Southern Ocean Observing System
West Antarctic Peninsula (WAP) Working Group Meeting
British Antarctic Survey, May 15-16th 2017

Attendees of the WAP WG Meeting, BAS Cambridge May 2017

1. Introduction and meeting aims:

The first meeting of the West Antarctic Peninsula (WAP) Working Group (WG) of the Southern Ocean Observing System (SOOS) was held at the Aurora Centre at the British Antarctic Survey, High Cross, Cambridge, on May 15-16th 2017. The aims of the meeting were:

- to establish some of the key scientific questions surrounding the WAP
- to share information about the existing sustained observational programs along the WAP and plans/aspirations for their futures
- to discuss how a WAP component of SOOS might be constructed in the context of these activities, and how such a system might be best implemented and operated.

Different sessions included a keynote talk and a number of shorter talks, from selected members of the WAP scientific community, with each day ending in a discussion session.

The meeting was supported by SOOS, the Scientific Committee on Antarctic Research (SCAR), the Scientific Committee on Oceanic Research (SCOR), and the Natural Environment Research Council (NERC-ORCHESTRA). A follow-on Royal Society International Scientific Meeting was held at Chicheley Hall, on WAP biogeochemistry (May 17-18th).

Attachment 1: Meeting program, with list of participants.
Attachment 2: Report from Royal Society International Scientific Meeting, May 17-18th, 2017.

2. Summary of key points:

The key 'big-picture' questions surrounding the West Antarctic Peninsula (WAP)

- How is the WAP changing?
- What's driving the changes?
- Why is the WAP heterogeneous?

The scientific issues from across all WAP science disciplines

- Complexities at different spatial and temporal scales
- Sampling bias in context of spatial and temporal heterogeneity
- Challenges in identifying the key processes and rates
- Challenges in identifying the key questions relating to latitudinal variation

Long-term solutions across the board

- Continued, basic long-term monitoring (from all nations)
- Improved data availability and sharing
- Developments in sampling – especially autonomous - methodologies
- Improved networking of stations
- Developments in portability of research infrastructure
- Improved networking of people, including in other disciplines such as glaciology, atmospheric science and ice core scientists
- Enhanced model capability
- Engagement with other organisations and with industry
- Engagement with citizen science, through conversations with cruise ships, and development of apps and approachable literature

Immediate priorities for the WAP Working Group

- WG mailing list
- Continued cross-discipline discussion within community with future meetings
- Reports and summaries for the general public
- Discussion of basic requirements for SOOS (in the form of both reports and Progress in Oceanography paper) and development of a WAP science meta-database (data, requirements, contacts, experts etc.)
- Dedicated effort for the engagement with industry, to be organised via email listing

3. Summary of discussions on research gaps, priorities and future vision:

The workshop comprised four sessions, each featuring a keynote presentation (of 30 minutes) and talks (of 15 minutes). There was a proportion of each day set aside for questions and discussions that arose from the talks. The speakers had been given the brief to include in the final slides some comments about the outstanding questions in their field, and where they see gaps and future research priorities. The discussion surrounding the talks focused largely on these final comments and some further questions posed by the chair: what are the barriers to filling these gaps? And how can we maximise the use of existing facilities?

The key questions surrounded the assessment of change on the WAP in a clear latitudinal context, and the understanding of the heterogeneity of the environment and the processes going on that control the "patchiness" of the WAP. The main barriers to this assessment were broadly accepted to be the lack of long records (sufficiently long to detect decadal variability, for example), and the

lack of high resolution of sampling, both spatially and temporally, for all observations across all disciplines. There is a lack of inclusion of process studies, and we do not have a full understanding of the fluxes between various components of this highly complex, highly connected system.

The solution to these issues - other than simply further funding - were discussed at length and were generally perceived to lie firmly in utilising and optimising existing infrastructure over the long-term. Fundamental long-term monitoring at all stations along the WAP is required to continue, and this needs to be the priority for core national funding. Closer communication between different stations would be beneficial, allowing standardisation of sampling and analytical methods. Larger scale collaborative, international effort is required for larger, new infrastructure initiatives, such as HF radar networks and under-ice sonar networks, with examples being taken from successful previous initiatives, as well as station infrastructure and personnel for winter work and wider use of portable container labs. Data availability was a topic of enthusiastic discussion, with the agreement that meta-data management should be a priority. It was proposed that a meta-data portal be set up containing information on projects ongoing and planned at the WAP, datasets and samples available, and who to contact for information, which would be available to the whole WAP community. SOOS would be an ideal host to such a meta-data portal, and the WG strongly supported this as a priority and clearly aims to participate as much as possible with this activity. The WG also agreed to encourage the networking of people, via maintaining an email list, especially people from other countries engaged in Antarctic research (not represented at this meeting), other SOOS WGs, and people from other SCAR disciplines (especially glaciologists, terrestrial biogeochemists, atmospheric scientists and palaeoclimatologists). Alternative routes to funding were also discussed at length, including engagement with industry and citizen science, including work with cruise ships and the development of user-friendly apps.

