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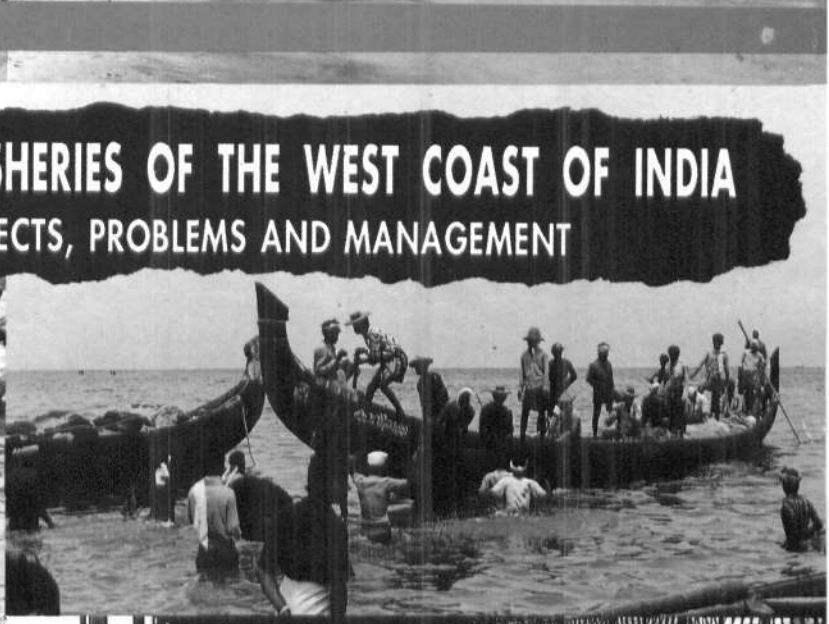
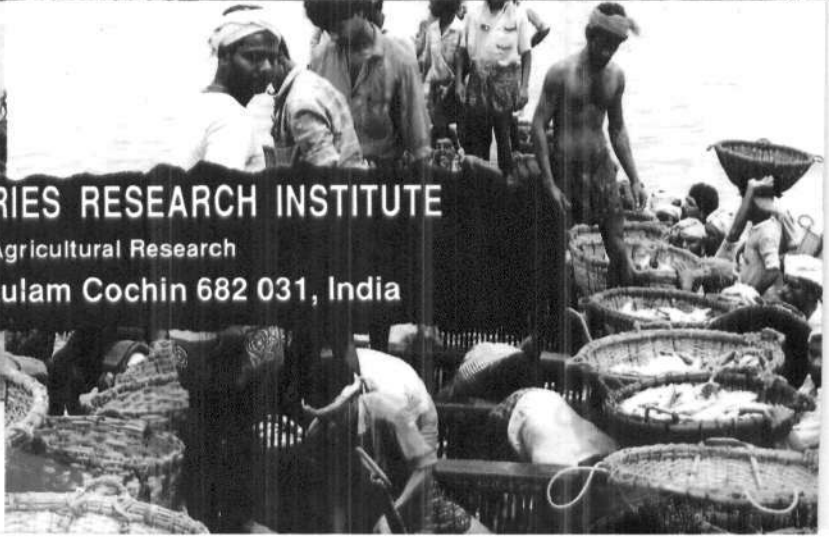
Bulletin 45

MONSOON FISHERIES OF THE WEST COAST OF INDIA

PROSPECTS, PROBLEMS AND MANAGEMENT





CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

Indian Council of Agricultural Research

Post Box No. 2704, Ernakulam Cochin 682 031, India

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CONTENTS

PREFACE

There have been significant developments in the exploitation of the marine fishery resources of India since early 1970s. These, on the west coast of India, include introduction of purse seine fishing, extension of fishing during monsoon months, multiple days fishing by the mechanised vessels, motorisation of country crafts and introduction of ring seines and similar other efficient gears. While these inputs have contributed to enhance the marine fish production, they have also brought forth a number of resource-related and socio-economic problems necessitating serious management considerations. One such problem area is the fishing during monsoon being practised by the mechanised vessels in some of the States along the west coast particularly in Kerala. This activity which was started in the seventies with the advancements in the operational capabilities of mechanised vessels in the context of increasing demand for fish in the internal and external markets, soon belied its advantages. It is perceived as competing with the artisanal fisheries in the inshore waters and fostering resource degradation as bottom trawling during monsoon period is apprehended to adversely affect the spawning populations and subsequent recruitment. This issue, in the context of increasing fishing pressure on the resources in the inshore waters and the widening social and economic imbalance between the artisanal and mechanised sectors, has led to serious conflicts between these two groups of fishermen exploiting the resource. Frequent clashes, often aggrevated and inflamed by the reported encroachment of the area demarcated for artisanal sector by the mechanised fishing group, have finally resulted in banning of fishing operations by the latter sector in the territorial waters from June to August. Thus, the fishing activities during monsoon, have in recent years, attracted considerable deliberations/ discussions on their impact on the resources, managerial strategies, regulatory measures to be adopted for safeguarding the resources and the interests of different sections of fishermen and their capabilities, and the law and order situation emerging from such conflicts. Besides the social, economic and political implications associated with the banning of fishing during monsoon, the questions often asked are : Does the monsoon fishing adversely affect the resources and their replenishing capabilities ? What steps are needed to utilise the full potential of the resource for the optimum benefit ? In this context, this Publication **'Monsoon Fisheries of the West Coast of India - Prospects, Problems and Management'** endeavours to consider these aspects in the light of the data and informations available with **the Central Marine Fisheries Research Institute.**

This Publication presents the background information on (i) the fisheries oceanographical features and productivity of the shelf waters of the west coast of India with particular reference to the Southwest Monsoon season, (ii) the status of the important fish and shellfish resources exploited during Premonsoon, Monsoon and Postmonsoon seasons and (iii) the socio-economic aspects of the fishermen and the fisheries. In the background of these informations, the impact of fishing during monsoon on the resource, interaction between fisheries or fishery interests

and possible management avenues that could be considered for sustained production and rational management of the resource are discussed. Though this Publication may not be a panacea for solving the complex issue of conflicts between the groups of fishermen of different ethnic and economic backgrounds, it is hoped that it would provide an insight into the biological and fishery-related problems associated with the exploitation of the resources during monsoon, so as to enable the Government to formulate policies for the rational exploitation and management.

Several of my colleagues who are all experts on their fields, have contributed for the preparation of this Publication. I appreciate very much their efforts and sincerely thank them all individually. My special thanks are due to Dr. P. Vedavyasa Rao, Dr. V. Sriramachandra Murty and Dr. K. Rengarajan who have spent considerable time in scrutinising and editing the papers. I also thank Dr. A. Noble, Dr. N. Gopalakrishna Pillai and all staff at the Technical Cell for their co-ordination, co-operation and technical assistance.

Cochin - 682 031,
15th October 1992.

P. S. B. R. James
Director
Central Marine Fisheries Research Institute

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INTRODUCTION

P. S. B. R. JAMES

Central Marine Fisheries Research Institute, Cochin 682 031

The Asian summer monsoon, heralded in ballards, history and literature and eulogised by poets, is synonymous with the prosperity of the countries in South and East Asia. A bountiful rainfall in the region, where more than 60% of the world's population inhabit, favours high vegetative and animal production, influences the life and social pattern of the people, their fortunes and in turn, the economy of the Nation. Failure of the monsoon rains in any part of the area would adversely affect the land-based production, causes miseries and often with disastrous consequences. Naturally this unique phenomenon which brings either the boon or the bane, has attracted the attention of the people from all walks of life over the centuries.

Although the basic mechanism of monsoons has been described about 300 years ago, its complex mechanism, behaviour and forecasting are not yet fully understood. According to Dr. Colin Ramage of the University of Hawaii "the more observations we get, the more complex the monsoon gets. Some of us think, we may be dealing with an intractable problem". Basically, the monsoon is generated by an enormous cycle of air set in motion by temperature difference over land and sea. Influenced and directed by the tilt of the earth on its axis and the Corioli's force due to the earth's spin, the trade winds bringing the summer monsoon, in the Southern Hemisphere along with the intense low level Somali jet stream, cross the Equator, bent right by the Corioli's force and move into the updraft of the intertropical convergence zone. Here the winds of the south meet those of the north. As the Southern Hemisphere Trade wind crosses the Equator and enters the Arabian Sea, it branches into two. The Arabian Sea branch blows into the western ghats and brings the southwest monsoon in that region. The Bay of Bengal branch is forced west at the Himalayas onto the Gangetic plain. During the Northern Hemisphere winter, the sea is warmer than land and cold air surges across the Far East to replace the air rising above warm southern seas, causing the winter or the northeast monsoon. The different aspects of Indian monsoon, its onset, withdrawl, inter-seasonal and inter-annual variations, its vagaries and the endeavours made for its forecasting have comprehensively been reviewed by Subbaramayya and Subba Rao (1985).

That there exists a close link among the physical properties of the sea, atmospheric conditions and the monsoon is now well established. The works of Walker (1924), Walker and Bliss (1937), Troup (1965) and others have shown that the variation of sea level pressure between the East Pacific and the Indian Ocean (Southern Oscillation) has a good positive correlation with the intensity of Indian southwest monsoon. Similarly, it has been observed that the warm water off Peru Coast (El Nino) is closely associated with the low index phase of the Southern Oscillation and that the three phenomena - Indian summer monsoon, Southern Oscillation and El Nino - are physically interlinked.

The weather in our country, which presents wide variation and contrast, is profoundly influenced by the monsoons, particularly the southwest monsoon. The Indian climate may broadly be described as tropical monsoonal climate. It is divisible into four seasons, namely, the winter season (January-February), the warm summer season (March-May), the southwest monsoon rainy season (June-September) and the postmonsoon season (October-December) which is also the northeast monsoon period in the southern peninsula.

The monsoons play a significant role in the ecological cycle and productivity of the sea. Solar radiation which forms the primary source of energy and is essential for photosynthesis, is dependent on the intensity and the length of the day light and atmospheric conditions. The biomass production in the sea is thus dependent on this energy and the nutrient supply generated through the complex physical, chemical and biological processes taking

place in the dynamic marine environment and subsequently transmitted to aquatic organisms at different trophic levels. Similarly, the upwelling phenomenon which occurs seasonally, is due to the strong monsoon winds. This process is important for refertilising the impoverished surface layers and has a great bearing on fish production, its distribution and abundance pattern. Besides, the turbulance, eddy diffusion and thermal stratification caused by the interaction among the sea and atmospheric conditions and wind speed, play major role in the supply of nutrients which determined the productivity of the sea.

The influence of weather on fish populations and their behaviour in general and that of the southwest monsoon on the Indian marine fisheries in particular, have been recognised long back. Studies on this aspect were being carried out at the **Central Marine Fisheries Research Institute** almost from its inception. The important investigations in this direction have been to correlate the variation in the oilsardine catch of the west coast with the intensity of southwest monsoon; sea surface temperature with the mackerel fishery; upwelling occurring during the southwest monsoon on the distribution pattern and movement of fish and prawn stocks in the shelf waters; mud bank fisheries and the prawn fishery of the west coast in relation to hydrographical conditions in the shelf water during different seasons. Recently Longhurst and Wooster (1990) have correlated the abundance of oilsardine with the upwelling on the southwest coast of India and sea level as an indicator of intensity of the upwelling and consequently the oilsardine catch.

Several commercially important marine fishes and shellfishes, including the major groups such as oilsardine, Indian mackerel and penaeid prawns, are known to breed or to have one of their peak spawning seasons during the southwest monsoon months (June - September) on the west coast (Qasim, 1973). The environmental factors prevailing in the ecosystem during this period trigger this biological activity. This aspect as well as the immediate postmonsoonal effect on the biological productivity of the sea, particularly at meso- and micro levels and on the bioenergetics of fish larval development and their survival have attracted several studies of the hydrodynamic control of biological processes in the sea during this critical period(Legendre and Demus, 1984; Krishnan Kutty, 1985). In fact, great emphasis has been given in recent years to base the management of fisheries on the factors governing the spawning and fish larval survival success rather than on the concept of growth overfishing.

The west coast of India, which principally receives the southwest monsoon rains, contributes to about 76% of the annual marine fish production of the country. Prior to Ninteen fifties, the fishing activities carried out by indigenous crafts and gears were confined to nearshore waters and this sector was the major contributor to the fish production of the country. From early fifties, expansion of the fisheries began with the introduction of mechanised fishing vessels, bottom trawling and synthetic gear material. This technological advancement and capabilities resulted in the extension of fishing operation from the nearshore waters to about 40-50 m depth zone on the continental shelf, increase of fishing effort and fish production. With further introduction of purse seiners in the seventies and due to intense fishing to meet the increasing demand for fish, the fishing pressure increased rapidly. Similarly, the motorization of country craft using outboard engines started in 1980 in Kerala soon became popular and helped not only to extend the area of operation and diversified/selective fishing, but also to increase the fish production and revenue to the fishermen. Consequently, the contribution from the mechanised sector enhanced considerably (66%) over that of the indigenous sector in the total marine fish landings of the country. Although the introduction of more efficient fishing technology and the expansion of the fishery were not inappropriate *per se*, the potential social and economical effects of these developments on the different fishing communities exploiting the resources were not visualised before hand. This led to the division of two social, economical and ethnic groups - one representing the artisanal or small-scale sector and the other, the mechanised fishing sector, both competing and exploiting the same resource in the inshore waters. In the meanwhile, realising the need for delimiting the areas of fishing by different types of vessels so as to avoid unfair competition among the larger vessels, small mechanised boats and country crafts, the Union Government prepared a draft Marine Fishing Regulation Bill and requested the maritime State Governments to adopt requisite regulations. Accordingly, several maritime State Governments formulated fishing regulations in the territorial sea

and in Kerala, the use of purse seines, ring seines, pelagic and midwater trawls in the territorial waters (22 km from the coastline) is prohibited. Similarly, fishing by mechanised vessels, except motorised country crafts, is prohibited within 20-30 m depth zone along the different sectors of the coastline of the State. However, the gradual widening in social and economic imbalance between the two groups and the increasing fishing competition in the inshore fishing grounds paved way to the conflict between them for the exploitation of the common property resource.

Prior to seventies, the fishing activities on the west coast of India used to be suspended during the southwest monsoon period from June to August. This practice was being followed traditionally since several years and this cessation of activities acted as a measure for the conservation of the fishery resources. However, the introduction of mechanised fishing vessels and more efficient gears, increasing demand for fish and enhanced value for the fish caught during the lean rainy season, made some of the enterprising mechanised fishing vessel operators to venture into fishing during this season also. This activity inflamed the conflict between the artisanal and mechanised fishing sectors, some times violently. This situation further aggrevated when apprehensions are expressed regarding overfishing of some of the stocks due to the increasing fishing effort, long term adverse effects of bottom trawling on the bottom ecosystem and in turn, the demersal fish resources, the biological needs of safe-guarding the spawning population and young fish in the nursery grounds of the inshore waters for management and conservation of the resources. The violent conflicts erupted on this problem made some of the maritime States, particularly Kerala, to constitute Expert Committees/Commissions to review the situation and recommend the course of action to be taken.

On careful consideration of the issues from the technical and socio-economic points of view, the Committees/Commissions appointed by the Government of Kerala recommended variously from reducing the number of mechanised fishing vessels in operation during the monsoon period to banning bottom trawling during June - August for varying periods within 22 km of territorial waters. Although these recommendations were being implemented by the Government, the conflict persisted and the controversy on the ban of fishing during monsoon period continued and challenged in the court of law. While those advocating banning put forward the argument of distruction of the resource and the urgent need for their conservation, those not favouring this regulation pointed out that the major portion of the catch realised during the monsoon season is accounted by the prawn *Parapenaeopsis s tylifera* and if this resource is not caught it would not only be a loss in the marine fish production front, but also the revenue by way of taxes and foreign exchange earnings, besides creating non-employment problems.

The management of monsoon fishery has thus become a problem of considerable magnitude. It needs careful consideration from the point of view of ensuring accessibility for the exploitation of the resource, but at the same time safeguarding its conservation for continued benefits and the interacting technological, economical and social situations prevailing in the two sectors. It is in this context, this publication presents the status of different stocks of fishes and shellfishes exploited in the inshore waters, particularly during the monsoon season and endeavours to provide an overview of the scope of management avenues available from the biological and fisheries considerations.

References

Krishnan Kutty, M. 1985. Recent advances in oceanography and new prospectives in fisheries management. *Mahasagar*, **18** (2) : 219-229.

Legendre, L. and S. Demus 1984. Towards dynamic biological oceanography and Limnology. *Can. J. Fish. Aquat. Sci.*, **41** : 2-19.

Longhurst, Alan R. and Warren S. Wooster 1990. Abundance of oilsardine (*Sardinella longiceps*) and upwelling on the southwest coast of India. *Ibid.*, **47** : 2407-2419.

Qasim, S. Z. 1973. An appraisal of studies on maturation and spawning in marine teleosts from the Indian waters. *Indian J. Fish.*, **20** (1) : 166-181.

Subbaramayya, I. and M. Subba Rao 1985. On the vagaries of the Indian southwest monsoon. *Mahasagar*, **18** (2) : 179-185.

Troup, A. J. 1965. The Southern Oscillation. *Quart. J. Roy Meteor. Soc.*, **91** : 491-506.

Walker, G. T. 1924. Correlations in seasonal variations of weather. XI. A further study of world weather. *Mem. Indian Meteor. Dept.*, **24** : 275-332.

Walker, G. T. and E. W. Buss 1937. World Weather. *Mem. Royal Meteor. Soc.*, **4** : 119-139.

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OCEANOGRAPHY OF THE ARABIAN SEA WITH PARTICULAR REFERENCE TO THE SOUTHWEST MONSOON

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Abstract

The oceanographic conditions in the Arabian Sea during the southwest monsoon is discussed. The main features occurring during this monsoon period in the Arabian Sea is the coastal upwelling along the southwest coast of India, the intensity of which is highest in the region Cochin to Mangalore. The currents along the coast during this season is southward. This also the season when mud-banks are formed at certain places along the coast. The effect of upwelling on primary and secondary production is also discussed.

Introduction

The oceanographic features show maximum changes in their characteristics during the southwest monsoon season mostly in the Arabian Sea than in the Bay of Bengal. These features and their impact on the ecosystem is considered in this paper.

Water Movements and Circulation

Along the west coast of India from Ratnagiri to Kanyakumari, during the southwest monsoon, a strong southward drift (especially in the region Calicut-Karwar) is prominent in the upper layers (Ramamirtham and Rao, 1974). A northward counter flow exists around the lower boundary of the thermocline, the flow being comparatively weaker and discontinuous.

In the region off Cochin, vertical turbulence has been found during the monsoon and early monsoon (Ramamirtham and Jayaraman, 1961). In the northern regions of Maharashtra and Gujarat during the middle of June predominance of eddies is noticed. Two distinct zones of salinity with zonal boundary off Bombay presenting higher values in regions north of this boundary are noticed. Dissolved oxygen values are higher in the region north of this boundary with values 7 ml/l and more off Jamnagar (Bapat *et al.*, 1982).

Upwelling

In the region between Kanyakumari and Karwar upwelling is noticed with the onset of southwest monsoon with the temperature discontinuity layer at a shallower level of 20 m (Rao and Ramamirtham, 1976). During July and August, the surface mixed layer becomes more or less obliterated with temperature maximum declining to 26.5°C and the oxygen deficit layer migrating even upto the surface (Fig. 1), indicating the existence of the coastal upwelling. The maximum intensity of the upwelling is in the Calicut-Karwar region (Rama Sastry and Myrland, 1959; Rao and Ramamirtham, 1976; Ramamirtham and Rao, 1974). This feature extends throughout the region from Kanyakumari to Karwar though the intensity is very less in the region south of Quilon. It is also noticed that upwelling starts in the southern region first and then extends northwards with the progress of the southwest monsoon season. The nature of the coastline towards southeast helps this trend (Ramamirtham and Rao, 1974). The coastal southward drift, the prevailing winds and the subsequent divergence in the Arabian Sea are the causes of this upwelling.

The depth of the thermocline along the west coast does not exceed 150 m in any month of the year and it is deepest in the months of January - February and shallowest during the peak monsoon, indicating upwelling upto August after which the thermocline tilts downward indicating sinking, the intensity of which is more during November and December (Sharma, 1968).

The Ekmann transport inferred from the wind-induced currents for the seas around India indicated the possibility of upwelling along the west coast of India, as well as in the southeastern

and central area off the east coast of India during the summer transition and southwest monsoon periods (Murty, 1981).

Dissolved Oxygen and Nutrients

During upwelling which starts with the onset of southwest monsoon waters colder than 26°C is found below 5 m in the coastal regions between Cochin to Karwar where the intensity of upwelling is highest. The thermocline (temperature discontinuity layer) is brought to the upper layers especially along the continental shelf. The dissolved oxygen lower than 2.5 ml/l is found in the surface layers below 10 m; and the oxygen discontinuity layer is also brought to the surface. The dissolved oxygen minimum layer with 0.5 ml/l starts from 50-75 m depth downwards during this season along the coast due to upwelling.

A general increase in phosphate and silicate contents of the waters has been observed in the region from Kanyakumari to Cochin during the southwest monsoon period when upwelling is prevalent. An increasing trend in the nutrient content of the waters is observed from south to north in this region. The Cochin region shows higher values than the region south of Quilon which may be due to the higher intensity of upwelling off Cochin compared to the southern region. Uniformly higher reactive phosphate values have been noticed at the bottom over the shelf region. The vertical distribution of phosphate shows an increase in phosphate content with depth

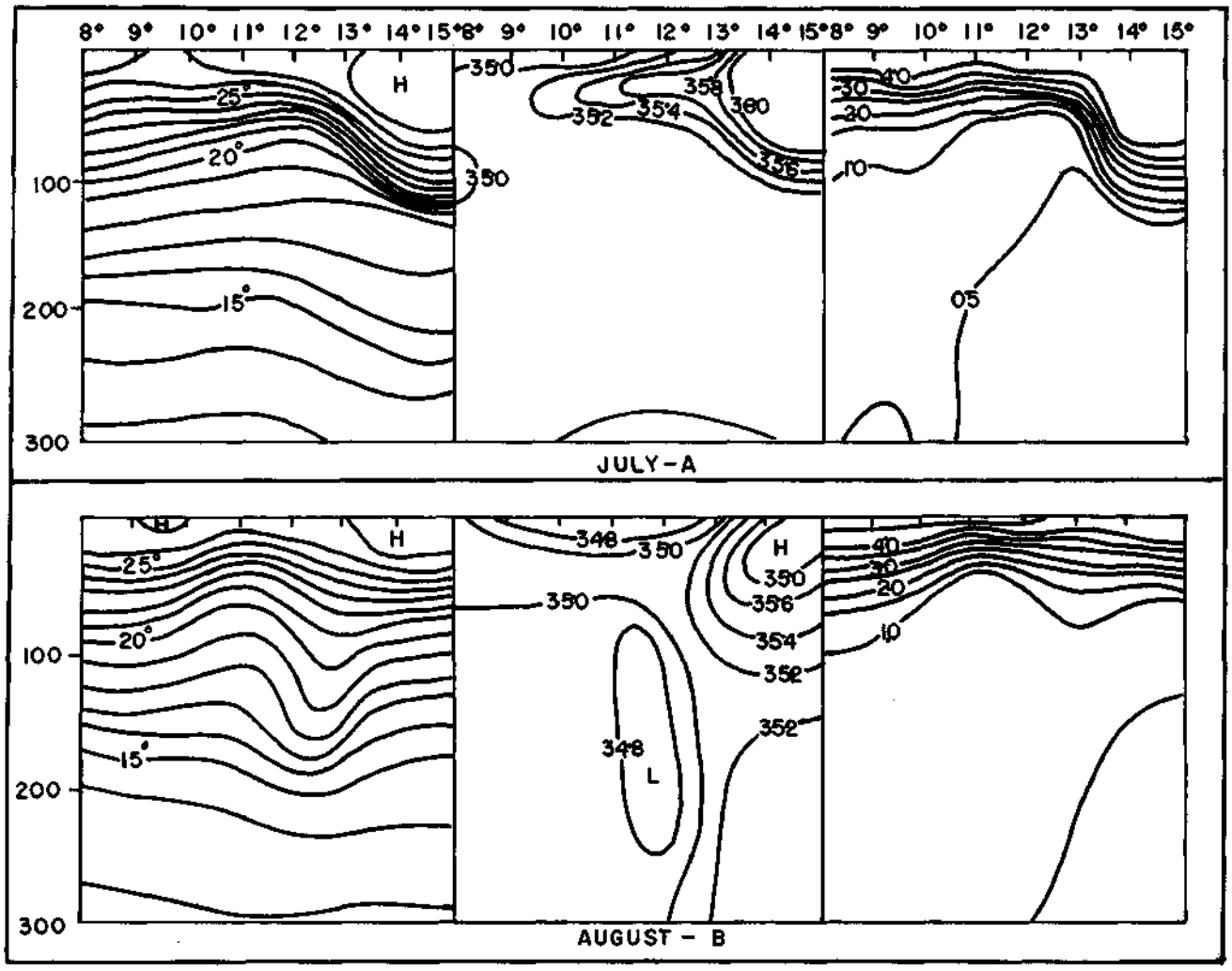

Fig. 1. Distribution of temperature (°C), salinity (‰) and dissolved oxygen (ml/l) in the meridional section during July and August (After Rao and Ramamirtham, 1976).

thus showing an inverse relationship with dissolved oxygen which decreases with increase of depth. The vertical distribution also shows an abrupt increase in the phosphate values within the thermocline layer (Rao, MS).

In the region off Cochin it is found that actual period of commencement of monsoon disturbances in the Arabian Sea could be assessed with an approximation of less than 10 days. The year 1985 noticed intermittence and failure in the southwest monsoon winds and rainfall from June to September. The monsoon characteristics and upwelling which are seen during June - July are found to disappear due to the failure of the southwest monsoon during the middle of August. This starts again with the revival of monsoon by early September. This type of intermittent upwelling following intermittency of occurrence of the SW monsoon was noticed in the year 1985 during the period June to September. The SW monsoon season also extended upto September during this year where as during the other years it was over by August. This type of intermittent upwelling affects the fishery of the region adversely (Ramamirtham, per. comm.).

Mud-Banks

Southwest monsoon season is the period when mud-banks are formed at some places along the southwest coast of India especially the Kerala Coast. This is a unique feature observed only in this region and has not been reported so far from any other place in the world. The source of mud for the Alleppey Mud-bank is the subterranean mud and the Vembanad Lake system provides the mud for this mud-bank (Rao *et al.*, 1980; Mathew *et al.*, 1981; Gopinathan *et al.*, 1984). "Mud-cones" or "Mud volcanoes" erupt in the weakest areas of the shore and in the intertidal zone. The eruption of these mud-cones does not occur every year, but during the year of occurrence of the mud-cones, it is found that the mud-bank remains over a period of 2-3 months from June to August whereas during the other years when no mud-cones occur the mud bank is present only for a short period of 2 to 3 weeks or even less. In the latter case the source of mud is the old mud brought to the region by the mud-cones erupted in any of the earlier years. The source of mud for the mud-bank between Parapanangadi and Tanur is the aggregation of coastal mud. The mud-banks at Chellanam-Manassery (Cochin Bar-mouth), Narakkal (Azhikode Bar-mouth), Valappad-Nattika (Chetwai River mouth), Elathur (Korapuzha River mouth), Quilandy (Kuttiyadi River mouth), Muzhippilangadi (Dharmadam River mouth), Kottikulam, Ajanur-N-Bella, Adakathubail (Chandragiri River mouth), Kumbala (Kumbala River mouth), Uppala (Uppala River mouth) and at Ullal (Netravati River mouth) are formed by the sediments and organic debris discharged from rivers and estuaries. Mud-bank at Vypeen (Cochin) is formed by the accumulation of mud resulting from dredging operation.

Mud-banks are maintained by the southwest monsoon with its westerly winds having more northerly components which cause the monsoon swells in the inshore region which along with the waves produce a constant thrust thereby preventing the mud from spreading into the sea. The monsoon swell also provides a continuous source of energy to keep the mud in suspension. The mud-banks formed on the southern side of the river/bar mouths remain only for a few days and then disappear.

The dissipation of the Alleppey Mud-bank takes place when the onshore thrust from the sea and from the backwater becomes reduced due to decline in the intensity of the monsoon. With this the heavy swells and waves which maintain the mud in suspension also declines in intensity and the southerly start reversing along the coast. The continued effect of the decline in shoreward winds, waves, swells and setting in of the northerly and onshore components of current help in the dissipation of loose mud in suspension and also in the settling down of the mud (Rao *et al.*, 1984; Mathew *et al.*, 1984).

The temperature and salinity in the mud-bank region are lowest compared to other seasons. The dissolved oxygen are lower during the monsoon season, lowest during the postmonsoon and highest during summer in the region of mud-bank. The reactive phosphate, silicate, nitrate and nitrite contents of the waters are highest in the region during the monsoon. These cooler waters being rich in nutrient content and low in salinity seem to favour primary production (Rao *et al.*, 1984). Primary production, surprisingly, is high only before and not during or after the formation of the mud bank. This is due to the turbidity of water in the region during the mud-bank season. Blooming

of *Noctiluca millaris* was observed at the time of dissipation of the mud-bank (Nair *et al.*, 1984).

The common belief that the mud-bank and fishery are interdependent, has been found to be incorrect. It is observed that when the fishing is almost suspended all along the coast, the mud-banks due to calmness in their environs provide ideal facilities for the fishermen to launch their craft. Direct observations have confirmed that bulk of the fish catch landed at the mud-bank area is from areas far away from the limits of the mud-bank. Taking advantage of the calm water, fishing units go in all directions in search of fish shoals. However, there have been occasions when good catches have also been obtained from within as well as outside the mud-bank areas. During this season a changing pattern of the fishery is seen (Regunathan *et al.*, 1984).

Phytoplankton in Relation to Upwelling

Upwelling along the southwest coast of India during the southwest monsoon has considerable influence on the coastal productivity. Along the west coast, maximum production of phytoplankton takes place during the southwest monsoon months after which there is a decline in the crop. The magnitude of the southwest monsoon bloom in the west coast waters is of a very high order surpassing those known from some of the most fertile waters of the world. Investigations on salinity, temperature and nutrients have shown that optimum conditions are obtained during southwest monsoon months, when the salinity of water falls from 35‰ or more to 30 - 31‰, the temperature decreases from 31-32°C to 23-25°C in the upper layers and the nutrients such as phosphate, nitrate and silicate become abundant due to upwelling and river discharges. These are the important factors for a high production of phytoplankton (Subrahmanyan, 1967).

Higher concentration of nutrients have been observed in the open part of the Arabian Sea at or near the base of the photic zone, especially at regions of upwelling with high production rate being recorded in the euphotic zone (Prasad, 1967).

Secondary Production in Relation to Upwelling

The productive value of upwelling is found to be reflected in the abundance of the total zooplankton biomass. Temporal and spatial lag of occurrence of zooplankton with respect to upwelling is noticed. Upwelling and plankton production are earlier in the southern regions of the coastline along the west coast then in the northern one (Murty, MS). Correlation of oceanographic features with zooplankton biomass and abundance of fish eggs and larvae (David Raj and Ramamirtham, 1981) shows that the continental shelf region along the southwest coast is markedly richer than the offshore regions as far as plankton biomass is concerned. The peak of plankton biomass is observed during peak southwest monsoon and postmonsoon periods, that is during and after upwelling, while the abundance of fish eggs and larvae shows a different trend with peak during premonsoon months.

The intensity of southwest monsoon plays a role in the long term fluctuations of the Indian oilsardine fishery, the higher intensity being favorable for the fishery. There is a critical intensity of monsoon turning in favour of the pelagic fishery (Murty and Edelman, 1971).

References

Bapat, S. V., V. M. Deshmukh. B. Krishnamoorthi, C. Muthiah, P. V. Kagwade, C. P. Ramamirtham, K. J. Mathew, S. Krishna Pillai and C. Mukundan 1982. Fishery resources of the Exclusive Economic Zone of the northwest coast of India. *Bull. Cent. Mar. Fish. Res. Inst.*, 33 : 1-86.

David Raj, I. and C. P. Ramamirtham 1981. Distribution of zooplankton biomass, fish eggs and larvae along the west coast of India. *J. mar. biol. Ass. India*, 23 (1 & 2) : 86-140.

Gopinathan, C. P., A. Regunathan, D. S. Rao, K. J. Mathew and A. V. S. Murty 1984. Source of mud of Alleppey Mud-bank : mud-cone and the message it conveys. *Bull. Cent. Mar, Fish. Res. Inst.*, 31 : 18-20.

Mathew, K. J., C. P. Gopinathan, A. Regunathan, D. S. Rao and A. V. S. Murty 1981. Mud-banks and the coastal ecosystem. *Proc. Seminar on status of Environmental studies in India*, pp. 243-254.

A. Regunathan, C. P. Gopinathan, D. S. Rao and A. V. S. Murty 1984. Ecology of Mud-Banks : the current system. *Bull. Cent. Mar. Fish. Res. Inst.*, 31 : 60-71.

Murty, A. V. S. 1981. Observations of coastal water upwelling around India. *In*: J. Light hill and R. P. Pearce (Ed.) *Monsoon Dynamics*. Cambridge University Press, pp. 735.

—— and M. S. Edelman 1971. On the relation between the intensity of the southwest monsoon and the oilsardine

fishery of India. *Indian J. Fish.*, 13 (1 & 2) (1966) : 142-149.

—— (MS). The characteristic features of neritic waters along the west coast of India, with respect to upwelling, dissolved oxygen and zooplankton biomass. *Indian J. Mar. Sci.*

NAIR, P. V. R., C. P. GOPINATHAN, V. K. BALACHANDRAN, K. J. MATHEW, A. REGUNATHAN, D. SADANANDA RAO AND A. V. S. MURTY 1984. Ecology of mud banks - Phytoplankton productivity in Alleppey Mud Bank. *Bull. Cent. Mar. Fish. Res. Inst.*, 31 : 28-34.

PRASAD, R. R. 1967. Organic production in Indian waters. *Souvenir, 20th Anniversary, CMFRI*, pp. 22-24.

RAMAMIRTHAM, C. P. AND R. JAYARAMAN 1961. Hydrographical features of the continental shelf waters off Cochin during the years 1958 and 1959. *J. mar. biol. Ass. India*, 2 (2) : 208-225.

—— AND D. S. RAO 1974. On upwelling along the west coast of India. *Ibid.*, 15 (1) (1973) : 306-317.

RAMA SASTRY AND P. MYRLAND 1959. Distribution of temperature, salinity and density in the Arabian Sea along the South Malabar Coast (South India) during the postmonsoon season. *Indian J. Fish.*, 6 (2) : 223-255.

RAO, D. SADANANDA AND C. P. RAMAMIRTHAM 1976. Seasonal variations in the hydrographical features along the west coast of India. *Ibid.*, 21 (2) (1974) : 514-524.

——, K. J. MATHEW, C. P. GOPINATHAN, A. REGUNATHAN AND A. V. S. MURTY 1980. Mud banks and coastal erosion in relation to fisheries. *Mar. Fish. Infor. Serv. T & E Ser.*, 19 : 1-10.

——, A. REGUNATHAN, K. J. MATHEW, C. P. GOPINATHAN AND A. V. S. MURTY 1984. Mud of the mud-banks : its distribution, physical and chemical characteristics. *Bull. Cent. Mar. Fish. Res. Inst.*, 31 : 21-24.

REGUNATHAN, A., K. J. MATHEW, D. SADANANDA RAO, C. P. GOPINATHAN, N. SURENDRANATHA KURUP AND A. V. S. MURTY 1984. Fish and fisheries of the mud banks. *Ibid.*, 31 : 60-71.

SHARMA, G. S. 1968. Thermocline as an indicator of upwelling. *J. mar. biol. Ass. India*, 8 (1) (1966) : 8-19.

SUBRAHMANYAN, R. 1967. Phytoplankton. *Souvenir, 20th Anniversary* CMFRI, pp. 89-93.

Bull. Cent. Mar. Fish. Res. Inst., 1992, 45 : 9 - 37

PRODUCTIVITY OF THE ARABIAN SEA ALONG THE SOUTHWEST COAST OF INDIA

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ABSTRACT

Monsoon plays a critical role in triggering environmental features such as seawater temperature, salinity, dissolved oxygen content and nutrient generation which in turn become responsible for production of phytoplankton and zooplankton. Along the southwest coast of India the intensity of southwest monsoon as evidenced by annual rainfall showed a declining trend during the years 1983 to 1988. An attempt is made here to correlate certain environmental features with the abundance and fluctuations in phytoplankton and zooplankton in the inshore waters off Cochin, Vizhinjam and Minicoy.

At Cochin, the annual total rainfall for the years 1986 to 1988 were respectively 2495, 2410 and 2895 mm as against expected rainfall of around 323 cm per annum. During the monsoon months the rainfall was 1295, 1490 and 1665 mm respectively. Generally, June received the maximum rainfall. At Vizhinjam the rainfall did not show any definite pattern. During 1984-85 the premonsoon period and during 1987-88 the postmonsoon period recorded more rainfall of about 490 mm.

At Cochin, the levels of gross primary production showed increase from 0.830 to 1.624 g C/m³/day corresponding with increasing rainfall during April to June 1986. Again in 1987 similar increase of production from 0.597 to 0.975 g C/m³/day was observed to coincide with increasing monthly rainfall from May to June and in August.

However, Chlorophyll *a* concentration in surface waters showed a decreasing trend during premonsoon, monsoon and postmonsoon months. This has been attributed to physiological state and productive potential of phytoplankters during the sampling period. The studies also revealed that productivity of 10 m station was around 50% of the productivity in the 20 m depth zone. Gross primary production also showed positive correlation with abundance of nutrients such as phosphates and nitrates in inshore waters which in turn is attributed to coastal upwelling.

The annual net primary production in the euphotic waters off Cochin was estimated as 731.43 tonnes Carbon/km² indicating high productivity.

Zooplankton biomass indicated higher volumes during monsoon months as also most of the constituent groups. Peaks of secondary production were observed in September of 1984 and 1986. While primary peaks of biomass abundance coincided with copepod maximum in July '85, '86 and August '88, the abundance of other groups contributed to the peak in July '84 and August '87 including blooms of *Fragilaria oceanica* or swarms of cladocerans or salps. The fluctuation in the abundance of various groups are discussed in detail. In terms of Carbon, the mean production in the area was worked out as 6.652 t C/km²/year.

The average displacement volumes at Vizhinjam recorded higher values during postmonsoon season and low values during premonsoon period. High salinity was observed to be a characteristic of premonsoon period. Within the overall range in salinity values, peaks of different plankton groups coincided with higher values of salinity. It was observed that landings of pelagic fishes were maximum during monsoon months, followed by postmonsoon months.

In the Lakshadweep, zooplankton was observed to be maximum during premonsoon period and lower in other months. Zooplankton volumes were higher in the open sea than in the lagoons.

INTRODUCTION

It is well known that the production of phyto and zooplankton in the sea has a great bearing on the fish yield. Environmental features such as monsoon, upwelling, temperature, salinity and dissolved oxygen and nutrients play vital role in this production, initially at the primary and subsequently at the secondary and tertiary levels. Among these, southwest monsoon in India is of critical importance in the production of phyto and zooplankton especially in the inshore upwelling areas. It has been known that an intense monsoon triggers of strong upwelling along the southwest

coast of India. The studies carried out by Subrahmanyan (1959), Qasim and Reddy (1967), Nair *et al.* (1968), Radhakrishna (1969), Subrahmanyan *et al.* (1975) have revealed that the phytoplankton production is at its peak during the southwest monsoon (June-September) all along the west coast. According to Silas (1972), the peak in the zooplankton production in the shelf area of the west coast of India occurs during June-October period. The later studies (Anon., 1976; Devidas Menon and George, 1977) have confirmed these findings. Mathew *et al.* (1989) have extended the period of high abundance for zooplankton in the the shelf waters upto December.

Since 1983, the southwest monsoon has been a failure along the west coast. The year 1987-88 was specially considered as a period of weak monsoon. Consequently there has been marked decrease in the catch of pelagic fish especially the oilsardine. In this situation, an understanding of the effect of monsoon on the fish production along the west coast has become an essential prerequisite. For this purpose a comparative study of the various environmental and productivity parameters in the inshore areas at selected centres *viz.* Cochin, Vizhinjam and Lakshadweep has been made and the present paper embodies the results of these studies.

Data Base

The area of study at Cochin, extends between Chellanam and Munambam, covering a coastline of 47 km and a shelf area of 1,175 km^2.

R. V. Cadalmin I & IX were engaged in the fortnightly collection of data from 10 m, 20 m and 30 m depth stations. The data included in the present paper pertain to chlorophyll *a* from the postmonsoon of 1986 to monsoon season of 1988 and gross and net primary productivity and rainfall for 1986-'88. Seasonwise nutrient data on dissolved phosphates, nitrates and silicates from the three stations for 1987 only have been used. The data obtained were pooled to get the monthly and seasonal averages.

The period of investigation was divided into three seasons *viz.*, premonsoon (February-May), monsoon (June-August) and postmonsoon (September-January). Chlorophyll *a* concentration was determined by Lorenzen's method (1967) using Spectrophotometer (ECIL: G. S. 8650); primary productivity experiments were conducted under simulated *in situ* condition for three hours by light and dark bottle - oxygen method and the values obtained were extrapolated for the day hours in which photosynthetic quotient was taken as 1.25 (Nair, 1970); primary production for the water column was estimated by the formula given by Steemann Nielsen and Aabye Jensen (1957). Monthly rainfall data for Cochin region were obtained from the 'Daily Weather Chart' of IMD; dissolved phosphate-P, nitrate-N and silicate-Si were estimated adopting the methods given by Strickland and Parsons (1968). The mean surface and column production values for 1986-88 were used to assess the productive potential of the region.

Zooplankton samples were collected at fortnightly intervals from two depth zones *viz.*, 15 m and 30 m in the fishing grounds off Cochin during July 1984 to August 1988. The net used for the collection of samples was a Bongo-20 net having a ring diameter of 20 cm each and fitted with a calibrated flowmeter. The twin cones of the net were made of nylon material of 0.5 mm square mesh. The sampling was made by oblique hauls from bottom to surface at an average speed of 2 knots. The samples were preserved in 5% formalin.

Biomass was determined as the mean wet displacement volume of the samples from the two cones. The plankton biomass in ml per 100 m^3 of water filtered was computed based on flowmeter readings. Similarly the mean number on different groups per 100 m^3 was also computed. Though samples were collected from two different depth zones, for the purpose of this study the region upto the 30 m depth zone off Cochin is treated as one.

Cushing's (1973) method was followed for calculating the biomass of the plankton for the different seasons based on the copepod generation time computed from the seasonal mean temperature and the secondary production was determined by adopting the formula 1 ml = 0.065 gC. The secondary production was thus estimated in terms of tonnes of carbon in an area of 1,175 km^2.

At Vizhinjam the rate of primary production was estimated by the light and dark bottle technique following Strickland and Parsons (1968). Fortnightly observations were made from two

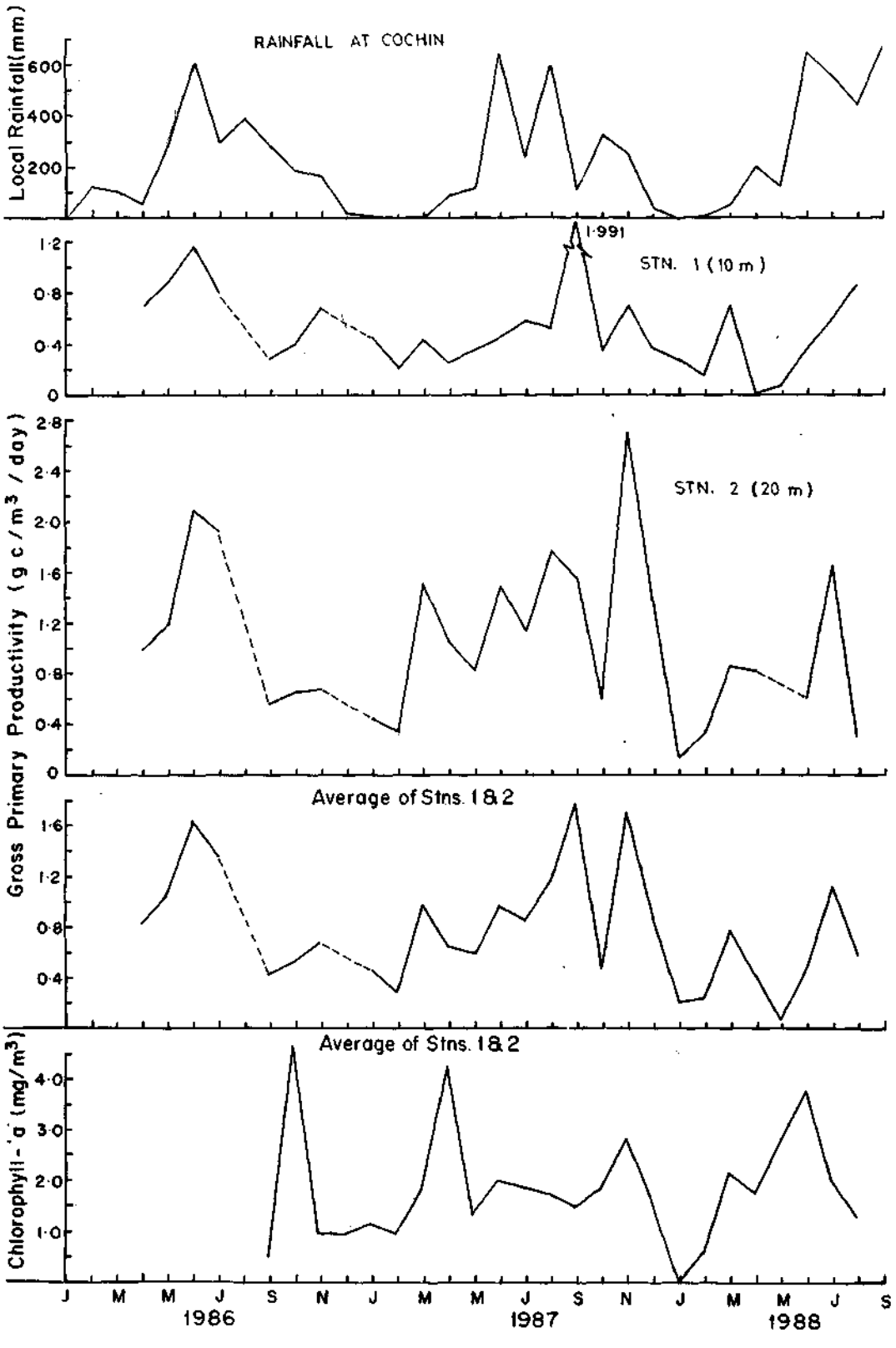

Fig. 1. Monthly trend of rainfall, gross primary productivity and chlorophyll *'a'* concentration at Cochin.

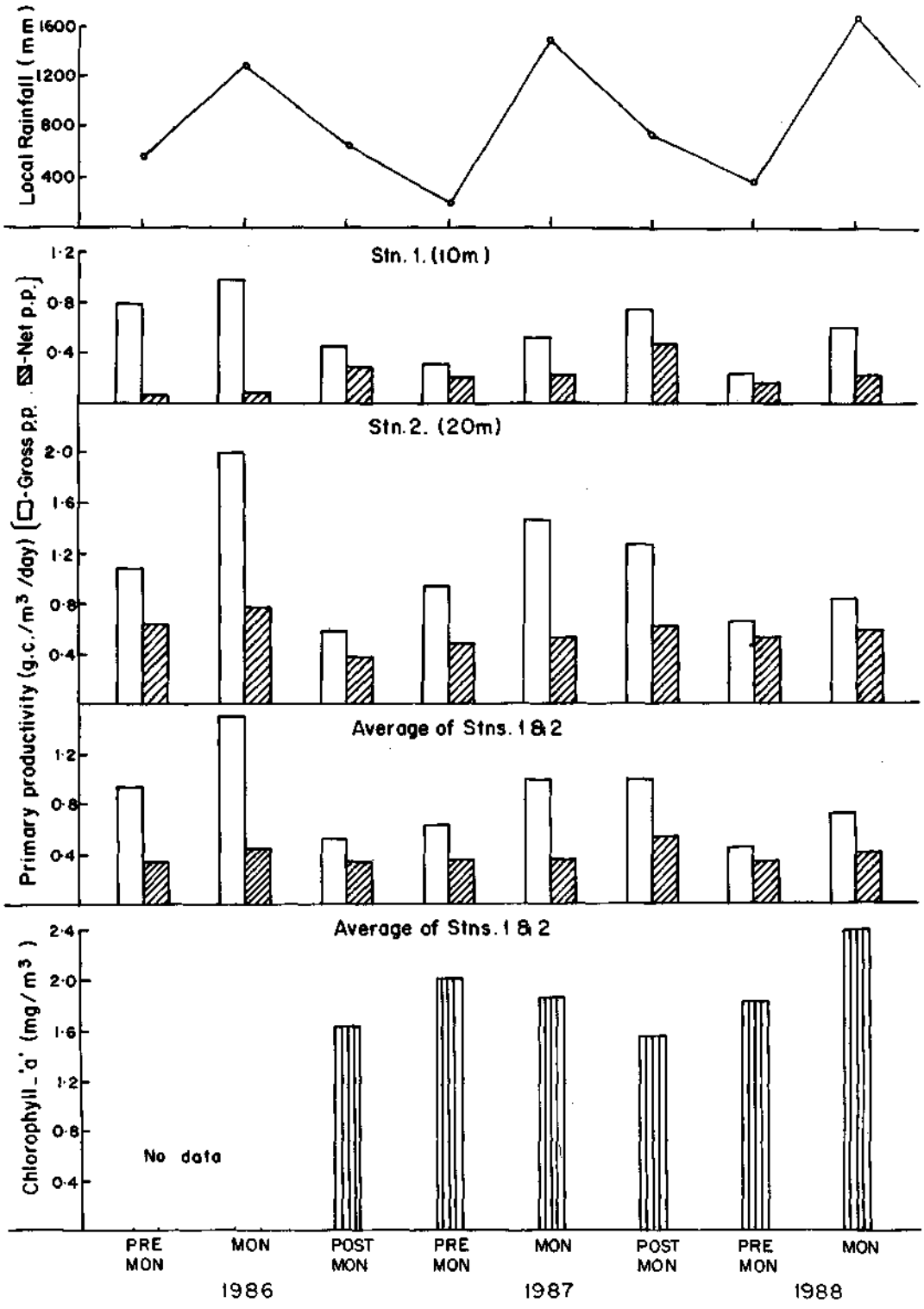

Fig. 2. Seasonal trend of rainfall, gross and net primary productivity and chlorophyll *'a'* concentration at Cochin.

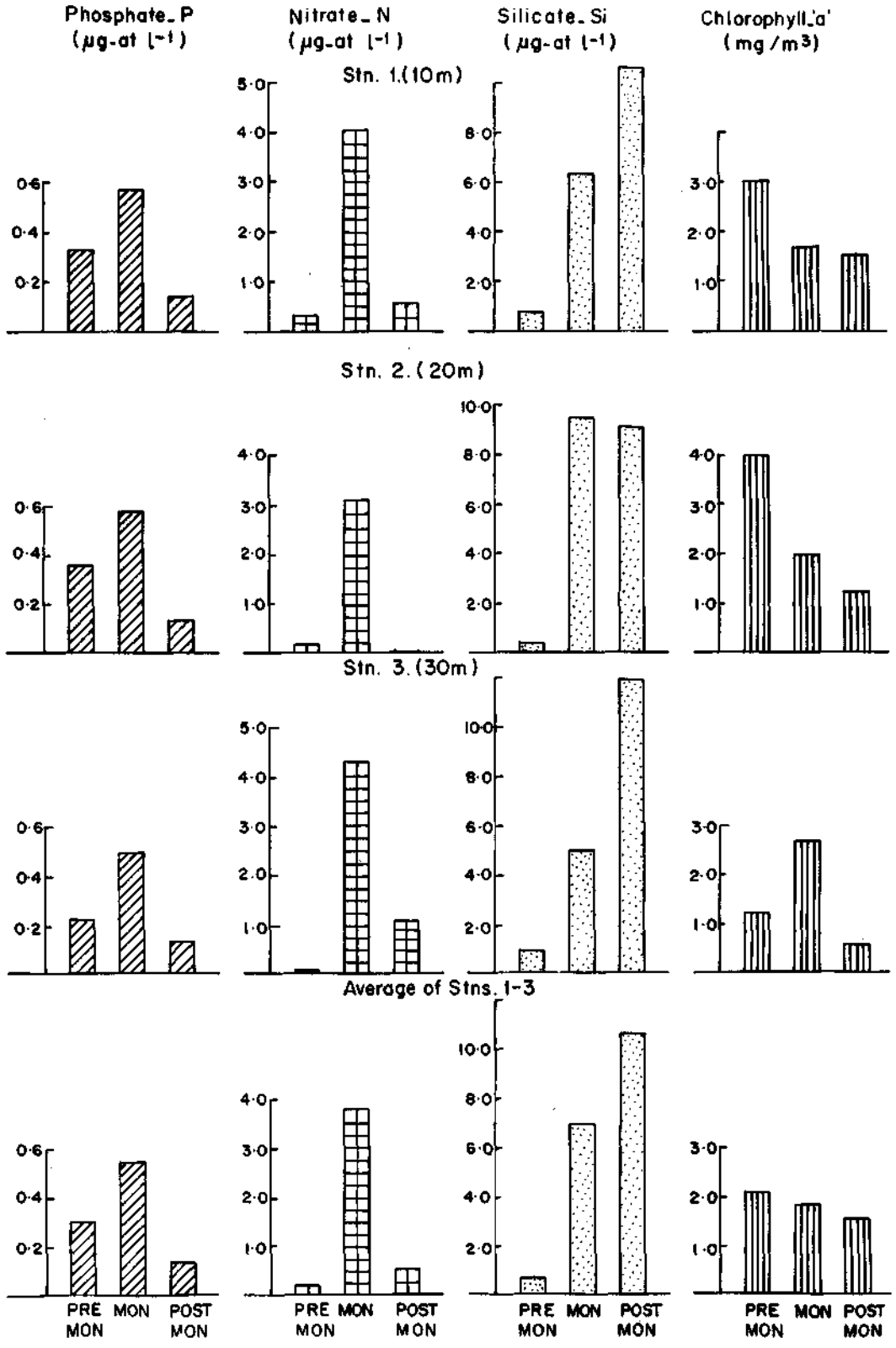

Fig. 3. Seasonwise distribution of phosphates, nitrates, silicates and chlorophyll 'a' in the surface waters off Cochin during 1987.

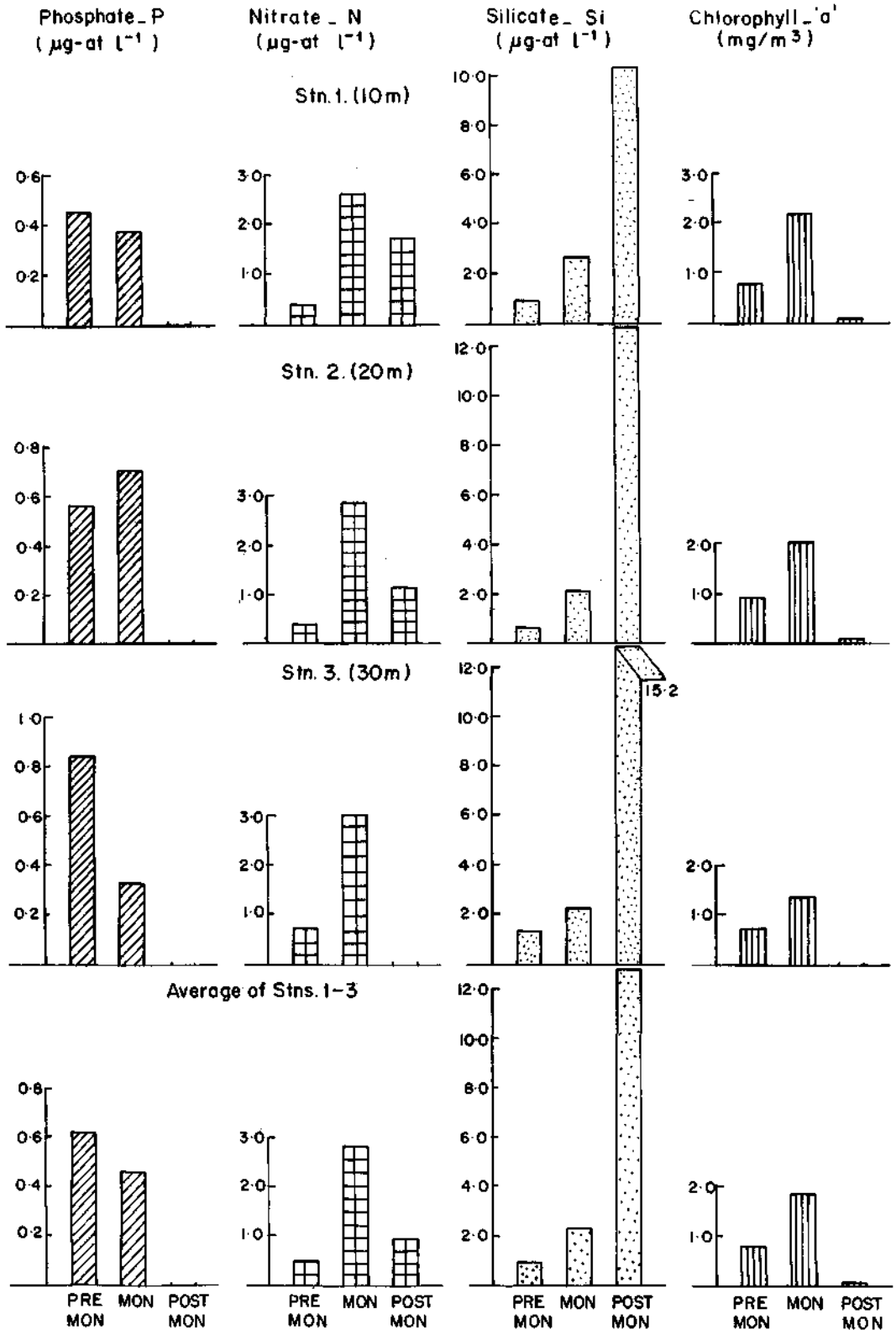

Fig. 4. Seasonwise distribution of phosphates, nitrates, silicates and cholophyll *'a'* in the bottom wates off Cochin during 1987.

stations at 15 m and 30 m depth points from February 1984 to January 1986. The values were averaged to represent seasons such as premonsoon, monsoon and postmonsoon. The relevant hydrographic parameters were also studied.

TABLE 1. *Yearwise and seasonwise fluctuations in rainfall (in mm) at Vizhinjam*

Season	1984-85	'85-86	'86-87	'87-88	Average
Premonsoon	729.9 (48.8)*	364.5 (26.0)	366.3 (29.7)	320.6 (16.0)	445.3 (29.0)
Monsoon	352.6 (23.6)	568.6 (40.4)	460.7 (37.3)	578.4 (28.8)	490.0 (31.9)
Postmonsoon	411.5 (27.6)	471.6 (33.6)	407.0 (33.0)	1109.2 (55.2)	599.8 (39.1)

* Percentages are given in parenthese

The zooplankton samples at this centre were collected fortnightly during 1984 to 1988 from one station at 30 m depth using a 50 cm mouth diameter conical net of 0.4 mm mesh size towed from a catamaran. The zooplankton was estimated for 100 m^3 of water. The hydrographic data were obtained by analysis of the water following standard methods.

Fortnightly sampling for zooplankton was carried out at Lakshadweep from two stations in the lagoon from November 1985 to August 1988. At Station 1 the samples were collected from the surface only in all the seasons while at Station 2 the samples were collected from surface and 5 m depth for the premonsoon and postmonsoon only. The zooplankton was collected by surface hauls for a duration of 10 minutes using a half metre mouth diameter conical net of 0.4 mm mesh size. The samples for hydrography were analyzed following standard methods.

RESULTS

The environment

Cochin

Rainfall : During 1986, Cochin had a wide-spread monsoon rainfall from May to September with its peak during June (610 mm) while 1987 data showed peaks in June (650 mm) and August (603 mm) with an intermittent break in July (237 mm). In 1988, monsoon extended upto September with peaks in June (654 mm) and September (674 mm). In general, December-February recorded very low rainfall (35 mm) during 1986-88 (Fig. 1) with an exception in February 1986 (118 mm).

The rainfall data showed a progressive increase from year to year recording 1295, 1490 and 1665 mm during the monsoon season, 633, 725 and 855 mm in the postmonsoon season in 1986, 1987 and 1988 respectively Fig. 2). The rainfall of postmonsoon season constituted about 50% of monsoon rainfall. The rainfall during premonsoon season was maximum in 1986 (567 mm) and minimum in 1987 (195 mm). Overall seasonal average rainfall for premonsoon, monsoon and postmonsoon during 1986-88 were 379, 1483 and 738 mm respectively, constituting an annual average rainfall of 2600 mm, while the annual rainfall values (aggregate of three seasons) for 1986, 1987 and 1988 were 2495, 2410 and 2895 mm respectively.

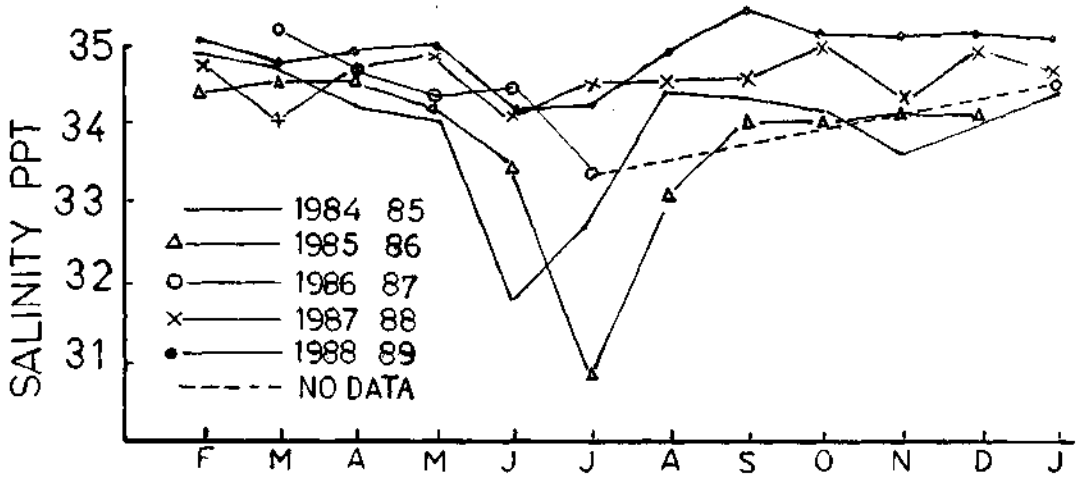

Fig. 5. Montly mean values for salinity during 1984-85 to 1988-89.

Dissolved nutrients : Seasonal averages of phosphate, nitrate and silicate concentrations for the surface and bottom waters at the three depth stations are shown in Fig. 3 & 4. The mean phosphate concentration was maximum in the bottom waters (0.62 µg at/l) during premonsoon and at surface (0.55 µg at/l) during monsoon; while the minimum values were recorded in surface and bottom waters during postmonsoon season.

In the case of nitrates, the mean values were higher in surface during monsoon (3.82 µg at/l) than at the bottom. During pre and postmonsoon seasons the mean values were relatively higher at the bottom. In general, low values were recorded at surface and bottom waters during the premonsoon, high values during the monsoon and medium values during the postmonsoon period.

In the case of silicates, the values were minimum at surface and bottom during premonsoon, medium at monsoon with surface values higher than bottom and higher during postmonsoon season in surface (10.6 µg at/l) and bottom waters (12.8 µg at/l).

Vizhinjam

Rainfall : The data obtained from the Meteorological Station indicate that the rainfall is rather protracted around Trivandrum and is influenced by both southwest (June - Aug.) and northeast (Nov. - Dec.) monsoons. The rainfall recorded during the southwest monsoon is considerably higher than that in the northeast monsoon. An examination of rainfall data for the various seasons (pre, post and monsoon) of 4 years (1984-85; '85- 86; '86-87 and '87-88), reveals that the rainfall never follows any set pattern (Table 1). The monsoon season of 1985-'86 and 1986-87 received maximum rain than in the other years. But in 1984-85 and 1987-88 the highest rainfall was recorded during premonsoon and postmonsoon periods respectively. While comparing the premonsoon period of various years it becomes evident that the rainfall was quite below the average during 1985-86 and 1987- 88. A similar deviation from the average rainfall could be noted during the monsoon period of 1984-85 and 1986-87 also. Postmonsoon figures of rainfall indicate an excess only in 1987-88 period while the same for other years were below average.

Salinity : Monthly mean values of salinity are given in Fig. 5. The monsoon dip in salinity was quite well marked during 1984-85 and 1985-86, while in other years the fluctuations were not so wide. The figures for rainfall during the monsoon period (June-Aug.) were 352.6, 568.6, 460.7 and 578.4 mm respectively (Table 1) for the years 1984-85, '85-86, '86-87 and '87-88, while the pooled average for the monsoon period of the above 4 years was only 490.0 mm. This shows that though the rainfall was less than the average during 1984-85, the salinity values showed a dip in the monsoon season. But the same trend could not be noticed in 1987-88 when the rainfall was higher than the average.

After the southwest monsoon dip, the salinity increases gradually and attains a level quite similar to that of the premonsoon period in some years. But during 1984-85 and '87-88 the salinity values for postmonsoon period were less than those of the premonsoon period and this may be attributed to northeast monsoon which is prevalent during October-November period. Rainfall recorded during these two months, when pooled, was 276.9, 331.1, 310.8 and 613.5 mm respectively for 1984-85, '85-86, '86-87 and '87-88. Here also the salinity fluctuations noted during these months have no correlation with the rainfall because in 1987-88 when rainfall recorded the maximum (1109.2 mm) the salinity value was also the maximum (34.7 ppt).

TABLE 2. *Seasonwise average salinity (ppt) of surface waters at Vizhinjam during 1984-85—1988-89*

Season	1984-85	'85-86	'86-87	'87-88	'88-89	Average
Premonsoon	34.5	34.4	34.6	34.6	34.8	34.6
Monsoon	32.9	32.5	33.9	34.3	34.4	33.6
Postmonsoon	34.1	34.1	34.6	34.7	35.1	34.5

Season wise analysis of salinity for the entire period indicates that the seasonal average for premonsoon period varies from 34.4 to 34.8 ppt, for monsoon period from 32.5 to 34.4 ppt and for postmonsoon period from 34.1 to 35.1 ppt (Table 2). The average salinity values for '84-85 and '85-86 were less than those noted for the subsequent years. The magnitude of differences on a season to season basis, in the average salinity values (Table 3) showed that it was 1.6 ppt between pre and monsoon period of 1984-85, while it was only 1.2 ppt between monsoon and postmonsoon period. These differences gradually narrowed as the years advanced and in 1987-88 these were 0.3 and 0.4 ppt respectively. Although the reason for this narrow differences is not clear, it appears that the rainfall during the various seasons of the same year has no bearing on the fluctuations in salinity.

TABLE 3. *Salinity difference between seasons for the years 1984-'85 to 1988-'89 at Vizhinjam*

Difference in salinity values between	1984-85	'85-86	'86-87	'87-88	'88-98	Average
Premonsoon & Monsoon	1.6	1.9	0.7	0.3	0.4	1.0
Monsoon & Postmonsoon	1.2	1.6	0.7	0.4	0.7	0.9

Temperature: Monthly mean values of temperature for the different seasons of the various years are given in Fig. 6. The dip in temperature during monsoon was quite well pronounced in all the years of observation. In all the years, the temperature was at its highest level (28-30°C) during the premonsoon period, but it started decreasing by June at the onset of southwest monsoon. After southwest monsoon, the temperature again started showing an upward trend; but during the postmonsoon period it never attained a premonsoon level except during 1987-88. The temperature recorded during the premonsoon period was also subject to considerable variation in all the years. During premonsoon of 1987-88 it was constantly at 30°C, while in 1984-85 at 28°C and in other years there were considerable month to month variations. The temperature after the southwest monsoon period, started showing an upward trend by September in all years. The temperature then reached a higher level by October, except during 1984-85 when it was at the lowest level for the year (24.75°C). The peak in temperature for the postmonsoon period was discernible during October in two years (1985-86) and 1988-86) and then declined by the onset of northeast monsoon and finally got established at 28°C (1988-89) or at 27°C (1985-86). There was actually no decrease in temperature during northeast monsoon period of 1987-88 and it was constant at 30°C during October-December period. The postmonsoon temperature of 1984-'85 was quite low (24.75 to 25.2°C).

