SOOS

SOUTHERN OCEAN
OBSERVING SYSTEM

IMPLEMENTATION PLAN

2016 - 2020

CONTENTS

PREFACE

The Southern Ocean Observing System (SOOS) is an initiative of the Scientific Committee on Oceanic Research (SCOR) and the Scientific Committee on Antarctic Research (SCAR). SOOS was officially launched in August 2011 with the opening of the International Project Office (IPO), hosted by the Institute of Marine and Antarctic Studies at the University of Tasmania, Australia. This was preceded, however, by almost a decade of discussion and planning by the Southern Ocean community. This planning phase included the development of the SOOS Initial Science and Implementation Strategy (Rintoul et al., 2012), which provides a comprehensive overview of the scientific rationale for SOOS, the status of the international activities and programmes that are stakeholders in SOOS, and provides a framework of potential implementation avenues for SOOS to achieve its objectives.

Since 2011, SOOS has focussed on developing its governance and policies, international connections, and network building. In 2013, SOOS published its 20-year vision (Meredith et al., 2013), which articulated our ultimate objective, and allowed a trajectory of actions to be defined towards achieving this objective. What is now required is a detailed Implementation Plan that specifies these steps towards achieving the overall SOOS vision:

"Sustained observations of dynamics and change of the physics, chemistry, geology and biology of the Southern Ocean system should be readily accessible to provide a foundation for enabling the international scientific community to advance understanding of the Southern Ocean and for managers to address critical societal challenges"

The Implementation Plan

This document is intended to define actions of the SOOS community for the period 2016 – 2020. This plan is deliberately flexible, to enable SOOS to adapt as new demands and priorities are identified. This Implementation Plan has been compiled by the SOOS Scientific Steering Committee, and has undergone international review and input by SCAR and SCOR.

This Implementation Plan clarifies the SOOS mission by articulating the specific role of SOOS and its relationship to key communities; outlines the vehicles of implementation that are required to facilitate activities (including both field activities, and activities to enhance knowledge acquisition and capabilities). It also includes a Strategic Plan, which defines the goals, objectives, and key deliverables (described as Key Result Areas (KRAs) from here on). Furthermore, this Implementation Plan includes an Operating Plan that identifies the communities and resources required to achieve each KRA.

The process used to develop this plan is illustrated in the Figure 1 below (modified from CIVICUS Strategic Planning Toolkit www.civicus.org/).