4. Full synopsis of meeting talks:

In the first session on physical oceanography and climate, **Mike Meredith** (British Antarctic Survey) discussed the role of freshwater on the dynamics of the WAP. One of the key findings is that the proportion of freshwater originating from sea-ice melt in the surface ocean is influenced strongly by the timing of the spring melt. **John Turner** (British Antarctic Survey) discussed atmospheric-ocean interactions, their temporal changes, and their role in climate change along the WAP. **Carlos Moffat** (University of Delaware) discussed oceanic pathways and circulation along the WAP shelf, highlighting the importance of canyons in deep-water supply to the shelf, and topographic mixing by mesoscale processes. He presented new eddy resolving models that can be used to further our understanding of these features. **Josh Kohut** (Rutgers University) presented work on the role of physics and oceanography on the foraging behaviour of penguins along the WAP, highlighting how the physical dynamics can influence behaviour of organisms and impact ecology. Josh presented new advances in surface current and particle monitoring, and the mapping of fronts, and how these relate to foraging behaviour.

This first session identified from the start one of the key questions: what is the long-term climate variability along the WAP? and how can we embed process studies into observations? All speakers suggested that the key gaps were winter-time data, which could be obtained from autonomous vehicles, float networks etc. including technology that could extend to the ocean surface and under the ice; more information about circulation and mixing (using terrain-following floats, HF radar deployments); sea-ice representation in models; limited-area models that are fully coupled with air-

sea-ice interactions; sustained observations that are eddy-resolving (provided by gliders and possibly by seal CTDs); and higher-resolution models with the matched higher-resolution observational data. Additional future directions for physical oceanographic research in this context included work on the deconvolution of glacial discharge versus precipitation as contributions to meteoric freshwater; an understanding of the fate of water intrusions along canyons, and the exchange of water between shelf and straits; and studies into the biological hotspots, and the mechanics that determine where these hotspots are situated.

In the second session on biogeochemistry, **Anita Buma** (University of Groningen) discussed climate change and the changes in biomass and phytoplankton community composition. She presented results on pigment analysis from the Rothera Time Series, illustrating changes in population structure, photoacclimation, and their correlations with environmental parameters, including some winter-time results. **Rob Sherrell** (Rutgers University) presented dissolved and particulate trace metal results, illustrating the natural micronutrient fertilization along the WAP. He also presented some of the trace metal clean sampling methods required for this research and brought up the important point that it is crucial to understand the bioavailability of the trace metals, in addition to simply their bulk concentration. **Irene Schloss** (Instituto Antártico Argentino) reviewed the research being carried out by the Argentinian Antarctic program, including monitoring, long-term data sets and emerging programs (noting that there is a lot of data available on Pangaea, via CCAMLR and via individual Principal Investigators), and highlighting the need for more sharing of data and a "wish list" for future collaborations. The science involved includes physics and hydrography, phytoplankton (HPLC), fish (note: via CCAMLR), penguins, mammals (land and sea based), flying birds, chemical contaminants, krill, zoobenthos, microbial ecology, ecophysiology and ecotoxicology, freshwater and terrestrial biology. **Kate Hendry** (University of Bristol) explored some of the possible applications to WAP science of the novel approaches that are being developed in isotope geochemistry. **Sian Henley** (University of Edinburgh) discussed the importance of macronutrient dynamics along the WAP, their links with sea-ice melt and upper ocean physics, and the interannual variability in their behaviour.

The speakers in this session highlighted the links between physics and biology, and the consequences of physical forcing on nutrient availability; the big questions in the field related to the factors that limit winter-time resupply of nutrients that feed the spring bloom; nutrient recycling and sedimentary processes. Current gaps in the understanding of biology and biogeochemistry are closely linked to similar issues with physical understanding, reflecting the close links between physical forcing, biology and chemistry. These include: identification of the relationship between biomass and sea-ice; the lack of winter and early-spring data; higher spatial resolution of sampling; sediment sampling and the incorporation of nutrient recycling and sedimentary processes in models; and the requirement for technological advances (e.g. moored time-series sampling methods, sampling from autonomous vehicles, sensor development, trace metal clean capabilities). There are also other future targets for biogeochemical research including collaborative efforts for targeted sampling, interlaboratory comparisons and standardisation of protocols.

