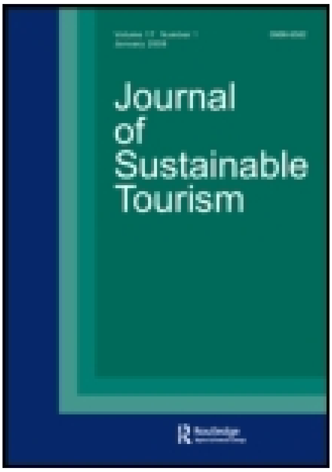

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Sustainable whale-watching tourism and climate change: towards a framework of resilience

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Whale-watching tourism, currently worth $1 billion p.a. worldwide, depends upon the continued presence of whale, dolphin and porpoise species (collectively called cetaceans) within a specific area. Current evidence suggests that the distribution and/or abundance of cetaceans is likely to alter in response to continued changes in sea surface temperature with global climate change (GCC). This paper reviews how such changes may affect the sustainability of whale-watching operators from a resilience perspective. Potential implications include changes to the presence and frequency of cetacean species targeted and changes to lengths of tourism seasons to coincide with shifts in migration patterns. The review presents an interdisciplinary framework for evaluating the resilience of whale watching to changes in species occurrence, whereby resilience is the degree of change in cetacean occurrence experienced before tourist numbers fall below a critical threshold. The framework combines likelihood of observing a cetacean, trip type and tourist type, which when quantified could identify which operators are likely to experience a change in tourist numbers given a specific scenario of changing cetacean occurrence. In doing so, a step is taken towards providing a means by which resilience to GCC effects on cetacean species could potentially be provided.

Keywords: whale watching; climate change; sustainable tourism; resilience; cetacean occurrence

Introduction

Climate change and its potential implications for tourism have received considerable attention within the literature. This has predominantly focused upon the mass summer tourism and winter tourism sectors (see Becken & Hay, 2007; Gössling & Hall, 2006a; United Nations World Tourism Organization, United Nations Environment Programme & World Meteorological Organization [UNWTO-UNEP-WMO], 2008), while studies of climate change impacts on nature-based tourism (see Nyaupane & Chhetri, 2009; Scott, Jones, & Konopek, 2007; Uyarra et al., 2005) appear less frequently. Smaller nature-based sectors, such as whale-watching tourism, have so far been mostly overlooked. Whale-watching tourism refers to commercial tours enabling tourists to observe, swim with and/or listen to any whale, dolphin or porpoise species (collectively called cetaceans) in their natural habitat (Hoyt, 2001). Having experienced rapid global development since the 1980s, the most recent valuation of total annual worldwide whale-watching revenue is over $1 billion p.a.

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(Hoyt, 2001). In many communities, whale watching has expanded into a highly profitable industry and is an integral aspect of local economies, such as in Kaikoura, New Zealand, and Lahaina, Hawaii (Hoyt, 2001; Hoyt & Hvenegaard, 2002). Alongside economic benefits, whale watching is valued for its contribution to environmental education and scientific research while being promoted by a number of non-governmental organisations as an economic alternative to whaling (Corkeron, 2004; Orams, 2002).

However, the future sustainability of whale watching and its associated benefits could be significantly affected by changes in the occurrence of local cetacean species in response to global climate change (GCC) (Craig-Smith, Tapper, & Font, 2006; Gössling & Hall, 2006b). Whale watching is dependent upon the predictable occurrence of cetaceans within a relatively small area. Predicted shifts in the occurrence of cetaceans (see Learmonth et al., 2006; MacLeod, 2009) represent a significant concern for whale watching, given evidence that where cetacean sightings do not occur, tourists often express frustration, disappointment and dissatisfaction (Anderson & Miller, 2006; Orams, 2000). Aside from Higham and Lusseau (2007), however, there remains limited consideration within the whale-watching literature of the relationship between whale watching and the occurrence of cetaceans, and no study to date has specifically considered the potential implications of GCC for the whale-watching industry.

This paper reviews for the first time how GCC could affect whale-watching tourism and develops a framework for evaluating the resilience of whale watching to changes in cetacean occurrence. The paper is structured to achieve the following objectives:

(1) to review evidence of how GCC could affect the distribution of cetacean species;
(2) to present a theoretical framework for evaluating the resilience of whale watching to changes in species occurrence.

Evidence of global climate change effects on cetaceans and implications for whale-watching tourism

GCC refers to any net change in climate over time which is a consequence of either natural variability or human activity (Intergovernmental Panel on Climate Change [IPCC], 2007a). GCC which occurs beyond the natural rate of variability is generally attributed to anthropogenic greenhouse gas (GHG) emissions causing an amplified greenhouse effect (Hadley Centre, 2005; Hulme et al., 2002; IPCC, 2007b). An example of this includes a 0.6°C ± 0.2°C increase in global mean surface temperature during the latter half of the twentieth century (IPCC, 2001). Consequently, under sustained or raised GHG emissions, global sea surface temperatures are projected to continue to increase between an average of 1.1°C and 4.6°C by 2100 from 1990 levels (European Environmental Agency, 2004). Changes are also predicted, for example, to ocean currents, ocean acidicity, climate patterns and climate variability (Hulme et al., 2002; IPCC, 2001, 2007a). Of the predicted changes to marine climates, it is the impact of changing sea surface temperature on marine ecosystems which is the most widely studied and the best understood. Many studies have examined the effects of past variation in temperature on the distribution, abundance, movements and life cycle phenology of marine organisms, and it is generally assumed that responses to climate variability can be indicative of how species are likely to respond to GCC. Examples include studies on plankton (Richardson, 2008), squid (Chen et al., 2006; Sims, Genner, Southward, & Hawkins, 2001), fish (Perry, Low, Ellis, & Reynolds, 2005), seabirds (Irons et al., 2008) and cetaceans (Azzellino, Gaspari, Airoldi, & Lanfredi, 2008; Macleod et al., 2005).

Only a small number of empirical studies have directly examined changing sea surface temperatures and subsequent effects on cetacean distribution. However, there is common agreement that GCC will affect cetaceans to some extent (Simmonds & Elliot, 2009). Numerous review papers, including Gambaiani, Mayol, Isaac and Simmonds (2008), Learmonth et al. (2006), MacLeod (2009), Simmonds and Isaac (2007) and Tynan and DeMaster (1997), identify both direct and indirect means by which changing sea surface temperature could affect cetacean distribution. These include the following: changes in the range of species distribution, the occurrence and abundance of individuals and the timing and length of migrations; effects on reproductive success and mortality levels; and changes to community composition and structure. Table 1 summarises these expected and recorded changes in relation to changing sea surface temperature.

Detailed predictions for how species are likely to respond to GCC are not yet available, making it difficult to identify which specific operators (i.e. individual businesses) are most likely to experience changes to cetacean occurrence. However, from the evidence summarised in Table 1, it is possible to gain a general insight based upon location and species inhabiting an area. For example, whale watching in Arctic areas (including Iceland, Norway and Alaska) is expected to experience changes before whale watching in other areas, given the higher rates of temperature change predicted for polar regions (IPCC, 2007a). Similarly, operators focusing on species that are restricted in their ability to track changes in sea temperature, such as the white-beaked dolphin in Scotland, could be especially affected.

