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10. CEPHALOPODS OF THE SOUTHERN OCEAN REGION: POTENTIAL RESOURCES AND BIBLIOGRAPHY+

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Introduction

Cephalopods (squids and octopuses) are known to be extremely important organisms in the trophic structure of the Antarctic ecosystems, constituting significant portions of the diets of sperm whales, seals, penguins, pelagic birds and fish. The southern hemisphere population of 500 000 sperm whales, for example, consumes about 50 million tonnes of cephalopods a year, according to Clarke's calculations (Voss 1973, p. 61). This value approximates to three-quarter of the world's current annual fisheries production.

The highly evolved nervous system of cephalopods allows them to be aggressive, fast-swimming predators. This characteristic, unique among invertebrates, makes them comparable in behaviour to many large predatory vertebrates. As predators, for example, cephalopods are estimated to consume about 100 million tonnes of Antarctic krill a year (Everson - this volume, paper 4).

Knowledge of the biology and species composition of the cephalopod fauna is almost completely lacking, making an assessment of the resource potential of cephalopods in the Antarctic extremely difficult. This lack of knowledge is due primarily to the strong swimming and net-avoidance capabilities of cephalopods, which have prohibited adequate sampling. Special sampling efforts are required therefore to elucidate their biology and resource potential.

Cephalopods inhabit both pelagic and benthic habitats in the Southern Ocean. The squids are primarily pelagic and constitute the major resource potential in terms of numbers of species and biomass. The octopuses are primarily benthic dwellers and their biomass and consequent contribution to energy flow are relatively minor in comparison to pelagic cephalopods. This is especially the case in the shelf waters of the Antarctic continent, whereas sub-Antarctic islands appear to support larger populations of octopuses.

Review of current information

Currently no commercial fishery for cephalopods exists within the confines of the Southern Ocean, but an active Japanese fishery, accounting for about 20 000 tonnes per year, operates in New Zealand waters for the squids *Nototodarus sloani* and *Todarodes filippovae* (Saito 1976, Nasu - this volume, paper 11). In southern Argentina, several species of squids (e.g., *Loligo patagonica, L. braziliensis, Illex argentinus*) and octopuses (e.g., *Eledone massyae, Octopus tehuelcus, Benthoctopus magellanicus*) are also commercially exploited (G. L. Voss, personal communication, Castellanos & Menni 1969).

Table 1 lists the species of cephalopods that may have a fishery resource potential from the Southern Ocean region. (Several families of deep-sea cephalopods are not included since their species are judged unsuitable for consumption - for example, Chiroteuthidae, because of its gelatinous consistency.) A number of species from sub-Antarctic and lower-latitude waters are included since some are currently being harvested and many represent a great potential resource. So little precise information about species composition, faunal zones and species distribution is available that this expanded list seems valuable, especially in view of the current emphasis on resource potential and food web relationships.

+This text, initially prepared for the Conference at Woods Hole in August 1976 on the Living Resources of the Southern Ocean, has not been up-dated on scientific grounds during preparation for publication.

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TABLE 1. REVIEW OF CEPHALOPODS WITH FISHERY RESOURCE POTENTIAL IN THE SOUTHERN OCEAN REGION.

