Universidade de Aveiro
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Ana Beatriz Pais Costa Fernandes

Dados científicos para elaborar políticas relativas à biodiversidade, conservação e áreas protegidas sob o Tratado da Antártida

Scientific evidence to develop policies related to biodiversity, conservation and protected areas under the Antarctic Treaty

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Biologia Marinha Aplicada, realizada sob a orientação científica da Doutora Ana Hilário, Investigadora Auxiliar do CESAM e Departamento de Biologia da Universidade de Aveiro e do Doutor José Xavier, Professor Auxiliar no Departamento de Ciências da Vida, Faculdade de Ciências e Tecnologia da Universidade de Coimbra.

“Imagine what’s possible once you stop doubting yourself”

o júri

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palavras-chave

Sistema do Tratado da Antártida, Espécies Especialmente Protegidas, União Internacional para a Conservação da Natureza, legislação, conservação

resumo

A região Antártida e o oceano que a rodeia estão sob inúmeras ameaças, incluindo atividades humanas, espécies invasoras, pesca ilegal, poluição e alterações climáticas. Para ajudar a proteger a região foi criado um sistema de governação internacional para a área a sul de 60°S de latitude, o Sistema do Tratado da Antártida (ATS). O ATS é composto por vários acordos, incluindo o Protocolo para a Proteção Ambiental do Tratado da Antártida e a Convenção para a Conservação da Fauna e da Flora Marinha da Antártida (Convenção CAMLR). No Anexo 2 do Protocolo para a Proteção Ambiental, é estipulada a designação de Espécies Especialmente Protegidas (SPS), um estatuto atualmente concedido apenas à foca Ross (*Ommatophoca rossii)*. Nesta tese, pretende-se (i) compreender o estado de conservação e proteção das espécies marinhas da Antártida, (ii) comentar o seu estado de risco de extinção atribuído pela Lista Vermelha da União Internacional para a Conservação da Natureza (IUCN) e (iii) determinar a necessidade de estas espécies serem, ou não, incluídas na lista de SPS. Dados obtidos a partir do website da Lista Vermelha da IUCN, foram filtrados para obter uma lista de espécies cuja área de distribuição se sobrepõe à área do Tratado da Antártida e/ou à área da Convenção CAMLR e cuja categoria de risco de extinção é igual ou superior a “quase ameaçada”, resultando em 13 espécies. Destas, foram selecionadas duas, o pinguim imperador (*Aptenodytes forsteri*) e a baleia anã da Antártida (*Balaenoptera bonaerensis*) cujo estado de conservação foi avaliado e comparado com o da foca Ross, utilizando uma lista de atributos de história de vida e parâmetros demográficos. Os resultados deste estudo mostram que das 13 espécies que têm uma classificação de “quase ameaçadas” ou superior pela IUCN, nenhuma tem o estatuto de SPS. Verificou-se também que a informação da IUCN sobre as três espécies em estudo apresenta diferenças em relação à informação atualmente disponível na literatura científica. É também revelado que o tratado da Antártida protege apenas cerca de dois terços das espécies marinhas localizadas no Oceano Sul, o que pode ser uma preocupação, uma vez que o resto das espécies estão apenas protegidas pela CCAMLR e não podem ser classificadas como Espécies Especialmente Protegidas, se tal for necessário. Face a estes resultados é recomendado que (i) a IUCN atualize as suas categorias e critérios face aos vastos e rápidos efeitos que as alterações climáticas têm nas espécies marinhas da Antártida, (ii) a avaliação do estatuto de conservação de mais espécies da Antártida seja revista tendo em conta os cenários de alterações climáticas, (iii) o estatuto de baleia anã da Antártida seja revisto, (iv) que seja feita uma recolha regular de dados demográficos e de distribuição para permitir uma melhor avaliação do estatuto de conservação das espécies e, (v) o estatuto de Espécie Especialmente Protegida da foca Ross seja avaliado pelo Comité Cientifico para a Investigação Antártida (SCAR) para compreender se há necessidade de um plano de ação e, portanto, a espécie mantém o estatuto de SPS ou se o estatuto já não é necessário.

keywords

Antarctic Treaty System, Specially Protected Species, International Union for Conservation of Nature, legislation, conservation

abstract

The Antarctic region and its surrounding ocean experience numerous threats including human activities, invasive species, illegal fishing, pollution, and climate change. To help protect the Antarctic environment a system of international governance for the area south of 60°S latitude was created, the Antarctic Treaty System (ATS). The ATS is comprised of several agreements including the Protocol on Environmental Protection to the Antarctic Treaty and the Convention on the Conservation of Antarctic Marine Living Resources (CAMLR Convention). In Annex 2 to the Protocol on Environmental Protection, Specially Protected Species (SPS) designation is stipulated, a status granted only to the Ross Seal (*Ommatophoca rossii).* In this thesis, it is intended to (i) understand the conservation and protection status of Antarctic marine species, (ii) to comment on their risk of extinction attributed by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species and (iii) to determine if any of these species should be included or excluded from the SPS list. Data obtained from the IUCN Red List of Threatened Species website was filtered to obtain a list of species whose geographic range overlapped with the Antarctic Treaty area and/or with the CAMLR Convention area and that were classified as “Near Threatened” or above by the IUCN. This resulted in a list of 13 species of which the emperor penguin (*Aptenodytes forsteri*) and the Antarctic minke whale (*Balaenoptera bonaerensis*) where chosen to evaluate and compare their conservation status with that of the Ross seal using a list of life-history traits and demographic parameters.

The results of this study show that of the 13 species classified as “Near Threatened”, or above by the IUCN none has SPS status. It was also found that the information about this species available in the IUCN is significantly different from that currently available in the scientific literature. Furthermore, it was also found that the Antarctic Treaty only protects around two thirds of marine species located in the Southern Ocean, this could be a concern since the rest of the species are only protected under the CAMLR Convention and cannot be design as SPS if needed. These results allows to recommend that (i) the IUCN should update their categories and criteria in face of the vast and rapid effects that climate change has on Antarctic marine species, (ii) more Antarctic species should have their assessments revised to take into consideration climate change scenarios, (iii) the Antarctic minke whale status should be revised, (iv) updated population and distribution data should be collected regularly to better assess the species conservation status, (v) the status of the Ross seal should be assessed by the Scientific Committee on Antarctic Research (SCAR) to understand if there is need for an Action Plan and therefore if the species should maintains its SPS status or if the status no longer is needed.

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1. Introduction

Antarctica, first discovered in 1820, has unique and extreme environmental conditions (López-Martínez, 2020): it is the windiest, coldest, and highest continent and contains about 70% of the planet's fresh water (Turner et al., 2009). Following a period of visitation during the 'heroic era' of exploration (c. 1897-1922), it was only after the Second World War that international scientific interest in the Antarctic region grew, and numerous geographical and scientific discoveries were made during the International Geophysical Year (1957/58) (Walton, 2013). At the same time there was an increase in the intensity of fishing activities and tourism became a significant commercial activity from the 1990s onward (Hughes et al., 2018; Walton, 2013).

Antarctica is surrounded by the Southern Ocean (Figure 1), which is a mass of water that influences ocean circulation and climate conditions on global scales (Bentley et al., 2021; Pertierra et al., 2021; Rintoul, 2018), playing a significant role in global ocean uptake of carbon (Chown & Brooks, 2019). The Antarctic Circumpolar Current (ACC), considered to be the northern border of the Southern Ocean, is of fundamental importance to Antarctica's environment, as it reduces meridional heat transport across the Southern Ocean. The ACC is today the largest and strongest ocean current, and the major means of exchange of water between oceans, linking the basins of the Atlantic, Indian and Pacific Oceans (Turner et al., 2009; Walton, 2013). The ACC is not a single front but a complex system of fronts (Figure 1) including the Antarctic Polar Front (APF), the Subantarctic Front and the Subtropical Front (Turner et al., 2009).

The Antarctic Polar Front can be important for marine species distributions (e.g. Queirós et al., 2021). Just north of the front the surface water temperature rises by about 3°C. This characteristic acts as a boundary for gene flow due to the high mortality observed when both adults and larvae are swept from their suitable habitat areas by currents (Shaw et al., 2004). This, in turn, contributes to the genetic differentiation and isolation of species by restricting their movements and thereby making Antarctica an isolated continent (Turner et al., 2009). In addition to this, a major phylogeographic break in the Southern Ocean's fauna is known to correspond with the position of the APF (Shaw et al., 2004). The specific adaptations to the environment produce physiological attributes in species that allow them to enhance or constrain capacities to respond to changes in the environment (Hawkins & Sutton, 2011); however, in cases were abrupt water temperature changes happen, the species adaptations may become incompatible with the new environment, restricting their distribution (Meredith & King, 2005).

It is not only the Southern Ocean that is important, but all region of Antarctica have relevance for sustaining life on our planet. For example, climate change on Antarctica ice sheets has various global implications (Chown & Brooks, 2019; IPCC, 2021). Simulations show that the melting of the ice sheets will increase temperature variability and will lead to a rise in sea level of 25 centimetres by 2100 (Golledge et al., 2019). Therefore,

understanding how changes in the Antarctica impact the rest of the planet is of upmost importance and urgency.