Whale-watching operators that focus on migratory species are potentially more likely to experience changes in cetacean occurrence compared with those which focus on resident populations. For example, whale watching in Alaska is reportedly benefiting from changes to the timing of whale migrations, with whales arriving earlier in the season and remaining for longer (Pagnan, 2003). Opportunities for whale watching have also improved in parts of Russia, where the abundance of grey whales has increased with altered migration patterns (Pagnan, 2003). However, research presenting evidence of changes in other areas is scarce. As such, while based on broad ecological relationships, there is still little empirical evidence for some of the predicted implications for whale watching presented in Table 1. In general, changes in the presence and frequency of cetacean species targeted by whale-watch operators are expected, while whale-watching seasons may need to be shortened, lengthened or shifted to coincide with changing migration patterns. As a result, while such changes have been beneficial to whale watching in some areas, it may have negative effects in others, with whale-watching activities potentially disappearing if whale occurrence declines substantially (Johnston, 2006).

It is important to note that the majority of GCC and cetacean research has focused on relatively few species, especially those which inhabit polar regions. While this is perhaps reflective of the alarming rate at which change is occurring in polar regions, GCC effects are likely to be observed across tropical and temperate regions, as well as polar regions (MacLeod, 2009; Whitehead, McGill, & Worm, 2008). Therefore, there are implications for whale watching on a global scale. Given that a currently unknown proportion of whale-watching operators are likely to experience changes to local cetacean occurrence at some point in the future, developing a greater understanding of how this will affect whale watching is essential for their sustainability. With no guidance to date as to how the issue of changing cetacean occurrence for whale-watching tourism could be addressed by researchers, we present a theoretical framework in an attempt to bridge this gap.

Table 1. Potential effects of changing sea surface temperature on cetacean distribution and implications for whale-watching tourism.

Potential effect	Ecological mechanism driving effect	Description	Examples and predicted effects	Possible implications for a whale-watching operator
Geographic range change	Niche conservatism	• As sea temperatures increase, species are expected to track required or preferential temperature conditions, with ranges shifting polewards • Species inhabiting polar areas, e.g. bowhead whale, narwhal and beluga whale, are predicted to have greatly reduced ranges, while range changes are less likely for species occurring in all water temperatures, e.g. killer whales, humpback whales and sperm whales (Learmonth et al., 2006; MacLeod, 2009; Simmonds & Isaac, 2007; Tynan & DeMaster, 1997).	• Recent strandings of previously unrecorded warmer water species in NW Scotland consistent with increasing sea temperatures, while a decrease in the abundance of white-beaked dolphin (a cold-water species) and increased abundance of common dolphin (a warmer water species) has been recorded (Macleod et al., 2005). • Predicted reduction in the range of Vaquita (a species of porpoise) in the Gulf of California and white-beaked dolphin in NW Scotland, as their ability to shift northwards with increasing water temperature is limited by land mass and requirement for shelf waters (Learmonth et al., 2006; MacLeod, 2009; MacLeod et al., 2005).	(1) Loss of target species (2) Presence of new species (3) Generation of whale-watching opportunities in new areas (Johnston, 2006; Pagnan, 2003) (4) Implications most likely for operators located at the current edge of a species range

Change in occurrence and abundance	Bottom-up regulation of the marine ecosystem	• Cetacean occurrence and abundance is strongly related to the distribution and density of prey species (Cañadas, Sagarminaga, & García-Tiscar, 2002; Friedlaender et al., 2006).	• Shifts in the distribution and density of prey in response to changing sea surface temperature are expected to be reflected by changes to the occurrence and abundance of cetacean species (Gambaiani et al., 2008; Learmonth et al., 2006; Simmonds & Isaac, 2007; Tynan & DeMaster, 1997).	(1) Change in the frequency of encounters with target species (2) Change in the distance required to travel to observe target species (3) Change in the number of individuals of each species observed
Changes to the timing and/or length of migration	Mismatch of phenological relationships and bottom-up regulation of the marine ecosystem	• Warming sea temperatures could result in species spending longer in their summer habitats, while GCC effects on prey availability are expected to affect the timing and length of migrations, which coincide with peak prey availability (Learmonth et al., 2006; Simmonds & Isaac, 2007; Tynan & DeMaster, 1997).	• Seasonally migrant whale species to the Barents and Bering Seas, including humpback and minke whales, are increasingly expected to range further north and remain there for longer in response to reducing sea ice extent and subsequent increases in prey availability (Moore & Huntington, 2008).	(1) Whale-watching seasons may need to shorten or lengthen to coincide with changing migration patterns (Pagnan, 2003)
Effects on reproductive success	Mismatch of phenological relationships	• Reproductive success of cetaceans is highly dependent on direct and indirect synchronisation with peak plankton production. Changes in the timing of plankton production with GCC are expected to have a knock-on effect on cetacean breeding success (Stenseth et al., 2002; Simmonds & Isaac, 2007).	• Breeding success and calf survival of northern and southern right whales has been linked to climate variability and sea surface temperature anomalies, both of which were mediated through their effects on prey species abundance (Greene & Pershing, 2004; Greene, Pershing, Kenney, & Jossi, 2003, Leaper et al., 2006).	(1) Change in the occurrence of target species within the area (2) Loss of target species within the area

(*Continued*)

Table 1. *(Continued)*

Potential effect	Ecological mechanism driving effect	Description	Examples and predicted effects	Possible implications for a whale-watching operator
Changes in community composition and structure	Niche conservatism and intra-specific competition	• Colonisation of existing ranges by additional species where previous barriers no longer exist (Harley et al., 2006; Learmonth et al., 2006; MacLeod, 2009).	• Increased sightings of mixed-species groups of common and striped dolphin recorded in the Spanish Mediterranean in 1999. The shift of common dolphin into deeper waters thought to be due to a reduction in the abundance of inshore prey species in response to a pronounced drop in sea surface temperature (Cañadas et al., 2002).	(1) Loss of target species within the area (2) Presence of new species within the area
Changes in mortality levels	Bottom-up regulation of the marine ecosystem	• Climate-driven changes to preferential prey abundance can affect cetacean mortality levels (Gambaiani et al., 2008; MacLeod, Santos, Reid, Scott, & Pierce, 2007a).	• Low recruitment of prey (sandeels) in the North Sea has been associated to higher sea temperatures and linked to a potential increase in the likelihood of porpoise starvation with climate change (Arnott & Ruxton, 2002; MacLeod et al., 2007a)	(1) Change in the occurrence of target species within the area (2) Loss of target species within the area

Note: Geographic range = the fundamental thermal niche occupied by a species, which is defined in part by sea surface temperature; occurrence = the distribution of individuals of species within their geographic range; abundance = the number of individuals of a species within a given area.

