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CEPHALOPOD RESEARCH IN THE ANTARCTIC

P.G. Rodhouse
(United Kingdom)

Abstract

Cephalopods are a major component of the Antarctic marine food web and it seems inevitable that they will be the subject of future commercial exploitation. Research is being carried out at BAS on the species composition and distribution of Antarctic cephalopods, their production and biomass, population dynamics and trophic relations. However, there is insufficient information at present for CCAMLR to formulate effective policy for management of Antarctic cephalopods. In view of the rapidity that cephalopod fisheries can develop there is need for co-ordinated international research effort. Any commercial fishing for cephalopods should be fully monitored, research should be concentrated on population biology and trophic relations of cephalopods, and a central reference collection of Antarctic cephalopods should be established. The Cephalopod International Advisory Council (CIAC) should receive the support of CCAMLR.

Résumé

Les céphalopodes forment un élément majeur de la chaîne trophique marine en Antarctique et il paraît inévitable qu'ils feront à l'avenir l'objet d'une exploitation commerciale. Des recherches se poursuivent actuellement au BAS (British Antarctic Survey) sur la composition et la répartition des céphalopodes antarctiques, leur production et leur biomasse, leur dynamique démographique et leurs relations trophiques. Faute d'informations suffisantes, la CCAMLR n'est cependant pas en mesure pour l'instant d'énoncer une politique efficace sur l'aménagement des céphalopodes antarctiques. La rapidité avec laquelle peut se développer l'exploitation des céphalopodes impose un effort de recherches coordonnées sur le plan international. Il serait nécessaire de contrôler toute exploitation commerciale des céphalopodes, de concentrer les recherches trophiques des céphalopodes, et d'établir une bibliothèque centrale de référence sur les céphalopodes antarctiques. Le Conseil Consultatif International sur les Céphalopodes (CIAC) devrait bénéficier du soutien de la CCAMLR.

Resumen

Los cefalópodos constituyen un importante componente de la red alimenticia marina antártica y parece inevitable que fueren objeto de una explotación comercial futura. Se está llevando a cabo una investigación en la Prospección Antártica Británica (BAS) sobre la composición de las especies y la distribución de los cefalópodos antárticos, su producción y biomasa, la dinámica de sus poblaciones y sus relaciones tróficas. Sin embargo, no existe actualmente información suficiente que permita a CCAMLR formular una política efectiva para la administración de los cefalópodos antárticos. En vista de la rapidez que pueden desarrollar las pesquerías de cefalópodos, existe la necesidad de un esfuerzo de investigación internacional coordinado. Toda pesca comercial de cefalópodos debería ser totalmente controlada, la investigación debería concentrarse en la biología de las poblaciones y las relaciones tróficas de los cefalópodos, y debería establecerse una colección de referencia central de cefalópodos antárticos. El Consejo Internacional de Asesoramiento sobre Cefalópodos (CIAC) debería recibir el apoyo de CCAMLR.

Резюме

Головоногие - одна из основных составляющих антарктической морской трофической цепи, и представляется неизбежным, что в будущем они явятся объектом коммерческой эксплуатации. В BAS (Британском управлении антарктической съемки) в настоящее время проводятся исследования по видовому составу и распределению антарктических головоногих, их продуктивности и биомассе, динамике популяции и трофическим связям. Тем не менее, имеющейся в настоящее время информации недостаточно для выработки АНТКОМом эффективной стратегии управления запасами головоногих Антарктики. Ввиду того, что промысел головоногих может возникнуть очень скоро, имеется потребность в скоординированной международной исследовательской деятельности. Любой коммерческий промысел головоногих должен полностью находиться под контролем; исследования должны быть сконцентрированы на биологии популяций и трофических связях головоногих, а также должна быть создана реферативная коллекция антарктических головоногих. Международный консультативный совет по головоногим (CIAC) должен получить поддержку АНТКОМа.

CEPHALOPOD RESEARCH IN THE ANTARCTIC

Paul G. Rodhouse
Marine Life Sciences Division
Natural Environment Research Council
High Cross, Madingley Road
Cambrdige CB3 0ET, United Kingdom

INTRODUCTION

The Southern Ocean is known to contain large stocks of cephalopods, especially squid, which form an important component of the diet of several species of whales, seals and birds (Roper, 1981; Clarke, 1983). Important commercial fisheries for squid currently exist in sea areas adjacent to the Antarctic - around New Zealand and the Falkland Islands - and there has been at least one exploratory squid-fishing expedition, south of the Antarctic Polar Front, in the vicinity of South Georgia. There is an expanding world market for squid and squid products and it is inevitable that, in the future, Antarctic squid stocks will come under pressure of commercial exploitation. Recent experience has shown that squid fisheries can rapidly become very large. It is therefore important that the Commission for the Conservation of Antarctic Living Marine Resources (CCAMLR) should be preparing plans for an effective management strategy before large scale fishing commences.

