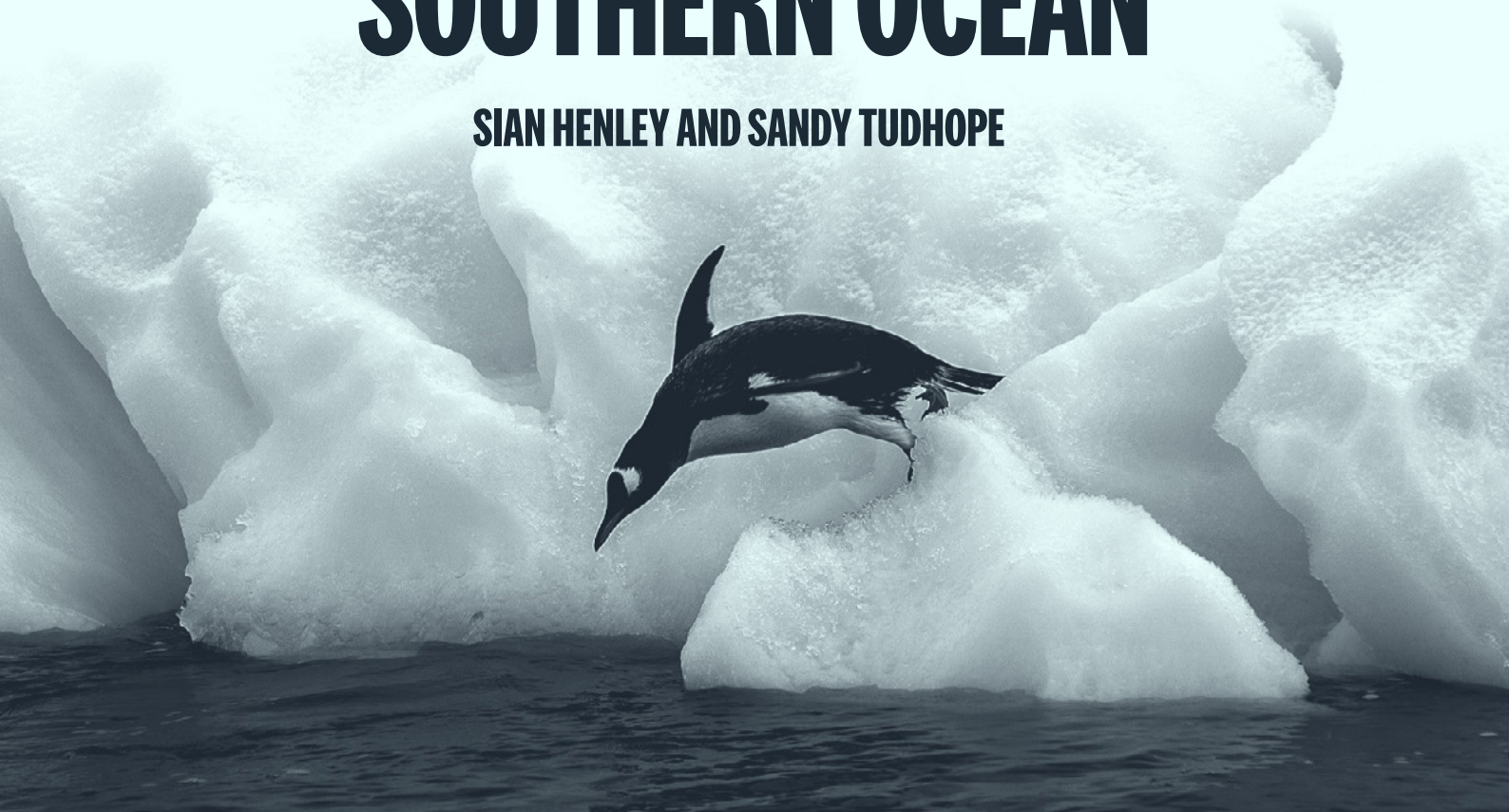
THE CLIMATE CASE FOR ENHANCED MARINE PROTECTION OF THE SOUTHERN OCEAN

SIAN HENLEY AND SANDY TUDHOPE



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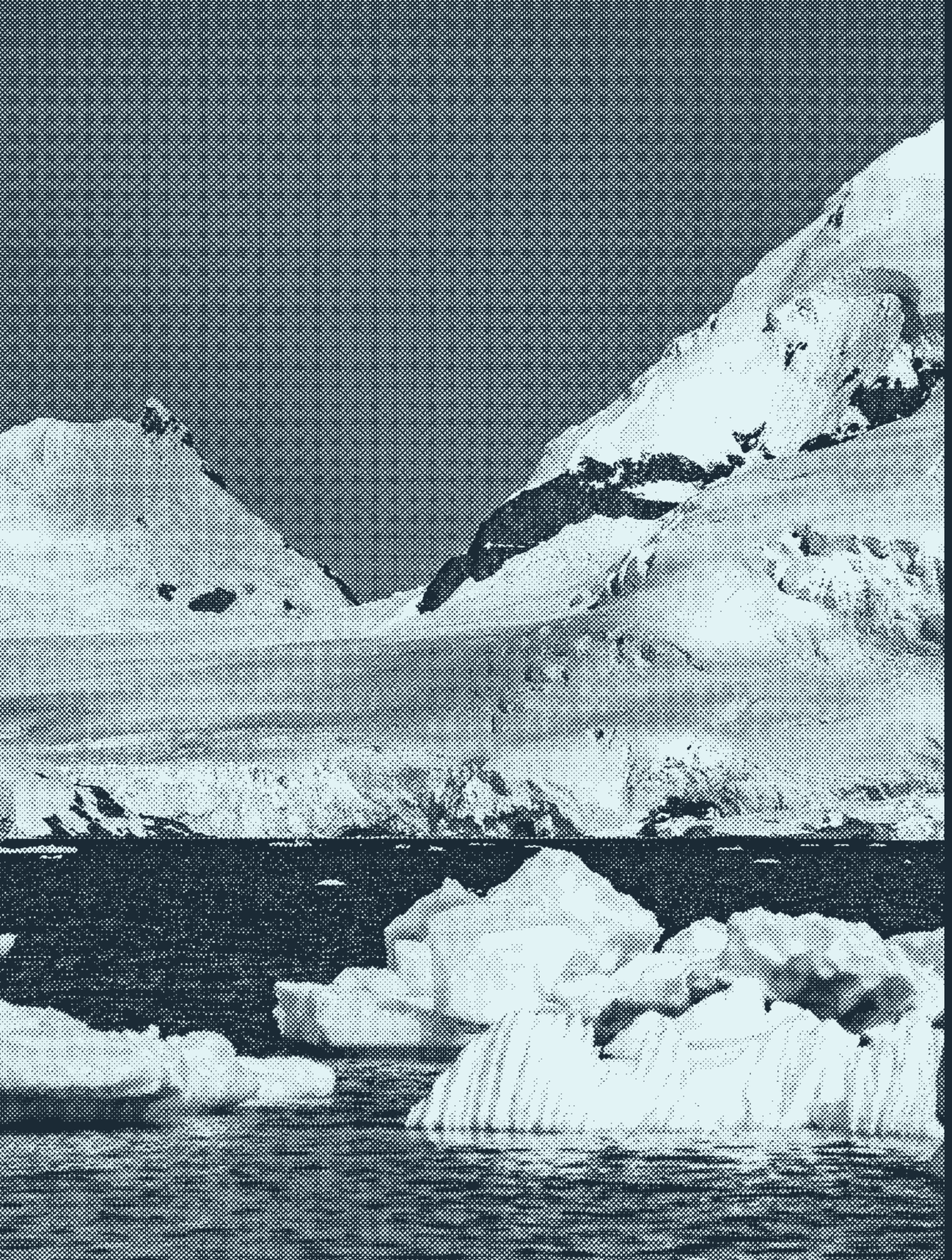

SUMMARY

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The Southern Ocean is the vast ocean region surrounding the Antarctic continent. It plays key roles in the global climate system, promotes global ocean health and biodiversity, and is essential to a wide range of iconic resident and migratory species. Over recent decades, the region has seen an encouraging recovery from the devastation of historical whaling. However, it now faces the twin threat of climate change and a rapidly-expanding industrial fishery targeting krill, an essential species that underpins the wider ecosystem. In this context, here we summarise the climate-related scientific case for enhancing marine protection in the region, including establishing new Marine Protected Areas.