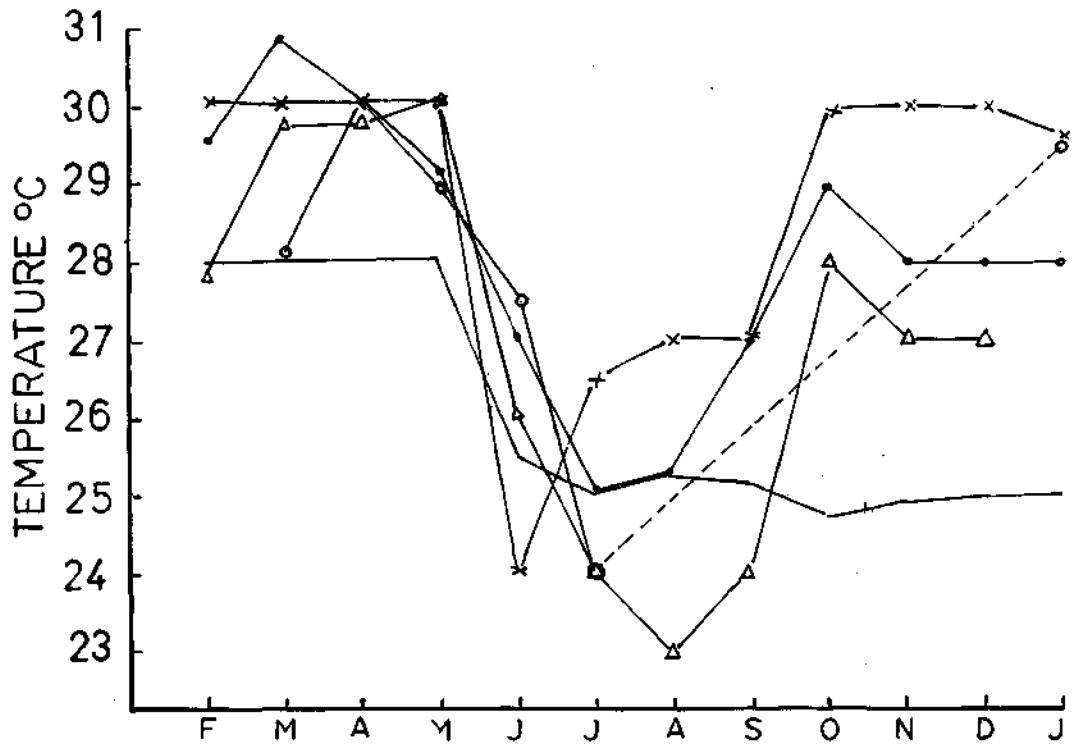

Fig. 6. Montly mean values for temperature during 1984-85 to 1988-89.

The differences in temperature between the seasons showed that during 1984-85 (2.7 and 0.3°C) it was much less than the average (4.0 and 2,2°C) and in 1987-88 they were above averages. Considering the general trend for the entire period it may be seen that the difference in temperature between the seasons increased as the years advanced. It is interesting to note in this context that in the case of salinity a reverse order of fluctuation was evident.

Dissolved oxygen : The monthly mean values for dissolved oxygen are given in Fig. 7. The highest and lowest values for dissolved oxygen vary very little. Highest values were common in premonsoon periods while the lowest, in the postmonsoon periods.The highest value, when considered monthwise, were in March (1984-85, 1986-87); February 1985-86, 1987-88) and in May/August (1988-89), while the lowest values in September (1984- 85, 1988-89); September-October (1985-86) and July (1987-88).

Lowering of dissolved oxygen content was characteristic of monsoon period of 1984-85, 1985-86 and 1987-88, but was equal to those of other seasons in 1986-87. In 1988-89, however, the value recorded was the highest when compared to the other two seasons. The differences in dissolved oxygen content were somewhat well marked as seen for monsoon and premonsoon in some years or not well pronounced as observed for monsoon and postmonsoon periods.

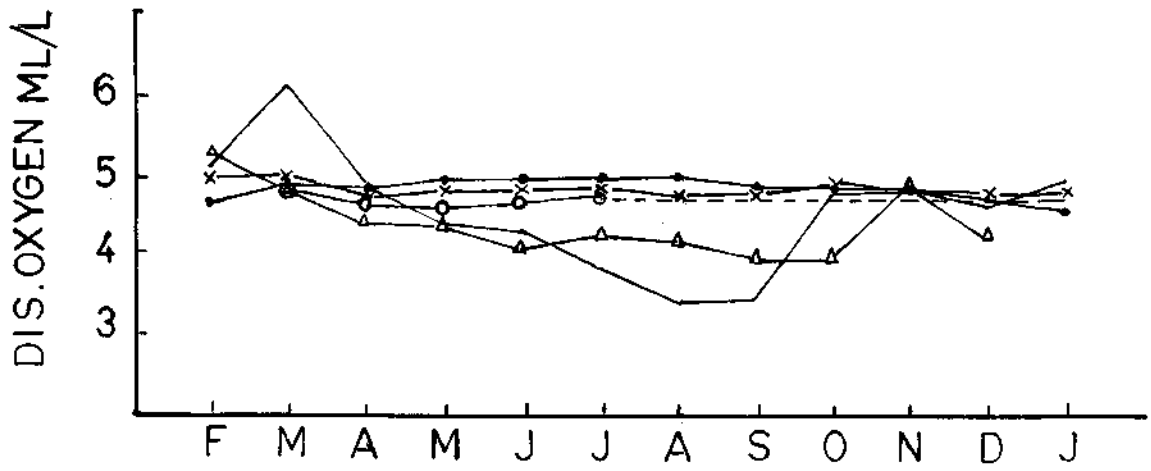

Fig. 7. Montly mean values for dissolved oxygen content for the period 1984-85 to 1988-89.

Phosphates : The earlier report (Rani Mary Jacob and Vasanthakumar, 1987) has given a range from 0.8-4. 08 µg at/1 for this area. A peak in the values for phosphate, according to the above authors, occurs during September-october.

Nitrite : The range of fluctuation in nitrite values recorded off Vizhinjam was quite narrow. The highest values were recorded during July-August (monsoon) period (Rani Mary Jacob and Vasanthakumar, 1987).

Nitrate : The values of nitrate fluctuated between 0.9 and 4.4/µg at/1 off Vizhinjam and October-November period registered the maximum value.

Lakshadweep

Temperature : Monthly mean values are plotted in Fig. 8 A & B. Lower temperature was recorded in the postmonsoon season and maximum in the premonsoon period. The trend in the variation was almost similar at both stations. Mean temperature varied from 27.3°C in November to 31.3°C in April. In general, high temperature prevailed during March-May.

Salinity : Monthly variations in salinity are presented in Fig. 8 C and D. The values showed fluctuations from 32.26‰ in June to 34.93‰ in March. In general, lower salinity was observed at Station 1. The low value obtained during June in the shallow water (Station 1) may be due to the land run off as a result of monsoon.

Dissolved oxygen : Monthly averages are presented in Fig. 8 E & F. The values ranged from 3.98ml/l in March to 4.66 ml/l in June. The fluctuation was not much at both stations. The values were generally higher in the surface water during monsoon months.

Productivity

Cochin

Chlorophyll a : Monthly mean values of chlorophyll *a* are indicated in Fig. 1. Seasonal analysis revealed that the mean chlorophyll *a* concentration was maximum (2.4 mg/m^3) during southwest monsoon

of 1988. In 1987, the seasonal mean values in surface waters were 2.093, 1.861 and 1.557 mg/m^3 during premonsoon, monsoon and postmonsoon respectively (Fig. 2 & 3), while the overall seasonal average surface values for 1986-88 were 1.963, 2.129 and 1.589 mg/m^3 during the three seasons respectively indicating highest concentration during monsoon season. The column average (1987 data) also indicated highest concentration during monsoon season.

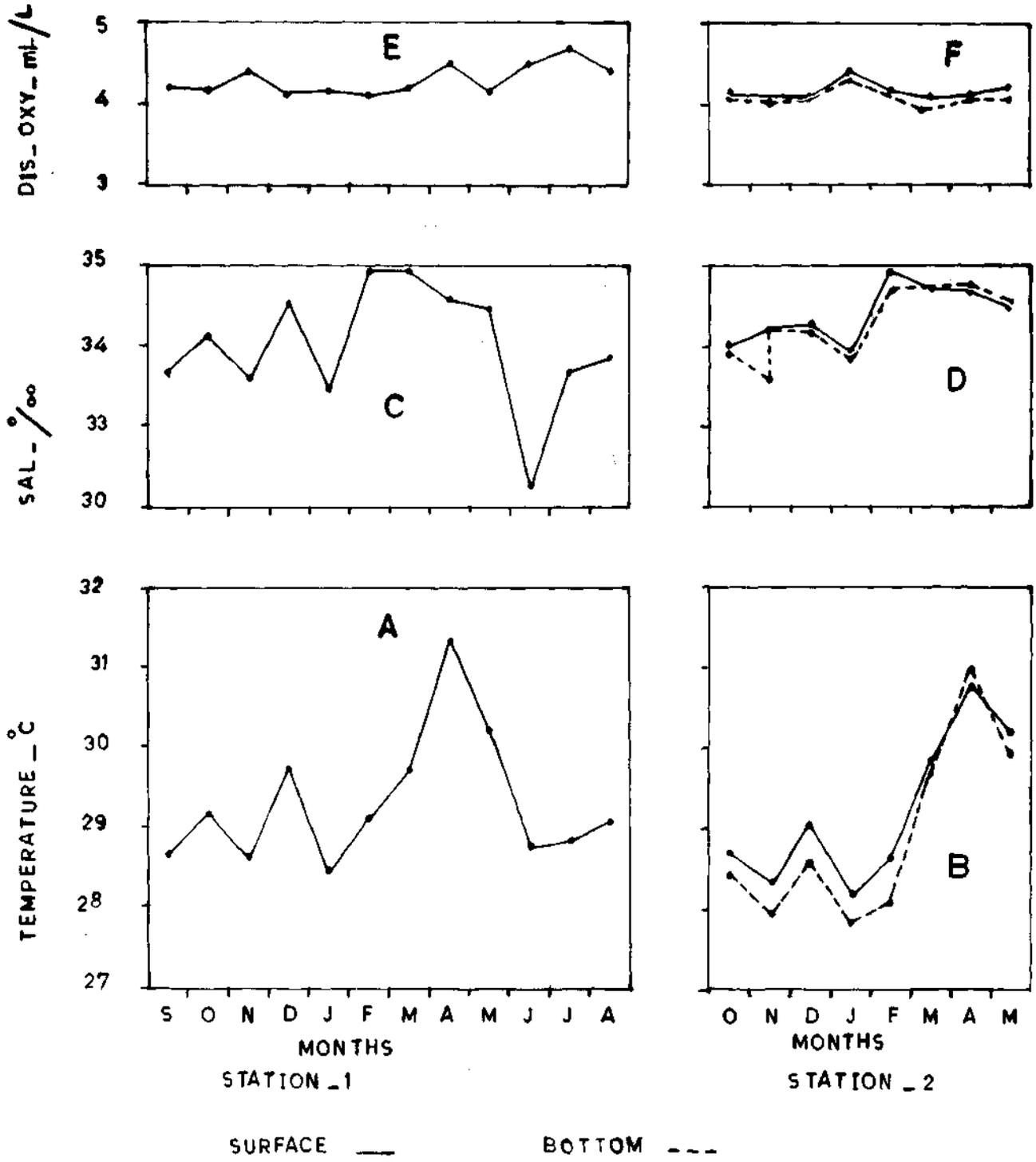

Fig. 8. Variations in temperature (A and B), salinity (C and D) and dissolved oxygen (E and F) at Lakshadweep.

Gross primary productivity : Monthly and seasonal mean values of gross productivity in surface waters upto 1 m depth are illustrated in Fig. 1 & 2 respectively. Maximum production rate of 1.991, 2.700 and 2.400 g C/m³/day were recorded at 10 m, 20 m and 30 m depth stations during September, November and October 1987 respectively (postmonsoon months); and in general, productivity was higher at 20 m depth station (Fig. 1). Seasonwise pooled data (1986-88) for premonsoon, monsoon and postmonsoon showed mean values of 0.444, 0.706 and 0.596 g C/m³/day at 10 m depth 0.899, 1.439 and 0.932 g C/m³/day at 20 m depth and an average 0.672, 1.072 and 0.764 g C/m³/day respectively in the inshore surface waters indicating peak production rate during the monsoon season (Fig. 2). The average monsoon values of 1986, 1987 and 1988 were 1.493, 0.995 and 0.729 g C/m³/day respectively indicating a decreasing trend from 1986 to 1988. The mean gross production estimates of the different seasons during 1986-88 per km² area off Cochin (K-5 zone) are given for the surface waters in Table 4.

the surface waters off Cochin, indicating highest net productivity during postmonsoon season, while the premonsoon season showed the minimum rate of net production during 1986-88 (Table 4).

The net production estimates in the column waters for the three seasons during 1986-88 per km² area are given in Table 5. On average, the net production values were 51.34, 37.78 and 57.85% in gross production during premonsoon, monsoon and postmonsoon respectively in the inshore waters, indicating very low percentage during monsoon season.

The estimated annual net production for the 1175 km² area of inshore waters (between Chellanam and Munamban) was 8,59,430 tonnes carbon. It was 2,18,902 tonnes carbon during monsoon season (92 days) constituting 25.47% of annual net production while it was 28.3% during premonsoon (120 days) and 46.23% during postmonsoon season (153 days). The monthly mean net production for the premonsoon, monsoon and postmonsoon sea-

TABLE 4. *Estimated surface primary production off Cochin (in tonnes carbon)*

	Premonsoon (120 days)	Monsoon (92 days)	Postmonsoon (153 days)	Annual (365 days)
Gross production				
Daily average production per Km² area	0.672	1.072	0.764	
Seasonal/annual prod. per Km²	80.640	98.624	116.892	296.156
Seasonal/annual prod. per 1175 Km²	94,752	1,15,883	1,37,348	3,47,983
Monthly mena per Km²	20.16	32.875	23.378	
Net production				
Daily production per Km² area	0.345	0.405	0.442	
Seasonal/annual prod. per Km²	41.4	37.26	67.625	146.285
Seasonal/annual prod. per 1175 Km²	48,645	43,780	79,460	1,71,885
Monthly mean per Km²	10.35	12.42	13.525	

Net primary productivity : Monthly and seasonal mean values of net productivity in surface waters are presented in Fig. 1 & 2 respectively. In general, higher rate of net production was observed in the 20 m depth station than at 10 and 30 m depth stations (Since regular monsoon data were not available for 30 m depth station, the data for 30 m station were not depicted in Fig. 1 & 2). Seasonwise pooled data for 1986-88 for the three seasons showed mean values of 0.137, 0.179 and 0.379 g C/m³/day at 10 m depth station; 0.552, 0.631 and 0.505 g C/m³/day at 20 m depth and on average, 0.345, 0.405 and 0.442 g C/m³/day respectively in sons were 51.75, 62.10 and 67.63 tonnes Carbon/Km² respectively (Table 5).

Vizhinjam

Primary production : In Vizhinjam inshore waters, the average seasonal values of gross and net production showed maximum during monsoon period in both the years of collection. During this season the highest rate of production was in June. The seasonal variations in the gross and net production in the inshore waters off Vizhinjam are given in Table 6.

TABLE 5. *Estimated net primary production off Cochin (Column production in tonnes carbon)*

		Premonsoon (120 days)	Monsoon (92 days)	Postmonsoon (153 days)	Annual (365 days)
Daily average prod. per Km² area	: 1986	1.680	2.180	1.700	
	: 1987	1.740	1.865	2.620	
	: 1988	1.755	2.030	2.310	
Daily average per Km² (1986-1988)		1.725	2.025	2.210	
% of net production in gross production		51.34%	37.78%	57.85%	
Seasonal/annual prod. per Km²		207.0	186.3	338.13	731.43
Seasonal/annual prod. per 1175 Km²		2,43,225	2,18,902	3,97,303	8,59,430
Monthly mean prod. per Km²		51.75	62.10	67.63	

No primary productivity studies were carried out at Lakshadweep.

Zooplankton productivity

Cochin

Biomass : Fig. 9 A shows that the biomass invariably recorded a primary peak in the southwest monsoon season in July, during 1984 (96 ml), '85 (237 ml) and '86 (541 ml) and in August during '87 (111 ml) and '88 (96 ml). A secondary peak in the postmonsoon season in September was discerned in '84 (51 ml) and '86 (46 ml). Following the occurrence of the primary peak in July '85, the biomass recorded in August was 86 ml, a little less than those of the primary peaks recorded in '84 and '88.

The primary peak recorded in July '86 was constituted by a volume as large as 541 ml, the largest volume observed during the entire period of this study. The biomass observed during the following August was 42 ml, a little less than that of the secondary peak, (46 ml) of September '86. While decrease in the biomass that followed the primary peaks was usually sharp, the decline that succeeded the secondary peaks gradually brought the volume down over a period of 3 or 4 months. The increase in the biomass observed in March 1987 (38 ml) was only one of its kind observed in the premonsoon season during the study.

Zooplankton

Copepods : The numerical abundance of copepods, which was high during July '85 (77,000), '86 (2,58,064) and August '88 (3,19,756) coincided with the primary peaks of plankton biomass, but the copepod peak occurred in September '84 (1,07,614) and during April (1,16,183) and June (1,00,744) in '88 when the plankton biomass was low (Fig. 9 B). It is significant that the copepod component was

TABLE 6. *Average seasonal values of primary productivity (mgC/m³/day), temperature (°C), Salinity (‰), dissolved oxygen (ml/l) and nutrients (µg/at/l) and rainfall (mm) in the premonsoon, monsoon and postmonsoon seasons at Vizhinjam for the period February 1984 to January 1986*

Productivity and environmental parameters	Seasons	1984-85	1985-86
Net production	Pr M	101	229
	M	170	516
	Pt M	106	no data
Gross production	Pr M	217	440
	M	270	711
	Pt M	241	no data
Temperature	Pr M	28.04	29.33
	M	25.28	34.30
	Pt M	25.04	26.50
Salinity	Pr M	34.48	34.44
	M	33.63	32.80
	Pt M	34.14	34.11
Dissolved oxygen	Pr M	5.15	4.75
	M	3.90	4.25
	Pt M	4.50	4.50
Phosphate	Pr M	1.51	0.82
	M	1.26	1.44
	Pt M	1.40	1.97
Nitrite	Pr M	0.48	0.21
	M	0.76	0.25
	Pt M	0.45	0.28
Nitrate	Pr M	1.57	1.08
	M	2.15	1.54
	Pt M	1.78	1.68
Silicate	Pr M	7.23	7.79
	M	13.93	9.65
	Pt M	10.40	11.97

Pr M = Premonsoon, M = Monsoon and Pt M = Postmonsoon

very poor in July '84 and August '87 and was comparatively less in July '85 when the biomass recorded the primary peaks for the respective years.

Cladocera : Cladocera occurred in swarms during July '85 (1,18,800), August '85 (1,25,200), '86 (1,61,800) and '88 (4,11,440). The swarm observed in August '88 was more abundant and nearly four times greater than those recorded during the rest of the period (Fig. 9 C). The abundance of cladocera observed in July '86 was nearly twice as much as those recorded in November '84, September '86, October '87 and April '88. It may be seen that between March and June '88 cladocera showed increase in abundance over those recorded in the corresponding period of the previous years.

Lucifer : The increase in the abundance of lucifers was normally observed in the monsoon season as in August '84 (4,600), July '85 (8,770), June '87 (39,330) and August '88 (6,980) except once in the postmonsoon season in December '84 (5,777) and once in the premonsoon season in May '88 (3,375), (Fig. 9 D). The numerical abundance recorded in June '87 remained the highest for the five year period '84-88.

Appendicularia : The peak of abundance observed particularly in July for three consecutive years, '84 (3,500), '85 (3,840) and '86 (48,588) was conspicuous by its absence during the month in '87 and '88 (Fig. 10 A). The mean monthly increase observed in February '86 was slightly more than that recorded in January '87, but almost equalled that abundance recorded in August '88. The Appendicularia showed marginal increase during November '84, June '87, April and June '88.

Siphonophores : Siphonophores were highly abundant in the monsoon in August '85 (5,827), '87 (11,283) and in the early postmonsoon in October '84 (6,086) and in September (17,838) and October (19,086) in '86 (Fig. 10 B). Besides, they tended to increase in abundance towards the end of the postmonsoon in January '88. It may be noted that maximum abundance in '88 was nearly six times greater than the maximum in '85 both occurring in the same monsoon season.

Chaetognatha : Chaetognatha abounded in the monsoon during July - August both in '85 (28,357; 10,181) and '87 (9,424; 10,736) and in the postmonsoon season during September both in '84 (10,440) and '86 (17,762) (Fig. 10 C). The abundance observed in November '84 (8,000) was less than that recorded in January '88 (8,700) by as much as it was more than that occurred in June '88 (7,100).

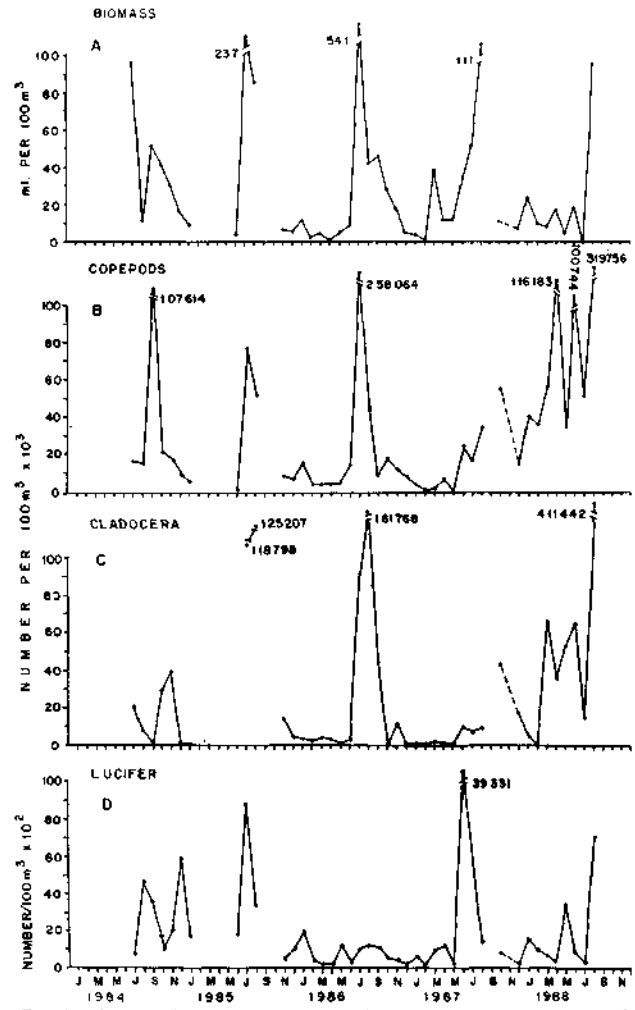

Fig. 9. Seasonal fluctuations in total zooplankton biomass amd abundance of zooplankton groups during 1984-88 at Cochin.

Polychaete larvae : The abundance of larval polychaetes recorded during the different years was 30,999 in July and 4,587 in October (both in '84), 44,384 in July and 47,223 in August (both in '85) and 32,360 in July '86 and 6,025 in August '87 and 4,686 in July '88 (Fig. 10 D).

Fish larvae : The monthly average number of fish larvae was 430 in October '84, 260 in September '86, 240 in August '87 and 945 in January, 310 in February, 270 in March, 260 in April and 320 in August (all in '88) (Fig. 11 A). During the rest of the period the number of fish larvae remained below 240.

Fish eggs : The monthly mean number of fish eggs observed was 920 in August and 560 in November (both in '84), 690 in August '85, 8,584 in August and 810 in September (both in '86) and 1,364 in May and 1,904 in August (both in '88) (Fig. 11 B). Unlike the increased abundance of fish eggs observed at least once during the different years, the maximum of the monthly mean recorded during '87 was as low as 490.

Decapod larvae : The monthly mean of the larval decapods observed during the monsoon in July '85 (6,680) and '86 (4,580), June '87 (53,840), June (13,573) and August (20,399) '88 was high and that recorded in June '87 was the highest for the five year period of this study (Fig. 11 C). In the postmonsoon in December '84, January and November '86, October '87 and January '88, the decapod larvae occurred more in number than during the rest of the months in the same season or the premonsoon season.

Secondary production: Table 7 shows secondary production estimated during the different seasons between 1984 and August 1988. The production in the monsoon season was maximum except in '84 during which year the production in the postmonsoon season (2,864 tonnes C) exceeded that of the monsoon (2,511 tonnes C). A comparison of the estimated values of the secondary production during the monsoon between '84 and '88 showed that there was an increase from 2,511 t of carbon in '84 to 6,352 t of carbon in '85 and further increased to 12,300 t of carbon in '86. But during '87 the monsoon production of 3,074 t of carbon decreased to nearly one fourth of previous monsoon and during '88 it decreased further to 2,379 t of carbon, slightly more than two third of the monsoon production of '87. The seasonal mean of secondary production was the highest in the monsoon at 5,309 tonnes of carbon or 4.52 t of carbon/Km^2 in the postmonsoon season and the premonsoon production was the least at 922 t of carbon or 0.79 t of carbon/Km^2 taking the third and last place. The average monthly zooplankton production for the seasons worked out to be 231 tonnes of carbon in the premonsoon, 1,774 t of carbon for the monsoon and 315 tonnes of carbon for the postmonsoon.

Vizhinjam

Total displacement volume of plankton : The monthwise displacement volume of plankton showed that all maximum were in postmonsoon months, while the minima were in the premonsoon period except during 1985-86 when it was in the postmonsoon period (Sept.). Plankton displacement volume (ml/100 m^3) calculated from pooled monthly data and presented for the entire period (Fig. 12 f) shows that there are actually 3 modes in the production of

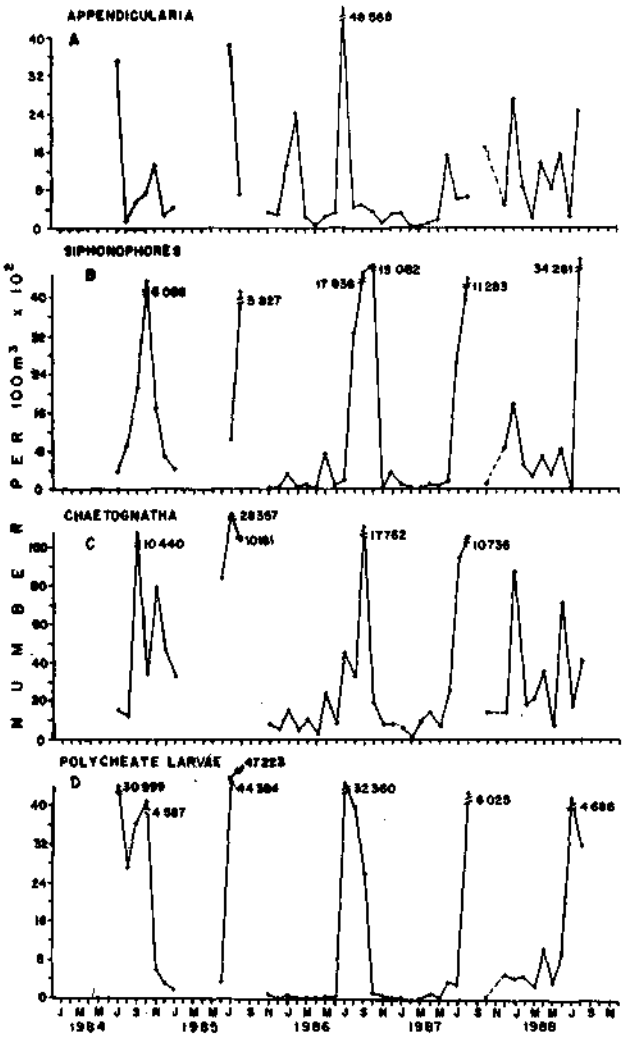

Fig. 10. Seasonal fluctuations in the abundance of zooplankton groups during 1984-88 at Cochin.

plankton off Vizhinjam. A dominant peak in the displacement volume could be noted in October (postmonsoon) followed by a secondary mode in June (monsoon) and a tertiary one in August (monsoon). It could further be seen that there was a premonsoon increase in plankton volume in 1984-85 (May) followed by a monsoon increase during 1985-86 (Aug.) and 1987-88 (June). Of these the first

one was caused by phytoplankters *Bellerochea malleus* and *Cerataulina* sp., the second was by hydromedusae and the third through the bloom of *Thalassiosira subtilis*. From this it becomes evident

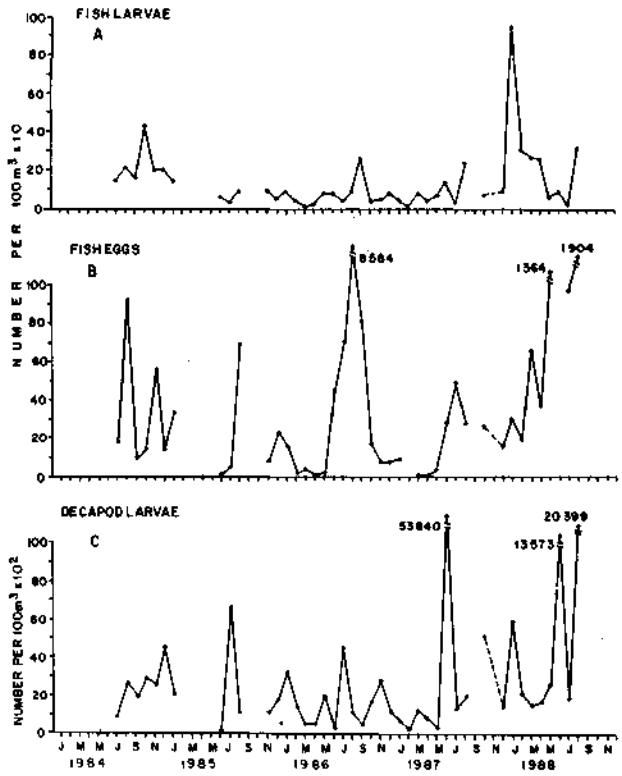

Fig. 11. Seasonal fluctuations in the abundance of zooplankton groups during 1984-88 at Cochin.

that displacement volume of plankton can often get exaggerated by occasional blooms or swarms. Hence, the secondary and tertiary modes, given in Fig. 12 f may be considered to be of minor significance while considering the plankton production for each year in detail.

Quarterwise analyses of displacement volume of plankton (Table 8) indicate that the postmonsoon period accounted for the maximum values, the only exception being the postmonsoon period of 1986- 87 and this is because of the paucity of data for all the months.

The average seasonal values of displacement volume vary considerably from year to year. The average value for the entire period shows that the premonsoon period recorded the minimum (4.9 ml/100 m^3) while the postmonsoon period, the maximum (13.9 ml/100 m^3)The average figures for the premonsoon period of different years (Fig. 13 a-e; Table 8) indicate that the values for 1986-87 and '87-88 were below the average. Likewise, a comparison of the average figures for the season shows that 1986-87 and '88-89 recorded a volume much less than the average for the entire period. The postmonsoon period, with the exception of 1986-87 recorded higher values than the average.

Blooms and swarms and their seasonality : Blooms and swarms may be suggested as the main cause of sudden outburst in plankton biomass in the sea. Though it is not possible to pinpoint any single environmental parameter responsible for such phenomena, they are of regular occurrence in the coastal waters than incidental. Generally blooms and swarms are of common occurrence during the postmonsoon and monsoon months and may be cited as a major reason for the sudden increase in the displacement volume of plankton.

Though blooms and swarms are cited as a cause for fish mortality in certain parts along the coast of India, so far no such deleterious effect on fish population has been recorded from this area. A seasonwise occurrence of blooms and swarms off Vizhinjam during the period 1984-85 to 1988-89 may be outlined as follows:

TABLE 7. *Estimated seasonwise secondary production off Cochin in tonnes of carbon (Area : 1175 Km²)*

Year	Premonsoon	Monsoon	Postmonsoon
1984	-	2,511	2,864
1985	-	6,352	611
1986	210	12,300	1,533
1987	1,655	3,074	1,292
1988	902	2,379	-
Mean seasonal production	922	5,309	1,575
Mean monthly production	231	1,774	315
Seasonal mean production/Km²	0.79	4.52	1.34

TABLE 8. *Seasonwise displacement volume of plankton for the period 1984-85 to '88-89 (based on averages) at Vizhinjam*

Season	1984-85	'85-86	'86-87	'87-88	'88-89	Averages
Premonsoon	6.9	5.4	3.3	3.7	5.6	4.9
Monsoon	10.5	13.4	4.5	14.8	6.3	9.9
Postmonsoon	15.9	16.0	3.6*	16.3	18.0	13.9

* Data insufficient

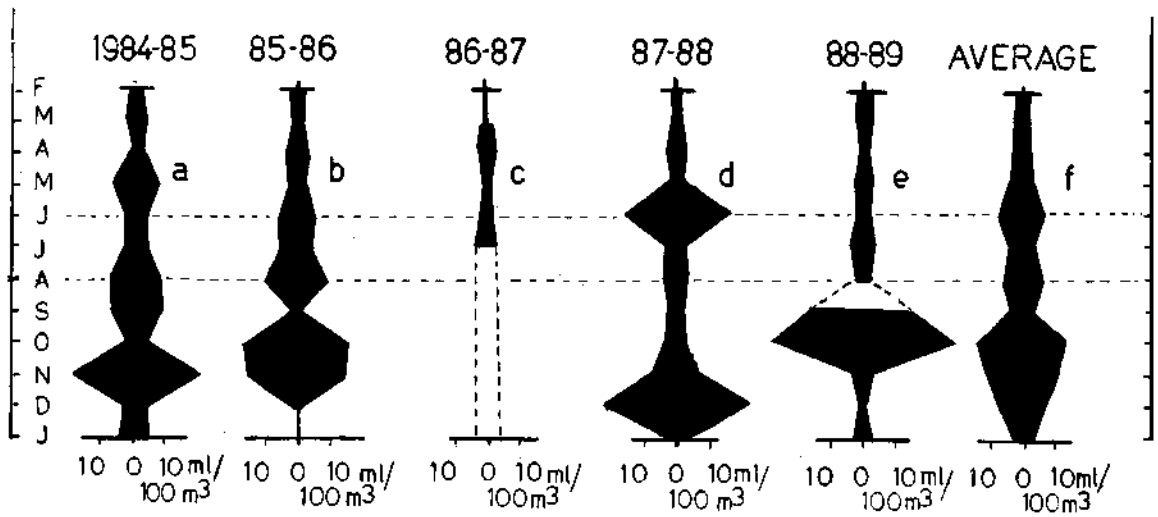

Fig. 12. Monthly displacement volume of plankton for the period 1984-85 to 1988-89; montly mean values for each year (a-e) and average monthly values for the entire period at Vizhinjam.

premonsoon period : During this period 4 blooms was observed off Vizhinjam. In February-March period (1984, '87) *Trichodesmium* caused outbursts occasionally. This was followed by a mixed bloom of *Bellerochea malleus* and *Cerataulina* sp. in May, 1984.

Monsoon period : The monsoon period witnessed 5 blooms, 4 were of a mixed nature and the 5th composed of a single species *Noctiluca miliaris*. Of the 3 swarms noted, one was of polychaete larvae (Aug. 1984) and the second was of hydromedusae (1985). Rhizostome medusae (*Netrostoma coerulescens* Maas) also could be seen washed ashore in plenty during August 1985.

Postmonsoon period : The total number of swarms noted during this period was 9 and blooms 4. It may be noted that the blooms were mostly of a mixed nature. Swarms outnumbered blooms in postmonsoon period while the condition was just the reverse in the monsoon period.

All the 4 blooms that occurred during the postmonsoon period were of *Noctiluca* sp. growing symbiotically with *Protoeuglena noctilucae* Subrahmanyan (1954), a speices of green flagellate. The specimens were of green colour and was first reported from the Gulf of mannar (Subrahmanyan,

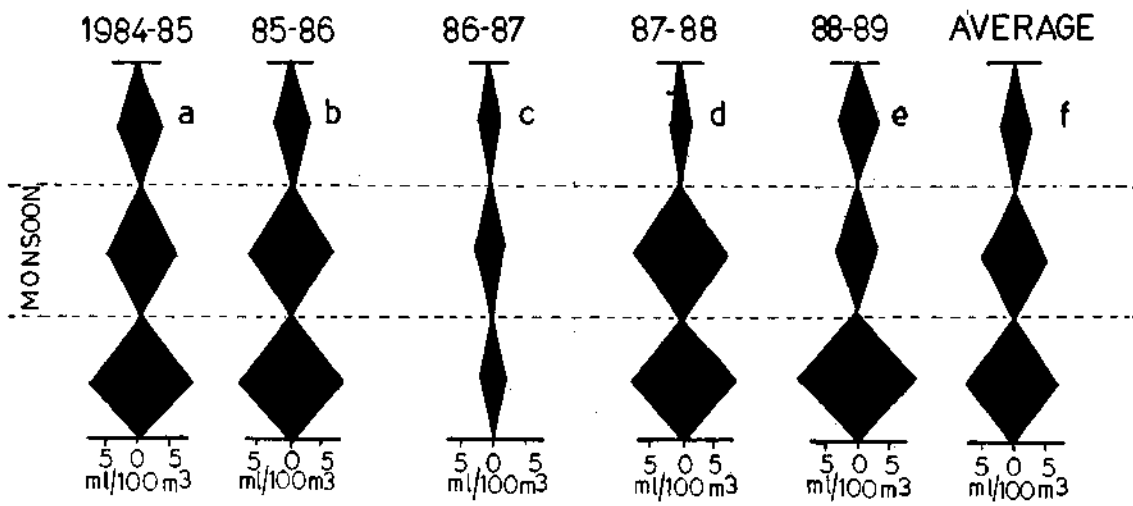

Fig. 13. Seasonwise displacement volume of plankton for each year : seasonal average and average for the entire period (f) at Vizhinjam.

1954) and then from Calicut (Prasad, 1958). This 'green' *Noctiluca* was recorded off Vizhinjam. The bloom of 'green' *Noctiluca* usually occur during November-December (1986, '87 and '88) months, while *Noctiluca* without such green symbionts usually occur during monsoon when hydrographical conditions are entirely different.

The blooms of phytoplankton are rather regular during the monsoon period and as many as 9 species, either as single species or in combinations, occur is this area. The postmonsoon period, on the other hand, is the season of swarms and the organisms involved may be holo or meroplanktonic forms. The most conspicuous among the various groups is medusae (both hydro and rhizostome). Hydromedusae are encountered during October-December period while large rhizomedusae are characteristic of August-September period. Washing ashore of *Netrostoma coerulesoena* Maas in large quantities is quite a regular phenomenon along this coast and their stranding coincides with 'onam' festival, they are known as 'Onachorri' in vernacular. Specimens measuring 10-40 cm diameter (umbrella) are common and the decay of such large specimens create problems to those who frequent the beaches or to nearby dwellers during this season. Cladocerans (*Evadne tergestina* Claus, *Penilia avirostris* Dana), ctenophores (*Pleurobrachia* sp.), copepods (mainly *Temora* sp.) and salps (*Salpa democratica* Forsskal) were the common groups which caused swarms during the postmonsoon period.

Hydrography in relation to blooms and swarms

A comparison of salinity and temperature in relation to bloom/swarm during various years shows that outburst of zooplankters/phytoplankters can occur under the following combinations.

a. Lower temperature and lower salinity

b. Lower temperature and higher salinity

c. Lower temperature and medium salinity

d. Medium temperature and higher salinity

e. Higher temperature and higher salinity

Table 9 shows that blooms/swarms are cyclic phenomena in the coastal waters, but what causes their outburst is not fully understood. It may be due to the interaction of several environmental parameters finally culminating in a condition quite congenial for them to cause a sudden spurt in their population.

Seasonal distribution of planktonic organisms and their numerical abundance

Nearly 31 groups of both mero and holoplanktonic organisms are encountered in the collections off Vizhinjam. Apart from these, a few phytoplankters which contribute to occasional blooms are also considered in the present study. Numerically speaking, copepods contribute more than 80% among the various groups. The availa-

TABLE 9. *Blooms/swarms in relation to salinity and temperature observed off Vizhinjam during 1984-89*

Combination / species groups	Month	Salinity (ppt)	Temperature (°C)	Season
a. *Lower temperature and lower salinity*				
1. *Noctiluca miliaris*	July, 8 '85	30.6	24.0	Monsoon
b. *Lower temp. and higher salinity*				
2. Polychaete larvae	Aug. '84	34.5	25.5	Monsoon
c. *Lower temp. and medium salinity*				
3. Rhizostome medusae	Sept. '85	33.8	24.0	Postmonsoon
4. Mixed bloom*	June '85	33.5	26.0	Monsoon
5. Mixed bloom **	June '87	34.0	24.0	Monsoon
6. *Temora* sp.	Nov. 84	33.6	25.0	Postmonsoon
7. *Pleurobrachia* sp.	Nov. '84	33.6	25.0	Postmonsoon
d. *Medium temp. & higher salinity*				
8. Mixed bloom***	May '84	34.1	28.3	Premonsoon
e. *Higher temp. & higher salinity*				
9. *Noctiluca* 'Green'	Nov. '87	34.3	30.0	Postmonsoon
10. *Noctiluca* 'Green'	Dec. '87	34.9	30	Postmonsoon
11. *Trichodesmium* sp.	Feb. '84 & Mar. '87	34.9	30.0	Premonsoon

* Species were *Fragilaria oceanica*, *Rhizosolenia* sp., *Thalassiones* sp. and *Bellerochea malleous*.

** Species were *Thalassiosira subtilis*, *Chaetoceros* spp. and *Rhizosolenia* sp.

*** Species were *Bellerochea malleus* and *Cerataulina* sp.

bility and the peak period of abundance of all these groups are subject to considerable fluctuations both in time and space. An assessment of the various planktonic groups in relation to season and hydrographical conditions is presented by Rani Mary Jacob *et al.* (1986). The above workers have, after the correlation analyses between pelagic fishery, plankton and hydrography have found that zooplankton volume did not exhibit significant relationship with any of the hydrographical factors investigated.

In order to study the abundance of planktonic organisms during the various seasons, months and years their numerical abundance and peak period of distribution were found out for each group/genus. Normally the main and a subsidiary peak were considered in almost all groups. The seasons (premonsoon, monsoon and postmonsoon) and months in which the primary peak occurs during each year was traced out. The time lapse (in months) between adjacent primary peaks was found out for each group. Thus the primary peaks for mysids were observed during May '84, Aug. '85, Jan. '87, Oct. '87 and June '88 (Table 10). In other words, the peaks were observed during premonsoon, monsoon, postmonsoon, postmonsoon and monsoon seasons respectively in various years. The time lapse between the peaks of 1984 and '85 was 15 months, between '85 and '87 was 17 months, between Jan.'87 and Oct. '87 was 9 months and between Oct. '87 and June '88 was 8 months. In this manner, the details pertaining to 27 groups of plankters were traced out, of which 12 common groups are given in Table 10. It is seen that numerical abundance (peak) is a regular phenomenon in each group. But there is no uniformity with regard to the time (month) of occurrence : so also the time lapse between adjacent peaks is never uniform or predictable. it is also not known whether the primary and secondary peaks in the same group are supported by the same species or by different species. The information now available is rather meagre and this situation can be improved only through tracing the primary and secondary peaks of any group based on the predominance of component species.

It is also evident from the Table that the time lapse between adjacent primary peaks is never constant; the interval can be short or protracted sometimes. What causes this strange phenomenon is still a matter of conjecture; it can be due to any change in the physico-chemical condition of the seawater induced by rain or by run off of nurients of terrestrial origin.

Peaks of plankters and their seasonality

With a view of studying the seasonality in the occurrence of peaks in different groups of plankters the peaks found in each group through different years were traced out in relation to season and the peak occurrence of 27 groups of plankters in the different seasons of the study period is given in Table 11.

TABLE 10. *Successive primary peaks and the time lapse in months between adjacent peaks in 12 groups of plankters off Vizhinjam*

Groups	Peak in 1984-85	Time lapse	Peak in 1985-86	Time lapse	Peak in 1986-87	Time lapse	Peak in 1987-88	Time lapse	Peak in 1988-89
Mysids	May 84	15	Aug. 85	17	Jan. 87	9	Oct. 87	8	June 88
Amphipods	Aug. 84	6	Feb. 85	23	Jan. 87	7	Aug. 87	8	Apr. 88
Chaetognaths	Sep. 84	6	Mar. 85	15	July 86	18	Jan. 88	9	Oct. 88
Copepods	Nov. 84	5	Apr. 85	15	July 86	15	Oct. 87	12	Oct. 88
Decapod larvae	Nov. 84	6	May 85	12	May 86	15	Aug. 87	14	Oct. 88
Cladocerans	Sep. 84	7	Apr. 85	13	May 86	17	Oct. 87	12	Oct. 88
Lucifer	Aug. 84	8	Apr. 85	13	May 86	12	May 87	10	Mar. 88
Polychaete Larvae	Aug. 84	12	Aug. 85	11	July 86	8	Apr. 87	18	Oct. 88
Gastropod larvae	Jan. 84	13	Feb. 85	13	Mar. 86	12	Mar. 87	11	Feb. 88
Fish eggs	Jan. 85	7	Aug. 85	8	Apr. 86	10	Feb. 87	8	Oct. 88
Fish larvae	Jan. 84	11	Dec. 85	6	June 86	8	Feb. 87	8	Oct. 88
Bivalve larvae	Sep. 84	11	Aug. 85	11	July 86	8	Mar. 87	20	Nov. 88

The peaks in majority of plankters occurred in the postmonsoon period (19 nos. in 1984-85, 11 nos. in 1987-88 and 11 nos. in 1988-89) followed by the premonsoon period of 1985-86 (16 nos) and monsoon period of 1986-87 (11 nos.).

Groupwise lucifer, ctenophores, gastropod larvae and cirripede larvae formed their peaks during premonsoon period more frequently, while the peak period of abundance or polychaetes, polychaete larvae, ostracods, phyllosoma larvae occurred during monsoon period. The peaks of cephalochordate larvae, chaetognaths, cladocerans, doliolids, copepods, echinoderm larvae, medusae, siphonophores, appendicularians and fish larvae were found during the postmonsoon period. The above findings clearly show that the postmonsoon period provides optimum conditions for many of the common plankters to multiply in this area.

TABLE 11. *Peak period of occurrence of different groups of plankters in relation to season at Vizhinjam during 1984-85—1988-89*

Groups/Genus	Seasons in which peaks observed				
	1984-85	'85-86	'86-87	'87-88	'88-89
Mysids	Pre	Mon	Post	Post	Mon
Cephalochordate larvae	Pre	Nil	Post	Post	Mon
Polychaete	Mon	Post	Mon	Pre	Nil
Polychaete larvae	Mon	Mon	Mon	Pre	Post
Ostracods	Mon	Mon	Nil	Pre	Nil
Amphipods	Mon	Pre	Post	Mon	Pre
Lucifer	Mon	Pre	Pre	Pre	Pre
Stomatopod larvae	Mon	Pre	Mon	Nil	Pre
Chaetognaths	Post	Pre	Mon	Post	Post
Cladocerans	Post	Pre	Pre	Post	Post
Doliolids	Post	Post	Nil	Nil	Nil
Copepods	Post	Pre	Mon	Post	Post
Cumaceans	Post	Pre	Post	Mon	Pre
Decapod larvae	Post	Pre	Pre	Mon	Post
Ctenophores	Post	Pre	Mon	Pre	Nil
Echinoderm larvae	Post	Pre	Mon	Post	Nil
Siphonophores	Post	Mon	Pre	Post	Post
Salps	Post	Pre	pre	Post	Nil
Medusae	Post	Post	Pre	Post	Post
Gastropod	Post	Pre	Pre	Post	Mon
Gastropod larvae	Post	Pre	Pre	Post	Mon
Appendicularians	Post	Pre	Mon	Post	Post
Fish eggs	Post	Mon	Pre	Pre	Post
Fish larvae	Post	Post	Mon	Pre	Post
Bivalve larvae	Post	Mon	Mon	Pre	Post
Cirripede larvae	Post	Pre	Pre	Nil	Mon
Phyllosama larvae	Post	Pre	Mon	Mon	Nil

Pre = Premonsoon, Mon = Monsoon, Post = Postmonsoon, Nil = Not traceable.

In groups like phyllosoma larvae and amphipods the peak period of occurrence was equally distributed among premonsoon and monsoon periods (2 each out of 5 years observed), in 5 groups (cumaceans, decapod larvae, salps, gastropods and fish eggs) the frequency of their peaks was equally distributed among pre and postmonsoon periods (2 each). Bivalve larvae, on the contrary, were abundant (peak) during monsoon and postmonsoon months (2 each). It is thus evident that the peak occurrence of any group can occur at any season of the year and the time lapse (in months) between successive peaks is never constant.

Plankton peaks in relation to salinity : Fig. 14 shows that plankters off Vizhinjam occur at a wide range in salinity (30-35 ppt) and hence distributed althrough the year. But a few other groups cannot tolerate such a wide range and hence occur during certain months of the year when salinity conditions are quite congenial for them to flourish. Peaks of many groups, as seen from Fig. 14 occur between 34.0 to 35.0 ppt range though in a few instances atleast one peak may occur below the above given range. This shows that the peaks of various plankters are concentrated at a higher range of salinity rather than in their lower ranges. In those groups which have narrow ranges, the peaks generally occur at higher levels of salinity. It is evident here that peak distribution of many of the groups of plankters is related to salinity and may take place at any season of the year when the salinity conditions are at the higher range, 34.0 to 35.0 ppt.

Plankton peaks in relation to temperature : Fig. 15 gives the peak occurrence of different groups of plankters in relation to temperature. Unlike in Fig. 14 (dealing with salinity) here no overcrowding of peaks in relation to higher or lower ranges is seen. The peak occurrence of many of the plankton groups was noted at lower temperature (25°C)

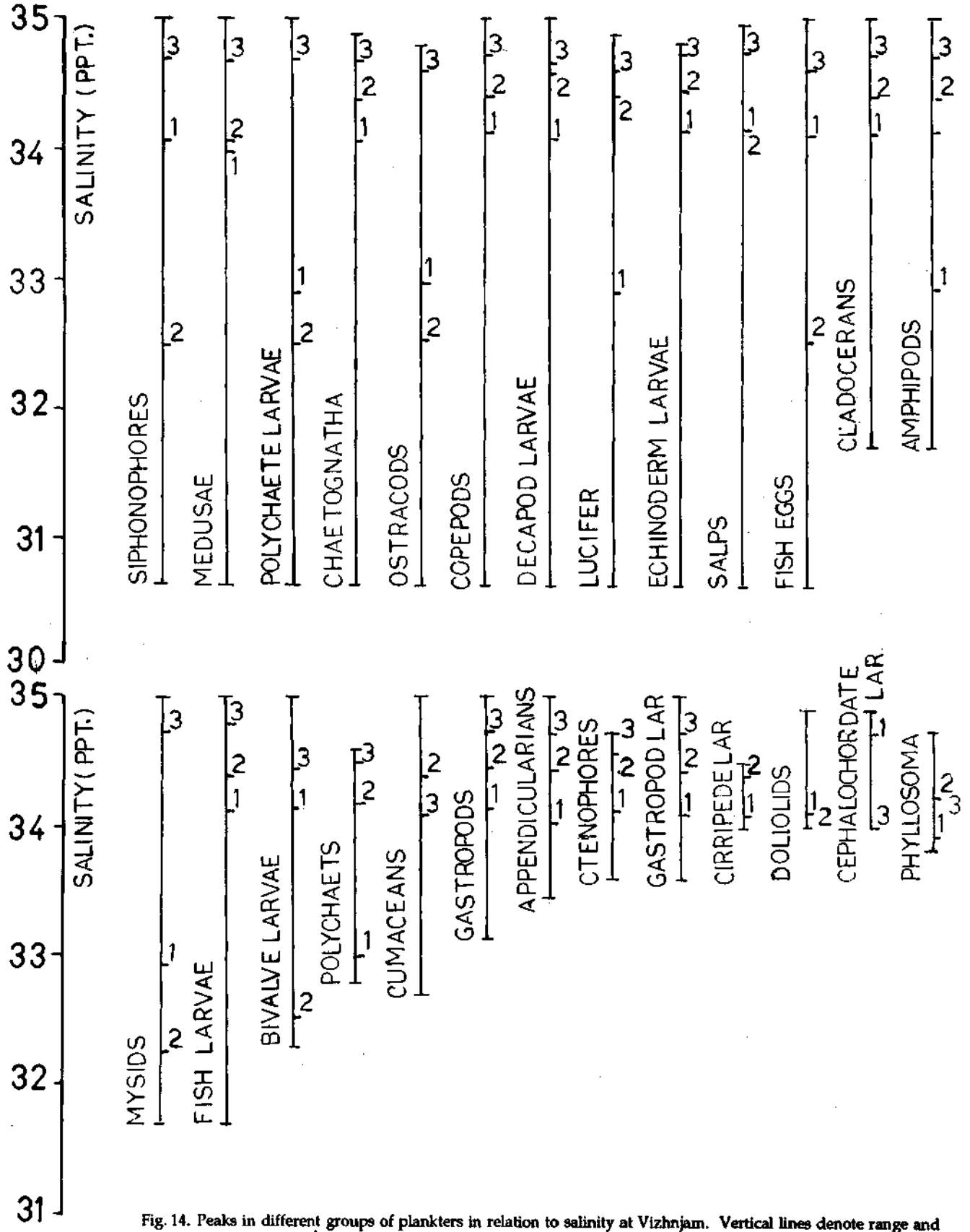

Fig. 14. Peaks in different groups of plankters in relation to salinity at Vizhnjam. Vertical lines denote range and horizontal lines mark the occurrence of peaks in 3 years, *viz.* 1984-85 (marked 1), 1985-86 (marked 2) and 1987-88 (marked 3).

during the first year *i.e.* 1984-85. But in 1985-86 a good number of peaks centered around higher temperature (29.0-30.0°C). In the third year (*i.e.* 1987-88) more peaks were discernible at 28°C. Generally the peak distribution of various planktonic groups are not directly related to temperature and can occur at any season.

Fish landing in relation to season

Some important groups of pelagic and a few demersal fishes that form sizable fraction of the total annual landings have been analysed in detail for a period of one year (1984-85) for pelagic groups, while the data for a period of 9 years (1979-87) have been utilised for demersal groups. Out of 19 pelagic groups considered, the peak landing of 17 groups could be noticed during the year 1984-85. While tracing out the peak landing of these 17 groups in relation to season, it was observed that during the premonsoon, monsoon and postmonsoon periods the number of peaks (primary) observed were 5, 8 and 4 respectively. In the case of secondary peaks in respect of the above groups, only 12 could be traced out. Secondary peaks, in any of the groups/species, did not occur during the monsoon period, but their occurrence during pre and postmonsoon periods were numerically found to be 4 and 8 respectively.

The important species constituting the groups showing premonsoon peaks (primary) were Lesser sardines, mackerel, *Euthynnus affinis*, *Auxis thazard* and *Sardinella longiceps*. A secondary peak for this group was also discernible in the postmonsoon period. The groups/species recorded during the monsoon period were *Stolephorus* spp., mullet, *Selar mate*, *Dussumieria* sp., carangids, leiognathids and *Alenetta* sp. Of these groups, a secondary peak was seen in the postmonsoon period only in the case of *Selar mate*, carangids and leiognathids, while in the case of mullet and *Dussumieria* sp. the secondary peaks was in the postmonsoon period. Groups/species like *Decapterus* sp., *Chirocentrus* sp., *Auxis rochei* and *Caranx crumenophthalmus* exhibited their peaks during the postmonsoon period and in all these cases their secondary peaks were in the premonsoon period. Perches, which form a sizeable fraction of the demersal landing at Vizhinjam, have been studied for a period of 9 years (Thomas *et al.*, 1989). Details such as seasonal abundance, landings by both mechanised and nonmechanised sectors have worked out for 8 families of perches (and perch-like fishes). When perches are considered a single group, the peak landings could be noticed during the monsoon period (Aug.), but when families are considered individually Nemipterids, Siganids, Ambassids showed peak landings during the monsoon period; Theraponids, during the premonsoon period and Lethrinids, Priacanthids, Lutjanids and Serranids in the postmonsoon period.

Lakshadweep

Temperature : Lower temperature was recorded in the postmonsoon season and maximum in the premonsoon period (Fig. 8 A & C). The trend in the variation was almost similar at both stations. Mean temperature varied from 27.3°C in November to 31.3°C in April. In general, high temperature prevailed during March-May.

Salinity : Monthly variations in salinity are presented in Fig. 8 C & D. The values showed fluctuations from 32.26‰ in June to 34.93‰ in March. In general, lower salinity was observed at Station 1. The low value obtained during June in the shallow water (Station 1) might be due to the land run off as a result of monsoon.

Dissolved oxygen : Monthly averages are presented in Fig. 8 E & F. The values ranged from 3.98 ml/l in March to 4.66 ml/l in June. The fluctuation was not much at both stations. The values were generally higher in the surface waters during monsoon months.

Zooplankton : The plankton biomass was comparatively high during January and March 1987; while in 1986 and 1988, the biomass was less in these months. The pooled data for 1985-88 showed that the biomass varied from 0.9 ml/haul in October to 12.9 ml/haul in January.

Discussion

Since the period of investigation and the methods in biological sampling differed at each centre of study, the results emerged at each centre are discussed separately in relation to the monsoon.

The annual average rainfall recorded for the Cochin sector during 1986-88 (2600 mm) falls far below the normal annual rainfall (3230 mm) of this region. Silas and Pillai (1975) stated that the southwest monsoon season along the southwest coast records more than 75% of the annual rainfall;

whereas in the present investigation, the percentages of monsoon rainfall were 51.9, 61.8 and 57.5% only and the values being 1295, 1490 and 1665 mm during 1986, 1987 and 1988 respectively indicating the low intensity of monsoon and its fluctuation from year to year.

650 mm from May to June was found to increase the productivity from 0.597 to 0.975 g C/m³/day. The results also indicated that the sudden increase in rainfall in August 1987 (603 mm) after an intermittent break in July (237 mm) was coinciding with an increase in primary productivity from 0.860

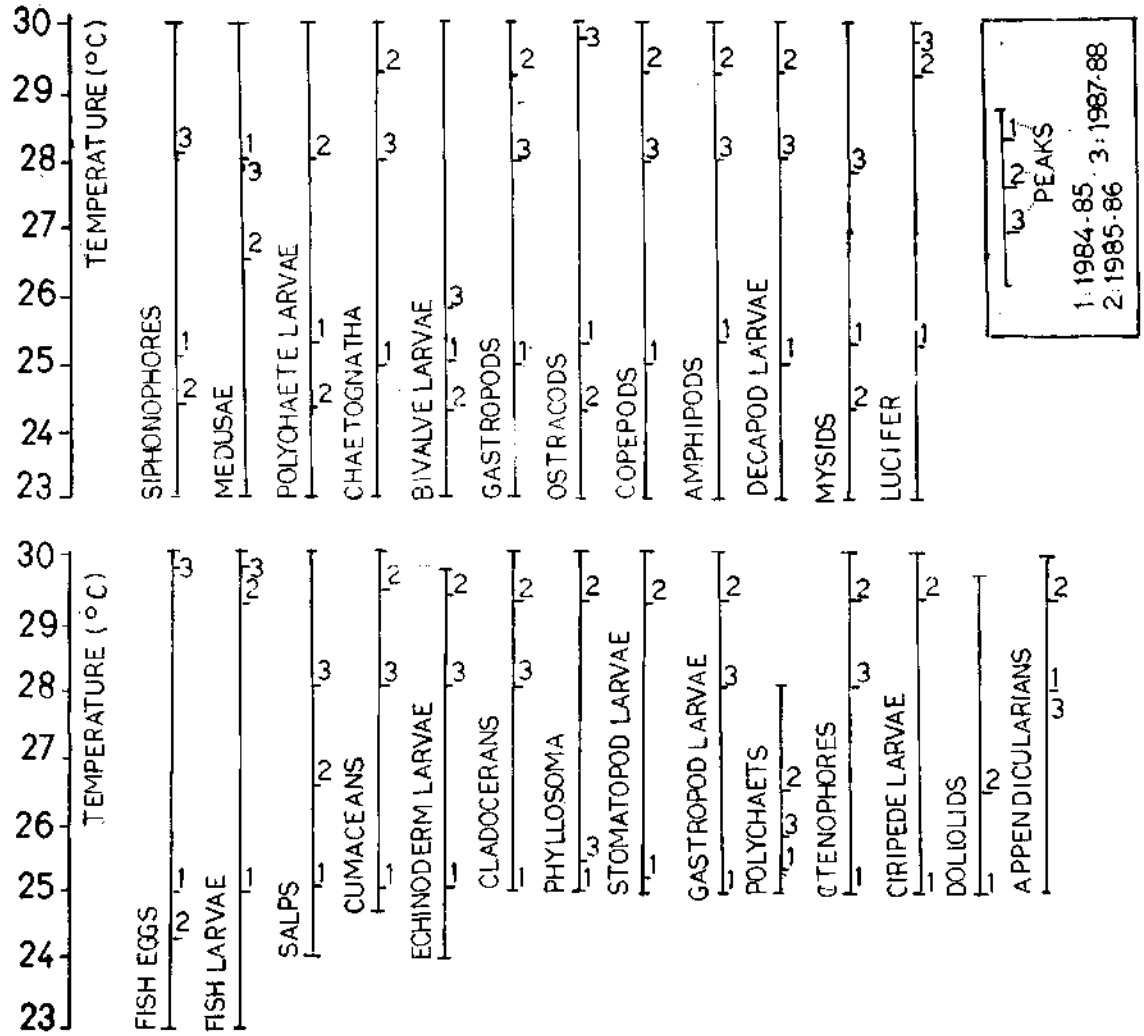

Fig. 15. Peaks in different groups of plankters in relation to temperature at Vizhinjam. Range and peaks marked as in Fig. 14.

The monthly and seasonal fluctuations observed in the rainfall data seem to show some relationship with the phytoplankton productivity in the inshore waters off Cochin. During 1986, the increase in rainfall recorded during April, May and June as 54, 291 and 610 mm respectively coincided with a progressive increase in gross primary productivity as 0.830, 1.042 and 1.624 g C/m³/day in the surface waters upto 1 m depth. Similarly in 1987, an increase in monsoon rainfall from 109 to

in July to 1.150 g C/m³/day in August (Fig. 1). The observations seem to favour that the rainfall has significant influence on primary productivity especially at the onset of monsoon and after an intermittent break during the monsoon season.

During 1987, the mean chlorophyll *a* concentration in surface waters showed a decreasing trend during premonsoon, monsoon and postmonsoon seasons while the mean gross and net production

rates indicated increasing trend respectively (Fig. 2). This might be attributed to the physiological state and productive potential of the phytoplankton elements present in the samples in the respective seasons. However, the mean chlorophyll *a* values were not less than 1.5 mg/m^3 whenever the mean gross primary productivity was lower than 0.450 g C/m^3/day in any of these seasons during 1986-88 indicating the general productivity of this region. But, the overall seasonal averages of chlorophyll *a* concentration and gross primary productivity for 1986 in the surface and column waters showed higher values during the monsoon season.

The results also revealed that the mean productivity at the 10 m depth region was about 50% of that at the 20 m depth region. The above findings indicate that the freshwater influx into the inshore waters beyond a certain level is not favourable for the phytoplankton productivity.

The relatively higher rate of gross primary production during monsoon season, the decreasing trend in productivity with increasing intensity of rainfall within the monsoon season of 1986-88 and the highest production rate recorded at the 20 m depth region than at the relatively low saline (10 m) and the high saline (30 m) depth regions confirm that optimum conditions are necessary for high production of phytoplankton. Gopinathan (1972) has stated that salinity, temperature and nutrients are the main factors controlling the abundance of phytoplankton in the inshore waters off Cochin where much dilution occurs, but concluded that temperature as such seems to have no direct influence on primary productivity. The influence of salinity on the phytoplankton abundance has been dealt by Qasim *et al.* (1972). In the present investigation, dissolved phosphates and nitrates were available sufficiently in the inshore waters during monsoon season when the primary production values were maximum. The higher values of phosphates and nitrates in surface waters during monsoon and low values recorded during premonsoon and postmonsoon seasons seem to have direct relationship with gross primary productivity. According to Subrahmanyan (1960, 1967), optimum condition such as a fall in water temperature from 30-31°C to 23-25°C and a fall in salinity of water from 35‰ or more to 30- 31‰ due to monsoon and abundance of nutrients (phosphate, nitrate and silicate) due to upwelling and river discharges are the important factors for high production of phytoplankton. The results revealed that the mean productivity values for the premonsoon, monsoon and postmonsoon were well above the average estimate given by Nair *et al.* (1973) for the inshore waters along the west coast of India. Such higher values recorded in all the seasons along the inshore waters off Cochin might be attributed to the influence of the Cochin Backwater system.

In the present investigation, the highest concentration of nitrates in surface and bottom waters at 30 m depth station, the decreasing trend in surface values from 30 m to 20 m and bottom values from 30 m to 10 m depth stations during the monsoon season, the lower concentration of the same in surface and bottom during premonsoon season at these stations and the increase in primary productivity at 20 m depth station than at the nearshore 10 m depth station clearly indicate that the dissolved nitrates brought by the upwelling process towards the coast by the influence of southwest monsoon have great role in primary productivity than those brought by the freshwater discharge through land drainage. Further, the day-to-day changes in the tidal bulge and the southerly drift of surface waters by the ocean current system during southwest monsoon and its course in the northerly direction during the other seasons along the southwest coast and the resultant mixing processes have significant role in the day-to-day and seasonal fluctuations in the environmental features and primary productivity.

The estimation of gross and net primary production revealed considerable percentage of loss in the primary level itself by the respiratory metabolism. The percentage of loss in gross production was 62% during monsoon season while it was about 49% and 42% during premonsoon and postmonsoon period respectively. The high percentage of loss during monsoon season might be attributed to the physiological state and stress caused by the unstable nature of the environment.

The annual net primary production in the euphotic waters off Cochin has been estimated as 731.43 t Carbon/Km^2 which amounts to 2.004 t Carbon/Km^2/day or 2.004 g C/m^2/day. Nair *et al.* (1973) have reported values over 2.0 g C/m^2/day during monsoon and postmonsoon months along the southwest coast within 50 m depth and estimated an annual net production of 260 tonnes Carbon/Km^2. According to Qasim (1977), the

average column production for the entire Arabian Sea is 0.468 g C/m^2/day. The above results indicate that the inshore waters off Cochin are highly productive.

Of the annual net production estimated, seasonwise analysis revealed that the premonsoon (120 days), monsoon (92 days) and postmonsoon seasons (153 days) contributed 207.0, 186.3 and 338.13 tonnes Carbon/Km^2 respectively indicating that the postmonsoon season provides the optimum environmental condition to obtain the highest net primary productivity along the inshore waters off Cochin. From the present investigation, the limiting factor for primary production appears to be the physiological state of the phytoplankton elements in relation to the fluctuations in the environmental factors. Apart from this, the grazing of phytoplankton by zooplankters and tertiary feeders also might play a vital role in the fluctuation of phytoplankton production and distribution.

As noticed by earlier workers on the waters off the southwest coast of India (Subrahmanyan, 1969; Qasim, 1973; Mathew and Nair, 1980) the maximum primary productivity in the Vizhinjam inshore waters takes place during the southwest monsoon months. Later, another peak of production takes place at any time during the premonsoon or postmonsoon periods, but this often is of a lesser magnitude compared with the peak in the monsoon period.

