ($M = 4.13$, SD = 1.01), followed by the earth and rock embankment ($M = 3.94$, SD = 1.03). Lowest mean acceptability was assigned to the concrete sea wall at both sites ($M = 2.03$, SD = 1.14 at Silverdale; $M = 2.20$, SD = 1.37 at Spurn). Acceptability of these photo preference coastal protection measures was found to differ significantly at each site (Silverdale $\chi^2(6) = 163.21$, $p < .001$ and Spurn χ^2 $(6) = 111.28$, $p < .001$) Pairwise comparison showed that this difference was due to the significantly lower mean acceptability of the concrete sea wall option, when compared with the other coastal protection options at both sites.

Table 7. Results of independent-samples Mann-Whitney U to test significance of difference between acceptability of coastal protection measures at Spurn and Silverdale. Shaded variables indicate significant ($p < .05$) differences between responses from Spurn and Silverdale.

Coastal protection measures	***Silverdale***				***Spurn***				***Combined***					
	Median	**Range**	**N**	**Mean rank**	**Median**	**Range**	**N**	**Mean rank**	**Total N**	**P**	**U**	**Z**	**r (effect size) $r = Z/\sqrt{N}$**	**Cohen's classification**
Concrete sea wall	2	4	112	95.54	2	4	81	99.02	193	.651	4372	-.452	-0.03	Small
Managed realignment	4	4	116	106.62	4	4	85	93.34		.094	4278.5	-1.676	-0.12	Small
Rock groynes	4	4	116	92.99	4	4	84	110.88		.025	4000.5	-2.236	-0.16	Small
Beach nourishment	4	4	115	96.27	4	4	83	103.98		.334	4401	-.966	-0.07	Small
Earth and rock embankment	4	4	114	94.05	4	4	83	105.8		.135	4167	-1.496	-0.11	Small
Saltmarsh	4	4	114	101.93	4	4	84	96.21		.464	4511.5	-.732	-0.05	Small
Marram grass	4	4	115	91.71	4	4	85	112.39		.009	3877	-2.616	-0.18	Small

Study area familiarity/ length of residency was the only significant (negative) predictor of coastal protection acceptability (**Table 8**), although perceived biodiversity changes (*p* = .08) and their impact on area enjoyment (.06) were close to statistical significance. Specifically, those resident for longer in the area were less accepting of coastal protection measures.

Table 8. Hierarchical linear regression analysis of acceptability of coastal protection measures (adjusted R^2 = .096). A significant regression equation was not found ($F(24, 43) = 1.298$, $p > .05$). Shaded cells highlight significant predictors within the model ($p < .05$).

Independent variables	***Acceptability of coastal protection measures***			
	B	**SE**	**β**	***t (p)***
Age	-.017	.056	-.043	-.300 (.766)
Gender	-.012	.203	-.008	-.061 (.951)
Education	-.016	.076	-.033	-.205 (.838)
Political values	.012	.099	.023	.117 (.908)
Membership of wildlife organisation	-.253	.239	-.171	-1.057 (.296)
NEP	.009	.160	.008	.057 (.955)
Location	-.104	.267	-.064	-.390 (.698)
Length of residency/ familiarity	-.169	.061	-.465	-2.770 (.008)
Coastal residency	.393	.294	.248	1.335 (.189)
"My home or other property has been damaged by storms"	.077	.308	.043	.251 (.803)
"I have been directly affected by storms, for example through travel disruption or my ability to work"	-.340	.237	-.224	-1.436 (.158)
"I experienced disruption of essential services, e.g. gas, electricity"	-.104	.277	-.067	-.377 (.708)
"Other people within two miles of where I live have experienced property damage from storms"	.306	.277	.209	1.104 (.276)
"My friends and/or family were directly affected by storm damage"	.096	.325	.059	.296 (.769)
"I heard or saw a lot about storm damage on television, radio or in the papers"	.035	.239	.021	.146 (.884)
"I have not experienced any of the above"	.241	.326	.111	.738 (.465)
Perceived physical changes	.069	.211	.070	.326 (.746)
Perceived biodiversity changes	-.374	.208	-.468	-1.796 (.080)
Impact of perceived physical change on enjoyment	-.204	.297	-.157	-.687 (.496)

Impact of perceived biodiversity change on enjoyment	.407	.212	.531	1.922 (.061)
Climate change scepticism	.073	.128	.119	.569 (.572)
Adequacy of current protection levels	-.075	.109	-.100	-.695 (.491)
Current storm risk perception	.122	.160	.137	.761 (.451)
Future storm risk perception	-.015	.088	-.028	-.171 (.865)

5. Discussion

This research was designed to address four key questions. Firstly, the social and psychological values attached to the coast and coastal saltmarshes were examined. Secondly, we sought to determine the predictors of perceived restorativeness and the extent to which this perceived restorativeness was impacted by climate change; namely, through storms and coastal flooding. Thirdly, the physical and biodiversity changes perceived on the coast were examined and the predictors of perceived risk from storms and coastal floods were investigated. Finally, the acceptability of coastal protection measures was examined, along with the predictors of coastal protection measure acceptability.

The following sub-sections are structured by these research questions and consider results in the context of the wider literature. The limitations of the study are discussed and, with these in mind, some implications for study area management are proffered.

5.1. Coastal value and utility

The first aim of this study was to determine the social and psychological values attached to the coast, and to coastal saltmarshes in particular. We found aesthetic beauty, tranquillity and nature experience to be salient values attributed to the coast, which were consistent with the findings of Tunstall and Penning-Rowsell (1998). They found that the undeveloped, naturalistic beach setting, tranquillity and lack of crowds at Spurn Point and also at Dunwich on the Suffolk coast, were a principal appeal for many visitors. Whilst these characteristics could offer an environment suitable for restoration, as was hypothesised in the present study, health and wellbeing value on the coasts at Spurn Point and Silverdale was less frequently cited than recreation through walking and nature tourism.

Environmental values significantly predicted saltmarsh value in this study. This would be anticipated, owing to the close association between people's image of nature and their aesthetic landscape preference (van den Berg and Konijnendijk, 2013). Preference for managed landscapes tends to be associated with anthropocentric values, whilst wilder landscapes are often preferred by those with more ecocentric values (Buijs et al., 2009; Dearden, 1984). Marsh environments, which exhibited little anthropogenic influence, were viewed as typically “natural” by most respondents in a Dutch study (Buijs et al., 2009). Furthermore, members of wildlife organisations may visit nature reserves and “wilderness” areas more often and thus have a greater familiarity with, and subsequent preference for, these landscapes (Dearden, 1984).

Whilst there was no significant difference between the importance of saltmarshes and sand flats to respondents’ wellbeing at Silverdale, the significantly greater value ascribed to sand dune environments at Spurn, when compared to saltmarsh importance, is notable. This could be ascribed to positive experience within a particular environment (e.g. Múgica and de Lucio, 1996); the birdlife associated with mudflats and sandflats may be of importance here. “Greenness” effects in photo preference studies may also influence aesthetic preference (Curado et al., 2014), whereby green canopies evoke greater feelings of calm, when compared with orange, yellow or red foliage (Kaufman and Lohr 2004). Responses to different hues and colour saturation may be based on perceived plant health and inherent landscape value to human health, as proposed in evolutionary survival theory (Kaufman and Lohr, 2004; Orians and Heerwagen, 1992). With this “greenness” effect in mind, we might anticipate that saltmarsh would be seen as an important contributor to enjoyment of the area. Greater perceived colour diversity in the sand dune photograph at Spurn, however, could have enhanced aesthetic preference for this environment type (Kaplan, 1985) when compared with the more homogeneous hues of the saltmarsh and mudflat images.

In partial contrast to previous research (Vaske et al., 2001), in which biocentric values were demonstrated by those with higher levels of educational attainment, education did not significantly predict saltmarsh value in the present study. Curado et al. (2014) found that recognition of the benefits derived from saltmarshes was shown to increase in line with levels of educational attainment in Huelva, Spain, with 75% of survey respondents considering them to be beneficial, despite low knowledge of saltmarsh ecosystem service provision. It may be that personal experience within the landscape is of greater importance in the current study (e.g. Zube and Pitt, 1981; Múgica and de Lucio, 1996), although length of residency/ familiarity with the study areas was not a significant predictor of saltmarsh value. Evidence of familiarity effects in other studies is mixed, however (Morgan and Williams, 1999). An effect of residents versus visitors to the study areas may have been anticipated here (e.g. Kaplan and Kaplan, 1989), although this could, perhaps, be outweighed by the high frequency of respondents at Spurn who identified as visiting the area for the first time or the potential for greater familiarity amongst wildlife organisation members. Similarly, coastal residency did not significantly predict saltmarsh importance. This could suggest that there was not a significant difference between the importance ascribed to saltmarsh environments by those who lived on the coast and those inland.

5.2. Perceived restorativeness

The second question this study sought to answer referred to the predictors of perceived restorativeness on the coast. As expected from previous research (e.g., Wyles et al., 2016), most people perceived the study sites to be restorative, but none of the independent variables used were significant predictors of perceived restorativeness. Consistent with Wyles et al. (2016), we found no effect of demographics on restorativeness. **We also sought to determine the perceived effects of climate change, through storms and coastal flooding, on restorativeness of the coast.** It was anticipated that storms and coastal floods would negatively impact restoration, as previous studies have demonstrated negative correlation between environmental tension/ inclement weather conditions and perceived restorativeness (Ulrich, 1983; White et al., 2010). This study does not reveal such an effect on the coasts at Spurn and Silverdale, as current and future perceived risk from storms and coastal floods did not significantly predict perceived restorativeness. Weather and tidal conditions and numbers of coastal users in the area (e.g. beach crowding) on survey days may, however, have shaped responses (Hipp and Ogunseitan, 2011) and were not measured in the present study. Alternatively, being at a more northerly latitude than coastal areas studied previously (e.g., Wyles et al., 2016), users of the sites studied here may have been more habituated to inclement weather. Additionally, there may be potential for respondents completing surveys onsite to give more emotionally-driven responses, whilst those surveys completed offsite may be more deliberative.

5.3. Perceived change and risk

5.3.1. Perceived change

The third research question sought to elucidate the pertinent changes perceived on the coast during the time in which respondents had known it and also the predictors of perceived risk from storms and coastal floods. The principal changes perceived on the coast divided into physical, social and biodiversity (also, notably, no perceived change). It was hypothesised that environmental changes would be less commonly identified than social changes. Surprisingly, environmental changes were alluded to more often than social changes, principally through the effects of coastal erosion. This may be attributable to the visual prominence of erosion in the landscape, particularly at Spurn, but also through saltmarsh erosion at Silverdale. Saltmarsh change was a notable feature for respondents on the Silverdale coast. This may be due to the cyclic saltmarsh dynamics in Morecambe Bay, whereby erosion of existing marsh or establishment of new areas is primarily determined by river channel movements (Pringle, 1995). These erosive effects can be exacerbated during storm conditions (Adam, 2000), and observable effects of this were noted by some respondents on the Silverdale coast. The saliency of storm effects at Spurn was also likely to have contributed to this appearing to be a more pertinent change for many; in fact, all physical changes were perceived to have worsened more significantly at Spurn than at Silverdale. Biodiversity of plants and wildlife were perceived to have worsened at Spurn, whilst perceived improvement was evident at Silverdale, with increased birdlife often cited in the open responses. Social changes were principally related to changes associated with visitors/ tourism and local demographic changes. The decline of the English seaside resort was a pertinent theme in a study by Jarratt (2013). This contrasts with the apparent popularity and increases in visitor numbers of the coastal areas in the present study.

5.3.2. What predicts risk from storms and coastal floods?

It was hypothesised that women, those with higher education, greater length of residency, direct storm experience and higher environmental values would have a higher perception of risk from storms and coastal floods. Contrary to expectation, location was the only significant predictor of current storm and flood risk, with Spurn perceived to be at greater risk, when compared to the Silverdale coast. This finding was also supported by the perception that current protection levels are less adequate at Spurn than at Silverdale, although this was not a significant predictor of current or future storm risk perception in the regression models. Visual storm impacts, evident in the rate of erosion of the Holderness cliffs (Elliott et al., 2014) and in tidal inundation at Spurn are arguably more immediately apparent than at Silverdale. It is also noteworthy that visitors to Spurn are warned not to cross the peninsula at high tide each day. Visitors would often be informed of the legacy of the December 2013 storm event on arrival at the visitor information centre, drawing attention to the loss of infrastructure and the daily tidal inundation of the neck of the peninsula. This information is also reiterated through onsite signage and a website, to highlight times when it is unsafe to cross (e.g. YWT, 2015). The effect of location in the regression may outweigh other variables, as the hypothesised variables were largely non-significant in the models.

Tunstall and Penning-Rowsell (1998) found that greater awareness of local conditions was reported amongst residents, for whom the coast formed an integral setting for their day-to-day routines. Interestingly, length of residency at Spurn and Silverdale was not a significant predictor of risk perception in our linear regression models, despite being shown to be a principal determinant of perceived risk in previous studies (Burningham et al., 2008; Whitmarsh, 2008).

An effect of media exposure on risk perception would have been anticipated for Spurn, as much national media attention was focused in this area in the aftermath of the December 2013 storm surge (BBC, 2013). Neither direct nor indirect storm experience were significant predictors of perceived storm risk in the study areas, however. This highlights the importance of context with regard to direct exposure to storm impacts at home; this experience is not necessarily translated beyond the immediate locality in the perception of storm risk elsewhere and such storm risk may not therefore, have tangible implications for respondents' personal welfare (Macnaghten, 2003; Whitmarsh, 2008).

5.3.3. Future storm risk perception

None of the independent variables were significant predictors of future storm risk perception in this study. An effect of environmental worldview would have been anticipated, although this was not significant. Direct storm experience does not appear to influence future storm risk perception and is in line with the findings of Whitmarsh (2008) in terms of attitudes towards climate change amongst victims of flooding. These associations could be explained by construal-level theory, whereby local experiences of weather/ flooding events are confined to localised risk perception, whilst climate change is seen as an abstract, distant concept (Trope and Liberman, 2010; Whitmarsh, 2008).

Educational attainment and political values were not significant predictors of perceived future increases in storms and coastal floods in the present study. The interaction between scientific knowledge and political values can enhance climate change scepticism or belief, in that higher levels of educational attainment can facilitate stronger arguments in support of an individual's ideology (Kahan et al., 2012). This may partly explain why a straightforward correlation between education and perceived future increases in storms and coastal floods is not apparent.

5.4. Acceptability of coastal protection measures

As predicted, soft-engineering protection measures were considered significantly more acceptable than hard-engineering options. The high mean acceptability of saltmarsh, managed realignment and dune stabilisation in this study, compared to concrete sea walls contrasts with observations of Tunstall and Penning-Rowsell (1998). They found minimal acceptance for allowing natural coastal processes to occur unimpeded and promoting resilient, "natural" functioning in the coastal environment; whilst study sites were valued for their perceived "naturalness," respondents preferred the use of hard protection measures, in a "hold-the-line" mentality (Tunstall and Penning-Rowsell, 1998). This notion of maintaining a fixed coastline is widely held in the Netherlands, where a 1990s baseline coast is maintained through a policy of "Dynamic Preservation," in response to the devastating storm surge of January 1953 (Koster and Hillen, 1995). However, there is no significant effect of direct and indirect storm experience on acceptability of coastal protection measures in the present study. A potential explanation for the partial inconsistency between the results of our study and those of previous research could be the prominence of aesthetics in decision-making; a photo preference method was adopted and "greenness" effects may play a role in acceptability ratings here (Curado et al., 2014). Whilst some respondents may have a "hold-the-line" mentality when asked to compare a naturalistic option, such as saltmarsh or sand dune conservation, with a concrete sea wall, the aesthetic appeal may well outweigh other rationales. This also corresponds with the clear distinction between built and natural scenes in photo preference studies where perceptual differences reflect perceived prevalence of human influence (Kaplan, 1985).

Length of residency/ area familiarity significantly predicted acceptability of coastal protection measures in the present study. The negative relationship between the variables is in line with previous research on place attachment theory, whereby those who are less attached to the area are more accepting of landscape changes compared to established individuals with greater place attachment and a greater resistance to change (e.g. Devine-Wright and Howes, 2010). Perceived biodiversity change on the coasts around Spurn Point and Silverdale was close to significant in predicting coastal protection acceptability in this study and corresponds with the greater acceptability of soft-engineering protection measures. This might be indicative of respondents considering the environmental implications of the different hard- and soft-engineering management options and suitability within the context of the local environment. This role of perceived change in biodiversity is supported by the joint most-cited reason for living on/ visiting the study coastlines being for wildlife and birdlife. It is important to note, however, that reasons for respondents' choices were not elicited directly in the survey. This central relationship between aesthetics and ecology in landscape preference was discussed by Gobster et al. (2007) through "ecological aesthetics." They concluded that consideration of future aesthetics in landscape management planning can be a powerful tool to attain ecological targets.

5.5. Limitations and further research

The relatively small sample size, the fact that the sample was somewhat older and more highly educated than the national average, and the case-specific nature of this study may limit the scope to generalise research findings to other areas of the UK coast, or non-UK settings. Owing to the multiple methods of survey distribution, it was unfortunately not possible to estimate response rate, and the samples may be inherently susceptible to a degree of self-selection bias. With regard to comparability of the two samples, it is acknowledged that the greater proportion of "local" respondents at Silverdale, and the consequent likelihood of greater familiarity with the study area, when compared with Spurn, will have the potential to affect responses. The contexts of the individual study sites, e.g. through landscape type and consequent risk posed to the coast by storms, erosion and flooding will also shape responses as it affects the individual's aesthetic experience within the landscape. The context of different personal/ social situations would likely influence an individual's experience, particularly with regard to restoration. Whilst these are limitations of the datasets, it has been demonstrated that other demographic characteristics between the samples do not differ significantly, or do not have a significant relationship with sampling location, which does improve confidence in their comparability.

It should be noted that the effects of in-situ survey completion compared to postal responses were not tested for in the analysis, yet the potential for significant difference between onsite and recalled perceived restorativeness could be worthy of consideration. Additionally, the use of photo-preference questions to elicit perceptual responses may have skewed responses towards the aesthetic level. Future research could therefore apply more deliberative techniques, in order to consider positive and negative attributes of different management options with the public, to gain insights beyond aesthetic value.

Some implications for study area management, do, however, arise from this research. Whilst public acceptability of more natural protection may appear to be important, the protection of key coastal infrastructure, such as the North Sea gas terminal at Easington, to the north of Spurn, from the effects of climate change is a clear priority for coastal management, as evident in the SMP2 for Spurn. This is also a pertinent issue for areas of the UK coast, in which nuclear power and waste reprocessing plants are situated, for example. Based on our findings, highlighting the aesthetic value of future coastal protection strategies and encouraging transparency regarding their ecological implications could help to gain greater public support for initiatives. In so doing, due concern should be given to the potential for such developments to impact negatively on place attachment and psychological restorativeness (Devine-Wright and Howes, 2010). Exploring the spatial correlation of perceived value and risk in the coastal zone at Spurn Point and Silverdale could provide further evidence to help prioritise resources for effective adaptation to and mitigation of climate change effects in a manner that is supported by the public.

6. Conclusions

This study has reported novel, empirical insights into coastal experience, perceived restorativeness and perceptions of change and risk from two UK coastal regions. These findings contribute to the fields of restoration and risk perception and could also help to support effective and democratic management in the coastal zone.

Environmental values significantly predicted saltmarsh importance to wellbeing in the study areas, yet saltmarsh did not rank highly in terms of its importance to participants' enjoyment of the areas, when compared to other coastal environments. In order to increase public awareness of saltmarsh benefits, it would therefore be advisable to develop environmental education strategies (e.g. Curado et al., 2014), whether through onsite interpretation boards or through other educational initiatives and workshops.

Both coastal regions were perceived to offer potential for restoration and we found that climate change impacts did not significantly predict perceived restorativeness. This restorative potential could be further enhanced through collaboration with health professionals to develop strategies which promote both psychologically and physiologically restorative experiences (White et al., 2010). Such programmes should clearly be tailored to both local and visiting populations.

Location was a significant predictor of current perceived storm and flood risk. Contrary to previous research, other variables used were not significant predictors of future perceived storminess risk. This study has also demonstrated the prominence of contextual factors in risk perception; storm experience at home does not necessarily translate to perceived risk on the coast, or to perceived future increases in storminess.

Soft-engineering protection measures were considered most acceptable at both study sites, as hypothesised. The pertinence of place attachment, aesthetics and, to some extent, perceived changes in biodiversity, have been highlighted in considering acceptability of coastal protection. Publicising these attributes in future coastal protection strategies may gain greater support in a climatically and politically dynamic time.

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Chapter 4. Spatial correlation of perceived value and risk from coastal storms

4.1. Preface

Consideration of non-monetary value in the coastal landscape is key to inform effective management on the coast (Clayton et al., 2015), particularly given the threat of changes in the frequency and magnitude of storms and coastal floods, due to global climate change. Valuing the environment is considered a prerequisite of action to protect it in principal psychological models of pro-environmental behaviour (Stern, 2000). The spatial dimensions of perceived value and risk have received limited attention, however, particularly on the UK coast. Divergence in expert and lay risk perceptions has been consistently demonstrated (Slovic, 2000), yet local communities may be able to contribute knowledge to the benefit of experts (Wynne, 1991). The geographic dimensions of lay risk perception and expert assessment have received little research attention, particularly on the UK coast.

This chapter further explores data obtained through the survey discussed in Chapter Three and focuses on the results of a participatory mapping exercise and accompanying open-response questions. Spatial analysis through kernel density mapping allowed hotspots of value and risk in the landscape to be identified, which may be used to guide effective resource allocation in the coastal zone. Considered alongside qualitative data, these provide a rich insight into perceptions of value and risk in the landscape. Spatial correlation between areas of perceived value and of perceived risk from storms and flooding in the landscape is examined. The perceptions of risk in the built and natural environment are compared. Correlation between expert-assessed flood risk maps and public-perceived storm and flood risk are explored. In light of the importance of place attachment in coastal protection measure acceptability in Chapter Three, the value and risk perceptions of residents and visitors to the study sites are also compared.

AUTHOR CONTRIBUTIONS

I declare that the work submitted is my own. The contributions by co-authors were as follows:

Lorraine Whitmarsh: Supervision, support in research design, review and editing

Katherine Selby: Supervision, review and editing

4.2. References

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Chapter 4. Spatial correlation of perceived value and risk from coastal storms

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ABSTRACT

Global climate change poses risk to the environment and to society on the coast, due to sea-level rise and projected increases in storminess (storm frequency and magnitude). The numerous benefits derived from coastal environments range from coastal protection, which can be quantified economically to psychologically restorative benefits to wellbeing. Consideration of non-monetary value and risk in the landscape is needed to inform democratic and integrated coastal zone management (ICZM). The spatial dimensions of value and risk on the coast have been little explored, however. This study gives novel, empirical insights into value and risk on the coast, discussing the results of participatory mapping from a survey of coastal visitors and residents from two sites on the east and west coasts of the UK. Sampling took place between March and December 2015 (N = 211). Through use of Geographical Information Systems (GIS)- and qualitative analyses, the spatial relationship between value and risk from storms and flooding on the coast was examined. Particular focus was given to the built and natural environments, correlation between expert-assessed and public-perceived risk, and the perceptions of residents and visitors

Significant negative correlation was found between perceived coastal value and risk at Spurn and Silverdale. The natural environment was generally perceived to be at greater risk than the built environment at both study sites, with foreshore regions perceived to be at greatest risk. Foreshore and saltmarsh landcovers were perceived to be at greater risk than urban regions at Silverdale, whilst both these landcover types accounted for equally low frequencies of perceived risk points at Spurn. A significant negative spatial correlation was found between expert-assessed and public-perceived risk at both sites. As was hypothesised, significant negative correlation was found between visitor- and resident-perceived risk and also value between these subgroups. Our findings suggest a potential need to increase storm- and flood- risk awareness amongst the public at the study sites.