CONTEXT

MEDIATOR OF GLOBAL AND REGIONAL CLIMATE

Processes occurring in the Southern Ocean exert strong controls on regional and global climate through two main avenues. Firstly, the Southern Ocean is disproportionately important in ocean CO_2 uptake through the physical and biological carbon pumps, sequestering this carbon into the deep sea.[1-4] This removes CO_2 from the atmosphere and reduces climate impacts over the coming decades to centuries. Secondly, changes in sea-ice[5] and ocean circulation[6] in the region are important regulators of global and regional climate through impacting the global heat budget.

HIGHLY SENSITIVE TO CLIMATE FORCING

The Southern Ocean is also highly sensitive to climate forcing, meaning that changes in global climate, for example driven through increasing atmospheric greenhouse gases, result in disproportionately large changes in regional climate and ocean conditions, including large-scale ocean circulation[7]. These in turn disrupt the ecosystems and biodiversity.[7,8]

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FUNCTIONING OF SOUTHERN OCEAN ECOSYSTEMS AND THE ROLE OF KRILL

The Southern Ocean is home to large and productive ecosystems and globally important biodiversity, supporting key life-history stages of many charismatic and functionally-important megafauna including whales, seals and penguins.[9] A foundational component of these ecosystems is Antarctic krill (*Euphausia superba*), small swimming crustaceans that feed on photosynthetic phytoplankton and small zooplankton and provide the primary food source for larger organisms.[10] This means they play a crucial role in connecting the entire food web and ultimately underpinning the biodiversity of the region and its global importance. Total Antarctic krill biomass has been estimated as 379 million tonnes[11]; the largest biomass of any multicellular wild animal species on Earth and similar to the total biomass of humans.[12] Their distribution varies around the Southern Ocean,

with the largest abundance found in the southwest Atlantic sector, where around

70%

of the population resides.[11,13]

REGULATOR OF GLOBAL OCEAN HEALTH

In addition to hosting remarkable productivity and biodiversity, the Southern Ocean supports global ocean health in two main ways. Firstly, the Southern Ocean exports nutrients to lower latitudes through ocean circulation, [14-16] thereby driving productivity in distant upwelling regions such as the equatorial Pacific. The size of this nutrient export is dependent on both biological and physical processes in the Antarctic and sub-Antarctic. [17-19] Secondly, migrations of species including marine mammals and seabirds between the Southern Ocean and more northerly latitudes play important roles in ecosystems as far away as the north Atlantic and along their migration routes.[20-22] Both of these ways in which the Southern Ocean supports large-scale ocean health are reliant on its ecosystems being healthy, productive and biodiverse in the long term.

THE CLIMATE-RELATED CASE FOR ENHANCED MARINE PROTECTION

The climate-related case for enhanced marine protection of the Southern Ocean revolves around two principal axes: a) to enhance resilience of already severely climate-impacted species and ecosystems, and, b) to reduce the likelihood of reductions in the biological carbon pump that would make it harder to meet climate commitments under the Paris Agreement (2015).

CLIMATE-IMPACTED SPECIES AND ECOSYSTEMS:

There is compelling evidence that climate change has already caused large disruptions to marine ecosystems in the region, with impacts ranging from the plankton, through to the top of the food web.[9,10,23,24] Some catastrophic declines have already been observed, for example in top predators such as penguins[25] and seals.[26] Climate-related impacts on krill are driven primarily by fluctuations and loss of sea ice cover, as this provides a nursery ground for juvenile krill and supports recruitment to adult life stages.[27,28] Ocean warming and acidification have also been shown to impact on krill, with increased ocean temperatures and lower-pH (more acidic) conditions altering metabolic processes and reducing reproductive success.[29,30]

