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Laws

SCAR GROUP OF SPECIALISTS

MARINE LIVING RESOURCES OF THE SOUTHERN OCEAN

6-8 OCTOBER, 1975

SCOTT POLAR RESEARCH INSTITUTE
CAMBRIDGE, ENGLAND

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Marine Living Resources of the Southern Ocean

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CONTENTS

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*From a letter to Dr. T. Nemoto dated 12 September, 1975.

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of the SCAR Group of Specialists on the
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SCAR Group of Specialists
on
Marine Living Resources of the Southern Ocean

BACKGROUND INFORMATION

Terms of Reference

At its meeting in 1972 in Canberra, Australia, SCAR Working Group on Biology has recommended the establishment of a Sub-Committee on Marine Living Resources of the Southern Ocean in an effort to cope with the problems and issues of these resources. The objectives of this Sub-Committee, as enunciated in its Terms of Reference, are as follows:

(1) To assess the present state of our knowledge of the Antarctic marine ecosystem from the point of view of structure, dynamic functions and biomass of the organisms at different trophic levels. Special emphasis should be placed on assessment of the stocks of krill, squids, fishes and whales since these organisms play key roles in the ecosystem.

(2) To encourage and stimulate investigations of the ecology and population dynamics of the organisms at different trophic levels with particular reference to Antarctic krill, squid, fishes and whales.

(3) To establish liaison between SCAR and relevant international organizations such as SCOR, FAO, IOC and IABO by bringing matters concerning the exploration of marine resources of the Southern Ocean to the attention of SCAR Working Groups on Biology and Oceanography and by conveying the views of SCAR, or its working groups, to appropriate international organizations.

(4) To lend assistance to SCOR, FAO, IOC and other organizations in the formulation of advice on matters concerning the living resources of the Southern Ocean.

(5) To cooperate with such organizations as FAO, in formulating guidelines for any further commercial exploitation.

At the SCAR Executive Meeting held in June, 1975, realizing that the Sub-Committee was becoming a most important field of activity for SCAR; it was decided that the present Sub-Committee should be constituted as a SCAR Group of Specialists on Marine Living Resources of the Southern Ocean.

The following Terms of Reference assigned to the Group of Specialists, are the following:

(1) To assess the present state of knowledge of the Antarctic marine ecosystem from the point of view of structure, dynamic functions and biomass of the organisms at different trophic levels;

(2) To encourage and stimulate investigations of the ecology and population dynamics of the organisms at different trophic levels with particular reference to krill, squid, fishes and whales;

(3) To maintain liaison with FAO;

(4) To advise SCAR (and SCOR) and through them other international organizations and in particular to respond to relevant recommendations of IOC and the Antarctic Treaty Consultative Meeting.

Relation with IOC

The Intergovernmental Oceanographic Commission Executive Council, at its fifth session in March 1975, having considered the recommendations of meeting in July of the IOC International Coordination Group for the Southern Ocean, had invited the SCAR Sub-Committee on Marine Living Resources of the Southern Ocean to prepare practical proposals for collaborative investigations in biological oceanography in the area and to prepare proposals for working towards the organization of multi-ship studies, for submission to SCAR and SCOR, and through them to ICG. Int. Coord. Gp IOC SO.

Relation with Antarctic Treaty

At the Eighth Antarctic Treaty Consultative Meeting held in Oslo in June, 1975, a recommendation (Recommendation VIII-10) with regard to the Antarctic Marine Living Resources was made. In this recommendation the Treaty invited SCAR to continue its scientific work on these matters and to consider convening, as soon as practicable, a meeting to discuss current work and report on progress for the study of conservation of Antarctic marine living resources.

- This request to SCAR from the Treaty Consultative Meeting was, in many respects, parallel to the request to SCAR from the fifth meeting of the Executive Council of the IOC.

- SCAR Executive agreed that those matters were of such importance that in order to stimulate early action, it was necessary for the Group of Specialists to meet in the near future;

(a) to consider how best to proceed in relation to IOC and Treaty requests;

(b) to prepare an interim progress report for SCAR to present to the Ninth Assembly of IOC in October 1975 (and to the SCOR Executive Committee in November);

(c) to prepare a larger meeting of experts in the U.S.A. in mid 1976 and to determine the main items for the program.

SCAR.

AGENDA

SCAR GROUP OF SPECIALISTS ON MARINE LIVING RESOURCES
OF THE SOUTHERN OCEAN

Scott Polar Institute
Cambridge, England

6-8 October, 1975

1. Adoption of agenda

2. Election of a rapporteur

3. Report on the activities of the Group since Montreal meeting in May, 1973.

4. Relation of the Group to: FAO, SCOR, IOC, etc.

5. Discussion of recent requests from IOC and Antarctic Treaty Powers.

6. Plans and preparation for an international conference on the Marine Living Resources of the Southern Ocean at the invitation of the U.S. (in 1976).

7. a. Discussion of the Group's Interim Report to SCAR (for transmittal to IOC and SCOR). for IOC, 22 Oct - 4 Nov.

   b. Discussion of plans for a more comprehensive report.

8. Other business.

Outline
of a Proposal to SCAR for the Study of the Marine Living Resources of the Southern Ocean

1. INTRODUCTION AND BACKGROUND and General Objectives.

    1.1 Historical background

    1.2 The rationale for a coordinated research program + provision of advice.

2. GENERAL OBJECTIVES

    2.1 The trophodynamics of the Antarctic Marine Ecosystem.

    2.2 The population dynamics and ecology of the krill

    2.3 The provision of data/information base for the conservation and wise management of the living resources. Gulland

    2.4 The provision of data/information for monitoring pollutants and their effects at all levels in the food-web and water column.

3. SUGGESTED RESEARCH PROGRAM

    3.1 Trophodynamics of the Antarctic Marine Ecosystem.

    3.2 Population dynamics and ecology of krill. McWhinnie

    3.3 Population dynamics and ecology of marine mammals.

    3.4 Pop. dyn. and Ecology of fishes, squids and other living resources (lobsters, crabs and seaweeds).

    3.5 Conservation and Management of the living resources of the Southern Ocean (includes: Modeling of the Ecosystem with special emphasis on the effect of resources exploitation). Gulland

    3.6 Pollutants in the Antarctic Marine Ecosystems.

    ~~3.7 Remote Sensing.~~ of resources

4. PRACTICAL IMPLEMENTATION OF THE PROGRAM

4.1 A proposal for a co-ordinated multi-ships program of simultaneous observations in Antarctic waters.

4.2 Supporting ship-based programs.

4.3 Supporting shore-based programs.

5. INTERNATIONAL CO-ORDINATION/COOPERATION with: FAO, SCOR, ACMARR, etc.

6. SUMMARY OF THE PROGRAM

Draft Proposal to SCAR for the Study of the Antarctic Marine Resources

Gulland

2. GENERAL OBJECTIVES

2.3 Provision of information base for conservation

The various living resources of the southern oceans (krill, squid, fish, whales, etc.) together constitute one of the larger potential sources of food from the sea. Their potential contribution may be gauged from the fact that in the 1930's the harvest of whales from the Antarctic accounted for some 5-10% of the total harvest of marine animals. The history of Antarctic whaling also shows clearly the essential need for proper conservation. Such conservation in turn depends inter alia on the availability of adequate data and information.

