STUDIES ON SPINY LOBSTER FISHERY OF SOUTH WEST COAST OF INDIA

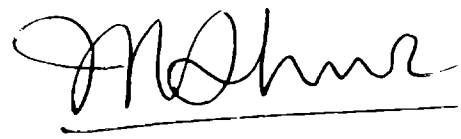
THESIS SUBMITTED TO
THE COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY

BY
K. V. MOHAN RAJAN M. Sc.

DEPARTMENT OF INDUSTRIAL FISHERIES
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COCHIN - 682 016
1991

C E R T I F I C A T E

This is to certify that this thesis is an authentic record of research work carried out by Sri.K.V. Mohan Rajan, M.Sc. under my supervision and guidance in the Department of Industrial Fisheries, Cochin University of Science and Technology, in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY and that no part thereof has been submitted for any other degree.



Cochin - 682 016

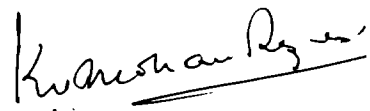
April, 1991

(M. SHAHUL HAMEED)
Supervising Teacher

Dr. M. SHAHUL HAMEED
Professor & Head of the Department
Department of Industrial Fisheries
Cochin University of Science
and Technology
Cochin - 682 016.

DECLARATION

I K.V. Mohan Rajan do hereby declare that the work presented in this thesis is the result of my own investigations and neither the thesis nor any part there of has been accepted nor is being submitted for any other degree. All the sources of information have been duly acknowledged.



K.V. MOHAN RAJAN

A C K N O W L E D G E M E N T S

First and foremost I record my heartfelt gratitude to Dr.M.Shahul Hameed, Professor and Head of the Department, Department of Industrial Fisheries, Cochin University of Science and Technology, Cochin-682 016, under whose guidance this work has been carried out.

I am thankful to Sri.M.R Nair, present Director, Central Institute of Fisheries Technology, Cochin 682 029 and Dr.C.C.Panduranga Rao former Director, for providing necessary facilities for carrying out this study at the Institute.

I express my thanks to Sri. P.A. Panicker, Head of the Fishing Technology Division of C.I.F.T. for his valuable support.

My thanks are also due to my colleagues Sri.M.R. Boopendranath and Dr.(Smt.) B. Meenakumari for the valuable help and suggestions received during the course of this investigation.

I am grateful to Dr.Kesavan Nair and Sri. Krishna Iyer, Principal Scientists of Statistics Division of C.I.F.T. for their help in analysis of the data.

I am indebted to several traditional lobster trap fishermen of S.W. coast for willingly and cheerfully carrying out different fishing operations according to my request, amongst whom Sri.Yesudas of Enayam and Sri.Maria John of Kadiapatnam in Kanyakumari district deserve special mention.

Support received from Fisheries officials of S.W. Coast of India in gathering information and conducting field studies are acknowledged with thanks.

My sense of appreciation and thanks to Dr. K. Ashok Kumar and Sri.K.V. Pauly, Research Scholars of Department of Industrial Fisheries for their help on different occasions.

Above all I express my gratitude to my wife Dr.(Mrs.) K.K. Kairaly who shouldered the entire responsibilities of the family, leaving me alone to pursue my research work.

I wish to place on record my gratefulness to Indian Council of Agricultural Research.

(K. V. MOHAN RAJAN)

CONTENTS

Page No.

Page

C H A P T E R - I

INTRODUCTION

1.1 PREAMBLE

The role of crustacea in the nutrition of a number of animals, including man, needs no emphasis. In recent years crustacean shell fish as a food item has gained considerable importance and today prawns, lobsters and other edible varieties play a very significant role in the fishery economy of many nations. Spiny lobsters (Fam: Palinuridae; Genus Panulirus) are an economically important and ecologically interesting group of organisms.

Spiny lobsters constitute a very valuable marine product exported from India fetching sizeable foreign exchange for the country. Lobsters are widely acclaimed as a cherished food delicacy and have a world wide market. In terms of the total value realised by export, this crustacean is second in importance only to prawns; whereas it occupies first position in terms of unit value realisation amongst all the marine products exported from the country. Price fetched by one Kilogram of prawns in foreign market in the year 1989 was Rs.80.00 as against Rs.149.36 fetched by same quantity of lobsters. India exported 1963 tons of processed lobsters earning a total foreign exchange of Rs.2931.37 lakhs during the year 1989 (Anon 1989). But India's share in the world trade is only fractional and demand for this epicurian delight is increasing.

Lobsters lend themselves for easy exploitation as they live in shallow waters and can be attracted into pots which do not require constant tending.

Catching of lobsters therefore, is a low capital enterprise with high returns. Catches in cold waters and northern lobsters have levelled off recently. Lobsters of western hemisphere is thought to be fully exploited. Lobster catches in Eastern Atlantic off Europe and Africa have also stabilized in recent years (Anon, 1977). The best hope for growth of production in future lies in spiny lobsters and slipper lobster resources. Largest producers of spiny lobsters are U.S.A., Canada, Australia, U.K., Cuba, France, S. Africa and Newzealand. Present yield from Indian ocean waters is estimated to be 15000 tons. Total landing of spiny lobsters in India during the year 1988 was 2610 tons (Anon, 1988).

South west coast of India is one of the most important lobster producing regions in the country. Spiny lobster fishery of S.W. Coast of India is in a critical stage of development. As far as a study of this fishery is concerned south west coast is ideally suited. The fishery developed and organised exploitation started from 1956-57 (Chacko et al., 1969) earlier than any where else in the country. The study of this fishery in Kanyakumari district of Tamil Nadu was taken up from the year 1957 itself by the Marine Biological Station at Cape Comorin with a view of following the trend of the fishery. Representatives of all the species of spiny lobsters available in India have been recorded from this place. Several types of fishing gear are employed in this region to exploit this fishery. They aim spiny lobsters as target of fishing operation unlike in other places, where lobsters form only a by catch in fishing gear operated for other fishes. The processing

and export of this marine product commenced from this place as early as 1962 with export of 53 tons to America. Of late there has been a shift in market to Japan. Now in India, rock lobster fishing and its trade are no more a subsistence business. After realisation of its potential as a very lucrative export commodity, there has been a sudden spurt of activity on all fronts like exploitation, processing and export since the last 25 years. Further development, conservation and judicial fishing will lead to production at a level of sustainable yield ultimately resulting in improvements to the socio-economic well being of that section of artisanal fishermen who make a living out of it.

Spiny lobsters of South west coast of India shot into lime light only in late fiffees, consequent to the establishment of frozen sea food industry and its demand as a gourmets delight and a speciality food product in world markets. Prior to this they supported only a subsistence fishery of diffused nature. Kanyakumari district of Tamil Nadu and Trivandrum district of Kerala are traditionally important lobster fishing areas contributing to lion's share of landings and providing employment to hundreds of traditional fishermen. This particular resource promises to be the mainstay of landings in times to come.

Marine fisheries research especially in actual field is seldom wasted. If it fails to disclose the potential for new and better developed fishery, it at least saves the time and trouble for future workers. If it succeeds in unearthing the evidence, and still through some extraneous causes the

fishery failes to develop, the data collected and the records are still there and this foundation can be used in any future time. The most common objectives of development of fisheries are, increase in the output, raise the standard of living, increase the export earnings and to maintain or increase the employment (Smith, 1979). To obtain the best results from any fishery it is necessary to carry on investigations insistently and persistently.

1.2 REVIEW OF PREVIOUS RESEARCH

There is voluminous and often repetetive literature on spiny lobsters from different parts of the world. A very extensive and annotated bibliography by Sims (1966) covers almost all literature concerning Palinuridae and Scyllaridae published between 1900 and 1965. One extensive and indexed bibliography on Palinuridae edited by Kanciruck and Herrnkind (1976) and another by Smolowitz (1978) list out all publications on spiny lobsters. Mckoy (1979) has published one exclusively on Newzealand rock lobster, Jasus edwardsii.

Studies on various aspects of spiny lobster fishery of India have been rather spasmodic. Investigations and reports on biological and related aspects of lobsters, are several, but the studies on methods of exploitation of natural stock, its effect on the fishery and suggestions on corrective measures, are not many. Sound management policies depend to a large extend on the knowledge of the lobster itself.

1.2.1 BIOLOGICAL STUDIES

One of the earliest reports about spiny lobsters from Indian coast was by Alcock (1901) who reported about deep water spiny lobster

Puerulus sewelli under the name Panulirus angulatus Spence Bate. Sewel also have recorded the same species in 1913. Gravely (1927) indicated the occurance of Panulirus dasypus around Krusadi islands. Rai (1933) has mentioned that Panulirus ornatus and P. fasciatus are represented in commercial landings at Bombay. Chopra (1939) stated that common species occuring in east coast is P. polyphagus. During the investigations on bottom fauna and bottom deposites within the depth range of 180 to 365 m between Mangalore and Puvar, John and Kurian (1959) reported the occurrance of P. sewelli along the continental shelf of Kerala. Department of Fisheries Madras State (later Tamil Nadu) have been engaged in observations on different aspects of spiny lobster fishery of Kanyakumari coast from 1957 itself. (Ramanathan and Chacko 1962; Chacko et al., 1969). A note on the first phyllosoma of Panulirus burgeri was given by Prasad and Tampi in 1959. Panulirus penicillatus was recorded from in shore waters off Quilon by Satyanarayana (1961) for first time. According to Kurian (1965) P. sewelli is moreorless a permanent inhabitant of continental shelf edges of Kerala. A new record of Panulirus langipes from South west coast of India was published by George and Rao in 1965. George and Rao (1966) mentioned about some Decapod crustaceans from south west coast of India. Deshmukh (1966) kept live puerulii of P. polyphagus in aquaria and found that they molted within a week into typical young lobsters. George (1967a) gave a general account of Indian spiny lobster. Certain biological factors such as the breeding season, growth rate, age composition and population characteristics concerning spiny lobster species, P. homarus have been investigated by George

(1967b). The movement and the growth of the species have been studied by Mohamed and George (1967) by tagging experiments. An account of the crustacean fishery resources of India was contributed by Jones (1967). Prasad and Tampi (1968) contributed an account of Palinurid and Scyllarid lobsters in India ocean. The occurrance of post larvae and juveniles of spiny lobster Panulirus polyphagus in Cochin backwaters during October to May has been noticed by Balasubramanyan (1969) and Rao and Kathirvel (1971). Mohamed et al. (1971) have described the first phyllosoma stage of P. sewelli. Kathirvel (1972) also reported the growth and regeneration studies on a single juvenile specimen obtained from back waters. Thomas (1972) studied about the growth of spiny lobster P. homarus in captivity in relation to moulting. An assessment of the total lobster resources of the country was made and species enumerated by George (1973). Vyasa Rao and George (1973) have described about the deep sea spiny lobster, Puerulus sewelli with particular reference to its commercial potentialities. The occurance of Panulirus longipes, P. penicillatus and P. polyphagus on the south east coast of India was reported by Nair et al. in 1973. Observations on some aspects of fishery and biology of deep sea spiny lobster Puerulus sewelli were carried out by Oomen and Philip (1974). Premkumar and Daniel (1975) have made an attempt to explain the distribution pattern of economically important spiny lobsters in Indian ocean area. Studies by Thampi and George (1975) and Prasad et al. (1975) have provided some knowledge mainly on the systematics and general distribution on Phyllosoma larvae occuring in the Indian ocean as a whole. Prasad (1978) has more critically examined larval stages of selected species of

Palinorid and Scyllarid lobsters with particular emphasis on growth numerical abundance and depth wise distribution and density of water. P. homarus was newly recorded from Minicoy by Meiyappan and Kathirvel (1978). Certain allometric relations of spiny lobster Panulirus polyphagus were worked out by Joseph Mathai and Nair (1979) from Goa. Growth and moulting of three species of spiny lobsters were studied by Nair et al. (1981). Spiny lobsters of India caught national head lines with the recent success of increase in the growth rate by eye stalk ablation, which is claimed to be a major break through in the scope of lobster culture (Silas 1982; Radhakrishnan and Vijayakumaran 1982). Bilateral eye stalk ablation accelerated the moulting frequency and weight gain in juvenile, maturing and mature P. homarus irrespective of their reproductive status (Radhakrishnan and Vijayakumaran, 1984a). Three to seven fold increase in weight gain was obtained by eye stalk ablation. Eye ablation induced accelerated gonadial growth in males and females indicating gonad inhibiting principle in the eye stalk. The normal antagonistic relationship of moulting and reproduction was changed to one of synergism in ablated lobsters (Radhakrishnan and Vijayakumaran, 1984b). Eye stalk ablation induced hyperphagia and increased food consumption by 50-75% (Vijayakumaran and Radhakrishnan, 1984). Length weight and tail length total length relationship in Panulirus homarus was presented by Meenakumari et al. (1986). The lethal oxygen levels, total oxygen consumed and the metabolic rate of Panulirus polyphagus were estimated at different salinities, temperature and oxygen partial presence by Mohamed Kasim (1986). Kagwade (1987) has determined the age and growth of P. polyphagus off Bombay waters

based on length frequency methods. Morphological relationships and conversion factors in Panulirus polyphagus from N.W. coast of India was determined by Kagwade (1987a) Pearl et al. (1987) have described the endophragmal skeletons of P. homarus and P. ornatus. An account of the magnitude of the lobster resources of India was recently presented by Kagwade et al. (1988).

1.2.2 STUDIES ON HARVEST TECHNOLOGY

Eventhough several diverse methods are employed for catching lobsters in different parts of the world, there are only very limited references on the harvest technology of spiny lobsters in India. Hornel (1950) and Job and Pantulu (1953) have dealt with traps, though not in the context of lobsters. Balasubramanyan et al. (1960) presented a preliminary account of experimental rock lobster fishing with bottom set gill nets which was further continued with a modified gear in 1961. Some earlier accounts of fishing methods prevalent in these parts were furnished by Chacko et al. (1969). Anchor hooks, trap fishing and scoop nets were described by Miyamoto and Shariff in 1961. Jones (1967) have mentioned about the use of bully nets called 'Gadas', wall sein nets and trammel nets along Bombay coast for catching lobsters. George (1973) have made a passing reference to the use of cast nets and bottom set gill nets from canoes in north Malabar coast. Mohan Rajan et al. (1981) have reviewed the spiny lobster fishing techniques employed in various parts of the world including India basing on selected literature. They have indicated much scope for an organised and systematic approach

for future developments of this fishery on scientific lines. Preliminary experiments on development of lobster traps were reported by Mohan Rajan and Meenakumari in 1982 and the development of efficient traps for lobsters with particular reference to the design aspects were reported in 1988 by the same authors (Mohan Rajan et al., 1988). Studies on the materials for traps for spiny lobsters were published by them in 1985 (Meenakumari and Mohan Rajan, 1985). A techno economic viability study of the lobster fishing with modern traps was carried out by Mohan Rajan et al. and was reported in 1984. The extend of the trials of the newly developed lobster traps in improved design in actual commercial fishery by local fishermen were studied and reported by Kaul and Kandoran (1987).

1.3 ARTISANAL FISHERIES

The expression "spiny lobster fishery of south west coast of India" essentially means the resources in inshore region, in shallow waters, along the coast line, which for more than the last 25 years formed the main stay of landings and simple fishing craft like catamaran or canoe and traditional gear like gill nets or traps employed by artisanal fishermen who exploit it. A fishing unit consists of a catamaran, a few units of gillnets or traps the total investment on which amounts to only less than Rs.10000/-. The fishery is truly artisanal one. The fleet of large trawlers exploiting deep sea lobster P. sewelli from the off shore region is a recent phenomenon which started only from 1987 onwards. And this has ground to a halt by

1990. Technological upgradation in this case can lead to the diversification of fishing effort, there by lessening the fishing pressure on conventional stocks. The next logical step will be attempt at regulating the components of efforts like fishing craft and gear (Anon, 1978).

While planning the strategies for development of artisanal fisheries in addition to technical feasibility, social and economic feasibilities also have to be taken into consideration. The aim of the developmental strategies should be primarily to improve the living standards of target population. There should be direct linkage between fisheries development and fishermen development such that, the success achieved in a fishery will be reflected in the improved socio economic conditions of the fishermen. Technology can be an instrument of social change and vice versa social changes can trigger off technological advances. Technologies which can be adopted by persons of smaller means can be adopted by persons of larger means; but the reverse is not true. This is an important parameter in developmental strategy and research. The production methods employed must be relatively simple so that the demands for high skills are minimised. A focus on improvements to the existing technologies and development of appropriate harvest technology will directly benefit traditional fishermen. But the production oriented development strategies unless carefully guided are likely to benefit only limited individuals, resulting in inequalities and disparities in traditional sector itself.

1.4 ENERGY EFFICIENT

Time has come for redefining the goals of marine fisheries in the country in the light of energy crisis. Small scale fishermen are more energy efficient and are in a better position to adapt and adopt renewable energy sources of power (Swaminathan, 1981). Major energy input into lobster fishery is human labour. Barring the recently commenced trawling operations by some large vessels for deep sea lobsters, the question of use of fossil fuels like petroleum for exploitation does not arise. Pollution of coastal waters and damage to the coastal ecosystem is reduced. Passive forms of gear like traps and gill nets employed in their exploitation and sailing crafts like catamaran or canoe using wind energy or paddles for propulsion are highly advantageous as energy savers.

1.5 SCOPE OF THE STUDY

A study on the different aspects of spiny lobster fishery of south west coast of India with respect to the factors relevant to production, including conservation and management measures for putting this fishery on sound basis needs no emphasis. There are some aspects of this fishery which have not been sufficiently inquired into and some others which have been touched upon intermittantly and in a languid way. The attempt here is to throw light on these aspects from a production point of view. Emphasis is on harvest technology and the conservation and management measures and it is proposed to make a critical review of such measures in vogue in other lobster fishing countries and discuss about suitable methods for this fishery.

Different types of fishing gear and methods employed in the fishery at present as well as those that have become obsolete, require a study in order to standardise some of them by bringing about modifications and improvements in their construction and mode of operation. Refinement of fishing gear to suit changing conditions of the fishery is a continuing process. Adoption of newer fishing techniques and location of new resources are likely to boost the trend of the fishery. Use of properly designed and more efficient fishing gear can contribute to increased catches by extending the areas of operations to deeper waters, thereby leading to the exploitation of resources hitherto untapped. Development of an off shore trap fishery to harvest the spiny lobster population from rough and untrawlable sea bottoms would increase the production and benefit the industry. It would also reduce the competetion for and the fishing pressure on the currently producing stocks.

Trap fishing is the most predominent mode of exploitation of lobsters in these parts. One striking feature here is, that there is a form of hereditary rights on the fishing grounds, fishing areas being divided amongst the fishermen with an understanding that the area fished by one is not encroached upon by another. Fishing right is passed from father to son. This is closely intermingled with the socioeconomic balance and calls for special approach.

There is an apparent decline in abunbance due to a variety of reasons. A study on the scope of introduction of conservation and management measures has become imperative since the fear of depletion of the stock is being heard from several quarters. Steps have to be formulated for reducing the

effort and optimising the production. A sustained production by capture from the natural sources is the primary occupation on which all other secondary trades exist.

The second chapter dealing with general aspects of the fishery include the species of spiny lobsters recorded from this coast with their identity, fishing season and its duration, geographical area, areas of greater abundance, the landings, ecological aspects like physical features of lobster grounds, zoanation by depth, effect of turbulence and lunar periodicity and catch.

Under Predators, Competetors and co occuring species (Chapter III) description of three important groups of predators namely Giant rock cod (Epinephelus malabaricus), three species of Morrays and Cuttle fish which are identified as main predators on spiny lobsters in this area is furnished. Fishes belonging to 37 families co occuring are identified and reported along with other faunistic features like seaweeds, Molluscan fauna, Echinoderms Crabs and Prawns found in the same ecosystem.

Chapter IV "Studies on baits" comprises different types of baits in lobster fishing, feeding behaviour of lobsters, feeding rhythm, experiments with different baits, endurance of baits and results and discussions.

Chapter on Harvest Technology of Spiny lobsters include fishing gear in use like lobster traps, traditional traps, draw backs of local traps, development of new traps, behaviour and its importance in gear design, concept of trap design, selectivity in traps, design and construction of modern traps,

trap materials, fishing operations, strategy of fishing, scope of mechanisation of fishing, gillnets, trawls, trammel nets, cast nets, fishing spears, hand picking, obsolete fishing gear and methods like anchor hooks and scoop nets, antiquity of lobster gear, fishing crafts in lobster fishery like catamaran, canoe and mechanised boats, and development of lobster fishing boat.

Chapter VI on post harvest utilisation includes account of local trade in lobsters, export trade of whole fresh and cooked lobsters and lobster tails, byproducts, quality standards, scope of export of live lobsters and storage centres.

Chapter VII on Conservation and Management comprises of general account of conservation, Role of technology in conservation, Traditional conservation methods and tropical fisheries, trends towards decline on S.W. coast, conservation and management measures for lobster fisheries in other countries, like Australia, Newzealand and Papua New Guinea, Canada, United States of America, Latin American countries, United Kingdom, Norway, Sweden, South Africa, Spanish Sahara and Cuba. Discussion on conservation and management measures for Spiny Lobster fishery of south west coast of India include Closed season, Prohibited area, Size regulations, Gear restrictions, Physical aspects of conservation like Escape gaps in traps and finalisation of its size, Limited entry system or Licensing, Marketing restrictions and berried lobsters.

Summary and conclusions are furnished in the last chapter.

C H A P T E R - II

THE FISHERY

2.1 Species of Spiny Lobsters

Spiny lobsters are found in tropical and subtropical seas throughout the world. They are variously known as rock lobster, spiny lobster, cray fish, sea craw fish, langouste and langosta. It is said that in no other class of animals except mammals has the generally accepted scheme of classification above the family level proved to be so inadequate as in the case of crustaceans. Only a limited number of species of spiny lobsters occur in Indian waters and they are well defined. Spiny lobsters and other members of the family Palinuridae are distinguished from true lobsters by the absence of large crushing claws characteristic of the latter as well as the presence of a flexible tail fan. They are characterised by large inflated and often spiny carapace or head shield covering the forward part of the body, a pair of stiff thorny antennae or feelers extending from the head region, five pairs of walking legs and a powerful abdomen or tail terminating in a flexible and some what leathery tail fan. In western Indian Ocean, lobsters are represented by 5 families and 47 species of which only a few are considered as of interest to commercial fishery (Fischer and Bianchi 1984).

One of the earliest reports about spiny lobsters from Indian coast was by Alcock (1901) who mentioned about deep water spiny lobster Puerulus sewelli under the name Panulirus angulatus Spence Bate. Occurrance of P. dasypus has been indicated by Gravely (1927) around Krusadi island in

Gulf of Mannar. Rai (1933) has mentioned in his account of shell fisheries of Bombay presidency that Panulirus ornatus and P. fasciatus are being represented in commercial landings. Chhapgar and Deshmukh (1964) reported that species of P. polyphagus constitute 99% lobster landings in Bombay. Chopra (1939) stated that common species occuring in east coast is P. polyphagus. Chacko et al. (1969) while discussing the trend of lobster fishery in Kanyakumari district state that fishery is more or less solely constituted by species P. dasypus (Latreille). Ramanandhan and Chacko (1962) also have mentioned about few of these species on an earlier occasion. The occurrance of deep water spiny lobsters Puerulus sewelli and Palinustus mossambicus in depths of 200 to 300 m along the continental slope of south west coast of India was reported by several authors (John and Kurian 1959; George and George 1965 and Kurian 1968). George (1973) and Nair et al. (1973) have recognised six shallow water species and two deep sea forms as constituting the fishery in Indian waters. They are Panulirus homarus (Linnaeus), Panulirus polyphagus (Herbst), Panulirus ornatus (Fabricus), Panulirus versicolor (Latreille), Panulirus penicillatus (Olivier) Panulirus longipes (Milne Edwards), Puerulus sewelli Ramadan and Palinustus mossambicus Barnard.

A comprehensive account of the classification of spiny lobsters from Indian ocean is given by George and Holthuis (1965). Holthuis (1946) also proposed synonymising Panulirus dasypus and Panulirus burgeri as Panulirus homarus and this was accepted by later authors (Gordan, 1953; George, 1963

and 1964 and Kubo 1963). George (1967) has followed this in the case of Indian spiny lobsters.

2.1.1 Systematic position

Correct identity of the species of lobsters that constitute the fishery is a necessary prerequisite in the study of the fishery. Taxonomic position of the spiny lobster is:

Kingdom	Animalia
Phylum	Arthropoda
Class	Crustacea
Subclass	Malacostraca
Series	Eumalacostraca
Super order	Eucarida
Order	Decapoda
Suborder	Reptantia
Section	Macrura
Family	Palinuridae

2.1.2 Characters of Taxonomic Importance

Crustaceans are mandibulate Arthropods with biramus jointed appendages, two pairs of antenna, one (or rarely more) pair of segmental excretary organs and often with stalked compound eyes, carapace, aquatic habits, gills and free swimming nauplius larva. Six anterior segments are fused with presegmental region (acron) to form a head, while the trunk is divisible into

an anterior thorax and a posterior abdomen terminated by a post segmental region or telson (Marshall and Williams 1972). With few exceptions crustaceans are aquatic in habit and occur in fresh water, in the sea, in brine pools and in subterranean caves (Patwardhan 1958). The body is covered externally by an exoskeleton made of chitinous cuticle which becomes thickened in regions where no movement is required, forming a series of hard parts or sclerites separated by flexible chitin. The exoskeleton is usually calcified. Sexes are separate and often display sexual dimorphism.

Sub class Malacostraca comprises of distinctly segmented crustacea with body clearly divided into a head, thorax and abdomen and with a telson constituting a post segmental region. There are a fixed number of segments, typically twenty; rarely twentyone. Of these, head constitutes six, the thorax eight and abdomen six or seven. The posterior margin of the head commonly fuses with one or more thoracic segments to form cephalothoracic carapace. There are no caudal styles. The antennules are often biramus.

Series Eumalacostraca include malacostracans with twenty body segments of which six constitute abdomen. Thoracic appendages are typically leglike.

Eumalacostraca with carapace which fuses to all thoracic segments to form a cephalothorax constitute super order Eucarida. The eyes occur on movable stalks. Development is usually indirect; typically with a zoea larval stage.

2.1.3 Order : Decapoda

The order Decapoda owes its name to the fact that its members have their hinder 5 pairs of thoracic limbs adapted for locomotion, typically as walking legs; some times as swimming organs. First three pairs of thoracic appendages are modified as maxillipedes. They have well developed elongated abdomen which is usually held in a extended position. The larva is characteristically a zoea.

2.1.4 Suborder : Reptantia

Decapoda which are usually dorsoventrally flattened and in which restrum is often short or absent. The abdomen may be well developed or strongly reduced; but the first abdominal segment is always shorter than the following ones. The peraeopods are strong with the first pair usually well developed and with pincer like claws. Pleopodes 1-5 are often reduced and are never adapted for swimming. They are creeping forms.

2.1.5 Section : Macrura (Palinura)

Reptantians in which the abdomen is well developed and has a broad tail fan. There are numerous gills. The rostrum is almost always small or absent while the body is often depressed.

2.1.6 Family : Palinuridae

The Palinuridae is a very successful group of benthic decapod crustacea comprising of about 47 species of spiny lobsters in the world. Spiny lobsters have carapace rounded in section (sub cylindrical) without distinct median

rostrum, ornamented with spines and granules of various sizes. Eyes are protected by strong spiny frontal horns. Antennae long and whip like, antennules slender, each consisting of a segmented peduncle and two flagella. In some genera bases of the antenna are separated by a broad antennular. plate usually bearing one or two pairs of spines but spineless in some species. A stridulating organ present at the base of antenna, producing sound. Tail with a well developed fan. Legs without true spincers. Abdominal segments either smooth or with one or more transverse grooves.

Most of them are shallow water forms (rarely extending beyond 100 m in depth) living singly or in groups. They hide in crevices and inside the holes of submerged rocks and lurk on stony corals and seaweed beds or other habitats that offer protection like stones and concrete blocks that buttress the foot of harbour walls. Some are more common in deeper waters upto 300 m in depth (Justicia, Linuparus and Puerulus).

2.1.7 Genus : Panulirus

The Caphalothorax is sub cylindrical and eyes are not enclosed in separate orbits formed by the edges of carapace; a flagellum is present in the second antenna in place of flat exopodite; there are no chelae the legs all ending in simple claws; antennae is of immense size and their proximal segments are fused with one another and with the carapace, quite crowding the epistoma.

2.1.8 Species, distinctive characters and distribution

In a recent revision of Indo West pacific spiny lobsters of the genus Panulirus, George and Holthuis (1965) have recognised eleven species, they

being Panulirus hamarus (L) P. ornatus (Fabricus) P. polyphagus (Herbst) P. versicolor (Latreille), P. penicillatus (Olivier), P. longipes (Miles Edwards), P. japonicus (von Seibold), P. pascuensis Reed, P. marginatus (Quoy and Gaimard) P. cygnus George and P. stimpsoni Holthuis.

According to Nair et al. (1973) and George (1973) only first six species of the genus Panulirus are found to occur along the coast of India. Diagnostic characters of the above species have been dealt with by Nair et al. (1973). In addition, one species each of the genus Puerulus and Palinustus have been recorded from deeper waters. Detailed description of all these species and their diagnostic characters are furnished by Fischer and Bianchi (1984).

2.1.8.1 Panulirus homarus (Linnaeus, 1758) Fig.1

Other Scientific names in use	:	P. dasypus (H. Milne Edwards, 1837)
		P. burgeri (De Haan, 1841)
Vernacular names	:	English - Scallopped spiny lobster
French	:	Langouste festonnee
Spanish	:	Langosta festoneada

Distinctive Characters

Carapace rounded, covered with numerous spines of varying sizes. Flagella of antennules longer than peduncle; rostrum absent; bases of antenna separated by a broad antennular plate, bearing 2 equal well separated principal spines and scattered smaller spines in between. Each abdominal segment with a transverse groove, sometimes interrupted in the middle; its anterior margins formed into shallow scallops. Legs 1 to 4 without spincers.

Fig: 1 **Panulirus homarus**

Colour: P. homarus is dark greenish with numerous very small white spots, without transverse bands, antennules banded with white and greenish. Legs with indistinct spots and stripes of white.

This species enjoys very wide distribution in the Indo-Pacific region extending from S. Africa through Red sea, South coast of Arabia and Indian seas and Japan. The record of this species in India was till recently in the name of two species, namely, P. dasypus and P. burgeri. These two have been synonymised with P. homarus (Holthuis, 1946). It is found to occur along the west coast and southern part of east coast. This species contributes to maximum landings in S.W. coast. The maximum size attained is 32 cm in length.

2.1.8.2 Panulirus penicillatus (Olivier, 1791)

Other Scientific names in use : none

Vernacular names: English - Proughorn spiny lobster
French - Langouste fourchette
Spanish - Langosta horquilla

Distinctive Characters

Carapace rounded with numerous spines and nodules of varying size; rostrum absent, bases of antennae separated by a broad antennular plate bearing 2 pairs of almost equal principal spines joined at their bases; their tips diverging. Each abdominal segment with a transverse groove not joining the pleural groove. Anterior legs 1 to 4 without spincers.

Colour: Ground colour ranging from yellow green through brown green to dark reddish brown with many cream spots on upper surface of carapace and many tiny spots on the abdomen. Antennular flagella uniform green or brown; legs with fine or broader longitudinal white to yellow stripes.

This species is known to occur through out India and southern Pacific oceans, records extending from South Africa through red sea and Indian seas to north Australia, New Guinea and Hawain islands. First record of this from Indian coast was by obtaining a single specimen from catches off Quilon (Satyanarayana 1961). Its occurrance in Minicoy islands Maldives and Srilanka has definitely been established. Species is known to grow upto about 45 cm in length.

2.1.8.3 Panulirus longipes (A. Milne Edwards, 1868) Fig.2

Other scientific names in use : Panulirus japonicus V. Siebold

Vernacular names : English - Longlegged spiny lobster

French - Longouste diablotin

Spanish - Longosta duende

Distinctive Characters

Bases of antenna separated by a broad antennular plate bearing one pair of principal spines followed by some scattered minor spines. Each abdominal segment with complete transverse groove joining the pleural groove.

Colour: Basic colour variable from brown through blue to indigo. Carapace and tail covered with numerous medium sized pale spots and a central darker

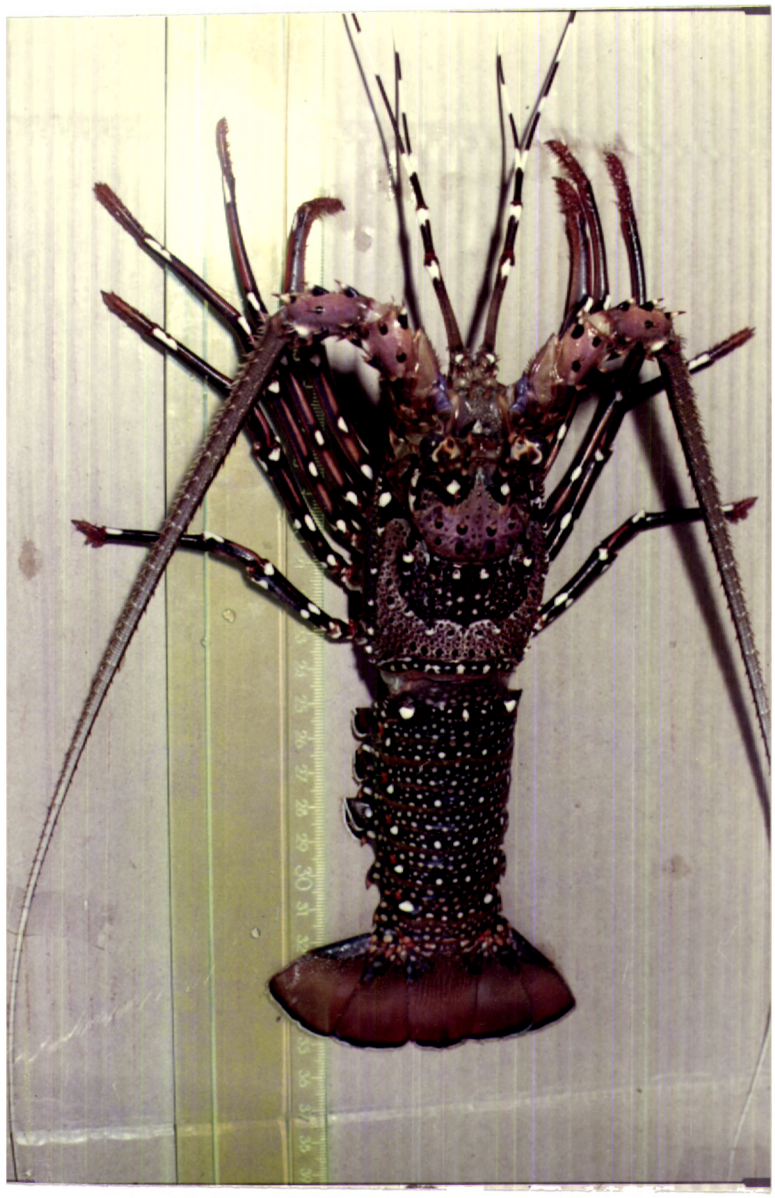


Fig:2 Panulirus longipes

region on carapace; antennal and antennular flagella cross banded; legs with spots of white and lines of yellow in between.

In the Indo west pacific, this species has very wide distribution, extending from East Africa, through Indian seas and Malayasia to Japan. P. longipes occurs both on the South East and South West coast of India. The confusion in the identity of Panulirus Japonicus group was cleared by George and Holthuis in 1965 in their revision of the genus Panulirus. Based on the colour pattern of the legs of P. longipes they recognised two subspecies viz. spotted form P. longipes longipes (A. Milne Edwards) and striped form P. longipes femoristriga (von Martens). The Indian form belong to the sub-species P. longipes longipes.

2.1.8.4 Panulirus polyphagus (Herbst, 1793)

Other scientific names in use : Panulirus fasciatus (Fabricus 1798)

Vernacular names : English - Mud spiny lobster
French - Langouste de vase
Spanish - Langosta fanguera

Distinctive Characters

Carapace covered with numerous spines and tubercles of different sizes; bases of antennae separated by a broad antennular plate bearing a single pair of principal spines; antennules very long, about $1\frac{1}{2}$ times the total body length; abdominal segments without transverse groove.

Colour: Dull greenish, abdominal segments each with a distinct transverse band of white (not black edged) across posterior margin. Antennules broad banded; legs irregularly blotched cream white.

This species has been frequently referred to as P. fasciatus (Fabr) which is a junior synonym of P. polyphagus (Premakumar and Daniel 1975). General distribution of this species is throughout Indo-pacific region from Mauritius through Indian seas to Java, Borneo and great Barrier reef. In Indian waters it occurs more on the west coast especially in northern region. It contributes to a fishery in Bengal coast also. On the south west coast it was recorded by George and Rao (1965). From S.E. coast it was first recorded by Nair et al. (1973). A maximum size of 45 cm is reached by the males.

2.1.8.5 Panulirus ornatus (Fabricus, 1798) Fig.3

Other scientific names in use : Nil

Vernacular names: English - Ornate spiny lobster

French - Langouste ornee

Spanish - Langosta ornamentada

Distinctive Characters

Carapace rounded, covered with numerous spines and tubercles of different sizes. Flagella of antennules longer than antennular peduncle, rostrum absent; bases of antennae separated by a broad antennular plate bearing one pair of principal spines anteriorly and a second pair half the size of the first in the middle of the plate. Each abdominal segment smooth, without transverse groove. Legs without pincers.

Colour: Bluish or greenish; spines on the Carapace yellow: anterior part of the carapace on and near the bases of frontal horns and anterior spines

Fig:3 Panulirus ornatus

with vermicular pattern of pale and dark lines; abdominal with a broad dark transverse brand over the middle of the segments; each segment with a large pale spot on the sides and an additional oblique elongate mark higher up on second, third and fourth segments; legs with distinct sharply defined dark and pale blotches.

This has a distribution in the Indo Pacific region from East Africa and Mauritius through Indian seas and Malayasia to northern Australia. In India it is found to occur on both west and east coast contributing to a fishery in some places. Prasad and Tampi (1969) show the records of this lobster from several localities on the west coast of India. It also grows to a maximum size of 46 cm in length.

2.1.8.6 Panulirus versicolor (Latreille, 1804) Fig.4

Other scientific names in use : Nil

Vernacular names:

English - Painted spiny lobster

French - Langouste barriolae

Spanish - Langosta coloreta

Distinctive Characters

Bases of antennae separated by a broad antennular plate bearing 2 pairs of unequal and separated principal spines. Abdominal segments without transverse grooves. Legs 1 to 4 without pincers.

Colour: Green blue with a distinctive pattern of blue black patches and white lines on carapace; a transverse band of white bordered by two black

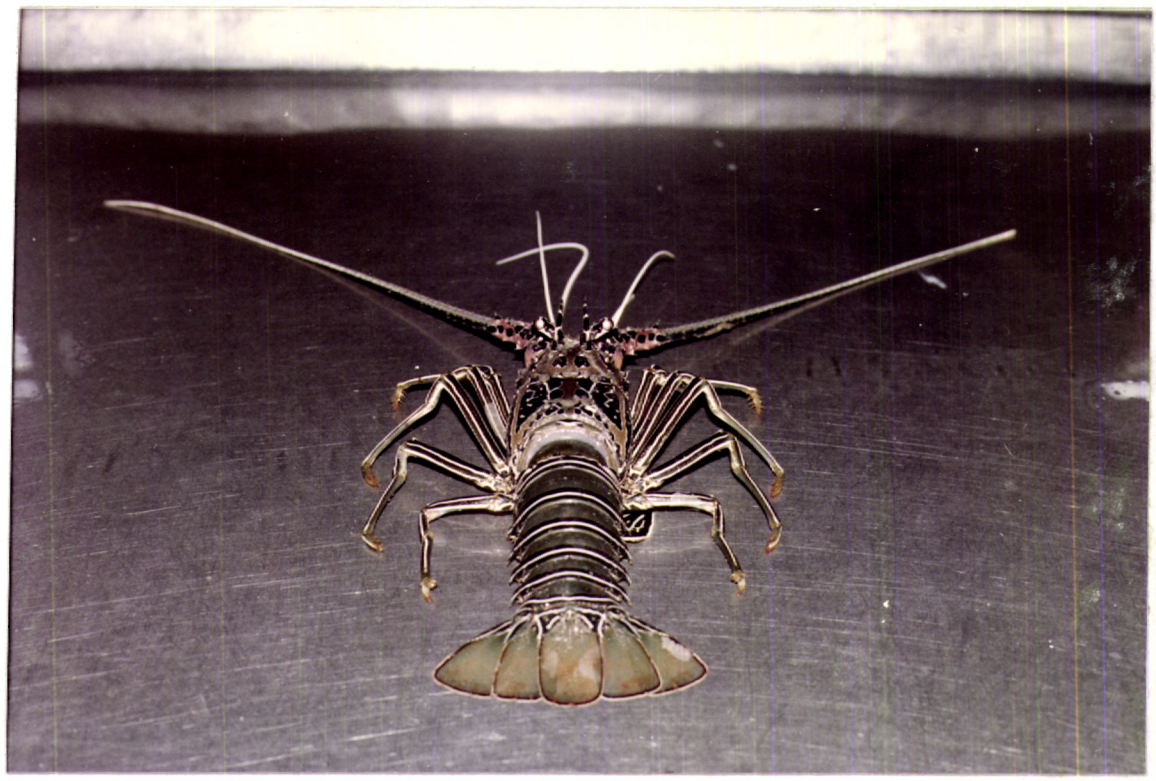


Fig:4 Panulirus versicolor

lines across each abdominal segment; legs and antennules longitudinally striped; bases of antenna bright pink not extending onto antennular plate.