Keywords: Risk perception; coasts; storms; values; climate change risk;

1. Introduction

Successfully responding to the impacts of a changing climate and understanding the implications for cultural ecosystem services (CES) or benefits from nature, upon which society depends, requires consideration of climate change risk perception and the consequences for human wellbeing (e.g. Clayton et al., 2015; Millennium Ecosystem Assessment, 2005; National Research Council, 2008). Consideration of CES is integral to landscape management, which transcends institutional boundaries (Plieninger et al. 2015). This issue is particularly pertinent on the coast, where risks posed by rising sea levels and increasing storminess affect low-lying ecosystems in a densely-inhabited area, with multiple-use pressures (O'Riordan et al., 2014). Of these coastal ecosystems, saltmarshes are a principal first line of protection in storm and flood risk reduction (Spalding et al., 2014). Increasing storminess may impact these ecosystems through increasing rates of deposition (e.g. de Groot et al., 2011) or erosion (e.g. Adam, 2000), the latter of which may threaten marsh integrity and ecosystem service provision.

A psychological perspective offers an important contribution to integrating research in the natural and social sciences (Clayton et al., 2015). Whilst value is often considered economically in Integrated Coastal Zone Management (ICZM), consideration of non-monetary value and perceived risk in the landscape is particularly important to inform effective management priorities and trade-offs in the coastal zone (Klain and Chan, 2012; Roe, 2000). For example, dominant psychological models of pro-environmental behaviour assume that a prerequisite of action explicitly to protect the environment is valuing the environment (Stern, 2000). Landscape values partly determine perceived climate change risks (Raymond and Brown, 2011), although few studies have investigated this relationship. Perception of where climate change risk is greatest (i.e. built or natural environments) can also vary markedly on the coast, with political ideology cited as a determining factor (e.g. Smith et al., 2016).

Much evidence points to an "expert-lay divide" on a range of technical and scientific issues (Lidskog, 2008), and studies have consistently shown differences between public and expert risk perceptions (e.g. Slovic, 2000). Yet, very little research has explored the spatial/ geographical dimensions of expert assessment and lay risk perception, including on the UK coast which is particularly at risk from climate change impacts (e.g., erosion, floods). Whilst management transcends institutional boundaries in the coastal zone, there is insufficient agreement between policy and administration at the local, national and international levels, which, paradoxically, hinders approaching ICZM in an integrated, holistic and long-term manner (Roe, 2000).

This paper offers novel insights into the spatial relationship between perceptions of value in the coastal landscape and of perceived risk from storms and flooding in two UK coastal regions. The results presented further our understanding of perceptions of value and risk on the coast in the built and natural environments, between visitors and residents and between expert risk assessment and public perception. This methodology also allows priorities for landscape management to be identified, in order to inform effective regional resource management in a changing climate.

1.1 Perception of value on the coast

The cultural value attributed to the coast is well established (White et al., 2010) and is reflected in the economic importance of coastal tourism to the UK economy. A substantial array of recreational, educational, aesthetic and spiritual benefits is offered by the coast; services which are fundamental to human wellbeing (Millennium Ecosystem Assessment, 2005). The coast has become an established destination for health and wellness since the Victorian era, and an increasing body of evidence demonstrates the restorative benefits of the coastal environment (e.g. White et al., 2010, 2013; Wyles et al., 2016).

Areas to which perceived value is ascribed may differ between residents and visitors, as local value can be attached to areas, which may otherwise be overlooked by visiting populations (e.g. Kaplan and Kaplan, 1989). Through participatory mapping and structured interviews with 93 people, Plieninger et al. (2013) found that the built environment was valued more highly by the local population of the Guttau municipality, East Saxony, Germany, on account of attachment through social networks, whilst visitors would principally value more natural environments for scenery and recreation.

Perceptions of value within the landscape were found to partly determine perceived risk in a study by Raymond and Brown (2011). They used a participatory GIS methodology to examine the spatial associations of perceived landscape values and risks from climate change in the Southern Fleurieu Peninsula, South Australia. Vector and raster-based methodologies through Jaccard coefficients and spatial cross-correlations revealed a strong positive spatial relationship between areas of biodiversity and intrinsic value and risk of biodiversity loss in the landscape. Value attributed to recreation was also shown to have strong positive spatial association with risks posed by rising sea levels, wave action and riparian flooding. However, little to no correlation was found between other landscape values and perceived climate change risk (Raymond and Brown, 2011). Wyles et al. (2014) took a novel approach to considering the effects of coastal visits, both on the wellbeing of coastal users, and the impacts of these visits on the coastal environment itself. Through use of questionnaires, sampling marine experts and a convenience sample of coastal-users through Plymouth University and international conference delegates, a positive correlation was found between value and risk during visits to rocky shores. These correlations were examined using all respondents' data, and then differences between marine experts and coastal users were explored.

While some studies have explored coastal values and others perceived risks on the coast, little research has explored the relationship between these variables. Of those studies that have examined this relationship, positive correlation has been found (e.g. Raymond and Brown, 2011). This relationship has not, as yet, been explored with regard to storms and coastal flooding in the UK.

1.2. Coastal risk perception

Storms and coastal flooding may pose a threat to the restorative benefits derived from the coastal environment. Yet, whilst the public largely acknowledges that a relationship exists between climate change, extreme weather and flooding, concern has not kept pace with the growth in awareness and there are doubts regarding severity or even reality of climate change in many developed nations (Capstick et al., 2015; Jenkins et al., 2009). The saliency of economic and social change on the coast may be prioritised over environmental risks, as the latter are often perceived to be more psychologically distant (Lorenzoni et al., 2007; Trope and Liberman, 2010). Furthermore, as worry increases regarding pertinent risk to an individual, concern for other risks decreases, suggesting a limited capacity to deal with numerous concerns (cf. the 'finite pool of worry hypothesis'). If environmental concerns are not a high priority, addressing other risks is likely to take precedence (Weber, 2010). Even those who have been directly affected by flooding may not express greater climate change concern (Clayton et al., 2015).

Place and experience play a key role in flood risk perception, as found in a longitudinal study of two flood-affected communities in Oxfordshire, England over a four-year period (Tapsell and Tunstall, 2008). They examined long-term effects on health, and the effectiveness of support and of recovery in the aftermath of the flooding event through a qualitative approach. Additionally, perceptions of flood risk over this time period were investigated, along with the effect of a new flood protection scheme in one of the study communities on perceptions of future flood risk. The majority of respondents had negatively impacted psychological health four years following the flood event.

Length of residency and the frequency and temporal proximity of flood events experienced may also determine flood risk perception. Burningham et al. (2008) assessed flood vulnerability of groups within the population through secondary analysis of quantitative and qualitative data from two Environment Agency flood risk projects. This study focused solely on awareness of whether property was located in a flood risk area. Where a substantial period of time had elapsed since the last flood event, this was found to "nullify" the perception of future flood risk to some extent.

The ease with which such events can be recalled affects their perceptual salience and, consequently, perceived risk may be influenced by media coverage; a literature focus on western nations, particularly in the US appears to mask growing international concern about climate change (Capstick et al., 2015).

At Spurn Point and Silverdale, UK, location was a significant predictor of perceived risk from storms and coastal floods and length of residency significantly predicted acceptability of coastal protection options (see Chapter Three). As such, exploring these attributes spatially is a particular focus in this paper.

A positive relationship between flood risk perception and flood experience was in line with much previous literature in a study of flood risk perception and preparedness in Switzerland (Siegrist and Gutscher, 2006). Also, on the Belgian coast, through a survey aimed at residents and tourist, Kellens et al. (2011) found that participants who lived in “high” flood risk areas had higher perceived risk than those in areas of low expert-defined flood risk.

1.2.1. Perceived risk to the built and natural environments

Differences exist between perception of climate-related risk to the built and natural environments in the coastal zone. Both of these environment types are valued for diverse reasons, but different people have different views (e.g. Elrick-Barr et al., 2015). Political ideology has been proposed to determine these differences (Carlton and Jacobson, 2013; Smith et al., 2016), whereby liberal participants identified biotic impacts faster than conservative respondents, whilst conservative respondents more readily identified impacts to the built environment (Smith et al., 2016).

1.3. Public and expert risk perceptions

Along with location, experience and ideology, a further important determinant of risk perception is expertise. Differences have been shown between public and expert perception of risk, however little empirical evidence has directly addressed climate change risk perception between lay-public and climate scientists (Weber, 2010). As discussed in section 1.2, there is a propensity for underestimating climate risks amongst the public, in contrast to most risk issues which are often amplified by the public (e.g. Kasperson et al., 1988). From a theoretical perspective, different explanations have been proffered for expert-lay differences in risk perception; these include experiential- versus analytic, model-informed perception (Weber, 2010) and different levels of exposure to risks, such as the ‘white male effect’ (Finucane et al., 2000; Palmer, 2003). Factors influencing public perceptions include affect, place identity, values, knowledge, experience, social and institutional factors (e.g. trust), while these factors are likely to be less influential (though not absent) in experts’ risk assessments (Sjoberg, 2000).

On the other hand, there is debate regarding the ‘expert-lay divide,’ and whether the two constructs are, in fact, meaningfully distinct, particularly with the increasing power of citizen science and the reflexive power of the public to evaluate the scientific "facts" (Lidskog, 2008). Indeed, one study in Switzerland, found public risk perceptions were highly correlated with expert risk assessments, whereby those living in areas designated at high risk from flooding had a higher perception of coastal flood risk, compared to those living in areas of low assessed flood risk. This highlights the importance of distinguishing different groups within the public; indeed, many contest the notion of a single 'public' (Wynne, 1991). Local communities may have unique insights to risk issues affecting them that experts are not aware of, highlighting the need to elicit and utilise (local) public views in risk management (Wynne, 1991).

However, while research has shown that local versus distal communities may have different risk perceptions, very little research to date has explored whether different areas are seen as more at risk or are valued differently by experts and publics. Furthermore, expert-lay differences in coastal storm and flood risk perception have yet to be explored spatially in the UK.

1.4. Research questions and hypotheses

The current research builds on the nascent research discussed above to address the following questions:

1. *Do areas of greatest perceived value coincide with those of greatest perceived risk?*

   H1: Some spatial association between values and perceived risks from storms and flooding is anticipated in the coastal zone at Spurn Point and Silverdale, (e.g. Raymond and Brown, 2011).

2. *Are low-lying coastal environments perceived to be at greatest risk from storms and coastal floods, or are neighbouring more densely populated towns, villages and urban infrastructure perceived to be at greatest risk?*

   Evidence from previous research is mixed and it is therefore difficult to hypothesise a clear-cut distinction between risk perception in the natural and built environments.

3. *Is there a correlation between expert-assessed and public-perceived risk from storms and coastal flooding in the landscape?*

   H2: Whilst divergence between expert-assessed and public-perceived risk is predicted. When considered from a spatial perspective, however, a positive spatial correlation would be anticipated between expert risk assessment and lay risk perception (Kellens et al., 2011; Siegrist and Gutscher, 2006).

4. *How do the perceptions of local residents and visitors to the study areas compare?*

H3: Resident and visitor perceptions are predicted to diverge, based on the results of Chapter Three. Geographical/ spatial variance would be expected, (e.g. Kaplan and Kaplan, 1989), whereby residents may hold greater value for certain areas through their place attachment.

2. Materials and methods

2.1. Study areas

This paper focuses on the UK coast, namely Silverdale and Spurn Point on the west and east coasts of England **(Figure 1)**. The Silverdale coast in this paper refers to an area which includes the Arnside and Silverdale Area of Outstanding Natural Beauty, which is situated in Morecambe Bay, on the northwest coast of England. Spurn Point is a spit of shingle and sand, which is located at the mouth of the Humber Estuary on the east coast. Both areas include saltmarsh and mudflat/ sandflat environments and have experienced the effects of storms and flooding; notably in recent years, the 5 December 2013 storm surge which had significant, yet highly variable effects at both locations.

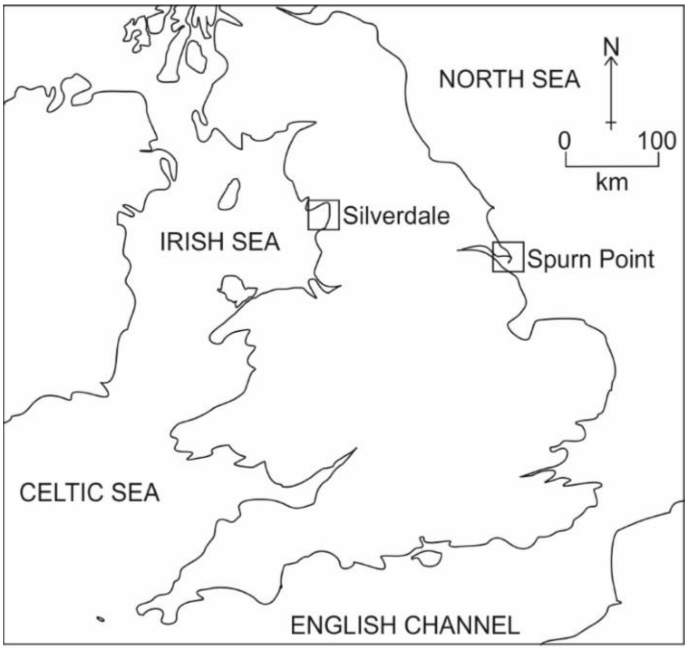


Figure 10. Map depicting the study areas on the Silverdale coast, Morecambe Bay and at Spurn Point, Humber Estuary, UK.

2.2. Participants

Across the study sites, 211 survey responses were obtained (Spurn Point = 86, Silverdale = 125). Survey participants were primarily female (59.7%) and more qualified than the national average, as

29.6% held a degree or equivalent and 28.1% had postgraduate qualifications. Whilst Silverdale respondents were principally resident in the area, the majority of respondents from Spurn were visitors. Greater familiarity with the study areas may be anticipated at Silverdale as 51.0% of visitors visited several times a year, whilst 52.2% of visitors were visiting for the first time at Spurn. Further discussion of the sample demographics is presented in Chapter Three.

2.3 Design and methods

This paper discusses spatial data on perceived value and perceived risk from storms and coastal floods, which were collected through two participatory mapping exercises from the Coastal Experience Survey. The survey comprised ten pages of qualitative and quantitative questions; the sampling methodology and results of which are reported in Chapter Three.

2.4. Materials and measures

See Chapter Three, section 3.4.1 and section 3.4.4 for details of the value and risk mapping exercise design for Q4 and Q9 of the survey. Copies of the surveys are included in Appendix One. The value and risk perception spatial data are used to address all four research questions. Additionally, secondary datasets from the Environment Agency (EA) and Ordnance Survey (OS) were used to address research questions two and three. These datasets and their analysis are discussed in the subsequent sections.

2.4.1. Environment Agency (EA) "expert-defined" flood risk

Shapefile data from the EA "Risk of flooding from Rivers and Sea (RoFRS)" database (available at: https://data.gov.uk/dataset/risk-of-flooding-from-rivers-and-sea1) were used to represent "expert-assessed" flood risk, to answer the third research question. The EA datasets divide up the English floodplain into 50m cells, each of which has been assigned one of four categories of flood risk likelihood (see **Table 1** for the definitions of flood risk likelihood). These assessments of flood risk account for the presence and condition of defences. Cells in which the likelihood of flooding is greater than 1 in 75 (1.3%) are identified in the dataset as these have been defined as "significant" in the Statement of Principles agreement between the British Government and Associated British Insurers. Confidence levels have been calculated for each cell based upon model performance and the quality of the input data. These data have been validated using EA local knowledge and expertise. It is for this reason that the data were chosen to facilitate a comparison of "expert-assessed" and public-perceived risk on the coasts at Silverdale and Spurn.

The area defined as the Silverdale coast in Morecambe Bay was encompassed in the EA RoFRS dataset by tiles 7400 Esk and Ehen, 7300 Leven and Kent, and 7200 Lune and Wyre; these tiles comprised the 2009/10 catchment update clipped to the August 2012 extreme flood outline. Spurn Point and the Humber Estuary were covered by tiles 2600 Hull, 2902 Grimsby and Ancholme, and 2901 Louth. The Hull tiles comprised May 2016 local model updates clipped to the November 2014 extreme flood outline; the Grimsby and Ancholme tiles were derived from 2009/10 catchment update clipped to the August 2012 extreme flood outline. Louth used March 2013 local model updates clipped to the August 2012 extreme flood outline.

Table 1. Environment Agency flood risk categories and their definitions, representing the likelihood of flooding each year.

EA risk categories	**Definition**
High	>1 in 30 (3.3%)
Medium	1 in 30 (3.3%) to 1 in 100 (1%)
Low	1 in 100 (1%) to 1 in 1000 (0.1%)
Very low	<1 in 1000 (0.1%)

2.5. Data analysis

2.5.1 Digitisation and analysis of survey data

2.5.1.1. Inputting point data layers of perceived value and risk

Value and risk point data from the Spurn and Silverdale Coastal Experience Surveys were input into ArcMap 10 in the British National Grid co-ordinate system. Despite mapping instructions explicitly asking for a single point of greatest perceived value (Q4a) and of greatest perceived risk (Q9a), these questions yielded a variety of response types. These were categorised into multipoints, polygons, lines, areas outside of the mapped extent and even the entire mapped area. So as to retain as much usable data as possible, the multipoint data, polygons and lines were digitised, and the centroids of these features were calculated and plotted using the "feature to point" tool. This uses a centre-of-gravity based algorithm. The resulting value and risk point data shapefiles were then combined to form perceived value and risk layers for Spurn and Silverdale, using the "union" tool. Following Brown and Pullar (2012) responses comprising a polygon, which covered between 50% and 100% of the study area were excluded from the analysis, as it does not usefully enable areas of greatest value and risk to be distinguished. Also of note is the frequency of respondents on the Silverdale coast (6) who chose Sandside, an area which is just located off the limits of the map, as being at greatest risk from storms and coastal floods. One respondent also chose the Lake

District as the area they valued the most, due to greater familiarity than the Silverdale coast and Morecambe Bay. These responses were excluded from the analysis, as, had this area been marked on the original map, greater numbers of respondents may have chosen it.

In order to answer RQ4, the combined layers of value and risk were divided into visitor and resident data, through recoding survey responses from Q1 (See Appendix One) "When did you first come to the coast around Silverdale [Spurn Point]?"[4] The response option, "I am a visitor to the area" was coded "1," whilst resident-related responses were coded "2" (I moved here in the last six months; I moved here between six months and two years ago; I moved here between two and five years ago; I have lived here all my life). New data layers of visitor and resident responses were created in ArcMap using the Select (Analysis) tool.

2.5.1.2. Kernel density maps of perceived value and risk

Polygons of landscape areas are ultimately implied with each point, and yet the extent of these polygons are unknown (Raymond and Brown, 2011). For this reason, kernel density estimation was used to identify hotspots of perceived value and risk in the landscape. This method identifies thresholds that statistically define the hotspot. Kernel density raster outputs were created for each layer, with output cell size and bandwidth standardised to facilitate comparison between the value and risk maps. A cell size of 100m was chosen to allow for reasonable degree of placement error and it was also considered a useful resolution for informing coastal zone management decisions. Bandwidth was standardised to the mean nearest neighbour (m) of the combined value and risk datasets at each site, to allow direct comparison of kernel densities within each study area. For Silverdale, this meant a bandwidth of 448.99m, and for the Spurn data, bandwidth was standardised to 217.35m. The "extract by mask" tool in Arcmap was used to show intersection of these density maps with EA-defined flood risk zones.

2.5.1.3. Statistical analysis

The "create random points" tool in ArcMap was used to create layers of 2000 randomly located points across the extent of the perceived value and risk rasters for both Spurn and Silverdale. These layers were used for random point sampling of the perceived value and risk kernel density rasters and the EA risk of flooding from rivers and sea data. This sampling was undertaken using the point sampling tool plugin in QGIS. True random sampling offers clear statistical benefits, yet by its very nature, clustering of random points can occur, leaving some areas unsampled. The choice of 2000 random points was designed to reduce the effect of point clustering, whilst also retaining some degree of sampling efficiency.

[4] Wording was tailored to the study sites.

Attribute tables were combined and exported into SPSS for further statistical analysis. The EA flood risk bands were recoded High = 3, Medium = 2, Low = 1. Where null values coincided across all sampled datasets, these were removed, so as to focus only on samples within areas of perceived value AND/OR perceived risk AND/OR EA-defined risk. This approach ensured that areas were also sampled, which were not considered to be at risk from sea or river flooding by the EA, but may have been valued by respondents, or perceived to be at risk from storms and flooding. Data were tested for normality and linearity (Q-Q and P-P plots with Shapiro-Wilk test for datasets <2000) and as all data were non-normally distributed ($p < .05$), Spearman's rho tests were performed to determine non-parametric correlations between perceived value and perceived risk in both study regions. Correlation between perceived risk and expert-defined risk, perceived value and expert-defined risk, and between visitor and resident perceptions was also undertaken in the same manner. As the data were non-normally distributed, bootstrapped confidence intervals were calculated, as, unlike significance values, they would be unaffected by the unknown sampling distribution. Bias corrected and accelerated 95% confidence intervals were calculated, and are reported in square brackets in the Results section (section 3). Correlations were all significant at the $p < .01$ or $p < .001$ levels (2-tailed).

To explore these correlations further, and to ensure that bias was not evident in respondents' placement of value and risk points in coastal areas, follow-up analyses were conducted. Value and risk points were paired by individual respondents and joined using the XY to line tool in ArcMap. Paired sets of 100 random points were generated across the same map extent as the survey sample points (thus ensuring that the map area which was available to respondents was encompassed). Normality of the datasets was tested and distributions of distances between the paired survey data points and distances between the random points were compared using Mann-Whitney U test.

The frequency of value and risk points which intersected each EA flood risk category was determined using the "select by location" tool in Arcmap. One-sample Chi-square test was used to compare the frequency of respondents' value and risk points, which were located within each EA risk category at the two study sites, with expected frequencies for each category.

To answer RQ 4, the select by location tool was also used to determine point frequencies within principal landcover classes of OS Strategi map data (1:250,000) (available at: https://www.ordnancesurvey.co.uk/business-and-government/products/strategi.html).
Landcover classes of interest within the OS Strategi data comprised urban regions, foreshore (sand polygons and other exposed Mean Low Water polygons) and woodland. Points located outside of these classes were categorised as "other" landcover classes. Saltmarsh extent data were obtained

from EA datasets: (available at: https://data.gov.uk/dataset/0e9982d3-1fef-47de-9af0-4b1398330d88/saltmarsh-extents) Extents of these landcovers were clipped to the same map extents, which were available for respondents in the survey and datasets merged using the "merge vector layers" tool in QGIS. The "calculate areas" tool in ArcMap was used to determine the areas of each landcover available to respondents, to consider whether greater or fewer respondents then expected perceived value or risk within these landcovers.

