Ross Sea Research Planning Meeting Oct 3-5 2022, University of Colorado Boulder

Workshop co-Conveners:

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Conceptual framework developed for conducting Ross Sea research in support of its Marine Protected Area aimed at better understanding Ecosystem Structure and Function in the face of Climate Change and Fishing Pressure. We envision a Research Network that integrates and coordinates several program elements, including Biophysical Modeling, Data Science & Cyberinfrastructure, Observation & Process Studies, and involving Public and Policy Engagement throughout.

Abstract

The Ross Sea region Marine Protected Area (RSRMPA) encompasses one of the healthiest marine ecosystems remaining on this planet, but one that is under increasing alteration from ongoing climate change and fishing pressure. The RSRMPA is among the world's largest MPAs, and the biggest and most comprehensive in multi-national waters. However, an RSRMPA workshop held in April 2021 identified numerous gaps in our understanding of the highly coupled nature of the Ross Sea marine ecosystem, gaps that need to be addressed to support conservation efforts in the Ross Sea region, including informing the efficacy and management of the RSRMPA for decades to come. Therefore, the *overarching goal* of the Ross Sea Planning Meeting was to refine existing questions and formulate an innovative and sustainable world-class research program aimed at better understanding, conserving, and managing the RSRMPA through the coordination of collaborative, inclusive, and interdisciplinary science. Towards that goal, the Planning Meeting focused on *three complementary research tracks* that together would build a sustainable research program in the Ross Sea. Those three research tracks were broadly (1) observations and ecosystem process studies, (2) data and model synthesis to improve our system-level understanding of the Ross Sea system, from its sensitivity to climate change and fisheries impacts to food web interactions, vulnerability and resiliency, and (3) data science and cyberinfrastructure to create data standards, integration and workflows for continuous tracking of data and updating predictions about the future ecosystem state. The development of a Research Network was seen as a critical next step, with a proposal submission currently under development. Such a proposed Research Network will advance and facilitate coordination between the research tracks and with relevant international communities. Public and policy engagement was also seen as a critical piece that spans all of the research tracks and networks. Participants closed the planning meeting with the development of a conceptual framework illustrating the research tracks, created preliminary working groups for each of those tracks, and developed a plan for communicating outcomes of the Planning Meeting to the wider Ross Sea research community.

1. Background

Due to the remarkable ecological value of the Ross Sea, in 2016, the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR) adopted a large-scale (>2 million km^2) marine protected area (MPA) in the region. The goal of the MPA is to protect the structure and function of the Ross Sea ecosystem, noting that the two main threats to the region are fishing and climate change. The MPA was negotiated over the course of five years and protects ecologically important regions, such as large swaths of the Ross Sea shelf and slope and the Balleny Islands. However, some other critical areas (e.g., Iselin Bank) were left out of the proposal to accommodate core toothfish fishing grounds. Although more than 70% of the MPA is off-limits to fishing, there are two fishing zones (a krill research zone/KRZ and a special research zone/SPZ) (Figure 1).

Every five years, with the first to commence this year (2022), CCAMLR member states must report on their research and monitoring activities in the MPA, and in ten years (in 2027), the Ross Sea region MPA (RSRMPA) will be under its first formal review. In 2027, CCAMLR will then assess if the MPA, in its current state, is meeting its objectives or if it should be modified. This five-year reporting and ten-year review will continue for the duration of the 35-year MPA and can inform potential modifications to the

MPA's boundaries (CCAMLR, 2016; Brooks et al, 2021). Further, if the MPA is effective at meeting its goals of conserving the structure and function of the Ross Sea marine ecosystem, it would provide rationale for CCAMLR to extend the MPA designation beyond the initial 35 year duration.

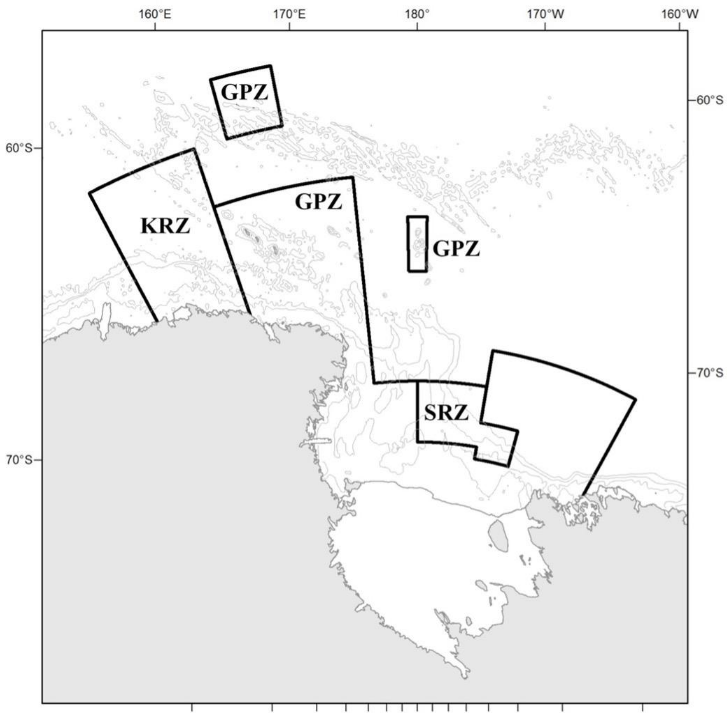

Figure 1. Ross Sea region marine protected area (RSRMPA) boundaries (other than coastlines) in black, including management zones: General Protection Zone (GPZ; three areas), Special Research Zone (SRZ), and Krill Research Zone (KRZ).

Since the MPA came into force in 2017, CCAMLR member states have been engaged in research and monitoring towards defining baseline data and assessing indicators of change in the Ross Sea. The United States has been among the leading countries in this effort. In April 2021, U.S. scientists convened a RSRMPA research and monitoring workshop. More than 50 individuals gathered to present ongoing Ross Sea research pertinent to the RSRMPA, and to discuss gaps and future research priorities (see Table 3 in Brooks and Ainley, 2022). Since 2010, U.S. scientists have published more than 300 articles directly relevant to the RSRMPA (either as baseline data or indicators of change) (see Table 2, Figures 2-3, in Brooks & Ainley, 2022). U.S. authors are also highly collaborative. Over the last decade, U.S. Ross Sea scientists have published work with co-authors from 26 different countries, including 19 of 25 CCAMLR Member States (Brooks & Ainley, 2022). (We note that with the recent addition of Ecuador, CCAMLR now has 26 Member States plus the European Union as of 2022.)

