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Commission for the Conservation of Antarctic Marine Living Resources
Commission pour la conservation de la faune et la flore marines de l'Antarctique
Комиссия по сохранению морских живых ресурсов Антарктики
Comisión para la Conservación de los Recursos Vivos Marinos Antárticos

SCIENTIFIC COMMITTEE

SC-CAMLR-39/BG/17

22 September 2020

Original: English

Report on United States research and monitoring in support of the Ross Sea region Marine Protected Area

Delegation of the USA

EN

Report on United States research and monitoring in support of the Ross Sea region Marine Protected Area

Bryan A Keller and Lauren G Fields

U.S. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of International Affairs and Seafood Inspection

Abstract

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) adopted the Ross Sea region Marine Protected Area (RSRMPA) in 2016, which entered into force in 2017. The RSRMPA was established to conserve marine living resources, maintain ecosystem structure and function, protect vital ecosystem processes and areas of ecological significance, and promote scientific research. This report summarizes the types of United States' research and monitoring in support of the RSRMPA. We identified 480 relevant awards, which funded research throughout the region between 1980 and 2020. These awards cover a wide range of research within the general study topics of Ecosystems, Fisheries, and Climate Change and Oceanography. Awards related to the study topics of Ecosystems and Climate Change and Oceanography were common, with Fisheries awards being less common. Sixty-four of these awards are active or ongoing, with 30 awards originating since the RSRMPA entered into force. Awards made prior to the time that the RSRMPA entered into force contribute baseline data to the protected area. In total, the awards mapped to most of the specific MPA objectives. This paper details the commitment of the U.S. Government to research within the RSRMPA and contributes to a foundation for future analysis of the effectiveness of the MPA for the 2022 scientific review.

Introduction

The United States, through the National Science Foundation (NSF), maintains three year-round research stations in the Antarctic and supports two Antarctic research vessels in the Southern Ocean. These research stations and ships host approximately 700 scientists and 2,500 support contractors annually to conduct research at the Antarctic Peninsula, South Pole, McMurdo Sound, and surrounding field camps and areas. McMurdo Station, the largest scientific research station in the Antarctic, is situated on Ross Island at the edge of the Ross Ice Shelf in

the Ross Sea. The United States has been conducting research in this area since the 1940s through support provided by various government agencies. As such, the United States is well-suited to offer a report on the ongoing and past projects in this region and analyze these and future research projects against the objectives of the Ross Sea region Marine Protected Area (RSRMPA). While NSF is the principal funder of research activities in this area, this project identified additional U.S. Government (USG) agencies funding or conducting research in the Antarctic and Southern Ocean including work conducted or funded by the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA). This paper focuses on Ross Sea region research supported by the USG over the past 40 years.

The RSRMPA was adopted in 2016 and entered into force December 1, 2017 (CM 91-05). CCAMLR Members are directed to submit reports on activities and results relevant to the RSRMPA Research and Monitoring Plan, and such a plan was endorsed by the Scientific Committee in 2017 (CM 91-05 paragraph 15, Dunn et al., 2017, SC-CAMLR-XXXVI paragraph 5.45). CM 91-05 paragraph 15 requires Members' reports be compiled no later than 6 months in advance of the annual meeting in 2022 and every five years thereafter. A ten-year review with synthesis will occur in 2027.

We acknowledge the paper submitted to the Scientific Committee by the delegations of New Zealand and Italy (SC-38-BG/25 Rev.1), and the updates to these studies submitted to 2020 e-Group discussions by the Working Group on Ecosystem Monitoring and Management (Pinkerton, 2020; Ghigliotti et al., 2020). We thank the authors for their comprehensive reports on research occurring in the Ross Sea region and have used the information display format originally used by New Zealand and Italy to convey our findings for ease of comparison and discussion.

Also similar to New Zealand and Italy, the United States undertook an analysis of USG-funded research and examined that research against the specific objectives of the RSRMPA and the types of research and priority elements for scientific research. This report builds upon the preliminary report prepared by the United States submitted to the 2020 e-Group discussions by the Working Group on Ecosystem Monitoring and Management (Keller and Fields, 2020). We analyze the relevant USG-funded research against one or more of the three types of research and the priority research elements they contain as specified in CM 91-05/Annex C Table 2

(Ecosystem, Fisheries, Climate Change/Oceanography). Each award was mapped to specific MPA objectives in line with the studies by New Zealand and Italy. Additionally, we report on the breadth of collaboration occurring with international partners in the RSRMPA.

Results and Discussion

Types of Research

We identified 480 awards from 1980 to March 2020 relevant to the types of research and priority elements listed in CM 91-05/Annex C Table 2. Of these, 64 of the 480 awards are currently active, while the periods of funding for the remaining 416 awards have been completed. Of the 480 awards, 470 were identified via the NSF award search engine (Appendix I). The remaining ten projects were identified through queries submitted to other USG entities: NASA (n=3: two active, one completed) and NOAA (n=7: two active, five completed). See Appendix I for detailed methods on how these awards were identified and categorized into the relevant research types, priority elements, and specific MPA objectives.

