Vulnerability of tourism-dependent Caribbean islands to climate change

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Abstract

Small islands in the Caribbean are expected to be particularly vulnerable to changing environmental and climate conditions because of their strong dependence on fragile marine and coastal resources for tourism and fisheries. The thesis investigates a range of issues surrounding the vulnerability of Caribbean marine and coastal tourism livelihoods to climatic change. Indicator-based vulnerability assessments are increasingly used as decision-support tools for policy development. A comparison of different assessment methods highlights some of the inherent methodological limitations of these approaches, and the value of case-study approaches to investigating island vulnerability. Subsequent analyses of marine and coastal characteristics of Caribbean islands, and of marine and coastal resource use by the tourism industry on the Caribbean island of Anguilla, identify important implications of climate-induced variations in hurricane activity for the tourism industry, and associated livelihoods and economies. An investigation of the social resilience of marine-dependent livelihoods on Anguilla highlights possibilities for adaptation to changing environmental conditions. However, these findings also emphasise the precariousness of natural resource-dependency on tropical small islands, and the urgent need for more effective environmental management to enhance the resilience of social-ecological marine systems. Finally, in order to understand current constraints to natural-resource management, an examination of the environmental governance of the Caribbean UK Overseas Territories suggests that a suite of common policy interventions, such as greater regional cooperation, capacity building and financial support, could help support sustainable and adaptive management of marine resources throughout the Caribbean.

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Chapter 1

General Introduction

Sandy Island, Anguilla

Chapter 1
General Introduction

Small islands are the subject of considerable environmental concern because of their vulnerability to numerous stressors, including habitat destruction, invasive species, resource over-exploitation and increasingly, the impacts of climate change (Wong et al. 2005). In addition, the Intergovernmental Panel on Climate Change has identified that small islands, primarily in the tropics and subtropics, share many common features that serve to increase their vulnerability to the effects of changing climatic and environmental conditions (Nurse & Sem 2001; Mimura et al. 2007). These characteristics include their geographical remoteness, small physical size and proneness to natural disasters, as well as socio-economic factors such as a dependence on natural resources, coastal infrastructure and limited financial support (Briguglio 1995; Nurse & Sem 2001).

Climate change is expected to affect tropical island ecosystems significantly with, for example, sea-level rise leading to the flooding of important coastal habitats (Wong et al. 2005), elevated sea temperatures causing coral bleaching and mortality (McWilliams et al. 2005), and potential increases in the intensity and frequency of hurricanes leading to accelerated coastal erosion and habitat destruction (Webster et al. 2005; Nicholls et al. 2007). These impacts are anticipated to have severe socio-economic consequences for the economies and livelihoods that depend on marine and terrestrial ecosystems for important ecosystem goods and services (Fischlin et al. 2007).

There is mounting evidence of direct global climate changes on island and coastal resource-dependent communities, principally in terms of negative impacts on marine and coastal tourism (Uyarra et al. 2005; Fish 2006), and fish stocks and fisheries

(Allison et al. 2009; Badjeck et al. 2010). Increases in the frequency and severity of coral bleaching in coastal zones is likely to affect reef-dependent tourism and fishing industries (McWilliams et al. 2005; Uyarra et al. 2005) and projected climate change impacts on fish species distributions may have major consequences for tropical fisheries (Cheung et al. 2009). For millions of people around the world that depend on marine and coastal resources for livelihood opportunities and food security, the repercussions of these environmental changes are expected to be considerable (Moberg & Folke 1999; Spalding et al. 2001).

Natural resource-dependency describes the fundamental association between the livelihoods of individuals, sectors or communities, and a natural resource and its local economy (Adger 2000). Such close links between social and ecological systems, of which island and coastal resource-users are a prime example, are considered to have major implications for the capacity to cope with and adapt to environmental change (Adger et al. 2005; Thomas & Twyman 2005). Island communities that depend strongly on already depleted natural resources and degraded coastal systems, and that may have few viable economic alternatives, are therefore extremely susceptible to changes in the conditions of the natural resources upon which they rely (Marshall 2010).

The small islands of the Caribbean are expected to be particularly affected by the negative impacts of climate change on marine and coastal resource-users. The Caribbean region comprises over thirty countries of which most are small island states (Daye et al. 2008) and all are dependent to an extent on the Caribbean Sea for marine-based livelihoods (Lewsey et al. 2004). The Caribbean 'sun, sea and sand' tourism industry, which depends almost entirely on beaches and coral reefs (Lewsey et al. 2004; Uyarra et al. 2005), is perhaps most important for providing livelihood and industry opportunities (WTTC 2004). Indeed, the Caribbean is considered one of the most tourism-dependent regions of the world (Becken & Hay 2007), attracting over 20 million annual stopover visitors (CTO 2005) and contributing approximately 15% of gross national product (GDP) and employment opportunities in the region (WTTC 2004). For some islands, this dependence is substantially higher (e.g. >70% of GDP and employment opportunities from tourism on the islands of Anguilla, Antigua and Barbuda; WTTC 2004). Pronounced reliance by the Caribbean tourism industry on marine and coastal ecosystems (Lewsey et al. 2004; Uyarra et al. 2005) means that many Caribbean island livelihoods and economies are likely to be highly vulnerable to future changes or variations in marine and coastal resources (Mimura et al. 2007).

The vulnerability of Caribbean marine and coastal ecosystems to future environmental change is also a consequence of long-standing regional environmental stressors, including over-fishing, hurricanes and coral bleaching (MEA 2005). There is substantial evidence that these chronic environmental problems are already a major issue for many Caribbean marine-dependent livelihoods. High-profile examples include the collapse of Jamaica's coral reef fishery, attributed to initial over-fishing, followed by successive hurricanes and disease (Hughes 1994; Hardt 2009), and the impact of hurricane Ivan on Grenada in 2004, which caused catastrophic losses to the island's tourism industry (Becken & Hay 2007). Against a background of historical and sustained environmental pressures, the capacity of Caribbean marine ecosystems and dependent-livelihoods to cope or adapt to future environmental change is already compromised (McClanahan et al. 2002; Mumby et al. 2007).

The implications of environmental change for the Caribbean marine-dependent tourism industry have, however, received relatively little attention. Some research has suggested that significant numbers of tourists may not return to the Caribbean islands of Bonaire and Barbados if coral reef or beach condition were reduced (Uyarra et al.

2005), and that beach loss in Barbados due to sea-level rise would have severe economic consequences for the island (Dharmaratne & Brathwaite 1998). However, there has been no research to date that investigates the implications of increasing North Atlantic hurricane activity (e.g. see Webster et al. 2005) on marine resource-dependent tourism livelihoods in the Caribbean. Considering the significance that global climate change projections of increases in hurricane activity and marine degradation from coral bleaching may have on thousands of Caribbean marine resource-users (Mimura et al. 2007), there is a clear need for research in this area.

Thesis structure

The overall objective of this thesis is to investigate issues surrounding vulnerable marine and coastal tourism livelihoods in the Caribbean to climatic change, and specifically with regards to the impacts of increasing hurricane risk. The resilience of Caribbean marine systems to cope or adapt to future environmental change is potentially reduced because of numerous chronic environmental pressures (Adger et al. 2005; Breton et al. 2006; Mumby et al. 2007). However, gaining a better understanding of specific environmental and socio-economic vulnerabilities of the Caribbean islands to changing environmental conditions may contribute to the development of adaptive measures that build ecological and social resilience to future environmental change.

The development of future projections of key climate variables such as temperature, sea-level rise and hurricanes can provide quantitative evidence of the specific environmental and socio-economic vulnerabilities of these Caribbean islands. For example, the IPCC (2007) have compiled information from numerous climate models and describe annual temperature increases for the Caribbean to range from 1.4ºC to 3.2ºC (with a median of 2ºC, and with 50% of models differing from the median by ±0.4ºC). More recent models, using climate projections based on the Special Report on Emissions Scenarios (SRES) also predict that the annual mean temperature of the Caribbean region may increase by between 1 and 5ºC by the 2080s under medium-high future emissions scenarios (ECLAT 2010); with the northwest Caribbean (Jamaica, Cuba) predicted to experience greater warming compared to the eastern island chain (Barbados, Grenada) (ECLAT 2010). Model projections of sea-level rise for the Caribbean show that the region may experience a 30-55cm rise in sea-level over the next 50 years (Government of Jamaica 2010).

In terms of future projections of hurricanes, model predictions vary considerably (see Webster et al. 2005; Knutson et al. 2010). For example, whilst models indicate the global frequency of tropical hurricanes may either decrease or remain unchanged, current models are inconsistent in the projected changes for individual basins (e.g. ranging from -6% to -34% globally, and up to ±50% or more hurricanes in individual ocean basins). There is also low confidence in the projected changes in tropical hurricane location, duration and storm surge flooding. High-resolution models of tropical hurricanes have, however, consistently indicated a likelihood of more intense hurricanes, with intensity increases of between 2-11% globally by 2100 (Knutson et al. 2010).

However, large variations in the model projections and wide ranges forecast for different climate variables present real challenges for communicating climate changes to policy-makers and/or other stakeholders. Uncertainties in the science and a lack of public understanding of modelling techniques in particular (see Yearley 1999) are some of the inherent problems of investigating the implications of climate change with impacted stakeholders or communities. Therefore, in order to investigate the vulnerability of Caribbean islands to climate change in terms of marine tourism-based livelihoods, rather than focus on uncertain future climate projections, this thesis uses a range of methods, including quantitative indicators of vulnerability, and qualitative approaches to describe and discuss the implications of climate change with various interested parties and stakeholders (e.g. policy-makers, tourists and marine resource-users).

With growing recognition that global climate change will negatively affect human-environment systems, there has been an increasing requirement for ways to effectively measure and assess vulnerability (Carter et al. 2007). In respect of this demand, Chapter 2 investigates some of the limitations of indicator-dependent, aggregated vulnerability assessment methods that are typically used to quantify vulnerability to environmental change (e.g. see Moss et al. 2001; Allison et al. 2009). The literature on vulnerability research does not currently include an empirical comparison of these types of methods, although they are used widely by policy-makers to support decision-making (Briguglio 2003; Patt et al. 2005). I aim to address this knowledge gap, to develop a better understanding of the constraints and benefits of these methods, by comparing the robustness of different assessment methods. This large-scale, regional island analysis provides a platform for developing a case-study approach in the remainder of the thesis, to address finer-scale aspects of Caribbean island vulnerability to climate change.

Having outlined some of the limitations of using aggregated indicator-dependent vulnerability assessment methods in Chapter 2, independent indicators of Caribbean island marine and coastal tourism-dependence are analysed in Chapter 3. A dependence on natural-resource tourism may indicate the potential necessity for an island to respond to environmental change and extrinsic stressors (Mimura et al. 2007; Moreno & Becken

2009). In order to explore this feature of island vulnerability, I investigate broad patterns in marine and coastal characteristics for the Caribbean and assess, at a finer scale, the marine and coastal resource-use of tourists visiting the case-study island of Anguilla, the smallest island in the Lesser Antilles. Anguilla, like many islands in the Caribbean is expected to be highly vulnerable to climate change impacts such as sea-level rise and increasing hurricane risk (Fish 2006; Mimura et al 2007), and is heavily dependent on fragile marine and coastal resources for tourism (WTTC 2004). For these reasons it was chosen as an ideal case-study. Chapter 3 provides an indication of fine-scale patterns in marine and coastal resource dependence by the tourism industry in Anguilla, the island's potential vulnerability to external shocks in terms of resource dependence, and enables broad comparisons with other Caribbean locations.

The implications that climate-induced variations in Atlantic hurricane activity may have for the tourism-dependent island of Anguilla are investigated in Chapter 4. The vulnerability of the Caribbean region and its tourism industry to any increase in hurricane risk is unmistakeable: the impact of hurricane Ivan on Grenada in 2004 resulted in the damage or loss of 90% of hotel rooms on the island (Mimura et al. 2007), and hurricanes Luis (1995) and Lenny (1999) inflicted severe damage (>26 million $US) to Anguilla's tourism infrastructure and marine resources (ECLAT 2000; Young 2005). For tourism-dependent islands in the Caribbean these direct impacts may be compounded by indirect impacts on tourist perceptions of the risk of extreme events. However, very little research exists regarding tourist perceptions to risk and extreme events in general (but see Prideaux et al. 2003; Meheux & Parker 2006; Eitzinger & Wiedemann 2007), and none that specifically investigates the implications of increasing hurricane activity on tourism. This chapter addresses this research gap and provides empirical evidence of the repercussions that changes in hurricane activity may have for the Anguillian marine and coastal tourism industry, with implications for other Caribbean holiday destinations at risk from hurricanes.

The social resilience of marine resource-dependent livelihoods in Anguilla, their ability to cope and adapt to environmental change, is explored in Chapter 5. While several studies have investigated the vulnerability of coastal and marine resource-dependent communities or nations to climatic change (e.g. see Thomas & Twyman 2005; Allison et al. 2009), the implications of climate variability on the lives and livelihoods of marine resource-users at local scales has been, until recently, less well explored (Badjeck et al. 2010). Having outlined the implications of increasing hurricane risk on tourist perceptions (and thus tourism demand) in Chapter 4, I use a livelihoods approach in Chapter 5 to assess the resilience of tourism-dependent marine and coastal livelihoods to the effects of hurricanes and the degradation of coral reefs.

Chapters 3 to 5 provide fine-scale evidence of marine and coastal resource-use by the tourism industry on Anguilla and show that this economic mainstay is highly susceptible to changing environmental conditions. The combination of marine resource-dependency and the reliance on a single climate-dependent industry makes Anguilla, and other comparable Caribbean islands, especially vulnerable to future environmental change. However, vulnerability may also be influenced by the management and governance structures in place to protect important natural resources from future stressors (Douglas 2003).

In Chapter 6, I address some of the issues of environmental governance for vulnerable small islands in the Caribbean, specifically the Caribbean UK Overseas Territories

(UKOTs). In total, there are six island UKOTs in the Caribbean, including the case-study island Anguilla. These islands are affiliated to the UK and, as a result, forgo aspects of political autonomy and sovereignty, but are entitled to certain financial resources, and social and economic support mechanisms (Pienkowski 1998; Douglas 2003). Environmental management is, however, a UKOT domestic issue (EAC 2006), and there are major concerns about the capacity of local UKOT governments to facilitate the environmental protection required, to address both current and future environmental changes (Pienkowski 1998; Fleming 2006; RSPB 2007). This chapter examines the concerns of key officials from UK and UKOT governments and non-governmental organisations, and identifies a series of common institutional limitations that currently constrain environmental management on these six Caribbean island states. These findings reveal common policy interventions that could help support adaptive and sustainable management of marine and coastal resources in these islands, and reduce their vulnerability to future environmental change.

Finally, the findings of this thesis are synthesised in Chapter 7, where insights from this research and key priorities for future research are discussed.

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Chapter 2

Caribbean island vulnerability to climate change: a comparison of vulnerability assessment methods

Fishing boat, Sandy Ground, Anguilla

Chapter 2

Caribbean island vulnerability to climate change: a comparison of vulnerability assessment methods

ABSTRACT

Climate change vulnerability assessments have become increasingly sought and used by policy-makers to inform decision-making for adaptation to changing global conditions. However, as vulnerability to climate change is context and scale dependent, there are currently numerous assessments for many different countries and regions throughout the world, with little indication as to the consistency between them. This study explores some of the methodological issues involved with the use of vulnerability assessment methods. With a focus on Caribbean island vulnerability to climate change, I compare different indicator-dependent assessment methods using the same indicator dataset, in order to identify the similarities and differences between the methods. The vulnerability rankings from all four methods are positively correlated. However, consistent rankings of individual islands were only apparent for the extreme cases (i.e. very vulnerable or not vulnerable islands). Islands with intermediate rankings were less consistent between methods. Thus while different assessment methods can consistently identify extreme cases of vulnerability, if their purpose is to provide detailed information on the relative vulnerabilities of a broad range of countries or regions, then the inconsistencies between methodological approaches need to be fully considered. In light of the discrepancies between these methods, it may be more applicable for policy-makers to rely on alternative ways to assess vulnerability, such as detailed case-study analyses or expert elicitation methods.

INTRODUCTION

It is increasingly being recognised that global climate change will greatly influence human and natural systems (MEA 2005a; IPCC 2007). As a result, there has been a growing demand for reliable methods to assess the relative vulnerability or adaptability of societies and ecosystems to likely climate change impacts (Briguglio 2003; Carter et al. 2007). However, as vulnerability to environmental and climate change is highly dependent on context and scale, varying widely across countries, communities and sectors, there is considerable variation in the approaches that have been used to measure vulnerability (Downing & Patwardhan 2005). In addition, vulnerability to environmental change is perceived differently among research disciplines (see Füssel & Klein 2006). Consequently there is no universally accepted definition for vulnerability (Downing & Patwardhan 2005) or methodological approach for its assessment (Brenkert & Malone 2005).

The development of numerous techniques to measure and quantify vulnerability is an inevitable product of both the diversity of vulnerable human-environment systems, and multiple conceptualisations of vulnerability by the research community (see Brooks 2003; Füssel 2005; Füssel & Klein 2006). For example, approaches range from international country-level assessments, typically focusing on national indicators to identify countries with similar or different risk profiles, to small-scale assessments to identify vulnerable groups of people or communities to specific local risks, through finer-scale participatory methods such as interviews or focus groups (Downing & Patwardhan 2005).

Conceptual differences in the interpretation of vulnerability to environmental change have also influenced the development of different areas of vulnerability assessment research. For instance, environmental-risk and natural hazards vulnerability research typically assess vulnerability in terms of biophysical impacts such as earthquakes, flooding and extreme weather events (e.g. Cutter 1996; Kaly et al. 1999). By comparison, the human geography and development research community perceive vulnerability to be principally driven by the underlying social, political or economic factors that influence community or individual ability to adapt to variability or change (e.g. Adger 1999; Adger & Kelly 1999). The majority of climate change vulnerability assessments, however, combine both of these perspectives, and integrate the social and biophysical factors that are expected to influence vulnerability to climate change (e.g. Moss et al. 2001; Turner et al. 2003; O'Brien et al. 2004).

While recognising these different conceptual perspectives among research disciplines, an integrated approach to assessing vulnerability to climate change (combining both biophysical and social dimensions), is advocated by the Intergovernmental Panel on Climate Change (IPCC) (McCarthy et al. 2001; Carter et al. 2007). The IPCC describe the key components that determine vulnerability as the 'exposure' of a system to climate variability or stress (i.e. biophysical component), the 'sensitivity' of a system to climate stress, and the 'adaptive capacity' or the ability of a system to cope and adapt to stress or change (i.e. biophysical and social components) (Carter et al. 2007). In order to combine both biophysical and social dimensions of vulnerability, particularly for large-scale assessments of regional or national vulnerability to climate change, a range of quantitative indicator-dependent assessment methods have been developed (e.g. see Moss et al. 2001; O'Brien et al. 2004; Brenkert & Malone 2005; Allison et al. 2009).

Indicator-dependent assessment methods typically combine a series of variables that each portrays an element (biophysical or social) of vulnerability, into a composite vulnerability index or score. By combining the key features of vulnerability for a system into a relatively simple index or score, these methods are regarded as having the potential to support policy makers in planning and developing environmental and/or social management decisions, targets or priorities (Briguglio 2003). In fact, the possibilities that these methods offer decision-making by government policy-makers or other authorities are perceived as one of their biggest benefits (Patt et al. 2005). Additionally, quantitative vulnerability approaches have been recognised for their capacity to disseminate complex information in a user-friendly way to stakeholders and the public, as well as being relatively simple and cheap to produce (Briguglio 2003).

However, several studies have also recognised inherent limitations of these types of methods. The criticisms range from theoretical concerns about conceptualising and representing the processes that cause vulnerability, to methodological issues such as the subjectivity of indicator choice, data availability, and the means by which indicators are combined through weighting and aggregating procedures (Briguglio 2003; Morse & Fraser 2005; Patt et al. 2005; Polsky et al. 2007). Thus, although indicator-dependent vulnerability assessment methods have gained recent support in the literature because of their potential application in policy decision-making (for example: O'Brien et al. 2004; Brenkert & Malone 2005; Allison et al. 2009), some critics have argued that the inherent methodological limitations outweigh the benefits of these approaches (Morse & Fraser 2005).

In this study I explore some of the issues and criticisms surrounding the use of indicator-dependent climate change vulnerability assessments. The islands of the Caribbean form the context for this analysis because they are particularly vulnerable to environmental change. For example, there is already widespread marine and land-based environmental degradation throughout the region (Gardner et al. 2003; Tompkins 2003; Potter et al. 2004; Paddack et al. 2009) and tropical islands, like those in the Caribbean, are expected to be susceptible to climate change impacts such as sea-level rise, coral bleaching and changes in hurricane risk (Mimura et al. 2007).

With a focus on Caribbean island vulnerability to climate change, I undertake a comparison of climate change vulnerability assessments to investigate the consistency of these types of methods. Despite their widespread use, the literature on vulnerability research does not at present include an empirical comparison of indicator-dependent vulnerability assessments, although there are studies that have examined the implications of using different indicators (e.g. see Patt et al. 2005; Polsky et al. 2007). I aim to address this knowledge gap by comparing the robustness of different assessment methodologies, through 1) an exploration of the literature on climate change vulnerability assessment methods (using the IPCC's integrated definition of vulnerability), and 2) a comparison of different methods, through the application of the same indicator dataset to each assessment approach.

METHODS

Selection of vulnerability assessment methods

A comprehensive review of climate change vulnerability assessments was undertaken with a web-based literature search, using ISI Web of Knowledge and Google Scholar search engines. This search revealed numerous examples of vulnerability assessment methodologies spanning diverse academic disciplines in both the peer review and grey literature, and exploring vulnerability to environmental change at different spatial and temporal scales, for many different countries and regions. This review also indicated that the types of approaches that are most commonly used for indicator-dependent vulnerability assessment are either categorised as 'normalisation procedures' (where the components of vulnerability are standardised, and then combined to form an index), or through 'scoring methods on a multi-point scale' (which involves categorising the occurrence of vulnerable factors) (Briguglio 2003; Downing 2005).

The following criteria were employed to select the methods for this comparative study. The first criterion required the method had been developed as a tool for integrated (i.e. including environmental, social and/or economic indicators) climate or environmental vulnerability assessment. Secondly, to reflect the main types of methods in common use, only those that were either 'normalisation procedures' or 'scoring methods on a multi-point scale' (see above and Briguglio 2003; Downing 2005) were considered. The third criterion required that the method was reproducible (i.e. studies were excluded where there was no clearly detailed methodological instructions, or an unattainable or specific computer programme was used). Finally, it was critical that the chosen methods differed appreciably in their methodological framework or structure, standardisation and weighting procedures of component indicators, and the construction or aggregation of the indicators into the vulnerability index or score.

The following methods from studies by Moss et al. (2001), Allison et al. (2009), Gleick (1990) and Downing (2002) met these selection criteria. The four methods are detailed in Table 1 and in the following section, and herein are referred to as methods A, B, C, and D, respectively. Methods A and B represent two examples of normalisation procedure approaches, and methods C and D represent two examples of vulnerability scoring approaches.

Table 1. *The four vulnerability assessment methods selected for comparison, with key features including method structure, indicator standardisation and weighting procedures, and indicator aggregation or index construction process. Method codes and references are included.*

Method code	Structure	Indicator standardisation	Index construction approach	Reference
A	Hierarchical aggregation of standardised indicators to produce a vulnerability index.	Indicators scaled against mean world values: = (100 x value) / world value	Indicators are categorised within either an adaptive capacity or sensitivity component. Indices for adaptive capacity and sensitivity are calculated as an unweighted mean of the standardised indicators within each component. The indices for adaptive capacity and sensitivity are summed to calculate an overall index.	Moss et al. 2001
B	Hierarchical aggregation of standardised indicators, option of weighted indicators, to produce a vulnerability index.	Indicators scaled using procedure: = (value – min value) x 100 (max value – min value)	Indicators are categorised within components (exposure, sensitivity or adaptive capacity). Indices for each component are calculated as an unweighted mean of the standardised indicators within each component. For the weighted approach, a mean of the exposure and sensitivity indices is calculated; this is averaged with the adaptive capacity index to produce an overall index.	Allison et al. 2009
C	Non-hierarchical structure. Indicators are scored according to defined thresholds, to produce a vulnerability score.	No standardisation procedure. Indicators are scored according to indicator-specific thresholds. If an indicator exceeds a defined critical threshold it is assigned a score of 1, if it does not exceed the threshold it is assigned a score of 0	Scores for indicators that have exceeded critical thresholds are summed together to produce an overall score.	Gleick 1990
D	Partial-hierarchical structure. Standardised indictors are aggregated into component indices, with grouping procedure to distinguish distinct categories of vulnerability.	Unspecified in paper. For application in this study, I use the standard procedure: (value – min value) x 100 (max value – min value)	Indicators are categorised within components (impacts or adaptive capacity). Indices for components are calculated as the sum of the standardised indicators within each component. Countries are ranked separately for each component index, and grouped into those with high or low impacts, and high or low adaptive capacity. Assigned a high or low score for both components, countries are grouped within one of four possible categories of vulnerability (see details below).	Downing 2002

Description of selected methods

Method A

Developed to measure the vulnerability of countries or regions to climate change, this method integrates the two components of vulnerability: sensitivity to environmental impacts, and the adaptive capacity potential. These components are comprised of quantitative, country-scale (environmental, social or economic) indicators that are intended to reflect key concepts of sensitivity or adaptive capacity to environmental change. The method requires several steps, the first of which involves standardising the indicators against mean world values, using the formula described in Table 1. In this study however, I scale the indicators to the mean Caribbean value because I am interested specifically in Caribbean island vulnerability. The sensitivity and adaptive capacity component indices are calculated as the unweighted mean of the standardised indicators within each component for each country. These two indices are summed together to form an overall index and a relative vulnerability value for each country.

Method B

This approach was formulated to compare the vulnerability of countries and national economies to the impacts of climate change on fisheries. Here, three components of exposure, sensitivity and adaptive capacity are combined to form an overall vulnerability index. Unlike method A, indicator values are standardised not to world values, but relative to the mean for each indicator (see Table 1). Two processes for constructing the final vulnerability index are described in the original study; a weighted and an unweighted version (both of which provided highly correlated results). Here I present the weighted version, in order to increase the variation between the four methods being compared. Similar to method A, the component indices are calculated as the mean of the standardised indicators within each component for each country. A mean of the exposure and sensitivity indices is calculated first, however, before averaging with the adaptive capacity index (thereby weighting one-half adaptive capacity and one-quarter each for exposure and sensitivity) to produce the final vulnerability index.

Method C

This method was developed to assess the vulnerability or risk of regional water catchment systems to climate variability. Unlike the previous two approaches, this method does not involve the hierarchical combination of standardised indicators into a final index. Instead, each indicator has a predetermined critical threshold that reflects an aspect of vulnerability (or resilience) to climate variability. These indicator-specific thresholds are used to establish how vulnerable a system is, using the scoring structure described in Table 1.

As the choice of thresholds is case-specific, I explored the robustness of using different thresholds (either the indicator mean or median). Both methods that were used to determine the calculation of the threshold produced very similar results and had little effect on the final vulnerability scores (r_s = 0.65, p<0.01, n = 29). I therefore, determined critical thresholds as the mean value of each indicator.

Method D

Devised to explore the adaptive capacity of developing countries to environmental impacts, this method categorises countries according to varying levels of adaptive capacity and vulnerability. Like methods A and B, this approach uses quantitative standardised indicators that correspond to either adaptive capacity or sensitivity (called 'impacts' in the original study) components. Indices for these components are calculated as the sum of their standardised indicators. However, rather than aggregating the component indices, they are used to cluster countries with similar expected levels of vulnerability. This involves ranking the countries by the sensitivity and adaptive capacity indices and then segregating the ranked countries into quintiles. The top two sensitivity quintiles are categorised as having high sensitivity, while the remaining three quintiles are categorised as having low sensitivity. The process is repeated for the adaptive capacity index. Each country therefore has a high or low value for sensitivity and adaptive capacity. Using these values, countries are grouped into one of four vulnerability groups, ranging from the most vulnerable (high sensitivity and low adaptive capacity), to the least vulnerable (low sensitivity and high adaptive capacity).

Caribbean indicators for assessing vulnerability to climate change

The Caribbean island indicators were selected because collectively they represent key features of either sensitivity or adaptive capacity to environmental change, as described by previous studies (e.g. see Moss et al. 2001; Adger et al. 2004; Adger 2006; Mimura et al. 2007; Allison et al. 2009). The Caribbean region is, however, reasonably data-poor and not all of the islands had data for every potential indicator. The availability of data was therefore also an important factor in indicator selection because only indicators with data for every island were included in the analysis. The indicators encompassed a range of environmental (e.g. hurricane frequency, % forest area), social (e.g. life expectancy, % literacy) and economic (e.g. GDP *per capita*, % GDP from tourism) factors that may be expected to influence Caribbean island vulnerability to climate or environmental change. A full description of the indicators, and their influence on the sensitivity and adaptive capacity components of vulnerability are provided in Table 2. Sources for the indicators are listed in Appendix A.

Table 2. *Quantitative indicators used in each of the four Caribbean island vulnerability assessments. Brief details of how each indicator is expected to represent the corresponding vulnerability component (adaptive capacity or sensitivity) are included. The direction of the association between each indicator and the corresponding component is also shown.*

Vulnerability component	Indicator	Indicator represents	Indicator association with component
Adaptive capacity	GDP *per capita* (US$)	*Economic capacity* e.g. resources available for adaptation and development	+
	Dependency ratio (dependent population per 100 productive population)	*Human and civic resources* e.g. social resources, human capital, education potential for adaptability	–
	% Literacy rate		+
	Altitude (m)	*Environmental capacity* e.g. biodiversity potential, landscape fragmentation and adaptability of ecosystems, human population pressure on ecosystems	+
	Forest area (% of total area)		+
	Population density (per km^2)		–
Sensitivity	Hurricane frequency (yrs)	*Settlement and infrastructure sensitivity* e.g. potential risks from storm surge, wind, sea-level rise, and access to basic services to mitigate climate variability	+
	% population living in areas <5m above sea level		+
	% of country without access to water		+
	% agricultural area	*Ecosystem sensitivity* e.g. degree of environmental land-use change, population and infrastructure pressure on terrestrial and marine ecosystems	+
	Annual tourist arrivals		+
	Annual cruise arrivals		+
	Total fertility % (number of children per woman)	*Human health sensitivity* e.g. basic human health condition, including nutrition, exposure to disease, access to medical treatment and services	+
	Life expectancy (yrs)		–
	% of GDP from tourism	*Economic stability and dependency* e.g. economic diversity, and dependence on climate sensitive marine ecosystems	+

Analyses

The indicators described in Table 2 were used to calculate Caribbean island vulnerability using the four vulnerability assessment methods (A, B, C and D, Table 1). All major Caribbean islands or island groups (n = 29) were included in the analysis. The same indicators were used for each of the selected methodological approaches to ensure that a fully standardised comparison was undertaken. The method outputs (the vulnerability index values, scores or categories), and the island vulnerability rankings were compared using Pearson's product-moment and Spearman's rank correlations. Mean differences in the island vulnerability rankings between methods were examined using the Friedman test (non-parametric two-way analysis of variance).

RESULTS

Comparison of rank output of methods

The four vulnerability assessment methods produced significantly correlated rankings of island vulnerability (n = 29). The closest comparisons were between methods B and C ($r_s = 0.72$, $p<0.01$), A and C ($r_s = 0.69$, $p<0.01$), C and D ($r_s = 0.53$, $p<0.01$), and A and D ($r_s = 0.51$, $p<0.01$). The least similar island rankings were between methods B and D, and A and B ($r_s = 0.45$ and $r_s = 0.46$, $p<0.05$, respectively).

However, despite the significant correlations of island rankings between each method, there are substantial differences in the relative rank of islands for each method. For example, no island has the same vulnerability ranking for all four methods, and just two islands (Haiti and Montserrat, at opposite ends of the scale), have the same rank for three of the methods. More islands have the same vulnerability ranking for two of the methods (72%, n = 21).The rank order of island vulnerability according to each of the four methods is shown in Table 3.

Table 3. *The vulnerability of Caribbean islands according to the four different assessment methods. Islands are ranked from the most to the least vulnerable. The dashed lines distinguish the five most and least vulnerable islands from the remaining islands. Tied ranks are indicated by superscripts.*

	Method			
	A	**B**	**C**	**D**
Most vulnerable	Haiti	Haiti	Antigua and Barbuda	Haiti[1]
	Aruba	Antigua and Barbuda	Jamaica[1]	Antigua and Barbuda[1]
	Barbados	St Kitts and Nevis	St Lucia[1]	Jamaica[1]
	Antigua and Barbuda	Anguilla	Saint Vincent and the Grenadines[2]	St Kitts and Nevis[1]
	St Vincent and the Grenadines	Grenada	Haiti[2]	Grenada[1]
	Jamaica	St Lucia	St Kitts and Nevis[2]	Barbados[2]
	St Lucia	St Maarten	Grenada[2]	St Maarten[2]
	Dom. Republic	Bahamas	Bahamas[2]	St Lucia[2]
	Grenada	Turks and Caicos	Barbados[3]	Aruba[2]
	Bonaire	Jamaica	Dom. Republic[3]	Puerto Rico[2]
	Curacao	Dom. Republic	US Virgin Islands[3]	Curacao[2]
	Dominica	Dominica	Aruba[4]	St Vincent and the Grenadines[2]
	Cuba	St Vincent and the Grenadines	Puerto Rico[4]	Bonaire[2]
	US Virgin Islands	Barbados	Cayman Islands[4]	Bermuda[2]
	Guadeloupe	St Eustatius	Turks and Caicos[4]	St Eustatius[2]
	Bahamas	US Virgin Islands	St Maarten[4]	US Virgin Islands[2]
	St Kitts and Nevis	Saba	Anguilla[4]	Saba[2]
	St Maarten	Guadeloupe	Bermuda[5]	Dom. Republic[3]
	Anguilla	Cayman Islands	Cuba[5]	Bahamas[3]
	Bermuda	Cuba	Martinique[5]	Turks and Caicos[3]
	Turks and Caicos	Trinidad and Tobago	Guadeloupe[5]	Anguilla[3]
	Trinidad and Tobago	Aruba	British Virgin Islands[5]	Dominica[3]
	Cayman Islands	Puerto Rico	Dominica[6]	British Virgin Islands[3]
	Puerto Rico	Martinique	Curacao[6]	Cayman Islands[3]
	St Eustatius	Bonaire	Saba[6]	Trinidad and Tobago[4]
	Martinique	Curacao	Trinidad and Tobago[6]	Guadeloupe[4]
Least vulnerable	Saba	Montserrat	St Eustatius[6]	Cuba[4]
	Montserrat	Bermuda	Montserrat[6]	Martinique[4]
	British Virgin Islands	British Virgin Islands	Bonaire	Montserrat[4]

The ranking of islands among the four methods most commonly differs by between six to 15 places. Island rankings that differed by fewer than six or greater than 20 places were, however, less common (Figure 1). Additionally, groups of islands with similar expected levels of vulnerability (i.e. the five most vulnerable, five least vulnerable and all remaining islands as presented in Table 3) showed no significant associations (all $p > 0.05$). This indicates that the four methods are not consistently identifying the same general level of vulnerability for each island, although there is constancy with the identification of extreme cases (e.g. Haiti, and Antigua and Barbuda are always in the five most vulnerable, and Montserrat is always in the five least vulnerable islands for all four methods).

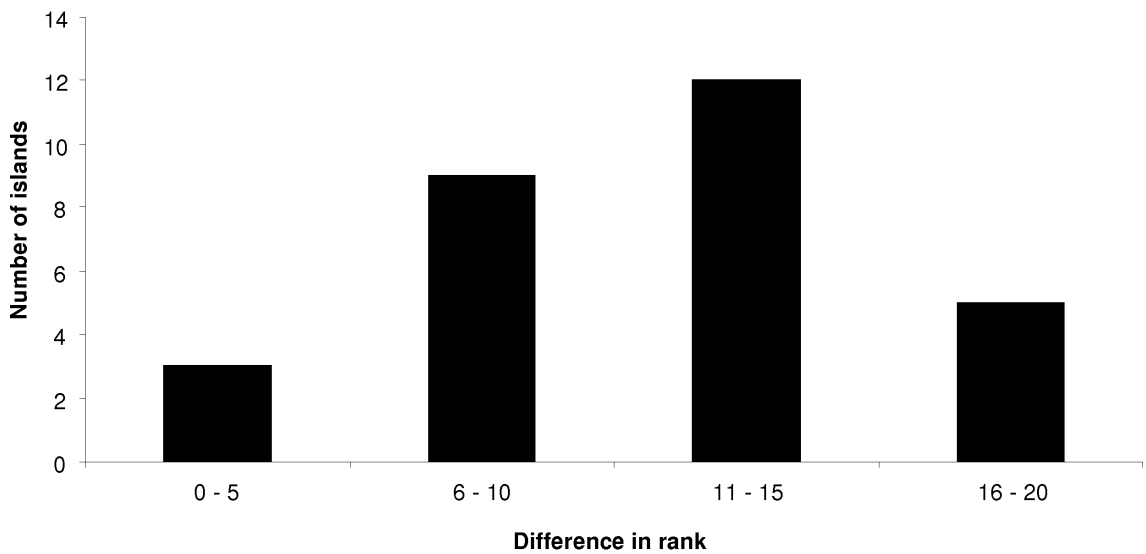

Figure 1. *Numbers of Caribbean islands differing in vulnerability ranking to varying extents from the four vulnerability assessment methods.*

Pair-wise comparisons of the variation in individual island rank from pairs of methods revealed that no two methods were ranking islands more similarly than any of the other methods (Figure 2). On average, islands differed by 5.2 to 7.0 ranked positions (± 3.5 to 5.0 SD) between methods. In a comparison of all four methods, islands differed in their rank position by an average of 11.1 places (± SD = 4.6) (Figure 2).

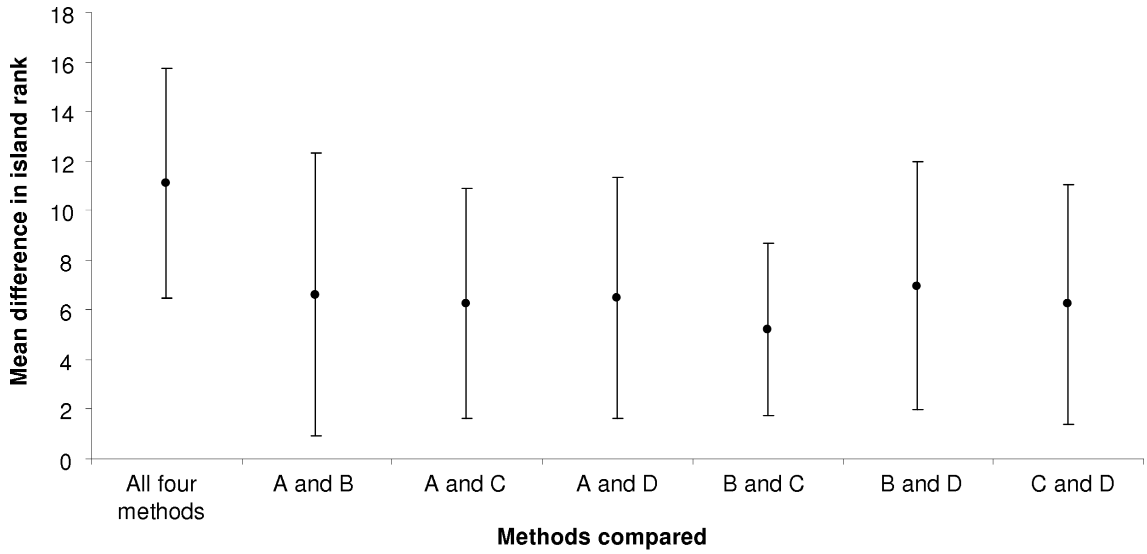

Figure 2. *Comparing the mean (± 1 SD) difference in island rank between all four vulnerability assessment methods and pair-wise method comparisons. Mean differences in island rank between sub-group comparisons were not significant ($\chi^2_3 = 1.44$, $p = 0.70$).*

The difference in ranking between methods (particularly among the middle-ranking islands) was explored using the raw indicator data (e.g. searching for anomalies or extreme indicator values, and assessing whether specific methods were weighting certain indicators more than others). This assessment did not, however, provide any obvious reason for the underlying variable ranking of islands, highlighting clear issues of methodological transparency and a loss of information. Furthermore, ranking exercises (e.g. Table 3) may also be limited by their ability to distinguish between relative and absolute rankings, hence potentially adding to a loss of information.

Comparison of island indices

Comparisons of the island vulnerability indices were undertaken for three of the methods that produced indices or scores (methods A, B and C). Again, the overall rankings are significantly correlated, while differences in the relative vulnerability of individual islands among the different methods were identified (Figure 3). This figure shows that about half of the islands at the extremes (the least or most vulnerable) are categorised with a similar level of vulnerability between methods, but there is far greater spread in the remaining islands. The positive correlations between methods are likely therefore to be driven by this closer match among islands at the extremes, implying that these methods are far more adept at identifying extreme levels of vulnerability than subtle differences.

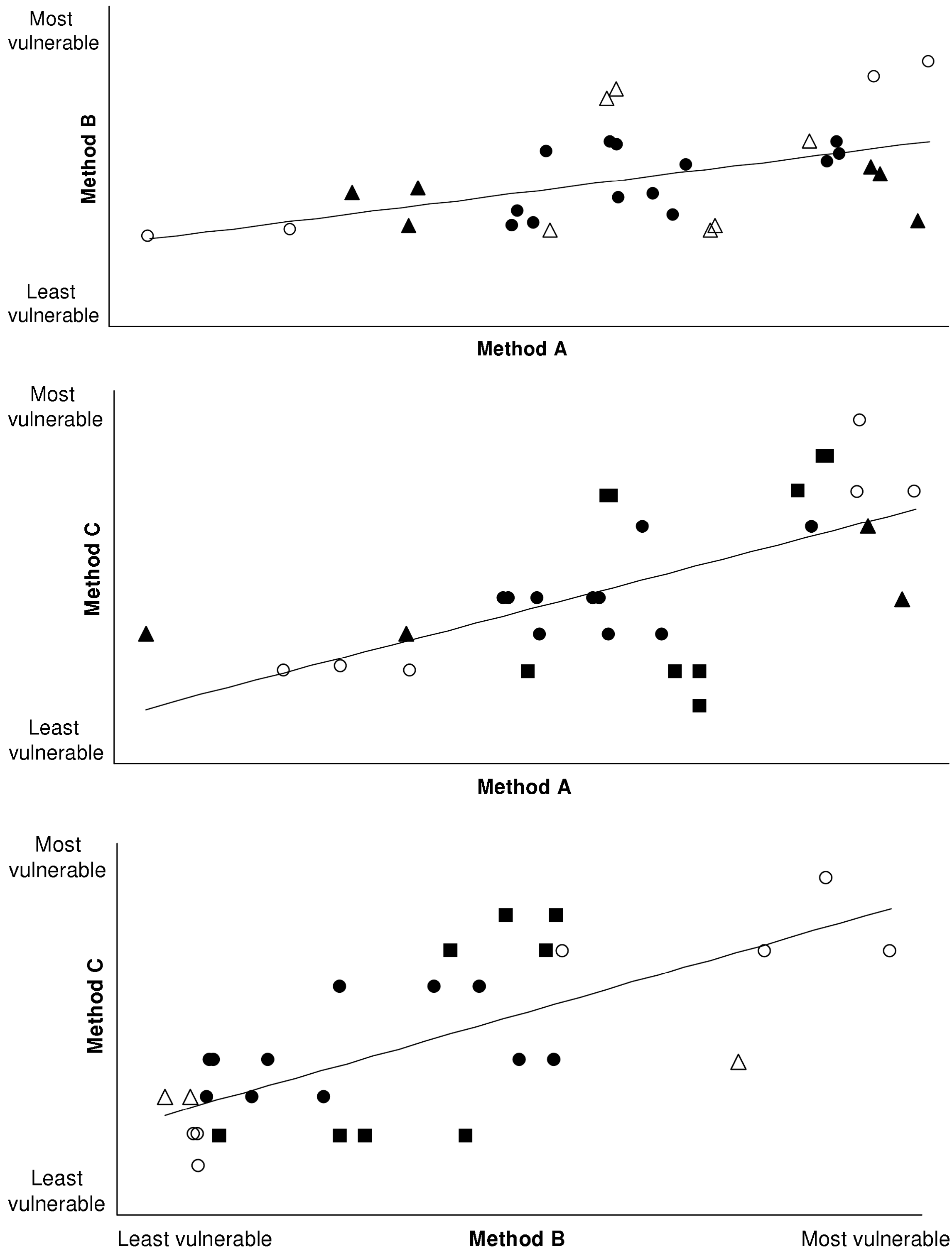

Figure 3. *Comparison of island vulnerability indices for methods A, B and C. Symbols indicate the five most and least vulnerable islands (method A: closed triangle, B: open triangle, C: closed square). Islands in the five least or most vulnerable for both methods are shown as open circles. Method C has tied rankings, therefore some groups have more than five islands (A and B: r =0.49; A and C: r =0 .62, B and C: r = 0.71, p <0.01 in all cases).*

DISCUSSION

Vulnerability assessments are increasingly used and sought by policy-makers to support planning and decision-making. There are currently hundreds of vulnerability studies and assessments underway in countries and regions across the globe, delivering information on a variety of different economic, social and environmental systems at risk (Patt et al. 2005). The use of assessments for climate change vulnerability to inform policy-making seems like the ideal integration of academic knowledge-transfer and evidence-based action, and a necessary step to advance decisions regarding adaptation to environmental change. However, this study shows that the precise methods used to calculate and quantify vulnerability can significantly influence the resulting rankings. This has major implications if these types of methods are to provide effective support for policy-makers in decision-making processes.