Towards a conceptual understanding of sustainable whale watching: a framework of resilience to changes in cetacean occurrence

In order to understand how future changes in cetacean occurrence may affect the sustainability of whale-watching operators, we first need to clarify what we mean by sustainable whale watching and how this can be assessed in relation to cetacean occurrence. Literature concerning the sustainability of whale watching is dominated by two main foci: reducing and managing negative interactions between whale-watching boats, cetaceans and their natural habitat (Higham, Bejder, & Lusseau, 2009; Hoyt, 2005); and achieving economic stability (Orams, 2002; Woods-Ballard et al., 2003). From the viewpoint of whale-watch operators, sustainability concerns this latter, production-led view, which primarily focuses upon the maintenance of income from tourists (Curtin, 2003; Higham & Lusseau, 2007). While environmental and social aspects are integral to the overall concept of sustainable tourism (Hardy, Beeton, & Pearson, 2002), here we examine sustainable whale watching and GCC from an angle which reflects this industry perspective. Applying a common approach to the study of sustainability (see Olsson, Folke, & Berkes, 2004), we focus on operator resilience to changes in cetacean occurrence induced by GCC, which is considered a key element to the sustainability of whale watching. Building upon the general definition of resilience provided by Folke et al. (2004) and Walker et al. (2002), we define operator resilience as the amount of change in cetacean occurrence that can be experienced before visitor numbers fall below a critical threshold. Operator resilience is, therefore, considered key to the sustainability of whale watching.

Assessing the resilience of an operator to changes in cetacean occurrence requires a detailed examination of the relationship between cetacean occurrence and tourist numbers. In general, GCC is widely expected to have an effect on tourist numbers. However, a key knowledge gap exists in understanding the likely response of tourists to GCC impacts, with location-specific and/or region-specific research needed to explore the point at which such changes in behaviour could become apparent (Gössling & Hall, 2006a; Nicholls, 2006; UNWTO-UNEP-WMO, 2008). To develop this understanding, we identify three key components, two of which are social and one of which is ecological, which are likely to be important in assessing the resilience of whale-watching operations to GCC impacts on cetaceans. While limiting this consideration to three variables allows for the development of the framework, there is no reason why additional components could not be added in the future. As whale watching is a complex and dynamic system comprising both social and ecological components (Farrell & Twining-Ward, 2004), research to understand how GGC could affect this system requires such an interdisciplinary approach (Dubois & Ceron, 2006). When integrated within a framework (Figure 1), the three components identified here could be used to assess the circumstances under which tourist numbers are likely or unlikely to remain above a critical threshold.

Taking each of the three components individually, the following sections provide the rationale behind their inclusion within the framework and discuss data requirements.

Likelihood of observing a cetacean

Understanding how cetacean occurrence is likely to change in the future provides the fundamental basis of Figure 1. From this, we can address how the interaction between cetacean occurrence and tourist numbers may alter in relation to trip type and tourist type. Predicting species occurrence in response to future GCC is a rapidly developing field of research, most widely applied to terrestrial and avian species (see Huntley, Green,

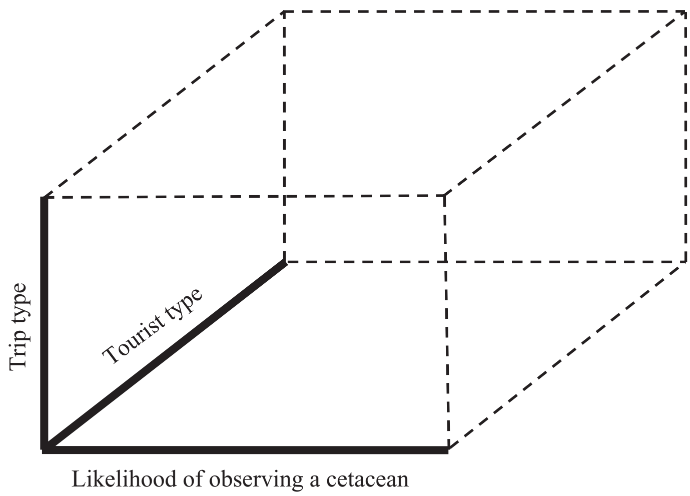

Figure 1. Key components contributing to the resilience of a whale-watching operator to GCC-induced changes in cetacean occurrence.

Collingham, & Willis, 2007; Peterson et al., 2002). To date, few studies have attempted to predict future changes in cetacean occurrence within a given area. Whitehead et al. (2008) predicted future cetacean diversity for the Atlantic, the Pacific and the Indian oceans upon the basis of projected sea surface temperatures. Modelling species occurrence in response to changing environmental variables typically involves two stages. The first stage is to generate statistical or mathematical models which relate observations of the species with a combination of geographic and/or climatic variables to predict their current distribution (Guisan & Thuiller, 2005; Guisan & Zimmerman, 2000; MacLeod, Mandleberg, Schweder, Bannon, & Pierce, 2008). These models are based on the principle that the distribution of individuals of a species is principally driven by climatic, ecological and geographic factors, which defines its ecological niche. Variables commonly used for cetacean distribution models include sea depth, sea surface temperature and seabed slope (Bräger, Harraway, & Manly, 2003; MacLeod, Weir, Pierpoint, & Harland, 2007b; Marubini, Gimona, Evans, Wright, & Pierce, 2009; Redfern et al., 2006). The second stage of the process involves applying scenarios of future climatic variables, such as sea surface temperature, to predict how a species distribution may change over time and under different emission scenarios (Huntley et al., 2007; Mustin, Sutherland, & Gill, 2007; Pearson & Dawson, 2003).

The specific technique used to predict cetacean occurrence is dependent upon the type of data available (Guisan & Thuiller, 2005; MacLeod et al., 2008). For example, data-sets which only record cetacean sightings provide “presence only” data, while data-sets which also record where no sightings occur provide “presence/absence” data. These two types of data require different modelling approaches (see MacLeod et al., 2008; Redfern et al., 2006). Scale is also important, in terms of both the time span and the geographic extent examined (Guisan & Thuiller, 2005; Redfern et al., 2006). For example, focusing only on a specific area (e.g. the west coast of Scotland) when modelling the future occurrence of species may not identify those species which are likely to colonise the area in the future, but which are currently absent. Comparatively modelling for a wider area (e.g. the whole of the north-east Atlantic) would allow such changes to be seen. Additionally, future projections of climatic variables, such as sea surface temperature, are less accurate and less reliable at smaller scales (IPCC, 2007a), making it difficult to predict precise changes in species distribution at a local, operator level (Dubois & Ceron, 2006). Furthermore, temperature preferences exhibited by cetaceans may be, at least partially, related to the temperature tolerance and preference of their prey species rather than to direct effects on the cetaceans themselves (Learmonth et al., 2006). As different prey species may respond differently to GCC (Genner et al., 2004), in terms of changing distributions, the effect on the distribution of cetaceans may be harder to predict when such indirect relationships exist than when the relationship with temperature is more direct.

However, the usual aim of modelling future species occurrence is not to provide precise predictions, but to predict a general pattern and magnitude of future changes (Pearson & Dawson, 2003). Studies predicting future species occurrence often make projections following a number of different GCC scenarios, involving varying degrees of climatic change and hence varying predictions about species occurrence (see Huntley et al., 2007; Peterson et al., 2002; Whitehead et al., 2008).