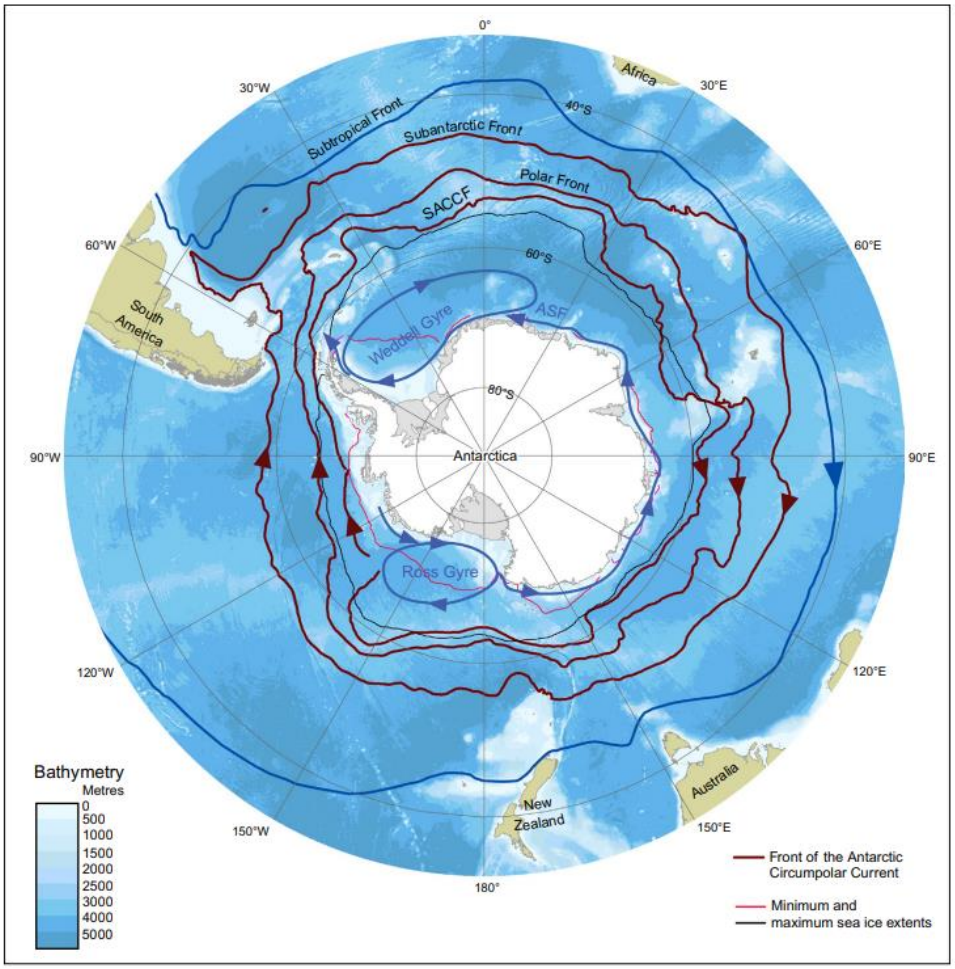

Figure 1. Map of the Southern Ocean, showing oceanic fronts, Subtropical Front, Subantarctic Front, Polar Front, Southern Antarctic Circumpolar Front (SACCF) and Antarctic Slope Front (ASF). Arrows indicate direction of current flow (Stark et al., 2018).

1.1. The Antarctic Treaty System

Antarctica is governed by a unique system of international governance predominantly applicable to the area south of the Antarctic Polar Front, known as the Antarctic Treaty System (ATS) (Hughes et al., 2018).

The International Geophysical Year was commenced in 1957 as an international scientific effort to collect geophysical data from around the world (Hughes et al., 2018). During that year, 67 nations participated in the programme, 12 of them were actively conducting research in Antarctica (López-Martínez, 2020) and agreed that, despite their political and legal differences, their scientific research in Antarctica should continue. In the

following year, these 12 governments came together to discuss the proposal to create a treaty that would ensure peace on the Antarctic continent. On 1st December 1959, the Antarctic Treaty was signed by the governments of Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the Soviet Union, the United Kingdom and the United States of America and entered into force on 23 rd June 1961 (SAT, 2021a; Walton, 2013).

Created in 1958, the Scientific Committee on Antarctic Research (SCAR) is a thematic organisation of the International Science Council (ISC). The Committee is charged with initiating, developing and coordinating high quality international scientific research in the Antarctic region. In addition, SCAR also provides objective and independent scientific advice to the Antarctic Treaty Consultative Meetings (ATCM) in matters related to science and conservation regard management of Antarctica and the Southern Ocean.

The Antarctic Treaty, a politically important milestone, governs the entire region south of 60°S latitude. It stipulates that Antarctica is freely accessible and should be used only for peaceful and scientific purposes and to promote international cooperation (Berkman et al., 2011; Hughes et al., 2018; Walton, 2013; Xavier & Convey, 2020). It also stipulates that no military activity or commercial exploitation is allowed and declared Antarctica as the first nuclear test-free zone (Berkman et al., 2011; Hughes et al., 2018). In addition to the Antarctic Treaty, more agreements and policy bodies were created and, together, they constitute the Antarctic Treaty System (Hughes et al., 2018). Recognizing a general concern about the vulnerability of Antarctic seals to commercial exploitation and the consequent need to regulate these activities to protect the stocks of Antarctic seals, the Convention for the Conservation of Antarctic Seals was created in 1972 and commenced in 1978. The Convention applied to the southern elephant seal (*Mirounga leonina*); leopard seal (*Hydrurga leptonyx*); Weddell seal (*Leptonychotes weddelli*); crabeater seal (*Lobodon carcinophagus*); Ross seal (*Ommatophoca rossi*) and the Antarctic fur seal (*Arctocephalus gazella*) (SAT, 2021a). However, due to the absence of commercial sealing activities in the Treaty area and since all native seals were given additional protection under the Protocol on Environmental Protection to the Antarctic Treaty, the Convention for the Conservation of Antarctic Seals currently receives low levels of engagement from Parties (Hughes et al., 2018).

The increasing commercial interest in Antarctic krill *Euphausia superba*, provided the context for the establishment of the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR) in 1982 under the international Convention for the Conservation of Antarctic Marine Living Resources (CAMLR Convention) with the main objective of conserving Antarctic marine ecosystems (Constable et al., 2000; Reid, 2018; Walton, 2013). CCAMLR aims to deliver precautionary management of fisheries operating in the Southern Ocean and its Scientific Committee (SC-CAMLR) provides scientific information to develop measures to conserve Antarctic marine resources (Constable et al., 2000; Hughes et al., 2018). However, its mandate is limited as it does not, for example,

include the protection of whales since this is under the jurisdiction of the International Whaling Commission (IWC).

Since 1998, the Protocol on Environmental Protection to the Antarctic Treaty, also known as the Madrid Protocol, has strengthened the necessary environmental protection for the continent, thus designating Antarctica as a 'natural reserve, devoted to peace and science' (Hughes et al., 2018; Xavier & Convey, 2020). The Protocol also established the Committee for Environmental Protection (CEP), whose purpose is to assist and advise the Parties to the Treaty on the implementation of the Protocol. The CEP meets annually to discuss the environmental status of Antarctica in the Antarctic Treaty Consultative Meetings. The Madrid Protocol has six Annexes, all dedicated to the environmental management and protection of Antarctica, its dependents and associated ecosystems, and intrinsic values. The Annexes focus on, Environmental Impact Assessment (Annex 1), Conservation of Antarctic Fauna and Flora (Annex 2), Waste Disposal and Waste Management (Annex 3), Prevention of Marine Pollution (Annex 4), Area Protection and Management (Annex 5) and Liability Arising from Environmental Emergencies (Annex 6; yet to enter into force).

Today the Antarctic Treaty has been signed by 55 Parties representing c.65% of the world population (SAT, 2021b). It should be noted that there is a discrepancy between the area covered by the Treaty and that protected by CCAMLR. Whereas the boundaries of the CAMLR Convention are based on the mean position of the Antarctic Polar Front, reflecting an ecological transition that restricts the movement of marine species (Reid, 2018), the Antarctic Treaty regulates all ocean south of 60°S (Figure 2). Therefore, the geographical limit of the CAMLR Convention covers a larger region incorporating sub-Antarctic islands whose governance is undertaken by several sovereign countries. These islands have their own exclusive economic zones (EEZ) and thus fall under national jurisdiction, but the nations also agree to consider measures decided by CCAMLR (Chown & Brooks, 2019). The remaining maritime area covered by the CAMLR Convention is outside national jurisdiction and is therefore under the jurisdiction of the United Nations Convention on the Law of the Sea (UNCLOS). The relationship between the Antarctic Treaty System and UNCLOS and their regulation of the waters around Antarctica remains vague.

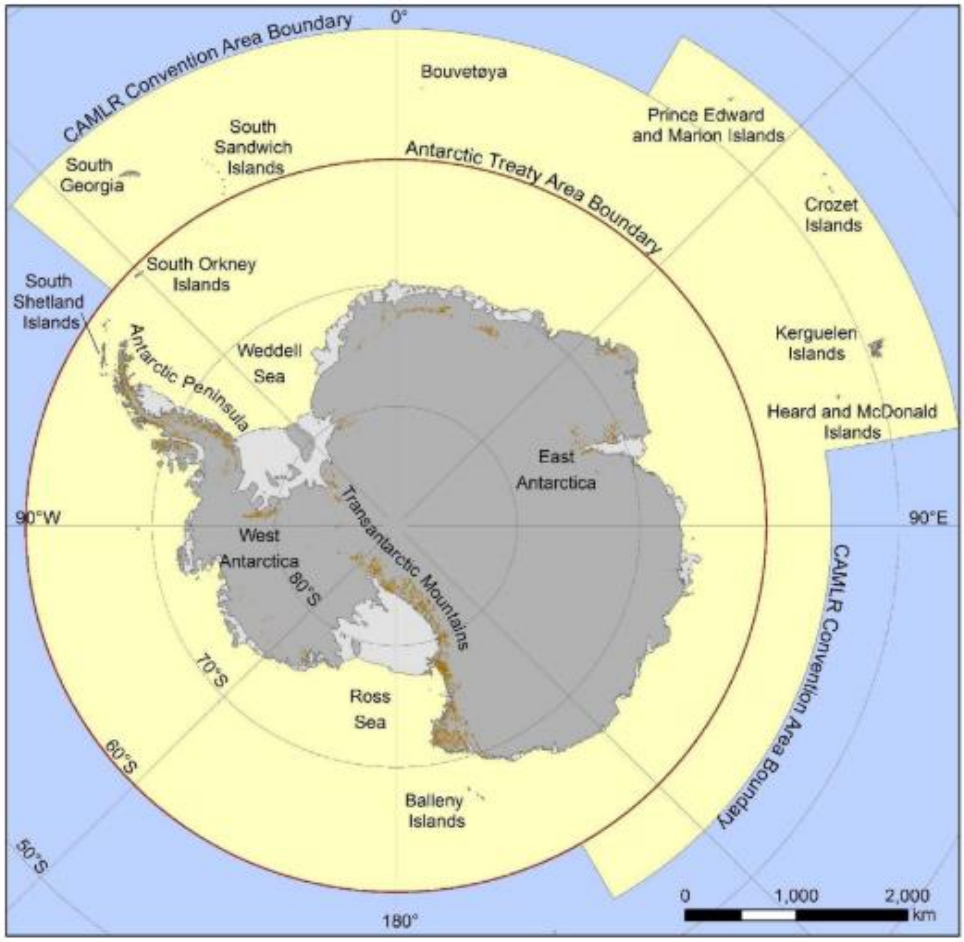

Figure 2. Map of the Antarctic region with the Antarctic Treaty area and the CAMLR Convention borders (Hughes et al., 2018).

