



2021 United Nations Decade
2030 of Ocean Science
for Sustainable Development

UN DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT (2021-2030)

REPORT : 1st SOUTHERN OCEAN REGIONAL WORKSHOP

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San Diego, CA USA

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WORKSHOP SPONSORS:



WORKSHOP OVERVIEW

The 1st Southern Ocean Regional Workshop to provide Southern Ocean community inputs to the Science Action Plan of the UN Decade of Ocean Science was held on 16 February 2020 in San Diego, CA, USA. The workshop was held prior to the 2020 Ocean Sciences Meeting to engage diverse participation. The 30 participants, who represented 11 countries, included representatives with expertise in ocean sciences, policy, governance and science communication, from all career stages.



Participants in the 1st Southern Ocean Regional Workshop held at the Hard Rock Hotel, San Diego, CA, USA 16 February 2020.

The workshop was structured around an opening plenary session, three themed sessions with accompanying breakout groups, and a final plenary session focused on cross-cutting themes (see also Appendix I + II). The opening plenary session provided information about the UN Decade of Ocean Science. This session informed the three theme sessions that focused on a Healthy and Resilient Ocean, a Predicted Ocean, and a Sustainable Productive Ocean. These three of the six UN Ocean Decade themes were chosen as the focus of the workshop because of relevance to the Southern Ocean, and these could be addressed in a one-day workshop. The other UN Ocean Decade themes, a Clean Ocean, a Safe Ocean, and a Transparent and Accessible Ocean, were included implicitly in the discussions of these three themes. The closing plenary session addressed cross-cutting themes. Additional information about the workshop organization is provided in Appendix II.

Summaries and recommendations from each of the theme-focused breakout groups and cross-cutting session follow.

THEME 1: Healthy and Resilient Ocean

The attributes of a Healthy and Resilient Ocean (HRO) highlighted in the session introduction are: 1) marine ecosystems that are mapped and protected, 2) multiple impacts, including climate change, are measured and reduced, and 3) provision of ocean ecosystem services is maintained. For the Southern Ocean, some efforts are underway to assess and map Southern Ocean ecosystems through national programs that provide ecosystem measurements, assess impacts of multiple stressors, and identify ecosystem indicators as reference points.

Similarly, ongoing research is focused on understanding the structure and function of Southern Ocean ecosystems, key drivers of change, and ecosystem resilience. International organizations (e.g. Southern Ocean Observing Systems, SOOS; Scientific Committee for Antarctic Research, SCAR; Integrating Climate and Ecosystem Dynamics in the Southern Ocean, ICED; Marine Ecosystem Assessment for the Southern Ocean, MEASO; IPCC) facilitate coordination and dissemination of results from these research programs. Through activities of the Convention for Conservation of Antarctic Marine Living Resources (CCAMLR) and SCAR, some provisioning of ecosystem services (e.g. fisheries and tourism) are being evaluated and assessed.

In the context of research to support a predicted and healthy and resilient Southern Ocean, the breakout groups were charged with addressing: 1) key science and societal issues, 2) required major activities, knowledge gaps and collaborations, and 3) what should be done and the resources required, with particular attention to key regional issues, science gaps and pathways for addressing these gaps. The **key priorities for the UN Decade of Ocean Sciences** that emerged from the discussions are as follows.

- **HRO Priority 1:** Improve understanding of key drivers of change and their impacts on Southern Ocean species and food webs.

Current understanding of the key physical, chemical and biological drivers of change for many species within the Southern Ocean is lacking. In addition, the processes involved or the impact of multiple and synergistic drivers are not fully understood. Such information is crucial for developing the suite of models required to generate ecologically meaningful outputs to aid in interpretation of changes in support of conservation and management.

