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CEPHALOPOD RESOURCES OF THE WORLD

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PREPARATION OF THIS DOCUMENT

FAO is preparing a comprehensive review of the world's marine resources as part of the Perspective Study of World Agricultural Development (PSWAD), previously known as the Indicative World Plan for Agricultural Development (IWP). A review entitled "The Fish Resources of the Ocean", compiled and edited by J.A. Gulland has already been published (Fishing News (Books) Ltd., 1971). FAO's Advisory Committee on Marine Resources Research (ACMRR), at its Sixth Session in Rome, 10-17 March 1971, recognized the importance of this activity as providing the kind of background needed for the further rational development and proper management of the resources and recommended that FAO should pursue this as a continuing programme identified as the FAO World Appraisal of Fishery Resources, which would ensure a current updating and expansion of the review.

The Appraisal of the Cephalopod Resources of the World is intended as a further supplement to the overall review and in its final form will contain, as far as possible, the available information on the present status of these resources, the quantities of cephalopods actually caught and estimates for their overall potential. It has been prepared by Dr. Voss under contractual arrangements with the Fishery Resources Division (FIR) and technical editing was carried out by staff of the Marine Biology and Environment Branch (FIRM).

The views expressed in this Circular are those of the author and not necessarily of the Food and Agriculture Organization of the United Nations. At this stage, the study is presented in a preliminary form. All readers are kindly invited to send any comments and proposals for corrections and amendments to the Fishery Resources Division.

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1. INTRODUCTION

There has never before been an attempt to survey the cephalopod resources and fisheries of the world on a broad comprehensive basis although there are several papers of either a cursory nature or that deal with the fisheries of specific countries or areas. Lane (1957) had a valuable chapter on cephalopod economics on a world basis. Fields (1950, 1965) described the fishery and biology of squid in Monterey Bay, California. In Europe, Clarke (1963) reviewed the economic importance of the squids of the North Atlantic and later (1966) discussed the potentials and distribution of the oceanic squids. Along the northwest African coast there exists a large fishery described by García Cabrera (1968). Ghirardelli (1961) has briefly reviewed the Mediterranean fisheries. In the U.S.S.R. Akimushkin (1965) and recently Zuev and Nesis (1971) have dealt with Soviet cephalopod fisheries. Voss (1960, 1971) described the fisheries of the Caribbean and with Williamson (Voss and Williamson, 1972) the economic species and fisheries in Hong Kong. The fisheries of mainland China have been briefly reviewed by Chang et al. (1955) and Chang and Chi (1961). Numerous papers have been published by Japanese workers but none of a survey nature have come to my attention. The oceanic resources have been reviewed by Clarke (1966), Voss (1967) and Idyll (1968). There are numerous other papers treating upon the fisheries in various aspects, their biology, distribution and systematics (for detailed bibliography see Lane, 1957, or Clarke, 1966).

The present study is an attempt to present the world fisheries on a global basis with information on catch and landings, the species of economic importance, a brief account of their biology where known, the various methods employed in their capture and an attempt to estimate the potential cephalopod resources of the world ocean. That it falls far short of the comprehensive work outlined is due to many reasons, not the least of which is the woeful lack of statistical data from all but a few regions of the world. Another reason not to be ignored is that the cephalopods have only risen to prominence in the fisheries in the years since the end of the second world war and the rapid rise of the Japanese fishing industry, the major exploiter of these resources. Undoubtedly with the increasing amount of attention being given this group of animals more information will be rapidly forthcoming.

The cephalopods belong to the highest class of the phylum Mollusca, a group containing many organisms of great economic importance: mussels, clams, oysters, scallops, etc. In contrast to these rather sluggish, inactive and often sessile animals, many being filter feeders situated near the bottom of the food chain, the cephalopods are active, often rather highly intelligent, predators at or near the top of the food chain. Some are benthic while others, including all of the squids and cuttlefish, are active, strong swimmers or at least neritic or oceanic in habitat. A number of species are either rare or seldom captured, while others are among the commonest of the predatory animals of the sea. There are by present accounts about 650 species of cephalopods throughout the world.

Cephalopods occur throughout the world ocean from the shores of the Arctic Sea and the Southern Ocean to the tropics, from the beach to mid-ocean and the surface downward to at least 5 400 m. They occupy the littoral, the benthos, the pelagic and the mid-depths (Voss, 1967). They are diverse in form and nature; some are active, strong animals while others live a more or less drifting life and are soft and almost gelatinous in consistency. Those species of economic value in general are stout bodied with thick muscular mantles.

Cephalopods are at the peak of the food chain. When young, they feed upon small planktonic crustaceans and fish larvae. As adults, while a few are plankton feeders most are active predators. The benthic octopods feed mainly upon crustaceans such as shrimp, lobsters, and crabs and gastropod and bivalve molluscs. Squid and cuttlefish feed upon various pelagic and benthic crustaceans, fishes, other squid and a number of suitable swimming organisms. They are agile, often exceedingly swift moving, intelligent animals adept at avoiding some types of fishing gear and hence difficult to sample quantitatively.

2. BIOLOGICAL ASPECTS

2.1 Classification

Living cephalopods are very diverse and belong to recent offshoots of the evolutionary tree with two exceptions: the pearly nautilus and the vampire squid. The class is divided as follows:

Nautiloidea - The only living descendents of this archaic and once numerous group is the chambered or pearly nautilus, Nautilus, and its perhaps five species of which N. pompilius is the best known. Its shells are an important item of commerce in the Indo-Pacific, in particular the Philippine Islands.

Sepioidea - This group contains the cuttlefish (members of the family Sepiidae) and the bottle-ass or bottle-tail squid such as Spirula, Rossia, etc. The most important economic members are the common cuttlefish, Sepia officinalis and its subspecies, Sepia pharaonis and Sepiella spp. The family Sepiidae has no representatives in the Americas.

Teuthoidea - These are the true squids and are further subdivided.

Myopsida: This suborder contains the loliginid squids (family Loliginidae), one of the most important group of commercial cephalopods in the world, best represented economically by Loligo pealei, L. vulgaris and L. edulis. They are coastal species seldom found beyond the edge of the continental shelf.

Oegopsida: This is the suborder containing the oceanic squids dwelling mainly beyond the edge of the continental shelf though coming inshore seasonally at which time they are usually caught in the fisheries. The most important economic squids belong to the family Ommastrephidae represented by Todarodes pacificus, Illex illecebrosus and Illex argentinus.

Vampyromorpha - The order of the vampire squids contains only one representative, Vampyroteuthis infernalis, a weird deep-water form of uncertain relationship and derivation.

Octopoda - The octopods are subdivided into two groups of markedly different form and habitat.

Cirrata (Pteroti): To this suborder belong the finned octopods and those with cirri on the arms. They are all mainly deep-water species of somewhat sluggish nature, soft consistency and of no commercial importance.

Incirrata (Apteroti): The animals of this group are highly diverse; it includes gelatinous planktonic forms and the heavy mantled, bottom dwelling forms. Species of major importance are Octopus vulgaris, O. macropus, O. dofleini and Cistopus indicus.

The cephalopods discussed in this report may be grouped into the following categories: cuttlefish (Sepia, Sepiella) and bottle-tail squid (Rossia, Sepiola, etc.); squid (oegopsids such as Ommastrephes and Illex and myopsids such as Loligo and Sepioteuthis); and octopus (Octopus, Cistopus and Eledone).

2.1.1 Cuttlefish and bottle-tail squid

The term cuttlefish is usually restricted to those sepioid cephalopods possessing a large calcified internal bone or sepion. They are restricted to the Old World ranging from northern Europe to South Africa, the Indian Ocean, Australia to Japan but do not extend eastward, except rarely, as far as western Polynesia. The two genera Sepia and Sepiella are represented by about 100 species, a number of them attaining a rather large size. They are excellent eating and are utilized to a greater or lesser degree practically throughout their range.

Cuttlefish are predominantly shallow-water animals living from the shore to the edge of the continental shelf and upper slope. The large eggs are attached separately to bottom objects such as tree limbs and brush, horny coral skeletons, etc. The freshly hatched young may spend a short time in the plankton or more generally immediately take up a bottom abode. There is some evidence that they grow very rapidly (Choe, 1966). Maturity is attained in one year and few animals probably are more than two to three years old. They perform seasonal in- and off-shore migrations, probably related to breeding. They feed primarily upon crustaceans and fish, lying in wait for them on the bottom.

The cuttlebones are very light and are washed ashore in great quantities near regions of major concentrations of the animals. They are often, however, transported great distances even to the shores of the southeastern United States. The presence of cuttlebones need not, therefore necessarily indicate the nearby presence of living animals. The shells are a major item of commerce in some areas of the world.

The bottle-tail squid are small, usually squat, heavy bodied animals. They occur throughout the world although a number of genera have limited distributions. They usually live on or near the bottom where they feed on various kinds of small invertebrates. They are caught incidental to other fishes in trawls and seines, especially in the Mediterranean Sea and Japan. They appear to have a short life span. Little is known of their numbers, distribution and biology.

2.1.2 Squids

Because of their very different habitat preferences and way of life the squids must be divided for consideration into two distinct categories: (1) neritic squids and (2) oceanic squids.

2.1.2.1 Neritic squids. The neritic squids include all of the myopsids such as Loligo, Sepioteuthis and Doryteuthis. While some of the oegopsids such as Illex come into inshore waters seasonally, they are considered here as oceanic squid (q.v.). The loliginids (nearly all of the myopsids belong to this family) form an important part of the commercial squids of the world.

The loliginids are shallow-water animals living along the inner part of the continental shelf and entering bays, harbours, lagoons and similar areas. With the sole exception of members of the genus Lolliguncula, the loliginids require near open ocean salinities; Lolliguncula prefers estuarine situations with salinities as low as 17°/oo (Voss, 1956).

While not all species have been so reported, many if not most loliginids come into near-shore waters to breed and may form vast, closely packed schools at such times. Great mortality occurs during mating and spawning (McGowan, 1954); the eggs are laid in single or communal clusters or mops attached to the sea floor, and the males and females usually die shortly thereafter.

The eggs may take several months to hatch. The young usually go directly into the plankton for some weeks but grow rapidly. In Sepioteuthis maturity is attained in about five to six months at which time the female may spawn (LaRoe, 1971). In other species maturity is reached in about a year. Thus, like octopods, the life span is short and an annual crop is produced. The loss of the spawned-out adults is wasteful. A few males appear to attain a life span of two to three years (Verrill, 1882; Tinbergen and Verwey, 1945; Fields, 1965).

Little is known about the ecology of the squid grounds. Migrations occur in some areas, probably consisting of on- and off-shore movements. The loliginids are tropical and warm to cold temperate animals.

Large concentrations of loliginids are known in only a few places in the world. Attention should be given to the hydrology and general ecology of squid grounds in order to assist in the search for similar areas. Exploratory fishing is in its infancy.

2.1.2.2 Oceanic squids. The oceanic squids include a large number of families and genera, a number of which have economic potentials but of which only a few are now utilized. These latter all belong to the important family Ommastrephidae. The major commercial species belong to the two genera Todarodes and Illex, occurring in the Pacific and Atlantic respectively. Both of these occur during at least part of their life history in inshore waters where the major fisheries are conducted. Other genera of great potential are Dosidicus, Ommastrephes and Symplectoteuthis. The oceanic squids have been recently reviewed by Clarke (1966).

The major fisheries for oceanic squids are in Japanese waters centred on Todarodes pacificus, the so-called common Japanese squid. Numerous studies have been made concerning its biology such as size at maturity, spawning, early development, occurrence of larvae in the plankton, etc. Migrations have been studied by means of tagging. It is the only oceanic squid for which much of its biology is known. Its counterpart, Todarodes sagittatus, in the eastern Atlantic is practically unstudied.

Illex is widely distributed in the Atlantic where four species are known of which three - illecebrosus, coindetii and argentinus are presently fished commercially. Practically nothing is known of their biology, even of Illex illecebrosus, which has been important in the cod fisheries for at least 200 years. It occurs in inshore waters in Newfoundland in late summer where it is only lightly fished; its whereabouts the rest of the year are unknown. The eggs are rarely met with and the larvae seldom seen in the plankton. Its major predator is the pilot or pot-headed whale which feeds upon it almost exclusively (Squires, 1957). Plotting of the seasonal distribution of the pot-head might well reveal the migrational pattern of the adults. The life span seems to be one to two years.

The remaining ommastrephids are mainly open ocean inhabitants. Little is known of their distribution, numbers and life history. Dosidicus gigas of the west coast of South America attains a large size, 3-4 m total length. Total length is measured from the posterior end of the body or mantle to the tip of the tentacles or arms, whichever are longest. The standard length for cephalopods is the mantle length measured dorsally in squid from the posterior tip of the mantle to the anterior margin in the mid-line. In octopus it is measured from the posterior tip of the mantle to the mid-point between the eyes. They are voracious predators. In the younger stages they are subject to mass catastrophies in some years when millions of individuals die along the Chilean coast (Wilhelm, 1954).

Other oegopsid squids attain considerable size and occur in large numbers in the mesopelagic zone and below. They will be discussed later when considering oceanic resources.

2.1.3 Octopus

Most of the eight-armed, bottom-dwelling octopods important in the fisheries belong to the three genera Octopus, Cistopus, and Eledone. There are perhaps 100 species occurring in various parts of the world. They are carnivorous animals living in holes, crevices, old shells and other refuges on the bottom from just below the intertidal region to the continental slope. Some species are gregarious while others seem to be highly territorial and live apart. Some show seasonal migrations from the outer shelf shoreward and return, usually associated with the breeding season, while others remain in a single area.

Females usually lay their eggs attached in caves, holes or other sheltered areas in clusters, layers or festoons ranging in number from only about 15 to 20 to several thousand eggs. Apparently most species produce small eggs and the newly hatched larvae are small and become part of the temporary plankton for periods varying from a few days to a month or two. Other eggs are larger, the young hatch out at a much more developed state and take immediately to the bottom habitat.

Hatching or incubation time varies but averages from 30 to 55 days; the eggs are brooded and cleaned by the female who usually ceases feeding during brooding and dies shortly after the eggs hatch.

Studies of the growth rate of several species of Octopus show that full maturity may be reached in from five to ten months at which time the female is ready to spawn (Boletzky, 1969; Wolterding, MS). Thus in some species there may be two generations per year, in others a single generation. The males seldom live much longer. Rearing experiments in several species have been successful with F_2 and F_3 generations attained in the laboratory (Thomas and Kotowitz, in press). Thus octopus represent a fast growing stock with an annual turnover that should be able to be heavily fished without significantly diminishing the stock.

2.1.4 Other forms

Besides the major groups discussed above, there are a number of other families, genera and species of cephalopods which may later prove to be important commercially. This is especially true of the mid-water squids which provide such a large part of the diet of the sperm whale and the pelagic octopods such as Tremoctopus and Ocythoe. Not discussed above is the rather large industry centred around the shells of the chambered nautilus. Nautilus with its five species occurs most commonly in the Indo-West Pacific region, particularly around Indonesia and the Philippines. The animals are trapped or netted and the animal eaten while the shells are sold to the United States and Europe where they are sold as decorations, lamps, carvings, etc.

2.2 Geographic distribution

Cephalopods are found throughout the world ocean; however, general patterns of distribution are seen either by systematic groupings or by biological factors. The cuttlefishes are, as stated above, confined to the Old World. Members of the family range from Scandinavia and the North Sea (but not the Baltic) to the Mediterranean and along the African coast to the Cape of Good Hope. The much preferred species Sepia officinalis is divided into a number of subspecies along its range from northern Europe to South Africa. A few species are confined to West Africa and only one Atlantic species, S. officinalis, enters the Indian Ocean. The distribution of Indian Ocean sepiids is not well known but Adam and Rees (1966) have compiled all available information to that date. While numerous species have limited distribution (South Africa, East Africa, Red Sea, etc.) others such as S. pharaonis range widely throughout the Indo-West Pacific from East Africa to Japan and Australia. The Malayan fauna is widely distributed from northern Australia to Japan, Philippines and the Chinese coast, at least in its southern parts. Australia presents an enigma at present concerning its cuttlefish, largely because of the confused state of their systematics in that continent. The cuttlefishes do not pass far eastward of Melanesia and Micronesia and are not found in Oceania.

The bottle-tail squids are numerous, speciose, and show some peculiar distributional patterns. The genus Sepiola, for instance, is confined to the Old World, being distributed from Asia to northern Europe but is absent from the Americas. The genus Rossia and its allies, an economically important group, ranges from the southern tip of South America throughout the Atlantic along the continental shelves, Europe, Africa and in small numbers and few species in Asian waters from Siberia to Australia with one species in the northeast Pacific. On the other hand, the genus Euprymna, similar in appearance and habitat, is numerous and widely distributed in the Pacific and Indian Ocean but is not found in the Atlantic Ocean nor on the west coast of the Americas.

The neritic squids, the loliginids, are worldwide in distribution in tropical and temperate seas. Sepioteuthis, an economically important genus, is strictly tropical. S. lessoniana ranges from Oceania throughout the Indo-West Pacific but does not occur on the west American coast - S. sepioidea is tropical western Atlantic. Both are largely associated with coral reef regions. The genus Lolliguncula is Tethyan in distribution, a species occurring in each of the tropical provinces of the world associated only with continental regions with areas of low or varying salinities. Doryteuthis with several economically important species again is tropical. The most widely distributed species is D. singhalensis extending from Japan to East Africa. By far the most important genus is Loligo. Four major species are fished: L. forbesi in Europe to the Madeira Islands; L. vulgaris from Europe and the Mediterranean through the Gulf of Guinea; L. edulis in the Indo-West Pacific and L. pealei from New England to the Caribbean Sea. Other species have more limited ranges and are too numerous to mention here. All are confined to the continental shelf.

The oceanic squids are extremely numerous and highly diverse both as to range and habitat. Economically the most important are those species belonging to the family Ommastrephidae. Ommastrephids occur in all seas, some are totally oceanic (beyond the edge of the continental shelf) while others migrate shoreward during certain seasons. The most important commercial groups only are mentioned here. Todarodes pacificus ranges from western Canada and the Aleutians southward to Japan, China, Taiwan and perhaps the northern Philippines. The other species, Todarodes sagittatus, ranges from the Kara Sea, along the European coasts including the Mediterranean as far south as the southern Gulf of Guinea. Another form occurs in South Africa and the western Indian Ocean. A closely related genus Nototodarus with its single species sloani, long confused with Todarodes in Japanese fisheries literature, ranges from New Zealand to Australia, the Philippines to Hawaii. It may also occur along the coast of western South America. The major commercial ommastrephid of the Atlantic is Illex illecebrosus of Newfoundland, distributed from northern Florida across the North Atlantic to Europe as far south as the United Kingdom. Other species or subspecies occur from southern Europe through the Mediterranean to the Congo (Illex coindetii), the Gulf of Mexico and Caribbean Sea (I. coindetii) and southern South America (I. argentinus). Other major ommastrephids are such as Ommastrephes pteropus and O. caroli and O. bartrami (Atlantic) and O. bartrami (Pacific), Dosidicus gigas (southern California to Chile) and Symplectoteuthis oualaniensis (East Africa to western South and Central America). Other oceanic squids are of potential importance but are of open ocean and mid-water distribution. They are discussed under oceanic resources (q.v.).

The economically important octopods are mainly distributed according to the size of their eggs which determines whether the young are planktonic larvae or immediately benthic. If the former, the distribution is very wide; if the latter, they are restricted in range. Examples of the small egg group are Octopus vulgaris and O. macropus. Both species occur throughout the world in tropical and temperate seas. On the other hand, O. maya is restricted as presently known, to the east coast of Mexico; O. dofleini ranges from California to western Canada, Siberia and Japan. An important species in the markets from Hong Kong through the Indo-Malayan region is Cistopus indicus, often confused with O. macropus but distinguishable by the presence of water pores on the oral web between the arms near the mouth.

2.3 Depth range

The depth range of the cephalopods does not seem to be restricted so much by pressure as by temperature, but at present the roles of these two important factors have not been sufficiently investigated. The major problem in determining the depth distribution of cephalopods is the lack of opening-closing nets for pelagic species; the depth range of benthic species may be easily determined.

In general the cuttlefishes are restricted to the edge of the continental shelf shoreward to the intertidal zone. However, some species also appear to make seasonal migrations to the upper part of the continental slopes at depths as great as 500 m (Sepia elegans) (Voss, in press). The bottle-tail squids or sepiolids and their allies, have much greater ranges and some live as deep as 3 000 m or so.

The loliginids are, as far as our present knowledge permits tabulation, all shallow water, continental species, living from bays and lagoons outward to the edge of the continental shelf and the upper slope. None are oceanic.

The oegopsids or oceanic squids vary greatly in their depth distribution (see Clarke, 1966; Voss, 1967, 1969). The ommastrephids are wide ranging; they are found down to over 1 000 m during the day in offshore waters, to the surface at night or into waters of a few metres depth during certain seasonal migrations. The majority of oegopsids are distributed in the mesopelagic and upper and lower bathypelagic layers by temperature preferences. The distributions of a number of species in the Gulf of Guinea are shown in Table 1 (from Voss, 1969). This is an area of upwelling and the ranges would all be displaced downward somewhat in mid-ocean or in areas of sinking water masses.

Table 1. Catch composition of Gulf of Guinea cephalopods according to depth

1.	0-50 m (27°-20°C) Rynchoteuthis larva of an ommastrephid
2.	51-300 m (20°-10°C) Abralia veranyi, Abraliopsis sp., Liocranchia reinhardti, Helicocranchia pfefferi.
3.	301-1 000 m (10°-4°C) Heteroteuthis dagamensis, Abralia veranyi, Abraliopsis sp., Enoploteuthis leptura, Pterygioteuthis gemmata, Octopoteuthis sicula, Onykia appelloffi, Bathyteuthis abyssicola, Histioteuthis corona, Brachioteuthis riisei, Liocranchia reinhardti, Japetella diaphana, Vampyroteuthis infernalis.
4.	1 001-3 000 m (less than 4°C) Abralia veranyi, Abraliopsis sp., Pterygioteuthis giardi, P. gemmata, Bathyteuthis abyssicola, Histioteuthis meleagroteuthis, Mastigoteuthis sp., Chiroteuthis sp., Galiteuthis armata, Liocranchia reinhardti, Helicocranchia pfefferi, Japetella diaphana, Vampyroteuthis infernalis.

2.4 Numbers

It is difficult to assess the numbers of cephalopods in the sea from direct observation. There are numerous reports of vast congregations of squid, cuttlefish and octopus, but few are quantitative in nature. McGowan (1954), Fields (1950), Voss (unpublished) have all commented upon the huge numbers of squids in the mating and spawning schooling of loliginids. Bullis (personal communication) reported seeing tremendous schools of large squid on the surface in the Gulf of Mexico. Sports fishermen have long been aware of the numbers and voraciousness of the Humboldt squids off Chile and Peru and Wilhelm (1954) has described the mass catastrophism of this species along the Chilean coasts. The numbers of cuttlefish are less reliably reported but the vast numbers of cuttlebones washed up on some beaches of Africa indicate extremely large standing populations. Octopus vulgaris at times occurs in such astronomical numbers on the south coast of England that they are considered as a plague and destroy the crab and lobster fisheries (Garstang, 1900; Rees and Lumby, 1954). Lane (1957) has given a general review of such reports. Catch statistics are equally unreliable and few catch per unit of effort data are available for cephalopods. The discussion of potential productivity is left for consideration at the end of this paper.

