Integrated analyses of circumpolar Climate interactions and Ecosystem Dynamics in the Southern Ocean (ICED) Science Planning Workshop, Cambridge, UK, 24–26 May 2005

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The Southern Ocean is a key system in the global ocean and there are important climate influences from lower latitudes across the Southern Hemisphere. Understanding the processes that control variability in the structure and dynamics of Southern Ocean ecosystems is increasingly recognised as one of the major challenges for future scientific effort. The last two decades has seen the development of a number of national programmes and the emergence of well-coordinated international programmes. During the last decade, the focus for Southern Ocean ecological programmes has shifted to encompass the whole system, from studies of ocean circulation and chemistry, through to analyses of organisms (from microbes to whales) at different trophic levels in the food web. Results from these studies will be the focus of synthesis and modelling activities in the coming years, as well as providing the basis for additional focused process studies.

An emerging result of these national and international programmes is a better understanding of circumpolar climate variability and its influence on the regional dynamics of Southern Ocean ecosystems. Similarly, there is now a better understanding of the importance of ecosystem structure in determining ecosystem function. For example, it is now recognised that carbon cycling, its retention in the surface waters and its export to depth, are functions of regional ecosystem structure. This type of holistic approach to understanding Southern Ocean ecosystems is even more vital now, given the impending climate change scenarios envisaged for this region. The next major steps in Southern Ocean ecosystems and biogeochemical research require integrated and coordinated circumpolar analyses. Although there has been a high level of coordination within the various international programmes this has often been limited in geographical coverage and generally focused on only one or two tropic levels or aspects of ecosystem operation.

The Integrated analyses of circumpolar Climate interactions and Ecosystem Dynamics in the Southern Ocean (ICED) is a new international and multi-disciplinary programme designed to address the need to understand how climate and anthropogenic forcings may affect the ecosystems of the Southern Ocean. ICED forms part of the new joint Scientific Committee on Oceanic Research (SCOR) and International Geosphere-Biosphere Programme (IGBP) initiative entitled Integrating Marine Biogeochemistry and Ecosystem Research (IMBER). ICED will build upon the research and experience of the recently completed Southern Ocean Joint Global Ocean Flux Study and the soon to be completed Southern Ocean Global Ocean Ecosystems and Dynamics (SO GLOBEC) programme. ICED will participate in the synthesis phase of SO GLOBEC and will integrate activities of the Climate Variability

Figure 1. Participants in the ICED workshop (left to right; back to front) are: J. Watkins, N. Johnston, W. Fraser, P. Chernyshkov, E. Pakhomov, M. Meredith, C. Summerhayes, G. Hosie, R. Holt, J. Turner, T. Trull, E. Hofmann, S. Blain, S. Nicol, F. Dehairs, D. Agnew, C. Lancelot, A. Atkinson, W. Smith, A. Sanchez, U. Bathmann, A. Worby, A. Beckmann, S. Reilly, P. Trathan, H. Wiemerskirch, T. Odate, K. Reid, E. Murphy and H-C. Shin. Absent from photo: J. Hall and G. Henderson. D. Theile and G. Sarthou contributed to workshop but could not attend.

and Predictability/Climate and Cryosphere (CLIVAR/CliC) programme, International Polar Year (IPY), Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), International Whaling Commission (IWC), GEOTRACES and the Surface Ocean-Lower Atmosphere Study (SOLAS).

To launch ICED, EUR-OCEANS, the Natural Environment Research Council, Scientific Committee on Antarctic Research (SCAR), SCOR, IMBER and SO GLOBEC funded the programmeís first workshop in May 2005. The workshop was held at the British Antarctic Survey, UK and involved 34 participants from 14 countries (Fig. 1).

During the first part of the workshop presentations were delivered by representatives of national Antarctic programs (Australia, Belgium, France, Germany, Japan, Republic of Korea, Russia, UK and USA) and international initiatives with a Southern Ocean research component (IMBER, SO GLOBEC, CLIVAR/CliC, IPY, CCAMLR, IWC, GEOTRACES and SOLAS) summarising their current research foci and highlighting key logistic and fieldwork issues.