1.2. Major threats to the Antarctic region

One of the main problems affecting Antarctica is climate change/global warming, which is influenced by human action. Changes all over the planet have been observed, and in the last four decades a successively greater increase in temperature has been observed (IPCC, 2021) with the Antarctic Peninsula and Scotia Arc being the places in Antarctica that show the most rapid environmental changes (Convey & Peck, 2019; Turner et al., 2009; Walton, 2013). Indeed, studies using model projections predict a decline of over 50% of the population of emperor penguin *Aptenodytes forsteri* during this century including populations located within protected areas due to the melting of coastal sea ice, upon which the emperor penguins depend for breeding (Hughes et al., 2021). In a further example, the fish *Pleuragramma antarcticum,* which is a key species in Antarctica's trophic web, depends on sea ice for reproduction. Because climate change has resulted in declining populations locally due to seasonal changes in sea ice., *P. antarcticum* is being replaced by

myctophids fish, which are becoming a greater part of the trophic web of that area (Turner et al., 2009).

In general, polar species are more vulnerable to changes due to the narrow range of environmental conditions that they can cope with. However, many of them may also be vulnerable to other human-induced stresses (biological invasions, pollution, infrastructures) and, if they cannot adapt, either by migration or physiological flexibility, they may become extinct (Turner et al., 2009).

The 6th IPCC report (2021) showed that polar glaciers will likely continue to melt for decades or centuries, the loss of permafrost carbon following permafrost thaw is irreversible at centennial time scales and the continued ice loss over the 21st century is likely for the Antarctic Ice Sheet (IPCC, 2021). At the same time, as a decrease in the Antarctic Ice Sheet is observed, there is an increase in precipitation in the form of rain rather than snow. This melting of snow in the terrestrial part of Antarctica will leave the area susceptible to colonization by new species, which could have negative effects on the species currently established in Antarctica (Duffy & Lee, 2019; Xavier & Convey, 2020). In the maritime part of Antarctica these precipitation changes will lead to an increase in biological production due to the reduction of the ice cover and the mixing of the water by the wind at the surface (Convey & Peck, 2019; Gutt et al., 2015; Turner et al., 2009).

With the increasing warming of the planet, it is predicted that the Antarctic marine ecosystem will suffer great impacts, particularly affecting low trophic level species, such as Antarctic krill which is a key species in Antarctic trophic chains (Gutt et al., 2015; Xavier & Convey, 2020). However, climate change will also have impacts upon the habitat and ecology of species in different trophic levels, which will lead to changes in the ecosystem (Chown & Brooks, 2019; Constable et al., 2014; Turner et al., 2009).

As mentioned before, the acceleration of climate change promotes biological invasions. As the ice melts, new habitats will be exposed and thus be available for colonization by new species that usually arrive at the continent by aircraft or ships due to tourism and scientific research activities (Frenot et al., 2005). This effect, associated with the growing human presence in Antarctica, will give rise to an increasing number of new species that will arrive and establish (Duffy & Lee, 2019). New invasive species may support new ecological and trophic functions and they could be strong competitors or predators for native species. This is of particular concern because resident species may have little or no capacity to adapt to the presence of new competitors/predators, making introduced species one of the biggest threats to local ecosystems (Frenot et al., 2005; Hughes et al., 2015; Walton, 2013; Xavier & Convey, 2020).

Another threat to Antarctica is pollution. This can originate from research stations, ship traffic, discharges from stations, and scientific experimentation but much more research is needed to fully understand the sources of pollution in this remote region of the planet (Aronson et al., 2011). Microplastic pollution has been an issue of increasing concern in recent years having already been found in many marine ecosystems (Waller et al., 2017).

There has been an increased in information and studies of microplastic effects on marine ecosystems including in Antarctica, where microplastics have been detected near research stations deriving from laundry activities but also due to ropes from fisheries discarded in the oceans (Bessa et al., 2019; Chown & Brooks, 2019; Fragão et al., 2021; Reed et al., 2018).

Commercial exploitation of biological resources in Antarctica began in the 18th century, being initially focused on seal hunting, namely the Antarctic fur seal and the southern elephant seal (Xavier & Convey, 2020). Both these species have been at risk of extinction; however, their populations are currently stable, with higher numbers of individuals, indicating a successful recovery of the two species compared to the times of hunting (Aronson et al., 2011; Chown & Brooks, 2019; Convey & Hughes, 2022; Forcada & Staniland, 2018; Hindell, 2018). The Patagonian toothfish *Dissostichus eleginoides* and Antarctic toothfish *D. mawsoni* are two of the top predator fish in Antarctica and their fisheries are regulated by CCAMLR. In the past, these species were overfished, mainly due to illegal fishing, which still occurs to a lesser degree today, and some of these populations are still recovering (Chown & Brooks, 2019; Reid, 2018; Turner et al., 2009).

Human activity in Antarctica is likely to increase and, with that, impacts due to human presence will continue to grow. Indeed, Antarctic research stations impact over 50% of the coastal ice-free areas of Antarctica (Chown & Brooks, 2019). Thus, more effective protective measures and policies are required (Hughes et al., 2018). Indeed, some of the changes occurring in the Antarctic mentioned above require a faster pace of information collection to enable policies on urgent issues to be implemented successfully (Chown & Brooks, 2019).

1.3. Protection measures for Antarctic fauna

Because of the impacts detailed above, the need for protection of Antarctic marine species is of utmost importance. Several tools and mechanisms to deliver effective protection are provided by the Antarctic Treaty System.

In Annex V to the Protocol on Environmental Protection to the Antarctic Treaty, entitled 'Area protection and management', there are two categories of protection described: Antarctic Specially Protected Areas (ASPA) and Antarctic Specially Managed Areas (ASMA).

An ASPA can be any area (marine or terrestrial) whose purpose is to protect Antarctic values (environmental, scientific, historic, aesthetic or wilderness) or scientific research (SAT, 2021a). Currently 75 ASPAs are designated (Figure 3) (CEP, 2021) covering an area of c.3860 km^2 (Hughes et al., 2021).

In contrast, ASMAs can be any area (marine or terrestrial) where activities can occur or are active now and are design to assist the planning and co-ordination of activities, as well as avoid conflicts, help minimise environmental impacts and improve co-operation between parties (SAT, 2021a). Currently six ASMAs are designated (Figure 3) (CEP, 2021).

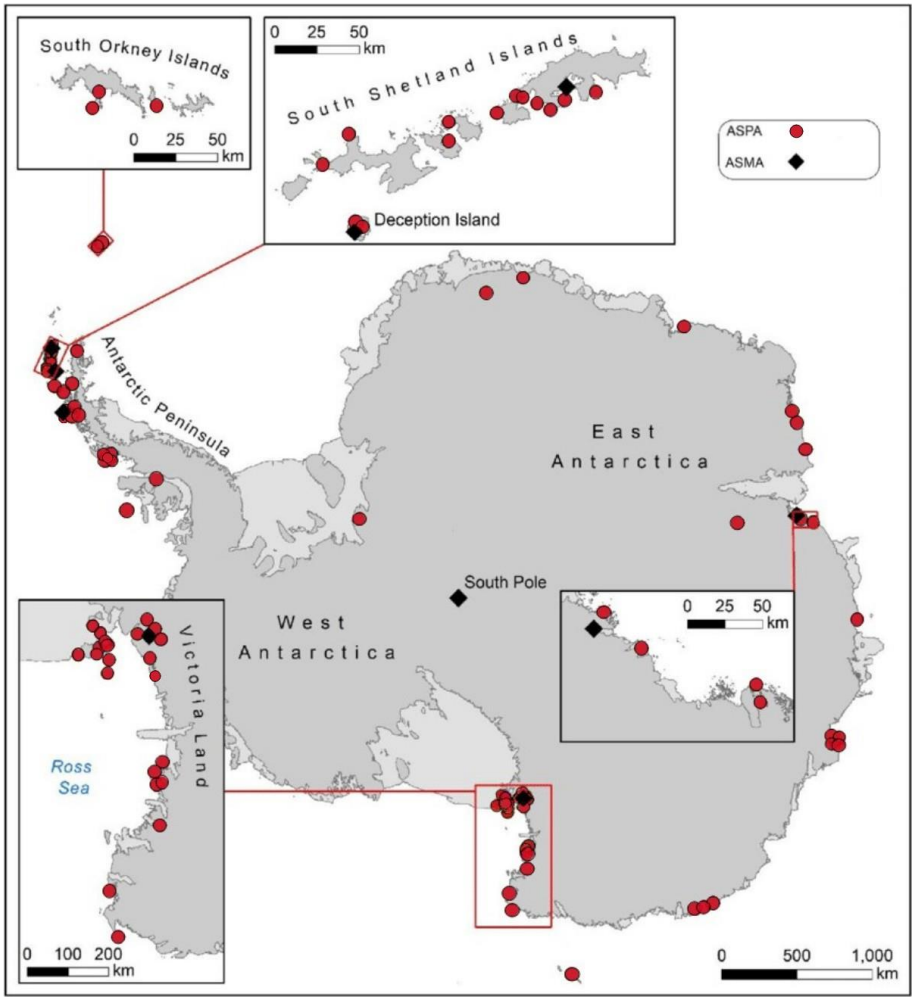

Figure 3. Map of Antarctica showing the distribution of the 75 Antarctic Specially Protected Areas (ASPAs) (red circles) and the six Antarctic Specially Managed Areas (ASMAs) (black diamonds). Adapted from Hughes et al., 2021 and updated according to CEP, 2021.

Marine protected areas (MPAs) are widely recognised as tools for managing and mitigating the negative effects of human presence to preserve biodiversity (Brooks et al., 2016). Most marine protected areas are created within the jurisdiction of one country; however, Antarctica is a unique case where it is the Antarctic Treaty that governs the area. Thus, the creation of protected areas must take into consideration the view of the 29 Consultative Parties to the Treaty (Hughes & Grant, 2017).

CCAMLR is a powerful conservation tool for the Antarctic Treaty System that governs the conservation of species in the ocean surrounding Antarctica. CCAMLR is often promoted as an exemplary case of fisheries management as it operates within ecological rather than political barriers (Brooks et al., 2016). Being responsible for the conservation

of Antarctic marine ecosystems CCAMLR uses an ecosystem-based management approach always based on the best scientific data available to protect key ecosystems as well as habitats, processes, and biodiversity within them (Brooks et al., 2016). MPAs are a tool used by CCAMLR to archive the conservation of marine living resources. 7,1% of the CCAMLR area is protected by MPAs and it would increase to 11,2% if all proposed MPAs were accepted (Figure 4) (Hindell et al., 2020).

MPAs can have numerous benefits for Antarctica such as reducing fishing pressure and associated damage to benthic communities, reduced transfer of non-native species, reduced habitat alteration, reduced pollution from local sources and others (Hughes & Grant, 2017). However, the Marine Protected Area status is not enough to show conservation benefits, as there is also a need for management and monitoring of the MPA (Hughes & Grant, 2017).

