Key climate change effects on the coastal and marine environment around the South Atlantic UK Overseas Territories

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EXECUTIVE SUMMARY

- The South Atlantic UK Overseas Territories (SAOTs) face challenges in assessing the potential impacts of climate change due to problems such as a lack of definitive baseline data, but also a lack of the capacity, resources, or funding to collect relevant data. Relevant datasets that exist are commonly recorded at a coarse, regional or global scales, with few existing locally for the SAOT areas.
- Balancing conservation priorities in developing nations such as the SAOTs can often prove challenging leading to conflict between environmental protection, economic development, political and cultural values.
- Further data, information and knowledge accumulation are required to develop keystone or indicator species for the area. This could then be combined with long-term oceanographic monitoring programmes.
- Action should be taken now in each of the SAOTs to try to ensure resilience and adaptation to climate change. This will require funding levels that the territories themselves cannot provide, so assistance will be required from external sources.
- Globally, there have been impacts on fisheries catches and compositions as a result of changes in climate, with a general shift toward the North and South Poles in key tuna species. This shift could result in a benefit to St Helena and Ascension Island by increasing habitat suitability and catch potential for certain species (Bigeye, Skipjack, Yellowfin tuna) as they move further south, but could result in Tristan da Cunha becoming less suitable for Southern Bluefin tuna. However, it is acknowledged that Ascension Island and Tristan da Cunha do not commercially fish these species so the impact to catch potential would be limited.
- Kelp forests are important pillars of the marine food chain (i.e. they are primary producers) that support many species in both Tristan da Cunha and the Falkland Islands, whilst also serving as carbon sinks via sequestration. Many of the key species they underpin are key fisheries species of economic and cultural importance such as the

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Tristan lobsters. There is no conclusive evidence of climate change impact locally on kelp species to date, but abundance and distribution has been shown to be impacted globally, with increases in some habitats and decreases in others.
- Further changes brought about by variations in climate are predicted to affect primary productivity, impacting both higher levels of the food chain and the industries they underpin (e.g. fisheries and tourism).
- Changes in arrival pathways for invasive species as well as more hospitable conditions for establishment and expansion could occur, with some concern over expansion of invasives currently found in the SAOTs (e.g. seagrapes in St Helena, and the House mouse on Gough Island).
- The designation of Marine Protected Areas, zones and marine spatial planning by each of the SAOTs is vital in building resilience against climate change and anthropogenic pressures.
- These protected areas place further challenges on the SAOTs such as being costly to maintain, sometimes competing with a developing economy or being at odds with traditional local practices. These challenges in maintaining protected areas are likely to intensify as climate change accelerates, and puts pressure on the SAOTs' already-limited resources.
- Impacts of climate change on key endangered/protected/key fisheries species such as the Green Turtle on Ascension Island, and lobster in Tristan da Cunha's waters could potentially be experienced resulting in impacts to cultural identity and economic security.
- Storms have caused significant damage to infrastructure as well as impacting species abundance on a number of the SAOTs. Expected increases in the frequency and severity of adverse weather conditions will likely result in both primary and secondary economic impacts as well as further direct loss of species.
- There are limited examples of 'nature-based solutions' within the SAOTs currently, often as a result of a lack of data availability, funding and capacity to implement schemes. Most examples focus on elements (habitats, species etc.) which are likely to be exacerbated by a change in climate, rather than addressing climate change factors directly.

DESCRIPTION OF OVERSEAS TERRITORIES IN THE REGION

The areas referred to as the 'South Atlantic UK Overseas Territories' (SAOTs) for the purposes of this paper are made up of the following islands Ascension Island, the Falkland Islands, Tristan da Cunha and St Helena. The territories span the South Atlantic region from just south of the equator to 1200 km north of the Antarctic Peninsula.

Ascension Island, Tristan da Cunha, and St Helena are small volcanic islands (<220 km^2), formed around the Mid-Atlantic Ridge. Each of the islands has designated an area of marine protection in its waters, covering a total area of over 1.5 million km^2, which, depending on the designation, allows or prohibits a variety of different activities to be undertaken within the marine environment. The Falkland Islands are a larger archipelago (>12,000 km^2), and although not having a formal marine protection designation, undertake a variety of marine spatial planning activities within their Exclusive Economic Zone (EEZ).

The territories are all relatively young in their economic development, with each of the SAOTs able to support itself to varying degrees. St Helena and Tristan da Cunha are currently provided with varying levels of Official Development Assistance (ODA) via the Foreign, Commonwealth and Development Office (FCDO) while the Falklands and Ascension islands are self-financing (noting that Ascension Island is supported by a significant military presence).

Each of the SAOTs is dependent to a certain extent on the waters surrounding it, be it for food security, maritime shipping, tourism or local recreational/cultural activities; the Tristan da Cunha lobster fishery provides 80% of the islands' GDP (Caselle et al., 2018) while St Helena's marine industries contribute over GB£1.2 million to the island's economy (Rees et al., 2016). The Falklands economy is largely focused on fisheries that account for 40% of the country's GDP (GB£13 million) (Falkland Islands Government, 2021). Ascension's marine economy has undergone a change since the MPA designation since 2019, with the prohibition of commercial fishing, the island is moving towards becoming an international centre for marine research and the expansion of a sustainable tourist industry (Ascension Island Government, 2020).

The flora and fauna of the territories are determined largely by their remoteness, insularity, their geographical position in the ocean (de Bettencourt and Imminga-Berends, 2015), and the islands in general have a high level of endemism as a result of this. The waters around the SAOT have a high abundance of a diverse array of marine life, with each being home to both locally resident species, and larger migratory species.

