COMMERCIAL FISHING VESSELS AS RESEARCH VESSELS IN THE ANTARCTIC – REQUIREMENTS AND SOLUTIONS EXEMPLIFIED WITH A NEW VESSEL

O.R. Godø✉
Institute of Marine Research
PO Box 1870
5817 Bergen
Norway
Email – olavrune@imr.no

C. Reiss
National Oceanographic and Atmospheric Administration
Southwest Fisheries Science Center
Antarctic Ecosystem Research Division
8901 La Jolla Shores Drive
La Jolla, CA 92037
USA

V. Siegel
Thünen Institut für Seefischerei
Palmaille 9
D-22767 Hamburg
Germany

J.L. Watkins
British Antarctic Survey
Natural Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET
United Kingdom

Abstract

The climate-induced changes presently seen in the ecosystems of the Antarctic region require a precautionary approach with respect to the human use of these ecosystems. In particular, resource harvesting requires enough basic knowledge, as well as adequate monitoring, to avoid unintended impacts on the harvested stocks and the associated ecosystem. Due to the vastness and remoteness of the Antarctic region, research vessel capacity is not readily available for conventional coverage of harvested stocks and their ecosystems. This paper describes the potential of using commercial fishing vessels to bridge the gap in research vessel capacity. The various tasks and required instrumentation are presented and discussed. To illustrate this concept a description of a Norwegian krill fishing vessel now under construction is presented. This type of combined fishing and research vessel could make a large amount of important data available for both management, through CCAMLR, and the broader scientific community and thus improve the basis for resource evaluation and management.

Introduction

The Antarctic region is vulnerable to human activity. In particular, under the impact of global climate change, Antarctic marine ecosystems are expected to undergo substantial changes, for example as a result of ice reduction (Flores et al., 2012a; Flores et al., 2012b; Melbourne-Thomas et al., 2013). Krill plays a key role in Antarctic marine ecosystems (Siegel, 2010). The combined impact of fishing activity and climate change might have unfavourable effects on the ecosystem, for example, reducing feeding success for land-based top predators (Trivelpiece et al., 2011).

Commercial exploitation of krill has varied dramatically over its 30- to 40-year history. The present annual catch in the Atlantic sector of the Southern Ocean of about 200 000 tonnes is small compared to the CCAMLR trigger level of 620 000 tonnes and the historic maximum catch of over 500 000 tonnes. The most up-to-date large-scale survey took place in 2000, and those data have been reanalysed several times as acoustic analysis methods have evolved; the CCAMLR-approved estimate of biomass in this sector now stands at just over 60 million tonnes (Demer and Conti, 2005; SC-CAMLR, 2010) with a precautionary catch limit of 5.6 million tonnes (Conservation Measure 51-01). Despite the low total catch, there is still considerable concern for the negative impact of fishing on the ecosystem (Alonzo et al., 2003) due to the geographical overlap between feeding areas of land-based krill predators and the krill fishery, which both exploit high concentrations of krill found in coastal and shelf areas. CCAMLR management is still dependent on the CCAMLR-2000 acoustic survey in the area (Hewitt et al., 2004) and little is known of the actual development of the total krill stock since then, although concern about declining krill abundance has been expressed (Atkinson et al., 2004; Flores et al., 2012a).

The vastness and remoteness of the Antarctic makes any scientific study expensive and routine monitoring on a large scale, as conducted in most other harvested ecosystems, difficult. For CCAMLR to maintain its ecosystem-based management approach, there is a huge requirement of better and more data. The use of commercial fishing vessels in resource surveying has been given substantial attention in recent years (ICES, 2007; Abe et al., 2011; Skaret et al., 2012). Much effort has been concentrated on how to use existing acoustic instrumentation on fishing vessels to enable collection of scientific information. This paper takes a more long-term perspective and its objective is to emphasise the potential to actively stimulate interaction between scientists and vessel owners so that new fishing vessels might be designed and instrumented with the option of operating as research vessels.

Basic requirements for research vessels for Antarctic research

Scientific studies and monitoring of the krill resource include measurements across a variety of disciplines; in this paper the basic requirements are defined for a modern Antarctic research vessel to enable it to be used to collect suitable scientific data, both during research cruises and during commercial fishing operations.

