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Island-specific preferences of tourists for environmental features: implications of climate change for tourism-dependent states

MARIA C. UYARRA[1], ISABELLE M. CÔTÉ[1]*, JENNIFER A. GILL[1,2,3], ROB R.T. TINCH[2,4], DAVID VINER[5] AND ANDREW R.WATKINSON[1,2,3]

[1]*Centre for Ecology, Evolution and Conservation, School of Biological Sciences, University of East Anglia, Norwich NR4 7TJ, UK,* [2]*School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK,* [3]*Tyndall Centre for Climate Change Research, Norwich NR4 7TJ, UK,* [4]*The Macaulay Land Use Research Institute, Aberdeen AB15 8QH, UK and* [5]*Climatic Research Unit, University of East Anglia, Norwich NR4 7TJ, UK*

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SUMMARY

Climate change may affect important environmental components of holiday destinations, which might have repercussions for tourism-dependent economies. This study documents the importance of environmental attributes in determining the choice and holiday enjoyment of tourists visiting Bonaire and Barbados, two Caribbean islands with markedly different tourism markets and infrastructure. Three hundred and sixteen and 338 participants from Bonaire and Barbados, respectively, completed standardized questionnaires. Warm temperatures, clear waters and low health risks were the most important environmental features determining holiday destination choice. However, tourists in Bonaire thereafter prioritized marine wildlife attributes (i.e. coral and fish diversity and abundance) over other environmental features, whereas tourists in Barbados exhibited stronger preferences for terrestrial features, particularly beach characteristics. The willingness of tourists to revisit these islands was strongly linked to the state of the preferred environmental attributes. More than 80% of tourists in Bonaire and Barbados would be unwilling to return for the same holiday price in the event, respectively, of coral bleaching as a result of elevated sea surface temperatures and reduced beach area as a result of sea level rise. Climate change might have a significant impact on Caribbean tourism economy through alteration of environmental features important to destination selection. Island-specific management strategies, such as focusing resources on the protection of key marine or terrestrial features, may provide a means of reducing the environmental and economic impacts of climate change.

Keywords: Caribbean, climate change, coral bleaching, environment management, sea level rise, tourism

* Correspondence: Dr Isabelle M. Côté Tel: +44 1603 593172 Fax: +44 1603 592250 e-mail: i.cote@uea.ac.uk

INTRODUCTION

Climate change can potentially have a major effect on global patterns of tourism because environmental considerations are a significant component of decision-making regarding holiday destinations (Braun *et al*. 1999). In some locations, increasingly favourable climatic conditions for tourism could have a beneficial impact on local economies if tourists respond to these changes by altering their choice of destination. However, changing climatic conditions and consequent environmental changes may also reduce the attractiveness of some holiday destinations. Several studies have examined the extent to which climate change can affect the economy of a country through its effect on environmental features. For example, exposure to sea level rise is likely to cause flooding of some coastal areas and affect infrastructure (Mimura 1999; Parsons & Powell 2001). In Scotland, the Alps, North America and Australia, changes in the duration and spatial distribution of snow may reduce revenue from recreational winter sports (Whetton *et al*. 1996; Abegg *et al*. 1998; Breiling & Charamza 1999; Harrison *et al*. 2001; Scott *et al*. 2003). In tropical coastal areas, where environmental features such as warm temperatures, coral reefs and beaches are strongly promoted by the tourist industry, global warming could impact on economies that are heavily dependent on tourism (Braun *et al*. 1999; Agnew & Viner 2001).

Over the past few decades, Caribbean islands have become extremely popular tourist destinations. Between 1981 and 1995, the number of stopover visits to the Caribbean increased from six million to 14.7 million (Beekhuis 1981; UNEP [United Nations Environment Programme] 1997). Tourism generates an average of 25.5% of the gross domestic product (GDP) of Caribbean islands and employs 2.37 million people (22.2% of total employment; UNEP 1997). The Caribbean region as a whole has become one of the most tourism-dependent regions in the world (European Commission 2002).