The effective management of stocks of Antarctic cephalopods will depend upon knowledge of :

1. The species composition and distribution of the Antarctic cephalopod fauna

2. Production and biomass

3. Demography and population dynamics

4. Trophic relations - role of cephalopods as predators and prey in the Southern Ocean ecosystem.

This paper considers the current state of knowledge for each of these topics in order to highlight key areas for research.

CURRENT STATUS OF ANTARCTIC CEPHALOPOD RESEARCH

Species Composition and Distribution

The Antarctic cephalopod fauna is poorly known because much of the material available to science has been the semi-digested remains from the gut contents of vertebrate predators. The approximate geographical range of the major species of the Antarctic is given by Fischer and Hureau (1985) but this list is not exhaustive (see Clarke, 1980) and there is almost no information about the relationships between species and particular water masses or current systems or their relationships with the continental shelf or island groups.

A cephalopod sampling programme, using a RMT25, was initiated by the British Antarctic Survey (BAS) during the 1986-87 Antarctic season. This net was fished open and produced an important collection of squid from the vicinity of the South Georgia shelf break. The collection, together with Antarctic collections from the 'Discovery' expeditions and from the 'Walther Herwig', 'Polarstern' and 'Professor Siedlecki' cruises, is being examined by the author at BAS. Considerable progress could be made by further sampling for cephalopods with large mid-water and bottom trawls and possibly with commercial jigging gear.

The distribution of the early-life phases of three common species of squid, in relation to the vertical structure of the Southern Ocean, has been examined at BAS by Rodhouse and Clarke (1985, 1986) and Rodhouse (in press a). These data, although very limited, suggest distinct patterns of distribution in relation to the hydrological structure of the ocean. Further sampling with opening/closing nets is needed to obtain information on vertical distribution of other species and at different geographical locations.

Production and Biomass

A considerable body of data has been collected by BAS, in collaboration with the Marine Biological Association of the UK (MBA), on the consumption of cephalopods by homeothermic vertebrate predators (Clarke et al., 1981; Clarke and McLeod, 1982a, b; Clarke and Prince, 1981; Croxall and Prince, 1982; Rodhouse et al., 1987; Rodhouse, in press b). These data have enabled Clarke (1983) to estimate the total cephalopod consumption in the Southern Ocean, and Croxall et al. (1985) to estimate consumption in the Scotia Sea. The estimates, 34.2 million tonnes and 3.7 million tonnes per year respectively, demonstrate the importance of squid in the ecosystem and, in the absence of any information on total production, highlight the need for prudent management plans.

Using currently available data it is impossible to estimate the standing stock of Antarctic cephalopods. It is unlikely that much progress in estimating stocks of Antarctic cephalopods can be made until commercial scale fishing operations commence. Stock assessment of target species will clearly be of the highest priority following the onset of commercial exploitation.

Demography and Population Dynamics

Cephalopod populations differ from other commercially exploited fish populations in a number of respects and provide special problems for management (Caddy, 1983; Amaratunga, 1987). There are no life-history data for any species of Antarctic cephalopod. Indeed the life histories of very few cephalopod species are known (Boyle, 1983). Data will be required on the biological parameters - growth, mortality, life span, fecundity and migrations - upon which population management models are based.

The author is currently engaged in research on the life cycles and growth of two species of cool temperate myopsid squid species, Alloteuthis subulata and Loligo gahi, from the UK and the Falklands Islands respectively, and the cool temperate oegopsid squid Illex argentinus from the Falkland Islands fishery. Data are being collected on growth,

maturation and the morphometric, histological and biochemical changes associated with these processes. The resulting analyses will be an important contribution to fundamental knowledge of cephalopod life cycles and will be valuable for comparative purposes as information from Antarctic species becomes available.

It is known that cephalopods generally have high growth rates and growth efficiencies. However, until recently, population studies have been hampered by lack of reliable methods of estimating age. Recent advances in validating the daily nature of micro-growth increments in the cephalopod statolith (Dawe et al., 1985; Hurley et al., 1985; Lipinski, 1986; Yang et al., 1986) now enable age to be determined with reasonable confidence. Studies at BAS on size at age for the species from the Falkland Islands fishery are being carried out and techniques for preparation and reading of statolith growth increments are being refined.

At BAS, cephalopod growth is also being studied using an index calculated from the ratio in the tissues of RNA to DNA. This index is based on the hypothesis that, within a living cell, nuclear DNA content is fixed, provided it is not dividing, but RNA content varies with protein synthesis rate. The RNA/DNA ratio may thus provide a means of assessing rate of metabolic turnover. This information can then be used to assess nutritional status and comparative growth rates of cephalopods caught in the field. A protocol for the assay of nucleic acids in cephalopod tissue has been developed and a growth experiment has been run with Sepia officinalis, fed at a range of food rations and temperatures. This material is being used to validate the nucleic acid ratio as an index of growth rate in cephalopods. If successful, the technique has the potential for enabling the assessment of nutritional status and comparative growth rate of juvenile cephalopods from net hauls in the Antarctic. This type of data in turn may be useful, in the future, for predicting year class strength of exploited species prior to recruitment.