family species	distribution	vertical range (m)
Ommastrephidae		
1. *Nototodarus sloani**	circum-New Zealand	0–500
2. *Nototodarus gouldi**	Southern Australia	0–500
3. *Todarodes sagittatus**	S. Atlantic, S. Indian ocean, S. Africa	0–800(2000)
4. *Todarodes filippovae**	sub-Antarctic, circumpolar	?
5. *Illex argentinus**	Patagonian Shelf–S. Atlantic	0–500
6. *Martialia hyadesi**	S. Pacific–Antarctic convergence	?
7. *Symplectotheuthis oualaniensis**	S. Indian, S. Pacific, S. Africa	0–1000(?)
8. *Symplectoteuthis luminosa**	S. Atlantic, S. Pacific, S. Indian, S. Africa	0–1000(?)
9. *Dosidicus gigas**	S. Pacific, Chile	0–1000(?)
10. *Ommastrephes pteropus**	S. Atlantic, S. Africa	0–1000
11. *Ommastrephes bartrami**	S. Pacific, Chile	0–1000
Histioteuthidae		
1. *Histioteuthis atlantica*	sub-Antarctic, Atlantic, Pacific	100–800
2. *Histioteuthis eltaninae*	sub-Antarctic, Atlantic, Pacific	100–800
3. *Histioteuthis macrohista*	sub-Antarctic, circumpolar	100–800
4. *Histioteuthis miranda*	sub-Antarctic, Australia, N.Z.	100–800
5. *Histioteuthis meleagroteuthis*	sub-Antarctic, Atlantic, Pacific	100–800
Psychroteuthidae		
1. *Psychroteuthis glacialis*	Antarctic	0–700
Neoteuthidae		
1. *Alluroteuthis antarcticus*	Antarctic	100–500(?)
Architeuthidae		
1. *Architeuthis* spp.	sub-Antarctic, N.Z., S. Africa	0–500(1200)
Bathyteuthidae		
1. *Bathyteuthis abyssicola*	Antarctic, sub-Antarctic, world-wide	500–2500
Gonatidae		
1. *Gonatus antarcticus*	Antarctic, sub-Antarctic	100–800
Onychoteuthidae		
1. *Onychoteuthis banksii*	sub-Antarctic, world-wide	0–150(800)
2. *Moroteuthis ingens*	Antarctic, circumpolar	0–400
3. *Moroteuthis knipovitchi*	Scotia Sea	400–500(?)
4. *Kondokovia longimana*	Scotia Sea	0–50(?)
Brachioteuthidae		
1. *Brachioteuthis picta*	Antarctic, sub-Antarctic (Atlantic)	50–1000
Cranchiidae		
1. *Mesonychoteuthis hamiltoni*	Antarctic, Atlantic	?
2. *Galiteuthis glacialis*	Antarctic, circumpolar	500–1000
3. *Galiteuthis aspera*	Scotia Sea	50
Loliginidae		
1. *Loligo braziliensis**	sub-Antarctic, S. America	0–200
2. *Loligo patagonica**	sub-Antarctic, Patagonian Shelf	0–200
Octopodinae		
1. *Octopus (Enteroctopus)* spp.*	sub-Antarctic	shallow–250
2. *Benthoctopus levis*	Antarctic, sub-Antarctic	10–150
3. *B. eureka*	Antarctic, sub-Antarctic	?
4. *B. berryi*	?sub-Antarctic	2200
5. *B. thielei*	sub-Antarctic	shallow
6. *B. magellanicus**	sub-Antarctic	150
7. *Pareledone charcoti*	Antarctic, sub-Antarctic	shallow–580
8. *P. turqueti*	Antarctic, sub-Antarctic	shallow–550
9. *P. polymorpha*	Antarctic	shallow–260
10. *P. harrissoni*	Antarctic	480–650
11. *P. adelieana*	Antarctic	510–540
12. *P. nigra*	sub-Antarctic	shallow
13. *P. antarctica*	Antarctic	?
14. *Eledone massyae**	sub-Antarctic	0–100
Bathypolypodinae		
1. *Graneledone antarctica*	Antarctic	2300
2. *G. microtyla*	Antarctic	1600–2050

Key: P. pelagic; B. benthic; B-P, bentho-pelagic; ML, mantle (body) length; * denotes species currently being fished in some portion of their range. Figures in parentheses indicate number of specimens known for a given species; + denotes spp. of pelagic cephalopods with ammonium ions concentrated in body tissues making them unpalatable when caught; this should not preclude them as potential food after a de-ammonization process.

TABLE 1 - *continued.*

habitat (P, B, B-P) (see key)	ML (cm)	weight (kg)	relative abundance	food potential	fishing technique
B-P	40	1.5	high	excellent	jigging, trawl
B-P	40	1.5	high	excellent	jigging, trawl
P	50	3	high	excellent	jigging, midwater trawl
P	40	1.5	?	excellent	jigging, trawl
B-P	30	1	high	excellent	jigging, trawl
P	40	1.5	?	?	?trawl
P	30	1	moderate	good	midwater trawl
P	20	1	moderate	good	midwater trawl
P	150	25	high	fair	jigging
P	40	2	high	good	night-light
P	30	1.5	high	good	night-light
P	10	0.5	high	unassessed-poor+	midwater trawl
P	7	0.5	low	unassessed-poor+	midwater trawl
P	7	0.5	high	unassessed-poor+	midwater trawl
P	20	1	low	unassessed-poor+	midwater trawl
P	7	0.5	moderate	unassessed-poor+	midwater trawl
P (B-P?)	15	1	low	unassessed-fair	trawl
P	5	0.1	low	unassessed-fair	midwater trawl
P (B-P?)	500	1000	high	poor+	?
P	7	0.1	high	unassessed-poor	midwater trawl
P	20	1	moderate	unassessed-good	midwater trawl
P	30	1	high	unassessed-good	midwater trawl
P (B-P)	100	25	high	unassessed	trawl
P?	23	1	rare(1)	unassessed	trawl
P?	26	1	rare(3)	unassessed	trawl
P	14	0.5	moderate	unassessed-good	midwater trawl
P	225	50?	moderate	unassessed-poor	midwater trawl
P	100	2	high	unassessed-poor	midwater trawl
P	32	1	rare(4)	unassessed-poor	midwater trawl
B (B-P)			high	excellent	trawl
B (B-P)			high	excellent	trawl
B	30	3	moderate-high	good	trap, bottom trawl
B	5.0		moderate-high	good	trap, bottom trawl
B	?		?rare	?good	trap, bottom trawl
B	4.7		rare	?good	trap, bottom trawl
B	6.5		rare	?good	trap, bottom trawl
B	?		rare	?good	trap, bottom trawl
B	7.4		?high	?good	trap, bottom trawl
B	5.6		?	?	trap, bottom trawl
B	6.6		?	?	trap, bottom trawl
B	5.1		?	?	trap, bottom trawl
B	3.8		?	?	trap, bottom trawl
B	4.0		rare	?	trap, bottom trawl
B	11.5		?rare	?	trap, bottom trawl
B	6.0		?	good	trap, bottom trawl
B	4.1		rare	?	bottom trawl
B	3.5		rare	?	bottom trawl