Although sensitivity analyses are undertaken in vulnerability research studies to confirm the robustness of their methods (e.g. see Moss et al. 2001; Fish 2006; Allison et al. 2009), this study has shown that a positive correlation between different techniques does not necessarily indicate a close match in individual vulnerability rankings. Although the correlations between the four methods in this study were positive and significant, the methods were only able to pick up similarities for the extreme cases. For example, although several of the islands in the top most and least vulnerable groups were categorised consistently by the methods (e.g. Haiti and Montserrat; see Table 3), the islands with intermediate rankings were far less consistent in their rankings (Figure 3). Although an exploration of the middle-ranking islands was undertaken, no obvious explanation was uncovered to explain why these islands ranked very differently between the four methods.

The results of this study lead to an important question regarding the perceived role of these methods in decision-making. If, for instance, the purpose of these types of methods is to identify the most or least vulnerable country, region or sector, then the results show that they are likely to produce relatively consistent outcomes. On the other hand, if the end-user wants to go further than simply categorising extremes, then the limitations of these methods need to be taken into consideration.

As all four of the methods tested in this study used exactly the same input data, and the output results are far from identical, the techniques used to combine indicators can clearly have a notable influence over the final output. Previous studies have also reported the inherent constraints of aggregating indicator data in the construction of vulnerability indices (e.g. Niemeijer 2002; Morse 2004; Morse & Fraser 2005; Patt et al. 2005; Polsky et al. 2007), although this has not been tested empirically. These studies stress that indicator-dependent vulnerability approaches lack transparency, and thus the ability to produce targeted outcomes for specific aspects of vulnerability. They also express concern about using these types of methods to assess vulnerability to climate change, because of the conceptual uncertainties in associating proxy indicators with components of vulnerability.

The findings of this study have shown empirically that the type of aggregation procedure has a clear impact on the final vulnerability ranking. Aggregated indices mask the influence of particular indicators, thereby reducing both the transparency of the analysis and the outcome values. Furthermore, if a particular indicator has a large value, this may also mask the influence of the other indicators, thereby causing a loss of information. It is difficult to discern why, in this study for example, the islands are ranked in a particular order, other than for those at the extremes. For example, Haiti was ranked as either the highest or among the highest in terms of vulnerability for every indicator considered (Table 2), so the four assessment methods were consistent in their categorisation of Haiti. However, for islands with less extreme indicator values, their rankings by the different methods are far less consistent (e.g. Aruba ranked 2nd most vulnerable in method A, and 22nd most vulnerable by method B; Table 3, Figure 3).

Interestingly, the island of Montserrat was also ranked consistently among the four assessment methods, but at the opposite end to Haiti in terms of vulnerability. This result draws attention to the importance of choosing the appropriate proxy indicators to conceptualise vulnerability. Montserrat, for instance, is highly vulnerable to volcanic eruptions, and the repercussions of recent eruptions have been severe for local communities and economies (Potter et al. 2004). With its recent history of significant environmental impacts, Montserrat may well lack the social, economic and environmental resilience to deal with further environmental change. The choice of indicators in this study does not, however, highlight this. Of course, any assessment method that uses indicators as proxies will be influenced to a certain degree by the subjectivity in indicator selection. Nevertheless, due to this limitation, the outputs of these types of assessment methods should be used cautiously.

However, assessing the vulnerability of human-environment systems to climate change is undoubtedly of high importance (MEA 2005b; Carter et al. 2007). If the limitations of these vulnerability assessment methods render them unreliable, then alternative assessment measures need to be developed and implemented. A variety of methodological suggestions have been made. These include a standardised protocol to aid the selection of indicators, and the post-hoc comparison of indicators among assessment studies (Polsky et al. 2007), reducing the complexity of vulnerability assessments by using fewer indicators (Niemeijer 2002), and narrowing the scope of the system that is being assessed (Patt et al. 2005).

In conclusion, avoiding the temptation to combine indicators and instead using entirely different methods, has been argued as perhaps the most effective means for assessing vulnerability (Patt et al. 2005). For example, focusing on the risks that a given community faces from predicted changes, by using a case-study approach (see Chapters 3, 4 and 5; Patt et al. 2005), or using expert opinion or stakeholder engagement to explore the issues behind a system's vulnerability to environmental change (see Chapter 6; Polsky et al. 2007) may produce results that have both fewer caveats and far greater insight.

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Chapter 3

The vulnerability of tourism to environmental change in the Caribbean island of Anguilla

Shoal Bay East, Anguilla

Chapter 3
The vulnerability of tourism to environmental change in the Caribbean island of Anguilla

ABSTRACT

Many tropical small island states are highly dependent on tourism as their primary source of income. As tourism on tropical islands is predominantly dependent on coastal and marine resources, this industry is likely to be particularly vulnerable to changes in the coastal and marine environment. Here I assess the vulnerability of tourism to environmental change in Anguilla, a typical Caribbean island. I use standardised questionnaires to examine tourist holiday preferences and the frequency with which different types of tourists expected to participate in different activities involving marine and coastal resources. Anguilla, like many Caribbean islands, offers a range of beach and water-based holiday activities. Tourist demand for beach-based activities is very high and ~80-90% of tourists expect to participate in beach-based activities on most days. Active recreational activities such as diving or fishing are less popular and very few tourists expect to partake in these activities more than once or twice. There is also a high demand for seafood, and younger tourists expect to consume fish and shellfish significantly more frequently than other groups. The high level of tourist expectation for these non-extractive and extractive marine and coastal activities suggests significant vulnerability of this market to environmental changes. For islands with few viable alternative industries other than marine-dependent tourism or fisheries, the need to sustainably manage the marine resources on which they rely is therefore critical.

INTRODUCTION

The Caribbean region comprises thirty-four countries representing a diverse array of natural landscapes, cultures and political structures, many of which have been shaped culturally and environmentally by a shared history of European colonisation (Daye et al. 2008). Within the Caribbean region there are twelve countries with ‘overseas territory’ status, retaining historical links to the UK (e.g. Anguilla), France (e.g. Martinique) and the Netherlands (e.g. Bonaire). While these countries forgo certain aspects of political autonomy and sovereignty, they are nonetheless entitled to benefits such as social subsidies and guaranteed export markets from their affiliated metropolitan nations, and as a result have developed comparatively healthy social and economic indicators (Pienkowski 1998; Douglas 2003). All of the other countries in the region are independent states, with diverse socio-economic and political characteristics, ranging from politically stable and comparatively wealthy nations (e.g. Barbados and the Bahamas) to politically less stable and poorer nations (e.g. Haiti and Cuba; Daye et al. 2008).

The environmental landscapes of the islands of the Caribbean vary considerably on account of diverse natural physical landforms and terrestrial and marine biodiversity (Watts 1987; McWilliams 2002; Spalding 2004). However, the environmental distinctiveness of the Caribbean islands has also been influenced by historical and recent human activity and development (Watts 1987). Across the Caribbean, significant land clearances occurred during European colonisation for plantation agricultural systems and timber harvesting in the seventeenth century (Tompkins 2003). This widespread deforestation caused destabilising erosion, declines in land fertility and the loss of biodiversity, shaping many of the Caribbean landscapes visible today (Tompkins 2003; Potter et al. 2004). More recently, during the twentieth century, land clearance and environmental decline has intensified on Caribbean islands due to large-scale development, particularly associated with the burgeoning tourism industry in the coastal zone (Burton 1998; Tompkins 2003).

Despite the substantial environmental degradation caused by tourism development in the Caribbean (Burton 1998; McElroy & de Albuquerque 1998), this industry has emerged as an attractive economic activity because of its potential to cultivate gross domestic product (GDP), employment opportunities (Potter et al. 2004) and attract significant foreign investment particularly from North America and Europe (Lewsey et al. 2004). The development of the Caribbean tourism industry has also been driven by a shortage of economically viable alternatives, on account of a declining agricultural sector (Lewsey et al. 2004) and limited natural resources (Potter et al. 2004).

Some Caribbean islands do possess sufficient quantities of resources to foster industry opportunities, most notably Cuba (nickel, petroleum), Jamaica (bauxite, alumina) and Trinidad and Tobago (petroleum, natural gas). However, because the distribution of natural resources throughout the region is geographically uneven, this is certainly not the case for all. The principle natural resources of many Caribbean islands are limited to sandy beaches, fresh seafood, and a tropical setting to attract tourists (Potter et al. 2004). Although some islands with limited natural resources have successfully developed alternative industries e.g. the offshore finance sectors in the Cayman Islands and the Bahamas (Roberts 1995; Cobb 2009), typically the islands in this region rely on 'sun, sea and sand' tourism as an economic mainstay (de Albuquerque & McElroy 1992; Becken & Hay 2007). The demand for tropical tourism has, however, been hugely profitable. Indeed, shifting the economic base away from past agricultural or manufacturing industries to tourism resulted in increases of more than 30% in the average *per capita* income for the Caribbean between 1975 and 1995 (Lewsey et al. 2004). As a result, the profitability and demand for tourism has driven the Caribbean to develop into one of the most tourism-dependent regions of the world (CTO 2005).

Economic dependence among Caribbean islands does vary. For example, although tourism generates on average 35% of GDP (± 25 SD) and 38% (± 28 SD) of employment opportunities, islands such as Anguilla, and Antigua and Barbuda are far more tourism-dependent (>70% of GDP and employment from tourism) than, for instance, Martinique and Puerto Rico (<10% GDP and employment from tourism) (WTTC 2004). Yet despite the inter-island differences in tourism dependence, common among all Caribbean islands is the tourism industry's fundamental reliance on coastal attractions such as pristine beaches and coral reef ecosystems (Rivera-Monroy et al. 2004; Uyarra et al. 2005). This emphasis on natural resource tourism, particularly for islands with substantial economic dependence on tourism and negligible alternative industries or natural capital (e.g. Anguilla; Potter et al. 2004) may potentially affect how an island can respond to economic or environmental shocks (Becken & Hay 2007).

There is growing concern that the small economies of the Caribbean islands are particularly exposed to externalities, such as climate change and extreme events exactly because they rely so heavily on one or a few economic activities (e.g. tourism and fisheries; Mimura et al. 2007). In this study I address this concern by focusing on the importance of marine and coastal tourism for Caribbean islands. The dependence on natural-resource tourism may indicate the potential necessity for an island to respond to environmental change and extrinsic stressors. In order to explore these issues, I investigate broad patterns in marine and coastal characteristics for the Caribbean region and assess, at a finer-scale, the marine and coastal resource use of tourists visiting the case-study island of Anguilla. The main objectives of this study were to 1) describe the Caribbean islands using marine and coastal characteristics and place the tourism-dependent case study island, Anguilla, within a Caribbean-wide context, 2) identify the socio-economic characteristics of tourists who holiday in Anguilla, and 3) investigate how tourists use Anguilla's marine and coastal resources. The results of this study should provide an indication of marine and coastal resource dependence by the tourism industry in Anguilla, the island's potential vulnerability to external shocks in terms of resource dependence, and enable broad comparisons with other Caribbean locations.

METHODS

The Caribbean region

The Caribbean region consists of the Caribbean Sea, enclosed to the west and the south by the Americas and encircled by island archipelagos to the north and east (Figure 1). The islands of the Caribbean are categorised into three main geographic groupings: the Greater Antilles, which includes many of the larger islands; the Lesser Antilles, a chain of smaller island countries in the east of the Caribbean Sea and fringing the north coast of South America; and the islands of the Bahamas and Turks and Caicos archipelagos in the north of the region. Further north in the Atlantic Ocean, is the small and isolated island of Bermuda (Figure 1).

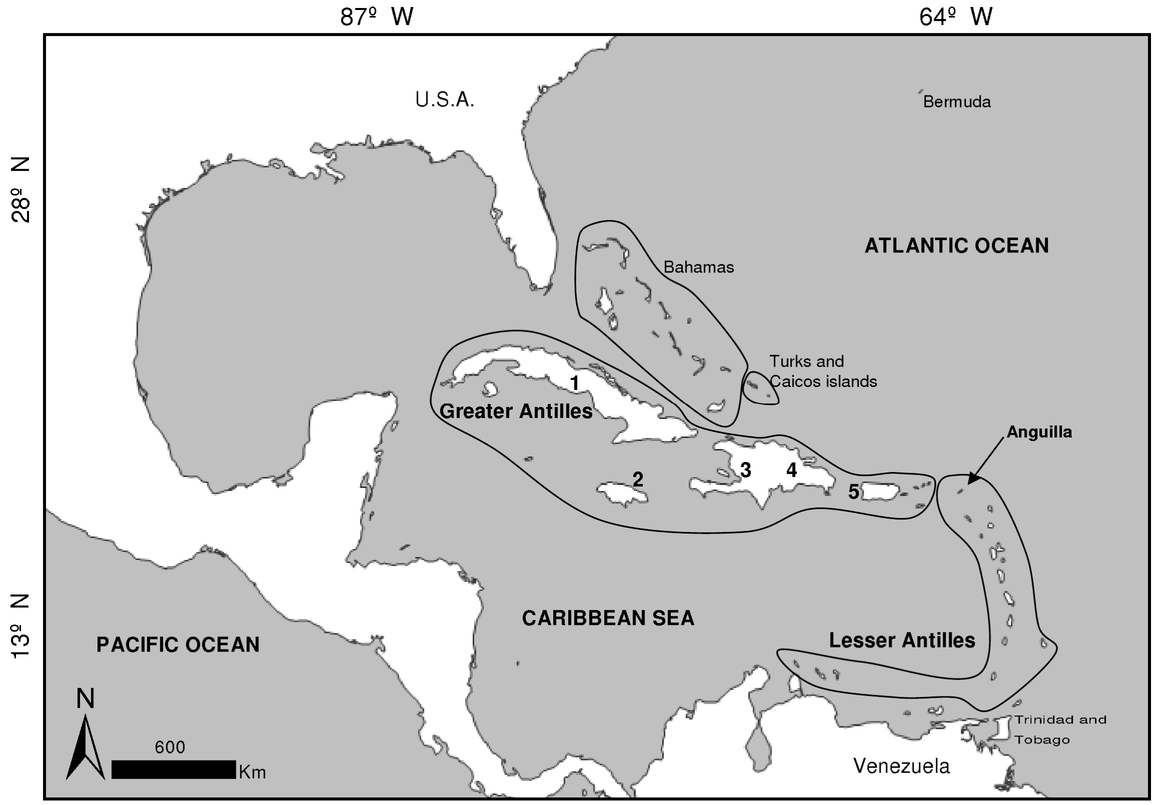

Figure 1. *The islands of the Caribbean comprise three main geographic groupings. The Greater Antilles (including (1) Cuba, (2) Jamaica, (3) Haiti, (4) Dominican Republic, and (5) Puerto Rico), the islands of the Bahamas and Turks and Caicos archipelagos, and the Lesser Antilles which include many smaller islands, including Anguilla at the north of the island chain. Bermuda is situated furthest north in the Atlantic ocean.*

The total land area of the Caribbean islands is approximately 235,000 km^2, and the islands vary considerably in size from the smallest, Bermuda (53 km^2), to the largest, Cuba (110,861 km^2) (UN 2006). The region as a whole has a population of approximately 60 million people (Daye et al. 2008), and the average population density is 284 people per km^2 (± 240 SD). Population densities between islands vary greatly, ranging from 55 people per km^2 on Montserrat (in the Lesser Antilles) to 1211 people per km^2 on Bermuda (UN 2010).

The Caribbean has a tropical maritime climate typically between 24 and 32ºC, with two predominant seasons, a long rainy season, which for most countries runs from May to October, and a dry season for the remaining part of the year. The rainy season coincides with the Caribbean summer hurricane season which lasts from June to

November (CARICOM 2003). The islands have varying topographies, some with densely forested mountainous and volcanic areas (e.g. St Lucia, Montserrat and Dominica in the Lesser Antilles), while other islands are primarily coastal and low-lying (e.g. Anguilla in the Lesser Antilles and the Cayman Islands in the Greater Antilles). All of the islands are fringed with white or dark sand beaches and coral reefs (CARICOM 2003).

The favourable climate, and coastal and marine environments of the Caribbean have predisposed this region to industries that depend on coastal and marine based resources, primarily tourism and fisheries (see Chapter 4; Spalding 2004). Indeed, the Caribbean has developed as one of the most tourism-dependent regions of the world, attracting approximately 22.5 million annual stopover visitors (CTO 2005), the vast majority of which come to experience the coast (Spalding 2004).

Broad-scale indicators of Caribbean marine and coastal resources

Data describing marine and coastal aspects of the Caribbean islands were collated from a range of literature and web-based sources (see Appendix B). These data enabled the islands to be compared in terms of marine and coastal resources and resource-use, while also placing the case study Anguilla in context relative to other islands in the region. Data were chosen to reflect broad-scale marine and coastal characteristics collectively and included island area (km^2), length of coastline (km), size of reef area (km^2), the number of marine parks, dive centres, marine and coastal tourist attractions and *per capita* fish consumption (kg/yr) for each island. The *per capita* GDP was also included and used as an indicator of wealth. The Caribbean region is reasonably data-poor and therefore not all of the islands had data for every characteristic. Only islands with data for all of the characteristics were included in the analysis.

Case study: Anguilla

Fieldwork was carried out on the island of Anguilla (18º 15' N, 63º 10' W), the smallest island in the Lesser Antilles chain. With a land area of 91 km^2 and a population of approximately 13,900, it is one of the least densely populated islands (*c.* 153 people per km^2) in the region (CTO 2009). Anguilla is also one of the most low-lying islands in the Lesser Antilles, with the highest point 65 m above sea-level (Carty & Petty 2000), and the island lies within the Atlantic hurricane belt (Mukhida & Gumbs 2008). Anguilla is renowned for having some of the most pristine white sand beaches in the Caribbean and as a result has developed into an upmarket beach tourist destination (Carty & Petty 2000). Like many islands in the Caribbean, Anguilla's economy is heavily dependent on tourism. According to the World Travel and Tourism Council (WTTC) the tourism sector generates more than 70% of the gross domestic product (GDP) and employment opportunities for the island (WTTC 2004).

The physical vulnerability of this island to hurricanes, and to climate change threats including sea-level rise and coral bleaching (Mimura et al. 2007), combined with a strong economic dependence on marine and coastal tourism, are however, typical traits for the small islands of the Caribbean region. For this reason, Anguilla was chosen as an ideal case-study because the threats this island faces in terms of climate change and marine resource dependency are also shared by many of the other islands in this region, thus enabling broad comparisons to be made.

Questionnaire surveys and sampling in Anguilla

Fieldwork in Anguilla was undertaken in 2008, during the peak holiday months of March and April (CTO 2009). Questionnaires with tourists were carried out on three of the main beaches on the north, west and south coasts (Figure 2) during the hours between 09.00 and 18.00. Most tourist accommodation is located on or near a beach, so survey sites were selected to represent the range of tourists visiting Anguilla, while also providing sufficient numbers of tourists to allow effective sampling; few people were encountered on four other major beaches away from the study beaches. The interviewer walked from one end of the beach to another, approaching each person in turn, asking if they were on holiday and if they would participate in the survey. For groups of tourists, only one member of each group was surveyed. Beaches were visited between 6 and 21 times, with care being taken to survey people only once.

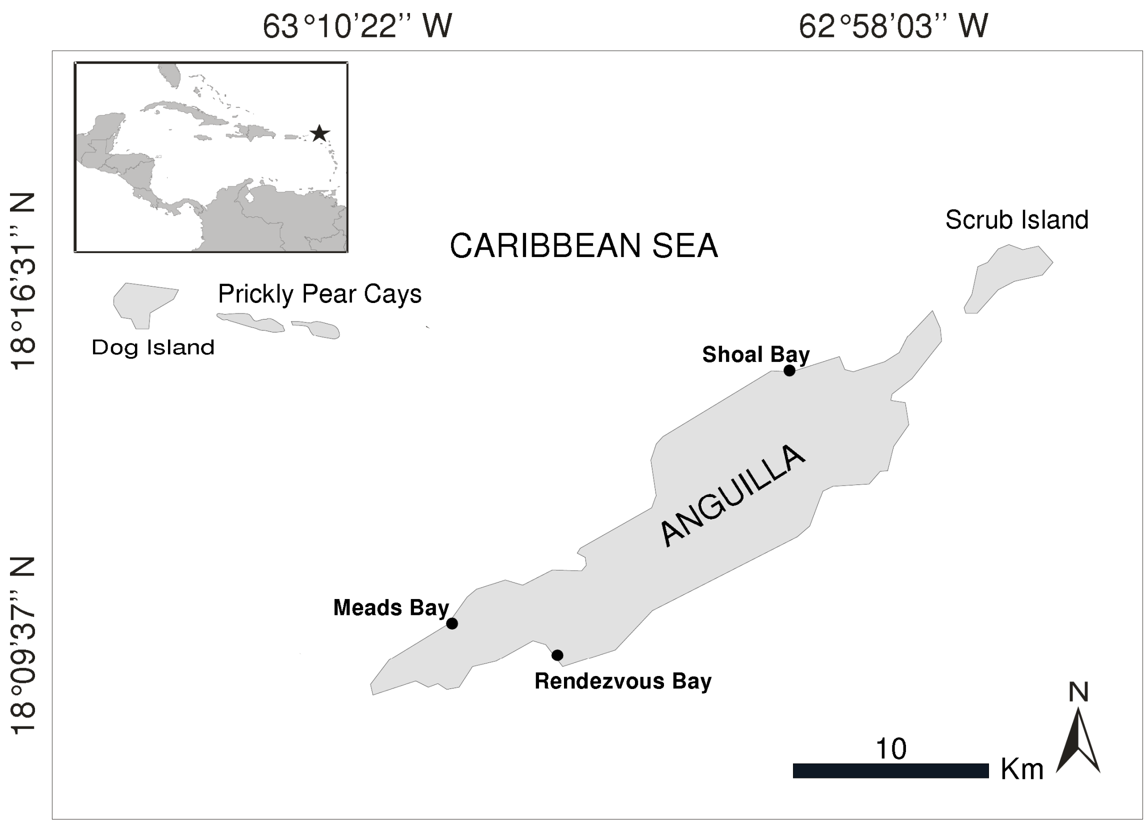

Figure 2. *Anguilla and its associated islands. The locations of the three study beaches are shown and the inset indicates the location of Anguilla within the Caribbean region.*

To establish the marine and coastal resource use of different groups of tourists in Anguilla, respondents were asked a series of questions to determine the activities in which they expected to participate while holidaying on the island. The ten activities included were: going to the beach, sunbathing, beach walking, swimming, diving, snorkelling, fishing, water sports, eating fish and eating shellfish. A 5-point likert scale was used to determine the amount of time tourists expected to participate in each of these activities during a one week holiday, where 5 = every day (i.e. 7 days), 4 = most days (5-6 days), 3 = roughly half (3-4 days), 2 = a few days (1-2 days) and 1 = never (0 days). The survey also included a series of questions to determine tourist demographic characteristics. Information on age, nationality, gender, education, employment status, income and number of dependents (classed as <16 years) was recorded. Age was categorised as 18-24 years and then in ten year classes up to and including 75 years plus. Educational achievement was categorised as: left school aged 16 years, left school aged 18 years, gained a vocational qualification, gained a university degree and gained a PhD/doctorate. Employment was classed as employed full-time, employed part-time, self-employed, student, retired, looking after the home full-time, unable to work, and other. Annual household income was categorised as ‘less than US$40,000’, and then in US$20,000 income brackets up to US$199,999, then ‘US$200,000 to US$399,999’, ‘US$400,000 plus’ and ‘unknown’. Income was presented either in US dollars, pounds sterling or Euros depending on each respondent’s nationality.

The questions were developed through consultation with related tourism studies (see Uyarra et al. 2005; Fish 2006), and personal communications with key informants (three senior staff members from the Anguilla Department for Fisheries and Marine Resources) to ensure the questions were relevant for the tourists that visit the island of Anguilla. To ensure the questions were meaningful and clear, a pilot survey with 30 respondents was also undertaken, allowing iterative changes to questions if necessary. A description of the survey guide is found in Appendix C.

Statistical analyses

In total, twenty-three independent respondent variables (10 holiday activities and 13 demographic characteristics) were collected from the questionnaires. The demographic characteristics of tourists that visit Anguilla was analysed using a Principal Components Analysis (PCA, with Varimax rotation) because this technique identifies groups or clusters of related variables (and many of these demographic variables were correlated). Relationships between respondents' demographic characteristics and holiday activity preferences were then assessed using the component scores from the PCA and examined using chi-squared tests and one-way Analysis of Variance (ANOVA).

RESULTS

Marine and coastal characteristics of Caribbean islands

Data were collected for a total of twenty islands (or island groups). Haiti (in the Greater Antilles), Guadeloupe and Martinique (in the Lesser Antilles) and Turks and Caicos Islands (north Caribbean) were excluded because data were unavailable for several of the marine and coastal characteristics.

With the exception of Cuba, Dominican Republic, Puerto Rico and Jamaica in the Greater Antilles, the majority of Caribbean islands are small in size, with over half having a land area <500 km^2 (Figure 3a). In addition, as many of the island names are collective names for island groups (e.g. Bahamas, Netherland Antilles), the individual islands have land areas, reef areas and coastlines far smaller than are represented in Figures 3a, c and d. Anguilla is the second smallest of the islands (91 km^2) (Figure 3a), with one of the smallest coastlines (61 km) and reef areas (*c.* 50 km^2, Figures 3c and d).

The distribution of wealth in terms of *per capita* GDP across the Caribbean is not uniform or proportionate to island size, with some of the smallest islands, Bermuda, British Virgin Islands (BVI) and the Cayman Islands, having relatively high *per capita* GDP (US$64,749; US$43,366; US$38,594 respectively) relative to the regional average (mean ± SD = US$15,413 ± 16,226). The case study Anguilla has a *per capita* GDP below the regional average (US$10,811, Figure 3b).

The three wealthiest islands (Bermuda, BVI and Cayman Islands) have the greatest number of marine parks relative to the other islands (Figure 4a), which may indicate that wealthier islands have more funds available for environmental management and marine conservation. However, the number of marine parks does not appear to indicate a lower level of risk experienced by the marine environment, as 100% of the coral reefs in Bermuda, BVI and Cayman Islands are listed as threatened by human activities (see Spalding et al. 2001). This severe threat level is common across the Caribbean, and all of the other islands are described as having between 89 and 100% of their coral reefs threatened by human activities. This includes Anguilla which has 100% of its coral reefs threatened.

All 20 islands (or island groups) depend heavily on marine and coastal resources for tourism. This is demonstrated by all of the islands' official tourist board websites and Rough Guides (Coates et al. 2008) which report attractions such as beaches, snorkelling, diving, water sports and fishing. Based on the number of dive centres on each island (Figure 4b), the Bahamas and the Netherlands Antilles are the main dive destinations in the Caribbean (and within the Netherland Antilles group, the small islands of Bonaire and Curaçao have 15 and 25 dive centres, respectively). Islands in the Greater Antilles (Cuba, Dominican Republic, Jamaica, Puerto Rico and the Cayman Islands) also have many dive centres, which may also indicate a heavy dependence on dive tourism. However, as coral reefs across this region are typically described as being entirely under threat from human activities (Spalding et al. 2001), the prevalence of dive tourism may not necessarily be an indication of healthier reefs. The case study Anguilla does not rely heavily on dive tourism, as demonstrated by having relatively few (four) dive centres (Figure 4b). In addition to common beach-based and diving attractions, official tourist board websites also report that the Bahamas, BVI, Cayman Islands, St Vincent and the Grenadines, Trinidad and Tobago and St Lucia provide attractions such as swimming with dolphins and sharks, and whale watching.

In terms of direct resource use, the *per capita* fish consumption (kg/yr) among these islands varies considerably. The average *per capita* fish consumption for the Caribbean region is 22.5 kg/yr (± SD = 12.2), although it ranges from very low in Puerto Rico and Aruba (1 kg/yr and 9 kg/yr, respectively) to very high in Bermuda and Barbados (44 and 40 kg/yr, respectively). Anguilla is documented as having a *per capita* fish consumption that is very close to the regional average (21 kg/yr).

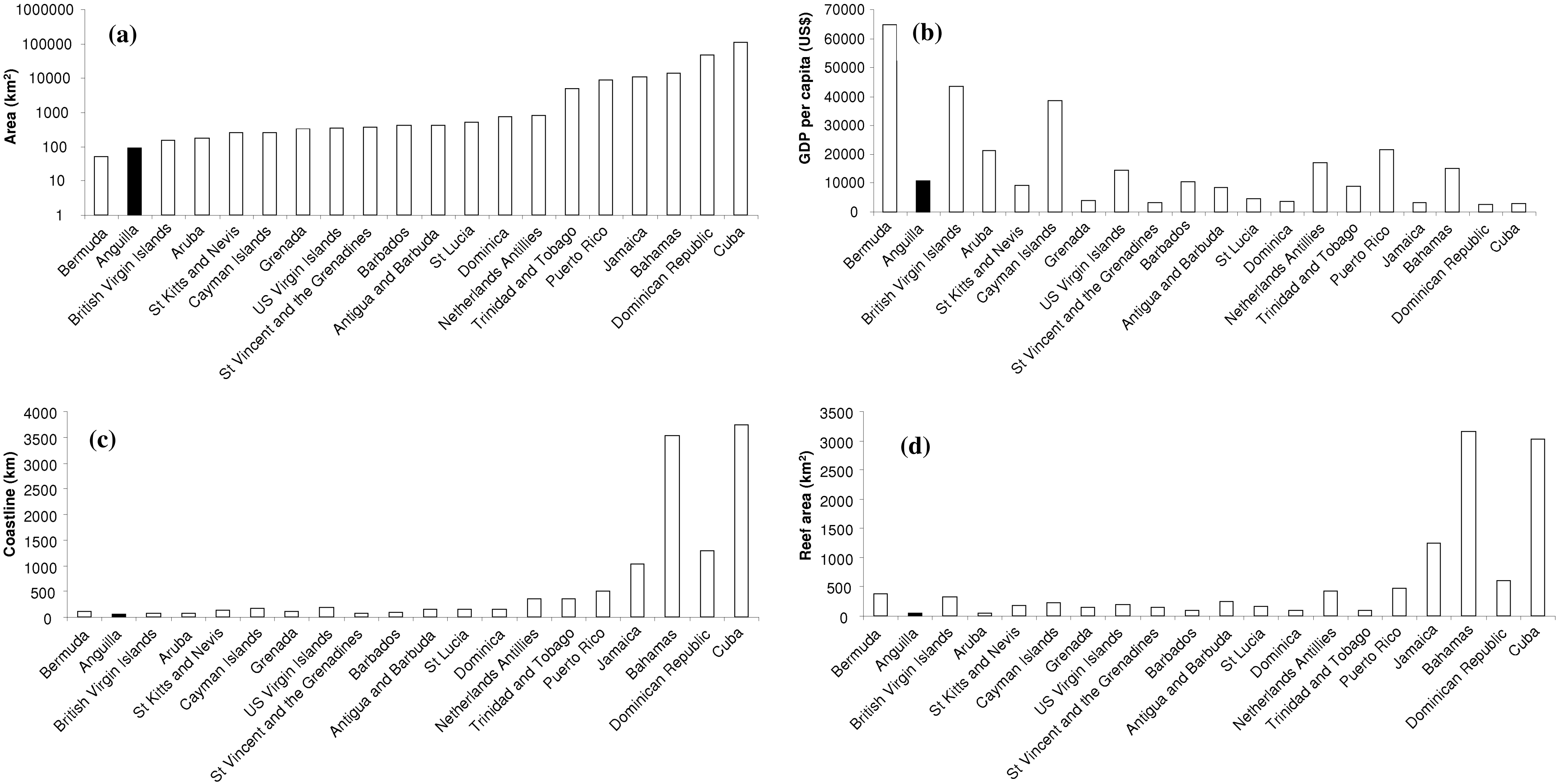

Figure 3. *Characteristics of Caribbean islands including (a) island area (km^2), (b) GDP per capita, (c) coastline (km) and (d) reef area (km^2). Islands are assorted by ascending area. The case study island Anguilla is highlighted in black.*

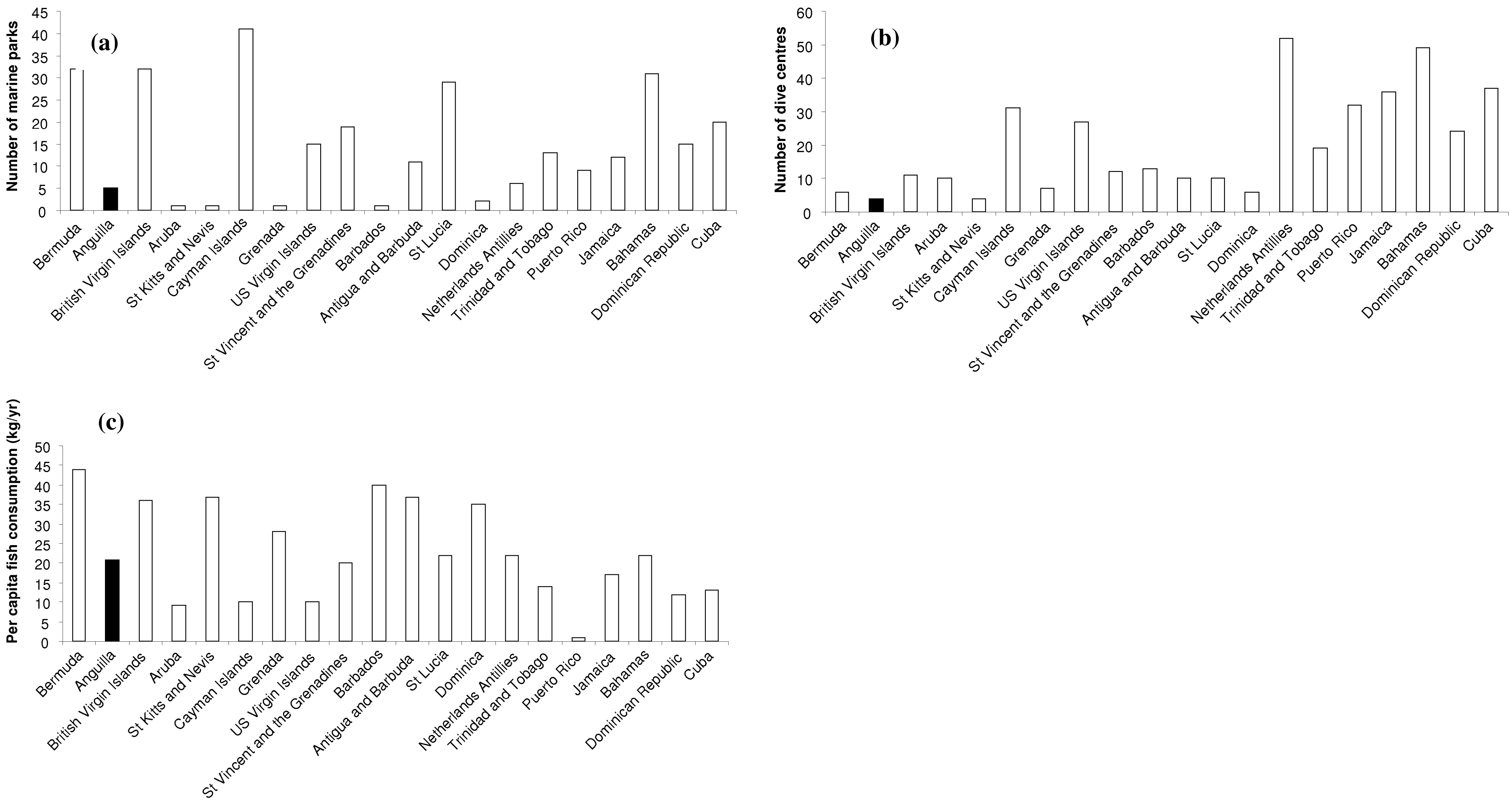

Figure 4. *Characteristics of Caribbean islands including (a) number of marine parks, (b) number of dive centres, and (c) per capita fish consumption (kg/yr). Islands are assorted by ascending area. The case study island Anguilla is highlighted in black.*

Describing the tourists in Anguilla

Three hundred tourists answered the questionnaire, corresponding to a 96% response rate. The distribution of completed questionnaires among the survey sites varied, with 75% completed on Shoal Bay. However, only 36% of these respondents were staying in accommodation on or near Shoal Bay, highlighting that this popular beach attracts visitors from across the island. The majority of respondents were American (78%), with 14% British/European and 6% Canadian. The survey was slightly female-biased (56% female) and the modal age category was 45-54 years, with 69% respondents aged >45 years. Respondents with children (<16 years) made up 25% of the sample. Respondents in full-time employment accounted for 48% of the sample, while 24% were self-employed and 15% were retired. Many visitors (70%) had a university degree, 12% had a PhD/doctorate and 10% a vocational qualification, while 8% and 2% of respondents left education aged 18 years and <16 years, respectively. In accord with Anguilla's reputation as an upmarket tourist destination, 38% of respondents stated an annual income of over US$100,000. Income was fairly evenly distributed among the other categories, although few respondents (9%) earned less than US$40,000 per annum.

Most respondents (75%) were visiting Anguilla for a period of 7 to 14 days, staying on average 10 days (± 8.3 SD) and the majority (61%) had previously visited Anguilla on holiday, with the number of prior visits ranging from 1 to 40 (mean ± SD = 6.5 ± 5.8). Most respondents (86%) had visited other Caribbean islands on holiday on previous occasions. The most popular destinations were the US Virgin Islands (12% of respondents), St Maarten/St Martin (8%), Barbados, BVI, Bahamas (each 6%) and Turks and Caicos Islands and the Cayman Islands (both 5%).

Tourist groupings

The PCA reduced the 13 demographic characteristics collected from the questionnaire to six factors (Table 1), which broadly related to 'age, employment and family status' (Factor 1), 'nationality' (Factor 2), 'education' (Factor 3), 'nationality' and 'education' (Factor 4), 'employment' (Factor 5), and 'wealth and family status' (Factor 6). These factors accounted for 15, 14, 12, 12, 11, and 10%, respectively, of the variance. The variance between factors is however, relatively similar, which indicates a certain level of homogeneity in the sample, indicative of Anguilla being predominately visited by older, wealthy American tourists.

Table 1. *Principal component factors describing the people who holiday in Anguilla according to different demographic groups. All factor loadings for the 13 demographic characteristics are included, with loadings >0.4 highlighted in bold.*

	Principal components					
Demographic characteristics	**Factor 1** ***Age, employment and family status***	**Factor 2** ***Nationality***	**Factor 3** ***Education***	**Factor 4** ***Nationality and education***	**Factor 5** ***Employment***	**Factor 6** ***Wealth and family status***
Gender	-0.129	0.089	0.003	0.024	**0.692**	-0.357
Household income	0.075	0.026	0.041	-0.082	-0.032	**0.813**
Children at home	**-0.437**	-0.044	-0.001	0.075	0.244	**0.501**
Age	**0.773**	0.168	0.040	0.125	-0.110	0.116
Left school age 18	0.075	-0.172	0.262	**0.677**	0.158	-0.140
Gained first degree	-0.085	0.137	**-0.876**	-0.317	-0.025	0.100
Doctorate degree	-0.057	0.050	**0.865**	-0.204	-0.087	0.139
Employed full-time	**-0.654**	0.103	0.058	0.080	**-0.612**	-0.099
Employed part-time	0.038	0.013	-0.045	-0.014	**0.709**	0.332
Retired	**0.860**	-0.090	0.004	-0.019	0.069	-0.110
American	0.035	**0.853**	0.003	**-0.438**	0.042	-0.035
Canadian	-0.016	-0.021	-0.135	**0.837**	-0.133	0.045
British/ European	-0.014	**-0.971**	0.070	-0.079	-0.020	-0.026

Marine and coastal tourism activities and resource use in Anguilla

The ten holiday activities broadly fall into 'beach-based' activities (i.e. going to the beach, sunbathing, beach walking, swimming), 'adventure recreation' (i.e. diving, snorkelling, fishing, water sports) and 'marine resource consumption' (i.e. eating fish and eating shellfish). The numbers of respondents that expected to participate in each of these activities are shown in Figure 4.

The level of expected respondent participation varied among activity types, with a significantly greater proportion of respondents expecting to undertake beach-based activities most days or every day (87-96% depending on the activity; Figure 4a; χ^2 = 52.02, df = 12, $p < 0.001$). By contrast, significantly more respondents expected to never or very rarely participate in adventure recreation activities (64% for snorkelling, and 93-98% for water sports, fishing and diving; Figure 4b; χ^2 = 362.43, df = 12, $p < 0.001$). The very small amount of variation in expected respondent participation within each of these activity types clearly demonstrates that participation is independent of respondent demographic characteristics.

Where there was more of a spread and variability in response is in the marine resource consumption activity group (Figure 4c; χ^2 = 122.84, df = 4, $p < 0.001$). Here the majority of respondents expected to eat fish (96%) and shellfish (86%) at some point during their holiday, although the frequency with which they expected to participate in these activities varied across the sample. This activity group was therefore explored in more detail to assess if there were differences in fish and shellfish consumption according to different types of respondents.