The concentration of phosphates at Vizhinjam is higher than that at the other centres like Calicut (Subrahmanyan, 1959), North Kanara Coast (Ramamurthy, 1963; Noble, 1968; Annigeri, 1977) and Ashtamudi estuary (Mathew and Nair, 1980). However, nitrite, nitrate and silicate contents are lower than those in these centres.

Subrahmanyan (1958) and Subrahmanyan *et al.* (1975) have shown that along the west coast of India, a fall in the surface temperature and salinity associated with enrichment of water during the monsoon period are some of the conditions responsible for the growth of phytoplankters. A similar pattern is observed in Vizhinjam waters accounting for a fairly high productivity during the monsoon period. However, in the other seasons although high rate of production is noticed during certain months there is no lowering of salinity, but a sharp decline in temperature was noticed especially in the postmonsoon period of the year 1984-85. Further in the earlier account (Jacob and Vasantha Kumar, 1987), although positive correlation between phosphate and primary productivity and significant negative correlation between nitrite and net productivity were evident, no such significant relationship was revealed between primary productivity and either temperature or salinity. The present study also shows that the peaks of productivity and nutrients do not occur simultaneously with the peak of rainfall and thus it is reasonable to think that these peaks are not caused by the rainfall though it seems to affect them.

At Cochin, most of the constituent groups of zooplankton were abundant either in July or August. Therefore, the biomass invariably recorded a primary peak in the monsoon season. A secondary peak of biomass could be discerned in September (postmonsoon season) in '84 and '86. The increase in the biomass observed in March '87 was caused by the swarm of *Salpa democratica* (16,000/100 m^3) and the absence of any such increase during the rest of the period make the changes in the biomass during the premonsoon season unpredictable. Close relationship between the peak abundance of zooplankton biomass during July-September and upwelling has been established by Menon and George (1977) and Murty (1987). Mathew *et al.* (1984) also observed high values of zooplankton biomass in the mudbank region of Alleppey during July-August.

While the primary peaks of the biomass recorded during July both in '85 and '86 and August '88 coincided with the copepod maximum for the respective years, those of July '84 and August '87 occurred when the abundance of copepods was extremely low. It may be noted that the abundance of larval polychaetes, doliolids, small-sized ctenophores, appendicularians, larvae of cirripedes, cladocera and fish larvae along with the blooms of *Fragilaria oceanica* contributed to the increased biomass observed in July '84, while the swarming of ostracods, especially the *Pyrocypris* sp. alongwith a large number of siphonophores, polychaetes, chaetognaths, fish eggs and larvae, cladocera and the blooms of *Fragilaria oceanica* caused the increase in the biomass in August '87.

While the secondary peak of biomass in September '84 contained nearly 7 times more number of copepods than the primary peak of that

year, the secondary peak in '86 was poor in copepods, but rich in siphonophores, chaetognaths and ostracods. Besides, when a significant increase in biomass occurred in March '87 due to the swarming of *salps*, the abundance of copepods was low.

Eventhough the number exceeded one hundred thousand copepods in April and June in '88, the biomass remained as low as 17 ml and 18 ml respectively. Similarly in October 87 when the abundance of copepods was an impressive 55,000 the biomass was a meagre 11 ml. It is interesting to note that the declining trend exhibited by the biomass between September '84 and January '85 and from September '86 to February '87 was so strikingly similar to those of the copepods recorded during the corresponding periods, that every decrease of the latter from one month to the next resulted in an almost proportional fall in the former during the same months.

Swarms of cladocera occurred thrice during July-August in the southwest monsoon seasons between '84 and '88. While *Penilia avirostris* was dominant during July—August and November, *Evadne tergestina* was more abundant during March-June and October. However, in August '88 the abundance of *Evadne tergestina* was more than that of *Penilia avirostris*. Cladocera are of great importance to pelagic fisheries and are believed to play an important role in the phosphate regeneration of the sea (Barlow and Bishop, 1965).

It is seen that the lucifers increased in abundance in the monsoon seasons of the four out of five years. But for a prolonged period between February '86 and May '87 lucifers showed no increase at all even during the most productive monsoon period.

The regularity in the occurrence of appendicularian abundance in July observed for three consecutive years from '84 to '86 disappeared during '87-'88. Besides, the abundance observed in January '88 was numerically superior to that recorded in August '88. The low abundance observed in July '87 and their occurrence in greater intensity in the postmonsoon season in January '88 instead of June-August of that year indicate that the monsoon induced changes in the environment are solely responsible for promoting proliferation of appendicularians during the season.

During 1985, 1987 and 1988, though the abundance of siphonophores occurred in August there was a wide disparity in the maximum in different years. It may be seen that the maximum abundance of '88 was nearly six times greater than the maximum of '85 both occurring in the same monsoon season. During 1984 and 1986 the abundance of siphonophores was extremely poor in the monsoon season, but the same was impressively high in the postmonsoon season during September-October.

It is significant that the abundance of chaetognaths recorded a peak in the postmonsoon season in the first year and in the monsoon season in the next, alternating in that order from '84 to '87, but was relatively less in January '88 and June '88. All these show that chaetognaths are equally prolific both in the monsoon and the postmonsoon season.

The occurrence of the larvae of penaeids and *Acetes* in large numbers during October-December and April-June is in agreement with the findings of Kuttyamma and Kurian (1982).

Except in '84, the number of larval decapods observed in the monsoon months, was more particularly in June both in '87 and '88, than those recorded in the pre and postmonsoon seasons. It is likely that the conditions prevailing as early as June in the monsoon are favourable for the larval decapods to thrive abundantly.

The occurrence of larval polychaetes in large numbers in July/August in all the five years (except the increase in September '84), shows that the polychaetes greatly prefer the monsoon season for their multiplication in the nearshore region off Cochin. It may be seen that the maximum of the monthly mean abundance of the larval polychaetes recorded during the different years showed an increase from '84 to '85, but declined during the rest of the period of this study recording a mere 4,686 in July '88.

Excepting during August '88 when it was 320, the number of fish larvae occurring in the monsoon season was normally less than those observed in the postmonsoon months. It appears to indicate that the hatching rate of the eggs is more in the postmonsoon months than during monsoon.

The occurrence of fish eggs in large numbers during monsoon probably indicates that the amount

of eggs being added to the medium is more and that merely enriches the plankton during the season since there is no significant increase in the number of fish larvae observed in the same season. David Raj and Ramamirtham (1981) reported increasing trends in fish eggs and larvae during the premonsoon months, but occasionally during the monsoon months.

The secondary production estimates off Cochin showed an increase in the postmonsoon of '84 over the monsoon of the same year. However this was not due to an actual increase in the rate of production, but one caused by the number of months included in the different seasons. On the other hand, the increase in the secondary production of the premonsoon in '87 over that of the postmonsoon of the same year shows a greater rate of production during the former season than in the latter season. However, the estimates for the premonsoon of '86 to '88 show that the season is not as productive as the postmonsoon whereas, the secondary production estimates for the monsoon period show high production in the season. Therefore, it is concluded that the secondary production in the monsoon is the maximum followed by the postmonsoon and the premonsoon.

The production during the monsoon season of '86 was the highest at 12,330 t of carbon/92 days. The mean production for the monsoon season of the five year period worked out at 4.52 t of carbon/km^2. The monthly mean for the monsoon season amounted to 1,774 t of carbon. However, the mean production for the entire area worked out to be 7,815.85 t of carbon/year or 6.652 t of carbon/km^2/year. Qasim *et al.* (1978) studied the biological productivity of the coastal waters upto 50 m depth in an area of 43 x 10 km extending from Dabhol to Tuticorin for a very brief period of one month during March 1977. They reported that the rate of secondary production was 60 t of carbon/km^2/year.

At Vizhinjam salinity showed considerable variations from year to year; in some years high salinity was characteristic of premonsoon period, while of postmonsoon period in other years. However, pooled annual as well as seasonwise data indicate that high salinity is characteristic of premonsoon period.

Displacement volume of plankton indicates that it is always at the highest during the postmonsoon and lowest during the premonsoon periods. Peaks of planktonic groups noted were more during the postmonsoon period as compared to the premonsoon period.

Temperature, like salinity, showed a sharp decline by the onset of southwest monsoon and increased as the season advanced. But during the postmonsoon period the temperature seldom reached a level as noted during the premonsoon months. Different zooplankters occurring off Vizhinjam, as seen from their distribution in relation to various months of any given year, are capable of tolerating wide fluctuations in temperature and salinity; but there are some groups which cannot tolerate such wide range and they prefer a particular period of the year which is congenial for them to flourish. Peaks of several groups coincide with periods of higher salinities while those with peaks exclusively in lower salinities are very rare. It is not well understood that peak of any given group that occurs in different salinity has the same species composition or not. Further studies on the qualitative composition of peaks with regard to varying salinities are needed.

In the case of temperature, such a preference to higher levels by plankters for their peak distribution is never noticed. On the contrary, the peaks can occur at any period within their overall range. This clearly shows that salinity is the major factor that governs the peak occurrence of planktonic organisms. This may, hence, be cited as the major reason for the occurrence of peaks in different seasons in different years when the salinity conditions are at a higher level.

Maximum values of dissolved oxygen content were noted during premonsoon months and the lowering trend during monsoon was rather negligible. The figures for pre and postmonsoon months were equal in some years.

Phosphate and nitrate contents showed peaks during postmonsoon months while nitrite, during the monsoon period. Blooms outnumbered swarms during the monsoon period, but the condition was just the reverse in the postmonsoon period.

While assessing the pelagic fish landings seasonwise it could be seen that the monsoon period accounted for the maximum landings followed by the postmonsoon period. The bulk in landing

effected during monsoon period may be attributed to the peak landing in 8 groups/species while landings of the postmonsoon period may be said to be the cumulative effect to peak (primary) landings in 4 groups and the secondary peaks in another 8 groups/species.

In the Lakshadweep, during the present investigation, the zooplankton biomass was at its maximum during January-March (premonsoon period) and it was low in all the other months. The fluctuation in the biomass from 0.9-12.9 ml/haul in the lagoon (present investigation) and that in the adjacent open sea from 2.0-16.0 ml/haul (Mathew and Gopakumar, 1986) indicates that the zooplankton biomass is relatively less in the lagoon than in the adjacent open sea. During the studies conducted by Tranter and George (1972) at Kavaratti and Kalpeni Atolls also, it was observed that the biomass depleted enroute from the open sea to the lagoon and they concluded that the coral reef community nourished the incoming plankton. Madhupratap *et al.* (1977) observed that higher diversity in the zooplankton biomass occurred in the waters surrounding the atolls than in the lagoons. The abundance in the zooplankton biomass during January-March in the lagoon indicates that the environmental features prevailing in these months would provide the ideal environment for high zooplankton production.

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References

Annigeri, G. G. 1979. Observations on the hydrographical features of the coastal waters of North Kanara during 1965-1966. *J. mar. biol. Ass. India*, 21 (1 & 2) : 128-132.

Anon. 1976. Progress Report. UNDP/FAO, Pelagic Fishery Project, 17 : 22 pp.

Barlow, P. J. and W. J. Bishop 1965. Phosphate regeneration by zooplankton in Cayuga Lake. *Limnol. Oceanogr.*, 10 : 15-24.

Cushing, D. H. 1973. Production in the Indian Ocean and the transfer from the primary to the secondary level. In: B. Zeitzschel (Ed.) *The Biology of the Indian Ocean. Ecological Studies*. 3, Springer-Verlag, Berlin, pp. 475-486.

David Raj, I. and C. P. Ramamirtham 1981. Distribution of zooplankton biomass, fish eggs and larvae along the west coast of India. *J. mar. biol. Ass. India*, 23 (1 & 2) : 86-140.

Devidas Menon, M. and K. C. George 1977. On the abundance of zooplankton along the southwest coast of India during the years 1971-75. *Proc. Symp. Warm Water Zooplankton*, NIO/UNESCO, pp. 205-213.

Gopinathan, C. P. 1972. Seasonal abundance of phytoplankton in the Cochin Backwater. *J. mar. biol. Ass. India*, 14 (2) : 568-577.

Jacob, Rani Mary and R. Vasantha Kumar 1987. Primary productivity in the nearshore waters of Vizhinjam, Trivandrum. *Ibid.*, 26 (1 7 2) : 66-70.

Kuttyamma, V. J. and C. V. Kurian 1982. Distribution of post-larvae of marine prawns in the southwest coast of India. *Indian J. mar. Sci.*, 11 (3) : 270-272.

Lorenzen, C. J. 1967. Determination of chlorophyll and phaeopigments: Spectrophotometric Equations. *Limnol. Oceanogr.*, 12 : 343-346.

Madhupartap, M., M. V. M. Wafar, P. Haridas, B. Narayanan, P. Gopala Menon and P. Sivadas 1977. Comparative studies in the abundance of Zooplankton in the surrounding sea and lagoons in Lakshadweep. *Indian J. Mar. Sci.*, 6 : 138-141.

Mathew, C. V. and G. Gopakumar 1986. Observations on certain environmental parameters in relation to surface tuna fishery at Minicoy Island, Lakshadweep. *J. mar. biol. Ass. India*, 28 (1&2) : 163-168.

Mathew, K. J. , C. P. Gopinathan, D. S. Rao and A. V. S. Murty 1984. Ecology of mud banks - Zooplankton. *Bull. Cent. Mar. Fish. Res. Inst.*, 31 : 35-39.

——, T. S. Naomi, Geetha Antony, D. Vincent, R. Anilkumar and K. Solomon 1989. Studies on zooplankton biomass and secondary and tertiary production of the EEZ of India. *Proc. First workshop Scient. Results FORV Sagar Sampada*, DOD/ICAR, pp. 59-69.

Mathew, Thresiamma and N. Balakrishnan Nair 1980. Phytoplankton of the Ashtamudi Estuary, Kerala. *Indian J. Mar. Sci.*, 9 : 253-257.

Murty, A. V. S. 1987. Characteristics of neritic waters along the west coast of India with respect to upwelling, dissolved oxygen and zooplankton biomass. *Indian J. mar. Sci.*, 16 (2) : 129-131.

Nair, P. V. R. 1970. Primary productivity in the Indian Seas. *Bull. Cent. Mar. Fish. Res. Inst.*, 22 : 1-58.

NAIR, P. V. R., SYDNEY SAMUEL, K. J. JOSEPH AND V. K. BALACHANDRAN 1968. Primary production and potential fishery resources in the seas around India. *Proc. Symp. Living Resources of the seas around India, CMFRI Special Publication*, pp. 184-198.

NOBLE, A. 1968. Studies on seawater off the North Kanara Coast. *J. mar. biol. Ass. India*, **10** (2) : 197-223.

QASIM, S. Z. 1973. Productivity of backwaters and estuaries. *In* : B. Zeitzschel (Ed.) *The Biology of the Indian Ocean. Ecological Studies* 3. Springer-Verlag, Berlin, pp. 143-154.

——, 1977. Biological productivity of the Indian Ocean. *Indian J. mar. Sci.*, **6** : 122-137.

—— AND C. V. G. REDDY 1967. The estimation of plant pigments of Cochin Backwater during the monsoon months. *Bull. Mar. Sci.*, **17** (1) : 95-110.

——, P. M. A. BHATTATHIRI AND V. P. DEVASSY 1972. The influence of salinity on the rate of photosynthesis and abundance of some tropical phytoplankton. *Mar. Biol.*, **12** : 200-206.

——, M. V. M. WAFAR, SUMITRA VIJAYARAGHAVAN, JOSEPH P. ROYAN AND L. KRISHNAKUMARI 1978. Biological productivity of coastal waters of India from Dabhol to Tuticorin. *Indian J. mar. Sci.*, **7** : 84.

RADHAKRISHNA, K. 1969. Primary productivity studies in the shelf waters off Alleppey, southwest coast of India, during the postmonsoon, 1967. *Mar. Biol.*, **4** : 174-181.

RAMAMURTHY, S. 1963. Studies on hydrological factors in North Kanara Coastal Waters. *Indian J. Fish.*, **10** A (1) : 75-93.

RANI MARY JACOB, K. RAMACHANDRAN NAIR AND R. VASANTHA KUMAR 1981. Zooplankton in relation to hydrography and pelagic fisheries in the inshore waters of Vizhinjam, Trivandrum. *J. mar. biol. Ass. India*, **23** (1 & 2) : 62-76.

—— AND R. VASANTHA KUMAR 1987. Primary productivity in the nearshore water of Vizhinjam, Trivandrum. *Ibid.*, **26** (1 & 2) : 66-70.

SILAS, E. G. 1972. Investigations on the Deep Scattering Layers in the Laccadive Sea. *Proc. First Symp. Corals and Coral Reefs*, MBAI, pp. 257-274.

—— AND P. P. PILLAI 1975. Dynamics of zooplankton in a tropical estuary (Cochin Backwater) with a review on the plankton fauna of the environment. *Bull. Dept. Mar. Sci. Univ. Cochin*, **7** : 329-355.

STEEMANN NIELSEN, E. AND E. A. JENSEN 1957. Primary organic production - the autotrophic production of organic matter in the oceans. *Galathea Rep.*, **1** : 49-136.

STRICKLAND, J. D. H. AND T. R. PARSONS 1968. A practical hand book of seawater Analysis. *Bull. Fish. Res. Bd. Canada*, **167** : 1- 311.

SUBRAHMANYAN, R. 1954. A new member of the Englemineae, *Protoeuglena noctilucae* gen. et sp. nov., occurring in *Noctiluca miliaris* Suriray, causing green discolouration of the sea and mortality among marine organisms off the Malabar Coast. *Indian J. Fish*, **1** : 182-203.

—— 1958. Ecological studies on the marine phytoplankton on the west coast of India. *Mem. Indian bot. soc.*, **1** : 145-151.

—— 1959. Studies on the phytoplankton of the west coast of India. *Proc. Indian Acad. Sci.*, **50** B (4) : 113-252.

—— 1960. Observations on the effect of the monsoons in the production of phytoplankton. *J. Indian bot. soc.*, **39** (1) : 78-89.

—— 1967. Phytoplankton. *Souvenir, 20th Anniversary*. CMFRI, pp. 89-93.

—— 1969. Fisheries oceanography in India. *Indian Farming*, **19** (9) : 47-52.

——, C. P. GOPINATHAN AND C. THANKAPPAN PILLAI 1975. Phytoplankton of the Indian Ocean - some ecological problems. *J. mar. biol. Ass. India*, **17** (3) : 608-612.

THOMAS, P. A., S. LAZARUS, S. G. VINCENT, MADAN MOHAN AND T. A. OMANA 1989. Perch fishery at Vizhinjam for the period 1979 to 1987 (MS).

TRANTER, D. J. AND JACOB GEORGE 1972. Zooplankton abundance of Kavaratti and Kalpeni Atolls in the Laccadive Sea. *Proc. Symp. Corals and Coral reefs, MBAI*, pp. 239-256.

Bull. Cent. Mar. Fish. Res. Inst., 1992, 45 : 38 - 55

MARINE FISH PRODUCTION OF MARITIME STATES OF THE WEST COAST OF INDIA

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ABSTRACT

To highlight the fishery in monsoon, an attempt has been made in this paper to evaluate the impact of monsoon fishing on the exploited marine fish stocks in the west coast of India and the trends in the production of various groups in different seasons discussed.

Except in Kerala where monsoon fishing is intensive due to the Mud Bank fishery and trawling off Sakthikulangara and Kochi, in the rest of the coast fishing activities are not as intensive as in Kerala during monsoon. The major gears used during monsoon are trawls and ring seines in Kerala.

AN OVERVIEW

Prior to eighties monsoon fishing was almost absent on the west coast of India except in Kerala. With the advancements in mechanised fishing and motorisation of country craft, fishing during monsoon was attempted and soon the intensity of fishing started increasing in eighties. Since the monsoon season is considered to be the spawning season for many of the commercially important fish stocks, this development, it is feared may affect the spawning and therefore, recruitment to the fishable stock. The purpose of this paper is to bring out the salient features of monsoon fishing in the west coast and to see whether there is any impact of monsoon fishing on the exploited fish stocks on the basis of data available with the Central Marine Fisheries Research Institute and to identify the gaps in the data base so as to improve the same for obtaining reliable information.

For the purpose of this study the seasons are considered as premonsoon (February to May) monsoon (June to August) and postmonsoon (September to January). This report covers the period from February 1984 to January 1988. The fishery year referred to is from February to January.

During the four year period an average of about 1.1 million tonnes of marine fish was landed annually along the west coast. Kerala accounted for 31% followed by Maharashtra (28%), Gujarat (21%), Karnataka (15%) and Goa (5%). More than 50% of the west coast landings was during postmonsoon accounting for about 0.62 million tonnes followed by premonsoon with 0.36 million tonnes and monsoon with 0.12 million tonnes. During the postmonsoon period, Maharashtra Coast landed more (31%) followed by Kerala (25%), Gujarat (20%), Karnataka (19%) and Goa (5%). During premonsoon also, Maharashtra contributed more (29%). During this season Gujarat landed (27%) marginally more than Kerala (26%), followed by Karnataka (13%) and Goa (5%). However, during monsoon, Kerala ranked first contributing 77% of the west coast landings followed by Maharashtra (13%), Gujarat (4%), Karnataka (4%) and Goa (2%). The impressive record of Kerala during the monsoon is mainly due to landing in the mud bank fishery and the successful fishery off Sakthikulangara and Kochi (Table 1 - 4).

SALIENT FEATURES OF STATEWISE LANDINGS

Kerala : Better catches of perches, whitebaits and penaeid prawns were noticed during the monsoon. About one third of trawl landings was accounted for during monsoon. Monsoon contribution varied from 5 to 32% of the total annual landings of the State.

Karnataka : Monsoon contribution varied from 1.5 to 4.0% of the total marine fish landings in this State. Penaeid prawns and carangids contributed more during this season. Motorised country craft using *Mattubala* contributed more to the penaeid prawn landings in the State during monsoon.

TABLE 1. *Statewise marine fish landings (tonnes) on the west coast during pre-monsoon period (monthly averages in brackets)*

	Kerala	Karnataka	Goa	Maharashtra	Gujarat	W.coast
1984-85	112356 (28089)	30420 (7605)	15640 (3910)	81120 (20280)	91327 (22832)	330,863 (82716)
1985-86	97369 (24342)	26923 (6731)	21575 (5394)	102808 (25702)	106279 (26570)	354,954 (88739)
1986-87	81571 (20392)	55316 (13829)	20181 (5045)	128050 (32013)	113913 (28478)	399,031 (99757)
1987-88	87218 (21805)	69113 (17278)	21621 (5405)	105861 (26465)	74204 (18551)	358,017 (89504)
Average	94,628	45,443	19,754	104,460	96,431	360,716
Percent	26.2	12.6	5.5	29.0	26.7	100

TABLE 2. *Statewise marine fish landings (tonnes) on the west coast during monsoon 1984-88 (monthly averages in brackets)*

	Kerala	Karnataka	Goa	Maharashtra	Gujarat	W.coast
1984-85	96108 (32036)	2024 (675)	4179 (1393)	14400 (4800)	5440 (1813)	122,151 (40,717)
1985-86	88902 (29634)	5324 (1775)	3157 (1052)	13235 (4412)	6049 (2016)	116,667 (38,889)
1986-87	103263 (34421)	6753 (2251)	3372 (1124)	17666 (5889)	5058 (1686)	136112 (45,371)
1987-88	97492 (32497)	3777 (1259)	796 (265)	17008 (5669)	4718 (1573)	123791 (41,263)
Average	96,441	4,470	2,876	15,577	5,316	124,680
Percent	77.3	3.6	2.3	12.5	4.3	100

TABLE 3. *Statewise marine fish landings (tonnes) on the west coast during postmonsoon 1984-88 (monthly averages in brackets)*

	Kerala	Karnataka	Goa	Maharashtra	Gujarat	W.coast
1984-85	168166 (33633)	90476 (18095)	20567 (4113)	218543 (43709)	145254 (29051)	643,006 (128,601)
1985-86	150807 (30161)	100190 (20038)	24554 (4911)	211093 (42219)	136671 (27334)	623,315 (124,663)
1986-87	185445 (37089)	121457 (24291)	37565 (7513)	169583 (33917)	117481 (23496)	631,531 (126,306)
1987-88	118391 (23678)	160206 (32041)	40347 (8070)	157575 (31515)	106716 (21343)	583,235 (116,647)
Average	155702	118082	30758	189199	126531	620,272
Percent	25.1	19.0	5.0	30.5	20.4	100

Goa : With a declining trend in the marine fish landings during monsoon in this State, contribution varied from 1 to 10% in the State.

Maharashtra : Major contribution came from trawling resulting in better landings of penaeid prawns, Bombay-duck, nonpenaied prawns and croakers. On an average, monsoon contribution was 5% only to the annual landings.

Gujarat : Mechanised gill netters and nonmotorised country craft contributed considerably during monsoon. Croackers, penaeid prawns and stomatopods were landed in good quantities during monsoon in this State.

From the above it is clear that monsoon fishery varies from State to State and points out to the need for deeper study. Changes in biological factors of the exploited resources, fishing activities and environmental factors have to be studied to draw valid conclusions on the impact of monsoon fishery on the exploited fish stocks of the region. The reports presented below give more details of the current status of the monsoon fishery in different maritime States of the west coast.

KERALA

The marine fish production in Kerala ranged from a minimum of 3.03 lakh tonnes in 1987 to a maximum of 4.9 lakh tonnes in 1988. The monthly average catch during premonsoon was minimum and maximum during postmonsoon season (Table 5), excepting postmonsoon season of 1987. In this year, an unusual fall in the landings during postmonsoon occurred.

TABLE 4. *Statewise total marine fish landings (tonnes) on the west coast during 1984-88 (monthly averages in brackets)*

	Kerala	Karnataka	Goa	Maharashtra	Gujarat	W.coast
1984-85 Feb Jan	376630 (31386)	122920 (10243)	40386 (3365)	314063 (26172)	242021 (20169)	1,096,020 (91,335)
1985-86 Feb Jan	337078 (28090)	132437 (11036)	49286 (4107)	327136 (27261)	248999 (20750)	1,094,936 (91,244)
1986-87 Feb Jan	370278 30857	183526 (15294)	61118 (5093)	315299 (26275)	236452 (19704)	1,166,673 (97,233)
1987-88 Feb Jan	303101 (25258)	233096 (19425)	62764 (5230)	280444 (23370)	185638 (15470)	1,065,043 (88,753)
Average	346,772	167,994	53,388	309,236	228,278	1,105,668
Percent	31.4	15.2	4.8	28.0	20.6	100

TABLE 5. *Seasonwise total marine fish landings in Kerala (tonnes) and monthly averages during 1984-1988*

Year	Premonsoon		monsoon		Postmonsoon	
	Total catch	Av. monthly catch	Total catch	Av. monthly catch	Total catch	Av. monthly catch
1984	112,356	28089	96,108	32036	168,166	33633
1985	97,369	24342	82,902	29634	150,807	30161
1986	81,571	20392	103,263	34421	185,445	37089
1987	87,218	21804	97,492	32497	118,391	23678
1988	93,262	23316	117,157	39052	282,844	56569

The important groups of fishes and crustaceans that were landed during the five year period were oilsardine, whitebaites, perches, croakers, carangids, mackerel, penaeid prawns, other sardines and catfishes.

Landings of important groups in different seasons

Of the 112,000 t landed in premonsoon of 1984, about 53% was contributed by oilsardine, 7% by penaeid prawns and 4% by perches (Table 6).

In 1984, though the contribution of perches during premonsoon season was only 4,000 t, during monsoon it increased to 17,900 t. Whitebait landings in the monsoon season formed 18% of the catches of the year. Penaeid prawns contributed to 15% of total catch and oilsardine, the least.

In 1985 also the situation was same as in 1984 in the case of oilsardine, whitebait, perches and penaeid prawn landings. However, there was an unusually high landings of ribbonfish during the monsoon and postmonsoon seasons. Of 97,000 t of total landings during the premonsoon period, 38% was accounted for by oilsardine landings. The penaeid prawns contributed to 10% of the total landings. Whitebait and perches contributed about 4% each during the season. During monsoon period perches contributed about 21% whereas whitebait formed 13% of the total catch. The contribution of penaeid prawns was 11%. As in 1984, the postmonsoon season recorded maximum landings in respect of oilsardine (27%) and whitebait (14%). About 5% of the catch was contributed by penaeid prawn during this season. Thus, oilsardine and whitebait landings were maximum during postmonsoon season whereas perches, penaeid prawns and ribbonfishes during monsoon.

Unlike in earlier years, oilsardine and whitebait landings declined in 1986. However, the landings of carangids increased considerably. Total landings during premonsoon was at 82,000 t, of which 20% was accounted for by oilsardine (4,900 t) followed by penaeid prawns (14%) and mackerel (11%). During the monsoon season, maximum landings were obtained in the case of

TABLE 6. *Landings (tonnes) of major groups of fishes and shellfishes in different seasons in Kerala during 1984-88*

Fishes/Groups	1984			1985			1986			1987			1988		
	PRM	M	PSM	PRM	M	PSM	PRM	M	PSM	PRM	M	PSM	PRM	M	PSM
Sharks	3187	678	2079	1194	360	3511	1021	473	3085	1487	553	1171	1538	1667	1912
Catfishes	2632	3046	4917	882	1233	3087	320	903	7277	162	2070	2359	362	3609	6017
Oilsardine	59987	12309	62609	37106	9415	40854	16291	59	8973	1712	17762	25486	2223	7948	66636
Other sardines	1722	1326	4448	1471	161	1908	2751	1821	4516	4860	554	3915	1195	2067	9671
Whitebaits	2399	16883	21153	3490	11342	21506	4866	7964	14265	3356	2787	10605	5155	15065	25853
Perches	3956	17867	4988	5061	18870	6629	4392	29589	12777	8032	15930	6484	8602	16067	7163
Croakers	2217	3706	3331	3394	2745	2295	1678	1676	9648	2233	3049	2851	1922	1829	5196
Ribbonfishes	784	5903	383	97	13348	11720	635	3941	7298	1021	11844	2390	2810	928	5189
Carangids	5481	2042	5872	3717	1959	7350	3048	19546	49464	7631	5191	9702	7229	9847	31657
Mackerel	3878	1533	6214	5332	2306	10476	9196	1221	11815	2896	2795	3880	4108	13257	27260
Seerfish	816	644	4546	1269	414	7145	483	307	3762	1212	649	3309	1694	615	8063
Tuna	2486	1062	2503	3535	1602	4596	570	511	8395	2237	4029	4234	3294	3123	7127
Penaeid prawns	7689	14572	12974	9881	9968	7443	11500	17575	8175	24887	14576	13132	19539	20346	29309
Cephalopods	637	891	4000	3012	1475	2772	1464	1714	12271	2791	736	3539	4779	2358	8049
Others	15085	13646	28149	17928	13704	13288	23356	15963	23724	22521	14967	25334	28818	18431	43742
Total	112356	96108	168166	97369	88902	150807	81571	103263	185445	88218	97492	118391	93262	117157	282844

PRM = Premonsoon; M = Monsoon; PSM = Postmonsoon.

perches (29%) followed by carangids (19%), penaeid prawns (17%) and whitebaits (8%). The postmonsoon season witnessed a major change in the composition of the catches, in that carangids formed the most dominant group (27%) followed by whitebait (8%), perches 7%, cephalopods (7%) and mackerel (6%). Penaeid prawn landings declined considerably and formed 4% of the season's catch.

During 1987, the catches declined with the estimated landings at 3.03 lakh tonnes. The decline occurred mainly during the postmonsoon season. The most dominant group in premonsoon season was penaeid prawns followed by perches, carangids, other sardines and others. In the monsoon season, oilsardine was most dominant followed by perches, penaeid prawns, ribbonfish and others. In the postmonsoon period, the important groups were oilsardine, penaeid prawns, whitebaits, carangids and others.

During the premonsoon of 1988, the landing was highest. The monsoon season witnessed a clear improvement in the landings of penaeid prawns, perches, whitebaites, mackerel and oilsardine compared to premonsoon. In the postmonsoon, the landings of oilsardine increased and touched the level of 66,700 t. The whitebaite estimate was of the order of 25,900 t.

Thus generally, monsoon witnessed better catches of perches, whitebait and penaeid prawns and the postmonsoon season indicated increased landings of oilsardine, whitebait and carangids. The major composition of the catches during the premonsoon season also were oilsardine, penaeid prawns and perches.

Landing by mechanised and non-mechanised units in different seasons

During 1984, about 69% of the total landings of 3.77 lakh tonnes was accounted for by the mechanised sector, of which 33% was contributed by the inboard craft and 36% by the craft fitted with outboard engines. Major gears operated in inboard engine craft were trawl net, drift/set gill net and purse-seines. In the motorised sector, boat seines, ring seines and drift/gillnet were important and the operation of hooks and lines was restricted in certain areas only. In the non-mechanised sector, boat seines, drift/gill net, shore seine and hook and line were the major gears operated during these years. About 74% of the landings of inboard craft was by trawl net. The percentage contributions during premonsoon, monsoon and postmonsoon seasons respectively were 30, 26 and 44 of the total landings of 1984.

In 1985, the landings from both inboard and outboard craft, contributed to 75% of the total landings of 3.37 lakh tonnes. Of this, 1.29 lakh tonnes were from the motorised craft. Seasonwise contributions were 29%, 26% and 45% respectively during premonsoon, monsoon and postmonsoon.

In 1986, the contribution of the inboard craft was 36%, whereas, outboard craft contributed 48%, thereby increasing the total share of mechanised sector catch to the tune of 84%. The non-mechanised catch was about 58,000 t (16%). There was increase in the landings during the postmonsoon season of 1986, the percentage being 50. Premonsoon and monsoon seasons' contributions were respectively 22% and 28%. From 1986 onwards the ring seine started operating from the motorised craft and about 13% of the catches (1.8 lakh tonnes) from this sector was accounted by this gear. 63% of the motorised catch was from the boat seines.

Compared to 1986, there was a reduction of 64,000 t in the catch in 1987, by motorised craft. However, a slight increase in the landings of small mechanised fishing vessels was noticed.

About 4.93 lakh tonnes of fish landings were recorded during 1988. The percentage contributions of inboard craft and motorised craft were respectively 43% and 50%. The artisanal sector brought only 7% of the total landings.

It was observed that there was steady increase in the landings of inboard craft contributing to half of the total landings of the State and the landings in the non-mechanised units decreased except in 1988. Thus year after year, the contribution of non-mechanised sector diminished and that of motorised sector increased.

Important gears and their catches in different seasons

Trawl net was the most important gear used in the purely mechanised sector. There was substantial increase in the catches of trawl net over the years (Table 7).

TABLE 7. *Total marine fish production by trawl net (tonnes) and that realised during monsoon in Kerala*

Year	1984	1985	1986	1987	1988
Total	90,862	98,425	118,020	144,018	202,433
Catch realised during monsoon	36,995	36,936	47,119	36,847	47,759

However, there is no substantial increase in the catches of trawl net during the monsoon season. During 1984, the percentage contribution of monsoon trawl to the total catch was about 41%, but there was no increase in the percentage contribution over the years and during 1988 it came down to 24%. The partial ban on trawl operations during the season might have resulted in the decreased production. However, over the years, an increase in the trawl catch was noticed during the postmonsoon season and during 1988 about 41% trawl catch was attributed to this season.

The drift/gill net forms the next important gear under the mechanised sector. The percentage contribution of gillnet catches to the total mechanised catches varied from 10% (12,900 t) in 1984 to 4% (8,400 t) in 1988. The maximum catch was obtained in the gear during postmonsoon season.

Boat seine was the foremost gear operated in the motorised sector. During 1984, the catches by the boat seine was to the tune of 103,000 t and upto 1986 almost the same trend prevailed. In 1987, the contribution of catches from this gear declined to 48,000 t. The reduction in the catches during 1987 was mainly attributed to the lesser contribution by this gear. However, during 1988, boat seine catches increased to 91,000 t. Nevertheless it was seen that most of the boat seines were gradually replaced by ring seines. Among the seasons, postmonsoon season contributed about half of the boat seine catches all the years.

Ring seine came into existence by the middle of 1986 and soon spread rapidly through out the coast. In 1987, about 30,000 t were accounted by this gear and by 1988, it increased to 88,000 t. About 79% of the ring seine catch was realised during the postmonsoon season.

The contribution from the non-mechanised sector diminished year after year and during 1988 only 7% of the total 4.93 lakh tonnes was accounted for by the non-mechanised sector. Boat seine, drift/gillnet, shore seine and hook and line were the major gears used.

Catch/Unit of major gears in different seasons

Table 8 shows catch/unit effort obtained in trawl unit drift/gillnet, boat seine and ring seine in different seasons.

The catch/unit of effort of trawl unit in different seasons showed much variation. In the premonsoon season it varied between 177 kg and 215 kg, whereas, during monsoon it ranged from 473 kg to 728 kg. Postmonsoon season had a slight edge over the premonsoon season. Monsoon season clearly indicated the abundance of resources, especially that of demersal fishes and crustaceans. Compared to premonsoon season, the catch/unit during monsoon was three times, except in 1988.

The data on C/E of drift/gillnet showed that monsoon season was again the best season, the resources being more abundant as compared to the other two seasons. During postmonsoon, catch rate of drift/gillnet operation on an average was on the higher side, indicating the availability of the resources, especially of pelagic groups.

TABLE 8. *Catch/unit of effort (Kg) by trawl net, drift/gill net (mech.), boat seine and ring seine in different seasons in Kerala during 1984-88*

Year	Trawl net			Drift/gill net (Mech.)			Boat seine			Ring seine		
	PRM	M	PSM	PRM	M	PSM	PRM	M	PSM	PRM	M	PSM
1984	195	563	279	103	176	154	290	298	428	-	-	-
1985	207	622	175	115	164	216	722	316	457	-	-	-
1986	177	728	244	100	118	161	257	265	517	-	247	624
1987	215	605	189	66	250	99	162	239	425	248	649	330
1988	210	473	192	107	196	109	196	310	699	101	456	782

PRM = Premonsoon; M = Monsoon; PSM = Postmonsoon.

The catch per unit of boat seine in the monsoon did not show much variation over the years. Premonsoon season also did not indicate much variation over the years, except in 1985, when an unusually high catch per unit (722 kg) was recorded. The landings of oilsardine was very high during this season. Among the seasons, postmonsoon realised better catch rate ranging between 425 kg (1987) and 699 kg (1988) in this gear.

The catch per unit of ring seine indicated that during the postmonsoon and monsoon seasons better catches were available, the premonsoon being the lean period. The minimum (330 kg) catch per unit was observed during 1987 postmonsoon season which was an unusual phenomenon; otherwise postmonsoon season recorded better catch rate, maximum being 782 kg.

Remarks

The annual estimated landings varied from 3.9 lakh tonnes to 4.5 lakh tonnes during 1985 to 1988, if the unusually low level catches during 1987 was excluded. The catches from the mechanised sector (including motorised craft) increased year after year and in 1988 its contribution rose to 93% of the annual estimate. The increase in the estimated landings could be attributed mainly to two gears, ring seine and trawl net. The catches from ring seines increased from 23,000 t in 1986 to 88,000 t in 1988. It could also be seen that the contribution of the postmonsoon was high, primarily due to the pelagic groups of fishes.

Generally monsoon season witnessed better catches from perches, whitebaites and penaeid prawns and postmonsoon indicated increased landings of oilsardine, whitebaites and carangids. The major composition in the landings of premonsoon season were oilsardine, penaeid prawns and perches.

The increased landing was primarily noticed in the traditional craft, fitted with motors, operating ring seines and marginally in the craft with inboard engine operating trawl net.

Most of the motorised boats operating boat seine were replaced by ring seine and it had spread almost the entire coast. The landings from the purely traditional sector (non-motorised) diminished year after year.

The differential catch per unit in the seasons indicate that the availability of resources is more during monsoon, especially for demersal fishes and crustaceans. However, catch per unit of operation of ring seine and boat seine indicate that the pelagic resources are abundant during postmonsoon season.

With the limitations of the data available for the assessment of the fishery resources of the different seasons, it appears that there is further scope for augmenting the catch during monsoon and postmonsoon seasons especially in the motorised sector provided the area of operation is widened. However, caution has to be exercised while increasing the number and to decrease the mesh size of the ring seine so as to sustain the resources. Continuous monitoring the resources data is of prime importance as innovations are introduced in the gears and more and more units are put into operation.

Karnataka

The marine fish landings in Karnataka ranged from 1.32 lakh tonnes in 1985 to 2.33 lakh tonnes in 1987, the annual average production being 1.5 lakh tonnes (Table 9).

Oilsardine, carangids, mackerel, whitebaites, penaeid prawns and stomatopods formed the major groups in the landings. The oilsardine catches fluctuated between 18,000 t in 1986 and 52,000 t in 1987 and a slight increasing trend was observed, though in 1988 it recorded 44,000 t with an average annual landings of 38,000 t. An improvement in the landings of carangids was observed during the period, the average catch being

Table 9. *Important groups of fishes and prawns exploited in the marine fishery of Karnataka during 1985-88 (in tonnes)*

	1985	1986	1987	1988	Average
Sharks	1349	2031	1522	2026	1732
Catfishes	1433	8802	2412	8766	5353
Oilsardine	36708	18174	51539	44130	37638
Whitebaits	6292	13048	7771	17401	11128
Carangids	9989	28282	24864	23053	21547
Indian mackerel	25139	20794	26213	22952	23774
Penaeid prawns	4335	5601	9624	8332	6973
Stomatopods	11224	19010	45713	24146	25023
Others	35968	67784	63438	54692	55470
Total	132437	183526	233096	205498	150938

22,000 t. However, the landings of mackerel did not indicate any upward trend, the average production being 24,000 t. Whitebaites catch recorded a slight improvement, but in 1987, an unusually low estimate of 8,000 t was recorded. Similarly, the landings of penaeid prawns also showed a slight improvement from 4,300 t of 1985 to 8,300 t in 1988 with an average catch of 7,000 t. Of late, the catches of stomatopods, primarily obtained through trawl net indicated an upward trend.

Seasonal changes

The important groups of fishes that landed in 1985, were constituted by oilsardine, mackerel, carangids, whitebaites and sharks. Among crustaceans, penaeid prawns and stomatopods formed the major share. During premonsoon of 1985, whitebaites, oilsardine, carangids, shark and catfishes landed in good quantities. However, during monsoon season oilsardine, mackerel and penaeid prawns landed only at a lesser magnitude. The postmonsoon season witnessed good catches of oilsardine, mackerel, carangids, whitebaites, penaeid prawns, stomatopods, sharks and catfishes (Table 10). A similar trend was observed in 1986 also; during premonsoon major contributors were oilsardine, whitebaites, mackerel, carangids, penaeid prawns, stomatopods, sharks and catfishes. In 1986, both premonsoon and postmonsoon seasons witnessed good catches of oilsardine, mackerel and whitebaites. Penaeid prawns and stomatopods were also available during these two seasons. However, during monsoon only penaeid prawns were available, but no stomatopods recorded (Table 11).

In 1987, oilsardine was available in all the seasons, whereas whitebait was mainly recorded during premonsoon. Mackerel was primarily available during postmonsoon season. Certain carangid groups were found in all the three seasons (Table 12).

The composition of the landings of major groups in the different seasons in 1988 also indicated a similar trend in the production (Table 13).

Catch per unit of mechanised units

During premonsoon, major gears operated were purse-seines, trawl nets and drift/gillnets (Table 14). Premonsoon was the lean period among

TABLE 10. *Gearwise and seasonwise contribution (tonnes) of major exploited resources in Karnataka during 1985*

Fish groups	Premonsoon					Monsoon					Postmonsoon					
	PS	TR	DN	NM	Total	PS	TR	DN	NM	Total	PS	TR	DN	HL	MN	Total
Shark	47	58	22	461	588	-	-	3	111	114	36	19	223	-	369	647
Catfishes	77	133	7	101	318	-	-	1	6	7	721	91	139	-	157	1108
Oilsardine	4269	1	-	8	4278	150	-	-	-	150	31099	423	758	-	-	32280
Whitebaits	3264	229	-	-	3493	-	-	-	4	4	4594	200	-	-	1	4795
Horsemackerel	-	2	-	1	3	-	-	-	-	-	540	-	1	-	19	560
Scads	-	-	-	-	-	-	-	-	-	-	683	1	-	-	25	709
Leather jackets	3	-	-	-	3	-	-	-	-	-	44	-	636	-	610	1290
Other carangids	360	95	-	145	600	-	-	-	105	105	5948	626	14	-	131	6719
Indian Mackerel	1321	2	-	95	1418	679	-	100	2964	3743	19894	1	17	-	66	19978
Penaeid prawns	56	2760	-	6	2822	-	190	2	62	254	1	1256	-	-	2	1259
Stomatopods	-	5334	-	1	5335	-	-	-	16	16	-	5863	-	-	10	5873
Others	1466	5303	3	1293	8065	-	16	26	889	931	11842	6770	490	3	5867	24972
Total	10863	13917	32	2111	26923	829	206	132	4157	5324	75402	15250	2278	3	7257	100190
Effort in units operation	14258	75764	496	92387		271	752	4290	60105		26066	67233	15164	217	153406	

PS = Purse-seine; TR = Trawl net; DN = Drift/gill net; NM = Non mechanized.

TABLE 11. *Gearwise and seasonwise contribution (tonnes) of major exploited resources in Karnataka during 1986*

Fish groups	Premonsoon					Monsoon					Postmonsoon					
	PS	TR	DN	NM	Total	PS	TR	MTBL	NM	Total	PS	TR	DN	MTBL	NM	Total
Sharks	38	78	731	459	1314	-	-	-	91	91	21	48	430	-	127	626
Catfishes	760	477	114	124	1475	-	-	-	17	17	6936	151	173	-	50	7310
Oilsardine	11009	1	-	57	11067	44	1	1	4	49	6884	-	1	15	158	7058
Whitebaits	5674	107	-	6	5787	-	-	-	15	15	7099	118	-	-	29	7246
Horse mackerel	-	1	-	62	63	-	-	-	-	-	1533	-	-	9	31	1573
Scads	-	1	-	2	3	-	-	-	-	-	10160	-	-	-	-	10160
Leather jackets	7	4	-	-	11	-	-	-	23	23	111	-	51	-	20	182
Other carangids	273	1095	2	82	1452	2	13	3	66	84	13056	1417	79	2	177	14731
Indian Mackerel	411	1	6	130	551	-	1	2	41	44	19838	1	73	-	287	20199
Penaeid prawns	106	3347	-	-	3453	108	77	28	338	551	28	1520	-	-	49	1597
Stomatopods	-	10342	-	18	10360	-	-	-	-	-	8	8616	-	-	26	8650
Others	2664	15638	122	1356	19780	1791	590	339	3159	5879	17045	17913	1600	87	5400	42125
Total	20942	31095	983	2296	55316	1945	682	372	3754	6753	82719	29784	2487	113	6354	121457
Effort in units operation	13174	105192	9297	89460	217123	791	3346	4	74958		22924	70243	25518	746	115030	234461

PS = Purse-seine; TR = Trawl net; DN = Drift/gill net; NM = Non mechanized; MTBL = *Mattubala*.

the seasons. On an average, the catch rate obtained by purse-seiner was 1591 kg, by trawl net 350 kg and drift/gill net 63 kg. Over the years, there was an increasing trend in respect of purse-seine and trawl net landings, suggesting the availability of the resurces. However, catch per unit of drift/gill net in 1988 was the minimum (17 kg).

In the monsoon season, there was a reduction of CPUE of purse-seine over the years. In 1985 it was 3059 kg, but it reduced to 1810 kg in 1988. The average CPUE of purse-seine worked out to 2104 kg during this period. However, catch per unit of trawl net indicated an increasing trend, though in 1987 it recorded 61 kg, the average CPUE

TABLE 12. *Gearwise and seasonwise contribution (tonnes) of major exploited resources in Karnataka during 1987*

Fish groups	Premonsoon						Monsoon						Postmonsoon						
	PS	TR	DN	HL	NM	Total	PS	TR	DN	MTBL	NM	Total	PS	TR	DN	HL	MTBL	NM	Total
Sharks	-	138	248	1	108	495	-	-	-	-	60	60	294	205	269	19	-	180	967
Catfishes	33	223	17	-	29	302	-	2	-	-	13	15	1250	337	177	1	-	330	2095
Oilsardine	5408	-	35	-	27	5478	15	-	283	204	502	43537	6	-	-	-	436	1588	45567
Whitebaits	2731	209	-	-	-	2940	-	1	-	-	15	16	4211	591	1	-	-	12	4815
Horse mackerel	-	-	-	-	-	-	-	-	-	-	5	5	2404	-	10	-	-	20	2434
Scads	-	31	-	-	-	31	-	-	-	-	-	-	2250	47	-	-	-	-	2297
Leather jackets	197	3	8	-	1	209	-	-	-	-	-	-	113	-	68	1	-	15	197
Other carangids	2302	3324	7	-	144	5777	11	18	-	19	81	129	10326	3278	47	3	87	44	13785
Indian mackerel	268	47	8	-	12	335	1		-	58	43	100	202	21839	26	50	-	8753	25676
Penaeid prawns	68	3158	-	-	13	3239	-	198	-	1	488	687	261	5435	-	-	-	2	5698
Stomatopods	5	25336	-	-	1	25342	-	-	-	-	1	1	-	20369	-	-	-	1	20370
Others	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	13952	53676	570	1	914	69113	38	528	79	382	2750	3777	96995	51669	2776	44	606	8116	160206
Effort in units operation	9152	127988	8926	96	45240		35	8720	504	1217	69854		36016	177474	36805	216	680	70106	

PS = Purse-seine; TR = Trawl net; DN = Drift/gill net; HL = Hook & Line; NM = Non mechanized; MTBL = *Mattubala*.

TABLE 13. *Gearwise and seasonwise contribution (tonnes) of major exploited resources in Karnataka during 1988*

Fish groups	Premonsoon						Monsoon						Postmonsoon								
	PS	TR	DN	HL	NM	Total	PS	TR	DN	OBMB	NM	Total	TR	PS	MGN	MHL	OBRN	OBMB	OBGN	NM	Total
Sharks	-	259	85	12	180	536	-	8	-	-	62	70	222	61	474	562	-	1	9	91	1420
Catfishes	204	1343	27	-	97	1671	-	26	-	-	-	26	2695	3831	498	19	-	11	-	15	7069
Oilsardine	20155	28	-	-	607	20790	-	-	-	-	-	-	4	22053	2	-	-	817	-	464	23340
Whitebaits	8369	977	-	-	3	9349	-	7	-	3	329	339	721	6973	-	-	-	9	-	10	7713
Horse mackerel	120	23	-	-	31	174	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scads	-	172	-	-	-	172	7	60	-	-	65	132	-	-	-	-	-	-	-	-	-
Leather jackets	5	15	24	3	-	47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other carangids	1606	2544	26	3	84	4263	-	-	-	-	-	-	4075	14002	68	9	-	62	4	45	18265
Indian mackerel	423	346	8	-	155	932	485	-	2	-	319	806	260	19306	623	-	1	514	22	488	21214
Penaid prawns	269	2667	-	-	-	2936	66	1091	-	856	118	2131	3210	48	2	-	-	-	-	5	3265
Stomatopods	-	13508	-	-	5	13513	-	-	-	-	3	3	10627	1	-	-	-	-	-	2	10630
Others	-	-	-	-	-	-	119	486	44	75	906	1630	12204	12214	2946	29	15	738	48	1344	29538
TOTAL	32154	43477	320	56	1900	77907	677	1678	46	934	1802	5157	34018	78489	4613	619	16	2152	83	2464	122454
Effort in units operation	12926	86696	18360	3268	53409	374	7279	461	1293	37152			108248	3960	49406	1460	13	5493	2905	79256	

PS = Purse-seine; DN = Drift/gill net; NM = Non-mechanized; OBRN = Outboard *ranibala*; TR = Trawl net; HL = Hooks & line; OBMB = Outboard *mattubala*; OBGN = Outboard gill net; MGN = Mechanised gill net; MHL = Mechanised hook & line.

being 193 kg. The landings by drift/gill net also showed an upward trend (Table 14). A remarkable phenomenon noticed during the monsoon season was the operation of *Mattu bala* and over the years, an increasing trend in the operation and catch per unit was noticed. During 1986 monsoon it recorded a CPUE of 360 kg and it rose to 722 kg in 1988, though a slight reduction was noticed in 1987. The average CPUE of *Mattu bala* was 465 kg.

Of the different seasons, postmonsoon season (Table 14) contributed to the maximum production as well as catch per unit. However, over the years, CPUE of purse seine was showing a slightly decreasing trend; during 1988 it recorded 1982 kg, whereas the average CPUE was 2794 kg. The CPUE of trawl net was found almost established around 314 kg, suggesting caution on further increase of effort input by these units. There was an increase in the operation of hook and line during the season and in 1988, it recorded a CPUE of 423 kg, though the average CPUE was 160 kg. There are indications that these units operate in deeper waters and stay back more time in the sea. The *Mattu bala* operation was also on the increase, but catch per unit did not depict a clear trend.

Remarks

During the eighties, marine fisheries in Karnataka made new strides and showed promising trends both in quantity and quality. The operation of purse seine on a commercial basis in 1977 saw the landings increasing again. It could be observed that introduction of trawlers improved the landings of demersal resources and the operation of purse-seines gave a fillip to the production of pelagic resources. *'Mattu bala'* introduced in 1986 is becoming popular, especially during monsoon, when it brings in penaeid prawns.

The major groups of fishes and prawns that landed during 1985 - 1988 were oilsardine, mackerel, carangids, whitebaits, penaeid prawns, stomatopods, sharks and catfishes. The increasing trend in the landings was primarily noticed in the case of oilsardine, carangids and stomatopods. The major groups that landed during premonsoon period was oilsardine, mackerel, whitebaites and sharks and during monsoon penaeid prawns. Oilsardine and carangids landed in all the seasons in 1987 and resulted in the maximum production of 2.33 lakh tonnes. Postmonsoon season generally brought oilsardine, mackerel, carangids, whitebaites, penaeid prawns, stomatopods and sharks. The composition of the landings of major groups over different years indicated more or less similar trends. The average monthly contribution of postmonsoon season was comparatively better than premonsoon.

The major gears used in the machanised sector were purse seine, trawl net, drift/gill net and hook and line. The purse seine landings were the important contributor to the total production in some years it touched 66% of the total production. The minimum percentage contribution of purse-seine was observed in 1987 (48%). Generally, purse-seine catches almost determines the level of production of the State. The next important gear operated along the coast was trawl net and its share in some years touched 45% of the total production. However, the contribution of this gear was to the tune of 39% of the total production in 1988. The drift/gill net contributed only 2% of the total estimates and the major component of the catches were sharks and catfishes. The drift/gill net operation had not improved over the years.

In the recent years the trawlers were seen operating in areas beyond conventional limits,

Table 14. *Catch per unit (Kg) of mechanised units operated in different seasons in Karnataka during 1985-1988*

Year	Premonsoon			Monsoon				Postmonsoon				
	PS	TR	DN	PS	TR	DN	MB	PS	TR	DN	H&L	MB
1985	762	184	65	3059	274	31	-	2893	227	150	14	-
1986	1590	296	106	2459	204	-	360	3608	424	98	-	151
1987	1524	419	64	1086	61	157	313	2693	291	75	203	891
1988	2488	501	17	1810	231	100	722	1982	314	93	423	392
Average	1591	350	63	2104	193	72	465	2794	314	104	160	478

PS = Pure-seine; TR = Trawl net; DN = Drift/gill net; H&L = Hooks & line; MB = *Mattu bala*

often their voyages extending to two days and more. For this purpose, small trawlers are remodelled with extra investments. Trawling is thus shifting gradually towards a capital intensive enterprise.

The motorisation of the country craft was seen picking up momentum for the operation of *mattu bala, rani bala* and gill nets. These units undertaking diversified fishing made it possible to tap the additional resources.

The near shore areas of Karnataka have been heavily exploited. Though marginal increase can be expected from the presently exploited area, the present situation does not warrant any further addition of purse-seines or tralwers as the catch rate is not that high. However, there is good scope for further expansion of drift/gill net fisheries along the coast.

Goa

Goa, with a coastline of 153 km and a continental shelf area of 10,000 Sq. km contributed 3.6% of the total marine fish landings in India during 1984-88. In the fisheries development of the west coast, Goa had played a prominent role by introducing new fishing methods. *Rampani* was introduced first in Goa in nineteenth century and of late introduction of purse-seining on a commercial scale was first effected in Goa. *Yendi* (shore seine) and gill net are the prominent among the indigenous gear operated in Goa and these together contribute nearly 90% of the landings by non-mechanised units. Trawl net, purse-seine, gill net and hooks and lines are the mechanised gears commonly operating in Goa.

Trawl net fishery

On an average 55% of total marine fish landings in Goa was by trawlers. Most of the trawl net landings was during premonsoon season and was least in monsoon period except during 1986. Trawl net fishery was very high in postmonsoon season in 1986 (Table 15).

Fishing effort in terms of unit operation was maximum in premonsoon period, except during 1986 and minimum during monsoon period (Table 15). Catch per unit effort was high during premonsoon and postmonsoon periods. It was minimum during monsoon except in 1985.

On an average 88% of trawl net landing during premonsoon period was constituted by demersal fishes. Stomatopods, penaeid prawns, croakers, crabs, catfishes, soles, big-jawed jumper and silverbellies formed the major demersal fishery of Goa during premonsoon period. During monsoon period penaeid prawns and silverbellies constituted the demersal group of fishes. Stomatopods, soles, penaeid prawns and big-jawed jumper accounted for the demersal group of fishes during postmonsoon. During premonsoon period pelagic fishes like ribbonfishes, other carangids and *Thryssa* sp. form the fishery. In monsoon period, the fishery was very poor. *Thryssa* sp., ribbonfishes and other clupeids formed the pelagic fishery during postmonsoon period.

Table 15. *Effort (units of operation), catch (tonnes), catch per unit effort (kg) of trawlers in different seasons during 1984-88 in Goa (values in brackets are percentage of demersal fish in each season)*

	Premonsoon			Monsoon			Postmonsoon		
	E	C	C/E	E	C	C/E	E	C	C/E
1984	35486	13451 (83)	379	17029	2913 (83)	169	36239	11847 (93)	326
1985	56018	17775 (88)	317	2635	1367 (94)	519	16902	6583 (89)	389
1986	34678	17317 (91)	499	6285	1302 (89)	207	70006	26340 (95)	376
1987	59424	17950 (88)	302	2844	279 (90)	98	32828	12430 (92)	378
1988	45089	20813 (89)	461	2530	346 (90)	13	-	-	-

E= effort, C= catch, C/E= catch per unit.

Gillnet fishery

Only 4% of the average marine fish landings was due to mechanised gillnets. Landings during monsoon period was very negligible in quantitiy (Table 16). Stoppage of gillnetting during monsoon would no way affect the fish landing during monsoon period.

On an average demersal fishes in gillnet landings accounted only 1% during premonsoon and 3% during postmonsoon period.

Among the pelagic group, carangids, lesser sardines, *Scomberomorus guttatus, Euthynnus affinis,* billfishes, *S. commersoni* are the major fishes accounted by gillnetters.

Purse-seine fishery

Twenty three percent of the total marine fish landings in Goa during the period (1984-1988) was by purse-seiners. Purse-seine landing was heavy during postmonsoon season and was least during monsoon period (Table 17). Fishing effort in terms of unit operation was maximum during postmonsoon period and minimum during monsoon period (Table 17). Catch per unit effort was more or less same during premonsoon and postmonsoon period and minimum in monsoon period (Table 17).

Hooks and line fishery

Landings and effort showed a decreasing trend during the period of five years (1980-1984)

TABLE 16. *Gillnet effort (units), catch (t) and catch per unit effort (kg) during 1984-88 in Goa (percentage of total landings in the season is given in the bracket)*

	Premonsoon			Monsoon			Postmonsoon		
	E	C	C/E	E	C	C/E	E	C	C/E
1984	3978	148 (1)	37	4567	35 (1)	8	17523	1019 (5)	58
1985	7009	283 (1)	40	2495	30 (1)	12	29975	2459 (10)	82
1986	22595	589 (3)	26	2910	85 (3)	29	27902	2010 (5)	72
1987	11827	197 (1)	17	463	6 (1)	13	13234	1161 (3)	88
1988	12805	879 (3)	69	398	11 (1)	28	-	-	-

TABLE 17. *Purse seine effort (units), catch (t) and catch rates (kg) in different seasons in Goa during 1984-1988 (% of total landings in the season is given in the bracket)*

	Premonsoon			Monsoon			Postmonsoon		
	E	C	C/E	E	C	C/E	E	C	C/E
1984	1344	1155 (7)	859	620	236 (6)	381	5192	5622 (27)	1083
1985	1866	2015 (9)	1080	-	-	-	9064	12561 (49)	1386
1986	2994	1735 (9)	579	213	85 (3)	399	11752	3936 (10)	335
1987	5443	2499 (12)	459	769	453 (57)	589	17834	25738 (64)	1443
1988	4982 (24)	7038	1413	264 (52)	426	1613			

except for 1984. The decreasing trend continued in respect of landings and CPUE during 1984-1988 also. On an average 0.6% of the marine fish landings in Goa was by hooks and lines. There was no landings during monsoon in 1984 - 1988. There was no hooks and lines operation during premonsoon period for the years 1984 and 1985. During 1987 there was no hooks and lines operation during the postmonsoon period.

Non-mechanised fishery

Only 9% of the average marine fish landings in Goa was by non-mechanised gears. Most of the non-mechanised landings was during postmonsoon period. *Rampani, Yendi* (shore seine) and gillnet were prominent among the indigenous gears operated in Goa.

Fishing effort in terms of unit operation was more or less same during premonsoon and monsoon periods and was maximum during postmonsoon period.

Pelagic fishes constituted the major portion of non-mechanised marine fish landings in Goa during monsoon, premonsoon and postmonsoon periods.

In general, the marine fish landings in Goa during the period 1984-1988 showed increasing trend. Trawlnet fishery was prominent in all seasons during the period. Contribution of hooks and lines fishery was not significant. Major contribution from Purse-seine fishery came during the postmonsoon season.

Maharashtra

Total landings

During the four year period (1984-88), the average annual marine fish landings in Maharashtra was 309,000 t, out of which the contribution of postmonsoon season ranked first forming 61.2%, followed by premonsoon period (33.8%) and monsoon period (5.0%) (Table 18).

Gearwise contribution

Data of 1986-88 indicated that the major contribution (97.2%) was by mechanised units. Among the mechanised units 150,000 t per year came from trawls followed by dol nets (105,000 t), gillnets (27,000 t), purse-seine (5,000 t), hooks and lines (1800 t) and cast nets (140 t). Non-mechanised units put together contributed only 8,300 t to the total annual average of 298,000 t (Table 19).

Table 18. *Seasonwise marine fish landings (tonnes) in Maharashtra during 1984-88 with monthly averages in brackets*

	Premonsoon (Feb.-May)	Monsoon (June-Aug.)	Postmonsoon (Sep.-Jan.)	Total
1984-85	81120 (20280)	14400 (4800)	218543 (43709)	314063
1985-86	102808 (25702)	13235 (4412)	211093 (42219)	327136
1986-87	128050 (32012)	17666 (5889)	169583 (33917)	315299
1987-88	105861 (26465)	17008 (5669)	157575 (31515)	280444
Average	104,460	15,577	189,199	309,236
Percent	33.8 (26,115)	5.0 (5192)	61.2 (37,840)	

Mechanised units

Trawls : As mentioned above, maximum contribution of about 150,000 t forming 50.3% to the total marine fish landings was from trawls. During postmonsoon, the landings were maximum with the annual average of 81,000 t forming 54.2% of the average annual trawl landings followed by premonsoon with 58,000 t (38.5%) and monsoon with 11,000 t (7.3%).

Table 19. *Gearwise and seasonwise marine fish landings (tonnes) in Maharashtra (average of 1986-88, values in brackets are percentages)*

Gear	Premonsoon (Feb.-May)	Monsoon (June-Aug.)	Postmonsoon (Sep.-Jan.)	Total
Trawl net	57717 (38.5)	10938 (7.3)	81268 (54.2)	149923
Dol net	48840 (46.3)	3880 (3.7)	52776 (50.0)	105496
Gillnet	7364 (27.2)	1137 (4.2)	18622 (68.6)	27123
Hooks and lines	882 (49.2)	9 (0.5)	900 (50.3)	1791
Purse-seine	427 (8.3)	- -	4742 (91.7)	5169
Cast net	-	-	72 (100.0)	72

Dol nets : The contribution from dol nets was the second major component in the total marine fish landings of Maharashtra. It contributed nearly 105,000 t to the total average annual landings forming 35.4%. In this case also postmonsoon landings were maximum (53,000 t; 50.0%) followed by those of premonsoon (49,000 t; 46.3%) and monsoon (3,900 t; 3.7%).

Gill nets : The third major contribution was from gill nets with average annual landings of 27,000 t forming 9.1% to the total landings. Here also the landings during postmonsoon were maximum (18,600 t; 68.6%) followed by those in premonsoon (7,400 t; 27.2%) and monsoon (1100 t; 4.2%).

The contribution from other gears such as purse-seines, hooks and lines and cast nets was about 2.4% only and the trend in their seasonwise contributions remained as in other gear mentioned above.

Non-mechanised units

Under this group comes small bag nets called *Bokshi*, cast nets and others. All these units contributed 2.8% only to the total annual marine fish landings of Maharashtra. The seasonwise trend was the same as found for other gear considered earlier. Maximum contribution was during postmonsoon period with 5,200 t forming 62.7% of the annual landings of non-mechanised units. During premonsoon period the landings were 1700 t (20.8%) and in monsoon the contribution was 1,400 t (16.5%) indicating that when compared to mechanised units, the relative contribution of non-mechanised units was more during monsoon period.

From the foregoing it is clear that during monsoon the operations of trawlers were more than other mechanised units and their contribution to the total landings was also considerable.

Resource-wise contribution

Among the finfish resources, Bombay-duck topped the list contributing about 16.0% to the total marine fish landings in Maharashtra followed by penaeid prawns (14.9%), non-penaeid prawns (14.4%), clupeids (8.3%), croakers (7.5%), ribbonfish (5.1%), pomfrets (4.2%), catfishes (3.9%), cephalopods (3.7%), elasmobranchs (3.4%), carangids (2.0%), perches (2.2%), seerfishes (2.1%), flatfishes (1.7%), eels (0.9%), tunnies (0.6%) and lobsters (0.5%).

Bombay-duck : The landings of Bombay-duck was maximum during postmonsoon season (32,000 t) and minimum during monsoon season (1600 t). During premonsoon season its contributions was 16,000 t (Table 20).

Penaeid prawns : Similar to the seasonal trend of Bomby-duck, this group contributed 29,000 t during postmonsoon season followed by 11,000 t during premonsoon and 6,300 t only during monsoon seasons.

Non-penaeid prawns : The contribution from this group more or less remained the same during postmonsoon (22,000 t) and during premonsoon season (21,300 t). During monsoon period only 1100 t of non-penaeid were landed.

Clupeids : Following the trend of Bombay-duck, this group contributed maximum (16,000 t) during postmonsoon period followed by 8500 t during premonsoon and 1100 t during monsoon seasons.

Croakers : With the same trend as above, maximum contribution of this group was during postmonsoon season with 15,000 t followed by 6800 t during

TABLE 20. *Seasonwise contribution (tonnes) of major resources to the marine fish landings of Maharashtra (averages of 1984-1988)*

Resource	Premonsoon (Feb.-May)	Monsoon (June-Aug.)	Postmonsoon (Sep.-Jan.)	Total
Elasmobranchs	4454	556	5348	10358
Eels	1148	72	1495	2715
Catfishes	4732	597	6675	12004
Clupeids	8477	1096	16053	25626
Bombayduck	16036	1571	31749	49356
Perches	2986	455	3507	6948
Croakers	6815	1096	15252	23163
Ribbonfish	5423	597	9749	15769
Carangids	1444	237	5633	7314
Pomfrets	3402	389	9095	12886
Seerfishes	1542	117	4748	6407
Tunnies	318	43	1525	1886
Flatfish	1826	192	3125	5143
Penaeid prawns	10919	6304	28848	46071
Non-penaeid prawns	21381	1130	22091	44602
Lobster	515	132	914	1561
Cephalopods	2363	99	9065	11527
Others	10686	884	14326	25896

premonsoon and only 600 t during monsoon seasons.