MAIN CLIMATE CHANGE DRIVERS

Before addressing some of the climate change drivers affecting the SAOTs, it is important to note the challenges they face when predicting or planning for those drivers.

A shortage or complete lack of historical baseline data enabling the assessment of environmental change, known as the 'shifting baselines concept' is a well-documented challenge in assessing change affecting the distribution and abundance of living organisms in the marine environment (Küpper and Kamenos, 2017). For the SAOTs, this lack of baseline is often related to lack of funding to be able to undertake data collection, as well as a lack of technical capacity or resources in some instances.

There is also the issue of competing priorities. A large amount of the world's threatened biodiversity is held within overseas territories and other small islands which often face difficult challenges in balancing conservation priorities, environmental protection, and economic development (Churchyard et al., 2016). For the SAOTs, programmes such as Darwin, OTEP, Blue Belt as well as other non-governmental organisation donor funding provide opportunities for detailed studies/interventions, but they are often highly specific, of a relatively short duration and difficult to maintain for long-term monitoring purposes once funding streams come to an end.

This often means the four SAOTs have datasets that are short in duration or only exist for fixed periods of time, and will not be able to account for the 'lost' years prior to collection. As a result, SAOTs are forced to use larger scale (often global) datasets which lack the granularity to be able to assess localised climate-change impacts given the relative sizes of islands and archipelagos. It is, however, to an extent, possible to assess observed and potential climate change impacts based on the SAOTs, their species, economies, and cultures, though some of the findings may be of a lower confidence than countries and regions with more-established research and monitoring methods.

The key climate change issues identified by the SAOTs are as follows:

- Changes in marine resources for consumption – fishes and invertebrates – and impacts upon food security.
- Changes in productivity – pelagic habitats, phytoplankton primary productivity.
- Changes in coastal communities and loss of/changes to cultural identity.

Climate change is likely to impact many of the benefits, or 'ecosystem services', that the SAOT communities derive from the ocean, with knock-on effects to their ocean economies and human welfare (Gaines et al., 2019). These impacts will have repercussions for those who both directly and indirectly depend on the marine environment for food security, recreation, nutrient cycling, waste processing, protection from natural hazards, climate regulation, and other services (Doney et al., 2012).

In the SAOTs, the implication of these climate change issues are even more important given the nature of their economies. The economies of the SAOTs, as with other small islands, are not well diversified and instead depend on a narrow range of goods and/or services (Brown, 2008) which leaves them more vulnerable to climate-change driven modifications to the underpinning ecosystem services.

PRIORITY 1: CHANGES IN MARINE RESOURCES FOR CONSUMPTION – FISH, FISHERIES, BENTHIC INVERTEBRATES AND FOOD SECURITY

WHAT HAS HAPPENED

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) concluded that changes in climate and ocean acidification observed since the 1950s are altering the oceans at a rate that is unprecedented. This warming of the oceans and increased acidity is having impacts at multiple trophic levels and will have implications for fisheries, food production, related human activities, and communities (Bindoff et al., 2019). Impacts of these climate-induced changes can be classed as both physical and biological (Yassin Mohammed and Uraguchi, 2013). The productivity of marine fisheries globally is likely to be affected by physical changes such as variations in ocean conditions such as sea-surface temperature rise, ocean currents and coastal upwelling, as well as biological changes affecting primary production, and fish stock distribution (Cheung et al., 2010).

Global evidence of these changes has been observed to date with changes in fisheries catch and compositions observed. According to the IPCC and (Bindoff et al., 2019) there has been an average decrease of approximately 3% per decade in population replenishment and 4.1% in maximum catch potential with many shelf-sea ecosystems increasingly dominated by warm-water species.

More specifically for the SAOTS, a range of key high value tuna species (Bigeye, Albacore, Yellowfin and Skipjack) are targeted in St Helena, and Ascension's waters at a variety of scales for both recreational – and in St Helena's case, commercial – purposes. According to analysis carried out by Erauskin-Extramiana et al. (2019) globally, 20 out of 22 tuna stocks have shifted poleward between the 1950s and 2000s and temperate tunas are projected to shift further poleward in the future. It is difficult to state currently whether these impacts have been felt at a local scale, with many of the SAOTs suffering from the shifting baselines concept highlighted earlier, but it is undoubtedly a cause for concern (Townhill et al., 2021).

There are instances of locally observed fisheries-related phenomena that could be attributed to climate change, but only with a low degree of confidence. For example, until 2013, St Helena had experienced a seasonal and relatively unpredictable catch of Albacore tuna (*Thunnus alalonga*), averaging around 29 tonnes, with higher yield years interspersed with years when little or no Albacore were landed. These catches often filled a 'lean' period of the fisheries landings and as such formed an important part of the islands economy and food security. Albacore tuna is a temperate tuna species that prefers cooler water (12–20 ºC) than that preferred by the tropical tunas, and its thermal preferences potentially act as barriers to its movements between different regions (Penney, 1994; ICCAT, 2016). However, there has not been a 'run' or recorded landings of Albacore tuna on St Helena since 2013, and although speculative, it is strongly felt locally that this could be attributed to a polar shifting of the species as an ecological response to changing temperatures.

Climate change is not the sole factor that is likely to impact on the productivity of the SAOTs and global marine fisheries (Doney et al., 2012) which makes it difficult to measure impacts on a local scale. For example, there are other negative externalities that are likely to arise as a result of the level of exploitation of species, which could well have a more detrimental effect, or at the very least compound the impacts of climate change on fisheries. Overexploitation of species is one of the most important non-climatic drivers affecting the sustainability of fisheries, and it is considered that effective fisheries management under a low climate-change emissions scenario would decrease risk by 63% (Bindoff et al., 2019). The major challenge for each of the SAOTs in this instance is that the pelagic species on which they rely are part of wider global migratory stocks which are impacted by actions elsewhere.

