

**Suggestions of topics of particular relevance to management of the krill fishery for discussion at: *Antarctic krill in a changing ocean - scientific workshop on effects of environmental change on Antarctic krill and implications for ecosystem-based management* being held at Texel, The Netherlands, 11 - 15 April 2011**

Produced as a result of discussions with: Stephen Nicol, Keith Reid, Volker Siegel, George Watters, David Agnew, Andrew Constable, So Kawaguchi, Angus Atkinson, Sophie Fielding, Eugene Murphy, Simeon Hill, Geraint Tarling, Jonathan Watkins, Katrin Schmidt, Phil Trathan, Hauke Flores and Jan Andries van Franeker.

## **1. Population size and trends**

### ***1.1. Are current sampling methods using acoustics and nets sampling the whole population of krill?***

Recent observations suggest that parts of the krill population are inhabiting the near-surface layer, deep strata (>200m), the seabed and inaccessible under-ice habitats. The rarity of the smallest size class (1-year olds) relative to older krill is repeatedly observed, and under-sampling of these could hinder estimates of recruitment indices and total population size. What percentage of the population may be missed by current sampling? Can we quantify this? If this is important, what are we going to do about it?

### ***1.2. Is an absolute biomass estimate of krill essential for management? (Is it possible? At what scale?). Should efforts focus on smaller scale and trends? How would this feed into management advice?***

Suggestions have been made that densities of krill within swarms (observed by divers or from photographs) are substantially higher than acoustically-derived observations. Net-based methods (traditionally thought to greatly underestimate krill density) have revealed surprisingly high densities relative to acoustics. Acoustic methods are currently in an active stage of development and re-appraisal. What are the most urgent priorities for improvement in the area of krill biomass estimation?

### ***1.3. Further analyses and reporting of long-term krill time series***

These time series include:

- a) KRILLBASE abundance and length frequency datasets
- b) US AMLR time series based on net and acoustics data
- c) Palmer LTER time series
- d) UK WCB and CEMP time series based on acoustic data and krill length frequencies from higher predators

Some progress in the updating and re-analysis of these datasets should be underway before the workshop, which can serve as a platform for discussion during the workshop and taking this forward to the WG-EMM. These time series have a number of uses in relation to longer term change; for example to establish whether there is an ongoing decline in krill abundance over

large (e.g. SW Atlantic) scales, or to establish whether there have been any changes in krill range or population dynamic (e.g. mean size, recruitment). Further, by using the intense inter-annual variability we see in environment, population size and population structure we can tease out what factors relate to recruitment variability and fluctuation in population size (see next point)

## **2. Response of krill populations to environmental change**

### ***2.1. Alternative hypotheses linking krill and sea ice – recruitment and climate change***

We need to achieve a more mechanistic understanding of how variation and change in the environment results in changing recruitment and thus population size. Such observational work is regionally-specific, but can krill-ice relationships derived for specific areas be scaled up? Can we identify critical life stages or phases that may be affected by a change in environment, thus acting as bottlenecks or tipping points in the population dynamics? Are there nursery areas? Is the data collection (e.g. on the larval phase) commensurate with the models being developed?

### ***2.2. Effects of changes in estimates of population parameters on potential yield?***

Growth and mortality are important to krill population dynamics but mortality is very poorly constrained by data. Growth for example has already been predicted to be affected by ongoing and future climate change scenarios. How sensitive is potential krill yield to such changes? Are there any developments in ageing krill?

## **3. Potential changes in the ecosystem function of Antarctic krill**

### ***3.1 What 'ecosystem services' of krill may be affected by environmental change? And can they be quantified?***

Various scientific investigations have highlighted how Antarctic ecosystems are directly or indirectly kept in balance through Antarctic krill. In food webs, krill is not only a key resource for birds and mammals, but is also highly important for predatory zooplankton and nekton. What do we know about the effect of changing krill populations on pelagic ecosystems? Can we quantify these effects in an ecosystem approach?

## **4. Consequences for an adaptive management approach**

Instead of assuming a stable environment, resource management can take account of on-going or expected environmental change, and implement it in its models and procedures. The outcome of this workshop would be a contribution towards an adaptive management of living resources in the Southern Ocean, setting the path for similar expert meetings focusing on adaptive management procedures.