Addressing this priority requires better understanding and measurements on key drivers of relevance to Southern Ocean biology. These drivers include sea ice, ocean temperature, ocean acidification, primary production, plankton community structure, stratification, fishing, oxygen, and extreme events. These efforts must focus on improving understanding of the relative importance of key driver(s) and the mechanisms by which they impact key species (i.e. species targeted by fisheries, conservation or important in the cycling of nutrients and biomass) via laboratory, experimental, and coordinated field studies. Understanding and quantifying the impacts of multiple and synergistic drivers are critical for parameterization, calibration and verification of modelling studies. The information on key species needs to be combined with

integrated analyses of the multiple effects of change in food webs to develop understanding of the impacts on ecosystem structure and functioning.

- **HRO Priority 2:** Improve understanding of sea ice, including its role in ecological processes of the Southern Ocean.

Sea ice plays a key role in shaping the physics, biogeochemistry and biology of Southern Ocean ecosystems. Addressing this priority requires an understanding of sea ice dynamics, especially responses to drivers, connections between ocean-sea ice, atmosphere-sea ice and coastal-open water. This is essential to better constrain observations of sea ice thickness and drift. Projections of sea ice require improved understanding of seasonality, including key processes, and changes in timing.

The understanding of the physical processes involved and of the relationships between sea ice and biology is limited. Defining the relationships between sea ice and biology is critical for projections of future states of the Southern Ocean ecosystem. This requires identification and quantification of the processes by which sea ice impacts the development of phytoplankton blooms, the dependency of various species on sea ice (including different life stages, both on and under the ice), and mechanisms by which sea ice impacts key species. As sea ice is predicted to decrease in the coming years, this information is vital for improving the prediction of sea ice in climate models and interpreting biogeochemical and ecological change. Much of the poor understanding is due to a lack of data caused by observational challenges, particularly during the winter and underneath sea ice.

Physical, biogeochemical, and biological aspects of sea ice can be addressed by multi-season observations, including ship and autonomous-platform based studies to observe both under (Argo, glider, tagged animals) and above (drones, aircrafts, satellite) the sea ice. This level of observation requires a circumpolar internationally coordinated field program. A parallel effort is to develop high-resolution models to explore sea ice dynamics and links to biology. ICED has initiated discussions aimed at developing an internationally coordinated study of Southern Ocean sea ice. The development and implementation of a coordinated, international, circumpolar research effort focused on the unifying theme of understanding sea ice processes and standardized comprehensive measurements provides a great opportunity for the UN Decade of Ocean Science.

- **HRO Priority 3:** Improve understanding of Southern Ocean biogeochemical cycling. The Southern Ocean plays a key role in biogeochemical cycling, particularly in regulating air-sea exchange of carbon dioxide in the global carbon cycle.

Quantitative understanding of Southern Ocean carbon fluxes is required to ensure correct representation in Earth System models. In addition, there is currently no consensus or quantification of the amount of living carbon that was removed from the Southern Ocean through historical fishing, the effects of this removal, or the effects of recovery from removal.

Key issues for this priority are to quantify the fate and time scales of carbon fluxes, both organic and inorganic and the role of food webs (from primary producers to high trophic level organisms) in these fluxes. This requires understanding seasonal and spatial variations in productivity, as well as studies that include vertical carbon transport and sub-system links (e.g. benthic-pelagic, ice-open water and coastal-open ocean).

Quantitative estimates of the amount of living carbon historically removed from the Southern Ocean are critical for carbon flux estimates and understanding of relevant processes. A coordinated development of a spatially mapped decadal time series of the amount of (living) carbon historically removed from the Southern Ocean (in a standard format) represents an equivalent of the “time series of annual land use and land cover” for the Southern Ocean.

- **HRO Priority 4:** Improve societal understanding of Southern Ocean issues and appreciation of the Southern Ocean for its global value in Earth systems and unique environment.

Poor societal understanding of Southern Ocean issues limits support and uptake of science by policy makers. Improved understanding can be facilitated by more science outreach to the public and policy makers by Southern Ocean scientists. The Southern Ocean community could collectively work towards the development of a sustained, coherent, and synergistic campaign of outreach activities. The UN Decade of Ocean Science provides an opportunity to develop the required infrastructure and training needed to work towards this challenge.