Ribbonfishes : Falling in the same line as croakers, landing of this group was maximum (9700 t) during postmonsoon and only 600 t during monsoon seasons.

Pomfrets : Maximum landings of about 4100 t were recorded during postmonsoon season followed by 3400 t during premonsoon and only 400 t during monsoon seasons.

Catfishes : During postmonsoon and premonsoon seasons the landings of catfishes were 6700 t and 4700 t respectively with a minimum of 600 t during monsoon seasons.

Cephalopods : In this case also maximum landings were in postmonsoon and premonsoon seasons with 9100 t and 4700 t respectively and minimum of 100 t only during the other season.

Elasmobranchs : The contribution of this group during postmonsoon and premonsoon periods was 5300 t and 4500 t respectively showing relatively less variations as in the case of non-penaeid prawns. During monsoon season the landings were low (600 t).

Carangids : Carangids also contributed maximum (5600 t) during postmonsoon season followed by 1400 t and 240 t during premonsoon and monsoon seasons respectively.

Perches : With contribution of 3500 t and 3000 t during postmonsoon and premonsoon seasons and with 460 t during monsoon seasons the trend remained the same for this group also.

Seerfishes : The landings of this group was maximum (4700 t) during postmonsoon season. Only 1500 t and 120 t were landed during premonsoon and monsoon seasons.

Flatfises : During postmonsoon and premonsoon seasons the landings were 3100 t and 1800 t respectively. During monsoon season the landings were only 200 t.

The other resources that have contributed to less than 1% of the total landings, significant among them being tunnies and lobsters. During post, pre and monsoon seasons the landings of tunnies were about 1500 t, 300 t and 40 t respectively. In the case of lobsters for these seasons the landings were 900 t, 500 t and 130 t respectively.

The contribution of the rest amounted to 8.4% to the total annual marine fish landings in Maharashtra during 1984-88. In this case also postmonsoon landings were maximum (14,000 t) followed by premonsoon (11,000 t). During monsoon season the landings were very low to the tune of about 900 t only (Table 20).

Remarks

In the light of the above it is clear that monsoon landings were very much less when compared to the other two seasons. The resources that contributed more than 1000 t during monsoon were penaeid prawns (6300 t), Bombay-duck (1600 t), non-penaeid prawns (1100 t) and croakers (1100 t), indicating that relatively more operations of shrimp trawling were resorted to during this season than other gears. Gearwise analysis also indicated that 11,000 t was contributed by the trawls during monsoon period followed by dol nets with 3900 t and gillnets with 1100 t.

In the overall average annual landings of 309,000 t, contribution during monsoon season was 16,000 t forming 5% only. To answer whether this resource would be available for exploitation in the subsequent period in the event of suspension or absence of monsoon fishing or not, detailed biological and environmental studies are required.

Gujarat

Marine fisheries is of great significance in Gujarat in view of its rich resources. The State has 1260 km coastline and about 165,000 Sq. km continental shelf area. The prominent fishing gears employed by fishermen in Gujarat are trawls, gillnets, dolnets (bag nets) and other traditional gears. The total marine fish production of the State has fluctacted between 185,638 and 248,999 tonnes during 1984-89 (Table 4).

Trawlnet fishery

On an average 49.5% of total marine fish landings in Gujarat was by mechanised trawlers. Most of the trawl net landing was during the postmonsoon season (52.1%). Trawl net fishing was least during the monsoon period forming only 0.4% of total trawl net landings. Fishing effort in

terms of unit operation was maximum in premonsoon period, except during 1985 and minimum during monsoon. Catch per unit effort was more during premonsoon period in all the years other than 1986 and 1987 when compared with other seasons. Catch per unit effort was very low during monsoon period (Table 21).

On an average 76.7% of trawl net landings was constituted by demersal fishes. Croakers, crabs, penaeid prawns, big-jawed jumper, stomatopods, in the order of abundance, formed the major demersal fisheries of Gujarat State during premonsoon and postmonsoon periods by trawls. During monsoon period, the demersal groups such as croakers, penaeid prawns and stomatopods formed the major fisheries. Among the pelagic fishes, ribbonfish, other clupeids, *Coilia*, wolf herring and *Thryssa* in that order, constituted the major fisheries during premonsoon period and *Thryssa*, ribbonfish, other clupeids, *Coilia* and wolf herring during postmonsoon period. Pelagic fishery during monsoon period was contributed mainly by *Coilia*, *Thryssa* and other clupeids.

Gillnet fishery

Nineteen percent of the average marine fish landing in Gujarat during 1984-88 was from mechanised gillnetters. 51% of the gill net landings was during postmonsoon period, 42% during premonsoon period and remaining 7% during monsoon period. The fishing effort in terms of unit operation was maximum during postmonsoon period except during 1986 and minimum during monsoon. On an average it was only 8.8%. There was not much difference in catch per unit effort from season to season. However, the average catch per unit effort was more during postmonsoon period and least during monsoon period (Table 22).

More than 52% of the average marine fish landings in Gujarat during monsoon period was from mechanised gillnetters. Hence stoppage of gillnetting during monsoon would affect the marine fish landings during monsoon, since there was not much difference in catch per unit effort from season to season, marine fish landing can be increased during monsoon by increasing gillnet operations.

On an average 55% of gillnet landings were constituted by demersal group of fishes, wolf herring, other shads, ribbonfishes, seerfishes and other tunnies, clupeids, horse mackerel and leatherjackets contributed the major pelagic fisheries of Gujarat by gillnetters. Among the demersal fishes, sharks, catfishes, croakers and pomfrets formed the major group in the gill net landings.

Dol net fishery

Twenty three percent of the average marine fish landings in Gujarat was by dol net. Most of the dol net landings was during postmonsoon period (68%), only 0.6% of dol net landings was during monsoon season. Fishing effort in terms of unit operation was maximum during postmonsoon and minimum during monsoon period (3%). The catch per unit effort was minimum during monsoon season. On an average catch per unit effort

TABLE 21. *Trawl landings (tonnes), Effort (unit operation) and Catch per Unit Effort (Kg) in different seasons in Gujarat during 1984-1988*

	Premonsoon			Monsoon			Postmonsoon		
	Catch	Effort	CPU	Catch	Effort	CPU	Catch	Effort	CPU
1984	58806 (64)*	45143	1302	236 (4)	547	431	57018 (39)	44913	1264
1985	44484 (42)	31757	1401	412 (7)	1582	260	73232 (54)	54217	1351
1986	61977	48806	1270 (54)	206	276	746 (4)	52279	37383	1348 (44)
1987	49423 (67)	47610	1038	764 (16)	1864	408	52972 (44)	44088	1202
1988	36753 (62)	34093	1078	379 (5)	1241	305			

* Percentage of trawl landing in the total landings.

TABLE 22. *Seasonwise gillnet landings (tonnes), Effort (unit operation) and CPU (Kg) in Gujarat during 1984-88*

	Premonsoon			Monsoon			Postmonsoon		
	Catch	Effort	CPU	Catch	Effort	CPU	Catch	Effort	CPU
1984	13639 (15)*	95660	143	2902 (53)	18256	159	23141 (16)	142132	163
1985	29810 (28)	11438	260	3068 (51)	24447	125	30443 (22)	153581	198
1986	15057 (13)	160915	94	3741 (74)	34103	110	20680 (18)	129476	159
1987	15923 (21)	113289	140	2226 (47)	23581	94	16990 (16)	122048	139
1988	12099 (20)	111445	108	2715 (38)	26025	124			

*Percentage of gillnet landing in the total landings.

was more during postmonsoon period. Dol net operation during monsoon season was not economical. Only 7% of the monsoon fish landings was contributed by dol net. 74% of the dol net landings was constituted by pelagic group of fishes. Bombay-duck, *Coilia*, ribbonfish and other clupeids formed the major group of fishes in the dol net landings of Gujarat during this period (Table 23).

Marine fish landings by non-mechanised craft

Only 7% of the average marine fish landings in Gujarat was by non-mechanised gears. Most of the non-mechanised landing was during monsoon period. Fishing effort in terms of unit operation was more during premonsoon period and less during the monsoon season. Generally, the catch per unit effort was low during monsoon period. Even then, non-mechanised gears contributed significantly towards the total marine fish landings in Gujarat during monsoon period (Table 24). Pelagic fishes constituted the major portion of non-mechanised marine fish landings in Gujarat during premonsoon and postmonsoon periods, whereas demersal fishes dominated the fishery during monsoon period (Table 24).

Apart from the above gears, hooks and lines was also operated during this period in Gujarat, contributing very little towards the total marine fish landings of the State.

REMARKS

Marine fisheries play an important role in the economy of Gujarat. About 23,000 families in the coastal villages are engaged in fishing and allied activities. Trawling is the major fishery in Gujarat, contributing 44.5% of the total marine fish landings of the State. But catch per unit effort is showing a declining trend over the years. It is very low during monsoon season and its contribution to total

TABLE 23. *Seasonwise dol net landings (tonnes), Effort (unit operation) and CPU (Kg) in Gujarat during 1984-1988*

	Premonsoon			Monsoon			Postmonsoon		
	Catch	Effort	CPU	Catch	Effort	CPU	Catch	Effort	CPU
1984	9487 (10)*	21363	444	459 (6)	5445	84	57352 (49)	72213	794
1985	19136 (18)	33082	578	414 (7)	5044	82	14019 (18)	136506	176
1986	33070 (20)	32967	1003	85 (2)	1407	60	34763 (30)	36205	960
1987	4646 (6)	31426	148	321 (7)	2592	124	28406 (27)	83546	340
1988	7738 (13)	33447	231	766 (1)	5552	142			

* Percentage of dol net landings.

TABLE 24. *Seasonwise catch (tonnes), effort (unit operation) and CPU (Kg) by nonmechanised craft in Gujarat during 1984-1988*

	Premonsoon			Monsoon			Postmonsoon		
	Catch	Effort	CPU	Catch	Effort	CPU	Catch	Effort	CPU
1984	9395 (10)*	235958	40	1841 (34)	118496	15	7725 (5)	140040	53
1985	12849 (10)	209482	62	2155 (36)	111934	20	8474 (6)	254445	33
1986	3430 (3)	182830	10	701 (14)	64434	8	4203 (4)	150037	28
1987	4188 (6)	175299	24	1372 (29)	122505	11	8093 (8)	224920	35
1988	2453 (4)	180604	14	3240 (45)	171437	19			

* Percentage of non-mechanised landings in the total landings.

marine fish landings in Gujarat during monsoon season also is not much.

Major share of monsoon fishery in Gujarat during 1984-88 was by mechanised gillnetters. There was not much difference in catch per unit effort from season to season. By increasing gillnet operation, during monsoon seasons, marine fish landings could be increased during that period.

Contribution of dol net fishery during monsoon season, to the marine fish landings in Gujarat was not much. Catch per unit effort was very low during this period. Hence increasing dol net effort is not of much use to the marine fish landings during monsoon season.

Non-mechanised gears contributed considerably to the marine fish alndings during monsoon season in Gujarat. Hence continued operation of non-mechanised gears during monsoon season is of paramount importance to the monsoon fishery of Gujarat.

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4. 2

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : TUNAS AND BILLFISHES

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ABSTRACT

Despite the fact that several communications in the past have dealt with the trend of tuna fishery at different centres along the west coast of India, no directed attempt has been made till date to study the tuna fishery during the southwest monsoon period along this coast and to synthesise its problems and prospects. The present communication deals with their trend, general fishery, craft and gear employed in the fishing, fishing grounds, seasonal variation in catch, effort and catch rate and characteristics during *premonsoon, monsoon* and *postmonsoon* seasons. In addition, the species composition and length composition of major species during different seasons and available information of the spawning biology of tunas along the west coast of India are also dealt with. The effect of tuna fishing, demand and price structure during monsoon period as compared to other seasons and the management measures are also presented and discussed.

At present, monsoon fishery for tunas is confined to the Kerala Coast along the west coast of India. Continued operation of Pablo boats, motorisation of the traditional crafts and innovation in the gears gave a sudden fillip in tuna production in this State since 1984. Results of study indicate that in other maritime States also, the extended area of operation and diversified fishing through motorisation of country crafts, for high priced larger pelagics including tunas, have enhanced the revenue of the small scale fishery sector. However, in view of the dwindling catch rates observed at certain centres during the present study, caution has to be exercised in promoting indiscriminate motorisation programme in the tuna fishery in the artisanal sector, eventhough no conflict has been reported between the fishermen operating non-motorised and motorised crafts (7 to 24 HP) operating for tunas.

Suitable demarcation of the region between sub-sectors, installation of Fish Aggregating Devices (FADs), diversification of fishing operation by the introduction of multi-day boats for driftnetting, increasing the mobility of purse seiners and intensification of the troll line and handline fishery during monsoon season by sail power are the suggested management measures for augmenting production of tunas during the southwest monsoon period along the west coast of India.

INTRODUCTION

Several communications in the past have dealt with the fishery characteristics, biology and management strategies of tuna fishery from different centres along the west coast of India (Silas *et al.*, 1979, 1984, 1986a, 1986b, 1986c, 1986d; Dhulkhed and Annigeri, 1988; Dhulkhed *et al.*, 1982; Muthiah, 1982, 1986; Saxena, 1984; Silas and Pillai, 1982, 1986a, 1986b; Madan Mohan *et al.*, 1986; James and Pillai, 1986, 1988, 1991; James and Jayaprakash, 1988; Jayaprakash, 1989; James, 1991; James *et al.*, 1986a, 1986b; Gopakumar and Sharma, 1989; Gopakumar *et al.*, 1986; Kurup *et al.*, 1987; Nair *et al.*, 1988; Kumaran *et al.*, 1988; Rao and Alagaraja, 1988; Lipton *et al.*, 1988; Pillai, 1990a, 1990b, 1991; Pillai *et al.*, 1986; Kagwade *et al.*, 1989; Balan *et al.*, 1989; Sivadas and Balasubramanian, 1989; Yohannan and Balasubramanian, 1988, 1989).

The tunas and billfishes landed from the neritic waters of the east and west coasts of India and Lakshadweep by the artisanal sector increased from 20,350 t in 1984 to 31,170 t in 1988. Of these, about 85.6% has been contributed by the tuna fishery along the west coast of India and Lakshadweep.

While examining the motorisation of the country crafts in Kerala, Balan *et al.* (1989) opined that the total marine fish landings were highest during monsoon (July to September) and post-monsoon periods (October to December), followed by summer (January to March) and premonsoon seasons (April-June). Areawise, highest landings were recorded during the monsoon season from the south and central Kerala, while in the post-monsoon season, maximum catches were obtained from the northern Kerala. According to them, the total tuna catch in Kerala by mechanised vessels increased from 2376 t (1980) to 11,960 t (1986) while tuna production by non-mechanised crafts declined from 8235 t (1980) to 2824 t (1986). High catch rates

of tunas by mechanised vessels along the Karnataka and Goa Coasts have been reported (Kurup *et al.*, 1987). In general, it is observed that the motorisation of the country crafts, improvement and innovation of the gears and the implementation of effective operational techniques have paved the way for the enhancement of tuna production along the west coast of India and Lakshadweep, especially in Kerala where active tuna fishing by mechanised crafts and motorised country crafts employing drift gillnets and hooks and lines are in operation during monsoon season. In the present communication, the tuna fishery characteristics and certain aspects of the biology of major species during premonsoon, monsoon and postmonsoon period along the west coast of India and Lakshadweep are comprehensively presented, the effect of tuna fishing during monsoon season on the resource are discussed and management measures are suggested.

Data Base

The present study is based on the tuna fishery data available during the period 1984-88 from Vizhinjam, Cochin, Calicut (Kerala), Mangalore (Karnataka), Goa and Minicoy Island and Agatti Island (Lakshadweep). In order to make the report comprehensive, available published information on the tuna fishery from the maritime States of Maharashtra and Gujarat along the northwest coast of India has also been included.

Observations

Crafts, gears and fishing grounds

The details of major crafts and gears employed in the tuna fishery along the west coast of India are presented in Table 1. Recent improvements in the crafts and gears include the fibreglass coated plank built boats of 5.5 m OAL with OB engines, catamarans fitted with OB engines, capable of reaching the new fishing grounds at 60-80 m depth zone for drift gillnet and hooks and line operations off Vizhinjam (Gopakumar and Sharma, 1989); introduction of plank built boats ('Kettuvallams') of 9 m OAL, with trasorn sterns to accommodate the OB engines, usage of mariner's compass for tuna fishing operations in the offshore areas and increased use of ringnet, which surround tuna shoals both horizontally and vertically (Yohannan and Balasubramanian, 1989; Sivadas and Balasubramanian, 1989) at Calicut.

Traditional fishing ground for tuna fishery was upto 40 m depth zone. But with the introduction of mechanisation of country crafts and innovations in the gears the tuna fishing operations have extended upto 80 m depth zone.

Gearwise catch and effort at different centres

Vizhinjam : The monthwise average catch, effort and C/E of tunas and the average monthwise tuna catch in the total fish catch are given in Figs. 1 and 2. The effort ranged from 5896 units in June to 9548 units in October. The average catch varied between 100.8 t in January to 333.5 t in September. The lowest catch rate of 13.6 kg was in January and the highest (41.4 kg) in September. The productive months were observed to be May and September-October with regard to the tunas. The average catch of billfishes ranged from 0.3 kg in August to

Table 1. *Crafts and gears engaged in the tuna fishery in India*

Crafts				Gears			
Type	OAL (m)	Material	Power (HP)	Length (m)	Depth (m)	Mesh size (cm)	No. of crew
Pablo boats	7.6-9.1	Wood	Inboard engine (24-45)	Drift Gillnets (800-1200)	5-8	6.5-14.0	3-4
Plank built boats/Dugout Canoes	5.5-9.0	Wood	OB Engine (7-12)	-Do-	-Do-	-Do-	3-10
Purse seiners	13.0-14.0	Wood	105-120	Purse seine (400-600)	40-60	1.4	16-25
Pole & line Boats	7.9-9.1	Wood	10-40	Pole = 3-4	-	-	10-15
Troll line Boats	3.0-8.8	Wood	Sail/OB Engine (7-12)	Troll line = 3-5	-	-	4-10
Catamaranas	7.5-8.4	Wood	OB Engine (7-12)	Drift gillnets & Hooks and lines			Variable

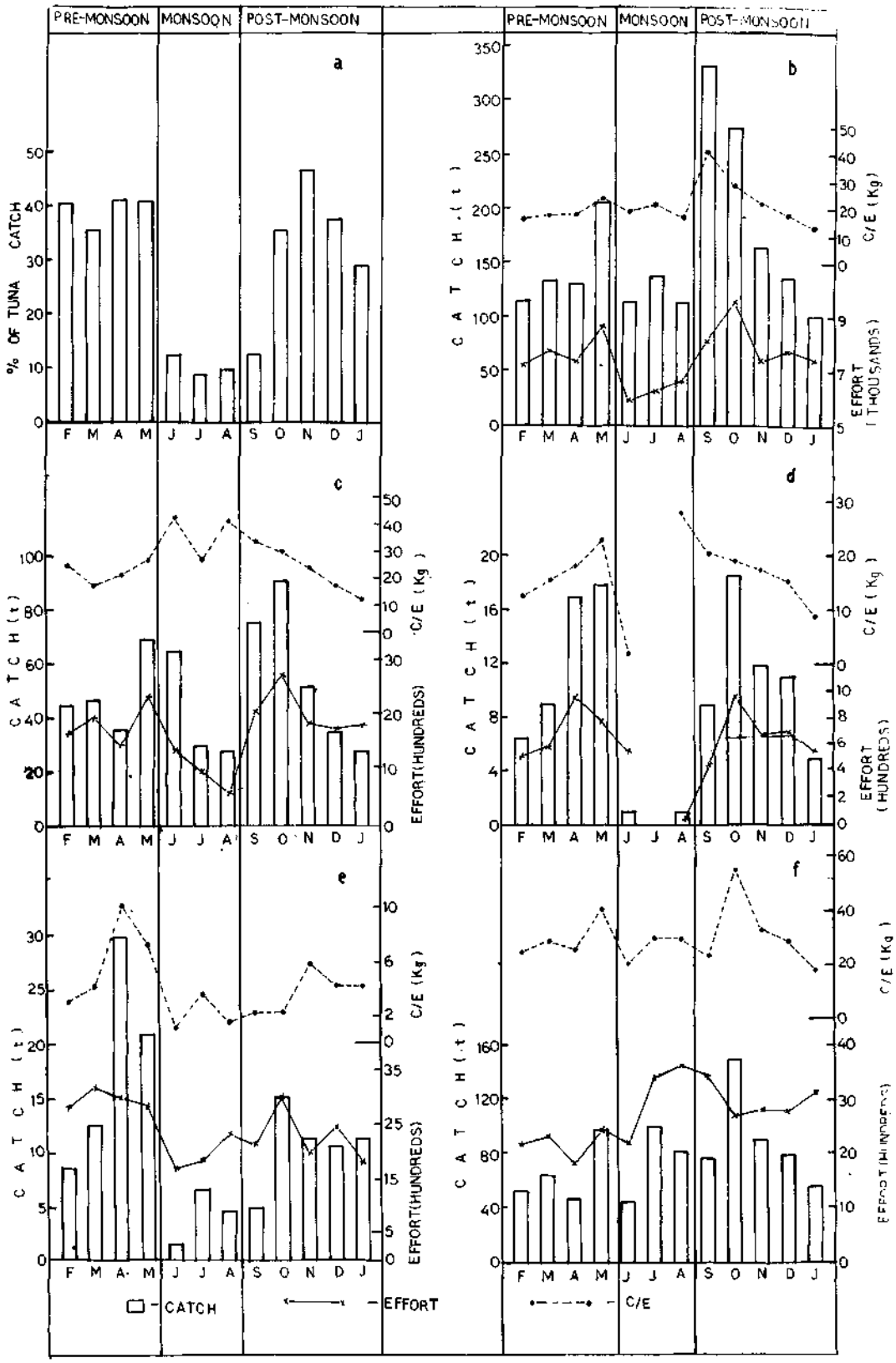


Fig. 1 a. The monthwise percentage of tuna catch in the total fish; b. Monthwise average catch, effort and C/E of tunas; c - f. Average monthly catch, effort and C/E of tunas in different gears (c = drift net, motorised; d = driftnet, non- motorised; e = Hooks and line, non-motorised; f = hooke and line, motorised) at Vizhinjam 1984-88.

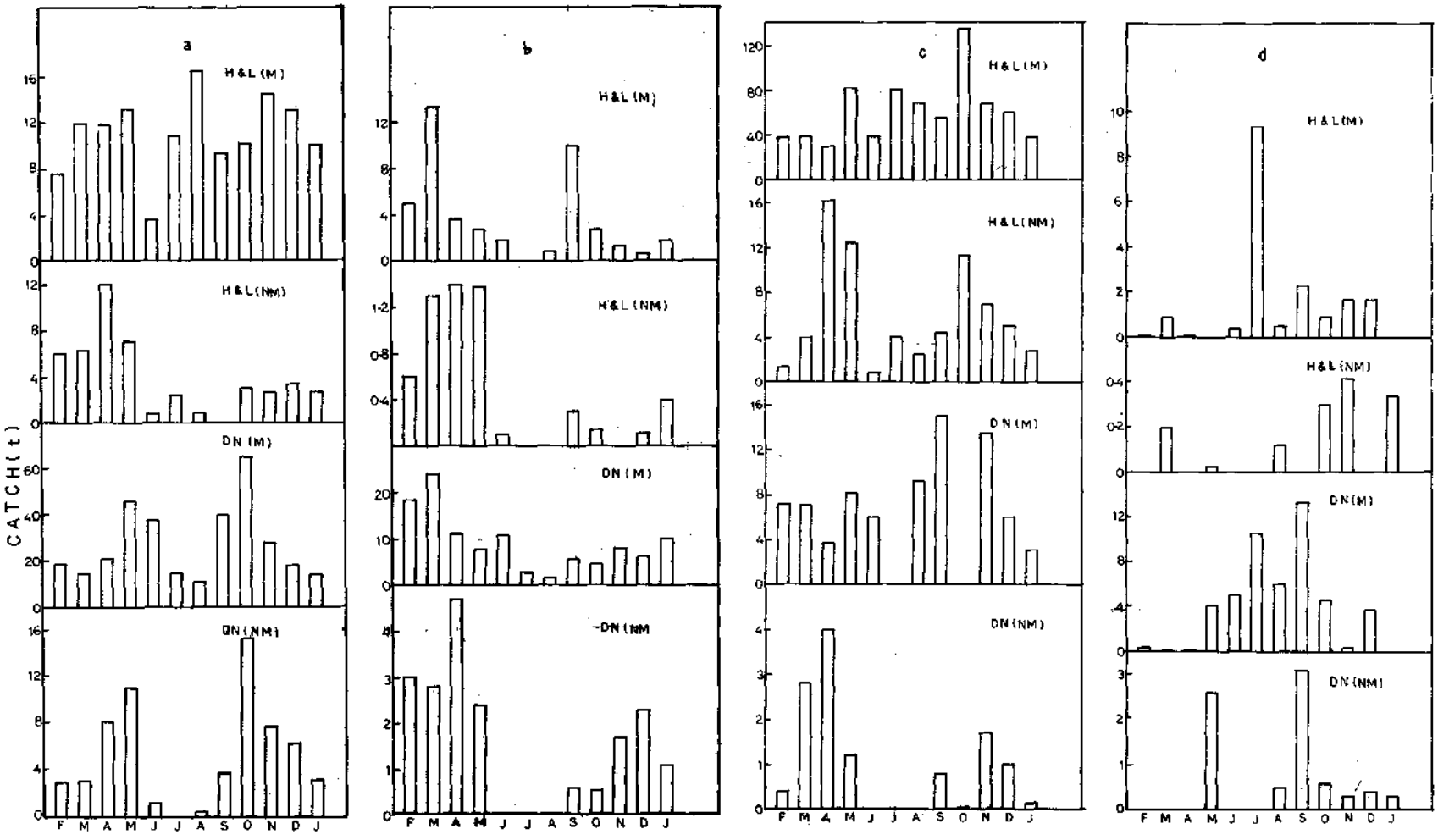


Fig. 2. The gearwise and monthwise catch of different species: a = *E. affinis;* b = *A. thazard;* c = *A. rochei;* d = *S. orientalis* at Vizhinjam.

7.9 kg in January. The peak fishing months were January to April. Maximum tuna catch was landed by hooks and lines (52.7%) operated from motorised crafts followed by drift nets operated from motorised crafts (33.6%) Hooks and lines and drift nets operated from non motorised crafts yielded only 7.7% and 6.0% respectively of the total tuna catch. Motorised hooks and lines landed 41.3% of the billfishes and motorised drift nets landed 23% of the total billfish catch.

The annual effort by non-motorised drift gillnetters varied from 1961 units in 1987-88 to 10,722 units in 1984-85. A reduction in the effort was seen from 1984-85 onwards. Maximum catch was in 1985-86 (175.9 t) and minimum catch was during 1987-88 (32.6 t). However, the C/E ranged from 13.9 kg per unit in 1984-85 to 21.3 kg per unit in 1985-86. May was the productive month in tuna fishery by these crafts. An increasing trend in the effort of motorised drift netters was observed from 1985-86. The annual effort ranged from 6677 units in 1984-85 to 26,515 units in 1987- 88. The annual catch ranged from 242.5 t in 1984-85 to 764.3 t in 1987-88 and the catch rate varied from 21.4 kg in 1986-87 to 36.3 kg in 1984-85. The peak catch and catch rates by motorised drift gillnetters were during May-June and September-October. The annual effort of hooks and line operated from non-motorised crafts ranged from 71,575 units in 1984-85 to 7746 units in 1987- 88. The tuna catch ranged from 201.9 t in 1984-85 to 41.0 t in 1987-88. The C/E showed a marginal increase from 2.8 kg (1984-85) to 14.1 kg (1987-88). The annual effort of motorised hooks and line ranged from 12,734 units (1984-85) to 37,940 units (1987-88). Range of catch and catch rates during these years were 236.3 t to 1154.5 t and 18.6 kg to 32.8 kg respectively.

TABLE 2. *Catch, effort expended and C/E of tunas in the purse seine fishery at Cochin 1984 - 88*

	Season	Catch (t)	Effort (units)	C/E (kg)
1984-85	PRM	-	4203	-
	PTM	-	4428	-
1985-86	PRM	16.4	3851	4.3
	PTM	265.1	2315	114.5
1986-87	PRM	261.2	1286	203.4
	PTM	1085.9	690	1573.0
1987-88	PRM	73.5	1018	72.2
	PTM	-	643	-

(PRM = Premonsoon season; PTM = Postmonsoon season)

Cochin : Monthwise total landings of tunas and billfishes by the drift gillnet fishery and purse seine fishery, effort expended and C/E are presented in Figs. 3, 4 and 5. The total catch and catch rate were relatively high during April-June period. In all the years considered, the C/E was maximum in June, except in 1985-86 when peak catch rate was recorded in April. Relationship between the monthwise effort and trend of monthly catch rate in the drift gillnet fishery indicated that the effort expended and catch rates were relatively high during April-August. Purse seine operations were confined during premonsoon and postmonsoon months only. The average effort expended during the premonsoon season was realtively high when compared to that of the postmonsoon months (Table 2). The catch and catch rate during the postmonsoon season were 280% and 390% respectively higher than that of the premonsoon season.

Calicut : The monthly catch of tunas and effort expended during different years are presented in Fig. 6. Peak catch was recorded in October during the years 1984-86 when the effort was also high. Minor peaks were observed in March-April period also. In 1987- 88, peak catch and effort was in July. Only drift gillnetters were employed in the tuna fishery.

Mangalore : The catch, effort and C/E in the drift gillnet fishery and purse seine fishery are presented in Fig. 7. Both the gears were operated during the premonsoon and postmonsoon months. October was found to be the productive period which accounted for 71% of the total catch followed by November. In the purse seine fishery, September and October during the postmonsoon season and March during the premonsoon period recorded high catch and catch rate.

Goa : The drift gillnet operations were confined to the months of Sepetmber to January. As in the case at Mangalore, maximum catch and catch rate were recorded during October followed by November (Table 3).

Minicoy and Agatti Islands (Lakshadweep) : Monthwise total tuna landings and the effort expended by the pole and line fishery and troll line fishery along with the C/E realised are presented in Figs. 8, 9 and 10. In the pole and line fishery at Minicoy, the catch and catch rate were relatively

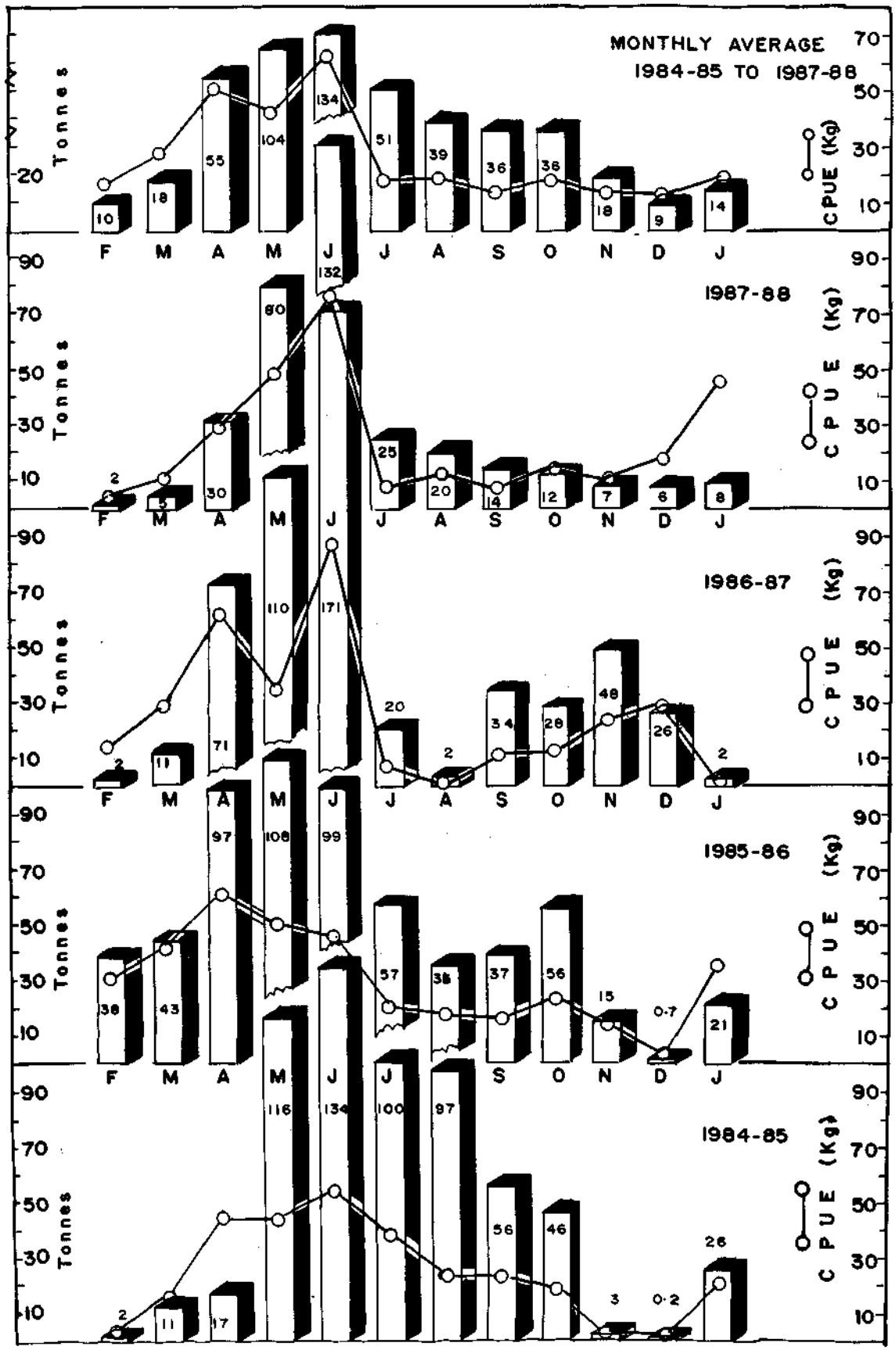


Fig. 3. a - d : monthwise catch and C/E of tunas and billfishes in the drift gillnet fishery off Cochin, 1984-88; e : average monthly variation of these parameters during the same period.

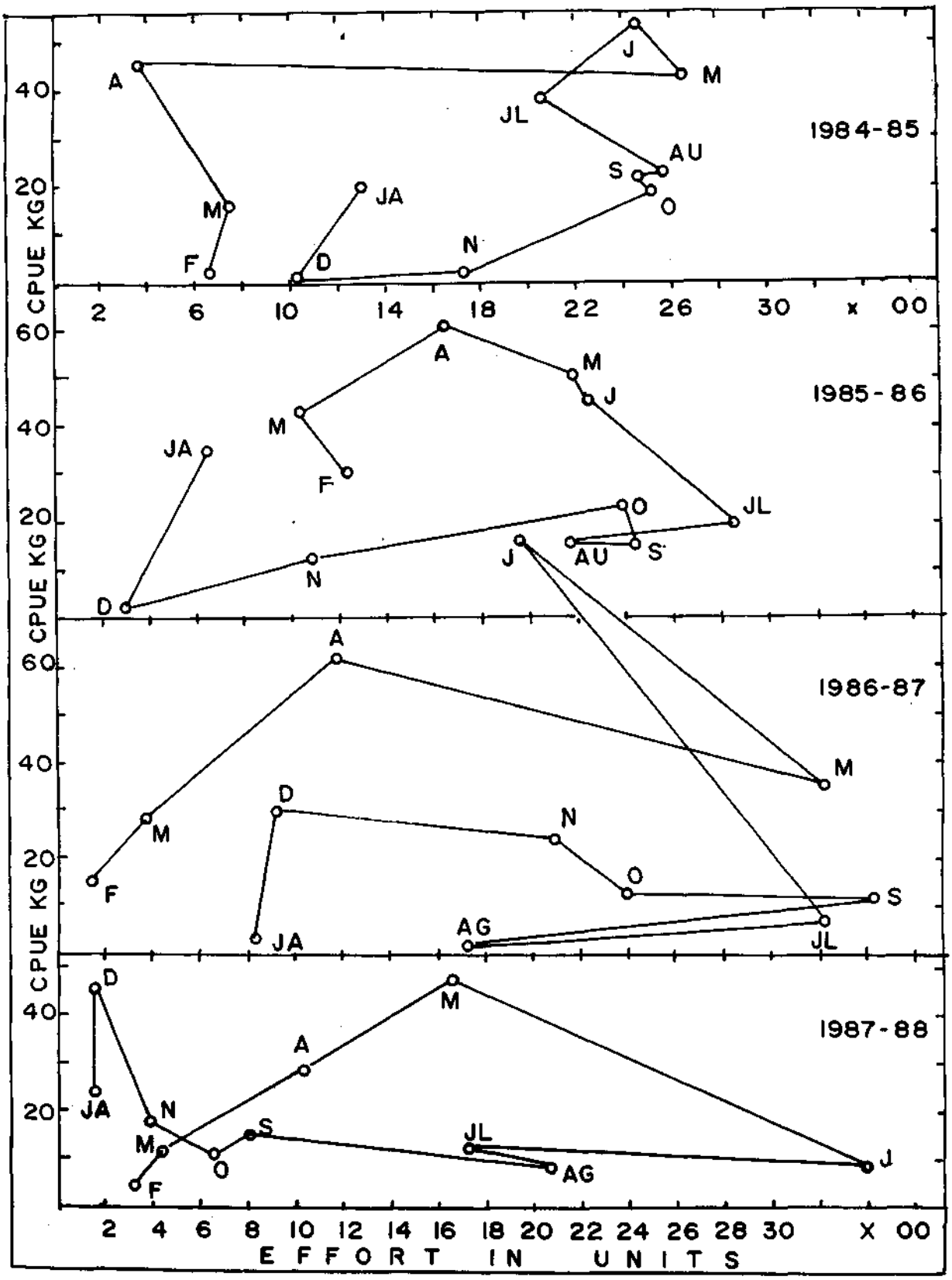


Fig. 4. Relationship between monthwise trend of effort expended and C/E of tunas in the drift gillnet fishery off Cochin 1984-88.

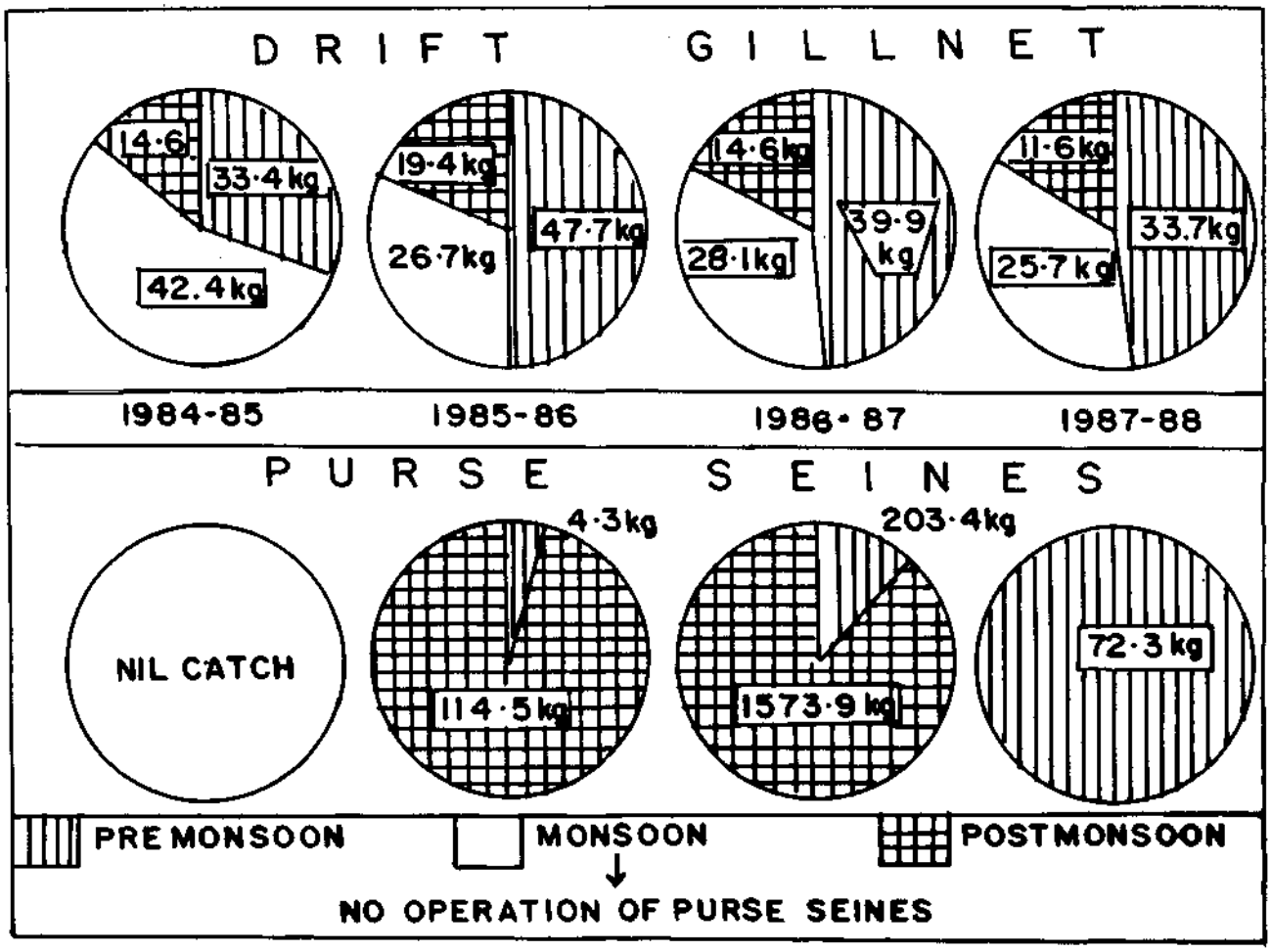


Fig. 5. Seasonal average values of C/E of tunas in the drift net fishery and purse seine fishery off Cochin, 1984-88.

high during January to April period of every year. During monsoon season, operation of pole and lines are suspended. In the troll line fishery, effort expended was high during monsoon months in all the years and the catch and catch rates were also high during the monsoon months. At Agatti, in the pole and line fishery, the catch, effort expended and C/E were relatively high during January-April.

TABLE 3. *Gearwise percentage composition of different species of tunas at different centres*

Centre	Gear*	*E. affinis*	*A. thazard*	*A. rochei*	*S. orientalis*	*T. albacares*	*T. tonggol*	*K. pelamis*
Vizhinjam	DGN (M)	54.2	18.9	13.1	8.1	1.1	4.2	0.4
	DGN (NM)	58.3	18.3	11.8	7.1	1.4	3.1	-
	HL (M)	14.2	4.8	77.0	1.9	0.8	1.0	0.3
	HL (NM)	35.9	4.5	52.6	0.9	2.4	3.1	0.6
Cochin	DGN (M)	72.1	19.1	0.8	0.8	4.0	2.9	0.3
	PS (M)	50.5	43.2	6.3	-	-	-	-
Calicut	DGN (M)	72.1	5.3	-	0.1	8.8	2.2	-
Mangalore	DGN (M&NM)	39.9	3.0	0.7	0.3	2.4	53.7	-
	PS (M)	72.0	24.1	3.7	0.1	-	-	0.1
Goa	DGN (M&NM)	36.7	13.5	-	3.9	-	45.9	-
Minicoy & Agatti	PL & TRL	4.0	1.8	-	18.0	-	-	76.2

* DGN (M) = Drift gillnet, mechanised; DGN (NM) = Drift gillnet, non-mechanised; HL (M) = Hooks and line, mechanised; HL (NM) = Hooks and line, non-mechanised; PS (M) = Purse seine, mechanised; PL = Pole and line; TRL = Troll line.

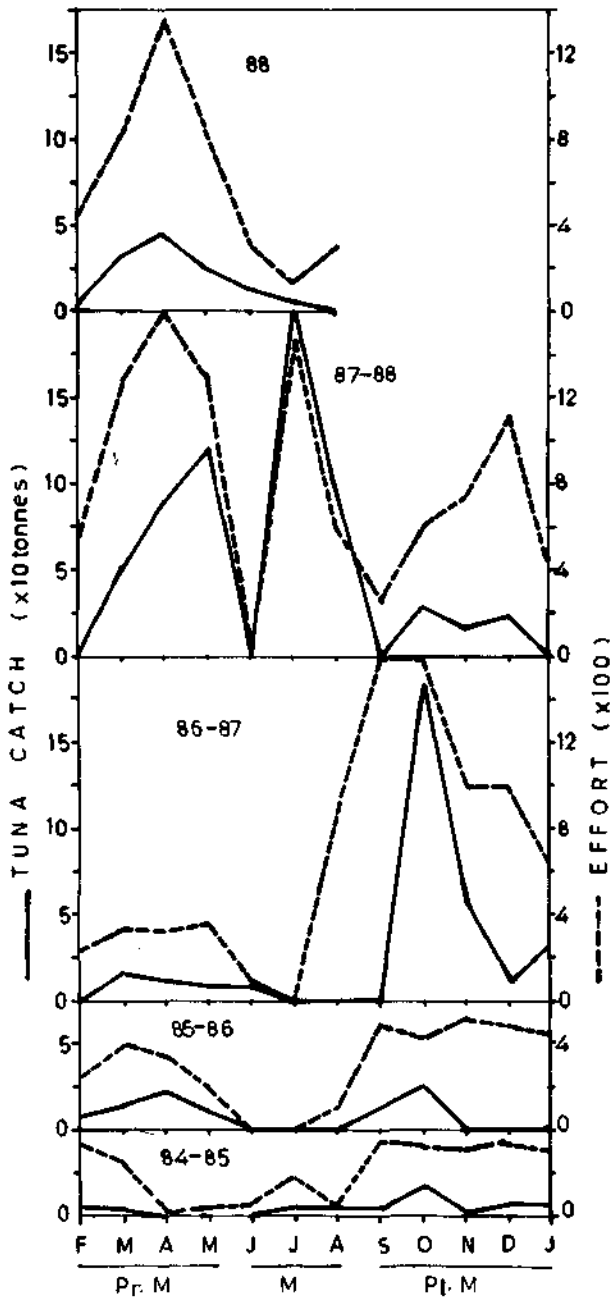


Fig. 6. Monthly total tuna catch and effort during 1984-88 at Calicut.

Seasonal Variation in Effort, Catch and Catch Rates (Gearwise)

Average gearwise catch rates of tunas for the three seasons for the period 1984-88 at the five centres are presented in Fig. 11. The tuna fishery during monsoon is found active at Vizhinjam (fibreglass coated plywood boats and catamarans with OB engine - Drift gillnets and hooks and line), Cochin (Pablo boats - Drift gillnets), Calicut (Plank-built boats with OB engine - Ring nets) and at Minicoy (Surface troll line fishery).

At Vizhinjam, maximum catch was landed during the postmonsoon period (41.6%), followed by premonsoon period (35.9%). Eventhough the tuna catch during the monsoon period was low, the C/E was higher (19.5 kg) than that in the premonsoon period (18.9 kg), with the maximum of 22.0 kg in July. Billfish catch was maximum during premonsoon period (54.9%). Gearwise catch indicated that maximum catch in the non-motorised drift net was in the premonsoon season (51.8%) followed by postmonsoon (46.0%). In the motorised drift net fishery, postmonsoon period contributed to the bulk of the catch (41.3%), followed by the premonsoon period (36.2%). The catch contribution during the monsoon period by the drift gillnetters was relatively low. Subsequent to the lift of ban on fishing operations in 1987, the catch rate of non-motorised drift gillnetters were 17.8 kg, 3.7 kg and 16.7 kg during the premonsoon, monsoon and postmonsoon seasons. On the other hand the catch rate of motorised gillnetters were 25.6 kg, 39.0 kg and 26.4 kg during the above three seasons.

The highest catch of non-motorised hooks and lines was obtained during the premonsoon period (57%) followed by postmonsoon period (33.6%). In motorised hooks and lines, the post-monsoon period contributed the maximum tuna catch (42.6%), followed by the premonsoon period (30.8%). The catch rates of non-motorised hooks and lines were 6.1 kg, 2.0 kg and 4.7 kg respectively for the premonsoon, monsoon and postmonsoon periods; the same for the motorised hooks and line units were 30.1 kg, 24.7 kg and 30.8 kg respectively for the above three seasons (Figs. 1, 2, 11).

At Cochin, drift gillnetters were in operation throughout the year, while purse seine operations were confined to the pre and post monsoon seasons only. Hence, detailed analysis of seasonal trend in catch, effort and C/E in this study pertains to drift gillnet fishery. The average C/E value for tunas during the premonsoon, monsoon and postmonsoon periods in this fishery were 39 kg, 31 kg and 15 kg, indicating the productive period to be from February to May (Figs. 11, 12). However, in the purse seine fishery, the average C/E value as high as 845 kg was recorded during the postmonsoon season (September-January).

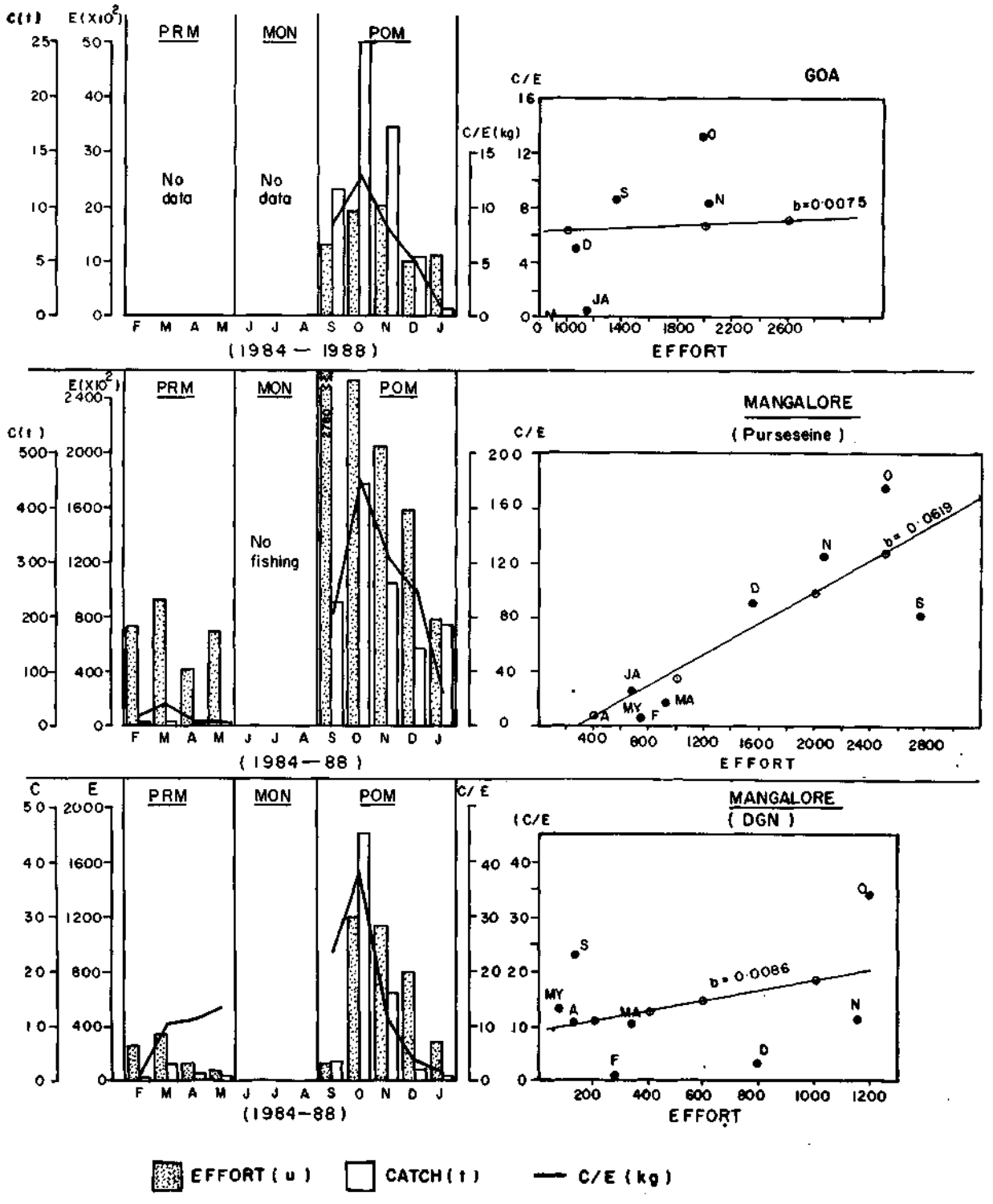


Fig. 7. Monthly catch and C/E of tunas and relationship between C/E and effort in tuna fishery at Mangalore and Goa, 1984-88.

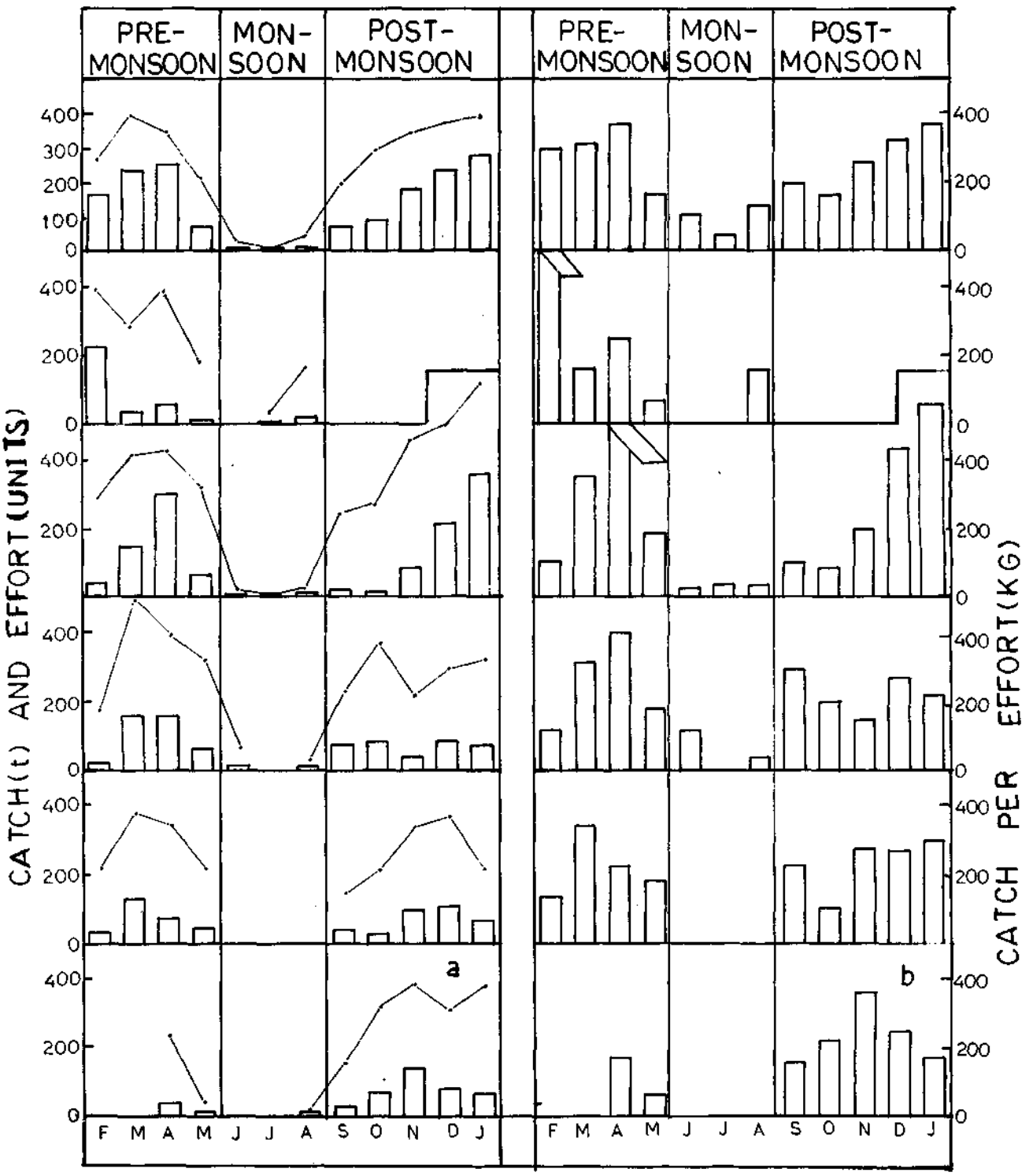


Fig. 8 a & b : Monthwise catch, effort and C/E in the tuna pole and line fishery, Minicoy 1984-88. Monthly averages are shown in the upper panel.

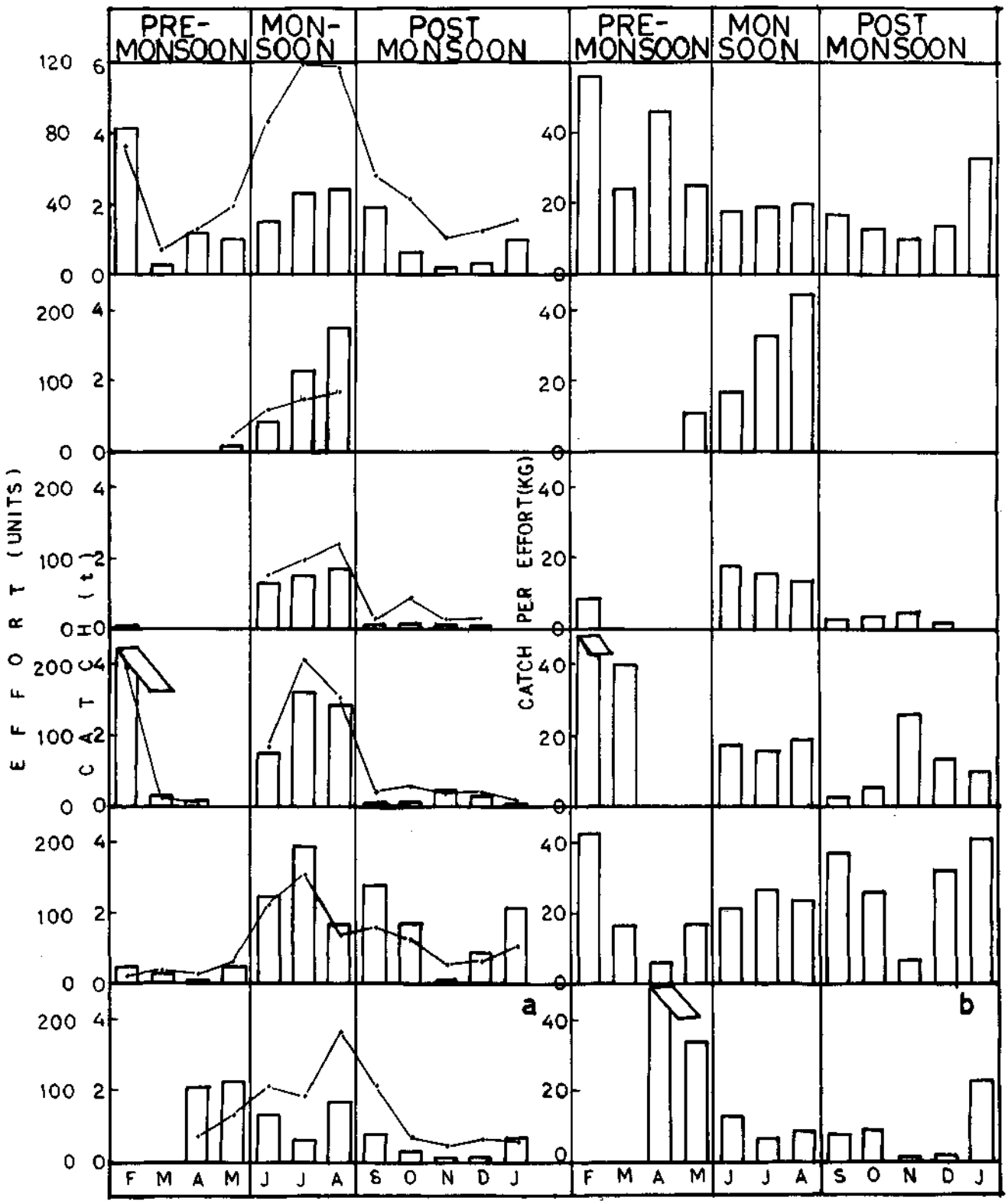
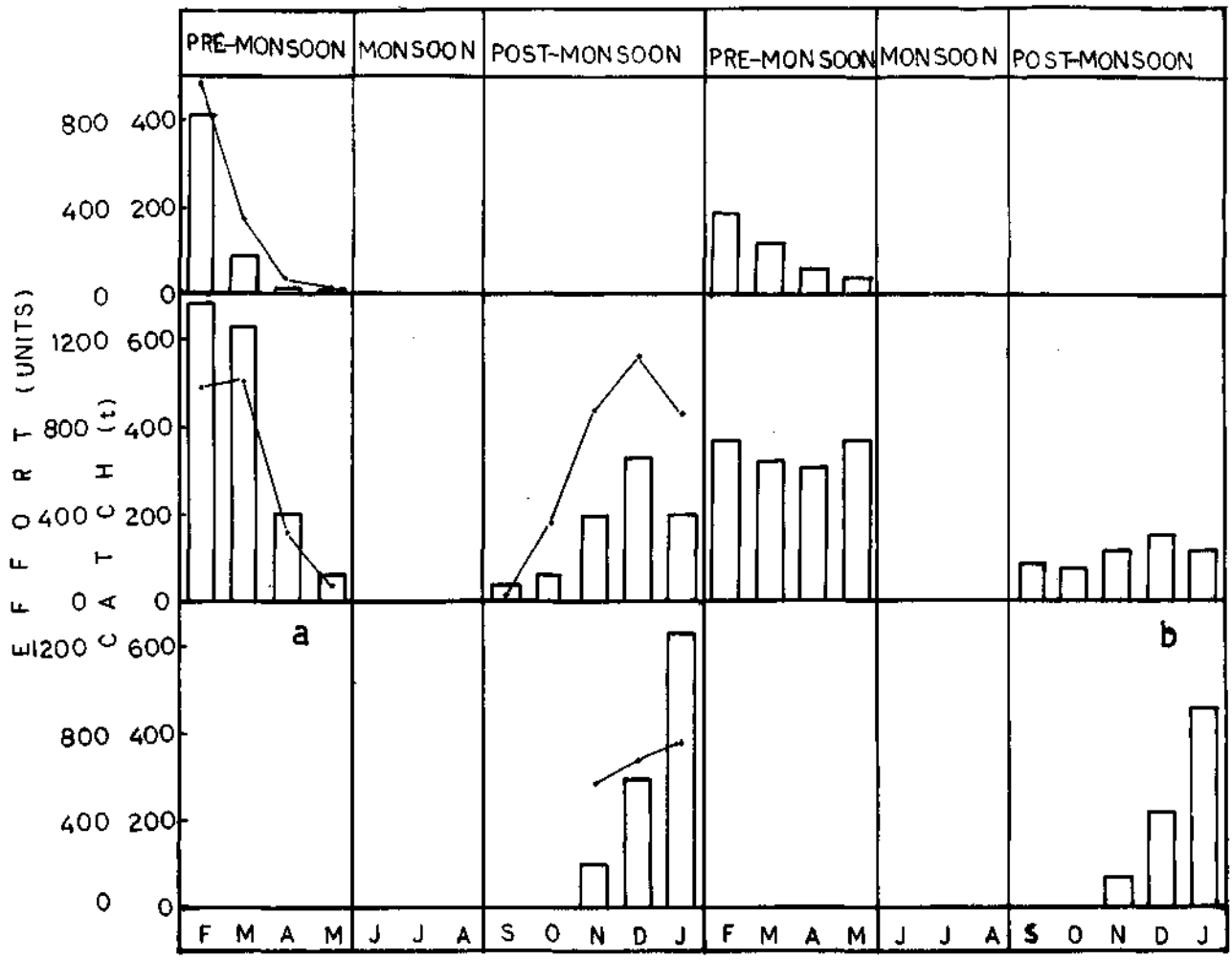


Fig. 9 a & b : Monthwise catch, effort and C/E in the troll line fishery, Minicoy 1984-88. Monthwise averages are shown in the upper panel.



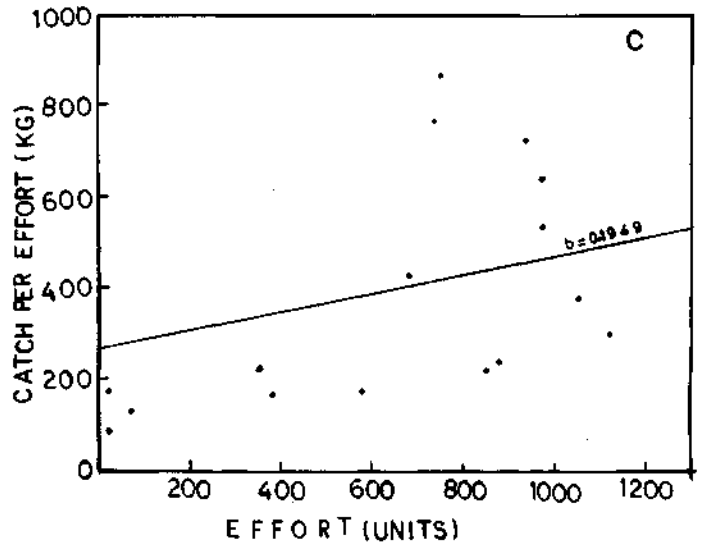


Fig. 10 a & b : Monthwise catch, effort and C/E in the pole and line fishery, Agatti 1984-88; c. Effort - C/E relationship in the pole and line fishery.

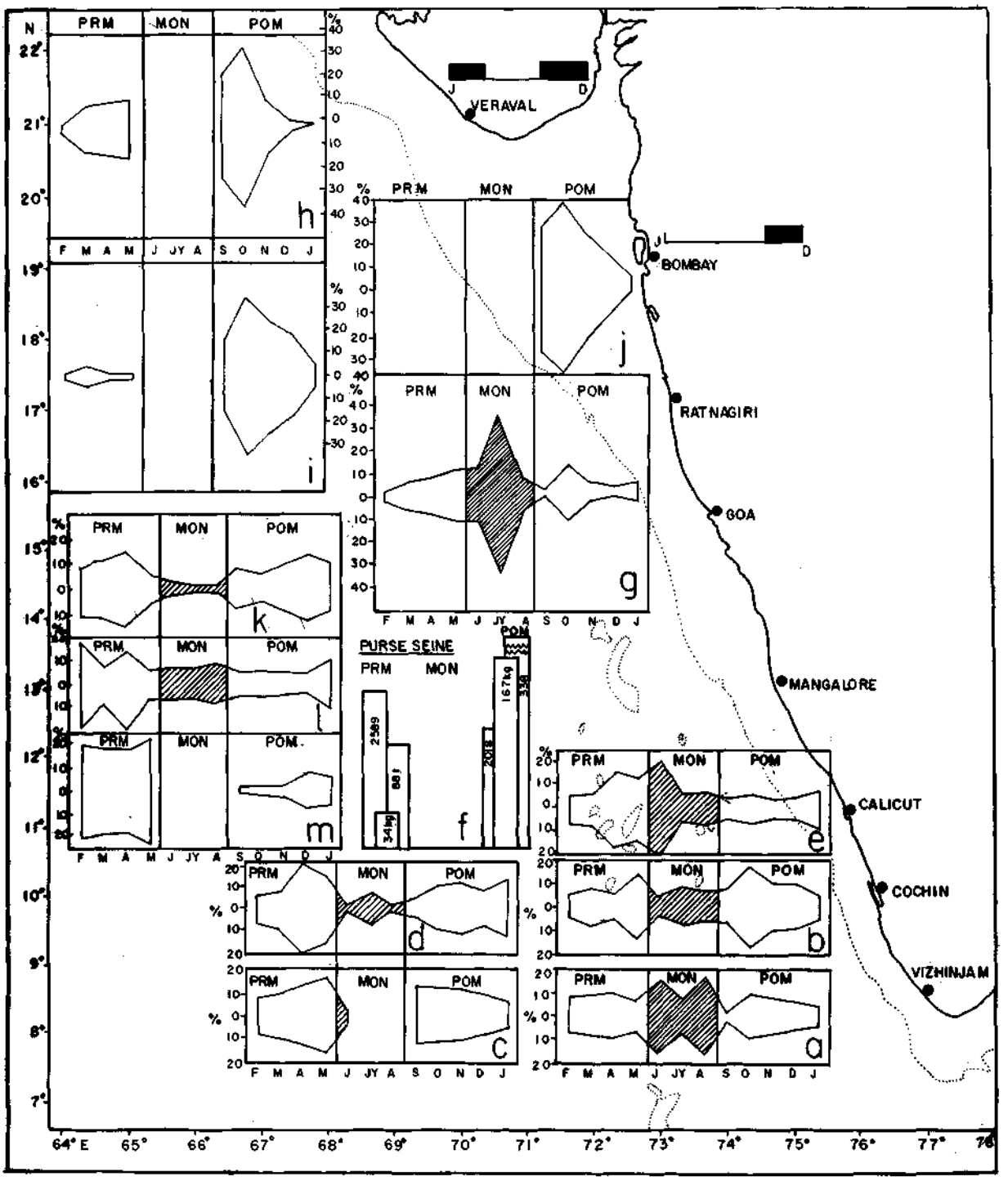


Fig. 11. Average C/E of tunas observed at different centres during the premonsoon, monsoon and postmonsoon seasons, 1984-88.