2.5 Edibility

Cephalopods have been eaten since time immemorial and have been and are considered to be true delicacies by Greeks, Italians, Spaniards, Portuguese, Japanese and Chinese and

food-educated northern Europeans and Americans. To most of the remainder, even the name of octopus or squid conjures up some degree of stomach revulsion, entirely undeserved. The main reason is lack of knowledge of how to prepare them for the table and even Idyll (1968:51) in his report on oceanic food resources continued the myth that squid are tough and indifferently palatable.

Squid, octopus and cuttlefish are all tender when properly prepared, deliciously flavoured and high in proteins. Leung, Pecot and Watt (1952) give the following analysis of squid flesh per 100 g.

	Food energy	Protein	Fat	Ash	Calcium	Phosphorus	Iron
	Cal.	g	g	g	mg	mg	mg
Raw	78	16.4	0.9	1.0	12	119	0.5
Dried	305	62.3	4.3	6.9	46	471	2.0

Amino acids in squid exceed those in fish; Japanese workers have identified 17 amino acids from Todarodes: proline, histidine, aspartic acid, glutamic acid, leucine, arginine, glycine and alanine. The vitamins B_2 and B_{12} are present, particularly in the viscera.

Cephalopods have little waste material as compared with other marine animals. In squid, about 80 percent of the animal is utilized.

3. FISHING METHODS

The methods of fishing for cephalopods are very diverse and run the range from methods as old or older than written history, to the most modern techniques and gear. It has not been possible here to review all of the literature nor is space available to describe it all. Such a survey, however, would be very useful. Techniques have been described by various persons from particular localities: Canada (Squires, 1957); Caribbean (Voss, 1971); Mediterranean (Ghirardelli, 1961); Saharan Bank (García Cabrera, 1968, 1970); Japan (FAO, 1972); Hong Kong (Voss and Williamson, 1972); California (Fields, 1950). A brief general survey of squid fishing gear was published by Zuev and Nesis (1971).

All of the methods and gear may be reasonably divided into a few fairly discrete categories.

3.1 Spearing or hooking

This is probably the oldest method with numerous variations. It is mainly a subsistence type fishery. For squid and cuttlefish, spearing is most successful at night with the use of torches, flares or electric lights. It is done today in the Orient and in the Mediterranean. Catches are not large. Spearing or hooking for octopus is commonly practised in tropical waters of the world. Essentially it consists of locating octopus on open bottom or in their lairs either by viewing through a glass-bottom bucket or by sprinkling a few drops of oil on the sea surface in order to smooth it. Octopus on open bottom are speared; those in their lairs are pulled out and captured by thrusting a short pole with a hook on the end of it into the lair, twisting it and hauling out the octopus. In most countries around the world the captured octopus is killed either by biting it between the eyes or "turning the cap", breaking the mantle free from the viscera and turning it inside out, exposing the viscera to the air.

3.2 Trolling or handline fishing

This method is used, with variations, in many areas. In the Mediterranean, fishing for cuttlefish is usually done by trolling a female cuttlefish slowly at the stern of the boat. Male cuttles approaching her for mating are speared or dipnetted. Artificial lures somewhat resembling cuttlefish are used in the Mediterranean and are reported from the

Orient. Various types of weighted jigs or jig-type lures are also trolled in deeper water and catch cuttlefish, squid and octopus. In Polynesia, cowrie shells with various ornaments made to resemble rats are trolled on the bottom for octopus. According to folklore, Polynesian octopus hate rats and attack them on every possible occasion. A variation of the octopus trolling is that practised in Mexico, "al garete". In this, the small fishing boats drift off before the wind towing up to 30 short lines baited with crabs along the bottom. The octopus are dipnetted when the line is hauled in.

3.3 Baskets, pots, "nummarellas"

In the Mediterranean wicker and wire basket traps are set on the bottom for cuttlefish, baited, and often with tree limbs and branches to encourage deposition and attachment of cuttlefish eggs. Cuttlefish are caught by hauling the trap and dipnetting the animals attracted to it. "Nummarellas" are series of clay pots, tied together at intervals, set out along the bottom in productive waters and buoyed for retrieval. The octopus enter them for shelter, protection and for lairs for spawning. They are hauled at intervals and the octopus captured. This method is used in the Mediterranean, Caribbean and Gulf of Mexico, Hong Kong and China and Japan. In Indo-Malaya a variation is the use of strings of the empty shells of the conch Pterocera. Hornell (1950) states that in the Palk Straits as many as 700-900 shells are attached to one line and hauled each morning (Lane, 1957). Lane states that on the north African coast, sections of pipe tile are laid on the bottom for the same purpose.

3.4 Trapnets

Traps are used in various areas and with varying success. In Newfoundland, the traps are floating, anchored and buoyed, with a webbing floor and long lead. They are hauled morning and evening and may yield 14-40 000 lb per day. Illex and Loligo were also caught along the U.S. coast in staked weirs but these have now been discontinued.

3.5 Seines

Two types of seines have been or are now in use for squid and cuttlefish. The beach or hand seine is used in some areas (Mediterranean, Africa, Japan, etc.) for capture of small squid when congregated in shallow water. Types of purse seines or lampara nets are used in the Mediterranean and Iberian fisheries, in Monterey Bay and Japan. In using these nets the squid are often attracted to lights, the net set around the school and when pursed down are either brailed or pumped out with a fish pump.

3.6 Bottom trawls

One of the most productive of all fishing methods is bottom trawling with otter trawls. Most of the squid, cuttlefish and octopus caught inadvertently in the scale fish or shrimp fishery are taken in this manner as described under the various regional surveys. Trawling for cephalopods on the Saharan Bank is done with conventional fish trawls but often with "octopus lifters" or loops of chain fastened to the footrope. The details of the Saharan Bank trawl are given by García Cabrera (1968).

3.7 Jigging

Jigging is the other major method of catching squid. There are many variations of this method. They are reviewed by Zuev and Nesis (1971). Hand jigging was long done in Newfoundland using a lead jig and single circle of barbless hooks. Hand jigging is also done in Japan, Philippines, Korea and elsewhere using single or multiple jigs on a single or double line with various types of spreaders, weights, etc. The kinds of jigs vary considerably according to whether it is for ommastrephids or loliginids. The present machine jigging has largely replaced hand jigging. This method utilizes either the hand cranked or power driven single or multiple jigging reels. Modern Japanese squid jiggers may have as many as 22 or more double reel jiggers.

4. MARICULTURE

With the increased demand for cephalopods for the market, the failure of the sea fisheries to keep pace with the demand, and the high prices now being paid, attention has turned to the problems of rearing animals for the market. This has also been spurred on by the demand for a continuous supply of experimental animals for nerve research. The U.S. National Institutes of Health estimate that each squid delivered to the research laboratory costs approximately U.S.$ 125. There is need for research on rearing or mariculture and the Japanese have been actively pursuing investigations on rearing octopus while at least one major fishing company in the Americas is interested in squid culture.

Mariculture in the field has, in fact, been practised in the Mediterranean Sea since classical times. This has involved putting out tree limbs and branches, particularly the mastic, for surface for attachment of cuttlefish eggs. It is still practised today (Ghirardelli, 1961). Clay pipe or hollow tile is used on the African coast for catching octopus but also increases the standing population.

Experiments on rearing cephalopods in the laboratory were begun in the Orient by Sang Choe in Korea and Y. Oshima in Japan in collaboration. Two papers Choe and Oshima (1961) and Oshima and Choe (1961) described experiments in rearing young cuttlefish and squid from the egg. Choe and Oshima (1963) published a brief note in English describing their work and in 1966 Choe reported on his further studies in rearing Sepia esculenta, S. subaculeata, Sepiella maindroni, Sepioteuthis lessoniana and Euprymna berryi. The eggs were hatched in and the fry grown in outdoor cement tanks. The animals were all grown to near adult size and although the hatching period is rather long (28-56 days), Sepia esculenta was grown to market size in 110 days. In a paper in 1966 Choe further described the growth, feeding rates and food conversion efficiency of cuttlefish and squids. In Japan, work has progressed on rearing Octopus, mainly from eggs taken in the wild and the fry grown from them. It is not known whether marketing has been accomplished or not.

Experimental rearing of cephalopods began at Miami, Florida, in about 1967 with experiments with Octopus. The first success was accomplished by Boletzky and Boletzky (1969) who reared Octopus joubini from the egg to adulthood and spawning in 160 days from hatching. Continued work by Thomas and Kotowitz (in press) has resulted in five generations of laboratory reared animals. LaRoe (1971) again at Miami, successfully reared the loliginid, Sepioteuthis sepioidea, from the egg to adulthood in 146 days and maintained adult Doryteuthis plei in the tanks for 38 days. Wolterding (in manuscript) raised Octopus briareus through two generations in the laboratory, with full growth occurring in five months

Boletzky continued rearing experiments in France at Banyuls-sur-mer. Boletzky et al., (1971) successfully reared the sepiolids or bottle-tail squids Sepiola rondeleti, S. robusta and S. sp., from the egg to sexually mature and spawning individuals in 140-170 and 180-220 days respectively. Sepietta obscura and S. neglecta reached maturity in 190 and 110 days respectively.

Successes with these experiments show that the commercial rearing of a number of species of cephalopods is possible and basic techniques have been worked out and have been published. Species so far successfully reared have all possessed large eggs with resulting large fry, making it easier to feed them in the smallest sizes. The extremely rapid growth and short time necessary to reach maturity indicate animals with considerable potential for mariculture They also show that the crop in the field can bear heavy fishing pressure and yet maintain a satisfactory level of production.

5. STATISTICS

The available statistics upon which the main part of this work are based are sketchy at best. As can be seen in the section on fishing methods, almost none of the techniques employed are quantitative in nature and in all but a few cases sample only a minor fraction of the stock present. Few areas have been extensively explored and fishing centres are

small and spotty in relation to the overall distribution of economic species. Much of the fisheries in all but the more highly developed nations are subsistence fisheries and almost no data are available on amounts caught, not even "guesstimates". Even those nations that produce recognizable quantities of cephalopods usually fail to list them separately from other molluscs, even when they comprise the major percentage. Quantitative sampling is, of course, irrelevant to tabulation of what is caught, but becomes most important in resource appraisal and stock assessment work.

Even major fishing countries seldom list the catch by species or even genus or family, referring to them as cuttlefish, squid and octopus, or uniting the first two under one or the other name. FAO reports, however, do not list annual landings of less than 100 tons, even when in the aggregate they might be significant.

The picture is further complicated in reported landings when only the port landings are given and not the area in which the catch was made. The statistics from Spain with three coastlines and the Canary Islands are particularly difficult to analyse. Several others are similar. It is certainly to be hoped, as the need for accurate statistics is recognized, that nations will revise their reporting methods, particularly where cephalopods are concerned. The time available for compiling the present report, about six weeks, did not permit the gathering of as much new data as was desired. Letters requesting information in particular fisheries, countries and areas were sent out to a few friends and colleagues and most helpful replies were received. These are acknowledged elsewhere in the pertinent sections but I wish specifically to thank the following persons for their very great help:

Boschi, E.E., Instituto de Biología Marina, Mar del Plata, Argentina

Chan, W.L., Agriculture and Fisheries Department, Hong Kong

Clarke, M.R., National Institute of Oceanography, Wormley, England

Mercer, M.C., Fisheries Research Board of Canada, St. John's, Newfoundland, Canada

Nesis, K.N., Institute of Oceanology, Academy of Sciences, Moscow, U.S.S.R.

Okutani, T., Takai Regional Fisheries Research Laboratory, Tokyo, Japan

Other data are from the literature on the result of questionnaires sent out privately on other research (Voss, 1971). Much information was derived from the FAO landing reports for 1969 and from the volume The Fish Resources of the Ocean edited by Gulland (1970). Several references were obtained from a manuscript on squid resources compiled by Mr. Miles Alton of the North West Fisheries Center, National Marine Fisheries Service, Seattle, Washington. Thanks are given for permission to use two tables from this document in the present paper and also Figure 1 updated to include FAO catch statistics for squid for 1971.

With these kinds of data only available, and with almost no information on egg production, numbers of larvae, etc., and little factual information on age at maturity, longevity, etc., estimates of potential production given here are at best "guesstimates", or educated guesses. It is interesting, however, that most of the people now engaged in the study of cephalopod biology and fisheries are convinced that these animals represent a vast stock, still largely unexploited, and capable of heavy fishing.

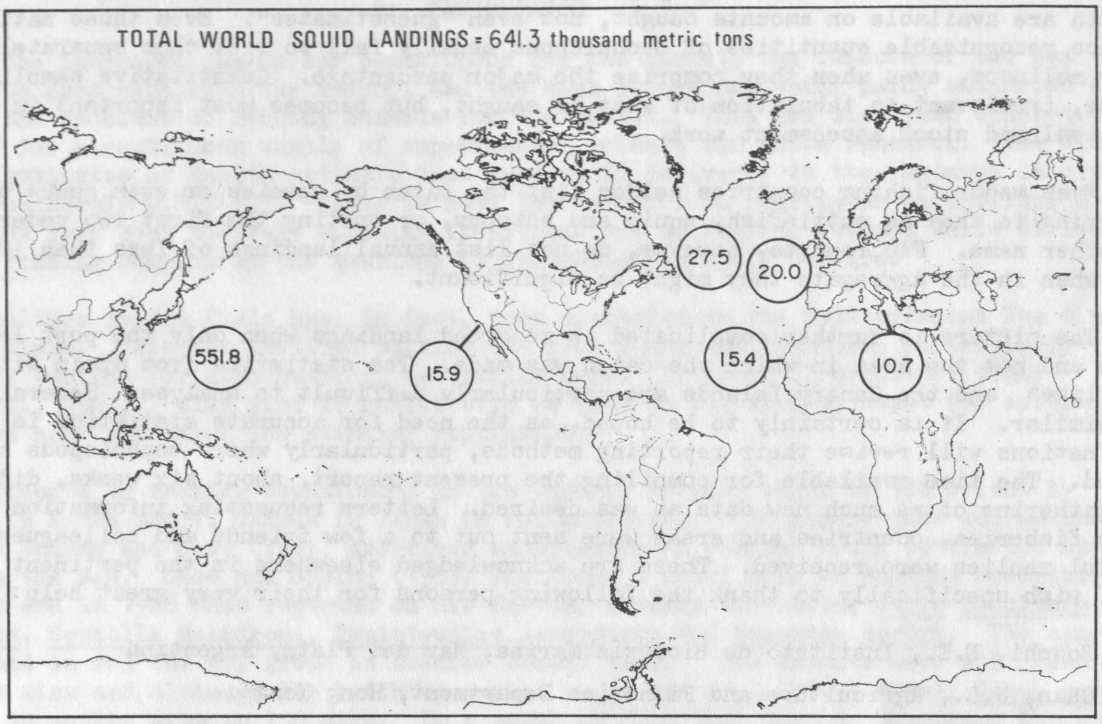

Figure 1. Total world squid production by major areas. Circled numbers are in thousand metric tons. FAO statistics for 1971.

6. RECOMMENDATIONS

If the cephalopod potential production of the world is to be greatly increased, a number of activities and research programmes need to be initiated or expanded. Among these, may be mentioned the following:

1. Development

   (a) initiate wide-scale exploratory investigations for new fishing grounds;

   (b) investigate the possibility of adapting or developing new fishing techniques;

   (c) expand the work already started on location and detection of squid by acoustic methods and their reaction and behaviour in relation to fishing gear.

2. Data collection and analysis for stock assessment/management purposes

   (a) improvement of present catch statistic data collection, encouraging nations compiling fisheries statistics to separate cephalopod data if possible by major groups;

   (b) biological sampling for data on length, sex, maturity, age, etc., and studies on growth, behaviour, etc.;

   (c) studies on present status of cephalopod stocks and their potential for further development.

3. Marketing

   (a) review present fisheries markets, processing, prices, etc., and make these data available to the commercial industry;

(b) identify potential new markets, new processing techniques and new ways to educate potential consumers, e.g., through preparation of booklets, etc.

7. AREA REVIEWS

7.1 General

The landings shown in this section are derived from FAO published statistics for 1969 (FAO, 1970), unless otherwise stated. Information on landings in the Central Western Atlantic are derived from questionnaires distributed by the writer to all countries bordering the area; an unusual 100 percent return was achieved so that this area can be more reliably reported upon especially as regards the individual fisheries. Further new and updated reports were obtained at the time of writing by requests made to the persons acknowledged in the introduction. Despite this, the accuracy of the reports is marginal, if accuracy exists at all, since many nations or areas do not report their cephalopod landings and in almost all cases the landings are not reported except at major ports or those from fish companies. As a result, the cephalopod statistics except in the few cases especially noted, are probably distinct underestimates at least on a national basis.

The delimitations given here match reasonably well the natural faunal provinces of the sea and are not artificially erected to fit certain political requirements. They differ from those officially recognized by FAO and from those given in "The Fish Resources of the Ocean" (Gulland, loc. cit.). Thus the central regions are also the tropical regions while the others represent north and south temperate zones and the Southern Ocean or Antarctic province. With the exception of the latter, the seaward boundary is drawn not far from the continental slope and all of the intervening oceanic regions are treated separately as their faunas require. This system permits better evaluation of stocks with separation of neritic species from those of the high seas which are widely distributed in each ocean or are cosmopolitan.

7.2 Region I - Northeast Atlantic

U.S.S.R. and Scandinavia to Gibraltar: Total 12 000 tons

The data as given in the FAO 1970 statistical report for 1969 are very difficult to use as they are compiled by country only.1/ Thus, both France and Spain have both an Atlantic and Mediterranean coast while Spain also heavily fishes the Saharan Bank. Even the landings reported from the U.S.S.R. and formerly (1966-68) referring only to the Northwest Atlantic in 1969 obviously include the Northeast Atlantic, Saharan Bank, Argentina, and the Northwest Pacific. The amounts landed by all countries within the Northeastern Atlantic total 102 000 tons in 1969 of which perhaps 12 000 tons originated in the Northwestern Atlantic. Countries reporting landings are given in Table 2 and include U.S.S.R., Norway, U.K., France, Spain, Portugal and Belgium.

Data on squid landings for the years 1967-69 taken from ICES Bulletin Statistique des Pêches Maritimes (1969, 1970, 1971), give some information on Northeast Atlantic landings and the areas of origin (Table 3). These data do not include those of the U.S.S.R.

These landings, according to the tables from which they were extracted, refer to Loligo spp. but it is likely that other loliginids such as Alloteuthis spp. and even some ommastrephids, Todarodes and Illex are also included. Most of the catch of the north European nations except for the U.S.S.R. is used for bait, mainly in the cod fishery.

Loligo vulgaris, the common European squid, ranges from the North Sea along the European coast to Africa. Its biology has been reported upon by Tinbergen and Verwey (1945)

1/ FAO 1971 Statistical Report (for 1970) has a rather different format

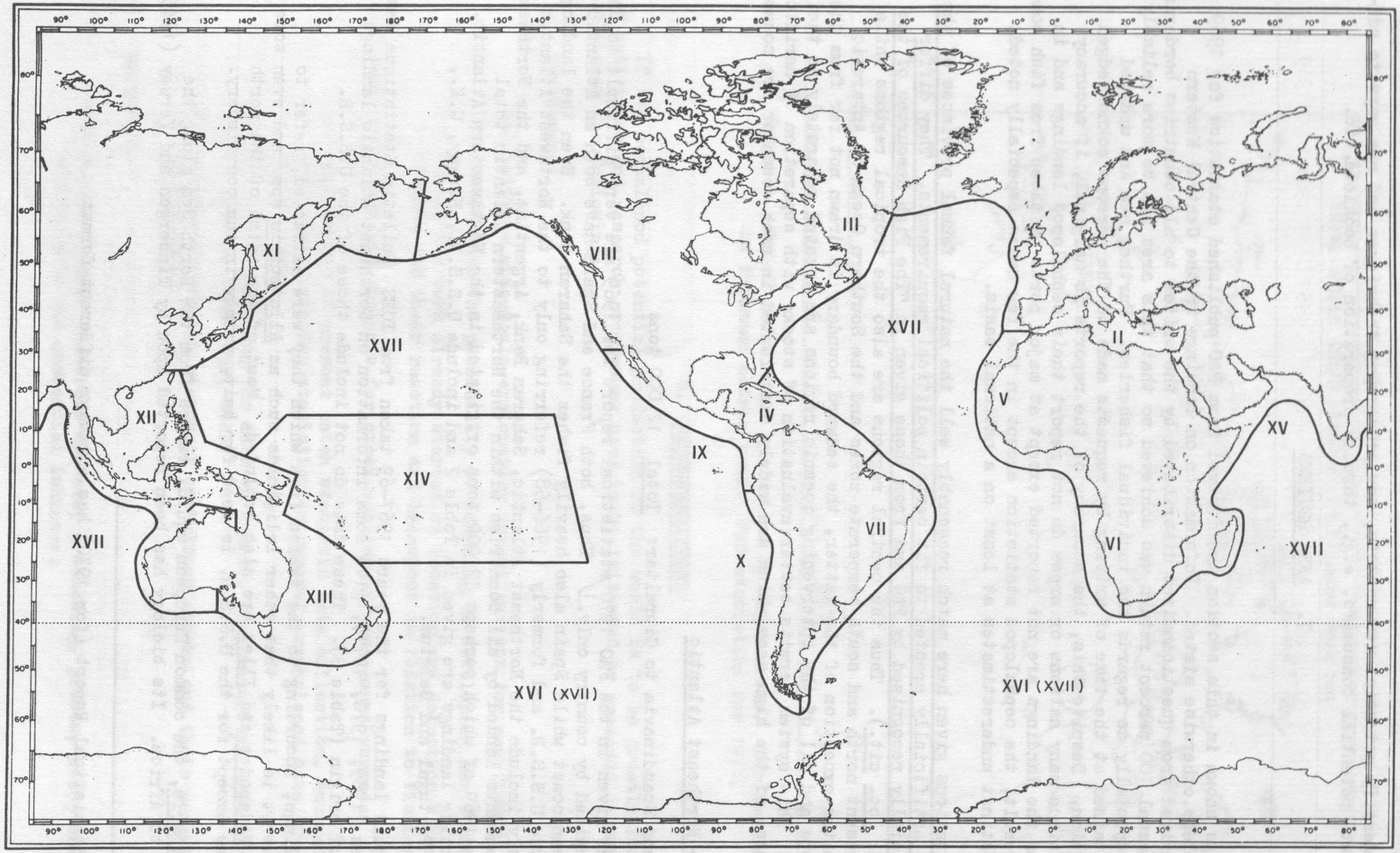

Figure 2. Areas referred to in the text

Table 2. Cephalopod landings reported by countries in Region I

	1964	1965	1966	1967	1968	1969
U.S.S.R., Squid	-	-	0.5	0.8	3.2	16.2
Norway, Squid	1.5	10.8	2.5	1.9	0.1	-
Denmark, Cuttlefish	0.0	0.0	0.0	0.0	0.0	0.0
U.K., Squid	0.2	0.2	0.1	0.2	0.2	0.3
Belgium, Squid	0.1	0.1	0.1	0.1	0.1	0.1
France, Squid and Cuttlefish	1.8	3.9	3.7	3.9	-	-
Portugal, Squid	1.3	2.5	1.2	2.0	0.9	0.7
Cuttlefish	2.2	2.6	2.1	2.4	2.1	1.9
Octopus	0.7	1.2	1.3	1.4	1.8	1.0
Spain, Squid	15.5	19.1	15.6	18.0	14.5	13.8
Cuttlefish	14.1	17.2	15.7	16.9	15.9	15.6
Octopus	23.4	55.3	60.5	63.6	63.8	52.3
Total	60.8	112.9	103.3	111.2	102.6	101.9

Table 3. Squid catch by fishing areas in the Northeast Atlantic (in metric tons)

	1967	1968	1969
Norwegian Sea			
Norway	1 617	90	-
North Sea			
Belgium	20	44	45
Scotland	107	34	3
England and Wales	-	2	-
U.K. and Ireland including English Channel			
Belgium	36	49	82
England and Wales	122	68	187
N. Ireland	12	11	12
Scotland	48	54	91
Iberian Peninsula, Bay of Biscay			
Portugal	1 721	632	495
Spain			
Total	6 776	3 116	3 121

from the Atlantic coast. There is some migration seasonally and large mating and spawning schools occur. However, most of the catch is taken incidental to bottom trawling for scale fish and no regular fishery is pursued. The species is widely taken on the coast of Portugal on an almost subsistence level. Loligo forbesi is distributed from Norway and the Faroe Islands to the U.K. and southward as far as the Madeira Islands. It is fished by the Norwegians and Faroe Islanders and in the U.K. off Scotland and southward to Devon. There

is some evidence that it migrates seasonally along the U.K. and several studies are in progress at Plymouth and Aberdeen. The other two loliginids, Alloteuthis media and A. subulata are smaller animals. A. media occurs from the southern part of the North Sea to the Mediterranean in depths from 30 to 130 m. A. subulata ranges from the North Sea and western Baltic southward to Spanish Sahara. It is described and discussed by Naef (1923:219) and Muus (1959:152). Both often enter the landings as Loligo and because of their smaller size are often considered to be juveniles of L. forbesi and L. vulgaris. From all of these loliginids there are large diverse local fisheries not included in landing statistics.