Basic oceanography

This requires the ability to deploy instrumentation (e.g. CTDs) over the side of the ship to measure water column environmental properties, and collect water samples at discrete depths. Future studies will also likely involve the deployment and recovery of instruments, such as gliders, autonomous vehicles, moorings and long-term instrument rigs, without damage. There will also need to be communications that support retrieval of satellite images and vessel-based sensors that collect data continuously. A weather station should collect basic meteorological information (wind speed and direction, relative humidity, air temperature, photosynthetically available radiation) during resource surveys and subsequent fishing activities. Other underway oceanographic data (sea-surface temperature, sea-surface salinity and fluorescence) are also usually collected. Similarly, active acoustic technologies like acoustic Doppler current profilers (ADCP) are also basic instruments in oceanographic studies.

Acoustic assessment

Acoustics is a basic tool for evaluation of the state of the krill stock, its distribution and behaviour. Scientific echosounders covering the frequencies 18, 38, 70, 120, 200 and 333 kHz are preferred in order to both assess krill and fish density and to separate both from other scatterers like salps and other pelagic taxa (Calise and Knutsen, 2012). Multibeam echosounders and sonars are also a useful tool for swarm studies (Cox et al., 2010). In recent years, most new research vessels, and also some fishing vessels, are being equipped with an instrument drop keel for the transducers to enhance registration conditions through minimising the impact of bubble noise (ICES, 2007).

Biological sampling

Sampling of marine organisms normally utilises a suite of trawls, nets and optical sampling tools. Fishing vessels are normally better equipped for trawling than research vessels. Operation of smaller nets and other specialised sampling tools might be more cumbersome and needs some consideration. However, smaller trawls that can sample young krill or larvae will be important in understanding the population dynamics, especially the production and recruitment, of krill.

Laboratory, office and accommodation capacity

Certain vessel facilities are essential for efficient use of the scientific samples and data collected. Often krill fishing vessels have laboratories for their own testing and production and utilising such space for biological sampling is normally easy. Equipping these laboratory facilities with basic scientific instruments, such as electronic scales, microscopes, etc. is an advantage to minimise transportation requirements. Sample storage facilities, particularly provision of low-temperature freezers (~ –80°C), will also need to be considered. Adequate working space for data analysis is essential and the provision of a fast high-capacity data network connecting all labs, offices and cabins will be important for existing data sharing and also as a way of adding instrumentation in the future. Sufficient cabin capacity to secure the welfare of technical and scientific personnel during long surveys will also be necessary.

General operation facilities

Scientific field operations require a large variety of facilities, including cranes, deck space, space for indoor storage and maintenance, etc. The operation of scientific instrumentation and tools might be cumbersome when introduced to traditional fishing vessels as deck arrangements and other facilities are designed for fishing purposes only. In contrast, normally it requires few resources to tailor facilities for scientific use when the vessel is new. In general, space for a 20 ft container laboratory van would be sufficient for those sampling and scientific requirements that cannot be accomplished within the factory laboratory space.

Vessel propulsion and noise characteristics

Vessel characteristics are important operational features for scientific studies using acoustics (ICES, 1995). Noisy vessels might impact the natural behaviour of the target animals and thus both affect the biological samples as well as the acoustic assessment (De Robertis and Handegard, 2013). While noise-induced escape behaviour by krill will be limited compared to fast-swimming fish, the signal-to-noise ratio will play an important role for the range of the higher acoustic frequencies in particular. Krill are weak acoustic targets and using the CCAMLR multiple-frequency identification approach (SC-CAMLR, 2010) requires the extended depth range of the higher frequencies. Reducing noise enhances signal-to-noise ratio and thus extends depth range where krill targets can be distinguished from background noise. This will also enable the use of multiple-frequency techniques for species identification at greater depths. Most importantly, this improvement also facilitates quality data from krill distributed in deep water and towards the bottom (Gutt and Siegel, 1994; Schmidt et al., 2011). Modern vessels normally take these factors into account, while this is often a problem when using older vessels as platforms for acoustic surveys.

Use of fishing vessels in krill research

With adequate research facilities and instrumentation available on commercial krill vessels, four ways of utilising this capacity are foreseen.

Scientific sampling which takes place during fishing but does not disrupt operations

Fishing vessels normally operate in two modes: (i) cruising from land to fishing areas or between fishing areas, and (ii) fishing operations, including all activities when remaining in one fishing area. This could be trawling and drifting or searching during production. Both activities may allow collection of acoustic and catch information without interfering with daily routines on the vessel. The methodology for handling information during fishing is not straightforward (Skaret et al., 2012). Although such information will give quality information about the krill densities in the fishing areas, developing quantitative statistical approaches that allow the use of information for stock evaluation purposes is of most interest. Most important is the potential to extract information about temporal changes during the fishing season, information which is unavailable from synoptic routine assessment surveys. On the other hand, data from transects during cruising can be used in a more standardised manner similar to routine surveys.