These anthropogenic threats combined with climate change has already seen a marked change in how the SAOTs manage their marine environments in an effort to make themselves more resilient to any potential impacts. The designation of marine protected areas or zones in Ascension Island, Tristan da Cunha, and St Helena, combined with the Falkland Islands marine spatial-planning activities, have established a framework for the SAOTs to monitor, manage and protect their ocean environments. Each of the SAOTs has implemented local fisheries management plans (including 'no take' for various sectors), non-Regional Fisheries Management Organisations (RFMO) designated limits and quota systems. Combined with zoning restrictions these are all ways that the SAOTs have sought ensure food security, and attempted to avoid exacerbating the potential effects of climate change.

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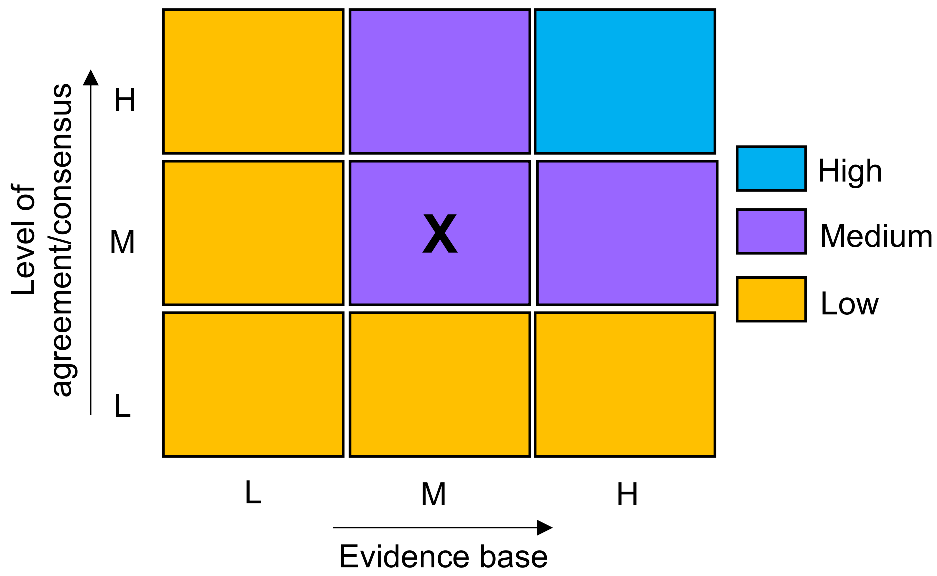

It is felt that there is a medium level of confidence in what has happened to marine resources for consumption as a result of climate change. Fisheries and other food security items have perhaps the best level of evidence for the SAOTs across marine issues and generally a good level of agreement about what has happened as a result of climate change.

WHAT MIGHT HAPPEN

The observed polar shifting that has been shown to have an impact on global fisheries is set to continue, which will result in decreases in the tropics and increases in abundance in temperate areas, with species distribution shifting an average of 72 km polewards each decade (Poloczanska et al., 2013). This potential re-distribution of catches is likely to impact the SAOTs, though there is debate over how this will manifest.

Work undertaken by Cheung et al. (2010) identified that there was likely to be an overall increase in the fisheries catch potential for Ascension Island, St Helena and Tristan da Cunha, but other more recent work indicates that under high emissions scenarios there could be reduction in catch for Ascension Island and St Helena, with a slight increase for Tristan da Cunha (FAO, 2018). As discussed in the early part of this paper, Townhill et al. (2021) highlight that species modelling is undertaken at a global scale and that data collection and studies on a more regional scale may provide results of more relevance. To highlight this a recent studies by Wright et al. (2021) on St Helena and Richardson et al. (2018) on Ascension for Yellowfin tuna (*Thunnus albacares*) showed degrees of site fidelity, which would not appear in global models and could translate to a higher resilience of the species to fisheries pressures, and to climate-change impacts, such as habitat suitability.

When discussing the topic of resilience, it is also necessary to consider the SAOTs in the context as geomorphological features (islands, seamounts, and archipelagos). These features by their nature provide ideal habitats for pelagic species to feed, and as a result could mean that species remain more tolerant to some of physical changes (e.g. sea surface temperature) that climate change may cause.

Further modelling work undertaken by Townhill et al. (2021) to assess the potential impacts of climate change in the coming century on species distribution concluded that Ascension Island and St Helena may well become more suitable habitats for Bigeye, Skipjack, Yellowfin, and Albacore tuna. Tristan da Cunha has been projected to become less suitable for Bluefin tuna, but remain more suitable than for other tuna species. However, given that Ascension Island and Tristan da Cunha do not commercially fish for this species they could provide a suitable 'havens' for these fish as a result, conversely more external pressures could be placed on the protected area to allow commercial fishing activity. It should be noted however that suitable habitats will not necessarily translate to increases in populations, as other externalities such as migration, larval distribution and fishing pressure elsewhere are not accounted for.

If these more-positive scenarios are realised, economies of SAOTs that commercially fish could see the benefits of increased fisheries catches as a result of climate change, at least in the short term. However, it places further importance on the Marine Protected Areas/Zones, though there is some doubt as to whether these small areas relative to the size of the populations would be effective in rebuilding stocks (Townhill et al., 2021), especially when considered as a wider Atlantic stocks managed by RFMOs. If less-positive scenarios were realised, the impacts in a reduction/loss of fisheries for all four SAOTs would be devastating, both as they form major parts of the territories' economies (commercial and tourism), and are also a major source of food security for the respective islands.