THEME 2: Predicted Ocean

The Predicted Ocean (PO) session introduction provided a brief overview of current understanding that informs prediction of Southern Ocean circulation, anthropogenic carbon dioxide (CO₂) uptake, the cryosphere (sea ice, ice sheets, ice shelves), sea level rise, modelling capability and observational capability and challenges. It was noted that 40% of anthropogenic CO₂ is absorbed by the Southern Ocean and that the upper ocean water masses formed in the Southern Ocean (e.g. Mode Waters) provide nutrients to low latitudes on time scales of a year to decades. In this regard the primary production in many parts of the global ocean is connected to the Southern Ocean. Thus, understanding and predicting these inputs are a priority for the global community.

The breakout groups were tasked with identifying the research opportunities for the UN Decade of Ocean Science that can address challenges of 1) understanding and quantifying sub-seasonal to decadal predictability in the Southern Ocean, 2) impacts of the Southern Ocean that project on other parts of the Earth system (e.g. atmosphere and ecosystem), 3) inclusion of these predicted mechanisms for guiding for the design of observing systems, and 4) understanding and identifying critical processes needed for improving predications. The **key priorities for the UN Decade of Ocean Sciences** that emerged from the discussions are as follows.

- **PO Priority 1:** Enhance and expand observational capability to support predictions.

The availability of observations with sufficient space and time resolution to validate process parameterizations and to develop scenarios was identified as a priority for developing a predictive Southern Ocean model. Data that are considered critical for improving predictive skill are high-resolution regional bathymetry, wind observations, especially over sea ice (a capability that needs development), CO₂ uptake and outgassing, and fluxes of upwelled Circumpolar Deep Water and downwelled Antarctic Bottom Water.

Due to distance from regular shipping routes and seasonal ice cover, continental shelf and coastal regions are undersampled. These regions are impacted by increased freshwater fluxes from sea ice melt or ice shelves/sheets and are critical in the generation of water masses (both bottom water and mode water) that are globally important. Cross-shelf processes are also critical. The current coastal and continental shelf observing networks need to be significantly enhanced so that fluxes can be constrained. Presently observations of critical austral fall and winter processes are limited.

No single country can afford enough funding and personnel support for a multiyear all-seasonal observation program in the Southern Ocean. Thus, coordinated year-round observing programs that include multiple countries are needed to address this deficit. Challenges for the UN Decade of Ocean Science are to coordinate and support existing observing programs, involve other nations (and stakeholders) in observational efforts, facilitate data sharing, and promote data

collection using standardized methods. Data quality must be sufficient to support high-resolution models used for climate studies.

- ***PO Priority 2:*** Improve and enhance Southern Ocean modelling capability.

The modelling needs vary depending on the time and space coverage of the desired prediction. Long-time scales are important for climate change and sustainability, but management and policy decisions are more often directed at time scales that range from weeks and months through sub-decadal to a few decades. Decadal predictability is a crucial skill that is needed to inform management decisions.

High-resolution regional models (e.g. Western Antarctic Peninsula, Weddell Sea, Ross Sea) are critical for prediction of ocean-ice sheet interactions, water formation, and freshwater fluxes (water balance). Development of these models and their inclusion in larger scale models (e.g. basin scale) requires expertise in parameterization, capacity building in the Southern Ocean modelling community, and sustained observational networks to provide initial conditions, boundary forcing, and calibration. Implementing this level of modelling is a challenge for the Southern Ocean modelling community. The UN Decade of Ocean Sciences provides a platform to advance this challenge.

THEME 3: Sustainable Productive Ocean

The introduction for the Sustainable Productive Ocean (SPO) session noted that governance of marine living resources in the Southern Ocean is done by CCAMLR, a multi-national body established by the Antarctic Treaty in 1980, through consensus-based decision making. CCAMLR is a recognized leader in ecosystem-based resource management and sets a precedent for regulation of marine living resource use in other ocean systems. The two major fisheries in the Southern Ocean are toothfish (*Dissostichus spp.*) and Antarctic krill (*Euphausia supbeba*), but other fisheries have the potential to develop. The exploitation of bio-resources for novel pharmaceuticals is likely to increase in coming years.