2.5.2. Qualitative analysis

Data from the two open-ended survey questions were coded thematically to identify principal themes and subgroups. A qualitative approach, alongside mapping, can allow greater insight into the importance of a particular area, feature or ecosystem service (Plieninger et al., 2013; Tyrväinen et al., 2007).

3. Results

3.1. Spatial correlation of perceived value and risk

Spearman's rho correlation showed moderate significant negative correlation between perceived value and perceived risk from storms and flooding in the coastal zone at both Spurn r = -.383, [-.612, -.138], p < .01 and Silverdale r = -.461, [-.559, -.368], p < .001. Perceived value and risk appeared far more spatially aggregated in the landscape at Spurn, than at Silverdale (**Figures 2-5**), with points of perceived value and risk at Spurn primarily located along Spurn Point itself. Risk points focused particularly around the area which was breached in the December 2013 storm surge. At Silverdale, higher densities of value points were evident around Grange-over-Sands, Silverdale village, Leighton Moss nature reserve/ Jenny Brown's Point and Bolton-le-Sands village, whilst risk points focused particularly around the villages of Silverdale and Arnside, with many appearing to fall in the intertidal zone.

The distances between Silverdale respondent's value and risk points (Mdn = 3326 km) were significantly smaller than those between sets of random points (Mdn = 8700 km), U = 5182, z = 7.09, p < .001, r = .54. At Spurn, the distances between respondents' perceived value and risk points (Mdn = 2026 km) were also significantly smaller than those between sets of random points (Mdn = 7698 km), U = 5889, z = 7.801, r = .60. This shows strong evidence of a relationship between respondents' placement of value and risk, when compared with distances between sets of random points. There may, however, be an effect of sampling locations and respondents' area familiarity on point placement here.

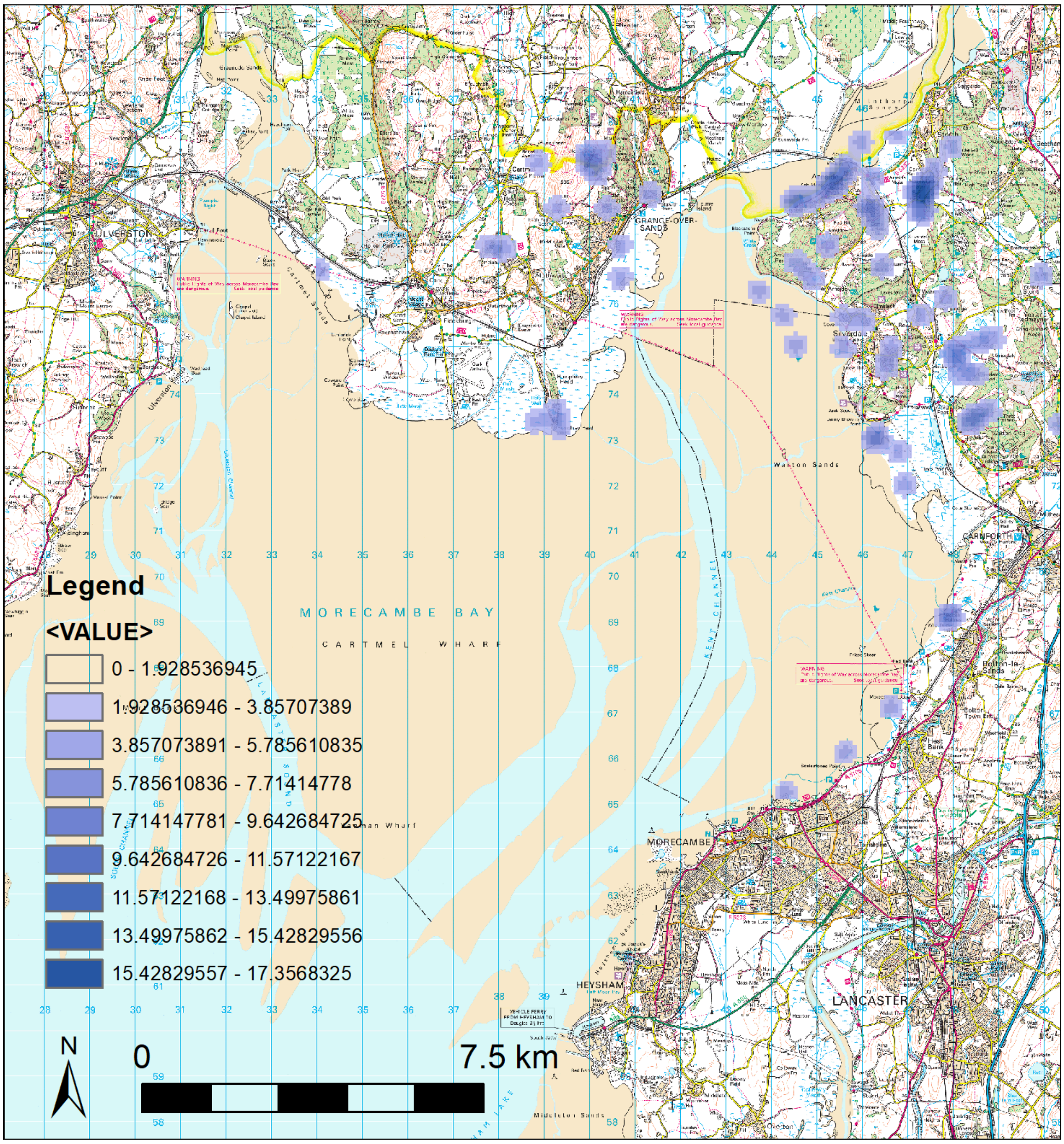


Figure 2. Kernel density map showing point densities for perceived value at Silverdale.

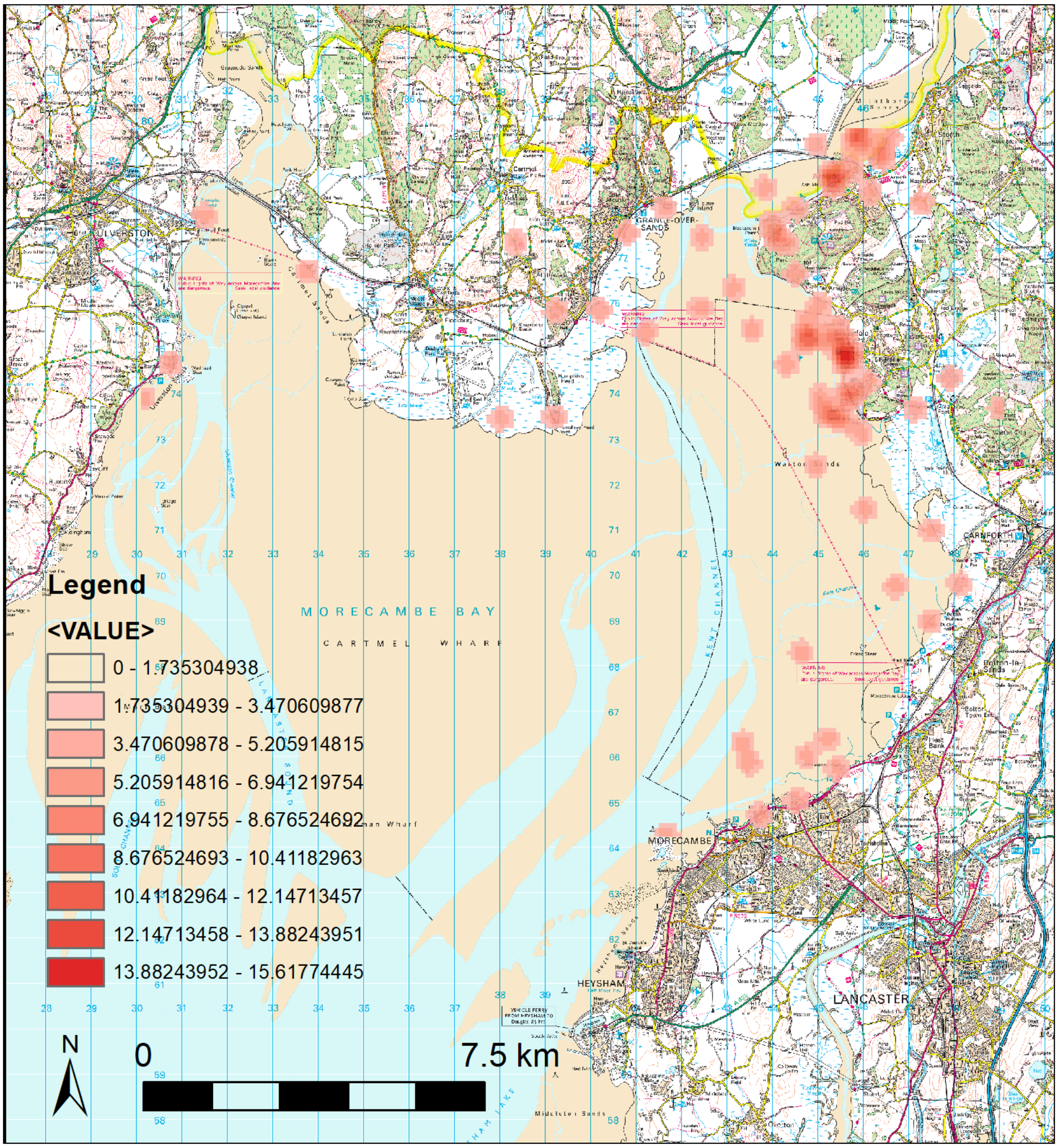


Figure 3. Kernel density map showing point densities for perceived risk at Silverdale.

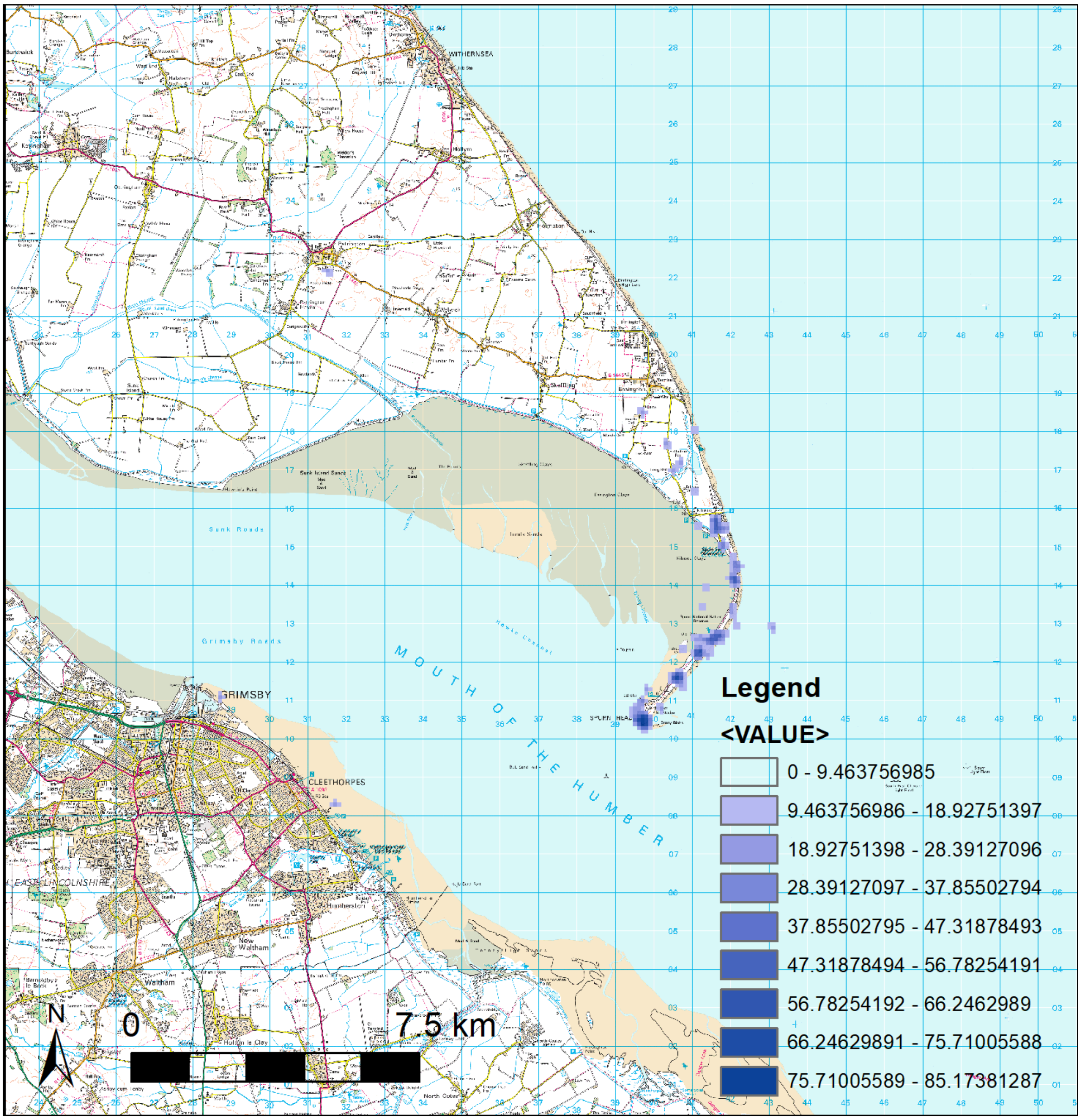


Figure 4. Kernel density map showing point densities for perceived value at Spurn.

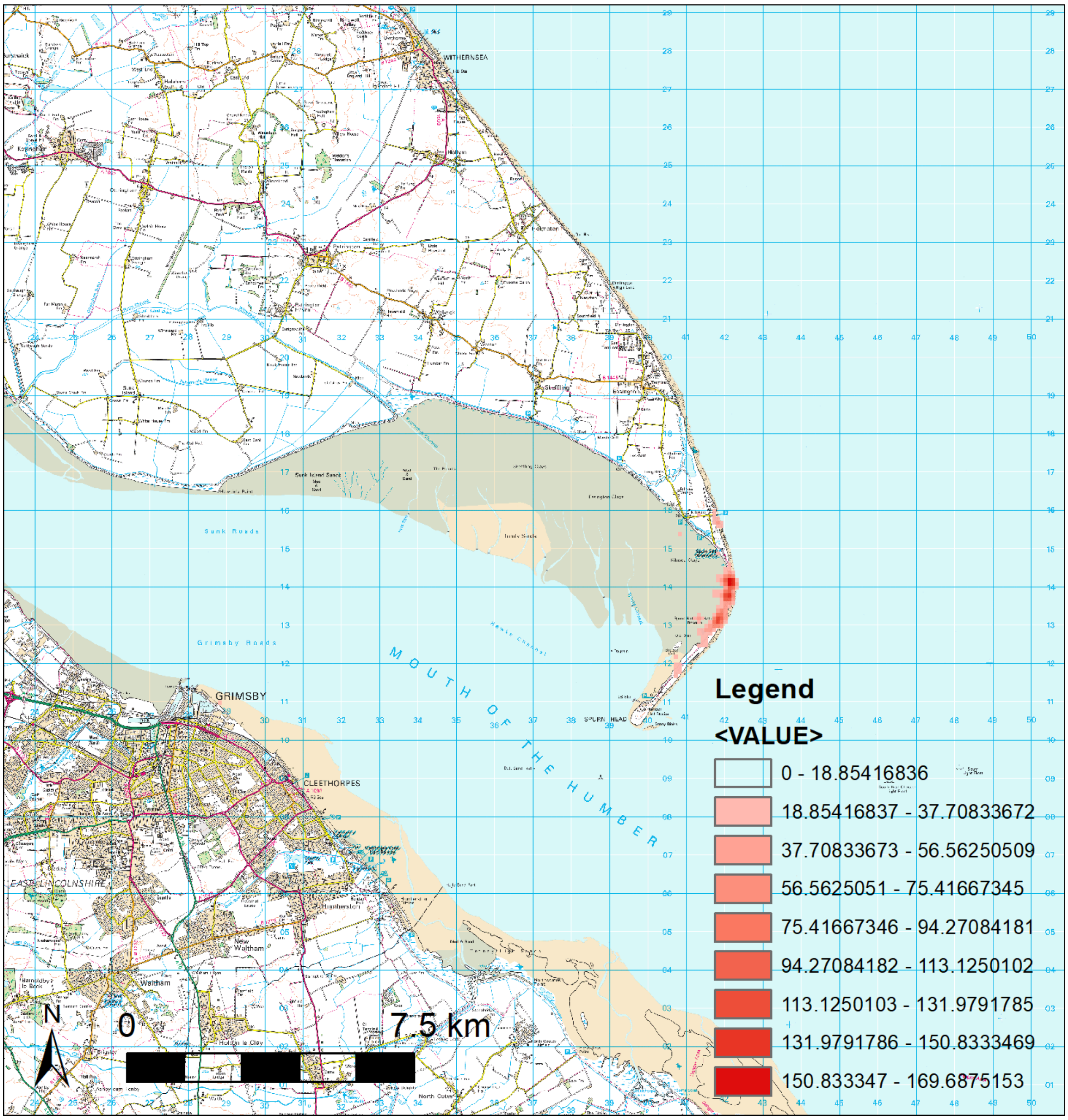


Figure 5. Kernel density map showing point densities for perceived risk at Spurn.

3.2. Perceived value and risk in the natural and built environments

Of the landcover types considered in the analysis, the foreshore regions were the principal landcover class in which perceived risk was located at Silverdale (N = 43 risk points, 58.9% of respondents) (**Table 2**). This corresponded with the foreshore occupying the greatest percentage of the map area in the survey. The percentage of risk points in the saltmarsh regions was high (13%), relative to the percentage map area covered by this landcover class. The percentage of risk points in urban regions (5.5%) and woodland (4.1%).

At Spurn, "other" landcover classes than those identified in the analysis were the areas of greatest perceived risk. Foreshore regions were the next most frequently chosen (41.0% of respondents) at Spurn, the foreshore covered only 12.6% of the survey map extent. Saltmarsh and urban regions both accounted for 2.6% of the sample responses, whilst occupying 0.6% of the landcover map area. None of the responses occurred in woodland areas.

On the Silverdale coast, respondents' value points were primarily situated in landcovers other than those investigated here (37% of respondents points within "other landcovers"). The foreshore regions contained the next highest frequency of value points (21%). Woodland contained the next highest % value points (11%), followed by urban regions (10%) and saltmarshes (7%)

The foreshore regions at Spurn were the principal landcover in which value points were located at Spurn (48.7%). "Other" landcover classes encompassed 46.1%, followed by urban regions (3.9%) and saltmarsh (1.3%). No respondents selected areas characterised by woodland regions.

Table 2. Frequencies of perceived value and risk point data within landcover classes from OS Strategi (1:250,000) and EA Saltmarsh Extents datasets. The area (km^2) of these landcover types, which was available to respondents in the survey map extents, along with the percentage of total map area these covered, are also presented for comparison.

	Perceived value		***Perceived risk***			
(a) Silverdale	**N**	**Total N**	***N***	***Total N***	***Landcover area (km²)***	***Landcover % of total map area***
Saltmarsh	8	115	*10*	*73*	12546.08	2.86
Urban regions	12	115	4	73	26656.01	6.07
Foreshore	24	115	43	73	177680.16	40.43
Woodland	13	115	3	73	19824.31	4.51
Other	43	115	13	73		
Total map extent					439435.10	
(b) Spurn						
Saltmarsh	1	76	2	78	2492.89	0.60
Urban regions	3	76	2	78	23372.14	5.65
Foreshore	37	76	32	78	52282.59	12.63
Woodland	0	76	0	78	***0***	0
Other	35	76	42	78		
Total map extent					413957.99	

3.3. Expert-defined and public-perceived storm and coastal flood risk

There was a significant negative correlation between expert-assessed and public-perceived coastal flood risk on the Silverdale coast, r = -.118, [-.202, -.028], p = .01. Significant negative correlation was also demonstrated between expert-assessed risk from coastal flooding and public perceived value, r = -.267, [-.347, -.185], p < .001. Whilst significant, these correlations are relatively weak. These spatial relationships are visually represented in **Figures 6 to 8**. At Spurn (**Figures 9 to 11**), significant negative correlation was evident between expert-assessed and public-perceived coastal flood risk, r = -.289, [-.409, -.177], p < .001. Again, although significant, the correlation is not very strong. A significant negative correlation was also found between expert-assessed flood risk and public-perceived value, r = -.255, [-.386, -.132], p < .001.

In partial contrast to the negative correlations, one-sample chi square test showed that more Silverdale respondents than hypothesised placed value points in high EA risk zones and areas of no EA risk (**Table 3**). Fewer than expected placed value points in the low- and medium-risk EA zones (χ^2 (3) = 73.49, p < .001). Again, this trend was apparent in the Silverdale perceived risk points, with more points than were expected placed in the high-EA risk and “no EA risk” areas, whilst fewer than hypothesised located their risk points in the medium- and low- risk EA zones (χ^2 (3) = 26.45, p < .001).

This trend of greater than hypothesised frequencies of respondents’ points in areas of no EA flood risk and high EA risk, and of fewer than hypothesised in low-and medium- risk EA zones was also apparent in both the Spurn perceived value data (χ^2 (3) = 59.95, p < .001) and perceived risk points (χ^2 (3) = 45.58, p < .001).

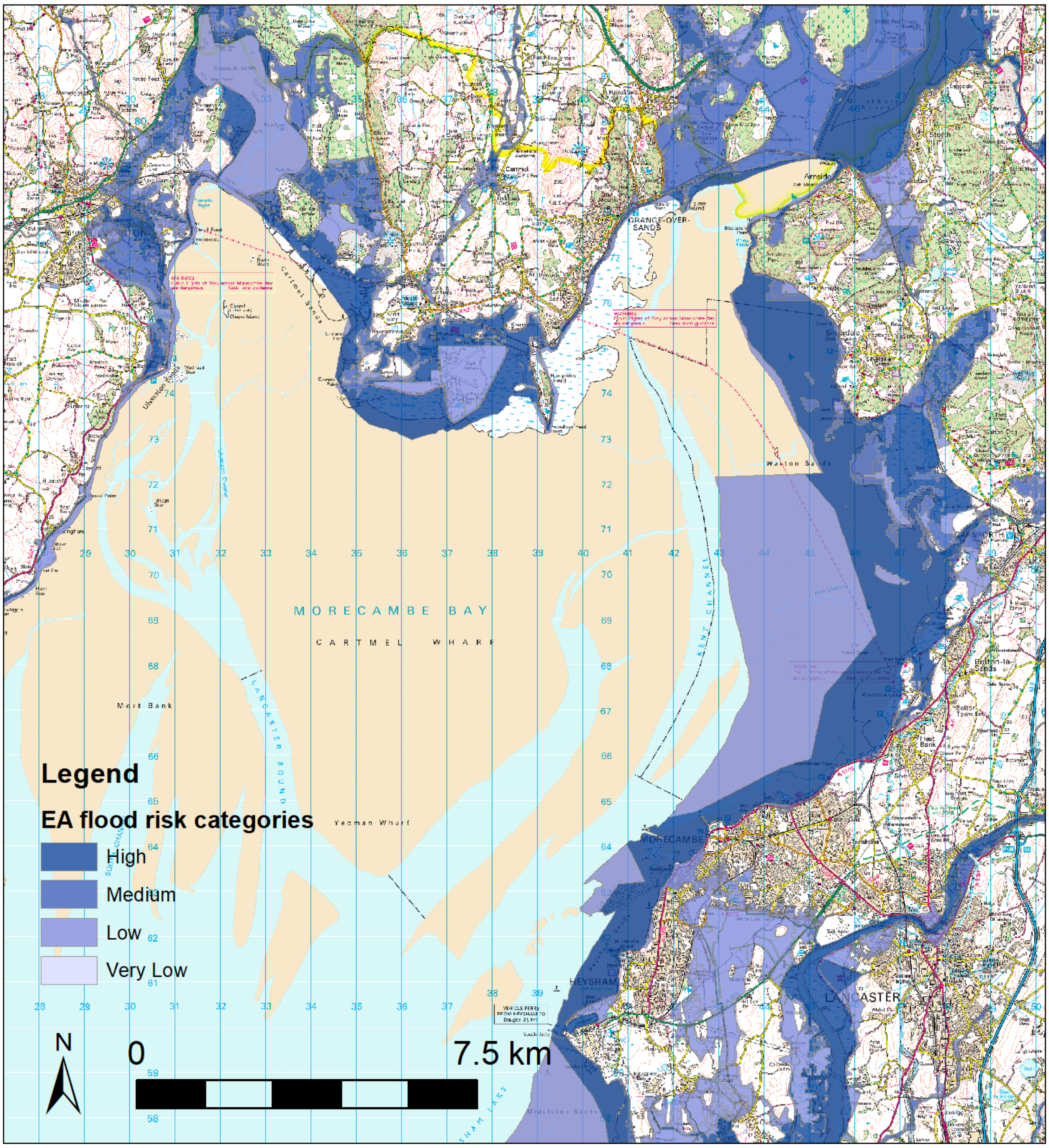


Figure 6. Map of the Silverdale coast, showing zones of EA-defined flood risk from rivers and sea.

