Australian Government
Department of the Environment
Australian Antarctic Division

The Krill fishery, its management and using the fishing fleet for science

So Kawaguchi[1] and Steve Nicol[2]

1) Australian Antarctic Division

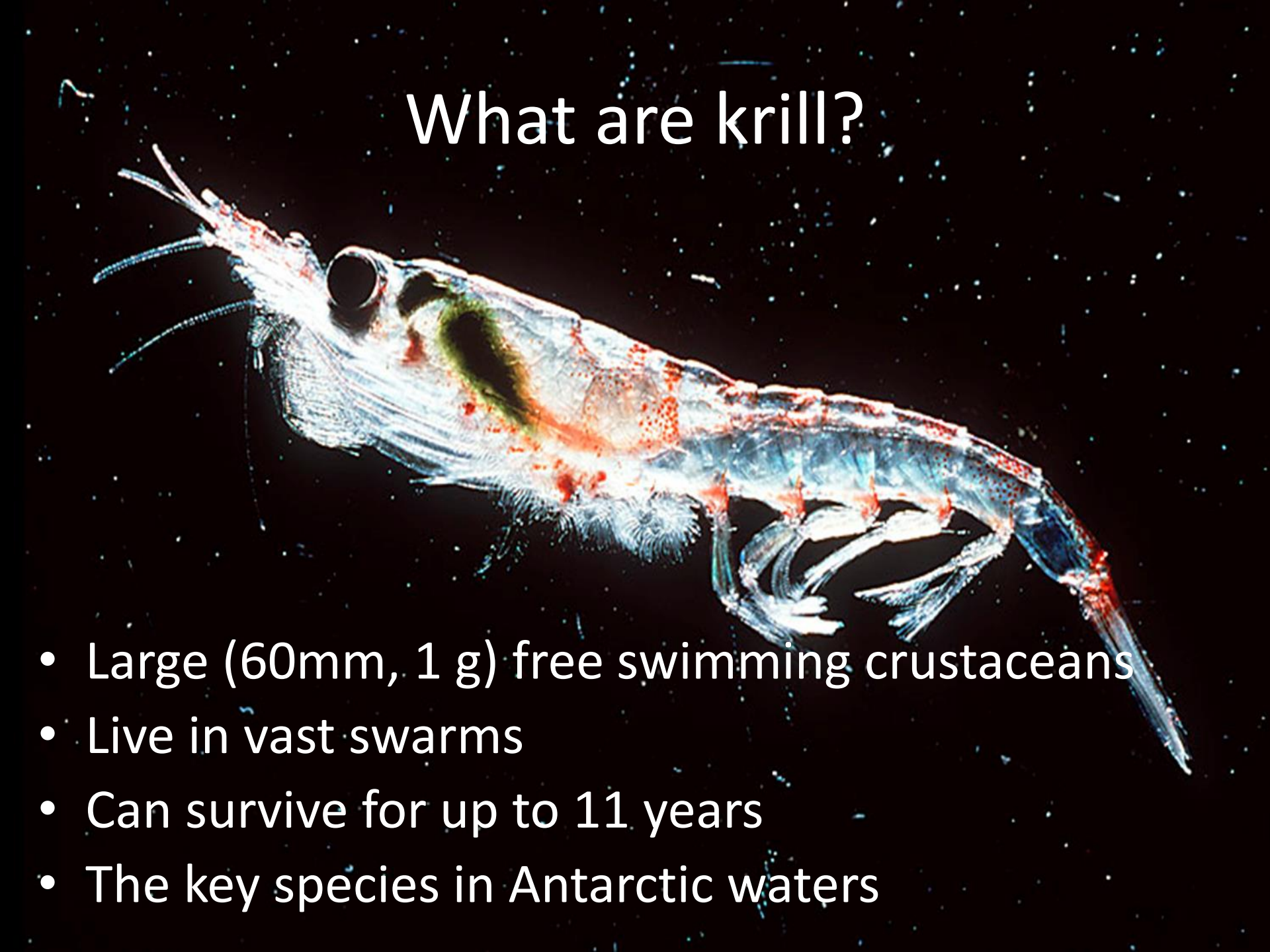
2) Institute for Marine and Antarctic Studies, University of Tasmania

And Scientific Adviser to the Association of Responsible Krill Fishing Industries (ARK)

Outline

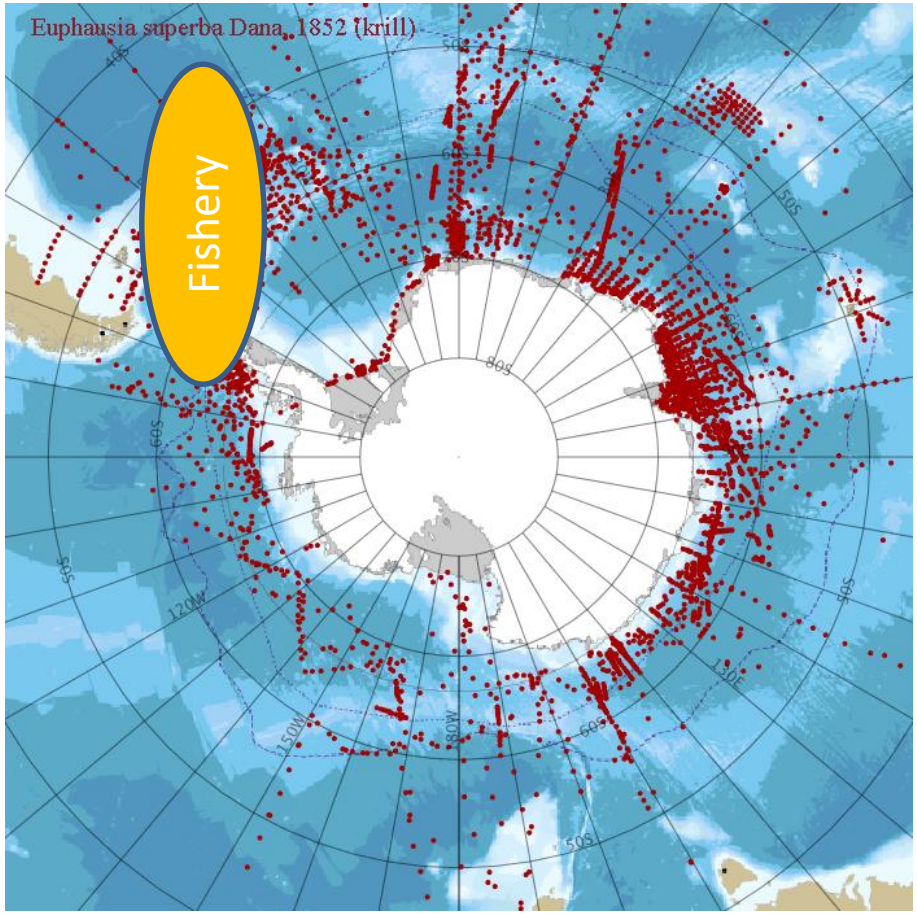
- The Krill Fishery
- Management
  - What is CCAMLR?
  - Precautionary management
  - Ecosystem Monitoring
  - Feedback Management
- Information gaps
- Fishing fleet capability
- The future