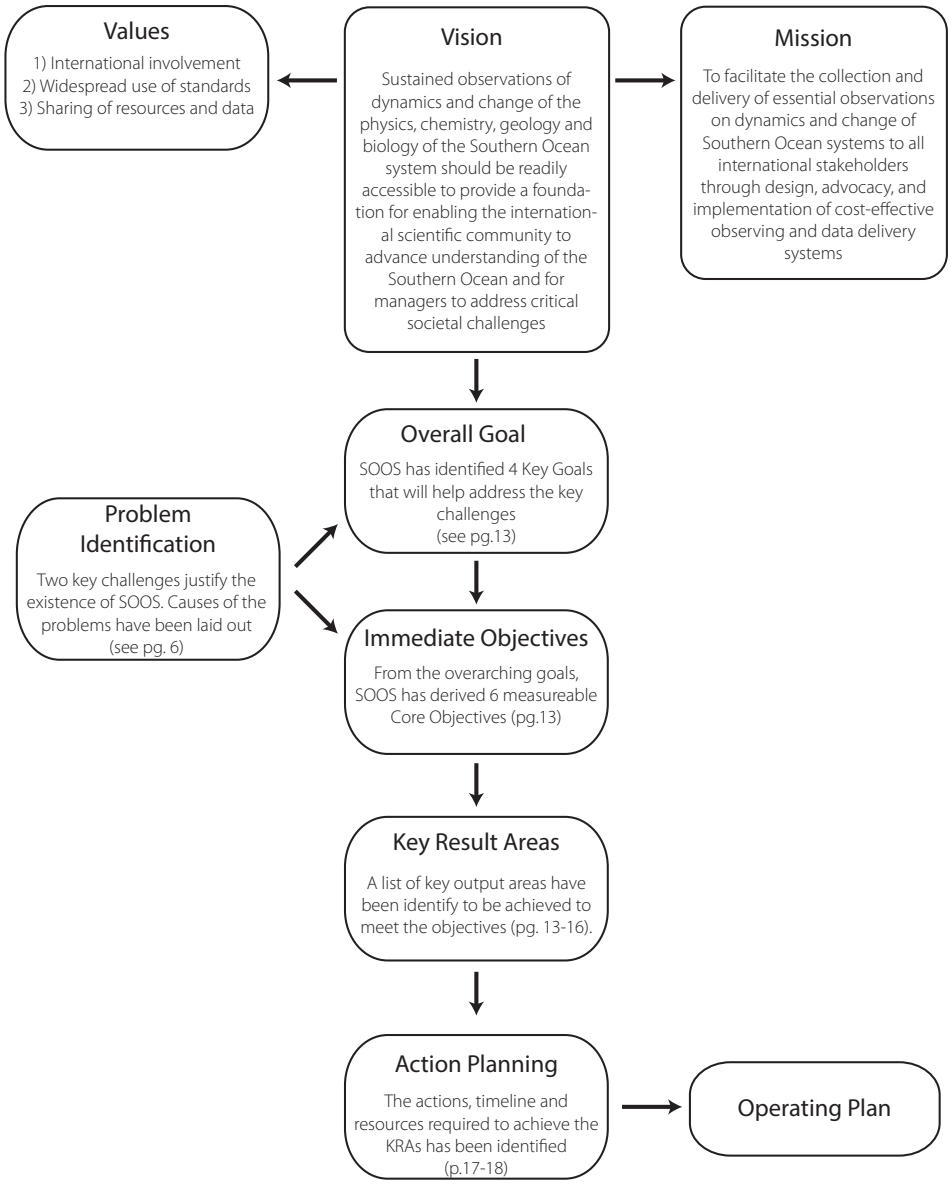

Figure 1: The CIVICUS Strategic Planning process as applied to the development of the SOOS Implementation Plan

THE NEED FOR A SOUTHERN OCEAN OBSERVING SYSTEM

Scientific Rationale

The Southern Ocean has a profound influence on global ocean circulation and the Earth's climate (Rintoul et al., 2012). The Southern Ocean provides the principal connections between the major ocean basins, and controls the connection between the deep and upper layers of the global overturning circulation, thereby regulating the capacity of the ocean to store and transport heat, carbon and other properties that influence climate and global biogeochemical cycles. The Southern Ocean contributes more to ocean storage of excess heat and carbon added to the Earth-atmosphere system by human activities than any other latitudinal band (Sabine et al., 2004; Purkey and Johnson, 2010), while export of nutrients by the upper limb of the overturning circulation ultimately supports 75% of the global ocean primary production north of 30°S (Palter et al., 2010).

Changes in the physical and biogeochemical state of the Southern Ocean are already underway, and will have global implications. The circumpolar Southern Ocean is warming more rapidly, and to greater depth, than the global ocean average (Purkey and Johnson, 2010; IPCC, 2013). The upper layers have freshened and widespread warming of the Antarctic Bottom Water has been observed (Böning et al., 2008; Durack and Wijffels, 2010; Purkey and Johnson, 2010). Since 1992, the satellite altimeter record shows an overall increase in sea level, with strong regional trends. Similarly, changes in sea ice extent are showing strong regional trends, with large increases in the Ross Sea sector contrasted with large decreases in the Bellingshausen Sea and around the Antarctic Peninsula (Parkinson and Cavalieri, 2012). The uptake of CO_2 by the ocean is changing its chemical balance, increasing the acidity and reducing the concentration of carbonate ions. The response of the Southern Ocean food web to changes in ocean chemistry remains largely unknown, but impacts on individual species are already being detected (e.g., Bednarsek et al., 2012; Constable et al., 2014).

Southern Ocean food webs rely on ice-associated intermediate trophic levels for the transfer of energy from primary producers to vertebrate predators. Generally speaking, the Southern Ocean food web is characterised by a keystone species, Antarctic krill, and this heavy dependence on a single species and aspects of the uniqueness of the Southern Ocean food webs and biogeochemical cycles make the system potentially vulnerable to climate variability and change (Murphy et al., 2012; Constable et al., 2014). There is evidence of changes in other components of the Southern Ocean food web, from phytoplankton to penguins and seals (e.g., Atkinson et al., 2004; Trivelpiece et al., 2011; Bost et al., 2015), however lack of long-term observations across large areas makes it difficult to assess long-term trends (Constable et al., 2014; Nymand Larson et al., 2014).

These recent changes underscore the importance of the Southern Ocean in the Earth system. Improved understanding of the links between Southern Ocean processes, global climate, biogeochemical cycles and marine productivity is needed to inform an

effective response to the challenges of climate change, sea-level rise, ocean acidification and the sustainable use of marine resources. In particular, it is critical to understand how the Southern Ocean system will respond to changes in climate and other natural and human forcings, as well as the potential for feedbacks. To achieve this enhanced understanding, sustained multi-disciplinary observations are essential.

Derived from these imperatives, SOOS activities will be focused to address 6 interconnected Scientific Themes:

1) The role of the Southern Ocean in the planet's heat and freshwater balance
2) The stability of the Southern Ocean overturning circulation
3) The role of the ocean in the stability of the Antarctic Ice Sheet and its contribution to sea-level rise
4) The future and consequences of Southern Ocean carbon uptake
5) The future of Antarctic sea ice
6) The impacts of global change on Southern Ocean ecosystems

A more detailed scientific rationale on the imperative of SOOS is available in the SOOS Initial Science and Implementation Strategy (Rintoul et al., 2012) and the SOOS 20-Year Vision (Meredith et al., 2014)

Key Challenges

The Southern Ocean Observing System has been established to overcome two important challenges for science and management in the region:

1) Southern Ocean observations are sparse, difficult, and expensive to obtain, and are often limited in space, time, quality, and variables measured, due to:

- Uncoordinated, short-term, single nation/discipline approach to observations leaves spatial and temporal gaps in a range of physical, chemical and biological observations.
- Lack of continuous funding for sustained observations leaves gaps in observations in time and space.
- Lack of strategic interfacing between nations, projects and disciplines on activities, plans, products and needs makes it difficult to streamline efforts and leverage investments to provide integrated datasets.
- Technological constraints have placed limitations on the type/amount of data that can be collected in an efficient and cost-effective way.
- Variation in observational methodologies and protocols hamper intercomparability of measurements made by different systems in different locations.