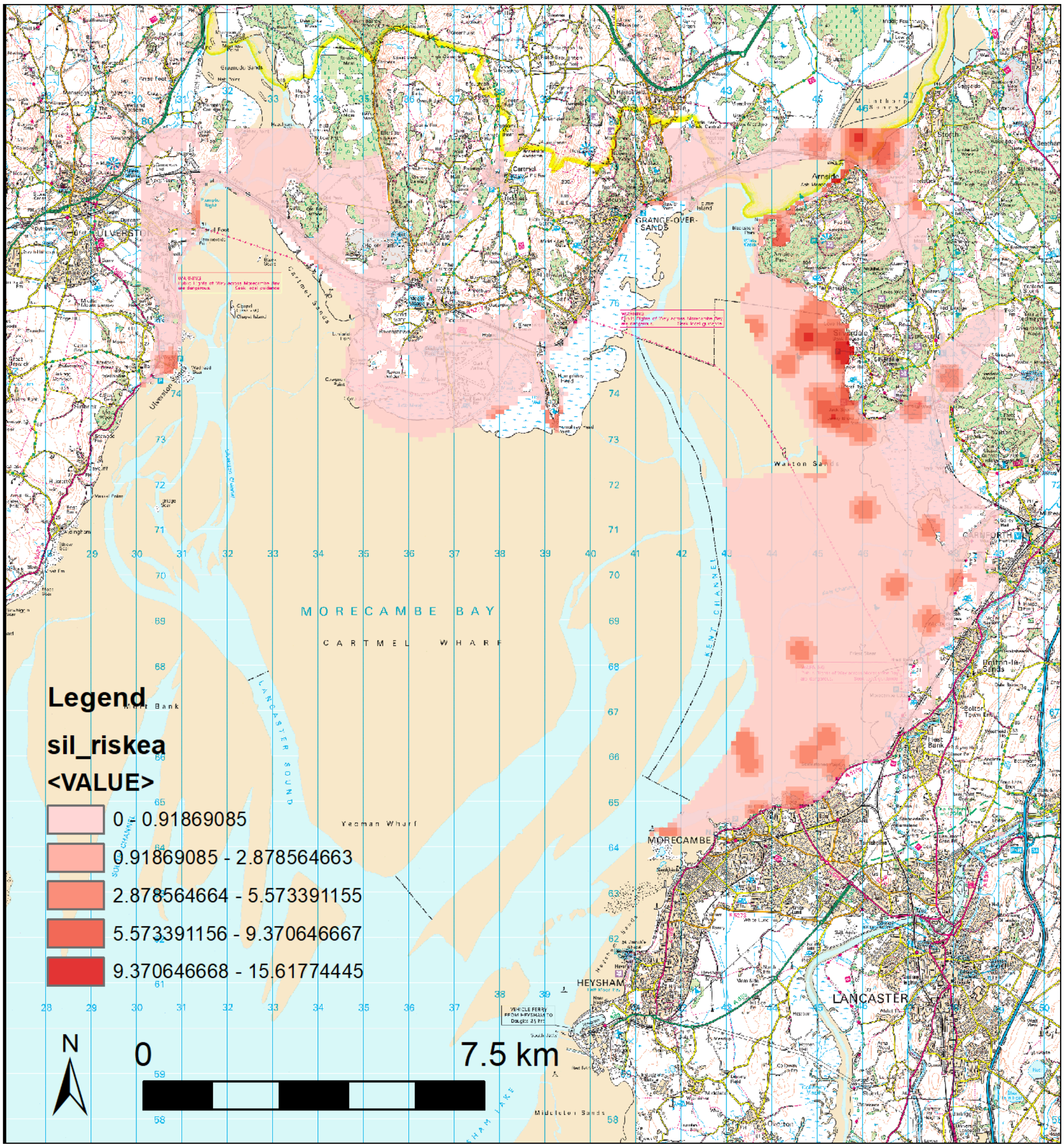


Figure 7. Map of the Silverdale coast, showing the intersection of perceived risk kernel densities with zones of EA-defined flood risk from rivers and sea.

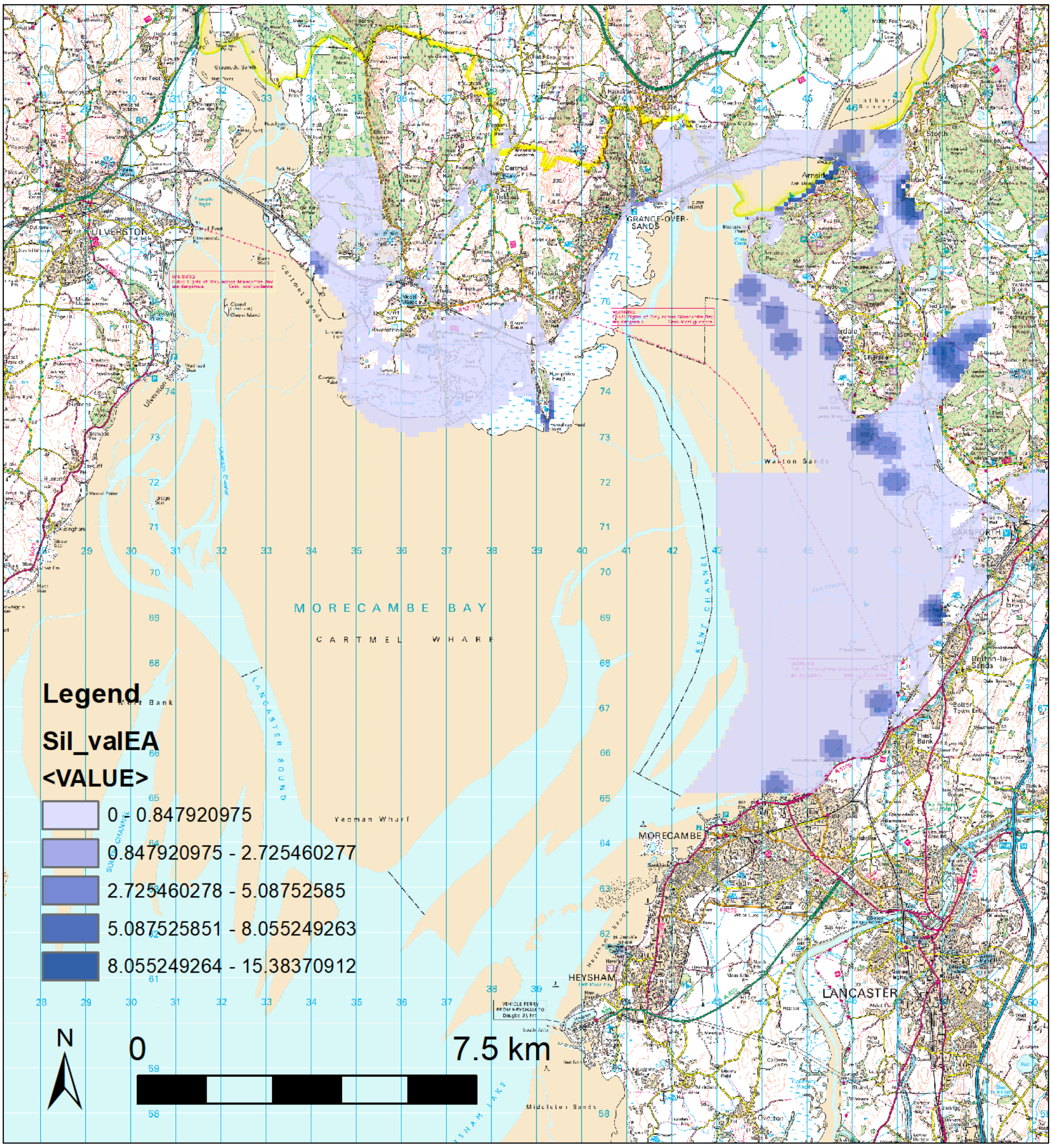


Figure 8. Map of the Silverdale coast, showing the intersection of perceived value kernel densities with zones of EA-defined flood risk from rivers and sea.

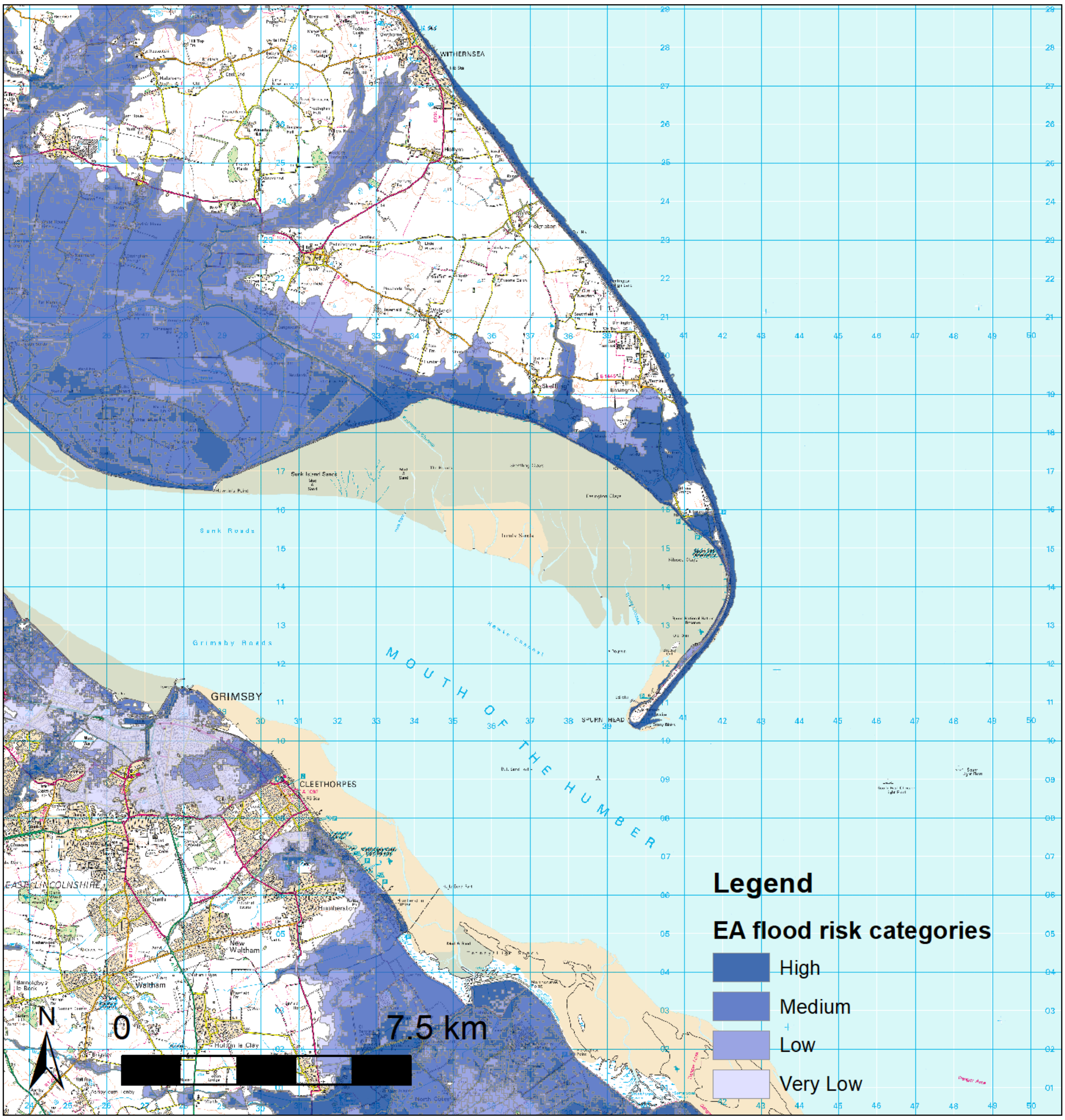


Figure 9. Map of the coast at Spurn Point, showing zones of EA-defined flood risk from rivers and sea.

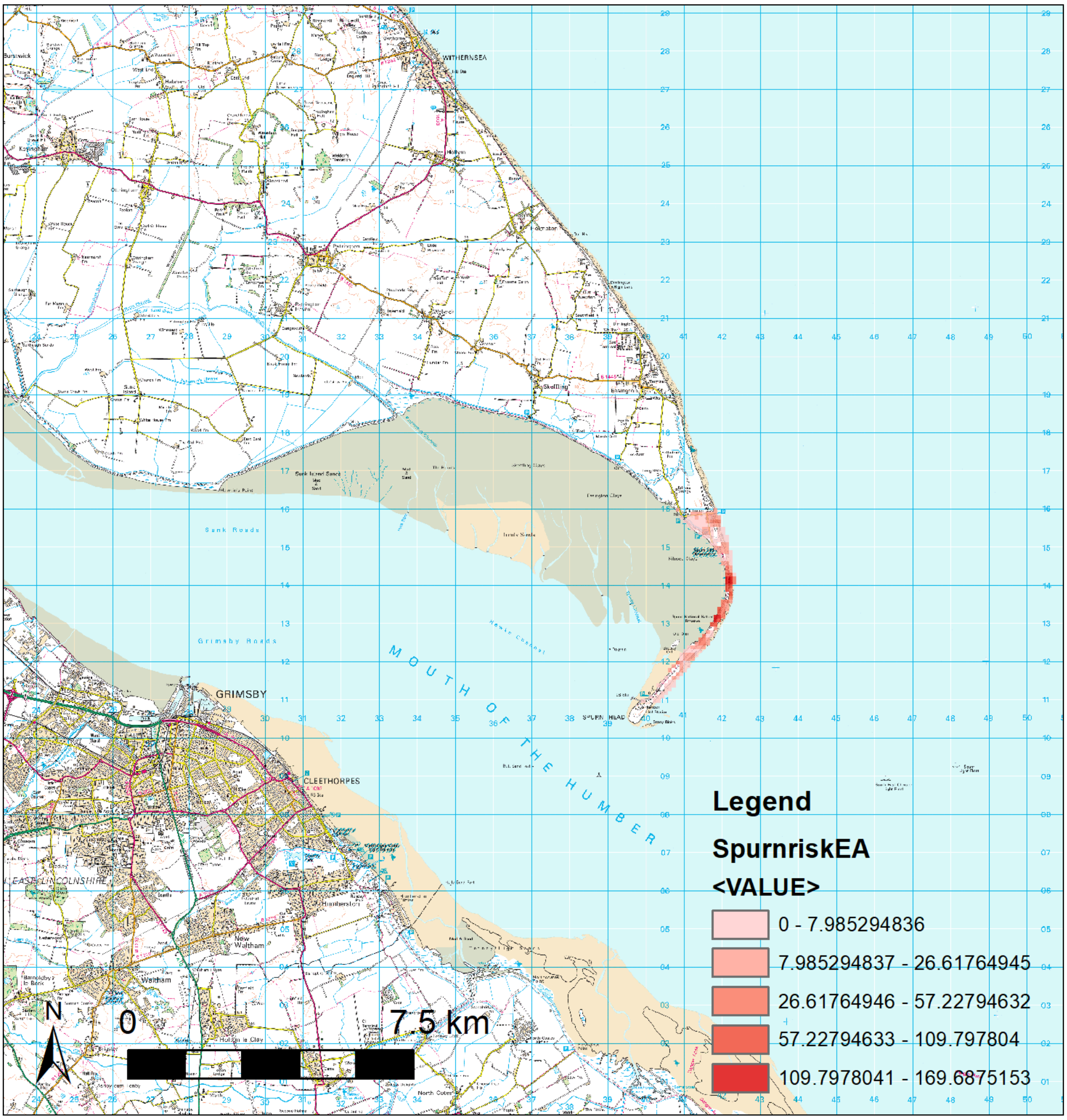


Figure 10. Map of the coast at Spurn Point, showing the intersection of perceived risk kernel densities with zones of EA-defined flood risk from rivers and sea.

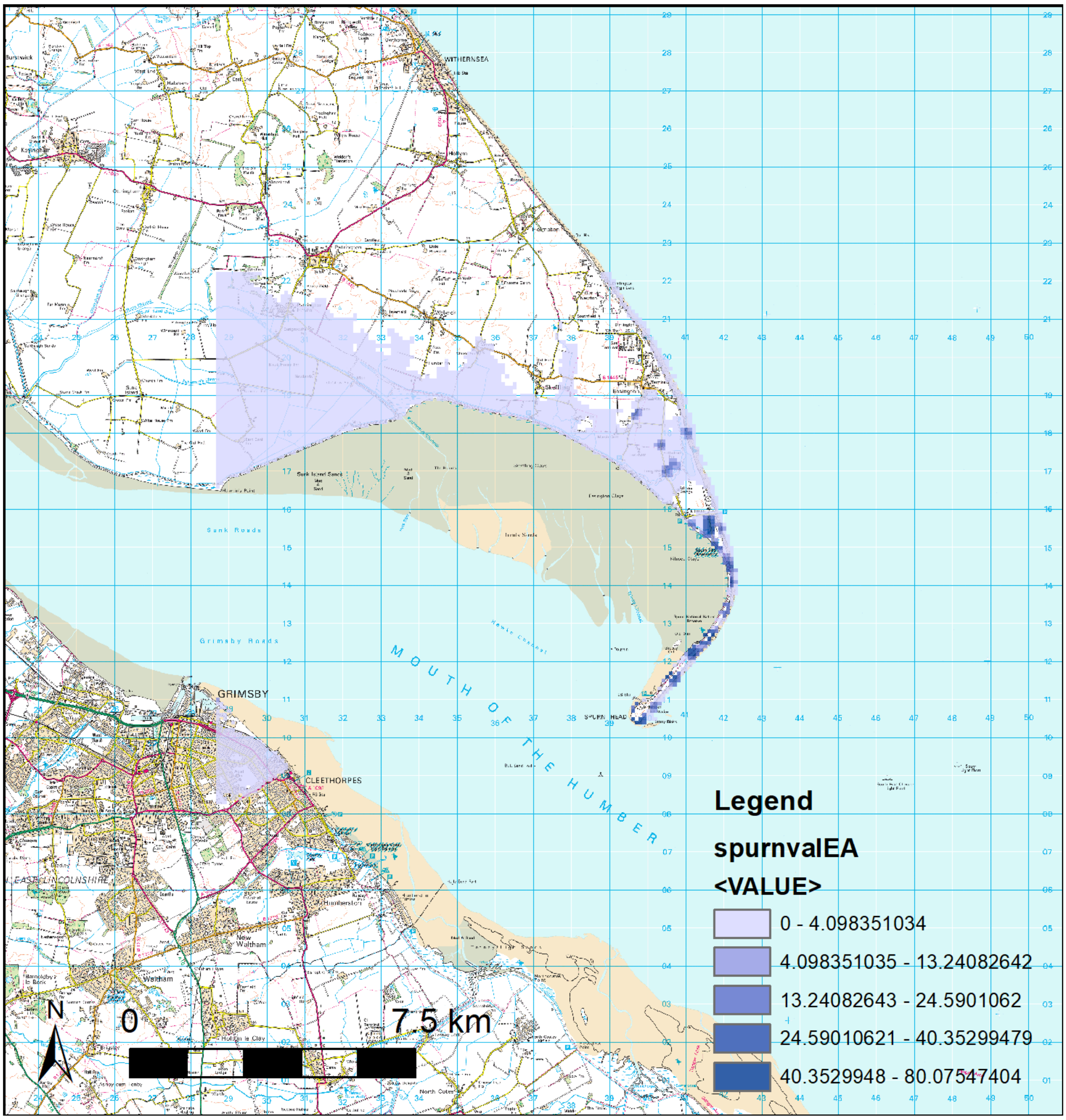


Figure 11. Map of the coast at Spurn Point, showing the intersection of perceived value kernel densities with zones of EA-defined flood risk from rivers and sea.

Table 3. Observed and hypothesised frequencies of perceived value and risk points within each of the risk categories from the EA risk of flooding from rivers and sea dataset. Hypothesised frequencies were derived through one-sample chi square tests. The “very low” EA risk category is not included here, as no perceived value or risk points were located in this category at either site.

			Perceived value				***Perceived risk***		
Location	**EA risk categories**	**Observed *N***	**Hypothesised *N***	**Residual**	**Total observed *N***	**Observed *N***	**Hypothesised *N***	**Residual**	**Total observed *N***
(a) Silverdale	High	32	28.75	3.25	115	31	18.25	12.75	73
	Medium	7	28.75	-21.75	115	5	18.25	-13.25	73
	Low	11	28.75	-17.75	115	10	18.25	-8.25	73
	Total	**50**	-	-	**115**	**46**	-	-	**73**
	No EA risk	**65**	28.75	**36.25**	**115**	**27**	18.25	**8.75**	**73**
(b) Spurn	High	34	19.5	14.5	78	31	19	12	76
	Medium	2	19.5	-17.5	78	2	19	-17	76
	Low	3	19.5	-16.5	78	7	19	-12	76
	Total	**39**	-	-	**78**	**40**	-	-	**76**
	No EA risk	**39**	19.5	**19.5**	**78**	**36**	19	**17**	**76**

3.4. Area familiarity and place attachment: comparing resident and visitor perceptions

3.4.1. How do the perceptions of visitors and local residents compare?

At Silverdale, visitor perceived risk showed moderate significant negative correlation with resident perceived risk, r = -.251 [-.375, -.116], p < .001. Visitor perceived value was also significantly negatively correlated with resident perceived value, r = -.253 [-.377, -.119], p < .001. Similarly, at Spurn, significant negative correlation was found between the perceived risk of visitors and residents, r = -.510 [-.829, -.085], p < .01.