Ad hoc sampling which may disrupt fishing operations

Modern krill trawlers are advanced vessels with facilities often comparable to, or better than, some research vessels. The personnel are highly qualified for marine operations, including those required for oceanographic field work. It is foreseen that much future data collection from the Antarctic will take place with autonomous instrumentation, including fixed or stationary moorings, buoys and rigs, and mobile platforms such as autonomous underwater vehicles and gliders. To be able to deploy, operate and recover these instruments using a commercial research vessel without sending a dedicated vessel might enhance efficiency of such operations. Many such operations probably can be done with a minimum of extra cost if the vessel is working close to the autonomous platform location. Another task could be to run a specific acoustic transect as part of a monitoring program. Such transects could be important reference data for use alongside opportunistic acoustic data collected during fishing.

Dedicated routine surveys

The use of fishing vessels to conduct biomass surveys prior to commencement of commercial fishing operations is increasing (ICES, 2007). Norway has, in recent years, run dedicated surveys using krill fishing vessels with success (Krafft et al., 2011). Small updates in acoustic instrumentation to more frequencies and also the inclusion of oceanographic instrumentation like CTD, or XBTs and XCTDs as well as ADCPs, and underway data collection systems will enable krill vessels to produce data of research vessel quality. Running such surveys during the fishing season is a challenge. Reducing the fishing time loss per vessel is the most important factor. However, such survey data will be invaluable in developing regular and robust estimates of local krill biomass that may be used in developing management advice for CCAMLR.

Tailored research cruises

Tailored research surveys include scientific operations for studying specific phenomena or exploration cruises for specific areas. Running such operations with fishing vessels has not been tried in the Antarctic. Nevertheless, considering the costs of bringing a dedicated research vessel to the region, it is absolutely a possibility of considering a well-equipped modern krill fishing vessel as a platform for research cruises. The supply services for these vessels are excellent and frequent and will allow transportation of equipment and personnel when needed. The required accommodations to support the scientific crew might be a limitation for such cruises. Given the cost of running research ships, a future model for some organisations may involve periodic charter of a suitable vessel rather than full-time ownership.

A new vessel for commercial and scientific fishing

Olympic Shipping is building a new krill trawler and has established contact with the Institute of Marine Research (IMR) for information on requirements for a research vessel. Olympic Shipping has experience in rebuilding fishing vessels into research vessels and has operated such vessels for research organisations. The intention is to use their own experience with the general requirements presented by IMR in the building process to minimise extra cost. The concept is that the vessel could be used for research purposes both during operational fishing and on special research contracts. This would extend the operational potential of the vessel and also demonstrate the role that a commercial fishing company may play in the CCAMLR ecosystem-based approach to fisheries management. In the following are plans of the new vessel compared to the requirements described above.

Vessel noise characteristics and acoustic performance

The vessel has diesel electric propulsion and all arrangements have been made to make it a quiet vessel. The big factory on board might be noisy but mounting of machinery will be done with noise insulating attachments. The ambition is to enable long-range detection of krill swarms with sonars (1 km or more), which requires a good signal-to-noise ratio (see also 'Vessel propulsion and noise characteristics'). Long-range observation of krill swarms over time is important for the vessel operation as the density dynamics, migration speed and direction of swarms are important factors for an efficient trawling strategy. Further, such performance is also crucial for scientific use of sonars to learn more about creation, movement and dissolution of krill swarms.

