

A scientific research plan for helping determine whether the licensed fishery for Antarctic krill is having an impact upon the Antarctic marine ecosystem

The following pages outline a draft programme of ecological research and monitoring activities that it is hoped will help improve the management basis for the fishery for Antarctic krill. This programme was developed following a request by the Antarctic Wildlife Research Fund (hereafter AWR) for such information.

The programme reflects a number of discussions with research scientists that have considerable experience of working with the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the international body that regulates the fishery for Antarctic krill.

On agreeing this draft programme, it is recommended that AWR commit the major part (90%) of their annual ecological funding to research proposals that support the different elements of this programme. However, it is also recommended that AWR should commit a small proportion (10%) of their funding to speculative scientific activities that may have considerable impact, but which may also be deemed to be high-risk.

It is recognised that scientific ideas and equipment evolve continuously; therefore it is recommended that this programme should be reviewed at least every 5 years. This should be undertaken by a suitably qualified group of scientists, preferably with extensive experience of CCAMLR and of monitoring the krill-based ecosystem in the Southern Ocean.

THE PRINCIPLE AIMS OF THIS PROGRAMME OF ECOLOGICAL RESEARCH ARE TO:

- a) Contribute to CCAMLR's work on the development of a feedback management system for the commercial fishery for Antarctic krill.
- b) Design and implement a series of candidate scientific reference areas to monitor natural variability and long term change.
- c) Design field and analytical methods for providing early warning signals about future ecological change.
- d) Observe and evaluate signals of ecological change with a view to determining, to the extent possible, the causes of change, whether natural or anthropogenically induced.

Research proposals submitted to this fund should focus on one or more of the topics listed below, but they must clearly identify how the proposal will contribute towards the main objective of the AWR program and how the proposal will increase existing capacities for management.

Each year AWR will target specific areas of research that will be prioritised, projects may target any of the areas listed below, but preference will be given to those areas identified as a priority for each call.

THE FOLLOWING RESEARCH AREAS ARE CONSIDERED IMPORTANT:

Field-based krill fishery studies

- 1) Analyses of active acoustic information derived from commercial krill vessels to determine if there are swarm characteristics and local densities preferred by commercial vessels.
- 2) Analyses of active acoustic information derived from commercial krill vessels to determine krill abundance in the areas fished, including before, during and after harvesting.
- 3) Scientific experiments to determine the number and size of krill that are caught in commercial nets, but which are extruded through the meshes of the net; these experiments should consider the probability of whether individual krill are killed, damaged, or survive after escaping the net.
- 4) Scientific observations to determine the species, number and size of finfish caught in commercial nets; these experiments should relate the by-catch of finfish to local krill density and to other environmental correlates.

Field-based krill ecology studies

- 5) Deployment of acoustic instruments, or other mechanisms, to estimate krill movement and flux at a range of spatial and temporal scales.
- 6) Deployment of networks of active acoustic devices on oceanographic moorings to determine seasonally related information about krill abundance and swarm structure; these studies should include the development of appropriate software tools for delivering a range of temporally resolved monitoring indices.

- 7) Deployment of multi-beam active acoustic devices to determine information about krill swarm structure; these experiments should relate the swarm structure to local krill density, predator abundance and to other environmental correlates.
- 8) Deployment of active acoustic devices on oceanographic gliders to capture information about krill abundance and swarm structure; these studies should include consideration of whether these gliders can be used for meso- or large-scale acoustic surveys.

Field-based predator studies

- 9) Scientific at-sea predator observations to determine the species and numbers of seabirds and marine mammals foraging in those areas regularly used by the fishery.
- 10) Aerial photographic surveys and remotely-sensed satellite surveys of breeding aggregations of seabirds and marine mammals, both on land and over pack-ice; these studies should include the development of appropriate software tools for delivering a range of geographically resolved monitoring indices.
- 11) Deployment of networks of automated cameras (or other instruments) to capture information about the reproductive behaviour (population size, timing and breeding success) of seabirds and marine mammals; these studies should include the development of appropriate software tools for delivering a range of geographically and temporally resolved monitoring indices.
- 12) Deployment of networks of passive acoustic devices on oceanographic moorings to collect information about the presence and number of baleen whales; these studies should include the development of appropriate software tools for delivering a range of temporally resolved monitoring indices.
- 13) Liaison with CCAMLR to refine the effectiveness of CCAMLR Ecosystem Monitoring Program (CEMP) protocols to ensure that they provide the most accurate data possible, and/or suggest alternative approaches.
- 14) Long-term monitoring studies of indicator species such as seabirds, especially penguins, and marine mammals, using the standard methods of the CCAMLR Ecosystem Monitoring Program. Selected endangered, threatened or recovering species should also be included. Research into alien invasive species should be considered.

- 15) Field campaigns to study the diet and at-sea foraging behaviour of seabirds and marine mammals; these studies should consider all times of year, including times when animals are not spatially constrained to provision their offspring.
- 16) Assessments of levels of biodiversity including the development of inventories for Antarctic marine living resources including identification of their breeding and feeding grounds (especially for finfish, seabirds and marine mammals).

Desk-based modelling studies

- 17) Analyses of catch and effort data from commercial krill vessels to determine whether consistent patterns of CPUE can be determined.
- 18) Assessments of levels of variability and/or changes in the physical environment, including in the cryosphere, together with analyses of changes in fishing patterns in relation to changes in the physical environment, especially in the cryosphere.
- 19) Development of oceanographic models to determine the flow of currents and the movement of krill between areas.
- 20) Development of quantitative models for understanding predator responses to krill population variability.
- 21) Development of temporally and spatially resolved habitat models to determine the preferred foraging areas of seabirds and marine mammals.

Desk-based management studies

- 22) Development of structured experimental designs that utilise information about krill, the krill fishery, predators and the environment in order to develop candidate no-take scientific reference zones; such areas might help increase understanding about changes brought about by climate change and changes brought about by the commercial krill fishery.
- 23) Studies to develop feedback management approaches that utilise information about krill, the krill fishery, predators and environmental indices in order to develop catch options.