3.4.2. Observations from the map outputs

3.4.2.1. Silverdale

Value in the landscape on the Silverdale coast primarily centred around the Leighton Moss reserve for visitors, whilst Arnside village and the Hampsfell area, above Grange, were clear value hotspots amongst residents (**Figures 12 and 13**). There were clear risk hotspots around Arnside and Silverdale villages amongst the residents' responses **(Figures 14 and 15)**; also hotspots, albeit of lower density for the saltmarsh on the foreshore at Grange-over-Sands. The risk hotspot around Silverdale centres over the intertidal area, which appeared as saltmarsh/ a coast "line" on the OS map used in the survey. The visitor-perceived hotspot neighbouring Silverdale village is centred south of the resident hotspot, around Lindeth Tor and Jack Scout (National Trust).

3.4.2.2. Spurn

It is clear from the kernel density maps in **Figures 18 and 19**, that the risk responses from local residents at Spurn are more spatially clustered than those of visitors. The highest density of risk points occurred around the neck of the spit, where surface elevation is low. This also encompasses an area of saltmarsh at Kilnsea Clays. Perceived risk is also notably oriented around the public car park and neighbouring flood storage lagoon. This area was overtopped during the December 2013 storm surge, with flooding and extensive deposition of debris.

The perceptions of storm and flood risk from visitors to Spurn were less spatially discrete, when compared to the residents' data, with one point located on the Lincolnshire coast, near Grimsby. As with resident respondents the neck of Spurn exhibited the greatest density of perceived risk points amongst visitors to Spurn. Unlike the resident responses, visitor points of perceived risk also extended into the higher elevation area of Spurn Point around "Greedy Gut."

Amongst Spurn residents, perceived value on the Point itself appears particularly important. Areas of greatest importance to residents also extend further to the north of Spurn, towards Easington, indicating the importance of place with regard to people's own homes.

Visitor value appears more aggregated on Spurn itself, particularly in the areas of higher elevation at the southern end of the peninsula, below the breached area and at the tip of the Spurn peninsula. Again, visitor responses cover a wider area, with value attributed to the Lincolnshire coast at Grimsby and Cleethorpes. A point located at Patrington also serves to broaden the extent of the kernel density raster.

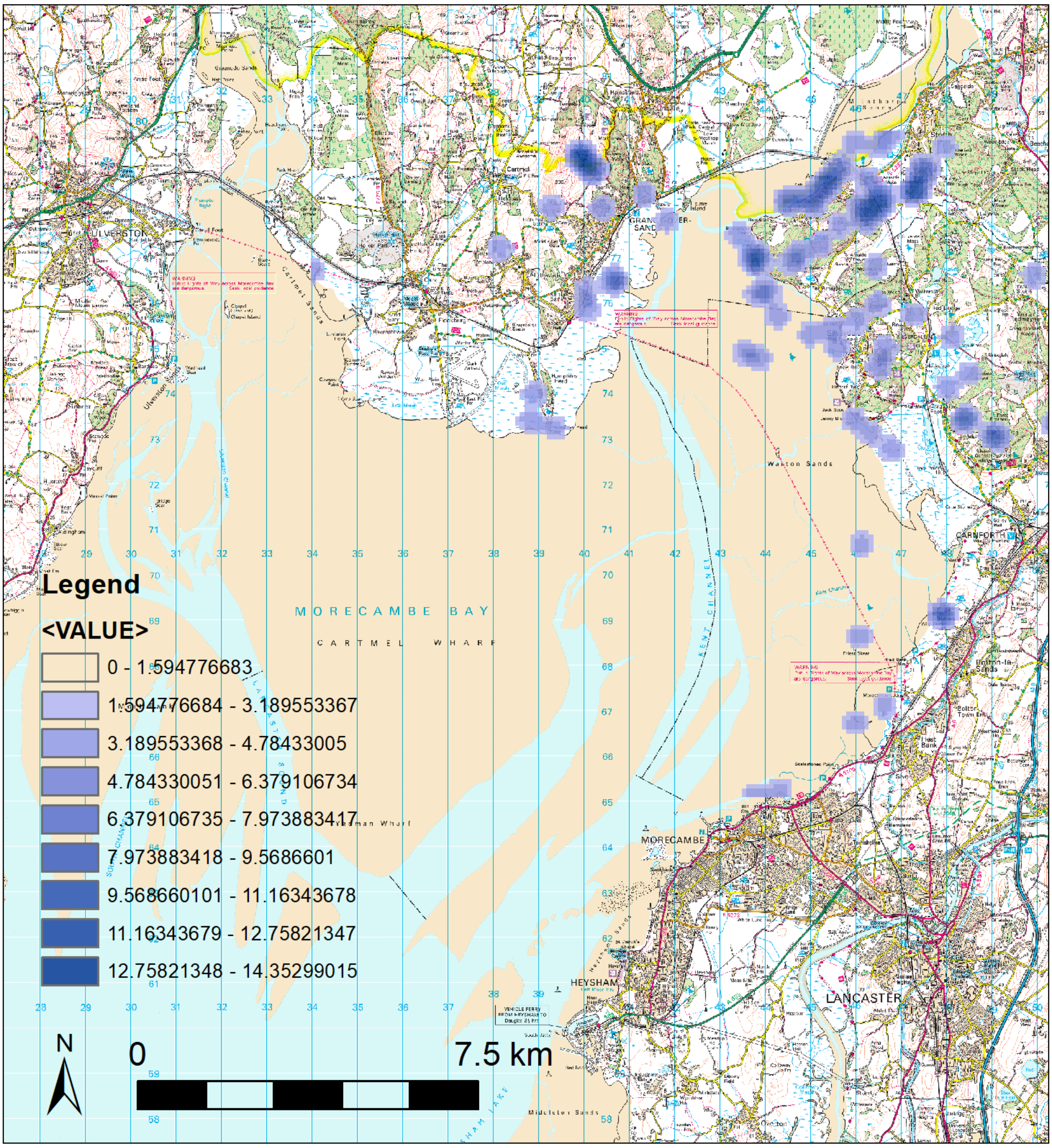


Figure 12. Kernel density map showing point densities for resident-perceived value at Silverdale.

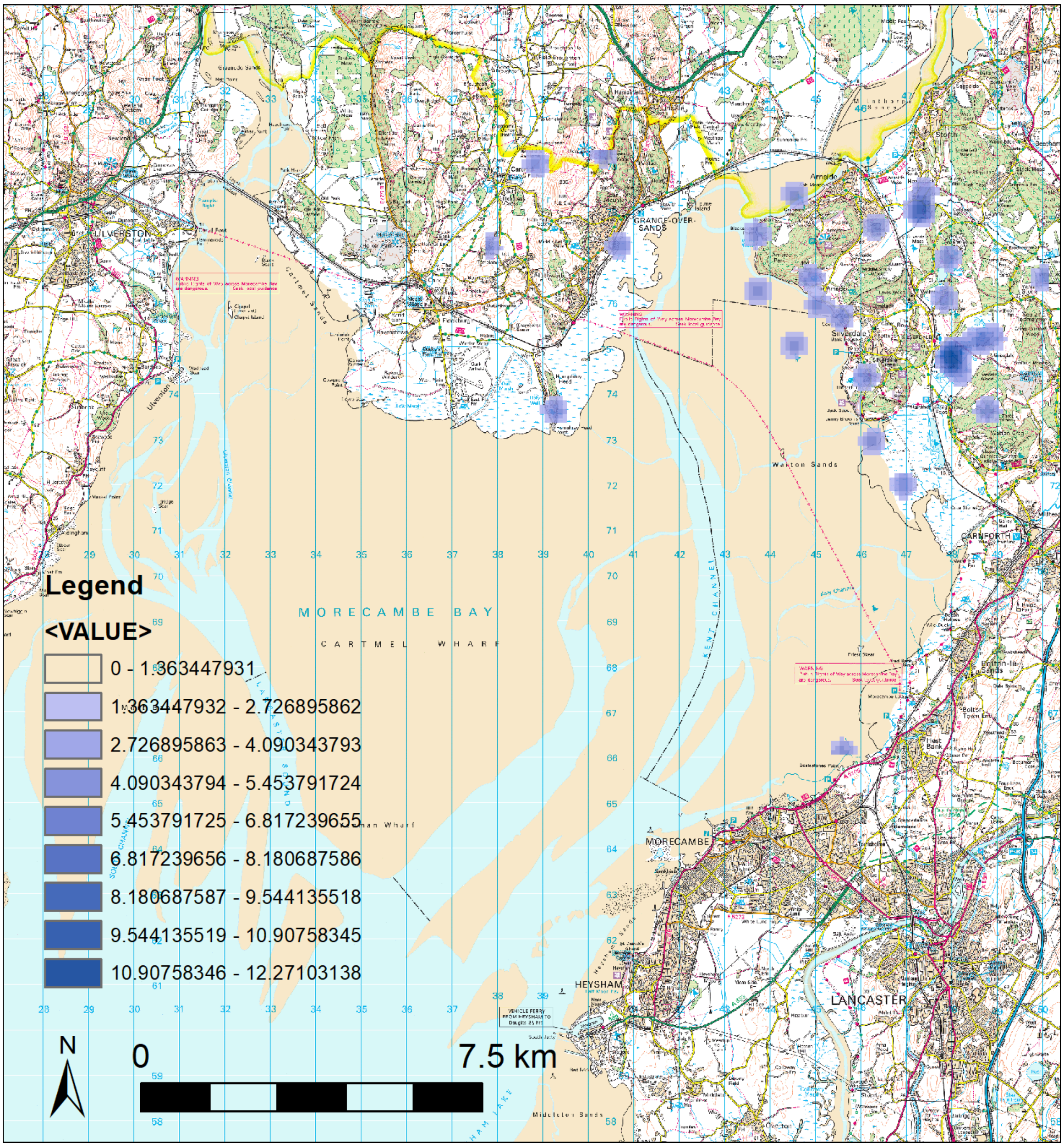


Figure 13. Kernel density map showing point densities for visitor-perceived value at Silverdale.

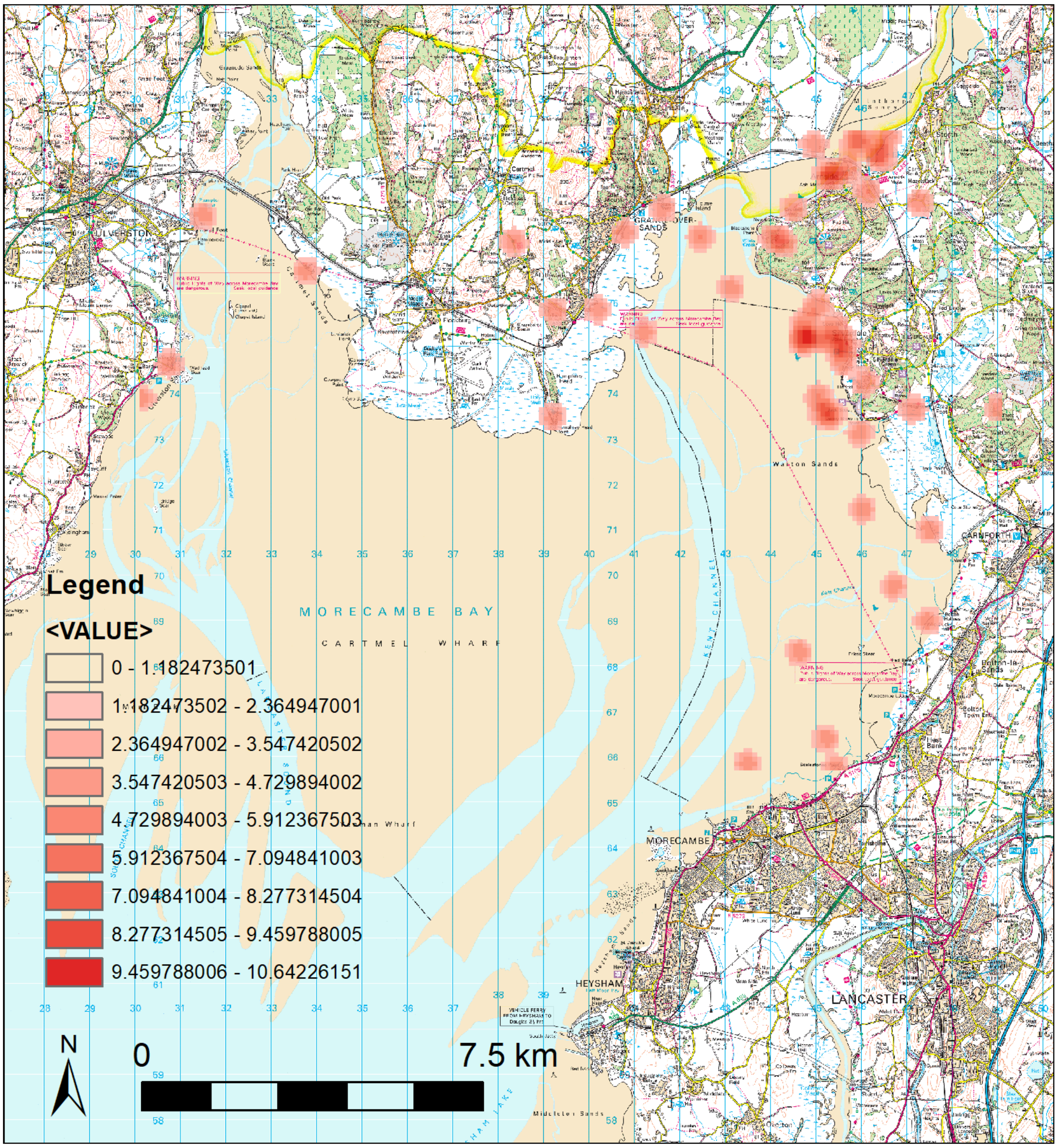


Figure 14. Kernel density map showing point densities for resident-perceived risk at Silverdale.

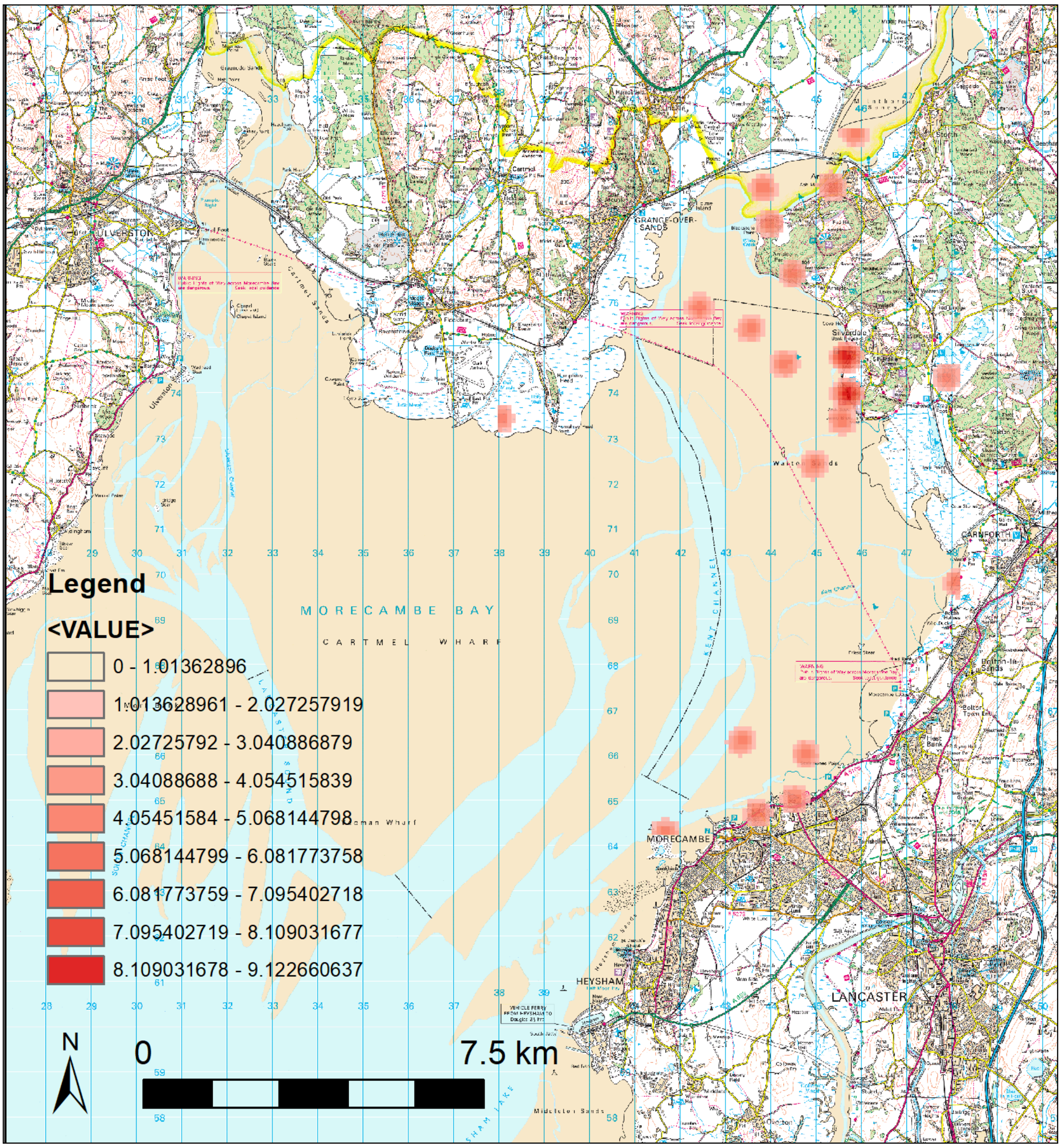


Figure 15. Kernel density map showing point densities for visitor-perceived risk at Silverdale.

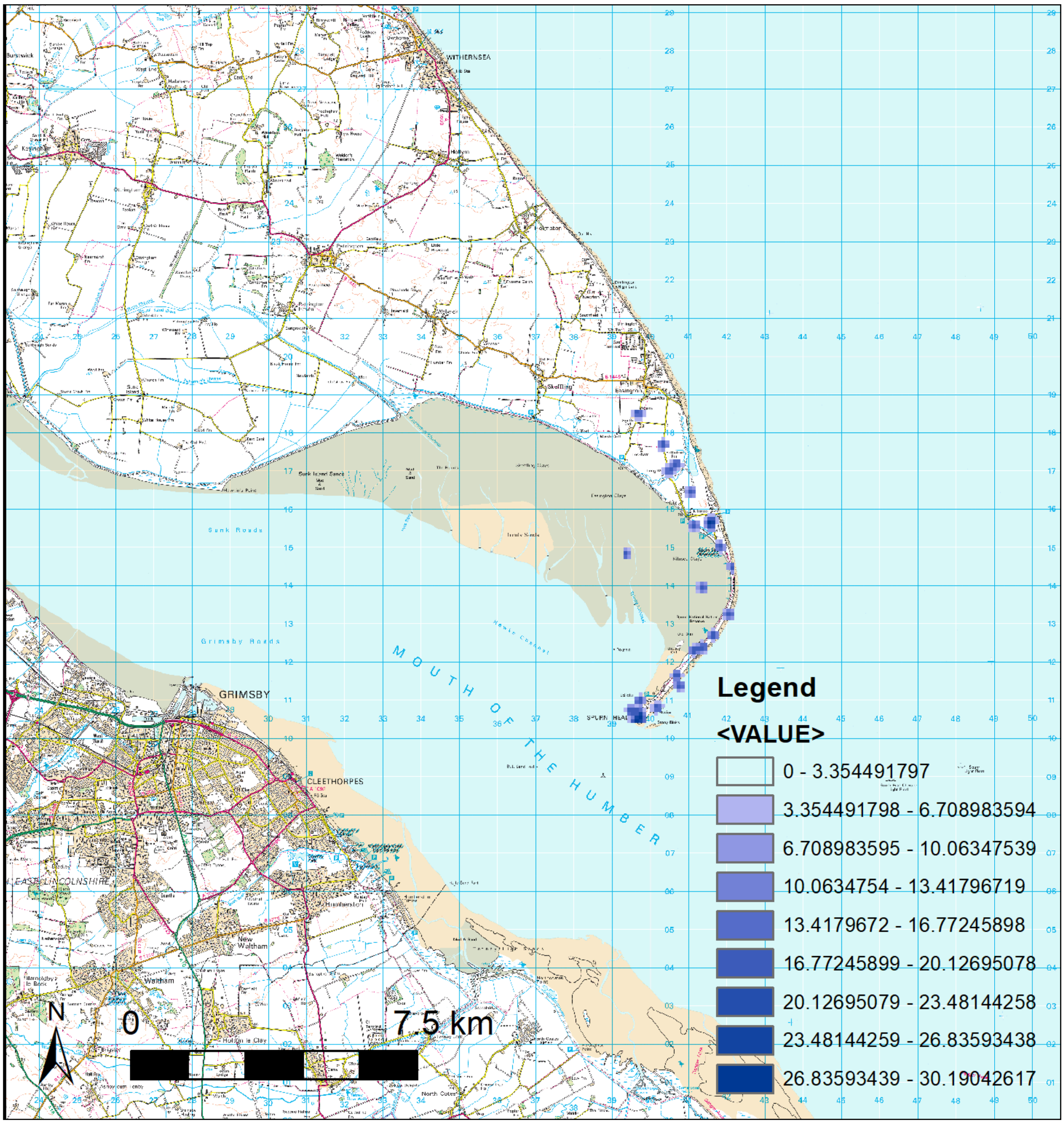


Figure 16. Kernel density map showing point densities for resident-perceived value at Spurn.

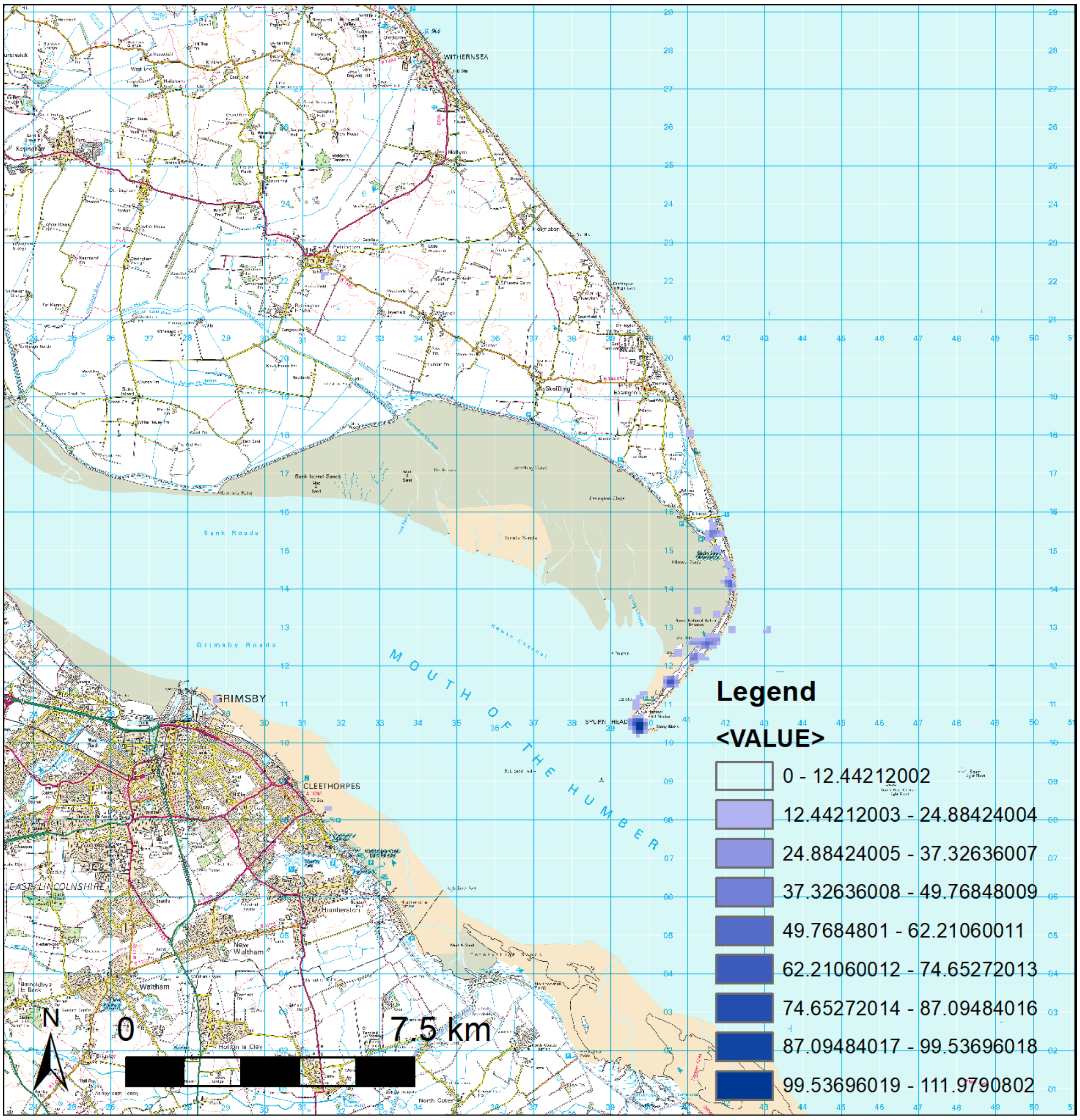


Figure 17. Kernel density map showing point densities for visitor-perceived value at Spurn.