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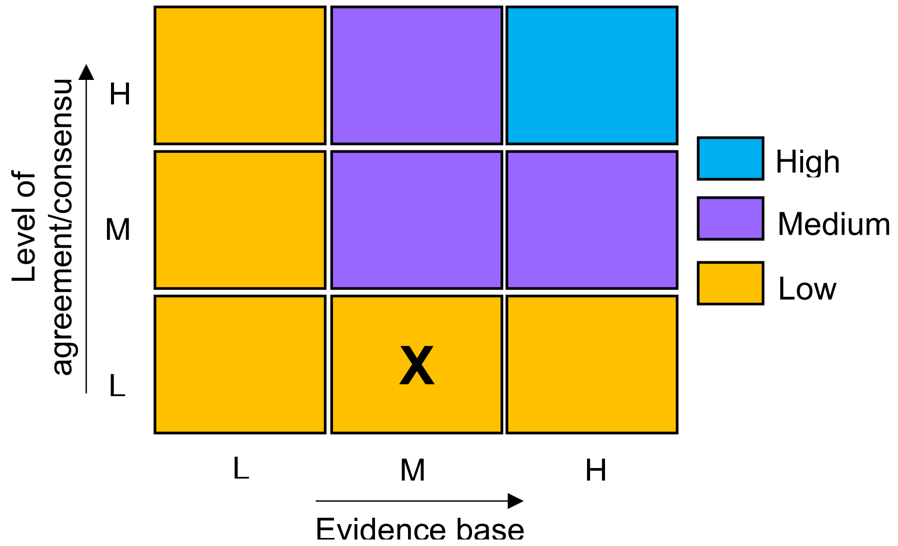

The confidence assment for what might happened as a result of climate change to marine resources for consumption is low. Thought there is a certain amount of evidence as to what might happened, the impact of potential anthropegic pressures on SAOT and global resources make it difficult to reach degrees of consensus .

PRIORITY 2: CHANGES IN PRODUCTIVITY – PELAGIC HABITATS, PHYTOPLANKTON PRIMARY PRODUCTIVITY; SPREAD OF INVASIVE SPECIES

WHAT HAS HAPPENED

Kelp forests are particularly important primary producers in the cooler shallow seas around Tristan da Cunha and the Falkland Islands and provide suitable habitat for many of the islands' species. They are some of the most productive and diverse ecosystems on Earth which often underpin critical ecosystem services. Their distribution, structure and productivity are influenced by environmental and ecological factors, changes to which can lead to rapid and widespread changes (Smale, 2020). In analysis conducted by Krumhansl et al. (2016), kelp distribution has changed globally with declines in 38% of ecoregions, with increases in 27%, and no detectable change in 35%. This was determined to have been driven by a range of factors, including temperature rise across a variety of different scales.

Kelp forests may be particularly vulnerable to climate change, though there is no recent evidence of ocean warming induced kelp loss in the South Atlantic which could be as a result of slower warming rates, unreported changes or a lower monitoring effort (Smale, 2020). Giant kelp (*Macrocystis pyrifera*) found in Tristan da Cunha has an upper temperature range of 20°C, and impacts (declines/disappearances) of increased temperatures on this species have already been experienced elsewhere such as the Baja California peninsula (Valdez et al., 2003). The maximum temperature reached was 19.3°C, records of which are already experienced at Tristan da Cunha's northern islands (Tristan, Nightingale and Inaccessible islands), there are visual accounts of kelp fronds disintegrating in summer, which could go on to have further impacts on the Tristan da Cunha's lobster population and the islands' economic security (Scott, 2017).

Kelp is also an important part of the Falkland Islands ecosystem, providing habitats on both the benthic floor and throughout the water column, as well as providing sequestration of carbon deposits (Bayley et al., 2017). Research data has suggested that kelp in the Falkland Islands may be more stable in structure than other habitats throughout the world, as the forests do not experience the same strong winter storms that affect frond biomass in other high latitude areas (Van Tussenbroek, 1993). A coverage estimate of kelp around the Falkland Islands have been estimated at 664 km^2 (0.02 % of the estimated mean global area of all macroalgae), with a stock value of US$22.20 million, with the annual sequestration of carbon to the deep sea of US$24.38 million yr-1 (ranging from US$16.58 to 32.17 million) (Bayley et al., 2017). The loss of this habitat affects a potential source of income to the island with the emergence of the 'Blue Carbon' economy, however, it is recognised that although value estimates are made as part of an ecosystems services assessment, the ability to be able to monetise these assets is still difficult or limited and being explored further by the SAOT's.

Other potential impacts of a change in climate on primary production have already potentially been observed in the Falkland Islands. In 2006, a cooling of the Antarctic current and warming of Brazilian current created a stronger gradient zone, boosting primary production resulting in higher commercial catches of *Illex* squid and other fish species in the northern part of the Falkland Conservation Zones (Pelembe and Cooper, 2011). It is, however, recognised that there are other factors that could have driven this catch variation (e.g. short-term oceanographic variability or fishing pressure) so must be treated with a low confidence.