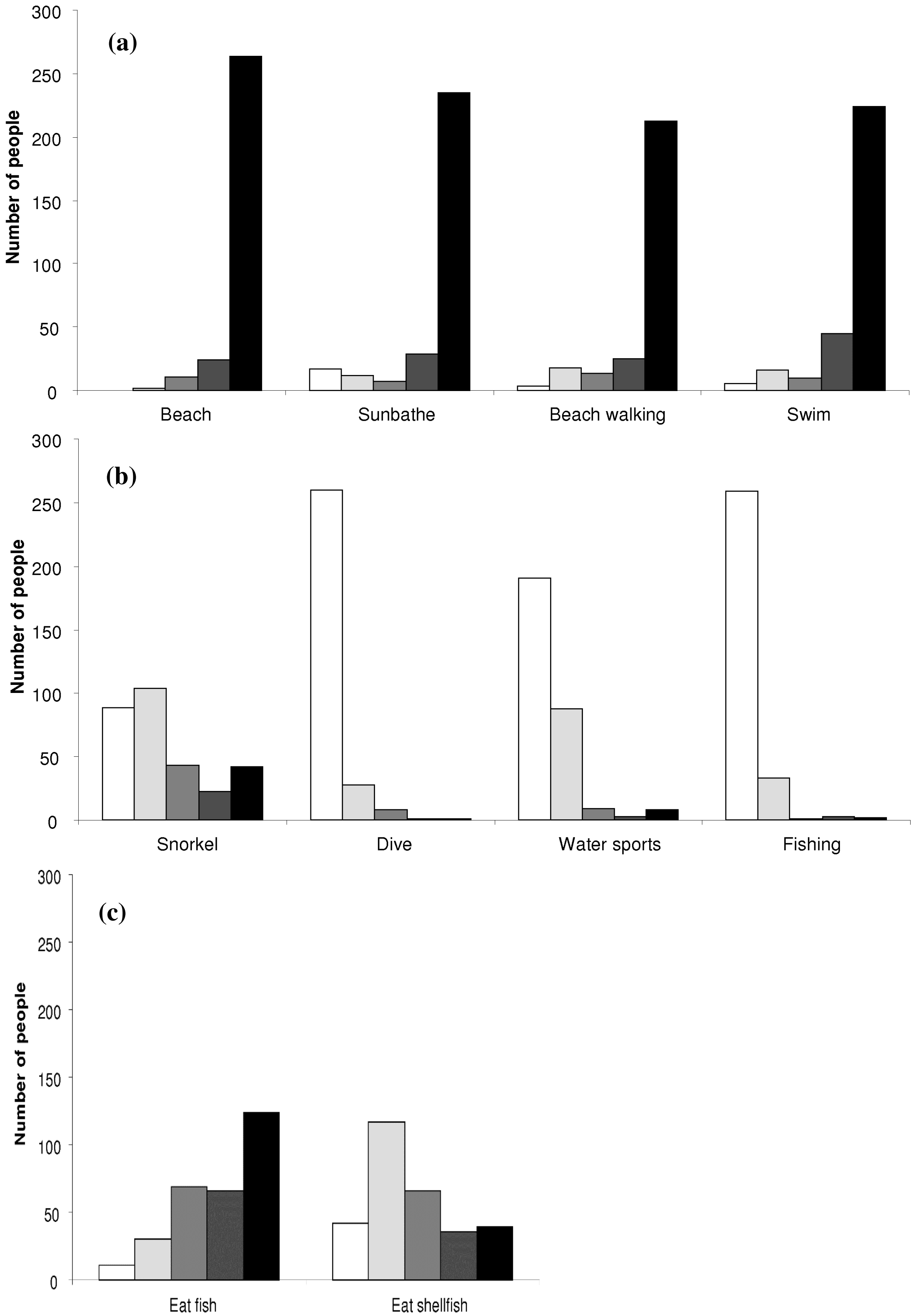

Figure 4. *The number of visitors to Anguilla who expected to participate in (a) beach-based (b) adventure recreation and (c) marine resource consumption activities. Bars show the number of respondents who expect* to *participate in each activity during a one week holiday (white = never, pale grey = 1-2 days, mid grey = 3-4 days, dark grey = 5-6 days and black = 7 days).*

Tourist marine resource consumption in Anguilla

Two of the PCA factors (as described in Table 1) relating to respondent demographic characteristics were significantly associated with fish and shellfish consumption. Factor 1 (age, employment and family status) and factor 5 (employment status) were associated with consumption of fish (Figure 5a and e) and factor 1 was also associated with consumption of shellfish (Figure 6a). All of the other PCA factor groups were not shown to be significantly associated with consumption of either fish or shellfish.

Respondents who were positively associated with factor 1 (i.e. people who are older, retired, with no children at home) were significantly less likely to eat fish and shellfish (Figures 5a and 6a) compared to respondents who were negatively associated with this factor (i.e. people who are younger, full-time employed, with children at home). However, a significant association was shown between respondents who were positively associated with factor 5 (i.e. in part-time employment) indicating that these people were significantly more likely to eat fish while on holiday compared to people in full-time employment (Figure 5e).

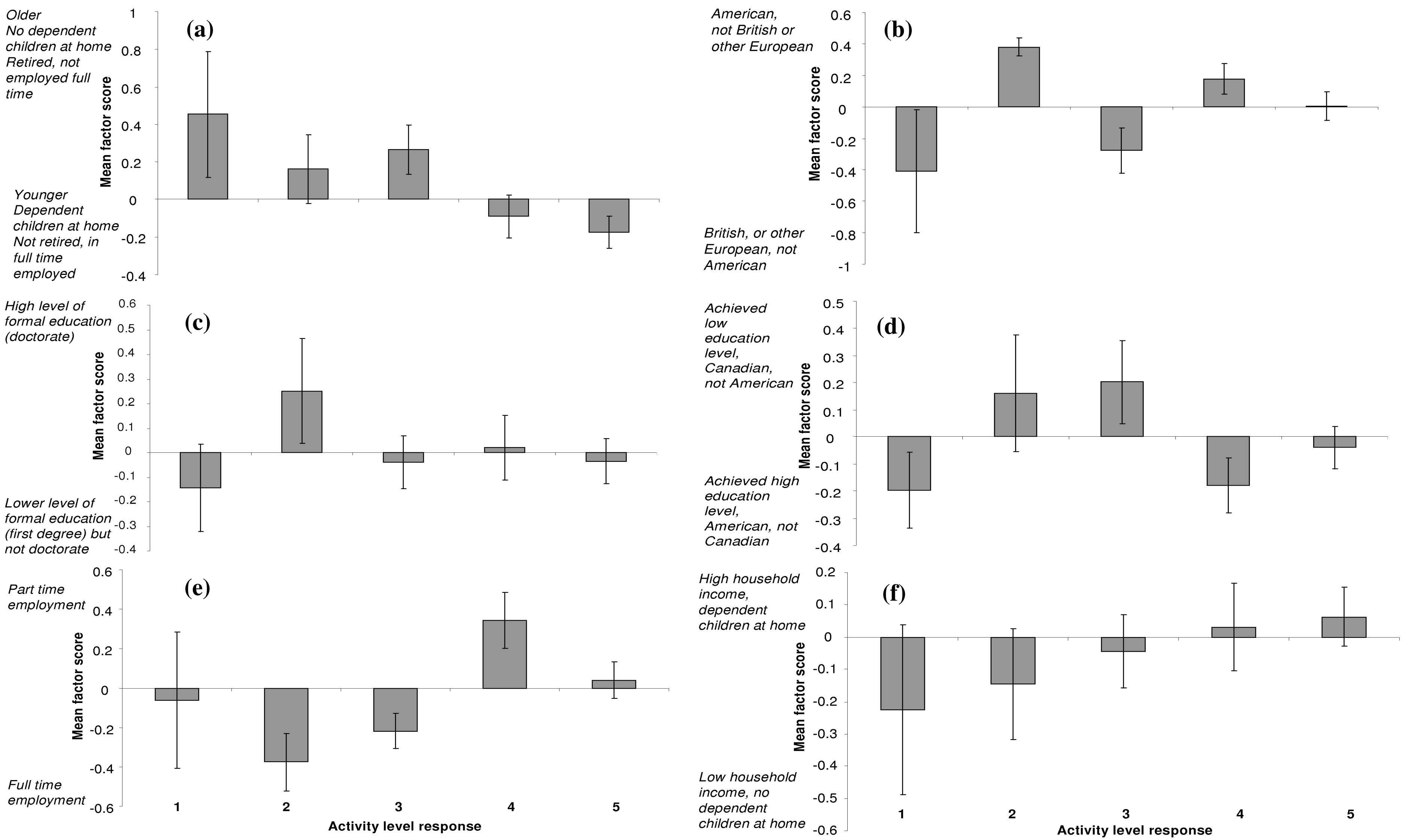

Figure 5. *Variation in the demographic characteristics of tourists expecting to eat fish with differing frequencies during a 7 day holiday (from 1 = never to 5 = every day). Demographic characteristics are presented as the mean (± 1 SE) PCA scores (see Table 1), for factors (a) 1($F_{4, 298}$ =3.18, p<0.01), (b) 2 ($F_{4, 298}$ =3.52, p=0.59), (c) 3 ($F_{4, 298}$ =0.6, p=0.55), (d) 4 ($F_{4, 298}$ = 1.59, p=0.27), (e) 5 ($F_{4, 298}$ =4.0, p<0.05) and (f) 6 ($F_{4, 298}$ = 0.47, p=0.17). Significance values from one-way ANOVA are included.*

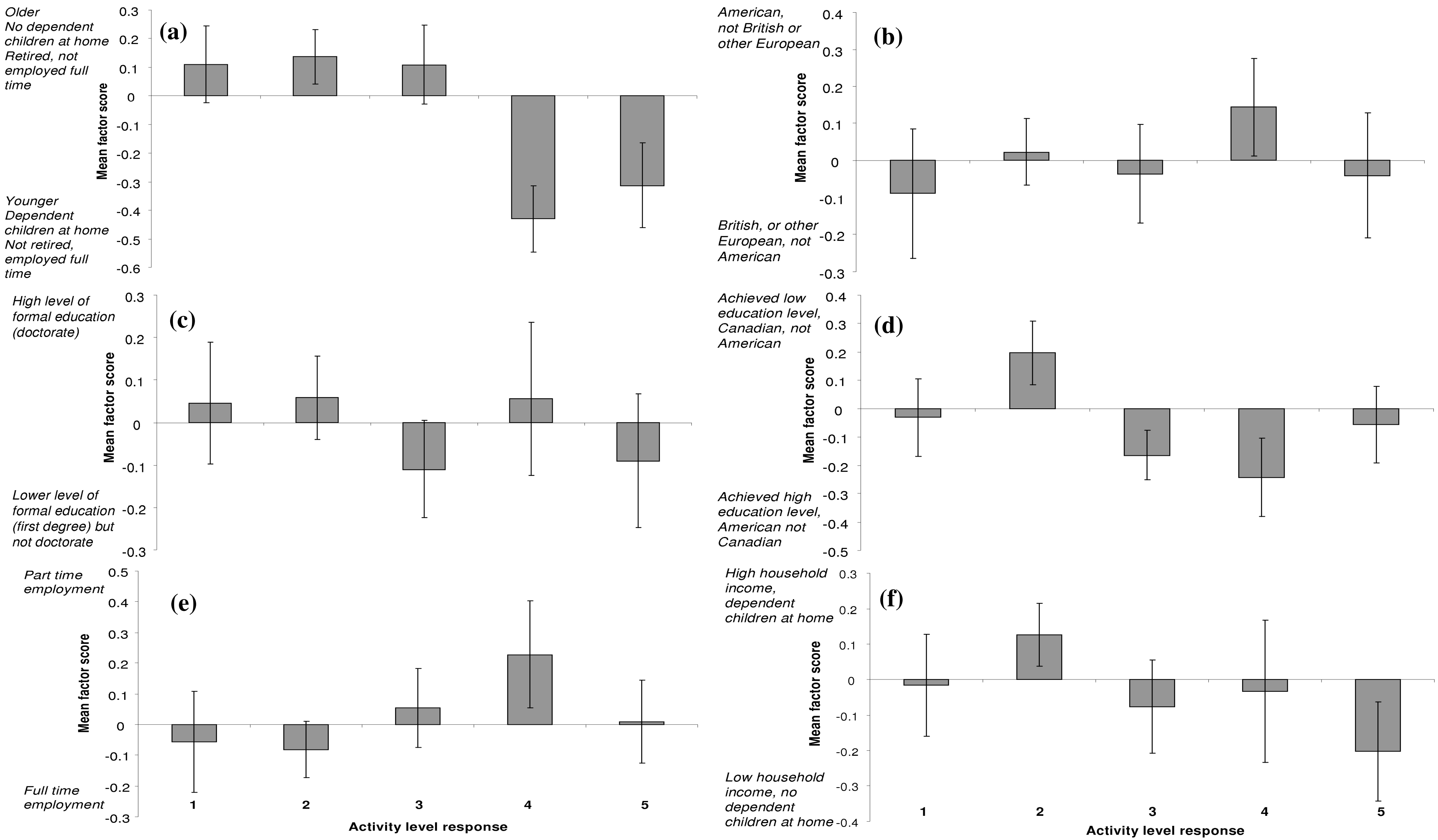

Figure 6. *Variation in the demographic characteristics of tourists expecting to eat shellfish with differing frequencies during a 7 day holiday (from 1 = never to 5 = every day). Demographic characteristics are presented as the mean (± 1 SE) PCA scores (see Table 1), for factors (a) 1($F_{4,\,298}$ =3.61, p<0.01), (b) 2 ($F_{4,\,298}$ =0.32, p=0.74), (c) 3 ($F_{4,\,298}$ =0.42, p=0.45), (d) 4 ($F_{4,\,298}$ = 2.18, p=0.11), (e) 5 ($F_{4,\,298}$ =0.74, p=0.27) and (f) 6 ($F_{4,\,298}$ = 0.97, p=0.15). Significance values from one-way ANOVA are included.*

Figures 5 and 6 suggest that age and employment status are key factors influencing the frequency with which tourists expect to consume seafood. Therefore, tourists' responses within different age and employment status groupings (PCA factors 1 and 5) were explored further. The trends in activity levels for these two significant factors were not however appreciably different, so only results for PCA factor 1 are shown here.

Irrespective of demographic groupings, more respondents expected to eat fish everyday of their holiday compared to lower activity level categories (Figure 7). However, respondents who were categorised as 'younger, employed, with children at home' (12% of sample) were more likely to eat fish everyday of their holiday, compared to the other demographic groups (i.e. 'older and retired' group (14%) and the remaining respondents (74%), Figure 7a).

Unlike fish consumption, all respondent groups irrespective of demographic characteristics, expected to eat shellfish less frequently; with most people expecting only to eat shellfish on a few days (activity level 2) or about half of the time that they are on holiday (activity level 3) (Figure 7b). There were also more respondents in the 'older and retired' group that expected not to eat shellfish compared to the other respondent groups.

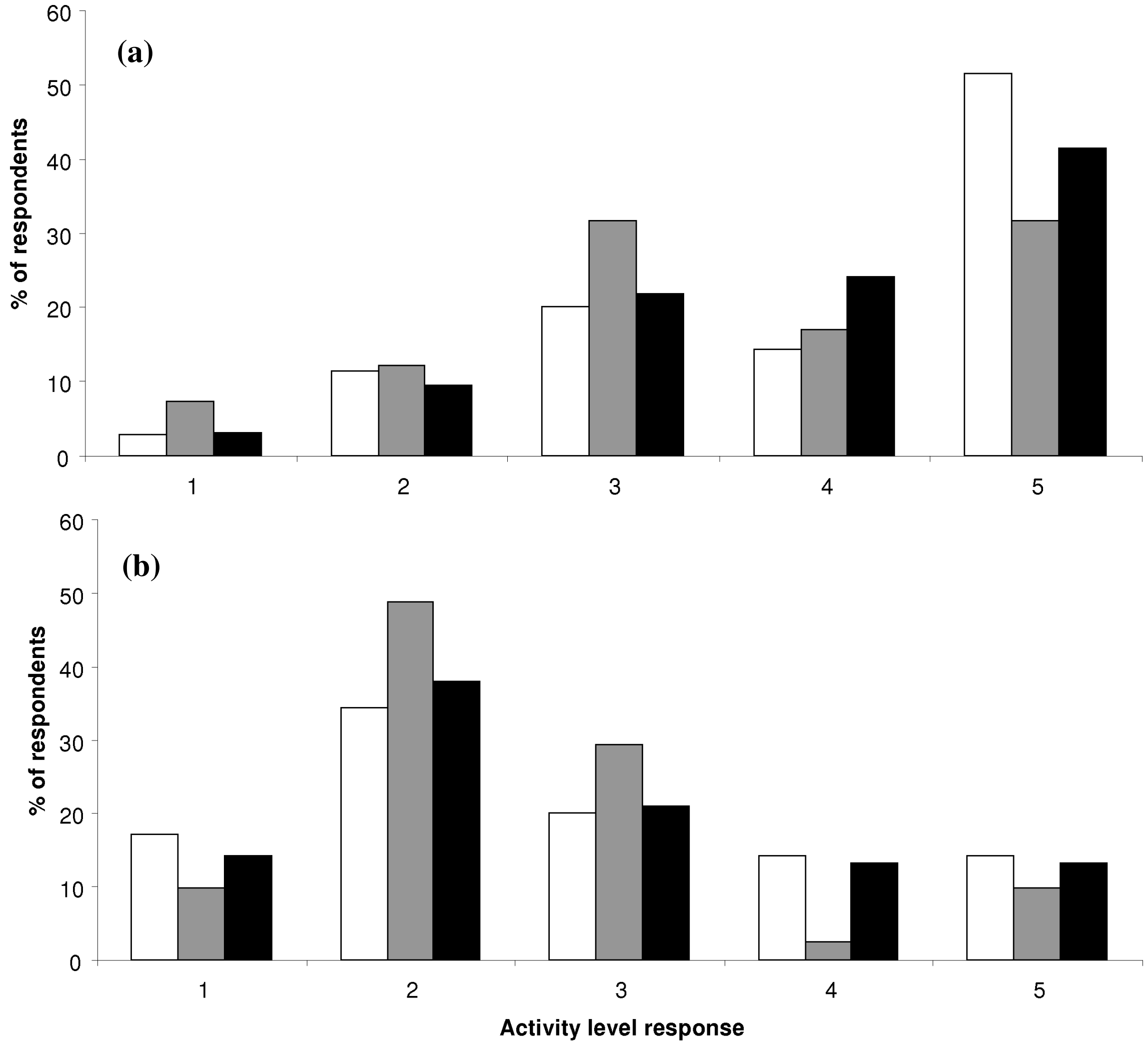

Figure 7. *Marine resource consumption of 300 visitors to Anguilla. Bars represent the percentange of respondents who expect to eat fish (a) and shellfish (b), with differing frequencies during a 7 day holiday (from 1 = never to 5 = every day). Respondent groupings are derived from PCA factor 1 (Table 1), and white bars represent 'younger (<55 yrs), full-time employed with children', grey bars represent 'older (>55 yrs), retired, no children at home', and black bars represent all of the remaining respondents.*

DISCUSSION

The islands of the Caribbean all depend to a large extent on marine and coastal resources for tourism. Typically, visitors are attracted to this region because of beach- and water-based activities, and all of the islands included in this study provide these types of tourist attractions. Although there are many common activities on offer (e.g.

beaches, swimming, snorkelling and diving), in terms of marine resource use there are differences among islands, particularly dive tourism opportunities and the consumption of fish. The multi-island analysis showed that the case study island, Anguilla, was not atypical in terms of certain characteristics (e.g. tourist attractions, coral reef health, GDP, per capita fish consumption), although this island is one of the smallest and least populated in the region.

Marine and coastal resource use in Anguilla

Responses to the questionnaire revealed that most of the tourists that visit Anguilla are American, older than 45 yrs and with no dependent children. Many respondents typically had high levels of education and income and were repeat visitors to the island. Consequently, this analysis concurs with the reputation of Anguilla as a high-end Caribbean tourist destination (Carty & Petty 2000). The Caribbean region as a holiday destination was also particularly popular among respondents, with the majority having visited other Caribbean islands on previous occasions. The popularity of the region is perhaps not surprising considering the proximity of the Caribbean to the USA and the proportion of American nationals who were interviewed for this study.

In terms of marine and coastal resource use, distinctions among holiday activities were identified, with significantly more respondents expecting to take part frequently in 'beach-based' activities, compared to 'adventure recreation' activities, such as diving or fishing. Considering that the holiday activity preferences were shown to be independent of tourist demographic characteristics, these results clearly demonstrate that tourism in Anguilla is driven principally by the demand for beach-related activities. Of the holiday activities that were considered, the consumption of marine resources is likely to be the most environmentally damaging, as this activity requires direct extraction of resources, and has led to sustained over-exploitation and the decline of coral reef ecosystems in the Caribbean (Hughes 1994; Hawkins & Roberts 2004). This aspect of tourism was therefore a particularly important one on which to focus.

Preference for seafood in Anguilla is high and is considered a key component of the holiday experience for many of the tourists who visit the island. Indeed, a previous study highlighted that the expansion of the luxury tourism market in Anguilla has created a high and growing demand for shellfish (Wynne & Côté 2007). Moreover, while the demand for reef fish in Anguilla is considered primarily to be driven by local people (Abernethy et al. 2007); this study has also indicated a strong preference for fish among visitors to the island. This demand for reef fish and shellfish is later confirmed by estimated daily catch rates and testimonials of Anguilla fishers in Chapter 5 (e.g. average daily reef fish catch 60 ± 35 kg/day n = 18, and lobster 53 ± 36 kg/day n = 15).

Although the level of seafood consumption by respondents was more variable by comparison to the participation levels for the other holiday activities (i.e. 'beach-based' and 'adventure recreation') the majority of respondents still expected to eat fish or shellfish at some point during their holiday (96% and 86%, respectively). Additionally, similar trends in seafood consumption were identified among different demographic tourist groups (Figure 7), with respondents categorised in the 'younger, employed, with children' group significantly more likely to eat fish and shellfish compared with respondents categorised in the 'older and retired' group. This could provide some capacity for education to reduce expectation for seafood consumption among the high consumers. However, considering that these two groups of respondents comprised just 12% and 14% of the sample respectively, this distinction in preference is unlikely to appreciably influence the demand for seafood on the island. Identifying different activity preferences based upon demographic characteristics is also limited by the demographic homogeneity of the tourists that visit the island (see Table 1).

Marine resource dependency on Caribbean islands

All of the islands included in this analysis, with the exception of Bermuda and the Cayman Islands are categorised by the United Nations as Small Island Developing States (SIDS) (UN-OHRLLS 2010; UNCTAD 2010). The SIDS are typified by certain disadvantages associated with small size, geographical remoteness, insularity and a proneness to natural disasters; and most notably these characteristics render their economies vulnerable to external impacts (Briguglio 1995; Pelling & Uitto 2001). It has also been suggested that the *per capita* GDP of some of the SIDS may in fact further conceal the true nature of their inherent vulnerability (Briguglio 1995). The omission of the Cayman Islands and Bermuda from the SIDS category may therefore relate to their relatively high *per capita* GDP (see Figure 3b), because on all other terms these islands share typical SIDS' physical and environmental qualities.

For the SIDS in the Caribbean, the resource-dependent tourism industry, which is highly susceptible to variations in consumer demand and to environmental change, forms a key element of their economic fragility (Pelling & Uitto 2001; Becken & Hay 2007). This is a particularly important issue for the Caribbean because, against a background of long-standing stressors such as over-fishing, pollution and development (MEA 2005; Breton et al. 2006), more recent threats associated with climate change (e.g. sea-level rise, greater hurricane risk and coral bleaching) are also expected to severely impact the marine environment (Wong et al. 2005; Mimura et al. 2007). As Caribbean resource-dependent industries (i.e. tourism and fisheries) are already vulnerable on account of sustained historical stressors, the ability of these industries and economies to adapt to future environmental change will be as critical to society as to the natural ecosystems on which they depend (Marshall 2010).

Defining resource dependency and associated vulnerabilities of the Caribbean islands may help to identify which islands are particularly susceptible to future impacts from environmental change. As demonstrated by this study, the use of broad-scale indicators can provide a rough picture of resource use and dependency and hence signal potential vulnerability. This study highlighted that islands in the Caribbean share many common features; however, it may be that other individual characteristics of the islands, such as social and political institutions contribute more significantly to their adaptability (see Chapter 5; Adger 2003; Smit & Wandel 2006). In addition, one concept of dependency suggests that economic specialisation can negatively affect how societies develop adaptation to environmental change (Adger 2000). Therefore on these terms, the development of additional industries (e.g. financial services in the Cayman Islands and mineral extraction in Jamaica (Roberts 1995; Potter et al. 2004), might also provide greater resilience or adaptability to uncertain and future environmental change.

Only by applying a case study approach can an accurate assessment of Caribbean island resource dependency be identified, with the potential to draw a fuller insight into vulnerability to environmental change. The case of Anguilla has demonstrated the importance of marine and coastal resources for this island. This island is also sufficiently representative for the region in terms of the marine and coastal characteristics (Figures 3 and 4) to make Caribbean-wide assumptions. It is reasonable to suggest therefore, that the heavy reliance on marine and coastal resources in Anguilla is similar to that of many other islands in the Caribbean.

There were of course differences between islands for some of the marine and coastal characteristics, allowing for potential distinctions to be made regarding vulnerability and marine resource dependence. For example, the Netherlands Antilles, Cayman Islands and Bahamas appear to rely more on dive tourism than some of the other islands (Figure 4b; Spalding 2004; Uyarra et al. 2005). Since tropical dive tourism is dependent on coral reefs (Parsons & Thur 2008; Kragt et al. 2009) and considering the established link between climatic change and coral reef decline (Hoegh-Guldberg 1999; Gardner et al. 2003), it could be implied that these dive-destinations are intrinsically more vulnerable to environmental change because of their reliance on climate sensitive coral reefs. Using this argument, by contrast the beach-destination islands of Anguilla (Carty & Petty 2000) and Barbados (Uyarra et al. 2005; Fish 2006) might be considered more resilient to environmental change because they rely on beach attractions and less on fragile coral reefs to attract tourists. The tourist expectation for seafood on Anguilla may however require an increase in seafood imports if its coral reefs are unable to adequately supply the market demand.

This assessment may well be too simplistic. Predicting and assessing Caribbean island vulnerability, based on resource dependence and adaptability potential involves the integration of a range of social, economic and environmental factors (see Chapter 2; Adger 2000; Folke 2006; Marshall et al. 2007), plus the uncertainty of future environmental impacts (Mimura et al. 2007; Allison et al. 2009). What is clear is that coastal societies may be dependent to a varying degree on specific coastal resources and that this will affect how they adapt to future environmental change (Adger 2000). This is certainly the case for the Caribbean, where there are island-specific differences in marine resource use (e.g. diving vs. beach destinations). However, there is widespread reliance on industries dependent on the common resources provided by the Caribbean Sea (Breton et al. 2006; Becken & Hay 2007). This embedded reliance on a single ecosystem, combined with sustained regional environmental threats, presents a level of vulnerability across the Caribbean region that requires an integrated and regional approach to environmental management.

CONCLUSION

On the island of Anguilla and other comparable islands in the Caribbean, tourists expect to use both non-extractive and extractive marine and coastal resources. This situation is unlikely to change in the short-term because of the clear economic benefits the tourism industry provides these islands (Lewsey et al. 2004). The islands of the Caribbean are therefore locked-in to high and potentially unsustainable levels of marine resource use, to which a dependence on tropical tourism significantly contributes.

Considering the importance of the marine environment for the Caribbean islands, and that many do not have economically viable alternatives to the marine-dependent tourism industry, the need to manage the marine and coastal resources they rely upon sustainably and adaptively is critical for these complex social-ecological systems. In order to deal with the environmental consequences of this resource-dependent industry and particularly in light of current environmental pressures and future climate change impacts, environmental management and adaptation mechanisms need to be applied at local and national, but also at regional Caribbean-wide scales.

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Chapter 4

The influence of changing risks of hurricane impact on tourist preferences in the Caribbean

Shoal Bay East, Anguilla

Submitted to *Climatic Change*

Forster J., Lake I.R., Watkinson A. R. and Gill J. A.

Chapter 4
The influence of changing risks of hurricane impact on tourist preferences in the Caribbean

ABSTRACT

Climate change could have major implications for the global tourism industry if changing environmental conditions reduce the attractiveness of holiday destinations. Countries with economies dependent on tourism and with tourism industries reliant on vulnerable natural resources are likely to be particularly at risk. This study investigates the implications that climate-induced variations in Atlantic hurricane activity may have for the tourism-dependent Caribbean island of Anguilla. Three hundred tourists completed standardised questionnaires and participated in a choice experiment to determine the influence hurricane risk has on decision-making regarding holiday preferences and risk perceptions. The beaches, climate and tranquillity of the island were most important in determining holiday destination choice, while coral reef-based activities were less important, and 40% of respondents had considered the hurricane season when making their holiday choice. Choice models demonstrated that respondents were significantly less likely to choose holiday options where hurricane risk is perceived to increase, and significantly more likely to choose options that offered financial compensation for increased risk. However, these choices and decisions varied among demographic groups, with older visitors, Americans, and people who prioritise beach-based activities tending to be most concerned about hurricanes. These groups comprise a significant component of the island's current clientele, suggesting that perceived increases in hurricane risk may have important implications for the tourism economy of Anguilla and similar destinations. Improved protection of key

environmental features (e.g. beaches) may be necessary to enhance resilience to potential future climate impacts.

INTRODUCTION

Tourism is one of the largest and rapidly expanding economic sectors in the world, and is critically important for the local and national economies of many countries (Agnew & Viner 2001; Gössling & Hall 2006; Becken & Hay 2007). Mass tourism is highly sensitive to climatic variation because favourable environmental conditions are a major component of decision-making regarding holiday destinations, particularly for the dominant ‘sun, sea and sand’ tourism industry (Uyarra et al. 2005; Bigano et al. 2006; Becken & Hay 2007). Climate change could have significant implications for the global tourism industry by reducing the attractiveness of currently popular destinations and/or increasing favourable conditions in alternative locations (Lise & Tol 2002; Scott et al. 2004).

Tourist destinations that are particularly vulnerable to change are those with economies already dependent on tourism and reliant on international travel rather than local markets (Wall 1998; Maddison 2001). Moreover, destinations that attract visitors because of location-specific natural resources, principally coastal areas, islands and mountainous regions are expected to be particularly vulnerable if changing climate affects those natural resources (Wall 1998). Small islands are frequently identified as places of significant concern since their economies often depend highly on tourism, and because the coastal attractions on which island tourism is typically founded are vulnerable to sea-level rise, storms and increasing sea temperatures (Lewsey et al. 2004; Becken & Hay 2007; Meheux et al. 2007; Mimura et al. 2007).

The Caribbean is one of the most tourism-dependent regions of the world, attracting 22.5 million annual stopover visitors (CTO 2005) and accounting for approximately 7% of world tourist arrivals (Daye et al. 2008). According to the World Travel and Tourism Council (WTTC), the tourism sector generates 14.8% of the gross domestic product (GDP) of the Caribbean region and employs 2.4 million people (15.5 % of total employment) (WTTC 2004). However, throughout the region, tourism's economic contribution varies with, for example, Antigua and Barbuda, the British Virgin Islands (BVI) and Anguilla each generating more than 70% of GDP and employment opportunities from tourism, compared to Puerto Rico, Haiti and Martinique each generating less than 10% of GDP and employment (WTTC 2004). Caribbean tourism, like many tropical island holiday destinations, is predominantly dependent on coastal attractions such as beaches and coral reefs (Lewsey et al. 2004; Uyarra et al. 2005). Pronounced dependence on these natural resources means that the Caribbean tourism industry, and especially islands such as Anguilla and BVI with economies almost entirely dependent on tourism, are likely to be particularly susceptible to climate change (Becken & Hay 2007; Mimura et al. 2007).

The impacts of climate change that are expected to be particularly important for the Caribbean include rising sea levels, changes in the frequency and intensity of hurricanes, elevated sea surface temperatures and changing rainfall patterns (Becken & Hay 2007; Mimura et al. 2007). Very few studies have specifically examined the direct effects these impacts could have on Caribbean tourism. Most notably, Uyarra et al. (2005) show that at least 80% of tourists visiting the Caribbean islands of Bonaire and Barbados would not return to these islands for the same holiday price if coral bleaching and reduced beach area occurred. The importance of Caribbean beaches was also demonstrated by Dharmaratne and Braithwaite (1998) who valued the Barbados coastline at US$13 million to the local economy, which indicates clear economic implications of beach loss resulting from sea-level rise. Changes in hurricane activity in the Caribbean Sea would also be highly significant for the Caribbean tourism industry (Becken & Hay 2007). There has, however, been little research to date that specifically investigates the effects of changing extreme events upon tourism (Bigano et al. 2005).

Since 1995, an increase in North Atlantic hurricane activity has led to ongoing debate on the relationship between increasing hurricane frequency and intensity, anthropogenic climate change and elevated sea surface temperatures (Goldenberg et al. 2001; Emanuel 2005; Trenberth 2005; Webster et al. 2005; Holland & Webster 2007). However, the vulnerability of the Caribbean region and its tourism industry to any increase in hurricane activity is unmistakable (Mimura et al. 2007). For example, the impact of hurricane Ivan on Grenada in 2004 resulted in the damage or loss of 90% of hotel rooms on the island and led to US$108 million of damage (Mimura et al. 2007). These losses accounted for 29% of Grenada's annual GDP (Becken & Hay 2007), and the impact of the same hurricane in the Cayman Islands led to economic damages estimated at 200% of GDP (Young 2005). Similarly, in Anguilla, hurricanes Luis (1995) and Lenny (1999) inflicted severe damage to the island's tourism industry (ECLAT 2000; Young 2005), with estimated industry losses after Lenny of US$26.3 million (ECLAT 2000).

In addition to the direct impacts of extreme events on tourist destinations, indirect impacts on tourist perception of the risk of extreme events can influence destination choice (Bigano et al. 2005; Gössling & Hall 2006) and the success of holiday regions may be highly dependent on these perceptions (Eitzinger & Wiedemann 2007). Little research exists regarding tourist perceptions to risk and extreme events in general (but see Prideaux et al. 2003; Meheux & Parker 2006; Eitzinger & Wiedemann

2007) and none to my knowledge specifically investigating the implications of increasing hurricane activity on tourism. The main objectives of this study were to 1) understand the socio-economic characteristics and holiday preferences of tourists to the Caribbean island of Anguilla, 2) investigate the influence of hurricane risk on tourist decision-making and holiday preferences, and 3) examine how these vary between different groups of tourists visiting the island. The results of this study should provide evidence of the repercussions that changes in hurricane activity may have for the Anguillan tourism industry, with implications for other comparable Caribbean holiday destinations.

METHODS

Study area

The study was carried out in Anguilla (18º 15’ N, 63º 10’ W), one of the islands of the Lesser Antilles chain in the Caribbean Sea. Anguilla has a land area of 91 km^2, a population of 13,900 and is one of the least densely populated islands (*c*. 153 people per km^2) in the region (CTO 2007). The topography is very flat and low-lying with the highest point 65 m above sea-level (Carty & Petty 2000). The island lies in the centre of the Atlantic hurricane belt and the regional hurricane season runs from June to November (Mukhida & Gumbs 2008). The island experiences a tropical storm or hurricane approximately once every three years (NOAA 2009), and over the last 50 years has been severely affected by three hurricanes; Donna in 1960, Luis in 1995 and Lenny in 1999 (Young 2005).

Tourism dominates Anguilla’s economy, generating 72% of the island’s GDP and 80% of total employment (WTTC 2004). Annual tourist arrivals to the island are approximately 78,000 (CTO 2007). The official tourist season runs from December to

April, with peak tourist arrivals during December, March and April. Tourist arrivals are generally lower throughout the June to November hurricane season (Figure 1), and decline most substantially from August to October (CTO 2009). Anguilla has developed as an upmarket tourist destination since the late 1970s, and the white sand beaches, described as some of the most pristine in the Caribbean mean that tourist activities are primarily beach-based (Carty & Petty 2000).

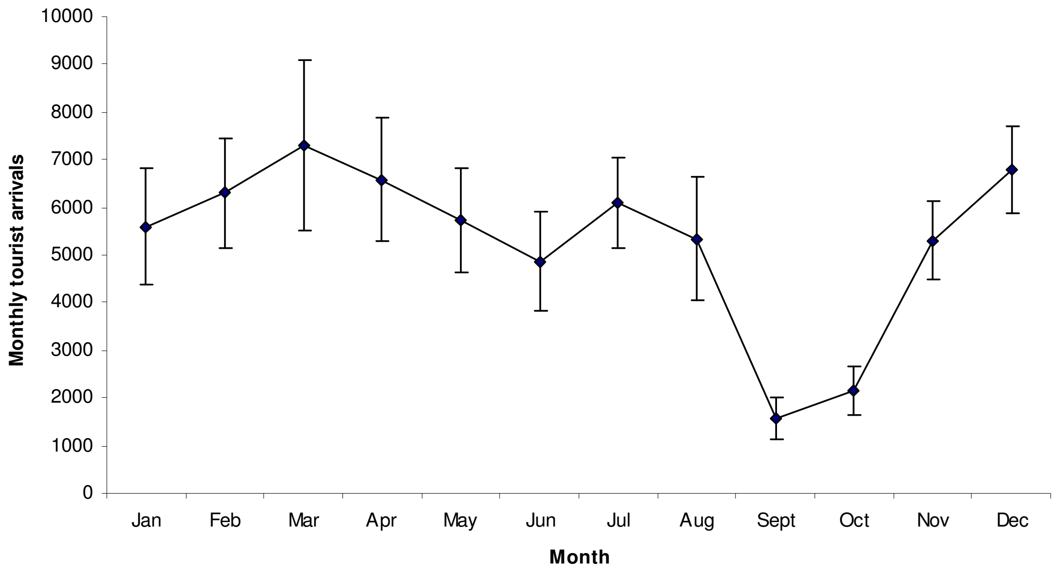

Figure 1. *Mean (± S.D.) monthly tourist arrivals for Anguilla from 2003 to 2008 (Data source; CTO 2009).*

Sampling and data collection

Questionnaires were completed with tourists visiting Anguilla between the peak holiday months of March and April in 2008. The study took place out of the hurricane season, but the demographic characteristics of tourists do not change appreciably throughout the year (Anguilla Tourist Board personal communication 2008), so these surveys should be representative of the whole tourist season. It is possible that tourists visiting Anguilla during the hurricane season may have different perceptions regarding hurricane risk. However, the numbers of tourists who visit during the hurricane months are far fewer compared with other times of the year, so their relative influence on the tourism industry is, therefore, likely to be less.

The questionnaires were carried out between 09.00 and 18.00 at three of the main beaches on the north, west and south coasts (Figure 2). Most hotels and guest houses are located on or near a beach, so survey locations were selected to represent the range of tourists visiting Anguilla, while also providing sufficient numbers of tourists to allow effective sampling; few people were encountered on four other major beaches away from the study beaches. The interviewer walked from one end of the beach to the other, approaching each person in turn, asking if they were on holiday and if they would participate in the survey. For groups of tourists, only one member of each group was surveyed. Beaches were visited between 6 and 21 times, with care being taken to survey people only once.

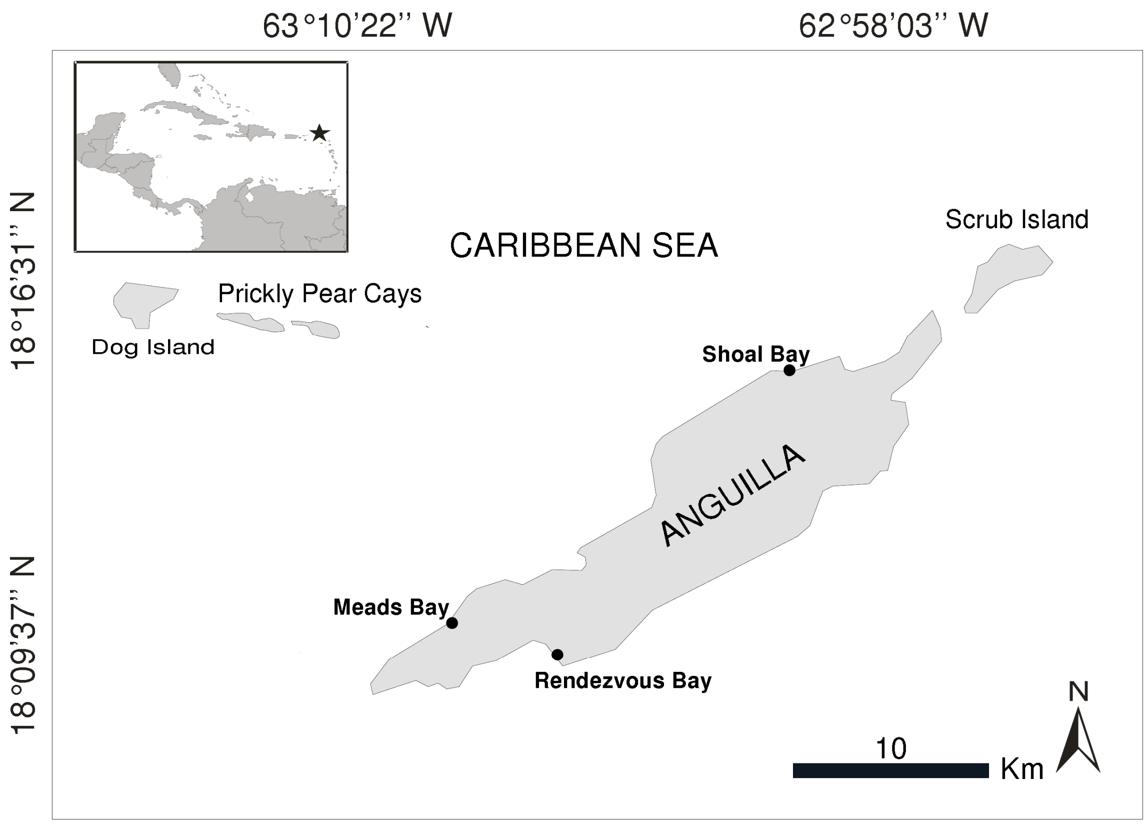

Figure 2. *Anguilla and its associated islands. The locations of the three study beaches are shown and the inset indicates the location of Anguilla within the Caribbean region.*

Questionnaire structure

The questionnaire consisted of four sections: a) questions to determine holiday information, attitudes and preferences; b) choice questions regarding hurricane risk; c) choice experiment follow-up questions; and d) demographic information (see Appendix C). For the purpose of this study, the term ‘hurricane’ hereafter refers to the risk of any category of hurricane (using the Saffir-Simpson scale) or tropical storm.

This chapter uses questions from section (a) that refer to the respondent’s stay in Anguilla (i.e. length of stay, seasonality of visit, reasons for visiting and place of stay), previous visits to Anguilla or other Caribbean islands, and their understanding of the hurricane season. The choice experiment (section (b) detailed below) was used to determine tourists’ perceptions of hurricane risk, and how this could affect holiday decision-making based on the relative importance of different hurricane risk attributes. Follow-up questions (section (c)) were used to explain further respondents’ perceptions and motivations. Finally, this chapter uses questions from section (d) to determine demographic information (i.e. age, nationality, gender, education, number of dependents, income) to relate to respondents’ choice experiment responses, and also to ensure the survey sample was representative.

The choice experiment method

Economists have developed a variety of techniques for estimating trade-offs between costs and benefits of environmental goods and services (Boxall et al. 1996; Bennett & Adamowicz 2001). One class of methods, known as ‘stated preference’ techniques, uses responses to questions regarding a person’s willingness to pay for hypothetical situations; the most commonly used method has been contingent valuation (Boxall et al. 1996). These methods, however, have been criticised because of the potential for respondents to intentionally misrepresent their preferences to influence the decision-making process in their favour. As a result, alternative stated preference techniques have developed, such as choice experiments (Bennett & Adamowicz 2001). Choice experiments attempt to reduce the incidence of inaccurate responses by providing respondents with multiple opportunities (called ‘choice sets’) to express their preferences (Hanley et al. 1998). Traditionally the choice experiment has been used for market research in tourism and transport economics (Hanley et al. 1998; Lindberg et al. 1999), and has gained prevalence in environmental resource valuation studies (Hanley et al. 1998; Bennett & Blamey 2001; Carlsson et al. 2003).

Choice experiments create a hypothetical situation in which respondents are asked to choose between different bundles of attributes and attribute levels. Usually one of these attributes is price (Hanley et al. 1998). If respondents choose a certain bundle of attributes, it is assumed they prefer the levels of attributes in that bundle over those of the alternative (Lindberg et al. 1999). The experimental aspect of this method is advantageous because it provides information on the willingness of respondents to make trade-offs between the individual attributes, and their likely responses to different situations (Boxall et al. 1996; Bennett & Blamey 2001). Because choice experiments provide a mechanism to assess preferences and trade-offs regarding environmental quality changes (Bennett & Adamowicz 2001), they are a useful tool for investigating tourist preferences relating to changes in the hurricane risk of a holiday destination.

The first steps when developing choice questions involve characterising the problem, then selecting appropriate attributes and levels. The two key variables that are used to describe hurricanes are their frequency and intensity (see Webster et al. 2005; IPCC 2007) and these variables are, therefore, used as the two hurricane attributes. The choice experiment also included a ‘cost’ attribute. Limiting the choice experiment to three attributes helped reduce the complexity of the experiment for the respondent. Although the scenarios presented in the choice experiment are hypothetical, attributes and levels must be meaningful and relevant for respondents (Bennett & Blamey 2001). For this purpose, a pilot survey was carried out with 50 respondents including 45 tourists and five key informants (three senior staff members from the Anguilla Department for Fisheries and Marine Resources (DFMR) and two experienced local fishermen) to gauge appropriate attribute levels and ensure the attributes and choice questions were meaningful and clear.