This also is a common species known through Indo Pacific region. But it is the rarest of commercial species along Indian coast. Though not contributing to any substantial fishery, it is found to occur in small numbers in several locations in both west and east coast of India. Very recently P. versicolor has been recorded from central Andhra Coast (Satyanarayana 1987). From Minicoy it was reported recently and it is estimated that P. versicolor may take 10 to 11 years to attain a length of 460 mm the maximum this species known to reach. (Pillai et al., 1985).

2.1.8.7 Puerulus sewelli Ramadan, 1938

Other scientific names in use : Nil

Vernacular names : English - Whip lobster
French - Langouste fouet
Spanish - Langosta de fusta

Distinctive Characters

Carapace angular with a medium and two lateral tuberculate longitudinal ridges behind the transverse cervical groove and three pairs of ridges in front; medium post cervical ridge with 8 small teeth; frontal horns compressed and sharply pointed with a single small sharp tooth on basal part of the anterior margin. Antennules slightly over reaching antennal peduncle; antennular plate present, without spines forming stridulating organ with antennal peduncle. Basal part of antennal peduncle with a large rounded ciliate lobe

on inner margin. Pleura of abdominal segments ending in one or two sharp teeth.

The genus Puerulus ortman includes three valid species viz. Pueruls angulatus (Bate) P. sewelli Ramdan and P. velutinus Holthuis. All these species occur in Indian ocean region. P. sewelli has been reported from Gulf of Aden, Arabian sea off S.W. coast of India, Gulf of Mannar and Ceylon at depth ranging from 73 to 1309 m (Holthus 1966). After initial record of the species off Travancore coast by Alcock (1901) the exploratory trawling off Kerala Coast has revealed its occurance in fairly large quantities to support commercial fishery in depths ranging from 200-300 metres. Since the last few years it has developed into a significant commercial fishery exploited by several deep sea trawlers. The maximum size obtained is 20 cm.

2.1.8.8 Palinustus mossambicus Barnard 1926

Distinctive Characters

Antennular plate and stidulating organ present; frontal horns truncated with anterior margin crenulate; first segments of antennular peduncle reaching beyond antennal peduncle. Abdominal pleura ending posteriorly in 2 almost equal spines; no additional spinnules on posterior margin.

Till recently it was considered to be rare, being known only from five male and one female specimen from Portuguese East Africa and Sulu Sea. George and George (1965) reported about one female specimen obtained

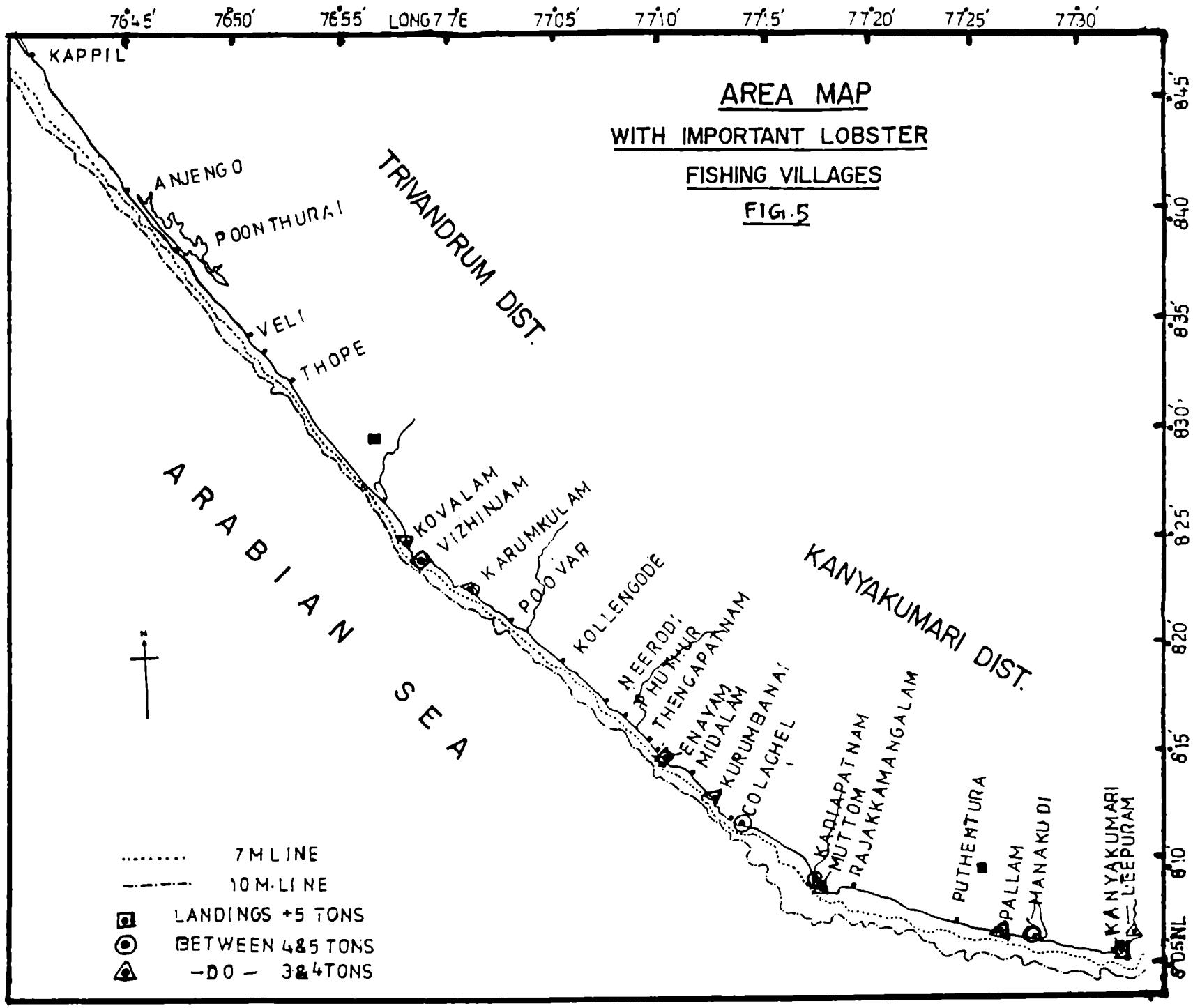
from the stomach of a fish caught off calicut. Since then it has been caught in fairly large numbers in exploratory trawling off Kerala coast and from other localities. The size of the specimen is not attractive, the maximum size noticed being 13 cm in total length.

2.2 Fishing Season

In Kanyakumari district a regular fishing season for lobsters commences by the first half of October corresponding to Tamil month of 'Alpasi' and lasts for about 6 months upto April corresponding to Tamil month of 'Pankuni'. In Trivandrum district fishing starts from September itself. But landings by gill nets are taking place whenever possible except during monsoon months. Peak landings are towards the beginning of the season. Amount of effort declines considerably from the month of February onwards.

2.3 Geographical Area

Arabian sea adjoining the coasts of Trivandrum district of Kerala and Kanyakumari district of Tamilnadu on the extreme S.W.coast of India constitute the geographical area for this study. It falls within the geographical range of 76° 42' 20"-77° 34' E Long. and 8° 4' 30" - 8° 46' N. Lat. (Fig.5). The length of the coast line is 146 km. Major share of landings in Trivandrum district is from mechanised boats and gill nets where as it is by traditional crafts and traps in Kanyakumari district. Out of 97 fishing villages in this area (48 in Trivandrum district and 49 in Kanyakumari district), only 30 villages are important from lobster fisheries point of view. Leepuram village in Kanyakumari district is actually on the Bay of Bengal side.


AREA MAP
WITH IMPORTANT LOBSTER
FISHING VILLAGES
FIG.5
76°45'
76°50'
76°55'
LONG 77°E
77°05'
77°10'
77°15'
77°20'
77°25'
77°30'
8°45'
8°40'
8°35'
8°30'
8°25'
8°20'
8°15'
8°10'
8°05'NL
KAPPIL
ANJENGO
POONTHURAI
VELI
THOPE
TRIVANDRUM DIST.
KOVALAM
VIZHINJAM
KARUMKULAM
POOVAR
KOLLENGODE
NEERODI
PHUTHUR
THENGAPATNAM
ENAYAM
MIDALAM
KURUMBANAI
COLACHEL
KADIAPATNAM
MUTTOM
RAJAKKAMANGALAM
KANYAKUMARI DIST.
PUTHENTURA
PALLAM
MANAKUDI
KANYAKUMARI
LEEPURAM
ARABIAN SEA
7M LINE
10 M-LINE
LANDINGS +5 TONS
BETWEEN 4&5 TONS
-DO- 3&4TONS

2.4 Area of Greater abundance

Abundance appears to be uniform in this stretch of coast but heavy landings are recorded from some fishing centres like Vizhinjam, Enayam, Kadiapatnam and Kanyakumari compared to others.

2.5 Landings

The total lobster landings at present from this stretch of the coast is estimated to be 101.9 tons annually. Out of 97 fishing villages in this geographical area, only 30 villages are important lobster producing centres. 3 centres namely Vizhinjam (10.7 tons) Enayam (5.2 tons) and Kanyakumari (5.2 tons) land more than 5 tons per annum. 3 others namely Kadiapatnam (4.8 tons) Colachel (4.8 tons) and Manakudi (4.0 tons) land between 4 to 5 tons a year. There are 7 centres which contribute around 3 tons a year, 8 centres with an average of 2 tons and 9 with 1 ton landings per year. In 18 fishing villages in this stretch there is no lobster fishery worth mentioning and the productions is negligible. Remaining 49 villages together contribute 19.6 tons.

Gear wise 40% of the production is contributed by traps 40% by gill nets 12% by trawls, 7% by trammel nets and 1% by hand picking and spearing. The trends of production by different gear systems in few important fishing centres are exemplified below:

a) Vizhinjam:

Active number of trap fishing units	:	40
Average landings/day/unit	:	0.9 kg.
Total landings by traps/day	:	36 kg.
Total landings for 120 active fishing days in a year	:	4320 kg.
No. of active gill net units in lobster fishery	:	60
Average landings/day	:	0.75 kg.
Total landings by gill net units/day	:	45 kg.
Total landings for 120 fishing days	:	5400 kg.
By other methods (incidental catches from trawls, trammel nets, hand picking etc.)	:	1000 kg.

Total : 4320 + 5400 + 1000 = 10720 kg.

b) Enayam;

Active number of trap units	:	40
Average landings/unit/day	:	1 kg.
Total landings for 120 days	:	40 x 120 = 4800 kg.
From other sources like hand picking spearing etc.	:	400 kg.
Total	:	5200 kg.

c) Kanyakumari:

Active numbers of trap units	:	20
Average catch/unit	:	0.5 kg.
Total catch for 120 days	:	1200 kg.
No. of gill net units	:	50

Total landings for 120 days at an average of 0.5 kg/day	:	25x120 = 3000 kg.
By other methods like trawling, trammel net hand picking etc.	:	1000 kg.
Total	:	1200+3000+1000
	:	5200 kg.

2.6 ECOLOGICAL ASPECTS

A field study concerning spiny lobsters require a broader foundation particularly of ecological sorts. Ecology determines the habitability and the abundance of fauna and flora in a given environment. Basic functional unit of ecology is the ecosystem. Aquatic ecosystems are poorly understood, relatively unmanageable, shared by multiple users and highly vulnerable to human intervention and climatic change. The functional unit called ecosystem embraces both the biotic and abiotic components in a defined geographical area. In this complicated functionary system, each species has its place. This place in the system is called ecological niche of the species. A natural functionary system is composed of a series of ecological niches, each of which is occupied by a certain species. The maintenance of this niche by the species is not only dependant on spatial position of the species but also on the role it place in the system. Marine environment is more or less continuous. It may therefore, be difficult to distinguish ecosystems from one another. Since it is difficult to demarkate an ecosystem in the sea, it is ultimately upto the ecologist himself to delimit the ecosystem he is working with. Unlike most scientific fields which have relatively well defined

boundaries, ecology is for practical reasons "an exceptionally multi disciplinary kind of biology" (Deevey, 1964). Lobster ground is a self supporting ecosystem. Ecological regimes do not differ substantially in lobster grounds. Sea bottom is the natural abode of lobsters. Most characteristic feature of the habitat of many of the Palinurids is the residence area or the den. Dens are not usually constructed by lobsters but are opportunistically chosen from the surrounding habitat. Lobsters are distributed non randomly among available den sites.

2.6.1 Physical Features

India's shore line tapers into a peninsula at the tip of which is the confluence of 3 seas, the Arabian Sea, Bay of Bengal and Indian ocean. The area under study forms a part of this extreme tip. Perhaps no where else is the coastal region subjected to such drastic changes in environment as it is along peninsular India because of two monsoons - the south west and north east. The rainfall, the run off fresh water from land and those disgorged by land rivers into the sea, together with abrasive action of the wind and waves cause tremendous ecological impact which is not fully fathomed.

Submarine plateau of S.W. Coast of India is bordered by two distinct contour lines of 7 m and 10 m. The 7 m line is less than 1 nautical mile from the shore and 10 m line 2 to 2.5 nautical miles. The later is broadest at Muttam point where it is about 2.5 nautical miles from shore. Very heavy surf breaks all along the coast and this shallow surf beaten rocky zone within the 7 m line is the home of majority of spiny lobsters.

The surface of the plateau is sandy in many places with outcrops of rocks in the form of flat or slightly inclining ledges, occasionally forming low terraces. The local fishermen are intimately familiar with these features. They have attributed separate identities to most of them from their intimate knowledge of the locale. Mahadevan and Nair (1974) have given an account of the ecology of Pearl and Chank beds. The features of lobster grounds are more or less similar in several respects. Character of the substratum in lobster ground in S.W.Coast is basically rocky. It is granite rock in some places like Colachel , Vizhinjam and Kadiapatnam and soft calcareous rocks forming 'Pars' in places like Pallam.

Sea floor is replete with multitudes of dead shells in places like Enayam, Kollengode and Thuthur where shell quarrying is a regular practice. Shell quarying for preparation of lime is a remunerative part time occupation generating reasonable income. Lobster fishermen who are good divers also resort to this, during the off season. In some villages this is the major source of sustenance during some months.

In some places elevated rocky edges suddenly drop vertically down to adjacent sandy grounds with deep cuts. Lobsters and varieties of fish abound in these under cuts. It is also not uncommon to see laminated rocky flats over which coarse particles mainly made up of broken shells and tongue of cuttle fishes are spread all over. Large empty Molluscan shells are fished out from such places and sold as curios. They include shells like Xancus pyrem, Hemifuses, Olivia, Lambis, Tonna dolium, Trochus, Turbo, Murex,

Nautilus, Cyprea, Pecten, Bulla, Turritella, Cardium and Crassostrea. Lobster grounds are always subjected to heavy oscillations at the bottom because of nearness to shore line. Long swells are always present, churning and throwing up the bottom. Between Colachel and Kanyakumari, the coast is particularly exposed and surf beaten throughout the year. Temperature in various centres during the active fishing season of October to March varies from 26°C to 32°C and pH from 8.00 to 8.60.

2.6.2 Zonation by depth

Some form of demarkation in depth wise distribution of lobsters is recognisable. Adult habitat preferance varies among Palinuridae from shallow intertidal surf zones to great ocean depths characterised by perpetual darkness and soft mud ooze substrates (Kanciruk 1980). Observations reveal that P. homarus moves progressively from shallow waters to deeper waters as they grow bigger and bigger. Largest specimens are always landed in traps operated little deeper or by gillnets which are always operated in deeper areas than traps. The robust build and stout legs of P. homarus enable it to navigate with sure footing among surf washed rocks. P. ornatus the other predominant species, inhabit deeper zones than P. homarus. P. longipes coexists with P. ornatus in the same depth zone. And among the shallow water forms P. polyphagus inhabit the deepest zone in even sea floor where they are caught by trawling. Of course Puerulus sewelli and Palinustes mossambicus are recorded only from depth beyond 150 m along S.W. coast. Similar observations were made in the case of P. argus from Caribbean waters (Munro, 1983).

Zonation by depth is best illustrated in clawed and spiny lobsters off Durban S. Africa. Berry (1969) records that clawed lobster Nephrops stewarti alone is found at depths greater than 300 fathoms. Between 300 fathoms and 230 fathoms, both N. stewarti and Metanephrops andamanicus coexist, but M. andamanicus is dominant crustacean on the ledge between 220 and 230 fathoms. P. gilchristi is the dominant crustacean trawled at shallow depths of 60 to 80 fathoms, while in the shallowest waters from coastal reefs to about 10 fathoms, spiny lobsters of the genus Panulirus particularly P. homarus predominate. Holthuis (1974) showed that in the Atlantic, there is a vertical zonation of sub families of nephropsid lobsters. George (1958) showed by tagging studies that there is an annual migration in November and December of preadults of P. cygnus into adult population in deeper waters. Detailed studies of preferred ecological habitats within one genus show that each species has particular environmental requirements within a generally acknowledged sympatric area (Phillips et al., 1980).

2.6.3 Effect of turbulence

Turbulence of water in lobster grounds and consequent churning effect is found to result in fairly increased landings of lobster the next day. Lobsters come out of their dens in large numbers and good catch result during such periods. It is noticed that water becomes turbid with suspended silt and sand particles and this is lashed into the lobster dens every now and then by current. This forces the lobster to come out of their dens into the open, and then they are believed to enter the traps by way of seeking shelter.

Water temperature is observed to be less than normal due to influx of cold water masses from adjoining areas or due to rains. Ample evidences exist that turbulence influence the movements of several species; yet such stimulii are not monitored in situ (Berry 1971; Heydorn 1969; Mitchel et al., 1969).

2.6.4 Lunar Periodicity and catch

Lunar periodicity has been found to influence the behaviour of several marine organisms, especially crustaceans. The effect is more pronounced in activities relating to reproduction and catch. Effect of different phases of moon on the spawning behaviour and catch has been observed and reported by several authors both in the case of vertebrates and invertebrates. In the case of fishes, such instances have been reported earlier in the case of East Anglian herring (Hickling 1956). Jayaraman et al. (1959) have observed that the catch rate for 'dara' (Eleutheronema tetradactylum) in trawling grounds off Dwaraka was higher in spring tide periods during January and May, and in neap tide periods in all other months. Bhatt et al. (1964) while studying the 'Ghol Dara' fishery off Gulf of Kutch have reported instances of lunar periodicity and high catch. Catches tend to be very good around new moon and full moon days.

Fluctuations in prawn landings are believed to be closely associated with phases of moon in the inland tidal systems. Marked lunar and diurnal variations in prawn landing are well established (Racek, 1959). Similar observations were made in Godavari estuarine system where the total prawn catches and migratory pattern of commercial prawns were closely linked with the

phases of the moon at the mouth region of the estuary (Subrahmanyam 1965). While dealing with fluctuations in prawn landings in Chilka lake, Subrahmanyam (1966) found that a remarkable alternating lunar periodicity in the relative abundance of the two species of prawns is demonstrated; Penaeus monodon showed abundance during the new moon fortnight while P. indicus showed abundance during the full moon fortnight. On further observations on the relationship between lunar periodicity on prawn abundance, it was observed that landings of P. monodon during the new moon phase were heavier than landings during full moon phase. Recruitment of post larvae shows special abundance during new moon fortnight (Subrahmanyam 1967).

Phototactic responses are inconsistent among Palinurids (Little Jr.1977). Illumination due to bright moon light has been shown to inhibit the foraging of adult lobsters (Sutcliffe, 1956). Phillips (1972) and Rimmer and Phillips (1979) report that recruitment of Western Australian Rock lobster, P. longipes cygnus occurs primarily during new moon, but Serfling and Ford (1975) found no lunar periodicity in post larval recruitment of California spiny lobster, P. interruptus. Little Jr. (1977) records that the inverse relationship between light and the post larval lobster recruitment is not always consistent in the case P. argus of South Florida Coast. Lunar periodicity in catch rate is now established in the case of Japanese lobster P. japonicus (Kubo, 1962; Kubo and Ishiwata, 1964). Studies of Morgan (1974) have established the same in the case of P. cygnus. Harada (1957) has reported on the nocturnal attraction of post larval P. japonicus. De Bruin (1962) observed differences

in landing of two species of spiny lobsters during full moon days in Ceylon. In the case of Norway lobsters, their emergence from the burrows are affected by tidal and lunar cycles. There is some evidence to show that larger catches are made during the period of neap tides. The reason for this is not fully understood, but it may be a direct effect of moon light (Howard, 1982).

The data pertaining to the lobsters landed by one traditional lobster trap fisherman from Enayam in the Kanyakumari district, operating 10 traps daily on an average for two seasons, namely 1988-89 and 1989-90, was monitored for ascertaining the relationship between lunar phases and the catch of lobsters by traps. The fishing starts by October and ends by April. The landings are more in the beginning of the season and largest specimens are also landed during this time. The catch gets gradually reduced and specimens become smaller and smaller as season advances. During peak fishing season traps are lifted every day except on Sundays. As the catch trickles down,they are lifted only once in two or three days.

A perusal of data (Table 1) reveal that increased catches are landed during newmoon period. This increase in landings commence two to three days prior to the new moon day and continues for five to six days after wards. Miyamoto and Shariff (1961) have also mentioned that increase in catches take place during new moon period by about twice that of full moon period. Lunar periodicity may help the organisms to bypass several environmental constraints in achieving the process of spawning and larval developments. It may be temporarily masking the inhibitive effects of environmental factors on the fishery. This helps in the movement of the organism to within the catching range of the gear resulting in increased landings.

TABLE - 1

Details of catch by one trap fisherman at Enayam

1988-89 and 1989-90 fishing season

Phase of the moon	Date	No. of lobsters landed	Weight (g)	Phase of the moon	Date	No. of lobsters landed	Weight (g)
●	10.10.88	22	5800		2.11.88	3	1250
	11.10.88	22	5200		3.11.88	1	350
	12.10.88	17	4200		5.11.88	1	175
	13.10.88	14	3800		7.11.88	4	1950
	14.10.88	9	2100		8.11.88	6	1400
	15.10.88	10	2400	●	9.11.88	7	1550
	18.10.88	13	4400		10.11.88	7	1500
	19.10.88	12	4300		11.11.88	3	800
	20.10.88	10	3500		12.11.88	3	800
	21.10.88	1	600		14.11.88	1	300
	22.10.88	13	4725		16.11.88	1	250
	24.10.88	30	12525		18.11.88	1	400
○	25.10.88	6	2550		19.11.88	1	450
	26.10.88	1	200		21.11.88	1	350
	27.10.88	1	350	○	22.11.88	1	310
	28.10.88	1	250		23.11.88	2	660
	31.10.88	4	1975		24.11.88	1	250
	1.11.88	1	500		25.11.88	1	280

Table - 1 (Contd...)

Phase of the moon	Date	No. of lobsters landed	Weight (g)	Phase of the moon	Date	No. of lobsters landed	Weight (g)
	28.11.88	2	580		30.12.88	2	620
	30.11.88	4	2200		2.01.89	2	700
	1.12.88	3	740		4.01.89	1	240
	3.12.88	1	240		5.01.89	4	1100
	5.12.88	3	1125		6.01.89	3	850
	6.12.88	1	280	●	7.01.89	3	800
	7.12.88	3	940		9.01.89	Traps not lifted	
	8.12.88	6	1875		10.01.89	1	500
●	9.12.88	5	1620		11.01.89	2	840
	10.12.88	5	1425		13.01.89	1	350
	12.12.88	1	350		16.01.89	1	300
	14.12.88	2	625		18.01.89	1	250
	16.12.88	1	280		19.01.89	2	1050
	17.12.88	2	600	○	20.01.89	4	1350
	19.12.88	1	240		21.01.89	2	550
	21.12.88	3	1475		23.01.89	1	275
○	23.12.88	2	650		25.01.89	1	200
	24.12.88	1	340		27.01.89	1	125
	26.12.88	2	950		30.01.89	3	625
	28.12.88	1	280		1.02.89	3	575

Table - 1 (Contd...)

Phase of the moon	Date	No. of lobsters landed	Weight (g)	Phase of the moon	Date	No. of lobsters landed	Weight (g)
	3.02.89	2	650	●	7.03.89	2	520
	4.02.89	2	650		8.03.89	1	270
●	6.02.89	3	800		9.03.89	1	260
	7.02.89	2	550		10.03.89	1	220
	8.02.89	2	400		13.03.89	2	480
	9.02.89	1	200		15.03.89	1	320
	11.02.89	1	260		17.03.89	1	280
	13.02.89	1	220		18.03.89	1	180
	16.02.89	1	240		20.03.89	2	410
	18.02.89	2	420		21.03.89	1	190
○	20.02.89	2	625	○	22.03.89	1	210
	21.02.89	1	225		25.03.89	1	240
	22.02.89	2	400		27.03.89	2	480
	24. 02.89	1	280		28.03.89	1	240
	27.02.89	3	850		29.03.89	3	800
	28.02.89	1	420		30.03.89	1	220
	2.03.89	1	280		1989-90 Season		
	3.03.89	2	475		17.10.89	1	400
	4.03.89	3	620		18.10.89	14	5100
	6.03.89	3	780		19.10.89	12	5050

Table - 1 (Contd...)

Phase of the moon	Date	No. of lobsters landed	Weight (g)	Phase of the moon	Date	No.of lobsters landed	Weight (g)
	20.10.89	8	4500		11.11.89	3	1650
	21.10.89	2	650	○	13.11.89	2	650
	23.10.89	3	950		14.11.89	4	1550
	24.10.89	2	600		16.11.89	3	1400
	25.10.89	3	800		17.11.89	1	300
	26.10.89	6	2850		18.11.89	1	300
	27.10.89	12	5100		21.11.89	2	500
	28.10.89	13	5800		23.11.89	2	700
●	29.10.89	6	2850		25.11.89	4	1280
	30.10.89	5	1675		27.11.89	4	1025
	31.10.89	4	1400	●	28.11.89	4	1550
	1.11.89	3	850		29.11.89	3	1225
	2.11.89	3	900		30.11.89	1	475
	3.11.89	8	3100		4.12.89	2	650
	4.11.89	3	1025		6.12.89	1	300
	6.11.89	10	4270		9.12.89	1	300
	7.11.89	3	1300		11.12.89	2	580
	8.11.89	2	950	○	12.12.89	1	375
	9.11.89	3	1075		13.12.89	2	700
	10.11.89	2	625		15.12.89	1	275

Table - 1 (Contd...)

Phase of the moon	Date	No. of lobsters landed	Weight (g)	Phase of the moon	Date	No. of lobsters landed	Weight (g)
	19.12.89	1	300		4.02.90	1	600
	22.12.89	2	650		7.02.90	1	450
	26.12.89	4	900	○	9.02.90	1	400
	27.12.89	4	1075		12.02.90	1	350
●	28.12.89	3	950		13.02.90	3	1050
	29.12.89	3	900		15.02.90	1	250
	30.12.89	2	525		17.02.90	1	275
	1.01.90	3	900		20.02.90	2	750
	2.01.90	2	700		22.02.90	2	550
	3.01.90	1	175	●	25.02.90	Traps not lifted	
	5.01.90	1	220		26.02.90	3	800
	8.01.90	1	450		27.02.90	1	325
	9.01.90	3	875		28.02.90	2	600
○	11.01.90	1	600		1.03.90	1	250
	13.01.90	1	275	○	11.03.90	Traps not lifted	
	18.01.90	1	650		12.03.90	2	450
	22.01.90	3	1350		15.03.90	1	250
	23.01.90	9	3400		17.03.90	1	260
	25.01.90	4	1240		19.03.90	1	200
●	26.01.90	5	1350		22.03.90	2	550
	29.01.90	1	450		24.03.90	1	400

C H A P T E R - III

PREDATORS, COMPETITORS AND CO-OCCURING SPECIES

Different organisms will be found associated in ecological communities or biocoenosis provided their environmental requirements with respect to physical and chemical conditions are the same. The presence of individuals of same or other species in the habitat, competing for space or food and modifying their microhabitat may be factors influencing the behaviour of an animal. In such an ecosystem every group and individuals are interacting directly or indirectly. This inter-relationship between different organisms on one hand and the organisms and the environment on the other, create a dynamic equilibrium in the system. Such relationships may be intergroup, interspecific or intraspecific. The pattern of these interactions are based on the behaviour of the organism in the ecosystem. The basis for such behaviour is various stimulii generated in relation to feeding and breeding or demands for living space. The apparent relationships of a group of organisms in an ecosystem, as in the case of spiny lobsters here, vis-a-vis others can be broadly identified as follows:

1) Predators: which prey upon them.
2) Prey: which form food of the lobsters (dealt with under feeding behaviour)
3) Competitors and co-occuring species: which include organisms that compete with lobsters either for food or living space and also those which co-exist in the same environment without directly affecting the physiological existence of lobsters.

3.1 PREDATORS

Predator-prey relationship is one falling within the realm of nutrition. Predation is a normal activity and most species are subjected to predation practically at every stage of their life history. Predators themselves may be prey for some species of higher trophic levels. Predators undoubtedly cause substantial mortality in all stages of lobsters. In predator prey relationship, predator species evolve adaptations for the capture of its food and prey species evolve corresponding protective devices. Strong rough spines on the carapace and appendages and hardy shell of lobsters are such protective devices. Prickles and spines usually occur among slow moving demersal organisms like spiny lobsters as protection against predators; where as others make use of their capacity to move fast and evade the predators without encountering them. Lobsters are also capable of delivering blows with their strong muscular tail. In water lobsters are highly pugnacious and are capable of defending themselves to some extend. When faced with danger, the animal moves backward by bending and stretching the tail.

Once outside the den, the organism is vulnerable and its period of foray outside is timed to minimise the risk of predation. Natural predators on all types of lobsters are usually bottom or reef inhabiting species. Rand (1959) has stated that seal (Artocephalus pusillus) preys on spiny lobsters Jasus lalandie in S. Africa. American lobsters particularly smaller individuals fall prey to fish and shark (Cooper and Uzmann, 1977), but Herrick (1911) and Wilder (1959) suggest that large lobsters with hard shell are probably

immune to predation. The major predators of adult and sub adult stages of P. argus in caribbean waters are skate, shark, various species of snappers (Lutjanidae), groupers (Serranidae) and Octopus. A small whelk (Murex pomum) is reported to kill lobsters in traps by boring through the carapace (Murno, 1983). Fin fish that are known predators of lobsters are active during nights (Anon, 1968). Berry (1969) records the teleost fish (Heliocolenus maculata) as the major predator of Metanephrops andamanicus with dog shark and Octopus as additional predators. In Maldives enemies of lobsters are sharks like Carcharinus albimarginatus and Muraenidae (Jon Klaas, 1967). Nephrops norvegicus is eaten by fish, rays as well as by Octopus and swimming crabs. Howard (1982) says that in Scottish waters chief predators of Nephrops are fish, cod being most important. In some areas upto 80% of cod stomachs examined are found to contain Nephrops. Nephrops of 20-35 mm carapace length are most abundant in stomachs of cod of 27-87 cm total length. The curled Octopus (Eledone cirrhosa) is often found attacking Nephrops caught in creels and probably also feeds on them. In Australia among direct predators on spiny lobsters are Octopus O. tetricus (Joll, 1977) and various fishes including groupers, snappers and whiskery shark (Chittleborough, 1975).

Three important groups of predators of shallow water spiny lobsters of S.W. coast of India were identified during the study. They are (1) The giant rock cod - Epinephelus malabaricus (2) Three species of Morays (Muraenidae) (3) Cuttle fish (Sepia pharaonis)

3.1.1 Epinephelus malabaricus (Schneider, 1801)

This fish is one of the most ferocious and tenacious of the predators of spiny lobsters. They are mostly solitary in nature ascending the estuaries in high tides. They are found in turbid waters and estuaries; but also occurs in coral reefs.

Day (1877) has recorded that the members of this genus ascend rivers not for breeding, but for predaceous purposes, restricting their range however to within the tidal influence. These fishes attain large size. There are several records of them ascending deep into the estuary. Doipode and Rekha Naick (1977) have reported an instance of giant rock cod Epinephelus malabaricus measuring 210 cm in length having been caught from Mandovi estuary, Goa. Day has given his description of a specimen from Hooghly estuary.

On migrating to the lobster grounds they lie in wait for any length of time if a lobster is spotted, till the lobsters venture out of their den and then pounce upon them. Lobsters become easy targets when caught in local traps fabricated out of vegetable fibres. In such cases, this fish dialates the meshes of the traps by inserting its head and jerking from side to side and secures entry. Such fishes encroaching into lobster grounds are caught by fishermen either in trap or by hook and line and they form an important and remunerative by-catch, since they are excellent food fish.

3.1.2 FAMILY : SERRANIDAE

Distinctive Characters

Body robust or some what compressed; mouth large with small slender inwardly depressed teeth on jaws, vomer and palatines; maxilla exposed with or without supramaxilla; a single dorsal fin with 7 to 12 strong spines and 10 to 19 soft rays; anal fin with 3 spines and 7 to 10 soft rays; caudal fin round or truncate; edges of preopercle serrate; opercle with 2 to 3 flat points or 3 distinct spines; lateral line single.

They are mostly demersal fishes of tropical and sub tropical areas ranging from shallow coastal waters to moderate depths. They inhabit coral and rocky bottom. Most of them are either synchronous or transforming hermaphrodite that begin life as females and later become males; but a few have separate sexes.

Generic and Specific Characters

Preopercle finely serrate, with a shallow notch; rear nostrils not more than the size of anterior nostrils; mid lateral part of the lower jaw with two rows of teeth. Dorsal fin with 11 spines and 14 to 16 soft rays; pored lateral line scales 56 to 67; mid lateral body scales distinctly ctenoid with minute auxiliary scales (Fisher and Bianchi 1984). Opercle with 3 spines the central one being the largest.

3.1.3 FAMILY : MURAENIDAE

Moray eels

Few species of the family Muraenidae are found to prey upon lobsters. In terms of the percentage of damage caused to the fishery by predation,

perhaps Muraenid as a group rank first. They are not only predators but also competitors in the sense that some species of them occupy the lobster dens; evicting the lobsters from their dens in the process. In lobster grounds they prey upon lobsters coming out into the open from their burrows; and the lobsters that are immobilised due to injuries etc. They also enter the traps and feed upon the entrapped lobsters. After feeding, these sluggish organisms make themselves comfortable in the traps only to be caught by the fishermen the next day. But they are not very much relished as food and have very little market value. They very often inflict painful wounds if not handled very carefully. As far as fishermen are concerned they have only nuisance value.

Distinctive Characters

They inhabit essentially shallow waters in tropical seas although few species invade deeper waters. Morays are most abundant on reefs or in rocky areas where they find protection in holes and crevices. They are scavengers and predators, becoming active during nights.

They are robust and powerful eels, the body muscular and compressed along tails. Typically the dorsal profile above and behind the eye is steep; posterior nostrils above the anterior portion of the eye; usually as a simple hole with a raised rim but somewhat tubular. Teeth in jaws usually strong. Each gill opening is restricted to a small roundish, lateral hole or slit. No spines on fins. Pectoral and pelvic fins absent. No scales. No lateral line pores on the body but a reduced component of lateral line on the head.

3.1.3.1 Lycodontis meleagris (Shaw and Nodder, 1795)

Head with steep profile. A single row of smaller but sharp teeth on vomer. Dark purplish brown in colour covered with numerous very small yellow spots less than the diameter of the eye. Gill opening black.

3.1.3.2 Siderea picta (Ahl, 1789)

Head with steep profile; snout fairly short and blunt; eyes relatively small; teeth conical uniserial on jaws; biserial and smaller on vomer. Dorsal fin originating on head just before gill opening. Colour: greyish or whitish covered with minute dark intermingling specks.

3.1.3.3 Echidna nebulosa (Ahl, 1789)

Snout short and blunt; teeth mostly blunt and in 2 rows. Colour variable but typically yellowish brown with 2 or 3 longitudinal series of darker, star shaped spots along the body, each with a yellow centre; the spots variably combined to form vertical bands.

3.1.4 CLASS : CEPHALOPODA

Sepia pharaonis (Cuttle fish)

They are dibranchiate decapoda with ten arms two of which are longer than the rest and retractile into special pouches (tentacular arms). An internal shell and lateral fin present. Sepia has a short body with fins inserted laterally more or less in the middle. Cuttle fish is also an active predator on spiny lobsters. Cuttle fish of the species Sepia pharaonis are seen browsing about in very shallow waters close to shore especially in spiny lobster grounds

along S.W. coast of India. They catch hold of lobsters moving about freely on the grounds or enter the traps and feed upon the lobsters already caught. In fact lobster head is one of the most successful bait for fishing squids and cuttle fishes with hook and line (Mohan Rajan, 1983). Cuttle fish do not devour the prey; they entwine the lobsters with their tentacular arms and pedunculate suckers. They prefer to extract the nutrients through soft and easily vulnerable parts like the eye orbit of the prey with the help of the mouth surrounded by membraneous circular lip beset with many papillae and horny jaws. In keeping with their active, predacious habits, the eyes are usually well developed.

Distinctive Characters

They are cephalopods with ten arms, eight being short and circumoral and 2 slender and tentacular. Suckers of the arms and tentacles stalked and equipped with armature. Shell (cuttle bone) internal and calcareous in nature. Body ovoid and dorsoventrally flattened. Fins narrow, marginal in position and extending on either side along the entire length of mantle not uniting at the end. Arms with mostly quadriserial suckers. Cuttle bone broadly oval in shape and with a spine at the posterior end. The mantle without a glandular pore at the posterior extremity. This is the largest species of cuttle fish found in Indian waters (Sarvesan 1974; Silas et al., 1986).

3.2 COMPETITORS AND CO-OCCURRING SPECIES

Competition between living organisms is induced when two or more species have similar ecological niches or when their niches overlap. Competition

is defined as a state existing between animals securing supplies of same resource from one region of the environment, resulting in an interaction that produces some actually or incipiently deleterious effects on one or each of the animals (Weatherly, 1979). Competition is the only mechanism that links the components of population into a larger unit, and in the sea, this is perhaps a part of the adaptive maximisation of the biomass in each cohort or generation. Thus if competitive advantage is obtained, the structure of trophical level is altered and hence the structure and nature of the ecosystem. Hutchinson (1959) proposed that a ratio of trophic apparatus size of roughly 1:3 was necessary between competitors to permit two species to co-occur in different niches. There may be a sense in which competition between populations maintains what structure there is in an ecosystem and changes its nature from time to time (Cushing, 1976). Presence of species of other groups which share the same food source has been found to affect the growth and reproduction of the species in question (Odum, 1976). However at the same time it has been observed that in a given niche, quite often two or more competing species co-occur with a degree of accommodation among themselves. Saunders (1969) says that such biological accommodation is natural in environment between co-occuring species which use the same food source. The resource partitioning and territorial marking is an accepted norm of biological accommodation which is manifested among competitors.

In S.W. coast of India, the dominant species is P. homarus which account for over 90% of landings. Over the entire range it is not found

to experience any severe competition from allied species. Several species of fishes and crabs compete with spiny lobsters for food. The frequency with which the species of crabs Charybdis annulata and P. sanguinolentus are landed in lobster traps indicate that these species may be strong competitors. In a sense sea urchin is a competitor with spiny lobsters for food. This echinoderm is found to feed on mussel which is the staple food of lobsters. Palinurids are gregarious intraspecifically and often interspecifically (Kanciruck, 1980). Sheard (1949) has stated that in Australian waters P. Cygnus experience direct competition with Jasus lalandie and it may not be so with five northern species which may fill quite different niches. Evidence put forward by Chittleborough indicates that octopus can compete with lobsters for shelter on reefs. Rock lobsters will actively avoid the sites occupied by octopus. In S.W. coast of India species of moray eels are found to occupy the burrows of lobsters. P. argus is found cohabitting with spotted moray in Caribbean. Berry (1971) observed P. homarus co-existing with moray Lycodentus undulatus. He postulated a symbiotic relationship of sorts; moray being a natural enemy of Octopus which is a predator on lobsters. Kanciruck (1980) has observed that this species of moray appeared to be attracted to lobster dens by the stridulating sound produced by residents.

The organisms mentioned below are grouped together not only because of their similar ecological realms but also because of economic criterion Income from resources other than lobsters like fishes, molluscan shells, prawns and crabs constitute 25% of lobster fishermens' earnings. It forms the only source of income and sustenance during the off season. Some species or

other are fished out all through the seasons. They are not just a heterogenous assembly. All of them are interdependent or interacting, directly or indirectly in ecological terms; but a grouping from economic point of view is more appropriate.

They are not just biological entitites, but more in the nature of economic entities from fishermens' point of view. In the case of fishes mentioned here, a noticeable feature is that majority of them are species attaining moderate size or smaller forms of larger species. Several of them are species resident to lobster grounds and the rest only visitors. Most commonly noticed forms alone are mentioned here.

3.2.1 FAMILY : ANGUILLIDAE

They are fresh water eels, rather secretive during the day but actively foraging during night feeding on a wide range of small bottom living invertebrates. They migrate to the sea for breeding and the ocean currents carry the young larvae (leptocephalii) coast wards where the juveniles invade freshwater and spends the subsequent part of the life. Only smaller forms of one species was encountered in lobster grounds during the study.