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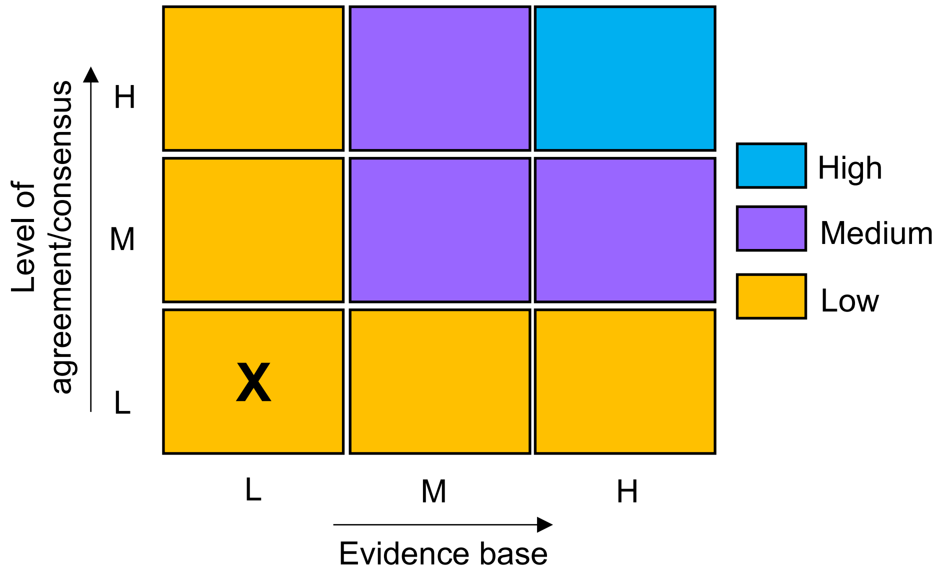

There is considered low confidence in what has happened to changes in primary production as a result of climate change. There has been little study of primary producers in the SAOTs and monitoring the impacts of and climate (or non climate) related changes.

WHAT MIGHT HAPPEN

There is a relatively high confidence that further changes in temperature and extreme weather events are likely to further exacerbate the current challenges facing kelp within the SAOT's and will likely bring further impacts to primary producers and as a result alter the community structures of marine organisms (Bindoff et al., 2019).

It is widely felt amongst the SAOTs that changes in currents, upwelling patterns as well as general oceanographic conditions could result in significant impacts on primary producers and marine environments, however it is also acknowledged that there is very little in the way of monitoring and data to be able to model and predict these changes on a local scale. As a result, a number of the SAOTs have begun small-scale monitoring projects to address these gaps.

Changes in primary production could result in a reduction of marine biomass, and further knock-on impact to higher trophic levels (i.e. fisheries, migratory mammals), reducing SAOT economic pillars such as fisheries and tourism. The impact in a loss of primary producers in climate change is in some way twofold, both the effects of the ecosystem they underpin, but also as their role in carbon sequestration and storage of carbon dioxide (Bayley et al., 2017). Impacts to the environment and subsequent knock on affects to these economic pillars are likely to be heavily felt by the SAOTs given that they are often contribute a large proportion of the islands' economies. Although not climate-change driven, as an example of their importance, on St Helena the Covid-19 pandemic reduced peak season arrivals by 80% between 2019–20 and 2020–21 (St Helena Government, 2021b) with almost no visitors other than those of St Helenian descent during that period. In 2019, visitor expenditures were estimated to have contributed GB£4.4 million to GB£6.0 million (St Helena Government, 2020b) to the local economy meaning the lost revenue is significant.

Concern is held amongst each of the SAOTs about impacts of Invasive Alien Species (IAS) and how they could be further exacerbated by climate change. The role of climate change in new marine invasions unclear, but changing temperatures, currents and weather patterns may open up new pathways for species to arrive (Sorte et al., 2010). It may also allow for conditions that facilitate the establishment and prevalence of these invasive species, in many cases out competing locally native species.

As part of a 10-year environmental monitoring programme, St Helena has seen an increase in abundance of sea grapes (*Caulerpa racemosa*) an invasive species widely distributed in temperate and tropical seas. The species has already been observed to invade other regions of the Atlantic, monopolising spaces and out competing native species in the Mediterranean (Bulleri et al., 2010) and Canary Islands (Verlaque et al., 2004). Propogation is generally by fragmentation, and it is conceivable that an increase in storm event/current alterations, as well as a warming of temperatures could further facilitate the spread and abundance of this species.

The potential impacts of IAS on other primary producers and remainder of the ecosystem is difficult to state, though some impacts to fisheries in the Atlantic have already been observed. For St Helena, changes as a result of the seagrape spread have already been observed at key dive sites around the island, reducing their aesthetic value as a result of mono-culture creation, and subsequently the potential attraction to tourists. Kelp have also been shown to be vulnerable to similar impacts by invasives such as macroalgae or turf-forming algae (Filbee-Dexter and Wernberg, 2018) which would have similar implications for Tristan da Cunha and the Falkland Islands.

In 2006, a free-floating semi-submersible oil platform brought by currents from Brazil was stranded on the southeast coast of Tristan Island. It had various non-native invertebrates and fish species associated with it by the time it stranded in Tristan da Cunha's waters and as a result one of these fish, the South American silver porgy (*Diplodus argenteus argenteus*), is now found off Tristan Island year-round. Concern is held around this invasives adaptation to the more temperate waters and a Darwin Plus project will help to address potential impacts on native populations and related economy.
Gough Island, part of the Tristan da Cunha’s Archipelago, has also been suffering impacts from an IAS, which is likely to be further impacted by a changing climate. The introduction of the House mouse (Mus musculus) has decimated the populations of the Tristan albatross (*Diomedea dabbenena*), Atlantic petrel (*Pterodroma incerta*) and great shearwater (*Puffinus gravis*) as a result of predation and chicks and eggs (Caravaggi et al., 2018). The

breeding success of both the albatross and the petrel are too low to sustain their populations and it is likely they will become locally extinct if the situation continues (Caravaggi et al., 2018). The problem is only likely to become exaggerated by changes in climate with predicted changing in southern ocean conditions more likely to prove favourable for the mice population (Angel and Cooper, 2006).