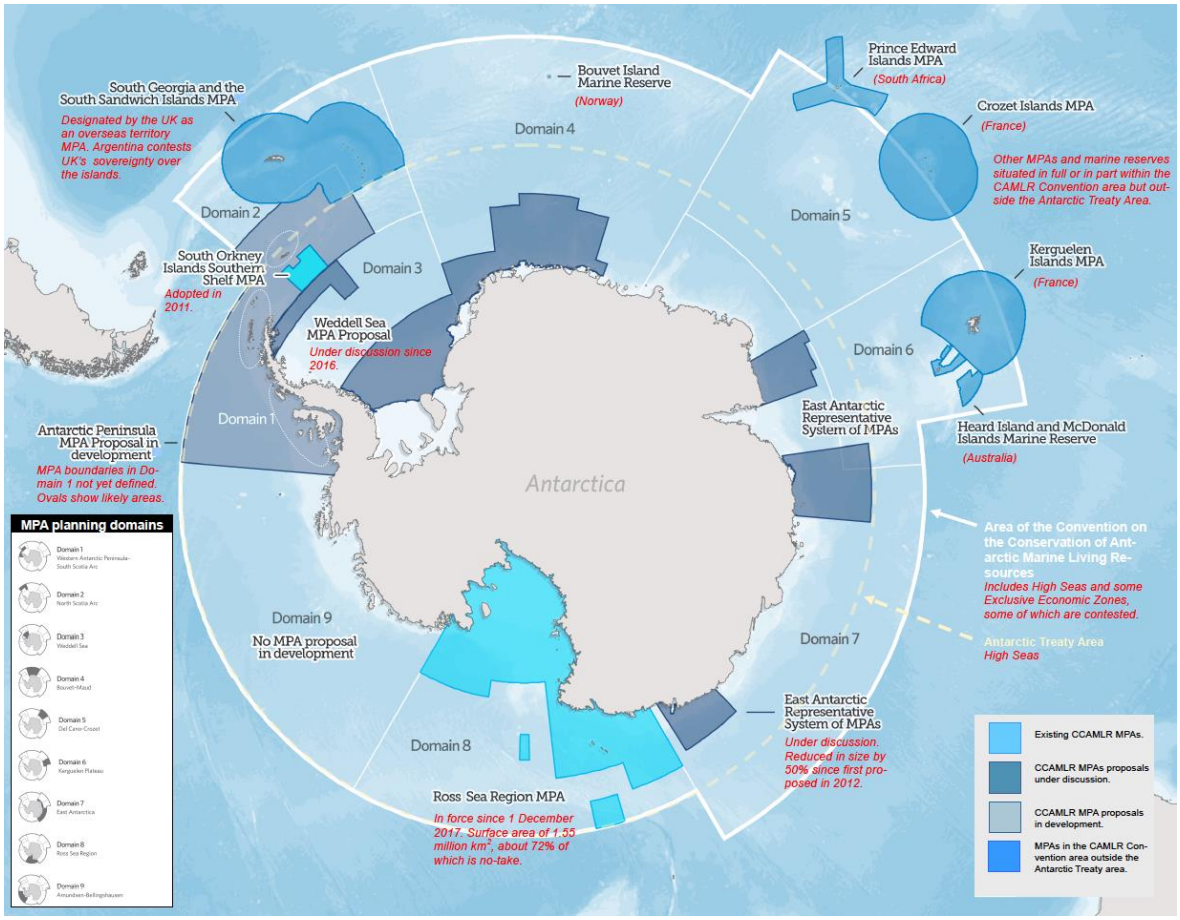

Figure 4. Map showing existing and proposals CCAMLR MPAs. By R.M.Roura 2017, based on MPA map by Pew Charitable Trusts 2016.

Annex II to the Protocol on Environmental Protection to the Antarctic Treaty concerns the 'Conservation of Antarctic fauna and flora'. The Annex provides for the designation of Specially Protected Species (SPS) (also called Antarctic Specially Protected Species in this document) which are species who have a conservation status considered by the Scientific Committee on Antarctic Research to be 'Vulnerable' or higher, and which has

subsequently been endorsed by the ATCM. Currently, this status has been granted only to the Ross seal (SAT, 2021a). However, this designation details neither the criteria for designation nor any mechanisms to ensure the protection of the species.

The XXVIII ATCM document WW002 entitled 'Guidelines for CEP Consideration of Proposals for New and Revised Designations of Antarctic Specially Protected Species under Annex II of the Protocol' (CEP, 2005) states that for new designations of Specially Protected Species

> *'a. If SCAR's assessment determines that the species is at significant risk of extinction (e.g. the conservation status is determined to be "vulnerable" or higher), then the CEP should recommend SPS designation to the ATCM and initiate a process to finalise the Action Plan for the species, in accordance with the guideline. The proponent should play a co-ordinating role.'*

Considering the climate change scenario that we are living in, it is important to understand the threats that Antarctica flora and fauna are facing. Climate change is continuing and as greenhouse gas emissions continue, the possibility of temperature increases slowing down seem low. Given this situation, many Antarctic species may be at risk and appropriate methods of protection need to be considered urgently. Therefore, the fact that the Ross seal is the only Specially Protected Species under the Antarctic Treaty suggests that this is an under-utilised conservation tool. Further opportunities may exist to use this tool to afford a higher level of protection to other vulnerable Antarctic species.

1.4. Objectives

The overall objective of this study is to document the existing extinction risk status attributed by the IUCN Red List to Antarctic marine species in order to identify further species that might merit designation as Specially Protected Species under the Antarctic Treaty. Therefore, the specific objectives of this master thesis are:

1. Assess species active in the Antarctic that have been evaluated using IUCN Red List criteria as 'Vulnerable' or greater, but have not been designated as Specially Protected Species through the Antarctic Treaty System;
2. Identify the species that are active in the Antarctic Treaty area and the CAMLR Convention area (assessing the number of species in each area) to understand if the Antarctic area is sufficiently big to protect species present in the Southern Ocean;
3. Review the ecology and the demography of the key species that potentially need to be protected through Annex II to the Protocol on Environmental Protection to the Antarctic Treaty and provide suggestions on how to proceed from a policy-making perspective.

2. Material and Methods

An advanced search was conducted on the IUCN Red List of Threatened Species website (www.iucnredlist.org) using the 'Atlantic - Antarctic', 'Indian Ocean - Antarctic' and 'Pacific - Antarctic' search filters on the 'Marine Regions' section.

The outcomes of this search were further filtered to obtain a list of species whose geographic range overlapped with the Antarctic Treaty area and/or with the CAMLR Convention area, according to IUCN Red List information.

For each species, the following parameters were recorded (based on information from the IUCN website): (i) the name of the species, (ii) the common name (when existing), (iii) the level of threat, (iv) the population trend, (v) the year of publication of the level of threat, (vi) the date on which the level of threat was analysed, (vii) the date of the last update and (viii) whether the species is found under the Antarctic Treaty area and/or the CAMLR Convention area. The level of threat was also recorded using the following categories: (i) Data Deficient, (ii) Least Concern, (iii) Near Threatened, (iv) Vulnerable, (v) Endangered, and (vi) Critically Endangered. In order to reduce this list of species there was a need to select the threat categories that were more relevant for this study. For that, the recommendations of 'Current Status of the Ross Seal *Ommatophoca rossii*: A Specially Protected Species under Annex II' by SCAR in the XXX Antarctic Treaty Consultative Meeting (SCAR, 2007) was followed. This recommendation states that:

> *'At XXIII ATCM an Intersessional Contact Group, chaired by Argentina, was established to discuss the criteria that could be used to designate Specially Protected Species. The Final ICG report was presented as XXV ATCM/ WP8. The advice to the ATCM was encapsulated in Resolution 1 (2002), which noted that the CEP had decided to adopt the IUCN criteria on endangerment to establish the degree of threat to species, requested SCAR to assist in reviewing those species which were classed as "vulnerable", "endangered" or "critically endangered" (taking into consideration regional assessments of populations), as well as reviewing those species classed as "data deficient" or "near threatened" which occurred in the Antarctic Treaty Area.'*

This recommendation was agreed by the ATCM Parties with guidance on implementation provided through the 'Guidelines for CEP Consideration of Proposals for New and Revised Designations of Antarctic Specially Protected Species under Annex II of the Protocol' (CEP, 2005).

Based on this information, a list of species with a risk of extinction of 'Vulnerable', 'Endangered', 'Critically Endangered' and 'Near Threatened' was compiled.

Finally, after looking through the information on these species, a small sub-set of species was chosen to be the focus of subsequent work. This selection was based on: (a)

the current status of the species under the Antarctic Treaty and the IUCN, (b) species distribution, (c) the population trend, and (d) whether or not the species is native or if the reproduction and feeding depend directly on the area they are found.

After this selection process, a list of life-history traits and demographic data that are considered important to evaluate the conservation status of the selected species was compiled and a bibliographic search was performed. The chosen species traits and demographic data were geographic range, population size, mature population size, population trend, breeding capacity, foraging capacity, conservation status, threats, habitat status and existing conservation measures/plans.

A similar search was performed for the Ross seal, as it is currently debated as to whether the Ross seal should remain on the list of Specially Protected Species of the Antarctic Treaty. This species is also protected under the Convention for the Conservation of Antarctic Seals (CCAS) that provides for commercial harvests of limited numbers of all species protected under the convention except for Ross seals which commercial catch or killing are prohibited due to their designation as SPS.

The information acquired on the selected species was compared to the information provided by the IUCN Red List and analysed through a series of questions described in SCAR (2007) that are critical for analysing the degree of endangerment of a species:

1) How large is the population and is it, either globally or regionally, increasing, stable or decreasing?
2) Is the geographic spread increasing, stable or decreasing?
3) Is the breeding population sufficient to ensure breeding success each year (for an annual breeder)?
4) Are there any known threats to the stability of the population?

3. Results

A total of 278 species that are present in Antarctica were found from the IUCN Red List information survey. Of these, one species is considered 'Critically Endangered', three 'Endangered', four 'Near Threatened', five 'Vulnerable', 225 of 'Least Concern' and 40 'Data Deficient'.

Therefore, out of the 278 IUCN-listed Antarctic species, 13 species were classified as 'Near Threatened' or above (Table 1) emperor penguin (*Aptenodytes forsteri*), sei whale (*Balaenoptera borealis*), sooty shearwater (*Ardenna grisea*), Antarctic minke whale (*Balaenoptera bonaerensis*), Antarctic blue whale (*Balaenoptera musculus ssp. Intermedia*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Kerguelen sandpaper skate (*Bathyraja irrasa*), portuguese dogfish (*Centroscymnus coelolepis*), southern rockhopper penguin (*Eudyptes chrysocome*), porbeagle *(Lamna nasus*), sperm whale (*Physeter macrocephalus*) and Atlantic petrel (*Pterodroma incerta*).