As individual awards are relevant to multiple types of research, there was a high degree of overlap between the categories (Fisheries, Ecosystems, and Climate Change/Oceanography). We respectively found 56, 306, and 352 awards related to Fisheries, Ecosystems and Climate Change/Oceanography (Table 1). A breakdown of awards by type of research and award status (active or completed) can be found in Figure 1.

Table 1. Breakdown of USG-funded research by the type of research in or pertaining to the Ross Sea region Marine Protected Area. The total number of awards was 480. Awards were sorted into one or more types of research as defined in CM 91-05/Annex 2 Table 2 (Ecosystem, Fisheries, Climate Change/Oceanography) which is why the total number of awards exceeds 480.

Bin	Completed	Active	Total
Ecosystem	264	42	306
Fisheries	46	10	56
Climate Change/Oceanography	307	45	352

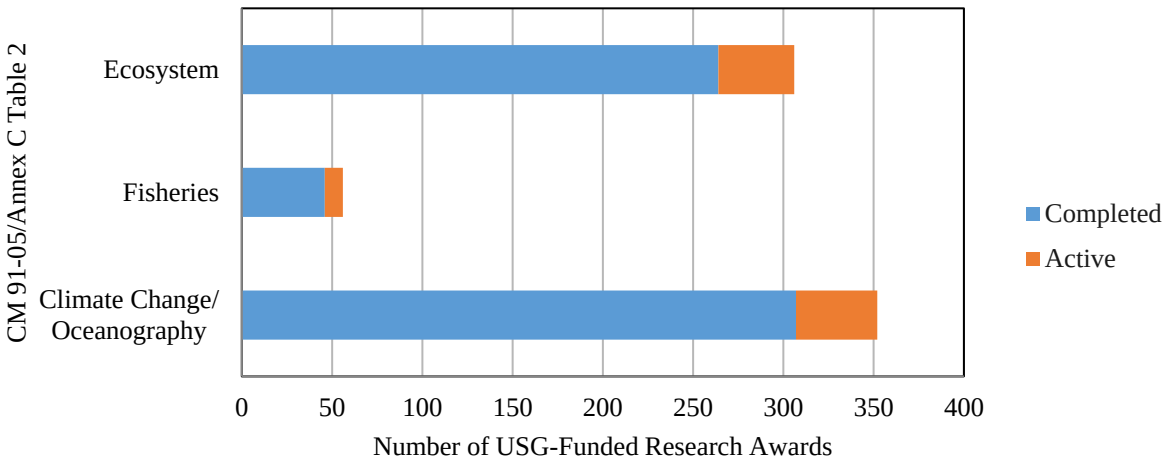

Figure 1. Breakdown of USG-funded research by priority element in, or pertaining to, the Ross Sea region Marine Protected Area. The total number of awards was 480. Awards were sorted into one or more types of research as defined in CM 91-05/Annex 2 Table 2 (Ecosystem, Fisheries, Climate Change/Oceanography).

Many funded awards were categorized into multiple types of research, which resulted in the observed overlap between categories. An analysis of the funded research reveals that there is significant overlap between the Ecosystem and Climate Change/Oceanography research as many studies focus on the effect of climate change or oceanographic influence on the ecosystem, ecology, or physiology of a species. These two types of research make up the majority of USG-funded research in the Ross Sea region between 1980 and 2020.

Fisheries grants make up a much smaller portion of the total USG-funded research (56 of 480). The rationale for this is that fishery-related research supported by NSF, which is the main USG funding source in this report, predominantly focuses on fundamental research aspects of life history or fishery-ecosystem impacts, such as top predator life-history research and possible impacts on these species due to fishing pressure on their prey. Directed fisheries research proposals tend not to be successful in the NSF peer-review process. Additionally, the low participation of U.S. industry in CCAMLR fisheries between 1980 and 2020 means there is limited industry-conducted fishery research. The USG conducts fishery-related research under NOAA's Antarctic Ecosystem Research Division (AERD); however, this research is primarily localized around the Antarctic Peninsula, in Statistical Subarea 48.1. An AERD-sponsored research project occurring in the Ross Sea region has been included in the toothfish discussion below. With the entry into force of the RSRMPA and increased academic interest in the Ross

Sea region, we expect to see an increase in funding requests by U.S. scientists interested in ecosystems, fisheries, and oceanography in the region.

Specific MPA Objectives

The USG-funded research activities were mapped to specific objectives of the RSRMPA and are displayed in Figure 2 following the approach taken by New Zealand and Italy (SC-38-BG/25 Rev.1; Pinkerton 2020; Ghigliotti et al. 2020). A single award can map to multiple MPA objectives, and thus, the total number of awards displayed in Figure 2 exceeds the 480 total funded awards.

