PACIFIC ISLAND WHALES IN A CHANGING CLIMATE

CET LAW

Blue Climate Solutions
A project of The Ocean Foundation

PROTECT PACIFIC WHALES – OCEAN VOYAGERS

SPREP
Secretariat of the Pacific Regional Environment Programme

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Page 4: Catlin Seaview Survey
Page 12: Niue Tourism
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CONTENTS

Introduction

Pacific island culture and history are intertwined with the ocean and its whale inhabitants; whether through voyage, ancestry, artefact or migration, the movements and stories cannot be separated. Whales feature in legends and history, serving in many roles such as guardians of voyagers on the ocean or as reincarnated ancestors. The arrival or sighting of whales can bring messages or signify certain events, such as the time to harvest yams. On some islands, parts of whales, particularly teeth, are culturally significant when exchanged. This interconnected chronicle continues to the current day, augmented by an economic dependence with the advent of a growing whale-watching tourism industry, and with the additional character of climate change joining the narrative.

Of all the carbon dioxide emitted by human activities, the ocean has absorbed approximately one-third, and continues to do so, along with most of the 0.6°C global temperature increase over the past 30 years (Hoegh-Guldberg & Bruno, 2010). Pacific Islanders, who collectively produce less than 0.03% of current global greenhouse gas emissions, disproportionately bear the brunt of climate change, being among the first nations in the world to feel the real effects of rising seas and intensified weather patterns (SPREP, 2017). Playing no role in their creation, whales are obliged to endure the direct and indirect consequences of climate change and other human activity to their habitat. Whaling greatly depleted whale populations in the South Pacific, to the extent that they are not yet fully recovered (Olavarria, et al., 2007; Jackson, et al., 2013). Climate change is likely to compound the impacts of non-climatic threats to whales, which, in turn, are likely to affect whales' ability to respond to climate change (MacLeod, 2009; Ashford-Hodges & Simmonds, 2014; Helmuth, et al., 2013).

Although there is much to still understand, this report explores the potential impacts of climate change on Pacific island whales, and implications for the region. By identifying the potential direct and indirect impacts of climate change, and the related consequences for both Pacific island whales and whale-watching economies, we can work towards identifying solutions for humans and whales alike, since, like the story of old, we are on this journey together.

Whales of the Pacific Islands and the Climate Change Challenge

The vast, ever-changing nature and inaccessibility of the ocean can be a barrier to data collection on whale populations (Hoegh-Guldberg & Bruno, 2010; Learmonth, et al., 2006). Over half of cetaceans in Oceania, as well as globally, are classified as data deficient by IUCN, meaning the status and condition of their population is unknown (Polidoro, et al., 2011; Simmonds & Eliott, 2009; Learmonth, et al., 2006; Miller & Prideaux, 2013). The Pacific islands region, administered by the Secretariat of the Pacific Regional Environmental Programme (SPREP), covers over 32 million km2, and surrounds 22 Pacific Islands Countries and Territories (PICTs) (SPREP, 2013). The region provides habitat to both resident and migratory, baleen and toothed whales (SPREP, 2013), and 26 distinct species of whales, dolphins and porpoises have been recorded here (Miller & Prideaux, 2013; SPREP, 2013). It is estimated that over half of these cetaceans depend on the waters of PICTs for feeding, migration, breeding, calving, and/or socializing (Miller & Prideaux, 2013; SPREP, 2013). Migratory whales, such as humpback whales, are also dependent on corridors and habitats outside of PICT waters (Constantine, et al., 2010).

Assessing the potential impacts of climate change on whales is challenging. Climate change is causing ocean warming, reduction of sea ice, and rising sea levels, but the nature and degree to which these effects will occur, how they will interact, and the responses of whales as complex ocean organisms are difficult to predict (Learmonth, et al., 2006). Changes in whales' prey distribution, reduced whale reproduction rates, changes in ocean salinity levels, and ever-increasing ocean-based human activities contribute to the complexity of modelling outcomes of climate change on whales (Kaschner, et al., 2011; Learmonth, et al., 2006). Thus, predictions of climate change effects on whales, their populations, and their responses to climate and ecosystem variations remain speculative (Learmonth, et al., 2006).

