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Antarctic Near-shore and Terrestrial Observing System (ANTOS)

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Working Paper submitted by SCAR, New Zealand, Australia, Italy, Korea (ROK), and the United States

Summary

The aim of SCAR's Antarctic Near-shore and Terrestrial Observing System (ANTOS) is to establish an integrated and coordinated trans-continental and trans-regional environmental surveillance system to identify and track environmental variability and change at biologically relevant scales. This valuable information will be used to provide a more complete understanding of changes occurring in the Antarctic region, by informing biological, physical, and earth science studies and supporting decision making. SCAR, New Zealand, Australia, Italy, the Republic of Korea, and the United States recommend that the CEP:

i) acknowledges and welcomes the concept and goals of ANTOS;
ii) encourages national programmes to engage in ANTOS, and to support the establishment of ANTOS sites within their areas of operation and make data available from such sites as soon as possible.

Background

The Antarctic Near-Shore and Terrestrial Observing System (ANTOS) is a biologically-focussed initiative to coordinate a cross-continent and cross-national programme-scale assessment of environmental variability and change. It was established by SCAR in response to the widely identified need for a long-term commitment to acquiring fundamental information to underpin identification of trends and changes in Antarctic ecosystems[1,2], and was previously highlighted in ATCM XXVIII IP19 *SCAR Annual Report 2014/15.*

The CEP has identified a need for long-term monitoring of change in terrestrial and marine environments to inform its work on priority issues. This is reflected in the science, knowledge and information needs identified in the Five-Year Work Plan under the priority issue 'Monitoring and state of the environment report', and also in the Climate Change Response Work Programme (CCRWP), which includes a call to 'Support and undertake long term monitoring of change, including collaborative efforts (e.g. ANTOS)'.

There is a critical need for long-term observations to underpin our ability to understand how the Antarctic environment and ecosystems are likely to respond to climate change. To accurately predict and identify such changes, it is necessary to understand existing patterns and processes, and the magnitudes and rates of natural variability in both marine and terrestrial systems, at spatial and temporal scales relevant to their biota and communities. Such information requires

[1] Kennicutt, II M.C., Chown, S.L., Cassano, J.J., Liggett, D., Massom, R., Peck, L.S., et al. (2014a) Six priorities for Antarctic science. Nature, 512: 23-5.

[2] Kennicutt, II M.C., Chown, S.L., Cassano, J.J., Liggett, D., Peck, L.S., Massom, R., et al. (2014b) A roadmap for Antarctic and Southern Ocean science for the next two decades and beyond. Antarctic Science. Doi:10.1017/ S0954102014000674.

long-term commitments to monitoring, and is crucial for informing effective management approaches.

Following a workshop held in August 2014 at the SCAR Open Science Conference in Auckland, ANTOS was established as a SCAR Action Group, with a remit to further develop the ideas behind ANTOS. The Action Group continued until 2016, at which point it was transitioned to an Expert Group. Further information on ANTOS, including recent workshop reports, is available at: https://www.scar.org/science/antos/home/.

Goals of ANTOS

ANTOS has been designed to be of relevance to all national programmes. Its goals are to:

- Establish an observation network of representative sites in the terrestrial and near-shore marine environments around Antarctica and the sub-Antarctic;
- Measure parameters, using the same instrumentation technology across the entire network and over the long-term, that will harness the sensitivity of biological response to enhance our understanding of environmental change;
- Stimulate the development of new observation technologies, data capture, and data sharing;
- Encourage buy-in and involvement of all national programmes through a 'tiered observation network' from basic and relatively inexpensive to more complex systems, requiring varying levels of resourcing, logistic and scientific capabilities (Annex 1);
- Provide opportunity for alignment of national and international programmes and projects, and an observational platform to underpin other science activities;
- Provide information to support policy decision-making, especially in terms of long-term monitoring of sites with high biodiversity and living values, including ASPAs and ASMAs.

Current status and next steps

A network of ANTOS instrument systems will be established at sites in terrestrial (including freshwater and ice/snow where appropriate) and near-shore marine environments. These ANTOS sites will be selected based on current long-term monitoring efforts, and will share basic characteristics of representative biodiversity for the region concerned, environmental features likely to be informative in the context of change studies, and practicality of access and working. The goal is a network of representative sites across Antarctica and the sub-Antarctic islands linked to other southern continents. This is likely to be achieved through building initially on a core set of existing and relatively well-documented locations, while at the same time identifying additional locations suitable for construction/installation of new sites.

Establishment of at least one ANTOS site in each Antarctic and Sub-Antarctic bioregion, including each of the 16 Antarctic Conservation Biogeographic Regions (ACBRs) is desired to begin to meet the goal of comprehensive spatial coverage. Thirteen potential ANTOS sites have been identified in the Antarctic Treaty Area, following a consultation process that included two SCAR community surveys to assess where long-term biological monitoring is occurring and to nominate other potential sites. These data and proposed sites, along with other as yet unidentified sites, will be discussed at an ANTOS workshop scheduled during the SCAR Biology Symposium in July/August 2023.

Biological baseline data will be collected at ANTOS sites using ANTOS installations of varying complexity and financial cost (Tier systems 1-3, as described in Annex 1). At each site, measurements of biologically relevant attributes of change will be made within six broad

criteria: physical environment, colonisation, diversity, distribution, function, and genetics. These attributes encompass desirable parameters required for detecting, understanding, and interpreting change in both near-shore and terrestrial systems.