As whale-watching tourists are known to express varying degrees of satisfaction in response to different cetaceans, it is important to focus on those species of cetacean present in the area of interest. For example, species which are more active and gregarious, such as killer whales and humpback whales, tend to be more popular (Cloke & Perkins, 2005; Orams, 2000), with Malcolm, Duffus and Malaspina (2002) recording that whale-watching tourists to Vancouver Island expressed greater satisfaction levels in areas where the main species watched were killer whales, as opposed to grey whales. Having considered the biological component of the framework, we now go on to consider the two social aspects, which are of equal importance.

Tourist type

Predicting tourist numbers in relation to cetacean occurrence requires an understanding of whale-watching tourists' motivations for partaking in whale watching, determinants of high/low satisfaction levels and their attitudes towards potential changes in cetacean occurrence in the future. Consideration of tourists' motivations and attitudes appears within the GCC/tourism literature (see Scott et al., 2007; Uyarra et al., 2005).

However, whale-watching tourists are not homogenous in their values, attitudes, expectations, motivations or demographic backgrounds, nor will they all respond in the same way to the same stimuli (Duffus & Dearden, 1990; Hoyt, 2001; Rawles & Parsons, 2005). Wide variation in the relationship between cetacean occurrence and tourist numbers is, therefore, expected. To address this, the segmentation of tourists into groups is proposed, according to key characteristics which influence their decision to go on a whale-watching trip (such as the importance of seeing relevant cetacean species and motivations for going on a trip). From here it would be possible to derive the effect of changing cetacean occurrence on specific types of whale watchers.

The generation and analysis of tourist typologies provides a widely used tool for the categorisation of tourists who share similar characteristics (see Beh & Bruyere, 2007; Hvenegaard, 2002). Various approaches have been used to segment tourist populations, which range from tourist attitude and motivation questionnaires to classifying tourists through researchers' observations (Hvenegaard, 2002). Duffus and Dearden (1990) for example, conceptually defined "specialist" and "generalist" wildlife tourists according to their need for infrastructure and facilities and their "pre-knowledge" of the habitat and wildlife. Tourist typologies are also applied to characterise tourists in relation to their motivations for undertaking an activity (see Beh & Bruyere, 2007; Curtin & Wilkes, 2005).

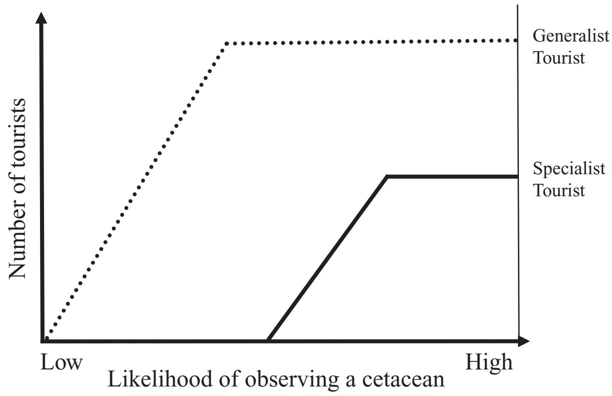

Figure 2. Hypothetical relationship between the number of tourists, the likelihood of observing a cetacean and the type of tourist.

Figure 2 illustrates how this variation in tourist type could hypothetically influence the relationship between cetacean occurrence and the number of whale watchers. The shape of this curve is likely to vary between locations and/or regions. For ease of understanding we present two types of whale-watching tourist. We have adopted the terms "generalist" and "specialist" to describe their different level of interest in observing a species of cetacean. As the likelihood of observing a cetacean falls, the number of both specialist and generalist tourists also declines. However, the point at which this decline occurs differs between the two types of tourists owing to their varying interest in observing a cetacean.

While previous work provides an overview of general traits of whale-watching tourists, such as economic background and area travelled from (see Hoyt, 2001; Parsons et al., 2003), no typology has been developed to describe the factors influencing whale watchers' decision-making at a given location (Higham & Lusseau, 2007). As emphasised by Higham and Lusseau (2007), research into whale-watching tourist types should ideally include those tourists which visit the area but do not take part in whale-watching activities (i.e. latent whale watchers). While these tourists do not currently go whale watching, changes in cetacean occurrence could open the market to other tourist types. By taking into account latent whale watchers, it becomes possible to determine under what conditions these tourists will commence whale watching and thereby to improve predictions of tourist numbers. More generally, the decision to go whale watching in a particular area involves at least two decisions, not necessarily independent, namely whether to go to that area in the first place and, once there, whether to go whale watching.

Trip type

Predicting how tourists will respond to GCC impacts is both complex and difficult (Gössling & Hall, 2006a; Perry, 2006; Wall, 1998), especially given the numerous factors which could influence the interaction between tourist numbers and cetacean occurrence, such as cost of travel or the presence of whaling boats (Higham & Lusseau, 2007). While the relevance of such factors is likely to widely vary across sites, regions and timescales, consistent reference is made within the whale-watching literature to the diversity in whale-watching trips offered, both between geographic regions and by individual operators within a given region. For example, operators offer trips which differ in length and price, the degree of educational

Table 2. Example of basic trip type categories for whale watching.

Trip type	Trip definition
A (Specialist)	Dedicated whale-watching trip, where primary aim is to search for and see cetaceans.
B	Aim of trip is to search for and see cetaceans and non-cetacean wildlife equally.
C (Generalist)	Aim of trip is to predominantly search for non-cetacean wildlife, although seeing cetaceans is still important.

information provided, the type of boat and which cetacean species and non-cetacean species can be seen and/or the presence of which is advertised by the operator (Hoyt, 2001; Orams, 2000; Warburton, Parsons, Woods-Ballard, Hughes, & Johnston, 2001). Characteristics such as length of trip, scenery and boat capacity have been shown to be important to tourists' motivation for going on a trip and subsequent satisfaction levels (Orams, 2000; Parsons et al., 2003). Clearly, although it is an important factor, the satisfaction of whale watchers is not solely dependent upon the presence on cetaceans.

Table 2 provides a hypothetical example of how the emphasis placed on searching for cetaceans could be used to categorise whale-watching trips. Trip type A is the most specialised whale-watching trip, while trip types B and C are progressively more generalised and less dedicated to searching for cetaceans. Figure 3 applies this categorisation to illustrate how trip type could hypothetically influence the interaction between the cetacean occurrence and the number of tourists. Generating a classification of trip type requires location-specific research to identify the relevant differences in characteristics of the various types of trips offered. Again, the shape of this curve is likely to vary between locations and/or regions.

It might be expected that a decline in cetacean presence would most affect specialist whale-watching trips (Figure 3a). However, as specialist trips are likely to dedicate the greatest proportion of a trip to searching for cetaceans, operators running these trips may be better able to maximize sightings, and hence maintain customer satisfaction, for a given level of cetacean presence. It is also likely that the characteristics of the tourists will differ between trip types, with specialist whale watchers going on the specialist trips and perhaps being less easily discouraged by low cetacean numbers than generalist tourists. Consequently, a more complex relationship between cetacean presence, tourist numbers and trip type may emerge (Figure 3b).