There is already some evidence that the Caribbean climate is changing in ways that may affect tourism. Mean atmospheric temperature in the eastern Caribbean has increased by 0.2–0.4°C per decade since 1976, and recent models indicate that it might rise by 1.4–5.8°C in the next century (IPCC [Intergovernmental Panel on Climate Change] 2001). Such

changes might cause discomfort for tourists (Balafoutis & Makrogiannis 2001; Morabito *et al.* 2005; Zaninovic & Matzarakis 2005) and encourage the spread of disease-transmitting mosquitoes (Hopp & Foley 2001), although the risk of increase in tropical diseases in the Caribbean, which is largely free of malaria (Nicolas *et al.* 2003), is unknown. Increases in sea temperatures have been linked to coral bleaching events (Hoegh-Guldberg 1999; Reaser *et al.* 2000), which have adversely affected reef fish compositions and aesthetic values of coral reefs (for example Wilkinson *et al.* 1999), as well as net revenue of some diving resorts (for example Cesar 2000). Specific predictions are difficult to make but the frequency, intensity and/or seasonality of hurricanes may be altered in future (IPCC 2001). The impact of these on beach erosion is not clear, but coastal development and the building of protective piers may restrict the scope of beaches to retreat landward in the face of storm surge and sea level rise, causing a reduction in beach area with potential economic and biodiversity consequences (Cambers 1999; Fish *et al.* 2005).

Bonaire and Barbados are two tourism-dependent islands in the eastern Caribbean, whose economies may be vulnerable to climate change. Tourism in Bonaire is growing by 7–10% annually (UNESCO [United Nations Educational, Scientific and Cultural Organization] 1997) and provides 40% of the GDP of the island (F. Simal, personal communication 2002). By contrast, the economy of Barbados is more diverse, with tourism contributing 12.3% to GDP (Sealey 2001). The islands differ greatly in their tourism strategies. The mass beach-oriented tourism of Barbados contrasts with the more environmentally-friendly tourism developed in Bonaire based on the pristine state of the island's coral reefs (Dixon *et al.* 1993). These differing strategies should give rise to contrasting clienteles with varying levels of interest in environmental features potentially affected by climate change.

The aim of this paper is to quantify the characteristics of the tourism markets and the importance of different environmental features to tourists on Bonaire and Barbados, in order to assess the range of implications of climate-induced environmental changes for Caribbean tourism. We first characterize tourists, and particularly their involvement in different holiday activities, and quantify the relative importance of 16 environmental attributes to visitors of these islands. We then focus on the environmental features identified as important, and likely to be severely impacted by climate change, to assess potential consequences for the tourism industries of the two islands. Our ultimate purpose is to propose island-specific environmental management strategies to limit any direct or indirect negative impacts of climate change on the islands' tourism industries.

METHODS

Study sites

The study was conducted from April to June 2002 on the islands of Bonaire (12°10′ N, 68°15′ W) and Barbados (13°05′ N, 59°37′W). Bonaire is a small (180 km^2), low-lying and sparsely populated island (37 inhabitants km^{-2}), 80 km north of Venezuela. The island lies south of the main hurricane belt, hence seasonality is not marked. The climate is arid (56 cm rain yr^{-1}) and the terrestrial habitat (only 8% of land area is developed) is dominated by low, thorny vegetation. Twenty per cent of the land area (6000 ha) has been designated as a national park since 1977, while 100% of the waters surrounding Bonaire and its satellite island, Klein Bonaire, have been protected to 60 m depth since 1979 (Spalding *et al.* 2001). In 2000, there were 50 395 tourist arrivals to Bonaire (TCB [Tourism Corporation Bonaire] 2001).

Barbados, the easternmost Caribbean island, is slightly larger (430 km^2) than Bonaire but has a similar, low-lying profile. In Barbados, climatic seasonality is marked, with heavier precipitation (142 cm yr^{-1}) concentrated in the summer and autumn. More than 85% of the land has been developed for urban or agricultural use and native vegetation is confined to a few patches in the central hills. Population density (623 inhabitants km^{-2}) is the highest in the Caribbean (UNEP 1998). Only 6.5% of the land area is protected for conservation, and a single 250-ha marine reserve exists on the west coast of the island (Spalding *et al.* 2001). In 2000, 544 696 tourists visited Barbados (BTA [Barbados Tourism Authority] 2001).