The ommastrephid squids Todarodes sagittatus and Illex illecebrosus and I. coindetii also are fished locally. T. sagittatus occurs from the Kara Sea (U.S.S.R.) around the North Cape into the North Sea and southward to Africa. At times it has been taken in some numbers in Norway for fish bait. In 1930-31 this species occurred in enormous numbers on the Scottish coast, affecting the herring fishery. Again in 1937 they came onto the Scottish coast causing considerable damage. Illex illecebrosus and I. coindetii both occur in northern Europe. The first ranges from the English Channel north and westward to the Americas while the latter extends from the North Sea to Africa. Little is known of the biology of any of the Atlantic ommastrephids.

The major cuttlefish of the Atlantic coast of Europe is Sepia officinalis of which the subspecies fillouxi occurs from France to Scandinavia and officinalis from France to northwest Africa. S. orbignyana and S. elegans both occur from the U.K. southward along the African coast. Few enter into the fisheries of the Northeast Atlantic. Denmark has a small catch but both Spain and Portugal take them on their coasts. They are not, however, a significant part of the catch as they are off the African coast and in the Mediterranean Sea.

Three species of octopus occur along the European Atlantic coast: the common octopus, Octopus vulgaris; the lesser octopus, Eledone cirrhosa and the musk octopus, Eledone moschata. The two species of Eledone are not important in the area although they are taken in benthic trawls. Octopus vulgaris is common on the French coast and in the Channel Islands. In certain years these have population explosions and "plagues" of octopus occur on the south coast of England (Garstang, 1900; Rees, 1952; Rees and Lumby, 1954). Late plague years in England have occurred in 1900 and in 1950-51, while France experienced one in 1922. The increase in octopus has serious effects upon the crab and lobster fishery but apparently no attempt has been made to capitalize upon the stock. The biology of O. vulgaris is still poorly known. Rees (1950) described the larvae and late larval stages and the manner of spawning and protecting the eggs. Behaviour has been extensively studied at the Zoological Laboratory at Naples, Italy. However, there is still considerable question about the length the larvae stay in the plankton (Mangold, 1963; García Cabrera, 1968; Rees, 1950; Voss, 1957).

On the basis of the very poor statistics it is impossible to estimate the potential productivity of the Northeastern Atlantic. That considerable stocks exist is unquestioned; perhaps these are in the order of several hundred thousand tons.

7.3 Region II - Mediterranean Sea

Total about 42 000 tons

The Mediterranean was long the only region fished for cephalopods; its fishery history dates back to classical times and the Greek methods of capture were described by Aristotle. Roman writers considered them to be culinary delights and Italy today is the chief cephalopod fishery region in the Mediterranean Sea. Unfortunately, the statistics concerning the landings along the coasts are extremely inadequate. The Spanish catch is listed by landings but not area of origin; this is also true of French data. Italian landings apparently refer directly to catches in Italian waters and north Africa (Mediterranean). Little or no data are available from Yugoslavia, Greece, and nearly the entire eastern and northern perimeter of the Mediterranean. In addition, the hydrography of the Mediterranean is such that conditions for high productivity of cephalopods is not as good apparently in the eastern part as it is in the middle and western regions.

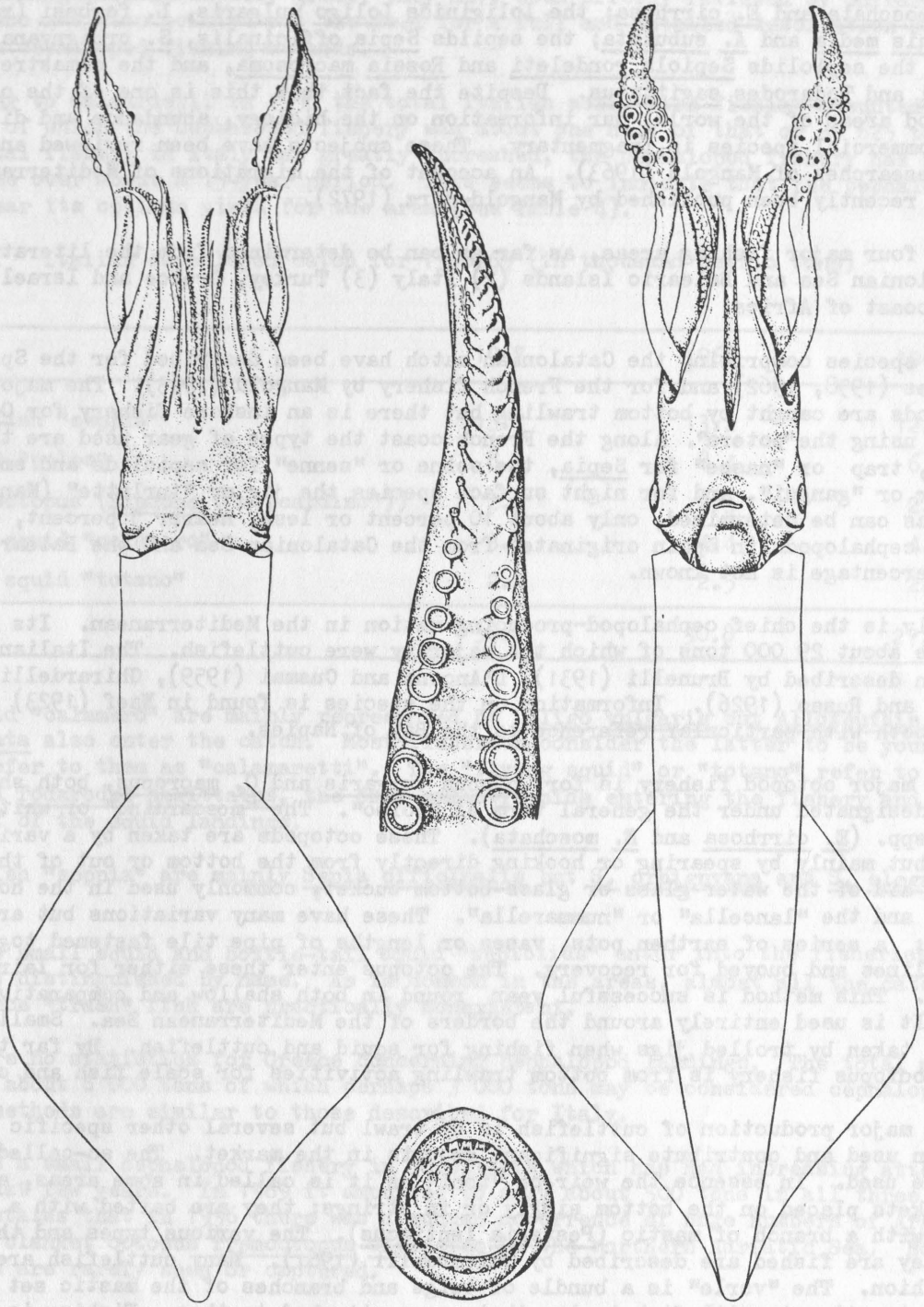

Figure 3. Loligo vulgaris from the Northeast Atlantic (from Adam, 1952)

The number of species taken is very large, though some species may not constitute a significant part of the fishery. These are: the octopods Octopus vulgaris, O. macropus, Eledone moschata and E. cirrhosa; the loliginids Loligo vulgaris, L. forbesi (rare), Alloteuthis media and A. subulata; the sepiids Sepia officinalis, S. orbignyana and S. elegans; the sepiolids Sepiola rondeleti and Rossia macrosoma, and the ommastrephids Illex coindetii and Todarodes sagittatus. Despite the fact that this is one of the oldest known cephalopod areas of the world, our information on the biology, abundance and distribution of the commercial species is fragmentary. These subjects have been reviewed and supplemented by the researches of Mangold (1963). An account of the migrations of Mediterranean cephalopods has recently been published by Mangold-Wirz (1972).

The four major fishing areas, as far as can be determined from the literature, are: (1) Catalonian Sea and Balearic Islands (2) Italy (3) Turkey, Greece and Israel (4) northwestern coast of Africa.

The species comprising the Catalonian catch have been described for the Spanish fishery by Morales (1958, 1962) and for the French fishery by Mangold (1963). The majority of the cephalopods are caught by bottom trawling but there is an inshore fishery for Octopus vulgaris using the "potera". Along the French coast the types of gear used are the trawl or "chalut", trap or "nasse" for Sepia, the seine or "senne" for sepiolids and small Sepia, the spear or "gangui", and for night surface species the jig or "turlutte" (Mangold, 1963:6). As near as can be determined, only about 10 percent or less, nearer 5 percent, of the total catch of cephalopods in Spain originates from the Catalonian Sea and the Balearics. The French percentage is not known.

Italy is the chief cephalopod-producing nation in the Mediterranean. Its landings for 1969 were about 29 000 tons of which the majority were cuttlefish. The Italian fisheries have been described by Brunelli (1931), D'Ancona and Cusmai (1959), Ghirardelli (1946a, b, c, 1961) and Russo (1926). Information on the species is found in Naef (1923) and Jatta (1896), both with particular reference to the Bay of Naples.

The major octopod fishery is for Octopus vulgaris and O. macropus, both shallow water species designated under the general term of "polpo". The "moscardino" or white octopus is Eledone spp. (E. cirrhosa and E. moschata). These octopods are taken by a variety of fishing methods but mainly by spearing or hooking directly from the bottom or out of their lairs with the aid of the water glass or glass-bottom bucket, commonly used in the hooker sponge fishery, and the "lancella" or "nummarella". These have many variations but are basically the same: a series of earthen pots, vases or lengths of pipe tile fastened together in bottom longlines and buoyed for recovery. The octopus enter these either for lairs or for spawning. This method is successful year round in both shallow and comparatively deep water. It is used entirely around the borders of the Mediterranean Sea. Smaller quantities are also taken by trolled jigs when fishing for squid and cuttlefish. By far the most productive octopus fishery is from bottom trawling activities for scale fish and crustacea.

The major production of cuttlefish is by trawl but several other specific methods have long been used and contribute significant amounts in the market. The so-called weir and "vorle" are used. In essence the weir, or "toni" as it is called in some areas, are wicker or wire baskets placed on the bottom singly or in strings; they are baited with a female cuttlefish or with a branch of mastic (Pestacia lentiscus). The various types and the areas in which they are fished are described by Ghirardelli (1961). Many cuttlefish are caught in this fashion. The "vorle" is a bundle of twigs and branches of the mastic set on the bottom in order to attract cuttlefish to lay their eggs attached to them. Fishing is done by raising the vorle and netting the cuttlefish swimming under or around it.

Another method in wide use in the Mediterranean is using a female as a lure. The female is towed astern of a small boat and males attracted to her are speared or dipnetted. Another method is by using a variety of different types of trolled jigs: the "fuso" or "totanara", the "latero" or "lontro" and the "purpara". All are lures of one type or another with hooks at one end, resembling cuttlefish, or sometimes baited with crabs.

Squid are also taken by trawling, trolled jigs and lights, and dipnets. Both cuttlefish and squid are also taken with trammel setnets and other types of nets and traps. The variety of fishing methods is very great; they have been briefly reviewed by Ghirardelli (loc. cit.) who has also pointed out the need for a full and detailed description of Mediterranean cephalopod fishing methods.

According to Ghirardelli in 1956 the total Italian scale-fish fishing amounted to 73 938 tons, of which the cephalopod fishery was about one half of that or 30 625 tons. While the total fishery in Italy has greatly increased, the cephalopod fishery has remained much the same over about a 15-year period. This seems to indicate that the cephalopod fishery is near its optimum yield for the area (see Table 4).

Table 4. Italian cephalopod catch for 1966-69 (in thousand metric tons)

	1967	1968	1969
Cuttlefish "seppia"	13.7	13.2	12.2
Octopus "polpo"	8.5	8.4	6.8
White octopus (Eledone ("moscardino"))	2.2	2.3	2.0
Common squid "calamaro"	3.9	4.4	4.3
Flying squid "totano"	2.4	2.5	2.4
Total	30.7	30.8	27.7

The squid "calamaro" are mainly represented by Loligo vulgaris but Alloteuthis media and A. subulata also enter the catch. Most fishermen consider the latter to be young of Loligo and refer to them as "calamaretti". The "flying squid" or "totano" refer to Illex coindetii and Todarodes sagittatus, the only ommastrephids entering the fishery and amounting to about half of the squid landings.

Cuttlefish "seppia" are mainly Sepia officinalis but S. orbignyana and S. elegans are also landed.

Numerous small squid and bottle-tail squid "sepiolids" enter into the fisheries but often are not distinguished by name. As is common in the areas, almost all the catch is utilized, hence "trash" fish are practically nonexistent.

There are no statistics for Greece concerning cephalopod landings. The total molluscan landings are about 6 000 tons of which perhaps 3 000 tons may be considered cephalopods. The fishing methods are similar to those described for Italy.

There is a small cephalopod fishery in Yugoslavia which has had increasing attention during the last few years. In 1969 it amounted to only about 500 tons in all three groups. Lane (1957) states that in 1936 there was a sudden occurrence of huge numbers of Argonauta argo and the blanket octopus Tremoctopus violaceus in the northern Adriatic Sea. Normally these animals are rarely seen or captured.

Turkey lands about 1 300 tons of cephalopods annually, presumably all from the Mediterranean.

Other fisheries including those mentioned above are given in Table 5 for the Mediterranean Sea. As Gulland (1970) has pointed out, the figures by area for the Mediterranean are misleading as Italy fishes the north African coast but does not differentiate the catch from that in Italian waters. Problems have already been discussed regarding Spain and France.

Table 5. Cephalopod landings for the Mediterranean Sea (in thousand metric tons)

	1964	1965	1966	1967	1968	1969
Spain						
Squids	0.8	1.0	0.8	0.9	0.7	0.7
Cuttlefish	1.2	2.8	3.0	3.2	3.2	2.6
Octopus	0.7	0.9	0.8	0.8	0.8	0.8
France						
Squid and Cuttlefish	0.1	0.2	0.2	0.2	-	-
Italy						
Squid	5.4	7.1	7.7	6.3	6.9	6.9
Cuttlefish	12.4	13.4	12.0	13.7	13.2	12.2
Octopus	9.7	9.9	12.4	10.7	10.7	8.8
Yugoslavia						
Squid	0.2	0.2	0.2	0.2	0.2	0.2
Cuttlefish	0.1	0.1	0.1	0.2	0.1	0.2
Octopus	0.1	0.1	0.1	0.2	0.1	0.1
Greece						
Cephalopods	-	-	-	2.7	3.2	-
Turkey						
Squid	-	-	-	0.1	0.1	-
Cuttlefish	-	-	-	0.7	1.0	-
Octopus	-	-	-	0.1	0.2	-
Morocco						
Cuttlefish	0.7	1.0	1.2	0.9	1.1	1.0
Arab Republic of Egypt						
Cuttlefish	0.9	1.1	1.1	-	-	-
Total	32.3	37.7	39.6	40.9	41.5	33.5

With the low productivity of Mediterranean waters and the already fairly high fishing intensity, it seems doubtful if the fishery potential is more than 100 000 tons.

Due to the low salinity of the Black Sea, few cephalopods enter even the surface waters and few statistics, if any, are available.

7.4 Region III - Northwest Atlantic

Total about 27 000 tons

The cephalopod fisheries of the Northwest Atlantic area are very underexploited and the fisheries are spotty. In the areas reporting the largest landings, eastern Canada and the eastern United States, the catch is mainly utilized as bait. In those areas where cephalopods are used for human consumption, the present catch is small and there are almost no separate cephalopod fisheries except in Mexico.

Table 6. Cephalopod landings Northwest Atlantic (in thousand metric tons)

	1964	1965	1966	1967	1968	1969
Canada	10.8	7.9	5.1	7.0	0.0	0.0
United States	1.0	1.2	1.2	1.8	1.7	1.7
Mexico, Squid	0.0	0.1	0.1	0.1	0.0	0.1
Octopus	0.3	0.8	1.1	1.6	1.9	2.2
Total	12.1	10.0	7.5	10.5	2.6	4.0

The figures in Table 6 do not include the Soviet and Japanese catch data reported later in this section. The production for this region is estimated using figures for "good" squid years in Newfoundland.

7.4.1 Newfoundland and eastern Canada

The statistics in Table 7 for eastern Canada, were provided by Mercer (personal communication).

Table 7. Landings of Illex illecebrosus in eastern Canada (in thousand pounds)

Year	Newfoundland	Nova Scotia	Quebec
1964	22 928	824	3
1965	17 199	379	0
1966	11 060	227	0
1967	15 222	256	0
1968	2	24	0
1969	48	NA	NA
1970	166	NA	NA
1971	3 513	NA	NA

The Newfoundland squid fishery is a very old one; its actual origin is unknown but probably squid were used as bait within a few years of the establishment of St. John's in the sixteenth century as a base for the Grand Bank cod-fishing fleet. Fresh squid were soon in high demand for bait. They are still used fresh locally. With the advent of freezer facilities, the squid bait supply was frozen and thawed for immediate use.

The Newfoundland squid fishery has been reviewed by Squires (1957, 1959) and Mercer (1970). The following account is abstracted mainly from these papers and personal studies of the fishery and fishing methods made by the writer in 1965 (Voss, 1967, 1971, and in preparation).

Until 1965, the squid fishery was mainly carried out by hand jigging, the traditional eastern Canadian method. The jig used was 3 inches-4 inches lead jig, oblong, with a single ring of barbless hooks at the lower end. Jigging was done from dories and launches in the principal squidding grounds of Conception and Trinity Bays but numerous other grounds (Placentia Bay, etc.) are distributed around the Avalon Peninsula. The depth of the grounds is not great and jigging was done at a depth of only a few fathoms, the squid often coming to the surface. Each fisherman operated several lines and the catch per man was a few hundred pounds per hour. Some fishermen used hookless spark plugs which the squid seized and were dipnetted when the lure reached the surface.

In 1965 a few Japanese hand-operated squid jigging reels were introduced into Newfoundland (Quigley, 1964). By this means a single fisherman could catch up to 22 000 lb per hour when jigging was good and hand jigging was almost universally abandoned except by boys. In that year also the Fisheries Research Board of Canada equipped an experimental squid vessel with a series of double-reel jigging machines with a power takeoff from the main engine. Large catches were obtained and it appeared that the fisheries would be revolutionized. Experimental lampara nets were also tried with some success.

Another method of squid fishing employed at that time was the use of larger buoyed and anchored net traps. Of the two in operation seen in 1965, one in Conception Bay and the other in Trinity Bay, only the latter was properly constructed and operated. It was hauled morning and evening with a large catch amounting to 14-40 000 lb per day (Voss, 1971).

The squid are landed at the fish company docks or trucked in from the smaller outports, washed once, frozen at 10°-20°F below zero in blocks of 20 kg each, packaged in cardboard containers and stored at -5° to -6°F. The freezer capacity in 1965 was about 15 000 tons but Mercer (personal communication) states that "storage facilities related directly to the squid industry have diminished over the past few years with the closing of some bait depots (e.g., the one at Recontre West where the settlement has been abandoned)".

The economics of the Newfoundland squid fishery are outmoded relative to other areas and are undoubtedly the cause of the lack of major development and increased freezer facilities in good years. The squid fishermen are paid only U.S. ½¢-2¢ per lb for their catch, the average being U.S. 1¢. On the other hand, nearly all the freezer stock is sold to the Portuguese, Spanish, Norwegian and Faroese handline cod-fishing fleet, the major portion going to the Portuguese. The sale is negotiated each year by fish company representatives who go to Portugal for direct bargaining. The prices paid by the Portuguese, etc., are a trade secret and no figures can be obtained from either end.

Feeble efforts to make some use of the catch available for human consumption have occasionally been made in the past. A fishery was conducted in the thirties at producing dried squid for export and, despite problems with the drying processes used, a trade with China was carried on for about 15 years but collapsed in 1946 and the fishery was abandoned. In 1965 one fish house prepared large frozen packs of squid and shipped them to England on a trial basis. Despite the demand for squid on the world market as food, Newfoundland processors do not look toward this market for several reasons: (1) they have an efficient syste operating at present with obviously a high margin of profit (2) as a food resource they would have to pay the fisherman more for his catch (3) quality control would have to be established (fresher delivery to the plant, four washes instead of one, etc.). It does not seem likely that the fisheries will be changed unless foreign interests develop.

A personal survey of the squid fishing centres in Nova Scotia and Quebec provinces in 1964 showed no major fishery for squid. The landings were small and most were for individual use. In Nova Scotia this was blamed on the availability of cheap bait in the form of redfish heads, etc., obtained by the barrel.

The sole species supporting the fishery is the common Newfoundland or "short-finned" squid, Illex illecebrosus. This species, or subspecies, ranges from the Bristol Channel and northern European waters to Iceland, Greenland, Labrador and Newfoundland southward along the eastern coast of the United States to Florida (Roper, Lu and Mangold, 1969). Little is known of the biology of the species (but see Squires, 1957 and 1966) although studies are now being conducted at Memorial University in St. John's by a number of differen investigators.

Nothing is known about spawning or spawning areas, eggs, larvae and early juveniles. It is presumed that spawning occurs in offshore waters perhaps off the New England states. Identifiable eggs have not been taken. It is presumed that the larvae have a Rhynchoteuthio stage similar to many ommastrephids but these have not been positively identified. The young squid feed on crustaceans, particularly euphausiids; older ones feed on the fish, capelin. Sexual dimorphism has been reported by Mangold, Lu and Aldrich (1969).