3.2.1.1 Anguilla bicolor (Mc Clelland, 1844)

Body elongate cylindrical anteriorly and somewhat compressed along tails. Head conical, flattened dorsally, lower jaw longer than the upper; eyes relatively small; teeth small inconspicuous and multiserial forming broad continuousbands on jaws and vomer. Dorsal fin originates above anus or

very nearly so. Minute scales embedded in the skin. Vertebrae 106 to 115. Colour: olive to dark bluish brown above, lighter below; colour changes with the onset of maturity. Changes in size of the eye, mouth and snout also occur as maturity approaches.

3.2.2 FAMILY : MURAENESOCIDAE

Pike congers are small to large sized fishes occuring in tropical waters. Shallow water species are apparently nocturnal feeding on bottom living fishes and crustaceans.

3.2.2.1 Congresox talabonoides (Bleeker, 1853)

Only smaller specimens are found in lobster grounds. Body elongate cylindrical in front, compressed along the tail. Head very sharply conical with snout and lower jaw markedly lengthened forward so that mouth is very large extending to well beyond the eyes; no lips, eye moderate; teeth generally large in 3 longitudinal rows on jaws and vomer; teeth on middle row of vomer prominent needle like. Dorsal and anal fins continuous with caudal fin around tip of the body. Pectoral free and relatively small. Lateral line pores before the level of anus 41 to 42 no. scales.

Colours: head and body olive to golden yellow. Vertical fins with narrow dusky edge.

3.2.3 FAMILY : ARIDAE

They are marine cat fishes sometimes occuring in brackish and fresh-waters. Skin is naked and scales absent. There is a complete lateral line.

They prefer rocky to clay bedded substratum. Sea cat fishes are oral incubators, the male carrying the developing eggs and young ones in the oral cavity for sometime. In mature males throat is often expanded, in mature females the pelvic fins are longer than in males and as spawning approaches the rays of these fins become thickened, the inner most developing large pads. Three species of cat fishes were identified from lobster grounds.

3.2.3.1 Arius jella (Day, 1879)

3 pairs of barbels around mouth, the maxillary pair as long as head extending to pectoral fin base or slightly beyond, head shield sparsely granulated to the posterior margin of the orbit. Palat teeth globular, in a single large irregularly ovate patch with loosely packed teeth. First dorsal fin and pectoral fin each with a strong serrated spine; first dorsal fin ray prolonged into a long filament; total analfin rays 17 or 18. Colour: Bluish black above becoming whitish on sides and below: adipose fin with a black blotch.

3.2.3.2 Arius platystomus (Day, 1877)

Snout more or less duck bill shaped. All barbels are fleshy. Head shield thinly granulated and rugose from behind the orbit. Palate teeth conical in single oval patch on each side. First dorsal and pectoral fins each with a strong spine; total anal fin rays 19. Colour: Bluish black on back becoming lighter on sides and belly.

3.2.3.3 Arius tenuispinis (Day, 1877)

Head shield thinly granulate and rugose; median longitudinal groove long, narrow and deep, running on to supra occipital process. The dorsal fin spine thin and as long as head (excluding snout) and equal to or slightly longer than pectoral fin spine; total fin rays 18. Colour: cement grey on dorsal surface merging to silvery grey on belly.

3.2.4 FAMILY : BOTHIDAE

Flounders which are flat fishes with eye on the left side of the body. Mouth asymmetrical, teeth present in jaws sometimes caniniform. Preopercle exposed, its hind margin free and visible, dorsal fin origin above or in front of the eyes. A single lateral line, sometimes faint or absent on the blind side.

Left eye flounders are bottom dwelling predators which burrow into the mud or sand, substrate. Bothids have the ability to change colour rapidly to match their background. Some species exhibit sexual dimorphism in interobital width, length of the fin rays, cephalic spination or colour pattern. They are very tasty table fishes.

3.2.4.1 Pseudorhombus arsius (Hamilton, 1822)

Body oval and flat. Both the eyes on left side. 6 to 13 canine teeth present in the lower jaw of blind side. Dorsal fin originates in front of the upper eye. Pelvic fin base of blind side almost equal in length to that of the eyed side. Lateral line curved above pectoral fin forming two branches

on head, upper ending between 8th and 12th fin rays. Scales cycloid on blind side. Colour: eyed side with a varying pattern of brown spots and blotches, but always a larger blotch on anterior and of straight part of laterial line and a smaller blotch half way to caudal fin base.

3.2.4.2 Pseudorhombus natalensis (Gilchrist, 1905)

This species is synonimised with P. arsius by some authors. Body oval and flat, canine teeth not developed, more than 20 close set teeth in lower jaw of blind side. Origin of the dorsal fin above posterior nostril of blind side; anal fin with 52 or less rays. Lateral line curved above the pectoral fin forming 2 branches on head. Colour: brownish with a number of distinct dark rings arranged symmetrically on body.

3.2.5 FAMILY : MUGILIDAE

Mullets are elongate fishes usually with a broad flattened head, blunt snout and cylindrical or little compressed body. Eyes often partly covered with adipose eye lids. Two short dorsal fins, the first with 4 slender spines. Pectoral fin set rather high on the body; anal with 2 or 3 spines. Lateral line absent.

They are medium sized, inhabiting coastal marine waters, estuaries and fresh waters. Most species are adaptible to great changes in salinity. Most of them spawn at the sea. Mullets are usually found schooling in shallow waters; they feed largely on plant materials obtained by grubbing through bottom detritus. In S.W. coast of India they are mostly caught by cast nets and by gillnets.

3.2.5.1 Mugil dussumieri (Valenciennes, 1836)

Body rubust, head wide dorsally flattened; adipose tissue covering iris, preorbital bone narrow, filling only 3/4 between the lip and the eye, anteriorly notched; pectoral axillary scales rudimentary or absent; anal fin with 3 spines and 9 soft rays. Scales in lateral line series 27 to 32. Colour: dark greenish above white below: caudal fin edged with black .

3.2.5.2 Mugil cephalus (Linnaeus, 1758)

Body robust, head much flattened dorsally; adipose tissue covering most of the eye; lips thin, lower lip with a high symphysial knob; pectoral axillary scales long 33 to 36% of pectoral fin length; anal fin with 3 spines and 8 soft rays; scales in the lateral line series 38 to 42. Colour: dark greenish on black, silvery on sides. 6 or 7; indistinct brown bands down planks. These fishes attain large size but only specimens upto 30 cm are recorded from lobster grounds.

3.2.6 FAMILY : MULLIDAE

Goat fishes have slightly elongate and somewhat compressed body. There are two long unbranched barbels on the chin. Two well separated dorsal fins with first 8 slender spines and 9 rays; anal with one spine and 6 rays.

Most goat fishes live in shallow water. They are usually found on open, sand or mud bottoms at least for feeding. The barbels which have chemosensory functions are actively moved over or into the sediment to

locate food organisms. These fishes often root with their snouts into the sediment for the food. They are cannivorous, feeding particularly on small crustaceans and worms. A few species prey on fishes. Different species of goat fishes form a sizeable fishery along this coast. 3 species were recorded during the study.

3.2.6.1 Upeneus vittatus (Forsskal, 1755)

Chin with 2 slender barbels which usually do not reach rear margin of preopercle, their length 1.5 to 2.2 times in head. First dorsal with 8 spines, the first spine minute, pectoral fin rays 15 to 17. Lateral line scales 33 to 36; $5\frac{1}{2}$ vertical rows of scales in space between dorsal fin; 11 or 12 vertical rows of scales along upper part of caudal peduncle. Colour: greenish on back shading to silvery white on sides and pale yellow ventrally with 4 orange yellow stripes; caudal fin crossed by broad dark bands, upper lobe with 4 or 5 and lower with 3 or 4.

3.2.6.2 Upeneus moluccensis (Bleeker, 1855)

Chin with 2 slender barbels which do not reach near margin of preopercle, their length 1.55 to 2.1, times in head. First dorsal fin with 8 spines, the first spine minute; pectoral rays 15 to 18, lateral line scales 33 to 36. 12 or 13 rows of scales along upper part of caudal peduncle. Colour: a golden yellow stripe about as broad as pupil passing from eye along upper side of body to upper caudal base; upper lobe of caudal fin with 6 or 7 transverse orangish bands; lower lobe of caudal fin longitudinally streaked with orangish and whitish.

3.2.6.3 Paraupeneus indicus (Shaw, 1803)

Chin with 2 slender barbels which reach to or slightly posterior to rear margin of preopercle, their length 1.2 to 1.4 times in head. A single series of well placed stout conical teeth in jaws. Pectoral fin rays 16 to 17; three vertical rows of scales in space between dorsal fins; 9 or 10 vertical rows of scales along upper part of caudal peduncle. Colour: greenish brown to reddish brown dorsally, with large horizontally elongate yellow spots centred on lateral line below posterior part of the first dorsal fin and interdorsal space ;a roundish black spot larger than eye posteriorly on caudal peduncle.

3.2.7 FAMILY : SCATOPHAGIDAE

Scats are small fishes found in harbours, brackish estuaries and the lower reaches of fresh water streams and embayments. They usually occur in agregations and feed diurnally on a variety of benthic organisms. They are landed in both gill nets and traps.

Highly compressed quandrangular shaped fishes. Head profile rising steeply to nape; mouth small horizontal and not protrusible. Head and body covered with very small ctenoid scales extending on to soft dorsal and anal rays.

3.2.7.1 Scatophagus argus (Bloch, 1788)

Body highly compressed and quadrangular shaped. Head profile rising steeply to nape, snout and interorbital space rounded; mouth small, horizontal and not protrusible. Dorsal fin with 11 spines, membranes deeply incised between spines; first spine procumbent, a deep notch between spinous and

soft portion of fin. Anal with 4 strong spines and 13 to 16 soft rays. Head and body covered with small ctenoid scales which extend on to soft dorsal and anal fins. Colour: greenish to silvery with numerous dark spots mainly confined to upper portion of slides.

3.2.8 FAMILY : EPHIPPIDAE

Some authors place this in the family of Drepanidae and Platacidae. Body very deep to almost orbicular, strongly compressed. Gill membranes broadly attached to isthmus. Dorsal fin with 9 spines. Inter spinous membranes deeply incised and occasionally filamentous, spinous part of dorsal fin separated from soft part by a deep notch; pectoral fin rounded and small.

Spade fishes are inhabitants of inshore tropical reefs in depths to about 30 m. They frequent rocky or reef areas as well as wrecks and pilings some times forming small shoals.

3.2.8. 1 Ephipus orbis (Bloch, 1787)

Large more compressed fishes without a strong spine at angle of preopercle; dorsal and anal fins often very elongate. Dorsal fin with a deep notch. Body shape orbicular with a steep upper profile; top of the head densly scaled; mouth small and terminal. First dorsal fin with one forward pointing spine, 9 normal spines and 19 to 20 soft rays. Scales small, finely ciliated, extending on to soft part of the vertical fin. Colour: 4 or 5 vertical black bars on body from dorsal fin almost to belly.

3.2.9 FAMILY : GERREIDAE

These fishes are inhabitants of coastal waters of all warm seas; there are few temperate species. Mostly found in sandy shallows but also in

estuaries. Small to medium sized fishes. Body compressed laterally; back elevated to varying degrees. Mouth strong and protractile pointing down wards when extended. A long single dorsal fin with 9 or occasionally 10 spines and similar number of soft rays. Pectoral fin long and pointed. Scales large and obvious. They are landed in both gill nets and traps.

3.2.9.1 Gerres filamentosus (Cuvier, 1829)

Body compressed, elevated; anteriodorsal profile ascending steeply at an angle to horizontal axis. Second dorsal spine laterally compressed, produced into filament whose tip extends past level of first anal spine; third dorsal spine laterally compressed. Pectoral fin long; 2nd anal fin spine much shorter than anal fin base. Colour: Silvery with 7 to 10 columns of ovoid spots on upper portion of sides. Iris silvery with a dark ovoid patch in anterodorsal quarter.

3.2.9.2 Gerres abbrevats (Bleeker, 1850)

Body deep its depth contained 1.9 to 2.3 times standard length. Anterodorsal profile ascending steeply at an angle of about 45°, in a straight line to base of first dorsal spine. Spines strong particularly the second anal which is either sub equal or much longer than the base of anal fin; pectoral fin long. Colour: Silvery tinged with brown dorsally; indistinct fine dark stripes following scale rows in older fishes; pelvic and anal fins yellowish.

3.2.10 FAMILY : AMBASSIDAE

They are perchlets with 2 dorsal fins anterior with 7 to 9 spines posterior with 1 spine and 8 to 12 soft rays; Pelvic with 1 spine and 5 soft rays.

Fishes of this family have compressed and diapharous body. They are translucent, often silvery with purplish reflections. They are eaten by poorer people and in sea they are foraged upon by several predators. They grow to about 20 cm and are found in shallow coastal waters. Benthic in nature.

3.2.10.1 Ambassis commersoni (Day)

D-7 $\frac{1}{10\text{-}11}$, A $\frac{3}{9\text{-}10}$, L.P. 30-33. Dorsal fin deeply notched; but continuous. Opercles mostly denticulated or armed. Double lower edge of preopercle serrated, interopercle entire; preorbital also strongly serrated. Two dorsal fins. Dorsal fin spines stronger, transversly lineated giving serrated appearance to the second. Lateral line continuous. Form of the body more or less elevated and compressed. Cleft of the mouth oblique or even nearly vertical. Dorsal and anal profiles about equally convex. Colour: Ambassis species are translucent, often silvery with purplish reflections.

3.2.11 FAMILY : APOGONIDAE

Most of the species are smaller than 12 cm. They are mostly benthic. They occur from coast line to about 1000 m depth; and also in brackish waters and fresh waters. Eyes are disproportionally large and anal fin has 2 spines.

3.2.11.1 Apogon frenatus (Day)

Opercle not spinate; Preopercle with a double edge serrated; a small opercular spine. Dorsal fin consisting of 2 completely separate parts. First

and second dorsal spines short; pectoral nearly as long as head excluding snout; caudal notched, upper lobe slightly longer. Lateral line with well developed tubes having small enlargement on either side near the base of each tube which become arborscent in adults. Colour: reddish, with a dark band along the bases of second dorsal and anal; dorsal, caudal, ventral and anal black tipped. A black spot may be present at the base of caudal fin.

3.2.11.2 Apogon endekataenia (Day)

D-7 $\frac{1}{9}$, P.13, V 1/5, A $\frac{2}{8}$ C. 17, L.1.26, L.tr.2/7 outer edge of preopercle lower edge of the orbit and shoulder serrated. A dark median and four or five lateral bands, a dark spot at the base of the caudal fin. Lateral line tubes distinct, those in the first half of the body with lateral arborescent branches. Colour: of a reddish brown tinge with a dark band from upper edge of orbit to the end of second dorsal. A black spot at the base of the tail.

3.2.12 FAMILY : BALISTIDAE

Commonly called 'trigger fishes', they are small or medium in size with deep moderately compressed bodies encased in very thick tough skin with large rectilinear scale plate easily discernible as individual units; scales above pectoral fin base usually enlarged forming a flexible tympanum. Most of dorsal and pectoral fin rays branched. Lateral line inconspicous.

Trigger fishes are often solitary, with some species being pelagic and others benthic around rocky and coral reefs. They feed on bottom

invertebrates often hard shelled species. Flesh of these fishes is believed to be toxic by coastal population. Toxins are said to be in the skin of the fish and they are sun dried after removing the skin. In some parts of S.W. coast of India there is a special type of net called 'Kachal' which is a ring net attached to a line and operated from catamaran during nights. Some species of Balistes thrive well in lobster grounds that are flat 'pars'.

3.2.12.1 Balistes maculatus (Day, 1877)

D 3/26-27, A 24-25, L.1 46-55, L.tr. 28. Free portion of the tail compressed. Body compressed; barbels absent; dermal covering rough. Teeth white uneven and notched; cheeks entirely scaled; a groove in front of the eye; no osseous scutes behind gill opening. Free portion of the tail compressed. Scales rough and granulated. Dorsal spine black. Eyes hazel. Colour: bluish black with light blue blotches.

3.2.12.2 Balistes mitis (Day, 1877)

D 3/29-31, A. 26-28, L.1.56-65. Free portion of the tail compressed. Teeth white uneven and notched; cheeks scaled; osseous scutes behind gill opening; 7 to 8 rows of small round tubercles on scales of the side. Colour: Brownish with a yellow ring round the mouth continued towards the pectoral fin.

3.2.12.3 Balistes stellatus (Day, 1877)

D.3/26-27, A. 24-25, L.1 46-55, L.Tr.28. Free portion of the tail depressed; teeth uneven and notched; first dorsal fin commences slightly

behind the orbit, its anterior spine strong; ventral spine movable. Scales covering the cheeks; some enlarged scute behind the gill opening. Two ridges on either side of the tail. Colour: generally grey dashed with olive green, three large white blotches extend from the back some distance down the sides; numerous small bluish spots scattered over the back. Pectorals yellow with a dark base.

3.2.13 FAMILY : BELONIDAE

Needle fishes are elongate with both upper and lower jaws extended into long beaks filled with sharp teeth. Nortrils in a pit anterior to the eye; no spines in fins.

Most of them are marine but some occuring in fresh waters and estuaries. They are carnivours feeding largely on smaller fishes which they catch side ways in their beak. They tend to leap and skitter at the surface when people get injured. These fishes are attracted by lights. Only one species was identified during the study.

3.2.13.1 Belone strongylura (van Hasselt, 1823)

Both the jaws elongated into a beak filled with sharp teeth; nostrils in a pit anterior to the eyes. No spines in the fins. Body elongated and rounded in cross section. No spines in the fins; dorsal fin rays 12 to 15; anal fin rays 15 to 18. Caudal peduncle without lateral keels; caudal fin rounded or truncate. Predorsal and anal fins covered with scales. Scales

small. Colour: Greenish above, silvery laterally. Caudal fin light with a prominent round black spot near its base.

3.2.14 FAMILY : CARANGIDAE

This is one of the most important families of commercial fishes all species of which are used for food. They are mostly schooling fishes. They include jacks, trevallies and scads etc. Body is extremely variable in shape ranging from elongate and fusiform to deep and strongly compressed. Caudal peduncle in some species with moderate keel, bilateral paired keels or grooves. Eyes with adipose eyelids negligible to strongly developed. Caudal fin forked with lobes equal in most cases.

3.2.14.1 Caranx malabaricus (Bloch and Schneider, 1801)

Body strongly compressed, almost ovate. Both the jaws with bands of small villiform teeth; vomerine tooth patch roughly triangular. Two separte dorsal fins first with 8 spines, the second with one spine and 20 to 23 soft rays, anal fin with 2 detached spines followed by one spine and 17 to 19 rays. Breasts naked ventrally. Lateraly the naked area of breast extends diagonally to naked base of pectoral fins including small area anteriorly just above pectoral fin base. Straight part of the lateral line with 19 to 36 weak scutes and 31 to 36 total elements. Colour: generally silvery with bluish grey above and white below; opercle with a small black spot on upper margin.

3.2.14.2 Alectis indicus (Rupell, 1830)

This is generally a solitary species. Body deep becoming more elongate with growth, and very compressed. Profile of the nape and head somewhat angular; suborbital depth relatively broad. Dorsal fin with 6 short spines (embedded and not apparent) followed by one spine and 15 to 17 soft rays. Anterior soft rays of dorsal and anal fins extremely long and filamentous in young; pectoral fins falcate. Lateral line anteriorly with a strong and moderately long arch, its posterior straight part with 6 plus 11 scutes. Body superficially naked, scale minute and embedded where present. Colour: mostly silvery with a dusky green tinge dorsally; juveniles with dark bars on the body.

3.2.15 FAMILY : CLUPEIDAE

Clupeidae includes sardines, sardinellas, shads, sprats and herrings. They are small mostly silvery fishes usually between 7 and 20 cm in length generally with fusiform sub cylindrical bodies. Scutes present along the cutting abdomen except in few cases. A single dorsal fin usually short and near the mid point of the body; fins lacking spiny rays. Caudal fin deeply forked. Scales always cycloid and smooth but easily shed. No lateral line. Most clupeids are marine but some can tolerate low salinities and some shads live in fresh water. Many are shoaling species of great commercial importance in Indias west coast.

3.2.15.1 Anodontostoma chacunda (Ham. Buch., 1822)

Body very deep and compressed, belly with a keel of scutes; mouth inferior, snout rounded and projecting; lower jaw flared at corners. A single dorsal fin which originates before the mid point of body, last dorsal fin ray not filamentous. Predorsal scales forming a single median series. Fins lacking spiny rays; no lateral line. 28 spines along the abdominal and thoracic edge 16 or 17 of which are anterior to the ventral fin. Caudal forked. Colour: back blue/green, flanks bright silver; a large jet black spot behind gill opening.

3.2.15.2 Nematalosa nasus (Bloch, 1795)

Body deep and compressed; belly with a sharp keel of scutes. Top of head with 6 to 11 frontoparietal striae; mouth inferior, snout projecting; lower jaw flared outward along its edge. Dorsal fin with last ray filamentous. Hind edges of scale toothed; a double series of overlapping predorsal scales. Colour: back blue/green or grey; flanks silvery, a dark spot behind the gill opening.

3.2.16 FAMILY : MURAENIDAE

Thyrsoidea macrura

Account of family Muraenidae is furnished earlier. Description of one more species is given below.

Body extremely elongate compressed especially along the tail. Mouth very large extending well beyond the eyes. Teeth biserial in jaws; several

large slender sharp, depressible teeth on intermaxillary. Scales absent. No obvious lateral line. It is reduced to two pores above and below gill opening which is a round mid lateral hole or slit. Vertebrae about 216. Colour: brownish grey above, lighter below.

3.2.17 FAMILY : PLOTOSIDAE

Stinging cat fishes, occur in marine, brackish and fresh waters of tropical and warm temperate regions; juveniles of these fishes often form dense aggregations.

Body elongate, compressed, tapering to a point posteriorly; gill membranes free from each other and from isthmus except anteriorly. 4 pairs of barbels; a pair of widely separated nostrils slit like; second dorsal fin, anal fin and caudal fin confluent; adipose fin absent. A dendric organ consisting of many vascularised epithelial folds present directly posterior to anus.

3.2.17.1 Plotosus canius (Hamilton - Buchanan, 1822)

4 pairs of barbels, the nasal barbel expending well behind eyes almost to nape; maxillary barbels extending to the base of pectoral fin; anterior nostril located on end of the snout at edge of upper lips. Eyes small 7 to 12% of the head length. Large vermiform papillae always present between gill rakers and filaments on both the faces of second and subsequent arches. Dorsal procurrent; caudal fin with 124 to 143 rays; anal fin with 106 to 131 rays, total number of rays in confluent fins 247 to 281.

3.2.17.2 Plotosus arab (Bleeker, 1862)

Head profile slightly arched from the tip of the snout to dorsal fin origin. The nasal barbels not extending well beyond posterior borders of eye maxillary barbels extending slightly beyond; anterior mostrils located on end of snout at edge of upper lip. First dorsal fin with 1 spine and 4 soft rays; pectoral fins with 9 to 13 soft rays. The dorsal procurement caudal fin with 69 to 115 rays; anal fin with 58 to 82 soft rays; total number of rays in confluent fins 139 to 300. Dendric organ present. Colour: 2 or 3 stripes (white or yellow while living) 2 of the stripes extend from snout to near caudal peduncle; margins of median fin blackish.

3.2.18 FAMILY : MONODACTYLIDAE

Moonies are median sized fishes occuring in shoals in estuaries and over shallow reefs; they are equally at home in fresh or salt water. They are of minor commercial importance. Two genera from this family were recorded.

3.2.18.1 Monodactylus falciformis (Lacepede, 1801)

Body oval, strongly compressed, covered with small deciduous scales extending on to median fins and head; body depth contained 1.5 to 2.0 times in standard length. Gill rakers on lower limbs of the first arch 22 to 24. Pelvic fins very small or absent in adults; dorsal fin with 7 or 8 spines and 25 to 30 soft rays; anal fin with 3 spines and 25 to 29 soft rays; pectoral fin rays 17 or 18 colour: adult silvery; tips of the dorsal and anal lobes dusky. Juveniles with 11 or 12 vertical bars.

3.2.18.2 Monodactylus argenteus (Linnaeus, 1758)

Body depth contained 1.2 to 1.6 times in standard length; gill rakers on lower limb of first arch 18 to 22. Colour: adults silvery: tip of dorsal and anal fin lobes dusky; juvenile dusky silver with 2 curved dark stripes across head.

3.2.19 FAMILY : DIODONTIDAE

Diodontidae includes porcupine fishes or spiny puffers. Body wide and capable of great inflaton covered with spines having large bases. The teeth fused to form a beak like crushing structure without a median suture dividing the upper and lower jaws into left and right half. Lateral line in conspicous. No normal scales.

Most species are benthic around coral and rocky roofs. Juveniles are pelagic in nature. They feed on hard shelled benthic invertebrates which are crushed with the powerful jaws. They inflate when disturbed and present a potential predator with a large spiny ball. Not normally eaten. The members of this species noticed in lobster grounds only have nuisance value since after entering the trap and they bloat and prevent the entry of lobsters into the trap. These fishes enter the trap for feeding on mussel. When entangled in nets also, these spiny organisms only become nuisance.

3.2.19.1 Diodon hystrix (Linnaeus, 1758)

Body wide and capable of great inflation, covered with spines which may be quite long; the spines with large bases; teeth fused into a single

beak like unit in each jaw. All the spines are two rooted long and erectile except for a few around gill openings, dorsal fin base and on caudal peduncle. Pectoral fin rays 22 to 25 and anal fins rounded, body relatively robust, width of the head more than 30% of the standard length. Colour: tan to brown.

Both Diodon hystrix and Tetrodon hispidus are nuisance to lobster fishermen when they enter their gear.

3.2.19.2 Chilomycterus reticulatus (Linnaeus, 1758)

All spines are long and erectile except for a few around gill opening, dorsal fin base and on caudal peduncle. All spines three or four rooted and fixed (except possibly one or two immediately behind the pectoral fin base or near the cover of the mouth). One or more spines on dorsal surface of caudal peduncle; spines short often reduced to only the subdermal bases; caudal fin normally with 10 rays; fish larger than 10 cm with black spots on the skin.

3.2.19.3 Chilomycterus orbicularis (Bloch, 1785)

No spines wholly on caudal peduncle; caudal fin normally with 9 rays; no black spot on fins. Spines few, 4 dorsally between pectoral fin bases, 8 or 9 enterior to dorsal fin base, a short movable spine near the cover of the mouth; all spines on top of head with 3 bases.

3.2.20 FAMILY : DREPANIDAE

These fishes are popularly called moon fishes or sickle fishes. They are shallow water forms attaining an average size of 25 cm. Though

inhabitants of sea, they sometimes enter brackish waters. Feeds on bottom living invertebrates and fishes. They abound in grounds where rock and sand stretch meet.

3.2.20.1 Drepane punctata (Linnaeus, 1758)

Body very deep and strongly compressed; head with a parabolic upper profile; snout short, scales absent in front of the eye and opercle. Mouth terminal and protrusible forming a downward pointing tube when protracted. A fringe of 4 to 6 short cirri ventrally on the lower jaw. Dorsal fin with 8 to 9 spines and 19 to 22 soft rays, the 4th dorsal spine the longest; pectoral fin long and pointed reaching to the base of caudal fin. Colour: generally silvery with greenish tinge on upper half and a large orange spot just above the base of pectoral fin; 4 to 11 vertical bars of small black spots on upper half of the body. They frequently enter traps and are also caught in lobster gill nets.

3.2.21 FAMILY : ENGRAULIDAE

The family includes anchovies. They are small and usually between 7 to 15 cm in length generally with subcylindrical bodies but sometimes quite strongly compressed. Snout usually pig like and projecting; hind tip of maxilla extending far back wards, some time projecting beyond gill cover. No spiny rays in fins. Scales cycloid and smooth to touch; no lateral line.

Most anchovies are marine, but some can tolerate low salinities or even fresh water. Some are shoaling species forming substancial fishery of economic importance in these parts.

3. 2.21.1 Stolephorus indicus (Van Hasselt, 1828)

Body slender, elongate, subcylindrical in cross section; belly rounded, with 3 to 5 small needle like scutes between pectoral and pelvic fin bases. Maxillae tip pointed reaching to or only just beyond anterior border of pre-opercle, isthmus tapering evenly forward to hind border of gill membrane. Anal fin origin below last dorsal fin rays. Colour: light transparent fleshy brown with a silver stripe down the flanks.

3.2.21.2 Stolephorus commersonii (Lacepede, 1803)

Body slender and oval in cross section; belly rounded with 1 to 4 small needle like scutes between pectoral and pelvic fin bases. Maxilla tip pointed; isthmus tapering evenly forward to hind margin of gill membrane. Pelvic fin tips reaching beyond dorsal fin origin; anal fin origin below last dorsal fin rays. Colour: light transparent, fleshy brown with a silver stripe down the flanks; back with 2 pigmented areas behind head and a double pigment line before dorsal fin origin.

3.2.21.3 Thryssa malabarica (Bloch, 1795)

Body fusiform, rather strongly compressed; belly with a sharp keel of scutes from isthumus to anus. Maxilla short reaching to gill opening or only just beyond; gill rakers usually 17 to 19 on lower limb of first arch. Anal fin long usually with 35 to 38 branched rays. Colour: back blue/green or brown with no dark median line, flanks silvery; a black venulose area behind gill opening. Dorsal and caudal fins yellow with narrow dusky margins;

anal fin deep yellow at the base, margin milky white, the two areas separated by a black band.

3.2.21.4 Thryssa mystax (Sehneider, 1801)

Body fusiform, compressed, belly with a sharp keel of scutes from isthmus to anus. Tip of snout at the level of eye centre; maxilla produced reaching to the base of first pectoral fin ray. Anal fin long usually with 31 to 36 rays. Colour: back blue/green, flanks silvery, a black venulose area behind gill opening with a golden area before it. Dorsal fin lemon yellow with a dusky tip, anal fin clear.

3.2.21.5 Coilia dussumieri (Valenciennes, 1848)

Body elongate, tapering evenly to a very slender tail; belly little rounded, with 5 or 6 sharp scutes before pelvic scutes. Maxilla tip pointed reaching to or just beyond the gill opening. Dorsal fin with a small spine in front; upper 6 pectoral fin rays filamentous; anal fin very long and joined to caudal fin. Colour: flanks silvery, with three rows of orange/gold spots.

3.2.22 FAMILY : HEMIRAMPHIDAE

Half beaks are elongate fishes with prolonged lower jaw and a short triangular upper jaw. Nostrils situated in a pit anterior to the eyes. Pelvic fin in abdominal position with 6 soft rays. Lateral line running down from pectoral fin origin and then backward along ventral margin of the body. Most species are marine; but some inhabitang fresh waters. Carnivorous, feeding on floating sea grass, crustaceans and small fishes. They are prone

to leap and skitter at the surface. Though not of great commercial interest most species are regularly found in local markets.

3.2.22.1 Hemiramphus lutkei (Valenciennes, 1846)

An elongate fish with greatly prolonged beak like lower jaw. Upper jaw short triangular and scale less; preorbital ridge absent. Total number of gill rakers on first gill arch 33 to 46; pectoral fin long, reaching beyond anterior margin of nasal pit when folded forward and contains 4.8 to 5.4 times in standard length. Caudal fin deeply forked, lower lobe much longer than the upper. Colours: dark bluish above, silvery white below with no spots or vertical bar on sides. Beak dark with bright red fleshy tip. This species form a sizeable fishery around Vizhinjam.

3.2.22.2 Hemiramphus archipelagicus

With greatly prolonged beak like lower jaw; upper jaw short triangular and scale less; preorbital ridge absent. Total number of gill rakers on first gill arch 25 to 32. Pectoral fin short not reaching past nasal pit when folded forwards. Colour: dark bluish above silvery white below without any vertical bar on sides. They inhabit the immediate vicinity of coasts but juveniles may sometimes be found with floating plants carried into the sea.

3.2.23 FAMILY : LEIOGNATHIDAE

Popularly known as 'silver bellies' they are small fishes with oblong or round bodies moderately to strongly compressed. Top of the head with

bony ridges and a well developed nuchal crest or spine; mouth strongly protrusible. A single dorsal fin with 8 spines and 16 or 17 soft rays. Caudal fin deeply emarginate or forked. Top of the head scaleless.

They are bottom living fishes in shallow waters with several species entering brackish waters especially estuaries. Some are found in dense schools and may constitute a major component of the catch.

3. 2.23.1 Gazza minuta (Bloch, 1797)

Body oval and somewhat compressed moderately deep, greatest body depth 2.27 to 3.14 times in standard length. Mouth pointing forward when protracted with distinct caniniform teeth in both the jaws. Colour: Silvery, back greyish, with dark yellow irregular marks extending to below the lateral line. Spinous dorsal fin membrane black edged; pectorals and pelvics colourless; caudal fin yellowish, its hind margin dusky. Inhabits coastal waters.

3.2.23.2 Leiognathus dussumieri (Valenciennes, 1835)

Body moderately slender; compressed, anterior part of the dorsal profile more strongly arched than anterior part of the ventral profile: body depth contained 2.02 to 2.28 times in standard length. Snout pointed, slightly longer than eye diameter. Mouth pointing downwards when protracted. Head scaleless, but conspicuous scales present on the breast. Colour: back greenish; belly silvery, fins yellowish; sides of the body with grey wavy vertical lines descending from the back to little beyond the lateral line; an elongate yellow spot on the below pectoral fin.

3.2.23.3 Leiognathus splendens (Cuvier, 1829)

Inhabits shallow waters down to a depth of 40 m. Found predominantly at bottom in schools. Enters estuaries. Body depth contained 1.75 to 2.05 times in standard length. Snout short and blunt; mouth pointing slightly downward when protracted. Head scaleless; but prominent scales present on the breast. Colour: belly silvery; back greyish silvery with faint grey wavy vertical lines above lateral line in adults; scales of lateral line, bases of the pectoral fins, margins of the dorsal and anal fins bright yellow; usually a black spot on upper third of spinous portion of dorsal fin.

3.2.24 FAMILY : PLATYCEPHALIDAE

Called crocodile fishes or spiny flat heads, they are elongate fishes with head moderately to strongly compressed. Mouth large with lower jaw longer than upper; long ridges of the head usually bearing spines or serrations. Two dorsal fins well separated; spinous dorsal with 8 to 10 spines; the first spine short and scarcely connected to the second. Colours: dark above pale below; dark colours into various shades of brown grey or black; in some with brighter hues. Some of them are benthic fishes found on sand bottoms; another group is associated with rocky substratum.

In spiny lobster grounds two species are encountered. They are occasionally landed in traps.

3.2.24.1 Platycephalus indicus (Linnaeus, 1758)

Head with smooth bony ridges; preopercular spines 2, the upper a little shorter than the lower and set at an angle to the lower. First dorsal fin with 7 to 10 spines (usually 9) first and last separated from the remainder

of fin. Pored lateral line scales 67 to 84. Scale rows slanting downwards above lateral line numbering from about 85 to 106. Colour: brownish or greyish above; whitish below: several indistinct dark bands crossing back in some specimens. Caudal fin with 2 or 3 horizontal black bars near rear margin.

3.2.24.2 Platycephalus crocodila (Tilesius, 1812)

Body ridges crossing cheek below eye with 3 spines, one in front of the eye, the second under middle of the eye, a third under rear margin of the eye; preopercular spines usually 2, the upper about 3 times longer than the lower; interopercular membrane with a small blunt flap. Second dorsal and anal fins with 11 soft rays; pored lateral line scales 52 to 55. Colour: small dark spots on top of head and back; caudal fin may have some dark spots towards the base and soft dorsal fin also with small dark spots.

3.2.25 FAMILY : NEMIPTERIDAE

They include thread fin breams. Three or four species are represented in the catches from spiny lobster grounds. They are small to moderate sized and slightly compressed fishes. Mostly living in shallow coastal waters. They are carnivorous in nature chiefly feeding on bottom living invertebrates. They are good food fishes which in some areas form sizeable part of the catch. Species usually encountered in lobster grounds are N. japonicus N. bleekeri and N. peronii in addition to Scolopsis bimaculatus.

3.2.25.1 Scolopsis bimaculatus

This is a separate family created by Fisher and Bianchi (1984). Body moderately deep with a convex dorsal profile and a pointed snout. Eyes medium sized with a stout backward projecting spine just below it. Dorsal fin with 10 spines and 9 soft rays continuous and unnotched; anal fin with 3 spines and 7 soft rays; pectoral fin with 2 unbranched and 16 branched rays. Predorsal scales reaching forward to the level of posterior nostrils; 4 to 5 transverse rows of scales on cheek; lower limb of preopercle with one or two rows of small scales. Colour: overall pale grey with elongated blackish patch on upper side, its upper portion intersected by lateral line; fins generally pale grey.

3.2.26 FAMILY : LUTJANIDAE

Commonly called snappers they are mostly demersal and common in tropical seas. Many are found in coral reefs and brackish estuaries. A few species may even enter rivers especially in juvenile phase and others in mangrove areas or in hypersaline lagoons. All snappers are predators, active during the night feeding on crustaceans, fishes and sometimes also on cuttle fishes and worms.

Typically perch like fishes moderately elongate to deep bodied and fairly compressed. Mouth terminal, moderate to large extending some what when opened (Protrusible); maxilla broadest posteriorly sliding under the sub orbital bone for great part of its edge; jaw teeth usually in a few rows; conical and sharp; preopercle usually serrate; anterior part of the head without scales.

3.2.26.1 Lutjanus sebae (Cuvier, 1828)

A deep bodied snapper with head profile straight or convex. Preopercular notch distinct and deep; interopercular knob marked; vertical and horizontal edges of preopercle finely serrated. Dorsal fin with 11 spines and 15 or 16 soft rays; anal fin with 3 spines and 10 or 11 soft rays; soft parts of dorsal and anal fins with a scaly sheath. Colour: deep red in large adults; juveniles and smaller adults pink with a dark red band from first dorsal spine through eye to the tip of snout; a second dark band from middle of the spinous part of dorsal fin to pelvic fin; and a third band running from base of last dorsal fin spines obliquely downwards across caudal peduncle and along lower rays of caudal fin.

Smaller specimens of Lutjanidae sometimes form catch in the traps in shallow waters.

3.2.26.2 Lutjanus malabaricus (Bloch and Schneider, 1801)

A deep bodied snapper with head profile straight or concave; preopercular notch shallow; inter opercular knob inconspicuous; vertical and horizontal edges of preopercle finaly serrated. Dorsal fin with 11 spines and 14 soft rays; anal fin with 3 spines and 8 or 9 soft rays. Longitudinal rows of scales on head beginning behind eyes; soft parts of dorsal and anal fins with scaly sheath. Colour: deep red in adults; juveniles red/brown above, silvery below, with dark longitudial stripes on body following scale rows; a saddle like black blotch on caudal peduncle surrounded by a silvery band, and a dark brown band down front of the head.

3.2.27 FAMILY : LETHRINIDAE

Perch like fishes with large head; lips often thick and fleshy; maxilla concealed without supplementary bone overlapping the premaxilla anteriorly. A single continuous dorsal fin with 10 spines and 9 or 10 branched rays. Cheeks upper surface of the head and preorbital area scaleless in Lethrinus but scaled in other genera.

Medium to large shaped fishes inhabiting tropical and sub tropical areas; mostly on rocky areas as well as soft substratum. Carnivorous in general feeding with their stout crushing jaws. Slow swimmers remaining close to the bottom usually forming small schools. They are considered to be good table fishes.

3.2.27.1 Lethrinus nebulosus (Forsskal, 1775)

Body depth greater than head length. Inter orbitals space convex. Snout profile straight a slightly concave above nostrils convex beyond forming an angle of 60°C to 68°C with chin; maxilla reaching a little beyond the vertical from anterior nostril; posterolateral teeth in jaws include distinct molars in adults; third to the fifth dorsal fin spine longest. Colour: olive green above, paler below, usually 2 or three blue streaks radiating from eye, each scale on back with a white to blue centre; usually several yellow longitudinal stripes on sides giving an overall effect of blue and yellow. They enter the lobster traps mainly to feed on mussel. They are caught in the gill nets also.

3.2.27.2 Lethrinus lentjan (Lacepede, 1802)

Body depth greater than head length. Interorbital space moderately convex; the snout profile forming an angle of 58° to 66° with maxilla; maxilla reaching opposite to anterior or posterior nostrils; distance between the 2 posterior nostrils small; posterolateral teeth in jaws include distinct molars in adult; anterior teeth caniniform. Fourth dorsal fin spine longest; six scale rows between lateral line and median dorsal fin spines. Colour: body green grey above; white spots sometimes on scale centres especially above lateral line. Head brownish mauve purple; a bright red margin to opercle and usually to pectoral fin base. They also feed on mussel put in the trap as baits using their crushing jaws.

3.2.28 FAMILY : MENIDAE: MENEMACULATA

This family is represented by one species Menemaculata (Bloch and Schneider, 1801). Body extremely compressed and discoid. Upper jaw protrusible; bands of villiform teeth in jaws. Dorsal fin long and low; anterior rays slightly elevated; anal fin very long and low, the rays very short and over grown with skin in adults; first two dorsal rays of pelvic fin fused and greatly prolonged in adults; caudal fin forked. Scale minute and disciduous (body apparently scaleless). Colours: dark blue dorsally and silvery white below; several small round black spots on dorsal part of the body. They are usually caught in lobster traps and gill nets.

3.2.29 FAMILY : SERRANIDAE

Characteristic features of family serranidae are mentioned earlier. In addition to Epinephelus malabaricus mentioned as predator on lobster,

few more species from this family are found in the catches from lobster ground both in traps and gill nets. Their behaviour as predators on lobsters is not explicit; but they are often found in the same ecosystem. Juveniles of them are sometimes residents, but adults migrate from deeper waters.