With ongoing climate change over the coming decades, these impacts are virtually certain to develop and increase.[7,8,31] A recent analysis[32] indicated a severe loss of suitable habitat for krill in two key regions by the end of the 21st century under high greenhouse gas emissions scenarios, whilst the outlook improved significantly under low emissions scenarios with krill-suitable habitat showing partial recovery by 2100. Reductions in the availability of krill have already been shown to influence their predators such as the Antarctic fur seal[33,34] and the Adélie penguin.[35] Continuing krill declines and their cascading impacts through the food web would also impact krill's role in ocean carbon and nutrient cycling,[16,36] with krill currently sequestering around 20 million tonnes of carbon per productive season through their faecal pellets alone.[37] Through impacting the biological carbon pump, nutrient cycling and migrating animals, changes to Antarctic krill populations and their predators could negatively affect many of the ecosystem services that the Southern Ocean provides, including climate change mitigation and sustaining large-scale ocean health.[37,38]

The capacity of these marine ecosystems and species to adapt and acclimate to the climate changes underway is further undermined by the large-scale extraction of krill by industrial fisheries,[13,39] especially since area-based management of the krill quota for the Atlantic sector was removed in 2024.[40] In this context, strong protection from direct disturbance, and in particular fisheries, is warranted to increase the resilience and capacity of these species and ecosystems to adapt and acclimate to climate change. Marine Protected Areas (MPAs) are an effective means of ensuring species and ecosystems are protected from direct and indirect human pressures, with two MPAs already established in Antarctic waters.[41,42] Proposals for three further MPAs around Antarctica are well supported by scientific evidence.[43-46] Crucially, the benefits of this proposed protection would accrue not only locally through increased ecosystem health, but globally through the many ecosystem services they provide to humankind.

EXACERBATING CLIMATE CHANGE VIA ATMOSPHERIC GREENHOUSE GASES:

The significant role of the Southern Ocean region in moderating atmospheric CO_2 via the biological carbon pump is underpinned by a healthy and stable marine ecosystem.[16,31] Large scale removal of species known to be important elements of the biological carbon pump (e.g. krill) risks reducing this important climate service,[37] leaving more CO_2 in the atmosphere. Removing krill (and hence negatively impacting the many species that depend upon it) will not, in isolation, drive large-scale global climate change. However, it would reduce the size of a natural carbon sink that is similar in the amount of carbon sequestered to salt marshes, mangroves and seagrass;[37] likely making it even harder to meet our Paris commitment targets by driving net atmospheric CO_2 accumulation in the wrong direction.

CONCLUSION

The Southern Ocean and its ecosystems are under increasing threat from both climate change and the direct impacts of intensifying human activity within and beyond the region.[47, 48] The loss of potential ecosystem services[38] to human populations worldwide necessitates urgent and ambitious action. Safeguarding the Southern Ocean ecosystem and the myriad functions it provides regionally and globally requires effective climate change mitigation and effective marine protection. For Antarctic krill in particular, a significant reduction in fisheries pressure is a fundamental pre-requisite for sustaining the Antarctic marine ecosystem in the long term.

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TAKEAWAYS

01 A healthy Southern Ocean stabilises the global climate and promotes ocean health and biodiversity, the effects of which are felt around the world.

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02 The Southern Ocean ecosystem, and krill in particular, are under intense pressure from climate and environmental change and from direct disturbance, such as intensive and unprecedented levels of krill fishing in key locations that are rich in biodiversity.

03 Antarctic krill play a pivotal role in a healthy and biodiverse Southern Ocean ecosystem, but their populations are under threat from industrial fishing by a few countries, for use as health supplements, food for farmed fish, and pet food.

04 Major losses of krill risk losing a small yet significant contribution to the ocean carbon sink and wider impacts on the ecosystem, which may include causing further harm to the capacity of the Southern Ocean to mitigate the impacts of climate change.

05 Safeguarding Southern Ocean ecosystems requires urgent greenhouse gas emissions reductions and effective marine protection, including the establishment of robust and extensive Marine Protected Areas in key biodiversity hotspots, such as along the Antarctic Peninsula.