Parasites and predators and growth, etc., have been described by Squires (1957 and 1966). The first appearance of Illex in Newfoundland is June; average mantle length in June is about 16 cm. The animals grow rapidly and in October the males average 23 cm while the females are about 25 cm. In late October and November the larger animals, approaching sexual maturity, begin to disappear from inshore waters. Because of the small size range in the monthly samples the populations appear to be homogenous and to represent an annual crop.

Illex shows a distinct seasonal migration. They are first encountered as early as May on the southwestern, southern and eastern edges of the Grand Bank. In June they reach Holyrood in Conception Bay. By August they may have reached northern Newfoundland and later reach the Labrador coast. During most of this time they occur in vast schools offshore and appear to migrate shoreward, even to stranding on the beaches, in pursuit of the capelin (Mallotus) which it eats as adults. During times of abundance they are found all along the coast but in greatest quantities at the major jigging grounds. Migration studies have been attempted by tagging programmes but these ceased when the fisheries failed in 1968. Attempts have been made by the Fisheries Research Board of Canada to provide a means of predicting the catch several months in advance by experimental trawling on the Grand Bank (Squires, 1959; Mercer, 1966). Small catches on the Grand Bank indicate small catches in coastal waters later in the season (Squires, 1957). Unfortunately nothing is known about the species after they leave Newfoundland inshore waters. As the major predator upon them is the pot-head or pilot whale Globicephala melaena, which apparently feeds almost exclusively on Illex, it may be possible to determine the migrations of the squid by plotting the seasonal changes in concentrations of the pilot whales.

The landings of Illex in Newfoundland show a distinct cyclic pattern, with near or partial failures of the stock at intervals (Figure 4). The most drastic of these occurred in 1968, effectually bringing to an end experiments in fishing methods, tagging, population analysis, etc. These failures probably reflect hydrographic or climatic conditions causing a failure in spawning or survival of eggs and larvae rather than to overfishing which is certainly not the case. The U.S.S.R. was actively fishing the Newfoundland stocks (Nesis, 1967 and personal communication) until the 1968 failure. The stocks are now on the increase.

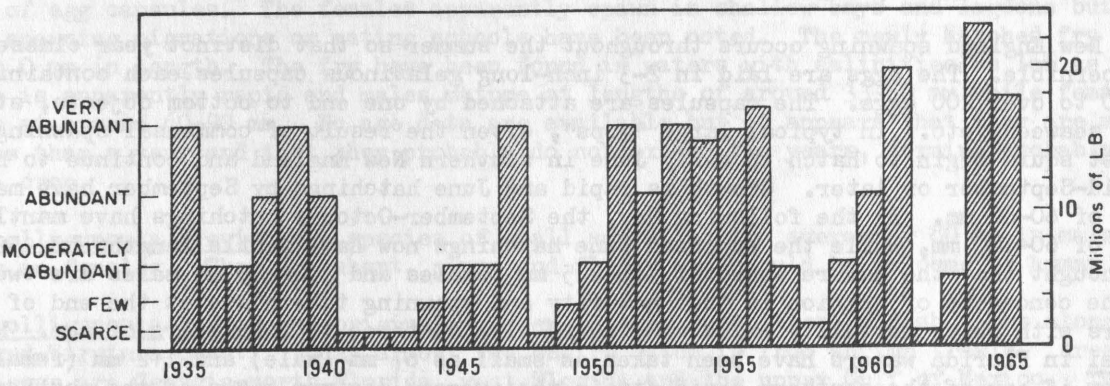

Figure 4. Relative abundance of squid in Newfoundland coastal waters, 1935-65. Information for 1935-53 from Squires (1957), for 1954-63 from Hodder (1964), and for 1964-65 from reports of the Department of Fisheries of Canada.

In predicting the Illex potential production in the Newfoundland area, Mercer (1970) states: "recent annual landings at Newfoundland have ranged from nil to 10 500 metric tons, most of which is exported to Norway and Portugal for use as cod bait. In years of abundance the resource inshore is enormous. At an average weight of 830 kg (Sergeant, 1962) and a feeding rate of 4°-6% body weight per day (extrapolated from congeners, data from Sergeant, 1969) the 10 000 pilot whales (Globicephala melaena) taken on the east coast of Newfoundland

in 1956 alone would eat approximately 33 000–55 000 metric tons in a 100-day season. (This odontocoete feeds almost exclusively on Illex in Newfoundland inshore waters - Sergeant, 1962). This is four to five times as great as the largest squid catch in one season from all of Newfoundland, indicating that fishing mortality is a small percentage of total mortality for squid in this area". Mercer (personal communication) states: "It may be fairly realistic to guess that in years of abundance we could increase our inshore landings several times, perhaps to 50 000 metric tons". Gulland (1970) has suggested that the potential catch is likely to be a fairly high proportion of the probably large standing stock - maybe of the order of hundreds of thousands of tons. To this, the present writer agrees.

7.4.2 Eastern United States and Gulf of Mexico

Landings along the eastern and Gulf coasts of the United States are small and incidental to scale-fish and shrimp bottom trawling and are mostly composed of Loligo pealei and Lolliguncula brevis. North of Cape Cod Illex illecebrosus is found along the Maine and Massachusetts coast. The U.S. fishery for Illex is small and inconsequential.

Loligo pealei, the "common" squid of the eastern United States, is distributed from Cape Cod southward to Florida and the Gulf of Mexico, and possibly into the Caribbean Sea. It is a neritic species occurring in normal salinity bays and coastal waters outward to the edge of the continental shelf. It is of insignificant value in the U.S. fisheries as there is little or no market for squid in the area. Thus there have never been studies undertaken on the fisheries or its biology from an economic point of view. Its major importance has been in medical studies where the giant dorsal axons are used in biophysical studies on nervous systems.

Biological studies have covered a wide field of interest: embryology (Arnold, 1965), larval development (Verrill, 1882; Voss, 1967), mating (Arnold, 1962; Drew, 1911), spawning (Drew, 1911; Verrill, 1882), age and growth (Verrill, 1882; LaRoe, MS; Summers, 1968), migrations (Verrill, 1882; Summers, 1967, 1969), exploratory fishing (Summers, 1967; Mercer, 1970a; Vovk, 1969), and early history of the fisheries. Most of the work done on L. pealei has been in northern waters, primarily Massachusetts and little is known of its biology in the southern end of its range (LaRoe, MS).

In New England spawning occurs throughout the summer so that distinct year classes are not discernible. The eggs are laid in 2-3 inch-long gelatinous capsules each containing from about 20 to over 200 eggs. The capsules are attached by one end to bottom objects, stones, shells, seaweed, etc., in typical large "mops", often the result of commensal spawning. The first squid begin to hatch in early June in southern New England and continue to hatch until mid-September or later. Growth is rapid and June hatchings by September have mantle lengths of 60–80 mm. By the following May, the September–October hatchings have mantle lengths of 60–100 mm, while the supposed June hatchings now have mantle lengths of 150–190 mm. It is thought that the mature squid of 175–225 mm females and 200–275 mm males are two years old. The concensus of opinion is that maturity and spawning take place at the end of one to two years with heavy mortality while some squid live to three to four years of age. Mature L. pealei in Florida waters have been taken as small as 67 mm (male) and 112 mm (female) while few if any of the southern squid attain the average maximum sizes of the northern populations. Mating and spawning take place in typical large schools in inshore waters during the summer. In the autumn, winter and early spring the squid congregate along the edge of the outer shelf or deeper (Summers, 1969; Vovk, 1969; Mercer, 1969, 1970).

In the early years of the fishery and until the second world war, most of the squid catch was obtained from coastal weirs from Provincetown, Massachusetts, to the Carolinas. Occasionally the catch was quite large but there was little or no market and the catch was used as bait or for fertilizer. In the early forties the weirs began to go into decline and the fishery is now mainly based on bottom trawling with otter trawls and is incidental to the scale-fish and shrimp fishery. Recent exploratory fishing by the U.S.A. (Summers, 1969), Canada (Mercer, 1969), the U.S.S.R. (Vovk, 1969) and the Japanese (Anon., 1970) have shown that the major concentrations of L. pealei are in the area from Cape Cod to Cape Hatteras

and in the winter are concentrated just below the edge of the shelf in the mid-Atlantic Bight where they are amenable to the trawl fishery. Summers estimated late winter abundances here as 3.4 and 2.1 x 10^6 kg respectively for 1967 and 1968. Sampling was done just prior to the spawning season and thus the estimates are minimal figures. The U.S.S.R. began fishing the area in the fifties. An analysis by Vovk (1969) of 3 420 trawls distributed from the Georges Bank to Cape Hatteras made between 1958-68 showed largest catches in June-November northeast of the Blake Canyon. "Catch per hour averaged 0.5 to 1 metric ton and ranged to 6 tons on the southern slopes of Georges Bank. Catches of 25 tons were made in 60-100 m off Wilmington, Delaware, and Baltimore, Maryland, abundance in a 30-mi^2 area off Wilmington being estimated at 6-7 000 tons". (Mercer, 1970).

Japan entered the eastern U.S. squid fishery in December 1969, when 14 vessels commenced squid trawling off New York. Because of decreasing catches, the number of vessels dropped to six in April when landings to that time were estimated at 13 000 metric tons. The catch was sold in Europe, primarily to Spain (Anon., 1970). The latter country planned to fish the area during the 1970-71 season.

The U.S. fisheries produced only about 1 700 metric tons in 1969 valued at around U.S.$ 220 000. Part of this catch came from the southern region including the Gulf of Mexico where another species, the thumbstall squid, Lolliguncula brevis, enters into the catch.

The thumbstall squid, Lolliguncula brevis, is a continental species of warm temperate and tropical distribution. It occurs from the Maryland-Delaware coast through the Gulf of Mexico to the Caribbean Sea and South America, its southern limit being about the southern border of Brazil. It does not occur in the Caribbean islands as it is associated with estuarine conditions, ranging into waters with salinities as low as 17°/oo (Voss, 1956). Its biology and morphology have been described by LaRoe (general, MS); Dillon and Dial (1962), morphology; Dragovich and Kelly (1962), biology and economics; Hafner (1964) morphometry; and Voss (1956, 1960 and 1971), systematics, distribution and fisheries.

In Florida (LaRoe, in MS) the species appears to spawn all year round, with a peak during January through April and again July and August. There is only one report (Moore, 1961) of egg capsules. The females apparently spawn in shallow bays and lagoons but no major spawning migrations or mating schools have been noted. The newly hatched fry are less than 3.0 mm in length. The fry have been found in waters with salinities as low as 19°/oo. Growth is apparently rapid and males mature at lengths of around 33-50 mm while females mature at around 60-90 mm. No age data are available but it appears that they are mature in less than a year and that they probably do not exceed two years, forming probably an annual crop.

Lolliguncula brevis is a species of small squid, adults averaging 80 mm in males and 100 mm in females. They are short, plump and fleshy and should be welcome as human food.

Lolliguncula brevis was originally taken in some quantities in fish weirs along the Maryland-Virginia coast. Today almost the entire catch is from shrimp trawls. Areas of prevalence are Georgia-north Florida, west Florida and the upper Gulf of Mexico. There are no estimates of catch or availability as most landings are grouped under squid (Loligo pealei) and are not separated. There is, however, a growing interest in the squid catch in the Gulf of Mexico and the potentials are present for a moderate-size fishery.

Cuban studies of the stomach contents of the yellowfin tuna (Thunnus albacares) revealed that the basis for their food was Loligo pealei and L. spp. including octopus (? Argonauta). Considering the size of the tuna stock and the rate of feeding, the abundance of squid in the Gulf must be very high (Juan A. Varea Rivero, Instituto Nacional de la Pesca, Cuba, personal communication).

A fairly significant squid catch is made in the Gulf of Mexico by shrimp boats. Some studies and experiments are now in progress in the area toward developing this as a food resource.

7.4.3 Mexico

The Mexican cephalopod fishery on the east coast is mainly carried out in the Gulf of Campeche, and is based on the single species (Octopus maya). The catch of this species in 1960 and 1961 was approximately half of the total octopus catch of Mexico (Solís, 1967) 255 and 235 metric tons respectively. Other fisheries are in Veracruz and squid, Doryteuthis plei, are caught in small numbers all along the coast incidental to the shrimp fishery.

The major fishery is for Octopus maya, until 1966 listed in publications on the Campeche fisheries as O. vulgaris. The biology and fisheries for this species have been described by Solís (1962, 1966, 1967, 1967a, b), its systematics and distribution by Voss and Solís (1966), and fisheries by Voss (1971).

O. maya spawns in the winter months in shallow water, depositing large eggs in festoons in holes and rock crannies or empty shells in clutches of 1 500–2 000 eggs. The young octopus hatch out in about 50–65 days. Growth rates and age at maturity have not been determined with certainty; although individuals attain a weight of several kilogrammes they probably do not live more than one to two years. The animals feed on crustaceans such as the stone crab, Menippe mercenaria, various bivalve molluscs and fish. Predators upon them are various species of small bottom fish that eat the eggs and newly hatched young and grouper and mackerel that feed upon the juveniles.

The major fisheries are located at Campeche, Champotón and Ceibaplaya, state of Campeche and Veracruz. The animals are fished for primarily in June through December with the peak fishing being in August through October. In Campeche most of the octopus fishing is done by drift-fishing. In this (Solís, 1967b) the boat is rigged to drift off broadside to the wind and 25–35 nylon or cotton lines are trailed out. Each is baited with a crab (Menippe mercenaria, Callinectes ornatus or Libinia) and weighted to fish the bottom. When a line becomes tight, it is hauled in, the octopus seized and killed by stabbing it in the brain between the eyes. Crabs of about 100 g weight are used and the supply often becomes depleted. Brightly coloured artificial lures (señuelos) shaped like the American lobster (Homarus americanus) have been used. The centre part of the back is filled with sponge rubber and this is saturated with fish oil. The lure is used in the same fashion as the natural bait. A variation of this method is to fish in the same fashion but to have five or more empty shells of Strombus gigas on each line. These, when dragged over the bottom, are seized by the octopus and it is hauled aboard. Around the port of Veracruz where the fishery was initiated by the Italians, the Mediterranean "nummarellas" or earthenware pots are used in this method; strings of pots are set out and the female octopus seeks them as refuge and for laying eggs. The method is very successful and permits fishing in times of the year when the animals are living in deeper water. Hooking and spearing are also used in shallow water. In 1971 some experimental trawling was undertaken in the Gulf of Campeche but the results have not been disclosed.

Statistics on the fisheries for octopus were begun in 1955. The landings have been increasing rather regularly since that date. In 1967 the catch for Veracruz and Campeche combined amounted to 1 617 metric tons with a value of U.S.$ 300 000. The catch is shipped to Mexico City and elsewhere. About 50–60 percent is frozen, 20 percent fresh and 20 percent canned. The fisherman receives about U.S. 10¢ per kg for which the housewife pays about U.S. 40¢ per kg. In recent years octopus has been shipped to the United States but has had difficulty competing with the Portuguese and Spanish imports. Octopus maya is seasonally available in markets in Miami.

In addition to this fishery there is a small catch of the loliginid squid (arrow squid) Doryteuthis plei in Campeche. The fishery is small, carried out from small boats at night with gas lanterns hung over the side. Lines are put over baited with half-beaks (Hemiramphus). When a squid seizes the bait it is drawn up to the surface and dipped with a handnet. The catch is very small and the price low. Loligo pealei, Lolliguncula brevis and Doryteuthis plei are also caught, sometimes in considerable numbers in shrimp trawls.

Further out on the Campeche Bank considerable quantities of squid occur. Cuban and Soviet trawlers have taken up to five to seven tons of squid per hour of trawling (Juan A. Varea Rivero, personal communication) on the bank but their distribution through the year is irregular.

7.5 Region IV - Caribbean and northern South America

Total about 900 tons

The status of the cephalopod fishery and estimates of production were reviewed by Voss (1960, 1971) and most of the information given here is from those papers supplemented by additional data from the literature, personal correspondence and recent personal surveys of various island fisheries. Information about the fisheries is particularly difficult to obtain because in many areas octopus and squid are taken locally in small quantities by the shore dwellers or in small quantities incidental to other fisheries and specimens never reach the local market where they could be seen by the fisheries officer. In some areas, for instance, octopus are taken in considerable quantities yet because they are not "landed" they are not listed in the yearly fisheries statistics. Fisheries of this kind are particularly difficult to judge.

Six species of squid are locally abundant and widely distributed throughout the area. These are the loliginids - Loligo pealei, Doryteuthis plei, Sepioteuthis sepioidea, Lolliguncula brevis (mainland coast); and the ommastrephids - Illex coindetii and Ommastrephes pteropus. Illex illecebrosus illecebrosus was formerly thought to be in the region but Roper, Lu and Mangold (1969) have shown that the Illex in the Caribbean is the same species as that of the eastern Atlantic.

At least four species of octopus - Octopus vulgaris, O. briareus, O. macropus and O. maya - are caught for food and sold in the markets; a few other species may be found incidentally. The distribution of all ten commercial species and the major fishing areas are shown in Voss, 1971. The catch of both squid and octopus will be discussed below by island and country.

7.5.1 Cuba

50+ tons

All four species of octopus and six species of squid are found in Cuban waters. However, the fisheries are small and most of the catch is not reported. The octopus are caught in fish traps or hooked out of their lairs using a short pole and a water glass or a few drops of oil to smooth the sea surface. No figures are given for the catch but in 1959 fresh octopus brought U.S. 80¢/kg in the market. The entire coastline produces octopus but the principal fishing areas are in the vicinity of the major towns and cities. Squid are caught incidental to bottom trawling. Figures for the squid catch from 1961-66 were furnished by Juan A. Varea Rivero (personal communication).

Catch of loliginids by Cuban vessels (in metric tons)

1961	1962	1963	1964	1965	1966
10	35	54	183	35	34

Much of the catch comes from the south coast of Cuba in the Gulf of Batabanó region but additional tonnage comes from the Gulf of Campeche and even more distant grounds. With the greatly increased fishing activities in Cuba and the formation of a large trawler fleet it is to be supposed that the annual catch has been greatly augmented.

7.5.2 Hispaniola

37 tons

No data are available from Haiti. There is a considerable fishery for octopus in the Dominican Republic. In 1967 the catch amounted to 11 tons with a value of U.S.$ 8 818. The catch is sold fresh immediately after capture. The whole coast is fished using traps or hand gear. The fisherman receives about U.S. 75¢/kg. The squid catch amounted to 26 tons in 1967 valued at U.S.$ 40 000. The squid are caught with dipnets and lights. The price to the fishermen is about U.S.$ 1.50/kg.

7.5.3 Puerto Rico

8 tons

In 1968 the island of Puerto Rico established a fisheries statistics programme. Only octopus are listed as squid are rarely taken. The major octopus is O. vulgaris. In 1969 the catch was 6 416 kg; in 1970 it was 7 307 kg (Table 8). The price to the fisherman was U.S.$ 128 per kg average. The fishery is spread all around the coast but largest catches are on the south coast. The greatest production is from October through March with production falling sharply during the summer. The large winter catch is made when the females come into shoaler water to spawn.

Table 8. Puerto Rican octopus catch by month for 1970 (in kilogrammes)[a/]

Month	North coast	South coast	East coast	West coast	Total	U.S.¢/kg
January	139	335	251	305	103	1.17
February	203	197	161	348	910	1.21
March	204	137	106	184	631	1.41
April	102	113	35	73	323	1.41
May	-	42	14	70	125	1.23
June	15	59	24	16	115	1.06
July	-	27	35	32	94	1.32
August	17	263	89	-	371	1.32
September	-	-	-	-	-	-
October	127	529	318	39	1 012	1.19
November	225	1 228	236	89	1 779	1.08
December	184	427	272	35	918	1.43
Total	1 307	3 358	1 539	1 191	7 307	

a/ Boletín informativo, División de pesca y vida silvestre, Departamento de Agricultura

According to Erdman (personal communication), by July the small octopus weigh about .15-.25 kg but by October over .50 kg and by February, 1 kg or better. The animals are caught thrusting a crawfish grain or 2-tine spear into the hole, giving it a quick twist, and usually an octopus is brought out. In larger holes on the north coast a 1 m iron rod is used with a barbless hook at the end. At La Parguera in 1959 there were about six part-time octopus fishermen who each make about U.S.$ 1 000 per year or half the average income of a Puerto Rican fisherman.

7.5.4 St. Lucia

10 tons

The octopus catch is negligible amounting to about 5 tons valued at U.S.$ 500. They are caught in other fisheries and most are used for bait. There are no figures for the squid landings but with a value of U.S.$ 500 per year, the catch must about equal that for octopus. Most of it is used for bait.

7.5.5 Honduras

There is no octopus fishery. According to Leach (personal communication) there is a small squid fishery, probably for Doryteuthis plei on the shelf in about 40 m from Punta Patuca to the Nicaraguan border. The catch is incidental to the shrimp fishery and runs about 67 000 kg annually with a value of U.S.$ 29 000. The price paid to the fisherman is U.S. 44¢ per kg. The catch is frozen and exported to the United States.

7.5.6 Colombia

About 5 tons

Squid L. brevis, L. pealei and D. plei are caught incidental to the shrimp fishery in the Caribbean and are frozen in 5-lb blocks for export mostly to Spain or for use in inland cities. Fishermen are paid about U.S. 20¢ per kg at Cartagena and about U.S. 40¢ per kg at Santa Marta.

7.5.7 Venezuela

672.5 tons

There are small fisheries for both octopus and squid. The total cephalopod catch is shown in Table 9.

Table 9. Cephalopod catch of Venezuela (in metric tons)[a/]

	1967	1968	1969
Octopus "pulpo"	9.2	?	100
Squid "calamaro, lurias"	663.2	300	500

a/ 1967 data from personal questionnaire, 1968-69 from FAO

The octopus catch is mainly from the central zone (Higuerote to Puerto Cabello) and the eastern zone (Higuerote to Güiria). The value at the wharf is U.S.$ 1.85 per kg for which the housewife pays 2.5 times more. The catch is sold fresh and canned. The squid are taken mainly from the Gulf of Venezuela in the shrimp fishery. In 1967 it had a value of U.S.$ 300 000. The catch is sold fresh or canned mainly in the Caracas-Valencia area. The canned squid and octopus are produced by the canneries at Cumaná. The cephalopods are eaten mainly by newly arrived immigrants from Spain.

7.5.8 French Guiana

50 tons

No octopus are caught. It is estimated that about 50 tons of squid are caught annually but only about 4 tons are landed; the rest are thrown overboard with the trash fish.

7.5.9 Others

Bahamas, Barbados, Turks and Caicos, Jamaica, Virgin Island, Antigua, Montserrat, Guadeloupe, Domenica, St. Vincent, Grenada, Trinidad and Tobago, Netherlands Antilles, Mexico (Caribbean), British Honduras, Guatemala, Nicaragua, Costa Rica, Panama, Colombia (Caribbean), Guyana, Surinam - No significant fisheries.

Based on these somewhat unreliable figures, the total cephalopod catch recorded for the Caribbean and adjacent areas in 1967 was approximately 900 metric tons, an insignificant figure considering the total fisheries yield of the area. On the other hand, for those countries where figures are available, 346 tons of canned cephalopods, primarily squid, are imported annually at a cost of about U.S.$ 258 917.