Since the April 2021 workshop, several new U.S. initiatives have included the use of gliders, drones, remotely operated vehicles, and high-resolution satellite imagery, in addition to new observational studies (Brooks and Ainley, 2022). Coincident demographic and foraging behavior studies have been utilized to investigate possible causes and effects of observed changes in the sizes, age/sex compositions, and productivity of indicator species (e.g., Goetz 2015; Shah et al. 2020; Kappes et al. 2021), however observational studies are still needed. In 2021 U.S. Ross Sea scientists emphasized the need for more stable long-term funding for observational studies, especially in the context of understanding climate change and fishing impacts on the Ross Sea region. "Overall, the U.S. Ross Sea science community was enthusiastic to contribute to research and monitoring of the RSRMPA" (Brooks & Ainley, 2022) – and this opportunity is now.

Given that the MPA will come under formal review in 2027, the U.S. research community and their international partners can make a strong contribution to assessing the effectiveness of the RSRMPA through enacting a large-scale Ross Sea research program to provide the necessary international networking, public and policy engagement, observations, modeling, data science, and cyberinfrastructure to best assess and manage the RSRMPA into the future. This was the overarching impetus for launching the Ross Sea Planning Effort, an effort initiated by the NSF-supported Planning Meeting held Oct 3-5, 2022.

2. Planning Meeting

2.1 Participants. There were 32 in-person participants and 29 virtual participants, for a total of 61, including 10 graduate students, and 11 post-graduate early career researchers. (See website for list of participants.) Participants came from a broad array of universities, research institutions, non-profit and conservation organizations, government institutions and agencies. There also was representation from the United Kingdom, New Zealand, Italy and China. There were many national and international representatives who expressed interest in the Ross Sea Planning effort but who were unable to attend the meeting (numbering 32 to date). They will continue to be involved in the Ross Sea Planning Effort through our Listserv, and we expect many more to join the planning effort as we continue to solicit feedback through the Ross Sea Research planning website, especially on the meeting outcomes and planned future events.

Figure 2. A subgroup of the in-person participants, who attended the Tuesday night dinner in downtown Boulder, Oct 4. From left to right, back row: David Ainly, Zephyr Sylvester, Kenza Himmich, Jim Lovvorn, Mattias Cape, Grant Ballard, Annie Schmidt. From left to right, front row: Leo Salas, Cara Nissen, Cassandra Brooks, John

Weller, Alice DuVivier, Eileen Hofmann, Mike Dinniman, Gert van Dijken, Ted Maksym, and Jack Pan. Front, kneeling: Sharon Stammerjohn.

2.2 Planning Meeting Summary

2.2.1 Where are we now - Day 1

The 3-day (October 3-5, 2022) planning meeting began with an overview of the meeting by Co-Chairs Cassandra Brooks and Sharon Stammerjohn, followed by nine keynote talks that spanned the morning to early afternoon. The talks covered the following topics (presenters/contributors in parentheses): (1) art, science and diplomacy (John Weller), (2) updates and resources from NSF (Maria Vernet), (3) data/model synthesis (Matt Long), (4) data science and cyberinfrastructure (Patrick Heimbach and Matthew Mazloff), (5) research networks (Eileen Hofmann), (6) current field activities and international connections (Michelle LaRue), (7) research, monitoring and the RSRMPA (George Watters), (8) Ross Sea initiatives in Italy (Laura Ghigliotti, Silvia Olmastroni, Marino Vacchi), and (9) Ross Sea initiatives in New Zealand (Nathan Walker, Matt Pinkerton, Gitte McDonald, Kim Goetz). Please see the Ross Sea Research planning website for the meeting agenda, schedule and links to talks.

The keynote talks were followed up by questions, most in reference to the MPA and the type of information needed for improving the assessment of MPA efficacy. Discussion highlights included the need for control areas, both as provided within the MPA (e.g., The Special Research Zone/SRZ, a designated lightly fished area against which the adjacent highly fished area to the north can be compared; see Figure 1), as well as control areas outside of the MPA (including outside of the Ross Sea), the spatial breadth of which underscores the need for international coordination and collaboration. Major efforts to date have focused on the synthesis of bio-regionalization maps for the Ross Sea (e.g., of pelagic and benthic types). Such maps facilitate the comparison of areas with and without similar physical and ecological characteristics (see extensive US led bioregionalizations in Ainley et al. 2010, Ballard et al. 2010), but they also highlight where there are observational gaps in regards to many ecological and physical characteristics, and also gaps in spatial coverage. However, it was also noted that bio-regionalization of mobile species is far more challenging than that of sessile species. Another highlight was how the large size of the MPA helps facilitate the study of climate change impacts, where in this sense the control is time, not space, an approach relevant for case study analysis, including predictive modeling. Finally, other important aspects discussed were identifying vulnerable marine ecosystems (e.g., benthic fish-nesting sites) and ecosystem valuations. To date, vulnerability and valuation have focused more on protecting ecosystem structure rather than ecosystem services. For example, there has been more focus on how much fishing would be displaced, and the impacts of that, but not necessarily on the value of the protection of the fish.

We then had small break-out group discussions (5-7 participants) focused on ‘where are we now’ within the context of the following: (1) how do we build a sustainable Ross Sea research program in support of the RSRMPA, focusing first on the near-term (3-5 years), (2) what types of networks are needed to create international coordination, data science synthesis, and data/model synthesis and prediction, (3) what types of science is needed to distinguish and assess the main threats to the Ross Sea ecosystem (e.g. climate change,fishing, tourism, pollution, pathogens, etc.), and (4) what are the major obstacles towards conducting successful science in the context of the RSRMPA?