Impacts of Climate Change on Pacific Island Whales

Whales face both direct and indirect impacts of climate change (Learmonth, et al., 2006; Kaschner, et al., 2011; Fleming, et al., 2015). Whales' responses to climate change may include changes in geographical distribution; changes in timing of events, such as migration or breeding; physiological adaptation; or extinction (Learmonth, et al., 2006; Doney, et al., 2012; Ramp, et al., 2015). As ocean conditions change, most whales are expected to exhibit behavioural changes where possible, rather than physiological responses (Kaschner, et al., 2011). Here we outline the effects of climate change and how they are expected to affect whale species in PICTs.

Direct Impacts

WARMING OCEANS

Models assessing ocean warming over the next 35 years indicate that the Pacific islands may experience reduced diversity of marine mammal species found in their waters (Kaschner, et al., 2011). Sea surface temperature influences the geographic range of many whale species (Lambert, et al., 2014; Ashford-Hodges & Simmonds, 2014; MacLeod, 2009). Without geographical barriers to movement, whales in PICTS are expected to move towards cooler waters (Kaschner, et al., 2011). Whale species may respond to climate change at different rates to each other, and to their prey (Ashford-Hodges & Simmonds, 2014; Parmesan, 2006), which can affect the success of range shifts (Ashford-Hodges & Simmonds, 2014; Lambert, et al., 2014). Where range size is reduced, which can be due to geographic barriers to whale population movement or changes in prey or habitat availability (Lambert, et al., 2014), the risk of extinction is increased (Parmesan, 2006). Using projections from the Intergovernmental Panel on Climate Change, it is estimated that, by the years 2040-49, ocean temperature change will cause 58% of cetacean species to experience range expansion, 2% to experience a stable range size, and 40% to experience a reduction in range size (Kaschner, et al., 2011).

In addition to changes in whales behaviour, warming oceans may increase the likelihood of illness and disease outbreaks (Hoegh-Guldberg & Bruno, 2010). Temperature change is expected to expand the ranges of some pathogens and vectors of disease, and elevated stress in whales may lead to whales' increased susceptibility to illness and disease (Hoegh-Guldberg & Bruno, 2010).

SOUND

Whales are dependent on sound to interact with each other and their environment (Ilyina, et al., 2009; Matsumoto, et al., 2014). Low-frequency sound is used by several baleen species found in PICTs, including fin and blue whales (Clark, et al., 2009; SPREP, 2013). Climate change is expected to alter the sound environment of the ocean. First, ocean acidification, caused by absorption of CO2 into the ocean, which reduces ocean pH levels (Zeebe, Zachos, Caldeira, & Tyrrell, 2008), will affect the chemical properties of the ocean that absorb sound (Ilyina, et al., 2009; Hester, et al., 2008), increasing the distance that low-frequency sound is able to travel through the ocean (Ilyina, et al., 2009). With sound travelling further, negative impacts on whales in PICTs could be behavioural, including avoidance of former habitats or disruption of normal activities, or physiological, including tissue damage or loss of hearing (Ilyina, et al., 2009). There may also be positive impacts for PICTs whales, such as the ability to communicate over longer distances (Ilyina, et al., 2009). The impacts of ocean acidification on noise are expected to be heightened by other impacts of climate change, and particularly ocean warming (Hester, et al., 2008).

Second, climate change may have far-reaching impacts on background noise in the Southern and Pacific Oceans, as larger icebergs separate from Antarctica (Matsumoto, et al., 2014). Large icebergs are noisier than smaller icebergs, and massive icebergs can be heard from the equatorial Pacific Ocean (Matsumoto, et al., 2014). These icebergs break down slower and travel further before disappearing, and the constant sound of their erosion, by waves and movement of water passed their submerged sides, subsequently lasts longer and travels further across the ocean (Matsumoto, et al., 2014; Silva, et al., 2006). However, the relationship between climate change and iceberg size and frequency, and the subsequent impacts on whales, are not well understood (Matsumoto, et al., 2014).