Of these 13 species, eight species are found in the Treaty area and CAMLR Convention area while the other five are only found in the CAMLR Convention area (Figure 5). Of the 278 IUCN-listed Antarctic species 175 are found simultaneously within the Antarctic Treaty area and the CAMLR Convention area, with the remaining 103 species found only within the CAMLR Convention area and, in many cases, within adjacent regions further north (Figure 5). This means that the Protocol on Environmental Protection to the Antarctic Treaty (through which SPS can be designated) protects about 62,95% of all IUCN listed marine species in the Southern Ocean.

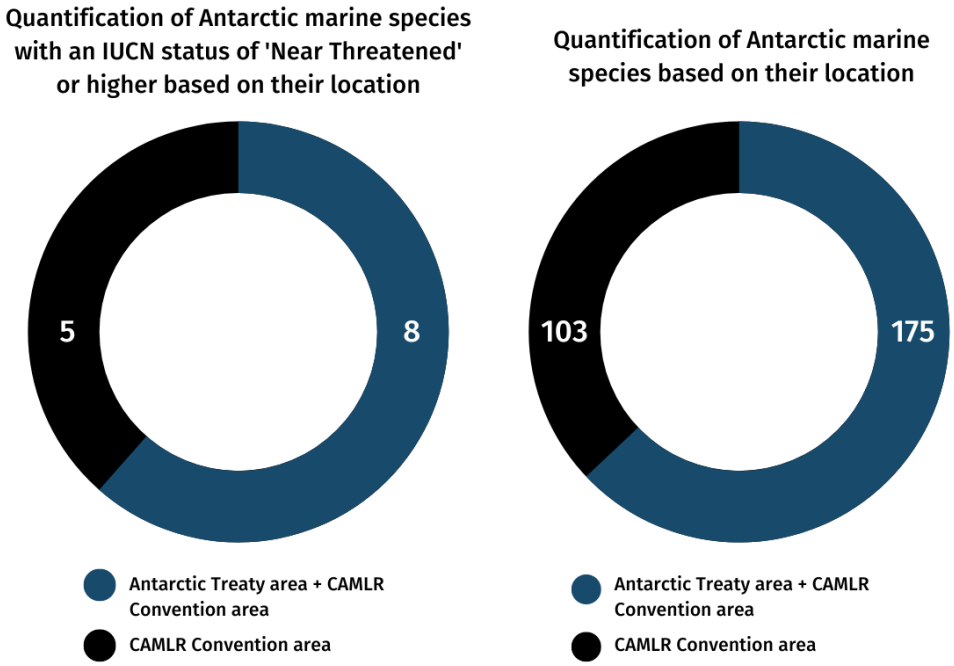

Figure 5. Quantification of Antarctic marine species with an IUCN status of 'Near Threatened' or higher based on their location (right) and quantification of Antarctic marine species based on their location (left).

Table 1. List of Antarctic marine species that present a level of threat of 'Vulnerable' (VU), 'Endangered' (EN), 'Critically Endangered' (CE) and 'Near Threatened' (NT) according to the IUCN Red List date base. The columns present the information found in the IUCN Red List website about each species, if they are present in Antarctic Treaty and/or CCAMLR area, the distribution of the populations and their association to the Antarctic Treaty area (native or if the reproduction and feeding depend directly on the area they are found).

Species	Common name	Threat	Population Trend	Year published	Date assessed	Last update	Antarctic Treaty	CCAMLR	Distribution	Association to the Antarctic Treaty area
Aptenodytes forsteri	Emperor penguin	NT	Decreasing	2020	Aug 2019	2018 NT	yes	yes	Circumpolar Antarctic	Native (Trathan et al., 2019)
Balaenoptera borealis	Sei whale	EN	Increasing	2018	Jun 2018	2008 EN	no	yes	Extant (resident) in South Georgia and the South Sandwich Islands	Sei whales found in the Antarctic are migratory, spending the summer at high latitudes for feeding and the winter at lower latitudes for calving and breeding (McDonald et al., 2005)

Species	Common name	Threat	Population Trend	Year published	Date assessed	Last update	Antarctic Treaty	CCAMLR	Distribution	Association to the Antarctic Treaty area
Ardenna grisea	Sooty shearwater	NT	Decreasing	2019	Aug 2019	2018 NT	yes	yes	Extant (non-breeding) in Antarctica	Rely on food resources located in Antarctic waters (Weimerskirch , 1998)
Balaenoptera bonaerensis	Antarctic minke whale	NT	Unknown	2018	Feb 2018	2008 DD	yes	yes	Extant (resident) in Antarctica	Sea ice is an important part in the foraging behaviour (Risch et al., 2019)
Balaenoptera musculus ssp. Intermedia	Antarctic blue whale	CE	Increasing	2018	Jun 2018	2008 CE	yes	yes	Extant (resident) in Antarctica	Locations of breeding grounds may be influenced by the location and abundance of krill during the austral winter. The exact breeding ground locations are unknown (Attard et al., 2016)

Species	Common name	Threat	Population Trend	Year published	Date assessed	Last update	Antarctic Treaty	CCAMLR	Distribution	Association to the Antarctic Treaty area
Balaenoptera musculus	Blue whale	EN	Increasing	2018	Mar 2018	2008 EN	no	yes	Extant (resident) in South Georgia and the South Sandwich Islands	Southern Ocean blue whale population are obligate krill consumers in the Southern Ocean (Lavery et al., 2014)
Balaenoptera physalus	Fin whale	VU	Increasing	2018	Feb 2018	2013 EN	yes	yes	Extant (resident) in Antarctica	Recent visual observations suggest that the region around Elephant Island serves as an important feeding area (Burkhardt et al., n.d.)
Bathyraja irrasa	Kerguelen sandpaper skate	VU	Decreasing	2020	Nov 2019	-	no	yes	Extant (resident) in Kerguelen, Heard Island and McDonald Islands	Located in the CCAMLR area but not in the Antarctic Treaty area

Species	Common name	Threat	Population Trend	Year published	Date assessed	Last update	Antarctic Treaty	CCAMLR	Distribution	Association to the Antarctic Treaty area
Centroscymnus coelolepis	Portuguese dogfish	NT	Decreasing	2020	Nov 2019	2003 NT	no	yes	Extant (resident) in Kerguelen	Located in the CCAMLR area but not in the Antarctic Treaty area
Eudyptes chrysocome	Southern rockhopper penguin	VU	Decreasing	2020	Aug 2020	2018 VU	yes	yes	Extant (non-breeding) in Antarctica; Extant (resident) in Heard Island and McDonald Islands	Some individuals migrate to South Shetland Islands to feed (Pütz et al., 2006)
Lamna nasus	Porbeagle	VU	Decreasing	2019	Nov 2018	2006 VU	no	yes	Extant (resident) in McDonald Islands	Located in the CCAMLR area but not in the Antarctic Treaty area

Species	Common name	Threat	Population Trend	Year published	Date assessed	Last update	Antarctic Treaty	CCAMLR	Distribution	Association to the Antarctic Treaty area
Physeter macrocephalus	Sperm whale	VU	Unknown	2019	Jun 2008	2008 VU	yes	yes	Extant (resident) in Antarctica	Peaks in catches at South Georgia and South Shetland whaling stations suggest a summer migration to high Antarctic latitudes and a return to the sub-Antarctic and subtropics in autumn (Miller & Miller, 2018)
Pterodroma incerta	Atlantic petrel	EN	Decreasing	2019	Jun 2019	2018 EN	yes	yes	Vagrant in Antarctica; South Georgia and the South Sandwich Islands	Only vagrant in the area

After carefully analysing the factors described in Table 1, it was decided to exclude for further analyses 1) species whose geographic distribution was not within the Antarctic Treaty area (Kerguelen sandpaper skate, portuguese dogfish and southern rockhopper penguin) since if they are not under the Antarctic Treaty geographic boundaries they cannot therefore be designated as Specially Protected Species, 2) species that have most of their populations outside of Antarctica (i.e. southern rockhopper penguin and Atlantic petrel) and 3) the sooty shearwater since this species is only extant in the area and its non-breeding. These exclusions resulted in a list containing the emperor penguin and all whale species.

The Ross seal is the only species currently present on the list of Specially Protected Species of the Antarctic Treaty and that is also protected under the Convention for the Conservation of Antarctic Seals. Annex I to CCAS provides for commercial harvests of limited numbers of all species protected under the convention except for Ross seals which commercial catch or killing are prohibited due to their designation as SPS. There is some doubt as to whether Ross seals should remain on the list of SPS since the original reason for the designation was due to lack of data available to make any judgement about their abundance (SCAR, 2005) however, recent studies show that, at present, population size may be around 250,000 individuals (Hückstädt, 2018). Due to these statements, it was decided that one of the study species should be the Ross seal.

The emperor penguin is a native species that depends directly on seasonal fast ice to reproduce and feed (Trathan et al., 2019) whose population trend is decreasing according to the IUCN data and that is already being worked on to be protected.

Lastly, because all whales fall under the jurisdiction of the International Whaling Commission, we decided to choose only one for further analyses, the Antarctic minke whale, as it has been subject to harvesting by Japanese whalers since 1987 and because this species is highly dependent on Antarctic Sea ice for foraging.

3.1. Study species' characteristics

Ross seals (Figure 6 a)) are distributed around the Antarctica continent, they travel north to forage in lower latitudes and spend most of their time south of the Antarctic Polar Front, but some individuals have been reported at several sub-Antarctic islands (South Georgia Island, Heard and McDonald Islands, Kerguelen Island, South Sandwich Islands, and Falklands Islands) (Hückstädt, 2015, 2018). This seal species needs to dive to forage, doing it continuously throughout the day and reaching depths of 200 to 500 m, where they usually eat small fish, squid, and other invertebrates (Hückstädt, 2018). Population estimates vary widely, with one source suggesting that there are approximately 250,000 individuals (Hückstädt, 2018) and their population trend is currently unknown (Hückstädt, 2015). Adults can grow up to 2.09 m in length and 216 kg in males and 2.50 m and 204 kg in females. They reach the final body size at approximately nine years of age and can live until 20 years of age (Hückstädt, 2015). They are protected under the Antarctic Treaty through designation as a Specially Protected Species, and harvesting is prohibited under the Convention for the Conservation of Antarctic Seals. The Ross seal is listened as 'Least Concern' under the IUCN Red List of Threatened Species (Hückstädt, 2015).

Figure 6. Study species: a) Ross seal, Ommatophoca rossii. Photo by Dominik Nachtsheim; b) Emperor penguin, Aptenodytes forsteri. Photo by Bernard Breton/Fotolia; c) Antarctic minke whale, Balaenoptera bonaerensis. Photo by Helena Herr.