The information presented on geographical distribution, range of depths, habitat, size (mantle length and total weight) and relative abundance is derived from the literature and from the author's research collections and notes. In many cases, the quality of a given species as food for human consumption is unassessed, so comments in the 'food potential' column are judgements based on the known natural consistency of the species' tissues and on whether the tissues contain ammonium ions (which are an aid to buoyancy).

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The bibliography that follows provides most of the references to the Antarctic cephalopod fauna. Because past research on Antarctic forms has been largely a result of survey-type explorations, most papers are taxonomic in scope. However, a few deal with aspects of biology and distribution (for example, Roper 1969, McSweeny 1978). Some references are given to works on cephalopods from sub-Antarctic and mid-latitude southern waters, in keeping with the general scope of this review.

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Recommendations

A thorough knowledge of the biology of cephalopod species should provide data upon which to base rational exploitation and to ensure maximum sustainable utilization consistent with conservation commitments and ecosystem energetics requirements.

1. Biological research

(*a*) Extensive taxonomic research on cephalopods of the Southern Ocean is required before detailed biological studies can be made. Correct assessment of the population and subsequent decisions concerning the management of the stock are dependent upon accurate identification of species and an understanding of the biology of each species.

(*b*) Biological studies for each species should include distribution, vertical range, seasonal occurrence and abundance, life history, feeding strategy, reproductive potential, migrations and relationship to the environment.

(*c*) Because cephalopod material available for study has been limited, future research programmes need to take advantage of every potential source of material – for example, from krill trawling operations, land-based stations and the stomach contents of predators.

(*d*) Studies should be conducted to determine the nutritional qualities of different species and even of different parts of the animal (e.g., mantle and viscera) to assess their value to predators and to human consumers.

(*e*) Research should be conducted on the behavioural responses of cephalopods to determine the effectiveness of various catching devices.

2. Sampling programme

The paucity of knowledge about cephalopods is directly related to problems of adequate sampling. Therefore, the achievement of the biological research programme is dependent upon a comprehensive sampling programme.

(*a*) A wide variety of trawling techniques should be utilized, including traditional midwater trawls (e.g. 3 m IKMT and RMT 1 and 8) and large commercial trawls (e.g., Engel's trawl). Trawling with these large nets should be conducted at depths greater than is customary for krill operations, i.e., throughout the water column and especially in the hitherto unsampled benthopelagic zone.

(*b*) Stomach contents from known predators (particularly sperm whales, seals, penguins, pelagic birds and fish) should be utilized for sampling cephalopods. A study of cephalopod beaks for identification and biomass assessment should be initiated based on material from identified cephalopod specimens. Eventually this should lead to the ability to identify beaks alone, which are so frequently found in predators' stomachs. A study of beaks taken by deep benthic dredges could assist in assessing the distributions of species.

(*c*) Larval collections should be conducted utilizing plankton, neuston and larval nets, and be used as an indirect means of assessing cephalopod populations.

(*d*) Net closing devices should be used to ensure precision in determining the vertical distributions of species.

(*e*) Techniques other than pelagic and benthic trawls should be employed to explore alternative methods for sampling and assessing cephalopod populations – for example, large purse seines, night lighting and jigging, baited cameras, submersibles with side-scanning sonar, TV and camera-equipped sleds.

(*f*) A standardized sampling protocol should be established to allow comparison of results from various programmes, such as depth regime and catch per effort.

(*g*) Acoustic techniques must be developed for locating aggregations of cephalopods and be used in association with trawling operations.

3. Implementation

If the objectives of the suggested research programme on cephalopods are to be achieved, full advantage must be taken of the several programmes of implementation.

Because of the unique situation of cephalopods in the Antarctic ecosystem, it is proposed that the delineation of the fauna and an understanding of its biology will be achieved most effectively by conducting a separate research project under a multi-ship programme. Multiple ships would be equipped with standardized sampling and acoustical gear to ensure direct comparability of results. The proposed cephalopod research programme could also be conducted in a multi-ship programme. In addition, much valuable data could be obtained from participation in supporting ship- and shore-based programmes. For example, co-operation with ships of opportunity, such as commercial trawlers and whaling factory vessels, should provide specimens and data that otherwise could not be obtained efficiently.

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