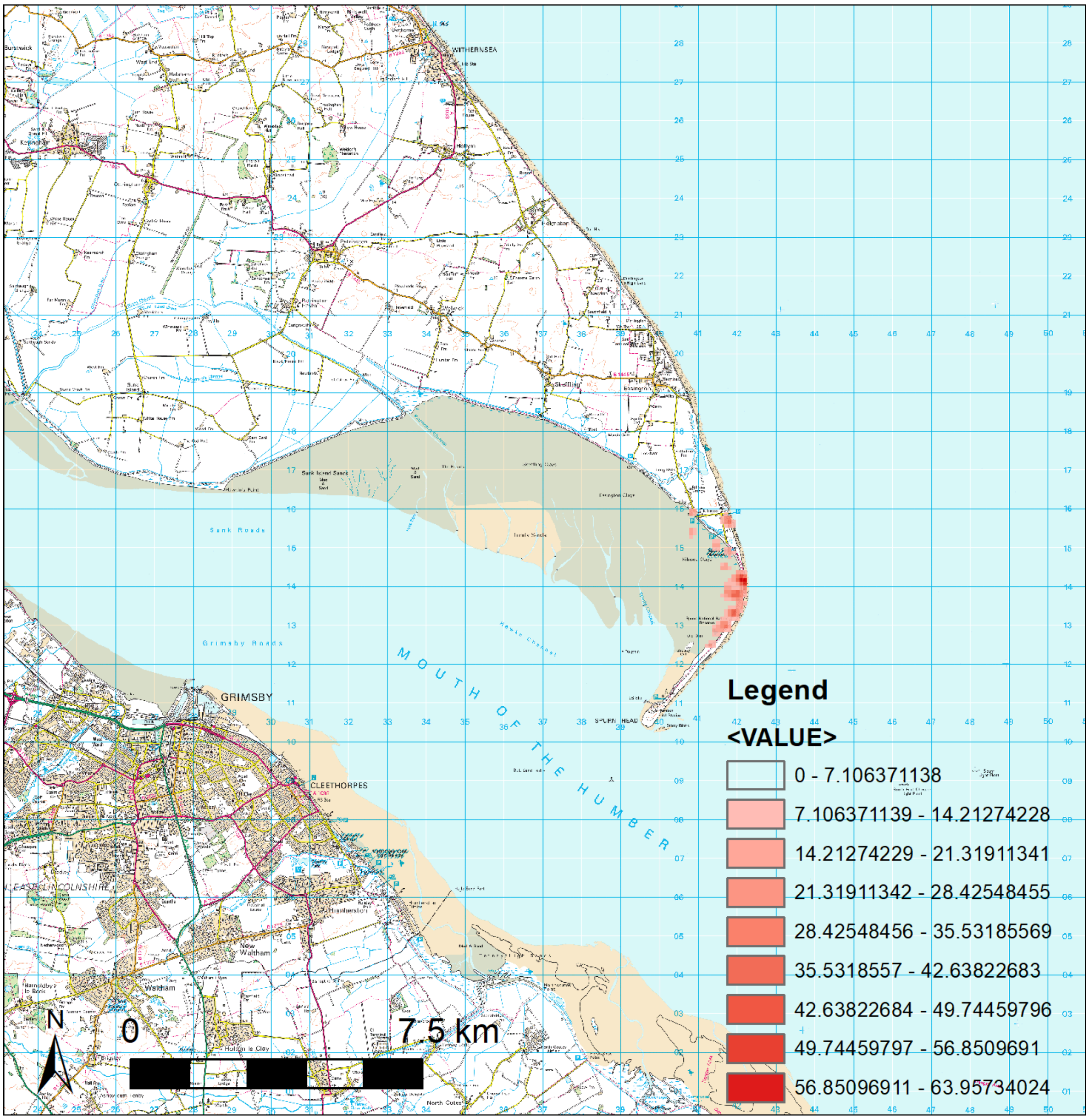


Figure 18. Kernel density map showing point densities for resident-perceived risk at Spurn.

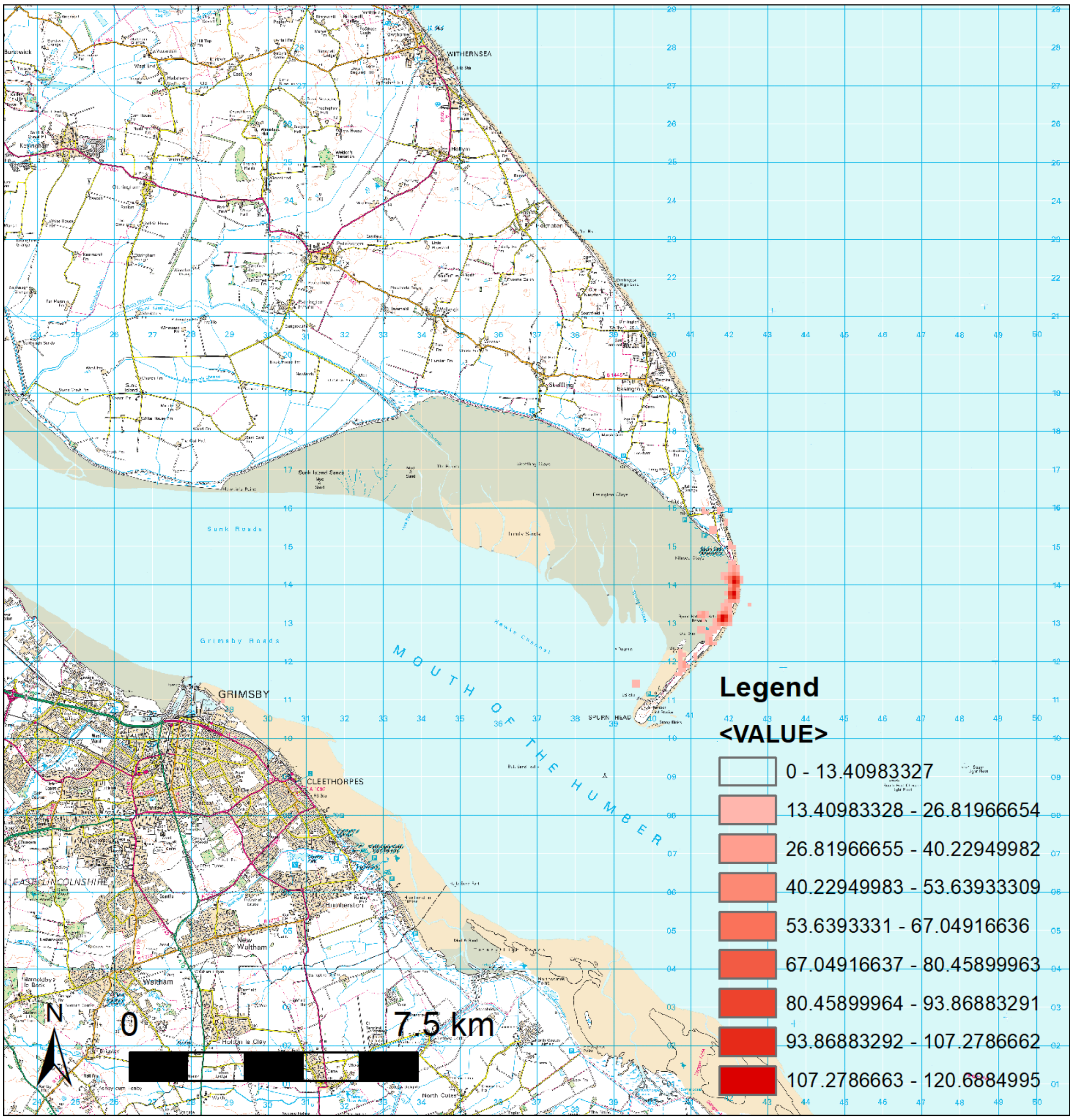


Figure 19. Kernel density map showing point densities for visitor-perceived risk at Spurn.

3.5. Themes of value and risk in the coastal zone

3.5.1. Perceptions of value

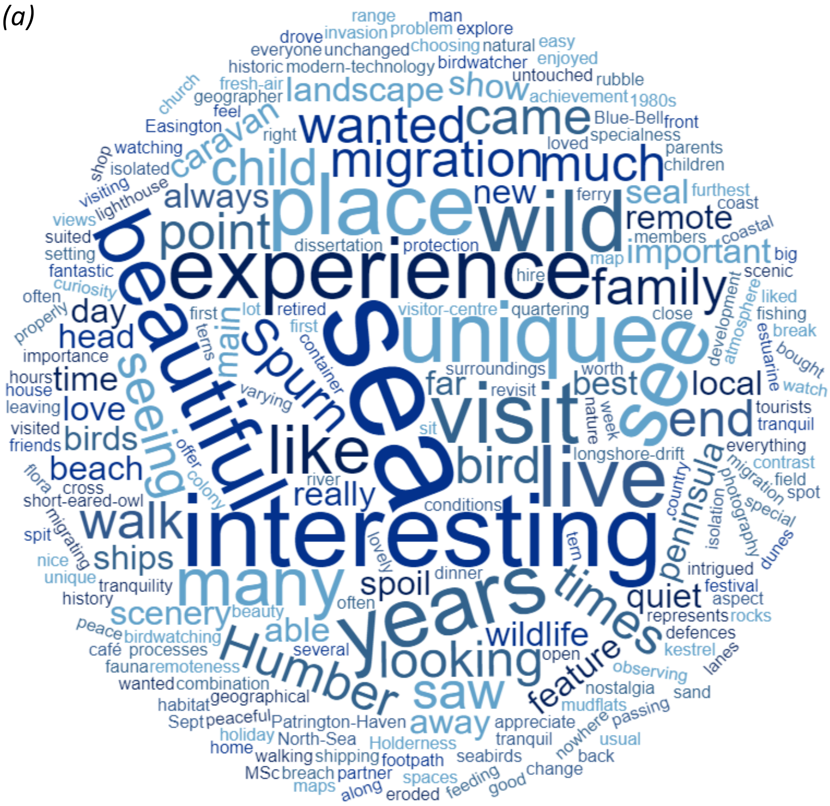
From the qualitative data, areas of greatest personal importance to respondents grouped into four principal themes; those of landscape attributes (N = 177), value ascribed to place (N = 123), social attributes (N = 104) and physical change/ dynamic nature (N = 21) (see **Figures 20 and 21** for word clouds of response data). A single response could be categorised in multiple themes and it should be noted that place includes both social and landscape attributes. Interestingly, whilst saltmarsh change was the most frequently cited physical change on the Silverdale coast in Chapter Three, saltmarshes were not explicitly mentioned in any response with regard to areas of greatest perceived value at either study site.

Aesthetic landscape attributes (N = 40) and views (N = 29) including waterscapes and hills were principal themes of value attributed to the physical landscape (e.g. *"combination of sea + landscape"*). Biodiversity, through natural history (N = 2), flora (N = 8) and fauna (N = 43), notably birdlife (N = 23) was also valued (e.g. *"very keen on bird and wildlife"*. Within social attributes, reference was made to facilities and services (N = 22) and specifically to recreational (N = 33) and educational (N = 4) services, with walking and running the most frequently cited at Spurn (N = 6) and Silverdale (N = 22).

A clear sense of place identity through belonging and compatibility was evident through responses such as *"I belong here"* and *"it is the best place on Earth"* (both from respondents on the Silverdale coast). At Spurn, value was specifically attributed to the turbulent nature of the environment, alluding to the concept of the sublime *"… I feel the wild isolated atmosphere which is one of the main reasons I visit so often."* Nostalgia and family ties were also apparent (e.g. *"favourite family haunt for walks").*

Physical change/ dynamic nature through coastal processes (N = 4) and management (N = 2) at Spurn (e.g. *"it represents the big problem of protection from the sea's invasion"*) and value ascribed to seasonal change (N = 3) and to the weather (N = 2) were of note on the Silverdale coast (e.g. *"changes with the time of day and weather"* and *"I love wildlife and Leighton Moss is constantly changing throughout the year"*).

(a)



(b)

Figure 20. Word clouds of respondents’ justifications for spatial location of (a) Spurn perceived value; and (b) Silverdale perceived value in question 4 of the survey. Neutral words, e.g. ‘area’ have been removed from the dataset for greater visual clarity. Word size denotes relative frequency of occurrence.

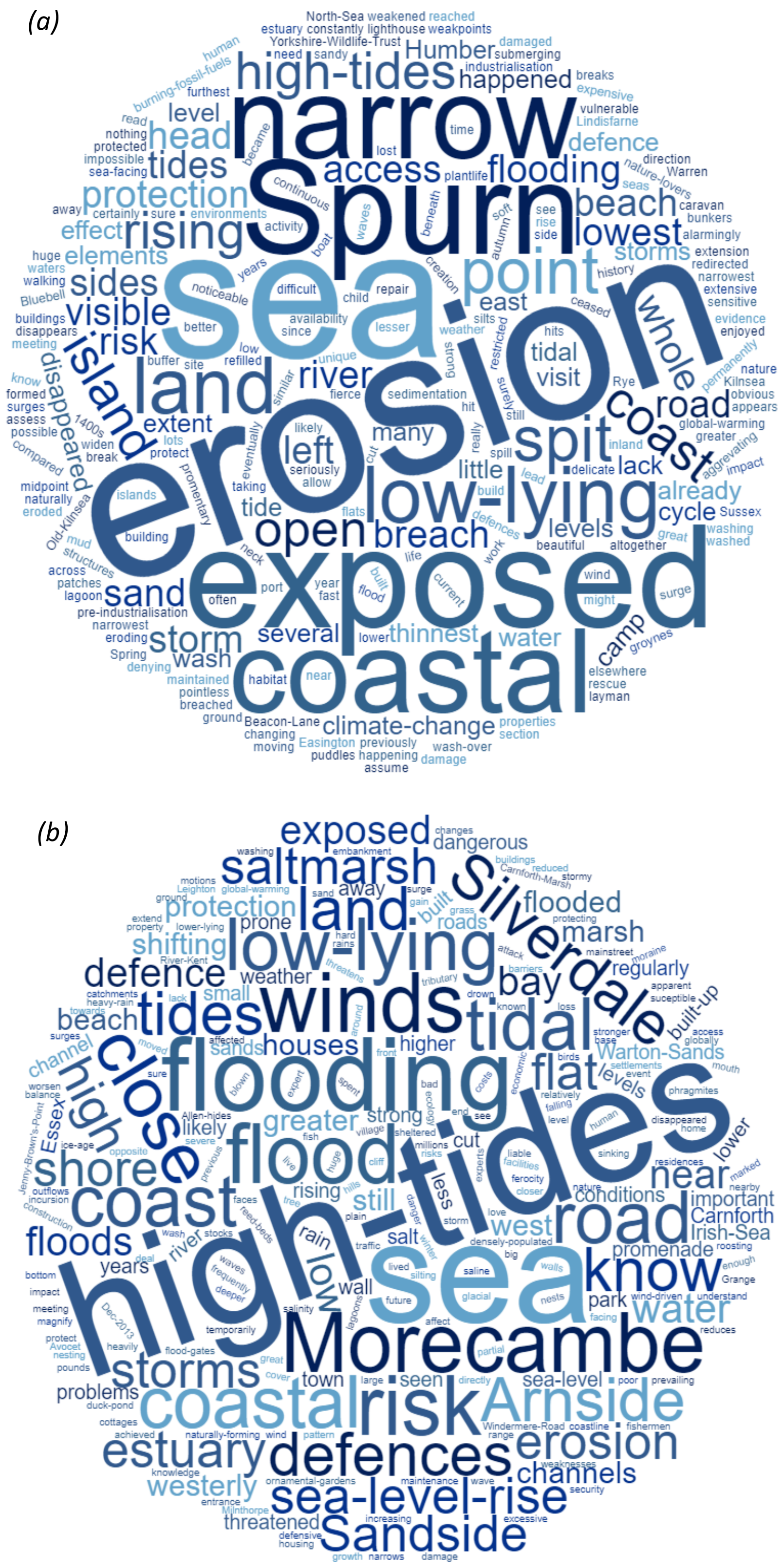


Figure 21. Word clouds of respondents' justifications for spatial location of (a) Spurn perceived risk; and (b) Silverdale perceived risk in question 9 of the survey. Neutral words, e.g. 'area' have been removed from the dataset for greater visual clarity. Word size denotes relative frequency of occurrence.

3.5.2. Perceptions of risk

Over-arching themes from the perceived risk qualitative responses comprised morphological/ topographical vulnerability (N = 159), process-based risk perception (N = 94), risk posed to society (N = 95), meteorology (N = 87), experiential effects of storms/ landscape change (N = 35) and allusions to climate change effects (N = 17). It is interesting to note that physical (morphological/ topographical) vulnerabilities (e.g. references to *"flat, low land"* and *"exposed nature"*) were more frequently alluded to than risks posed to society (e.g. *"road close to estuary – used heavily. Home close to areas of flooding"*). Perceived risk to the built environment through infrastructure, access and property accounted for 40.4% of perceived risk to society (N = 38). Of the process-based risk perception, flooding (N = 14) and erosion (N = 16), particularly to saltmarsh (N = 6) and perceived saltmarsh vulnerability (N = 5) were of note on the Silverdale coast, where one respondent described how saltmarsh extent has *"reduced by 30 m+ in 5 years, [with] erosion at the base of [the] flood embankment,"* and another observed that it had *"almost disappeared."* A further respondent highlighted the *"saltmarshes from Silverdale to Carnforth"* as being at greatest risk, as they are "*low-lying… [and] therefore very exposed in [the] event of any tidal surge or rise in sea level."* One respondent at Silverdale alluded to the coastal protection value of saltmarshes and topographical vulnerability of the coastline to storm surges, such as that of 5/6 December 2013; *"Low lying coastline – no defensive saltmarsh."* Washover and breach at Spurn (N = 19) were notable features. Interestingly, despite the emphasis on the physical perceived risk at Spurn, saltmarsh was not explicitly identified as being at risk, although erosion was a pertinent risk (N = 18).

Sea-level rise was the most frequently mentioned impact of climate change (N = 8), whilst three respondents at Silverdale considered the risk of an increase in coastal flooding and one at Spurn an increase in storminess *("the spit could break in half permanently with a rise in sea level or more fierce storms").*

Meteorological influences, such as *"weather pattern from the west"* and references to "high tides" and "huge tidal range" were evident at Silverdale, whilst at Spurn, *"the evidence of the tidal level was alarmingly narrow."* Experiential effects of storms and flooding in the landscape were also evident in respondents' rationales e.g. *"always has flooded at high tides," "the promenade [at Grange] can also be relatively dangerous in stormy conditions"* and *"the coast has disappeared, when I was a child I used to camp on what is now water and sand."*

4. Discussion

The aim of this study was to examine the spatial correlation of perceived value and risk from storms on the coast, with a particular focus on the built and natural environment, correlations between expert-defined and public-perceived risk and between the perceptions of residents and visitors. This was achieved through spatial analysis and qualitative analysis of data obtained through the Coastal Experience Survey.

4.1. Perceived risk in the natural and built environments

Through exploring the distribution of value and risk across the built and natural environments, an emphasis on perceived risk to the natural environment is apparent. The second research question sought to determine whether low-lying coastal environments, namely saltmarshes, or neighbouring urban infrastructure, were perceived to be at greatest risk from storms and coastal floods. Evidence from previous research is mixed on this point and it was therefore difficult to predict a clear-cut distinction between perceived risk in the natural and built environments. A greater percentage of perceived risk points were located in areas of saltmarsh than in urban areas on the Silverdale coast relative to percentage landcover, whilst at Spurn perceived risk within these landcovers was found to be equally low.

Risk posed to saltmarshes by storms and coastal floods was a key “morphological/ topographical vulnerability” in the risk themes at Silverdale. Awareness of saltmarsh change in Morecambe Bay was also found to be markedly high, possibly due to the visual salience of cyclic erosion and deposition in Morecambe Bay (as was discussed in Chapter Three). This could, in part, explain the greater percentages of value and risk points in the saltmarsh environment at Silverdale.

The prominence of perceived risk in the foreshore regions (including sandflats and mudflat areas below mean low water) is noteworthy. Sandflats and mudflats had greater relative importance to area enjoyment than saltmarshes in a photo-preference study (discussed in Chapter Three). The value attributed to these environments could be reflected in a greater perception of risk within these environments. This appears to be in line with the roles of value and experience in risk perception (Burningham et al., 2008; Tapsell and Tunstall, 2008). It is difficult to attribute an effect of value on the perception of risk with certainty, however, as this was not explored directly in the analysis. That “other” landcover classes than those identified in the analysis were of greatest perceived risk appears to be due to the majority of Spurn Point itself being unclassified by the landcover types used in the OS Strategi mapping data.

4.2. Spatial correlation of perceived value and risk

A degree of spatial correlation between perceived value and risk from storms and flooding was anticipated on the coasts at Spurn and Silverdale. Contrary to expectation, significant negative spatial correlation was, in fact, evident at both study sites. This finding contrasts with previous research (e.g. Raymond and Brown, 2011), which found that landscape values partly determined the spatial perception of climate change risk. Whilst we did not test for causality in our study, it is anticipated that value, through for example, place attachment, may constitute a certain degree of risk acceptance, and thus negative correlation with perceived risk.

The comparison of distances between the value and risk survey points and sets of random points shows strong evidence of a relationship between people's placement of value and risk. There may, however, be a potential effect of sampling location and area familiarity on point placement here.