What are krill?



- Large (60mm, 1 g) free swimming crustaceans
- Live in vast swarms
- Can survive for up to 11 years
- The key species in Antarctic waters

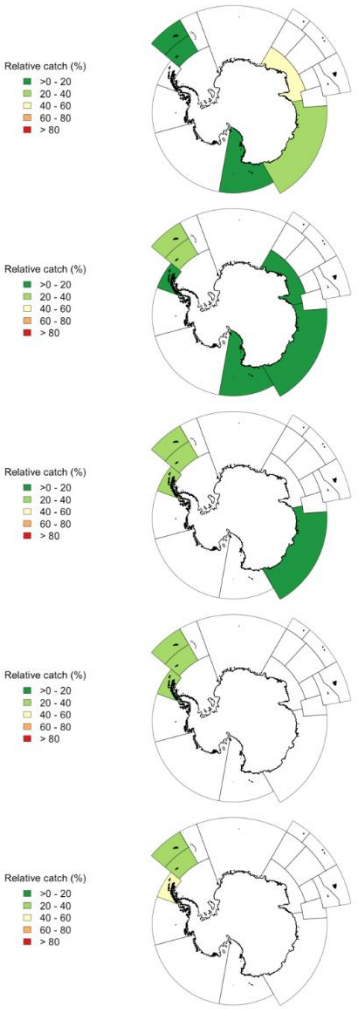
The distribution of Antarctic krill



Somewhere between 12 and 32 million km^2
(The area of Australia is 7.7 million km$^{2)}$

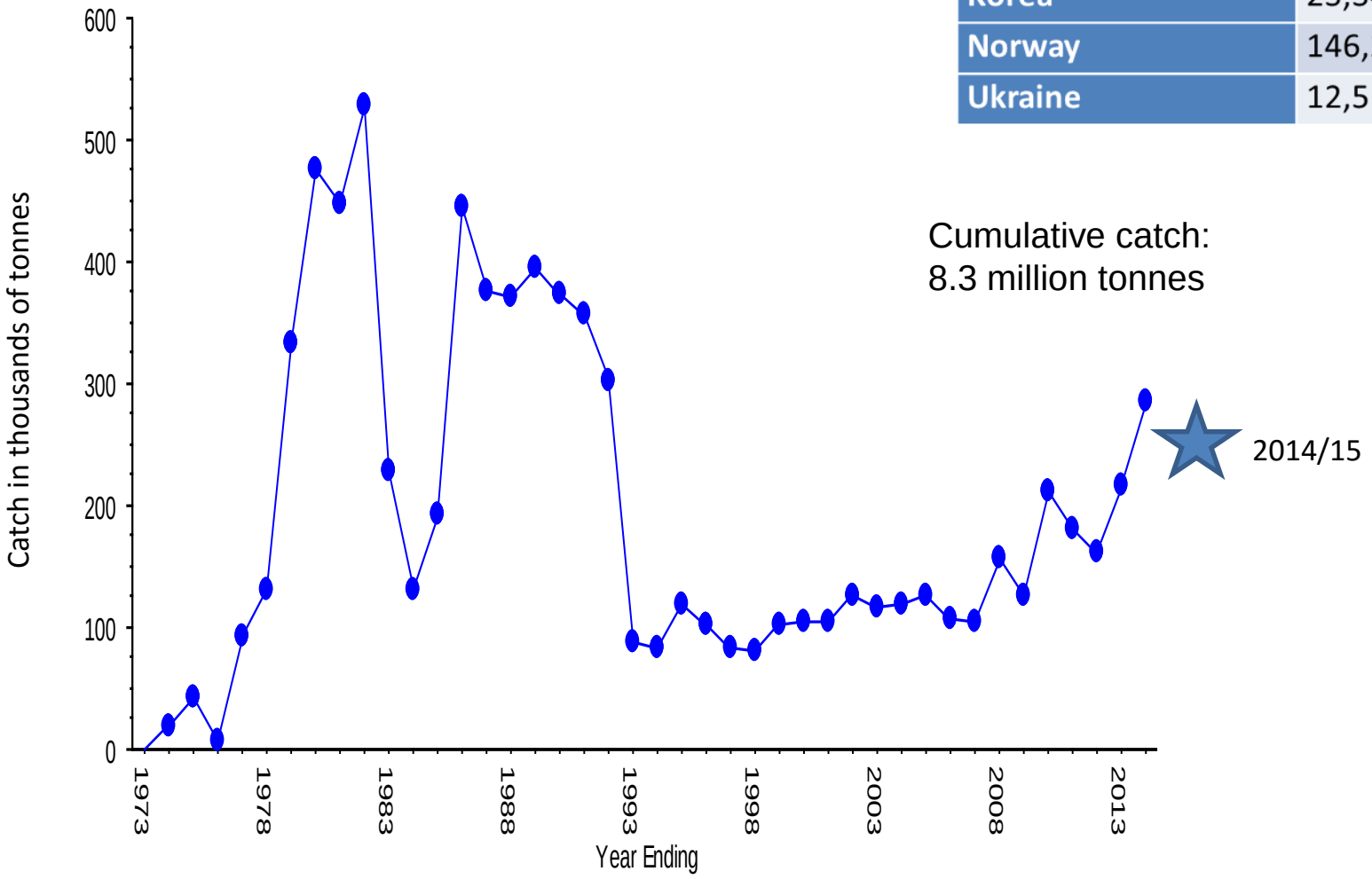
Change in fishing grounds

- Gradual contraction as the fishery matured.
- Concentration of fishing effort in the South Atlantic after the mid-1990s
- The S. Atlantic is closer to ports, has less ice and a longer fishing season.
- Established fishing grounds.