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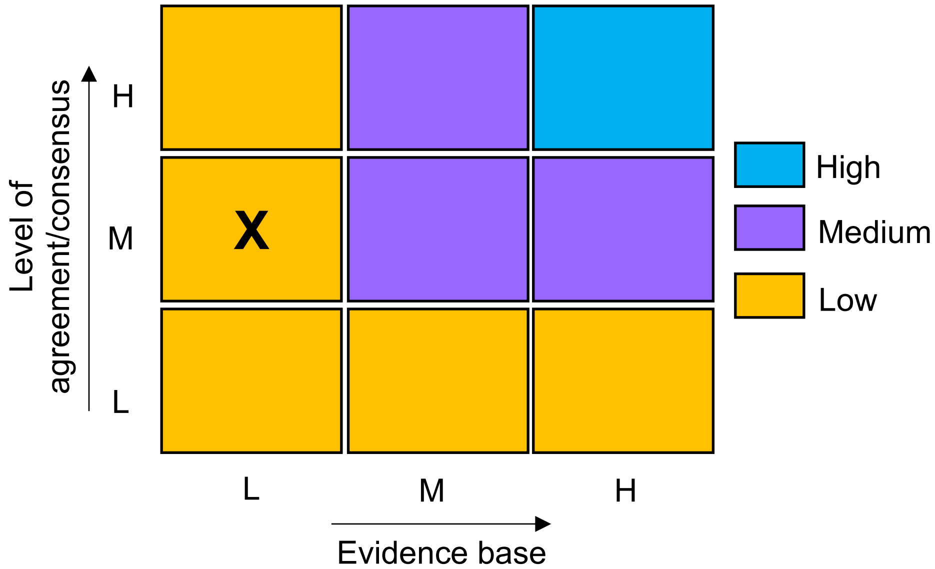

There is low confidence in the confidence assessment in relation to what might happened to primary production as a result of climate change. There is a general agreement on what is likely to happen, but the evidence base is not sufficient to determine this with any certainty.

PRIORITY 3: CHANGES IN COASTAL COMMUNITIES AND LOSS OF CULTURAL IDENTITY

WHAT HAS HAPPENED

As has been discussed previously, each of the SAOTs has a varying degree of marine protection in their waters with climate change being identified as a key threat in each of the four territories' management plans. The strategy of the establishment of marine protected areas/zones and no-take reserves is likely to form more stable populations and intact communities that are more resilient to climatic disturbances (Harley et al., 2006). It is considered that the designation of protected areas should be in some way based on known spatial or temporal refuges that can act as buffers against climate-related stress (Allison, 2004). Many of the overall management measures undertaken by the SAOTs are focused on the short-term anthropogenic pressures faced. It is possible however that these same measures could also double as climate resilience measures meaning the SAOTs end up becoming the 'havens' for impacted species.

These designations are not without impacts to local communities economically and socio-culturally. First, marine protection and no-take zones are expensive to create, implement and maintain, which can often be difficult in developing economies such as the SAOTs. The issue of competing local priorities often makes the implementation of these protected areas a challenge, and relies on external funding to implement. Three of the four SAOTs have received funding from the UK Government's Blue Belt Programme to assist with this implementation, with Tristan da Cunha also receiving donor funding to account for future lost fisheries revenues. Creation of these protection zones may also be at odds with traditional local practices. For example, various SAOTs have a cultural history of landing small-scale quantities of shark, something which has been prohibited following the creation of legislation and MPAs. St Helena has also introduced catch restrictions on fisheries, which restrict recreational fishers' activities across variables such as species, location, size and quantities.

Studies have shown that rising sea levels have been experienced in both the Falkland and Ascension islands. On Ascension Island an estimate of sea-level change between 1955 and 2001 has been generated, with an average trend of 0.93 mm y^{-1} (SE 0.69). There is evidence that would appear to show this rise accelerating with 2.55 mm y^{-1} (SE 0.13) from tide gauge data, and 2.07 mm y^{-1} from altimeter data (SE 0.30) experienced between 1993-2009 (Woodworth et al., 2012). This information is deemed relatively low in confidence due to the limitations in the historical data, but can be used as an indication of the general change. As a result of the profile of beaches and the nesting habitats they house, the Ascension Island Marine Management plan identifies this as a threat to the Green turtle (*Chelonia mydas*) population.

The Falkland Islands has also experienced a similar change in sea levels, rising by an average of 0.75 mm y^{-1} between 1842 and the early 1980s. Again, similar to Ascension Island, there also appears to be evidence that this sea-level rise has accelerated to nearly 2.5 mm mm y^{-1} since 1992, and also is consistent with observations from other locations in the southern hemisphere (Woodworth et al., 2010). This does not appear to have had impacts to date but is predicted to have an effect on coastal dwellings and infrastructure in Stanley which are often marine related.

Although these observed sea-level rises have had little-known impact to date on the islands and their ecosystems, possible future scenarios could impact local communities and their cultural identity (especially for culturally synonymous species) which are discussed later in this paper. It is acknowledged that there are few monitoring records from ocean islands, and even fewer available for the southern hemisphere (Woodworth et al., 2005) and to that end, the maintaining of existing level records and establishment of new longer term oceanographic monitoring is critical.

