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Title **DESIGN OF THE ITALIAN ACOUSTIC SURVEY IN THE ROSS SEA FOR THE AUSTRAL SUMMER 2003-04**
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ABSTRACT

In agreement with the Report of the IXX WG-EMM (Art. 2.78; p.128), the current paper presents the next Italian survey, that will be carried out in the Ross Sea during the austral summer 2003-2004.

The research consists of three core activities: (1) Acoustic sampling on krill (*E. superba* and *E. crystallophias*) populations and concurrent censuses of their top predators for estimating krill distribution and abundance, and the effects of predators on altering them; (2) Net sampling for describing krill demography, energetic/physiology and genetics; (3) CTD and XBT sampling for identifying the characteristics of the water masses which influence krill ecological behaviour. All these activities will be undertaken synoptically along a cruise track (about 2500 nm) that gives an uniform density of acoustic, net and CTD samplings across the whole area (90000 nm²).

The primary objective of the research is to improve those measurements required for the conservation of krill biology in the Ross Sea and the adjacent area of the Pacific Ocean. The second main objective is to use krill as model organisms for studying the interactions between environment and organism variability. The third main objective is to investigate the relationships between krill (*E. superba*) and their main competitive or predator species.

Keywords: Research project - Acoustic survey - *Euphausia superba* - *Euphausia crystallophias* - Antarctica - Ross Sea

SUMMARY OF FINDINGS AS RELATED TO NOMINATED AGENDA ITEMS

Agenda Item Findings

3.5 The plans of the next survey on krill in the Ross Sea are presented to the WG for analysis, discussion and approval.

This paper is presented for consideration by CCAMLR and may contain unpublished data, analyses, and/or conclusions subject to change. Data contained in this paper should not be cited or used for purposes other than the work of the CCAMLR Commission, Scientific Committee, or their subsidiary bodies without the permission of the originators/owners of the data.

Introduction

In the WG-EMM meeting of 2000 (Taormina, Sicily, Italy, 17-18 July) Italy agreed to submit the plans of the future acoustic survey on krill in the Ross Sea to the Working Group for analysis and discussion (Report of the Meeting of the SC, Art. 2.78, p. 128).

In July 2001, a survey project was proposed to the Italian National Project of Antarctic Research (PNRA) in the context of the research activity in the Ross Sea for the period 2002-2003. The title of the project was: "Krill, Environment and Predators: interactions, functional relationships and ecological implications for the Ross Sea resources management" (Acronym: KEP).

In December 2001 the research project has been accepted and financed by the Scientific Commission (S.C.) of PNRA. The project was included in the SCAR disciplinary sector "Oceanography and marine ecology/structure and evolution of the ocean ecosystem", coordinated by Prof. Giancarlo Spezie of Naples University. However some plan reductions were done by S.C. to the original project for logistic and economic reasons.

In particular the S.C. decided that the survey has to be conducted in austral early summer 2003/04 instead of the proposed summer 2002/03, and in 15 days, while the requested period was 20 days at least.

The current paper describes the rationale, the program, the objectives and the methodology of the research programme. It should be emphasised that data on krill, environment and predators collected in the expeditions 1989/90, 1994, 1997/98 and 2000 are the key basis to reach the objectives described in the paper.

Rationale

In contrast with the regions of Atlantic sector, where krill have been studied regularly by many countries since 1980, relatively few studies have concerned krill populations from the Pacific sector, and in particular in the Ross Sea. In order to improve the krill knowledge in the Ross Sea, the Italian National Project of Antarctic Research (PNRA) has supported acoustic surveys and net samplings since 1989. From these expeditions it results that:

- Two similar, and probably interacting, krill species (*E. superba* and *E. crystallorophias*) dominate the pelagic biomass and play a central role in the Ross Sea ecosystem.
- Both krill populations face large but specific variations at all time and space scales. However the part of Ross Sea northern than 73° is largely dominated by *E. superba* and only *E. superba* aggregations were detected in a Pacific area, adjacent to the Ross Sea but separated by it.
- Both krill species aggregate in swarms, but only *E. superba* is able to form extensive and dense swarms up to superswarms, as the one found in the expedition 1994 (Azzali et al., 1999).
- Both krill are devoured by carnivores, but *E. superba* is the most preferred (or the only?) food of the Minke whales. In all the four expeditions the herds of Minke whales were found around the nuclei of *E. superba* populations (Azzali et al., 1999).

