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# ECOSYSTEM MANAGEMENT OF ANTARCTIC KRILL IN THE SOUTH ATLANTIC

## UNCERTAINTIES AND PRIORITIES

### THE ANTARCTIC AND SOUTHERN OCEAN COALITION (ASOC)

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# ECOSYSTEM MANAGEMENT OF ANTARCTIC KRILL IN THE SOUTH ATLANTIC: UNCERTAINTIES AND PRIORITIES

## 1. CCAMLR's management of krill - precautionary catch limits

CCAMLR is generally considered a pioneer in establishing an ecosystem-based, precautionary approach to the management of marine resources. Article II established the objective of the Convention as the conservation of Antarctic marine living resources.

An ecosystem approach concentrates not only on harvested species, but also requires that management takes into account ecological inter-relationships in order to minimize the fisheries impact on dependent and related species, and on the ecosystem as a whole – as expressed in Article II, 3 (b) of the Convention. In the context of CCAMLR, the precautionary approach was formulated as a mandate to prevent or minimise the risk of changes in the marine ecosystem, which are not potentially reversible over two or three decades - Article II, 3 (c).

In order to provide catch limits for the krill fishery, CCAMLR designed a “Krill Yield Model” (KYM). The KYM was developed in 1990 as an attempt to determine the proportion of krill biomass to be harvested each year that accounted for krill being prey for many species in the Antarctic. In the early application of the KYM, the potential effect of krill harvesting on dependent predators was discussed and a “discount” factor was introduced in order to reduce yield calculations in a proportionate manner.<sup>1</sup> Detailed modelling of the impact that the krill fishery might have on such predators, in order to provide reliable quantitative results, had not yet been developed. Thus, CCAMLR decided to follow an ad hoc approach to set catch limits. For example, the requirements of krill predators were incorporated by establishing a level of krill escapement of 75% of the pre-exploitation biomass, instead of the 40-50% level normally used in single-species management. This has been called the “predator criterion” and it reflects an arbitrary level that needs to be revised to take into account information on the functional relationship between abundance of prey and recruitment in predator populations as it becomes available (Constable *et al.*, 2000).

Following the KYM, CCAMLR has established krill catch limits in Area 48 (Atlantic sector of the Southern Ocean) and Subarea 58.4 (Indian Ocean sector), covering just over 51% of the total CCAMLR Area. The current catch limit for krill in the Southwest Atlantic, where the fishery is currently focussed, is established by CCAMLR's Conservation Measure 51-01 (2002),<sup>2</sup> which subdivides the overall limit of 4 million tonnes into lower limits for the following subareas:

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<sup>1</sup> For a more detailed description of the KYM, See Constable *et al.*, 2000.

<sup>2</sup> With regard to the Indian Ocean, precautionary catch limits for krill fishing in this area are established by Conservation Measures 51- 02 and 51- 03 (2002). According to Conservation Measure 51- 02, the total catch limit for krill in Statistical Division 58.4.1 shall be 440,000 tonnes, which is subdivided as follows: 277,000 tonnes west of 115°E, and 163,000 tonnes east of 115°E. Conservation Measure 51- 03 sets the precautionary catch limit in Statistical Division 58.4.2 at 450,000 tonnes.

- Subarea 48.1: 1,008 million tonnes
- Subarea 48.2: 1,104 million tonnes
- Subarea 48.3: 1,056 million tonnes
- Subarea 48.4: 0.832 million tonnes

These quotas are complemented by the provision that, if the total krill catch in Area 48 in any fishing season exceeds 620,000 tonnes (the so-called “trigger level”), catch limits would be subdivided into smaller management units, following the advice of the Scientific Committee. This “trigger level” was adopted to prevent local depletion of krill, in the event of a rapid expansion of the fishery.

In 2002, addressing concerns that localised intensive fishing might compromise the availability of krill for predators in certain areas of the South Atlantic, the Commission - following the advice of the Scientific Committee - subdivided the subareas in Area 48 into 15 smaller units for the management of the krill fishery (Small-Scale Management Units or SSMUs). The Commission also instructed the Scientific Committee to consider how the krill catch limit could be allocated among these SSMUs.

As acknowledged by CCAMLR, SSMUs are key to the development of management procedures for krill fisheries that can adequately account for localised effects of fishing on krill predators. The Scientific Committee, particularly through its Working Group on Ecosystem Monitoring and Management (WG-EMM), is now given the task of providing advice to the Commission on how to subdivide existing catch limits amongst SSMUs.