Annual catch of Antarctic krill

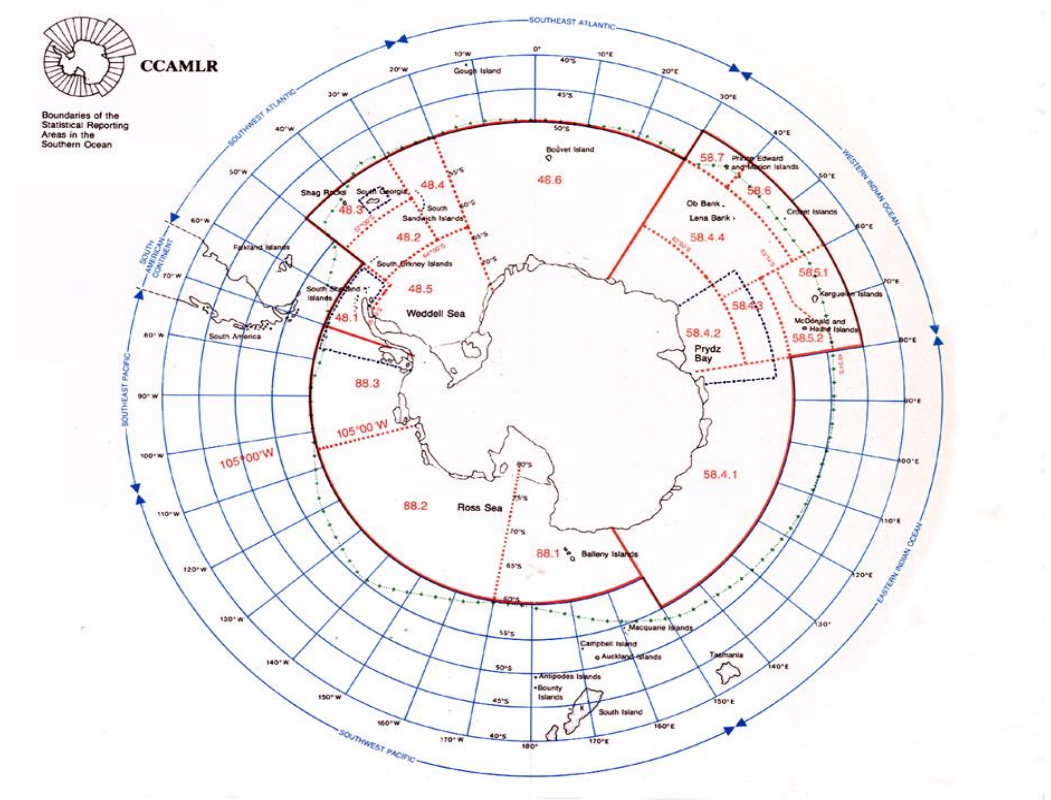
Nation	Catch (tonnes)
Chile	7,211
China	31,770
Korea	23,342
Norway	146,208
Ukraine	12,517



How is the fishery managed??

CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources)

The headquarter is located in Hobart, Australia



The Southern Ocean is divided into statistical areas mall boxes, and catch limits for harvested species are set for relevant areas.

Start of CCAMLR

- *Adopted because of:*
  - ***Historical over-harvesting of seals and whales***
  - ***Region with high conservation values***
  - ***Development of the krill fishery***



Precautionary management

If not sure, then do not take the risk
and walk along the safer side

CCAMLR's rules for krill fishing.

- CCAMLR has evolved a scheme for krill management over the last 34 years.
- It took CCAMLR 9 years to develop the first management measures for krill.
- In 2016 there are 8 Conservation Measures specific to the krill fishery covering:
  - Precautionary Catch Limits and trigger levels (4)
  - Exploratory krill fisheries
  - Scientific Observation
  - Notifications
  - Data reporting
- Another 7 general Conservation Measures that apply to all fisheries.

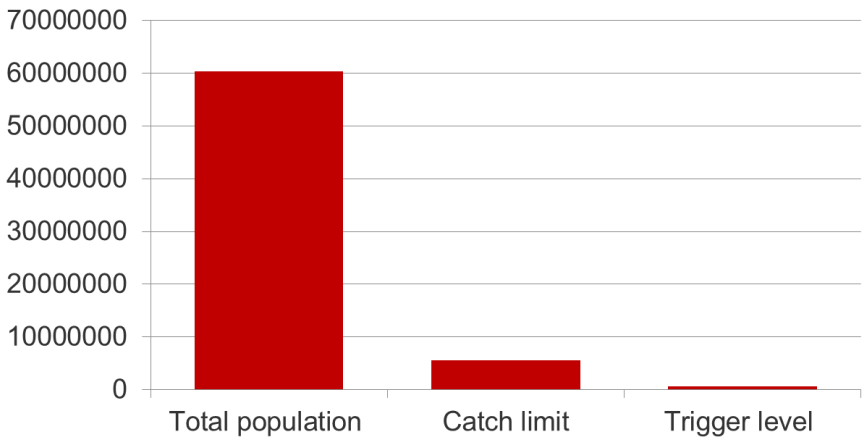
How is the krill fishery managed?