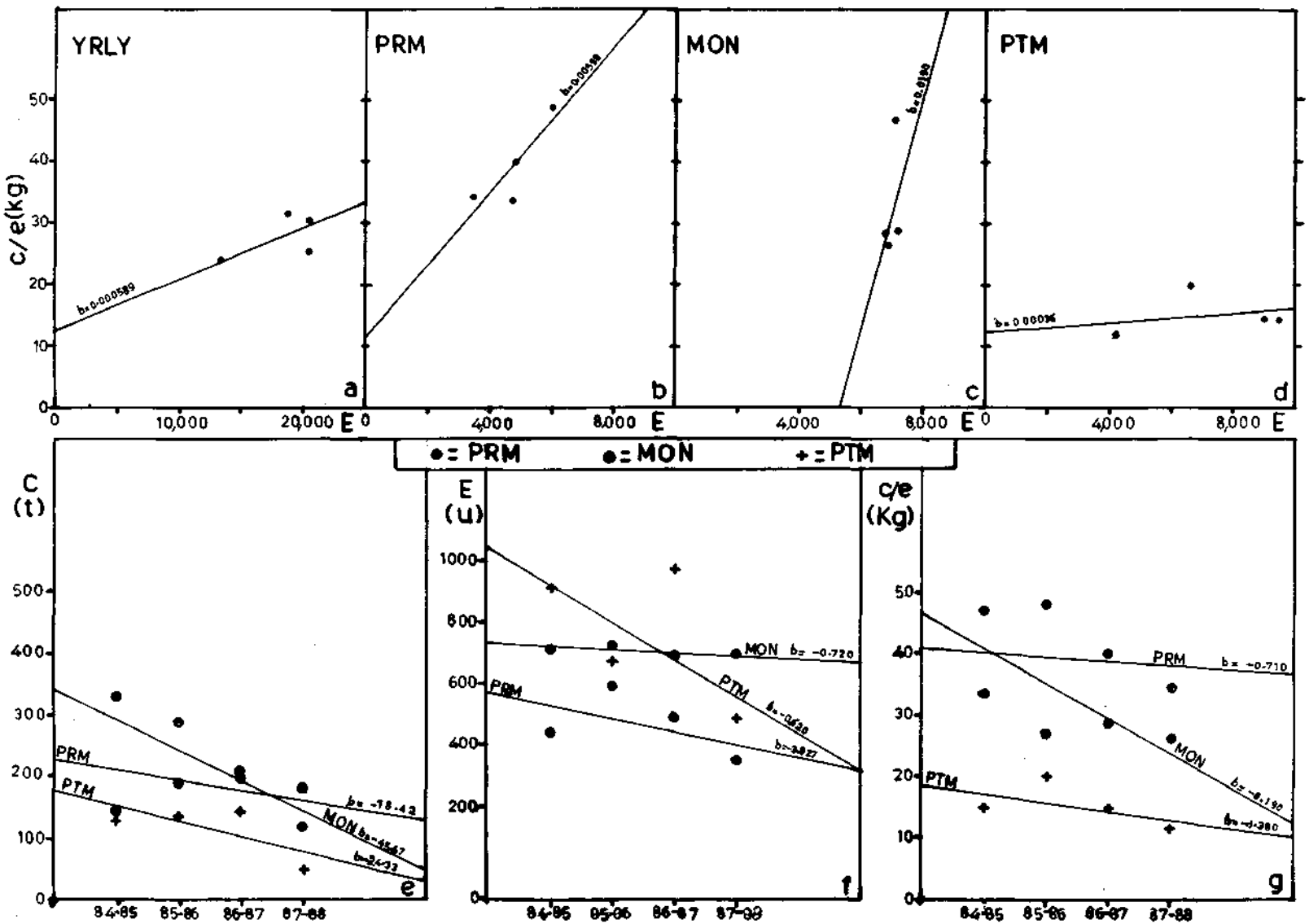


Fig. 12 a - d : Relationship between the annual and seasonal trend of C/E and Effort distribution in the drift gillnet fishery at Cochin 1984-88; e - g : seasonal trend of catch, effort and C/E of tunas in the drift gillnet fishery over time at Cochin.

Regression analysis was carried out to study the trend of fishery during different years and three seasons. Although the relationship between the catch, effort and C/E indicated a downward trend, the relationship between the effort and C/E was positive for all the periods considered. Total annual C/E values tended to increase with increase in fishing effort and during monsoon both the C/E and effort expended were relatively high.

The data on the tuna catch at Calicut during different periods of all the years are given in Fig. 13. It is evident that maximum catch was recorded during the premonsoon period and minimum during the postmonsoon period. The maximum C/E was observed during the monsoon period and the minimum in the postmonsoon months. The trend of changes in the catches in different periods over the years was studied using regression of catch on time. A definite increasing trend in all the periods was observed, with only slight variation in the tuna catch rate. Increase was fast in the premonsoon period, followed by postmonsoon and monsoon seasons. The trend of increase in effort during different seasons also evinced the same pattern. During monsoon season, the rate of increase was relatively less.

At Mangalore, in the drift net fishery, postmonsoon period was observed to be the most productive season for tunas, accounting for about 92% of the annual catch. The catch rate ranged from 7.9 kg in 1984-85 to 43.7 kg in 1986-87, the average value being 17.8 kg. Billfishes contributed to 0.3% of the drift gillnet catch during the premonsoon period and 0.32% during the postmonsoon period. In the purse seine fishery, during the premonsoon period, the catch rate of tunas ranged from 28.4 kg (1984-85) to nil (1986-87), with an average value of 8 kg. Postmonsoon period accounted for about 98% of the tuna landings. The catch rate varied from 11.1 kg (1984-85) to 191.7 kg in 1985-86, with an average value of 113.3 kg (Fig. 7).

At Goa, tuna fishery was totally absent during the monsoon period and during the postmonsoon season, the productive period was observed during October and November (Fig. 7).

At Minicoy and Agatti, tuna pole and line fishery operations were in vogue during the premonsoon and postmonsoon periods and at Minicoy, troll line fishery was conducted during monsoon period. Regression analyses carried out between C/E and effort on the tuna pole and line fishery data over three seasons and during different years indicated that the relationship was positive at Minicoy. C/E increased with the increase in effort. Eventhough only a few units were operated during the beginning of monsoon, the relationship between C/E and effort was observed to be high. In the troll line fishery, the relationship was positive during all the seasons except in monsoon, when catch rate decreased with increased effort. Annual trend also indicated that the pole and line fishery was in the developing stage. At Agatti, the regression analysis between annual effort and catch and also on the relationship between effort and catch rate indicated that the former was positively correlated while the latter evinced negative trend, with declining catch rate with increasing effort. However, the gross pattern of fishery indicated that the catch rate of tunas was relatively high during the premonsoon periods (Figs. 14-18).

Species Composition

Available information on the species composition of tunas during different years from six centres are summarised and presented in Table 3 and in Figs. 19-21. It is discernible that seasonal variation in species composition is not pronounced and *Euthynnus affinis* constituted the major species, followed by *Katsuwonus pelamis, Auxis thazard, Thunnus tonggol, Auxis rochei, Thunnus albacares* and *Sarda orientalis*. However, at Vizhinjam, *A. rochei* constituted about 57% of the total tuna catch.

Length Composition

Length composition of *E. affinis, K. pelamis, A. rochei, A. thazard* and *T. tonggol* at different centres are presented in Figs. 22-28. The size range of the important species during different seasons is as follows:

Species	Size range in the fishery (cm)		
	Premonsoon	Monsoon	Postmonsoon
E. affinis	20-72	16-72	18-80
A. thazard	20-46	20-48	20-48
T. tonggol	42-48	38-62	22-82
A. rochei	20-26	16-28	20-28
K. pelamis	20-72	45-65	20-72

It was observed that small-sized specimens of *E. affinis* and *A. rochei* were recorded in the fishery during monsoon season in fewer numbers.

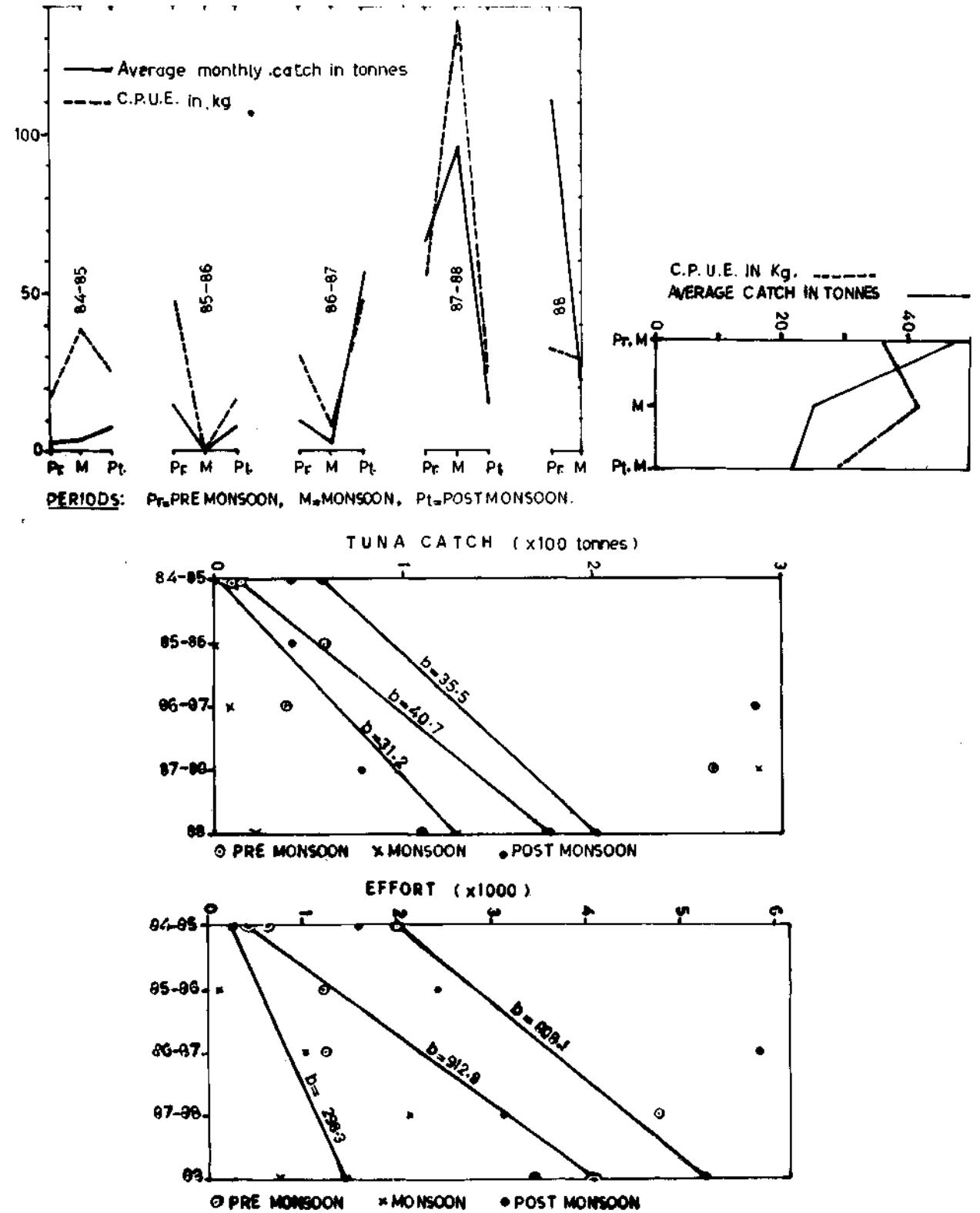


Fig. 13. Monthly average catch of tunas and C/E in different periods during different years (upper panel); Monthly average catch of tunas and C/E for all the years during different periods (upper panel); Regression of catch of tunas during different periods of time (middle panel); Regression of effort during different periods on time (Calicut 1984-88).

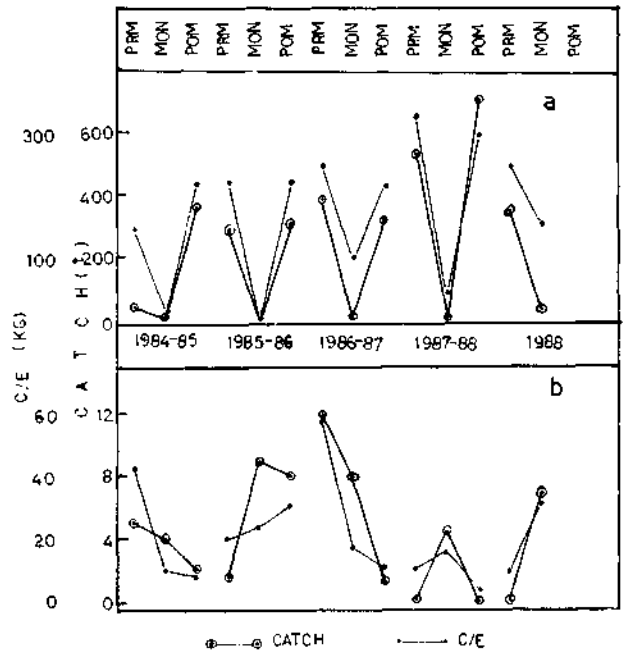


Fig. 14. Seasonal average values of catch and C/E for tunas in the pole and line fishery (a) and troll line fishery (b), Minicoy 1984-88.

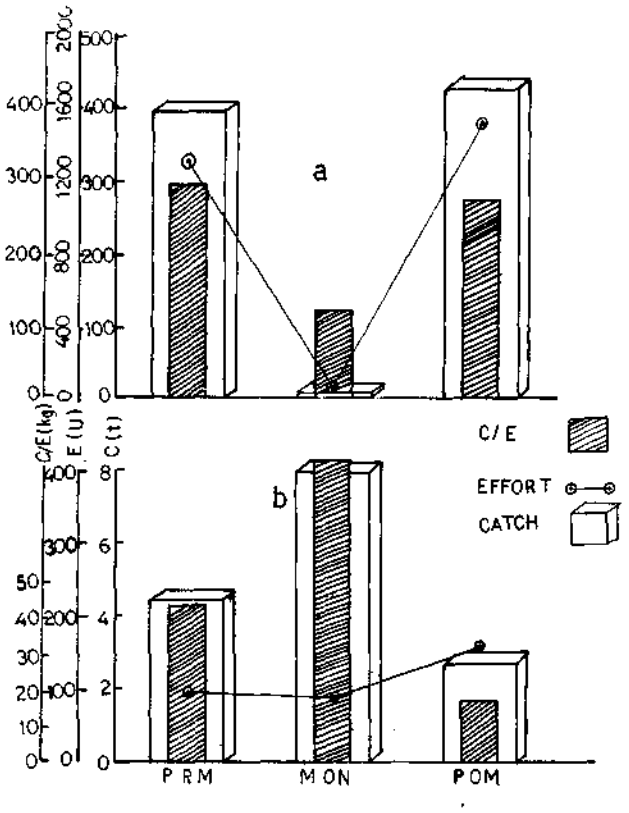


Fig. 15. Average seasonal pattern of fishery parameters for tunas in the pole and line fishery (a) and troll line fishery (b), Minicoy 1984-88.

Spawning

Based on the available published information, the spawning season of tunas along the west coast of India and in Lakshadweep is considered as during April-September. As the recruitment to the fishery is regular over the period of study, the tuna fishery during the monsoon period appears to be not affecting the spawning stock.

Discussion

The motorisation of the country crafts and targeted operation of mechanised boats (with inboard engine) for tunas along the southwest coast of the mainland of India and Lakshadweep, witnessed significant increase of tuna catch in the artisanal sector. This region at present contribute to about 67% of the All-India total tuna production estimated at 63,600 tonnes of tunas. On account of the increased mobility and accessibility to deeper fishing grounds, the total tuna catch increased from 7280 tonnes (1984) to 25,990 tonnes (1988) along the west coast and Lakshadweep. The impact of motorisation of the country crafts traditionally operating drift gillnets and hooks and line on the increase in the tuna production at Vizhinjam Coast (SW coast of India) has been reported by Gopakumar and Sharma (1989). According to them, the significant advantages due to this development and introduction of fibre-glass coated plywood boats (5.5 m OAL) with OB engine are the accessibility to offshore fishing grounds at a depth zone of 60 - 80 m, increase in the catch rate of *Auxis rochei* and the ability for operation during monsoon season. The catch rate of tunas by these crafts increased considerably in comparison with the non-mechanised crafts. At Calicut, the motorisation of the country crafts, introduction of improvised canoes and gears have been reported by Yohannan and Balasubramanian (1988, 1989) and Sivadas and Balasubramanian (1989). During 1986-87 period, all the country crafts and plank built boats were motorised and tunas and seerfishes became their target species. The use of mariner's compass has also facilitated the fishermen to operate the boats during monsoon season.

Jayaprakash (1989) evaluated the effort inputs and returns in the drift gillnet fishery at Cochin during the period 1981-82 and 1986-87 seasons and opined that the effort by mechanised Pablo boats during the SW monsoon months (May

to September) was the maximum and it was mainly directed to tap the tuna resources. During monsoon months, the income realised was 42% to 62% of the total annual income. According to him, during 1982 and 1987 the monsoon period realised the highest catch rate of tunas by the Pablo boat operations and the percentage contribution of tunas varied between 60 and 77% of the total tuna catch in the drift gillnet fishery.

At Cochin, the decrease of catch and catch per unit effort during 1984-88 in the drift gillnet fishery and increase of these parameters in the purse seine fishery during this period was observed. The operational area of both the gears is in the depth zone 25-40 m. It requires further detailed study whether the operation of these two gears would result in the overfishing of the inshore tuna population.

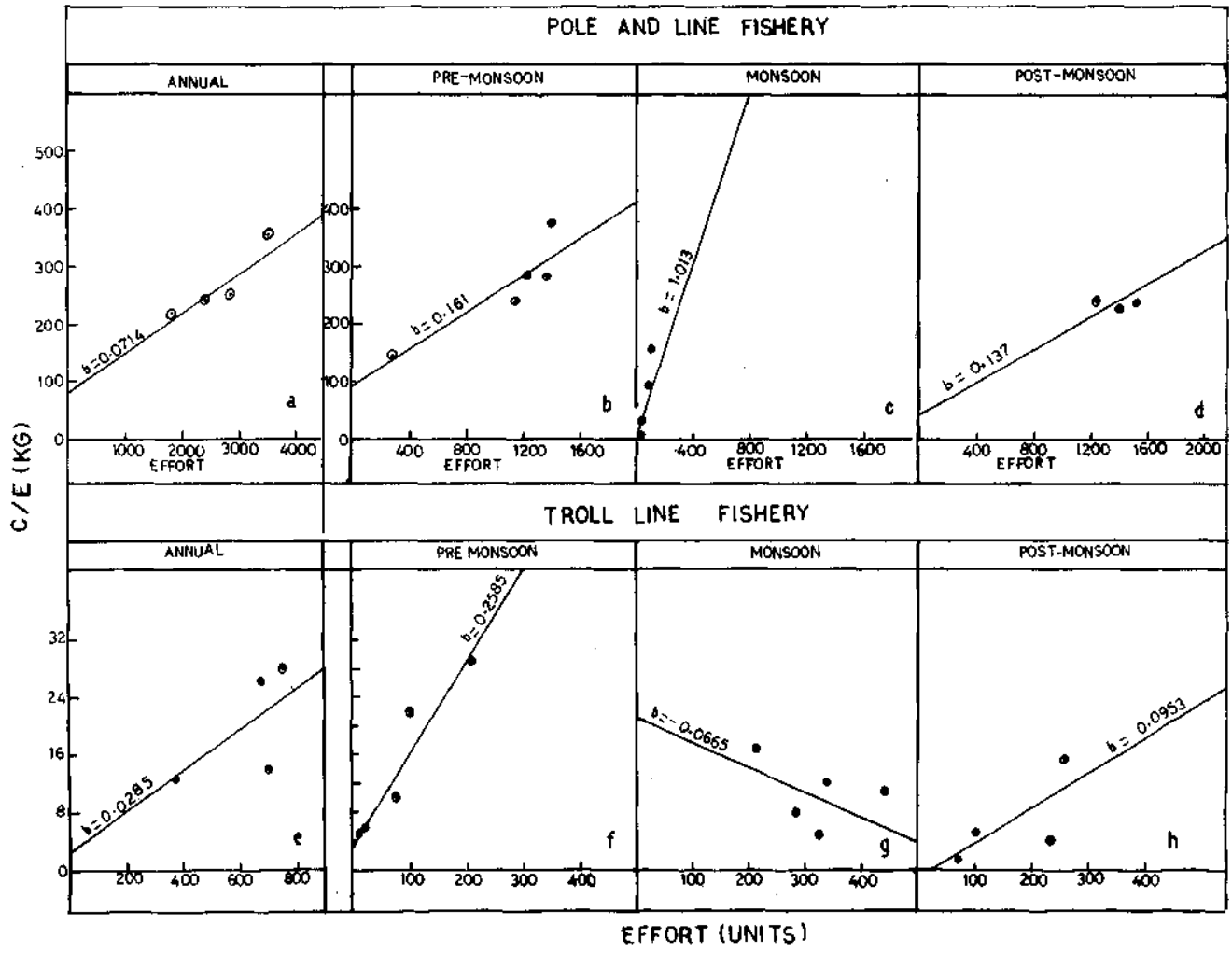


Fig. 16. Relationship between annual and seasonal trend of effort and C/E in the pole and line fishery (a - c) and troll line fishery (d - f), Minicoy 1984-88.

The size composition of major species indicates that *E. affinis* and *A. rochei* belonging to smaller size groups are caught during the monsoon period. However, it is felt that detailed size composition analyses for few more years are necessary before any regulation is recommended.

At Calicut, the tuna catch is bound to increase with the increase in effort. However, the present level of fishing is found not affecting the stock. *E. affinis* is not having at present local consumer demand. If better marketing facilities are provided, there appears to be considerable scope to develop the tuna fishery at Calicut.

Further, this diversification of fishing may also help to divert the fishing pressure now exerted on mackerel and oilsardine.

the troll line fishery the trend of increase was passive. At Agatti, eventhough effort was increased substantially during 1984-88 period, the

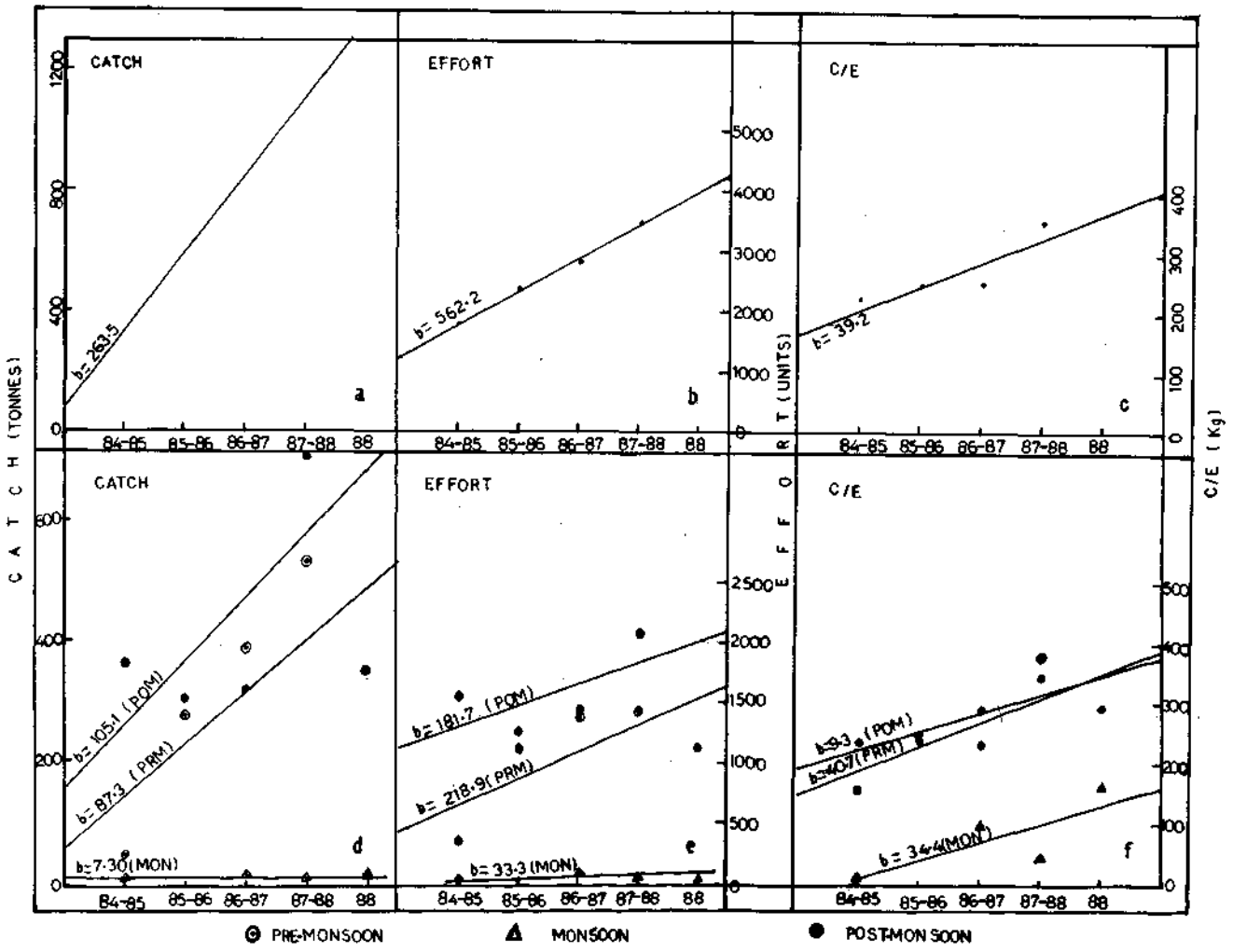


Fig. 17. Annual and seasonal trend of catch of tunas, effort and C/E in the pole and line fishery for tunas over time in Minicoy 1984-88.

As observed from the published information (Lipton *et al.*, 1988; Dhulkhed and Annigeri, 1988; Kagwade *et al.*, 1988; Rao and Alagaraja, 1988), the monsoon fishing operations are suspended in Karnataka, Goa, Bombay and Veraval and the peak period of occurrence of tunas are during post-monsoon months. It is recommended that the country crafts fitted with OB engines be encouraged for operation during monsoon season also, which would fetch good returns in the artisanal sector.

In Minicoy, the trend of tuna fishery by pole and line gear recorded an increasing trend, but in catch and catch rate recorded a declining trend, which might be due to the non-availability of tuna shoals for fishing or the negative biting response. In the small scale mechanised and non-mechanised fishery sector in Lakshadweep, controversies or clashes have not been reported.

As opined by James and Pillai (1990) and Pillai (1991), installation of Fish Aggregating Devices, diversification of fishing operations by the introduction of multi-day boats and intensification of troll line and handline fisheries during the monsoon months using sail power would contribute to the enhancement of tuna production in the artisanal sector in India.

It is customary on the part of the fishermen to increase or decrease the fishing effort depending upon the net economic returns. In view of this, estimation of economic parameters such as cost

fishing industry for continued operation of crafts and gears during monsoon season also and aim at larger pelagics such as tunas and seerfishes beyond the traditional fishing grounds, which in turn

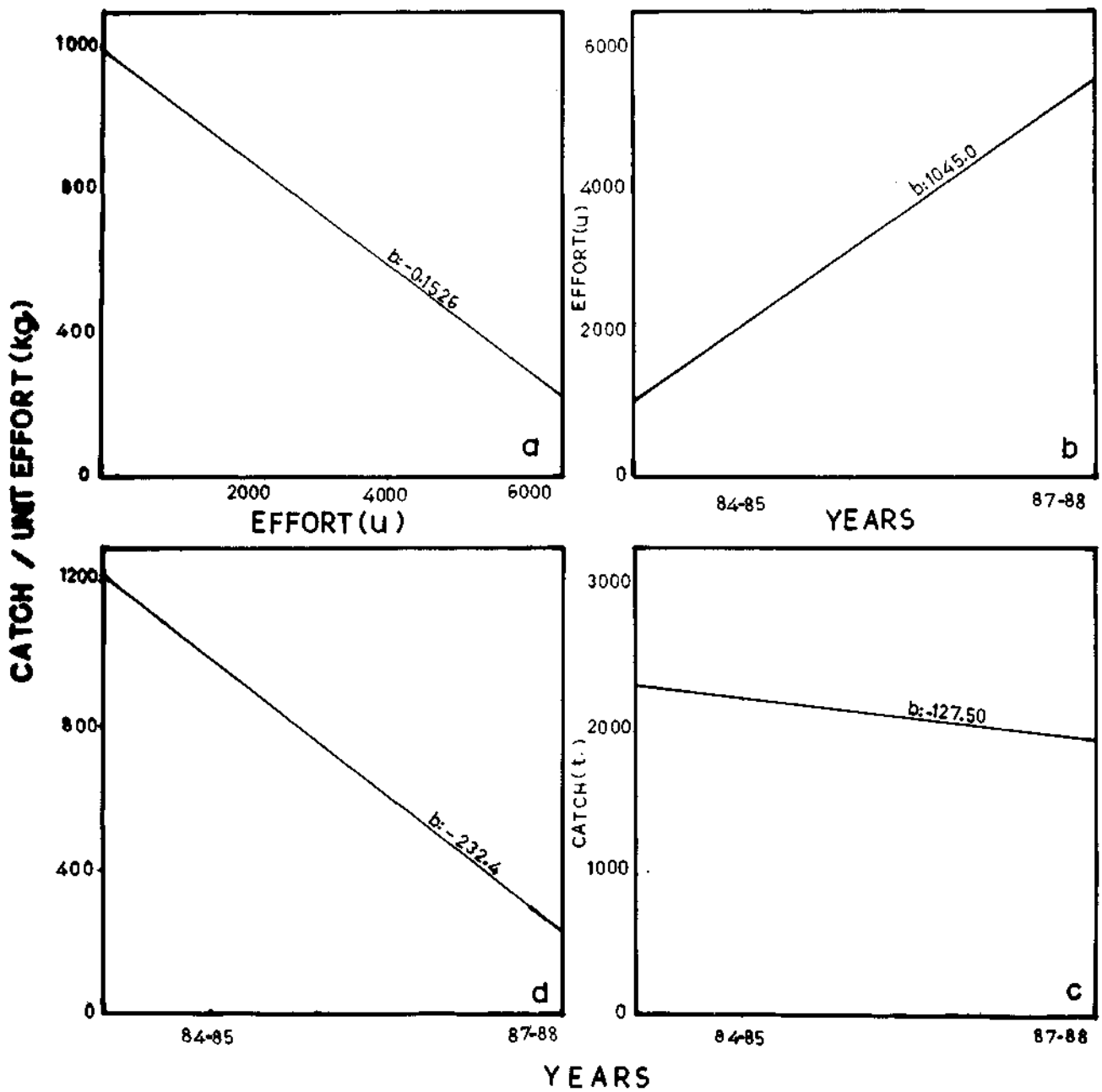


Fig. 18. Annual and seasonal trend of catch, effort and C/E in the pole and line fishery for tunas, Agatti 1984-88.

benefit ratio and maximum economic yield of the tuna fishery operation during the monsoon season would be relevant in taking effective management decisions. It would also prompt the artisanal

would enhance the production of tunas especially the longtail and yellowfin tunas and also contribute to the economic betterment of the fishing community in the artisanal sector.

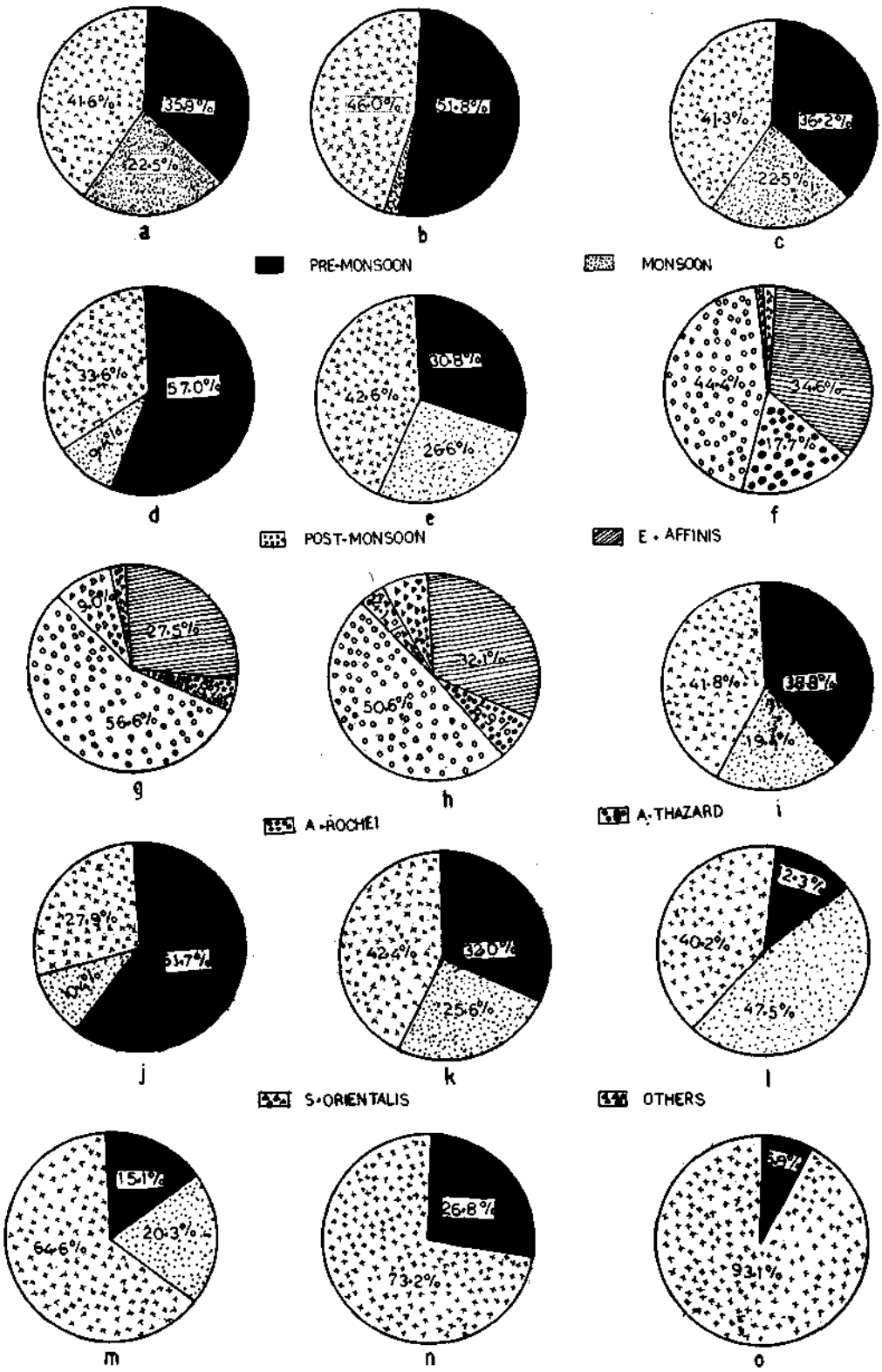


Fig. 19 a. Percentage composition of tuna catch during the premonsoon, monsoon and postmonsoon periods. b - e : Gearwise tuna catch in relation to monsoon b = Drift gillnet, non-motorised crafts; c = Drift gillnet, motorised crafts; d = hooks and line, non-mechanised crafts; e = hooks and line, mechanised crafts; f - h : Species composition of tunas during the premonsoon, monsoon and postmonsoon months (f = Premonsoon period; g = Monsoon period; h = Postmonsoon period).

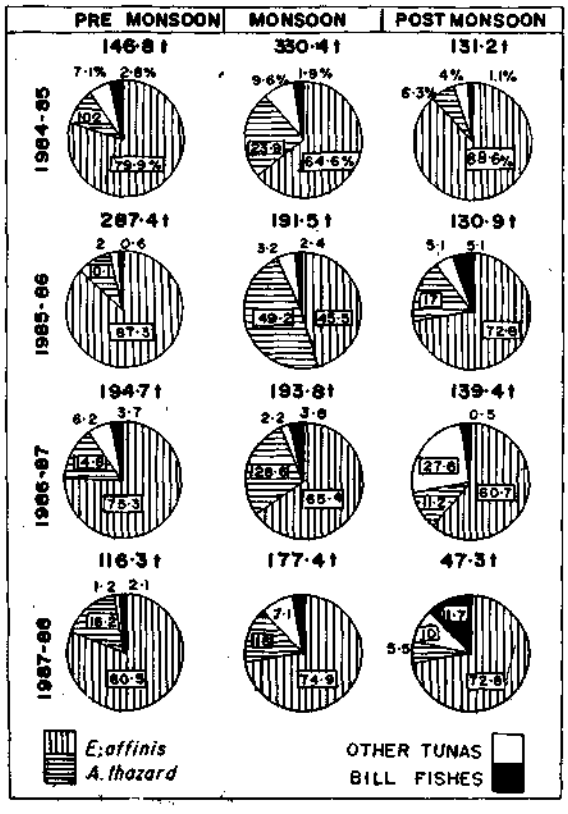


Fig. 20. Species composition of tunas in the drift gillnet fishery off Cochin 1984-88.

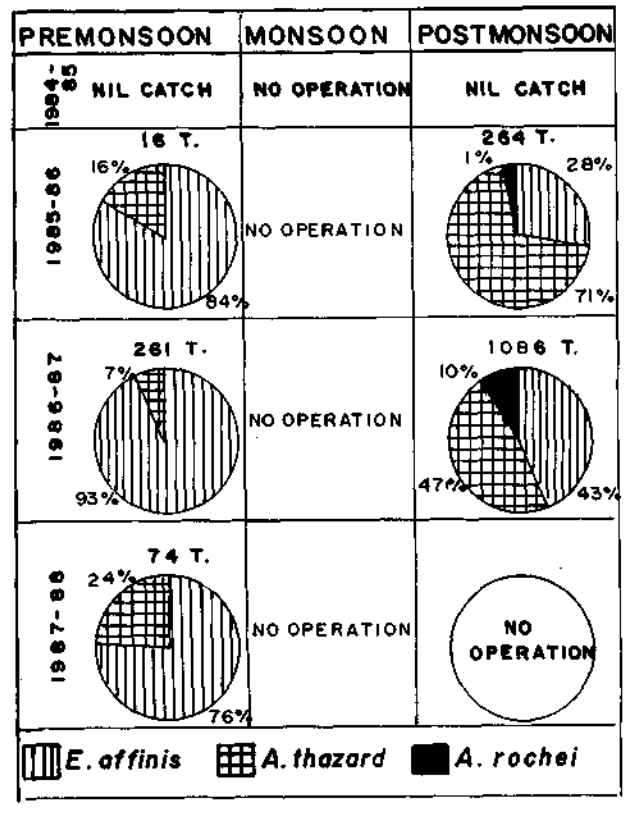


Fig. 21. Species composition of tunas in the purse seine fishery off Cochin 1984-88.

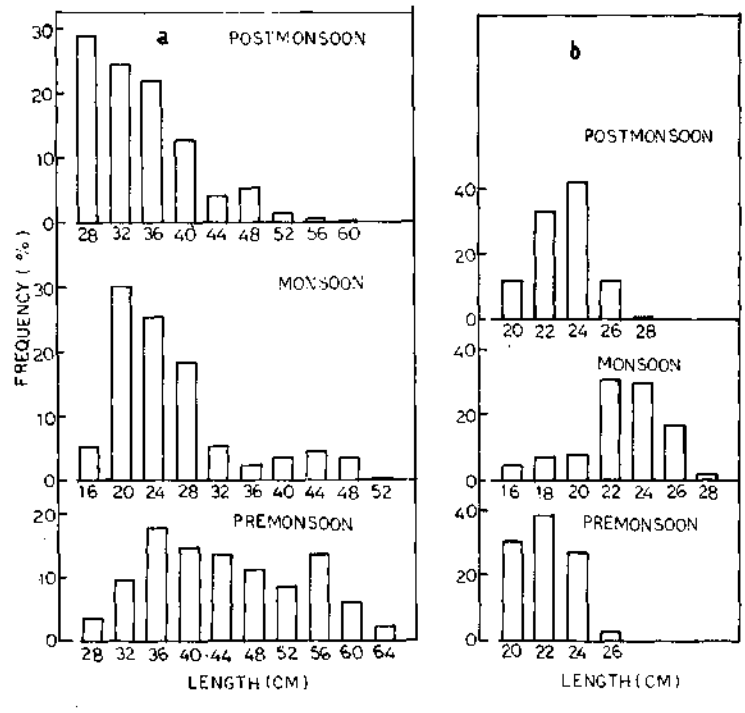


Fig. 22. Size composition of *E. affinis* and *A. rochei* at Vizhinjam 1984-88.

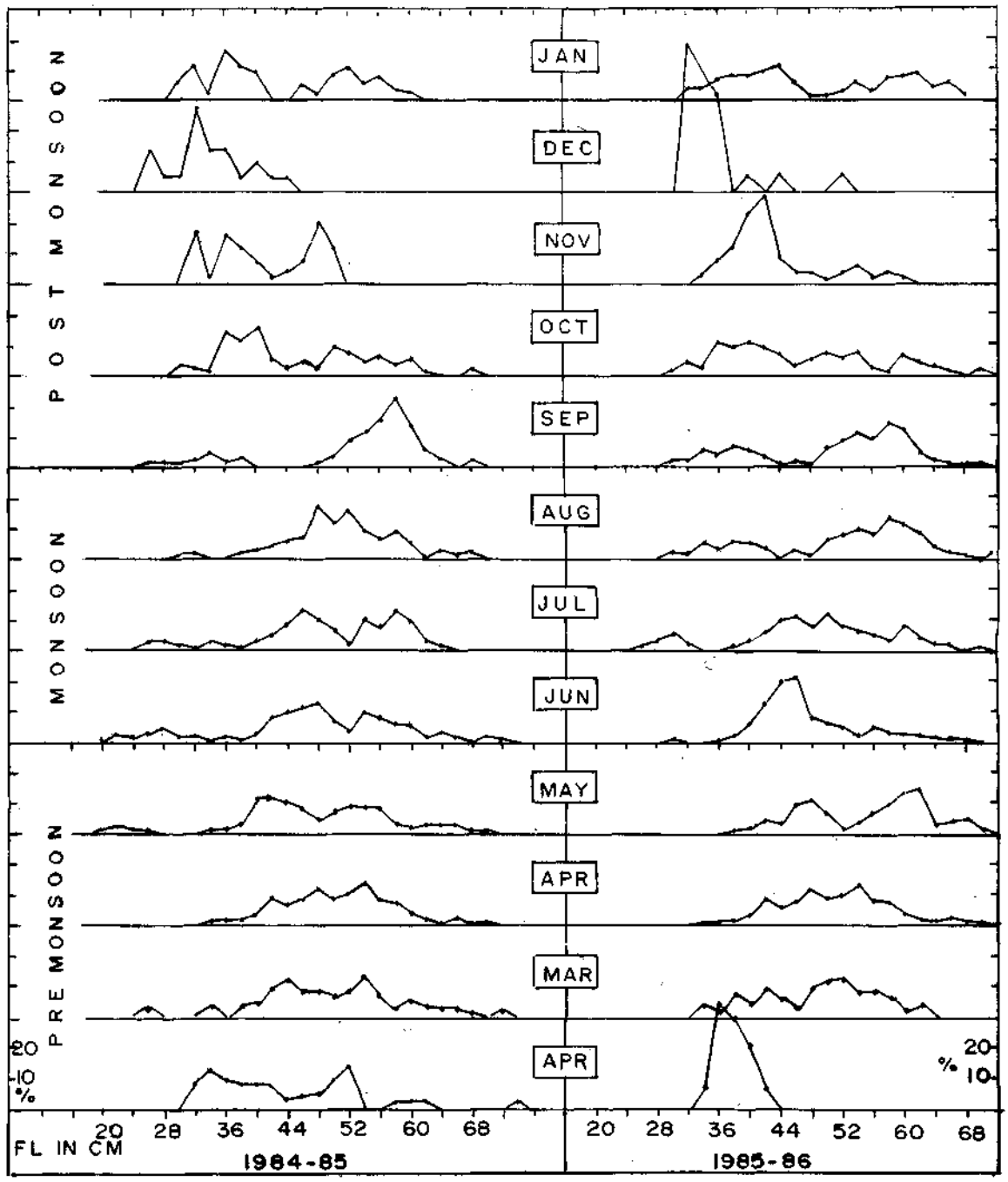


Fig. 23. Monthwise size distribution of *E. affinis* in the drift net fishery and purse seine fishery off Cochin 1984-86.

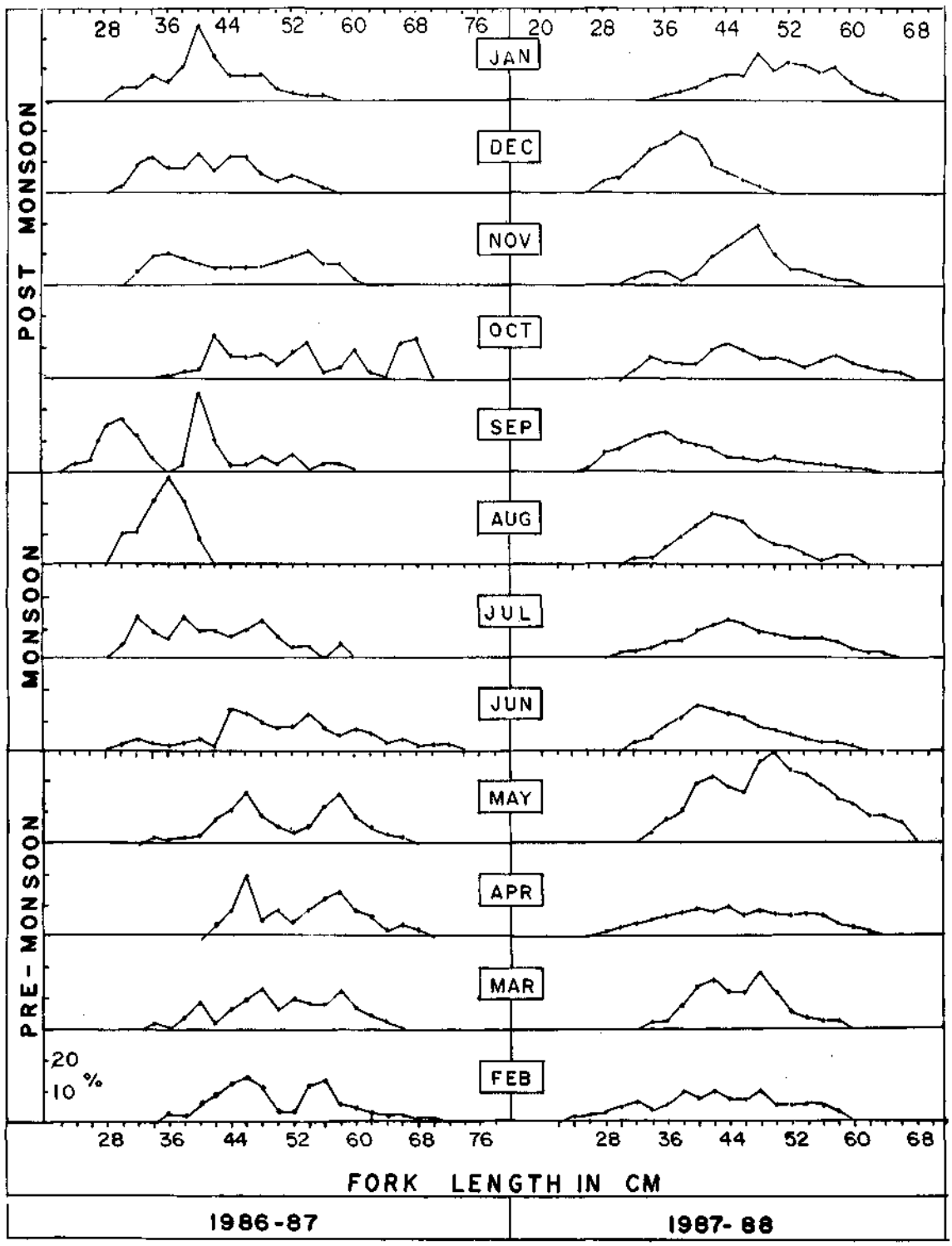


Fig. 24. Monthwise size distribution of *E. affinis* in the driftnet fishery and purse seine fishery off Cochin 1986-88.

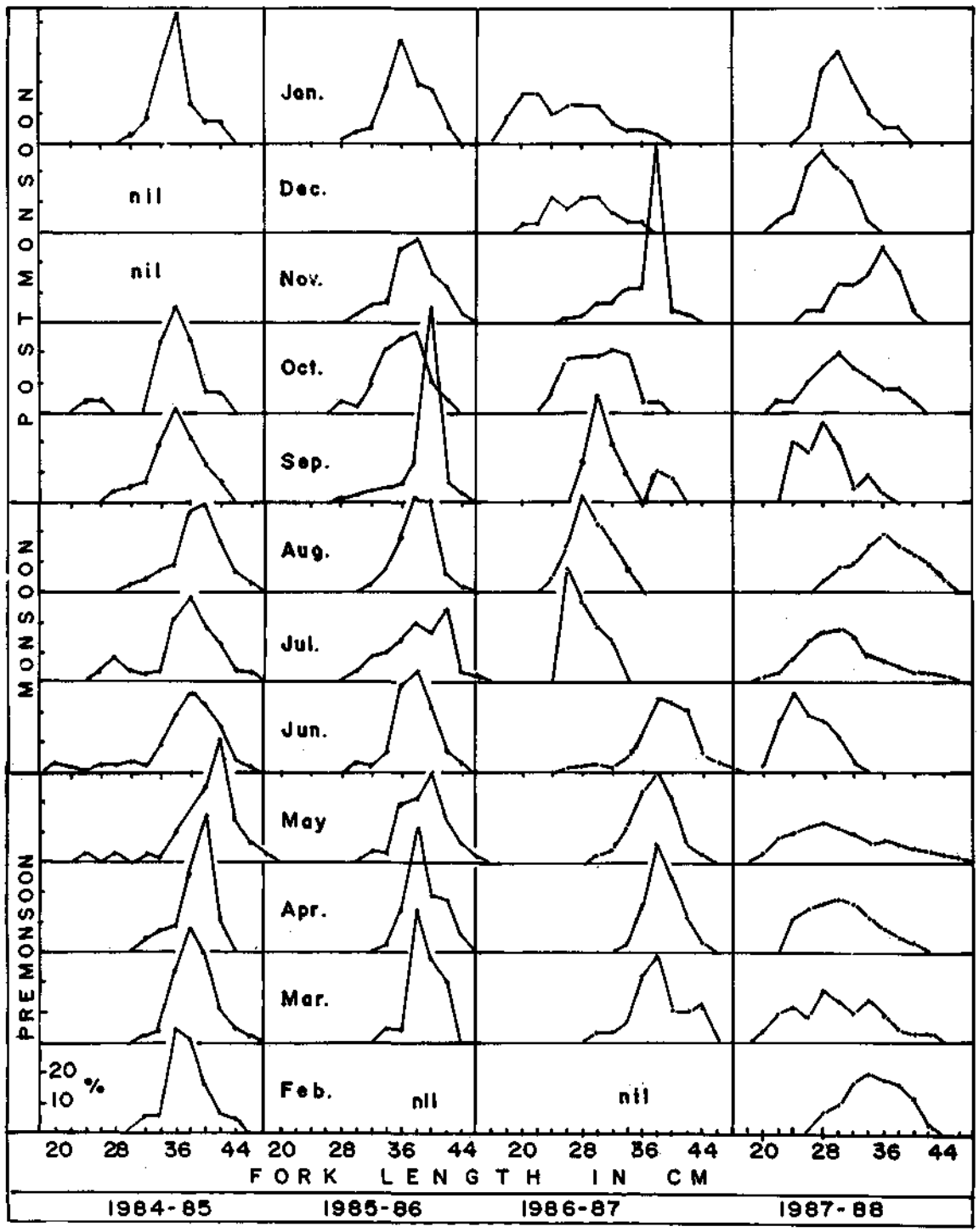


Fig. 25. Monthwise size distribution of *Auxis thazard* in the drift net fishery and purse seine fishery off Cochin.

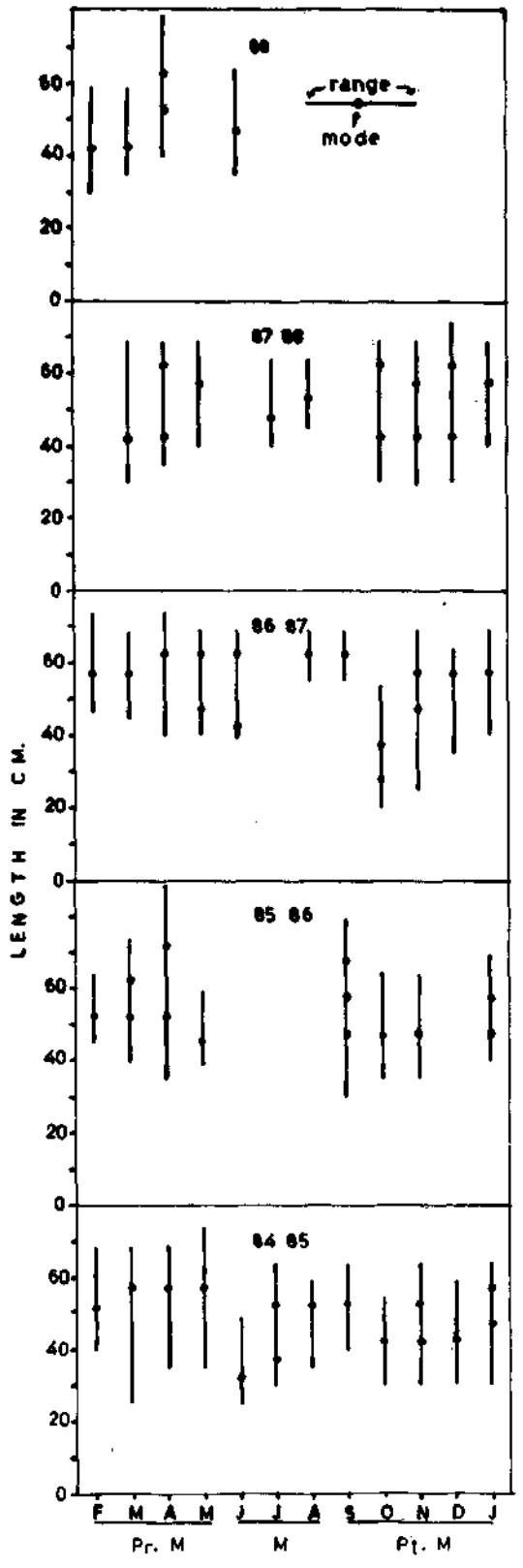


Fig. 26. Size range and modal values of tuna caught during different months at Calicut 1984-88.

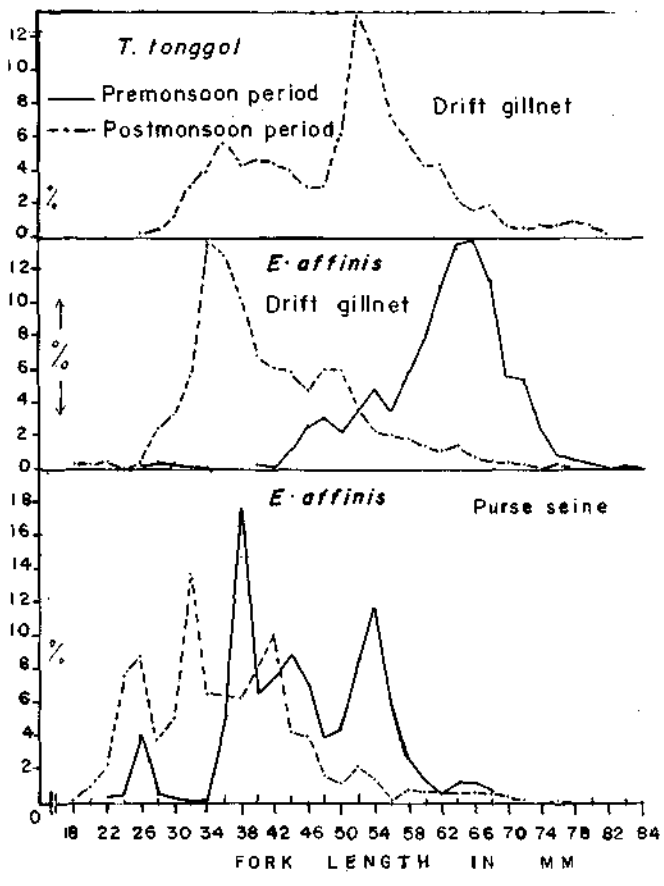


Fig. 27. Pooled size composition of *E. affinis* and *T. tonggol* at Mangalore 1984-88.

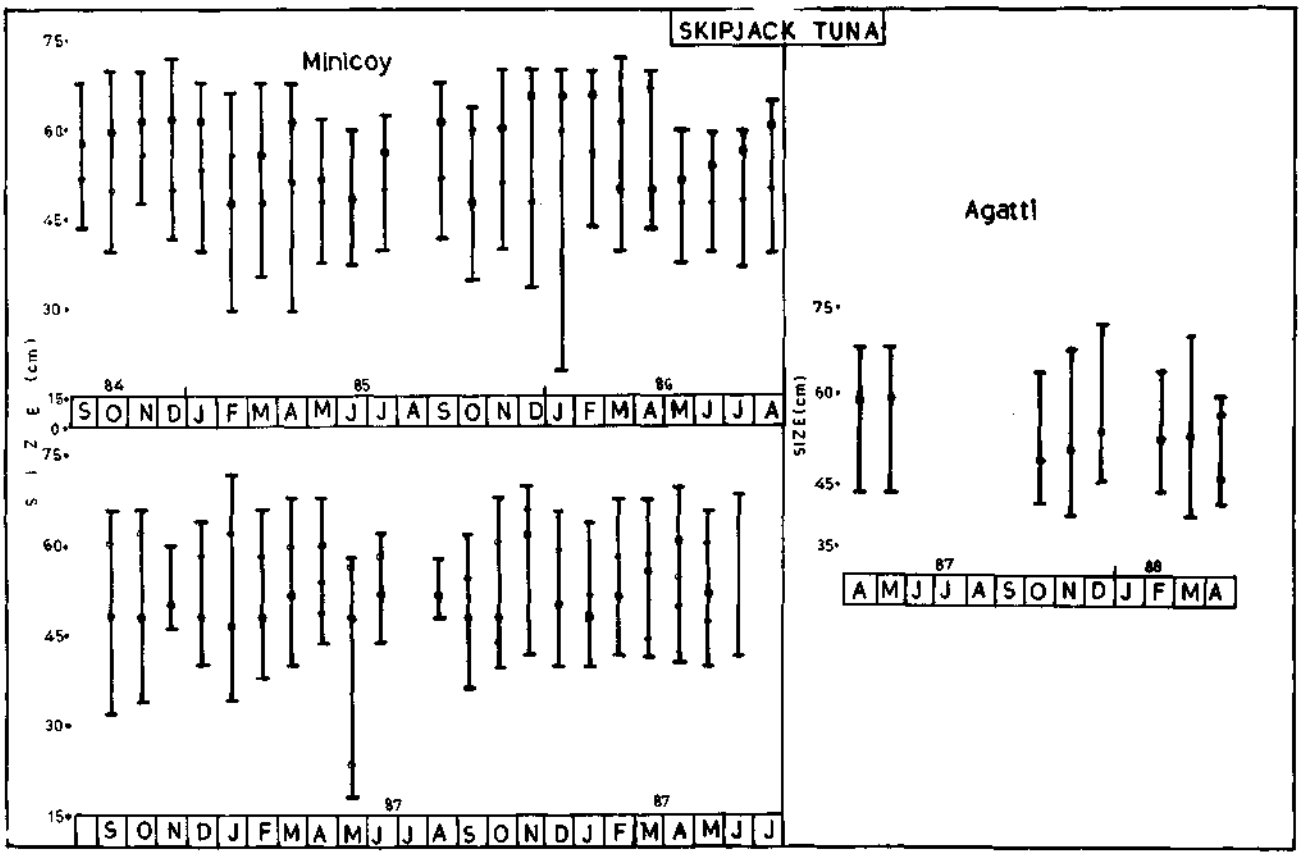


Fig. 28. Observed size distribution (monthly range and modes) of skipjack tuna at Minicoy and Agatti Islands, Lakshadweep 1984- 88.

References

Balan, K., K. K. P. Panikkar, T. Jacob, Joseph Andrews and V. Rajendran 1989. Motorisation of country crafts in Kerala - an impact study. *CMFRI Spl. Publ.*, **45** : 1-74.

Dhulkhed, M. H., C. Muthiah, G. Syda Rao and N. S. Radhakrishnan 1982. The purse seine fishery at Mangalore (Karnataka). *Mar. Fish. Infor. Serv. T & E Ser.*, **37** : 1-7.

—— and G. G. Annigeri 1988. Marine Fish Calendar - Karwar. *Ibid.*, **88** : 1-13.

Gopakumar, G., N. Gopalakrishna Pillai and P. N. Radhakrishnan Nair 1986. Mechanisation of traditional crafts with outboard motors at Vizhinjam. *Ibid.*, **69** : 23-28.

—— and P. S. S. Sharma 1989. The present status of coastal tuna fishery at Vizhinjam, Trivandrum. *Ibid.*, **97** : 7 pp.

James, P. S. B. R. 1991. Review of tuna fisheries in India : status paper. TWS/90/20, *Coll. Vol. Working Doc.*, FAO/IPTP, **4** : 359-370.

—— and A. A. Jayaprakash 1988. Current knowledge on the distribution, behaviour and abundance of tunas with suggestions for the development of tuna fishery in the Indian EEZ. *Proc. First Indian Fisheries Forum*, pp. 211-220.

—— and P. P. Pillai 1986. A review of the National tuna fishery in India. *Coll. Vol. Working Doc.*, FAO/IPTP, **2** : 342-352.

—— and —— 1988. Skipjack tuna fishery of Lakshadweep. *Ibid.*, **3** : 12 pp.

——, G. Gopakumar and P. P. Pillai 1986 a. Small scale pole and line tuna fisheries in Lakshadweep - Problems, present trend and strategies for further development. *Mar. Fish. Infor. Serv. T & E Ser.*, **77** : 1-10.

——, T. Jacob, C. S. G. Pillai and P. P. Pillai 1986 b. Prospects of development of marine fisheries in Lakshadweep. *Ibid.*, **68** : 51-54.

——, M. Srinath and A. A. Jayaprakash 1987. Stock assessment of tunas in the seas around India. *Coll. Vol. Working Doc.*, FAO/IPTP, **2** : 353-366.

—— and P. P. Pillai 1991. Strategies for tuna fishery development and management in the Indian Exclusive Economic Zone. *CMFRI Bull.*, **44** (3) : 619-642.

JAYAPRAKASH, A. A. 1989. Trends in drift gillnet fishery off Cochin with special reference to effort inputs and returns during 1981-82 and 1986-87. *In: Studies on Fish stock assessment in Indian waters. FSI Spl. Publ.*, **2** : 87-105.

KAGWADE, P. V., S. K. CHAKRABORTY, MOHAMMED ZAFAR KHAN AND J. D. SARANG 1989. Marine Fish Calendar - Bombay. *Mar. Fish. Infor. Serv. T & E Ser.*, **89** : 12 pp.

KUMARAN, M., T. M. YOHANNAN AND FEROZ KHAN 1988. Marine Fish Calendar - Calicut. *Ibid.*, **81** : 9 pp.

KURUP, K. N., G. KRISHNANKUTTY NAIR, V. P. ANNAM, ABHA KANT, M. R. BEENA AND LATHA KHAMBADKAR 1987. An appraisal of the marine fisheries of Karnataka and Goa. *CMFRI Spl. Publ.*, **36** : 34 pp.

LIPTON, A. P., T. APPA RAO, S. G. RAJE, C. GOPAL, RANJIT SINGH, P. B. THUMBER AND H. K. DHOKIA 1988. Marine Fish Calendar - Veraval. *Mar. Fish. Infor. Serv. T & E Ser.*, **86** : 1-20.

MADAN MOHAN, P. LIVINGSTON AND K. K. KUNHIKOYA 1986. Fishery and bionomics of tunas at Minicoy Islands. *CMFRI Bull.*, **36** : 122- 137.

MUTHIAH, C. 1982. Drift gillnet fishery of Dakshina Kannada Coast. *Mar. Fish. Infor. Serv. T & E Ser.*, **37** : 8-15.

—— 1986. Fishery and bionomics of tunas at Mangalore. *CMFRI Bull.*, **36** : 51-70.

NAIR, P. N. RADHAKRISHNAN, N. GOPALAKRISHNA PILLAI, P. S. S. SHARMA, A. K. VELAYUDHAN, MATHEW JOSEPH, K. T. THOMAS AND T. A. OMANA 1988. Marine Fish Calendar - Vizhinjam. *Mar. Fish. Infor. Serv. T & E Ser.*, **87** : 1-14.

PILLAI, P. P. 1990 a. Tuna fisheries in Lakshadweep. *Coll. Vol. Working Doc.*, FAO/IPTP, **4** : 370-385.

—— 1990 b. Live bait resources in Lakshadweep. *Ibid.*, **4** : 1-21.

—— 1991. Tuna Fishery Resources and their exploitation by low energy fishing techniques. In: *Proc. Nat. Worshop on Low Energy Fishing*, SOFT (in press).

—— M. KUMARAN, C. S. G. PILLAI, MADAN MOHAN, G. GOPAKUMAR, P. LIVINGSTON AND M. SRINATH 1986. Exploited and potential resources of live-bait fishes of Lakshadweep. *Mar. Fish. Infor. Serv. T & E Ser.*, **68** : 25-32.

RAO, K. V. N. AND K. ALAGARAJA 1988. Present status and prospects of exploitation of pelagic fishery resources of Karnataka Coast. *Proc. Seminar on Problems and Prospects of marine fishing and fish processing in Karnataka, Coll. Fisheries, Mangalore* pp. 15-21.

SAXENA, B. S. 1984. Letter to the Editor. *Fish Byte*, **2** (1) : 2- 3.