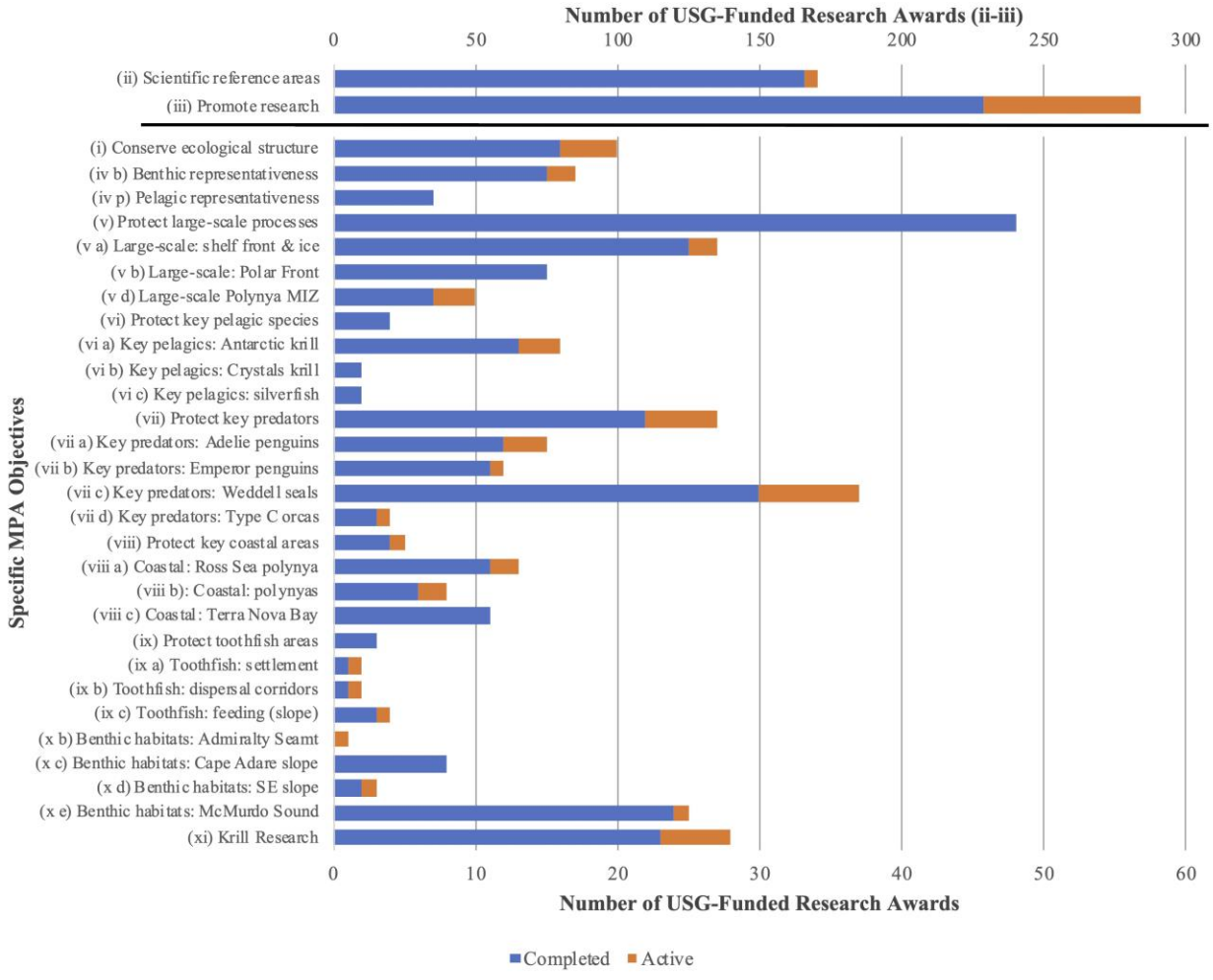

Figure 2. Summary of USG-funded research projects from 1980 to March 2020 for research occurring in, or relating to, the Ross Sea region by specific objective of the RSRMPA (CM 91-05, paragraph 3 and Annex 91-05/B, paragraph 1). Completed awards are those for

which the funding period has ended. Active awards are those projects for which funding has been allocated and the research is currently in progress. About half of the Active awards began activities after the RSRMPA entered into force. Note the difference in axis scale above and below the line separating specific MPA objectives ii and iii from the other objectives.

A dual axis was used for Figure 2 to separate the scale of those grants mapped to two of the specific objectives from the scale of the other objectives. The specific objectives ii and iii included a wide range due to their broad scope. The MPA specific objective ii "*to provide reference areas for monitoring natural variability and long-term change, and in particular a Special Research Zone, in which fishing is limited to better gauge the ecosystem effects of climate change and fishing, to provide other opportunities for better understanding the Antarctic marine ecosystem, to underpin the Antarctic toothfish stock assessment by contributing to a robust tagging program, and to improve understanding of toothfish distribution and movement within the Ross Sea region*," encapsulated much of the research on oceanography, carbon flux, ice melt and sea ice monitoring, ecosystem monitoring, and effects of climate change, to name a few. MPA specific objective iii "*to promote research and other scientific activities (including monitoring) focused on marine living resources*" encapsulated physiological studies on organisms not necessarily specified as key species under the other MPA objectives, as well as large-scale ecosystem studies with marine living resources focus, such as phytoplankton bloom and circulation studies. Several research activities that were mapped to other MPA objectives were also captured in objectives ii and iii. We noted Ghigliotti et al. (2020) appeared to use a similar approach where a single research project may map to multiple objectives, with specific objectives i, ii, and iii containing more projects than the other objectives.