- Using scientifically derived precautionary catch limits for Statistical Areas. These are based on:
    - Derived values of mortality, recruitment and growth
    - Estimated requirements of krill predators.
- These parameters are then fed into a generalised yield model and a Precautionary Catch Limit is set using a set of conservative decision rules.
- Catch limits are set at ~ 10% of the estimated biomass from large-scale surveys
- Trigger levels (further limits below the calculated precautionary catch limit) have been set until this total catch limit has been allocated between smaller management units

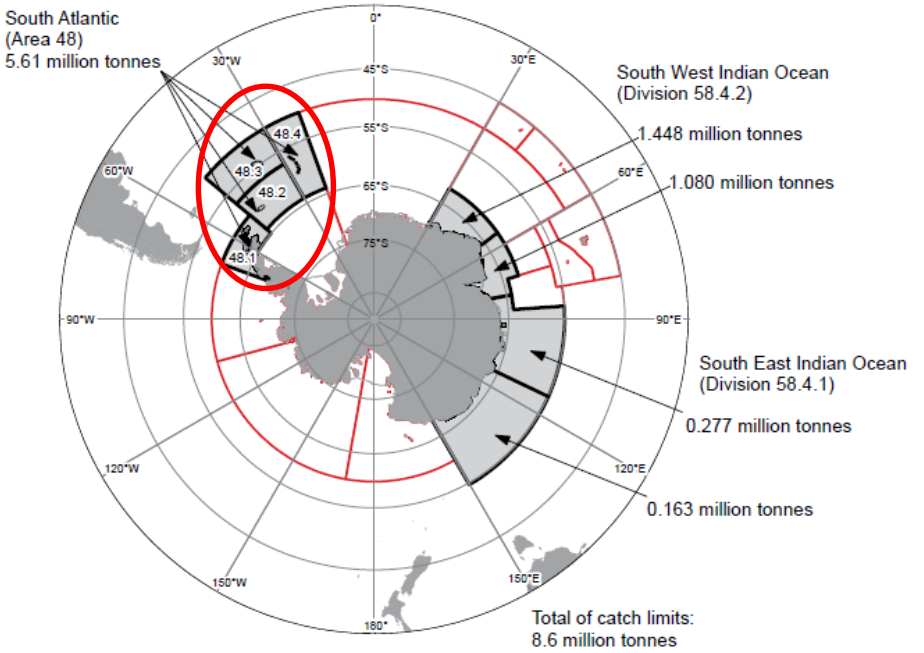
Precautionary Management

South Atlantic – precautionary catch limits for krill

- Estimate of krill population - 60.3 million tonnes
- Catch limit of 5.61 million tonnes/year
- Trigger level: 620,000 t (total fishery cannot exceed this level in any season)
- Trigger level further divided into 4 subareas



Trigger level
620 thousand tonnes



Euphausiacea Map 15 Precautionary catch limits on Antarctic krill fishery in the CCAMLR Area. Statistical areas are outlined and surveyed areas outlined and labelled (Nicol *et al.* 2012).

(Courtesy of Keith Reid)

What about fishing in other areas?

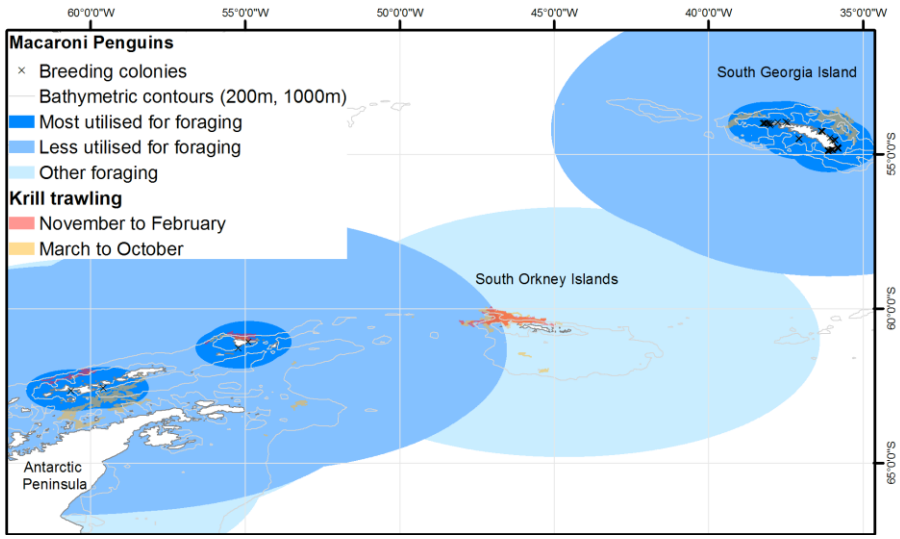
- Fishing in the South Indian and South Pacific sectors has occurred in the past.
- There are considerable krill stocks in these regions.
- All of the South Indian Ocean is covered by precautionary catch limits so could be fished.
- The fishing industry indicates that it is unlikely to fish in these regions.
  - Short fishing season,
  - Too far from home ports
  - Would need a fleet of vessels
  - Too much sea ice and too many icebergs
  - No established fishing grounds.

- Fishing in un-surveyed regions is covered by CM 51-04 (exploratory krill fishery measure).

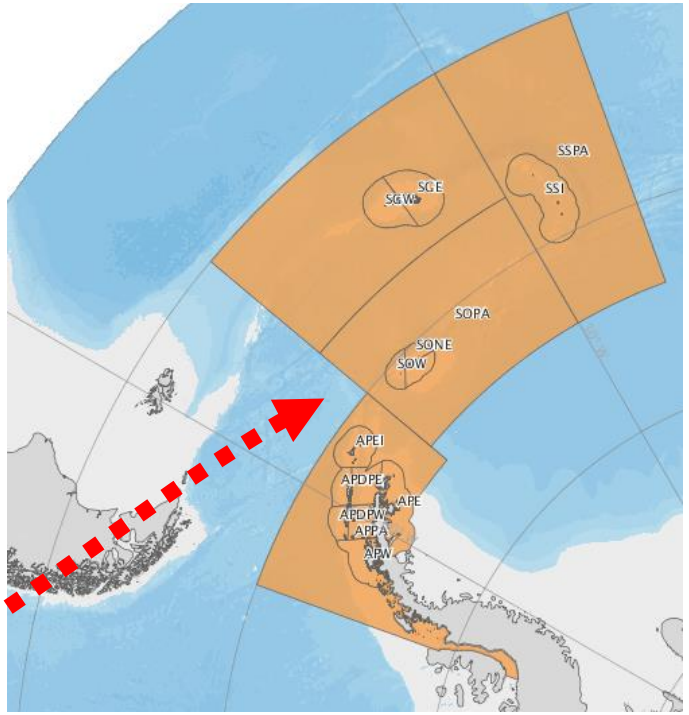
What does CCAMLR need to ensure?