Each break out room had a rich discussion. Some topics included discussing the role of Research Coordination Networks (RCNs) or Accelerating Research through International Network-to-Network Collaborations (AccelNet). It was noted that an RCN program would provide the means by which (1) investigators can share information and ideas, (2) coordinate ongoing or planned research activities, and (3) foster synthesis and new collaborations. RCN's do not fund primary research, but they do support the type of communication and coordination needed between funded research tracks (e.g., see cover figure). RCN's are especially suited for innovative ideas for implementing novel networking strategies, collaborative technologies, training, broadening participation, and/or development of community standards for data and meta-data. An AccelNet program on the other hand is specifically meant to support strategic linkages among U.S. research networks and complementary networks abroad that will leverage research and educational resources to tackle grand research challenges that require significant coordinated international efforts. With an AccelNet program, each network of networks is expected to engage in innovative collaborative activities that promote synergy of efforts across networks. As for which funding mechanism might be more appropriate for kick-starting a Ross Sea research initiative would be a topic saved for future discussions.

We discussed a need for international networking for data census and synthesis and the need to look to SCAR (the Scientific Committee on Antarctic Research), SOOS (the Southern Ocean Observing System), and GEOTRACES (an international study of the marine biogeochemical cycles of trace elements and isotopes) for examples and coordination. Participants also discussed the need for consistent metrics in assessing MPA effectiveness, including the use of 'indicator species'. We also discussed the implications of the MPA's current boundaries, with the main concern being the areas just outside the MPA, where the commercial fishery operates and where heavy fishing for Antarctic toothfish occurs (See Figure 2, in Delegations of NZ and USA, 2014). Discussions covered the need to include these areas in control studies, whether current boundaries sufficiently include higher trophic levels, and how the political and ecological aspects of the MPA will change with climate change.

Participants also discussed the need to have creative ways to collect data – e.g., AUVs and mooring, collecting not only physical variables but also ecological variables, and broadening international collaborations. For example, partnering with collaborators from Italy and South Korea Antarctic programs for field logistics, including icebreakers. It was also noted that opportunities should be explored with private foundations and nonprofit organizations like the Schmidt Ocean Institute and Blue Nature Alliance. In terms of moorings, we discussed a need to assess past and current moorings and to explore what is needed (sensor-wise). In terms of timelines, participants discussed some ideas of what may be realistic and doable in the short term, like deploying moorings and laying the groundwork for international collaboration and modeling (noting there is still a lack of clarity on which model inputs are needed). Participants noted the need to look into what can be done with models versus fieldwork. In the midst of discussions, we honed in on a new topic deemed critical to the Ross Sea planning effort, a topic not previously considered during the pre-planning of the meeting: Data science and cyberinfrastructure. This would include creating data standards, cloud computing, open-source tools, and workflows for continuous tracking of data, for data integration and synthesis, and for updating predictions. In this vein, it was thought that SCAR, SOOS, Pangeo and others could provide insights and opportunities for co-developing tools and sharing data. We summed up the day with the notion of having one umbrella program with several linked research tracks, and the feasibility of kick-starting the program by next spring (2023) through several complimentary proposal submissions.

2.2.2 Where do we need to go - Day 2

The morning continued the small group discussions, this time focused on 'where we need to go' while building on the discussions from Day 1. Regarding ideas for a network to coordinate Ross Sea research in support of the MPA, there was general agreement that a RCN-type proposal would need to be broader than just the RSRMPA but could also include all Southern Ocean MPAs. An overarching motivation might be to assess how the bioregionalisation of the Southern Ocean is evolving, using MPA and non-MPA areas as case studies for assessing different physical changes linked to different ecosystem changes, as well as the different impacts from fishing and climate change. It was noted that the proposed Research & Monitoring Plan (RMP) for the RSRMPA is also a source for questions/hypotheses that could be broadened into the science justification for a network proposal. In terms of stakeholders, the need to bring in representatives from the fishing industry was discussed. Finally, it was noted that different funding mechanisms (e.g., RCN, AccelNet, or even Mid-Scale R1 proposal) could be more relevant or flexible for developing a Ross Sea coordinated network in support of the RSRMPA, but it was acknowledged that more research was needed for distinguishing these different funding mechanisms. Related to that question was whether we should aim to develop an overarching program similar to SOGLOBEC (Southern Ocean Global Ecosystem Dynamics) or GEOTRACES, but after hearing a summary of how those programs came to be, and the time it took to develop them (10+ years), it was discussed that an iterative approach (e.g., through an RCN and/or AccelNet) might be better, at least in the short-term.

Regarding cyberinfrastructure and observational networks (including autonomous platforms), we discussed the need to prioritize large scale investments across both US and international partners. We also discussed the possibility of leveraging new technology to address threat mitigation by autonomously monitoring illegal fishing while also collecting useful data, as well as using artificial intelligence (AI) for data flow and interpretation. We discussed the critical need to compile all observations, including from known scientific sources (research stations, research vessels, satellite remote sensing, and autonomous – airborne, land-based and underwater platforms, and citizen scientists) but also from less utilized sources (tourist ships, fishing vessels). We explored the potential for a cabled observatory between New Zealand and McMurdo Station and what that might mean for research opportunities in support of the RSRMPA. We discussed different instrumentations that could be linked to the cable, including hydrophones, upward-looking Acoustic Doppler Current Profilers, equipment to track tagged animals, geolocating waypoints for autonomous underwater vehicles, cameras to observe benthic ecosystems, and an undersea network of power stations. We then discussed possible environmental impacts of an under-sea cable and noted that detailed mapping of its location would be needed not only to avoid irreparable damage to the benthos but also danger of animal entanglement (e.g., whales). Some participants noted the important distinction between a cabled observatory vs. a fiber optics cable for high data transmission (currently, the latter, 'smart cable', is being discussed). Related to the potential impacts of fishing in the Ross Sea, a question arose about the effect of long lines on benthic communities and the need to investigate this further.

Regarding data/model synthesis, we noted the need to connect global climate models to regional ecosystem models, the need to connect modelers with those collecting the data, as well as the need to involve historians and other academics. We discussed the synergy of using physical models as input for ecosystem/food web models and the need for a consistent approach. We discussed the value of creating something like a Ross Sea model intercomparison project. We also noted the opportunity to engage millions of people as community scientists monitoring and protecting the Southern Ocean, and the need to involve filmmakers.