SILAS, E. G. AND P. P. PILLAI 1982. Resources of tunas and related species and their fisheries in the Indian Ocean. *CMFRI Bull.*, **32** : 174 pp.

——, M. S. RAJAGOPALAN AND P. P. PILLAI 1979. Tuna Fisheries in India : Recent trends. *Mar. Fish. Infor. Serv. T & E Ser.*, **13** : 12 pp.

——, A. A. JAYAPRAKASH AND M. A. PILLAI 1984. Focus on small scale fisheries: Drift gillnet fishery off Cochin, 1981 and 1982. *Ibid.*, **55** : 1-12.

—— AND P. P. PILLAI 1986 a. Fishery, biology and population dynamics of tunas and seerfishes - an update for India. *Coll. Vol. Working Doc.* FAO/IPTP, **1** : 327-349.

—— AND —— 1986 b. Indian tuna fishery development - prospective and a management plan. *CMFRI Bull.*, **36** (2) : 193 - 208.

—— P. P. PILLAI, A. A. JAYAPRAKASH AND M. A. PIALLI 1986 a. Fishery and bionomics of tunas at Cochin. *CMFRI Bull.*, **36** (4) : 28-43.

——, P. P. PILLAI, M. SRINATH, A. A. JAYAPRAKASH, C. MUTHIAH, V. BALAN, T. M. YOHANNAN, PON SIRAIMEETAN, MADAN MOHAN, P. LIVINGSTON, K. K. KUNHIKOYA, M. A. PILLAI AND P. S. S. SHARMA 1986 b. Population dynamics of tunas : Stock Assessment. *Ibid.*, **36** (3) : 20 - 28.

——, P. P. PILLAI AND PON SIRAIMEETAN 1986 c. Observations on the tuna fishery at Ratnagiri-Malwan area, NW coast of India. *Ibid.*, **36** (1) : 184 - 198.

——, K. V. N. RAO, P. P. PILLAI, MADAN MOHAN, G. GOPAKUMAR, P. LIVINGSTON AND M. SRINATH 1986 d. Exploited and potential resources of tunas of Lakshadweep. *Mar. Fish. Infor. Serv. T & E. Ser.*, **68** : 15-25.

SIVADAS, M. AND K. K. BALASUBRAMANIAN 1989. Introduction of 'Ringuvala' along Calicut Coast with a note on its general impact. *Ibid.*, **96** : 8-10.

YOHANNAN, T. M. AND K. K. BALASUBRAMANIAN 1988. Tuna fishery of Calicut area during the seasons from 1981-88. *Indian J. Fish.*, **35** (4) : 304- 308.

—— 1989. Drift gillnet fishery at Calicut with special reference to scombroids. *Mar. Fish. Infor. Serv. T & E. Ser.*, **95** : 1-5.

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PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : INDIAN MACKEREL

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ABSTRACT

The Indian mackerel *Rastrelliger kanagurta* contributes to 3% of the total mackerel catch of the west coast during the monsoon period. The catch trend at important centres *viz.* Vizhinjam, Cochin, Calicut, Mangalore, Karwar and Goa and the biological aspects such as length composition, maturation during monsoon, premonsoon and postmonsoon seasons are dealt with. In the light of the information available at present, it is suggested that a reduction in the fishing effort on mackerel stock along the west coast in the later half of the premonsoon and during monsoon may help to replenish the populations for sustained exploitation of the resources.

INTRODUCTION

The Indian mackerel *Rastrelliger kanagurta* is one of the important pelagic resources exploited along the west coast of India. Wide fluctuations in its landings from year to year are well known. During 1979-88 the total annual catch of mackerel along the west coast fluctuated from 15,503 tonnes in 1983 to 80,375 t in 1988 (Fig. 1). Monsoon and related changes in environment are found to influence its availability in the fishing area (Pradhan and Reddy, 1962; Noble, 1972; Rao *et al.*, 1973; Yohannan and Balasubramanian, 1991). An attempt is made here to study its fluctuations in space and time in relation to monsoon months giving suggestions on methods to improve the catch.

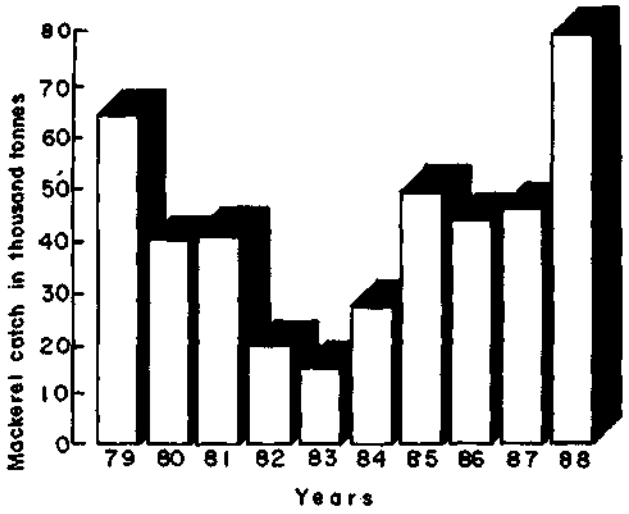

Fig. 1. Mackerel catch along the west coast of India.

DATA BASE

Data on the fishery and biology of the Indian mackerel from Vizhinjam, Cochin, Calicut, Mangalore and Karwar from February 1984 to August 1988 and from Goa from February 1984 to January 1988 form the basis of this study. Data during an year is pooled for the periods, premonsoon (February-May), monsoon (June-August) and postmonsoon (September-January). As the durations of these periods are unequal, average monthly estimate of each period is taken for comparison.

OBSERVATIONS

Fishery

Figure 2. gives the average total mackerel catch for each period at different centres. At all centres, peak catches are recorded during the postmonsoon period except at Vizhinjam where the catches are observed to be relatively high in the premonsoon period. The average seasonal catch, effort and catch per unit of effort (CPUE) at different centres are given in Figs. 3 - 6. It is seen that the bulk of the mackerel catch at Cochin, Mangalore, Karwar and Goa is realised by the purse seine. Only at Vizhinjam and Calicut, where purse seines operations are not available the fishery continues to be artisanal. But here also motorisation of indigenous crafts over the years has resulted in the mechanisation of all the country crafts at Calicut (Yohannan and Balasubramanian, 1991) and 85% of the drift net units and 80% of the hooks and line units at Vizhinjam (Gopakumar *et al.*, 1986).

The fishery is found to be most active in the postmonsoon period especially where the purse seines are in operation. Relatively high catches of mackerel are observed at the centres as compared to those in the centres where this gear is not in operation. The catch in general is the lowest during the monsoon period (Fig. 2) except at Calicut and Goa where the monsoon catches are higher than that of the premonsoon period.

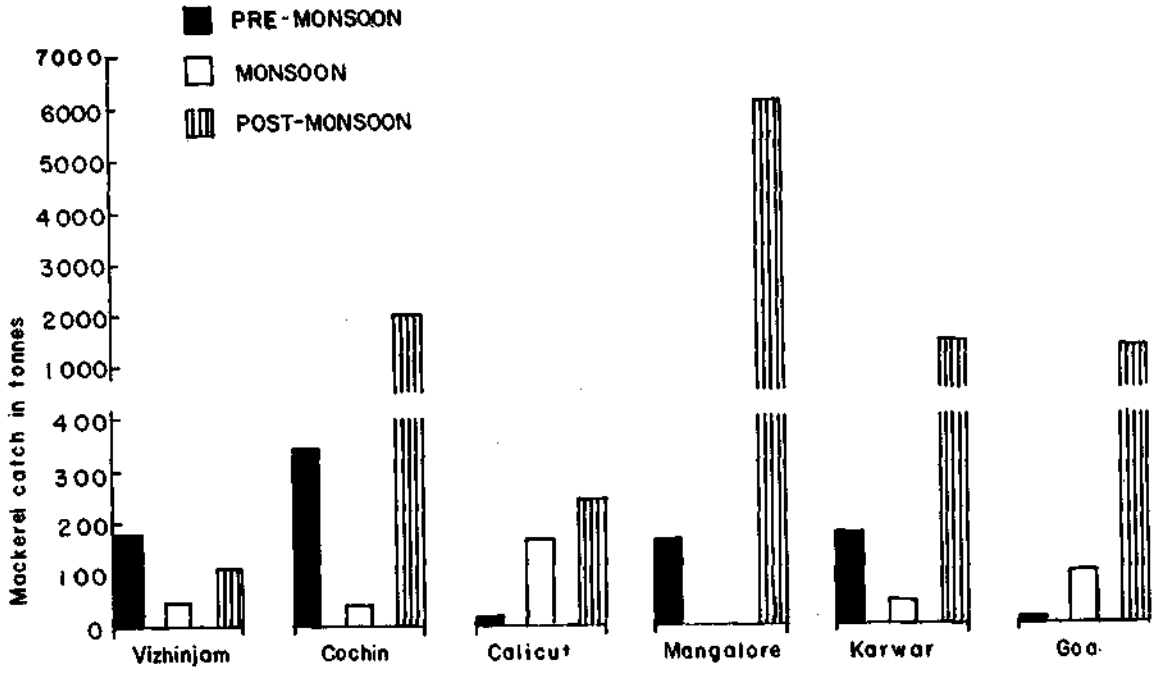

Fig. 2. Average total mackerel catch in different seasons during February 1984 - August 1988.

At Vizhinjam (Fig. 3) the catches in drift nets, particularly those operated onboard the motorised crafts, were high. In both drift net and hooks and line, whether mechanised or not, the CPUE during monsoon period was the highest in 1987-88. During other years, it was highest in premonsoon period. *Chala vala*, boat seines and shore seines also landed mackerel in small quantities apart from the drift nets and hooks and line.

At Cochin (Fig. 4) where purse seines contribute to the bulk of the mackerel catch, the peak landings were in the postmonsoon period. Purse seines suspend operations in monsoon months. Fishing activity was high also during premonsoon period when appreciable quantities of mackerel were caught. Trawl nets and drift nets also landed mackerel here as by-catches. In 1987-88 and 1988 mackerel catches by trawl nets increased considerably. Drift nets used to get better CPUE during the monsoon period. The average monthly CPUE during different periods in the years reviewed ranged between 1.26 and 2.36 kg in drift net and from 1.76 to 7.32 kg in trawl net. While the maximum effort and relatively high catch of mackerel were observed in the drift nets during the monsoon of 1988, they were better in the trawl nets operated during the premonsoon period.

At Calicut (Fig. 5) *patten kolli* (boat seine) and *ayila chala vala* (gill net) were the important gear employed in the mackerel fishery. Peak catches were observed during the postmonsoon period in the *patten kolli vala* (1988). But catches were high in the monsoon period and poor during premonsoon period. In 1987-88, however, all the gears landed appreciable catch of mackerel during the monsoon period. A small type of boat seine, namely *nethal vala* also landed mackerel in good quantities during the monsoon periods. Drift nets, *mathi chala vala* and trawl nets too landed mackerel as by-catches. The effort, catch and catch rate of *ayila chala vala* and *nethal vala* were generally higher during monsoon.

At Mangalore (Fig. 6) purse seine was the gear used in the mackerel fishery with peak landings occurring during the postmonsoon period. The gear was not operated during monsoon. The

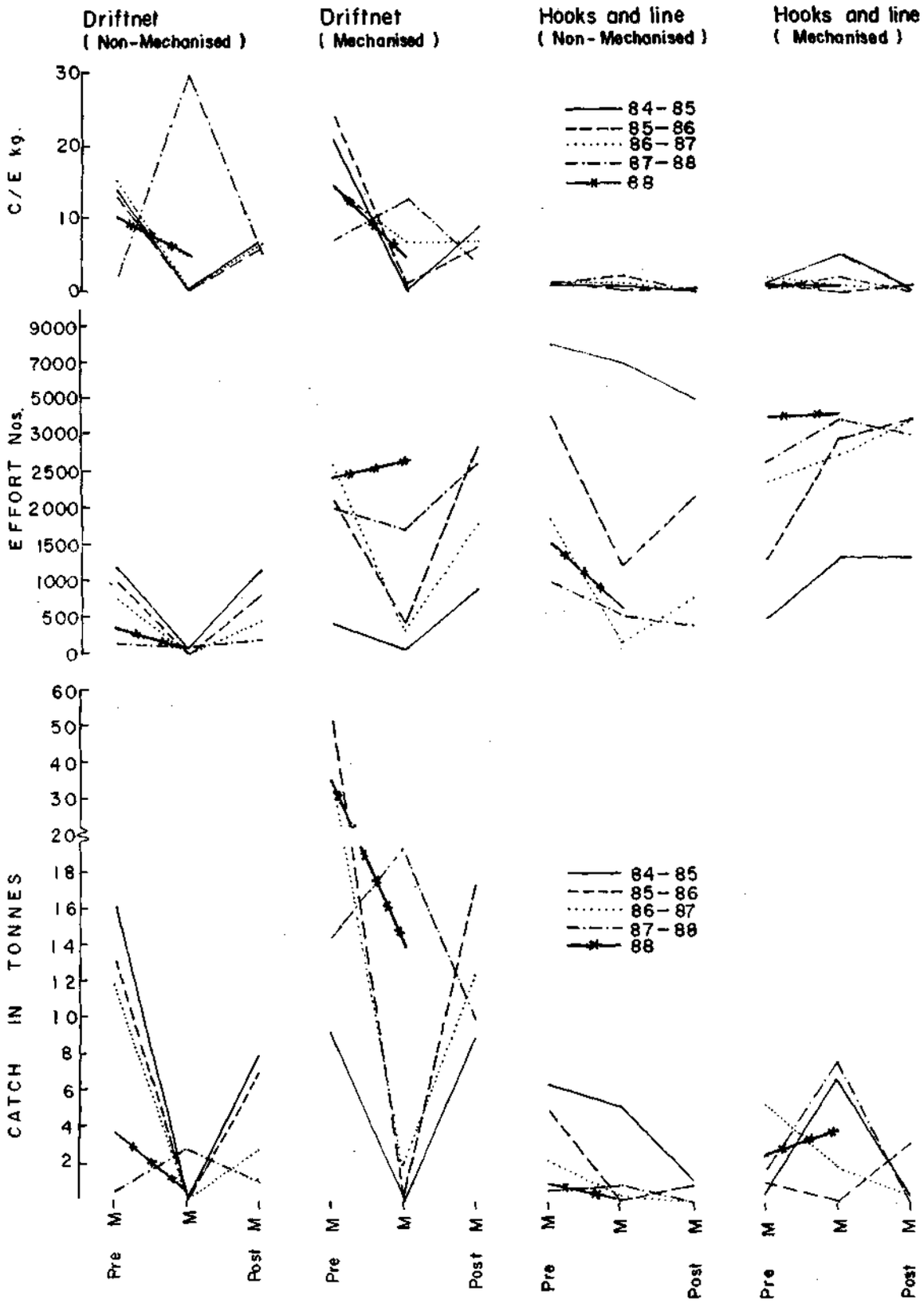

Fig. 3. Average seasonal catch, effort and catch per effort at Vizhinjam during 1984 -'88.

catches were poor during the premonsoon period when compared to the heavy catches recorded during the postmonsoon period. But the quantities landed regularly during this period were appreciably higher than that landed during the same period at other centres. Trawl nets also landed mackerel here in small quantities.

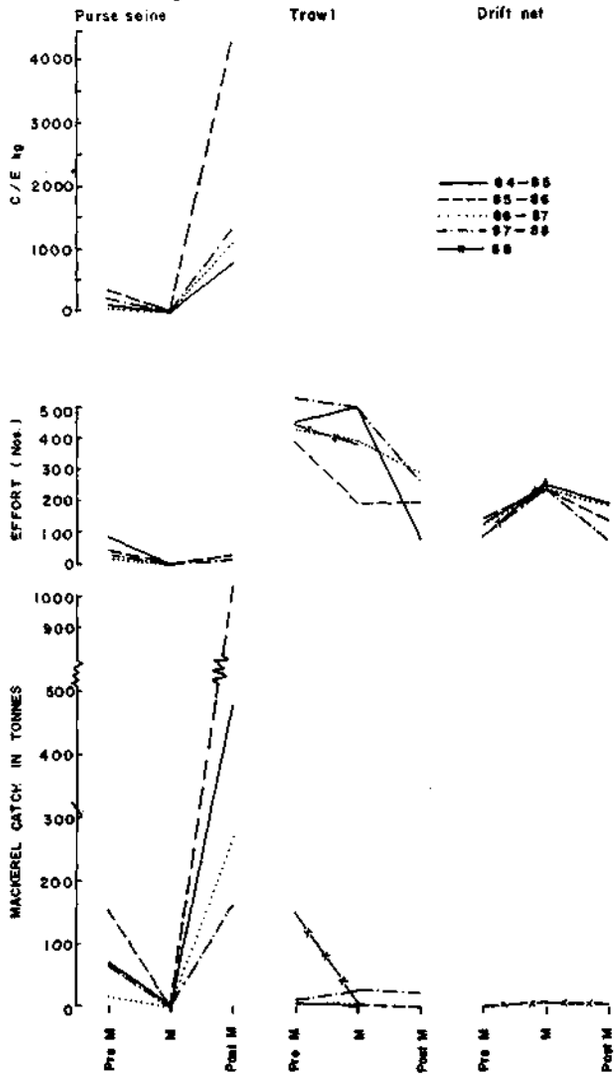

Fig. 4. Average seasonal catch, effort and catch per effort at Cochin during 1984 -'88.

At Karwar (Fig. 6) also, the purse seines landed major portion of the mackerel catch. Peak catches were made during the postmonsoon period when fishing activity was intense. But some purse seining activity was observed here in the monsoon period also. Though the activity was at the minimum, the catch rates were high during this period. In the first 3 years, maximum CPUE was obtained during monsoon period. The catch rates were generally poor during the premonsoon period. Small quantities of mackerel catch were obtained by *yendi* (small shore seine) and *rampan* (large shore seine). *Rampan* which had almost disappeared from the scene reappeared in the postmonsoon period of 1987-88 catching 4 t in 3 operations.

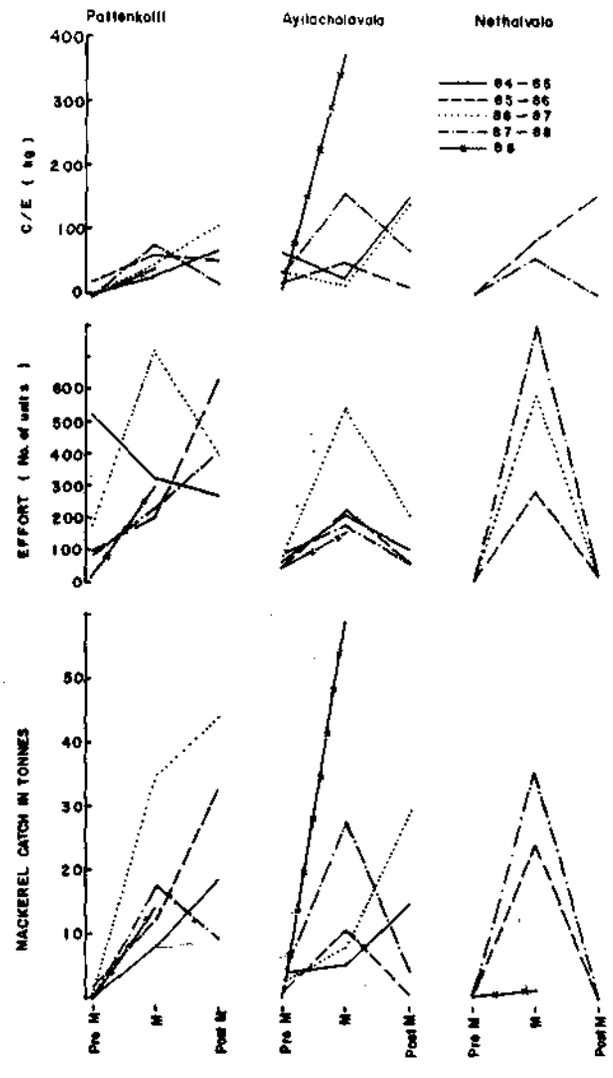

Fig. 5. Average seasonal catch, effort and catch per effort at Calicut during 1984 -'88.

At Goa (Fig. 6) only purse seines were operated during 1984-88. The fishing activity was lowest during the monsoon period and highest during postmonsoon period. But, catch rates were very poor during premonsoon period. Peak CPUE was obtained during the monsoon periods of 1984-85 and 86-87 and during the postmonsoon periods in 1985-86 and 87-88. The landings were invariably maximum during postmonsoon periods.

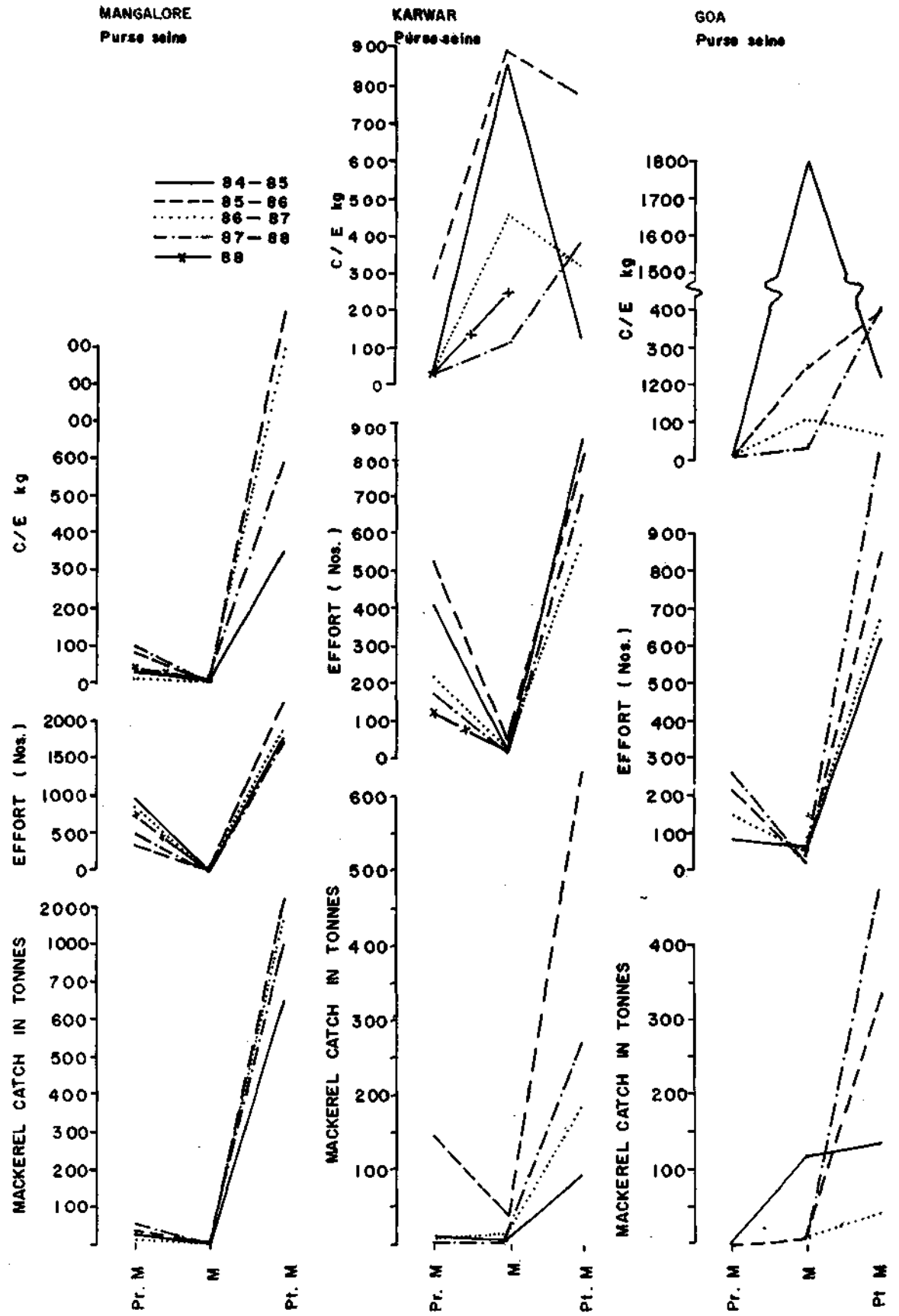

Fig. 6. Average seasonal catch, effort and catch per effort at Mangalore, Karwar and Goa during 1984 -'88.

Biology

Length composition : Figure 7 gives the size distribution of mackerel during different seasons at different centres. During the premonsoon seasons the dominant size groups were from 210 to 270 mm at all centres except Mangalore where it was 110 - 140 mm. Such small sizes formed a very minor peak at Calicut and Goa.

During the monsoon period, at Vizhinjam and Calicut, smaller fishes measuring from 70 to 110 mm dominated the catches. At Goa, fishes of 130-150 mm length range dominated. At Karwar the dominant size group was between 160 and 180 mm. Minor peaks at 240 mm at Vizhinjam, 220 mm at Calicut and Goa and 230 mm at Karwar were also noticed.

The size groups from 160 to 240 mm dominated the catches during the postmonsoon season at all the centres. The mode was at 220 mm at Vizhinjam and Cochin. At Calicut the distribution was bimodal with a primary mode at 170 mm and a secondary one at 200 mm. At Mangalore the dominant mode was at 200 mm and the next one at 230 mm. At Karwar and Goa also the mode at 200 mm dominated. At Goa another prominant mode was observed at 100 mm.

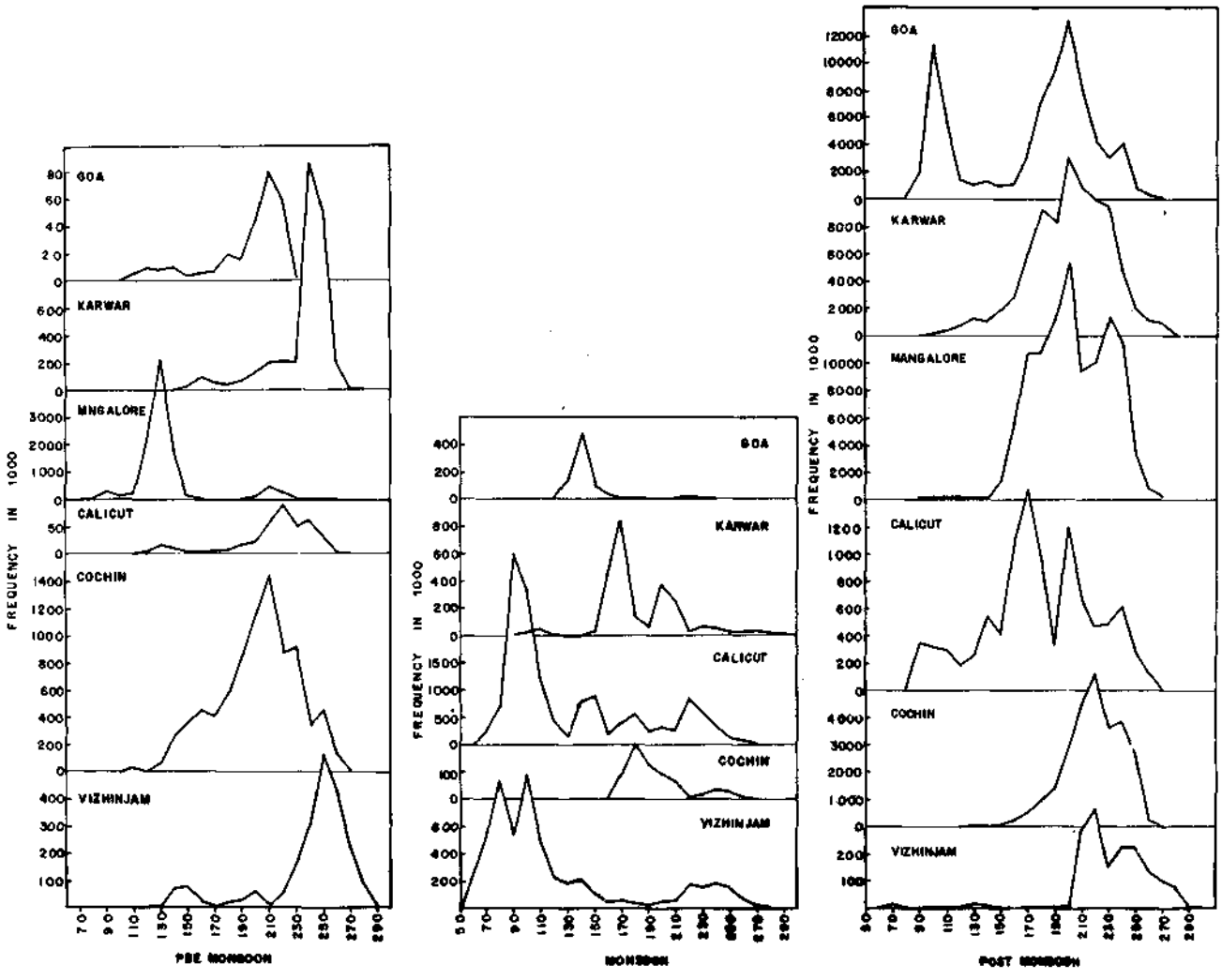

Fig. 7. Length Frequency distribution of mackerel during different seasons at different centres.

In general, large size groups dominated the fishery during premonsoon period. Juveniles were the mainstay of the monsoon fishery. Medium, commercial size groups formed the bulk of the catches during postmonsoon period.

Maturation

Figure 8 illustrates the percentage of mature mackerel during different months at Vizhinjam and Calicut. Maximum percentage of mature mackerel were observed from March to July with a peak in May. At Vizhinjam a secondary peak was observed in October indicating another spawning period of minor importance.

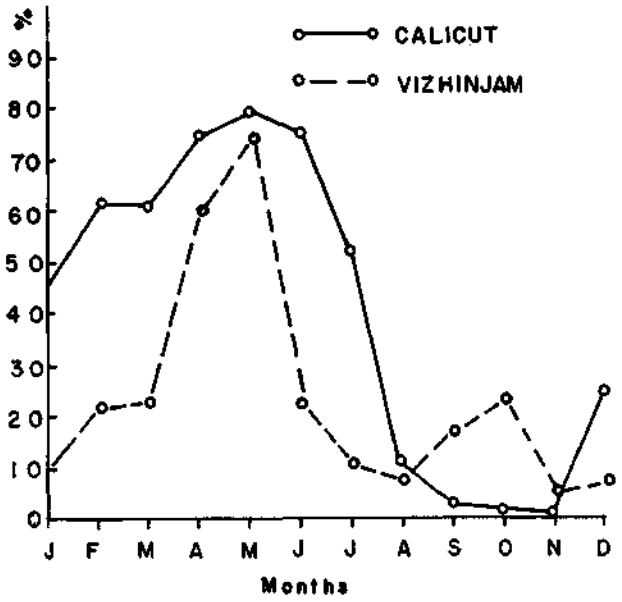

Fig. 8. Percentage of mature mackerel at Vizhinjam and Calicut.

Discussion

On the whole around 90% of the mackerel catch was made in the postmonsoon period, 7% in the premonsoon period and 3% in the monsoon period.

The reason for the low catches during the monsoon period was generally due to decreased effort. Besides, the adverse sea conditions also restricted the fishing units from operation. But during certain years, peak catch per unit of effort was recorded in the monsoon period from different centres. In 1987-88 peak CPUE was recorded in this season at Vizhinjam and Calicut. In 1984-85, 1985-86 and 1986-87 Karwar recorded maximum CPUE during this season. In 1988 also it was high. Goa recorded maximum CPUE during monsoon in 1984-85. With the use of outboard engines for propulsion of country crafts there was a steady increase in effort during the monsoon season at Vizhinjam and Calicut (Fig. 3 and 5). But this is a situation which has to be watched cautiously. Fig. 7 and 8 indicate that in the beginning of monsoon season the fishing is on the spawning stock and subsequently switching over to capture of juveniles of non-commercial importance in large numbers. The figures further indicate intensive spawning to take place around May and large scale removal of its products in the succeeding monsoon season lead to growth overfishing. Fig. 7 and 8 further indicate that during pre-monsoon the fishing pressure is on the mature and spawning mackerel that continues into the early part of the monsoon period. There is an active premonsoon fishery at all centres except Calicut and Goa. At Vizhinjam, peak catches are obtained during the premonsoon period. At Cochin though the peak catches are made during the postmonsoon period, its premonsoon catches exceed the corresponding catches at Vizhinjam. The catches by trawl nets at Cochin are on the increase during the premonsoon period. Yohannan and Balasubramanian (1991) have found a relation between spawning stock and subsequent mackerel fishery.

In the light of the above observations it may be suggested that a reduction in the fishing pressure on mackerel stocks along the west coast in the later half of the premonsoon and during monsoon may help to replenish the mackerel population and subsequent recruitment to the fishery in the postmonsoon season.

References

Gopakumar, G., N. Gopalakrishna Pillai and P. N. Rahdakrishnan Nair 1986. Mechanisation of traditional crafts with outboard motors at Vizhinjam. *Mar. Fish. Infor. Serv. T & E Ser.*, 69 : 23 - 28.

Noble, A. 1972. Surface temperature and its relation to the duration of mackerel fishery at Karwar. *Indian J. Fish.*, 19 (1) : 167-170.

Pradhan, L. B. and C. V. G. Reddy 1962. Fluctuations in mackerel landings at Calicut in relation to hydrographical factors. *Ibid.*, 9 (1) : 100-109.

Rao, D. S., C. P. Ramamirtham and T. S. Krishnan 1973. Oceanographic features and abundance of the pelagic fishes along the west coast of India. *Proc. Symp. Living Resour. of Seas around India, C. M. F. R. I.*, pp. 400-413.

Yohannan, T. M. and K. K. Balasubramanian 1991. Mackerel fishery of the Calicut area and its fluctuations during the seasons from 1980-81 to 1985-86. *J. mar. biol. Ass. India*, 33 (1 & 2) : 246 - 254.

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4. 4

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : OILSARDINE

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ABSTRACT

Considerable fluctuations coupled with a general decline in the oilsardine landings have been observed along the southwest coast of India during 1984-85 to 1988-89. The catch and effort data for oilsardine fishery during the different seasons have revealed that postmonsoon period is the most productive period for the fishery. The decline in the fishery is attributed to the indiscriminate exploitation of juveniles and potential spawners by purse seiners and ring seines. The traditional sector has been adversely affected by the operations of purse seines in recent years in northern Kerala. Exploitation of spawning stock of oilsardine during the breeding season from May to September is of great consequence for the conservation of the resource. Eventhough good monsoon is most likely to have a positive impact on the stock size and facilitate spawning and recruitment, the likely advantage is offset by indiscriminate exploitation. Regulation of mesh size of boat seines and restricting the operations of purse seines and ring seines are expected to restore the fishery to its pre-eminent position and protect the interests of the traditional sector.

INTRODUCTION

The oilsardine *Sardinella longiceps* which enjoys a pre-eminent position in Indian marine fisheries, is mainly caught from the coastal waters of Kerala and Karnataka and to some extent from Goa and Southern Maharashtra on the west coast. Over the years, large scale annual and seasonal fluctuations have been observed in the oilsardine landings. Despite the fact that investigations on its fishery and biology are being carried out for more than sixty years, the exact fishery dependant and fishery independant factors responsible for the fluctuations in its availability in the coastal fishing belt are not fully known. To forecast the vagaries in the fishery, information on the exploitable resources is a prime requisite. An attempt is made in this paper to analyse critically the fluctuations in the fishery as reflected in the landings in Kerala, Karnataka and Goa and its relation to the monsoon of the southwest coast.

The oilsardine fishery restricted to the narrow coastal belt of about 15 kilometres from the shore, used to be exclusively exploited by indigenous crafts and gears. The boat seine *Mathikkolli vala*, used exclusively for capturing oilsardine, and *Pathu vala* and *Thattum vala* operated till the late sixties have become obsolete with the introduction of nylon nets and their place has been taken over by *Pattenkolli vala* which is used for the capture of small sized fishes especially oilsardine and mackerel in the inshore areas. Indigenous gears like *Rampani* and gill net have been important gears operated for oilsardine fishery in Karnataka. But the large scale introduction of purse-seine in Karnataka and purse-seine and ring seine in Kerala in the late seventies changed the trend in pelagic fish landings and made the most effective traditional gear *Rampani* in Karnataka and boatseines in Kerala almost obsolete. Purse-seines are operated within 50 metres depth, but the majority of the catches are realised from 11-20 m depth during the peak fishing season (September to January). Its mesh size at the time of introduction was 14-18 mm and this has been reduced to 8-14 mm in recent years in some units.

The fishery and biology of oilsardine of the southwest coast have been reviewed earlier by Nair and Chidambaram (1951), Nair (1960), Sekharan and Dhulkhed (1963), Sekharan (1965), Antony Raja (1969), Prabhu (1971), Prabhu and Dhulkhed (1970), Balan and Reghu (1979), Jacob *et al.* (1982) and Balan (1984). Nair and Chidambaram (1951) attributed the success of the fishery along the southwest coast to the abundance of small-sized immature oilsardine shoals in inshore waters. Hornell and Nayudu (1924), Devanesan (1943), Chidambaram and Menon (1945), Chidambaram

(1950) and Antony Raja (1969) reported that oilsardine exclusively feed on plankton, the major constituent being diatoms and suggested a direct relationship between the abundance of plankton and pelagic fishery landings. The shoreward movement of juveniles of oilsardine towards the end of southwest monsoon has been attributed to the abundance of the diatom *Fragilaria oceanica* and the prevalence of optimum temperature and salinity (Nair and Subrahmanyam, 1955). Mukundan (1971) stated that the abundance of planktonic food organisms during the postmonsoon period is due to the abundance of dissolved nitrogenous substances and slightly warmer temperature. Murty and Edelman (1970) observed some relation between the intensity of the southwest monsoon and the availability of oilsardine. Stock assessment of oilsardine off the west coast of India was reported by Kurup *et al.* (1989).

Data Base

The results of investigations based on the fishery and biological data of oilsardine collected from major fish landing centres at Goa, Karwar, Mangalore, Calicut, Cochin and Vizhinjam from February 1984 to August 1988 are dealt with in this paper. The resources have been studied based on gearwise catch, effort and maturity data from different centres and the quantitative estimates of the exploited stocks in different depth zones and seasons are also given. For the sake of convenience in discussing the fishery during different seasons, an year is divied into the three seasons, premonsoon (February-May), monsoon (June-August) and postmonsoon (September-January). The data on estimated total landings were collected from NMLRDC of CMFRI. The rainfall data were collected from the Indian Meteorological Department, Trivandrum.

Observations

General fishery characteristics in different States

Traditional gears like boat seine, shore seine and gill net are generally employed for oilsardine fishery all along the southwest coast. But the trend has considerably altered consequent to the operations of purse-seine and ring net in Goa, Karnataka and Kerala in recent years.

In Goa, the annual oilsardine landings varied from 917 t (1986) to 17,988 t (1988) with an annual average of 7025 t and the majority was by purse-seine (Table 1). The average production during 1984-1988 period was 964 t in premonsoon, 12 t in monsoon and 6049 t in postmonsoon with seasonal percentages of 13.7, 0.2 and 86.1 respectively. In purse-seine, premonsoon (81.7%) and postmonsoon (97.4%) yielded the bulk of the catch; whereas in gill net, the corresponding percentages were only 12.2 and 0.9. The premonsoon production ranged from 94 t (1986) to 1418 t (1985), monsoon yield varied from 5 t (1985) to 55 t (1987) and postmonsoon landings from 643 t (1984) to 16,649 t (1988).

Table 1. *Seasonal oilsardine production (t) in Goa during 1984-1988 and the average gearwise contribution*

	Seasons			
Year	Premonsoon	Monsoon	Postmonsoon	Total
1984	303	-	643	946
1985	1418	5	2612	4035
1986	94	-	823	917
1987	864	55	9518	10437
1988	1339	-	16649	17988
Average	964.0 (13.7%)	12.0 (0.2%)	6049.0 (86.1%)	7025
Purse-seine	787.2 (81.7%)	11.0 (91.7%)	5892.1 (97.4%)	
Gill net	117.2 (12.2%)	-	53.1 (0.9%)	
Others	59.6 (6.1%)	1.0 (8.3%)	103.2 (1.7%)	

Oilsardine is mainly caught by purse seine in Karnataka and trawl net, gill net and shore seine land only limited quantities (Table 2). During 1984-88, the annual total landings varied from 18,174 t (1986) to 51,539 t (1987) with a mean of 37,145 t. The postmonsoon yielded peak landings of 73.2% of the total. The production during this season fluctuated from 7058 t (1986) to 45,567 t (1987) with an average of 27,195 t. The average premonsoon landing amounted to 9809.4 t forming 26.4% of the total landing. The landing during the monsoon was only negligible, 140.2 t forming 0.4%. Gill nets accounted for 40.2% of the landing during the monsoon. The landing during the premonsoon was 98.0% by purse-seine (9614.8 t) and the postmonsoon landing by purse-seine was 26128.2 t (96.1%).

The exploitation of oilsardine along the Kerala Coast is mainly by ring seine, boat seine,

TABLE 2. *Seasonal oilsardine production (t) in Karnataka during 1984-1988 and the average gearwise contribution*

	Seasons			
Year	Premonsoon	Monsoon	Postmonsoon	Total
1984	7442	-	27733	35175
1985	4278	150	32280	36708
1986	11067	49	7058	18174
1987	5470	502	45567	51539
1988	20790	-	23340	44130
Average	9809.4 (26.4%)	140.2 (0.4%)	27195.6 (73.2%)	37145
Purse-seine	9614.8 (98.0%)	63.8 (45.5%)	26128.2 (96.1%)	
Trawl net	6.1 (0.1%)	0.2 (0.1%)	89.8 (0.3%)	
Gill net	8.6 (0.1%)	56.3 (40.2%)	379.2 (1.4%)	
Others	179.9 (1.8%)	19.9 (14.2%)	98.4 (2.2%)	

TABLE 3. *Seasonal oilsardine production (t) in Kerala during 1984-1988 and the average gearwise contribution*

	Seasons			
Year	Premonsoon	Monsoon	Postmonsoon	Total
1984	59987	12309	62609	134905
1985	37106	9415	40854	87375
1986	16291	59	8973	25323
1987	1712	17762	25486	44960
1988	2223	7948	66636	76807
Average	23463.8 (31.8%)	9498.6 (12.9%)	40911.6 (55.3%)	73874
Purse-seine	3040.2 (12.9%)	-	8111.4 (19.8%)	
Ring seine	7412.0 (31.6%)	3822.2 (\$0.2%)	21162.6 (51.7%)	
Boat seine	5873.0 (52.0%)	4285.0 (45.1%)	6852.8 (16.7%)	
Trawl net	71.4 (0.3%)	1.4 (0.0%)	109.2 (0.3%)	
Gill net	5324.0 (22.7%)	944.8 (9.9%)	3590.4 (8.8%)	
Others	814.6 (3.5%)	445.2 (4.8%)	1085.2 (2.7%)	

purse-seine and gill net. The annual landing varied from 25,323 t (1986) to 134,905 t (1984) with an average of 73,874 t (Table 3). During the years 1984-88, the average premonsoon landing was 23,463.8 t (31.8%) and the postmonsoon average was 40,911.6 t (55.3%), whereas the monsoon fishery was 9498.6 t (12.3%). In the premonsoon, the percentage contribution in the landing by ring seine, boat seine, gill net and purse-seine were 31.6, 25.0, 22.7 and 12.4 respectively, whereas the corresponding percentages during the postmonsoon were 51.7, 16.7, 8.8 and 19.8. During the monsoon the majority of the landing was by ring seine (40.2%) and boat seine (45.1%).

Seasonal trend in the landings and fishing effort at different centres

Goa : The average purse-seine landing of oilsardine during the premonsoon, monsoon and postmonsoon was 282 t, 25 t and 938 t respectively (Table 4). In the premonsoon, the highest catch per unit effort of 839 kg was in 1984. An average of 23% of the total oilsardine catch was during this season with an average catch per effort of 390 kg. There was fishing only in August during the monsoon which contributed only 2% of the total annual oilsardine landings. Postmonsoon is the peak fishing season which accounted for about 75% of the total catch with an average catch per effort of 227 kg. In 1985-86 there was a sharp increase in the catch to 1604 t, but the landings declined in the next year. The seasonal percentage contribution to the total oilsardine catch was as high as 98% in 1986-87 with a minimum of 38% in 1984-85.

Karwar : The premonsoon of 1984-85 was more productive for oilsardine with a catch of 2222 t and the catch per effort was 1342 kg (Table 5). During the premonsoon of 1986-87, the effort declined by 57% over the previous year and the catches further declined by 35%. The catch per effort was 809 kg. Purse-seines were not operated during June and July and the landings during the monsoon are generally very poor. In 1985-86, the catches during the monsoon amounted to 114 t with a catch per effort of 905 kg. However, in 1986-87, even though the effort showed an increase by 29% over the previous year, the landings declined to 13 t. The postmonsoon is more productive than the other two seasons. During 1984-85, the postmonsoon accounted for 3096 t which formed 58.2% of the total catch of oilsardine that year. In 1986-87, the catches declined to 3377 t and the catch per effort also decreased.

TABLE 4. *Seasonal fishing effort, oilsardine catch (tonnes) and catch per unit effort (Kg) of purse-seine at Panaji (Goa) during 1984-85 to 1987-'88*

Year	Premonsoon			Monsoon			Postmonsoon			Total
	E	C	C/E	E	C	C/E	E	C	C/E	C (t)
1984-85	336	282	839	196	-	-	3130	179	57	461
1985-86	858	515	600	109	5	46	4266	1604	376	2124
1986-87	608	14	23	175	55	314	3370	771	229	840
1987-88	1091	319	293	72	4	54	5775	1196	207	1519
Average	723	282	390	138	25	181	4135	938	227	989

Mangalore : Purse-seine is the only gear by which oilsardine is landed during the premonsoon period. Oilsardine catches and catch per effort in purse-seine during the premonsoon period was maximum in 1986, being 2395 t and 699 kg respectively when compared with other gears. Minimum catch and catch per effort of 362 t and 119 kg respectively were recorded during 1988 (Table 6). Purse-seines were not operated during monsoon period at Mangalore. Indigenous gear *Matubala* landed 31 t of oilsardine during the monsoon of 1987 with a catch per effort of 24 kg. Postmonsoon period was the most productive period for oilsardine landings. The landings of the postmonsoon period accounted for 85%, 96%, 41%, 96% and 92% of the annual landings during 1984-85, 1985-86, 1986-87, 1987-88 and 1988-89 respectively. The average catch per effort for the postmonsoon season of 1984-85 was 1177 kg; for 1985-86, 1468 kg; for 1986-87, 179 kg; for 1987-88, 1860 kg and for 1988-89, 330 kg. In 1987-88 postmonsoon period, tremendous revival of the fishery was observed when compared to the previous year and a record monthly catch to the tune of 9713 t was recorded in September 1987 and minimum catch of 635 t in November. In 1988-89, the maximum catch of 1922 t was accounted in January 1989 and the minimum of 408 t in September.

Calicut : The composition of oilsardine in the annual fish landings varied from 13.6 to 33.2% with an annual average of 25.7%. The average annual landings of oilsardine during the four year period 1984-88 was 1873 t. The highest landing of 2719 t was during 1984-85 with a catch per standard effort of 374 kg and the lowest during 1985-87, being 626 t with the lowest catch per standard effort of 117 kg which was the lowest recorded so far from Calicut (Table 7). During 1984-88, 67.6% of the total oilsardine landings was during the postmonsoon period followed by premonsoon (17.6%) and the lowest during monsoon (14.8%). Major portion of the landings was affected by boat seine *Pattenkolli* (77.2%) followed by *Nethal vala* (20.5%) and the lowest was by *Mathichala vala* (2.3%).

TABLE 5. *Seasonal fishing effort, oilsardine catch (tonnes) and catch per unit effort (Kg) of different gears of Karwar*

	1984-85			1985-86			1986-87			1987-88			1988		
	E	C	C/E	E	C	C/E	E	C	C/E	E	C	C/E	E	C	C/E
Purse-seine															
Premonsoon	1656	2222.0	1341.8	2057	1100.7	535.1	889	718.9	808.7	725	204.8	282.5	505	56.0	110.9
Monsoon	20	1.5	75.0	126	114.0	904.8	89	13.1	146.8	41	7.8	190.2	91	-	-
Postmonsoon	4293	3096.8	721.4	4111	3782.8	920.2	2869	405.6	141.4	3523	2764.5	784.7	-	-	-
Yendi															
Premonsoon	424	1.0	2.4	533	-	-	340	-	-	482	-	-	613	3.2	5.2
Monsoon	882	1.0	0.0	1185	0.9	0.1	168	-	-	1362	1.6	1.2	1478	-	-
Postmonsoon	574	-	-	158	0.5	3.4	561	-	-	672	13.5	20.1	-	-	-
Rampani															
Premonsoon	1	0.9	900	-	-	-	-	-	-	-	-	-	-	-	-
Monsoon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Postmonsoon	-	-	-	-	-	-	-	-	-	14	2.4	171.4	-	-	-

TABLE 6. *Seasonwise catch (tonnes), fishing effort and CPUE (t) of oilsardine for different gears at Mangalore*

	1984-85			1985-86			1986-87			1987-88			1988-89		
Seasons	E	C	C/E	E	C	C/E	E	C	C/E	E	C	C/E	E	C	C/E
Purse-seine															
Premonsoon	3826	1933	0.505	1378	627	0.455	3424	2395	0.699	2018	686	0.340	3044	362	0.119
Monsoon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Postmonsoon	9135	10753	1.177	11409	16749	1.468	9203	1650	0.179	8621	16038	1.860	11961	3954	0.330
Total	12961	12686	0.979	12787	17376	1.359	12627	4045	0.320	10639	16724	1.572	15005	4316	0.288
Mattubala															
Premonsoon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monsoon	No Data			405	-	-	648	-	-	1327	31.31	0.024	1510	-	-
Postmonsoon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	405	-	-	648	-	-	1327	31.31	0.024	1510	-	-

TABLE 7. *Seasonal fishing effort, catch (tonnes) and catch per unit effort (Kg) of oilsardine by different gears at Calicut during 1984-'88*

	Pattenkolli vala			Mathichala vala			Nethal vala			Total		
Year/Season	E	C	C/E	E	C	C/E	E	C	C/E	SE	C	C/SE
1984-85												
Premonsoon	2170	857	395	96	4	42	-	-	-	2180	861	395
Monsoon	895	206	230	172	1	6	-	-	-	900	207	230
Postmonsoon	1541	659	428	1252	58	46	1924	933	485	3858	1650	428
Annual	4606	1722	374	1520	64	42	1924	933	485	7271	2719	374
1985-86												
Premonsoon	941	101	107	86	-	-	-	-	-	941	101	107
Monsoon	469	212	452	22	1	45	841	221	263	957	434	453
Postmonsoon	2843	1498	527	1092	47	43	-	-	-	2933	1545	527
Annual	4253	1812	426	1200	48	40	841	221	263	4883	2081	426
1986-87												
Premonsoon	618	503	814	7	-	-	-	-	-	618	503	814
Monsoon	2702	19	7	27	2	74	-	-	-	2914	21	7
Postmonsoon	1854	80	43	349	9	26	41	12	293	2335	101	43
Annual	5174	603	117	383	11	29	41	12	293	5366	626	117
1987-88												
Premonsoon	342	61	178	-	-	-	-	-	-	342	61	178
Monsoon	700	224	320	277	23	83	2113	328	155	1799	575	320
Postmonsoon	2459	1361	553	367	18	49	125	50	400	2581	1429	553
Annual	3501	1645	470	644	41	64	2238	378	169	4393	2064	470
1988-upto August												
Premonsoon	57	13	228	70	1	14	57	-	-	62	14	228
Monsoon	893	48	54	84	1	12	-	-	-	903	49	54
Average												
Premonsoon	826	307	344	52	1	11	11	-	-	829	308	372
Monsoon	1132	142	213	116	6	44	591	110	84	1495	257	172
Postmonsoon	2174	900	388	765	33	41	523	249	295	2927	1181	403
Annual	4132	1349	326	953	40	43	1125	359	319	5251	1746	333

E = Effort; C = Catch; SE = Standard effort.

Seasonwise landings of oilsardine by different gears for the period 1984-85 to 1988 is shown in Fig. 1. The oilsardine landings during the premonsoon ranged from 14 to 861 t with an average of 308 t. The landings during the monsoon varied from 21 to 575 t with an average of 257 t. The landings during the postmonsoon varied from 101 to 1650 t with an average of 1181 t. The average standard effort during the different seasons was premonsoon, 829, monsoon, 1495 and postmonsoon, 2927. The average catch per standard effort was premonsoon, 372 kg, monsoon 172 kg and postmonsoon 403 kg. The annual standardised effort was highest during 1984-85 (7271) with a catch per standard effort of 374 kg and low during 1987-88 (4393) with a catch per standard effort of 470 kg which was the highest. The trends in the landings and catch per standard effort for the different seasons during 1984-88 are depicted in Fig. 2. The annual catch by *Pattenkolli* was the highest during 1985-86 (1812 t) with a catch per effort of 426 kg, whereas it was the lowest during 1986-67 (603 t) with a catch per effort of 117 kg. The highest catch by *Nethal vala* was during 1984-85 (933 t) with a catch per effort of 485 kg and the lowest catch of 12 t was in 1986-87 with a catch per effort of 293 kg.

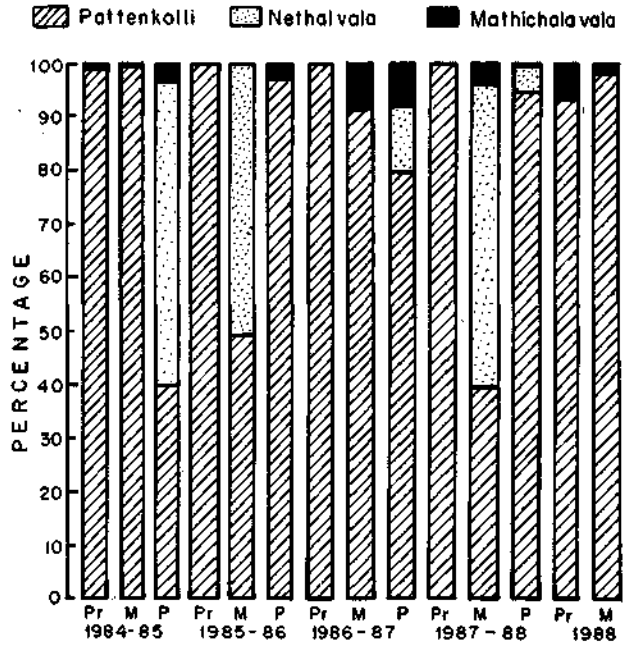

Fig. 1. Seasonwise landings (percentage weight) of oilsardine by different gears during 1984-88 at Calicut. (Pr = Premonsoon; M = Monsoon; P = Postmonsoon).

Cochin: The annual average landing at Cochin was 3761 t which showed a declining trend since 1984-85 with very low catches in 1987-88, when only 34.2 t were landed. Purse-seine contributed to 98.8% of the total catch with an annual catch rate of 1245 kg (Table 8). The ring seine contributed 0.9% with an annual catch rate of 351 kg. The contribution of trawl net was merely 0.28% with an annual catch rate of 0.22 kg.

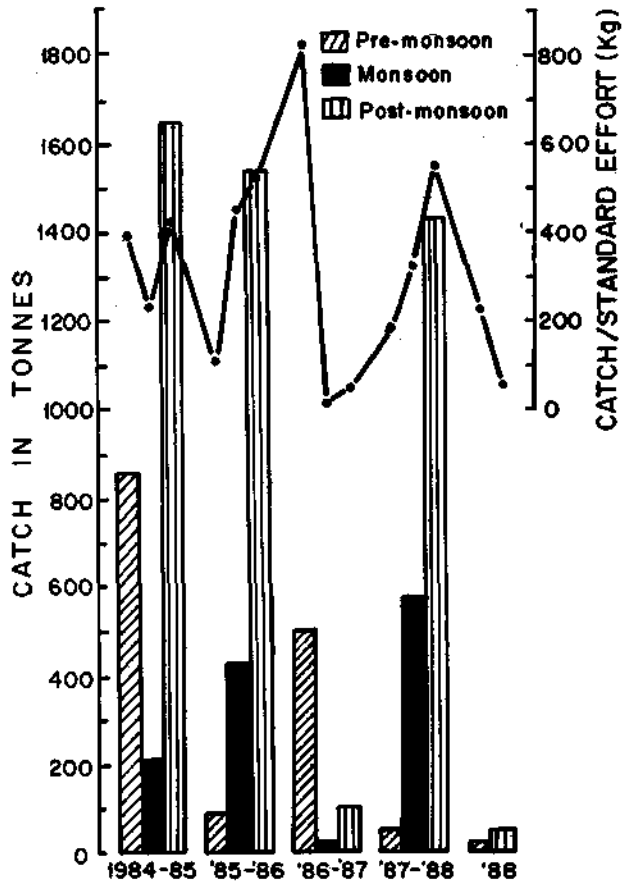

Fig. 2. Seasonal trends in the catches of oilsardine and catch per standard effort during 1984-88 at Calicut.

The annual catch rate in purse-seine declined from 1984-85 and reached an all time low during 1987-88 (Fig. 3). The catch improved in 1988-89 with a catch rate of 144.6 kg. The ring seine landed 99.8% of the oilsardine catch at Cochin during 1987-88. The seasonal contribution of the different gears to the oilsardine fishery at Cochin centre is given in Table 9. The purse seine on an average landed 1859.4 t and 1858.3 t respectively during the premonsoon and postmonsoon months with a catch rate of 1262.3 kg and 1228.2 kg respectively (Fig. 4). The ring seine operated throughout the year and on

an average landed 8177, 9004 and 15,463 t of oilsardine during the premonsoon, monsoon and postmonsoon periods with catch rates of 743.4 kg, 191.6 kg and 441.8 kg respectively.

Vizhinjam : The annual catch varied from 2.9 t in 1986-87 to 62.2 t in 1985-86 with an annual average of 30.6 t (Fig. 5). The highest catch (67%) was in premonsoon period followed by monsoon period (31%). In the postmonsoon period the catch formed only 2% of the annual catch. During the 5-year period more than 74% of the annual catch was landed in premonsoon months, except in 1987- 88 when it was higher in monsoon period (82.3%). In

TABLE 8. *Annual gearwise landings of oilsardine (tonnes) at Cochin for the period February '84 to January '89*

	Gear operated			
Year	Trawl net	Ring seine	Purse-seine	Annual
1984-85	32.807	30.737	14098.964	14162.508
1985-86	16.783	11.169	4219.582	4247.534
1986-87	1.765	46.979	157.307	206.051
1987-88	0.000	34.196	0.057	34.253
1988-89	1.448	40.141	112.511	154.100
Total	52.803	163.222	18588.421	18804.446
Average	10.561	32.644	3717.684	3760.889
Percentage	0.281	0.868	98.851	100.000

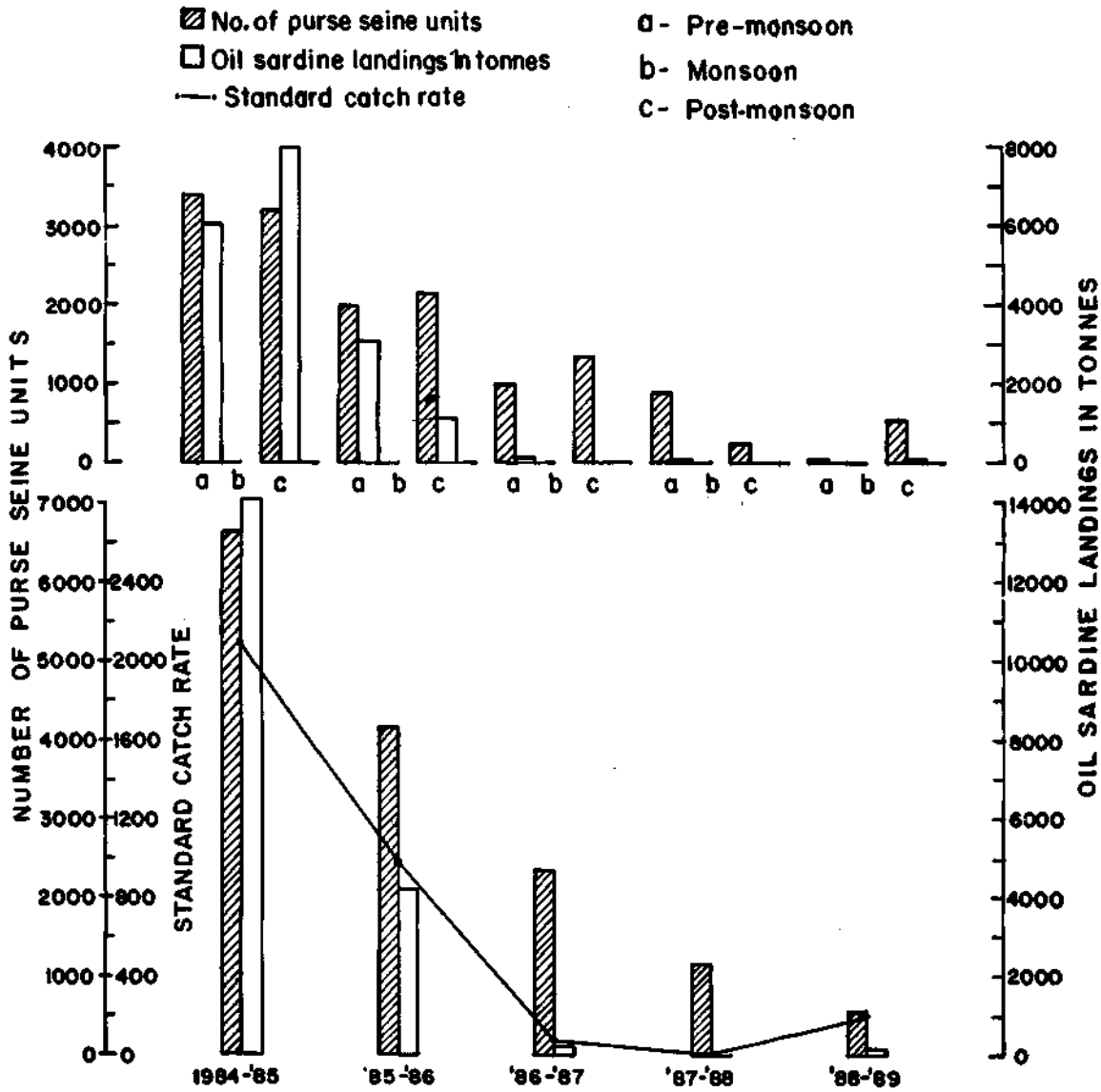

Fig. 3. Annual and seasonwise oilsardine landings at Cochin by purse-seine during February 1984 to January 1989.

TABLE 9. *Average gearwise landing (Kg) of oilsardine at Cochin during the premonsoon, monsoon and postmonsoon months for the period February 1984 to January 1989*

	Trawl net			Ring seine			Purse-seine		
Season	E	C	C/E	E	C	C/E	E	C	C/E
Premonsoon	18533	10035.6	0.541	11	8177.4	743.4	1473	1859422.6	1262.337
Monsoon	14135	7.8	0.00055	47	9004.2	191.579	No Operation		
Postmonsoon	15928	517.2	0.0325	35	15462.8	441.794	1513	1858261.6	1228.197
Total	48596	10560.6	0.2173	93	32644.4	376.456	2986	3717684.2	1245.038

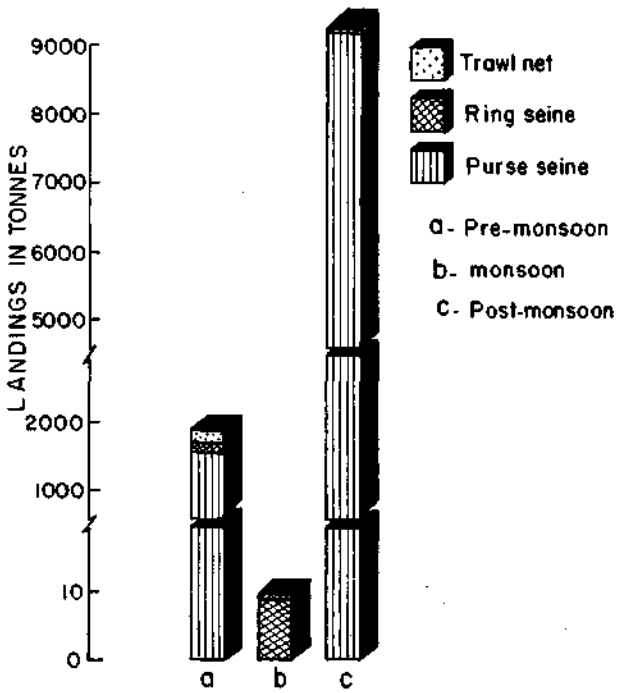

Fig. 4. Average seasonwise oilsardine landings at Cochin by different gears during February 1984 to January 1989.

1986-87 the fish was encountered only in premonsoon. The catch rate also showed simultaneous increase during premonsoon (4.1 kg). Maximum catch and catch rate was in May forming 16.5 t and 7.8 kg respectively. 88% of the *Chala vala* catch was landed in premonsoon, 9.6% in monsoon and 2.4% in postmonsoon period (Fig. 5). The catch per effort was also highest in premonsoon forming 4.05 kg. In boat seine nearly 96% of the catch was landed in monsoon and the rest in premonsoon. Shore seine landed oilsardine only in May (90%) and September (10%).

Depth-wise expolitation

At Calicut 76.9% of the oilsardine catch during 1984-88 was from areas with bottom depth between 11-20 m, 12.1% with depth upto 10 m and 11.0% with depth between 21-30 m (Table 10). In general, the catch (1343 t) and catch per standard effort (300 kg) were the highest in depth range 11-20 m, followed by depth zone less than 10 m with a catch of 211 t and catch per standard effort of 327 kg (Table 11). The catch from depth zone 21-30 m was low (194 t) with a low catch per standard effort (221 kg). The standard effort expended in depth zone upto 10 m, 11-20 m and 21-30 m were 635, 3726 and 879 respectively. Thus, when comparing the catch per standard effort in the three zones, the yield was low in 21-30 m depth regions.

TABLE 10. *Percentage of oilsardine caught (in quantity) from different depth zones during 1984-'88 at Calicut*

Season	< 10 m	11-20 m	21-30 m
Premonsoon	2.9	85.1	12.0
Monsoon	6.2	61.1	32.7
Postmonsoon	15.7	78.1	6.2
Annual	12.1	76.9	11.0

The catch per standard effort in regions from 11-20 m bottom depth was always higher during all the years except in 1986-87 when the highest catch per standard effort was from depth upto 10 m. Better catches of oilsardine were sometimes obtained in slightly deeper areas in the monsoon and premonsoon seasons, whereas during the postmonsoon, good concentrations were in shallower regions. This supports the view that the offshoreward movement of sardine shoals begins towards the end of the postmonsoon season.

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Size at first maturity

A total of 2576 fish were examined from February 1984 to August 1988 at Mangalore. Only those in maturity stage III and above were considered as mature. Size at first maturity has been estimated at 158 mm (Fig. 6).