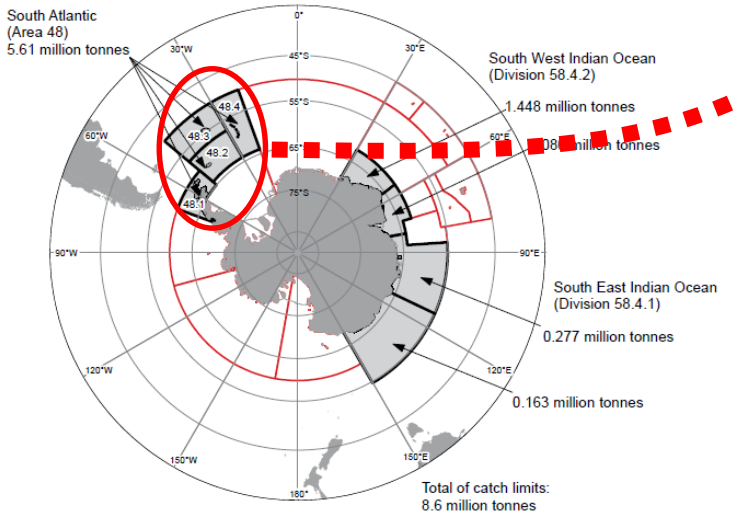
- Krill catches are not too localised.
- Krill catches do not adversely affect breeding land-based predators.
- That there is some indication of the health of krill stocks.
- There is some indication of the health of the rest of the ecosystem.
- There is good information on the state of the fishery.
- The management system is simple, understandable and effective.

Overlap between Krill Fishery and Predator Foraging occur at localised scales



Nicoll & Douglass 2012





Euphausiacea Map 15 Precautionary catch limits on Antarctic krill fishery in the CCAMLR Area. Statistical areas are outlined and surveyed areas outlined and labelled (Nicol *et al.* 2012).

Move into smaller scale management units based on predator foraging range

And further…

From Static Management
To
Feedback Management (FBM)

Feedback Management (FBM)

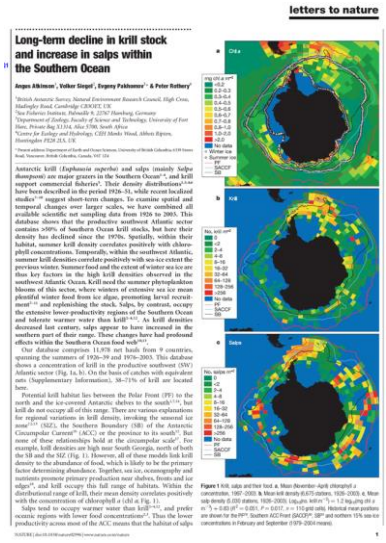
- FBM is a system of managing the krill fishery that uses information on the status of the ecosystem to change the levels of catch.
- This process relies on monitoring the status and dynamics of important features of the ecosystem
  - Krill stocks
  - Their predators
  - The fishery

Major sources of information for FBM

- Scheme of International Scientific Observation
- CCAMLR Ecosystem Monitoring Program
- Information from krill fishery operations
  - Scientific Observers
  - Catch data
  - Biological sampling
- Information on krill biology and dynamics

Krill issues of interest to CCAMLR

- Has the population of krill really declined in the last 40 years?
- What causes fluctuations of krill biomass in local areas?
- What proportion of the krill population lives below 200m?
- How are the life-history stages of krill distributed and does this affect our estimates of recruitment?
- Do krill really migrate inshore in winter?
- What causes differences in aggregation types?
- Are krill merely particles wafting in the currents?
- How much krill is actually eaten by other animals?
- Fish bycatch in the krill catch – is it a problem?
- Can we sensibly estimate global krill biomass? Do we need to?


letters to nature

Long-term decline in krill stock and increase in salps within the Southern Ocean

Angus Atkinson[1], Volker Siegel[2], Evgeny Pakhomov[3,4] & Peter Rothery[5]

Major sources of information

- Scheme of International Scientific Observation
- CCAMLR Ecosystem Monitoring Program
- Information from krill fishery operation
- Information on krill biology and dynamics

- ***We need to make better use of information that can be obtained from the fishery if we are serious about managing the effects of krill fishery***
- ***Fishing vessels are the only platforms that allow us to monitor krill in the fishing grounds through out the year.***