These results confirm that the study of krill is inherently a multidisciplinary field that forces to take an ecosystem prospective.

The spatial and temporal variations of krill can be used to characterise the water masses that influence differently the two krill species, to study their variable responses to the environmental variations and to go deeper into the bio-oceanography of the Ross Sea.

It is known that krill can adapt their biological characteristics to the environmental conditions (Zone et al., 1998), that vary greatly in the different regions of Antarctic. The geographical separation between *E. superba* (Antarctic krill) population of the Ross Sea and that of the adjacent area of Pacific Ocean, detected in the four Italian expeditions, is strongly suggestive. Is the Antarctic krill population of the Ross Sea endemic or have some overlapping with the population of Pacific Ocean?

The study of the relationships between the krill aggregations and the local oceanographic characteristics will increase our understanding of how krill can oppose the effects of water turbulence and how the density of particularly extended *E. superba* swarms may modify the local environment (Okubo, 1986). Moreover these aggregations provide model systems for studying the evolutionary and behavioural ecology of group formation (Azzali et al., 1999; Hammer WM, and Hammer PP, 2000): is there in the Ross Sea an optimal group size, that can provide the highest feeding rate for each of the two krill species? What are the spatial relationships between the two krill species aggregations?

The interactions between krill and their predators are another area where the general problems of Southern Ocean intersect with the particular problems of the Ross Sea (Ainley, 1985; Croxal, 1999). It is not known if birds and seals are generalised predators of both krill species or if they turn their attention to *E. crystallophias* (Ice krill), albeit less attractive, only when their preferred prey (*E. superba*) becomes scarce. Moreover, it is not known if Antarctic krill is the preferred or the only food for Minke whales.

The fundamental problem of ecology in Antarctic ecosystem is the conservation biology of krill because: (1) krill is central to pelagic marine food web in the sense that most organisms are krill predators and others depend indirectly from krill; (2) krill fisheries continues to develop (Nicol and Enolo, 1999). The magnitude of the problem is such that a group of CCAMLR's specialists have addressed it for many years and have developed and applied in the Atlantic krill fisheries an original krill yield model, which is unique in that it allows to manage krill resources using an ecosystem approach (Butterworth et al., 1994, 1995; De la Mare, 1994; Hewitt et al., 2000; Nicol et al., in press). It is possible that this model, developed for regions where a single krill species has a central role in the pelagic ecosystem, needs some changes to be used in the Ross Sea, where two krill species dominate the marine food web.

The survey design and execution

The research on board of the vessel will consist of three core activities, undertaken by specialised Research Groups (R.G.):

- (1) Acoustic sampling for estimating spatial distribution, abundance and biomass of krill populations and concurrent censuses of their top predators for estimating krill distribution and abundance, and the effects of predators on altering them. The "Krill and krill predators" R.G. will be entrusted with these activities.
- (2) Net sampling for describing krill demography (size/age composition and distribution, growth and mortality), biochemical composition and genetics. The "Krill biology" R.G. will be entrusted with this activity.
- (3) CTD and XBT sampling and continuous T/S recording for identifying environmental characteristics of survey area and the water masses which influence krill distribution, krill transport and swarming. A further activity regards the measurements of sea surface temperature, and ice distribution from satellite images. The "Bio-oceanography" R.G. will be entrusted with these activities, in close collaboration with the CLIMA project.

Observation on phytoplankton fluorescence (ARES project), data obtained by pumped sea water supply, macrozooplankton and ittioplankton species composition obtained by net samplings, are secondary data for the project, but would provide valuable contribute to the core ones.

The vessel must be supplied with all the equipments necessary for acoustic, net and CTD samplings and with suitable laboratories to carry out all the above activities. In particular the vessel needs a protection window, acoustically transparent and properly located, for the three transducers installed on the hull and a bow for towing the three transducers mounted on a V-fin. The requirements are a 40x50 cm window in polyurethane to withstand a pressure of 40 kg/cm² and a 2 m bow to tow 1000 kg at 10 knots.