Indirect Impacts

DISRUPTED FOOD CHAINS

Changes in prey availability due to climate change, particularly fluctuations in sea surface temperature, are already being observed in some regions (Fleming, et al., 2015; Hauser, et al., 2016; Ramp, et al., 2015). Reduction or changes in whales' prey availability could be as strong a driver of changes in whale distribution as temperature (Kaschner, et al., 2011). Ocean acidification can affect behaviour, stunt growth, or otherwise impact the development of fish, squid, phytoplankton, zooplankton, and coral reef-forming organisms (Doney, et al., 2012; Kaplan, et al., 2013; Hoegh-Guldberg & Bruno, 2010; Zeebe, et al., 2008). These animals and plants are important to whales, either as components in their food chains, or as reef building species that provide important habitat for prey (Fleming, et al., 2015; Doney, et al., 2012; Kaplan, et al., 2013). Ocean acidification is expected to affect all habitats of PICTs whales, from the Antarctic to the tropics (Fabry, et al., 2008; Doney, et al., 2012), with irreversible consequences for food chains (Doney, et al., 2012; Sydeman, et al., 2015). However, predicting the impact on whales of this disruption is complex, as some plant species at the base of the whales' food chains are expected to increase production in response to acidification (Doney, et al., 2012; Kroeker, et al., 2010; Sydeman, et al., 2015).

Whales may develop adaptation strategies to climate-driven changes in food availability, or face extinction (Doney, et al., 2012; Learmonth, et al., 2006; Ramp, et al., 2015). In response to changes in prey availability in the Northeast Pacific, humpback whales have been recorded switching from their usual prey, krill, to anchovy and sardines (Fleming, et al., 2015), and gray whales have produced fewer calves (Salvadeo, et al., 2015). In the North Atlantic, the timing of humpback whales' migration has shifted, possibly due to climate-driven changes in timing of prey availability (Ramp, et al., 2015). In PICTs, both ocean warming and ocean acidification may affect toothed whale prey, such as fish and squid (Kaplan, et al., 2013; Learmonth, et al., 2006). Effects of ocean warming on toothed whale prey may include changes to their development, behaviour and distribution (Learmonth, et al., 2006). Acidification may further affect the future availability of squid for whales, as well as reduce availability of whale prey species that are dependent on coral reef habitats (Kaplan, et al., 2013; Doney, et al., 2012; Hoegh-Guldberg & Bruno, 2010; Zeebe, et al., 2008). While some PICTs' coral reefs have adapted to naturally acidified waters, it is unknown whether these will continue to provide suitable habitat for species important for whales' food chains in the event of climate-driven acidification (Shamberger, et al., 2013).

Most baleen whale species do not feed in Pacific island waters, they migrate to feeding grounds in Antarctic waters during austral summer (Constantine, et al., 2010). These whales are dependent on the availability of their primary prey, Antarctic krill (Clapham, 2016; Hofman, 2017). Krill availability is dictated by ice cover and ocean fronts, which will shrink with warming oceans (Kaschner, et al., 2011; Thomas, et al., 2015). Reduced krill abundance is expected to cause whale malnourishment and population decreases (MacLeod, 2009; Learmonth, et al., 2006), and may disrupt the migration patterns of Pacific island whales, including length and timing (MacLeod, 2009), as migratory whales in PICTs are expected to travel an additional 3-5o of latitude further south to find foraging grounds (Thomas, et al., 2015).

INCREASED COMPETITION

Climate change could be a significant factor in increasing competition between whale species whose ranges were formerly separated (MacLeod, et al., 2007; Ramp, et al., 2015). Overlap may occur where whale populations with expanding ranges encroach upon species with contracting ranges (Ashford-Hodges & Simmonds, 2014; MacLeod, 2009), or through changes to timing of migrations (Ramp, et al., 2015). It is difficult to predict the likelihood and outcomes of such occurrences (MacLeod, 2009). Climate-forced range overlaps add complexity to established food chains, compound existing threats with increased competition, and can result in exclusion of formerly dominant whale species from the limited resources (Ashford-Hodges & Simmonds, 2014; MacLeod, et al., 2007).

CLIMATE-INDUCED HUMAN ACTIVITY

Changes in human behaviour associated with climate change, called tertiary effects, are likely to result in increased encroachment of human activities upon whale habitats (Alter, et al., 2010). Examples include human migration to areas that become increasingly habitable, including coasts, and increased activities in newly-accessible ocean and polar areas, such as shipping, mining, and fishing (Alter, et al., 2010). This encroachment into whale habitats and the associated threats are expected to exacerbate the impacts of climate change on whales (Alter, et al., 2010).

Non-climate Stressors

Existing and emerging threats to whales, unrelated to climate change, remain a factor in whales' responses and ability to adapt to climate change (Thomas, et al., 2015). Because of their life history traits, such as slow growth, lower population densities, and reliance on multiple distinct habitats, whales are at higher risk of extinction than smaller mammals (Schipper, et al., 2008). Accidental whale mortality, through entanglement in fishing gear or ship strikes, is thought to be the most prevalent threat to whales in Oceania and around the world, followed by pollution, including chemicals, plastics and sound (Schipper, et al., 2008; Polidoro, et al., 2011; Thomas, et al., 2015). The International Whaling Commission now includes these impacts, as well as competition with fisheries, in its remit (Hofman, 2017).