A survey of the data given above shows that even where no true fishery exists, the price paid for octopus and squid is relatively high (U.S. 20¢-U.S.$ 1.80 per kg) and upsets the often given statement that there is no demand.

7.5.10 Potentials of the fishery

In order for either the octopus or squid fisheries to develop their maximum potential, it is necessary to develop a suitable market. While it has been shown that practically no local market presently exists in some of the countries surveyed, we have the interesting and contradictory situation that octopus and squid in some of these areas bring a higher price on the local market than do many other seafoods. Undoubtedly, a more consistent supply of this resource would open a larger market, but it is also necessary to sell the idea of eating these animals to the general public.

Besides the local market, an export market can certainly be developed. There is a large demand for these animals in the Orient and in other parts of Latin America. Companies in Argentina and Chile are now processing these animals and producing a fairly acceptable canned product which, however, is still not as acceptable as the Spanish or Portuguese product. Although no one has yet surveyed, to my knowledge, the market value of the dried squid and octopus imported from Hong Kong to the United States and other areas with large Chinese and Japanese populations, the total must be high. It is mainly dried, a method easily suitable in many Caribbean areas, and brings a high price, averaging about U.S.$ 2.50-3.00 per kg in the store. Various attempts have been made to produce a quality dried squid product in California and Newfoundland, with considerable success in the former and dried octopus was formerly exported to the Orient (Philippines) from the United States.

The potential of the fishery itself is difficult to determine. Observers repeatedly report large concentrations of squid throughout the Caribbean, and several fisheries officers have considered that the stocks were sufficient to consider an export-oriented fishery. The loliginid squids in particular are found almost throughout the entire region and in areas school in large quantities. Unfortunately at the present time reliable figures as to distribution, numbers, places of concentration and seasonal abundance are almost completely lacking.

Studies of the biology of several species (Sepioteuthis sepioidea, Lolliguncula brevis) indicate that these two species at least have a very short growing period, reaching maturity in about six months. Their life span is probably not much more than one or two years. Loligo pealei is presumed to live for two to three years on the average. Most of them are highly prolific. On the other loliginids we have little information.

Illex coindetii, the arrow squid, in the Caribbean lives at depths of 180-450 m. Fishing for these does not seem practicable with present gear unless it can be shown that they come into shallow water on seasonal runs. No information is available on this. These squid are very numerous.

Ommastrephes pteropus is a heavy squid. It is found offshore over the outer part of the continental slope. It occurs in great quantities and appears at the surface at almost

every open ocean station within a few minutes of the turning on of an outboard light. They seem to be almost inexhaustible in number and could easily support a large fishery.

Bullis from the research ship OREGON and scientists aboard the PILLSBURY both in the Gulf of Mexico and in the Caribbean Sea have on occasions reported sighting vast schools of squid on the surface at night. In addition, it is known that around the Lesser Antilles, both large and small species of toothed whales concentrate seasonally. As their diet to a large degree consists of squid, it must be presumed that these areas support large stocks of the latter. No direct observations have been made.

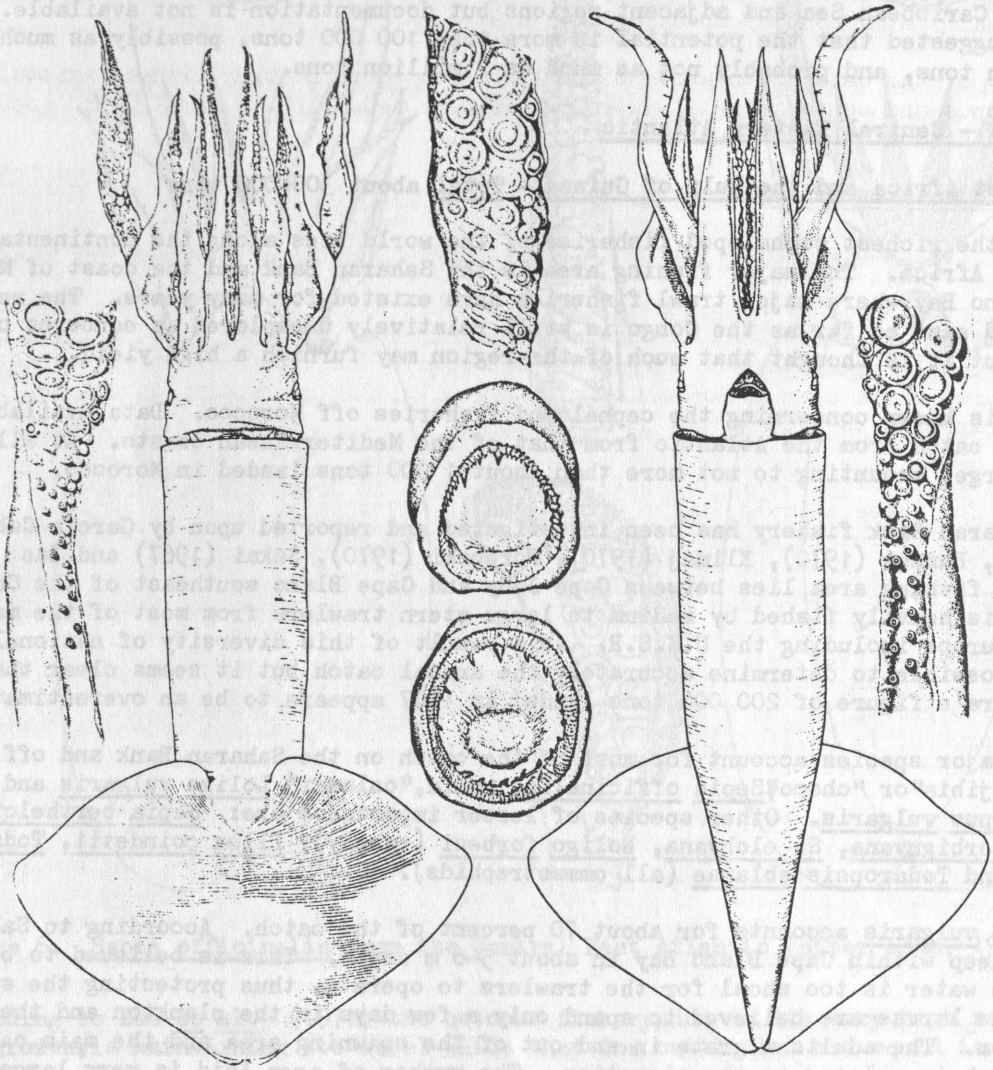

Figure 5. Ommastrephes pteropus (after Adam, 1952)

The octopus potential is very large. Octopus of several species are commonly found throughout the area both in shallow water and at greater depths. Octopus in general throughout the Gulf and Caribbean come inshore in the autumn and winter months to feed and to spawn and hatch their eggs. The major fishing period for these species is from October through December with the peak period occurring in November. By April most of the octopus have returned to deeper waters beyond the reach of the presently used gear.

I know of no assessments of the standing stock of octopus in any area. However, the evidence points to large populations. These animals have a short life span, generally not considered to extend past the spawning period but this is based upon aquarium studies and may not hold true in the wild. At all events, the life span probably does not usually exceed one to two years. Most of the possible commercial species lay large numbers of eggs, from a few hundred to 150 000 (Octopus vulgaris). The limit to the populations does not appear to be food but living space. Evidence of their abundance under favourable circumstances is shown in the periodic great octopus invasions of the British coast (Rees and Lumby, 1954) and privately reported occurrences of similar invasions in the upper Gulf of Mexico.

In summary, there can be little doubt that vast potential stocks of octopus and squid occur in the Caribbean Sea and adjacent regions but documentation is not available. Gulland (1970) has suggested that the potential is more than 100 000 tons, possibly as much as 0.5–1 million tons, and probably not as much as 2 million tons.

7.6 Region V - Central Eastern Atlantic

Northwest Africa and the Gulf of Guinea - Total about 300 000 tons

One of the richest cephalopod fisheries of the world lies along the continental shelf of northwest Africa. The major fishing area is the Saharan Bank and the coast of Mauritania off Cape Blanc Bay where major trawl fisheries have existed for many years. The region to the south and east as far as the Congo is still relatively unexplored as concerns cephalopod potentials but it is thought that much of the region may furnish a high yield.

Little is known concerning the cephalopod fisheries off Morocco. Data available do not separate the catch from the Atlantic from that of the Mediterranean coasts. At all events, it is not large, amounting to not more than about 1 000 tons landed in Morocco.

The Saharan Bank fishery has been investigated and reported upon by García Cabrera (1968, 1970), Bonnet (1970), Klimaj (1970), Porebski (1970), Sakai (1967) and Bas et al., (1971). The fishing area lies between Cape Juby and Cape Blanc southeast of the Canary Islands and is heavily fished by medium to large stern trawlers from most of the maritime nations of Europe including the U.S.S.R. As a result of this diversity of nationalities, it has been impossible to determine accurately the annual catch but it seems clear that García Cabrera's figure of 200 000 tons landed in 1967 appears to be an overestimate.

Three major species account for most of the catch on the Saharan Bank and off Mauritania: cuttlefish,"jibia"or "choco",Sepia officinalis, squid,"calamar", Loligo vulgaris and octopus, "pulpo",Octopus vulgaris. Other species of lesser importance are: Sepia bertheloti, S. elegans, S. orbignyana, S. elobyana, Loligo forbesi (rarely), Illex coindetii, Todarodes sagittatus and Todaropsis eblanae (all ommastrephids).

Octopus vulgaris accounts for about 70 percent of the catch. According to Sakai (1967) they spawn deep within Cape Blanc Bay in about 5–6 m depth. This is believed to be a safeguard as the water is too shoal for the trawlers to operate, thus protecting the spawning grounds. The larvae are believed to spend only a few days in the plankton and then to settle to the bottom. The adults migrate in and out of the spawning area and the main catch in December–March is related to the migration. The number of eggs laid is very large and the life span is only one to two years or one spawning period. It has been stated that it is this high fertility and short life span that have kept the fishery at a high level despite intensive fishing (Bas et al., 1971).

The fishery in or near Cape Blanc Bay was reportedly discovered in 1965 by a Japanese trawler of the Taiyo Gyogyo K. K. fleet in waters only 8–25 m deep. The catch was large and doubled in that year.

The Spanish trawl for the Saharan Bank has a footrope of 68 m length. In trawling for octopus the Japanese attach chains known as "octopus-lifters" to the footrope. Normally they

make nine drags per day but during the height of the octopus season the fishing rate may rise to as many as 14 drags daily. Cuttlefish are caught more abundantly in daytime while octopus fishing is best at daybreak and just after sunset (Sakai, 1967).

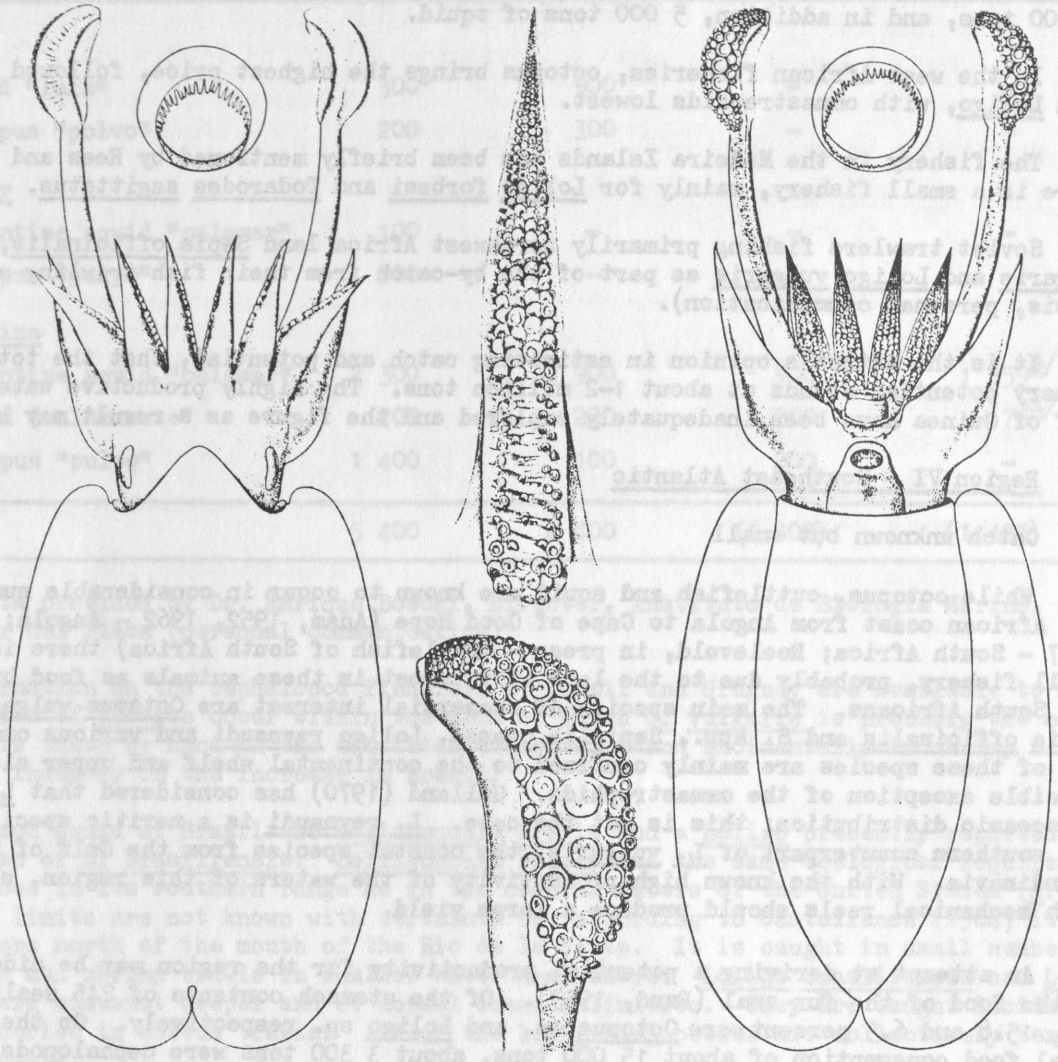

Figure 6. Sepia officinalis from the Central East Atlantic (after Adam, 1952)

According to Bas et al. (1971) the octopus fishery, due to its very high replacement and fast growth, is maintaining its level while that for cuttlefish and squid is decreasing slightly.

The fishery was unrecognized until about 1960 when the catch began to increase rapidly. The reasons may be found in the overfishing for scale fish and the resultant removal of predators of octopod larvae, juveniles and adults. Trash fish thrown overboard from the trawlers may also have enriched the bottoms and the cephalopods have replaced the scale fish at the top of the food chain.

At the present time most of the cephalopod catch from Canary Island trawlers is sold to Spanish and Japanese freezer ships permanently stationed at Las Palmas and Santa Cruz de Teneriffe outside the harbours. In addition, the Japanese have their own trawler fleets in the area.

Further southward into the Gulf of Guinea the cephalopod fishery is just beginning. Japanese squid vessels are now fishing the Gulf of Guinea but catch statistics are not available. In 1969 Japan took 52 213 tons of octopods and 40 825 tons of cuttlefish from west Africa, all areas (Okutani, personal communication), but these figures are not in complete agreement with other Japanese data which suggest the figure for cuttlefish is about 25 000 tons, and in addition, 5 000 tons of squid.

In the west African fisheries, octopus brings the highest price, followed by cuttlefish, then Loligo, with ommastrephids lowest.

The fishery in the Madeira Islands has been briefly mentioned by Rees and Maul (1956). There is a small fishery, mainly for Loligo forbesi and Todarodes sagittatus.

Soviet trawlers fishing primarily northwest Africa land Sepia officinalis, Octopus vulgaris and Loligo vulgaris as part of the by-catch from their fish trawling activities (Nesis, personal communication).

It is the author's opinion in estimating catch and potential, that the total cephalopod fishery potential stands at about 1-2 million tons. The highly productive waters of the Gulf of Guinea have been inadequately explored and the figure as a result may be higher.

7.7 Region VI - Southeast Atlantic

Catch unknown but small

While octopus, cuttlefish and squid are known to occur in considerable numbers along the African coast from Angola to Cape of Good Hope (Adam, 1952, 1962 - Angola; Voss, 1962, 1967 - South Africa; Roeleveld, in press - cuttlefish of South Africa) there is only a very small fishery, probably due to the lack of interest in these animals as food by the Angolese and South Africans. The main species of commercial interest are Octopus vulgaris and O. spp., Sepia officinalis and S. spp., Sepiella cyanea, Loligo reynaudi and various ommastrephids. All of these species are mainly confined to the continental shelf and upper slope with the possible exception of the ommastrephids. Gulland (1970) has considered that L. reynaudi has an oceanic distribution; this is not the case. L. reynaudi is a neritic species and may be the southern counterpart of L. vulgaris, the coastal species from the Gulf of Guinea to Scandinavia. With the known high productivity of the waters of this region, squid jigging with mechanical reels should produce a large yield.

An attempt at deriving a potential productivity for the region may be aided by looking at the food of the fur seal (Rand, 1959). Of the stomach contents of 245 seals killed at sea, 15.8 and 6.5 percent were Octopus sp. and Loligo sp. respectively. On the basis of the total food consumption of about 15 000 tons, about 3 300 tons were cephalopods. Gulland (loc. cit.) has suggested that the cephalopod potential productivity is in the magnitude of several hundreds of thousands of tons. This figure seems reasonable.

7.8 Region VII - Southwest Atlantic

Northern Brazil to Cape Horn - Total about 5 400 tons

This region has a long and varied coastline with extensive shelf areas. It varies from coralline bottom in the tropics to mud and sand covered with iceberg-deposited boulders in the south. In the vicinity of the mouth of the Amazon and the Rio de la Plata salinities are low and as a consequence in these areas cephalopods are excluded with the exception of the low salinity-associated thumbstall squid, Lolliguncula brevis, off the Amazon.

The FAO listed landings for the entire area are given in Table 10.

Table 10. Cephalopod landings from eastern South America (in metric tons)

	1967	1968	1969	1970
Brazil				
Squid "lula"	300	900	-	-
Octopus "polvo"	200	300	-	-
Uruguay				
Argentine squid "calamar"	100	-	-	-
Octopus "pulpo"	900	-	-	-
Argentina				
Argentine squid "calamar"	2 300	2 900	900	1 259[a]
Squid "calamarete"	200	200	200	176[a]
Octopus "pulpo"	1 400	100	200	-
Total	5 400	4 400	(1 300)	(1 435)

a/ Data provided by Dr. Enrique Boschi, Director, Instituto de Biología Marina, Mar del Plata (personal communication)

No information on the cephalopod fisheries of Brazil and Uruguay are available to me. Several species of Octopus occur within the area of which O. vulgaris is probably the most common. It is taken by hand in the subsistence fisheries and incidentally in shrimp trawling, an industry on the increase in Brazil.

The common squid of Brazil are Lolliguncula brevis and a Loligo presently reported under the name of L. brasiliensis. Lolliguncula brevis has the same ecological requirements and preferences in its southern range as in the coastal waters of the United States (q.v.). Its southern limits are not known with certainty but according to Castellanos (1964) it stops somewhere north of the mouth of the Rio de la Plata. It is caught in small numbers in scale-fish and shrimp trawls in shallow water near shore. Loligo brasiliensis and L. sp. occur in waters somewhat deeper and of normal ocean salinities. They are caught incidental to other fisheries in bottom trawls. All of the loliginid species are collectively termed "lulas" in Brazil.

A brief review of the Argentine squid fishery has been given by Castellanos (1964). She divided the Argentine grounds into three areas: Argentine, Magellanic and Antarctic and listed the supposed species of economic importance.

Argentine:

Loligo brasiliensis (very common) xx
Lolliguncula brevis (less common)
Rossia tenera (less common)
Onychoteuthis banksi (limited)
Pterygioteuthis giardi (limited)
Illex illecebrosus argentinus (very common) xx

Magellanic:

Loligo patagonicus (less common) x
Loligo ellipsura (less common) x
Rossia tenera (common) x
Onychoteuthis banksi (limited)
Pterygioteuthis giardi (limited)
Moroteuthis ingens (limited)
Illex illecebrosus argentinus (common) xx

Antarctic:

Rossia tenera (less common)
Moroteuthis ingens (limited)
Alluroteuthis antarcticus (limited)
Bathyteuthis abyssicola (rare)
Hansenioteuthis antarctica (rare)
Galiteuthis suhmi (rare)
Architeuthis sp. (rare)

It is difficult to evaluate Castellanos' estimates of economic potential or actual use. Those marked xx are the only ones that appear to actually be fished. Those marked x may occur in commercial quantities but no data are available. All of the others are open-ocean pelagic species, some of quite small size, and do not appear to offer any potential unless occurring in very large numbers for which there is no evidence at present. She has also defined the Spanish names "calamarete" for species of loliginids, "calamar" for Illex and "calamarcito" for Semirossia tenera, a species of small sepiolid.

The loliginid squid "calamarete de Brasil", Loligo brasiliensis, is a coastal species and is fished from the Mar del Plata in the north to Rawson in the south, the first mentioned area being the primary fishing ground. It is occasionally fished for specifically but is usually taken incidental to the shrimp and langostino fishery. The fishing depth is about 4-20 m. The usual gear is the "rano" or beam trawl and the "red de portones" or otter trawl. The principal fishing time is February through August after which there is a sharp drop in the catch. The full life history is unknown but some of the biology has been described by Castellanos (1967). The squid probably reach maturity in under one year and thus represent an annual crop. There are no estimates of the stock size and thus no reliable potential figures can be given.

According to Castellanos (1964) the "calamarcito", Semirossia tenera, although small, under 5 cm in length, is of some commercial value and is fished in the Gulf of San Matias and some locations on the south coast.

While an octopus catch of a few hundred tons is given in the statistics of FAO, no data are available. The fishery is probably incidental to the trawl fishery. The species of octopus in Argentine waters is still unsettled.

The major cephalopod fishery in the southwestern Atlantic is for an ommastrephid squid, the common Argentine squid or "calamar de Argentina", Illex argentinus. The writer suggested that this species represented a subspecies of Illex illecebrosus to which it is closely related but Roper, Lu and Mangold (1969) have considered it to represent a distinct southern species. What is known of its biology and fisheries has been described by Castellanos (1964). It occurs apparently from about 36°S to 45°S along the middle and outer shelf.

The main spawning occurs December through March although it appears that some spawning occurs throughout the year. The young squid grow rapidly and by the following summer have reached an average total length of 400 mm and by that winter an average length of 500 mm. Sexual maturity is reached at a total length of about 240 mm. The life span is probably one to two years, more likely the former. They feed upon fish (young hake?), crabs, shrimp and crayfish (Angelescu and Boschi, 1959). In turn they form one of the major items of diet of the hake, Merluccius (Angelescu et al., 1958), and the movements of the one correspond to those of the other. The main fishery is on the outer shelf between about 30-100 fath, subsidiary to the hake fishery. The usual gear is the otter trawl. At times, when there is a great demand for squid, they may be fished for separately in the area of 43°S and in about 50 fath depth (Boschi, personal communication). Otherwise the fishery is located mainly off Buenos Aires Province in waters of 5°-15°C. They are marketed both fresh and frozen. The U.S.S.R. was formerly taking significant numbers of Illex from Argentine waters but the fishery has now ceased (Nesis, personal communication).