2) Access to multidisciplinary, quality-controlled, observational data from the Southern Ocean is difficult and time consuming due to:

- Many fragmented, unconnected, mono-disciplinary or mono-platform data centres
- Lack of funding and/or action on data sharing and platform interoperability
- Variations in national/institutional data policies and data-sharing cultures
- Lack of general knowledge on the data that are being collected, are already available, and accessible

The role of SOOS

SOOS aims to deliver an integrated base-level set of observations needed to facilitate assessments of the multidisciplinary state of the Southern Ocean, by linking existing data streams and facilitating new ones where needed. SOOS will provides an international interface for communication between nations and programs to streamline efforts and advocate for consistent best practices for data collection. The goal is for SOOS to the enable the international community to address the question "What do we need to measure to elucidate and explain fundamental system dynamics and change?". This will require that observations are sustained, multi-disciplinary, standardised, quality-controlled and accessible. Traditional field process and targeted observational studies can then focus on more specific questions requiring additional/different measurements or more intensive data coverage. Whilst aspects of some SOOS activities may overlap with other programs, SOOS fills a gap that is not currently addressed by existing international efforts. Where overlap exists, SOOS will not duplicate efforts, but rather make every effort to support and work with aligned endeavours.

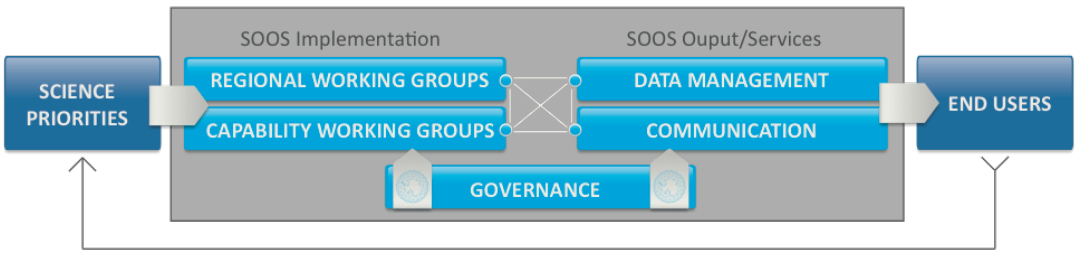

Figure 2: The core elements of SOOS include Implementation, output/services, and governance. Strong connections exist with key external science communities and end-users. The scope of SOOS is encompassed by the grey box.

SOOS works within the 2 core elements shown in Figure 2 above, with the SOOS governance structure of Scientific Steering Committee members, sponsors, partners and the IPO, all underpinning and managing the core elements:

1) SOOS Implementation:

- Bringing the community together to create a set of best practices and requirements (e.g., system design, methodologies)

- Coordination of international efforts towards enhanced collection of standardised observations

2) SOOS Output/Services
    - Data discovery/delivery
    - Communication of activities and products, informing the community

Mission and Values

The mission for SOOS is to facilitate the collection and delivery of essential observations on dynamics and change of Southern Ocean systems to all international stakeholders (researchers, governments, industries), through design, advocacy, and implementation of cost-effective observing and data delivery systems.

Underpinning this mission are values that are shared by SOOS and form the basis for our collaboration and connection with stakeholders.

- Open involvement of all interested nations, programmes, organisations and projects across all relevant disciplines, industries, and stakeholders
- Widespread adoption of international standards in data quality control and methodologies
- International sharing of resources and knowledge
- Open access to data and data products

Governance

SOOS has a relatively simple governance structure, with close connections to external scientific and coordination bodies. It is important to note that the governance bodies of SOOS, including the IPO, are not the core implementers of SOOS activities. They are support structures to provide guidance and strategic direction for the implementation groups (see Vehicles of Implementation below). The SOOS IPO and committees will:

1) Identify key communities already working towards addressing issues and build partnerships with these communities to facilitate their efforts;

2) Identify gaps in existing efforts and develop capability working groups or task teams from within the broader community to address these gaps; and

3) Develop strategies for the outcomes/outputs of the abovementioned efforts to be implemented through the regional working groups towards enhanced observations and data delivery

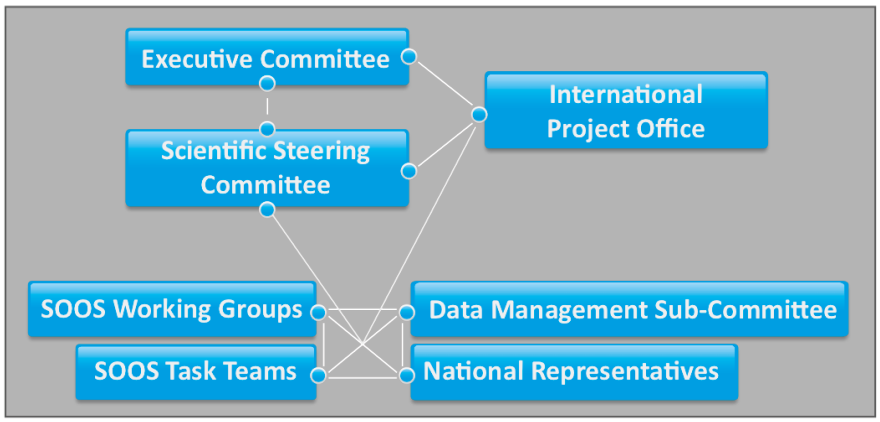

Figure 3: The governance and implementation structure of SOOS).