This information will come in part from the results of scientific research, whether directed specifically in support of conservation programmes, or with other objectives, but data from the harvesting operations themselves are likely to be of vital importance. The scientific advice on conservation of most fish stocks and of whales, have generally been based very largely on the catch, effort and other data from the commercial fishing operations. Research scientists are aware of the importance of making the results of their studies available to the scientific community, but on the other hand commercial operations are not anxioux to spend time and money collecting data unless they have to, and indeed often wish to keep confidential any information that might be of potential economic interest. Special attention needs to be paid to obtaining data from commercial operations, including pilot-scale and experimental activities, such as those already being carried out on krill by Japan, U.S.S.R. and others.

The provision of data requires first that the types of data and information needed should be clearly identified, second that those concerned accept the responsibility for collecting and reporting the information, and finally the central collation and dissemination of the information. Research scientists presumably know what information they are trying to collect will be of general interest, and other elements of the general SCAR proposal will emphasize the types of information that are of particular importance. Commercial, and semi-commercial operations are directed towards specific and relatively narrow goals, and useful information for research studies may not be collected unless special arrangements are made. Particular attention in the early stage of research planning needs therefore to be given to determining the types of data that should be collected and reported by operators of commercial or semi-commercial vessels (e.g. total catch, sizes of animals caught, time and position of capture, catching effort, including size and type of gear used, etc.).

Reporting and dissemination is also simple for research results, as part of the normal scientific process, either as research papers and reports, or as input to data centres, but reporting from other activities will require more attention. It would be useful to have established definite responsibilities (preferably by governments) for ensuring that the necessary data are collected, and channels (e.g. specific offices within each country) whereby data are collected and forwarded to a central point.

For simple data the central point could handle and process the actual data. For example, oceanographic data for the southern oceans (sea temperatures, etc.) would presumably be handled by existing Oceanographic Data Centres. Equally, the simpler data (catches, etc.) coming from any commercial type of operation could be handled in the same way as fishery data is handled by the regional fishing bodies such as ICES, or ICNAF, or by FAO. The more complex information, e.g. on the biology of krill, is not amenable to this semi-mechanical processing. It is less important to have the actual information stored centrally than to ensure that any interested scientists can easily find out what information is available where. For published papers and similar scientific literature, a number of information retrieval systems exist (e.g. the Aquatic Sciences and Fisheries Information Service established by FAO with support from IOC, or the Antarctic Bibliography). These may be fairly easily extended to cover the less conventional literature, e.g. meeting documents and reports, but a special system may be necessary to maintain a general awareness of what information, often of considerable scientific interest, is available from the non-scientific, semi-commercial operations in the southern oceans.

3.5 Conservation and management of the living resources

Gulland.

Conservation and management involve four steps - collection of the necessary data; the scientific analysis to predict the effects of different management measures being considered for implementation, and to monitor the effects of any measures that have been introduced; discussions on the choice of measure, taking account also of social and economic factors; and the implementation and enforcement of the chosen measure. The last is of purely legal and administrative concern; the discussion on the choice of measures is also largely the responsibility of non-scientists - though scientists have played an important role in these types of discussions in other areas - and require no significant research work. The major research activity is concerned with the second stage of assessing the state of various stocks, and the effects of possible management measures. One part of this is the estimation of the elements of the population dynamics of the major species. These elements include the identification of any independent stocks into which the animals of a given species living in the southern oceans can be divided. The other parameters required, which if possible should be estimated for each stock or sub-population separately, include the total numbers, or biomass; the growth pattern of the individual animals; the life-span, or natural mortality rate; and the reproductive rate. In the long run it is highly desirable to understand how these rates vary with changes in the abundance of the species under consideration, or of other species. This is however probably not a realistic target for study in the immediate future.

The techniques for estimation will depend on the species being studied, but the major requirement is some method for estimating absolute abundance - or at least failing this, relative abundance - of the total stock, and also the relative composition of different sizes (or ages) of animals in the population.

The methods available for estimating abundance of different animals include:

Whales: sightings from ships; probably reliable with experienced observers, but with a high variance requiring much ship's time to get good estimates

Seals: sightings from ships or aircraft; better knowledge of behaviour patterns may be needed to interpret results. Observations may need to be done at critical times or places to be most effective.

Fish: acoustic surveys; effective for giving relative measures for pelagic fish; can also give absolute abundance if the target strength of the fish can be measured. Should be combined with some fishing, e.g. with mid-water trawl to identify species concerned.

surveys with fishing gear; effective for bottom fish on good bottom using normal trawls. Other gears (mid-water trawl, gill-net, etc.) give less quantifiable results.

Squid: no good survey method available. Certain fishing gear, e.g. jigging, can give some idea of relative abundance, and (with caution) species and size composition.

Krill: no good survey method available. The animals are too active to be sampled quantitatively by normal plankton gear. Large nets towed quickly may work. Alternatively a combination of acoustic methods (to locate and delimit shoals) and some type of net, or other method to determine the density within a shoal, may be most effective.

In addition, once large-scale exploitation starts, a number of methods can be applied, e.g. relating changes in relative stock abundance to the removals.

The necessary research work involves, first, experimental work on catching or other methods to determine the best survey method or methods, particularly for squid and krill and, second, detailed planning of the survey work - including setting out the requirements of ship's time, in terms of types of ship and gear used, and season and place of operation needed to get results with an acceptable degree of precision and reliability. The third and final stage would be to carry out the actual surveys.

The other major research problem is to develop the necessary methods of analysis and types of models for analysing the data and providing meaningful advice on the needs for conservation, and the effects of different possible measures. Existing techniques and models as applied to fish and whales seem fine for single species situations. Scientific difficulties over whales arise either from data shortages (e.g. good estimates of the unexploited abundance of minke whales) or small and essentially unimportant differences of interpretation (e.g. of the precise state of the present sei whale stock relative to the stock giving the MSY), which became critical because of the details of the present whale management policy.

The real scientific problems arise from the interactions between species. Many of the current conservation questions concern these interactions, e.g. would fishing down minke whales promote the faster recovery of blue whales? To what extent would harvesting of krill affect whales and other stocks? There is no way at present of answering these. The first step would be to develop suitable models; these would probably not in the first instance provide quantitative answers, but rather identify specific parameters for which measurements need to be made, e.g. over what areas and what periods do blue and minke whales occur together? What overlap, in these areas, is there in the food eaten?