Choosing the attribute levels for the choice experiment

The 45 tourists were asked a series of questions to identify appropriate levels for the hurricane frequency and cost attributes (see Appendix C for pilot survey). Respondents were first asked to describe the likelihood of hurricane occurrence that would prevent them from coming on holiday (using a ratio scale in which a 1:100 risk equates to a hurricane being expected during one week for every 100 weeks visiting the same holiday destination). Respondents were then shown a series of cards with picture grids depicting likelihoods of hurricane occurrence ranging from 1:100, 5:100, 10:100, 15:100, 20:100, 30:100, 40:100 to 50:100 (see Appendix C). The cards were shuffled, shown separately to each respondent and for each card, respondents were asked if they would choose to come on holiday. The cards were shuffled again and respondents were asked to describe each picture in terms of the level of hurricane risk they perceive, using the scale: very low, low, medium, high or very high. Finally respondents were asked to estimate the price of their current holiday (per person/per week (pp/pw)). Information on gender, age and nationality was also collected from each respondent.

As the frequency of hurricane risk increased, the number of respondents who said they would not choose that holiday also increased. On average, hurricane frequencies of 1:100 and 5:100 were perceived ‘low risk’, 10:100 to 20:100 were ‘medium risk’ and 30:100 to 50:100 were ‘high risk’. At the 15:100 level almost half (44%) of respondents said they would choose not to come on holiday. However, for hurricane frequencies in excess of 10:100, the credibility of the experiment was increasingly questioned by respondents. Consequently, the levels selected for the questionnaire survey were 1:100 (which is closest to the current hurricane risk in Anguilla), 5:100 (between the upper and lower frequencies chosen) and 10:100 (the maximum risk many of the respondents considered meaningful).

The mean holiday price was US$2525 pp/pw (± 1142 SD) and holiday price ranged from US$500 to US$5000 pp/pw. The cost attribute levels were chosen to reflect this mean, maximum and minimum holiday price, in order to capture a realistic range of price reductions for the choice experiment. Thus, levels included a baseline, which was called ‘No change’ (i.e. current price), and then a range of reductions from the mean holiday price, including 10% (*c.* $250), 20% (*c.* $500), 50% (*c.* $1250) and 80% (*c.* $2000).

The ‘hurricane strength’ attribute levels were determined during the key informant interviews. These discussions helped identify the main holiday characteristics affected by a hurricane, including the number of beach/swimming days lost and whether other outdoor activities and/or flights from the island would be possible (Appendix C). The key respondents were then asked to indentify how a weak (tropical storm to category 1 hurricane), medium (category 2 – 3 hurricane), or strong (category 4 – 5 hurricane) might influence these key holiday characteristics.

The design and facilitation of the choice experiment

The choice experiment attributes and levels determined by the pilot survey are shown in Table 1. These were combined into 45 (3 x 3 x 5) different scenarios, one of which was the 'status quo' or current situation. These were presented as 45 'choice set' cards, each consisting of the 'status quo' option and one of the alternative scenarios. An example choice set is shown in Figure 3. A status quo situation is usually included in each choice set (Hanley et al. 2001) to determine whether respondents are willing to change from their current situation (Bennett & Adamowicz 2001). The status quo was always labelled 'Option A', and the alternatives were all labelled 'Option B'. For each choice set, respondents were asked to choose between the two options.

Table 1: *Holiday attributes and levels used in the choice experiment. The lowest levels for each attribute ('1 in 100', 'weak' strength, and 'no change' in holiday cost were combined to form the status quo 'Option A').*

Holiday attributes	**Levels**	**Additional level details**
Likelihood of hurricane	1 in 100 5 in 100 10 in 100	low chance medium chance high chance
Strength of hurricane	Weak	1-2 beach/swimming days lost Other outdoor activities possible Flights from the island
	Medium	3-4 beach/swimming days lost No other outdoor activities possible Flights from the island
	Strong	At least 7 beach/swimming days lost No other outdoor activities possible No flights from the island
Cost in US$ (pp/pw)	No change $250 less $500 less $1250 less $2000 less	

To make the experiment manageable for respondents, a blocked factorial design was used (Bennett & Adamowicz 2001) in which respondents were presented with a subset of nine of the 45 choice sets. To ensure each alternative was seen by the same number of respondents, the 45 choice set cards were shuffled and nine were used for the first respondent, the next nine for the second respondent and so on, until all cards had been viewed. The choice set cards were then re-shuffled and the process was repeated five times, resulting in a sample size of criteria for this method (Bennett & Adamowicz 2001; Hensher et al. 2007). One choice set had identical attribute levels for Option A and Option B; so this card was always excluded, and one in every five respondents was therefore shown eight cards.

Before beginning the choice experiment, respondents were provided with contextual information and an explanation of the attributes and levels (see Appendix C). Respondents were also taken though an example choice set (shown in Figure 3), given a clear description of Option A and what a possible alternative option might look like.

	Option A	**Option B**
Likelihood of hurricane	1 in 100 (low chance)	5 in 100 (medium chance)
Strength of hurricane **Beach/swimming days lost** **Other outdoor activities possible?** **Flights from island**	Weak 1 – 2 days Yes Yes	Weak 1 – 2 days Yes Yes
Change in holiday price (per person per week)	No change	$250 less

Figure 3. *An example of a choice set card that was presented to respondents during the survey. Option A and Option B indicate two different holiday alternatives and together they form a choice set. Respondents were asked to choose between Option A and Option B based on their respective hurricane and cost holiday attributes.*

The questionnaire and choice experiment was piloted using 30 respondents to ensure the survey was comprehensible to respondents and of acceptable length. In order to reduce the hypothetical nature of the experiment, the survey was carried out on beaches while respondents were experiencing their holiday (see Fish 2006). In addition, to remind respondents of the risks to which I am referring, respondents were asked to try and consider the following key points when they made their choices: that there is no risk to personal safety between options; that all other holiday characteristics remain the same between options; and to consider each option independently.

Statistical analyses

The choice experiment approach is typically described using random utility theory models, whereby an individual presented with a choice of goods will choose the one that has the greatest 'utility', or value to them (Boxall et al. 1996; Lindberg et al. 1999). In this study, respondents were asked to choose between the current situation Option A, and a hypothetical alternative Option B. The cost or benefit associated with each choice made by the respondent is considered to be incorporated into the value of each Option B alternative. Binary logit models may be used to estimate the associated value of the attributes of the two alternatives (Boxall et al. 1996); where the dependent variable (y) is explained as the choice between the alternative scenarios Option B (1), or the status quo Option A (0). The probability (P) of a respondent choosing Option B over Option A can be modelled as a function of the attributes making up Option B, and the coefficients (βx) indicate the relative influence of each attribute (x) on the likelihood that each alternative Option B scenario (i) is chosen. The residual variation in the model is described as (e), and the model can be expressed as:

$$\text{logit}\,(P) = y = \beta x_i + e_i \qquad (1)$$

However, each respondent was presented with a bundle of 9 (or in some cases 8) choice sets, so responses from each individual were not independent of one another. Multilevel logistic regression models were, therefore, used to investigate the choice response and between-individual variation. A two level hierarchical structure was used, with the random component split into two parts: variation at the level of choice (e_i), and at the level of the individual (u_j). This can be expressed as:

$$y_{ij} = \beta x_{ij} + u_j + e_{ij} \qquad (2)$$

The model was run using the multilevel modelling package MLwiN (Rabash et al. 2000) and included the three attributes (hurricane frequency, hurricane strength and cost of holiday). Twenty-three independent respondent variables (10 holiday attributes and 13 demographic characteristics (see Chapter 3 for analysis of demographic characteristics) were collected from the questionnaires. As many of these variables were correlated, a Principal Components Analysis (PCA, with Varimax rotation) was used to identify groups of individuals or preferences, and component scores were then used as predictor variables in the model.

The multi-level model was first run with data from all respondents, and then repeated with the respondents that always selected the status quo Option A excluded, because these respondents provide no information about changes in attribute levels (Fish 2006), and because the validity of their responses may be questionable. However, as there was no appreciable difference between the two models, I report only the initial model with a larger number of respondents. The Wald test statistic was used to calculate Chi-squared and p values to test the significance of each attribute level and PCA factor coefficient. Odds ratios were calculated from the exponentials of the coefficients, and used with p values to interpret the model results and response trends. The odds ratios identify the relative importance of each attribute (compared to its baseline level) in establishing whether the alternative Option B was chosen over Option A. Odds ratios >1 indicate an increased likelihood of the alternative Option B being chosen.

Whilst other studies have used choice experiment approaches to develop willingness-to-pay (WTP) estimates (e.g. see Hanley et al. 1998; Carlsson et al. 2003), the objective of this study was to explore tourists' perceptions of risk, and how these perceptions affect holiday decision-making. Thus WTP estimates were not calculated for this study, therefore only the odds ratios are presented in the results.

RESULTS

Characterising the tourists of Anguilla

A total of 300 tourists were surveyed in Anguilla during March and April 2008, which corresponded to a 96% response rate. The sample which was 56% female and predominantly American (78%) is likely to be representative of the whole tourist demographic in Anguilla. The modal age category was 45-54yrs, with 69% of respondents aged >45 yrs and 25% with dependents <16 yrs old. Respondents in full time employment represented 48% of the sample, while 24% were self-employed and 15% were retired. The majority of respondents (70%) had a university degree, 12% had a PhD/doctorate and 10% had a vocational qualification. The upmarket nature of this destination was highlighted by 38% of respondents stating an annual income of over US$100,000. Income was fairly evenly distributed among the other income brackets, although relatively few respondents (9%) earned less than US$40,000 per annum. The distribution of completed questionnaires around the island varied, with 75% of questionnaires completed on Shoal Bay. However only 36% of these respondents stayed in accommodation near or adjacent to Shoal Bay, which is indicative of this being the most popular beach in Anguilla (Mukhida & Gumbs 2008), attracting tourists from across the island as well as those staying in the vicinity.

Sixty-five percent of respondents were visiting Anguilla for a period of 7 to 14 days and the mean holiday length was 10 days (± 8.3 SD). The majority of respondents (61%) had visited Anguilla previously and the number of prior visits ranged from 1 to 40 (mean ± SD = 6.5 ± 5.8). Most visitors (86%) had also visited other Caribbean islands before. Respondents' previous visits to Anguilla were not evenly distributed throughout the year; most respondents chose to visit Anguilla in March (24%) and April (15%), and while 14% of respondents had previously visited Anguilla at some point during the six month hurricane season (June to November), only 3% had visited during the peak hurricane months of August and September.

The majority of respondents (80%) were aware of the hurricane season: of these 84% said hurricanes were most likely in September, 31% knew the season started in June and 42% knew it ended in November. Just 9% of respondents thought that the hurricane season fell outside of the June to November period. The hurricane season was considered by 40% of respondents when they made their current holiday reservation.

Respondents provided a variety of reasons for visiting Anguilla during March and April (Figure 4). The attractive Caribbean climate and the unfavourable climate in respondent home countries were ranked as the two most important reasons, followed by the low hurricane risk during March and April, holiday cost and the timing of work or school holidays.

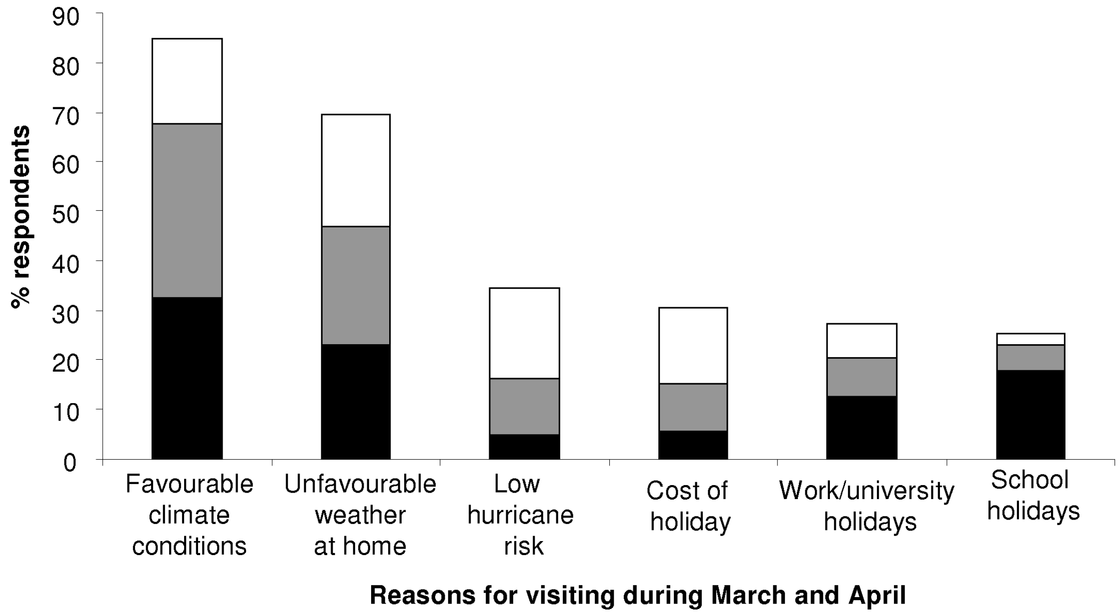

Figure 4. *Tourist reasons for visiting Anguilla during the survey period. Bars show the percentage of respondents ranking each factor first (black bars), second (grey bars) or third (white bars).*

Specific reasons for choosing Anguilla as a holiday destination are shown in Figure 5. Beach and beach activities were rated in the top five reasons for visiting Anguilla by 92% of respondents, and the climate and tranquillity of the island were rated in the top five by 88% and 84% of respondents, respectively (Figure 5).

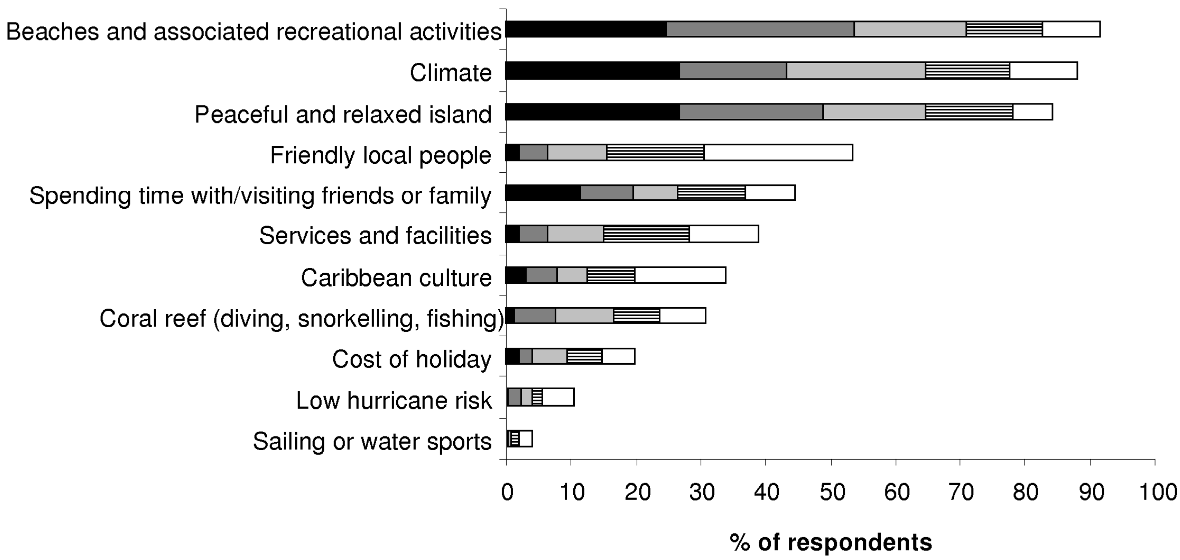

Figure 5. *Tourist reasons for choosing Anguilla as a holiday destination. Bars show the percentage of respondents ranking each factor in their top five reasons, ranked from first (black) to fifth (white).*

The PCA reduced the 10 holiday attributes to four factors, of which the positive factor scores broadly relate to people who like ‘beach activities’ (Factor 1), ‘eating seafood on holiday’ (Factor 2), ‘underwater activities’ (Factor 3), and ‘other water activities’ (Factor 4), and accounting for 18, 14, 13 and 13%, respectively, of the total variance (Table 2).

Table 2. *Principal component factors describing the people who holiday in Anguilla according to holiday activity groups. Factor descriptions relate to the positive factor scores. All factor loadings for each of the 10 holiday activity attributes are included, with loadings >0.4 highlighted in bold.*

	Principal components			
Holiday activities	**Factor 1** ***Typical beach activities***	**Factor 2** ***Eating seafood while on holiday***	**Factor 3** ***Underwater holiday activities***	**Factor 4** ***Other water activities***
Beach	**0.806**	-0.072	0.021	-0.150
Swim	**0.675**	-0.118	**0.451**	-0.057
Dive	-0.258	-0.004	**0.639**	0.196
Snorkel	0.177	0.073	**0.807**	-0.009
Fishing	-0.033	0.005	-0.012	**0.822**
Eat fish	0.134	**0.847**	-0.016	-0.049
Eat shellfish	-0.029	**0.782**	0.069	0.174
Sunbathe	**0.503**	0.199	-0.109	0.243
Water sports	0.133	0.112	0.165	**0.670**
Beach walking	**0.534**	0.117	-0.068	0.127

The 13 demographic characteristics were reduced by the PCA to six factors, of which the positive factor scores broadly relate to: ‘older, retired respondents, with no children at home’ (Factor 1), ‘Americans (not Europeans)’ (Factor 2), ‘highly educated respondents’ (Factor 3), ‘Canadians (not Americans), and ‘left education early’ (Factor 4), ‘part-time employment and with children’ (Factor 5), and ‘high income and with children’ (Factor 6). These factors accounted for 15, 14, 12, 12, 11, and 10%, respectively, of the variance (and are detailed in full in Chapter 3, Table 1). The variance between factors is however, relatively similar, indicting a certain level of homogeneity in the sample. This is indicative of Anguilla being predominately visited by older, wealthy, American tourists.

Multilevel models of tourist choice responses regarding the hurricane and cost attributes

All respondents (n = 300) answered the choice questions, providing 2640 responses for analysis (Table 3). The odds of choosing the alternative to the status quo, Option B, decreased significantly as both hurricane attributes increased. As the holiday price reduction increased, the odds of choosing Option B significantly increased. However, the model results show that a reduction in holiday price overrides the effect of both hurricane attributes on respondents' choice decisions, as even the lowest holiday price reduction has a greater impact on choice decisions ('$250 less' odds ratio = 61.50) relative to the hurricane attributes ('5 in 100 frequency' odds ratio = 0.17 and 'medium strength' = 0.10, Figure 5). Between individual respondents, the model also revealed a significant variation in choice decisions ($p < 0.0001$).

Table 3. *Results of a multi-level model of the probability of choosing each of the hurricane and cost attributes. The lowest level of each attribute is the baseline which the other attribute levels are compared.*

Attribute	Level	Odds ratio	95% confidence intervals Lower	Upper	df	*p* value
Likelihood of hurricane	1 in 100	1	-	-	-	-
	5 in 100	0.17	0.12	0.24	1	<0.0001
	10 in 100	0.05	0.04	0.08	1	<0.0001
Strength of hurricane	Weak	1	-	-	-	-
	Medium	0.10	0.07	0.14	1	<0.0001
	Strong	0.03	0.02	0.05	1	<0.0001
Cost in $	No change	1	-	-	-	-
	250 less	61.50	15.41	245.43	1	<0.0001
	500 less	160.29	40.09	640.98	1	<0.0001
	1250 less	324.73	81.05	1301.15	1	<0.0001
	2000 less	549.50	136.87	2206.14	1	<0.0001

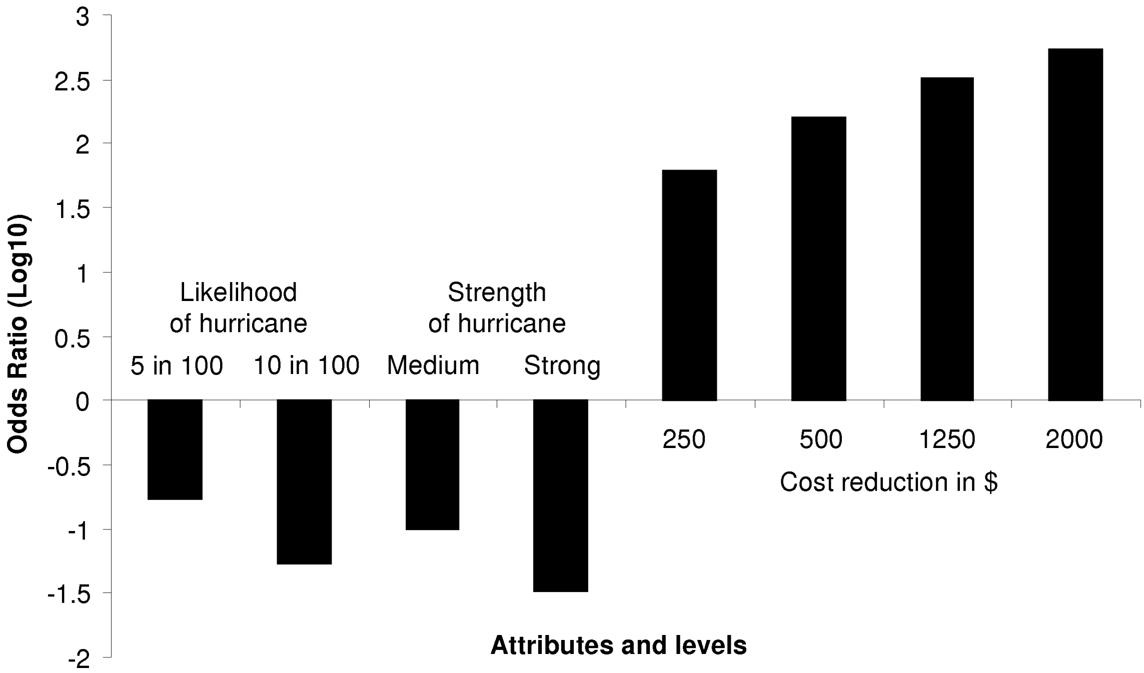

Figure 6. *Odds ratios for hurricane and cost attribute levels calculated from a multilevel model of the probability of choosing each attribute level. Bars depicting odds ratios >1 indicate an increase in the probability of Option B being chosen in preference to the status quo.*

The 10 PCA factors relating to holiday attributes (four factors) (Table 2) and demographic characteristics (six factors) (Table 1, Chapter 3) were included as predictor variables in the multilevel model (see Table 4). The probabilities of choosing each hurricane and cost attribute do not change appreciably between the model including the additional PCA factors in Table 4 and the original model (see Table 3). Three of the PCA factors were significantly associated with not choosing any given Option B alternative compared to Option A: respondents who enjoy typical beach activities while on holiday; retired, older respondents with no young children; and Americans.

Table 4. *Results of a multi-level model of the probability of choosing each of the hurricane and cost attributes, with PCA factors for holiday activities and demographic characteristics of tourists included as predictor variables. Factor descriptions relate to the positive factor scores. The lowest level of each attribute is the baseline to which the other attribute levels are compared. Significant PCA factors are highlighted in bold.*

Attribute	Level	Odds ratio	95% confidence intervals Lower	Upper	df	*p* value
Likelihood of hurricane	1 in 100	1	-	-	-	-
	5 in 100	0.17	0.12	0.25	1	<0.0001
	10 in 100	0.05	0.03	0.07	1	<0.0001
Strength of hurricane	Weak	1	-	-	-	-
	Medium	0.09	0.06	0.13	1	<0.0001
	Strong	0.03	0.02	0.05	1	<0.0001
Cost in $	No change	1	-	-	-	-
	250 less	58.67	14.40	239.13	1	<0.0001
	500 less	167.34	40.90	684.71	1	<0.0001
	1250 less	313.25	76.55	1281.77	1	<0.0001
	2000 less	504.21	122.73	2071.44	1	<0.0001
PCA factors						
Beach activities		0.72	0.56	0.92	-	**0.009**
Seafood on holiday		0.90	0.70	1.16	-	0.414
Underwater activities		0.92	0.71	1.18	-	0.497
Other water sports		1.08	0.85	1.36	-	0.528
Retired, older, no young children		0.73	0.57	0.95	-	**0.016**
Americans		0.74	0.58	0.93	-	**0.012**
Highly educated		0.85	0.66	1.08	-	0.178
Left education early		0.84	0.66	1.08	-	0.176
Part time employed with children		0.89	0.70	1.13	-	0.328
High income, with children		0.80	0.63	1.02	-	0.069

Influences on decision-making of respondents in terms of the hurricane and cost attributes

Of the 300 respondents who participated in the choice experiment, 82% (n = 247) opted for the alternative Option B at least once. The hurricane and cost attributes affected decision-making differently (see Table 5), with 255 respondents stating the hurricane attributes influenced their decisions and 212 respondents stating the cost attribute influenced their decisions during the choice experiment. However, 149 respondents said that they focused most strongly on the likelihood of hurricane, 111 focused most strongly on strength of hurricane and 31 respondents said their decision was influenced most by the cost attribute. People who always chose Option A show a similar trend, with greater numbers of respondents focusing on the likelihood of hurricane (n = 38) and strength of hurricane (n = 23) attributes, compared to the cost attribute (n = 2) (Table 5).

Table 5. *The influence of the hurricane and cost attributes on respondent decision-making, including the number of respondents that considered each attribute and how many focused strongly on each attribute. The numbers and percentages of respondents are included for (a) the total sample and (b) respondents that always chose Option A.*

Influence of attributes on respondent decision-making	(a) Total sample of respondents (n = 300)		(b) Only respondents that chose Option A (n = 53)	
Attribute considered	**Number**	**%**	**Number**	**%**
Likelihood of hurricane	255	85.6	48	90.6
Strength of hurricane	255	85.6	41	77.4
Cost	212	71.1	25	47.2
Attribute focused on strongly				
Likelihood of hurricane	149	50.3	38	71.7
Strength of hurricane	111	37.5	23	43.4
Cost	31	10.5	2	3.8

A range of factors influenced whether respondents chose Option B in preference to Option A; the ten most common are shown in Table 6. All respondents (n = 300) provided at least one reason that they felt influenced their decisions during the choice experiment. Of this total sample, the most common reason given by 44% of respondents was that good weather and being able to go to the beach are the most important elements for their holiday. Thus, an alternative holiday, Option B, which may jeopardise these holiday characteristics, would be less attractive. Personal safety, risk aversion, and being concerned about hurricanes were the next most common reasons that influenced respondents' choices. Only 4% of respondents explicitly stated that hurricanes did not concern them. On the other hand, comparatively few respondents (8%) stated that their decisions were predominantly influenced by cost, i.e. whether or not they would receive a price reduction for their holiday. Similarly, respondents who always chose the status quo, Option A, stated decisions were primarily based on concerns regarding hurricanes, safety, and the importance of good weather, rather than holiday price (see Table 6). These results help to contextualise the outcome of the choice experiment and show confidence in the results that respondents made decisions based on considered reasons.

Table 6. *The ten most common factors that influenced whether respondents chose the alternative Option B in preference to the status quo Option A, for (a) the total sample and (b) the sample of respondents who only chose Option A.*

	(a) Total sample of respondents (*n* = 300)		**(b) Only respondents that chose Option A (*n* = 53)**	
Factors influencing respondents' decision-making	**Number**	**%**	**Number**	**%**
Having good weather and beach days are most important for our holiday	133	44.3	16	30.2
Safety is important and I am risk averse	44	14.7	9	17.0
I am very worried about hurricanes	41	13.7	18	34.0
The trade-off between the likelihood of hurricane and cost	35	11.7	-	-
Cost was the main focus	24	8.0	-	-
The trade-off between strength of hurricane and cost	23	7.7	-	-
Money is not an issue/I would rather pay more and be sure of a good holiday	19	6.3	5	9.4
Not worried about hurricanes	13	4.3	-	-
The trade-off between all three attributes	8	2.7	1	1.9
I have experience of hurricanes and the impact it has on a holiday	7	2.3	3	5.7

DISCUSSION

Tourist characteristics

The results from this study suggest that the majority of tourists visiting Anguilla are American, older than 45 yrs, and with relatively high levels of education and income. The most important criteria for choosing Anguilla as a holiday destination are the beaches, the climate and the tranquillity of the island, consistent with the environmental features and upmarket tourism promoted on the island (Carty & Petty 2000; ATB 2009). Activities such as diving and fishing are however less important. The hurricane season was not the dominant reason for the seasonality of travel to this destination. However, the risks associated with hurricanes are clearly a contributing factor in the choice of holiday, as 40% of respondents considered the hurricane season when choosing Anguilla as a holiday destination. Given the predominance of American visitors to the island (CTO 2009), and the impact hurricanes have in the United States (NOAA 2009), awareness and concerns regarding hurricanes is not surprising.

Modelling tourist perceptions of changing risks of hurricane impact

The choice experiment indicates that respondents are progressively less likely to choose holiday options when the 'likelihood of a hurricane' or 'strength of hurricane' attributes increase. Although both factors are important, the likelihood of a hurricane attribute was more strongly associated with the choice to be made. Respondents were also highly price-responsive and progressively more likely to choose options with increased hurricane risk where monetary compensation increases from the status quo. Interestingly, only 30% of respondents mentioned cost as an influencing factor in decision-making (with just 8% stating cost as the main focus; Table 6). However, the multilevel model results (Tables 3 and 4) indicate that cost was by far the most important factor in determining whether respondents chose an Option B alternative in preference to the status quo Option A. The decision to choose alternative holiday options over the status quo option was also significantly influenced by respondents' characteristics. In particular, visitors in the 'retired, older and with no young children' category; American visitors; and people who enjoy beach activities while on holiday, were significantly less likely to choose any given alternative holiday option over the status quo.

Factors influencing holiday choice preferences

The probability associated with choosing each hurricane or cost attribute as determined by the multilevel models was not consistent with respondents' perceptions of the importance of each attribute in terms of personal decision-making. For example, models of choice experiment responses (Tables 3 and 4) show that a price reduction is more likely to influence respondents' decisions compared to either of the hurricane attributes. By comparison, the open-ended 'follow-up' questions which were used to further explain perceptions and motivations of respondents' decisions showed a different result. Answers to these questions indicated that respondents focused most strongly on the likelihood of hurricane attribute to determine whether or not to choose Option B in preference to Option A, followed by the strength of hurricane and cost attributes (Table 5). A common human preference for negative information, or a 'negativity bias' (Eitzinger & Wiedemann 2008) could help explain this result. By focusing on the hurricane attributes and associated negative consequences rather than the more positive cost attribute, respondents' explanations for their decision-making (see Table 6) support the theory that people typically have extreme aversions to loss and place greater weight on negative information (Eitzinger & Wiedemann 2008). Yet interestingly, despite respondents' reasoning for their decisions, it appears that respondents are in reality more responsive (perhaps subconsciously) to price than any of the factors on which they were questioned.

The factor analyses demonstrated that different types of tourist tend to exhibit differing holiday behaviours. Previous studies have shown tourist preferences and behaviours can vary significantly among demographic characteristics such as age, nationality, income, marital status and gender (for example Gibson & Yiannakis 2002; Lise & Tol 2002; Lepp & Gibson 2003; Simpson & Siguaw 2008; Hamilton et al. 2009), and particularly in relation to tourism-related risks (Gibson & Yiannakis 2002; Lepp & Gibson 2003; Simpson & Siguaw 2008). It has been suggested that learning theory may provide an explanation for certain differences in the way risk is perceived among different groups of people (Simpson & Siguaw 2008). For instance, risk-aversion among older people may differ from younger people, as a consequence of greater personal life experiences or through the experience of learning from others (Simpson & Siguaw 2008). The reduced likelihood of choosing any given alternative holiday option over the status quo by tourists from the 'older and retired' group, supports this theory, and is also consistent with the finding that a preference for tourism-related risk decreases with age (Gibson & Yiannakis 2002).

Specific holiday activities, environmental features and climatic conditions are significant factors in determining the attractiveness of a destination, and preferences relating to these holiday attributes may also relate to tourist demographics (Lise & Tol 2002; Uyarra et al. 2005; Hamilton et al. 2009). In this study, Americans and people who enjoy beach activities were less likely to choose alternative holiday options in place of the status quo, and thus appear to place greater emphasis on selecting hurricane-free holidays.

Implications of increased hurricane risk for tourism

This study suggests that, if hurricane activity on Anguilla increases, or is perceived to increase, many tourists may seek alternative holiday destinations. In addition, the types of tourist that would be less likely to visit if the current holiday conditions change (‘older, retired’, Americans, and ‘beach lovers’), represent the main tourist groups that currently holiday in Anguilla. As 61% of respondents in this study were repeat visitors, a change in tourist behaviour could be very significant for the island’s tourism industry.

It is difficult to predict changes in tourist behaviour accurately in response to environmental change (Lise & Tol 2002), or the impacts environmental change will have on the relative attractiveness of individual island destinations (Uyarra et al. 2005). However, tourists have been shown to change their behaviour if the climate or environmental attractiveness alters or if tourism-related risks increase. For example, arrivals to Grenada and the Cayman Islands fell by 4 and 35% respectively after hurricane Ivan in 2004. It is likely that other destinations in the region, unaffected by the hurricane benefitted from those more severely affected (Daye et al. 2008).

In response to a change in tourist demand, tour operators may also be able to switch products. However, suppliers of tourism services, or the owners of hotels or resorts are much less flexible (Lise & Tol 2002). The luxurious resorts that cater for the tourism industry in Anguilla target organised and independent mass tourists, who tend to be among the most risk-averse and therefore likely to change holiday plans if risk is perceived (Lepp & Gibson 2003). Thus, although tourists and tourist operators may be able to adapt their behaviour in the face of perceived risk and/or unfavourable environmental changes, the same may not be said for local tourist providers and local tourism economies (Lise & Tol 2002). This study has however revealed that if local tourist providers are able to reduce their cost, they may be able to adapt to increasing risk because tourists are highly receptive to price.

The use of market segmentation approaches to categorise tourists according to specific demographic, behavioural or psychological traits has frequently been employed to analyse tourist holiday preferences (see Hamilton et al. 2009). These findings have demonstrated that holiday preferences and risk perceptions vary among different tourist groups visiting Anguilla. For environmental change impact studies, an approach which segments tourists according to preferences can provide useful information on potential future changes in demand. These findings have highlighted which groups of people are most concerned about changing hurricane risk, and therefore which may be more likely to adapt their destination choice behaviour. The results have major implications for the tourism industry in Anguilla, and could be used by tourism planners to inform marketing strategies for specific groups of tourists.

In this study I considered only the influence that tourists' perceptions of increasing hurricane activity may have on holiday choice decisions. However, the direct impacts of extreme events, such as damage to key environmental features and infrastructure also affect tourism demand and capacity (ECLAT 2000; Birkland et al. 2006; Becken & Hay 2007). For example, infrastructure and property damage on Anguilla caused by hurricane Lenny in 1999 continued to constrain the tourism sector for up to two years after the hurricane impacted (ECLAT 2000). Additionally, whether tourists' decisions are affected by hurricane activity or any other environmental impact will also, in reality, depend on the alternative holiday options available.

Most tourists visit Anguilla outside of the hurricane season, which is certainly a significant advantage for the island. Anguilla's tourist demographic is also mainly interested in beaches, which have the potential to recover from extreme events naturally or with artificial beach nourishment (Browder 2002; Hayasaka et al. 2009; Houser & Hamilton 2009). Compared to tourism destinations fundamentally reliant on climate-sensitive ecosystems, such as the reef-based tourism island of Bonaire (Uyarra et al. 2005), Anguilla's tourism industry is perhaps relatively more resilient. Nevertheless, the response of the tourism industry to climate change impacts remains uncertain, and these results have shown increased hurricane activity could significantly affect tourist revenues and tourism economies on this island. For that reason, enhancing the island's socio-ecological resilience to future climate change is crucial (Adger et al. 2005; Hughes et al. 2005). Achieving this through effective environmental protection and management, together with sympathetic and sustainable development would help to protect key environmental resources and provide long-term economic benefits to the natural resource-dependent tourism industry.

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Chapter 5

Caribbean island marine-dependent livelihoods and resilience to environmental change

Conch diver, Sandy Ground, Anguilla

Chapter 5
Caribbean island marine-dependent livelihoods and resilience to environmental change

ABSTRACT

There is increasing concern over the consequences of environmental change for people and communities that depend on already fragile marine resources. With mounting evidence of the implications of sustained over-exploitation and climate change impacts on marine systems, the resilience of marine resource-dependent livelihoods to changing resource conditions could be critical. Using a local-scale livelihoods approach, this study explores the potential social resilience of marine-dependent livelihoods to environmental change. Using semi-structured interviews with fishers and marine-based tourism operators in the Caribbean island of Anguilla, I identify the impacts that previous hurricane events have had on marine livelihoods, the perceptions of resource-users and their potential adaptability to future change. In both sectors of resource-users, there is evidence of diversified livelihood strategies and financial stability, which may provide resilience to future impacts or resource variability. In addition, behavioural changes that were developed following previous hurricane events indicate flexibility to changing conditions. However, strong personal and cultural attachment to occupations, particularly among fishers, may hinder resilience. Additionally, the reliance by all of these marine resource-users on the climate-dependent tourism industry may undermine their capacity to cope with future environmental change. Many of these problems are common throughout the Caribbean, as thousands of marine-dependent livelihoods are vulnerable to marine degradation and climate change impacts. Urgent attention is therefore required to support the development of adaptive, sustainable management of marine resources that may enhance resilience to environmental change.

INTRODUCTION

Coastal communities throughout the developing world are recognised as being particularly vulnerable to environmental change (MEA 2005; Mimura et al. 2007; Allison et al. 2009). Many are dependent upon already depleted natural resources and degraded coastal systems, and may consequently be highly susceptible to changes in the condition of the natural resources upon which they rely (Thomas & Twyman 2005; Marshall 2010). In tropical regions, coastal ecosystems and communities may also be at risk from the impacts of natural phenomena such as earthquakes, tsunamis and hurricanes, with serious implications for human security and livelihood opportunities (Adger 1999; Pomeroy et al. 2006). In addition, there is recent growing evidence of global climate change effects on coastal resource-dependent communities; for example through impacts on fish stocks and fisheries (Allison et al. 2009; Dulvy & Allison 2009), increases in the frequency and severity of coral bleaching events (Wilkinson et al. 1999; McWilliams et al. 2005) and threats to coastal resources from sea-level rise (Mimura & Nunn 1998; Fish 2006). Consequently, there is considerable concern regarding the repercussions of global and local environmental change on coastal resource-dependent communities and industries (Badjeck et al. 2010; Marshall 2010).

Natural resource-dependency describes the direct association between the livelihoods of individuals, sectors or communities, and a natural resource and its local economy (Adger 2000). Close links between social and ecological systems, of which coastal resource-dependent users and industries are a prime example, can have major implications for managing and adapting to environmental change (Adger et al. 2005; Thomas & Twyman 2005). The ability of social-ecological systems to adapt to environmental and climatic change has gained recent prevalence, notably through the concept of 'resilience' (for example, see Adger 2003; Fraser et al. 2003; Hughes et al.

2005; Folke 2006). The resilience of social-ecological systems is identified by their ability to cope with external stresses and disturbances resulting from social, political, or environmental change (Gallopin 2006), and it is also considered a loose antonym for vulnerability (Adger 1999).

The resilience of many coastal communities largely depends on the flexibility of individual resource-users, or the 'social resilience' available to deal with and adapt to change or variability (Adger 2000; Marshall et al. 2007), as well as the ability of communities to act collectively (i.e. their 'social capital' see Adger 2003). The social resilience of individuals can be influenced by a series of key components, including individual perception of risk associated with change, ability to plan, learn and reorganise, and social, economic and environmental dependencies such as the level of attachment to specific occupations and places, employability, family characteristics and financial status (Marshall & Marshall 2007). For example, it has been suggested that individuals with few family responsibilities, more financial security, and weak attachment to a resource-dependent occupation, may be more able or willing to change occupation, hence increasing their resilience and reducing their vulnerability (Marshall et al. 2007). The existence of diverse livelihood systems has also been identified as an important component that can enhance individual and community adaptability to disturbance and change (Badjeck et al. 2010). Livelihood diversification can reduce the threat of livelihood failure in resource-dependent systems, by spreading risk across more than one source of income, and it may help to overcome variations associated with resource seasonality, market failures and uncertainties (Allison & Ellis 2001).

Several studies have investigated the vulnerability of coastal and marine resource-dependent communities and nations to climatic change (Thomas & Twyman 2005; McClanahan et al. 2008; Allison et al. 2009). However, until recently, the implications of climate variability on the lives and livelihoods of marine resource-users at local scales are less well explored (Badjeck et al. 2010). Investigations of local scale perceptions of environmental change on individuals have commonly used a livelihoods approach (see Allison & Ellis 2001; Badjeck et al. 2010). This approach focuses on local scale assets (land, stock, savings etc.), capabilities and activities of resource-dependent people, and assesses how different livelihood strategies can affect the ability of people or groups to withstand disturbance or change (Allison & Ellis 2001).

Here I apply a livelihoods approach to assess the resilience of marine and coastal resource-users to environmental change on the Caribbean island of Anguilla. I focus primarily on the effects of hurricanes, and the degradation of coral reefs from coral bleaching and over-exploitation, as the islands of the Caribbean are particularly at risk from these environmental stressors (see ECLAT 2000; McWilliams et al. 2005; Wilkinson & Souter 2008). The occurrence of hurricanes and coral bleaching is also expected to increase throughout the Caribbean due to changes in global climate conditions (Mimura et al. 2007), although specific changes in hurricane risk for the Caribbean are not yet fully understood (e.g. see Trenberth 2005; Webster et al. 2005). Nevertheless, hurricanes have a considerable impact on Caribbean islands (see Chapter 4; ECLAT 2000; Becken & Hay 2007) and the increasing prevalence of these extreme events is a major concern for the region. Similarly, the implications of increasing coral bleaching events are expected to be significant for the Caribbean marine environment (Hoegh-Guldberg 2004; McWilliams et al. 2005), and the communities and economies that depend on the coral reefs (Wilkinson 1996; Uyarra et al. 2005).

The aim of this study is to explore the social-resilience of marine resource-dependent livelihoods on the Caribbean island of Anguilla to environmental stressors by 1) identifying the characteristics of marine and coastal resource-dependent users and livelihoods in Anguilla, 2) assessing the impacts of previous hurricane events on these resource-dependent livelihoods, and 3) investigating resource-user perceptions of future environmental change on the resource and livelihood security.

METHODS

The study location

The study was undertaken in Anguilla, a small island in the Lesser Antilles chain in the Caribbean Sea (Figure 1). Like many islands in the Caribbean, the island of Anguilla depends heavily on its marine and coastal resources for fisheries and tourism (see Chapter 3).

Fishing in Anguilla is largely artisanal, and there are approximately 300 outboard-powered open-top fishing vessels, most of which are between 5 and 10 m in length (Mukhida & Gumbs 2008). The majority of fishers operate close to shore, but due to low inshore catch rates, many vessels have expanded their range to within an approximately 65 km radius of the island (Mukhida & Gumbs 2008). The inshore coral reef fishery principally targets fish (groupers (Serranidae), parrotfish (Scaridae), surgeonfish (Acanthuridae)) and lobsters (spiny lobster (*Panulirus argus*) and spotted spiny lobster (*P. guttatus*), known locally as crayfish; Abernethy et al. 2007).

Anguilla currently has five marine parks, with several other sites in the waters surrounding the island designated as no-anchoring zones. There are limited technical restrictions and regulations on the fishery, including a ban on taking egg-bearing lobsters, (*P. argus* and *P. guttatus*), a minimum size and weight restriction for *P. argus*, a minimum fish trap mesh size and a ban on the use of gillnets and poison for fishing. There are no no-take areas or closed fishing seasons (S. Wynne, personal communication 2010).

Tourism dominates Anguilla's economy and generates over 70% of the island's gross domestic product (GDP) and employment opportunities (WTTC 2004). The tourist season in Anguilla is highly seasonal; the official tourist season runs from December to April, with peak tourist arrivals during December, March and April. Tourist arrivals are generally lower throughout June to November, declining substantially from August to October (see Chapter 4, Figure 1).

Since the late 1970s, Anguilla has developed into an upmarket beach tourist destination, and is renowned for its pristine white sand beaches (Carty & Petty 2000). The rapidly expanding luxury tourism industry on the island has also created a growing demand for seafood products such as lobster and crayfish, in addition to the high demand for reef fish among the local population (Abernethy et al. 2007). As a result, the fishing industry has become an important contributor to the island's economy, currently employing an estimated 5% of the population (*c.* 400 individuals); although the majority of people employed in fishing work part-time (Mukhida & Gumbs 2008).