Issues facing Southern Ocean living marine resource management are sustainability, by-catch, illegal fishing, identification of vulnerable marine ecosystems via indicator taxa, and the designation of Marine Protected Areas (MPAs) for overall ecosystem and biodiversity conservation. Development of research and management plans that demonstrate the effectiveness of MPAs is a priority. Increased eco-tourism is introducing new issues, such as the potential introduction of diseases and invasive species, in addition to the potential stress on existing populations of seabirds and mammals.

The breakout groups were tasked with identifying the research opportunities for the UN Decade of Ocean Science that can address challenges of 1) defining science-based safe and sustainable thresholds for Southern Ocean fisheries, 2) facilitating effective Southern Ocean spatial planning, and 3) implementing MPAs. The **key priorities for the UN Decade of Ocean Sciences** that emerged from the discussions are as follows.

- **SPO Priority 1:** Increase the suite, types and reliability of measurements, including those focused on ecosystem change, needed to inform management and policy.

The availability of ice-capable ships that can operate in regions relevant to management is a priority and the continued use of dedicated scientific voyages for collecting high-quality measurements is essential, however it is unlikely that such voyages will ever be able to collect enough data in the Southern Ocean. Increased use of ships of opportunity (e.g. tour boats) is one approach for expanding observations, especially of higher trophic levels, however data quality is paramount and thus standard operating procedures of appropriate quality are essential.

Nevertheless, simple counts of higher trophic levels are not sufficient to discern climate impacts (e.g. marine heat waves). Autonomous vehicles, cameras, and animal tags provide platforms to acquire information about habitat use and foraging behaviour in regions with limited access and during the austral winter. Approaches such as employing artificial intelligence methods provide a way to optimize the value of these data and support development of robust demographic models that can interface with climate models. Making this happen is a challenge for the UN Decade of Ocean Science.

- **SPO Priority 2:** Ensure a sustainably harvested and productive Southern Ocean by working towards a stronger interface between science and policy.

This demands working in coordination with CCAMLR and other adjacent regional management bodies to build relationships and determine science-management gaps following best practices for co-production of knowledge. Identifying and resolving barriers to cross this interface are critical to developing mechanisms and bridges that facilitate informed decisions and policy.

A component of this is to develop a risk assessment-decision making model based on our current knowledge and couple this with ecosystem models (physics-ecosystem-climate) that are used for decision making and communication between scientists and policy makers. Engagement of social scientists in developing and delivering communications to government policy makers is critical and should be an important component of the UN Decade of Ocean Science.

- **SPO Priority 3:** Ensure science-based and effective MPAs and uphold sustainable fisheries management.

This relates to the above priorities by ensuring that, as acquired, data are provided to managers in a usable format. This also includes working towards identifying when and where, based on identifying critical, vulnerable or threatened areas important for biodiversity, MPAs can be used as a management tool. Further, fishing regulations should be coordinated with MPA development in and outside of CCAMLR boundaries.

Fisheries in the subpolar Southern Ocean are regulated by organizations other than CCAMLR (e.g., national governments and adjacent Regional Fisheries Management Organizations). With climate change, the connectivity between the Southern Ocean and subpolar ecosystems may increase. Increased communication with the organizations regulating fishery resources will enable sustainability over the long term. The extent to which the Southern Ocean fisheries can address global protein demand in the future is unknown as is whether the Southern Ocean ecosystem can sustain continued or increased industrial exploitation. The development of MPAs around fish nursery grounds provides an approach for maintaining sustainable fishery resources. The UN Decade of Ocean Sciences provides an international forum to develop coordination of Southern Ocean fisheries with other organizations and to continue assessing efforts towards Southern Ocean MPAs.