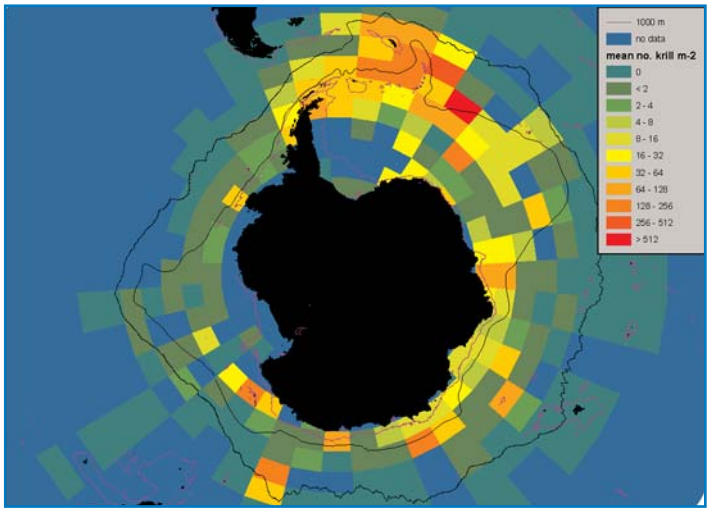

Figure 2. Mean density of Antarctic krill (Euphausia superba) (numbers per m^2) across the Southern Ocean. Data based on 6675 net samples taken between 1926 and 2003. Source Atkinson et al., (2004).

During the second part of the workshop presentations were given by invited delegates on scientific issues in Southern Ocean ecosystems research under the following scientific themes: 1) Atmosphere-ice-ocean connections, 2) Biogeochemistry and nutrient chemistry, 3) Ecosystem structure and dynamics, 4) Sustainable management and ecosystem structure and 5) Circumpolar models. The workshop discussed the above scientific themes and identified two major aspects:

1. The potential value of large-scale comparative studies of the operation of whole ecosystems. This could be between major regions such as the Weddell Sea and Ross Sea;
2. The importance of circumpolar integration studies linking across climate, biogeochemical and ecosystem processes.

The need for large-scale comparative studies is highlighted by a recent study (Atkinson *et al.*, 2004) showing changes in the distribution of two important grazers, Antarctic krill (*Euphausia superba*) and salps (*Salpa thompsoni*), in the Southern Ocean food web (Fig. 2). The changing sea ice (Fig. 3) environment is just one of many ecosystem components that link and integrate biogeochemical and ecosystem processes at a circumpolar scale. The ICED Program is focused on important circumpolar questions that will be the major challenge for Southern Ocean science over the next ten years. To achieve this requires an interdisciplinary approach at the circumpolar scale and not just research effort at the local or regional scale.

The third part of the workshop was aimed at identifying key questions and issues that should be addressed by ICED to ensure circumpolar coverage and integration of Southern Ocean research. To achieve this, delegates dispersed into separate groups and discussed 1) Data collection and management (including data mining and synthesis), 2) Field plans (including process studies) and 3) Model developments. The outcomes and recommendations were then presented to the whole delegation for consideration. The key outcomes from these discussions were that:

1. Previous studies and programmes have generated extensive data series that would be extremely valuable for examining large-scale ecosystem operation, variability and change in the Southern Ocean. These data are stored in a wide range of formats including original notebooks, individual data holdings and fully accessible electronic databases. Focusing effort on developing access to historical data archives will be an important task for ICED.
2. Although extensive data sets exist, there are major gaps in our knowledge of key ecological processes and geographical regions. For example, how ecosystems operate from “end-to-end”, how they vary and are connected around the Southern Ocean. Although a wide range of studies are planned over the next 5 to 10 years they are fragmented and do not give complete circumpolar coverage. Further field work will be required linking analyses of climate influences on the Southern Ocean with studies of biogeochemistry and the ecology of key species as part of wider studies of the operation of Southern Ocean food webs. Integrating these studies so they focus on key questions within ICED will be extremely important.
3. A coordinated approach to modelling studies is required. Much of the modelling effort undertaken previously has been focused on particular geographic areas or upon limited questions that address a small number of species or interactions in the food web. There is therefore a pressing need to increase the spatial and biological coverage of the available models. This is particularly timely given the focus that IMBER has placed upon the need to better understand the role of food-web processes in developing analyses of the role of ecosystems in global biogeochemical cycles. ICED aims to develop complex models for assessing and forecasting the impacts of future climate. A major focus will be the extension of existing biological and circulation models to the circumpolar scale and development of

circumpolar "end-to-end" ecosystem models that integrate nutrient cycling and the dynamics of microbes to higher predators.