Krill fisheries are active in the same Antarctic waters as whales that feed on krill (Hofman, 2017). Pacific island whales that migrate to Antarctic waters face potential ship strikes, and are likely competing for resources with these fisheries (Hofman, 2017). Growing demand for krill, and the development of technology that reduces the cost of krill fishing, are likely to result in industry pressure for increased catch allowances (Hofman, 2017). Balancing conservation and fishery activities could diminish the principles of conservation outlined in the Convention on the Conservation of Antarctic Marine Living Resources (CAMLR Convention) (Hofman, 2017). Krill fisheries therefore have the potential to exacerbate any negative ecological impacts of climate change on krill-dependent food chains, including humpbacks and other baleen whales (Hofman, 2017).

Impacts of Climate Change on the Whale-Watching Industry

Whale-watching tourism around the world is growing, as tourists increasingly seek authentic experiences in natural habitats (Cisneros-Montemayor, et al., 2010). Growth of this sector in the Pacific island region was estimated at 45% per year during the period between 1998 – 2005 (SPREP, 2013). A 2005 study reported US $7.5 million of direct economic benefit, and US $21 million of total economic benefit to the region (SPREP, 2013). In Vava'u, Tonga alone, over the 10-year period between 1999-2009, the economic benefits of whale-watching increased more than tenfold, providing approximately US $600,000 in direct economic benefits and over US $5,000,000 in total economic benefit to an area estimated in a 2001 census to have 14,922 inhabitants (Orams, 2017). '

As a nature-based economy, whale-watching is directly dependent on the health of whale populations and their habitats, and will therefore be affected by the impacts of climate change on whales (Meynecke, et al., 2017). Although many species of dolphins and whales are found in the Pacific Island waters (SPREP, 2013), the whale and dolphin watching tourism industry focuses on the humpback whales, and humpback whales will be the focus of this section. Like most baleen whales, humpbacks in the South Pacific are migratory (Ramp, et al., 2015; Constantine, et al., 2010). South Pacific humpbacks travel to feeding grounds in Antarctica in austral summer, where they forage on a range of small fish and krill species, and migrate to the Pacific islands during austral winter for breeding and calving (Constantine, et al., 2010). Economies based on these whales therefore have a stake in ensuring the long-term protection of food and habitat at Antarctic feeding grounds.

Humpback whales are known for their seasonal site fidelity in certain breeding and feeding locations throughout their range, however some Pacific island waters are used as corridors (Constantine, et al., 2010). This subpopulation of Oceania humpback whales is one of only two populations of humpback whales on the planet listed as "endangered" (IUCN, 2017; Thomas, et al., 2015). Given the humpback whales' economic importance to PICTs, along with the endangered status of this humpback population, managing threats to these whales in order to enhance their resiliency to climate change is crucial.

SEASONAL VARIANCES

Whale-watching in the Pacific islands is a seasonal economy that follows the patterns of migrating humpback whales. The whale season is anywhere between May and November, depending on the Island State. Climate change may affect the timing of whale migrations, resulting in earlier or later humpback whale arrivals and/or departures, with the potential to shorten or lengthen the whale-watching season (Meynecke, et al., 2017). The impact of changes to whale migration timing may reduce predictability of whale occurrence, important for both tourist satisfaction and businesses, and particularly in the shoulder seasons (i.e. those first and last months when the whales are arriving and departing) (Meynecke, et al., 2017). For operators and businesses that indirectly benefit from whale-watching, such as hotels and restaurants, income and staff contracts may be affected (Lambert, et al., 2010). In addition, given the investment of time and money required to travel to PICT countries, ongoing shifts in timing and the corresponding lack of certainty may reduce the attractiveness of the Pacific islands as a whale-watching destination, both to tourists and businesses (Cisneros-Montemayor, et al., 2010).