The geographic area object of investigation (figure 1) is included in the statistical CCAMLR division 88.1. It is approximately the western part of the Ross Sea (from Latitude 77° S to 71° S and from the Victorian Land coast to Longitude 180° E) and a strip of the Pacific Ocean, adjacent to the Ross Sea (from Latitude 71° S to 68° S and from Longitude 172° E to 178° E). The extension of the surveyed area will be around 90000 nm². It will be covered with zigzag transects from East to West and vice versa (about 2500 nm at an average vessel speed of 10 knots), spaced in such a way to allow an uniform sampling density. The survey should be conducted in the early austral summer 2003/04.

The main priority for the program of "Krill and krill predators" R.G. is the estimation of the abundance and distribution of krill and of their predators. Preliminary necessary operations for acoustic sampling are: (1) characterisation of the vessel acoustic noise at 8-10 knots at each working frequency for the two transducer sets (one installed on the vessel hull and one mounted on the V-fin); (2) calibration of the acoustic system at each working frequency on both transducer sets, immediately before and after the survey. Bio-acoustic data will be acquired continuously during the survey (24 hours per day) at 38, 120 and 200 kHz, from either towed body mounted transducers or hull installed transducers, depending on weather conditions. Data collection will be controlled in real-time with an appropriate software. Data stored on CD at the end of each survey day will be analysed during the survey, using multifrequency method (Azzali et al., 2001). Continuous bird and sea mammals observations will be carried out independently but in close collaboration with the continuous krill monitoring to make valuable comparison between the presence of prey and predators. Due to the particular importance of Minke whales in the Ross Sea (Ichii, 1990; Tamura et al., 1997), it is our intention to present a proposal to IWC to have a whale observer during the survey. The principal investigator and the referents for the main activities of the "Krill and krill predators" R.G. are reported in table 1.

The main priority for the program of "Krill biology" R.G. will be the determination of demographic and biological structure, biochemical composition and genetics characteristics of krill populations in the surveyed area. The requirements for estimates of net density and target identification are of secondary importance given that much information on krill identification and density will come from three frequency method. In general, net samples will be carried out four times (midnight, 6 a.m., midday, 6 p.m.) every day survey, and at least two times (midnight and midday), depending on the biological and meteorological situation, for a total of around 50 net samplings (figure 1). In general a haul will last 30 min and will sample up to 200 m. However on the basis of the acoustic detection, the timing would be flexible to allow some shift. The representative samples of krill will be measured on board and the results will be entered onto computer prior to the end of the cruises. A sub-sample will be appropriately frozen/preserved and sent to Italy for further analysis and in particular for biochemical and bimolecular analysis. These analysis will intend to determine the different bioenergetics strategies in populations inhabiting different environments. The principal investigator and the referents for the main activities of the "Krill biology" R.G. are reported in table 1.

The main priority for the program of "Bio-oceanography" R.G. is to identify the water mass that influence krill distribution, krill transport and swarming. CTD samplings will be undertaken at the end of each net samplings. In general the CTD casts over the open ocean should sample up to 1000 m. However, in particular, geographical areas could be important to sample deeper levels of water. In average 50 CTD stations will be conducted (figure 1). Between the CTD stations, vertical temperature profiles (until 760 m) will be acquired by XBT launches. A further task of this R.G. will be the production of maps of the marine ice and sea surface temperature distributions. The principal investigator and the referents for the main activities of the " Bio-oceanography " R.G. are reported in table 1.

The calculated ship time necessary to cover acoustically the surveyed area is: $(2500)/(10 \times 24) = 11$ days. While to conduct 50 CTD/net stations are required about 4 days

(almost 2 h per station). The total ship time necessary to perform the complete research program is not less than 15 days with favourable sea and weather conditions.

Objectives of the research.

The primary objective of the research is to improve those measurements required for the conservation of Antarctic krill biology in the Ross Sea. That is:

- (1) estimating pre-exploitation *E. superba* biomass and abundance;
- (2) mapping *E. superba* distribution;
- (3) describing *E. superba* length/age composition and distribution, biological structure and biochemical composition.

These parameters are required in the CCAMLR krill yield model to ecologically estimate the sustainable krill yield. However, it should be emphasised that Ross Sea is a two-krill-species food web and may require a different approach compared to that applied in the single species Atlantic areas. Therefore, all the above measurements will be carried out also for *E. crystallorophias*.