Committees

Executive Committee – www.soos.aq/about-us/ssc

The strategic vision and direction for SOOS is led by the Executive Committee (EXCOM) comprising a Biological Sciences Co-Chair and Vice Chair, a Physical Sciences Co-Chair and Vice Chair, and the Executive Officer. The EXCOM is in regular contact with sponsors and core stakeholders to ensure international input in the strategic governance of SOOS.

Scientific Steering Committee (SSC) – www.soos.aq/about-us/ssc

All SOOS activities are overseen by the international SOOS Scientific Steering Committee (SSC). The SSC meets annually and provides scientific direction for the SOOS in achieving its mission. The SSC comprises three organisational levels: EXCOM members, Scientific Members, and ex-officio representatives from key sponsors, nations and organisations.

Data Management Sub-Committee (DMSC) – www.soos.aq/data/dmsc

The SOOS Data Management Sub-Committee (DMSC) advises the SOOS SSC on the most effective collaboration mechanisms for managing and publishing observational data from the Southern Ocean. The DMSC comprises members who have professional data management expertise and who are affiliated with international and national data centres, networks, and programs.

The International Project Office (IPO) – http://soos.aq/about-us/ipo

The SOOS IPO is currently staffed by two personnel; an Executive Officer and a Data Officer, both with very different roles. The role of the Executive Officer is not one of SOOS implementation, but of support and facilitation of SOOS implementation. In addressing the 4 Objectives of SOOS (see page 14), the Executive Officer contributes predominantly to Objective 4, whist providing support for the greater community to achieve the other objectives. The Data Officer's role contributes predominantly to Objective 3, while again providing support across the other objectives as required.

VEHICLES FOR IMPLEMENTATION

Implementation of SOOS will be carried out by a combination of SOOS working groups and task teams, and through strategic partnerships with *external* programs and initiatives.

Working Groups

Regional Working Groups – www.soos.aq/activities/regional-wg

SOOS will ultimately be implemented regionally based on interconnected sectors of national infrastructure and activities. The Southern Ocean community has identified five priority regions for development as Regional Working Groups (RWGs): The Southern Ocean Indian Sector (SOIS), the Ross Sea, the Weddell and Dronning Maud Land, the West Antarctic Peninsula, and the Amundsen/Bellingshausen Sea.

The Regional Working Groups will coordinate and implement the observing system in their region, including facilitating improved readiness and ability where needed. Development of Regional Working Groups allows identification of overlap in national areas of focus and observational activities that could be translated into better logistic coordination, scientific collaboration, and sharing of operational resources. It also allows the creation of joint funding proposals to progress SOOS in these regions, where such mechanisms exist.

Participation in any given RWG is flexible and defined by the location of national infrastructure, shipping routes, and involvement in regionally defined activities (e.g., any countries working in a region can be "member nations"). Although membership is flexible, there will be a small number of representatives responsible for the overall coordination of each Sector, and for communication of information to and from the SOOS SSC (and other relevant Stakeholders).

Capability Working Groups – www.soos.aq/activities/capability-wgs

The development and implementation of technologies, improvement in observational design, efficiency and coverage, as well as processes for information management and dissemination will be managed by Capability Working Groups. These working groups may take advantage of new developments in science and technology or be established to fill important gaps identified by RWGs or the SSC.

Task Teams – www.soos.aq/activities/task-team

Task Teams are short-term initiatives developed to produce a specific SOOS product (e.g., publication or document), scope out community needs and readiness for actions on specific capabilities, or organise an activity. Task Teams are predominantly initiated

and driven by SOOS IPO and SSC, but input from the greater scientific community is sought where required. Task Group products will be made freely available from the SOOS website and/or the SOOS Zenodo Catalogue.