3.2.29.1 Epinephelus tauvina (Forsskal, 1775)

Body depth contained 3.1 to 3.5 times in standard length width of the body 1.6 to 2.2 times in depth. Pored lateral line scales 67 to 74. Lower gill rakers 18 to 20: mid lateral part of the lower jaw with 3 or 4 rows of teeth; maxilla extends well beyond the eye. Colours: head and body greyish, covered with small dull orange red to dark brown spot; the spot not sharply outlised; spots smaller and more numerous on larger fishes; a large blackish bloch often present on body at base of last 4 dorsal spines and extending on to lower part of fin. They are caught both in traps and gill nets and is a fish of high market value.

3.2.29.2 Chromileptus altivelis (Valenciennes, 1828)

Body compressed; dorsal profile of the head markedly concave giving the fish a humplack appearance; opercle with 2 apparent spines; rear nostril a large crescentric slit. Dorsal fin with 10 spines and 17 to 19 soft rays; anal fin with 3 spines and 10 soft rays: Colour: pale greenish brown, with dark spot all over the head body and fins. In local landings several other species of Serranidae like. E. chlorostigma, E. areolatus, E. morhua etc. are noticed. These fishes ascend shore wards for predacious purposes restricting their range to within tidal influence.

3.2.30 FAMILY : SIGANIDAE

Only one genera of family Siganus is represented. They include rabbit fishes, which are moderate sized herbivarous forms of shallow coastal waters; some species live in pairs around corals and others in schools around rocks, coral reefs and estuaries.

Body is laterally compressed, oval, covered with small scales. Dorsal fin with 13 strong spines and 10 soft rays, preceded by a forward projecting spine. Pelvic fins with 3 strong spines separated by 3 soft rays, this character being unique to the family. The spines are venomous.

Several species of this small fishes are found to be present in the lobster grounds nibbling at the algal encrustrations on rocks. Some of them enter the traps and few are caught in gill nets. Shore siens operated in this area also land plenty of them. They are not of much economic importance since quantity landed is small in term of weight.

3.2.31 FAMILY : SCORPAENIDAE

Moderately compressed to rebust fishes usually bass like in appearance with large spiny heads. Mouth terminal oblique, and protractile a ridge of bone below eye extending posteriorly and firmly attaching to preopercle. A single dorsal fin usually notched at posterior end of spinous part. Pectoral fin broad based, large fan like. Venom glands associated with spines. Lateral line always present sometime incomplete or represented only as a scaleless groove. Fleshy skin flaps or warts present on the head and body.

3.2.31.1 Pterois russellii (Bennett, 1831)

Head with feeble spinations in young, better developed in adults. Dorsal fin with 13 long spines, dorsal fin membrane strongly incised almost the entire height of the fin; 3 anal spines; upper 3 or 4 pectoral fin rays free from membranes for about half their length Colour: reddish-brown 4 dark cross bars on head. Segmented part of the dorsal, and caudal fins plain without spots; pectoral fin membranes usually covered with dark spots. Pelvic fin mostly dusky with light round spots.

3.2.32 FAMILY : SILLAGINIDAE

Commonly called Sillagos, they are small to medium sized fishes inhabiting sandy or muddy bottoms in shallow marine waters and estuaries.

Body elongate and slightly compressed tapering from middle of spinous dorsal fin to head and tails. Opercle with a small sharp spine; mouth small and terminal. Two separate dorsal fins first with 9 to 12 slender spines; the second dorsal with 1 spine and 16 to 26 rays, pelvic fin origin slightly behind the origin of pectoral fin. Lateral line slightly arched.

3.2.32.1 Sillago sihama (Forsskal, 1775)

Snout pointed; upper profile slightly convex. Lateral line with 66 to 73 scales, 5 or 6 scale rows above lateral line. Swim bladder with 2 post coelomic extensions. Colour: back light brown belly whitish or silvery, without dark blotch. Second dorsal fin usually without dark spots. They inhabit in shallow waters and feed on small invertebrates. Commonly called 'Silver whiting'.

3.2.32.2 Sillago vincenti McKay, 1980

This species known only from S.W. coast of India was also recorded during the study. Lateral line with 70 to 74 scales. Swimbladder with a single post caelomic extension. Colour: Second dorsal fin pale with 5 to 7 rows of blackish spots, other fins pale. Caudal sometimes with dark lower lobe.

3.2.33 FAMILY : SOLEIDAE

Oval or some what elongate and strongly compressed flat fishes with eyes on the right side of the body. Preopercles without a free margin, embedded in skin. No spines in fins; dorsal fin extending far forward on head; scales moderately large sometimes modified into skin flaps fringed with sensory filaments. Pectoral fins well developed and almost equal; dorsal and anal fins separate from caudal fin. Soleidae is represented in the catches by members of genera Synaptura, Solea and Zebrias.

3.2.34 FAMILY : TERAPONIDAE

Therapons inhabit inshore marine and brackish waters and some species also enter fresh waters. Small to medium sized perch like fishes with an oblong to ovate body; jaws equal, the upper not reaching beyond centre of the orbit; preopercle serrate, serrations being more prominent in juveniles. Opercle with 2 spines, the lower one larger and stronger. Dorsal fin single and arched with 11 or 14 spines and 8 to 14 soft rays. Colour: body tan or light grey. Two species are noticed in the same grounds as lobsters. (1) Terapon jarbua with 3 down wardly curved longitudinal stripes along side

of the body and 12 to 15 gill rakers on the lower limit of the first gill arch and (2) T. puta with 2 to 4 straight longitudinal stripes along the side of the body and 18 to 24 gill rakers on lower limb of the first gill arch.

3.2.35 FAMILY : LACTARIDAE

This family is represented by a single species Lactarius lactarius Bloch & Schneider, 1801. They occur in shallow waters on a wide range of bottom types. They constitute a sizeable fishery along the entire coast and is good table fish. Commonly called false trevally. Mouth is large and oblique with a prominent lower jaw; one pair of small sharp canine teeth at front of each jaw. Two dorsal fins of about equal height first with 7 or 8 spines and second with 1 spine and 20 to 22 soft rays. Caudal fin forked; anal fin with 3 spines and 25 to 28 rays. Colours: Silvery green with a blue iridescence above; Silvery white below. A dusky spot on the upper half of gill cover.

3.2.36 RAYS AND SKATES

3.2.36.1 Trygon walga (Day)

Disk as broad as long and oval or rhomboidal in shape; pectorals are continued to the extremity of the snout where they become confluent. Tail long and slender without any lateral folds. Nasal valves coalescent forming a guadrangular flap. Teeth small, having a transverse elevated ridge. One or two large serrated spines on the tail at the commencement of the second third. Between this and the base of the tail exists a median

line of about seven short spines. Numerous fine tubercles exist at the inter-orbital space and for varying width along the middle of the back. Pectoral fins united anteriorly. Colour: dull grey or brown superiorly, white beneath.

3.2.36.2 Narcine timlei (Day)

Trunk broad and disk smooth; outline of the disk somewhat rounded; disk distinct from the tail. Anterial nasal valves confluent and forming a guadrangular flap. An electric organ situated between the pectoral fin and the head. Along the side of the tail is a broad skinny keel reaching the base of the caudal fin. Spiracles close behind the eyes. Two dorsal fins present, the anterior behind the ventrals and usually smaller than the posterior. The anterior dorsal fin usually commences just behind the ventrals but occasionally over their posterior extremity. Caudal with its hinder edge rounded and confluent with the inferior. Colour: Body and fins irish golden.

3.2.37 SHARKS

FAMILY : HEMISCYLLIDAE

3.2.37.1 Chiloscyllium indicum

A small shark; body slender, with low lateral line ridges; precaudal tail slender, longer than trunk. Snout narrowly rounded or pointed; 5 small gill slits with a large spiracle below the eyes; eye elevated with a low supra-orbital ridge above them without nictitating eyelids; nostrils with short barbels; mouth small and transverse. Two dorsal fins without attenuated projecting free rear tips; first dorsal fin origin over inner margins of pelvic fins and behind pelvic intersections; anal fin long low and broadly rounded. Caudal

peduncle cylindrical without keels or precaudal pits. Colour: light brown above, cream below, with numerous dark spots on body, tail and fins, these often forming indistinct vertical bars and saddles.

FAMILY : CARCHARHINIDAE

3.2.37.2 Scoliodon sorrakowa

A small shark. Body moderately stout and markedly compressed. Head and snout strongly depressed; snout long narrowly rounded with its length greater than width of mouth; labial furrows very short; anterior nasal flaps with short narrowly triangular lobe; eyes moderately large without a posterior notch, spiracles absent. Teeth errect or oblique with sharp more or less compressed cusp without serrations. First dorsal fin moderately large, its origin well behind free rear tips of pectoral, its base closer to pelvic than to pectoral fin bases; second dorsal fin very small, its origin over or slightly anterior to anal fin insertions. Pectoral fin small broad and triangular and not falcate; upper precaudal pit transverse and crescentic. Colour: bronzy grey above, white below and fins sometimes darker than body.

3.2.38 Prawns

Class	:	Crustacea
Subclass	:	Malacostraca
Series	:	Eumalacostraca
Superorder	:	Eucarida
Order	:	Decapoda
Sub order	:	Dendrobranchiata

3.2.38.1 Penaeus indicus

Carpace hairless. Rostrum slender and long with 7 to 9 teeth on dorsal and 4 to 6 teeth on ventral margin; adrostral crest and groove extending so far as or just beyond epigastric tooth; the groove shallow; gastrofrontal and hepatic crest absent; in adult males dactyle of 3rd maxilliped about as long as propodus. Petasma with distomedian projections; outer surface of lateral lobes with a few rows of minute tubercles. Thelecum with lateral plates, anterior process rounded distally; posterior process ill calcified and almost completely inserted between lateral plates. Colour: body pale pink to yellowish, semi-translucent, rostral and middorsal abdominal crests mostly brown but reddish at base; pleopods pink or red; distal part of the uropods green or red.

3.2.38.2 Metapenaeus dobsoni

Almost the entire body pubescent; rostrum long extending beyond antennular peduncle armed with 7 to 9 rostral teeth but toothless on its distal half; adrostral crest reaching as far as epigastric tooth; telson armed only with spinules; basal spine of 3rd percopod extremely long and barbed; merus of 5th pereopod with one or two large triangular teeth. In females 5th pereopod often reduced to coxa and basis; thelecum with long grooved tongue like anterior plate partially unsheathed in a horse shoe like process

formed by lateral plates. Colour: body pale yellow to brownish with red, brownish or greenish specks; antennae red; pereopods and pleopods white to pinkish, uropods grey brownish.

3.2.38.3 Metapenaeus monoceros

Body pubescent; rostrum armed with 9 to 12 teeth along entire dorsal margin; post rostral crest reaching posterior margin of carapace; telson armed only with spinules. In adult males, merus of the fifth pereopod with a proximal notch followed by a long inwardly curved spiniform process and a row of tubercles; distomedian projections of petasma convoluted; greatly swollen and bulbiform. In females anterior plate of the thelecum long and deeply grooved; lateral plates with strongly raised lateral margins forming 2 longitudinal crests. Colour: body pink or whitish with brown specks; antennae red; distal part of the uropod purple blue; external margin of exopod red.

3.2.39 CRABS

3.2.39.1 Portunus sanguinolentus

It is a common species of crab occuring both in inshore and brackish waters. Commercial fishery is supported by specimens upto 140 mm across carapace.

The anterolateral borders are cut into nine teeth of which the last is the largest. There is no spine on the posterior border of the arm of the cheliped. Colour: dark grey with three conspicuous blood red spots

ringed with white posteriorly. The anterior male abdominal appendages are quite straight and have no sharp band near the tip. The margin in the distal part are beset with somewhat stout spines.

3.2.39.2 Neptunus pelagicus

Fishery is generally constituted by larger specimens measuring 100-150 mm. This species is recognised by the presence of a spine at the far end of the posterior border of the arm of chelipeds. Colour: in male pinkish purple with extensive irregular white spots; the tips of the chelae and the distal segment of the legs purple; females sand coloured. Anterior male abdominal appendages are quite straight and have no sharp bend near the tip. The margins in the distal part are beset with a large number of spines.

3.2.39.3 Charybdis annulata

It is a very common crab in rocky regions and submerged rocks. In this the upper borders of merus, carpus, propodus and dactylus and the lower borders of propodus and dactylus of the legs are fringed with hairs. The posterior border of the propodites of the last pair of legs is serrated in a large part. The sixth male abdominal segment is nearly as long as broad. Colour: flesh coloured or purple with creamy blotches, with a light greenish tinge. Legs and chelepeds with a circular purple and creamy band.

3.3 OTHER FAUNISTIC FEATURES

3.3.1 Sea weeds

Presence of sea weeds is a characteristic feature of lobster grounds. Sea weed and sea grass beds particularly around mangroves are inhabited by post larval and early juvenile stages of lobsters. They provide a natural, smooth and reselient feel conducive for growth of lobsters. Munro (1983) believes that shallow areas with mangroves and sea grass serve as nursery areas for preadult population of P. argus wherever such habitats are available.

Sea weeds are confined to narrow littoral and sublittoral belts of this environment. The density of algal population seems to be moderate in this stretch. Pieces of commonly recognised species of algae are brought to the surface while fishing with gill nets and traps or are washed ashore. Among them Sargassum sp was most common followed by Gracilaria, Gelidium and Ulva sp Presence of Porphyra in the intertidal region of Capecomorin is reported by Rao (1973). The density of sea weed population is maximum at Vizhinjam and Varkala, even though harvestable quantities of sea weeds are present in other localities like Pallam, Kurumbanai and Colachel.

3.3.2 Sponges and Corals

Dense growth of sponges is present in some localities. Growth of gorgonid is also confirmed by specimens and pieces of them landed in nets. Sponges are very frequently collected in traps and nets.

3.3.3 Molluscan fauna

Several species of Molluscan fauna are residents of spiny lobster grounds and they constitute one of the most important group of organisms in this ecosystem. Most striking feature is the presence of species of Modiolus spreading like a mattress on the bottom. Other important representatives are species of Pinna, Olivia Cyprea, Bulla, Hemifuses, Xancus, Murex, Conus, Dentalium, Arca Meretrix and Bursa. Hemifuses sometimes enters the lobster traps and so also chanks. Chank diving is an import avocation pursued by coastal fishermen side by side with lobster fishing in Trivandrum and Kanyakumari Coasts. Mahadevan and Nair (1974) say that the narrow strip on the extreme south west coast of India from Colachel to Trivandrum is a place where either chank or pearl oyster or both occur in fairly large numbers. From class Cephalopoda, cuttle fishes Sepia pharaonis, S. aculeata and squids like Loligo duvaucelli and Sepioteuthis arctipinnis can be noticed. Octopus sp is also occassionally encountered. Shells of Nautilus are often collected from these grounds. Among the commercially important and edible bivalves forming a part of the same ecosystem are, green mussel Perna viridis and a lesser percentage of brown mussel P. indica. Mussel is a delicacy food item consumed by entire coastal population. Green mussel is fairly abundant throughout this stretch. On the other hand brown mussel has a very restricted distribution extending from south of Quilon to Tirunelveli Coast (Jones, 1950; Rao, 1958; Rao, 1974). Sessile forms like limpets and chitons are prevalent in inter tidal zones.

- G.5046 -

3.3.4 Echinoderms

Important representatives of Echinoderm fauna are two species of sea urchins: Salmacis bicolor and S. dussumieri. They are often gathered from floor of the sea and the ripe roe is eaten by fishermen population. Of the cake urchins Clypeaster sp is frequently noticed. Star fishes are considerable in number and are often washed ashore by waves; Pentaceraster and Protoreaster being the most common. Solaster sp. is also recorded. Sea stars are notably voracious feeders on bivalve molluscs.

Barnacles are present permanently cemented to rocks, shells and other solid objects and so also Lepas. Latter is sometimes found attached to various parts of the body of spiny lobsters.

T
639.515 (210.5:540
VOH

C H A P T E R - IV

IV. STUDIES ON BAITS

Baits constitute an important component in exploitation of spiny lobsters with traps and the role of the bait is very crucial in this method of fishing where the principle involved is that of luring the organism. The term bait denotes food or some substitute used as allurement. Any natural organism which can be employed to catch is generally termed live bait. Although the bait may not be actually alive at the time of use, the term is broadly applicable neverthless. In angling parlance, the live bait is called cut bait or strip bait when it has been changed in form to serve some special purpose. Varieties of baits are employed in lobster fishing all over the world.

4.1 Types of baits in lobster fishing

The early literature reflects the long held view that spiny lobsters are scavangers, feeding opportunistically on dead animal materials. This belief was perpetuated by extensive use of fish heads and stale baits in baited traps. The western rock lobster (P. cygnus) is basically a scavenger, feeding on sedentary or semisedentary reef flora and fauna (Phillips et al., 1980). Wicksten (1982) has reported that many of the crustaceans taken in the trap in California were scavengers attracted to baits. Bardach et al., (1972) says that spiny lobsters may act as scavengers; but exhibits a marked preference for fresh foods. From India George (1967b) has reported that spiny lobsters are omnivorous feeders, frequently of a scavenging type.

Firth (1944) has recorded that baits for lobsters in United States consists of low priced or salted fish, trimmings from nearby canneries or

spoiled fish. Oily fish, either fresh or salted or partially decomposed seem to possess the greatest attraction for lobsters. American lobsters eat practically anything. According to Pease (1965) all species were of equal efficiency as long as they were fresh; but putrid bait appeared to be less attractive. Davis (1958) records that lobsters are dirty feeders and are usually caught with any fish remains and are particularly fond of stale wrasse. In Australia about 30 varieties of baits are used which include sheep head, fish head and the whole fish (Hughes, 1971). A canned product with fish offal as base has been developed in Australia, the use of which appears to be satisfactory (Gates, 1961). According to Forsyth (1946) 'stale baits for lobsters and fresh baits for crabs' is the advice given to fishermen. If fish used aresalted lightly and kept in barrel for a few months, a strong smell of fish oil is emitted and this forms a most attractive lure for lobsters. Fish offal and skinned and salted sea birds are also used in some places. In Srilanka, baits used are the cheapest available, namely fish heads (De Bruin, 1960). In Maldives, Jonklaas (1967) used chunks of freshly speared fish without much success. But the use of mantle and muscle of Tridacna gave satisfactory results. In Haiti 80% of the catch is landed by traps baited with conch meat. From India, Miyamoto and Shariff (1961) have referred to the use of mussel (Perna sp) as bait while fishing for spiny lobsters with traditional traps in S.W. coast of India. Mohan Rajan et al. (1981) have mentioned about the occassional use of sea urchins (Echenes sp) as bait for lobsters.

4.2 Feeding behaviour

After analysis of stomach contents and from laboratory observations Kanciruck (1980) concluded that the old belief of spiny lobsters being scavangers feeding on dead animals is generally untrue. Most of the materials are eaten alive or in freshly killed condition and lobsters are selective feeders when possible (Carlberg and Ford, 1977). Because Palinuridae are characterised by slow movements (except in tail flap retreat) and lack of chela, they are usually limited in their diet to sluggish and easily captured organisms or animals fixed to the substratum. Berry (1971) described the distribution of P. homarus in South East Africa as being correlated with the availability of brown mussel, Perna perna on the inshore reefs. Mussel grows attached to the rocky substratum. During the course of the present study also, it was observed that spiny lobsters predominantly occur in grounds in the vicinity of which there is abundant growth of mussel. Though both the species of mussel (P. viridis and P. indica) are present, more than 90% of population is of green mussel (P. viridis). It is quite possible that spiny lobsters in general have similar dietary fare reflecting their habitat specialisation.

Palinurids in general can be considered as omnivores with great emphasis on animal foods. George (1967b) has reported that normal food of spiny lobsters include marine worms, molluscs and small crustaceans. During the present study it was noticed that in certain localities if the population of mussel which is the natural food of spiny lobsters is sparse in the proximity, they feed upon algal encrustations. In certain habitats

they may be the major benthic carnivore (Berry, 1977; Davis, 1977). But Beurois (1971) described Jasus paulensis in Indian ocean as primarily vegetarian. Heydorn (1969) reported that Jasus tristani was observed to be entirely vegetarian feeding on red and brown sea weeds. This dietary fare may not be one of choice, but likely due to lack of prey, since they eagerly consumed fish when offered as bait in traps.

4.3 Feeding Rhythm

A definite rhythm in the feeding behaviour of spiny lobsters was discernible during this study. Feeding rhythm has a lot to do with the effectiveness of baits. Usually lobster traps remained set under water for whole of the day and the catch was collected early in the morning and the traps were reset after rebaiting. But on some days when few traps could be set only before dusk and the catch was collected next day morning, it was noticed that there was no significant difference in the catch from the other traps which remained set for the whole of the day. At the same time few traps which were set early in the morning and retrieved in the evening did not yield any catch. These observations point to the fact that the lobsters do not normally venture out of their dens during the day time and seek bait; but comes out during dark hours for feeding. From the direct observations it is found that feeding activities of spiny lobsters P. homarus which constitute about 90% of the landings are on a peak during the dusk and the dawn with the maximum intensity at the twilight hours of dusk.

Observations on similar lines on the feeding activities of spiny lobsters have been reported by other workers. Herrnkind et al. (1975) and Olsen et al. (1975) described nightly foraging movements for P. argus and reported that foraging began at dusk and ended in the early morning. Munroe (1974) says that P. argus feeds only at nights and specimens captured by day invariably have empty guts. Japanese spiny lobster Panulirus japonicus (Von seibold) is a nocturnal forager and its daily rhythmic activity is crespecular in nature. Bimodality of the nocturnal activity is found to exist (Kubo, 1962; Kubo and Ishiwata, 1964). Basing on the results obtained during their studies they believed the mechanism in question to be as follows. Sudden changes of the under water light intensity in dawn or dusk give stimulus for activity of lobsters and consequently increases the catch. Under water light intensity ranges between $2.4\text{-}3.5\times10^{-4}$ and $2.2\text{-}2.8\times10^{-4}$ $\mu w/cm^2$ in the full moon light and new moon light respectively. Chittleborough (1975) thought that feeding behaviour of P. cygnus was similar to that of P. japonicus having a bimodal feeding activity with peaks corresponding to dusk and predawn. Studies of Kanciruck and Herrnkind (1978) both in the field and the laboratory corroborate this. During field observations carried out by Chapman and Howard (1979) on emergence rhythm of Norway lobster Nephrops norvegicus, it was found that the peak period of emergence of these organisms from the burrows generally occured around dusk and dawn. The emergence is certainly a feeding activity as the use of baits in some experiments confirmed. Bait attraction occures only when the animal is stimulated during feeding excursions. The activity patterns are rhythmical,

and are related to the intensity of light at the sea bed (Howard, 1982). De Bruin (1962) have reported that all the species of spiny lobsters recorded from Srilanka are essentially nocturnal creatures coming out into the open only at nights perhaps for feeding.

4.4 Experiments with different baits

Baits usually employed in lobster fishing with traditional traps in S.W. coast of India are what forms a general part of the diet of the organism. Baits represent a major expense in trap fishing. No study has been carried out in India on the different types of baits and their effectiveness in lobster fishing. Trap fishing accounts for more than 40% of the total lobster landings in this place and this method is one where a bait is essential to act as a lure. Miyamoto and Shariff (1961) have mentioned about the usé of mussel (Perna sp) as bait in traditional trap fishing. Mohan Rajan et al. (1981) have referred to the occasional use of sea urchins (Echenes sp) as bait for lobsters. Pieces of cuttle fish or squids are attached as baits on to the hooks on the lure line employed in scoopnet net fishing for lobsters in some places. Small shore crabs are also uses in this fasion. During the present study fishing experiments were carried out with five types of baits in order to assess their effectiveness in trap fishing and the performance assessment of the baits tried are presented here.

4.4.1 Materials and Methods

Studies were carried out from selected lobster fishing centres in south west coast of India, with five kinds of baits which are different from

one another in order to assess their comparative effectiveness in attracting lobsters to the pots. They include four baits of biological origin like mussel, sea urchins, cattle hocks and animal guts and one nonbiological bait namely diesel oil. Five different types of baits were experimented from 5 different traps.

Live and tender mussels (Perna viridis and P. indica) thriving in natural habitat of rocky intertidal zone in the vicinity of the lobster grounds were prised with a chisel and gathered before setting out for fishing. On reaching the fishing ground, about 100 to 200 numbers of them, mostly in an encrusted mass were introduced into one trap before setting it on the floor of the sea. Fully ripe specimens of sea urchins (Echenes sp) were picked up from the sea bottom by the fishermen by diving before the commencement of the fishing operations. After the spines are scrapped off, the globular shell full of roe is thrashed so as to expose the contents. The ripe roe which is the edible portion forms the alurement in sea urchins (Mohan Rajan and Meenakumari, 1984). Two or three such crushed specimens are kept in a trap as bait. Small intestine of the ruminants was the other bait used. About 200 g to 300 g of freshly cut small intestine was kept in a perforated plastic container and was introduced into another trap. Cattle hocks of moderate size were also tried as baits. The terminal portion of the cattle legs cut 2 cm above the fetlock along with hooves were obtained from slaughter houses and two or three of them were suspended with twine in the hind portion or left as such in the trap to serve as bait. Diesel oil was the only nonbiological type of the bait employed in the study. Half

portion of a mud brick of the size 10 x 5 x 3 cm was cut and soaked in diesel oil by keeping it completely immersed for an hour and then was introduced into a trap. Mud brick function as an absorbant and holding medium for the diesel oil which gradually leaches out into the water spreading the aroma all around. A fully soaked brick piece was found to retain traces of the absorbant even after 24 h in water.

Fishing experiments were carried out using modern lobster traps developed by Central Institute of Fisheries Technology. (Mohan Rajan et al., 1988) from two selected lobster fishing centres along south west coast of India namely Kadiapatnam (77°11'E, 18°8'N) and Enayam (77°11'E, 18°13'N). The fishing grounds were located at a distance of 0.5 to 3 km from the shore at depths ranging from 8 m to 15 m. Four logged boat catamaran was the fishing craft used to reach the fishing ground and back. Local fishermen were employed to set and retrieve the traps by resorting to skin diving. The period of setting of the trap was for 24 h. The positions of the traps were rotated every day, providing equal chances for all the traps to be tried from every point of setting. This was not strictly adhered to under adverse sea conditions as well as in grounds where lobster population was believed to be homogenous.

4.4.2 Endurance of Baits

For a bait to be effective in functioning as a lure in fishing, it should last long enough till the lobsters come out and start feeding. Advantages of mussel are that they are not fed upon by other organisms because of the shell, and remain alive and do not get carried away by currents nor

get exhausted otherwise till the lobsters set out feeding. As far as sea urchins are concerned, they are thrashed into pieces and spread in the trap early in the morning at the time of setting. By dusk, when lobsters come out for feeding bait is exhausted either by having been drifted away by currents or having been fed upon by other organisms. A good portion of the bait is also washed out when the trap is lowered into the bottom for setting. But the effect of diesel oil continues to be present for whole period for which the trap remains fishing. Cattle hocks were found to last till the time of retrieval the next day. But fleshy materials especially with traces of blood become target of predation by carnivorous fishes. The presence of predators in the vicinity of traps either for eating the baits or preying upon the lobsters, naturally drives away the lobsters.

4.4.3 Results and discussions

The catch details indicate significantly high performance of mussel as bait for lobsters followed by diesel oil. 61.24% of the total catch was landed by using mussel as bait. Even though diesel oil (soaked bricks) nearly equals mussel in respect of average weight per lobster it accounted for only 27.8% of total catch and sea urchins accounted for only 9.34%. The other types of baits did not yield any significant results. No catch was obtained using animal gut as bait.

Catch data on the number of lobsters caught every day with each type of bait was analysed separately for three sets of experiments. The first set involves a comparison of performance of mussel, diesel oil and

sea urchins, the second set that of mussel, diesel oil, cattle hocks and sea urchins and the third one of mussel, diesel oil and cattle hocks. The differences in the efficiency of the baits used were compared using Friedman's test (Siegel, 1956).

Table IV. Friedman's test for comparing performance of baits

Set	n	k	x^2	
1	25	3	9.922*	Highly significant
2	30	4	42.76**	"
3	8	3	9.81**	"

The table shows that difference between bait is highly significant in all the three sets of experiments. Analysis of variance also showed the same result. Paired comparison among the baits were made by means of least significant difference. For this purpose the average catch in numbers along with the least significant difference for the three sets of experiments are worked out and presented in Table V.

Table V. Average catch in numbers of lobsters caught daily for the specified baits for the three sets of experiments

Set Nos.	Mussel	Diesel Oil	Sea Urchins	Cattle Hocks
1	2.6	1.5	1.0	-
2	3.2	1.2	0.2	0.2
3	2.0	0.8	-	-

The first set of experiments reveal that mussel is superior in performance to both diesel oil and sea urchins and diesel oil is superior to sea

urchins. Second set shows that mussel is better than all the other three baits namely diesel oil, sea urchins and cattle hocks and also that diesel oil is second only to mussel. The third set also gives identical results with cattle hocks being least efficient. The over all results clearly indicate superiority of mussel, over diesel oil, sea urchins and cattle hocks. Next to mussel, diesel oil emerges as superior to other kinds of baits tried.

Little difference existed between the sizes of spiny lobsters attracted by different kinds of baits. No species specificity also was noticed in the performance of different kinds of baits in attracting lobsters to the pot, it being dependent on the density of lobster population in the particular ground.

Attraction to food is probably the earliest bait used in both fishing and hunting. Bait in a broad sense is used for attracting organisms by stimulating the so called prey complex. The response of lobsters to various baits appears to be partially conditioned by the food preferences of the moment (Dow and Trott, 1956). Edible bait stimulates the senses of smell and taste (Von Brand, 1969). Bait fishing and chumming to attract and excite aquatic organisms are age old practices taking advantage of chemical senses of fishes (Atema, 1980). Specific chemotactic response of an animal may be elicited by specific organic or in organic chemical (Neff and Anderson, 1981).

Some affinity between the concentration of crustacean resources and underground petroleum deposit was suspected since a long time, basing

on the reports that wherever concentration of prawns and other crustacean occur there is found to be large underground petroleum deposits. Thomson et al. (1977) reported that scarlet prawns (Plesiopenaeus edwardsianus) were attracted in large numbers to a benthic oil deposit off Aruba, Dutch West Indies. Atema and Stein (1974) reported that dispersed crude oil at a nominal concentration of 10 ppm was repellent to lobster, Homarus americanus and inhibited feeding activity. However low concentrations of Kerosene (normal concentration 10 µg/litre) attracted lobsters and stimulated feeding activity (Atema, 1976). A wide variety of other behavioural responses of lobsters to oil have been reported (Blumer et al., 1973). Diesel oil is a chemical stimulant. Chemical stimulii can aggregate fish or guide them into traps and act as feeding enhancers. Their presence lasts beyond the moment of production and they are themselves usually nondirectional (Von Brandt, 1969). Primary method of food identification in Palinuridae is chemoreception using antennules and tip of pereiopods (dactyles) (Kanciruck, 1980).

Mussel is the natural food of lobsters in this area. If natural food like mussel which spiny lobsters are accustomed to is available in the proximity, they always choose them and do not seek other kinds of baits. Whole live mussel with shell is introduced into the trap as bait. Dead mussel or mussel flesh removed from the shell and used as bait was found to have no effect. Spiny lobsters would in fact prefer to extricate each individual mussel from an encrusted mass, and break the shell and feed on the flesh. A large mass containing mussel encrustations should be scraped and kept

as such instead of a number of individually separate mussels. Primary method employed by lobsters to extract the flesh is to crack the shell by gnawing at the soft edges. Often it is also observed, that in an obvious bid to break the shell, mussel is taken on to the sternum with lobsters lying ventral side up and continues to beat with muscular tail. Tender mussel is preferred since its shell is thin and easy to break. Normal feeding habits of lobsters are such that once the food is located the periopods close over it and manoeuvre it to the maxillipeds. These hold the food against the mandibular blade which chew, masticate and then ingest it. Lobsters are believed to detect the presence of mussel in the traps by the noise generated by latter. Even though the source of this 'sound' is not clear, the traditional lobster fishermen have reported that an uninterrupted buzzing noise is always present in the mussel beds. This sound may be within the sensory capabilities of spiny lobsters. The capacity of lobsters to both produce and perceive sound is well-known (Hindley, 1977). Acoustical bait stimulates the effect on acoustic nerve and tactile senses. It is well-known that some species of fish are attracted by sounds which are similar to those produced by their prey. The beating and sprinkling of water such as in pole and line fishing for tunas, is said to simulate the sound of the feeding frenzy created by live baits thrown into water. Shark rattles made of coconut shells used in South Asia and Oceana are supposed to cause vibrations ressembling wounded prey. The fact that lobsters are concious of sounds familiar to them is proved by following observation. When a small live lobster was kept tied

in trap at the time of fishing (with or without other kinds of baits) such traps were found to attract more numbers of lobsters and land more catch. In such cases lobsters are found to be caught in the traps even during the day time. A plausible explanation for this phenomenon is that the lobsters are able to detect the presence of a young of its kind in the trap from the 'cry' or the sound produced by the later.

Considering the difficulty in procuring mussel in large quantities and since its availability is restricted to limited areas, diesel oil proves to be a cheap and alternate bait for lobster fishing. It is the non-availability of natural bait in some localities and difficulty in procuring it, that forces the fishermen to resort to other methods of fishing. In course of time when mussel is bound to be exploited and used entirely for human consumption, its availability for bait purposes will become difficult and expensive. An alternate nonbiological bait will be the only recourse in such an eventuality and diesel oil will be an apt substitute. The same holds good in respect of localities where mussel population is sparse or absent.

TABLE - II

Bait Performance and Catch Details

Centre/ Year	No. of viable fishing operations*	Catch landed by							
		Mussel		Diesel Oil		Sea Urchins		Cattle hocks	
		No. lobster	Wt. gm.	No. lobster	Wt. gm.	No. lobster	Wt. gm	No. lobster	Wt. gm
Kadiapatnam									
1982	10	61	8490	17	3180	5	0750	4	0580
1983	15	36	8280	20	3390	-	-	1	0085
1984	22	64	11720	37	6515	22	3185	-	-
Enayam									
1982	7	16	3235	6	0930	-	-	-	-
Total	54	177	31725	80	14015	27	3935	5	0665
Catch/Operation		3.28	0587	1.48	0260	05	0073	0.09	0012
Average wt. of lobster			0179		0175		0145		0133
Percentage of total catch		61.24	63.02	27.68	27.84	9.34	7.81	1.73	1.32
Frequency		54		46		7		2	

* Viable fishing days: The days with no catch excluded.

Table - III

Analysis of Variance of Number of lobsters caught

	Source	ss	df	ms	v. ratio
Set 1	Total	322.32	74		
	Between baits	31.92	2	15.96	4.01*
	Between days	99.6533	24	4.1522	1.04
	Error	190.74	48	3.9739	
Set 2	Total	853.2	119		
	Between baits	188.1333	3	62.7111	10.95**
	Between days	166.70	29	5.7483	1.00
	Error	498.3667	87	5.7283	
Set 3	Total	29.8333	23		
	Between baits	16.3333	2	8.1667	16.33**
	Between days	6.5	7	0.9286	1.86
	Error	7.0	14	0.5	

* Significant at 5% level.

** Highly significant

C H A P T E R - V

V. HARVEST TECHNOLOGY OF SPINY LOBSTERS

Spiny lobster fishery of S.W. coast of India is entirely a capture fisheries. The catch is completely made of lobsters harvested from wild state. Hence the harvest technology assumes great importance in judicious exploitation and utilization of the resources. Success achieved in a fishery is measured in terms of the appropriateness of the fishing gear employed and the fishing method adopted. The role of the gear is quite significant in over all landings as well as maintenance of healthy conditions of fishery.

Till recently lobster fishing gear along S.W. coast was completely traditional in nature and indigenous in origin. Different types of fishing gear have been developed, modified and perfected from time to time by the fishermen themselves. Some gear have been discarded when they have become obsolete. This obsolescence stems from the changing conditions of fishery. All these indigenous gear however, stand out as testimony to the ingenuity of traditional fisherman.

5.1 FISHING GEAR PRESENTLY IN USE

Spiny lobsters are subjected to intense multigear exploitation, the use of traps being the foremost. Fishing gear exclusive for exploitation of the spiny lobsters or aiming spiny lobsters as the target species are predominant only in this part of the country where as in other regions, lobsters form by catch in the gear operated for other fishes. Types of gear used for fishing spiny lobsters at present include traps, gill nets, trawls, trammel nets, cast nets and fishing spear. Hand picking is also done by resorting to skin diving.

5.1.1 Lobster Traps

Lobsters are conventionally caught by special traps. Traps or Pots are inpounding devices which allow the pray to enter, but makes it difficult to escape. Genuine mechanical traps, which close by a mechanism released by the prey are seldom employed for fishing. The technique is to entice the lobsters into traps by employing suitable baits, through narrow tapered entrances or retarding devices such as gorges or funnels, through which it is difficult to escape. A baited trap is a simple but effective snare to way lay an organism. The trap was probably the earliest of devices that fishermen ever resorted to for catching fish and other crustaceans, long before the nets and other highly evolved tackle were thought of (Job and Pantulu, 1953). Trap is a highly versatile gear which has demonstrated proficiency in lobster fishing operations throughout the world and is highly adaptable to large scale or small scale fishing (Pease, 1965). Traps are more selective than lines or trawls and they can be left in the sea during bad weather and collected later (Anon 1980). Lobsters caught by traps can be retrieved alive in an undamaged condition acceptable to the processors. Traps are believed to be several generations old in this coast. Hornel (1950) considers traps as the earliest form of fishing gear used in Orients, which have been later introduced to several other parts of the world. The findings of Arocha (1964) support this assumption. A form of woven reed trap similar to Indian lobster trap is in use in Panama (Pease, 1965). Using pots to harvest a variety of marine resources reduces the labour and increases the

boat share. There has been a marked increase in the use of pots and traps to exploit crustaceans and fishes in several countries of the world. Though this may sound regressive as men were using pots when they first walked out of their caves, it has some advantages in that small number of people can, with modern equipments, handle a large number of capturing units (Wilimovsky and Alverson, 1971).

5.1.1.1 Traditional traps

Traditional local traps (Koodu - in Tamil) as innovated by fishermen and used for fishing spiny lobsters along S.W. coast of India are called 'Colachel traps'. They have remained unchanged for several generations without any attempt to improve upon them. These traps were described in detail by Miyamoto and Shariff (1961). They are arrow headed contrivances fabricated by fishermen themselves out of Palmyrah leaf stock fibres (Borassus flabellifer) or date palm leaf stalks (Phoenix dactylifera). Fibres are 1.5 m to 2 m in length, about 3 cm broad and 2 to 3 mm thick. About 100 fibres are required for one trap. Traps are woven in hexagonal meshes and consists of 3 parts namely 'floor', 'side and roof' and 'flapper'. These parts are fabricated separately and then joined together with the same fibres. The roof at the hind portion is not joined; but looped on the sides so that it can be loosened for emptying the catch and introducing the baits. The trap measures 75 cm (10 meshes) in length, 60 cm (8 meshes) in breadth and 50 cm (7 meshes) in height. Flapper is made of 4 upper meshes and 3 lower meshes.

5.1.1.2 Draw backs of local traps

The indigenous traps have some inherent draw backs. Being fabricated out of biodegradable materials, they are subjected to fast material decay and lack sufficient strength to stand rough sea conditions, and need heavy ballasts to sink. Considerable time is spent on procuring the raw materials and fabricating the traps. Life of these traps seldom exceeds three weeks and require frequent replacements during a single fishing reason. Being fabricated out of light materials, they are easily collapsible and quickly distorted. They are subjected to very frequent mechanical damages as a result of which both the catch and the trap are lost at times. Often a lot of sand and mud get washed into the traps. Traps become half laden with it and when hauled they are invariably torn to pieces. And also, it is not possible to use them in a mechanised mode of fishing. The practice of using local materials in fabrication of such fishing gear has resulted in such gear remaining confined to certain localities. They have remained restricted in popularity to certain pockets of the coastline since their fabrication techniques and mode of operation are known only to a few fishermen. The traditional trap though cheaper are less productive and does not lend itself to modernisation.

5.1.1.3 Development of New traps

Prospects of upgrading of fishing gear exist in several fields and trap is one of them (Mohan Rajan and Meenakumari, 1988). But in the case of lobster traps of S.W. coast of India, the need was for developing

a modern trap. Introduction of a uniform gear throughout the region for exploitation of the fishery will be the stepping stone for introduction of control measures. A modern and efficient trap was developed by CIFT (Mohan Rajan et al., 1988) after intensive studies and it has become popular with the traditional lobster fisherman. Wide spread adoption of the improved trap will enable judicious exploitation.

5.1.1.4 Behaviour and its importance

Fishing method and gear technology have not reached the stage to permit beyond doubt, the specifications of optimum gear and method for every fishing condition. But the behaviour of the organism with reference to the gear (both in the vicinity of the gear and within it) plays a crucial role and provides a lead in design of a particular gear.