Visitor surveys

On both islands, we surveyed tourists in airports, hotels, dive shops, and beaches using standardized questionnaires. We initially tested the questionnaires on each island by collecting responses from three sets of 20 respondents, refining the questionnaire progressively to the specific nature of each island. We distributed the questionnaires in English and Spanish.

The final questionnaires comprised three parts. The first section asked for general information related to the tourist market of each island. We then asked tourists to use a 5-point Likert scale (1 = not at all important, 2 = slightly important, 3 = important, 4 = very important, 5 = extremely important) to indicate how important 16 environmental attributes were in selecting Bonaire or Barbados as a holiday destination. In addition, we asked whether the same attributes affected negatively, neutrally, or positively the respondent's enjoyment of the holiday. The attributes considered were derived partly from Shafer and Inglis (2000) and a review of the impacts of climate change on tropical coasts (Uyarra 2002), and were specifically designed to reflect features known to be important to tourists on tropical islands and key environmental features likely to be influenced by climate change and associated sea level rise. The 16 attributes were related to marine wildlife (for example fish diversity, coral health, presence of turtles), beach structure, presence of tropical diseases, temperature, water clarity, landscape characteristics, number of tourists and bird diversity. We included one question to gauge the willingness of tourists to pay the same price to return to Bonaire or Barbados if key environmental attributes identified in the preliminary surveys, namely coral reefs and beaches,

were negatively affected by climate change. Thus, we offered respondents scenarios of coral suffering 'severe bleaching and mortality' and/or beaches which had 'largely disappeared' as a result of sea level rise. On both islands, the survey period covered the last month of the high season and the beginning of the low season.

Statistical analyses

Respondent ages and incomes were recorded in categories. Holiday cost was expressed as price per day, to control for variation in length of stay. All incomes and costs were calculated in US$.

We first assessed the relative importance of the 16 environmental attributes in influencing tourists' choice and enjoyment of their holiday destination with pairwise comparisons of Likert scores on both islands. To account for multiple comparisons, we adjusted the critical p values using Bonferroni corrections.

We then carried out two separate principal components analyses (PCAs) (with Varimax rotation) of the Likert scores relating to destination choice and holiday enjoyment. These PCAs allowed the 16 attributes to be grouped into four factors containing related variables. Likert scores for attributes within each factor were averaged first within respondents, and second within factors, and then subject to inter- and intra-island comparisons. The clumping of attributes within the four factors was identical in the PCAs of destination choice and holiday enjoyment, so only the former is presented in this paper.

RESULTS

Tourist and market characteristics

Seventy-one per cent of visitors approached in Bonaire and 82% in Barbados completed the questionnaires. The surveys yielded 316 usable questionnaires (55% males, 45% females) from Bonaire and 338 (42% males, 58% females) from Barbados. Not all sections were completed in all usable questionnaires.

The tourism markets on Bonaire and Barbados differed markedly in a number of key characteristics. The age structure of tourists differed significantly between the two islands (Kolmogorov Smirnov test, $\chi^2_6 = 64.5$, $p < 0.001$), with tourists on Barbados being significantly younger (median age category 31–40 years) than those on Bonaire (median 41–50 years). The distribution of household income was also different between islands (Kolmogorov Smirnov test, $\chi^2_5 = 24.2$, $p < 0.001$). Although the income of tourists on Bonaire was similar to that of tourists on Barbados (median US$ 50 000–90 000 per annum), more people on Barbados than on Bonaire reported incomes of < US$ 50 000 (37% in Barbados versus 23% in Bonaire), with the converse occurring for incomes of >US$ 90 000. Visitors to Bonaire were predominantly American (65%) or Dutch (22%), whereas in Barbados, tourists were mainly British (72%) or American (15%) nationals.

Holidays were significantly more expensive in Bonaire than in Barbados (mean cost per day ± SD, Bonaire: US$ 240 ± 179, Barbados: US$ 166 ± 130; $t_{613} = 7.52$, $p < 0.001$) and included different activities. In Bonaire, the main activities included were dive packages and, on rare occasions, windsurfing. By contrast, water sports (windsurfing, jet skiing, snorkelling and sailing), catamaran trips, golf and turtle watching were the most frequent activities included in Barbados packages.