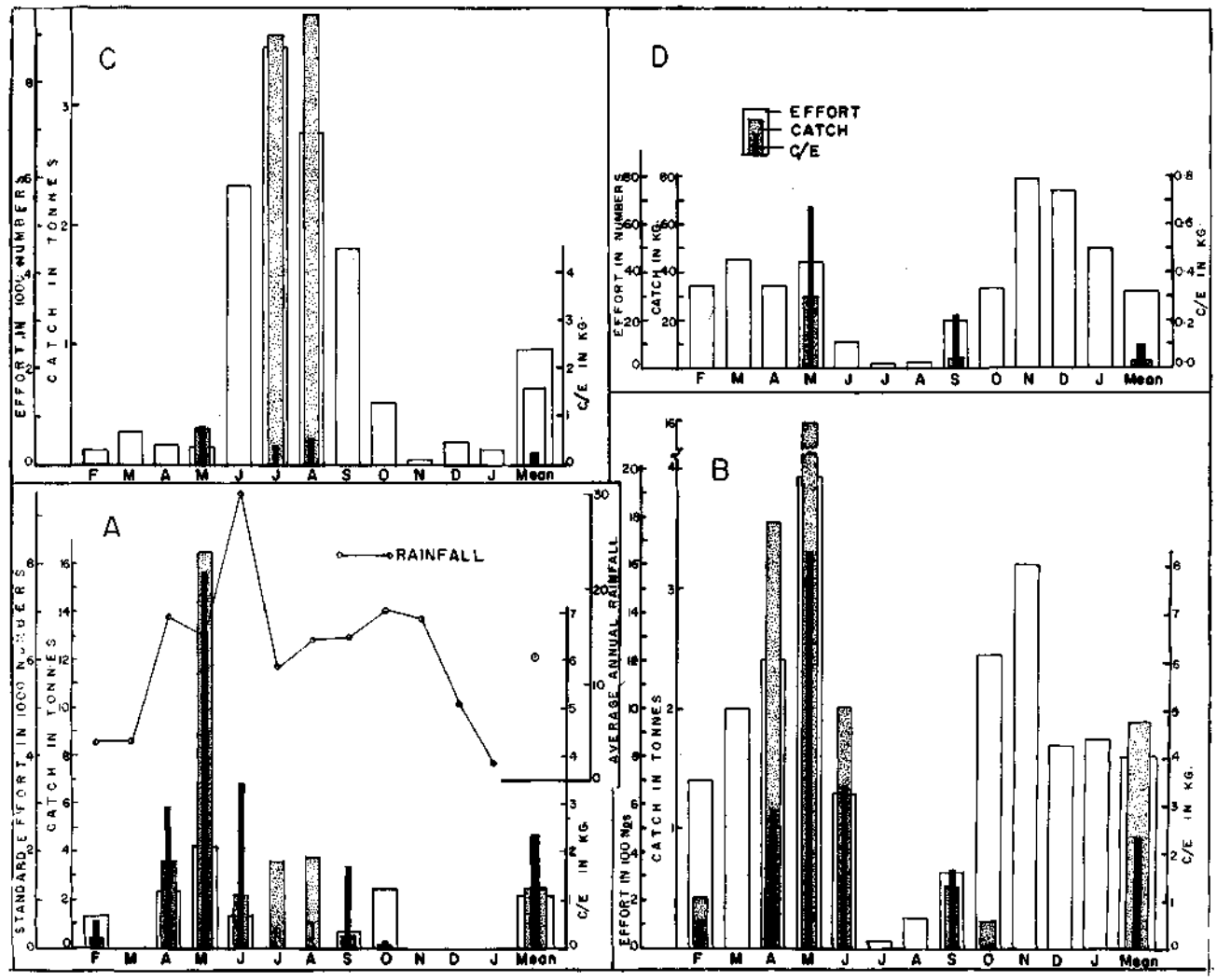

Fig. 5. Gearwise monthly effort, catch and C/E of oilsardine during 1984-85 to 1988 at Vizhinjam : A. Pooled data for all gears along with average monthly rainfalls, B. *Chala vala* (Gillnet), C. *Boat seine* and D. *Shore seine*.

Spawning season

At Mangalore, estimation of monthwise percentage of different stages of maturity of adult fish for the period from February 1984 to January 1988 showed that fish in advanced stages of maturity were available from April to October in good numbers in 1985-86, from May to October in 1986-87 and May to September in 1987-88 seasons. Spent fishes were encountered from September to January, indicating that oilsardine has protracted spawning season from May to October with a probable peak during monsoon months in Mangalore area. Sekharan and Dhulkhed (1963) have given spawning season of oilsardine from July to November at Mangalore.

Data on maturity stages for premonsoon, monsoon and postmonsoon are given in Table 12. Mature fishes were available in good numbers in premonsoon period during all the four years. Mature fishes were also observed during postmonsoon period of 1986-87 and 1987-88. During monsoon period of 1987, mature fish accounted for the bulk of the catch.

The estimated number of adults and the percentages of gravid and spent females in the landings during different years at Calicut are given in Table 13. The largest number of adults in the landings was in 1987-88 (8078^{104}) which was almost double the annual average of 4080^{104} and the lowest

TABLE 11. *Seasonal and depthwise estimated standard effort, catch (tonnes) and catch per standard effort (Kg) at Calicut during 1984-'88*

Year/Season	< 10 m			11-20 m			21-30 m		
	SE	C	C/SE	SE	C	C/SE	SE	C	C/SE
1984-85									
Premonsoon	78	4	51	1854	783	422	248	74	298
Monsoon	190	8	42	425	148	348	285	51	179
Postmonsoon	516	216	419	3240	1412	436	102	22	216
Annual	784	228	291	5719	2342	410	768	147	191
1985-86									
Premonsoon	24	2	83	848	93	110	69	6	87
Monsoon	39	4	103	633	289	457	285	141	495
Postmonsoon	361	208	576	1826	1280	701	746	57	76
Annual	520	214	412	2951	1662	563	1412	204	144
1986-'87									
Premonsoon	50	30	600	482	401	832	86	72	837
Monsoon	247	4	16	2243	15	7	424	2	5
Postmonsoon	123	29	236	1748	48	27	464	24	91
Annual	264	63	277	4128	464	112	974	98	101
1987-'88									
Premonsoon	42	12	286	220	22	100	80	27	338
Monsoon	212	56	264	1080	316	293	507	203	400
Postmonsoon	728	286	393	1580	954	604	273	189	692
Annual	1212	354	292	2398	1292	539	783	419	535
1988-upto August									
Premonsoon	-	-	-	21	10	476	41	4	98
Monsoon	184	7	38	328	19	58	391	23	59
Average (1984-88)									
Premonsoon	39	9	256	685	262	382	105	37	352
Monsoon	174	16	92	942	157	167	378	84	222
Postmonsoon	432	185	428	2099	923	440	396	73	184
Annual	645	211	327	3726	1343	360	879	194	221

during 1986-87 (1205^{104}). The annual percentages of gravid individuals varied from 0.2% to 8.6% with an average of 4.7% of the landings, whereas spent females constituted 7.3% to 16.1% with an average of 11.9%. Considering both the gravid and spent individuals in the exploited population, it was concluded that the spawning period in North Malabar extended from May to October.

Fishes with gravid and spent gonads were observed in the landings at Cochin during the late premonsoon and spent fishes formed the dominant group followed by gravid fishes during the monsoon months. At Vizhinjam the mature fish was more in February to April and spawners in May-June months. More spent fish was noticed in September. This indicated that at Vizhinjam the peak spawning might be during May-July or August, the monsoon period. It would appear that spawning takes place a little earlier along the southern Kerala Coast than that in the northern Kerala and Karnataka.

Recruitment

The success of the oilsardine fishery along the southwest coast is mainly dependent on the recruitment strength of early juveniles (5-10 cm) during the postmonsoon months. Juveniles start appearing from late August and from then onwards form the mainstay of the fishery in the southern regions. Juveniles appear in the fishery from late September in the northern regions. The main reason for the failure of the oilsardine fishery in 1986 at Mangalore was the failure of recruitment of juveniles during September-November. But in the following years recruitment of juveniles was very good and a record production of 9713 t was estimated in November alone. Oilsardine was recorded in *Matubala* catches at Mangalore only during monsoon season of 1987 and juveniles in strength were seen during August itself. Since purse seining is prohibited from June to August when early juveniles and mature fish occur in abundance, it would have some beneficial effect on recruitment.

Age and growth

At Mangalore, in the beginning of the fishery early in September, adult fish appear in large numbers and by the end of September juveniles start appearing in the fishery. From October onwards recruitment of juveniles intensifies and fishes of wide range of length are observed in the catches. The modal sizes in the pooled frequency data for the quarterly periods of four years from 1984-85 to 1987-88 are presented in Fig. 7. The growth pattern of the different broods of oilsardine born in different years is evident from the progression of their modal sizes in the fishery at Mangalore. It is seen that brood 'A' attained a modal size of 125 mm, 170 mm and 195 mm by the end of 12, 24 and 36 months respectively. Similarly the brood

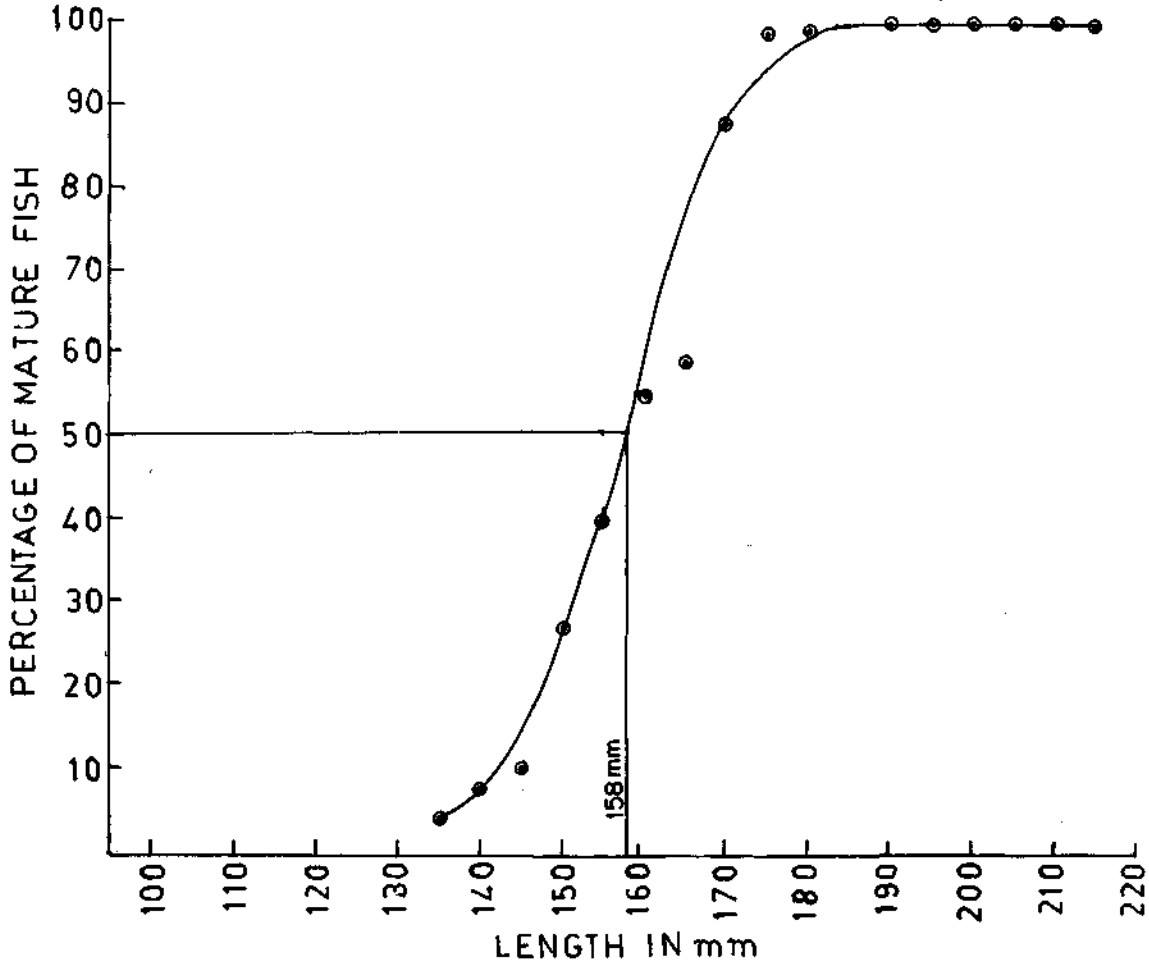

Fig. 6. Length at first maturity of oilsardine at Mangalore.

TABLE 12. *Seasonwise percentage of adult fish in different stages of maturity from February 1984 to January 1988 at Mangalore*

Season/year	No. of fish examined	Maturity stages Immature/Resting	Maturing	Mature	Spent
1984-85 (Annual)	(871)	(45.74)	(6.77)	(35.07)	(12.42)
Premonsoon	436	44.50	13.53	34.63	7.34
Monsoon	-	-	-	-	-
Postmonsoon	435	46.97	0.00	35.50	17.53
1985-86 (Annual)	(1165)	(52.65)	(11.63)	(30.99)	(4.73)
Premonsoon	314	38.22	23.25	36.94	1.59
Monsoon	-	-	-	-	-
Postmonsoon	851	67.10	0.00	25.03	7.87
1986-87 (Annual)	(390)	(21.21)	(27.11)	(45.76)	(5.92)
Premonsoon	165	42.42	40.00	11.52	6.06
Monsoon	-	-	-	-	-
Postmonsoon	225	0.00	14.22	80.00	5.78
1987-88 (Annual)	(508)	(25.93)	(29.20)	(37.71)	(7.16)
Premonsoon	89	10.11	56.18	29.22	4.49
Monsoon	60	0.00	18.33	75.00	6.67
Postmonsoon	359	67.69	13.09	8.91	10.31

'B' grew to a modal size of 135 mm and 165 mm, and brood 'C' to 125 mm and 161 mm at the end of 12 and 24 months respectively. Brood 'D' attained a size of 130 mm by the end of 12 months. It would thus appear that the species grows to an average size of 128 mm, 166 mm and 195 mm by the end of first, second and third year of life at monthly growth rate of 10.67 mm, 3.17 mm and 2.42 mm respectively.

The size distribution of oilsardine at Vizhinjam in relation to the monsoon is given in Fig. 8. In the premonsoon period, the size range was 135-210 mm with a major mode at 165 mm. In the monsoon period, the frequency showed almost bimodal distribution. The size ranged between 105 mm and 205 mm and the main modes were at 120 mm and 160 mm. The commercial fishery was mainly dependant on 140-185 mm size group to which 73.5% of the fish belonged. In postmonsoon period the size range was 105-220 mm and the frequency showed a trimodal pattern with major modes at 125 mm, 165 mm and 195 mm. The commercial catch was represented by two groups, one in the size of 135-165 mm forming 39.1% and the other 185-200 mm forming 32.3%. Young fish below the size of 140 mm was present in the monsoon and premonsoon periods.

TABLE 13. *Estimated number (10^4) of adults in the landings and percentages of gravid and spent females at Calicut*

Year	1984-'85	1985-'86	1986-'87	1987-'88	1988 (Upto) Aug.	Average
Estimated number of adults	6595	4454	1205	8079	66	4080
Gravid (%)	5.9	8.6	2.6	0.9	0.2	4.7
Spent	13.6	7.3	11.2	13.7	16.1	11.9

Seasonal abundance of different age groups

At Karwar, the premonsoon fishery was mainly supported by one and two year old fishes in 1984-85, three year olds in 1985-86, and zero and one year groups in 1986-87, while there was almost equal representation of zero, one and two year groups in 1987-88. The monsoon fishery was supported by two and three year old fishes during 1987-88. The postmonsoon fishery was constituted by zero year group fish.

The percentage age composition at Mangalore during the three season is given in Table 14.

It is evident from the Table that during the premonsoon season one year old fishes contributed heavily to the fishery during the years 1984, 1987 and 1988 while in 1985 two year class and in 1986 0+ year old fish dominated in the fishery. In monsoon season of 1987, 0+ year old fish occurred lowest was in 1986-87 (4068[104]). The 0-year group dominated the landings during the postmonsoon months in all the years except 1985-86 when there was good landings of juveniles during the monsoon (Table 16). The strength of 1+ year group was moderately high during the premonsoon and post-

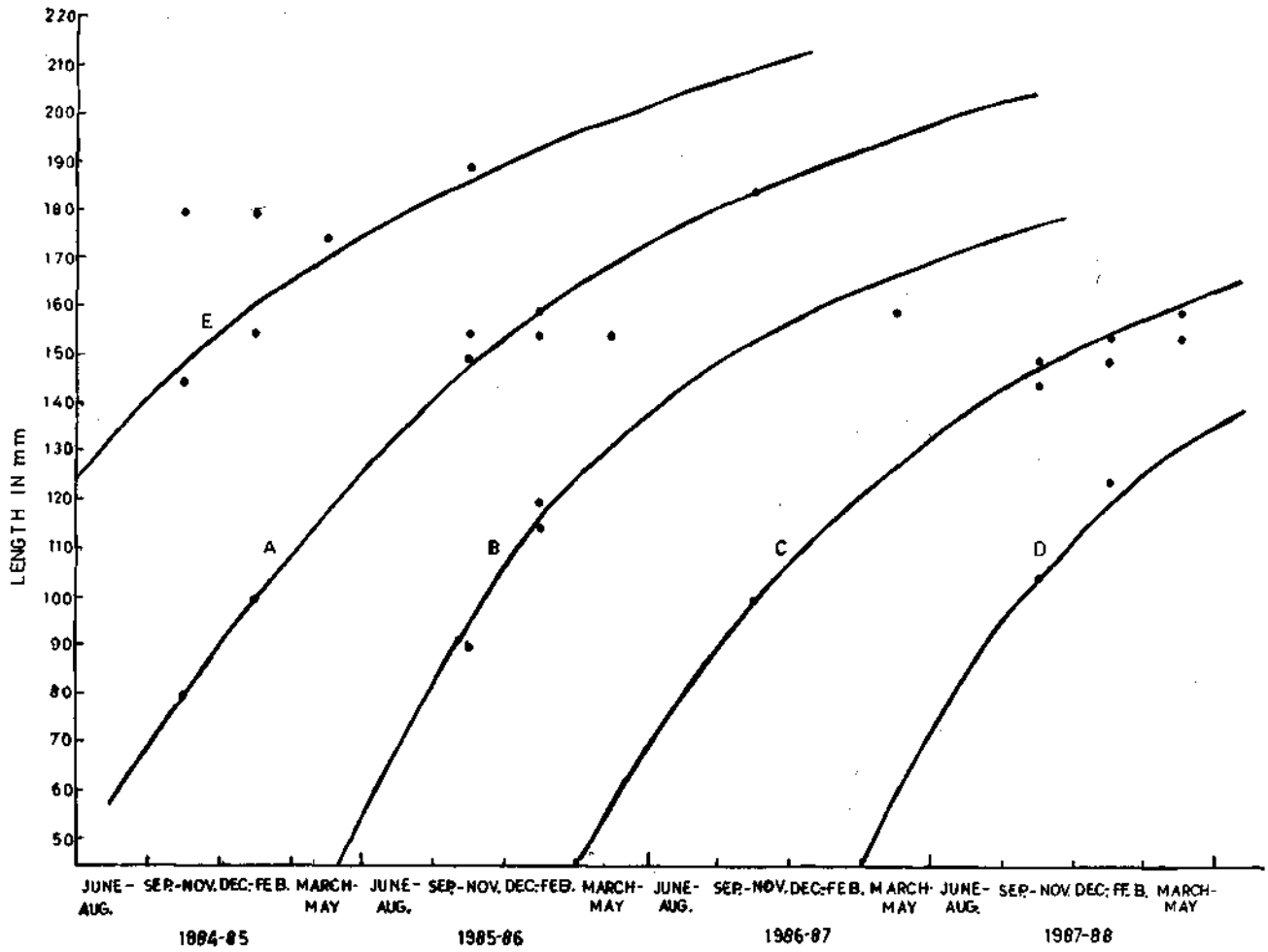

Fig. 7. Quarterly distribution of modal lengths of oilsardine at Mangalore.

in good quantities. During postmonsoon season in 1984, 0+ age group made the bulk, during 1985 one year old fish dominated, during 1986 two year olds dominated and during 1987 one year olds contributed heavily to the fishery.

The annual estimated average number of 0-year group in the landings at Calicut was 10627[104] whereas, the strength of 1+ year, 2+ year and above 2+ year age groups constituted 2574[104], 1445[104] and 61[104] respectively, the annual landings being 14707[104] (Table 15). The largest number of oilsardine landed was in 1984-85 (33988[104]) and the monsoon of 1984-85 and postmonsoon of 1985-86 and 1987-88 and generally very low during the monsoon in all the years except in 1987-88. The percentage of 1+ year old fish during 1987-88 was the highest among all the years despite the fact that the preceding year 1986-87 witnessed the lowest annual landings. The high landings of oilsardine during the postmonsoon months of September to January indicated indiscriminate exploitation of juveniles and potential spawners and consequent decline in recruitment in the ensuing spawning period.

TABLE 14. *Age composition (%) of oilsardine during premonsoon, monsoon and postmonsoon period from February 1984 to January 1989 at Mangalore*

Seasons/years	Age classes			
	0+ year	1 year	2 year	3 year
1984-85 (Annual)	(38.81)	(52.20)	(8.95)	(0.04)
Premonsoon	4.70	90.49	4.81	0.00
Monsoon	-	-	-	-
Postmonsoon	72.92	13.91	13.10	0.07
1985-86 (Annual)	(26.87)	(34.24)	(38.33)	(0.57)
Premonsoon	18.51	22.24	59.25	0.00
Monsoon	-	-	-	-
Postmonsoon	35.22	46.24	17.40	1.14
1986-87 (Annual)	(35.86)	(20.94)	(42.90)	(0.30)
Premonsoon	55.07	41.11	3.82	0.00
Monsoon	-	-	-	-
Postmonsoon	16.66	0.76	81.97	0.61
1987-88 (Annual)	(36.13)	(60.74)	(3.04)	(0.09)
Premonsoon	0.00	98.86	1.14	0.00
Monsoon	81.84	12.90	5.00	0.26
Postmonsoon	26.54	70.47	2.99	0.00
1988-89 (Annual)	(53.52)	(42.23)	(4.25)	(0.00)
Premonsoon	27.66	69.16	3.18	0.00
Monsoon	-	-	-	-
Postmonsoon	79.37	15.30	5.33	0.00

The estimated number of young oilsardine given in Table 17 shows that immature oilsardine of 0-year group constitued 50.8% (1987- 88) to 85.5% (1988) of the annual landings in different years with an annual average of 72.3%. The percentage of juveniles landed by *Pattenkolli* varied from 19.4% (1984-85) to 85.5% (1988) in the annual total landings with an average of 32.1%. The percentage of juveniles landed by *Nethal vala* varied from 9.5% (1986-87) to 61.2% (1984-85) of the annual total landings with an annual average of 40.2%. The majority of the landings of juveniles were during the postmonsoon, both by *Pattenkolli* (21.9%) and *Nethal vala* (29.9%) and the lowest during the premonsoon (5.2%).

Instantaneous rate of mortality

Jackson's (1939) method has been applied for estimating value of instantaneous rate of mortality

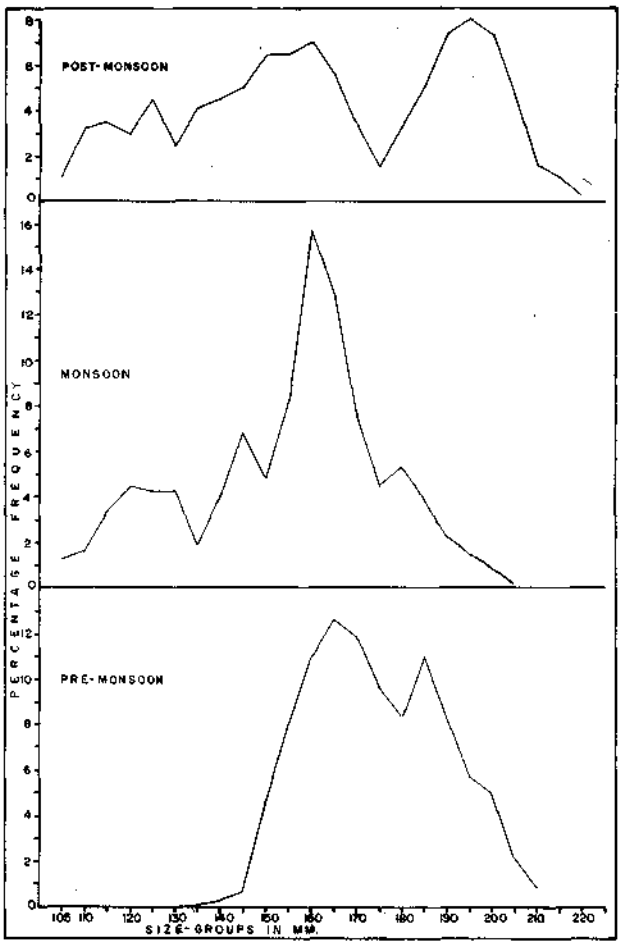

Fig. 8. Size frequency of oilsardine in different seasons (% frequency) at Vizhinjam.

(Z) at Mangalore. The value of Z was estimated as 3.05 for 1984-85/1985-86, 2.65 for 1985-86/1986- 87 and 4.03 for 1986-87/1987-88. The average instantaneous rate of total mortality (Z) was 2.99.

Dhulkhed and Uma Bhat (1985) estimated annual rate of survival as 0.1 and the instantaneous rate of mortality (Z) as 2.3 for 1977-1981 oilsardine fishery by purse seine. When traditional gear *Rampani* was in operation at Mangalore, the Z value

TABLE 15. *Estimated number (10^4) of oilsardine by age in the landings at Calicut during 1984-'88*

Age	1984-'85	1985-'86	1986-'87	1987-'88	1988 (upto August)	1984-1988 Average
0 year	27393	14153	2863	8337	390	10627
1 + year	3754	2464	968	5648	36	2574
2 + year	2744	1828	215	2416	21	1445
Above 2 + year	97	162	22	15	9	61
Total	33988	18607	4068	16416	456	14707

TABLE 16. *Seasonwise estimated number (10^4) of oilsardine by age in the landings at Calicut during 1984-'88*

	1984-85			1985-86			1986-87			1987-88			1988 (upto August)	
Age	Pr	M	P	Pr	M	P	Pr	M	P	Pr	M	P	Pr	M
0 year	1631	-	25762	686	8098	5369	1389	41	1433	49	2766	5522	86	304
1 + year	2200	214	1340	328	399	1737	930	11	27	1007	1440	5201	20	16
2 + year	1269	530	945	318	389	1121	170	30	15	46	370	-	-	21
Above 2 + year	10	7	80	4	32	126	17	-	5	5	10	-	-	9
Total	6110	751	27127	1336	8918	8353	2506	82	1480	1107	4586	10723	106	350

was low and varied between 1.66 (Sekharan and Dhulkhed, 1963) and 1.3 (Prabhu and Dhulkhed, 1970). Thus the higher value of Z of the oilsardine in recent years is indicative that its population is subjected to heavy fishing pressure by the purse-seine fleet off the Mangalore Coast.

Trend in the fluctuations in the catch in relation to the monsoons

Considerable seasonal and annual fluctuations in the abundance of oilsardine have been observed all along the southwest coast. Analysis of the data for the period 1984-88 showed that at all major landing centres the highest catch was obatined during the postmonsoon period of September to January and the lowest catch was during the monsoon months of June to August. Examination of the data on rainfall, total oilsardine catches, fishing effort and catch rate at Mangalore during the premonsoon, monsoon and postmonsoon periods did not reveal any consistent relationship. On annual basis also there was no relation between the rainfall and catch or catch rate in the oilsardine fishery at Mangalore.

At Calicut, the oilsardine landings were highest in 1984-85 (2718 t) when the rainfall was the highest (3070 mm) (Table 18). The lowest catch was in 1986-87 (625 t) when there was moderate rain (2514 mm), but the catch was better in 1987- 88 (2065 t) when the rainfall was the lowest (1899 mm). When considering the rainfall in the monsoon season of all the years, rainfall was the lowest in the monsoon of 1987-88 (1026 mm), but the catch was the highest during that period (575 t). The highest monsoon rainfall was in 1985-86 (2075 mm) when the catch during that season was fairly good (434 t). During the postmonsoon, the rainfall though highest in 1987-88 (771 mm), catch during the season was only 1429 t, whereas the catch during the postmonsoon was highest in 1984-85 (1650 t) when the rainfall was moderate (611 mm). Figure 9 gives the average monthly oilsardine

TABLE 17. *Seasonal abundance in number (10^4) of young oilsardine below 140 mm and percent to the total oilsardine landings at Calicut during 1984-85—1988*

Season	1984-'85		1985-'86		1986-'87		1987-'88		1988 (upto August)		Average	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Pattenkolli												
Premonsoon	1631	4.8	686	3.7	1389	34.1	49	0.3	86	18.8	768	5.2
Monsoon	-	-	3294	17.7	41	1.0	-	-	304	66.7	728	5.0
Postmonsoon	4962	14.6	5369	28.9	1045	25.7	4718	28.7	-	-	3219	21.9
Annual	6593	19.4	9349	50.3	2475	60.8	4767	29.0	390	85.5	4715	32.1
Nethul vala												
Premonsoon	-	-	-	-	-	-	-	-	-	-	-	-
Monsoon	-	-	4804	25.8	-	-	2766	16.9	-	-	1514	10.3
Postmonsoon	20800	61.2	-	-	388	9.5	804	4.9	-	-	4393	29.9
Annual	20800	61.2	4804	25.8	388	9.5	3570	21.8	-	-	5912	40.2
Total	27393	80.6	14153	76.1	2863	70.3	8337	50.8	390	85.5	10627	72.3

landings and rainfall at Calicut and surface temperature and salinity in the inshore fishing grounds for the period 1984 February to1988 August. The average monthly rainfall was highest during June (922 mm) followed by July (560 mm). The fishery was generally high from September to January and very low from April to June. The values of average surface water temperature and salinity ranged from 27.0°C to 28.2°C and 31.9‰ to 33.35‰ during the postmonsoon months of September to December when the oilsardine landings were also higher. The surface temperature and salinity for the monsoon months of June, July and August are not available, but these are likely to be slightly lower than in the other months due to the rains. Even though the rainfall and oilsardine landings during different seasons did not show any direct relationship, it could be generalised that the oilsardine landings were better two or three months after fairly heavy rains when the surface temperature and salinity were somewhat lower. It was also seen that both higher temperature and higher salinity normally from January were associated with decrease in oilsardine landings. Prabhu and Dhulkhed (1970) stated that the best catches of oilsardine at Mangalore area were during September to December when the temperature and salinity ranged from 25.5°C to 28.6°C and 28.98‰ to 34.36‰ respectively. According to Suresh and Reddy (1980), good catches of oilsardine at Mangalore Coast in 1967-77 were in September to March when the temperature ranged from 27.7°C to 29.9°C and surface salinity ranged between 32.6‰ and 34.9‰. Thus it is seen that intermediate values of surface temperature and salinity together with fairly strong monsoon which enrich the nutrient supply in the surface and subsurface layers of the sea would be favourable for good oilsardine fishery.

The analysis of the oilsardine landings and rainfall data at Cochin showed that fairly good rain during the monsoon probably had some positive impact on the abundance of juvenile oilsardine during the succeeding postmonsoon months. Reduced rain fall intensity might have an adverse impact on the shoal formation at the surface. Murty and Edelman (1970) suggested that monsoon intensity above a critical value was favourable for the enrichment of the sea by nutrients and oxygen which in turn would result in higher oilsardine landings.

At Vizhinjam, the premonsoon period was the peak season for oilsardine fishery and postmonsoon was the lean period. This indicated that here the fishery was dependant on the northeast monsoon in October-December and hence a good fishery after that in the ensuing premonsoon period of February-May.

Discussion

The present low level of total landings of oilsardine in the inshore coastal belt upto 30 m depth zone all along the southwest coast during the period 1984-88 clearly indicates that there is considerable decline in the landings over the years. The postmonsoon period is the most productive period for oilsardine fishery. In spite of the increase in effort, there has not been any increase in the total oilsardine landings which shows that the yield is not commensurate with the increase in effort. There is only a downward trend in the total oilsardine landings and the catch per effort with the adoption of ring seines and purse-seines which implies that the traditional sector has been adversely affected.

Examination of the data on rainfall, total oilsardine catch, fishing effort and catch rate during the premonsoon, monsoon and postmonsoon periods at Mangalore, Calicut and Cochin did not reveal any consistent relationship. On annual basis also, there was no correlation between the rainfall and catch or catch rate in the oilsardine fishery.

Table 18. *Seasonal rainfall (mm) and oilsardine landings (tonnes) at Calicut*

Season	1984-'85		1985-'86		1986-'87		1987-'88		1988-'89	
	Rainfall	Catch	Rainfall	Catch	Rainfall	Catch	Rainfall	Catch	Rainfall	Catch
Premonsoon	484	861	369	101	101	503	102	61	362	14
Monsoon	1969	207	2075	434	1756	21	1026	575	2010	49
Postmonsoon	617	1650	333	1545	657	101	771	1429	-	-
Total	3070	2718	2777	2080	2514	625	1899	2065	2372	63

Studies on growth and age revealed that oilsardine grows to 128 mm in the first year, 166 mm in the second year and 195 mm in the third year of its life with monthly growth rate of 10.67 mm, 3.17 mm and 2.42 mm at respectively. Size at first maturity has been estimated at 158 mm at Mangalore. Data on maturity indicate that the species has protracted spawning season from May to October. Mature fishes are generally available in good numbers during late premonsoon period and monsoon period. Whenever catches of breeders have been during May-June, oilsardine fishery in premonsoon months are also very good. Good concentration of spawners in the coastal waters off the coast just at the onset of monsoon appears to be a good indicator for better recruitment and good production in the postmonsoon period.

The oilsardine resources off the southwest coast appear to be under heavy fishing pressure by purse-seine fleets as evident from the high instantaneous mortality rate (Z) of 2.99 in recent years. In spite of an increasing trend in purse-seine operations in Cochin and Southern Karnataka, there has been no increase in the total oilsardine landings of Kerala and Karnataka (Silas *et al.*, 1986). According to Alagaraja *et al.* (1982), the purse-seine operations have increased the landings in Karnataka, but this increase is not reflected in the total landings. Decline in the total oilsardine landings and the increase in the purse-seine and ring seine catches only indicate that their operations have affected the catches of indigenous gears operating in the nearshore waters in all the regions. Fishery dependant factors like rate of exploitation and size at capture seem to have a greater impact on the available stocks and recruitment of oilsardine than fishery independant factors. Unrestricted operations of purse-seines and ring seines would not only be detrimental to the fishery, but also would adversely affect the catches by traditional gears and the activities of the artisanal fishermen. Decline in the total oilsardine catches during the past few years clearly indicates that adverse effects on the traditional sector have already set in. Conflict has already started between indigenous operations and purse-seine/ring seine operators in the fishing grounds.

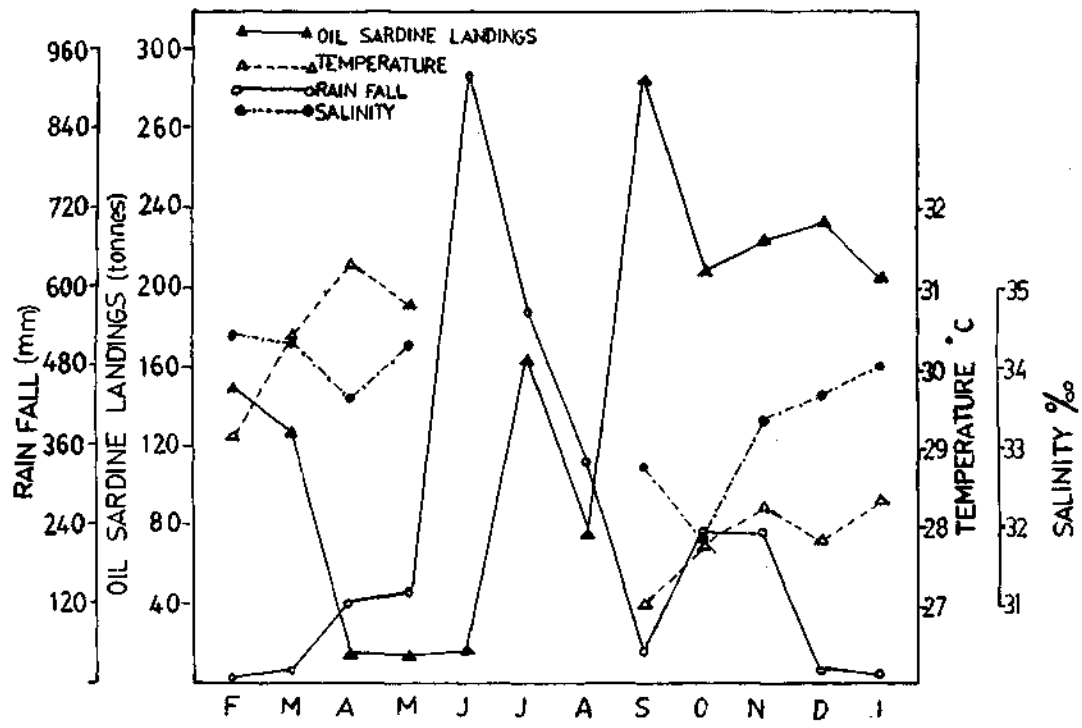

Fig. 9. Oilsardine landings, rainfall, temperature and salinity at Calicut (Pooled data 1984-88).

Conclusions

Large scale indiscriminate fishing for juveniles of oilsardine by purse-seine and ring seine in Kerala and Karnataka will have dangerous repurcussions on the future yield from the fishery. To protect the resource and to increase the total annual yield in future, such indiscriminate fishing practices should be controlled. Considering the adverse impact of purse-seine and ring seine operations, it is suggested that measures as indicated below will ensure sustainable yield from the fluctuating oilsardine resources and safeguard the interests of the traditional sector which is labour intensive by giving better economic returns.

1. The cod end mesh size of boat seines (*Pattenkolli* type) operated by country crafts should not be less than 13 mm.

2. The number of purse-seines and ring seines (mini purse seines) now being operated in Kerala, Karnataka and Goa may be reduced by 50%. The mesh size should not be less than 14 mm. The operations by purse-seines and ring seines should be permitted only from October to March.

3. Simulated commercial fishing operations and monitoring the exploited stocks have to be made at regular intervals and environmental factors such as rainfall, temperature and salinity have to be studied to ascertain the abundance of the oilsardine population and for taking suitable management measures to sustain the fishery.

References

Alagaraja, K., K. Narayana Kurup, M. Srinath and G. Balakrishnan 1982. Analysis of marine fish landings in India : A new approach. *CMFRI Spl. Publn.*, 10 : 1-42.

Antony Raja, B. T. 1969. The Indian oilsardine fishery. *Bull. Cent. Mar. Fish. Res. Inst.*, **16** : 1-128.

Balan, V. 1984. The Indian Oilsardine fishery : A review. *Mar. Fish. Infor. Serv. T & E Ser.*, 60 : 1-10.

Balan, V. and R. Reghu 1979. The Indian Oilsardine. *Ibid.*, **14** : 1-13.

Chidambaram, K. 1950. Studies on the length frequency of the oilsardine *Sardinella longiceps* Cuv. & Val. and on certain factors influencing their appearance on the Calicut Coast of the Madras Presidency. *Proc. Indian Acad. Sci.*, 31 B (5) : 252-286.

—— and M. Devidas Menon 1945. The correlation of the west coast (Malabar and South Kanara) fishery with plankton and certain oceanographical factors. *Ibid.*, 22 B, 355-67.

Devanesan, D. W. 1943. A brief investigation into the causes of fluctuations of the annual fishery of the oilsardine of Malabar, *Sardinella longiceps* Cuv. & Val., determination of its age and an account of the discovery of its eggs and spawning grounds. *Madras Fish. Bull.*, 28 : 1-38.

Dhulkhed, M. H. and Uma Bhat 1985. The purse seine fishery for oilsardine in South Karnataka and its effect on the indigenous fishery. *Indian J. Fish.*, 32 (1) : 55-63.

Hornell, J. and M. R. Nayudu 1924. A contribution to the life history of the Indian sardine with a note on the plankton of the Malabar Coast. *Madras Fish. Bull.*, 17 : 129-97.

Jackson, C. H. N. 1939. The analysis of an animal population. *J. Anim. Ecol.*, 8 : 238-246.

Jacob, T., K. Alagaraja, S. K. Dharmaraja, K. K. P. Panikkar, G. Balakrishnan, U. K. Satyavan, V. Balan and K. V. N. Rao 1982. Impact of purse seine operations on traditional fishery with special reference to oilsardine in Kerala during 1980 and 1981. *Mar. Fish. Infor. Serv. T & E Ser.*, 40 : 8-11.

Kurup, K. N., V. Balan, P. Vijayaraghavan and M. Kumaran 1989. Stock assessment of the Indian oilsardine (*Sardinella longiceps*) off the west coast of India. In : S. C. Venema and N. P. Van Zalinge (Ed.) *Contributions to tropical fish stock assessment in India*. Papers presented by the participants at the FAO/DANIDA/ICAR National follow-up training course in Fish Stock Assessment, Cochin, India 2-28 Nov. 1987.

Mukundan, C. 1971. Plankton of inshore waters and its relationship with coastal pelagic fisheries. *Indian J. Fish.*, 14 (1 & 2) : 271-292 (1967).

Murty, A. V. S. and M. S. Edelman 1970. On the relation between the intensity of the southwest monsoon and the oilsardine fishery of India. *Ibid.*, 13 (1 & 3) : 142-149.

Nair, R. V. 1960. Synopsis of the biology and fishery of the Indian sardines. Species synopsis No. II. *Proc. World Sci. Meet. Biol. Sardines and Related Species*, FAO, Rome, 2 : 329- 414.

—— and K. Chidambaram 1951. A review of the Indian oilsardine. *Proc. nat. Inst. Sci. India*, 17 (1) : 71-85.

—— and R. Subrahmanyan 1955. The diatom *Fragilaria oceanica* Cleve, as an indicator of the abundance of the Indian oilsardine *Sardinella longiceps* Cuv. & Val. *Curr. Sci.*, 24: 41-42.

PRABHU, M. S. 1971. Oilsardine fishery at Kozhikode during the seasons 1959-60 to 1962-63. *Indian J. Fish.*, 13 (1 & 2) : 679-700 (1966).

—— AND M. H. DHULKHED 1970. The oilsardine fishery in the Mangalore zone during the seasons 1963-64 to 1967-68. *Ibid.*, 17 (1 & 2) : 57-75.

SEKHARAN, K. V. 1965. On the oilsardine fishery of the Calicut area during the year 1955-56 to 1958-59. *Ibid.*, 9 A (2) : 679- 700.

—— AND M. H. DHULKHED 1963. On the oilsardine fishery of the Mangalore zone during the years 1957-1963. *Ibid.*, 10 (2) : 601- 626.

SILAS, E. G., T. JACOB, K. ALAGARAJA AND K. BALAN 1986. Exploitation of marine fishery resources and its contribution to Indian economy. *CMFRI Spl. Publn.*, 29 : 1-32.

SURESH, K. AND M. P. M. REDDY 1980. Variations in oceanographic factors and their possible relation to fluctuations in oilsardine and mackerel catches of Mangalore Coast. *Indian J. Fish.*, 27 (1) : 1-9.

Bull. Cent. Mar. Fish. Res. Inst., 1992, **45** : 111 - 120

4. 5

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : WHITEBAITS

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Abstract

On the basis of data from Vizhinjam, Cochin and Mangalore, the trends in fishery, species composition, biology of different species and distribution in space and time of whitebait are presented with reference to premonsoon, monsoon and postmonsoon seasons. Of the three centres, the fishing grounds off Mangalore are found to be most productive for whitebaits. In the inshore fishing grounds at Cochin and Mangalore, the whitebaits seem to be absent during monsoon months. At Vizhinjam, however, the main whitebait fishery season coincides with the monsoon period. In the light of the data presented, the rational exploitation of whitebait resources during monsoon, postmonsoon and premonsoon seasons is discussed.

Introduction

The present whitebait production in the country is around 85,000 tonnes, accounting for about 8% of the pelagic fish catch or about 4% of the total marine fish production. Most of the catch (97%) is obtained along the southern maritime States : Karnataka (17%), Kerala (45%), Tamil Nadu (20%), Pondicherry (1%) and Andhra Pradesh (14%). Further, the southern stretch of the west coast extending from Kanyakumari to north Karnataka accounting for about 70% of the total whitebait catch is the most productive region for whitebait in the country.

Data Base

Data on effort, catch, species composition, length composition and distribution of maturity stages of gonads collected at Vizhinjam, Cochin and Mangalore during the period 1984-88 have been analysed with special reference to the premonsoon (February- May), monsoon (June-August) and postmonsoon (September-January) seasons. Observation centres at Vizhinjam, Cochin and Mangalore are taken to represent the southern, central and northern sectors of the southwest coast. A fishing trip of a gear is taken as a unit of effort and the catch per unit of effort is expressed as catch rate. Values given in brackets following ranges of catches and catch rates are their averages. Fishes of 60-64 mm and above of *S. devisi*, 80-84 mm and above of *S. bataviensis* and 45-49 mm and above of *S. buccaneeri* are considered as adults. Fish with gonads in maturity stages V-VII are taken as mature. Whitebait is exclusively caught by *Netholi vala* which is specially designed to catched this resource. They are also caught in appreciable quantities in purse seines; in other gears they form the by-catch.

Observations

Trends in the whitebait fishery : Gearwise effort, catch, catch rate and species composition of the whitebait in the three seasons as well as over the three seasons; species composition, gearwise, and in the catch pooled from all gears over the period (1984-88) for the three observation centres Vizhinjam, Cochin and Mangalore are given in Tables 1 to 3. Monthly trends of whitebait landings as also the effort and catch rates in the different gears at the three centres are shown in Figs. 1 - 4.

Vizhinjam : At Vizhinjam the annual whitebait landings ranged between 311 t and 555 t (427 t). Though whitebait were caught by one or more gears almost throughout the year, significant quantities were obtained only during May-October period. Monsoon period witnessed the bulk (78%) of the annual catch followed by postmonsoon (15%) and premonsoon (7%) periods. Boat seines landed greater portion of the catch (86%) followed by gillnet (12%) and shore seine (2%) at catch rates of 12 kg, 32 kg and 14 kg respectively.

TABLE 1. *Gearwise and seasonwise effort, catch (kg) and catch rate (in parenthesis) for whitebait and the component species, as well as the species composition over the period 1984-88 at* Vizhinjam

Season	Effort	Sd	Sbt	Sbc	San	Sin	Total
Boat seine							
Premonsoon	1856	625 (0.34)	521 (0.28)	-	-	246 (0.13)	1,392 (0.75)
Monsoon	21,267	105,807 (4.98)	118,533 (5.57)	91,026 (4.28)	11,954 (0.56)	3242 (0.15)	330,562 (15.54)
Postmonsoon	6,645	18,757 (2.82)	16,456 (2.48)	-	-	1445 (0.22)	36,658 (5.52)
Over the period	29,768	125,189 (4.21)	135,510 (4.55)	91,026 (3.06)	11,954 (0.40)	4933 (0.17)	368,612 (12.38)
% species composition	-	33.96	36.76	24.69	3.24	1.34	
Shore-seine							
Premonsoon	171	1,925 (11.26)	275 (1.61)	256 (1.50)	-	179 (1.05)	2,635 (15.41)
Monsoon	15	62 (4.13)	61 (4.07)	-	-	-	123 (8.2)
Postmonsoon	256	2,384 (9.31)	315 (1.23)	77 (0.30)	25 (0.10)	649 (2.54)	3,450 (13.48)
Over the period	442	4,371 (9.89)	651 (1.48)	333 (0.75)	25 (0.06)	828 (1.88)	6,208 (14.05)
% Species compositon	-	70.41	10.49	5.36	0.40	13.34	
Gillnet							
Premonsoon	891	20,452 (22.95)	5,192 (5.83)	-	-	-	25,644 (28.78)
Monsoon	49	649 (13.24)	113 (2.31)	-	-	-	762 (15.55)
Postmonsoon	674	23,293 (34.56)	2,342 (3.47)	13	-	-	25,648 (38.05)
Over the period	1614	44,394 (27.51)	7,647 (4.74)	13 (.008)			52,054 (32.25)
% species composition		85.28	14.69	0.02			
Annual average catch		173,954	143,808	91,372	11,979	5761	426,874
% Species composition (All gear)		40.75	33.69	21.40	2.81	1.35	

Sd = *Stolephorus devisi*; Sbt = *S. bataviensis*; San = *S. andhraensis*; Sin = *S. indicus*; Sbc = *S. buccaneeri*.

Though boat seines were operated throughout the year, 72% of their effort was expended during the monsoon period followed by postmonsoon (22%) and premonsoon (6%) periods. Nearly 90% of the boat seine whitebait catch was obtained during the monsoon period with catch rates of 6 - 24 kg (16 kg) followed by postmonsoon period (10%) with the catch rates of <1-27 kg (5.5 kg). Only stray and insignificant amounts of whitebait were obtained during the premonsoon period in this gear.

Much of the gillnet effort was expended during the premonsooon period (55%) followed by postmonsoon period (42%) with more of less equal contribution (49% each) to the annual landings. Catch rates of 17-32 kg (29 kg) were obtained during premonsoon period and 33-78 kg (38 kg) during the postmonsoon period. Early part of the monsoon period (June) accounting for about 3% of the annual effort contributed to 2% of the annual catch at catch rate of 10-20 kg (16 kg).

TABLE 2. *Gearwise and seasonwise effort, catch (kg) and catch rate (in parenthesis) for whitebait and the component species, as well as the species composition over the period 1984-88 at Cochin*

Season	Effort	Sd	Sbt	Sbc	Sc	Sm/Sh*	Si	Total
Trawlnet								
Premonsoon	17,110	70,692 (4.13)	103,173 (6.03)	21,345 (1.25)	2,185 (0.13)	494 (0.03)	12 (0.0007)	197,901 (11.57)
Monsoon	11,765	37,435 (3.18)	67,817 (5.76)	15,837 (1.35)	-	-	-	121,089 (10.29)
Postmonsoon	10,010	222,757 (22.25)	148,578 (14.84)	1949 (0.19)	11,628 (1.16)	1187* (0.12)	347 (0.03)	386,446 (38.61)
Over the period	38,885	330,884 (8.51)	319,568 (8.22)	39,131 (1.01)	13,813 (0.36)	494 (0.01)	359 (0.01)	705,436 (18.14)
*S. *heterolobus* (over the period 1187/(0.03) (0.17%)								
% species composition		46.90	45.30	5.55	1.96	0.07	0.05	
Purse seine (1984-85 & 85-86)								
Premonsoon	1718	125,942 (73.31)	-	-	-	-	-	125,942 (73.31)
Monsoon	-	-	-	-	-	-	-	-
Postmonsoon	1344	38,978 (29.00)	1031 (0.77)	16,832 (12.52)	-	-	-	56,841 (42.29)
Over the period	3062	164,920 (53.86)	1031 (0.34)	16,832 (5.50)	-	-	-	182,783 (59.69)
% species composition		90.23	0.56	9.21	-	-	-	-
annual average catch		495,804	320,599	55,963	13,813	494	359	888,219
*S. *heterolobus* (annual average catch) = 1187 (0.13%)								
% Specis composition (All Gear)		55.82	36.09	6.30	1.56	0.06	0.04	

Sd = *Stolephorus devisi*; Sbt = *S. bataviensis*; San = *S. andhraensis*; Si = *S. indicus*; Sbc = *S. buccaneeri*; Sc = *S. commersonii*; Sm = *S. macrops*; Sh = *S. heterolobus*.

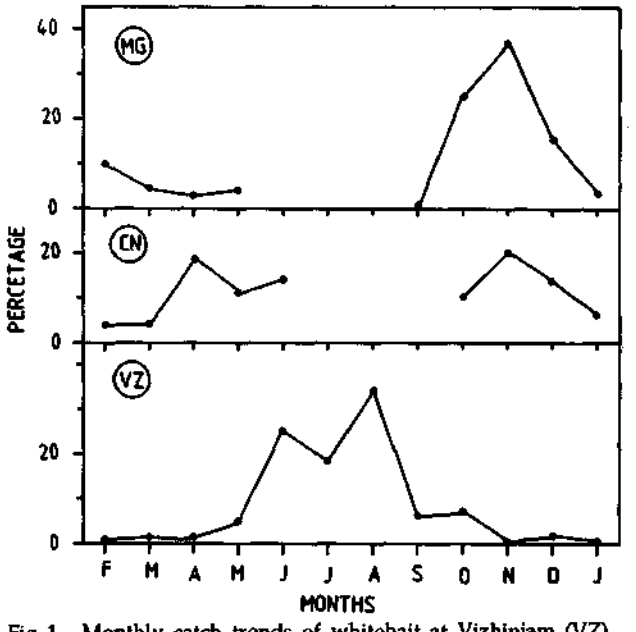

Fig. 1. Monthly catch trends of whitebait at Vizhinjam (VZ), Cochin (CN) and Mangalore (MG).

Bulk of the shore seine effort (58%) was expended during postmonsoon period with its contribution of 56% to the annual catch, at a catch rate of 2-33 kg (13 kg). The premonsoon season effort of 39% accounted for 42% of the annual catch at catch rates of 1-29 kg (15 kg). The monsoon period accounted for only 3% of the annual effort with its contribution of 2% to the annual catch at catch rate of 7-20 kg (8 kg).

Cochin : At Cochin the annual whitebait landings ranged between 306 t and 1725 t (888 t) in the mechanised sector. Nearly half the annual catch was landed in postmonsoon period followed by 36% in premonsoon period and 14% in early monsoon period. Trawl net landed the bulk (80%) of the catch and the rest by purse seine at catch rates of 18 kg and 60 kg respectively. Whitebait occurred in the catches during October-June period, good catches being obtained around November-December and April-May. The trawling effort was

TABLE 3. *Gearwise and seasonwise effort, catch (kg) and catch rate (in parenthesis) for whitebait and the component species, as well as the species composition over the period 1984-88 at Mangalore*

Season	Effort	Sd	Sbt	Sbc	Sc	Sm	Total
Trawlnet							
Premonsoon	25,472	59,702 (2.34)	110,194 (4.33)	-	-	21,349 (0.84)	191,245 (7.51)
Monsoon	-	-	-	-	-	-	-
Postmonsoon	20,258	29,619 (1.46)	96,926 (4.78)	15 (0.001)	42 (0.002)	3373 (0.17)	129,975 (6.42)
Over the period	45,730	89,321 (1.95)	207,120 (4.62)	15 (0.0003)	42 (0.0009)	24,722 (0.54)	321,220 (7.02)
% Species composition	-	27.81	64.48	0.005	0.01	7.70	
Purse seine							
Premonsoon	2721	496,199 (182.36)	-	312 (0.11)	-	353 (0.13)	496,864 (182.60)
Monsoon	-	-	-	-	-	-	-
Postmonsoon	8875	2684,691 (302.50)	4520 (0.51)	14,456 (1.63)	-	8148 (0.92)	2,711,815 (305.56)
Over the period	11,596	3180,890 (274.3)	4520 (0.39)	14,768 (1.27)	-	8501 (0.73)	3208,679 (276.71)
% Species composition	-	99.13	0.14	0.46	-	0.26	-
Annual average catch	-	3270,211	211,640	14,783	42	33,223	3529,899
% Species composition	-	92.64	6.00	0.42	0.001	0.94	
(All Gear)							

Sd = Stolephorus devisi; Sbt = S. bataviensis; Sc = S. commersonii; Sm = S. macrops.

observed almost throughout the year, the share of the premonsoon, monsoon and postmonsoon periods being respectively 43%, 31% and 26% and the share of the whitebait catch being 28%, 17% and 55% with catch rates at 12 kg, 10 kg and 39 kg respectively. Whitebait was absent in the trawl catch during July - September throughout the period. Purse seine effort was observed throughout the year excepting the monsoon period. Premonsoon and postmonsoon periods shared it in the order of 57% and 43% respectively with the catches and catch rate at 69% and 31%, and 73 kg and 42 kg respectively. In trawlnet good catches with catch rates of 40-72 kg were obtained during November-December followed by May-June with catch rates at 20-22 kg. It would appear that the whitebait school nearer to the bottom during postmonsoon period at Cochin. In purse seines good catches as well as catch rates were obtained in April (410 kg/net) and November (268 kg/net).

Mangalore : At Mangalore the annual whitebait landings ranged between 1640 t and 8835 t (3530 t) in the mechanised fishing sector. Mechanised fishing operations in this area remain suspended from 1st June to 31st August as per restriction imposed by the Government of Karnataka. Whitebait landings were obtained during the rest of the period, very good catches being obtained around November. Purse seine landed the bulk (90%) of the annual whitebait catch and trawlnet landed the rest at catch rates of 277 kg and 7 kg respectively. In the case of tralwing, premonsoon period witnessed intense fishing activity as well as good catches with their share of 56% and 60% of the annual trawling effort and whitebait catch respectively with catch rate of 1-16 kg (8 kg). Postmonsoon period accounted for 44% of the annual effort and 40% of the annual catch at an average catch rate of 7 kg. Better catch rates of 9-16 kg were obtained during April-May and of 10 - 13 kg during November-December.

In the case of purse seining, on the other hand, postmonsoon period witnessed intense fishing activity as well as whitebait catches with their

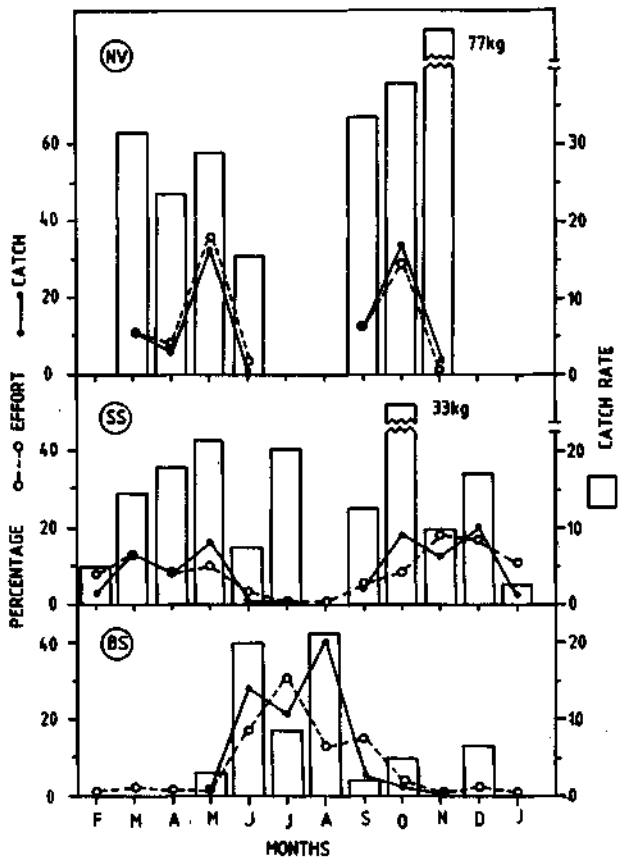

Fig. 2. Gearwise monthly trends in effort, catch and catch rate (kg) at Vizhinjam (NV=Netholi vala, SS=Shore seine and BS=Boat seine).

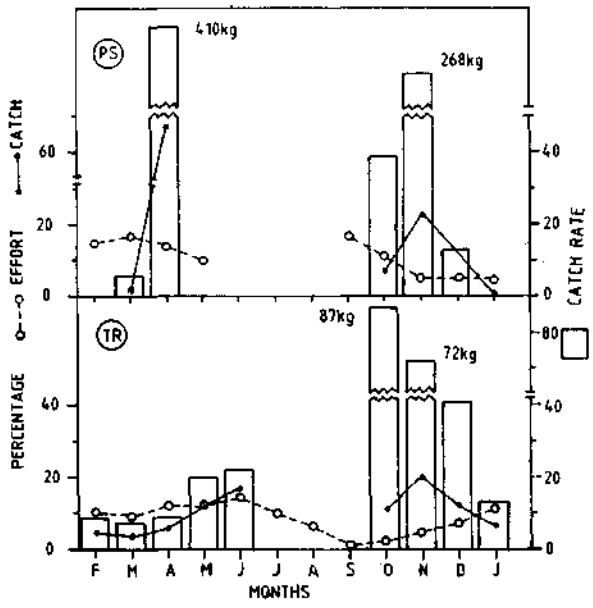

Fig. 3. Gearwise monthly trends in effort, catch and catch rate (kg) at Cochin (PS=Purse seine and TR=Trawl).

share of 77% and 85% respectively of their annual estimated values. The catch rate being 7-614 kg (306 kg). The premonsoon period accounted for only 23% of the annual effort and 15% of the annual catch at catch rate of 83-417 kg (183 kg). Better catches of 300-614 kg were obtained during October-December and of 132-417 kg during February-March. Thus October-March may be considered as the good whitebait fishery season for purse seine at Mangalore.

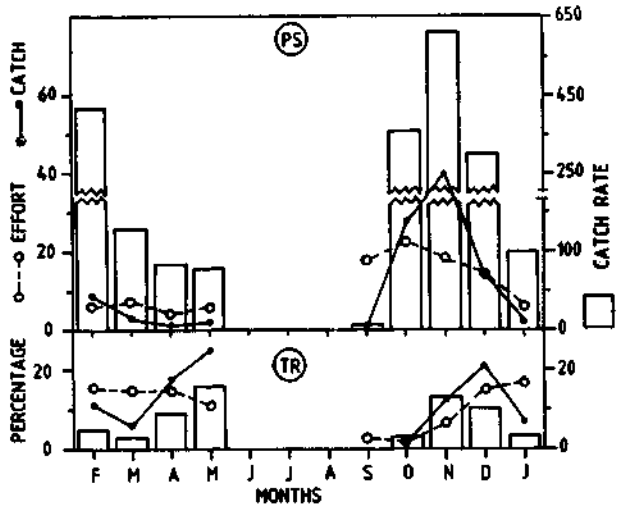

Fig. 4. Gearwise monthly trends in effort, catch and catch rate (kg) at Mangalore.

Species composition : Seven species of whitebait occurred along the west coast (Table 4). However only two species namely, *Stolephorus devisi* and *S. bataviensis* constituted the bulk of the whitebait landings together accounting for 74% at Vizhinjam, 92% at Cochin and 99% at Mangalore. *S. buccaneeri* occurring in increasing abundance from south to north constituting 21%, 6% and <1% respectively at the above three centres is yet another species of some regional importance. These three species together accounted for 95-99% of the whitebait landings along south-west coast (Tables 1-3).

Fishery and biology of the important species : Monthly trends of the landings of each of the three important species pooled from all gears are given in Fig. 5. Size ranges and the dominant size groups of the three species in each season at the three centres are given in Table 4. Seasonal abundance

(in percent) of the fish with gonads in advanced stages of maturity for each of the three species at the three centres are given in Fig. 6. Specieswise catch and the salient features of their biology at the three centres are discussed here.

S. DEVISI

Annual catch trend

At Vizhinjam the annual landings of this species ranged from 117 t to 297 t (174 t). The three seasons accounted for 13%, 61% and 26% respectively of the annual catch. Boat seine accounted for the bulk (72%) of this catch followed by gillnet (26%) and shore seine (2%) the average catch rates being 4.2 kg, 27.5 kg and 9.9 kg respectively.

At Cochin the annual landings were 120 t - 1100 t (495 t). The three seasons accounted for 39%, 8% and 53% respectively of the annual catch. Shrimp trawls landed the bulk (67%) of the catch and purse seine landed the rest (33%) at the average catch rates of 8.5 kg in trawlnet and 54 kg in purse seine.

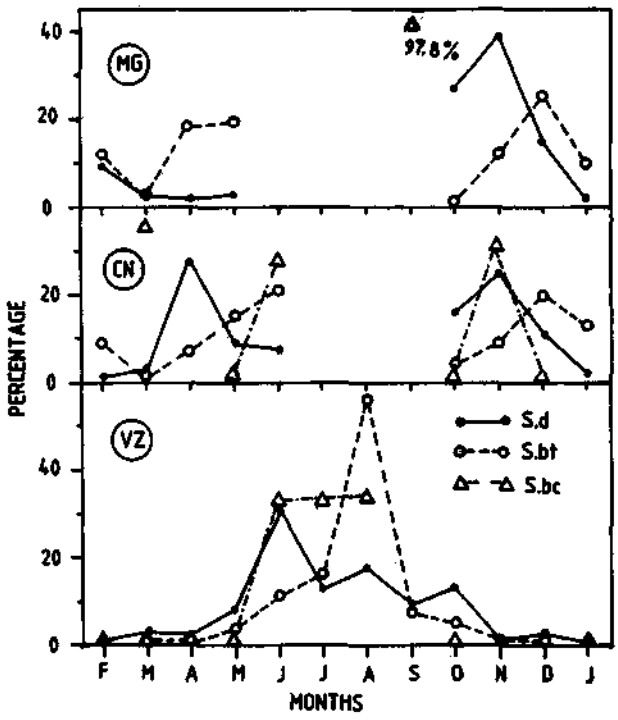

Fig. 5. Monthly trends in the landings of the three important species of whitebait at Vizhinjam, Cochin and Mangalore (S. d =*S. devisi*, S. bt =*S. bataviensis*, S. bc =*S. buccaneeri*).

At Mangalore the annual landings ranged between 1251 t and 8470 t (3270 t). The three seasons accounted for 17%, nil and 83% of the annual catch. Purse seine landed most of this catch (97%), shrimp trawl contributing the rest at catch rates of 71-794 kg (174 kg) in purse seine and upto 158 kg (2 kg) in shrimp trawl.

TABLE 4. *Size range (mm) and dominant size (in parenthesis) of the three dominant species of Stolephorus in the three seasons at Vizhinjam, Cochin and Mangalore (1984-88)*

Centre	*S. devisi*	*S. bataviensis*	*S. buccaneeri*
Premonsoon			
Vizhinjam	30-99 (30-39 & 60-84)	35-94 (45-49 & 75-85)	30-54 & 60-94 (35-49)
Cochin	50-104 (65-89)	35-109 (60-89)	50-94 (75-79)
Mangalore	45-99 (65-84)	55-104 (70-94)	-
Monsoon			
Vizhinjam	30-94 (55-75)	40-104 (45-49 & 65-80)	45-105 (60-84)
Cochin	45-74 (50-54)	55-109 (70-74)	65-94 (70-79)
Mangalore	-	-	-
Postmonsoon			
Vizhinjam	30-44 & 60-99 (30-34 & 65-89)	60-104 (70-90)	35-54 & 70-99 (40-44 & 85-89)
Cochin	55-99 (70-84)	60-104 (70-94)	70-99 (85-94)
Mangalore	65-99 (70-84)	75-104 (85-94)	-

Monthly catch trend

At Cochin *S. devisi* was landed during October-June, catches being better during April-June and October-December. At Mangalore this fish was landed during October-May, main fishery season being October-December. When mechanized fishing was resumed in September after the monsoon season, this species was not available to both the mechanized gears. Same was the case at Cochin also. This indicates that *S. devisi* enters the present fishing ground of the central and northern sections of the southwest coast about a month after the close of the southwest monsoon. In the southern sector (Vizhinjam), on the other hand, June-October was the main fishery season although the fish was landed throughout the year.

Fishery and biology

In the postmonsoon period, bulk of the catch of *S. devisi* was obtained during October-December both at the northern and central sectors accounting for 81% and 51% of the annual catch respectively. January accounted for only 2% in each sector and nil during September at both the centres in spite of fishing effort. During this season purse seine landed the bulk of the catch both at Mangalore (89%) and Cochin (64%) and shrimp trawl landed the rest. In the southern sector (Vizhinjam), however, September-October period yielded good catches accounting for 22% and the remaining three months accounting for only 4% of the annual catch. In the southern sector both juveniles (30-34 mm length) and adults (65-89 mm length) formed the dominant catch during the postmonsoon period. Fish in advanced stages of maturity formed 80%. Gillnet (52%) and boat seine (42%) landed bulk of the catch during this period, shore seine landing the rest (6%). At Cochin adult fish of the size range 70-84 mm formed the dominant catch. Fish in advanced stages of maturity formed only 12%. Bulk of the catch (85%) was landed by shrimp trawl and the rest by purse seine. At Mangalore also adult fish of the size range 70-85 mm length formed the dominant size. Fish in advanced stages of maturity formed 80%. Most of the catch (99%) during this period was landed by purse seine and the rest by shrimp trawl.

During the succeeding period (premonsoon), February witnessed good catches at Mangalore accounting for 9% and rest of the three months together accounting for only 8% of the annual catch. At Cochin April-May accounted for 37% and the rest of the three months for only 3% of the annual catch. At Vizhinjam 8% of the annual catch was obtained in May and the remaining three months of the season (February-April) together accounted for only 5%. Both juveniles and adults with dominant sizes at 30-39 mm and 60-84 mm occurred in the catches. Bulk of the adult fish (84.5%) was with gonads in advanced stages of maturity. Gillnet landed bulk (89%) of the catch of this season followed by shore seine (8%) and boat seine (3%). At Cochin and Mangalore adult fish of the size range 65-89 mm and 65-84 mm respectively formed the dominant component of the catch, fish with gonads in advanced stages of maturity being 9% and 59% at Cochin and Mangalore respectively.