Emperor penguins (Figure 6 b)) are distributed around Antarctica having their colonies found on the land-fast sea ice (Fretwell & Trathan, 2021), with the largest colonies being located in the Ross Sea and Weddell Sea (BirdLife International, 2020). They feed mostly on fish, krill, and cephalopods (BirdLife International, 2020). The population is considered to be around 595,000 individuals (Fretwell et al., 2012) and c. 250,000 breeding pairs (Jenouvrier et al., 2020). Breeding starts with the arrival of individuals into their preferred breeding sites in late March-April, after which they lay the eggs from May to June. The eggs hatch after 65 days and chicks fledge from December to January. From February to March the adults haul out to moult and travel long distances from the breeding site to areas with seasonally persistent pack ice where they will remain (BirdLife International, 2020; Fretwell & Trathan, 2021). Due to climate change, Antarctic Sea ice extent is predicted to decrease and data show that the current population size will suffer a decrease of c.86% if colonies cannot find more suitable breeding habitats (Fretwell &

Trathan, 2021). The species is listened as 'Near Threatened' under the IUCN Red List of Threatened Species (BirdLife International, 2020; Cerchiara, 2018); however, some of the breeding sites of the species are under the Ross Sea region Marine Protected Area (RSR MPA) and others are located within Antarctic Specially Protected Areas (ASPA) (BirdLife International, 2020; Cerchiara, 2018).

Antarctic minke whales (Figure 6 c)) are species that are found south of 60°S in summer in parts of the Weddell and Ross Seas, they are associated with sea ice and are less abundant in ice-free waters (Cooke et al., 2018; Risch et al., 2019). The estimated population for this species is around 500,000 (registered between the years 1993 and 2002); however, this represents a decrease in the population since past assessments (registered between the years 1986 and 1991) recorded 720,000 animals (i.e., a 31% decline) (Cooke et al., 2018; Filun et al., 2020; Herr et al., 2019; Risch et al., 2019). Antarctic minke whales breed all year around, females reach age of reproduction at 7-8 years and calves are born 10 months after conception and remain with their mother for 5-6 months. They feed mostly on euphausiids (krill) (Cooke et al., 2018) and their foraging behaviour is characterized by extremely high feeding rates and relatively shallow dives (<100 m). This behaviour represents a high proportion of foraging effort. Antarctic minke whales take advantage of the sea ice habitat because their small size allows them to navigate in and around ice in search of krill (Friedlaender et al., 2014). The species is listened as 'Near Threatened' under the IUCN Red List of Threatened Species (Cooke et al., 2018) and under Appendix II on the Convention on Migratory Species (CMS).

The information on the traits and demographic and conservation data selected to evaluate the species status are summarized in Table 2. For some of the traits there was no information found showing gaps in the scientific information available.

Table 2. Available information in the scientific literature of the traits and data considered important to evaluate the conservation status of Ross seal, emperor penguin and Antarctic minke whale.

	Ross seal	**Emperor penguin**	**Antarctic minke whale**
Geographic range	Circumpolar Antarctic distribution (Hückstädt, 2018)	Circumpolar distribution (Fretwell & Trathan, 2021)	Circumpolar distribution (Risch et al., 2019)
Population size	~250,000 individuals (Hückstädt, 2018)	~595,000 birds (Fretwell et al., 2012)	~500,000 (Filun et al., 2020)
Mature population size	40,000 (Hückstädt, 2015)	250,000 breeding pairs (Jenouvrier et al., 2020)	No information
Population trend	No information	No information	31% decline (Filun et al., 2020; Herr et al., 2019; Risch et al., 2019)
Breeding capacity	Return to areas with heavy pack ice for breeding (October to December) and again at the time of molting (January to March). Adult females give birth to one pup in November. (Hückstädt, 2018)	Annual mean Antarctic Sea ice extent will decrease by 48%, and breeding habitat for the most endangered colonies, in the north of the range, will probably be lost during the egg laying season as sea ice formation is delayed by warmer temperatures. (Fretwell & Trathan, 2021)	Breeding can occur year-round, and calves are born roughly 10 months after conception. Calves remain with their mothers for 5-6 months, and females reach the age of reproduction at 7-8 years. Female minke whales appear to be able to give birth to one calf every year. **(https://iwc.int/minke-whale)**

	Ross seal	Emperor penguin	Antarctic minke whale
Foraging capacity	Due to their pelagic nature, reductions of sea ice may cause longer travel distances to reach their preferred foraging areas. (Hückstädt, 2015)	Solo travels and search at depth, with rises to hunt and capture fish under the ice. Shallow dives represent an important source of food consumption. 30–60 % of dives during foraging trips to sea are to less than 50 m in depth. (Ponganis et al., 2000) In years with high sea surface temperatures, they will probably have difficulties in finding food, which could increase mortality. (Barbraud & Weimerskirch, 2001)	The sea ice is important in the foraging behaviour because excursions under sea ice come with a large diving cost; They take advantage of this habitat because their small size provides manoeuvrability required to navigate in and around ice in search of krill; Although this feeding mode has never been described before, this behaviour represents a high proportion of foraging effort. (Friedlaender et al., 2014)
Conservation status	Least Concern	Near Threatened	Near Threatened
Threats	Natural predators; climate change; reduction in sea ice; expansion of fisheries activities in the Southern Ocean; Other potential impacts include changes in the ecosystem structure and biological productivity. (Hückstädt, 2018)	Vulnerable to altered wind regimes, rising temperatures, reduced sea ice extent and persistence. (Fretwell & Trathan, 2021; Trathan et al., 2019)	Climate change; natural predators and whaling. (Risch et al., 2019)
Habitat status	Climate change may result in loss of sufficient areas of consolidated ice habitat that are used for pupping, resting, and avoidance of predators. (Hückstädt, 2015)	Climate model simulations project sea ice retreat over the latter part of this century, but the amount and pattern of retreat remains difficult to assess. (Fretwell & Trathan, 2021)	Due to climate change and the recession of ice, the habitat will be narrowed significantly in the coming decades. (Ainley et al., 2012)

	Ross seal	Emperor penguin	Antarctic minke whale
Existing conservation measures /plans	Protected under the Protocol on Environmental Protection to the Antarctic Treaty and the Convention for the Conservation of Antarctic Seals (CCAS) of 1972. (Hückstädt, 2018). No management plan currently exists	Action Plan produced by members of the CEP, but was not agreed	Listed under Appendix II on the Convention on Migratory Species (CMS)

3.2. Endangerment evaluation of the study species

As described in SCAR (2007) there are four points that are critical to analyse the degree of endangerment of a species: 1) the population size and its variation, either globally or regionally; 2) the geographic spread and how this is varying; 3) if the population is sufficiently large to ensure breeding success each year; and 4) if there are known threats to the stability of the population.

The data acquired in the bibliographic review performed to assess the endangerment of the study species is compared with the IUCN data in Tables 3 (Ross seal), 4 (emperor penguin) and 5 (Antarctic minke whale).

Ross seal

Table 3. Critical data for analysing the degree of endangerment of Ross seal with IUCN data and bibliographic data.

Data found in the literature review	IUCN data
How large is the population and is it, either globally or regionally, increasing, stable or decreasing?	
New data from genetic studies estimating the effective population size of the species suggest a larger population size for the Ross seal than that estimated using traditional population size surveys (~250,000 individuals). (Hückstädt, 2018)	'The most ambitious and coordinated effort to determine abundance of this species to date was the Antarctic Pack-Ice Seal (APIS) project which conducted aerial and shipboard surveys around the continent during 1996-2001. (…) APIS surveys resulted in an estimate of 78,500 (95% CL 39,400-231,200) Ross Seals in the surveyed areas.' Population trend classified as unknown
Is the geographic spread increasing, stable or decreasing?	
Few information available. Due to the annual variability in the distribution of ice it is difficult to maintain specific sites for breeding and molting since it is constantly moving due to wind and currents. (Davis et al., 2008)	No information regarding existing trends and data on geographic spread of the specie
Is the breeding population sufficient to ensure breeding success each year (for an annual breeder)?	
There are records of 40,000 mature individuals (Hückstädt, 2015). It can presumed the breeding population is sufficient to ensure breeding next year, however, since the population trend is unknown there are some uncertainties	40,000 mature individuals
Are there any known threats to the stability of the population?	
Climate change will lead to a reduction in sea ice affecting the habitat areas used by Ross seals for pupping, resting, and avoidance of predators forcing longer travel distances for the species. However, the effect of loss of substantial amounts of ice in seals is still largely unknown. (Hückstädt, 2015)	'Our very limited knowledge about the species makes it difficult to make any projections about how global climate change might affect the Ross seal. However, is suggested that Ross seal numbers may decline with increasing temperatures if Antarctic Sea ice is significantly reduced. Other authors suggest that they will be among the least impacted of the Antarctic seals because they do not feed in sea-ice covered areas'

Emperor penguin

Table 4. Critical data for analysing the degree of endangerment of the emperor penguin with IUCN data and bibliographic data.

Data found in the literature review	IUCN data
How large is the population and is it, either globally or regionally, increasing, stable or decreasing?	
VHR satellite imagery, revealed that the population comprised ~595,000 birds (Fretwell et al., 2012). Some colonies have shown to be decreasing their population: • Auster – 10,963 pairs (1988); 785 individuals (2009) • Taylor – 2,900 pairs (1988); 519 individuals (2009) • Kloa Point – 6,000 individuals (1992); 3,283 individuals (2009) • Cape Darnley –~7,000 individuals (1992); 3,456 individuals (2009) • Amanda Bay –~8,000 individuals (1992); 6,831 individuals (2009) (Fretwell et al., 2012; Robertson, 1992; Todd et al., 1999)	'A survey of satellite images from 2009, updated in 2019 considered 54 colonies containing approximately 256,500 breeding pairs to be a plausible breeding population estimate. The current population trend is considered stable: from a survey based on satellite images the total population was estimated at 238,000 breeding pairs while the updated figure for 2019 was 256,500 breeding pairs.' Population trend classified as decreasing
Is the geographic spread increasing, stable or decreasing?	
50 colonies are extant since 2019 and recently eight new colonies and three new breeding sites were confirmed making a total of 61 breeding locations. These new discoveries may indicate an increase in the geographic spread; however, some of the previously identified colonies are no longer extant and are reunited with larger colonies. (Fretwell & Trathan, 2021)	'In recent years, some colonies may have relocated' No information about the state of geographic spread of the specie.
Is the breeding population sufficient to ensure breeding success each year (for an annual breeder)?	
There are 250,000 breeding pairs (Jenouvrier et al., 2020). The population appears to have a breeding population that can assure breeding success each year; however, with sea ice declines and breeding habitat disappearing (Fretwell & Trathan, 2021) in the future the population may not be able to ensure breeding success to the following years.	'After the middle of this century, if the current factors leading to Southern Ocean change continue, the annual decrease in net Antarctic Sea ice is predicted to reach 48%. A number of emperor penguin colonies are then likely to experience complete loss of breeding habitat during the critical egg-laying season. Receding sea ice, along with consequent changes in fisheries, are also expected to affect fish and krill stocks, thus threatening the food supply of predators such as emperor penguins. '

Are there any known threats to the stability of the population?	
Emperor penguins are vulnerable to altered wind regimes, rising temperatures and reduced sea ice extent and persistence (Fretwell & Trathan, 2021). Since emperor penguin is a sea ice dependent species in a future world alternate habitat would have to be used (Trathan et al., 2019).	'The species is threatened by the effects of projected climate change, primarily through ongoing and future decreases in sea ice concentration, thickness and duration, which are affected by wind speed and persistence, as well as changes in other climatic variables that affect ocean properties. Another threat to emperor penguins is a change in food availability; changes to ocean circulation due to increasing melt of Antarctic ice may interfere with the natural processes that bring nutrients and carbon from the deep ocean back to the surface waters. Human disturbance is a threat in some areas, where problems to colonies are caused by the proximity to scientific bases and aircraft movements.'