POPULATION DYNAMICS AND POPULATION ECOLOGY OF KRILL

Considerations Prepared* for
WORKING Group on BIOLOGY, SCAR

McWhinnie

One of the most important aspects of biological research in polar/antarctic marine environments is the elucidation of population characteristics of a species. The long term objective to define a species, and its interactions with all other elements of the ecosystem would result in a description of the dynamic environment of the biota in general and, each species in particular. These other elements constitute the biotic as well as the interaction of all physico-chemical, hydrographic and meteorological phenomena.

These objectives represent the most complex of all biological questions and in <u>sensu strictu</u> have never been achieved through the extensive studies of diverse ecosystems conducted to the present; and these objectives are the most difficult to accomplish with planktonic systems and species.

Fundamental to progress toward the previously noted objective is prior knowledge of the life history, population ecology and, the temporal and geographic variations of each species. From a vast inventory of circumscribed or single species information, the next level of elucidation can be approached; e.g.

(a) intra- and interspecies interactions and dependencies,
and, (b) responsivity to, and influence of, the manifold physical phenomena.

It is the first level of life history of the dominant antarctic krill to which the following considerations are directed.

Though the growth potential of any population is especially great it is never achieved in a natural environment since spawning,

* by M. A. McWhinnie, DePaul University

hatch rates and their percentages of total spawn, individual growth rates, time to maturity and death processes (natural and consequent to predation), are all modulated by environmental characteristics and their fluctuations. It would appear evident that it is essential to understand in considerable detail, the growth rates, time to maturity and longevity of *E. superba*. This is necessary to determine whether generalized values for these parameters apply to this antarctic species or, whether they vary on a regional or annual basis as a result of fluctuations in the physical parameters with time (e.g., light, ice cover, temperature).

In a detailed study of reproductive development and life span of *E. superba*, Bargmann (1937, 1945) concluded that maturity and breeding occur in the second year of life and, that size of the individual and attainment of maturity are only poorly correlated. Those studies included dissection of thousands of specimens to determine gonadal development from samples collected predominantly in the Weddell-Scotia Sea areas. Fraser (1937) had also observed a lack of correlation between size and maturity. His study showed that early larval stages occur in deeper waters in the Bransfield Straits (high egg density) and subsequently, metanauplii appear in the Scotia Sea. Late furcilia larvae (stage 6) and adolescents were found to occur at the edge of the pack-ice in the regions of South Georgia and Bouvet Island; larval stages showed a marked diurnal vertical migration while adolescents tended to remain in surface swarms. In general, development of *E. superba* includes 13 stages (nauplius to sixth furcilia) which are completed by the time larvae reach an average of 10 mm in length (Maximum, 13 mm) at the end of their first summer (approx. 6 months to June). By the following January adolescents are reported to be 22 to 24 mm long and remain at this stage through their second year, becoming mature and breeding adults (28 mm and longer) in the succeeding year. This same sequence was also described by Marty (1969), Makarov and Shevtsov (1971) and Voronina (1971).

In contrast, study of samples collected through ten years led Bargmann (1945) to the interpretation that E. superba become mature and breed within the second year of life. She concluded that in the Falkland Sector, eggs are found in abundance in the 1000 to 250 meter level, from November to February with a peak in January/February. Nauplius and metanauplius stages are abundant from January to April, and calyptopis appear from January to late April. Furcilia stages over-lap calyptopis from January to October but are dominant from June to October; adolescents appear in August to January but become dominant from October onwards.

Bargmann's data, derived from samples collected between 20°E, east of Bouvet Island to about 68°W in the Bellingshausen Sea through several annual cycles, showed the earliest appearance of adolescents in August. Based on reproductive development, male E. superba on an average mature in October at 37 mm but some few differentiate in August and are larger, as are those of February to April (40 and 53 mm, respectively). Females also show considerable variance in size as they differentiate to maturity. Some reach maturity at 22 mm in October, while those reaching maturity from February to June were considerably larger (average length, 49 mm). It was measurement and assessment of reproductive development of numerous adolescent males and females which led to the conclusion that there is a marked lack of agreement between size and maturity stage.

Availability of food appears to influence rate of growth and size of adolescents taken at the ice-edge at 146°W and at 155°W. Since there are meridional differences in primary production, this could be, at least, one cause of the difference in growth rates. Whether size ranges of mature males (Sept. 34 mm to Apr. 54 mm) and females (Aug. 39 mm to Mar. 46 mm; Bargmann, 1945) represent different age classes or reflect different phytoplankton densities, is not entirely clear. In a summary of considerable work, El-Sayed (1970) reported wide meridional variation in phytoplankton productivity. The latter was especially evident in samples obtained from the Weddell and Bellingshausen Seas and the Bransfield and Gerlache Straits, areas in which such variance in size and maturity of krill appears to occur (1965; 1968).

Fertilization and spawning are at a peak in January/February but were observed to occur sporadically from October to April. This has been re-confirmed by Mackintosh (1972) after study of samples from the same collections. A long reproductive period would provide many broods of larvae throughout the summer as well as provide some resilience against reductions by harvesting a particular age class.

Bargmann concluded that the life span of E. superba is characterized by a first year in which eggs develop to adolescents through approximately nine months (Nov./Dec. to the following Sept/Oct.). The next austral summer and the following 12 to 13 months are spent as a growing adolescent with maturity developing by the following September/October. Breeding would be initiated the second summer, and the majority appear to die after spawning. In the studies of Bargmann and Nemoto it was suggested that the decline of mature females in winter may be due to death or, less likely, descent to deeper layers for further spawning.

This life cycle would provide, during any given summer, three age classes;

--- initial egg and larval stages of the current year;
--- the adolescent population of the previous year;
--- the mature, breeding adults subsequent to two years of development;

Voronina (1971) also estimated that the life cycle to breeding extended for two or more years. The one and two year classes described by Nemoto (1959) and taken from samples in the Pacific Sector, differed considerably from those of Bargmann being 15 to 40-45 mm for year one (= 2) and 45-50 mm for year two (= 3). More recently, Nemoto and Nasu (1975) and Yanase (1972) also suggested that E. superba is a bi-annual species.

A different time scale for the life cycle of E. superba has been proposed by Ivanov (1970). Growth and age data were derived from a large number of individuals randomly selected from surface swarms (0 to 10 meters) in the vicinity of the island groups in the Scotia Sea, in one season only (Feb. to early Apr. 1968). A modification of Bargmann's maturity stages was employed but both reflect essentially equivalent stages of development.

Distribution of size-frequency curves of euphausiids collected at six stations showed distinct peaks which were interpreted to represent year classes. Summarily, Ivanov proposed the life cycle to be characteristically of four years:

--- Year 1: less than 22 mm consisting of larvae and early adolescent;
--- Year 2: 24 to 36 mm, with sex characteristics immature;
--- Year 3: 36 to 45 mm with the majority of individuals immature;
--- Year 4: 45 to 54 mm breeding adults;
--- Year 4-plus: more than 57 mm.