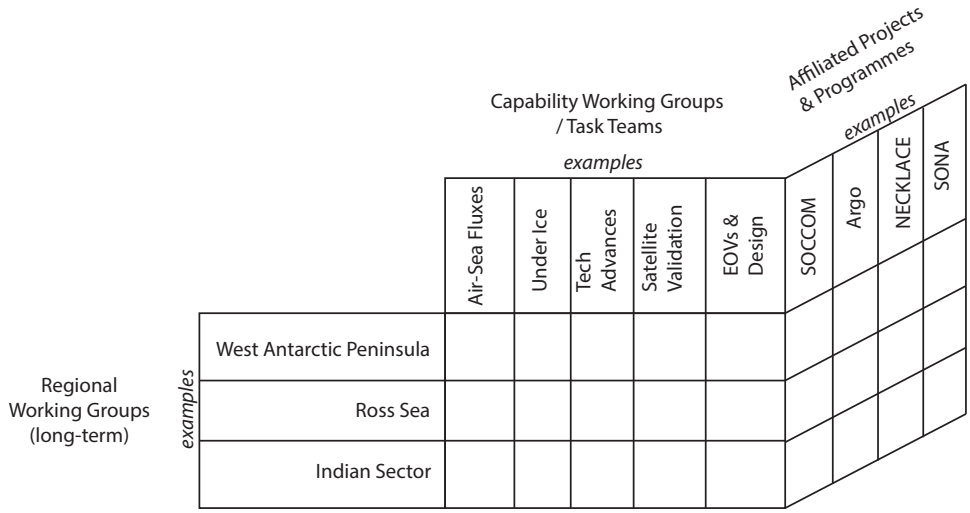

Figure 4: Existing national and international projects and programs contribute to SOOS and their efforts need to be identified and recognised as contributing regionally and/or to enhancing capabilities. This schematic visualises the relationship between Working Groups, Task Teams and affiliated activities in three dimensions.

Strategic Partnerships

There are numerous existing programs and initiatives that facilitate and coordinate some aspects of the planning, organisation, collection and management of observational data. These communities are therefore important for SOOS to connect to, and are direct contributors to SOOS implementation.

In instances where these communities are already active in efforts that will address SOOS objectives, SOOS will not duplicate efforts but rather identify ways that we can support the existing effort, if required. Where existing efforts require a level of modification to deliver against SOOS objectives, SOOS will work with the community to build on the existing effort and tailor outputs to SOOS requirements. In instances that no active efforts exist but SOOS has identified a requirement, SOOS Working Groups or a Task Team will work with any relevant community to address the issue.

In all cases, SOOS Working Groups and Task Teams will identify key programs and initiatives that should be engaged in the SOOS effort, to achieve common goals, avoid duplication and to enhance impact and reach.

More information on specific programmatic connections is available at www.soos.aq/network/programmatic-connections

SOOS NETWORK

SOOS has identified a network of programs and initiatives that must be connected to, to efficiently achieve our mission. The network encompasses communities that connect through both Governance structures and Implementation Vehicles, and also include end users of SOOS. Figure 5 below illustrates the network, as identified in 2016, whilst recognising that this is a flexible schematic that will likely change throughout the life of the Implementation Plan.