2.2.3 Plan for getting to where we need to be - Day 2 & 3

The afternoon of Day 2 was focused on 'plan for getting to where we need to be' within the context of the four proposed program elements: (1) biophysical modeling, (2) data science and cyberinfrastructure, (3) observations and process studies, and (4) a coordinated research network for tying all elements together. For the Research Network, we continued discussions on funding mechanisms, noting that choices may depend on the timing and approach of the other three program elements as well. Nonetheless, next steps for this program element include additional information gathering on the various funding mechanisms. Regarding Data Science and Cyberinfrastructure, we continued discussions on data streams, data standards, workflows (especially for updating predictions), AI, open-source tools, trust-building, cloud computing and finally, incorporating opportunities to engage citizen scientists, the private sector, early career researchers, and international partners. Next steps for this program element include consulting with SOOS, the Animal Tracking Network, the new NSF directorate on Technology, Innovation and Partnerships (TIP), Earthcube, Pangeo and other data communities. Regarding Biophysical Models, discussions continued on the need to connect models at different scales and with different biological components to address bio/ecosystem impacts from climate change and fishing and to future predictions. We also discussed the need to coordinate with other regional modeling groups (e.g., SOCCOM - the Southern Ocean Climate and Carbon Observations and Modeling community), as well as those already involved in data science (including state estimations) to best coordinate data needed for validation and initialization. Finally, for Observations and Process Studies, a two-prong approach was discussed. The first prong involved the study of a particular ecosystem feature, such as the preyscape in a given region, to serve as an example of the kind of integrated multidisciplinary and multiplatform approaches needed for better understanding coupled ecosystem processes. Such a case study might leverage autonomous platforms in the short term, while parallel efforts focused on a multidisciplinary/multiplatform field campaign, ideally involving international partnerships. The second prong involved the creation of a Ross Sea Observational Network, starting in the short term with the coordination and expansion of autonomous observations and partnering with other observing programs (e.g., SOOS, SOCCOM). Such an effort would be followed by a longer term coordination of multiplatform observing systems and field campaigns. It was recognized that the other three program elements (Research Network, Data Science/Cyberinfrastructure, Biophysical Modeling) are also integral components of an observing network.

2.2.4 Conceptual Frameworks for a Ross Sea Research Initiative - Day 2 & 3

The late afternoon of Day 2 was spent discussing, and then sketching, a conceptual framework that would capture the elements needed to conduct Ross Sea science in support of its MPA. It was acknowledged that such a conceptual framework would need to define the type of science, networks, and public/policy engagement needed to allow for better assessments of the impacts from fisheries and climate change on any portion of the Ross Sea ecosystem. The group sat in a circle and iteratively sketched out (on the equivalent of a white board) ideas on how to define and illustrate such a conceptual framework.

With regards to ecosystem science, it was acknowledged that our knowledge gaps span the entire water column but with an observational network, to help coordinate national/international efforts towards year-round observations, together with well-targeted process studies, progress can be made towards better understanding ecosystem structure and function and how any one component might be more/less vulnerable to change. It was also acknowledged that climate variability is extremely large in the Southern Ocean and Antarctica, which further challenges any distinction between the impacts from fishing versus climate change, but coupling observations/process studies with biophysical modeling efforts can help explore related hypotheses and 'what if' scenarios.

2.2.5 Finalizing the conceptual framework - Day 3

On our final day, and with a draft of the Conceptual Framework in hand (see Cover Image), which also comprises our one-page flier (meant to advertise the Ross Sea Initiative), we then broke into the same four groups from the previous afternoon to draft conceptual sub-frameworks for the four proposed program elements. We note that the Conceptual Framework was also integrated into a one-page flier that was composed to help advertise the Ross Sea Initiative.

The Research Network group discussed implementation plans for the different network options, and by way of example, agreed that for an RCN proposal, the focus would be on Southern Ocean MPAs. The conceptual sub-framework for the Research Network is shown in Figure 3 below. It was noted that the connections among the groups (yellow) and the actions (blue) illustrate the different processes involved in a research network. For example, observations, cyberinfrastructure, and modeling need to include both the researchers and stakeholders (e.g., CCAMLR, national governments, industry, civil society) in an interactive sense. The 'Communication' element embraces both the public policy and public engagement, and ultimately influences and feeds back into observations and processes.

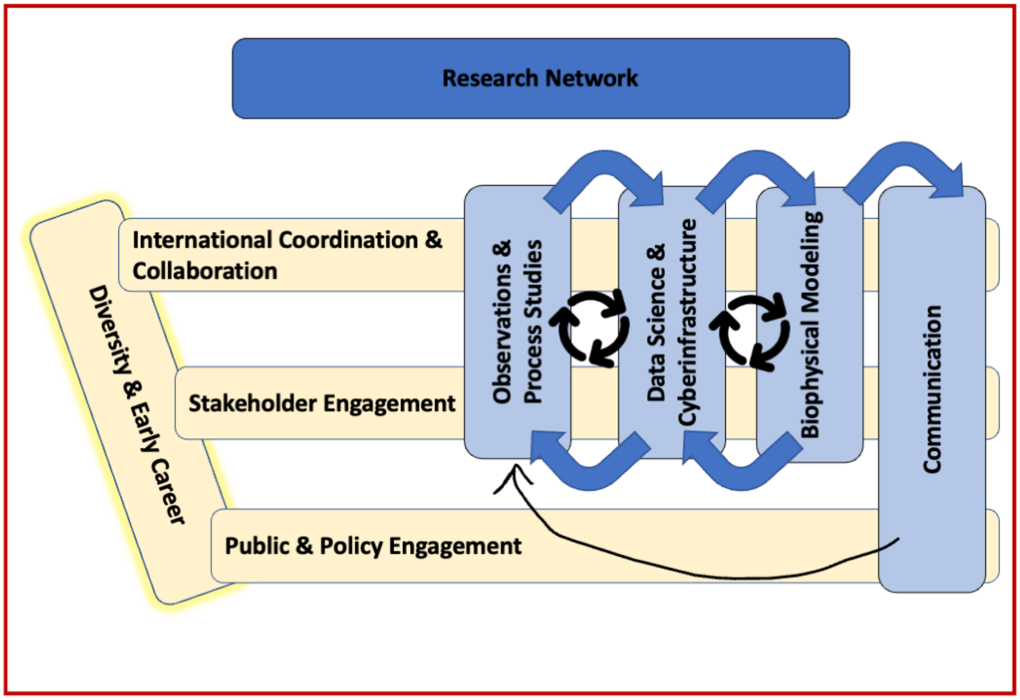

Figure 3. Conceptual Sub-framework for the Research Network.