This study offers evidence that the life cycle is extended by one-plus years longer than that estimated by Bargmann (1945), Marr (1962), Voronina (1971) and Makarov and Shevtsov (1971), but agrees, at least in part, with Fraser (1937) and an earlier study of Nemoto (1959). More recently Moiseev (1971) stated that this shrimp lives for 4 years or longer while Mackintosh (1972) re-studying Discovery collections re-states a 2 year life cycle. The 2-year figure has been reported subsequent to an FAO Conference (1974) on this species. In that report juveniles (= adolescents ?) have been identified as individuals with a modal length of about 35 mm which Ivanov places as "Year 2, immature individuals". Fraser had characterized animals of 28 mm or more as mature and breeding which agrees, at least in part, with the size and state of development indicated by Bargmann. In a study of energy metabolism Chekunova and Rynkova (1975) recently identify juveniles as second year, and adults as third year animals ranging from 24 to 58 mm in length.

Rearranging the size classes and degree of maturity achieved, it is possible to find a four-year cycle for some samples of E. superba in the data of Bargmann (1945).

The numerous cases of sexual maturity of this species reported by Bargmann (1945), Fraser (1937) and Nemoto (1959), at considerably smaller sizes than those stated for Years 3 and 4 by Ivanov (1970) require some other interpretation. Study of differences in,

(a) the availability of food,
(b) annual temperature cycles (warm vs. cold years),
(c) in various antarctic regions (Scotia-Weddell Seas vs. Ross Sea vs. Indian Ocean Sector),

may disclose population differences in growth rates and life histories resulting in evidence for both two/three and three/four year populations. Since Ivanov's data were derived for one season in a more restricted region, while Bargmann studied considerably more samples from many annual cycles and a large sector of antarctic waters (20^{O}E to 70^{O}W), differences in reported growth rates may reflect real population differences.

If it becomes evident, through further study, that such is a more accurate interpretation of growth rates, then these studies would emphasize the need for regional and annual specifications of harvestable age (= size). It is of interest that each of these studies recorded a wide variance in individual sizes. In Ivanov's study it was reported that samples taken from the same areas in 1965 and 1967 showed the population to be generally smaller (down to 29.7 and 30.5 mm) though considerations regarding maturity and/or its differences were not discussed. It is evident that substantial study is required to define where possible, the timing of the life cycle of these euphausiids to elucidate the number of age classes which exist in any one season, and their disposition with respect to geographic location and swarms.

As crustacean growth is dependent on molting it would appear that a clue to growth rates would emerge from knowledge of molting frequency and the net increment associated with each molt. There is a paucity of information on this subject but one study (Mackintosh, 1967) conducted under semi-laboratory conditions suggests an intermolt period of approximately 14 days for 25-30 mm animals. However, under the conditions of that study there was no increase in body length through 2 and 3 molts. Such data appear to point to sub-optimal conditions which probably prevail under confinement, and Mackintosh noted the lack of feeding through some seven weeks of observation. Despite this limitation it remains desirable to obtain information concerning molting frequency and size increase for at least the three principal phases of euphausiid development (e.g., larval stages, adolescent, and adult) under conditions designed to approach the natural environment if achievable. The effect of sub-optimal conditions on larval types has been described by Makarov (1974). That study reports an increase in larval stages which deviate from the main larval sequence and increase the number of larvae of *E. superba*.

RECOMMENDATIONS

Implicit in the foregoing and in keeping with the recommendations of the Sub-Committee on Marine Living Resources of the Southern Ocean (Working Group on Biology SCAR; XIII Meeting, Sept. 74), it is evident that while a substantial body of information concerning krill is available, essential details on the life history of *E. superba* and its apparent variability must be defined with a higher degree of precision. This will serve the best interests of species conservation while useful exploitation of this unconventional animal protein source can proceed reasonably and successfully to meet the world need. Thus, to provide the required information to achieve these ends it is recommended that:

1. The dominant antarctic krill, imminently susceptible to harvesting, be studied with respect to:

   -- fecundity,

   -- larval types, sequence, longevity (calendar age) and variation,

   -- characteristics of adolescents, size, weight/volume, correlations with gonadal development, duration of this phase,

   -- characteristics of mature/adult animals, size, (size range), weight/volume, gonadal characteristics, sex ratios, spermatophore load,

   -- as these relate to, and vary within, and between, swarms,

   to, vertical distribution,

   to, seasonal cycles,

   to, annual cycles (minimum three),

   to, geographic location (minimum three)

2. As krill are a potential nutritional resource, study of their spatial distribution is needed to allow better (more quantifiable) estimates of their standing stock at the locations of most probable harvesting (e.g., Scotia Sea, Weddell Sea, Bransfield Straits, Kerguelen Islands, (less likely), northern and eastern Ross Sea).

   Data permitting estimates on the potential animal harvest must be developed from:
   (a) such surface studies as may be formulated, which should be coupled with,
   (b) satellite imagery to achieve this end, as well as to disclose the degree of reliability which can be assigned to estimates derived from surface studies,

3. Correlations should be developed between deep scattering layers and bona fide analyses of plankton populations responsible for these layers.

4. Population characteristics of krill aggregations/swarms resulting from artificial induction (illumination, electrical discharges, etc.) must be defined (e.g., age classes, homogeneity, sex ratios, etc.).

5. Based on existing data, geographic and temporal variation in population (sub-population) characteristics should be verified, detailed, and correlated, minimally, with hydrographic and meteorological features. Correlative biotic characteristics (phytoplankton populations, consumer populations such as whales, seals, squid, birds) are also basic to the explication of regional or sub-populational differences.

6. Correlation of larval and adolescent distribution with temperature, e.g., sampling at particular depth horizons through which finely resolved thermal profiles are concurrently taken.

7. It is essential that studies be conducted throughout all seasons (where feasible) within the pack-ice zone and at its edge.

8. Molting frequency and growth increment (volume as well as length) per molt (of larvae, adolescents and adults) must be assessed to estimate growth rates (distinct from morphogenetic molts) so that longevity and age classes, presently assessed on a statistical basis, can be established with greater certitude. This requires successful laboratory maintenance, a challenge of some magnitude, but needed to resolve the presently unclear longevity.

9. Population characteristics should be studied in major water masses relative to the (better understood) West Wind Drift and the (less studied) East Wind Drift.

10. Enzymatic analyses (gene based isozymic patterns) should be conducted routinely on a seasonal and a regional basis, to determine whether the standing stock studied represents a single circum-antarctic stock or relatively isolated independent stocks.

11. Factors and forces which induce natural swarming must be elucidated though this aspect of E. superba biology has its highest priority primarily from the point of commercial harvesting.