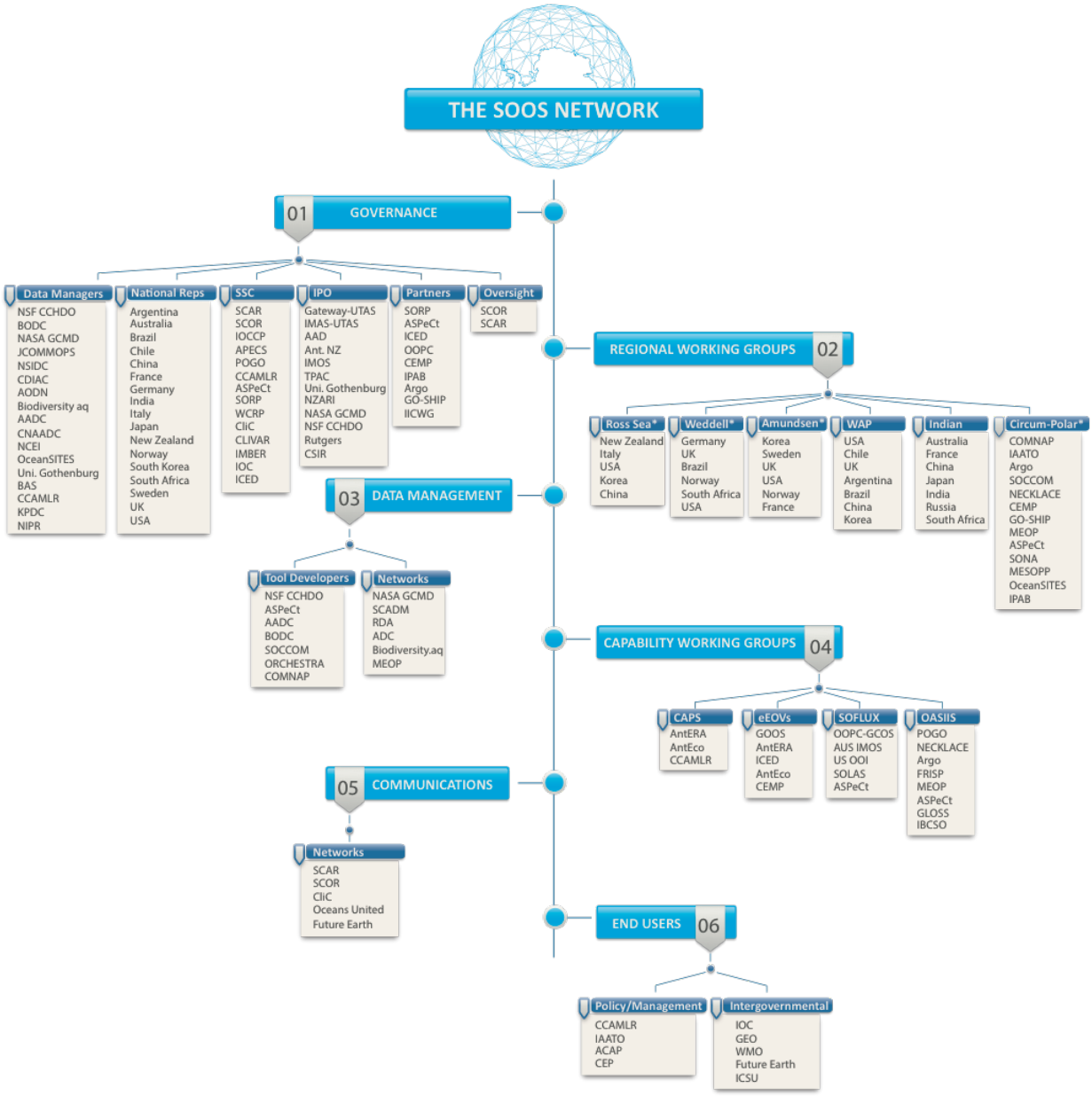

Figure 5: Schematic showing the programs, nations and initiatives that form the broad SOOS network. Many of these communities are Strategic Partners and help to implement activities and efforts towards SOOS objectives.

THE 5-YEAR STRATEGIC PLAN

SOOS has identified 4 key goals that will help address the key challenges (page 6), and from this, we have derived 4 Core Objectives and specific result areas that will address the causes (also page 6) of the key challenges.

Overall Goals

Goal 1: A coordinated, integrated, efficient, and sustained international program to deliver long-term, sustained observations of essential elements of Southern Ocean systems.

Goal 2: Regional implementation of long-term, sustained observations to achieve circumpolar coverage of Southern Ocean systems built upon existing efforts by national programs.

Goal 3: Facilitation and promotion of activities to improve observations of Southern Ocean systems, through international coordination and technological research and development, including the affiliation of projects and programs with this work.

Goal 4: Efficient and internationally integrated data management systems to enable stakeholders to access observations and synthesis products on the dynamics and change of Southern Ocean systems.

Objectives

Objective 1: Facilitate the design of a comprehensive and multi-disciplinary observing system for the Southern Ocean

- KRA 1.1: Establish criteria for adopting EOVs and communicate them
- KRA 1.2: Southern Ocean Essential Ocean Variables are identified and the manner in which they satisfy the criteria are communicated
- KRA 1.3: Spatio-temporal, system-level EOV sampling requirements are identified, documented and agreed, and strategies for implementation developed if needed.
- KRA 1.4: A strategy for the uptake of EOVs within the Regional Working Groups is developed

Objective 2: Unify and enhance current observation efforts and leverage further resources across disciplines, and between nations and programmes

- KRA 2.1: Working Groups and Task Teams that coordinate efforts across disciplines and programs, and between nations are developed to fill priority gaps

KRA 2.2: Key products for the Southern Ocean that aid in information transfer and facilitate collaborative efforts are identified and produced

KRA 2.3: Collaborative, multidisciplinary and multinational workshops and meetings are undertaken, resulting in the SOOS mission being achieved

Objective 3: Facilitate linking of sustained long-term observations to provide a system of enhanced data discovery and delivery, utilising existing data centres and programmatic efforts combined with, as needed, purpose-built data management and storage systems

KRA 3.1: A multidisciplinary metadata portal is developed and populated and continuously updated with records. Efforts include archiving of orphan datasets and advocating for direct links to the data in metadata records

KRA 3.2: Up-to-date information on key Southern Ocean data programmes, centres, and repositories is provided

KRA 3.3: Web-based tools will be explored and, as needed, developed to aid data discovery and delivery; the wider community is encouraged to adopt and enhance tools that already exist

KRA 3.4: Community-developed data synthesis tools and products for the Southern Ocean are accessible through the SOOS website

Objective 4: Provide services to communicate, coordinate, advocate and facilitate SOOS objectives and activities

KRA 4.1: The need for sustained Southern Ocean observations is strongly articulated

KRA 4.2: Engagement with international stakeholders, across all disciplines and nations, is maintained

KRA 4.3: A SOOS community bibliography is developed

KRA 4.4: The SOOS Communication Strategy is implemented

KRA 4.5: Support for SOOS International Project Office is maintained and enhanced

KRA 4.6: SOOS Administration, facilitation of Strategic Plan activities, and delivery of support services is maintained

Key Milestones, deliverables and timeline

Over the lifetime of this 5-year plan, SOOS plans to deliver the following outcomes/outputs