The second main objective of the research is to use krill as model organisms for studying the interactions between environment and organism variability. That is to identify:

- (1) the water masses which influence Antarctic krill and Ice krill distribution and transport;
- (2) the local environmental characteristics (included ice, phytoplankton, zooplankton, ittioplankton and top predators) that influence the formation, the split and the amalgamation of the swarms;
- (3) the characteristics/differences of the water masses in the Northern part of the Ross Sea and in the adjacent area of Pacific Ocean that may cause a spatial separation between the *E. superba* population of Ross Sea and that of the adjacent Pacific Ocean;
- (4) the biochemical and genetic structure of the *E. superba* population in the Ross Sea and in the adjacent Pacific Ocean.

The third main objective of the research is to investigate on the relationships between *E. superba* and the other fundamental species of the Ross Sea ecosystem. That is:

- (1) spatial and temporal relationships between Antarctic krill population and the similar and probably interacting Ice krill population;
- (2) spatial and temporal relationships between *E. superba* population and its top predators (mainly Minke whales);
- (4) spatial and temporal relationships between Ice krill and its main predators (mainly birds and seals).

It is emphasised that the achievement of the above objectives requires a close collaboration with other PNRA projects and in particular with the CLIMA project.

Retrieving the information on krill, on environment and on predators collected from the previous four expeditions will contribute greatly to reach the above objectives.

Methodology

Acoustic samplings will be made following, as far as possible, the protocols used in the CCAMLR 2000 survey and described in the CCAMLR web site:

http://www.nerc-bas.ac.uk/public/mlsd/synoptic/oldwebsite/bo_proto_acou.htm

Regarding the survey design, on the basis of the previous experiences the surveyed area is divided into 150 rectangles of constant area (600 nm²) spaced 1° in Longitude and with variable intervals in Latitude. The cruise track (around 2500 nm) will pass once through each rectangle, sampling 20-30 nm. It is supposed that the observed krill densities are representative of the rectangles within which are collected. However the pre-planned track (figure 1) can be increased in areas in which very dense concentrations of krill will be detected (such changes will produce a lower CV, but the same expected mean krill biomass).

Concurrent with acoustic survey, censuses will be taken of the mammals and of the birds for 30 min. every hour, using the fixed width strip transect method (Dr. S. Manoukian, table1).

As in the previous 1994/95 and 2000 surveys (Azzali et al., 1999; Sala et al., 2002), krill samples will be collected using Hamburg Plankton Net (HPN). The nominal mouth opening is 5 m² and the mesh size 1000 microns. The net will be equipped with a mechanical flowmeter (General Oceanics, Inc. – Miami, Florida) attached at the net mouth to determine the water volume filtered in each haul. The average towing speed during each haul will be 3.0 knots, varying between 2 and 4 knots. The net will be deployed in a double oblique fashion and an underwater trawl monitoring system (Simrad Integrated Trawl Instrumentation) will be used to control in real-time the depth of trawling.

The “Krill biology” R.G. (Dr. A. Sala, referent of the topic "Demography, Population structure", table1) is involved in a research project for the development of an efficient macro-zooplankton net (HPRI-99 net), which will serve for marine plankton monitoring. The project, financed by the EC Commission, is in collaboration with the Norwegian University of Science and Technology at Trondheim (see the Appendix A). If the HPRI-99 net will prove to be more efficient in sampling krill, larvae and juvenile fish, it will replace the HPN.

In order to obtain accurate data on krill composition, a subsample will be examined from each haul onboard the ship. Using a dissecting microscope (Zeiss-Stemi 2000C) connected to a video analysis system (Zeiss-KS100), several body measurements (total body length AT; carapace length; diameter of the compound eye) will be collected both for Antarctic krill and Ice krill. In accordance with the procedures described by Makarov and Denys (1980), the condition of the sexual maturity stage will be assessed only for Antarctic krill.

Frozen and preserved krill samples will be analysed in Italy using gas-chromatography and HPLC, to estimate the biochemical composition and pigment spectrum (Prof. Danovaro, table 1), and biomolecular techniques to determine the genetic structure (Dr. Iakimov, table 1).

The CTD unit for the survey will be a SBE 9/11 plus. The CTD stations will be conducted every 6 hours, at the end of each haul. A launch of Sippican T-7 XBT probe will be made every 2 hours. Surface T/S will be continuously recorded. The CTD unit is the same used in the previous cruises (Russo, 2000; Russo et al., 1999).