A key difference between tourists on the two islands was their level of involvement in marine-based holiday activities. Only three tourists (<1%) in Bonaire did not practise snorkelling during their holiday, whereas in Barbados, more than one-third (115 of 338) of respondents did not snorkel. Significantly more people engaged in scuba diving in Bonaire (251 individuals, 79%) than in Barbados (62 individuals, 18%) ($\chi^2_1 = 248.0$, $p < 0.001$), and divers in Bonaire were more experienced than those in Barbados, based on the number of total dives that they had logged (mean number of dives ± SD, Bonaire: 153 ± 305 dives, Barbados: 115 ± 31 dives; $t_{250} = 9.38$, $p < 0.001$). Finally, a significantly greater proportion of respondents in Bonaire (77 individuals, 24%) than in Barbados (30 individuals, 9%) were members of environmental organizations ($\chi^2_1 = 29.1$, $p < 0.001$).

Importance of environmental attributes to tourists

We found significant differences between islands in the Likert scores for 10 of the 16 environmental attributes in terms of their contribution to holiday destination choice (Table 1). In general, tourists in Bonaire scored attributes relating to marine wildlife more highly than tourists in Barbados, whereas the latter placed more importance on terrestrial environmental features, particularly those relating to beaches. Clear water and bird diversity were similarly rated on both islands, and provided the highest and lowest incentives, respectively, for visiting Bonaire and Barbados.

All environmental attributes had positive effects on holiday enjoyment (i.e. no attribute scored < 2.0; Table 1). However, marine wildlife attributes contributed significantly more to holiday enjoyment on Bonaire than on Barbados, while visitors to Barbados derived more enjoyment from land-related features (Table 1). Interestingly, on Barbados clear waters and the presence of sea turtles contributed more to holiday enjoyment than on Bonaire (Table 1).

The PCA of scores relating to destination choice reduced the 16 environmental attributes to four main factors (Table 2) broadly relating to marine wildlife (Factor 1, six attributes), health (Factor 2, three attributes), terrestrial features (Factor 3, four attributes), and weather and sea conditions (Factor 4, two attributes) and accounting for 31.6, 17.5, 15.3 and 10%, respectively, of the variance. Only 'low numbers of tourists' was not clearly aligned with any factor (Table 2).

Table 1 Importance of 16 environmental attributes in the choice of destination (Likert scores, 1 = not important to 5 = extremely important) and enjoyment of holiday (1 = negative, 2 = neutral, 3 = positive) for tourists visiting Bonaire ($n = 316$) and Barbados ($n = 338$). Mean scores are given (±1 SD). Inter-island differences were tested with Mann-Whitney U tests. All significant p-values remained so after Bonferroni correction.

Environmental attribute	*Contribution to choice of destination*			*Contribution to enjoyment of holiday*		
	Bonaire	*Barbados*	*p*	*Bonaire*	*Barbados*	*p*
Coral diversity	4.10 (1.19)	2.79 (1.31)	< 0.001	2.81 (0.43)	2.43 (0.67)	< 0.001
Coral cover	4.13 (1.22)	2.88 (1.38)	< 0.001	2.69 (0.60)	2.40 (0.69)	< 0.001
Coral health	3.98 (1.17)	2.81 (1.35)	< 0.001	2.63 (0.59)	2.43 (0.67)	< 0.001
Fish diversity	4.23 (1.12)	3.03 (1.41)	< 0.001	2.76 (0.53)	2.56 (0.63)	< 0.001
Fish abundance	4.18 (1.14)	2.98 (1.38)	< 0.001	2.70 (0.60)	2.54 (0.68)	0.006
Presence of sea turtles	3.28 (1.34)	3.07 (1.40)	0.076	2.37 (0.75)	2.64 (0.58)	< 0.001
Bird diversity	2.50 (1.28)	2.77 (1.31)	0.009	2.43 (0.58)	2.35 (0.59)	0.11
Landscape attractiveness	2.85 (1.30)	3.87 (1.00)	< 0.001	2.33 (0.67)	2.70 (0.56)	< 0.001
Water clarity	4.46 (0.88)	4.46 (0.80)	0.629	2.65 (0.63)	2.84 (0.43)	< 0.001
Air temperature	4.21 (1.00)	4.43 (0.79)	0.004	2.67 (0.55)	2.77 (0.49)	0.009
Few tropical diseases	3.90 (1.33)	3.97 (1.28)	0.606	2.63 (0.52)	2.72 (0.49)	0.028
No malaria	3.98 (1.35)	4.03 (1.32)	0.666	2.69 (0.47)	2.73 (0.48)	0.158
No vaccination requirements	3.96 (1.31)	3.89 (1.40)	0.682	2.67 (0.48)	2.68 (0.52)	0.554
Beach size	2.79 (1.20)	3.92 (1.10)	< 0.001	2.07 (0.69)	2.75 (0.54)	< 0.001
Sand quality	2.87 (1.27)	4.27 (0.90)	< 0.001	2.06 (0.71)	2.86 (0.39)	< 0.001
Low number of tourists	3.68 (1.12)	3.64 (1.16)	0.764	2.64 (0.54)	2.60 (0.58)	0.613

