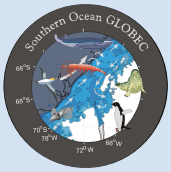

The Southern Ocean GLOBEC Programme

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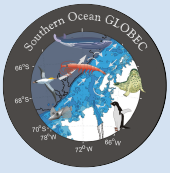

Planning for the Southern Ocean Global Ocean Ecosystems Dynamics (SO GLOBEC) began with the convening of the first official workshop in May 1991 at the Scripps Institution of Oceanography in La Jolla, California. Participants at this workshop represented the broader Southern Ocean research community, which set SO GLOBEC as a co-operative international programme from the outset. Through additional planning and implementation workshops during the 1990s, the SO GLOBEC programme objectives were refined to focus on understanding the physical and biological factors that contribute to enhanced Antarctic krill (*Euphausia superba*) growth, reproduction, recruitment, and survivorship throughout the year. Overwintering strategies were highlighted as an important but largely unknown component of the Antarctic ecosystem. The SO GLOBEC science questions reflect a broad view of the Antarctic marine ecosystem that includes studies of the habitat, prey, predators, and competitors of Antarctic krill, as well as studies specifically focused on Antarctic krill biology and physiology (Fig. 1). The science questions have been addressed through field studies in different regions of the Antarctic (Fig. 2) that used complementary techniques, thereby allowing comparative analyses.

The articles in this special section provide synopses of national field programmes that contributed to SO GLOBEC and provide brief descriptions of some of the key results from these studies. It is clear that the extensive multidisciplinary datasets acquired as a result of these programmes are providing new and important insights and understanding of Antarctic marine ecosystems. The role of circulation and sea ice in structuring Antarctic krill distributions is better defined at small and large scales. It appears that Antarctic krill use a suite of overwintering mechanisms which provides considerable flexibility in their response to winter conditions. The role of Circumpolar Deep Water in producing biological hot spots along the west Antarctic Peninsula is clear, as is the effect of these regions on biological

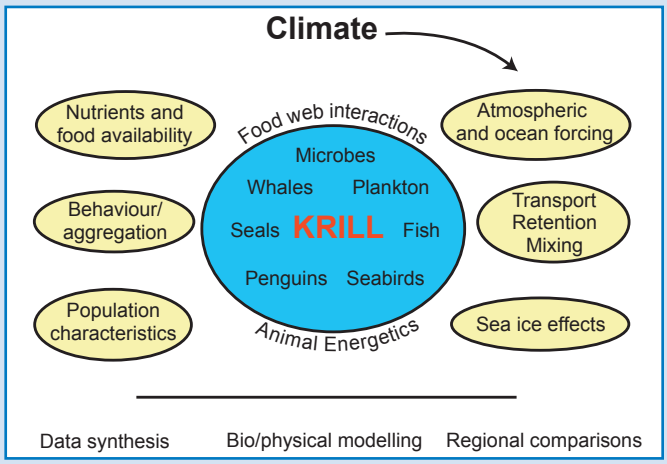

Figure 1. Schematic of SO GLOBEC programme components and approach.

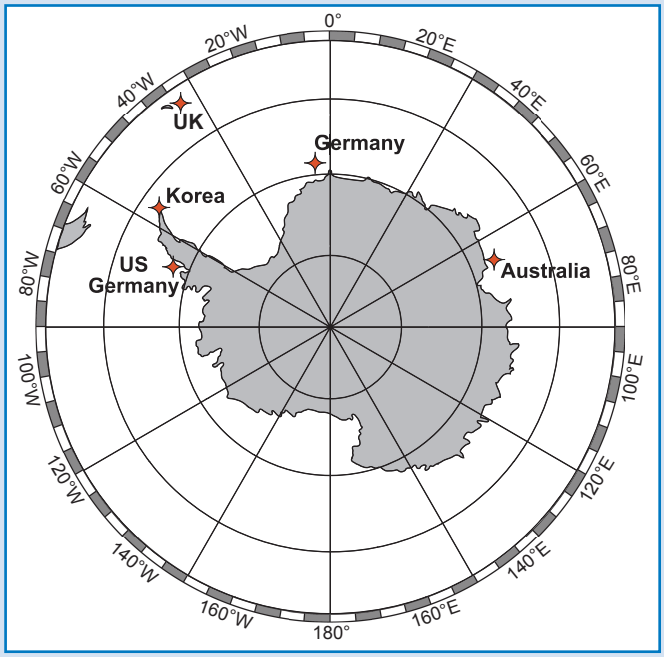

Figure 2. Location of SO GLOBEC field study sites. The German SO GLOBEC programme along the west Antarctic Peninsula took place in March-April 2001, just prior to the first US SO GLOBEC study in this region in April-June 2001.

production at all trophic levels, especially during the winter. Alternative food chains are being identified, which have important implications for carbon and nitrogen cycling. Fish are an important alternative food source for upper trophic level predators. Climate variability at interannual and sub-decadal scales is recognised as a significant moderator of ecosystem processes.