The Biophysical Modeling group discussed gaps in geophysical and biological modeling and how to address them. Various modeling frameworks were discussed, including ROMS and/or other geophysical models coupled with primary productivity and food web models, and habitat models focused on key species. It was agreed that the modeling effort should be well integrated with efforts involving data assimilation and field observations to best determine the most relevant types of simulations and case studies to explore. The conceptual sub-framework for the Biophysical Modeling component is shown in Figure 4 below.

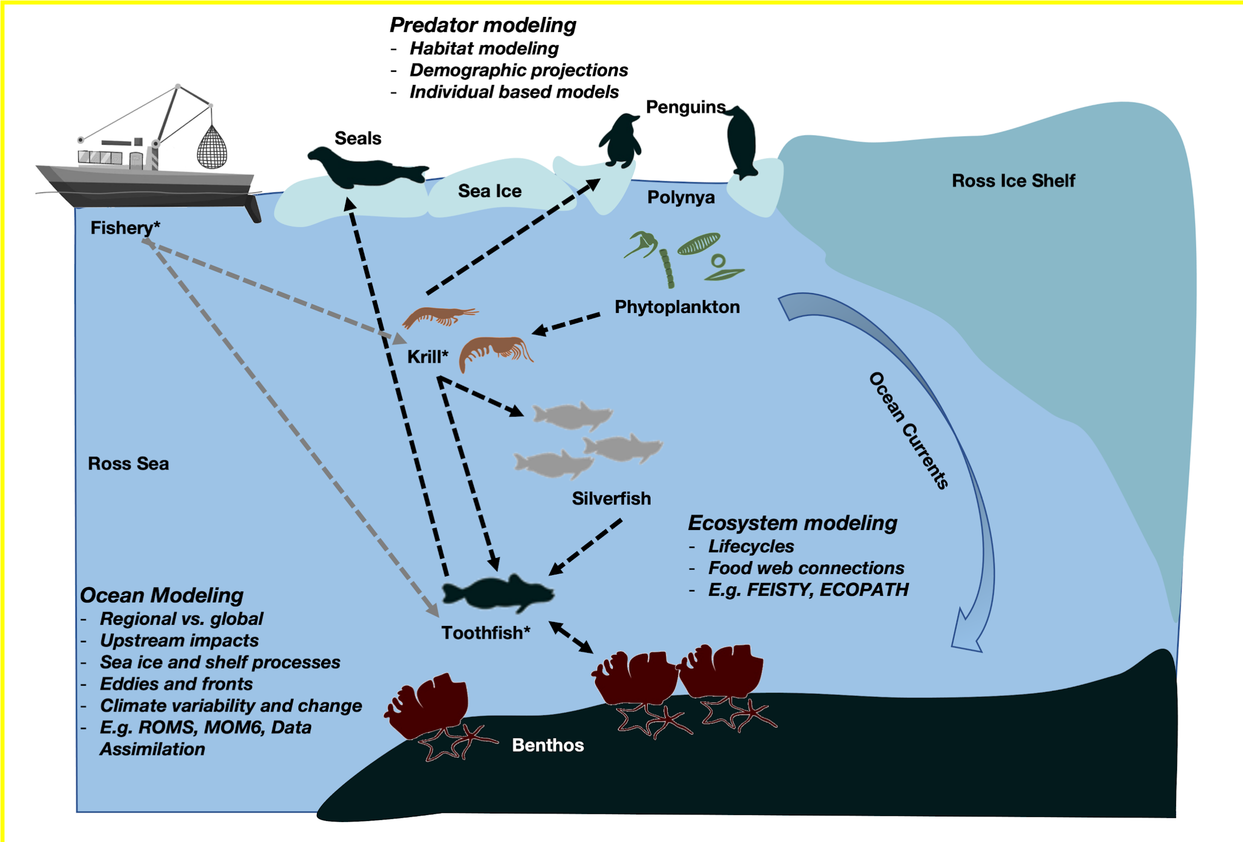

Figure 4. Conceptual Sub-framework for Biophysical Modeling. The black dashed arrows indicate possible ecosystem connections (note that this is not meant to be fully inclusive of the ecosystem, and species are not to scale; ocean modeling would also include polynya processes). Grey dashed lines indicate known fishery species.

The Data Science and Cyberinfrastructure group had a very focused discussion on the key elements needed for an appropriate conceptual sub-framework. Different data sources were identified first, including biologging, sensors, historic/qualitative, ecological/observational, industry, and community science. Different processes applied to the data sources were next identified and included shared standards (e.g., types of collections, naming conventions, metadata, API's), shared workflows (including code for data synthesis and analysis and tools for training and testing AI), and quality control, together serving as a shared resource for modeling efforts (e.g., predictive biological models, downscaled biophysical models). The conceptual sub-framework for the Data Science and Cyberinfrastructure component is shown in Figure 5 below.