A resilience framework

Having discussed each component of Figure 1 individually, we now consider how these components could combine to provide an overall indication of operator resilience to potential changes in cetacean occurrence. Effective assessment of operator resilience requires each component of Figure 1 to be included within the analysis, in order to reflect the social-ecological dynamic of the whale-watching system.

Figure 4 builds upon Figure 1 by illustrating how the integration of research components could be used to identify which combinations of trip type and tourist type are likely to see a change in tourist numbers given a specific scenario of changing cetacean occurrence. The hypothetical surface inside the three-dimensional framework graphically represents an example of the combined characterisation, and to some extent quantification, of components. The shading of the surface is indicative of the number of tourists (where darker shades

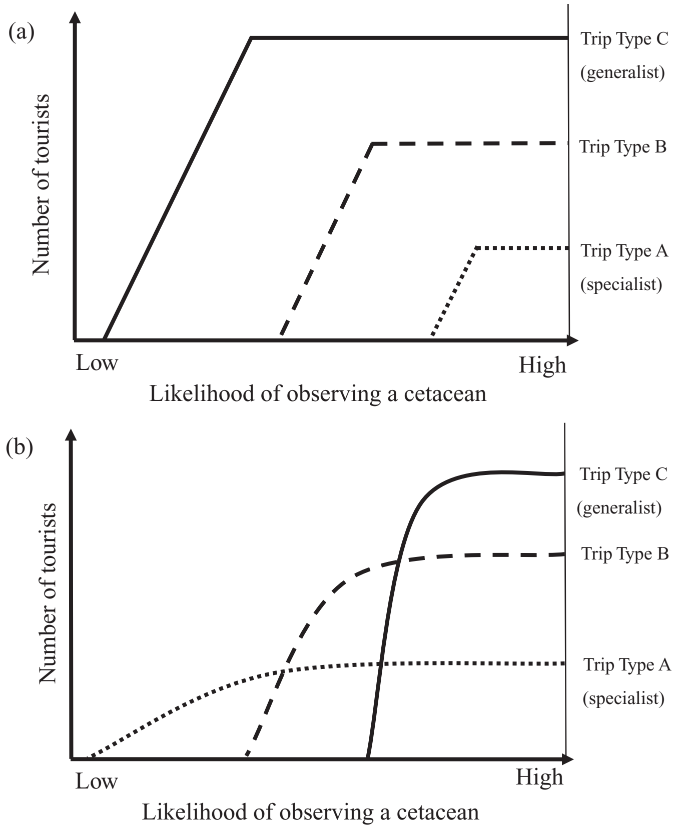

Figure 3. (a, b) Hypothesised interaction between the likelihood of observing a cetacean and the number of tourists for different trip types.

represent greater numbers of tourists) and is expected to vary between sites and regions owing to differences in the species, types of trips and types of tourist present. The position of an operator's trip upon the surface signifies a measure of how tourist numbers are likely to respond to a changing likelihood of observing a specific species of cetacean. The greater capacity an operator has to move along the three axes (i.e. to vary trip type and tourist type, and to maximise the likelihood of observing cetaceans), the greater the resilience will be to specific changes in cetacean occurrence. Application of the framework, therefore, requires input from operators in order to determine their capacity to move along the three axes. The following section provides a brief example of how the framework is being applied to assess the resilience of whale-watch operators in western Scotland.

Ongoing work to operationalise the framework in Scotland

Research is currently in progress to apply the framework in relation to whale-watch operators in western Scotland, using a mixed-methods approach. The first stage of the work has gathered empirical data relating to each of the three axes of Figure 1 (i.e. tourist type, trip type and likelihood of observing a cetacean). The second stage has used tourist questionnaires to estimate the likely response of each type of tourist, on each trip type, to changes in cetacean occurrence, as illustrated in Figure 4. The third and final stage will

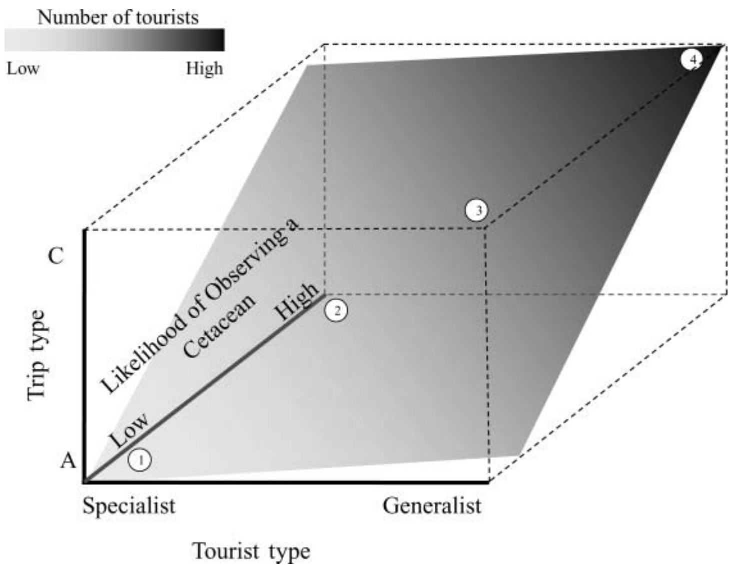

Figure 4. A resilience surface: the relationship between tourist numbers and cetacean occurrence. ① Specialist tourist/Trip A/low likelihood of observing a cetacean; ② Specialist/Trip A/high likelihood of observing a cetacean; ③ Generalist/Trip C/low likelihood of observing a cetacean; ④ Generalist/Trip C/high likelihood of observing a cetacean.

evaluate the capacity of operators to move along the axes of Figure 1 to adapt to changes in cetacean occurrence and will thereby present an assessment of resilience. While the study is yet to progress beyond the first stage, we summarise our approach below in utilising the framework for stages two and three.

With reference to the first stage of the research, the likelihood of observing a cetacean axis is being quantified through a combination of habitat and thermal niche modelling, developed from previous work by MacLeod et al. (2007b) and Kaschner, Watson, Trites and Pauly (2006). This is still to be completed and published. A variety of potential IPCC GCC scenarios have been applied (each with varying changes in sea surface temperature) to project the likely occurrence of 10 cetacean species common to the waters off western Scotland, up until 2050. For each scenario, projections will provide an indication of the direction of change in likelihood of observing a cetacean, the extent of this change and the point in time at which this change is likely to become apparent.

Still with reference to stage one, classification of trip types was generated through extensive background research on whale watching in western Scotland. Covering mainland western Scotland and the Inner Hebrides, 31 operators were visited in total. Data on operator type were compiled through visiting operators' offices and/or visitor centres, examining marketing materials and participation in a wide range of available trips. While an extensive and divergent number of trip characteristics were evident, generating a reliable and usable classification required a focus on two trip characteristics: (1) the proportion of time spent searching for cetaceans (from dedicated to generalised trips, as defined in Table 2) and (2) the length of the trip (either a day trip or a trip which includes overnight stays onboard). Upon the basis of these criteria, four categories of trip type were identified for the study area. While applicable to western Scotland, other areas are likely to require alternative trip categories according to the specific characteristics of operators in the area/region.