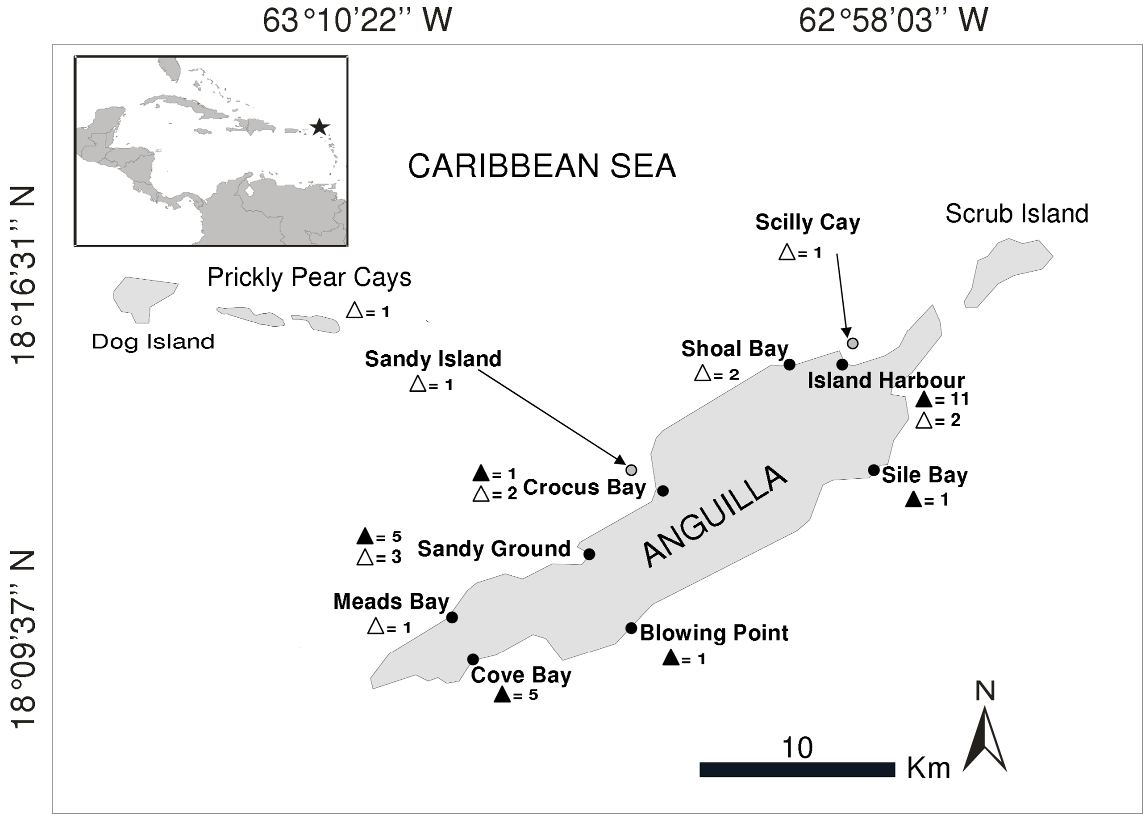

Figure 1. *Anguilla and its associated islands and cays. The location and names of the study sites are indicated, with the numbers of respondents (fishers (black triangle) and tourist operators (white triangle)) interviewed at each site. The inset shows the location of Anguilla within the Caribbean region.*

Interviews with marine resource-users

Fishers

Interviews were conducted between February and April 2008, with 24 fishers from six harbours (see Figure 1 for study sites, and Appendix D for respondent details and codes). Island Harbour, in the north of the island, is Anguilla's main fishing village (Mukhida & Gumbs 2008) and where most of the fishers on the island are based. Sandy Ground on the north coast and Cove Bay on the south coast are also relatively well-populated harbours. The fishers that were interviewed all relied on fishing the coral reefs for all or part of their income, targeting the inshore reef fishery for reef fish and/or shellfish using fish or lobster traps (hereafter called traps) and hand-lines. Respondents were chosen on the basis of recommendations from key informants (senior employees from the Anguilla Department for Fisheries and Marine Resources (DFMR), and experienced local fishers), and through snowball sampling (whereby respondents recommended further potential interviewees; Bunce et al. 2000).

Marine-based tourist operators

There are 13 marine-based tourism businesses (hereafter called ‘tourist operators’) on Anguilla; three dive shops, two glass-bottom boat companies, one beach equipment hire, four boat charter companies and three inshore tourist destinations with on-site restaurants (Sandy Island, Prickly Pear Cays, and Scilly Cay, see Figure 1). Interviews were conducted with all 13 proprietors of these businesses between February and April 2008.

Semi-structured interviews with fishers and tourist operators

Interviews with fishers and tourist operators consisted of a series of (a) structured closed questions to generate quantitative data on relevant background variables (gender, age, marital and family status, nationality, education), and (b) open-ended, semi-structured questions to provide qualitative information on fishing practices and livelihood strategies, aspirations, market-demand, and perceptions of marine ecosystem health and environmental change. Information on the impacts of previous hurricanes in Anguilla was gathered specifically as hurricanes are a particularly prevalent environmental stressor in the Caribbean. Fishers were also asked to indicate on maps (1:50,000 and 1:175,000 scale) of Anguilla where they fished (see Appendix D for full interview guides). Interviews were tape-recorded and transcribed verbatim.

Data analyses

Respondent responses to open-ended questions were manually coded and analysed using an 'open coding' method (see Bryman 2004), in which similarities and differences in responses to questions are assessed. Conceptually similar responses or opinions were grouped together into 'categories' which were defined using a common theme. This method ensures that the response themes directly reflect the issues that emerged from the interviews.

Triangulation was used to confirm or validate the results of interviews by cross-checking either particularly repeated (e.g. boat or engine size, target species) or unusual sources of information (e.g. extreme catch sizes) with other interviewees and key informants from the wider fishing and tourist community, and government officials from the DFMR. Interviewee responses were also cross-validated with personal observations (e.g. target species, boats and gear type) at the harbour and during fishing trips. These practices affirmed the accuracy of the interview data (Bunce et al. 2000).

Spearman rank correlations were used to explore relationships within specific measures of fishing effort (number of traps, weight of catch and fuel expenditure) for individual fishers. A measure of fisher effectiveness was also determined for each fisher (and calculated as gross profit per unit effort (PPUE) in \$US) for the period of time (between February and April 2008) that the survey took place. PPUE was determined separately for reef fish and lobster as market prices differ, and was calculated as:

$$\text{PPUE} = \frac{V - C}{T} \qquad (1)$$

where V is the catch value, using the market price per unit weight (kg) for the period the survey took place (depending on the species); C is the cost of the trip (fuel in

\$US); and T is the effort taken to check traps (number of traps x days per week needed to check traps). Fishers provided information on the time spent fishing and/or the number of traps they owned. The subsequent analyses used the total number of traps to calculate effort (T) because this figure was provided by all of the fishers, and it correlates well with time spent fishing (see Abernethy et al. 2007). Results are given for all 24 fishers, however where the denominator is smaller, this is due to missing data.

Seasonal variation in tourist demand was quantified for the tourist operators. Each tourist operator provided an estimate of tourist demand for each month of the year, in various units e.g. \$US or number of visitors. For individual respondents, tourism demand was standardised relative to the mean of all 12 months to give a relative monthly demand. This was then averaged across all 13 tourist operators.

RESULTS

Inshore fishers

Demographic characteristics

All of the 24 fishers interviewed were male Anguillian nationals, with all but one having lived in Anguilla for their entire life. The majority of respondents had left education after secondary school (67%, n = 14 (of 21)), with three completing high school and one holding a graduate qualification. Only three respondents stated they had left education after primary school. Most of the respondents were married (71%, n = 15 (of 21)) and of these the majority (93%) had children. In terms of these education and family status indicators, the respondents are typical of the male working population for the island (Government of Anguilla 2001a, b). In total, 81% (n = 17 (of 21)) of respondents stated that they were responsible for dependents (children or family members).

The average age of the fishers was 46 years (± 16 SD), with ages ranging between 19 and 70+ years. Most of the fishers were categorised in the 45-54 (n = 8) and 55-64 year groups (n = 4), with three fishers aged 65+ years. By comparison to the employed male population in Anguilla, these fishers are on average older, with 75% >35 years and 42% >50 years (the national census shows that 55% of working males on Anguilla are >35 years and 17% are >50 years (Government of Anguilla 2001c). Only six respondents were younger than 35 years. The majority of fishers started their fishing career in their late teens or straight after secondary school (mean age ± SD, 18 ± 6 years). Most respondents were from fishing families, following a hereditary occupation as demonstrated by 92% (n = 22) with grandfathers or fathers that fished before them. Eight respondents currently fished with family members (i.e. fathers, sons and/or brothers).

Fishing strategies

The majority of respondents (83%, n = 20) considered fishing to be their main occupation and source of income, although half subsidised their fishing with alternative employment, including construction work and private boat charters. Fishers were relatively similar in terms of their fishing strategies; 20 respondents (83%) targeted both fish and lobster (among these respondents, two also catch crayfish). Fewer (n = 4) respondents target single species, with two fishers targeting only fish and two targeting only lobster. In addition, 14 fishers stated they also use hand- or long-lines to target species such as red snapper (*Lutjanus campechanus*). The number of traps used, however, differed substantially among fishers. For the months that the survey took place, total traps per fisher ranged from 20 to 380 (mean ± SD, 82 ± 75), with the number of fish traps ranging from 13 to 120 (48 ± 59 traps), and lobster traps ranging from 8 to 300 (59 ± 65 traps). Average daily catch for all gear types (i.e. combining fish and lobster traps and hand-lining) was 72 kg/day (SD ± 37 kg/day). Daily catch for only fish traps was 60 kg/day (± 35 kg/day) and for lobster traps was 53 kg/day (± 36 kg/day). The number of traps was significantly related to the weight of catch (total combined catch $r_s = 0.66$, $p < 0.01$, $n = 22$; fish $r_s = 0.64$, $p < 0.01$, $n = 18$; lobster $r_s = 0.86$, $p < 0.001$, $n = 15$). Interviews revealed that, due to species-specific survival rates, fishers check their lobster traps once a week whereas fish traps are checked every 2-3 days.

Although based at different harbours (Figure 1), respondents were reasonably homogenous with regards to the inshore fishing grounds they target. The grounds to the north and west of Anguilla were targeted by all of the respondents for fish and lobster trap fishing, while the deeper fishing grounds along the north ‘Anguilla Bank’ is fished by fewer respondents ($n = 6$) using deep slope fish traps and line fishing for red snapper (Figure 2). Fishers typically fished across large areas, moving their traps across the inshore fishing ground throughout the year.

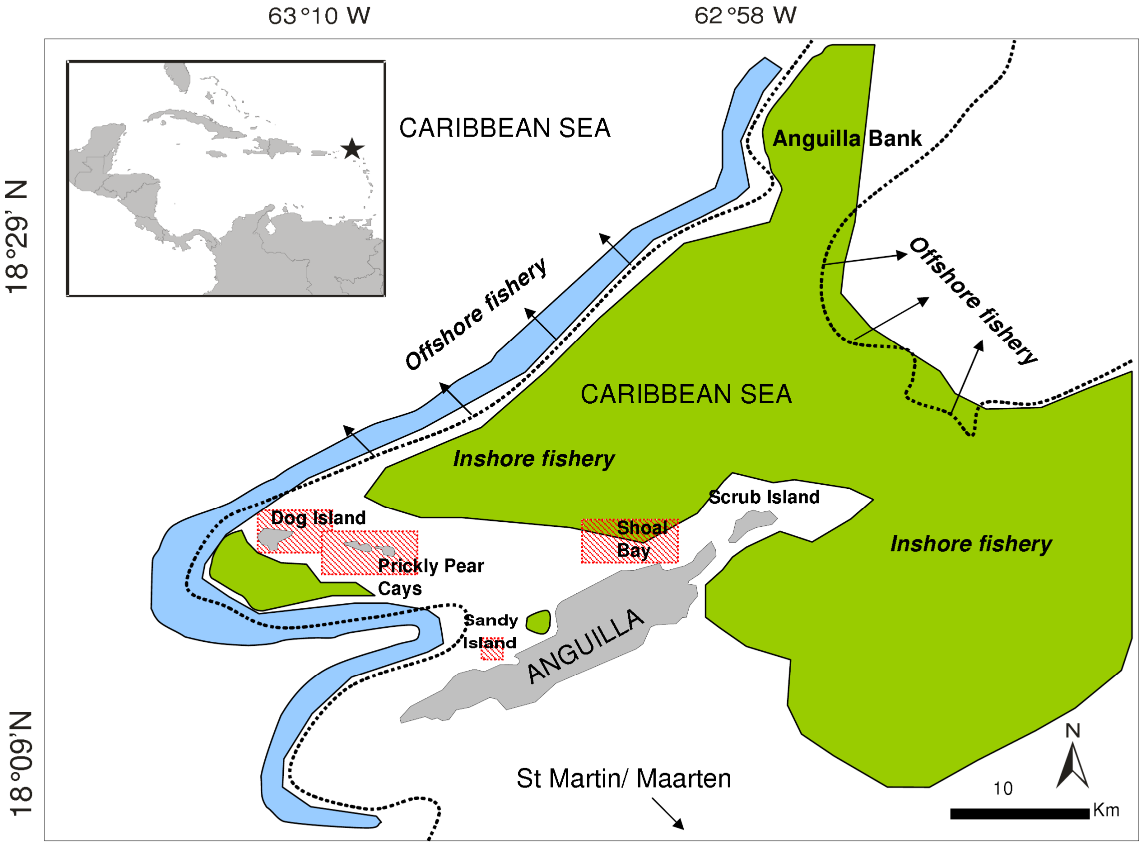

Figure 2. *Presence of fishing activity around Anguilla and associated islands as indicated by interviews with fishers. All inshore fishers targeting coral reef fish, crayfish and lobster (n = 24) fish within the inshore area (green). Fewer fishers (n = 6) fish along the deep slope bank (blue) or towards the offshore fishing areas. The island oceanic shelf is indicated by the dashed line and signifies the outer reaches of the inshore fishing grounds. The red boxes indicate the five marine parks. The inset indicates the location of Anguilla within the Caribbean region.*

Fishing costs, income and assets

Anguillian fishers accumulate many occupation-specific assets. For example, interviews revealed that the cost of typical fishing boats, excluding the outboard-motor(s) was *c.* 25,000 $US. All of the fishers stated that they fished using their own boat. These fishers all built their own traps, the cost of which was dependent on the materials used (e.g. quality of wire mesh). Respondents estimated however, that the cost of fish or lobster traps was between 135 and 225 $US per trap (excluding labour costs). Given the average total number of traps (mean ± SD, 82 ± 75), fishers therefore have between 11,020 $US (± 10,125 SD) and 18,450 $US (± 16, 875 SD) worth of traps.

After the initial costs incurred by building traps and boat acquisition, other running costs (e.g. bait, wages, general maintenance) were considered by respondents to be negligible compared to the cost of fuel. Weekly fuel expenditure ranged from 120 to 750 $US (mean ± SD, 382 ± 173 $US), which is symptomatic of the variation in the number of days respondents fished (between 1 and 6 days/wk, mean ± SD, 3 ± 1.4 days/wk). As expected weekly fuel expenditure was significantly associated with fishing days/wk ($r_s = 0.72$, $p < 0.001$, $n = 24$).

The standard market price of catches varied according to species. During the time of surveying, lobster market price (18.5 $US/kg) was higher than for reef fish (11 $US/kg), reflecting a demand for lobster by the luxury tourism industry, compared with the local demand for reef fish. All fishers ($n = 24$) commented that they could always sell their fish or lobster at any time of the year. The profitability of lobster varied according to season, with the price reducing by approximately half from the peak tourist season (November to April) to the off-peak tourist months. For this reason, and also because egg-bearing lobsters are present during the off-peak summer months, many fishers tend to switch to targeting only reef fish between May and November.

Using the above market prices, the estimated values of weekly catch per fisher at the time of sampling ranged from 600 to 3750 $US for reef fish (mean ± SD, 2116 ± 1023 $US) and from 298 to 2253 $US for lobster (1106 ± 584 $US). Fishers average weekly takings after fuel costs, ranged from 450 to 3150 $US for fish (1671 ± 730 $US) and from 210 to 1753 $US for lobster (836 ± 458 $US), highlighting the profitability of fishing in Anguilla. Respondent testimonies also emphasise this:

"Fishermen make a decent living…you can't miss on selling fish" (C1)

"…it's pretty profitable to do fishing" (IH5)

"You can get your loans paid, get your bills paid and save some [money]…[fishing is] still doing well". "If you can go out twice a week and you can catch 100 lb of lobsters, easy money. Some of the ministers, people employed as secretaries ain't get that kinda money" (CB5)

Fisher effectiveness

Fisher effectiveness (PPUE, $US/traps/week) varies between fishers, for both fish and lobster target species. However, the pattern for each catch species shows that a small number of fishers have relatively high PPUE, while the majority of fishers have similar, and lower levels of PPUE (Figure 3). The PPUE for lobster trap fishing was slightly higher than for fish trap fishing, though not significantly (mean ± SE, fish traps, 12.3 ± 1.6, 95% CIs = 8.8 – 15.8; lobster traps, 14.7 ± 2.4, 95% CIs = 9.6 – 19.8). The greater standard market price for lobsters and lower frequency with which lobster traps are checked might suggest that PPUE would be significantly higher for lobster traps than fish traps. In addition, because fishers commonly set fish and lobster traps in the same location to limit the distances they travel to haul traps, the fuel costs incurred for fish and lobster traps are likely to be similar within individual fishers.

However, lobster catch is highly variable according to season and this may affect the PPUE for fishers at certain times of the year. The PPUE values calculated here refer to the months of March and April. Anecdotal evidence collected during the interviews revealed that these months, known locally as 'lent season' are renowned for having low lobster catch rates. This may have influenced the PPUE calculation for these respondents. In addition, the variation in fishers PPUE may be influenced by additional factors that were not incorporated into this calculation, such as money invested into their fishing boats or supplementary equipment.

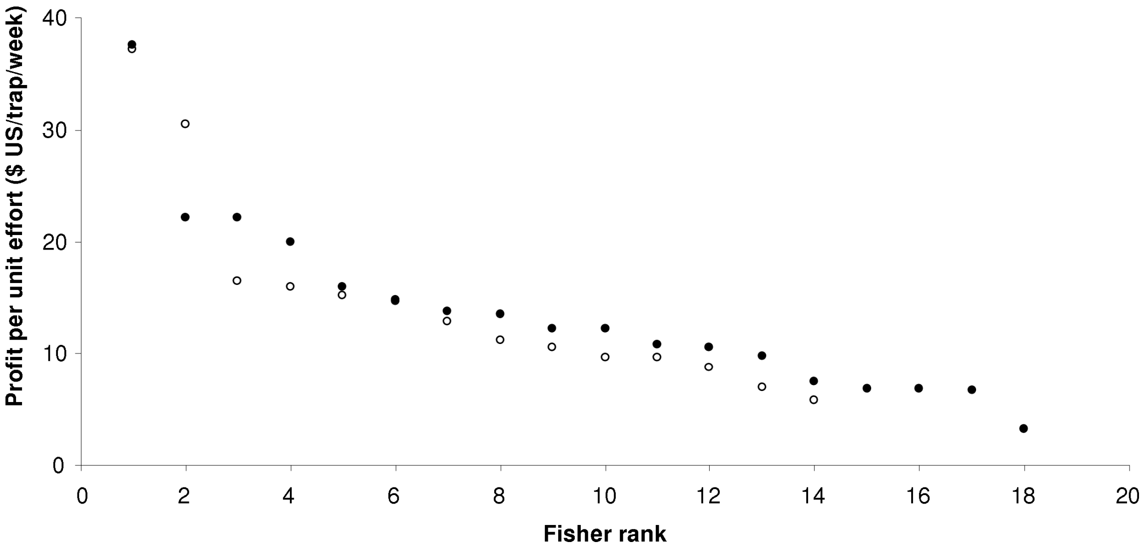

Figure 3. *Variation in profit per unit effort (PPUE, $US/trap/week) of individual fishers using fish traps (black dots, n = 18), and lobster traps (white dots, n = 14). Fishers are ranked in order of decreasing PPUE, and rankings for fish and lobster fishers are independent.*

Environmental change effects on fishers

Previous hurricane impacts on fishing livelihoods

The most recent hurricanes that severely impacted Anguilla are hurricanes Luis in 1995 and Lenny in 1999. Hurricane Lenny caused significant flooding and damage to land-based infrastructure, but less impact at sea or on the fishing community. Consequently, when recounting impacts suffered from hurricanes, respondents predominantly focused their responses to the effects of hurricane Luis (Table 1). The accuracy of these recollections may be enhanced by both the age of these fishers and that many were fishing during hurricane Luis, in addition to the general significance of hurricane Luis for the whole island.

Table 1. *Fisher response categories to the open question "If you were fishing during previous hurricanes did they affect your fishing?" All responses relate to the effects of hurricane Luis (1995) on Anguillian fishers and fishing. The number and percentage of respondents that mentioned each response is reported.*

Fisher responses	Number of responses	Percentage of responses
Lost fish and/or lobster traps	18	75
The hurricane changed fishing grounds, fish moved away	7	29
The hurricane destroyed fishing grounds and coral reefs	6	25
Many hotels shut or had no electricity for two months, they could not freeze fish, there was no demand for fish or lobster	3	12.5
The fishing industry took two years to fully recover	2	8
It took around two months to build traps and be able to go fishing	2	8
The hurricane caused damage to, or the loss of, fishing boats	2	8
Lost thousands of dollars in missed income	1	4
Hotels on the island took a year to return to pre-Luis state	1	4
Stopped fishing for a long time (three years)	1	4

The majority of respondents (75%) lost gear (fish and/or lobster traps) as a consequence of hurricane Luis, with losses per fisher ranging from 13 to 250 (mean ± SD, 86 ± 67) traps. Interviewee responses suggest that the entire Anguillian fishing community was affected by hurricane Luis:

"[Luis was] very bad, everyone lost their traps" (IH11)

"[Luis was a] big disaster to fishermen. I found one pot [trap] after Luis. I had over 100 pots in the water at that time, fish pots and lobster pots. I saved that one" (CB5)

Two fishers mentioned that the traps they found after Luis had passed the island were filled with lobsters, possibly taking refuge. However, because many of the hotels were damaged or shut, or with no electricity (to freeze the lobsters), there was no demand for their catch. The combination of lost gear and the impact of the hurricane on hotels meant that fishers were unable to fish for at least two months (Table 1), although one fisher stated he did not return to fishing for approximately three years. Respondents stated that the Anguilla government provided some financial assistance to the fishing community by giving each fisher three traps to re-start fishing, and offering subsidies on wire mesh and buoys to help fishers rebuild their traps.

In addition to the substantial financial impacts accrued, six respondents stated that the fishing grounds had been altered by the hurricane. Another six respondents mentioned that the fishing grounds had been completely destroyed. Testimonies from several respondents describe some of these impacts:

"[Luis] messed up the bottom of the ocean, put sand in areas we go fishing where there wasn't any sand. After Luis we'd go up to places we used to put our traps and they were covered with sand. After a couple of years they start cleaning out…and the lobsters were able to come back out of the deep and go in the holes" (IH5)

"When I dived after hurricane Luis it [coral reef] was terrible…it was like a desert, it totally destroyed the [sea] feathers and all the spiny little corals" (SG1, diving for conch at the time)

"The hurricane damaged the ground plenty. It killed a lot of fish. It broke down a lot of the havens where the fish live. You don't find any fish schooling around there no more because there's no reef" (CB5)

All respondents continued to fish after the devastation of this hurricane, even though some took several years to return to fishing. Only two respondents mentioned that they knew of fishers who left the fishery, but in both instances this was unrelated to hurricane Luis. It would appear that despite the destruction of the hurricane, fishing remained a viable occupation, and the profitability of fishing in Anguilla will likely have influenced the decision of these fishers to continue fishing.

The personal and cultural ties that fishers have with their occupation, hereafter termed 'fisher ethic' may provide an additional explanation for why fishers continued to fish after the impact of hurricane Luis. When asked why they fished, 63% (n = 15) of respondents stated their motive was because of an ingrained cultural or personal desire to fish. These respondents had a strong 'fisher ethic'. By comparison, fewer respondents (33%, n = 8) mentioned the financial motivation. Examples of respondent responses illustrating 'fisher ethic' are shown in Table 2.

Table 2. *Fisher responses to the open question "Why do you fish?" Fifteen fishers stated their motive was related to the desire to fish rather than purely financial reward. These respondents had a strong 'fisher ethic'. Selected examples of these responses are shown.*

Selected examples of respondent responses
"I grew up around the sea, it's something I like and I'm good at it" (IH1)
"The sea is where I should be…we love it, if we don't fish we don't feel right" (IH7)
"When you fish you don't have no boss" (IH4)
"I kind of feel its [fishing] in my blood. I was drawn to fishing from very young. Right out of school I just wanted to do fishing for the rest of my life" (IH10)
"I took up fishing because I am from this area, born in Island Harbour" (IH2)
"I just love it. I grew up around guys that do fishing, my father also" (S1)
"I fish because I love it…[and] I can make enough money" (CB1)
"Fishing is great. Fishing is beautiful. I love fishing. And not only fishing, I love the fact of being on the sea. I could go on the ocean, sit down fishing, not catching anything and I feel good" (SG5)
"I've been fishing ever since I've been born…grew up with my father fishing, I just continued as a little boy doing the same thing" (BP1)

Longer term implications of hurricane Luis

The impact of hurricane Luis manifested in seasonal changes in the fishing practices on Anguilla. As a direct response to the losses sustained by the fishing community from this hurricane, fishers have developed more risk-averse fishing practices (Table 3).

Before hurricane Luis, fishers did not bring their traps inshore during the hurricane season. However, the majority of fishers (n = 16) now bring some or all of their traps inland or inshore at the start of the hurricane season, although specific strategies vary among individuals. A few fishers (n = 2) also adjust their traps by adding different buoys or rope to increase trap robustness to storm impact. Only three respondents stated that they have not changed their fishing practices, and continue to leave their traps in the fishing grounds regardless of hurricane risk.

Table 3. *Fishers' responses to the June-November hurricane season. The number and percentage of respondents that mentioned each response is reported.*

Fisher response categories	Number of responses	Percentage of responses
Bring all traps inland at the start of the hurricane season (because of the risk of the hurricane season and the off-peak tourist season means there is no-demand; a good time to rest the fishing grounds)	8	33
Switch traps from lobster to reef fish, less money but this way I can fish all year round	5	21
Stop fishing for lobster April/May because of lobster spawning season. Take lobster traps out of the water but do not switch them to reef traps.	3	12.5
Leave the traps out regardless of hurricane forecast/they are too far and it is too much effort to bring them in	3	12.5
Bring in traps closer/leave them in the inshore reef (which is safer)	3	12.5
Continue fishing for reef fish as normal, but fit traps with smaller buoys and longer rope (less drag/damage if there is a hurricane)	2	8
Stop fishing during the hurricane season, rely on alternative income	2	8
Bring some traps in and leave some out	2	8
Switch from inshore reef fishing to offshore hand-line fishing	1	4
Only bring in traps if I hear that a hurricane is coming	1	4
During hurricane season I fish less but prepare for these months by saving more and spending less	1	4

Fishers' perceptions of future environmental change

Considering the impacts of previous hurricanes on the fishing community in Anguilla, fishers were understandably concerned about future hurricane impacts. When asked how they would feel if hurricane risk increased, 12 respondents stated that they would be very concerned. Five of these respondents stated that they would be concerned about the impact specifically on their fishing. For example, two Island Harbour respondents said that they would have to *"…look for something else to do"* (IH4) and *"…[if] you can't go out [fishing], you can't go out to sea, you feel lost"* (IH7). Perceptions relating to broader implications of environmental change elicited fewer responses (n = 7), including specific concerns about coral bleaching (n = 2), sea-level rise (n = 1), longer lasting hurricanes (n = 1) and increases in sea temperature affecting fish movement (n = 1).

With regards to environmental changes in the fishery, of greatest concern to these respondents were the changes in fish abundance. The majority of respondents considered that at present there are fewer fish (n = 16) and smaller fish (n = 6) than there were 20 years ago, particularly reef fish species such as groupers and parrot fish. Responses related the changes in fish abundance to an increase in the number of fishers (n = 7) and irresponsible fishing practices (n = 3), such as 'ghost fishing' from abandoned traps. One respondent perceived the problem of overfishing to be caused by the number of traps in use, rather than the number of fishers; while another stated that modern fishing gear has increased the effectiveness of fishing in Anguilla. As a result, some respondents wanted to see changes to current fishery regulations, through implementing seasonal bans (n = 5), no-take areas (n = 1) and a ban on spear-fishing (n = 1). One respondent disagreed vehemently with the concept of fishery restrictions.

Marine-based tourist operators

Demographic characteristics

There was greater demographic variation among the 13 tourist operators in comparison to the fisher group. While most (n = 10) of the tourist operators were male, there were also three women running marine-dependent tourist businesses. The majority of respondents in this group were Anguillian nationals (n = 11) but two were European. Under half of the respondents were married (38 %, n = 5), and slightly more had children (46%, n = 6). More respondents in this group had achieved a higher level of education, with three having been to university. The most common age category for these respondents was the 35 – 44 year group (n = 7). Two respondents were younger than this modal age category, while four were older (n = 1 in the 45-54 year and n = 3 in the 55 – 64 year group).

Livelihood strategies of tourist operators

The majority of tourist operators owned their business (n = 10), while the remaining three businesses were family-run enterprises. Respondents had worked in these businesses for between 1.5 to 27 years (mean ± SD, 8 ± 7 years), and employed between one and eight people in their businesses (7 ± 3 employees), with 85% of employees being Anguillian nationals.

Almost all respondents (n = 10) stated that their tourism business was their only or main source of employment. Five respondents had additional sources of income e.g. fishing, commercial diving, restaurant work (although this was predominantly during the off-peak tourist season, see below). There was general agreement among respondents (n = 10) that there were other viable employment opportunities in Anguilla if necessary, although one respondent stated there was *"nothing else I want to do"* (T1).

Seasonal variation in tourist demand

During the tourist season (December to April), the average number of days respondents work for their businesses is 5.5 days/wk (± 1 SD). For the off-season months when businesses are still open (May to July), the average number of days respondents work decreases slightly (4 ± 3 days/wk). Tourist demand in Anguilla is strongly seasonal, with a sharp decline during the off-season summer months (August to November). Figure 4 highlights the seasonality in demand, determined by the tourism revenue or tourist numbers of each of the 13 tourist operators.

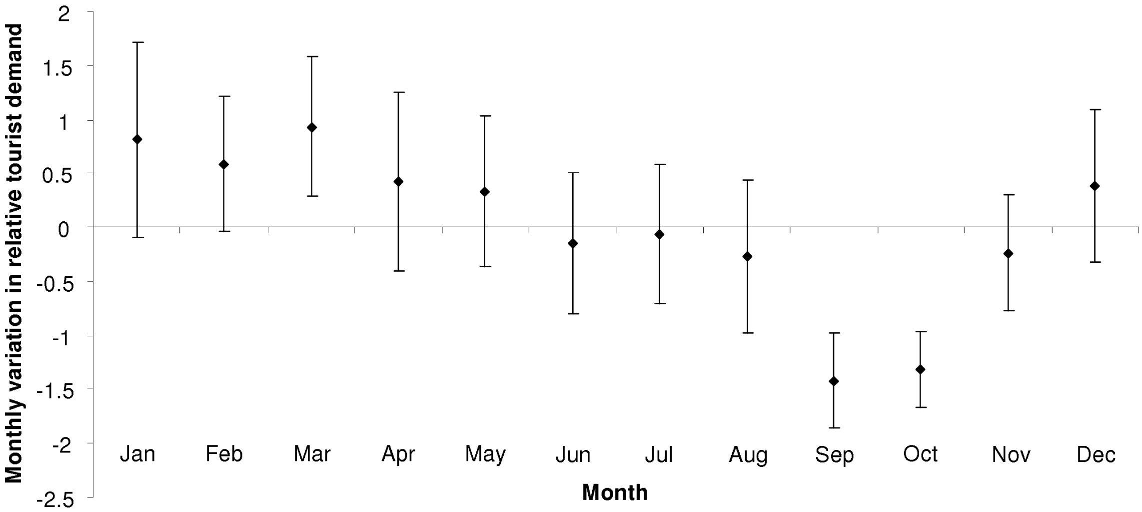

Figure 4. *Monthly relative tourist demand for all (n = 13) marine-based tourist operators in Anguilla. Bars show ± 1SD.*

The seasonality of the tourist industry affects many of the tourist operators' livelihoods (Table 4). Interviews revealed that due to the combination of low tourist numbers and increased hurricane risk, most businesses close between August and October (n = 9, 69%), and only three remain open (one glass-bottom boat, the beach equipment hire and Prickly Pear Cay). Interviews did not uncover a particular reason why these three businesses remain open, although they are clearly able to rely on local demand. Of the businesses that close, four respondents stated they take alternative seasonal employment during the off-peak season, or are able to rely on financial contributions from other family members.

The majority of respondents (n = 11, 85%) considered that the hurricane season (June to November) affects tourism in Anguilla to some degree. Two respondents stated that the hurricane season did not affect tourism, with one adding that the seasonality in tourism is principally driven by the lack of demand from American tourists who stay in the USA during their warmer summer months.

Table 4. *Tourist operator responses to the open question "Do you think that the hurricane season affects tourism, and if so how? The number and percentage of respondents that mentioned each response is reported.*

Tourist operator responses	Number of responses	Percentage of responses
Tourists are scared of hurricanes and avoid coming on holiday in the hurricane season	5	38
Hurricanes damage our beaches and tourism infrastructure	4	31
If a hurricane is forecast then tourists do not want to come here, or they cannot travel	4	31
After a hurricane, tourist arrivals decline	3	23
Hurricane season does not affect tourist demand, instead the summer tourist market changes with Americans staying in the USA.	2	15
If a hurricane impacts Anguilla and tourists are here, they cannot go to the beaches and so they will not return here again on holiday	1	8
The weather generally is not very good in the summer, as it is very hot and it rains more	1	8

Environmental change effects on tourist operators

Previous hurricane impacts on marine tourism livelihoods

Many of the tourist operators on the island were also severely affected by hurricane Luis in 1995 (Table 5) although unlike the fishers, more of these respondents were younger and so may have relied to an extent on family-member's recollections of this extreme event. Five of the respondents' businesses suffered financial losses, both from direct damages and loss of earnings. As these marine tourist businesses vary substantially in terms of their infrastructure and assets, so too did their financial losses. For example, the direct impacts of the hurricane on Anguilla's surrounding islands and cays caused severe losses to Scilly Cay restaurant (estimated at 1 million $US in damages and 500,000 $US in lost earnings) and Prickly Pear Cay restaurant (estimated as 20,000 $US in damages and more from loss of earnings) by their respective owners. Major losses were also sustained by the owners of Sandy Island, which was completely washed away by the hurricane. It has since taken a decade to rebuild Sandy Island and was described by its owner as Anguilla's *"poster child for vulnerability"* (T12). Other tourist businesses *(n* = 5) suffered more from the decline in numbers of tourists visiting Anguilla in the months and years following the hurricane. None of the respondents indicated that the damages caused their businesses to close permanently and, despite sustaining financial losses, these businesses have since been able to rebuild.

Table 5. *Tourist operator responses to the open question "Did hurricane Luis (1995) affect your business?" All responses are included, and the number and percentage of respondents that mentioned each is reported.*

Tourist operator responses	Number of responses	Percentage of responses
My business sustained financial losses from direct damages and loss of earnings	5	38
There was a decline in the number of tourists of between six months and two years, causing loss of earnings	5	38
Damage to the beaches and coral reefs	5	38
My business was unaffected by the hurricane	3	23
I was not working in my current business at that time	3	23
We had no electricity for two months	2	15
I had to rely on alternative sources of income	2	15
All of the hotels were shut	1	8

Tourist operators' perceptions of environmental change

Many respondents (n = 8) stated they would be concerned if hurricane risk increased, because of the implications of the hurricane season on tourism and the impacts sustained from hurricane Luis. Only two respondents said that they were not worried about hurricane risk. Testimonies from several respondents describe common concerns:

"If we have damage to the island, we can't host tourism" (T5)

"[if hurricane risk increased] our business would get hit very hard, [it] takes a long time to get tourists back, lots of tourists are not going to come back" (T7)

"It [increasing hurricane risk] would be disastrous for the island in terms of tourism and business, it will affect everyone and everything. Recovery takes a while" (T13)

Like the fishers, perceptions regarding climate change elicited relatively few responses (n = 5) from the tourist operators (Table 6). The climate change related threats that were of concern included increasing water temperature and coral bleaching (n = 2), changing weather and tide patterns (n = 2) and the increasing risk of hurricanes (n = 1). When the tourist operators were asked specifically for their perceptions on the condition of the coral reef ecosystems, seven respondents stated that they had witnessed changes in the state of the reefs during their lifetime.

Table 6. *Tourist operator response categories to the open question "What do you feel are the causes of change to the coral reefs?" All responses are included, and the number and percentage of respondents that mentioned each is reported.*

Tourist operator response categories	Number of responses	Percentage of responses
Hurricane and storm damage	10	77
Overfishing/irresponsible fishing and no fisheries enforcement, we are seeing fewer and smaller fish and lobsters	8	62
Damage to coral from divers/snorkelers/spear-fishing	5	38
Warmer sea temperatures causing coral bleaching	3	23
More algae on the coral reef	1	8
Anchor damage	1	8
Pollution e.g. suntan lotion and diesel from boats	1	8

Hurricane and storm damage was mentioned by most respondents (n = 10) as the primary cause of coral reef decline in Anguilla. The second most commonly mentioned stressor was fishing (n = 8), and respondents spoke of the combination of too many fishers, irresponsible fishing practices and a lack of enforcement leading to major declines in fish and shellfish abundance, with knock-on implications for the coral reef.

"Nature [hurricanes] takes its course, we can't stop this, but fishermen are the main concern affecting the reefs… [Fishing] traps are more of a problem than hurricanes if you want tourism, [for example] the coral and beaches that bring tourists to the island" (T7)

"[Coral reefs are in] serious need of some help. It is not pretty, vibrant, full of life like before. Hurricanes destroyed the most of it, but if there was a lot of fish left to clean and do the work of nature it would recover. Ignorance of the young [fishers], overfishing is the biggest problem… if the fish were still there things would change" (T8).

Increased prevalence of coral bleaching was a concern of some tourist operators (*n* = 3), with one respondent stating that *"elkhorn [coral] used to be so nice and pretty, [the] nice colours have gone. Coral has started to lose its nice pattern"*(T7). Additional changes to the coral reefs were also mentioned by individual respondents, including the growing prevalence of algae, damage caused to reefs by boat anchors and marine-based pollution. The majority of respondents (*n* = 11, 85%) agreed that coral reef condition affects their business, because unhealthy coral reefs mean there are fewer fish, and their client-base wishes to see fish and coral. Several respondents also referred to tourist demand for seafood, and that coral reef condition affects this aspect of the tourism market:

"If the reef is damaged there is nowhere to take the tourists. Also the fishermen don't catch much crayfish or lobster" (T2)

"Crayfish is such a big deal with hotels" (T8).

"If there are lots of fish then divers come back. If the reef is all dead then divers don't come back" (T3)

"They [tourists] love to see pretty corals and plentiful fish on the reefs, that's why they come [to Anguilla]" (T13).

One dive business owner commented, however, that because Anguilla was not a 'dive destination' the health of the reef did not affect his business significantly, although it limits the chance of Anguilla attracting more dive tourism.

DISCUSSION

The island of Anguilla is heavily dependent on tourism and fisheries for livelihood opportunities. However, like many Caribbean islands, marine-dependent livelihoods on Anguilla are particularly susceptible to impacts on the marine environment from hurricanes, and the degradation of marine resources from over-exploitation and coral bleaching (Spalding 2004; Wilkinson & Souter 2008). Previous hurricane events on Anguilla, in particular hurricane Luis in 1995 which represents the most significant environmental disaster in living memory, have demonstrated the vulnerability of these livelihoods to a variety of impacts, including the loss of fishing gear and damage to business infrastructure, reduced catch rates, and a decreased demand for seafood. Therefore, expected increases in hurricane risk and coral bleaching events due to changing global climate conditions which will cause further degradation of the marine environment, are likely to have major consequences for marine-resource livelihoods. The extent to which fishers and marine tourist operators responded to the impacts brought by hurricane Luis on Anguilla may have implications for their potential resilience to future changes in the marine environment.

Environmental threats to marine-dependent livelihoods

Hurricanes represent the most severe environmental threat affecting marine resource-users in Anguilla, causing both short- and long-term impacts. Immediate effects from hurricane Luis in 1995 included damage to fishing gear and boats, reducing the ability of fishers' to catch fish, and damages to business infrastructure and the decline in tourist arrivals causing major financial losses for tourist operators. In addition, the market-demand for seafood from hotels and restaurants was also significantly reduced, resulting in fishers being unable to sell what little catch they had. Both groups of marine-resource users are also vulnerable to the longer-term environmental impacts of hurricane events, in particular the destruction of coral reefs and fishing grounds, and associated changes in fish abundance.

Chronic environmental problems caused by the over-exploitation of marine resources and coral bleaching episodes are also a major issue for both fishers and tourist operators. For example, the current depletion of the inshore reef in Anguilla may mean that more fishers are forced to start exploiting offshore fishing grounds, while other fishers may choose to leave the fishery altogether in the future. There may also be market-demand implications; if fish and shellfish become scarcer and/or if reliance on imports increases, then prices may increase on the island. Tourist operators that depend directly on the coral reefs (dive businesses, charter boat companies) are also expected to suffer from further coral reef decline. However, by comparison to the economic and environmental impacts sustained after a hurricane, issues of over-exploitation and coral bleaching may have smaller and more incremental affects on these marine-dependent livelihoods.

This study has shown that fishers and tourist operators were able to respond to the severe 1995 hurricane, through behavioural and livelihood adaptations, such as changes in fishing strategies. However, if hurricanes become more frequent or severe (see Webster et al. 2005; Mimura et al. 2007), the effects on these marine resource-users may be devastating. The coral reefs and fishing grounds surrounding Anguilla, as is common for the Caribbean region, are already in a critical condition because of sustained over-fishing and hurricane damage (e.g. see ECLAT 2000; Paddack et al. 2009). Consequently, it is questionable whether the island's coral reefs and fishing grounds would be able to sustain another major hurricane, although clearly there is a certain level of inevitability that another hurricane will impact on Anguilla, regardless of the effect that climate change has on hurricane return times and intensity. .Indeed, several respondents in this study commented that due to the present degradation of the coral reefs in Anguilla, they did not believe the reefs could withstand another extreme event like hurricane Luis. These resource-users had identified that the ecological resilience (e.g. see Bellwood et al. 2006; Hughes et al. 2007) of this marine system is already heavily compromised.

Marine-dependent livelihoods and social resilience to environmental change

Despite variation among fishers in terms of personal characteristics, gear owned, time spent fishing, fuel costs, and fisher effectiveness, their livelihood strategies and responses to hurricane Luis were largely similar. Indeed, the legacy of hurricane Luis has manifested in a suite of direct responses by this sector (Table 3), and provided evidence of marine resource-users adapting livelihood strategies to withstand environmental uncertainty. The vast majority of respondents utilise mixed fishing strategies (fish and lobster traps, hand-lines) and many switch target species or fishing practices according to seasonal variations in prey abundance and hurricane risk. In addition, while most respondents considered fishing to be their principle occupation, approximately half subsidised their fishing with alternative employment. These features are all expected to contribute to fisher's social resilience to environmental variability or change.

In addition, the profitability of fishing in Anguilla, with some fishers earning many thousands of dollars each month (see Figure 3), suggests that this is not the 'occupation of the last resort', thereby rejecting the typical characterisation of small-scale artisanal fishers as 'the poorest of the poor' (Allison & Ellis 2001). The income that Anguillian fishers can make together with the substantial asset-base that they can accumulate, together with the flexibility shown by their changes in behaviour post-hurricane Luis, may collectively enhance their intrinsic social resilience, by enabling them to buffer some of the consequences of change or variation in resource productivity (Marshall & Marshall 2007). The strong social cohesion within some of these respondents' fishing families and communities may also buffer individuals against uncertainty or fluctuations in the resource (Hicks et al. 2009; Ramirez-Sanchez & Pinkerton 2009).