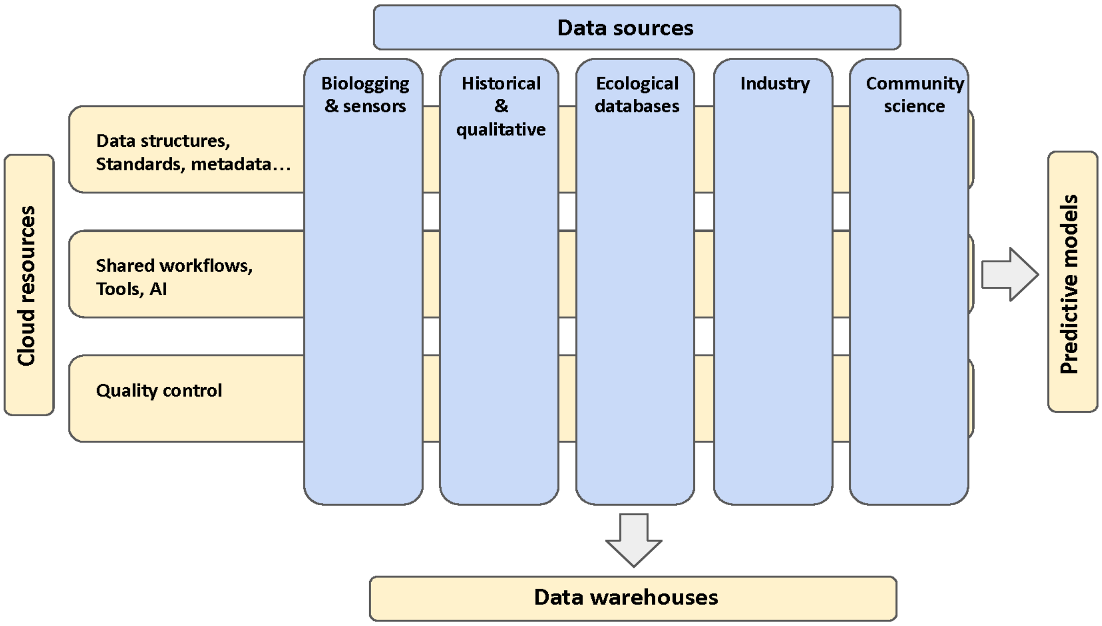

Figure 5. Conceptual Sub-framework for Data Science and Cyberinfrastructure.

The Observations and Process Studies group continued discussions of both near- and long-term goals, including the types of observations needed to achieve those goals that would ultimately lead to the creation of a Ross Sea Observing Network in support of the RSRMPA. It was acknowledged that there is a clear need to develop and improve biosensors to help address gaps in biological monitoring. The group also emphasized the need to be well-integrated with the other program elements (i.e., Data Science and Cyberinfrastructure and Biophysical Modeling). The conceptual sub-framework for the Observations and Process Studies component is shown in Figure 6 below.

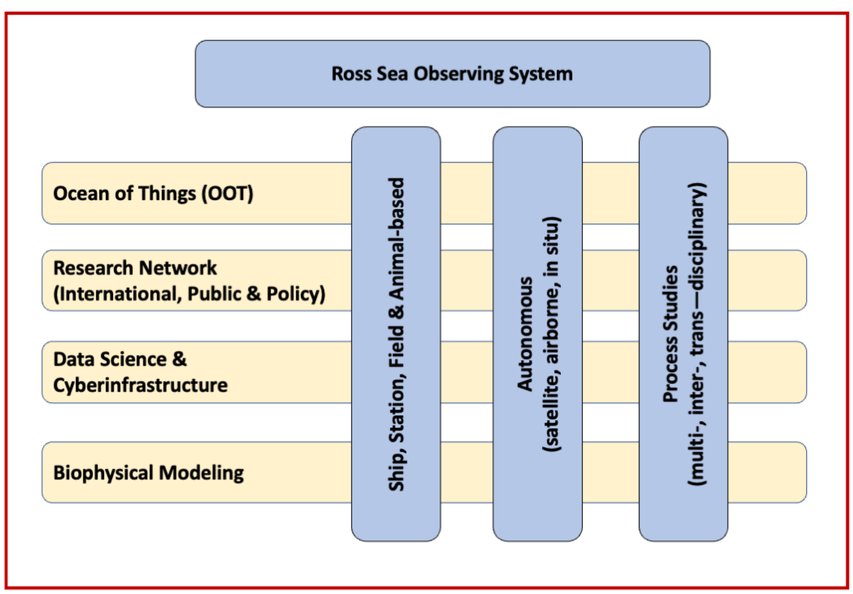

Figure 6. Conceptual Sub-framework for Observations and Process Studies, comprising the 'Ross Sea Observing System'.

In terms of Process Studies and being able to maximize output from field experiments, discussions focused on the use of well-integrated multidisciplinary and multiplatform approaches (e.g., see Figure 7 and 8), an example of which included the concept of "Ocean of Things" (OOT) (originally conceived by DARPA/Defense Advanced Research Projects Agency). Here, discussions focused on how an OOT concept (e.g., Figure 7; see also https://oceanofthings.darpa.mil) could be tailored for the Ross Sea to provide relevant science in support of the RSRMPA.