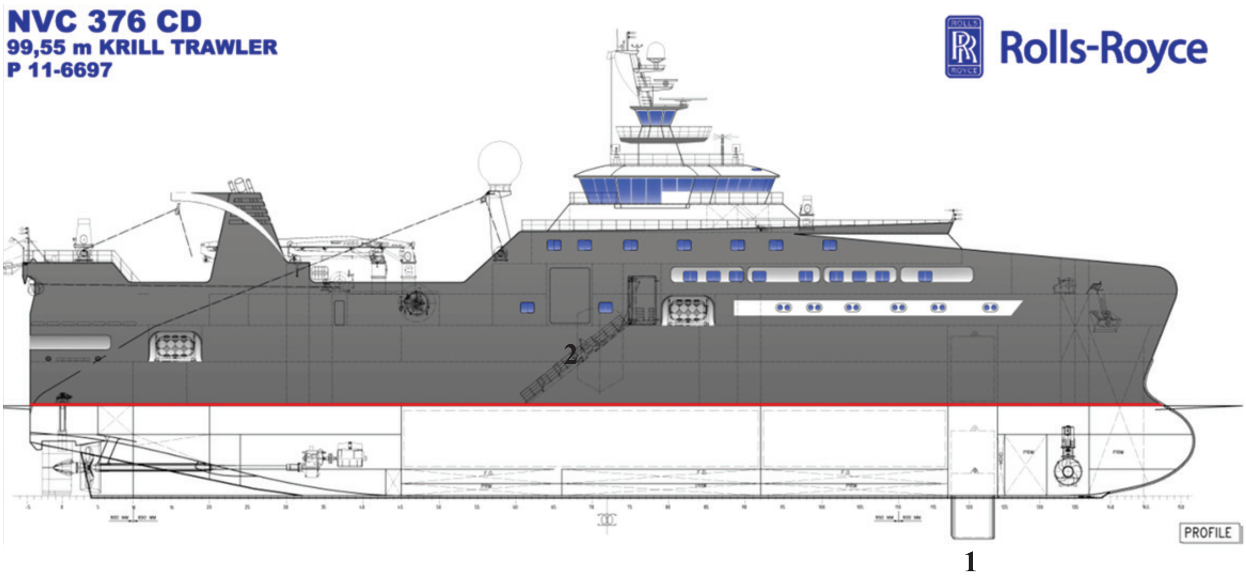

Figure 1: The new krill vessel with an instrument drop keel (1) and a hangar for operation of ROV and oceanographic and biological sampling gears (2). The vessel is 99 m long and has diesel electric propulsion.

The acoustic transducers of the vessel will be mounted on a drop keel (Figure 1), thus improving the quality of the acoustic recordings.

Basic oceanographic studies

The vessel is planned to have permanently installed CTD with a dedicated winch to be operated from the hangar (Figure 1). From the same hangar, it will be possible to deploy and operate other oceanographic equipment like buoys, drifters, gliders, etc. The vessel also has cranes and deck arrangements that allow launch and retrieval of oceanographic rigs. The vessel will be equipped with a dynamic positioning system allowing precise navigation during such operations. Also, a meteorological station will be installed and the advanced communication system will allow transfer of satellite sensor information when needed.

Acoustic assessment

The vessel is planned to have the requested echosounder frequencies installed in the drop keel. It is further suggested that the tip of the keel can be replaced so that scientists can bring their own acoustic modules instrumented in accordance with the objectives of that particular investigation (Figure 2). The keel will be retractable so as to allow replacement to be done in the open sea. The vessel will also be equipped with low- and high-frequency multibeam fisheries sonars with scientific data output allowing scientific long-range detection as well as close-up studies of the structure of swarms.

Biological sampling

Trawl sampling will be done similar to the commercial trawling. Net sampling and operation of other sampling tools can be done from the hangar. Operation of large frame trawls like MOCNESS, or larger nets appropriate for krill sampling, might preferably be done from deck. It is still not known to what extent the vessel will be equipped with adequate cables and winches for operation of such gears, but suitable deck mounts for extra winches will be available.

Laboratory, office and accommodation capacity

The plans of the vessel include extensive laboratory space for scientists as well as office space and conference rooms of varying size. Also, some of the accommodation is located in proximity to the wheelhouse so as to ease the interaction between scientists and officers during survey operations. The vessel may at maximum accommodate 20 scientific crew on longer cruises. The vessel will have a dedicated fibre optic network for research personnel only.

Figure 2: The tip of the drop keel with six acoustic frequencies (from RV *G.O. Sars*). The intention is that the tip can be demounted and replaced by another module with tailored sensors in accordance with cruise objectives.

General operation facilities

The crane, deck and indoor facilities appear fully adequate for most of the work expected to be done during research surveys.

Conclusion

The vessel under construction for Olympic Shipping satisfies all major requirements to operate as a krill research vessel. Further, instrumentation and infrastructure also allow more general oceanographic cruises to be operated from this vessel. Such commercial fishing vessels might strongly enhance research capacity in the Antarctic region.

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