WEATHER PATTERNS

Weather is expected to become more severe and unpredictable due to climate change, including the intensity and patterns of rainfall and frequency of cyclones (Carabine & Dupar, 2014). Circumstances may increase that lead to loss of customers or revenue (Meynecke, et al., 2017), for example, boats may be unable to launch, tourists unable to view or swim with whales, or tourists may be uncomfortable. Poor weather conditions may also increase search time on the water, which may both reduce tourist satisfaction and increase fuel expenditure (Meynecke, et al., 2017). Some PICTs are well-suited for land-based whale-watching (IFAW, 2008). If weather patterns intensify as predicted, alternative land-based infrastructure would provide an adaptive measure for the industry. Land-based experiences could relieve boat-based stress on the whales, provide an economical option and a more comfortable experience for those who do not fare well on the sea.

ABUNDANCE

With protective measures in place, most humpback whale populations around the world have been increasing (Thomas, et al., 2015). However, it is unclear to what extent, the Oceania subpopulation of humpbacks is following suit (Constantine, et al., 2010), and this subpopulation remains one of two endangered humpback whale species on the IUCN Red List (IUCN, 2017; Thomas, et al., 2015). Negative impacts of climate change on humpback whale abundance may increase search time, competition, pressure on individual whales, and associated costs to the whale-watching operators, as well as reduce customer satisfaction.

SPECIES DIVERSITY

Models indicate that, with warming oceans and a lack of geographic barriers to movement, PICTs will experience a net reduction in species diversity (Kaschner, et al., 2011). As whale-watching in PICTs is focused on humpback whales, species diversity is not currently an issue for the industry. However, the health of PICT humpback whale populations is of importance to the health of whale-watching economies. The presence of whale species other than humpbacks could enable diversification of whale-watching activities, and may enable year-round whale-watching. Alternative tours could potentially create more economic stability for the whale-watch industry, and thus resilience in a time of unpredictable climate change (Meynecke, et al., 2017).

WHALE BEHAVIOUR

Whale behaviour plays a notable role in the tourism experience with tourists being more satisfied with species that are "more active and gregarious", such as humpback whales (Cloke & Perkins, 2005; Orams, 2000). Humpback whales come to the Pacific islands to breed, calve and sing (Constantine, et al., 2010), making display of these natural behaviours part of the tourism draw. Whales undernourished or stressed by climate change and anthropogenic stressors may not exhibit these behaviours regularly: climate change has been demonstrated to affect reproductive success of humpbacks (Lambert, et al., 2010), which could affect the number of mother-calf pairs in the PICTs.

Role of Whales in Climate Change Mitigation

The contribution of whales to ecosystem function has been gaining recognition in scientific literature (Hofman, 2017; Roman, et al., 2014) and support from members of the IWC (IWC, 2016). A significant aspect of the influence of whales on marine ecosystems is that, through their unique behaviours, long life spans and large body size, whales contribute to climate change mitigation (Lavery, et al., 2012; Pershing, et al., 2010; Roman, et al., 2014). This occurs in two ways: first, whales increase the ocean's ability to absorb CO2, a greenhouse gas; and second, whales act as carbon sinks that store organic carbon in the ocean (Pershing, et al., 2010; Roman & McCarthy, 2010). This carbon captured and stored by ocean and coastal organisms, such as whales, is termed "blue carbon".

INCREASING CARBON CAPTURE

In oceans where low nutrient availability limits uptake of CO2 by plants, whales contribute to blue carbon by increasing the level of nutrients at the ocean surface, through the release of faeces and through their swimming and diving movements (Lavery, et al., 2010; Lavery, et al., 2012; Roman & McCarthy, 2010). These nutrients enable and promote the growth of phytoplankton, marine plants that obtain energy through photosynthesis, a process which captures carbon from the atmosphere (Roman & McCarthy, 2010; Lavery, et al., 2010). For example, in the Southern Ocean, sperm whales eat at depth and release faeces containing iron in surface waters, which can then be used by marine plants (Lavery, et al., 2010). Through their movement alone, whales increase nutrient availability by mixing up stratified layers in the ocean (Lavery, et al., 2012), and deliver nutrients into their breeding grounds through life processes, such as shedding skin (Roman, et al., 2014).

STORING CARBON

Whales also contribute to the ocean's carbon storage capacity by storing organic carbon, passed along through ocean food chains, in their large bodies (Pershing, et al., 2010). This carbon is stored both over the whales long lifespans and, when whale carcasses eventually sink, the carbon stored in their biomass can enter sediments (Pershing, et al., 2010). This is one way that carbon is effectively retired from the carbon cycle, and is unlikely to re-emerge as a greenhouse gas for hundreds to thousands of years (Pershing, et al., 2010).