The process of fish capture involves complex of interactions between physical properties of the gear and behavioural characteristic of the fish to be caught. Biotechnical gear development and yet other facets of capture fisheries rely to a substantial account on understanding fish behaviour. Majority of marine animals possess highly complex and stereotyped pattern of behaviour, which are highly species specific and are essential components of the functional biology and ecology of the population. As in the case of all animals with a central nervous system, the nature of response of an organism to a stimulii from the environment depends upon the inherited characteristics of nervous system, on what it has learned from the past experience and on the nature of the stimulii. Behaviour to a large extend is in the form

of responses to the different kinds of stimulii like visual, olfactory and acoustic. Knowledge of natural behaviour of fishes and the possibilities to cause by artificial stimulation a certain favourable behaviour of the fishes to be caught, is so important that the fishing can be considered a kind of applied behaviour research (Von Brandt, 1969). But it is clear that very little is yet known of the pattern of behaviour of the organism in the vicinity of the fishing gear and the principal stimulii generating it under non visual conditions (Parrish, 1969). The importance of non biological stimulii and behavioural responses of fishes generated by them is apparent to any one faced with the design, evaluation or improvement of fishing gear (Saila, 1969). In fact fishing gear design is considered as a sub set of general problems involving fishing tactis. Since numerical interpretation of the behaviour of a marine organism which significantly affects the catching ability is difficult, it is difficult to express the fishing efficiency of the gear by way of theoretical calculations. Usually fishing efficiency of the gear is proved empirically after the gear has been put to tests.

5.1.1.5 Relevant behaviour of spiny lobsters

As far as spiny lobsters are concerned, what we are dealing with are essentially a sedentary population of dull witted, but easily scared and gregarious organisms which are lured into the traps by means of baits. Bennet (1974) has stated that the catch of a baited trap is the result of a sequence of complex and variable events, the physical characteristics of the trap being decisive only at the end of the sequence. It begins with initial awareness

of the animal that attractive feed is present in the trap (Mackie, 1973) and ends up with entry, consumption of the bait and attempt to escape thereafter. This means that the process of catching takes place in two stages namely attraction and entry. In this, physical properties of the gear can influence the entry part alone since attraction is performed by baits. While designing the funnel of the trap it was made to gradually slope up so that a benthic organism like lobster can smoothly ascend it till internal opening, hence it falls to the floor of the trap in its quest for the prey. Mouth opening is situated higher and close to the upper portion so that the entrapped lobsters are not able to locate it in a bid to escape. Spiny lobsters whose principal movement is by legs on the floor (sub order : Reptantia) move about only on the floor of the trap looking for ways of escape, unlike fishes which rise immediately to the top when entrapped (Mohan Rajan et al., 1988). Hence the escape gap is provided very close to the floor on one side of the trap.

5.1.1.6 Concept of trap design

The knowledge of movement, habit of seeking cover, escape reactions and the food of the target organism influence the design of small traps. Environmental factors like the water current, nature of bottom and the fishing depth also influence the design. But the people so far have been relying on experience and assumptions in designing fishing gear. A trap being a rigid harvesting device does not lend itself to change of shape during fishing, unlike nets. Hence the design of the trap and structural parameters

consistant with the known behaviour of the organism can be finalised before the gear is fabricated. Fishing efficiency of a stationary gear like trap depends upon factors governing the entry of the organism into the trap and capacity of the trap to hold them in. The design of the trap itself cannot influence the approach of lobsters to any significant degree. Lobster traps have to be stable and strong when set under the highly dynamic and aggressive condition of sea at different depths of operation. An optimum weight and sufficiently broad base are the characteristics required in this context. Some times traps work on the principle of lobsters entering them to take shelter and then not being able to escape. Other features to be kept in mind while designing traps are (a) selection and identification of a suitable material for construction (b) optimum space requirements within the trap (there is no separate parlour and kitchen and the entire trap holds the catch) (c) ease of handling and operation (d) a streamlined shape which offers minimum resistance in water and (e) easy storage and maintenance.

5.1.1.7 Selectivity in traps

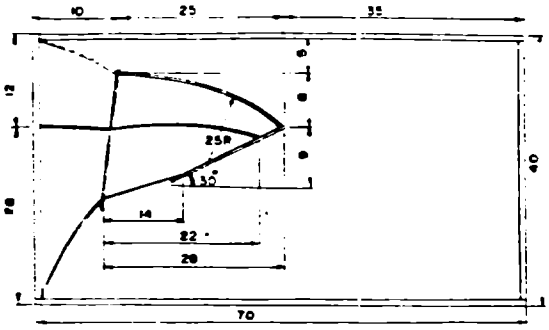
During a study on the influence of the gear and behaviour in Nephrops fishery in Norway it was found that the selection process in most fishing operations is a mainly a combination of (1) selective properties of the fishing gear and (2) selective properties due to the specific behaviour of the organism to be caught. Process of catching by baited creels mainly depend on a two step behaviour dependent selection, like 'attraction stage' (long distance attraction by olfactory stimulii) followed by 'gear stage' (in close vicinity

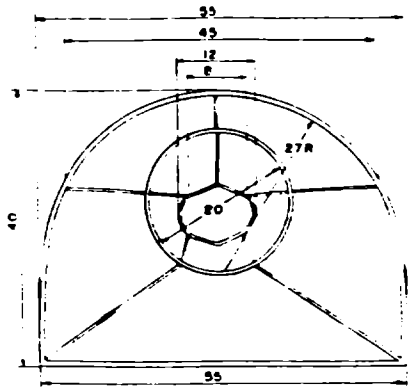
of the gear). Chapman and Howard (1979) suggest that extension of feeding excursions is positively correlated with the size of the animal. Then a small Nephrops will have a fairly restricted feeding range and a low possibility of reaching the creels. So we can assume that there is a selection process even before lobsters are in contact with the gear, giving a relatively high proportion of large individuals in the gear stage. Less than 10% of the Nephrops that were attracted to the creel during the field observations did eventually enter. Like the attraction stage the entering process also seem to be size dependent thus contributing to the total selection pattern.

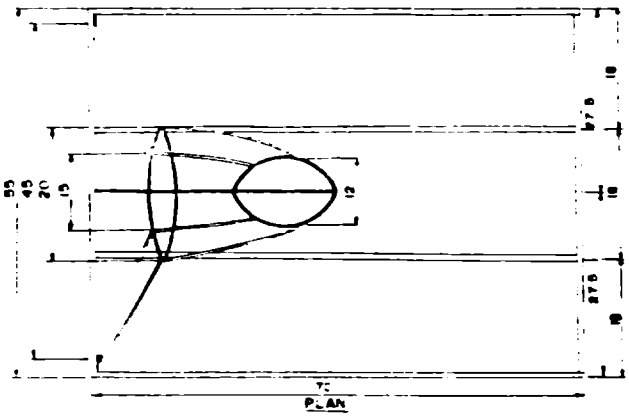
MODERN LOBSTER TRAP

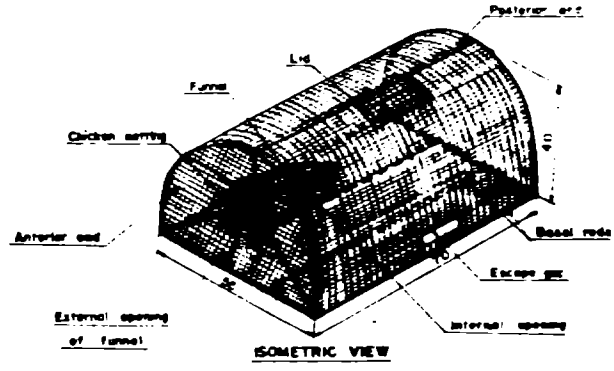
5.1.2 Design and construction

The design of an effective trap requires careful consideration of the geometric form desired. The choice of most rational design in gear construction is of primary importance than theoretical calculations. The newly developed trap (Fig.6) is semi cylindrical in appearance and measures 700x550x400 mm with a frame of rectangular base and semicircular ribs made of 10 mm dia MS rod. MS welded mesh (25 mm x 25 mm square mesh, 2.11 mm thick) is used as covering material on skeletal frame work. The trap is a single entry type with a trunk shaped funnel of 350 mm in length located at one end. The funnel is designed and attached in such a way that the lobsters are guided by a gradual inclination to the internal opening through which they fall into the floor of the trap. Anterior end of the trap as such tapers into a circular ring of 200 mm dia located 100 mm inside the trap and held in position by 6 mm rods attached to the

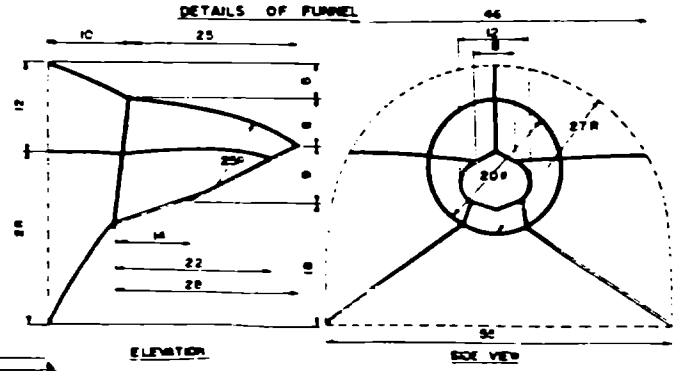


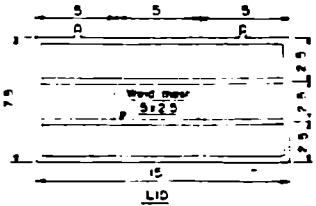


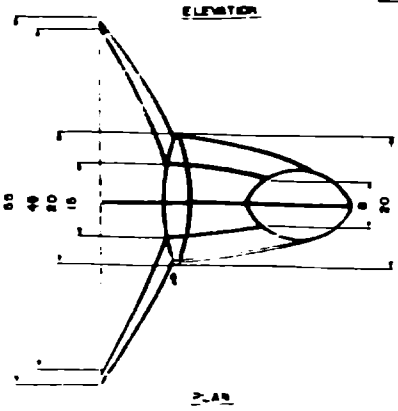




DETAILS OF FUNNEL







MATERIALS

1. Frames with M.S. rod 10 mm dia
2. Funnel with M.S. rod 4 mm dia &
   chicken netting 1.25 cm hexagonal mesh.
3. Mounting materials
   (a) welded mesh 2.5 cm^2
   or
   (b) chicken wire netting 1.25 cm hexagonal mesh

FIG. 6

MODERN LOBSTER TRAP DESIGN

corners. The internal opening is formed of an elliptical ring of 180 mm in length and 120 mm breadth attached at an inclination of 30° being 130 mm below the roof of trap and 270 mm above the floor. Hexagonal meshed chicken wire netting (125 mm mesh, 0.89 mm thick) is used to cover the funnel. An escape gap of 150 x 35 mm is provided on one side, 10 mm above the floor for possible escape of under sized and juveniles. A lid of 120 mm x 120 mm is provided on the upper middle portion of the trap with suitable hinge arrangements for baiting and removal of the catch. No separate holding compartment is necessary since the entire trap holds the catch. In order to over come the possibility of the gear continuing to fish even when it is lost from human control (ghost fishing), a small portion of the trap can be covered with biodegradable material like canvas or cotton cloth which will decay and give way for the entrapped organisms to escape.

5.1.2.1 Materials for traps

Materials used for fabrication of traps for operation in inshore waters with hard substratum should be resistant to biodeterioration, corrosion and abrasion. Durability, comparable strength, easiness of fabrication and susceptibility to preservative treatment are also necessary qualities. Such gear being commonly used by artisanal fishermen, the investment should be low but economically advantageous in the long run (Meenakumari and Mohan Rajan, 1985). Metal traps made of MS rods and welded mesh, fully covered with a rigid plastic protective coating performed efficiently and

lasted several seasons. A trap fabricated with mild steel rod is heavy enough to sink and with stands rough handling and buffeting action under the water. Chicken wire netting as well as welded mesh form a compact covering when cut to the required size and mounted. These materials give the feel of a hard stable substratum to which rock lobsters are accustomed. Plastic coating forms a uniform covering on the iron traps which makes it impervious to water and prevents corrosion and increase the service life. In water, it provides the same smooth and resilient feel as Kelp, a sea weed generally found on the lobster grounds (Anon, 1965).

5.1.2.2 Fishing operations

The traps are laid and retrieved by local fishermen by resorting to skin diving. Traps are set individually. Fishermen engaged in this kind of fishing are good divers. The fishing grounds are normally located at a distance of 0.5 to 3 km from the shore at depths ranging from 8 to 15 m. On an average 10 traps are carried at a time on a 4 logged catamaran which is the fishing craft employed. The crew consists of 2 or 3 men. On reaching the ground, the traps are baited with 100 to 200 mussel (Perna sp) put in the form of an encrusted mass. Baited trap is thrown overboard and as it sinks, a fisherman dives down and collects it under water and sets it in strategic position in the rocky substratum while the other fisherman on the craft immediately makes a mental note of the position by 4 point bearing method in relation to prominent objects on the shore (Kaniyan - in Tamil). There is some kind of hereditary rights on the fishing

ground operated by every fisherman. Pots are visited and hauled daily. For hauling, fishermen set out early in the morning with sufficient stock of baits. After pin pointing the position of the trap, one fisherman dives down with a wooden hook tied to one end of a coir rope of 50 m in length and 2 cm in thickness, kept coiled on the catamaran. On locating the trap this hook is connected on to the trap and a signal is given to the person on the catamaran by way of a jerk on the rope when the later hauls up the trap. After the catch is emptied, the bait is replenished and the diver, after few minutes of rest dives again to reset the trap. Catamaran then moves on to the next trap.

5.1.2.3 Strategy of fishing

The strategy of fishing is related to the feeding behaviour of the organism. As pointed out in the chapter on 'studies on baits', a definite feeding rhythm was discernible in the case of lobsters during the study. Observation in this context point to the fact that lobsters do not normally venture out of their dens during the day time; but come out during dark hours for feeding. Feeding activities of P. homarus which constitute about 90% of landings on S.W. coast of India are on a peak during dusk and dawn with the maximum intensity at twilight hours of dusk. In a diel sense fishing will be most successful in dark hours.

This observation can substantially alter the strategy of fishing. Instead of shooting the traps early in the morning and leaving it for all the 24 hours in water, the traps can be set just before the dusk or dawn and

collected after 2 or 3 hours. This will save a lot of time for the fisherman. This time can be utilised for some other occupation to earn additional income. Generally in an economic sense this will minimise the extraction cost and maximise the theoretical potential yield. During such operations the fear of poaching, or the traps and accessories being stolen will be eliminated since the fishing craft and the fishermen are present in the ground during the period of fishing. The same strategy applies to other modes of fishing also. In the case of gill net fishing for lobsters this strategy will substantially reduce the scope of destruction of gilled lobsters by predators.

5.1.2.4 Scope of mechanisation of fishing

This mode of fishing has several limitations. Since fishing is by resorting to skin diving it restricts the depth of operation to shallow waters. The latent spiny lobsters population in grounds beyond this depth remain not fully exploited. It has been established that lobsters on attaining larger and larger sizes move deeper and deeper. Further, some species like P. polyphagus prefer open sea floor little away from the surf region. Physical endurance and the hardships of a person to dive every time a trap is set or retrieved, also limits the total number of traps handled at a time to minimum. All these point to the fact that there is scope and need for increasing the landings by operating more number of traps and extending the operations to deeper grounds and exploiting the latent resources. This can be achieved only by changing the mode of operation in such a way as to dispense with the need for diving and by partialy mechanising the shooting

and hauling operations. It is believed that by utilisation of long lining techniques for pots, fishermen could fish upto 300 pots per day. The development of advanced hydraulic winches and new over the side hauling techniques for traps have provided a means by which fisherman can set a large number of units in a effective geographic pattern, retrieve, rebait and reset them in a short span (Wilimovsky and Alverson, 1971). In several areas of the world there have been very rapid transition to pots for capture of great number of crustaceans.

5.1.2.5 Studies on mechanisation

Some studies in this direction were carried out from Kanyakumari from a 13 m fishing vessel of department of Fisheries Tamil Nadu. A series of traps were operated using a main line and branch lines at the ends of which traps were attached (Fig.7). Each branch line was 5 m in length made of 12 mm dia HDPE rope attached to the main line at a distance of 11 m each. The main line was more than 100 m in length and was made of 18 mm dia HDPE rope kept coiled on the foredeck. An anchor or a heavy stone is attached to the outward end of the main line. To the same joint, a long float line of 6 mm dia HDPE rope is tied at the end of which a large float and flag is attached. Flag is tied on to a bamboo pole of 3 m in length. Traps are baited and kept ready for shooting.

On reaching the ground and after recording the data like depth, nature of sea bottom and the direction of the current, the vessel steams in a

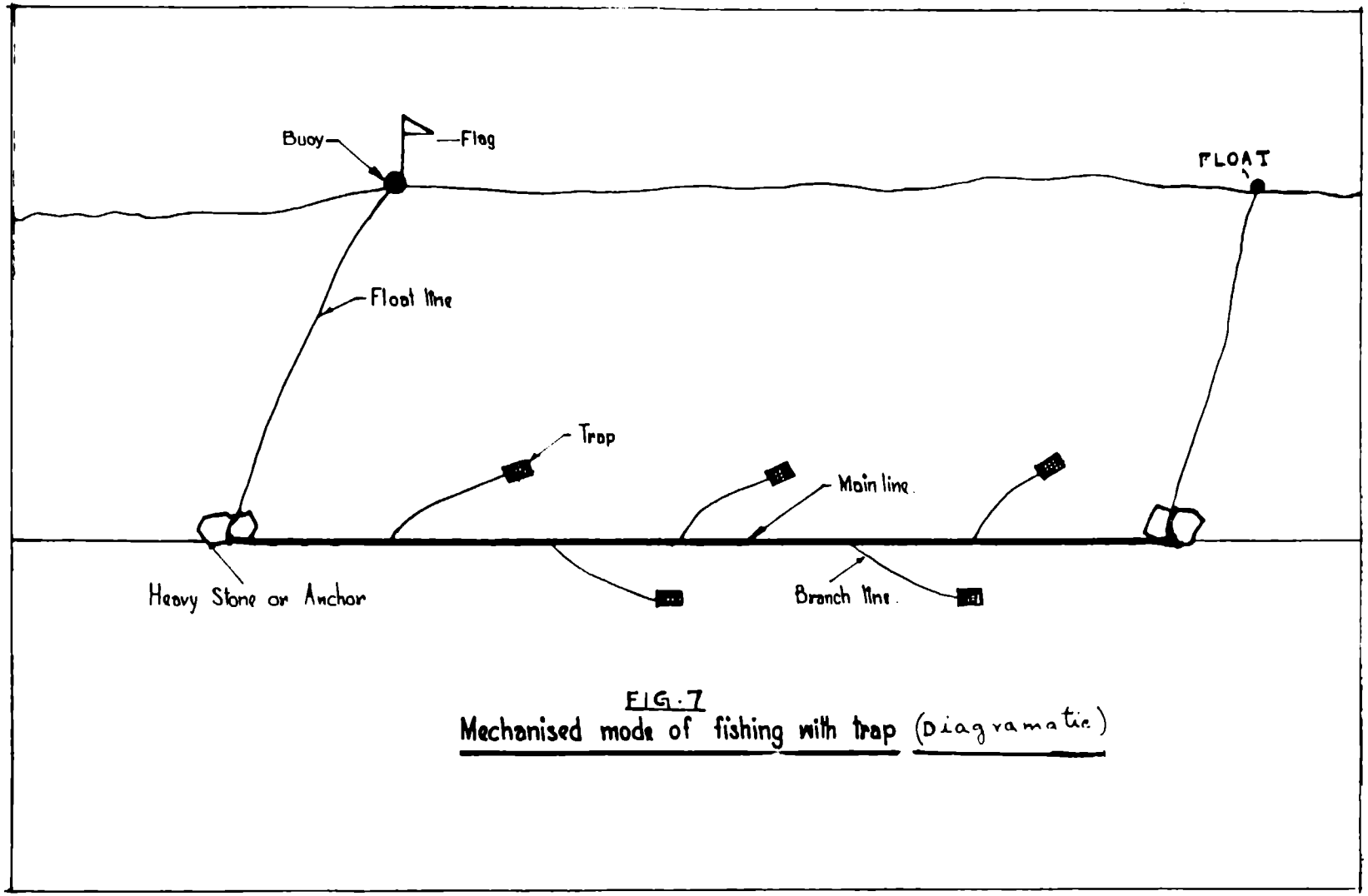


FIG. 7
Mechanised mode of fishing with trap (Diagramatic)

direction opposite to current. The flag mast and the float is first thrown into the sea along with float line. The float serves as a marker, enabling the location of the gear the next day at the time of hauling. Afterwards anchor is lowered into the sea. When it is ensured that the anchor has got the grip, the vessel proceeds further and the first trap along with the connecting branch line is shot into the sea. Care is taken to see that the trap sinks down and settles in an upright position on the sea floor. After ensuring this, the vessel proceeds further to about 11 meters and shoots the next trap and branch line into the sea. Traps are laid alternatively on either side of the main line. Few meters after the point of attachment of the last branch line a large granite stone sinker is attached on the last leg of the main line. After the last trap is set in the sea this main line leg with stone sinker is also put into the sea.

At the time of hauling the flag end is collected first with float and the anchor. This is followed by each trap and branch line and corresponding length of main line. In this operation, if arrangements can be made to haul the main line or a line hauler or gurdy, and collect each branch line by hand as they come by, the manual handling of the gear can be partially done away with.

5.1.3 Gill nets

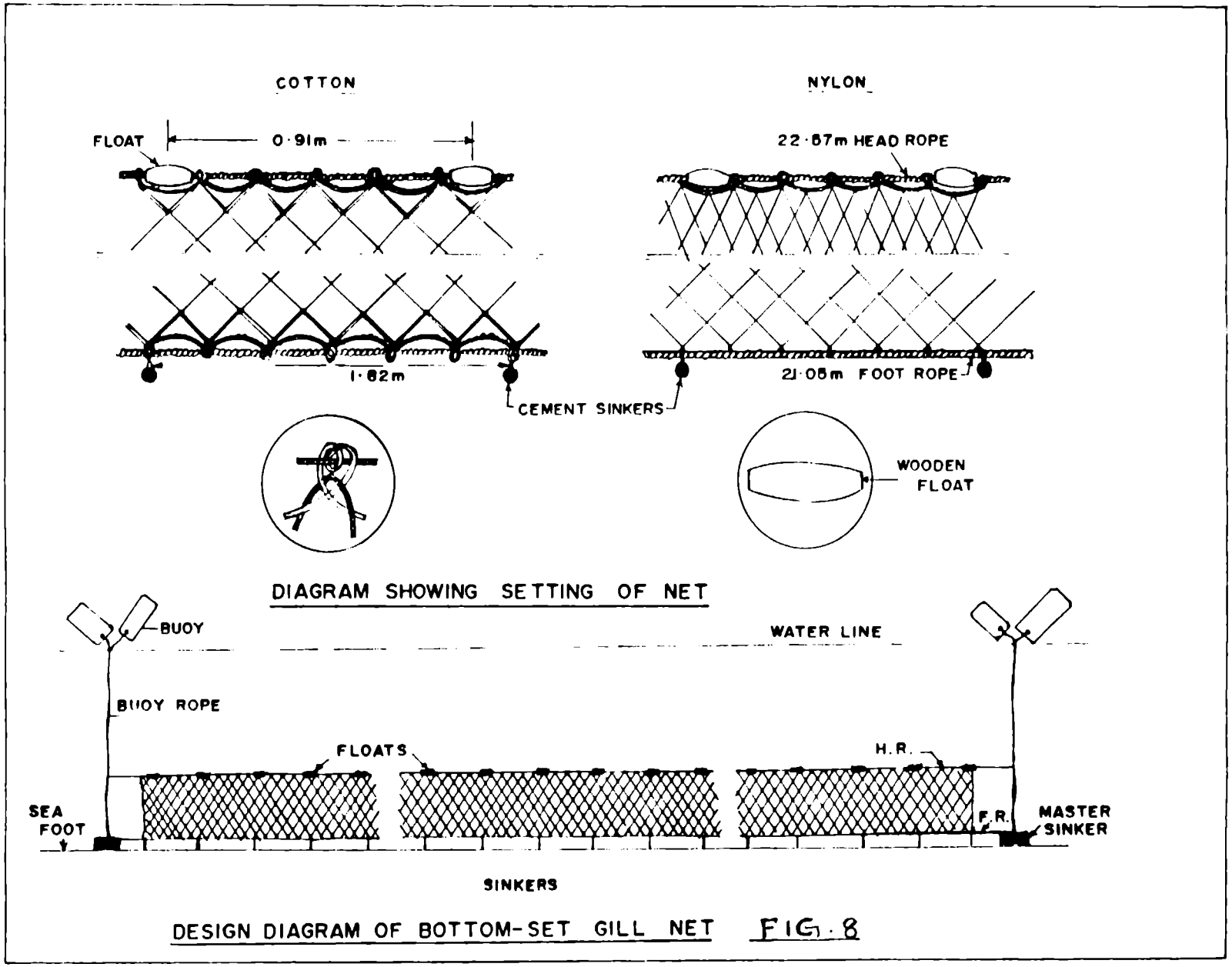
Gill net is an extensively employed gear in all major fisheries of the country. Though passive in nature, it is a light fishing gear and highly

selective in function. The top of the webbing is seized to a head rope with floats and the bottom to a foot rope with sinkers. The combined action of the floats and sinkers maintains the vertical stretch of the net. Lobsters are mostly caught in gill nets by the process of entangling rather than true gilling. Lobsters equipped with spines and long legs become entangled in the nets the more they struggle to get free. Gill net fishing is very effective for lobsters in grounds free of rocks and under water obstructions.

Before the year 1960 and before the commencement of the present active phase of lobster fishery in S.W. coast, some old pieces of gill nets used to be joined together and operated as bottom gill nets around rocks for catching lobsters. Old surface gill nets made of hemp twine were used for this, and each piece was 250 meshes in length 50 meshes in depth with a stretched mesh size of 145 mm (Balasubramanyan et al., 1960). The net was mounted on a 0.84 dia coir rope with 45% take up. There was no foot rope. Several old pieces, usually 8 in number were joined together and was operated as bottom set gill nets after attaching 2 to 3 stone sinkers of 2 kg each on the lower webbing. The net used to be buoyed up with 8 wooden floats made of local light wood (Albizzia sp). The fishing operations were carried out during nights from small catamaran and the nets used to be hauled up the next day morning.

5.1.3.1 New lobster gill nets

Miyamoto and Shariff (1958) designed a simple bottom set gill net and conducted some trial fishing from Muttam with encouraging results.



DESIGN DIAGRAM OF BOTTOM-SET GILL NET FIG. 8

An improved type of gill net (Fig.8) was designed and constructed by Balasubramanyan et al. (1960) both in nylon and cotton with changes in proportion, mesh size and buoyancy for further studies. A preliminary account of the experimental fishings conducted by them were reported. The detailed specification of these nets are given below.

I. Main webbing

	Cotton net	Nylon net
a) Mesh size	15.24 cm (stretched)	15.24 cm (stretched)
b) Kind of knot	Single trawl knot	Double knot
c) No. of meshes in length per shot	250	250
d) No. of meshes in depth	15	15
e) Weight of each shot	2.20 kg	2.75 kg
f) Percentage of take up on head rope	46	46
g) Percentage of take up on foot rope	50	50

II. Head rope

a) Material	Sisal	Coir
b) Length required	22.5 m + 0.46 m extra on either side	22.5 m + 0.46 m extra on either side
c) Thickness	4 mm	-
d) No. of ropes required	1	2

III.	Foot rope		
a)	Material	Sisal	Coir
b)	Thickness	6mm	2mm
c)	Length	21.05m and 0.46 m extra on either side	21.25 m and 0.46 m extra on either side
d)	No. of ropes required	1	3
IV.	Buoy rope		
a)	Material	Coir	Coir
b)	Thickness	1.92 cm	1.92 cm
c)	No. of ropes	2	2
IV.	Floats		
a)	Material	Wooden floats made of 'Elavu' (Bombax sp)	Same as in cotton nets
b)	Shape	Spindle shaped with 0.8 cm	"
c)	Dimension	10 cm in length 3.8 cm in breadth at centre tapering to 2.5 cm at the end	"
d)	Buoyancy of each float	0.045 kg.	"
e)	Total number of floats	23	"
f)	Distance between each float	91 cm	"
VI.	End marks buoys	2 or 3 wooden floats made of 'Elavu' (Bombax sp.)	"

VII.	Sinkers		
a)	Material	Specially made cement sinkers	Same as in cotton nets
b)	Shape	Disc shaped with 6.35 cm dia.	"
c)	Average weight	283.5 gm	283.5 gm
d)	Total nos. on each unit	10 - 15	10 - 15
e)	Distance between each sinker	150 to 184 cm apart	150 - 184 cm apart
f)	Master sinkers	2 to 3 nos. of granite stones of 4.5 to 7.2 kg each.	as in cotton nets

The study revealed that both Cotton and Nylon can be used for fabricating lobster gill nets. The results of comparative fishing experiments showed that the catching efficiency of both cotton and nylon gill nets are more as less the same as far as lobsters are concerned but it was more for fishes in Nylon nets.

5.1.3.2 Further Development

A further account of the rock lobster fishing experiments with modified version of the net was furnished by the same authors in 1961 (Balasubramanyan et al., 1961). The modifications brought about in the gear were as follows: The depth of the net was reduced from 15 to 10 meshes. In some cases mesh size was increased from 15.24 to 16.71 cm without altering the total area of the webbing by keeping 230 meshes lengthwise and 9 meshes depth-wise. Number of floats were reduced from 23 to 20 with a total buoyancy

of 0.91 kg per shot of net instead of 1.02 kg earlier. Sinkers were of lead and spindle shaped, each weighing 45 gm; total weight on the foot rope being 1.36 kg. Webbing was fully of synthetic material. The head and foot ropes were of 3 mm and 5 mm dia nylon ropes. Introduction of synthetic netting material is considered as one of the factors that revolutionised the modern fishing.

5. 1.3.3 Method of fishing

Fishing craft was a 9.5 m open decked mechanised boat without any deck machinery. Hauling and shooting of the gear was manual.

The net was shot from the stern and hauled up from the port or star board side depending on the direction of the current and wind. Required number of pieces were joined together both on the head and foot ropes and the floats and sinkers were attached. On reaching the ground, shooting operations commence, first with the release of flag mark with the buoy and anchor followed by each shot of netting. After shooting all the pieces of net, the buoy rope with float, flag and anchor attached to the end of the last piece of netting is also released into the sea. The nets are left in the ground to fish over night. Result of these studies showed that these nets are very effective gear for catching spiny lobsters and bottom set gill nets became very popular with fishermen thereafter.

5.1.3.4 Gill nets in commercial fishery

Gill nets being operated by fishermen in present commercial fishery vary from place to place. East of Muttam and west of Kanyakumari fishing

for lobsters is mostly by gill nets. Records show that bottom set gill nets for lobsters were first introduced in 1957-58. At that time local fisherman made big hue and cry against its introduction. In some villages like Kollengode in Tamil Nadu gill nets alone are used for exploiting lobsters and no other gear. In some other villages like Enayam in Kanyakumari district the use of gill net is prohibited by the fishermen themselves by a voluntary ban. But in several villages other types of gear also are employed along with nets. Mechanised 'Pablo' boat with bottom set gill net came into lobster fishery by 1958-59. Almost the same time indigenous nets locally called "Pachuvalai" made of jute were being used at colachel area by a fishermen co-operative society. They were being operated upto 10 fathoms and were so successful that trap fishermen started protesting. However subsequently gill net fishing came to be established as a recognised mode of fishing for spiny lobsters. From Thikkoti George (1967) has recorded the use of a bottom set gill net called 'Kantativala'. The length of one piece of this net is 40' and depth 12' with a mesh size of 8 cm. This used to be made of natural fibres like hemp twine in olden days; but now it is of synthetic twines (Nylon or HDPE) of 2 to 3 mm thickness. 10 to 12 shots of them are joined together to one unit and set at the bottom, in depths of 4 to 8 m in rocky region during nights with the help of old canoes.

The gill nets operated by fishermen in commercial lobster fishing in S.W. tip of the penninsula is 30 to 50 m in length and 2 m in depth. 10 to 15 such shots are joined together and used at a time. Normally they are fabricated out of Nylon code numbers 210/2/3 or 210/3/3. But of late

even numbers 1/2 and 1 with smaller meshes are used. Nets with thinner twines are observed to be more effective. In some places gill nets made of old webbings alone are used because bottom set gill nets operated amongst rocks are frequently torn and lost. Meshes are 10 to 12 cm in stretched size and the webbing is mounted on the head rope with 50% hanging. This hanging allows enough slackness on the net so that it can also facilitate in entangling. Head rope is 6 mm dia HDPE rope and foot rope 10 mm dia coir rope. Circular plastic floats 10 cm in dia meter and 12 mm thick with a hole in the middle are distributed on head rope at intervals of 3 m for buoyancy. Foot rope is weighted with granite stones weighing 0.5 kg attached at a distance of 2 m each. The nets are laid in a zigzag fasion on the rocks and not exactly surrounding it. They are laid in the morning and collected the next day. Fishes get gilled during the day time and the lobsters during the night.

One disadvantage of net fishing is that most of the lobsters caught would have been dead by the time they are landed. Lobsters caught in the net whether dead or alive become the target of attack by predators. Sometimes only empty shells are landed in the net. Often meshes cut through the body of gilled organisms.

5.1.4 Trawl nets

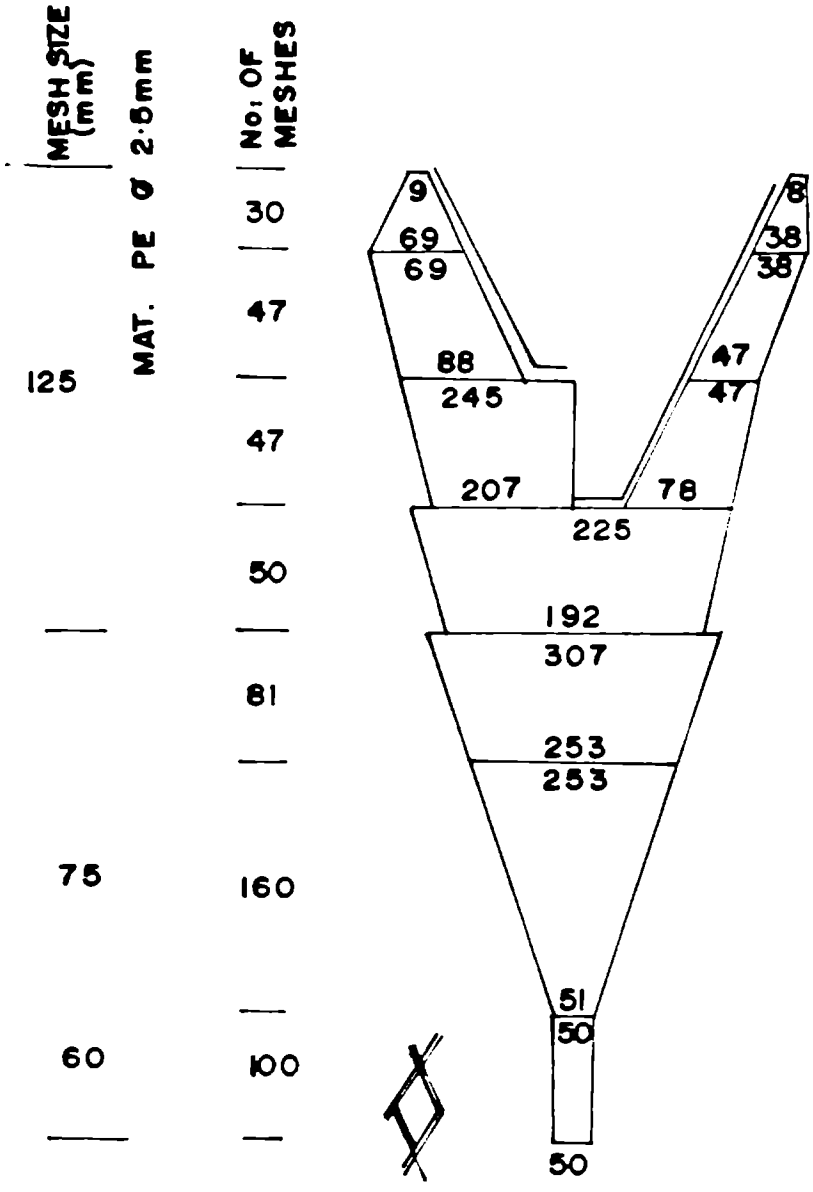
The trawl has been defined as a bag of netting towed through water, the mouth of which is kept open by floats and sinkers and either by a frame, a beam, otter boards or kites. Sometimes this is achieved by the gear

25·6M. TRAWL NET FOR LOBSTERS

FIG. 9

TRAWL
BOTTOM, OTTER
ROUGH BOTTOM
ARABIAN SEA
ROCK LOBSTER

VESSEL
L O A 25 - 30M.
H P 400 - 600



DOORS : ELIPTICAL
400 - 500 Kg
FLOATS: PL. 15 - 20
Ø 200 mm
SINKERS : 150 Kg.

being towed by two vessels. The name trawl is derived from the manner of operation of the net rather than the peculiarity of the net itself and trawling is the method of the operation of the trawl.

Several attempts were made in India on introduction of the trawling since the beginning of the century. Although it was initiated in 1902, it was taken up on commercial scale in the later half of 1950s in S.W.coast (Kurian, 1965). Now trawling has established as the most important method of fishing with mechanised boats. In trawling, size selection is mainly determined by the gear design especially the sizes of the cod end meshes. Regular commercial trawling for spiny lobsters was non existent till the year 1987 when few medium sized steel vessels started trawling for deep sea spiny lobsters (Puerulus sewelli) off this coast. They are working as stern trawlers using single net. During '88 about 14 large vessels were operating on this ground landing more than 100 tons. But afterwards catches suddenly droped and now there are no trawlers operating in this ground and catch of deep sea lobsters have trickled down to a zero. Exploratory trawling was conducted by the then Indo Norwegian Project and by the training vessels of CIFNET in 1970s which resulted in the location of potential ground for deep sea spiny lobsters between 90 to 140 fathoms of S.W.coast of India (Menon et al., 1970). CIFNET Cochin has also carried out some successful trawling for deep sea lobsters off Krishnapatnam in East Coast. They have developed a trawl net design for exploiting lobsters (Fig.9). Fishery Survey of India has carried out limited off shore prospecting for lobsters. In the uneven rocky substratum of near shore waters which is the abode of common

species of spiny lobsters, trawling cannot be done as a common practice. Lobsters form only stray catches while trawling for other ground fishes beyond shallow surf region.

Commercial trawling for lobsters is employed in Norway (Jensen, 1967), Sweden and France for catching 'Scampi' (Nephrops norvegicus). Debruin (1960) has reported catches of spiny lobster in Granton trawls at depths of 20 fathoms from Srilanka. Fisherman of United States have dragged for lobsters since 1950 especially on the north eastern banks. Offshore lobsters are harvested either by otter trawls that are specially rigged for catching lobsters or to catch lobsters incidentally while fishing for ground fish (Doliber, 1973). Trawling is done on aggregation of migratory lobsters in the middle of gulf of Papua (Moore & Mac Farlane, 1980).

5.1.5 Trammel nets

This is essentially a fresh water gear. The use of trammel net for fishing prawns and lobsters started only recently, around 1985 in southern most tips of both the coasts. Strong objections and protests have also taken place against its introduction. Trammel nets are used in Bombay coast for catching lobsters since a long time (Jones, 1967). Trammel net is a multilayered net with three layers of webbing seized on to the same head and foot ropes. Between two rather wide meshed outer walls, a slack layer of interior webbing of small meshes is inserted. The sizes of the meshes in the outer two walls are 4 to 5 times larger than the inner webbing. The mechanism of capture is as follows. When an organism swims through large

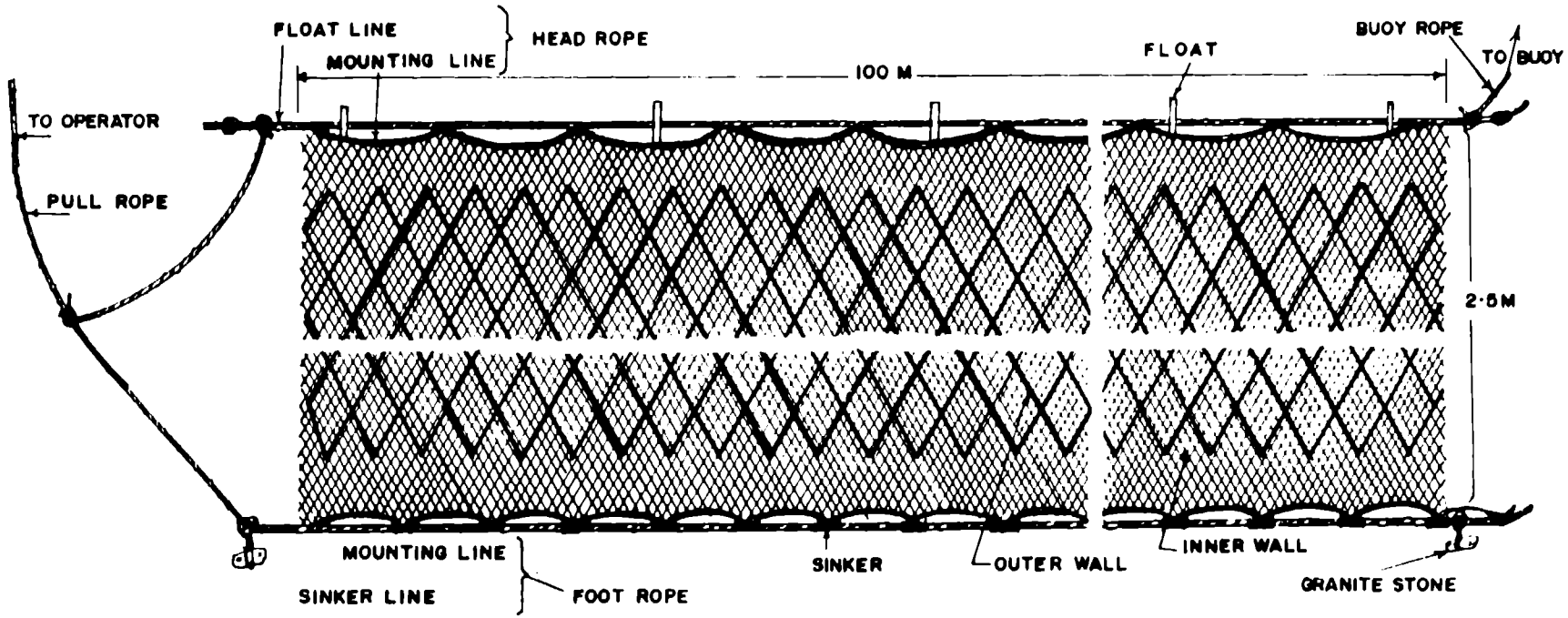


FIG.10. DESIGN OF A 'DISCO VALAI' (TRAMMEL NET)

MODE OF ENTANGLEMENT OF LOBSTERS

outer meshes, it encounters and pushes against the loose interior webbing so that a pouch is formed around it in which it becomes entrapped. To be successful in its purpose the large meshes of two outer walls must fit exactly one upon the other so that a pouch will not be prevented from developing (Von Brandt, 1972).