In agreement with the univariate analyses, tourists in Barbados and Bonaire differed significantly in 'marine wildlife' ($U_{585} = 20058$, $p < 0.001$) and 'terrestrial features' scores ($U_{585} = 18089.5$, $p < 0.001$; Fig. 1*a*). Marine wildlife was significantly more important in destination choice for tourists in Bonaire than those in Barbados, who were significantly more attracted to land and beach features (Fig. 1*a*). There were no significant differences in the importance placed on 'health' ($U_{585} = 42281$, $p = 0.76$) and 'weather and sea conditions' ($U_{585} = 42490$, $p = 0.84$) between the two islands (Fig. 1*b*).

However, at both locations, the 'weather and sea conditions' factor was significantly more important for destination choice than all other factors (Fig. 2*a*, *b*). The importance ranking of

Table 2 Loadings of 16 environmental attributes on principal components factors explaining choice of holiday destination by tourists on Bonaire and Barbados. Loadings <0.2 are not shown. Attributes in bold script are considered to characterize the relevant factor.

Environmental attribute	*Principal components*			
	Factor 1: Marine wildlife	*Factor 2: Health conditions*	*Factor 3: Terrestrial features*	*Factor 4: Weather and sea conditions*
Coral diversity	**0.92**			
Coral cover	**0.92**			
Coral health	**0.93**			
Fish diversity	**0.94**			
Fish abundance	**0.93**			
Sea turtles	**0.67**		0.31	
Bird diversity	0.37		**0.61**	
Landscape attractiveness			**0.76**	
Water clarity	0.25			**0.79**
Air temperature				**0.84**
Few tropical diseases		**0.92**		
No malaria		**0.95**		
No vaccination requirements		**0.90**		
Beach size			**0.77**	0.21
Sand quality	− 0.21		**0.79**	0.25
Low numbers of tourist		0.31	0.25	0.23