#		Additional Information	Implementers	Proposed Start	Proposed Delivery	Dependencies	Contribution to KRAs
#	**Objective 1: Facilitate the design of a comprehensive and multi-disciplinary observing system for the Southern Ocean**						
1	Published table of status of EOVs		SSC, Regional working groups, Capability Working Groups, broad community input	2017	2018		1.1; 1.2
2	Published, internationally defined criteria for EOVs		SSC, Regional working groups, Capability Working Groups, broad community input	2017	2018	#1	1.1
3	Compiled EOV descriptions and supporting documentation		SSC, Regional working groups, Capability Working Groups, broad community input	2018	2018	#2	1.1; 1.2; 1.3
4	Development of 5 international networks for regional coordination of SOOS implementation (Regional Working Groups)	Each regional working group will have group-specific products and outputs	Broad national, disciplinary and programmatic involvement	2016	2018		1.3; 1.4; 2.1; 2.3
5	Reviews of current status of EOV coverage, key gaps and requirements	Involves several workshops	Conducted regionally, by Regional Working Groups	2017	2019	#4	1.3
6	5 Regional implementation strategies		Regional working groups, Capability Working Groups, international field programs	2019	2020	#5	1.3; 1.4
31	Report identifying core satellite data requirements for the Southern Ocean		Designated SOOS Task Team, broad community input	2015	2016		2.2; 4.1
7	International strategic plan for observing the ocean beneath Antarctic sea ice and ice shelves	Other products/outcomes as a result of this working group are defined here	Capability working group, broad community input	2017	2019		1.3; 2.1
8	Coordinated network to enhance Southern Ocean flux observations	Specific products resulting from this coordinated network can be found here	Capability working group, broad community input	2016	2020		1.3; 2.1
9	International standards, methodology and strategy for sustained and reliable remote sensing-based monitoring of pack-ice-seal populations	Details on these products can be found here	Capability working group	2016	2020		1.3; 2.1
10	Development of international initiative to Benchmark Southern Ocean ecosystems, including implementation of eEOV-based system design	Specific products resulting from this initiative will be defined in the working group TORs and made available on the SOOS website	Capability working group	2016	2022		1.2; 1.3; 2.1

#							
#	**Objective 2: Unify and enhance current observation efforts and leverage further resources across disciplines, and between nations and programs**						
11	Database of Upcoming Expeditions to the Southern Ocean	www.duesouth.soos.aq http://data.aad.gov.au/duesouth/	IPO, DMSC, broad community engagement	2015	2017		2.2; 3.3
12	SOOS Map		IPO, DMSC, JCOMMOPS, EMODnet Physics, broad community	2016	2018		2.2; 3.3
13	Community annual calendar		IPO	2017	2017		2.2
14	Capability and Regional Working Group workshops	Each working group will likely hold a workshop/meeting each year, either virtually or in-person	Working Group members and broader community, IPO and SSC as required	As needed			2.1; 2.3
15	Capacity- or community-building workshops	Different to working group workshops, these events will focus on enhancing connections or building capacity in a specific aspect of SOOS (e.g., SOOS-Asian Workshop 2013; SOOS-SOCCOM joint workshop 2016; SOOS-AWI Symposium 2017)	Specific community focus but generally open to all	As needed			2.3
16	International conference sessions, town-halls, side meetings, information sessions		SSC, IPO, Regional working groups, Capability Working Groups	As needed			2.3; 4.1; 4.4

#	Objective 3: Facilitate linking of sustained long-term observations to provide a system of enhanced data discovery and delivery, utilising existing data centres and programmatic efforts combined with, as needed, purpose-built data management and storage systems						
17	Metadata Portal (NASA GCMD)	http://gcmd.nasa.gov/portals/soos/	IPO, DMSC, SCADM	2014	Ongoing		3.1
18	International Mooring Network	- Up-to-date list and interactive web-map of all Southern Ocean moorings http://www.soos.aq/activities/soos-at-sea/moorings - Registration of all mooring platforms at JCOMMOPS - Potential development of a THREDDS server to allow straightforward subsetting and merging of mooring datasets (not yet resourced)	IPO, DMSC	2015	2017		2.2; 3.1
19	Orphan data rescue	- International mooring data rescue - International glider data rescue	IPO, DMSC, GliderDAC, OceanSITES, other communities as required	2016	2020		3.1
20	Southern Ocean Glider Network	- Up-to-date list and interactive web-map of all Southern Ocean glider deployments and tracks - Registration of all glider platforms at JCOMMOPS	IPO, DMSC, GliderDAC,	2018	2020		2.2; 3.1
21	NECKLACE data management policy	- A data management policy is agreed by the NECKLACE community and documented by the IPO	IPO, NECKLACE community, DMSC	2016	2017		2.2; 3.1
22	Up-to-date catalogue of Southern Ocean data providers	- A list of data providers is published on the SOOS website and kept current	IPO, SSC	2016	2016		3.2
23	Federated Data Search tool	- A federated search tool enables direct searching of multiple data repositories simultaneously - Development requires a funding stream and a team of collaborators	IPO, DMSC, Broad community engagement	2017	2020		2.2; 3.3
24	Catalogue of key Southern Ocean data synthesis tools and products	- Lists of key Southern Ocean data synthesis products and tools are provided on the SOOS website. http://www.soos.aq/data/analysisvisualisation	IPO, SSC, DMSC	2017	2019		2.2; 3.4
25	Annual SOOS Data management sub-committee meetings		DMSC, observers	Annually			3.1; 3.2; 3.3; 3.4; 4.2; 4.6