Locally this net is nicknamed as 'Disco Vala' (Fig.10) and has became rage in Kanyakumari district and is spreading to Trivandrum district. Even though it is primarily used for catching prawns, lobsters, fishes and other crustaceans are also landed. It has actually obliterated the use of conventional prawn gill nets called 'Ralvala'. The inner wall of webbing has 4500 horizontal and 72 vertical meshes of 20 mm bar made of Nylon Code No.$\frac{1}{2}$. The outer walls is made of Code No.2 Nylon twine and has 583 horizontal and 8 vertical meshes of 135 mm bar. Head and foot ropes are of 10 cm in length. Floats numbering 165-170 in total are synthetic and round in shape (50 mm dia and 10 mm thick). Sinkers are of lead and spindle shaped, 20 mm in length with a thickness of 15 mm in middle and 10 mm towards the edges. There are 500 numbers of such lead sinkers each weighing 20 gms. These are found to land a large quality of juveniles and smaller form of both prawns and lobsters.

The lobsters get entangled and retained in the pockets of webbing created. The net is operated as bottom set. One disadvantage is that a large quantity of webbing and netting material is required to fabricate a net which increases the capital input. Such a gear will be economical

only in the case of high quality products. Lobster being a marine product of high individual value the use of this gear for it exploitation may not be uneconomical. The advantages of this gear in lobster fishery is that the specimens of all sizes are landed and in live condition with minimum injuries, and damages unlike in gill nets.

5.1.6 Cast nets

Cast nets belong to the category of falling gear and are circular nets thrown into the water. The gear can be a simple circle of netting and the organisms get entangled in the webbing which collapses when carefully hauled. Cast nets sometime have pockets at the edges where fish get caught while hauling. They have a radius of 2 to 3 metres. There is a central line which is held by hand for hauling the gear. If the ground is uneven, fish and lobsters cannot be completely covered by nets and will escape sideways. On such occasions fishermen may dive down to arrange the net in right position under the water and prevent the escape. Casting the net requires practical experience as net is cast merely by the skilled movements of the body. Fishermen of South India are said to be especially skillful in operating cast nets from boats. It was suggested by Von Brandt (1972) that cast nets originally developed in India and spread over to East and South Asia into Oceana, Middle East and Europe.

Even though its use in lobster fishery has diminished, cast nets cannot be considered as a defunct gear. It is still an active gear in estuaries, backwaters and inland water sources. In some villages south of Vizhinjam

and in Kanyakumari district this net is cast from rocky elevations to catch lobsters in low tide. George (1967) has recorded that a form of cast net locally called 'Muruvala' is the most important gear for catching lobsters around Thikkoti. In olden days it was made of hemp twine with a mesh size of 4.5 to 5 cms. The net is operated from dug out canoes, at depths of 4 to 8 metres during day time when the water is clear. Another type of cast net called 'Karavala' with smaller meshes of 3 cm in size is also used. This is operated from shore.

5.1.7 Fishing spears

Fishing spear in its simple form is the fisherman's most primitive gear since prehistoric times arising out of the need to extend the range or reach of human arm (Von Brandt, 1972). Prey is taken by piercing or wounding. Fishing spear is used for catching spiny lobsters, cuttle fishes and demersal perches along S.W. coast of India. Mohan Rajan (1983) has described this implement and the method of fishing with it. It is metallic and rod shaped with a lance point at one end and an eyelet at the other. Of the two sizes, only the smaller one is employed for spearing lobsters. It measures 100 to 120 cm in length and 10 mm in thickness, with a pointed barb welded to the tip. This barb prevents the effort of the animal to escape. Barb which forms the arrow head is 3 cm long set at an angle of 30° to the rod. A coil of rope passes through the eye of the tackle which is kept twisted around the fore arm of the fisherman while firmly holding the rod at the time of fishing. The larger one is 200 cm in length and 15 mm in thickness with the barb attached with the help of a pin.

Whenver a target organism is sighted a fisherman dives down wearing only the mask and strikes the arrow head into the body thereby arresting its movements. Such operations are carried out upto a depth of 15 m and only when water is clear and turbidity less. This is a highly injurious mode of fishing from several points of view. Specimens get invariably lacerated and damaged by the piercing spear rendering them unmarketable. Secondly, spearing is noticed to drive away the lobsters from the locality resulting in a temporary depopulation of the area. When spiny lobsters are molested, they are found to leave the neighbourhood. Since they are some what gregarious in nature there is a possibility that escape of speared lobsters may cause a general exodus from the immediate locality (Smith, 1958). Success of such injuring methods depend on the individual skill and physical endurance of the fishermen which is on decline. But one advantage is that it offers income earning capacity to otherwise unskilled, unemployed and impoverished individuals.

5.1.8 Hand Picking

In the classification of the fishing gear, hand picking falls under the category of fishing without gear. Fishing without gear but only by means of hand is the very beginning of man's fishing activities. It is the purest form of gathering economy. All other fishing technique have developed and evolved from this primitive method.

During the low tide when water recedes, partially exposing the rocky substratum, fishermen wade through water and pull out the lobsters by hand from their dens. Their presence become conspicous by the antennae and

antennules with the flagellum which are always kept projecting and moving outside the dens. In deeper waters fishermen dive down wearing masks and pull out lobsters by their flagellate appendages. A net bag or small basket is carried for collecting the catch. This is not done on a commercial scale but such catch is utilised for personal consumption.

5.2 Obsolete fishing gear and methods

Some fishing gear and fishing methods that were prevalent few years back have gone completely out of use. This obsolescence of fishing gear stems from various reasons. They are highly passive and slow in operation requiring a lot of time and patience. They could be practiced with a fair amount of success only when spiny lobster population was dense. Consequent to the present thinning out of lobster population, success with such gear have become much less. In otherwords, it is the growing scarcity of catch which lead to the disuse of such gear. Some of the methods were resulting in bodily injuries to lobsters which are not accepted by processors thus denying any monetary return to the fishermen. Considering the hereditary rights of traditional lobster fishermen on the grounds they fish, and where they would prefer to operate traps, the scope of availability of natural common stock has been considerably reduced. Further, such type of fishing used to be carried out during nights from primitive crafts like catamaran which is tossed by the vagaries of nature, rendering the fishing very hazardous. All these have contributed to the gradual fading away of such fishing gear and methods. Two methods belonging to this category are anchor hook and scoop net fishing.

5.2.1 Anchor hooks

Anchor hook otherwise called 'Nangooram' in Tamil (Fig.11) is made of sharp curved hooks radially arranged at the end of a stout cylindrical iron stem with an eye at the free end looking like a grapnel anchor or an opened umbrella. It consists of 3 parts: a hook, brass wire and cotton line, and an accessory called 'Sarani' for releasing the hooks fouled or struck amidst rocks. The stem is 10 to 12 cm long. About 5 m of brass wire of 16 guaze in thickness is attached to the eye at the top of the stem and kept coiled and twisted to a fold of 30 cm length. The line with which the anchor hook is operated used to be 50 m in length prepared by twisting cotton yarn of the specification 20 count, 36 threads 3 ply or 10 count 21 threads 3 ply (Miyamoto and Shariff, 1961). The line was twisted by the fishermen themselves and dyed in the bark of the tree locally called 'Udiyam' (Odina wodier). The accessory called 'Sarani' consists of a stone and a line used for releasing the hook when they get struck in the rock. Mussel (Perna sp.) (Sippi-in Tamil) growing on submerged rocks all along the coast are the only kind of bait used. Fishermen dive and prise the mussel from the submerged rocks with a special scrapper (Kallikka Aruva- in Tamil) and collect them in Palmyrah leaf baskets. In this kind of fishing oldest and the largest mussel are preferred unlike in trap fishing. A good mussel suitable for bait is about 7 cm x 2.5 cm in size. Usually two or three days requirements are collected and a basket of these live mussels is kept submerged in sea water near the beach and removed before setting out for fishing. The meat of 3 to 4 mussel is tied to the middle of the brass

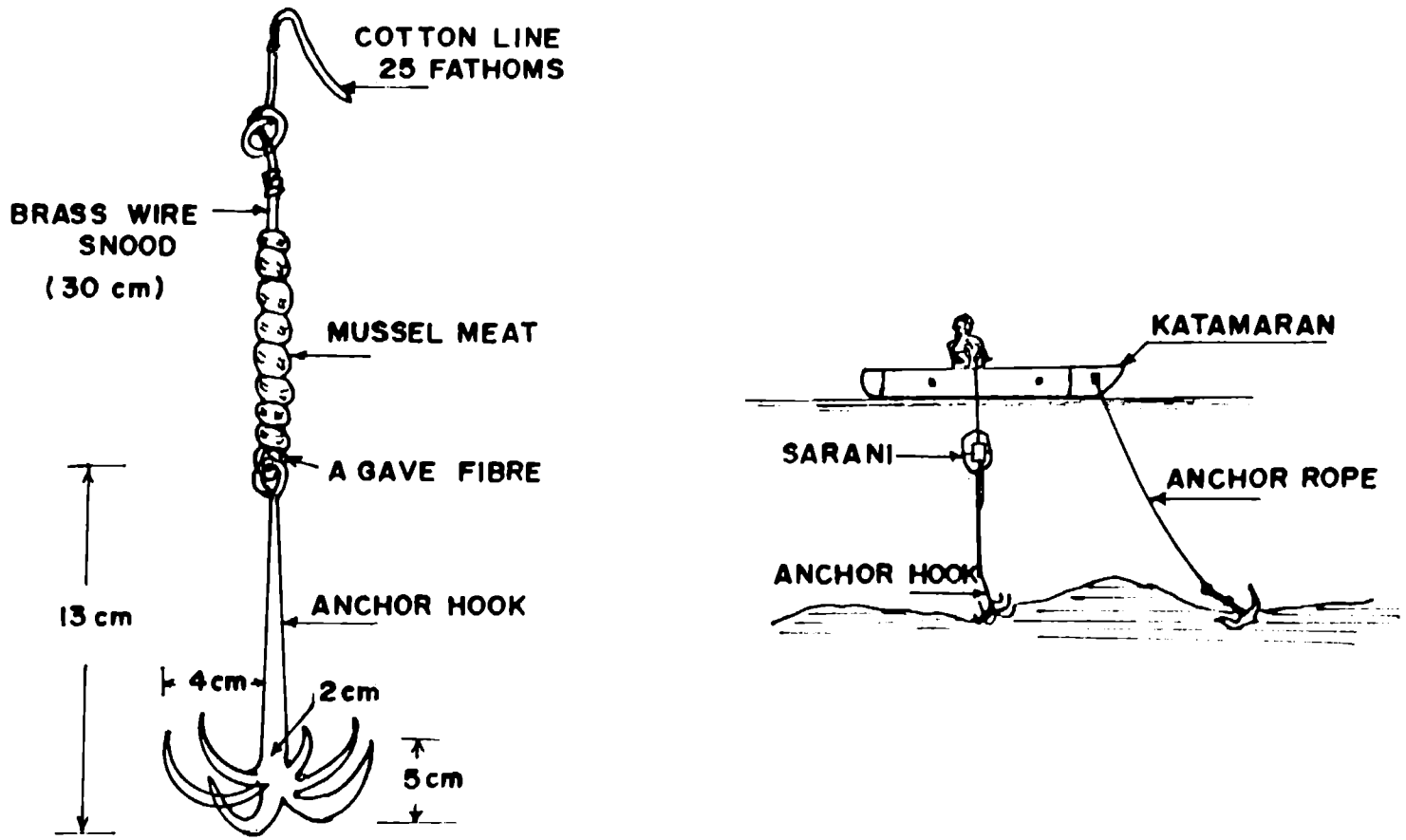


FIG.11 ANCHOR HOOK

wire snood by very thin white fibres extracted from leaves of Agave (Kathalai in Tamil). About 75 mussel are taken into the sea for a night's fishing. In Puthenthurai, Manakudi and Pallam where mussel bait is scarce the fishermen procure them from adjacent villages.

5.2.1.1 Method of operation

Fishing with anchor hook used to be carried out during nights only and all the catamarans sail and reach the ground by about dusk. The crew used to be only one fisherman or rarely two. After anchoring the catamaran, the line is baited and the gear is lowered into the sea where lobsters abound. When the bite of the lobster is felt on the line in the hands of fisherman, it is fiercely pulled up with a deft jerk of the hand when the organisms get hooked on the sharp arm of the anchor hook. Fishing operation continues for the whole night. A fisherman used to catch upto 20 lobsters a day. When hooks get struck a midst the rock, 'Sarani' which is a hard spherical stone looped on to the anchor hook line is sent down as a messenger which helps in disentangling the hooks. Sometimes snood will get snapped and the hook lost.

Anchor hook fishery has the relative advantage of low investment and less recurring expenditure. But fishermen have to stay in the sea on a primitive craft throughout the night. Another disadvantage is that the lobsters are often injured. The skill of the individual operator is most important in such fishing methods and now this is on decline.

5.2.2 Scoop nets

Another method which was practiced during olden days was scoop net fishing otherwise called Kuntham in Tamil. In this case, flesh of some mussel was tied in a piece of webbing of smaller mesh in the shape of a small ball. This was attached to a long cotton line and was operated much in the same way as anchor hooks. On reaching the fishing ground this line with the bait bag is lowered to the bottom of the sea. Lobsters, attracted by the baits cling to the bag. When the presence of lobster is felt on the gear, the line is slowly and steadily pulled up till it comes up within the reach of the fisherman. Then the whole thing is scooped up with a scoop net. This method, in its slighly modified form is practiced even now in some villages like Kollengode. Instead of putting the bait in a net bag, bait is attached to a hook and lowered to the sea floor. In this case even pieces of cuttle fish or squids and small crabs are employed as baits.

In addition to the fishing hazards mentioned in connection with anchor hooks, the percentage of escape of lobsters is very high and the returns very low. But the specimens can be landed in good condition without any damage. George (1967) has also mentioned that few lobsters are caught on hook and line operated for perches around Thikkoti. It is a method akin to 'bobbing' practiced in same European countries, where the victim maintains hold of the bait untill it can be pulled from the water on to the shore or into vessel. Craw fish can clasp and hold the bait so fast with their claws

that they may be caught in this way. In some cases even crabs are fished like this.

5.2.3 Antiquity of Lobster Gear

The records of Technological Station of department of Fisheries at Kanyakumari show that the anchor hooks used to be the popular fishing tackle at Kanyakumari proper till 1956-57. About 100 Catamaran units used to operate this gear from Kanyakumari. Though popular at other centres, anchor hooks and scoop nets are supposed to have reached Muttam and Manakudi only later since the trap was the most predominent gear in these places. When once it became successful, there were instances of even 300 anchor hook units operating from Muttam. Scoop nets were more popular at Manakudi and Pallam, where about 200 units were in operation during later half of 50s. Miyamoto and Shariff (1961) believe that Gillnets were introduced to Kanyakumari from Colachel in 1956. Record of fisheries department Kanyakumari, mention that this was in 1957-58. Gill net fishing was most predominent at Colachel several years prior to this. Traps are the earliest of fishing tackle used to catch lobsters and was the most important gear at Muttam and Colachel during this period. Both anchor hook and scoop net are believed to have gone out of active commercial use by about 1960.

5.3 Fishing crafts in Lobster fishery

Important fishing crafts employed in spiny lobster fishery of S.W. Coast of India are two indigenous types namely Catamaran and Canoe and small mechanised boats used occasionally.

5.3.1 Catamaran

These are non rigid types of fishing crafts of variable dimensions used on surf beaten coasts. These simple crafts consists of 3 or 4 logs tied together in a raft like fasion and is mostly prevalent from Quilon to Colachel from which place onwards improved variety of boat catamaran make their appearance. Catamaran generally used in lobster fishing in S.W. Coast of India are 4 logged types with 2 middle logs being the stoutest fitting keel wise at a lower level than the other two which rise sufficiently on either side to form a trough shaped hollow in between. At either end of the logs, a transverse two horned block of wood is lashed together with them, secured by coir ropes passing through grooves cut in the sides of the logs. They are 23' in length by 3' in width.

Three logged catamarans are also used in some areas. In three logged catamaran central log is the stoutest and all the three are fitted together in such a way that the central log fits keel wise at a lower level than the other two which rise sufficiently high to form a trough shaped hollow (Zeiner and Rasmussen, 1958). At each end, logs are planed flush on the under surface.

Propulsion of catamaran is by sails or paddles. A small triangular type sail is used to carry the craft to and from the fishing ground. This is fitted to the head of a dimunitive spar 3 m in length set up with a strong rake forward right in the bow. A light bamboo yard of 10 m carries the tanned cotton sail. Large split bamboo or specially prepared broad paddles

are also used for propulsion. Men keep standing all the time for paddling. While sailing, a drift plank is used between two inner logs. A split bamboo paddle serve as the rudder. The absence of free board in catamaran renders the manual shooting and hauling of lobster traps with an ease not possible in high free board crafts. The coast from Quilon to Kanyakumari is dotted with little coves and bays which give just enough security for beaching the catamarans even in bad weather.

5.3.2 Canoes

Old Canoes are used to operate gill nets for catching lobsters. Dug out canoe or its plank built counterpart variously known as vallam, odam or thoni is the most common fishing vessel found all along the west coast. Use of canoes for lobster fishing is most predominent at Quilon and extends upto Vizhinjam. Typical canoe is made by hollowing out a single log of wood and is of varying sizes. Canoe is a keel less boat. Only small versions and old ones are used in lobster fishing. They vary from 3.6 m to 4.5 m in length. The outrigger type of plank built boats which are essentially dug out canoes with planks stitched to the sides are also present in the area. Canoes are driven by oars and sails.

5.3.3 Mechanised boats

Old mechanised boats of 30' in size are used in the inshore waters for operating gill nets for lobsters. They are of 'Pablo' design with transom stern and some what lower free board. Undoubtedly transom stern would

provide a large aft deck. It is a sea kindly boat with less resistance. Main measurements of a 30' coastal fishing boat are: length overall 30', breadth 8'2" depth 4' 1" and draught maximum 3' (Zeiner and Rasmussan, 1958). Few large steel trawlers in the range of 22 to 33 meters are seasonally used by some fishing companies to trawl for deep sea lobsters off S.W. Coast at depths ranging from 150 m to 300 m. They operate as stern trawlers using special nets with thicker twine and large meshes.

5.3.4 Development of lobster fishing boat

In the whole scenario of fishing crafts in India, boats for operating special type of fishing gear for lobsters and crabs are missing. This lacuna has to be filled up. Lobster is a seasonal fishery and the grounds are close to the shore which could be reached by small traditional crafts. Scarcity of financial resources on the part of lobster fishermen was an important reason for lack of attention for introduction of a modern craft for its exploitation. The importance of development of resource specific vessels is receiving due recognition in the country only now. Even here the stress is on vessels for bulk fisheries. An experimental fishing boat for lobsters and crabs can be developed and constructed with a comparatively little investment.

The competition in this fishery is bound to be severe with more and more of fishermen chasing the same resource leading to ever diminishing individual returns. The way out is to tap the latent resources in unexplored grounds. This cannot be achieved by primitive traditional craft now being

employed and by manual operation of the fishing gear now practiced. For exploitation of deeper waters and for more intensive fishing of currently producing stocks, technological improvements in the craft and gear are necessary. Mechanising the mode of operation of the trap fishing also calls for specialised mechanised boats. In any case, when the fishing becomes intense, the manual operation of fishing craft and gear have to give way for mechanisation. Since the types of gear are light, any small mechanised boat can be adapted for this purpose. A combination vessel for fishing with traps as well as gillnets will be ideal.

5.3.5 Proposed Lobster fishing boat

The qualifications of a specific boat for lobster fishing should be high maneuverability and accurate steering. To get good grip on the water, hull should have deep forward section and substantial forefoot. The proposed new design should be semiplaning, 'V' bottomed launch with high displacement. Free board should be low with sufficient aft deck by having the wheel house as forward as possible. Fishing accessories should include pot tipper, pot hauler and echosounder. A well for keeping the lobsters live will be a welcome feature. A mechanised boat of 10 m in OAL with 50 HP engine will serve the purpose for exploiting shallow water lobsters.

C H A P T E R - VI

VI. POST HARVEST UTILISATION

Spiny lobsters are primarily destined for export because of their high unit value and great international demands. In fact, the spiny lobster fishery in India is sustained and completely oriented for export only. The gradual increase in export volumes and the dramatic increase in export values have accelerated the development and expansion of lobster fishery of India.

6.1 Internal trade in lobsters

All processing factories have their own collecting agents in fishing villages who are middle men in reality. Local trade in lobsters is only to the extent of fishermen surrendering their catch to these agents. Local consumption is negligible and is restricted to those specimens unaccepted by processors. As soon as the catch is landed, it is taken by the fishermen to the buying agent and is handed over after weighing. The payment may be made on the spot or on weekly basis. Fishermen are indebted to these middle men who advance loans to them during off-season both for maintenance of their fishing craft and gear and livelyhood. This amount is deducted in instalments from the value of the catch surrendered. This process of advancing loans and repayment in instalments is a never ending cycle. It is at this point of activity that the economic exploitation of the fishermen is at its maximum. They are cheated both in weight and value. Illiterate and often gullible fishermen are unaware of the rates fetched for their lobsters by the middle men. Middlemen often join together and deliberately bring down the prices in a whole area. In several villages lobster fishermen

co-operative societies were organised to handle the pooling and trade of lobsters to processors among other things. These co-operative societies, which were thought to be panacea for all the economic ills of the fishermen, turned out to be a damn squib mainly due to the lack of sincerity and integrity on the part of the personnel who man them. The organisations became generally inert.

6.2 Export Trade

Export of lobster tails from India commenced in 1963 with a small quantity of 53 tonnes to U.S.A. Since then the export of lobster tails and whole cooked lobster (from a subsequent date) have been steadily increasing. In the year 1972 there was a shift in the export from U.S. to Japan. As far as lobster trade is concerned India's share of export on a global basis is only a fraction. The existing market demand for lobsters is estimated to be around 40,000 tonnes per year. This demand is to be met by different species like American lobsters (Homarus americanus), European lobsters (H. gammarus), Spiny lobsters (Family : Palinuridae), Slipper lobster (Family : Scyllaridae), Scampi or Norwegian lobsters (Nephrops norvegicus) and fresh water cray fish (Astacus and Procambarus sp)

U.S.A. is the world's largest market for lobsters and there is good demand for Indian lobsters, especially deep sea forms. But as far as India is concerned, Japan occupies the leading position as the biggest buyer followed by U.S.A. Export figures of rock lobsters from India to major markets in the last four years are furnished below:

TABLE - VI

Spiny lobster exports from India during last 5 years

	1985	1986	1987	1988	1989
Quantity in kg.	14,64,647	12,29,024	6,99,523	9,58,855.	19,63,000
Value in Rs.	12,09,52,569	13,02,05,875	9,43,72,414	13,46,43,888	2,93,13,700

TABLE - VII

Export of rock lobsters to various countries

(Q=quantity in tonnes; V=Value in Rs. lakhs)

Market		1989-90	1988-89	1987-88	1986-87
Japan	Q:	1132	880	1253	841
	V:	2055.23	1348.43	1759.78	1079.63
U.S.A.	Q:	360	273	347	196
	V:	551.03	462.93	455.10	228.22
West Europe	Q:	480	400	164	87
	V:	640.38	351.82	189.25	115.94
Singapore	Q:		2	82	7
	V:		1.91	47.05	6.46
Others	Q:	95	108	17	1
	V:	115.80	195.35	22.34	1.25
Total	Q:	2067	1663	1863	1132
	V:	3362.44	2360.44	2473.52	1431.50

The whole cooked lobster, the production of which began in 1983 is today the main export product. This product requires not only a strict control of processing procedure, but also good quality raw materials, like live lobsters in optimum conditions, with no physical damages (broken legs etc.). If these requirements are not fulfilled, lobster is used for the production of raw frozen tail, the utilization index of which is comparatively low. The quality of the product is ensured by strict adherance to standard technological procedures and quality specifications for various manufactured products in all the processing plants in the country.

6.2.1 Whole lobsters

There is good demand for whole lobsters individually frozen in both fresh and cooked conditions, especially in Japan. The whole lobsters are washed thoroughly in chlorinated water. The lobsters are then cleaned and scraped with a brush to remove extraneous matter and adhering eggs and again washed in potable water before being packed for freezing.

While cooking is resorted to, washed lobsters are cooked generally by immersing in boiling brine of 5% concentration for about 8 minutes in the case of specimens of 50 gm to 250 gm weight and for 12 minutes for bigger ones; when they develop good red colour. Cooked lobsters are spread out to cool before shelling or wrapping. Cooked products undergo less changes in cold storage than frozen lobsters. If dead specimens are boiled for cooking, they develop some black spots on the carapace. Therefore only live or freshly killed specimens are used for cooking. They are then graded according to size. The grading appears to be dictated by the buyer's demand. Graded

specimens are wrapped in polythene papers individually and secured by rubber bands. Then they are individually frozen at -40°C and stored at -20°C.

6.2.2 Lobster tails

If the lobsters are not suitable for cooking in the whole form or when the demand is only for tails, the abdomen or the tail is broken off and is preserved in crushed ice at the landing centre itself. At the processing plants, in the first instance tails are washed throughly in chlorinated water. The vein in pulled out through the anterior end carefully. The tails are cleaned and adhering eggs, if any, are scraped off. The tail and the swimmerettes are cleaned with brush and pieces of meat etc. are removed and washed with potable water. Tails from the size of 28 gm onwards are used for this purpose. These are then graded according to size and each of them is wrapped in polythene paper and secured with rubber bands. In some cases only the exposed meat at the cut ends are covered. These are then frozen individually at -40°C and stored at -20°C till exported.

6.2.3 By products

Other lobster products of export from India include rock lobster meat from tail portion in both fresh and cooked forms. But no worthwhile production of meat from head, legs and antennae is being resorted to. There is good demand for such products in countries like Japan. The head, after removal of flesh can be dried and powdered and used in the preparation of fish meal. The heads can also be processed for conversion into chitosan.

6.2.4 Quality Standards

Now particular attention is being paid to meet the high quality requirements of foreign markets. Quality control standards adopted in this country are as follows:-

The appearance of uncooked rock lobster/tail/meat should be snow white to white or light pink to pink depending upon species.

Total bacterial count should not be more than 5,00,000 per gm. E.Coli maximum is 20 gm. Maximum permitted staphylococcus is 100. Salmonella should be absent.

In the case of whole cooked lobster/tail/meat characteristic cooked colour should be present and maximum bacterial count shall not be more than 1,00,000 per gm. Coagulate positive staphylococcus shall not exceed a maximum of 100. Salmonella and E. coli are to be completely absent.

6.2.5 Packing

Frozen material is packed in plywood or dealwood or cardboard cartons. Each master carton contains 2 cartons weighing 5 kg each. Container is bound securely using iron or nylon hoops and is stored at or below -18°C.

6.2.6 Scope of export of live lobsters

There is good market for live lobsters abroad and lobsters are being exported in live condition by countries like Australia, South Africa and Sri Lanka to countries like Japan and U.S.A. Even a small country like Sri Lanka had started export of live lobsters to Paris in 1970 (Anon, 1970).

Since then it has been exporting to different countries almost every week during peak season by air shipments. In Canada handling of lobsters in live condition for export trade started by about 1904 itself by construction of tidal pounds for storage, (Levett, 1965). Australia, which is the largest producer and exporter of rock lobsters have a flourishing trade in live lobsters with Japan, U.S.A., and France. There are special wells in the fishing boat itself to keep the lobsters alive. Live lobsters are mostly transported by air. But this has not caught up in India. Since the procedure for packing live lobster is simple and it fetches very good price, this possibility has to be explored on a priority basis.

6.2.7 Storage centres

A prerequisite for trade in live lobster is the facility for storage of lobsters in live condition or 'storage centres'. They will act as receiving points for catch from lobster boats and base for fishing operations. Location of such centres should correspond to important fishing centres and shall be close to fishing zones. During peak periods, when large volumes of catch are landed, the storage centres will regulate the quantity sent for processing so as to achieve better utilisation of installed capacity. Given the characteristics of live storage, location of storage centres should be carefully selected in order to ensure optimum hydrometerological conditions such as currents (particularly tidal currents), salinity, oxygen content and temperature. It also calls for special lobster fishing boats with built in storage tanks. Such

storage centres are functioning successfully in countries like Cuba (Lamagrid Hugo and Blanco, Wilfredo, 1986) Canada, Australia and France. Establishment of such centres will generate employment potential for local population.

C H A P T E R - VII

VII. CONSERVATION AND MANAGEMENT

International Conference on Law of the Sea held in Geneva in 1958, defined conservation as the aggregate of the measures rendering possible the maximum substainable yield from the resources so as to secure a maximum supply of food and other marine products. The objective of conservation in a self reproducing resource is not merely inviolate preservation, but maintenance of full utilisational and aesthetic values in a profitable and enduring way. The ultimate objective is the sustained yield of the resource at the best possible level (Dow, 1964) - a yield that can be taken year after year without depleting the stock. Conservation ensures indefinite continuance at the highest possible level. Full utilisation and conservation are not opposing concepts. Any long term full utilisation programme must take into account the demands of conservation, since long range productivity of a stock is adversely affected by exploitation beyond its maximum biological limits. This limit is directly related to the renewable nature of the resources. Biological basis of fishery management and the economic difficulties encountered by any regulated fishery were clearly stated by Michael Graham (1935) and expressed in his great law of fishing "Fisheries that are unlimited become unprofitable or inefficient". He used the term 'unlimited' in the context of amount of effort. This holds good even today (Gulland, 1974). Beverton (1953) pointed out that social and political objectives make it desirable for efforts to be somewhat greater than what is called for by economic objectives alone, though this will make the fishery less profitable. But there is no debate about the desirability of maintaining the values at the highest possible

level. The idea of managing fisheries by Maximum Sustainable Yield (MSY) began to catch on about 30 years ago (Larkin, 1977). Although the concept became increasingly fasionable, its value has been recently challenged. George (1973) has estimated the population of lobsters in areas south of Trivandrum as about 500 tons. And he says that an exploitation upto 60% is not harmful. Basically food production systems relying on a natural resource (a wild stock) can generate in the long term, at the best a steady yield or a yield oscillating more or less around some mean value (Pauly, 1990).

Conservation and management methods adopted in spiny lobster fishery around the world are directed to ensure a maximum yearly yield without diminishing subsequent crops. While critically reviewing the state of N.Atlantic lobster fishery (Homarus americanus) it was pointed out that while the productivity of lobster is conditioned more by natural factors than by regulations, the later are necessary not only from a conservation stand point but also for their economic effects (Anon 1964). The most important economic consideration is value realised by fishermen for their catch (Dow, 1964).

Advisory Committee of Marine Resources Research (ACMRR) on the management of living resources in near shore tropical waters is of opinion that the scientific and administrative technique for tackling management problems have been developed in the large scale fisheries of temperate waters, but they cannot be directly applied to small scale fisheries of tropical inshore waters (ACMRR, 1983). It might be recognized that a fixed fish resource

cannot provide adequate income and employment to an ever expanding population. The problems of a tropical fisheries, especially an artisanal one like that of spiny lobster fishery of South West coast of India, are usually complex. For that matter, the laws of conservation of any fisheries function within the context of biological, economical, technological, social and political diversity. Smith (1979) says that all empirical problems stemming from conservation - biological, technological and socio-economic - are complimentary and interacting.

There is a perennial debate with regard to the objectives of conservation. The biologists argue that the objective of fishery management should be to achieve maximum sustainable yield and maximise the physical production. Economists take the view that objective of fisheries management should be to achieve maximum economic yield. These two become less irreconcilable if they are approached less dogmatically. Both the concepts are concerned with prevention of waste. But both serve the ulterior objective of furthering human welfare; which may be adversely affected by the waste of physical resources of the sea or by the waste of the manpower and capital applied to their harvest (Koers, 1973).

Management systems should be preventive rather than remedial in character. It is important to take action to control the fishery before over capacity develops. The objective of management should include a reduction of conflict between user groups, improving the conditions of the poorest fisherman and preservation of resources. Preservation of resources should receive priority because it is the objective which can be readily understood

and accepted by fishermen. While adopting management measures, severe imbalances on economical, ecological and social fronts should be avoided. Implementation of conservation should not be hampered by capricious measures nor should they look like pedantic dabling by academicians. Fisheries management policies should provide alternate employment opportunities in the long run and limit fishing effort through either economic disincentives or by limiting the components of production. In this context it is to be noted that lobster fishermen of S.W. coast of India are rarely conversant with any nonfishing skill. Hence conservation can be achieved only after educating them about its advantages, without displacing them from the fishery and through their cooperation.

There are differences between artisanal fishery management problems and problems of large scale industrial fisheries. Human beings play a major role in artisanal fisheries. It is also highly energy efficient. As the case of many coastal fisheries illustrate, the damage done by poorly planned developments often fall on the less fortunate and the poorest of the fishermen.

7.1 ROLE OF TECHNOLOGY IN CONSERVATION

In a capture fisheries like spiny lobster fishery of S.W. coast of India, where catch comes from the natural wild stock, the input of science and technology can affect only harvest and post harvest sectors and not influence the factors which determine the level of increase in biomass. Technological innovation need not be antagonistic to conservation. Most of the technological factors in the conservation of fishery resources are concerned with fishing

methods and fishing tackle. But relative contribution of the increase in fishing population and the introduction of the inappropriate or imperfectly controlled technologies on the problems of management are very important. It is pointed out that the rate of increase in fishing capacity due to the introduction of new technology far exceeds the rate of increase in fishing effort due to population increase. Under such circumstances, technological improvement should be only with sufficient conservation safe guards. But in the case of spiny lobster fishery of S.W. coast of India, problem is not one of irresponsible application of technology and consequent damages; but increase in coastal population and more persons taking to fishing the same resource. Or rather, a percentage of excess labour which originate from the increase in population gets dumped on the fishery inadvertently.

The most relevant aspect of fishing technology in relation to conservation is that fishing gear is never completely selective. The laws concerning marine fisheries must take into account that this lack of gear selectivity may cause regulations in a specific fishery to have an undesirable effect on other fisheries (Koers, 1973).

7.2 TRADITIONAL CONSERVATION METHODS AND TROPICAL FISHERIES

Traditionalism has played a dominant role in determining management policies in fisheries all over the world. Regulations that have a precedent based on local customs are viewed with relative sympathy by the fishermen But many of the customs have broken down as a previously subsistence economy shifted to a market economy and fish changed from social security

to an export commodity. Johannes (1981) while discussing Pacific Island reef fishery says that "history of tropical fisheries management is the repeated disappearance of traditional conservation methods and failure of western science to replace them. The reef islanders have deviced and employed almost all main conservation measures, we continent dwellers developed only recently". These strong words concerning the failure of western conservation practices may be only partially justified since their implementation have been always handicapped by many problems inherent in tropical fisheries.

Some form of self imposed control measures are in existence in spiny lobster fishery of S.W. coast of India. There is a ban on the use of gillnets for lobster fishing in villages like Enayam in Kanyakumari District. There is also a common agreement on the date of beginning and the end of the season amongst the fisherman in the entire stretch. Use of spears for killing lobsters is looked upon with a general apathy by all. But when the fishery moved away from the realm of subsistence economy to that of siege economy and as a consequence intra group competitions increased, these measures alone were found to be falling short of requirements.

7.3 TRENDS TOWARDS DECLINE

Spiny lobster fishery of S:W. coast of India is highly vulnerable to exploitation. A limited supply coupled with strong increase in demand in the world markets have led to shooting prices. This has resulted in intensive exploitation and corresponding strains on the stock. The increased demand and reduced supply lead to an annual cycle of statements about impending destruction of fisheries which disappears by the beginning of next season.

The fishery which was being mostly exploited by traps alone till about 1980, is being fished recklessly with trawls, gill nets and trammel nets. Stock has not absorbed the increased effort in full and continued exploitation at the present rate is a threat to the resources. A fishery suffering from such conditions can be identified by persistent low rates of returns, poor profitability and falling or static production with increased physical effort (Scott, 1984).

The data monitored from Kanyakumari centre regarding the number of specimens landed, average weight of the specimens and the total quantity for the last five years from 1985-89 is furnished in Table VIII. A perusal of this shows that the numbers landed are either static or getting reduced year by year. Average size is showing a clear reducing trend from 200 gm

TABLE - VIII

Trends in Lobster catch at Kanyakumari and adjoining areas together

Year	Nos.	Average weight	Total weight
1985	26350	180 gm	52.70 tons
1986	25139	170 gm	47.76 "
1987	25988	170 gm	46.77 "
1988	19072	160 gm	32.42 "
1989	20394	140 gm	30.59 "

in 1985 to 140 gm in 1989. But in some fishing centres like Vizhinjam in Kerala, catch has shown an upward trend during 1988-89 season which is

an exception. Again during 1989-90 season, landings were alarmingly low. The fishery is in a process of exhaustion and destruction by recklessness. The resource base is being endangered and the need for introduction of conservation and management measures is becoming evident. Fishermen who are in this fishery for whole of their life, voice the opinion that the size of specimens landed some years back was much larger and total catch was much more. This reduction is size is a pointer to the general decline.

Expression of this fear in hushed tones were heard from '60s itself. Chacko et al. (1969), after a study of the trend of lobster fishery from 1957 to '66 observed that from the year 1962-63 onwards a high percentage of lobster catch (31.21% to 35.56%) was found to be immature and below 6 cm in carapace length. There also has been a steady decline in the numbers of lobsters landed each year from 800,000 in 1956-57 to 200,000 in 1963-64. The authors further observed that the increasing demand from processing industry coupled with increase in catching effort may sooner or later cause the depletion of basic stock of lobsters in the coast. Observing this continued declining trend in total number of specimen landed, need for imposing certain restrictions were felt and a draft notification and draft licences were finalised and issued by the department of Fisheries Government of Madras,in 1965 itself through order No.K.Dis.281 B/66 dt.14.6.1965.

Lobsters are not migratory and as such have very little scope of repopulation by migration from other areas. Mark recovery experiments

conducted with the help of suture tags on Indian spiny lobsters in the south west coast of India (Mohammed and George, 1971) also showed that their movements in the fishing ground are very restricted in nature. Long migratory movements were not observed. Nearly 40 to 45 per cent of the catches were found to be berried and immature ones. Immature lobsters measuring less than 6 cm in carapace length formed as high as 32.21 to 35.56 per cent. The same report further contends that the phyllosoma larva being well represented in plankton and its distribution being facilitated by long larval life and lobsters having a high rate of fecundity, the success or failure of the lobster fishery is largely dependent on the availability or otherwise of rocky substratum for larval settlement. Since these conditions are favourable, there is not much risk of over exploitation of lobster fishery. One may hold the view that lobster fishery on the south west coast of India is a fluctuating one. But one will have to agree that berried females and juveniles should be saved from indiscriminate fishing. Another serious caution regarding the depletion of spiny lobster fishery in the south west coast of India was sounded by Balasubramanyan in 1967. He observed that a proper assessment of the available stock of lobsters in natural resources and the need if any, for the measures of conservation are important. Early attention should be paid to proper stabilisation of the fishery. The present landings have become alarmingly low. George (1967) after observing the decline in catches during 1959-60 and 1960-61, has stated that minimum size limits have to be fixed for the lobsters landed. But he feels that the exploitation rate at that time appeared to be well within the limits and exploitation

could be further raised without detrimental effects to the stock. An exploitation rate of 60% is considered not to be harmful to any fishery. Percentage of berried lobsters recovered by him from Thikkoti during the months of August to October was 8.31% in 1963 and 35.3% in 1964. But during the last twenty years, since these observations were made, the situation has changed very much. Intensity of exploitation has increased and the need for reduction in fishing effort in order to achieve more profitable operation is recognised.

7.4 Conservation and Management measures for lobster fisheries in other countries

7.4.1 Australia

Management of rock lobster fishery in Australia is achieved through regulations which are aimed at limiting the effort to maintain an average annual catch. These regulations have been reviewed by Bowen (1971). Principal regulations were introduced in 1963 and they limit the number of licenced boats and pots (Phillips et al., 1980). Amature fishermen are limited to two pots and the use of spear guns and hand guns are prohibited. There are no such restrictions on professional fishermen. The bag limit for the catch by amature fishermen are eight rock lobsters per day. Closed seasons are observed from 1 July to 14 March for Abrolhos Island area and from 1 July to 14 November for all other western Australian waters. Minimum of 76 mm carapace length and a 140 g tail weight are restrictions based on size. Rock lobster pots are required to have an unobstructed rectangular escape gap measuring not less than 54 mm in width and 305 mm in length

fitted to the side or top of the pot. Rock lobsters may only be processed or cut up or dismembered by registered processing and export establishments. Processing in Abrolhos Island area is prohibited.