Factors associated with mortality in cephalopods are poorly understood. Clearly, predation by vertebrates is a major factor in the Southern Ocean but the contribution to total mortality is not known. In

many species of cephalopod for which the life history is known, life span is approximately one year; spawning occurs once and is quickly followed by death. Size frequency distributions of the cephalopod prey of Antarctic predators (cf. Rodhouse et al., 1987), estimated from beak size distributions, suggest that populations of most species consist of a single year class. However, this may reflect selective feeding by the predators and further information from other sampling methods is required before firm conclusions can be drawn about the life span of Antarctic cephalopods.

Fecundity of cephalopods from temperate and tropical seas tends to be relatively low (Caddy, 1983) and the eggs are usually large. The evolution of semelparity in the group suggests that juvenile mortality is generally low. There is evidence that the evolution of life history patterns in marine organisms has been influenced by latitude (A. Clarke, 1983) and so it is possible that there are differences between high latitude species and those from warmer waters.

Knowledge of seasonal patterns of migration in relation to life history is often important for the management of exploited cephalopod populations. Data are entirely lacking for Antarctic species.

Trophic Relations

Research on the role of cephalopods as prey for Southern Ocean homeothermic vertebrate predators continues at BAS and includes studies on Southern Elephant Seals (Mirounga leonina) and Wandering, Grey-headed and Black-browed Albatrosses (Diomedea exulans, D. chrysostoma and D. melanophris). Information from this research will be essential if cephalopod stocks are to be managed with due consideration for the conservation of those species of birds, whales and seals which consume cephalopods as a major part of their diet. Predation by fish has not been researched but this is also a question which should be addressed. Total allowable catch will have to be set in any future fishery so that the yield to predators is maintained at a level which ensures their stable recruitment.

It is also important that, in the future, some emphasis should be placed on elucidating the role of squid as predators in the Southern Ocean's pelagic/meso-pelagic community. In this context BAS is collaborating with the Zoology Department at the University of Aberdeen, through a Natural Environment Research Council (NERC) CASE postgraduate award, to explore the use of serological methods to analyse the gut contents of Antarctic cephalopods.

Antibodies to Antarctic krill (Euphausia superba) have been successfully raised in rabbits and testing is being carried out for cross reactions with other pelagic species which are putative prey items of Antarctic cephalopods. When these tests are complete, the gut contents of three species of squid, collected by BAS during the 1986/87 season, will be tested for the presence of Euphausia superba. In addition to the serology programme, research is also being carried out on the functional morphology of the beaks of Antarctic squid.

Future research will also include more conventional analyses of cephalopod gut contents such as the use of eye remains to identify prey species and estimate their size (see Nemoto et al., 1985)

International Co-ordination of Cephalopod Research

Cephalopod research is in progress at several institutes world-wide. The Cephalopod International Advisory Council (CIAC) sponsors symposia, workshops and scientific publications relating to the Cephalopoda as well as publishing a newsletter. It provides an international forum for scientific exchange on matters of cephalopod biology.

CONCLUSIONS

The Southern Ocean contains large, unexploited stocks of squid which potentially have a high commercial value. Two major fisheries for squid exist adjacent to the Southern Ocean, in the south-east Pacific and South Atlantic. It is almost inevitable that attention will soon turn to

Southern Ocean stocks. Experience elsewhere, notably in the Falkland Islands fishery, has shown that squid fisheries can develop very rapidly. If this were to happen in the Antarctic, without adequate management, there would be potentially serious consequences for the squid stocks and for the predator populations - birds, whales and seals - for which squid are a major food resource.

Current knowledge of the biology of Antarctic squid stocks is inadequate for CCAMLR to formulate effective management policy. There is therefore a pressing need for international effort in this field. This could be achieved by concentrated effort on the following topics :

1. Co-ordination of research effort so as to pool resources and information. It is particularly important to increase our knowledge of the species composition and distribution of the Antarctic cephalopod fauna.

2. Any commercial cephalopod fishing in the Antarctic should be monitored fully and scientific information from such activities should be maximised. Catch and effort data, based on a meaningful effort index, are clearly of prime importance for making stock estimates. However, given the state of knowledge of the Antarctic cephalopod fauna, the value of obtaining specimens from commercial catches should be emphasized. Considerable benefit to science and commerce would be derived from placing scientific personnel aboard commercial vessels fishing for cephalopods in the Antarctic.

3. Increasing research effort into the population dynamics of Southern Ocean cephalopods; in particular ensuring uniformity of criteria and methodology used in age determination.

4. Investigations of the trophic relations of cephalopods, both as predators and prey.

5. Establishment of a central reference collection of Antarctic cephalopod material.

6. The Cephalopod International Advisory Council (CIAC) is the international organization for professional cephalopod workers. Where its activities are relevant to the Antarctic it should receive the support of CCAMLR.

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