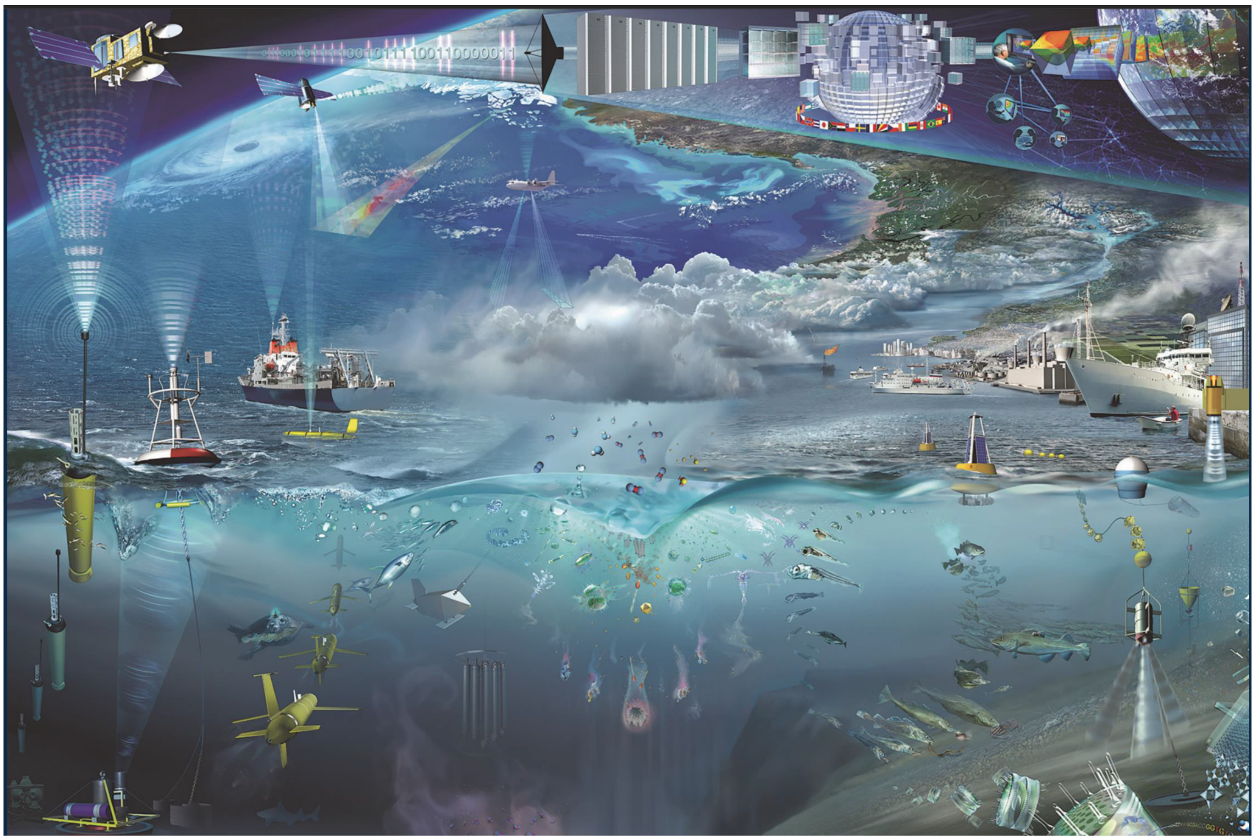

Figure 7. An "Ocean of Things" (OOT) which could be applied to a Ross Sea Observing Network to provide relevant science in support of the RSRMPA. (Figure credit Glynn Gorick, courtesy Jack Pan).

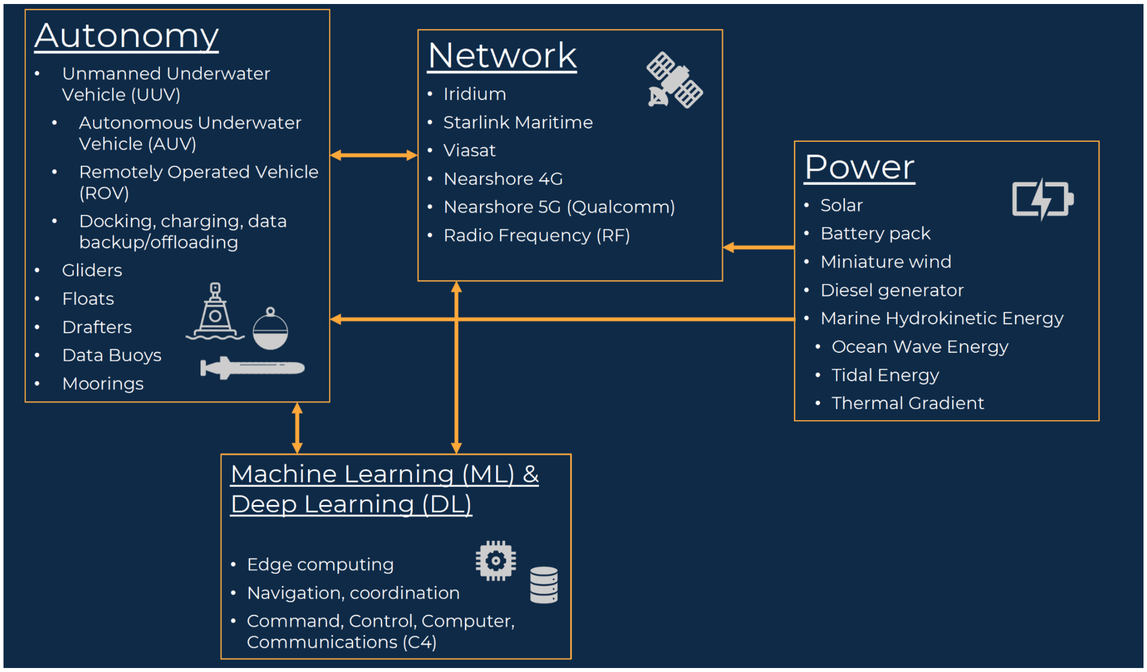

Figure 8. An "Ocean of Things" (OOT) tailored for the Ross Sea Research Initiative (drafted by Jack Pan).

2.3 Meeting Wrap-up

Final large group discussions for the Planning Meeting focused on wrapping up the discussion on the type of network needed to kick-start a Ross Sea Research Initiative. Additional information was shared about how SOGLOBEC came to be, helping to confirm that the first step towards creating such an overarching program would be the creation of a coordinating network. Once a network is initiated, the Conceptual Framework can guide the development of the larger program by providing the necessary resources for detailing a Science and Implementation Plan inclusive of international coordination and public and policy engagement. In regards to the outlook and timing on when field studies could be supported, it was acknowledged that the U.S. Antarctic Program will soon be a one-ship operation in Antarctic waters, thus there is the critical need to coordinate international partnerships (as initiated by the Research Network) to help co-develop field supported activities. In that sense, the MOSAIC program serves as a nice example of first identifying an international partner or partners who are able to commit field resources, and once established, additional U.S. funding is more easily leveraged.

We then wrapped up the meeting by identifying willing participants for each of the four Working Groups, including designating 2-3 lead coordinators for each group (see list here), and this invite will be extended to the community-at-large via our Listserv and Website post-meeting. It was also agreed that a charter (of expectations, time lines, etc) would be helpful for coordinating and guiding the working groups (and this would be forthcoming post meeting). Finally, a Meeting Report, followed by a journal paper, will provide an overview of the ideas discussed at this Planning Meeting, including the Conceptual Framework for promoting a Ross Sea Initiative. (We intend to target a high profile journal to help spread the word.)

In terms of keeping the dialogue going on a Ross Sea Research Initiative, virtual meetings will serve to continue the discussions and planning, while in-person meetings will take place during several upcoming international meetings, e.g., SOOS 4th International Ross Sea Symposium in Naples, Italy (Jul 3-7, 2023); SCAR Biology Symposium in Christchurch (Jul 31 to Aug 4, 2023); and the SOOS Symposium on 'Southern Ocean in a Changing World' in Hobart (Aug 14-19, 2023). It was also duly noted that as we plan for future meetings, it is critical that we include CCAMLR participation. With regards to the SOOS Symposium in Hobart, it was noted that there is a complementary effort underway that is proposing a 'Southern Ocean Year' that would facilitate a 'year' of circumpolar ocean observations, through international coordination and in alignment with the Southern Ocean Decadal Plan; several countries are already discussing this effort (U.S., BAS/U.K., Norway, AVI/Germany).