12. Because of the need for concurrent studies of different regions and,

    - because of the time scale considered essential to provide meaningful data (several years), and,

    - because of the scope and intensity of the studies recommended,

    it is considered essential that significant and coherent knowledge, more free of the uncertainties and variances which characterize present knowledge, be obtained,

    It is recommended that a multi-nation, multi-ship program be developed to provide a strong scientific inventory and synthesis upon which reasonable krill harvesting can be based.

    In this effort, international coordination and cooperation seem essential.

13. Consequent to existing and imminent efforts to harvest krill it is further desirable that information-flow keep pace with development of a krill-fishery. Thus, during the course of comprehensive studies international conferences seem essential

to achieve the highest yield from the large research effort and cost which these recommendations portend.

14. Because of the near-shore occurrence of this species, as well as its oceanic distribution, it is recommended further that shore-based studies be initiated at feasible coastal stations. Such studies should provide information on the biological characteristics of multiple (sub- ?) populations in circum-antarctic waters.

Further, it is likely that useful information on particular aspects (e.g., molting) can be gained during the course of planning a comprehensive study such as is described in the preceeding recommendations and which is dependent upon extensive logistics and very considerable financial resources.

Commensurate with the goals of the Working Group on Biology, SCAR, it is not considered by this writer that testing the efficiency of various types of trawling gear is appropriate. Though it is recognized that such a goal is pressing in the face of global food needs, it is also recognized that the magnitude of the fundamental work identified here would preclude additional systematic and comprehensive study of catch efficiency. The need for information on multiple aspects of the biology of krill is of a higher priority than the time and effort which would also be required for those aspects which will be/are undertaken by those engaged in development of a krill fishery.

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NOTA N° 479 (CB-118) 12 SET 1975

TOMO

Dr. T. Nemoto
Ocean Research Institute
University of Tokyo
Nakano, Tokyo
164 Japón

Dear Dr. Nemoto:

I have received your kind letter dated August 25. I hope that my reply will reach you before our meeting in Cambridge. Regarding your request of a draft on problems in ecology and population dynamics of krill, I would mentioned some of these problems which were not yet encountered, always based on what is known through publications and issues:

1) We have carried out a research work on growth, mortality, biomass and production that was submitted to the III Symposium on Biology held in Washington. I am sending you a copy of the paper by separate cover.

2) On the basis of our research work as well as yours and that of other investigators on Antarctic krill, I realize that there is yet much to do, for example:

a) To know the structure of the population or populations over at least a term of several years;

b) On this basis, to know the growth and natural mortality, biomass, productivity and production;

c) To know the present status of the stock, whether it shows a surplus or is steady;

d) To know the structure of the swarm as regards the ratio of males and females, of both the stage of maturity; and being the swarms unisexual to find out when they mate and what place of the Antarctic they chose for reproduction;

e) To determine the spawing places;

f) To know something about the circulation of the swarms and the dispersion poles.

g) To determine some ecological parameters such as: feeding, reproduction and metabolism.

h) Through ecological data to determine the flow of energy or matter from primary production to krill, and then, to the upper trophic levels such as fishes, birds and mammals.

///...

i) Based on the above mentioned data (ecological, dynamics, and energy and matter flow) to carry our ecological models in order to predict the behavior of the populations with the future impact of fishing.

j) To determine some parameters on the physiology of the behavior of krill within the swarm and in the laboratory.

k) To undertake studies on artificial culture of the species in a pilot plant to find out if this can be done. We have experienced with some individuals of E. superba keeping them alive in an acquiarium during 60 days. The individuals survived to changes of temperature. Now we should investigate how to feed them.

We feel that these studies should be encouraged working in cooperation and colaboration with different investigators on board research ships and in the laboratories of the SCAR institutions. In this ways we can avoid duplication of efforts and then accelerat the investigations on the species.

I hope that this information can be of help to your request of cooperation. I remain looking forward to meeting you in Cambridge.

Cordially your,

DR. ALDO TOMO

DNA
M.B.

PD: Would you ask Dr. T. Matsudo if he has received my letter dated July 25. I am looking forward to his reply. Thank you very much.

c.c. Dr. Sayed Z. El-Sayed.

COMODORO (R) CARLOS RUBEN RODRIGUEZ
JEFE DPTO. CIENTIFICO

3.3 Population dynamics and ecology of marine mammals

Laws.

The two groups of marine mammals represented in the Southern Ocean are the seals and whales. Both represent substantial potential sources of food and the seal stocks now, and whales formerly, are (or were) vastly more important than their Northern Hemisphere counterparts in terms of number and biomass. There are no autochthonous peoples engaged in hunting in the South as occur in the North. But as is well known, the stocks of large whales have been overfished in commercial operations, beginning in 1904, and with the exception of the minke whale are still very low compared with their former abundance. Small whales have not been hunted and very little is known about the 9 species that frequent antarctic waters.

The fur seals and elephant seals were brought almost to extinction during the nineteenth century. With protection elephant seal numbers increased and at South Georgia the species was the subject of a rationally managed industry taking only adult males from 1910 to 1964. The fur seal took longer to recover but a spectacular population explosion is occurring with complete protection in the Scotia Sea area where at current rates of increase stocks may reach their former abundance, measured in millions, in 15-20 years. The other true Antarctic seals have effectively not been hunted as yet.

There is a need for proper conservation and management and a growing awareness of complex interactions between seals and whales involving possible competition for food with each other and with birds, fish and squid. Two international conventions are concerned with the marine mammals, the International Whaling Convention, dating from 1931, and the Convention for the Conservation of Antarctic Seals concluded in 1972 but not yet in force. Adequate conservation and management depends on a continuing input of data and information.

Objectives

1. The identification of unit breeding or management stocks, their location, movements and possible mixing.

2. To obtain full data by species, sex, age and size for all catches.

3. Stock assessment and the estimation of potential yields.

4. Understanding of the interactions between whales and seals between individual whale and seal species and with other groups at a similar trophic level, such as birds, fish or squid.

5. The formulation of suitable conservation and management procedures.

Research Programme

1. Information on the physical environment is basic to the whole programme outlined in this document, not just to understanding of the marine mammals. The mapping of seasonal pack ice distribution and type is particularly important in extrapolating sample seal densities to larger areas and, again primarily for seals, to investigate the significance of residual pack ice regions in summer for the separation of stocks.

2. Research should be carried out throughout the range of species including, for baleen whales, the winter period spent outside the Southern Ocean.

3. Information from scientific research needs to be supplemented by data from whaling and sealing operations. The only way of estimating sustainable yields is by using data on catches and effort, to determine the effect of various levels of

exploitation on the stocks. A programme of pelagic research captures from specially equipped whaling vessels such as the Norwegian Peder Huse which was a combined whale catcher and factory ship; and from other vessels including ice breakers for the seals in the pack-ice, is necessary to complement and extend the results from commercial operations.