Another key element of this management regime is CCAMLR’s Ecosystem Monitoring Program (CEMP).<sup>3</sup> The program is restricted to monitoring a few selected krill predators and is established in only a few areas. Currently, monitoring data is not available in several SSMUs that are regularly fished (Hewitt *et al.*, 2004). CCAMLR has yet to resolve how to best integrate CEMP data into management policy.

## 2. Recent fishery developments

Although the Antarctic krill fishery has been relatively stable for the last decade with catches around 100,000 tonnes, it appears about to expand significantly (Nicol & Foster, 2003). The large and growing demand for fishmeal and fish oil for the aquaculture industry is currently the main driving factor for krill fishing.<sup>4</sup> This is because krill has excellent value as nutrient source for aquafeeds, especially for farmed salmon.<sup>5</sup>

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<sup>3</sup> The CEMP was initiated in 1986 to detect significant changes to the ecosystem, particularly to krill predators, and to signal when such changes were the consequences of fishing. Fieldwork and data acquisition for the CEMP are voluntarily carried out by CCAMLR Member countries (Constable *et al.*, 2000).

<sup>4</sup> A study commissioned by FAO in 2003 indicated that, nearly 2.1 million tonnes of fishmeal and 0.7 million tonnes of fish oil were used by the global aquafeed industry in 1999. By the year 2015, these figures may go up to 4.6 million tonnes of fishmeal and nearly 1.9 million tonnes of fish oil. Demand for fish oil has the potential to exceed the average historical

In addition, recent application of modern technologies to krill fishing in the Antarctic, which include the catching and simultaneous on-board processing of krill, enables operators to increase catch projections up to 120,000 tonnes per year per vessel (Engoe, 2006). With this technology, it would take only five vessels to approach the trigger level.

### 3. Ecological risks and uncertainties

#### *Overlap between the krill fishery and predators*

CCAMLR conservation measures for Antarctic krill are not yet adequate to avoid impacts on the ecosystem as a result of fishing. Although current krill fishing levels are still well below established catch limits, these limits are set for large areas of the ocean and do not take into account the ecological relationships between krill, dependent species and fishing operations, which occur at much smaller scales (Croxall & Nicol, 2004; Constable & Nicol, 2002).

The current fishery for krill coincides almost entirely within the foraging ranges of land-based predators (Constable & Nicol, 2002). In addition, fishing operations are highly concentrated in certain areas of the South Atlantic. Between 1993 and 2002, 66% of the krill catch in Subareas 48.1, 48.2 and 48.3 was removed from only three of the 15 SSMUs (Antarctic Peninsula Drake Passage West; South Orkney West; South Georgia East); another three adjacent SSMUs bring the proportion up to 90%. This is significant because all these areas contain large land-based, krill-dependent predator populations. By contrast, pelagic SSMUs have had considerably smaller levels of catches for the last decade and are operationally less desirable for fishing (Hewitt *et al.*, 2004).

Good evidence exists for potential competition for krill between fishing vessels and krill predators. This evidence is based on consumption rates in local areas and at critical times of the year for predators.<sup>6</sup> Consequently, a significant risk of excessive quantities of krill being removed from local areas exists, with potential associated impacts on dependent species. CCAMLR scientists have acknowledged that the potential for localised effects of the krill fishery on predators is great unless controls are established for smaller areas and not just for large harvesting units, as is currently the case (Constable & Nicol, 2002).

#### *Environmental considerations*

Environmental factors also impact Antarctic krill populations – with subsequent risks and impacts for the entire Antarctic ecosystem. Key spawning and nursery areas of krill are located in the Western Antarctic Peninsula, one of the world's fastest warming areas (Atkinson *et al.*, 2004). Scientists have

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annual supplies of fish oil before the year 2010 and to reach 145% by 2015. According to this study, farmed salmon will remain the major fishmeal consumer in aquaculture in 2015 (taking 24%) (New & Wijkström, 2003).

<sup>5</sup> Krill have outstanding properties such as its protein and energy contents, essential amino acids, natural pigment and palatability (Sclabos & Toro, 2003).

<sup>6</sup> SC- CCAMLR WG-EMM, *Report of the Meeting of the Working Group on Ecosystem Monitoring and Management*. SC-CCAMLR-XXII/3, para. 5.23.

discovered an important relationship between krill recruitment and sea ice coverage. A study conducted in the Southwest Atlantic - which contains more than 50% of the Southern Ocean krill stocks - has found a significant decline in krill density in this area since the 1970s. The results of this study show that summer krill densities correlate to both the duration and the extent of sea ice during the previous winter. It was also found that sufficient winter ice in the Antarctic Peninsula and Southern Scotia Arc, which are major krill spawning and nursery areas, affects krill density across the whole ocean basin, including areas north of the Seasonal Ice Zone (Atkinson *et al.*, 2004).