Antarctic minke whale

Table 5. Critical data for analysing the degree of endangerment of Antarctic minke whale with IUCN data and bibliographic data.

Data found in the literature review	IUCN data
How large is the population and is it, either globally or regionally, increasing, stable or decreasing?	
31% decline in the population and even with lack of confidence in parts of the assessment this trend gives reason for concern and motives to act to understand what is causing this decline in the population. (Filun et al., 2020; Herr et al., 2019; Risch et al., 2019)	The IWC Scientific Committee in 2012 agreed upon abundance estimates totaling 720,000 for the period 1986-91 and 515,000 for the period 1993-2002, making a 31% decline. However, 'the confidence intervals of the two estimates overlap and the IWC report listed a number of factors that could affect the comparison' - Population trend classified as unknown
Is the geographic spread increasing, stable or decreasing?	
No evidence of changes. However, there is a correlation between Antarctic minke whale prevalence and high abundance of krill so any changes in this species may be significant. (Murase et al., 2002)	No information about the state of geographic spread of the species
Is the breeding population sufficient to ensure breeding success each year (for an annual breeder)?	
No data regarding the number of the mature population. Yet, due to their high number, it can presumed the breeding population is sufficient to ensure breeding next year; however, since the population trend is decreasing in a few years this ability may be lost.	No information
Are there any known threats to the stability of the population?	
Climate change: they are the largest ice-dependent krill predators in the Southern Ocean, they are directly tied to sea ice for foraging of krill and changes that can affect que quality or quantity of their habitat and food can be significant. This can mean that the species will have to relocate to regions that are covered with ice and the ones that do not relocate will be at higher risk of predation from killer whales and will have to compete with other predators for krill. Whaling: mostly by Japan research programs. (Risch et al., 2019).	'Substantial catches have been made by pelagic expeditions only since 1971, following depletion of the larger baleen whales. Since 1987, pelagic whaling continued by Japan under special permit at a reduced level. Nearly 11,000 Minke Whales were taken under such permits during 1987-2014. Catches were suspended for the 2014/15 season following a ruling by the International Court of Justice but resumed from the 2015/16 season with an annual catch target of 333 whales.'

4. Discussion

4.1. Conservation status of Antarctic species under the Antarctic Treaty System and IUCN

The results show that there are 13 species that have 'Near Threatened' status or above (Table 1). None of these species is on the Specially Protected Species list of the Antarctic Treaty. The reason for this may be related to the data available (which is unknown for some population trends), the distribution of the species (some of them are only found in the CAMLR Convention area and therefore cannot be proposed for the SPS status), and the species itself, for example, whales fall under the jurisdiction of IWC and therefore cannot receive the SPS status. Most of the species identified are whales and penguins, important predators at high trophic levels in the Antarctic food web (Figure 7). Changes in any of these species may result in a cascade of indirect interactions and feedbacks through the food web leading to unpredictable consequences (Trebilco et al., 2020).

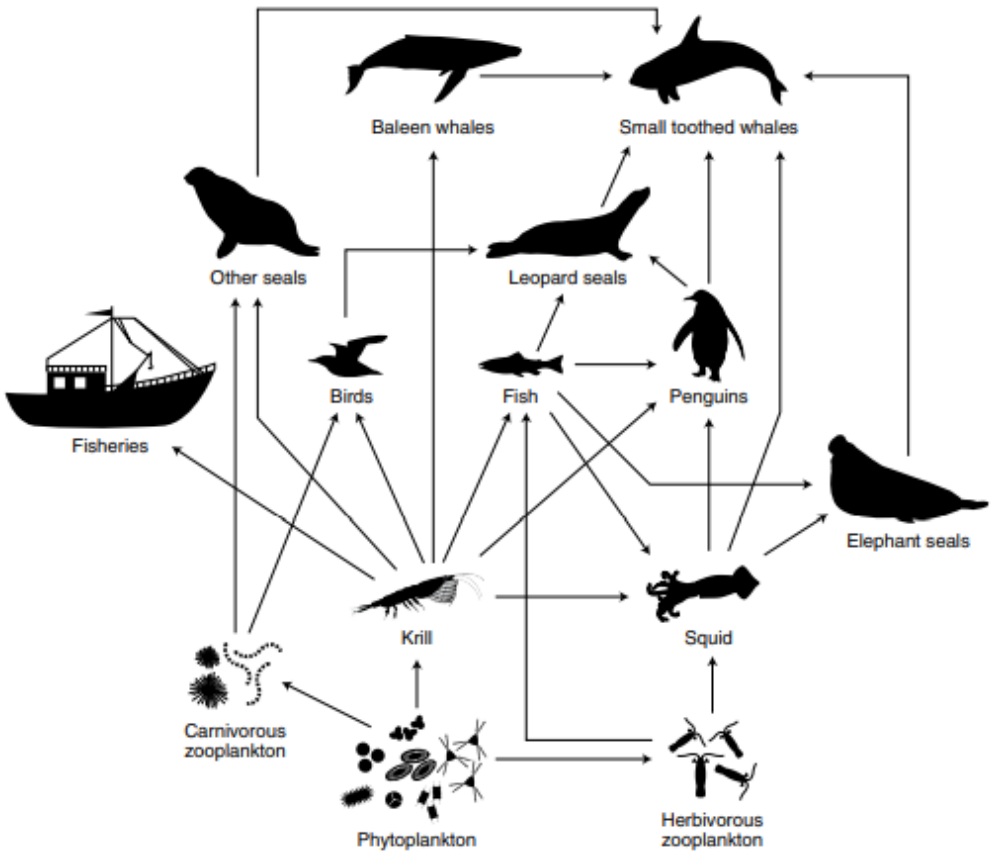

Figure 7. Southern Ocean food web. Image by McBride, 2019

Although some of these species have their population trend increasing (sei whale, Antarctic blue whale, blue whale and fin whale) they still have an IUCN classification considered to be threatened. It is also important to consider the lack of information on the population trends of some species (Antarctic minke whale and sperm whale).

Even though this study was focused on the Ross seal, the emperor penguin and the Antarctic minke whale, the Southern Ocean ecosystem and its preservation needs to be one of the top priorities for the policy bodies and in this study, we produced a clear list of where conservation efforts for new species should begin.

IUCN and the ATS define different status and therefore different ways of their application. Even though the ATS uses the IUCN status as a starting point to attribute SPS status the next steps to decide if the status is attributed are different. For example, the IUCN uses a system of categories and quantitative criteria (population size, subpopulations, mature individuals, generation, reduction, continuing decline, extreme fluctuations, severely fragmented, extent of occurrence, area of occupancy, location and quantitative analysis) for designing such categories (IUCN, 2012), including the 'threatened' status.

For proposing the SPS status there needs to be a scientific justification and a draft Action Plan for the species in question. The Action Plan needs to include information regarding the species reproductive and foraging ecology, past and present distribution including critical habitat, population trends (past, present and future estimates), risk of extinction status by the IUCN, agents of decline (including uncertainties and potential future threats), past and current management/conservation measures and legal framework under the Environmental Protocol/Antarctic Treaty System (CEP, 2005). The Action Plan also needs to include goals and objectives regarding how to downgrade the threatened status and actions were there are described specific actions to be taken, who should do the work, performance measures and prioritization if necessary (CEP, 2005).

Although some of the criteria are common in both the IUCN and ATS the way they are looked at are different, for example the ATS looks at past, present and future estimates of the population trends but in the IUCN, it is required a minimal measure of 10 years, or 3 generations and climate change scenarios are not considered when applying this criteria. In the case of the geographic range of the species the ATS looks at past and present distribution; however, the IUCN looks at geographic range in two ways, the extent of occurrence and area of occupancy and once again it does not consider if the present or future reduction in occurrence or occupancy is due to climate change.

The current version (3.1.; second edition) of the IUCN Red List Categories and Criteria was published in 2012. However, this second edition retains the same assessment system presented in the 2001 publication. In the past 21 years a lot has changed specially regarding the scientific knowledge on climate change, how it is progressing and how is it going to affect biodiversity. In this way we believe that the IUCN Red List Categories and Criteria should be revised and updated so that it considers climate change effects in the species and their environment.

4.2. Representation of Antarctic species under CAMLR Convention and Antarctic Treaty System areas

The results show that the Antarctic Treaty area (south of latitude 60^{o}S) only protects around two thirds of all marine species on the IUCN Red List that inhabit the Southern Ocean (Figure 5), the remaining one third fall under the jurisdiction of CCAMLR as well as national jurisdiction, representative of the sub-Antarctic islands, and international jurisdiction conforming to the UNCLOS. Even though the CAMLR Convention applies conservation measures that determine the use of marine living resources in the Antarctic it may be concerning that the Antarctic Treaty does not cover and protect all the Southern Ocean marine species. As mentioned before, the species that are only found in the CAMLR Convention area cannot be designed as Specially Protected Species. In this way, it would be important to understand if the protection given by CCAMLR is enough or if extra measures that are found in the Antarctic Treaty area are required.

Under a climate change scenario, it is possible to project the presence of invasive species in the region and new measures and actions may need to be made. Indeed, climate is usually seen as barrier to alien species; however, the existing climatic barriers to alien species will weaken as warming continues to rise in the Antarctic region (Duffy et al., 2017). The CAMLR Convention area, as it is located north will suffer firstly the effects of invasive species, as the waters in the Southern Ocean get warmer. In this way, it is imperative to 1) understand the future impacts that climate change will have in allowing invasive species to reach the Southern Ocean and 2) establish monitoring and surveillance programs.