4. Observations from ships, including ice breakers and aircraft to establish distributions, to estimate densities and absolute abundance especially of protected whale species such as blue and humpback, and of seals in the pack-ice. Seals cannot be counted in the water and counts on the pack-ice give a minimal estimate of abundance; diurnal changes in the proportion hauled out vary with different species and the proportions remaining in the water when peak numbers are hauled out is still unknown. To resolve this problem behavioural observations in the pack-ice will be necessary, using under water television or hydrophone arrays as developed for studies of Weddell seals in fast ice areas. Estimates of the abundance of elephant, Weddell or fur seals, in which a portion of the stock concentrates on land or fast ice to breed, can be made by extrapolation from counts of pups if the age structure of the population is known. These counts can be made on the ground or from aerial photographs, but the timing is critical - for example before 31 October and 20 December respectively for elephant and fur seals at South Georgia, because the pups disperse and counts are incomplete. Differential dispersal at sea by season, sex and age means that direct counts of the total population of land breeders are not possible.

Information on the distribution and abundance of small whales is almost totally lacking and indirect methods such as radio- and sonic- tagging and hydrophone arrays must be employed.

5. Continue existing marking programmes and develop new ones especially for smaller species. Develop methods for the study of individual whales (and pelagic seals) possibly including satellite tracking, radio-telemetry, and sonic-tagging.

6. The use of marking/recapture data, studies of population genetics, morphometrics and other indicators of discrete populations to establish unit stocks. Much can also be learned from captured seals (drug immobilised) for example by collection of blood samples, for serological and reproductive studies, and of nails for age determination, without killing them.

7. For animals killed both primarily on commercial operations and also in research operations using special ships, the following basic studies are required:

(a) Morphometrics.

(b) Age determination to establish growth rates, population structure and natural mortality rates, and age-specific reproductive parameters. Good age criteria exist for a number of species from earlier studies, for example annual layers in teeth (dentine or cement), nails, or ear plugs. Because of the numerous age groups (up to 80 or more in baleen whales, 33 in crabeater seals) relatively large samples will be needed.

(c) Analysis of reproductive state and reproductive history. This should include back-calculation of age at puberty from ear plug and tooth structure, to establish possible trends in the mean age at puberty. The age-specific and time-specific pregnancy rates are also required.

(d) Investigation of food habits and ecological separation by species sex and age. Preliminary studies indicate a more or less clear ecological separation in terms of geographical distribution, adaptations for feeding (morphology, visual pigments) and food preferences. More detailed quantitative information is needed to refine existing knowledge and to establish possible seasonal and geographical differences.

(e) The development of models for estimating metabolic rates and energy flow. Just as biomass is a better measure than numbers for establishing the significance of a species in the ecosystem, so energetic terms are preferable to biomass, particularly in studies of interactions and competition for a possibly limiting food resource.

8. Continuing analysis of the various parameters (stock sizes, growth, mortality, reproductive rates, feeding patterns) in an attempt to discover how they vary with changes in the abundance of seals, whales or other groups. This will not, however, lead to early results.

9. Finally, the development of better and more dynamic ecological models and population models for seals and whales, to help in the formulation of conservation and management strategies.

3. SUGGESTED RESEARCH PROGRAMS

HUREAU

3.4 Ecology of fishes, squids and other living resources.

The program embodied in the following proposal provides ~~for~~ an attempt to acquire basic information about benthic and pelagic fishes, squids and other living antarctic marine resources. Cold waters of the North Hemisphère provided world fisheries during several centuries. But the great demand of proteins from human populations needs exploration and management of tropical waters and antarctic waters. So it is time now to use every endeavour to develop biological oceanographic research in Antarctica before beginning any commercial exploitation of the resources of these waters.

Several objectives can be outlined as follows :

1. Taxonomy of marine invertebrates and vertebrates. A complete systematic survey has to be done for benthic and pelagic fauna. A such inventory is necessary as soon as ecological studies and population dynamic studies are planned.

2. Zoogeographical relationships. Some fondamental themes are to be studied in order to explain the migrations of the species or of the populations. The main topics of this objective are : how to explain the origin of the deep-sea tropical fauna ? Do we find in the abyssal fauna the same phenomena as in the shallow waters (diminution of the number of species) from West to East ? is the absence of bathyal fauna along the antarctic continent true or not?

3. Abundance and biomass of fishes, squids and crustaceans. Virtually no estimates of the abundance, biomass or structure of fish populations have been made in the Antarctic: only local works on these problems have been made, but, up to now, no general evaluation of the biomass is published. Nothing is known about squids in Antarctica. Concerning crustaceans, evaluations of krill biomass is studied in paragraph 3.2 and other crustaceans (king crabs and spiny lobsters) are locally abundant on the bottom around some isolated islands.

4. Ecological and basis biological data concerning the species which are expected as commercial resources are to be collected. In fact no population dynamic studies can be done if these data are unknown.

These objectives can be attained through the following research programs:

1. Taxonomic survey must be as complete as possible. The main groups to be studied are : the fishes (and specially the nototheniids), benthic and pelagic; the molluscs and cephalopods, the crustaceans (krill, crabs, amphipods, isopods); but the research programs must also study the fauna which has a size of less than 10 mm. The surveys have to explore, not only the shallow waters along the antarctic continent or around the subantarctic islands, but also the bathyal and abyssal waters. These waters and their macro and microfauna are a very important part of the total antarctic ecosystem.

2. Zoogeography is so closely dependant upon taxonomy that advances in the former must wait upon the latter. One important controversy concerns the interpretation of the Kerguelen and Scotian species which depend upon the variation and relationship found in those species or populations which occur at the intervening islands. Zoogeographical relationships are important to study not only from a fundamental point of view but also to explain the migrations. These problems of zoogeography can be solved with the organisation of joint cruises between different countries interested by Antarctica.

3. Abundance and biomass of fishes can be estimated with acoustic methods : echosounders and echointegrators assure quantitative measurements of registered signals. Echointegrators can be fed into a computer for automatic logging of the total number of echoes added up for each nautical mile over considerable sailing distances. This is of great importance when investigating the abundance of fish and for comparison of registrations at different times. These data led to the evaluation of the global biomass. The same acoustic methods could be used to estimate krill swarms. Concerning the squids, up to now, there is no method available to estimate the abundance. It is suggested that the research programs could insist on this gap.

4. Ecological and biological data are the basis of every population dynamic study. In order to build a mathemetical model or an ecological model concerning a population of fishes, it is necessary to collect a certain number of ecological data about : - migrations: spawning, trophic or seasonal migrations.

- behaviour and particularly structure of communities of fishes
- physiology and anatomy in relation with the environment
- trophic relations
- reproduction, growth, mortality and all the parameters used in population dynamic.