All ANTOS installations should be consistent in design and makeup (for near-shore marine and terrestrial, respectively). Instrumentation will measure a suite of agreed parameters at the specified resolution and temporal scale so that data can be integrated and usefully compared. Data will be automatically uploaded to an open-source database, and made available immediately.

The success of ANTOS will be dependent on the extent of spatial coverage and national programme participation, and on the long-term sustainability of the monitoring effort.

Full technical manuals have been developed for each Tier system (1-3) for both near-shore marine and terrestrial installations. Near-shore marine and terrestrial biological survey manuals are being developed and will be launched at the SCAR Biology Conference (July/August 2023). The ANTOS database has been developed by, and is now being hosted by the Korea Polar Research Institute (KOPRI). There are currently four trial Tier 1 terrestrial systems installed at Cape Adare and the McMurdo Dry Valleys, and the first Tier 3 terrestrial system is scheduled to be installed at Casey Station during the 2023/24 season. Trial near-shore marine Tier 1-2 systems are currently being tested at Cape Evans, Granite Harbour and Terra Nova Bay.

Recommendations

To ensure that the work of the CEP is supported by the most up-to-date understanding of change in near-shore and terrestrial environments and ecosystems, SCAR, New Zealand, Australia, Italy, the Republic of Korea, and the United States recommend that the CEP:

i) acknowledges and welcomes the concept and goals of ANTOS;

ii) encourages national programmes to engage in ANTOS, and to support the establishment of ANTOS sites within their areas of operation and make data available from such sites as soon as possible.

Annex 1: Details of ANTOS terrestrial and near-shore marine tiered systems

Terrestrial Tiered system

Change	Tier 1 ($)	Tier 2 ($$)	Tier 3 ($$$)
Physical	• Wind speed and direction • Air temp (2 for calibration) • RH (air) • Light • PAR • Due point • Soil Moisture and temp	• Wind speed and direction • Air temp (2 for calibration) • RH (air) • Light • PAR • Due point • Precipitation/snow fall • Active layer (soil moisture and temp – 10cm intervals) • Possibly – WiFi capability for local slave sensor arrays	• Wind speed and direction • Air temp (2 for calibration) • RH (air) • Light • PAR • Due point • Precipitation/snow fall • Active layer (soil moisture and temp – 10cm intervals) • WiFi capability for local slave sensor arrays
Remote Sensing	NA	MODIS-basic snow cover assessment	MODIS, ISAT, Worldview 2, 3
Aeolian	Passive	Active inc. composition and particles size	Active inc. composition and particles size Ice core analysis
Respiration	NA	CO_2 gas Flux (local)	Soil CO_2 Gas Flux (regional) Soil CO_2 flux subsurface array Gas cycling
Biological activity	NA	PAM – photosynthesis	PAM – photosynthesis Eddy covariance
Biodiversity	Basic local survey: • Composition • Distribution • Basic vegetation mapping	Complete survey (NZTABS style-10 yearly): • Composition • Distribution • Comprehensive vegetation mapping (5 yearly)	Complete survey (NZTABS regional style): • Comprehensive composition survey • Distribution • Comprehensive vegetation mapping • Spectral mapping • Population genetic survey
Soil Geochemistry	Basic Nutrients EC Conductivity	Nutrients, TOC, TON Elements (ICP-MS) EC	Nutrients, TOC, TON Elements (ICP-MS) EC

Near-shore Marine Tiered System

These Tier systems build on each other; i.e., Tier 2 systems collect all Tier 1 data and more, and Tier 3 systems collect all of the Tier 1 and Tier 2 data and more.

	Tier 1 ($)	Tier 2 ($$)	Tier 3 ($$$)
Site Description	**General description** • Location • Surroundings • Habitats • Sea ice characteristics/ Chlorophyll *a* /Sea Surface Temperature (SST)	**General description** • Sea-ice characteristics	**General description** • Water column assessment (CTD) • Multibeam hydroacoustic mapping • Contaminants
	Environment time series data Temperature • Photosynthetically active radiation (PAR) • Conductivity • Chlorophyll *a* • pH/ (Alkalinity/DIC/ pCO_2)	**Environment time series data** • pH/ (Alkalinity/DIC/ pCO_2) /Turbidity/ O_2	**Environment time series data** • Current (ADCP) • [Optional] Real-Time Data Transmission
Diversity/ Abundance/ Distribution	**General description of Flora and Fauna** **Epifauna / Flora** **Infauna –Macrofauna,** **Infauna - Meiofauna** **Plankton** **Seafloor substrate** • Sediment characteristics (grain size, Chlorophyll *a*, organic content) • Hard substrate characterisations Biogenic habitat	**Greater Replication** • Capture spatial variability as well as permanent transects **Epifauna / Flora** • Photogrammetry (diver / ROV) • Sample and ID discrete specimens (genetic and morphological analyses) **Infauna** • Macrofauna, meiofauna **Plankton** • Water sample / net (genetic analysis)	**Nested Replication** **Broad-scale Mapping** • ROV/AUV/Vessel-towed imaging systems **Seawater** • eDNA (emerging standard)
Colonisation	• Settlement by epifauna/flora • Larval dispersal	**Epifauna / Flora** • Genetic analysis (barcoding / metabarcoding) of settlers/dispersers **Infauna** • Sediment trays/cups (genetic analysis of settlers)	
Ecosystem function		**Epifauna / Flora** • Trophic connections (isotope analysis) • Assessment of benthic primary production • Identify sentinel species	**Epifauna / Flora** • Time-lapse cameras (long-term) • Sentinel species (behaviour, fecundity, gene expression) • Ecophysiology • Experiments • Microbiome