USG-funded krill research mapped to specific objective xi "*to promote research and scientific understanding of krill, including in the Krill Research Zone [KRZ] in the northwestern Ross Sea region*" encapsulates krill research as it relates to the entire Southern Ocean system and not solely krill research occurring in the KRZ. Currently there is no USG-funded research occurring in the KRZ though research is ongoing or anticipated for this area by New Zealand and Italy (Pinkerton 2020; Ghigliotti et al. 2020).

There were a number of awards that mapped to overarching specific objectives but were outside of the species or areas specifically detailed within the list of objectives in the RSRMPA management plan (Annex 91-05/B). We included these in Figure 2 as overarching items because these activities contribute to building broader knowledge towards the respective objectives. For

example, specific objective vii "*to protect core foraging areas for land-based top predators or those that may experience direct trophic competition from fisheries*" further identifies Adélie penguins (vii a), emperor penguins (vii b), Weddell seals (vii c), and Type C killer whales (vii d). We included research projects that address specific objective vii, yet whose species are either general (e.g., "whales") or referred to a specific species not included in vii a-d but may nevertheless experience direct trophic competition from fisheries, such as other seals or whales that rely on krill as a key prey species (e.g., minke whales). Similarly, for specific objective viii "*to protect coastal locations of particular ecological importance*," funded research projects were categorized as relevant to specific objective viii if they addressed the ecological importance of a coastal location even if the coastal location was not one of the five coastal locations recorded as viii a-e. Active, USG-funded research did not map to several specific objectives. USG-funded research is not currently conducted in the Balleny Islands (v c, x a), Eastern Ross Sea multi-year ice (v e), Victoria Coast platelet ice formation zone (viii d), Pennell Bank polynya (viii e), or the Scott seamounts (x f) and as such, these specific MPA objectives are not included in Figure 2.

International Collaboration

We identified 56 awards that indicated collaboration with other countries in their request for funding abstract or project description (Table 2). These 56 awards represent a total of 104 international collaborations, with New Zealand (n=23), Italy (n=15), and the United Kingdom (n=14) being the most common partners to USG-funded researchers. Across these awards, 20 individual countries were identified, 17 of which are CCAMLR Members or an Acceding State.

Table 2. A total of 56 USG-funded research awards denoted collaboration with international partners or research institutions. An award with international collaboration was likely to occur with more than one international partner. Collaborations with CCAMLR Members and Acceding States are in bold.

Collaborating Country	Number of Funded Awards
Argentina	1
Australia	10
Bermuda	1
Brazil	2
Canada	1
Chile	4

China, People's Republic of	2
Denmark	1
France	6
Germany	6
Italy	15
Japan	3
Korea, Republic of	1
Mexico	1
Netherlands	1
New Zealand	23
Norway	2
Poland	2
Sweden	8
United Kingdom	14

Antarctic research is inherently collaborative, with many stations situated close to one another and with information and resource sharing among research teams and across national programs. International collaboration in the Antarctic is critical to advancing scientific priorities and the list of countries identified in Table 2 is not an exhaustive catalog of countries that have aided in U.S. Antarctic research. The identification of these countries was contingent upon the principal investigator identifying areas of international collaboration in the abstract or project description of each funded award, which may have precluded the identification of additional countries where collaboration was not identified in the abstract or project description. This potential limitation does not downplay the importance or gratitude of the United States towards international collaboration but is an artifact of our methodologies.

Active Research Award Specific MPA Objectives

There are 64 USG-funded research projects that are active in or around the Ross Sea region MPA. There are 30 funded research projects that began after the RSRMPA entered into force. The 34 additional grants that are currently active but have grant start dates that predate the entry into force of the MPA still represent ongoing research in this region that is relevant to an assessment of the level of U.S. research activity in this region. The active research awards represent a smaller sub-set of the specific MPA objectives from Figure 2 and are shown in Figure