The SO GLOBEC field studies are continuing through the German LAzarev Sea KRIll Study (LAKRIS; Fig. 2), which is designed to quantify Antarctic krill seasonal population dynamics and physiological condition in a little studied area of the Antarctic (http://www.awi.de/en/research/research_divisions/biosciences/biological_oceanography/projects/lakris/?0=). This programme, which has an emphasis on winter processes, consists of three cruises that are designed to provide seasonal coverage in the Lazarev Sea. The final cruise, which is scheduled for 2007/08 will mark the end of the official SO GLOBEC field studies. However, SO GLOBEC-like field studies will continue through ongoing national research programmes that focus on science questions that are similar to those of SO GLOBEC. Also, the establishment of long-term oceanographic measurement sites (e.g. Rothera Oceanography and Biological Time-Series; Clarke, p.84) provides a framework for continuing observations that can be used to understand physical and biological interactions in marine systems.

Combining results from the many and diverse experiments and field programmes to provide new conceptual understanding and models of how Southern Ocean marine ecosystems work is a goal of the synthesis, modelling, and integration phase of SO GLOBEC, which is now ongoing. The synthesis studies are already leading to revisions in the understanding of Antarctic food webs, the relative effect of top-down versus bottom-up controls on biological production, the role of the sea ice and circulation in ecosystem dynamics, and the effect of large-scale climate cycles on Antarctic ecosystems. The SO GLOBEC synthesis activities will provide inputs for comparative studies with other GLOBEC programmes and also important contributions to the development of management policies for Southern Ocean marine resources.

The recognition that larger scale processes affect regional physical and biological interactions is the basis for the Integrating Climate and Ecosystem Dynamics (ICED) programme (http://www.antarctica.ac.uk/Resources/BSD/ICED), which is an international, multidisciplinary initiative launched in response to the increasing need to develop integrated circumpolar analyses of Southern Ocean climate and ecosystem dynamics. Understanding variability at a circumpolar scale is basic to understanding ecosystem effects resulting from long-term and large-scale climate change. The knowledge and lessons learned from the SO GLOBEC programme provide a strong basis for continuing into this next phase of Southern Ocean research.

The SO GLOBEC programme has received encouragement and support from the US National Science Foundation, the Scientific Committee for Oceanic Research, the Scientific Committee for Antarctic Research, the International Whaling Commission and science funding agencies in individual nations. This support is much appreciated.

Flux and KAOS: Australian research in support of SO GLOBEC

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One of the key questions in Antarctic marine ecology is whether the populations of krill are resident in an area or whether they are merely drifters in the currents – a phenomenon referred to as krill flux. The answer to this question obviously affects our understanding of how animals such as penguins, which have a relatively fixed geographic location during their breeding season, interact with their major food source – krill. It also affects the way in which the krill fishery is managed; if the krill population in an area is transitory and is sourced from production elsewhere then localised fishing effects can be far less serious than if the local population is produced *in situ*. Unfortunately this is an extremely difficult issue to tackle, requiring concerted study at a number of different temporal and spatial scales using a range of complementary techniques. It is made more difficult by the vagaries of Antarctic operations.

In the summer of 2000–01 the first Australian attempt was made to examine the question of krill flux on a voyage called KACTAS (Krill Availability, Community Trophodynamics and AMISOR Surveys). This study was described in the GLOBEC International Newsletter 8(1): 28-30 and occurred in the waters off the Béchervaise Island CCAMLR Ecosystem Monitoring Program site near Mawson where the population biology of Adélie penguins has been studied for 12 years. The idea was to use satellite tracking to define the area of the ocean where penguins were feeding during their breeding season, then to position the 'Aurora Australis' in this area and rapidly survey the physical and biological environment of the area a number of times to examine changes that occur with time. In particular, the short term changes in krill distribution were to be examined using the ship's hydroacoustic instruments and to relate these changes to currents measured using shipboard instruments and satellite buoys. Unfortunately, as the ship was close to completing the first pass of the survey area it was recalled from scientific duties to assist a resupply ship in difficulty. Despite the curtailment of the survey some useful data were obtained and many valuable lessons were learned.

Thus, in the summer of 2002–03 the 'Aurora Australis' sailed south to once again examine the krill flux question. The idea was to repeat the survey in the same area, though much more quickly this time. Experience from the curtailed survey had indicated that the krill population can change incredibly rapidly and that there can be considerable differences in the pattern of distribution from day to night. Consequently, on the 2003 survey (now named KAOS – Krill Acoustics and Oceanography Survey), the survey work would only be done by day with any sampling being conducted at night. This made for a complicated survey pattern but has allowed for easier interpretation of the results. In addition to the use of acoustics to study krill, a suite of shipboard instrumentation was used to examine the oceanographic environment where the penguins were foraging and satellite-tracked buoys were used to follow the currents in the area. Nets and water bottles yielded samples which could be used to determine the biological activity of the organisms in the area and sighting surveys of birds and whales completed the picture.

Despite an abundance of low pressure systems which slowed progress, the survey went almost to plan. The survey area was essentially the same as that examined in 2000-01 because real-time results from penguin tracking in 2003 indicated that the same area of ocean was being utilised by the birds. This had the added advantage of producing results that were directly comparable between seasons. The first pass of the area was completed in eight days and revealed a scarcity of krill compared to the 2000-01 season - krill were low in