Boschi (personal communication) warns that even though at times this squid is extremely abundant, it is at present an unexploited resource and estimates of the potential stock must be regarded with suspicion. Angelescu and Cousseau (1969) have inferred an important stock of squids based on their importance in the diet of the hake Merluccius hubbsi, and the estimated biomass of the latter. The actual landing statistics are doubtful since the area is now being fished by ships of European countries and other American nationalities (Cuba, etc.) from which the landings are not available. Gulland (1970:184) has given an estimated squid potential for the region of about 500 000 tons or greater.

7.9 Region VIII - Northeast Pacific

Alaska, western Canada, United States - Total about 15 000 tons

Practically the total cephalopod production of the northeast Pacific comes from the California fishery for Loligo opalescens centred at Monterey Bay. This squid is widely distributed from Mexico to western Canada (scarce). There is a potential fishery for Todarodes pacificus in western Canada; at present no fishery for cephalopods exists there.

The cephalopod fisheries of California are based upon several species of octopus whose scientific names have yet to be cleared up, and the squid Loligo opalescens. It is an underexploited resource and is capable of great extension and development.

The main species of octopus entering the fisheries are probably Octopus dofleini and Octopus fitchi although their identity is by no means certain. Octopus have been harvested in California since the advent of the Chinese around the mid-1800s. The fishery is small and in its peak year, 1924, only amounted to about 83 tons while in 1970 it was less than 2 tons. The catch is consumed locally both as food and as bait in the longline fishery. In peak years shipments have been made abroad, primarily to the Orient. The fishery is capable of expansion if there is a market for the catch. The life span of the smaller species of octopus is only about one year or less; the larger species such as O. dofleini probably live a number of years but no valid data are available. The 1969 octopus catch was valued at only U.S.$ 282, with a price per kilogramme of approximately U.S.$ 1.25 in 1969.

The squid fishery, as mentioned above, is based upon Loligo opalescens. This is a small species of loliginid, averaging about 30 cm in overall length. It is distributed from off Vancouver Island, British Columbia, to southern California. Its occurrence in the Gulf of California has yet to be confirmed. The fishery for and biology of L. opalescens have been covered in considerable detail by Fields (1950, 1965), Classic (1929), Longhurst (1969), Phillips (1941) and Scofield (1924). As with most loliginids, the animals congregate in vast spawning schools in near-shore waters or bays over sandy bottom. Mass spawning occurs at which time the squid are oblivious to all else and are easily caught. In southern California spawning occurs in January or February; in Monterey Bay the schools appear around April. After the spawning occurs the bottom of the area may be littered with dead, spawned-out females and dead males.

Eggs are laid in shallow water in large clusters of elongate capsules attached to form the typical "sea mop". Each of several hundred capsules may hold as many as 300 or more eggs imbedded in a gelatinous matrix. Development is rapid and the 5 mm larvae hatch out at from 3 to 4 weeks. They feed on a variety of small crustaceans changing to shrimp, fish and other squid as they grow older. The squid reach market size and maturity in one year. The life span is one to four years with few surviving three years. They may be considered an annual crop.

The California squid fishery was begun in 1863 by a group of Chinese fishermen at Monterey Bay. They were originally caught by attracting schools to the glare of blazing torches and then netting them with a purse seine. The catch was dried and exported to China. In 1905 Italian fishermen introduced the lampara net, capable of taking 20 tons of squid at a single haul. The data in table 12 show the annual cephalopod catch from 1916 to 1971. Most of the catch until 1933 was dried and exported to China. In the twenties the catch began to be sold canned and frozen. At present about 1 000 tons are sold fresh or frozen for bait. The remainder are canned and exported primarily to the Philippines and Greece in competition with Japanese products. The fishery peaked in 1946 with a catch of 14 000 tons; since then it has fluctuated between about 1 500 and 10 000 metric tons (Table 11). The value of the squid fishery in 1969 was U.S.$ 555 426.

The major fishing areas are Monterey Bay, Los Angeles and Santa Barbara, in decreasing order of importance. In the Monterey area the major fishing period is from May to September. The fishery is conducted by vessels of approximately 9–15 m in length employing the lampara net used in the fashion described by Fields (1965:16). Usually the schools are located at night by the luminescence created by their movement but there may also be "blind" sets during the day. The Monterey fishery is now prohibited from the use of lights and fish pumps but recommendations have been made that these controls be revoked (Longhurst, 1969).

While the fishery has traditionally been centred at Monterey, there are many areas along the coast where spawning migrations and concentrations occur. In southern California the squid are attracted to the side of the ship by outboard lights and then brailed aboard. Recently, studies have been made of using the fish pump with considerable success (Kato, 1970; Anon., 1970)

California squid are mainly canned for export but over a million pounds are shipped frozen to various U.S. cities (Lyles, 1968), including New York and Miami. It is sold for food and bait in fish markets and supermarkets. The catch is washed several times, soaked in a brine solution for several hours and packaged in 5–10 lb (2.3–4.5 kg) cardboard cartons.

Table 11. Landings (converted into tons) and value of squid catch in California 1960–68

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Tons	1 162	4 666	4 249	5 244	7 454	8 446	8 630	8 891	11 309
U.S.$		231 000	168 000	240 000	333 000	308 000	451 000	439 000	553 000

There are occasional small catches of the jumbo squid, Dosidicus gigas, off the California coast (Clark and Phillips, 1936). Due to its larger size off California it does not compete with L. opalescens.

The fluctuations in the catch of both Octopus spp. and Loligo opalescens are shown in Table 12.

Undoubtedly the squid resource of California is grossly underexploited and if there were a good market and the known areas of concentration were fished the catch could be greatly increased (Longhurst, 1969). Gulland (1970) suggests a potential catch of 600 000 tons per year.

Table 12. Octopus and squid landings from 1916 to 1971

	Year	Total (tons)	Year	Total (tons)
Octopus	1916	12	1944	3
	1917	17	1945	6
	1918	15	1946	17
	1919	10	1947	24
	1920	32	1948	55
	1921	26	1949	34
	1922	45	1950	27
	1923	50	1951	13
	1924	75	1952	8
	1925	60	1953	8
	1926	29	1954	14
	1927	17	1955	12
	1928	4	1956	7
	1929	40	1957	14
	1930	35	1958	7
	1931	29	1959	1.2
	1932	10	1960	0.8
	1933	14	1961	1.4
	1934	14	1962	6
	1935	37	1963	34
	1936	28	1964	18
	1937	11	1965	9
	1938	15	1966	8
	1939	13	1967	4
	1940	12	1968	8
	1941	18	1969	2.1
	1942	3	1970	1.8
	1943	8	1971	0.4
Squid	1916	125	1944	4 961
	1917	199	1945	6 906
	1918	164	1946	17 248
	1919	1 677	1947	7 050
	1920	231	1948	8 734
	1921	196	1949	3 111
	1922	95	1950	2 720
	1923	535	1951	5 617
	1924	3 099	1952	1 665
	1925	858	1953	4 044
	1926	1 422	1954	3 699
	1927	2 728	1955	6 474
	1928	613	1956	8 838
	1929	2 114	1957	5 647
	1930	4 976	1958	3 383
	1931	789	1959	8 914
	1932	1 919	1960	1 162
	1933	374	1961	4 666
	1934	694	1962	4 249
	1935	370	1963	5 244
	1936	429	1964	7 454
	1937	228	1965	8 446
	1938	725	1966	4 548
	1939	527	1967	8 891
	1940	817	1968	11 309
	1941	649	1969	9 400
	1942	428	1970	9 000
	1943	4 157		

(Original data in total pounds have been converted to metric tons)

The octopus fishery of the region is practically nonexistent. There are considerable stocks of Octopus dofleini in Alaska, western Canada and the U.S. Pacific northwest. This is not exploited while the same species in Siberia is fished by the U.S.S.R. and commands a high price in the markets. Small octopus of various species occur along the California and northern Mexican coast but they are fished only incidentally. There is a small octopus fishery on the Mexican coast.

7.10 Region IX - Central East Pacific

Baja California to Ecuador - Total about 500 tons

There is no regular squid or octopus fishery throughout the entire coastline of this otherwise highly productive area. Both groups are caught and marketed in the Mexican part of the region but no statistics are available to me that give a breakdown as to the area of origin. Squid are caught in relation to shrimp trawling while octopus are caught by several of the traditional methods.

The octopods available belong to a number of poorly known and characterized species. In the northern part of the range (Pacific coast of Baja California) these may be Octopus vulgaris, O. fitchi and O. dofleini. In the tropical area (all the rest of the region including the Gulf of California) Octopus vulgaris, O. chierchiae and O. selene are the commoner species (Voss, 1967, 1971).

The loliginid squids similarly show a distinct break. Along the Pacific coast of Baja California, Loligo opalescens is present in some quantities. Marquez (1966:4) states that at times they are very abundant in the Bahía de Todos Santos, coming inshore in early summer and remaining until early winter. They are highly desirable nationally and for export fresh, dried or canned. In 1965 the anchovy fishermen caught approximately 60 tons constituting the primary product of the packing plant La Portena in Ensenada. The full potential was not realized as the plant was working at capacity.

In the Gulf of California and southward to Ecuador, the loliginid Loliolopsis diomedeae is the common squid. No capture records of this species are available; it probably is not recognized as a separate genus and species. Its abundance is not known; personal experience in the Gulf of Panama in 1967 indicated large spawning schools present. Undoubtedly there is a large resource but its extent is not definable at this time. Squid are taken in fair numbers by the Panamanian shrimpers but are usually thrown overboard. Very few reach the local market.

In the Gulf of Panama and probably widely distributed as far as Ecuador is another loliginid, Lolliguncula panamensis. This species is very similar to L. brevis in the Caribbean but is a heavier and somewhat stouter species. It enters the shrimp catch in Panama and Colombia but is not recorded in the statistics. It is another potential squid resource.

In 1969 and 1970 the Colombian Government conducted a survey of its Pacific fisheries using the trawler CACIQUE (Squires et al., 1971). It took Lolliguncula brevis along the coast in depths from 20 to 35 m and temperatures of 21°-27°C. Highest catches were in November-December north of Buenaventura (79 squid per hour) and in April north of Buenaventura (25 per hour). These are small squid averaging 50 to the kilogramme. Prorating the average catch for the whole Colombian shrimp fleet the total catch would amount to 150 tons of squid for 1969.

These loliginid squids are caught incidental to the shrimp fishery all along the coast of Central America. Some poundage is marketed but most is consumed locally. In Guatemala the value of the squid fishery in 1967 was U.S.$ 900.

Two ommastrephid squids are found in the region: the jumbo or "giant" squid Dosidicus gigas and the Indo-Pacific squid Symplectoteuthis oualaniensis. Small Dosidicus and

and Symplectoteuthis are easily confused as they have a similar general appearance. Both are oceanic squids occurring over or near the continental slope. The species are not fished but occur in considerable numbers. In 1971 the Japanese squid vessel RYOUN MARU caught 12 tons of squid in one night off the southern tip of Baja California (Commer. Fish. Rev. 33(11/12):48). The squid were said to resemble the "surume-ika" (Todarodes pacificus) of Japan. Although Symplectoteuthis oualaniensis has the Japanese name of "tobi-ika", they are often marketed as "surume-ika" and this may have been the species involved. These squid are very plentiful along the coast and probably represent a very large potential in this area. Both species occur rarely from Southern California to Ecuador with Dosidicus in large numbers from there southward.

The cephalopod fisheries of the Central Eastern Pacific are little known and hardly exploited over the whole area. Undoubtedly a large resource is waiting to be tapped. It is impossible to estimate its potential at this time but it must run to at least 100 000 tons.

7.11 Region X - Southeast Pacific

Peru to Cape Horn - Total 1 000 tons

The exceedingly rich upwelling waters along the west coast of South America support very large populations of ommastrephid squids. Because of the very narrow to nonexistent continental shelf, there are probably no large numbers of octopus sufficient to support a productive fishery although small numbers, locally abundant, occur. The numbers of loliginid squids are unknown although again, due to the lack of shelf area, their numbers are probably few, but this is not certain (Table 13).

Table 13. Cephalopod catch (Western South America) 1967-69
(in thousand metric tons)

Country and species	1967	1968	1969
Peru			
Octopus "pulpo"	0.0	0.0	0.0
Squid "calamar"	0.1	0.1	0.2
Squid "jibia"	0.3	0.3	0.6
Chile			
Squid "jibia"	0.3	0.2	0.1
Total	0.7	0.6	0.9

The loliginid squid Loligo gahi is widely distributed along the coast of South America (Thore, 1959). It is caught in trawls incidental to other fisheries. Peru in 1969 landed 200 tons of this species called "calamar".

The ommastrephid squid Dosidicus gigas ranges from California (rarely) to Cape Horn with its major concentrations off Peru and the northern two thirds of Chile. It is often called the South American "giant" squid or Humboldt squid. It attains, as an adult, a total length of 2-3 m. The larger ones occur in offshore waters while younger ones congregate closer to the coast. In the younger stages (25-50 cm) they are often confused with Symplectoteuthis oualaniensis of the same size. This species is not numerous (Dall, 1910).

Dosidicus has been eaten since earliest times and several Spanish accounts relate that the Indians caught and ate them at the time of the Conquest. Later accounts state that they were eaten by the Indians and poorer persons of Spanish extraction. They are distinguished from the loliginids "calamares" and are listed as "jibias" (Nesis, 1970).

There are several accounts of mass catastrophies of the Dosidicus stock along the Chilean coast where at times dead squid choke harbours and stretch along the coasts for hundreds of miles (Wilhelm, 1954). The numbers killed on these occasions are fantastic and indicate exceedingly large stocks. However, they are now little fished. In 1969 Chile landed only 100 tons while Peru caught only 600 tons. The numbers caught locally and not recorded are unknown. From estimates of the squid "jibia" stocks based on anchoveta predation and the standing crop of sperm whales (Boerema, 1970) the figure of about 1 million tons is derived of which perhaps 500 000 tons could be harvested on an annual basis.

7.12 Region XI - Northwest Pacific

Total estimated at about 1 million tons

This region may well be considered the cephalopod centre of the world both as to annual catch and amount consumed. More species of cephalopods are caught and eaten in Japan than in any other country or region of the world. China and South Korea may perhaps be second and third in this category. The overall statistics for the region are not available nor comparable; these will be considered separately under each area.

7.12.1 Eastern Seas of U.S.S.R.

The U.S.S.R. has not developed its cephalopod fisheries in the region. According to Nesis (personal communication), Octopus conispadiceus and O. dofleini are taken in the Japan Sea and South Kuril Islands as a by-product of the bottom trawl fishery. In previous years rather large quantities of the gonatid squid Berryteuthis magister were taken off the Bering and Medny Islands in the Bering Sea as a by-product of the redfish fishery (2 700 tons in 1965) but at present this species is rarely utilized. What amounts of the common squid, Todarodes pacificus, are taken, if any, are not known.

7.12.2 Democratic People's Republic of Korea (North)

No data available

Republic of Korea (South)

The South Korean (Republic of Korea) squid fishery has been described by Kim and Chang (1966). Catch statistics are given in Table 14. The main commercial species is Todarodes pacificus. As in Japan (q.v.) the fishery is seasonal because of the migrational pattern of this species. There is no fishery during the winter months. In the spring the squid begin appearing in the north and in June the fisheries is in full operation off Mukko and the Ulnung Islands with peak operations in July and August. In September the fishery is located in the southern region off and north of the port of Pusan. The main fisheries are located off North Kyongsang (33 percent), South Kyongsang, Kangwan (61 percent) and Hamgyang provinces. About half of the catch is sold fresh. The remainder is either dried, for home consumption and export, or canned. South Korea is not ideal for open air squid drying and in long periods of wet to damp weather the squid are salted and bring a lower price. Over half of the dried squid are exported. Formerly much of this went to Japan but this market has decreased and most of the export goes to Southeast Asia including Hong Kong. In 1965, 6 595 metric tons of dried squid were exported at a value of U.S.$ 4.7 million (Table 15). Canned squid in 1965 amounted to 6 440 cases valued at U.S.$ 49.4 thousand.

Table 14. Republic of Korea (South) Cephalopod catches from 1964 to 1969 (in thousand metric tons)

	1964	1965	1966	1967	1968	1969
Squid	86.6	70.6	75.5	41.7	84.7	59.9
Cuttlefish	-	-	-	-	3.9	5.0
Octopus	1.2	1.0	2.7	1.9	4.1	2.7
Total	87.8	71.6	78.2	43.6	92.7	67.6

Table 15. Export of squid from the Republic of Korea (1965)
(in thousand metric tons)

Product	Quantity	Value (in thousand U.S.$)
Dried squid	6.5	4 655
Seasoned squid	0.8	798
Canned squid	6 440 cases[a/]	49
Total		5 502

a/ 48 one-pound cans/case

A number of other species of cephalopods are caught besides T. pacificus, including many of the species listed for Japan. Experiments in mariculture have been conducted by Sang Choe (lit. cit.) on several species including loliginids and cuttlefish. The ecology of T. pacificus in Korean waters has been studied by Lim (1966) and results of tagging experiments reported by Park (1962) and Park and Lim (1968).

7.12.3 People's Republic of China

There were no up-to-date catch statistics available for mainland China at the time this report was written. The information on the economic cephalopods given here was gleaned from two papers, Chang et al. (1955) and Chang and Chi (1961), English translations of them being furnished to me by Dr. Williamson, formerly of the Fisheries Research Station, Aberdeen, Hong Kong. These authors reported that China annually (1956) produced 50 000 tons of sepiids, 7 000 tons of Loligo and much octopus. They are sold either fresh or dried according to the species. They are also used as bait, particularly octopus in the shark fisheries. Undoubtedly these figures are woefully inadequate today but they and the following account give an interesting description of the fishery.

Sepiella japonica (S. maindroni of Chang and Chi) is stated to account for about 90 percent of all of the sepiids caught on the Chinese coast, or about 40 000 tons for the country. It is the number one commercial cephalopod and one of the four main fisheries of China. It is caught mainly in eastern and southern China, particularly in Chekiang and Kiangsu. A few are caught in Fukien and Kwangtung but little is caught in the region from the Yangtze Kiang to the Yellow Sea. They move into shallow water to breed in spring and summer when the temperature is about 16°-19°C and the salinity 30°/oo or above. The eggs are laid among seaweed and take about a month to hatch at 20°-26°C. The young are strongly negatively phototropic. The adults live mainly on bivalves and small fish and themselves are preyed upon by eels and sharks. The fishery is seasonal:

Kwangtung: February-March
Southern part of Fukien: February-March
Northern part of Fukien: April-May
Southern part of Chekiang: April-May
Northern part of Chekiang: May-June
Southern part of Shantung: June-July

The dried Sepiella are exported to southeast Asia and the interior of China. The ink is used as ink by most Chinese and the shell is a herbal medicine.

Sepia esculenta is most abundant in the northern part of the Yellow Sea. The catch around the provinces of Shantung and Sukiang is about 80 percent of all sepiids but the total tonnage is low. According to reports of the Shantung and Tsingtao research stations they spawn when the temperature is 15°-20°C and the eggs take about a month to hatch at 18°-22°C. The species is caught by trawling at the various times given below:

Kiangsu: End of April to early May
Shantung: Beginning of May to middle of June
Tsingtao: Beginning of May to end of June

Sepia andreana occurs in small quantities in northern China where they are caught by trawling and setnets. Sepia pharaonis (=S. tigris of Chang et al.) is restricted to southern China south of Chekiang. They are caught both by trawling and handlines. Sepia latimanus (=S. hercules of Chang et al.) occurs along the eastern coast caught by setnets and handlines. Sepia lycidas (=S. subaculeata of Chang et al.) occurs at Fukien and southward where they are caught by trawls and handlines. They are large, are usually dried, and most are exported. The small sepiolids Sepiola birostrata and Euprymna berryi are occasionally eaten.

Four species of loliginids are fished commercially: Loligo formosana, L. japonica, L. beka and Sepioteuthis lessoniana, the four together yielding an annual catch of 7 000 tons of which 90 percent is L. formosana. It is common in Japan, the Ryukyu Islands, southeastern China, Taiwan and South Vietnam. This species is caught in China in three main fishing grounds: (1) Pekpoi Wan - from February to April; (2) Nanping Tao (off Namoa Island opposite Swatow) - from May to September and (3) off Amoy, Fukien Province - from June to September. These are large delicious squid, usually dried, and bring a high price on the market.

Three main octopods are fished: Octopus vulgaris, O. ocellatus, and O. variabilis. They live along the shelf and are often caught using crabs for bait. They are eaten both fresh and dried.

7.12.4 Japan

The Japanese cephalopod fishery is the world's largest and is worth examining in some detail. For much of this information on the Japanese fisheries I am indebted to Dr. Takashi Okutani (personal communication) of the Tokai Regional Fisheries Research Laboratory.

7.12.4.1 Species. The cephalopod fauna of Japan is among the best known in the world, partly because of a long history of systematic studies and partly because of their economic importance. The major works on the cephalopod fauna are by Sasaki (1929), Taki (1964), and Okutani (1967). About 80 species are known from Japanese waters.

By far the most important economic species is the common Japanese squid, Todarodes pacificus "surume-ika" erroneously referred to as Ommastrephes sloani pacificus by almost all but the most recent Japanese authors. Wherever the latter name is used concerning Japanese cephalopods it refers to Todarodes. This is the best studied oceanic squid. It occurs from western Canada across the North Pacific to about Taiwan but apparently is replaced further north by Nototodarus sloani philippinensis. There is a considerable literature on its biology, mostly in Japanese but often with English abstracts: spawning (Hamabe, 1961), early development (Okutani, 1965; Okiyama, 1965a), stomach contents (Okiyama, 1965b; Okutani 1962; Abe, 1965), population structure (Ito, 1965; Katoh, 1964; Shintani, 1965), spawning grounds (Watanabe, 1965), ecology (Hamabe and Shimizu, 1966), migrations (Kasahara, 1967; Machinaka, 1959; Soeda, 1950), and tagging experiments (Shimizu and Hamabe, 1966; Machinaka, 1959). At least one of the spawning grounds appears to be along the edge of the continental shelf southwest of Kyushu in the winter (Watanabe, 1965) and larvae and young are transported northward by the Tsushima or Kuroshio currents. An annual migration appears to take place around the Japanese Islands, based upon tagging experiments and seasonal fisheries. During June through November the fisheries are in northern Japan, February-April in western Japan and on both coasts of central Japan in December-January and in May. The population structure is complex and much more study is needed before problems related to this can be solved.

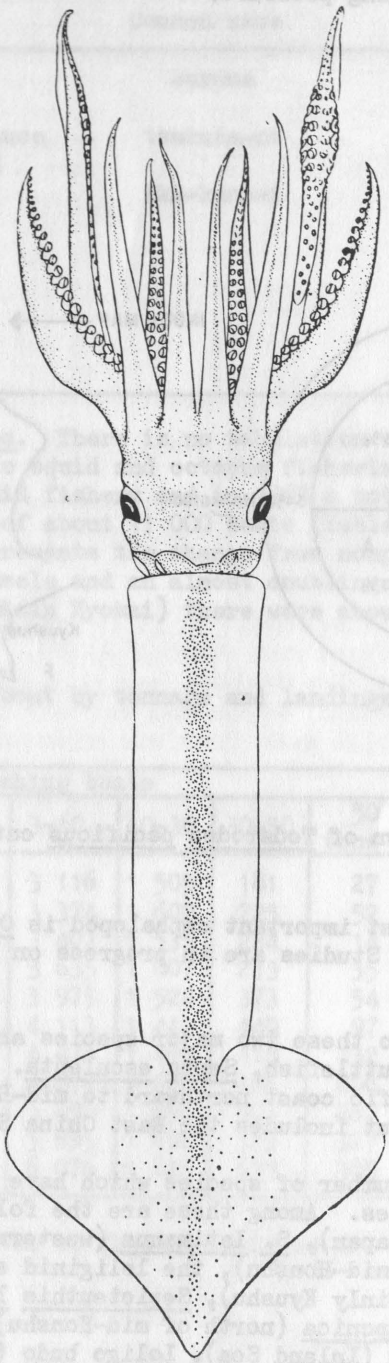

Figure 7. Todarodes pacificus (after Voss and Williamson, 1971)

More than 80 percent of the catch (see Figure 8) comes from the Pacific coast of Hokkaido and Honshu. The catch varies between about 300 000-500 000 tons annually, the fluctuations probably due to changing hydrographic conditions rather than to fishing pressure.

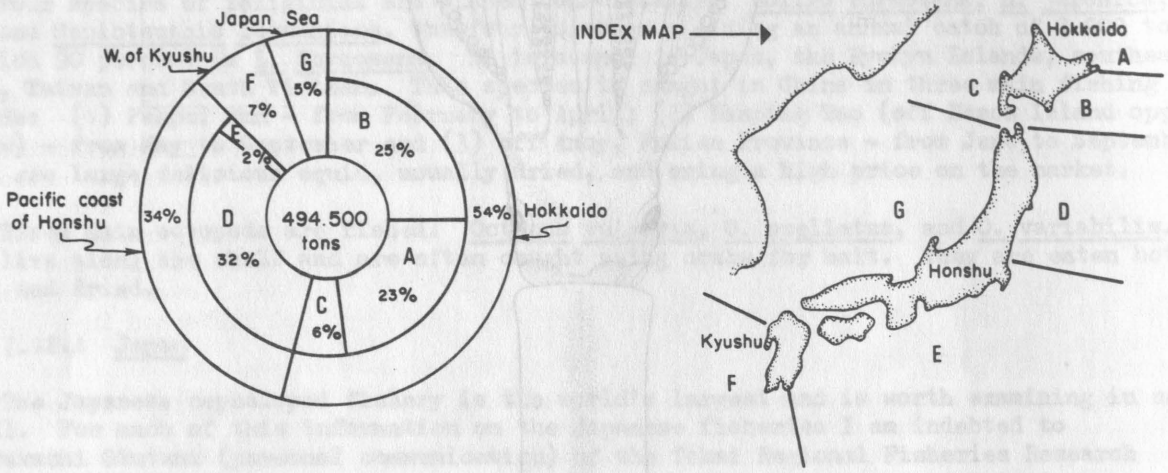

Figure 8. Regional breakdown of Todarodes pacificus catch, mean for 1959-63 (after Araya, 1967)

The second most important cephalopod is Octopus vulgaris. It is caught all around Japan. Studies are in progress on mariculture, both pondculture and tank systems.

Subordinate to these two major species are the loliginid Doryteuthis bleekeri and the cuttlefish, Sepia esculenta. The former is distributed in the Japan Sea and Pacific coast northward to mid-Honshu. The latter has a similar distribution but includes the East China Sea.

There are a number of species which have a more restricted range and support local fisheries. Among these are the following: the cuttlefishes Sepia lycidas (western Japan), S. latimanus (western Japan), Sepiella japonica (western Japan to mid-Honshu), the loliginid squids Doryteuthis kensaki (western Japan, mainly Kyushu), Sepioteuthis lessoniana (western Japan to mid-Honshu), Loligo japonica (north of mid-Honshu), Loligo edulis (western Japan), Loligo sumatrensis (Inland Sea), Loligo budo (western Japan Sea), the oegopsid squids Symplectoteuthis oualaniensis (Okinawa), Watasenia scintillans (Toyama Bay, Japan Sea), and the octopods Octopus ocellatus (throughout Japan but mostly in Inland Sea), O. macropus minor (western Japan) and O. dofleini (northeastern Japan, mostly Hokkaido).

Other cephalopods of occasional commercial importance are Sepia pharaonis, Euprymna morsei, Loligo ?chinensis, Ommastrephes bartrami, Onychoteuthis banksi borealijaponicus, Thysanoteuthis rhombus and others.

Table 16. Utilization of squid in Japan (Tanikawa, 1965) for 1962

Product	Common name	Production (in metric tons)
Dried squid	surume	31 258
Canned squid		992 781
Squid in soy sauce	tsukuda-ni	18 047
Fermented squid		8 697
Smoked squid	ika-kunsei	8 518
Squid oil		3 181
Fodder		1 453
Fertilizer		490
Salted squid		356
"Fish" sausage		?
"Fish" meal		?

7.12.4.2 Fisheries. There is no tabulation of all of the fishing boats engaged in both the squid and octopus fisheries. By far the larger number is engaged in the squid fishery and in 1968 a total of 33 320 boats were in the fleet, a decrease of about 11 000 boats (Table 17). This figure is misleading, however, as it represents the change from nonpowered small fishing boats to larger powered vessels and an almost doubling of the catch over a ten-year period. In 1960 (Asin Kyokai) there were about 56 000 fishermen in the squid fishery.

Table 17. Numbers of fishing boat by tonnage and landings of squid angling fishery

Number of fishing boats								Catch (1 000 tons)		
Year	Total	Non-powered	3 tons >	3-10	10-30	30-50	50 tons <	Total	Todarodes pacificus	Value Yen 1000 M
1958	44 145	19 817	19 499	3 116	1 505	181	27	352.7	336.5	96.2
1959	44 624	18 606	20 765	3 374	1 602	225	52	470.3	453.4	81.3
1960	44 087	16 235	22 672	3 407	1 535	224	14	470.0	454.0	114.0
1961	44 328	15 106	23 672	3 635	1 607	273	35	377.7	360.3	116.2
1962	40 783	11 919	22 938	3 975	1 524	373	54	533.2	513.8	143.3
1963	36 565	8 626	21 848	4 113	1 441	440	97	580.2	566.4	189.1
1964	35 695	7 513	21 715	4 424	1 493	418	132	237.2	215.8	141.3
1965	36 070	6 128	22 695	4 874	1 680	484	208	387.0	373.9	159.6
1966	36 128	4 842	23 340	5 490	1 693	503	260	378.5	362.1	245.2
1967	35 993	4 059	23 637	5 695	1 696	579	327	472.0	450.9	233.7
1968	33 320	2 785	21 610	6 076	1 825	639	385	649.1	637.1	335.4

The annual catch of these vessels in all categories is given in Table 18.

Table 18. The cephalopod catch by Japanese fishing boats, 1959-69

Year	Cephalopod Total	Todarodes pacificus	Sepia spp.a/	Other squids	Octopus spp.
1959	589 167	480 669	19 279	38 465	50 754
1960	599 447	480 661	19 116	42 069	57 601
1961	513 757	383 993	19 845	53 062	56 857
1962	678 069	536 470	23 735	52 303	65 561
1963	731 024	590 647	14 937	61 538	63 902
1964	396 349	238 290	23 216	67 868	66 975
1965	577 424	396 902	20 394	82 071	78 057
1966	550 578	382 899	15 421	86 707	65 551
1967	694 978	477 012	15 736	104 100	93 130
1968	876 495	668 364	15 348	90 065	102 718
1969	682 216	478 160	16 465	95 173	92 418

a/ Mostly S. esculenta, probably very small amount of Sepiella may be also included.

Note: Source: Statistics for Marine and Freshwater Fisheries and Aquiculture Productions annually published from Ministry of Agriculture and Forestry, Japan.

As can be seen from Table 19, it is difficult to separate the catch from Japanese waters and that from foreign waters. Today, Japanese vessels are fishing the waters of New Zealand, west Africa, the eastern United States and the west coast of Mexico, to mention the most prolific areas. Until a few years ago when the high seas fleet was enlarged, Japan imported sizeable quantities of squid from other countries, Korea, the Philippines, etc. Today only small amounts of fresh Todarodes pacificus may be imported from Korea. Instead, the high seas fleet accounts for the foreign imports.

Table 19. Catch by type of fishery, 1959–1969 (in tons) **Northwest Pacific**

(A) Decapodous cephalopods

Year	Total	Subtotal: Adjacent Seas of Japan	Subtotal: High Sea	Squid Jigging	Trawl: *High sea trawl	Trawl: Trawl in East China Sea	Trawl: Offshore trawl	Trawl: Small sized trawl	Fixed net: Large fixed net	Fixed net: Small fixed net	Others (Misc.)
1959	588 406	522 899	15 507	470 025	17	15 374	7 943	5 432	19 577	9 873	10 165
60	541 846	525 094	16 752	469 618	302	16 419	8 272	5 205	21 101	10 847	10 032
61	456 900	429 050	27 850	377 229	12 841	14 982	6 281	5 339	19 633	9 771	10 824
62	612 508	588 597	23 911	532 718	9 939	13 956	7 481	5 330	18 629	8 639	15 775
63	667 122	633 807	33 315	579 661	20 298	13 008	7 349	5 055	19 212	10 452	12 087
64	329 374	290 220	39 154	236 755	20 336	18 818	7 483	6 841	19 465	11 907	7 819
65	499 367	441 589	57 778	386 463	38 637	19 141	10 099	7 098	16 295	12 191	9 533
66	485 027	489 311	54 716	377 918	33 089	21 625	8 736	7 411	14 462	11 784	10 052
67	596 248	512 443	64 485	471 464	44 191	29 214	11 405	7 416	16 101	13 493	12 359
68	773 777	716 217	57 560	648 859	37 466	20 093	13 635	6 360	13 929	19 182	14 273
69	589 798	531 519	58 279	467 156	40 825	17 451	13 198	7 766	11 931	17 021	14 450

*Mostly W. coast of Africa, the major catches are Sepia officinalis hierredda and S. o. vermiculatis

(B) Octopodous cephalopods

Year	Total	Subtotal: Adjacent Seas of Japan	Subtotal: High Sea	Trawl: *High sea Trawl	Trawl: Offshore Trawl	Trawl: Small sized trawl	Angling	Longline	Trap etc.	Others (Misc.)
1959	50 754	50 754	-	-	8 143	4 651	6 144	14 423	16 355	1 8 3
60	57 601	57 601	-	-	8 583	5 658	7 520	15 711	19 150	939
61	56 857	56 857	-	-	7 129	5 745	8 467	12 222	22 295	9 9
62	65 561	61 853	3 708	3 703	7 831	7 159	8 352	12 401	23 296	1 614
63	63 902	56 903	6 999	6 999	5 522	5 641	7 047	13 463	21 127	1 133
64	66 975	56 505	10 470	10 448	3 707	6 809	6 370	12 775	23 124	1 012
65	78 057	44 661	33 396	32 330	4 922	6 421	4 334	11 375	16 241	1 311
66	65 551	42 953	22 598	22 526	3 870	6 394	4 467	10 260	17 649	344
67	98 130	42 911	55 219	65 173	3 692	8 295	3 539	9 030	16 263	1 308
68	102 718	37 899	64 819	64 791	3 973	7 360	2 939	7 529	14 371	1 435
69	92 418	40 118	52 300	52 213	4 111	8 613	2 910	6 563	15 868	2 030

* Mostly W. coast of Africa and Oceania

Japan also exports cephalopods, both dried squid "surume" and canned squid and octopus (the latter is commonly found in U.S. supermarkets along with Spanish and Portuguese squid). There are no statistics on the amount of canned cephalopods exported. The export dried squid is listed in Table 20.

Table 20. Export of dried squid "surume" for 1965-69

Amount (in metric tons)					Value (1 000 U.S.$)				
1965	1966	1967	1968	1969	1965	1966	1967	1968	1969
50	86	525	229	470	91	167	496	221	412

7.12.4.3 Fishing methods

(a) Jigging The early fishing methods for squid in Japan involved hand jigging for squid using an artificial lure resembling shrimp or fish. These were used at night with a light to attract the squid. The shrimp lures were eventually so beautifully carved that they have become much collected and prized art objects, some of great antiquity. Later the traditional jigging gear consisted of a single or double rod, shortline and multipointed or tined jig made of deer horn. Today the jigs are mostly made of plastic and are of various sizes and shapes according to the type or species of squid being fished. Fishermen formerly had their own type of jigs coloured according to their purported effectiveness: brightly coloured, dull coloured, curved, fluorescent, leadloaded, etc.

After 1945 the squid jig and jigging methods underwent radical change. A double line of several jigs each was developed, the two lines hung from the ends of a metal spreader with central porcelain and lead weight, the whole lowered from a hand-cranked drum or reel. This was shortly changed to a longline of jigs operated by a hand reel with an overside roller higher than the reel so that the squid fell off of the jig into a trough leading into fish pens on deck. These were later mechanized (Igorashi, Mikami and Kobayashi, 1968) and are now the main equipment on squid jigging vessels. Some further details are also given in FAO 1972 which also provides,in English translation from the Japanese, recent scientific reports on the use of echosounders for detecting squid.

The modern commercial jigging vessel is about 28 m in length overall and is equipped with 20-24 double mechanized reels. The crew numbers from about 18-20 or greater on a few larger vessels. Such vessels may take 20-30 tons of squid per night during good fishing periods.

(b) Trawling Much of the cuttlefish and octopus is caught by the "high seas trawlers", large stern trawlers working the coast of west Africa (Sepia officinalis and Octopus vulgaris), New Zealand and the East China Sea (Sepia esculenta). When fishing for octopus the trawls are fitted with chains referred to as "octopus-lifters". Offshore and small-sized trawlers in Japanese and nearby coastal waters catch sepiids, loliginids (e.g., Doryteuthis bleekeri) as well as Todarodes pacificus, and the octopods Octopus vulgaris and O. dofleini.

(c) Fixed nets Large and small fixed nets are fished in some areas. The catch is mostly Todarodes pacificus and loliginids.

(d) Octopus-trap or pots The traditional Japanese octopus fishery was conducted using unglazed earthenware pots, singly or fastened together in longlines similar to the Italian "nummarellas". These have been modified and are now actual traps. The traps are semi-cylindrical, made of cement and equipped with a lid that closes when the octopus touches a trigger inside. The largest traps are for Octopus dofleini, a somewhat smaller size is used for O. vulgaris. A small trap is used for Octopus occelatus, the smallest species commercially fished.

7.12.4.4 Potential. There is a considerable variance of opinion concerning the potentials of the Japanese fishery for Todarodes pacificus. Some (Soeda, 1956) consider that the fishery is now operating at the highest sustainable yield. Others (Japan Fisheries Agency, 1968) assume that only half of this stock is being used and that it has an exploitable potential of about 1 million tons. Okutani (personal communication) considers that there is no scientific evidence one way or the other and that the estimate is highly arbitrary.

7.13 Region XII - Western Central Pacific

Total about 100 000 tons

Few good figures are available for this region except for Hong Kong and Thailand. Taiwan, the Philippines and Malaysia all have old or newly expanded trawl fisheries and earlier data are poor or nonexistent (Table 21). There are no statistics for the Republic of Vietnam (south), the Democratic Republic of Vietnam (north), the Khmer Republic and Indonesia.

Table 21. Cephalopod landings for the Western Central Pacific (in metric tons)

	1967	1968	1969	1970	1971
Hong Kong[a]					
Squid	-	2 700	3 052	2 695	1 955
Cuttlefish	-	1 100	705	676	666
Octopus	-	200			
Taiwan					
Squid	4 200	2 700	3 500	-	-
Cuttlefish	6 700	8 100	8 200	-	-
Octopus	500	1 100	500	-	-
Other cuttlefish and squids	2 900	3 200	3 300		
Philippines					
Squid	9 900	17 900	13 100	12 100	-
Cuttlefish	-	-	-	-	-
Octopus	-	-	-	-	-
Malaysia					
Squid	2 100	2 600	-	-	-
Thailand					
Squid, Cuttlefish	19 611	29 733	24 529	59 973	
Total	45 600	69 338	56 886	75 464	incomplete

a/ Data supplied by Dr. W.L. Chan, Agriculture and Fisheries Department, Hong Kong

This area is a part of the tropical-warm temperate Indo-West Pacific faunal region. The commercial species include a number of those found in Japan but with an admixture of more tropical species. There is no full report on the commercial fisheries of any part of the region except for that of Voss and Williamson (1972) on Hong Kong. Except for Taiwan where the common Japanese squid Todarodes pacificus still occurs, the primary commercial species of ommastrephid squid is Nototodarus sloani philippinensis. Octopus vulgaris is largely replaced by the common economic octopus of the Indian Ocean, Cistopus indicus and the Pacific octopus, Octopus aegina. Little is known of the biology of any of these species.

7.13.1 Hong Kong

Voss and Williamson (loc. cit.) have described the commercial cephalopods of Hong Kong. The squid and cuttlefish are mainly caught by the trawling fleet incidental to the other fisheries. Octopus are taken customarily in earthenware pots strung in longlines on favourable bottom, or caught by hand with oil and short pole and hook. They are also taken by pair and stern trawlers on the shelf. The total annual catch is about 4 000 metric tons, only about a quarter of the 16 000 metric tons of cephalopods required annually by Hong Kong for eating and export. The major commercial species are: Sepia pharaonis, S. lycidas, S. aculeata, S. esculenta, S. recurvirostra, Loligo edulis, L. formosana, L. duvaucelii, Doryteuthis singhalensis, Sepioteuthis lessoniana, Octopus aegina, and Cistopus indicus. A few years ago (1955) Sepiella japonica was locally abundant and resulted in large landings. They have formed an insignificant part of the catch since then. For a full review of species and the fishery, see Voss and Williamson (loc. cit.). The Hong Kong fishery is conducted primarily on the shelf in both Hong Kong and Chinese territorial waters.

7.13.2 Taiwan

Little has been written about the commercial cephalopods of Taiwan. Sasaki (1929) listed some species as of significance in the catch of the Island. Ho (1959) in a list of the edible molluscs of Taiwan listed the following species: Octopus vulgaris, Loligo edulis, L. formosana, L. duvaucelii (=L. oshimai of Ho), Sepioteuthis lessoniana, Euprymna morsei, Sepia formosana, Sepia tigris, Sepia subaculeata and S. aculeata. Undoubtedly there are others not recognized at the time, including possibly Todarodes pacificus.

The Taiwan fisheries statistics do not mention any species of squid by name but it is possible that the "common squid" is Loligo formosana which Chang and Chi (1961) list as being common in the waters of Taiwan. The "common squid" is mainly taken in the offshore fisheries by means of bullnets and most of the catch is landed at Keeling City. Inshore coastal squid are caught with light and nets at night and mainly landed at P'eng-hsien and Kaohsiung City. Most of the catch is in the summer months with August through September being the peak of the fisheries. According to the Fisheries Yearbook of Taiwan (1967) squid and cuttlefish imports far exceed local production and have amounted to between 1.0-1.8 million metric tons, an unbelievably high figure and probably a misprint for thousands.

7.13.3 Philippines

The Philippine cephalopod fishery is largely a subsistence fishery but there are also small localized fisheries. Octopus, squid and cuttlefish are widely eaten and are found, both dried and fresh in many markets. The major octopods are Cistopus indicus and Octopus macropus. Commercial loliginids are: Doryteuthis singhalensis, Sepioteuthis lessoniana, Loligo duvaucelii, and Loligo edulis. Cuttlefish are Sepia pharaonis, S. esculenta and S. latimanus.

Octopuses are usually caught on the reefs by hand at night using torches. They are also caught when in their dens by squeezing into the hole the juice of a plant called "tubli" in the Viscayan dialect. The octopus immediately leaves its home and is seized by the fishermen.

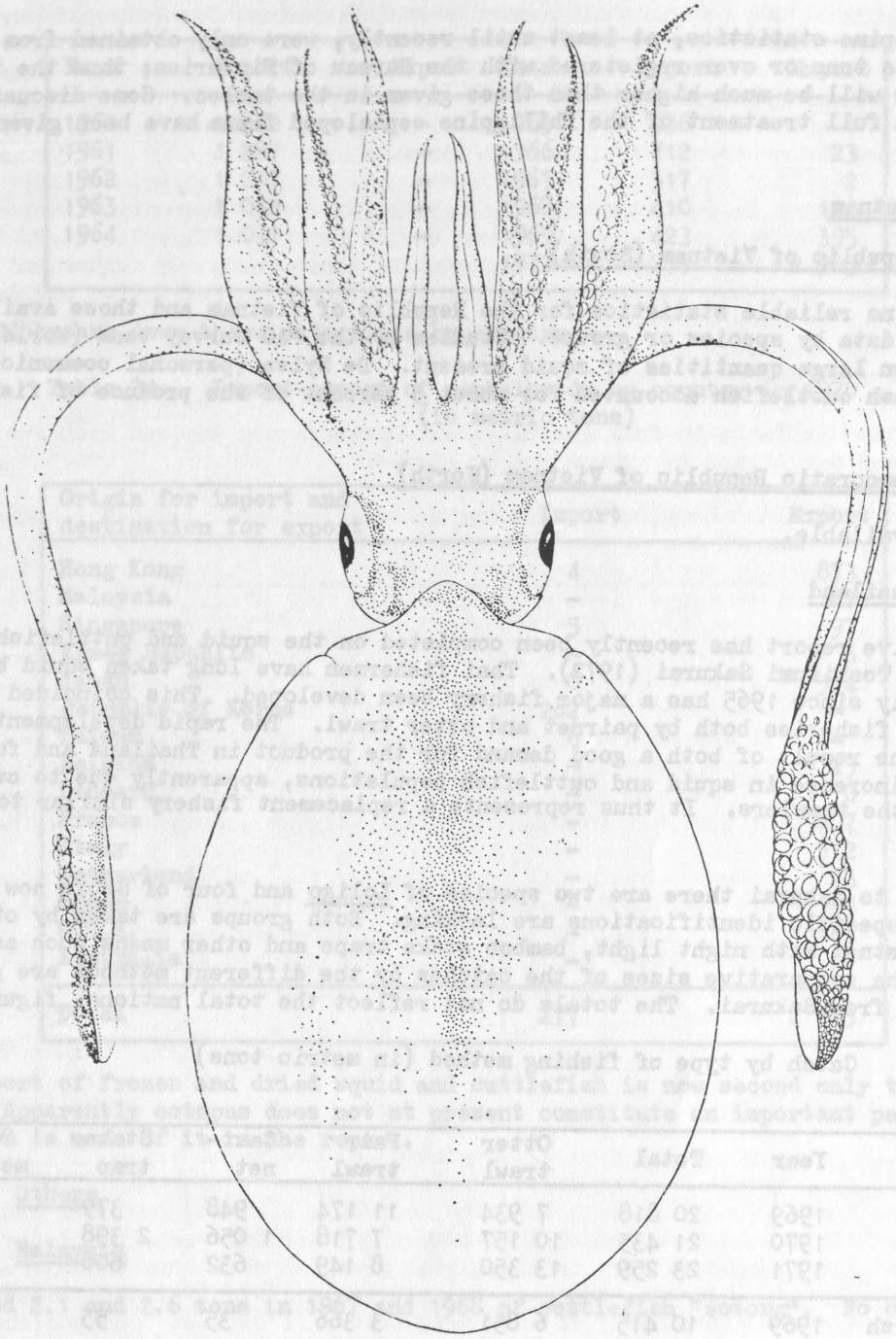

Figure 9. *Sepioteuthis lessoniana* **from the Hong Kong area (after Voss and Williamson, 1971)**

Squid and cuttlefish are caught at night from boats, dipped by night under lights, jigged or caught in purse seines or trawls along with fish.

The Philippine statistics, at least until recently, were only obtained from licensed boats of 3 gross tons or over registered with the Bureau of Fisheries; thus the total catch for the islands will be much higher than those given in the tables. Some discussion of the fisheries and a full treatment of the Philippine cephalopod fauna have been given by Voss (1963).

7.13.4 Vietnam

Republic of Vietnam (South)

There are no reliable statistics for the Republic of Vietnam and those available do not break down the data by species or groups. Studies by the FAO survey team (World Fishery, 1970) have shown large quantities of squid present. De Sylva (personal communication) states that fresh cuttlefish accounted for about 5 percent of the produce of fish markets viewed in 1972.

Democratic Republic of Vietnam (North)

No data available.

7.13.5 Thailand

An extensive report has recently been completed on the squid and cuttlefish fisheries in Thailand by Toshifumi Sakurai (1972). Thai fishermen have long taken squid by trap and castnet but only since 1965 has a major fishery been developed. This coincided with the start of trawl fisheries both by pairnet and otter trawl. The rapid development of the fisheries is the result of both a good demand for the product in Thailand and for export and the rapid increase in squid and cuttlefish populations, apparently due to overfishing of scale fish by the trawlers. It thus represents a replacement fishery similar to that of the Saharan Bank.

According to Sakurai there are two species of Loligo and four of Sepia now being exploited but specific identifications are lacking. Both groups are taken by otter trawl, pair trawl, castnet with night light, bamboo stake traps and other means such as handlines and dipnet. The comparative sizes of the catches by the different methods are given in Table 22 taken from Sakurai. The totals do not reflect the total national figures.

Table 22. Catch by type of fishing method (in metric tons)

Species	Year	Total	Otter trawl	Pair trawl	Cast-net	Stake trap	Other methods
Squid	1969	20 818	7 934	11 174	948	379	383
	1970	21 435	10 157	7 718	1 056	2 398	106
	1971	23 259	13 350	8 149	632	608	520
Cuttlefish	1969	10 415	6 851	3 366	35	55	108
	1970	11 326	8 246	3 033	-	-	47
	1971	13 232	9 161	3 809	31	-	231

An examination of the catch by month shows little overall change. The cuttlefish catch remains fairly constant throughout the year while the squid catch drops slightly in January and February with a peak from May to October.

Until 1968, Thailand imported dried squid from Japan. The Thai people had long eaten squid but even today do not desire cuttlefish. Both cuttlefish and squid, however, maintain a price stability in the market. Table 23 reflects the total import-export volume of cephalopods.

Table 23. Import-export of cephalopods (in metric tons)

Year	Import	Export	Year	Import	Export
1960	1 322	-	1965	936	1
1961	1 287	-	1966	712	23
1962	1 207	-	1967	517	2
1963	1 052	-	1968	410	124
1964	1 031	-	1969	423	395
			1970	277	2 905

Table 24 breaks down these categories by country.

Table 24. Import-export of cephalopods by country in 1970 (in metric tons)

Origin for import and destination for export	Import	Export
Hong Kong	4	873
Malaysia	-	67
Singapore	5	97
Khmer Republic	-	6
Japan	0	514
Republic of Korea	262	-
Taiwan	6	-
Belgium	-	25
Denmark	-	0
France	-	407
Italy	-	512
Netherland	-	43
Spain	-	195
U.S.A.	-	165
Australia	-	0
Total	277	2 905

The export of frozen and dried squid and cuttlefish is now second only to the export of shrimp. Apparently octopus does not at present constitute an important part of the catch as no mention is made of it in the report.

7.13.6 Others

Malaysia

Produced 2.1 and 2.6 tons in 1967 and 1968 of cuttlefish "sotong". No other data available.

Khmer Republic, Democratic Republic of Vietnam and Indonesia

No data available.

7.13.7 Potential

Shomura (1970) has discussed the general productivity of southeast Asian waters and noted its low fisheries production (note, however, Thailand above). This may be due partly

to actual lower potential but it is mainly lack of trawler activity in the area. The region is known to have a large number of suitable cephalopod species and to provide a rich habitat. Exploratory fishing should reveal a considerable exploitable stock of the octopod Cistopus indicus and various commercially important cuttlefish.

7.14 Region XIII - Southwestern Pacific

Catch unknown

This region as here defined includes New Zealand, eastern Australia, Tasmania and New Caledonia. Cephalopods generally are not eaten by the people of European descent in the region and the fisheries have been only incidental to other groups of fishes and crustaceans. The recent advent of Japanese and other high seas trawlers into Australian and New Zealand waters has resulted in some significant cephalopod catches off North Island, New Zealand, but amounts are not available and are included under the general category of "high seas" catches in Japanese cephalopod statistics.

The statistics in Table 25 from Australia and Tasmania are derived from Australian fisheries data and are listed by groups and by states.

Table 25. Australian cephalopod landings in tons (original data in pounds) 1966-1970

	NSW	Vic.	Qld.	S.A.	W.A.	Tas.	N.T.	Total
1966-1967								
Octopus	-	14	33	16	1.4	-	-	183
Loligo	-	111			7.3	0.1	-	
Cuttlefish	-	0.1			0.04	-	-	
1967-1968								
Octopus	-	7	-	16	1.1	-	-	180
Loligo	-	115	37		3.4	0.01	-	
Cuttlefish	-	0.18			0.19	-	-	
1968-1969								
Octopus	-	14	-	18	0.61	-	-	185
Loligo	-	106	41		5.5	-	-	
Cuttlefish	-	3	-		-	-	-	
1969-1970								
Octopus	-	28	-	34	0.18	-	-	286
Loligo	-	118	90		13	0.28	-	
Cuttlefish	-	2.2	-		2	-	-	

These data reflect a steadily increasing catch in these waters since 1966. The waters of Australia are rich in cephalopods. Loligo etheridgei has a wide distribution around the continent and numerous cuttlefish of economic quality are found in Australian waters. The cephalopod fauna has been described by Berry (1918), Cotton and Godfrey (1940), Adam and Rees (1966) and is being studied at present by Adam (unpublished). Little or nothing is known of the biology of the squid and cuttlefish. Voss (MS) is studying part of the octopod fauna. New Zealand waters are also rich in cephalopods. Its fauna has been described by Dell (1952, 1959). Both areas have reasonably large concentrations of the ommastrephid squid Nototodarus sloani, the southern counterpart of Todarodes pacificus. The cephalopod fauna of New Caledonia and the surrounding area have recently been described for oceanic forms by Rancurel (1970) based upon mid-water trawl samples and tuna stomach contents analysis.

Much exploratory fishing is needed before valid estimates can be made of the cephalopod potential productivity of this region but it seems not unreasonable to estimate a potential of several hundred thousand tons.

7.15 Region XIV - Oceania

Catch unknown

The area of Oceania includes all of the Central Pacific Islands from Hawaii south through the low islands and westward to include Melanesia and Micronesia, but not the large islands of the East Indies. The islands of Oceania are either volcanic oceanic high islands or low atolls; in either case they have no shallow shelf areas in which to prosecute a fisheries. The local people in all areas support a subsistence fishery which is either pelagic or coral reef and lagoon-based, offering very limited habitats for shallow water cephalopods. Without a highly productive shelf and slope area, stocks of oceanic ommastrephid species are probably smaller than off continental areas and are more dispersed. An exception may be Symplectoteuthis oualaniensis which occurs widely throughout the region. Loliginids do not occur over most of the area except for the ubiquitous Sepioteuthis lessoniana. The important economic group of cuttlefishes does not extend eastward of Australia-Philippines-Japan, despite the strandings of floating shells.

The major species taken in the subsistence fisheries therefore are Sepioteuthis lessoniana and various species of reef octopus, mainly Octopus cyaneus, O. aegina, O. ocellatus, O. vulgaris and numerous others. They are taken by fire fishing at night, hand collected from their dens or caught with cowrie shell lures. The catch over the entire area must be rather large but of insignificant proportions to the world fisheries.

7.16 Region XV - Indian Ocean coastal waters

Catch unknown

Gulland (1970) has described the hydrographic conditions, topography, and general ecology of the region and has stressed the almost total lack of fisheries statistics over the entire region with the possible exception of crustacean (lobster and shrimp) records. He also remarked that there was "little information about the resources of cephalopods in the area, even in comparison with the same data on fish". He estimated that the production in areas of upwelling will include a substantial quantity of squid, "possibly at least several hundreds of thousands of tons". I have been able to find little information on cephalopod resources of the region.

There are no comprehensive reports, even of a systematic nature, on the cephalopods of the Indian Ocean with the exception of the cuttlefish (Adam and Rees, 1966). Other reports deal mainly with the Andaman Sea area (Goodrich, 1896; Massy, 1916; Adam, 1939). The only fisheries report noted is that by Rao (1954) on the Palk Bay area. Silas (1968) reported on the cephalopod resources around India. As this section was being written a small book by Zuev (1971) was received dealing with the resources of the northwestern part of the Indian Ocean. Numerous small systematic and faunistic papers dealing with Indian Ocean cephalopods are listed in this work.

Cephalopods are numerous both in numbers and species throughout most of the coastal waters of the Indian Ocean. Probably over a hundred neritic and benthic species occur throughout the region.

7.16.1 Burma and Bangladesh

There are no statistics or descriptions of the cephalopods or their resources in this area.

7.16.2 India and Sri Lanka

There are several brief accounts of the cephalopod resources of India (Jones, 1970; Silas, 1968; Rao, 1954; Zuev, 1971). According to Jones the following are the main commercial species: the cuttlefish Sepia pharaonis, S. aculeata, S. rostrata, Sepiella inermis; the loliginids Sepioteuthis lessoniana, Loligo indica, L. hardwicki and Loliolus affinis; and the octopods Octopus vulgaris, O. globosus, O. herdmani and O. hongkongensis. According to the same author Sepioteuthis is found more commonly in southern India while Sepia spp. and Octopus spp. are widely distributed on both coasts. The major fishery for Sepioteuthis is in Palk Bay and the Gulf of Mannar where they occur in "enormous" quantities in March through June and are caught in bag seines and by trawlers. In Ramanathapuram District the demand is fairly high and the squid are marketed in all the coastal towns and villages mainly fresh but some are sun-dried. Along the southeastern coast, lines of hundreds of Pterocera shells are set out for octopus which are used as bait for longline fishing for seerfish, carangids, sharks and rays.

7.16.3 Northwestern Indian Ocean

Zuev (1971) has reported upon Soviet investigations of cephalopod resources in the area. He reported 16 species taken in trawl investigations in the region. Of these the following were recommended as occurring in commercial quantities: Loligo duvaucelii, L. edulis, L. sp., Sepia pharaonis, and the ommastrephid Symplectoteuthis oualaniensis. He enumerated 15 regions where cephalopod fisheries might be profitable: the Aden shelf, Ras Fartak, the Gulfs of Cumar, Saucara, Masira, Gvadar, Sonmiani (Arabian Sea), the shallow Saiy-de-Malja, the shelf around the Saishai islands, etc. He reported catches of 200-500 per kg per h of trawling. Symplectoteuthis was reported in large concentrations in the Gulf of Aden and the Arabian Sea. The species of cephalopods in the Red Sea have been reported upon by Adam (1959, 1960).

A paper by Druzhinin (1973) on the fishery resources of the Gulf of Aden lists 11 species of cephalopods caught by bottom trawls in the area: Sepia arabica, S. braggi, S. murrayi, S. pharaonis, S. prashadi, S. trygonina, S. sp., Sepiella cyanea, Loligo duvaucelii and Octopus cyanea. Of these, Sepia pharaonis is very important in the commercial trawl fishery with Loligo duvaucelii second to it.

Sepia pharaonis, the widespread Indo-West Pacific species, occurs on the fishing banks at depths between 19-79 m (according to the trawling of NISSHIN MARU 52). They ranged in mantle length from 7 to 42 cm and weights of 50-4 850 g. The average weight was 1 420 g and length 23.9 cm. The smaller specimens were taken to the west of Ras-Fartak and the largest to the north of this cape in April-May. In August-September the smallest were in the Aden area and the largest to the north of Ras-Fartak. The larger cuttlefish were mostly in the Aden area in April and in the areas to the west and north of Ras-Fartak in September.

The area to the west of Ras-Fartak is the most important area for the fishery. Here the NISSHIN MARU 52 caught 55 410 kg of cuttlefish with an average per hour catch fluctuating between 2 and 1 375 kg. The greatest quantity was caught in the area to the north of Ras-Fartak - 78 084 kg with an average catch varying around 165 kg per tr.h.

Squid were caught in small quantities on all trawl grounds with mantle length of from 5.5 to 25.5 cm. They were trawled in more or less commercial quantities in the Ras-Binnah area, to the east of Ras-Fartak and in Ras-Madraka area; 30 kg, 220 kg and 170 kg respectively were caught.

Japanese commercial trawlers caught about 4 000 tons of cuttlefish during 1970-71. It is thought that the catch could be doubled without destroying the stock.

Squid will be more sought after and the catch can reach 500 and more tons per year. It is possible to catch at least 10 500 tons of cephalopods per year (all this information was taken from Druzhinin, loc. cit.). I believe this is an underestimate and that extensive scale-fish trawling may well result in a replacement fishery of much higher cephalopod stocks.

7.16.4 East Coast of Africa and Malagasy Republic

There are no data on cephalopod resources of this region. Loliginids do not appear to be common but cuttlefish are numerous both as to species and individuals. Octopus cyaneus, O. aegina, O. vulgaris and an as yet unidentified large species from Madagascar and Mozambique are all commonly taken in the widespread subsistence fisheries. Little trawling has been done in the region but undoubtedly the cephalopod by-product would be of significant size. The cephalopods of the South African region have been reported upon by Voss (1962, 1967) and the cuttlefish by Roeleveld (in press).

7.17 Region XVI - The Southern Ocean

Catch unknown

The fisheries potential of the Southern Ocean south of the subtropical convergence has never been investigated except as far as marine mammals are concerned. Little trawling has been done in the area, perhaps the most extensive being that accomplished from the USNS ELTANIN from about the longitude of South Georgia to the westward of the Ross Sea. All of the cephalopods from these continuing cruises are in the possession of the writer and are in the process of being written up.

It is difficult to judge the quantities of ommastrephids in this region. Nets are difficult to use for this family and weather conditions have not permitted much use of other gear. Some stocks of Martialia hyadesi occur in the area opposite South America. Further westward in the Australian-New Zealand region Nototodarus sloani is prevalent. The size of the stocks of neither of these is known but they apparently provide much of the diet of many marine mammals of the region.

The two most numerous squids of the region are oceanic and small, Bathyteuthis abyssicola and Galiteuthis glacialis. Neither are of commercial value.

The genus Octopus is rare in the Southern Ocean, its place being taken by the benthic shelf-dweller Pareledone spp. This genus contains a number of species of small to large octopods, firm-fleshed and potentially valuable. They occur in some numbers on the Antarctic Shelf and northward to the Falkland Islands and the Burwood Bank off southern Patagonia.

Present data indicate large concentrations of cephalopods in the Southern Ocean. However, exploratory studies using commercial gear are necessary before it can be determined if the stocks are usable. No estimate of potential is possible on the meagre data available.

7.18 Region XVII - The oceanic regions beyond the continental shelf

Probably less than 10 percent of the ocean's surface is at present being fished for cephalopods, i.e., that part from the middle of the slope to the shoreline. From this area is taken probably 99 percent of all of our present cephalopod catch. This is derived from benthic and neritic species and those oceanic squids that come inshore during part of their life cycle (Todarodes pacificus, Illex illecebrosus and I. argentinus and Dosidicus gigas).

Thus about 90 percent of the ocean's area is unexploited, yet this is the home of very large numbers of species of cephalopods that seldom stray inshore but spend their entire life cycle in the high seas. A considerable number of these oceanic squids are of a size

and consistency that should make them acceptable commercially. Little is known, however, about their concentrations in the open sea. Reported sightings of large numbers of squid at the sea surface are inconclusive but suggestive. Sperm whales feed largely upon squid (Clarke, 1962, 1962a, 1963; Okutani and Nemoto, 1964, etc.). The species consumed are all of a size and nature indicative of commercial potential. From the distribution and concentrations of sperm whales in former times it can be deduced as to areas worthy of investigation in cephalopod exploratory studies. Rathjen (personal communication) reported the numbers of whales west of the Windward Islands and observed large squid concentrations. The pot-head or pilot whales feed almost exclusively on ommastrephids (Squires, 1957). Another source of information are recent Soviet studies on squid beaks in bottom sediments. Belyaev (1962, 1970) has plotted the distribution and numbers for square metre of beaks on the floor of the North Pacific. Highest concentrations (several 1 000's/m^2) are found along the continental margins but a broad belt across the tropical Pacific contains from 100 to 500 beaks/m^2. This belt conforms to the position of the upwelling or mixing areas along the equatorial current system. Okutani and Nemoto (loc. cit.) noted the high concentration of squid found in the diet of sperm whales to lie in the central part of the Bering Sea along the chain of the Aleutian Islands. These types of evidence indicate large numbers of squids in the open ocean and some, at least, areas of possible importance.

Only a small proportion of the species of oceanic squids are potentially suitable commercially. The total species of oceanic squids of the world have been reviewed by Clarke (1966) and all squids and cuttlefishes by Voss (in press). From the total, the following groups and species may be considered to be potentially important.

Potentially important oceanic squid[a/]

Family Ommastrephidae

- *Ommastrephes pteropus*
- *O. caroli*
- *O. bartrami*
- *Todarodes sagittatus*
- *Illex illecebrosus*
- *Dosidicus gigas*
- *Symplectoteuthis oualaniensis*
- *Nototodarus sloani*

Family Histioteuthidae

- *Histioteuthis bonellii*
- *H. atlantica*
- *H.* spp.

Family Lepidoteuthidae

- *Pholidoteuthis boschmai*
- *P. adami*
- *Martialia hyadesi*

Family Onychoteuthidae

- *Onychoteuthis banksi*
- *Moroteuthis robsoni*
- *M. ingens*
- *M. robustus*
- *Ancistrocheirus lesueuri*

Family Veranyidae

- *Taningia danae*

Family Gonatidae

- *Gonatus fabricii*
- *G. magister*
- *Gonatopsis borealis*

Family Cranchiidae

- *Mesonychoteuthis hamiltoni*

a/ From Clarke (personal communication), Okutani and Nemoto (1964) and files

Clarke (personal communication) considers that the ommastrephids and histioteuthids offer the greatest potential: in colder waters *Gonatus* and *Todarodes* in the north and *Moroteuthis* and *Mesonychoteuthis* in the south. Roper (personal communication) states that the histioteuthids dominated mid-water trawl catches from the WALTER HERWIG in the South Atlantic cruise of 1971, as many as 2-3 dozen specimens per trawl.

The problem of how best to fish the oceanic resources is unresolved. Large trawls such as the Engel's with a 116 ft x 65 ft mouth dimension simply does not do an adequate job on these large, swift animals. Seines may be more effective, especially when used in conjunction with surface or subsurface lights. Open ocean jigging needs to be tried on a systematic basis using a variety of types of jigs. Imaginative experimentation has a high chance of success in this field.

Attempts to assess the potential productivity of the oceanic area have yielded a wide range of estimates (2-100 million tons, Gulland, 1970). Clarke (personal communication) states "From my work on sperm whales I estimate the southern hemisphere population of about half a million individuals eats 40-100 million tons of squid a year. This is based on four methods of estimation and I think 50 million tons is probably a reasonable estimate if one figure is needed".

If we accept Clarke's figure of 50 million tons, which seems conservative, we have a basis for further estimates. Certainly the present state of sperm whales after nearly 200 years of exploitation, represents at least no more than one fifth of its original size, which may have been of the order of 2.5 million for the southern hemisphere. It is also reasonably safe to assume that the stock in the northern hemisphere was approximately one third to a half the size of the stock in the southern hemisphere. Thus the sperm whale predation alone, predicating an original stock of 3 750 000 whales, would consume annually 375 million tons of squid! This does not include the predation of the smaller toothed whales such as the pot-heads or pilot whales that feed almost exclusively upon ommastrephids. Even if we assume, which is almost certainly too high a figure, that the whale stocks consume half of the standing stock, we come up with a stock figure of 750 million tons of oceanic squid. Without the predation pressure of the former whale stocks, the tonnage is probably greater. Boerema (1970) has considered that the estimated 50 000 sperm whales off Peru eat about 1.46 million tons of squid annually. Even with this much lower figure than Clarke's (about 30 tons annual consumption per whale), the standing stock, using similar calculations to those above, would be 204 500 000 tons, by far too low a figure. Taking either of these two figures, both considered conservative by their proponents, the annual potential catch of oceanic squid lies within the range of from 100 million to 300 million tons and probably as high as 500 million tons!

8. TOTAL CEPHALOPOD POTENTIAL PRODUCTION OF THE WORLD'S OCEANS

As has been noted repeatedly in this account, at the present state of our knowledge of the cephalopod fisheries it is difficult to give any reality to our estimates of catch potential. We lack in almost all areas usable data on egg production and distribution, growth, longevity, stock sizes, fishing effort and even landing statistics. Nonetheless, some data are available and some estimates of potential have been made. Table 26 summarizes the catch statistics available for each region and the estimated potential as gathered from various sources or by personal estimate.

It is not improbable that the total cephalopod catch of the world lies somewhere between 1.5 and 2.0 million metric tons at the present time. The estimated potential of the shelf and upper slope regions is probably overconservative and the potential lies between 8.0 to about 12.0 million metric tons.

If the estimates given on oceanic potentials are even approximately correct, the oceanic potential is somewhere between 8 and 60 times that of the shelf region, probably nearer the higher figure. In contrast to estimates of oceanic fish production, these figures are based only upon the larger oceanic squids preyed upon by whales, and does not include the myriad of smaller cephalopods potentially useful for fish meal and fertilizer.

It is obvious that even using the lowest figures given in these discussions that cephalopod potential productivity of the seas is very significant. To harvest the regions of the shelf takes only an expansion of effort as the requirements rise. To harvest that of the open ocean will require ingenuity, imagination, research and development and a greatly increased knowledge of the geographical and depth distribution of the species involved.

Table 26. Landing statistics and estimated potentials for the continental shelf fisheries

Regions	Landings (tons)	Estimated potential (tons)
Northeast Atlantic	12 000	> 100 000
Mediterranean Sea	42 000	100 000
Northwest Atlantic	27 000	500 000
Central Eastern Atlantic	300 000	1 000 000
Caribbean Sea	900	> 100 000
Southeast Atlantic	?	> 200 000
Southwest Atlantic	5 400	500 000
Northeast Pacific	15 000	600 000
Central Eastern Pacific	500	> 100 000
Southeast Pacific	1 000	500 000
Northwest Pacific	1 000 000	2 000 000
Western Central Pacific	40 000	500 000
Southwest Pacific	500	200 000
Oceania	500	500 000
Indian Ocean	500	500 000
Total	1 445 300	> 7 400 000

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