Some recommandations for future studies can be made :

- developpement of good survey methods for krill and squid biomass evaluatio
- study of the most important species of fish which can offer a possibility of commercial fishery : Notothenia gibberifrons, N. neglecta, N. squamifrons, Dissostichus eleginoides, D. mawsoni, Channichthys rhinoceratus, Chaenocephalus aceratus.
- organisation of trawling surveys and acoustic surveys to detect and evaluate krill, pelagic fishes and benthic fishes biomasses
- organisation of oceanographical cruises to collect basic data and ecology and biology of fishes.
- organisation of oceanographical cruises to study general taxonomy and zoogeography.

It should be desirable if all scientific programs of the Antarctic oceanographical cruises could be coordinated through an international organisation (SCAR).

SCAR GROUP OF SPECIALISTS ON MARINE LIVING RESOURCES Holt.

Meeting, October 6-8, 1975, Cambridge, to plan an International Conference on Antarctic Marine Resources, in USA, 1976.

<u>Provisional Agenda Item 5</u>: International Coordination and Cooperation

Discussion Notes by S.J. Holt 18 August 1975

1. There are four reasons why a marine biological Antarctic research programme needs to be conceived as a whole and executed cooperatively:
   a) The size of the area and the inability of any one country to work it alone;
   b) The need, for cost and operational reasons, to make the fullest multiple use of certain facilities - vessels and bases;
   c) The facts not only that the Antarctic ecosystem is a complex unity, but particularly that the present human impact on certain resources (e.g. whales) is already, it seems, significantly affecting other resources, and there are now coming into being plans for commercial exploitation of other resources;
   d) As far as the current Law of the Sea discussions go, the future status in international law of the seas surrounding Antarctica is ambiguous. Although there has been no formal declaration, and countries with special interests include those party to the Antarctic Treaty and those which now, or once did, conduct whaling operations in the Southern Ocean, the resources of the region may be viewed as a "common heritage" of mankind as a whole, both present and future generations.

(v) to encourage and review the development of relevant theory, methods and instruments, with particular reference to the problems of obtaining measurements in the winter and in the presence of ice;

(vi) to develop plans for the gradual evolution of a comprehensive study of the southern ocean.

Composition: Countries interested in Antarctic oceanographic research, with observers from SCOR, SCAR; ACMRR, ACOMR /Resolution V-5 states WMO/ and other interested organizations.

The present operational status of SOC should be determined from the IOC Secretariat. While the IOC is constitutionally attached to Unesco, it serves, with respect to marine research, as a "joint specialized mechanism" of other interested U.N. bodies, specifically FAO, WMO and IMCO, as well as of the UN itself. As far as living resources are concerned--

c) FAO is the operative body. FAO has no field activity at present, but it has been designated as the "Executing Agency" for a large marine resources exploration and development project - with presumably a considerable input of research - by UNDP which is providing the international funds, with bilateral backing.

d) The ACMRR of FAO - a scientific advisory body of individual scientists (which is, like SCOR, also advisory to IOC) - is active, at present, with respect to evaluating the status of Antarctic resources of seals and cetaceans. The study is financed by UNEP and bilateral funds, and also by FAO itself. The work will culminate in a World Scientific Conference on Marine Mammals in Bergen, September 1976. An important feature of this study is the formulation of a long-term research programme on marine mammals. It is already clear, however, that a meaningful programme must look deeply into ecosystem structures, because of complex changes which have been observed and which could be the consequence of interactions between different whale species, between whales and other mammals and also birds and fishes.

2. There exist a number of international organizations, at various levels, which have expressed interest in the resources of the Southern Ocean, and several of these have active biological programmes of one kind or another. They include:

Non-governmental

a) ICSU - SCAR

b) ICSU - SCOR

(I am not aware of SCOR's current interest and activity; no doubt other participants will be familiar.)

c) IUCN (Quasi-governmental)

No active programme, but has Specialist Groups of its S.S.C. on seals and on whales which are concerned. One resolution of the IUCN-sponsored Second World Conference on National Parks, September 1972, recommended "the establishment of Antarctica as a World Park under U.N. auspices", and included "the surrounding seas" in this.

Inter-governmental (U.N. System and others)

a) Antarctic Treaty Organization

b) IOC of Unesco.

Has an International Coordination Group for the Southern Ocean (SOC), the terms of reference for which are:

(i) to assemble and distribute details of firm oceanographic cruise plans in the southern ocean, preferably at least one year in advance;

(ii) to encourage the pre-allocation of blocks of time for oceanographic research on Antarctic supply vessels whenever practicable;

(iii) to develop means of co-ordinating existing and planned oceanographic research programmes in the region;

(iv) to encourage the evaluation of existing oceanographic data from the region with a view to fostering specific studies of limited extent to fill gaps in present knowledge and capable of being carried out in the foreseeable future;

The proposed exploitation of krill also has important implications for forecasts of whale stock abundance, recovery rates and sustainable yields.

e) The IWC has launched - on paper - an International Decade of Cetacean Research, in response to proposals from UNEP and others. It has asked UNEP, FAO and perhaps other bodies for funds. It has been suggested that the International Banks might also be interested. IWC has also just embarked on a "new management policy" for whaling by its Member States, which requires, for effective application, considerably expanded research, to reduce the present great uncertainties in whale stock assessment, and to resolve problems arising from inter-specific inter-actions.

f) The Permanent Commission for the Resources of the South Pacific (Chile, Ecuador, Peru) presumably has an interest in Southern whale research, at least in the areas of Chilean whaling operations. I know nothing of its current activity but I think there is very little.

The above comments regarding whales and interspecific interactions make it evident that conceptually, at least, research on living resources, say, south of the convergence, must be linked with

1) land-based research on the food competors, seals and penguins;
2) research on the whales which reside part-time in more northerly, warmer waters;
3) concurrent and relevant research on the physical and chemical environment.

3. Experience, especially within IOC, of the problems of organizing cooperative studies of broad scope in which several existing organizations have a substantive interest suggests that new coordination arrangements may be needed at several levels. This makes the "bureaucracy" a little heavy but it seems to be unavoidable.

i) An implementation group, having representatives of all participating states, and reporting to one or several "parent" bodies - e.g. to IOC, the Antarctic Treaty Organization and the FAO Committee on Fisheries (COFI);

ii) A planning group of selected scientists, in their individual capacities, with a chairman, convenor, or coordinator, to give his full time to the project for its duration;

iii) A committee with representatives of the secretariats or officials of participating international organizations, including possible participation from international funding bodies such as UNEP and UNDP.