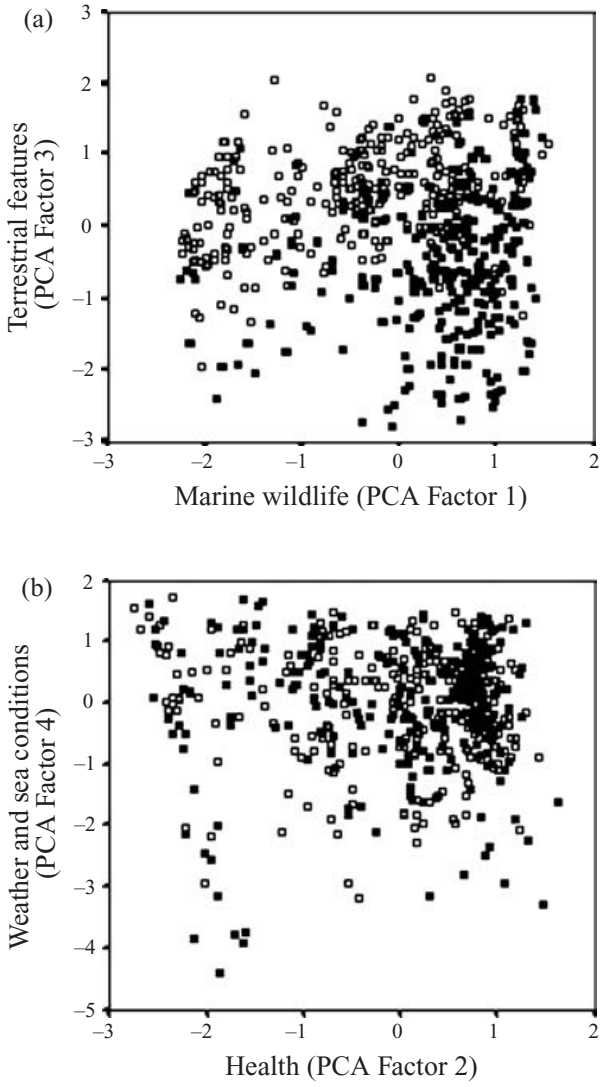

Figure 1 Relative importance of (*a*) marine wildlife (PCA Factor 1) and terrestrial features (PCA Factor 3), and (*b*) health (PCA Factor 2) and weather and sea conditions (PCA Factor 4) in the choice of holiday destination by tourists visiting Bonaire (filled squares) and Barbados (open squares). Positive values indicate the importance of each factor to each respondent and negative scores reflect a lack of importance.

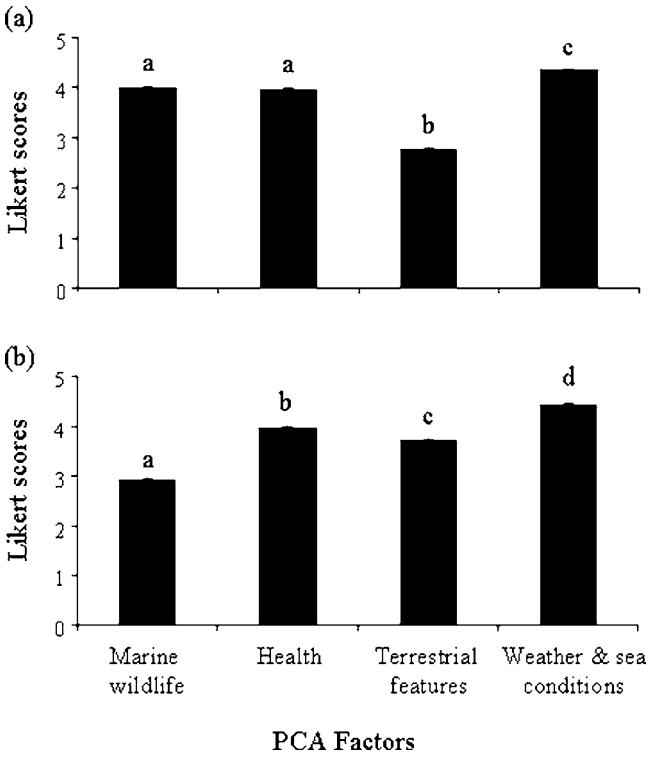

Figure 2 Likert scores (1 = not important to 5 = extremely important) for four PCA factors describing environmental attributes affecting the choice of holiday destination by tourists in (*a*) Bonaire ($n = 318$), and (*b*) Barbados ($n = 336$). Means ± 1 SE. Means with different superscripts were significantly different ($p < 0.05$) in Mann-Whitney U tests after Bonferroni corrections.

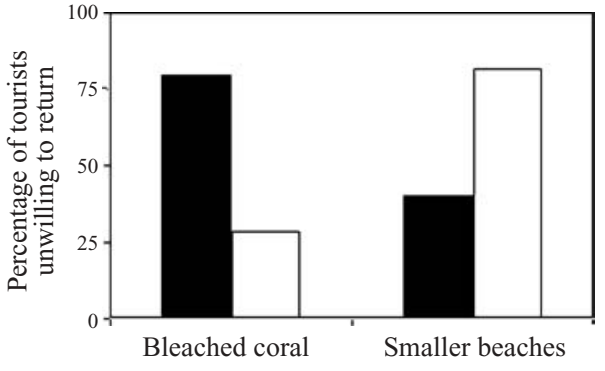

Figure 3 Percentage of tourists unwilling to return to either Bonaire (filled bars) Barbados (open bars) for the same holiday cost if coral bleaching or beach loss occurs as a result of climate change.

the other three factors differed between islands. In Bonaire, 'marine wildlife' and 'health' scored similarly highly, and both were significantly more important than 'terrestrial features' (Fig. 2*a*). By contrast, for tourists in Barbados, 'health' was significantly more important than 'terrestrial features', which in turn was significantly more important than 'marine wildlife' (Fig. 2*b*).