To construct a tourist typology, 222 questionnaires were completed by tourists taking part in trips of each type. The questionnaire contained four key questions to achieve this objective. Developed from Duffus and Dearden's (1990) concept of specialist and generalist wildlife tourists, these questions related to the extent of tourists' interest and motivation for going whale watching:

(1) the number of whale-watching trips respondents had previously taken,
(2) motivations for taking the trip (both wildlife and non-wildlife),
(3) the importance for the respondent of seeing specific cetacean and non-cetacean species during the trip and
(4) the importance for the respondent of going on the trip in their decision to visit the area.

Factor analysis will be used to segment groups of tourists according to these criteria and to form the basis of a tourist typology for whale watchers in this region of Scotland. Identifying specific tourist types (and the number of different tourist types present) was ongoing at the time of writing (November 2009).

Stage two of the research will seek to estimate the likely response of tourists to predicted changes in cetacean occurrence. The questionnaires referred to above were also used for this second stage. Respondents were asked, using a series of Likert-scale questions, the extent to which they would still want to go on a trip in the future, given specific changes in species occurrence. The specific changes directly relate to those species whose future occurrences were modelled during the first stage. General linear modelling will be used to explore how tourists respond to questions in relation to (1) the species of cetacean, (2) trip type and (3) tourist type. From this, the combination of factors under which tourist numbers are likely to remain constant, reduce or increase will be determined and hence the framework in Figure 4 populated. The extent of change in occurrence predicted for each species over time will be used to estimate the likelihood, and point in time, of each combination occurring. While presenting tourists with hypothetical scenarios to predict future behaviour was considered the most appropriate approach for this study, it is necessary to be aware of data accuracy issues. Taking into account the relationship between attitudes and behaviour, for which there has been extensive debate (Kraus, 1995), presents an important challenge to be addressed in relation to this framework.

Stage three will use operator interviews to both disseminate findings to individual operators and gain feedback on key questions regarding their capacity to move along the axes of Figure 1 (and hence gain an assessment of resilience). For example, is an operator able to target different tourist types? Could the trip type(s) offered be altered? And if so, in what ways? Could an operator offer longer trips to increase the opportunities for observing cetaceans? What are the key barriers to moving along each of the axes? Interviews will also explore the ability of the framework to relate to practical decision-making for tourism operators. For example, does a better understanding of tourist type, trip type and the response of tourists to potential changes in cetacean occurrence translate to operators being better able to respond to changes in cetacean occurrence?

Although we believe the framework offers significant value in taking a first step towards understanding operator resilience to GCC affects on cetacean occurrence, and in engaging directly with operators, an initial assessment of its utility must await the completion of ongoing research in Scotland. Emerging and anticipated issues in trying to operationalise the framework thus far, relate to the willingness of operators to engage in stage three interviews in the context of often stiff competition for tourists in a relatively small geographic area. Reassuring operator interviewees of the confidentiality of responses is important and may prove problematic. It is also useful to underline the challenges of working within a framework which demands a mixed-methods approach. While pursuing interdisciplinary wildlife/nature-based tourism research is paramount within the context of GCC, it is an inherently complex and time-consuming process and may require a considerable degree of skill collaboration and development.

Conclusion

GCC clearly presents potential implications for both cetacean species and whale-watching tourism (Table 1). Accurately forecasting the response of whale-watching tourists to GCC is difficult, given the inherent complexity of this social-ecological system. However, we offer a possible conceptualisation of whale watching in relation to GCC effects on cetacean occurrence, which also provides an important step in addressing a knowledge gap in understanding how tourists are likely to respond to the environmental impacts of climate change. While we have concentrated on three components considered most important in defining this relationship, we suggest that future work could expand upon this conceptualisation to explore additional components. For example, application of the framework in countries which partake in whaling activities (such as Iceland or Norway) could also take into account the presence/absence of whaling activities in the area visited during a trip (see Higham & Lusseau, 2008). At the same time we have reviewed some of the key issues in relation to whale watching and GCC. In doing so, the framework presented goes some way towards providing an approach to understanding how the resilience of this system to changes in cetacean occurrence could be assessed. Where resilience can be enhanced, the goal of sustaining visitor numbers in the light of GCC would have greater chance of longevity. From here operators would be in an improved position to adapt and evolve alongside GCC effects on cetacean occurrence. While work is currently ongoing on the west coast of Scotland to apply the framework presented (Figure 1), whale watching throughout the world in the light of GCC requires further attention within the academic literature.

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References

Anderson, M.S., & Miller, M.L. (2006). Onboard marine environmental education: Whale watching in the San Juan Islands, Washington. *Tourism in Marine Environments, 2*, 111–118.

Arnott, S.A., & Ruxton, G.D. (2002). Sandeel recruitment in the North Sea: Demographic, climatic and trophic effects. *Marine Ecology Progress Series, 238*, 199–210.

Azzellino, A., Gaspari, S.A., Airoldi, S., & Lanfredi, C. (2008). Biological consequences of global warming: Does sea surface temperature affect cetacean distribution in the western Ligurian sea? *Journal of Marine Biological Association of the United Kingdom, 88*, 1145–1152.

Becken, S., & Hay, J.E. (2007). *Tourism and climate change: Risks and opportunities*. Clevedon, UK: Channel View Publications.

Beh, A., & Bruyere, B.L. (2007). Segmentation by visitor motivation in three Kenyan national reserves. *Tourism Management, 28*, 1464–1471.

Bräger, S., Harraway, J., & Manly, B.F.J. (2003). Habitat selection in a coastal dolphin species (*Cephalorhynchus hectori*). *Marine Biology, 143*, 233–244.

Cañadas, A., Sagarminaga, R., & García-Tiscar, S. (2002). Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. *Deep-Sea Research I, 49*, 2053–2073.

Chen, C.S., Pierce, G.J., Wang, J., Robin, J.-P., Poulard, J.C., Pereira, J., et al. (2006). The apparent disappearance of *Loligo forbesi* from the south of its range in the 1990s: Trends in *Loligo* spp. abundance in the northeast Atlantic and possible environmental influences. *Fisheries Research, 78*, 44–54.

Cloke, P., & Perkins, H.C. (2005). Cetacean performance and tourism in Kaikoura, New Zealand. *Environment and Planning D: Society and Space, 23*, 903–924.

Corkeron, P.J. (2004). Whale watching, iconography, and marine conservation. *Conservation Biology, 18*, 847–849.

Craig-Smith, S.J., Tapper, R., & Font, X. (2006). The coastal and marine environment. In H. Gössling & C.M. Hall (Eds.), *Tourism and global environmental change: Ecological, social, economic and political interrelationships* (pp. 107–127). London: Routledge.

Curtin, C. (2003). Whale-watching in Kaikoura: Sustainable destination development? *Journal of Ecotourism, 2*, 173–195.

Curtin, S., & Wilkes, K. (2005). British wildlife tourism operators: Current issues and typologies. *Current Issues in Tourism, 8*, 455–478.