When rock lobster fishing began in western Australia on a commercial scale, there were few regulations till 1960 (Anon, 1970). In Australia the most comprehensive management measures are in existence in Western Australia, where they include a restriction on the number of boats in the fishery, the compulsory fitting of escape gaps in pots, minimum legal length and closed season (Hughes, 1971). In southern cray fish fishery there is a minimum legal carapace length of 11.5 cm for Jasus lalandei in the territorial waters of Tasmania and Victoria. In Commonwealth proclaimed waters adjacent to all the states concerned, a closed season for female cray fish is in force from June 1 to October 31. In Victorian territorial waters also, the same period is treated as closed season as far as female cray fish are concerned. Caputre of berried females and soft shelled lobsters are prohibited through out Australia (Anon, 1964).

7.4.2 New Zealand

In New Zealand a legislation enacted in October 1977 made fishing for rock lobsters in North Cape area illegal, because of the possible role of this area as nursery for Jasus verreauxi. Although the closure of North Cape grounds to rock lobster fishery restricts the taking of small number of legal size fish available in the area, the restriction ensures less mortality and damage to the under-sized specimens due to handling (Booth, 1979).

The current minimum legal size for rock lobster Jasus edwardsii through out New Zealand is 152 mm in tail length. Before 1950 there was no size limits for this species. In addition to legal size requirements other measures include introduction to escape gaps in lobster pots and closed season. Escape gap measure 38 mm x 152 mm has to be incorporated in lobster pots in Otago area. It is 54 mm x 305 mm elsewhere in New Zealand (Annala, 1977).

7.4.3 Papua New Guinea

The effect of large trawl catches on recruitment of adult lobsters into Yule Island fishery and the larvae into the Torres Strait has been of major concern in this country. A ban on the trawling for lobsters in the Gulf of Papua introduced in 1979 was one of the management measures imposed at what is regarded as a critical stage in the development of spiny lobster fishery (Moore & Mc Farlane, 1980). Quota restrictions were introduced in 1977.

7.4.4 Canada

Canadian lobster industry almost from the beginning have been subjected to regulations. The forces and interests influencing the introduction or withdrawal of specific regulations cannot always be identified. But at various times fishermen themselves, buyers, processers, government administrators and other groups have been influential in changing the rules. Whatever guise under which various regulations have been adopted, many of them have influenced the economic development and efficiency of lobster fishery. The

regulations are inter related, but sometimes at least partially incombatible (Anon 1968).

Law exists both in Canada and Newfoundland obliging the fishermen to put egg bearing lobsters back into the sea. By 1930 the Canadian government had so restricted the fishing season and applied other restrictive measures that enough protection was thought to be given to the lobsters (Templeman, 1937). Of the many regulations now in effect, the following four are the most important (Wilder, 1954).

Closed season: Fishing is prohibited in different areas for six to ten months in an year in relation to the weather conditions.

Berried lobsters: Sale of egg bearing lobsters is prohibited.

Size limit: Sale of lobsters below certain size is prohibited.

Lath space: Trap laths must be spaced far enough to permit the escape of short lobsters.

(Only legal way to fish lobsters in Canada is with the conventional traps). The practice of providing wider spaces for liberation of small lobsters was introduced in Maritimes and Quebec only in 50s, but has a long history in Newfoundland area. Neilson (1892) established the general principle of using wider spaces between the lowest side laths on either side of the traps to allow small lobsters to escape. As a result of Wilder's lath spacing experiments, laws were passed in 1949 to the effect that all lobster traps in St. Lawrence are to have a space not less than $1\frac{1}{4}$ inches between two under-

most laths. The lath spacing regulations for Maritimes and Quebec were revoked in 1955 (Anon, 1969).

7.4.5 United States of America

The first protective legislation for lobsters in America was formulated in 1812 in Province Town. Subsequently laws were enacted in Massachusetts in 1874 and in Maine in 1895. Many states require that pots and buoys have means of identification as a way of law enforcement. Some types of gear are banned outright, such as scuba gear in Maine. Trawlers are not allowed to operate in certain areas. Egg bearing females are also protected (Smolowitz, 1978).

The lobster fishery regulations and principles in the state of Florida are exhaustively dealt with by Smith (1958). Closed season is observed from March 31 to August 1 depending on the weather conditions. Catching or possession of berried craw fish is prohibited. Regulations specify 15 cms tail length as the minimum size for the specimens landed. The gear restrictions include that the wooden traps of slat dimensions 90x60x60 mm alone should be used in addition to bully nets. The use of spears and grains are completely prohibited. Certain areas are closed for fishing and there are restrictions on the marketing also.

7.4.6 Latin American countries

Windley (1968) has given an account of the conservation and management measures prevalent in some of the Latin American countries. In Bahamas

the use of traps and spears are prohibited by law. Lobsters must have a minimum carapace length of 8 cm and weigh at least 450 g; tails must be at least 142 g. Exporters and processors of lobsters must be licensed and only Bahamian citizens are allowed to catch lobsters in their waters. In Brazil, fishing is prohibited between latitude 33°30' and 7°50' South and between 39°7' and 38°48' West. Lobsters must have a minimum size of 50 mm cephalothorax measurement. In British Honduras, spiny lobsters are under strict conservation regulations with seasonal catch limits and closed seasons. Colombian law prohibits lobster fishing from April 1 to August 31 in Atlantic; and forbids the catch of lobsters less than 25 cm in tail measurement. More than 20% of the catch should be made available for internal consumption. In Mexico Panulirus interrupts which mainly supports the fishery is protected by a closed season from March 15 to September 30. The specimens landed should have a minimum length of 82 mm for cephalothorax. Panulirus inflatus which supports a small fishery has a closed season from June 1 to September 15 and same limits to the size. The Carribean fishery which is based on Panulirus Argus enjoys a closed season from March 15 to July 15. The minimum legal size is 145 mm tail length. The government of Venezeula maintains a closed season from May 1 to September 30 in the case of its major spiny lobster fishery of P. argus. The capture of lobsters measuring less than 8 cm in length from the point between the eyes to the end of the crapace, or females with eggs are prohibited. The use of flash lights or anyother types of light in capturing lobsters is also banned.

7.4.7 United Kingdom

In U.K. the authorities are desperately concerned about the catastrophic fall in the stock of craw fish, to say nothing of the lively hood of the fishermen. O'Farrel (1966) feels that "the answer lies in artificial rearing from eggs and cosseting the young lobsters until they can look after themselves. If this is impracticable it may be necessary to close areas on a rotational basis for two years. Otherwise it seems inevitable that catches will dribble to a near full stop". Escape gaps are provided in pots to allow undersized lobsters to escape. There was a ban on landing and selling of berried lobsters. The minimum size of the lobsters that can be marketted has also been fixed (O'Farrel, 1966).

7.4.8 Norway

Legislation specific to Nephrops trawling was introduced in 1962. Fishing season is restricted from April 1 to October 31 in Morayfirth and from May 1 to September 30 in Firth of Clyde. In 1968 more bylaws came into operation. Nets with stretched mesh of less than 70 mm is prohibited. Landing and sale of immature Nephrops with a carapace of less than 25 mm is also prohibited.

7.4.9 Sweden

Fishermen and researchers alike have considered government regulations as one way to protect lobster resources since the early days of the fishery. One of the first restrictive pieces of legislation was enacted in Sweden in 1686 (Smolowitz, 1978).

7.4.10 South Africa

The South African government have restricted the number of landing points for the spiny lobsters and the number of boats licenced for fishing. Rock lobsters will have to be sold through a single channel in local, as well as export markets. The product will have to comply with the compulsory specifications of South African Bureau of Standards (Anon, 1969).

7.4.11 Spanish Sahara

Along the coast of Spanish Sahara, the green Mauritanian spiny lobster (Panulirus regius) forms a good fishery, and the first move at conservation was by restricting the fishing to six months from March 1 to August 1. There is a distinct possibility that foreign fishermen will be excluded altogether in future (Anon, 1967).

7.4.12 Cuba

Cuba observes a three months closed season coinciding with the main reproductive period of the species beginning with the months of March. A legal minimum size of 21 cm in total length has also been established. Gravid females are thrown back into the sea. These regulatory measures have contributed towards increased catches (Lamarid Hugo and Blanco Wilfredo, 1986).

7.5 Discussions on Conservation and Management Measures for Spiny Lobster fishery of S.W. coast of India

When a fishery is at a biological risk there is an obvious justification and responsibility of the Government to intervene to protect the resource.

Spiny lobster fishery has so far been resilient to variations in degree of exploitation to some extend. But the stock may not fully recover if the reduction in the size of the fishery allows competitors and other co-occuring species to fill the ecological niche that was being previously occupied by lobster stocks. One might argue that it will be unkind to introduce control measures in view of the acute poverty of lobster fishermen in this area. But management measures should be so directed that fishermen may take a small portion of the population and yet obtain a large catch.

Major share of the fishery of spiny lobster in S.W.coast is constituted by single species namely P. homarus accounting for more than 90%. Hence the nature of the fishery of this particular species form the main stay of observation here. The methods are mostly based on output controls.

7.5.1 Closed Season

Closed season is primarily effective in reducing the pressure of fishing upon the stock rather than in increasing the breeding potential (Smith, 1958). Closed season with reference to lobster fishery evolves in relation to the interplay of seasons, weather conditions, water temperature and moulting (Wilder, 1973). Closed seasons have certain advantages and disadvantages. The cost of fishing is reduced and the fishermen get an opportunity to concentrate on other fisheries and avocations during the off season. Fishing can be restricted to certain times of the year so as to land lobsters when they are in excellent conditions or when the prices are highly favourable.

But Wilder (1954) feels that shortened fishing seasons however, may lead to a keen race among the fishermen and this greatly increases the cost of fishing and reduces the net profit.

In South African lobster fishery closed season is observed for berried lobsters alone. In the case of a fishery where intensive and thorough exploitation takes place during a short open season by employing more men and gear, it appears extremely doubtful whether closed fishing season is of such a great conservation value.

In S.W. coast of India, trap fishing for lobsters is carried out only for about seven months from October to April. The fishing remains suspended for the rest of the year. The purpose will be served if this off season is extended or altered to cover the periods when the exploitations is detrimental or injurious to the fishery at large. According to George (1967) the breeding season appears to be in the early months of the season namely November to December. Chacko et al. (1969) also have recorded that the peak breeding activity is during November and December, when 70% of the females are berried. Recent observations have confirmed the occurance of gravid lobsters during September and October. If a closed season is intended to protect all the berried specimens, fishing will have to be prohibited throughout the season, in view of the prolonged period of about seven months for which the lobsters are in berry. This may not be a practical proposition. Hence if the onset of the active fishing season which now takes place towards

the end of September or the beginning of October, is delayed by another two months, it will amount to giving a chance for majority of the berried specimens to hatch and shed their roe before they are fished out. It will also give an opportunity for juvenile specimens to grow and increase in biomass and attain good marketable size. It is reasonable to delay the commencement of the fishing season till early December and restrict the season to five months from December to April for all types of gears. Such a move may not seriously affect the livelihood of the fishermen.

7.5.2 Prohibited Area

This is used as an alternative to closed season. In this case, fishing in certain stretches of sea coast is prohibited and sometimes an area is declared as a 'sanctuary', when it is believed that a concentration of the brood fishes and juveniles is taking place there. But in the case of spiny lobster fishery of S.W. coast of India no such area is identified yet. As far as rocky shallow waters along the coast where lobster fishing is concentrated at present are concerned, there is a sense of territorial rights among lobster fishermen, whereby an area operated upon by one is not encroached upon by another. This right over the respective areas is treated as hereditary. Miyamoto and Shariff (1961) also corroborate this observation. Any attempt to treat an area as completely forbidden for fishing is beset with social repercussions since it will deprive the fishermen of their livelihood. But protection of the habitat of lobsters collectively or individually by fishermen themselves can form a part of conservation. Since the traditional way of

trap fishing is by resorting to skin diving which limits the depth of operation, there is a heavy concentration of fishing effort is shallow waters. Balasubramanyan (1967) has also made similar observations. This heavy localisation of fishing effort can be diffused when once the necessary mechanisation of trap fishing is brought about. Hence the concept of a prohibited area as far as the spiny lobster fishery is concerned does not appear to be essential.

7.5.3 Size Regulations

A legal minimum size is considered as an effective biological and economic tool (Wilder, 1974; Thomas, 1973). Size limits are generally enforced with a view to allow as many lobsters as possible to spawn at least once before they are caught and also to permit the young ones to reach a marketable size. Minimum size limits help in increasing the sustained yield either by allowing more lobsters to mature and reproduce, or take advantage of the period when the growth is rapid enough to more than offset the losses from natural mortality. In case of P. argus in caribbean waters, it has been pointed out that any restraint on harvesting of small specimens will result in substantial increase in yield (Munroe, 1983) and crustaceans taken in traps can be managed by minimum size regulations. Enforcement of minimum size regulation would result in increased recruitment by effectively protecting very young stages which are indiscriminately being harvested in nursery areas at present. This increment in a population can reach many orders of magnitude given an opportunity for growth and expansion. Majority

of lobster specimens landed nowadays in S.W. coast of India are of smaller size falling within the range of 100 to 150 mm in total length. George (1967) suggested that a minimum size limit of about 130 to 140 mm in total length should be enforced in the fishery prohibiting the landing of lobsters of lesser size. But taking into consideration the sizes of lobsters landed at present, such a size limit will deprive the fishermen a major portion of their livelyhood and reduce the supply of raw materials to the processing industry.

Minimum acceptable size by foreign buyers is 80 to 100 g. A specimen weighing 80 g will have a tail weight of 28 g since tail forms only 35 to 37% of the total weight on an average. Length weight relationships of specimens in this range recorded from the field are given in Table No.IX.

TABLE - IX

Length Weight Relationships of spiny lobsters of S.W. Coast of India

Weight (g)	Head Length (cm)	Tail Length (cm)	Total Length (cm)
120	6.5	12.5	19.0
105	5.5	9.5	15.0
100	5.0	9.5	14.50
96	5.0	9.0	14.0
90	4.5	8.0	13.5
90	4.8	8.5	13.3
90	4.8	8.8	13.6
85	4.6	8.5	13.1
82	4.5	8.0	12.5
80	4.5	8.0	12.5

Table - IX (Contd..)

Weight (g)	Head Length (cm)	Tail Length (cm)	Total Length (cm)
80	4.0	8.0	12.0
80	4.0	8.5	12.5
75	4.0	8.0	12.0
75	4.0	7.9	13.0
70	4.0	7.0	11.0
70	4.3	7.2	11.5
65	4.0	7.5	11.5
65	3.5	7.0	10.5

The data reveals that specimens weighing 80 g have normally a total length of 120 mm with 40 mm of carapace length and 80 mm of tail length. The possibility of correlating first maturity and breeding to the minimum legal size is out of question, since spiny lobsters are found to attain maturity only in sizes much larger than this in this coast. About 40 to 45% of the catch nowadays is constituted of immature ones. Taking these factors into consideration, fixation of minimum legal size at 120 mm total length with a carapace length of 40 mm appears to be more realistic. The landing of specimens of lesser sizes should be prohibited. The presence of sub legal specimens in the catch shall invite penalties for the fisherman. Above all no specimen of less than legal size shall be bought by the factories for processing and export. This will act as a disincentive for fishermen to catch smaller specimens. Processing factories whose consignment is found to contain sub legal sizes should be made liable for prosecution.

7.5.4 Gear Restrictions

Restrictions on fishing gear achieve the ends of conservation in many ways. Restrictions on number, size and the type of fishing gear are generally resorted to. When conservation and management measures are aimed at a single type of fishery as in the case of spiny lobster fishery of south west coast of India, this method can be used with a high degree of success. Sometimes even efficient fishing methods have to be prohibited taking the overall welfare of less efficient fishing units into consideration.

Main type of gear employed in exploitation of spiny lobster fishery of S.W. coast are, traps, gill nets, trammel nets and trawls. Spearing of the lobsters is also resorted to which is highly injurious to the fishery. Some fishing methods like anchor hooks and scoopnets are not being practiced now.

Even though fishing techniques have drastically changed during recent years especially with reference to schooling fishes, they have remained basically the same in such localised fisheries like that of spiny lobsters, which is confined to shallow inshore region. The limitations imposed on lobster gear will not cause much side effect on other fisheries. As far as the selectivity of the gear is concerned lobster trap being a gear operated exclusively in areas populated by lobsters, the degree of selectivity is bound to be of a high order. At present there is no restriction regarding the number of traps or gill nets operated by a fishing unit. The indigenous traps at present used do not have any device by which the undersized

specimens will escape before they are landed. This drawback is rectified with the introduction of the newly designed and improved traps with escape gaps. The use of a uniform type of gear will be one step forward as far as an enforcement of management measures are concerned.

7.5.4.1 Escape gap

The catchability parameters of a gear determines the size composition of the catch landed. The size composition of the catch is very much affected by the action of gear like the selection of the mesh in the trawls, escape gap and entrance appertures of traps and by difference in response to baits by the size and even the sex. Escape gaps in lobster pots have been shown to be successful in reducing the quantity of undersized spiny lobsters that are captured (Bowen, 1963). Escape gap regulations have been introduced in many countries. Some advantages of escape gap in pots are saving of time in picking out undersized lobsters from catch, minimising the injuries to small lobsters and a probable decrease in natural mortality rates. It may also help overcome the problems posed by fisherman's inherent reluctance to release back the juveniles after they are caught. It will also result in a probable reduction in the number of small cray fish eaten by predators after they are released back. But it is not always easy to adjust the size of escape gap to ensure escape of all undersized specimens, at the same time satisfying the fishermen that all their legal sizes catch will be retained in the gear. Neverthless, escape gaps are being used successfully in various countries as a measure of conservation (Hancock, 1980).

7.5.4.2 Fixation size of escape gap in lobster traps

Size of the escape gap has been finalised after taking some relevant behaviour of the lobsters also into consideration. Spiny lobsters being more or less creeping organism (suborder: Reptantia) moving about on the floor with the help of legs, look for an escape close to the floor of the trap. So the escape gap was provided on one side close to the floor, 10 mm above the basal plate, being the allowance for silt and mud getting washed into the trap and blocking the way. In a dorso ventrally flattened organism like spiny lobster, the highest point in the body to slip through the gap is posterior portion of the Carapace. Maximum height of the body is at this point. This maximum height was measured and recorded from several specimen.

On an average the maximum carapace height of the proposed legal size specimens of 40 mm carapace length was found to be 30 mm to 31 mm. Hence the height of the gap was fixed at 30 mm so that specimens with a carapace height of less than this can only escape. When the organism is in its normal moving posture the maximum distance between legs of one side to the other is the minimum horizontal distance required by it to escape through a gap. This in the case of specimens in the range of 90 mm to 120 mm was found to be between 100 to 120 mm. Hence the length of the escape gap was fixed at 150 mm giving sufficient margin. The escape gap recommended was 150 mm in length and 30 mm in height located on one side 10 mm above the basal rod.

TABLE - X

Data on Carapace Height

Weight (g)	Head length (mm)	Tail length (mm)	Carapace height (mm)
85	40	80	31
85	40	80	31
80	40	80	31
80	40	82	31
80	40	80	30
85	40	85	32
85	40	82	32
70	36	72	28
70	38	77	30
75	40	80	30
65	34	73	28
65	35	73	28
120	51	92	32
100	49	88	34
100	50	92	32
100	52	85	35
110	50	93	35
140	43	82	33
140	56	100	36
130	55	100	36
110	49	95	35
110	46	96	35
90	45	82	31
95	50	85	33
75	40	80	30
80	42	78	31
75	44	75	30
72	40	76	29
75	44	75	30
70	40	71	27
70	41	72	29

Further experimental fishing using traps with and without escape gaps showed significant decrease in the number of undersized lobsters in the traps with vents. The decrease in catch of sub legal specimens was to the tune of 60% compared to the traps without vents. The traps with escape gaps consistently landed greater number of legal specimens. The mean size of lobsters caught in vented gear was significantly greater than in control traps.

The bottom set gill nets are used for catching lobsters almost throughout the year. The use of these nets during the months of August and September, before the onset of regular trap fishing season and when the berried and juvenile population is abundant, leads to indiscriminate destruction. The nets are so laid that all the organisms coming out of the dens are entangled. In some villages like Enayam of Kanyakumari district, the fishermen themselves are exercising a self imposed ban on the use of bottom set gill nets in the village. Recognising that individual restraint would not work unless practised by all, fishermen tried to restrain fishing by commonly agreed law. Similar instances where fishermen in local areas have imposed voluntary control of the gear are reported in the case of Atlantic lobster stock. Mesh size limitations in lobster gillnets is the next aspect deserving consideration. It is doubtful whether reducing or restricting the size of the meshes have much perceptible impact in regulating the catch, since the principle involved is not truly gilling but entangling. However Balasubramanyan et al. (1961) have suggested a mesh size of 15.24 to 16.71 cm

for lobster gillnets. Chacko et al. (1969) have prescribed a mesh size of 15 cm stretched measure. But this is not being observed in actual practice and most of the nets in the commercial fishery are of smaller mesh sizes. The gillnets should not be allowed to be operated before the commencement of trap season.

The use of fishing spear is still being practised in some villages. Spear fishing offers income earning capacity to otherwise unskilled or impoverished individuals. In grounds where the lobster stock is scattered and sparse, fishermen resort to skin diving and with the help of spears (sometimes attached to poles) strike at the lobsters and catch them. This is an injurious fishing and has to be banned outright. Lobsters so caught are damaged and rendered unmarketable. Spearing is noticed to drive away lobsters from the locality, resulting in a temporary depopulation of the area. When spiny lobsters are molested, they are said to leave the neighbourhood. Since they are some what gregorious in nature, there is a possibility that the escape of lobsters that have been speared may cause a general exodus in large numbers from the immediate locality (Smith, 1958). This population displacement and dispersion due to harrassment is strongly vouched by the local fishermen also.

Trawling is moving closer and closer to the shore in these days of diminishing returns. Even in uneven rocky bottom which is the abode of lobsters where trawling was never attempted earlier it is being carried out

now. This always disturbs the lobster stock and its ecosystem. A large quantity of peurulii which remain attached to the rocks as well as juveniles present in the sea bottom are scooped up and destroyed by demersal trawling very close to the lobster ground especially during the months of September to March. Some ban on trawling in depths less than 22 m is in force in Kerala. Such measures have to be extended to fishing grounds in Kanyakumari also. Operation of trawls should not be allowed in shallow waters less than 10 m in depth.

Multilayered gillnet locally called 'disco' net is primarily meant for catching prawns. But in nets operated close to lobster grounds, a good quantity of juveniles are caught. It is worthwhile to attempt to gather them in live condition and hold them in special chambers built in sea itself, till they attain marketable size.

The restrictions on the fishing gear in spiny lobster fishery of S.W. coast of India, therefore, may include uniform introduction of traps with prescribed escape gaps, restricting the use of gillnets to the period of regular trap fishing season, out right ban on the use of spears, enaction and enforcement of a ban on operation of trawl nets in shallow waters less than 10 m in depth and attempts to collect and culture juveniles and undersized ones caught in multilayered gillnets in special chambers constructed in the sea till they attain marketable size.

7.5.5 Limited Entry System or Licencing

One of the management measures recommended by both economists and biologist is a reduction in fishing effort if a fishery is believed to be operating beyond its maximum sustainable yield and net economic yield (Dewolf, 1974). According to Larkin (1977) the best way of reconciling maximum sustainable yield and economic religion has been held to be the limitation of entry into commercial fishery. Economists suggest that since greatest physical yield does not necessarily provide greatest revenue nor greatest profits, the objective of conservation can be attained by restricting the entry into the fishery and allowing those who enter to use most efficient gear available (Royce, 1972). Where overfishing already occurs, policies aimed at increasing fishing effort in a traditional fishery may be self defeating (Smith, 1979). In a unique controlled study at Florida (Davis, 1977) size frequency of a previously protected lobster population exposed to new commercial pressure was quickly reduced to below legal size. Fishing pressure on spiny lobster fishery of S.W. coast of India is entirely due to commercial reasons. But in another study by a working group on Homarus, despite the general support to limited entry as a system of management, it emerged that the recognition of traditional right of an individual to take fish will hamper any attempt to control the number of fishing licences. Such traditionalism evidently is not uncommon in determining the management policies in lobster fisheries (Dow, 1980).

The process of reducing the fishing effort is achieved by limiting the entry of fishing units into the fishery. The first step towards limiting

the entry is enumeration of the existing units followed by issue of licences for the crafts and gear presently employed. Licencing helps in the process of controlled fishing. Another method is introduction of taxation. This differs from the licencing system in that it attempts to reduce the effort by using a levy to eliminate in-efficient enterprises (Dewolf, 1974). Taxation is applicable only to a highly organised fishery and in the present conditions of the spiny lobster fishery of S.W. coast of India, it looks unwarranted. Regarding the licencing of craft and gear it must be remembered that it is not being implemented even in other major fisheries of the country.

7.5.6 Marketing Restrictions

As such, almost the entire quantity of lobsters landed go for export trade only. ISI specification No.2892 which deals with the classification of lobster tails have not fixed any minimum size grade of lobster tails meant for export, allowing even the 'tiny' (below 50 g) to be exported. But in actual practice specimens of even smaller sizes are now accepted by processors. On the export front a ban has to be imposed on trading lobsters of less than 28 gm in tail weight or 80 gm total weight which will form a disincentive for the fishermen to capture undersized ones.

7.6 Berried Lobsters

Protection and special attention for berried lobsters are considered necessary to allow them to reproduce atleast one crop before they are fished out. Nearly 40 to 45 per cent of the total catch observed by Chacko et al.

were berried and during a recent sampling percentage of berried lobsters was 23%. There had been some rethinking in Britian regarding the prohibition of capture of ovigerous females. It was concluded that nothing is going to be gained by protecting berried lobsters. The ban on the landing of berried lobsters has been repealed since July 1966 in Britain. Dewolf (1974) also concludes that protection of berried females have little effect on annual landings. But Canada (Wilder, 1965) and Australia have retained berried lobster regulations as a precautionary measure. In India opinion is in favour of providing protection to berried lobsters as a measure of precaution.

C H A P T E R - VIII

VIII. SUMMARY AND CONCLUSIONS

8.1 Summary

The role of crustacea in the nutrition of a number of animals including man needs no emphasis. Spiny lobsters (Family: Palinuridae, Genus: Panulirus) constitute a very valuable marine product exported from India fetching sizeable foreign exchange. Catches of cold water lobsters have levelled off recently and hope for growth of production in future lies in spiny lobsters found in tropical and subtropical seas. South west coast is one of the important lobster producing regions where systematic development and organised exploitation started first in the country. But this fishery is in a critical stage at present. A study regarding the different aspects of spiny lobster fishery of this region with special reference to factors relevant to production including conservation and management measures is the need of the hour.

In the introductory chapter, a review of the previous research work including biological studies, and studies on harvest technology are furnished. Spiny lobster fishery of south west coast is an artisanal one employing traditional craft and gear. A focus on improvements to the existing technologies and development of appropriate harvest technology will directly benefit the traditional fisherman. Refinement of a fishing gear to suit the changing conditions of a fishery is a continuing process. Lobster exploitation is a low energy fishing. Passive gear like traps and gillnets and sailing crafts like catamaran and canoe employed in their exploitation are highly advantageous as energy saves. Adoption of newer fishing techniques and

location of new resources will provide a means to successfully diversify the fishing effort. It will reduce the competition for and fishing pressure on currently producing stocks.

Second chapter gives an account of the species of spiny lobsters in the area, geographical area of the study, fishing season, landings and ecological aspects such as zonation by depth, effect of turbulence and lunar periodicity and catch.

Six species of shallow water lobsters belonging to family Palinurus and the genus Panulirus have been recorded from south west coast. They are Panulirus homarus, P. penicillatus, P. longipes, P. polyphagus, P. ornatus and P. versicolor. Two deep water species of spiny lobsters recorded from this coast are Puerulus sewelli and Palinustus mossambicus.

Fishing season commences by first half of October and lasts for about 6 months till April. In Trivandrum district fishing starts a little earlier, in September itself.

Area of the study constitute the coasts of Kanyakumari district of Tamil Nadu and Trivandrum district of Kerala. It falls within the geographical range of 76°42' 20" - 77°34' E.L. and 8° 4' 30" - 8° 46'N.Lat. Of the 97 fishing villages in this area only 30 are important from lobster fisheries point of view.

The total landings at present from this area is estimated to be 101.9 tonnes annually. Only 3 centres namely Vizhinjam, Enayam and Kanyakumari

land more than 5 tonnes per annum. Gearwise 40% of the production is contributed by traps and 40% by gillnets.

A field study concerning spiny lobsters require a foundation particularly of ecological sorts. Most characteristic feature of the habitat of many of the Palinurids is the residence area or the den. The tip of peninsular India which is the confluence of 3 seas is subjected to drastic changes in environment due to 2 monsoons. The submarine plateau of south west coast is bordered by two easily distinguishable countour lines of 7 m and 10 m. The sea floor is replete with multitude of dead shells. Shell quarrying is a remunerative part time occupation for the lobster fishermen. Some form of demarkation in the depth wise distribution of lobsters is recognisable. Observations reveal that P. homarus moves progressively to deeper waters as they grow bigger. Ample evidence exists that turbulence influences the movement of several species. Lunar periodicity in catch rate of several species of lobsters is now established.

Third chapter deals with predators, competitors and co-occuring species. Predators cause substantial mortality in all stages. Three important groups of predators of spiny lobsters of south west coast of India were identified namely giant rock cod (Epinephelus malabaricus), three species of Morays (Muraenidae) and cuttle fish (Sepia sp). Giant rock cod is solitary in nature ascending the estuaries in tides and is the most ferocious of predators. They form an important and remunerative by catch since they are excellent food fish. Few species of family Muraenidae are found to prey upon lobsters. They are not only predators but also competetors in the sense that some

of them occupy lobster dens evicting the lobsters in the process. Three species were identified viz. Lycodontis meleagris, Siderea picta and Echidna nebulosa. Cuttle fish (Sepia pharaonis) is also an active predator on lobsters.

P. homarus which is the dominant species along this coast is not found to experience any severe competition from allied species. But several species of fishes and crabs compete with spiny lobsters for food. Fishes from 37 families were recorded as co-occuring with spiny lobsters; so also some species of crabs and prawns. Several species of Mollusca and Echinodermata, species of sea weeds, sponges and corals are also recorded.

The IV Chapter deals with bait studies, types of baits feeding behaviour, feeding rhythm, experiments with different baits, endurance of baits and results and discussions. A definite feeding rhythm in behaviour of spiny lobsters was discernible during the study. The strategy of fishing can be substantially altered if feeding rhythm is properly understood. Observations show that feeding activities of P. homarus are on a peak during dusk.

Fishing experiments were carried out with 5 different kinds of baits namely mussel, sea urchins, cattle hocks, animal guts and diesel oil in order to assess their comparative effectiveness in attracting lobsters to the pots. Catch analysis indicate significantly high performance of mussel followed by diesel oil. 61.24% of the catch was landed by using mussel as bait, 27.8% by diesel oil and 9.34% by sea urchins. If natural food like mussel is available in the proximity, spiny lobsters always choose them and do not seek other kinds of baits. Lobsters are believed to detect the presence

of mussel by the noise generated by latter For a bait to be effective it should last long enough till the lobsters come out for feeding. Mussel, diesel oil and cattle hocks are found to last long enough; but fleshy material like cattle hock become target of predation by carnivorous fishes.

Chapter V incorporates various aspects of harvest technology of spiny lobsters.

Spiny lobster fishery of S.W. coast of India is entirely a capture fisheries. It is subjected to intense multigear exploitation, the use of traps being the foremost. Traditional traps have some inherent draw backs. Being fabricated out of biodegradable materials, they are subjected to fast material decay and lack sufficient strength to stand rough sea conditions. They have also remained restricted in popularity to certain pockets of the coast line since their fabrication techniques and mode of operation are known only to a few fishermen. There is need for development of a modern lobster trap.

Knowledge of fish behaviour is so important that the fishing can be considered as a kind of applied behaviour research. The catch of a baited trap is the result of complex and variable events. It begins with initial awareness of the animal that attractive feed is present in trap and ends up with entry, consumption of the bait and attempts to escape thereafter. The process of catching takes place in two stages namely attraction and entry. Fishing efficiency of a stationary gear like trap depends upon the factors governing the entry of organism into the trap and the capacity of

the trap to hold them in. The newly developed trap is semi-cylindrical in appearance and measures 700x550x400 mm with a frame of rectangular base and semicircular ribs made of 10 mm M.S. rods. They are given a plastic coating as a measure of protection against corrosion.

There is sufficient scope for the mechanisation of trap fishing, there by extending fishing to deeper waters. By utilising the long lining techniques for pots, they can be successfully operated without resorting to skin dividing. Though gill nets are passive in nature, they are highly selective. Lobsters get entangled in the nets rather than truly gilled. Records show that in this region bottom set gill nets for lobsters were first introduced in 1957-58. At present each shot of gill net in commercial lobster fishery is 30 m in length and 2 m in depth fabricated of nylon No.210x2x3 or 210x3x3 with 10 to 12 cm stretched mesh size and mounted with 50% hanging.

In lobster grounds trawling cannot be done as a common practice. Lobsters form only stray catches while trawling beyond the shallow surf region. Trammel nets were recently introduced into this region. It is a multilayered net with 3 layers of webbing siezed onto the same head and foot ropes. Lobsters get entangled and retained in pockets of webbing created.

There is only limited use of cast net in lobster fishing. Spearing of lobsters is being practiced by some fishermen. Hand picking also is occasionally done. Some fishing gear and methods like anchor hook and scoopnet have become obsolete due to various reasons.

Fishing crafts employed in spiny lobster fishery of S.W. coast of India are of two indigenous types namely catamaran and canoe. Small mechanised boats are used occasionally. In the whole scenario of fishing crafts in India, boats for operating special type of gear for lobsters are absent. This lacuna has to be filled.

Post harvest utilization form the scope of VI Chapter. Spiny lobsters are primarily destined for export. Practically there is no internal trade in lobsters except that of fishermen surrendering their catch to local collecting agents. It is at this point that the economic exploitation of the fishermen is at its maximum. During 1989 India exported 1963 tonnes of lobsters valued at Rs.293 lakhs. There is good scope for export of live lobsters to other countries. But a pre-requisite for trade in live lobsters is storage centres which will act as receiving points for catch from boats and regulate the quantity sent for processing so as to achieve better utilization of installed capacity. This can lead to generation of local employment for the fishermen.

Conservation and management aspects form the contents of VII Chapter. Any long term full utilization programme of a resource must take into account the demands of conservation. Management systems should be preventive rather than remedial in character. Technological innovations need not be antagonistic to conservation.

There are some traditional methods of conservation existing in many tropical fisheries. Some self imposed control measures are in existence in spiny lobster fishery of S.W. coast of India also. The regulations that have a precedent based on local customs are viewed with relative sympathy by the fishermen.

A limited supply with strong increase in demand have resulted in intensive exploitation and corresponding strain on the fishery. The stock has not absorbed the increased effort in full and continued exploitation at this rate is a threat to the resources. Average weight of the specimen and total landing are showing declining trends. The resource base is being endangered and the need for introduction of conservation and management measures is becoming evident. Lobsters are not migratory and as such there is little scope of repopulation by migration, from other areas.

Brief account of conservation and management measures for lobster fisheries in countries like - Australia, Newzealand, Papua New Guinea, Canada, U.S.A., Latin American countries, U.K., Norway, Sweden, S. Africa and Cuba are furnished. Various conservation and management measures for spiny lobster fishery of S.W. coast of India are discussed. Wherever a fishery is at the risk of being overfished, there is obvious justification for Governmental intervention to protect the resources. Pros and Cons of different conservation methods with reference to practical implementation are discussed and noted under conclusions.

8.2 Conclusions

1. Spiny lobster fishery of S.W. coast of India is an artisanal one employing traditional craft and gear. It is entirely a capture fisheries.

2. Lobster exploitation is a low energy mode of fishing. Passive gear like traps and gillnets and sailing craft like Catamaran and Canoe

employed in their exploitation are highly advantageous as energy savers.

3. Adoption of newer fishing techniques and location of new resources will provide means to successfully diversify the fishing effort. It will also reduce the competition for and fishing pressure on currently producing stocks.

4. P. homarus moves progressively to deeper waters as they grow big.

5. Turbulence of water and consequent churning effect during the night is found to result in increased landing of lobsters the next day.

6. Lunar periodicity influences the catch. Increased landings are recorded during new moon period.

7. Three types of organisms are found to be active predators on spiny lobsters in this coast namely (1) gaint rock cod (Epinephelus malabaricus) (2) three species of Morays (Muraenidae) and cuttle fish (Sepia sp).

8. A definite feeding rhythm in the behaviour of spiny lobsters was discernible during the study. Observations show that feeding activities of P. homarus are on the peak during dusk and dawn.

9. Observations on feeding rhythm can substantially alter the strategy of fishing.

10. Diesel oil was found to be a successful alternate bait in lobsters fishing.

11. If natural food like mussel is available in the proximity spiny lobsters do not seek other kinds of baits.

12. Fleshy baits become target of predation by carnivorous fishes, which drive away the lobsters.

13. Traditional gear like lobster traps have remained restricted in popularity to certain pockets of coast line since their fabrication techniques and mode of operation are known only to a few fishermen.

14. Studies on lobster behaviour both in the vicinity and within the gear require urgent attention.

15. There is scope for mechanisation of lobster trap fishing by using long lining techniques, thereby extending fishing to deeper waters and exploit untapped resources.

16. Some fishing gear and methods like anchor hook and scoopnet have become obsolete due to various reasons.

17. There is scope for production and export of meat from head, legs and antennae and earn more foreign exchange which is not being resorted to now.

18. Markets existing in leading countries for live lobsters is not being tapped by India. Storage centres are essential pre-requisites for export of live lobsters.

19. Among different methods of conservation and management, closed season is primarily effective in reducing the fishing pressure upon

the stock rather than increasing the breeding potential. Commencement of lobster fishing season in S.W. coast shall be delayed till December and the season be restricted to five months from December to April for all types of gears.

20. Prohibited area can be used as an alternative to closed season. But this conservation method is not necessary at present in spiny lobster fishery of S.W. coast.

21. Minimum size limits help in increasing the sustained yield either by allowing more lobsters to mature and reproduce or take advantage of the period when growth is rapid enough to more than off set the losses from natural mortality. A minimum legal size of 40 mm carapace length or 120 mm total length should be imposed in the case lobsters landed.

22. Restrictions on the fishing gear in spiny lobster fishery of S.W.coast of India may include

(a) introduction of traps with an escape gap of 150 mm in length and 30 mm in height located on one side, 10 mm above basal rod.

(b) restricting the use of gill nets to the period of regular trap fishing season.

(c) Out right ban on the use of spears.

(d) enforcement of a ban on operation of trawl nets in waters less than 10 m in depth.

23. The under sized specimens landed in different gear have to be collected and reared till they attain marketable size.

24. Limited entry system or licencing also is a tool in the management. But this is not being implemented in other fisheries of the country. Taxation also is unwarranted at present.

25. A ban has to be imposed on trade in lobsters of less than 28 g in tail weight or 80 g in total weight.

26. Berried lobsters should be protected to allow them to reproduce at least one crop before they are fished out.

27. In order to achieve progressive recuperation of the fishery it is essential to respect the minimum legal size and at the very least maintain the fishing effort at current levels.

28. Educate and convince the fishermen about the ultimate benefits of conservation and management.

It is not easy to formulate proper management measures; but is far more difficult to implement or enforce them. The measures should not be empirically formulated and weakly implemented. The modalities of enforcement, the nature of policing the act and the heirarchical levels at which powers are to be vested with, can be worked out when once the administrative decision to enforce the conservation and management measures in the spiny lobster fishery is taken. The most important aspect is to educate and convince the fishermen about its ultimate benefits. Those responsible for formulation and implementation of measures of conservation of fishery

resources can never escape the consideration of clash of a group of interests which must be put in balance as fairly as possible. Whatever be the chosen method, management of this valuable resource places a great responsibility on scientists and administrators - a far cry from the days when spiny lobsters were thrown away or when prawns were being used as agriculture manure.

REFERENCES

REFERENCES

ACMRR, 1983. Report of Advisory Committee of Marine Resources Research (ACMRR) Working party on the management of Living Resources in Near-Shore tropical waters. Rome, 28 Feb. 4 Mar. 1983. FAO Fish. Rep., (284) : 78p.

Alcock, A. 1901. A descriptive catalogue of the Indian deep sea Crustacea, Decapoda, Macrura and Anomala in the Indian Museum, being a revised account of the Deep-Sea species collected by the Royal Marine Survey Ship 'Investigator' Calcutta, India, 286 pp.

Annala, J.H., 1977. Effects of Increases in the Minimum Legal Size on the Otago Rock Lobster Fishery. Fish Res. Div. Occasional Publication No. 13 pp 15.

Stock fish [illegible] ing. lobster [illegible]

Anon 1963. Comml. Fish. Abstr. 16, 3.

Fisheries Minister emphasizes need for scientific research

Anon 1964. Comml. Fish. Rev. 26(3): 43-44.