Potential impact of climate change on willingness to revisit islands

Significantly more tourists in Bonaire would not return to this island for the same price if corals were severely bleached as a result of increasing sea temperatures than if beaches largely disappeared as a result of sea level rise ($\chi^2_1 = 99.7$, $p < 0.001$; Fig. 3). A converse response was observed in Barbados, with fewer tourists expressing a willingness to return for the same price if beaches largely disappeared than if corals were severely bleached ($\chi^2_1 = 213.1$, $p < 0.001$; Fig. 3). Overall, a similarly high proportion of tourists in Bonaire and Barbados

were unwilling to revisit if their preferred environmental feature (coral reefs and beaches, respectively) was affected by climate change ($\chi^2_1 = 0.36, p = 0.55$). For comparison, 43% of respondents on Bonaire and 39% of those on Barbados were repeat visitors.

DISCUSSION

Environmental attributes affecting destination choice and enjoyment

Consistent with other studies (Sheller 2004), warm temperatures, clear waters and low health risk were the most important criteria for choosing Bonaire and Barbados as holiday destinations. However, we found marked differences between the two study islands in the secondary environmental features that influenced destination choice and holiday enjoyment. Tourists chose and enjoyed Bonaire largely because of its marine wildlife, notably extensive, healthy corals and abundant, diverse fish fauna. The majority of tourists surveyed on Bonaire had snorkelled and dived during their holiday, and attributes such as large fish and a high per cent coral cover are important to divers (Pendleton 1994; Williams & Polunin 2000). By contrast, tourists on Barbados were mainly attracted to and derived enjoyment from land-based features, particularly beach size and sand quality.

The environmental features influencing destination choice coincide with those promoted heavily by the tourism boards of these two islands (BTA 2001; TCB 2001). The close correlation between factors contributing to destination choice and holiday enjoyment suggests that holiday expectations, which are largely derived from third-party information, were being fulfilled by actual experiences. Interestingly, the presence of sea turtles was given an intermediate rating of importance in destination choice by tourists on both islands. However, sea turtles contributed significantly more to holiday enjoyment on Barbados than on Bonaire. This difference is perhaps because of the higher public awareness and potential for participation in sea turtle research on Barbados (M.C. Uyarra, personal observation 2002).

Economic impacts of changes in preferred environmental attributes

The environmental attributes valued by tourists when choosing a holiday destination may be altered by a variety of mechanisms and lead to shifts in travel destinations (for example Braun *et al*. 1999; Agnew & Viner 2001; Lise & Tol 2002). For example, natural disasters and human exploitation of resources can clearly reduce environmental attractiveness. Tourism itself can also negatively impact tourism, both through crowding, which deters some tourists from previously unfrequented locations, and through provision of infrastructure, which can accelerate the degradation of environmental features that initially attracted tourists (for example Tisdell 1991; Davis & Tisdell 1995).

Many environmental attributes will also be affected by climate change. Although the extent to which they will respond is difficult to predict on regional or local scales, many impacts are expected to be detrimental to the tourism industry (for example Wall 1998). Eighty per cent of tourists indicated that they would be unwilling to revisit their holiday island for the same price if their preferred environmental features (i.e. coral reefs and beaches for Bonaire and Barbados, respectively) were affected negatively by climate change. In a cross-sectional study such as this, it is not possible to assess whether future behaviour will match exactly stated preferences. However, a marked reduction in the number of divers visiting a popular resort in the Philippines was noted in the years following the mass-bleaching event of 1998 (Cesar 2000). Tourists can therefore respond strongly to changes in environmental conditions. Given that approximately 40% of visitors had previously visited Bonaire or Barbados, the economic repercussions of climate-induced shifts in holiday destinations could be severe, if realized.