Aesthetics in the physical landscape was a principal value sub-theme amongst the "landscape attributes" themes identified in the open-responses. This corresponds with the primary reasons people gave for visiting these coastal areas, which included aesthetic beauty, tranquillity and nature experience, as reported in Chapter Three. The prevalence of value attributed to landscape attributes is also in line with results discussed in Chapter Three, where, contrary to expectations, environmental changes were more pertinent to respondents than social changes in the study areas. This was proposed to be related to the visual prominence of erosion in both study areas.

4.3. Expert-defined and public-perceived storm and coastal flood risk

The density maps in **Figures 7 and 10** appear to show some degree of divergence between expert-defined and public-perceived risk. A significant negative spatial correlation between expert-assessed and public-perceived risk in the coastal zone at Spurn and Silverdale was found. Whilst some divergence in expert and public-perception risk perception was anticipated, we expected a positive spatial correlation between them, based on the findings of previous studies. The strength of this relationship has been shown to differ across different regions (e.g. Siegrist and Gutscher, 2006). Whilst the strength of the relationship between lay-person perceived and expert-assessed risk differs slightly between the two study regions, as would be expected, they are both significant at the $p < .001$ level. Although it was not possible to determine in this study, it would be interesting to consider the extent to which these perceptions of risk are independent of expert assessment, i.e. exploring knowledge and awareness of flood risk maps - Siegrist and Gutscher (2006) highlighted a lack of awareness of flood risk maps in Switzerland, for example. This could also be the case at Spurn and Silverdale, with the correlations potentially highlighting a need to raise awareness of flood risk at the study sites.

4.4. Area familiarity and place attachment: comparing resident and visitor perceptions

Visual differences were apparent between the locations of visitor and resident responses in **Figures 12-19**. Divergence in visitor and resident perceptions was anticipated, and, visitor- and resident-perceived risk were significantly negatively correlated. Visitor- and resident- perceived value were also significantly negatively correlated at both study sites. The strength of the correlations at the two sites are quite different, however. Correlation between the perceptions of visitors and residents was slightly higher at Spurn, although geographically, the propensity for points to be located on Spurn Point itself, may perhaps be an effect of sampling primarily taking place here. The potential for media effects and visual salience of storm effects in the landscape may have contributed to greater correlation between visitors' and residents' perceptions of risk here, when compared to Silverdale. The strength of resident-visitor value correlations is much lower at Spurn than at Silverdale. This may reflect differing place attachment, experience and values between those visiting and those living on the coast. The values of residents may reflect greater familiarity with the area and a consequently higher differentiation amongst, and appreciation for, the landscape characteristics close to where they live (e.g. Kaplan and Kaplan, 1989). Greater importance of community and social networks may also be evident in their attachment to place (as was found by Plieninger et al. (2013)), as some respondents chose their own home or village as the area which was most important to them.

Not all respondents completed the mapping questions. If respondents felt that the coast at Silverdale/ Spurn Point was "not at all" at risk from storms and coastal floods, they were prompted to skip the subsequent mapping question. At Silverdale, 7.2% of respondents skipped the mapping question because they felt there was no storm or flood risk posed to the area, whilst all respondents at Spurn felt there was some degree of risk, so there was no "conditional" non-response. Levels of non-response to the mapping questions were higher for perceived risk than for perceived value at both study sites (Silverdale perceived risk: 27.2%; Spurn perceived risk 11.6%; Silverdale perceived value 5.6%; Spurn perceived value 8.1%). Klain and Chan (2012) explored rationales for refusals to answer spatial questions in a study, which mapped coastal values using participatory methods. Some found that they could not place a hard boundary on value or risk in the landscape, whilst others felt that in defining particular areas as being of greater value than others, this would leave excluded areas vulnerable to development pressures. Whilst we did not explicitly explore the reasons for non-response to spatial questions in our survey, non-response would typically occur if respondents did not know where was at greatest risk, citing that they "don't know" or were insufficiently familiar with the area.

4.5. Management implications

The significant negative correlation between value and perceived risk, and between expert- and public perceived risk has potentially important policy implications, as it suggests a need to raise awareness of flood risk at the study sites.

4.6. Limitations and further research

The population represented in the survey data was older and more highly educated than the national average. The sample size is also relatively small, which may constrain the ability to generalise research findings (see Chapter Three for further discussion of sample limitations).

Interpretation of "the coast around Silverdale" appeared to be ambiguous for some, so if respondents felt that Silverdale village itself was not at risk from storms and floods, they may have been inclined not to respond. Klain and Chan (2012) found that "sizeable minorities" refused to respond to the mapping question in their study. This may have implications for how representative the sample is of the population.

It is acknowledged that the outline of the "coastline" on the OS map used for the Silverdale coast may have biased responses towards the intertidal zone, particularly around Silverdale village and Warton Marsh, where respondents may have interpreted an inland/ marsh area, which has been eroded and is not present on the current OS Mastermap basemaps. Interpretation of the map topography was met with varying degrees of comprehension; one respondent, for example, chose a cliff-top path, near Silverdale village as being at greatest risk from storms and coastal floods, as the area was "flat."

Whilst the feature-to-point methodology allowed a greater frequency of single point data to be extracted from multipoint, polygon and line features, using a standardised methodology, the central point was not necessarily located within the environment type selected by the participant. On one map, for example, the respondent chose two low-lying intertidal areas at Grange and Holker. The centroid of these points, however, was located in an area further inland, at Allithwaite, which is characterised by higher elevation and more built infrastructure.

As each open response used in the value and risk themes presented in section 3.5.1 and 3.5.2 could be grouped into multiple themes, the values presented have not been normalised for the number of respondents or the frequency of words, which they uttered.

Further exploration of awareness and familiarity with expert-assessed flood risk maps would certainly be a valuable line of research to pursue, to guide knowledge of effective climate change risk communication and inform future policy. This could examine the role of providing expert information in potentially changing perceptions and how this information might be filtered through prior attitudes and values. The effectiveness of different communication strategies for translating expert storm and flood risk assessment to the public (e.g. social media channels used by the UK Met Office, Environment Agency and local institutional networks) is also worthy of attention. There is also a need to explore how other individual differences, such as ideology, affect perceptions and values, since this has been found in previous work (Carlton and Jacobson, 2013; Smith et al., 2016).

5. Conclusions

This study has provided a novel insight into the spatial relationship between perceptions of value and of risk posed by storms and flooding on the UK coast. The results of this research may have implications for flood risk communication at the study sites.

Significant negative correlation was found between perceived value and risk on the coast at Spurn and Silverdale. The prevalence of risk in the foreshore regions suggests that the natural environment was perceived to be at greater risk from storms and coastal floods than the built environment. There is a need to better communicate the benefits of and risks posed to the saltmarsh environment. Indeed, the saliency of physical attributes, which was evident in the perception of storm risk is important. Significant negative correlation between the perceptions of visitors and residents, and also between public- and expert-assessed coastal flood risk at both study sites suggests a need to raise flood risk awareness at the study sites. Climate change risk communication, which highlights physical storm effects in the landscape, rather than more psychologically distant aspects of climate change may be more effective in these study areas.

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CHAPTER 5. General Discussion

5.1. Summary of thesis aims and results

This study aimed to consider perspectives from environmental science and environmental psychology to assess coastal storm effects on saltmarshes and the role of storms in shaping the psychological benefits derived from the coastal environment. In so doing, this research sought to evaluate the utility of saltmarshes as storm record archives and thus provide long-term, historical context to coastal management. Considering storms and coastal flooding from a psychological perspective, this study examined perceptions and drivers of change, value and risk on the coast and investigated attitudes towards, and relationships with, the coastal landscape.

In Chapter Two, methods of sediment core stratigraphical, geochemical and geochronological analyses were employed to identify potential storm signatures in the sediment record at Spurn Point and Warton Marsh. Heavy mineral sand deposits were identified, which may represent records of the storms of September 1969, November 1977, January 1978 and February 1997 at Spurn Point and March 1968, November 1977 and February 2002 at Warton Marsh. In addition to these storm events, there were numerous storms which did not appear to be recorded in the stratigraphy. These records were evaluated through consideration of documented storm characteristics. It was clear that from the interpretation of the sediment record alone, the potential effects of storms could be under- or over-estimated, if they were extrapolated to the landscape scale. The ways in which contextual forcing factors can contribute to variability in storm effects within saltmarshes was highlighted, including through storm meteorology, marsh geomorphology, bathymetry, sediment availability and management effects. It was advised that borehole sediment stratigraphies are considered holistically, alongside these factors and high-resolution field analyses, to inform coastal management.

Against this backdrop of historical storms and their diverse effects on the coast, which were explored through the saltmarsh sediment records, Chapter Three considered the potential impacts of storms on these study coasts on a more contemporary timescale and from a psychological perspective. Quantitative and qualitative data were examined from the Coastal Experience Survey, which was conducted at Spurn and Silverdale. Aesthetic values, tranquillity, nature experience and recreation were principal values attributed to the coast. However, less than half the surveyed populations directly cited value to health and wellbeing. The contribution of saltmarshes to coastal wellbeing relative to sand dunes and mudflats/sandflats was measured through a photo preference task. Whilst the importance of sandflats and saltmarshes was not found to differ significantly at Silverdale, sand dune environments at Spurn were significantly more important to respondents' wellbeing than saltmarshes. Predictors of perceived restorativeness were examined through regression analysis, as was the extent to which climate change was perceived to impact upon restorativeness. Most people perceived the coast to offer potential for restoration, with a mean restorativeness rating of 4.37 out of 6.00 for the study sites. Perceived storm risk did not significantly predict restorativeness. Changes perceived on the coast were examined through qualitative and quantitative approaches. Physical changes were perceived to be negative at both sites, with negative perceived biodiversity change at Spurn, whilst biodiversity changes were minimal, yet positive at Silverdale. The extent of change in erosion, coastal flooding and storms was perceived to be significantly worse at Spurn than at Silverdale. Physical changes were also found to be the principal theme in the open response data, followed by social change, no perceived change and biodiversity changes. Location was the sole predictor of storm and flood risk, with higher perceived risk at Spurn than at Silverdale. Finally, acceptability of coastal protection measures, and the predictors of their acceptability were examined. A preference for soft-engineering protection measures was found and they were considered significantly more acceptable than hard-engineering measures. The importance of place and experience, and to some extent perceived changes in biodiversity, predicted preferences. The photo-preference methodology may have heightened the role of aesthetics over other ideologies and factors for respondents.

To gain an even greater depth of understanding of respondents' perceptions in the Coastal Experience Survey, the fourth chapter examined the spatial distribution of value and risk at Spurn and Silverdale. Digitisation of participatory mapping data allowed kernel density maps to be created, which facilitated examination of the spatial distribution of value and risk perception in the landscape. Random sampling across the kernel density raster data allowed correlation analyses to be undertaken. Perceived value and risk showed significant negative spatial correlation at both sites. Greater frequencies of perceived risk points were located within the natural environment than the built environment at both study sites. This was supported by the qualitative responses, which showed that physical, morphological/ topographical vulnerability was most pertinent, relative to societal risk. Correlation between public-perceived and expert-assessed flood risk was negative and relatively weak, yet significant. This may suggest a need to raise levels of storm and flood risk awareness at the study sites. The perceptions of visitors and residents were significantly and negatively correlated. This divergence between the perceptions of visitors and residents is in agreement with the role of length of residency and area familiarity, which was found to predict acceptability of coastal protection measures in Chapter Three.

5.2. Theoretical implications

This study contributes to the growing body of research into climate change risk perception. The importance of mixed-methods and a multi-disciplinary approach is evident in the *breadth* of evidence and contextual understanding, which has been garnered through considering psychological and environmental perspectives. The application of mixed-methods research, allows greater depth of understanding, through the synthesis of findings from multiple approaches (Devine-Wright and Howes, 2010). An important understanding of climate change risk perception has been gained, through demonstrating the prominence of contextual factors, and revealing the saliency of physical landscape impacts in people's perception of risk. This finding is consistent with previous literature and would suggest that in the study areas considered in this research, highlighting physical environmental effects in climate change risk communication may be more salient than other more "distant" aspects of climate change (e.g. Carlton and Jacobson, 2013).

Numerous studies have shown the potential for restoration from the coastal environment (Wheeler et al., 2012; White et al., 2010, 2013). Far less research has considered the effects of climate change on these restorative benefits, particularly when compared to studies of economic valuation. In considering the role of climate change risk perception in the restorative benefits of the coastal experience, risk perception did not significantly predict restorativeness at the two UK coastal study sites. The role of place attachment in preferences for coastal protection strategies is also noteworthy. Visiting populations, and those who were less attached to the study areas were more accepting of landscape changes than respondents who were more established in the area, with greater place attachment and a concurrent greater resistance to change. This is in line with research concerning place attachment and industrial development in restorative coastal environments (e.g. Devine-Wright and Howes, 2010), whereby contradiction between project and place were found to pose a threat to identity amongst those with strong place attachment.

This study also contributes towards the field of storm surge science, furthering understanding of storm surge effects and their records in UK saltmarshes, through the use of stratigraphical and geochemical methods. Whilst this research has identified potential storm surge records in saltmarsh sediment from Warton Marsh and Spurn Point, a significant challenge remains for future studies to establish a baseline of evidence in these environments, to achieve certainty in the attribution of sediment signatures to storm events. Despite significant technological advances in the field (Rothwell and Croudace, 2015), this may not be possible due to the variability that is inherent within these ecosystems and to the storm records contained within them (e.g. de Groot et al., 2011; Nikitina et al., 2014). Spencer et al. (2015) highlighted the need to consider storm effects on a case-by-case basis, and to assemble archives of their pathways and landscape impacts. Haigh et al. (2015) have made substantial progress in this respect, through the synthesis of the UK SurgeWatch database, from which surge data were derived in Chapter Two. Such archives represent an important source of contextual evidence to further understanding of diverse storm effects on the coast.

5.3. Implications for policy on coastal storm and flood risk management

This research has contributed novel, empirical data, with theoretical implications for the fields of environmental (storm surge) science and environmental psychology. The principal value in adopting this cross-disciplinary, participatory approach, however, lies in the holistic picture of storm effects in the coastal landscape, a landscape of complex social-environmental interactions, multiple uses, stakeholders and pressures (e.g. Barbier et al., 2011).

Within- and between- site heterogeneity has been demonstrated through the environmental effects of storms and perceptions of value and of risk from these storms. This highlights the importance of contextual factors, both in their potential to shape the different landscape effects of coastal storms and in the perception of risk posed by them. Whilst this theme of context-specificity is key to understanding the variability in social-environmental storm effects (Spencer et al., 2014), there are some important insights arising from this research which can be extrapolated to the management of other UK coastal areas, and perhaps, to a broader, non-UK context.

Insights from the sediment record not only provide a record of past events, but can inform modelling of future climate change scenarios on the coast. Accounting for such spatial and temporal variability in coastal models will improve flood risk preparedness for coastal communities (Spencer et al., 2014, 2015). Addressing such within- and between-site variation in both the social and environmental datasets presents a significant challenge for future coastal management and has implications for coastal infrastructural development, e.g. power generation and housing, as well as for food security through the impacts on agricultural land and water supply.

The protection of key coastal infrastructure, such as the North Sea gas terminal at Easington, and of the nuclear power station at Heysham, situated at the south of Morecambe Bay, from risk posed by climate change, is a clear coastal management priority. Nuclear power and waste reprocessing plants are situated on the coast and expansion plans, e.g. Sizewell C on the rapidly-eroding Suffolk coast will require long-term protection strategies (McKenna et al., 2008; Suffolk Coastal District Council and Waveney District Council, 2017). Highlighting the aesthetic value of such protection schemes and encouraging transparency with regard to their ecological impacts is advisable, in order to gain greater public support. The negative correlation identified between perceived value and risk in this study, and negative correlation with expert-assessed risk, however, suggest a need to heighten awareness of flood risk in these areas. Highlighting physical storm effects in the landscape, rather than more psychologically distant aspects of climate change may be a more effective climate change risk communication strategy in these study areas.

The sites studied in this research were generally perceived to offer restorative potential, adding further support for the importance of the coast as beneficial to health and wellbeing. Policy makers are showing increasing interest in research on the wellbeing benefits of the coast (White et al., 2013). At a time when the UK's National Health Service spending is under scrutiny, the restorative mental health and wellbeing benefits associated with coastal locations should not be underestimated and it is advisable to develop programmes which will enable local and visiting populations to gain maximum benefit from the coastal environment.

Saltmarshes and other low-lying coastal ecosystems are a fundamental component in coastal storm and flood risk reduction, alongside engineering, and socio-cultural methods (Spalding et al., 2014). Whilst coastal management may transcend institutional boundaries to some extent, strategy effectiveness is hindered by overarching political timescales and priorities (e.g. Roe, 2000). Initiatives, such as "Futurescapes" in Morecambe Bay (Ecosystems Knowledge Network, n.d.); a bay-wide approach to management amongst coastal stakeholders, including the RSPB and Natural England, to facilitate a more coherent vision of land management, nature conservation and community identity presents an encouraging step towards holistic management, which may be upheld beyond political timescales.

5.4. Limitations and areas for future research

It is acknowledged that the sample size considered in this study was relatively small, and the population rather older and more highly educated than the national average, which may somewhat limit the ability to generalise findings. Indeed, comparability between the samples used in this study may be affected by the multiple methods through which respondents were recruited, the potential for greater area familiarity among the Silverdale sample and the different landscape characteristics and visual evidence of storm effects at the study sites themselves. Confidence in the sample comparability is improved, however, by the fact that other demographic attributes did not differ significantly between the two sites, nor exhibit a significant relationship with sampling location.

The sample consisted of in-situ and postal responses, although the effects of in-situ completion and recalled perception of restorativeness were not tested for in the analysis. Yet this could have had an effect on perceived restorativeness, through the potential for distortion in reconstructing experience within the study environment (Scopelliti and Giuliani, 2004). Furthermore, the limitations of the photo preference methodology adopted in the survey are acknowledged, with the potential for this method to have biased responses to the aesthetic level. Employing more deliberative techniques in future research, which consider positive and negative characteristics of different coastal management strategies, would allow insights beyond the aesthetic level.

Whilst correlations have been drawn between the perceptions of visiting and resident populations in the current study, to examine the role of place attachment in value and risk perception, there is a need to examine the effects of other individual differences, such as political ideology, as these attributes have been shown to predict risk perception in previous research (Carlton and Jacobson, 2013; Smith et al., 2016). Exploring the roles of other demographic variables, such as environmental worldview, on the spatial distribution of value and risk perception in the landscape would also be worthwhile. Whilst there was significant, if relatively weak negative spatial correlation between public-perceived and expert-assessed risk on the coast, the level of awareness of participants regarding expert flood-risk maps was not discerned in this study. To inform effective climate change risk communication, future research should consider awareness of expert flood-risk maps, and the role they may play in contributing to individual risk perception. This study compared sites on the east and west coasts of the UK. Owing to the case-specific nature of social-environmental storm effects on the coast, there is a clear need for further such multi-disciplinary research elsewhere on the coast, to inform effective and place-appropriate coastal zone management.

As the data collection and analysis for environmental science and environmental psychology approaches occurred in parallel for the current research, it was not possible to directly incorporate insights from the environmental science data into the design of the survey. The correlational nature of findings in this research mean that causality in observed relationships cannot be inferred. This could be addressed in future research through working with coastal stakeholders at the study sites over a longer timeframe. Through focus groups and participatory mapping workshops, a phenomenological approach could be taken to measure coastal storm effects on risk perception and perceived restorativeness in the immediate aftermath of an event. Change in perceptions and the role of availability heuristics over time following the event could also be explored. Such an approach could work in partnership with established holistic coastal management initiatives, such as Futurescapes at Morecambe Bay, for example.

5.5. Conclusions

This research has provided insights into saltmarsh storm records and their variability, the psychological benefits derived from the coastal environment and the effects of storms on these benefits. The predictors of perceived value and coastal storm and flood risk and the roles of place and experience in predicting coastal protection acceptability have also been identified. As with storm signatures in the sediment record, extreme events, such as storms and coastal flooding become fixed points in the individual and collective memory of those communities affected; shared experiences, which engender a sense of place and community cohesion. This experience, in turn, shapes perception of risk and preparedness for future extreme events. This research has demonstrated the importance of the dual perspectives for the breadth of understanding which can be obtained when coastal storms are considered through environmental records and social perceptions. Institutional barriers, such as political timescales remain an impediment to effective, long-term management in the coastal zone. It is hoped that through greater adoption of cross-disciplinary research methods and through collective, holistic coastal management strategies, progress can be achieved towards a more inclusive, democratic management.

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Appendices

Appendix 1. Spurn and Silverdale Coastal Experience Surveys

Coastal experience survey

This survey examines the benefits, values and changes you have experienced on the coast around Spurn Point. This project is being undertaken by the University of York in collaboration with Cardiff University and Yorkshire Wildlife Trust and is funded by the Natural Environment Research Council (NERC).

Date ………/…………/………..

Location ……………………..

Benefits and values

1. a) When did you first come to the coast around Spurn Point? (Please tick **one** statement)

I moved here in the last six months (go to Q2)	
I moved here between six months and two years ago (go to Q2)	
I moved here between two and five years ago (go to Q2)	
I moved here more than five years ago (go to Q2)	
I have lived here all my life (go to Q2)	
I am a visitor to the area (go to Q1b)	

1. b) How often do you visit? (Please tick **one** statement)

This is my first visit	
I visit once to twice a year	
I visit several times a year	

2. Why did you choose to visit/ live on the coast around Spurn Point? (Please tick **all that apply**)

To be close to nature	
To see birds and wildlife	
To see a range of plants	
For peace and tranquillity	
For the beautiful scenery and landscape	
For walking	
For health and wellbeing benefits	
For fishing	
For a family outing	
For holidays	
For work	
Other (please specify) ………………………………………………………………………………………..	

3. To what extent do the following statements describe your experience of the coast around Spurn Point? (Please tick as appropriate)

	Not at all						Completely
	0	1	2	3	4	5	6
It is an escape experience							
Spending time here gives me a good break from my day-to-day routine							
There is much to explore and discover here							
I would like to spend more time looking at the surroundings							
There is a great deal of distraction							
It is chaotic here							
I have a sense that I belong here							
Being here suits my personality							

4. a) Indicate with a cross on the map opposite, the one area which is most important to you personally: (This may or may not be the place that you spend most time)

4. b) Why did you choose this area?

....

....

5. To what extent are the following types of environment important to your enjoyment of the area? (Please circle as appropriate)

a)

Saltmarsh

Not at all				Very important
1	2	3	4	5

b)

Sand dunes

Not at all				Very important
1	2	3	4	5

c)

Mudflats

Not at all				Very important
1	2	3	4	5


KINGSTON UPON HULL to
GRIMSBY
CLEETHORPES
Discovery Centre
A1098
HUMBER
MOUTH OF THE HUMBER
Bull Sand Fort
Bull
SPURN HEAD
Spurn National Nature Reserve
Spurn Bird Observatory
South East Chequer
Spurn
Kilnsea
Easington
Skeffling
Weeton
Out Newton
Welwick
Underground Bunker
B1445
Patrington
Sunk Island
Sunk Island Sands
Scale 1:100000
0 1 2 3 4 5 6 7 8 9 10 km
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Digimap
Mapping sourced from Ordnance Survey

<u>Changes</u>

If this is the first time you've visited, <u>please skip questions 6 and 7</u>

6. What changes have you noticed in the area since you started living/ visiting here?

....

....