The potential cumulative impacts of climate change and fishing on krill and krill predators are unknown and have not yet been considered by CCAMLR in the development of models for krill management. The Scientific Committee has acknowledged difficulties in determining whether changes in the ecosystem are caused by fishing operations or by environmental factors.<sup>7</sup> Consequently, there is a need to integrate these uncertainties into krill management procedures on a precautionary basis.

#### 4. Options for subdividing catch limits among SSMUs

In recent years, the WG-EMM has been considering approaches to allocate krill catch limits for the South Atlantic to the different SSMUs defined in 2002. The methods that are under consideration are:<sup>8</sup>

1. Spatial distribution of catches by the krill fishery;
2. Spatial distribution of predator demand;
3. Spatial distribution of krill biomass;
4. Spatial distribution of krill biomass minus predator demand;
5. Spatially explicit indices of krill availability that might be monitored or estimated on a regular basis; and
6. Pulse-fishing strategies in which catches are rotated within and between SSMUs

Presently, WG-EMM is in the process of evaluating these candidate methods to subdivide the krill catch limit in Area 48. For that purpose, WG-EMM is developing performance measures on the different elements involved (krill, predators and fishery), as well as simulation models, in order to

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<sup>7</sup> The Scientific Committee has acknowledged that the current design of the CEMP may never allow these different factors to be satisfactorily distinguished. It has been suggested that a method that may assist in overcoming this problem is to establish an experimental fishing regime whereby fishing could be concentrated in local areas in conjunction with appropriate predator monitoring programs. SC-CCAMLR, *Report of the Twenty-Second Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources* (CCAMLR, 2003), para. 3.12.

<sup>8</sup> SC- CCAMLR WG-EMM, *Report of the Meeting of the Working Group on Ecosystem Monitoring and Management*. SC-CCAMLR-XXIV/3, para. 2.1

determine how well these options would meet CCAMLR's objectives.<sup>9</sup> The WG-EMM has identified three issues that need to be further incorporated by future models: (i) seasonality; (ii) alternative krill movement hypotheses; and (iii) threshold krill density below which a fishery will not operate.<sup>10</sup>

## 5. Current management challenges

CCAMLR's ecosystem approach means that, when considering options for the allocation of catch limits among SSMUs, priority should be given to those options that involve direct consideration of predator needs and ecosystem interactions. It is also important to bear in mind that all the options currently under discussion are affected by uncertainty.<sup>11</sup> However, this should not postpone management of the krill fishery at the SSMU level. CCAMLR conservation principles require that precautionary options be selected in order to incorporate these uncertainties.

CCAMLR needs to adopt a flexible approach to the establishment of krill catch limits at the SSMU level. This will allow the management system to be refined as new information becomes available. It is thus critical to establish a management procedure that: a) follows criteria for catch limit allocations that account for the needs of krill-dependent predators in each SSMU; b) incorporates uncertainties, especially those associated with climate change, on the basis of precaution, and c) allows for further revisions in light of new information. CCAMLR should give priority to considering how to allocate krill catch limits among SSMUs with due regard of these issues.

In this context, it is important to bear in mind that the options currently under consideration would have little impact on fishing operations at current catch levels. However, as fishing effort increases, CCAMLR will need to achieve a balance between options that are more precautionary but more likely to displace the fishery, and those that are more likely to cause disruptions in the ecosystem but do not displace the fishery (Hewitt *et al.*, 2004). For this reason, the adequate management procedures need to be in place before the fishery expands.

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<sup>9</sup> The Krill-Predator-Fishery-Model (KPFM) received considerable attention at the 2005 meeting of the WG-EMM. The model is designed to investigate the performance of the different options and their sensitivity to numerical and structural uncertainty. The WG-EMM considered that the KPFM, although necessarily simplifying a complex system, provides a flexible framework for investigating the roles of krill transport, production, predation and harvesting. SC- CCAMLR WG-EMM, *Report of the Meeting of the Working Group on Ecosystem Monitoring and Management*. SC-CCAMLR-XXIV/3, para. 2.3- 2.5.

<sup>10</sup> *Id.*, para. 2.11.