Conclusions

The above research project, slightly different from the original one, was the outcome of an intensive debate between the groups coordinated by Prof. G. Spezie. The major differences and limitations of the above project respect the original one are logistic: the proposed survey length (20 days at least) was shorted (15 days), the proposed survey period (summer 2002-03) changed (early summer 2003-04). Some aspects of the current project need further analysis and much work remains to be done by all the researchers involved in the project, before the survey will be performed. The helps received from the members of the WG-EMM on the different topics in comments, suggestions and literature, during the workshop or for correspondence, will be greatly appreciated.

Acknowledgements

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We would also like to thank the two anonymous referees, who gave us the benefit of their comments and suggestions during the research project submission and in advance the members of the WG-EMM for their constructive criticism.

Table 1: Main Topics, methodology used and referents for the Italian Acoustic Survey in the Ross Sea (2003-04).

Research Title: Krill, Environment and Predators: Interactions, functional relationships and ecological implications for the Ross Sea resources management. Acronym: KEP.

Principal investigator: Massimo Azzali

Research groups involved in the project:

(1) "Krill and krill predators" Research Group

Principal investigator: Massimo Azzali

azzali@irpem.an.cnr.an

Topic: Abundance, Biomass, Spatial distribution, swarming

Methodology: Multi-frequency acoustics

Referent: Massimo Azzali

azzali@irpem.an.cnr.it

Topic: Predator abundance, Predator-prey interactions

Methodology: Visual samplings and photo-identification

Referent: Sarine Manoukian

manoukian@irpem.an.cnr.it

(2) "Krill biology" Research Group

Principal investigator: Ermanno Crisafi

crisafi@talas.ist.me.cnr.it

Topic: Demography, Population structure

Methodology: Morphometric analysis on net collected fresh samples

Referent: Antonello Sala

sala@irpem.an.cnr.it

Topic: Energetic, Physiology

Methodology: Gas-chromatography and HPLC on preserved sub-samples

Referent: Roberto Danovaro

danovaro@unian.it

Topic: Genetics

Methodology: sequence analysis of several mitochondrial genes on frozen sub-samples

