**1 | INTRODUCTION**

The world’s oceans and their ecosystems are changing due to accumulating pressures such as climate change, extractive activities (fishing, mining etc), and pollution (litter, land runoff etc) (Coll et al., 2008; Cooley et al., 2022; Hoegh-Guldberg & Bruno, 2010; Jennings & Kaiser, 1998; Pauly et al., 2005). The over exploitation of a single species or degradation of a habitat can have dire consequence at the ecosystem level (Coll et al., 2008; Jackson et al., 2001; Pauly et al., 1998; Worm et al., 2006). With the use of management strategies such as marine protected areas, improved and reduced land-based pollution and runoff […] many regional ecosystems have been able to improve in recent decades. For example, changes to fisheries management has led to Australian Orange Roughy stocks to recover and the fishery becoming sustainable (Doonan et al., 2015; Kloser et al., 2015), and marine protected areas in New Zealand and Australia have demonstrated increases in fish abundance and biodiversity (Allard et al., 2022; Edgar et al., 2014, 2017; Knott et al., 2021).

Nevertheless, climate change adds a layer of complexity and uncertainty. Global ocean water temperatures are warming or cooling, pH is altering, CO2 sequestration is changing, ocean currents are shifting direction and intensity, and the timing and quantity of sea ice melt is changing and this is having ecosystem level impacts (Boyd et al., 2016; Constable et al., 2014; Johnson et al., 2011; Wassmann et al., 2011). The changing oceans are resulting in changes to species distributions and leading to biological invasions, and range extensions or contractions (Johnson et al., 2011; Schickele et al., 2021). The measure of climate velocity represents the speed and direction of range shift in a species distribution (Arafeh-Dalmau et al., 2021). Understanding how these pressures [which pressures? Climate change? Or linking it back to fishing and pollution above?] and climate influence a species or whole communities is important to aid adaptive management, monitoring programs, and identify areas that require protection or greater management to avoid further loss (Arafeh-Dalmau et al., 2021; Emblemsvåg et al., 2022).

The key to understanding and predicting ecological change is to have suitable long-term data sets. Oceanographic data has been collected over large spatial scales for decades (e.g. NOAA ref). However, long term (>10 years) biological monitoring or ecological datasets (i.e. species’ occurrence and abundance data) are relatively rare. In the era of big data, increased computing capacity and innovative approaches to ecological modelling have made it possible for researchers to ask more complex questions and to model at larger spatial and temporal scales (Franklin et al., 2017; Tikhonov, Duan, et al., 2020). This includes working with whole species assemblage data across large spatial scales to develop joint species distribution models (Norberg et al., 2019; Ovaskainen et al., 2017; Tikhonov, Duan, et al., 2020). These modelling approaches allow ecologists to explore correlations across environmental gradients and produce full-coverage ecological maps for all species. This also allows researchers to make future predictions under different [climate change?] scenarios (Evans, 2012).

The Southern Ocean represents approximately 10% of the world’s oceans and it plays a pivotal role in oceanic primary production, exports nutrients and oxygen the world’s ocean and supports valuable biodiversity (Auger et al., 2021; Constable et al., 2014; Le Quéré et al., 2007; Van de Putte et al., 2021). Studies on the physical oceanography of the Southern Ocean have documented changes in temperature, CO2 sequestration, and even ocean currents (Constable et al., 2014; Van de Putte et al., 2021). The Commission for theConservation of Antarctic Marine Living Resources (CCAMLR), the management body for this region, has acknowledged the need to better incorporate the effects of climate change into decisions on resource, biodiversity, and ecosystem management in the Southern Ocean (Cresswell et al., 2021). The biodiversity of the Southern Ocean is unique and characterised by a high level of endemism in fish species (Constable et al., 2014). This is particularly driven by the sub-order Notothenioids, of which 86%are endemic to this region (Eastman & McCune, 2000). This group of fishes is also the most abundant on the shelf regions of Antarctica and the sub-Antarctic islands such as Heard and McDonald Islands. Both historic and predicted changes in Southern Ocean fish assemblages are mostly unknown. It is expected that the southward shift in ocean frontal systems is likely to have the largest influence on species distributions. However, changes in distribution and abundance of fish communities are also affected by confounding effects of fishing (and associated management decisions), making interpretations difficult. In the study we aimed to establish if the benthic fish community of the HIMI region of the Kerguelen Plateau has changed since the beginning of regular sampling in Year ….. We then relate any changes in prevalence and abundance of benthic fishes to environmental change, marine reserve zoning or changes to management or fishery practices. To achieve this, we use a joint species distribution modelling (JSDM) approach. We were able establish how much of the variation in each species prevalence and abundance is due to environmental filtering and random processes, and how these vary across spatial and temporal scales. This joint species modelling approach provides assemblage level information on the impacts of climate change and fishing and will provide informationrelevant to the ecosystem-based management requirements of CCAMLR. The results from this study have the potential to be applied to other regions of the Southern Ocean and help better understand the implications of climate change, fisheries management, and conservation management at a much larger scale.

The Kerguelen Plateau, located halfway between South Africa and Australia in the Indian Ocean sector of the Southern Ocean is a large dominant geographic feature. It is a productivity hotspot, supporting a diversity of marine life as well as supporting a lucrative demersal fishery, primarily for Patagonian toothfish (Duhamel & Welsford, 2011; Hill et al., 2017). The location and geography of the Kerguelen Plateau means it is highly exposed to the effects of climate change through warming waters and changing ocean currents and polar fronts. The management of this region is split with France managing the northern half of the Plateau and Australian managing the central portion of the Plateau. Australia has an exclusive economic zone that encompasses Heard and McDonald Islands. The uniqueness and ecological importance of this region were globally recognised with Heard Island and McDonald Island being World Heritage Listed in 1997 and the formation of a no-take marine reserve in 2002. Species of key economic importance in this region (namely Patagonian toothfish and mackerel icefish) have been well studied for stock assessment and fisheries management. The fishery started as trawl fishery in the 1990s but a change to long-line fishing started in 2003 to maximise catches of Patagonian toothfish while minimising bycatch (Welsford et al., 2011). There is still some trawling effort to target mackerel icefish. Historically this region was also exposed to significant illegal fishing. This has led to increase is surveillance of the area since the 1990s. [necessary?] Maybe a sentence here about how there is regular sampling? Understanding how changes in management and fishery decisions and increased compliance have led to changes at a species assemblage level is important for ecosystem-based management.

There is a significant knowledge gap of how the fish assemblage as a whole is structured across the Plateau and if and how it has changed through time (Hill et al., 2017). In this study we used a long-term annual stratified trawl survey to establish if the benthic fish community of the HIMI region of the Kerguelen Plateau has changed through time. We then relate any changes in prevalence and abundance of benthic fishes to environmental change, marine reserve zoning or changes to management or fishery practices. To achieve this, we use a joint species distribution modelling approach. We establish how much of the variation in each species prevalence and abundance is due to environmental filtering and random process, and how these vary across spatial and temporal scales. This joint species modelling approach provides assemblage- level information on the impacts of climate change and fishing and will provide information to facilitate managers to the requirements of CCAMLR. The results from this study have the potential to be implied to other regions of the Southern Ocean and help better understand the implications of climate change, fisheries management, conservation management at a much larger scale.