<sup>11</sup> For example, options 1-5 were developed on the basis of the following assumptions: (i) harvesting methods will remain the same as those currently employed; (ii) mitigation measures to reduce fisheries by-catch are adequate; (iii) current seasonal and geographic pattern of catches remains the same; (iv) transport of krill between SSMUs remain constant; (v) climate-induced changes to the ecosystem are negligible (Hewitt *et al.*, 2004). Changes in fishing technologies are taking place that question the reliability of assumption (i). Assumption (ii) is affected by the lack of consistent, complete data in relation to by-catch in the krill fishery, since observer coverage is voluntary and still insufficient. Important uncertainties affect also assumptions (iii) through (v) - note, for example, the recent assessments of the effects of climate change on krill populations. In addition, there is limited information in relation to population estimates and distribution of krill predators, diet preferences and prey switching (Hewitt *et al.*, 2004).

In developing ecosystem management procedures for krill at the SSMU level, CCAMLR needs to address existing uncertainties by:

- 1) Requiring further information from the fishery through scientific observation programs;
- 2) Improving the monitoring of the ecosystem in order to increase CCAMLR's capability to detect possible localised impacts on predator populations. A priority should be to establish some form of monitoring in those SSMUs where currently no data are available;
- 3) Investigating krill stocks dynamics in the South Atlantic, particularly in relation to krill movement within and between SSMUs; and
- 4) Developing strategies to incorporate climate change considerations into the management of Antarctic krill.

CCAMLR has mechanisms already in place to address actions (1) and (2) above - *CCAMLR Scheme of International Scientific Observation*, and *CCAMLR's Ecosystem Monitoring Program*, respectively. Thus, it is important to enhance these mechanisms and their contributions to krill management procedures. Concerning (1), full observer coverage on board krill vessels should be required, in accordance with *CCAMLR Scheme of International Scientific Observation*.<sup>12</sup> In relation to (2), *CCAMLR's Ecosystem Monitoring Program (CEMP)* should be extended to cover those areas that are currently not monitored. In addition, parameters to be monitored by CCAMLR Members participating in the CEMP should be standardised in order to allow comparison of information.

In relation to issues (3) and (4) above, CCAMLR needs to develop further inter-sessional work. It is important that CCAMLR gains a broader understanding of the potential impacts of environmental effects and krill fishing on krill populations. Also, CCAMLR needs to better understand how krill transport between and within SSMUs may affect local abundance and availability of krill, and therefore catch limits, at the SSMU level.

In the interim, under the current regime, CCAMLR should ensure that fishing operations do not result in irreversible impacts on krill-dependent predator populations. Precautionary measures should be considered in relation to sensitive and non-monitored areas<sup>13</sup> and fishing-predator interactions at critical times of the year.

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<sup>12</sup> As addressed in ASOC, *Improving monitoring and control of the krill fishery*, tabled also to CCAMLR XXV.

<sup>13</sup> In their description of the five allocation options outlined above, Hewitt *et al.* (2004) offer some important considerations in relation to the possibility that certain areas should be closed to krill fishing for different reasons. For example, under the allocation options that explicitly take into account predator needs - options (4) and (5) - the SGW (South Georgia West) SSMU would need to be closed to krill fishing because, in that area, estimated predator demand already exceeds the estimated standing stock for krill. Similarly, there are many areas where monitoring simply does not exist, and therefore, data are not available. Hewitt *et al.* further suggest that it may be argued that these SSMUs should remain closed until some form of monitoring is established.

## 6. Conclusions

Ecosystem management of krill is a central task to CCAMLR. Krill's vital role in the Antarctic marine food web means that precautionary decisions need to be taken to protect krill-dependent predators, particularly those land-based marine mammals and seabirds whose foraging ranges overlap with krill fishing grounds in the South Atlantic. Recent market and technological developments could very well lead to a rapid expansion of the krill fishery. This means that the trigger level could be reached before CCAMLR has adopted and implemented management procedures that take full account of ecosystem-fishery interactions.

CCAMLR needs to adopt a flexible approach to the allocation of krill catch limits among SSMUs, to allow incorporating new information as it becomes available. Meanwhile, more data should be gathered, through scientific observer programs – which need to be mandatory for the krill fishery - and an improvement of the CEMP.

CCAMLR should also integrate uncertainties into the management regime in relation to environmental and oceanographic factors. In this context, a priority should be to understand better the impact of climate change on krill populations, as well as the issue of krill transport between and within SSMUs.

The subdivision of krill catch limits among SSMUs represents a fundamental task that CCAMLR should undertake as a leading priority. In the interim, CCAMLR should ensure that no irreversible impacts occur on predator populations as a result of fishing, particularly in sensitive areas and at critical times of the year.

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