To this structure should be added the "support" services, which might be provided by one nation, or shared among several, or set up as a new unit. An important decision is by what route, and by what intermediate stops, the data and results find their way into the World Data Centre System (WDC's). I believe it will be necessary to establish or to designate a Southern Oceans Regional Data Centre as has been done for most of the Cooperative Investigations under the auspices of the IOC. Such a centre must, especially in the case of an Antarctic study, have a responsibility for universal and rapid dissemination of results, beyond those who have at present the means to conduct research in this difficult and distant area, and those who now or soon will have the technical and investment possibility to exploit the resources studied. This is the spirit of the "New Economic Order" proclaimed by the Sixth Special Session of the UN General Assembly.

As regards the inter-governmental coordination aspects, an existing body needs to take the initiative, and this should, I suggest, be the IOC, whose members I believe include all the parties to the Antarctic Treaty (please check this).

The existing ICSPRO Committee can bring together the interested UN bodies, and the Chairman of IOC; to this might be coopted - for the Antarctic project discussion only - representatives from non-UN bodies - the Treaty Organization, IWC, IUCN and perhaps others.

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4. März 1975

Sahrhage

Az. Prof. Sa/Bor

Research and Exploration of Antarctic Krill from the Federal Republic of Germany

In view of the very substantial resources of Krill in the Antarctic and their potential importance as human food and for other purposes the Federal Fisheries Research Board in Hamburg, in collaboration with the Institute for Marine Science at the University of Kiel, are planning a survey in the southern ocean during 1975/76.

This survey which is expected to start around 2o October 1975 will last 8 months (with about 6 months operational time in the survey area from mid November 1975 till mid May 1976) and will be carried out by the German F.R.V. "Walther Herwig" (225o GRT, 46oo h.p.) and a government - chartered trawler of about 25oo GRT and 3ooo h.p. The area of investigation will primarily be the Atlantic sector of the Antarctic (between roughly 7o°W and 3o°E), however the programme may be adapted in accordance with the observed distribution of Krill.

The main purpose of the survey is an investigation on the feasibility of developing a fishery by German long distance trawlers in these waters. The survey will comprise a fully integrated programme in the following sectors:

(a) <u>Location and catching</u>

The vessels will be equipped with high power acoustic instruments for the detection of Krill. Pelagic trawls will be adapted and used for exploratory fishing on a semi-commercial basis for establishing realistic catch rates.

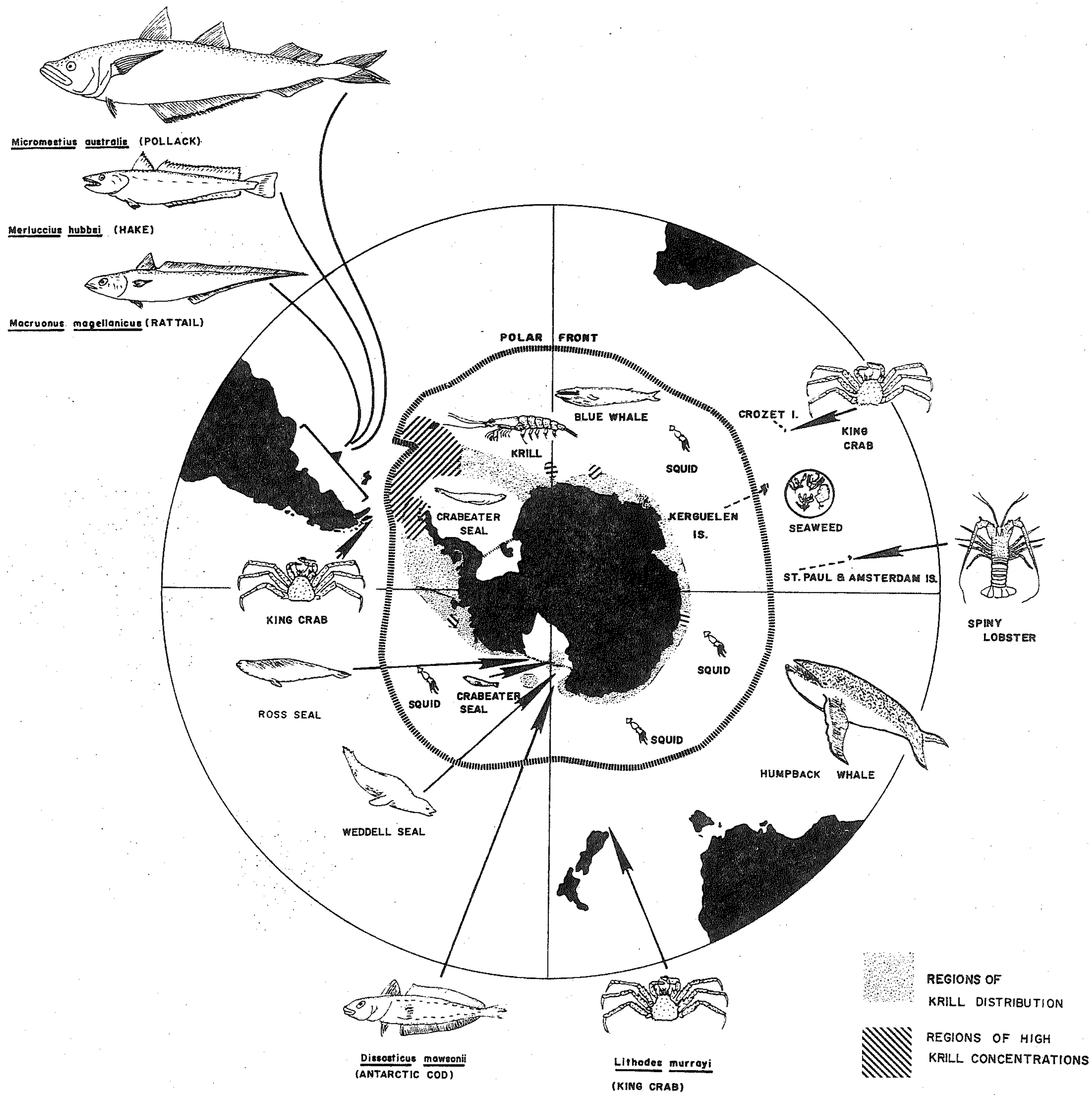
(b) <u>Processing and marketing</u>

Investigations will be made on the development of Krill products, in particular Krill protein concentrate for human consumption, deep-frozen Krill meat, and Krill meal for industrial purposes (animal feeding). Marketing studies will be undertaken with the landed Krill and products.

(c) <u>Biology and environment</u>

Quantitative scientific catches of Krill and its young stages will be made to study the distribution, density and biological parameters as a basis for an improved estimation of these resources and their potential for optimal long-term utilization. Hydrographic observations will provide information on water masses, currents, e.t.c. in relation to the distribution of Krill.

It is envisaged to establish collaboration with other countries having programmes in this field, at least through exchange of programmes and other information, or also in the form of active cooperation in the survey area.



MARINE LIVING RESOURCES OF THE SOUTHERN OCEAN (EL-SAYED, UNPUBLISHED)