3. As with Figure 2, a dual axis was used in Figure 3 to separate the scale of those grants mapped to MPA objective iii.

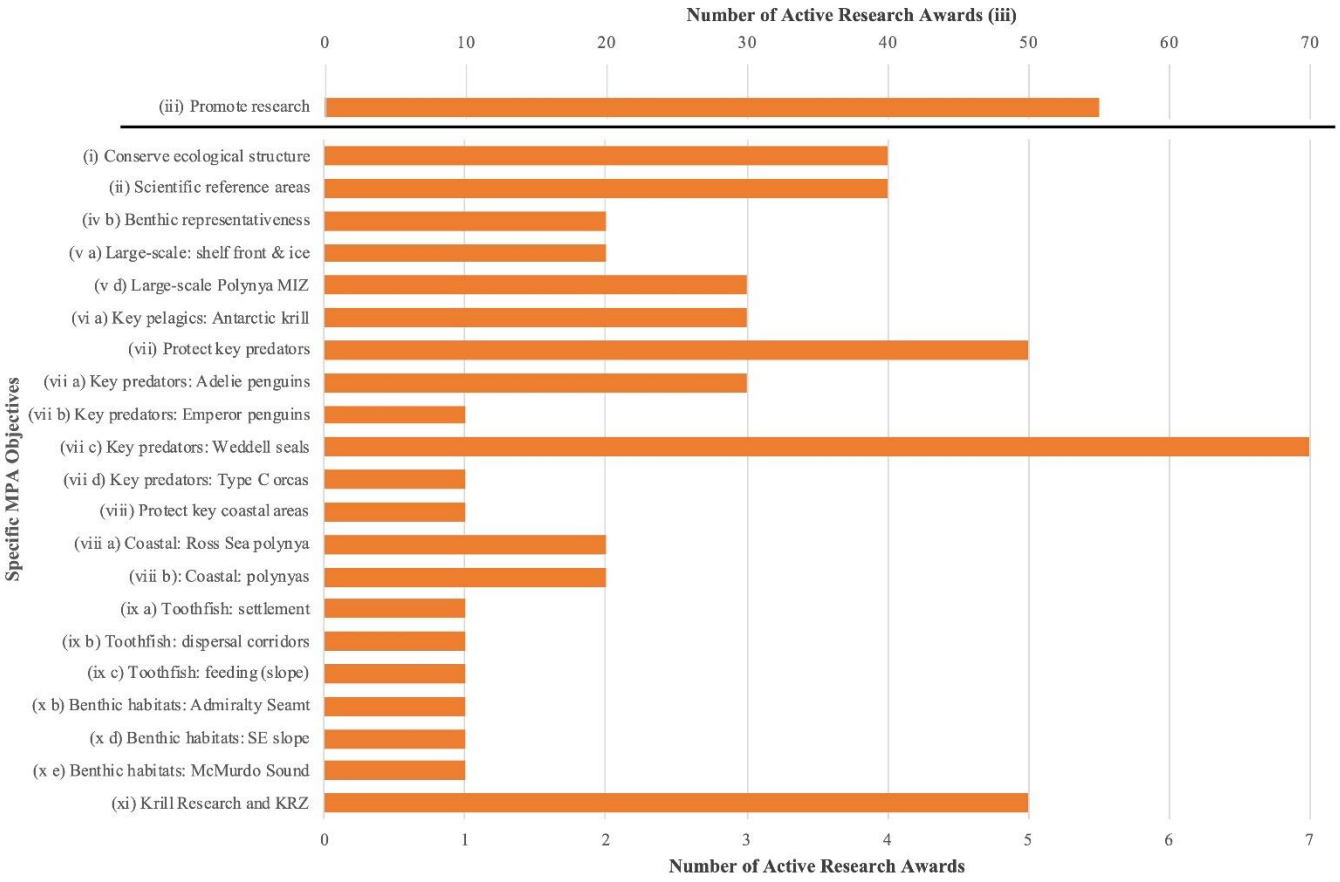

Figure 3. Breakdown of active USG-funded research by specific MPA objective. There are currently 64 active grants occurring within or relevant to the RSRMPA. Note the difference in axis scale above and below the line separating specific MPA objectives iii from the remaining objectives.

Awards considered for this study (1) conducted research in the RSRMPA or (2) either did not specify an area of operation within the Ross Sea region or related to whole system science for the Southern Ocean with implications for the RSRMPA (for a detailed description of assigning area of operation, see Appendix I/Table 4). For awards that specified research activities occurring in the Ross Sea, we mapped the area of operation according to CM 91-05/Annex C Table 2. Of the active awards, 57% of the 64 awards were documented to take place

within the Ross Sea region. This value is relatively similar to the percentage of all active and completed (n=480) that were documented to occur within the Ross Sea region (62%).

Priority elements for scientific research and monitoring

In addition to binning grants into the aforementioned types of research, we further divided each active award into the priority elements under each type of research associated with the RSRMPA (CM 91-05/Annex C Table 2). For the 30 projects that commenced study after the MPA entered into force, fisheries-focused awards focused solely on the final "Fishery" priority element: "*Surveys and sampling to investigate life history hypotheses, biological parameters, ecological relationships and variations in biomass and production of Antarctic krill.*" The Ecosystem type of research category exhibited a wider spread of awards with projects touching upon nearly all of the priority elements under this category. Most funded awards with a focus on Climate Change/Oceanography skewed toward building or understanding ocean circulation models, sea ice, and bottom water formation (Table 3). We were unable to map each of these priority elements to their respective areas within the RSRMPA. We anticipate that as more researchers apply to conduct research in the RSRMPA, more of these priority elements will be addressed.

Table 3. The 30 USG-funded awards since the entry into force of the RSMRPA mapped to the priority elements for research and monitoring as identified in CM 91-05/Annex C Table 2.

Type of Research	Number of Identified Awards	Priority Elements
Ecosystem	12	Directed studies to address biological and ecological questions related to species demography and life history
	9	Monitoring and research on pinnipeds and seabirds, including studies of reproductive biology and success as well as diets and foraging dynamics
	2	At-sea surveys or censuses to estimate the distribution and abundance of marine mammals, seabirds, fishes and invertebrates