Referent: Mikhail Iakimov

iakimov@talas.ist.me.cnr.it

(3) "Bio-oceanography" Research Group

Principal investigator: Aniello Russo

russo@irpem.an.cnr.it

Topic: Oceanography, Interaction between environment and organism variability

Methodology: CTD & XBT samplings, continuous 5 m T&S recording

Referents: Aniello Russo, Elio Paschini

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paschini@irpem.an.cnr.it

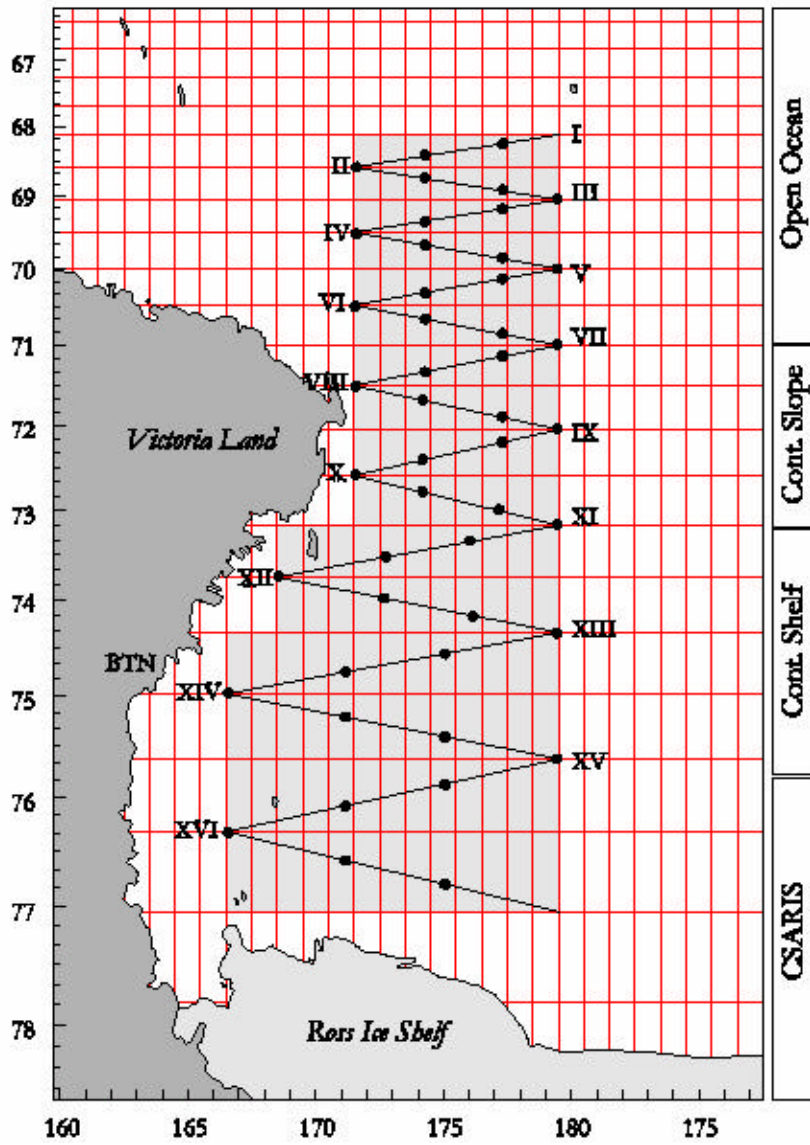


Figure 1: Proposed survey design for studying krill and their role in the Ross Sea ecosystem. On the basis of the environmental conditions (ice cover, weather, etc.), the design will undergo modifications.

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Appendix A

Development of an efficient macrozooplankton net for marine bio-resources monitoring

Research Project No. *HPRI-1999-CT00060* financed by the Commission of the European Communities
within the 5th Framework Programme
the Improving Human Research Potential Research Infrastructures Programme

Scientific responsible: *Antonello Sala*

Development Staff: *Antonello Sala, Gabriele Buglioni, Vito Palumbo, Silvia Schiavoni*

Introduction

To study effectively and economically the horizontal distribution of marine animals it is essential to use towed sampling devices. Net samples is also essential to provide further data to examine different demographic parameters of zooplankton, using data on sex, maturity stage and size composition. But the interest to develop efficient trawl sampling systems is far broader, for example during the acoustic surveys, trawl samples yield indispensable information to identify the acoustic targets and animal size-data in order to convert acoustic backscatter measurements into a biomass estimate for both management and scientific studies (Everson and Miller, 1994). Such sampling nets have been used since the first Discovery expeditions (Kemp et al., 1929; Marr, 1938; Foxton, 1963), but difficulty has been experienced in finding a suitable technology for sampling macrozooplankton (copepods, krill, plankton of no commercial interest, etc.) and micronekton such as fish larvae, decapods and cephalopods. In fact, recent studies conducted during the last Italian Antarctic expeditions (Guglielmo, 1992), have demonstrated the ineffective at catching adult stages of krill (<10 individuals per haul) and macrozooplankton using some of the present horizontal plankton nets (Isaacs-Kidd-Midwater-trawl and Ez-Net-Bioness).

Methods

There is considerable experience in Japan and Eastern Europe from commercial fishing of krill (Budzinsky et al., 1985). However, little technical information on fishing equipment is published. Based on the accessible results from commercial fisheries, in the actual project an experimental plankton net will be designed with the aim of obtaining a larger mouth opening and a lower towing resistance. The prototype of the new trawl which is designed at IRPEM-CNR (Ancona, Italy) will be tested for the first time at Trondheimsfjord (Trondheim, Norway), where the waters are rich in zooplankton, compared to the Mediterranean Sea, and therefore suitable for plankton trawl developing experiments. Modifying a demersal trawl, so to operate pelagically, will be achieved through a combination of rigging modifications including use of small otter boards to increase the horizontal spread. The development and operation of the plankton net will be assisted by the improved monitoring capability of *Scanmar* acoustic trawl monitoring system, so that the exact depth of the net and gear performance will be indicated aboard. The ability to constantly monitor all performance parameters during towing operation will enable rapid assessment of trawl performance under a range of operating conditions (Fiorentini et al., 1994; 1998). Researchers will be therefore be able to assess the effectiveness of rigging modifications on performance in an attempt to fine tune the trawl. *Scanmar* sensors will be mounted on the trawl in order to measure the horizontal net wingend spread, the vertical opening and the net fishing depth below the sea surface. This system will be connected to the Personal Computer and the measurements will be transferred to it in real time through an appropriate software program developed by IRPEM group (Fiorentini et al., 1993). When the tests will be carried out on the "*Harry Borthen I*" (a