4.3. Guidance for development of legislation for the conservation of marine species under the Antarctic Treaty

In some cases, the IUCN information is outdated on points that are essential for the conservation of species. For example, in the case of the Antarctic minke whale the 2018 assessment explains why the status of the species is 'Near Threatened' instead of 'Vulnerable'. According to the 'IUCN Red List Categories and Criteria' (IUCN, 2012) a taxon is vulnerable when the best evidence indicates that it meets any of the criteria (A to E). These criteria are related to reductions in the population size (A), geographic range (B), population size of mature individuals (C), population size and/or restriction (D) and probability of extinction (E). However, the IUCN criteria do not have in consideration the changes that global warming can induce in the species and its habitats.

Their latest assessment of the Antarctic minke whale showed a reduction of population size above 30%, which would lead to the assignment of the 'Vulnerable' status (criterion A). However, because this species has a generation time of 22 years, the

population reduction should have been assessed over a period of three generations (subcriterion A2), i.e., from 1952 to 2018, and since there are no estimates for this period, the classification is 'Near Threatened'. This means that without a 66-year assessment period to show the decline the IUCN criteria do not apply. The same document also states that 'considering all available evidence, Least Concern, Near Threatened, and Vulnerable are equally plausible', so this being the case, there is no justification for not having given the classification of 'Vulnerable'. The IUCN should have followed a precautionary approach when it comes to the assignment of a status to a species.

Additionally, the lack of regular assessments is a failure when it comes to monitoring the population trends of this species. In an era when climate change is having increasingly negative effects on species, and at a faster pace, there is a need to monitor more frequently species that are under threat or vulnerable to regional or global extinction. In the case of the Antarctic minke whale only three assessments were made: 1996, 2008 and 2018 when a classification was first attributed to this species. Although the high costs associated to these assessments must be recognized, a 10-year interval for a species that is threatened is a long time.

In relation to the Ross seal, only four assessments have been made to date, in 1965, 1996, 2008 and most recently in 2015, being classified as 'Least Concern' since 1996.

The discussion of whether the Ross seal still merits designation as a Specially Protected Species is not new. In SCAR, 2007 the status of the Ross seal was analyzed and concluded that the species does not depend on conservation measures and is far away from meriting a classification as 'Vulnerable'. However, SCAR recommends that the Ross seal is maintained as a SPS as a precaution, because there is insufficient data available (SCAR, 2007). The IUCN data indicate that there is no variation in the population, but genetic studies point to about 250,000 individuals (Hückstädt, 2018) while IUCN data indicate that there are about 78,500 individuals. This is a considerable variation in the assessment of population size and may be significant if the Specially Protected Species status needs to be revised. However, even though the Ross Seal continues to be designated as a SPS there is still no Action Plan designated for this species, which puts into question the usefulness of SPS status in this case.

The emperor penguin has recently received a lot of attention by the Antarctic Treaty Parties who consider the species as meriting SPS status (see below). Indeed, of all the three species given further scrutiny in this study, the emperor penguin is the one that has had more assessments made, the most recent, and the one with most information made available by the IUCN. At the meeting of the Committee for Environmental Protection in June 2022, all but one Party were in consensus on the emergent threat that the species is facing and that it merited SPS status. However, China is blocking the designation as a SPS because they did not agree that the species faced any threat and the fact that the species had a classification of 'Near Threatened' given by the IUCN was also a factor for not agreeing with the designation of SPS status. Other geopolitical factors may have been

involved in this position, including the prevention of further restrictions on fishing activities in the vicinity of emperor penguin colonies. This situation raises a question, if the fact that the emperor penguin classification of 'Near Threatened', as given by the IUCN, is a valid reason for not agreeing with the designation of Specially Protected Species status for the emperor penguin, then why should the 'Least Concern' status of the Ross seal be enough for maintaining SPS status?

The protection of these three species should be revised by the IUCN but also by CEP. However, within Annex II to the Protocol there are gaps that need to be corrected since the status of 'Antarctic Specially Protected Species' automatically provides neither criteria nor mechanisms to ensure additional protection to the species so designated (Argentina, 2002b). In a working paper, Argentina (2002) addresses the gaps existing in the Protocol to protect species, since it is not clear in the Protocol what is being protected, how it is being protected and from what is it protected. In face of this problem, in 2005, the CEP agreed a set of Guidelines for consideration of proposals for new and revised designations of SPS under Annex II of the Protocol. These guidelines are now the start point for every proposal of designation, revision, or de-listing of an Antarctic SPS, they provide valuable information regarding the proposed assessment process including a template of an Action Plan (which must present an overall goal and specific objectives) for a species proposed for designation.

Although through the IUCN criteria the emperor penguin cannot yet be classified as 'Vulnerable' there are already efforts being made by the Parties to encourage the CEP to consider adding the species to the SPS list. In 2021, SCAR reported to the CEP that it considered the emperor penguin to merit a classification of 'Vulnerable', given predicted changes in habitat availability associated with climate change. A draft for an Action Plan for the emperor penguin was recently made by an international consortium of CEP Members and presented at the XLIV Antarctic Treaty Consultative Meeting, this draft presents a list of objectives for reducing and preventing threats to emperor penguins and their habitat taking account of the potential impacts of climate change and a list of actions to achieve each one of the objectives of the Action Plan. At the same meeting a competing proposal for development of a targeted research and monitoring plan for the emperor penguin was presented by one Party (China, 2022) who did not consider there to be sufficient information to designate the emperor penguin with SPS status. Neither proposal received agreement.

It is important to understand why it is necessary to grant the status of SPS under the Antarctic Treaty and not only a protection status by the IUCN, which is a global organization. Primarily, this is because the Antarctic Treaty System is responsible for governance within the Antarctic Treaty area, with the IUCN have responsibility in the area north of latitude 60^{o}S (i.e., the rest of the world). The advantage for a species to have this status focuses on the fact that SPS will receive greater attention from the Parties when planning activities and greater monitoring and research efforts will be made for these species (Argentina, 2002b). Furthermore, some species are allocated a low conservation status by IUCN when the global populations is analyzed but when seen through a regional

perspective they can be endangered and therefore need to be designated as an SPS. This was thought to be the case of the southern giant petrel *Macronectes giganteus*, a species classified by the IUCN as 'Least Concern', and whose global population is considered to be increasing. However, doubts regarding the status of this species in the Antarctic, where the size of some colonies seem to be decreasing (Dunn et al., 2016; Krüger, 2019), resulted in further investigation until it was decide that the SPS designation was not necessary (SCAR, 2008). Indeed, in the last assessment that classified the southern giant petrel as 'Least Concern' in 2018 (BirdLife International, 2018) the authors indicate studies showing an increase in the global populations (Quintana et al., 2006; Reid & Huin, 2008; Ryan et al., 2009). Although the studies used to support that trend were undertaken prior to 2010, leaving a large year gap between the year of the assessment (2018) and the year of the studies (2009, the most recent), there are in fact recent studies showing and increase in the population of southern giant petrels in Antarctica (Poncet et al., 2020).

5. Conclusions/Final recommendations

The obtained results allow to make several recommendations to policymakers operating within both the ATS and IUCN.

5.1. Antarctic species need to have their assessments revised by the IUCN Red List

There are 225 species in the Antarctic Treaty System area classified as 'Least concern' and, following the IUCN criteria none of the assessments made for those species takes into consideration the effects of climate change. This raises the question, how many species have received a lower threat classification by the IUCN but are in fact in danger of changes in their populations and habitat due to climate change? The recommendation is that more Antarctic species should have their assessments revised considering future climate change scenarios. More specifically, it was also considered that the Antarctic minke whale status should be revised; as mentioned before, the species has a status of 'Near Threatened' but in the assessment made by the IUCN it is mentioned that either the classification of 'Near Threatened' or 'Vulnerable' are valid and since the latter is a higher classification of endangerment is not quite clear why a precautionary approach was not taken, and the 'Vulnerable' classification given. Reviewing, and possible improving, the status of key Antarctic species may allow the development of policies to protect their most used foraging habitats in the future. Indeed, the Southern Ocean is facing challenging changes and management approaches, such as MPAs, ASPAs and ASMAs are necessary do deal with these future changes. To help protect Antarctic species we also need to protect their foraging and breeding areas so, the continuing assessment and monitoring of the protected areas and management areas are of upmost importance.

5.2. IUCN assessments need to consider the impacts of the rapidly changing Antarctic conditions

As shown in the cases presented, the IUCN criteria for application of conservation status does not appear to take into consideration the climate change conditions the world is facing. Antarctica is the place on Earth where these changes are happening more rapidly making the species that inhabit the area the ones that will likely experience the first effects. Therefore, to help protect these species, the IUCN needs to consider the possible effects that climate change can have on them and on their habitats. The emperor penguin could be a pioneer case, where the climate change scenario is taken into consideration when evaluating the status of a species. The revaluation and possible new status of emperor penguins within the IUCN criteria would certainly be helpful for the Parties who are trying

to make the emperor penguin a Specially Protected Species since the current IUCN status is an obstacle for one Party in particular.

5.3. Regular collection of population and distribution data of existing Red List species to allow assessment of species conservation status

As shown previously in this study the number of species with a category of 'Near Threatened' or above is low. However, in almost all the species studied and population trends determined, the two assessments are separated by an interval of over 10 years. With the increased threats presented for marine species, especially in Antarctica, waiting 10 years for a new assessment may not be sufficient. Therefore, data should be updated and collected more regularly, and assessments should be made more frequently. For instance, take the case of Antarctic minke whale. In 2008 the species was classified as 'Data Deficient' due to a lack of information regarding the population and only in 2018 a new assessment was made, and the species classified as 'Near Threatened', with an unknown population trend, even though some authors proposed a decline in the population of c. 30%.

5.4. The Ross seal case

The Ross seal was given Specially Protected Species status in 1998, but an Action Plan for the species was never developed. However, now there are 'Guidelines for CEP consideration of proposals for new and revised designations of Antarctic Specially Protected Species' that can help to make an informed and solid decision regarding the future of the protection status of species. The application of Specially Protected Species status needs to be consistent, for example, if the status is denied to the emperor penguin because its IUCN status is only 'Near Threatened', then why can the Ross seal maintain its status if its IUCN status is 'Least Concern'? In this way we recommend that the species and their population status (trend and number of individuals) should be assessed by SCAR to understand if there is need for an Action Plan and, therefore, the species maintains the SPS status or if the status no longer is needed.

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