The fishers also share features that potentially may restrict their capacity to develop resilience. Family status and education can be important measures of how reliant resource-users are on a resource and therefore how resilient they might be to change (Marshall & Marshall 2007). For example, the majority of fishers in this study have families and children, which may mean that these individuals are less able to experiment with alternative employment options, as family responsibilities mean they need to retain employment stability. Consequently, these respondents may be less flexible to future changing conditions affecting their occupation (Marshall et al. 2007). Likewise, many of these respondents had left the education system early, worked in the fishery for most of their lives and may therefore have relatively few transferable skills. It is recognised that these factors may reduce the flexibility of individuals to move away from resource-dependent livelihoods such as fishing (Allison & Hobbs 2004; Marshall et al. 2007). However, many fishers in this study stated that they are able to secure alternative employment and there was no indication that they were unable to support their families during the hardship brought by hurricane Luis, or during subsequent hurricane seasons. Importantly, all of these respondents were able to return to, or build back their marine-dependent livelihood after hurricane Luis.

The factor that may present the greatest limitation to adapting to change is, however, 'fisher ethic'; the expression of an entrenched attachment by fishers to their primary occupation. This study revealed there was a strong desire among respondents to return to fishing after the events of hurricane Luis, even though these fishers sustained substantial losses in gear, the fishing grounds were damaged and the market-demand had plummeted. Fishers in this study and others have shown that there is more to the occupation of fishing than purely the financial incentive (Pollnac & Poggie 2006, 2008). This connection to their occupation has been attributed to the psycho-cultural characteristics of people who fish (e.g. being adventurous, courageous, active, independent), but notably because fishing is more than an occupational preference, it is at the core of the self-identity of a fisher (Pollnac & Poggie 2006). Fishers who are strongly attached to their resource-dependent livelihood are therefore potentially less resilient to change or uncertainty in the resource (Marshall et al. 2007).

By comparison, the tourist operators may be more resilient to change and uncertainty than the fishers because many already have more diversified livelihood strategies, in addition to relatively high levels of education and greater transferable skills from working in other sectors. Fewer of these respondents have family responsibilities, and the vast majority of respondents also stated that there were other possible employment opportunities on the island if necessary. The combination of these factors may make individuals more flexible and dynamic in their livelihood strategies and future planning (Allison & Ellis 2001; Marshall et al. 2007). The recovery of the tourist operators following the devastating events of hurricane Luis, in some cases even rebuilding their entire business infrastructure, suggests that these tourist operators have the financial buffer to withstand stress. Finally, while all of these tourist operators have strong personal or family ties to their businesses, by comparison to the fishers, there did not appear to be the same degree of social or cultural dependency on their occupation. Collectively, these attributes infer that the marine tourist operators may have potentially more social resilience to environmental change.

However, in broader terms there was little variation between the fishers and tourist operators with regards to their livelihood strategies, their strong dependence on the marine environment, and their susceptibility to environmental impacts from hurricanes and coral reef degradation. In addition, and of particular importance was also the dependence by all of these respondents on the tourism industry. For example, even though many of the fishers and tourist operators stated they had the means to generate income aside from their primary occupation, the vast majority of their alternative occupations were also tourism-dependent.

This dependence on the tourism industry may have the most significant implications for the vulnerability of these marine resource-users to environmental change. As has been shown, tourists visit Anguilla primarily for the beaches and not for the coral reefs (see Chapter 3); which might indicate some resilience by the island's tourism industry (and tourism operators) to cope with changes in coral reef health. The implications of hurricanes on tourism-dependent livelihoods may, however, be more substantial. For example, although the seasonality in tourism demand on Anguilla (Figure 4) is not fully understood, it may be driven by the risk of hurricanes (during June to November), or it may be a consequence of favourable summer conditions in the home countries of the tourists that visit the island (e.g. mainly USA nationals; also see Chapters 3 and 4). Yet either way, tourism-dependent livelihoods are potentially vulnerable if future environmental change negatively affects tourism demand. For instance, if hurricane risk in Anguilla increases (or is perceived to increase), tourists may choose not to holiday on the island (Chapter 4). On the other hand, global warming is expected to change the climate conditions in the countries of the tourists that currently visit Anguilla (e.g. USA, Europe; see Chapter 3; IPCC 2007), which could also affect future travel patterns and demand (and is clearly unrelated to hurricane activity). Consequently, the strong dependence by all of the marine resource-users in Anguilla on the tourism industry may ultimately undermine their capacity to develop social resilience to future environmental change.

CONCLUSIONS

Fishers and tourist operators in Anguilla are highly dependent on marine and coastal resources. The capacity of these marine-dependent livelihoods to use resources is significantly affected by hurricane impacts and marine resource degradation. Marine-dependent livelihoods in Anguilla have been able to respond and rebuild their livelihoods after past impacts from hurricanes through adaptations such as changes in fishing strategies, which suggests a capacity for resilience in the face of environmental stress. However, their ability to cope with future stresses will clearly depend on the extent of the environmental changes. While Anguilla may be relatively unusual, in terms of its high-end tourism, which boosts the demand for expensive seafood and provides fishers with a stable and often high levels of income, the threat of environmental change on marine-dependent livelihoods is common throughout the Caribbean. Indeed, Caribbean-wide changes in the marine environment show that issues of marine degradation are widespread throughout the region (Gardner et al. 2003; Paddack et al. 2009), and are expected to worsen with climate change (Hoegh-Guldberg 2004; Mimura et al. 2007). Recognition that many thousands of marine-dependent livelihoods throughout the Caribbean are threatened because of already depleted marine resources and may suffer substantially from future environmental changes therefore requires urgent attention.

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Chapter 6

Marine biodiversity in the Caribbean UK Overseas Territories: perceived threats and constraints on environmental management

Conch shells, Sandy Ground, Anguilla

Chapter 6
Marine biodiversity in the Caribbean UK Overseas Territories: perceived threats and constraints to environmental management

ABSTRACT

Islands are often considered to be a priority for conservation because of their relatively high levels of biodiversity and their vulnerability to a range of natural and anthropogenic threats. The capacity of islands to conserve and manage biodiversity, however, may also be influenced by governance structures. Many island states are affiliated to other countries through an 'overseas territory' status, which may provide them with access to resources and support mechanisms. For example, the United Kingdom has 12 island Overseas Territories (UKOTs), most of which support biodiversity of high conservation concern. I investigate perceptions of the environmental threats to marine ecosystems and constraints to environmental protection on the six Caribbean UKOTs, through semi-structured interviews with officials from UK and UKOT government departments and relevant non-governmental organisations. Coastal development, pollution and over-fishing were perceived as the threats of most concern for the next decade, but climate change was perceived as by far the greatest future threat to the islands' marine ecosystems. However, a series of common institutional limitations that currently constrain mitigation and conservation efforts were also identified, including insufficient personnel and financial support, a lack of long-term, sustainable projects for persistent environmental problems and inadequate environmental legislation. These findings highlight the need for regional cooperation and capacity building throughout the Caribbean and a more concerted approach to UKOT environmental management by the UK and UKOTs' governments.

INTRODUCTION

Islands and their surrounding marine ecosystems typically support high levels of biodiversity, partly as a result of their geographical isolation and unique evolutionary history (Wong et al. 2005; Whittaker & Fernández-Palacios 2007). Islands represent just 3% of the earth's land mass but they contribute disproportionately towards global biodiversity (Fisher 2004) in terms of both species endemism and taxonomically unique groups (Cronk 1997; Kier et al. 2009). Consequently, in a global analysis outlining conservation priority regions or 'biodiversity hotspots', nine out of 25 regions were comprised entirely or mainly of islands and almost all tropical islands were represented by at least one hotspot region (Myers et al. 2000). Island ecosystems also provide important regulating, provisioning and cultural ecosystem goods and services for an estimated 500 million islanders (Wong et al. 2005; Fischlin et al. 2007).

Many islands are also the subject of considerable conservation concern because of their vulnerability to extrinsic disturbances including invasive species, habitat change and, increasingly, climate change (Wong et al. 2005; Mimura et al. 2007). For example, the Intergovernmental Panel on Climate Change (IPCC) highlight the characteristics of small islands that make them especially vulnerable to the effects of climate change, including their small size, geographical remoteness, coastal infrastructure and dependence on natural resources (Nurse & Sem 2001; Mimura et al. 2007). Major climate change impacts expected to affect island ecosystems include sea-level rise, leading to the flooding of important coastal habitats such as coral reefs, mangroves and wetlands (Klein & Nicholls 1999; Wong et al. 2005), elevated sea temperatures causing coral bleaching and increased coral mortality (McWilliams et al. 2005; Wilkinson & Souter 2008), ocean acidification causing reductions in coral reef-building organisms (Kleypas & Yates 2009) and potential increases in the intensity of hurricanes and storm surge, leading to accelerated coastal erosion and habitat destruction (Webster et al. 2005; Nicholls et al. 2007). Projected increases in air temperature and rainfall could also dramatically alter island ecosystems (McWilliams 2002; Wong et al. 2005). In addition climate change is likely to have important socio-economic consequences for island economies and livelihoods through impacts on commercial and subsistence fisheries (Wong et al. 2005; Allison et al. 2009), tourism-dependent industries (also see Chapter 5; Uyarra et al. 2005) and coastal protection (Fischlin et al. 2007).

Environmental vulnerability may also be influenced by governance structures (Douglas 2003). Some islands are independent states (e.g. Barbados, Cuba), while others are constituent parts of larger states (e.g. Sicily (Italy) and Sardinia (France)) and are therefore accountable to their national and/or regional environmental policy initiatives and have access to national funding support mechanisms (Douglas 2006). However, many islands that are linked to other countries do not have such close administrative connections, for example the European Union's (EU) overseas entities (Douglas 2006). Six EU Member States, including the United Kingdom (UK), France, the Netherlands, Portugal, Spain and Denmark have links with 28 overseas entities (comprising 7 'Outermost Regions' and 21 'Overseas Countries and Territories'). They are distributed throughout the Atlantic, Indian and Pacific oceans, South America and the Antarctic, and the majority are small tropical islands (Petit & Prudent 2008). The relationship between each overseas entity and its Member State differs with regards to political autonomy, sovereignty and citizenship (Petit & Prudent 2008).

The relationship each Member State has with its overseas entities also differs with regards to environmental governance, with potential consequences for environmental management issues. For example, France's Outermost Regions ('Départments d'outre mer') in the Caribbean and Indian oceans exist as integral regions of France, each having the same governance status as mainland 'Départments', and adhering to French and EU environmental policy initiatives (Douglas 2006). By contrast, the Dutch and UK overseas entities do not form part of, respectively, the State of the Netherlands or the UK in the same regard, and thus fall outside of national and EU environmental directives and funding mechanisms (Hintjens 1997; Douglas 2006).

The distant administration by the UK of its Overseas Territories (UKOTs) has led to a relatively removed approach to environmental management and biodiversity conservation issues (Oldfield & Sheppard 1997). However, the need for more effective environmental management and conservation in the UKOTs has recently gained political momentum, following the publication of a series of Parliamentary committee reports (see EAC 2006; NAC 2007; EAC 2008; FAC 2008; EAC 2009), as well as significant evidence from key non-governmental organisations (NGOs) (RSPB 2007; Walling 2008; UKOTCF 2009).

The UK has links with 14 Overseas Territories, of which 12 are small islands (FCO 1999; McWilliams 2002). Like many small islands, the UKOTs are globally significant in terms of biodiversity because of the unique ecosystems and large number of rare and threatened species they support (Petit & Prudent 2008; DEFRA 2009). Current governance arrangements between the UK and the UKOTs state that biodiversity conservation and environmental management is a UKOT domestic issue (EAC 2006), despite the fact that the UK government has obligations to protect biodiversity under international agreements, including the Convention on Biological Diversity (CBD) (DEFRA 2009). Most of the UKOTs have 'Environment Charters' that contain the guiding environmental commitments agreed by both the UK and UKOTs governments (EAC 2008). In order to support the implementation of the Environment Charters, the UK Overseas Territories Environment Programme (OTEP) was set up and provides funding for environmental work in the UKOTs (FAC 2008). The OTEP fund currently has an annual budget of £1 million for environmental funding for all of the UKOTs, and is jointly provided by the UK Foreign and Commonwealth Office (FCO) and the UK Department for International Development (DFID). In addition, the UK Department for Environment and Rural Affairs (DEFRA) has committed approximately £2 million towards UKOTs environment projects through the Darwin Initiative fund and other smaller funds, and created the Overseas Territories Challenge Fund in 2009, to provide additional financial support for UKOTs' environmental work (UKOTCF 2009).

Despite the commitments outlined in the Environment Charters and the financial support provided by the UK, many organisations with experience in the UKOTs are concerned for their future, particularly in relation to funding, governance and the capacity of local governments and NGOs in small UKOT communities to facilitate environmental protection (Pienkowski 1998; Fleming 2006; RSPB 2007). For example, the cost of biodiversity conservation in the UKOTs has been estimated to be £16.1 million per year (RSPB 2007), a figure that greatly exceeds current available funds. The UKOTs are also currently ineligible for international funds including the Global Environmental Fund (GEF, the key funding mechanism for the CBD), other EU funds available to metropolitan UK (e.g. rural development funds) (DEFRA 2009) and UK charitable funding sources, which classify the UKOTs as foreign (EAC 2008). Consequently, environmental governance of the UKOTs has been described as 'falling down the cracks' between the UK's domestic and international support for environmental management (Pienkowski 1998).

In order to explore the issues influencing environmental management in the UKOTs, I investigate the perceptions of government and non-government officials from the UK and Caribbean UKOTs of the environmental threats to marine ecosystems and biodiversity, and the constraints to environmental protection. I focus on the Caribbean UKOTs because they share features making them particularly at risk from marine and coastal biodiversity loss and are sensitive to a range of common environmental issues. The overall aims were to 1) investigate current perceptions of the state of the Caribbean UKOT marine ecosystems, and the current and future major threats to these ecosystems, 2) consider the limitations and constraints to managing these threats and, 3) propose policy recommendations to tackle these environmental issues.

METHODS

The UK Overseas Territories

The UKOTs are distributed across tropical and polar regions, in the southern Atlantic, Caribbean, Pacific and Indian oceans (Figure 1). With the exception of Gibraltar and the British Antarctic Territory, they are all small oceanic islands.

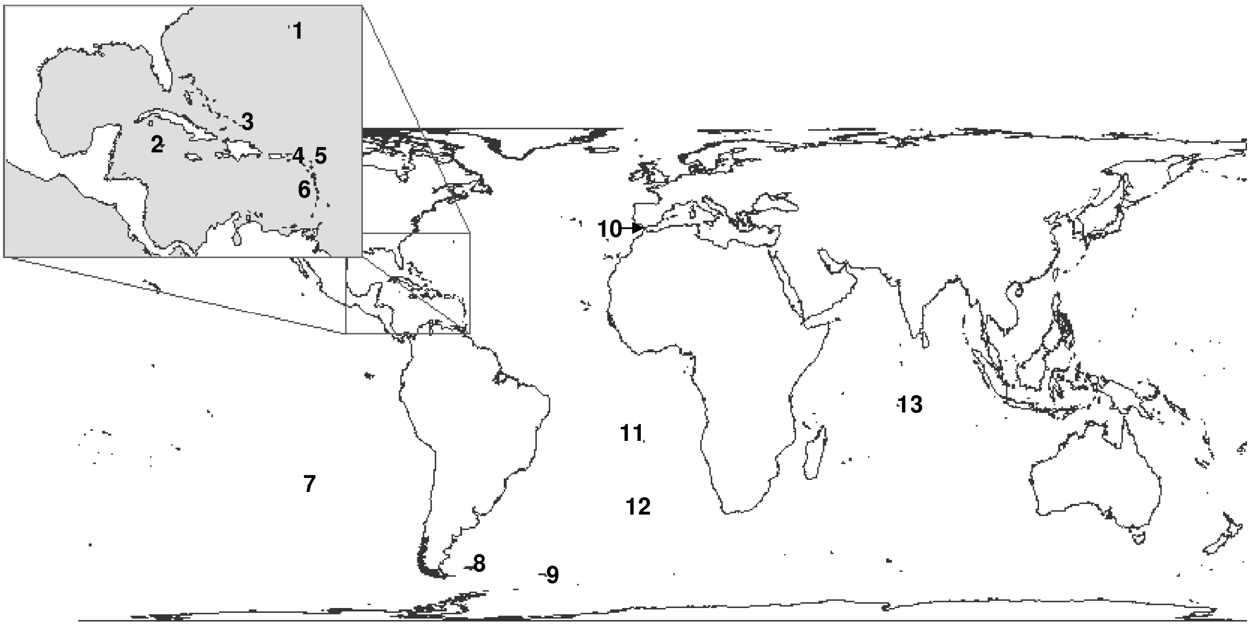

Figure 1. *The global distribution of the 14 UK Overseas Territories: (1) Bermuda, (2) Cayman Islands, (3) Turks and Caicos Islands, (4) British Virgin Islands, (5) Anguilla, (6) Montserrat, (7) Pitcairn Islands, (8) Falkland Islands, (9) South Georgia and South Sandwich Islands, (10) Gibraltar, (11) St Helena and Ascension Island (12) Tristan da Cunha (13) British Indian Ocean Territory, and British Antarctic Territory (not shown).*

The UKOTs support a large number of endemic flora and fauna, regionally and internationally important populations of rare, migratory and threatened species, in addition to large expanses of undisturbed habitats of international conservation significance (Oldfield & Sheppard 1997; Procter & Fleming 1999) (Table 1). While some of the UKOTs are subject to location-specific threats such as volcanic or hurricane activity, many are vulnerable to a range of environmental problems that commonly affect island ecosystems (see Table 1).

The Caribbean UK Overseas Territories

The six Caribbean UKOTs are Anguilla, Bermuda, British Virgin Islands (BVI), Cayman Islands, Montserrat, and the Turks and Caicos Islands (TCI). These islands all have characteristics that make them particularly sensitive to biodiversity loss and susceptible to environmental threats, especially those attributed to climate change (Table 1; Sear et al. 2001; Brown 2008; Walling 2008). The Caribbean UKOTs are all small islands (ranging from 53 km^2 (Bermuda) to 430 km^2 (TCI)) and most are heavily populated (Petit & Prudent 2008). Much of their landmass is low-lying, making them particularly susceptible to sea-level rise and storm surges (Sear et al. 2001), they are prone to natural disasters such as hurricanes (Lewsey et al. 2004; Wilkinson & Souter 2008) and their economies are all heavily dependent on marine ecosystems for tourism and fisheries (Petit & Prudent 2008). As a result of their small size and strong dependence on marine and coastal ecosystems most settlements and socio-economic infrastructures lie close to the shoreline (Nicholls et al. 2007).

Table 1. *Numbers of reported endemic and threatened species of flora and fauna for each island UKOT and the UK mainland (*including 400 endemic invertebrates for Ascension Island). Significant breeding populations and key ecosystems of each UKOT indicate the diversity of ecosystems supported by these islands. Major threats for UKOT ecosystems are signified by (✓). Table compiled with data from McWilliams 2002, Fleming 2006 and RSPB 2007.*

UK Overseas Territory	Endemic species	IUCN red listed threatened species	Significant breeding populations	Key ecosystems	Major threats to ecosystems							
					Habitat loss	Introduced animals	Introduced plants	Sea level rise	Hurricanes, storm surge	Damage to coral reef	Pollution	Volcanic activity
Anguilla	43	18	Seabirds	Scrub, mangrove, salt ponds, coastal, coral reef	✓	✓	✓	✓	✓	✓	✓	
Bermuda	17	47		Coral reef, dry forest, mangrove	✓	✓	✓	✓		✓		
British Indian Ocean Territory	5	7	Seabirds, Marine turtles	Coral reef, mangrove		✓		✓		✓		
British Virgin Islands	8	30	Seabirds	Coral reef, coastal, mangrove, dry forest, scrub	✓	✓		✓	✓	✓	✓	
Cayman Islands	58	19	Seabirds	Coral reef, dry forest, mangrove	✓			✓	✓	✓		
Falkland Islands	16	27	Seabirds	Grassland, bog, rocky outcrop	✓	✓	✓	✓			✓	
Montserrat	7	23		Rainforest, coastal	✓	✓	✓	✓	✓	✓		✓
Pitcairn Islands	26	27		Coral reef, cloud forest, coastal	✓	✓		✓				
South Georgia and South Sandwich Islands	1	12	Seabirds	Grassland, bog, mire		✓		✓				
St Helena and Ascension Island	520*	38	Seabirds, Marine turtles	Lava desert, mountain, forest, Scrub	✓	✓	✓					
Tristan da Cunha	55	22	Seabirds	Grassland, coastal, bog	✓	✓	✓	✓				
Turks and Caicos	12	20	Seabirds	Coral reef, forest, scrub, saltmarsh, mangrove	✓	✓		✓	✓	✓		
Total UKOT	**772**	**307**										
UK mainland	**61**	**59**										

Interviews with UK and UKOT government and NGO officials

Individuals who were engaged specifically in environmental policy or governance in the UKOTs were interviewed (‘elites’; Richards 1996; Lilleker 2003). Although elites may provide a subjective account of an event or topic (Davies 2001), their opinion may represent those of a large organisation or government department.

Respondents were either UK- or UKOT-based (Table 2) and included representatives from each of the UK government departments with an environmental interest in the UKOTs (the FCO, DFID and DEFRA) and from conservation organisations engaged in environmental work in the UKOTs (the UK Overseas Territories Conservation Forum (UKOTCF) and the Joint Nature Conservation Committee (JNCC)). The UKOT category comprised senior officials from each Caribbean UKOT government Environment Department. Respondents were asked to relate responses to their specific island, although examples from other Caribbean islands were encouraged. For UK-based officials, responses generally related to the Caribbean UKOTs group, although specific island examples were referred to where applicable.

Table 2. *Details of the organisations and government departments represented, and the professional positions held by the respondents who took part in this study.*

Sector	**Organisation and position held by respondent**
UK government	Overseas Territories Environment Programme manager, Foreign and Commonwealth Office (FCO)
	Environment and natural resources advisor for the Overseas Territories, Department for International Development (DFID)
	Head of international biodiversity policy, Department for Environment, Food and Rural Affairs (DEFRA)
UK conservation, non-governmental	Overseas Territories officer, Joint Nature Conservation Committee (JNCC)
	Chairman, UK Overseas Territories Conservation Forum (UKOTCF)
UKOT government	Director, Anguilla National Trust
	Minister for Agriculture, Land, Housing and the Environment, government of Montserrat
	Under secretary for the Ministry of Natural Resources, government of Turks and Caicos Islands
	Senior research officer, Environment Department, Cayman Islands government
	Environmental education officer, government of the British Virgin Islands
	Director, Department of Environmental Protection, government of Bermuda

The majority of interviews were undertaken during the International Union for Conservation of Nature (IUCN) conference on ‘Climate change and biodiversity in the European Union Overseas Entities’ in Réunion Island, July 2008. This conference offered a unique opportunity to gather the views of key players from the Caribbean UK and UKOTs governments, and NGOs that deal with environmental issues in the UKOTs. Individuals who were not present at the conference were interviewed in London during October 2008. Interviews consisted of closed structured questions to generate quantitative data on the conservation status and threats to marine and coastal biodiversity in the Caribbean UKOTs. This was followed by a series of open-ended, semi-structured questions to provide qualitative responses on the resources available to manage environmental decline, and recommendations for the future management of the marine and coastal environment. The interview guide is detailed in Appendix E. All interviews were tape recorded and transcribed verbatim.

Interview data and analysis

Respondents were asked to describe the current state of marine biodiversity in their island (for UKOT respondents) or the Caribbean Territories group (for UK respondents) using a 5-point Likert scale, and to rank the top three short-term (5-10 yrs from present) and long-term (more than 10 yrs from present) threats to the marine environment. In order to gauge perceptions regarding specific climate change impacts for these two timescales, respondents were also asked to rank the top three climate change impacts likely to affect their specific island (for UKOT respondents) or the Caribbean Territories group (for UK respondents).

Questions aimed at investigating respondents' perceptions of the current resources provided by the UK and UKOTs' governments to tackle existing and future environmental problems and recommendations for environmental management were analysed using an 'open coding' method (see Bryman 2004), in which similarities and differences in respondents' responses to questions are assessed. Conceptually similar responses or opinions were grouped together into 'categories', which were defined using a phrase or common theme from the data (also called 'in vivo' coding, see Dey 1993). Consequently, the response themes and policy recommendations in this study directly reflect the concepts and categories that emerged from the interviews.

RESULTS

Perceptions of the current state and major threats to marine and coastal ecosystems in the Caribbean UKOTs

Three of the 11 respondents (all three were UK-based) chose not to answer questions on the status of marine and coastal ecosystems as they did not represent a single island. Although seven of the remaining eight respondents perceived the current state of the Caribbean UKOTs' marine and coastal ecosystems to be 'fair' (Table 3), four of the five UK-based respondents mentioned that both the level of decline of these ecosystems and their health status are highly variable between islands. It was suggested that this was because of differences in the activity of local communities, NGOs and the UKOT government departments responsible for environmental protection. Four of the UKOT-based respondents perceived the health of their island's marine and coastal ecosystems to be either in decline and/or currently under threat from environmental pressures (Table 3). A lack of environmental baseline data was highlighted by two of the UKOT respondents as a limitation to current assessments of marine and coastal ecosystem health.

Table 3. *Respondent perceptions of Caribbean UKOT marine and coastal ecosystem health, for the island(s) they represent are provided. Perceptions are gauged using a 5-point scale from 'very poor' to very good' and responses are indicated by (✓). Respondent comments are provided to contextualise answers.*

Island(s) represented by respondent	Very poor	Poor	Fair	Good	Very good	Respondent comment
Caribbean UKOTs			✓			"…they are all aware of this [the threats to marine biodiversity], but some of them are doing more than others…the UKOTs are a mixed bag in the Caribbean…I would say 'fair', but there are extremes on both sides"
Montserrat			✓	✓		"between fair and good…in Montserrat, the things in its favour are there's a small population…[but] habitat loss through development is a big issue"
Anguilla		✓	✓			"baseline data are not available…but based on anecdotal evidence…in terms of fish stocks and conch stocks…it appears to have been declining. I do not think it is the healthiest, but I think it could be worse"
Montserrat			✓			"Quite a bit of it [marine biodiversity] is under threat"
TCI				✓		"We are seeing a decline, I think it is being affected by the various developments"
Cayman Islands			✓			"I would say it is [decline of marine ecosystems] medium, could be better, could be worse…we have got a very good system of marine protected areas…our reefs are not in pristine condition however..."
BVI			✓			"the biodiversity is rich, but under lots of pressure"
Bermuda			✓	✓		"purely biodiversity, probably four ['good'], but no-one is out there collecting data or doing surveys"

Respondents were asked to rank the top three short-term (5-10 yrs) and long-term (10+ yrs) threats to the marine and coastal environments. Development was ranked as the threat of most concern in the short-term, with eight of the 11 respondents selecting this in their top three, resulting in a modal rank value of one. Pollution and overfishing were mentioned as threats by six and five respondents, respectively, and hurricanes and climate change were both mentioned by four respondents, although hurricanes has a higher modal rank (2) than climate change (3), indicating that respondents considered hurricanes to be a slightly greater short-term threat. Invasive species, reef damage, habitat loss (in this case not specifically related to development), and volcanic activity (mentioned by the representative from Montserrat) were all mentioned by between one and three respondents. Immediate and tangible issues such as increasing and uncontrolled development, pollution and marine resource exploitation thus appear to be perceived as greater problems than climate change at this timescale (Figure 2a).

For the long-term timescale (10+ yrs), climate change is perceived to be the most important threat (Figure 2b). All of the respondents mentioned climate change as a major concern, and ranked it most commonly as their top threat (modal rank value of one). Hurricanes, development and pollution were all mentioned by five respondents, although hurricanes and development had higher modal ranks (1) than pollution (3). Because of the association of hurricane activity and climate change, there is the potential for overlap with regards to perceptions of these two issues; however none of the respondents specifically acknowledged this in influencing their response. Habitat loss, invasive species, unsustainable resource use and reef damage were all mentioned by between two and three respondents. Most of the issues mentioned for the long-term scale (Figure 2b) are the same as for the short-term scale (Figure 2a) though the notable difference is that climate change is considered to be a much greater long-term threat.

Perceptions regarding the short- and long-term environmental threats, however, differed between UK- and UKOT- based respondents. Interestingly, only the UK- based individuals ranked climate change among the top three threats for both time scales

(Table 4). Respondents from the UKOTs ranked pollution and hurricanes as short- and long-term threats, but ranked climate change as the primary long-term threat (Table 4).

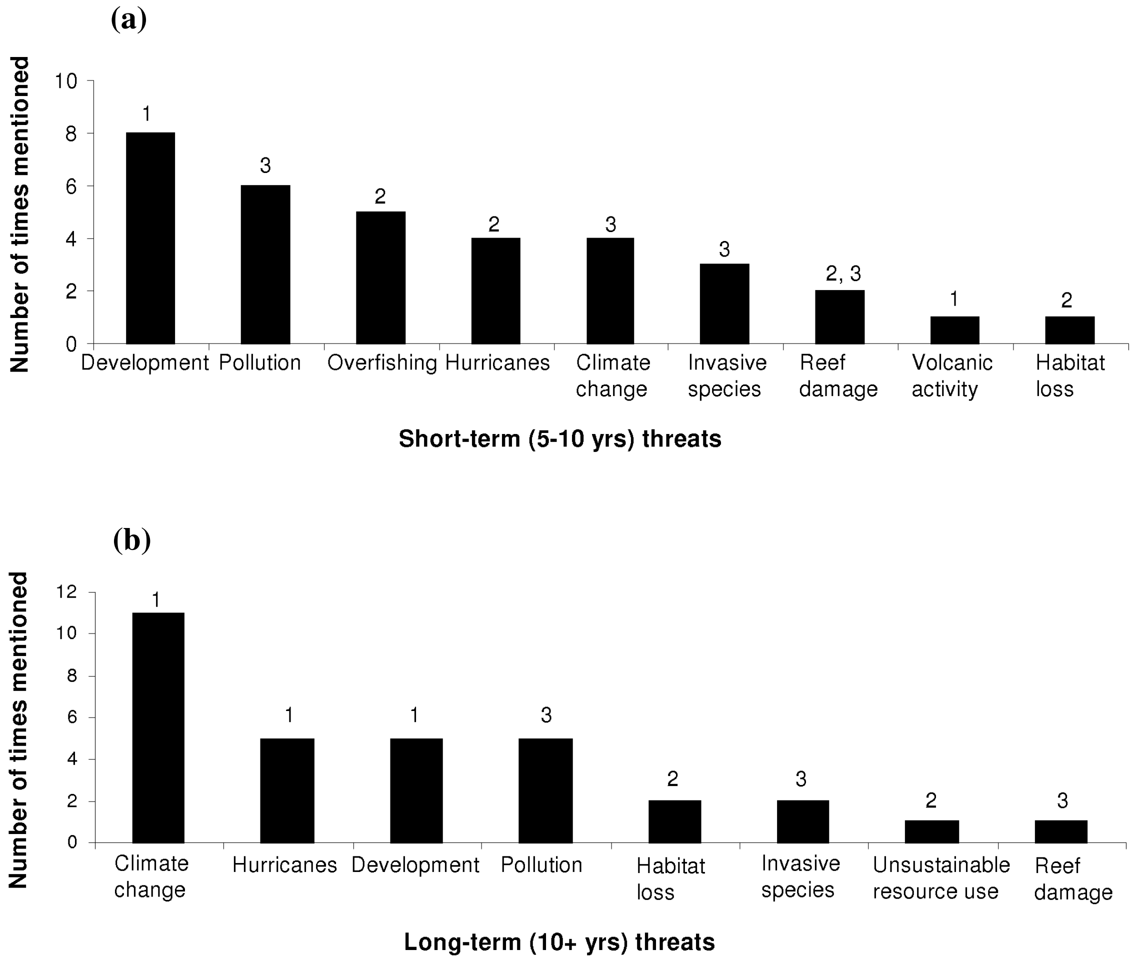

Figure 2. *Responses regarding perceptions of* (a) *short-term and* (b) *long-term environmental threats to Caribbean UKOT marine and coastal ecosystems. Bar values depict the total number of times particular threats were mentioned by respondents. Numbers above bars denote the modal rank (or bimodal ranks) for each threat.*

Table 4. *Ranking of the top three short- and long-term threats to marine and coastal ecosystems in the UKOTs by respondents based in the UK or the UKOTs.*

Respondent group	Top three short-term (5-10yrs) threats	Top three long-term (10+ yrs) threats
UK-based	1. Development 2. Climate change 3. Pollution/invasive species	1. Climate change 2. Development 3. Habitat loss
UKOT-based	1. Pollution 2. Hurricanes 3. Development	1. Climate change 2. Hurricanes 3. Pollution

When different potential impacts of climate change were assessed separately, nine out of 11 respondents perceived hurricane intensity as the most important threat (modal rank of one) in the short-term. Six respondents perceived sea surface temperature rise as important (modal rank three) and five respondents considered storm surge important (bimodal ranks of one and three). Rainfall variations and hurricane frequency were both mentioned by four respondents, although rainfall variations had a higher modal rank (1) than hurricane frequency (2). Sea-level rise and air temperature were mentioned by two and one respondents respectively (Figure 3a).

With regards to long-term (10+ yrs) threats, eight respondents mentioned hurricane intensity and sea-level rise as important climate change impacts, although hurricane intensity had a higher modal rank (1) than sea-level rise (2) (Figure 3b). As illustrated by Figure 3a, hurricane intensity was also considered the top short-term threat. However, by contrast, respondents perceived sea-level rise important only in the long-term. Sea surface temperature rise was mentioned by six respondents (modal rank three) and rainfall variations by five respondents (modal rank one). Hurricane frequency, storm surge and changing air temperature were impacts mentioned by between two and one respondents. It is not clear from the results why the respondents felt storm surge risk would decrease over time.

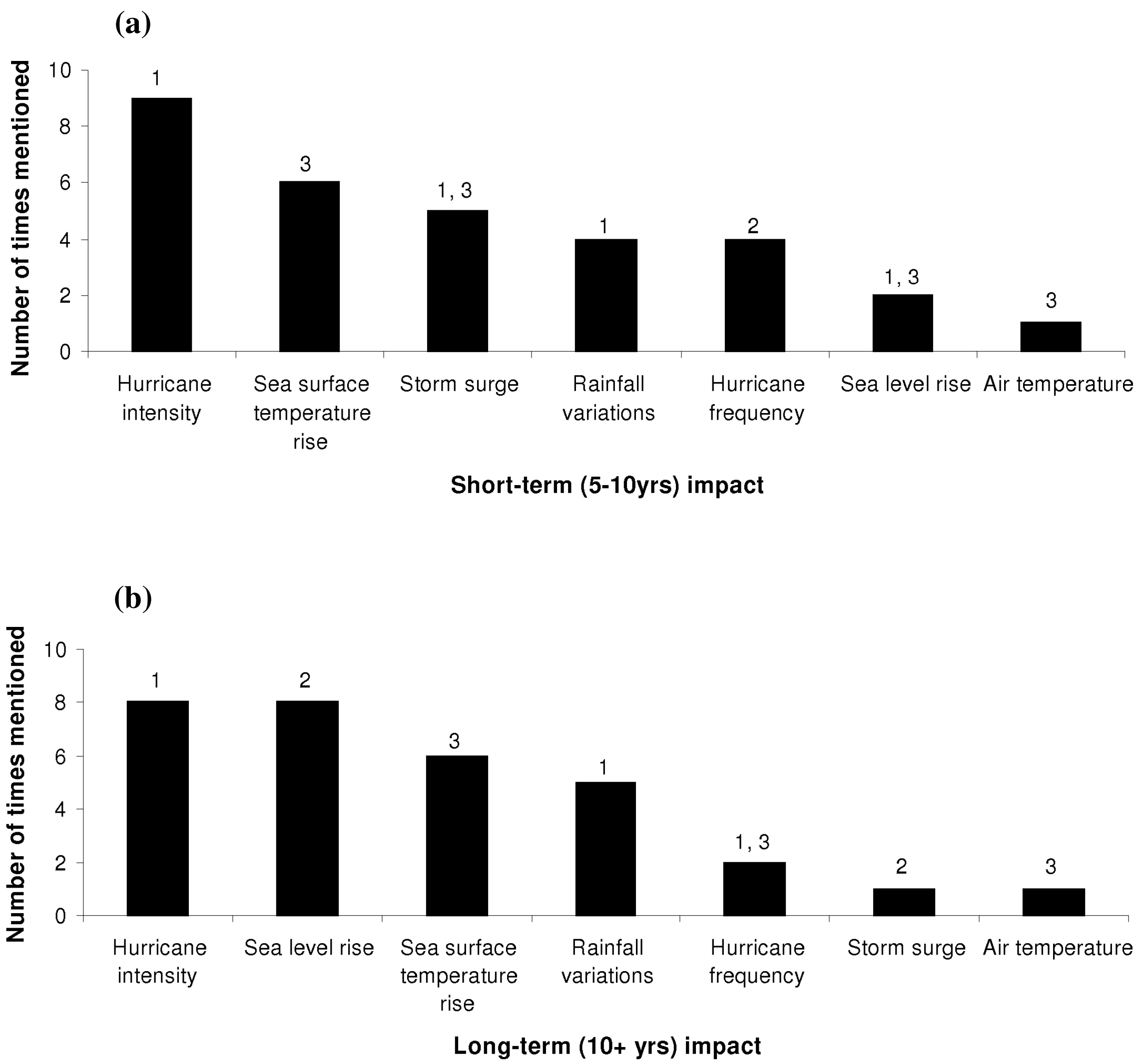

Figure 3. *Responses regarding perceptions of the* (a) *short-term and* (b) *long-term climate change impacts for the Caribbean UKOTs. Bars depict the number of times each impact was mentioned by respondents. Numbers above bars denote the modal rank (or bimodal ranks) for each threat.*

Constraints to protecting marine and coastal ecosystems in the Caribbean UKOTs

Respondents identified five major constraints to protecting marine and coastal ecosystems in the Caribbean (Table 5).

Insufficient financial support

The most commonly mentioned constraint on environmental management was insufficient financial support. Nine of the 11 respondents mentioned that the current available funding does not meet the environmental needs of the islands. Two of the UK government officials accepted the need for more support, but emphasised the difficulty of assigning limited funds to the UKOTs when there are many other worthwhile projects; *"if we were to suddenly give 16 times as much money, what would we be doing 16 times less of? Where would it [money] come from?...no matter how much it was, it would never be enough, environmental challenges are so great you can always do more"* and *"I think there needs to be a big budget for this work. Now, where this money comes from is the big question, the (UK government) does not have it"*.

Environmental legislation

Seven respondents mentioned constraints imposed by outdated environmental legislation that was insufficient for current needs (Table 5). Three of the UKOT-based respondents commented that new or updated environmental legislation is in the process of being passed. Another three of the respondents also noted the related and difficult issue of enforcing environmental law, and that the Caribbean UKOTs cannot protect their marine environment from the range of threats associated with biodiversity loss and environmental change without appropriate legislation in place. One UKOT-based respondent commented that their environment department currently works *"against a background of having no [environmental] legislation"*.

Reluctance to deal with climate change

Six of the respondents commented there has been reluctance by the islands' governments and NGOs to address the issue of climate change (Table 5). For example, the environmental NGOs with links to the islands have generally focused their work on specific aspects of biodiversity conservation rather than broader issues of climate change. The numerous other social and economic concerns were also considered to limit the UKOTs approach to dealing with climate change-related issues, *"when a country has limited resources, environmental factors do not become a priority"* (UKOT-based respondent).

The recent decision by DFID to provide financial assistance (*c.* £300,000) for Caribbean UKOTs to participate in the Caribbean Community Climate Change Centre's adaptation programme was identified as a step to enable the islands to address the issue of climate change: *"DFID is supporting the Overseas Territories in the Caribbean to participate in a regional program...called Mainstreaming Adaptation to Climate Change [MACC]…specifically looking at indentifying for each of the Caribbean states or Territories, which sectors are most vulnerable, and then helping them to put in place strategies…to help them be more resilient"* (UK-based respondent). Participation in the MACC programme was identified as a potential way to support the islands with engagement in the climate change debate at a higher policy level.

Capacity constraints

The small resident populations of these islands were identified with a shortage of capacity for the environmental sector by several of the respondents as an important constraint to environmental management. Two respondents mentioned the problem of under-staffed departments potentially inhibiting islands from taking on large-scale and long-term projects, even if funding were available. The capacity constraint is compounded by the complexities of accessing financial support; three of the respondents mentioned the arduous grant application process which adds to the difficulties faced by under-resourced and over-stretched environment departments.

Sustainable long-term programs

Longevity of funding was also identified as a constraint on current and future environmental management. Two UKOT-based respondents mentioned the need for longer-term project funding (in addition to the small-scale grants currently available). This was accepted by one of the UK government representatives, although with the caveat that, in order to achieve sustainable project funding, the UKOTs would be required to *"buy in"* because the current UK budget for the UKOTs cannot independently sustain longer-term projects. However, the ability of these islands to support sustainable large-scale programs is also dependent on human capacity constraints.

Table 5. *Responses regarding the major constraints to environmental protection in the Caribbean UKOTs. The number of respondents that mentioned each constraint is reported along with examples of respondents' comments to contextualise each constraint.*

Constraint	Number of respondents	Selected examples of respondent responses
Insufficient financial support	9	"There is a big shortfall between what is being provided and what is needed". "The UK spends approximately 1 million pounds a year on environmental conservation small projects in all the Overseas Territories put together". "…very limited resources [provided by the UK]". "[funding is] a drop in the ocean considering the biodiversity that is on the island compared to the UK". "Funding is very limited…I think all of us [UK and UKOT] could be doing more".
Legislation	7	"The problem with the Environment Charters, they are not enforceable, there is no legal basis for them…What you need is legislation in place. You have got the Cayman Islands whose environmental legislation, conservation legislation from the 1970s does not extend to the outer islands because in that time they were uninhabited". "There are some [UKOTs] that do not have appropriate legislation to designate protected areas". "I think the new [fisheries] legislation that is coming out …there should be something in there that relates back to climate change", "Whether or not the legislation is actually enforced, that is a different matter". "One of the things that we are about to do is a review of our [Bermuda] environmental legislation…identify any gaps in the legislation".
Reluctance to deal with climate change	6	"OTEP has had real problems over the years trying to get the Territories and the NGOs interested in things like climate change", "For a lot of the Territories, climate change is very new to them…some of the Territories are doing a lot…but none of its really hitting home yet…it tends to be the individuals seeing it rather than the governments, it is quite a difficult issue". "The problem is that when a country has limited resources, environmental factors do not become a priority". "I think we [Cayman Islands Department of Environment] think it is very important but we are not doing anything about it". "In the climate change area, there is now a round table that is happening, but it is not driven by the government, it is driven by private interest".
Capacity constraints	4	"This is the big issue; the capacity in the islands is tiny. They are all under-staffed… [OTEP] is never spent fully". "They have got so few people they cannot take on massive multi-million pound projects…it is not worth drafting some complicated project proposal and getting all the partners and jumping through the hoops that are required", "[some grant proposals are] so much red tape and such a long complicated bureaucratic process that it is just not worth the money at the end of the day". "The funding would be less of an issue if there were less hoops associated with it". "We [Bermuda] cannot do it because there are too few of us…we lack the depth, so we are always pulling consultants in to get things done", "I do not have time to write grants".
Sustainable programs	3	"The problem is you need it to be sustainable, and the only way it will be sustainable is if the [UKOT] government buys in…their budgets are so tight they could not guarantee in three years time to be able to fund [a project]". "We [UKOTCF] are satisfied with the small project funds, what is lacking is for longer projects".

Policy recommendations for more effective environmental protection in the Caribbean UKOTs

In addition to identifying constraints to environmental management, respondents identified five potential policy recommendations to address some of these issues (Table 6).

The provision of more support

The need for more support (financial and personnel) from the UK and UKOT governments was the most common policy change, suggested by nine of the 11 respondents. The issue of inadequate UK funding was mentioned throughout the interviews as both a major constraint to current environmental management (Table 5) and an area in need of policy change (Table 6). However, three of the respondents commented that, while it is necessary for the UK government to provide more funding, UKOT governments also need to provide more support for their island's environment sector.