	3	Radio and archival tagging, remote sensing and shore-based population censuses of marine mammals and seabirds
	3	Ecosystem modelling, informed by diet and stable isotope sampling of key trophic components
	2	Targeted sampling of Ross Sea shelf and slope communities with focus on middle trophic level organisms
	3	Investigate oceanographic drivers of phaeocystis- vs. diatom- dominated production and consequences for higher-level trophic ecosystem function
Fisheries	3	Surveys and sampling to investigate life history hypotheses, biological parameters, ecological relationships and variations in biomass and production of Antarctic krill
Climate Change/ Oceanography	1	Sea-ice remote sensing (type, concentration and extent) Long-term monitoring of benthic ecosystem function
	3	Development and validation of high-resolution circulation model of the Ross Sea shelf and slope (e.g. ROMS), including resolving effects of sea-ice (especially polynyas), ice-shelf cavity, cross-shelf exchange and deep bottom-water formation in the Ross Sea. Addition of biological model
	2	Investigate deep bottom water formation (relevant to global oceanic circulation), slope water intrusion and cross-shelf nutrient exchange

Relevant ongoing research:

Antarctic toothfish research for fishery management

Of the active research awards, there is one study examining toothfish life history in the Ross Sea region. NOAA's Antarctic Ecosystem Research Division (AERD) is conducting a joint study with New Zealand's Institute for Water and Atmosphere deploying pop-up satellite archival tags (PSAT) on Antarctic toothfish in the RSRMPA General Protection Zone (GPZ). Tags were deployed on toothfish in the Ross Sea southern shelf, Terra Nova Bay, McMurdo Sound, and in the northern Ross Sea seamounts outside of the RSRMPA. If the study is successful, these data will provide insight as to the vertical movement of

Antarctic toothfish (*Dissostichus mawsoni*) in the water column, movements between various regions of the Ross Sea, and different zones of the RSRMPA. The study also collects valuable oceanographic information about the Ross Sea to allow analysis of the recorded data against salinity, temperature, and depth information. Additionally, this study will examine the ecosystem services of the MPA whether fish are exported from the RSRMPA GPZ to habitats open to the fishery.

Antarctic krill fishery management

More USG-funded krill research occurs in the Antarctic Peninsula region than in the Ross Sea region, though we identified five active studies that are examining Antarctic krill in the Antarctic ecosystem generally. These studies all take a circumpolar approach to krill research that may not focus or occur solely in the Ross Sea region, yet the results of the studies have system-wide implications relevant to the RSRMPA. Three of these studies specifically examine predator-prey relationships between baleen whales and Antarctic krill as their main food source with one 2019-2020 project examining how krill predators, the krill they depend on, and the Antarctic marine ecosystem as a whole will respond to current challenges such as global climate change and the expanding commercial fishery for Antarctic krill. Another study focuses on the effect of climate change on food web dynamics and krill-dependent predators.

Adélie penguins in the Ross Sea Region

The Ross Sea is home to the southern-most breeding populations of Adélie penguin (*Pygoscelis adeliae*), and the United States has been funding research on these populations for more than 20 years, including nest surveys and population abundance estimates. Three active studies are examining Adélie penguins in the Ross Sea region with focuses on the demography of Adélie penguin colonies through study of nesting habitats and sea ice use. A 2019 study funded by NASA is specifically examining winter habitat use by Adélie penguins in the context of the RSRMPA. The study uses animal-borne bio-loggers and remote sensing to assess the dependence of migration on sea ice movements and the strength of ocean currents, identify important winter foraging areas, and assess whether the RSRMPA GPZ includes important penguin winter foraging

habitat boundaries and zones, especially compared with adjacent areas that will receive differing degrees of fishing intensity specifically within the confines and objectives of the MPA.

Weddell seals in the Ross Sea Region

The McMurdo Sound population of Weddell seals (*Leptonychotes weddellii*) is the subject of a long-term mark-recapture project that has been continuous for nearly four decades. This has resulted in individual tagging and identification of nearly the entire population within Erebus Bay and led to comprehensive pedigrees of the seal pups born in this region. U.S. researchers maintain a database on the Weddell seals in this region (http://www.montana.edu/rotella/weddell-seals/) and one of the permit conditions for researchers intending to conduct research on Weddell seals in McMurdo Sound for U.S. and New Zealand researchers is that data on activities conducted during field seasons be reported to this data repository. As female Weddell seals pup on the sea ice and remain above ice with their pups providing exclusive parental care, this has provided the opportunity for many early life history studies and maternal resource requirement studies. An active, 2016 NSF-funded study commenced before the RSRMPA entered into force examines environmental changes with population changes for Weddell seals. The results of this study are specifically looking at effects of climate change, fishery operations putting pressure on available food resources, and the value of marine protected areas for Weddell seal populations. This study is ongoing with an anticipated funding end date of 2021. An ongoing 2018 study similarly is looking at population dynamics of the Weddell seal specifically in the RSRMPA, focusing on energetic costs of diving and other factors as they relate to female reproductive success.

Sea ice changes and access to fisheries

A number of USG-funded researchers are examining Antarctic Bottom Water (ABW) formation, circumpolar deep water, and circulation models to study sea ice formation and the phytoplankton blooms that drive ecosystem services for the Southern Ocean food web. One such active study is examining historic sea-ice extent records to understand their variability and uncertainty to model future sea-ice extent under changing climatic

conditions. These comparisons will be a useful benchmark as sea ice variation affects access to fisheries.