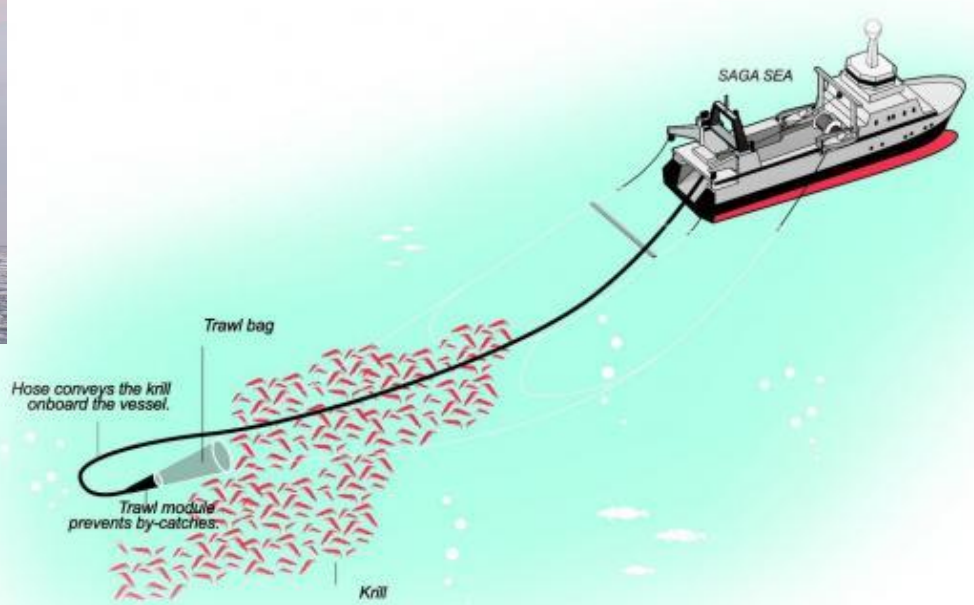
Feedback Management

Krill Fishery

- Using huge nets (500-1000m^2)
- 10-12 hauls per day
- Sophisticated acoustics
- Year-round operation
- Repeatedly operate on same aggregations
- Increased use of pumping

Scientific surveys

- Small nets (8m^2)
- Several tows per day
- Scientific acoustics
- Snapshot survey
- Operations restricted in space and time



Aker Biomarine's patented "Eco-harvesting Technology"

Pumping krill may be better than trawling for krill, the ecosystem and scientists.

- The pumping technology uses a smaller net (20 X 20m mouth opening)
- The net can be left in water for several weeks.
- The krill arrives on board alive so there is little spoilage
- Continuous supply of krill for scientific analysis
- The krill come from precisely known locations and depths.

Emergence of new hybrid vessels

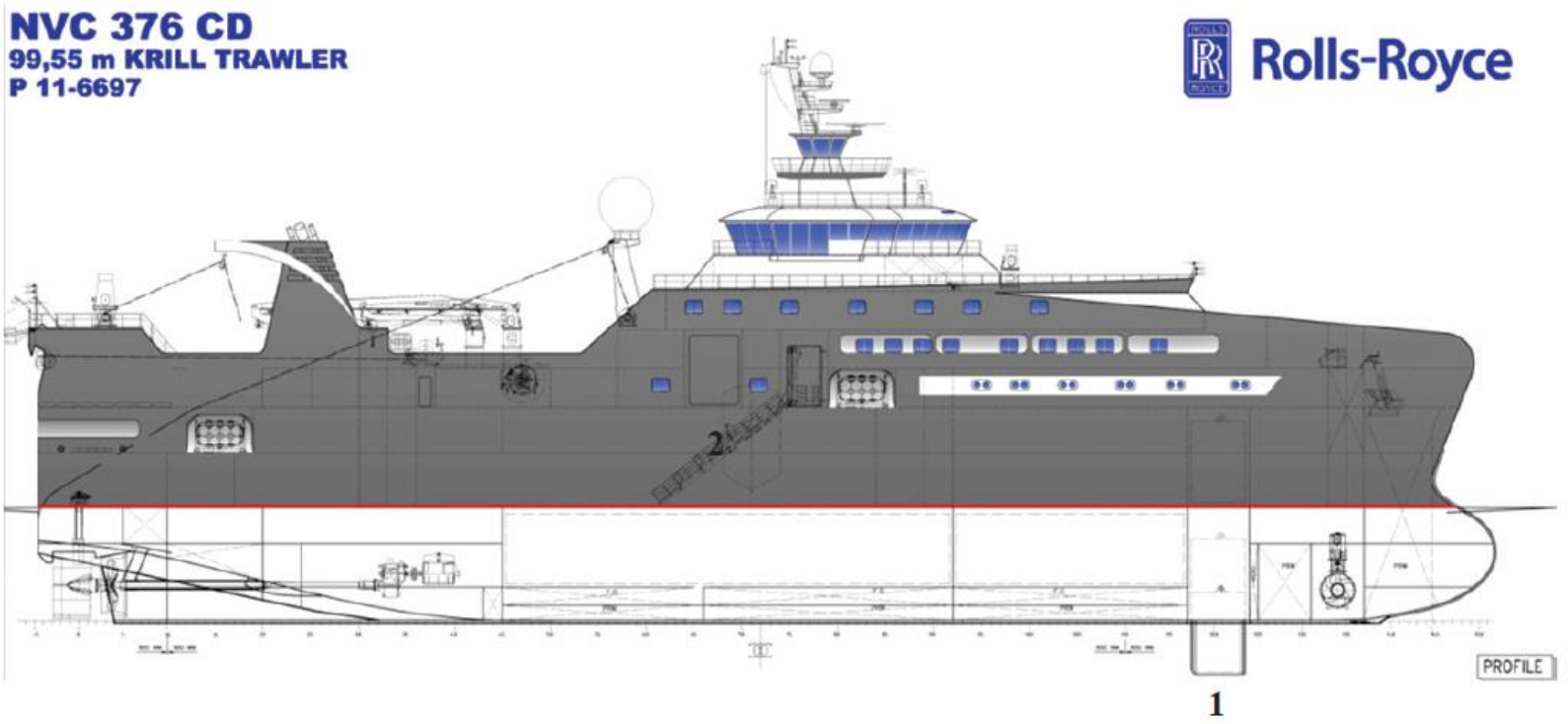


Figure 1: The new krill vessel with an instrument drop keel (1) and a hangar for operation of ROV and oceanographic and biological sampling gears (2). The vessel is 99 m long and has diesel electric propulsion.