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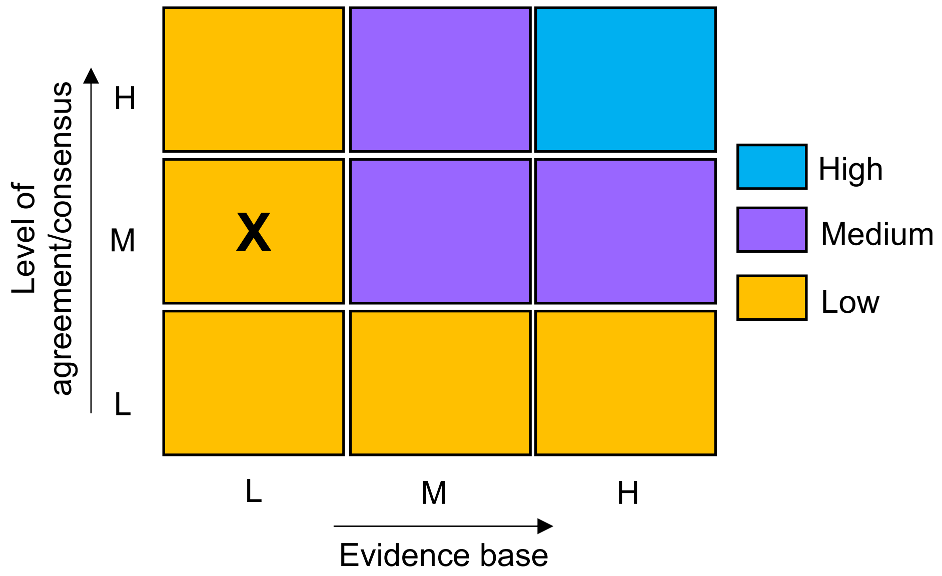


There is a general level of agreement in changes that have occurred in coastal communities, however the evidence base to attribute these directly to climate change rather than other pressures is not considered sufficient.

WHAT MIGHT HAPPEN

Many islanders feel a deep connection, as well as a sense of identification, with the marine environment, and the species that inhabit it (Ascension Island Government, 2021). One example of climate changes' potential impact on marine species and cultural identity is the Green turtle on Ascension Island. The island is home to the second largest breeding colony in the Atlantic (with over 20,000 nests dug annually), with the turtle a deeply rooted part of the islands' cultural identity.

A loss of suitable nesting habitat as a result of sea-level rise poses a significant threat to turtle populations worldwide and is predicted to have a medium impact on the Ascension turtle population (Ascension Island Government, 2015). Rising beach temperatures are also predicted to become a major threat to marine turtles, altering sex ratios and reducing hatch success (Hawkes et al., 2009; Tilley et al., 2019), with a medium impact predicted to Ascension turtles. These potential impacts combined with other anthropogenic effects have led the territory to introduce a Species Action Plan for turtles, implemented as part of the islands' National Biodiversity Action Plan.

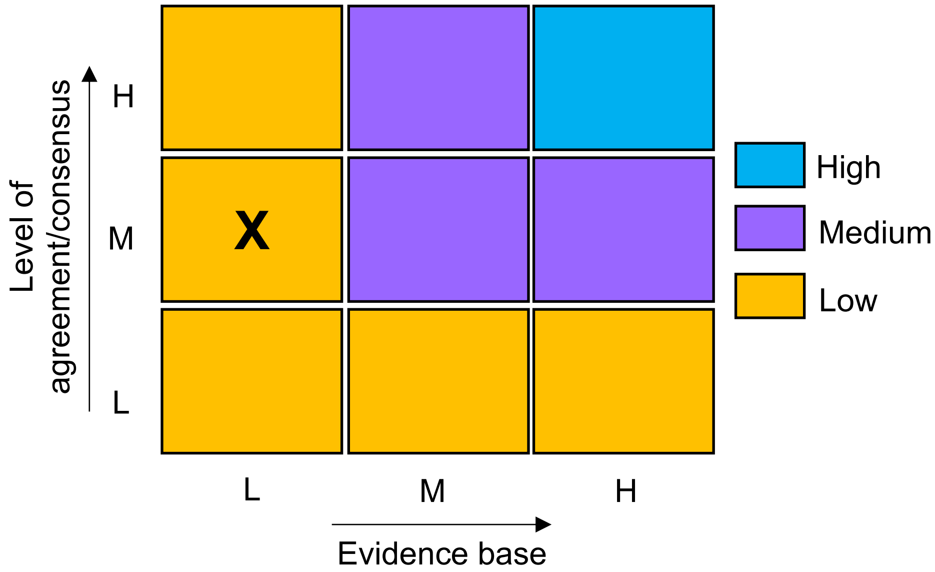
Other SAOTs face similar challenges in relation to a number of their species, either as a result of a destruction of habitat, or a change in variables outside of species tolerances, which could result in either a complete, partial, or local/regional loss or displacement of species. For example, a shift south of the Tristan Rock lobster (*Jasus tristani*) as a result of increasing temperatures could result in reduced local landings, forcing vessels to range further, as well as changes in benthic ecology and community structure (Silva et al., 2021).

The impact to Tristan da Cunha's economy notwithstanding, these species are synonymous with island life forming part of the culture for work across genders, a primary food source, and even features on the Tristanian flag. Other larger sea-level rises posing longer-term risk could see effects such as a rise in seawater encroaching on native habitats, forcing species such as the northern rockhopper penguin (*Eudyptes chrysocome moseleyi*) and sub-Antarctic fur seal (*Arctocephalus tropicalis*) that breed in the coastal zone, further inland (Brown, 2008).