Dubois, G., & Ceron, J. (2006). Tourism and climate change: Proposals for a research agenda. *Journal of Sustainable Tourism, 14*, 399–415.

Duffus, D.A., & Dearden, P. (1990). Non-consumptive wildlife-orientated recreation: A conceptual framework. *Biological Conservation, 53*, 213–231.

European Environment Agency. (2004). *Impacts of Europe's changing climate: An indicator-based assessment*. Copenhagen: Author.

Farrell, B.H., & Twining-Ward, L. (2004). Reconceptualising tourism. *Annals of Tourism Research, 31*, 274–295.

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L., et al. (2004). Regime shifts, resilience and biodiversity in ecosystem management. *Annual Review of Ecology, Evolution and Systematics, 35*, 557–581.

Friedlaender, A.S., Halpin, P.N., Qian, S.S., Lawson, G.L., Wiebe, P.H., Thiele, D., et al. (2006). Whale distribution in relation to prey abundance and oceanographic processes in shelf waters of the Western Antarctic Peninsula. *Marine Ecology Progress Series, 317*, 297–310.

Gambaiani, D.D., Mayol, P., Isaac, S.J., & Simmonds, M.P. (2008). Potential impacts of climate change and greenhouse gas emissions on Mediterranean marine ecosystems and cetaceans. *Journal of the Marine Biological Association of the United Kingdom, 89*, 179–201.

Genner, M.J., Sims, D.W., Wearmonth, V.J., Southall, E.J., Southward, A.J., Henderson, P.A., et al. (2004). Regional climatic warming drives long-term community changes of British marine fish. *The Royal Society of London Series B, 271*, 655–661.

Gössling, S., & Hall, C.M. (2006a). An introduction to tourism and global climate change. In S. Gössling & C.M. Hall (Eds.), *Tourism and global environmental change: Ecological, social, economic and political interrelationships* (pp. 1–34). London: Routledge.

Gössling, S., & Hall, C.M. (2006b). Uncertainties in predicting tourist flows under scenarios of climate change. *Climatic Change, 79*, 163–173.

Greene, C.H., & Pershing, A.J. (2004). Climate and the conservation biology of North Atlantic right whales: The right whale at the wrong time? *Frontiers in Ecology and the Environment, 2*, 29–34.
Greene, C.H., Pershing, A.J., Kenney, R.D., & Jossi, J.W. (2003). Impact of climate variability on the recovery of endangered North Atlantic right whales. *Oceanography, 16*, 98–103.
Guisan, A., & Thuiller, W. (2005). Predicting species distribution: Offering more than simple habitat models. *Ecology Letters, 8*, 993–1009.
Guisan, A., & Zimmerman, N.E. (2000). Predictive habitat distribution models in ecology. *Ecological Modelling, 135*, 147–186.
Hadley Centre. (2005). *Climate change and the greenhouse effect*. Exeter, UK: Hadley Centre for Climate Prediction and Research.
Hardy, A., Beeton, R.J.S., & Pearson, L. (2002). Sustainable tourism: An overview of the concept and its position in relation to conceptualisations of tourism. *Journal of Sustainable Tourism, 10*, 475–496.
Harley, C.D.G., Randall, H.A., Hultgren, K.M., Miner, B.G., Sorte, C.J.B., Thornber, C.S., et al. (2006). The impacts of climate change in coastal marine systems. *Ecology Letters, 9*, 228–241.
Higham, J.E.S., Bejder, L., & Lusseau, D. (2009). An integrated and adaptive management model to address the long-term sustainability of tourist interactions with cetaceans. *Environmental Conservation, 35*, 294–302.
Higham, J.E.S., & Lusseau, D. (2007). Urgent need for empirical research into whaling and whale watching. *Conservation Biology, 21*, 554–558.
Higham, J.E.S., & Lusseau, D. (2008). Slaughtering the goose that lays the golden egg: Are whaling and whale-watching mutually exclusive? *Current Issues in Tourism, 11*, 63–74.
Hoyt, E. (2001). *Whale watching 2001: Worldwide tourism numbers, expenditures and expanding socioeconomic benefits*. Crowborough, UK: International Fund for Animal Welfare.
Hoyt, E. (2005). Sustinable ecotourism on Atlantic islands, with special reference to whale watching, marine protected areas and sanctuaries for cetaceans. *Biology and Environment: Proceedings of the Royal Irish Academy, 105B*(3), 141–154.
Hoyt, E., & Hvenegaard, G.T. (2002). A review of whale-watching and whaling with applications for the Caribbean. *Coastal Management, 30*, 381–399.
Hulme, M., Jenkins, G.J., Jones, R., Lu, X., Turnpenny, J.R., Mitchell, T.D., et al. (2002). *Climate change scenarios for the United Kingdom: The UKCIP02 scientific report*. Norwich, UK: Tyndall Centre for Climatic Change Research.
Huntley, B., Green, R.E., Collingham, Y.C., & Willis, S.G. (2007). *A climatic atlas of European breeding birds*. Barcelona: Lynx Edicions.
Hvenegaard, G.T. (2002). Using tourist typologies for ecotourism research. *Journal of Ecotourism, 1*, 7–18.
Intergovernmental Panel on Climate Change. (2001). *Climate change 2001: Synthesis report, summary for policymakers*. Geneva: Author.
Intergovernmental Panel on Climate Change. (2007a). *Climate change 2007: The physical science basis – Summary for policymakers*. Geneva: Author.
Intergovernmental Panel on Climate Change. (2007b). *Climate change 2007: Synthesis report*. Geneva: Author.
Irons, D.B., Anker-Nilssen, T., Gaston, A.J., Vernon, Byrd. G., Falk, K., Gilchrist, G., et al. (2008). Fluctuations in circumpolar seabird populations linked to climate oscillations. *Global Change Biology, 14*, 1455–1463.
Johnston, M.E. (2006). Impacts of global environmental change on tourism in the polar regions. In S. Gössling & C.M. Hall (Eds.), *Tourism and global environmental change: Ecological, social, economic and political interrelationships* (pp. 37–53). London: Routledge.
Kaschner, K., Watson, R., Trites, A.W., & Pauly, D. (2006). Mapping world-wide distributions of marine mammal species using a relative environmental suitability (RES) model. *Marine Ecology Progress Series, 316*, 285–310.
Kraus, S. (1995). Attitudes and the prediction of behavior: A meta-analysis of the empirical literature. *Personality and Social Psychology Bulletin, 21*, 58–75.
Leaper, R., Cooke, J., Trathan, P., Reid, K., Rowntree, V., & Payne, R. (2006). Global climate drives southern right whale (*Eubalaena australis*) population dynamics. *Biology Letters, 2*, 289–292.
Learmonth, J.A., MacLeod, C.D., Santos, M.B., Pierce, G.J., Crick, H.Q.P., & Robinson, R.A. (2006). Potential effects of climate change on marine mammals. *Oceanography and Marine Biology: An Annual Review, 44*, 431–464.

MacLeod, C.D. (2009). Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. *Endangered Species Research, 7*, 125–136.