Regional cooperation, capacity building and communication

Seven of the respondents mentioned the need to address a series of related management issues, including the regional coordination of environmental work, capacity building and effective communication. The islands currently have considerable capacity constraints, and it was suggested that building closer links between islands, to *"pool our resources"* and *"speak with one voice"* may help tackle the issues of capacity and human resources. Three of the respondents felt that effective regional cooperation and communication may enable the Caribbean UKOTs to be more resilient to environmental pressures and particularly the long-term threats associated with climate change.

Move climate change up the political agenda, supported by appropriate legislation

Six of the respondents mentioned the need to place climate change firmly on the political agenda. One UK-based respondent commented that, at present, climate change related work generally occurs because of *"individuals seeing it rather than government"*. Thus, despite broad recognition that *"climate change is going to have a huge impact"*, several respondents implied that a modest amount of work is currently underway in the Caribbean UKOTs regarding climate change, relative to the scale of the impacts expected. Participation in the regional Caribbean adaptation programme (MACC) was identified as a means to address the issue. However, without specific climate change policy initiatives and adequate environmental legislation, protecting these islands from large-scale, long-term impacts is likely to remain difficult.

Cohesive UK governance

A lack of coordination across UK government departments with regards to environmental governance in the UKOTs was a problem highlighted by two of the UK government respondents. One respondent suggested that DEFRA should also consider providing more funding and expertise to the UKOTs, a proposition that echoes several UK government reports on this issue (FAC 2008; EAC 2009). A more joined-up approach to environmental governance by key UK government departments (the FCO, DFID and DEFRA) was suggested, in part to clarify departmental responsibilities regarding UKOT environmental management, but also to improve communication and trust between the UK and the UKOTs.

Develop integrated environmental projects

The need to develop broader environmental projects in the Caribbean UKOTs was mentioned by two of the UK government respondents. However, it remains unclear whether this is being effectively communicated to the UKOTs, because despite concerns that the UK is not providing enough financial support (RSPB 2007), the OTEP fund was under-spent for 2008 because there was *"quite a poor turn out [of applications] from some of the Territories"* and they [UKOTs] are *"not putting in good applications"*. It is proposed that the development of future environmental projects should incorporate the *"bigger picture"*, for example with greater links to livelihoods, human well-being and environmental change. This could be beneficial for the UKOTs in terms of meeting the remit of the UK government funders, while also managing future environmental challenges more holistically.

Table 6. *Responses regarding suggested policy recommendations for more effective environmental management in the Caribbean UKOTs. The number of respondents that mentioned each recommendation is reported, along with examples of respondents' comments to contextualise each recommendation.*

Policy recommendation	Number of respondents	Selected examples of respondent responses
UK and UKOT governments provide more financial and personnel support	9	"Territories really need to start doing things themselves". "[UKOTs have identified] what needs are not being addressed". "On the one hand, proper resourcing from the UK and on the other hand, proper implementation of planning procedures in the Territories themselves". "Provide more money, if not money they [UK] could provide more expertise". "I think all of us [UKOTs] could be doing more", "[UKOTs] need to start taking our expectations off the UK for assisting us with everything and become more proactive".
Regional cooperation, capacity building and communication	7	"It's important that we [UK] streamline". "We [UKOTs] need to operate coordination of the major projects and that although we are separate islands, negative impacts on one can have negative impacts on the others…", "If we tackle climate change on a regional basis, with the support of the international community then we would be in a much better position to participate in the global control of climate change". "We are realising that we [UKOTs] really need to rely on each other and to pool our resources...[leading to] encouragement, support, networking, the greater voice and the greater representation globally…I think that the future is quite promising, even in the face of doom and gloom or challenges of climate change". "Speak with one voice…put the [climate change] agenda within a larger framework, so we [UKOTs] are approaching this in the same manner as the rest of the world".
Move climate change up the political agenda, develop appropriate legislation	6	"Individuals seeing it rather than government", "We [UK] will help where we can, but [UKOTs] really need to do something about it [climate change and biodiversity loss]". "As a whole it needs to come up on the political agenda, both in the Territories and UK political agenda, especially with climate change". "Wise officials in the UK government are giving similar messages to ours but it is not being done institutionally, or at a high political level", "Britain's reluctance to give strong guidance to the Territories is a failure".
Cohesive UK governance	2	"This is where there is confusion across Whitehall. DEFRA has the expertise but they do not have the capacity. We [FCO] have got a little bit of capacity but we do not have the expertise. And DFID fall in the middle of all of us". "[DEFRA] ought to have a policy lead on biodiversity and conservation, but they stop at the British Tunnel…I do not see why this is not extended".
Integrated environmental action plans	2	"Just focussing on biodiversity and conservation is misleading…pure biodiversity conservation is somewhat hard to argue for here [DFID], it is something that has a much stronger connection to livelihoods or people's well-being", "[UKOTs] have done a very good job in terms of identifying conservation priorities. I think what they need to focus on in the future is implementing those action plans, but also finding ways to better integrate environmental issues across government activities". "They are [UKOTs] not putting in good applications…it is actually quite a poor turn out from some of the Territories".

DISCUSSION

There is extensive evidence for declines in the health of marine ecosystems throughout the Caribbean (see Gardner et al. 2003; Burke & Maidens 2004; Wilkinson 2008), with which the people I interviewed concurred. Responses to the questionnaire highlight a multitude of threats affecting the coastal zone in the Caribbean UKOTs. The UKOT-based respondents considered current environmental risks from pollution, hurricanes and coastal development to these islands' marine ecosystems to be greater short-term risks than those associated with climate change, but climate change was perceived to be the most significant long-term threat. By contrast, the UK-based respondents considered climate change to be the most important threat to these islands' marine ecosystems for short and long time-scales. The interviews revealed a variety of limitations to current environmental protection for the islands, including insufficient financial support, out-dated environmental legislation, a reluctance by UKOT governments to address climate change, and a lack of long-term projects to manage climate change and other persistent environmental issues. In response to these constraints, management and policy recommendations to mitigate further environmental decline were identified by respondents.

Although the principle drivers of declines in the health of Caribbean marine and island ecosystems have been habitat change, over-exploitation and pollution (MEA 2005; Wilkinson 2008), there is clear recognition of the growing threat of climate change for these ecosystems (Harley et al. 2006; Hoegh-Guldberg et al. 2007; Wilkinson & Souter 2008). The vulnerability of the Caribbean UKOTs to future climate change is well documented (see Sear et al. 2001; McWilliams 2002; Walling 2008), and widely accepted by the representatives from the UK and UKOT departments and organisations documented in this study. A previous study of the impacts of climate change in the UKOTs carried out in 2001 (Sear et al. 2001) indicated that among the Caribbean UKOTs there was little concern or awareness of climate change because of a lack of information and understanding about its relevance to island communities. Respondents in the Sear et al. (2001) study typically considered that in terms of climate change associated risks, *"only hurricanes are important threats"*. Consequently, the authors recommended more awareness and education campaigns throughout the islands. Interestingly, seven years later, this study indicates that hurricanes remain a major focus of concern (see Figure 3), a result that emphasises their devastating impact throughout the Caribbean region (see ECLAT 2000; Becken & Hay 2007).

However, respondent responses from this study also signify the perceived importance of other climate change impacts, in particular sea-level rise, elevated sea temperatures and changing rainfall patterns. This may be a reflection of the islands' reliance on coastal ecosystems (Petit & Prudent 2008), and an awareness of the threat of rising sea temperatures causing coral bleaching (Hughes et al. 2003; McWilliams et al. 2005) and sea-level rise potentially increasing coastal flooding and beach loss (Nicholls et al. 2007). In addition, erratic rainfall leading to overstretched water resources is already a problem in the Caribbean (Bernal et al. 2004) and is expected to increase with climate change (Mimura et al. 2007). Ocean acidification was not perceived as a threat, perhaps because it has only been raised relatively recently.

These findings suggest that there has been growing awareness of climate change and its potential impacts on Caribbean UKOT ecosystems and societies. In addition to the global media coverage of climate change issues, this awareness may have been influenced by recent publications on practical climate change adaptation and biodiversity conservation, targeted directly at the UKOTs (see Tompkins et al. 2005; Brown 2008; Walling 2008), in combination with high profile events and projects (e.g.

the IUCN conference ‘Climate change and biodiversity in the European Union Overseas Entities’ and the MACC project). Constraints to environmental management, and in particular with regards to risks associated with climate change, are therefore unlikely to be due to a lack of awareness. Instead, issues relating to financial support, institutional capacity and governmental prioritisation of climate change were highlighted by the respondents in this study as some of the principle limitations to environmental protection in the Caribbean UKOTs.

There is substantial evidence to suggest that the financial resources available to all of the UKOTs to manage and protect their environment from future environmental stressors appear to be insufficient (Table 5, Pienkowski 1998; RSPB 2007; EAC 2008). However the under-spend on the OTEP fund, which is administered by the FCO and DFID and is specifically ring-fenced for environmental work in the UKOTs, also highlights the need to develop the institutional and personnel capacity for environmental management. A possible means of addressing this problem could be to re-evaluate the current timescale for funding available for environmental management in the UKOTs. For example, presently the OTEP scheme provides primarily short-term technical assistance for projects (EAC 2007). This may, however, limit opportunities to retain and sustain the human capacity built during the lifetime of a project. In recognition of this problem, the UK government is currently considering alternative options for longer-term funding of environmental work in the UKOTs (EAC 2009).

Developing funding for longer-term and larger-scale environmental projects may also provide opportunities to develop regional approaches to environmental management. Capacity-building within islands can potentially be strengthened by building stronger links and communication pathways between islands. For example, the inclusion of the Caribbean UKOTs in the Caribbean-wide climate change programme

(MACC) has the potential to develop stronger networks between Caribbean UKOTs and other countries in the region, and may increase scientific and environmental management capacity within the Caribbean UKOTs. However, recognition of the importance of climate change through continued political investment is needed from both the UK and UKOT governments to enable the islands to develop their role within this important programme.

Developing a more integrated approach to environmental governance in the UKOTs may also help to address institutional capacity constraints within these islands. Integrating environmental governance across different administrations is certainly not straightforward for the UKOTs, with environmental management largely a local government issue (Oldfield & Sheppard 1997), and with other governing responsibilities recognised by the UK (FCO 1999). Nevertheless, building closer ties between key government departments including the FCO, DFID and DEFRA could enhance the expertise available to the UKOTs, help clarify departmental responsibilities and may lead to more effective communication within government and outside parties (EAC 2008). The development of the DEFRA Overseas Territories Challenge Fund is an indication that more support for the UKOTs is potentially available (UKOTCF 2009), while the Inter-Departmental Ministerial Group on Biodiversity is currently focusing attention on the UKOTs (EAC 2009), suggesting that a coordinated approach by UK government departments may be in progress. Developing closer links between government departments with the aim of enhancing institutional capacity is particularly important for the UKOTs because of their relatively distant administration by the UK (Oldfield & Sheppard 1997), and the associated limitations in terms of national and international financial support for environmental protection (Pienkowski 1998; Douglas 2003).

CONCLUSIONS

The UK has international obligations to protect biodiversity, and is a signatory to the Convention on Biological Diversity (CBD), and thus the commitment to significantly reduce the rate of biodiversity loss by 2010 and its successor targets (IUCN Countdown 2010; DEFRA 2009). This commitment is also a component of ensuring environmental sustainability under the Millennium Development Goals (DEFRA 2009). Improving the effectiveness of environmental management in the UKOTs could help towards the CBD commitment, in addition to other Multilateral Environmental Agreements which relate to biodiversity conservation and contribute to the 2010 target.

This study has demonstrated that environmental protection in the Caribbean UKOTs is constrained by a variety of institutional constraints, which currently hinder their chances of meeting these international conservation targets. Although I focussed only on the Caribbean UKOTs, many of the issues and constraints to environmental management are likely to be applicable to the other UKOTs. Addressing the principle constraints which relate to financial support and human capacity in the UKOTs has the potential to help meet international conservation commitments and to help UKOTs to adapt and build resilience to the future environmental threats to which they are likely to be particularly vulnerable.

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Chapter 7

General Conclusions

Island Harbour, Anguilla

Chapter 7
General Conclusions

Understanding the specific environmental and socio-economic vulnerabilities to which small islands are exposed is essential for the development of adaptive and sustainable measures to build greater ecological and social resilience to future environmental change (Turner et al. 2007). Small islands in the Caribbean are expected to be particularly susceptible to changing environmental and climate conditions because of their strong reliance on marine and coastal resources for tourism and fisheries (Wong et al. 2005; Mimura et al. 2007). However, little research to date has investigated the vulnerability of Caribbean islands to climate change in terms of marine and coastal-tourism dependency (but see Dharmaratne & Brathwaite 1998; Uyarra et al. 2005). The research presented in this thesis attempted to address this knowledge gap, by providing a fine-scale analysis of the potential implications that global climate projections of increases in hurricane activity and marine degradation from coral bleaching may have on the marine-dependent tourism industry and resource-users on the Caribbean island of Anguilla. In the light of these results, and the regional implications that climate change is expected to have in the Caribbean, a suite of broader-scale policy interventions based on expert elicitation are considered.

Assessing Caribbean island vulnerability to environmental change

With growing concern about the capacity of small islands to cope or adapt to environmental and climatic change impacts, there is a clear need to address vulnerability and social justice issues (Adger & Kelly 1999; Carter et al. 2007). In addition, when financial resources are limited, there may be a demand for more cost-effective approaches to measure vulnerability. Indicator-dependent vulnerability assessment approaches have developed as a popular choice for the quantification of vulnerability (see Brooks 2003; Füssel 2005; Füssel & Klein 2006), because of their potential to support policy-makers in environmental and/or social management decisions, to disseminate complex information in a user-friendly way to stakeholders, as well as being relatively simple and cheap to produce (Briguglio 2003; Patt et al. 2005). This study has shown, however, that vulnerability is not easily reduced to a single measure and caution should be applied in interpreting approaches (i.e. indices) that aim to represent vulnerability in this way. Indeed, the analysis reported in Chapter 2 suggests that assessment methods that are typically used for quantifying vulnerability may only be consistent in terms of highlighting the extreme cases of vulnerability. For cases with less extreme levels of vulnerability, these types of approach are far less consistent. As the outputs of different approaches can vary to such an extent, greater transparency in the presentation of their structures and rankings may be necessary, and their capacity to provide the justification for undertaking costly investment or management measures may be questionable (Patt et al. 2005).

Measuring and investigating vulnerability of countries or regions to environmental change may require a combination of different methods and dimensions of vulnerability to be explored. Confidence in the use of vulnerability assessment may also be improved by using them in combination with other methods, such as fine-scale case-study approaches and expert elicitation. Analysing the different dimensions of vulnerability (environmental, social and economic) separately may also help to increase transparency in the results and to avoid the inherent uncertainty in aggregated assessment outputs apparent in Chapter 2.

For that reason, in Chapter 3 some of the aspects of marine tourism-dependent Caribbean islands were explored separately, to draw conclusions about their relative vulnerability to changing environmental conditions (see Uyarra et al. 2005; Becken & Hay 2007). All of the Caribbean islands included in these analyses depend to a large extent on marine and coastal resources for tourism, although there are between-island differences, particularly in dive tourism opportunities and the consumption of fish. Finer-scale analysis of the case-study island of Anguilla produced a clearer picture of marine and coastal resource-use by the tourism industry, the most important economic sector on the island. For example, as tourist demand for beach-based activities is very high, compared to active recreational activities (e.g. diving, fishing), it is likely that changes in the conditions of Anguilla's beaches under future environmental change would have significant social and economic impacts on the island. By contrast, for islands that depend more on coral reefs for tourism opportunities (e.g. dive destinations such as Bonaire or the Cayman Islands), changes in the conditions of the reefs may have more severe economic consequences (also see Uyarra et al. 2005). The demand by tourists for extractive marine resources (fish and shellfish) is also high on Anguilla, which suggests that this feature of the tourism industry may also be particularly susceptible to changes in resource availability.

Arguably, assessing the disaggregated indicators of marine and coastal characteristics, and using a case-study approach to analyse marine resource-use on Anguilla, provides a deeper insight into Caribbean island resource-dependency and vulnerability to changing climatic conditions than could have been achieved using typical vulnerability assessment.

Implications of changing hurricane risk and marine degradation on Caribbean island tourism and related livelihoods

The overall objective detailed in Chapter 1 was to investigate issues surrounding vulnerable marine and coastal tourism livelihoods in the Caribbean to climatic change, and specifically the impacts of increasing hurricane risk. The approach developed in Chapter 4 addressed this by investigating the implications that increasing hurricane activity may have on the tourism-dependent island of Anguilla. This involved determining tourist perceptions of hurricane risk, through their participation in a standardised questionnaire and choice experiment (see Bennett & Blamey 2001).

Accordingly, the results provide empirical evidence of tourists' risk perceptions of extreme events, and the implications that future changes in hurricane activity may have on the Caribbean tourism industry. Interestingly, while tourists' decision-making was influenced by the risk of hurricanes (by both 'hurricane frequency' and 'hurricane strength'), holiday price was revealed to be the most important factor influencing tourists' holiday choice preferences. These findings suggest that local tourist providers might be able to adapt to the risk of increasing hurricane activity on Anguilla, if they are able to reduce their costs. The study also highlighted the usefulness of market segmentation approaches that categorise people according to specific demographic, behavioural or psychological traits (Hamilton et al. 2009). For example, holiday preferences and risk perceptions differed among different groups of tourists visiting Anguilla, highlighting the groups that are most concerned about changing hurricane risk (typically older people and Americans), and therefore may be more likely to adapt their destination choice behaviour. Potentially, these findings could be used by tourism planners and operators in Anguilla, to inform marketing strategies for specific groups of tourists in the event of changing hurricane risk and/or environmental conditions.

Having explored the influence that increasing hurricane activity may have on marine and coastal tourism demand, Chapter 5 considers some of the implications of environmental change for the people whose livelihoods rely on the tourism industry. This study is the first assessment of the resilience of marine and coastal livelihoods in Anguilla to changing environmental conditions, specifically from hurricane risk and marine resource degradation. Using empirical evidence from previous hurricane impacts (primarily hurricane Luis in 1995), the analyses revealed that fishers and tourist operators on Anguilla were able to respond to this severe hurricane through a range of behavioural and livelihood adaptations. This may indicate livelihood flexibility to future changing conditions. In addition, there is evidence that many fishers and tourist operators have diversified livelihoods and financial stability, features which also indicate potential for resilience to cope or adapt to future impacts or resource variability (Allison & Ellis 2001; Marshall & Marshall 2007; Marshall 2010). However, strong personal and cultural attachment to occupations, particularly among fishers, may hinder resilience (Pollnac & Poggie 2006; Marshall et al. 2007). Additionally, and perhaps most importantly, the reliance by all of these livelihoods (and many of the alternative occupations available), on the climate-dependent tourism industry, may undermine their capacity to cope with future environmental change.

The findings detailed in Chapters 4 and 5 contribute to understanding island social resilience to environmental change, and highlight the importance of integrating fine-scale social and economic dimensions in vulnerability research. Chapter 5 also demonstrates the advantages of using a livelihoods approach to appreciate resource-user's incentives, socio-economic constraints and cultural ties, and the capacity of people and communities to adapt to uncertain environmental change or variability (Allison & Ellis 2001; Badjeck et al. 2010).

However, chronic environmental stressors affecting the Caribbean marine ecosystem (e.g. over-exploitation, pollution and development) have significantly reduced the capacity of this social-ecological system to buffer future change (Gardner et al. 2003; Breton et al. 2006; Mumby et al. 2007). As many of these Caribbean islands are locked into high and potentially unsustainable levels of marine resource use, to which a dependence on tourism significantly contributes, the situation is unlikely to change in the short-term (see Chapter 3). Considering the importance of marine and coastal ecosystems for Anguilla and other Caribbean islands, and that many islands do not have economically viable alternatives to the marine-dependent tourism industry (Potter et al. 2004), there is an urgent need for policy interventions that promote sustainable and adaptive management of Caribbean marine and coastal resources.

Policy interventions to improve resilience to future environmental change

Previously, a lack of awareness of environmental and climate change issues by the governments and communities on some Caribbean islands was identified as a limitation to environmental management and climate change adaptation (Sear et al. 2001). This is evidently not the case, however, for the case-study island of Anguilla, or the other islands (Caribbean UK Overseas Territories (UKOTs)) included in an analysis of constraints to environmental management (see Chapter 6). Indeed, from the fishers and tourist operators described in Chapter 5, to the expert elicitation of government officials and conservationists in Chapter 6, there is evidently broad awareness of the problems facing the marine and coastal environment in the Caribbean, both in terms of chronic stresses and more recent climate change impacts. This is an important point, because it indicates that an awareness of these problems is not being matched by an appropriate level of practical policy change. For example, on an island scale, many of the fishers and tourist operators supported greater restrictions on the coral reef fishery in Anguilla (including no-take areas and closed seasons), recognising that the degradation of this important resource had major consequences for the future of the ecosystem, and their socio-economic well-being. Only very few of these respondents did not consider that marine degradation was a problem for their livelihoods, and specifically did not agree with stronger regulations and restrictions on marine resource extraction (Chapter 5).

At a larger, Caribbean-wide scale, Chapter 6 proposes policy and management interventions that could help retain and build social and ecological resilience to future environmental change. The six Caribbean UKOTs were the subject of this analysis, because they form a politically unique and environmentally vulnerable group of islands in the Caribbean (Sear et al. 2001; McWilliams 2002; RSPB 2007). This group of islands was, however, expected to be reasonably aware of climate change issues because of previous research in this area (see Sear et al. 2001; Tompkins et al. 2005). A suite of common institutional limitations emerged, which currently constrain mitigation and environmental management efforts on these islands. This analysis indicated that, while there are island-specific differences, many issues such as inadequate environmental legislation, and insufficient personnel and financial support are regional problems that are perceived to limit the capacity to build resilience to future changing environmental conditions. These findings also support earlier work that outlined the key elements for adaptation to climate change in the Caribbean UKOTs, including legislation and enforcement, financing and regional support networks (see Tompkins et al. 2005, p51). Importantly, these findings emphasise the urgent need for policy interventions that boost regional cooperation, capacity building, and longer-term funding for environmental management across the Caribbean UKOTs.

Future directions for research

The overall conclusions drawn from this thesis support a mixed-methods, multi-scale ecosystem approach, to develop a better understanding of island vulnerability to environmental change. Small-scale case-study analyses can clearly provide important information on local concerns and vulnerabilities, and the potential capacity for people and communities to develop resilience to changing conditions. However, as the findings from case-study based research may be highly context-specific (e.g. marine-dependent livelihoods in Anguilla, Chapter 5), there are inherent difficulties identifying the degree to which the findings can be generalised to other systems. For this reason, broader regional-scale assessments are also important (Chapters 2 and 3), as they can contextualise the selected case-study (and thus allow wider generalisations to be made), and reveal common issues, or constraints that need to be addressed. An approach that incorporates the multiple dimensions (environmental, social, economic) of vulnerability to environmental change, at various scales (local, regional, international) is therefore critical to the development of sustainable, adaptive Caribbean marine management.

The ecosystem approach to fisheries (EAF) is one such approach that has gained relatively recent political and scientific support (FAO 2003; Jennings 2005). Although still considered to be in the conceptual stage of implementation (Garcia & Cochrane 2005), the EAF was developed because of a pressing demand for more holistic management of marine ecosystems, and aims to address the links between ecological factors, as well as the needs and desires of resource-users and societies (FAO 2002). The values and concepts of EAF are also similar to the integrated coastal zone management (ICZM) guidelines, which similarly supports the integration of social, economic and environmental factors in the management of the coastal zone (DEFRA 2008).

These alternative methods and perspectives may provide a useful starting point for the development of a regional ecosystem approach to managing Caribbean marine and coastal systems to environmental change (also see Chakalall et al. 2007). However, as the findings in Chapters 5 and 6 clearly show, the real constraints to environmental protection may relate more to political or institutional limitations, and the availability of adequate financial and human capacity. Consequently, for the effective protection of Caribbean marine ecosystems, and in order to operationalise a regional ecosystem approach, full support of local, regional and international governments will undoubtedly be required.

As with most research studies, certain aspects of the work undertaken for this thesis should be developed further, and particularly the aspect directed at informing policy choices: the institutional analysis described in Chapter 6. On reflection, this work has certain limitations in terms of the scale and depth of the assessment, largely a consequence of the opportunities for data collection (i.e. semi-structured interviews during the Réunion Island conference, with a limited number of key respondents). Developing this work further could provide a greater understanding of environmental governance in the Caribbean region. For example, a more in-depth assessment of a range of formal (e.g. constitutional and market-based instruments) and informal (e.g. property rights or tenure) governance structures would provide a greater understanding of the constraints to current environmental management, enforcement and stakeholder compliance, and consequently the limitations or opportunities for adapting to future environmental change. Whilst the work undertaken in this thesis touched upon many of these issues, a larger-scale assessment of the complex environmental governance landscape would provide invaluable insight for environmental managers and policy-makers within the Caribbean region.

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Appendices

Appendix A

Caribbean island vulnerability indicators applied to each vulnerability assessment approach in Chapter 2. The data source is included for each indicator.

Indictor	**Source**
GDP *per capita* (US$)	United Nations (UN) (2004): http://unstats.un.org/unsd/snaama/Introduction.asp and cia.gov Central Intelligence Agency (CIA) The World fact book (2007): www.cia.gov
Dependency ratio (dependent population per 100 productive population	Pan American Health Organisation (PAHO) (2005): http://www.paho.org/English/SHA/coredata/tabulator/newTabulator.htm
% literacy rate	PAHO (2005): http://www.paho.org/English/SHA/coredata/tabulator/newTabulator.htm
Altitude (m)	UN (2005): http://esa.un.org/unpp/
Population density (per km^2)	CIA (2007): www.cia.gov
Forest area (% of total area)	UN (2000) http://unstats.un.org/unsd/ENVIRONMENT/q2004indicators.htm
Hurricane frequency (yrs)	Hurricane City (2007): http://www.hurricanecity.com/cities.htm
% population living in areas <5m above sea level	Centre for International Earth Science Information Network (CIESEN), Population, Landscape And Climate Estimates (PLACE) (2003): http://sedac.ciesin.columbia.edu/plue/nagd/place.html
% of country without access to water	UN (2002) http://unstats.un.org/unsd/demographic/products/socind/default.htm PAHO for missing data: http://www.paho.org/english/sha/profiles.htm
% agricultural area	UN (2002) http://unstats.un.org/unsd/ENVIRONMENT/q2004indicators.htm
Annual tourist arrivals	World Tourism Organization (WTO) (2004): http://www.unwto.org/facts/menu.html
Annual cruise arrivals	Caribbean Tourism Organization (CTO) (2004): http://www.onecaribbean.org/information/documentview.php?rowid=4318
Total fertility % (number of children per woman)	PAHO (2005): http://www.paho.org/English/SHA/coredata/tabulator/newTabulator.htm
Life expectancy (yrs)	PAHO (2005): http://www.paho.org/English/SHA/coredata/tabulator/newTabulator.htm
% of GDP from tourism	World Travel and Tourism Council (WTTC) (2004): http://www.wttc.org/eng/Document_Resource_Centre/index.php

Appendix B

The literature or web-based sources for the Caribbean island marine or coastal characteristics data presented in Figures 3 and 4, Chapter 3.

Figure	Caribbean island characteristic	Source
3a	Area (km^2)	United Nations Statistics Division, environment statistics, main environmental indicators. URL: http://unstats.un.org/unsd/ENVIRONMENT/q2004indicators.htm (Accessed 20 November 2006).
3b	GDP *per capita* (US$)	United Nations Statistics Division, National accounts, main aggregates database. URL: http://unstats.un.org/unsd/snaama/Introduction.asp (Accessed 20 November 2006).
3c	Coastline (km)	Central Intelligence Agency. World fact book. URL: https://www.cia.gov/library/publications/the-world-factbook/ (Accessed 10 January 2010)
3d	Reef area (km^2)	Spalding, M. D., Ravilious, C., Green, E.P. (2001) World atlas of coral reefs. UNEP World Conservation Monitoring Programme, University of California Press, Berkeley, USA.
4a	Number of marine parks	MPA Global, a database of the world's marine protected areas. URL: http://www.mpaglobal.org/index.php?action=search (Accessed 25 November 2006).
4b	Number of dive centres	Spalding, M. D. (2004) A guide to the coral reefs of the Caribbean. University of California Press, Berkeley, USA.
4c	*Per capita* fish consumption (kg/yr)	Spalding, M. D., Ravilious, C., Green, E.P. (2001) World atlas of coral reefs. UNEP World Conservation Monitoring Programme, University of California Press, Berkeley, USA.

Appendix C

Tourist questionnaire (sections A and D) and choice experiment (sections B and C) (including follow-up questions, pilot choice experiment and final choice experiment cards), used for Chapters 3 and 4.

A: TOURIST QUESTIONNAIRE

IDENTIFICATION

Date of interview:

		/			/	**0**	**8**

Surveyor's name: ______________________

Survey site: ______________________ Questionnaire number: ____________

Start time: ______________________ Finish time: ______________________

Hello, I am sorry to disturb you. I am a researcher at the University of East Anglia in the UK. I am studying tourism here in Anguilla. I was wondering if you could spare about 20 minutes to answer some questions.

If yes, proceed to Question 1
If no, Thank you. Sorry to have bothered you, **and fill in refusal sheet.**

Before I begin, can I ask if you are here on holiday? Yes [ ] No [ ]

If no, thank them and explain that I am only surveying tourists at the moment.

If I use any terms that you do not understand, please feel free to ask me to clarify.

1. Gender: Male: [ ] Female: [ ]

A: HOLIDAY INFORMATION, ATTITUDES AND PREFERENCES

HOLIDAY INFORMATION

2. How long are you staying in Anguilla? [#] Days

3. a) Is this your first trip to Anguilla? Yes [1] **(Go to Q4)** No [0] **(Go to b)**

bi) How many times have you been to Anguilla on holiday? #

bii) Which month did you visit Anguilla during your last trip | Month(s) visited |

4. What were the factors that prompted you to come to Anguilla?

____

____

5. a) What were the reasons you came at this time of year? **(SHOW CARD A5)** Please can you rank the **3** important factors in order of importance to you when you decided to come on holiday to Anguilla at this time of year (1 = most important and so on)

		Rank
A	Cost of holiday	
B	Low hurricane risk	
C	Favourable climate conditions	
D	Work or university holidays	
E	Children's school holidays	
F	Unfavourable weather at home	

Other: ____________________________________

b) Why do you not come here in the summer months?

____

6. **(SHOW CARD A6)** Please look at this card and rank the **5** most important factors in order of preference to you when you were deciding to visit Anguilla on this occasion? Please indicate in order of preference (**1 to 5**), so that 1 = most important, 2 = next most important, 3 = the next most important and so on.

	Holiday characteristic	**Rank**
A	Climate (e.g. air temperature, water temperature, sunshine etc.)	
B	Low hurricane risk	
C	Cost of holiday	
D	Beaches and associated recreational activities (e.g. sunbathing, swimming, walking)	
E	The coral reef and related recreational activities (e.g. diving, snorkelling, fishing)	
F	Peaceful and relaxed island	
G	Services and facilities (e.g. restaurants/bars etc.)	
H	Spending time with family or relatives	
I	Friendly local people	
J	Sailing or water sports	
K	Caribbean culture	

7. a) Have you been on holiday to any other Caribbean islands, (excluding day trips)?

   Yes [1] **(Go to part b and c)** No [0] **(Go to Q8)**

   b) Which was the other island you visited?
   Excluding this trip, include only the most recent trip island ______________ [Month visited?]

   c) Please can you tell me up to 3 of the most important factors for visiting this other island:

1. ____

2. ____

3. ____

8. Do you know when the hurricane season is in Anguilla?

   a) Yes [1] No [0]

   b) When? ______________________

9. Did you consider the hurricane season when you were booking your holiday to Anguilla?

   Yes [1] No [0]

10. **(SHOW CARD A10)** While you are on holiday, how many times do you expect to do the following (days/wk) **(Circle)**

	Activity	Every day 7 days	Most days 5-6 days	About half 3-4 days	A few days 1-2 days	Never 0 days	Don't know
A	Go to the beach	1	2	3	4	5	99
B	Swim/paddle in the sea	1	2	3	4	5	99
C	Go diving	1	2	3	4	5	99
D	Go snorkelling	1	2	3	4	5	99
E	Go fishing	1	2	3	4	5	99
F	Eat fish	1	2	3	4	5	99
G	Eat shellfish (lobster/crayfish)	1	2	3	4	5	99
H	Sunbathing	1	2	3	4	5	99
I	Water sports (not diving)	1	2	3	4	5	99
J	Beach walking	1	2	3	4	5	99

11. How much did you pay for your holiday, per person, per week? (**Circle currency**)

		Currency **$ £ Euro**
A	All inclusive (flight and accommodation)	#
B	Flight	#
C	Accommodation	#
D	Other	#

B: CHOICE EXPERIMENT

This study aims to increase our understanding of the potential impact that changes in the number and strength of hurricanes may have on the tourism industry in Anguilla.

Offer this information if necessary:
There is recent evidence to suggest that hurricane intensity has increased over the last 30 years in the Caribbean, and in particular that the proportions of category 4 and 5 hurricanes (the strongest and most destructive) have increased during this time period. There is also some evidence to suggest that hurricane frequency in the North Atlantic may be increasing. These changes are well matched with increasing tropical sea temperatures necessary for hurricane formation, and appear most likely to be associated with global climate warming.

This card **(Show Example Card 1)** shows a holiday situation much like your own. It describes a holiday with a very low risk of a hurricane, so the likelihood of a hurricane during your stay is described as 1 in 100, or 'low chance' **(Show Hurricane Frequency Card)**. In other words, if you were to come on a week's holiday here 100 times, then you would expect that a hurricane would occur once. Hurricanes are not all the same however, some are weaker and some are stronger. I have categorised hurricanes into three strengths and described the effect each may have on your holiday, here they are **(Show Hurricane Strength Card)**. See that the holiday situation described by **Example Card 1** has 'weak' hurricane strength. Also, the cost of this holiday option is the price you paid for your holiday, and is therefore labelled 'No change'. This is what I will call **OPTION A**.

EXAMPLE CARD 1

	Option A
Likelihood of hurricane	1 in 100 (low chance)
Strength of hurricane **Beach/swimming days lost** **Other outdoor activities possible?** **Flights from island**	Weak 1 – 2 days Yes Yes
Change in holiday price **(per person per week)**	No change

In a moment I'm going to show you a number of cards with alternative holiday situations to the **OPTION A** holiday. Each alternative situation I'm going to show you will have some variation to Option A, but varying only in the likelihood of a hurricane, the strength of a hurricane or the cost of your holiday per person, per week. Apart from those shown, all other holiday characteristics will stay the same, including other weather conditions (e.g. wind, rain, cloud etc). **There is also no change in risk to personal safety between the different options.**

So here is an example question: *Suppose you had a choice between two holidays at roughly the same time of year, which would you choose? Option A or Option B?*

Here, the alternative holiday example shows that the likelihood of a hurricane during your holiday is greater than Option A, and has increased to a ‘medium chance’ or a 5 in 100 chance, the strength of the hurricane however would still be ‘weak’, but you would get a $250 reduction in price per person per week for the holiday.

EXAMPLE CARD 2

	Option A	Option B
Likelihood of hurricane	1 in 100 (low chance)	5 in 100 (medium chance)
Strength of hurricane **Beach/swimming days lost** **Other outdoor activities possible?** **Flights from island**	Weak 1 – 2 days Yes Yes	Weak 1 – 2 days Yes Yes
Change in holiday price **(per person per week)**	No change	$250 less

I’m now going to show you a series of cards similar to this Alternative option. To make things simpler, **I will always keep Option A the same.** In each case all you have to do is decide which holiday option (A or B) you would choose.

Remember:

All other characteristics of your holiday will remain identical.

Please consider all options carefully, thinking about each of the characteristics shown.

Please consider each choice irrespective of whether previous questions seemed better of worse.

Treat each option as the only one available to you.

Choice set	**Answered YES to OPTION A**	**Answered YES to OPTION B**	Q order
B1	0	1	
B2	0	1	
B3	0	1	
B4	0	1	
B5	0	1	
B6	0	1	
B7	0	1	
B8	0	1	
B9	0	1	
B10	0	1	
B11	0	1	
B12	0	1	
B13	0	1	
B14	0	1	
B15	0	1	
B16	0	1	
B17	0	1	
B18	0	1	
B19	0	1	
B20	0	1	
B21	0	1	
B22	0	1	
B23	0	1	
B24	0	1	
B25	0	1	
B26	0	1	
B27	0	1	
B28	0	1	
B29	0	1	
B30	0	1	
B31	0	1	
B32	0	1	
B33	0	1	
B34	0	1	
B35	0	1	
B36	0	1	
B37	0	1	
B38	0	1	
B39	0	1	
B40	0	1	
B41	0	1	
B42	0	1	
B43	0	1	
B44	0	1	
B45	0	1	

Each respondent is shown 9 choice sets.

Circle one response only for each choice set (A or B), entering the question number for each choice set in the Q order column.

Shuffle all 45 cards.

Take the top 9 for one respondent, then the next 9 for the next respondent and so on until all 45 cards have been used (this will take 5 respondents). Do not reshuffle until all 45 cards have been used.

C: FOLLOW-UP QUESTIONS

1. Which attribute(s) did you focus on? **(Circle all that apply)** and how strongly did you focus on these attributes (on a scale of 1 (not at all) to 5 (very strong focus)).

		Importance				
		Very strong	Strong	Sometimes	A little	Not at all
1	Likelihood of hurricane	5	4	3	2	1
2	Strength of hurricane	5	4	3	2	1
3	Cost of holiday	5	4	3	2	1

2. What would you say was the main reason for choosing the choices that you did?

____

D: DEMOGRAPHIC INFORMATION

In this final part of the survey, I am going to ask you a few questions about yourself. These will be used for statistical purposes only and all the answers are entirely confidential.

1. Where are you staying?

		Name	Location
Hotel 5*	1		
Hotel 4*	2		
Hotel 3*	3		
Hotel 0-2*	4		
Rented villa/apartment	5		
Friends/family	6		
Own villa/apartment	7		
Other (specify)	8		

2. Where are you from? Nationality ________________

3. Looking at this card (**SHOW CARD D3**) could you tell me which number best applied to you? (**Circle**)

	Age in years
1	18-24
2	25-34
3	35-44
4	45-54
5	55-64
6	65-74
7	75 or over
8	Refused

4. Looking at this card **(SHOW CARD D4)** could you tell me which number best applies to you? **(Circle)**

	Education
1	I left school aged 16 or younger
2	I left school aged 18
3	I have a vocational qualification
4	I have a university or college degree
5	I have a PhD/doctorate

5. Looking at this card **(SHOW CARD D5)** could you tell me which numbered statement best applies to you? **(Circle)**

	Employment
1	Employed full-time
2	Employed part-time
3	Self-employed
4	Unemployed
5	Student
6	Retired
7	Looking after the home full-time
8	Unable to work due to illness or disability
9	Other (please specify):

6. a) Could you tell me how many how many children under 16 and adults over 16 you have in your household?

   b) How many of them are with you on holiday? (<16 and >16)

	On holiday	**In household**
<16 years	#	#
>16 years	#	#

7. Looking at this card **(SHOW CARD D7 most appropriate for the respondent's nationality)**, could you tell me which number best describes your total annual household income before tax. **(Circle)**

   If necessary, reassure the respondent that this information is completely confidential and that this information is collected because this is the best indicator of whether I have interviewed a representative range of people.

	£ per year	**$ US per year**	**Euro per year**
1	Less than 20,000	Less than 40,000	Less than 30,000
2	20,000 – 29,999	40,000 – 59,999	30,000 – 39,999
3	30,000 – 39,999	60,000 – 79,999	40,000 – 54,999
4	40,000 – 49,999	80,000 – 99,999	55,000 – 66,999
5	50,000 – 59,999	100,000 – 119,999	67,000 – 79,999
6	60,000 – 69,999	120,000 – 139,999	80,000 – 94,999
7	70,000 – 79,999	140,000 – 159,999	95,000 – 106,999
8	80,000 – 89,999	160,000 – 179,999	107,000 – 119,999
9	90,000 – 99,999	180,000 – 199,999	120,000 – 134,999
10	100,000 – 199,999	200,000 – 399,999	135,000 – 269,999
11	200,000 or more	400,000 or more	270,000 or more
12	Don't know	Don't know	Don't know
13	Refused	Refused	Refused

This is the end of the questionnaire. Thank you so much for your time, and I hope you enjoyed your holiday/enjoy your holiday!!

PILOT SURVEY FOR CHOICE EXPERIMENT

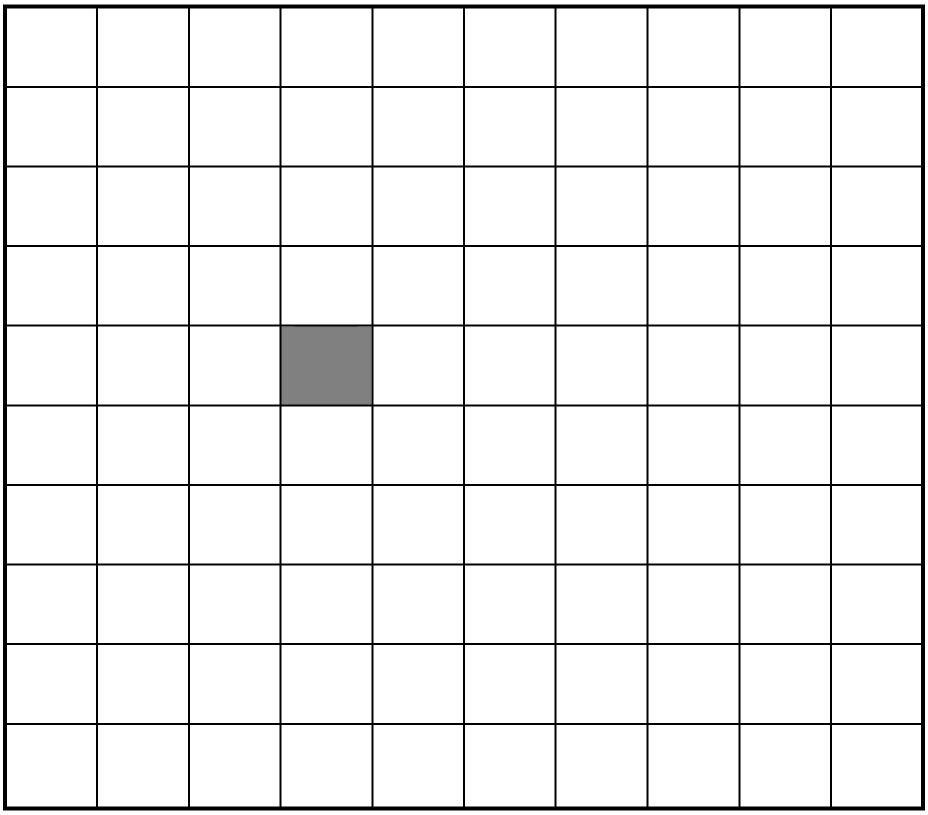
The interviewer introduces herself and explains that she is working on a project that is interested in assessing tourists' perceptions to hurricane risk in Caribbean holiday destinations. Explain that she does not know what risk tourists might consider high or low, and was hoping that they might be able to help. Ensure the respondent that there is no difference in risk to personal safety between the different levels of risk. The interviewer takes note of age, gender and nationality, to ensure a fair sample is surveyed in the pilot.

Questions

1. Could you tell me the hurricane risk level you would not consider coming on holiday. e.g. If I said there was a 1 in 100 chance that a hurricane would occur during your week's holiday in Anguilla, would you come on holiday? Or in other words, if you come on holiday here 100 times, there is the chance that for one of those times a hurricane would impact the island.
2. Show pilot hurricane frequency cards (grids depicting different frequencies 1:100, 5:100, 10:100, 15:100, 20:100, 30:100, 40:100 and 50:100) to respondents. The cards are shuffled and the respondent is asked if they would come on holiday if the risk looked like this.
3. If there was monetary compensation would they consider differently? What would be the maximum hurricane risk they would consider for a pay-off? e.g. a 5:100 chance of a hurricane with a $100 off their holiday price per person/per week.
4. What would be the maximum monetary compensation they would consider taking for the maximum risk?
5. (Show random shuffled frequency cards again) Show approximately 4 cards to each respondent and ask them to describe each picture in turn using the scale, very low, low, medium, high or very high risk.
6. (Show price card) Ask respondent to estimate the price of their current holiday per person per week.