Cross-cutting Themes

The introduction to the cross-cutting themes (CCT) stressed the importance of the Southern Ocean in the global climate, CO₂ uptake, and global ocean productivity. The need to engage the public in understanding the importance of the Southern Ocean was highlighted as was the need to develop user-driven solutions. A view of what the UN Decade of Ocean Science can deliver was given that included a comprehensive digital atlas of the ocean, high resolution observations for all ocean basins, high resolution models with predictive capability, and understanding of ecosystem structure and function. This vision includes data and information portals, integrated multi-hazard warning systems (e.g. winds, wave height), capacity building, technology transfer and solution science.

The **key priorities for the UN Decade of Ocean Sciences** that emerged from the plenary discussion of the cross-cutting themes are as follows.

- **CCT Priority 1:** Undertake planning for remote sensing capability that will improve capability to measure winds, backscatter for biomass, chlorophyll, salinity, temperature, sea ice, and land ice, in the Southern Ocean. Improved remote sensing capability will significantly enhance the ability to forecast and project circulation, ecosystems and their interactions over a range of space and time scales.

CCT Priority 2: Frame Southern Ocean questions and issues in terms of social needs. This requires the development of a community that bridges the gap between science and the public and can communicate the transdisciplinary nature of the Southern Ocean issues. This can be facilitated through the communication action plan of the UN Decade of Ocean Science.

- **CCT Priority 3:** Implement a coordinated, international, circumpolar observational program to elucidate processes that 1) allow life histories of key species in the Southern Ocean ecosystem to be quantified, 2) allow a total carbon budget to be developed, 3) provide coverage of the annual cycle, and 4) quantify the role of sea ice in regulating ecosystem productivity. The UN Decade of Ocean Science may provide a platform for engaging national programs in such an effort.
- **CCT Priority 4:** Raise participation and importance of the Southern Ocean through the UN Decade of Ocean Science. The Southern Ocean community needs to be more visible in activities such as OceanObs and other international ocean efforts. The Southern Ocean community needs to develop stronger linkages with policy and decision makers in international and national governments, non-governmental bodies, and governmental organizations.

- **CCT Priority 5:** Enhance predictive skill across climate, circulation, cryosphere, and ecosystems. The Southern Ocean community can add scenarios, such as freshwater inputs in the Southern Ocean, to understand climate sensitivity. End-to-end integration across ecosystems is needed to improve estimations of carbon fluxes, understand the effects of multiple stressor on ecosystems, identify biological hotspots, and evaluate the effects of living resource extraction on biological productivity. This requires working across disciplines, comprehensive observational systems, community engagement, and resources.
- **CCT Priority 6:** Facilitate capacity development and engagement of new communities. The current Southern Ocean community capacity is not sufficient to address the issues that are now being faced, many of which have important social implications. It is imperative that programs be developed to engage new research communities and early career researchers in Southern Ocean activities and to build a community with transdisciplinary capability. This is an important challenge that can be addressed through national and international programs that focus on education, training and capacity building. The UN Decade of Ocean Science provide the opportunity to coordinate across these programs.

APPENDICES

Appendix I. Workshop organization information.

The Southern Ocean workshop had 30 participants, who represented 11 countries, and included representatives with expertise in ocean sciences, policy, governance and science communication, from all career stages. Nevertheless we note that because the workshop was held prior to the Ocean Sciences Meeting, there was no representation from the Antarctic nearshore coastal and glaciology communities and limited international participation. Inputs from these communities will be solicited in subsequent workshops focused on the UN Decade of Ocean Science. Planning is underway to hold a second workshop at the Scientific Committee for Antarctic Research (SCAR) Open Science Conference in August 2020 in Hobart, Tasmania.