The meeting ended on a very high note when John Weller announced that he was working on a film project that would highlight ideas discussed during this Planning Meeting into one narrative describing a Ross Sea Research Initiative in support of its MPA.

3. Post-Meeting Timeline and Anticipated Outcomes

- **Oct 2022**: Organizing Committee finalizes Conceptual Framework.
- **Nov 2022**: Meeting Report draft shared with NSF and Organizing Committee.
- **Dec 2022**: Final Meeting Report posted on Website, along with the Charter & Sign-Up doc for Working Groups (WGs). An email was sent to the Listserv with a short summary of the meeting and links to Meeting Report and WG sign-up doc.
- **Dec 2022 thru May 2023**: WG's continue to discuss proposal ideas and look to gather at meetings in boreal summer 2023 (see below). Draft and submit Overview Paper on Ross Sea Research Initiative in peer-reviewed journal.
- **Apr 2023**: Submission of either an RCN or AccelNet proposal to NSF;
- **Apr-Aug 2023**: continue discussions of a Ross Sea Research Initiative at the following meetings: (1) CCAMLR special intersessional MPA meeting (Santiago, Chile; **Apr 2023**, date to be confirmed); (2) SOOS 4th International Ross Sea Symposium (Naples, Italy; **Jul 3-7, 2023**); (3) SCAR Biology Symposium (Christchurch, New Zealand; **Jul 31-Aug 4, 2023**); and (4) SOOS Symposium 'Southern Ocean in a Changing World' (Hobart, Australia; **Aug 14-19, 2023**).

See website for ongoing updates: http://www.rossseareseearch.org/

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APPENDIX 1 - Resources

Funding - all opportunities hyperlinked

Funding opportunities at NSF

- NSF Funding search
- Antarctic Sciences now has two different calls:
    - Research not requiring field support (NSF 23-508) - rolling deadline
    - Research requiring field support (NSF 23-509) - due January 17
- Paleo Perspectives on Present and Projected Climate (P4CLIMATE) competition is a coordinated paleoclimate science initiative funded by NSF Divisions of Atmospheric and GeoSpace Sciences (AGS), Earth Sciences (EAR), Ocean Sciences (OCE), and Office of Polar Programs (OPP) in the Geosciences (GEO) Directorate. The annual P4CLIMATE competition supports the scientific objectives of the NSF by fostering interdisciplinary research and synthesis of climate data. The goal of the interdisciplinary P4CLIMATE solicitation is to utilize observational and modeling studies to provide paleo perspectives addressing the two research themes: 1) Past Regional and Seasonal Climate; and 2) Past Climate Forcing, Sensitivity, and Feedbacks.

Support for early scientists

- OPP Postdoc Program (updated solicitation NSF 22-635)

NSF opportunities for networking:

• Research Coordinated Networks (RCN), NSF 17-594
• Accelerating Research through International Network-to-Network Collaborations (AccelNet, NSF 21-511)

NSF Major Instrumentation and Infrastructure
• Major research Instrumentation Program (MRI), NSF 18-513,1M to 4M, see also here.
• MidScale Infrastructure – 1 (MidScale RI-1), NSF 21-505, <20M
• MidScale Infrastructure – 2 (MidScale RI-2), NSF 21-537, 20M to 100M

Science and Technology centers
• Science and Technology Centers: Integrative Partnerships, NSF- 22-521, 44M- 47M
• Cyberinfrastructure for Sustained Scientific Innovation (CSSI)
• Elements Awards: These awards target small groups that will create and deploy robust services for which there is a demonstrated need, and that will advance one or more significant areas of science and Engineering. Contact Allen Pope (apope@nsf.gov), Polar Cyberinfrastructure Program Director.

International Funding
• Classic collaboration with international partners, the collaboration is included in an NSF proposal, the international partner writes a letter of collaboration. The international partner is funded by their own funding agency.
• NSF has established bi-lateral funding agreements:
    • NSF/GEO – UK NERC opportunity for collaborative proposals (DCL 16-132)
    • NSF-DFG opportunity for Molecular and Cellular Biology (DCL 22-015)
• Office of International Science and Engineering (OISE), OISE's focuses on three activities: (1) promoting the development of a globally competent U.S. workforce, (2) facilitating and supporting international partnerships and networks to leverage NSF and foreign resources, and (3) providing opportunities for U.S. leadership to shape the global science and engineering agenda.
Projects: MULTIPLIER, PIRE, IRES, AccelNet
• Partnerships for international Research and Education (PIRE), NSF 22-546, 1.5M for 3 years, contact Paul Raterron
• Horizon Europe, 2021-2027

NSF Partnerships
• A Landscape Study
• Computer and information Science and Engineering (CISE): support advanced cyberinfrastructure that enables and accelerates discovery and innovation across all science and engineering disciplines; international Partnerships
Deadline: 6 February 2023
• Graduate Research Fellowship Program (GRFP)

NASA
NASA Funding Search
Cryospheric Sciences
Biological Diversity & Ecological Conservation

Other Potential Funding
Antarctic Wildlife Research Fund
Lenfest
Lenfest Ocean Program
Lenfest RFP (Due January 23, 2022): Managing Protected Areas in a Changing Climate.
Pew Charitable Trust's Protecting Antarctica's Southern Ocean
Pew Marine Fellows
IAATO Antarctic Fellowship (early career focused)
CCAMLR Scientific Scholarship Scheme (early career focused)
SCAR (Scientific Committee on Antarctic Research) Fellowship (early career focused)
SCAR Ant-ICON/SC-ATS science-policy fellowship programme (early to mid-career focused, fellow will attend CCAMLR or the Antarctic Treaty meeting with the SCAR delegation)

Potential Logistical Support
Schmidt Ocean Institute New Vessel (vessel time)
Rev Ocean (Vessel time and technical support)
IAATO (International Association of Antarctic Tour Operators) Science Support

Potential Coordination & Collaboration
Southern Ocean United Nations Decade of Ocean Science for Sustainable Development
SOOS Due South database of upcoming expeditions
SOOS Ross Sea Working Group
SCAR Science & Research Groups
Ocean Motion Technologies - Ross Sea MPA