Anon 1965. Dome Shaped lobster trap designed with unique features. Comml. Fish. Rev. 27(1): 67-69.

Larger lobsters are active at night, study shows.

Anon 1968. Comml. Fish. Rev. 30(6): 35.

The economics of lobster fishing in canada.

Anon 1968. Fish. News 7(5): 86-88.

Anon 1969. Lath spacing in lobster traps. Prog. Rept. Atl. coast Station, 69, Biological Station, St. John's, Nfld.

Lobsters a big dollar earner.

Anon 1970. Fish. News 9(4): 41.

Lobster pot hauler.

Anon 1973. Aust. Fisheries. 33, 19.

The world market for lobster continues to grow.
Anon. 1977. World fishing vol. 26 no.9.
Promise in pots and creels.
Anon 1980. Fish. News Int. 9, 46.

Anon 1981. Proc. of the seminar on Role of Small Scale Fisheries and Coastal Aquaculture in Integrated Rural Development. CMFRI Bulletin 30-A, p 1.

Anon 1988. Statistics of Marine Products Export 1988. MPEDA Cochin pp 214.

Anon 1989. Statistics of Marine Products Export 1989. MPEDA Cochin pp 214.

Fisheries of Margarita island
Arocha, A.M., 1964. Fish. News Int. 3, 294.

Atema, J. and Stein, L.S. 1974. Effects of crude oil on the feeding behaviour of the lobster, Homarus americanus. Environ-Pollut. 6: 77-86.

Atema, J. 1976. Sublethal effects of petroleum fractions on the behaviour of lobster, Homarus americanus and the mud snail, Nassarius obsoletus, (In) M. Wiley (ed.) Estuarine Processes vol.I, uses stresses and adaptation to Estuary. Academic Press, New York pp 392-12.

Atema, J. 1980. Chemical senses, chemical signals and feeding behaviour in fishes. (In) Bardach, J.E. J.J. Magnuson, R.C. May and J.M. Reinhart (ed.) Fish Behaviour and its uses in capture and culture fisheries. pp 57-101 ICLARM conference proceedings 5, 512p. International Centre for Living Aquatic Resource Management, Manila, Philippines.

Balasubramanyan, R., Satyanarayana, A.V.V., and Sadanandan, K.A., 1960. A preliminary account of the experimental rock lobster fishing conducted along south west coast of India with bottom set gill nets. Indian J. Fish. 7:407-422.

Balasubramanyan, R., Satyanarayanan, A.V.V. and Sadanandan, K.A. 1961. A further account of rock lobster fishing with bottom set gill nets. Indian Journal of Fisheries Vol.8 No.1 269 p.

Spiny lobsters of India and the present status of their fishery.
Balasubramanyan, R. 1967. Indian Sea Foods. Vol.IV No.3.

Balasubramanyan, R. 1969. On the occurance of Palinurid Spiny lobsters in Cochin back waters. J. Mar. Biol. Ass. India, 9(2): 435-438.

Bardach, J.E., Ryther, J.H., and W.O. Mc Larney, 1972. "Aquaculture : Farming and husbandary of fresh water and marine organisms". Wiley (Inter Science), New York.

The effects of pot immersion time on catch of crabs, Cancer pagurus
Bennet, D.B. 1974. J. Cons. Int. Explor. Mer. 35, 332.

Berry, P.F. 1969. The biology of Nephrops andamanicus Wood - Mason (Decapoda - Reptantia). S. Afr. Oceanogr. Res. Inst. Invest. Re. 22: 1-55.

Berry, P.F. 1971. The spiny lobster (Palinuridae) of east coast of South Africa. Distribution and ecological notes. Oceanogr. Res. Inst., Invest. Rep. 27, 1-23.

Berry, P.F. 1977. A preliminary account of a study of biomass and energy flow in a shallow subtidal reef community on the east coast of South Africa, involving the rocklobster Panulirus homarus. Circ. CSIRO. Div.Fish. Oceanogr. 7. 24.

Beurois, J. 1971. Regime alimentaire de la langouste Jasus paulensis (Heller, 1862) des iles Saint-Paul et Amsterdam (Ocean Indien). Resultats preliminaires. Tethys 3(4): 943-948.

Beverton, R.J.H. 1953. Some observations on the Principles of fishery regulation. J. Cons. Int. Explor. Mer. 19 : 56-68.

Bhatt, Y.M., M.N. Kutty, K.V. Subba Rao and D.M. Punwani, 1964. Ghol-Dara fishery in Gulf of Kutch. Indian J. Fish. Vol. XI. No.1.

Blumer, M., J.M. Hunt, J. Atema and L. Stein 1973. Interaction between marine organisms and oil pollution. Environmental protection Agency, Elogical Research Series - R3-73-042.

Booth, J.D. 1979. North Cape - a 'nursery area' for the pack horse rock lobster, Jasus verreauxi (Decapoda : Palinuridae). Newz. J. of Mar. & Fresh Water Res., 13(4) : 521-528.

Bowen, B.K. 1963. Preliminary report on the effectiveness of escape gaps in cray fish pots. West. Aust. Dep. Fish. Fauna Rep.(2) 1-13.

Bowen, B.K. 1971. Management of western rock lobster. FINS (West. Aust.) Dep. Fish. Wild., Perth. 4(2): 29-34.

Carlberg, J.M. and Ford, R.F., 1977. Food preferances, feeding activity patterns and potential competition between Homarus americanus, Panulirus interruptus and Cancer antennarius. Circ. CSIRO, Div. Fish. Oceanogr. (Aust.) 1, 23.

Chapman, C.J., and F.G. Howard, 1979. Field observations on the Ermergence Rhythm of Norway Lobster Nephrops norvegicus, using different methods. Mar. Biol., 51: 157-165. (Aberdeen, Scotland).

Chacko, P.I., R. Srinivasan and R. Anantanarayanan, 1969. On the lobster fishery trend and conservancy measure in Kanyakumari district, Madras State. Madras, J. Fish. 5: 72-81.

Chhapgar, B.F. and S.K. Deshmukh, 1964. Further records of lobster from Bombay. J. Bom. Nat. Hist. Soc., 61(1): 203-207.

Chittleborough, R.G. 1975. Environmental factors affecting growth and survival of juvenile western rock lobsters Panulirus longipes (Milne-Edwards) Aust. J. Mar. Freshwat. Res., 26: 177-196.

Chopra, B.N. 1939. Some food prawns and crabs of India and their Fisheries. Jour. of Bom. Nat. Hist. Soc. 41(2), 221-234.

Cobb, J. Stanley, Philips, Bruce F. and R.W. George 1980. Biology and management of lobsters. Vol.II (edts. Cobb & Philips) Ecology and management. Academic Press inc. Newyork pp. 1-82.

Cooper, R.A. and Uzmann, J.R. 1977. Ecology of juvenile and adult lobsters, Homarus americanus, Homarus gammarus and Nephrops norvegicus. Circ. Div. Fish. Ocenogr. (Aust.) No.7 pp. 187-208.

Cushing, D.H. 1976. The Ecology of the Seas. (Cushing, D.H. and J.J. Walsh edt.) Black well Scientific publications, London p. 9.

Davis, F.M. 1958. An account of the fishing gear of England and Wales, Fishery Investigation Series 2, 165.

Davis, G.E. 1977. Effects of recreational harvest on a spiny lobster, Panulirus argus, population. Bull. Mar. Sci. 27 (2), 223-236.

Day, F. 1877. Fishes of India 1 and 2.

De Bruin, G.H.P. 1960. Lobster fishing in Ceylon. Bull. Fish. Res. Stn. Ceylon, 9 pp. 18.

De Bruin, G.H.P. 1962. Spiny lobsters of Ceylon. Fish Res. Stn. Ceylon. 14 pp 28.

Deevey, E.S., Jr. 1964. General and historical ecology. Bio Science 14, 33-35.

Deshmukh, S. 1966. The puerulus of spiny lobster Panulirus polyphagus (Herbst) and its metamorphosis into the post puerulus. Crustaceana, 10(2): 137-150.

De Wolf, G.A. 1974. The lobster fishery of Maritime Province: Economic effects of regulations, Bull. Fish. Res. Bd. Canada. 187 pp. 59.

Doiphode, P.V. and Rekha Naick, 1977. On the occurance of giant rock cod Epinephelus malabaricus (Bloch and Schneider) in the estuarine waters of river Mandovi, Goa. J. Mar. Biol. Ass. India, 17(2): 244-245.

Doliber, E. 1973. Lobstering inshore and offshore, p 108. Associated Press, Newyork.

Dow, R.L. and Trott, T.T. 1956. A study of major factors of Maine Lobster productions. Dept. of Marine Resources, Augusta, Maine.

Dow, Robert L. 1964. Supply, sustained yield and Management of the Maine lobster resource. Comm. Fish. Rev. 26(11a): 19-26.

Dow, R.L. 1980. The clawed lobster fisheries. (In) Biology and Management of Lobsters (ed.) Cobb & Phillips. Academic Press Inc. Newyork pp. 265-316.

Firth, Frank E. 1944. Construction and operating Lobster Fishing Gear. U.S. Fish and Wildl. Ser. Bureau of Comml. Fish. Fishery Leaflet 64:1-13.

Fischer, W., and G. Bianchi (eds.), 1984. F.A.O. Species, identification Sheet for fishery purposes, western India Ocean (Fishing Area 51).

Forsyth, W.S. 1946. Lobster and Crab fishing pp. 103, Adam and Charles Block 4, 5 & 6 Soha Square, London.
This market is worth £A 4.8 million.

Gates, D.J. 1961. Fishing News Int. 1, 57.

George, M.J. and K.C. George, 1965. Palinustus mossambicus Barnard (Palinuridae : Decapoda), a rare spiny lobster from Indian waters. J. Mar. Biol. Ass. India, 7(2): 463.

George, M.J. and P. Vedavyasa Rao, 1965. A new record Panulirus longipes (Milne Edwards) from South west coast of India. J. Mar. Biol. Ass. India. 7(2): 461.

George, M.J. and Vedavyasa Rao, P. 1966. On some decapod crustaceans from the South West Coast of India. Proc. of the symp. on crustacea, Marine biological association of India Part I pp 327-336.

George, M.J. 1967(a). Mark recovery experiments in crustaceans Proc. Symp. crustacea, Mar. Biol. Ass. India 4 : 1284-1295.

George, M.J. 1967(b). Observations on the biology and fishery of the spiny lobster Panulirus homarus (Linn.) Proc. of the symp. on crustacea, Marine Biological Association of India part 4 pp. 1308-1316.

George, M.J. 1967(c). The Indian Spiny Lobster - 20th Anniversary Souvenir of CMFRI pp 82-86.

George, M.J. 1973. Lobster fishery resources of India. Proc. of Symp. on living Resources of the seas around India. pp 570-580.

George, R.W. 1958. The status of 'white' cray fish in western Australia. Aust.J. Mar. Fresh Wat. Res., 9: 537-545.

George, R.W. 1963. Report to the Govt. of Aden on the craw fish resources of Eastern Aden Protectorate. Rep. FAO/EPTA (1696) 23 pp.

George, R.W. 1964. Variations and possible geographic populations in the Indo west Pacific Scalloped cray fish, Panulirus homarus.CSA Specialists meetings on crustaceans (Zanzebar 19-26 April) Crustacea, 64(11), 6 pp.

George, R.W. and L.B. Holthuis, 1965. A revision of the Indo west Pacific spiny lobsters of the Panulirus japonicus group. Zoologische verhandeiingen, 72:1-36.

Gravely, F.H. 1927. Orders Decapoda (except paguridae) and stomatopoda. The littoral fauna of Krusadi Islands in the Gulf of Mannar and Palk Bay. Indian J. of Fish., 1 (1&2): 94-129.

Graham, M. 1935. Modern theory of exploiting a fishery and application to North sea trawling. J. Cons. int. Explor. Mer., 110 : 15-20.

Gulland, J.A. 1974. Fishery Science and problems of management (In) Sea

Hancock, D.A. 1980. Introduction to Management. (In) The Biology and Management of lobsters II .(edts) J. Stanley Cobb and Bruce F. Philips. Academic Press Inc. London. P. 184.

Harada, E. 1957. Ecological observations on Japanese spiny lobster Panulirus japonicus (Von Siebold) in its larval and adult life. Publ. Seto. Mar. Biol. Lab 6(1): 99-124.

Herrick, F.H. 1911. Natural history of American lobster. Bull. U.S. Bur. Fish 29: 149-408.

Herrnkind, W.F., Vander Walker, J. and Barr, L. 1975. Population dynamics, ecology and behaviour of spiny lobster, Panulirus argus of St. John, U.S. Virgin Islands. Habitation and pattern of movements. Result of Tektite programme. Vol.2 Sci. Bull., Nat. Hist. Mus., Los Angeles city, 20: 31-45.

Heydorn, A.E.F. 1969. South African rock lobster Jasus Tristani at Verma Sea Mount, Gough Island and Tristan Da Cunha.S. Afr., Div. Sea Fish., Invest. Rep. 73.

Hickling, C.F. 1956. The Herring Fisheries of Milford Haven. Joun. Mar. Biol. Assn. U.K. 26(3).

Hindley, J.P.R., 1977. A review of some aspects of behaviour of juvenile and adult Palinurids. (In) workshop on lobster and rock lobster ecology and physiology, edited by B.F. Phillips and J.S. Cobb. Circ. Div. Fish. Oceanogr. CSIRO, Melb., (7) : 133-41.

Holthuis, L.B. 1946. The Decapod Macrura of the 'Snellius' Expedition Temminckia, 7:1-178.

Holthuis,L.B. 1946. The Stenopodidae, Nephropsidae, Scyllaridae and Palinuridae. The Decapod Macrura of the Snellius Expedition 1 Temminckia, Leiden, 7:1-178.

Holthuis, L.B. 1966. On spiny lobsters of the genera Palinurellus, Linuparus and Puerulus (Crustacea, Decapodae Palinuridae). Proc. Symposium on crustacea. Mar. Biol. Ass. India, Part I : 260-278.

Hornell, J. 1950. Fishing in many waters, Cambridge University Press, London. 207 pp.

Howard, F.G. 1982. The Norway lobster, Scottish Fish Inf. Pam. 7 : pp 15. Dept. of Agriculture and Fisheries, Scotland.

Hughes, W.D. 1971. Australian lobster fishery : gear and methods, Aust. Fish., 30 : 4-11.

Hutchison, G.B. 1959. Homage to Santa Rosalia or why there are so many kinds of animals. American University; 93:145-195.

Ingle, Robert M. and Ross Witham, 1968. Biological considerations in spiny lobster culture. Contribution No.123. Marine Research Laboratory. Florida Board of Conservation.

Jayaraman, R., Seshappa, G., Mohamed, K.H. and Bapat, S.V. 1959. Observations on trawling fisheries of the Bombay and Saurashtra waters, 1949-50 to 1954-55. Indian J. Fish., 6(1), 58-144.

Jensen, A.J.C. 1967. The Norway Lobster, Nephrops norvegicus in north sea, Skagerak and Kattegat. Proc. Symp. Crustacea. 3 pp 1320-1327.

Job, T.J. and Pantulu, V.R. 1953. Trap fishing. J. Asiat. Soc. Sci. 19, 175.

Johanness, R.E. 1981. Words of the Lagoon: Fishing and marine lore in the Palun District of Micronesia. pp 223, University of California Press, Berkely, California, U.S.A.

John, C.C. and C.V. Kurian, 1959. A preliminary note on the occurance of deep water prawn and spiny lobster off Kerala Coast. Bull. Cent. Res. Inst. Trivandrum, Ser. C 7(1): 155-162.

Joll, L.M. 1977. The predation of pot-caught western rock lobster (Panulirus longipes cygnus) by octopus. Rep. West. Aust. Dep. Wildl.,(29) : 58 pp.

Jones, S. 1950. Observations on the bionomics and fishery of the brown mussel (Mytilus sp) of the cape region of Peninsular India. J. Bombay Nat. Hist. Soc., 49: 519-528.

Jones, S. 1967. The crustacean fishery resources of India. Proc. Symp. Crustacea, Part III: 1328-1340.

Jonklaas, R. 1967. A preliminary investigation on the Spiny Lobster Resources of Maldive Islands. Proc. Symp. Crustacea, Mar. Biol. Ass. India 4: 1341.

Joseph Mathai, T. and Kesavan Nair, A.K. 1979. On certain allometric relations of spiny lobster Panulirus polyphagus (Herbst) Fish. Technol. 16: 83-85.

Kagwade, P.V. 1987 Age and growth of spiny lobster Panulirus polyphagus (Herbst) of Bombay waters. Indian J. Fish. 34(4): 389-398.

Kagwade, P.V. 1987(a) Morphological relationships and conversion factors in spiny lobster Panulirus polyphagus (Herbst) from south west coast of India. Indian J. Fish 34(3): 348-358.

Kagwade, P.V., M. Manickraja, V.D. Deshmukh, M. Rajamani, E.V., Radhakrishnan, V. Suresh, M. Kathirvel and G.S. Rao, 1988. Magnitude of lobster resources of India, Symp. on Tropical Marine Living Resources (abstracts). Mar. Biol. Ass. of India. Cochin 12-16 January, 1988.

Kanciruck, P. and Herrnkind, W.F. 1976. Sea Grant Programme Rep.No.8, pp 99. State University System, Florida.

Kanciruck, P. and Herrnkind, W.F. 1978. A field and laboratory study of the mass migration of spiny lobster Panulirus argus (Crustacea : Palinuridae) : Behaviour and environmental correlates. Bull. Mar. Sci. 28(4) : 601-623.

Kanciruck, P. 1980. Ecology of juvenile and adult Palinuridae (spiny lobsters) (In) The Biology and Management of lobsters 2 (edt.) J. Stanley Cobb and Bruce F. Philips Academic Press Inc. London. 59-96.

Kathirvel, M. 1973. The growth and regeneration of an aquarium-held spiny lobster, Panulirus polyphagus (Herbst) (Crustacea:Decapoda:Palinuridae). Indian J. Fish. 20(1): 219-221.

Kaul, P.N. and Kandoran, M.K. 1987. Extend of trial of improved design of lobster traps. Fishery Technology Vol.24 No.1 pp 67-70.

Koers, Albert W. 1973. International Regulation of Marine Fisheries. A study of Regional Fisheries Organisations. pp 368. Fishing News (Books) Ltd., London.

Kubo, I. 1962. On the bimodality found in the catch of Japanese lobster Panulirus japonicus. Bull. Jpn. Soc. Sci. Fish. 28(3): 322-325.

Kubo, I. 1963. Systematic studies on the Japanese Macrurans Decapod crustacea - VI. A new and imperfectly known Species of Palinurid lobster. J. Tokyo Univ. Fish., 49(1): 63-71.

Kubo, I. and Ishiwata, N. 1964. On the relationship between activity of Japanese Spiny Lobster and under water light intensity. Bull. Jpn. Soc. Sci. Fish. 30(11): 884-888.

Kurian, C.V. 1965. Deep water prawns and lobsters of Kerala coast-Fishery Technology, 2(1): 51-53.

Kurian, C.V. 1968. Occurance of lobster in the off shore waters of Kerala. Seafood Trade Journal, 3(6): 22-26

Kurian, G.K. 1965. Trends in development in prawn fishing techniques in India - A review. Fish. Technol. 2: 64-68.

Kuthalingam, M.D.K., Luther, G. and S. Lazarus, 1980. Rearing of early juveniles of spiny lobster Panulirus versicolor (Latreille) with notes on Lobster fishery in Vizhinjam area. Indian J. Fish. 27(1 & 2): 116-119.

Lamarid, Hugo, B. and Blanco, A. Wilfredo, 1986. Handling of live lobsters in Cuba - Infofish. Marketing digest 6/86 pp 44-46.

Larkin, P.A. 1977. An epitaph for the concept of maximum sustainable yield. Trans. Am. Fish. Soc. 106(1): 1-11.

Little, E.J., Jr., 1977. Observations on the Recruitment of Postlarval spiny lobsters, Panulirus argus, to the south Florida Coast. Fla. Mar. Res. Publ. No.29, 35 pp.

Coast of the King lobster
Levett, J. 1965. Fishing News International 4(1): 92-94.

The chemical basis of food detection in lobster, Homarus gammarus
Mackie, A.M. 1973. Mar. Biol. 21:103.

Mahadevan, S. and Nagappan Nair, K. 1974. Ecology of Pearl oyster and chank beds (In) Commercial molluscs of India. Bull. Cent. Mar. Fish. Res. Inst. 25: 106-121.

Marshall, A.J. and Williams, W.D. (eds.) 1972. Text book of zoology volume 1. Invertebrate. The Macmillian Press Ltd., London.

Mckoy, J.L. 1979. Fisheries Research Division Occasional paper 18, pp 16. Newzealand Ministry of Agriculture and Fisheries, Wellington.

Meenakumari, B. and Mohan Rajan, K.V. 1985. Studies on materials for traps for spiny lobsters. Fisheries Research, 3(1985) 309-321 Elsevier Publishers, Amsterdam.

Meenakumari, B., Mohan Rajan, K.V., and Kesava Nair, A.K. 1986. Length weight and Tail length - total length relationships in Panulirus homarus Linnaeus of south west coast of India. Fishery Technology Vol.23 pp 84-87.

Meiyappan, N.M. and M. Kathirvel, 1978. On some new records of crabs and lobsters from Minicoy, Lakshadweep (Laccadives). J. Mar. Biol. Ass. India, 20 (1&2): 116-119.

Menon, T.R., Rajendran, R. and Radhakrishnan Nair, P. 1970. Development of Fishing gear and methods (In) Proc. of Symp. on Development of Deep Sea Fishing : 253-258.

Mitchel, C.T., Turner, C.H. and Strachan, A.R. 1969. Observations on the biology and behaviour of California spiny lobster, Panulirus interruptus (Randal) Calif. Fish Game 53: 121-131.

Miyamoto, H. and Shariff, A.T. 1958. Investigations on Lobster fisheries. Paper presented at the symposium on "Improved types of fishing from small mechanised boats" Cochin.

Miyamoto, H. and Shariff, A.T., 1961. Lobster fishery off the south west coast of India. Anchor hook and trap fisheries. Indian J. Fish., 8(1) 252-258.

Mohamed, K.H. and George, M.J. 1971. Results of tagging experiments of Indian spiny lobsters, Panulirus homarus (Linnaeus) - Movement and growth. Indian J. Fish., Vol. 15, pp 15-26.

Mohamed, K.H., P. Vedavyasa Rao and C. Suseelan, 1971. The first phyllosoma stage of the Indian deep sea spiny lobster Puerulus sewelli. Ramadan, Proc. Ind. Acad. Sci. B. LXXIV: 208-215.

Mohamed Kasim, H. 1986. Effect of salinity, temperature and oxygen partial presence on respiratory metabolism of Panulirus polyphagus (Herbst). Indian J. Fish. 33(1): 66-75.

Mohan Rajan, K.V., Meenakumari, B., and Balasubramanyan, R. 1981. Spiny Lobsters and their fishing techniques. Fishery Technology, 18, pp 1-11.

Mohan Rajan, K.V. and Meenakumari, B. 1982. Development of lobster traps: preliminary experiment with three new designs of Rectangular, Australian pot and Ink well traps. Fishery Technology, Vol.19, pp 83-87.

Mohan Rajan, K.V. 1983. Some indigenous fishing gear and methods for squids and cuttle fishes along S.W. coast of India. Sea food Export Journal 16 (6): 19-30.

Mohan Rajan, K.V., Meenakumari, B., Kandoran, M.K. and Balasubramanyan, R. 1984. Lobster fishing with modern traps - A viability report. Fish Technology News letter Vol.III No.12.

Mohan Rajan, K.V. and Meenakumari, B. 1984. Sea urchin roe has high export potential. Fishing Chimes 8(10).

Mohan Rajan, K.V., Meenakumari, B. and Kesavan Nair, A.K. 1988. Development of an efficient trap for lobster fishing. Fishery Technology, Vol.25, No.1. pp. 1-4.

Morgan, G.R., 1974. Aspects of population dynamics of western rock lobster, Panulirus cygnus George, 2(11). Seasonal changes in catchability coefficient. Aust. J. Mar. Freshwat. Res. 25: 249-259.

Moore, R. and Mac Farlane, J.W. 1980. Aust. Fish 39, 4.

Munro, J.L. 1983. The Biology Ecology and Bionomics of Spiny Lobsters (Palinuridae), Spider crabs (Mujiidae) and other crustacean Resources. (in J. Munro Edt.). Caribbean coral reef fishery resources. ICLARM Studies and Reviews 7: 276 pp. International Centre for Living Aquatic Resource Management, Manila, Philippines.

Nair, R.V., R. Soundararajan and K. Dorairaj, 1973. On the occurrance of Panulirus longipes, Panulirus penicillatus and Panulirus polyphagus in the gulf of Mannar with notes on the lobster fishery around Mandapam. Indian J. Fish 20(2): 332-350.

Nair, R.V., Soundararajan, R. and Nanda Kumar, G. 1981. Observations on growth and moulting of spiny lobsters Panulirus homarus (Linnaeus) P. ornatus (Fabricus) and P. penicillatus (Olivier) in captivity. Indian J. Fish 28: 25-35.

Neff, Jerry M. and Jack, W. Anderson, 1981. Response of marine animals to Petroleum and specific Petroleum Hydrocarbons. Applied Science Publishers. 172 pp.

Nielson, 1892. Ann. Rept. Nfld. Fish Comm. for the year 1891, Appendix No.2 pp. 76-77.

Odum, E.P. 1976. Fundamentals of Ecology (Third Edn.) W.B. Saunders Co., Newyork.

O'Farrel, R.C. 1966. Lobsters, crabs and crawfish, Fishing News (Books) Ltd., London. 120 pp.

Olsen, D., Herrnkind, W.F. and Cooper, R. 1975. Population dynamics, ecology and behaviour of spiny lobster, Panulirus argus of St. John, U.S. Virgin islands. Introduction Sci. Bull. Nat. Hist. Mus., Los Angeles Cty. 20, 11-16.

Parrish, B.B. 1969. A review of some experimental st ''es of fish reactions to stationary and moving objects of relevance to ,1 capture processes. FAO Fish. Rep. (62) Vol.2: 232-245.

Patwardhan, S.S. 1958. Palaemon. The Indian Zoological Memoirs on Indian animal types. The Zoological Society of India, Calcutta (Publishers).

Pauly, Daniel. 1990. On Malthusian over fishing. NAGA. The ICLARM Quarterly January 1990 pp. 3-4.

Pearl, Thomas Mary, P. Sitarami Reddy and R. Thangavelu 1987. On the endophragmal skeletons of spiny lobsters Panulirus homarus and P. ornatus. Indian J. Fish 34(2): 218-222.

Exploratory fishing for spiny lobsters, sand lobsters and scallops in Panama.
Pease, N.L. 1965. Comml. Fish. Rev. 27, 1.

Phillips, B.F. 1972. A semiquantitative collector of the puerulus larvae of the western Rock lobster Panulirus longipes cygnus George (Decapoda, Palinuridae). Crustaceana 22: 147-157.

Phillips, B.F., G.R. Morgan and C.M. Austin, 1980. Synopsis of biological data on western rock lobster, Panulirus cygnus George 1962 FAO Fish. Synop., (128): 64 pp.

Pillai, C.S. Gopinatha, Madan Mohan and K.K. Kunhikoya, 1985. Observations on the lobsters of Minicoy attol. Indian J. Fish. 32(1): 112-122.

Prasad, R.R. and Thampi, P.R.S. 1959. A note on the first phyllosoma of Panulirus burgeri (de Haan). Proc. Ind. Acad. Sci., 49(6)A: 397-401.

Prasad, R. Raghu and P.R.S. Thampi, 1968. On the distribution of Palinurid and Scyllarid lobsters in Indian Ocean. J. Mar. Biol. Ass. India, 10(1): 78-87.

Prasad, R.R., P.R.S. Thampi and M.J. George, 1975. Phyllosoma larvae from Indian Ocean collected by DANA Expedition 1928-30 J. mar. biol. Ass. India, 17: 56-107.

Prasad, R.R., P.R.S. Thampi and M. Kathirvel, 1978. On some new records of crabs and lobsters from Minicoy, Lakshadweep (Lacadives). J. Mar. Biol. Ass. India, 20(1&2): 119-126.

Prasad, R.R. 1978. Studies on the Phyllosoma Larvae from the Indian Ocean: I - Distribution and growth. J. Mar. Biol. Ass. India, 20(1&2): 142-156.

Premkumar, V.K. and Daniel, A. 1975. Distribution pattern of the economically important spiny lobsters of the genus Panulirus White, in the Indian Ocean. J. Mar. Biol. Ass. India 17(2): 36-40.

Racek, A.A. 1959. Prawn investigations in Eastern Australia. Res. Bull. State Fish. N.S.W., 6: 1-57.

Radhakrishnan, E.V. and M. Vijayakumaran, 1982. Unprecedented growth induced in spiny lobsters. Mar. Fish. Inform. Serv. T&E Ser., No.43: 6-8.

Radhakrishnan, E.V., and M. Vijayakumaran 1984(a). Effect of Eye stalk ablation in spiny lobster Panulirus homarus (Linnaeus):1 On moulting and growth. Indian J. Fish. 31(1): 130-147.

Radhakrishnan, E.V. and M. Vijayakumaran 1984(b). Effect of Eye Stalk ablation in the spiny lobster Panulirus homarus (Linnaeus):3. On Gonadial maturity. Indian J. Fish 31(2): 209-216.

Rai, H.S. 1933. Shell fisheries of Bombay Presidency. Jour. of Bom. Nat. Hist. Soc. 36: 884-887.

Ramanadhan, R. and Chacko, P.I. 1962. A preliminary report on the lobster fishery of Kanyakumari coast. Fisheries station reports and year book, Department of Fisheries, Madras. April '57 to March '58, 86-93.

Rand, R.W. 1959. The cape fur seal (Arctocephalus pusillus) distribution, abundance and feeding habits off south western coast of Cape Province. S. Afr., Div. Sea Fish, Invest. Rep. 34: 1-125.

Rao, K. Satyanarayana 1974. Edible bivalves: Mussels and oysters (in) : Commercial molluscs of India. Bull. Cent. Mar. Fish. Res. Inst. 25: 4-39.

Rao, K. Virabhadra, 1958. Molluscan Fisheries (In) (S. Jones Edt.) Fisheries of west coast of India : 55-59.

Rao, M. Umamaheswara 1973. The sea weed potential of the seas around India. Proc. Symp. on Living Resources of the seas around India: Cent. Mar. Fish Res. Inst. Cochin : pp 687-692.

Rao, P. Vedavyasa and Kathirvel, M. 1971. On the seasonal occurrance of Penaeus semisulcatus de Haan, Panulirus polyphagus (Herbst) and Portunus pelagicus (Linnaeus) in Cochin backwater. Indian J. Fish. 19: 129-134.

Rao, P. Vedavyasa and George, M.J. 1973. Deep sea spiny lobster, Puerulus sewelli Ramadan: Its commercial potentialities. Proc. Symp. on Living Resources of the seas around India (CMFRI), pp. 634-640.

Rimmer, D.W. and B.F. Philips, 1979. Diurnal migration and vertical distribution of Phyllosoma larvae of western rock lobster, Panulirus cygnus George. Mar. Biol., 54: 109-124.

Royce, William, F. 1972. Introduction to fishery science. Academic Press Inc. Newyork, pp 322.

Saila, S.B. 1969. Some applications of observations and experiment on fish behaviour in designing fishing gear and devising tactics, with suggestion for future studies. Proc. of FAO Conf. on Fish Behaviour in relation to Fishing Techniques and tactics, Norway . FAO Fish. Rep., No.62 Vol.2: 49-57.

Sarvesan, R. 1974. Cephalopods (In) Commercial Molluscs of India. Bull. 25. Cent. Mar. Fish. Res. Inst. Cochin: 63-84.

Saunders, H.L. 1969. Benthic marine diversity and stability time hypothesis, Diversity and Stability in ecological system. Brook Haven Symp. on Biol. 22: 71-81.

Satyanarayana, A.V.V. 1987. Panulirus versicolor (Latrielle) A new record from Central Andhra Coast (Bay of Bengal). Fishery Technology. Vol. 24, No.2 pp 134-135.

Scott, J.B. 1984. Fisheries Management - some economic considerations Aust. Fish 43, 6.

Siegal, S. 1956. Non parametric statistics for Behavioural Sciences. McGraw - Hill Book Company, Inc. Tokyo, Japan.

Serfling, S.A. and R.F. Ford, 1975. Ecological studies of puerulus larvel stage of Californian spiny lobster, Panulirus interruptus. Fish. Bull. 73(2): 360-377.

Sewel, R.B.S. 1913. Notes on the biological work of R.I.M.S.S. 'Investigator' during survey seasons 1910-1911 and 1911-1912 - Journ. Proc. Asia. Soc. Bengal 9: 329-390.

Sheard, K. 1949. Marine cray fishes of western Australia. Bull. CSIRO Aust., (247): 45 p.

Silas, E.G. 1982. Major break through in spiny lobster Culture Mar. Fish Infor. Serv. T & E Ser. No.43: 1982.

Silas, E.G., K. Satyanarayana Rao, K. Prabhakaran Nair and M.M. Meiyappan, 1986. Identity of common species of cephalopods of India. In : (E.G. Silas Ed.) Cephalopod Bionomics, Fisheries and Resources of the Exclusive Economic Zone of India, Bull. Cent. Mar. Fish Res. Inst. 37: 13-37.

An annotated Bibliography of the Spiny lobsters.

Sims, H.W. 1966. Fla. Bd. Cons. Tech. Ser. 48, pp 84.

Spiny lobster industry of Florida.

Smith, F.G.W. 1958. Floride St. Bd. Conserv. Ed. Ser. 11, 1136.

Smith, Ian R. 1979. A Research frame work for traditional fisheries. ICLARM stud. and Rev. (2), International Center for Living Aquatic Resources Management, Manila. 45 p.

Ghost fishing and gear loss.

Smolowitz, R.J. 1978. Mar. Fish. Rev. 40, 59.

Subrahmanyam, M. 1965. Lunar, Diurnal and tidal periodicity in relation to the prawn abundance and migration in Godaveri Estuarine Systems. Fishery Technology 2 (1).

Subrahmanyam, M. 1966. Fluctuations in prawn landings in Chilka lake·Proc. Indo-Pacific Fish. Coun., 12(11): 202-209.

Subrahmanyam, M. 1967. Further observations on Lunar periodicity in relation to the Prawn abundance in the Godavari Estuarine Systems. J. Mar. Biol. Ass. India, 9 (1) : 111-115.

Sutcliffe, W.H. 1956. Effect of light intensity on the activity of Bermuda Spiny lobster, Panulirus argus. Ecology 37(1) : 200-201.

Swaminathan, M.S. 1981. Proc. of seminar on the role of Small Scale Fisheries and coastal Aquaculture in integrated Rural Development, CMFRI Bulletin 30-A pp 1-198.

Templeman, W. 1937. Lobster and lobster fishery, Can. Fisherman, May 1937.

Thampi, P.R.S. and M.J. George, 1975. Phyllosoma larvae in the IIOE (1960-65) Collections - Systematics. Mahasagar - Bull. Natn. Inst. Oceangr. 8: 15-44.

Thomas, M.M. 1972. Growth of the spiny lobster, Panulirus homarus (Linnaeus), in captivity. Ind. J. Fish., 19: 125-129.

Thomas, J.C. 1973. An analysis of commercial lobster (Homarus americanus) fishery along the coast of Maine August, 1966 through December 70. NOAA Tech. Rep., NMFS SSRF 667: 1-15.

Thomson, H.C., Jr., R.N. Farragut and M.H. Thompson, 1977. Relationship of scarlet prawns (Plesiopenaeus edwardsianus) to a benthic oil deposit off north-west coast of Aruba, Dutch West Indies. Environ. Pollut. 13: 239-253.

Varghese P. Oomen and K.P. Philip, 1974. Observations on the fishery and biology of the deep sea spiny lobster Puerulus sewelli. Ramadan. Indian J. Fish. 2(2): 369-385.

Vijayakumaran, M. and E.V. Radhakrishnan, 1984. Effect of eye stalk ablation in the spiny lobster Panulirus homarus (Linnaeus) : 2 on food intake and conversion. Indian J. Fish. 31(1): 148-155.

Von Brandt. 1969. Application of observations on fish behaviour for fishing methods and gear construction. FAO Fish. Rep. (62) Vol.2: 461 p. (Ben - Tuvia, A. and W. Dickson edt.).

Von Brandt, A. 1972. Fish catching methods of the world. Fishing News Books Ltd. England: P 212.

Weatherly, A.H. 1979. Growth and Ecology of Fish populations. Academic Press Inc. (London Ltd. pp 293.

Wicksten K. Mary, 1982. Crustaceans from baited traps and gill nets off Southern California. Calif. Fish and Game 68(4): 244-248.

Wilder, D.G. 1954. Lobster fishery of southern gulf of St. Lawrence. FRBC general series Circular No.24. 16 pp.

Wilder, D.G. 1959. Canada's lobster fishery. Can. Georgr. J. pp 1-201.

Wilder, D.G. 1965. Lobster Conservation in Canada. Rapp. P.V. Reun., Cons. Int. Explor. Mer. 156 : 21-29.

Wilder, D.G. 1973. The American Lobsters. Environment Canada Fisheries and Marine Service, Fact Sheet No.5. 8 pp.

Wilimovsky, N.J. and Alverson, D.L. 1971. Future of Fisheries (In) Modern fishing gear of the world, vol.III Kristjonsson, H. (Edt.) Fishing News (Books), London : 509-516.

Windley, D.W. 1968. United States Department of Interior Stewart, L. Udall, Foreign Fisheries Leaflet 171.

Zeiner, Paul B. and Kjeld Rasmussen, 1958. Report No.1 to the Govt. of India on Fishing boats. 138 pp.

LIST OF PUBLICATIONS BY THE AUTHOR

1. Spiny lobsters and their fishing techniques - K.V. Mohan Rajan, B. Meenakumari and R. Balasubramanyan (1981) Fishery Technology Vol.18 No.1 : 1-11.

2. Development of Lobster Traps - preliminary experiments with three New Designs of Rectangular, Australian pot and Ink well Traps - K.V. Mohan Rajan & B. Meenakumari (1982) Fishery Technology Vol.19 No.2 pp 83-87.

3. A success story of Redeployment of Mechanised boats for shark long lining - K.V. Mohan Rajan (1982) Sea Food Export Journal Vol.XIV No.8 pp 1-9.

4. Some indigenous Fishing Gear and Methods for Squids and Cuttle fishes along S.W. coast of India (1983) Sea Food Export Journal Vol.XV No.6 pp 1-10.

5. Sea Urchin Roe has High Export Potential - K.V.Mohan Rajan and B. Meenakumari (1984) Fishing Chimes Vol.3 No.10 pp 10-11.

6. Scope of Application of Stimulii and stimulation Gadgets in Fishing - K.V. Mohan Rajan.(1984) - Proceedings of the Summer Institute on Application of Indigenous Electronic Instruments for Fishing and Fisheries Research.

7. Lobster fishing with Modern traps - A viability Report K.V.Mohan Rajan, B. Meenakumari, M.K. Kandoran and R. Balasubramanyan (1984) - Fish Technology Newsletter Vol.III No.12 pp 9-12.

8. Studies on materials for traps for spiny lobsters. B. Meenakumari and K.V. Mohan Rajan (1985) Fisheries Research (Elsevier Science Publishers, Amsterdam) No.3 pp 309-321.

9. Length-weight and Tail length - Total length Relationships in Panulirus homarus Linnaeus of South West Coast of India (1986). B. Meenakumari, K.V. Mohan Rajan and A.K. Kesavan Nair Fishery Technology Vol.23 pp 84-87.

10. Small Scale Fisheries - (1986) K.V. Mohan Rajan - Seafood Export Journal Vol.XVIII No.12 8 pp.

11. Energy Alternative in Fisheries Sector (1987) K.V. Mohan Rajan, Fishing Chimes Vol.6 No.11 pp 45-50.

12. Cast iron propellers are Economical for Fishing Boats (1987) - K.V. Mohan Rajan. Fishing Chimes Vol.7 No.6 pp 49-51.

13. Development of an Efficient trap for Lobster Fishing (1988) - K.V. Mohan Rajan, B. Meenakumari and A.K. Kesavan Nair - Fishery Technology Vol.25 No.1 pp 1-4.

14. Conversion of Idle cargo vessels for Deep sea Fishing (1988) - K.V. Mohan Rajan Fishing Chimes Vol.7 No.12, 4 pp.

15. Operation of coloured Gillnets off Saurashtra Coast (1988) K.V. Mohan Rajan and P. George Mathai - Fishing Chimes Vol.8 No.2 pp 30-37.

16. Growing Acceptance of FRP as Boat Building Material in Gujarat Coast (1988) - K.V. Mohan Rajan - Fishing Chimes Vol.8 No.3 : 50-56.

17. History of Trawling at Veraval : A study (1989) K.V. Mohan Rajan, P. George Mathai and Puthra Pravin Fishing Chimes Vol.9 No.1 pp 30-36.

18. Studies on optimisation of Bridle Lengths in demersal trawls (1990). K.V. Mohan Rajan, M.R. Boopendranath, P. George Mathai and N.Subramonia Pillai Fishery Technology Vol.27 No.2 pp 87-91.

19. Studies on Polypropylene Gill nets (1991) - K.V. Mohan Rajan, P.George Mathai, R.S. Manohardoss and Puthra Pravin. Fishery Technology Vol.28 No.1 pp 1-4.