fully equipped oceanological research vessel, which serves the Trondheimsfjord), will be possible to measure additional parameters. In fact, it is equipped with GPS Satellite receiver (vessel position) and a Doppler Log (vessel speed in relation to sea bed). Moreover, an electronic load cell will be used to determine simultaneously the warp force. The portable computer will record on the hard disk all the measurements made at a rate of every ten seconds. A set of measurements will be collected for every haul and then processed later at the Biological Station. For each haul, the data collected before the gear performance was stabilized or while changing speed, will be discarded. Then an average will be computed on the remaining data. Sometimes the hauls will be done in reciprocal directions in order to determine the effects of the sea current (Sala et al., 2002). By paying out or hauling in the towing warp, or by changing the ship speed, it will be possible to direct the net exactly into a plankton rich water layer, as indicated by echo sounder. For each haul, all the catch will be collected and analysed ashore at the Biological Station. For every haul, the number and the weight of each species will be converted in number and *grams per km²* by taking into account the horizontal net opening (measured by *Scanmar* system), the vessel speed (measured by the vessel's Doppler Log) and tow duration. The tow duration will be considered as the time between the reach of the optimal gear opening and the moment when the speed will be reduced to recover the warp. On the base of the gear performance results obtained, the relationships between the fishing depth, the horizontal and vertical net openings and warp length will be calculated. These relationships will allow to estimate the respective values when experimental data for the hauls will not be available. In particular, gear performance measurements will also be very important when carrying out stock assessment surveys of commercial plankton populations. In fact, these surveys require knowledge of trawl swept area, and may form the basis for determining sustainable fishery yields, as is the case in the Northern and Mediterranean trawl fishery.

Specific project goals

This RI-project is concerned with the development of an efficient macrozooplankton net which will serve for marine plankton monitoring. Consequently it will be of use to fisheries biologists, industrial fishing gear technologists and fisheries managers.

- 1) The main objective is to develop a plankton net, which could catch large amounts of macrozooplankton for demography, energetic/physiology and genetics study applications. It is essential that the new design can combine the features of high headline height and net horizontal opening with a low towing resistance. The new plankton net will be possibly used in the next Italian Antarctic project (2003-2006): "*Krill, environment and predators: interactions, functional relationships and ecological implications for the Ross Sea resources management (KEP)*", financed to IRPEM-CNR Institute by the Italian Ministry of the University and Scientific Research and Technology. The Antarctic project will shortly start with a collection of the present-day data on new towed sampling devices in use by the fisheries biologists. The current RI-project will early provide essential information for a possible efficient sampling net.
- 2) A strategic Research Programme (Olsen et al., in prep.), financed by the Norwegian Research Council, has early pointed out that significantly higher quantities of bio-resources are available if we also harvest at the grazer or the plants levels of the food web. Probably in a little while, there will be a growing demand for zooplankton as bio-resources for fish feed and industrial raw material. A complementary outcome from this project will be an innovative sampling gear which will efficiently catch high concentrations of zooplankton for aquaculture industry world wide. During the sea trials, it will be attempted to request the participation of a local fishing industrial technologists.
- 3) The current RI-project is strongly linked to the project n.2 "*Concept for harvesting technology of zooplankton*" of the strategic Research Programme (Olsen et al., in prep.). In the project 2, an industrial harvesting gear has been already optimised and tested at Trondheimsfjord. In order to assess the relative catching efficiency of the

macrozooplankton sampling net, comparison with that of typical industrial harvesting gear will be conducted in the same fishing area.

Common interests, related groups and collaboration

In an early stage of the last Trondheim Marine Systems RI-project (Sala, 2001), net samplings were carried out on board the RV "Harry Borthen I". Krill samples were collected using a horizontal I-KMT (Isaacs and Kidd, 1953). Despite some problems concerning the catch of the krill species (less than 20 individuals per haul), the previous RI-project has permitted to establish strong links with Prof. Y. Olsen in order to develop a more efficient towed sampling gear for macrozooplankton monitoring and harvesting.

Exploitation and dissemination activities

The prototype of the new plankton net is not yet patented and the dissemination to the scientific community will be done via papers in peer-reviewed journals. These journals could be Fisheries Research, ICES Journal of Marine Science and Aquatic living resources for fisheries aspects and so on.

The fishing industry will be made aware via articles written for the international fishing press and for national fishing press for fishermen.

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