7. a) Please indicate the extent to which the following issues have improved or worsened in this area over the time you have known it. (Please tick as appropriate)

	Extent of change						
	Significantly worsened			Neither worsened nor improved			Significantly improved
	-3	-2	-1	0	1	2	3
Erosion							
Coastal flooding							
Storms							
Hotter weather and droughts							
Amount and range of wildlife							
Amount and range of plants							

7. b) Please indicate how these changes have affected your use or enjoyment of the area. (Please tick as appropriate)

	Your use or enjoyment of the area						
	Significantly worsened			Neither worsened nor improved			Significantly improved
	-3	-2	-1	0	1	2	3
Erosion							
Coastal flooding							
Storms							
Hotter weather and droughts							
Amount and range of wildlife							
Amount and range of plants							

8. To what extent do you think the coast around Spurn Point is at risk from storms and coastal floods? (Please tick **one** statement)

A great deal (go to question 9)	
Somewhat (go to question 9)	
A little (go to question 9)	
Not at all (go to question 10)	

9. a) Indicate with a cross on the map overleaf, roughly the area which is most at risk from storms and coastal floods.

9. b) Why is this area particularly at risk?

……

……

……

10. To what extent are current levels of protection from storms and coastal floods adequate in this area? (Please circle as appropriate)

Completely inadequate				Completely adequate
1	2	3	4	5

11. How acceptable would you find the following coastal protection measures for this area? (Please circle as appropriate)

a)

Concrete sea wall to reduce erosion and flooding

Completely unacceptable				Completely acceptable
1	2	3	4	5

b)

Managed realignment, where land is allowed to flood with the tide, to reduce flooding risk elsewhere

Completely unacceptable				Completely acceptable
1	2	3	4	5


Patrington
B1445
Underground
Bunker
Out
Newton
25
Welwick
Weeton
5
Skeffling
Sunk Island
Easington
Sunk Island Sands
Kilnsea
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Spurn National
Nature Reserve
GRIMSBY
SPURN HEAD
6
CLEETHORPES
Bull Sand Fort
Bull
MOUTH OF THE HUMB
Spurn
South East Chequer
A1098
Discovery Centre
KINGSTON UPON HULL to
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Digimap
Mapping sourced from
Ordnance Survey
Scale 1:100000
0 1 2 3 4 5 6 7 8 9 10 km

c)

Rock groynes to encourage build-up of beach material and absorb wave energy

Completely unacceptable				Completely acceptable
1	2	3	4	5

d)

Beach "nourishment" through redistribution of sand, to replace lost beach material and help reduce erosion

Completely unacceptable				Completely acceptable
1	2	3	4	5

e)

Earth and rock embankment to reduce erosion and flooding

Completely unacceptable				Completely acceptable
1	2	3	4	5

f)

Saltmarsh to reduce wave energy

Completely unacceptable				Completely acceptable
1	2	3	4	5

g)

Dune stabilisation through marram grass planting to

Completely unacceptable				Completely acceptable
1	2	3	4	5

The future

12. To what extent do you think that the frequency and severity of storms will increase in this area in the future?

Not at all						Extremely
0	1	2	3	4	5	6

About you

13. Please indicate your age

18-24	
25-34	
35-44	
45-54	
55-64	
65-74	
75-84	
85+	
Prefer not to say	

14. Please indicate your gender

Male	
Female	

15. What is your profession?

……………………………………………………………………………………

16. What is your highest level of education?

No formal qualifications	
GCSE/ O-level	
A-level/ Higher/ BTEC	
Vocational/ NVQ	
Degree or equivalent	
Postgraduate Qualification	
Other (please specify below)	

……………………………………………………………………………………

17. Where on this scale would you position yourself politically?

Politically, I see myself as…

Very liberal (1)	
Liberal (2)	
Slightly liberal (3)	
Neutral (4)	
Slightly conservative (5)	
Conservative (6)	
Very conservative (7)	

18. Are you a member of / do you regularly donate to a wildlife organisation? (E.g. RSPB or WWF) (Please circle as appropriate)

Yes/ No

19. To what extent do you agree or disagree with the following statements? (Please tick as appropriate)

	Strongly disagree				Strongly agree
	-2	-1	0	1	2
'Humans have the right to modify the natural environment to suit their needs'					
'Humans are severely abusing the planet'					
'Plants and animals have the same rights as humans to exist'					
'There is solid evidence that the Earth is warming because of human activities'					
'Nature is strong enough to cope with the impact of modern industrial nations'					
'Humans were meant to rule over the rest of nature'					
'Climate change is just a natural fluctuation in Earth's temperatures'					
'The balance of nature is very delicate and easily upset'					

20. Do you live on or near the coast? (Please circle as appropriate)

Yes/ No

21. Specifically thinking about storm damage (e.g. flooding, erosion, wind damage) **in the last two years**, which of the following applies to you ? (Please tick **all that apply**)

My home or other property has been damaged by storms	
I have been directly affected by storms, for example through travel disruption or my ability to work	
I experienced disruption of essential services, e.g. gas, electricity	
Other people within two miles of where I live have experienced property damage from storms	
My friends and/or family were directly affected by storm damage	
I heard or saw a lot about storm damage on television, radio or in the papers	
I have not experienced any of the above	

22. Please provide your full postcode (this is entirely optional but really helpful for the analysis!!)

…………………………………………………………..

23. Please indicate the approximate distance you have travelled today

…………………………………………………………..miles

Many thanks for your participation in this survey. If you wish to receive a copy of the results of this research, please provide your email or postal address. As with all of your answers, your contact details will remain **strictly confidential** and will not be passed on to anyone else.

☐ I would like to receive a copy of the results of this research

Email address: ____

Postal address: ____

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UNIVERSITY of York

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

THE wildlife TRUSTS

NERC SCIENCE OF THE ENVIRONMENT

Coastal experience survey

This survey examines the benefits, values and changes you have experienced on the coast around Silverdale. This project is being undertaken by the University of York in collaboration with Cardiff University and Yorkshire Wildlife Trust and is funded by the Natural Environment Research Council (NERC).

Date ………/…………/……….

Location ……………………..

Benefits and values

1. a) When did you first come to the coast around Silverdale? (Please tick **one** statement)

I moved here in the last six months (go to Q2)	
I moved here between six months and two years ago (go to Q2)	
I moved here between two and five years ago (go to Q2)	
I moved here more than five years ago (go to Q2)	
I have lived here all my life (go to Q2)	
I am a visitor to the area (go to Q1b)	

1. b) How often do you visit? (Please tick **one** statement)

This is my first visit	
I visit once to twice a year	
I visit several times a year	

2. Why did you choose to visit/ live on the coast around Silverdale? (Please tick **all that apply**)

To be close to nature	
To see birds and wildlife	
To see a range of plants	
For peace and tranquillity	
For the beautiful scenery and landscape	
For walking	
For health and wellbeing benefits	
For fishing	
For a family outing	
For holidays	
For work	
Other (please specify) ………………………………………………………………………………………	

3. To what extent do the following statements describe your experience of the coast around Silverdale? (Please tick as appropriate)

	Not at all 0	1	2	3	4	5	Completely 6
It is an escape experience							
Spending time here gives me a good break from my day-to-day routine							
There is much to explore and discover here							
I would like to spend more time looking at the surroundings							
There is a great deal of distraction							
It is chaotic here							
I have a sense that I belong here							
Being here suits my personality							

4. a) Indicate with a cross on the map opposite, the one area which is most important to you personally: (This may or may not be the place that you spend most time)

4. b) Why did you choose this area?

....

....

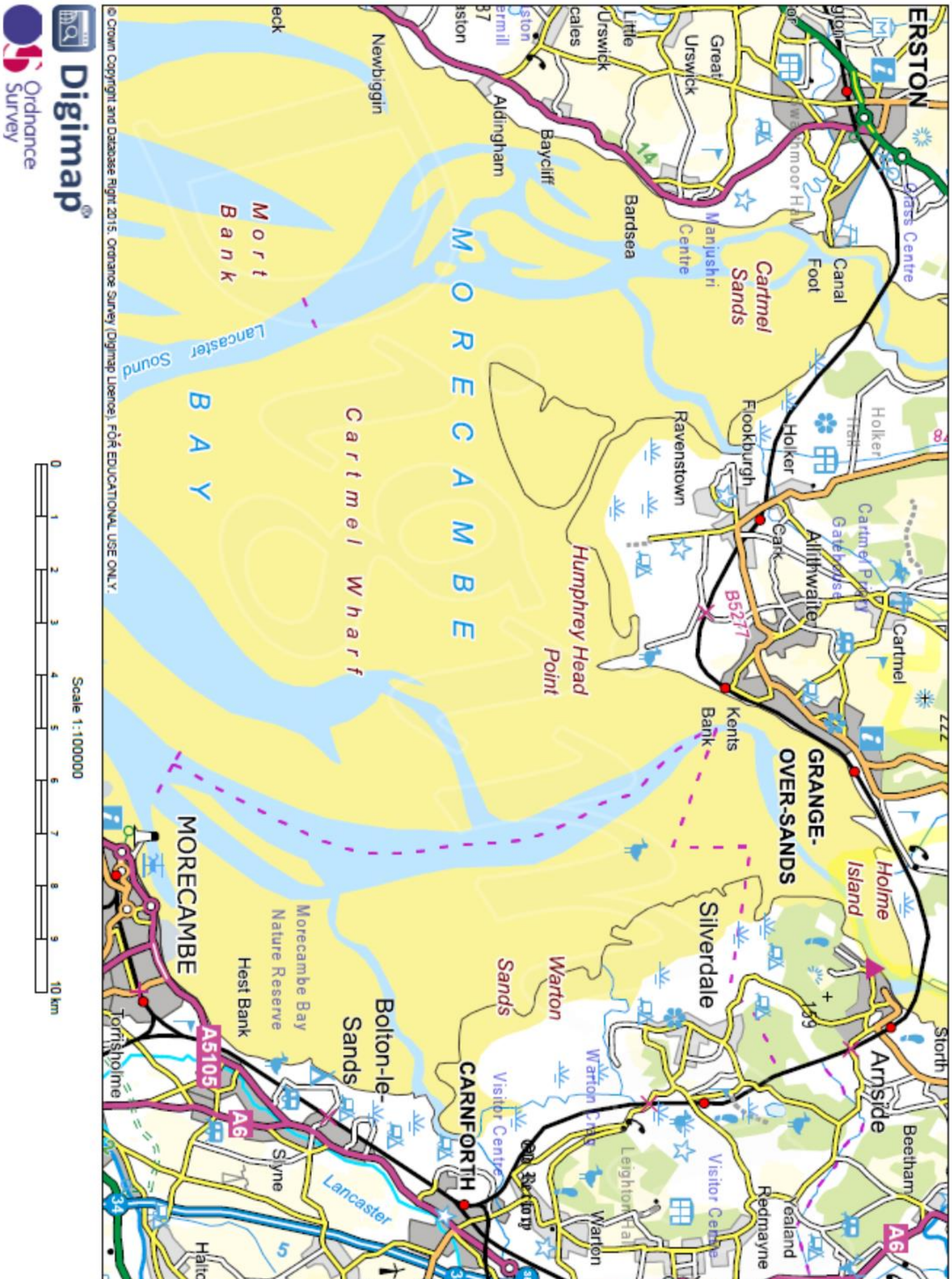
5. To what extent are the following types of environment important to your enjoyment of the area? (Please circle as appropriate)

Saltmarsh

Not at all				Very important
1	2	3	4	5

Sandflats

Not at all				Very important
1	2	3	4	5



GRANGE-OVER-SANDS
Kents Bank
Cartmel
Allithwaite
Cark
Flookburgh
Holker
Ravenstown
Humphrey Head Point
Cartmel Sands
Canal Foot
Bardsea
Baycliff
Aldingham
Newbiggin
Great Urswick
Little Urswick
M O R E C A M B E B A Y
Cartmel Wharf
Mort Bank
Lancaster Sound
Holme Island
Silverdale
Arnside
Storth
Beetham
Warton Sands
Warton
Redmayne
Yealand Conyers
CARNFORTH
Bolton-le-Sands
Hest Bank
Morecambe Bay Nature Reserve
MORECAMBE
Torrisholme
Slyne
Halton
Nether Kellet
Borwick
Over Kellet
Lancaster Canal
Visitor Centre
B5277
A5105
A6
A6070
Scale 1:100000
0 1 2 3 4 5 6 7 8 9 10 km
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Changes

If this is the first time you've visited, __please skip questions 6 and 7__

6. What changes have you noticed in the area since you started living/ visiting here?

....

....

7. a) Please indicate the extent to which the following issues have improved or worsened in this area over the time you have known it. (Please tick as appropriate)

	Extent of change						
	Significantly worsened			Neither worsened nor improved			Significantly improved
	-3	-2	-1	0	1	2	3
Erosion							
Coastal flooding							
Storms							
Hotter weather and droughts							
Amount and range of wildlife							
Amount and range of plants							

7. b) Please indicate how these changes have affected your use or enjoyment of the area. (Please tick as appropriate)

	Your use or enjoyment of the area						
	Significantly worsened			Neither worsened nor improved			Significantly improved
	-3	-2	-1	0	1	2	3
Erosion							
Coastal flooding							
Storms							
Hotter weather and droughts							
Amount and range of wildlife							
Amount and range of plants							

8. To what extent do you think the Silverdale coast is at risk from storms and coastal floods? (Please tick **one** statement)

A great deal (go to question 9)	
Somewhat (go to question 9)	
A little (go to question 9)	
Not at all (go to question 10)	

9. a) Indicate with a cross on the map overleaf, roughly the area which is most at risk from storms and coastal floods.

9. b) Why is this area particularly at risk?

....

....

....

10. To what extent are current levels of protection from storms and coastal floods adequate in this area? (Please circle as appropriate)

Completely inadequate				Completely adequate
1	2	3	4	5

11. How acceptable would you find the following coastal protection measures for this area? (Please circle as appropriate)

a)

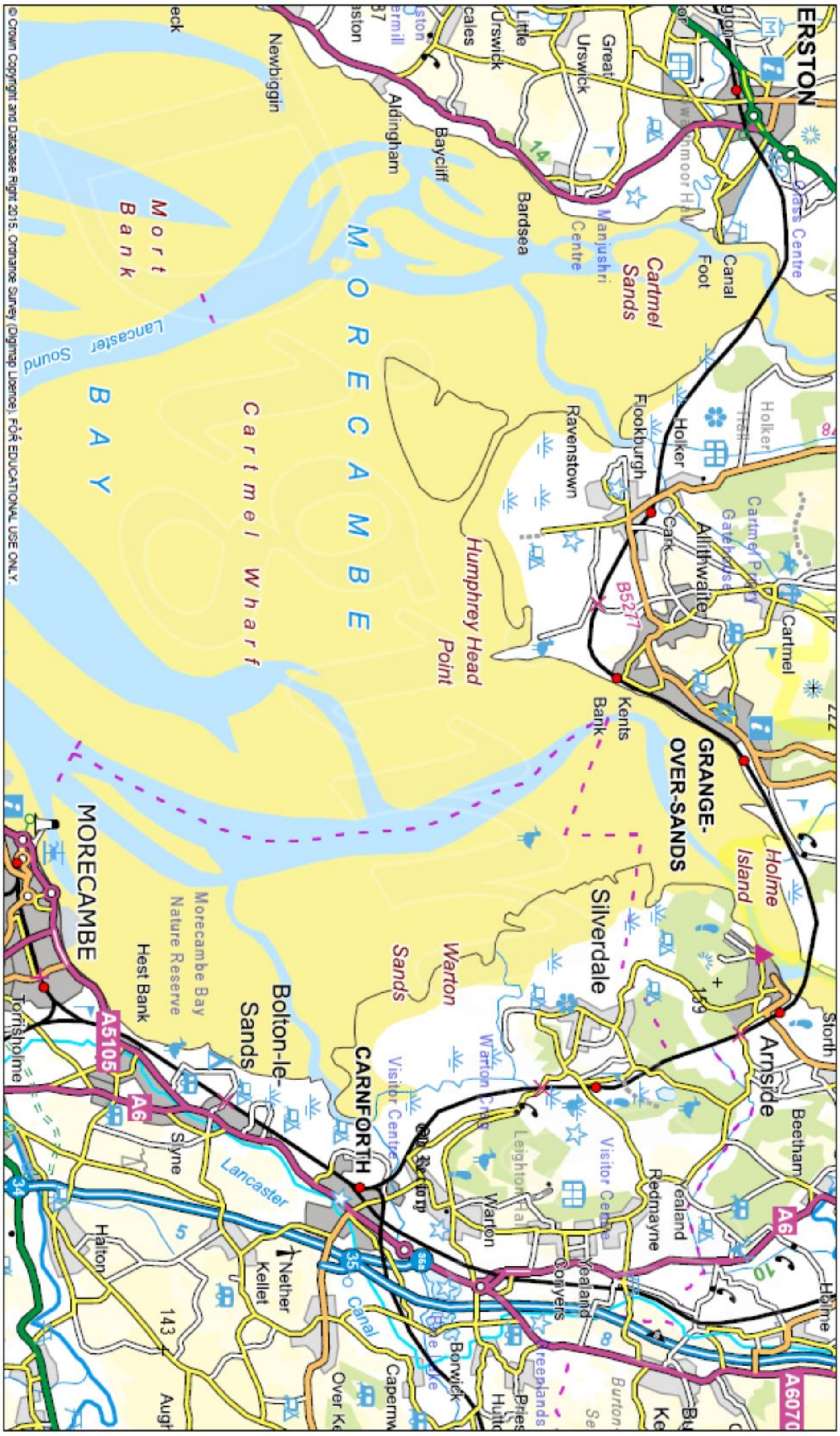
Concrete sea wall to reduce erosion and flooding

Completely unacceptable				Completely acceptable
1	2	3	4	5

b)

Managed realignment, where land is allowed to flood with the tide, to reduce flooding risk elsewhere

Completely unacceptable				Completely acceptable
1	2	3	4	5



Scale 1:100000

Rock groynes to encourage build-up of beach material and absorb wave energy

Completely unacceptable				Completely acceptable
1	2	3	4	5

Beach “nourishment” through redistribution of sand, to replace lost beach material and help reduce erosion

Completely unacceptable				Completely acceptable
1	2	3	4	5

Earth and rock embankment to reduce erosion and flooding

Completely unacceptable				Completely acceptable
1	2	3	4	5

Saltmarsh to reduce wave energy

Completely unacceptable				Completely acceptable
1	2	3	4	5

Dune stabilisation through marram grass planting to

Completely unacceptable				Completely acceptable
1	2	3	4	5

The future

12. To what extent do you think that the frequency and severity of storms will increase in this area in the future?

Not at all						Extremely
0	1	2	3	4	5	6

About you

13. Please indicate your age

18-24	
25-34	
35-44	
45-54	
55-64	
65-74	
75-84	
85+	
Prefer not to say	

14. Please indicate your gender

Male	
Female	

15. What is your profession?

……………………………………………………………………………………

16. What is your highest level of education?

No formal qualifications	
GCSE/ O-level	
A-level/ Higher/ BTEC	
Vocational/ NVQ	
Degree or equivalent	
Postgraduate Qualification	
Other (please specify below)	

……………………………………………………………………………………

17. Where on this scale would you position yourself politically?

Politically, I see myself as…

Very liberal (1)	
Liberal (2)	
Slightly liberal (3)	
Neutral (4)	
Slightly conservative (5)	
Conservative (6)	
Very conservative (7)	

18. Are you a member of / do you regularly donate to a wildlife organisation? (E.g. RSPB or WWF)
(Please circle as appropriate)

Yes/ No

19. To what extent do you agree or disagree with the following statements? (Please tick as appropriate)

	Strongly disagree				Strongly agree
	-2	-1	0	1	2
'Humans have the right to modify the natural environment to suit their needs'					
'Humans are severely abusing the planet'					
'Plants and animals have the same rights as humans to exist'					
'There is solid evidence that the Earth is warming because of human activities'					
'Nature is strong enough to cope with the impact of modern industrial nations'					
'Humans were meant to rule over the rest of nature'					
'Climate change is just a natural fluctuation in Earth's temperatures'					
'The balance of nature is very delicate and easily upset'					

20. Do you live on or near the coast? (Please circle as appropriate)

Yes/ No

21. Specifically thinking about storm damage (e.g. flooding, erosion, wind damage) **in the last two years**, which of the following applies to you ? (Please tick **all that apply**)

My home or other property has been damaged by storms	
I have been directly affected by storms, for example through travel disruption or my ability to work	
I experienced disruption of essential services, e.g. gas, electricity	
Other people within two miles of where I live have experienced property damage from storms	
My friends and/or family were directly affected by storm damage	
I heard or saw a lot about storm damage on television, radio or in the papers	
I have not experienced any of the above	

22. Please provide your full postcode (this is entirely optional but really helpful for the analysis!!)

…………………………………………………….

23. Please indicate the approximate distance you have travelled today

…………………………………………………….miles

Many thanks for your participation in this survey. If you wish to receive a copy of the results of this research please provide your email or postal address. As with all of your answers, your contact details will remain **strictly confidential** and will not be passed onto anyone else.

☐ I would like to receive a copy of the results of this research

Email address: ____

Postal address: ____

____

____

____

Appendix 2. Themes derived from analysis of open survey question about local change

1) <u>Physical Change</u>
    a) Landscape change
        i) Unspecified landscape change
        ii) Erosion
            (1) Unspecified erosion
            (2) Beach erosion
            (3) Cliff erosion
            (4) Erosion of infrastructure
            (5) Erosion of access
        iii) Accretion
            (1) Estuary “silting up”
            (2) Mudflat accretion
        iv) Saltmarsh/ “grass” change
            (1) Unspecified saltmarsh change
            (2) Saltmarsh erosion
            (3) Saltmarsh increase/ spread of *Spartina*
            (4) Saltmarsh storm debris
        v) Sand dune change
        vi) 2013 storm effects
        vii) Channel changes
        viii) Shifting of sands
        ix) Increased wildlife habitat
        x) Reduced wildlife habitat
        xi) Increased woodland care
        xii) Anthropogenic - windfarm
    b) Weather/ meteorological change
        i) Unspecified weather change
        ii) Storms
        iii) Rainfall (reduced)
        iv) High tides
        v) Flooding
            (1) Flooding increase
            (2) Flood defence construction
        vi) Favourable microclimate

2) <u>Biodiversity change</u>
   a) Flora
   b) Fauna
3) <u>Social change</u>
   a) Visitors/ tourism
      i) Increase in visitors/ tourism
      ii) Decrease in visitors/ tourism
      iii) Education (increased information regarding, and increased promotion of the area and coast)
      iv) Visitor facilities
         (1) Visitor centre (negative)
         (2) Caravan site expansion
         (3) Improved birdwatching facilities
         (4) More recreational activities
         (5) Toilets moved
         (6) Require more car parking
         (7) Reduction in facilities/ services
         (8) Reduced dog-walking opportunities
      v) Increased traffic/ busier roads
         (1) Increased roadside litter
      vi) More cyclists
      vii) Business change
         (1) Increased diversity of businesses
         (2) Loss of local amenities in favour of tourist-oriented business
   b) Increased development/ housing/ building
   c) Loss of infrastructure & reduced access
   d) Demographic changes
      i) Increased affluence
      ii) More families
      iii) More moving to area from elsewhere
      iv) Reduced sense of community
      v) Spurn lifeboat crew and families no longer living on the Point
      vi) Need to adapt
   e) More dogs
4) <u>No perceived change</u>
   a) No change

b) Not known area long enough

c) Remained unspoilt