Conclusion

In the more than 40 years of active research in the Antarctic, the United States has made, and will continue to make, substantial investments in research relevant to the goals and objectives of the RSRMPA. Much of the completed research cited here was used to design the MPA and contributes to the baseline for which the effectiveness of the MPA might be assessed in the future. This paper highlights new USG-funded research occurring in this region, including those research projects that are in active status or commenced following the entry into force of the RSRMPA. Many of the research projects benefitted from collaboration with international partners. The United States acknowledges that international collaboration is pivotal to advancing the goals and objectives of the RSRMPA pursuant to CM 91-05 paragraph 3. Continued engagement between Members' national researchers through international fora, such as the Scientific Committee for Antarctic Research (SCAR) and other groups, advances scientific understanding of the region. Future collaborative efforts should be a priority for all Members in order to conserve marine living resources, maintain ecosystem structure and function, protect vital ecosystem processes and areas of ecological significance, and promote scientific research.

Acknowledgements

We would like to specially thank Nature McGinn (NSF) for her efforts to cross-check Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) permits for Southern Ocean research against the NSF Antarctic Conservation Act permits to identify USG-funded research not already included in the list of relevant grants pulled from the NSF awards database. We would also like to thank Samantha Simmons at the Marine Mammal Commission (MMC) for extracting fiscal year 2019 marine mammal research from the MMC's Federally Funded Marine Mammal Research Survey, Amy Sloan (NOAA) for retrieving MMPA and ESA permit information for Southern Ocean marine mammal species research, and Keith Gaddis (NASA) for assisting in identifying awards on NASA's Biodiversity & Ecological Forecasting Mapped tool. And finally, George Watters (NOAA), Mi Ae Kim (NOAA) and Polly Penhale (NSF) for their guidance in preparation of this study and report.

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Appendix I

Detailed Methods

This project examined funding sources across the U.S. Government to identify relevant research in, or relating to, the RSRMPA. The U.S. National Science Foundation (NSF) is the primary funding agency for Antarctic research however research projects funded by the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) were also identified.

National Science Foundation (NSF) funded research:

The mission of NSF is to support hypothesis-driven research and education in non-medical fields of science and engineering. Unsolicited grant proposals from the research community, primarily from academic institutions, are subject to a peer-review process which evaluates grant proposals, resulting in awards for research projects. Since the proposals are unsolicited, the resulting research is not generally coordinated in a purposeful attempt to answer specific questions posed by CCAMLR. The NSF maintains a database of awarded grants, which can be accessed via https://nsf.gov/awardsearch/. We queried the database for active and completed awards matching the program codes for, inter alia, biology, Antarctic sciences, chemical and physical oceanography, and glaciology. We identified over 5,000 awards relevant to these program codes. NSF supports grants for a discrete period of time. Active awards are those whose funding has been supported by NSF and whose primary investigators are in the process of conducting the research project. Completed awards are those awards whose funding was approved but the funding period has ended. Some collaborative projects result in individual awards to principal investigators at different institutions, and these duplicate listings resulting from multiple awards for support of the same project were removed.

We used a series of keywords to search abstracts and identify which awards funded research within the Ross Sea region Marine Protected Area (RSRMPA). The full list of relevant keywords can be found in Appendix II. We also identified awards that funded research that occurred throughout the greater Antarctic region, or where the research area was not identified, but specifically addressed priority elements listed in CM 91-05/Annex C Table 2. While these research efforts may not have taken place within the RSRMPA, the findings are of circumpolar relevance and are therefore within the scope of the scientific objectives related to the RSRMPA,

such as funded research on circumpolar bottom water formation or historic trends in the creation of sea ice to better inform climate change projections and impacts on sea ice-associated organisms.

Other U.S. Government-funded research:

U.S. Marine Mammal Commission (MMC):

The U.S. Marine Mammal Commission, an independent USG agency that furthers the conservation of marine mammals and their environment under the U.S. Marine Mammal Protection Act (MMPA), conducts an annual survey of USG-funded marine mammal research through their *Survey of Federally Funded Research* (https://www.mmcsurvey.org/) (U.S. Marine Mammal Commission, 2020). This information is stored in a data repository and accessible by Marine Mammal Commission staff. A query of this system for projects funded after the entry into force of the RSRMPA identified 12 projects funded in fiscal year 2019. Fiscal year 2018 data were not available. The Survey of Federally Funded Research identified 11 NSF-funded awards that we had already identified via the NSF award search function and one new award funded by NASA for Southern Ocean blue whale remote sensing research which was added to the list of relevant awards.

National Aeronautics and Space Administration (NASA):

The National Aeronautics and Space Administration (NASA) conducts Antarctic science; however, many research projects are entirely based on remote sensing. Using NASA's Biodiversity & Ecological Forecasting Mapped tool (https://cce.nasa.gov/biodiversity/_biomap/projmap.html) constrained to search within "Antarctica" and "Southern Ocean," we identified two additional NASA-funded research projects for inclusion in this study.

National Oceanic and Atmospheric Administration (NOAA):

The relevant awards funded by NSF were also checked against the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Office of Protected Resources' Authorizations and Permits for Protected Species (APPS) database (https://apps.nmfs.noaa.gov/index.cfm). The APPS database was searched for research by U.S.

researchers involving species listed under the MMPA or the U.S. Endangered Species Act (ESA) using search terms for worldwide and Southern Ocean permitted research. An output of 22 permits from APPS was checked by NSF against the issuance of Antarctic Conservation Act permits, which were then identified to individual relevant grants on our list. Six permitted research projects were identified that were not also NSF-funded. These research projects were funded either by the NOAA Southwest Fisheries Science Center or other, unspecified funding sources.