MacLeod, C.D., Bannon, S.M., Pierce, G.J., Schweder, C., Learmonth, J.A., Herman, J.S., et al. (2005). Climate change and the cetacean community of north-west Scotland. *Biological Conservation, 124*, 477–483.

MacLeod, C.D., Mandleberg, L., Schweder, C., Bannon, S.M., & Pierce, G.J. (2008). A comparison of approaches for modelling the occurrence of marine animals. *Hydrobiologia, 612*, 21–32.

MacLeod, C.D., Santos, M.B., Reid, R.J., Scott, B.E., & Pierce, G.J. (2007a). Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: Could climate change mean more starving porpoises? *Biology Letters, 3*, 185–188.

MacLeod, C.D., Weir, C.R., Pierpoint, C., & Harland, E.J. (2007b). The habitat preferences of marine mammals west of Scotland (UK). *Journal of the Marine Biological Association of the United Kingdom, 87*, 157–164.

Malcolm, C.D., Duffas, D.A., & Malaspina, R. (2002). *The case for site-specific education strategies in ecotourism management: Whale-watching on Vancouver Island, B.C.* Paper presented at the tenth Canadian Congress on Leisure Research, Alberta, Canada.

Marubini, F., Gimona, A., Evans, P.G.H., Wright, P.J., & Pierce, G.J. (2009). Habitat preferences and interannual variability in occurrence of the harbour porpoise *Phocoena phocoena* off northwest Scotland. *Marine Ecology Progress Series, 381*, 297–310.

Moore, S.E., & Huntington, H.P. (2008). Arctic marine mammals and climate change: Impacts and resilience. *Ecological Applications, 18*, S157–S165.

Mustin, K., Sutherland, W.J., & Gill, J.A. (2007). The complexity of predicting climate-induced ecological impacts. *Climate Research, 35*, 165–175.

Nicholls, S. (2006). Climate change, tourism and outdoor recreation in Europe. *Managing Leisure, 11*, 151–163.

Nyaupane, G.P., & Chhetri, N. (2009). Nature-based tourism in the Nepalese Himalayas. *Tourism Geographies, 11*, 95–119.

Olsson, P., Folke, C., & Berkes, F. (2004). Adaptive co-management for building resilience in social-ecological systems. *Environmental Management, 34*, 75–90.

Orams, M.B. (2000). Tourists getting close to whales, is it what whale-watching is all about? *Tourism Management, 21*, 561–569.

Orams, M.B. (2002). Humpback whales in Tonga: An economic resource for tourism. *Coastal Management, 30*, 361–380.

Pagnan, J.L. (2003). *The impact of climate change on Arctic tourism: A preliminary review*. Paper presented at the World Tourism Organisation first International Conference on Climate Change and Tourism, Djerba, Tunisia.

Parsons, E.C.M., Warburton, C.A., Woods-Ballard, A., Hughes, A., Johnston, P., Bates, H., et al. (2003). Whale-watching tourists in west Scotland. *Journal of Ecotourism, 2*, 93–113.

Pearson, R.G., & Dawson, T.P. (2003). Predicting the impacts of climate change on the distribution of species: Are bioclimate distribution models useful? *Global Ecology and Biogeography, 12*, 361–371.

Perry, A. (2006). Will predicted climate change compromise the sustainability of Mediterranean tourism? *Journal of Sustainable Tourism, 14*, 367–375.

Perry, A.L., Low, P.J., Ellis, J.R., & Reynolds, J.D. (2005). Climate change and distribution shifts in marine fishes. *Science, 308*, 1912–1915.

Peterson, A.T., Ortega-Huerta, M.A., Bartley, J., Sánchez-Cordero, V., Soberón, J., Buddemeier, R.H., et al. (2002). Future projections for Mexican faunas under global climate change scenarios. *Nature, 416*, 626–629.

Rawles, C.J.G., & Parsons, E.C.M. (2005). Environmental motivation of whale-watching tourists in Scotland. *Tourism in Marine Environments, 1*, 129–132.

Redfern, J.V., Ferguson, M.C., Becker, E.A., Hyrenbach, K.D., Good, C., Barlow, J., et al. (2006). Techniques for cetacean-habitat modelling. *Marine Ecology Progress Series, 310*, 271–295.

Richardson, A.J. (2008). In hot water: Zooplankton and climate change. *ICES Journal of Marine Science, 65*, 279–295.

Scott, D., Jones, B., & Konopek, J. (2007). Implications of climate and environmental change for nature-based tourism in the Canadian Rocky Mountains: A case study of Waterton Lakes National Park. *Tourism Management, 28*, 570–579.

Simmonds, M.P., & Elliot, W.J. (2009). Climate change and cetaceans: Concerns and recent developments. *Journal of the Marine Biological Association of the United Kingdom, 89*, 203–210.

Simmonds, M.P., & Isaac, S.J. (2007). The impacts of climate change on marine mammals: Early signs of significant problems. *Oryx, 41*, 19–26.

Sims, D.W., Genner, M.J., Southwards, A.J., & Hawkins, S.J. (2001). Timing of squid migration reflects North Atlantic climate variability. *The Royal Society of London Series B, 268*, 2607–2611.

Stenseth, N.C., Mysterud, A., Ottersen, G., Hurrell, J.W., Chan, K.S., & Lima, M. (2002). Ecological effects of climate fluctuations. *Science, 297*, 1292–1296.

Tynan, C.T., & DeMaster, D.P. (1997). Observations and predictions of Arctic climatic change: Potential effects on marine mammals. *Arctic, 50*, 308–322.

United Nations World Tourism Organization, UN Environment Programme and World Meteorological Organization. (2008). *Climate Change and Tourism – Responding to Global Challenges.* Madrid, Spain: UN World Tourism Organization.

Uyarra, M.C., Côté, I.M., Gill, J.A., Tinch, R.R.T., Viner, D., & Watkinson, A.R. (2005). Island-specific preferences of tourists for environmental features: Implications of climate change for tourism-dependent states. *Environmental Conservation, 32*, 11–19.

Walker, B., Carpenter, S., Anderies, J., Abel, N., Cumming, G., Janssen, M., et al. (2002). Resilience management in social-ecological systems: A working hypothesis for a participatory approach. *Conservation Ecology, 6*(1), 14.

Wall, G. (1998). Implications of global climate change for tourism and recreation in wetland areas. *Climatic Change, 40*, 371–389.

Warburton, C.A., Parsons, E.C.M., Woods-Ballard, A., Hughes, A., & Johnston, P. (2001). *Whale-watching in West Scotland*. London: UK: Department for Environment, Food and Rural Affairs.

Whitehead, H., McGill, B., & Worm, B. (2008). Diversity of deep-water cetaceans in relation to temperature: Implications for ocean warming. *Ecology Letters, 11*, 1198–1207.

Woods-Ballard, A.J., Parsons, E.C.M., Hughes, A.J., Velander, K.A., Ladle, R.J., & Warburton, C.A. (2003). The sustainability of whale-watching in Scotland. *Journal of Sustainable Tourism, 11*, 40–55.