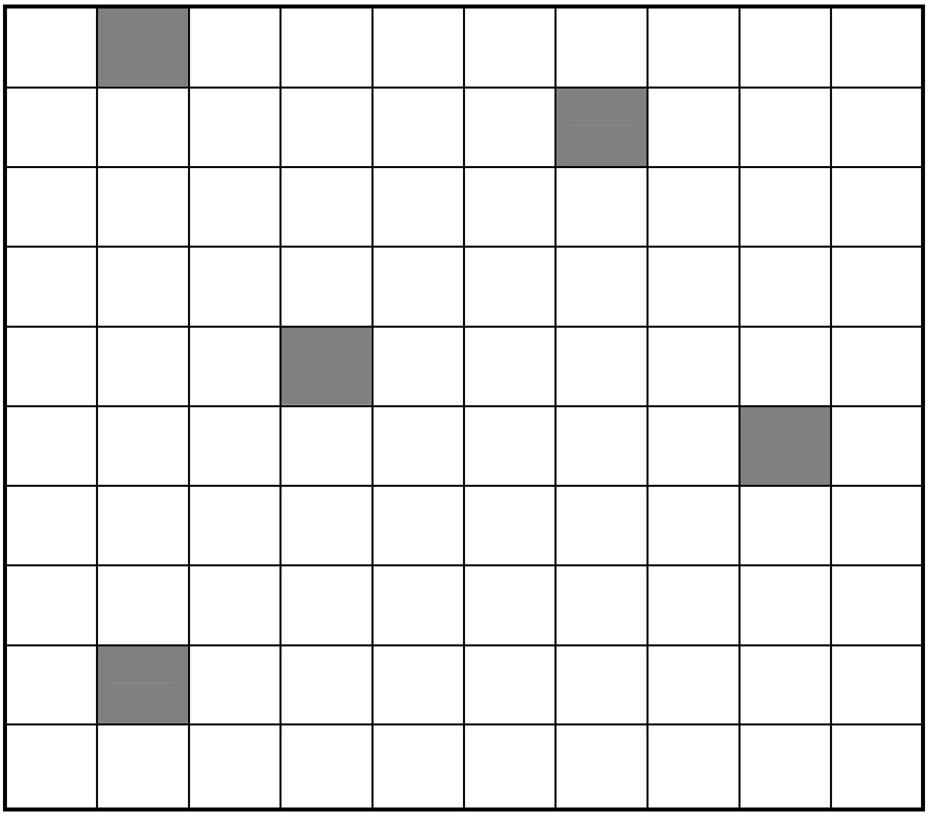
PILOT HURRICANE FREQUENCY CARDS

1 in 100 chance of a hurricane



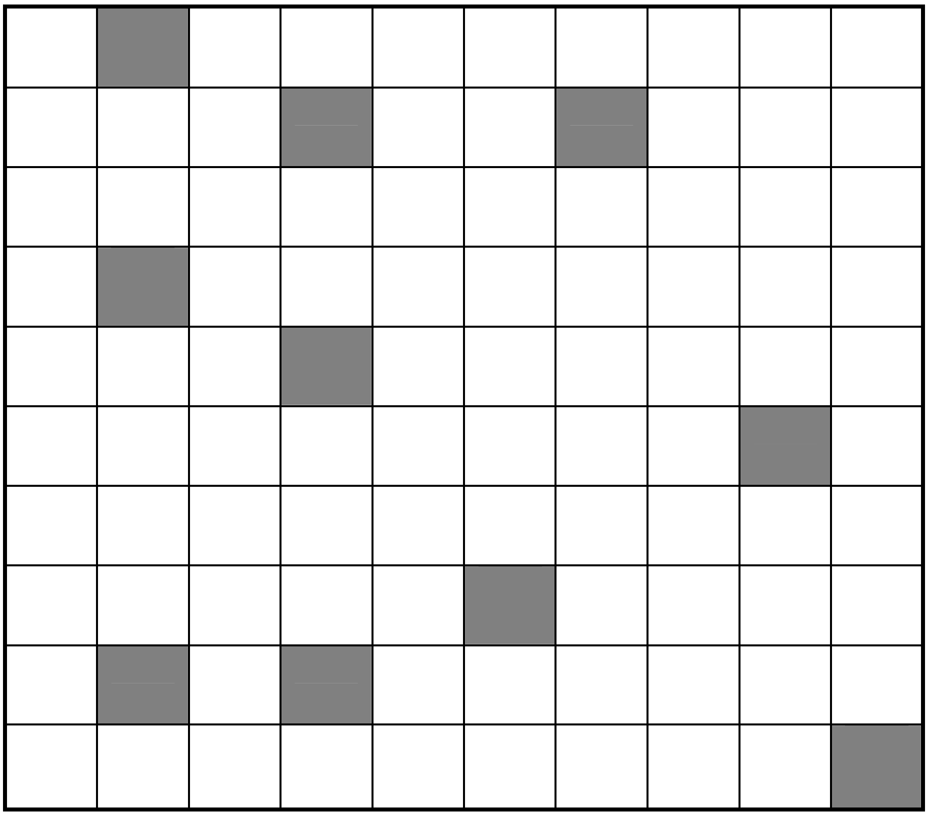
The chances of a hurricane during a one week holiday in Anguilla are 1 in 100. In other words, if you were to come on a week holiday here 100 times, then you should expect that a hurricane would happen once.

5 in 100 chance of a hurricane



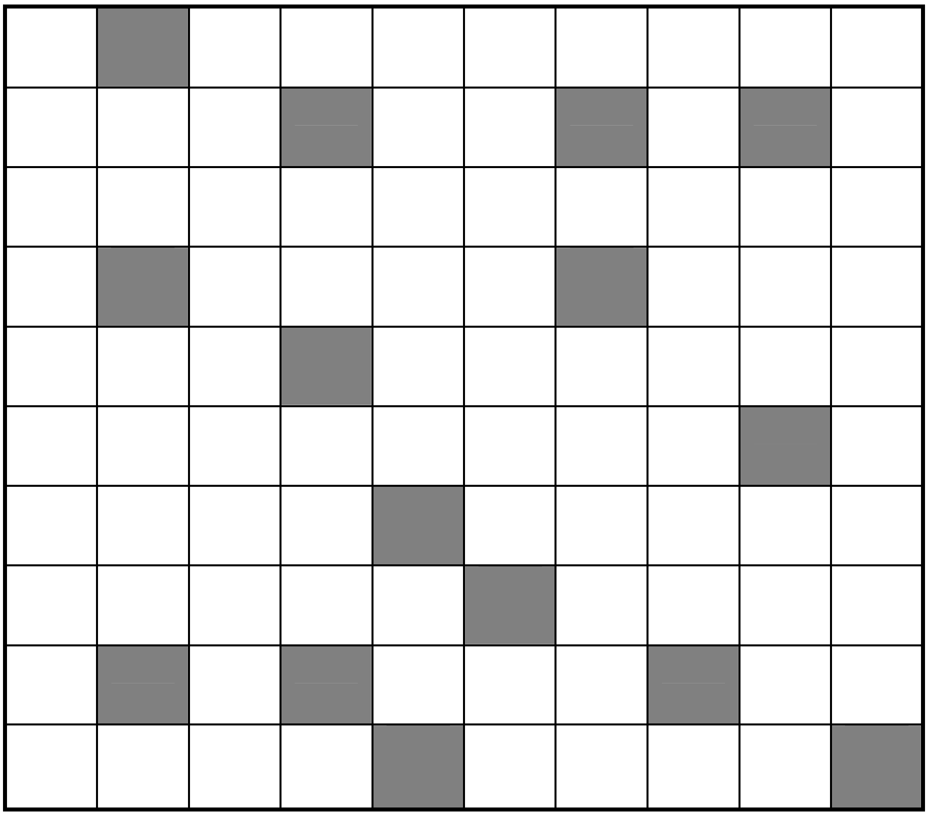
The chances of a hurricane during a one week holiday in Anguilla are 5 in 100. In other words, if you were to come on a week holiday here 100 times, then you should expect that a hurricane would happen during 5 of those weeks.

10 in 100 chance of a hurricane



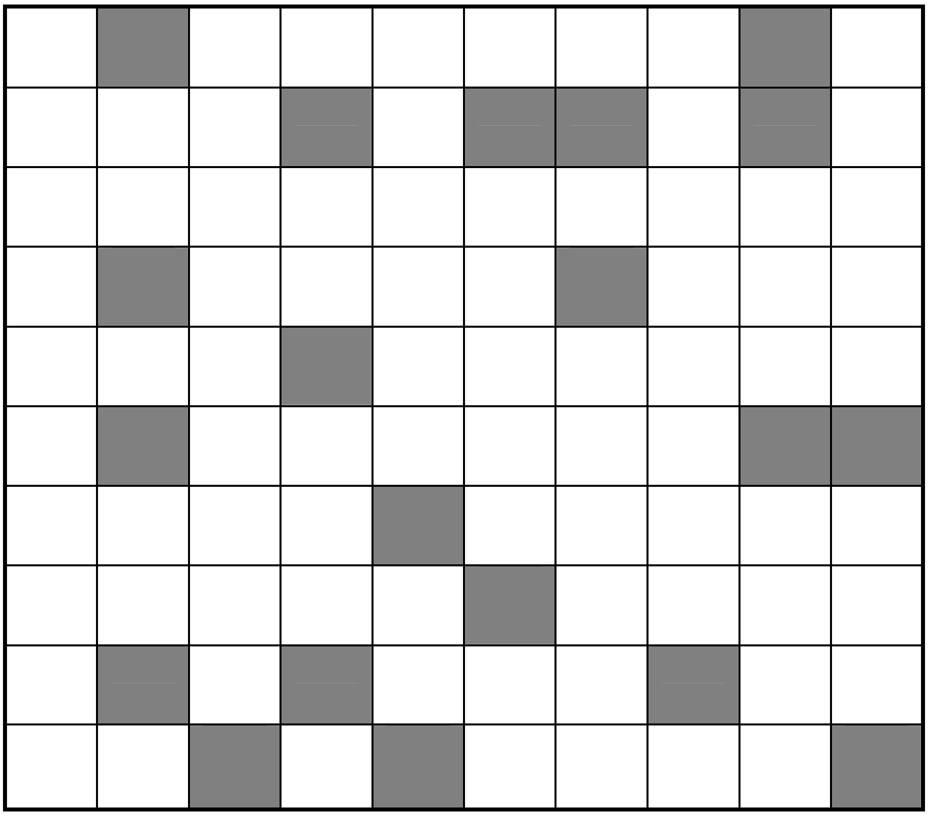
The chances of a hurricane during a one week holiday in Anguilla are 10 in 100. In other words, if you were to come on a week holiday here 100 times, then you should expect that a hurricane would happen during 10 of those weeks.

15 in 100 chance of a hurricane



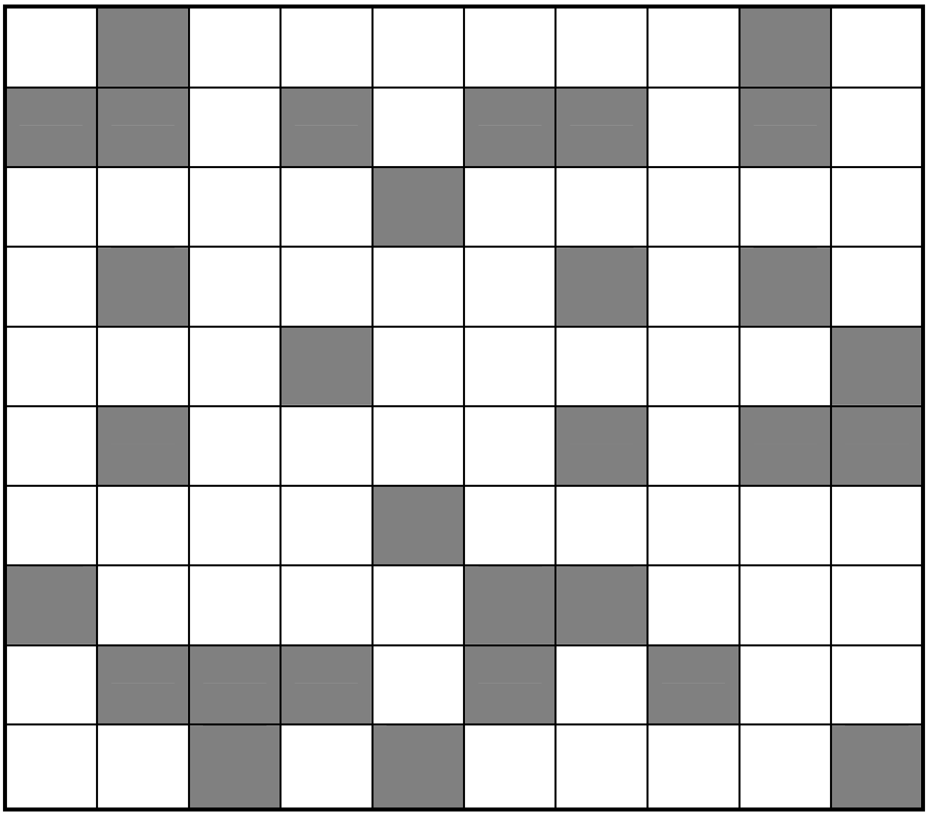
The chances of a hurricane during a one week holiday in Anguilla are 15 in 100. In other words, if you were to come on a week holiday here 100 times, then you should expect that a hurricane would happen during 15 of those weeks.

20 in 100 chance of a hurricane



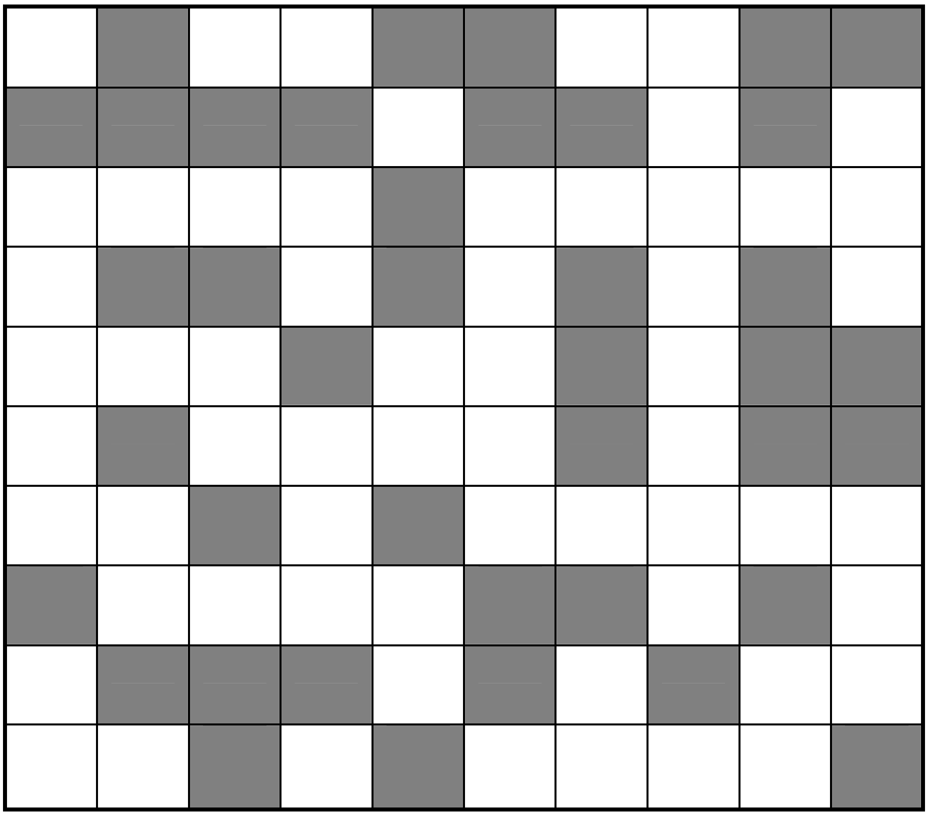
The chances of a hurricane during a one week holiday in Anguilla are 20 in 100. In other words, if you were to come on a week holiday here 100 times, then you should expect that a hurricane would happen during 20 of those weeks.

30 in 100 chance of a hurricane



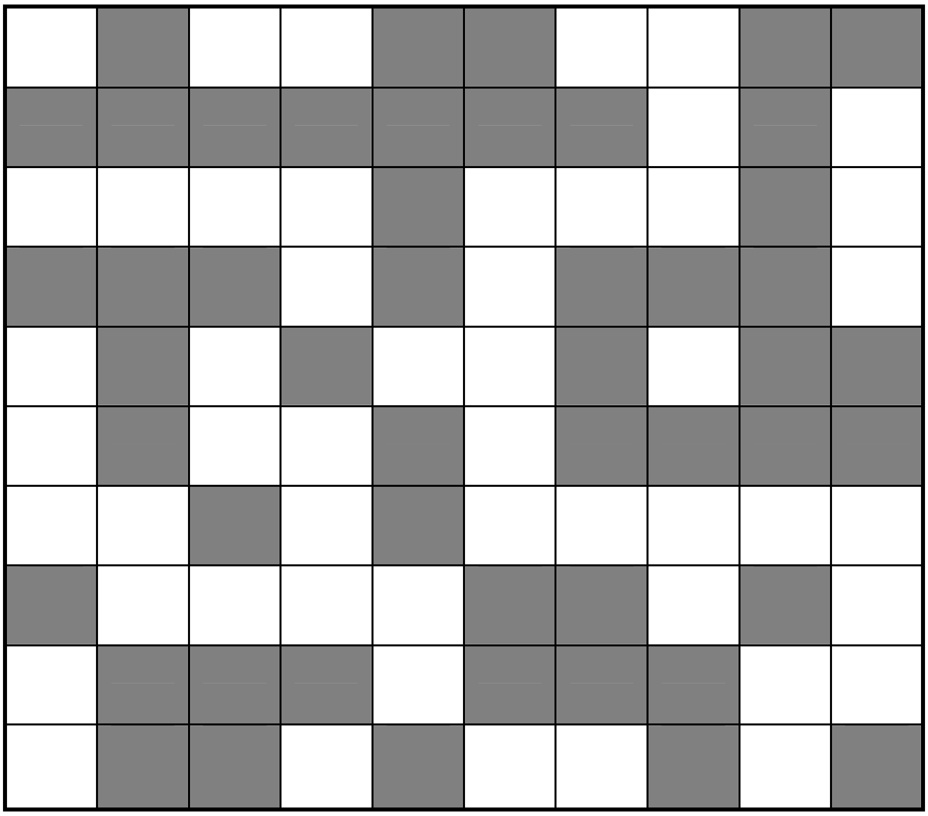
The chances of a hurricane during a one week holiday in Anguilla are 30 in 100. In other words, if you were to come on a week holiday here 100 times, then you should expect that a hurricane would happen during 30 of those weeks.

40 in 100 chance of a hurricane



The chances of a hurricane during a one week holiday in Anguilla are 40 in 100. In other words, if you were to come on a week holiday here 100 times, then you should expect that a hurricane would happen during 40 of those weeks.

50 in 100 chance of a hurricane



The chances of a hurricane during a one week holiday in Anguilla are 50 in 100. In other words, if you were to come on a week holiday here 100 times, then you should expect that a hurricane would happen during 50 of those weeks.

PILOT PRICE CARD

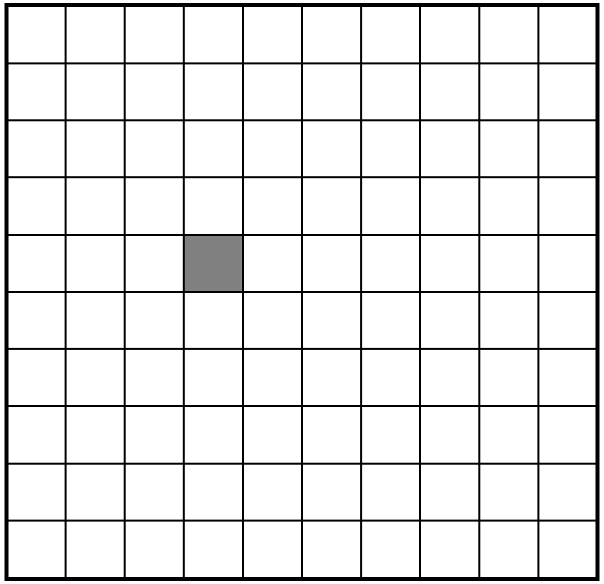
Price in US Dollars	Price in UK Sterling	Price in Euro
Less than 1000	Less than 500	Less than 670
1000	500	670
1500	750	1005
2000	1000	1340
2500	1250	1675
3000	1500	2010
3500	1750	2345
4000	2000	2680
4500	2250	3015
5000	2500	3350
6000	3000	4020
7000	3500	4690
8000	4000	5360
9000	4500	6030
10,000	5000	6700
More than 10,000	More than 5,000	More than 6,700

FINAL CHOICE EXPERIMENT HURRICANE STRENGTH CARD

	Strength of Hurricane **Weak**	Strength of Hurricane **Medium**	Strength of Hurricane **Strong**
Beach/swimming days lost	1 ~ 2	3 ~ 4	7 minimum
Other outdoor activities possible	Yes	No	No
Flights from island	Yes	Yes	No

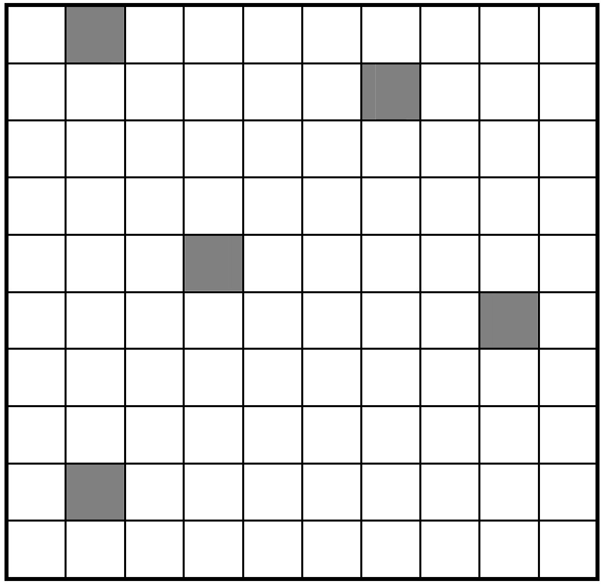
FINAL CHOICE EXPERIMENT HURRICANE FREQUENCY CARDS

1 in 100 or a low chance of a hurricane



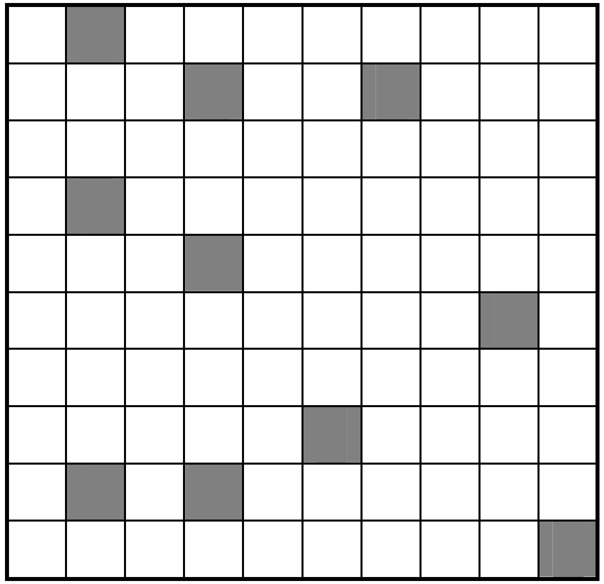
The chances of there being a hurricane during a one week holiday in Anguilla are 1 in 100. In other words, if you were to come on a week holiday here 100 times, then you should expect that a hurricane would happen once.

5 in 100 or a medium chance of a hurricane



The chances of there being a hurricane during a one week holiday in Anguilla are 5 in 100. In other words, if you were to come on a week holiday here 100 times then you should expect that a hurricane would happen 5 times

10 in 100 or a high chance of a hurricane



The chances of there being a hurricane during a one week holiday in Anguilla are 10 in 100. In other words, if you were to come on a week holiday here 100 times then you should expect that a hurricane would happen

Appendix D

Interview respondent codes for fishers (Chapter 5). Prefix letters refer to the harbour at which each is based. Interview date, fishing harbour and fishing strategies used are given for each respondent.

Interview date	Respondent code	Harbour	Fishing strategy
27.02.08	IH1	Island Harbour	fish/lobster traps, deep slope line fishing
27.02.08	C1	Crocus Bay	fish/lobster traps, inshore line fishing
05.03.08	S1	Sile Bay	lobster traps
10.03.08	CB1	Cove Bay	fish traps, deep slope line fishing
13.03.08	IH2	Island Harbour	lobster traps
13.03.08	IH3	Island Harbour	fish/lobster traps
13.03.08	IH4	Island Harbour	fish/lobster traps
19.03.08	IH5	Island Harbour	fish/lobster traps
20.03.08	IH6	Island Harbour	fish/lobster traps
20.03.08	CB2	Cove Bay	fish/lobster traps
21.03.08	IH7	Island Harbour	fish/lobster/crayfish traps, inshore line fishing
21.03.08	IH8	Island Harbour	fish/lobster/crayfish traps, inshore line fishing
31.03.08	IH9	Island Harbour	fish/lobster traps, inshore line fishing
01.04.08	SG1	Sandy Ground	fish/lobster traps, deep slope line fishing
01.04.08	CB3	Cove Bay	fish/lobster traps, inshore line fishing
02.04.08	CB4	Cove Bay	fish/lobster traps, inshore line fishing
03.04.08	IH10	Island Harbour	fish/lobster traps, inshore line fishing
03.04.08	IH11	Island Harbour	fish/lobster traps, inshore line fishing
08.04.08	BP1	Blowing Point	fish/lobster traps, deep slope line fishing
08.04.08	SG2	Sandy Ground	fish/lobster traps
08.04.08	SG3	Sandy Ground	fish traps, inshore line fishing
08.04.08	CB5	Cove Bay	fish/lobster traps
10.04.08	SG4	Sandy Ground	fish/lobster traps, deep slope line fishing
10.04.08	SG5	Sandy Ground	fish/lobster traps, deep slope line fishing

Interview respondent codes for tourist operators (Chapter 5). Interview date, interview location (or the location at which each is based) and the type of marine tourism business are given for each respondent.

Interview date	Respondent codes	Interview location	Tourist operator business
04.03.08	T1	Shoal Bay	dive business
14.03.08	T2	Island Harbour	glass bottom boat
18.03.08	T3	Meads Bay	dive business
18.03.08	T4	Shoal Bay	beach equipment hire
20.03.08	T5	Sandy Ground	dive business
21.03.08	T6	Island Harbour	island day trip destination
22.03.08	T7	Island Harbour	glass bottom boat
25.03.08	T8	Sandy Ground	boat charter
02.04.08	T9	Crocus Bay	boat service - for snorkelers
02.04.08	T10	Sandy Ground	island day trip destination
04.04.08	T11	Sandy ground	boat charter
08.04.08	T12	Sandy Ground	island day trip destination
11.04.08	T13	Crocus Bay	boat charter

Consent form for fishers interviews

Thank you for participating in this survey. It provides me with invaluable data for my PhD research at the University of East Anglia.

Purpose of the study
The purpose of this study is to explore key factors influencing the future sustainability of coral reef dependent livelihoods in Anguilla under environmental change. To achieve this I will be assessing the extent to which the inshore coral reef fishery in Anguilla has been influenced by previous hurricane events and the changes these events have had on fishing practices. The types of questions I will be asking will relate to the day-to-day aspects of your work, past experiences, future aspirations, and the seasonality of your job.

I hope that these interviews will provide a clearer understanding of the types of decisions that fishers make, the constraints they face and the potential for adaptation, particularly in the face of changing environmental pressures on marine ecosystems in Anguilla. This information can then be used to develop more sustainable marine management, which takes into consideration the incentives and decisions of fishers.

Right to refuse or end participation in the study
If you agree to join this study, we can agree a time for an interview that is convenient for you. You can decide to participate in this study or not and have the right to refuse to answer any questions, or withdraw from the interview completely.

Study procedures
I will contact you to arrange a time and a place to meet. I expect the interview may take approximately an hour. My contact details are XXX@uea.ac.uk and my Anguilla phone number is XXX if you have any questions about this study, please don't hesitate to contact me.

Confidentiality
Your name or any facts that could identify you will not appear in any report of this study. All of your answers will be kept confidential and can not be traced back to you. The interview notes will be kept in a safe place that only I have access to.

Agreement
The project information was read and explained clearly, anything I didn't understand was explained to me and all my questions were answered.

Respondent agrees to participate? YES NO

Signature of participant :________________________________ Date: _________

OR verbal consent given, date/time/place ________

Fisher semi-structured interview guide

Date of interview:

		/			/	**0**	**8**

Surveyor name: ____________________

Survey site: ____________________ Survey number: ____________________

Respondent name: ____________________

Start time: ____________________ Finish time: ____________________

Respondent general characteristics

1. Gender: Male: ☐ Female: ☐
2. Age (circle): 18-24 25-34 35-44 45-54

   55-64 65-74 75 or over Refused
3. Marital status____________________
4. # of dependents in family (i.e. wife/husband & children under age 5)_____
5. Nationality: ____________________
6. How long have you lived in Anguilla? Always: ☐ No. years: ☐
7. What is the highest level of education you have reached? (circle)

   No education Primary Junior

   Secondary University Post-graduate

Occupation and aspirations:

1. Is fishing your only occupation?
2. What other livelihoods do you undertake? How long do you spend in each one?
3. Which is the most important livelihood and why?
4. How does this vary in and out of the hurricane season?
5. Were able to work during or after Hurricane Lenny (1999), or Hurricane Luis (1995)? If you were out of work, how long did this last? Were you able to take other employment?
6. Why did you become a fisher?
7. How long have you fished for a living?
8. What occupation did you have before you began fishing?
9. What is the family history of fishing?
10. Would you ever consider leaving fishing?
11. Do you know people who have left the reef fishery? Why did they leave?

Fishing effort:

1. What fishing gear do you own?
2. What fishing methods do you use? How long do you spend with each method/gear type (in and out of the hurricane season)?
3. Have your fishing methods altered during your lifetime? If so, why?
4. Do you fish alone or with others? If so, why?
5. What type of boat do you use? Do you own your boat?
6. How long does it take you to prepare gears/bait for each fishing trip, both in and out of the hurricane season?
7. How much do you spend on fuel per week/trip?
8. What other costs does fishing incur?
9. How many hours a day/week/month do you spend fishing (in and out of the hurricane season)? What determines this?

10. Are there constraints on your time spent fishing? Has your fishing effort changed during your fishing career?

Fishing location:

1. Where do you fish, and when?
    a. Show map of Anguilla (1:50,000 and 1:175,000 scale), and ask the respondent to mark on the map the fishing grounds they use, with the number of traps or fishing gear
    b. How many of these traps do you check each day at this time of year?
2. Have you always fished there?

Catches, perception of fish abundance, and market demand

1. What are your target species? Does this vary in and out of the hurricane season?
2. Have these changed during your fishing career?
3. Have you seen any changes in the number of fishes/lobsters?
4. Do you change your target species according to times of year? Which species and at what times of year do you switch, and why?
5. Can you always land target species?
6. Have you seen any changes (abundance/size) in your target species?
7. Are there fishes that you can no longer catch, but which used to be regularly caught?
8. What is your average catch per trip, in and out of the hurricane season (weight, species, $US). Has this changed?
9. What is a ‘good’ and ‘bad’ haul?
10. What is your worst and best ever catch?
11. Do you throw any of your catch back into the sea?
12. Are there any constraints (restrictions/regulations) on fishing in Anguilla?
13. Where do you sell your catch? Who to you sell to?
14. Can you always sell your catch?

15. What is your perception of the diet of people in Anguilla? What is the major source of protein for local people?

Perception of environmental change:

1. What condition would you say Anguilla’s coral reefs are in?
2. Are many corals bleached? Does coral bleaching concern you?
3. Has this changed during your lifetime?
4. What do you feel are the causes of change to the reefs?
5. Do you think reef condition affects fish?
6. How do you feel about hurricanes? If they got worse, how would you feel?
7. Have you heard of climate change? Does it concern you?

Consent form for tourist operator interviews

Thank you for participating in this survey. It provides me with invaluable data for my PhD research at the University of East Anglia.

Purpose of the study
The purpose of this study is to explore key factors influencing the future sustainability of coral reef dependent livelihoods in Anguilla under environmental change. To achieve this, my study aims to better understand the effect that tropical storms and hurricanes may have on coral reef tourism-dependent livelihoods. The types of questions I will be asking will relate to the day-to-day aspects of your work, past experiences, perceptions of the marine environment, and the seasonality of your job.

I hope that these interviews will provide a clearer understanding of the types of decisions that coral reef resource-users make, the constraints they face and the potential for adaptation, particularly in the face of changing environmental pressures on marine ecosystems in Anguilla. This information can then be used to develop more sustainable marine management, which takes into consideration the incentives and decisions of resource-users and livelihoods.

Right to refuse or end participation in the study
If you agree to join this study, we can agree a time for an interview that is convenient for you. You can decide to participate in this study or not and have the right to refuse to answer any questions, or withdraw from the interview completely.

Study procedures
I will contact you to arrange a time and a place to meet. I expect the interview may take approximately an hour. My contact details are XXX@uea.ac.uk and my Anguilla phone number is XXX if you have any questions about this study, please don't hesitate to contact me.

Confidentiality
Your name or any facts that could identify you will not appear in any report of this study. All of your answers will be kept confidential and can not be traced back to you. The interview notes will be kept in a safe place that only I have access to.

Agreement
The project information was read and explained clearly, anything I didn't understand was explained to me and all my questions were answered.

Respondent agrees to participate? YES NO

Signature of participant :________________________________ Date _______

OR verbal consent given, date/time/place ________

Tourist operator semi-structured interview guide

I am a researcher at the University of East Anglia in the UK. I am studying coral reef-dependent tourism livelihoods in Anguilla. I was wondering if you could spare about 45 minutes to answer some questions. **This is independent research and answers to all of the following questions are entirely confidential.** I would be happy to send you a short report of this project on completion if you are interested. If I use any terms that you do not understand, please feel free to ask me to clarify.

Date of interview:

		/			/	**0**	**8**

Surveyor's name: ____________________

Survey site: ____________________ Survey number: ____________________

Respondent's name, occupation and place of work: ______________________________

____

Start time: ____________________ Finish time: ____________________

Respondent background information

1. Gender: Male: ☐ Female: ☐

2. Nationality: ____________________

3. How long have you lived in Anguilla? Always? # years? ____________________

4. How long have you lived away from Anguilla? ____________________

5. Number of dependents in family
   (i.e. wife, husband, grandparents, extended family, children under 16)

____

____

Occupation

6. Is this your own business?______________________________

7. How many employees are there in this business?

Male	#	Full-time	#	Locals	#
Female	#	Part-time	#	Non-locals	#

8. How many people do you supervise?______________________________

9. For how many years has this business been open? | # | yrs

10. How long have you worked in this job? | # | yrs

11. What did you do before and for how long?________________________ | # | yrs

12. Currently, is this your only job? **(If No go to Q13)**

____

13. What other jobs do you have, and roughly, how many hours a week do you spend in each one?

____

____

14. If you have more than one job, which is most important to you and why?

____

____

15. Do you work in this job during the hurricane season? **Yes/No/Why?**

____

____

16. Do you have any additional employment during the hurricane season?
(If yes go to Q17, no go to Q18)

____

____

17. Which is the most important job to you during the hurricane season, and why?

____

18. Are your earnings any different during the hurricane season compared with the rest of the year? Why?

____

19. Are you able to support your family throughout the year? **Yes/No**

How? ____

20. Do you remember Hurricane **Lenny in 1999** and/or Hurricane **Luis in 1995**?

Hurricane Lenny____

____

Hurricane Luis ____

____

21. What job(s) did you have at this time?

____

____

22. Were able to work during and after these hurricanes? **Yes/No/Why/How long out of work?**

23. Are there alternative job opportunities for you in Anguilla?

24. What are the main occupations of the other members of your household?

Resource use and seasonal variation

25. Where do you take the tourists on dive trips/boat trips etc?

    a. Show map, and ask the respondent to mark on the map the area they take their customers.
    b. How often do you visit these areas at this time of year, and for other times of the year, if different?

26. How many hours a day/week/month do you spend working in this job? How does this vary in and out of the hurricane season?

Hours	**Out of hurricane season 1st Dec – 30th May**	**In hurricane season 1st June – 30th Nov**
Per day		
Per week		
Per month		

If there is a difference, why: ____

____

Tourist demand

27. Could you estimate the number of tourists and the average tourist spend for each month of the year? (Use takings as the variable if the average tourists spend is not available).

Month	Jan	Feb	Mar	Apr	May	Jun
Number of tourists						
Tourists spend per month						

Month	Jul	Aug	Sept	Oct	Nov	Dec
Number of tourists						
Tourists spend per month						

28. What are the main nationalities of your customers? (%)

____

29. How many customers do you have each year? What are the yearly takings? **(Fill in as much as possible)**

Year:	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**
Number of tourists									
Annual takings									

	1995	**1994**	**1993**	**1992**	**1991**	**1990**
Number of tourists						
Annual takings						

30. Do you think the hurricane season affects tourism?

Yes [1] No [0]

Why/How? ____________________________________

____

Perception of coral health and fish abundance

31. a)What condition would you say the reefs are in that you take tourists to?

____

____

b) And using this scale, what is the condition of the reefs you visit?

Very good	**Good**	**Fair**	**Poor**	**Very poor**
5	4	3	2	1

32. Are many corals bleached (%)? ____

33. Acropora abundance (%)? ____

34. Diadema abundance (%)? ____

35. Has this changed over the last 10/20/30/40 years? (years dependent on respondent's knowledge)

____

36. What do you feel are the causes of change to the reefs?

____

____

37. Do you think reef condition affects abundance of fishes?

____

____

38. Do you think that reef condition affects this/your business? How?

____

____

Demographic Information

39. Could you tell me which age group best applied to you? **(Circle)**

	Age in years
1	18-24
2	25-34
3	35-44
4	45-54
5	55-64
6	65-74
7	75 or over
8	Refused

40. Could you tell me which education level best applies to you? **(Circle)**

	Education
1	I left school aged 16 or younger
2	I left school aged 18
3	I have a vocational qualification
4	I have a university or college degree
5	I have a PhD/doctorate

End of survey - thank you so much for your time!

Appendix E

Consent form and survey guide for representatives from UK and UK Overseas Territories governments, and non-governmental organisations (Chapter 6).

University of East Anglia

Consent form

Research project on the vulnerability of small Caribbean islands to climate change: focussing on tourism and marine and coastal resource use.

Please put a tick or cross in the relevant boxes

I, …………………………………… [participant's name] agree that this interview material may be used by the research team at the University of East Anglia [Johanna Forster, Prof Andrew Watkinson, Dr Jenny Gill, Dr Iain Lake]	
I have read and understood the background information.	
I agree that my name may be cited in the research.	
Or	
I would prefer to remain anonymous.	
I agree that the contents of the interview may be used for this research project, and for associated work relating to this research project: in any subsequent presentations, reports and publications.	
I am willing to be contacted again to participate in future stages of the project if necessary.	
I understand that I can withdraw consent for this interview to be used at any point by contacting Johanna Forster.	
I would like to receive a copy of this statement.	

Signature of participant……………………………………………Date…………………

Signature of researcher…………………………………………...Date…………………

Contact: Johanna Forster
Post Graduate Researcher (PhD)
Climatic Research Unit
School of Environmental Sciences
University of East Anglia
Norwich
NR4 7TJ
Tel: XXXX
Email: XXX@uea.ac.uk

CRU Tyndall°Centre for Climate Change Research

UKOT and UK spokesperson interview guide

Background information:
This research project explores the vulnerability of small Caribbean islands to climate change, focussing on the dependency of local communities on marine and coastal resources, in particular relating to the tourism industry. Small islands may be particularly vulnerable to climate change because of their geophysical characteristics, the coastal positioning of many of their settlements and infrastructure and their dependency on a narrow range of economic activities that rely on fragile natural resources, specifically coral reef fisheries and tourism.

The aim of this research project is to better understand environmental governance in the Caribbean UK Overseas Territories, in particular with regards to managing coastal and marine biodiversity, and the impacts of climate change.

This research is entirely independent and will be used for my PhD thesis. You have the option to remain anonymous in any published material produced as a result of this interview. Personal information will only be accessible to the named research team and will be held in confidence. The session will be recorded to ensure that all of your comments are captured. Participation in this research is completely voluntary and you are at liberty to withdraw at any time.

Your participation in this research is greatly appreciated,

Johanna Forster

UEA PhD researcher

Survey guide

Note: For this interview I'd like to limit the discussion to UK Overseas Territories in the Caribbean.

1. How would you describe the current status of marine and coastal biodiversity in the UK Overseas Territories (UKOTs) in the Caribbean? (Ideally for the islands as a group, but specifics are of interest also).

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And then using this scale, 1 = very poor to 5 = very good

Very Poor	Poor	Fair	Good	Very Good
1	**2**	**3**	**4**	**5**

2. Please rank in order of importance, the direct threats (e.g. overfishing, temperature rise, hurricanes, and invasive species) to the marine and coastal environment in the Caribbean UKOTs? (Immediate threats mean during the next 5-10 years and long term to mean from 10+ years).

	Top 3 immediate threats	**Top 3 long term threats**
1		
2		
3		

3. Given the threats we have just talked about, how important do you consider climate change as a threat to marine and coastal biodiversity conservation, and sustainable resource use and development in the Caribbean UKOTs?

	To Biodiversity Conservation	**Sustainable marine resource use and development**
Short term threat	Most important	Most important
(5 – 10 years)	Fairly important	Fairly important
	Lesser important	Lesser important
Long term threat	Most important	Most important
(10+ years)	Fairly important	Fairly important
	Lesser important	Lesser important

4. What climate change impacts or climate/weather variables are of most concern in the Caribbean UKOTs, and on what time scales? Please rank the top three for each of the two time scales.

	Short term (5 – 10yrs) climate threat	**Rank**
A	Temperature	
B	Rainfall variations	
D	Hurricane frequency (more storms)	
E	Hurricane intensity (stronger storms)	
F	Sea-level rise	
G	Storm surge	
H	Sea surface temperature rise	
I	Other	
	Long term (10+ years) climate threat	**Rank**
A	Temperature	
B	Rainfall variations	
D	Hurricane frequency (more storms)	
E	Hurricane intensity (stronger storms)	
F	Sea-level rise	
G	Storm surge	
H	Sea surface temperature rise	
I	Other	

5. (a) Which socio-economic sectors are particularly threatened by climate change impacts and marine and coastal biodiversity loss within the Caribbean UKOTs?

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(b) Is anything being done (by the UK government, or another organisation) to tackle these problems?

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6. (a) Does the UK Government provide resources to deal with the issue of marine and coastal biodiversity conservation, sustainable marine and coastal resources and climate change impacts in the Caribbean UKOTs? (e.g. management strategies, regulations, financial aid, and expertise.)

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   (b) What are these resources?

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   (c) How do you feel about the current level of resources being provided by the UK government (or other funding bodies)?

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7. a) The RSPB's 2007 report 'Costing biodiversity priorities in the UKOTs' suggests that funding for OTEP, at around £1 million per year, is insufficient to meet UKOTs biodiversity needs. RSPB reports that the costs are actually around £16.1 million per year (for 2007 – 2011). What are your views on this?

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8. (a) How do you think marine and coastal biodiversity conservation in the UKOTs in the Caribbean compares to similar islands that are independent countries without Overseas Territory status? Or compared to other EU overseas territories/outermost regions?

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(b) And how about for the sustainability of marine and/or coastal resources?

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9. How do you view the future status of marine and coastal biodiversity and marine and coastal resource sustainability in the Caribbean UKOTs?

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10. What are the key messages the UK Government is sending its Overseas Territories in the Caribbean (or other UKOTs) regarding marine and coastal management, biodiversity conservation, and climate change?

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11. DFID/FCO was not present at the IUCN Réunion Island conference on Climate change and biodiversity in the European Union Overseas Entities in July 2008. What are your thoughts regarding this?

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Any other comments: