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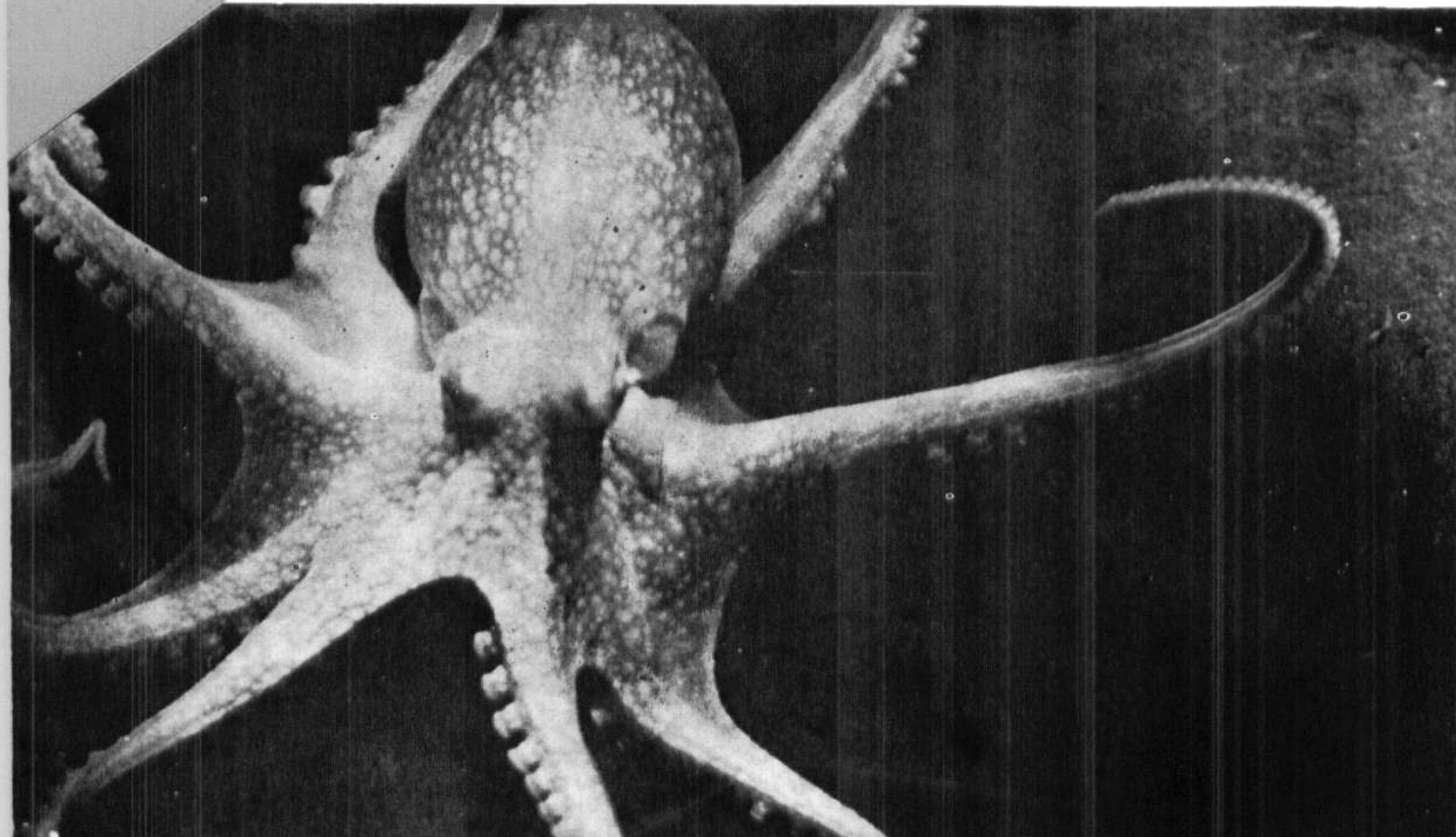

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P.B. No. 2704, Cochin 682 031, India

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PREFACE

The stagnation in marine fish production in the last decade, despite various development measures, has been a matter of concern. The declaration of the Exclusive Economic Zone in 1976 gave high hopes of accelerated augmentation of fish production by planned surveys followed by commercial exploitation. A critical look at the situation throughout the World indicates that beyond the continental shelf in the tropical seas major conventional resources are tunas and tuna-like fishes, billfishes, pelagic sharks and squids. The mix of mesopelagic and bathypelagic species form part of the non-conventional resources. Barring these, the cetaceans are an endangered group, now largely protected. Thus the known conventional commercial resources boil down to two important groups, namely, tunas and squids and cuttlefishes. Squids are also present in the continental shelf waters where cuttlefishes occur as demersal resource.

Squids, cuttlefishes and octopuses thus form an important resource which has been largely neglected hitherto. In fact the squid or the cuttlefish was the first item to be picked up and thrown over board from the trawl catch since the fishermen felt that the ink they squirt would contaminate the shrimp catch. As such, until the mid-seventies there have been considerable constraints working on this resource, leave alone getting catch statistics of squids and cuttlefishes. I recall the days in the sixties when collecting cuttlefish and squids for examination was not considered fashionable. Times have changed and it is deemed very respectable today to handle and work on this resource. The possibilities of export of these animals to Japan in the frozen form from the mid-seventies was an incentive to the fishermen to save squids and cuttlefishes for processing, the animals being picked up and segregated separately in baskets or containers on deck in the mechanised fishing boats.

Along certain coastal areas squids and cuttlefishes have also constituted subsistence fisheries of seasonal nature. Even today there is no internal market for squids and cuttlefishes. It is still the poor man's food along the coast. Thus from a by catch and a discard item to a potentially important resource is a big leap and in this the Central Marine Fisheries Research Institute has substantially contributed to our knowledge on different species, their biology and fisheries.

The first important contribution other than taxonomic reports on cephalopods is that of Shri K. Virabhadra Rao who made a detailed study on the Palk Bay Squid *Sepioteuthis lessionana* (*S. arctipinnis*) published in 1954. Thence on there had been a virtually complete lacuna on cephalopod studies until I took up the work on the cephalopods of the west coast mainly based on the trawl, mid-water and plankton collections made during the cruises of the research vessel VARUNA of the erstwhile Indo-Norwegian Project. This also enabled me to review the state of art of our knowledge on the subject. In view of the squids and cuttlefishes being potentially important as a food resource, I initiated a research project programme in 1976 at the CMFRI with Centres at Veraval, Bombay, Cochin, Vizhinjam, Mandapam, Porto-Novo, Madras, Kakinada and Waltair and in 1979 at Mangalore to monitor and evaluate the catch and abundance of selected species and study the aspects of their biology (Project under Code Number MOL/RE/1.2). The technical programme envisaged was as follows : (1) To study the fishery and biology of species of cephalopods that are landed from mechanised vessels, exploratory and experimental fishing vessels, indigenous craft and other traditional methods. (2) Collection of pelagic oceanic squids in exploratory surveys for studying the extent of resources and spatial and vertical distribution. Their life history studies, distribution and abundance of larval cephalopods in relation to hydrographical factors. (3) To suggest exploitation of suitable species of cuttlefishes and squids on a commercial scale for the purpose of internal consumption and export to foreign markets.

There has been paucity of staff especially those familiar with the identification of cephalopods, but by experience a team of research scientists has been built up to deal with this important marine resource. The participation of the scientific staff in the Project is as follows :

E. G. Silas	Project Leader	Cochin	1976-March, 1981
M. M. Meiyappan	Associate	Cochin	1976-March, 1981
M. V. Jadav	Associate	Veraval	1976-1977
H. Mohmed Kasim	Associate	Veraval	1979-March, 1981
Kuber Vidyasagar	Associate	Bombay	1976-March, 1981
K. Satyanarayana Rao	Associate	Mandapam & Mangalore	1976-March, 1981
K. Prabhakaran Nair	Associate	Vizhinjam	1976-March, 1981
P. Natarajan	Associate	Mandapam	1976
D. Sivalingam	Associate	Mandapam	1979-March, 1981
P. V. Srinivasan	Associate	Porto-Novo	1976-1978
R. Sarvesan	Associate	Madras	1976-March, 1981
Y. Appanna Sastry	Associate	Kakinada	1976-March, 1981

In addition to the scientific personnel the project has also received considerable support from a handful of technical staff. Those who have rendered technical assistance are B. Narayana Rao, Waltair (1976—March 1981), T. A. Omana, Vizhinjam (1976—March 1981), J. P. Karbhari, Veraval (1976), K. A. Unnithan, Mandapam (1976—1978) and D. Nagaraja, Mangalore (1979—March 1981).

The data presented here chiefly refer to the period 1976—March 1981, but work at different centres was taken up at different times, depending upon the availability of personnel, as given below :

Veraval	1976-1977 & 1979-March, 1981
Bombay	1976-March, 1981
Mangalore	1979-March, 1981
Cochin	1976-March, 1981
Vizhinjam	1976-March, 1981
Mandapam	1976-March, 1981
Porto-Novo	1976-1978
Madras	1976-March, 1981
Kakinada	1976-March, 1981
Waltair	1976-March, 1981

For completeness the fishery data have been taken for the period 1968—1984 mostly from the log records of the Fishery Resources Assessment Division. In this work we had valuable support from this Division.

It is hoped that this report will help in developing better monitoring and data acquisition for stock assessment of squid and cuttlefish resources and their judicious exploitation. In short we hope this report will once and for all establish that we have to give due importance to squids and cuttlefishes as a major food resource and foreign exchange earner.

I take this opportunity to sincerely thank my colleagues both scientific and technical, who were associated with me in this Project at various stages. The expertise developed through this exercise, I am sure, will go a long way in helping towards the rational utilization and management of this potentially important resource.

Cochin,
7 June, 1985.

E. G. Silas,
Project Leader (MOL/RE/1.2) and
Director,
Central Marine Fisheries
Research Institute,
Cochin.

1

CEPHALOPOD FISHERIES OF INDIA—AN INTRODUCTION TO THE SUBJECT WITH METHODOLOGIES ADOPTED FOR THIS STUDY

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ABSTRACT

The world production of cephalopods is briefly reviewed with observations on the situation in India. The methodologies adopted for the present studies on the taxonomy, aspects of biology and stock assessment of the resources of squids and cuttlefishes in some of our fishing grounds are outlined. For fully utilizing the resources the need for a close link up of product development and marketing with resource surveys and commercial harvesting is stressed.

INTRODUCTION

Three recent publications on cephalopods of the world oceans have helped to focus greater attention on squids, cuttlefishes and octopods, considered in many areas as non-conventional resources. The Report on ' Stock Assessment of Cephalopod Resources Fished by Japan ' (Okutani, 1977) ; ' Advances in Assessment of World Cephalopod Resources ' (Ed. Caddy, 1983a) and ' Cephalopods of the World—An annotated and Illustrated Catalogue of Species of Interest to Fisheries ' (Roper *et al.*, 1984) have in a way updated our knowledge of this lesser exploited resource. Countries such as Japan, Spain, the Republic of Korea, Thailand and the U.S.S.R. have established squid, cuttlefish and octopod fisheries. With the advent of the Law of the Sea and the declaration of the Exclusive Economic Zone (EEZ) by many nations, the cephalopod resource is gaining considerable importance from mere subsistence fisheries to directed fisheries in many developing countries and Island States.

In the oceanic waters cephalopods are second only to Tunas and Billfishes. Voss (1973) estimated the cephalopod potential from the continental shelf and slope as 8 to 12 million tons and opined that in oceanic waters the Oegopsid squids' potential could be 8 to 60 times that of the neritic shelf resources. While these are optimistic figures, we may also take into consideration that large areas of the world oceans have never been sampled for cephalopod resources although indirect information of occurrence and abundance is available from the food of toothed whales or from the occurrence and distribution of larval forms collected during international expeditions. Squids and cuttlefishes are short-lived species and the improved methods of stock assessments that are being evolved should help eventually in giving a more realistic picture of the resource. Today the world production of cephalopods stands around 1.5 million tonnes, and as mentioned earlier, in many countries cephalopods form only subsistence fisheries. In view of the possibilities of export earnings and the development of new markets for cephalopods, in the recent past, a number of countries have started cephalopod fisheries or intend doing so in the immediate future. Cephalopods, particularly cuttlefishes have in many areas in tropical waters formed an important by-catch in the shrimp fisheries. For long these have been discarded and only now efforts are made to use this also for processing and product development.

WORLD CEPHALOPOD PRODUCTION

The annual estimated World production of cephalopods has fluctuated during 1977-'81 between 0.98 (1977) and 1.5 million (1981) tonnes (Year Book of Fishery Statistics, F.A.O., 1983). Of this about three fourths catch has been squids, both from neritic and oceanic waters (0.71 to 1.16 million tonnes). The cuttlefish catch has fluctuated between 0.1 and 0.2 million tonnes while octopods have ranged between 0.15 and 0.19 million tonnes.

Japan ranks as the leading cephalopod fishing country of the world with an average annual production of 604,734 t during 1977-'81, followed by Spain (111,430 t), Republic of Korea (109,992 t), Thailand (81,115 t) and China (60,025 t). The other countries in the order of production are U.S.S.R., Canada, Italy, Argentina and Philippines. The high production is achieved by Japan not only from her waters but also from distant water fishing operations, using diverse gears such as mechanised jigs with light fishing, drift nets and trolling lines. The Ommastrephid squid *Todarodes pacificus* is the most important species of the catches. Spain is the second largest cephalopod producing country with an annual production ranging between 102,117 to and 130,904 t and Republic of Korea third with yearly production of 69,883 t to 145,265 t. India's average annual production of 12,370 t (C.M.F.R.I., 1982) shows that the country ranks seventeenth in the World in cephalopod production.

World Squid Landings

The annual World squid landings ranged from 845,110 t to 1,169,308 t during 1977-'81 and contributed 73.3% of the total cephalopod landings. In squid production also Japan is the leading country with an average annual production of 526,888 t. China is second with landings of 60,024 and Republic of Korea third with 56,312 t. The other squid producing countries in the order of production are U.S.S.R., Thailand, Canada, Argentina, Spain, Philippines and U.S.A.

World Cuttlefish Landings

The annual World production of cuttlefish ranged between 178,103 t and 208,013 t and contributed an average of 14.1% to the world cephalopod production. The Republic of Korea is the largest producer of cuttlefish in recent years with an average annual landings of 35,508 t during 1977-81. Thailand is next in importance with an average production of 30,121 t and Spain third with 22,425 t. Japan, Vietnam, Italy, PDR Yemen, Malaysia, Morocco and France are the other countries in the order of importance and their production varied between 4,099 t and 21,097 t.

World Octopod Landings

The world annual production of octopods during the period 1977-'81 varied from 151,790 t to 190,419 t and accounted for 12.6% of the total cephalopod production. Spain is the largest octopus fishing country with an average annual production of 57,885 t followed by Japan (56,749 t). The Republic of Korea ranks third but its production is much lower, being 18,333 t. Italy, Morocco, Thailand, Mexico, Portugal, U.S.S.R and Tunisia are the other important octopus fishing countries and their annual production varied between 3,416 t (Italy) and 11,535 t (Tunisia).

India's Contribution

Cephalopods are fished from the seas around India from very early times and constitute one of the important exploited marine fishery resources of our country at present. The cephalopod landings of India were low, less than 1,400 t until 1972 and have been gradually increasing only from 1973 onwards with the commencement of export of frozen cephalopod products to several countries—a transition from a discard to a quality resource. The production rose steeply from 3,677 t in 1974 to 21,079 t in 1984 with slight fluctuations during 1979-'82. The bulk of the production includes cuttlefishes which account for about 60% and the rest consists of squids and negligible quantities of octopods.

Valuable contributions have been made on the systematics and identity of cephalopods of the Indian region by Goodrich (1896), Massy (1916), Adam (1939b) and Adam and Rees (1966) who have described a number of species of squids, cuttlefishes and octopods. Hornell (1917, 1951) has given an account of the fishing gear and fishery for cephalopods in Madras Presidency. In recent decades the biology and fishery of cephalopods have attracted the attention of some workers in India. Rao (1954) has investigated the morphology, biology and fishery of the Myopsid squid *Sepioteuthis arctipinnis* (= *S. lessoniana*) of the southeast coast of India. Alagarswami (1967) has described the eggs and early developmental stages of *S. arctipinnis*. Silas (1968) has given an exhaustive account of the cephalopod species distributed in the Indian Ocean and the occurrence and abundance of planktonic developmental stages as well as adults collected from the continental shelf waters along the southwest coast of India and the Lakshadweep Sea together with a bibliography of the literature on the subject. Sarvesan (1969b) has given an account of parental care and hatching in *Octopus dollfusi*. Oommen (1971, 1975, 1976, 1977a, b) has carried out studies on the identity and biology of some cephalopods of Cochin area.

Publications such as 'The Cephalopods of the Philippine Island' by Voss (1963), 'A review of systematics and ecology of oceanic squids' by Clarke (1966), 'Cephalopods of Hong Kong' by Voss and Williamson (1971), 'Biology of Cephalopods' by Nixon and Messenger (1977) and 'Octopus' by M. J. Wells (1978) need special mention. Some interesting papers have also been published in the Proceedings of the Symposium on Mollusca conducted by the Marine Biological Association of India at Cochin in 1968.

The report of Filippova (1968) on the distribution of cephalopods in the Indian Ocean; the report of the Fishery Agency of Japan (1976, 1977) on the capture of squids in jigs and hand-lines in the Northern Arabian Sea; the squid jigging feasibility study conducted by the Japan Marine Fisheries Research Centre (1979, 1980) in southwestern Pacific Ocean off the east coast of Tasmania, Bass Strait and the waters off the west coast of Tasmania, the book 'Fisheries of Japan, Squid and Cuttlefish' by Yoshikawa (1978) on the cephalopod resources, gear and utilization in Japan, the reports of erstwhile Exploratory Fisheries Project (1979a, b, c, 1982) about the results of fishing programmes; and the series of papers of Court (1980) and others in *Mar. Fish. Rev.*, 42 on fisheries, processing and utilization of squids in various countries are of great interest in programmes of investigation and exploitation of cephalopod resources in the Indian Ocean.

In February, 1976 India declared an Exclusive Economic Zone extending our jurisdiction up to two hundred nautical miles from the coastline and efforts are necessary to explore and exploit the resources in the vast areas open for fishing. Recognizing the importance of cephalopods as a potential fishery resource which is now not properly exploited, at the Central Marine Fisheries Research Institute I had initiated a major research project on the spatial distribution, fisheries and biological aspects of potentially important species in different areas along the east and west coasts of India. In the present work, our knowledge of the identity, distribution, existing fisheries, results of the exploratory fishing programmes and biological aspects of cephalopods of India are presented comprehensively. It is hoped that this publication will generate greater interest in the systematics, abundance and exploitation of cephalopods in the seas around India and will lead to intensive studies and proper exploitation of the resources.

Plan of Work and Methodologies adopted

In this work the pertinent literature on cephalopods and cephalopod resources of the Indian region have been briefly dealt with in the Chapter on the Resume of work.

In the Chapter on the identity of the common species of cephalopods, identification keys are provided for the field identification of the various potentially important species, with brief descriptions based on a study of the material and relevant literature.

For biological studies of squids and cuttlefishes, random samples were collected at selected centres twice a week for study on aspects such as sex ratio, maturity, spawning, age and growth, length-weight relationship, food and distribution. For studying the maturity and spawning of the squids and cuttlefishes, four stages of maturity—immature, maturing, mature and spawning/spent were recognized based on the appearance of the reproductive organs. In immature male squids the testis is elongate and thin and in immature male cuttlefishes it is small and triangular; the spermatophoric sac and penis are small and spermatophores absent. The ovary of females in stage I is small with small immature ova; the nidamental glands appear as small patch-like structures and the accessory nidamental glands are not discernible. In stage II the maturing stage, the testis is larger and thicker than in the I stage and developing spermatophores are present in the spermatophoric sac; hectocotylization is apparent. In stage II females the ovary is larger and occupies about one fourth of the mantle cavity and ova with reticulate pattern clearly seen; the nidamental glands are larger and lobe-like in squids and pear-shaped in cuttlefishes; accessory nidamental glands are small and not coloured.

In stage III males the testis is mature, fully developed, prominent and spermatophoric sac packed with fully developed spermatophores; the hectocotylus is well developed. In stage III females, the ovary is mature and prominent filling the posterior mantle cavity; the ova are ellipsoidal or ovoid in shape with reticulate surface; the nidamental glands are fully developed, conspicuous, creamy white in colour and with distinct anterior pore; the accessory nidamental glands are orange in colour.

In stage IV males the testis is either thick or thin and the spermatophoric sac is either partly or almost empty; in females the ovary contains loosely disposed ova; ripe ova could be seen in the oviduct. The nidamental glands are creamy white and robust before spawning and flabby in the spent condition. The accessory nidamental glands are of light orange red colour. The size at which 50% of the species matured was considered as the size at first maturity.

Age and growth of different species were determined by studying the modal progression of dorsal mantle length. Using dorsal mantle length frequency data as basic input and assuming the growth of the species following von Bertalanfy's growth formula, growth parameter $L\infty$ and K were estimated by the straight line method suggested by Alagaraja (1984). Stock estimates were made by length cohort analysis of Jones (1981).

Data on the estimated cephalopod production and total marine fish production in various zones of maritime states of India have been obtained from the records of the Fishery Resources Assessment Division of the Central Marine Fisheries Research Institute. The Institute collects data on marine fish landings by a multistage stratified random sample survey design which is a time-space stratified system, and areawise and gearwise production is estimated. For the period 1968-'72, as information on gearwise effort was not always available, the monthly and seasonal variations in the cephalopod landings in various areas and their percentage in total marine fish production alone have been studied. For the period 1973-'77, data on gearwise effort and cephalopod and all fish production in the different areas were available and from these the seasonal, annual and gearwise production in different areas, CPUE and percentage of cephalopods in total marine fish production have been determined.

The cephalopod fishery has been studied in greater detail during 1976-'80 at eleven important centres in the country *viz.*, Waltair (Visakhapatnam), Kakinada, Madras, Portonovo, Mandapam, Rameswaram and Keelakarai on the east coast of India and at Vizhinjam (Trivandrum), Cochin, Mangalore and Bombay on the west coast where biological studies were also made. At these centres the species composition and CPUE have been investigated.

The catch data of the trawlers of the erstwhile Exploratory Fisheries Project (now Fishery Survey of India) based at Bombay and Visakhapatnam have been analysed and the monthwise, annual, areawise and depthwise cephalopod catches, catch rates and percentage in total trawl catches have been studied.

Data on the magnitude and value of cephalopod products exported from India have been taken from the published reports of the Marine Products Export Development Authority, Cochin (MPEDA, 1985) and the annual trends analysed.

The ensuing chapters could form baseline studies of cephalopods of the Indian seas. The effort should be considered as an initiation to a much more enhanced National programme to be closely linked with both the artisanal and commercial fisheries sectors. It is our view that immense potential exists in this sector for the development of major fisheries for squids and cuttlefishes. The projects taken up at the Central Marine Fisheries Research Institute with proper infrastructure facilities in manpower and vessel facilities should help in improved data acquisition, stock assessment of important species and rapid dissemination of results. An active cooperative programme on product development and marketing of cephalopod products both internally and exports should closely be linked with resource surveys and harvesting if we are to take full advantage of our cephalopod resources.

2

RESUME OF THE WORK ON CEPHALOPODS OF THE INDIAN OCEAN

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ABSTRACT

The available literature on the cephalopods of the Indian Ocean with particular reference to those of the Indian Seas has been reviewed under five sections: systematics and distribution, biology, ecology, fishery and resources, and utilization.

INTRODUCTION

The cephalopods of the Indian Ocean have not received as much attention as the other shellfishes and finfishes. Information that is available on the cephalopods is confined mainly to faunistic records and taxonomic studies, besides some isolated accounts on the biology and natural history. With the realisation of their importance as a potential marine resource, concerted attention is now being paid to the study of the biology and ecology as an essential pre-requisite for their better utilization.

The scope of this brief review is to elucidate as much literature as possible on the cephalopods of the Indian Ocean, with particular stress on that in regard to the species of the Indian EEZ. This is not intended to be a complete literature review, but to highlight all essential aspects concerning systematics and distribution, biology, ecology, fishery and resources, and their utilisation.

SYSTEMATICS AND DISTRIBUTION

Noteworthy works on the cephalopods of the Indian Ocean are those of Chun (1910, 1915), Wülker (1920) Robson (1924a, 1924b, 1929, 1932), Massy (1927), Adam (1934, 1938, 1939a, 1939b, 1939c, 1939d, 1954, 1960, 1979), Thore (1945) and Adam and Rees (1966). Among several works dealing with cephalopods of the Atlantic and Pacific Oceans, mention is made of many Indian Ocean species also by Verrill (1881, 1882), Hoyle (1886), Berry (1912), Pfeffer (1912), Sasaki (1929), Pickford (1946, 1949a, 1949b, 1952, 1959), Voss (1956, 1963), Roper (1966) and Roper *et al.*, (1984). The important works pertaining to the cephalopods of the Indian Seas, Sri Lanka and Maldive Archipelago are by Ortmann (1891), Goodrich (1896), Massy (1916), Hoyle (1905), Robson (1921), Winckworth (1926, 1936), Rao (1954) and Silas (1968).

Velain (1877) has recorded the deep sea squid *Architeuthis sancti-pauli* from St. Paul Island in the southern Indian Ocean. Hoyle (1885a, 1885b, 1885c, 1885d, 1885e, 1886, 1904a, 1904b, 1905, 1907a, 1907b), has given an exhaustive account of many cephalopod collections from the H. M. S. Challenger Expedition, the specimens collected by Prof. Herdman from Sri Lanka in 1902, and the cephalopods of the Laccadive and Maldive Archipelagos. Robson's (1921, 1924a, 1924b, 1926a, 1926b, 1929, 1932) works also include cephalopods of many parts of the Indian Ocean. Winckworth (1926, 1936) has reported on the cephalopods around Sri Lanka and described *Sepia prashadi* from Madras waters.

Goodrich (1896), based on the collection of cephalopods in the Indian Museum, has described 18 species of decapods and 10 species of octopods, of which 11 were new species. Subsequently Massy (1916) has described 43 species in detail with morphometric measurements of many of them; *Sepia arabica* has been described as a new species. Most of these cephalopods were taken in the INVESTIGATOR Expedition off the Indian and Burmese coasts at depths of 9 m to 1,723 m. In a major revision of nomenclature of many of the cephalopods in the Indian Museum, Adam (1939b) has redescribed 53 species under 23 genera. These and some unidentified species number 65 till that time. Gravely (1941) identified six species of cuttlefish under the family Sepiidae from shells (cuttlebone) washed ashore along the Madras beach. Satyamurthi (1956) described three sepiids and two loliginids from Krusadai Island. Moses (1948, 1949) published preliminary reports on the cephalopods *Loligo, Enoploteuthis, Sepia, Sepiola, Octopus* and shells of *Spirula* and *Nautilus* in the erstwhile Baroda State.

Sasaki's (1929) monograph of the dibranchiate cephalopods, though mainly of the Japanese and adjacent water species, includes cephalopods that are also distributed in the Indian Ocean. Based on the collection of cephalopods of the ALBATROSS Expedition in the Philippine Islands, Voss (1963) has described 46 species, among them many occurring in the Indian Ocean. The classical review of the family Sepiidae by Adam and Rees (1966) includes many Indian Ocean species. Adam (1979) has given a detailed systematic account of many species of sepiids of west Australian waters in the Southeast Indian Ocean.

Pickford (1959) has mapped 15 known records of the deep water octopod *Vampyroteuthis infernalis* from the Indian Ocean collected by the INVESTIGATOR, DANA, DISCOVERY and GALATHEA Expeditions. Adam's (1965) redescription of two sepiids from the Indian Ocean, viz. *Sepia recurvirostra* and *Sepia brevimana*, was followed by Burgess's (1967) record of a new species of squid, *Loliolus rhomboidalis*, from Bay of Bengal collected by R. V. ANTON BRUUN during the International Indian Ocean Expedition. Maes (1967) has collected shells of *Nautilus pompilius* from the Cocos-Keeling Islands in the Indian Ocean ; *Sepioteuthis lessoniana, Octopus cyanea* and an unidentified species of *Octopus* also were recorded from these islands. Clarke's (1966) monumental review of the systematics and ecology of oceanic squids includes about fifty species which are distributed in the Indian Ocean ; this work deals with the distribution, eggs, larvae, juveniles, growth, maturity, egg-laying, food, predators as well as economic uses of many of the species.

A great and long-felt need in compiling a list bringing together all the known cephalopods of the Indian Ocean has been fulfilled by Silas (1968), who has catalogued 201 species, including the dibranchiate cephalopods collected by him from the west coast of India and the Laccadive Sea during the cruises of R. V. VARUNA. This work gives the synonyms, distribution and references for the taxonomic discussion of each species. This also extends the distributional records of five oegopsid squids and one octopod to the Arabian and Lakshadweep Seas.

Filippova (1968) has reported on the extensive collection of cephalopods made by the research vessels VITYAZ, ACADEMICIAN KNIPOVITCH and SOVETSKAJA ROSSIA from the Indian Ocean upto 41° S. Of these collections, eight species are recorded for the first time from the Indian Ocean. A clear latitudinal zonality in the distribution of the ommastrephid squids is established : while *Symplectoteuthis oualaniensis* inhabits the tropical waters within 20° S, *Ommastrephes bartrami*, together with *Todarodes sagittatus angolensis* occur in the areas between 20° S and 37° S, and further southwards upto 41° S the third species becomes dominant.

Oommen (1966, 1967, 1971, 1973, 1975, 1976, 1977a) has recorded many cephalopods of the families Sepiolidae (one species), Loliginidae (two species), Opisthoteuthidae (one species), Octopodidae (five species), and Argonautidae (one species) from the Arabian Sea. Of these, *Opisthoteuthis philippi* is a new species collected from a depth of 275-365 m off Alleppey on the southwest coast of India and this is the third species of *Opisthoteuthis*, the other two being *Opisthoteuthis extensa* collected off Sumatra and *Opisthoteuthis medusoides* obtained off East Africa (Thiele, 1915). Of the five species of Octopodidae, *Octopus varunae, Berrya keralensis* and *Berrya annae* are new species described by Oommen. He has also recorded the octopod *Argonauta argo* for the first time from the Arabian Sea (Oommen, 1980).

Sarvesan (1969a) has listed 33 species of cephalopods under 9 families in the Reference Collection Museum of the Central Marine Fisheries Research Institute. Okutani (1970, 1973a) has described three species of squids (*Sepioteuthis lessoniana, Doryteuthis singhalensis* and *Symplectoteuthis oualaniensis*) from the Seychelles Bank in the Indian Ocean, and made a preliminary note of the planktonic cephalopods belonging to the oegopsid families Enoploteuthidae, Brachioteuthidae and Cranchiidae, collected during the International Indian Ocean Expedition. Chandra Mohan and Rao (1978) have recorded the occurrence of *Sepiela oweniana* off Visakhapatnam.

The cephalopods of the Red Sea and the Gulf of Aqaba have been reviewed by Adam (1959, 1960). In a subsequent work he (Adam, 1973) has enumerated 23 species, 6 of which where reported from the area for the first time. Mienis (1978) has recorded two species of *Argonauta* and one species of *Spirula* from the Red Sea. Voss (1962, 1967) has reported on the bathypelagic and other cephalopods of South Africa. Pickford (1974) has discussed the taxonomic status of *Cistopus indicus*, a common Indo-Malayan species of octopod. Again, Adam (1975) has described a new species of ommastrephid squid, *Todarodes filippovae*, from the Indian Ocean. Sanjeeva Raj and Kalyani (1971) have recorded the squid *Euprymna morsei* from Madras coast, together with a redescription of the species. Based on the plankton collections of the International Indian Ocean Expedition, Aravindakshan and Saktivel (1973) have broadly indicated the areas of occurrence and abundance of planktonic cephalopods in the Indian Ocean. Sarvesan (1976) has extended the distributional record of the cuttlefish *Sepia trygonina* by describing it from the Gulf of Mannar. Rao (1977) has given the faunistic distribution of cephalopods of Digha Coast, Bay of Bengal. Ray (1937) recorded *Loligo duvaucelii* from Burma for the first time, and Imber (1978) described a new species, *Gonatus phoebetriae*, from an Indian Ocean Island. Taki (1981) has given a catalogue of the cephalopods of Wakayama Prefecture, which includes many species that are also distributed in the Indian Ocean.

BIOLOGY

In his pioneering work on the biology of the Palk Bay squid *Sepioteuthis arctipinnis* (=*Sepioteuthis lessoniana*), Rao (1954) has studied the growth and longevity, length-weight relationship, age and size at sexual maturity, food and feeding habits, and spawning. Alagarswami (1966) has described its egg clusters, egg capsule, egg and the newly hatched young ones. Rahaman (1968, 1980) has studied the gonad and hepatic indices, sexual maturation and spawning of this squid and also of the cuttlefish *Sepia aculeata*. Karnekamp (1979) reported on the shell growth and aberrent shape of the shell of *Sepia gibba* from the Red Sea. Some biological aspects such as age and growth, length-weight relationship, stages of maturity and food and feeding habits of the cuttlefish *Sepiella inermis* of Mandapam area on the southeast coast of India were studied by Unnithan (1982).

Nagabhushanam (1968a, 1968b) has reviewed the studies on the physiology of chromatophores in cephalopods and on the neurosecretion in cephalopods as well as other molluscs. The calcium, strontium and radium contents of the cuttlebone of *Sepia* have been estimated by Rao and Viswanathan (1968). Pandit and Magar (1972) and Suryanarayan and Alexander (1980) have estimated the chemical composition of some cephalopods from Indian waters.

The spawning grounds of the cuttlefish *Sepia pharaonis* have been located off Orissa and Visakhapatnam coasts (FAO UN, 1961). Sarvesan (1969b) has observed the breeding behaviour and hatching process of *Octopus dollfusi*. Sivalingam and Pillai (1980) have discussed the breeding season and hatching of the squid *Sepioteuthis arctipinnis* and the hatching of the cuttlefish *Sepia aculeata*.

Oommen (1977b) has given a detailed account of the functional morphology and food and feeding of the squid *Loligo duvaucelii* and the cuttlefishes *Sepia aculeata* and *Sepiella inermis* collected off the west coast of India. He has further noticed cannibalism in some of the species. Kore and Joshi (1975) also observed cannibalism in *Loligo duvaucelii*. Jothinayagam (1981) has studied the seasonal abundance, sex ratio, maturity stages and food habits of *Sepiella inermis* of the Madras coast.

ECOLOGY

In the ' Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Mannar ', Herdman (1903-1906) has mentioned that the octopods are abundant in some of the pearl banks of Tuticorin and that they are well-known to live at the expense of oysters and mussels. Mahadevan and Nair (1967, 1974) have found that the octopod *Polypus* (=*Octopus*) sp. inhabits the pits and crevices in the pearl banks of Gulf of Mannar, and sometimes it haunts the empty shell of oysters ; it is often seen opening the shell of live pearl oysters to eat the flesh, and is considered as one of the predators of pearl oyster. Sarvesan (1974) also mentions that *Octopus herdmani* preys upon pearl oysters, and that another small poisonous octopod is dangerous because of its bite, rendering it unsuitable for use as food or bait.

Tampi (1959) has recorded that in the salt water lagoons of Mandapam the young ones of the squid *Sepioteuthis arctipinnis*, and occasionally *Loligo* sp., occur early in the year when the water level is high.

Gopalakrishnan (1970), while studying the shore ecology of Okha on the northwest coast of India, has noticed *Octopus* sp. and *Sepia* sp. in the midlittoral reef region, hiding in rock crevices and submerged pools ; he has also observed a large number of cuttlebones washed ashore.

In the ' Report on Cruise of the R. V. SHOYO MARU in the North Arabian Sea Survey ', it has been recorded that the oceanic squid *Symplectoteuthis oualaniensis* seems to avoid the upwelling areas ; it sinks in the low-oxygen layer, in day time but moves to the oxygen-saturated upper layers at night for feeding (Fishery Agency of Japan, 1976, 1977 ; Yamanaka *et al*., 1976). Silas (1969a) records that during the exploratory fishing by R. V. VARUNA, schools of *Symplectoteuthis ouala-*

niensis have been attracted by light towards the ship at night and were found to feed on planktonic organisms. Filippova (1968) draws a parallel between this oceanic squid and the tropical epipelagic fishes in their ecology. For both the sub-tropical convergence (18°S to 20°S) seems to be the southern boundary of distribution in the Indian Ocean. She also remarks on the association between the pelagic octopod *Argonauta hians* and the pleiston organisms such as *Velella*, and between the young of another pelagic octopod *Tremoctopus violaceus* and *Physalia*.

There are very few records of parasites on cephalopods. Kalavati *et al.* (1977, 1978) have recorded a microsporidian parasite, *Steinhausis spraguei*, and a mesozoan parasite, *Dicyemmennea coromandelensis*, from the cuttlefish *Sepia elliptica* collected from Bay of Bengal. Belyaeva (1979) mentions about some squids of the Indian Ocean as the intermediate hosts of helminth parasites. A new parasite species, *Aggregata kudoi* was recorded from *Sepia* sp. by Narasimhamurti (1979). A new species of a dicyemid mesozoan parasite under a new genus, *Dodecadicyema loligoi*, has been recorded by Kalavati and Narasimhamurti (1980) from the renal appendages of *Loligo* sp.

The cephalopods are prey of a great variety of fishes, cetaceans and cephalopods themselves. The literature on this prey-predator relationship is rich in that there are numerous references to cephalopods as one of the items of food of many marine fishes. Often the identification of the prey cephalopods to the species or genus level is not possible, and in most references they have been mentioned as cephalopods, squids, cuttlefish, and sometimes as *Loligo*, *Sepia* and *Octopus*. Okada (1933) has observed a single specimen of *Spirula* in the stomach of a yellowfin tuna from Sumatra. According to Mimura *et al.* (1963), octopods formed 46.1% of the food of the yellowfin tuna around 10°S in the East Indian Ocean, and 15.9% in the area around 20°S. Talbot and Penrith (1963) found that *Loligo reynaudi* and *Abralia gilchristi* formed part of the food of *Thunnus alalunga*, *Thunnus albacares* and *Histioteuthis bonellina*; *Loligo reynaudi* was noticed in the stomach of *Thunnus obesus*, and various species of squids in the food of *Thunnus thynnus orientalis*. In the stomach contents of the little tuna *Euthynnus affinis* collected from the East African waters, squids were found to occur as part of the food (Williams, 1963). Okutani and Suzuki (1975) have noticed the bathypelagic *Spirula spirula* and the epipelagic *Argonauta bottgeri* in the stomach of a single yellowfin tuna taken off the southern coast of Sri Lanka.

Williams (1964, 1967) has found the following fishes caught in long lines off East Africa to feed on cephalopods: *Carcharhinus amblyrhynchus*, *Thunnus albacares*, *Thunnus alalunga*, *Euthynnus affinis*, *Tetrapterus audax*, *Istiophorus gladius*, *Acanthocybium solandri* and *Alepisaurus ferrox*. They formed upto 44% of the stomach contents. Mienis (1977) has observed squid in the stomach contents of the deep water shark *Iago omanensis* from the Arabian Sea.

Many workers have recorded cephalopods in the stomach contents of scombroid fishes of the Indian Seas. Raju (1964) has observed that cephalopods formed 21.8% by volume of the food of the skipjack caught in pole and line off Minicoy, Lakshadweep, and that in the stomachs of this fish below the size of 400 mm (TL) there were no cephalopods, between 401 mm and 550 mm they formed 19.4%, between 551 mm and 700 mm 25.2%, and above 700 mm, 37.8%. Silas (1963) mentions about squids as a food item of the dog-tooth tuna *Gymnosarda unicolor*. Kumaran (1964) has recorded that *Sepioteuthis* sp. and *Loligo* sp. formed food of *Euthynnus affinis affinis* collected from Vizhinjam (upto 56.5%) and larger individuals of *Auxis thazard* and *Auxis thynnoides* (upto 22.7%). Squids and *Octopus* formed substantial portion (upto 75% by volume) of the stomach contents of *Katsuwonus pelamis* of the Laccadive Sea (Raju 1964). Rao (1964) has observed cephalopods in the food of adult *Scomberomorus guttatus* landed at Lawson's Bay, Waltair.

Among threadfins, the adult *Polynemus indicus* has been found to have fed on *Sepia* and *Octopus* by Karekar and Bal (1958), and *Polynemus heptadactylus* on *Sepia* sp. by Kagwade (1969).

James (1967) has observed young of *Sepia* and *Octopus* in the stomach contents of ribbon fishes collected from the Palk Bay and Gulf of Mannar. Cuttlefish remains have been noticed by Sivaprakasam (1967) in the food of *Parastromateus niger* at Veraval on the Northwest coast of India. Suseelan and Nair (1969) have found cephalopods to form part of the food of many demersal fishes of Bomaby coast: *Pseudosciaena diacanthus*, *Otolithoides brunneus*, *Otolithus rubex*, *Johnius dussamieri*, *Johnius axillaris*, *Pomadasys hasta*, *Muraenesox talabonoides* and *Arius thalassinus*. The 'ghol' *Pseudosciaena diacanthus* of Bombay waters (Rao, 1968), the catfish *Tachysurus thalassinus* of Waltair coast (Mojumder, 1969), *Pomadasys hasta* of Bombay and Gujarat coasts (Deshmukh, 1973), the deep sea shark *Haleolurus hispidus*, *Eridancis radcliffei* and *Iago omanensis* collected from a depth of 150-200 fathoms (273-364 m) off the southeast coast of India (Nair and Appukuttan, 1973), the juveniles of the flatfish *Psettodes erumei* and the eel *Muraenesox cinereus* of Portonovo coast (Devadoss and Pillai, 1973, 1979), the flat fishes

Psettodes erumei and *Pseudorhombus arsius* of the same coast (Natarajan and Natarajan, 1980), the juveniles (42-53 cm) of *Otolithoides brunneus* of Bombay waters (Jayaprakash, 1974), the torpedo travelly *Megalaspis cordyla* of Vizhinjam coast (Sreenivasan, 1974), the carangid *Decapterus dayi* of the same coast (George *et al.*, 1976) and the catfish *Tachysurus tenuispinis* collected in trawl nets off Visakhapatnam (Mojumder and Dan, 1979) have been reported to have consumed cephalopods as food.

Rabindranath (1966) has recorded cephalopods in the stomach contents of *Rastrelliger kanagurta, Decapterus russelli, Auxis thazard, Otolithus argentius, Caranx crumenophthalmus, Selaroides leptolepis, Selar kalla Sphyraena acutipinnis, Indocybium guttatum, Cybium commersoni, Saurida tumbil, Chirocentrus dorab,* and *Nemipterus furcosus* collected mostly from Trivandrum coast and partly from Quilon and Cochin coasts of Kerala. Cephalopods formed 2.7% of the gut contents of the 'velameen' *Pristipomoides argurogammicus* taken off the southwest coast of India (Oommen, 1976).

Thus it will be seen that cephalopods form an important forage for several species of fishes and a very significant constituent of the food of tunas and billfishes.

Cephalopods, especially squids, are a very favourite food of sperm whales. According to Matthews (1938), cephalopods formed part of the food of sperm whales caught off Southeastern Africa, and Hollis (1939) recorded octopods as well as squid species of the genera *Moroteuthis, Histioteuthis, Stenoteuthis* and *Architeuthis* from the stomachs of sperm whales from west and northwest Australian waters. Based on a large number of beaks collected from the stomachs of sperm whales caught off Durban (South Africa), Albany (Western Australia) and the yellowfin tuna *Thunnus albacares* caught off East Africa, Clarke (1977) reported that many species of squids belonging to the families Histioteuthidae, Cycloteuthidae, Ommastrephidae, Pholidoteuthidae, Octopoteuthidae and Cranchiidae formed food of sperm whales and Enoploteuthidae and Ommastrphidae that of tunas. He has also made a rough estimate of the total weight of cepahlopods consumed by sperm whales in a year and briefly mentioned about their importance in the ecology of the oceans. In regard to the Indian waters, Silas *et al.*, (1985) have recorded that *Chiroteuthis* formed part of food of the sperm whale *Physeter macrocephalus* stranded on the east coast of India.

Fishery and Resources

Hornell (1917), in his account of the edible molluscs of Madras Presidency, states that the cephalopod fishery was then restricted to the Palk Bay, where the squid *Loligo* (= *Sepioteuthis lessoniana*) was caught in a special type of shore seine, locally called 'ola valai', (upto 5,000 squids in a single haul), and in a type of hand jig operated in the shallow areas. He also makes mention of the commercially important cephalopods of South India in general (Hornell, 1922, 1951). Rao's (1954) account of the Palk Bay squid describes the fishing methods adopted in this region and also gives the fishing seasons. Krishnamurthi (1957) also records that these squids are taken in shore seines in the Palk Bay area where they come to shallow waters for depositing their eggs among seaweeds. Light fishing experiments were conducted in the Gulf of Mannar, and squids along with clupeoids and half-beaks formed the main catch (CMFRI, 1957). Chellappa (1959) has given an account of the light fishing experiments conducted in the same area with the aid of a 'kelong' and a 300-candle power kerosene petromax lamp, in which squids were one of the important items of the catch. Jones (1968) lists the edible cephalopods of India and briefly mentions about their importance as an incidental catch in the marine fish landings. Rao (1958, 1969a, 1969b, 1973) mentions the important species of cephalopods that are obtained in the fish landings in India, and refers to the Palk Bay and Gulf of Mannar squid and octopod fishery, pointing to the need to develop the fishery not only as a source of food but also to prevent young shoaling fishes from being preyed upon by squids. Passing mention of this localised fishery is also made in a review of the fishery resources of India (CSIR, 1962). Prasad and Nair (1973) also refer to the seasonal squid fishery in the Palk Bay and Gulf of Mannar.

Giving a preliminary account of the fisheries of Vizhinjam, Nair (1958) records the catch of *Sepia* for 1950-'54. Radhakrishnan (1973) recognises Vizhinjam area as an important centre of cephalopod landings. Jayabalan and Ramamurthi (1977) give a brief account of the fishery and relative abundance of cephalopods at Portonovo. Varghese (1981), discussing the present status of small-scale fisheries in Lakshadweep, gives the landings data of *Octopus* spp. for the period 1973-77. Rayudu and Chandramohan (1982) briefly mention about the cephalopod fishery of Visakhapatnam.

Many workers have recorded cephalopods in the catches taken in trawl fishing in the various parts of the seas around India. Tholasilingam *et al.* (1968) record the squid catches obtained in exploratory trawl fishing conducted in depths of 274-474 m off Alleppey. Rao and Dorairaj (1968) have indicated the productive areas for cephalopods off Goa, and from the catch/

hour data they have also estimated the potential yield of the area. Bapat *et al.* (1972) have observed cuttlefish in the trawl catches of Karwar. In the northwestern part of the Bay of Bengal squids were caught in exploratory trawl fishing on the continental shelf area at a depth of 15-128 m (Sekharan *et al.*, 1973). In Kakinada region they formed 0.95% to 1.22% of the total demersal fish catch (Muthu *et al.*, 1975; Narasimham *et al.*, 1979). In the trawl surveys off Visakhapatnam during 1972-78 by the Fishery Survey of India (previously, Exploratory Fisheries Project), cephalopods contributed 1.2% of the total catch (CMFRI, 1980).

The trawl survey conducted by M.T. MURAENA in area between 15°N and 24°N off the northwest coast of India during 1977 revealed the occurrence of cephalopods which formed 0.2% of the total trawl catch (Bapat *et al.*, 1982). *Sepia aculeata*, *Sepia pharaonis* and *Loligo duvaucelii* constituted the bulk of the catch.

The UNDP/FAO Pelagic Fishery Project surveys on the southwest coast of India has revealed the occurrence of cephalopods in normal to good quantities (UNDP/FAO, 1974a, 1974b, 1976a, 1976b, 1976c, 1976d, 1977). In pelagic trawling squids formed upto 34% in Quilon-Kanyakumari and Gulf of Mannar areas, upto 50% in Quilon-Mangalore area and upto 25% in Mangalore-Ratnagiri area. In bottom trawling also they formed upto 50% of the total catch in the southern areas. There is also mention of the traditional coastal fishery of Trivandrum, locally called 'nonnavu' fishery, in which post-larval and early juvenile stages of various fishes together with young cephalopods and sergestids are caught. The trawlers of the Fishery Survey of India have surveyed areas off Bombay and Gujarat coasts, off Kerala and the Wadge Bank on the southwest coast, and these surveys revealed good concentration of squids and cuttlefishes (EFP, 1979a, 1979b, 1979c, 1982; Sulochanan and John, 1982).

The importance of the oceanic squids as a potential resource has been pointed out by Silas (1969b), stressing the need to exploit them by India. In a detailed report on the exploratory fishing by R. V. VARUNA and other vessels in the neritic deep waters and the upper continental slope (75-450 m) between 8°N and 14°N on the southwest coast of India, Silas (1969a) has recorded that cephalopods formed a major group in the trawl catches. The drift net fishing surveys conducted between 7°-15°N and 71°-78°E revealed the occurrence and abundance of the oceanic squid *Symplectoteuthis oualaniensis*; its concentrations were noticed beyond 180 m depth off Trivandrum-Cochin area, and off Calicut upto 14°N and also in deeper waters between 10°-12°N and 72°-73°E. The deep water octopod *Berrya keralensis* has been recorded in small quantities in trawl catches from continental slope at 200-350 m depth off Kerala coast, and *Sepia* spp. at 75-350 m from the same area.

Silas *et al.* (1976) drew attention to the importance of cephalopods as a potential resource, at present obtained as a bye-catch and earlier discarded at sea owing to lack of local demand and to prevent contamination of fish and shrimp catches with their ink. These authors have also stressed the need to exploit the commercially important squid and cuttlefish resources including the oceanic squid *Symplectoteuthis oualaniensis.*

Hida and Pereyra (1966) have recorded cephalopods in the catches taken in bottom trawling by ANTON BRUUN in 1963 from Thailand, Andaman Islands, Burma, Bangladesh, India, Pakistan, Oman and Arabia. Druzhinin (1972) has recorded squids in the trawl catches from southern Burmese waters in the Bay of Bengal. According to Zupanovic and Mohiuddin (1973), *Sepia* sp. and *Loligo* sp. were obtained from a depth of 46-123 m and *Octopus* sp. from 80-125 m in trawl survey in the northeastern Arabian Sea off Pakistan. The Norwegian vessel, R/V Dr. FRIDTJOF NANSEN, which surveyed North Arabian Sea, has frequently taken the oceanic squid *Symplectoteuthis oualaniensis* in such quantities as 8 kg at 21°57'N, 62° 41'E and 58 kg at 23° 37'N, 59° 22'E. (Institute of Marine Research, 1975). The Fishery Agency of Japan (1976, 1977) and Yamanaka *et al.* (1976) report that one of the most important findings during the cruise of R. V. SHOYO MARU in the North Arabian Sea Survey to assess the pelagic fish stocks is the occurrence of the potential pelagic squid *Symplectoteuthis oualaniensis* (23-50 cm) taken in jig fishing from wide areas in the North Arabian Sea and central portion of the South Arabian Sea. Sanders and Bouhlel (1981, 1983) have conducted experiments to determine the mesh selection properties of trawl cod ends of various mesh sizes involving alternate haul method for the exploitation of the cuttlefish *Sepia pharaonis* in the PDR Yemen.

Dayaratne (1978) has studied the cuttlefish catches from the Wadge Bank trawl fishery. The species (*Sepia pharaonis*) in the range of 10-36 cm was taken at depths of 33-69 m from the area.

Sarvesan (1974) has briefly reviewed the fishing methods by which cephalopods are caught in India. These include fishing with shore seines, boat seines hooks and lines, hand lines, trawl nets and shore trap, for octopods.

In India cephalopods form nearly 4% of the total bye-catch in the shrimp fisheries, the States of Maharashtra, Gujarat and Kerala accounting for the substantial portion of the catch (CMFRI, 1981). Silas *et al.* (1982) have briefly dealt with the magnitude of cephalopod landings in India (11,335 tonnes in 1980) and constituent states and the prospects for increasing production.

Regarding the potential cephalopod resources of the Indian Ocean, our information is very limited. Gulland (1970) estimates it to be over several hundreds of thousands of tonnes. Voss (1973) puts the potential at 500,000 tonnes and Tussing (1974), recognising cephalopods as one of the categories which forms a resource, also gives about the same estimate. Still another proposition is 200,000 tonnes (Anon, 1977).

Belyaev (1962) observed that cephalopod beaks are abundant in the sediment in the northwestern part of the Indian Ocean, upto a maximum 15,000 beaks/m². According to Zuev and Nesis (1971) this abundant distribution of beaks and the hydrographical conditions like upwelling are clear indications of the rich cephalopod resources in the pelagic zone of the Arabian Sea. Based on Soviet investigations in the northwestern part of the Indian Ocean, Zuev (1971) has identified *Loligo duvaucelii, Loligo edulis, Loligo* sp., *Symplectoteuthis oualaniensis* and *Sepia pharaonis* as occurring in commercial quantities and also suggested some potential regions. Druzhinin (1973), giving an account of the fishery resources of the Gulf of Aden, estimates a potential of 10,500 tonnes for this area, which Voss (1973) considers an underestimate. Discussing the present condition of the exploitation and the latent stock of the cephalopod resources of the world, Okutani (1973b) suggests *Sepia pharaonis* and *Symplectoteuthis oulaniensis* as the latent species in the western Indian Ocean and *Sepia* spp. and *Nototodarus sloani* in the eastern Indian Ocean. From the catch and effort data in respect of trawlers operated by Japan, PDR Yemen and U.S.S.R. in the Arabian Sea off the coasts of Yemen, he states that the maximum sustainable yield of cuttlefish in this region might be about 6,500 tonnes, and with the present level of fishing effort the recent fishery has been operating at around the optimum level. Payne (1978) is of the opinion that the stocks of cephalopods are widely distributed in the Arabian Sea, and that the commercial harvest of cuttlefish is taking place southwest of the Arabian Peninsula. Sanders (1979) has made some preliminary stock assessment studies of the cuttlefish *Sepia pharaonis* taken off the coast of PDR Yemen. Based on the catch and effort data for *Sepia pharaonis* (forming 95% of the cephalopod fishery) and three other Sepiids taken during 1967-1980 Sato and Hatanaka (1983) have estimated the MSY of cuttlefish off PDR Yemen as 8,500 tonnes with an effort of 1,200 standard days.

George *et al.* (1977) have estimated that the cephalopod potential of the Indian Economic Zone would be of the order of 180,000 tonnes; of this 55% would be the contribution from the upper east coast, 11% from the lower east coast, 20% from the southwest coast, 11% from the northwest coast and the remaining 3% from the Laccadive Sea.

For the student reader we would refer a recent book 'Marine Fisheries' by Bal and Rao (1984) which summarizes some aspects of cephalopods and their fisheries in India along with other marine fishery resources of the country.

Apart from the above mentioned references on the fishery and resources of cephalopods of the Indian Ocean, the 'Advances in Assessment of world Cephalopod Resources' (FAO Fisheries Technical Report 231 edited by Caddy (1983) contains some papers dealing with stock assessment of cephalopods. Chikuni (1983) discusses the present status of the cephalopod fishery, potential yield of the neritic species and the problems involved in the future development in the Indo-Pacific region. Worms (1983) reviews the cephalopod fisheries of the north and northwest Indian Ocean among other geographic areas.

Utilization

Except for some periodic reports on cephalopods as an item of the export trade, given by various maritime countries, and for a few stray references to cephalopod products and their marketing in the context of localised fisheries, the literature on their utilization is very scanty. In Hornell's (1917) account on the edible molluscs of Madras Presidency, it was mentioned that the cephalopods were of economic importance in the Palk Bay area both as food and as an item (cuttlebone) of export. Rao (1954) has briefly dealt with the processing of the Palk Bay squid for local market and Mukundan (1968) has referred to the use of the ink of *Sepia* by artists. The several ways of utilization of cephalopods have been mentioned by Sarvesan (1974).

There are many references to cephalopods as an effective bait in the hooks and line fishery (Jones, 1968; Sarvesan, 1974; Silas and Pillai, 1982; Rajagopal *et al.* 1977; 1982). According to Silas and Pillai (1982), squids (*Loligo* spp.) are one of the most important baits in the tuna longline fishery; they have also given the catch data of the southern bluefin, albacore, bigeye and yellowfin taken in squid-baited longlines by the Japanese during 1965-81.

Sreenivasan (1962) has dealt with the bacterial discolouration of squids. Padmanabhan (1970) has discussed the prospects of developing cephalopods into fishery products for internal and export trade and has given the methods of processing and preservation. Sastry and Srikar (1982) have studied the changes in total nitrogen, salt-soluble and water-soluble proteins, non-protein nitrogen and total free amino acids of the cuttlefish *Sepia aculeata* preserved in ice at 0°C over a 14 day period of storage.

Abdulla and Idrus (1978), dealing with the fish processing industry of Peninsular Malaysia, give the quantity of cuttlefish products of the country for 1976. Menon (1978) mentions that frozen squids and cuttlefish are among over 37 major items of marine products exported from India. According to Venkataraman and Devadasan (1978), the increase in the export of cephalopod products fetches good returns to the fishermen of India, and according to Yeoh and Merian (1978), squids and cuttlefish are among the traditionally processed marine products in the processing industry of Malaysia. Santhanakrishnan (1982a, 1982b, 1982c) has listed the cephalopod products which have potential export market and has given the methods of drying the squid and preparing it for export. In a series of periodic publications, the Marine Products Export Development Authority, Government of India, are giving all the relevant data in regard to the export of cephalopods from India. Particular mention must be made of a special feature on the quality requirements and methods of processing squids and cuttlefish for export (Indian Seafoods, July-December, 1976). Shenoy (1985) has briefly described the method for processing dried squid which has a potential export market in Japan.

3

IDENTITY OF COMMON SPECIES OF CEPHALOPODS OF INDIA

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ABSTRACT

A key to the identification of the common cephalopods of Indian Seas which are of commercial importance is given with brief descriptions of nine species of cuttlefishes, six species of neritic squids, four species of oceanic squids, seven species of octopods and *Nautilus pompilius*. A Glossary of technical terms used in the descriptions of cephalopods is included.

INTRODUCTION

Cephalopods are exclusively marine molluscs and there are about 660 species in the world oceans, which are diverse in form, size and nature (Voss. 1973, 1977 ; Voss and Williamson 1971; Worms, 1983). Of these less than a hundred species are of commercial importance. Cuttlefishes, squids and octopods are the three major groups of cephalopods which belong to the highly evolved Class of the Phylym Mollusca, namely Cephalopoda, animals with feet around head. Owing to the rapid development of an export market for squids and cuttlefish there is a greater need felt now than ever,for more information on the identity of cephalopods of the Indian Seas.

There are about 80 species of cephalopods of commercial and scientific interest distributed in the Indian Seas (Silas, 1968 ; Oommen, 1977a ; Sarvesan, 1974). Other literature on cephalopods also indicates the rich cephalopod fauna of our seas (Hoyle, 1886 ; Goodrich, 1896 ; Massy, 1916 ; Adam, 1939a, b, c, d, 1954 ; Adam and Rees, 1966 ; Rao, 1954 ; Satyamurti, 1956 ; Silas, 1969 ; Pickford, 1974 ; Silas *et al.*, 1976 ; Roper *et al.*, 1984). A comprehensive list of species recorded and reported from Indian Ocean till 1968 is given by Silas (1968).

For a broad classification of living cephalopods reference is invited to Voss and Williamson (1971) and Voss (1977).

Identifiation of Cephalopods

For the proper identification of various species of cephalopods a knowledge of the external morphology and certain internal characters is necessary. The works of Hoyle (1886), Robson (1929), Adam (1939b), Adam and Rees (1966), Voss (1963), Voss and Williams (1971), Roper *et al.* (1969) Okutani (1973b ; 1980) and Roper *et al.* (1984) are very useful works in this regard.

The key characters which are used for the identification of cephalopods are illustrated in Figs. 1-4. This will provide a general idea of the characters which are mentioned in the key and in the descriptions. The other anatomical and meristic features that are easily observable in specimens are also included in the illustrations. The definitions and explanatory notes of the unfamiliar terms are listed in the glossary.

The key is mainly based on the morphological features of the adult and fairly full grown specimens. The characters that could be readily observed externally and a few internal characters are considered. The key is intended for the identification of only those commercially important species both of food and aesthetic value which are listed and described here. The works of Voss (1963), Voss and Williamson (1971), Wormuth (1976) and Roper *et al.* (1984) have been of considerable help in developing these identification keys and descriptions which in most cases have also been corroborated with examination of actual specimens.

The three different basic body patterns of external features of cephalopods are presented in the Figs. 1, 2, 3 and 4. Based on this the main categories *viz.*, cuttlefish (*Sepia*), squid (*Loligo*) and octopod (*Octopus*) are easily distinguished. With the help of the following key and brief descriptions, the species under different families could be identified.

EXPLOITED AND POTENTIALLY IMPORTANT CEPHALOPODS OF INDIA

Class	CEPHALOPODA
Subclass	NAUTILOIDEA Agassiz, 1847
Family	Nautilidae Blainville, 1825
Genus	*Nautilus* Linnaeus, 1758
	Nautilus pompilius Linnaeus, 1758
Subclass	COLEDIDEA Bather, 1888
Order	Sepiodidea Naef, 1916
Family	Sepiidae Keferstein, 1866
Genus	*Sepia* Linnaeus, 1758
	Sepia pharaonis Ehrenberg, 1831
	Sepia aculeata Orbigny, 1848
	Sepia trygonina (Rochebrune, 1886)
	Sepia brevimana Steenstrup, 1875
	Sepia elliptica Hoyle, 1885
	Sepia arabica Massy, 1916
	Sepia prashadi Winckworth, 1936
Genus	*Sepiella* Gray, 1849
	Sepiella inermis (Orbigny, 1848)
Family	Sepiolidae Steenstrup, 1861
Genus	*Euprymna* Steenstrup, 1887
	Euprymna stenodactyla (Grant, 1833)
Order	TEUTHOIDEA Naef, 1916
Suborder	Myopsida Orbigny, 1845
Family	Loliginidae Steenstrup, 1861
Genus	*Loligo* Schneider, 1784
	Loligo duvaucelii Orbigny, 1848
	Loligo uyii Wakiya and Ishikawa, 1921
Genus	*Doryteuthis* Naef, 1912
	Doryteuthis singhalensis (Ortman, 1891)
	Doryteuthis sibogae Adam, 1954
Genus	*Sepioteuthis* Blainville, 1824
	Sepioteuthis lessoniana Lesson, 1830
Genus	*Loliolus* Steenstrup, 1856
	Loliolus investigatoris Goodrich,1896
Suborder	Oegopsida Orbigny, 1845
Family	Onychoteuthidae Gray, 1849
Genus	*Onychoteuthis* Lichtenstein ,1818
	Onychoteuthis banksii(Leach, 1817)
Family	Ommastrephidae Steenstrup, 1857
Subfamily	Ommastrephinae
Genus	*Ommastrephes* Orbigny, 1835
	Ommastrephes bartrami (LeSueur, 1827)
Genus	*Symplectoteuthis* Pfeffer, 1900
	Symplectoteuthis oualaniensis(Lesson 1832)
Family	Thysanoteuthidae Keferstein, 1866
Genus	*Thysanoteuthis* Troschel, 1857
	Thysanoteuthis rhombus Troschel, 1857
Order	OCTOPODA Leach, 1818
Suborder	Incirrata Grimpe, 1916
Family	Octopodidae Orbigny, 1845
Genus	*Octopus* Lamarck, 1798
	Octopus dollfusi Robson, 1929
	Octopus aegina Gray, 1849
Genus	*Cistopus* Gray, 1849
	Cistopus indicus (Orbigny, 1840)
Genus	*Hapalochlaena* Robson, 1929
	Hapalochlaena maculosa (Hoyle, 1886)
Genus	*Berrya* Adam, 1939
	Berrya keralensis Oommen, 1966
Family	Argonautidae Naef, 1912
Genus	*Argonauta* Linnaeus, 1758
	Argonauta argo, Linnaeus, 1758
	Argonauta hians, Solander, 1786

1. SUBCLASS NAUTILOIDEA Agassiz, 1847

Shell external, coiled and chambered, more than 10 (63 to 94) circumoral appendages without suckers, two pairs of gills, funnel bilobed. (Living Monotypic Genus *Nautilus* : *Nautilus pompilius*).

2. SUBCLASS COLEOIDEA Bather, 1888

Shell internal except in Family Argonautidae, embedded in tissue, calcareous, chitinous or cartilaginous, 8 or 10 circumoral appendages with suckers, only one pair of gills, funnel tube-like.

1. **Order Sepioidea** Naef, 1916

Internal shell (sepion) calcareous and either straight and laminated or coiled and chambered or vestigeal and chitinous or absent ; eyes covered with skin and a supplementary eye lid present ; eight sessile arms ; two tentacular arms contractile and retractile into pockets ; suckers without stalks ; fin lobes free posteriorly.

2. **Order Teuthoidea** Naef, 1916

Internal shell (gladius or pen) chitinous, feather or rod-shaped, eight sessile arms ; two tentacular arms contractile but not retractile, pockets absent, tentacles lost secondarily in some, suckers stalked and with or without

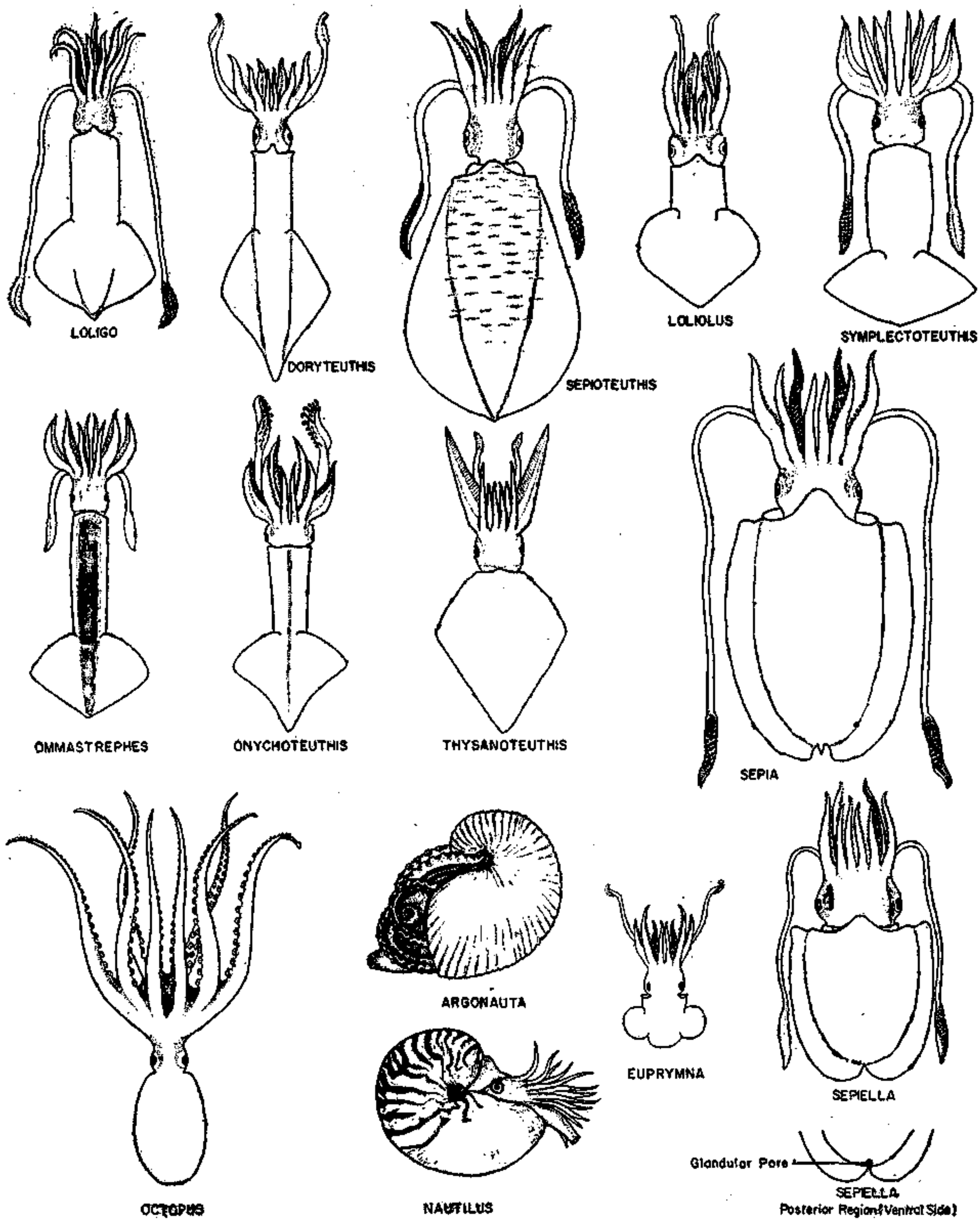

Fig. 1. Body form of some important groups of cephalopods.

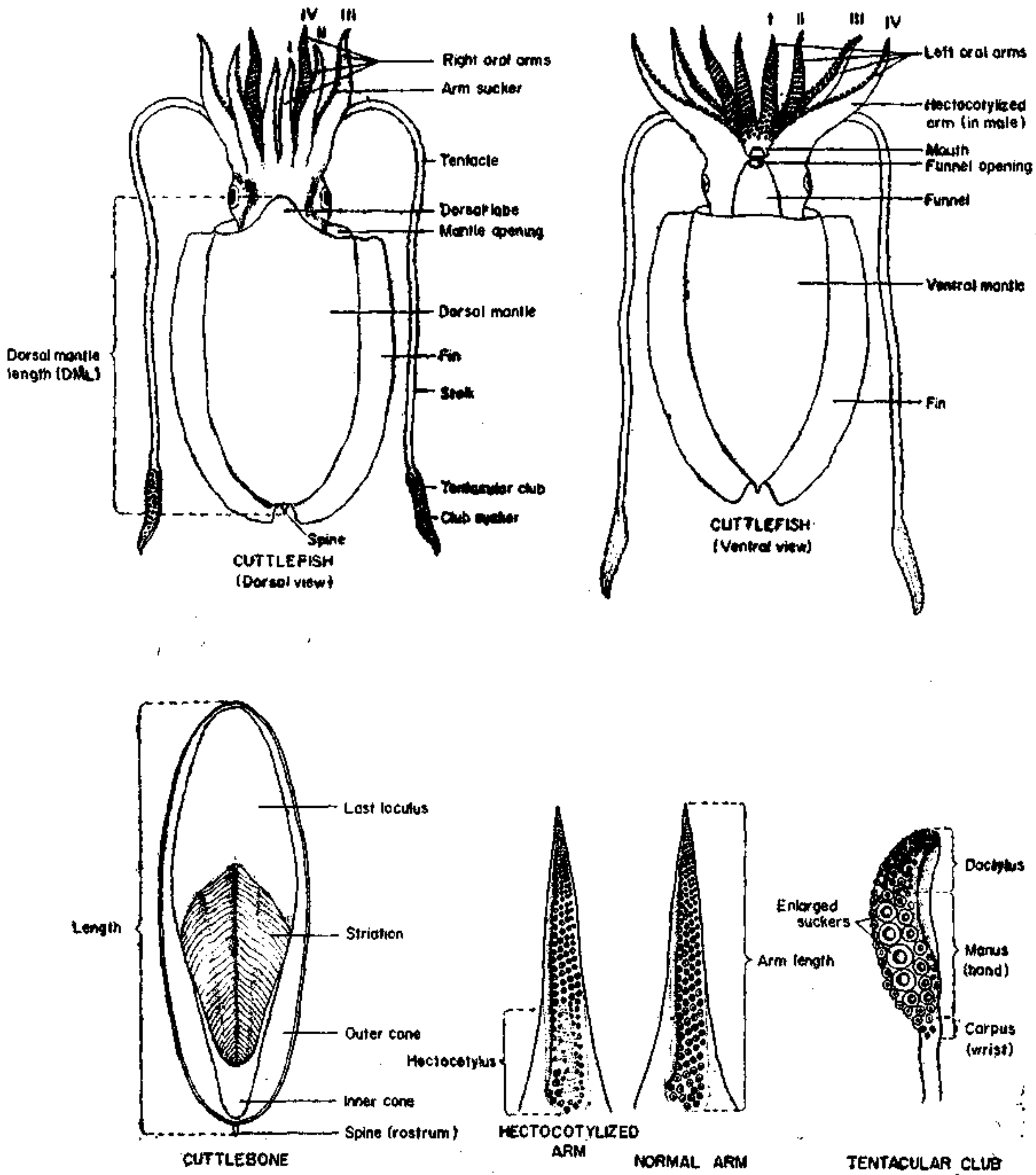

FIG. 2. Schematic drawings of a cuttlefish showing salient characters as an aid for identification.

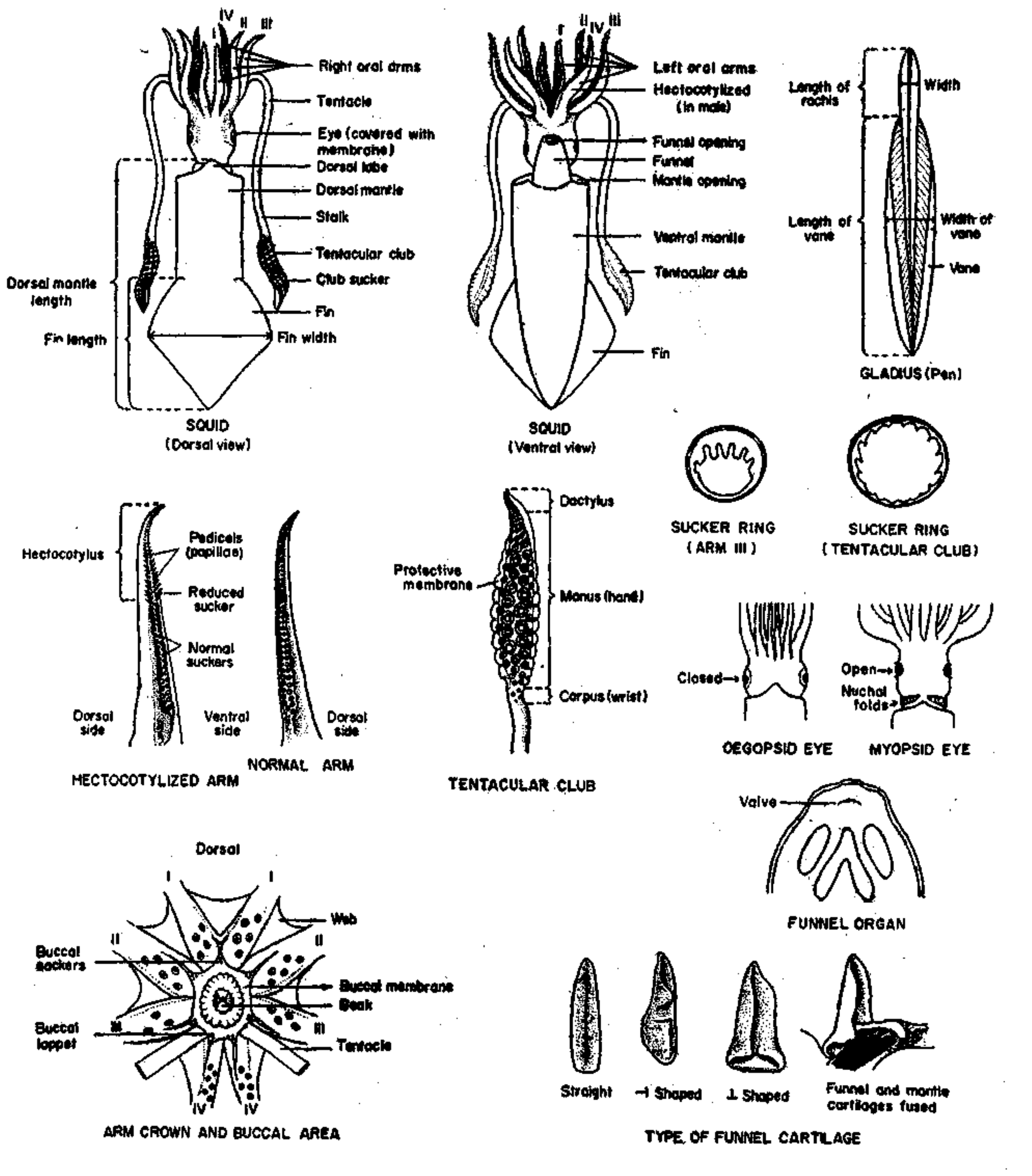

FIG. 3. Schematic drawings of a squid showing salient characters as an aid for identification (Types of funnel cartilage : From Roper *et al.*, 1969).

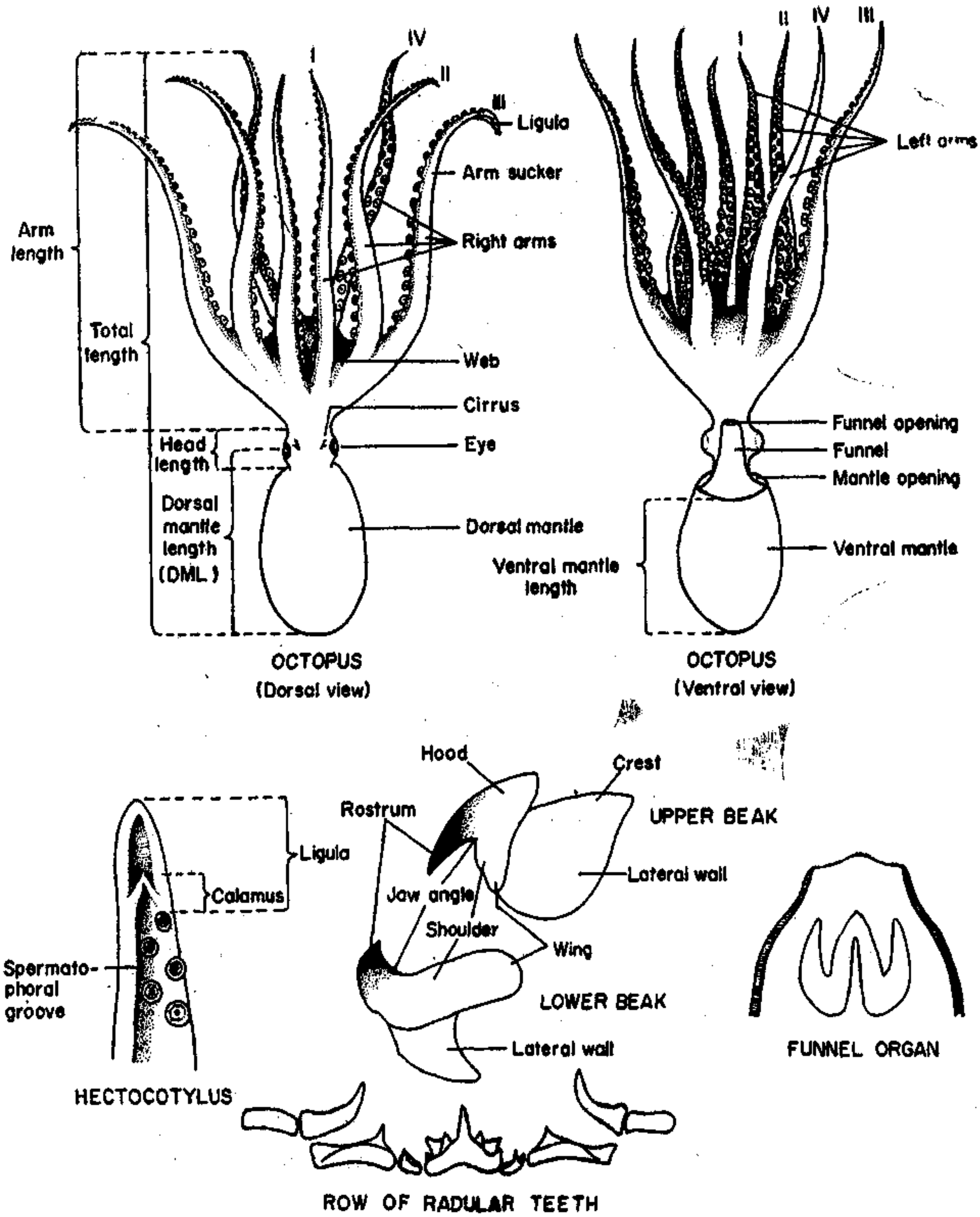

FIG. 4. Schematic drawings of an octopod showing salient characters as an aid for identification (Upper and lower beaks: From Voss and Voss, 1962).

hooks ; fin lobes fused posteriorly. Eyes either covered or open and without supplementary eyelid.

3. **Order Octopoda** Leach, 1818

Internal shell vestigeal and cartilaginous except in females of *Argonauta* which has an external, calcified shell. Eight arms, suckers without stalks and without chitinous rings ; tentacles absent ; fins absent except in a few deep water species ; light organs absent.

ORDER SEPIOIDEA

The salient features to be examined for the identification of genera and species of cuttlefishes are as follows :

1. Cuttlebone : General shape, nature of the dorsal surface, structure of the inner cone, number and nature of grooves and ridges on the ventral side, the nature of growth lines found in the striated area and the spine.
2. Tentacular clubs : Number of transverse rows of club suckers and their relative size (diameter), the nature of protective membrane on the sides of the clubs.
3. Hectocotylization : Structure of the hectocotylized arm with regard to the modified portion, the number and arrangement of normal and modified suckers and the extent of modification of the arm.
4. Shape and disposition of fins along the mantle.
5. In some species the characteristic external colouration and colour pattern of the mantle, head and arms noticeable in fresh material.

KEY TO THE IDENTIFICATION OF GENERA AND SPECIES OF COMMERCIALLY EXPLOITED CUTTLEFISHES OF THE INDIAN SEAS

1. Body either elongate and broad or very slender and dorsoventrally flattened ; fins marginal and narrow, extending all along mantle on either side ; internal shell (sepion) present ; head free from dorsal mantle ; light organs absent (Family : Sepiidae) 2

   Body saccular, wide, round bottomed ; fins circular ; internal shell lacking ; dorsal mantle and head united by a nuchal commissure ; saddle-shaped light organ present on ink sac. (Family: Sepiolidae) .... *Euprymna stenodactyla*

2. Body without a glandular pore at posterior extremity ; cuttlebone mostly with a spine (rostrum) at posterior end. (Genus : *Sepia*) 3

   Body with a distinct glandular pore at posterior extremity on ventral side; with browaish fluid oozing out ; cuttlebone devoid of spine (Genus : *Sepiella*) .... *Sepiella inermis*

3. Body small and narrow, broadest part of body excluding fins distinctly less than half mantle length ; fins narrow and marginal ; cuttlebone very much slender and lanceolate in shape 8

   Body wide and muscular, ovoid or elliptical in shape ; broadest part of body excluding fins equal or distinctly more than half of mantle length; fins marginal, moderate to wide ; cuttlebone chalky, elongate, wide and nearly ovoid in shape 4

4. Tentacular clubs with suckers of unequal size, a few in the manus very much enlarged; mantle, head and arms with transverse stripes 5

   Tentacular clubs with smaller and subequal suckers but none greatly enlarged ; no transverse stripes on mantle, head and arms 6

5. Body robust, fins broad commencing from edge of anterior mantle margin ; tentacular clubs moderately long and well expanded ; 5 or 6 suckers in middle row of manus greatly enlarged ; cuttlebone broad, thick and with a midventral groove flattenning anteriorly in striated area ; striae 'Λ' shaped ; inner cone forms a conspicuous yellowish flat ledge ; a sharp thick spine present ; when live, body brownish, tigerstripe pattern prominent .... *Sepia pharaonis*

   Body not robust ; fins narrow commencing a few mm behind edge of anterior mantle margin ; tentacular clubs short, expanded ; not more than 3 suckers in middle row of manus greatly enlarged ; cuttlebone narrow, midventral groove narrow and distinct, striae anteriorly broadly truncate with lateral corners slightly produced forward ; dorsal surface pinkish in colour ; a sharp thin spine present. When live, dusty brownish, transverse stripes less distinct .... *Sepia prashadi*

6. Tentacular clubs very long, with 10-14 rows of minute subequal suckers. Cuttlebone broad and thick with a median longitudinal ridge with a faint groove running medially on striated area ; inner cone forms a ledge-like callosity .... *Sepia aculeata*

Tentacular clubs either short or moderately long, with 6-10 rows of small suckers. Cuttlebone thin and elliptical or acuminate in shape with or without ridges on striated area, innercone without callosity 7

7. Tentacular clubs short with 6-8 small subequal suckers. Cuttlebone flat and distinctly acuminate anteriorly, dorsal surface rugose, a shallow median groove in the striated area, the striae 'Λ' shaped with a median shallow groove broadening anteriorly ; inner cone and its limbs pinkish in colour; spine small, sharp and slightly curved .... *Sepia brevimana*

Tentacular clubs moderately long, with 10 rows of small suckers of uniform size. Cuttlebone thin, elliptical in shape, dorsal surface smooth ; two conspicuous lateral ridges more prominent anteriad resulting in three longitudinal furrows in striated area ; spine thick, sharp, long and well curved .... *Sepia elliptica*

8. Two prominent ear-shaped fleshy projection present on head below eyes. Fins do not extend upto end of mantle ; tentacles with short and curved clubs, small subequal suckers in 5 or 6 rows. Cuttlebone lanceolate with rounded anterior tip ; spine absent and edges of cone not winged but spatulate posteriorly .... *Sepia arabica*

No fleshy projections on head ; fins extend upto end of mantle ; tentacles with short clubs, suckers in eight rows, about five in third row enlarged. Cuttlebone lanceolate with acuminate anterior tip with edges of outer cone winged giving an arrow head appearance ; spine small .... *Sepia trygonina*

Apart from the above species of cuttlefishes which are included in the key, a number of other species *viz. Sepia latimanus* Quoy and Gaimard, *S. murrayi* Adam and Rees, *S. omani* Adam and Rees, *S. kobiensis* Hoyle, *S. recurvirostra* Steenstrup, *S. savignyi* Blainville *Sepiadarium kochii* Steenstrup, *Euprymna berryi* Sasaki and *E. morsei* (Verrill) have been recorded from the Indian Ocean. Some more sepiids which have been reported from the father parts of Indian Ocean *viz. Sepia apama* Gray, *S. australis* Quoy and Gaimard, *S. braggi* Verco and *S. esculenta* Hoyle are also likely to occur in Indian Seas.

ORDER TEUTHOIDEA

The various characters used in identifying the different species of neritic and oceanic squids (Order Teuthoidea) are given below. The definitions and details of important characters and terms are given in the glossary of technical terms.

1. General shape of the mantle.
2. The shape and proportion of fins, the contour of the anterior and posterior margins of the fin lobes ; position of fins on the mantle *viz.* terminal or marginal ; united or separated at the posterior end.
3. The relative size of head and arms ; size, shape, number and arrangement of suckers on the arms and tentacular clubs ; the nature and dentition of the chitinous rings of the suckers.
4. Presence of hooks and/or suckers on the arms and tentacular clubs.
5. Details of hectocotylization, the number and arrangement of normal and modified suckers and the extent of other modifications affecting the arm.
6. Presence or absence of light organs (photophores), their shape, number and position.
7. Nature of the funnel locking apparatus.
8. Presence or absence of accessory nidamental glands.
9. Shape of gladius.
10. Shape of eggs and egg clusters.

Key to the identification of commercially important Neritic and Oceanic squids of the Indian Seas

1. Eyes completely covered with a corneal membrane (MYOPSIDA : Neritic Squids) 2

Eyes not covered with a corneal membrane and open to the surrounding medium (OEGOPSIDA : Oceanic squids) 7

2. Body elongate, cylindrical in outline ; fins marginal, wide and muscular, very long almost running along entire length of mantle ; elliptical in shape

.... *Sepioteuthis lessoniana*

Body elongate, narrow, either slender or stout, sides parallel or tapering; fins narrow, terminal running less than 65 per cent of mantle length and either rhombic (*Loligo*) or heart-shaped (*Loliolus*) 3

3. Body elongate or short and stocky, posterior end of mantle blunt; fins broad, rhombic or heart-shaped, with head and arm crown more than 50 per cent of mantle length; vane of gladius broad with thin curved margins 4

Body narrow and slender, posterior end of mantle pointed; head with arm crown distinctly less than 50 per cent of mantle length 6

4. Small squids, mantle length of adults less than 60 mm; fins heartshaped; vane of gladius conspicuously broad at midlength................ .... *Loliolus investigatories*

Moderately large squids; fins typically rhomboid; vane of gladius narrow throughout 5

5. Body elongate, mid-rib of gladius not visible through mantle skin; fins 50-57 per cent of mantle length; tentacular clubs large median manal sucker ring with 14-17 teeth; in males distal half of left ventral arm hectocotylized, papillae not fused .... *Loligo duvaucelii*

Body short and stout; mid-rib of gladius clearly visible through dorsal mantle skin as a median dark line; fins 55-65 per cent of mantle length; Tentacular clubs large median manal suckers with smooth rings; in males left ventral arm hectocotylized almost the entire arm; papillae on ventral margin fused with membrane.......... .... *Loligo uyii*

6. Mantle very long and slender with a ridge along midline in males; fins wide and long and more than 60 per cent of mantle length; more than half of left ventral arm hectocotylized distally in males; gladius narrow with almost straight margins and tapering gradually to a narrow point .... *Doryteuthis singhalensis*

Mantle long, narrow and slender, no ridge but chromatophore concentration ventrally along midline; fins narrow and less than 60 per cent of mantle length; less than half of left ventral arm hectocotylized distally in males; gladius narrow, sharply acuminate posteriorly .... *Doryteuthis sibogae*

7. Oceanic squids with muscular body; head with nuchal folds on dorsal side at posterior end; rachis of gladius visible as a longitudinal ridge middorsally along the entire length of mantle; tentacular clubs with two rows of hooks, marginal suckers lacking............................ .... *Onychoteuthis banksii*

Oceanic squids with muscular body; head without nuchal folds on dorsal side at posterior end; rachis of gladius not visible through dorsal mantle; tentacular clubs without hooks 8

8. Funnel locking-cartilage '⊣' shaped consisting of a narrow longitudinal groove and a short transverse groove branching from it medially (Fig.3). Fins broad and rhombus-shaped occupying nearly entire length of mantle .... *Thysanoteuthis rhombus*

Funnel locking-cartilage '⊥' shaped consisting of a vertical groove and a transverse groove at right angles to it posteriorly (Fig. 3). Fins terminal and less than 60 per cent of mantle length 9

9. Funnel and mantle cartilages of the locking apparatus fused together. An oval photophoric patch present middorsally near anterior margin of mantle; muscle of mantle ventrally without embedded light organs; two intestinal photophores present .... *Symplectoteuthis oualaniensis*

Funnel and mantle cartilages of the locking apparatus not fused. An elliptical gold coloured stripe present midventrally from mantle opening to level of fin insertion; muscle of mantle ventrally with numerous closely packed small irregularly shaped light organs, some interconnected; no intestinal photophores .... *Ommastrephes bartrami*

A number of other species of oceanic squids *viz. Ancistrocheirus lesueuri* (Orbigny) (Pl. IX C and D), *Taningia danae* Joubin, *Architeuthis* sp., *Histioteuthis dofleini* (Pfeffer), and *Todarodes eablnae* (Ball) have been reported from the Indian Ocean (Roper *et al.*, 1984). Several other species of squids such as *Loligo chinensis* Gray, *L. edulis* Hoyle, *L. forbesi* Steenstrup, *Sepioteuthis australis* Quoy and Gaimard, *Moroteuthis robsoni* Adam, *Pholidoteuthis boschmai* Adam, *Histioteuthis* *bonnellii* (Ferussac) and *Nototodarus gouldi* (McCoy) are distributed in the neritic and oceanic regions of the contiguous areas of Indian Ocean. It is likely that some of these species may occur in the EEZ of India and adjacent high seas.

ORDER OCTOPODA

In the present report four genera of the family Octopodidae and one genus under the family Argonautidae are included. The majority of commercially important octopods belong to the family Octopodidae whereas *Argonauta* is a collectors item, valued for its beautifully sculptured external fragile shell popularly known as Paper Nautilus. The *Argonauta* is distributed in tropical and warm-temperate waters, living in the surface waters of the open ocean forming forage to predatory fishes such as Tunas and Billfishes (Voss and Williamson, 1971).

The systematics of the family Octopodidae have not yet been studied thoroughly and a state of uncertainty persists (Robson, 1929; Voss and Williamson, 1971; Roper *et al.*, 1984). This is also true for the Octopodidae of Indian seas and very little work has been carried out so far. It was considered that 'Morphologically .... this group is featureless' (Robson, 1929). However, there are certain characters which are useful in the identification of octopods:

1. The shape and sculpture of mantle such as warty, smooth and rugose.
2. The comparative lengths of arms and relative sizes of the suckers; structure and modification of the hectocotylized arm, especially the ligula.
3. General shape and structure of spermatophores.
4. Structure of the reproductive organs.
5. Gills and number of gill filaments.
6. Structure of the radula.
7. Permanent colour and colour pattern.
8. Habit and habitat.

KEY TO THE IDENTIFICATION OF IMPORTANT OCTOPODS OF THE INDIAN SEAS

1. Cephalopods with eight arms; without an external shell; internal shell either vestigial or lacking; no great disparity between males and females in size; benthic in habit (Family Octopodidae) 2

   Cephalopods with eight arms; external shell present (in females); sexual dimorphism very marked, males very small; pelagic in habit (Family Argonautidae) 6

2. Right third arm in males hectocotylized with well developed ligula, calamus and spermatophoric groove; no water pores and embedded pouches between arm bases 3

   Hectocotylized arm only slightly modified, ligula small about 3 per cent of arm. Small water pores leading to embedded pouches between bases of arms on oral surface .... *Cistopus indicus*

3. Body either globular or slightly elongate and of firm consistency; arms long and tapering with moderately developed web between them; funnel not fused with head 4

   Body short and stumpy, of semi-gelatinous consistency and posteriorly rounded; arms very short with well developed web between them; funnel fused with head; ligula prominent (11 to 15 per cent of arm) and cone shaped with deep calamus and groove ...... *Berrya keralensis*

4. Body elongated oval; moderately large in size; dorsal surface of body and arm with reticulate pattern; no concentric rings of chromatophores on the body; ligula about 5 to 10 per cent of arm; penis and diverticulam long 5

   Body globular, smaller in size; skin smooth without reticulate pattern; while fresh dusty brown in colour with prominent bluish rings on mantle, head, web and arms .... *Hapalochlaena maculosa*

5. Eyes prominent; a single large cirrus posterior to each eye. Ligula small, 5 to 8 per cent of arm; with shallow groove; penis and diverticulam together form U-shaped loop; spermatophores long and unarmed .... *Octopus aegina*

   Eyes inconspicuous; no eye cirrus. Ligula 8 to 10 per cent of arm; with well formed groove and calamus. Long penis and short diverticulam together form reversed 6-shape; spermatophores long and armed with spines .... *Octopus dollfusi*

6. Shell and aperture narrow and not inflated; compressed laterally; keel narrow with numerous sharp nodules (knobs); ribs on sides bifurcated; colour white with faint brownish markings on shell and nodules .... *Argonauta argo*

Shell and aperture wide and strongly inflated; nodules prominent, rounded and widely spaced on keel; on sides long full ribs alternate with short ribs .... *Argonauta hians*

In addition to the above mentioned species, some more species of octopods such as *Octopus cyaneus* Gray, *O. globosus* Appellof, *O. membranaceus* Quoy and Gaimard, *O. macropus* Risso, *O. vulgaris* Cuvier, *O. varunae* Oommen, *O. tetricus* Gould, *Berrya annae* Oommen, *Scaeurgus unicirrus* Orbigny are also known to occur in the Indian Seas and other parts of the Indian Ocean.

Glossary of Technical Terms

While describing various species of cephalopods many scientific terms are used. As these terms are not generally very familiar, brief descriptions and explanations of the same are given here.

Aequiferous pores: A pair of small openings present on the dorsal and ventral surfaces of head at a short distance below the base of arms in *Tremoctopus*.

Anal flaps: A pair of papillae present on either side of the anterior opening of the anus.

Arms: Cephalopods possess circumoral arms or appendages arising from the head (Cephalopoda — Head footed). In Decapods (squids and cuttlefishes) there are eight such sessile arms and two long tentacles; Octopods have only eight arms; Nautiloids possess numerous appendages.

All arms are paired and designated as left or right arms (Figs. 2, 3 and 4). The dorsal arms are known as the first pair, the dorsolateral arms are the second pair, the ventrolateral arms are the third pair and the ventral ones are the fourth pair of arms; they are provided with one or more rows of suckers on the oral side.

Armature: Arrangement of either or both of suckers and hooks on the arms and tentacular clubs.

Arm formula: The relative lengths of arms are expressed in 'arm formula' in order of decreasing length e.g., 2.3.4.1 to denote $2>3>4>1$.

Beak: Refers to the beak-like jaws of cephalopods; also known as mandibles or jaws; in shape they are like a parrot's beak (Fig. 4).

Buccal lappets: Small 6-8 lobed triangular flaps of the buccal membrane (Fig. 3) which in some cephalopods bear one or more minute suckers.

Buccal membrane: Web-like membranous sheath surrounding the mouth in squids and cuttlefishes (Fig. 3). Absent in octopods.

Calcification: Deposition of calcium carbonate. Cuttlebone in cuttlefishes—chalky calcified or calcareous.

Calamus (Calimus): A small conical projection of the extreme tip of the spermatrophoral groove in the hectocotylized arm of octopods (Fig. 4). The length of calamus is the distance from the distal sucker of the arm to the tip of ligula.

Carpal clusters: A group of small suckers and fleshy knobs on the basal (carpus) portion of tentacular clubs.

Carpal knobs: Small roundish, fleshy protuberances on the carpus portion of tentacular clubs.

Carpal suckers: Cup-like small suckers on the carpus of tentacular clubs.

Carpus: Proxmal portion of the clubs also known as wrist where small suckers and sometimes also knobs are present (Figs, 2 and 3).

Chitin: A horny polysaccharide material that forms the gladius, sucker rings, hooks and beaks.

Chromatophores: Contractile pigment sacs in the outer skin of cephalopods. They are under nervous control and responsible for colour, colour pattern and colour change of cephalopods.

Cirri: Small, slender, fleshy protuberances of the skin, usually over the eyes (ocular cirri) and mantle.

Corneal membrane: A thin, transparent membranous skin, covering the eyes of myopsid and sepioid cephalopods; absent in oegopsids (Oceanic squids).

Cuttlebone: The thick chalky, calcified internal shell of cuttlefishes (Fig. 2).

Dactylus: The distal portion of tentacular clubs where usually small suckers are present (Figs. 2 and 3).

Dentition: The presence of teeth on horny rings of arm suckers.

Diverticulam: The tube-like structure posterior to the penis (mainly in octopods).

Faveola: Membranous folds or ridges of skin that form a pocket-like structure in the funnel groove found in some oegopsid squids.

Fins: The pair of muscular flaps which originate along the dorsolateral plane of the mantle and are useful in locomotion.

Fixing apparatus: Small fleshy knobs and suckers on the carpal portion of the tentacular clubs that facilitate the two clubs to adhere during capture of prey.

Funnel: Also known as siphon is situated below the head in a groove on its ventral side. Exhalent water from the mantle cavity is pumped through the funnel.

Funnel groove: The pit-like excavation in the postero-ventral part of head in which the free portion of funnel lies.

Funnel locking apparatus: Refers to funnel and mantle locking mechanism found in squids and cuttlefishes to keep the base of the funnel and the inner mantle wall in locked-up position. This is effected by cartilaginous grooves or depressions on each side of the funnel on the posteroventral region (Fig. 3) into which corresponding cartilaginous thickenings on the inner wall of the mantle fit so that exhalent water passes through the funnel and not through the mantle opening.

Funnel organ: A glandular structure present on the inner wall of funnel; usually a 'W' or 'VV' shaped structure in octopods (Fig. 4) and an inverted V-shaped one with two oval patches on either side in decapods.

Gill lamellae: The series of elongate leaf-like folded structures of the gills (Ctenidia). They are also known as gill filaments.

Gladius: Thin, feather-like chitinous internal shell present in squids. Also known as pen (Fig. 3).

Hectocotylus: The structural modification of one of the arms in male cephalopods for transfer of spermatophores (Figs. 2, 3 and 4). Suckers, pedicels and protective membranes of the arms are modified variously in squids (Fig. 3), cuttlefish (Fig. 2) octopods (Fig. 4) and Nautilus.

Hooks: The sharp curved chitinous structures of the suckers present on the arms and or tentacular clubs in some oceanic squids.

Ink sac: A bag-like structure in which ink is produced and stored in cephalopods. The sac is located anteriorly in squids and posteriorly in cuttlefishes and octopods. In some octopods (deep sea) it is greatly reduced or absent.

Keel: The mebranous extension of arms, tentacle and clubs on the aboral surface; also known as swimming membrane. In *Argonauta* keel is the narrow flattened connecting portion of the two sides of the shell.

Light organ: A specialized structure in some cephalopods that produces bioluminescence, either by chemical action or through symbiotic bacteria. Also known as photophores and luminous organs.

Ligula: The spoon-shaped tip of the hectocotylized arm in octopods; generally its oral surface is grooved and has transverse ridges (Fig. 4).

Mantle: The muscular body wall of cephalopods that surrounds the internal organs.

Manus: Refers to the mid-portion of the tentacular club; also known as hand; usually the suckers in manus portion are larger in size (Figs. 2 and 3).

Pedicel: The conical shaped fleshy stalks of sucker- of arms and tentacular clubs in squids and cuttle fishes.

Protective membranes: The web-like membranes present on the sides of oral surface of arms and tentacular clubs which are strengthened by trabeculae.

Rachis: The thickened midaxis of gladius (Fig. 3).

Radula: The chitinous band in the buccal mass of cephalopods with several transverse rows of teeth (Fig. 4) on its surface used for rasping food.

Side pockets: The small slender fleshy ridges that form pocket-like structures on the lateral sides of faveola.

Spermatophore: A complicated tube-like structure produced by male cephalopods for storing sperms; it consists of a proximal sperm reservoir, a middle cement body and a distal ejaculatory apparatus.

Spermatophoral groove: The groove formed by the curbing of membrane of the ventral margin of the hectocotylized arm which ends in calamus in octopods. Aloug the groove the spermatophores are conducted to the ligula during mating.

Suckers: The muscular cup like structures on the arms and tentacular clubs; some are pedunculated i.e., placed on contractile stalks as in squids and cuttlefishes; some are sessile and directly embedded on arms as in octopods.

Sucker ring: The horny dentate rings that encircle the sucker opening in deca pods (squids and cuttlefishes); the suckers of octopods have no rings.

Tentacle: Two elongate slender appendages arising by the side of the mouth and terminating in expanded clubs in squids and cuttlefishes. They are contractile and rectractile into pockets at the base in between the third and fourth arms in cuttlefishes; they are only contractile in squids. Absent in octopods.

Tentacular club: The flattened and expand terminal portion of the tentacle which bears suckers, hooks or both (Figs. 2 and 3).

Trabeculae : The muscular rod-like transverse ridges which lend support to the protective membranes.

Vane : The thin, transparent lateral expansion of the gladius (Fig. 3).

Water pores : The small openings leading to internal small pouches embedded in the oral surface of each interbrachial web between the arm bases in *Cistopus.*

Brief descriptions of exploited and potentially important Cephalopods of India

CUTTLEFISHES

Sepia pharaonis Ehrenberg, 1831

(Plate I ; A-F)

This is the largest cuttlefish known from Indian seas. The body is ovoid in shape, broadest at about the middle, slightly narrow at the anterior end and narrower at the posterior part of the mantle. Body is robust with muscular mantle and fins. The latter are broad, originate from the anterior margin of the mantle opening, have a slight forward projection anteriorly and extend along the entire margin of mantle ; the fins are wider near the posterior end. On the dorsal side the skin of mantle has numerous minute granular papillae, a series of small longitudinal faint ridges along the periphery of the mantle and a narrow whitish line along the base of fins demarcating the mantle and the fins. The head is short and about as broad across the two prominent eyes as long.

The oral arms are long, subequal in length, with well developed keels and with tapering ends. Dorsal arms are the shortest and the lateral arms are much compressed. The suckers on all arms are arranged in four transverse series ; suckers in the basal rows are larger and become gradually reduced in size towards the distal end, those at the tips very minute. The buccal membrane is thick and the lappets bear minute suckers at the tips ; the dark coloured rostrum of the horny beak embedded in the buccal mass is seen in the middle.

The tentacles are moderate in length and not very much longer than the body ; the stem is thick and triangular in cross section. The tentacular clubs are broad, moderate in length being only about one fourth in dorsal mantle length ; clubs are distinctly broader than those of *Sepia aculeata* and have a broad swimming membrane the end of which reaches a little beyond the base of the club. The protective membranes on either side are narrow, extend slightly beyond carpus and not united at the base. Club suckers are unequal in size and very characteristic. Suckers of the carpus and dactylus portions are small ; those in the middle part of manus are large in size and arranged in eight transverse series ; about six suckers in the two median series are much enlarged and prominent ; the sucker rings have wavy edge without denticulation.

The left ventral arm is hectocotylized in males ; the modified part is in the middle portion of the arm ; basally 12-14 transverse series of suckers of this arm are normal in size, the next 4-10 series have normal ventral rows of suckers but the dorsal rows of suckers are much reduced. These two rows are separated by a thick ridge with grooves across. The females are more robust than males ; in the latter the mantle is comparatively slightly narrower.

The cuttlebone is elongate, broad and oval in shape, the surface is rugose in texture and has three longitudinal faint ribs. The Chitinous outer edges are broad and yellowish brown in colour on the dorsal side of the cuttlebone.

The ventral surface has a characteristic wide, deep, longitudinal groove in the middle, running along the entire length of striated zone. The striae or growth lines are distinctly ' $\wedge$ ' shaped. The inner cone is broad in the middle and forms a plate-like prominent callosity. The spine is short, stout and without keels.

Males attain a maximum mantle length of about 430 mm and females 330 mm (Roper *et al.,* 1984).

In fresh condition, the dorsal surface of the mantle, head and oral arms have dark brown transverse stripes. This colouration is conspicuous in adult males. The colour pattern is variable.

Sepia aculeata Orbigny, 1848

(Plate II ; A-D)

The mantle is broadly ovate in outline, width 3/5 in length ; fins moderately broad and extend along the entire length of mantle. The head is large, about as long as wide and narrower than the mantle opening.

The oral arms are short, subequal in length in the order 3.4.2.1. The dorsal arms are rounded on the outer side, the lateral arms are keeled and the ventral ones broad at the base with strong swimming membrane. The buccal lappets bear a few minute suckers with smooth, chitinous rings. The arm suckers are uniformly arranged in four rows and bordered by protective membranes on either side. The left ventral arm in male is hectocotylized with modification at the proximal half of the arm. At the base of the arm, there are about 12 rows of normal suckers followed by about 6 transverse rows of very minute suckers, with a pit-like excavation in the middle of the modified portion and this is distinct in adult males.

The tentacles are comparatively very long, slender and keeled on the outerside; the stem is triangular in cross section. The tentacular clubs are long, about 1/3 mantle length and slender but not much expanded; beyond the base of the club the protective membranes run as two ridges on the oral side of the tentacular stem. The club suckers are minute, subequal in size and arranged in about 10-12 longitudinal series in males whereas females possess 13 or 14 series; the numerous minute suckers on the tentacular clubs give them a spongy appearance.

The cuttlebone is elongate oval in shape with granular rough dorsal surface and has three low longitudinal ribs; the chitinous margin is very narrow. The ventral surface has a slightly convex striated zone anteriorly and is concave at the posterior end where the posterior innercone has a thick, rounded ridge in contrast to the distinct plate-like form in *S. pharaonis*. On the ventral surface, in the striated zone there is a longitudinal medial ridge with a faint groove running medially; the striae are notched in the middle. The last loculus is short and its medial portion is slightly concave. Spine is small, strong and not keeled.

The maximum size recorded is 230 mm (Voss and Williamson, 1971).

The colouration of the dorsal mantle is very variable and consists of different shades of gray or brown with white spots, streaks or patches in varying patterns with numerous chromatophores.

Sepia brevimana Steenstrup, 1875

(Plate III ; A-E)

The mantle is broadly ovate, its anterior margin projects prominently in the middorsal plane into a lobe which is very acuminate; the ventral anterior margin is slightly emarginate in the middle. The posterior end is also very much acuminate owing to the presence of a long and pointed spine at the extremity of the cuttlebone. The fins are narrow, originate a little posterior to the mantle margin and extending along the sides do not unite at the end. The acuminat contour of the posterior end of the mantle is distinctly seen on the ventral side. The head is as long as wide and eyes are prominent. The buccal membrane is seven lappetted.

The ora arms are short, subequal and less than half the length of mantle. The arm suckers are quadriserial and small in size.

Tentacles are slender and moderate in length. Clubs are very short and bear about eight oblique rows of small suckers; enlarged suckers absent.

The cuttlebone is very distinct, thin, flat and elongately ovoid in outline. On the dorsal surface it is rough due to the presence of numerous small tubercles which form three definitive longitudinal ridges. On the ventral side, the cuttlebone is concave and a deep median groove is present in the striated zone. The striated area and the outer cone are separated laterally by a broad, smooth area on either side. The inner cone and its lateral limbs are distinctly pink coloured. The spine is long, thin and slightly keeled. The cuttlebones of male and female differ in shape. The cuttlebone of female is generally broader and more acuminate than that of male. The tubercles on the dorsal side are not prominent in the female.

The maximum size attained by this species is 95 mm.

The dorsal surface of the cuttlefish is generally dark coloured. The arms, neck region, sides and ventral surface are whitish in fresh condition.

Sepia elliptica Hoyle, 1885

(Plate IV ; A-D)

The mantle is broadly ovoid in outline, stout and broad at the mantle opening, not very much tapering at the posterior end. The mid-dorsal projection, over the head inbetween the eye lobes, is sharp and prominent. The funnel is conical, short and does not reach the base of ventral arms. The head is short but broad with prominent eye lobes.

Arms are short, stout, subequal in length, about half in mantle length and have acuminate tips; the arm formula is 4.3.2.1. or 4.2.3.1. The suckers are arranged in four uniform series on all the oral arms; they are moderate in size and gradually become reduced towards the distal ends. The horny rims of the suckers are not provided with distinct teeth but marked with notches. The left ventral arm in male is hectocotilyzed. The hectocotilyzed arm is normal for one third of its length from the base and the middle third of the arm is modified with great reduction of the suckers especially the dorsal suckers. The distal portion of the arm is not affected by hectocotilyzation.

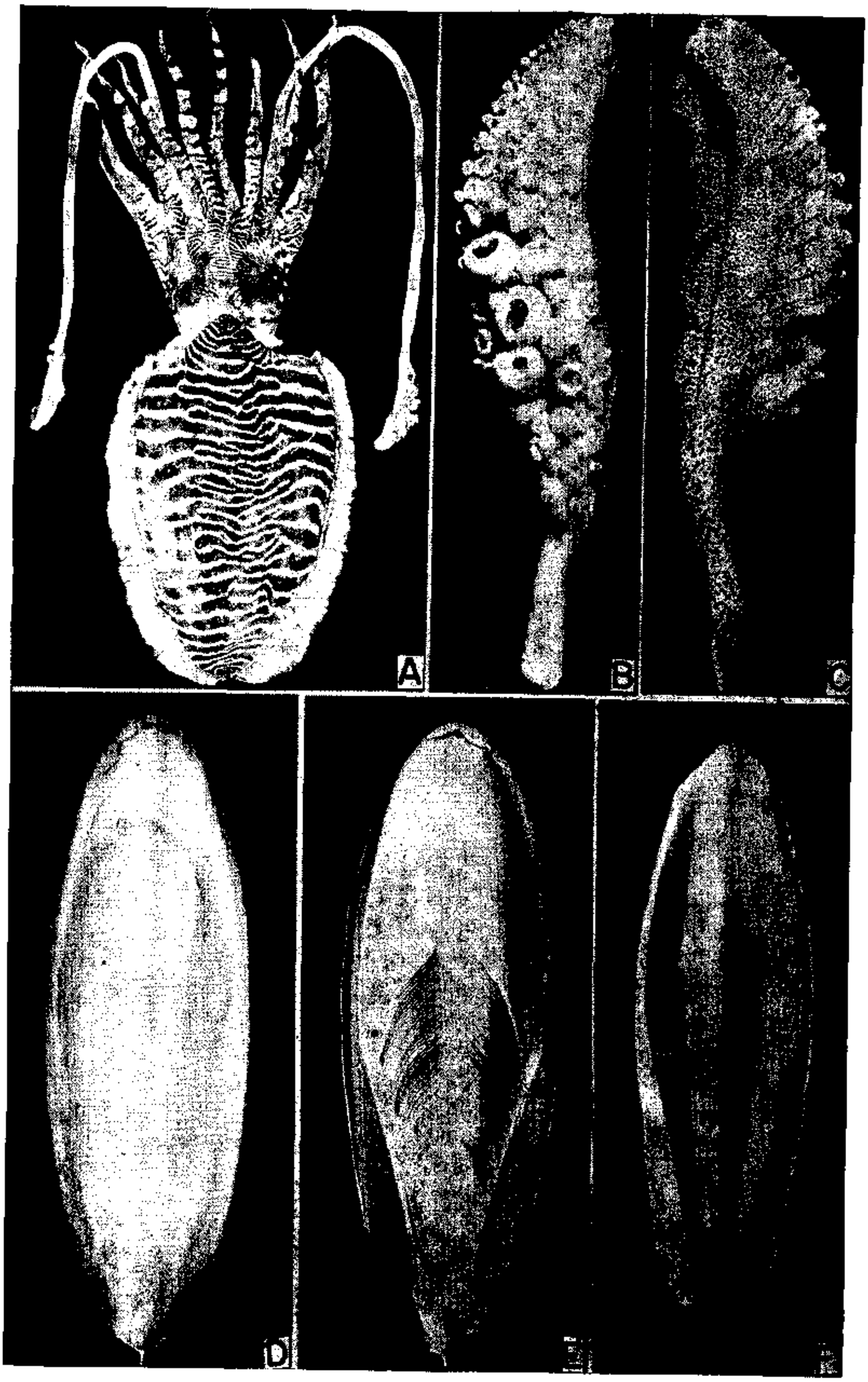

PLATE I. *Sepia pharaonis.* A. Dorsal view of male. B. Oral view of tentacular club. C. Aboral view of tentacular club. D. Dorsal view of cuttlebone (female). E. Ventral view of cuttlebone (female). F. Ventral view of cuttlebone (male).

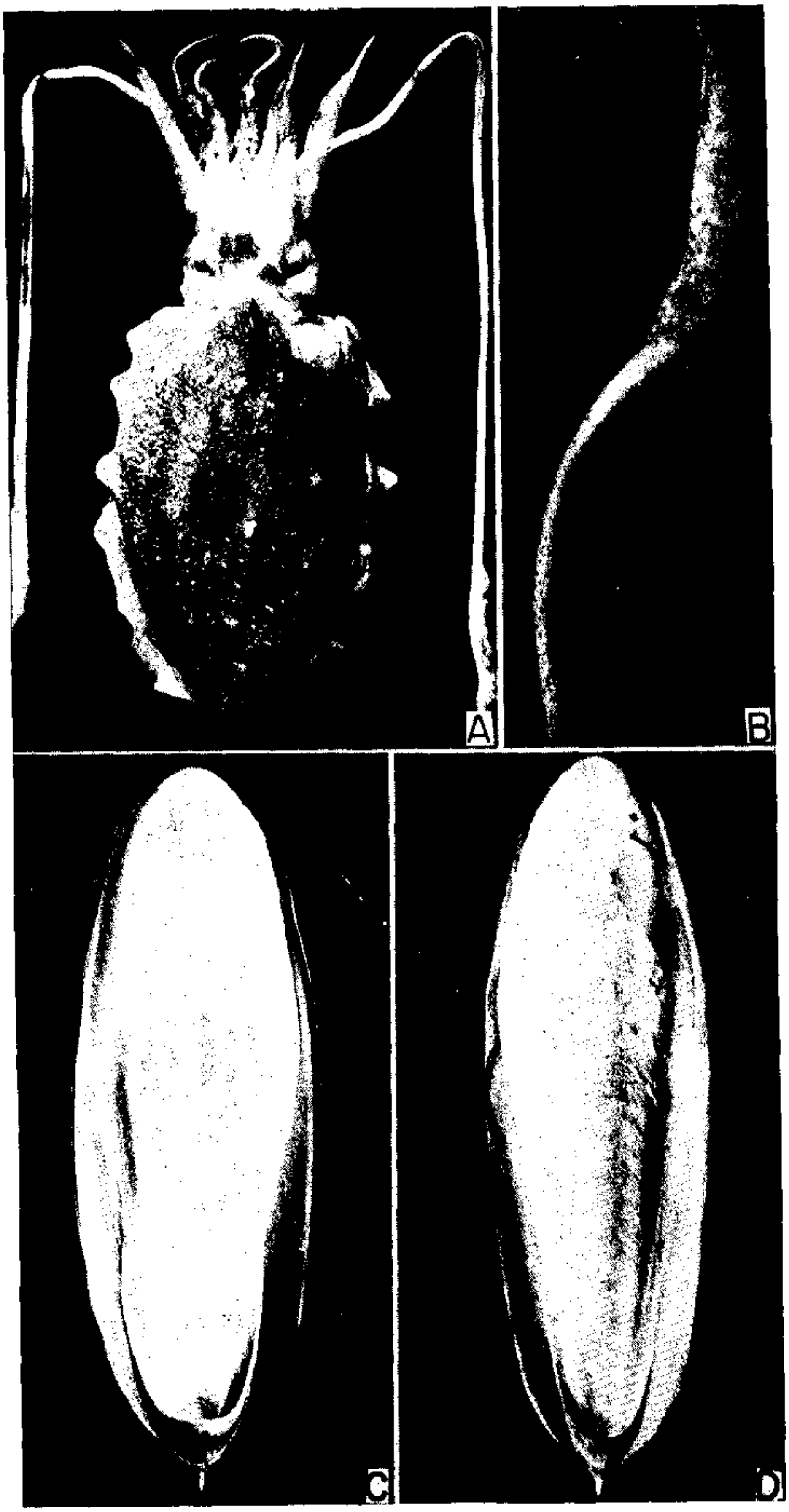

PLATE II. *Sepia aculeata*. A. Dorsal view of female. B. Tentacular club. C. Ventral view of cuttlebone (female). D. Ventral view of cuttlebone (male).

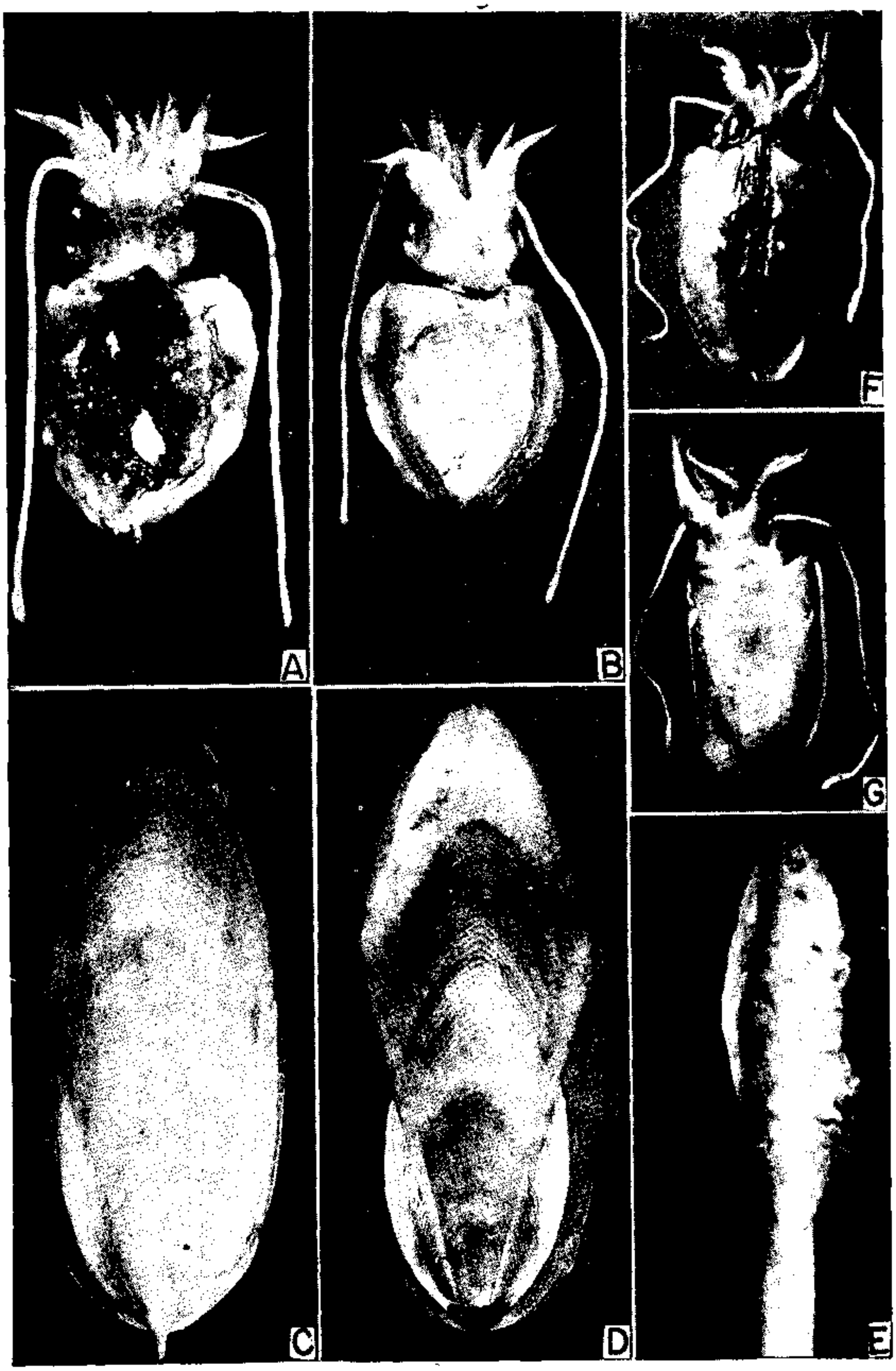

PLATE III. *Sepia brevimana*. A. Dorsal view of female. B. Ventral view of female. C. Dorsal view of cuttlebone (female). D. Ventral view of cuttlebone (female). E. Tentacular club. *Sepia trygonina*. F. Dorsal view of male. G. Venrtal view male.

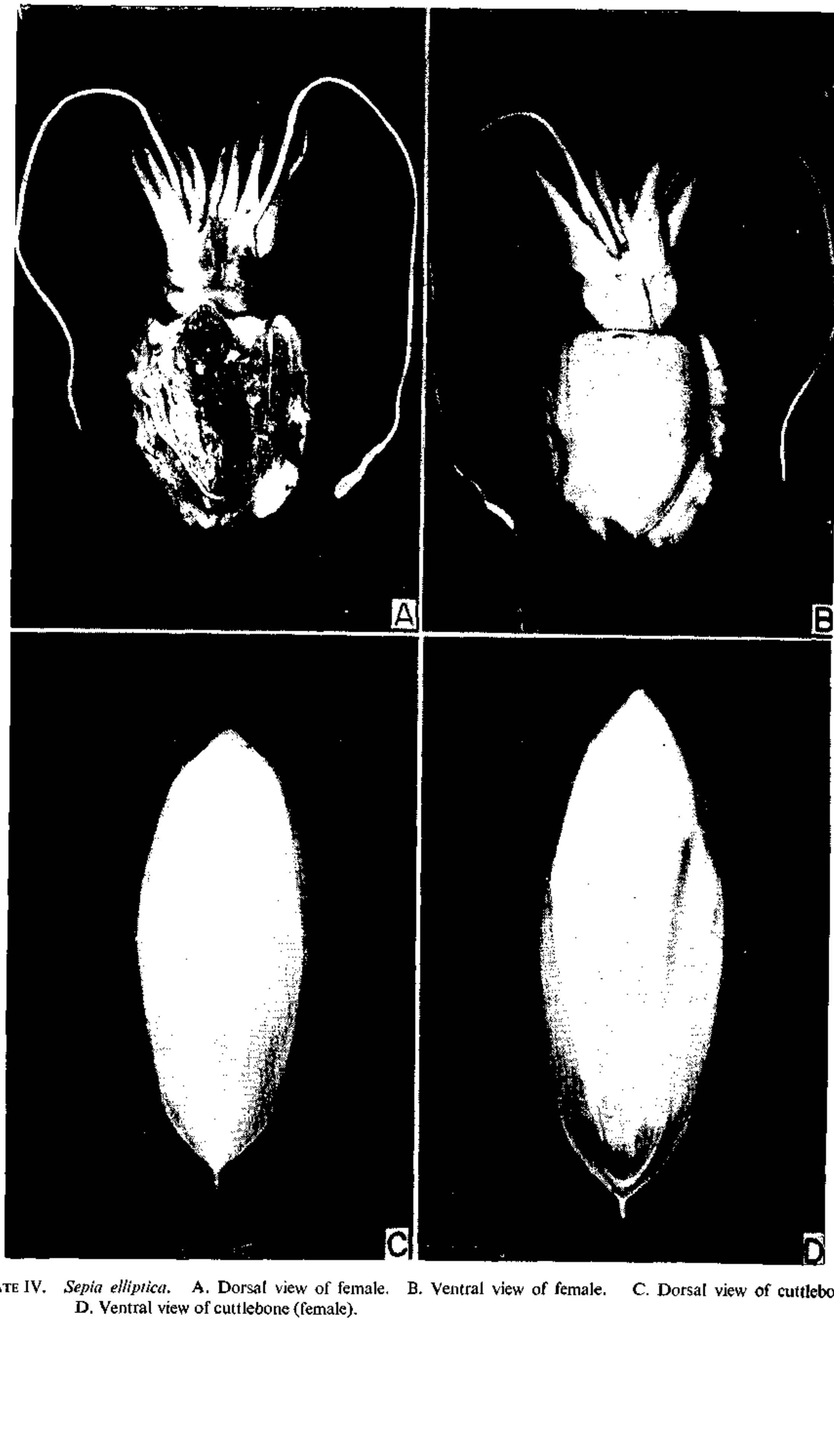

PLATE IV. *Sepia elliptica*. A. Dorsal view of female. B. Ventral view of female. C. Dorsal view of cuttlebone (female). D. Ventral view of cuttlebone (female).

The tentacles are short and about as long as mantle length ; the stem is thin and triangular in cross section ; the clubs are moderate in size, slightly expanded and bear about eight to ten rows of minute suckers of uniform size ; the protective membrane is well developed on either side and united at the base, swimming membrane is broad. The horny rings of the suckers are smooth without teeth.

The cuttlebone is broad, thick, and typically elliptical in outline. The shell is acuminate at the anterior end, more so in females, and the posterior part is slightly wide. The terminal spine is thick, sharp and curved dorsally. The dorsal surface of the cuttlebone is somewhat smooth and there are three feeble longitudinal ridges. The ventral surface has two prominent lateral ridges and three longitudinal furrows in the striated area and consequently the striae show three or more sinuations along the entire length. The last loculus is convex whereas the posterior part is hollowed.

The maximom size of males reported is 129 mm and that of females 119 mm.

The dorsal surface of mantle and head is pale greyish in fresh specimens and becomes very dark sometime after capture.

Sepia prashadi Winckworth, 1936

(Plate V ; A-E)

Body is rather slender, elongate and oval in outline; the anterodorsal margin projects strongly with well excavated sides. The fins are moderate in width, begin a short distance before the anterior mantle margin and extend along the sides. At the posterior end of the mantle they are distinctly separated. The head is rather small, as long as broad.

The arms are subequal and well tapering. The arms are provided with but narrow protective membranes. The dorsal arms are slightly keeled on the outer sides at their distal ends, the lateral arms are strongly keeled along their ventral margins, whereas the ventral ones have strong outer swimming membranes. The arm suckers are more or less globular in males and arranged quadriserially throughout the length. The outer marginal suckers of the arms are smaller in size than the inner ones in the greater proximal portion of the arms ; but at the distal tapering end, the outer suckers are slightly bigger than the inner ones except on the ventral pair of arms (Adam and Rees, 1966). The left ventral arm is distinctly hectocotylized in males. It has two groups of normal quadriserial suckers at its base. The modified portion occupies the greater length of the arms with prominent transverse folds. The suckers are very much reduced in size, the two ventral rows of suckers are arranged very closely and it appears as though they are set in a single row. The dorsal series of suckers are larger in size in the transformed portion. There are 12 to 14 transverse rows of four suckers each on the modified portion.

The tentacles end in short and broad clubs. The stem is rounded. A strong swimming membrane is present on the dorsal side of the tentacular clubs and extends a little beyond the end of clubs ; the manus of the club is distinctly separated from the tentacles by a deep furrow under the dorsal protective membrane. The protective membranes are well developed and come very closely at the base but they do not unite. The club suckers are arranged in eight oblique transverse series. The suckers are very much unequal in size. In the middle portion of the clubs, three suckers of the third series are very much enlarged.

The cuttlebone of this species is very distinct, its dorsal surface being pinkish in colour. The cuttlebone is elongately ovoid ; the dorsal surface is rugose with granulose texture especially in the anterior region and the lateral margins of the posterior end and bears three longitudinal ridges. On the ventral side, the striated zone is rather thick and convex and has a median distinct furrow along the entire length of its ventral surface. The striations are very closely set and broadly truncated with lateral corners slightly produced forwards. There is a small, slender but strong spine at the posterior part which is slightly directed upwards.

The maximum size recorded is 140 mm (Roper *et al.*, 1984).

The general colouration is light brownish with conspicuous streaks on the surface of the dorsal mantle and base of the arms. The presence of the transverse stripes gives a 'Zebra' pattern to the animal which makes this species distinctive.

Sepia trygonina Rochebrune, 1884

(Plate III ; F and G)

Mantle is elongate and narrow, tapering posteriorly and slightly compressed dorso-ventrally. The mid-dorsal projection of the mantle is blunt and reaches the point between the eyes. Fins narrow originate a few millimetres behind the anterior margin of mantle and are separate at the end of the body. The head is slightly wider than long. The buccal lappets are devoid of suckers. The funnel is very small and does not reach the interbrachial space between the ventral arms.

The arms are unequal in length and in the order 1.2.3.4. in the female and 1.4.3.2 in the male. The ventral and ventrolateral arms are laterally compressed and keeled. The web is absent between the ventral arms and it is rather shallow between the other arms. In males, suckers are arranged in four rows on all arms except the dorsal ones. The dorsal arms possess quadriserial suckers in the proximal two thirds of their length and biserial in the rest. In the females all the arms have quadriserial suckers in the proximal two thirds portion and biserial in the rest. The biserial suckers are minute in size and widely spaced.

The fourth left arm in male is hectocotylized. It has a single or two transverse rows of normal suckers basally. The middle one third of the arm is the modified portion where the suckers are situated wide apart. The protective membranes are well developed on the ventral and dorsal margins. The distal portion of the arm becomes abruptly slender and the narrow oral surface has four rows of minute suckers.

The tentacles are very slender and long. The clubs are very short and provided with a well developed swimming membrane extending from the proximal part to the tip of the club. The suckers of the club are arranged in seven or eight oblique rows of which five suckers of the third row are enlarged.

The cuttlebone is slender, long and lanceolate in shape; widest at the anterior third and the posterior end is more acuminate than the anterior end. The dorsal surface is finely granular and possesses a median low ridge. There is a distinct narrow groove medially which becomes shallow anteriorly and is feeble in the last loculus. The striated area is separated and elevated from the marginal zone on either side by two slender ribs of the inner cone. The spine is small and sharp. The dorsal surface of the cuttlebone is reddish in colour (Adam, 1966; Sarvesan, 1976).

This is a small sized cuttlefish with a maximum recorded size of 50 mm.

The head and mantle are pale brownish. There is a series of small, circular dark brown blotches along the fins on the dorsal surface of mantle in males.

This cuttlefish is easily recognised by its small size, very slender tentacles, short tentacular clubs and lanceolate shaped cuttlebone with a small spine at the posterior end.

Sepia arabica Massy, 1916

(Plate VI; E-G)

The mantle is narrow, elongate and slightly compressed; size small and posterior end blunt. The mid-dorsal projection of the mantle is well excavated on the sides. The head is small, narrower than the mantle opening and slightly flattened. The funnel is small and wide. Eyes are large. Two prominent ear-shaped fleshy lobe-like projections are present one on either side of the eyes, their outer surface bear bluish transverse stripes in fresh condition. Originating a few millimetres behind the anterior margin of the mantle, the fins are narrow at the anterior end and become slightly broader posteriorly; the fins do not reach the extreme posterior end of mantle. The arms are short, subequal in length and have attenuate tips; they are well compressed and consequently the sucker bearing surface is narrow; the protective membranes of the arms are broad and therefore the quadriserially arranged small suckers are covered by the membranes to a large extent; suckers on the outer rows are smaller than those on the inner rows. The interbrachial web is well developed between the lateral arms, shallow between the dorsal arms and absent between the ventral ones. The horny rings of the arm suckers are generally smooth without teeth but have a few notches (Massy, 1916).

The left ventral arm in male is hectocotylized, but the hectocotylization does not involve much modification; only the sucker bearing surface is almost completely covered by its protective membranes (Adam and Rees, 1966).

The females are slender and thin; the terminal clubs are crescent shaped; the suckers are subequal and arranged in 5 or 6 transverse rows; swimming membranes are well developed and exceed slightly the length of the clubs; the horny rings of the suckers have some minute widely spaced teeth.

The cuttlebone is long, slender, extremely narrow, rounded anteriorly and tapers posteriorly. The posterior portion of the cuttlebone is curved. The dorsal surface is granulated and possesses a broad calcareous median rib; lateral surface is chitinous and shows faint striae. On the ventral side, a longitudinal narrow groove runs along the entire length of the cuttlebone. The striae which begin as transverse lines at the posterior end deepen and are 'V' shaped at the last loculus. The striated area is separated from the outer cone by a smooth zone in between the limbs of the inner and outer cones; the former extends anteriorly to about half the length of the cuttlebone. The outer cone is narrow and enlarged to surround the posterior part of the innercone. At the posterior end a number of sharp keeled ridges radiate from the inner cone which are united with each other with calcareous material to give a rounded spatulate shape at the posterior end. A spine is lacking.

The maximum size recorded is 67 mm.

This cuttlefish is generally brownish; the dorsal side is darkish; ventral mantle is pale; 10-12 circular purplish patches are present at the base of the fins at the posterior half of the mantle.

Sepiella inermis Orbigny, 1848

(Plate VI; A-D)

This species is readily recognized by the smaller size, absence of a spine in the cuttlebone, the oval outline of the shell and the presence of a distinct glandular pore at the extreme posterior end of the mantle.

The mantle is broadly oval; the dorsal margin is angularly rounded and mid-doral projection is not much pronounced; the ventral margin of the mantle is emarginate; the mantle has a pigmented gland and an orifice at its posterior end ventrally. The funnel is short and thick. The fins begin slightly behind the anterior mantle margin, are narrow anteriorly and are broader posteriorly. The head is rather short and broad. The arms are stout, subequal in length, laterally compressed and tapering to slender tips. The arm suckers are uniformly minute and arranged quadriserially. The basal suckers are larger and are progressively reduced in size towards the distal end. The protective membranes of all arms are well developed. In females the arm suckers are provided with smooth rings whereas those of males have strong dentate ring.

The tentacles are very long and slender. The swimming membrane of the tentacular clubs is slightly shorter than the club. The clubs are provided with minute, subequal, numerous suckers arranged in 16 to 24 transverse rows. The clubs are long but not very much expanded.

In males the left ventral arm is hectocotylized and in its proximal half there are ten rows of minute suckers set widely apart in four rows and transverse ridges are also present. The distal half of the arm is narrow and has quadriserially arranged normal suckers.

The cuttlebone is oval in shape and with out spine. The dorsal surface is granulose and has a low mid-rib and the ventral surface has wavy striae with a distinct median narrow groove and many jointed radiating furrows on the striated area. The last loculus is short and concave. The inner cone has 'V' shaped limbs and a small thick rounded knob at the end. The outercone is broad and extends beyond the innercone and is rounded at the posterior end with a slight marginal notch on either side. The outer cone is very brittle and thin.

This is a moderate size cuttlefish with a maximum mantle length of 124 mm.

The dorsal surface of head, mantle and arms is greyish with numerous melanophores; in the fresh condition faint longitudinal stripes extending from the base of arms to their tips on the aboral side are seen. There is a row of dark ornamental ocelli on either side of the fins on the margins on the dorsal side in males.

Euprymna stenodactyla Grant, 1833

(Plate XI; D and E)

The body is saccular and bell-shaped, the mantle is broad and rounded posteriorly. The fins are semicircular in outline and originate at the middle of the mantle on the dorsal side. There is no internal shell or gladius. The mantle and head are united by a broad dorsal commissure in the nuchal region. Excepting for this connective commissure the head is free from the mantle opening. The funnel is long and tubular and its proximal portion is completely covered by the mantle.

The arms are long, slender and subequal in length; the second pair are longest and the fourth pair shortest. The arms are keeled and the web between them is not prominent. The arm suckers are globular, have long stalks and are arranged in four rows on all arms, excepting for proximal few pairs. The suckers differ considerably in shape from those of other cephalopods and are placed on pedicles laterally. The suckers are lost easily on handling because of their delicate pedicles. Sexual dimorphism exists in size and arrangement of suckers.

The left dorsal arm is hectocotylized in males in a very characteristic form. The basal suckers in the first few rows of the hectocotylized arm are normal, and distal to these there are two fleshy papillae on the ventral margin followed by a dense group of elongate pedicles of the suckers fused together giving a palisaded effect to the dorsal portion of that arm. As a result, this makes the tip of the arm very thick.

The tentacles are short with round stem. The clubs are very short and have numerous rows of very minute suckers crowding to give a 'swab' like appearance A pair of saddle-shaped luminous organs are present on the inksac.

This is a small species, about 35 to 45 mm in dorsal mantle length.

While fresh the mantle is whitish with numerous dark chromatophores both on dorsal and ventral sides; the fins have a few chromatophores at the base where they are united with the mantle. In live condition these animals live with their body partly buried in the bottom and covered by sand.

SQUIDS

Loligo duvaucelii Orbigny, 1848

(Plate VII ; C and D)

The mantle is cylindrically elongate and tubular with almost parallel sides up to the point where the fins originate, then tapers to a blunt posterior point. The mid-dorsal projection of the anterior margin of mantle is rounded. The fins are small and short, 50-55 per cent of mantle length and rhombic in outline. They are broadest near the middle, the anterior margin is nearly straight or slightly convex and the posterior margin is concave. The head is small, as long as broad and slightly flattened dorsoventrally. There is a strong pit-like excavation on the ventral side in between the eye lobes to accommodate the free end of the funnel.

The oral arms are moderately long and in the order 3.2.4.1. They are laterally compressed and keeled along the length, the third pair being the broadest. The suckers of the arms are uniformly in two rows and well protected by membranes; they are provided with horny rings which bear about seven plate-like teeth on the distal margin while the proximal margin is smooth without dentition. The left ventral arm in the male is hectocotylized for over half of its distal portion. The pedicles of the suckers in the modified portion are prominent and produced into fleshy papillae-like projections. The papillae in the ventral row are larger than those in the dorsal row. The proximal rows are provided with greatly reduced minute suckers, and the distal papillae are devoid of suckers. Inside the mantle cavity near the rectum the ink sac possesses two small ovoid light organs on each side.

The tentacles are slender and long with expanded clubs. Club suckers are arranged in four rows; the suckers on the manus of the club are largest, the median ones being much more enlarged than the marginal ones. The large manus suckers bear about 14-17 pointed teeth on the rings.

A maximum size of 290 mm has been reported for this species.

In fresh condition immediately upon capture the squid is colourless and mantle transparent showing the internal visceral organs. There are numerous light brown chromatophores scattered all over the mantle, fins, head and arms. On the ventral side chromatophores are less dense and appear whitish.

Loligo uyii Wakiya and Ishikawa, 1921

(Plate VII ; A and B)

The body is short and stout with the posterior end bluntly pointed. Females are larger than males; The fins are rhombic in shape, their length 55-65 per cent of mantle length and angles are rounded. The midrib of gladius shows distinctly through the dorsal mantle skin along the anterior part as in *Loliolus* spp. Comparatively the head is longer than in other *Loligo* spp. The head is large, eyes prominent; the arm crown is conspicuously large and more than half of mantle length.

The oral arms are in the order 3.4.2.1 with the ventral arms by far conspicuously longer and robust. The dorsal arms are distinctly shorter than others. The arm suckers are globular and arranged biserially on all the arms of both male and female. The suckers of the third arm pair are more globular and bigger among arm suckers. The large suckers of this arm have four very broad plate-like teeth on the distal margin of the horny rings. The proximal margin of the rings are smooth without dentition.

The left ventral arm is hectocotylized in males. It is not the usual type that is found in *Loligo* but is similar to that of *Loliolus*. The distal portion of the arm remains unmodified whereas the proximal portion is involved in the modification. The ventral row of the arm bears several papillae fused together with the protective membrane to form a single sheath-like crest, gradually which decreases in width distally. On the dorsal side the row consists of normal conical papillae with minute suckers separated from each other. The top of the crest also bears reduced suckers.

The tentacles are slender, more than twice the length of mantle. tentacular clubs are distinct, long, slightly expanded and lanceolate in shape; club has quadriserial suckers throughout; about eight suckers in the manus are much enlarged; club suckers have smooth rings.

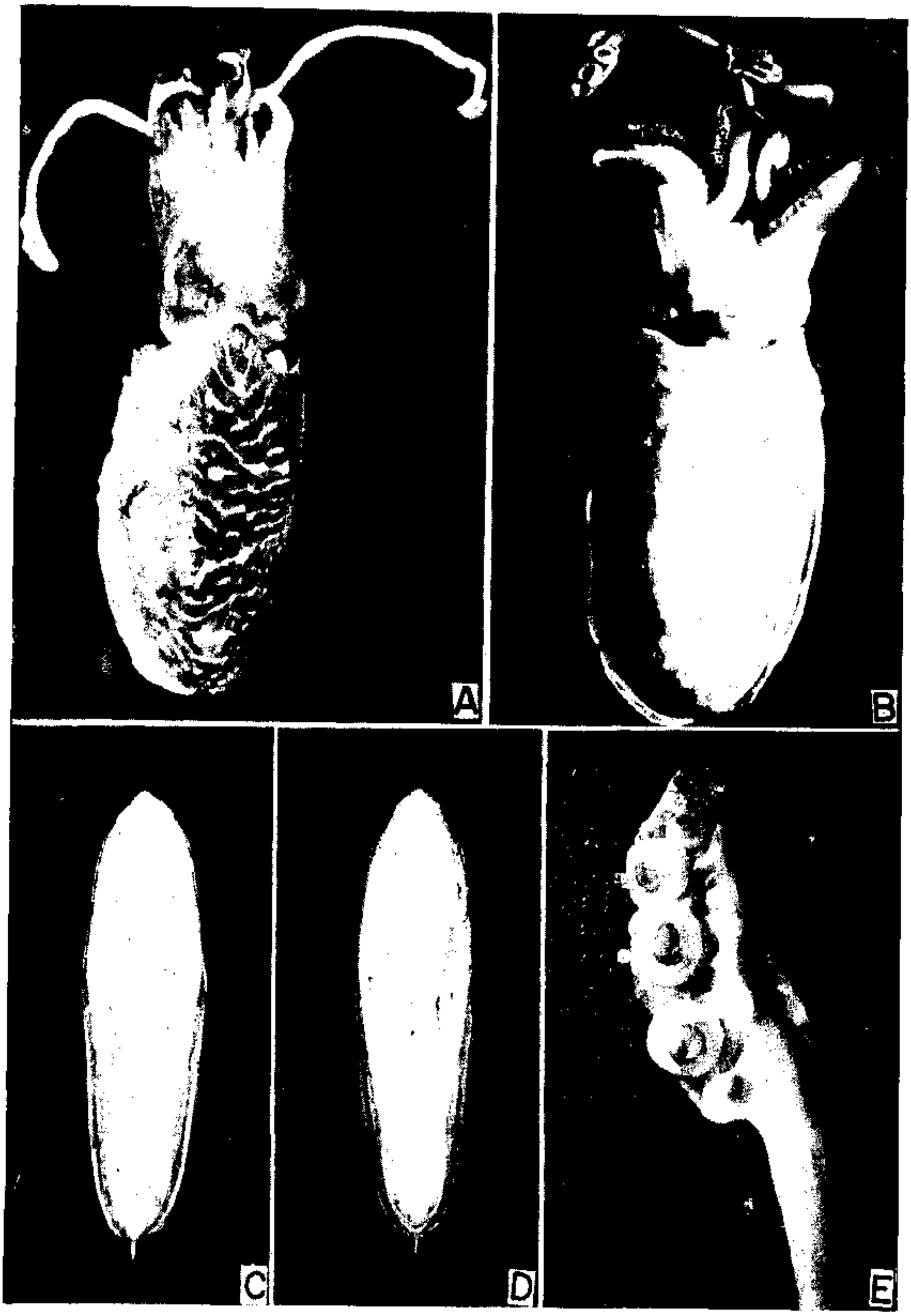

PLATE V. *Sepia prashadi*. A. Dorsal view of female. B. Ventral view of female. C. Dorsal view of cuttlebone (male). D. Ventral view of cuttlebone (male). E. Tentacular club.

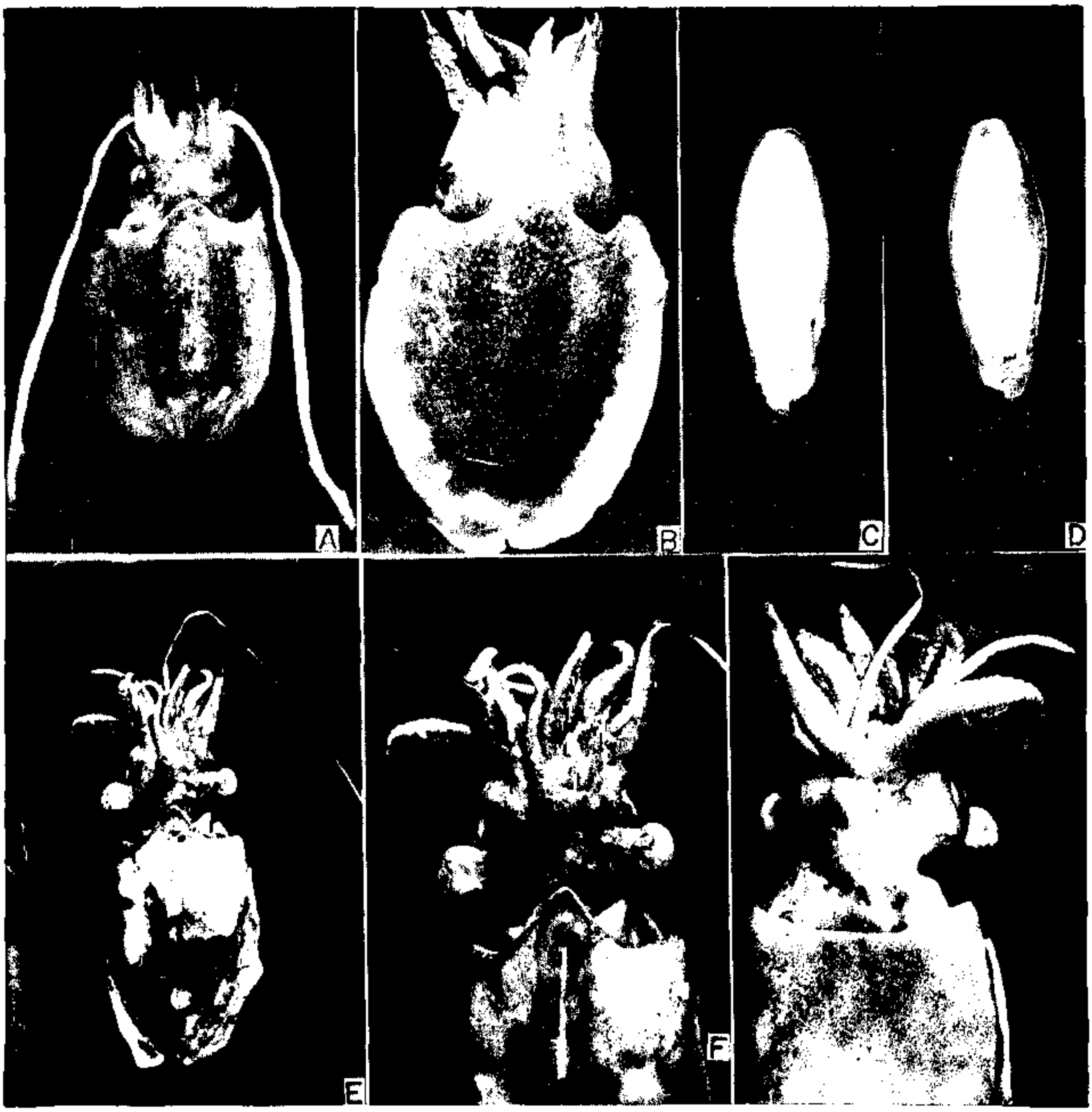

PLATE VI. *Sepiella inermis*. A. Dorsal view of female. B. Dorsal view of juvenile (male). C. Dorsal view of cuttlebone (female). D. Ventral view of cultlebone (female). *Sepia arabica*. E. Dorsal view. F. Dorsal view of head G. Ventral view of head.

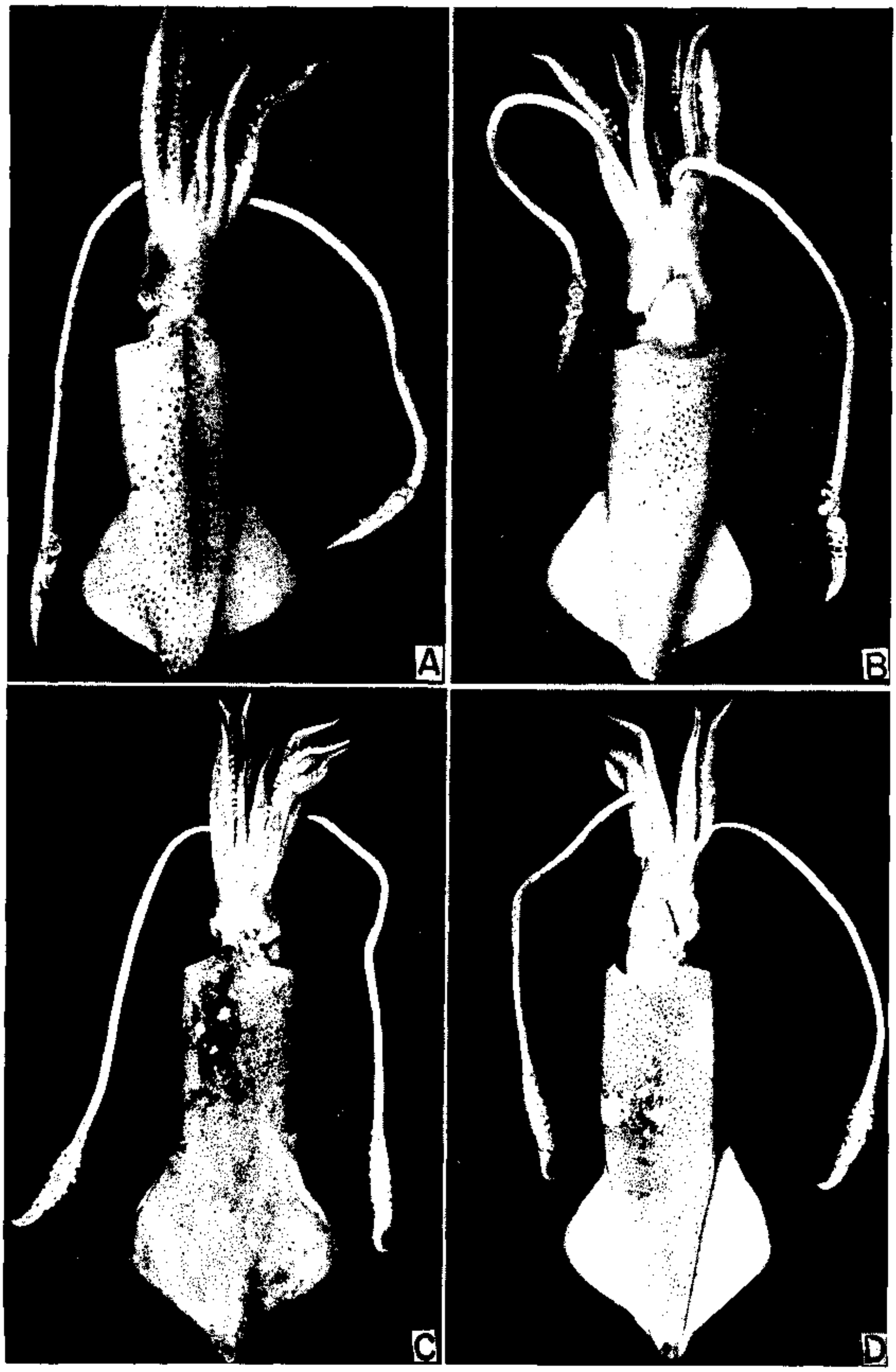

PLATE VII. *Loligo uyii*. A. Dorsal view of female. B. Ventral view of female. *Loligo duvaucelii*. C. Dorsal view of male. D. Ventral view of male.

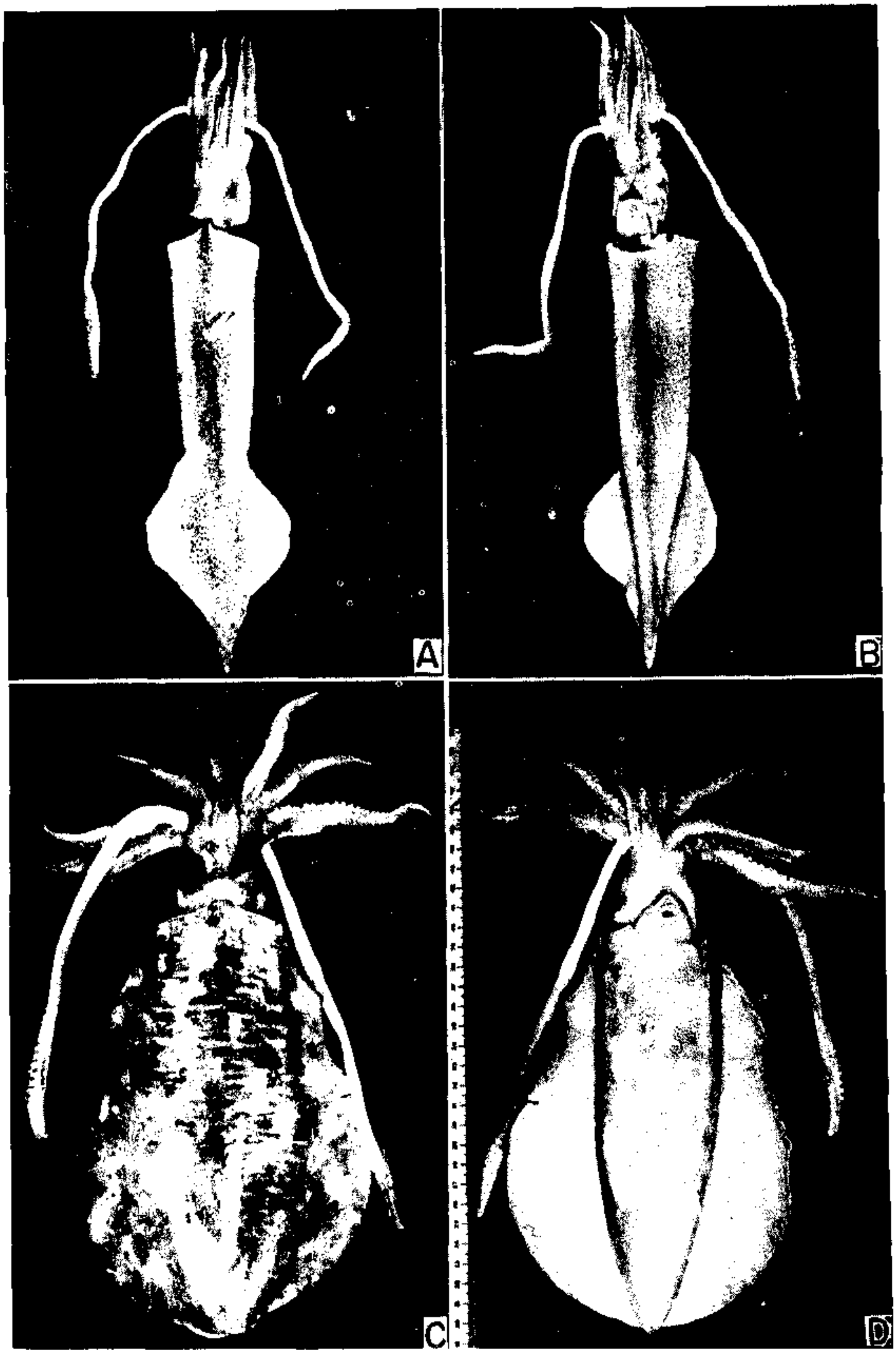

PLATE VIII *Doryteuthis sibogae*. A. Dorsal view of male.. B. Ventral view of male. *Sepioteuthis lessoniana*. C. Dorsal view of male. D. Ventral view of male.

The maximum size reported for males and females of this species is 81 mm and 113 mm respectively (Natsukari, 1983).

In fresh condition, the mantle, head and fins are pale whitish with a large number of chromatophores.

Doryteuthis singhalensis (Ortmann, 1891)

Mantle long, thick, muscular and narrow tapering posteriorly to a sharp end. The anterior middorsal projection is rounded at the tip. The ventral margin is emarginated at the middle. Fins large and rhombic in shape extending along more than 60 per cent of the length of the mantle. They are widest at about the middle; the anterior margin of fin lobes is slightly convex and the posterior margins are concave. Head relatively small, eyes large. The buccal membrane has seven projections and each possess about eight minute suckers. The funnel is small, stout and placed in a deep furrow beneath the head.

Arms are rather short 20 to 30 per cent of the mantle and in the order 3.4.2.1 or 3.2.4.1. The third pair of arms are longer and stout, well compressed and have poorly developed swimming membrane; the protective membrane on either side is well developed. The horny rings of the larger arm suckers bear on the distal side 6 to 11 slender teeth; the proximal side is smooth (Okutani, 1970).

The distal half of the left ventral arm of males is hectocotylized and the proximal portion of the arm bears about fifteen pairs of normal suckers which are more or less equal in size but smaller than those on other arms. The pedicels of the suckers in the modified distal portion are fleshy and enlarged and those on the ventral row are greatly enlarged. The pedicels in the modified portion bear minute suckers without horny rings.

The tentacles are moderately long, slender and compressed. The clubs are short and slightly expanded with a trabeculate protective membrane on either side. The club suckers are arranged in four rows; those on the two median rows are slightly larger than the lateral suckers. The rings of the suckers bear about 20-22 sharp curved teeth. The teeth are not of uniform size; a few of them are smaller and arranged alternately with long curved teeth. An oval shaped light organ is present on either side of the rectum (Okutani, 1971). The gladius is narrow with nearly straight margins gradually tapering to a point.

The maximum mantle length recorded for this species is 50 cm in males and 31 cm in females (Roper *et al.*, 1984).

Doryteuthis sibogae Adam, 1954

(Plate VIII; A and B)

The mantle is long and slender, widest at about the middle; from the point of insertion of fins it becomes narrow and tapers to a sharp end posteriorly. The middorsal projection of the mantle is pointed anteriorly; the corresponding ventral margin of mantle is emarginated. A distinct longitudinal concentration of chromatophores is present midventrally on the mantle. Excepting for this there is no ridge present on the ventral side. Such concentration of chromatophores is distinct only in males and is feeble in females. There are a pair of light organs on the ink sac far behind the anal flaps. The fins are typically rhombic in shape, occupying less than half of the mantle length. Head is very small, slightly longer than wide; eyes are large. The funnel is short with the anterior free portion reaching upto the anterior margin of the eyes. The funnel furrow is deep.

The arms are short, usually in the order 3.4.2.1. All arms are keeled and slightly compressed. The aboral keels on the ventro-lateral arms are well developed in the form of swimming membrane. Suckers are arranged in two rows on all the arms and bordered by protective membranes. The horny ring of the largest arm sucker has 5-9 blunt, squarish teeth on the distal half, whereas the proximal half of the ring is either smooth or wavy edged.

The left ventral arm in males is hectocotylized. It is longer than the corresponding arm on the right side and possesses 15-19 normal suckers at the base; distal to these suckers are 20-22 fleshy, conical pedicels arranged in two rows along the margins of the arm, gradually reducing in size anteriorly and becoming very minute at the tip.

The tentacles are slender and moderate in length; the clubs are only slightly expanded with feebly developed swimming membrane. The club suckers are arranged quadriserially, the lateral ones being smaller in size than the median row suckers in the manus portion. The chitinous rings of the large club suckers bear 22-26 sharp, curved and conical teeth on the margin; the teeth on the distal margin are slightly larger than the others. Larger males tend to have about 31-35 such teeth on the club sucker rings. The suckers of the arms and club are generally moderate in size and the largest sucker of arm III and the largest club sucker are almost of the same size. There are seven lappets on the buccal membrane each lappet having 5-11 minute suckers.

The vane of the gladius is broad at the anterior region but tapers to a sharp posterior end with straight margins. The gladius of females is slightly wider than that of males. There are five ribs on the gladius, one median and two lateral ribs extending along the whole length of the gladius including the rachis, the two marginal ribs extending from the vane to the posterior slender tip.

The maximum size recorded for this species is 205 mm in males and 165 mm in females (Silas *et al.*, 1982).

In fresh condition, the mantle is whitish with dark brownish chromatophores on the dorsal side. On the ventral side the chromatophores are concentrated medially in the form of a thin line. Eyes are dark in colour.

Sepioteuthis lessoniana Lesson, 1830

(Plate VIII ; C and D)

The mantle is elongate, conico-cylindrical and tapering to a rounded blunt point posteriorly. Anterodorsally the mantle extends over the neck region as a small rounded point ; the ventral margin at mantle opening is emarginated. The fins are characteristically very large and wide, extending from the anterior margin of mantle to the posterior end. Anteriorly at the beginning, the fins are narrow but gradually broaden behind, broadest at about the posterior third of the body beyond which they narrow down rapidly and unite with each other at the posterior end. The fins are very thick and muscular. The head is large, eyes prominent and greenish at the base, funnel is large and provided with prominent funnel valve. The arms are unequal in length in the order 3.4.2.1, the second and third pairs prominently keeled ; suckers of all the arms are arranged in two alternating rows ; the horny rings of the suckers are provided with blunt squarish teeth on the proximal margin and sharp conical teeth on the distal margin. There are about 20 such teeth on the smaller suckers and 23 teeth on large suckers of the arms.

The left ventral arm is hectocotylized in males. At the base upto 20 pairs the suckers are normal ; in the next 6 pairs the pedicels are thick and prominent with minute suckers ; in the remaining portion of the arm upto tip, only the pedicels are present. The pedicels on the dorsal margin are slightly larger than those on the ventral row.

The tentacles are moderate in length and the stalks are stout and slightly laterally compressed ; clubs are alrge and provided with trabeculate protective membranes on the sides. Suckers arranged in four rows transversely, those in the middle rows are larger than the lateral ones ; horny rings of large club suckers have 14 to 23 teeth as in arm suckers.

The gladius is lanceolate and colourless in fresh condition.

The largest size recorded is 36 cm for males and 30 cm for females (Voss and Williamson, 1971).

The colour of the animal on dorsal side is darkish due to crowding of chromatophores, the ventral side is less pigmented. The general colouration in fresh specimens is pinkish brown, with whitish ventral side, the base of the eyes and the surroundings have a greenish tinge. on the dorsal surface of the mantle and fins greyish transverse streaks are found which are conspicuous in males.

Loliolus investigatoris Goodrich, 1886

The body is conical in shape with the greatest width at about the middle. The adult females are always a little larger in size and relatively broader than males. The mantle is small and is rounded posteriorly. The anterior margin of mantle is produced into a small lobe middorsally as in other loliginids. The midrib of gladius is seen clearly through the skin middorsally in the anterior part of mantle. The fins are large and broad and extend along more than 70 per cent of the mantle length ; their anterior and lateral margins are rounded and the two fin lobes together are heart shaped. The fins of females are broader than in males. The head is small, as long as wide but narrower than the mantle width.

The arms are rather short and subequal in length. The arms of males are slightly larger than those of females. The first and third pairs of arms are well-compressed laterally whereas the second and fourth pairs are less compressed. The arm suckers are globular and arranged in two series and the sucker rings are provided with 3 or 4 teeth. Those on the lateral arms are slightly larger than the suckers of other arms. In males, the suckers on the ventral row of the lateral arms are distinctly larger than the dorsal ones.

The left ventral arm is hectococylized in males ; the hectocotylization differs from that in *Loligo* spp. The distal portion of the modified arm is devoid of normal suckers and there are several ridges along the edge which gives it corrugated appearance. The protective membrane in the region is well developed.

On the dorsal margin, the membrane is very narrow and has several small papillae.

The tentacles are short and very thin and end in narrow clubs which have small, subequal suckers arranged in four rows. The median suckers of the manus are larger in size than the peripheral ones. The gladius is short and the vane is conspicuously broad at midlength.

The maximum mantle length of females is 55 mm.

The body is colourless and transparent when fresh. On preservation the mantle becomes somewhat whitish with diffused chromatophores pale brown in colour and distributed all over the body. The midrib of gladius on the anterior dorsal mantle is seen as a dark brown line.

Onychoteuthis banksii (Leach, 1817)

Body muscular, long, cylindrical and tapering gradually to an acuminate posterior tip ; greatest width about one fourth the length of mantle. Head slightly flattened dorsoventrally ; the nuchal area around the neck with 9 or 10 conspicuous elongate folds. Eyes are large with wide eye-opening, a large patch-like photophore present on the ventral surface of each eye. Fins thick and muscular, sagittate in shape and distinctly wider than long, fin length being about 60 per cent of mantle length ; fin angle at the posterior end about 50°. Arms are moderately long, the lateral arms are longer and about half in mantle length ; suckers are arranged in two rows.

Tentacles are about as long as mantle ; clubs not expanded and possess a fixing apparatus consisting of about 20 small fleshy cup-like suckers and pads at the base ; the rest of the portion is armed with 12-23 large and strong chitinous curved hooks arranged in two rows ; the lateral rows of suckers are lacking ; hooks of the manus portion on the ventral margin well developed and larger ; other hooks reduced in size anteriorly and posteriorly. Lateral rows of suckers are lacking.

The rachidian ridge of gladius visible as a conspicuous dark-brown line through the skin along middorsal mantle surface. Two large oval-shaped light organs are present on the ventral side of intestine along its midline.

The bite of this squid is reported to be toxic and likened to the sting of a wasp in its effect (Roper *et al.*, 1984).

The maximum size recorded for this species is 30 cm (Roper *et al.*, 1984).

Ommastrephes bartrami Lesueur, 1821

Mantle nearly cylindrical and muscular ; sides parallel upto origin of fins then tapers gradually to a posterior blunt point. Head is long, as wide as mantle opening and slightly tapering from base to the point of origin of oral arms. Funnel is short, heavy and muscular ; funnel pit deeply excavated ; faveola with six or seven longitudinal ridges and on either side of this three or four secondary pockets present. Mantle-funnel locking cartilages are free and not fused. An elliptical golden stripe present along the midventral line from mantle opening to the point of fin insertion. Fins transversely rhombic in shape with a fin angle of 55-60° ; the anterior margins of fin lobes slightly covex and the posterior margins slightly concave ; fins wider than long.

Arms are subequal in length, the first pair being always the shortest ; ventro-lateral arms thickest with well developed swimming membrane. Protective membrane well developed with strong trabuculae on all arms ; the dorsal membrane is wider than the ventral one. Large arm suckers bear several flattish teeth on their chitinous rings. In males either the left or right arm is hectocotylized in the distal half. Tentacles moderate and about as long as mantle in length. A fixing apparatus is present consisting of 2-4 knobs on the dorsal edge at the base of clubs ; clubs elongate and slightly expanded in the middle ; suckers are arranged in four rows ; suckers on the median two rows in manus are larger than the lateral ones ; the chitinous rings of these large suckers bear four sharp prominent teeth, one in each quadrant interspaced with five or more small teeth. Dentition on the rings similar to that of *Symplectoteuthis oualaniensis.* Ventral side of mantle with numerous closely packed small irregularly shaped and interconnected light organs ; patches of such light organs are also present on the ventral surface of head.

Maximum size reported is about 50 cm in mantle length in females and 32 cm in males (Roper *et al.*, 1984).

Symplectoteuthis oualaniensis (Lesson, 1830)

(Plate IX ; A and B)

The mantle is long, muscular and cylindrical upto the point of origin of fins and tapers abruptly to a narrow point at the posterior end. The dorsal margin is slightly produced in the middle. The fins are short, muscular and broad with convex anterior margin and from an angle of about 65° laterally. The head is large and as wide as mantle and bears comparatively short arms. The funnel is short, compact and set in a deep pit present on the ventral side of the head ; faveola with 7 to 9 longitudinal folds in the central pocket and 3 to 5 lateral pockets on either side. Funnel locking apparatus is ' ⊥ ' shaped and fused in its middle portion with the mantle groove so that separating the funnel free from mantle-lock is difficult.

The arms are large, strong in the order 3.2.4.1 and compressed with the third pair strongly keeled. Arm suckers are biserial ; the protecting membranes have prominent trabeculae ; the larger arm suckers are provided with about 12 sharp teeth around the entire rim of the horny rings.

The left ventral arm in males is thicker and longer than the right ventral arm and hectocotylized. About one half of its distal part is devoid of suckers and papillae. In the basal portion of the hectocotylized arm 14 or 15 suckers are present in two rows protected by flap-like membranes. There is a series of pits in a single row along the base of the protective membranes (Voss and Williamson, 1971).

The tentacles are short and muscular and laterally compressed. The clubs are small and slightly expanded ; the suckers are quadriserial with the inner rows on the manus larger. The larger suckers of the club bear about 20 sharp teeth on the rims of which four are larger and located one in each quadrant. An oval photophoric patch is present on the anterodorsal surface of mantle ; there are also two photophores on the intestine.

This is a large species of oceanic squid attaining a size of 35 cm (Roper *et. al.*, 1984).

The head, dorsal mantle, fins and arms are uniformly of chestnut brown colour.

Thysanoteuthis rhombus Troschel, 1857

The epipelagic oceanic species is a very large and muscular bodied squid. Mantle is thick cylindrical, wide anteriorly and gradually tapering to a blunt end posteriorly. The fins are long and occupy the entire length of the mantle along the sides ; shape of the fin is characteristically rhombic being very broad at the middle. The head is short and nearly as long as wide. Eyes are prominent. The oral arms are long with broad cirrate trabeculate protective membranes. Suckers arranged in two rows ; sucker rings possess 20-26 sharp teeth. The funnel mantle locking apparatus is typical ; the funnel cartilage is ' ⊣ ' shaped consisting of an elongate and narrow longitudinal groove and a short and broad transverse groove emerging from the middle part (Fig. 3).

The tentacles are rather weak and the clubs are slightly expanded in the middle. The suckers are small arranged in four rows, and carpus extended ; sucker rings with 15-20 fine teeth.

The maximum size reported is about 100 cm in mantle length (Roper *et al.*, 1984).

OCTOPODS

Octopus dollfusi Robson, 1928

(Plate X ; D)

The mantle is elongately oval in shape, head small, eyes well developed but not conspicuous, there are no cirri over the eyes.

The arms are moderately long, subequal and stout at their base ; the first pair of arms are shortest. The interbrachial membrane is well developed between all the arms except in between the first pair where it is narrow. The arm suckers are cup-like and fleshy without chitinous rings and are directly set on the arms uniformly in two alternating rows. The normal suckers are large at the base, become smaller progressively along the length of arms and minute at the tips. There are a few slightly enlarged suckers at the base of the second and third arms in males.

In males the third right arm is hectocotylized. This arm is slightly shorter in length than the left third arm, the ventral margin of the web is rolled into the form of a deep groove which serves as the spermatophore groove and extends upto the ligula. The ligula and calamus are well developed and the former is about 8-10 per cent of the arm. There are eight or nine lamellae in each demibranch of the gills. One of the characteristic anatomical features of this species is that the male reproductive system consists of an elongate and slender penis and a large coiled diverticulum together forming a reverse 6-shaped structure. The spermatophores are moderately long and distinctly armed with a series of teeth-like cirri.

This is a moderate size octopod with a maximum mantle length of 9 cm (Voss and Williamson, 1971).

The body and arms are of light greyish brown colour with a reticulate pattern all over the body.

Octopus aegina Gray, 1849

Mantle rounded to elongately oval in shape and closely covered with small tubercles or fine papillae and fine reticulate pattern on the dorsal surface. Head is small with a narrow neck region. Eyes are prominent

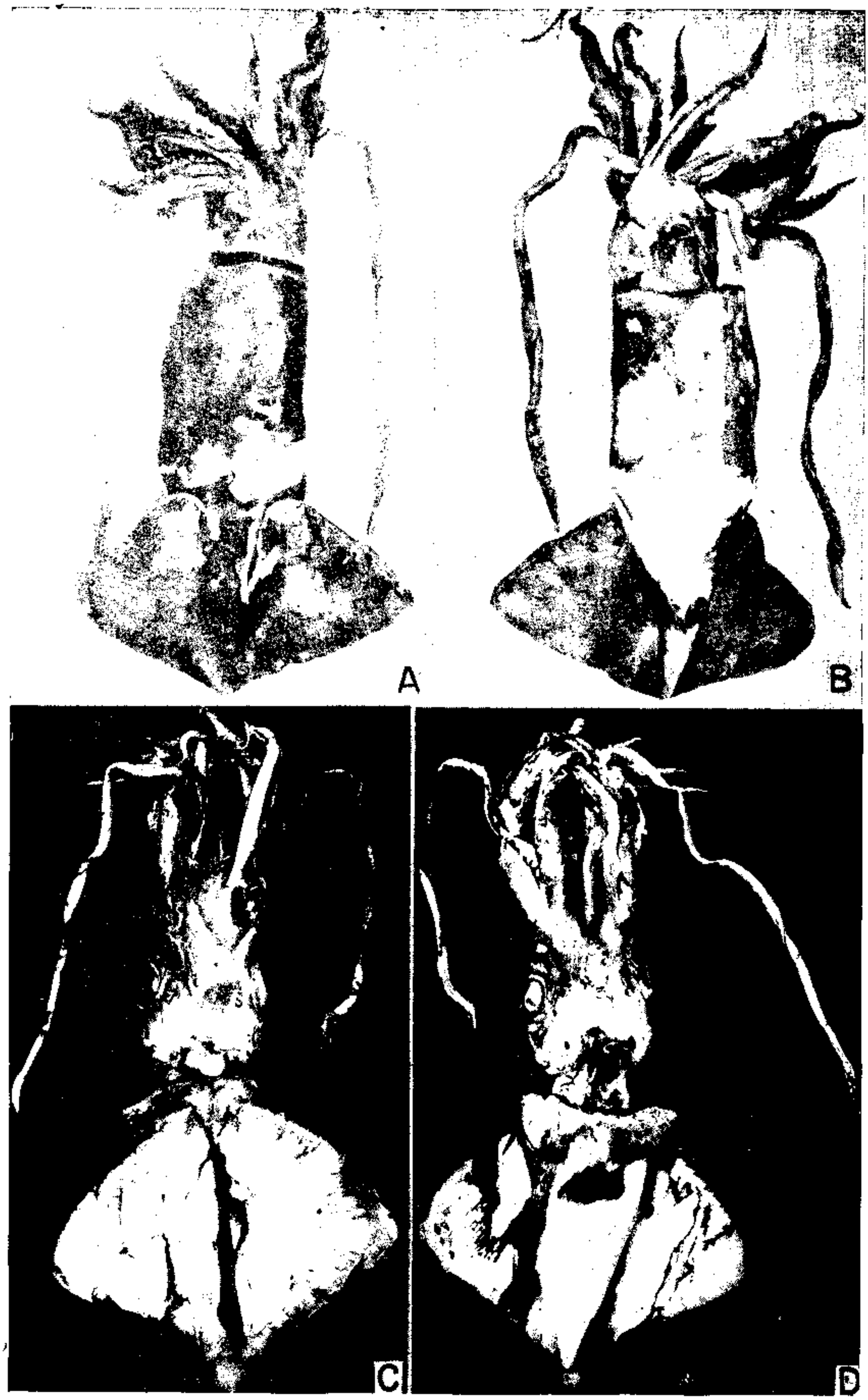

Plate IX. *Symplectoteuthis oualaniensis*, caught off Rameswaram in drift gill net. A. Dorsal view of female. B. Ventral view of female. *Ancirtrocheirus leneuri* caught by FORV SAGAR SAMPADA in pelagic trawl net at 13°26,7'N 69°28,2'E on 16th February 1985. : C. Dorsal view : D. Ventral view.

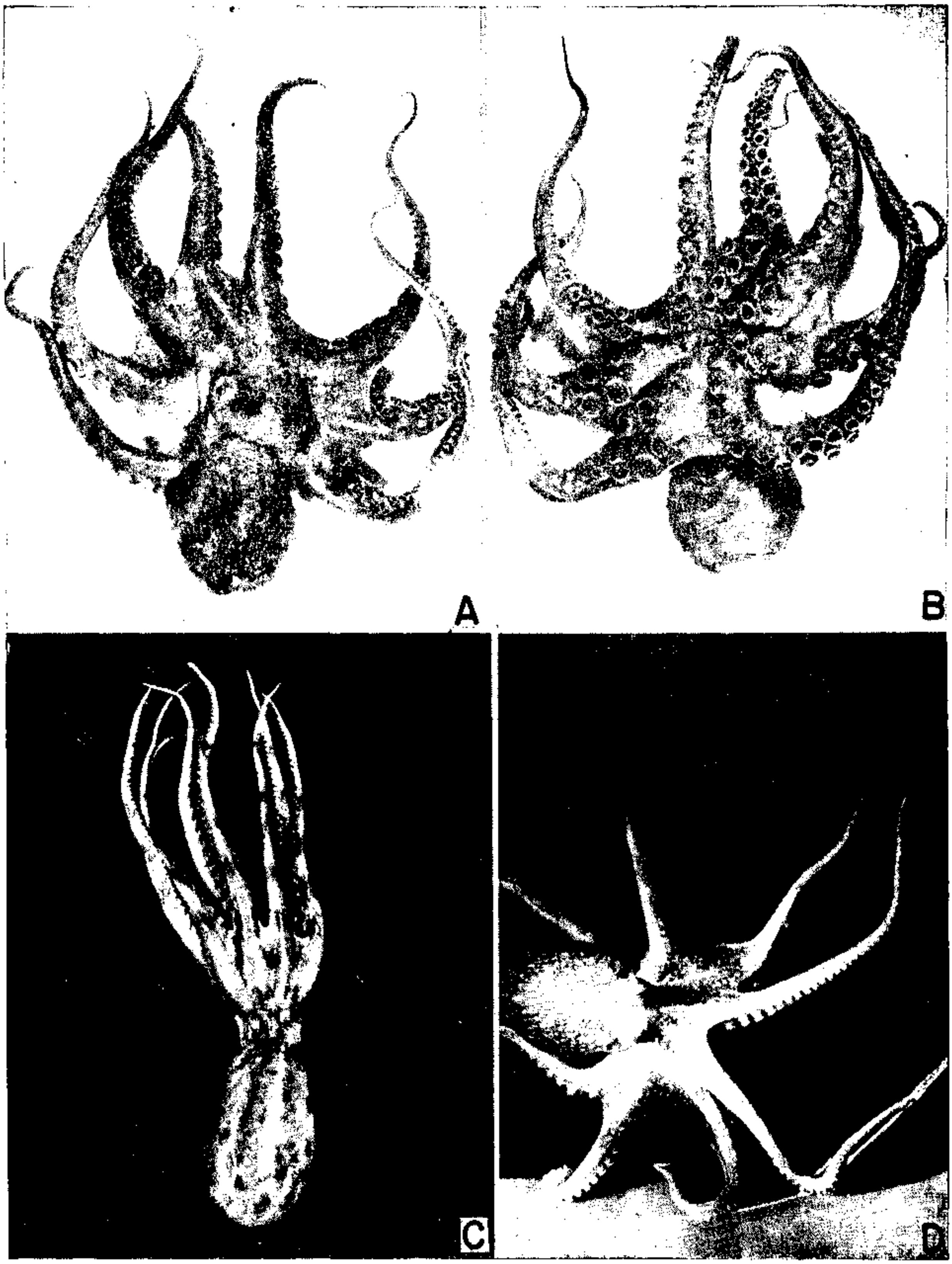

PLATE X. *Octopus globosus*. A. Dorsal view of male. B. Ventral view of male. *Hapalochlaena maculosa*. C. Dorsal view of female. *Octopus dollfusi*. D. Dorsal view of female.

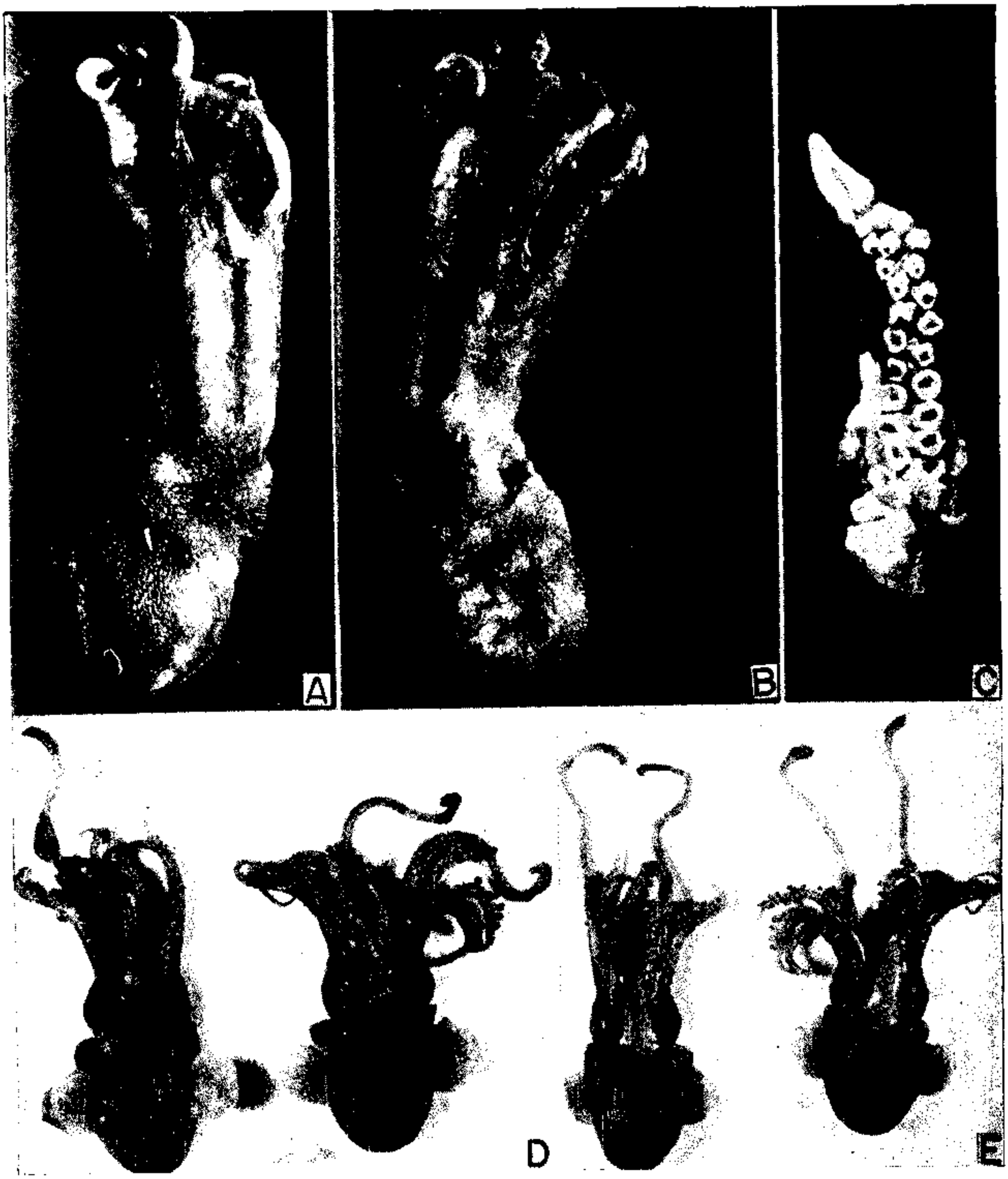

PLATE XI. *Berrya keralensis*. A Dorsal view of male.: B. Ventral view of male: C. Hectocotylized arm. *Euprymna stenodactyla*. D. Dorsal view of female and male. E. Ventral view of female and male.

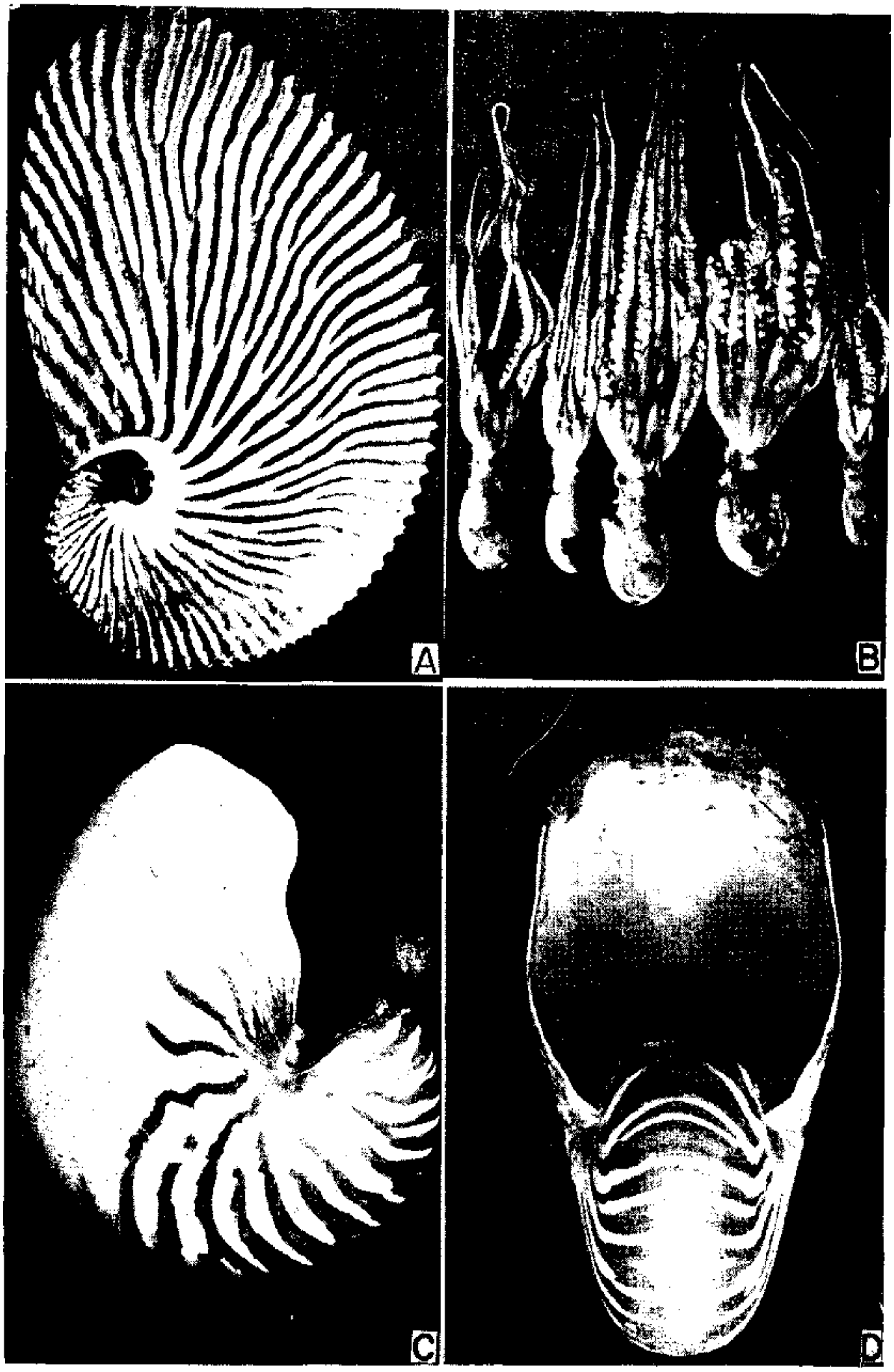

PLATE XII. A. Shell of *Argonauta argo* (from Dell, 1952). B. *Cistopus indicus*. C. and D. Shell of *Nautilus pompilius*.

and have a single large cirrus near the base of each eye ; fresh specimens with a narrow distinct white band across the base of head between eyes. Arms are long and stout, the dorsal pair distinctly shorter than others. The web between dorsal arms is very shallow ; depth between other arms moderate ; on the dorsal side of each arm a cluster of dark chromatophores present at the base of each sucker. The right third arm in males is long, slender and hectocotylized ; ligula is short and about 5 to 8 per cent of the hectocotylized arm ; groove very shallow and without ridges ; calamus very small and distinct. In males abruptly enlarged suckers may or may not be present. Male genital organ consist of a characteristic long, slender penis and a long diverticulum together forming a 'U' shaped structure terminating in an additional secondary loop. Spermatophores are long and unarmed.

The maximum size recorded is about 10 cm (Roper *et al.*, 1984).

The species is of dull brown colour with a fine reticulate pattern on the dorsal surface of mantle, head, arms and web. The oral surface of arms is whitish. At the base of each sucker on all arms there is dark pigmentation.

Cistopus indicus Orbigny, 1940

(Plate XII ; B)

The body is large and somewhat loose in consistency when compared with other species. The mantle skin is smooth. The head is small and united with the mantle by a narrow nuchal region. The eyes are very small.

The arms are very long and tapering to attenuate tips, the dorsal ones are always the longest ; arm formula usually 1.2.3.4. The web between the arms is well developed ; the suckers are fleshy and without any chitinous rings and are arranged in alternating double rows on all the arms. The basal suckers are large and the distal ones very minute. There are eight water pores, each located in between the interbrachial membrane near the base of the arms, each pore leading to a small oval shaped pouch embedded in the oral side of the muscular web. The pouches can be easily seen by gently teasing out the superficial layer of skin in fresh animals.

In males, the third arm on the right side is hectocotylized and the ligula is small, smooth, poorly developed and not easily discernible ; it forms only about 3 per cent of the arm.

This is a large octopod with a maximum total length of 60 cm, mantle length of 18 cm and weight of 2 kg (Roper *et al.*, 1984).

The species is of dull greyish or ash colour and has smooth mantle surface. The posterodorsal and posterventral surfaces of the body have greenish iridescence.

Hapalochlaena maculosa Hoyle, 1886

(Plate X ; C and front cover)

The mantle is small, globular to elongate and smooth. The head is small, slightly narrower than the mantle, the pallial aperture is not more than the width of the head. Eyes are very small and not prominent. The funnel is small and narrow, the anterior free portion is about half the length of the funnel. The arms are moderately long, subequal in length in the order 4.3.2.1, slightly stout at the base and have attenutated tips. The web is well developed between the arms and continues along the margin of the arms for some distance forming a wide membrane. The web between the third and fourth arms is wider than that between other arms. The third right arm in the male is hectocotylized and the modification is simple ; the ligula is very small and rounded at the tip, having only a shallow groove in the middle with faint transverse ridges. The calamus is well developed and the spermatophore groove is broad.

The maximum size for this species is a mantle length of 47 mm and total size of 147 mm.

The external colouration is very characteristic. In live condition the whole body is dusty brown in colour with a number of blue to violet coloured small rings over the mantle, head and arms. Hence this venomous octopus is popularly known as blue-ringed octopus ; the colouration of the rings is very intense and bright ; sometimes dark bands appear on the body. The coloured rings are very conspicuous against the general dusty brown colour of the body. The somewhat wide circular rings assume the form of small speckles and the dusty brown colour of the body is lost on preservation.

Berrya keralensis Oommen, 1966

(Plate XI ; A-C)

The body is short and stumpy and the posterior region is rounded. The head is somewhat narrower than the body and is demarcated from it by a slight constriction. Eyes with small external openings. The mantle is characteristically soft, loose and semigelatinous and has fine reticulations with minute papillae.

There are two distinct tubercles over the eyes. Smaller tubercles are present all over the dorsal surface of the mantle which is very distinct in males.

The mantle opening is very much reduced and is as broad as only the base of the funnel. The funnel is stout and compressed ; it is fused with the head except for the extreme end portion near the opening.

Arms are very short, stout and tapering. The web between the arms is very wide except between the ventral arms where it is somewhat shallow. The fleshy suckers are arranged in two alternating rows but for the base where the first three suckers are in a single row. On preservation the suckers appear to be not globular in shape. Males do not possess any specially enlarged suckers.

The third right arm is hectocotylized and the hectocotylization is very characteristic in this species. The spermatophoric canal extends along the ventral margin of the arm from its base to the tip where it ends in the calamus. The latter is acutely conical in shape and the groove is very deep. The ligula is also somewhat conical in shape and forms about 11 to 15 per cent of the arm. The ink sac in this deep sea species is very much reduced.

Maximum mantle lengths of 55 mm and 39 mm have been recorded for males and females respectively (Oommen, 1966).

In preserved specimens the colour of the octopod is brownish red on the dorsal side with paler colouration on the ventral side. There are papillae on the mantle and they are surrounded by a circle of very minute reddish brown chromatophores.

Genus *Argonauta* Linnaeus, 1758

The systematics of the species of genus *Argonauta* are still unsettled. The taxonomy of this genus is primarily based on the external shell characteristics of the various species (Dell, 1952 ; Voss, 1963 ; Voss and Williamson, 1971 ; Roper *et al*., 1984). *Argonauta* known commonly as the paper nautilus or the paper shelled nautilus are distributed throughout the warm and warm temperate waters of the world and about six species are recognised presently. They exhibit a remarkable degree of sexual dimorphism. Males are minute, scarcely exceeding 15 mm in total length. Their hectocotylized arm is coiled up in a large thin sac which is capable of self amputation (autotomy) at the time of mating and leaving it inside the mantle cavity of the female. The females are relatively quite large, about fifteen times the size of the males. The external shell which is secreted by the membranous flaps of the dorsal arms, is used as an incubation chamber for the eggs as well as the females to reside. The shell is held by the flap of the dorsal arms spreading over the shell and adherence to the inner wall of the shell by suckers. The shells of *Argonauta* are more widely known and well described than the animals. Within the species the shells are highly variable in sculpture and form. There are two species *Argonauta argo* Linnaeus and *A. hians* Solander known from the Indian Seas (Robson, 1929 ; Silas, 1968 and Oommen, 1974).

Argonauta argo Linnaeus, 1758

(Plate XII ; A)

Sexual dimorphism is marked ; males are minute, 15 to 20 mm in total length. In the females the mantle is narrow to broadly oval in shape with blunt posterior end. The head is smaller than the mantle opening ; the eyes are large. Arms are long and subequal in length, the dorsal arms quite thick at their base with large web-like membranous expansion along the entire length. The arm suckers are biserial.

The shell is large, thin and fragile ; compressed well with a narrow keel ; aperture narrow and 30 to 40 per cent of the diameter of shell. The narrow keel bears on either side numerous small and sharp nodules 10 to 12 numbers per 20 mm. The nodules are arranged in pairs in transverse rows on the keel, and each pair is united by a low ridge. The external sides of the shell bear a number of simple bifurcate ribs, most of which originate from the columella and extend to the carinal nodules ; some of the outer ribs are separate and form the secondary ribs. The sides of the shell along the edge of the aperture are not turned widely outward unlike in *A. hians* (Voss and Williamson, 1971).

The main body of the shell is glistening marble white and the keel and the nodules are brownish black. In live condition the animal is predominantly bluish white in colour with the dorsal arms and webs iridescent white with tints of purple red chromatophores. Eyes are steel blue. Maximum length of shell is about 17 cm (Voss and Williamson, 1971).

Argonauta hians Solander, 1786

The shell is highly variable in sculpture. It is rather small, with widely inflated aperture, about 50 per cent of shell length. The keel is wide and bears the characteristic 15 to 23 prominent, large and blunt nodules placed in pairs over the keel. Great variations exist in size and form of the nodules. The ribs on the sides of the shell extending from the crainal knobs are less numerous when compared to the other species with less bifurcation. There are two types of ribs present, the long and full sized ribs extending from the nodules to the nucleus which are in regular alternating series with the secondary ones ; the latter are short and extend upto half way from the nodules. The colour of the shells varies from white with brownish black tint on the nodules and adjacent ribs to light brown with sooty brown pigmentation over most of the surface of the shell (Voss and Williamson, 1971).

Nautilus pompilius Linnaeus, 1758

(Plate XII ; C and D)

Nautilus popularly known as pearly nautilus or the chambered nautilus in contrast to the other interesting remarkable cephalopod the paper nautilus *Argonauta* is the only living representative of the Sub Class Nautiloidea. Species of *Nautilus* have been described by Owen (1832), Griffin (1900), Willy (1902), Saunders (1981) and others. The remarkable feature of the pearly nautilus is its beautiful coloured external shell which distinguishes this from other cephalopods.

Nautilus pompilius is extensively distributed in Indian Ocean, Western and Central Pacific Ocean, Phillippines to Australia and in Polynesia (Silas, 1968).

The body is enclosed in an external calcareous, spirally coiled and multichambered shell. The animal occupies the last chamber which is the largest ; the inner surface of the chamber is pearly and the outer surface procellanous and pigmented with wavy reddish brown bands on whitish background. The colour markings on the shell are very conspicuous.

The successive chambers of the shell are separated by a system of concave septa which are perforated in the middle and a shelly tube is formed running through the chambers ; through this the vascular prolongations of the tip of the mantle, the siphuncle runs. Although the tubular siphuncle runs through the chambers to the apex of the shell, it does not open into the chambers. Except the outermost recently formed chamber in which the body is present, all the other chambers are filled with gas which gives buoyancy to the animal.

The body of the animal consists of head which bears eyes, a system of tentacles and a sac-like visceral mass. Arms are absent, funnel is bilobed. Mouth is situated at the end of the head and surrounded by foot with two sets of lappets forming an inner and an outer circle. The edges of the circles are beset with numerous, small, thin and annulated retractile tentacles. The tentacles are devoid of suckers and are adhesive in nature. A special fleshy hood used for closing the last chamber as an operculum is present above the head region. Arms and suckers are absent. Unlike other cephalopods *Nautilus* possesses two pairs of gills, two pairs of kidneys and two pairs of auricles. Sexes are separate. A portion of the tentacle crown which involves four tentacles of the lappets on the right side is modified to form the spadix.

4

SOME ASPECTS OF THE BIOLOGY OF SQUIDS

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ABSTRACT

The results of studies on the biological aspects such as sexuality, sex ratio, size at first maturity, spawning, age and growth, distribution of adults, food, predators, life-history and distribution of juveniles of three species of squids *Loligo duvaucelii*, *Sepioteuthis lessoniana* and *Doryteuthis sibogae* are presented. The breeding period of all the three species was found to be prolonged. In *Loligo duvaucelii* the males attained sexual maturity earlier than females in the various fishing grounds investigated.

Loligo duvaucelii Orbigny

BIONOMICS AND LIFE-HISTORY

REPRODUCTION

Sexuality

This species is heterosexual and males are distinguishable by the hectocotylization of the left ventral arm. The males grow to a larger size than females.

Sex ratio

Along Waltair coast females were generally the dominant sex with the average sex ratio during 1976-80 being F 52 : M 48. However, in the various years in one to four months which differed from year to year males outnumbered females (Fig. 1). In contrast along Kakinada coast the males were the dominant sex with the average sex ratio during 1977-80 being M 54 : F 46 (Fig. 1). Only in a few months sexes were equally distributed in the two areas. As on the Kakinada coast males dominated along Madras coast also with an average sex ratio of M 56 : F 44. Females exceeded males in one to five months and only in one month, August, 1977 the two sexes were in equal ratio (Fig. 2).

At Vizhinjam on the west coast on a comparison of the average annual totals of the two sexes, females were seen to be the dominant sex (F 58 : M 42). Only in one to three months at different periods of the year males were the dominant sex (Fig. 3). Along Cochin coast males were dominant especially during the months February-May and September-October (Fig. 3). Along Bombay coast the sex ratio did not show any well-defined seasonal changes (Fig. 2).

Unlike *Loligo duvaucelii* of Indian coasts, the ratio of males and females is 1 : 1 in squids of spawning schools as well as immature squids of *Loligo opalescens* of Monterey Bay, California (Fields, 1965).

Maturity

Along the east coast, males mature within the size range 50-150 mm at Waltair and 50-130 mm at Madras with 50% maturing at 67 mm and 85 mm in the two areas respectively (Fig. 4). All the males mature by the time they grow to 150 mm at Waltair and 130 mm at Madras. Males mature at a larger size on the west coast, the size of 50% maturity being 108 mm at Vizhinjam and 122 mm at Cochin. All the males reach the mature stage at sizes of 170 mm at Vizhinjam as well as at Cochin.

Females were found to attain maturity at a larger size as compared with males. On the east coast the size at first maturity is 108 mm at Waltair and 96 mm at Madras. The females attain maturity when they range in size between 50 mm and 170 mm at Waltair and between 70 mm and 150 mm at Madras. All females reached the mature stage at 170 mm at Waltair and at 150 mm at Madras. On the west coast the size of 50% maturity is 110 mm at Vizhinjam and it is slightly higher, 128 mm at Cochin. The size ranges in which maturity was attained by this species at Vizhin-

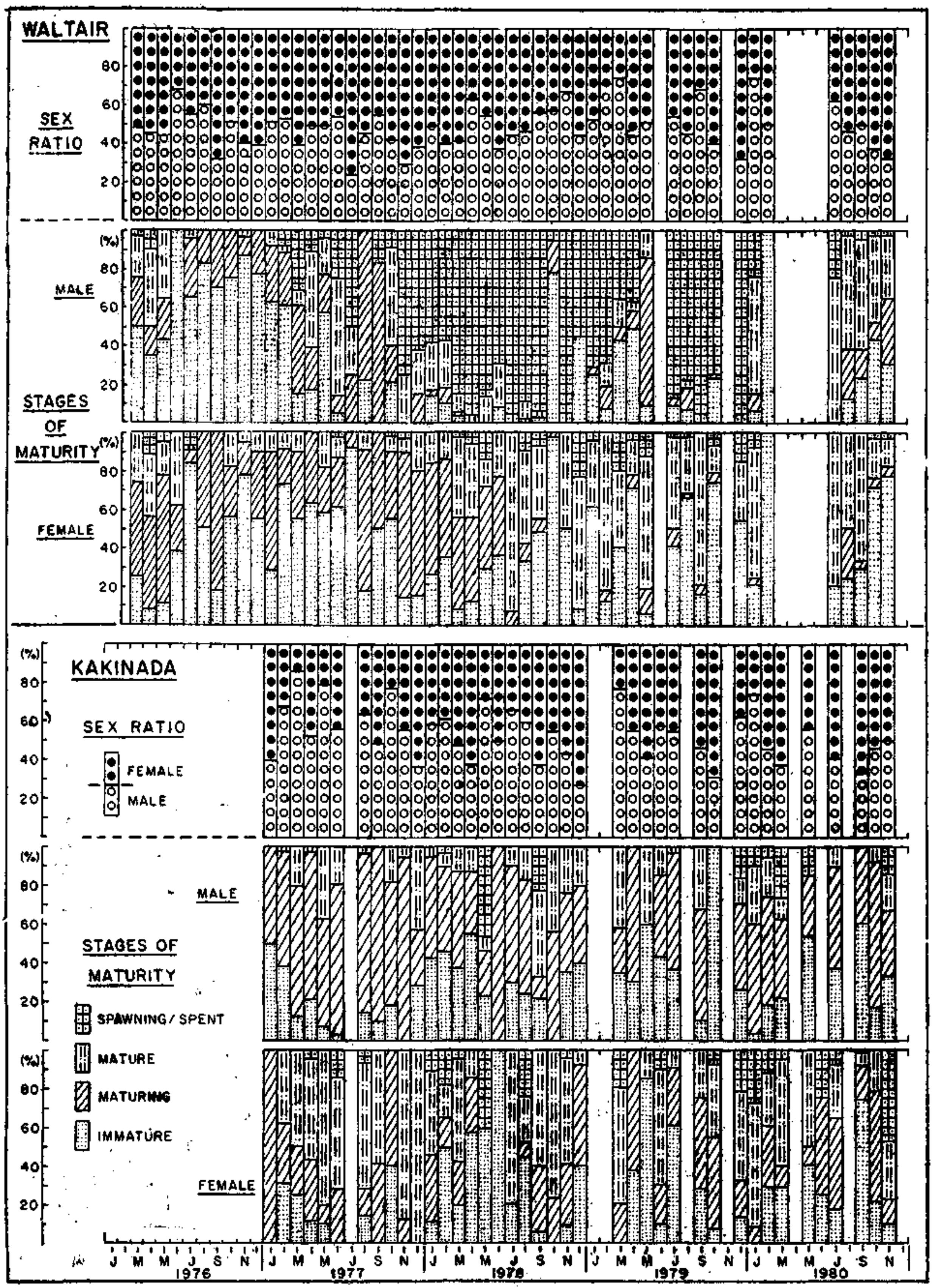

FIG. 1. Sex ratio and stages of maturity of *Loligo duvauceli* off Waltair (Visakhapatnam) and Kakinada.

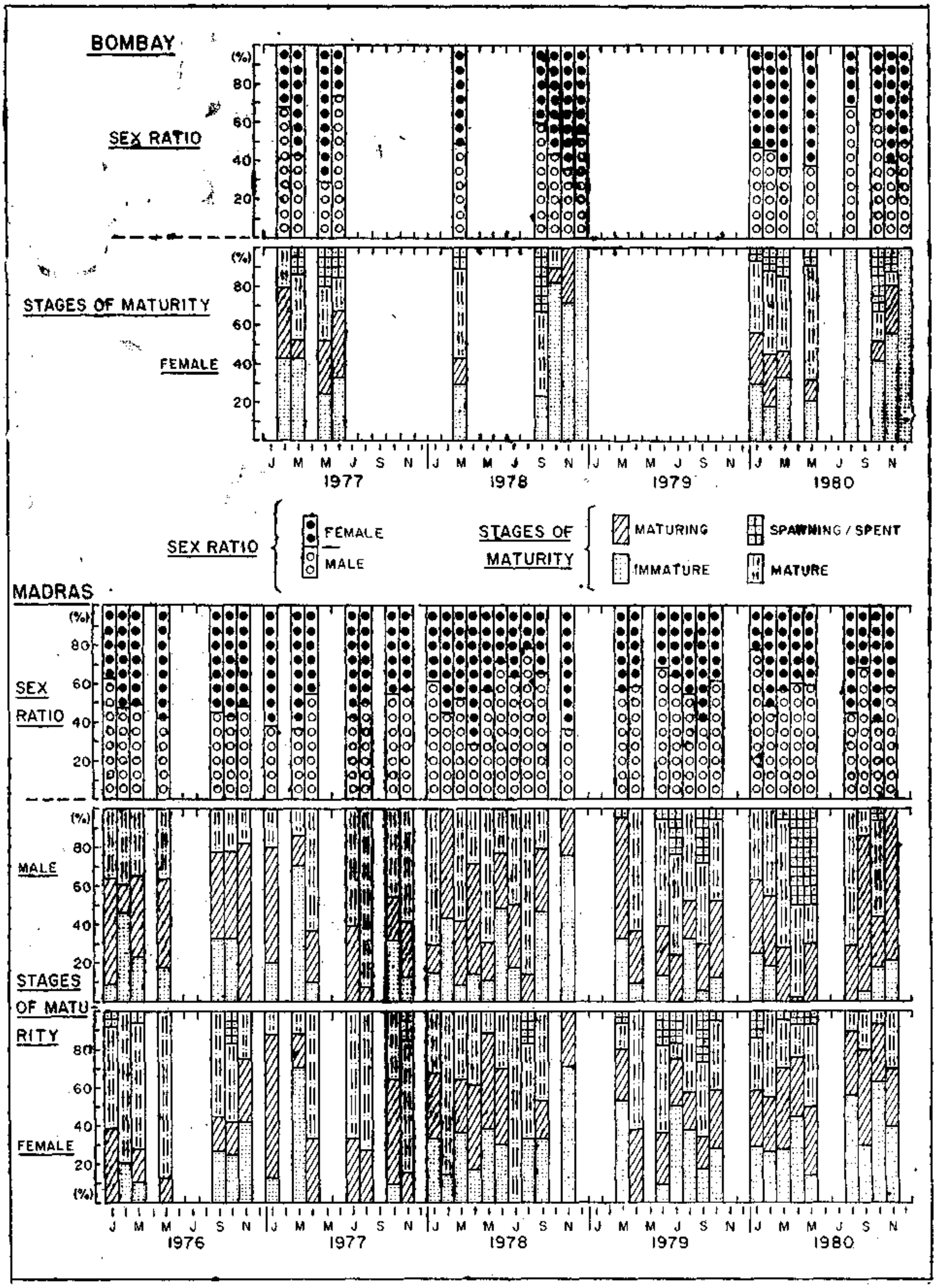

FIG. 2. Sex ratio and stages of maturity of *Loligo duvaucelii* off Bombay and Madras.

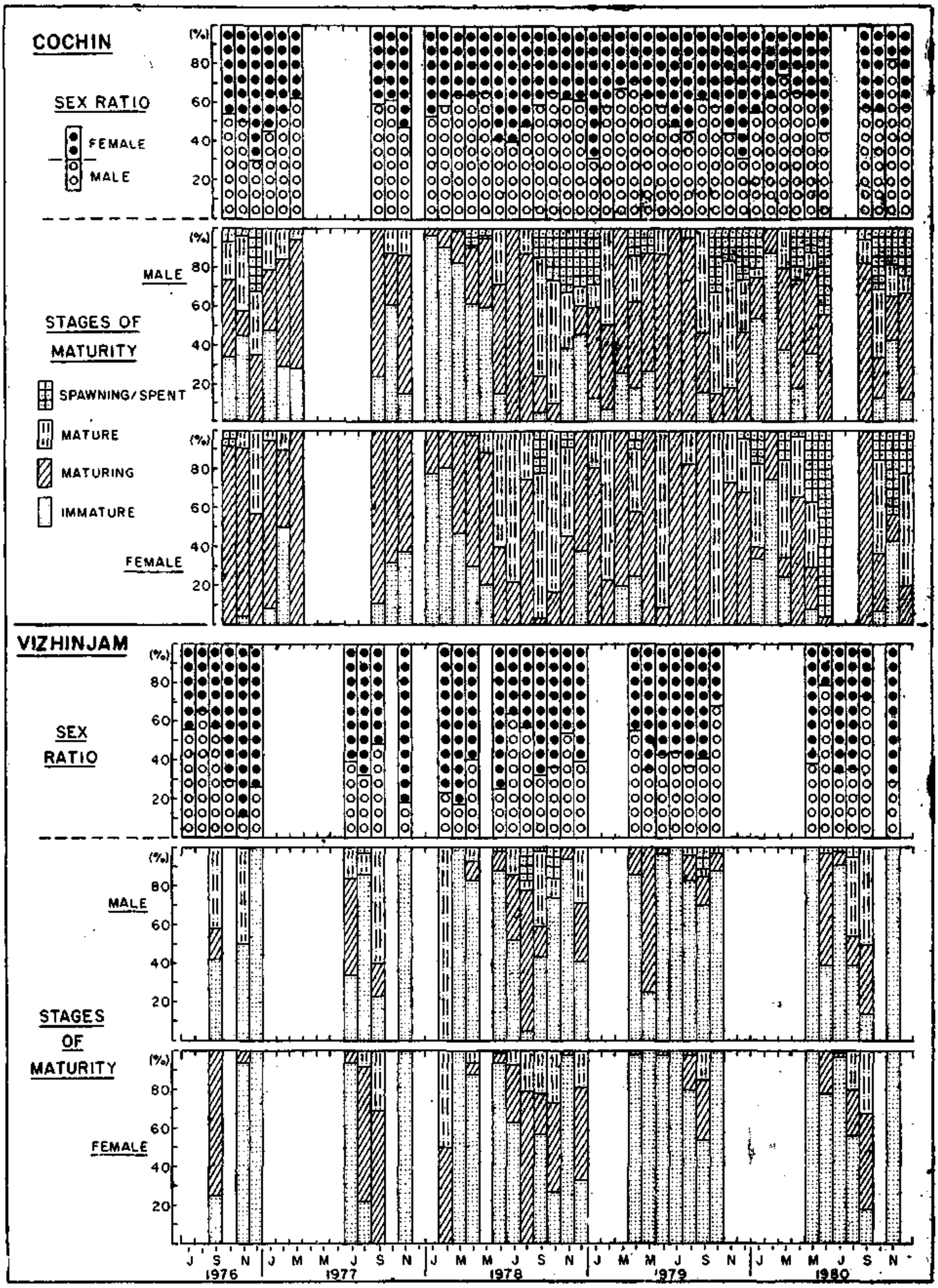

FIG. 3. Sex ratio and stages of maturity of *Loligo duvaucelii* off Cochin and Vizhinjam.

jam and Cochin were 90-190 mm and 90-170 mm respectively. All the females attained mature stage when they reached a size of 170 mm at Cochin and only at 190 mm at Vizhinjam.

The studies carried out on *Loligo duvaucelii* at different centres shows that males of the species mature at comparatively smaller size than females in all the areas. Another noteworthy feature is that squids of the two sexes become sexually mature at smaller sizes along the east coast than those along the west coast. The factors responsible for the differences are not clear and require an in-depth study. Maturation of reproductive organs of squids is considered to be controlled by hormonal stimulation in turn influenced by environmental factors like day length and water temperature (Grieb and Beeman, 1978).

The size at which all the squids reached mature stage is higher in both sexes of *Loligo duvaucelii* along the east and west coasts of India as compared to *L. opalescens* of California coast, in which it has been observed (Fields, 1965) that males attain maturity in the size range 70-130 mm and females in the range 81-140 mm.

Spawning

Maturing males and females were recorded at all centres along the east and west coasts of India in several months indicating that maturation takes place all through the year. At Waltair mature females were found all round the year with peak numbers in January-March, May, July, September and December. Spawning females occurred in small percentages in several months indicating breeding activity almost throughout the year (Fig. 1). Mature males were common or moderately so in different months. Spawning males were very common in the months January-April, June-September and November-December.

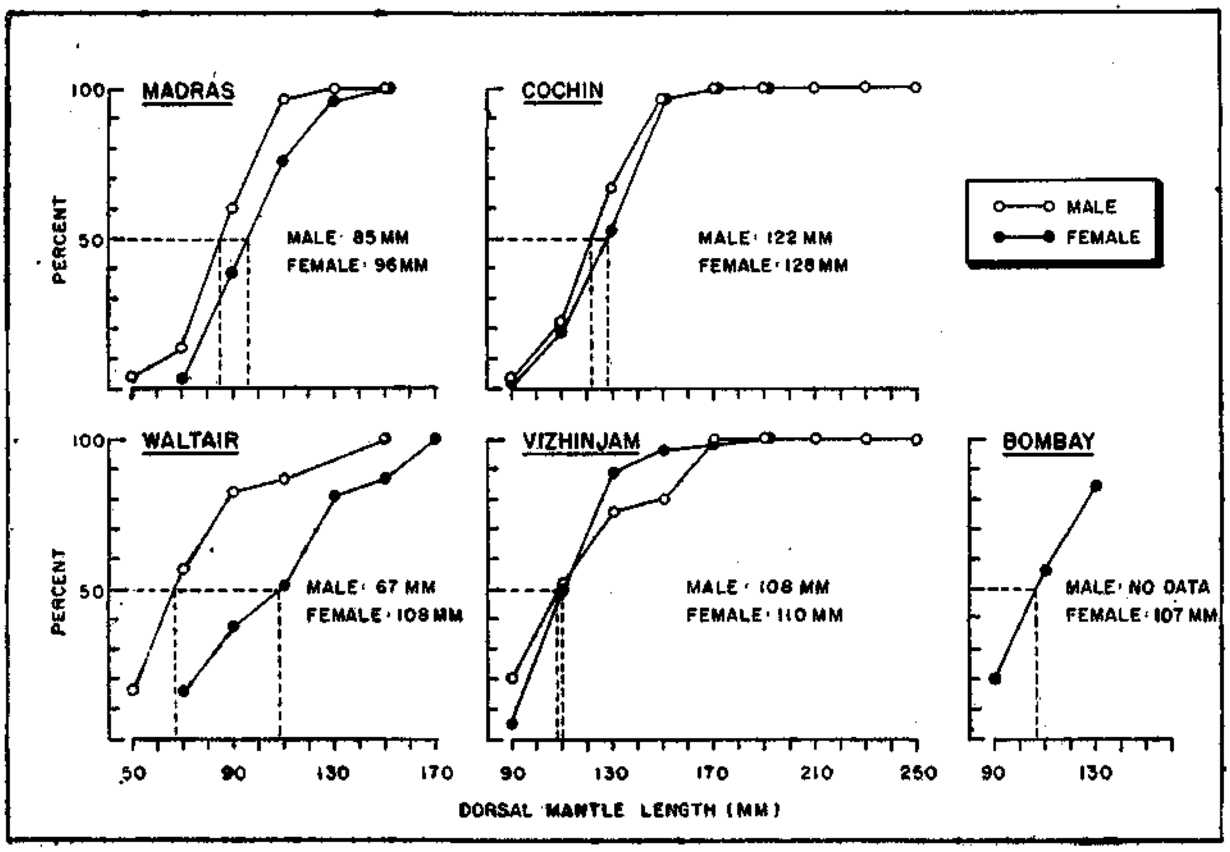

FIG. 4. Size at first maturity of *Loligo duvaucelii* off Madras, Cochin, Waltair (Visakhapatnam), Vizhinjam and Bombay.

At Kakinada mature females were common and spawners were in small percentages all round the year (Fig. 1). Mature males were found in small to moderate percentages almost throughout the year and spawners in all months except October.

At Madras mature females were common from January to November with peak numbers in six months February, April, May and July-September (Fig. 2). As at the northern centres Waltair and Kakinada, spawning females were found at Madras only in small percentages except for February and December when they were not recorded. Like the females, mature males also were found from January to November, with peaks in January, April to August and October. Spawning males occurred in small or moderate numbers in different months except January, February, August and November-December.

At Vizhinjam mature females were found in all months except March, May and November and they occurred generally in small percentages except in February and September when they were moderately common (Fig. 3). Spawning females were not observed along Vizhinjam coast. Mature males were recorded throughout the year except in January, March and May and they were very common in two months viz., February and September while spawning males in small numbers were observed only in three months August-October.

Along Cochin coast mature females were encountered in varying abundance. They were very common in June, July and October, moderately so in February, April, August, November and December and less common in other months (Fig. 3). Generally spawning females occurred in small numbers along this coast in all months except July-August. Mature males were commonly seen from September to December and they were moderately common in the other months. Males in running condition were observed in all months except February-March and July-August and they formed fairly good percentages in June and October-December.

Along Bombay coast mature females were common from January to May and in September and they were less common in June and October (Fig. 2). Spawning females occurred along with the mature ones and were common in September and moderately so in May, June, October and November. The studies carried out show that along both the coasts the spawning season of *L. duvaucelii* is very much prolonged with peaks in varying months.

Fields (1965) has considered that in Monterey area two populations of *L. opalescens* entered spawning grounds, one a dominant one from January to June and the other which migrated from south of Point Conception from July to December.

In sexually ripe *L. duvaucelii* females the ovary and oviduct with ova are large and fill the entire posterior region of the mantle cavity while the nidamental glands are large, firm and white and the accessory nidamental glands orange red in colour. In ripe male squids the testis is elongated, thick and milky white and the spermatophore sac is filled with fully formed spermatophores. The mantles and fins of the mature male and female squids are thick and well developed.

After spawning, the mantle of females become thin and flaccid. The ovary contains a few residual ova and there are a few or no ova in the oviduct. The nidamental glands are small in size and flabby while the accessory nidamental glands are pale pink in colour. In spent males the testis is thin and the spermatophore sac is small containing small number of spermatophores. The body and fins of spent males show a loss in size and shape but this is not as much as in the case of spent females.

It is not possible to state whether *Loligo duvaucelii* die after one spawning. Some male squids of the species *L. peali* have been considered by Summers (1969) to survive after first spawning season and may live upto three years. Fields (1965) opined that females of *L. opalescens* spawn only once and die and since the ratio of males and females is equal, males including precocious ones spawn only once in their lifetime.

ADULT HISTORY

Growth

Based on a preliminary study of the progression of modes of both males and females combined it was found that on Waltair coast this species grows to a size of 64 mm at the end of 6 months and 112.8 mm at the end of 1 year. The rate of growth of this species along Kakinada coast is higher than at Waltair with the squids attaining a size of 83 mm at the end of 6 months and 121 mm in one year.

On the west coast the growth rate of *L. duvaucelii* is more or less similar in Vizhinjam and Bombay areas upto the age of one year. In Vizhinjam area this species grows to 69 mm at the end of 6 months, 122.2 mm in one year, 167 mm in 1½ years and 209 mm in 2 years. Along Bombay coast a growth of 68.6 mm in 6 months, 124.4 mm in one year, 170.5 mm in 1½ years, 208.4 mm in 2 years, 232.8 mm in 2½ years and 262.7 mm in 3 years was noticed.

It may be seen that the growth attained by this species is more or less similar upto the end of first year along both east and west coasts. While a growth of 149 mm is reached at the end of 1½ years along east coast, a higher size of 167 to 176 mm is attained on west coast. Along the latter coast this squid grows to 209-220 mm in 2 years, 233-255 mm in 2½ years and 263 mm in 3 years. Along both coasts of India broods originate at different periods of the year in various areas indicating that recruitment is not confined to any particular period. It is most interesting to note that the growth of *L. duvaucelii* is very fast as compared to that in *L. opalescens*. Fields (1965) has recorded a growth of 65 mm, 120 mm and 150-165 mm at the end of first, second and third years in *L. opalescens* in Monterey Bay.

Detailed studies on the growth of males and females of this species carried out at Cochin and Madras using Von Bertalanfy's formula indicated differential growth rates for males and females at Cochin. But in the same species off Madras coast the growth pattern was similar in both sexes within the size range 45-155 mm.

Relative age	*Cochin*		*Madras*
	Males (mm)	*Females* (mm)	*Males and Females* (mm)
6 months ..	86	91.9	75.3
12 months ..	149.3	142.6	122.3
18 months ..	196.0	170.6	151.5
24 months ..	130.0	186.0	169.8

Length-weight relationship

Study of the length-weight relationship of this species of the Madras and Cochin coasts showed that the rate of increase in weight in relation to length differed in males and females. The allometric growth formulae for the two sexes are as follows.

Centre	*Males*	*Females*
Madras	$W = 0.000683\ L^{2.3769}$	$W = 0.000377\ L^{2.5201}$
Cochin	$W = 0.00103\ L^{2.2408}$	$W = 0.0005655\ L^{2.3985}$

Distribution of Adults

This is a neritic species adults of which are common from the coastal shallow waters upto depths of about 80 m on the continental shelf of both the coasts of India.

The size range of adult males caught in trawl nets off Madras is 50—155 mm while it is slightly higher, 50-175 mm at Waltair. Adult females 70-155 mm and 70-170 mm in size were obtained in the above two areas. In the trawl catches off Kakinada females ranged between 80 mm and 165 mm in size while males measured a maximum of 184 mm. In Bombay area adult males with a maximum size of 285 mm were caught in trawl nets while adult females obtained in the same gear measured only 80-165 mm. On the southwest coast in the trawl catches at Cochin and boat seine and hooks and line catches at Vizhinjam, adult males were 90-255 mm and adult females 90-190 mm.

Maximum size

The largest size of adult males found along the east coast were 184 mm (at Kakinada) and 170 mm (at Madras) and the largest sizes attained along the west coast were higher being 285 mm (at Bombay) and 190 mm (at Cochin and Vizhinjam). The largest female along east coast (Waltair) and on the west coast (at Cochin and Vizhinjam) measured 190 mm.

Food

Prawns and fishes form the chief item of food of this species. Other items like crabs, stomatopods and euphausids also form the diet of this squid. Cannibalism has been often noticed.

Kore and Joshi (1975) reported that the food of *L. duvaucelii* of Ratnagiri coast consisted of crustaceans, fish and squids, the crustacean portion including mysids, euphausids and ostracods. A decrease in feeding intensity was noticed in the squids in the spawning season.

Oommen (1977) studied the structure of the alimentary canal, digestive enzymes and food and feeding habits of *L. duvaucelii* of Cochin area. He found that squids with empty stomach formed as much as 54% of the total number of squids examined. Crustaceans and fishes were the important diet of the squid. The former were dominant in April-May and the latter were common from October to March. The stomach contents were identified by noting the species caught along with the squids in trawl nets and examining the skeletal remains found in stomachs of squids. Prawns, crabs and *Squilla* were the most common crustaceans and sardines, anchovies, mackerel, *Synagris* and *Lactarius* the most common fishes to form the food, (Oommen 1977). Cephalopods including *Loligo duvaucelii* and *Loliolus* sp. were found throughout the year and amounted to 16%.

In *Loligo pealei*, Vovk (1972) recorded seasonal and diurnal changes in feeding intensity. There was active feeding during day time with peak about 16.00 hrs. Fields (1965) found that crustaceans, fishes and polychaetes were the common food of *L. opalescens* of Monterey area and with increase in size the proportion of crustaceans decreased while that of fish increased. Squids above the size of 120 mm showing cannibalism. Karpov and Cailliet (1978) studied the food and feeding habits of *L. opalescens* caught in mid-water and bottom trawls along California coast and observed that euphausids, copepods and other crustaceans formed the main

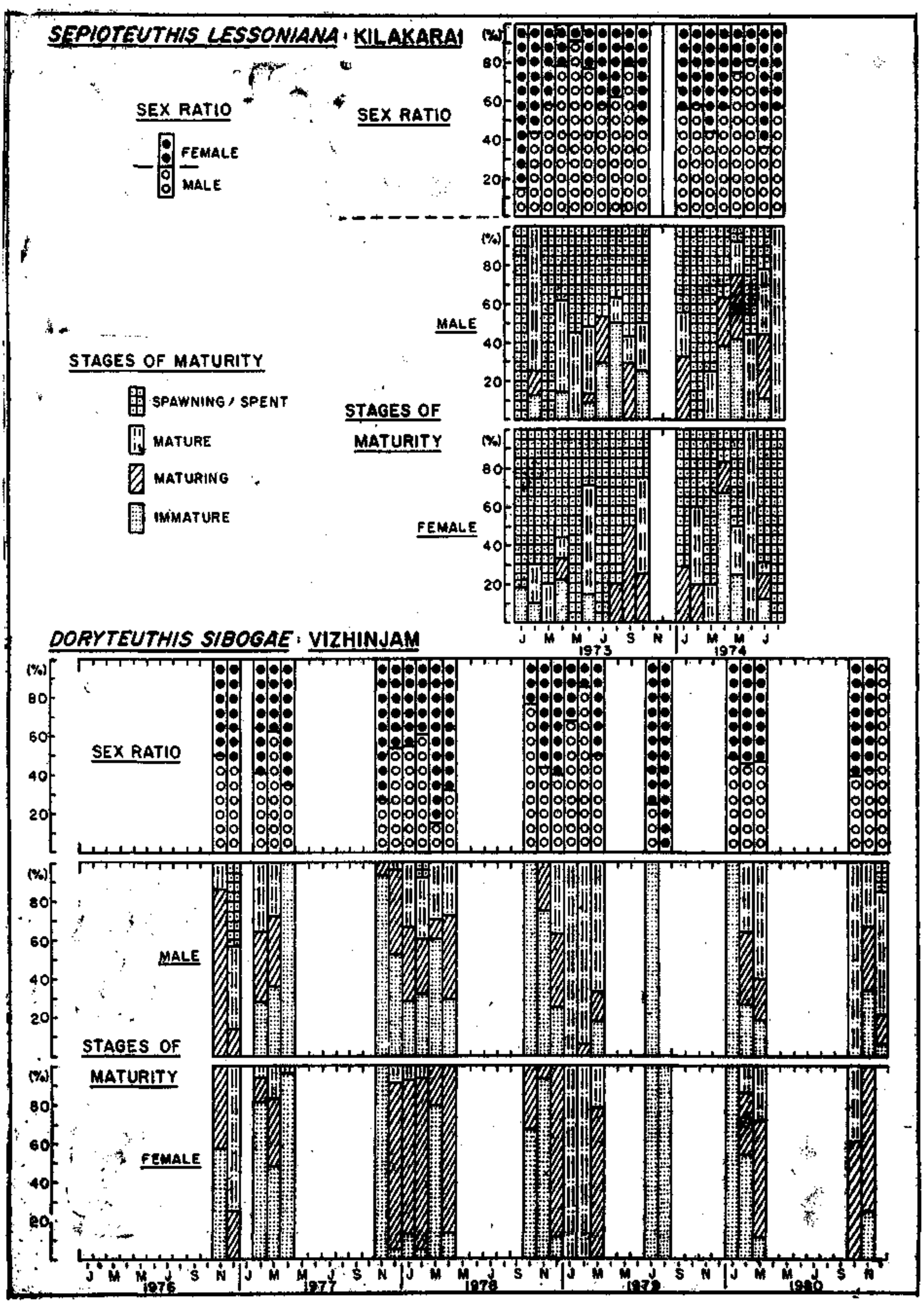

Fig. 5. Sex ratio and stages of maturity of *Sepioteuthis lessoniana* off Kilakarai and *Doryteuthis sibogae* off Vizhinjam.

food item of *L. opalescens* which was also found to be cannibalistic. The authors noted that fish, gastropods, radiolarians and polychaetes formed only minor components of the diet of the species. Few differences were noticed in the food in relation to sex or size. It was reported that squids captured in deeper waters off California fed more on euphausids and copepods as compared to those from shallow waters. Bidder (1950) determined that in *Loligo* digestion is completed in 4 to 6 hours and the species feeds once or twice a day and also more often when food is available but it does not feed continuously.

Predators

Loligo sp. has been found to form food of *Euthynnus affinis affinis* and large sized *Auxiz thazard* and *A. thynnoides* off Vizhinjam coast. Talbot and Penrith (1963) have recorded that *Thunnus alalunga, T. albacares, T. obesus* and *Histioteuthis bonellina* of South African waters prey on *Loligo reynaudi.*

LIFE HISTORY

Distribution of Juveniles

Juveniles of this species measuring up to 45 mm have been recorded in trawl catches at Waltair, Kakinada and Madras on the east coast and at Cochin and Bombay on the west coast throughout the year. They were obtained in small quantities in shore seines and boat seines along the two coasts.

Sepioteuthis lessoniana Lesson

BIONOMICS AND LIFE-HISTORY

REPRODUCTION

Sexuality

This species is heterosexual and in males which are larger than females the left ventral arm is hectocotylized.

Sex ratio

In 1973 males of this species were dominant in Kilakarai area from March to September (M 58 : F 42—M 91 : F 9) and females were dominant (F 56 : M 44—F 85 : M 15) only in two months January-February (Fig. 5). The two sexes were in equal ratio in October, 1973. In 1974 males outnumbered females in a number of months January-February, April-June and August. Only in March and July females were dominant (F 56 : M 44—F 64 : M 36). The overall average sex ratios during 1973 and 1974 show that males were the dominant sex in the two years. The data of Rao (1954) show that among mature squids, females were dominant in four out of eight months when observations were made viz., June, October and February-March. When the overall averages were compared males were found to be the dominant sex constituting 55% as in 1973-74 data.

Maturity

The observations carried out during 1973-74 have shown that males and females mature in the size range of 90-190 mm with 50% of the two sexes attaining maturity at sizes of 112 mm and 98 mm (Fig. 6). All squids of both sexes were mature at 190 mm. Rao (1954) stated that males of this species reach sexual maturity within the size range of 67.5 mm—112.5 mm and females within 102.5—112.5 mm.

Spawning

Mature females were found to occur in seven months viz., February to July and October and were more common in February, June and October. Mature males were observed continuously from January to October with dominance in February, May, June and August. Spawning females and males were recorded from January to October. Spawning females were most common from January to May and July to September. The data indicate prolonged spawning period from January to September or October in this species. Based on observations made in two fishing seasons during 1950-51, Rao (1954) found that the gonads of the species were in fully, partially or wholly spent condition in May-June, wholly spent from July to October and in a state of fulness from December to February and from this inferred that the spawning period extends from January to June.

After spawning drastic changes take place in the structure of reproductive organs and also mantle and fins. In the sexually mature females the mantle and fins are thick and the ovary has a large number of ripe ova which occupy greater portion of the posterior part of the mantle cavity, the nidamental glands are arge and glossy white and the accessory nidamental glands are of orange red colour. On copulation spermatophores are deposited on their buccal membranes. After spawning the mantle and fins become thin, the ovary has only a small number of eggs, the nidamental glands are of pale colouration and the accessory nidamental glands pinkish. In mature males the testis is large and glossy and fully developed and spermatophores are present in the spermatophore sac. After spawning the testis is thin and flabby and the spermatophore sac contains a few residual spermatophores. The mantle and fins of males also become thin after spawning as in females.

Spawning takes place in shallow coastal waters of Mandapam area at depths of 3-10 m as it is evident from the capture of gravid and partly spawned squids caught in shore seines which are operated within about 1 km from the shore (Rao, 1954).

ADULT HISTORY

Growth

Growth studies of the species of Kilakarai Coast (Mandapam area) carried out during 1973-75 and the determination of average growth, showed that the species attains a size of 69 mm at the end of 6 months, 129 mm at the end of one year, 178 mm at the end of one and half years, 217 mm at the end of two years, 246 mm at two and half years and 265 mm at the end of three years. Rao (1954) found that the species from Mandapam-Rameswaram area attained lesser sizes of 95 mm, 166 mm and 219.5 mm at the end of the first, second and third years of the life of the squid.

Distribution of Adults

Adults measuring 65-340 mm are caught in coastal waters of Palk Bay and Gulf of Mannar in shore seines and hand jigs. Squids of moderate size 120-180 mm are caught in trawling grounds off Mandapam. Stray individuals of this species are obtained off Vizhinjam also.

Maximum size

Males grow to a much larger size than females. The highest sizes of males and females recorded in Mandapam area are 340 mm and 209 mm respectively.

Food

Rao (1954) recorded that bony fish comprised the main food of squids and prawns and crabs formed part of diet to some extent. A good number of squids were also seen to be cannibalistic. The food organisms in the stomachs were found to be broken pieces which made specific identification difficult. Observations on this species in Kilakarai area during 1973-74 indicated

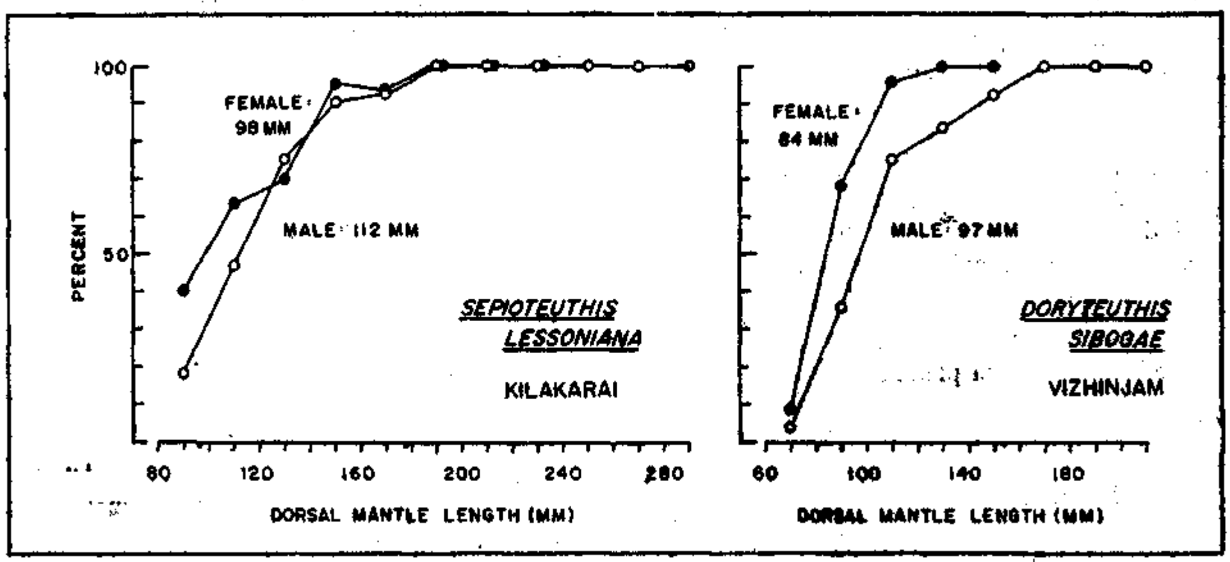

FIG. 6. Size at first maturity of *Sepioteuthis lessoniana* off Kilakarai and *Doryteuthis sibogae* off Vizhinjam.

hat fishes including *Leiognathus* sp., *Upeneus* sp., *Apogon* sp. and others were the most common items of food. Prawns were next in importance while alpheids and stomatopods were found only in a small number of squids. Only a few instances of cannibalism were noticed during 1973-74.

LIFE-HISTORY

Eggs

The eggs are present in egg capsules which consist of a central gelatinous matrix from which finger-shaped capsules numbering fifty or more radiate (Alagarswami, 1966). The egg clusters lie attached to floating or stationery algae, tree branches or other hard, submerged structures in littoral waters. The egg clusters are common in the shallow sheltered coastal waters of Mandapam area where seaweeds abound. The egg capsules have jelly-like consistency with a firm translucent outer wall and are 62-68 mm in length and 12-13 mm in width. Six or seven eggs are present in a linear row in each capsule with spaces in between and are visible through the gelatinous capsule. The eggs of *S. lessoniana* are large, elongately oval and telolecithal. They measure 6 mm in length and 4.6 mm in breadth and are covered by a chorion with the micropyle at the animal pole of the egg and a perivitelline space surrounding the ovum.

Early development

The early development has been studied by Alagarswami (1966). The cleavages of the egg result in 64 cell stage and later the blastoderm. On the fifth day after collecting, the shell gland is seen as a depression around which there is a ridge, the primordium of the mantle. Below this is in the depression, the primordia of ctenidia are present. The stomodaeum is formed anteriorly and rudiments of eyes anterolaterally. The primordia of the ventral arms also are formed as thickenings at the lower edge of the blastoderm. By the sixth day the eyes are more well-developed, the mantle grows and covers the primoridia of various organs and more arms are budded off.

On the seventh day the ctenidia are long and plume-like, the systemic and branchial hearts are well developed and funnel cartilages formed. The primordia of fins develop by the eighth day. By the fourteenth day the developing embryo appears like a miniature adult with the eyes, mantle, arms and visceral organs well formed. At this stage the embryo moves inside the chorion.

The newly hatched squid measures 7.5 mm in total length (including arms) and 3 mm in width and resembles the adult in basic structural features. In the newly hatched young one, the mantle is transparent, the visceral organs can be seen from outside, yellow and brown chromatophores are found on the mantle, head, arms and dorsal surface of fins, the arms are well developed and funnel completely formed.

The eggs were hatched and the young ones reared by Sivalingam and Pillai (1983) for a period of ten days by feeding them with plankton.

Distribution of juveniles

Young squids 20-60 mm in size are caught in shore seines in Palk Bay and Gulf of Mannar in Mandapam area from February to October. Juveniles measuring 40-60 mm are obtained in small numbers in shore seines along Vizhinjam Coast.

Doryteuthis sibogae Adam 1954

Bionomics and Life-History

Reproduction

Sexuality

Sexes are separate. In addition to hectocotylization of the left ventral arm, the males are larger and have generally slender body with ventro-medial concentration of chromatophores on the mantle.

Sex ratio

The data collected during November, 1976-December, 1980 (Fig. 5) show that females were generally the dominant sex. Males outnumbered females in March 1977, February and October 1978, January and February 1979 and December, 1980. The two sexes were in almost equal ratio in November and December, 1976 and March 1979. When the annual ratios of males and females were compared, females were dominant over males in three years, 1977-79 the ratios being F 56 : M 44, F 54 : M 46 and F 54 : M 46 respectively. In 1976 and 1980 males were proportionately more and formed 57% and 54% respectively.

Maturity

The studies made at Vizhinjam during 1976-80 (Fig. 6) indicate that males attain maturity in the size range 70-170 mm with 50% being mature at a size of 97 mm. Females reach the mature condition in the size range 70-130 mm with 50% maturity at 84 mm. All males and females become mature when they grow to sizes of 170 mm and 130 mm respectively.

Spawning

Sexually mature females were recorded in October, December and January to April with dominance in December, January and February (Fig. 5). Mature males occurred from October to April with preponderance in October, December and January-March and spawning males in December and February. The occurrence of mature squids in several months during the period October-April suggests that the breeding season of the species is protracted.

Adult History

Growth

The study of the modal sizes has indicated that the squid grows to a size of 106-120 mm with an average size of 113 mm at the end of the first year and a size of 182 mm at the end of the second year. The longevity of the species appears to be over two years.

Distribution of Adults

Adult squids 70-205 mm in dorsal mantle length occur in the coastal waters of Vizhinjam and are captured in shore seines, boat seines and hooks and lines. The larger individuals are frequently caught in the last mentioned gear.

Maximum size

Males grow to a maximum size of 205 mm and the largest size of females recorded is 165 mm.

Food

The stomach contents of this species include fish, cephalopods and crustaceans.

Life History

Distribution of Juveniles

Juveniles measuring 20-60 mm are caught in shore seines along Vizhinjam Coast during January-February and in some years upto June.

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SOME ASPECTS OF THE BIOLOGY OF CUTTLEFISHES

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ABSTRACT

The biological aspects namely, sexuality, sex composition, size at first maturity, spawning, age and growth, distribution of adults, food and distribution of juveniles of six species of cuttlefishes *Sepia pharaonis*, *S. aculeata*, *S. elliptica*, *S. brevimana*, *S. prashadi* and *S. inermis* are discussed here. *Sepia pharaonis* showed differential growth and the rate of growth of females was higher than that of males. By contrast growth rate of *Sepia aculeata* was almost similar in both sexes.

Sepia pharaonis Ehrenberg

BIONOMICS AND LIFE-HISTORY

REPRODUCTION

Sexuality

The species is heterosexual. The left ventral arm is hectocotylized in males which are less broader than females that are more muscular and robust. The conspicuous stripes across the dorsal side of mantle, fins, head and arms are more prominent in males than in females.

Sex ratio

Data on sex composition of this species obtained in commercial trawl catches of this species off Waltair recorded during 1976-80 (Fig. 1) showed that females were generally the dominant sex (F 54 : M 46-F 90 : M 10). Only in a few months viz. November, 1978, February, March and December, 1979 and March, October and November, 1980 males outnumbered females (M 53 : F 47-M 75 : F 25). Only in four months October 1977, January 1978, May 1979 and February 1980, the two sexes were in equal proportion. There was dominance of females (in Madras area (F 52:M 48-F 80:M 20) in most of the months as along Waltair coast and only in five months February and April, 1976 and April, June and October, 1980 males formed the dominant sex (M 56 : F 44-M 71 : F 29).

On the west coast in the landings of hooks and line fishery at Vizhinjam also, the females were generally dominant (F 53 : M 47-F 77 : M 23) and males outnumbered females on in five months January 1977, July 1978, February and March 1979 and January 1980 accounting for 52-100% (Fig. 2). The two sexes were in equal porportion only in a single month February 1977. In the trawl catches off Cochin coast male *S. pharaonis* dominated in March (M 58 : F 42 and July 1980 (M 57 : F 43) and in all other months except June, 1980 when the two sexes were in equal ratio, there was preponderance of females (F 54: M 46-F 80 : M 20) (Fig. 3).

Maturity

Males and females of this species were found to mature from a minimum size of 90 mm onwards along Waltair coast (Fig. 4). The size at first maturity was 119 mm in males and 120 mm in females. Males and females of the sizes 150 mm and 170 mm and above were all mature. Maturation studies at Madras indicated that the size at first maturity is slightly higher compared to that at Waltair being 121 mm in males and 138 mm in females. In both sexes maturity was attained in the sizes 110-190 mm, all the cuttlefishes becoming mature by the time they grow to a size of 190 mm.

On the west coast this species reaches the mature stage at higher sizes in comparision to those along the east coast. At Vizhinjam the size at first maturity is 145 mm in males and 160 mm in females. The males attain sexual maturity within the size range of 130-220 mm and females in the range of 150-230 mm.

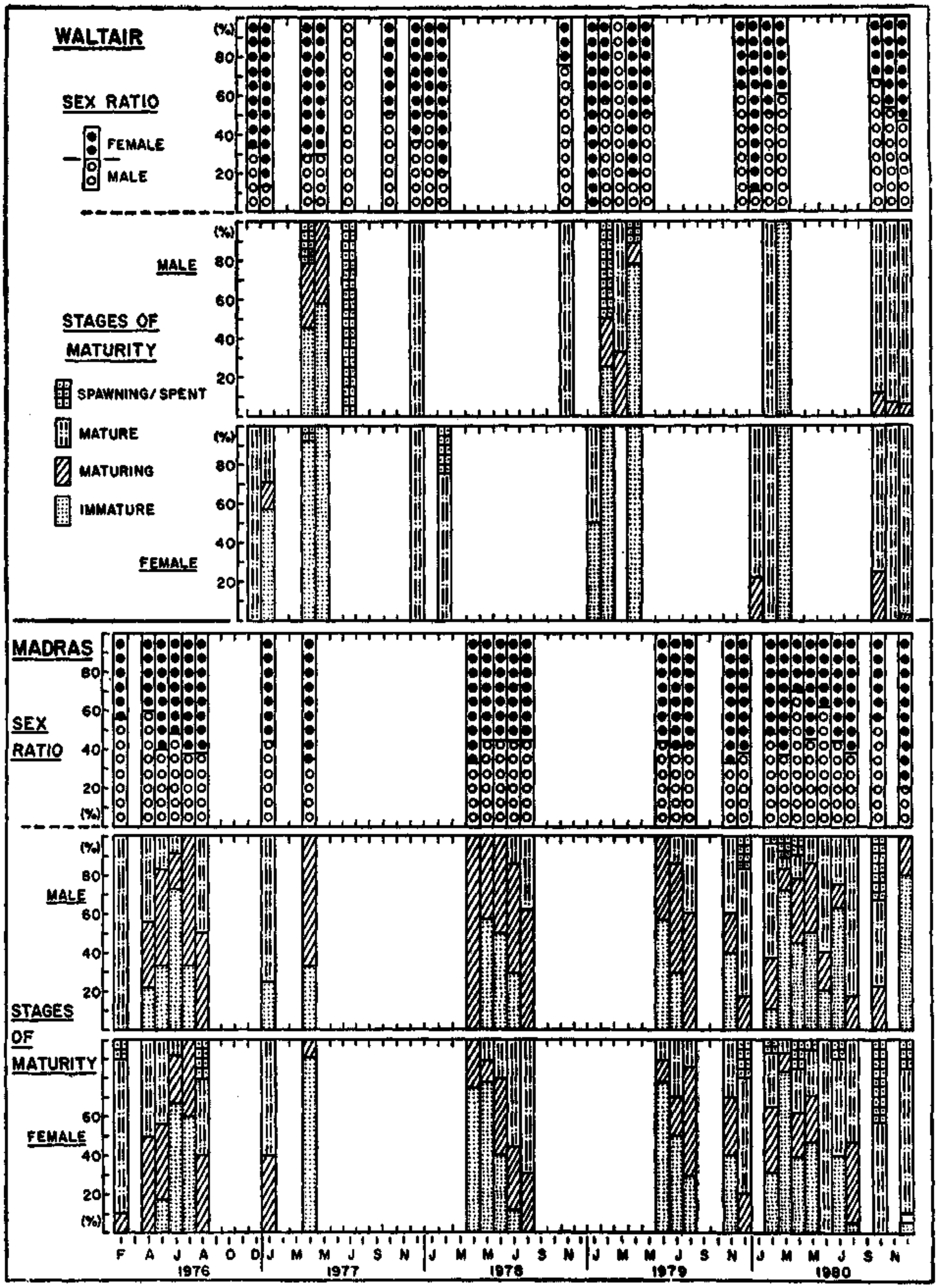

FIG. 1. Sex ratio and stages of maturity of *Sepia pharaonis* at Waltair and Madras.

In Cochin area the size at first maturity is more or less the same as at Vizhinjam in the two sexes, 154 mm in males and 157 mm in females. However, the size at 100% maturity is lower, being 190 mm in both sexes.

Spawning

In Waltair area mature females occurred from October to February and mature males from October to March (Fig. 1). Female spawners were observed in the area in February and April and male spawners in February, April and July. This species appears to breed in the period October to April along the Waltair coast. Cuttlefish in all the maturity stages were found almost throughout the year off Madras coast (Fig. 1). In constrast to Waltair area, sexually mature females were observed from October to August and males in all months except September. Spawning females were seen in seven months viz., February, April, May, July, August, October and December and spawning males in March, April, October and December. The data on the occurrence of mature cuttlefish and spawners suggests that the spawning season of this species is very much prolonged as in *S. aculeata* extending from October to August.

Along Vizhinjam coast, cuttlefish in maturing stage were noticed in January, March, April and August-November in hooks and line fishery (Fig. 2). Mature cuttlefish occurred (during January-April, July and September-December. Higher percentages of mature females with ripe ova were observed in three months January, April and December. Mature males were frequently observed in the catches over a longer period during September-December, March, April, and July and male spawners during March-April. The seasonal abundance of mature and spawning cuttlefish suggest that the species breeds in this area from October to April.

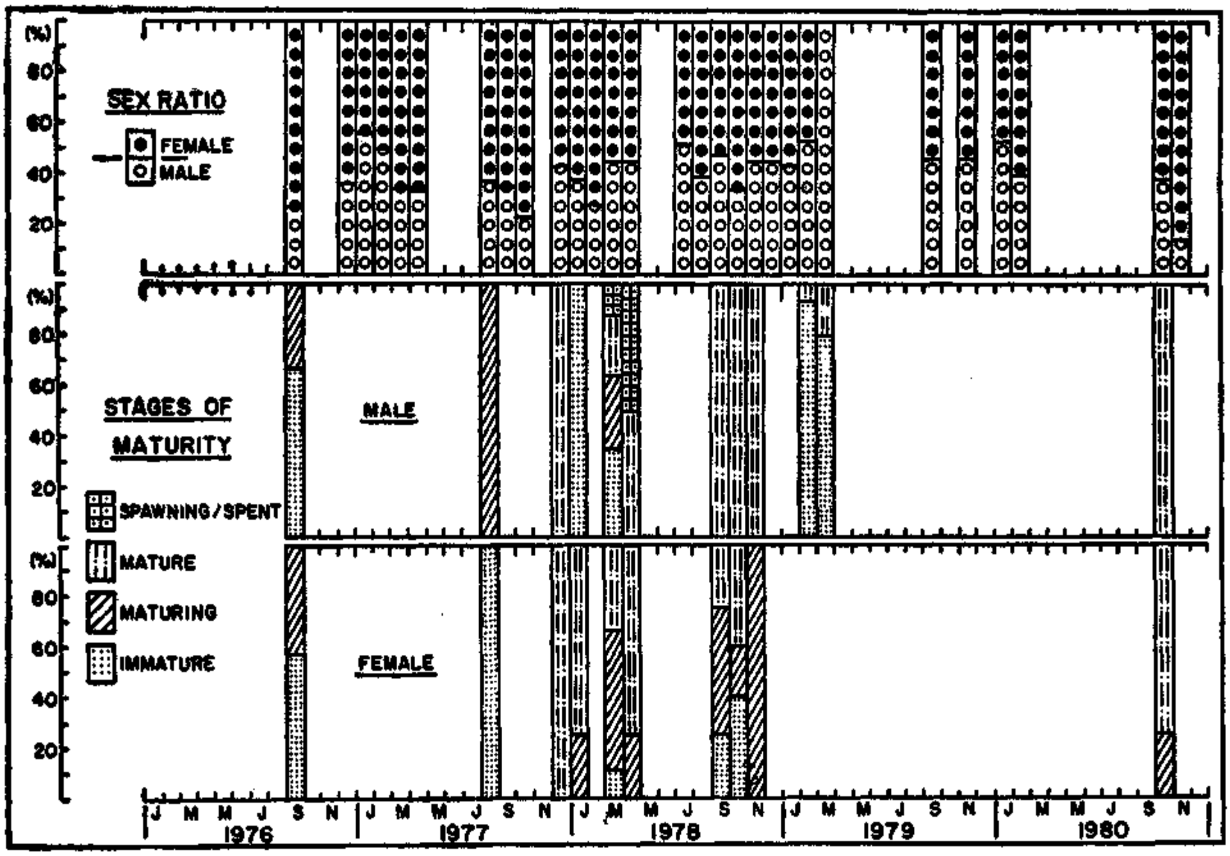

FIG. 2. Sex ratio and stages of maturity of *Sepia pharaonis* at Vizhinjam.

In Cochin area maturing cuttlefish of this species were common throughout the year (Fig. 3). Sexually mature females were noticed in April, June and October and spawners only in December. Mature males occurred in April, July, October and December and spawners in September and December. Along both east and west coasts of India the species spawns over a long period extending from October to April and in

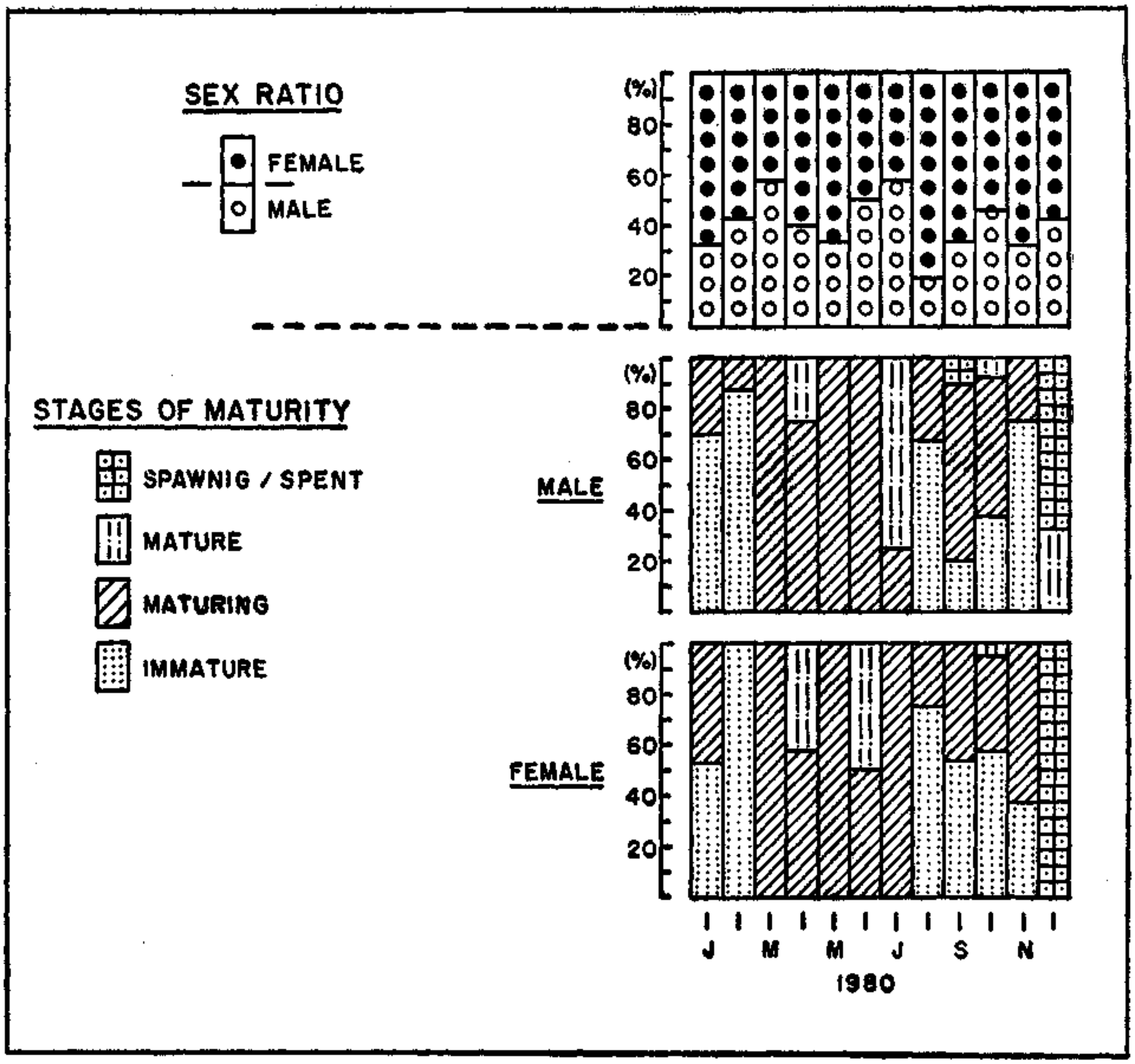

FIG. 3. Sex ratio and stages of maturity of *Sepia pharaonis* at Cochin.

some areas up to August. Voss and Williamson (1971) have stated that this species spawns in a restricted period March-May in Hong Kong area and the cuttlefish come to the coastal waters for the purpose. Spawning grounds of this species have been reported to exist off Orissa and Visakhapatnam coasts (FAO) UN, 1961).

REPRODUCTION

ADULT HISTORY

Growth

Preliminary growth studies based on the length frequency distribution of both sexes of *S. pharaonis* combined together from the commercial trawl catches off Madras coast show that the species attains a size of 100 mm in 6 months, 165 mm in one year and 197 mm in 16 months on the east coast.

A detailed study of the size frequency composition of males and females of *Sepia pharaonis* caught by hooks and lines off Vizhinjam coast indicated differential growth in the two sexes. The relative age and size was estimated to be as follows :

Relative Age	Male (mm)	Female (mm)
6 months	109.4	119.9
12 months	186.1	197.8
18 months	239.7	248.3
24 months	277.3	281.2
30 months	303.6	302.5
36 months	322.0	316.3

In *Sepia pharaonis* of PDR Yemen also the rate of growth is faster in females but the ultimate size reached is higher in males and they survive longer due to high level of post-spawning mortality of females (Sanders, 1981).

Length-weight Relationship

Study of the length-weight relation of the species caught off Vizhinjam coast showed differences in the rate of increase in weight in relation to length in males and females. The allometric growth formulae for the two sexes are as follows :

In males $W = 0.000988\ L^{2.5058}$

In females $W = 0.000726\ L^{2.5478}$

Distribution of adults

This is a widely distributed species contributing to the commercial fisheries along both coasts of India. Adults are caught in large quantities in hooks and lines in Vizhinjam area and in trawl nets in the other areas. Off northern Andhra adult males 90-150 mm and adult females 90-170 mm in size are caught in trawl nets. Off Madras coast trawlers obtain adult males and females of the size range 110-190 mm. On the west coast much larger sizes are obtained. The size ranges of males and females caught in the Cochin area by tralwers range from 130 mm to 190 mm while in Vizhinjam area adult males 130-210 mm and adult females 150-230 mm are fished.

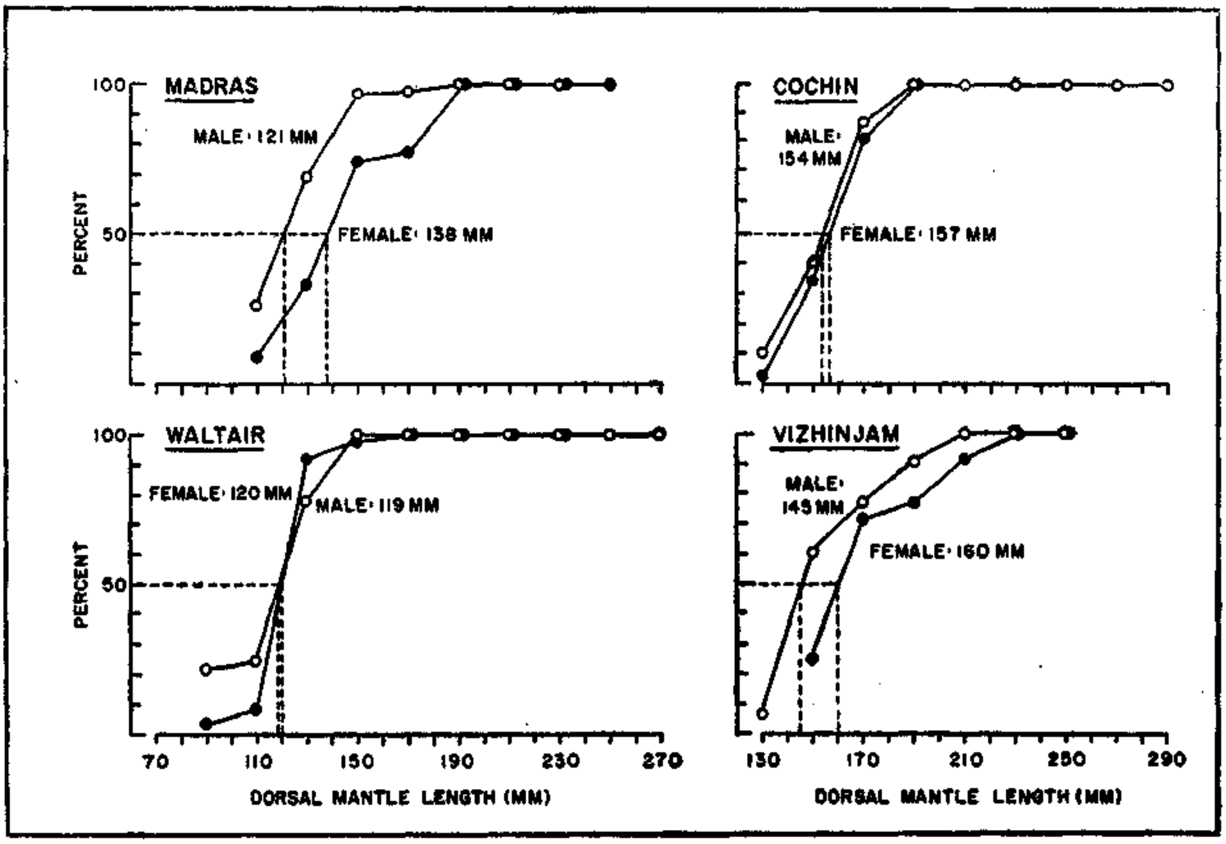

FIG. 4. Size at first maturity of *Sepia pharaonis* at Madras, Cochin, Waltair and Vizhinjam.

Maximum size

The greatest sizes recorded for the males and females of this species on the east coast are 265 mm (at Waltair) and 245 mm (at Madras) respectively. As this species grows to a larger size on the west coast, the corresponding sizes for males and females along this coast are 334 mm and 320 mm (at Vizhinjam) respectively.

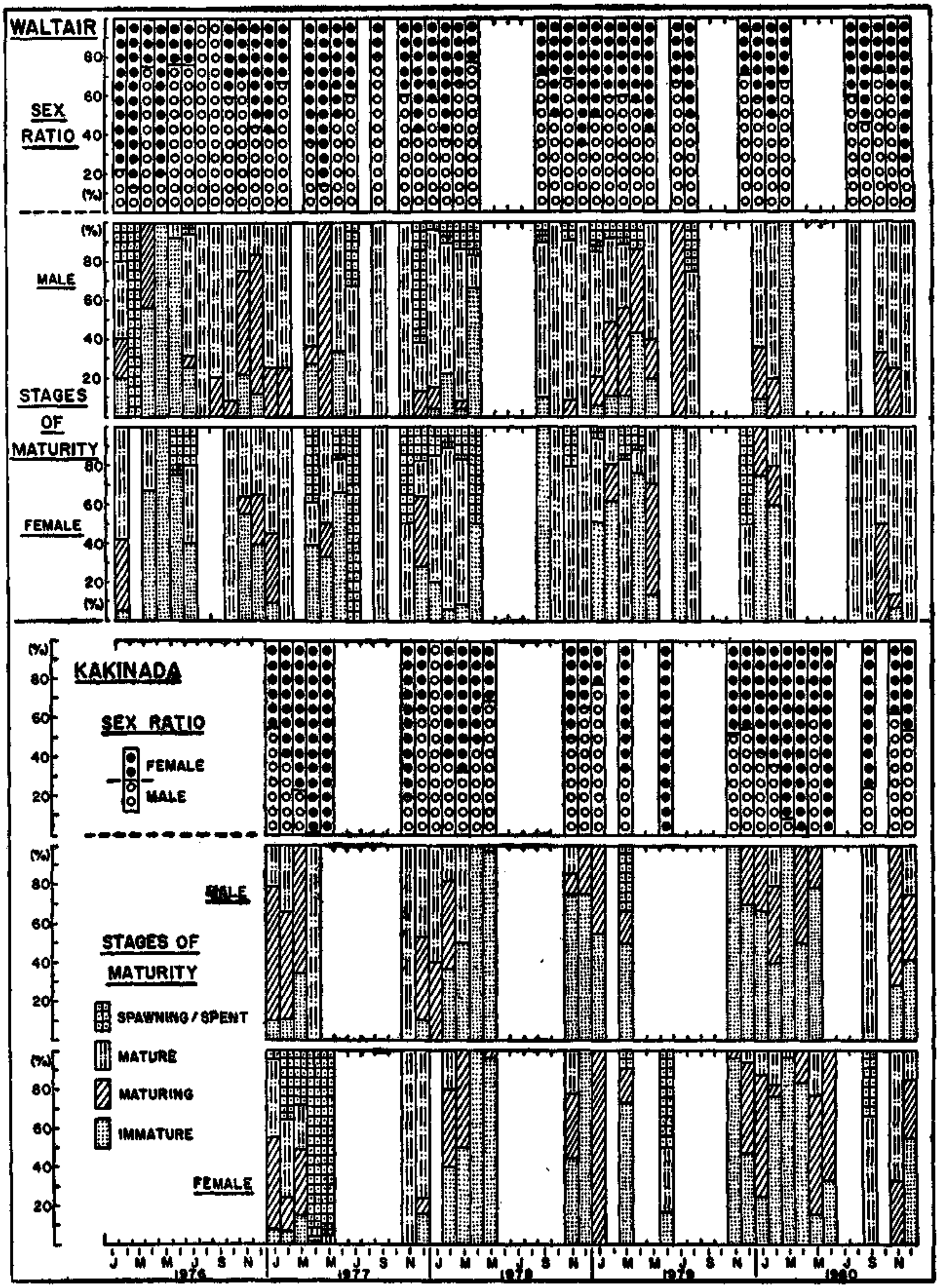

FIG. 5. Sex ratio and stages of maturity of *Sepia aculeata* at Waltair and Kakinada.

Food

S. pharaonis is an active predator and exclusively carnivorous feeding on fish, crustaceans and sometimes on cephalopods. Scales, eye balls, otoli h and bones of fishes, macerated and partly digested fishes and parts of crus aceans such as prawns, crabs and *Squilla* are found in the stomachs.

Eggs

Egg clusters of this species have been collected from the fishing grounds off Vizhinjam coast.

Distribution of juveniles

Juveniles of the species measuring up to 80 or 100 mm in size occur in the inshore waters and are caught in shore seines, boat seines and from depths up to 40 m in trawl nets particularly in Waltair, Madras and Mandapam areas. The juveniles are obtained from January to July in Waltair area and throughout the year with the exception of September in Madras area. Juveniles up to a maximum size of 120 mm are obtained in trawl nets in Cochin area all round the year except in June and December and in Vizhinjam area from January to April and in August.

Sepia aculeata Orbigny

Bionomics and Life-history

Reproduction

Sexuality

Sexes are separate. The mantle as well as the cuttlebone are less broader in males than in females and quadriserial suckers in the hectocotylized left ventral arm are abruptly reduced in size as compared to normal suckers near the base of the arm. Females can be distinguished as in all cuttlefishes by the presence of nidamental glands which can be easily seen through the mantle opening by disengaging the funnel mantle locking device or by cutting open the mantle centrally.

Sex ratio

In the trawl catches off Waltair coast during 1976-80, generally males dominated (57-100%) except in some months when females were found in more numbers (F 54 : M 46-F 87 : M 13). The two sexes were found distributed in equal proportion only in five months—June 1977, October 1978, January and August 1979 and February 1980 (Fig. 5).

Females were usually the dominant sex along Kakinada coast in most of the months during 1977-80 with female : male sex ratios of 57 : 43-96 : 4 except in the months January and December 1977, May and December, 1978, January, November and December, 1979 and May November and December, 1980 when males were the dominant sex (M 53 : F 47-M 79 : F 21). The two sexes were in equal proportion only in three months April, September and November, 1978 (Fig. 5).

The sex ratio of this species in the commercial trawl catches in Madras area showed a different trend (Fig. 6). In 1976, males dominated only in July (M 53 : F 47). In August both sexes were in equal ratio. In 1977 males outnumbered females in March and April and females were the dominant sex in February and November. In 1978 females dominated (F 57 : M 43-F 65 : M 35) in all months except June and August while in 1979 they were dominant only in two months viz., June and October (F 55 : M 45-F 67 : M 33). In 1980 the two sexes were in equal porportion in April. June and September and in several months females were the dominant sex (F 53 : M 47 and F 68 : M 32). The overall sex ratio for the entire period 1976-80 showed female predominance with a ratio of F 58 : M 42.

During the period 1976-78 males were the dominant sex along Porto Novo coast in most of the months when observations were made (Fig. 6). The two sexes were represented in equal ratio only in two months August, 1976 and January, 1977.

The sex ratio of the species in Mandapam area did not show any definite pattern (Fig. 7). In 1976 males were the dominant sex in a number of months such as January, March, May, August and November-December with sex ratios of M 52 : F 48:M 68 : F 32 while in the other months there was dominance of females. In 1977-78, only in four months viz., January, July and November 1977 and April 1978 males were dominant (M 51 : F 49 to M 70 : F 30). The overall sex ratio of males and females during 1976-78 did not indicate marked dominance of a single sex.

On the west coast females were dominant in trawl catches in Cochin area in six months in 1980 with sex ratios of F 53 : M 47-F 72 : M 28 (Fig. 8). In March and June 1980, the two sexes were distributed in equal porportion while in the other four months there was preponderance of males (M 59 : F 41-M 74 : F 26).

In Bombay area the sex ratios showed male dominance (M 53 : M 47-M 83 : F 17) in most of the months in 1978 and 1980 (Fig. 9). In the month of September in 1978 and 1979 the two sexes were in equal ratio or almost so while in September, 1980 females were dominant (F 65 : M 35). The average sex ratio during the period 1978-80 showed dominance of males (M 60 : F 40).

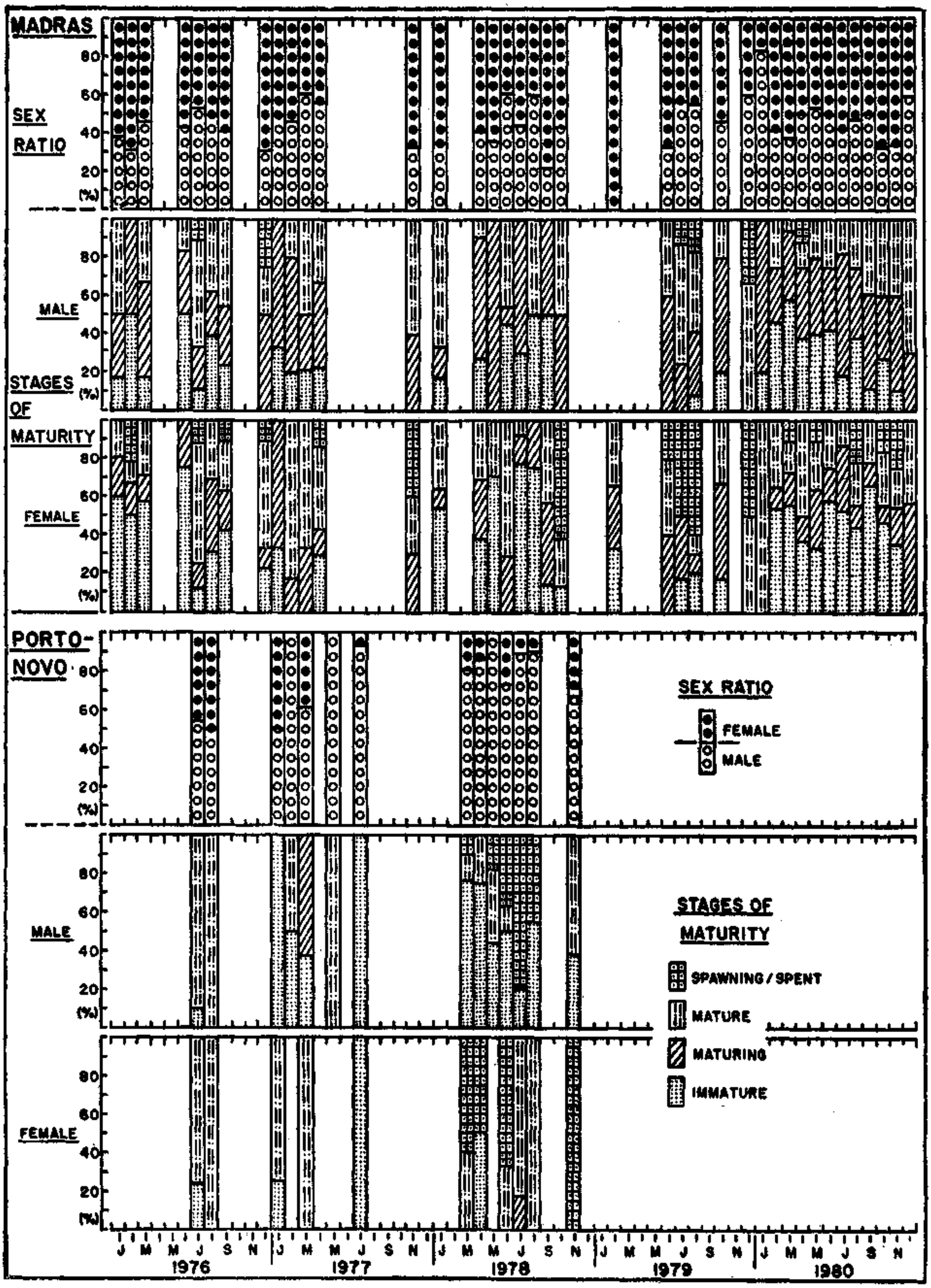

FIG. 6. Sex ratio and stages of maturity of *Sepia aculeata* at Madras and Portonovo.

Maturity

Along Waltair coast males and females were found to mature from the size of 70 mm onwards (Fig. 10). 50% of the males and females were mature when they attained sizes of 77 mm and 102 mm respectively. All the individuals of the two sexes were matured when they attained a size of 150 mm.

Along Madras coast the catches consisted of cuttlefishes in all stages of maturity. The frequency of maturity stages at different sizes indicated that the size of 50% maturity for males is 100 mm and that for females 118 mm. Males in the population attain the mature stage in the size range 70-130 mm and female in the range 90-170 mm. Both sexes became mature when they are 130 mm and 170 mm respectively. The size at 50% maturity is lesser viz., 83 mm for males at, Mandapam and that for females is, however, similar 110 mm when 10 months old. In Mandapam area male and female cuttlefish reached maturity at a minimum size of 70 mm. All the males and females attained mature stage by the time they grow to sizes of 150 mm and 190 mm respectively.

On the west coast, study of the stages of maturity in relation to size revealed that the size of 50% maturity was higher than on the east coast viz., 124 mm in the case of males and 130 mm in females in Cochin area. The cuttlefish of the two sexes become mature within the size ranges 90-170 mm and 110-170 mm with 100% maturity at 170 mm.

The onset of maturity was first observed in females of Bombay region at a size of 90 mm and all the females were mature by the time they grew to 150 mm. The size at 50% maturity of females in Bombay area was similar to that in Cochin area, being 132 mm.

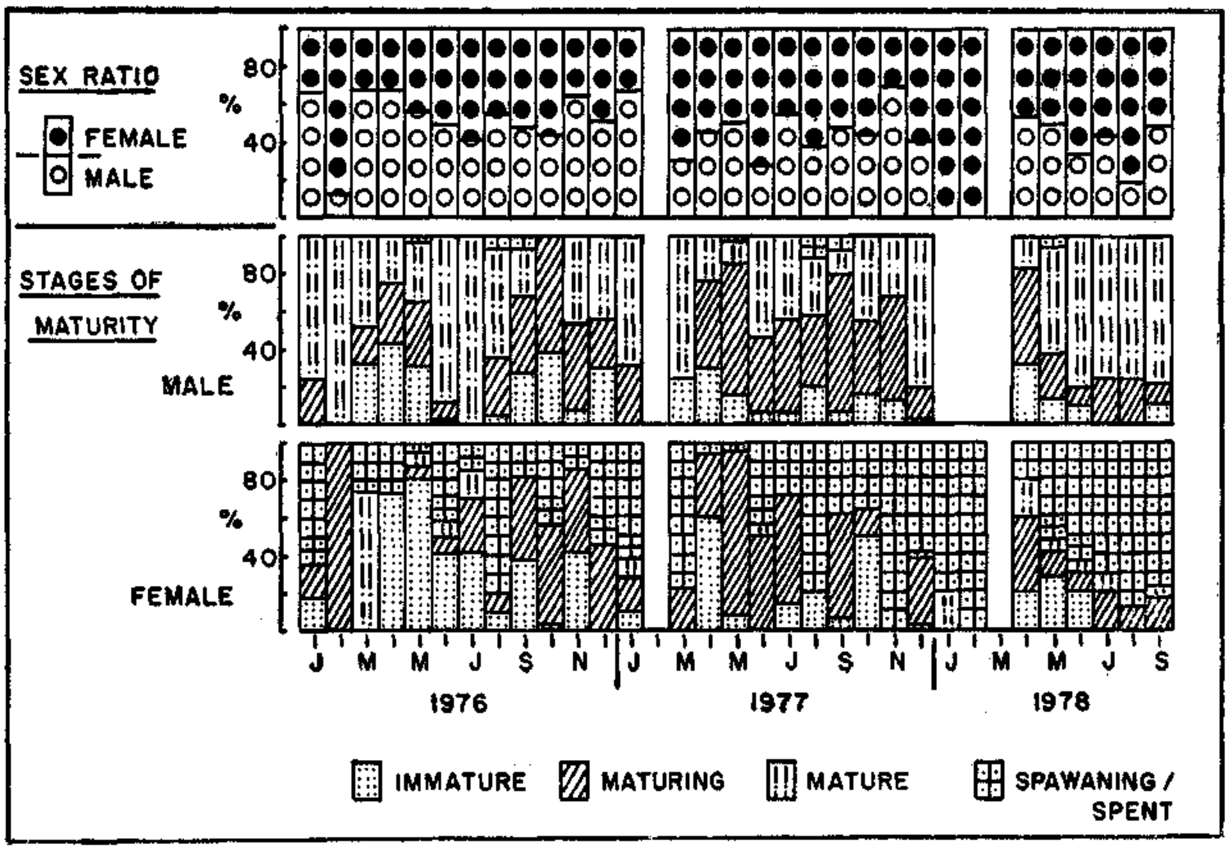

FIG. 7. Sex ratio and stages of maturity of *Sepia aculeata* at Mandapam.

The data on the size at first maturity of *Sepia pharaonis* and *Sepia aculeata* indicate that in these two species male cuttlefish attain sexual maturity at smaller size than females. Further in both these species the cuttlefishes of the two sexes become sexually mature at smaller size on the east coast than those along the west coast. The causative factors for the differences need to be studied. Durchon and Richard (1967) have observed that a secretion of the optic gland of *Sepia officinalis* controls maturation of reproductive organs. Defretin and Richard (1967) have reported that the optic gland of cuttlefish is controlled by photoperiod, being active when day length is short and inhibited by long day length.

Spawning

Cuttlefish in maturing stage were found in greater or lesser numbers along both the coasts throughout the year indicating maturation in the species all through the year. Mature and spawning cuttlefish were also seen almost in all months clearly indicating breeding activity during a prolonged period.

out the year while males in these stages were noticed in good numbers almost around the year (Fig. 6). In Portonovo area females in advanced stages of maturity were noticed in good percentage in January, March-April, June-August and November and males of the stages in February, May-August and November (Fig. 6).

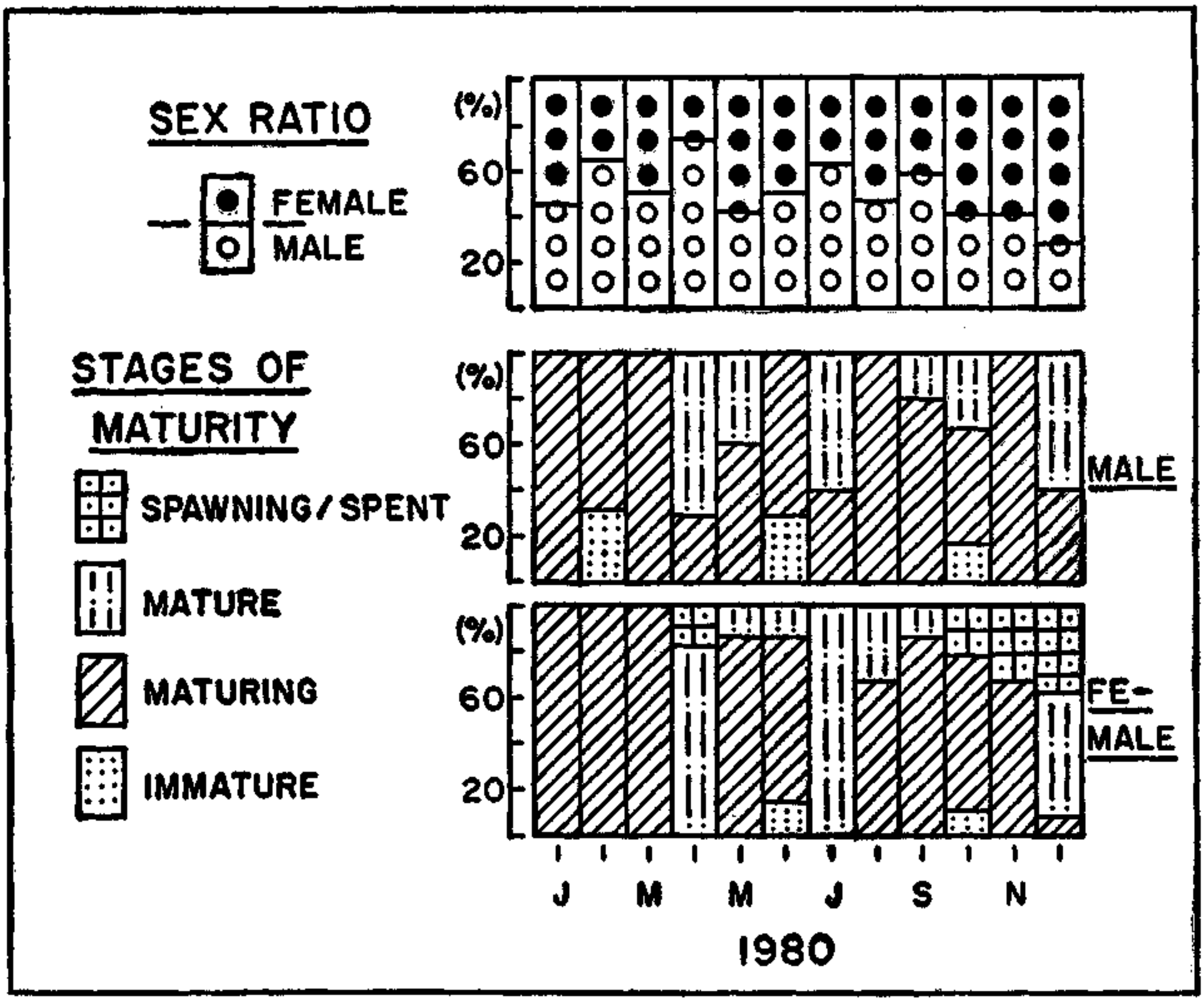

FIG. 8. Sex ratio and stages of maturity of *Sepia aculeata* at Cochin.

On the Waltair coast mature and spawning females were very common from January to April and from July to December (Fig. 5) and mature and spawning males were commonly observed throughout the year. Along the Kakinada coast females in mature and spawning stages were common in February, April-May, September and November (Fig. 5). Males in the same stages were in several months and were more common in April, September and November.

Mature and spawning females were common or very common in trawl catches off Madras coast through-

In the trawl catches in Mandapam area during 1976-78 mature and partly spawned females as well as males were common throughout the year (Fig. 7). Rahman (1967) reported that the species appears to breed biannually in neighbouring Thondi area the first season extending from February to April and the second one from July to August.

The observations at Cochin on the west coast in 1980 indicated occurrence of mature and spawning female *S. aculeata* in trawl catches off Cochin coast from April to December with dominance in three months viz., April, July and December (Fig. 8). Sexually mature males were observed in several months viz. April, May, July, September, October and December with large numbers in April, May, July and December. Data collected on females of this species caught by trawlers off Bombay show that mature and spawning *S. aculeata* form high percentages in five months February, March and September-November (Fig. 9).

The data at seven centres presented above indicate breeding in the species during an extended period along both coasts of India.

Study of the age and growth of this species in Madras area showed that the growth rate is almost similar in both sexes. The relative age and size are as follows :

Relative age		*Size* (mm)
6 months	..	88.6
12 months	..	138.9
18 months	..	167.5
24 months	..	183.7

The observations made in Mandapam area indicate growth to sizes of 74 mm, 123 mm and 155 mm at the end of six months, one year and one and half years respectively.

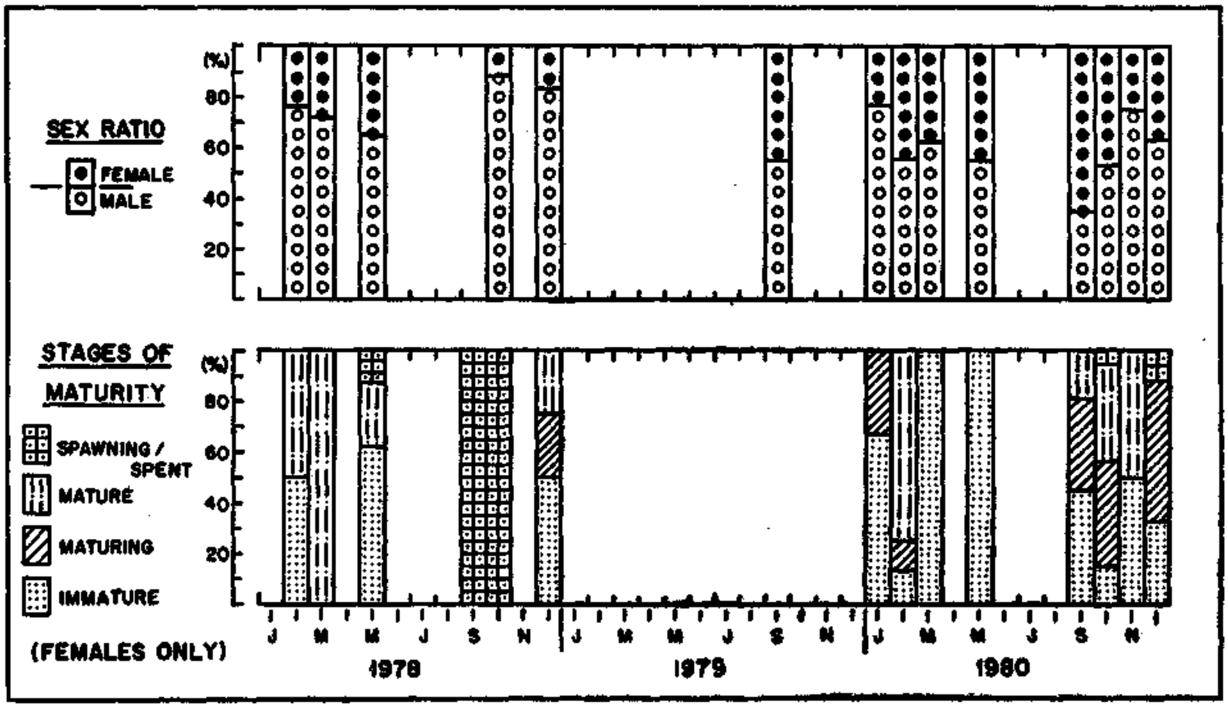

FIG. 9. Sex ratio and stages of maturity of *Sepia aculeata* at Bombay.

ADULT HISTORY

Growth

Progress of modal sizes was analysed for males and females together for growth studies at Waltair, Kakinada Mandapam and Bombay. At Madras the males and females were treated separately. Growth studies on this species at Waltair show that it attains a size of 59 mm at the end of 6 months, 103 mm at the end of one year, 135 mm at the end of one and half years, 158 mm at the end of two years and 165 mm at the end of 26 months.

Along Kakinada coast the growth is initially similar to that along Waltair coast and a size of 61 mm is reached at the end of six months but later there is a slight decrease in rate of growth, the size reached in one year and one and half years being 96 mm and 124 mm respectively.

The growth of this cuttlefish in Bombay area is similar to that in Mandapam area in the first year of its life with a growth of 67 mm and 122 mm in six months and one year respectively, but in the second year the growth is faster in comparison to that on the east coast, and sizes of 164 mm and 202 mm are attained in one and half years and two years respectively.

Length-weight relationship

The study of length-weight relationship of the species of Madras coast indicated that the rate of increase in weight in relation to the dorsal mantle length differed in males and females. The allometric growth formulae for the two sexes are as follows.

In males $W = 0.00045\ L^{2.6671}$

In females $W = 0.000346\ L^{2.7427}$

Distribution of adults

This is a common species in the continental shelf waters especially up to a depth of 60 m. Adults of the size ranges 50-150 mm and 70-190 mm support the trawl fishery along Waltair and Madras coasts. The sizes obtained in trawl catches on the southeast coast in Mandapam area are higher with a range of 70-190 mm. On the west coast adult females 90-200 mm are caught by trawlers off Cochin and Bombay coasts.

fishes and other organisms caught along with the species in trawl nets and identification of the prey organisms found in the stomach contents, Oommen (1977) reported in the stomachs of this species a number of fishes *Nemipterus japonicus, Platycephalus scaber, Opisthotarus tardoore, Saurida tumbil, Cynoglossus* sp., *Pseudohombus* sp., *Anchoviella* spp., *Sardinella* spp., *Plotosus* sp., *Scatophagus argus* and *Rastrelliger kanagurta*, the crustaceans, *Metapenaeus* sp., *Penaeus* sp., *Squilla holoschista*, and *Neptunus sanguinolentus*, the squid

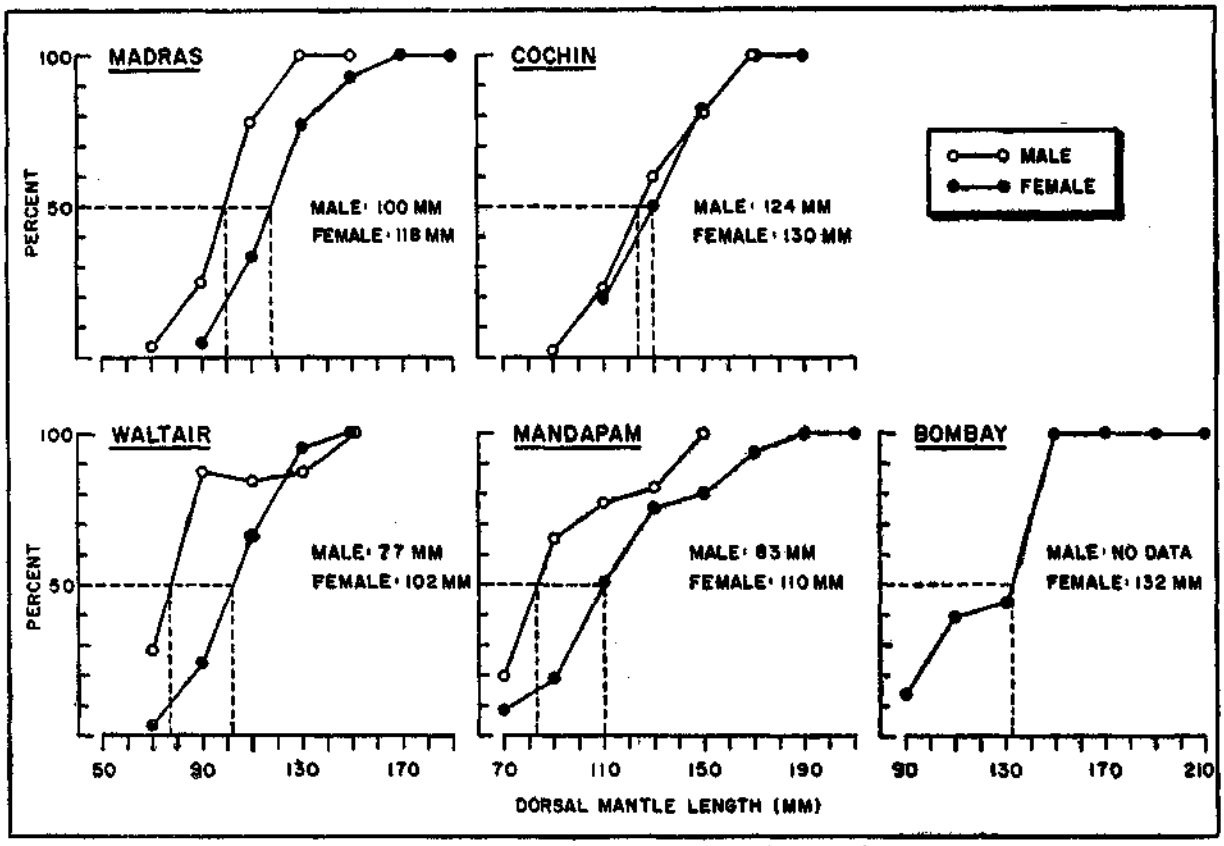

FIG. 10. Size at first maturity of *Sepia aculeata* at Madras, Cochin, Waltair, Mandapam and Bombay.

Maximum size

The largest sizes for males and females on the east coast are 190 mm and 200 mm respectively (at Mandapam) and on the west coast the maximum sizes for the two sexes are 245 mm and 200 mm (at Bombay).

Food

Like all other cephalopods this species is highly carnivorous and predatory. The common food items are fish and prawns. Crabs, stomatopods and polychaetes also form diet of this species to a small extent.

Oommen (1977) studied the structure of the alimentary canal, digestive enzymes and food and feeding habits of this species from the southwest coast of India. The stomach contents were usually found in well macerated condition. However, based on the occurrence of

Loligo duvaucelii and *Loliolus* sp. and the foraminiferans *Nonion sloanii* and *Entzia tetrastomella*. Oommen (1977) did not find any seasonal changes in the feeding intensity. Crustaceans were dominant food throughout the year with peaks in March and April followed by fishes which were very common in May and October. Cephalopods were rarely found in the stomach contents.

Eggs

During periods of intensive spawning egg clusters are commonly seen in trawl and shore seine catches in Palk Bay, Gulf of Mannar and other parts of east coast. Bunches of egg capsules are found washed ashore in the monsoon period October-December. On two occasions in September 1976, egg clusters of this species attached to gorgonids had been collected from trawl catches off Madras in the fishing area 13-80/1C at a depth of 25-40 m where the bottom was muddy with shells. A brief account of the rearing and hatching of eggs is given by Sivalingam and Pillai (1983).

Distribution of juveniles

On the east coast juveniles 20-50 mm in size were found throughout the year along Kakinada and Mandapam coasts and from January to October off Madras coast. Along Waltair coast they were represented in January, February, April, May, August and December. Juveniles ranging between 20 and 70 mm were observed throughout the year in Bombay area and from January to August off Cochin on the west coast.

REPRODUCTION

Sexuality

Sepia elliptica is heterosexual and the two sexes can be distinguished externally from the hectocolylization of the left ventral arm in males. In addition females are broader than males.

Sex ratio

Data on sex ratio of cuttlefish caught by trawlers in Cochin area is inadequate for the period 1976-78 due to poor catches. During 1979-80 this species was obtained in good numbers and males were the dominant sex in March, May, July, September-December, 1979 and April, August and September, 1980 (M 52 : F 48—

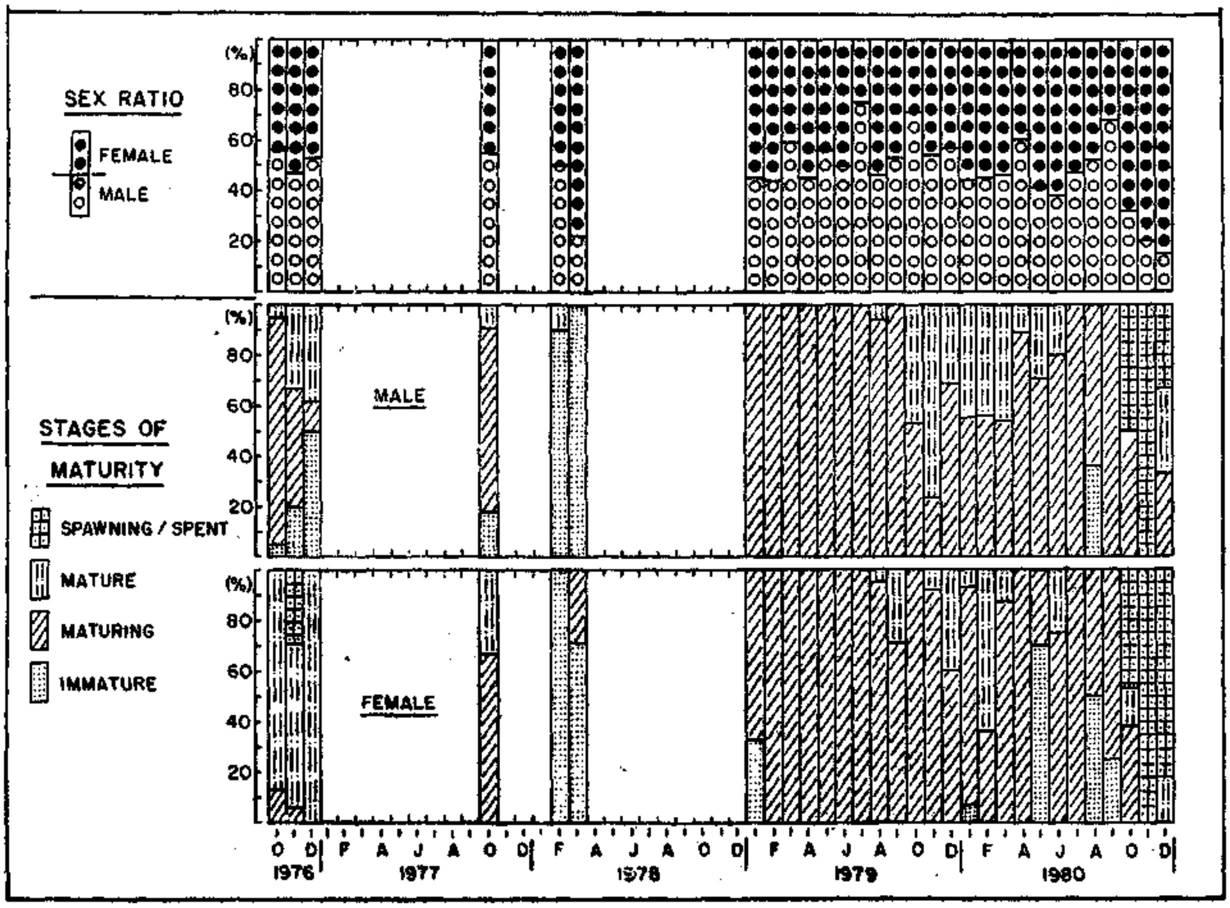

FIG. 11. Sex ratio and stages of maturity of *Sepia elliptica* at Cochin.

M 75 : F 25) (Fig. 11). Only in one month June, 1979 both sexes were represented in equal ratio and in all other months of the 1979-80 period females dominated in the population (F 53 : M 47—F 85 : M 15).

Sepia elliptica Hoyle

BIONOMICS AND LIFE-HISTORY

This is a small sized species supporting a fishery at Cochin and is caught in trawl nets almost throughout the year.

Maturity

Males and females of this species of Cochin area attain sexual maturity at a minimum size of 75 mm and all individuals of the two sexes are mature when they reach a size of 115 mm (Fig. 12). The size of 50% maturity is 93 mm for males and 96 mm for females.

Spawning

Sexually mature females were represented in the trawl catches in several months of the year January-March, June and August-December (Fig. 11). Similarly mature males were also found in January-May, August and October-December. Spawning females and males were recorded from October to December. Spawners occur only in three months. But the presence of mature cuttlefish of both sexes in a number of months suggests that breeding activity extends over a long period in a year.

Distribution of adults

Adult males and females 75-115 mm are commonly captured from the trawling grounds off Cochin coast at depths beyond 30-40 m.

Maximum size

The largest sizes recorded for males and females of *S. elliptica* caught in trawl nets in Cochin area are 129 mm and 119 mm respectively.

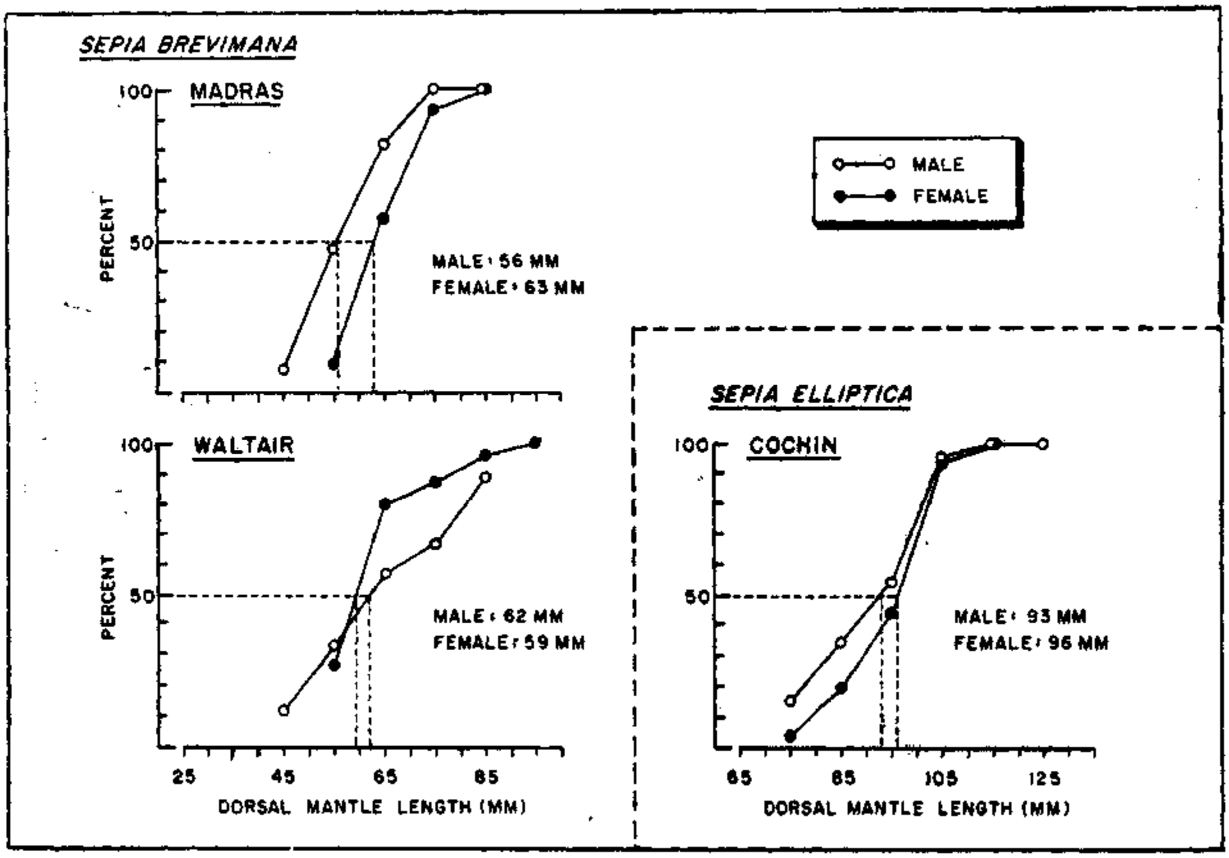

FIG. 12. Size at first maturity of *Sepia brevimana* of Madras and Waltair and *Sepia elliptica* at Cochin.

ADULT HISTORY

Growth

Study of the progression of modal sizes of males and females together showed a growth of 75 mm in six months and 117 mm in one year in this species.

Food

Penaeid prawns form the main item of food of this species and the other food items which occur in the stomachs are fishes, *Acetes*, crabs and stomatopods.

Distribution of juveniles

Juveniles measuring 36-74 mm are obtained in trawl catches in Cochin area in January-May and August-September.

Sepia brevimana Steenstrup

Bionomics and Life-History

This is one of the small sized cuttlefishes which are landed in moderate quantities in trawl nets at Madras and Waltair.

Reproduction

Sexuality

Sexes are separate and males can be distinguished from females by the hectocotylization of the left ventral arm. In females the mantle is broader and the cuttlebone accuminate anteriorly.

Sex ratio

Females were dominant on Waltair coast in several months (F 55 : M 45—F 86 : M 14) in 1976 and 1979 while in 1977, 1978 and 1980 females outnumbered males in some months (F 51 : M 49—F 75 : M25) and *vice versa* in other months (M 51 : F49—M 74 : F 26) (Fig. 13). The two sexes were represented in equal ratio only in four months May 1977, August 1978, May 1979 and March 1980. The annual sex ratios show that the two sexes were almost in equal proportion in 1977, 1978 and 1980 while females were dominant (F 58 : M 42 and F 57 : M 43) in the years 1976 and 1979.

On the Madras coast during 1976 and 1977 when data was available in a few months, females were dominant in March and August 1976 and February, March and November, 1977 (F 60 : M 40—F 65 : M 35) while in February and July, 1976 the two sexes were in equal or almost equal ratio (Fig. 13). During the period 1978-80, males predominated in the catches in February March and May 1978, March, June, July and September 1979 and January, February, May and November 1980 (M 53 : F 47—M 73 : F 27). The two sexes were in almost equal ratio in June, 1978. The overall annual sex ratios show preponderance of females during 1976-78 and 1980 (F 54 : M 46—F 57 : M 43) and only in one year, 1979 males were dominant (M 58 : F 42).

Maturity

Males and females of this species mature for the first time at sizes of 45 mm and 55 mm respectively on the Waltair coast and the sizes at 50% maturity of the two sexes are 62 mm and 59 mm respectively (Fig. 12). All the females and males mature at a size of 95 mm.

In Madras area also males and females of the species become mature at sizes of 45 mm and 55 mm respectively (Fig. 13.) But the size of 50% maturity is 56 mm in males and 63 mm in females. All the males and females are found to mature at sizes 75 mm and 85 mm respectively.

Spawning

In Waltair waters maturing and mature females were observed throughout the year (Fig. 13). The latter were seen in large numbers in January-April, June-October and December. Partially spawned females were noticed in January, February, April, September, October and December. Mature males were found all round the year while spawners were noticed in January-May, September and December.

In Madras area mature females formed high percentages in February, May, July and November and spawning females in January, February and from July to November (Fig. 13). A similar trend is seen in males with high percentage of mature ones in January-March, May, July-September and November. The data indicate spawning activity during a very prolonged period in this species along Madras and Waltair coasts.

Adult History

Growth

Preliminary study of the progression of monthly modes of males and females together showed that this species grows to sizes of 29 mm, 56 mm and 75 mm at the end of 6 months, one year and one and half years in Waltair area while in Madras waters it attains sizes of 34 mm, 58 mm and 76 mm respectively at the same ages.

Distribution of adults

Adult cuttlefishes of the size ranges 45-95 mm and 45-85 mm comprise the trawl catches in Waltair and Madras areas respectively.

Maximum size

The maximum sizes of males and females recorded at Waltair are 89 mm and 95 mm respectively whereas 85 mm was the largest size recorded for both the sexes at Madras. Voss and Williamson (1971) have observed 80 mm as the maximum size for this species in Hong Kong waters.

Food

Qualitative study of the stomach contents of this species of Waltair and Madras coasts showed that it feeds on various species of prawns, fishes and other crustaceans such as *Squilla* and crabs.

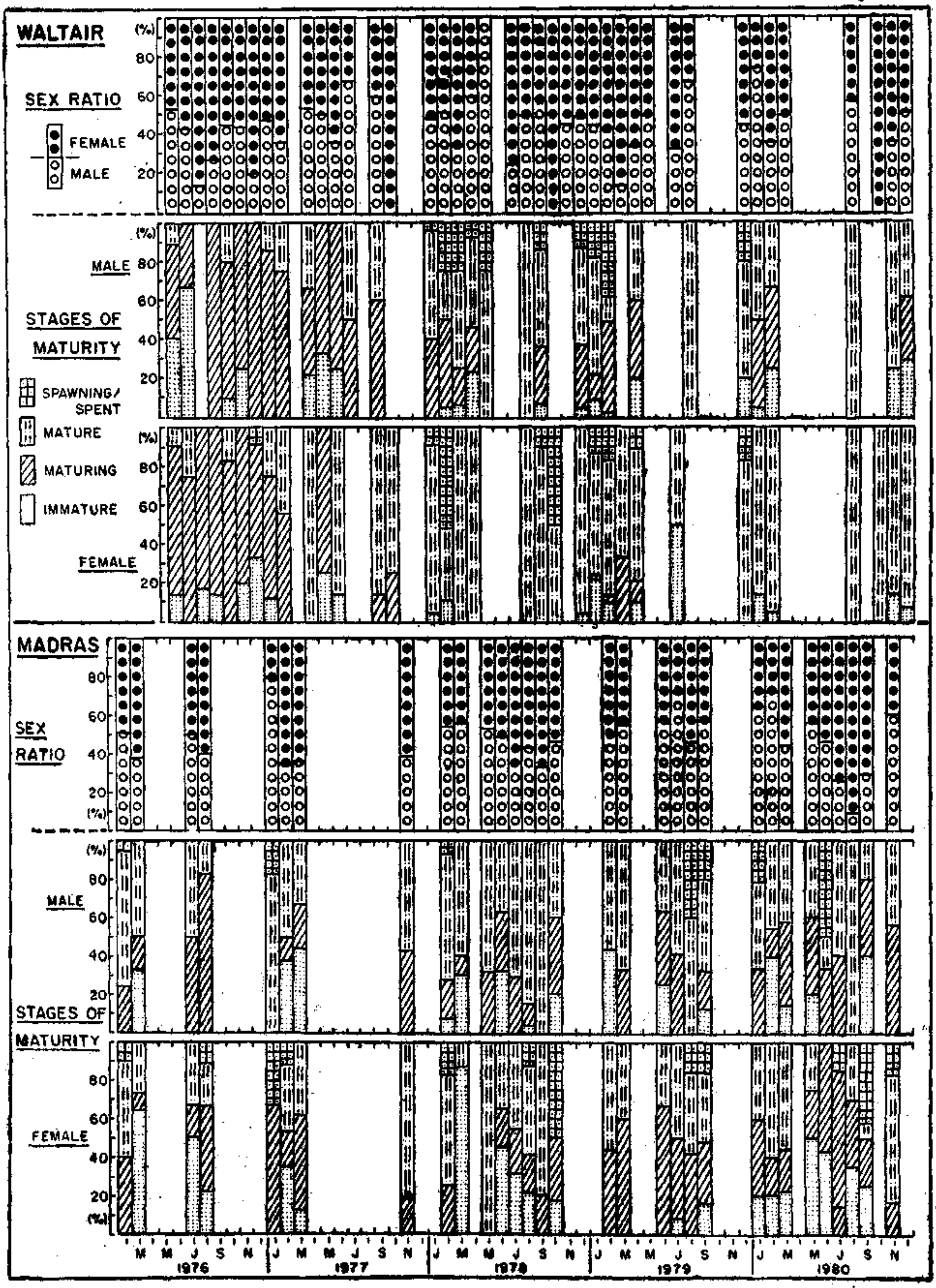

FIG. 13. Sex ratio and stages of maturity of *Sepia brevimana* at Waltair and Madras.

Distribution of juveniles

Juveniles of *S. brevimana* 20-40 mm in size were caught by trawlers along Waltair coast in April-May and November 1978, January-February and April 1979 and January, February, November and December 1980. Juveniles 30-40 mm have been recorded in trawl catches off Madras coast almost throughout the year.

Sepia prashadi Winckworth

BIONOMICS AND LIFE HISTORY

This is also a small-sized cuttlefish like *Sepia brevimana* and *S. elliptica* and looks like a small sized *S. pharaonis* due to the presence of horizontal stripes on the dorsal surface of the mantle. It has been recorded from Veraval on the northwest coast and Waltair and Madras on the east coast. This species is obtained in very small quantities in trawl catches off Waltair and Madras at depths beyond 40 m.

Very little information could be collected on this species due to the sporadic occurrence in the trawling grounds. On Waltair coast it has been observed in the months January-August and October-December and on Madras coast this species has been found from January to April along with upwelled deeper water fishes such as *Psenes indicus* and *Priacanthus* sp. Cuttlefish 50-109 mm in size contribute to the commercial trawl catches along Waltair coast. Preliminary studies on Waltair coast show that males and females of this species attain maturity at a minimum size of 67 mm and 72 mm respectively.

Sepiella inermis Orbigny

BIONOMICS AND LIFE-HISTORY

REPRODUCTION

Sexuality

In males the left ventral arm is hectocotylized with a series of transverse ridges and grooves and very minute suckers at the basal portion of the arm. In addition, there is a row of small oval, white patches along the fins at their base and this feature is distinctly seen in fresh condition.

Sex ratio

The studies carried out on the species caught in trawl nets off Waltair coast (Fig. 14) show that females were the dominant sex in most of the months during 1976-80 with sex ratios of F 52 : M 48—F 91 : M 9. Males outnumbered females in June, July, September and November 1976, May and October 1977, May and September 1978, January, July and August 1979 and October 1980 when they formed 52-100%. The two sexes were almost in equal ratio only in two months in August 1978 and 1980. The overall sex ratio during 1976-80 showed dominance of females (F 56 : M 44).

Along Kakinada coast also (Fig. 14) there was generally dominance of females in trawl catches (F 52 : M 48—F 90 : M 10) and in August, October and November 1976, September-November 1977, February-April, June and September 1978, March and October 1979 and March, May and November 1980 males exceeded females (M 53 : F 47—M 72 : F 28). The two sexes were in equal ratio or in almost equal ratio in December 1977, August and October 1978, April and December 1979 and July and September 1980. The sex ratio of cuttlefishes in the entire period 1976-80 indicated almost equal ratio of the two sexes.

As in the preceeding two northern areas there was female dominance in Madras area (F 55 : M 45—F 86 : M 14) (Fig. 15). Only in two months, August 1978 and July 1979, the two sexes were in equal proportion and in a few months in some years viz., November 1976, January, February and December 1977 and June, August, September and November 1980 males dominated in the catches (M 52 : F 48—M 80 : F 20). The overall sex ratio during 1976-80 revealed that females were dominant among the two sexes.

The data on sex ratio of this species of Portonovo coast during 1977-78 (Fig. 15) showed dominance of males in three months July and October 1977 and May 1978 (M 55 : F 45—M 63 : F 37) and in all the other months the percentage of females was higher (F 52 : M 48—F 92 : M 8). In Mandapam area also females were found to be the dominant sex from January, 1973 to May, 1974 except in two months (Unnithan, 1982).

In contrast to the ratio of the sexes with dominance of females in different areas along the east coast, males dominated in the trawl catches in most of the months in Cochin area on the west coast (M 56 : F 44— M 75 : F 25) (Fig. 16). Only in five months February and March 1977, February 1978, November 1979 and April 1980, females were dominant (F 56 : M 44—F 71 : M 29). The ratio of cuttlefishes of the two sexes in the period 1976-80 showed a distinct preponderance of males (M 58 : F 42).

Maturity

On the east coast males of this species were found to attain mature condition at a minimum size of 45 mm along Madras and Portonovo coasts while at Waltair males became mature at a minimum size of 35 mm

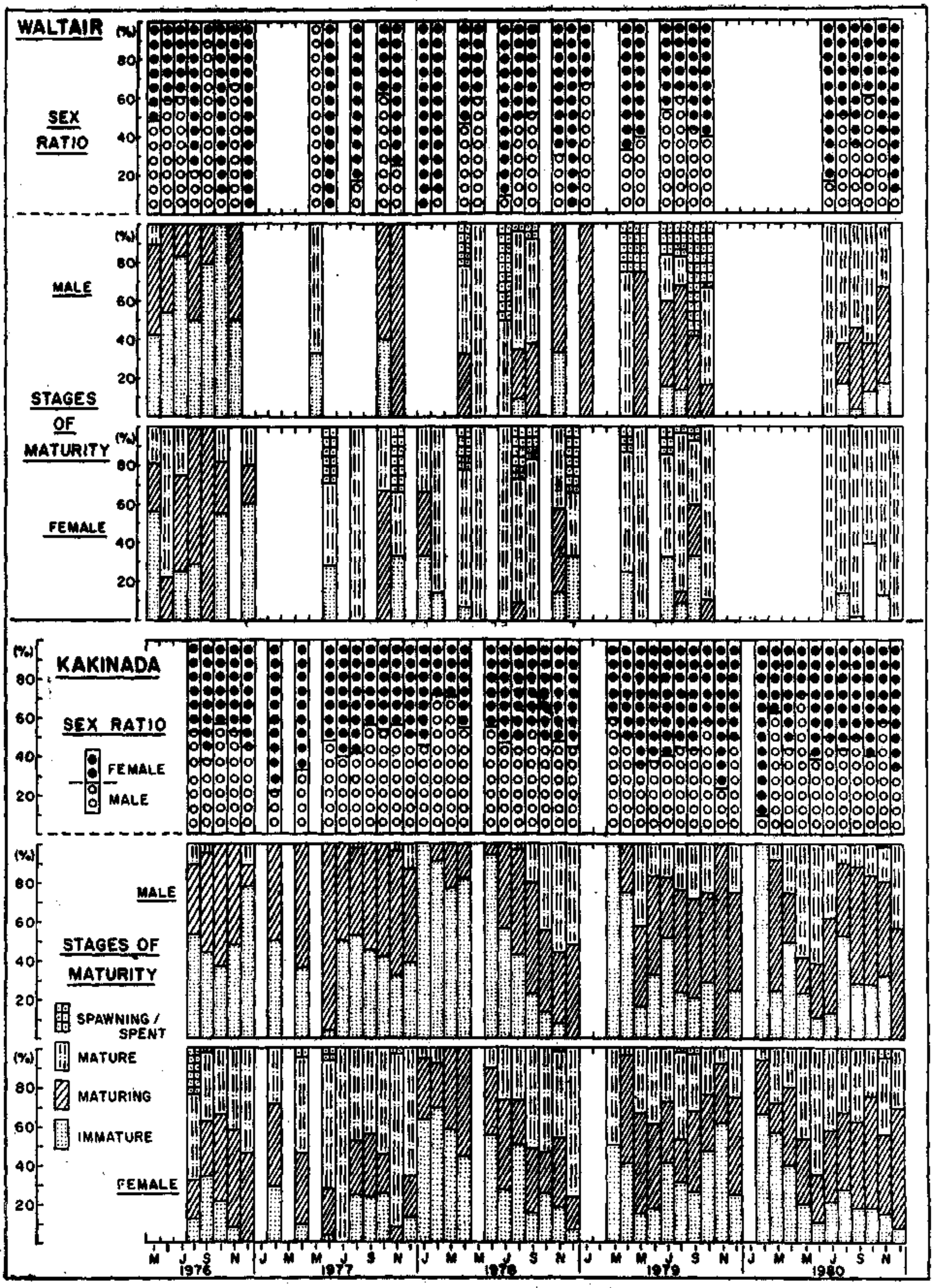

FIG. 14. Sex ratio and stages of maturity of *Sepiella inermis* at Waltair and Kakinada.

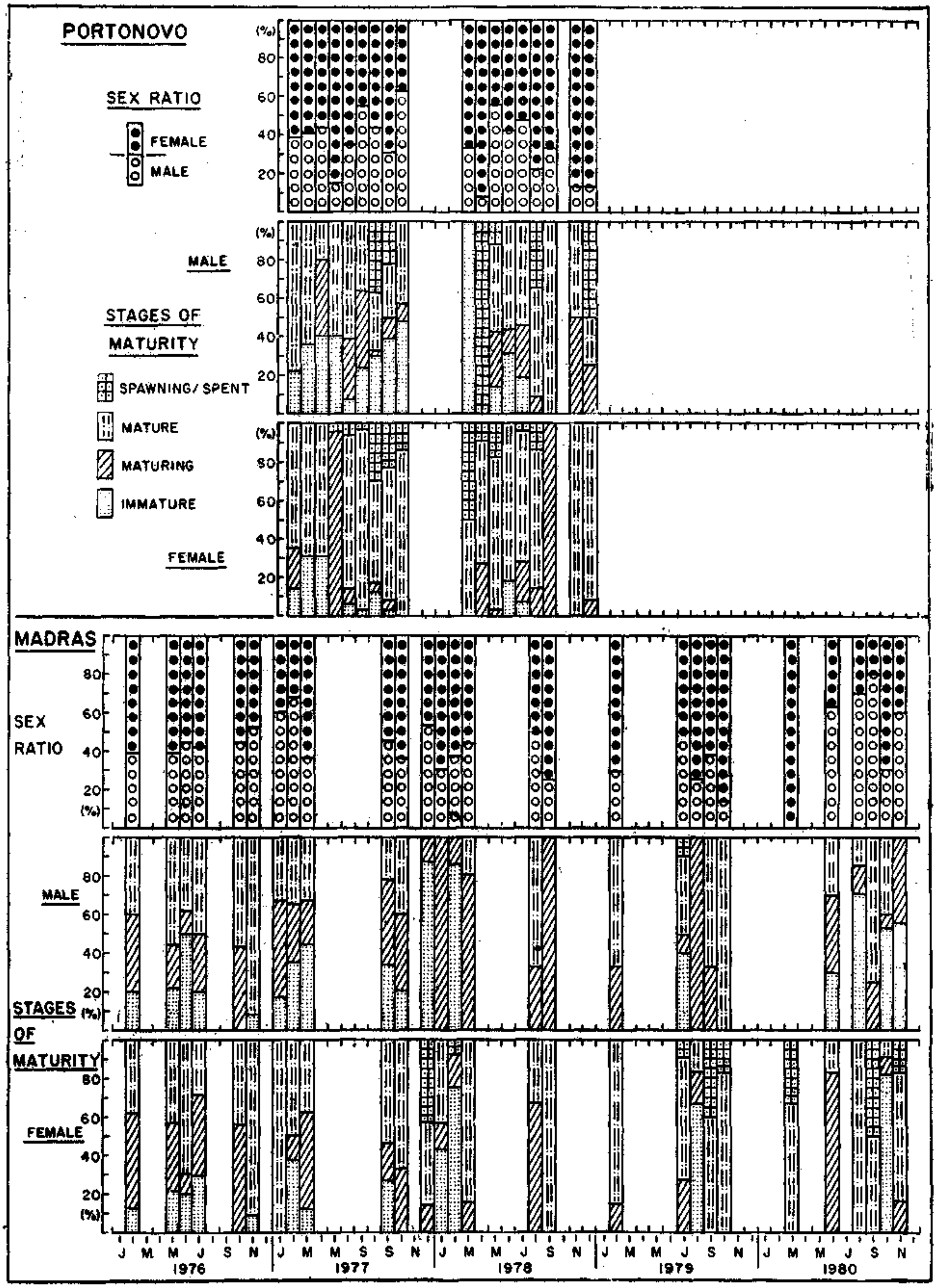

FIG. 15. Sex ratio and stages of maturity of *Sepiella inermis* at Portonovo and Madras.

(Fig. 17). However, the size at 50% maturity for males is similar at the above three centres being 53 mm, 56 mm and 54 mm respectively. All the males attained mature stage at sizes of 65 mm and 75 mm at Madras and Portonovo. Females of this species became sexually mature when they are 45 mm at Waltair and Portonovo and 55 mm at Madras. All the females reached mature stage at a size of 85 mm at Waltair and Portonovo and at 75 mm itself at Madras. The size at first maturity was 50 mm at Portonovo, 52 mm at Waltair and 61 mm at Madras. In Mandapam area the size at first maturity is 51 mm for males and 31 mm for females (Unnithan, 1982).

In distinct contrast to the cuttlefish of the east coast the size at first maturity of males as well as female on the west coast in Cochin area are higher viz., 81 mm and 83 mm respectively. Males and females became mature for the first time when they are 55 mm and 65 mm in size respectively and all the individuals of the two sexes are mature on growing to a size of 105 mm.

Spawning

On Waltair coast mature females were common throughout the year except March while spawners were recorded in April, June-September and November (Fig. 14). Mature males were observed in April, May and July-December and male spawners during April-May and July-October. At Kakinada mature females were very common in trawl catches throughout the year except January-February when they were moderately common (Fig. 14). Spawning females occurred in small percentages in April, June and August-September and November. Mature males were observed in good numbers continuously from March to December while only small numbers of spawning males were noticed in one month, November, 1980. On Madras coast sexually mature females were very common throughout the year except April and spawners were recorded in all months but for January, April-June and August (Fig.15). Mature males were very common all round the year except April and December when

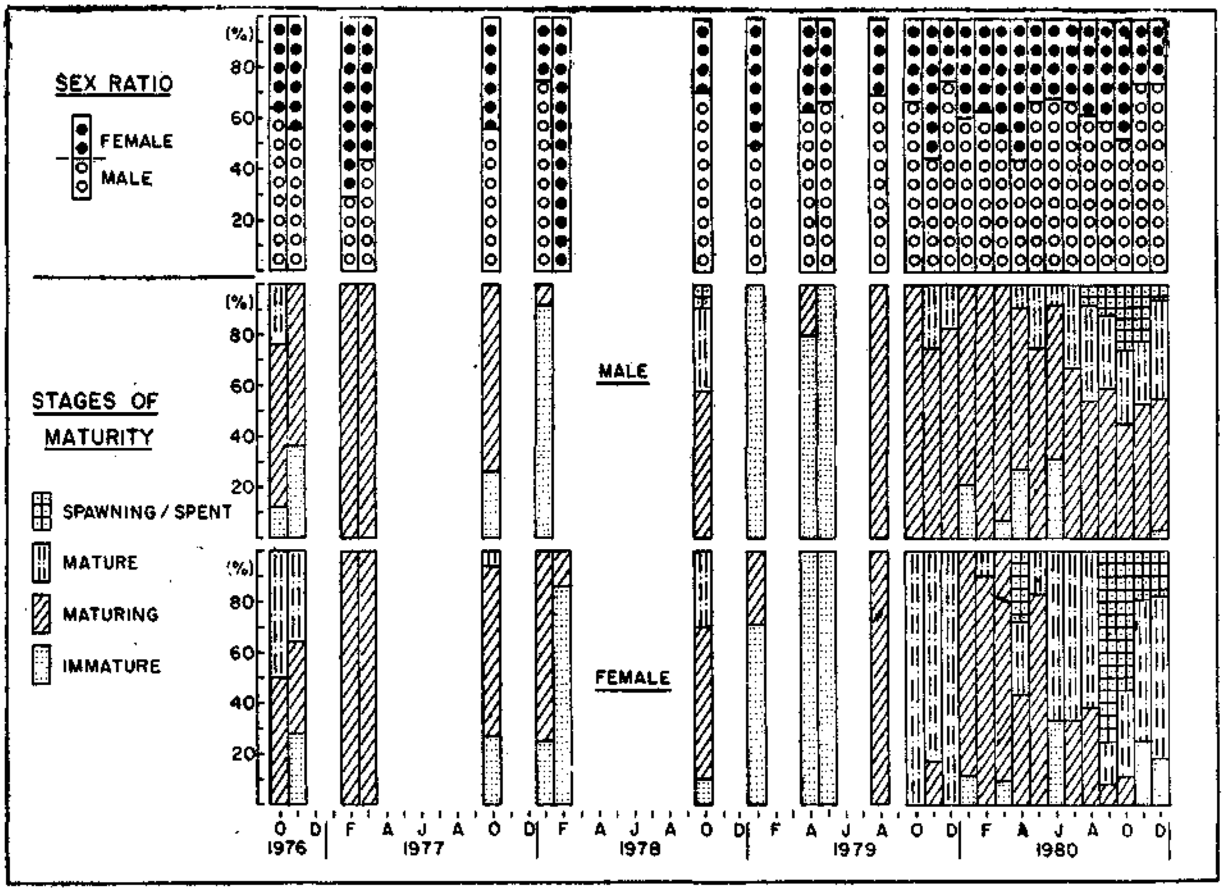

FIG. 16. Sex ratio and stages of maturity of *Sepiella inermis* at Cochin.

they were not observed. Spawning males were noticed only in July, 1979. Along Portonovo coast mature females and males occurred from February to December with dominance in several months (Fig. 15). Spawners of both sexes were recorded on this coast in a number of months.

Along Cochin coast mature cuttlefish of both sexes occurred in commercial trawl catches from April to December with dominance of females in June-July and October-December (Fig. 16). Female spawners were common in April and September-December and

ADULT HISTORY

Growth

Study of the progression of modal sizes of males sand females of this species together on Waltair coast shows that it grows to a size of 33 mm at the end of 6 months, 57 mm at the end of one year and 73 mm at the end of one and half years. The growth trend is almost similar at Kakinada with the 6 months, 12 months and 18 months old cuttlefish exhibiting sizes of 29 mm, 53 mm and 74 mm respectively. Along the Madras coast *S. inermis* showed a slightly faster

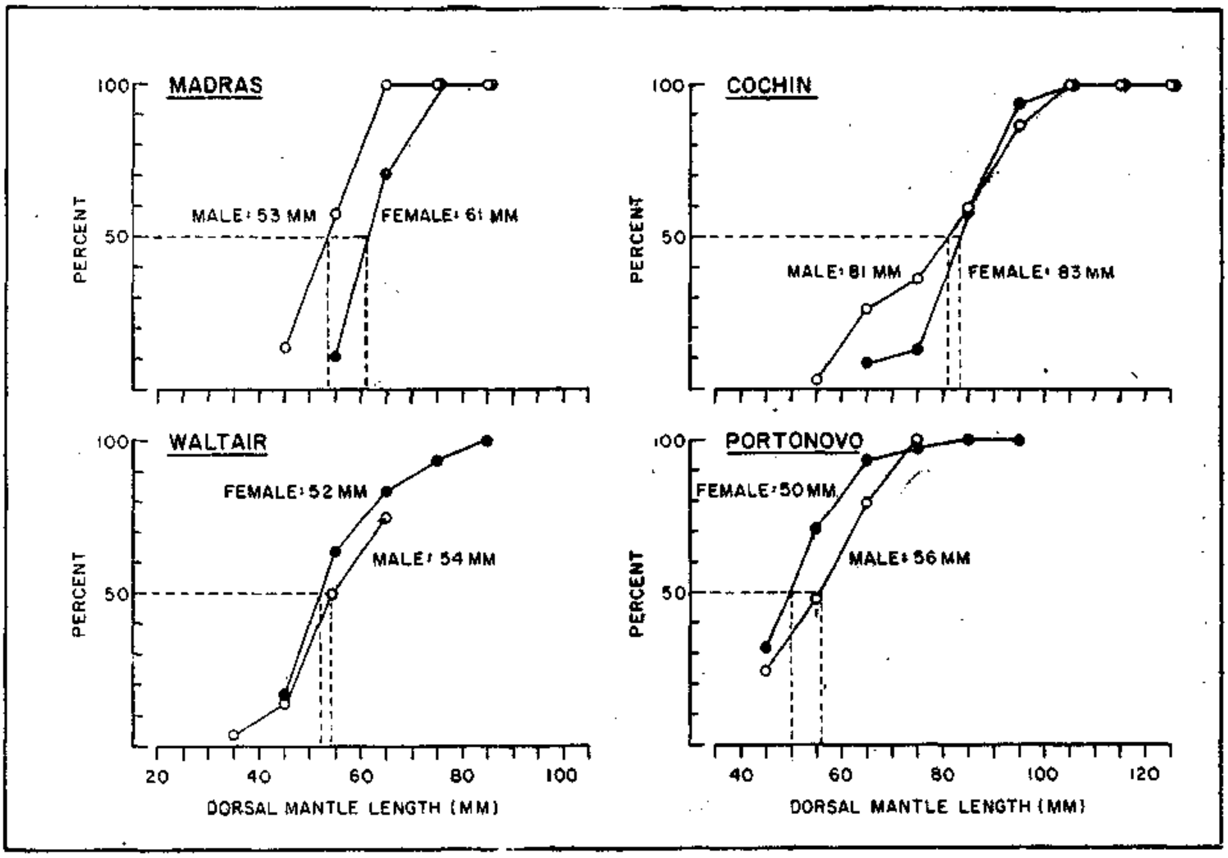

FIG. 17. Size at first maturity of *Sepiella inermis* at Madras, Cochin, Waltair and Portonovo.

male spawners were observed in the latter half of the year from August to December in low to moderate numbers.

The data on the occurrence of cuttlefish in advanced stages of maturity in several months at different centres along east coast indicates that breeding takes place in this species throughout the year. But at Cochin on the west coast the species breeds only from April to December as is evident from the occurrence of mature cuttlefishes.

growth as it attains a size of 35 mm in six months 61 mm in one year and 82 mm in 18 months. The rate of growth of this species in Portonovo waters is similar to that along the Madras coast. In Mandapam area this species has been found to grow to a size of 51 mm at the end of one year and 80 mm at the end of the second year (Unnithan, 1982). The growth pattern of this cuttlefish in Cochin area on the west coast is similar to that on the east coast with sizes of 35 mm, 61 mm and 81 mm reached at the end of six months, one year and one and half years. However, a size of 101 mm is reached in two years along Cochin coast compared to only 80 mm in Mandapam area.

Distribution of adults

Adults of this species are distributed in the shallow coastal waters of both the east and west coasts of India. They are caught in trawl nets and shore seines and occasionally in boat seines. Adults 35-85 mm are obtained in the trawl catches off Waltair, Kakinada and Portonovo coasts while the size range of adults captured off Madras coasts is 45-75 mm. The size range of adults occurring in trawl catches off Cochin is 55-105 mm.

Maximum size

The maximum sizes recorded for males and females on the east coast are 84 mm (Madras) and 94 mm (Portonovo). On the west coast at Cochin the maximum size noticed in the trawl fishery is 124 mm for both the sexes.

Food

Correlation was not observed between the stages of maturity and intensity of feeding. Penaeid prawns were the main food item of the species along Waltair coast followed by other crustaceans such as *Acetes* sp., fish crab and *Squilla* and. In Mandapam area the intensity of feeding of this species was higher from January to April than in other months and prawns formed the common food item followed by fish, stomatopods and crabs (Unnithan, 1982).

Oommen (1977) who studied the digestive system and food and feeding habits of this species reported that it feeds mostly on fishes, crustaceans and unidentifiable matter along the Cochin coast with squids occurring in a few individuals. Along Madras coast *Alpheus*, *Penaeus* spp., *Metapenaeus* spp. and *Acetes* sp. were noted in the stomach contents with *Alpheus* being dominant in April and *Acetes* in July and August (Jothynayagam, 1981).

Fecundity

The total number of eggs found in mature ovaries of cuttlefish 69-71 mm in mantle length of Mandapam area varied between 470 and 850. In the ripe ovaries the ripe eggs formed 37.5-62.6% (Unnithan, 1982).

Eggs

The diameter of intraovarian eggs of this species in Mandapam area ranges from 2.56 mm to 3.84 mm (Unnithan, 1982).

Distribution of juveniles

Juveniles measuring 10-44 mm have been recorded throughout the year along Kakinada, Madras and Portonovo coasts while along Waltair coast juveniles 20-34 mm were noticed only in four months April-June and August. On the west coast juveniles of the size range 30-54 mm occurred in the trawl catches throughout the year except September and December in Cochin area.

6

STOCK ASSESSMENT : SQUIDS AND CUTTLEFISHES AT SELECTED CENTRES

E. G. SILAS, M. M. MEIYAPPAN, R. SARVESAN, K. PRABHAKARAN NAIR, M. SRINATH AND K. SATYANARAYANA RAO

ABSTRACT

Stock assessment studies have been made on the squid *Loligo duvaucelii* of Madras and Cochin areas, the cuttlefish *Sepia aculeata* of Madas area and *Sepia pharaonis* of Vizhinjam area. The exploitation rate, total mortality, instantaneous mortality, average annual stock and standing stock have been estimated and discussed. The study shows that in Vizhinjam area there is scope for increasing production in the existing fishing grounds.

INTRODUCTION

Cephalopods comprising squids and cuttlefishes are one of the important marine fishery resources in India especially since they are processed and exported to various countries. However, so far no detailed studies have been attempted on the stocks of this resource which is distributed in various parts of the Indian coasts. Stock assessment and management of cephalopod resources of Japan Sea and different areas of Atlantic, Pacific and Indian Oceans have been investigated or reviewed by Okutani (1977), Sanders (1981), Lange and Sissenwine (1983), Osako and Murata (1983), Sato and Hatanaka (1983), Chikuni (1983) and Caddy (1983). Studies on the stocks of cephalopods have been carried out at three selected centres viz., Madras, Cochin and Vizhinjam (Trivandrum) in the present work and the results obtained are presented here.

DATA BASE

Squids and cuttlefishes are obtained as by-catch mostly in shrimp trawl nets, shore seines and boat seines. Only along the southwest coast of India between Kanyakumari and Vizhinjam there is an organised fishery for cuttlefishes exploited with hooks and lines. In this work, the cuttlefish *Sepia pharaonis* fishery at Vizhinjam conducted with hooks and lines during 1978-'80 and trawl catches of *Loligo duvaucelii* at Madras and Cochin and the cuttlefish *Sepia aculeata* catches at Madras during 1979-'80 have been studied. The fishery is limited to the 50 m depth line in the traditional trawling grounds as it is the case in most of the marine fisheries of the country.

The data base consists of sexwise weighted length frequency composition on observed days from which the monthly estimates are arrived at. The average length frequency data which has been used in the stock assessment was obtained by considering the average contribution of each length class during the study period.

ESTIMATION OF GROWTH PARAMETERS

It is assumed that growth in dorsal mantle length of the species considered follows von Bertalanffy's (1938) equation, its functional form being

$$L_t = L_\infty (1-e^{-K(t-t_0)}) \qquad (1)$$

where L_t = length at age t

L_∞ = asymptotic length that is attained if the fish is assumed to grow to an infinite age.

K = a growth parameter, which determines how rapidly the fish approaches the limiting length L.

t_0 = intercept on the age of axis corresponding to zero length.

The growth parameters L_∞ and K were estimated by applying the straight line method proposed by Alagaraja (1984) which is similar to ELEFAN proposed by Pauly and David (1981). The estimated parametric values for different species at different centres are given below :

			$L\infty$(mm)	K (annual)
Cochin	*Loligo duvaucelii*	Male	327	0.61
		Female	205	1.19
Madras	*Loligo duvaucelii*	Male	200	0.945
		Female	200	0.945
Madras	*Sepia aculeata*	Male	205	1.1318
		Female	205	1.1318
Vizhinjam	*Sepia pharaonis*	Male	365	0.7128
		Female	342	0.8634

Stock Estimation

Cohort Analysis

In studies on fish stock assessment, a basic assumption is that, within any one age group, the decline in number with age follows an exponential curve. In cohort analysis this curve is replaced with a 'step function' with two assumptions viz., (1) the entire catch of that age group is fished at exactly the middle of the age interval, and that (2) only natural declines take place continuously in an exponential form.

The adjustments that have to be made to the procedures based on age data to make them applicable to the length data (Jones, 1981) are adopted here.

In cohort analysis, by examining the numbers of the species caught at successive intervals during their lives, it is possible to understand what is happening to the stock, if the data considered represents average conditions. Further the length of the species could be used to define boundaries between successive intervals. Each length interval denotes a successive interval in the life of the typical year class, though the duration of the interval will vary.

It is assumed that the input length composition in length cohort analysis, is representative of a steady state situation and that the numbers caught represent annual catches per length group. But this is not likely to be in practice. However, a useful approximation can be obtained by determining the average length composition over a period of as many years as possible.

Formulation (Jones, 1981)

The basic equation

$$N_t = N_{t+\Delta t}\, e^{M \Delta t} + C_t\, e^{M \Delta t/2} \quad \ldots\ldots (2)$$

Where N_t = number in sea at age t

C_t = catch during age interval

t = time required to grow from the beginning to end of a length interval

The time required to grow from the beginning (L_1) to the upper limit of a length interval (L_2) had been calculated with von Bertalanffy's growth equation rearranged as

$$\Delta t = t_2 - t_1 = (1/K) \ln [(L\infty - L_1)/L\infty - L_2)] \quad \ldots (3)$$

This equation is a function of $L\infty$ and K but independent of t. This expression for Δt had been used in conjunction with equation (2) to arrive at the following one for analysing the length composition :

$$N_1 = (N_2 X_L + C_{1,2}) X_L \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where $C_{1,2}$ represent the number caught during a year with lengths between L_1 and L_2, and

$$X_L = [(L\infty = L_1)/(L\infty - L_2)]^{M/2K} \quad \ldots\ldots\ldots (5)$$

N_1 and N_2 represent numbers in the sea with length L_1 and L_2 respectively.

This equation is a function of $L\infty$, M and K ; more particularly since the M and K appear as the ratio M/K, the equation is a function of the two variables $L\infty$ and M/K.

The procedure involves first the estimation of a value for the number of the particular species reaching the length corresponding to the beginning of the largest length group. Successive application of the equation (4) leads to the estimates of numbers reaching a particular length for successively smaller animals.

If the oldest age group comprises all individuals older than a certain age, an input value of F/Z is required. The effect on the estimates among the younger ages, of adopting different values for F/Z will depend on whether the stock is heavily exploited or not. When the stock is heavily exploited, the choice of terminal F/Z value is not likely to effect the calculations critically.

Estimates of exploitation rate designated by the ratio F/Z has been determined directly for each length interval using the relationship

F/Z = number caught/number dying.

Calculation of instantaneous fishing mortality rate integrated over a particular time interval is attained from the relationship

$$F \Delta t = (F/Z)(Z \Delta t) \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

TABLE 1. *Cohort analysis of the numbers landed in different length groups of males of* Loligo duvaucelii *at Madras during* 1979-'80.

L ∞ = 200 (mm) K = 0.9450 (annual) M/K = 1.5

Length* Class (mm)	Numbers landed	Numbers in the sea	Zdt	F/Z	Fdt	Z	Average numbers in the sea
40 —	2130	716547	0.0999	0.0313	0.0031	1.4632	46571
50 —	18400	648402	0.1338	0.2265	0.0303	1.8327	44317
60 —	30711	567183	0.1701	0.3461	0.0589	2.1679	40925
70 —	63100	478461	0.2709	0.5557	0.1506	3.1903	35594
80 —	78408	364906	0.3911	0.6639	0.2596	4.2174	28004
90 —	77578	246802	0.5549	0.7381	0.4096	5.4125	19419
100 —	54542	141698	0.6969	0.7670	0.5345	6.0833	11690
110 —	29651	70586	0.7908	0.7687	0.6078	6.1271	6296
120 —	7142	32011	0.4835	0.5820	0.2814	3.3910	3619
130 —	4990	19739	0.5650	0.5857	0.3309	3.4212	2490
140 —	8665	11219	2.4320	0.8458	2.0569	9.1909	1113
150 —	690	986		0.7000			

0 Lower limit

TABLE 2. *Cohort analysis of the numbers landed in different length groups of females of* Loligo duvaucelii *at Madras during* 1979-80.

L ∞ = 200 (mm) K = 0.9450 (annual) M/K = 1.5

Length* Class(mm)	Numbers landed	Numbers in the sea	Zdt	F/Z	Fdt	Z	Average numbers in the sea
40 —	3074	642560	0.1018	0.0494	0.0050	1.4912	41724
50 —	12892	580343	0.1272	0.1860	0.0237	1.7415	39793
60 —	24111	511045	0.1623	0.3149	0.0511	2.0690	37010
70 —	24285	434472	0.1813	0.3372	0.0611	2.1386	33679
80 —	47211	362448	0.2802	0.5330	0.1494	3.0353	29182
90 —	76521	273871	0.4998	0.7130	0.3550	4.8935	22014
100 —	43864	166145	0.4945	0.6767	0.3346	4.3847	14783
110 —	44259	101326	0.8251	0.7775	0.6415	6.3701	8936
120 —	27193	44399	1.3303	0.8326	1.1076	8.4674	3857
130 —	7564	11739	1.5162	0.8256	1.2518	8.1293	1127
140 —	1804	2577	—	0.7000	—	—	—

* Lower limit.

TABLE 3. *Cohort analysis of the numbers landed in different length groups of males of* Sepia aculeate *at Madras during* 1979-'80.

L∞ = 205 (mm) K = 1.1318 (annual) M/K = 1.5

Length * Class (mm)	Numbers landed	Numbers in the sea	Zdt	F/Z	Fdt	Z	Average number in the sea
30 —	1039	341596	0.0914	0.0348	0.0032	1.7589	16971
40 —	2194	311745	0.1012	0.0731	0.0074	1.8317	16379
50 —	7408	281744	0.1281	0.2187	0.0280	2.1730	15586
60 —	9852	247877	0.1500	0.2853	0.0428	2.3754	14538
70 —	18036	213344	0.2093	0.4477	0.0937	3.0739	13105
80 —	20888	173059	0.2626	0.5226	0.1372	3.5563	11239
90 —	18973	133091	0.3021	0.5468	0.1652	3.7460	9263
100 —	17540	98393	0.3635	0.5849	0.2126	4.0899	7332
110 —	17028	68405	0.4823	0.6505	0.3138	4.8576	5389
120 —	14293	42229	0.6526	0.7061	0.4608	5.7774	3503
130 —	8120	21988	0.7442	0.7036	0.5236	5.7270	2015
140 —	4209	10447	0.8606	0.6981	0.6008	5.6241	1072
150 —	1563	4418	0.8308	0.6270	0.5209	4.5511	548
160 —	875	1925	1.1729	0.6583	0.7721	4.9679	268
170 —	417	596	—	0.7000	—	—	—

* Lower limit.

TABLE 4. *Cohort analysis of the numbers landed in different length groups of females of* Sepia aculeata *at Madras during 1979-'80.*

L∞ = 205(mm) K = 1.1318 (annual) M/K = 1.5

Length * Class (mm)	Numbers landed	Numbers in the sea	Zdt	F/Z	Fdt	Z	Average numbers in the sea
30 —	650	367136	0.0901	0.0205	0.0019	1.7333	18252
40 —	1020	335499	0.0970	0.0329	0.0032	1.7554	17663
50 —	4943	304493	0.1173	0.1467	0.0172	1.9896	16932
60 —	10909	270805	0.1506	0.2881	0.0434	2.3847	15878
70 —	11843	232939	0.1708	0.3238	0.0553	2.5106	14568
80 —	26020	196364	0.2771	0.5475	0.1517	3.7515	12669
90 —	22848	148835	0.3160	0.5666	0·1790	3.9170	10295
100 —	19779	108509	0.3689	0.5909	0.2180	4.1495	8067
110 —	13818	75034	0.3902	0.5700	0.2224	3.9481	6141
120 —	12853	50792	0.5134	0.6302	0.3235	4.5907	4443
130 —	9543	30397	0.6447	0.6607	0.4260	5.0035	2887
140 —	3842	15953	0.5694	0.5548	0.3159	3.8130	1816
150 —	4189	9027	1.0762	0.7040	0.7577	5.7359	1037
160 —	2154	3077	—	0.7000	—	—	—

*Lower limit

TABLE 5. *Cohort analysis of the numbers landed in different length groups of males of* Loligo duvaucelii *at Cochin during* 1979-'80

$L\infty$ = 327 (mm) K = 0.61 (annual) M/K = 1.5

Length* Class (mm)	Numbers landed	Numbers in the sea	Zdt	F/Z	Fdt	Z	Average numbers in the sea
40 —	3050	1156498	0.1111	0.0251	0.0028	0.9385	129613
60 —	90818	1034851	0.2144	0.4547	0.0975	1.6779	119037
80 —	213836	835115	0.4452	0.7126	0.3173	3.1841	94237
100 —	296725	535052	1.0405	0.8575	0.8922	6.4223	53878
120 —	80506	189028	0.7679	0.7946	0.6101	4.4539	22749
140 —	35266	87707	0.7954	0.7652	0.5704	3.8376	11824
160 —	7730	41622	0.4220	0.5416	0.2274	1.9960	7151
180 —	17381	27349	1.4545	0.8292	1.2060	5.3557	3914
200 —	4435	6386	1.8163	0.8293	1.5063	5.3615	997
220 —	727	1039	—	0.7000	—	—	—

* Lower limit.

TABLE 6. *Cohort analysis of the numbers landed in different length groups of females of* Loligo duvaucelii *at Cochin during* 1979-'80

$L\infty$ = 205 (mm) K = 1.19 (annual) M/K = 1.5

Length* Class (mm)	Numbers landed	Numbers in the sea	Zdt	F/Z	Fdt	Z	Average numbers in the sea
50 —	1987	1655192	0.1013	0.0125	0.0013	1.8075	88219
60 —	7949	1495734	0.1128	0.0498	0.0056	1.8786	84939
70 —	37764	1336168	0.1458	0.2083	0.0304	2.2545	80426
80 —	83850	1154843	0.2055	0.3908	0.0803	2.9303	73215
90 —	75464	940305	0.2263	0.3963	0.0897	2.9567	64406
100 —	134419	749876	0.3648	0.5864	0.2139	4.3157	53116
110 —	146576	520645	0.5322	0.6822	0.3630	5.6172	38248
120 —	113274	305796	0.7101	0.7286	0.5174	6.5769	23639
130 —	59697	150327	0.7982	0.7222	0.5765	6.4252	12865
140 —	46054	67665	1.7266	0.8279	1.4294	10.3706	5364
150 —	2561	12037	0.5851	0.4803	0.2811	3.4348	1552
160 —	2650	6705	1.0256	0.6162	0.6320	4.6510	925
170 —	1683	2404	—	0.7000	—	—	—

* Lower limit.

TABLE 7. *Cohort analysis of the numbers landed in different length groups of males of* Sepia pharaonis *at Vizhinjam during* 1978-'80

L ∞ = 365 (mm) K = 0.7128 (annual) M/K = 1.5

Length* Class (mm)	Numbers landed	Numbers in the sea	Zdt	F/Z	Fdt	Z	Average numbers in the sea
100 —	305	175161	0.1196	0.0155	0.0018	1.0860	18175
120 —	405	155423	0.1305	0.0213	0.0028	1.0925	17408
140 —	911	136405	0.1468	0.0489	0.0072	1.1242	16569
160 —	5786	117779	0.2085	0.2610	0.0544	1.4469	15320
180 —	8245	95613	0.2703	0.3641	0.0984	1.6814	13468
200 —	12680	72968	0.4063	0.5204	0.2115	2.2294	10929
220 —	11254	48603	0.5221	0.5693	0.2972	2.4823	7969
240 —	5486	28834	0.5060	0.4792	0.2424	2.0529	5577
260 —	3953	17385	0.6268	0.4883	0.3060	2.0893	3875
280 —	5369	9289	1.6294	0.7190	1.1715	3.8045	1963
300 —	1288	1821	3.2385	0.7362	2.3840	4.0525	432
320 —	50	—	—	0.7000	—	—	—

* Lower limit.

TABLE 8. *Cohort analysis of the numbers landed in different length groups of females of* Sepia pharaonis *at Vizhinjam during* 1978-'80

L ∞ = 342 (mm) K = 0.8634 (annual) M/K = 1.5

Length0 class (mm)	Numbers landed	Numbers in the sea	Zdt.	F/Z	Fdt.	Z	Average numbers in the sea
100 —	11	263659	0.1294	0.0003	0.0004	1.2955	24708
120 —	107	231648	0.1421	0.0035	0.0006	1.2996	23612
140 —	2328	200961	0.1690	0.0745	0.0126	1.3944	22330
160 —	6938	169714	0.2203	0.2068	0.0455	1.6328	20548
180 —	17379	136164	0.3495	0.4327	0.1512	2.2829	17593
200 —	22252	96000	0.5285	0.5647	0.2984	2.9750	13246
220 —	14228	56593	0.6076	0.5521	0.3355	2.8917	8912
240 —	10511	30823	0.8410	0.5996	0.5043	3.2347	5419
260 —	3982	13294	0.8805	0.5117	0.4505	2.6520	2934
280 —	3572	5511	2.6089	0,6996	1.8252	4.3114	1184
300 —	284	406	—	0.7000	—	—	—

* Lower limit.

Actual time intervals Δt for each length interval have to be taken into account in estimating the annual mortality rates Z and F. This requires additional input information. Besides knowing M/K, it is also necessary to know either one of them. Assuming that the value of M is known, then the total instantaneous mortality rate is

$$Z = M / (1-F/Z) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The basic input data in the present study are (1) M/K taken as 1.5 on the assumption that 99% of the individuals die when they attain 95% of $L\infty$ and (2) terminal F/Z taken as 0.7 besides the $L\infty$ and K and average annual length composition of the study period.

Results and Discussion

The sexwise exploitation rate, total numbers and average numbers in the sea, total mortality and instantaneous mortality rate for *Loligo duvaucelii* and *Sepia aculeata* along Madras coast, *Loligo duvaucelii* along Cochin coast and *Sepia pharaonis* at Vizhinjam are given in Table 1-8, and the stock estimates (in tonnes) in the three areas in Table 9.

Table 9. *Stock Estimates at Selected Centres (in tonnes)*

		Average landings	Average annual stock	Standing stock
		Loligo duvaucelii (Cochin)		
Male	..	32	70	11
Female	..	35	180	14
Total	..	67	250	25
		Loligo duvaucelii (Madras)		
Male	..	15	51	5
Female	..	18	53	5
Total	..	33	104	10
		Sepia aculeata (Madras)		
Male	..	15	75	6
Female	..	17	93	8
Total	..	32	168	14
		Sepia pharaonis (Vizhinjam)		
Male	..	45	295	51
Female	..	61	341	53
Total	..	106	636	104

The results show that the average annual stock of *L. duvaucelii* of Cochin area is 250 t which is nearly 2½ times that of Madras area. Correspondingly the standing stock in Cochin area (25 t) is also higher than in Madras area (10 t). In both areas the average annual stock as well as the average landings of females are greater than males. The standing stock of the two sexes are of equal abundance in Madras area while in Cochin area the standing stock of males is lesser than that of females.

In the case of *Sepia aculeata* of Madras coast the average annual stock amounts to 168 t of which females account for 55%. The standing stock of this species (14 t) is slightly more than that of *Loligo duvaucelii* of Madras coast (10 t) and females are dominant in the stock.

The average annual stock of *Sepia pharaonis* in Vizhinjam area where it supports a good fishery, is high, 636 t and females form 54% of the population. The standing stock of the species is 104 t comprising of males and females more or less in the same proportion.

The exploitation of the three species studied is greater in the case of females than males in all the three centres.

The effect of change in fishing mortality from the present rate on the yield was analysed for all the three species (Fig. 1). It could be observed that in the case of *Sepia pharaonis* of both sexes the yield will increase with increase in further fishing mortality. In the case of females of *Sepia aculeata* of Madras area and females of *Loligo duvacuelii* of Cochin area by increasing the effort by another 20% only a marginal increase in the yield can be realised.

Since squids and cuttlefishes form only a small percentage of the total trawl catches any further increase or decrease in fishing effort has to be considered keeping in view the multispecies nature of the gear which is directed mainly at shrimps.

Based on the stocks estimated at Madras, Cochin and Vizhinjam, assuming that the density of stocks and rate of exploitation of the three species studied are uniform all along the coasts, the all India average annual stock and standing stocks of the three species which accounted for major portion of the country's landings, have been worked out from the average all India landings of cephalopods for the period 1978-'80 and the estimates are as follows :

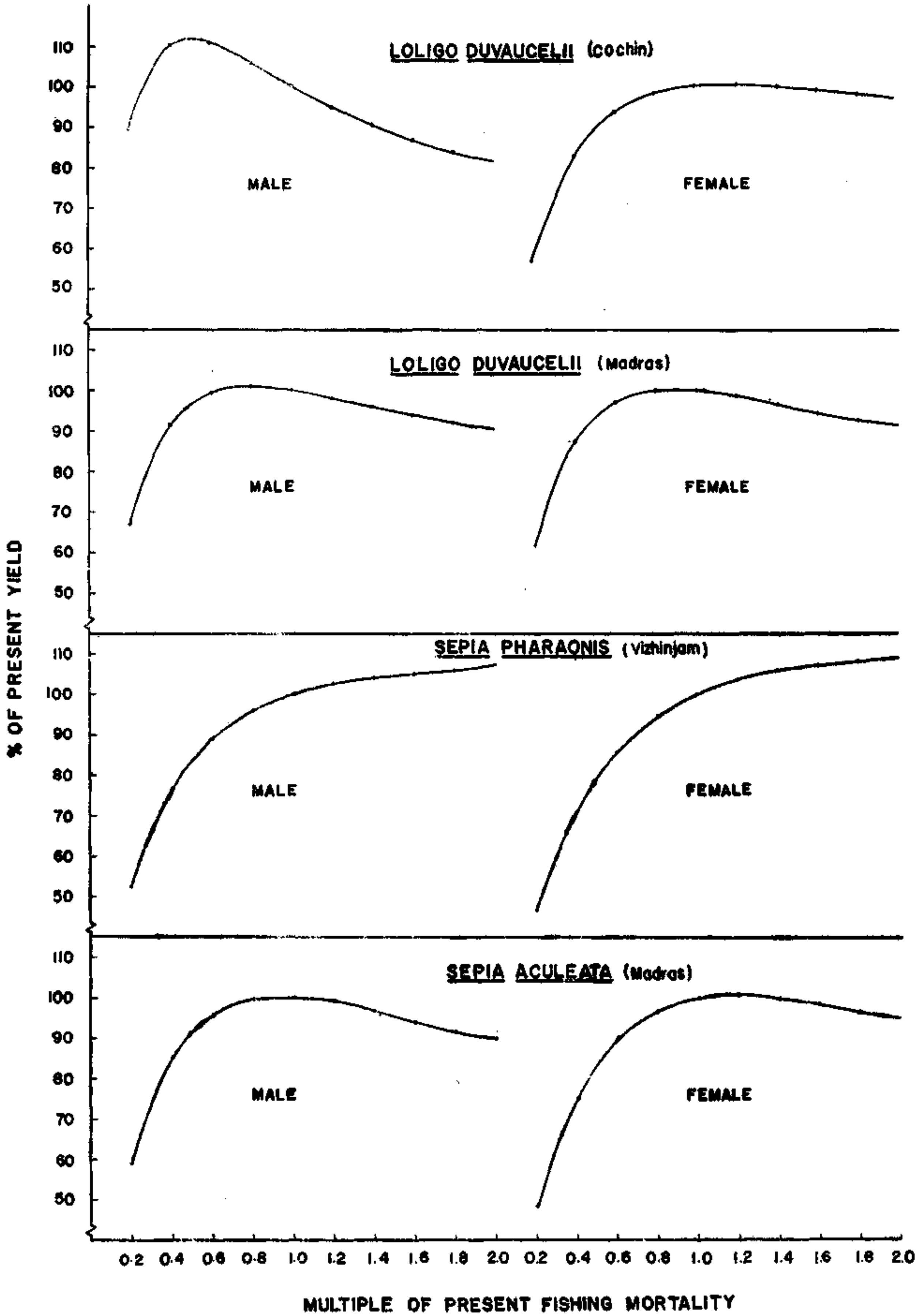

FIG. 1. The effect of change in fishing mortality on yield of males and females of *Sepia aculeata* (Madras), *Sepia pharaonis* (Vizhinjam) and *Loligo duvaucelii* (Madras and Cochin).

	Average landings	Average annual stock	Standing stock
Loligo duvaucelii	5142 t	18203 t	1800 t
Sepia aculeata	4483 t	23536 t	1961 t
Sepia pharaonis	2397 t	15245 t	2352 t
Total	12022 t	56984 t	5513 t

The reasons for the lesser estimated annual stocks of males than females in the case of all the three species studied are not clear. It may be due to factors like differential bathymetric distribution of the sexes or migration of males. This aspect has to be studied.

There are good possibilities for increasing production of the cuttlefish *Sepia pharaonis* in Vizhinjam area by stepping up the effort. At presen(indigenous hooks are only used in fishing cuttlefish in the area. Employing modern methods of fishing as with special types of jigs may improve yield from the fishery.

The stock estimates for the three centres studied represent the figures for the existing fishing grounds within the 50 m depth zone which are being traditionally exploited at present. For increasing the production substantially, fishing range has to be extended to neighbouring grounds within the 50 m depth zone and also beyond the 50 m contour in the continental shelf and upper continental slope.

This is the first study on stock assessment of squids and cuttlefishes in selected grounds in the Indian seas. The study brings out the urgent need for assesing the standing stock of squids and cuttlefishes specieswise in all other major fishing grounds and taking up exploratory surveys for neritic and oceanic squids.

7

CEPHALOPOD PRODUCTION IN INDIA AND CONSTITUENT MARITIME STATES

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ABSTRACT

The fishing craft and gear in which cephalopods are obtained in India and the all India, statewise and east and west coast cephalopod production are presented. The bulk of the cephalopod catches is obtained along the west coast and trawl net accounts for major portion of landings. Maharashtra, Kerala, Tamil Nadu and Gujarat are the leading states in production.

FISHING CRAFT AND GEAR

The cephalopods have been obtained until the last two decades mainly in conventional gear such as shore seines, boat seines, fixed bag nets and hooks and lines operated from indigenous craft. With the advent of trawlers the trawl net has become an important gear in which cephalopods are caught in good quantities from a number of areas.

FISHING CRAFT

Catamaran

This is a simple age-old craft consisting of three to five logs of wood tied together in the form of a raft and operated by two to four fishermen. The crafts are used along the east coast from Orissa to Kanyakumari and extending upto South Kerala on the west coast for operating boat seines and hooks and lines.

Canoes

Different kinds of canoes such as dug-out canoes, plank-built canoes, flat-bottomed canoes and out-rigger canoes are used. Of these the dug-out canoes made by scooping out a log of wood are most common in Kerala and Karnataka. The canoes measure 6.10-12.50 m in length and are used for operating boat seines and shore seines. In recent years a large number of canoes operating in Kerala are being fitted with out-board and inboard engines.

Plank-built boats

These are sturdy craft 6.5-13 m in length made of strong wooden planks. The shape of the plank-built boat varies in different areas in relation to the nature of the sea coast and conditions in the sea such as wave action and wind force. The boats are used in the northeastern and northwestern coasts for operating shore seines and boat seines.

Mechanised craft

There are over 18,000 mechanised boats in the country out of which about 10,000 are trawlers which do trawling mainly for shrimps. There is a continuous increase over the years in the fleet of trawlers in most of the maritime states due to the high returns from shrimp fishing and the financial assistance given by the Government. The trawlers are 6-13 m in length and fitted with 10-60 b.h.p. engines. In addition there are about 80 steel trawlers (23 m and above in length) with 90-300 or higher b.h.p. engines and refrigeration facilities which operate in offshore areas.

FISHING GEAR

Varied types of gear are employed in the commercial marine fisheries for the capture of pelagic and demersal species. Only in a few among those *viz.* the trawl nets, and the traditional gears shore seines, boat seines, fixed bag nets (*dol* nets) and hooks and lines squids and cuttlefishes are caught.

Shore seine

This is a beach seine with a conical bag net which is operated along both the east and west coasts of India. There are wide variations in the size and design of the net as in the case of *Sarini jal* of West Bengal, *Pedda vala* and *Alivi vala* of Andhra Pradesh, *Kara valai* and *Perla valai* of Tamil Nadu, *Kara vala*, *Kara madi* and *Kamba vala* of Kerala and *Rampan* and *Yendi* of west coast. The net is payed out from plank-built boats or canoes and dragged towards the shore by 20-30 or more men. Squids and cuttlefish in the littoral waters are caught in the gear. In the Ramanathapuram area on the southeast coast of India, a special kind of shore seine, the *Ola valai*, with split palmyarah leaves tied to the wings as flares to drive the squids into the net is used to capture the squid *Sepioteuthis lessoniana.*

Boat seine

This is a conical shaped bag net operated using two canoes or catamarans for pelagic fishes. Fairly good quantities of squids are obtained in this gear of different sizes known as *Iraga vala* of Andhra Pradesh, *Turi vala* of Tamil Nadu, and *Thattu madi*, *Kolli vala* and *Paithu vala* of Kerala.

Fixed bag net (*Dol* net)

This is a funnel shaped bag net either tied to stakes or kept in position by means of floats and sinker stones. The net is in horizontal position facing the tide and is operated for prawns and Bombay duck in the littoral waters where there are currents of appreciable intensity off Maharashtra and Gujarat.

Hooks and line

There are different types of hooks and lines viz, long line, trolling line, hand line and hand jigs in which the number and size of hooks, length of line and mode of operation differ. Although hooks and lines are operated in several areas along the east and west coasts of India for fin-fishes, cephalopods are obtained in large quantities in the gear only in southern Tamil Nadu and southern Kerala. In the latter areas apart from the usual type of hooks and lines, specialized types of hand jigs are used for catching cuttlefishes and also squids. One kind of hand jig consists of umbrella rib or iron rod provided at the end with two or more circles of hooks tied in a grapnel manner. In Colachel-Vizhinjam area hand jigs with bait are operated by means of a long line which is tied to the jig and manipulated from a catamaran.

Trawl net

The trawl net which is operated for shrimps on a large scale in a number of areas off both the coasts of India is at present the gear in which large quantities of cephalopods are caught. Two or four seam trawl net with headline length of 7 to 27 m between upper wing ends and provided with otter boards of appropriate size and weight is the common trawl net used in India. In recent years trawling with bulged belly trawl, high opening trawl and outrigger trawl is also being carried out in certain areas.

Cephalopod production

Although squids and cuttlefish have been obtained as by-catch in indigenous gear such as shore seine, boat seine and hooks and line since very early times forming localised fisheries in some places, realising their importance as a potential resource, the Central Marine Fisheries Research Institute has started collecting statistics on cephalopod production in the country from 1959. During the period 1959-64 the estimated annual cephalopod production was low and varried from 93 t (1961) to 464 t (1964) (Fig. 1). As there was significant increase in the operation of indigenous gear as well as mechanised vessels doing trawling in later years, the annual production showed a rise to 951 t in 1966 and 1,636 t in 1968. With the demand for cephalopods for export the production more than doubled in 1974 and amounted to 3,677 t compared to that in 1968. The year 1975 was yet another landmark in cephalopod fishery when once again the production more than doubled (7,889 t) compared to the landings in the previous year. Then onwards the production continued to rise progressively in the succeeding years, reaching a maximum of 15,931 t in 1978. However, in the recent years, there has been a fall in landings to 15,032 t in 1979, 11,335 t in 1980 and 9,548 t in 1981. The fall in the All India production was due to a marked decrease in landings by 35-64% in Kerala and by 13-74% in Maharashtra in these years.

CEPHALOPOD LANDINGS IN MARITIME STATES

Data on cephalopod landings in the maritime states of India are available for a number of years. Fig. 1 shows the annual landings (including the offshore cephalopod catch in some of the states) in West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Pondicherry, Kerala, Karnataka, Goa, Maharashtra, Gujarat and Lakshadweep for the period 1960-79, the statewise percentage contribution to the all India cephalopod production based on the annual average catch for 1960-78, the seasonal trend of the landings in each state derived from the average catch for the period 1968-78, and the gears in which the cephalopods were obtained in these states.

Among the major cephalopod producing states, Kerala has been ranking first, contributing 38.5% to the country's production during 1960-78, but it was relegated to the second place with 26.7% by Gujarat during 1979-81 accounting for 32.2%. Gujarat has improved considerably to this position from the fourth place with 11.9% of the production during 1960-78. While Maharashtra's share remained almost the same during the respective periods (19.2% and 19.1%), that of Tamil Nadu improved slightly from 14.1% during 1968-78 to 17.9% during 1979-81. Gujarat, Kerala, Maharashtra and Tamil Nadu together accounted for 92.2% of the total cephalopod production in the country during the period 1978-81. The fluctuations in the annual cephalopod landings in each of the maritime states are dealt with below.

West Bengal

Up to 1967 the combined figures of annual cephalopod landings of West Bengal and Orissa are available and they varied from 1 t to 12 t. In later years cephalopods were not landed except in three years 1971, 1978 and 1980 when the annual production amounted to 82 t, 30 t and 4 t resp ctively (Table 1, Fig. 1). Cephalopods formed 0.1-0.9% in the total marine fish production of West Bengal and the state contributed less than 1% to 5.4% to the country's cephalopod production.

Orissa

Unlike in West Bengal, cephalopods were caught in small quantities in Orissa during the years 1968-79 and the annual landings varied between 2 t (1969 and 1975) and 27 t (1976). In 1980 the production was much higher, 98 t, and there was a decline in the landings to 57 t in 1981. In the annual total fish production of Orissa, cephalopods formed less than 1% and the state's contribution to the annual cephalopod landings of India was less than 1% to 1.2%.

Andhra Pradesh

The cephalopod production of Andhra Pradesh fluctuated between 1 t (1960) and 10 t (1968) during the period 1960-69. The highest production of 663 t was obtained in 1970. In the later years, 1971-76, there was decline in catches. During the years 1977-81 the annual landings varied between 297 t and 523 t with the highest landings of 523 t and 512 t in 1979 and 1981. The cephalopods constituted only less than 1% in the State's annual fish production. The state accounted for 0.2% (1960) to 56.0% (1970) in all India cephalopod production during 1960-70 and 1.9% (1975) to 7.6% (1971) during 1971-81.

Tamil Nadu

Tamil Nadu is the leading state in cephalopod production on the eastcoast of India accounting for 6.5-37.4% of the country's production during 1975-81. The landings were low during 1960-67 ranging between 2 t and 195 t. In the period 1968-74 there was a rise in the catches reaching a maximum of 955 t in 1974. The highest annual landings of 2,953 t were obtained in 1975 and in the later years, 1976-81, the production varied between 1,042 t (1978) and 1,903 t (1979). Cephalopods constituted 0.1-1.3% of total marine fish production in Tamil Nadu during 1960-81 and the state contributed 2.1-38.1% to all India cephalopod production during the same period.

Pondicherry

The annual cephalopod landings of the state varied between 9 t and 58 t during 1968-75 and in the subsequent period, the highest catch of 211 t was obtained in 1976. Thereafter the catch dropped to 36 t in 1978. The landings formed up to 2.1% of total marine fish production of Pondicherry and the state accounted for 0.2-3.3% of the country's cephalopod production.

Kerala

The landings in the state during 1975-81 constituted 11.0-49.7% of the all India production. The annual cephalopod landings varied between 17 t and 714 t during 1960-67 and increased to 1,122 t in 1968 followed by a decrease in 1970-73. During 1974 and 1975 the production was again higher, 2,175 t and 3,342 t respectively. The period 1977-81 was characterised by large fluctuations in annual landings between 2,376 t (1981) and 6,516 t (1978). Cephalopods constituted up to 1.8% of the annual marine fish production of Kerala

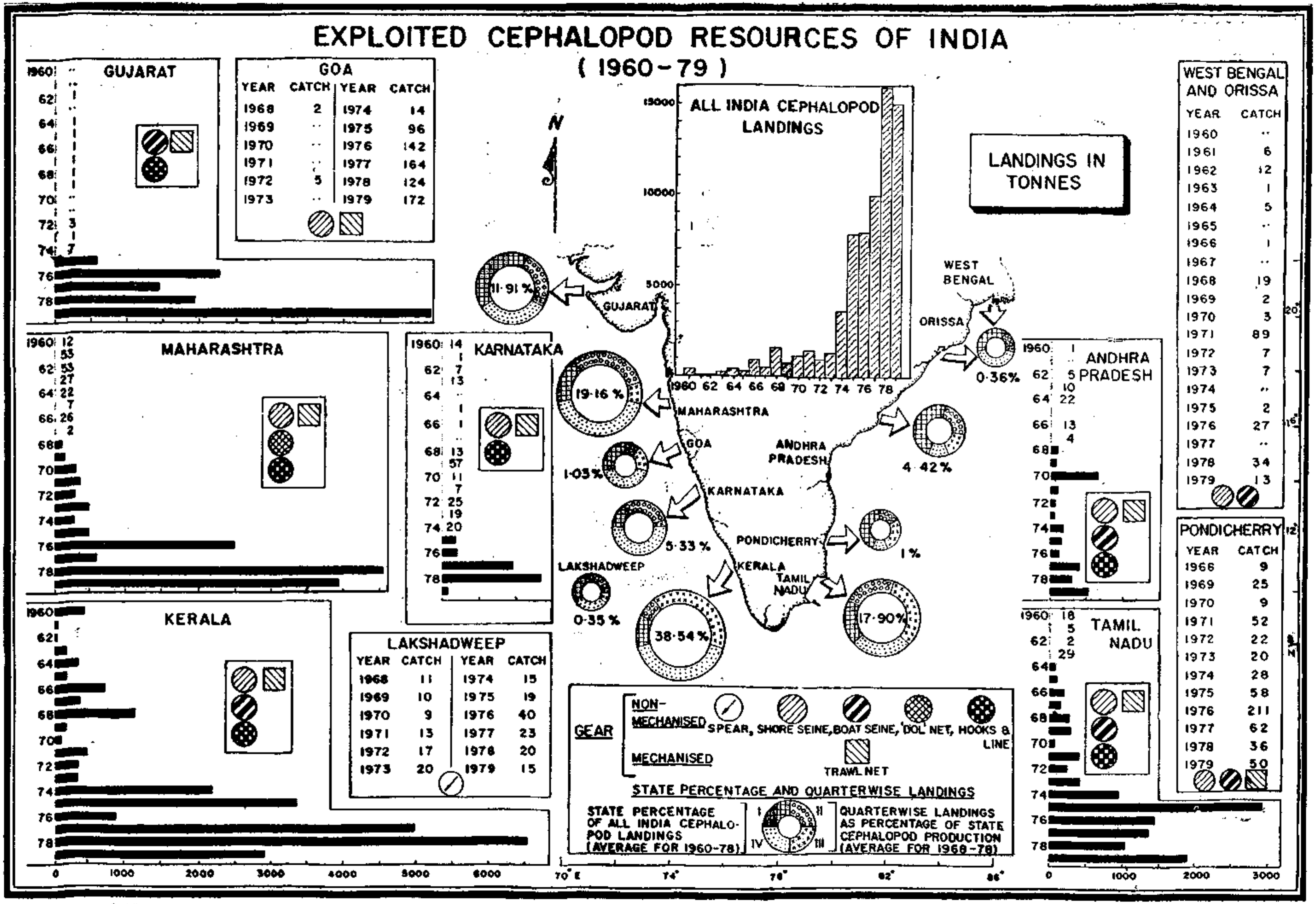

FIG. 1. Annual all India cephalopod landings during 1960-'79. Statewise landings, state percentage of all India landings (average for 1960-'78) and quarterwise landings, as percentage of state production (average for 1968-'78) and gears used in the exploitation of cephalopods.

and the State's contribution to annual cephalopod production of the country varied from 7.3% (1970) to 90.3% (1960).

KARNATAKA

Up to 1974 the annual production in the state was very low, within the range 1 t to 57 t and there were no landings in some years. The landings increased to 175 t in 1975 and to a maximum of 1,346 t in 1978 During 1979-81 there was a decline in the landings. Cephalopods formed 1% to 8.5% of the annual fish production of the state, and the state's share in the total cephalopod production of India ranged up to 9.6%.

GOA

The annual cephalopod landings of Goa amounted to only 2-14 t in the years 1968-74. In the subsequent years the landings were higher, but showed fluctuations. The annual production increased from 96 t in 1975 to 164 t in 1977, decreased to 124 t in 1978 and rose to 210 t in 1980. In 1981 there was a fall in production to 94 t. The maximum contribution of cephalopods to the total fish landings in the state was 1.8% and the state's share in the all India cephalopod production 1.9%.

MAHARASHTRA

Till 1967 the cephalopod landings were low, though their percentage contribution to the country's landings was quite high. From 1968 to 1975 the landings were moderately high, 147-501 t. In the subsequent period starting from 1976 the production rose steeply to 2,488 t, declined to 597 t in the next year and rose to a high level of 4,557 t in 1978 when production was high in other states like Kerala, Karnataka and Gujarat also. The landings showed a descending trend till 1980, and then improved slightly to 1,755 t in 1981. Cephalopods constituted 0.1-1.6% of annual marine fish production of Maharashtra and the State's cephalopod production accounted for 0.4% (1967)—57% (1961) in the country's annual cephalopod production.

GUJARAT

The annual cephalopod production of Gujarat was nil or very negligible till 1974. In 1975 the cephalopod landings amounted to 611 t and increased by over three times to 2,286 t in 1976. In the next two years there was a decrease in the catches followed by a steep rise to the highest ever peak of 5,351 t in 1979. The landings were lower subsequently, 3,471 t and 2,743 t in 1980 and 1981. These data show that there are wide fluctuations in the cephalopod landings in the state during recent years. Cephalopods formed up to 2.8% of the state's annual marine fish production. Gujarat's contribution to the country's cephalopod production was very insignificant till 1974 but it rose to 12.3-35.6% during 1976-81.

LAKSHADWEEP

The cephalopod production of Lakshadweep consists entirely of octopods. During 1968-81 the annual production of the Islands varied between 9 t (1970) and 40 t (1976). The octopods formed 0.5-1.6% of the annual marine fish production of the Islands and they contributed from less than 1% to 1.7% to the country's annual cephalopod production. One of us (E.G.S.) noted spear fishing for octopods in the reefs of Agati and Minicoy islands.

ANDAMAN-NICOBAR ISLANDS

There is regular exploitation of octopods in the Car Nicobar Island. One of us (E.G.S) has seen as far back as 1960-61 light fishing for octopods in the reefs of Car Nicobar. Octopus fishing is carried out mainly at night by spearing and with the help of torches made of coconut twisted palm leaf. Hundreds of families from different villages participate in this fishing. During daytime women and children go to the reefs and poison rock pools, tidal pools and tidal rivulets with ground paste of *Barringtonia* seed. The catch thus obtained includes small octopods, fishes and crustaceans. Similar subsistence fishery exists in other Nicobar islands. A variety of traps are laid at night and picked up at dawn and this yields octopods with fishes. Bait may or may not be used in trap fishing.

CEPHALOPOD PRODUCTION ALONG EAST COAST OF INDIA

The cephalopod landings of the east coast of India, coming from West Bengal, Orissa, Andhra, Pondicherry and Tamil Nadu (excluding its southwest coast), constituted 19-59% to the country's production during 1968-75 but accounted for only 6-16% in 1976-78. The production along the east coast showed two peaks, one in 1970 and another higher peak in 1975 (Fig. 2). The landings increased from 307 t in 1968 to 686 t in 1970 and after a fall to 245 t in 1972 rose to 879 t in 1974 and 2,292 t in 1975. In the later years 1976-78 the cephalopod production was much

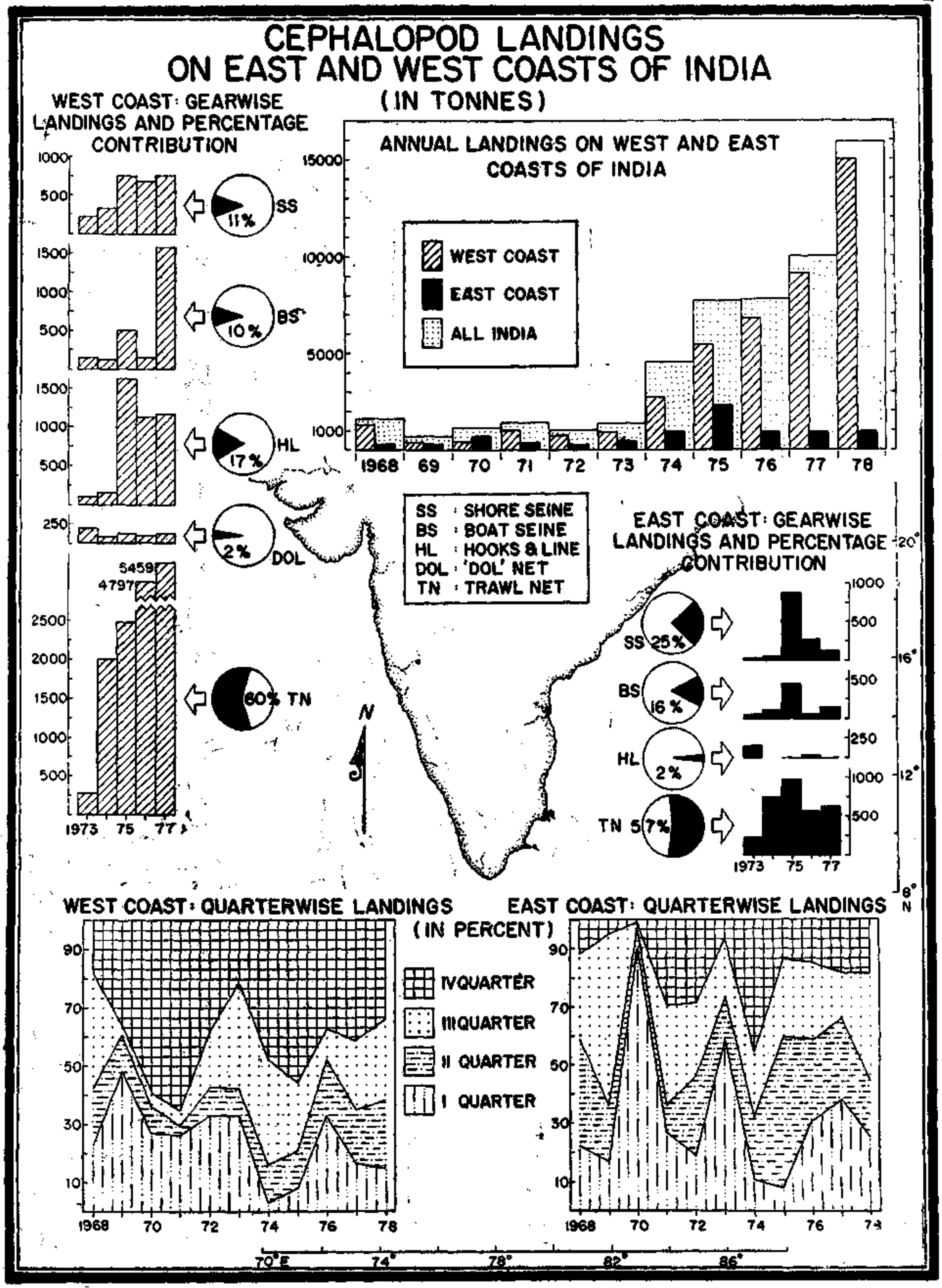

FIG. 2. Annual cephalopod landings along east and west coasts of India during 1968-'78, gearwise landings and percentage contribution (1973-'77) and quarterwise landings along east and west coasts of India (1968-'78).

lower and fluctuated between 915 t and 960 t. Along the coast the best months for cephalopods were March and April and the catches were moderately good in August and November. In some years fairly good catches were obtained in other months, e.g., January (1973), February (1970), May and July (1975). Quarterwise, the landings were higher in the first and third quarters than in other quarters.

Gearwise cephalopod Landings along East Coast of India

1. *Shore seine landings*

Cephalopods are caught in maximum quantities in shore seines among the non-mechanised gear, 5.1 to 38% of the total annual landings being obtained in this gear (Fig. 2). The landings by shore seines amounted to 30.3 t and 44.6 t in 1973 and 1974 respectively but sharply increased several-fold to 871.8 t in 1975 though the effort rose only by 27%. However, there was a fall in the catches to 282.4 t and 138.1 t in 1976 and 1977 when there was a decrease in effort by 27% and 23% respectively. The average annual landings from shore seines during 1973-77 were 273.4 t and average CPUE (Catch/Unit) 1.69 kg. The best catches were obtained in the months February to June and in some years in August and September. The average monthly CPUE varied between 0.03 kg and 9.81 kg and high CPUEs were observed in April and June.

2. *Boat seine landings*

10.3% to 19.3% of the total cephalopod catches along the coast during 1973-77 were obtained in boat seines which were the second important non-mechanised gear in which cephalopods were caught along the east coast. The boat seine landings showed a trend similar to those of shore seines. The catches were low, 53.9 t and 90.7 t, in 1973 and 1974 and there was a steep rise to 443.3 t in 1975 although there was no significant difference in effort compared to that in the previous two years. The landings declined to 107.7 t and 157.5 t in 1976 and 1977 when there was fall in effort by 21.2% and 25.3% compared to that in 1975. The average cephalopod landings of boat seines in the period 1973-77 amounted to 170.6 t and the average CPUE was much less than that of shore seines, being 0.2 kg. The average monthly CPUE varied between 0.07 kg and 0.41 kg with high CPUEs in January, April, May and November. The best catches were obtained in January, April-May and November.

3. *Hooks and line landings*

Hooks and lines contributed 0.2% to 33.9% to annual cephalopod catches along the coast during 1973-77. A total of 154.4 t of cephalopods were caught in this gear along the coast in 1973 but there were no landings in 1974. Compared to 1973 there was a decrease in effort by 34.2% in 1974. The landings were very low, 1.63-13.80 t during 1975-77. The average annual landings during 1973-77 amounted to 34.3 t and average CPUE 0.11 kg. The average monthly CPUE varied over a low range of 0.01-0.66 kg. The best months for cephalopod catches from hooks and lines were January and February.

4. *Trawl net landings*

The major portion of the cephalopod catches 47.7% (1973) to 84.6% (1974) (average 60%) of the total production along the coast was obtained in trawl nets. The trawl net catches increased from 217.2 t in 1973 over four times to 974.8 t in 1975 when there was a large rise in effort by 148%. The production decreased to 555.70 t in 1976 when the effort showed a decrease by 16.6% and a rise to 617.9 t in 1977 when the effort rose by 43%. The average annual landings during 1973-75 amounted to 621.8 t and average CPUE 1.83 kg. The average monthly CPUE varied from 0.96 kg to 3.16 kg with high CPUEs in February, June, July-September and November. Squids and cuttlefishes were obtained in trawl nets throughout the year and the catches were higher in March, May-September and November than in other months.

Cephalopod Landings along West Coast of India

The cephalopod landings along west coast of India comprising those of Gujarat, Maharashtra, Goa, Karnataka, Kerala and Kanyakumari coast of Tamil Nadu formed 41-81% of the total landings of the country during 1968-75 and in the subsequent years the catches along the coast constituted as much as 84-94% (average 89.2%). The landings show three peaks in 1968, 1971 and 1978 (Fig. 2). They decreased from 1,327.5 t in 1968 to 415.6 t in 1969 increased to 1,056.2 t in 1971, showed a fall by 30.6% in the next year but the period from 1973 onwards was one of continuous rise in catches reaching a maximum of 14,977 t in 1978. The highest catches of cephalopods were obtained along the west coast from September to December and in April. In some years large catches were obtained in May (1975, 1977 and 1978) and July (1975) also. Quarterwise, the last quarter of the year was the period when large quantities were obtained and the first quarter was the next one in which squids and cuttlefishes were fished in good quantities.

Gear-Wise Cephalopod landings along West Coast of India

1. *Shore seine landings*

As on the east coast, cephalopods are caught in maximum quantities in shore seines among non-mechanised gear, this gear accounting for 8.3-25.6% of the total cephalopod landings along the west coast. The landings increased from 224.7 t in 1973 to 734.6 t in 1975 when the effort showed a small fall by 3% (Fig. 2). There was a decrease in landings by 8.1% in 1976 although the effort increased by 33% and it was followed by a recovery of the fishery in 1977 when the landings amounted to 748.5 t although the effort declined by as much as 31%. The average annual cephalopod production along the coast during 1973-77 was 542.8 t and average C P U E 2.20 kg. The average monthly C P U E varied between 0.4 kg and 9.36 kg and high C P U E s were recorded in September, October and December.

2. *Boat seine landings*

2-18.2% of the annual cephalopod landings along the coast during 1973-77 were obtained in boat seine and this gear is the third important non-mechanised gear, the second one being hooks and lines. The boat seine landings amounted to 152.3 t and 106.4 t in 1973 and 1974 and showed a large rise to 503.5 t in 1975 when the effort was only 9% higher than in 1974. In 1976 there was a fall in production by over 72.% to 136.6 t. The highest ever landings of 1,572.5 t were recorded in 1977 when the effort was over twice that in 1976. The average annual boat seine landings during 1973-77 amounted to 495.7 t and average C P U E 0.4 kg. The C P U E showed a range of 0.01-1.68 kg with high C P U Es in July, September and October. The best catches were obtained from July to October.

3. *Hooks and line landings*

The hooks and line landings formed 100.8 t and 155.1 t in 1973 and 1974 and rose to a maximum of 1,628.7 t in 1975 although the effort was higher in that year only by 10.3%. In 1976 the landings amounted to 1,113.2 t when the effort was higher by 4.3%. In 1977 the landings were 1,161.1 t when the effort was less by 32% as compared to that in 1975. The average annual cephalopod landings of hooks and lines during 1973-77 were 831.8 t and average CPUE 1.1 kg. The CPUE of the gear ranged between 0.01 kg and 3.57 kg with maximum CPUEs of 1.46 kg-3.57 kg in September-November. The largest catches were obtained from September to November and in some years in January and December also.

4. *Dol net landings*

The *dol* nets landed 1.4-13.7% of the total annual cephalopod landings during 1973-77. The annual *dol* net catches of cephalopods amounted to 111 t in 1973 but in the next two years 1974 and 1975 the landings declined to 44 t (1974) and 83 t (1975) when the effort decreased by 19.7% and 2.7% respectively. In 1976 although the effort was seven times that in 1975, the landings were less by 5% being 78.9 t. The catches were extremely low, 3.4 t, in 1977 when there was a large decline in effort by 92% compared to that in 1976. The average annual landings with this gear during 1973-77 were 98.8 t and average CPUE 0.16 kg. The average monthly CPUE varied between 0.01 kg and 0.55 kg. The catches were better in September November and December than in other months.

5. *Trawl net landings*

The major portion of the cephalopod production along the west coast ranging from 31.1% to 79.9% was obtained in trawl catches during 1973-77. The total annual landings were only 272.3 t in 1973 but increased progressively in subsequent years 1974-77 when the effort also increased progressively. A maximum of 5,459 t were caught in 1977 when the effort was double that in 1973. The average annual trawl landings of cephalopods during 1973-77 amounted to 3,002.4 t and average CPUE 5.38 kg. The average monthly CPUE varied during 1973-77 over a wide range of 2.1 kg (December) to 14.3 kg (October). High CPUEs of 5.19 kg to 14.3 kg were recorded in April, July and September-November. The best cephalopod catches were obtained in the months March-May and September-November.

The estimated cephalopod production in India and constituent maritime states in the recent years 1980-'84 are given below :

		1980	1981	1982	1983	1984*
West Bengal	..	4	..	6	18	42
Orissa	..	98	57	195	119	59
Andhra Pradesh	..	470	512	595	519	450
Tamilnadu	..	1,472	1,687	3,238	3,877	3,694
Pondicherry	..	40	44	84	121	37
Kerala	..	4,244	2,376	3,536	1,727	5,406
Karnataka	..	122	266	153	979	319
Goa	..	210	94	66	394	401
Maharashtra	..	1,191	1,755	4,781	6,613	7,650
Gujarat	..	3,471	2,743	3,023	3,972	3,007
Lakshadweep	..	13	14	22	16	14
All India	..	11,335	9,578	15,799	18,355	21,079

* provisional figures

After the marked decline in landings in 1981, the production rose progressively to 15,799 t in 1982 and 21,079 t in 1984. The rise in production was due to a substantial increase in landings in Maharashtra, Kerala, Tamilnadu and Gujarat. Highest production was in Maharashtra which accounted for 30-36% of the country's production and it was an all time high of 7,650 t in 1984. Kerala contributed 9-26% of the landings, Tamilnadu 18-21% and Gujarat 14-22%.

8

AREAWISE AND GEARWISE PRODUCTION OF CEPHALOPODS

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ABSTRACT

The coasts of the maritime states of India have been divided into subareas and the annual and seasonal trends of the areawise and gearwise landings of cephalopods and CPUE have been studied in detail.

WEST BENGAL

West Bengal which has a coastline of 600 km is treated as a single area. In this state cephalopods amounting to 82 t have been landed only in 1971 and there was no production in the other years during 1968-77 (Fig. 1). The entire landings of 82 t of cephalopods were obtained in the shore seine *Sarini jal* in November, 1971 and formed 1.9% in that month's total catch and 0.9% in the annual catch.

ORISSA

The State which has a coastline of 480 km has been divided into two areas viz., A-extending from Gadhadharpur to Chandnipal (288 km) and B-from Pentakota to Kavitysonapur (192 km). In the period 1968-72 as well as in 1973-77, there were no cephalopod landings from area A (Fig. 1). In area B, small quantities of cephalopods were obtained in the months January to May and November. Annual landings of 1.6-18.5 t were caught in the period 1968-72 and the landings varied between 0.2 t and 27 t in 1973-77. The cephalopods formed 0.1% of the total production during 1968-72 and 0.6% during 1973-77.

In area B cephalopods were caught in two types of gear, shore seines (*Pedda vala*) and boat seines (*Iraga vala*). Boat seines were employed throughout the year but cephalopods were obtained only in March and April. Shore seines were also operated all round the year but cephalopods were caught only in six months, January-May and November. In the cephalopod catches during 1973-77 boat seines accounted for 67.5% and shore seines 32.5%. The boat seine landings were obtained in March and April in 1973 and 1976, when they amounted to 3.3 t and 21.3 t (Figs. 1 and 2). The CPUE in 1976 was higher (0.8 kg) compared to that (0.1 kg) in 1973 although the effort was only 42% of that in 1973. In boat seine all fish catches, cephalopods formed 0.2% and 4.4% in 1973 and 1976 respectively. The annual shore seine cephalopod catches fluctuated between 0.2 t to 6.2 t and CPUE between 0.01 kg and 0.5 kg, the landings showing no distinct changes in relation to variations in effort. The catch rates were better in March and April than in other months. In the total shore seine catches cephalopods represented only 0.03 to 1.0%.

Hooks and lines had been employed from January to April in all the five years in area B, but there were no cephalopod landings. Trawls nets were operated in several months in 1973 and 1975 in area A but cephalopods were not obtained in this gear also.

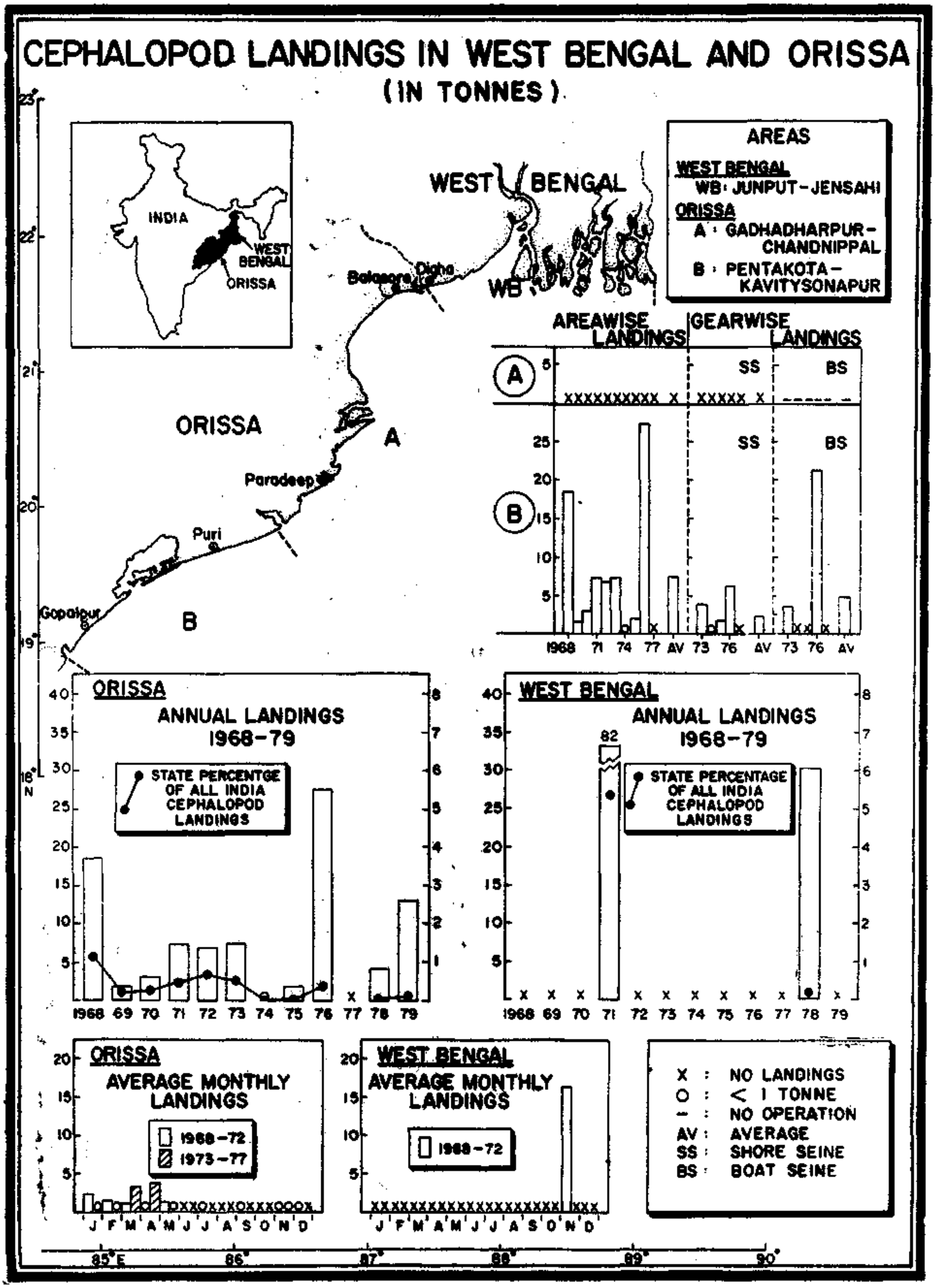

FIG. 1. Annual landings, state percentage in all India cephalopod landings (1968-'79) and average monthly landings (1968-'72) in West Bengal, and annual landings, State percentage in all India cephalopod landings (1968-'79) areawise (1968-'77) and gearwise (1973-'77) landings and average monthly landings (1968-'77) in Orissa.

ANDHRA PRADESH

The coast of Andhra Pradesh extending over 982 km has been divided into five areas viz., A-extending from Donkuru to Geddalapadu (83 km), B-Kumuduvanipeta to Dhonipeta (71 km), C-Chintapalli to Kothapatnam (119 km), D-Bangarammapalem to Bhairavanipalem (161 km) and E-Pandi to Pulinjerikuppam (548 km) (Fig. 3).

During the period 1968-72 the best catches were obtained in area A with average annual landings of 165.3 t. Areas C and D were next in importance but the average production was comparatively much less viz., 13.9 t and 2.1 t respectively. In areas B and E there were no cephalopod landings (Fig. 3). In area A the cephalopod landings showed a sharp increase from 58 t in 1968 to 642 t in 1970 but underwent a steep fall to 9.6 t in 1972. The average monthly landings in 1968-72 varied from less than 1 t to 100.4 t and the best catches were obtained from February to April. In this area cephalopods formed up to a maximum of 7% (February) with average annual percentage of 1.4% in total marine landings. In area C the annual production was 40.3 t in 1968 and in other years it fluctuated between 2 t and 14 t. In this area moderately good catches were got in February, August and September. Cephalopods formed less than 1% of the total marine production in the area. The annual cephalopod landings from area D amounted to 7.9 t in 1969 and formed 2.8 t and 0.1 t in 1968 and 1971 respectively. The catches were obtained only in a few months February, April, August and November and they were better in the earlier two months.

During 1973-77 period, the cephalopod production was highest in area D with average landings of 92.7 t

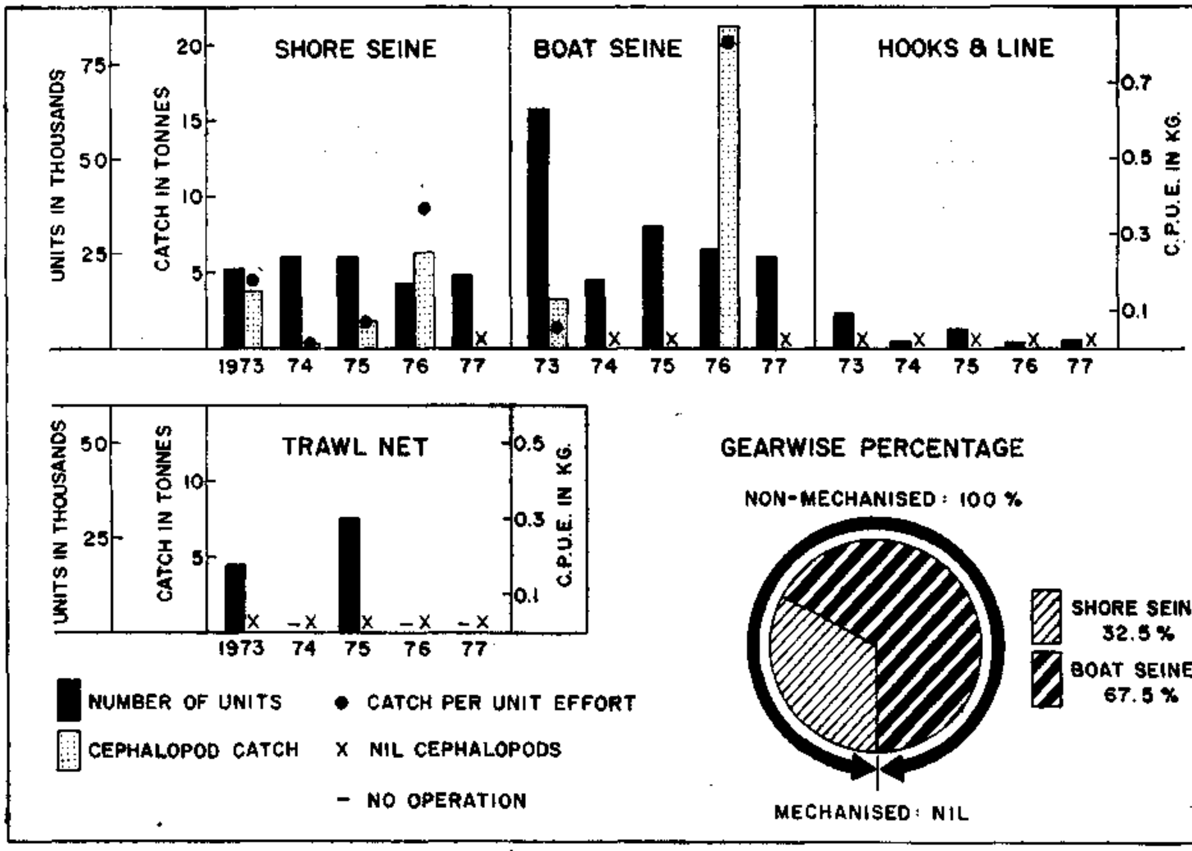

FIG. 2. Gearwise units, catch, C.P.U.E. and percentage in total cephalopod catches in Orissa, 1973-'77.

The other areas in the order of abundance of landings were area C (30.5 t), area B (14.9 t), area A (10.7 t) and area E (1 t).

In Andhra Pradesh during 1973-77 period, 62.9% of the cephalopod landings were obtained in trawl nets and the rest in three non-mechanised gears viz., boat seines (*Iraga vala*) 21.6%, shore seines (*Pedda vala*) 15.2% and 0.3% in hooks and lines (*Galamu*) (Fig. 4). Among the various gears, the average monthly CPUEs of trawl nets were highest (0.5-3.2 kg) and shore seines were next in importance. The best cephalopod catches were obtained in trawl nets in March, May, September

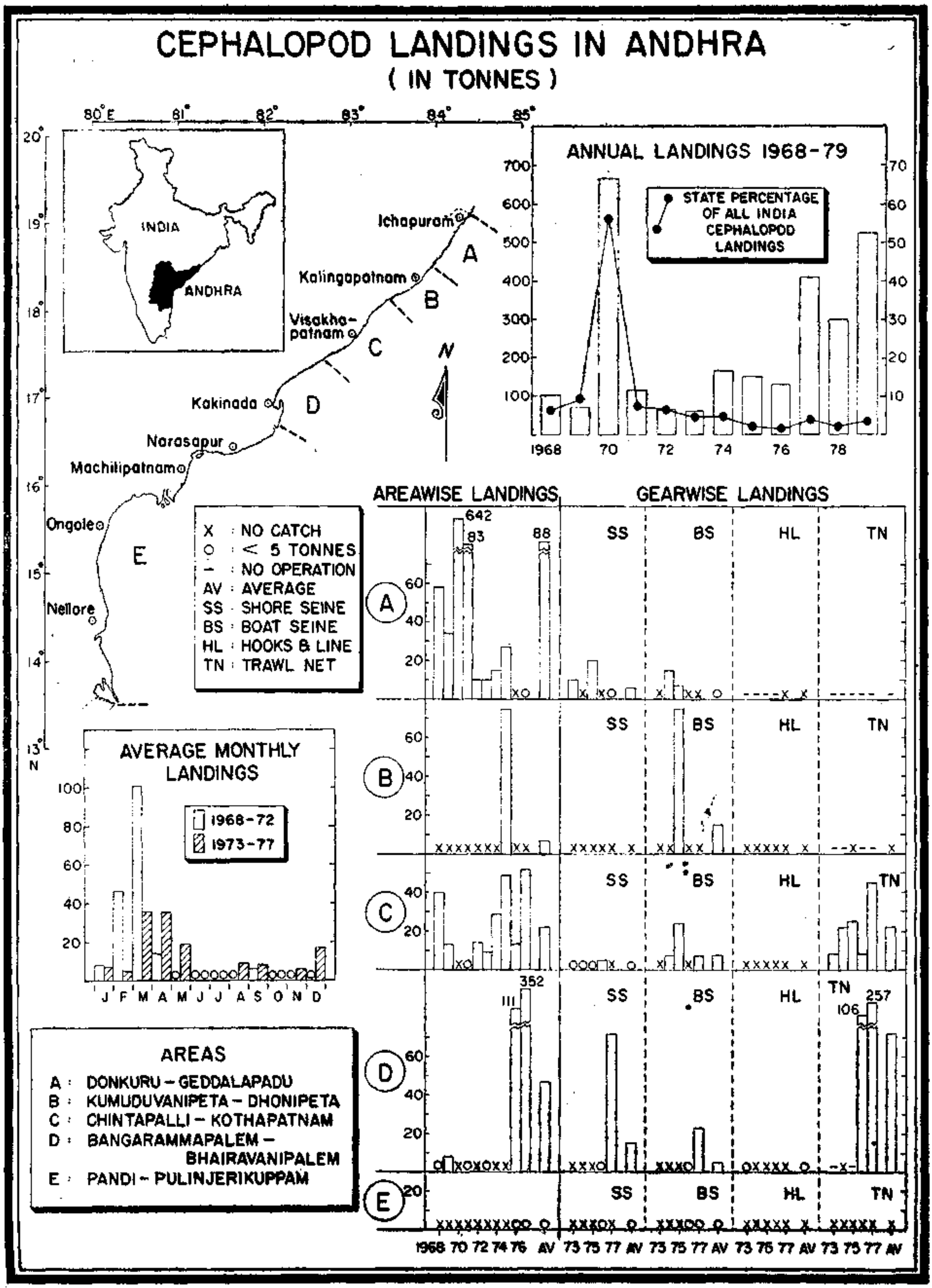

FIG. 3. Annual landings, state percentage in all India cephalopod landings (1968-'79), areawise (1968-'77) and gearwise (1973-'77) landings and average monthly landings (1968-'77) in Andhra Pradesh.

and December and in shore seines and boat seines in March-April.

In area D the landings were negligible (1 t) in 1973 and increased sharply to 110.6 t in 1976 and 351.8 t in 1977. The best catches were obtained in March-May and December. In this area cephalopods formed 0.1 to 1.3% in total marine landings. Trawl nets were operated in this area in 1974, 1976 and 1977. The landings amounted to 105.7 t in 1976 and increased by nearly two and half times in 1977 to 256.8 t as a result of a rise in effort by 76%. The CPUE showed a rise from 3.2 kg in 1976 to 4.5 kg in 1977. In the total fish production of trawlers in this area, cephalopods formed 1-1.1%. Cephalopods were not landed in 1974. The cephalopod landings of shore seines amounted to only 1.8 t in 1976 but increased sharply to 71.7 t in 1977 although the rise in effort was only 13.4%. The CPUE was only 0.1 kg in 1976 and increased to 4.2 kg in 1977. The boat seine cephalopod landings also increased from 3.1 t in 1976 to 23.3 t in 1977 though there was not much change in the effort. Only in 1973 hooks and lines landed small quantities of cephalopods with the annual landings amounting to 1 t.

The cephalopod production in area C showed a rise from 8.8 t in 1973 to 49.1 t in 1975, a fall in 1976 to 13.4 t followed again by a rise to 51.7 t in the next year. Good catches were obtained in this area from March to May and in all the other months the catches were much less. In this area cephalopods accounted for less than 1% in the total marine production. The landings of trawlers in the area showed a rise from 8.3 t in 1973 to 45 t in 1977 following an increase in

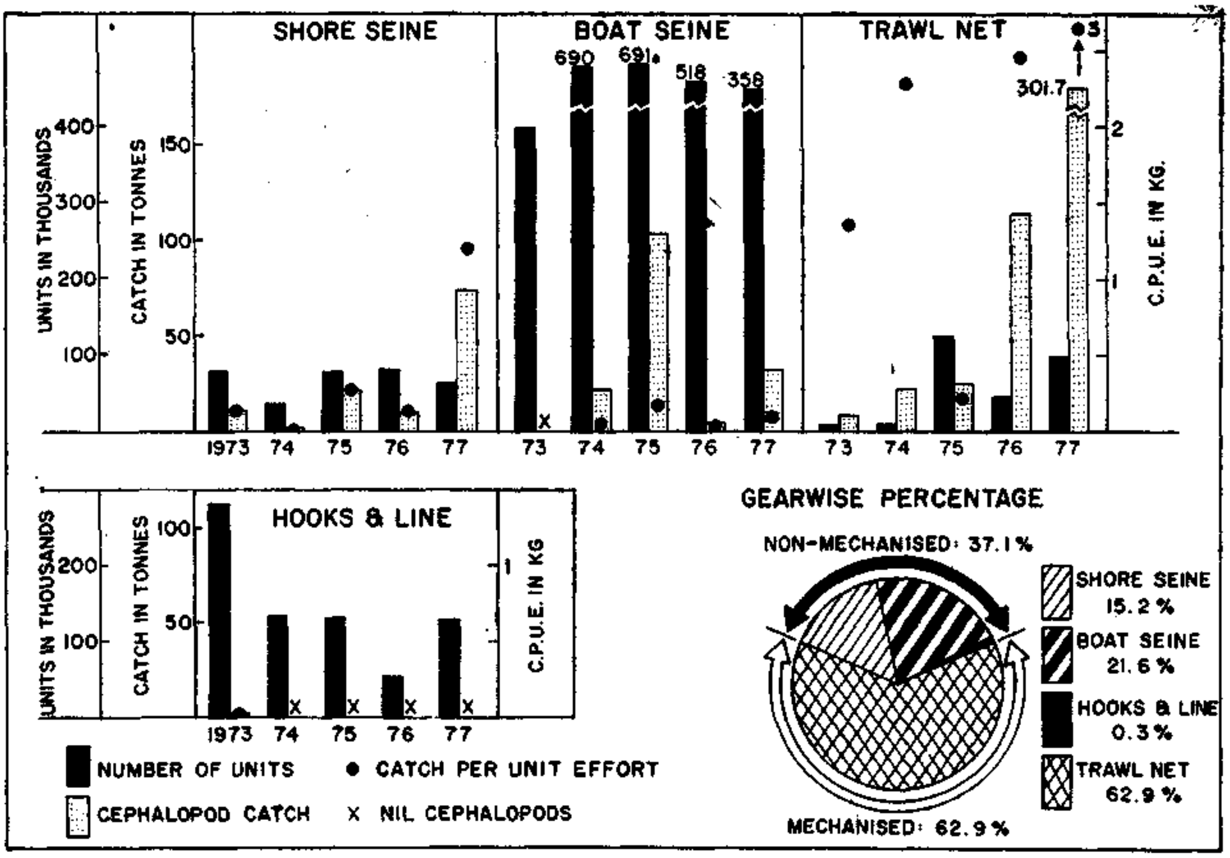

FIG. 4. Gearwise units, catch, C.P.U.E. and percentage in total cephalopod catches in Andhra Pradesh, 1973-'77.

effort by seven times. The CPUE increased from 1.5 kg in 1973 to 3.6 kg in 1974 and decreased to 1.1 kg in 1977. The cephalopods contributed less than 1% to 1.9% of the total trawl landings. The boat seines landed 6.6 t to 24.2 t during 1974-'75 and 1977 with CPUEs varying between 0.4 kg and 0.1 kg. The annual landings by shore seines amounted to 0.2 t to 5.3 t and the CPUE fluctuated over a narrow range of 0.02 kg and 0.3 kg. Though hooks and lines were operated on a large scale no yield of cephalopods was noticed.

In area B cephalopods were landed only in one year, 1975 during the period 1973-'77. 99% of these landings were obtained in a single month April and the rest in September in boat seines. Cephalopods were not got from this area in shore seines, hooks and lines and trawl nets.

The annual cephalopod landings in area A ranged between 9.6 t and 27.1 t during 1973-75 and decreased to 2.1 t in 1977. Good landings were obtained in this area only in one month, March. The shore seine landings increased from 9.6 t in 1973 to 20.5 t in 1975 although there was a fall in effort by about 39%. There was a steep fall in the landings to 2.1 t in 1977 although there was an increase in effort by about 22% compared to that in 1975. Boat seines were operated in this area in all the five years, 1973-'77 but cephalopod catches were obtained only in 1974 and 1975 when they amounted to 14.8 t and 6.6 t respectively. Hooks and lines were employed only in 1977 and there were no cephalopod catches. Trawlers were not at all operated in this area.

Very small quantities of cephalopods were landed by shore seines and boat seines in area E during 1976 and 1977 with the annual production amounting to 2.6 t and 2.5 t respectively. The catches were obtained in the months January, July and September.

TAMIL NADU

The Tamil Nadu coast which extends over 1,000 km is divided into eight areas viz., area A-extendin,g from Arangamkuppam to Alamharikuppam (11 km), B-from Thiruvattiyurkuppam to Thiruvanmiyurkuppam (35 km), C- from Muthukkadukuppam to Pudupettai (79 km), D-from Porto novo to Arasanagiri (254 km), E-from Sundarapandianpattinam to Rochema Nagar (235 km), F- Rameswaram Island (69 km), G- from Vembar to Chinnamuttom (151 km) and area H-from Kanyakumari to Neerodi (66 km) (Fig. 5).

During 1968-72 the average annual cephalopod production was highest in area H with average annual landings of 254.8 t and areas B and E ranked second and third with average landings of 68.6 t and 40.8 t respectively. Areas D (25.5 t) and C (24.6 t) were next in importance. The landings were very low in areas F (9.3 t), G (2.9 t) and A (2.3 t).

In area H the cephalopod landings were highest 195.2 t in 1971 and decreased to 55.5 t in 1972 and good catches were obtained in February, April, November and December. In area B the landings were high, 143.9 t and 121.1 t in 1969 and 1972 and the catches were good in July and August. In area E the annual landings varied from 28.8 t to 88.2 t during 1968-71 and declined to 7.1 t in 1972. In this area the best catches were obtained in April-May. During 1968-70 the annual landings in area D varied between 3.7 t (1970) and 25.2 t (1969) and the production was higher during 1971 and 1972 being 43.1 t and 40.7 t respectively. The catches were better during July-September and November. The landings from area C amounted to 46.2 t and 41 t in 1968 and 1971 and were less viz., 22.5 t and 13.3 t in 1969 and 1972 respectively with higher catches in July, August and October than in other months. The cephalopod catches from area F increased from 11.2 t in 1968 to 19.8 t in 1969 and there was a distinct fall in the catches during 1970-72. Good catches were obtained in the months March-May. The production in area G was low, the annual landings amounting to 12 t and 2.5 t in 1968 and 1971 respectively with catches during the last quarter of the year only. The landings from area A were also low with annual catches varying from less than 1 t to 5.3 t.

During 1973-77 the cephalopod production was maximum in area H with an average annual landings of 564.6 t followed by area D (318.8 t) and area B (265.6 t). The other areas in the order of importance were area E (197.8 t), area C (50.1 t) area F (21.1 t), area A (9.5 t) and area G (4.3 t).

In the period 1973-77, trawl nets accounted for 35.1%, hooks and lines (*Choondal*) 28.5%, shore seines (*Kara valai, Peria valai, Ola valai*) 20.6% and boat seines (*Thuri valai, Thattumadi, Kacha valai*) 15.8% (Fig. 6). The CPUE of shore seines was highest 3.1 kg, of trawl nets 1.9 kg, of hooks and lines 0.8 kg and of boat seines 0.5 kg. The highest cephalopod landings were obtained in shore seines in January-April and June, in boat seines in May, July-September and November-December, in hooks and lines in January-February and September-December and in trawl nets in a number of months viz., February-March, June-September and November.

The average annual landings of 564.6 t obtained from area H during 1973-77 were over seven times that in 1968-72. The total production in this area rose steeply from 16.8 t in 1973 to 927.9 t in 1977 though there was not much change in the effort put in. The highest yields were obtained in September-October and fairly good catches in November-February. In this area the cephalopod catches of hooks and lines amounted to as much as 66.3% and the landings from this gear increased sharply from 88.7 t in 1974 to 813.6 t in 1975 although the increase in effort was only 22.2%

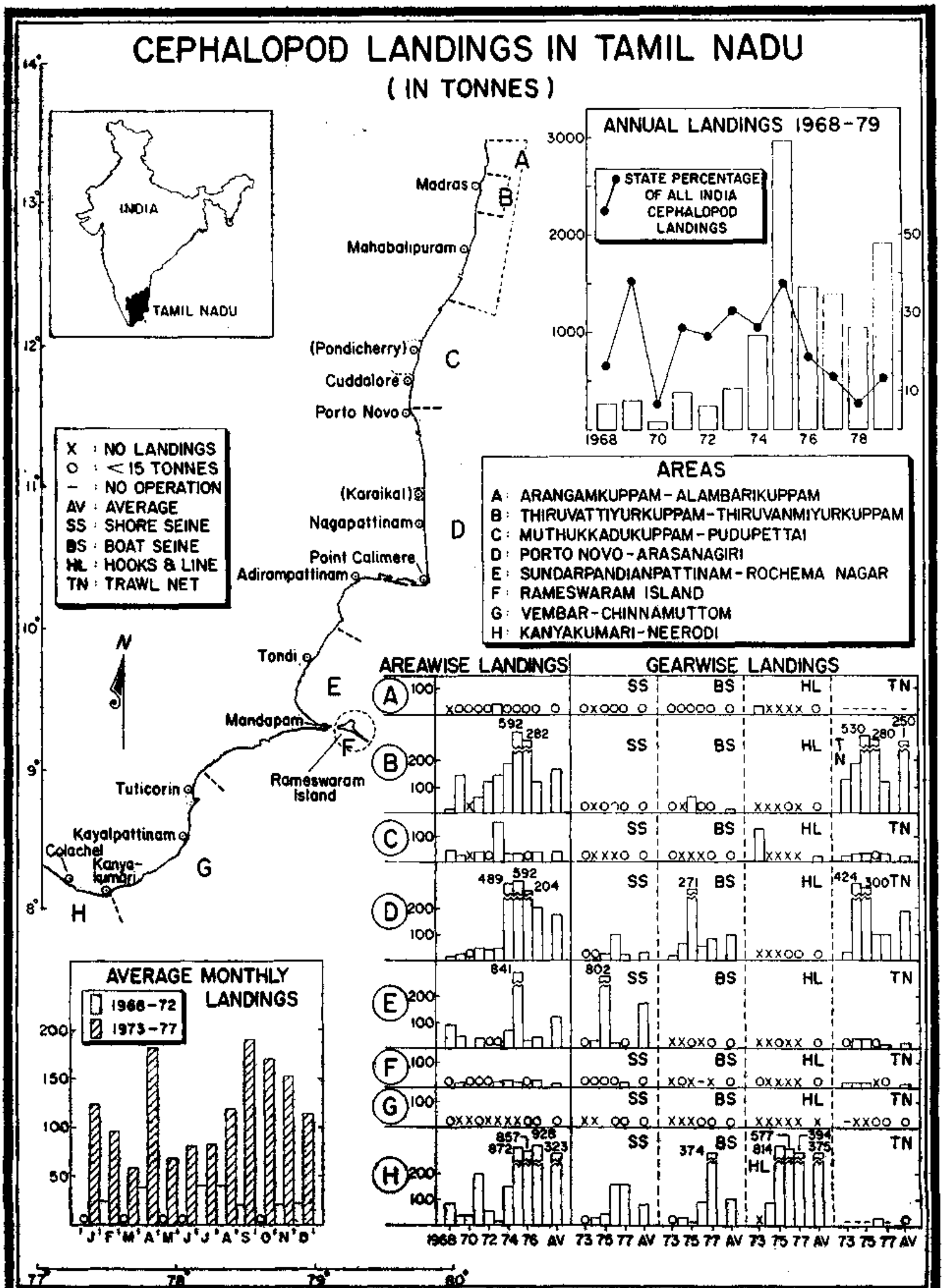

FIG. 5. Annual landings, State percentage in all India cephalopod landings (1968-'77), areawise (1968-'77) and gearwise (1973-'77) landings and average monthly landings (1968-'77) of Tamil Nadu.

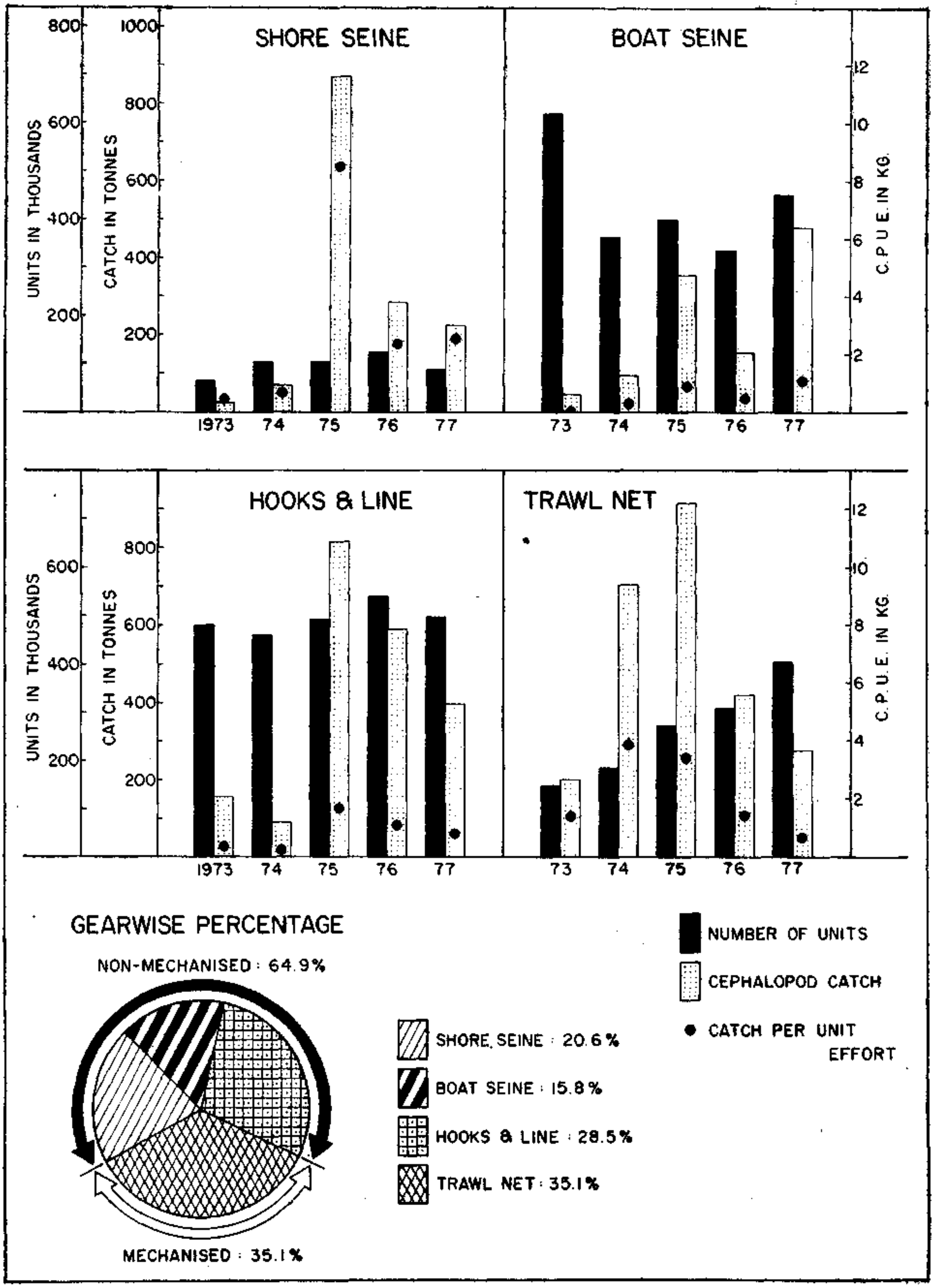

FIG. 6. Gearwise units, catch, C.P.U.E. and percentage in total cephalopod catches in Tamil Nadu, 1973-'77.

Later there was a fall in landings to 576.5 t and 394.1 t in 1976 and 1977 when there was not much change in the effort put in. The CPUE showed a trend similar to that of the landings with highest value of 12.4 kg in 1975. Cephalopods were an important item of hooks and lines catches forming 6 to 12% during 1975-77. Boat seines accounted for 18.6% of the cephalopod landings in this area. Though the effort decreased by 17.9%, the cephalopod landings by boat seines increased from 6.9 t in 1973 to 373.9 t in 1977 and the CPUE showed an increase from less than 1 kg to 2.5 kg. In the boat seine landings cephalopods formed from less than 1% to 1.8%. The shore seines landed 14.1% of the cephalopods in the area and the catches exhibited a large increase of over fifteen times from 9.9 t in 1973 to 160 t in 1977 when the effort rose by about 100%. During the same period the CPUE increased from 0.6 kg to 4.9 kg, the cephalopods forming 1.2-5.6% of the shore seine landings. Trawl nets were operated in this area only in 1976 and 1977 and in the former year 28.4 t of cephalopods with a high CPUE of 26.2 kg were obtained, accounting for about 1.0% of the trawl landings.

In area D, the cephalopod landings exhibited a large increase from 46 t in 1973 to 591.7 t in 1975 although the total effort put in decreased by 28%. In 1977 the landings decreased to as much as 204.4 t in spite of a rise in effort by as much as 59%. In this area the best catches were obtained in May and November and moderately good catches in March, June and December. 59.4% of the cephalopod production in this area was landed by trawlers. The annual landings were high viz., 423.7 t and 300.1 t in 1974 and 1975 respectively. In 1976 although the effort increased by as much as 46.8% the landings steeply declined to 98.1 t and in 1977 with a fall in effort by 40%. The production was similar (98.5 t) to that in the previous year. The CPUEs closely followed the trend of catches with higher values of 6.9 kg and 3.7 kg in 1974 and 1975 and lower values of 0.8-1.4 kg in other years. Cephalopods formed 1.7 to 3.1% in the trawl landings in 1974-75 and in other years they formed less than 1%. The boat seine catches of cephalopods formed 30.1% of the total landings in this area and rose from 18.3 t in 1973 to 271 t in 1975 inspite of a fall in effort by 63.7%. The landings showed a steep decline to 80.6 t in 1977 though the effort spent in that year was more than double that in 1975. The CPUE of boat seines was 4.1 kg in 1975 and varied between 0.1 kg and 0.6 kg in the other years. In boat seine catches cephalopods formed less than 1% in 1973 to 14.1% in 1975. The cephalopod landings of shore seines which accounted for 9.5% of the total production in this area increased from negligible quantities in 1973 to 98.6 t in 1976 when the effort more than doubled and declined to 23.7 t in 1977 with a fall in effort by 60%. The average CPUE was 3.5 kg in 1976 and decreased to 2.1 kg in 1977. Hooks and lines were operated throughout 1973-77 but only in 1976 and 1977 small catches of cephalopods of 13.1 t and 1.6 t were landed with CPUEs of 0.3 kg and 0.2 kg respectively.

A high cephalopod production of 591.7 t was observed in 1975 in area B but in other years the production was much less and fluctuated between 122.9 t and 282.1 t. The best catches were obtained in this area from June to August. The predominant cephalopod catches amounting to 93.8% were obtained in this area in trawl nets. The landings increased by more than four times from 129.8 t in 1973 to 529.9 t in 1975 although there was a decrease in effort by 15.7%. The production declined to 118.4 t in 1977 inspite of rise in effort by about 16%. The CPUE was high, 13.2 kg in 1975 and decreased to 2.6 kg in 1977. Cephalopods formed 6.6% of the total trawl landings in 1975 but accounted for only 2.1% in 1977. The catch of boat seines amounted to 5.7% of the total production in this area. The landings were moderately good in 1975 with an annual production of 61.6 t but in the other years they amounted to only 0.4-9.5 t. The cephalopod landings of shore seines in this area were very low and only in 1973 they amounted to 3.3 t with a CPUE of 1.4 kg. Hooks and lines were operated in this area in good numbers in all the years but only in 1976 a meagre catch of 0.7 t was obtained.

As in areas B, D and H, in area E also the annual cephalopod production was very high, 841.5 t in 1975. However, in the other four years of the period 1973-77, the landings were low, 10.1 t (1973) to 68 t (1974). The highest catches were obtained in two months, April and May. 88.5% of the production from this area was obtained in shore seines. The shore seine landings in 1975 were very high, 801.6 t but in the other years they were very low, 10 t (1973)—30.4 t (1974) with no well defined variations in the catches in relation to the effort put in. The CPUE and percentage contribution of cephalopods were very high in 1975 being 30.7 kg and 14.8% respectively and the values were very low in other years. 9.9% of the cephalopod landings in the area were obtained in trawl nets and the rest by boat seines and hooks and lines. The trawl net production was 37.6 t and 34.9 t in 1974 and 1975 but amounted to only 6.6 t and 18.6 t in the next two years, 1976 and 1977 inspite of increase in effort by 4% and 23%. Annual landings of 3.3 t and 10.9 t were obtained in boat seines in the area only in two years 1975 and 1977 and hooks and lines landed 1.7 t in 1975.

In area C, the cephalopod landings were highest, 150.4 t in 1973 and declined very much in subsequent years with catches varying between 7.3 t (1976) and 34.1 t (1977). The catches were better in January, June and July than other months. Hooks and lines and trawl nets accounted for bulk of the landings of 49.8% and 45.3% and shore seines and boat seines 4.3% and 0.6% respectively. Hooks and lines formed 82.9% of the entire cephalopod production in 1973 with a catch of 124.7 t with a CPUE of 9.9 kg and percentage contribution of 54.2. There were no landings from this gear during 1974-77. The annual trawl landings varied between 6 t and 28.9 t and showed no correlation with the effort put in. The CPUE of the trawlers varied from less than 1 kg to 3.4 kg and cephalopods formed 0.6-3.0% of total trawl landings. Shore seines and boat seines were employed during all the years but cephalopod yields were very poor.

In area F, the annual cephalopod production varied between 2.2 t (1976) and 30.8 t (1974). The landings were better in February and from May to August. Most of the catches were obtained in trawl nets (71.8%) and shore seines (28%). The cephalopod production of trawlers varied between 8 t (1977) and 25.5 t (1974). The CPUE was less than 1 kg. The annual cephalopod landings of shore seines formed 5.2 t and 21.7 t in 1974 and 1977 and were still lower in the other years. The average CPUEs in 1974 and 1977 were 2.4 kg and 5.3 kg. Boat seines and hooks and lines operated in small numbers landed very meagre quantities of cephalopods.

The annual cephalopod catches from area A amounted to 39.1 t 1973 but in latter years they were extremely low (0.1-3.6 t). 73% of the cephalopod landings in 1973 (28.6 t) were obtained in hooks and lines but in the other years no cephalopods were landed by this gear although they were operated in large numbers. The annual boat seine cephalopod production amounted to 9.8 t in 1973 and decreased very much in subsequent years. Although cephalopods were obtained in shore seines the annual landings were very less (0.02-3.3 t).

In area G there were no cephalopod landings during 1973-75 but the production amounted to 8.8 t and 12.8 t in 1976 and 1977. About 81.5% of the cephalopod landings in this area came from boat seines and the rest was accounted for by trawl nets (11.9%) and shore seines (6.6%).

PONDICHERRY

Pondicherry is divided into two areas viz., A-Kanagachettikulam to Murthikuppam (22 km) and B-Mandapathoor to Thirumalarayanpattinam (13 km) (Fig. 7).

Areawise figures on cephalopod production in Pondicherry were available only from 1972. The annual landings of area A amounted to 14.7 t and those of area B were less, 7.7 t in 1972. During this year the highest catches were obtained in area A in three months, May, June and August and in area B in September.

During 1973-77 the average annual cephalopod land, ings were only slightly higher in area A viz., 39.2 t when compared with that in area B viz., 36.6 t. Good catches were obtained in March in area A and in January and August-October in area B.

In the period 1973-77, shore seines (*Karai valai*) accounted for 43.0% of the cephalopod production in the State closely followed by trawl nets, 40.6% and boat seines (*Thuri valai*), 16.4% (Fig. 8). Along the Pondicherry coast although hooks and lines (*Choondai*) were employed, cephalopods were not obtained. The best cephalopod catches were obtained in shore seines in March and August, in boat seines in January, and in trawl nets April-May and August-October.

Maximum cephalopod landings of 151 t were observed in area A in 1976 during 1973-77. In the other years the production was much lower varying between 3.7 t and 35 t. The catches were better in January, March and April than in other months. Cephalopods formed on an average 2.4% but in March 1976 they accounted for as much as 54%. The major portion (73.5%) of cephalopods caught in area A were obtained in shore seines, 26.1% in trawl net and the rest in boat seines. The shore seine landings of cephalopods amounted to 138.7 t in 1976 although the effort was less by 20% as compared to that in 1975. In other years the landings were extremely low. In 1976 the catches formed 28.8% of the total production by the gear and CPUE was high, 23.5 kg. The cephalopod landings of trawlers were very less in 1973 and 1975 but there was an improvement in the fishing in 1976 and 1977 when the annual production amounted to 12.4 t and 34.3 t with CPUEs of 2.7 kg and 3.9 kg respectively. Boat seienes and hooks and lines were operated in all the years and only in one year, 1973 meagre landings of 1.6 t of cephalopods were landed in the former gear.

In area B the maximum landings were obtained in 1976 as in area A but the catches were much lesser than

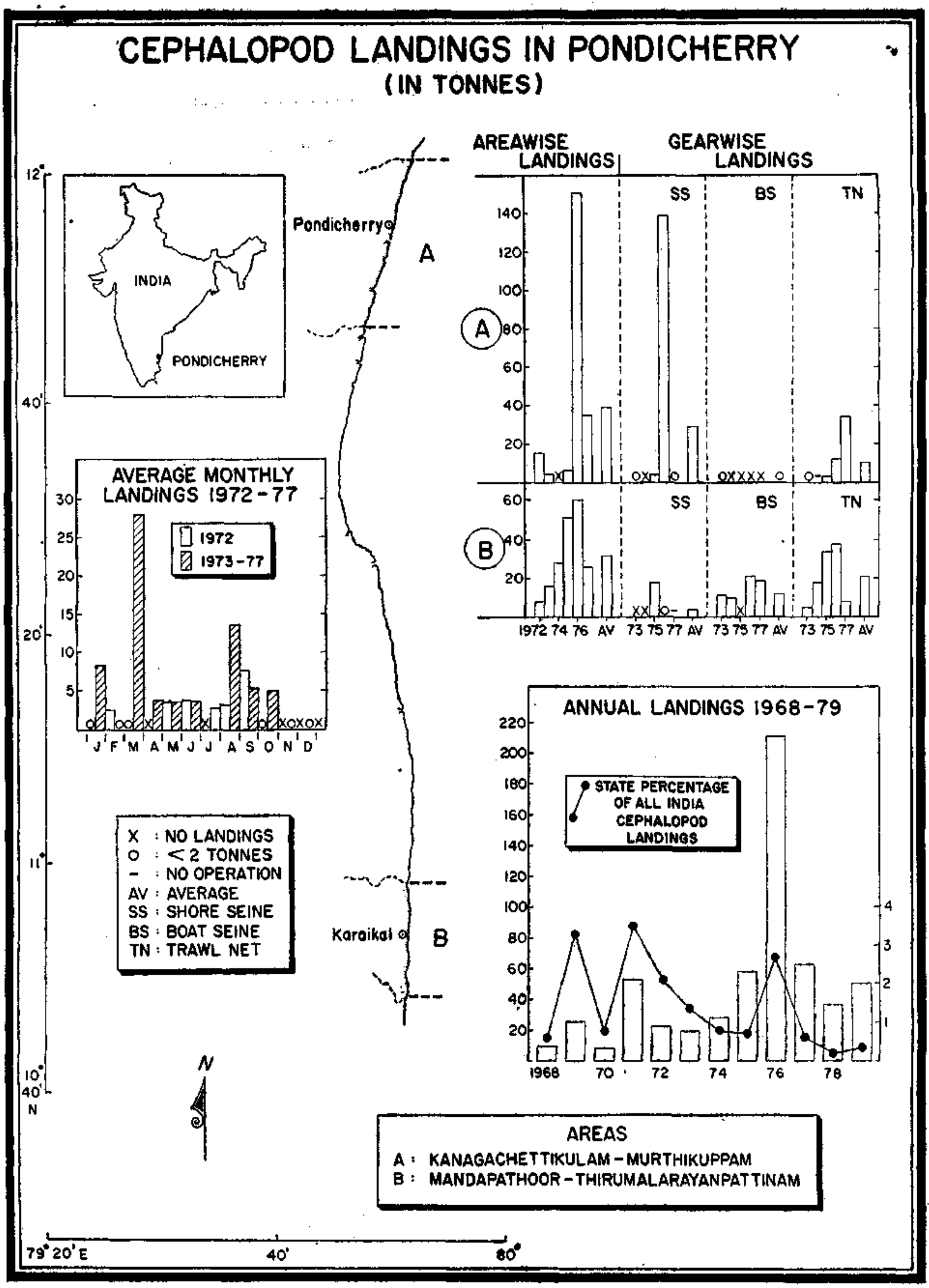

FIG. 7. Annual landings, State percentage in all India cephalopod landings (1968-'79), areawise (1972-'77) and gearwise (1973-'77) landings and average monthly landings (1972-'77) of Pondicherry.

that in area A, being 60.7 t. In the remaining years the production varied between 16.4 t and 52 t. The productive months in this area were January and August to October. In area B, trawl nets landed 56.4% of cephalopods, boat seines 33.1% and shore seines 10.5%. The cephalopod production of trawlers was higher viz., 33.9 t and 38.3 t in 1975 and 1976 compared to those in 1973-74 due to a rise in effort. However, there was fall in catch to 7.6 t in 1977 even though the effort spent was slightly more than that in 1976. During 1975-'76 the CPUE varied between 3.0 kg respectively. In 1973-'74 no cephalopods were netted in this gear and it was not at all operated in 1977. Hooks and lines were operated in this area only in 1976 and there were no cephalopod landings.

Kerala

The Kerala coast is demarcated into seven areas viz., A-Kollengode to Valia Veli (40 km), B-Pallithura to Pozhimukkam (46 km), C-Eravipuram to Than-

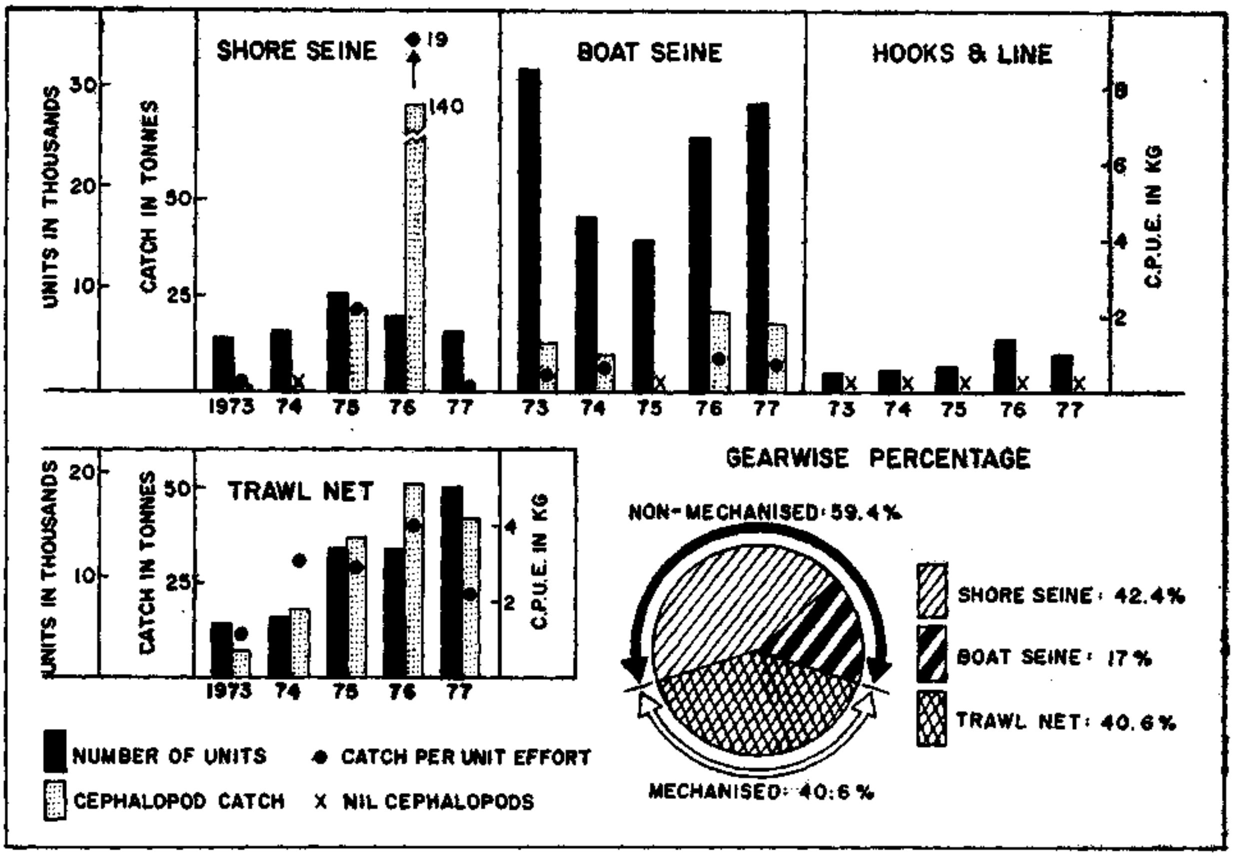

Fig. 8. Gearwise units, catch, C.P.U.E. and percentage in total cephalopod catches in Pondicherry, 1973-'77.

and 4.7 kg. In trawl catches cephalopods formed 1.3% (1973) to 4.1% (1974). During 1975 there were no cephalopod landings by boat seines but in the other years of the period 1973-77 the annual catch fluctuated between 9.8 t (1974) and 21.2 t (1976). The CPUE amounted to only 0.7 kg to 1.2 kg and the percentage contribution of cephalopods 1.7-3.2. The shore seine production amounted to 18.1 t in 1975 and declined to 1.2 t in 1976 following a fall in effort by 39%. In 1975 the CPUE and percentage contribution of cephalopods were high, 7.8 kg and 18.5% niazhikkal (54 km), D-Tharayilakadaby to Ottamasser (50 km), E-Vettakkal to Kathialam (54 km), F-Attupuram to Ponnani (71 km) and G-Koottayi to Kunnathur (245 km) (Fig. 9).

The cephalopod landings in Kerala during 1968-72 indicate that area B ranks first in production with 52% of the State's cephalopod production and area A occupied the second place with 42.5%. The remaining small landings were obtained from the areas C, D, G and E and no landings were observed

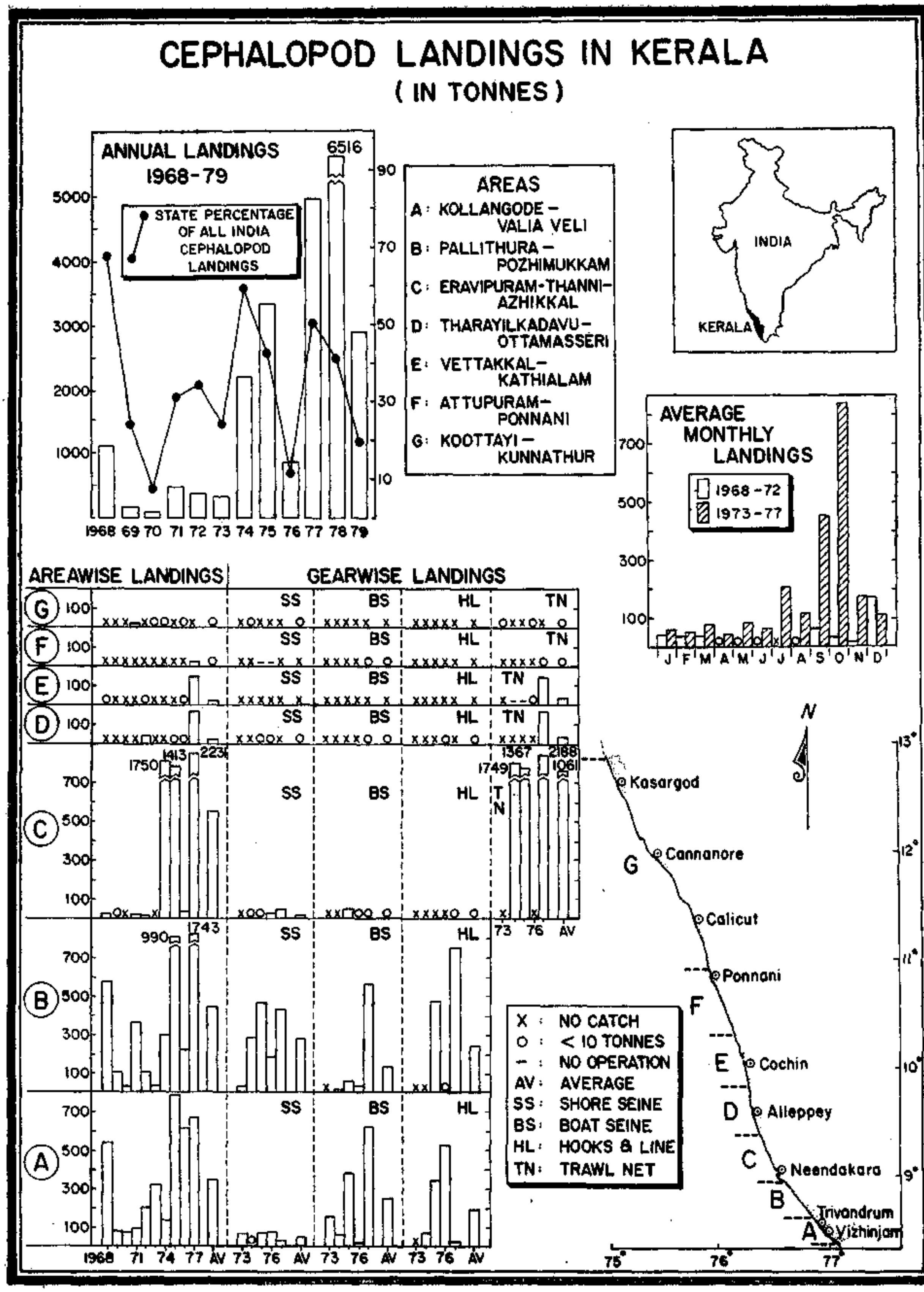

FIG. 9. Annual landings, State percentage in all India cephalopod landings (1968-'79), areawise (1968-'77) and gearwise (1973-'77) landings and average monthly landings (1968-'77) of Kerala.

in area F. The annual cephalopod landings were highest in 1968 in area B, showed a decline to 20.8 t in 1970 and once again increased to 356.4 t in 1971. The landings amounted to only 100.2 t in 1972. The best months for cephalopod catches in area B were January, September, October and December. The cephalopod landings in area A formed 528.7 t in 1968, decreased very much in the next three years and there was a slight recovery of the fishery in 1972 when the annual landings amounted to 186.9 t. In this area best catches were obtained in February-March, September-October and December. While cephalopods formed less than 1% to 11.3% in area B, they formed a maximum of 6.7% in area A. The annual landings in area C were low with maximum production of 20.9 t and 19.7 t in 1968 and 1971 respectively.

In contrast to 1968-72, area C accounted for highest cephalopod landings in the State during 1973-77 with 47% of the production. Area B (28.3%) and A (21.6%) were next in importance.

48.9% of the State's cephalopod production came from trawl nets, 19.7% from hooks and lines (*Choonda*), 16.8% from boat seines *Thattumadi, Thanguvala, Kollivala*) and 14.6% from shore seines (*Karamadi, Kamba vala*) during the period 1973-77 (Fig. 10). The CPUE of trawl nets was high (6.2-22.8 kg) in July, September and October, of hooks and lines (1.2-4.5 kg in January, October and November, of boat seines (0.6-1.5 kg) in July, September and October and of shore seines (2.1-13-4 kg) in March, June, September and December.

The annual cephalopod landings in area C were high in 1974 and 1975 with production of 1,749.9 t and 1,413.3 t and after a sharp decline in 1976, once again rose to a peak level of 2,231.1 t in 1977. The best cephalopod landings were obtained in May and from July to November. 96.8 to 99.9% of the production in this area was obtained by trawlers with CPUEs ranging from 4.8 kg to 11.7 kg. There was no relationship between the effort expended and the landings. The maximum cephalopod production of 2,188.2 t was got by trawlers in 1977 and it accounted for 0.9 to 3.5% in the total trawl landings. The shore seines landed 1.5% of the cephalopods caught in the area and the annual landings formed only 0.9 t and 5.5 t in 1974 and 1975 but increased to 32 t and 40.5 t in 1976 and 1977. The CPUE increased from less than 1 kg in 1974 to 3.01 kg in 1977 and in the latter year the cephalopods formed 2.8% in the total shore seine catches. The boat seines landed only 0.8% of cephalopods caught in the area. The landings amounted to 40.4 t in 1975 but they were very low in 1977 although the effort spent was slightly higher. Hooks and lines were operated in large numbers throughout the period in this area but only negligible landings were obtained in 1977.

The cephalopod landings in area B increased from a low level of 22.8 t in 1973 to 990.3 t in 1975 when the effort increased only by about 31%. After a fall to 216 t in 1976, the landings again increased steeply to 1,742.9 t in 1977 following an increase in the effort by only about 56% compared to that in 1976. The best cephalopod catches were obtained in this area in March, June and September to December. The shore seines accounted or 42.2% of the cephalopod production in the area. The landings showed two peaks, 463.8 t and 429 t in 1975 and 1977 and fluctuated between 22.8 t and 281 t in the other three years of the 1973-77 period. In the years of the peak catches the CPUEs were 9.2 kg and 5.8 kg and cephalopods formed 4.9 to 5.1% in total catches. The hooks and lines were the next important gear which landed 37.5% of cephalopods in this area. The landings amounted to 472.7 t and 749 t in 1975 and 1977 but in other years there were either no catches as in 1973-74 or they were negligible. The CPUEs of hooks and lines were high 11.3 kg and 11.3 kg in 1975 and 1977 when cephalopods formed 62.9% and 44.6% of the total landings from the gear in the area. 20.3% of the cephalopod production in the area came from boat-seines. The annual landings amounted to only 12.5t 53.8 t during 1974-'76 and showed a sharp rise to 564.7 t in 1977 although there was not much difference in the effort expended. In 1977 the CPUE as well as the percentage contribution of cephalopods to the total landings were high, 9.8 kg and 8.7% respectively. Trawlers did not operate in this area.

In area A the estimated cephalopod landings increased from 314.3 t in 1973 to 784.4 t in 1975 and in the succeeding two years they amounted to 604 t and 663.8 t. In this area the best months for cephalopods were January and July to October. Boat seines landed 49.1% of the production in the area. The cephalopod landings by this gear more than doubled in 1975 and amounted to 381.5 t although the effort was less than that in 1973 by 26%. The landings increased much further to 622.1 t in 1977 inspite of a further decrease in effort by 32%. The CPUE of boat seines ranged from less than 1 kg to 5.7 kg. In the total production of boat seines, cephalopods formed 0.2 to 5.5%. Good quantities of cephalopods, were landed by hooks and lines also, the production from the gear amounting to 42%. Catches from this gear increased from 98 t in 1973 to 526.7 t in 1976 when

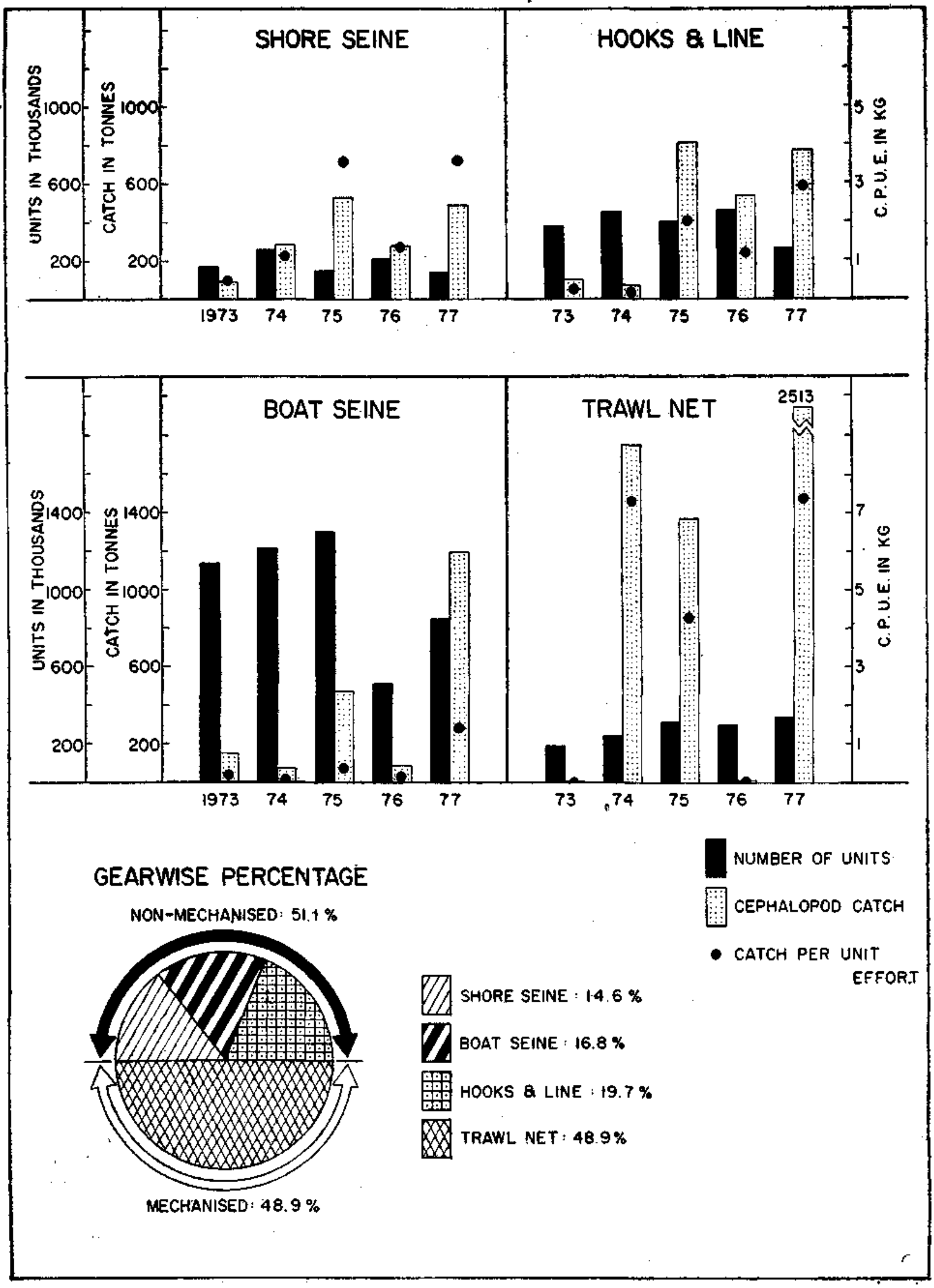

FIG. 10. Gearwise units, catch, C.P.U.E. and percentage in total cephalopod catches in Kerala, 1973-'77.

there was a rise in effort by 31% but declined to 16.9 t in 1977 following a fall in effort by 63%. The CPUE of hooks and lines fluctuated from less than 1 kg to 1.6 kg and cephalopods formed 7.8 and 11.1% in total production in 1975 and 1976. Only low to moderately good landings ranging between 3.3 t and 65.4 t were obtained from shore seines and the catches did not show any well-defined changes with the effort. Cephalopods accounted for 0.4 to 5.7% of the total shore seine landings. Trawlers were not operated in this area.

In area D the cephalopod landings were very poor, 5-7 t in 1975-1976 and sharply rose to 175 t in 1977 when the effort increased only by 18% compared to that in 1976. The cephalopods were obtained in good quantities in October. 99.9% of the total cephalopod production in this area during 1973-77 was obtained in trawl nets in 1977 when the average CPUE was 3.2 kg and percentage contribution 1.9. Meagre landings of 6.1 t were obtained in shore seines in 1975 and 6 t in hooks and lines from this area.

In area E, the cephalopod landings amounted to only 9 t in 1976 with a CPUE of 0.1 kg and increased to 141 t with a CPUE of 2.2 kg in 1977 when there was a fall in effort by about 13%. The cephalopod catches were better in February and October than in other months. The entire production in this area was accounted for by trawl nets and there were no landings from other gears though they were employed.

In area F there were no cephalopod landings during 1973-76 and only in 1977, a total of 19.1 t were obtained out of which 10.1 t were from boat seines and 9 t from trawl nets. In this area also, though shore seines and hooks and lines were operated, there were no catches. In this area cephalopods were landed in April-May and August-September.

Area G too is one with very poor landings with annual catches of 1.2-3 t. Cephalopods were obtained in January and April in trawl nets (80%) and shore seines (20%).

Karnataka

The Karnataka coast is divided into three areas viz., area A-Talapady to Coondapoorkodi (106 km), B-Kharvikeri to Kasarkodi (115 km) and C-Alivekodi to Gotnebag (79 km). During 1968-72 the cephalopod landings in area C were higher than in areas A and B and varied from 2.2 t (1970) to 57 t (1969) with an average annual production of 20.2 t. The cephalopod catches were better in January and February than in other months in area C. In area A the cephalopod catches were very poor, the annual landings increasing from 0.4 t in 1968 to 9.1 t in 1970 and decreasing to very low level in 1971 and 1972 (Fig. 11). In this area the cephalopods were caught from September to November. In area B only 1.5 t of cephalopods were obtained in 1971 and there were no landings during the other four years.

Unlike in 1968-'72 the cephalopod production was highest during 1973-77 in areas B being 71.2% of the state's production in the period. Areas C and A accounted for 24.4% and 4.4% respectively of the production during 1973-77.

Along Karnataka coast the major portion of the catches of 85.5% were obtained in trawl nets, 14.3% in shore seines (*Rampani, Yendi*) and 0.2% in hooks and lines (*Gala, Beppu*). Boat seines were operated but no cephalopod catches were obtained. Cephalopods were caught in trawl nets during January-May, September and December, in shore seines in January, February, April and September-December and in hooks and lines in October (Fig. 12).

In area B, the cephalopod production was very high, 947.8 t in 1977 which amounted to 98.8% of the cephalopod production in 1973-77. However, in the period prior to 1977, the annual production was very low 0.2-7.4 t eventhough the effort was almost similar or much higher in the different years. The best cephalopod catches were obtained in the months March-May. 98.8% (947.1 t) of the total cephalopod production of this area during 1973-77 came from trawl catches and the rest from shore seines and hooks and lines. Though trawlers were operated throughout the period, cephalopod catches were obtained only in 1977 when the CPUE was 34.2 kg and the percentage contribution was 13. The shore seine landings ranged from 0.2 t (1974) to 7.4 t (1975). In 1975 the CPUE was 6.2 kg but it was much less in the other years. 2.8 t of cephalopods were caught in hooks and lines only in one year, 1973.

The production from area C increased from 14.4 t in 1973 to 156.5 t in 1975 following an increase in effort by 23% and decreased to 141.6 t in 1976 with a fall in effort by 18%. There was a drastic decline in landings to 16.2 t in 1977 in spite of about 11% increase in effort and the best catchs were obtained in two months March and October. About 52.2% of the cephalopod production in this area was contributed by shore seines. The shore seine landings amounted to 141.6 t in 1976 but were low in other years. The CPUE was 24.6 kg in 1976 with a percentage contribution of 1.2. Trawlers

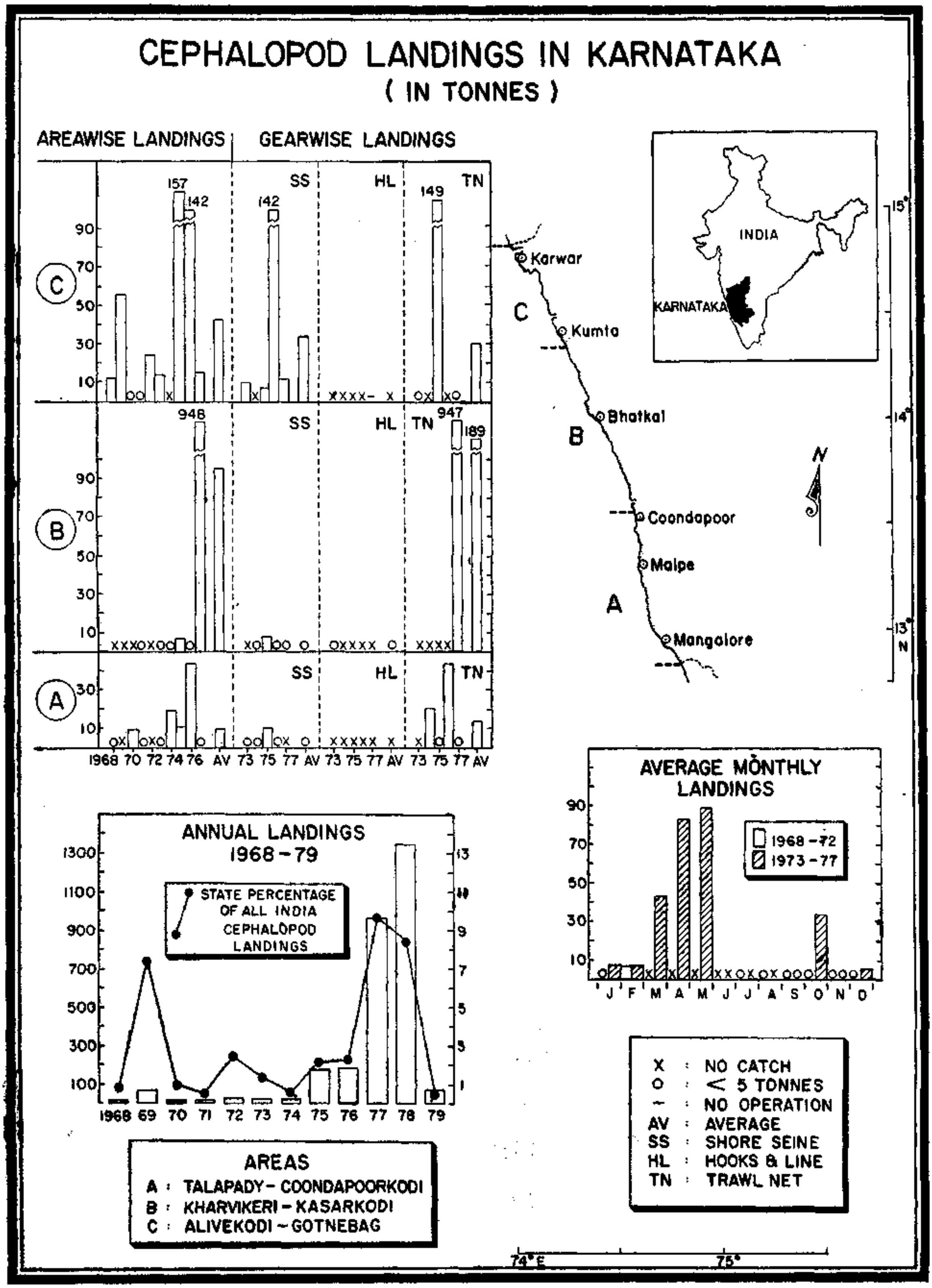

Fig. 11. Annual landings, State percentages in all India cephalopod landings (1968-'79), areawise (1968-'72) and gearwise (1973-'77) landings and average monthy landings (1968-'77) of Karnataka.

accounted for 47.8% of the cephalopod production of the area and the highest production of 149.2 t was in 1975 with a CPUE of 9.0 kg and a percentage contribution of 2.8. In 1973 and 1977 trawlers landed only 3.8 t and 4 t and in 1974 and 1976 there were no cephalopod landings. Boat seines and hooks and lines were operated in this area in small numbers but no cephalopod yield was obtained.

In 1973 and 1977 the annual cephalopod production in area A was very meagre, 1.0-1.8 t and during 1974-76 the production was higher, 11.4-44.9 t. Cephalopod catches were better in January-February. Trawl nets obtained 82.3% of the total cephalopod production with better catches of 19.6 t and 42.5 t in 1974 and 1976 with CPUEs of 1.5 kg and 1.8 kg. The trawl landings in this area in successive years did not show any clear trend compared to the effort put in. The shore seines accounted for the rest of the catches, 17.7% with the annual landings varying between 0.4 t in 1974 to 10.1 t in 1975. The CPUE of this gear fluctuated between less than 1 kg and 1.6 kg. Cephalopods were not obtained in boat seines and hooks and lines although the gears were operated in the area.

GOA

The Goa coast is divided into two areas viz., area A-extending from Polem to Majorda (75 km) and B-from Cansaulim to Querim (78 km) (Fig. 13).

The cephalopod landings were low (6.3 t) in area A in 1974 and in the next three years they were higher varying between 44 t (1976) and 80 t (1977). In this area the catches were higher in January, February September and October compared to other months, In area B the cephalopod landings increased steadily from 8.2 t in 1974 to 98 t in 1976. In 1977 the production decreased to 84 t. The best catches were obtained in this area in February, September, October and December. The average landings in area B during

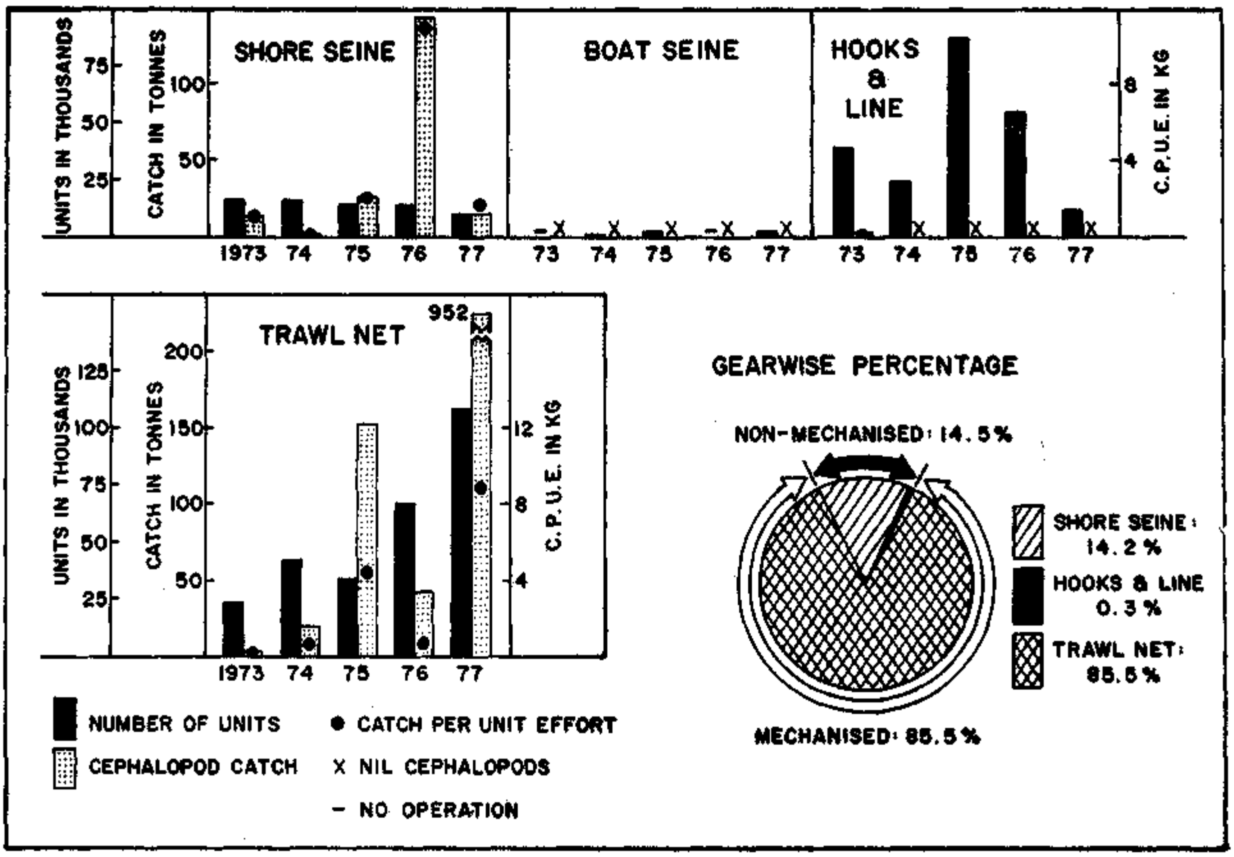

FIG. 12. Gearwise units, catch, C.P.U.E. and percentage in total cephalopod catches in Karnataka, 1973-'77.

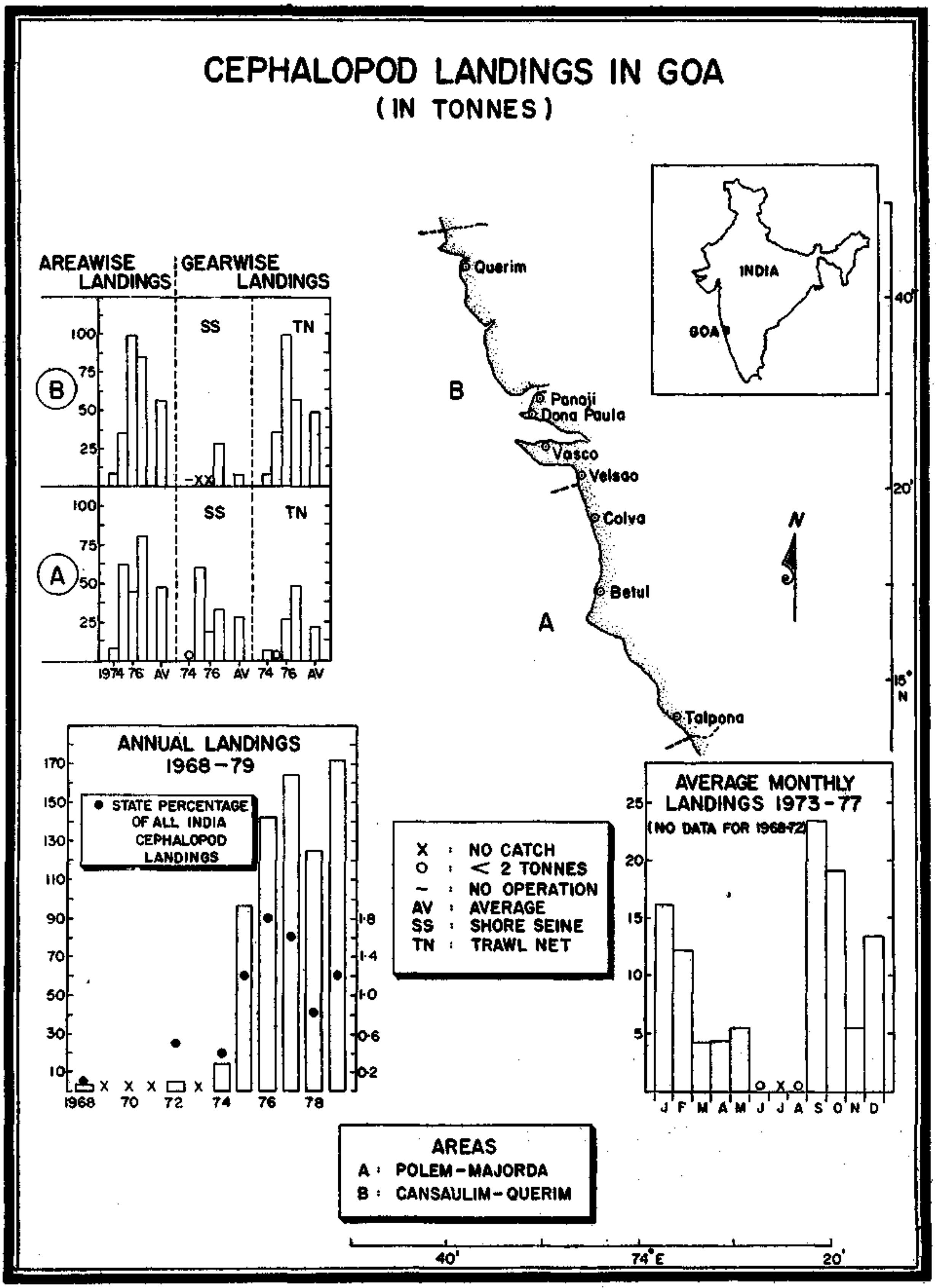

FIG. 13. Annual landings, State percentages in all India cephalopod landings (1968-'79), areawise and gearwise landings (1974-'77) and average monthly landings (1968-'77) of Goa.

1974-77 were slightly higher (56.2 t) compared to that in area A (47.8 t).

67% of the cephalopod landings along Goa coast were caught in trawl nets and the rest in shore seines (Fig. 14). Boat seines were not operated along Goa coast while hooks and lines were employed in small numbers but there were no cephalopod landings from the gear. The average CPUEs of trawlers were 2.6 kg with higher CPUE (4.8-10.6 kg) in January, September during 1975-'77. The cephalopod landings of trawlers in this area amounted to 6.1 t and 1.4 t in 1974 and 1975 respectively. There was distinct rise in the landings to 26 t and 48 t in 1976 and 1977 when there was an increase in effort by 39 to 40% as compared to that in 1975. The CPUE increased from 0.5 kg in 1974 to 4.6 kg in 1977

In area B the shore seine cephalopod landings during 1974-'77 amounted to only 12.4% and the rest were

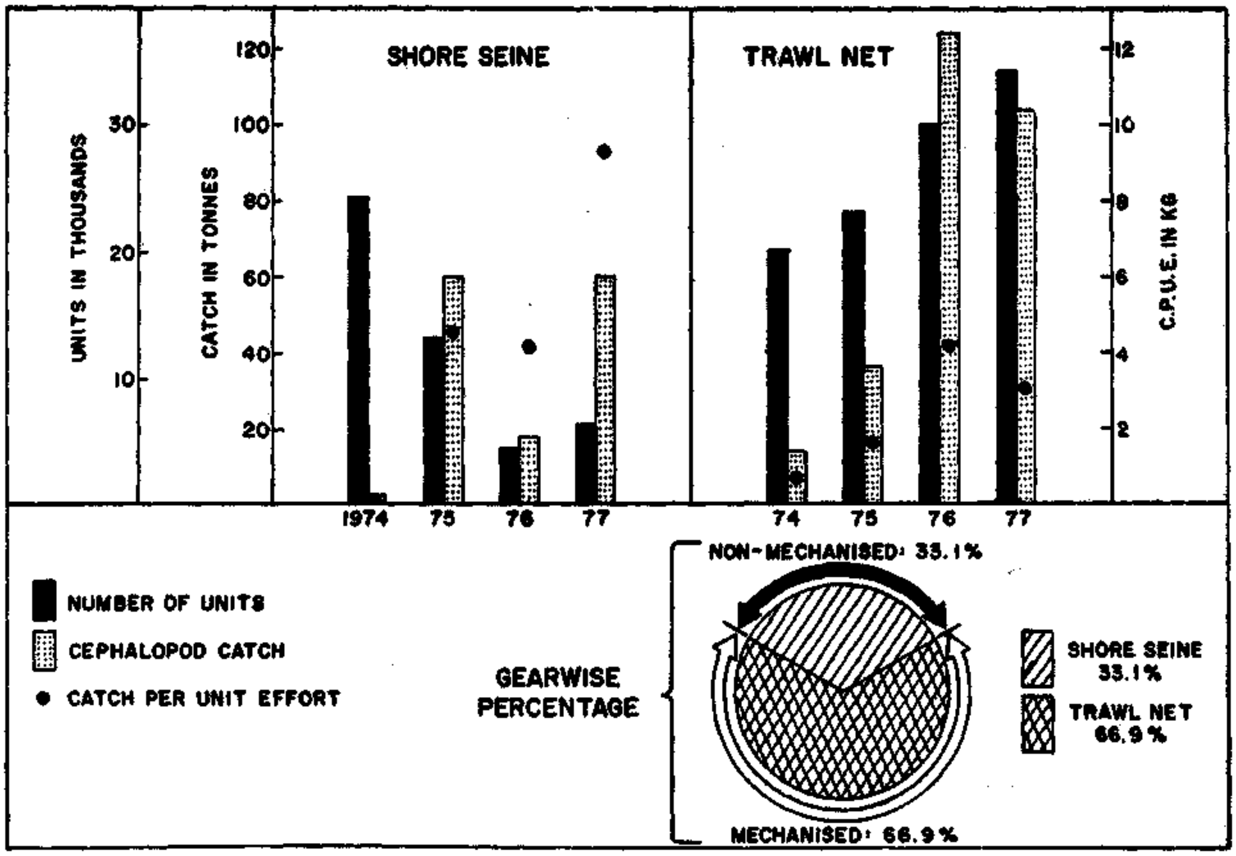

FIG. 14. Gearwise units, catch, C.P.U.E. and percentage in total cephalopod catches in Goa, 1974-'77.

and October. The average CPUE of shore seines was 2.9 kg with higher values (9.1-11.5 kg in October and December.

In area A, shore seines landed 57.4% of cephalopod production and trawl nets 42.6%. The shore seine landings increased from very low level in 1974 to 59.7 t in 1975 though there was a decrease in effort by about 46%. The production decreased to 32 t in 1977 when the effort declined by 70%. The CPUE of shore seines varied from 4.5 kg to 8.1 kg accounted for by trawlers. The cephalopod production of trawlers increased from 8.2 t in 1974 to 98 t in 1976 following a large increase in the effort by nearly three times. In spite of a further rise in effort by about 23%, the production decreased to 56 t in 1977. The CPUE of trawlers showed an increase from 1.2 kg in 1974 to 5.0 kg in 1976 and a fall to 2.4 kg in 1977. The entire shore seine production of 27.9 t was got obtained in 1977 with a CPUE of 11.4 kg and there were no cephalopod landings in 1975 and 1976 from the gear although they were operated.

MAHARASHTRA

The Maharashtra coast is divided into five areas, viz., A-Redi to Rameswarwadi (87 km), B-Vijayadurg to Dhabol (142 km), C-Boorondi to Mora (205 km), D-Sassoon Docks to Arnala (125 km) and E-Datiwari to Zavi (161 km) (Fig. 15).

During 1968-72, the highest cephalopod production was obtained from area D with 55.4% of the total cephalopod landings. In areas B and A, 23.6% and 20.5% of the total landings of the state were obtained and area C accounted for a negligible portion (0.5%). There were no cephalopod landings in area E at the northern end of Maharashtra. The landings in area D increased progressively from 33.2 t in 1968 to 268.6 t in 1971 but there was a decrease to 211.8 t in 1972. The best catches were obtained in this area in the first and last quarters. In area B the highest catches (150.9 t) were obtained in 1970 followed by a steep fall to 3.5 t in 1972. The landings were higher in this area in January, February and October-December. The production amounted to 79.7 t in 1970 in area A and later stabilized at 61.1 t and 66.8 t in 1971 and 1972 with good catches in February, September and October. In area C the catches were very poor and only in November 1971, 5.7 t were landed.

In the period 1973-77 also the cephalopod landings were highest in area D as in the previous five year period but the average annual production (508.3 t) was nearly four times that in 1968-72 Areas B and A were next in importance with average annual production of 225.5 t and 90.7 t respectively. The average annual production in area C was only 47.1 t and that in area E was insignificant (1.4 t). The cephalopod landings in area D exhibited a very steep rise by over five times from 286.7 t in 1973 to 1,541.5 t in 1976. However, there was a drastic decline to 120.2 t in 1977. In area B, the landings were low varying between 14.5 t and 48.4 t during 1973-75. But in 1976 the production was very high comparatively, 666 t and in 1977 there was a fall by about 46% to 361 t. In area A the cephalopod landings amounted to 176.4 t and 135.2 t in 1973 and 1976 and the production was much less during the other three years with annual landings of 29-82.6 t. In area C the cephalopod production was very meagre (6 t) in 1974 and 1975, increased to 145.3 t in 1976 and showed large decrease (77.2 t) in 1977 as in other areas. In area E there were no cephalopod landings during 1973-76 and only in 1977, a total of 6.7 t were landed.

The major portion of the production of Maharashtra amounting to 81.4% was obtained in trawl nets, 11.3% in *Dol* nets, 6.8% in shore seines (*Rampan*) and the rest in hooks and lines (*Hath gal, Garkadi*) (Fig. 16). The average CPUE of trawl nets during 1973-77 was 9.1 kg with high values (10.4-17.5 kg) in the months February, April, September and November-December. The average CPUE of shore seines was 7.5 kg with better yields (9.1-15.7 kg) in January, September and October. The CPUE of *Dol* nets and hooks and lines were very low.

In area D, trawl nets accounted for 86.2% of the total cephalopod production during 1973-'77 and the rest of the production was obtained in *Dol* nets. Although hooks and lines and shore seines were operated on a small scale in this area, no cephalopods were obtained. The annual trawler landings increased from 171.4 t in 1973 to 271 t in 1975 and there was a five-fold increase in 1976 to 1,447.8 t with an increase in effort by 49% compared to that in 1975. The CPUE increased steadily from 4.5 kg in 1973 to as much as 27.7 kg in 1976. In 1977 the catch as well as CPUE showed a sharp fall to 87 t and 3.0 kg respectively. The cephalopods formed a maximum of 2.5% of the total landings in 1976 and they accounted for less than 1% in other years. The *Dol* net landings amounted to 115.3 t in 1973 and in the succeeding years they were, less varying between 33.2 t (1977) and 93.6 t (1976) when the effort showed a decrease by 13-45% except in 1976 when there was a seven-fold rise in effort. The annual CPUE of *Dol* nets was 0.7 kg in 1973 and much less in other years.

In area B also the major portion of the production, 97.1%, came from trawl nets while 2.8% was from *Dol* nets and the rest from hooks and lines. During 1973-75 the cephalopod landings from trawlers varied between 3.1 t and 38 t and there was a sharp rise to 666 t in 1976. In 1977 with a fall in effort by 34% compared to that in the previous year, the landings decreased by about 47% to 354.3 t. The CPUE showed a very large increase from 1.2 kg in 1973 to 23.4 kg in 1976 while in 1977 it was 18.8 kg. In the period 1973-75 cephalopods formed less than 1% of the total trawl landings. But in 1976 and 1977 they accounted for as much as 8.4% and 5.2%. The annual landings from *Dol* nets were quite low, 4.4-10.4 t and correspondingly the CPUE was also low, less than 1 kg. Hooks and lines were operated in moderate to fairly good numbers but only in 1974 about 1 t of cephalopods was caught. Shore seines were operated in small numbers but no cephalopod yields were obtained.

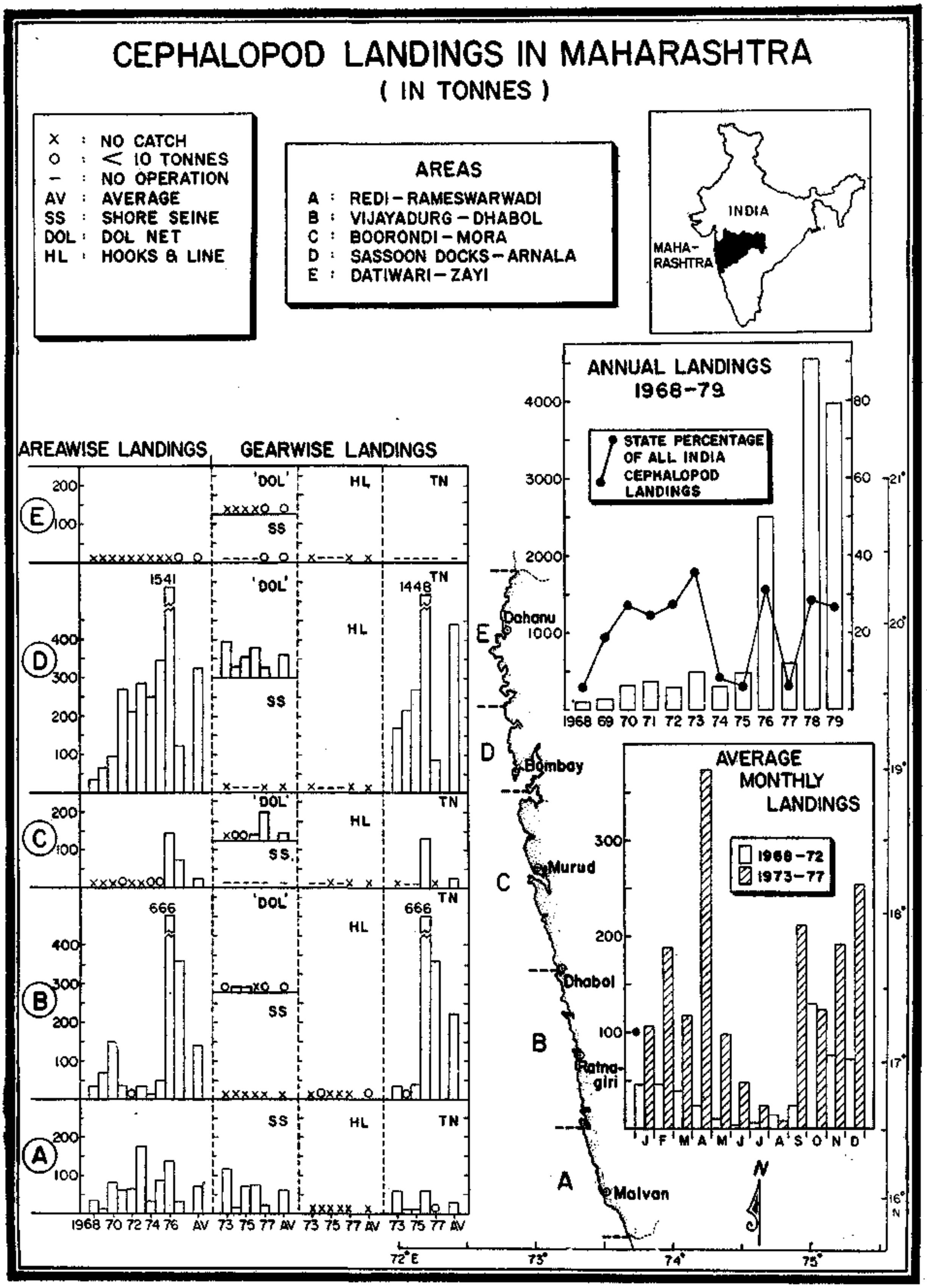

Fig. 15. Annual landings, State percentages in all India cephalopod landings (1968-'79), areawise (1968-'72) and gearwise (1973-'77) landings and average monthly landings (1968-'77) of Maharashtra.

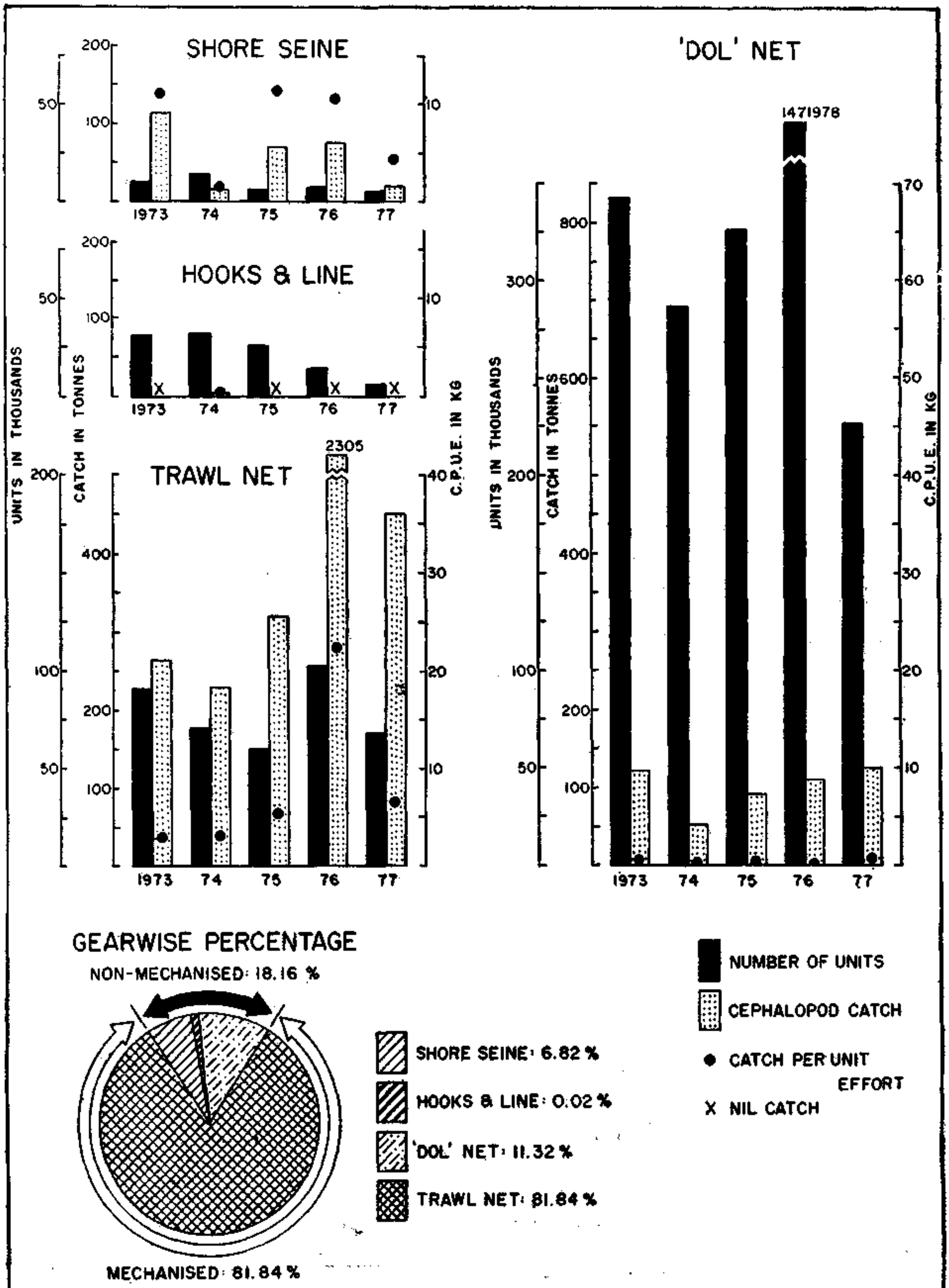

FIG. 16. Gearwise units, catch, C.P.U.E. and percentage in total cephalopod catches in Maharashtra, 1973-'77.

In area A shore seines landed 65.6% of the total cephalopod production and the rest (34.4%) by trawl nets. The highest annual production 114.3 t was obtained in shore seines in 1973 with a CPUE of 11.7 kg. During the rest of the period the landings fluctuated between 17.1 t and 74.3 t with the higher landings in 1975 and 1976 in which years the CPUE also was high (12.4 kg and 11.4 kg). The landings of trawl nets amounted to 62.1 t and decreased to 11.9 t in 1974 and 1975 when there was a fall in effort by 14% and 68% respectively. There was a rise in production to 60.9 t in 1976 though effort increased only by 7.3%. Notwithstanding the effort being 2.5 times that in 1976 there was a sharp decline in the landings to 9.3 t in 1977. The CPUE amounted to 2.9 kg and 8.2 kg in 1973 and 1976 but it was less than 1 kg in other years. Cephalopods formed from less than 1% to 3.8% of the total trawl landings. Hooks and lines were operated in all the years but cephalopods were not caught in the gear. *Dol* nets were not operated in this area.

55.4% of the total cephalopod production in area C during 1973-'77 was obtained in trawl catches in a single year, 1976 with a CPUE of 9.1 kg and the rest (44.6%) in *Dol* nets in the period 1974-77. In 1973 and 1977 trawlers were operated but cephalopods were not netted. The *Dol* nets landed 6.4-15 t of cephalopods during 1974-76. The landings increased to 77.2 t in 1977 in spite of a fall in effort by 18%. Shore seines were not operated while hooks and lines were operated in two years 1975 and 1977 and no cephalopods were caught in the gear.

In area E, only in 1977 *Dol* nets landed 6.7 t of cephalopods and 0.02 t was landed by shore seines. Cephalopods were not caught in these gears in other years. Hooks and lines were operated in small numbers in two years, 1973 and 1977 without any cephalopod yield. Trawl nets were not at all operated in this area.

GUJARAT

Among the maritime states of India, Gujarat has the longest coast extending to 1,663 km. The Gujarat coast is divided into three areas viz., area A-Ambergoan to Cambay (400 km), B-Ghogha to Porbander (491 km) and C-Maini to Hanjiasar (772 km) (Fig. 17).

The estimated cephalopod production in Gujarat during 1968-'72 was extremely low, 5.3 t. Of this 1.4 t and 1.6 t were landed from areas A and C in 1972 and 1.4 t and 1 t from area B in 1968 and 1969 respectively. The small landings of cephalopods were obtained in the months September and October in area A, February and August in area B and November in area C.

During 1973-'77 the cephalopod landings continued to be very poor or there were no landings at all in areas A and C. The annual landings amounted to 1.4 t and 9.5 t in area A in 1973 and 1975 while in area C only in two years 1974 and 1975 the annual production amounted to 6.3 t and 4.2 t. In area B there were no landings up to 1974 but in 1975 a high production of 597 t was obtained for the first time in the state which very sharply increased by over 3¾ times to 2,284.9 t in 1976. In 1977 there was a fall in the landings by 37% to 1,439 t in spite of the effort being more than double that in 1976. Very good catches were obtained in area B in six months January-April and October-November.

Most of the cephalopod production amounting to 99.5% was obtained in trawl nets while boat seines (*Golwa, Gunja*) accounted for 0.4% and hooks and lines (*Gul, Dor, Hat Dori*) 0.1% (Fig. 18). High CPUEs of 11.4-14.0 kg were observed in the case of trawl catches in March, April and October.

The cephalopod production from area B during the period 1975-'77 amounted to 4,320.9 t which constituted 99.5% of the state's production during 1973-'77. Although trawlers were operated in large numbers during 1973-'74, cephalopods were not caught. The trawl catches of cephalopods increased from 597 t in 1975 to 2,284.9 t in 1976 following a rise in effort by about 56%. However, with a further rise in effort by 31% in 1977, there was a fall in the production by 37% to 1,439 t. The CPUE more than doubled from 6.5 kg in 1975 to 15.9 kg in 1976 and it was 7.6 kg in 1977. In the total trawl catches cephalopods formed 0.8-1.7% during 1975 and 1977 and 2.8% in 1976.

In area A boat seines landed 1.4 t and 9.5 t of cephalopods in 1973 and 1975 with CPUEs of 0.1 kg and 0.6 kg respectively. But during other years there were no landings despite operation of the gear in small to large numbers. Even though the other cephalopod gears viz., trawl nets, hooks and lines and *Dol* nets, the last mentioned in large numbers, were employed in this area, cephalopods were never netted.

In area C, boat seines and hooks and lines landed small quantities of cephalopods, 7 t and 3.5 t respectively. The boat seine landings decreased from 5.9 t in 1974 to 1.1 t in 1975 although the effort increased by more than three times. The CPUE amounted to 2.7 kg

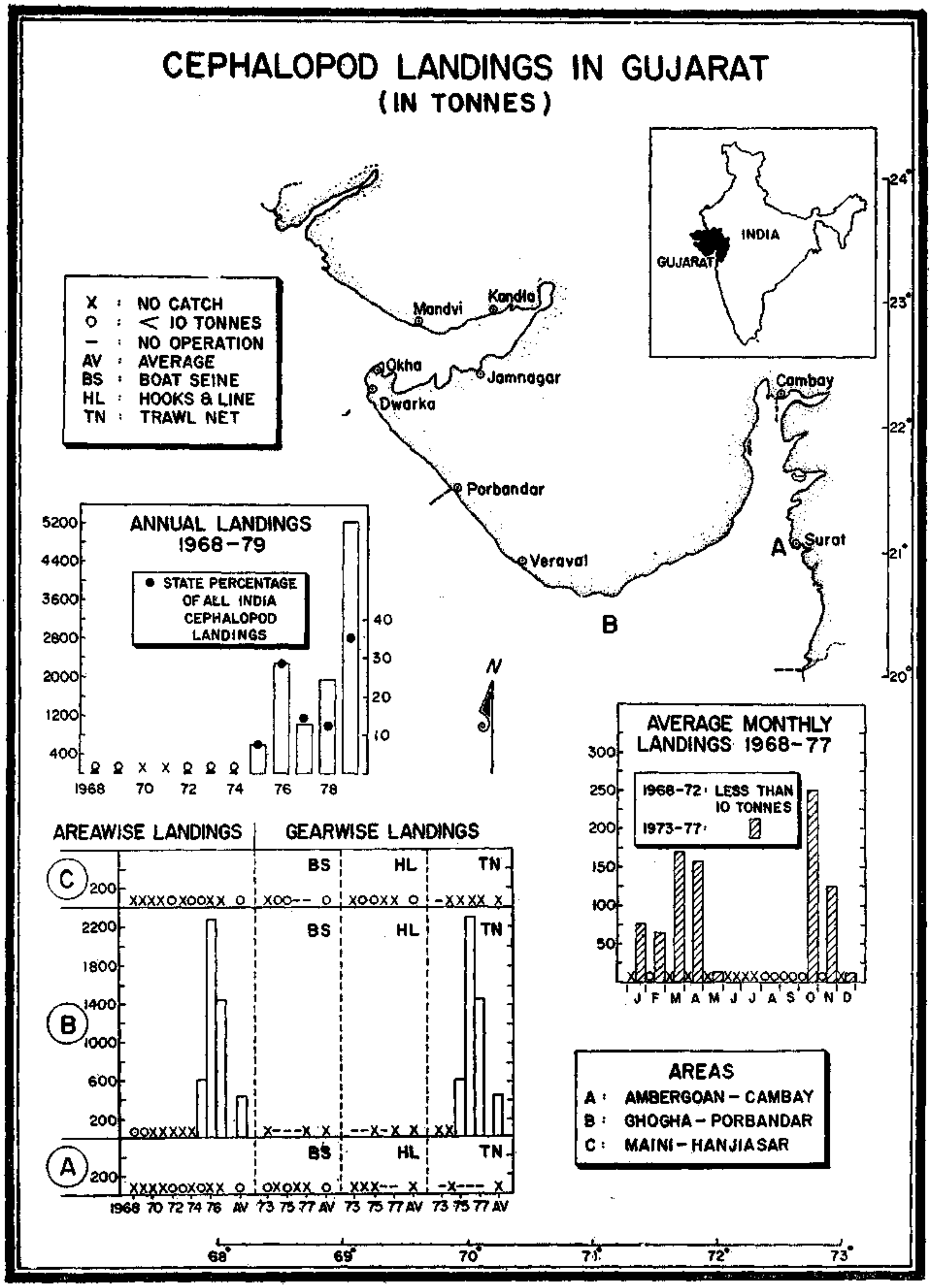

FIG. 17· Annual landings, State percentage in all India cephalopod landings (1968-'79), areawise(1968-'77) and gearwise (1973-'77) landings and average monthly landings (1968-'77) of Gujarat.

of total boat seine catches in the area in 1974 but they accounted for less than 1% in the succeeding year. The hooks and line catches in the area were less than 1 t in 1974 but amounted to 3.1 t in 1975 though there was a slight decrease in effort. The CPUE varied between 0.1 kg (1974) and 1.3 kg (1975). In 1975 cephalopods contributed 4.4% of the hooks and line catches in the area. Trawl nets and *Dol* nets were operated in the area, the former in moderate to large numbers but there were no cephalopod landings.

at low tides and octopods taking shelter therein are caught.

The annual octopod landings of Kalpeni island varied between 0.2 t and 1. 9 t in the period 1968-'75 and only in 1976 and 1977 the production was higher viz., 7.9 t and 5.5 t respectively (Fig. 19). There were no landings in 1969 and 1970. The octopods formed 1% (IV quarter) to 2.1% (II quarter) in the average quarterly production of this island.

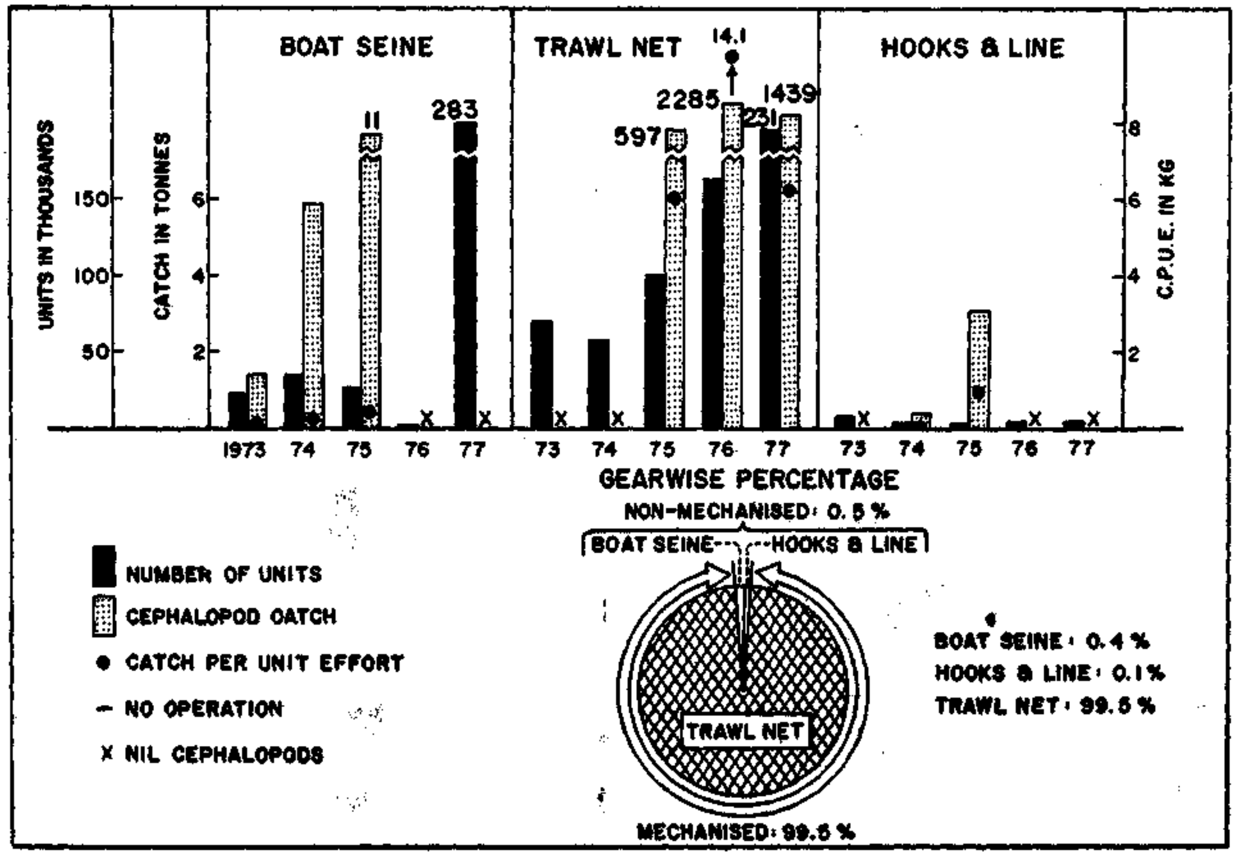

FIG. 18. Gearwise units, catch, C.P.U.E. and percentage in total cephalopod catches in Gujarat, 1973-'77.

LAKSHADWEEP

The Lakshadweep comprises of twenty seven islands, out of which ten viz., Minicoy, Kalpeni, Kavarathi, Agati, Androth, Amini, Kadamat, Kiltan, Bitra and Chetlat are inhabited. The cephalopod fishery in the Lakshadweep is supported exclusively by octopods which are fished in all the inhabited islands. The method of fishing employed is spearing which is carried out throughout the year. The spear used is an iron rod, about one metre or more in length which is sharpened at one end. The spear is thrust into coral crevices

The annual production of Kavarathi island was highest, 5.3 t in 1972 and in the other years it fluctuated between 0.3 t (1969) and 3.9 t (1976). Octopods formed 1.7% (IV quarter) to 2.4% (III quarter) in the average quarterly production of the island.

In Agati island the annual octopod catches varied between 0.1 t (1977) and 3.4 t (1973). There were no landings in 1972, 1974 and 1976. Compared to the other quarters the catches were comparatively poor in the first quarter with a contribution of about 10%.

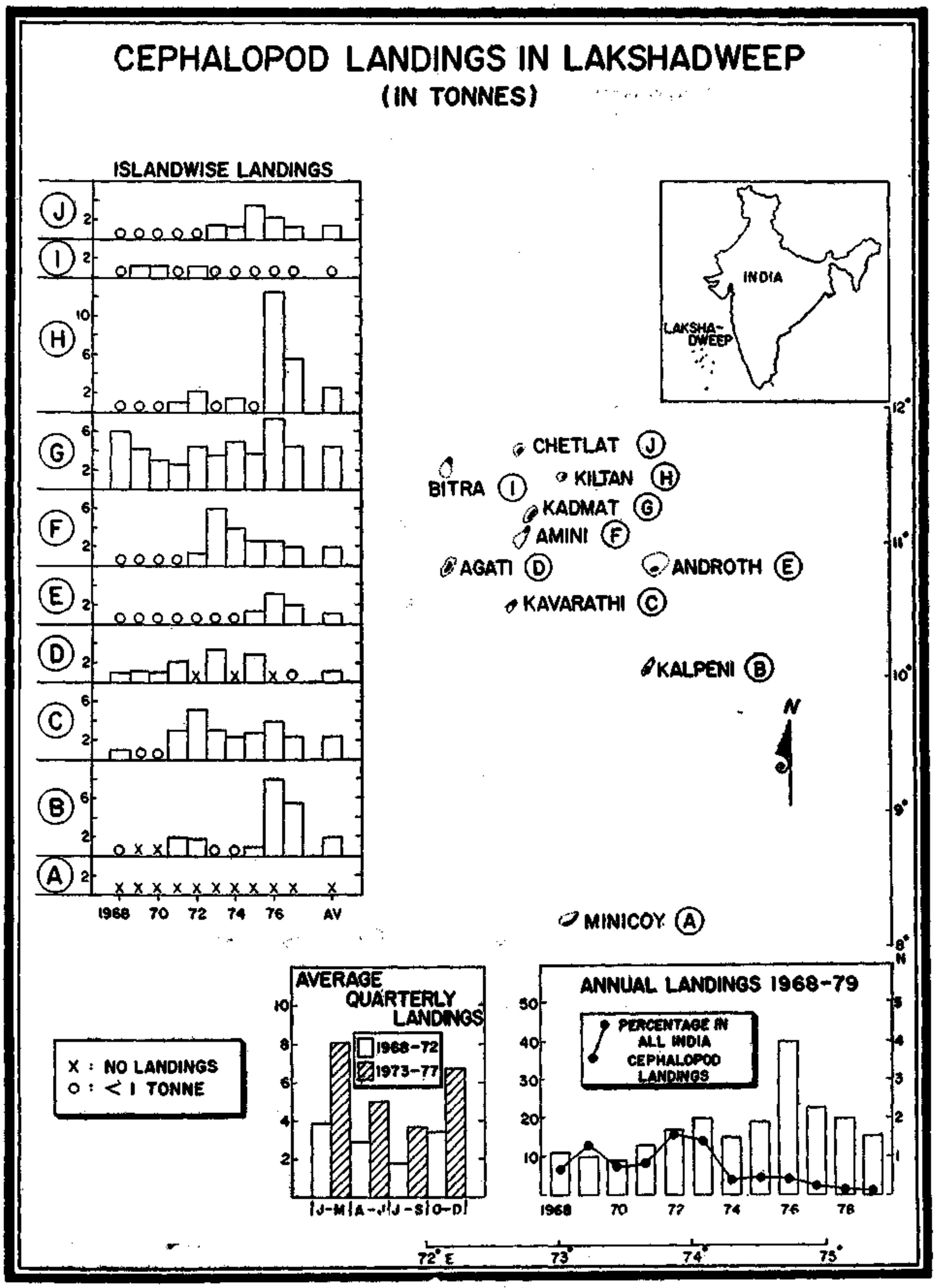

FIG. 19. Annual landings, percentage in all India cephalopod landings (1968-'79), average quarterly landings (1968-'72 and 1973-'77) and Islandwise landings (1968-'77) of Lakshadweep.

The annual landings around Androth island amounted in 1974. Cephalopods formed as much as 23.3% to less than 1 t during 1968-'74 and fluctuated between 1.4 t and 3.2 t in the period 1975-'77. The catches were less in the first quarter (18%) than in the other quarters.

The Octopod landings around Amini island in 1973 were 6 t. But in the other years they varied between 0.1 t (1968) and 4 t (1974). Octopods formed 1.6% (III quarter) to 2.4% (II quarter) in the average quarterly marine production of the island.

In the octopod production of Lakshadweep, the Kadamat island was foremost with a total production of 44.1 t in the period 1968-'77. The annual landings varied between 2.6 t (1971) and 7.3 t (1976). The best catches were obtained during first quarter (47%) and last quarter (24%). The octopods formed 3.8% of the total fish production in the island.

The octopod catch of Kiltan island formed 12.4 t and 5.6 t in 1976 and 1977 and in the other years they fluctuated between 0.8 t and 2.2 t. The catches were better in the first and fourth quarters. In this island octopods formed 2.9% of the total marine production.

Very poor landings varying from less than 1 t to 1.2 t only were landed in Bitra island. In Chetlat island also the landings of octopods were poor with a maximum of 3.5 t in 1975 while in other years the landings varied between 0.7 t and 2.2 t. In this island the octopods accounted for about 1.4% of the all fish landings.

9

CEPHALOPOD FISHERIES AT SELECTED CENTRES IN INDIA

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ABSTRACT

The cephalopod fisheries at eleven selected centres, Waltair, Kakinada, Madras, Portonovo, Mandapam, Rameswaram and Kilakarai on the east coast and Vizhinjam, Cochin, Mangalore and Bombay on the west coast have been studied and the annual and seasonal trends of the total cephalopod catches, species composition and CPUE investigated. Cephalopods were obtained in appreciable quantities in trawl nets in most of the areas studied. There is an organized fishery with hooks and lines for cuttlefish and squids at Vizhinjam. (Trivandrum).

INTRODUCTION

Squids and cuttlefishes are obtained as by-catch in conventional gears such as shore seines, boat seines, hooks and lines and trawl nets from the inshore waters at a number of centres along both coasts of India. As the cephalopods have become an important item of export they are being sought by the industry and a good amount of interest is evinced in the resources at some of the major centres in the country. The specieswise production of cephalopods caught in different gears ; the percentage in total landings ; and the CPUE of cephalopods at eleven centres viz., Waltair, Kakinada, Madras, Portonovo, Mandapam, Kilakarai and Rameswaram on the east coast and Bombay, Mangalore, Cochin and Vizhinjam on the west coast have been investigated and the results are presented here.

FISHERY AT WALTAIR

Waltair (Visakhapatnam) is one of the most important centres for cephalopods on the east coast and squids and cuttlefish are caught in three gears viz., shore seines, boat seines and trawl nets. During 1976-80, 833.6 t of squids and cuttlefishes were landed by all the gears together forming 3.7% of total landings. The average annual landings were 166.7 t in which *Loligo duvaucelii* was predominant accounting for 46.6% and the other species in the order of abundance were *Sepia aculeata* (26.1%), *Sepiella inermis* (9.0%), *Sepia pharaonis* (8.4%), *Sepia brevimana* (6.2%), *Sepia prashadi* (2.0%), *Doryteuthis singhalensis* (1.5%) and *Loliolus investigatoris* (0.2%). The catches of trawlers of the erstwhile Exploratory Fisheries Project are dealt with in Chapter 10.

About 18 shore seines operate in Lawson's Bay in the period October-May and squids and cuttlefishes are caught in small quantities. The annual catches were low and varied from 19 kg to 818 kg (Fig. 1). *Loligo duvaucelii* was the common species in the catches and a few individuals of *Sepia aculeata*, *S. pharaonis* and *Sepiella inermis* occurred in the catches occasionally.

About twenty five boat seines which operate for prawns, perches and clupeoids off Waltair coast at a distance of 3 to 5 km from the shore at depths of 5 to 8 m net squids in small quantities. The boat seine cephalopod catches consist of a single species the squid *Loligo duvaucelii* and its annual catches varied from 158 kg (1977) to 1,445 kg (1978) accounting for 0.6% and 2.9% of total catches (Fig. 1). In 1976 and 1980 *Loligo duvaucelii* was not found in the boat seine catches.

A total of 200 trawlers operate off Waltair coast between Lat. 17° and 18°N and Long. 82°30' and 84°E at depths of 10-70 m. The estimated total cephalopod production of the trawlers during 1976-'80 was 829.9 t and average annual production was 166 t

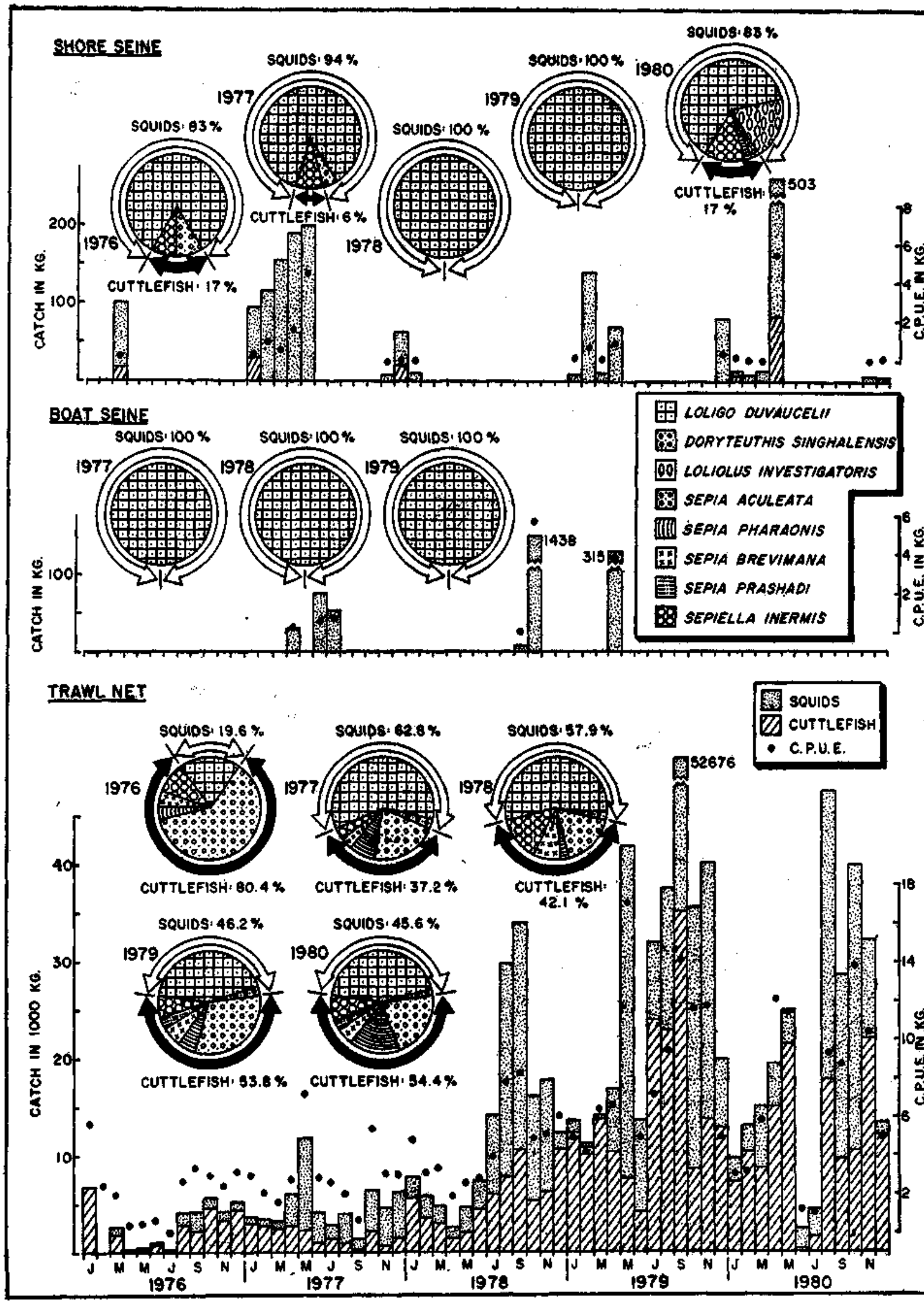

FIG. 1. Monthly total cuttlefish and squid catches, CPUE and annual species percentage composition of cuttlefishes and squids landed by shore seines and boat seines at Lawson's Bay, and trawlers at Waltair (Visakhapatnam) during 1976-'80.

forming 3.7% in total trawl catches. During the five year period *Loligo duvaucelii* was the dominant species (46.4%), *Sepia aculeata* was next in importance (26.2%) and the abundance of the other species is similar to that in all-gears combined figures. The annual cephalopod landings of the trawlers progressively increased from 36,302 kg in 1976 to a peak of 329,059 kg in 1979 and there was a sharp decline in the catches by 23.9% to 250,520 kg in 1980 with a decrease in effort by only 2.4%. The CPUE showed a similar trend with a maximum of 8.7 kg in 1979. During 1976 squids formed only 19.6% of cephalopod landings while in 1977 they amounted to 62.8% (Fig. 1). During 1978-'80 there were no large differences in the catches of squids and cuttlefishes the annual percentages of the two groups varying between 45.6% and 57.9% and 42.1% and 54.4% respectively.

Among squids, *Loligo duvaucelii* was the predominant species and formed 95-99% of the catches. The landings of this species rose from 7,104 kg in 1976 to 145,085 kg in 1979 and declined to 110,267 kg in the next year. The peak months for *L. duvaucelii* were May, August and September to November when the CPUE also was higher than in other months. *Doryteuthis singhalensis* and *Loliolus investigatoris* were represented only in very small quantities.

The cuttlefish landings which amounted to 29,190 kg in 1976 showed a rise to 176,915 kg in 1979 and a fall to 136,202 kg in 1980. Five species *S. aculeata, S. pharaonis, S. brevimana, S. prashadi* and *S. inermis* comprised the cuttlefish catches. The annual landings of *S. aculeata* varied between 12,045 kg (1977) and 102,245 kg (1979) and the best months were September to February. The annual landings of *S. pharaonis* increased from 1976 and high landings of 18,570 kg and 41,948 kg were obtained in 1979 and 1980. For this species the peak months were March and September to December. *S. brevimana* amounted to only 1,733 kg and 2,626 kg in 1976 and 1977 but the landings increased several fold and amounted to 14,409 kg and 20,618 kg in 1978 and 1979 respectively. Peak catches of this species were obtained in February, July, September and November. *S. prashadi* occurred in small numbers in January and March, 1978 but in the next two years it was caught in a number of months and the annual landings amounted to as much as 11,380 kg in 1979. Highest catches were obtained in January and February. The landings of *S. inermis* were very low in 1976-'77. But there was a ten to twelve fold rise in subsequent years the annual landings amounting to 21,656 kg and 24,102 kg. The peak months for this species are July to October.

Fishery at Kakinada

Cephalopods are obtained along Kakinada coast mainly in trawl catches. In shore seines *L. duvaucelii, S. aculeata* and *S. inermis* are caught in stray numbers. There are about 150 trawlers at Kakinada which operate between Lat. 16°35' and 17°25' N and Long. 82°20' and 83°10' E at depths of 5-70 m. Kakinada is one of the major centres for cephalopods and total production in the period 1976-'80 was 747,355 kg which indicates an average annual production of 149,471 kg forming 1.1% of trawl landings. In the cephalopod landings during 1976-80 *S. aculeata* and *S. inermis* were the dominant species (35.1% and 32.7% respectively), *L. duvaucelii* was the next dominant species (24.9%) and the others represented were *S. pharaonis* (7.1%) and *L. investigatoris* (0.2%).

The annual cephalopod landings rose from 105,634 kg in 1976 to an all time high of 256,783 kg in 1977 (Fig. 2) following an increase in effort by about 43%. During the period 1978-80 when there was not much significant change in the effort put in, the landings were lesser and stabilized at 124,151 kg-139,916 kg. The monthly catches of cephalopods showed much variation in different years but it could be stated that good catches are got generally from September to May. The monthly CPUE of cephalopods varied from 0.6 kg to 27.5 kg and high CPUEs were recorded in March, May and August-December. The cuttlefishes were dominant in trawl catches forming 67.8% to 79.6%. Squids accounted for only 20.4% to 32.2% in 1976-'80 and were represented by *L. duvaucelii* mostly with an annual catch which varied from 25,362 kg (1979) to 58,758 kg (1977). The peak catches were obtained in the months May, August, September and December. 1,099 kg of *Loliolus* sp. were got in trawl nets in September 1978.

Cuttlefish landings comprised of three species *S. aculeata, S. pharaonis* and *S. inermis* and the peak months for cuttlefishes were January, March, May and September-December. *S. aculeata* was the dominant species (46.9%) among cuttlefishes and the annual catch varied from 22,158 kg (1978) to 129,719 kg (1977) with high CPUEs in January, March, September and December. The annual catches of *S. pharaonis* varied between 3,808 kg (1978) and 26,468 kg (1980). The yearly catches of *S. inermis* varied between 27,989 kg (1976) and 62,769 kg (1978) with maximum CPUEs from August to December.

Fishery at Madras

Trawlers based at Madras obtain cephalopods by otter trawling between Lat. 12°20'N and 14°N and

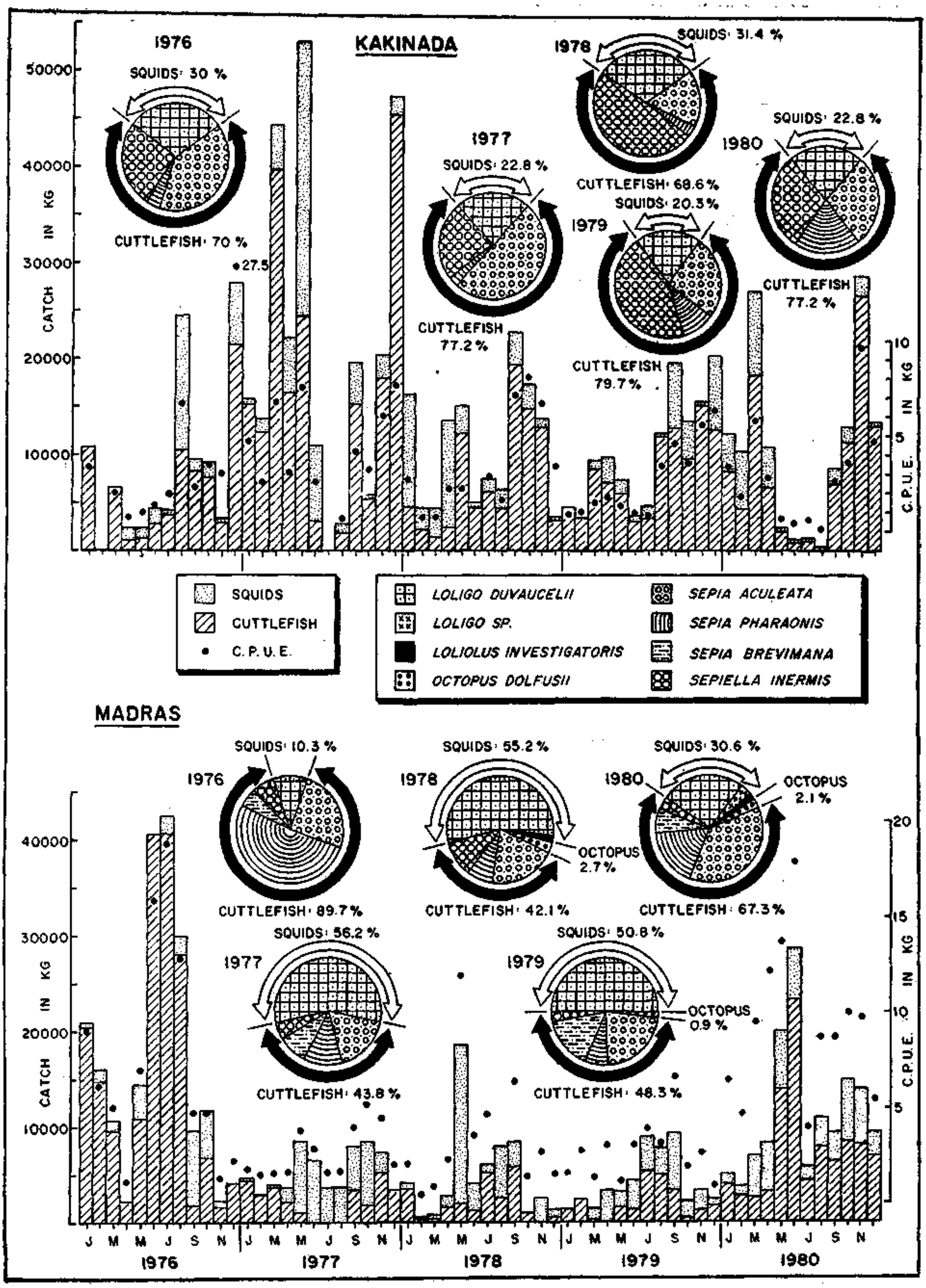

FIG. 2. Monthly total cuttlefish and squid catches, CPUE and annual species percentage composition of cuttle fishes and squids landed by trawlers at Kakinada and Madras during 1976-'80.

Long 80°20' and 80°40'E at depths of 10-30 m. The estimated cephalopod production of the trawlers during the years 1976-'80 was 517,442 kg with an average annual production of 103,688 kg, forming 6.4% of trawl landings. *L. duvaucelii*, *S. pharaonis* and *S. aculeata* were the common species in the catches forming 29.1%, 28.7% and 26.7% respectively and the other species in the order of abundance are *S. brevimana*, *S. inermis*, octopods, *Loligo* sp. *Loliolus investigatoris*, *Euprymna stenodactyla* and *S. prashadi*. The annual cephalopod catch was highest, 205,383 kg in 1976 and in the succeeding years it decreased following a fall in effort by 5.5% to 56.5% and only in 1980 there was a recovery of the fishery with landings of 137,815 kg (Fig. 2). The peak periods of catches varied much in the five years but usually large catches were obtained during January and May-October. The monthly CPUE varied markedly from 0.65 kg to 18.8 kg. The annual CPUE varied between 2.6 kg (1977) and 9.5 kg (1980). The relative contribution of squids and cuttlefishes varied over the years. In 1976 and 1980 squids formed 10.3% and 30.6% and in 1977-'79 they amounted to as much as 50-8%-56.2%. Cuttlefish formed 89.7% and 67.3% in 1976 and 1980 respectively but in 1977-'79 they accounted for only 42.1% to 48.3%. Octopods occurred sporadically in trawl catches between February and September and annual catches of 476 kg to 2,940 kg were obtained off Madras coast during 1978-'80. As in the catches off Waltair and Kakinada, *L. duvaucelii* was the predominant species forming 84.6% to 100%. Good catches of the squids were got from April to June and in August and November. The annual CPUE showed a rise from 0.80 kg in 1976 to 2.4 kg in 1980. *Loligo* sp. and *Loliolus investigatoris* formed 0.2% to 10.5% of squid catches.

The best months for cuttlefishes were January and May-August. The annual landings of *Sepia aculeata* varied from 11,297 kg (1979) to 52,499 kg (1980) forming 27.9% to 56.6% of the cuttlefish landings. The annual CPUE increased from 0.5 kg in 1977 to 3.6 kg in 1980. *Sepia pharaonis* was the dominant cuttlefish species in 1976 with a catch of 108,760 kg (59% of cuttlefish catch). The annual landings of this species varied between 3,452 kg and 24,719 kg (4.1% to 26.7% of cuttlefish landings) during 1977-'80. The annual catches of *Sepia brevimana* varied from 5,890 kg to 10,632 kg. *Sepiella inermis* formed 5.5% to 12.7% of the cuttlefish landings with yearly catches of 1,610 kg to 13,355 kg and CPUE of 0.1 kg to 0.5 kg and *Sepia prashadi* occurred only in very small quantities in two years, viz., 1977 and 1980. The dumpling squid *Euprymna stenodactyla* and octopods were also represented in the trawl catches in small quantities only.

Fishery at Portonovo

About 40 trawlers trawl off Portonovo coast between Lat. 11°10' and 12° N and Long. 79°55' and 80°10'E and moderately good catches of squids and cuttlefish occur. During the period May, 1976 to December, 1978 an estimated catch of 28,315 kg of cephalopods were obtained and the average annual catch was 10,618 kg forming an average of 1.3% of the total trawl catches. *Sepiella inermis* and *Sepia aculeata* were the dominant species in the cephalopod landings at Portonovo forming 39.3% and 37.6% respectively. *Sepia pharaonis* is third in importance (18.7%) and two species *Loligo duvaucelii* (3.9%) and *Euprymna stenodactyla* (0.5%) were of minor importance.

The contribution of squids to the total cephalopod catches was only 16.4% and the rest consisted of cuttlefishes in 1976 but in 1977 and 1978 squids contributed only 2.4 to 3.3% while cuttlefishes amounted to 97.6% and 96.7%. The estimated annual cephalopod landings amounted to 16,158 kg in 1977 and decreased to 9,250 kg in 1978 (Fig. 3). There was a shift in the species domination from 1976 when the fishery was mainly supported by *Sepia aculeata* to later years when *Sepiella inermis* dominated in the catches. The annual catches of *Loligo duvaucelii* were low, 111 kg. and 526 kg.

Cuttlefish catches were better in January and from May to August compared to other months. Among cuttlefishes the catches of *Sepia aculeata* varied from 1,815 kg to 4,483 kg (28.7% to 74.7%), those of *Sepia pharaonis* from 388 kg to 4,892 kg (0.1% to 31.3%) and those of *Sepiella inermis* 227 kg to 6,257 kg (0.3% to 51.6%). In March and July small numbers of *Euprymna stenodactyla* were obtained by a few trawlers.

Fishery at Mandapam

About 120 trawlers based at Mandapam do otter trawling throughout the year and cephalopods are got in the trawl catches in greater or lesser quantities. Trawling is carried out between Lat. 9°10' and 10°N and Long. 79° and 79°20' E at depths of 10-40 m. In the period January, 1976 to September, 1978, a total of 83,611 kg of cephalopods were landed and average annual catch was 30.4 t forming 0.5% of total trawl production.

The estimated annual cephalopod landings amounted to 40,579 kg in 1976 and decreased by 41.1% to 23,903

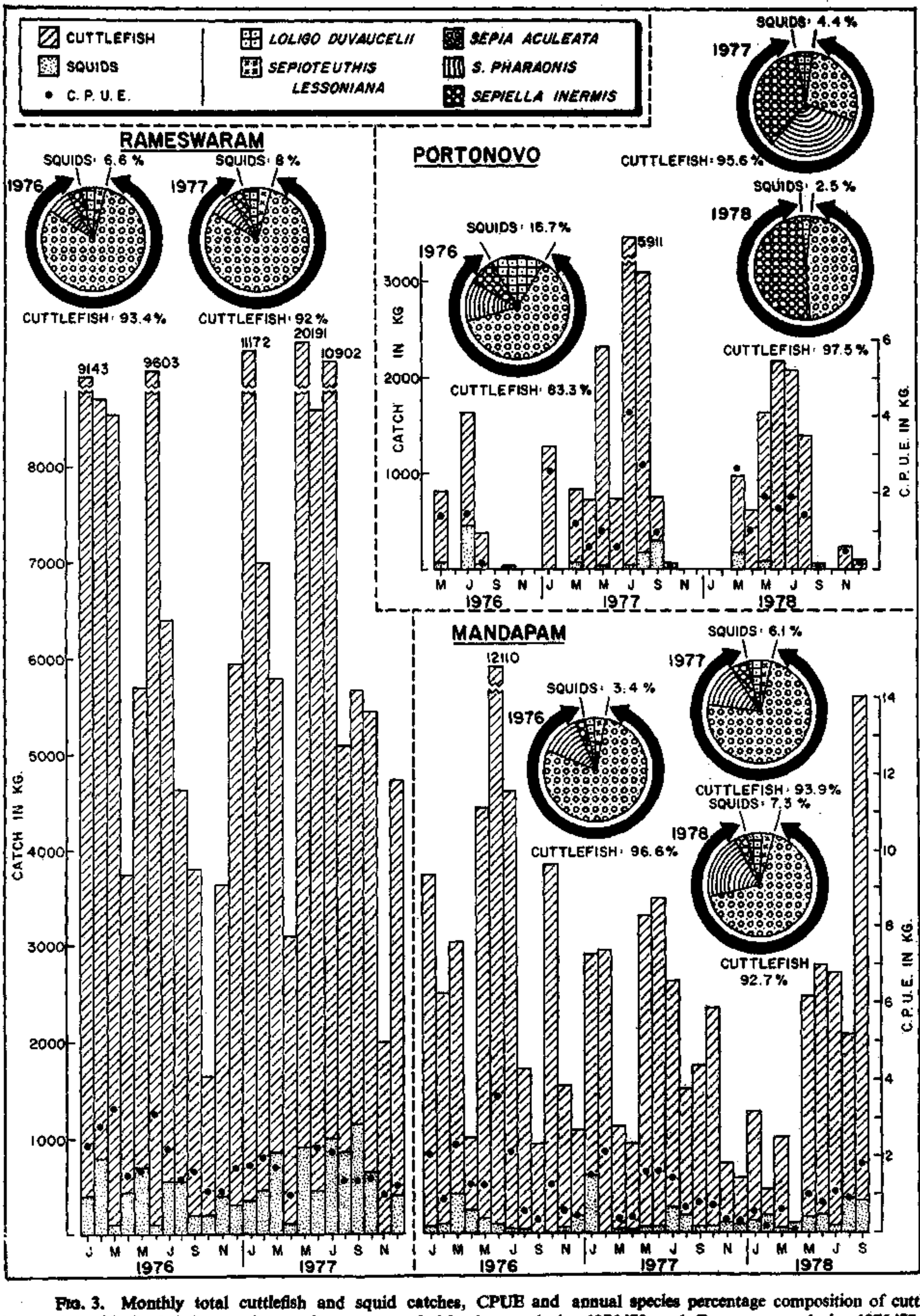

Fig. 3. Monthly total cuttlefish and squid catches, CPUE and annual species percentage composition of cuttlefishes and squids landed by trawlers at Portonova and Mandapam during 1976-'78 and Rameswaram during 1976-'77,

kg in 1977 with a decrease in effort by 8.7% (Fig. 3). The catches during the period January-September, 1978 were 19,129 kg which were only slightly lower than those in the corresponding period of the previous year (20,643 kg). Along Mandapam coast the best months for cephalopods were May to July.

Cuttlefishes predominated in cephalopod catches forming as much as 92.7% to 96.6% and squids accounted for the rest (3.4% to 7.3%). The annual cephalopod catches amounted to 39,213 kg in 1976 and decreased by 42.8% in 1977. The best cuttlefish catches were obtained in January, May to July and October. The cuttlefish landings consisted of three species *S. aculeata, S. pharaonis* and *Sepiella inermis* of which *S. aculeata* was the dominant one constituting 69.8 to 83.2%. *Sepia pharaonis* accounted for 11.7 to 20.1% and *Sepiella inermis* 1.7% to 5.6%. The CPUEs of cuttlefishes were generally higher in the months January to July than in other months. The catches of the common species *Sepia aculeata* amounted to 33,765 kg in 1976 but decreased by as much as 47.2% to 17,813 kg in 1977 which is indicative of wide fluctuations in yearly catches. During 1976 and 1977, the landings of *Sepia pharaonis* amounted to 4,777 kg and 3,299 kg respectively. *Sepiella inermis* is a minor component of the catches with annual landings of 671 kg and 1,334 kg in the two years. The annual squid landings amounted to only 1,366 kg and 1,457 kg in 1976 and 1977. *Loligo duvaucelii* formed 25.1% to 34.5% and the rest consisted of *Sepioteuthis lessoniana* in the two years.

Fishery at Rameswaram

About 140 trawlers which do bottom trawling between Lat. 9°20′ and 10°N and Long. 79°10′ and 79°40′ E land cephalopods. The fishing grounds coincide to a large extent with those of the trawlers based at Mandapam. The cephalopod landings at Rameswaram amounted to 160.6 t during 1976-77 forming 1.1% of the total trawl landings. The annual landings increased from 70,823 kg in 1976 by 26.7% to 89,773 kg in 1977 (Fig. 3) following an increase in the boat trips by 34.3% in the year. The average CPUE of cephalopods was slightly higher (2.15 kg) in 1976 compared to that (1.93 kg) in 1977. The cephalopod landings were high in two periods in the year viz., January to March and May to July or September.

As in the cephalopod catches at Mandapam, in the landings at Rameswaram also, cuttlefishes dominated forming 92.1% to 93.4% and squids amounted to only 6.6% to 8.0% (Fig. 3). The best months for cuttlefishes were the same as those for total cephalopods. The species composition of cuttlefishes was similar to that in the Mandapam landings. During 1976 and 1977, *Sepia aculeata* amounted to 58,463 kg (82.5%) in total cephalopod landings and 73,936 kg (82.3%), *Sepia pharaonis* formed 5,332 kg (7.5%) and 6.082 kg (6.8%) and *Sepiella inermis* 2,348 kg (3.3%) and 2,617 kg (2.9%) respectively. The squid catches amounted to 4,685 kg in 1976 and 7,138 kg in 1977. In contrast to landings at Mandapam *Loligo duvaucelii* was the dominant species forming 54.7% to 62.6% among squid catches and *Sepioteuthis lessoniana* accounted for only 37.4% to 45.3%.

Fishery at Kilakarai

The squid *Sepioteuthis lessoniana* is caught in the shore seines *Kara valai* and *Ola valai* and handlines. The annual landings of the species from *Kara valai* varied between 3,781 kg and 4,797 kg during 1973-'75 but in 1977 the catches were very low, 329 kg. The fishing season for the squid extends from January to May or June in the area. In some years as in 1973 and 1974 it was caught in small quantities in the second half-year period also. The peak catches are got in the months January to March and June and high CPUEs ranging from 9.3 kg to 15.6 kg were noticed in the months of peak landings. *Sepioteuthis lessoniana* formed 5.5% to 9% of the total *Kara valai* landings during 1973-'75 but accounted for only 0.5% in 1977. Apart from *Sepioteuthis lessoniana* stray numbers of *Sepia aculeata* were obtained rarely in March, 1974. In earlier decades the special type of shore seines *Ola valai* used to be employed regularly in the period January-June and *Sepioteuthis lessoniana* were caught in large numbers along the Ramanathapuram coast (Rao, 1954). But in the recent years this net is employed only occasionally even during the fishing season. The reason for this is that the fishermen owning the nets go to work in trawl fishing where they get better income. *Sepioteuthis lessoniana* landings of *Ola valai* varied from 213 kg to 761 kg during the fishing seasons of 1973-75 and the catch was 207 kg in 1977. This species was the predominant one in the catches of the gear forming 83.8% to 93.9%. The monthly CPUE of the species varied over a range of 3.8 kg to 11.6 kg.

Sepioteuthis lessoniana is caught in small quantities in handlines in the Mandapam area and around Rameswaram Island in the period October to March or April and sometimes up to June. The handlines are used by fishermen from a dug out canoe or standing in shallow coastal waters. The annual landings from this gear were meagre, 143 kg to 480 kg with monthly CPUEs

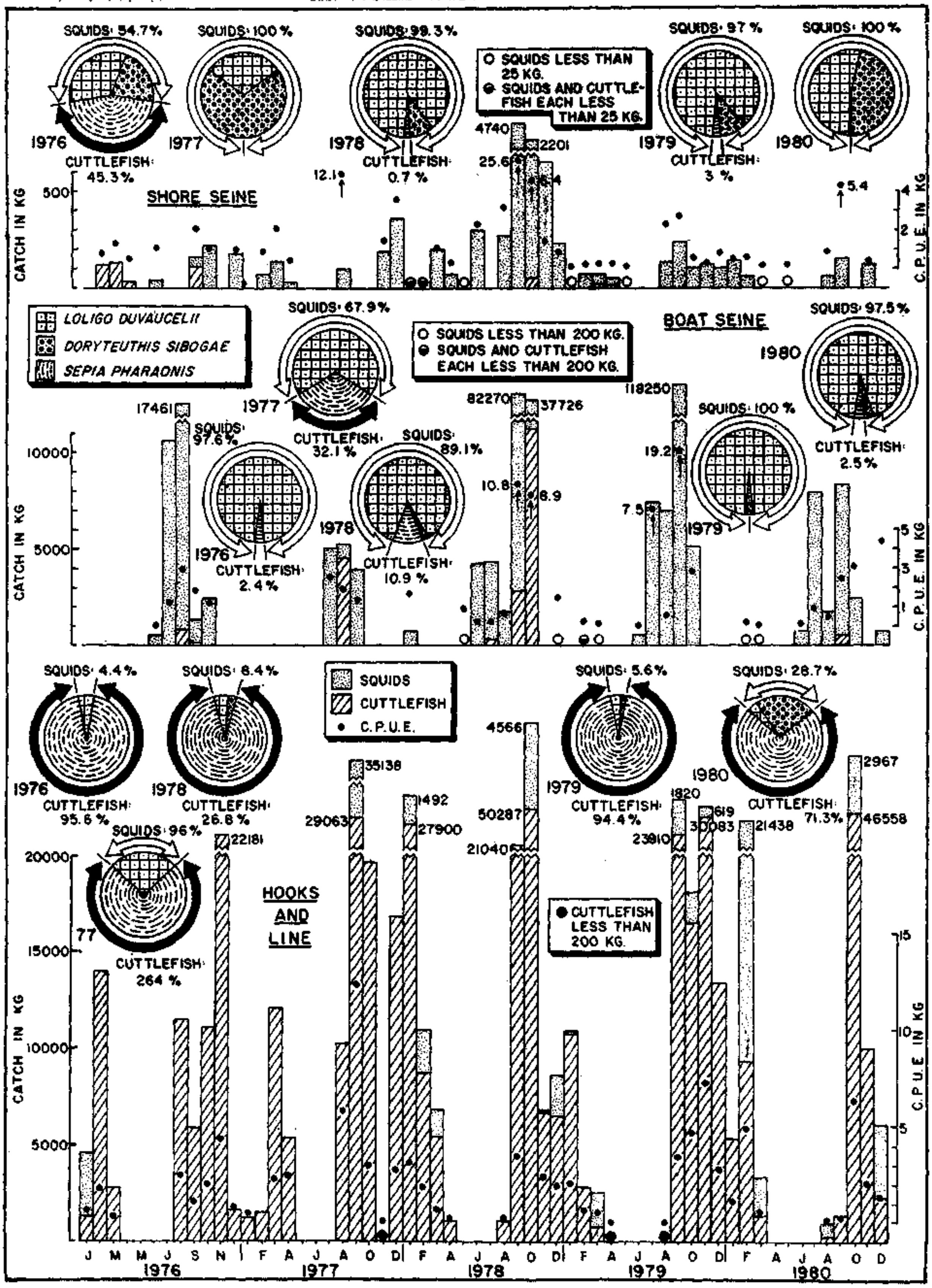

FIG. 4. Monthly total cuttlefish and squid catches, CPUE and annual species percentage composition of cephalopods landed by shore seines, boat seines and hooks and lines at Vizhinjam during 1976-'80.

of 0.9 kg to 12.4 kg. In earlier times the squids were caught with hand jigs by fishermen squatting on a look-out pole called *machan* (Hornell, 1917).

Fishery at Vizhinjam

Squids and cuttlefishes are obtained at Vizhinjam (Trivandrum) in shore seines, boat seines and hooks and lines. The total cephalopod production at Vizhinjam during the years 1976-'80 was 909.9 t and the three gears contributed 1.3%, 37.2% and 61.5% respectively. The average annual production was 181,783 kg and *L. duvaucelii*, *Doryteuthis sibogae* and *Sepia pharaonis* accounted for 41.7%, 4.1% and 54.2% respectively. 82.9% of total *L. duvaucelii* production were got in boat seines and 14.6% in hooks and lines. 84.7% of *Doryteuthis sibogae* were caught in hooks and lines, 10.3% in boat seines and 5% in shore seines. 95.8% of the cuttlefish *S. pharaonis* were obtained in hooks and lines and 4.1% in boat seines. Earlier, Radhakrishnan (1973) reported good annual catches fluctuating between 43,871 kg and 176,759 kg during 1965-67 in the period October-November to February-March.

About six shore seines operate at Vizhinjam and the total cephalopod production of shore seines during 1976-'80 was 11,898 kg with an average annual landings of 2,380 kg which form 2.4% of total shore seine landings. The annual cephalopod catch of shore seines increased steeply by more than ten times from 859 kg in 1976 to 8,698 kg in 1978 following a rise in effort by 54% but decreased to 565 kg in 1980 with fall in effort by 37.5% (Fig. 4). Cephalopods form 0.7% to 5.9% of total shore seine catches (average 2.4%). The peak season is September to November. Squids were predominant or occurred exclusively forming 54.7% to 100% and cuttlefishes accounted for 0.7% to 45.3%. In the landings of the five year period 1976-80 *Loligo duvaucelii* formed 80.1%, *Doryteuthis sibogae* 15.9% and *Sepia pharaonis* 4%. At times stray individuals of *Sepioteuthis lessoniana*, *Sepia aculeata* and *Sepiella inermis* occurred in the catches.

About 200 boat seines are operated at Vizhinjam and in recent years in addition to these, boat seines belonging to neighbouring fishing villages also operate and land at Vizhinjam. This net is used from April to October and in some years up to December or March. The total cephalopod production of boat seines during 1976-80 was 338,352 kg with an average annual production of 67,670 kg accounting for 2.3% of total landings. The squid and cuttlefish production increased over four times from 33,092 kg in 1976 to 138,211 kg in 1979 with increase in effort by 54% and exhibited a sharp decline to 21,738 kg in 1980 following a fall in the number of units by 52.5% (Fig. 4). July to September or October is the peak period of boat seine cephalopod fishery when highest catches were got. Squids were the dominant cephalopods constituting 67.9% to almost 100% while cuttlefishes formed only 0.01% to 32.1%. Among the squids *Loligo duvaucelii* formed 88.4% to 100% and *Doryteuthis sibogae* 0.5% to 11.3%. Solitary individuals of *Sepioteuthis lessoniana* occurred occasionally. High values of CPUE of *L. duvaucelii* were observed in September and October. *Sepia pharaonis* was the only cuttlefish species obtained in boat seines and its CPUE varied over a low range of 0.01% kg to 2.6 kg.

Hooks and lines are the gear in which the major part of the squid and cuttlefish catches are obtained along Vizhinjam coast. About 150-200 catamarans go out for fishing with this gear. The estimated cephalopod production of hooks and lines during 1976-'80 was 558,668 kg with an average annual landings of 111,734 kg. The annual cephalopod catches increased from 73,601 kg in 1976 by nearly 100% to 141,029 kg in 1978 although the effort decreased by 9.5%. In 1980 the landings were less, being 107,735 kg even though there was an increase in the effort put in by 8.3% as compared to 1978 (Fig. 4). The cephalopods formed 7.1% to 16.6% (average 11.5%) of the total annual hook and line fishery landings. The best months for cephalopod catches were February-March and September-October, sometimes extending up to December.

In the cephalopod catches, squids formed only 4.4% to 28.7% (average 14.8%) whilst the cuttlefishes represented by a single species *S. pharaonis* accounted for 71.3% to 95.6% (average 85.2%). *L. duvaucelli* formed 69.3% to 100% during 1976-'79, but in 1980 it accounted for only 14.6% of the squid landings indicating large variations in the contribution to the fishery. *Doryteuthis sibogae* amounted to 30.7% to 31.1% of the landings in 1978-79 and as much as 85.4% in 1980. The peak months for *L. duvaucelli* was September when the CPUE was high. *Doryteuthis sibogae* occurred in the catches only during some months, January to February or March and October and was obtained in good quantities in February, 1980. The peak catches of *S. pharaonis* were obtained in the months September to January in Vizhinjam area and high CPUEs were noticed in the months August to November and in some years, in January also.

Fishery at Cochin

Cephalopods are caught by shrimp trawlers off Cochin coast between Lat. 9°50′ and 10°10′ N and Long. 75°15′

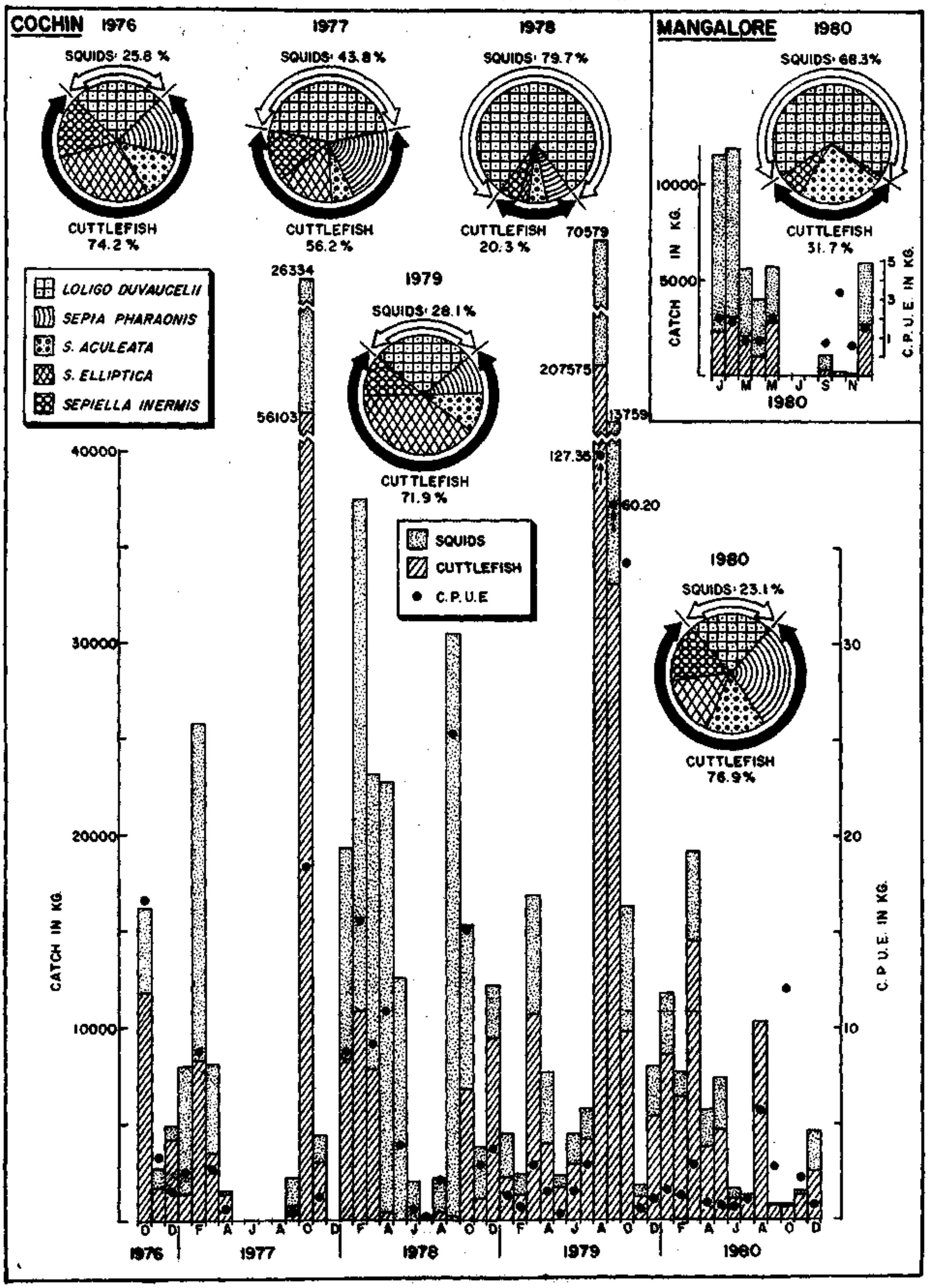

FIG. 5. Monthly total cuttlefish and squid catches, CPUE and annual species percentage composition of cuttlefish and squid landed by trawlers at Cochin during 1976-'80, and at Mangalore during 1980.

and 76°10′ E at 15-50 m depth. On an average about 140 trawlers do otter trawling in the area for prawns, and cephalopods are caught as by-catch. In the period 1977-'80 the estimated total cephalopod production was 781.9 t with an average annual production of 195.5 t. The total squid and cuttlefish landings rose from 132,313 kg in 1977 to 395,104 kg in 1979 although there was a marginal decrease in effort by 10.2%. In 1980 there was a sharp decline in the landings to 72,560 kg although there was an increase in the fishing effort by 7.2% (Fig. 5). The drastic decline in the landings in 1980 was due to the operation of much reduced number of trawlers in the months July to November owing to the non-availability of prawns. Cephalopods formed 0.8% to 3.5% of the total annual trawler landings at Cochin and were obtained throughout the year. The landings showed two distinct peaks one during January to February or March and another from August to October. The CPUE varied widely in different months. Very high CPUEs were recorded in October 1977 (18.4 kg), February, 1978 (16.6 kg), September, 1978 (25.3 kg), October, 1978 (15.1 kg), August, 1979 (127.4 kg), September, 1979 (60.2 kg), October, 1979 (34.2 kg) and October, 1980 (12.0 kg). The total squid landings increased from 57,974 kg in 1977 to 144,943 kg in 1978 when they formed 79.7% of cephalopod catch but later showed a downward trend and in 1980 they accounted for only 16,759 kg. The peak periods for squids were the same as for cephalopods as a whole. The cuttlefish landings were highest, 284,065 kg (71.9%) in 1979 but decreased to 55,801 kg in 1980.

The squid landings consisted almost entirely of *L. duvaucelii* which formed 99.9% to 100%. *Loliolus investigatoris* were caught in small quantities in the months July-August in 1978 and 1979. The monthly CPUE of *L. duvaucelii* fluctuated over a wide range of 0.1 kg to 32.3 kg, the highest values being in the months of peak catches. The cuttlefish catches consisted of four species viz., *S. aculeata, S. pharaonis, S. elliptica,* and *S. inermis* the landings of all of which showed an ascending trend with peak catches in 1979 and sharp decline in 1980. The relative contribution of the four species varied very much. The dominant species were *S. pharaonis* and *S. elliptica* in 1977, *S. aculeata* and *S. pharaonis* in 1978 and 1980 and *S. elliptica* in 1979. The landings of *S. aculeata* were low, 7,701 kg in 1977, rose steeply to 41,918 kg in 1979 and underwent sharp decline to 12,006 kg in 1980. *S. pharaonis* catches were highest, 42,402 kg in 1979 and decreased by as much as 50.2% in the next year. *S. elliptica* exhibited wide yearly fluctuations, the catches decreasing from 20,235 kg in 1977 to 4,701 kg in 1978 shooting upto 1,58,354 kg in 1979 and declining by 92% in the succeeding year. The catches of *S. inermis* were highest, 41,391 kg in 1979 and fell to 11,326 kg in the next year. Corresponding to the trend of the landings, the CPUE of all the four component species exhibited an increase in 1979 and a sharp fall in 1980. The best months for all the four cuttlefish species were August to October.

Fishery at Mangalore

Cephalopods are caught by about 200 trawlers off Dakshina Kannada (South Kanara) coast between Lat. 12°30′ and 13°10′ N and Long. 74°30′ and 74°45′ E at depths of 9 to 40 m. The estimated annual cephalopod catches in 1980 amounted to 45,897 kg (Fig. 5) and they formed 0.2% to 1.7% of the total trawl catches in the various months except in October when for 52 boat trips 177 kg of cephalopods were landed, and since in that month, the total trawl landings were poor (363 kg) cephalopods accounted for 47.97%. The best months for cephalopods in 1980 were January and February. In March, May and December moderately good catches were got and the catches were lowest in September and October.

Squids represented by a single species *Loligo duvaucelii* were predominant component of cephalopods and they formed 68.3% of the catches. The rest of the catch of 31.7% comprised of three species of cuttlefishes *Sepia aculeata, S. pharaonis* and *Sepiella inermis*. The estimated annual catch of *Loligo duvaucelii* was 31,353 kg and that of the next common species was 11,126 kg accounting for 24.2%. *Sepia pharaonis* and *Sepiella inermis* were obtained in very small quantities and formed only 0.6% and 7% of the cephalopod landings. The average CPUEs of *L. duvaucelii* and *S. aculeata* were 0.99 kg and 0.35 kg whilst those of *S. pharaonis* and *S. inermis* were very low. The best months for *L. duvaucelii* were December to March and the peak periods for *S. aculeata* were December to March and May.

Fishery at Bombay

Cephalopods are caught mainly by trawlers off Bombay coast between Lat. 18° and 20° N and Long. 72° and 73° E at depths of 30-50 m. In *dol* nets operated in the area for Bombay duck, squids and cuttlefishes occur in stray numbers. About 100 to 150 trawlers land at two centres Sassoon Duck and New Fishery Jetty at Bombay. During 1977'-80 the trawlers landed a total of 4,580.8 t of cephalopods with an average annual catch of 1,145.2 t which formed 3.9% of total

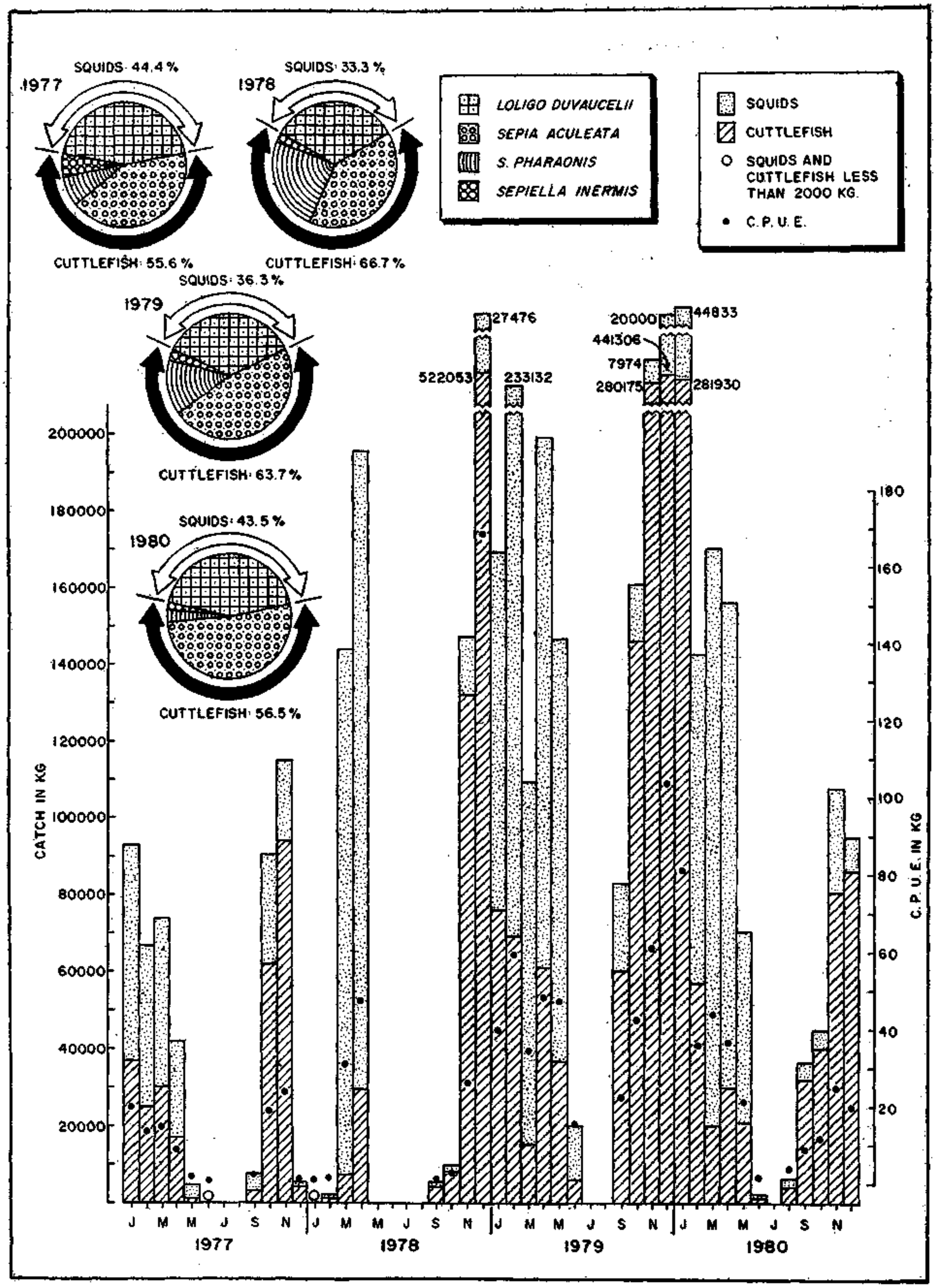

FIG. 6. Monthly total cuttlefish and squid catches, CPUE and annual species percentage composition of cuttlefish and squids landed by trawlers at Bombay during 1977-'80.

trawl catches. The annual estimated cephalopod catches at both the centres together show a gradual rise from 494,553 kg in 1977 to a maximum of 1,872, 142 kg in 1979 and thereafter a decrease by as much as 38.1% to 1,158,471 kg in 1980 though there was an increase in effort by 5% (Fig. 6). The CPUE showed a trend similar to that of the catches and it was highest, 47.56 kg in 1979.

Squids formed 33.3% to 44.4% of cephalopod catches and the rest consisted of cuttlefish. The annual squid catches varied from 219,686 kg (in 1977) to 680,296 kg (in 1979) and cuttlefish catches between 274,687 kg in 1977 and 1,191,846 kg. When the total squid and cuttlefish catches in the four year period are considered it is seen that cuttlefish are dominant forming 61.7% and squids account for 38.3%. A very interesting seasonal pattern is seen in the occurrence of squids and cuttlefishes in Bombay area. Squids are common in the period January to May or June and cuttlefishes are abundant in the period September-December.

When the total cephalopod landings of trawlers during the period 1977-'80 are considered together, it is seen that *Sepia aculeata* was the dominant species forming 46.3%, *Loligo duvaucelii* was the second dominant species (38.3%) and the others obtained were *Sepia pharaonis* (13.7%) and *S. inermis* (1.7%).

The annual landings of *L. duvaucelii* varied from 219,686 kg (1977) to 680,296 kg (1979). The catches of the squid were especially good in the periods March-April, 1978, January-May, 1979 and February-April, 1980 when the CPUE varied from 21.9 kg to 41.6 kg. The annual catches of *Sepia aculeata* ranged from 208,062 kg (1977) to 878,432 kg (1979) and decreased to 606,933 kg in 1980. *S. pharaonis* showed a similar trend of catches with a rise from 38,261 kg in 1977 to 286,826 kg in 1979 and a fall to 34,070 in 1980. Peak landings of *S. aculeata* were obtained in the period September to December and maximum catches of *S. pharaonis* during October-December, when the CPUEs were also high. The yearly total landings of *S. inermis* varied between 5,550 kg (1978) and 28,544 kg (1977), and the best months for this species were November to January.

10

CEPHALOPOD RESOURCES REVEALED BY EXPLORATORY SURVEYS IN INDIAN SEAS

E. G. SILAS, KUBER VIDYASAGAR, K. PRABHAKARAN NAIR AND B. NARAYANA RAO

ABSTRACT

The areawise and depthwise cephalopod catches of fishing vessels of Government of India and some Agencies which conducted exploratory fishing in offshore areas have been presented and discussed. The exploratory fishing by Government of India vessels in Bombay-Gujarat region during 1977-80 yielded a maximum of 7,609 kg of cephalopods a year at a catch rate of 6.8 kg/h. The highest catch rates were recorded from the area 19-70 and the depth zone 80-89 m. In Visakhapatnam region the cephalopod catch was poor during 1968-75 but during 1977-80 the annual catch increased to 3,283 kg. The most intensively fished area was 17-83. The catch was composed of four species of cuttlefishes and three species of squids. The results of trawl surveys in other parts of Indian waters are also dealt with.

INTRODUCTION

Although cephalopods would have formed a part of the general trawl catch, their inclusion in the list of components has come into vogue only in very recent years. Earlier they had been thrown overboard or later recognised and included in the miscellaneous catch. On account of this, our present knowledge of this group as a trawl fishery resource is quite inadequate. Whatever little information is available at present is mainly from the trawling data provided by the erstwhile Exploratory Fisheries Project (now the Fishery Survey of India), Government of India. Catch particulars are available for the Bombay-Gujarat region from 1977 onwards and for the Visakhapatnam region from 1968 onwards, besides some data from areas off Goa and the Wadge Bank.

BOMBAY-GUJARAT REGION

Three trawlers, viz., MEENA BHARATHI (22.5 m, 262 b.h.p.), MEENA PRAPI and MEENA SANGRAHAK (each 17.5 m and 200 b.h.p.) conducted exploratory trawling from Bombay base during 1977-80.

From 1977 onwards there was steady increase in the annual cephalopod catch and catch rate (CPUE) from 4,497 kg and 2.56 kg/h in 1977 to 7,609 kg and 6.79 kg/h in 1979 but the values came down to 2,749 kg and 2.77 kg/h in 1980. The fishing effort showed a progressive reduction from 1,751.87 h in 1977 to 989.90 h in 1980.

Ten areas (each 1° square) were covered during this period, of which six areas were fished in all the four years. The maximum effort (2,277.53 h) was expended in the area 18-72 which also contributed the maximum catch (6,552 kg).

Trawling was done in nine depth zones (each having 10-metre interval) from 20-29 m to 100-109 m. Except for the 100-109 m depth zone, all the others were covered during all the years.

Fig. 1 shows the areawise and depthwise distribution of cephalopods, based on the annual average catch-per-hour returns during 1977-80. The areas 19-70 and 17-71 have yielded cephalopods at the rate of 18.86 kg/h and 10.19 kg/h respectively in 1977, and the area 18-71 at the rate of 10.92 kg/h in 1978 ; in 1977 no area contributed more than 10 kg/h. In general, catch rates were below 10 kg/h from most of the areas and in a few cases it was less than 1 kg/h or nil. On an average the area 19-70 yielded 11.75 kg/h but this area was poorly fished, since the effort spent was only 40.16 h during the entire 4-year period. The most intensively fished area was 18-72 from where the average catch rate recorded was 3.80 kg/h with a minimum of 2.31 kg/h in 1978 and a maximum of 7.50 kg/h in 1979.

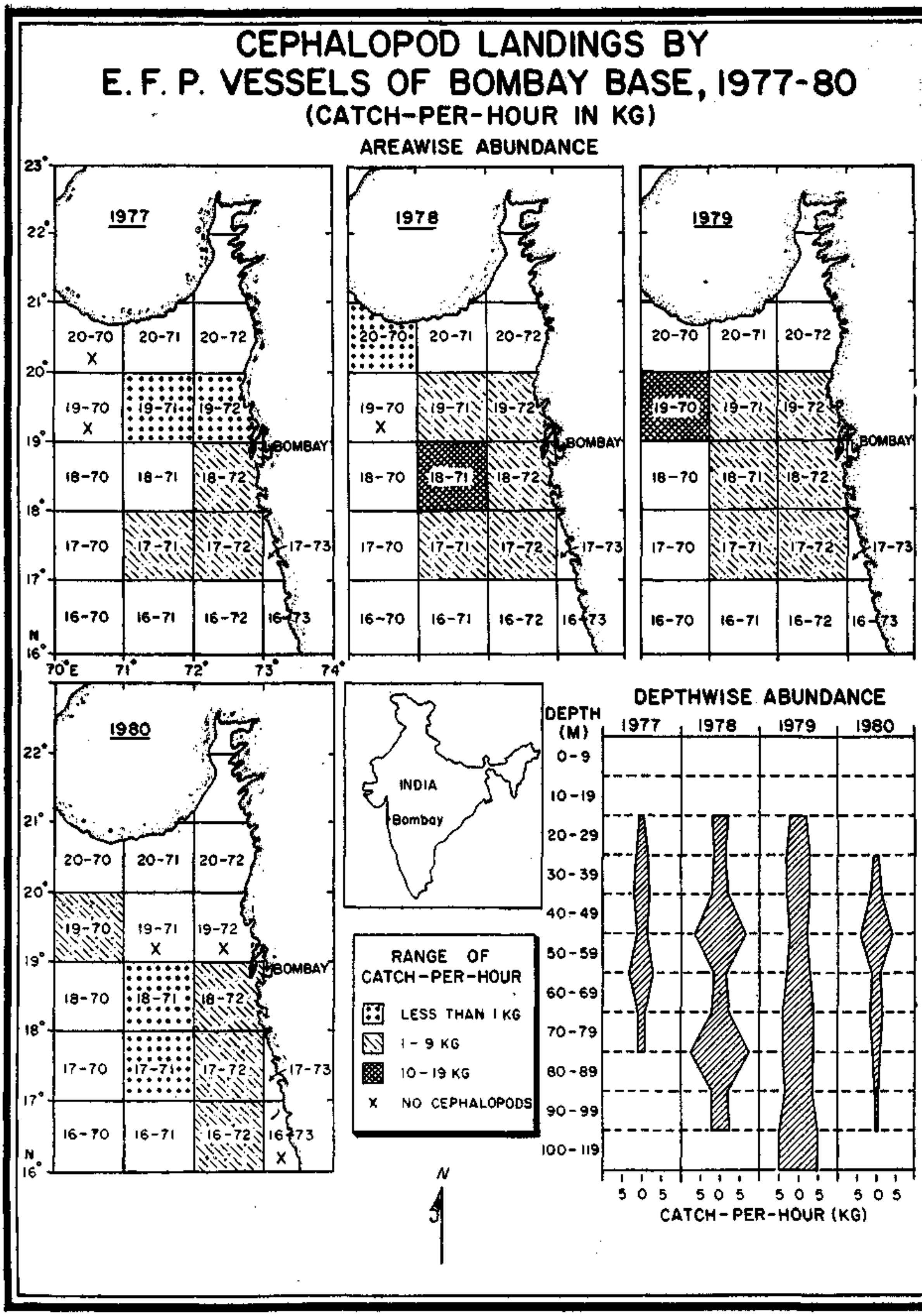

FIG. 1. Areawise and depthwise abundance of cephalopods caught by E.F.P. vessels of Bombay base during 1977-'80 off Bombay-Gujarat Coast.

Cephalopods were obtained from six of the nine depth zones covered during 1977, and the maximum catch rate of 6.28 kg/h was obtained from 60-69 m. In 1978 more depth zones yielded cephalopods and the highest return (15.68 kg/h) was from 80-89 m. In 1979 trawling was extended upto 100-109 depth zone which also accounted for the maximum catch rate of 10.28 kg/h; in other depth zones the catch rate ranged from 3.90 kg/h to 7.92 kg/h. In the subsequent year no cephalopods were obtained from 20-29 m, and the 100-109 m depth zone was not fished; among other depth zones 50-59 m gave the highest catch rate of 7.98 kg/h. The maximum fishing effort (1,077.05 h) was put in the depth zone 30-39 m during the 4-year period, and the average catch rate from here was 3.54 kg/h. During this period the highest average catch rate (7.03 kg/h came from the 50-59 m depth zone.

Fig. 1 gives the areawise seasonal availability of cephalopods based on the average values calculated from pooled monthly effort, catch and catch-per-hour for the period 1977-80. Except for the areas 17-71, 17-72, 18-71 and 18-72, all the other areas were not regularly trawled. Even in the above mentioned areas there was little fishing during the monsoon months of June, July and August. From area 17-72 moderate to high catch rates of 7.78 kg/h and 17.96 kg/h were obtained in April and November respectively. March to June, October and December were the good months for cephalopods (8.63 kg/h to 22.50 kg/h) from the area 18-71. The catch rates from the area 18-72 were between 2.10 kg/h and 6.90 kg/h. The highest monthly catch rate (33 kg/h) came from the area 19-71 during the month of October; in all the other months when there was fishing, the catch rates were very poor, except in March (7.30 kg/h).

The seasonal depthwise distribution of cephalopods is given in Fig. 1. The depth zones 20-29 m, 30-39 m and 40-49 m only were fished in all the months, and most of the other depth zones were not covered during the monsoon months of June, July and August. In many of these depth zones there was a general increase in catch rates from January to April, and to May in some cases. Such a trend was not perceptible from October to December, though good catch rates were obtained from some of the depth zones: 7.40 kg/h to 18.20 kg/h from 50-59 m, 8.86 kg/h to 12.77 kg/h from 80-89 m. The maximum catch rate (21.23 kg/h) was obtained from 90-99 m depth zone in the month of November.

M. T. MURAENA (69.34 m, 1,620 b.h.p.) has conducted trawl survey in the areas between 15° N and 24° N at a depth of 55-360 m off the northwest of India during the year 1977 (Bapat *et al.*, 1982). A quantity of 1,015 kg of cephalopods was caught and this formed 0.2% of the total catch. Of this, 761 kg came in bottom trawl and 254 kg in pelagic trawl. In both the cases the maximum catches of cephalopods were obtained from the depth range 55-90 m. The highest catch rate of 23.45 kg/h was recorded during January-February. Seven species were represented in the landings: *Sepia aculeata, Sepia esculenta, Sepia pharaonis, Sepiella inermis, Loligo duvaucelii, Argonauta argo* and *Octopus vulgaris*. Of these, *Sepia aculeata, Sepia pharaonis* and *Loligo duvaucelii* constituted the bulk of the catch. While cuttlefishes were obtained from almost all the depth ranges upto 360 m, squids were restricted to the depth range 55-90 m.

The exploratory surveys in the northwestern region off Bombay-Saurashtra coasts by vessels operating from Porbander, Veraval and Bombay bases during 1978-79 showed that cephalopods were obtained from the areas 20-69 at a catch rate of 81.70 kg/h, 21-68 at 120.40 kg/h, 21-69 at 88.60 kg/h, 21-70 at 116 kg/h, and 22-68 at 96.60 kg/h (EFP, 1979a). One small square (2E) in the major area 21-68 gave a catch rate of 138.89 kg h during June-September 1979, and this came from a depth of 95-96 m; the average from the major area for this period was 54.61 kg/h (EFP, 1979b). These high catch rates were obtained by MATSYA NIREEKSHANI (40.6 m, 2,030 b.h.p.). The depth zone 50-59 m yielded the maximum catch rate of 110 kg h. The catch rates from other depth zones were 50 kg/h (40-49 m) and 76.40 kg/h (60-69 m). The smaller vessels (17.5 m) recorded lesser catch rates from these areas and depth zones.

VISAKHAPATNAM REGION

Sekharan *et al.*, (1973) have recorded small quantities of squids in the trawl catches off Visakhapatnam and Orissa coasts. These came from the areas 17-83, 18-84, 19-85 and 19-86 between a depth of 9 m and 128 m. According to Muthu *et al.*, (1975), cephalopods formed 0.95% of the total catch taken in commercial trawling off Kakinada during 1968-70 by trawlers of the size 9.14 m, 9.75 m and 11.41 m. In subsequent operations in the same area during 1971-74 period they accounted for 1.22% of the total catch (Narasimham *et al.*, 1979).

The Exploratory Fisheries Project operated seven vessels from Visakhapatnam base during 1968-80: M. T. ASHOK (200 b.h.p.), M.F.V. CHAMPA (165 b.h.p.), M. V. MEENA SHODHAK, M. V. MEENA JAWAHAR, M. V. MEENA PRADATA (each 17.5 m and 200 b.h.p.), M. V. MATSYA SHIKARI (39.8 m and 1,740 b.h.p.) and M. V. MATSYA DARSHINI

(36.5 m and 1,160 b.h.p.). The data in respect of trawl fishing conducted by these vessels are available, the analysis of which revealed the following results :

During the period 1968-75 the annual cephalopod catch varied from a very negligible 31 kg to a maximum of 881 kg. Almost the entire catch came from a single area, 17-83, which alone was fished during all the years. During 1968-71 only this area was fished. The area 16-82 was trawled in 1973 and 1975 but there was no cephalopod catch ; the area 17-82 was fished in 1972, 1974 and 1975 but only in 1975 there was small catch of cephalopods. The areas 18-83 and 18-84 yielded cephalopods in 1972 and 1975 and there was no catch in 1974. The area 19-85 was trawled in 1975 but did not yield cephalopods.

Of the six depth zones explored during the period, 30-39 m and 40-49 m depth zones yielded cephalopods throughout ; no catch was obtained from 20-29 m depth zone in 1970 and 1973. The maximum catch and catch rates were recorded from 40-49 m depth zone.

The areawise average monthly catch particulars for the period 1968-75 showed that the area 17-83 yielded cephalopods in all the months. The higher catch rates from this area came during April, May, November and December. Other areas were not fished in all the months. Some of these areas gave high catch rates but the monthly effort put in was very small, 0.72 h to 1.20 h. Except the depth zones 10-19 m and 60-69 m, all the other depth zones were fished all through the months. Of these, 20-29 m depth zone did not yield any cephalopods in some months. The maximum average monthly catch came from 40-49 m (34 kg and 1.27 kg/h) and 50-59 m (24 kg, and 1.75 kg/h) during April, and from 30-39 m (29 kg and 0.8 kg/h) during May.

During the period 1976-80, the cephalopod landings increased from 1,449 kg forming 1.20% of the total fish catch in 1976 to 3,283 kg (2.50%) in 1977, but afterwards there was decrease to a minimum of 885 kg (0.31%) in 1980. The catch rates also showed similar trend : from 0.87 kg/h in 1976 it increased to 2.79 kg/h in 1977 and decreased in the subsequent three years to 2.18 kg/h, 0.82 kg/h and 0.52 kg/h. The effort put in was the maximum (1,946.74 h) in 1979.

Nine areas were covered during the period 1976-80, of which only three areas, viz. 17-83, 18-83 and 18-84 were fished in all the five years ; 16-81, 16-82 and 17-82 were fished in four years, and 15-80, 15-81 and 17-84 in one year Fig. 2. Of these, the most intensively fished area was 17-83, where a total effort of 4,318.30 h was put in for a return of 5,990 kg during the 5 year period at an average catch rate of 1.39 kg/h. Five depth zones, 20-29 m, 30-39 m, 40-49 m, 50-59 m and 60-69 m, were fished in all the years. The depth zone 10-19 m was fished in three years and 70-79 m and 80-89 m in one year.

Fig. 2 shows the areawise and depthwise distribution of cephalopods, based on the annual average catch-per-hour returns during the 5-year period 1976-80. The area 18-84 yielded cephalopods at the rate of 4.64 kg/h during 1977 and 3.65 kg/h during 1978. The catch rates from the area 18-83 were 2.14 kg/h in 1977 and 2.66 kg/h in 1978. Besides these, the only other area which gave catch rates above 2 kg/h was 17-83 (2.71 kg/h in 1977). In all the other years the areawise catch rates were less than 2 kg/h in many cases and less than 1 kg/h in most cases.

The most intensively fished depth zones were 40-49 m and 30-39 m, where the efforts put in were 2,279.73 h for a realisation of 3,246 kg of cephalopods at the rate of 1.42 kg/h, and 2,273.60 h for a catch of 3,370 kg at the rate of 1.48 kg/h, respectively. The depth zones 20-29 m, 50-59 m and 60-69 m yielded catch rates between 2.46 kg/h and 8.07 kg h in 1977, and between 1.27 kg/h and 4.10 kg/h in 1978.

Fig. 3 gives the areawise seasonal distribution of cephalopods based on the averages calculated from pooled monthly effort and catch-per-hour for the period 1976-80. Only the area 17-83 was fished all through the months. Maximum number of areas were fished in March ; during June to August the coverage was the minimum. In general, the catch rates did not show much monthly variation.

The seasonal depthwise distribution (Fig. 2) indicates that the depth zones 20-29 m to 50-59 m, fished in all the months, have yielded cephalopods at catch rates varying from 0.49 kg/h in March (50-59 m) to 4.75 kg/h in the same month (20-29 m). The maximum catch-per-hour (12.43 kg/h) was recorded from 60-69 m depth zone in July but the average effort put in was only 1.13 h. On the whole the higher catch rates were obtained from many depth zones during January, March, April, May, July, August, November and December.

The cephalopods obtained in exploratory trawling were composed of the squids *Loligo duvaucelii* and the cuttlefishes *Sepia aculeata*, *Sepia pharaonis*, *Sepia brevimana* and *Sepilla inermis*. Besides these species, stray numbers of the squids *Doryteuthis singhalensis* and *Loliolus investgatoris* also contributed to the catch to a very small extent. The monthly landings of squids

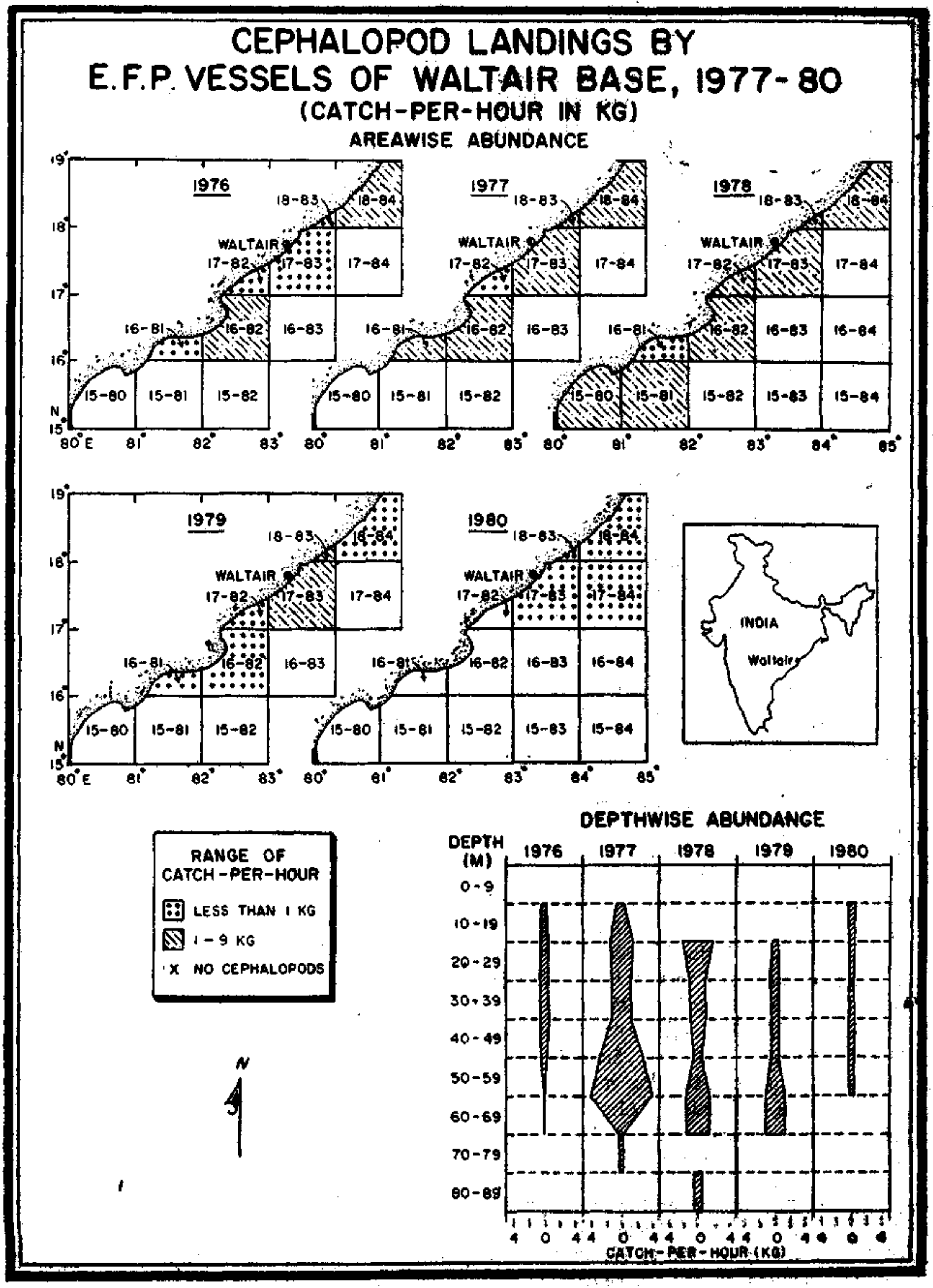

FIG. 2. Areawise and depthwise abundance of cephalopods caught by E.F.P. vessels off Waltair (Visakhapatnam) base during 1977-'80.

and cuttlefishes, their gross catch-per-hour and the annual species composition of the landings are shown in Fig. 3.

In all the years, except 1978, cuttlefishes were more in quantity than squids, forming as much as 67.9% in 1976, 55.2% in 1977, 61.6% in 1979 and 76.7% in 1980. In 1978 the squids and cuttlefish were in almost equal proportions (50.4% and 49.6% respectively). The highest monthly catch rate for squids was 2.94 kg/h recorded in March 1977. During the years 1977 and 1978 the catch rates of 1-2 kg/h were obtained in 11 months. During the rest of these two years, and during the other years the monthly catch rates were less than 1 kg/h. For cuttlefish the highest catch rate was 3.68 kg/h in July 1977, followed by 2.49 kg/h in November 1980. In 20 months during the 5-year period the catch rates were between 1 kg/h and 2 kg/h.

Loligo duvaucelii: This is the single species that constituted almost the entire squid fishery. The higher catch of 1,468 kg was obtained in 1977 forming 44.7% of the total cephalopod landings that year. The maximum monthly catch (265 kg) was in March at a catch rate of 2.94 kg/h. The catch rates in other months varied between 0.49 kg/h and 1.60 kg/h. In 1978 the catch came down to 1,203 kg at a catch rate of 1.05 kg/h forming 48.3% of the total cephalopods. The monthly catch rates ranged from as low as 0.10 kg/h to 1.90 kg/h. In 1976, 1979 and 1980 the catches were low, being 452 kg, 610 kg, and 206 kg respectively.

The length frequency distribution of *Loligo duvaucelii* for 1976-80 ranged from 20 mm to 169 mm, and in the individual years the size ranges were : 20-169 mm (1976), 30-169 mm (1977, 1978), 30-139 mm (1979) and 50-159 mm (1980). In most of the months the frequency distribution was unimodal, and only in a very few months there were more than one mode. The monthly modal values ranged from 45 mm to 145 mm. The annual length frequency distribution shows that the maximum frequency was at 75 mm in 1976 and 1977 at 85 mm in 1978 and 1979, and at 105 mm in 1980. It is noticed that the bulk of the squid catch is compose of individuals below about 100 mm. Since the sized at which 50% of the squids in this area reach maturity is 76 mm for males and 108 mm for females (see Chapter 4) the mainstay of the fishery is the squids that are maturing or have attained maturity.

Sepia aculeata ; This was the most important cuttlefish obtained in exploratory trawl fishing. The annual catch varied from 417 kg in 1980 to 937 kg in 1977. The annual contribution to the cephalopod fishery varied from 28.5% in 1977 to 48% in 1976. The highest monthly catch rates during the first three years were 1.12 kg/h in December 1976, 1.47 kg/h in July 1977 and 1.42 kg/h in November 1978. In other years the monthly catch-per-hour returns were very low.

The length frequency distribution of *Sepia aculeata* ranged from 30 mm to 179 mm in 1976, 20 mm to 169 mm in 1977, 40 mm to 169 mm in 1978, 50 mm to 169 mm in 1979, and 70 mm to 169 mm in 1980. The data for April-December 1978, and the whole years of 1979 and 1980 were meagre. In 1976 there were three modes, at 75 mm, 115 mm and 145 mm, and in 1977 there was only one mode, at 95 mm. Most of the cuttlefish were maturing or mature.

Sepia pharaonis: During the 5-year period 1976-80 the annual landings of this cuttlefish formed 12.3%, 18%, 3.9%, 26% and 14.4% of the total cephalopod landings in the respective years. The monthly catch rates were uniformly low, except in July 1977 (2.28 kg/h) and November 1980 (1.74 kg/h). The size of this cuttlefish ranged from 60 mm to 249 mm, with majority within the range of 140-179 mm.

Sepia brevimana: This cuttlefish formed 3.9% to 14.2% of the annual cephalopod landings. The highest annual catch was only 279 kg (1978) obtained at a catch rate of 0.24 kg/h forming 11.2% of the total cephalopods. This species was caught in small quantities in all the months of that year. In size this is a small cuttlefish ; in trawl catches it ranged between 35 mm and 104 mm.

Sepiella inermis ; The catch of this cuttlefish, was very negligible, the annual landings varying between 9 kg and 123 kg. The highest annual contribution to the total cephalopod catch was only 4.9% (1978). Except in March and April this cuttlefish was obtained in very small quantities in all the months of 1978. One of the smallest among commercial species of cuttlefishes, in the surveys this had a size range of 35-75 mm.

Other Areas

In the exploratory survey off Goa by M. T. KALYANI IV and V in 1967-68, two major areas, 15-73 and 16-73, have yielded cephalopods which formed 1.03% of the total trawl landings (Rao and Dorairaj, 1968). The catch rates were 11-20 kg/h in 15-73(2E, 4B and 5D ; 6-10 kg/h in 15-73/3A, 3E, 4A, 4D, 5B, 5C, 6C, 6D and 16-73 3B ; upto 5 kg/h in 15-73(2C, 2D, 3B, 3C, 3B, 4C, 4E, 6B, 16-73 1B, 2B, and 2C. The depth from which they were fished was 10-70 m, with maximum catch rates coming from 30-39 m depth zone. In the survey off Goa during 1978-1979 very small quantities of cephalopods were obtained from

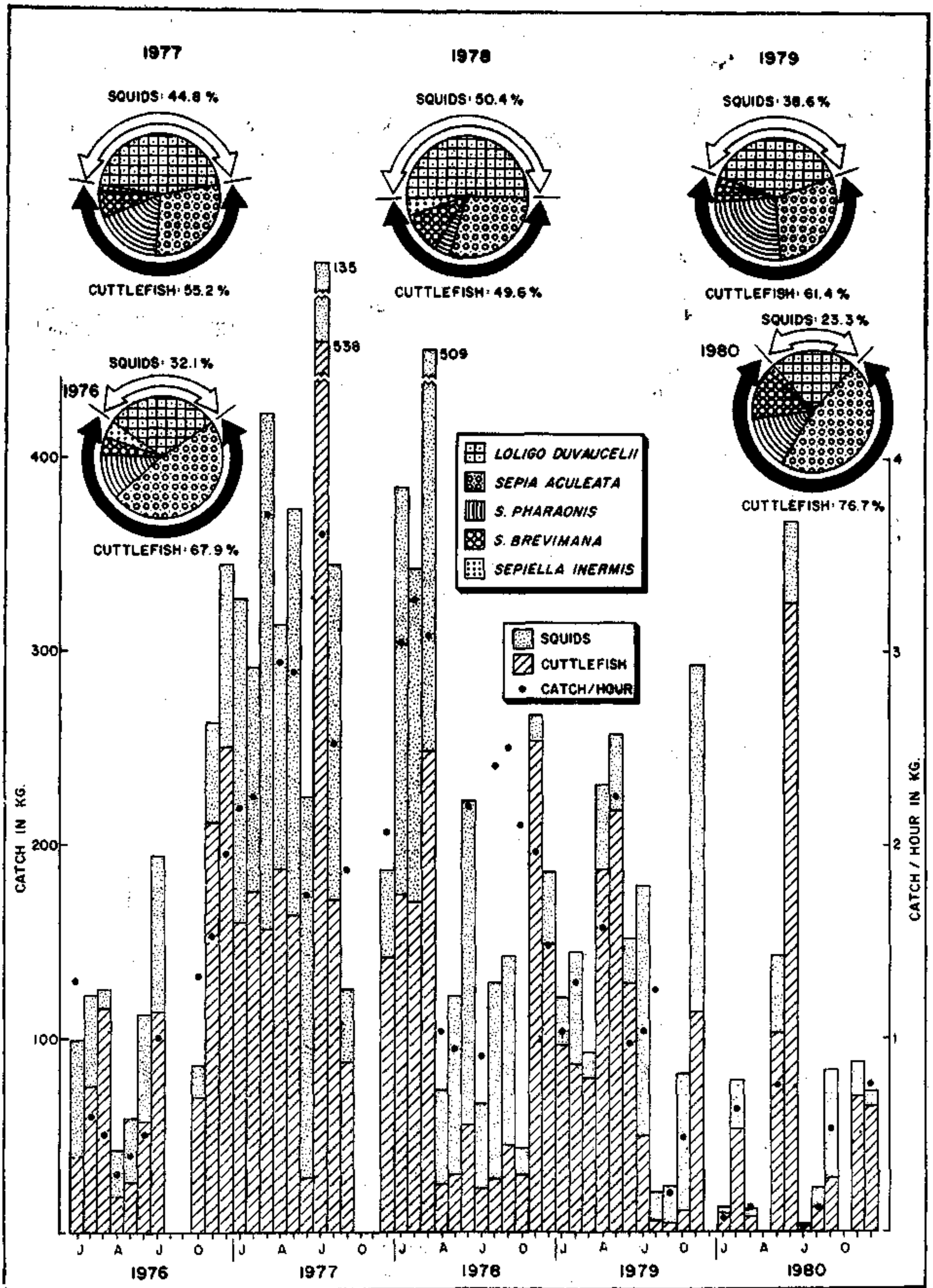

FIG. 3. Monthly cuttlefish and squid catches, catch/hour and annual percentage composition of cephalopods caught by E.F.P. vessels based at Waltair, Visakhapatnam during 1976-'80.

the areas 14-73 and 15-73 at catch rates of 0.80 kg/h and 1.10 kg/h respectively. In these areas the catches were recorded from a depth range of 20-59 m (EFP, 1979c).

In the trawl survey off Karwar by three small vessels (8.5m, 10.6 m and 13.1 m) of the Indo-Norwegian Project, cuttlefish formed 1.33% of the total fish catch. The survey was carried out during 1963-66 in areas between 14° 30'-15° N and 73°40'-74°20' E upto a depth of 20 fathoms (36 m) (Bapat *et al*., 1972).

During the exploratory trawling off Alleppy and Ponnani in Kerala by M. F. V. KALAVA in 1963 300 kg of squids forming 1.9% of the total catch were taken from a depth of 274-329 m (Tholasilingam *et al*., 1968). During 1978-79 period, the 17.5 m trawlers of the Exploratory Fisheries Project operated off Kerala coast. The areas 8-76, 9-75, 9-76, 10-75, 10-76 and 11-75 have yielded cephalopods at catch rates varying from 0.40 kg/h to 5.30 kg/h. They were trawled from a depth of 20-89 m the maximum catch rate of 6.3 kg/h coming from 50-59 m. The areas 12-80 and 13-80, off Tamil Nadu have yielded cephalopods from a depth range of 40-69 m but the catch rates were very insignificant (0.10 kg/h to 0.20 kg/h) (EFP, 1979c). According to Sulochanan and John (1982) exploratory survey during 1979-'81 on the southwest coast indicates that productive grounds for cephalopods occur off Calicut and Quilon and in the Wadge Bank.

In the exploratory trawling by R. V. VARUNA and other vessels in the neritic deep waters and the upper continental slope on the southwest coast of India during 1966-68, cephalopods formed a part of the trawl net and drift net catches obtained from a depth of 75-450 m (Silas, 1969a). The cephalopods in trawl landings included small quantities of the octopod *Berrya keralensis* besides the cuttlefish *Sepia*. In the exploratory drift net fishing on the southwest coast of India and in the Laccadive Sea during August 1965 to January 1968, the oceanic squid *Symplectoteuthis oualaniensis* was found to occur in most of the shelf and oceanic areas. Silas (1969a) has charted out the areas of occurrence and the areas of abundance of this squid, pointing to the need to collect more information on the economically important oceanic squids for exploring the possibilities of developing a fishery.

The UNDP/FAO Pelagic Fisheries Project Surveys in the southwest coast and part of the Gulf of Mannar showed that the cephalopods formed one of the components of the catches taken in the pelagic and bottom trawls (UNDP/FAO 1974a, 1974b, 1976a, 1976b. 1976c, 1976d, 1977). Squids formed an average of 1.60% (range 0.60-13.30%) of the total catch taken in pelagic trawl from the areas between 8° N and 15° at N a depth of 20-39 m. In the subsequent operations of this gear at depths 20-80 m, squids formed 3.34% of the total catch in Quilon-Kanyakumari area and the Gulf of Mannar area. In Quilon-Mangalore area they accounted for 1.50% of the total catch obtained from depths up to 80m, whereas in Mangalore-Ratnagiri area, they formed 2-25%. In bottom trawling the percentage contribution of cephalopods to the total catch was 5-50% from Quilon to Kanyakumari and Gulf of Mannar, 1-30% from Quilon to Mangalore and 1% from Mangalore to Ratnagiri.

The exploratory survey of the Wadge Bank carried out by MATSYA NIREEKSHANI during October-December, has revealed good grounds for cuttlefish (EFP, 1982). The areas 7-77, 7-78, 8-76, 8-77 and 8-78 yielded cuttlefish at catch rates upto a maximum of 176 kg/h. This catch rate of cephalopods, the highest recorded so far from any area in our waters, was obtained from the area 8-78 at a depth of 34-42 m in November 1981. In this area the cephalopods formed 87.8% of the total trawl catch. In the area 8-77 the depth zone 20-39 m yielded cuttlefish at a rate of 75.40 kg(h. The present survey, though very short, has indicated the richness of Wadge Bank area for cephalopods comparable to, or even better than, that of the northwestern region.

The liberalised charter policy of the Government of India has resulted in issue of licence to a good number of Taiwanese trawlers to operate under charter agreement in our shelf waters. Bull-trawling (pair-trawling) has been the main method of fishing. The vessels have a fish hold capacity of 150 t or more and were mainly fishing off the Saurashtra-Maharashtra coast. Special effort was expended for cuttlefishes and squids. It is estimated that 30% or more of the catches stored in the hold were cuttlefishes and another 10-20% squids, and the rest finfish species of preference in the eastern markets. The details of the number of chartered vessels operating in the grounds and the number of voyages each vessel undertook yearwise are not available with us. However, the species of cuttlefishes and squids thus harvested in large quantities from this continental shelf area are mainly *Sepia pharaonis, Sepia aculeata, Sepia elliptica* and *Loligo duvaucelii*.

The chartered vessels are expected to operate beyond 40 fathoms (73 m) but there have been several infractions and some have been impounded for fishing in shallower inshore waters. It is understood that due to indiscriminate slaughter fishing by the chartered pair-trawlers infringing also into waters less than 40 fathoms the charter arrangement for such operations is being phased out.

11

OCTOPOD RESOURCES

E. G. SILAS, R. SARVESAN AND K. SATYANARAYANA RAO

ABSTRACT

The Octopod resources of the Indian seas are dealt with and the possibilities for organising a fishery by adopting modern methods of fishing are discussed.

INTRODUCTION

Among cephalopod resources, octopods are the least exploited in India. It is known that octopods occur in fair quantities in different parts of the Indian coasts (Hornell, 1917). In earlier years there has been fishing of octopods in some areas along the mainland coast. However, at the present time, the exploitation of octopods is chiefly in the Nicobar Island and in the Lakshadweep where it supports subsistence fishery.

As many as 200 species of Octopodidae are known to occur in the World Oceans (Worms, 1983). Of these about 60 species are known from the Indian Ocean (Hoyle, 1886; Goodrich, 1896; Massy, 1916; Robson, 1929; Adam, 1938, 1939b; Oommen, 1966, 1967, 1971, 1976, 1977a; Silas, 1968; Pickford, 1974; Roper *et al.*, 1984). Thirty eight species of octopods belonging to the family Octopodidae, Tremoctopodidae, and Argonautidae abound the Indian Seas including Andaman and Lakshadweep Seas (Table 1). Of these,

TABLE 1. *Distribution of species of octopods in the Seas around India*

Seas around Mainland	Andaman Sea	Lakshadweep Isands*
Octopus aegina Gray	*Octopus arborescens* (Hoyle)	*Octopus gardiner* (Hoyle)
Octopus areolatus Orbigny	*Octopus elegans* Brook	
Octopus cyaneus Gray	*Octopus cyaneus* Gray	
Octopus defilippi Verany	*Octopus globosus* Appellof	
Octopus dollfusi Robson	*Octopus hongkongensis* Hoyle	
Octopus fusiformis Brook	*Octopus horridus* Orbigny	
Octopus globosus Appellof	*Octopus michalumpshrot* Goodrich	
Octopus herdmani Hoyle	*Octopus nierstrazi* Adam	
Octopus hongkongensis Hoyle	*Octopus prashadi* Adam	
Octopus macropus Risso	*Octopus rugosus* (Bosc)	
Octopus membranaceus Quoy & Gaimard	*Octopus taprobanensis* Robson	
Octopus pallida Hoyle	*Octopus vulgaris* Cuvier	
Octopus rugosus Bosc	*Teretoctopus alcocki* Robson	
Octopus varunae Oommen	*Berrya keralensis* Oommen	
Octopus winckworthi (Robson)	*Benthoctopus profundorum* Robson	
Cistopus indicus (Orbigny)	*Tremoctopus violaceus* Della Chiaje	
Scaergus unicirrhus Orbigny	*Argonauta bottgeri* Maltzan	
Hapalochlaena maculosa (Hoyle)		
Berrya annae Oommen		
Berrya hoylei (Berry)		
Berrya keralensis Oommen		
Teretoctopus alcocki Robson		
Teretoctopus indicus Robson		
Tremoctopus violaceus Della Chiaje		
Argonauta argo Linnaeus		
Argonauta hians Solander		

* the resource information is incomplete.

the common species are *Octopus dollfusi*, *Octopus globosus* and *Cistopus indicus*.

Many octopods such as *Octopus dollfusi*, *O. cyaneus*, *O. aegina* and *Cistopus indicus* occur in shallow coastal waters in the intertidal and subtidal areas among rocks, stones or corals hiding themselves among crevices. Unlike squids and cuttlefishes octopods lead a solitary life and do not form schools. Some species such as *Berrya* spp. occur in deep waters along the continental shelf edge and upper continental slope. A few others such as *Ocythoe* and *Tremoctopus* are pelagic (Voss, 1973).

Some octopods are known to make seasonal migrations which are influenced by breeding activity. Octopods are exclusively carnivores and they feed on crustaceans, fishes and mollusus. There is very little information on the biological aspects of octopods of Indian Seas. Sarvesan (1974) studied the brooding habits of *Octopus dollfusi*.

At present there is no demand for octopods within the country except in the bait fishery and where they are caught as subsistence fishery. There appears to be scope for developing an octopus fishery, particularly in the Andaman, Nicobar Islands, the Lakshadweep, the Gulf of Mannar and Palk Bay and the Gulf of Kutch.

Subsistence Fishing

Shell traps consisting of lines of shells such as *Lambis*, *Tonna dolium*, *Rapana bulbosa*, *Murex virgineus* and *Hemifusus* were commonly used for fishing octopus at Tondi, Devipatnam and Mandapam on the southeast coast of India (Hornell, 1917 ; Sarvesan, 1974).

As early as in 1902, Boden Kloss in his travels through the Andaman and Nicobar Islands wrote about the torch light fishing in Car Nicobar. One of us (E.G.S.) had occasion to witness this in January, 1960 at Car Nicobar. During low tide extensive areas of this reef are exposed and when this happens at night hundreds of villagers congregate along the shoreline with 2 metre or longer torches made of dried coconut palm leaves which would keep burning for a couple of hours. Different types of spears are used for spearing fish and octopods from the coral rock pools and from between submerged boulders. This is almost a ritual fishing and may last for about two to three hours at night.

During daytime, at Malacca Bay, Car Nicobar (Pls I and II) when the tide is receding, women and children can be seen harpooning in or poisoning coral rock pools for fish and octopods. The poison used is the seed of *Barringtonia* which tree is abundant along the water front. The spiny rachi of a palm is used as the base for grating the seed and the mash is mixed in the water in tide pools or in receding rivulets which are at one end funnelled to a trap using coconut palm leaves on dead coral boulders (Pl. I D). The different types of spears and harpoons used in fishing from the reef area (photographs by E.G.S.) are shown in Pl. III.

At Agati one of us (E.G.S.) has seen octopods being caught from the lagoon and reef by using a long, straight iron rod barbed at the tip. The octopods (species not confirmed) caught weigh about 700 gm to 1 kg or so and are used for local consumption and as bait.

Octopus Fishing in Other Countries

The octopod fisheries and fishing methods adopted in the major octopod producing countries are relevant and hence are briefly dealt with below. Major exploitation of octopods is concentrated in the Pacific and Atlantic Oceans and the Mediterranean Sea by various countries of which Spain, Japan, Republic of Korea, Italy, Morocco, Thailand, Mexico, Portugal, U.S.SR. and Tunisia are leading in production. The world octopod production was of the magnitude of 190,129 t in 1981 accounting for 14.6% of world total cephalopod production (F.A.O., 1983). The octopods contribute slightly more than the cuttlefishes to the world cephalopod production as the latter accounted for 13.7% in the world production. Spain is the foremost country in octopod production with an annual production of 61,589 t in 1981. Japan has been the leading country until recently but her production has declined and was 56,749 t in 1981. The average annual octopod production of the ten major countries during 1977-'81 are given in Table 2. It may be

Table 2. *Average annual octopod production in ten leading countries during* 1977-'81.

Country	Production (tonnes)
Spain	57,885
Japan	56,749
Republic of Korea	18,333
Italy	11,535
Morocco	9,482
Thailand	6,460
Mexico	5,791
Portugal	5,065
U.S.S.R.	4,137
Tunisia	3,416

Source : F.A.O. (1983)

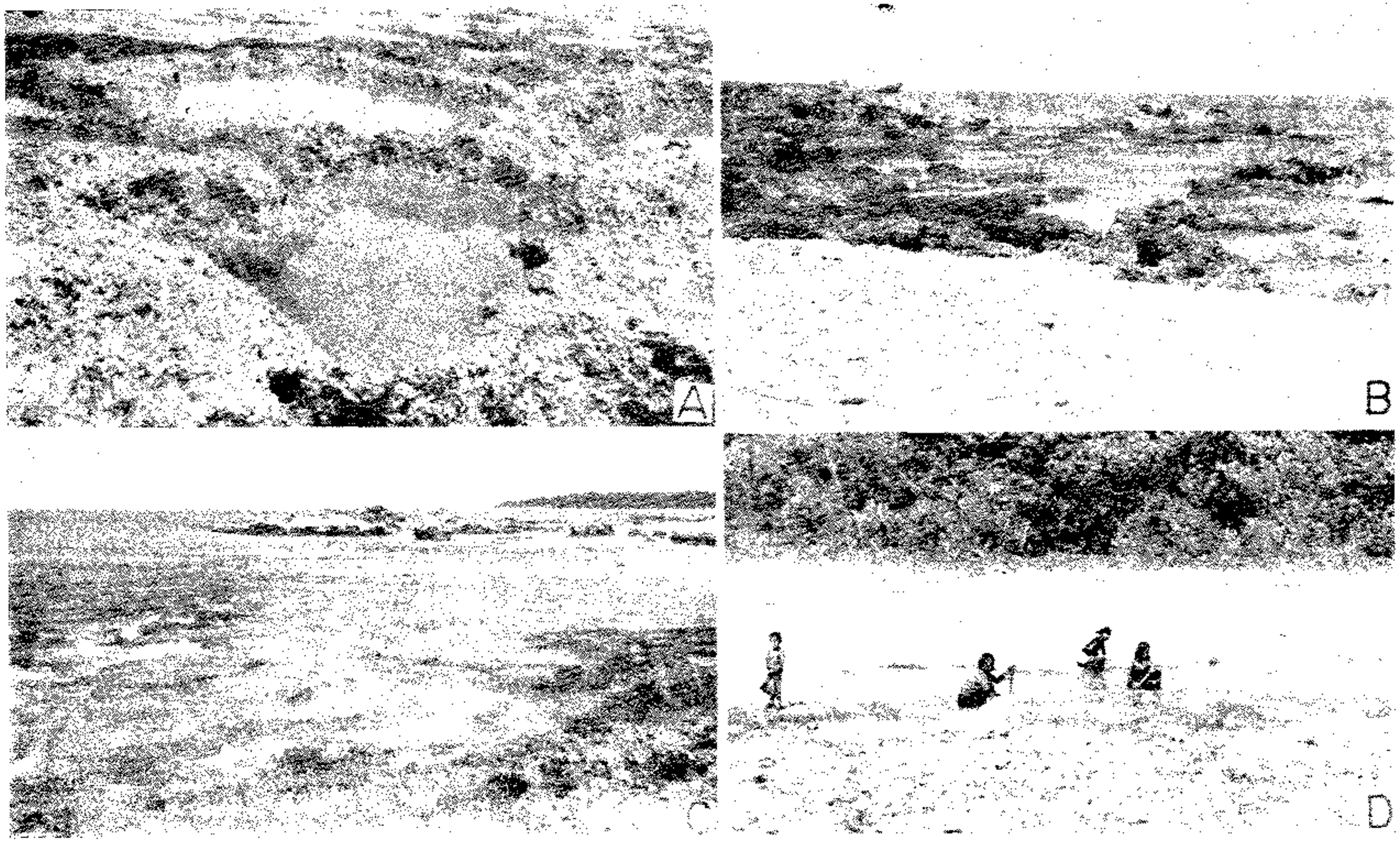

Plate I. A-C. Exposed reef at low tide, Malacca Bay, Car Nicobar. D. Women grating and mixing *Barringtonia* seed with the water to poison reef animals for capture. (Photos : E. G. S.)

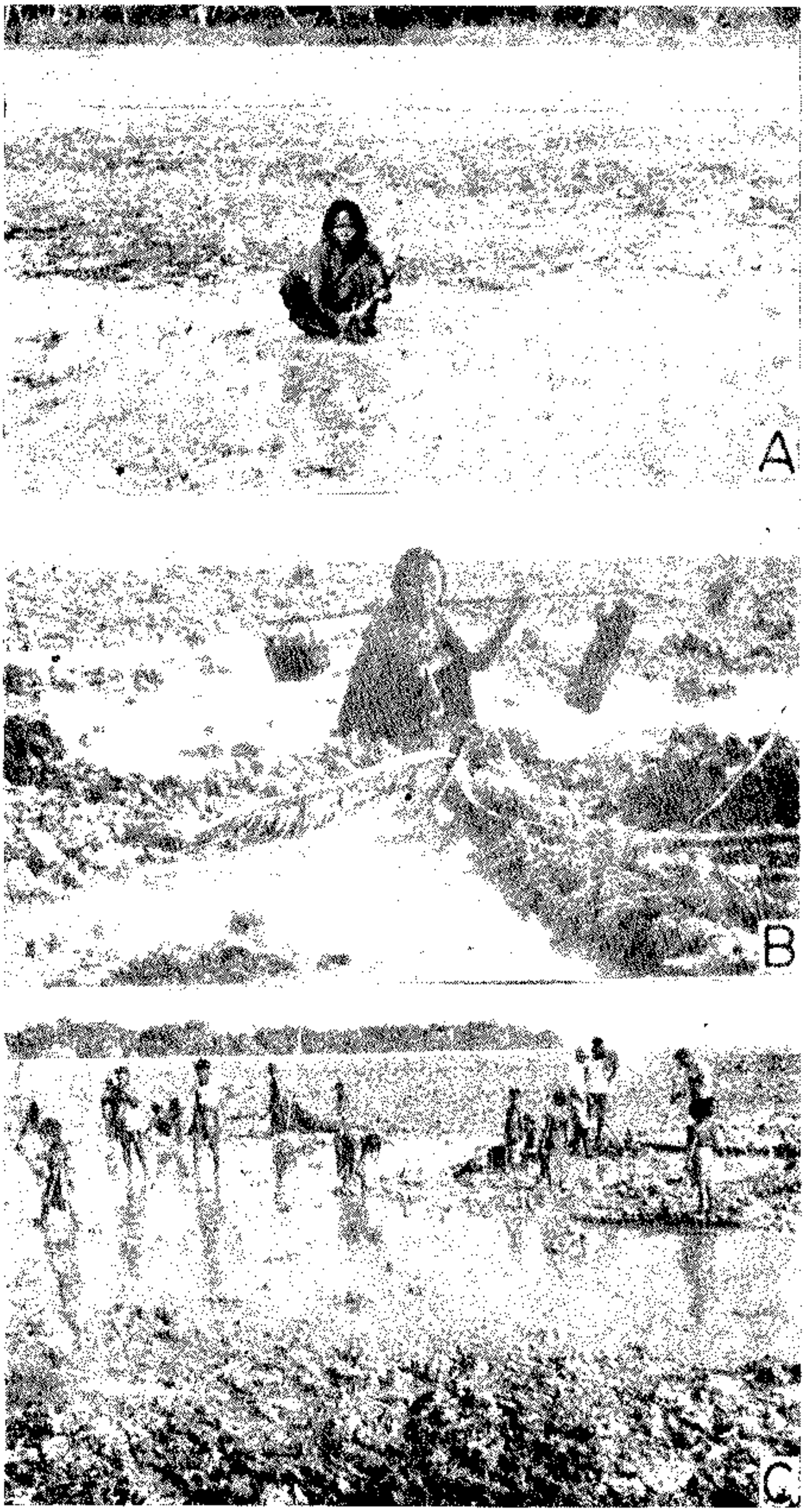

PLATE II. A-C. Malacca Bay, Car Nicobar at low tide when women and children fish for fin fishes and octopods after poisoning the rock pools and receding rivulets and also use traps (B). (Photos : E. G. S.)

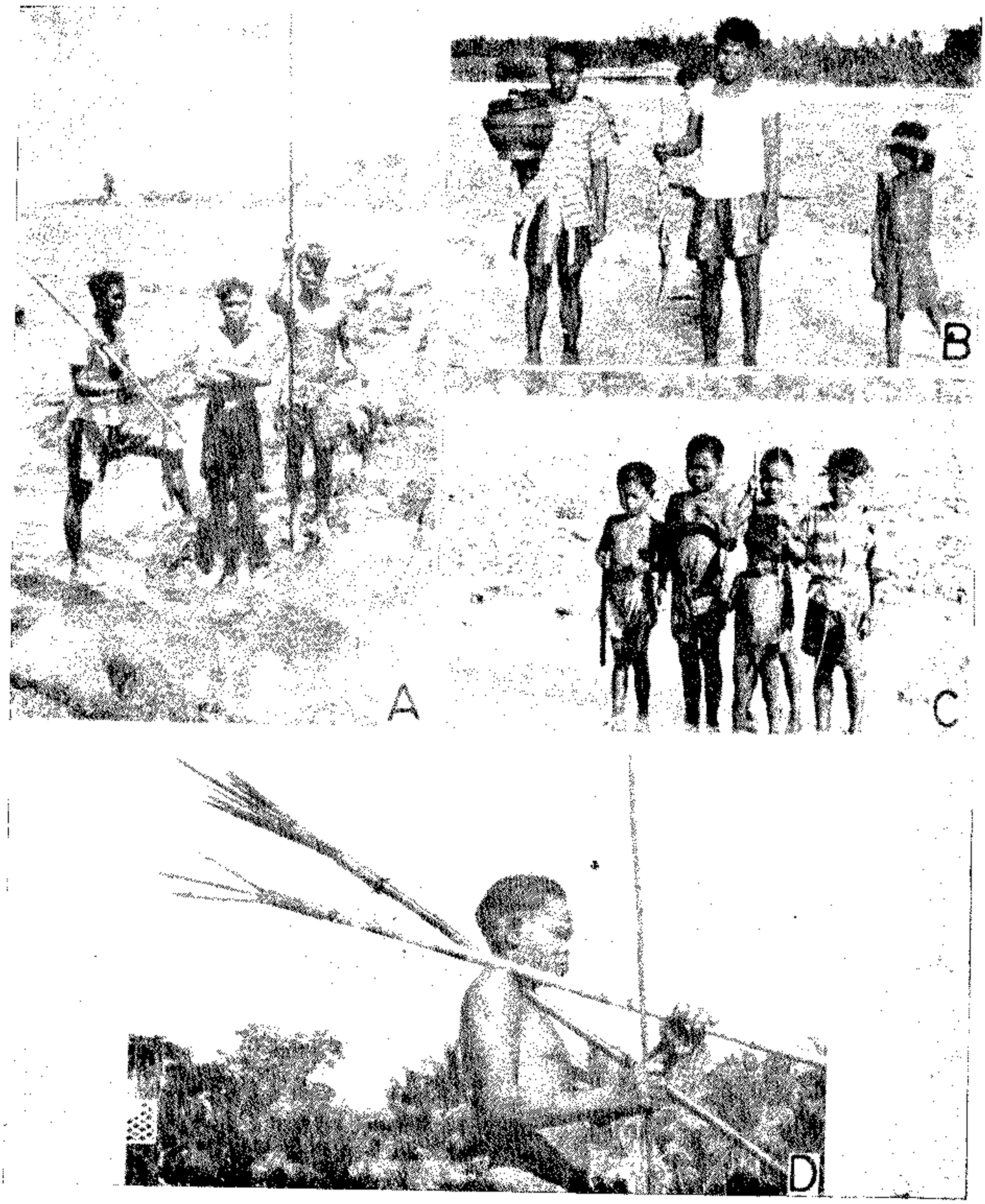

PLATE III A. Spearing fish and octopods in Aberdeen Bay, Port Blair, Andamans. B and C. Returning after a morning's catch at Malacca Bay, Car Nicobar. D. Types of spears used for fishing on the reefs in Car Nicobar. (Photos : E. G. S.)

seen that fairly good quantities of octopods are also harvested by the Republic of Korea and Italy. Most of the species of octopods exploited in commercial fisheries in various parts of the world belong to the genera *Octopus, Cistopus* and *Eledone.*

Spain's octopod production in the Eastern Central Atlantic is obtained from bottom trawling by medium and large stern trawlers (Anon, 1977). The catches comprise of three species of octopods viz., *Octopus vulgaris, Eledone cirrhosa* and *Eledone moschata*. Japan exploits octopus resources present in her coastal waters, the oceanic areas around Hokkaido in the Pacific Ocean and distant waters in the Eastern Central Atlantic Ocean off Sahara and Mauritania.

In Japanese waters there are two distinct octopod fisheries, fishery in the Inland Sea and that in oceanic waters. In the octopod fishery in the coastal waters of the Inland Sea of Japan which is mainly for *Octopus vulgaris* from Hokkaido to Okinawa and the northern oceanic fishery around Hokkaido for larger-sized species such as *Paroctopus dofleni,* the bottom trawl is the main gear employed. Octopus fishing in the coastal waters of Japan is carried out almost throughout the year and accounts for 30 per cent of Japan's octopod production. Fishing is generally restricted to 20-30 m depth and has been recently extended to 80 m zone. Fishing operations are conducted when tidal current is strong. The stocks in the inshore waters consisted of *Octopus vulgaris* and *Octopus ocellatus* and are fished by trawling and gears such as octopus pots, trailing hooks, long lines, hand lines and spears. The fishing methods and gears employed depend on the behaviour of the octopods and nature of the environment.

Fishing with octopus pots takes advantage of the hiding habit of octopus in crevices and hollows in the reefs or rocky areas. Ceramic pots of different sizes and shapes or wooden boxes are tied in series to a main line and laid on the sea bottom with or without bait. Each unit or 'basket' consists of 600 to 800 metre mainline with 50-100 pots or boxes. The pots are lifted after 1-3 days. In recent years ceramic pots and wooden boxes are being replaced by boxes of vinyl chloride (Yamashita, 1976).

Trailing hooks operated in waters of 10-50 m depth from a small boat are hooks with fish or entrails of octopus as bait and provided with a line and they are dragged over gravel or rocky bottom. The trailing hooks are also operated by allowing them to drift with the current or the wind, attached to buoys (Yamashita, 1976; Anon, 1981). One fisherman can operate 15-20 such hooks from a small boat of less than 3 t. The length of the lines from buoy to the hook is carefully adjusted according to the nature of bottom and water depth and is approximately 1.3 times the depth. When an octopus is entangled, the buoy stops drifting and the line is hauled up.

Long-lines employed in octopus fishing in Japan consists of a mainline 450-2,000 m in length with about 2,000 hooks. The long-lines are of two types, those with baited hooks and those without bait. In the latter type of hooks the reverse movement of octopus is made use of for hooking. The long-lines can be used by a fisherman with a small boat of 5 t capacity and a set of 10-20 long-lines are laid at depths ranging from 70-150 m. The fishery is conducted during the spawning season of octopods when they migrate from deeper to shallow waters.

Handlines with various types of barbless hooks arranged around a stem like a jig are also employed in octopus fishing. The handline hooks are usually baited and operated from a small boat in shallow to moderately deep waters.

Apart from the above methods of fishing, spears, harpoons or rakes are also used in Japan for catching octopus found in shallow waters in the subtidal zone. In this method the fisherman make use of a glass bottomed bucket to locate octopus crawling at the bottom.

Three species of cotopods *Octopus aegina, O. dollfusi* and *Cistopus indicus* are obtained in bottom trawl nets from the continental shelf of Hong Kong. *O. aegina* occurs at depths of 30-120 m in Hong Kong waters and the annual production of this species is about 100 t (Voss and Williamson, 1971). *Octopus dollfusi* and *Cistopus indicus* are distributed from shallow depths upto to 50 m. *Cistopus indicus* is a common octopod captured in kelongs of Singapore and consumed (Pickford, 1974).

A keen demand exists for octopod products in some countries especially Japan (Anon, 1977; Santhanakrishnan, 1984). There are good possibilities for organizing a fishery in the country for this nonconventional resource by adopting suitable methods for their sustained exploitation.

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OCEANIC SQUIDS

E. G. Silas, R. Sarvesan and M. M. Meiyappan

Abstract

The various species of oceanic squids distributed in the Indian Ocean especially in the Exclusive Economic Zone of India and adjacent waters and their importance form the point of view of exploitation are discussed. The need for conducting experimental fishing and use of suitable fishing and drift net fishing for developing a fishery for oceanic squids is emphasized.

Introduction

The oceanic squids are comprised of the Oegopsida, which are distinguished by the presence of an opening (slit) in the corneal membrane exposing the lens of the eye to the surrounding medium. Excepting a very few, e.g., *Todarodes pacificus* and *Illex illecebrosus*, almost all oceanic squids spend their entire life span in the open ocean.

There are about 200 species of oceanic squids belonging to 28 families known to occur in the world oceans (Worms, 1983). Our knowledge about the oceanic cephalopods of Indian Ocean is through the works of Clarke (1966), Filippova (1968) and Silas (1968, 1969 a, 1969 b and Silas *et al.* (1976). A comprehensive list of species of cephalopods known from the Indian Ocean has been given by Silas (1968). In that work, sixty nine species of oceanic squids representing forty three genera of thirteen families are reported from this region. Many of the oegopsid squids and a few other cephalopod species are considered to form stocks which have been hitherto unexploited in the Indian Ocean and the seas around India. Some of the commercially important squids are known to abound in our Exclusive Economic Zone and contiguous areas. Upto now no quantitative estimates have been made of the available resources. However, the exploratory works and planktological investigations carried out in the past indicate that extensive resources exist especially in the North Arabian Sea, off west coast of India and in the oceanic waters of the Bay of Bengal. We have some idea of the general distribution of many of these oceanic squids and their juveniles. The report by Filippova (1968) based on the large collections of cephalopods made from a total of 190 stations in Indian Ocean by R/V VITYAZ (1959-67), R/V ACADEMICIAN KNIPOVITCH (1966) and by the Factory Ship SOVETSKAYA ROSSIA (1966-67) throws more light on the occurrence of some of these species in the different areas of the Indian Ocean up to 41°S. Silas (1969) has presented the results of the investigations made during cruises of R.V. VARUNA on the distribution and abundance of cephalopod larvae, juveniles and adults belonging to the families Loliginidae, Enoploteuthidae, Bathyteuthidae, Histioteuthidae, Ommastrephidae and Cranchidae. Based on the observations made, the distributional charts with information on the seasonal cycles of abundance pertaining to *Abralia andamanica*, *Abraliopsis gilchristi*, *Rhyncoteuthis* larvae of *Symplectoteuthis oualaniensis*, *Doratopsis* stage of *Chiroteuthis* sp., *Liocranchia* spp. and *Thelidioteuthis alessandrinii* have been given.

Studies on the distribution and relative abundance in time and space of cephalopod juveniles in general have been made by Aravindakshan and Sakthivel (1973).

The studies were based on plankton collections obtained from a wide area during the Internatioal Indian Ocean Expedition from the Bay of Bengal, Somalia Sea, North Arabian Sea and East Arabian sea. A comparison of occurrence of cephalopod juveniles in different areas showed that they are abundant in the Bay of Bengal, Andaman Sea, southwest off Sri Lanka, off Kutch, South Arabian Coast, parts of Somali Coast, certain isolated areas along equaltorial zone and southern area off South African Coast. Seasonal variations in the abundance of cephalopod juveniles with peak abundance during southwest monsoon period in the Bay of Bengal (April-September) were observed in these areas. In the North Arabian Sea, the major peak (was noticed in November and December followed by a minor peak in June and July. The general pattern observed is that juveniles are more abundant along the South Arabian Coast during the northeast monsoon period than in other months whereas their abundance is during southwest monsoon period in the Bay of Bengal (Aravindakshan and Sakthivel, 1973).

Prevalence of similar conditions has been reported along the west coast of India (Silas, 1969). The larvae of cephalopods were in greater abundance during the periods April-July and November-December in the Wadge Bank off Cape Comorin and between Quilon and Cochin.

It is interesting to note that of all the areas explored in the Indian Ocean, greater abundance of cephalopod larvae and juveniles were recorded in the Bay of Bengal area, in the Wadge Bank off Cape Comorin and areas off Kutch in the northwest coast of India.

Although a number of species occur in oceanic waters, many owing to their small size and unfavourable consistency of their body, are not suitable for human consumption but are important as forage to tunas, billfishes and toothed whales. Only a few species of oceanic squids are commercially and potentially important and they belong to the families Ommastrephidae, Histioteuthidae, Lepidoteuthidae, Onychoteuthidae, Veranyidae, Gonatidae and Cranchiidae (Voss, 1973). A list of selected oceanic species of cephalopods distributed in Indian ocean based on the work of Silas (1968) and Filippova (1968) is given here (Table 1). Of these, the members of the family Ommastrephidae are by far the most important because many species of this family are already exploited in commercial fisheries by some countries particularly in the Pacific and Atlantic waters.

TABLE 1. *Oceanic Species of Cephalopods of importance distributed in the Indian Ocean Region* (*Silas*, 1968)

Family Lycoteuthidae Pfeffer
- *Lycoteuthis diadema* (Chun)

Family Enoploteuthidae Pfeffer
- *Enoploteuthis dubia* Adam
- *Abralia andamanica* Goodrich
- *A. steindachneri* Weindl
- *A. renschi* Grimpe
- *A. lucens* Voss
- *A. armata* (Quoy and Gaimard)
- *A. sparcki* Grimpe
- *Abraliopsis gilchristi* (Robson)
- *A. morrisii* (Verany)
- *A. hoylei* (Pfeffer)
- *A lineata* (Goodrich)
- *Ancistrocheirus lesueuri* (Orbigny)
- *Theliodioteuthis alessandrini* (Verany)
- *Pterygioteuthis giardi* Fischer

Family Octopoteuthidae Berry
- *Octopoteuthis sicula* (Ruppell)
- *Taningia danae* Joubin

Family Onychoteuthidae Gray
- *Onychoteuthis banksii* (Leach)
- *Onychia carribea* LeSueur
- *Moroteuthis lonnbergii* Ishikawa and Wakiya
- *M. robsoni* Adam
- *M. robusta* (Verrill)

Family Lepidoteuthidae
- *Tetronychoteuthis dussumieri* (Orbigny)

Family Architeuthidae
- *Architeuthis sancti-pauli* Velan
- *Architeuthis* sp. Clarke

Family Histioteuthidae Verrill
- *Histioteuthis bonnellii* Ferussac
- *Calliteuthis hoylei* (Goodrich)
- *Calliteuthis reversa* Verrill
- *C. miranda* Berry
- *C. japonica* (Massy)
- *Histiochromius chuni* Pfeffer

Family Bathyteuthidae Pfeffer
- *Bathyteuthis abyssicola* Hoyle

Family Ctenopterygidae Grimpe
- *Ctenobteryx sicula* (Verany)

Family Brachioteuthidae Pfeffer
Brachioteuthis riisei (Steenstrup)
B. picta Chun

Family Ommastrephidae Steenstrup
Illex coindeti (Verany)
Todarodes eblanae (Ball)
T. sagittatus (Lamarck)
T. pacificus Steenstrup
Nototodarus sloanii (Gray)
N. gouldi (McCoy)
Ommastrephes bartrami (LeSueur)
Symplectoteuthis oualaniensis (Lesson)
S. luminosa Sasaki

Family Thysanoteuthidae Keferstein
Thysanoteuthis rhombus Troschel

Family Chiroteuthidae Gray
Chiroteuthis imperator Chun
C. macrosoma Goodrich
C. pellucida Goodrich

Family Mastigoteuthidae Verrill
Mastigoteuthis cordiformis Chun
M. glaukopsis Chun

Family Grimalditeuthidae Pfeffer
Grimalditeuthis bonplandi (Verany)

Family Cranchiidae prosch
Cranchia scabra Leach
Leachia cyclura Lesueur
L. eschscholtzii (Rathke)
Liocranchia gardineri Robson
L. reinhardti (Steenstrup)
L. valdiviae Chun
L. intermedia Robson
Pyrgosis pacificus (Issel)
P. rhynchophorus Rochebrune
Sandalops melancholicus Chun
Megalocranchia abyssicola (Goodrich)
M. maxima Pfeffer
Anamalocranchia impensis Robson
Henseniateuthis joubinii Pfeffer
Galiteuthis armata Joubin
Corynomma speculator Chun
Toxeuma belone Chun
Taonidium chunni (Pfeffer)

Among the important oceanic squids in the Indian Ocean which are either presently exploited or exploitable, mention must be made of *Symplectoteuthis oualaniensis*, *Ommastrephes bartrami*, *Thysanoteuthis rhombus*, *Onychoteuthis banksii* and *Notatodarus sloani*. Our knowledge about the resources of these species as to their biological and ecological aspects is scanty. The available information on these species is mainly based on their distribution in the Pacific Ocean and surveys carried out in the Indian Ocean as they are beginning to be exploited commercially by Japan and a few other countries following full exploitation of the stocks of the common Japanese squid *Todarodes pacificus*. *Notatodarus sloani* and *N. gouldi* support good fisheries in Australian waters.

Symplectoteuthis oualaniensis (Lesson)

This is a widely distributed Indo-Pacific oceanic squid, recorded from Oualan Islands (Clarke, 1966) and subsequently reported from Red Sea, Arabian Sea, Laccadive Sea, Coast of Sri Lanka, Bay of Bengal, off Natal, South Africa, East Africa, Cocos Islands and West coast of Australia in the Indian Ocean. In the Pacific Ocean this species is distributed widely from Japan, Taiwan, Philippines, South Sea and up to west coast of South and Central America (Silas, 1968 ; Okutani, 1982). A detailed numerical taxonomic study has been made by Wormuth (1976) on the oceanic squid family Ommastrephidae.

S. oualaniensis is a large-sized ommastrephid which is most abundant and appears to be restricted to northern and central parts of Indian ocean approximately up to 20°S. The southern boundary of *S. oualaniensis* coincides with the zone of subtropical convergence and the area is situated in the limits of the tropical waters (Filippova 1968). Such distributional pattern has also been observed for tropical zooplankton and epipelagic fishes (Parin, 1967). In the Pacific Ocean *S. oualaniensis* has been found to be distributed in the regions further north of 20°N (Wormuth, 1976).

The biology and ecology of this oceanic squid is now better known as compared to the other ommastrephids of the Pacific Ocean. Our knowledge about *S. oualaniensis* is from the works of Clarke (1966), Silas (1968), Voss (1973), Roper and Young (1975), Filippova (1968), Wormuth (1976) and Okutani (1977). Apart from these, the recent exploratory surveys conducted in the northern Arabian Sea, off Pakistan and in the South give additional information on this species (Fishery Agency of Japan, 1975 ; Yamanaka, 1976).

The *Rhynchoteuthis* larvae of *S. oualaniensis* were abundant in plankton collections obtained during the exploratory cruises of R/V VARUNA (Silas, 1969) in the Arabian Sea particularly within the areas between Lat. 7°N-17°N and Long 70°E-78°E beyond the continental shelf or beyond 200 m. depth off Mangalore, Calicut, Quilon, in the Wadge bank and off the east coast of India. Their seasonal distribution indicates that though *Rhynchoteuthis* larvae are present almost throughout the year excepting June and August, there are two periods of peak abundance in March to May and November—December. This distribution pattern of the larvae of *S. oualaniensis* suggests that spawning may also take place within the Exclusive Economic Zone of India. However, further exploratory surveys are needed in this direction to assess the larval abundance and recruitment in this area. Apart from the larvae in the plankton, squids were also captured frequently in drift nets, and very often 15 to 20 specimens were obtained per operation. They were also often attracted towards the light from the research vessel when working hydrographic stations during night (Silas, 1969). *Symplectoteuthis oualaniensis* exhibits positive phototaxis and is of aggressive nature. This species is commercially caught by hooks and lines with light at night in the waters around Okinawa to Taiwan (Tung, *et al.*, 1973 ; Okutani and Tung, 1978 ; Okutani, 1980 ; Caddy, 1983). It is reported that *S. oualaniensis* usually forms small schools consisting of about thirty individuals of nearly the same size, most likely to avoid cannibalism (Wormuth, 1976).

Information on predators of *S. oualaniensis* is limited. A number of predatory fishes are believed to feed extensively on squids. According to Wormuth (1976) *Coryphaena hippurus* and *Gempylus serpens* and several species of tuna (Alverson, 1963) feed on *S. oualaniensis* Apart from these fishes, some of the sea birds of Christmas Island in the Pacific Ocean, viz. *Phaethon rubricauda, Puffinus nativiatatis, Pterodroma alba, Sterna muscata, Anous stolidus, A. tenuirostris, Gygis alba* and *Procelsterna cerulea* (Ashmole and Ashmole, 1967) also feed on this species. In addition to these the Sooty tern and Brown Noddy are also known to feed on *Symplectoteuthis oualaniensis*, (Brown, 1973).

S. oualaniensis appears to feed on small fishes and occasionally on other squids. The stomachs of this squid examined for food items included amphipods, megalopa larvae, small shrimps, stomatopod larvae crab zoea, large copepods, euphausiids, enoploteuthid squids and predominantly fishes. Most of the small crustaceans and other organisms would have come from the stomachs of the fishes consumed by *S. oualaniensis* (Young, 1975). These squids are occasionally seen actively preying upon small fishes, mostly Myctophids (lantern fishes), seizing the prey with tentacles and bite just behind the head, severing the backbone. In Hawaiian waters, the prey species of this squid included *Stolephorus purpureus, Exocetus volitans, Oxyporhamphus micropterus, Ceretoscopelus, Vinciguerria, Hygophum* spp., *Diaphus* spp. and *Myctophum* spp. (Wormuth, 1976). Other squids frequently found in the stomachs of *S. oualaniensis* were *Onychoteuthis banksii* and *Hyaloteuthis pelagica.*

Exploratory Fishing in the Arabian Sea by Japanese Vessels

The recent exploratory surveys conducted by R/V SHOYA MARU of the Fishery Agency of Japan to assess the Pelagic fishes and squid stocks in the North Arabian Sea, off Pakistan (Fishery Agency, 1976) and in the South Arabian Sea in the oceanic waters (Fishery Agency, 1977) provide some important and basic information on the distribution, behaviour, biology and environmental aspects of this squid. During the survey a most significant stock of *Symplectoteuthis oualaniensis* was discovered in the North Arabian Sea. The surveys were conducted by the FAO with the cooperation of I.O.P. in 1975-76 and 1976-77. Besides the oceanographic data, biological surveys have been conducted along with visual observations, trolling and sampling of eggs and larvae. Midwater handline, bottom handline, bottom long line, midwater trawl and bottom trawl gears were also employed. In midwater handline, bottom handline and midwater trawling, squids (*S. oualaniensis*) were obtained both in the North Arabian Sea and in the Southern areas.

In midwater handline test operations totally 130 squids, ranging in size from 12 to 36 cm and 75 to 137.5 gm in weight were obtained from 19 stations out of 33 stations scattered throughout the survey area (Fishery Agency of Japan, 1977). In an earlier survey during 1976, also considerable numbers of *S. oualaniensis* were noticed in the North Arabian Sea off Pakistan distributed around the upwelling areas.

The most significant finding during the above exploratory fishing was the discovery of these squids in dense concentrations recorded in the acoustic surveys. Analysis of these data obtained from 1975 to 1977 indicate that the squids mostly occur at depths of 120 to 200 m and below in day time. These squids appear to make vertical migration descending in the day time to low oxygen layer of 0.18 ml to 0.3 ml/1 and moving to oxygen saturated upper layer at night for feeding when they are taken easily in jigs.

S. oualaniensis is not at present exploited in Indian waters or in any part of Indian Ocean. The stock in the Pacific is subjected to commercial exploitation along with other species of oceanic squids off Okinawa

(Japan) and Taiwan (Okutani, 1977). Some aspects of the fishery biology of this species have been investigated on the populations around Taiwan. There appears to be three seasonal subpopulations differing in size-maturity relationship (Tung *et al.*, 1973 ; Tung, 1976) in Taiwanese waters.

Ommastrephes bartrami (LeSueur)

This oceanic ommastrephid squid is known from the tropical and warm temperate waters of the Indo-Pacific and the Mediterranean (Clarke, 1966 ; Silas, 1968). The species has been recorded from Indian Ocean by Pfeffer (1912) ; from South Africa and Chagos Islands by Robson (1921) and by Filippova (1968) from the subtropical region of Indian ocean between Lat. 23° and 37°S and Long. 60° and 113°E. Wormuth (1976) has recorded it from several localities in the northern and southern Pacific Ocean.

This species is mainly distributed in the surface layers in the warm oceanic environment and seems to be abundant in the northern and southern limits of Indian and Pacific oceans (Okutani, 1977). *Ommastrephes bartrami*, in general appearance has similarity with other ommastrephids such as *Symplectoteuthis oualaniensis*. The former is a very large sized oceanic squid sometimes growing to 40-50 cm in mantle length and 2 to 3 kg in weight. It possesses subcutaneous photophores on the ventral side of the mantle, head and centrolateral and ventral arms. Information on the biology, life-history and ecology of this species is limited. Some information on the ecology and age and growth of *O. bartrami* in Japanese waters are given by Ishii (1977) and Murata and Ishii (1977). *O. bartrami* like other oceanic squids, has been observed to form schools, and the size of the school usually tends to decrease as the size of individual squid increases. Large individuals measuring about 50 cm in mantle length appear to be solitary (Wormuth 1976). *O. bartrami*, like other ommastrephids, is a very strong and rapid swimmer, often being reported to leap out of water. Hence it is known as the 'flying squid' (Clarke, 1966). It has also been observed at times gliding above the surface of the ocean during daytime (Araya, 1954).

Although there was no commercial exploitation of *O. bartrami* until recently, a beginning has been made in the capture of the species in good quantities since 1968. It has become the main target species of jig fishery in north Japan (Okutani, 1977 ; Murata, 1977). According to Okutani (1977) about 27,000 tons to 90,000 tons of *O. bartrami* were landed during 1974 to 1976 at Hokkaido and North East Honshu. Most of the catches were exploited in the Northwest Pacific off Northeast Honshu and Hokkaido along with *Todarodes pacificus*. An initial investigation made on the oceanic squids by Japan mainly in the area 152°E and 40°N45°N since 1968 to 1976 indicates an estimated potential of 150,000 to 600,000 tons which represents only a part of the total population that came within the survey area (Okutani, 1977). Similar estimates on the stocks in the Indian Ocean region are not avilable and the potential existing in the area is not known. The distribution of *Ommastrephes bartrami* in commercial quantities in the Southern Indian Ocean in the waters around Australia and New Zealand has been indicated by the capture of good quantities of the squid by the Tiwanese research vessel *HAI KUNG* with surface gill net which is one of the effective gears for oceanic squids (Collins and Dunning, 1981).

Some aspects of the biology and ecology of *O. bartrami* caught in the jigging experiments in the Pacific off northern Japan during 1968-76 are given by Murata and Ishii (1977). Generally, the female squids obtained were larger in size than males and the size difference between the sexes increased with increasing age. Squids measuring 36 cm and above in mantle length were found to be females. The males appear to mature prior to females when they attain a length of 31 cm in mantle size and 15-20 g in testis weight, whereas the females grow up to 40 cm in size and 20-50 g in ovary weight. The investigations carried out from 1968 to 1976 showed that there were two distinct groups in the *O. bartrami* population in the Pacific off North Japan which are distinctly differenti in growth pattern ; one group was found to be large-sized whereas the other was a small-sized one. The average monthly growth in mantle length attained by the former group was 3-4 cm in June-October, 1-2 cm in October-December and 0.5-1 cm in December-February and in the small-sized group 2-3 cm in June-December and 1-2 cm in December-February. It was also obrserved that the main spawning season of squids of both the groups was January to May. The life span of *O. bartrami* was estimated to be about one year.

Prey and predators

The stomachs of *O. bartrami* obtained in New Zealand waters which were examined were full of fishes belonging to the genera *Hygophum*, *Symbolophorus*, *Lampanyctus*, *Nansenia*, *Scopelosaurus* and *Centrobranchus*. They are also found to be cannibalistic and include squids in their diet (Wormuth, 1976). The main predator of *O. bartrami* seems to be the sperm whale *Physeter catodon* (Kawakami, 1976).

Thysanoteuthis rhombus Troschel

This oceanic squid is a cosmopolitan pelagic species usually found in warm water areas of the world oceans. This is the only known species of the genus *Thysanoteuthis* and normally occurs in small groups of two or more individuals swimming in the surface waters. Adults commonly grow to a large size of about 60 cm in mantle length (Okutani, 1977). According to Roper *et.al.* (1984) the maximum size attained by this species is about 100 cm with a body weight of 20 kg. Sausage-like gelatinous floating eggmass 16-17 cm in length and 15-20 cm in diameter with two rows of embryos and early stage larvae of *T. rhombus* have been described by Sanzo (1929) from the Mediterranean Sea and recently by Misaki and Okutani (1976) from Japanese coast. This species was first recorded from the Mediterranean Sea and subsequently from North and South Atlantic near the Cape of Good Hope (Bernard, 1947), Algoa Bay (Bruggen, 1962), in the Pacific Ocean off Japan (Sasaki, 1929); China and the Bor Islands (Nishimura, 1964) and from the Indian ocean for the first time by Filippova (1968). More details of distribution of this species in Atlantic and Pacific are given by Voss and Eradman (1959).

This squid has been subjected to commercial exploitation only in recent years in Japan. The fishery for *Thysanoteuthis rhombus* according to Okutani (1977) was initiated in 1962, in Hyogo Prefecture, Japan. They are usually taken in small quantities by jigging from boats while drifting, but in recent years they are captured in single jigs connected to a drifting float (Nazumi, 1975). The catch statistics for this species for Huogo Pr fecture (Okutani, 1977) show that in certain years they were landed in good quantities, with annual catches of about 500 to 600 tons. The annual catches fluctuated highly from about 2 to 620 tons during 1962-74.

Thysanoteuthis rhombus has been recorded by Filippova (1968) from Indian Ocean from 9 stations scattered in the western, central and eastern parts. On one occasion, a juvenile was also obtained, which indicates that the spawning of this species takes place in the area surveyed. This thus appears to be a potentially important species.

Onychoteuthis banksii (Leach)

This is a cosmopolitan species distributed in warm and temperate oceanic waters and considered to be common from surface waters upto 150 m depth (Clarke, 1966; Filippova, 1968). It may also be found in deep waters of 800 m (Roper *et. al.*, 1984). In Indian Ocean this has been recorded from a number of places (Pfeffer, 1912; Rees, 1949) the east Indies (Pfeffer, 1912) Philippines (Pfeffer, 1912; Voss, 1956, 1963) Formosa (Pfeffer, 1912, Sasaki, 1929), east Australia (Gould, 1852; Braizier, 1892; Cotton and Godfrey, (1940; Allen, 1945) and Goodrich (1896). This is a moderate sized oceanic squid reaching a mantle length of about 30 cm. This species, known as 'Clubhook squid' is often caught in dipnets but there is not much information of its biology.

While the cephalopods in the neritic areas are exploited by India to some extent by traditional gears, there is no exploitation of the oceanic squids of different species in the oceanic waters off India. For fishing the oceanic squids distributed in the high seas, the development of suitable types of mechanised vessels capable of appropriate capture methods such as jigging, light fishing and drift gill net fishing is necessary. Great advances have been made by Japan in fishing techniques for oceanic squids. What is needed is a major effort at experimental fishing in the oceanic areas by adoption of fishing techniques known to be efficient for the capture of oceanic squids. We feel that training of our manpower under Japanese expertise will be essential for developing a major fisheries for oceanic squids in our EEZ and contiguous high seas.

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ON THE CEPHALOPODS OBTAINED IN EXPERIMENTAL TRAWLING AND LIGHT FISHING CONDUCTED AT VIZHINJAM

K. PRABHAKARAN NAIR AND T. A. OMANA

ABSTRACT

Trawling and light fishing with different types of lamps for light attraction were carried out at Vizhinjam. One Species of cuttlefish and two species of squids formed part of the trawl catches while three species of squids were obtained in light fishing. The biological characteristics of these cephalopods are briefly dealt with.

INTRODUCTION

The Research Vessel CADALMIN II of the Central Marine Fisheries Research Institute was available at Vizhinjam during March-April, 1978, primarily for conducting light fishing experiments in connection with the anchovy live-bait culture. During day time the vessel was employed for carrying out trawling experiments, in which cephalopods were one of the major components of the catch. In light fishing also squids formed an important item, besides anchovies. The results of the experimental trawling and light fishing were reported by Kuthalingam *et al.* (1982) and Luther *et al.* (1982). The present report is on the squids and cuttlefishes obtained during the course of these experiments. Though the catch of cephalopods (as also other shellfish and finfish) was not high by quantity or number, their occurrence may be indicative of a potential resource in the area.

The CADALMIN II is 13.25 m long and fitted with 88 b.h.p. Ashok Leyland marine engine, mechanical winch and Simrad echosounder. It can accommodate seven personnel including scientists, and has a laboratory for conducting experiments on-board.

TRAWLING

Experimental trawling was conducted in the area 8-76/3F (8°20'8°30'N and 76°50'-77°E) off Vizhinjam. A total of 17 hauls of one hour duration each were made in the depth ranges 10-20 m, 20-30 m and 30-40 m, with a 30-metre otter trawl having a cod-end mesh of 25 mm.

During the course of trawling operations the surface temperature ranged between 30°C and 31.5°C and the salinity between 30.01‰ band 35.64‰. The bottom values of these parameters also did not show much variations: temperature ranged from 28.4°C to 29°C and salinity from 30.52‰ to 36.37‰. The bottom of the trawling areas was predominantly sandy, at some places mixed with mud.

The total catch of fish and shellfish was 920 kg, of which cephalopods were 36.5 kg forming about 4%. Most of them were taken from the depth 30-40 m at a catch rate of 4 kg/hour of trawling; the catch rate from the other two depth zones (10-20 m and 20-30 m) was 0.7 kg/h each.

The cephalopod catch was composed of the cuttlefish *Sepia pharaonis* and the squids *Loligo duvaucelii* and *Doryteuthis sibogae*. Apart from these, a very few specimens of *Sepia aculeata* were also obtained. The length-frequency, stages of maturity, and condition of stomachs of *Loligo duvaucelii* and *Sepia pharaonis* and the body weight—shell (cuttlebone) weight and body weight—mantle weight relationships in *Sepia pharaonis* are shown in Fig. 1 and that of *Doryteuthis sibogae* in Fig. 2.

Sepia pharaonis

Of the 19 cuttlefishes obtained in trawling, 14 in the range of 80-229 m were males; the females were only

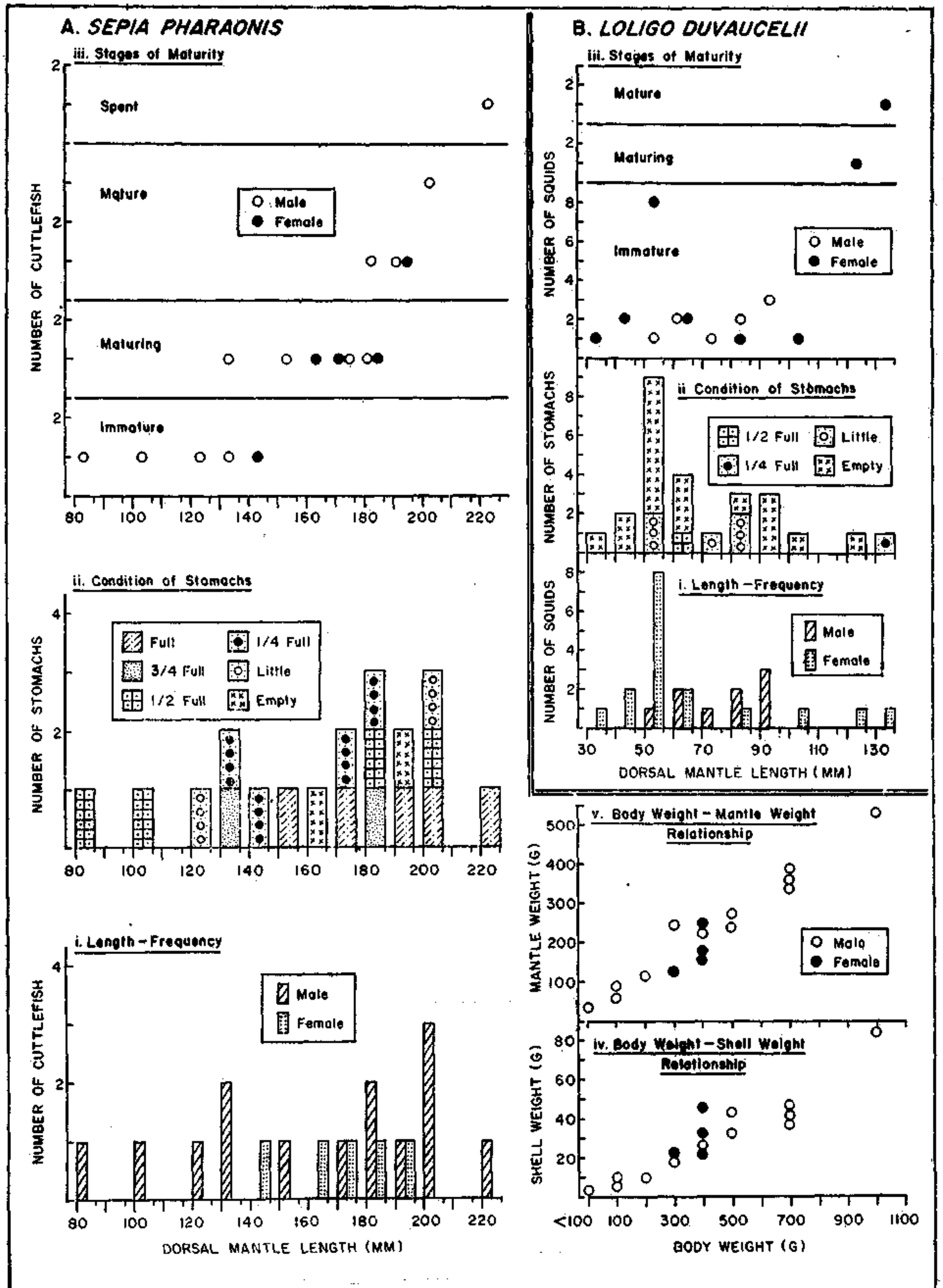

FIG. 1. Cephalopods obtained in trawling: A. *Sepia pharaonis* : (i) Length frequency ; (ii) Condition of stomachs ; (iii) Stages of maturity ; (iv) Body weight—shell (cuttlebone) weight relationship ; B. *Loligo duvaucelii*, (i) Length frequency ; (ii) Condition of stomachs ; (iii) Maturity stages.

five in number and had a smaller size range, 140-199 mm (Fig. 1 A i-iv). Majority of the cuttlefishes had stomachs with food in varying degrees of fulness ; only two had empty stomachs. Fish and crustaceans in almost equal proportions were the food. Above the length of 180 mm the males were mature and one male cuttlefish of the size 220 mm was found to be in spent condition. The maturing and immature males had a size range of 130-139 mm and 80-139 mm respectively. Among females there was only one mature individual 190 mm in size ; others were maturing and immature. In males the shell (cuttlebone) weight ranged from 3 g to a maximum of 84 g, with a mean value of 29 g. corresponding figures being 51.6%, 41.4% and 81.4% in the range of 125 g and 246 g.

Loligo duvaucelii

Twenty six specimens of this squid were obtained, of which 9 were males in the size range 50-99 mm and 17 were females in the size range 30-139 mm (Fig. 1B, i-iii). Both the sexes combined, the maximum number was in the length group 50-59 mm. Over 75% of the specimens had empty stomachs. The rest of the squids had stomachs with food comprising fish (68%) and crustaceans (32%). All the males were immature. Among females one specimen measuring 120 mm was

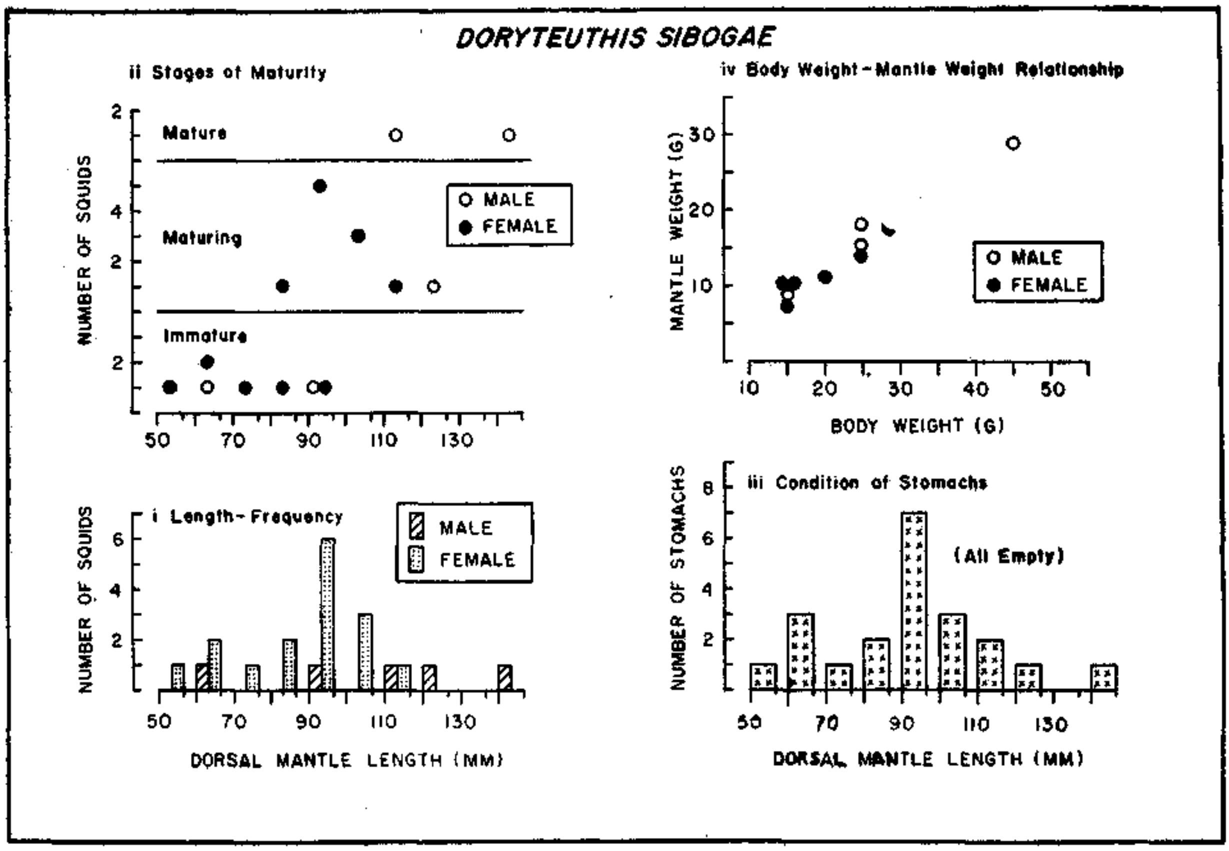

FIG. 2. Cephalopods obtained in trawling : *Doryteuthis sibogae*. (i) Length frequency ; (ii) Stage of maturity ; (iii) Condition of stomachs ; (iv) Body weight-mantle weight relationship.

forming 6.6% of the total body weight. In females the cuttlebone weight was generally higher than in males. Within a range of 22 g and 47 g the average weight was 31 g forming 8.2% of the body weight. The average mantle weight in male cuttlefish was 56.7% of the total body weight with a minimum of 48.6% and a maximum of 82.3% within the range of 27.5 g and 535 g. In females all the values were lower, the maturing and another one of the size 130 mm was mature ; all the others were immature.

Doryteuthis sibogae

Of a total of 21 squids in the size range 50-149 mm, five were males (60-149 mm) and 16 females (55-119 mm). The maximum number was in the length group 90-99 mm (Fig. 2 i-iv). Among males two were

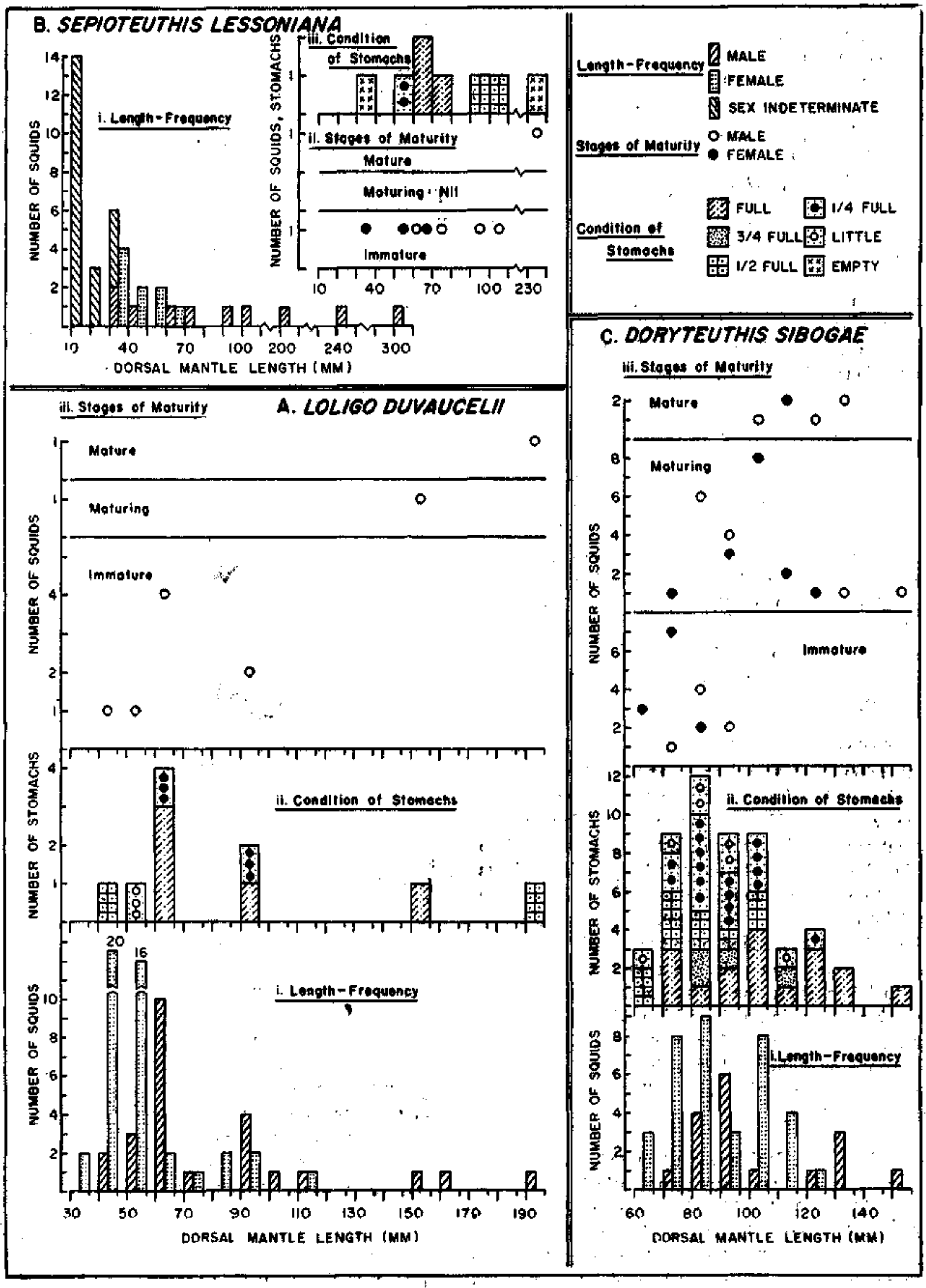

FIG. 3. Cephalopods obtained in light fishing. (i) Length frequency; (ii) Condition of stomachs; (iii) Maturity stages of A. *Loligo duvaucelii*, B. *Sepioteuthis lessoniana* and C. *Doryteuthis sibogae*.

immature, one maturing and two mature. Six females in the range 50-99 mm were immature and 10 females in the range 80-119 mm were maturing. There were no fully mature females. All the 21 squids had empty stomachs. In male squids the mantle weight formed an average of 64% of the total bodyweight, with a minimum of 60% (9 g) in squids weighing 15 g, and a maximum of 64.4% (29 g) in squids weighing 45 g. In females the average mantle weight was 60% of the total body weight within a range of 55-66% (8.5-16 g).

Apart from the above mentioned cephalopods, five small specimens of the cuttlefish *Sepia aculeata* were taken in the trawl. They ranged from 21 mm to 93 mm ; four of them were males.

Light Fishing

The source of artificial light was a 500-Watt lamp, a 1000-Watt lamp and a 160-Watt fluorescent lamp, lighted by a generator kept on-board. Besides these electric lights, a kerosene petromax lamp with the mantle directed downwards and giving a light intensity of approximately 200 candles power was also used. These were tried separately, and the petromax light was found to be the most effective, since the attraction of squids to this light was much greater than to the electric light.

The principal catching device was a bag-like monofilament nylon net 1.5 m deep having a 3.5 m × 3.5 m square rim made of cane. The net could be lowered into the water and lifted up by means of four corner ropes that ran over four pulleys fastened to two bamboo poles rigged horizontally to the vessel. By tying weights at its bottom the net could be kept in position when lowered into the water. The light, whose height could be adjusted, was suspended over the middle of the net from another bamboo pole. Normally the light was kept 1 to 1.5 m above the surface of the water. When the net was in the lowered position with the rim well below the surface, the squids attracted towards the light were trapped by suddenly lifting the net by pulling the corner ropes. The squids were collected from the net by using a hand-net.

Most of the light fishing was attempted in the Vizhinjam Bay where the water was comparatively more calm than outside and devoid of strong under-currents. The depth of the area where the fishing was done ranged from 8 m to 20 m. The sky was clear or partly cloudy and very rarely it was completely cloudy. The sea condition was calm to slightly rough and the water temperature throughout the period was within the range of 29-30°C.

Outside the Bay, fishing was attempted but many difficulties were met with. The sea was always rough or moderately rough causing rolling of the vessel, Because of this the light could not be suspended steady. with the result that the attraction of squids was poor. The net was drifted away from the normal position by undercurrents and therefore quick pulling up of the net was difficult. The resultant delay has often caused the squids that have collected below the light to escape from the net.

The squids that were caught in light fishing were *Loligo duvaucelii*, *Sepioteuthis lessoniana* and *Doryteuthis sibogae*. No cuttlefish was attracted by light, except for a small *Sepiella inermis* measuring 35 mm. The squids came in small groups comprising individuals of about the same size, and with slight disturbance like the moving of the light or net and rolling of the vessel, the entire group moved away at high speed. Often the small fishes attracted towards light seemed to be scared away by the approaching squids.

While the electric light attracted squids, though to a lesser extent compared to the petromax, the sound of the generator seemed to be a deterrent to squids coming towards the light. With the engine of the vessel kept off, the petromax light attracted more number of squids. Light fishing was also attempted in the night next to fullmoon, and since there was bright moon light throughout, the response of squids (as also fish) to petromax light was poor.

The length-frequency, condition of stomachs and stages of maturity of *Loligo duvaucelii*, *Sepioteuthis lessoniana* and *Doryteuthis sibogae* are shown in Fig. 3.

Loligo duvaucelii ; The male squids ranged in size from 40 mm to 199 mm with the main mode at 65 mm, followed by a smaller mode at 95 mm. The females had a smaller size range of 30-119 mm with the main mode at 45 mm, followed by a smaller mode at 95 mm. Among the squids examined for maturity stages and condition of stomachs, there were no females. The male squids upto a length of 99 mm were immature ; one squid measuring 159 mm was in maturing stage and another one of 199 mm was mature. All the stomachs had food, most of them full. Fish was the sole item of food found in the stomachs of these squids.

Sepioteuthis lessoniana ; Fortyone squids were obtained during the light fishing experiments. Except for three males of the size between 200 mm and 300 mm, all the others were juveniles. Of these, 7 (30-109 mm in size) were males and 9 (30-69 mm) females ; the remaining 21 were small and their sex could not be determined externally. Among 8 squids examined for condition of stomachs, 6 had stomachs with food in different degrees of fulness. In this case also fish was the most important food.

Doryteuthis sibogae ; The male and female squids did not show much variation in size range. The males were of the size 70-159 mm with the main mode at 95 mm and another one at 135 mm. The females ranged from 60 mm to 129 mm with modes at 85 mm and 105 mm. Both the sexes combined, the mode was at 85 mm. About 59% of the males and 66% of the females were maturing and mature ; the maximum sizes of immature squids were 99 mm for males and 89 mm for females. As in the case of *Loligo duvaucelii,* this squid did not have empty stomachs. The incidence of full stomachs was over 32%. The food was composed entirely of fish.

The present trawling and light fishing experiments were short and preliminary, and the cephalopods obtained were only incidental. From the results of these experiments it is not possible to make any estimates of the available cephalopod resources of this area. However, with more effort to conduct regular trawling and light fishing with light-attraction system and catching devices such as jigging for squids and improved hooks for cuttlefish it may be possible to exploit cephalopods to a much greater extent than being done at present by the traditional fisheries.

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HAND-JIGGING FOR CUTTLEFISH AT VIZHINJAM WITH A NOTE ON MODERN SQUID JIGGING

K. Prabhakaran Nair

Abstract

At Vizhinjam on the southwest coast of India almost the entire catch of the cuttlefish *Sepia pharaonis* is taken in a modified type of hooks, the hand-jigs. The hand-jig consists mainly of a small iron rod with tires of hooks and a long monofilament line. The baited jig is operated on the sea bottom from a catamaran and normally one cuttlefish is taken per haul. A brief note on the modern squid jigging as practised in Japan is also given.

Introduction

Though squids and cuttlefish are obtained as a by-catch in the landings by shore seines, boat seines, hooks and lines and trawl nets all along the Indian coast, 'hand-jigging' is employed exclusively for cuttlefish at Vizhinjam (Trivandrum). Almost the entire catch of cuttlefish landed at Vizhinjam is taken by modified hooks (jigs), and a small portion in hooks and lines. Since both these types of gear are taken in the same craft (catamaran) and operated in the same fishing ground, the combined catch is recorded under the gear category 'hooks and lines'. However, it is estimated that over 95% of the cuttlefish taken in hooks and lines at Vizhinjam are got by hand-jigging. This fishery has developed during the last decade.

The hand-jig, so named because of its general similarity to a typical squid jig having one or more circles of hooks attached to a wooden, metal or plastic shaft tied to a line, is purely a local innovation restricted to Vizhinjam and some nearby fishing villages on the southern part of the southwest coast of India where the large-sized cuttlefish *Sepia pharaonis* is abundant. While trawling accounts for almost the entire catch of cuttlefish in the other parts of the Indian coast, trawl fishing is not being attempted in this region because of the uneven nature of the sea bottom.

Locally known as *nangoora choonda*, literally meaning 'anchor hook', because of its resemblance to a grapnel, the hand-jig has mainly three parts: a thin rod with two or sometimes three tiers of hooks, another rod with a weight attached to it, and a 40-60 m long line tied to the latter. The first rod is a piece of umbrella rib about 30 cm long and tied to its one end in a circle are 4 or 5 hooks of No. 9-12 (Plate IB). About three centimetres above this circle, there is another circle of similar hooks. Above this there is a still larger single hook of No. 7 or No. 8. The free end of the rod is tied to a long plastic monofilament line. About 150 cm above the rod, another small rod 30 cm in length is attached on the line parallel to it. An iron weight of about 100-150 g is tied at the middle of this rod with a 30 cm string. The long line is wound on a wooden line holder (Plate IA).

The description given above is of a typical hand-jig but in the jigs used by fishermen, though the basic features are the same, there may be small variations in the size and number of hooks, length of the rod, size of the weight and the length of the long line.

The hand-jig is operated from a catamaran during daytime. After reaching the fishing ground, bait fishes are caught by using hand lines with small hooks (No. 16). For catching the bait fishes, baits such as pieces of small squids, arms of cuttlefish or small fishes are taken when the fishermen start their fishing trips. The bait fishes generally obtained are small fishes such as *Nemipterus*, sardines, sciaenids, carangids, *Chirocentrus* and ribbon-fish. The fish is cut into small pieces and a piece is either pierced through on the single hook or tied to the rod with a very thin thread. If the bait fish is small, its head portion is hooked on to the single hook and keeping the fish along the rod its tail portion is tied to the rod.

The baited jig is lowered into the water, releasing the required length of the line. When the weight touches the bottom, the fisherman sitting on the catamaran holds the line in the hand or sometimes on the toe. The baited jig will be lying in a horizontal position on the bottom, away from the weight. Since the latter is tied to the second piece of iron rod, the jig is enabled to move freely, staying clear of the line without any entanglement. Usually two units are operated by a person, with one on either side of the catamaran, and likewise two or even three persons conduct fishing simultaneously from a catamaran, except the person steering the craft who uses only one unit of the gear. The cuttlefish, on seeing the bait, entangles it with all its arms trying to pull it and this is felt on the line by the fisherman operating the hand jig. The animal has the habit of holding the prey or bait with all its arms and clinging firmly to it unless disturbed strongly. This habit is taken advantage of in the fishery by hand jigging. When the heaviness of the cuttlefish holding or pulling the bait is felt on the line, the line is gently lifted up for a short while, and after making sure that it is still holding the bait, the line is given a sudden jerk. With this the cuttlefish in hooked on one or more of the hooks of the jig (Plate ID). The gear is then slowly hauled up and when the cuttlefish reaches near the surface, it is collected with a small scoop net. Once out of water, the cuttlefish may drop off the jig but the scoop net prevents such escape. Sometimes the cuttlefish may not be hooked at all but it will cling to the bait until it is hauled up and collected.

In most cases, only one cuttlefish is taken in a haul but when a school of them happen to be around the jig, more than one and sometimes upto three or four, including one clinging on to the weight, are taken in a single haul, though such instances are rare. The magnitude of the catch depends on the availability of cuttlefish in the fishing ground ; however, on an average 10-20 cuttlefishes are taken on a day's fishing. In good seasons the number may go upto 100 or even more per catamaran per day.

Normally the fishing is done 5 to 7 km away from the shore but sometimes upto 10 km, especially in the summer months of February to April when the water is clear and the cuttlefishes migrate to deeper waters. The usual range of the depths of operation is 30-50 m but sometimes fishing is done upto 60-75 m. The fishermen go for fishing early in the morning and return in the afternoon. Since the hand jig units are taken for fishing along with hooks and lines, the duration of fishing depends on the period of combined fishing, which may last for 5-6 hours.

After bringing the catch to the shore it is auctioned to the agents of export firms or to private persons who extract the mantle, clean them and sell them to exporters. Women of the fisherfolk are engaged in removing the head, cuttlebone and viscera. The mantles are skinned, cleaned, washed and kept in ice until the lot is taken in refrigerated vans to the processing plants. The head portion and the nidamental glands are sold for local consumption, while the cuttlebones are collected for export.

SQUID JIGGING

Because of the rapid strides squid jigging has made in the commercial fishery, much has been written in recent years about this type of fishing. The literature provides a good source of information, and the present review is largely based on the following publications : Ben-Yami (1976), Hamabe *et al.* (1976a, 1976b, 1981), Hamuro and Mizushima (1976), Kasahara and Nasumi (1976), Ogura (1976), Ogura and Nasumi (1976), R. Saito (1976), T. Saito (1976), Yajima and Mitsugi (1976), Okutani (1977), Court (1980), Hurley (1980), Jaunico (1980), Long and Rathjen (1980), Hernado and Flores (1981) and Nelson *et al.* (1983). Of these, particular mention must be made of Ben-Yami (1976) and Hamabe *et al.* (1981) who give detailed account of squid jigging. Many of the other references mentioned above are included in the FAO Fisheries Reports No. 170, Supplement 1, 1976 (Expert Consultation on Fishing for squid and other Cephalopods).

Though squids are caught the world over as a by-catch in a variety of gears such as trawl nets, set nets, lampara, gill nets and purse seines, jigging with light attraction system is practised exclusively for catching squids. The Japanese have developed this type of fishing, and are currently practising on such a large scale that over 70% of Japan's squid landings are realised by jigging. The method has been evolved based on certain aspects of the behaviour of squids. Squids are easily attracted to a fast-moving bait or bait-like object and on contact with it get entangled or often they cling to it with their arms. Any escape bid by sudden jet-propelled backward movement is prevented by the numerous recurved hooks of the jig. Squids are attracted to artificial light and they aggregate close to the illuminated area. As these habits are taken advantage of in this fishery, the jig is found to be a very effective gear for squids.

Squid jigging in Japan in early times was with simple pole and line jigs and hand-line jigs using pine-root torches for light attraction and this method has remained unchanged for many years. The beginning of modern squid jigging was marked with the progressive replacement of pine-root torches by kerosene and acetylene lamps and later by electric incandescent lamps, with concomitant changes in the fishing gear and fishing methods. Mechanised boats of 10-30 t displacement using hand-line jigs and battery-powered lamps were introduced in the 1930s for fishing in the inshore waters. Further innovation was the introduction of serial jigs (many jigs to a line), manually operated drums and line reels. With the complete automation of the entire fishing operation that followed, ocean going vessels of 100-300 t or even upto 500 t started operating from the 1970s. This has increased the operational range of the vessels which enabled the Japanese to extend the fishing operations beyond their traditional waters to Australia, New Zealand, West Africa and the east coast of North America.

The jig is so named because it is operated by jerking or jigging (moving up and down). A typical jig consists of a shaft-like body or stem made of flexible plastic and one to three circles of sharp barbless steel hooks at the lower end (Plate IC). A steel rod or wire passing through the shaft secures the hook rings to the shaft. The rod has a ring at each end for the attachment of the line. It is used as in angling, when the squid comes up near the surface of the water. The hand-line jigging unit consists of a 20-30 m line with a series of 15 to 20 jigs spaced at regular intervals and a weight at the lower end. In this gear the line consists of short sections tied to the upper or the lower ring of the jigs. The depth of operation of the jig can be adjusted according to the depth of concentration of squids, which is determined by echo sounding. The operation of the gear became more easy with the introduction of a hand-operated drum to release and haul up the line and a roller for the line to move on.

The mechanisation of the jigging operations by the Japanese has accelerated the pace of development of squid fishery in recent times. The main parts of an automatic jigging unit are two drums or reels having a single shaft that passes through a motor assembly, a line with jigs and weight on each drum, two outboard plastic rollers and a netted frame. The drum is oval in shape with six sides, so that the line when payed out and hauled up has a jigging motion. The drums are rotated by means of an electric motor of 1/4 to 1/3 hp. The different jigging units fixed on a boat can be operated independently. The units are mounted on the sides of the boat and when in operation they are tilted outboard. The line is made of nylon monofilament and its diameter varies between 0.8 mm and 2 mm according to the depth of operation. The line near the bottom end has a lesser diameter than that near the surface as the latter is subjected to more strain. It is found that thinner the line the more will be the catch because of less visibility. About 20-50 jigs are attached to each line at intervals of 80-100 cm. A lead sinker weighing 700 g-1 kg or sometimes more, is tied at the lower end of the line to keep it vertical in the water. Such a line with the jigs and sinker is attached by means of a swivel to a 100 m long main line having a diameter of 2 mm. The jig line, when payed out and hauled up, runs through the roller. Each jigging unit is equipped with a push button control box, and this arrangement enables one man to control several units, thus reducing the manpower involved.

The length of the stem ranges from 42 mm to 75 mm though there are larger jigs. They are also of a variety of shapes and colours. The colour of jig depends on the colour preference of the squid species. In Japan red and green coloured jigs are more common, though other colours (blue, white, yellow, black, orange or transparent) are also used. In California transparent jigs were found to be very effective, followed by red and pink, and green and silver were the least effective.

Squids are attracted by artificial lights fixed on the vessel and they concentrate near the boundary between the lighted zone of the water and the shadow of the vessel. Therefore the position of this boundary zone in relation to the position of the jigs is of great significance. This can be adjusted by altering the height of the lamps in such a way that the jigging lines enter the water at or near the boundary between the lighted zone and the shadow of the vessel. While the bright lights attract the squids towards the vessel the shaded area between the vessel and the jigging line where they congregate enables them to react to the motion of the jigs. Generally (a row of mercury vapour lamps of 500-2000 watts or incandescent lamps of 2000-4000 watts are used. Though the latter are more commonly used, comparative tests show that mercury vapour lamps are about 2.5 times more efficient in converting

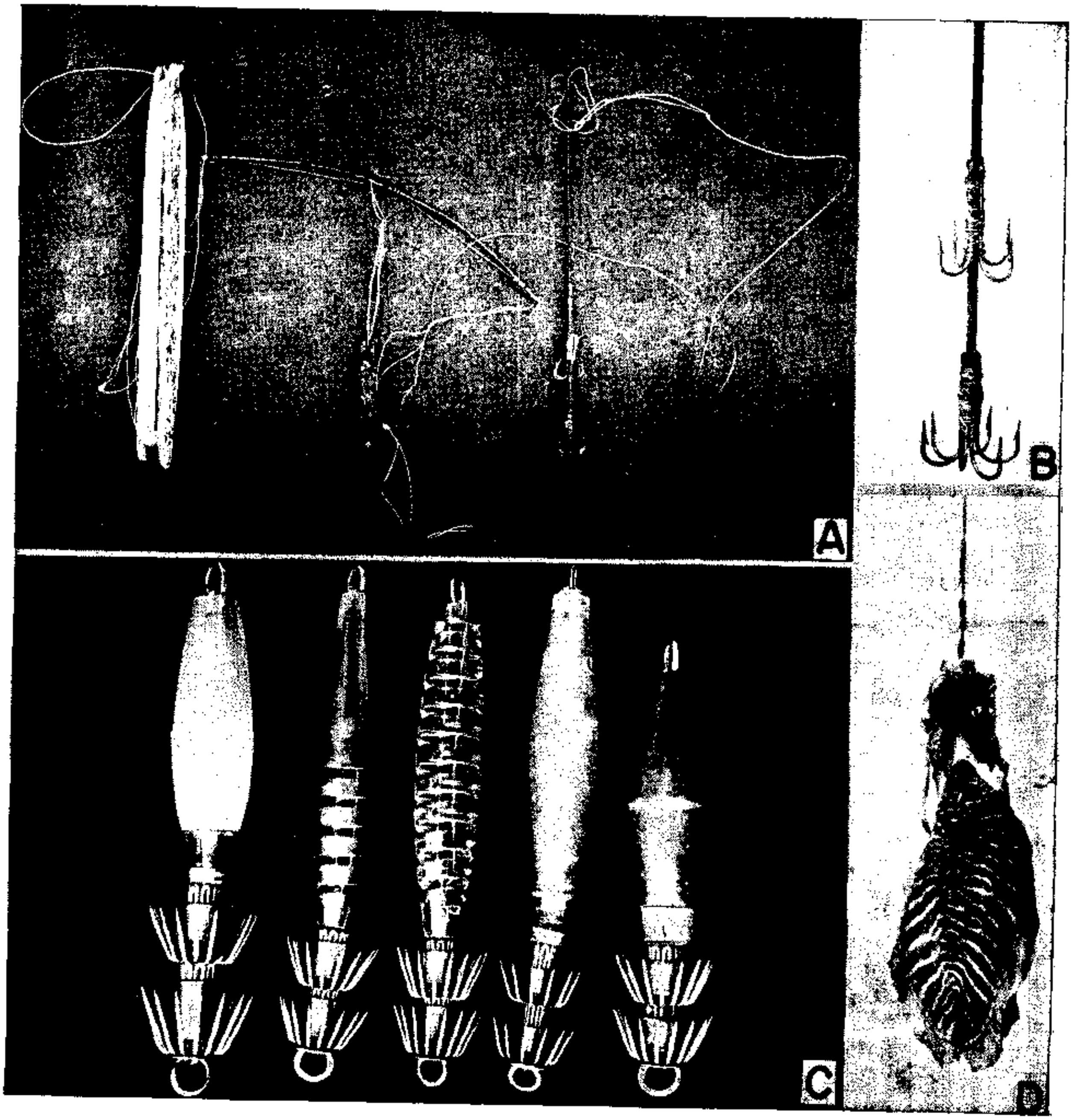

PLATE I. A. Hand jig unit with line, weight, line holder and jig. B. Hand jig. C. Different types of Japanese jigs. D. A cuttlefish caught in a hand jig.

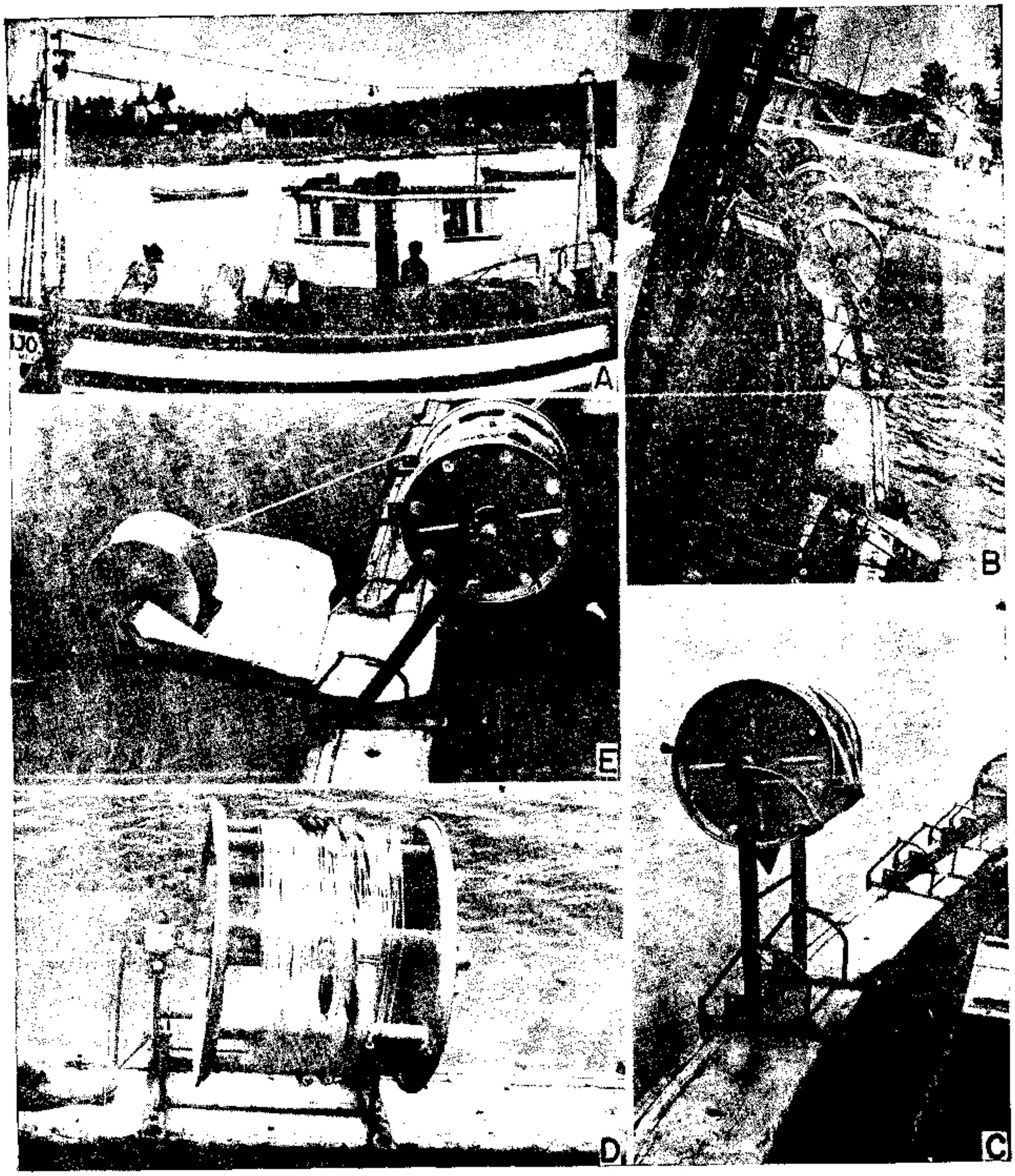

PLATE II. A. A 43' mechanised vessel, *Maijo* rigged for squid jigging with mounted lights and jigging units. B. Arrangement of jigging units on one side of the vessel. C. and D. Close up views of jigging unit. E. A unit in operation.

electric energy into light energy. They also have a longer life, but are costlier than incandescent lamps. Of late, halogen lamps are being used in Japan and they are found to be more efficient and durable.

The lamps are fixed in a horizontal line in the middle of the ship between the foremast and the mizzen mast. If the vessel is larger, two rows of lamps are kept above the deck slightly inward, one on either side of the vessel. Up to a certain level the catch increases with light intensity and after that it decreases. This level is related to the size of the vessel, which is about 2500 watts per one ton displacement for vessels up to 15 t. Therefore the number of lamps and light intensity are determined by the size of the vessel. A 100 t vessel may have a 130 kW generator and 44 lamps of 2000 watts each, arranged in two rows. The light provided on a typical 5.6 t vessel which operates in the nearshore areas is three 2000W bulbs, three 1500W bulbs and three 1000W bulbs with a combined power of 13.5 kW.

On the fishing ground the presence of squid shoals is determined by echo sounding. When the vessel is positioned, a nylon parachute sea anchor is lowered from the bow of the vessel allowing the vessel to slowly drift with the current. To keep the vessel in proper position a mizzen sail or spanker is rigged near the stern ; this also reduces the rolling of the vessel and the chances of the jigging lines getting entangled. The lamps are turned on at dusk. Jigging is done when squids are attracted towards light. The jigging unit is tilted outboard and the line is payed out from the drum. There is a depth control knob in the jigging machine that enables the line to be adjusted to fish at desired depth. There is also provision to stop the machine automatically in case there is sudden entanglement of jigs or line. While the line travels down, a jigging motion is produced due to the oval shape of the drums. Sometimes, after the line reaches the required depth, it is hauled up and lowered down several times at short intervals. Finally the line is fully hauled up at a speed of 60-75 m per minute. As the line passes through the shoal of squids, individual squids are caught on the jigs. Passing over the roller as the line is hauled up and wound on the drum, the squids get unhooked or their arms and tentacles get disentangled from the jigs, fall on the netted frame and slip into a collecting basket. These are then washed, arranged in trays and kept in chilled fish holds. Even the latter processes are carried out automatically in some vessels which are equipped with conveyor belts or water flow pipes to carry the catch continuously to the storage place.

Though fishing continues throughout the night, the catches increase around midnight. Often the peak is at about 0400 to 0500 hrs, and the high catch is popularly known as the *morning harvest*. There are fluctuations in the catch according to the phases of the moon ; the best squid catches are obtained during dark nights and high tides. The catches during a new moon phase are invariably more than around full moon. Strong currents, winds and waves adversely affect jigging operations due to frequent tangles between the lines and jigs of adjacent jigging units. In such cases, only the alternate units are operated.

The advantages of jigging are many. Firstly the method is comparatively simple. Since the jigging machine is fully automated the manpower required is very low. In hand jigging the expenditure involved is not at all high when compared to other methods of fishing. Any existing fishing vessel can easily be converted into a jigger with simple outfits. This can be done at very little cost and without making any structural changes in the vessel. Since jigging is done in the night, other types of fishing can also be done from the same vessel during daytime. As the squids taken in jigging are fresh and without much damage, they are suitable for processing.

Todarodes pacificus is the mainstay of the fishery in Japan, followed by *Ommastrephes bartrami* and these two species form more than 85% of the squids from Japan's waters. In winter, jigging activity is at a minimum, and during this time many of Japan's larger vessels shift their operation to the southern hemisphere, off Australia and New Zealand. Japan has also cooperated with other nations by conducting feasibility jig fishing and these efforts have shown that there are good stocks of squids to sustain profitable fishing. The important species of squids in these regions are *Loligo pealei* and *Illex illecebrosus* in Newfoundland, *Illex argentinus* in Argentina, *Nototodarus sloani gouldi* in Austrslia, *Nototodarus sloani sloani* in New Zealand and *Dodidicus gigas* in California and Mexico.

It is worthy of mention here that the Marine Products Export Development Authority, Government of India, has recently taken some initiative in attempting light fishing for squids, utilising the services of a Japanese fishing expert. One 43'—mechanized fishing boat has been rigged with four hand-operated jigging units and a stick-held dip net with separate light arrangement for both (Plate II, A-E ; Fig. 1). The experimental fishing was carried out off Cochin and Vizhinjam. In Cochin, squids were obtained both in jigs and dip net and a maximum number of 100-150 squids were caught in a night's fishing for about two hours (Yamasaki, personal communication). At Vizhinjam the attempts had to be given up because the sea conditions were not favourable. The results of these trial operations, though only preliminary, indicate the possibility that squids can be taken by jigs and dip nets with light attraction, in spite of the fact that the trials were conducted when the squid fishing season had almost come to a close and the monsoon conditions had already set in.

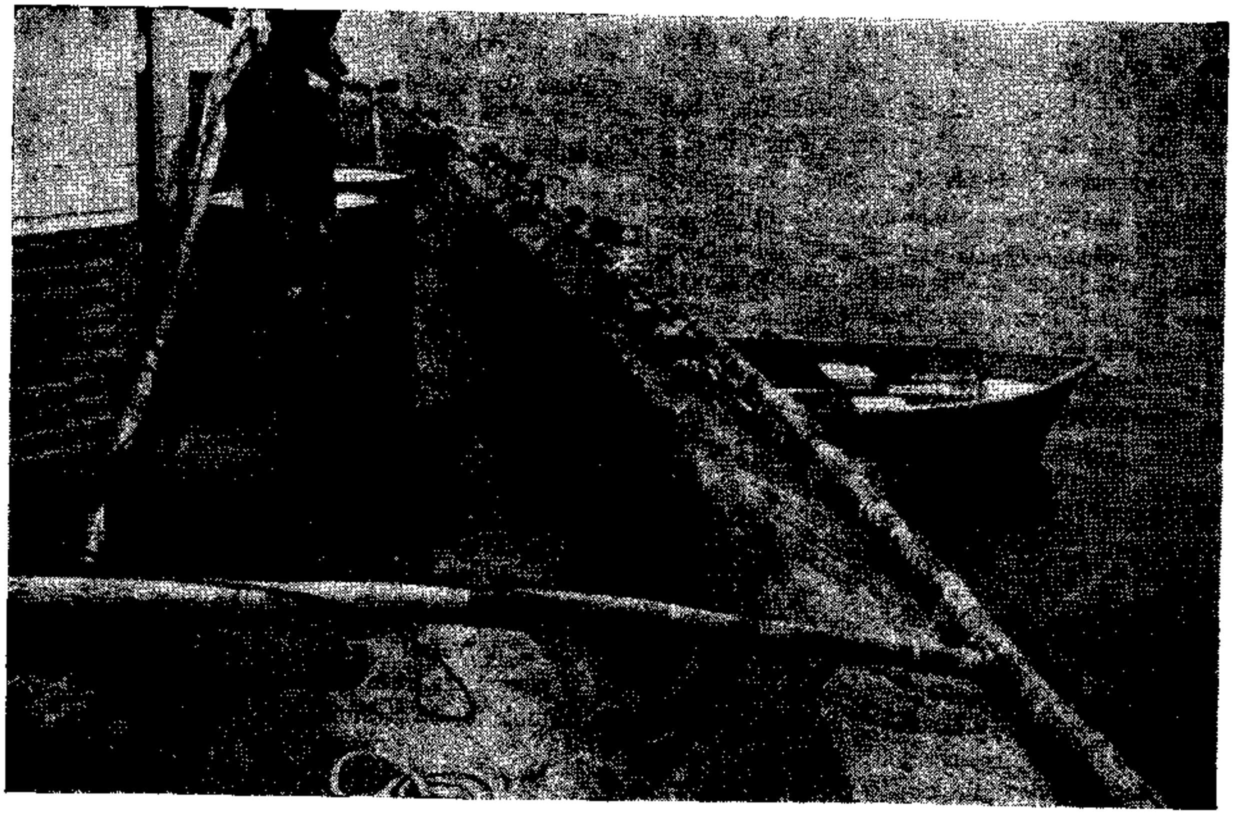

FIG. 1. A type of dip net used in light fishing drawn up on board.

15

SOME OBSERVATIONS ON THE HATCHING AND POST-HATCHING BEHAVIOUR OF THE CUTTLEFISH *SEPIA PHARAONIS* EHRENBERG

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ABSTRACT

Egg capsules of the cuttlefish *Sepia pharaonis* were collected off Vizhinjam and the hatchlings studied in the laboratory. Most of the young ones hatch out within a period of eight days, and a few had premature hatching. The hatched young ones resembling the adult externally were found to move by swimming, crawling or darting by jet propulsion. They settled on the bottom and were attracted towards light. The young ones were reared for a period of twenty three days in the laboratory.

INTRODUCTION

A bunch of egg capsules of the cuttlefish *Sepia pharaonis*, which is the only species contributing to the cuttlefish fishery at Vizhinjam, was brought to the laboratory on January 4, 1974. These capsules were found attached to a bundle consisting of a piece of nylon fishing net, coir strands and a small dry twig. The bunch was collected in a shore seine operated in the Vizhinjam Bay (Trivandrum). There were over 600 capsules in the bunch. Another egg mass attached to the stem of a gorgonid and consisting of about 750 capsules was collected on December 22, 1981 from a depth of 45-50 m off Vizhinjam (Plate. IA). On both the occasions the capsules were kept for observations in aquarium tanks containing sea water which was changed periodically and aerated constantly. The account of the hatching and post-hatching behaviour given below is based on these observations.

OBSERVATIONS

The egg capsules were spherical to oval in shape having a length of 15-20 mm and a diameter of 14-17 mm. Each capsule was attached at one end to the substratum by a small stalk which in some cases was about the same length as the capsule or more upto 30 mm (Plate. IB). The free end of the capsule was sometimes drawn into a small teat-like projection. The capsules were opaque with a gelatinous consistency. Embryos were present in most of the capsules, seen through as a white mass and occasionally moving within the capsules. Some of the capsules, especially those in the interior of the egg mass, contained eggs in decaying condition and microscopic examination revealed very high concentration of ciliates around these eggs.

As the development of the embryo progressed within, the capsule became more transparent and slightly enlarged with the absorption of water. The embryo with its mantle, head, and arms resting on the globular yolk sac was more clearly visible through the capsule and when the embryo was dissected out of the capsule and placed in a watch glass, the expansion and contraction of the mantle were clearly seen. The posterior half of the mantle on the dorsal side was white because of the shell (cuttlebone) inside. Ventrally the internal ink sac was visible as a dark spot in the middle of the mantle. Within the capsule the embryo lay supine and this position was maintained even when the capsule was turned in different directions. At times it showed jerking movements within the capsule.

Fourteen days after the collection of the first bunch of the egg mass, the capsules became more enlarged; the largest one measured 25 mm in length and 20 mm in diameter. Except for the diminished yolk sac, the embryo with the suckered arms and chromatophores all over the body had general resemblance to an adult cuttlefish.

The young ones hatched out when they were fully-grown within the capsule. Before hatching they floated in the capsule for sometime and wriggled out through a small slit in the capsule. By the time the embryo became a full-grown young within the capsule, the yolk would have been fully absorbed. But in a few cases the diminished yolk sac still persisted and this was ejected before hatching. The discarded yolk sac could be seen within the empty capsule. In very rare cases the young ones hatched with the small yolk sac intact and its ejection took place only subsequently.

The hatched young ones were the miniature replicas of the adult cuttlefish externally. At this stage they measured 6.5-7 mm in dorsal mantle length. The chromatophores were very clear and distributed all over the body (Fig. 1 a, b). Generally the body was pale yellowish brown in colour, with prominent brown dots. When the young was disturbed the whole colour changed in a flash to pale white and then to dark brown. The zebra-pattern colouration of the adult was not seen in the newly-hatched young ones.

In the night of the 17th day after the collection of the first batch of egg mass, 10 young ones hatched out and by about the 24th day most of the hatchings took place. In the second set of experiments also it took 7 days for all the young ones to hatch out. A notable feature of the hatching process was that most of the hatchings took place during night time (this was true in the first case also) as seen in Table 1.

TABLE 1. *Details of hatching and mortality during 7 days from 27-12-1981 to 2-1-1982.*

Day	Number of eggs hatched			Mortality (nos)
	Day	Night	Total	
1	5	15	20	Nil
2	15	80	95	2
3	35	200	235	5
4	20	60	80	5
5	25	100	125	2
6	25	75	100	2
7	5	25	30	3
Total	130	555	685	19

A few egg capsules contained the white remnants of the cuttlebone, indicating that the embryos might have aborted and disintegrated within the capsule. A still fewer number had premature hatching, probably due to the stress caused by changing of water or the transfer of the capusules from one container to another.

After hatching, the young moved about by swimming in water or crawling on the bottom. Occasionally they showed a tendency to come to the surface for a while and then to return to the bottom and settle there.

The young ones showed good response to light. Often they crowded together, at times even one upon the other, in a corner of the tank where there was more light. When small pieces of stones were put in the tank the young ones settled near or on the stones, especially in the interspaces. The concentration was more near the place where there was more light.

In order to study their reaction to light, a table lamp (100 W) was placed at one side of a glass through containing newly-hatched young ones. All of them showed strong phototaxis and migrated to a position close to the light (Plate. I C, D). This sort of positive response to light was noticed only in the case of newly hatched young ones for a period of about 48 hours, and afterwards there was no regular response to light.

The posture of settling on the bottom is characteristic in that the fins and the arms are bent downwards as a support to the ventral mantle which is pressed against the substratum. When disturbed, the young slowly move about on the bottom using the arms and fins, or sometimes dart backwards suddenly by expelling water from the mantle cavity through the funnel. While moving by jet propulsion, the young cuttlefish even on the day of hatching emits ink upto 3-4 times in quick succession. Jet propulsion follows sudden excitement and on all such occasions the colour of the young one turns black and remains so for sometime.

On the bottom, the young move in small leaps by pressing the arms against the ground and moving forwards in short leaps. They also walk on the bottom with the help of the third pair of arms which are the largest among all the arms. These arms are moved alternately forwards and backwards. The other arms are held together and pointed forwards. Occasionally these arms are also used as support touching the bottom. Sometimes the first pair of arms may be moved freely in different directions as feelers. On a few occasions the young were seen moving with the third pair of arms probing the ground. When moving like this the body is kept in an oblique position with the head directed downwards; for maintaining balance the support is given by the movement of the fins.

In swimming, the movement is slow and the young move in all directions even without changing orientation. This is achieved by the undulating movements of the fins. When moving slowly the mantle is expanded and the animal assumes a more roundish shape The first pair of arms are pointed forwards or sometimes upwards. All the other arms are held together and bent downwards without moving them.

The retractile tentacles are not seen outside; they are always kept in the pouches, except at the time of capturing the prey.

Most of the settling or swimming young ones were not seen feeding, eventhough they were provided with

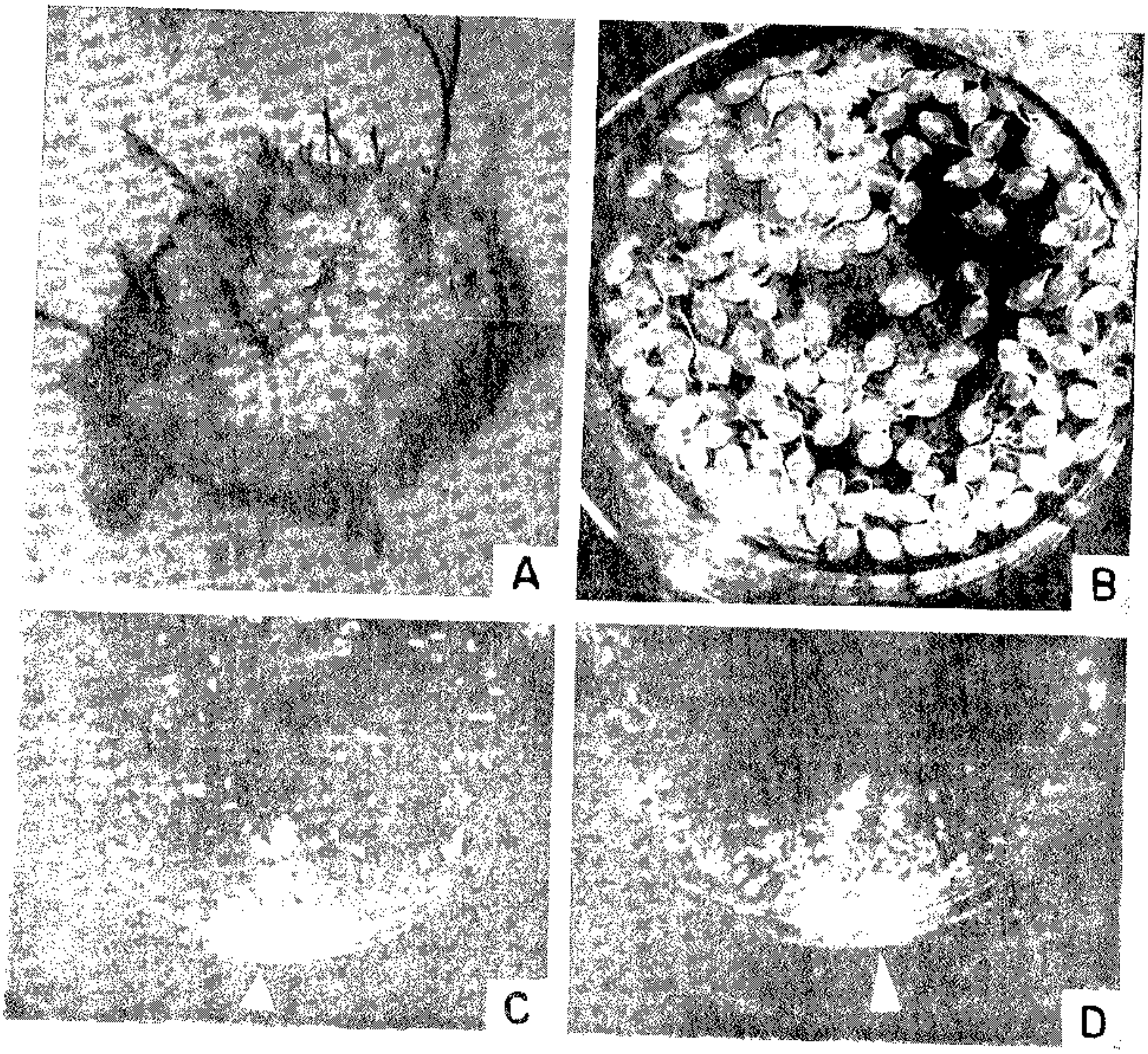

PLATE I. A-D. Egg capsules and young ones of *Sepia pharaonis* : A. Bunch of egg capsules attached to a gorgonid ; B. Capsules separated from the gorgonid : emryos are seen inside the capsules ; C. Young ones begin to move towards light ; D. Young ones congregate near the light. (Arrows show source of light).

live and dead plankton, finely minced fish and artificial feed. In a few instances when live mysids were introduced, some of the young responded positively. On sighting the prey they suddenly released the tentacles from the pouches, and in a very swift action the prey was caught with the tentacular clubs and slowly conducted to the mouth where it was held by the oral arms.

A few days after hatching, the young ones were found to come to the surface more frequently than before and started floating. When they were gently touched with a fine brush, some showed a tendency to migrate to the bottom and then to return to the surface again. They remained in a peculiar position with only the posterior portion of the animal touching the surface of the water ; the mantle and the head were obliquely pointed downwards. They were motionless in this head-down position, and when disturbed, the response was very feeble. They never attempted to swim away, except that the arms were moved very faintly. The chromatophores became thin, with the result that there was no sudden and strong change of colour. There was also no ejection of ink. The number of such floating young ones increased day by day, as evident from Table 2.

TABLE 2. *Details of surfacing of the young ones during* 10-1-1982 *to* 18-1-1982.

Day	Total no. of young ones	No. of young ones surfaced
1	666	11
2	655	45
3	610	50
4	560	50
5	510	40
6	470	105
7	365	105
8	260	130
9	130	130
Total	—	666

It is clear from the Table that the number of floating young ones was low during the first five days but increased sharply from the 6th day onwards. Each of the floating young one remained there for 1-2 days and died subsequently. In the first experiment the young remained alive for 10 days between the hatching of the first and the death of the last young ones, and in the second experiment they remained for a longer period, 23 days.

Discussion

From the foregoing account it is seen that, apart from the striking morphological resemblence to the adult, the young ones at hatching have acquired most of the adult behaviour such as locomotion (crawling walking, swimming and jet propulsion), prey-capture, ejection of ink and sudden change of colour associated with excitement and escape bids. The periodic settling on the bottom is typical of a benthic adult life. According to Boleteky (1977), the young of *Sepia* show a tendency to settle on the bottom at a very early stage. They attach themselves to the substratum with the ventral integument of the mantle and the ventral arms. The behaviour of surfacing and floating of the young followed by death in the present experiments is peculiar, and the exact reasons for this are not known. Lack of feeding and the resultant reduction in metabolism rendering the animal unable to maintain the delicate buoyancy mechanism may be among the possible factors that cause floating and subsequent death.

Though feeding was poor, mysids seem to be the favourite food for the young of *Sepia pharaonis*. These small crustaceans were found to be preyed upon by the young of other cuttlefishes such as *Sepia esculenta, Sepia subaculeata, Sepiella maindroni* (Choe, 1966) and *Sepia aculeata* (Sivalingam and Pillai, 1983). According to Messenger (1977), very young cuttlefish (*Sepia officinalis* had fed on mysids during the first few days of their life after hatching. The prey capture of the young is similar to that of the adult. This is achieved by a visual feedback system. There are three phases of attacking the prey : fixating the prey binocularly, positioning itself in an attacking position, and striking the prey with the ejection of tentacles (Messenger, 1977). It is important that the prey must be in the visual field of the young one for it to initiate prey capture. Therefore, feeding may largely depend upon the availability of the right prey within the visual filed of the cuttlefish. In the present experiments, lack of availability of mysids in sufficient concentration within the visual fields of the young, especially of the settling ones, may perhaps account for the poor feeding and the subsequent events leading to death within a few days of hatching.

Choe (1966) has reared *Sepia subaculeata* to a full commercial size of 350-400 g. According to Sivalingam and Pillai (1983) the young ones of *Sepia aculeata* hatched in the laboratory survived for only 5 days. In a subsequent experiment the young of *Sepia* sp. were reared upto a size of 67 mm ; these were fed with mysids during the first month and with larval fishes during the later period (CMFRI Newsletter No. 26, 1984). With running water facilities and ideal conditions such as optimum environmental requirements, proper food and sufficient water space, it may be possible to rear the cuttlefish in the laboratory to a much larger size.

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INSTANCES OF REGENERATION IN THE CUTTLEFISH *SEPIA PHARAONIS* EHRENBERG AND IN THE SQUID *LOLIGO DUVAUCELII* ORBIGNY FROM INDIAN WATERS

K. PRABHAKARAN NAIR AND B. NARAYANA RAO

ABSTRACT

Instances of regeneration of the first, third and fourth right arms and both the tentacles of a cuttlefish *Sepia pharaonis*, caught off Waltair, the left tentacle of a cuttlefish of the same species, and the third and fourth right arms and both the tentacles of a squid *Loligo duvaucelii* collected at Vizhinjam are dealt with.

INTRODUCTION

Animals have the ability to repair small or sometimes extensive damage caused to their body accidentally or otherwise. This may involve the repair of the damaged tissue of the body or even regeneration of a lost organ. Regeneration exists in almost all groups of the animal kingdom, but it is more common in invertebrates and lower vertebrates.

The first stage of repair, as in salamanders for example (Balinsky, 1981), is that the epidermis from the periphery of the wound starts spreading over the wound and covers the entire open space. This begins to bulge out in more or less a conical shape, and underneath it a mass of cells accumulates and actively proliferates. These cells and the epidermal covering together form what is called the 'regeneration bud' or 'blastema'. Further growth of the lost organ is from this blastema.

In cephalopods, instances of regeneration have been reported by many authors since Steenstrup (1856). Feral (1978), while discussing the post-traumatic regeneration of the arms in young *Sepia officinalis*, has listed the records of regeneration in the following species of cephalopods : *Loligo pealei*, *Ommastrephes illecebrosus* (Verrill, 1881), *Sepioteuthis lessoniana* (Adam, 1937), *Architeuthis harvesi* (Verrill, 1882), *Architeuthis dux* (Aldrich and Aldrich, 1968), *Sepia officinalis*, *Sepiola atlantica* (Feral, 1977), *Eledon aldrovandi* (Parona, 1900), *Eledon moschata* (Hanko, 1913), *Eledon cirrosa* (Lange, 1920), *Octopus fusiformis*, *Octopus inconspicuus*, *Octopus cutieri* (Brock, 1886), *Octopus vulgaris* (Parona, 1900 ; Hanko, 1913 ; Lange, 1920 ; May, 1933 ; Callan, 1940), *Octopus defilippii* (Riggenbach, 1901), *Octopus* sp. (Steenstrup, 1856) and *Tremectopus violaceus* (Portmann, 1952). So far there is no record of regeneration in cephalopods of our waters. The present account deals with instances of regeneration of arms and tentacles in the cuttlefish *Sepia pharaonis* collected off Waltair and Vizhinjam, and in the squid *Loligo duvaucelii* from Vizhinjam area.

One cuttlefish measuring 230 mm in dorsal mantle length was caught in trawl net off Waltair in May, 1982, and this had its first, third and fourth right arms and both the tentacles regenerating (Plate, 1A). This cuttlefish was healthy and robust with well-developed mantle, fins and arms. The regenerated portions of the arms and tentacles are clearly distinguished from the rest of the arms by their subnormal size and thinner colouration due to lack or sparse distribution of chromatophores. Moreover, the suckers, whenever, present, are invariably much smaller than normal.

First Right Arm

This arm has a length of 38 mm including the regenerated portion of 12 mm which is narrow and tapering towards the distal end. There is a small notch-like depression aborally, just like a healed cut, and this is apparently the place where the portion of the arm was severed off. The suckers on the arm upto the point of regeneration are normal in size but in the regenerated portion they are very small and distributed in four rows as in a normal arm (Fig. 2a).

Third Right Arm

This arm is very short, 44 mm in length including the regenerated portion of 32 mm (Fig. 2b). The suckers on the proximal part of the arm, that is below the regenerated portion are normal in size and arranged in four rows. On the regenerated portion upto about one-third of its length, the suckers are smaller in size and closely packed ; above this upto the distal end they progressively become smaller and are arranged in four rows.

Fourth Right Arm

The regenerated portion of this arm is 14 mm in length and it sharply tapers to the distal end. The suckers are very minute and normally arranged (Fig. 1c).

Right Tentacle

The total length of this regenerating tentacle is only 155 mm, whereas a normal tentacle is much longer. The regenerated portion measures 60 mm (Fig. 2d). The portion below the point of regeneration is more or less conical in outline but the regenerated portion is somewhat cylindrical becoming narrow towards the distal end till it is flattened at about one-third of its length. This flattened portion has the gross shape of a tentacular club but it is much smaller in size. From about one-fourth above the point of regeneration upwards on the inner (oral) side, there are minute suckers and on the flattened distal portion the suckers are larger in size and arranged irregularly. The marginal membrane with crenulate border, present in normal tentacular club, has not yet formed. Chromatophores are faintly distributed on the outer (aboral) side of the regenerated part of the tentacle.

FIG. 1. Regeneration of arms and tentacles of A. *Loligo duvaucelli* (Vizhinjam); B. *Sepia pharaonis* (Waltair) ; C. *Sepia pharaonis* (Vizhinjam).

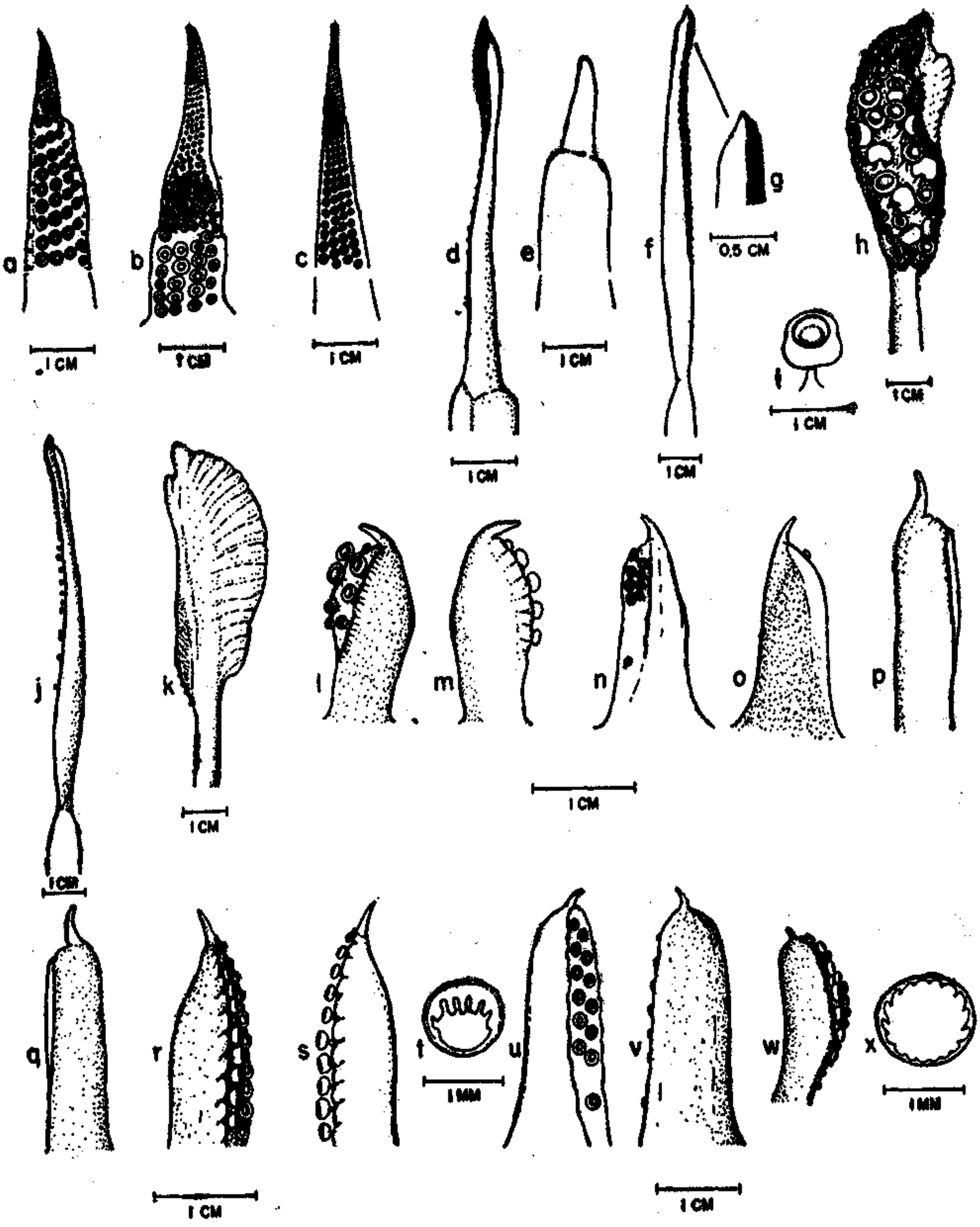

FIG. 2. Regenerated arms and tentacles. (*a-e*) *Sepia pharaonis* (Waltair): (*a*) I right arm; (*b*) III right arm; (*c*) IV right arm; (*d*) right tentacle; (*e*) left tentacle. (*f-k*) *Sepia pharaonis* (Vizhinjam); (*h*) normal right tentacular club oral view; (*i*) largest sucker of right tentacular club; (*j*) left tentacle, aborolateral view; (*k*) normal right tentacular club, aboral view. 1-x *Loligo duvaucelii* (Vizhinjam); (*l*) III right arm, orolateral view; (*m*) aborolateral view of III right arm; (*n*) IV right arm, orolateral view; (*o*) aborolateral view of IV right arm; (*p*) right tentacle's right side; (*q*) right tentacle's left side; (*r*) III left arm, dorsal side; (*s*) ventral side of III left arm; (*t*) sucker ring of III left arm; (*u*) IV left arm, orolateral view; (*v*) aborolateral view of IV left arm; (*w*) left tentacle; (*x*) ring of largest sucker of left tentacle.

Left Tentacle

This tentacle is very short in size, only 60 mm long, including 17 mm of regenerated portion which is just a stub with blunt distal end (Fig. 2e), and has no tentacular club, suckers or chromatophores.

In another male cuttlefish (*Sepia pharaonis*) measuring 225 mm in dorsal mantle length and weighing 910 g taken in hooks and line off Vizhinjam on 17th May, 1982, the left tentacle was regenerating (Fig. 1c). The tentacle is only 290 mm long including 90 mm of regenerated portion, as against the normal right tentacle measuring 435 mm. Figs. 2f, g, h, i, j show the oral and aboral sides of the normal tentacular club and orolateral and aborolateral sides of the regenerating tentacular club. The regenerated portion which begins from a constriction on the tentacular stalk is flattened laterally tapering to the distal end (Fig. 2f). Minute suckers cover the upper two-thirds of the inner (oral) side of the regenerated portion (Fig. 1g). Towards the distal end the suckers become progressively smaller in size and are very closely arranged in four rows. The largest sucker on this tentacle is only 1.5 mm in diameter, whereas the largest one of the normal right tentacle is 7.5 mm (Fig. 2h, i). There are no chromatophores on the tentacular stalk below the constriction but they are thinly distributed on the aboral side of the regenerated portion (Fig. 2j). The marginal membrane of the normal tentacular club (Fig. 2k) is not present.

The second right arm and the first left arm are cut off; the remaining proximal portions of these arms measure 23 mm and 30 mm respectively. It appears that these arms were lost just before the capture of the cuttlefish, since the wounds were still fresh and did not show any sign of healing. All other arms and the remaining right tentacle were normal and well developed.

A sample of squids of the species *Loligo duvaucelii* collected on 28th July, 1983 from boat seine landings at Vizhinjam contained a male squid measuring 125 mm in dorsal mantle length and weighing 54 g, and this squid showed signs of regeneration on its third and fourth right arms and both tentacles (Fig. 1a). The specimen was otherwise normal and healthy.

In all the arms and tentacles the regenerated portions are in the form of buds which look almost similar in size and shape. They measure only 1.5-3 mm in length and do not possess any suckers. Most of these buds have very small chromatophores on the aboral side.

Third Right Arm

This measures 19 mm including 2 mm of regenerated portion. There are only 8 suckers on the aboral side of the arm, arranged in two longitudinal rows (Fig. 2l) and the largest sucker has a diameter of 1.5 mm. The aboral keel is feeble and it is restricted to the proximal part of the arm. The marginal membrane is present on both sides of the oral plane of the arm and it is more prominent on the ventral side. The regeneration bud is small, pointed and bent towards the oral side. The outer skin of the arm continues on to the bud on which there are a few minute chromatophores aborally. The chromatophores are distributed along the entire dorsal side but on the ventral side they are restricted to the aboral part (Fig. 2m).

Fourth Right Arm

The total length of this arm is 21.5 mm including the regenerated bud which measures 1.5 mm. On the distal half of the arm there are 8 suckers arranged in two rows besides a single sucker on the proximal half (Fig. 2n), and these are smaller in size than those on the third right arm. The aboral keel is well developed. The marginal membrane is restricted to the middle portion of the arm. There are no chromatophores on the dorsal side but on the opposite side they are well distributed, becoming sparse towards the distal end with none on the regeneration bud (Fig. 2o).

Right Tentacle

This has a total length of 75 mm including 3 mm of the regeneration bud. The tentacular club is entirely absent, and what remains is only the tentacular stalk (Fig. 2p). Proximal to the regeneration bud the oral side is slightly flat. Chromatophores are present on the distal half of the tentacular stalk on the left side (Fig. 2q) but on the right side they are very few, restricted to the aboral side upto the tip of the regeneration bud.

Third Left Arm

Of the total length of 41 mm, the regeneration bud measures 3 mm (Fig. 2r). The suckers on the ventral side of the arm are slightly larger than those on the right side (Fig. 2s). There are 24 suckers arranged in two longitudinal rows, their size becoming smaller towards the distal end. The diameter of the largest sucker is 1.75 mm and that of the horny ring is 1.25 mm. The inner margin of the sucker ring bears on its upper side seven broad plate-like teeth and the lower side is smooth (Fig. 2t). The aboral keel is present upto the tip of the arm and the outer skin continues on to the regeneration bud. The marginal membrane is well developed on the ventral side and the distribution of chromatophores is more pronounced on the opposite side. There are very few small chromatophores on the aboral side of the regeneration bud.

Fourth Left Arm

This has a total length of 26.5 mm, including the regeneration bud which measures 2.5 mm. There are 13 small suckers on the oral surface with marginal membrane on either side (Fig. 2u). The aboral keel is well developed. The right side of the arm is devoid of any chromatophores but on the opposite side they are well distributed extending on to the regeneration bud (Fig. 2v).

Left Tentacle

This tentacle is 92 mm in total length including the tentacular club of 21 mm (Fig. 2w). At the distal end of the club there is a regeneration bud measuring 1.5 mm. At the proximal part of the tentacular club the suckers are very small but beyond the middle portion they are larger in size. The largest sucker measures 2 mm and its horny ring 1.25 mm in diameter (Fig. 2x). The ring has 17 marginal teeth, the lateral ones being pointed with broad bases; those on the anterior and posterior margins are blunt. The marginal protective membrane is present on both sides of the club. Chromatophores are sparsely distributed on the distal half of the tentacular stalk and the left side of the club, but on the right side they are thickly distributed extending on to the aboral side of the regeneration bud.

Since all the regeneration buds on the arms and tentacles of this squid are in the same stage of growth and as there is not much difference in their sizes (1.5-3 mm), it is evident that all these appendages were cus off at the same time.

There are many morphological characteristics associated with the regenerated arms and tentacles. These appendages are always shorter and thinner than the normal arms and tentacles. The outer skin and chromatophores (whenever present) smoothly continue on to the regenerated portion eventhough there may be a constriction or healed cut between the original and the regenerated portions. Sometimes the regenerated portions will be a protrusion (blastema) without suckers and chromatophores or with the latter alone. The suckers when present on the regenerated portions are invariably smaller in size, often a few in number and irregular in distribution. The marginal membrane are either poorly developed or absent.

These characteristics have been observed in the oceanic squid *Ommastrephes bartrami* with regenerated tentacles and arms by Murata *et al.* (1981), who have found that a large number of squids with missing or regenerating tentacles survive normally. According to these authors the tentacles do not always seem to constitute an indispensable organ for preying. There were no noticeable differences in the mantle length composition and the mantle length—body weight relationship between squids with regenerated arms and tentacles and those with normal appendages. The reasons for the loss of arms and tentacles are not clearly understood. According to these authors the tentacles of *Ommastrephes bartrami* are easily dismembered at the stalk portion when they fall off the jig lines operated by automatic squid jigging machines. This may be the reason why there occur large number of squids of this species with missing or regenerating tentacles in the catch taken by jigging; their incidence is upto 15% of the total number of squids. However, in all cephalopods it is possible that the appendages are lost either in encounters with prey animals (mainly fish, crustaceans and other cephalopods) or in escape bids made from enemies.

Feral (1978) has observed different stages of regeneration in the arms and tentacles of the squids *Loligo vulgaris* and *Loligo forbesi*. He has also performed experiments on the young ones of the cuttlefish *Sepia officinalis* in the laboratory by amputating the arms and tentacles, and based on the results, he has recognised six stages in the continuous process of regeneration: (1) wound healing; (2) formation of a bud; (3) growth of regenerating arm; (4) formation of the suckers; (5) appearance of the first chromatophores and (5) recovery of motor function.

While most of these stages were met with in the regenerating arms and tentacles of the present material, some characters of the different stages seem to co-occur, or the order of occurrence of these stages shows some exceptions. The regenerating portions of the first, third and the fourth right arms and the right tentacle of the Waltair specimen, and the left tentacle of the Vizhinjam specimen (both cuttlefish) are in the growing stages in having developing suckers and chromatophores. As they measure 12-32 mm (arms) and 60-90 mm (tentacles), in all probability they must have motor function, moving along with the remaining part of the respective arm or tentacle. According to Feral's stages, appearance of the first chromatophores is the fifth stage, but in the case of the squid collected at Vizhinjam the chromatophores are present even on the blastema which is in the very early stage of regeneration. However, these variations are to be expected, as the comparison is among totally different species and between organisms obtained from the wild and those subjected to experiments in the laboratory.

Suffice it to say that these damages do not seem to have any adverse effect on the animals. What will be interesting is to know how soon in nature this healing and regeneration process takes place.

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UTILISATION AND EXPORT OF CEPHALOPODS

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Abstract

A major portion of the cephalopod catch in India is used as food in the coastal areas and a small portion as bait in the long-line fishing. Other uses such as poultry feed, manure, abrasives etc. are also indicated. About one-third of the catch is exported as frozen cuttlefish, frozen cuttelfish fillets, frozen squids and cuttlebone. The trends in the export of cephalopod products in recent years are indicated.

Introduction

Cephalopods have many uses, and by far the most important among them is the use as human food. Apart from having been mentioned in folklore, and some of them, especially octopus, depicted as among the monsters of the sea, the cephalopods were used by man as food from time immemmorial. There are references to the Greeks, Egyptians and many other people such as those of Polynesia as eating octopus since very ancient times. Today the world catch of cephalopods has gone up to 1,304,154 t in 1981 (FAO Yearbook of Fishery Statistics, 1983) and almost the entire catch is being used for culinary purposes.

Utilisation

The meat of cephalopods is clean with good flavour, nourishing and delicious. The natritive value is high and comparable to some of the good-quality fishes. The squid meat is a good source of protein which forms about 20% wet weight. The biochemical constitutents of the Japanese squid are crude protein 17.3%; fat 1.8% and carbohydrates 7.1% wet weight; the caloric value is 117 cal/100 g (Tanikawa and Suno, 1952; Dracowich and Kelly, 1963). The Tasmanian squid is high in protein and phosphorus, and contain traces of calcium, thiamine and riboflavin (Australian Fisheries, May 1979). According to Howard (1981) the composition of *Loligo vulgaris* is protein 15-19%, and fat 1.1-1.5%. The edible portion of cephalopods consisting of the mantle, arms, tentacles and fins forms 60-80% of the body weight, and this is much higher than in finfish or other shellfish. The high protein and low fat content of the meat of cephalopods make them suitable for human consumption (Roper *et al.*, 1984).

Most of the cephalopods are consumed fresh and in the cooked form. The Japanese eat cuttlefish meat and sometimes squid meat raw ('sashimi') with sauce. The overseas exports from cephalopod producing countries are mostly in frozen form, and a small portion as dried or canned products.

The Japanese have mastered a large variety of culinary preparations out of squids, cuttlefishes and octopods. They range from raw dishes to various fried, roasted and boiled preparations. Some of them include squid pickled in yeast, rice or wheat, pickled with red pepper and soy sauce, roasted squid, boiled squid, salt-fermented squid with ground pepper, uncooked squid with herring or seaurchin roe, diced and boiled squid with kelp, smoked squid, lemon-flavoured and soy sauce-flavoured squid, and various other products (Court, 1980). Dried squid ('surume-ika') is a highly esteemed item used on ceremonial occasions like weddings and festivals. In 1977 about 400,000 t of squid were converted into a variety of dried and seasoned products (Sheehy and Vik, 1980). Sun-drying is still practised but most of the drying is now automated which is faster and more economical. Among 'surume-ika', there are many varieties: 'Surume' (sun-dried or unseasoned dried squid), 'daruma' (slightly seasoned, semi-dried squid with skinless mantle and fins), 'noshi-ika' (dried mantle with fins that have been flattened, stretched and softened by rollers) and 'saki-ika' (seasoned and shredded mantle).

In India cephalopods were considered as poor man's food for a long time and even today the stigma continues. In spite of the increased production and great demand as a commodity for export, their inclusion in our diet is still a far cry. This may be due to the conventional food habits and preference for fish and prawns to any other marine products.

Consumption of cephalopods has been restricted to some localised coastal areas mainly by fishermen and other poor sections of people. Rao (1954) recorded that in Mandapam and nearby areas on the southeast coast of India where there was a good fishery for the Palk Bay squid, the squids were sold mainly in fresh condition in the local markets, and at times of good catches a portion was cured with salt and dried in the sun. According to Sarvesan (1974) the large quantities of squids (*Loligo duvaucelii*) caught in trawl net at Mandapam were taken in baskets with crushed ice to Ramanathapuram and Kilakarai markets where they are sold in small lots; when the catch is very good a portion is cured.

The local consumption of cephalopods has increased in recent times, with the result that only about one-third of India's cephalopod landings is being exported, the rest consumed internally. The large and medium sized squids and cuttlefishes are exported; the small-sized ones, the octopods and those landed during the off seasons are used as food. These are sold at the landing centres or taken to local markets near the coastal areas.

At Vizhinjam, on the southwest of India, the squid and cuttlefish catches are auctioned to agents of exporters or to private individuals who make the preliminary processing and sell the products to the exporters. Only the large and the medium-sized squids and cuttlefishes are taken for processing. After removing the skin, viscera, head and the cuttlebone or pen (of squid), the mantles are washed, kept in ice water and then taken to the processing shed for further processing and transporting in refrigerated vans to the freezing plant. In recent years, the price of cuttlefish meat ranged from Rs. 12 to 18 per kg at the landing centre and that of squids Rs. 8-10 per kg. At times of great demand, cuttlefishes at Vizhinjam are sold at higher prices and large-sized ones of 300-340 mm size fetch Rs. 25 to 35 each. The head and arms are sold to local people, the price ranging from 50 paise to 1 Rupee depending on the size. The nidamental glands of the female cuttlefish are also sold at 25-50 paise per each pair. The small sized squids and cuttlefishes are taken to local markets and sold by number or by small lots. At times of good landings, a portion of the squid catch is sun-dried as also the head and arms of cuttlefish, after removing the mantle for export. The cuttlebone is sold for export at the rate of Rs. 6-10 per 100.

At Madras the cuttlefish meat (mantle) fetches a price of Rs. 10-14 and squids (whole) Rs. 6-7. At Cochin the price of whole cuttlefishes is Rs. 7-10 and squids Rs. 5-7. At Mandapam and Rameswaram areas the squid *Sepioteuthis lessoniana* is sold at a higher price than the cuttlefish; the whole squid costs Rs. 10-12 per kg. The cuttlefishes *Sepia aculeata*, and the squid *Loligo duvaucelii* are sold at Rs. 5-7 per kg.

Use as bait

Cephalopods are a favourite bait for long-line fishermen engaged in catching tunas, billfishes and other pelagic fishes. In the hooks and line fishery at various places along the Indian coast, cephalopods have been used as an effective bait (Jones, 1968; Sarvesan, 1974; Rajagopal *et al.*, 1977; Silas and Pillai, 1982). According to Silas and Pillai (1982) squids are the most important bait in the tuna long-line fishery for the southern bluefin, albacore, bigeye and yellowfin.

Other uses

Apart from being a good source of human food and an effective bait in long-line fisheries, cephalopods have many other uses. Byproducts such as oil and liver extracts are made from squids in Japan. Squid liver extracts are used for human consumption and in the dehydrated form they are used as food for live-stock (Takahashi, 1965). The viscera of squids is a good poultry feed (Kawata *et al.*, 1955). Ambergris, obtained from sperm whales and used as a fixative in perfumery, is formed around beaks of squids consumed as food (Lane, 1962). Squids are also used as manure, and the waste from squids and other cephalopods are converted into fish meal.

The cuttlebones are commercially used in preparing fine abrasives and dentifrices (Dees, 1961). The powdered cuttlebone is a good source of food for poultry and cage birds. It is also provided to cage birds as a grinding stone for their beaks. Pulverised cuttlebones are used for cleaning the surface of woodwork and motor vehicles before they are painted (Sarvesan, 1974). Powdered cuttlebone is a good cleansing agent for glass and other smooth surfaces. Medicinal value is attributed to cuttlebone and *Sepia* ink (Boycott, 1957). The ink of cuttlefish has been used by artists

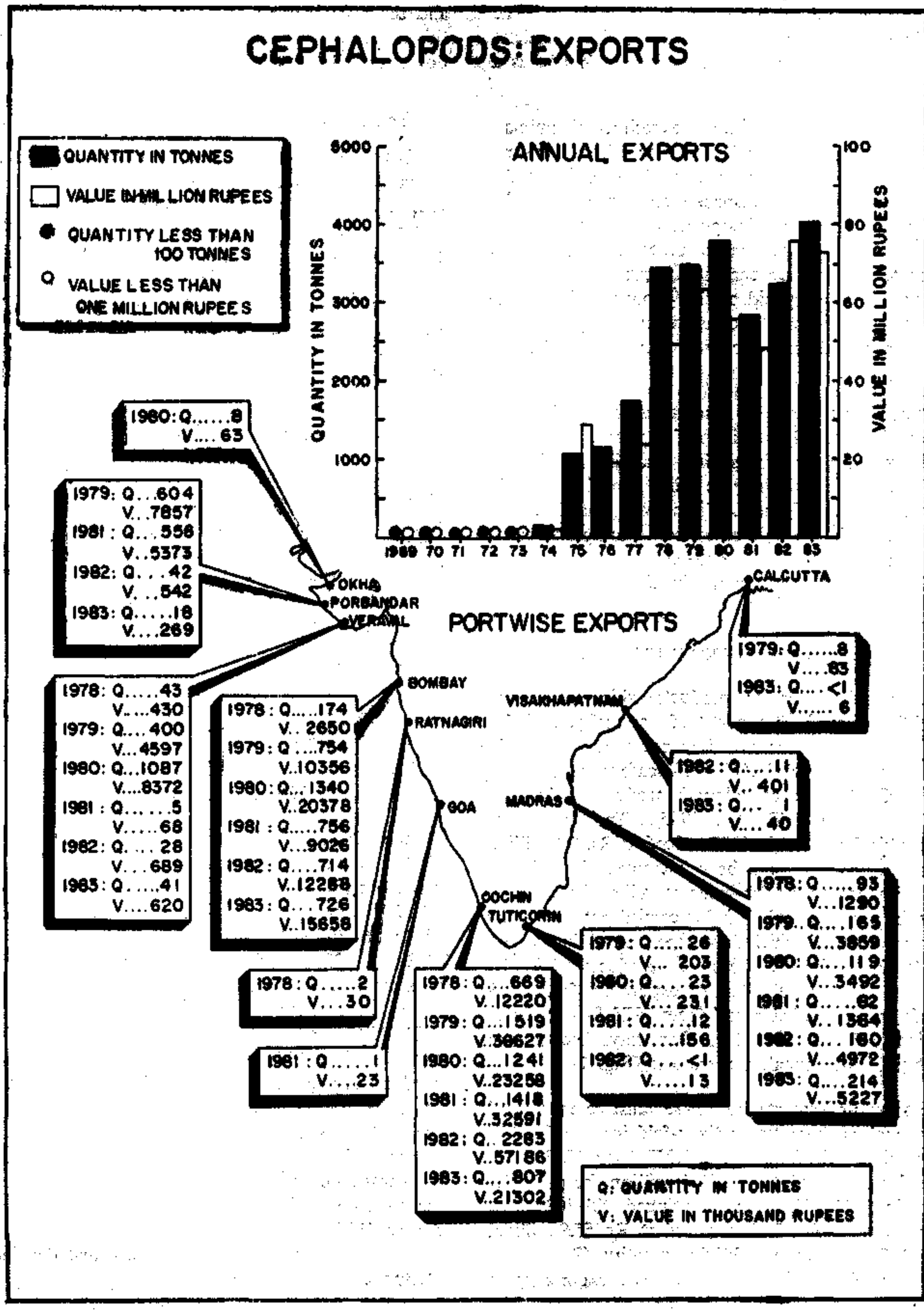

FIG. 1. Quantity and value of annual (1969-'83) and portwise (1978-83) exports of cephalopod products (portwise export figures for 1983 include only frozen cuttlefish and cuttlefish fillets).

as a natural *Sepia* pigment. The Romans have been using finely ground cuttlebone as a cosmetic. In the Japanese cuttlebone craft, a variety of fancy articles are made from cuttlebone. The shell of *Nautilus* is a shell collector's delight.

Live cephalopods are good experimental animals in the field of research and education. The discovery of the giant nerve fibres or axons of the squid by Dr. J. Z. Young in 1936 has opened up great avenues for research in electrophysiology and cellular neurophysiology which have great practical applications. The researches that are currently being carried out on the giant nerves of squid at the Woods Hole Marine Biological Laboratory and elsewhere may help in developing new drugs which will work on the human nervous system.

Jacques Cousteau in, his fascinating book 'Octopus and Squid, the Soft Intelligence' points out how an octopus was used to salvage the coal that was lost in the sea by a ship during the First World War. To quote Cousteau, 'Chinese, Vietnamese and Japanese salvage workers have used octopuses to bring up objects from sunken ships. The octopus in other words, took over the role of a human diver.'

CEPHALOPOD EXPORTS FROM INDIA

Among India's marine products which earn over Rs. 3,500 million from export trade annually, cephalopods have emerged as an important component in recent years. Out of 86,169 t of seafood exported in 1983, 4,050 t were cephalopod products valued at Rs. 72.7 million (MPEDA, 1985). The growth of export trade from 46 t in 1973 valued at Rs. 0.4 million to the present level has been phenomenal, and this gives an impetus to the fishermen as well as the industry. Today the overseas trade is being carried out with many countries some of which have been providing steady markets for Indian cephalopod products. Initially, cuttlebone was the only item of export but from 1973 onwards frozen cuttlefish and from 1975 frozen squids were included and since then they have become the mainstay of the cephalopod exports (Fig. 1).

The growth of exports from 1973 must be considered phenomenal as there was a three-fold increase in 1974 and an eight fold increase to 1,072 t by 1975. The value also increased to Rs. 29.4 million from Rs. 1.9 million in 1974. The spurt continued till 1980 with the quantity reaching 3,818 t valued at Rs. 55.8 million, but in 1981 there was a fall in quantity (2,830 t) as well as value (Rs. 48.6 million). The exports again picked up when the quantity reached 3,260 t in 1982 and the all-time high of 4,050 t in 1983. However, this trend was not reflected in the value which came down from Rs. 76.1 million to Rs. 72.7 million.

Products of Export

Though the cephalopod fishery in India consists of cuttlefish, squids and octopods to a very small extent, only the first two are being exported at present. The cuttlefish products include frozen cuttlefish, frozen cuttlefish fillets and cuttlebone, and in 1983 these together formed 45% of the total cephalopod exports. Squids are exported in frozen form, and the quantity exported in 1983 was 55% of the total exports. The trends of the export of all the four items, and also their major foreign markets are shown in Fig. 2.

1. *Frozen Cuttlefish*

The beginning of the export of cuttlefish products other than cuttlebone was made in 1973 with the shipment of 13.8 t of frozen cuttle fish worth Rs. 0.2 million to Japan. Since then there was a marked increase in exports and in 1980 a record quantity of 926 t worth Rs. 18 million was exported and this record export (quantitywise) has not been surpassed in the subsequent years. In 1981 the quantity came down to 243 t valued at Rs. 4.6 million. In the following years, however, the quantity picked upto 639 t and the value to Rs. 15.2 million in 1982, and 886 t and Rs. 21.6 million in 1983; in the latter year this item formed 21.9% of the total export of cephalopod products accounting for 29.8% of the value.

Japan is the top buyer of Indian frozen cuttlefish all through the years. In 1983 the export to Japan was 609 t which amounted to 69% of the total export of this product and earned foreign exchange equivalent of Rs. 16 million (74.6%). After a good performance (202 t to 339 t) during 1975-77, the exports dropped to a mere 30 t but picked up again in 1977 (300 t) and continued through 1983, except for another drop in 1981 (95 t). France is another regular buyer of frozen cuttlefish since 1975, taking 16% of the export of this product during 1983. A quantity of 143 t valued at Rs. 3 million was exported to France during that year. The export to that country started in 1975 and it increased till 1978 but showed ups and downs during the subsequent years. Other than Japan and France, the countries which imported the product from India during 1983 were Bahrain, Kuwait, Belgium, Spain, Saudi Arabia, the Netherlands, U.S.A. and the Federal Republic of Germany.

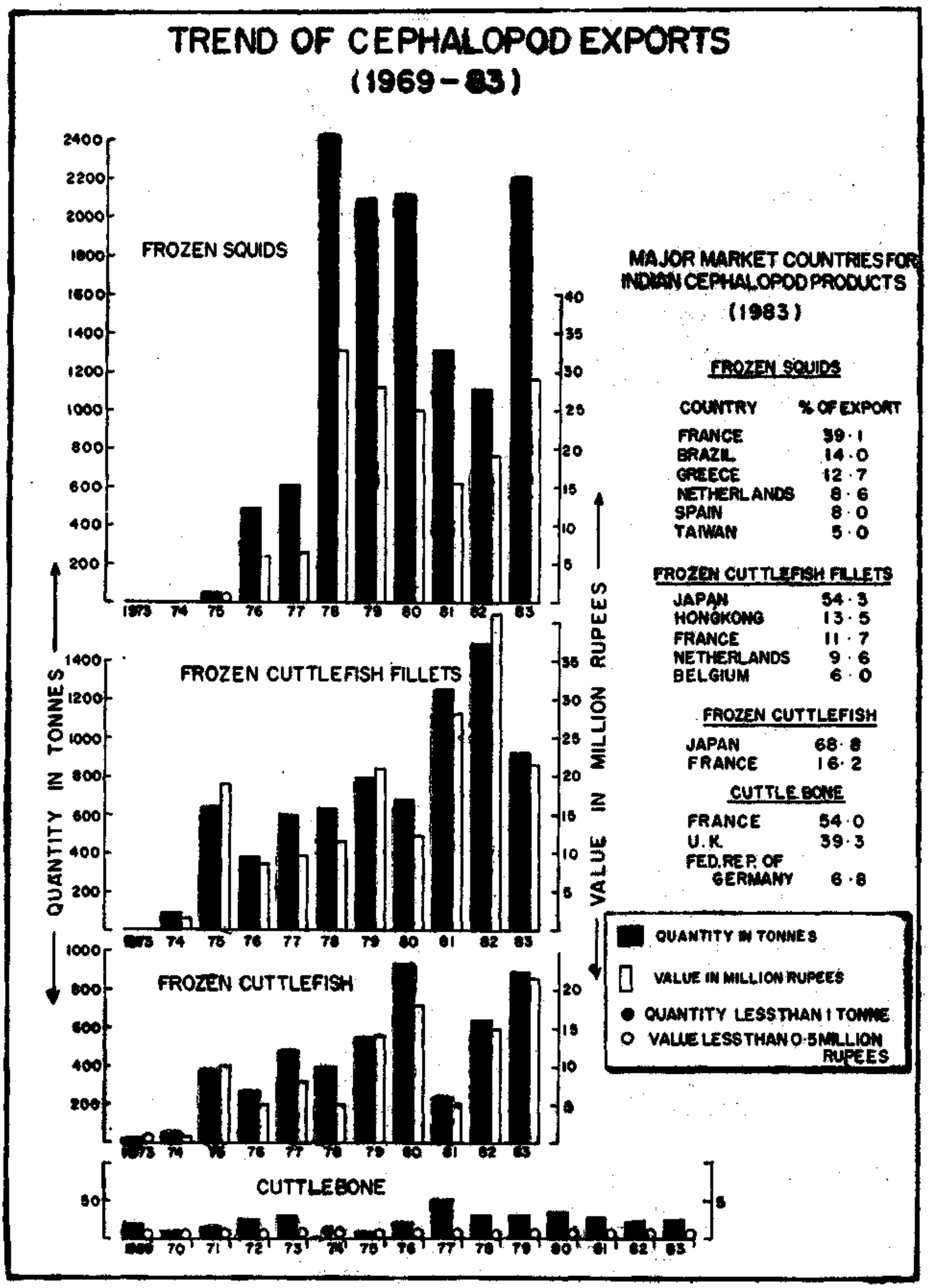

FIG. 2. Trend of itemwise exports of cephalopod products during 1969-'83 and major market countries in 1983.

2. *Frozen Cuttlefish Fillets*

The export of frozen cuttlefish fillets during 1983 was 921 t valued at Rs. 21.6 million. This was 22.7% of the total cephalopod export and 29.7% of its value. As in the case of frozen cuttlefish, the frozen cuttlefish fillets also was first exported to Japan in 1974 with a quantity of 93 t valued at Rs. 1.5 million. In the next year there was a seven fold increase in the quantity and a thirteen fold increase in the value. After a fall in 1976, the export again improved in 1977 and increased till 1979 but dropped slightly in 1980. The exports were very good in 1981 (1,245 t, Rs. 27.9 million) and 1982 (1,488 t, Rs. 41.3 million). The year 1983 witnessed a big drop by 38% in quantity and 47% in value.

Japan is a regular buyer of Indian frozen cuttlefish fillets since 1974 and has been importing 92 t to 835 t annually. The maximum quantity was exported to Japan in 1982, and the value also was the highest, Rs. 28.8 millions that year. In 1983, export to Japan was 500 t which formed 54.3% of the total export of this product and the value realised was Rs. 13.2 million forming 61.3% of the total value. Apart from Japan, there are 14 other countries which have imported or continue to import cuttlefish fillets from India. Among them Hong Kong and France took 125 t (13.5%) and 108 t (11.7%) respectively in 1983; the Netherlands, Belgium, Singapore, U.A.E. and Nepal together shared 20.5%. The monetary realisation from exports to Hong Kong and France were Rs. 2.4 million (11%) and Rs. 1.9 million (8.8%) respectively.

3. *Frozen Squids*

Frozen squids is the largest single item of export among all the cephalopod products. In 1983 a quantity of 2,217 t worth Rs. 29.2 millions was exported. The export of this item was started in 1974 with a trial shipment of 454 kg valued at Rs. 6,823 to Australia. The regular exports commenced in 1975 and Australia, Belgium, France, Spain and U.S.A. together took 46 t. There was tremendous increase in exports since then, and in 1978 it has reached the highest peak of 2,429 t valued at Rs. 32.8 millions. But from 1979 to 1982 there was a decline in the exports to 1,108 t. However, the export of this product showed a healthy trend by doubling the quantity in 1983.

Twenty four countries have been buying frozen squids from India during the last ten years. Among these, France offers a steady market all through the years with the import into that country varying from the initial 9 t in 1975 to the maximum, 2,101 t in 1978. In all the years the quantity was over 400 t except in 1977 (279 t). Australia imported Indian squids regularly from 1975 to 1982 but in 1983, she did not import this product. Among the major importers Belgium, the Netherlands and Spain still continue to buy this product. Japan which provides the largest market for Indian frozen cuttlefish and cuttlefish fillets has taken frozen squids only in 1976 (13 t), 1978 (4 t) and 1979 (30 t). In 1983 France took 868 t of the product worth Rs. 12.3 million which formed 14% of the total export by quantity and 42.2% by value respectively. A significant aspect of the export performance in 1983 was the finding of a new market in Brazil. A quantity of 307 t (14%) valued at Rs. 3.5 million (12%) was exported to Brazil, Greece took 12.7%, followed by the Netherlands (8.6%) and Spain (8%). Taiwan, Switzerland, Belgium, U.S.A., the Federal Republic of Germany, Saudi Arabia, Italy, and Kuwait together imported 17.7% of this product.

4. *Cuttlebones*

Of all the cephalopod products, cuttlebone was the first item to be exported from India. The available data show that 17.3 t of cuttlebone valued at Rs. 50,348 were exported in 1966. From 1967 the exports showed marked fluctuations from less than a tonne to 49 t in 1977; though there was decline in the quantity exported during 1978-83, the value increased from Rs. 0.2 million to Rs. 0.5 million. In 1983, a total quantity of 26 t of cuttlebones worth Rs. 0.3 million were exported. This product was being exported to about 14 countries but in 1983 their number came down to three viz., U.K., France and the Federal Republic of Germany. U.S.A. was a regular buyer from 1975 to 1981, and New Zealand from 1975 to 1980. From 1974 onwards U. K. continues to import cuttlebone from India, and in 1983 the quantity taken was 10 t worth Rs. 0.2 million. Though France has taken more quantity (14 t), the return was comparatively less (Rs. 68,000). The Federal Republic of Germany which is in the market since 1977 has taken only 1.8 t in 1983.

It is of interest to note that all the cuttlefish products (frozen cuttlefish, frozen cuttlefish fillets and cuttlebone) put together, quantitywise form 45% of the total cephalopod exports, the rest (55%) being frozen squids, but in value the cuttlefish products account for 60%. It is also pertinent to mention that Japan and France provide the largest overseas markets for Indian cephalopod products. In 1983, Japan lifted 609 t of frozen cuttlefish and 500 t of frozen cuttlefish fillets, together forming 27% of the overall total exports. The value realised for both the products was Rs. 29 million which formed 40% of the total export value. Rs. 18 million (25%) came from France for 1,133 t (28%)

of all the cuttlefish and squid products. Thus Japan and France together account for 55% of the export by quantity and 65% by value. As it stands today, our success in the export trade in regard to cephalopod products depend on their market demands in these two countries.

Portwise Export of Cephalopods

The Indian cephalopod products are exported from many ports, viz., Calcutta, Visakhapatnam, Madras, Tuticorin, Cochin, Mangalore, Ratnagiri, Bombay, Veraval, Porbunder and Okha (Fig. 1). Of these Cochin, Bombay, Madras, Veraval and also Porbundar and Tuticorin to a great extent ,are the ports for the regular exports during almost all the years. At other centres the export is only occasional and on a small scale, from less than 1 t to 11 t annually. The annual export from Cochin port varied from 669 t in 1978 to 2,283 t in 1982 within a range of 33-50% of the country's cephalopod exports. In foreign exchange inflow also Cochin port was topping the list, with Rs. 12 million to Rs. 57 million annually (42-75%). The annual exports from Bombay ranged from 714 t to 1,340 t with the value of the products varying from Rs. 9 million to Rs. 20.4 million. The export from Veraval was 5 t to 1,087 t, from Porbundar 18 t to 604 t, from Madras 81 t to 214 t, and from Tuticorin 0.5 t to 26 t. The high positions of Kerala, Maharashtra, Gujarat and Tamil Nadu in the all India cephalopod production are reflected in the export performance at the ports of Cochin (Kerala), Bombay (Maharashtra), Veraval and Porbundar (Gujarat) and Madras and Tuticorin (Tamil Nadu). The proximity to landing places, better transportation networks and location of the processing plants facilitate quick and more efficient exports from these ports.

Among 159 firms engaged in processing and exporting marine products from India, listed by MPEDA, 139 firms deal with squids and cuttlefishes as one of the major items. Of these, 43 are in Cochin (72 in Kerala), 31 in Madras (35 in Tamil Nadu), 21 in Bombay (23 in Maharashtra) and the rest in other maritime states (9 in Gujarat, 3 in Goa, 9 in Karnataka, 3 in Andhra Pradesh, 1 in Orissa and 4 in West Bengal).

Consumer acceptibility of any product depends upon the quality of the product and therefore the quality of cephalopod raw material and finished products is to be ensured before they are processed and exported. In the case of frozen products, the external appearance, colour, texture, flavour, thickness of mantle and degree of freshness are very important. There are detailed guidelines and methods for processing frozen cuttlefish and squids under strict quality control requirements (MPEDA, 1976). In 1976, the MPEDA had arranged a training programme in processing squids and cuttlefishes, and a team of Japanese experts imparted practical training at Calcutta, Paradeep, Madras, Quilon, Cochin, Mangalore and Bombay. Shenoy (1985) has given the method for processing dried squids according to quality requirements in the Japanese market. According to the Market Study Team sponsored by MPEDA, which visited Japan, there is immense scope for exporting Indian dried squid to Japan as the demand there for this commodity is about 12,000 t a year. The price is very attractive, which is about Rs. 65 per kg, and accroding to the committee's estimation, India can export 2000 t of dried squid a year.

With the increased production of cephalopods, improved handling and processing techniques under strict quality control measures, India has bright prospects in the overseas trade in cephalopod products.

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CEPHALOPOD RESOURCES: PRESPECTIVES, PRIORITIES AND TARGETS FOR 2000 A.D.

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ABSTRACT

Estimates of cephalopod resources of the Indian Ocean and the EEZ of India are discussed. Attention is drawn to major lacunnae in resource assesment. The importance of cephalopods also as forage, as bait, for neuro-physiological studies, behaviour studies and so on are discussed. The cephalopod potential and the prespectives and production targets for 2000 A.D. along with modalities of achieving the same are outlined.

INTRODUCTION

There is general consensus that cephalopods constitute potentially an important marine living resource where future exploitation to a high magnitude is possible. Estimates are that the present global production of 1.5 million tons can be increased many-fold. Nearly 70 per cent of the presently exploited resources of squids, cuttlefishes and *Octopus* come from the neritic waters where directed fisheries for this resource is sparse. While Cephalopods are considered a nonconventional resource in many areas, its high protein and low fat content can make it an important item of human diet. In fact, there has been a quantum jump in the cuttlefish and squid catches in the world during the decade 1970 to 1980 of 84 and 57 per cent respectively as against a growth of hardly 8 per cent of total world fish production. An FAO projection places this trend of production of cephalopods in the world fisheries to go up to about 2 million tons by 1990. Accordingly (Anon, 1983), the total world food requirements of cephalopods will be between 1.7-1.9 million tons by 1990, about 227,000 to 499,000 tons more than the present level. To maintain the present level of *per capita* consumption, the production should attain atleast the lower limit. The estimated projections given in Tables 1-3 will give an overview of the situation, especially for the countries viz., Japan, Republic of Korea, China, Spain, Italy, France, Mexico, Thailand and Philippines presently involved with the fisheries in a big way.

TABLE 1. *Projected Demand for Cephalopods in Japan 1990 (After Anon, 1983)*

		1980 Esti-mated '000 tons	1990 Pro-jected live weight	1980 Esti-mated Per Capita kg.	1990 Pro-jected Per Capita kg.
FRESH/FROZEN					
Home consumption					
Squids/Cuttlefish	..	234.2	249.0	2.02	2.30
Octopus	..	43.3	48.0	0.37	0.44
Sub total	..	277.5	297.0	2.39	2.79
Institutional Catering					
Squids/Cuttlefish		85.3	130.0	1.22	1.54
Octopus	..	51.0	65.0		
Sub total	..	136.3	195.0	1.22	1.54
Processed					
Preparations	..	316.5	331.5	2.73	2.77
Others :					
Canned	..	5.1	4.0		
Dried, Salted & smoked	..	41.0	45.0	0.56	0.56
Salted fermented	..	18.6	22.0		
Sub total	..	381.2	402.5	3.29	3.33
Total Human Food	..	795.0	894.5	6.90	7.66
Bait	..	36.0	30.0		
Total Demand	..	831.0	924.5		

TABLE 2. *Actual supply and prospective deamnd for Cehalopods in 1990 in selected countries (After Anon. 1983, SCS/DEV/83/24*

Country	1980 *Per Capita* kg.	Total '000 tons	1990 *Per Capita* kg.	'000 tons
Mexico	0.39	27.0	0.41	38
Japan	6.82	763	7.08	895
Korea, Rep. of	2.16	110.6	2.63	118
Philippines	0.67	33.0	0.79	50
Thailand	0.83	26.0	0.97	56
France	0.28	14.6	0.32	18
Italy	1.57	89.1	1.85	108
Spain	3.50	132.0	3.73	151

TABLE 3. *General prespective for World Consumption of Cephalopods in 1990. (After Anon. 1983. SCS/Dev/83/24* ('000 tons)

	Approximate per cent consumption (1980)	Prespective consumption in 1990 Low[a]	High[b]
World Total[c]	**1447.6**	**1674**	**1946**
Africa	2.0	3	5
Latin America	32.0	43	53
Mexico	27.0	35	38
Other	5.0	8	15
Asia and Middle East	**1127.9**	**1314**	**1518**
Japan	795.0	845	895
Korea, Rep. of	110.6	129	157
Philippines	33.0	42	50
Thailand	18.3	48	56
Other Asian	171.0	250	360
Europe	**265.7**	**284**	**325**
France	14.6	15	18
Italy	89.1	91	108
Spain	132.0	142	151
Other European	30.0	36	48
Other Developed Countries	20.0	30	45

[a] Assuming no increase in *per capita* consumption.

[b] Including the effect of income increass for all, and also for price effects in the case of Japan.

[c] Excluding bait (approximately 46,000 tons) and inventories

What is most revealing is that while the prespective consumption for 1990 (high) for the countries traditionally involved with Cephalopod fisheries is to the tune of about 264 thousand tons (100,000 tons for Japan), it is the senario for the 'Other Asian Countries' that is significant—a jump from 171.0 to 360.0 tons. While these may be only indicative projections, I feel, India has a vitally important role to play in filling up part of this gap of about 189,000 tons.

Today we are in a fortunate position to have many added facilities for our resources survey leading to constructive development programmes. With a fleet of large fishery exploratory survey vessels with the Fishery Survey of India and Sister Organisations of the Department of Fisheries and DARE of the Ministry of Agriculture and Rural Development, Government of India, and the acquisition of the Fishery Oceanographic Research Vessel SAGAR SAMPADA of the Department of Ocean Development, Government of India, we are uniquely set to carry out from the deeper neritic waters and our contiguous high seas resources surveys and evaluations as well as quite a lot of basic information that is required on the ecology, behaviour and stocks of cephalopods that are essential for sustained commercial operations. If we take the example of Thailand, great innovations are possible in the shallower neritic waters in our small scale fisheries sector and the continental shelf waters.

No development programme for cephalopods, a non-conventional resource for us can succeed unless we link it with a good internal marketing strategy. Thus there is an urgent need for a constructive product development and marketing programme even for the existing catch part of which is discarded. As introduction of specialised fishing methods are necessary to augment production from the present level of about 18,400 tons (Av. for three years 1982-84), largely taken as bycatch in the shrimp fisheries, what should be our strategy? Upgrading the existing fisheries with innovations in light fishing with lift nets in the small scale sector and the establishment initially of joint venture programmes with buy back arrangements appear feasible propositions.

An expansion of the Cephalopod fisheries in India may throw up a number of problems and will also need special attentions in several areas including basic and applied research to support developmental programmes. I would like to touch on some of these before attempting a long term development projection for India.

RESOURCE ASSESSMENT

1. The expansion in cephalopod fisheries will involve tapping of new resources for utilization besides the traditionally exploited species. Proper species identification for developing resource management strategies is essential. Our species inventory, especially those from our oceanic waters is far from complete. Hence this basic element has to receive immediate attention through collection of samples and documentation from resource surveys and exploratory fishing for neritic, epipelagic and mesopelagic species. Identification of life-history stages is an equally difficult task. It is

imperative that we have identification aids or keys for larvae and juveniles so that recruitment monitoring of at least the commercially important species could be made more effective.

While living cephalopods number fewer than 1000 species (650 ?) belonging to 43 families, there are wide range of differences in their life habits, and behaviour ; some are benthic, others pelagic or pass through an early pelagic phase exhibiting ontogenic descent ; some solitary or as the oceanic squids, shoal in large schools. Size-wise they range from minute species hardly 2 cm to the giant squid *Architeuthis* sp. attaining over 20 metres in length and weighing well over a ton. However, most of the commercial species fall within the range of 30 gms to 2 kg in weight.

2. Use of Cephalopod beaks in species identification : A method for identifying beaks and on beak size estimating body weight and mantle length has been developed by Wolff (1984). Studies of this nature are very important since in many cases we get only the beaks from predator stomach and gut. Effective means of species identification thus becomes important and so also an estimate of the size of the prey. Perhaps this approach could eventually help in estimating prey biomass.

Mercer *et al.* (1980) have gone one step further in using beak morphometrics of the Ommastrephid squid *Illex illecebrosus* in sex determination. The significance of cephalopod beaks and the possibilities of beak size—body weight estimations have been discussed by Clark (1962a, 1962b and 1966). Wolff and Wormath (1979) have used beak morphology for separating two morphologically similar species of ommastrephid squids.

A whole new area has thus been opened up for studies on species and sex identification as well as estimation on growth and predator prey relationship. It is hoped that some attention will be given to such studies and estimations in our waters.

3. Diel vertical migrations :

Spectacular diel vertical migrations are undertaken by many species of oceanic cephalopods. Roper and Young (1975) categorie a variety of patterns of vertical distribution of cephalopods as :

Near surface dwellers
First order diel vertical migration
Second order diel vertical migration
Diel vertical shifters
Diel vertical spreaders
Non-migrators
Vertical wanderers
Species associated with the ocean bottom ; and
species exhibiting ontogenic decent.

While we have carried out some studies on the Deed Scatting Layers (DSL) and the vertical migrations of macro-zooplankters (Silas, 1969), more work is needed in this direction specifically with reference to cephalopods for the following reasons :

(*a*) To understand the effect of temperature, light productivity and competitions in regulating or limiting the distributions of the species.

(*b*) In the Eastern Arabian Sea we have an oxygen minimum layer and the relationship of this with the occurrence of pelagic cephalopods, especially those associated with the DSL needs study.

(*c*) Determination of swimming layers of the commercially important species and the phases of feeding activity on the bait organisms in the DSL. From the north east Arabian Sea, Yamanaka (1976) has reported capture of the oceanic squid *Symplectoteuthis oualaniensis* with hand lines from a depth of 400 m during day and from near the surface attracted by light at night. This species is also said to avoid upwelling areas and during day time its swimming layer is said to correspond to the oxygen minimum layer (0.18-0.38 ml/1). Two DSL, one at 350-450 m and the second still deeper at 800-900 m have been reported from the Lakshadeep Sea (Silas, 1969) and the occurrence of cephalopods and their percentage composition in the DSL should be of considerable interest. The closing nets which could be operated at reasonably high speed is a must for quantitative studies on some of the mesopelagic squids. In a series of papers Clarke and Lu (1974, 1975) and Lu and Clarke (1974, 1975) have demonstrated the more effective use of two nets, namely the Isaacs Kidd Midwater Trawl with catch dividing buckets (IKMT) and a Rectangular Midwater Trawl (RMT) with good success.

We have facilities for use of such gear from our research vessels ; especially R. V. SAGAR SAMPADA and I hope constructive programmes will be developed for obtaining better quantified data.

Cephalopods as Forage

1. Cephalopods form forage to a wide variety of predators, viz., large perches, Tunas and tuna—like fishes including sword fish, sailfish and marlins, lancet fishes (*Alepisaurus ferox*), pelagic sharks and rays,

sea birds, dolphins and toothed whales. Clark (1979) 1980) estimates on the basis of beak of cephalopods in stomachs of sperm whales that the whales may consume squids as much as or more than the quantity harvested in world fisheries for squids. A proper evaluation of cephalopod as forage from our seas is necessary in order to understand whether excessive degree of preying on any particular species by predators would affect recruitment of any of the commercially important species. Besides it may be worth examining whether some of the forage species could be good indicators of aggregating areas of pelagic fish such as Tunas. Stomachs of lancet fishes caught in tuna longline fishery invariably contain fresh forage on which they would have fed and form excellent biological samplers. The importance of cephalopods as forage will be evident from the growing literature on the subject. A few pertinent references on prey-predator relationship are Krumholz and de Sylva (1958), Maksimov (1969), Dragovich and Potthoff (1972), Pervin, Warner and Fiscus (1973), Rancurel (1971, 1976), Clarke and MacLeod (1974), Mercer (1974), Imber (1975) and Toll and Hess (1981).

Cephalopods as Bait

Estimates are that nearly 46,000 tons of Cephalopods harvested, predominantly squids are used as bait in the global fishery activities. The demand is most for small sized squid of 150-200 gms for tuna long lining. Japan is esimated to use about 36,000 tons as bait in her distant water tuna long line operations. This demand for bait is likely to continue if not rapidly increase in the coming years as many of the developing countries may enter longline fishing and other types of line fishing where cephalopods may have to be used as bait. A decline in use of cephalopods (squids) as bait is predicted for Japan. A proper assessment of our requirements and the species suitable as bait needs study as we have made a start in exploratory surveys and joint ventures programmes in tuna long lining. In short the right species and the right size have to be decided and the size of the blocks in which they have to be frozen for easy transport and handling on board determined.

Cephalopod Behaviour

We have practically no studies on behaviour of cephalopods from our waters. An understanding of Cephalopod behaviour is equally important for the exploitation of the resources. We need information on the gregarious and non-gregarious habits of the species, existence of dominance hiearchies, feeding pattern ; degree of sociability, communication between arrivals by agnostic displays, territorial habits, protective adaptations to discourage perdators, escape behaviour, inking pattern, frequency and quantity and other antipredator behaviour, diel rythms, habitat preferences, swimming postures, ritualized reproductive behaviour and courtship patterns during sexual interactions, copulation and egg-laying ; ritualised colour patterns (light, dark, striped, bars and spots, dymantic or black spot display and other patterns such as zebra stripe, upward V-curves, longitudinal streaks and cryptic and defensive patterns) ; bioluminescence and its role in behaviour ; and semelparity.

Reproductive behaviour is of special interest. What triggers egg laying in a site ? According to Grimrpe (1926) in *Sepia officianalis*, the laid eggs may induce optical stimulation in spawning females in selecting an egg deposition site. In the case of *Loligo opalescens* an egg cluster is known to be a visual stimulus for females to attach freshly laid eggs to the cluster (Hurley, 1977). Confirmatory information for our tropical species is wanting.

The works of Wells (1962), Wells and Wells (1972), Young (1962), Moynihan and Rodaniche (1977, 1982) and Moynihan (1983) are but a few useful references which are indicative of the wealth of information that could be collected an aspects of the behaviour of the species, information on some of which are vitally necessary for managing the resource.

Neuro Physiological Studies

A good amount of effort has gone into the study of the giant nerve fibre system and the stellate ganglion of squids to understand the pathways of response transmission to enable split second body movements and reactions. The giant axon of the squids has thus been found to be important for neurophysiological and pharmacological studies (Rosenburg 1973). The basic processes connected with the nerve excitation and nerve conduction have been clarified by the study of squid giant axons (Hodgkin, 1964 ; Tasaki, 1968). More significant has been the outcome of the study of the nervous system of the *Octopus* by Wells (1962, 1966, 1978), Young (1971, 1977) and of the *Nautilus* by Young (1965).

We have made no use of such excellent material available in our waters for biomedical research.

Octopus Toxins as Pharmacological Tools

Some of the octopods secrete substances which may be lethal to prey invertebrates such as crustaceans (Ghiretti, 1960). Gage and Dulhunty (1979) while listing a number of instances and records of fatal bites of the Octopod *Hapalochilena maculosa* report the symptoms as '........respiratory distress, numbness

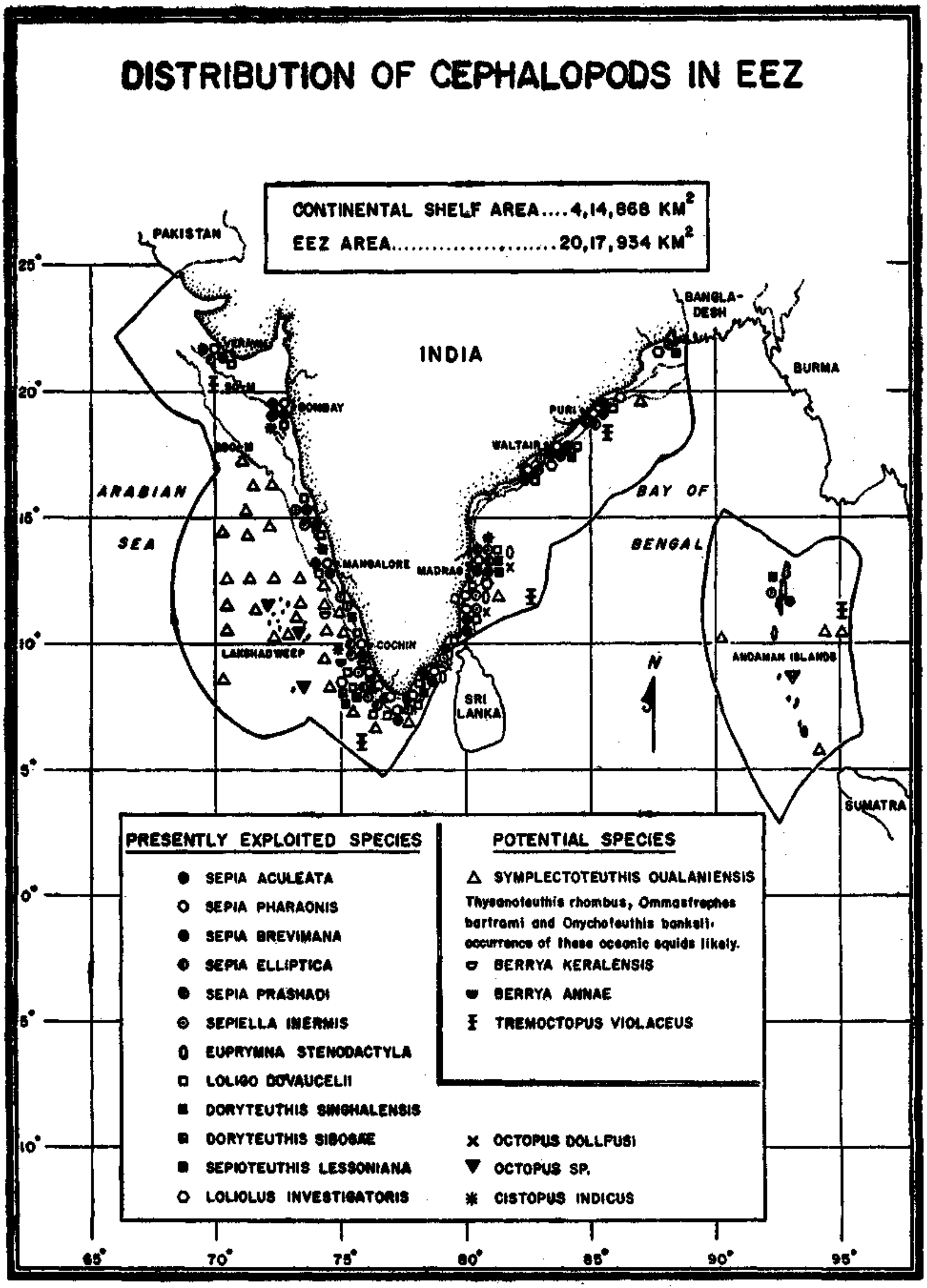

Fig. 1. Occurrence of exploited and potentially important species of cephalopods in the Exclusive Economic Zone of India.

of the mouth and tongue, blurring of vision, difficulty of speech and swallowing, loss of tactile sensation, ataxia and muscular paralysis ' followed by death. The toxin is identified as Maculotoxin which has pharmacological effects (Trethewie, 1965), akin to Tetradotoxin and Saxotoxin obtained from marine organisms. Since the death is caused by paralysis, the artificial ventilation of the victim is said to improve the chances of survival.

It will be worthwhile to understand the mechanism by which *H. maculosa* protects itself from its own toxin. It has been observed to squirt saliva from its beak into the water above the prey organism (crab) and move away and wait for the prey to die before approaching it again to feed on. The possibility of synthesising new and more effective anesthetic agents need study, in short, the therapeutic uses of Maculotoxin. For more information on the use of Maculotoxin reference is also invited to Flecker and Cotton (1955), Freeman and Turner (1970) and Dulhunty and cage (1971). *Haplochelaena maculosa* occurs in our waters and is occasionally caught in trawl operations along Tamil Nadu Coast. We have hitherto no reported cases of fatalities due to the bite of this species from our waters, perhaps as fishermen instinctively know it from its distinctive colouration and know that it is an undesirable species to handle. Lot of basic research needs to be done on the toxin of this and other cephalopods.

Life Cycle and Biology

A major lacunae as of data is that we lack information on the complete life cycle, biology and connected sequence of growth processess of even a single species of cephalopod from our waters. Information on semelparity or high post-spawning mortality is suspected for some species, males outlasting females in many, but confirmatory data is lacking from our waters. Some of the species are harvested in the 0-year class, I-year or II-year beyond which there is no information. In most species sexual maturity is rapid and a large body size is attained within a short time of less than a year. This is a reflection of the highly predatory habit and ability to forage on diverse orgnaisms. Canibalism has been observed of larger individuals preying on smaller ones of the same species.

The shorter generation time is probably compensated in numbers, some species occurring in very large aggregations. In short, our knowledge about the extrinsic and intrinsic factors that affect cephalopod mortality if fragmentary. Semelparity and abbreviated life span (1-3 years) of species are important information for the commercial exploitation and management of species.

Some species of squids and cuttlefishes attain sexual maturity at different sizes, but an adequate explanation is wanting. There is a need for understanding the factors responsible for such variations in body size at maturity in natural populations. Similarly the factors accelerating gonadial maturity also needs study.

Summers (1983) discusses the spawning—induced mortality in a terminal spawner *Loligo pealei* and the problems connected there with. There are other species which have intermittent spawning since ' spent ' animals have also been observed in commercial catches. Whether successive spawnings is a quick or slow process needs study. In *Octopus*, many females are semelparous and die after caring for their eggs through the embroyonic development, but males outlive females.

As earlier mentioned, aging in cephalopods is still a problem and the use of beaks, statoliths and length frequency studies are feasible, but have their drawbacks as well. Age markers, however, need proper identification. For example, in the case of *Loligo opalescens* this has been attempted on the basis of population statistics, statolith ring counts and laboratory rearing experiments, each giving different interpretation (Hixon, 1983).

Mesh size and type of gear operated introduce bias in sampling from commercial catches where immature and juvenile stages are bond to be left out. Sampling of planktonic stages themselves have great short comings in methodology and types of gear used. In many species, the breeding areas and spawning may be spatially seperated. Refinements in sampling methods have to be adopted for more precise populations estimates.

There is hardly any information on the effects of macro and micro parasites on natural populations of cephalopods. Our species have not been critically screened for parasites.

Transportation of live squids to be kept in captivity for research on aspects of physiology and behaviour are gaining ground. Some of the problems connected with live transportation and maintenance are discussed by Matsumoto (1976).

Cephalopod Mariculture

The culture of cephalopods (*Octopus*, squids and cuttle-fish) has been attempted and is technically feasible. However, in view of the large untapped resources yet available in capture fisheries aquaculture of cephalopod will continue to have a low priority except for selected species which may be need for biomedical research or as choice food for a limited market.

In the context of a long range programme, the economic viability of culture of some of the commercially important species should be attempted. The factors in favour are the availability of spawners and eggs in inshore waters, the rapid growth and short generation period and hardiness of some of the species. Rapid decline in population under heavy fishing pressure of some commercial species may encourage attempts at mariculture of the species.

Cephalopod Fisheries

It is known that for any effective fisheries management, efforts are necessary for an understanding of the gaps in our knowledge on the commercially important species, viz. their life span (rate of growth, maturation and mortality); change in seasonal distribution and abundance, migration and stock discriminations. For the estimates of biomass of squids, acoustic surveys combined with underwater video measurements of the density of the population has been suggested as an effective tool (Caillict and Vaughan, 1983).

Established fisheries in some areas indicate periodic cycles of abundance (Shin, 1982). In capture methods we have no information from our waters about the reactions of squid and cuttlefish to our trawl gear nor any idea about escapement. Yet, the bulk of our landings are from shrimp trawling operations, where cephalopods from only a small proportion of the catch. No large scale jigging or light fishing or trap fishing are in vogue except in very localised situations.

Cephalopods, especially squids are considered to be opportunistic species which evince an explosive increase in population size when there is a depletion in other species due to intensive fishing. The best examples are the Thai trawl fisheries (Gulf of Thailand), the trawl fisheries in the northwest Atlantic and the northwest coast of Africa. We have never critically looked into this aspect in our inshore trawl fisheries, where, with increased effort the catch rates of some of the traditionally important fish and crustacean species have been known to decline. Whether the incidental catch of squids and cuttle-fishes have thereafter increased in specific fishing grounds may be examined from past data. This information may also be necessary for developing directed fishery for squids and cuttlefishes in the small scale fisheries sector. Such explosive increase may have to be supported and sustained by an abundance of forage organisms for squids and cuttlefish among other factors. An *in toto* study of such a problem in our water is necessary and I can think of no better place for such a critical exercise as the south west coast (Kerala) of India.

The conventional methods of yield-per-recruit may be difficult to apply to cephalopods on account of the high post-spawning mortality. One suggestion is that (Anon, 1982) estimates may have to be made for two or more phases such as, pre spawning phase of moderate mortality and high mortality during and after spawning. I would refer workers to the excellent exposition by Caddy (1983) on the methods of assessment of squid stocks; analysis of catch and effort data and its use; estimation of recruitment of short lived species; tagging; and short and long-term management measures for cephalopod stocks. He has suggested specific regulatory measures for cephalopod fisheries some of which may have relevance to our situation.

There is also an urgent need to further streamline monitoring of our multispecies fisheries and data acquisition system for cephalopods and other components which may prey on cephalopods from our coastal fisheries for the timely detection of changes in population abundance.

Prespectives and Targets for 2000 A.D.

Gulland (1971) estimated the global biomass of cephalopods to be anywhere between 2-100 $\times 10^6$ t. Voss (1973) estimated the potential world catch of cephalopods from the neritic and continental slope areas to be around 8 to 12 million tons of which only about 1.5 to 2 million tons are being harvested. The world potential of oceanic species (Oegopsids) was estimated by him as anywhere from 8 to 60 times those from neritic shelf resources—about 500 $\times 10^6$ t globally. These are theoretical estimates based partly on feeding rates of sperm whales on predominantly oceanic squids when sperm whale populations were optimal. In fact, Kawakami (1980) estimated the weight of squids consumed by sperm whales to be to the order of 100-320 $\times 10^6$ t. Indirect evidence of abundance of squids is seen in some areas from the very hevy concentrations of the beaks of oceanic squids in benthic deposits. Chikuni (1983) estimated the potential yield of neritic cephalopods from the Indo-Pacific Region to be about 1.1-1.4 million tons as against a catch of 0.3 million tons.

It is evident that some of these estimates greatly exceed today's world fish production of about 76 million tons. While these optismistic estimates point to a high magnitude of cephalopod biomass, the harvesting of the resources may have to be considered in the light of the high energy (fuel) costs ; predator-prey relationship as besides the sperm whale and other marine mammals, cephalopods are also choice food of a wide variety of fishes (Lange and Sissenwine, 1980, Dong, 1981). Nevertheless the fact remains that large resources of oceanic squids are yet to be tapped. According to Caddy (1983) '.... the high productivity/biomass ratio of cephalopods (predicted on their high rate of populations turn over or natural mortality rate), may mean that the standing stock that could produce the above production may be significantly lower than for a fish stock of corresponding productivity, so that in fact the proportion of the standing stock found at high enough densities for harvesting to be economically feasible is probably quite low'.

It is also estimated that when good fishing for cephalopod exist as in the North West Pacific and the North West Atlantic, they constitute about 4.7 and 4.0 per cent respectively of the total fish catch from the region (FAO Areas 61 and 21 respectively), while in other geographical areas the percentage of cephalopod catch is very low. In the two aforesaid areas, the bulk of the catch of cephalpods is that of oceanic squids, and the presemption and implication is that in the other geographical areas globally oceanic squids are greatly under exploited. Not only this, Mercer (1974), Fiscus (1982) and others have shown that the locations from where the stomach contents of marine mammals have been examined and found to contain a preponderance of squids are spatially widely separated from the areas of abundance of these squids as evident from fishing operations.

Two important areas where production could be augmented in the littoral and island states of the Indian ocean are :

1. The neritic waters which wholly accounts for the cephalopod production in the Indian Ocean today.
2. The oceanic waters for pelagic squids which has remained untapped, but exploratory surveys in different parts of the Indian ocean have indicated resources of high magnitude.

The same holds good for India as well. First there is an urgent need for developing directed fishery for cephalopods from our continental shelf waters and the most promising method for immediate development seems to be the utilization of some of the mechanised boats of 9 to 13 m for light fishing with lift nets. There is also need for upgrading the traditional gears for specific capture of squids and cuttlefishes as well as use of traps, pots etc. for *Octopus*, the latter especially in the reefs and lagoons. There is also considerable scope for improving the utilization of the presently exploited resources from the continental shelf waters in our multispecies trawl fisheries by better post-harvest handling and product development to create greater internal demand and cater to the export trade. Chikuni (1983) has given the nominal catch of cephalopods by area in 1970 and 1975-1981 ('000 t) as follows :

Area		1970	1975	1976	1977	1978	1979	1980	1981
Bay of Bengal	..	1	4	3	11	10	12	9	9
Eastern Arabian Sea	..	0	5	6	8	19	15	12	14

Part of this catch is accounted from the shallower neritic waters along the Indian Coast. According to him, the major species of cephalopods in the above two sub-areas are as follows :

Species	*Bay of Bengal*	*Eastern Arabian Sea*
CUTTLE FISH		
Sepia pharaonis	+	++
S. aculeata	+	+
S. recurvirostrata	(+)	(+)
S. latimanus	+	(+)
S. esculenta	(+)	(+)
S. kobiensis	+	+
S. prashadi	(+)	++
Sepiella inermis	+	+
NERITIC SQUID		
Loligo edulis	+	(+)
L. chinensis	++	+
L. singhelensis	+	++
L. duvaucelii	++	++
L. uyii	+	+
Notodarus philippensis	+	+
Sepioteuthis lessoniana	+	++
OCEANIC SQUIDS		
Onchoteuthis banksii	+	+
Symplectoteuthis oualaniensis	+	+
OCTOPUS		
Octopus vulgaris	+	+
O. aegina	+	+
O. macropus	+	+
Cystopus indicus	+	+

\+ Present ; ++ Abundant ; (+) Probably present.

In addition to these species listed by Chikuni (1983), many others occur along our coast some of which may eventually turn out to be equally important on the basis of their occurrence and abundance.

Based on Silas *et al* (1982), Chikuni (1983), has given the catch of cephalopod by species groups for the east and west coasts of India as follows :

Species group		1970	1975	1976	1977	1978	1979	1980	1981
A. EAST COAST AND ANDAMAN SEA									
Cuttlefish	..	0	2	1	1	1	1	1	1
Squid	..	0	2	1	1	1	1	1	1
Octopus	..	?	?	?	?	?	?	?	?
Sub total	..	?	4+	2+	2+	2+	2+	2+	2+
B. WEST COAST									
Cuttlefish	..	0	2	3	4	7	6	5	6
Squid	..	0	2	3	4	7	6	5	6
Sub Total	..	?	4+	6+	8+	14+	12+	10+	12+
Total	..	?	8+	8+	10+	16+	14+	12+	14+

\+ Given here.

Chikuni has arbitrarly shown the proportion of squid and cuttlefish as 50 : 50, but the cuttlefish catch has always been higher accounting for 60 per cent or more of the total catch from our waters. There has been a stepping up of Cephalopod production since 1981 and the annual landings for India for 1982, 1983 and 1984 are 15,799, 18,355 and 21,079 tons respectively. The average for these three years for the east coast of India is 4351 tons and for the west coast and Lakshadweep Islands 14026 t. These figures also reflect the increase in production after the mid-seventies when an export trade for cephalopods from India to Japan started developing. It needs reiteration that the entire catch comes from the small scale fisheries sector ; the major quantity from the trawl fishery and the rest from hook and line, shore seines, boat seines, gill nets and stake nets. About half the catch is utilized for local consumption. In the Nicobar Island and the Lakshadweep, *Octopus* spp are caught at the subsistence level for use as food and bait.

An important development during the first half of the eighties was fishing under charter agreement involving a large number of Taiwanese vessels used for Bull trawling especially along the north west coast of India (Gujarat, Maharashtra). This has confirmed the existence of excellent squid and cuttlefish grounds in the area, but precise estimates of catch are not available and is not reflected in the catch from India. When the charter agreement was in full operation in 1983-84, my estimate was an annual take of about 15,000 t of cuttlefishes (@ 70%) and squids (@ 30%) besides quality fin fish from the area. These operations have been phased out.

On available information for the sub-area Bay of Bengal and Eastern Arabian Sea, Chikuni (1984) estimated the potential harvest of cuttlefish and squids to be 10-fold over the present catch. His estimates of potential yield of neritic cephalopod ('000 t) is as follows :

Sub Area	*Average catch 1979-81*	*Estimated potential*	*Catch/ Potential*
Bay of Bengal ..	10	50-100	0.20-0.10
Eastern Arabian Sea ..	14	100-150	0-14-0.09

That the values of catch/potential are too low from these two areas will be quite evident when these figures are compared with those for two sub areas where high exploitation of cephalopods takes place. *viz.*, The Yellow Sea—East China Sea and the South China Sea as estimated by Chikuni (1983).

Yellow Sea and East China Sea	119	200-250	0.60-0.48
South China Sea	96	200-250	0.47-0.38

While these figures indicate the possibilities of the greater scope for the expansion of the neritic and oceanic fishery for cephalopods from the Bay of Bengal (East Coast of India and Andaman Sea) and the Eastern Arabian Sea (West Coast of India and the Lakshadweep Sea), I feel that Chikuni's estimates are rather conservative. Assuming that the market constraints within the country and the export trade will improve, I would give the projection for 2000 A.D. for our Cephalopod Fisheries Development as follows :

SECTORS	PRESENT PRODUCTION (AV. for 1982-1984)		POTENTIAL HARVEST (1990) (A & B Combined (t)	POTENTIAL HARVEST (2000 A.D.) (A & B Combined) (t)
	A. West Coast & Lakshadweep	B. East Coast & Andaman Sea		
1. Small Scale Fisheries (Neritic)	14026	4351	25000	50000
2. Oceanic Squids	Nil	Nil	2500	25,000-50,000
Total			27,500	75,000-100,000

CEPHALOPODS: RESOURCES AND UTILISATION

PRESENT STATUS

OF OVER 650 SPECIES OF LIVING CEPHALOPODS, ABOUT 70 ARE COMMERCIALLY IMPORTANT; NEARLY 15 SPECIES CONTRIBUTE TO CEPHALOPOD FISHERY IN INDIA (*Ca* 21,079 TONNES IN 1984); LATENT RESOURCE MANIFOLD

COMPONENTS

CUTTLEFISHES

60% of cephalopod catch; 7 species: *Sepia pharaonis, S. aculeata, S. elliptica, S. brevimana, S. prashadi, Sepiella inermis, Euprymna stenodactyla*

SQUIDS

Slightly less than 40%; 6 species: *Loligo duvaucelii, L. sp., Doryteuthis sibogae, D. singhalensis, Sepioteuthis lessoniana, Loliolus investigatoris*

OCTOPODS

<1%; 3 species: *Octopus dollfusi, O. sp., Cistopus indicus*

GEAR

SHORE SEINE

13% of cephalopod catch; mostly squids; operation all along coast

BOAT SEINE

11%, mostly squids; operation all along coast

HOOKS & LINE

14%; cuttlefish and larger squids; all along coast; modified hooks used for cuttlefishes

DOL NET

1.5%; fixed bag net used along Maharashtra and Gujarat coasts, squids

TRAWL

>60%; small boats operate within 50 m, larger vessels upto 150 m or more; cuttlefishes, squids and occasionally octopods

SPEAR

Exclusively for octopods in Lakshadweep and Nicobar islands

UTILISATION

AS FOOD

Ca 65% used as food in coastal areas; mostly small-sized cuttlefishes, squids, and octopods

AS BAIT

Small quantity used as bait in hooks & line fishery for finfish

EXPORT

Ca 35% exported as frozen cuttlefish, frozen cuttlefish fillets, frozen squids and cuttlebone; foreign exchange earning Rs 73 million in 1983

RESOURCE

UNDER-EXPLOITED

All neritic species; obtained as by-catch; no exclusive fishery except some localised effort; good scope for a 10-fold increase in production

UNEXPLOITED

Oceanic squids fairly abundant in EEZ and contiguous high seas as seen from larvae, juveniles and adults from surveys, and from indirect evidence as food of fishes, cetaceans

FUTURE STRATEGIES

EXPLORATORY SURVEYS

To locate new fishing grounds in deeper neritic waters and reefs for cuttlefishes and octopods, and oceanic waters for squids

FEASIBILITY STUDIES

To attempt new techniques such as squid jigging, and lift net fishing with light, mid-water trawling, encircling, pot fishing for octopods

RESEARCH MANAGEMENT

Biological studies, stock identity and assessment, population studies, fishery management and exploitation

IMPROVING POST-HARVEST TECHNOLOGY

Popularising cephalopods as food, development of market for local consumption, preservation, processing, product development, export

A positive and dynamic approach is necessary for achieving any success. Our ambivalence in the development of tuna fisheries has already left us high and dry and let it not be repeated in our development programme of the cephalopod fisheries. We may consider the following :

1. Systematically carry out exploratory surveys for squids from the deeper neritic and oceanic waters.

2. Streamline the data acquisition system for species-wise information on catch as well as on the discards.

3. Develop improved post harvest handling, storage and transportation.

4. Priority to be given for product development of items for the internal market and to cater to the export trade.

5. Improved techniques and gears for capture of cephalopods from the neritic waters. Special attention may be paid for developing light fishing with lift nets using some of the existing mechanised boats with required modifications. This will call for also short term foreign expertise and training.

6. Tap the resources of oceanic squids based on Resource Surveys, demonstration fishing and training and encouraging joint venture programmes. Foreign expertise will be needed especially in the areas of resource surveys and training for operatives.

7. Cephalopods are non-conventional resources for us but so was prawns in the early fifties. A major extension programme at government level at utilization of this high protein low fat marine product should be generated to get results. At the National level, the Fisheries Division of the Department of Agriculture and the Department of Agricultural Research and Education(ICAR) of the Ministry of Agriculture and Rural Development ; the Marine Products Export Development Authority of the Ministry of Commerce ; the Department of Ocean Development ; and the Fisheries Departments of the maritime states and Union Territories all have an important role to play in planning and executing extension programmes for developing cephalopod fisheries as a major fisheries for India.

Conservation and Management

Conservation of the cephalopod resources is not an immediate priority concern. However as it is known that heavy fishing pressure could completely deplete the resources, the short life-span of species posing a serious problem, recovery may take considerable time. Immediate concern should be on the following :

1. Whether squid and cuttlefish spawning grounds are being indiscreminately disturbed or destroyed by trawling and other man-made activities. Heavy sedimentation of the bottom in inshore areas due to man-made causes such as dumping of sludge affecting benthic conditions could have an adverse effect on recruitment. As a case study the Vizakapatnam coast where one of the largest steel producing complex is being set up may be considered, as enormous quantities of sludge is going to be let into the inshore waters. There is a reasonably good cephalopod fishery (cuttlefish) is this area.

2. Coral reefs are fragile ecosystems and excessive fishing for *Octopus* from such places are bound to adversely affect this resource and also create imbalances in the reef ecosystem.

3. Squids particularly are migratory in habit and any fishery for these would need close monitoring. Our system of data acquisition at the national level should be strengthened and streamlined for information on species-wise resources as well.

4. The exploitation of oceanic squids will also involve monitoring of the catch, unit stock identification and regional cooperations. I propose that an International Data Centre for Cephalopods for the Indian Ocean Area be developed at the Central Marine Fisheries Research Institute which will have the facility of rapid processing and discimination of the data as well. It may be examined how best the system of Data acquisition for such a Centre could be developed. We are at an advantage since major fishing efforts are yet to be expended in the Indian Ocean Region for caphalopods.

In conclusion, I am optimistic that Cephalopd Fisheries has an important future second only to the tunas and related fisheries from our exclusive economic zone and contiguous high seas. The efforts which have gone into this publication should point to the future possibilities and aid as a sound base for the future development of cephalopod fisheries Research and Development in our country.

REFERENCES

ABDULLA, I. M. AND A. Z. IDRUS 1978. The fish processing industry in peninsular Malaysia. *Proc. Symp. Fish Utilization Technology and Marketing in the IPFC Region, 18th Session*, Manila, Philippines : 45-60.

ADAM, W 1934. Cephalopoda. Result Sci. Voy. Ind. Orient. Meerl. *Mem. Mus. r. Hist. Nat. Belgique*, 2 (16) : 1-28.

ADAM, W 1937. Notes sur les cephalopodes : VII—sur un cas de regeneration chez *Sepioteuthis lessoniana* Lesson, 1830. *Bull. Mus. r. Hist. nat. Belg.* 13 (45) : 1-4.

ADAM, W. 1938. Sur quelques cephalopodes octopodes des iles Andamans. *Bull. Mus. r. Hist. nat. Belgique*, 14 (7) : 1-25.

ADAM, W. 1939a. Notes sur les cephalopodes. 13. Sur une nouvelle espece de Sepia, *Sepia winckworthi* sp. nov. *Bull. Mus. r. Hist. nat. Belgique*, 15 (32) : 1-11.

ADAM, W. 1939b. The Cephalopoda in the Indian Museum, *Calcutta. Rec. Indian Mus.*, 41 : 61-110.

ADAM, W. 1939c. Cephalopoda. Pt. I. Le genre *Sepioteuthis* Blainville, 1824. *Siboga Exped. Monographie*, 55a : 1-33.

ADAM, W. 1939d. Les cephalopodes de l'expedition du Siboga Pt. II. Revision des especes Indo-Malaises du genre *Sepia* Linne, 1758. Pt. III. Revision du genre *Sepiella* (Gray) Steenstrup, 1880. *Siboga Exped. Monographie*, 55b : 35-122.

ADAM, W. 1954. Cephalopoda. Pt. III & IV. Cephalopodes a l'exclusion des genres *Sepia, Sepiella* et *Sepioteuthis. Siboga Exped. Monographie*, 55c : 123-193.

ADAM, W. 1959. Les Cephalopodes de la mer Rouge. Mission Robert Ph. DOLLFUS en Egypte (1927-1929), *Res. Sci.* 3 *partie*, 28 : 125-193.

ADAM, W. 1960. Cephalopoda from the Gulf of Aquaba. Contr. Knowl. Red Sea. 16. *Bull. Sea-Fish. Res. Stn. Israel*, 26 : 3-26.

ADAM, W. 1965. Redescription deDeux Especes de *Sepia* Insuffisamment Decrites par J. Steenstrup, 1875. *Vidensk. Medd. fra Dansk naturh. Foren.*, 128 : 169-176.

ADAM, W. 1973. Contributions to the knowledge of the Red Sea. No. 47. Cephalopoda from the Red Sea. *Bull. Sea-Fish. Res. Stn. Haifa*, : 9-47.

ADAM, W. 1975. Notes sur les cephalopodes. 26. Une nouvelle espece de *Todarodes todarodes filippovae* sp. nov. de l' Ocean Indian. *Biologie, Bull. Inst. r. Sci. nat. Belg.*, 50 (9) : 1-10.

ADAM, W. 1979. The Sepidae (Cephalopoda, Decapoda) in the collection of the Western Australian Museum. *Rec. W. Aust Mus.*, 7 (2) : 109-212.

ADAM, W., AND W. J. REES. 1966. A review of the cephalopod family Sepiidae. *John Murray Exped. Sci. Rept.*, 11 (1) : 1-165.

ALAGARAJA, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian J. Fish.*, 31 : 177-208.

ALAGARSWAMI, K. 1966. On the embryonic development of the squid (? *Sepioteuthis arctipinnis* Gould) from the Gulf of Mannar. *J. Mar. Biol. Ass. India.* 8 (2) : 278-284.

ALDRICH, F. A., AND M. M. ALDRICH 1968. On the regeneration of the tentacular arm on the giant squid *Architeuthis dux* Steenstrup (Decapoda, Architeuthidae). *Can. J. Zool.*, 46 (5) : 845-847.

ALLAN, J. K., 1945. Planktonic cephalopod larvae from the Eastern Australian coast. *Rec. Aust. Mus.*, 21 (6) : 317-350.

ANON 1977. Development potential of selected fishery products in the regional member countries of the Asian Development Bank. 7 : *The international market for cephalopods.* SCS/DEV/76/16 : 95 p.

ANON 1981. Three questions on octopus. *Fishery Jour.* 13 (Yamaha Motor Co., Japan) : 1-8.

ANON, 1982. Review of Methods used for studying and Assessing squid resources. *IPFC : RRD/82/5 Date March* 1982, *Sydney, Australia*, 7 p.

ANON, 1983. South China Sea Fisheries Development and Coordinating Programme. Joint ADB/FAO (SCSP-INFOFISH Market Studies. Vol. V. The International Market for Cephalopods. SCS/DEV/83/24, 53 p.

ARAVINDAKSHAN, P. N., AND M. SAKTIVEL 1973. The location of cephalopod nurseries in the Indian Ocean. *Handbook to the International Zooplankton Collections*, 5 : 70-75.

ASHMOLE, N. P., AND M. J. ASHMOLE 1977. Comparative feeding ecology of sea birds of a tropical oceanic island. *Yale Univ. Peabody Mus. Nat. Hist., Bull.*, 24 : 1-131.

BAL, D. V., AND K. VIRABHADRA RAO 1984. *Marine Fisheries* Tata McGraw Hill Publishing Company Ltd., New Delhi, 470 p.

BALINSKY, B. I. 1981. *Introduction to Embryology.* Philadelphia, Pa.: Saunders College, 688 p.

BAPAT, S. V., N. RADHAKRISHNAN AND K. N. RAJACHANDRA KARTHA. 1972. A survey of the trawl fish resources off Karwar, India. Symposium on Demersal Fisheries, *Proc. Indo-Pacific Fish. Coun.*, 13 (3) : 354-383.

BAPAT, S. V. *et al.* 1982. Fishery resources of the Exclusive Economic Zone of the northwest coast of India. *Bull. Cent Mar. Fish. Res. Inst.*, 33 : 86 p.

BARNARD, K. H. 1947. Rare squid at the cape (*Thysanoteuthis rhombus* Troschel). *J. Conch. Lond.*, 22 : 286.

BELYAEV, G. M. 1962. Beaks of cephalopod molluscs in oceanic bottom deposits. *Okeanologila*, **2** (2) : 311-326.

BELYAEVA, G. F. 1979. Squids of the Indian Ocean as intermediate hosts of helminths. *In* : Bauer, O. N. (Ed.), Abstracts of proceedings : 7th All-Union Conference on Fish-parasites and Diseases. Nauka, Moskow, 1979 : 1-131.

BEN-YAMI, M. 1976. *Fishing with light*. FAO Fishing Manual Fishing News Books Ltd., England, 121 p.

BERRY, S. S. 1912. The Cephalopoda of the Hawaiian Isladns. *Bull. U. S. Bur. Fish.*, **32** : 257-362.

BERTALANFFY, L. VON. 1938. A quantitative theory of organic growth. *Hum. Biol.*, **10** (2) : 181-213.

BIDDER, A. M. 1950. The digestive mechanism of the European squids, *Loligo vulgaris, L. forbesii, Alloteuthis media* and *A subulata. Quart. Jour. Micr. Sci.*, **91** (1) : 1-32.

BOLETZKY, S. V. 1977. Post-hatching behaviour and mode of life in cephalopods. *Symp. Zol. Soc. London*, 381, 557-567.

BOYCOTT, B. B. 1957 The cuttlefish *Sepia. New Biol.*, (25 : 98-118.

BRAZIER, J. 1892. *List of the Cephalopoda in the collection of the Australian Museum.* Sydney, 3 p.

BROCK, J. 1886. Indische Cephalopoden. *Zool. Jb.*, **2** : 591-624.

BRUGGEN, A. C. VAN. 1962. *Thysanoteuthis rhombus* in Algoa Bay. *Ann. of the Natal Museum*, **15** : 267-272.

BURGESS, L. A. 1967. *Loliolus rhomboidalis*, a new species of loliginid squid from the Indian Ocean. *Bull. Mar. Sci.*, **17** (2) : 319-329.

CADDY, J. F. (ed.). 1983a. Advances in assessment of world cephalopod resources. *FAO Fish. Tech. Pap.*, (231) : 452 p.

CADDY, J. F. 1983b. The Cephalopods : Factors relevant to their population dynamics and to the assessment and management of stocks. *In* : Caddy, J. F. (ed.), Advances in assessment of world cephalopod resources. *FAO Fish. Tech. Pap.*, (231) : 416-452.

CAILLIET, G. M. AND D. L. VAUGHAN, 1983. A review of the methods and problems for quantitative assessment of *Loligo opalescens. Biol. Oceanogr.*, **2** : 379-400.

CALLAN, H. G. 1940. The absence of a sex hormone controlling regeneration of the hectocotylus in *Octopus vulgaris* L. *Pubbl. Staz. Zool. Napoli*, **18** : 15-19.

CHANDRA MOHAN, P. AND D. RATNA RAO. 1978. On the occurrence of *Sepietta oweniana* (Cephalopoda) from Visakhapatnam. *Current Sci.*, **47** (22) : 879-880.

CHELLAPPA, D. E. 1959. A note on the night fishing observation from a *kelong. J. Mar. Biol. Ass. India.* **1** (1) : 93-94.

CHIKUNI, S. 1983. Cephalopod resources in the Indo-Pacific Region. *In* : Caddy, J. F. (ed.), Advances in assessment of world cephalopod resources. *FAO Fish. Tech. Pap.*, (231) : 264-305.

CHUN, C. 1910. Die Cephalopoden. I. Teil : Depopsida. *Wissenchaftliche Ergebnisse deutschen Tiefsee—Expedition* '*Valdivia*' 1898-1899, **18** : 1-402.

CHUN, C. 1915. Cephalopoda. II. Teil : Myopsida, Octopoda. *Wissenchaftliche Ergebnisse deutschen Tiefsee-Exedition* 'Valdivia' 1898-1899, **18** : 405-552.

CLARKE, M. R. 1962 a. The identification of cephalopod 'Beak' and the relationship between beak size and total body weight. *Bull. Brit. Mus.*, *(N.H.) Zoology* **8**(10) : pl. 13-22, 421-480.

CLARKE, M. R. 1962 b. Significance of cephalopod beaks. *Nature*, 193 (4815) : 560-64.

CLARKE, M. R. 1966. A review of the systematics and ecology of oceanic squids. *Adv. Mar. Biol.*, **4** : 91-300.

CLARKE, M. R. 1980. Cephalopoda in the diet of sperm whales of the southern hemisphere and their bearing on sperm whale biology. *Discovery Rept.* **37** : 1-324.

CLARKE, M. R. AND C. C. LU. 1974. Vertial Distribution of Cephalopods at 30°N 23°W in the North Atlantic. *J. Mar. biol. Ass. U.K.* (1974) **54** : 969-984.

CLARKE, M. R. AND C. C. LU. 1975. Vertical Distribution of Cephalopods at 18° N and 25°W in the North Atlantic, *Ibid.*, (1975) **55** : 165-182.

CLARKE, M. R. AND N. MAC LEOD. 1974. Cephalopod remains from a sperm whale caught off Vigo Spain. *J. Mar. Biol. Assoc. U.K.*, 54 : 959-968.

CLARKE, M. R. AND N. MAC LEOD. 1976. Cephalopod remains of whales caught off Iceland. *J. Mar. Biol. Assoc. U.K.*, **56** : 733-749.

CLARKE, M. R. 1977. Beaks, nets and numbers. *Symp. Zool. Soc. Lond.*, **38** : 89-126.

CMFRI, 1957. Annual Report of the Chief Research Officer for the year ending 31st March 1956. *Indian J. Fish.*, **4** (2) : 387-418.

CMFRI, 1980. Industrial fisheries off Visakhapatnam coast. based on exploratory surveys during 1972-1978. *Mar. Fish. Infor. Serv. T & E* Ser., No. 15 : 1-15.

CMFRI. 1981. By-catch of the shrimp fishing in India. *Mar. Fish. Inform. Serv.* T & E. Ser. No. 28 : 1-13.

CMFRI. 1982. Trends in marine fish production in India—1981. *Mar. Fish. Infor. Serv.* T & E. *Ser.* No. 41 : 1-32.

COLLINS, S. AND M. DUNNING. 1981. Tasman squid studies demonstrate gill netting effective. *Aust. Fish.*, **40** (8) : 4-6.

COTTON, B. C., AND F. K. GODFREY. 1940. The Mollusca of south Australia. Pt. 2. Scaphopoda, Cephalopoda, Aplacophora and Crepipoda. Adelaide, 317-600.

COURT, W. G. 1980. Japan's squid fishing industry. *Mar. Fish Rev.*, **42** (7-8) : 1-9.

COUSTEAU, J. Y., AND P. DIOLE. 1973. *Octopus and Squid—The Soft Intelligence.* A & W Visual Library, New York, **304** p.

CSIR. 1962. *The Wealth of India. Raw Materials Vol.* 4 *Supplement. Fish and Fisheries.* Coun. Sci. Ind. Res., New Delhi, 132 p.

DAYARATNE, N. M. P. J. 1978. A preliminary study on the cuttle fish catches from the Wadge Bank trawler fishery. *Bull. Fish. Res. Stn. Sri Lanka*, **28** : 21-35.

DEES, LOLA T. 1961. Cephalopods : cuttlefish, octopus, squides *Fish. Leaf.* (524) : 1-10.

DEFRETIN, R. AND A. RICHARD. 1967. Ultrastructure de la glande optique de *Sepia officinalis* L. (Mollusque, Cephalopode) Miss en evidence de la secretion et de son controle photoperio dique. *C. R. Hebd. Seances Acad. Sci., Ser. D* **265** : 1416-1418.

DELL, R. K. 1952. The recent Cephalopoda of New Zealand. *Bull. Dom. Mus. Wellington,* (16) : 1-157.

DESHMUKH, V. M. 1973. Fishery and biology of *Pomadasys hasta* (Bloch). *Indian J. Fish.,* **20** (2) : 497-522.

DEVADOSS, P. AND P. K. MAHADEVAN PILLAI. 1973. Observations on the food of juveniles of *Psettodes erumei* (Bloch). *Indian J. Fish.,* **20** (2) : 664-667.

DEVADOSS, P. AND P. K. MAHADEVAN PILLAI. 1979. Observations on the food and feeding habits of the eel *Muraenesox cinereus* (Forskal) from Porto Novo. *Indian J. Fish.,* **26** (1 & 2): 244-247.

DONG, Z. 1981. The Present status of the prospects of cephalopod resources in the West Pacific. *J. Fish. China,* **5** (3) : 263-70 (Not consulted in original)

DRACOVICH, A. AND J. A. KELLY JR. 1963. A biological study and some economic aspects of squid in Tampa Bay, Florida. *Proc. Gulf and Carib. Fish. Inst.,* 15th Annual Session (1962) 87-102.

DRAGOVICH, A. AND T. POTTHOFF. 1972. Comparative study of food of skipjack and yellowfin tunas off the coast of West Africa. *Fish. Bull. U.S.,* **70** : 1087-1110.

DRUZHININ, A. D. 1972. Observations on the trawl fishery of Southern Burma. Symposium on Demersal Resources, *Proc. Indo-Pacific Fish. Coun.,* **13** (3) : 151-209.

DRUZHININ, A. D. 1973. On the fishery resources of the Gulf of Aden and some adjacent areas. FAO, Rome, DP 9/12 PDY 64/501/7.

DULHUNTY, A. F., AND GAGE, P. W. 1971. Selective effect of an Octopus Toxin on action potentials. *J. Physiol. (London),* **218** : 433-445.

DURCHON, M. AND A. RICHARD. 1967. Etude, en culture organotypique, du role endocrine dela glande optique dans la maturation ovarienne chez *Sepia officinalis* L. (Mollusque, Cephalopode). *C. R. Hebd. Seances Acad. Sci., Ser. D* **264** : 1497-1500.

EFP. 1979a. Fishing news and notes. Survey of EEZ. *Explo. Fish. Project Newsletter.* **2** (2) : 21-23.

EFP. 1979b. Results of operation of M. V. *Matsyanireekshani* along northwestern part of Indian EEZ during May to October, 1979. Survey of EEZ Series. No. 2. *Exp. Fish. Project,* Bombay : 1-15.

EFP. 1979c. Results of the exploratory fishing conducted during 1978-79. *Bull. Explo. Fish. Project.* **9** : 66 pp.

EFP. 1982. Results of exploratory survey of fishery resources of Wadge Bank. *Progress Report 1. Explo. Fish. Project,* Bombay : 26 p.

FAO. 1983. Year book of Fishery Statistics 1981 : Catches and Landings. *FAO Yearb. Fish. Stat.* (52).

FAO/UN. 1961. Report to the Government of India on a survey of the Fishery Resources of the Bay of Bengal. Project FAO/ETPA 158-53, based on the work of V. M. Naumov, FAO/TA Marine Fisheries Biologist.

FERAL, JEAN-PIERRE. 1978. La regeneration des de la seiche *Sepia officinalis* (Cephalopoda, Sepioidea) (1). I-Etude Morphologique. *Cahiers de Biologie Marine,* XIX : 355-361.

FIELDS, W. G. 1965. The structure, development, food relations, reproduction and life history of the squid, *Loligo opalescens* Berry. *Calif. Dept. Fish and Game, Fish Bull.* (131) : 1-108.

FILIPPOVA, J. A. 1968. New data on the Cephalopoda of the Indian Ocean. *Proc. Symp. Mollusca,* Mar. Biol. Ass. India, Pt. **1** : 257-264.

FISCUS, C. H. 1982. Predation of marine mammals on squids on the eastern North Pacific Ocean and the Bering Sea. *Mar. Fish. Rev.,* **44**(2) : 1-10.

FISHERY AGENCY OF JAPAN. 1976. Report on cruise of the R. V. SHOYO MARU in the North Arabian Sea Survey, in cooperation with the IOP, FAO, to assess the pelagic fish stocks, 2 October 1975—14 January 1976. *Res. Dev. Div., Fish. Agen. Japan,* 110 pp.

FISHERY AGENCY OF JAPAN. 1977. Report on cruise of the R. V. SHOYO MARU in the North Arabian Sea, in cooperation with IOP, FAO, to assess the pelagic fish stocks, 2 October 1976—13 January 1977. *Res. Dev. Div., Fish. Agen. Japan.* 165 p.

FLECKER, H. AND COTTON, B. G. 1955. Fatal bites from Octopus. *Med. J. Aust.,* **2** : 329-331.

FREEMAN, S. E. AND TURNER, R. J. 1970. Muculotoxin, a potent toxin secreted by *Octopus maculosus* Hoyle. *Toxicol. Appl. Pharmacol.,* **16** : 681-690.

GAGE, P. W. AND A. F. DULHUNTY. 1979. Effects of toxin from the Blue-ringed Octopus *Haplochlaena maculosa.* In : Marine Toxins and other bioactive marine Metabolites Ed. Y. Hashimoto, *Jap. Sci. Soc. Press.* Ch. **3** : 85-106.

GEORGE, A. I., M. S. NAZIR AHMED AND T. N. SIVADASAN ASARI 1976. Observations on the carangid fishery of Vizhinjam coast, Trivandrum, with special reference to *Decapterus dayi.* (Wakiya). *Bull. Dept. Fish. Kerala,* **1** (1) : 9-15.

GEORGE, P. C., B. T. ANTONY RAJA AND K. C. GEORGE. 1977. Fishery Resources of Indian Economic Zone. *Silver Jubilee Souvenir,* Integ. Fish. Proj., October, 1977 : 79-116.

GHIRETTI, F. 1960. Toxicity of octopus saliva against Crustaceans. *Ann. N. Y. Acad. Sci.* **90**, 726-741.

GOODRICH, E. S. 1896. Report on a collection of Cephalopoda from the Calcutta Museum. *Trans. Linn. Soc. London,* **7** : 1-24.

GOPALAKRISHNAN, P. 1970. Some observations on the shore ecology of the Okha coast. *J. Mar. Biol. Ass. India,* **12** (1 & 2) : 15 - 34.

GOULD, A. A. 1852. 12. Mollusca and shells United States Exploring Expedition 1838-1842 under the command of C. Wilkes, 510 p.

GRAVELY, F. H. 1941. Shells and other animal remains found on the Madras beach. I. Groups other than snalis etc. (Mollusca : Gastropoda). *Bull. Madras Govt. Mus. (New Ser.). Nat Hist.*, 5 (1) : 112 p.

GRIER, T. M., AND R. D. BEEMAN. 1978. A study of spermatogenesis in the spawning population of the squid, *Loligo opalescens In* : Recksiek, C. W. and H. W. Frey (eds.) Biological, oceanographic, and acounstic aspects of the market squid, *Loligo opalescens* Berry. *Calif. Dept. Fish. and Game, Fish Bull.*, 169 : 11-21.

GRIFFIN, L. E. 1900. The anatomy of *Nautilus pompilius. Mem. Nat. Acad. Sci.*, 8 (5) : 1-197.

GRIMPE, G. 1926. Biologische Beobachtungen an *Sepia officianales. Verhandl. D. Zool. Gen. Suppl. Zool. Anz.* 31 : 148-153.

GULLAND, J. A. (Ed.). 1970. The fish resources of the ocean. FAO/Fishing News (Books) Ltd., Surry, England, 255 p.

HAMABE, M., C. HAMURO AND M. OGURA. 1982. *Squid jigging from* small boats. FAO Fishing Manuals, Fishing News Books Ltd., Farnham, England, 74 p.

HAMABE, M., T. KAWAKAMI, Y. WATABE AND T. OKUTANI. 1976a. Perspectives for Japanese Overseas squid fisheries. *FAO Fish. Rep.* 170 (Suppl. 1) : 47-52.

HAMABE M. T. KAWAKAMI, Y. WATABE T. OKUTANI AND K. IKEDA. 1976b. Review of cephalopod resources and their exploitation by Japan. *FAO Fish. Rep.* 170 (Suppl. 1) : 1.3-

HAMURO, C. AND S. MIZUSHIMA. 1976. Concept and design of the 99 GT Squid jigging vessel. *FAO Fish. Rep.* 170 (Suppl. 1) : 103-106.

HANKO B. 1913. Uber einen gespaltenen arm von *Octopus vulgaris. Wilhelm Roux Arch. Entw. Mech. Org.* 37 : 217-222.

HERDMAN W. A. 1903-1906. *Report to the Government of Cyelon on the Pearl Oyster Fisheries of the Gulf of Mannar (with Supplementary Reports upon the Marine Biology of Ceylon Naturalists). Roy. Soc. London* 1 : 1-307 : 2 : 1-300 : 3 : 1-384 : 4 : 1-326 : 5 : 1-452.

HERNANDO A. M. (JR) AND E. C. FLORES. 1981. The Philippines squid fishery : A review. *Mar. Fish. Rev.* 43 (1) : 13-20.

HIDA, T. S. AND W. T. PEREYRA. 1966. Results of bottom trawling in Indian Seas by R/V ANTON BRUNN in 1963. *Proc. Indo-Pacific Fish. Coun.* 11 (2) : 156-171.

HIXON, R. F. 1983. *Loligo opalescens.* In Ed. P. R. Boyli Cephalopod Life-Cycles. Vol. I. Species accounts. Academic Press. pp. 95-114.

HODGKIN, A. L. 1964. The conduction of the nervous Impulse. Liverpool Univ. Press, Liverpool, England, pp. 20-29.

HORNELL, J. 1917. The edible molluscs of Madras Presidency. *Madras Fish. Bull.*, 11 : 1-51.

HORNELL, J. 1922. The common molluscs of South India. *Madras Fish. Bull.*, 14 : 97-215.

HORNELL, J. 1950. Fishing in many waters. Chapter XV. Fishing for *Octopus*, Cuttlefish and Squid. *Cambridge Univ. Press. Cambridge*, 130-135.

HORNELL, J. 1951. *Indian Molluscs. Bombay Nat. Hist. Society, Bombay*, 96 p.

HOWARD, F. G. 1981. Cephalopods : An under utilized resource. *Scotish Fisheries Bulletin*, 46 : 26-29.

HOYLE, W. E. 1885a. Brief notice of the 'Challenger' Cephalopoda (p. 472). *Rep. Scient. Resul. Voy. 'Challenger'* (1873-76), Narrative 1, 657 p.

HOYLE, W. E. 1885b. Diagnoses of new species of Cephalopoda collected during the cruise of H.M.S. 'Challenger'. Part I. The Octopoda. *Ann. Mag. nat. Hist. Ser.* 5, 15 : 222-236.

HOYLE, W. E. 1885c. Diagnoses of new species of Cephalopoda collected during the cruise of H.M.S. 'Challenger' Part II. The Decapoda. *Ann. Mag. nat. Hist. Ser.* 5, 16 : 181-203.

HOYLE, W. E. 1885d. Preliminary report on the Cephalopoda collected by H.M.S. 'Challenger'. Part I. The Octopoda *Proc. Roy. Soc. Edinburgh*, 13 : 94-114.

HOYLE, W. E. 1885e. Preliminary report on the Cephalopoda collected by H.M.S. 'Challenger'. Part II. The Decapoda *Proc. Roy. Soc. Edinburgh*, 13 : 281-310.

HOYLE, W. E. 1886. Report on the Cephalopoda collected by H.M.S. 'Challenger' during the years 1873-1876. *Rep. Scien Resul. Voy. 'Challenger'* (Zoology), 16 (44) : 1-245.

HOYLE, W. E. 1904a. *Sepia burnupi* n. sp. from Natal. *J. Conch. London*, 11 : 27-28.

HOYLE, W. E. 1904b. Report on Cephalopoda collected by Prof. Herdman at Ceylon, 1902. *Rep. Ceylon Pearl Oyster Fish.* 2, Suppl. 14 : 185-200.

HOYLE, W. E. 1905. The Cephalopoda. *In :* S. Gardiner. *The Fauna and Geography of the Maldive and Laccadive Archi pelagoes*, 2, Suppl. 1; 575-988.

HOYLE, W. E. 1907a. The Cephalopoda. The marine fauna of Zanzibar and East Africa from collections made by Cyril Crossland in 1901-1902. *Proc. Zool. Soc. London*, 450-461.

HOYLE, W. E. 1907b. Reports on the marine biology of the Sudanese Red Sea. 6. On the Cephalopoda. *J. Linn. Soc* (Zool.), 31 : 35-43.

HURLEY, A. C. 1977. Mating behaviour of the squid *Loligo opalescens. Mar. Behav. Physiol.*, 4 : 195-203.

HURLEY, G. V. 1980. Recent development in the squid, *Illex illecebrous* fishery of Newfoundland, Canada. *Mar. Fish Rev.*, 42 (7-8) : 15-22.

IMBER, M. J. 1975. Lycoteuthid squids as prey of petrels in New, Zealand Seas. *N. Z. J. Mar. Freshw. Res.*, 9 : 483-492.

IMBER, M. J. 1978. The squid families Cranchiidae and Gonatidae. (Cephalopoda : Teuthoidea) in the New Zealand region. *New Zealand J. Zool.* 5 (3) : 445-484.

INSTITUTE OF MARINE RESEARCH. 1975. Report on Cruise Nos. 1 and 2 of R/V DR. FRIDTJOF NANSEN, Indian Ocean Fishery and Development Programme. Pelagic Fish Assessment Survey of North Arabian Sea. Bergen, Institute of Marine research, 15 p.

ISHI, M. 1977. Studies on the growth and age of the squid, *Ommastrephos bartrami* (Le Sueur) in the Pacific off Japan *Bull. Hokkaido Reg. Fish. Res. Lab.*, (42): 25-36.

IVERSEN, I. L. K. AND L. PINKAS. 1971. A pictorial guide to beaks of certain eastern Pacific Cephalopods. *In*: Food habits of Albacore, bluefin tuna and Bonito in Californian Waters. *Fish. Bull.*, 152 : 83-105.

JAMES, P. S. B. R. 1967. The ribbon fishes of the family Trichiuridae of India. Memoir 1, *Mar. Biol. Ass. India*, 228 p

JAUNICO, M. 1980. Development in South American squid fisheries. *Mar. Fish. Rev.*, 42 (7-8) : 10-14.

JAYABALAN, N. AND K. RAMAMURTHI. 1977. Cephalopods of Porto Novo. *J. Annamalai Univ.* (Sci.), 31 : 29-34.

JAYAPRAKASH, A. A. 1974. Food and feeding habits of juveniles of 'Koth' *Otolithoides brunneus* (Day) in Bombay waters. *Indian J. Fish.*, 21 (1): 127-140.

JMFRCC. 1980. Report of feasibility study 1978 on squid jigging fisheries in the southwestern Pacific Ocean, 178 p.

JONES, R. 1981. The use of length composition date in fish stock assessments (with notes on VPA and COHORT analysis). *FAO Fish. Circ.*, (734) : 55 p.

JONES, S. 1968. The molluscan fishery resources of India. *Proc. Symp. Mollusca*, Mar. Biol. Ass. India, Pt. 111 : 906-918.

JOTHINAYAGAM, J. T. 1981. Studies on *Sepiella inermis* (Ferrusae and d'Orbigny) population occurring along the Madras coast. *Proc. Symp. Echol. Anim. Popul.*, Zool. Surv. India, Pt. 1 : 83-89.

JUANICO' MARCELO, 1983. Squid Maturity Scales for population analysis. In : Caddy J.F. (ed). Advances in Assessment of Cephalopod Resources. *FAO Fish. Tech. Pap.* (231) : 341-378.

KAGWADE, P. V. 1969. Food and feeding habits of *Polynemus heptadactylus* Cuv. and Val. *Indian J. Fish.*, 16 (1 & 2), 188-197.

KALAVATI, C. AND C. C. NARASIMHAMURTI. 1977. *Steinhausia spraguei* n.s.p.a microsporidian parasite of the excretory cells found inthe renal appendages of *Sepia elliptica*. *Rivista Parassit.* 38(2-3 : 271-275.

KALAVATI, C. AND C. C. NARASIMHAMURTI 1980. A new dicyemid mesozoan *Dodecadicyema loligoi* n. gen., n. sp. from the renal appendages of *Loligo* sp. *Poc. Indian Acad. Sci (Anim. Sci.)*, 89 (3): 287-292.

KALAVATI, C., C. C. NARASIMHAMURTI AND T. SUSEELA 1978. A new species of *Dicyemmennea*, *D. coromandelensis* n. sp. from *Sepia elliptica* Hoyle. *Proc. Indian. Acad. Sci.*, 87 B (6) : 161-167.

KAREKAR, P. S. AND D. V. BAL. 1958. The food and feeding habits of *Polynemus indicus* (Shaw). *Indian J. Fish.*, 5 (1) : 77-94.

KARNEKAMP, C. 1979. An aberrantly shaped sheild of *Sepia* sp. and a response to this. *Kreukel. Amst.*, 15 (7-8) : 60.

KARPOV, KONSTANTIN, A. AND G. M. CAILLIET 1978. Prey composition of the Market Squid, *Loligo opalascens* Berry in relation to depth and location of capture, size of squid and sex of spawning squid. *Calif. Coop. Ocean Fish. Invest. Repts.* 20 : 51-57.

KSAAHARA, S. AND T. NASUMI. 1976. Present status and future aspects of the fishery for the common squid *Todarodes pacificus* (Steenstrup) in the sea of Japan. *FAO Fish. Rep.*, 170 (Suppl. 1): 30-46.

KAWAKAMI, T. 1980. A review of sperm whale food. *Sci. Rep. Whales Res. Inst.*, (32) : 199-218.

KAWATA, H., K. KATAYA, U. AND T. TAKAHASHI 1955. Studies on the complete utilization of whole fish IV. The chemical composition of some fish viscera and the soluble feed made from cuttlefish liver. *Bull. Japan. Soc. Sci. Fish.*, 21 (7) : 503-508.

KLOSS, C. B. 1902. *Andaman and Nicobars*, Reprint 1971, Vivek Publishing House, Delhi, 373 p.

KORE, B. A. AND M. C. JOSHI 1975. Food of the squid *Loligo duvaucelii* d'Orbigny. *Proc. Indian Acad. Sci.*, 81 B (1) : 20-28.

KRISHNAMURTHI, B 1957. Fishery resources of the Rameswaram Island. *Indian J. Fish.*, 4 (2) : 229-253.

KRUMHOLZ, L. A. AND D. P. DE SYLVA. 1958. Some foods of marlins near Bimini, Bahamas. *Fla. Ocar. Res. Publ.*, 28 : 1-31

KUMARAN, M 1964. Studies on the food of *Euthynnus affinis affinis* (Cantor), *Auxis thazard* (Lacepede), *Auxis thynnoides* Bleeker and *Sarda orientalis* (Temminck and Schlegel) *Proc. Symp. Scombroid Fishes*, Mar. Biol. Ass. India, Pt. 11 : 599-606.

KUTHALINGAN, M. D. K., G. LUTHER, S. LAZARUS AND K PRABHAKARAN NAIR 1982. Experimental trawling off Vizhinjam *Mar. Fish. Infor. Serv. T & E Ser.*, No. 40 : 5-7.

LANE, F. W. 1962. *Kingdom of the octopus. The life history of the Cephalopoda.* The worlds of science (Zoology) Pyramid Publications, New York. 287 p.

LANGE, A. M. AND M. PSISSENWINE, 1980. Biological considerations relevant to the management of squid (*Loligo pealei* and *Illex illecebrosus*) of the northwest Atlantic. *Mar. Fish. Rev.*, 42 (7-8) : 23-38.

LANGE, A. M. T., AND M. P. SISSENWINE 1983. Squid resources of the northwest Atlantic. *In :* Caddy, J. F. (ed.), Advance. in assessment of world cephalopod resources. *FAO Fish. Tech. Pap.* (231) : 21-54.

LANGE, M. M. 1920. On the regeneration and finer structure of the arms of the cephalopods. *J. exp. Eool.* 31 (1) : 1-57.

LONG, D. AND W. F. RATHJEN 1980. Experimental jigging for squid off the Northeast United States *Mar. Fish. Rev.*, 42 (7-8): 60-66.

LU, C. C. AND M. R. CLARKE. 1975. Vertical distribution of cephalopods at 40°N, 53°N and 60°N at 20°W in the North Atlantic. *J. Mar. biol. Asm. U.K.* (1975) 55 : 153-163.

LU, C. C. AND M. R. CLARKE. 1975. Vertical distribution of cephalopods at 11°N, 20°W in the North Atlantic. *Ibid.* (1975) 55 : 369-389.

LUTHER ,G,. P. N. RADHAKRISHNAN NAIR, G. GOPAKUMAR AND K. PRABHAKARAN NAIR 1982. Present status of small-scale traditional fishery at Vizhinjam. *Mar. Fish. Infor. Serv TN & E Ser.*, o. 38 : 1-16.

MAES, V. O. 1967. The littoral marine molluscs of Cocos—Keeling Islands (Indian Ocean). *Proc. Acad. Nat. Sci. Phila.*, **119** (4): 93-217.

MAHADEVAN, S. AND K. NAGAPPAN NAYAR 1967. Underwater ecological observations in the Gulf of Mannar off Tuticorin. *J. Mar. Biol. Ass. India*, 9 (1): 147-163.

MAHADEVAN S. AND K. NAGAPPAN NAYAR 1974. Ecology of pearl oysters and chank beds. The commercial molluscs of India. *Bull. Centr. Mar. Fish. Res. Inst.*, **25**: 106-121.

MAKSIMOV, V. P. 1969. Pitanie bol'skegla zogo tuntsa (*Thunnus obesus* Lowe) i mechry by (*Xiphias gladius* L.). Vostochnoi chasti tropichesko i Atlantikii, Atl. Nauchno-Isaled. Int. Rybn. Khoz. Okenogr. (Atl. NIRO). **25**: 87-99 (Engl. transl. Fish. Res. Bd. Can. Transl. Ser. 2248).

MASSY, A. L. 1916. The Cephalopoda of the Indian Museum. *Rec. Indian Mus.*, **12**: 185-247.

MASSY, A. L. 1927. The Cephalopoda of the South African Museum. *Ann. S. African Mus.*, **25**: 151-167.

MATSUMOTO, G. 1976. Transportation and maintenance of adult squid (*Doryteuthis bleekeri*) for physiological studies. *Biol. Bull.*, **150**: 279-285.

MAY R. M. 1933. La formation des terminaisons nerveuses dans les ventouses du bras regenere du cephalopode *Octopus vulgaris* Lam. *Ann. St. Oceanogr. Salammbo* **7**: 1-15.

MENON, K. K. P. 1978. Fish processing industry in India. *Proc. Symp. Fish Utilization Technology and Marketing in the IPFC Region*, 18th Session, Manila, Philippines, 73-84.

MERCER, M. C. 1974. Modified Leslie - Deluny assessments of the northern pilot whale (*Gobicephalus malaena*) and annual production of the short-finned squid (*Illex illecebrosus*) based upon their interaction at Newfoundland. *ICNAF Res. Doc.*, 74/49: 14p.

MERCER, M. C., R. K. MISRA, G. V. HURLEY. 1980. Sex determination of the ommastrephid squid *Illex illecebrosus* using Beak morphometrics. *Can. J. Fish. Aquat. Sci.*, **37**: 283-286.

MIENIS, H. K. 1977. Squid from the stomach of a deep water shark. *Correspondentieblad ned. Malac. Veren.*, **178**: 707.

MIENIS, H. K. 1978. Who found *Spirula* or *Argonauta* on the Mediterranean coast of Israel or in the Red Sea *Levantina*, **15**: 170-172.

MIMURA, K. AND STAFF OF NRFRL 1963. Synopsis of biological data on yellowfin tuna, *Neothunnus macropterus* Temminck and Schlegal, 1842. *FAO Fish. Rep.* **6** (2): 319-349.

MISAKI, H. AND T. OKUTANI 1976. Studies on early life history of Decapodan Mollusca—VI. An evidence of spawning of an oceanic squid, *Thysanoteuthis rhombus* Troschel, in the Japanese waters. '*Venus*', *Jap. Jour. Malacology*, **35** (4): 211-213.

MOJUMDER, P. 1969. Food of the catfish *Tachysurus thalassinus* (Ruppell). *Indian J. Fish.*, **16** (1 & 2): 161-169.

MOJUMDER, P. AND S. S. DAN 1979. Studies on food and feeding habits of catfish *Tachysurus tenuispinis* (Day). *Indian J. Fish.*, **26** (1 & 2): 115-124.

MOSES, S. T. 1948. A preliminary report on the Cephalopoda of Baroda. *Bull. Dept. Fish. Baroda State*, **13**: 1-3.

MOSES, S. T. 1949. A preliminary report on the cephalopods of Baroda. *Proc. 35th Indian Sci. Congr.*, 198.

MOYNIHAN, M. 1975. Conservation of displays and comparable sterotyped patterns among cephalopods. In: Eds. Bacrends, Beer and Manning: *Function and Evolution in Behaviour*, Chapter 13: 276-291.

MOYNIHAN, M. 1983. Notes on the behaviour of *Idiosepius pygmaeus* (Cephalopoda: Idiosepiidae). *Behaviour*, **85**: (1-2): 42-57.

MOYNIHAN, M. AND A. RODANICHE, 1977. Communications, Crypsis and mimicry among Cephalopods. In: How animals communicate (Seb-cock, T.A. Ed). Indiana Univ. Press, Bloomington.

MOYNIHAN, M. AND A. F. RODANICHE. 1982. Behaviour and Natural History of the Caribbean reef squid *Sepioteuthis sepioidea* with a consideration of social, signal and defensive pattern. for difficult and dangerous environments. pp. 1-151. Verlag Paul Parey. Berlin and Hamburg.

MPEDA 1976. Processing of cuttlefish and squid for export. *Indian Sea Foods*, **XII** (2 & 3): 21-29.

MPEDA 1985. *Statistics of marine products exports* 1983. The Marine Products Export Development Authority, Cochin 264 p.

MUKUNDAN, C. 1968. Molluscs in Indian tradition and economy! *Souvenir, Symp. Mollusca*, Mar. Biol. Ass. India, Cochin, January 12-16, 1968: 45-52.

MURATA, M. AND M. ISHII, 1977. Some information on the ecology of the oceanic squid, *Ommastrephes bartrami* (Lesueur) and *Onychoteuthis borealijaponicus* Okada in the Pacific Ocean of Northeastern Japan. *Bull. Hokkaido Reg. Fish. Res. Labs*, (42): 1-23.

MURATA, M., M. ISHII, AND M. OSAKO 1981. On the regeneration of tentacle of the oceanic squid *Ommastrephes bartrami* (Lesueur). *Bull. Hokkaido Reg. Fish. Res. Lab.*, **46**: 1-14.

MUTHU, M. S., K. A. NARASIMHAM, G. SUDHAKARA RAO, Y. APPANNA SASTRY AND P. RAMALINGAM 1975. On the commercial trawl fisheries off Kakinada during 1967-70. *Indian J. Fish.*, **22** (1 & 2): 171-186.

NAGABHUSHANAM, R. 1968a. Physiology of chromatophores in Cephalopoda. *Proc. Symp. Mollusca*, Mar. Biol. Ass, India, Pt. II: 568-571.

NAGABHUSHANAM, R. 1968b. Studies on neurosecretion in Mollusca. *Proc. Symp. Mollusca*, Mar. Biol. Ass. India, Pt. II: 572-579.

NAIR, R. V. AND K. K. APPUKUTTAN. 1973. Observations on the food of deep sea sharks *Halaelurus hispidus* (Alcock), *Eridacnis radcliffei* Smith and *Iago omanensis* Compagno and Springe *Indian J. Fish.*, **20** (2): 575-583.

NAIR, S. GOPALAN 1958. A preliminary account of the fisheries of Vizhinjam. *Indian J. Fish.*, 5 (1): 32-55.

NARASIMHAM, K. A., G. SUDHAKARA RAO, Y. APPANNA SASTRY AND W. VENUGOPALAN 1979. Demersal fishery resources off Kakinada with a note on economics of commercial trawling. *Indian J. Fish.*, 26 (1 & 2) : 90-100.

NARASIMHAMURTI, C. C. 1979. The emeriid, *Aggregata kudoi* n. sp. from *Sepia elliptica*. *Angewandte parasit*, 20 (3) : 154-158.

NATARAJAN, N. AND R. NATARAJAN 1980. Food and feeding habits of *Psettodes erumei* (Bloch and Schn.) and *Pseudorhombus arsius* (Ham. Buch.). *Matsya*, 6 : 30-42.

NATSUKARI, Y. 1983. Taxonomical and morphological studies on the Loliginid squids—III. *Nipponololigo*, a new subgenus of the Genus *Loligo*. *Venus, The Jap. Jour. Malacol.*, 42 (4) 313-318.

NAZUMI, T. 1975 Notes on the species of squids collected in the Tajima region of the Japanese Sea, 1974. *Bull. Hyogo Pref Fish Stn.*, 15 : 9-13 (in Japanese)

NELSON, M. *et al.*, 1983. On the fishery and biology of the giant squid *Dosidicus gigas* in the Gulf of California, Mexico *In:* Caddy, J. F. (ed), Advances in assessment of world cephalopod resources. *FAO Fish Tech. Pap.*, 231 : 306-340

NISHIMURA S. 1966. Notes on the occurrence and biology of the oceanic squid, *Thysanoteuthis rhombus* Troschel in Japan. *Publ. Seto. Mar. Biol. Lab.*, 14 (4) : 327-349.

NIXON, N. AND J. B. MESSENGER 1977. The biology of the cephalopods. Proceedings of a Symposium held at the Zooloigcal Society of London on 10 and 11 April 1975. *Symp. Zool. Soc. London*, 38 : 615 p.

OGURA, M. 1976. Fishing tackle and fishing efficiency in squid jigging. *FAO Fish. Rep.*, 170 (Suppl. 1) : 99-102.

OGURA, M. AND T. NASUMI 1976. Fishing lamps and light attraction for squid jigging. *FAO Fish. Rep.*, 170 (Suppl. 1 : 93-98.

OKADA, Y. 1933. Animal of *Spirula*. *Venus*, 3 (1) : 144-145.

OKUTANI, T. 1970. A small collection of gastropod and decapod molluscs from the Scychelles Bank, Indian Ocean, by the trawling vessel KOYO-MARU, 1968. *Venus, The Jap. Jour. of Malacology*, 29 (4) : 123-130.

OKUTANI, T. 1973a. Preliminary note on planktonic Oegopsid cephalopod larvae obtained by the International Indian Ocean Expedition. *J. mar. biol. Ass. India*, 15 (1) : 213-217.

OKUTANI, T. 1973b. Guide and keys to squid in Japan. *Bull. Tokai. Reg. Fish. Res. Lab.*, (74) : 83-111.

OKUTANI, T. 1977. Stock assessment of cephalopod resources fished by Japan. *FAO Fish. Tech. Pap.*, (173) : 62 p.

OKUTANI, T. 1980. Useful and latent cuttlefish and squids of the world. Published from National Coop. Ass. of Squid Processors for the 15th Anniv. of its foundation : 66 p.

OKUTANI, T. AND SUZUKI, K. 1975. Concurrence of bathpyelagic *Spirula spirula* and epipelagic *Argonauta boettgeri* in stomach contents of a yellowfin tuna from the Indian Ocean. *Venus, The Jap. Jour. of Malacology*, 34 (1 & 2) : 49-51.

OKUTANI, T. AND TUNG, I. H. 1978. Review of biology of commercially important squids in Japanese and adjacent waters. 1. *Symplectoteuthis oualaniensis* (Lesson). *Veliger*, 21 (1) : 87-94.

OOMMEN, V. P. 1966. The Octopoda of the Kerala coast. I. A new species of the genus *Berrya*, Adam 1943. *Bull. Dept.. Mar. Biol. Oceanogr. Univ. Kerala*, 2 : 51.

OOMMEN, V. P. 1967. New records of octopoda from the Arabian Sea. *Bull. Dept. Mar. Biol. Oceanogr., Univ. Kerala*, 3 : 29.

OOMMEN, V. P. 1971. *Octopus varunae*, a new species from the west coast of India. *Bull. Dept. Mar. Biol. Oceanogr., Univ Cochin*, 5 : 69.

OOMMEN, V. P. 1975. New records of decapod cephalopods from the Arabian Sea. *J. mar. biol. Ass. India*, 17 (2) : 186-190.

OOMMEN, V. P. 1976. A new species of the genus *Opisthoteuthis* Verrill, 1883 (Cephalopoda : Mollusca) from the southwest coast of India. *J. mar. Biol. Ass. India*, 18 (2) : 368-374.

OOMMEN, V. P. 1977a. Two octopods new to Arabian Sea. *Indian J. Fish.*, 24 (1 & 2) : 25-32.

OOMMEN, V. P. 1977b. Studies on the food, feeding and fishery of certain cephalopods from the west coast of India. *Bull. Dept. Mar. Sci. Univ. Cochin*, 8 : 73-152.

ORTMANN, A. S. 1891. Cephalopoden von Ceylon. *Zool. Jb. Syst.*, 5 : 669-678.

OSAKO, M. AND M. MURATA 1983. Stock assessment of cephalopod resources in the Northwestern Pacific. *In :* Caddy, J. F. (ed.), Advances in assessment of world cephalopod resources. *FAO Fish. Tech. Pap.*, (231) : 55-144.

OWEN, R. 1832 Memoir on the Pearly Nautilus *Nautilus pompilius* Linnaeus, London, 68 p.

PADMANABHAN, V. 1970. On new fish products—Cuttlefish and squids. Quart. Newsletter, Govt. of India, Indo-Norwegian Project, 2 (2 & 3): 4-6.

PANDIT, A. R. AND N. G. MAGAR 1972. Chemical composition of *Sepia orientalis* and *Loligo vulgaris*. *Fish Technol*, 9 (2): 122-125.

PARIN, N. V. 1967. The materials on the distribution and biology of the snake mackerel—*Gempylus serpens* Cuv. (Pisces) Gempylidae in the Pacific and Indian Ocean : *Vopr. Icthhyology*, 7 (6) : (in Russian), 990-999.

PARONA, C. 1900. Sulla dicotomia della braccia nei cefalopod. *Boll. Musei Lab. Zool. Anat. Comp. r. Univ. Genova*, 96 : 1-7.

PAULY, D. AND N. DAVID 1981. ELEFAN1, a BASIC program for the objective extraction of growth parameters from length frequency data. *Meeresforsch*, 28 (4) : 205-211.

PAYNE, R. L. 1978. Note on possible priorities for future commercial fisheries of demersal and small pelagic species. *Report of the FAO/Norway Workshop on the Fishery Resources of the North Arabian Sea*, 2 : 194-201.

PFEFFER, G. 1912. Die Cephalopoden der Plankton—Expedition. Zugleich eine monographische Ubersicht der Oepgopsiden Cephalopoden. *Ergebnisse der Plankton—Expedition der Humbodt—Stiftung*, 2 : 1-815.

PERRIN, W. F., R. R. WARNER, C. H. FISCUS AND D. B. HOLTS 1973. Stomach contents of porpoise *Stenella* spp. and Yellowfin tuna, *Thunnus albacares*, in mixed-species aggregations. *Fish. Bull U.S.*, 71 : 1077-1092.

PICKFORD, G. E. 1946. *Vampyroteuthis infernalis* Chun. An archaic dibranchiate cephalopod. I. Natural history and distribution. *Dana Rept.*, **29** : 1-40.

PICKFORD, G. E. 1949a. Distribution of the eggs of *Vampyroteuthis infernalis* Chun. *J. mar. Res.*, **8** (1) : 73-83.

PICKFORD, G. E. 1949b. *Vampyroteuthis infernalis* Chun. An archaic dibranchiate cephalopod. II. Extrnal anatomy. *Dana Rept.*, **32** : 1-132.

PICKFORD, G. E. 1952. The Vampyromorpha of the Discovery Expedition. *Discovery Repts.*, **26** : 197-210.

PICKFORD, G. E. 1959. Vempyromorpha. *Galathea Rept.*, **1** : 243-253.

PICKFORD, G. E. 1974. *Cistopus indicus* (Orbigny) : A common Indo-Malayan species of Octopus. *J. mar. biol. Ass. India*, **16** (1) : 43-48.

PORTMANN, A. 1952. Les luas dorsaux de *Tremactopus violaceus* delle chiaje. *Revue Suisse Zool.*, **59** (13) : 288-293.

PRASAD, R. R. AND P. V. RAMACHANDRAN NAIR 1973. India and the Indian Ocean fisheries. *J. Mar. Biol. Ass. India*, **15** (1) : 1-19.

RABINDRANATH, P. 1966. Biology and seasonal distribution of the pelagic food fishes of Travancore coast. *Kerala Univ. Publ.*, 1-140.

RADHAKRISHNAN, N. 1973. Pelagic fisheries of Vizhinjam. *Indian J. Fish.*, **20** (2) : 584-598.

RAHAMAN, A. A. 1967. Gonad and hapatic indexes of the Indian cephalopods *Sepioteuthis arctipinnis* Gould and *Sepia aculeata* Ferrussac and d'Orbigny. *Proc. Indian Acad. Sci.* **67** B (3) : 104-113.

RAHAMAN, A. A. 1980. Ecological observations on spawning of a few invertebrates of the Madras coast. *J. Madurai Kamaraj Univ.* (Sci.), **9** (1) : 71-77.

RAJAGOPAL, K. V., S. RAVICHANDRA REDDY AND K. SAKUNTALA 1977. Fish baits : Need for collection, care, preparation and propagation in India. *Seafood Export Juor.*, **9** (5) : 9-13.

RAJU, G. 1964. Observations on the food and feeding habits of the oceanic skipjack *Katuswonus pelamis* (Linnaeus) of the Laccadive Sea during the years 1958-59. *Proc. Symp. Scombroid Fishes*, Mar. Biol. Ass. India, Pt. II : 607-625.

RANCUREL, P. 1971. Less contenus stomacauxd ' *Alepisaurus ferox* daus le Sud-oues Pacifique (Cephalopods). *Cah. O.R.S.T. O.M. Ser. Oceanogr.* 8 (4) 3-87.

RANCUREL, P. 1976. Note suries Cephalopodes des contenus stomacaux de *Thunnus albacares* (Bonnaterre) dans le Sud-ouest Pacifique. *Ibid.*, 14(1) : 71-80.

RAO, K. SRINIVASA 1964. Observations on the food and feeding habits of *Scomberomorus guttatus* (Bloch and Schneider) and the juveniles of *S. lineolatus* (Cuvier and Valencinnes) *S. commerson* (Lacepede) from the waltair coast. *Proc. Symp. Scombroid Fishes*, Mar. Biol. Ass. India Pt. II : 591-598.

RAO, SUBBA M. V. 1977. Molluscs of Digha coast, West Bengal, 2. Bivalvia, Scaphopoda and Cephalopoda. *Newsl. Zool. Surv. India*, 3 (5) : 298-302.

RAO, K. VENKATASUBBA 1968. Some aspects of the biology of ' ghol ' *Pseudosciaena diacanthus* (Lacepede). *Indian J. Fish.*, **10** (2) : 413-459.

RAO, K. VIRABHADRA 1954. Biology and fishery of the Palk-Bay squid *Sepioteuthis arctipinnis* Gould. *Indian J. Fish.*, **1** : 37-66.

RAO, K. VIRABHADRA 1958. Molluscan Fisheries. *Fisheries of the West Coast of India. Cent. Mar. Fish. Res. Inst.*, : 55-59.

RAO, K. VIRABHADRA 1969a. Molluscs have many uses. *Indian Frmg.*, **29** (9) : 41-45.

RAO, K. VIRABHADRA 1969b. Distribution pattern of the major exploited marine fishery resources of India. *Bull. Cent. Mar. Fish. Res. Inst.*, **6** : 1-69.

RAO, K. VIRABHADRA 1973. Distribution pattern of the major exploited marine fishery resources of India. *Proc. Symp. Living Resources of the Seas around India*, CMFRI Special Publication : 18-101.

RAO, K. VIRABHADRA AND K. DORAIRAJ 1968. Exploratory trawling off Goa by the Government of India fishing vessels. *Indian J. Fish.*, **15** (1 & 2) : 1-14.

RAO, S. R., S. M. SHAH AND R. VISVANATHAN 1968. Calcium, Strontium and Radium content of molluscan shells. *J. Mar. Biol. Ass. India*, **10** (1) : 159-165.

RAY, H. C. 1937. Contribution to the knowledge of the molluscan fauna of Maungmagan, Lower Burma (with descriptions of one new genus and species of the Family Turridae (Gastropoda)). *Indian Mus.*, Calcutta, **8** : 1-150.

RAYUDU, G. V. AND P. CHANDRA MOHAN 1982. A note on the fishery of squids and cuttlefish of Visakhapatnam. *Seafood Exp. Jour.*, **14** (4) : 23-27.

REES, W. J. 1949. Note on the hooked squid, *Onychoteuthis banksi. Proc. malac. Soc. Lond.*, **28** : 43-45.

RIGGENBACH, E. 1901. Beobachtung uber selbstverstummehung *Zool. Anz.*, **24** : 587-593.

ROBSON, G. C. 1921. On the Cephalopoda obtained by the Percy Sladen Trust Expedition to the Indian Ocean in 1905. *Trans Linn. Soc. London*, **17** (2) : 429-442.

ROBSON, G. C. 1924a. Preliminary report on the Cephalopoda (Decapoda) procured by the S. S. ' Pickle '. *Rep. Fish. mar. biol. Surv. Union S. Africa*, 3, *Spec. Rept.*, 9 : 1-14.

ROBSON, G. C. 1924b. On the Cephalopoda obtained in South African waters by Dr. J. D. F. Gilchrist in 1920-1921. *Proc, Zool. Soc. London* : 589-686.

ROBSON, G. C. 1926a. Notes on the cephalopoda. No. 1. Descriptions of two new species of *Octopus* from southern India and Ceylon. *Ann. Mag. nat. Hist.*, Ser. 9, **17** : 159-167.

ROBSON, G. C. 1926b. The Cephalopoda obtained by the S. S. ' Pickle ' (Supplementary Report). *Fisheries and Marine Biological Survey Report*, No. 4, *for the year* 1925, 1-6.

ROBSON, G. C. 1929. *A Monograph of the Recent Cephalopoda.* Part I. *Octopodinae.* British Museum (Nat. Hist.) London, 236 p.

ROBSON, G. C. 1932. A monograph of the recent cephalopoda. Part II. The Octopoda (excluding the Octopodinae), London. British Museum (Natural History), 359 p.

ROPER, C. F. E. 1966. A study of the genus *Enoploteuthis* (Cephalopoda : Oegopsida) in the Atlantic ocean, with a redescription of the type species, *E. leptura* (Leach, 1817). *Dana Rept.*, *66 : 1-46.*

ROPER, C. F. E., M. J. SWEENEY AND C. E. NAUEN 1984. Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. *FAO Fish. Synop.*, (125) 3 : 277 p.

ROPER, C. F. E. AND R. E. YOUNG. 1975. Vertical distribution of pelagic cephalopods. *Smithsonian Contr. Zool.*, No. 209 : 1-51.

ROPER, C. F. E., R. E. YOUNG AND G. L. VOSS 1969. An illustrated key to the families of the order Teuthoidea (Cephalopoda). *Smithson. Contrib. Zool.*, 13 : 32 p.

ROSENBERG, P. 1973. The Giant Axon of the squid : A useful preparation for neurophisiological and pharmacological studies. F. Reiner Ed. *Methods of neurochemistry*, Vol. IV, Marcel Dekker, New york, 327 pp.

SAITO, R. 1976. The Japanese fishery (jigging) for *Nototodarus sloani sloani* in New Zealand waters. *FAO Fish. Rep.*, 170 (Suppl. 1) : 53-60.

SANDERS, M. J. 1979. Development of fisheries in areas of the Red Sea and Gulf of Aden. Preliminary stock assessment for the cuttlefish *Sepia pharaonis* taken off the coast of the People's Democratic Republic of Yemen. FAO Field Document, FAO-FI-RAB- 77/008, 58 p.

SANDERS, M. J. 1981. Revised stock assessment for the cuttlet fish *Sepia pharaonis* taken off the coast of the Peoples' Democratic Republic of Yemen. RAB/77/008/13. 44p. FAO, Project for the development of fisheries in areas of the Red Sea and Gulf of Aden, Cairo, Egypt.

SANDERS, M. J. AND M. BOUHLEL 1981. Interim report of a mesh selection study conducted in the People's Democratic Republic of Yemen on the cuttlefish *Sepia pharaonis*. FAO/UNDP Project on Development of Fisheries in areas of the Red Sea and Gulf of Aden : 35 p.

SANDERS, M. J. AND M. BOUHLEL 1983. Mesh selection study conducted in the People's Democratic Republic of Yemen on the cuttlefish *Sepia pharaonis*. *In :* Caddy, J. F. (ed.), Advances in *assessment of World Cephalopod Resources, FAO Fish. Tech. Pap.*, 231 : 181-203.

SANJEEVA RAJ, P. J. AND M. KALYANI 1971. *Euprymna morsei* (Verrill, 1881) (Sepiolidae : Cephalopoda) from the Indian Coast. *J. mar. biol. Ass. India*, 13 (1) : 135-137.

SANTHANAKRISHNAN, G. 1982a. Diversified markets for Indian marine products. *Seafood Export Jour.*, 14 (4) : 9-12.

SANTHANAKRISHNAN, G. 1982b. Dried squid. Part I. A value-added diversified product and its potential export markets *Seafood Export Jour.*, 14 (6) : 9-11.

SANTHANAKRISHNAN, G. 1982c. Dried squid. Part 2. A note on processing, packing and storing. *Seafood Export Jour.* 14 (7) : 1-13.

SANTHANAKRISHNAN, G. 1984. Diversification of products and markets. Octopus and un-exploited marine resource for diversification. *Seafood Export Jour.*, 15 (9) : 11-16.

SARVESAN, R. 1969a. Catalogue of molluscs. 2. Cephalopoda. *Bull. Cent. Mar. Fish. Res. Inst.*, 9 : 23-25.

SARVESAN, R. 1969b. Some observations on parental care in *Octopus dollfusi* Robson (Cephalopoda : Octopodidae). *J. Mar. Biol. Ass. India*, 11 (1 & 2) : 203-205.

SARVESAN, R. 1974. V. Cephalopods. *In :* The Commercial Molluscs of India. *Bull. Centr. Mar. Fish. Res. Inst.*, 25 : 63-83.

SARVESAN, R. 1976. On the occurance of *Sepia trygonia*. (Rochebrune) (Cephalopoda : Sepiidae) in Gulf of Mannar, *Indian J. Fish.*, 23 (1 & 2) : 256-260.

SASAKI, M. 1929. A monograph of the dibranchiate cephalopods, of the Japanese and adjacent waters. *Fac. Agric. Hokkaido Univ.*, Suppl., 20 : 1-357.

SASTRY, H. M. C. AND L. M. SRIKAR 1982. Protein and related changes in cuttlefish *Sepia aculeata* in iced storage. *Symposium Son Harvest and Post-harvest Technology of Fish*, 24-27 *November* 1982, *Cochin, Soc. Fish. Technologists.* Abstract.

SATO, T. 1976. Results of exploratory fishing for *Dosidicus gigas* (d' Orbigny) off California and Mexico. *FAO Fish. Rep.*, 170 (Suppl. 1) : 61-67.

SATO, T. AND H. HATANAKA 1983. A review of assessment of Japanese distant-water fisheries for cephalopods. *In :* Caddy, J. F. (ed.), Advances in assessment of world cephalopod resources. *FAO Fish. Tech. Pap.*, (231) : 145-180.

SATYAMURTHI, S. T. 1956. The mollusca of Krusadai Island (In Gulf of Mannar). II. Scaphopoda, Pelecypoda and Cephalopoda. *Bull. Madras Govt. Mus. (New Ser.) Nat. Hist. Sect.*, 1 (2) Pt. 7 : 202 p.

SAUNDERS, W. B. 1981. The species of living *Nautilus* and their distribution. *Veliger*, 24 (1) : 8-17.

SEKHARAN, K. V., M. S. MUTHU, K. VENKATA SUBBA RAO, V. RAMAMOHANA RAO, P. MOJUMDER AND S. REUBEN 1973. Exploratory trawling on the continental shelf along the northwestern part of the Bay of Bengal. *Proc. Symp. Living Resources of the Seas around India*, CMFRI Spl. Publication : 280-337.

SHEEHY, D. J. AND S. F. VIK, 1980. 'Sake-ika' : Dried squid processing squipment and markets. *Marine Fisheries Review*, 42 (7-8) : 92 p.

SHENOY, A. S. 1985. Squids from India to Japan. *Infofish marketing Digest*, (*FAO*), No. 2 : 43-44.

SHIN, P. K. S. 1982. The Hong Kong Squid Fishery. In Review of National Squid Fisheries, IPFC/RRD/82/Inf. 8 (a), March 1982, Sydney, Australia, 10 p.

SILAS, E. G. 1963. Synopsis of biological data on dogtooth tuna *Gymnosarda unicolor* (Ruppel) 1838 (Indo-Pacific). *FAO Fish. Rep.*, 6 (2) : 877-899.

SILAS, E. G. 1968. Cephalopoda of the west coast of India collected during the cruises of the research vessel 'VARUNA', with catalogue of the species known from the Indian Ocean. *Proc. Symp. Mollusca.* Mar. Biol. Ass. India, Pt. I: 277-359

SILAS, E. G. 1969a. Exploratory fishing by R. V. VARUNA. *Bull. Cent. Mar. Fish. Res. Inst.*, 12 : 86 pp.

SILAS, E. G. 1969b. Pelagic fisheries of the Indian Ocean *Indian Frmg.*, 19 (9) : 63-66.

SILAS, E. G., S. K. DHARMARAJA AND K. RENGARAJAN 1976 Exploited marine fishery resources of India—a synoptic survey with comments on potential resources. *Bull. Cent. Mar. Fish Res. Inst.*, 27 : 25 p.

SILAS, E. G., K. S. RAO, R. SARVESAN, K. P. NAIR AND M. M. MEIYAPPAN 1982. The exploited squid and cuttlefish resources of India : A review. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 34 : 1-16.

SILAS, E. G. AND P. P. PILLAI 1982. Resources of tunas and related species and their fisheries in the Indian Ocean. *Bull. Cent. Mar. Fish. Res. Inst.*, 32 : 174 p.

SIVALINGAM, D. AND S. KRISHNA PILLAI, 1983. Preliminary experiments on breeding of cephalopods. *Proc. Symp. Coastal Aquaculture.*, Part 2, Mar. Biol. Assn. India, 633-635.

SIVAPRAKASAM, T. E. 1967. Observations on the food and feeding habits of *Papastromateus niger* (Bloch) of the Saurashtra coast. *Indian J. Fish.*, 10 (1) : 140-147.

SREENIVASAN, A. 1962. Two cases of bacterial discolouration of squids. *Curr. Sci.*, 31 (9) : 381-382.

SREENIVASAN, P. V. 1974. Observations on the food and feeding habits of the 'Torpedo Travally' *Megalaspis cordyla* (Linnaeus) from Vizhinjam Bay. *Indian J. Fish.*, 21 (1) : 76-84.

STEENSTRUP, J. J. 1856. Hectocotyldannelsen hos octopodslaegeterne *Argonauta* og *Tremoctopus*, oplyst ved Iagttagelse at lignende Dannelser hos Blacksprunt-terne i Almindelighed K. *danske Vidensk. Selsk. Skr.*, 5 *R.*, 4 : 186-215, 2 pl.

SULLIVAN, D., AND J. M. CULLEN. 1983. Food of the squid *Nototodarus gouldi* in Bass Strait. *Aust. J. Mar. Freshw. Res.*, 34 : 261-85.

SULOCHANAN, P. AND M. E. JOHN 1982. Cephalopod resources in southwest coast of India. *Symposium on Harvest and Post-harvest Technology of Fish*, 24-27 *November*, 1982, *Cochin* Soc. Fish. Technologists, Abstract.

SUMMERS, W. C. 1969. Winter population of *Loligo pealei* in the Mid-Atlantic bight. *Boil. Bull.*, 137 (1) : 202-216.

SUMMERS, W. C. 1983. *Loligo pealei.* In Ed. P. R. Boyle *Cephalopod Life Cycles*, Vol. 1 : Species accounts. Academic Press. pp. 115-142.

SURYANARAYANAN, A. AND K. K. ALEXANDER 1980. Biochemical studies on the molluscan muscle. 2. Studies on the muscles of some bivalves and cephalopods. *J. Anim. Morph. Physiol.* 27 (1-2) : 180-189.

SURESLAN, C. AND K. V. SOMASEKHARAN NAIR 1969. Food and feeding habits of the demersal fishes off Bombay. *Indian J. Fish.*, 16 (1 & 2) : 56-74.

TAKAHASHI, T. 1965. Squid meat and its processing. *In :* Fish as Food. G. Borgstrom (ed.), Academic Press, New York : 339-354.

TAKI, I. 1981. A catalogue of the Cephalopoda of Wakayama Prefecture. *In :* A catalogue of molluscs of Wakayama Prefecture, The Province of Kii. 1. Bivalvia, Scaphopoda and Cephalopoda. Sato mar. biol. Lab. Japan, 301 p.

TALBOT, F. H. AND M. J. PENRITH 1963. Synopsis of biological data on species of the genus *Thunnus* (*Sensu lato*) (South Africa). *AFO Fish. Rep.*, 6 (2) : 608-646.

TAMPI, P. R. S. 1959. The ecological and fisheries characteristics of a salt water lagoon near Mandapam. *J. Mar. Biol. Ass. India*, 1 (2) : 113-130.

TANIKAWA, E. AND M. SUNO 1952. Studies on the complete utilization of the squid (*Ommastrephes sloanii pacificus*) 5. Nutritive value and digestibility of squid meat. *Bull. Fac. Fish. Hokkaido Univ.*, 3 (1) : 73-94.

TASAKI, I. 1968. *Nerve Excitation.* Charles C. Thomas Springfield Illinois, pp. 200-26.

THIELE, J. 1915. *In :* Chun, C. Wiss. Ergebn. Deutsche Tiefsee Exped., Bd. 18 Pt. 2.

THOLASILINGAM, T., G. VENKATARAMAN, K. N. KRISHNA KARTHA AND P. KARUNAKARAN NAIR 1968. Results of the exploratory trawl fishing on the continental slope of the southwest coast of India by M. F. V. 'Kalava'. *Indian J. Fish.* 11 (2) : 547 558.

THORE, S. 1945. On the Cephalopoda of Professor O. Carlgren's Expedition to South Africa in 1935. K. fysiogr. Sallsk. Lund Forh., 15 : 49-57.

TOLL, R. B. AND S. C. HESS. 1981. Cephalopods in the diet of the sword fish, *Xiphias gladius* from the Florida Strait. *Fish. Bull. U.S.* 79(4) : 765-774.

TRETHEWIE, E. R. 1965. Pharmacological effects of the venom of the common octopus, *Hapalochlaena maculosa. Toxicon* 3 : 55-59.

TUNG, IH-HSIU 1976. On the reproduction of common squid, *Symplectoteuthis oualaniensis* (Lesson). *Rep. Inst. Fish. Biol.* Taipei, 3 (2) : 26-48 (in Chinese with English summary).

TUNG, IH-HSIU, CHI-SHENG LAN AND CHEN-CHIN-HU 1973. The preliminary investigation for exploitation of common squid resources. *Rep. Inst. Fish. biol., Taipei*, 3 (1) : 211-247 (in Chinese with English summary).

TRESING, A. R. 1974. Fishery management issues in the Indian Ocean. Indian Ocean Programme, FAO, Rome, IOFC/DEV/ 74/35 : 39 p.

UNDP/FAO 1974a. Survey Results 1972/73. *Progress Report No.* 6 : 141 p.

UNDP/FAO 1974b. Plankton—Fish eggs and larvae studies. *Progress Report No.* 7 : 21 p.

UNDP/FAO 1976a. Survey Results 1973/74. *Progress Report No.* 12 : 32 p.

UNDP/FAO 1976b. Survey Results 1974/75. *Progress Report No.* 13 : 21 p.

UNDP/FAO 1976c. Pelagic fishery Investigation on the south-west coast. *Final Report of the Norwegian Agency for International Development* (NORAD) *and the Institute of Marine Research Bergan* : 55 p.

UNDP/FAO 1976d. A synopsis of the information on pelagic resources off the southwest coast of India. *Progress Report No.* 18 : 31 p

UNDP/FAO 1977. Report of acoustic survey along the south-west coast of India, November 1976. Progress Report, 1. FAO, Rome FIRS-IND/75/0348 : 28 p.

UNNITHAN, K. A. 1982. Observations on the biology of cuttlefish *Sepiella inermis* at Mandapam. *Indian J. Fish.*, 29 (1 & 2) : 101-111.

VERGHESE, G. 1981. Present status of small scale fisheries in Lakshadweep. *Bull. Cent. Mar. Fish. Res. Inst.*, 30 B : 60-64.

VELAIN, C. 1877. Remarques generales an sujet de la faune des iles St. Paul et Amsterdam, Suivies d'une description de la faune malacologique des deux iles. *Archs. Zool. exp. gen.*, 6 : 1-144.

VENKATARAMAN, R. AND K. DEVADASAN 1978. Marine products processing industry in India : Its growth and future prospects *Proc. Symp. Fish Utilization Technology and marketing in the IPFC Region, 18th Session*, Manila, Philippines : 38-44.

VERRILL, A. E. 1881a. Report on the cephalopods and on some additional species dredged by the U. S. Fish Commission Steamer ' Fish-hawk ', during the season of 1880. *Bull. Mus. Comp. Zool.*, 8 : 99-116.

VERRILL, A. E. 1881b. Regeneration of lost parts in the squid *Loligo pealei. Amer. J. Sc.*, (3rd ser.), 21 : 333-334.

VERRILL, A. E. 1882. Report on the cephalopods of the north-eastern coast of America. *Rep. U. S. Comm. Fish and Fisheries*, 1879, 7 : 211-455.

Voss. G. L. 1956. A review of the cephalopods of the Gulf of Mexico. *Bull. mar. Sci. Gulf. Carib.*, 6 (2) : 85-178.

Voss, G. L. 1962. South African cephalopods. *Trans. R. Soc. S. Africa*, 36 (4) : 245-272.

Voss, G. L. 1963. Cephalopods of the Phillippine Islands. *Bull. U. S. nat. Mus.*, 234 : 1-180.

Voss, G. L. 1967. Some bathypelagic cephalopods from South African waters. *Ann. S. African Mus.*, 50 (5) : 61-88.

Voss, G. L. 1973. Cephalopod resources of the world. *FAO Fish. Circ.* (149) : 75 p.

Voss, G. L. 1977. Present status and new trends in cephalopod systematics. *Symp. Zool. Soc. London*, 38 : 49-60.

Voss, G. L. AND D. S. ERDMAN 1959. *Thysanoteuthis rhombus*, a large cephalopod new to Western Atlantic. *Mar. Lab. Univ. Miami, Nautilus*, 73 (1) : 23-25.

Voss, G. L. AND G. R. WILLIAMSON 1971. *Cephalopods of Hongkong*. Government Press, Hongkong : 138 p.

VOVK, A. N. 1972. Method of determining maturing stages in gonads of the squid *Loligo pealei. Zoologicheskiy Zhurnal* (USSR), 51 (1) : 127-132. (Translation Ser. No. 2337, 1973, Fish Res. Bd. Can.)

WELLS, M. J. 1962. Brain and Behaviour of Cephalopods. Heines mann, London.

WELLS, M. J. 1966. Cephalopod Sense organs. *In* [physiology of Mollusca, Edited by K. M. Wilbur and C. M. Younge, New York, Academic Press. Vol. 2 : 523-45.

WELLS, M. J. 1978. Octopus : Physiology and behaviour of an advanced invertebrate. Chapman and Hall London and John Wiley and Sons, New York, 417 p.

WELLS, M. J. AND J. WELLS. 1972.Sexual display and mating of *Octopus vulgaris* Cuvier and *O. cyanea* gray and attempts to alter performance by manupulating the glandular condition of animals. *Animal Behav.* 20 : 293-308.

WILLIAMS, F. 1964. The Scombroid fishes of East Africa. *Proc. Symp. Scombroid Fishes*, Mar. Biol. Ass. India, Pt. I : 107-164.

WILLIAMS, 1967. Longline fishing for tuna off the coast of East Africa, 1958-1960. *Indian J. Fish.*, 10 (1) : 233-290.

WILLY, A. 1902. *Contribution to the natural history of the pearly nautilus Part 6. of Zoological Results based on material from New Britain, New Guinea, Loyalty Islands.* (34) Cambridge.

WINCKWORTH, R. 1926. A list of Cephalopoda in the Colombo Museum. *Spolia Zeylan.*, 13 : 323-331.

WICNKWORTH, R. 1936. Marine Mollusca from South India and Ceylon. 4. A new Indian *Sepia. Proc. Malac. Soc. Londom* 22 : 16-23.

WOLFF, G. A. 1984. Identification and estimation of size from the beaks of 18 species of Cephalopods from the Pacific Ocean. *NOAA Tech. Rept. NMFS* 17 : 1-50.

WOLFF, G. A. AND J. H. WORMUTH. 1979. Biometric Separation of the beaks of two morphologically similar species of the squid family Ommastrophidae.*Bull. Mar. Sci.* 29(4) : 587-592.

WORMS, J. 1983. World fisheries for cephalopods : A synoptic overview. *In :* Caddy J. E. (ed.), Advances in Assessment of world cephalopod Resources, *FAO Fish. Tech. Pap.*, (231) : 1-20.

WORMUTH, J. H. 1976. The biogeography and numerical taxonomy of the Oegopsid squid family Ommastrephidae in Pacific Ocean. *Bull. Scripps. Inst. Oceanogr.*, 23 : 90 p.

WULKER, G. 1920. Ueber Cephalopoden des Roten Meeres. *Sneckenbergiana*, 2 : 48-58.

YAJIMA, S. AND S. MITSUGI 1976. Japanese squid jigging gear. *FAO Fish. Rep.*, 170 (Suppl. 1) 85-88.

YAMANAKA, H. 1976. Summery Report on cruise of R. V. *SOHYO MARU* in the Northern Arabian Sea, Oct. 1975-Feb. 1976. Far Seas Fisheries Research Laboratory, Japan Fisheries Agency pp. 1-9 with 30 figs, 7 tables, 6 plates and 2 appendices.

YAMANAKA, H., Y. NISHIGAWA AND J. MORITA 1976. Summary Report on cruise of the R. V. SHOYO MARU in the North Arabian Sea. FAO/UNDP Indian Ocean Programme Technica Report No. 11, 47 p.

YAMAZAKI, T. AND M. CHUENCHITPONG. 1981. Survey Report on squid stick-held dip net at Ban PHE District. *SEAFDEC Training Dept*. MP/No. **10** : 1-14.

YAMAZAKI, T. P., MASTHAWEE AND S. SAKARANG. 1983. Survey Report on a *new type of squid lift net*. *SEAFDEC Training Dept*. TD/MP/15 : 1-16. June 1983.

YAMASHITA, Y. 1976. The octopus Fishery of Hokkaido. Suppl. to the Report of the Expert Consultation on Fishing for Squid and other cephalopods. FAO Fish. Rep. (170) Suppl. 1, 142-143.

YEOH, Q. L. AND Z. MERICAN 1978. Processing of non-commercial and low-cost fish in Malaysia. *Proc. Symp. Fish Utilization Technology and Marketing in the IPFC Region*, 18*th Session*, Manila, Philippines : 572-580

YOUNG, R. E. 1975. A brief review of the biology of the oceanic squid, *Symplectoteuthis oualaniensis* (Lesson). *Comp. Biochem. Physiol.* **52 B** : 141-143.

YOUNG, J. Z. 1962. Courtship and mating by the coral reef octopus (*O. horridus*). *Proc. Zool. Soc. London*, **138** : 157-62.

YOUNG, J. Z. 1965. The Central Nervous System of *Nautilus*. *Philos. Trans. R. Soc. Biol. Sci.*, 249 : 1-25.

YOUNG, J. Z. 1971. Anatomy and Nervous system of *Octopus vulgaris*. Clarandon Press, Oxford.

YOUNG, J. Z. 1977. Brain, behaviour and Evolution. *Symp. Zool. Soc. London*, **38** : 377-434.

YOSHIKAWA, N. 1978. Fisheries in Japan. Squid and cuttlefish, Publ. by Japan Marine Products Photo Materials Association. Tokyo, 162 p.

ZUEV, G. V. 1971. *Cephalopods from the northwestern part of the Indian Ocean, Moscow*, 223 pp.

ZUEV, G. V. AND K. N. NESIS 1971. *Squid* (*Biology and Fishery*), Pishchevaya Promyshlennost Press, Moscow.

ZUPANOVIC, S. AND S. Q. MOHIUDDIN 1973. A survey of the fishery recources in the northeastern part of the Arabian Sea. *J. mar. Biol. Ass. India*, **15** (2) : 496-537.