Implications for the Pacific Islands Region

Research Priorities

Few studies focus on climate change and whales in the PICTs, and even in well-studied regions there are gaps in understanding of both the impacts on whales, and how whales will respond (Sydeman, et al., 2015). Whale migrations and their drivers are not fully understood, and potential impacts of climate change on destination habitats and migration timing are difficult to identify (MacLeod, 2009). The value of whales for their ecosystem services is being recognised in international fora (IWC, 2016), however, few studies record and quantify these services (Pershing, et al., 2010). The contribution of whales to ocean productivity, removal of carbon dioxide from the atmosphere and its storage as organic carbon in the PICTs, is unknown (Roman, et al., 2014). Continued and increased data collection is vital to advance understanding and improve predictions of climate change impacts on whales, and the role of whales in climate change mitigation (Learmonth, et al., 2006; MacLeod, 2009; Roman, et al., 2014).

Intense research efforts can help identify impacts and responses to climate change (MacLeod, 2009; Ilyina, et al., 2009), including potential causes of range shifts, their likelihood and outcomes (MacLeod, 2009). These may include long term monitoring of whales, use of satellite and remote sensing technology, traditional surveys, local knowledge, cross-disciplinary approaches to understand noise and chemical changes, and assessment of relationships between whales and their habitats. Focused research in the PICTs can enable application of whale conservation measures to meet international climate change mitigation targets, as well as estimates of the carbon-market value of whale conservation (Martin, et al., 2016). Payments to protect natural carbon storage in coastal ecosystems are already a reality, and benefits shared with communities encourage stewardship of natural resources (Locatelli, et al., 2014). Ultimately, when climate change projections are combined with understanding of other threats to whales, conservation and management plans can incorporate proactive measures to address expected conflicts between whales and human activities (MacLeod, 2009), reducing avoidable stressors and enhancing resilience of whale populations to climate change.

Opportunities for Collaborative Conservation

Given the geographical scope of PICT waters and the importance of migratory whales to whale-watching economies, collaborative partnerships between governments, organisations and researchers are essential to tackling climate change issues (Meynecke, et al., 2017). Combined with the precautionary principle, research efforts can guide climate mitigation and adaption strategies that benefit Pacific island whales and their ocean habitats, and support their cultural and economic roles (Meynecke, et al., 2017). Current international conservation action and policy, which is often based on IUCN evaluations, does not account for potential impacts of climate change (Lambert, et al., 2014). Collaboration between PICT governments could promote and encourage a more holistic approach to whale conservation and management throughout their range, including within PICT waters, in Antarctic areas governed by the CAMLR Convention, and in areas beyond national jurisdiction (ABNJ).

Nationally, collaborative partnerships to address issues related to climate change and industry can be formed between government, research, private sector, and NGOs. Environmental assessment, planning, management, or other mechanisms considering and regulating the impacts of industry, could be updated to consider likely cumulative impacts of human activities and climate change on ocean ecosystems and whales.

For whale populations with ranges that cross national borders, international collaboration will help to identify key habitats, and establish consistent and effective conservation and management measures therein. Baleen whales, including humpbacks, are dependent upon Antarctic feeding grounds, and thus the success of ecosystem based fisheries management (EBFM) of Antarctic krill (Hinke, et al., 2017). This EBFM aims not only to protect krill populations, but also predator populations, including whales, and the entire ecosystem (Hinke, et al., 2017). PICTs with baleen whale populations, and particularly those with livelihoods and economies supported by humpback whales, have a stake in the ongoing efficacy of these protections (Hinke, et al., 2017). Identification of areas where industry-whale interactions are most likely, and allowance of fishery harvest rates that will not diminish resources for whales, are essential for EBFM to reduce risks to whales (Hinke, et al., 2017). However, at present, there is no formal requirement for management of the krill fishery to consider the effects of climate change on krill resources, predator populations, or the broader ecosystem (Hofman, 2017).

Although most of the waters of the Pacific islands region are within EEZs, whales migrate freely through the surrounding areas beyond national jurisdiction (ABNJ). In 2015, the United Nations General Assembly adopted a resolution to develop an agreement to address the conservation and sustainable use of marine biological diversity in ABNJ (UN ABNJ agreement) (UNGA, 2015). The development process is currently underway, and provides an opportunity for the PICT region to unite with other like-minded states, regions and/or organizations, to be a strong voice for the protection of whales and their habitats in the high seas, including their safe passage through migratory corridors.