This does not mean there will be an 80% reduction in tourist revenues to Bonairian and Barbadian economies. Since coral bleaching and beach erosion are likely to occur regionally, environmental features on other Caribbean islands vying for tourists will also be affected. However, localized variation in weather patterns, sea levels, geology, and reef and beach structure and condition may result in increases in coral bleaching or losses in beach area on particular islands but not others. In addition, many respondents indicated a willingness to return to Bonaire or Barbados for a cheaper price, should reefs or beaches be adversely affected by climate change (Uyarra 2002). Climate change could also result in increasingly favourable climatic conditions, which may attract tourists despite any associated environmental changes. The relative attractiveness of Caribbean islands to tourists may thus be altered by climate change, but the impacts on individual islands cannot currently be predicted (IPCC 2001). Nevertheless, if our results are representative of most Caribbean islands, the economic repercussions of climate-induced changes in environmental attributes could be marked. This could be potentially more important on Bonaire, where the relatively low number of wealthy tourists (*c*. 50 000) contributes *c*. 40% of the GDP.

Island-specific management strategies

Our findings suggest that strategies to limit the economic impacts of climate change should be island-specific and based on the environmental features that are valued by tourists. Thus, the value of marine attributes to tourists on Bonaire suggests that maintaining features such as healthy corals and fish populations is more important for this island than for Barbados. For Barbados, terrestrial issues, such as maintaining or enhancing beaches, are of greater concern. Note that there may be other attributes of marine or terrestrial environments that are important to tourists but which were not included in our questionnaires.

Tackling the direct causes of climate change will require international cooperation. However, current anthropogenic stressors affecting coral reefs and beaches on a local scale will exacerbate many impacts of climate change. It is expected that climate change will compound direct anthropogenic impacts, such as terrigenous sedimentation and pollution, overfishing, coral mining and habitat alterations (Wilkinson 1996). Reefs, however, can recover and effective management of direct human impacts could mitigate climate-related impacts (Westmacott *et al*. 2000). Similarly, the capacity of sandy beaches to cope with rising sea levels and the likely consequent increases in erosion (Nicholls 1998) will be compromised by local activities such as sand mining, coastal development, degradation of coral reefs and mangroves, and disruption of sand transport systems (Brown & McLachlan 2002; Wong 2003).

For islands dependent on reef-based tourism, the protection of reefs may be best achieved through the effective implementation of marine protected areas (MPAs). Although sea surface warming will not respect MPA boundaries (Reaser *et al*. 2000), MPAs with no fishing pressure and limited landward development may provide the best opportunity for reefs to cope with climate change (West & Salm 2003). For example, following the extensive coral bleaching events of 1998, recovery has been greatest for well-managed reefs experiencing low anthropogenic stresses (Wilkinson 2004). In addition, high abundances of large fish, which attract tourists, are also more common in well-managed MPAs (Mosqueira *et al*. 2000; Williams & Polunin 2000).

Coastal development and protection strategies, including set-back building regulations, conservation of beach vegetation, beach nourishment and limitation of coastal construction, such as of piers, groynes and sea walls, will be key tools for islands dependent on beach-based tourism. Although beach nourishment and hard structures have been successful in enhancing beach areas in several locations (Crain *et al*. 1995; Everts & Eldon 2000; Jones & Hanna 2004), they can disrupt natural sand transport patterns and lead to escalating erosion and consequent loss of habitat (Brown & McLachlan 2002). Mangroves and coral reefs can also protect beaches from storm damage (Wong 2003); thus the maintenance of attractive environmental features for beach-based tourism will require a holistic approach to coastal habitat management.

Although in this study we considered only the potential economic impacts of climate change on the tourist industry, the industry itself can be an accelerator of climate change. For example, aviation fuel is a major source of greenhouse gases (IPCC 1999; Ponater *et al*. 1999; Olsthoorn 2001), and the rapid expansion in air travel for beach-based mass tourism, in particular, may contribute to climate change (Agnew & Viner 2001). Thus, in addition to the well-documented short-term impacts of tourism on the environment (Gössling 2002), the main mode of tourist transport to the Caribbean, namely air travel, has significant associated energy costs (Høyer 2000, Becken *et al*. 2003), and may contribute to the climate-induced degradation of the environmental features attracting tourists to those islands. Moreover, tourism-associated developments such as beach-front hotels can increase beach erosion and thus exacerbate the effects of sea level rise and climate change. Nevertheless, our results suggest that effective environmental protection is likely to yield significant economic benefits where tourism depends on attributes amenable to environmental management.

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