The opening plenary session began with a welcome and overview of the workshop. The following three presentations provided overviews of the UN Decade of Ocean Science from different perspectives. The first, a video presentation by Dr. Vladimir Ryabinin, Intergovernmental Oceanographic Commission (IOC) Executive Secretary, emphasized the importance of the UN Decade of Ocean Science and discussed the vision and approach for reaching the goal of providing *“delivery of the information, action and solutions needed to achieve the 2030 Agenda for Sustainable Development”*. Dr. Ryabinin also discussed the six themes that underpin the UN Decade, the science objectives of the Decade, and the current level of science capacity.

The second overview presentation given by Mr. Craig McLean, Assistant Administrator National Oceanic and Atmospheric Administration and member of the UN Decade Executive Planning Group, outlined the goals of the UN Ocean Decade and its importance for the next decade of ocean science. Mr. McLean also stressed the importance of providing inputs to the Science Action Plan for the UN Ocean Decade that is now in development.

The final overview presentation by Dr. Salvatore Aricò, Head of the Ocean Sciences Section, IOC Secretariat, emphasized points made in the two previous presentations and highlighted the goal of the UN Ocean Decade to make ‘step-function’ changes in approaches to ocean science and the importance of thinking long-term and having identified milestones to assess progress.

The final presentation of the opening plenary session was an overview by Prof. Eileen Hofmann of a background paper that briefly discussed the status of Southern Ocean research, which was provided to attendees prior to the workshop. The intent of the background paper was to provide a starting point for breakout group discussions. This presentation also stressed the long history and experience of the Southern Ocean community in international collaborative research.

Following the opening plenary session, the workshop moved to the three theme sessions. Each session began with a short plenary presentation that introduced the theme. The workshop attendees then organized into three breakout groups to discuss the theme and make recommendations about key Southern Ocean issues that require focus by the UN Ocean Decade, key science and information gaps and pathways for solving these issues, key capacity building needs and pathways for solving issues, partnerships needed to achieve progress, key pathways for improving access to information, data and knowledge. Each breakout group then reported back in plenary session.

The cross-cutting plenary session considered issues of approaches for framing Southern Ocean research in terms of societal needs, approaches for engagement of public, policy makers and stakeholders, and development of platforms for community science.

Appendix II. Workshop Agenda

Session 1 – Introduction to the UN Decade of Ocean Science		
09:00	Welcome + introduction	Taco de Bruin NIOZ
09:20	Video message by Vladimir Ryabinin, Executive Secretary Intergovernmental Oceanographic Commission (IOC)	Vladimir Ryabinin IOC
09:30	Impact and benefits of the UN Decade of Ocean Science for Sustainable Development	Craig McLean NOAA
09:40	Shaping the UN Ocean Decade 2021-2030	Salvatore Aricò IOC
10:00	Introduction discussion paper on Southern Ocean science in the framework of the UN Ocean Decade	Eileen Hofmann ODU
10:30	Health break with Tea/Coffee	
Session 2 – Healthy and Resilient Ocean		
11:00	Introduction to UN Decade Theme III: A Healthy and Resilient Ocean	Conveners: Eugene Murphy/ Nadine Johnston
	Breakout Group discussions	
	Report back in Plenary	
Session 3 – Predicted Ocean		
12:00	Introduction to UN Decade Theme IV: A Predicted Ocean	Conveners: Matt Mazloff/ Stuart Corney
	Breakout Group discussions	
	Report back in Plenary	
13:00	Group photo and Lunch (provided)	
Session 4 – Sustainable Productive Ocean		
14:00	Introduction to UN Decade Theme V: A Sustainably Harvested and Productive Ocean	Conveners: Christian Reiss/ Cassandra Brooks
	Breakout Group discussions	
	Report back in Plenary	
15:00	Health break with Tea/Coffee	
Session 5 – Cross-cutting Themes and workshop close		
15:30	Cross-cutting Themes: Introduction and Discussion (in plenary)	Convener: Joellen Russell Rapporteur: Louise Biddle
16:30	Next steps, wrap up	Eileen Hofmann/ Taco de Bruin
17:00	Close Meeting	