#	Objective 4: Provide services to communicate, coordinate, advocate and facilitate SOOS objectives and activities						
26	Stakeholder Engagement Strategy	Internal document only	IPO, SSC, EXCOM	2017	2018		4.2; 4.6
27	5-Year Business Plan and Funding Strategy	Internal document only	IPO, SSC, EXCOM	2016	2018		4.5; 4.6
28	Annual SOOS scientific steering committee meetings		SSC, EXCOM, IPO, Observers	Annually			4.2; 4.6
29	Annual SOOS Executive Committee meetings		Executive Committee	Annually			4.5; 4.6
30	“SOOS Update” quarterly newsletter		IPO	2012	Ongoing		4.4
32	Progress reports to key stakeholders	SSC, SCAR, SCOR, ATCM, Sponsors	IPO, EXCOM	2012	Annual		4.1; 4.2; 4.3; 4.4; 4.5; 4.6
33	Products database	Online database of presentations, posters, publications, videos, science strategies and reports	IPO	2012	Ongoing		2.2; 4.4
34	An up-to-date website is provided		IPO	2012	Ongoing		2.2; 4.1; 4.2; 4.3; 4.4; 4.6
35	An efficient and productive International Project Office		IPO, EXCOM	2012	Ongoing		4.5; 4.6

Closing Statement

The SOOS 5-Year Implementation Plan communicates a step-wise, logical and realistic strategy towards achieving our ambitious long-term vision. The operating plan articulates the community effort required for each step, the resources required, and the measurable indicators of success. The governance structure for SOOS, and key international stakeholders and end-users, will play an important role in reviewing progress throughout the life of this plan. A detailed review of efforts will also take place in 2020, as part of the planning process for the following 5 years of SOOS implementation. Given the aim of sustained observation of the Southern Ocean, several core activities defined herein are likely to continue on into future implementation plans, as indicated in the Operating Plan. These efforts will require sustained resourcing and support at a minimum of the existing level, although growth in SOOS activities is required moving forward, and enhanced support is being sought to support this growth.

REFERENCES

Atkinson, A., Siegel, V., Pakhomov, E., Rothery, P., 2004: Long-term decline in krill stock and increase in salps within the Southern Ocean, Nature, 432, 100–103. doi:10.1038/nature02996

Bednarsek, N., et al.,., 2012: Extensive dissolution of live Pteropods in the Southern Ocean, Nature Geoscience, 5, 881-885. Doi:10.1038/ngeo1635

Böning, C.W., Dispert, A., Visbeck, M., Rintoul, S.R., and Schwarzkopf, F.U., 2008: The response of the Antarctic Circumpolar Current to recent climate change, Nature Geoscience, 1, 864–869.

Bost, C.A., Cotte, C., Terray, P., Barbraud, C., Bon, C., Delord, K., Gimenez, O., Handrich, Y., Naito, Y., Guinet, C. and Weimerskirch, H., 2015: Large-scale climatic anomalies affect marine predator foraging behaviour and demography, Nature Communications, 6: 8220. Doi:10.1038/ncomms9220

Constable, A.J., et al., 2014: Climate change and Southern Ocean ecosystems I: how changes in physical habitats directly affect marine biota, Global Change Biology, 20, 3004-3025.

Durack, P. J., and Wijffels, S.E., 2010: Fifty-year trends in global ocean salinities and their relationship to broad-scale warming, Journal of Climate, 23, 4342–4362

IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Murphy, E.J., et al., 2012: Developing integrated models of Southern Ocean food webs: Including ecological complexity, accounting for uncertainty and the importance of scale, Progress in Oceanography, 102, 74-92.

Nymand Larson, J., Anisimov, O., Constable, A.J., Hollowed, A., Maynard, N., Prestrud, P., Prowse, T., Stone, J., 2014. Chapter 28: Polar Regions, in: Field, C.B., Barros, R.B. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Report of Working Group II. Intergovernmental Panel on Climate Change, San Francisco, p. 71 pp.

Palter, J.B., Sarmiento, J.L., Gnanadesikan, A., Simeon, J., and Slater, R.D., 2010: Fueling export production: Nutrient return pathways from the deep ocean and their dependence on the meridional overturning circulation, Biogeosciences, 7, 3549–3568, doi:10.5194/bg-3547-3549-2010

Parkinson, C.L., and Cavalieri, D.J., 2012: Antarctic sea ice variability and trends, 1979-2010, The Cryosphere, 6, 871–880, doi:10.5194/tc-6-871-2012.

Purkey, S.G., and Johnson, G.C., 2010: Warming of global abyssal and deep Southern Ocean waters between the 1990s and 2000s: Contributions to global heat and sea level rise budgets, Journal of Climate, 23, 6336–6351.

Rintoul, S.R., Sparrow, M., Meredith, M.P., Wadley, V., Speer, K., Hofmann, E., Summerhayes, C., Urban, E., and Bellerby, R., 2012: SOOS Initial Science and Implementation Strategy. soos.aq/resources/science-strategies

Sabine, C.L., et al., 2004: The oceanic sink for anthropogenic CO2, Science, 305, 367–371.

Trivelpiece, W.Z., Hinke, J.T., Miller, A.K., Reiss, C.S., Trivelpiece, S.G., and Watters, G.M., 2011: Variability in krill biomass links harvesting and climate warming to penguin population changes in Antarctica, Proceedings of the National Academy of Sciences, 108, 7625–7628. doi:10.1073/pnas.1016560108