Information on one NOAA NMFS-funded project was obtained directly from the participants in the project at the Southwest Fisheries Science Center's Antarctic Ecosystem Research Division.

Categorization of relevant funded research projects:

After identifying funded research awards relevant to the types of research listed in CM 91-05/Annex C Table 2, we reviewed each abstract and binned awards into the following research types: Ecosystem, Fisheries, and/or Climate Change/Oceanography (Figure 1). Awards could be categorized as relevant to any number of these categories.

We then binned each abstract into the types of research listed in CM 91-05/Annex C Table 2, the priority elements therein, and specific MPA objectives (CM 91-05, paragraph 3). While the keywords (Appendix II) we used to identify relevant awards were comprehensive and precise, our filtering process resulted in the inclusion of awards that contained such keywords but were not relevant to the RSRMPA. For example, inclusion of "Ross" Island in the search for relevant awards also returned results for research occurring on "James Ross Island" which is located in the Antarctic Peninsula. Awards found not relevant to the RSRMPA were removed prior to conducting our analyses. Additionally, awards initially deemed relevant to the RSRMPA area were also removed from the list of relevant awards if they were not found relevant to any priority element or MPA objective. Examples of these types of awards include meteorological studies occurring in the Ross Sea region, neutrino studies, and many seismic, glaciological, and geological studies that did not match any priority element or specific MPA objective. Because of this, many ongoing terrestrial and atmospheric studies in the RSRMPA are not included in this report. Awards that were outside the scope of any priority element but relevant to specific MPA

objectives were retained, such as studying the ecological effects of sea level rise in the Antarctic using reference areas within the RSRMPA to monitor these long-term changes.

We identified international collaborators from each abstract where principal investigators denoted such collaboration. The funding applicants, however, were not required to specifically disclose international collaborations, and this method likely resulted in under-identifying international partners.

The potential research locations were organized geographically according to the categories described in CM91-05/Annex C, paragraph 5. For this report, we added two additional categories: "Whole System or Unknown" to account for awards occurring throughout the Antarctic region or pertaining to the entire Southern Ocean system, and still relevant to specific MPA objectives, and "Ross Sea Unknown" for any awards specified as occurring within the Ross Sea region but with an unspecified finer-scale distribution (Table 4).

Table 4. Location of funded research assigned to each award as denoted in project descriptions or funding abstracts as specified in CM91-05/Annex C, paragraph 5. Most awards specified a specific research site for the focus of the study that could be mapped to the table in CM91-05 but some took a whole system approach or did not specify a study location within the Ross Sea region (denoted beneath dividing line). Study location was inferred in some instances from the species being studied (i.e.: seabird colonies found only in the Sub-Antarctic Islands or population surveys of Weddell seals where it was known the principal investigator works exclusively in the Ross Sea region).

Location	**Description**
Ross Sea continental shelf	Research occurring within the boundaries of the Ross Sea continental shelf.
Ross Sea continental slope	Research occurring within the boundaries of the Ross Sea continental slope.
Balleny Islands and vicinity	Research occurring at or near the Balleny Islands.
Northern Ross Sea region and seamounts	Research occurring within the northern Ross Sea region and near seamounts.
Northwestern Ross Sea region	Research occurring within the Northwestern Ross Sea region.

Ross Sea region Unknown	Research occurring within the boundaries of the Ross Sea region, but in unspecified locations.
Whole system or Unknown	Research not specifically occurring in the Ross Sea region but with a whole Southern Ocean system focus.

Appendix II

List of keywords used to identify relevant USG-funded research awards in project descriptions and funding abstracts. See Appendix I for criteria used to categorize grants per MPA Objectives and priority elements. Appendix I also describes criteria in which an award containing these keywords would be excluded from our database.

Keywords	
Ross	Cape Washington
Terra Nova Bay	Edmonton Point
McMurdo Sound	Krill (*Euphausia*)
Drygalski Basin	Toothfish (*Dissostichus)*
Crary Bank	Weddell Seal
Joides Basin	Penguin
Pennell Bank	White Island
Iselin Bank	Joint Global Ocean Flux Studies (JGOFS)
Glomar Challenger Basin	Antarctic Pack-Ice Seals Program (APIS)
Adare	Southern Ocean
Mawson Bank	Dry Valley or Valleys*
Hayes Bank	Western Antarctic Ice Sheet (WAIS)*
Houtz Bank	Fish
Little America Basin	Notothen
Admiralty seamount	Shackleton Glacier*
Fishing	Scott Seamount and adjacent underwater features
Victoria Coast	Climate Change
Coastal Polynya	Adaptation
Environmental Variability	Balleny Islands and adjacent seamounts
Krill Research Zone	Cetacean
Special Research Zone	Type C killer whale
Pacific Antarctic Ridge Seamounts	Silverfish (*Pleurogramma*)

* Most of the awards identified in the initial keyword search using these keywords were later excluded as these projects related specifically to glaciological or geological studies that did not map to specific MPA objectives.