The final part of the workshop was dedicated to planning the future development of ICED. This included discussion of an appropriate timeline, mechanisms for spreading excellence (e.g. training courses, workshops, meetings and a website), building upon and linking to other programs and initiatives and the anticipated outputs of ICED.

The outcomes of the workshop are currently being collated and will form the basis of the ICED Science Plan. Information on the progress of ICED is available at www.antarctica.ac.uk/Resources/BSD/ICED/. As a follow up to the Science Plan, ICED will hold a special science session at the Scientific Committee on Antarctic Research (SCAR) Open Science Conference in Hobart, Australia between the 12th and 14th of July 2006 to ensure the international development of ICED.

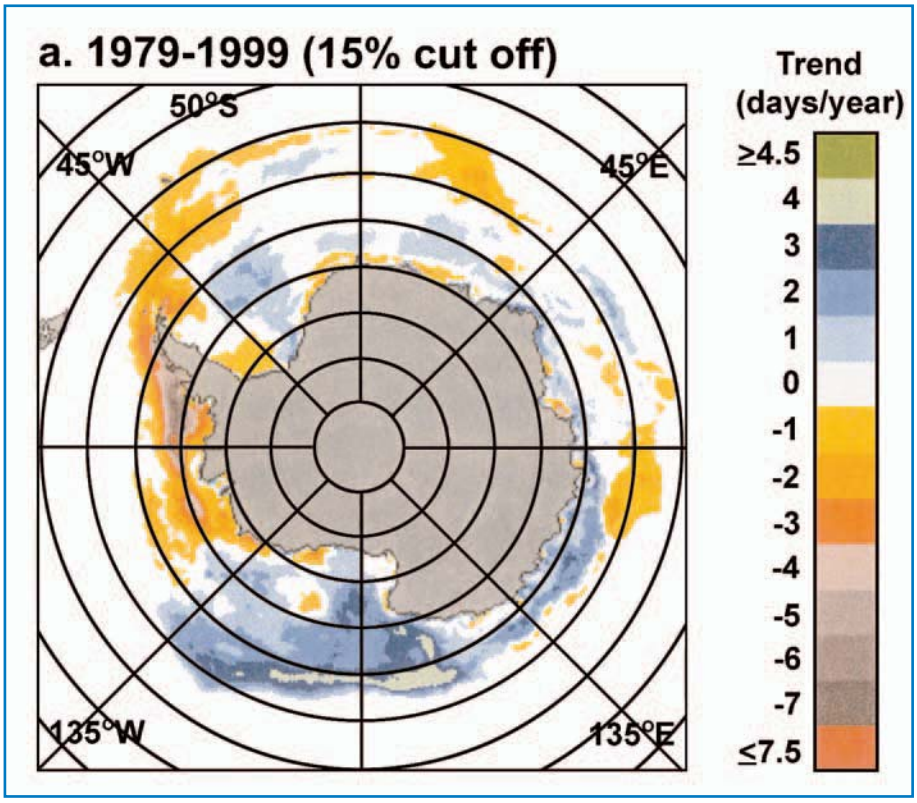

Figure 3. Changes in duration of the Southern Ocean winter sea ice season (d yr^{-1}) between 1979 and 1999. Source Parkinson (2002).

ICED Interim Steering Group

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References

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

Parkinson C.L. 2002. Trends in the length of the Southern Ocean sea-ice season, 1979-99. Annals of Glaciology 34:435–440

For further information see:

ICED: www.antarctica.ac.uk/Resources/BSD/ICED

ICED-IPY: www.ipy.org/development/eoi/proposal-details. php?id=92

EUR-OCEANS: www.eur-oceans.org

Framework 6: www.fp6.cordis.lu/index.cfm?fuseaction= UserSite.FP6HomePage=IMBER: www.imber.info