Each of the SAOTs also relies on their coastal ports as links to the outside world, bringing in valuable goods and supplies. Due to the isolated and often exposed nature of the islands, storm events can have major impacts on these activities, as well as causing significant damage to infrastructure. Tristan da Cunha has suffered the impact of a series of storms in the recent past which have caused significant damage to the islands' buildings and infrastructure, with repairs being extremely costly and time -consuming to reprair owing to the remoteness of the Island. Many of the SAOTs are regularly visited by cruise ships and yachts, helping to generate income to the economy, which could become more difficult/impossible if adverse conditions were to be experienced more regularly or in extremes (Petit and Prudent, 2010). Storms have also been shown to impact marine species directly with the Falkland Islands experiencing a high mortality rate and nesting success failures of its Black-browed albatross and Rockhopper penguins following storms in 2010 (Wolfaardt et al., 2012) and 2020.

With climate change likely to result in an increase in the frequency and/or extremity of these storm events, increasingly there is the potential for the sometimes severe impacts to affect the SAOTs environments, economies and communities in a way that they are not able address without outside assistance. Tristan da Cunha, for example, has recently been subjected to a number of severe storms causing significant damage that has required UK government, private sector and donor funding to rectify over extended periods of time. If the frequency/severity of these storms were to increase the impact to the community, its long-term future could be devastating. The Falkland Islands, in response to the threat of more-frequent severe storm events, uses its building regulations to ensure many of the buildings are more resilient to these extreme weather events.

CONFIDENCE ASSESSMENT



Similarly to changes that have already occurred in coastal communities, there is a general level of agreement in the SAOTs, however the evidence base, due to other global factors mean there is not sufficient evidence to adequately predict what might happen.

Qualitative level of confidence in the science presented in this review of based on the expert judgement of the present authors.

REGIONAL NATURE-BASED SOLUTIONS: CASE STUDY

There are limited examples within the SAOTs of marine-focused nature-based solutions in relation to combat climate change. Some of the examples that do exist are to address elements that are likely to be exacerbated by a change in climate rather than address climate change directly.

One example of this is the Gough Island restoration programme. As a result of the imminent threat to the Tristan albatross (*Diomedea dabbenena*), Atlantic petrel (*Pterodroma incerta*) discussed earlier, RSBP and the Tristan da Cuhna government have implemented conservation measures to try and save the species. This involves a large-scale eradication programme of the invasive House mouse (*Mus musculus*) – the impact of its accidental introduction is predicted worsen in a changing climate.

St Helena also has a series of projects being undertaken which seek to adapt for and mitigate climate-change impacts. Historically, these methods have relied on hard-engineered intervention (Chausson et al., 2020), and an effort to ensure 100% of the St Helena's energy is generated via wind turbine, solar power is an example of this (St Helena Government, 2020a). A terrestrial nature-based solution is also being implemented to improve the management of island water resources, provide security of supply and enable resilience to climate change by restoring the islands cloud forest habitat (St Helena

Government, 2021a). The restoration of cloud forest habitat also has the capacity to be a significant sink of carbon increasing rates of sequestration (Ellick, 2015). Better water management for the island also has the capacity to decrease runoff, potentially reducing freshwater runoff into the marine environment, one of the suspected causes of widespread demersal fish die off in 2020. Similar land-management based approaches are also being undertaken for peat habitats in the Falkland Islands, which have been calculated to store 934 Mt C (778 t C/ha) but are in danger of becoming carbon sources as opposed to sinks, as a result of impacts from a changing climate combined with poor land-management practices (Upson et al., 2016).

Other programmes have also been established that form part of long-term monitoring studies, which assist in monitoring change that may be associated with climate change. St Helena has been undertaking SHOTS (St Helena Open-Ocean Time Series) a time–series record of oceanographic measurements to monitor seasonal cycles in its pelagic ecosystem and investigate how oceanography influences that system, which has assisted in a better understanding of ocean stratification and primary productivity (St Helena Government, 2019). This combined with the underwater visual habitat surveys conducted over a period of 10 years, and global datasets such as PIRATA serve as an important tool in monitoring for change and protecting its marine environment.

NEXT STEPS

Data on the impacts of climate change in the SAOTs are relatively poorly documented and understood, and there are often multiple stressors that may prove more damaging long before the long-term effects of climate change. Although it is considered that some climate-change impacts have potentially been observed, most can only be classified as low confidence as a result of lack of data, understanding of the species, or the influence of other (usually anthropogenic) pressures.

It is clear from the three priorities that have been identified that more research and data collection is required to understand, predict change and plan mitigating actions more accurately. Where evidence of impacts that can be attributed to climate change have already been identified, such as examples in this paper, more funding is also required to help instigate and implement mitigating actions against these impacts. Due to the limitations discussed in this paper (funding, competing priorities etc.), it is likely that this will have to focus around keystone species, or indicator species, as it is not possible to study everything in a sufficient level of detail.
Combining this with long-term oceanographic monitoring will help build a better understanding of the islands' marine ecosystems, thus enabling better predictions of impacts at primary production level, and the resulting knock-on effects to higher trophic levels.

However, alongside monitoring, precautionary action should also be taken now in each of the SAOTs to try to ensure resilience and adaptation, which may in the first instance for most of the territories likely take the form of a detailed scoping exercise. This, and any future proposed mitigation measures will require funding, that largely cannot be provided by the SAOTs themselves so will be required to come from outside sources. That said, small island communities are used to adapting in order to survive, and as a result are well practiced at innovatively in adapting to change.

Continued data, information and knowledge accumulation is also crucial at a policy and management level, both to ensure that management and resilience methods employed are based on evidence informed decisions, and also to enable effectiveness tracking of measures introduced. Each of the SAOTs are unique, but like all small islands face similar challenges in many ways. Improved networking and knowledge sharing has been established through programmes like the UK Government's 'Blue Belt', and other NGO initiatives and these should be continued and strengthened to allow a co-ordinated effort in attempting to combat the effects of and mitigate the impacts of climate change.

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