Feedback Management

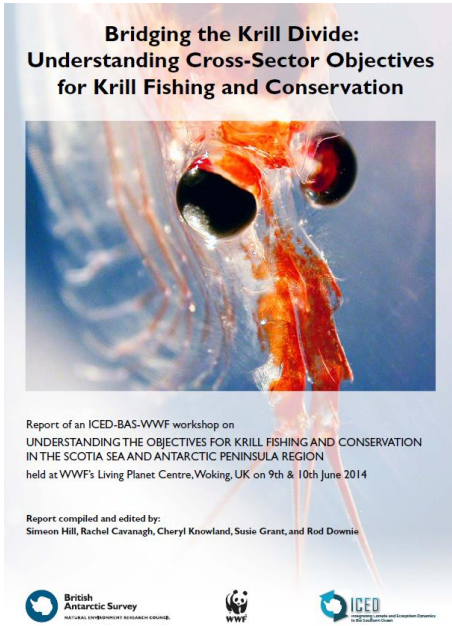
Industry , scientists and managers all require information that can best be obtained from the fishery. Through cooperation CCAMLR can move forward in improving practical management of the krill fishery.

AWR | ANTARCTIC WILDLIFE RESEARCH FUND

WWF

The future

- Much greater involvement by bodies external to CCAMLR:
  - Industry
  - MSC
  - ARK
  - Fishing vessel research
  - External scientists
  - NGOs
- However, the fishery will always be controversial and unpopular.



Association of Responsible Krill harvesting companies

Marine Stewardship Council
Certified sustainable seafood

Summary

- International interest in the krill fishery remains high
- Demand for krill products may grow.
- The dynamics of the fishery may change – new entrants new technology, new products.
- CCAMLR needs to continue to take a precautionary approach to make sure the krill fishery develops in an orderly manner.
- Good science is essential to improve our understanding of krill life history and for a successful ecosystem management regime through CCAMLR.
- A strong commitment by governments, industry, management, science and the operators is the key to successful management of the krill fishery.
- The fishing fleet has the potential to revolutionize our understanding of krill biology and ecology

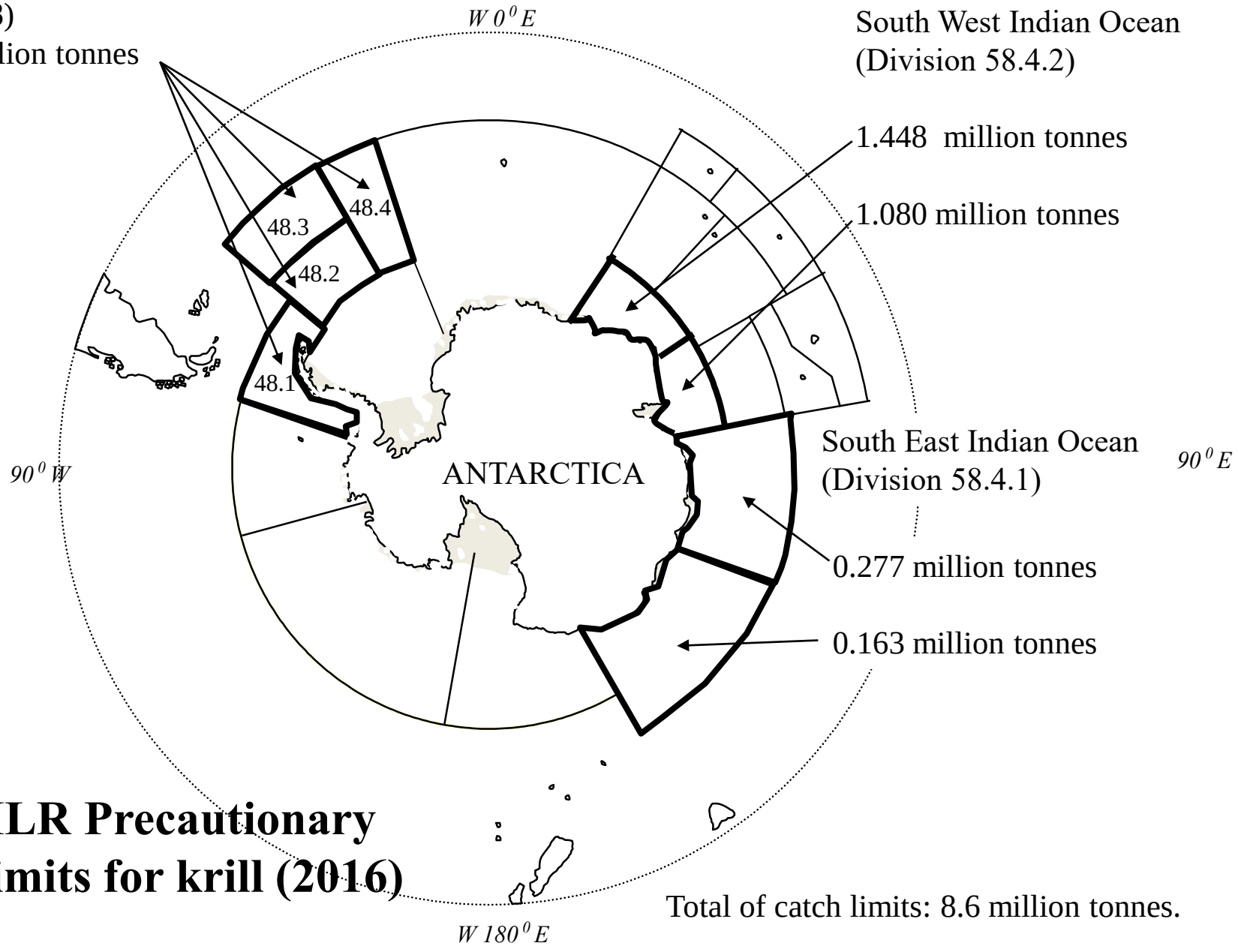
Thank you

Precautionary management

If not sure, then do not take the risk
and walk along the safer side

Reducing uncertainties
improves the management

The CCAMLR Convention requires that ecosystem effects of fisheries are taken into account.



CCAMLR Precautionary catch limits for krill (2016)

Total of catch limits: 8.6 million tonnes.

Pumping krill may be better than trawling for krill, the ecosystem and scientists.