Conclusions and Recommendations

Climate change will affect the feeding behaviour, distribution, sound environment and migration patterns of whales, forcing adaptive responses or extinction (Ashford-Hodges & Simmonds, 2014; Ilyina, et al., 2009). Many models attempt to predict marine mammal distribution in response to climate factors such as temperature (Kaschner, et al., 2011; Salvadeo, et al., 2015), however few consider the potential, and likely significant, indirect effects such as changes in prey distribution and abundance (Kaschner, et al., 2011; Lambert, et al., 2014).

Climate change is enabling human exploration and industry to expand and to enter new regions of Antarctic waters (Hinke, et al., 2017). As a result, the potential for human disturbance to Pacific island whales is consequently increased, including noise, ship strikes and pollution (Thomas, et al., 2015). Non-climate related threats will be compounded by climate change, and simultaneously exacerbate climate change impacts on prey and habitat, as well as the direct mortality of whales (MacLeod, 2009). Since restoration of whale populations could help mitigate global warming (Clapham, 2016), activities that negatively impact whale populations will also limit their mitigation potential.

WHALE CONSERVATION AND MANAGEMENT

Conservation and management strategies, such as marine protected areas, need to address both climate and non-climate related threats to be successful (Hoegh-Guldberg & Bruno, 2010). When applied in key areas, these measures can increase resilience to climate change, and help to reduce stress from anthropogenic impacts (Ashford-Hodges & Simmonds, 2014). Conservation and climate change strategies that recognise blue carbon services of whales could be used as mechanisms to finance whale conservation and management (Pershing, et al., 2010), and secure co-benefits for whale-watching economies.

WHALE-WATCHING ECONOMIES

Economies based on whale-watching tourism are dependent on both the continued presence of whales and positive tourist experiences (Meynecke, et al., 2017). Whale-watching economies in PICTs are largely focused on migratory humpback whales, thus engagement with the international community for the protection of whale habitats and migratory corridors, with consideration for the impacts of climate change, will be essential for the continued success of these economies. Diversification of whale-watching opportunities can increase resilience of the whale-watch industry (Meynecke, et al., 2017), such as land-based observation of whales, or inclusion of other whale species in tours.

RESEARCH

Research is required to inform proactive policies and management decisions, including priority areas and actions (Kaschner, et al., 2011). The drivers that define the niche for each whale species are not well understood, both in PICTs and globally (Ashford-Hodges & Simmonds, 2014). Collaborative and long-term research would improve understanding of large scale processes, identify likely range shifts and other behavioural changes (Kaschner, et al., 2011). Traditional knowledge could be gathered to enhance observations, along with insights from researchers, fishers and boat-based tourism operators, on trends and anecdotal observations on the water (Meynecke, et al., 2017). Combined with studies into the role of Pacific island whales in climate change mitigation, this research could also inform projects that aim to preserve and restore healthy whale populations for their carbon sequestration services (Pershing, et al., 2010).

STRATEGIES IN NATIONAL WATERS

In PICTS, marine management practices that incorporate climate change adaptive measures could be encouraged and formalised through customary and introduced law. Impacts on ocean ecosystems, and thus whales and their habitats, could be systematically incorporated into assessment criteria of ongoing and future activities. Climate adaptation discussions, plans and frameworks could tap into the potential of whales and their blue carbon services (Pershing, et al., 2010). Formal recognition of the necessity of addressing the impacts of climate change on whales, alongside other threats, and support for action, can enable development of management plans and advocacy with international bodies for policy and financial support. Community engagement and outreach could help increase understanding of, and support for, protecting whale species (Meynecke, et al., 2017).

STRATEGIES FOR MIGRATORY WHALES

To ensure protection of migratory whales, their habitats, food webs and migratory corridors outside of Pacific Island waters, PICTs could support efforts to secure strong ocean governance in the new UN ABNJ agreement, for example the inclusion of mechanisms to establish marine protected areas. The next Preparatory Committee meeting is 10-21 July 2017. To enhance the resilience of baleen whales to climate change, PICTs could demonstrate support for the current conservation principles of the CAMLR Convention, and encourage consideration of climate change in proactive management measures for Antarctic krill fisheries in whale feeding grounds (Hinke, et al., 2017; Hofman, 2017).

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