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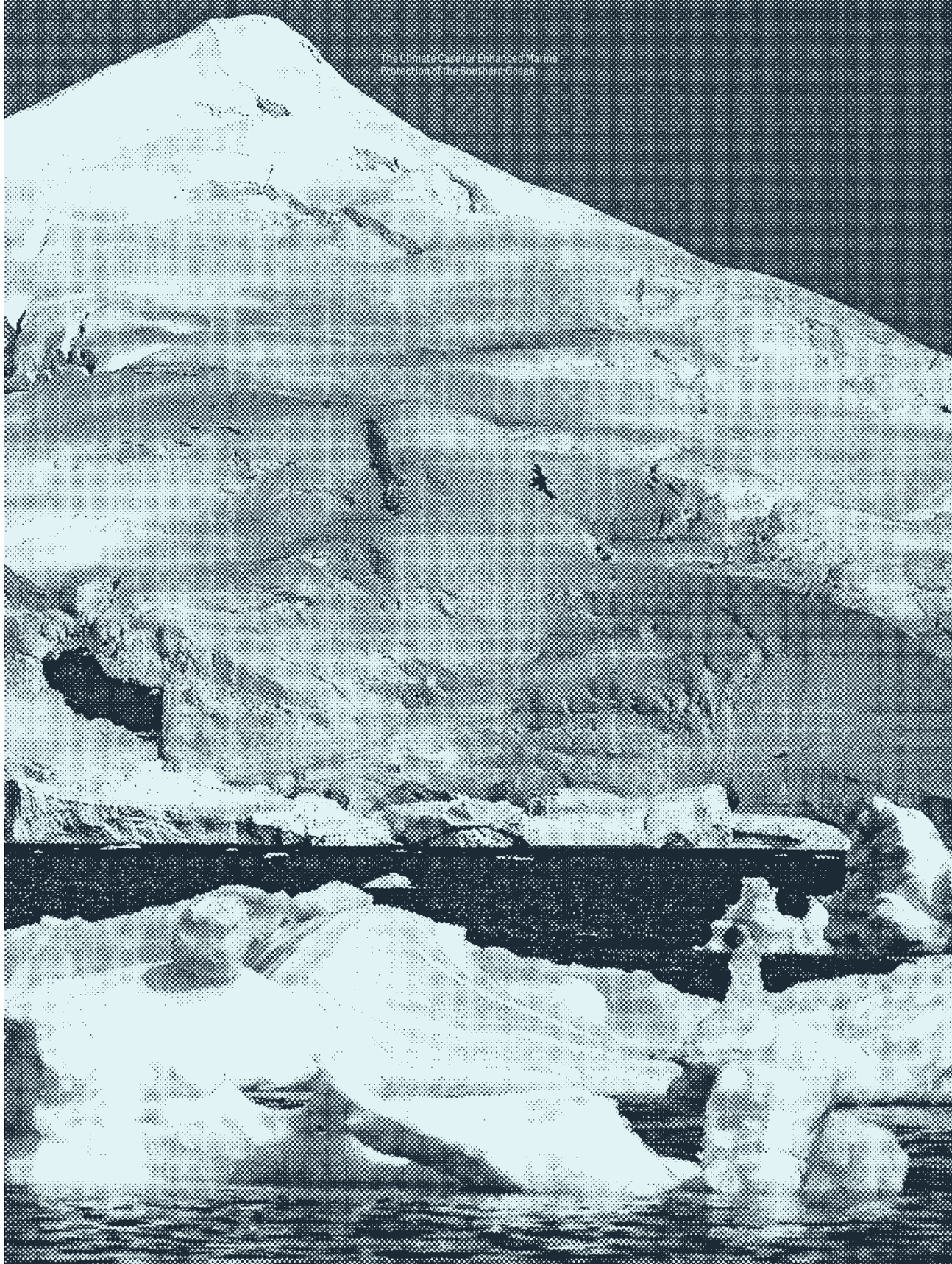

THE FATE OF ANTARCTICA AND OUR WORLD, HANGS IN THE BALANCE. RUTHLESS EXPLOITERS TIGHTEN THEIR GRIP, THREATENING OUR OCEAN AND THE LIFE WITHIN. BUT WE SEE THE DANGER, AND WE WON'T LOOK AWAY. WILL THE FORCES OF GOOD RISE IN TIME, OR WILL THE LAST WHALE SING ITS FINAL SONG?

Our Antarctica has mobilised a group of scientists, ocean leaders, wildlife photographers, policymakers and other high ambition individuals, in one united voice of the Antarctic Avengers, calling to protect one of the world's last remaining wildernesses, the Southern Ocean.

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