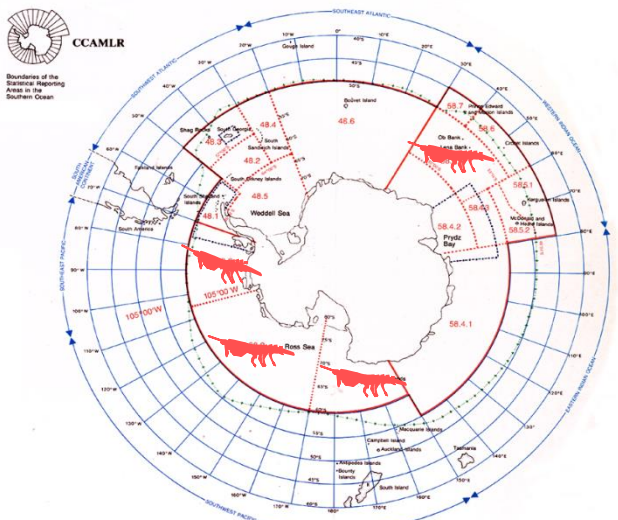
- The pumping technology uses a smaller net (20 X 20m mouth opening)
- This is lowered into a krill swarm and can be left there for several weeks.
- Because the supply is continuous it is possible to monitor the catch and turn off the pumps if there is evidence of bycatch.
- The krill arrives on board alive so there is little spoilage
- There is a continuous supply of krill for scientific analysis
- The krill come from precisely known locations and depths.

Un-surveyed areas

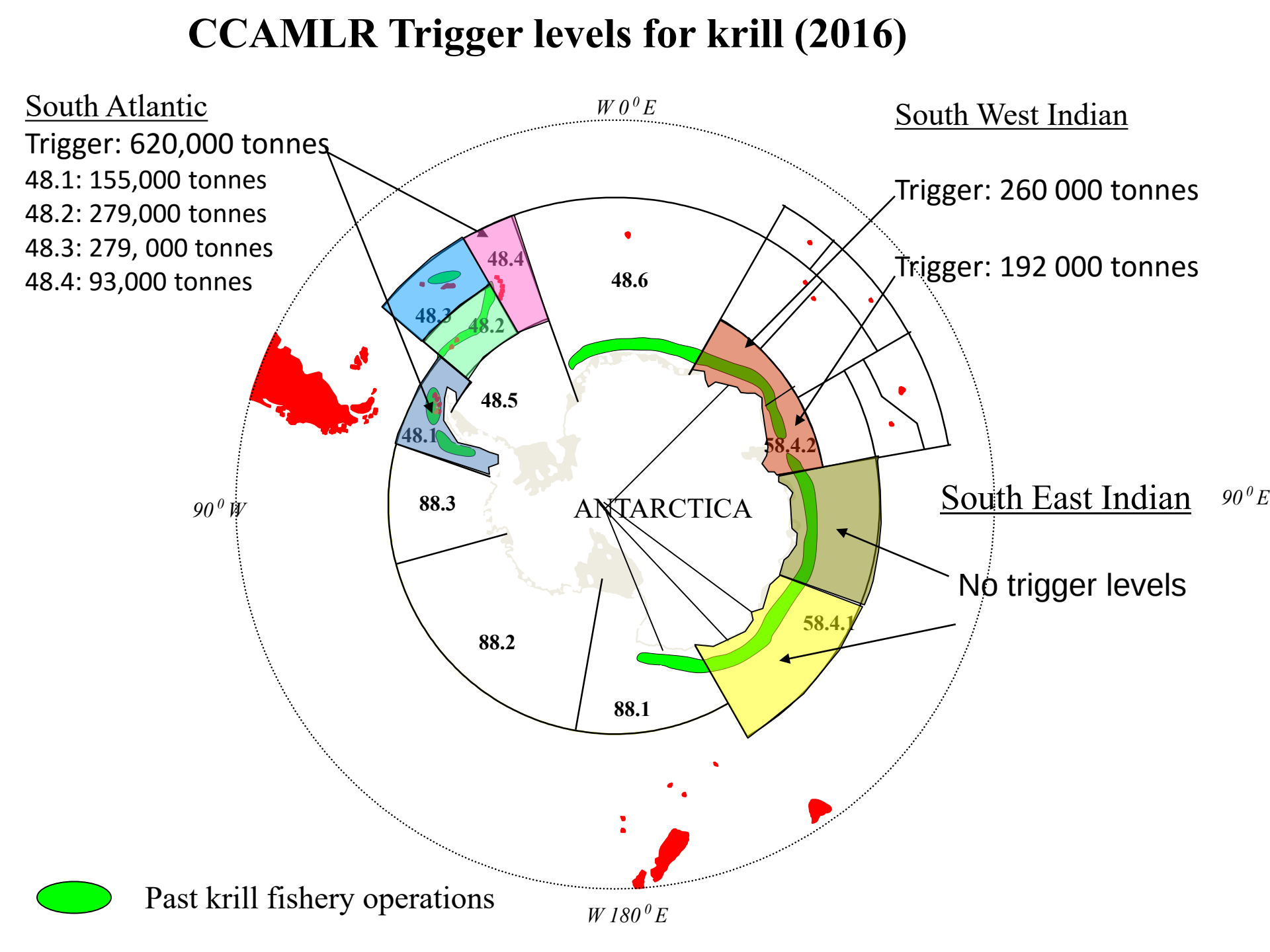
Between 9 and 18 days fishing at current catch rates

CONSERVATION MEASURE 51-04 (2015) General measure fo exploratory fisheries for *Euphausia superba* in the Conventio in the 2015/16 season

- Fishing in any statistical subarea or division shall cease when the reported catch reaches the specified catch limit (15,000 tonnes) and that subarea or division shall be closed to fishing for the remainder of the season.
- No more than 75% of the catch limit shall be taken within 60 n miles of known breeding colonies of land-based krill-dependent predators.
- Needs a Data Collection Plan



CCAMLR Trigger levels for krill (2016)



Krill data from CCAMLR Scientific Observers

- Collection of high-quality length-frequency distribution data.
- Krill sampled every few days depending on time of year
- Assessed for length, sex and maturity.
- Feeding colour and presence of ‘black spot’ also checked.