In the third session on foodwebs, **Debbie Steinberg** (Virginia Institute of Marine Science) reviewed the zooplankton and foodweb interactions studied in the LTER program, including macrozooplankton and ichthyoplankton (larval fish), mesozooplankton, and microzooplankton (the latter without sustained observations). She highlighted new sampling methods including MOCNESS

sampling nets, and acoustic sampling. **Cesar Cardenas** (Chilean Antarctic Institute - INACH) reviewed the activities of the Chilean Antarctic program. He started by reviewing the status of the research stations: Yelcho is reopening, and Carvajal is also partially reopening to some science in the near future. There are some important international joint funding opportunities (e.g. NERC-CONICYT) and several research themes are highlighted, including a socio-economic line of enquiry. Future developments include continuous measurements (e.g. moorings and sediment traps; underway sampling from ships). **Leonardo Saravia** (Universidad Nacional de General Sarmiento) discussed Potter Cove food webs, and how understanding the interactions today will help to predict changes in the future: are there small changes that can be made to improve our predictions? The food webs are modelled – after network simplification – using a stochastic network interaction model. The models are used to investigate sensitivities of the system: what can destabilise a system and how? What are the impacts of ice berg scours? What are the impacts of invasive species? **Eugene Murphy** (British Antarctic Survey) presented the Integrated Climate and Ecosystems Dynamics in the Southern Ocean (ICED) project, investigating biodiversity, integrated with ecosystem dynamics, and potential feedbacks with the Earth system. He highlighted the power of sustained observations and the need to bring in other people at this stage for project assessment. An important future development would be the development of an ecological observing system through SOOS, using the existing platforms in the Scotia Sea as templates: e.g. BAS-POETS (ecosystem studies at a variety of spatial and temporal scales in the Scotia Sea, including technologies such as predator observations and SCOOBIES). Whilst this work is going on in the Scotia Sea, there is a significant upstream influence from the WAP, highlighting the need for the different WGs to have a good two-way flow of information.

The discussion during this session raised key questions surrounding the location of hotspots of biological activity, and whether the study locations that are utilised are representative of the WAP more generally. Gaps in ecosystem observations were highlighted: food web structures and their ties with physical forcing, geographic data vs. regional data, connectivity and seasonality, and the need for more technological advances (building on autonomous platforms and drone technology), modelling efforts (building of food web models that include key species) and large scale observational studies (e.g. Observation System Simulation Experiments (OSSE)). Eugene Murphy also brought the International Marine Ecosystem Assessment for the Southern Ocean (MEA SO18), Hobart, 2018, to the attention of the audience. Again, the need for wintertime data was emphasised. Further avenues of future research include the development of proxies of nutritional value in food webs, a better mechanistic understanding of microzooplankton grazing and mesopelagic processes, and more interactions with other scientists in order to assimilate data describing species diversity and assemblage abundance over the long-term.

In the final session on documenting and understanding change, **Lloyd Peck** (British Antarctic Survey) reviewed the work being carried out at Rothera Research Station on benthic biology, including monitoring and repeat survey work, and long-term experiments. These studies have implications not only for the ecosystems but also for carbon drawdown by secondary production, physiology and performance of organisms within ecosystems, and for socio-economic studies (e.g. understanding of fouling). He highlighted the need for very long-term monitoring (e.g. acclimation experiments), often beyond the scope of a PhD project. **Dan Costa** (University of California Santa Cruz) presented current research on large predators along the WAP, and discussed their role in partitioning of resources and space within ecosystems. The key questions highlighted included: how will these predators adapt in the future? Can they change, can they migrate? And how will these

shifts in predator abundance and behaviour influence community structure? Lastly, there was also a reminder of the utility of predators in collecting oceanographic data via CTD tagging. **Sevrine Sailley** (Plymouth Marine Laboratory) discussed the role of data analytics and food web modelling in understanding processes along the WAP. The development of these models requires higher-resolution data, as well as a sound understanding of processes and their rates, and feedback from the community. **Corina Brussaard** (NIOZ Royal Netherlands Institute for Sea Research) reviewed some of the work being carried out in the field of marine virus ecology, and their complex interactions with individuals up to the ecosystem scale. Viruses are an important factor in carbon production: viral lysis results in the removal of nutrients away from higher trophic levels, reduces organic matter export and releases carbon dioxide. She highlighted various projects in the pipeline, including studies into "who infects whom" and the environmental impacts of virus-host interactions. Lastly, **Doris Abele** (Alfred Wegener Institute) discussed the role of microorganisms in WAP ecosystems, and the role of succession of organisms during blooms. She also presented a new study on the nature of dissolved organic matter during blooms, including quantitative descriptions of ligands that have an important role in trace metal availability, and a study on toxin tracking. She highlighted the potential of novel biomarkers, molecular and genomic approaches in WAP ecosystem studies and proposed the utility of an event-triggered monitoring system.

The speakers in this final session summarised again some of the important issues surrounding documenting change on the peninsula. The system is highly heterogeneous, and we need high-resolution spatial and temporal observations to document variability, to provide appropriate parameters for modelling efforts, and to – very fundamentally – understand why the system is so "patchy". Connectivity between different components of the system is key: understanding not only air-sea-ice connections, but also benthic-pelagic coupling. We also need to grasp a wide variety of processes linked with these connections, and their rates. There are still clear gaps in our knowledge and approaches, many of which have been reiterated by every session: the need for long-term records and baselines (from direct measurements and palaeoclimate studies), the need for winter-time sampling, and the fundamental importance of accurate estimates of biomass and how organisms cycle and remove carbon and nutrients within the system, including estimates of microbial production.