Antarctic Climate & Ecosystems CRC

Antarctic Marine Ecosystems Program

The Southern Ocean, in particular the coastal region around Antarctica, hosts a vast and complex marine ecosystem that supports the fisheries of Australia and several other nations. In comparison with the Atlantic, Pacific and Indian Oceans, this region remains relatively under-sampled and poorly understood but is internationally acknowledged as region of great ecological importance.

The ACE CRC Antarctic Marine Ecosystems Program is exploring relationships among the biological patterns and processes of the marine ecosystem around East Antarctica and relating them to physical oceanographic processes. This knowledge will help guide Australian government and industry decision-makers in the formulation of policy and management strategies in response to harvest of some resources and to future climate change.

Program Leader

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Background

Several physical features of the Southern Ocean and Antarctic continental shelf combine to make this a unique system:

- The Antarctic Circumpolar Current flows from west to east around Antarctica and provides the only connection between the Pacific, Indian and Atlantic Ocean basins.
- The Antarctic Coastal Current flows from east to west, forming a number of gyres in the large bays and seas around the continent.
- During the winter, some 20 million square kilometres of sea ice covers the ocean around the Antarctic continent. Approximately 80% of this ice melts during the Antarctic summer.
- Ice shelves, floating glaciers and melting icebergs contribute significant amounts of freshwater to the ocean environment.
- The region is subject to extremes of temperature, wind and light availability.

Most marine life is found in the surface mixed layer of the ocean, typically to about 200 metres deep, where light from above and nutrients from below provide the foundations of productivity. The interplay among the physical features listed above results in a dynamic environment that supports a complex ecosystem that scientists are only now beginning to understand.

Many of the vertebrate species (e.g., whales, seals and penguins) of the Antarctic region are of high conservation value and depend primarily on Antarctic krill for food. The current inability to predict the effects of environmental changes on their populations makes it difficult for bodies such as the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the International Whaling Commission (IWC) to establish sound long-term management strategies.

Australian research has already highlighted the structure and dynamics of the krill-based Southern Ocean ecosystem. Much of this research has led to the adoption by CCAMLR, to which Australia is a signatory, of many precautionary proposals for management of biological resources around Antarctica. CCAMLR manages the krill harvest, which is the Antarctic's

largest fishery and the one with the greatest potential to impact widely on the food web in the region. The krill fishery is projected to expand into one of the world's largest fisheries, yet the effects of climate change on krill stocks, and on the species dependent on krill (seabirds, penguins, seals and whales), are unknown. The ACE CRC is examining the predicted environmental changes and their implications for sustainable management of Southern Ocean fisheries and the marine life protected through CCAMLR.

Program Objectives

To identify how biological productivity is affected by sea ice extent and properties, and by ocean circulation.

Productivity in the Southern Ocean has been linked to the winter sea ice cover and to large-scale ocean circulation patterns, both of which are sensitive to climate change.

ACE CRC researchers are combining oceanographic data, satellite data and ship-based observations with historical data from ice and sediment cores, penguin rookeries and operational records. They will use this data to test the hypothesis that reduced sea ice extent due to climate warming or other factors will lead to a smaller sea ice algal community and to explore what impacts such changes would have further up the food chain.

To quantify and describe processes that link sea ice, and primary and secondary productivity.

The sea ice edge is a particularly productive zone. As ocean water freezes, salts are left behind and a dense salty brine results. Some of this brine is trapped in pockets or channels in the ice. This briny water serves as habitat for a variety of microscopic algae. When the ice melts in the spring, these organisms are released to the ocean and provide the basis of the food chain for higher level organisms including zooplankton, fish, birds and mammals.

The linkage between the physical environment and the Antarctic marine food web is poorly understood at present. ACE CRC research will result in models of the small scale processes linking the physical and biological components of the system. The models will be used as the basis for predicting the impacts of physical or biological changes on the overall function of the Antarctic marine ecosystem.

To project the effects of long-term change on Antarctic ecosystems.

The Antarctic environment is highly variable in space and time. We need to account for this variation in ecosystem processes in order to develop accurate predictive models for the Southern Ocean. We also need improved models to predict how local changes caused by climate change and fisheries might impact the greater ecosystem. ACE CRC scientists are using remote sensing of ocean colour and water movements, as well as field-based oceanographic and biological measurements, to improve our abilities to accurately model the effects of ocean circulation and sea ice on biological productivity.

To translate predictions of the effects of climate change on Southern Ocean ecosystems into sustainable management models.

The ACE CRC embarked upon a major voyage early in 2006 to survey the oceanographic and biological characteristics, including krill abundance, in approximately half of eastern Antarctica. This voyage will provide critical data for development of the regional coupled physical-biological model described above.

These data and models will be used to predict the effects of ecosystem changes on harvested species and the food web. This work will also be used in combination with credible models of fishery dynamics to promote more effective management of marine living resources.

Recent Achievements

ACE CRC researchers completed a review of available ecosystem models and created conceptual models for key taxa in the Antarctic marine ecosystem. They also established a framework for developing Antarctic marine ecosystem models, which was submitted to the Scientific Committee of CCAMLR to assist in its work in developing sustainable krill management procedures. These efforts have provided a core framework for international collaboration on the development of ecosystem models for Antarctica and the Southern Ocean that may assist in planning for ecosystem-based management in the region by CCAMLR and Australia.

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