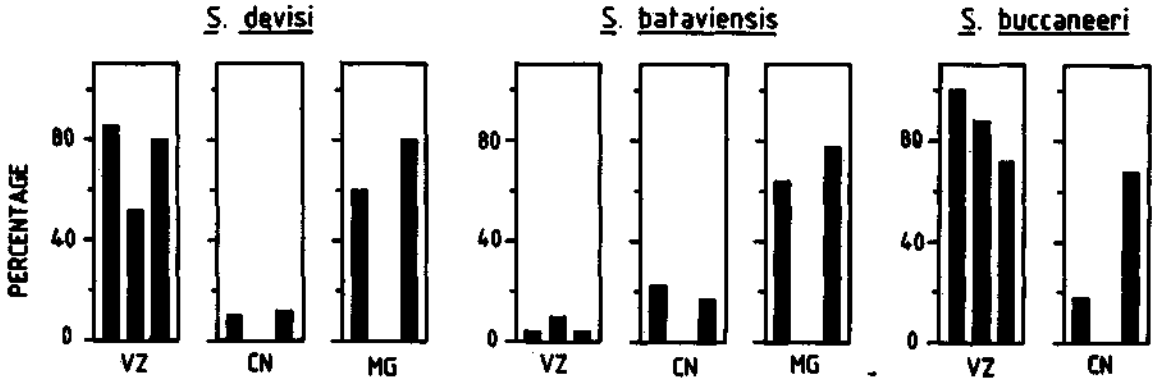

Fig. 6. Percentage composition of fish in advanced stages of maturity (Stages V-VII) in the premonsoon, monsoon and postmonsoon periods respectively (shown as bars).

During the monsoon season, as mentioned earlier, mechanized fishing is suspended at Mangalore. But at Cochin, despite fishing effort (entirely by shrimp trawl) this species was not met with in the catches during July-August, the month of June accounting for only 8% of the annual catch.

In the southern sector, about 61% of the annual catch was obtained during this season about half of this catch being obtained during June alone. Boat seines landed 99% of the catch of this species. Pre-adults and adults formed the catch during this period at Vizhinjam with the dominant size at 55-75 mm. Fish with gonads in advanced stages of maturity formed only 52%. At Cochin, mostly juveniles of 50-54 mm length formed the dominant catch. Only fish with resting and developing gonads were met with at this centre.

S. BATAVIENSIS

Annual catch trend

At Vizhinjam the annual landings of this species ranged between 66 t and 394 t (144 t). The three seasons accounted for 4%, 83% and 13% respectively of the annual catch. Boat seine accounted for most of the catch (94%) followed by gillnet (5%) and shore seine (1%), the average catch rates in the three gears being 4.6 kg, 4.7 kg and 1.5 kg respectively. At Cochin annual landings of this species ranged between 22 t and 789 t (321 t). The three seasons accounted for 32%, 21% and 47% respectively of the annual catch. Nearly the entire catch (99.7%) was landed by trawlnet and a small quantity by purse seine at catch rates of 8 kg and 0.8 kg respectively. At Mangalore the annual landings of this species ranged between 92 t and 380 t (212 t). The three seasons accounted for 52%, nil and 48% respectively of the annual catch. Most of the catch (98%) was landed by shrimp trawl and the rest by purse seine at the catch rates of 4.6 kg and 0.4 kg respectively.

Monthly catch trend

The main fishery season of this species at Vizhinjam occurred during June-August coinciding with the monsoon season although the fish was available during March-December. Despite fishing effort this fish was not available in catches during January-February. At Cochin it occurred during October-June, good catches being obtained during November-February and May-June. Although fishing was carried out in July-September, fish was not available in the catches. At Mangalore *S. bataviensis* supported the fishery, during October-May with better catches during November-February and April-May, as at Cochin. However, this fish was not available in September.

Fishery and biology

During the postmonsoon period bulk of the catch of *S. bataviensis* was obtained during November-January both at northern and southern sectors accounting for 47% and 43% of the annual catch respectively. October contributed to only 1% at the northern sector and 5% in central sector, and nil during September in both the sectors. In the southern sector, however, September-October period yielded catches accounting for 12.8% of the annual catch and November-December for 0.5% and nil catch during January. Shrimp trawl yielded most of the catch of this species at Cochin (99.7%) and Mangalore (97.8%) and the rest was by purse seine. At Vizhinjam boat seine landed the bulk (94%) followed by gillnet (5%) and shore seine (1%). In the northern and central sectors pre-adults and adults in the length range of 85-94 mm and 70-94 mm were dominant. Fish in advanced stages of maturity were dominant (77%) in the northern sector, but such fish formed only 17% in the central sector. Most of the catch was landed by trawlnet both at Mangalore (98%) and at Cochin (99.7%) and the rest by purse seine.

During the succeeding period (premonsoon) at the northern and central sectors, April and May together accounted for 36% and 22% of the annual catch respectively followed by February 12% and 9% . The month of March witnessed poor catches amounting to 4% and 1% respectively at these two centres. At the southern sector (Vizhinjam) poor catches were obtained during most of the period, only May witnessing relatively better catches accounting for 4% of the annual catch. Bulk of the catches comprised pre-adults and adults of the size 70-94 mm and 60-89 mm at Mangalore and Cochin respectively. Fish in advanced stages of maturity formed 64% and 22% respectively at these two centres. The entire catch of the season was landed by shrimp trawl at both the centres. At Vizhinjam, however, early juveniles, pre-adults and adults with dominant sizes at 45-49 mm and 75-85 mm formed the fishery. Bulk of the catch of this species was landed by gillnet (86.7%) followed by boat seine (8.7%) and shore seine (4.6%).

During the monsoon season this fish was landed only in June at Cochin entirely by trawlnet accounting for 21% of the annual catch. At Vizhinjam abount 83% of the annual catch was obtained during this season, the month of August alone accounting for 56% of the annual catch. Most of the catch (99.8%) was landed by boat seine, stray catches occurring in the other two gears. Early juveniles and pre-adults of 45-49 mm and 65-80 mm length at Vizhinjam, pre-adults of 70-74 mm length at Cochin formed the dominant catch. Fish in advanced stages of maturity formed only 9% at Vizhinjam, but such fish was absent at Cochin during this period.

From what has been stated above, this species appears to make periodical movements in

and out of the regular fishing grounds. It is more abundant off Mangalore and cochin during pre-monsoon period, and during the monsoon period off Vizhinjam. Again, it is more abundant in the central and northern sectors during the post-monsoon period.

S. BUCCANEERI

Annual catch trend

At Vizhinjam the annual landings of this species ranged between 22 t and 235 t (91 t). The three seasons accounted for 0.3%, 99.6% and 0.1% respectively of the annual catch. Boat seines landed most of the catch (99.6%) followed by shore seine (0.4%). Very rarely, it is caught in gillnet also. Average catch rates of 0-3 kg and 0-0.75 kg were obtained in boat seine and shore seine respectively. At Cochin the annual landings of this species ranged between nil and 100 t (56 t). The three seasons accounted for 38%, 28% and 34% respectively of the annual catch. Bulk of the catch (70%) was landed by trawl net and the rest (30%) by purse seine at the average catch rate of 1 kg and 9 kg respectively in the two gears. At Mangalore this species was rare. Over the period of this study it occurred in the catches in four months and the total catch was 59 t at this centre.

Monthly catch trend

This species is highly sporadic and occurred in spurts along the west coast. At Vizhinjam, however, it occurred in boat seine almost regularly during June-August. Throughout the period of study it was rare in the gillnet and in shore seine it was caught only occasionally in very small quantities. These three gears accounted for 99.62%, 0.01% and 0.36% respectively of the annual catch. At Cochin this species was encountered only during 1987 and 1988. Bulk of the catch (70%) was caught in trawlnet and the rest by purse seine. Three months - March (36%), June (28%) and November (31%) accounted for 95% of the annual catch. At Mangalore this species was met with only during 1987 and 1988 as at Cochin, but September accounted for the bulk of the catch (97.8%). However most of the catch was by purse seine (99.9%) and only a very little by trawlnet.

Fishery and biology

Generally, adult fish and fish in advanced stages of maturity formed the bulk of the catch whenever it occurred at the three centres. At Vizhinjam, however, juveniles formed bulk of the landings during the premonsoon period and fish with resting and developing gonads formed most of the catch in the premonsoon period at Cochin.

Distribution of whitebait in time and space : Examination of the seasonal trends of the catch and catch rate of whitebait as well as the fishing effort expended by the different types of gears at the three centres (Figs. 1-4) brings to the fore the seasonal distribution pattern of the whitebait in time and space. To determine the status of the fishery in a month, comparison was made of the monthly percentage of the effort in relation to the catch and catch rate. For example, at Cochin in the trend line of the trawl catch the monthly percentages of catches during February-April is below the effort, whereas the trend line of the effort during October-December is much below the catch and the monthly catch rates are also high indicating the former period (February-April) to be poor fishery season for whitebait by shrimp trawl. And during July-August, although very high trawling effort was expended, there was no catch indicating that whitebait was absent in the fishing grounds. Similar approach was made to elucidate the seasonal trend for the whitebait fishery by the other gears at the other centres.

In the Vizhinjam area the whitebait keep moving into the inshore fishing grounds during March-December. During this period they seem to school close to surface and shoreward during March-May and September-December and get caught in surface gillnets. During June-August, whitebait seem to school in deeper waters and get caught in boat seine operated at mid depths. At Cochin these fishes seem to be distributed nearest the bottom during May-June and October-December than during January-April and move away from the inshore fishing grounds during July-September. In this connection it may be pointed out that boat seines at Vizhinjam obtained good catches of whitebait during this period (July-September). Further, the whitebait in the Vizhinjam area is distributed over the entire column of inshore water during the postmonsoon period and closer to the surface during March-April, and thus get caught by surface gillnets. At Mangalore the distribution pattern of whitebait during the monsoon period remains unknown as operations of both purse seine

and trawlnet were suspended during the period. However, from the very poor returns by purse seine and nil catches in trawl nets during September it is clear that whitebait abandon the inshore fishing ground off Mangalore area during monsoon period and enter the fishing ground about a month after the close of the monsoon. Here, the whitebait seem to school more towards the bottom during January and April-May, but towards the surface during February and October-November and over the entire column of inshore waters during December. In March the catch was relatively less as related to the effort put in by both the gears.

General Remarks

From the foregoing account it is evident that the fishing ground off Mangalore is more productive for whitebait than at Cochin. Vizhinjam, where indigenous units fitted with out-board motor for propulsion are operated, ranks third among the three centres. During the monsoon months the fishing activity by the trawlers and purse seines is suspended at Mangalore whereas only the latter gear is not employed at Cochin. And the whitebait itself seems to be absent in the inshore fishing grounds of these two centres during the monsoon months. Thus the question of enforcing any regulatory measures in fishing for whitebait during monsoon period for conservation of this fishery resource off Mangalore and Cochin does not arise. At Vizhinjam, however, the main whitebait fishery season coincides with the monsoon period. Neither the magnitude of the whitebait fishery nor the biological characteristics of the two primary species at this centre attract any fishery regulation measures.

Acknowledgements

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4.6

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : RIBBONFISHES

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ABSTRACT

The average annual ribbonfish production of the west coast is estimated at 56,883 tonnes which forms 5.71% of the total fish landings of the coast. Postmonsoon season realised 47% of the catch followed by premonsoon (39%) and monsoon (14%) seasons. This trend is well seen in States like Maharashtra and Karnataka. In Kerala, however, the peak landing (49%) was found during monsoon months while in the other two States it was during the premonsoon period. Trwal net is the only gear operated in all the States during all the seasons and it accounts for about 67% of the total catch. Boat seine occupies the second place (10%) and is limited only to Kerala where it brings in the bulk during monsoon months. Dol net comes third (9.9%) and is employed in States like Maharashtra and Gujarat. Other gears which are employed for the exploitation of ribbonfish along the west coast are purse seine, shore seine, hooks and line and a variety of gill nets. *Trichiurus lepturus* Linnaeus is predominant in all the States, while *Eupleurogrammus muticus* (Gray), *E. intermedius* (Gray), *Lepturacanthus savala* (Cuvier) and *T. auriga* Klunzinger are also found in some places. The exploitation of ribbonfish in relation to monsoon is discussed.

INTRODUCTION

Among the exploited finfish resources of India, the ribbonfishes occupy an important place along both the coasts. They rank seventh among the exploited fish groups in the order of predominance (James *et al.*, 1986 a) and contribute about 4% to the total marine fish landing in India (Chakraborty, 1990). The fishery is mainly confined to the depth zone shallower than 50 m and continues to be predominantly in the hands of the traditional and small mechanised sectors. The present account deals with the ribbonfish fishery of Indian west coast with reference to the exploitation during the monsoon period.

DATA BASE

The ribbonfish landing data from the west coast for the period 1984- 88 collected and maintained by the Fisheries Resources Assessment Division (FRAD) of CMFRI are utilised for the study. Apart from these, the fishery and biological data collected by CMFRI's Research Centres at Vizhinjam and Bombay, the environmental data collected at Vizhinjam and the rainfall data recorded at Trivandrum Air Port are also utilised. For the purpose of analysis, an year is divided into three seasons : premonsoon (February-May), monsoon (June-August) and postmonsoon (SeptemberJanuary) and the data are pooled accordingly.

OBSERVATIONS

Trend of the fishery

The average annual production of ribbonfish in the west coast during 1984-88 is estimated at 56,883 t (Table 1), forming 5.7% of the total marine fish landings of the coast (Fig. 1 A). All the five maritime States of the west coast contribute to this resource (Fig. 1 B-F). Maharashtra and Kerala produce more or less equal quantity, 15,769 t (27.7%) and 15,302 t (26.9%) respectively and Karnataka only 5,775 t (10.1%) of the total catch. In Gujarat the estimated catch is 18,569 t whereas in Goa only 1,469 t (2.8%) are landed.

Of the total ribbonfish catch of the west coast, an estimated total of 26,725 t (4.7%) was landed during the postmonsoon period followed by 21,939 t (38.6%) in the premonsoon period (Fig. 1 G) and 8,219 t (14.45%) in monsoon period. This trend is seen in States like Maharashtra and Karnataka (Fig. 1 K, I). In Kerala (Fig. 1 H) however, the lean season is observed during the premonsoon months and the peak during monsoon forming 49.1% (7,515.25 t) of the year's catch and is followed by 43.4% (6,646 t) during the postmonsoon period. Gujarat and Goa (Fig. 1 L, J) show more or less the same trend in which the premonsoon period provides the peak landing

TABLE 1. *Statewise and seasonwise average landings (tonnes) of ribbonfish and all fish in the west coast*

	premonsoon	monsoon	postmonsoon	Ribbonfish Total	%	All fish total	% of ribbon-fish in total
Kerala	1140.75	7515.25	6646.00	15302.00	26.90	366496.75	4.18
Karnataka	2797.67	37.00	2940.00	5774.67	10.15	173327.67	3.33
Goa	932.50	22.50	514.00	1469.00	2.58	52721.00	2.79
Maharashtra	5423.25	597.00	9748.75	15769.00	27.73	189198.50	8.33
Gujarat	11645.00	47.25	6876.50	18568.75	32.64	214603.00	8.65
Total	21939.17	8219.00	26725.25	56883.42	100.00	996346.92	
Percentage	38.57	14.45	49.98				5.71

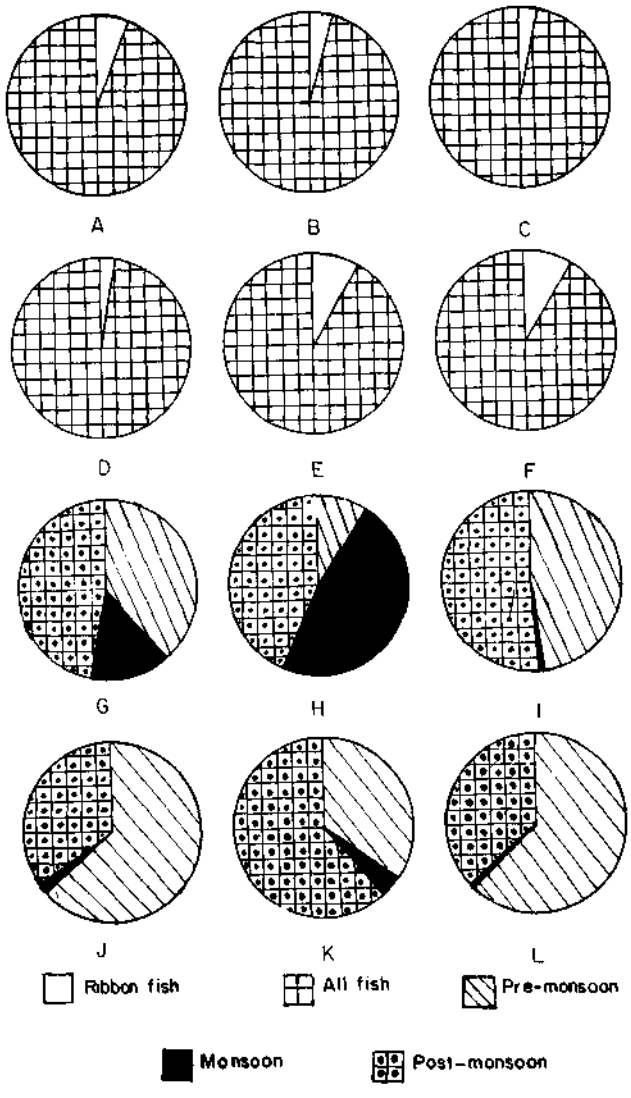

Fig. 1. Share of ribbonfish in the total fish landings of : A - west coast, B - Kerala, C - Karnataka, D - Goa, E - Maharashtra and F - Gujarat, and ribbonfish landings during the premonsoon, monsoon and postmonsoon seasons of : G - west coast, H - Kerala, I - Karnataka, J - Goa, K - Maharashtra and L - Gujarat.

followed by the postmonsoon and the lean period during the monsoon months. In Goa (Fig. 1 J) the premonsoon landing is estimated at 932.5 t (63.48%) and in the postmonsoon, 514.00 t (34.99%). In Gujarat (Fig. 1 L) the premonsoon catch is around 11,645.0 t (62.71%) and the postmonsoon around 6876.5 t (37.03%). The monsoon catch is only 47.25 t (0.25%) and 22.50 t (1.53%) respectively in Gujarat and Goa.

Gearwise contribution to the fishery

In Kerala the ribbonfishes are exploited mainly by boat seine, trawl net, gill net, hooks and line and shore seine and contribute 50.5%, 22.6%, 17.2%, 5.0% and 4.5% respectively to the fishery (Fig. 2 A). About 0.2% is brought by purse seine (not shown in the figure). Gears like boat seine, hooks and line and gillnet are operated both from motorised and non-motorised crafts. In the case of hooks and line about 83% of the units which operate them are fitted with out-board engines while in the case of boat seine and gillnet, 20% and 16% respectively of the units only are fitted with out-board engines. Almost the entire catch (99.7%) during the premonsoon period is brought by trawl net (Fig. 2 B) with CPUE ranging from 3.27 kg to 8.27 kg. The bulk of the catch (61.5%) during the monsoon months (Fig. 2 C) is brought by boat seine. Trawl net (28.9%), shore seine (6%), hooks and line (1.9%) and gillnet (1.7%) are also operated during the season in small numbers. The maximum CPUE recorded for boat seine during monsoon appears to be 5.9 kg for motorised and 5.3 kg for non-motorised units. In the postmonsoon season the main share of ribbonfish catch is taken by gill net (40%). Trawl net and boat seine contribute respectively 34.8% and 15.6% of the catch (Fig. 2 D) and the remainng catch was by hooks and line

(9.2%) and shore seine (0.4%). The maximum CPUE recorded for gillnet during the postmonsoon period was 9.3 kg for the motorised crafts and 3.5 kg for the non-motorised sector. Except boat seine and shore seine all the units contribute more during the postmonsoon period (Table 2). The catch by the above two nets is more during monsoon period. Ribbonfish catch in Karnataka is accounted mainly by trawl net, purse seine and some non-mechanised gears like drift net and *Matu bala* and each contribute respectively 87.6%, 10.6% and 1.8% of the total catch (Fig. 2 E). Of the total trawl catch, 63% and 36% respectively are landed during pre and postmonsoon periods and 1% during the monsoon period. In the case of purse seine 99% of the catch comes from postmonsoon fishing, while the rest during the other two seasons. There is not much difference in the catch by non-mechanised gears in the three different seasons (Table 2). The ribbonfish is dominant in the trawl catch during pre and postmonsoon periods (Fig. 2 F, H) and during monsoon,the non-mechanised units contribute to the bulk (Fig. 2 G). The average CPUE during pre and postmonsoon periods by trawl net is 0.03 kg and 0.02 kg respectively. The CPUE by purse seine during postmonsoon is better (0.03 kg) when compared to those of other two seasons.

About 92% of the catch in Goa is obtained by trawl net and the remaining is shared almost equally by purse seine, gillnet and other non-mechanised units (Fig. 2 I). This overall trend is seen for all the periods except for monsoon period, when the contribution from the mechanised sector is found to be slightly higher than the other two periods (Fig. 2 J, K, L). Though trawl net contributes to the bulk of the total ribbonfish catch of the State, it fetches only small quantity (1.6%) during monsoon months (Table 2). Pre and postmonsoon periods contribute 64.8% and 36.7% respectively of the total catch. The average CPUE recorded is 0.02 kg for the premonsoon, 0.003 kg for the monsoon and 0.012 kg for the postmonsoon periods. Contributions by purse seine and non-mechanised units are more during the postmonsoon period than in the other two periods. There is no catch by the gill net during monsoon. During the other two periods, its contribution to the fishery is 40 and 60% respectively.

In Maharashtra a variety of gears contribute to the ribbonfish fishery, but the important ones are trawlnet and dol net contributing respectively 50.3% and 35.4% of the total ribbonfish catch (Fig. 2 M). The other gears involved in the fishery are gillnet (9.11%), purse seine (1.74%), hooks and line (0.60%), cast net (0.1%) and other non-mechansied units (10.0%). Almost the same overall trend can be observed for the three periods (Fig. 2 N, O, P). The landings are good in all the gears during postmonsoon period (Table 2) followed by the premonsoon months, but contribute the least during the monsoon months.

Trawl net, dol net, gill net and other non-mechanised units contribute respectively 78.1%, 13.9%, 6.1% and 1.9% to the ribbonfish fishery of Gujarat Coast (Fig. 2 Q). A more or less similar trend in which trawl net contributing more is observed during pre and postmonsoon periods (Fig. 2 R, T), but during the monsoon period the bulk of the catch comes form gill net (Fig. 2 S). Among the trawl catch, 65.7% comes during the premonsoon period (Table 2) with an average CPUE of 0.2 kg; 34.2% during the postmonsoon

TABLE 2. *Contribution (%) of ribbonfish by the different gears during different seasons in the west coast*

	Kerala			Karnataka			Goa			Maharashtra			Gujarat			Average for the coast		
	Pr	M	Pt	Pr	M	Pt	Pr	M	Pt	Pr	M	Pt	Pr	M	Pt	Pr	M	Pt
Trawl net	29.60	9.21	61.19	63.05	0.07	36.88	64.76	1.57	33.67	38.50	7.30	54.20	65.68	0.15	34.17	52.32	3.66	44.02
Boat seine	0.10	87.70	12.20	-	-	-	-	-	-	-	-	-	-	-	-	0.10	87.70	12.20
Dol net	-	-	-	-	-	-	-	-	-	46.30	3.70	50.00	76.28	0.02	23.70	61.29	1.86	36.85
Gill net	0.08	7.30	92.62	-	-	-	40.43	-	59.57	27.20	4.20	68.60	27.46	2.14	70.40	23.79	3.41	72.80
Purse seine	-	-	-	0.28	0.19	99.53	3.70	3.70	92.59	8.30	-	91.70	-	-	-	4.09	1.30	94.61
Other nonmechanised	-	-	-	14.93	43.95	41.12	11.24	12.36	76.40	20.80	16.50	62.70	78.15	0.27	21.58	31.28	18.27	50.45
Hooks and line	-	26.90	73.10	-	-	-	-	-	-	49.20	0.50	50.30	-	-	-	24.60	13.70	61.70

Pr = Premonsoon, M = Monsoon, Pt = Postmonsoon.

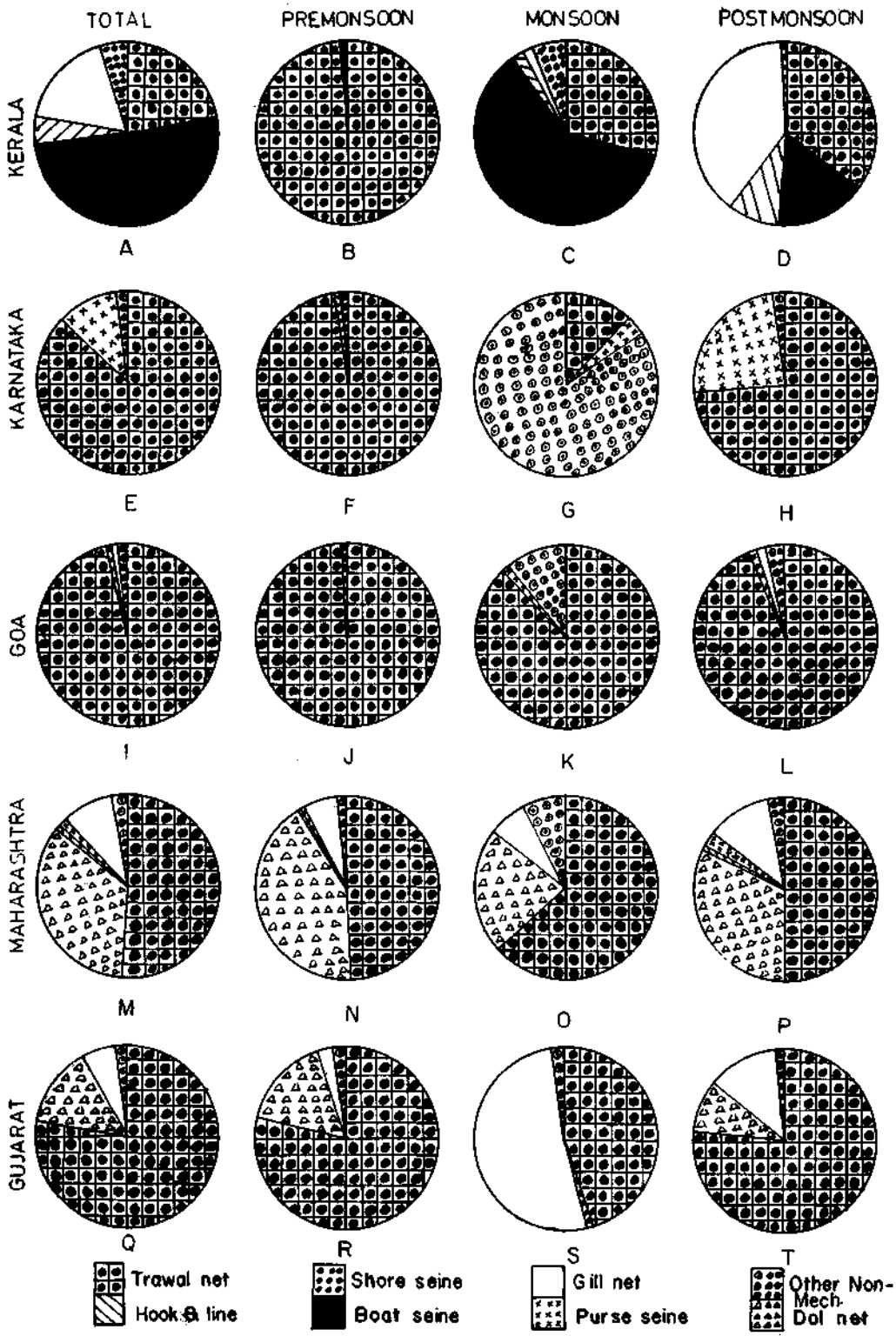

Fig. 2. Gearwise contribution of ribbonfish in different maritime States along the west coast of India during premonsoon, monsoon and postmonsoon and total.

period with CPUE of 0.1 kg and the remaining 0.1% during the monsoon months with CPUE of 0.02 kg. Similarly other non-mechanised units and dol net also contribute more during the premonsoon period than in the other two seasons. The average CPUE recorded for these two units during the period are respectively at 0.01 kg and 0.06 kg, but in the case of gill net, the contribution during the postmonsoon season is more (70.4%) than in the other two seasons.

Thus trawl net appears to be the only gear in operation in all the States during all the seasons along the west coast for the exploitation of ribbonfish. It accounts for 67.2% of the overall catch (Fig. 3 A) of the entire west coast. Out of this, only 3.7% (Fig. 3 B) is fished during the monsoon months. Its peak landing is seen in the premonsoon months in all the States except Kerala and Maharashtra where it falls in the postmonsoon months. Though boat seine ranks second (10.09%), it is limited only to Kerala where it brings the bulk during monsoon months (Fig. 3 C) forming 87.7% of the total catch. It contributes only 0.1% and 12.2% respectively to the pre and postmonsoon landings. Dol net, another important gear employed in the exploitation of ribbonfish in Maharashtra and Gujarat, accounts for 9.9% (Fig. 3 A) of the total catch. Like the trawl net this gear also brings only a meagre quantity (1.86%) during the monsoon months and the first and second peaks in landings are in the pre and postmonsoon periods respectively (Fig. 3 D). Except Karnataka, in all the States the ribbonfishes are caught in a variety of gill nets accounting to 6.6% of the total catch. Like trawl net and dol net for this gear also the lean period is seen during the monsoon months (Fig. 3 E). But, unlike the other two gears, the peak landing is observed during the postmonsoon period. In States like Karnataka, Goa and Maharashtra, ribbonfish forms a part in the catches of purse seine forming 2.6% of the total catch (Fig. 3 A). It is mainly a postmonsoon fishery (Fig. 3 F) in all the above three States contributing above 95% of the catch during the postmonsoon months. About 1.6% of the total catch is being landed by a variety of gears operated by non-mechanised crafts in all the States except Kerala (Fig. 3 G). Here also the fishery is poor during monsoon months. Hooks and lines are used for the exploitation of this resource in Kerala and Maharashtra and it forms about 1.1% of the total catch contributing to about 13.7% only during the monsoon months (Fig. 3 H). The contribution by shore seine is only 0.9% and is restricted to Kerala where it brings the maximum (96.3%) quantity during monsoon period (Fig. 3 I). Thus, boat seine and shore seine are the two principal gears employed in the monsoon fishery for ribbonfish on the west coast and that too only in Kerala. In all the other States the monsoon landings seem to be meagre.

Biology

Five species of ribbonfishes namely, *Trichiurus lepturus, Lepturacanthus savala, T. auriga, Eupleurogrammus muticus* and *E. intermedius,* occur along the west coast of India. Of these, *T. lepturus* and *E. muticus* contribute to the fishery of the Vizhinjam region, the former predominating the catch. Along the Karnataka Coast, *T. lepturus* and *L. savala* support the fishery. On the northwest coast (Maharashtra and Gujarat), *T. lepturus* forms the main stay of the trawl fishery, while *L. savala* and *E. muticus* together with *T. lepturus* constitute the dol net fishery. Considering the entire west coast of India, *T. lepturus* is found to be the principal species supporting the fishery. Consequently more biological information is available on the species and the same is summarised along with the length details of *L. savala* and *E. muticus* from Bombay waters.

Trichiurus leptures : The peak season for *T. lepturus* falls between June and September in Kerala, October and December in Karnataka, Goa and Maharashtra, December and February in Gujarat. This species is exploited mainly from 15-40 m depth zone by boat seine in Kerala, 4-50 m depth zone by trawl net and gill net in Karnataka and from 40 to 90 m depth zone by trawl net and dol net in other States of the west coast. This species is known to undertake diurnal vertical migrations and is found close to the bottom during day time and ascends to the vertical water column and disperses at night (Rao *et al.*, 1977).

Length frequency data collected separately from boat seine and hooks and line at Vizhinjam during 1986-88 period is presented in Fig. 5. Boat seine landings in June are comprised of fishes ranging in size from 150 to 650 mm while for hooks and line it is from 50 to 650 mm. Two modes are seen at 250 and 500 mm in boat seines and at 200 and 500 mm in hooks and line operated from

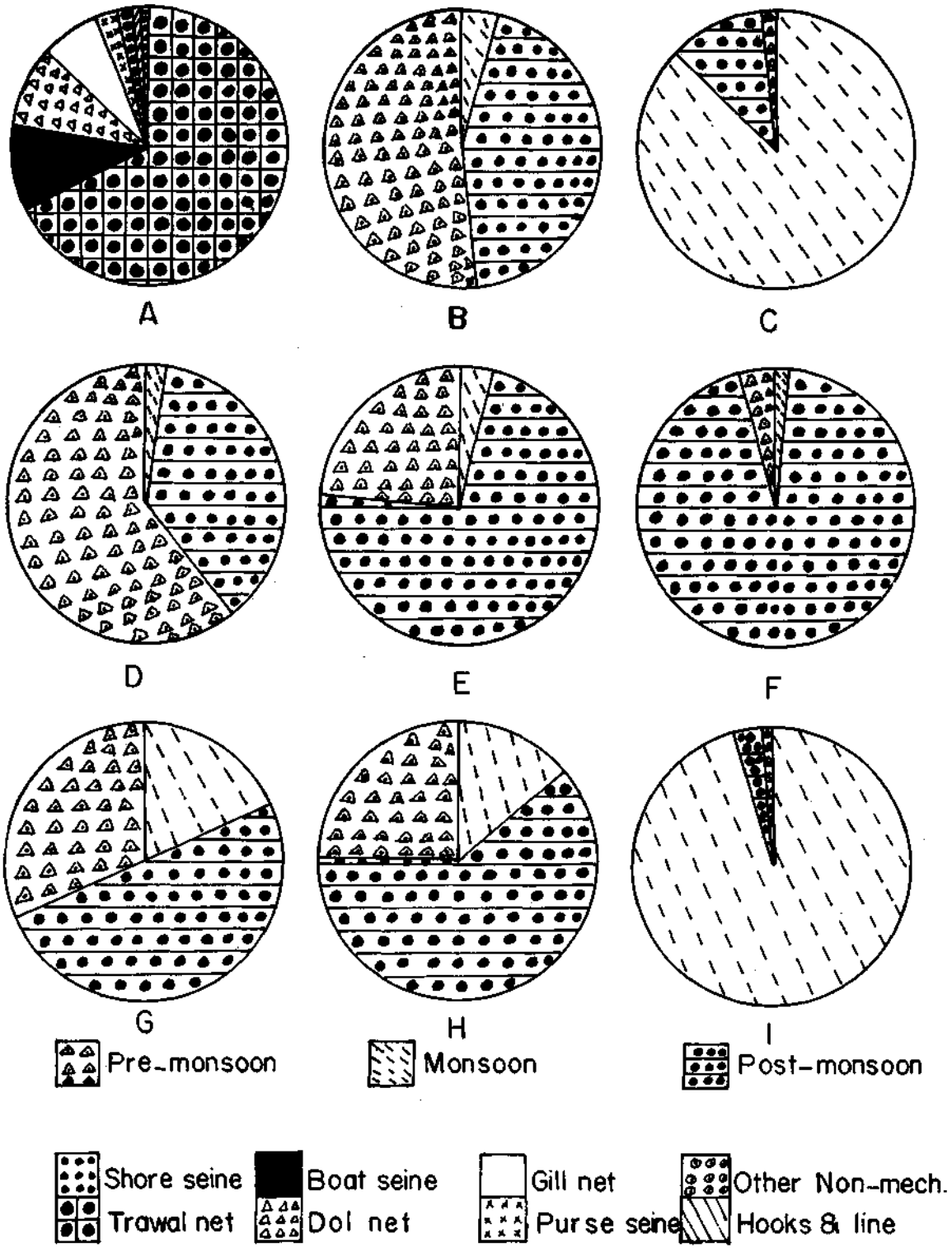

Fig. 3 A. Gear wise contribution of ribbonfish in the west coast and seasonwise contribution of ribbonfish by : B - Trawl net, C - Boat seine, D - Dol net, E - Gill net, F - Purse seine, G - other nonmechanised units, H - Hooks and line and I - Shore seine.

mechanised crafts. The distribution of various size groups in the above gears shows that the landing in hooks and line are composed of smaller specimens the modal difference being 50 mm less in this gear as compared with those in the boat seine catch. Of the two dominant modes noticed in June, only one representing the larger specimens is traced to July in both the gears, while the other disappers completely from the fishery. Though the fishes registered a growth of 50 mm during the period (one month), a difference of 50 mm is still discernible when the peak modes in both the gears are compared. During August, the length distribution in both the gears are similar with a mode at 650 mm. Towards the end of the season, during September-October the fishery is supported by larger specimens (650-1100 mm) and are caught by hooks and line from greater depths (50 m and above). The absence of fishes from boat seine landings towards the fag end of the season may suggest that they disappear from the surface zones as boat seine operations are confined to about 15 m from the surface. Thus, during the onset of fishing season the smaller size groups are equally distributed both in the surface as well as in the deeper areas of Vizhinjam and are caught by boat seines and hooks and line with equal intensity. As the season advances, the larger ones in the surface columns get fished and those in deeper areas, grow to larger size. The size frequency distribution observed during the fag end of the season supports this view. It is also observed that as the fish attains a size of 650 mm it shows a tendency to get confined to greater depths.

T. lepturus at Mangalore waters attains 39.1, 58.7, 70.8 and 82.8 cm at the end of I-IV year of its life (James *et al.*, 1978). Chakraborty (1990) has reported still faster growth rate for this species from Bombay with the estimated lengths at the end of I to V years at 51.2, 82.5, 101.0, 112.3 and 119.2 cm respectively.

The size distribution of *L. savala* and *E. muticus* occurring off Bombay is given in Fig. 6. The range in size group of *L. savala* in dol net is from 15-19 to 115-119 cm and of *E. muticus* from 15-19 to 80-84 cm. No other details are available.

Maturity and spawning : Data collected on the maturity of *T. lepturus* at Vizhinjam during 1986-88 are presented in Table 5. About 73% of the fish examined in June are immature (Stage I). But by July about 79% of the fish caught by boat seine and 84% by hooks and line are in maturing condition (Stage II). Fishes in all maturity stages (except in the spawning) could be observed in August and September. By October, the percentage of mature specimens increased to 44.5. The above findings show that monsoon fishery removes only immature and maturing specimens from the sea off Vizhinjam.

Studies at Mangalore (James *et al.*, 1978) indicate a prolonged spawning for this species in almost all the months of the year. Rao *et al.* (1977) have also reported a similar condition for this species from the west coast. They have observed adults with fully developed and spent gonads during May-July in the catches between 8° to 10°N and juveniles from December to February and from May to August in the northern and central shelf regions. The minimum size at maturity is 43.1 cm for female and 41.2 cm for male. The number of mature ova was found to vary between 1000 and 134,000 (James *et al.*, 1978). It appears that peak spawning of this species takes place during April-May in the northwest coast. However, mature and spent specimens are recorded from February to May and again in October (Bapat *et al.*, 1982).

Food and feeding habits : James *et al.* (1978) observed food items such as mackerel, oilsardine and prawns in the stomach of larger fish and *Stolephorus, Thrissocles* and shrimp (*Acetes*) in the smaller ones. Ribbonfish shoal following the whitebait shoal has been reported by Luther (1981). Similarly ribbonfish within 10-50 m depth is seen generally mixed with those of whitebait (Rao *et al.*, 1977). In general, *T. lepturus* is a voracious carnivore and predominantly piscivorous, occasionally exhibiting cannibalism.

Fishery and environment

Monthly ribbonfish landings at Vizhinjam and rainfall recorded at Trivandrum Air Port during the period February 1984 to January 1988 are given in Table 3 and 4. The maximum monthly average rainfall, 238.4 mm, is recorded in June, the month in which the southwest monsoon starts in this area, the second peak (218.3 mm) is recorded in October and is mainly due to the northeast monsoon; a third peak in August, during the southwest monsoon period (Fig. 4). A comparison of the ribbonfish landings and rainfall shows that

the maximum landing is recorded during July, the month following the peak rainfall. However, the other two peaks in rainfall do not seem to have an influence on the ribbonfish landings of the area.

month of July when the values of these two parameters are at their minimum. The dissolved oxygen content of the surface water is also low during April-October when there is ribbonfish

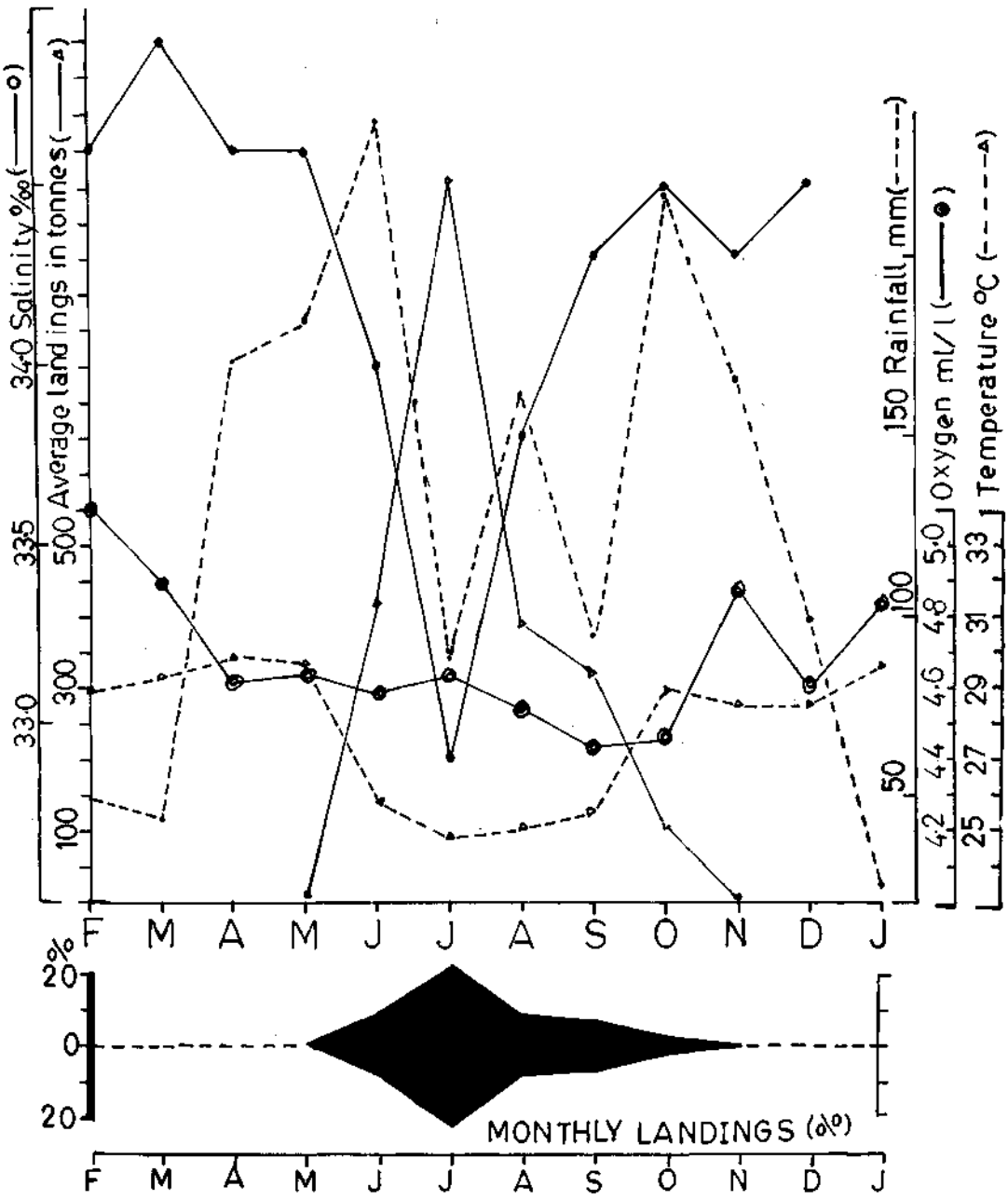

Fig. 4. Monthly average and percentage landings of ribbonfish at Vizhinjam with the environmental parameters recorded simultaneously.

Among the other parameters studied, the surface salinity and temperature seem to have some bearing on the peak landing of ribbonfish at Vizhinjam. The peak landing is observed in the fishery (Fig. 4). The investigation of Rao *et al.* (1977) also shows that the ribbonfishes can thrive in oxygen deficient waters as low as 0.5 ml/1.

Discussion

The contribution of ribbonfish to the local fisheries of Vizhinjam has been reported as 19.4% (712 t) in the fifties by Nayar (1958), 23.5% (592 t) in the sixties by Radhakrishnan (1973), 22.6% (102 t) in the seventies by Luther *et al.* (1982) and 43% (2124 t) during the period 1979-81 by Lazarus and Sarma (MS). Althrough these years the main fishery season was confined only to the monsoon months. According to Rao *et al.* (1977) there is considerable scope for increased exploitation of this resource, because of its rich potential off Kerala Coast. They have even suggested to intensify the fishery during the monsoon months since appreciable standing stock is found during that period. According to them the concentration of ribbonfish shifts northward from 8° to 16°N during November/December and thereafter a southward movement commences by about April/May and a good portion of the biomass is found between 8° and 11°N from July to September when low salinity and temperature due to southwest monsoon prevail in the region.

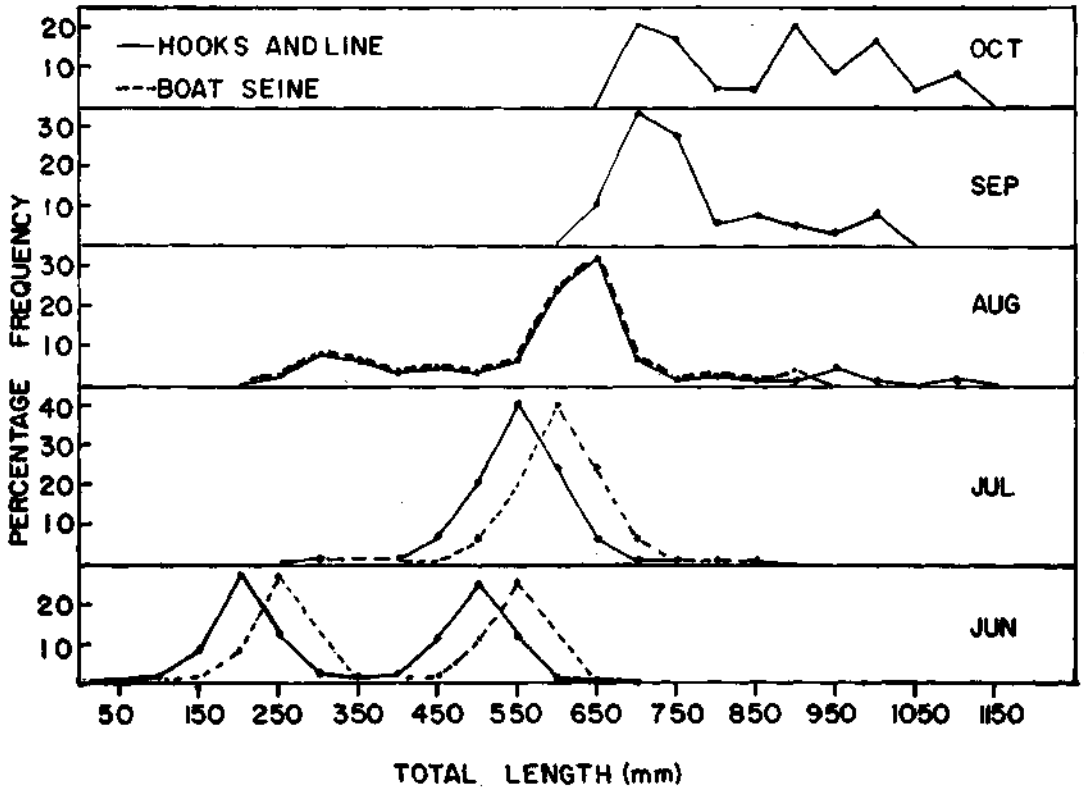

Fig. 5. Length frequency distribution of *Trichiurus lepturus* in the catches by boat seine and hooks and line at Vizhinjam.

Table 3. *Monthly landings (kg) of ribbonfish at Vizhinjam*

Year	Premonsoon				Monsoon				Postmonsoon					% in total
	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Total	fish catch
1984-85	-	-	-	-	199800	584130	11734	1500	4104	60	-	-	801328	14.27
1985-86	-	-	-	1384	611810	1469459	399335	507343	434695	-	-	-	3424026	33.02
1986-87	-	-	-	-	715508	1057945	385624	992310	93741	904	-	-	3246032	31.02
1987-88	-	-	-	-	520105	1366017	1106239	112235	-	-	-	-	3104596	38.88
1988	-	-	-	-	35830	555689	48740	-	-	-	-	-	640259	15.42
Total	-	-	-	1384	2083053	5033240	1951672	1613388	532540	964	-	-	11216241	
Average	-	-	-	276.8	416610.6	1006648.0	390334.4	322677.6	106508.0	192.8	-	-	2243248	26.52

Trichiurus lepturus is the only species that predominates the ribbonfish fishery of the west coast. According to Lazarus and Sarma (MS) the fish spawns off Vizhinjam around May-June. They have also observed the existence of a fishery for the juveniles (4-12 cm size) at vizhinjam during July.

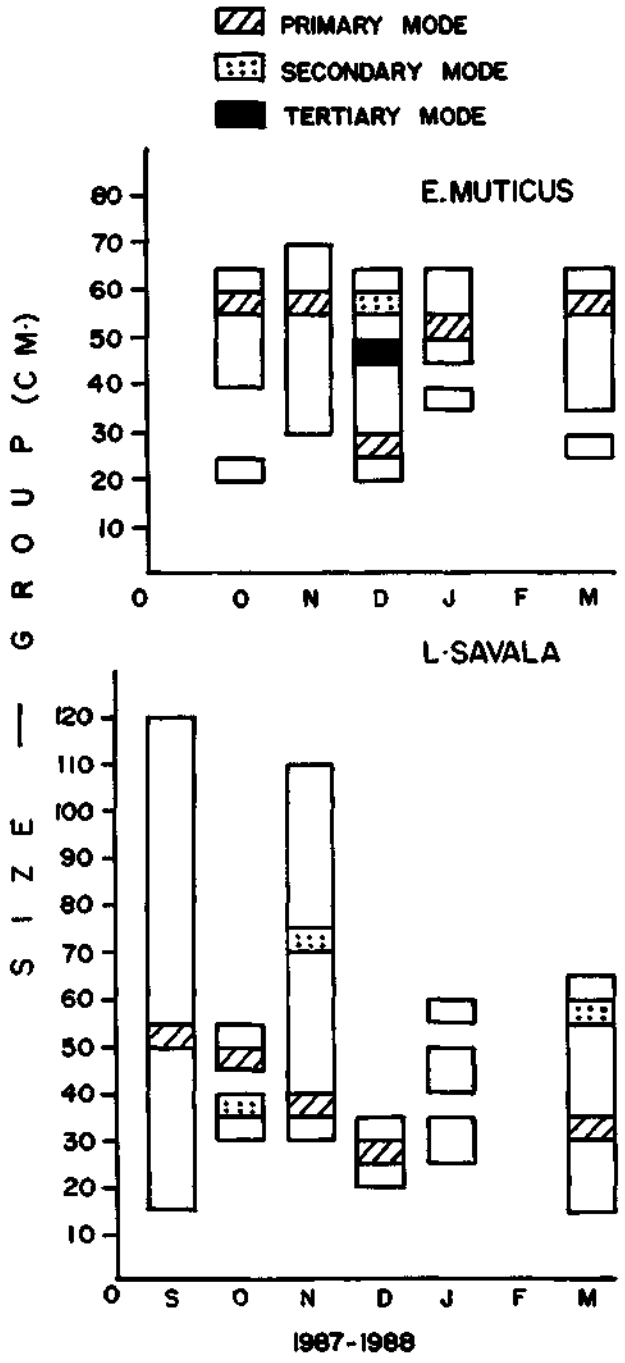

Fig. 6. Size distribution of *Lepturacanthus savala* and *Eupleurogrammus* in the catches off Bombay.

Though this phenomenon is not observed during the present study, such a situation should be viewed seriously and proper regulatory measures have to be adopted to protect this population from exploitation. However, as larger fish are available in deeper waters, especially beyond 50 m depth, it is worthwhile to consider their exploitation for advantage. Further, in consideration of the diurnal habit of ribbonfish, Rao *et al.* (1977) suggested bottom trawling during day and pelagic trawling or purse seining during night.

All States except Kerala along the west coast, have no fishery for this group during the monsoon months. This may not be due to the non-availability of the stock. The acoustic surveys and fishing experiments conducted by the Pelagic Fisheries Project (Rao *et al.*, 1977) in this area have shown that good concentration of ribbonfish occurs from April to September with the maximum intensity between May and July upto 80 m depth. Large concentration of young *T. lepturus* (200-250 mm) is located at 250 m depth along the southern side of Wadge Bank, which may be an important nursery ground for this species.

It was earlier thought that the ribbonfish catches are always obtained from inshore waters and that it is essentially a pelagic resource obtained through gears such as shore seines, boat seines and drift nets. With the recent developments in fishing methods and extension of fishing activities to deeper areas of the sea, the resource is now increasingly being exploited from deeper waters. James *et al.* (1978, 1986 b) have suggested that this resource may be exploited by trawl nets and boat seines from the deeper areas of the southern and northern parts of the west coast.

According to Rao *et al.* (1977) the average standing stock of ribbonfish in the area between the Gulf of Mannar and Ratnagiri is about 4 times higher than the present landings and its catch could be doubled without adversely affecting the stock. The exploratory survey conducted by *M.T. Muraena* has also indicated significant resource of ribbonfish along the northwest coast of India, forming about 28.2% of the catch beyond 55 m (Bapat *et al.*, 1982). The exploitation ratio (E) for *T. lepturus* at Bombay waters is found to be 0.46 (Chakraborty, 1990) which indicates that the stock is not under pressure or threat of depletion.

TABLE 4. *Monthly rainfall (mm) recorded at Trivandrum during 1984-85 — 1987-88*

Month	1984-85	1985-86	1986-87	1987-88	Total	Average	%
Feb.	128.2	40.2	28.8	0.0	197.2	49.3	3.21
Mar.	151.0	13.6	2.1	7.9	174.6	43.7	2.84
Apr.	297.0	87.4	184.5	116.2	685.1	171.3	11.16
May	153.7	223.3	150.9	196.5	724.4	181.1	11.80
Jun.	205.5	424.3	147.7	176.1	953.6	238.4	15.53
Jul.	126.0	82.5	103.0	48.5	360.0	90.0	5.86
Aug.	21.1	61.8	210.0	353.8	646.7	161.7	10.53
Sep.	40.2	96.8	77.5	162.4	376.9	94.2	6.14
Oct.	205.1	162.7	90.4	414.9	873.1	218.3	14.22
Nov.	71.8	170.4	220.4	198.6	661.2	165.3	10.77
Dec.	2.7	39.5	16.6	333.3	392.1	98.0	6.38
Jan.	91.7	2.2	2.1	0.0	96.0	24.0	1.56
Total	1494.0	1404.7	1234.0	2008.2	6140.9	1535.3	100

The reasons for the present lower level of exploitation may be the inaccessibility of the resources to the indigenous non-mechanised craft and gear, and the inability of the small mechanised craft to go out and trawl in the deeper waters. Operation of bottom trawls during day and pelagic trawls during night and also purse seining as suggested by Rao *et al.* (1977) seem to be an effective alternative to enhance the production. And for this, only larger vessels are suitable. However, as this is not an exclusive resource, appropriate exploitation measures may have to be considered in cognizance of other resources available in the ground as well.

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The authors wish to express their sincere thanks to Dr. P. S. B. R. James, Director, CMFRI, Cochin for the suggestions and encouragement and to Dr. P. A. Thomas for critically going through the manuscript. The environmental data received from Mrs. Rani Mary George, the rainfall data received from Meteorological Centre, Trivandrum and the technical assistance received from Miss. T. A. Omana are gratefully acknowledged.

TABLE 5. *Maturity distribution (%) of* Trichiurus lepturus *at Vizhinjam*

Stages of	Boat seine					Hooks & line (Mechanised)					Boat seine and hooks and line combined				
Maturity	June	July	Aug.	Sep.	Oct.	June	July	Aug.	Sep.	Oct.	June	July	Aug.	Sep.	Oct.
I	73.2	10.7	8.8	-	-	-	-	16.7	22.2	11.2	73.2	9.1	11.5	22.2	11.1
II	26.1	79.0	59.6	-	-	-	83.8	36.7	27.8	22.2	26.1	79.8	51.7	27.8	22.2
III	0.7	7.3	19.3	-	-	-	8.1	23.3	22.2	44.4	0.7	7.4	20.7	22.2	44.5
IV	-	3.0	-	-	-	-	8.1	13.3	22.2	22.2	-	3.7	4.6	22.2	22.2
V	-	-	-	-	-	-	-	3.3	5.6	-	-	-	1.2	5.6	-
VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VII a	-	-	12.3	-	-	-	-	6.7	-	-	-	-	10.3	-	-
VII b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

References

Bapat, S. V., V. M. Deshmukh, B. Krishnamoorthi, C. Muthiah, P. V. Kagwade, C. P. Ramamirtham, K. J. Mathew, S. Krishna Pillai and C. Mukundan 1982. Fishery Resources of the Exclusive Economic Zone of the North west coast of India. *Bull. Cent. Mar. Fish. Res. Inst.*, **33** : 1-81.

Chakraborty, S. K. 1990. Fishery, age, growth and mortality estimates of *Trichiurus lepturus* Linnaeus from Bombay waters. *Indian J. Fish.*, **37** (1) : 1-7.

James, P. S. B. R., T. R. Chandrasekhara Gupta and S. L. Shanbhogue 1978. some aspects of the biology of ribbonfish *Trichiurus lepturus* Linnaeus. *J. mar. biol. Ass. India*, **20** (1 & 2) : 120-137.

——, K. A. Narasimham, P. T. Meenakshisundaram and Y. Appanna Sastry 1986 a. Present status of ribbonfish fishery in India. *CMFRI Spl. Publ.*, **24** : 1-49.

——, K. Alagarswami, K. V. Narayana Rao, M. S. Muthu, M. S. Rajagopalan, K. Alagaraja and C. Mukundan 1986 b. Potential marine fishery resources of India. *Ibid.*, **30** : 44-74.

Lazarus, S. and P. S. S. Sarma 1991. The resources characteristics of the ribbonfish *Trichiurus lepturus* Linnaeus at Vizhinjam, southwest coast of India. *J. mar. biol. Ass. India*, **33** (1 & 2) : 89-98.

Luther, G. 1981. Anchovy fishery of the southwest coast of India with notes on characteristics of the resources. *Indian J. Fish.*, **26** (1 & 2) : 23-29.

——, P. N. Radhakrishnan Nair, G. Gopakumar and K. Prabhakaran Nair 1982. The present status of small scale traditional fishery at Vizhinjam. *Mar. Fish. Infor. Serv. T & E Ser.*, **38** : 1-17.

Nayar, S. G. 1958. A preliminary account of the fisheries of Vizhinjam. *Indian J. Fish.*, **5** (1) : 32-35.

Radhakrishnan, N. 1973. Pelagic fisheries of Vizhinjam. *Ibid.*, **20** (2) : 584-598.

Rao, K. V. N., M. Kumaran and J. Sankarasubramanian 1977. Resources of ribbonfish and catfish off the southwest coast of India. *Sea food Export Journal*, **9** (1) : 9-25.

Bull. Cent. Mar. Fish. Res. Inst., 1992, **45** : 133 - 153

4.7

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : CATFISHES

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ABSTRACT

The availability, abundance and yield of catfishes are very much influenced by the monsoon along the west coast of India. More than 55% of the annual total catfish production from the west coast (1984-'88) is realised during postmonsoon period and 35.6% in premonsoon and 9.2% in monsoon. The gearwise and seasonwise catfish production, abundance and species composition in different States and at selected fishing centres on the west coast are presented. Catfish resource has high abundance during monsoon at Veraval, Bombay, Calicut and Cochin. Although the yield is low during the monsoon period, it is proportionate to the effort put in at all the centres. All along the west coast, *Tachysurus dussumieri* (32.4%) is the most dominant species in the fishery of premonsoon period and *T. thalassinus* (42.4%) in that of monsoon. The percentage contribution of *T. tenuispinis* and *T. dussumieri* during postmonsoon is about 28.

The size frequency and spawning of the dominant species in various fishing centres during the three seasons are discussed. The spawning season of all the species is found to be during the end of monsoon or in the beginning of postmonsoon. An attempt is made to correlate the seasonal resource abundance with rainfall and the results show a positive correlation at Calicut and Cochin.

INTRODUCTION

The catfish production from the coastal waters of India is about 59,000 tonnes mostly realised from 0-50 m depth belt, whereas the estimated potential is 123,000 t. Acoustic surveys and fishing experiments of the Pelagic Fisheries Project along the west coast have revealed abundant catfish stocks on the western shelf during peak upwelling season of southwest monsoon (Rao *et al.*, 1977). Fishery Survey of India's surveys (Philip, 1986) in 11° - 15°N along the west coast have also indicated catfish concentration in depth belts of 20 - 50 m (25%) and 50-100 m (21%).

The fishing surveys conducted by FORV *Sagar Sampada* also located catfish concentration pockets during monsoon (June) in bathymetric belt 40-70 m off Kerala (James and Pillai, 1990). Southwest monsoon directly influences the coastal catfish resource abundance and their migration.

Although the potential available along the west coast (Rao *et al.*, 1977) gives scope for the future possibilities for its exploitation, indiscriminate fishing on brooder/spawning population of catfishes by more efficient purse seines from Karnataka waters (Silas *et al.*, 1980; Dhulkhed *et al.*, 1982; Muthiah and Syda Rao, 1985) has necessitated to search for ways and means for a rational management of the resource. Thus, the relevance of the present study centres round not only on the mere exploitation, but also conservation of affected species.

In this account, informations such as Statewise, centrewise, gearwise catfish production during premonsoon, monsoon and postmonsoon seasons, abundance of commercially important species and their biology are incorporated. An attempt is made to interpret the possible relation between rate of production of total catch and various species with the seasonal rainfall.

DATA BASE

Gearwise catfish catch and effort data for various States along the west coast were categorised into premonsoon, monsoon and postmonsoon. These data were taken from the NMLRDC of CMFRI. Centrewise, gearwise and specieswise seasonal catch, effort data and biology of important species were collected from major fishing centres at Veraval, Bombay, Mangalore, Calicut and Cochin for 1984-1988 period. Seasonal rainfall data were obtained from Indian Meteorological Department.

Observations

General fishery characteristics in different States

Along the west coast catfishes are generally caught by non-mechanised gears such as drift net, hooks and line, boat seine, dol net and mechanised gears like trawl net, purse seine and drift net or gill net. In addition to these, plank-built canoe and catamaran with IBM and OBM also operate gears such as drift net and hooks and line for catfish fishery. In general, catfishes are caught as a by-catch in trawlers; whereas they form a major component in drift net. Purse seiners exploit catfishes, whenever they form breeding shoals and move towards the shore or migrate parallel to the coast along surface drifts. On the other hand hooks and line (longline) fishing yields mostly catfishes and often accounts for the major share (28%) of the total line catch.

In Gujarat, catfishes were landed by trawlnet (40.9% of the total catfish catch), gill net (46.1%) and dol net, hooks and line and other non-mechanised gears (13%). Average production during 1984-1988 was 4,656 t in premonsoon, 447 t in monsoon and 3,502 t in postmonsoon with seasonal percentage of 54.1, 5.2 and 40.7 respectively (Table 1). In trawl net, premonsoon (45.6%) and postmonsoon (39.5%) yielded the bulk of the catch; whereas in gill net, the corresponding percentages were 45.3 and 44.0. About 73.8% of the total catch of monsoon was realised by gill net. In this State, premonsoon production ranged from 3,586 t (1987) to 6,408 t (1986), monsoon yield varied from 293 t (1987) to 596 t (1984) and postmonsoon landings from 2,627 (1980) to 4,402 t (1986).

Table 1. *Seasonal catfish production (t) in Gujarat during 1984-1988 and the average gearwise contribution*

Year	Premonsoon	Monsoon	Postmonsoon	Total
1984	4349	596	3334	8279
1985	4198	353	4367	8918
1986	6408	518	4402	11328
1987	3586	293	2772	6650
1988	3439	476	2637	7852
Average	4656 (54.1%)	447 (5.2%)	3502 (40.7%)	8605
Trawl net	2123.2 (45.6%)	14.0 (3.1%)	1382.6 (39.5%)	
Drift net	2106.8 (45.3%)	330.4 (73.8%)	1539.4 (44.0%)	
Others	426.0 (9.1%)	102.6 (23.1%)	580.0 (16.5%)	

Catfishes were mainly caught in trawl net, gill net and hooks and line along Maharashtra. During 1984-1988 period, the all gear total catch ranged from 11,469 t (1986) to 17,922 t (1988) with a mean of 13,188 t. Almost 80% of the catfish catch was realised from Greater Bombay and Ratnagiri. Postmonsoon season yielded peak landings of 50.8% of the total. In this season the production fluctuated from 5,613 t (1984) to 7,474 t (1985) with an average of 6,701 t. Premonsoon was the next dominant season for catfish with a mean catch of 5,912 t forming 44.8% of the total landing. The premonsoon catch varied from 3,870 (1985) to 10,629 t (1988). Monsoon season was the least productive as there was limited operation by mechanised units. Catfish production during monsoon (mainly by gill nets and hooks and line) accounted for about 4.4% of the annual total catch. The catch in this season showed no wide fluctuation and it ranged from 456 t (1984) with a mean of 575 t (Table 2).

Table 2. *Seasonal catfish production (t) in Maharashtra during 1984-88*

Year	Premonsoon	Monsoon	Postmonsoon	Total
1984	5448	456	5613	11517
1985	3870	655	7474	11999
1986	3966	697	6809	11469
1987	5645	583	6805	13033
1988	10629	488	6805	17022
Average	5912 (44.8%)	575 (4.4%)	6701 (50.5%)	13188

Catfishes were exploited mainly by purse seine (63.7% of total yield), trawl net (25.3%) and drift net (5.3%) along Karnataka. The average landing during 1985-88 was estimated to be 5,421 t with seasonal values of 1,009 t (18.6%), 16.3 t (0.4%) and 4,395.5 t (81.0%) during premonsoon, monsoon and postmonsoon respectively. During the four years the all gear premonsoon catfish catch fluctuated from 302 t (1987) to 1,675 t (1988), in monsoon the landing varied from 7 t (1985) to 26 t (1988); whereas in postmonsoon the yield ranged from 1,108 t (1985) to 7,310 t (1986). Purse seine was the chief gear used to exploit catfishes from waters of Karnataka. More than 92% of annual catfish catch was landed during premonsoon (39.7%) and postmonsoon (59.8). Similarly, drift net caught 85.5% of the catfishes in postmonsoon and the remaining in premonsoon (Table 3).

TABLE 3. *Seasonal catfish production (t) in Karnataka during 1985-88 and the average gearwise contribution*

Year	Premonsoon	Monsoon	Postmonsoon	Total
1985	318	7	1108	1433
1986	1475	17	7310	3802
1987	302	15	2095	2412
1988	1671	26	7069	8766
Average	1009 (18.6%)	16.3 (0.4%)	4395.5(81.0%)	5421
Purse seine	265.5 (26.6%)	-	3184.5(72.4%)	
Trawl net	544.0 (53.9%)	7 (42.9%)	818.5(18.6%)	
Drift net	41.3 (4.1%)		248.8(5.7%)	
Others	155.2 (15.4%)	9.3 (57.1%)	143.7(2.3%)	

TABLE 4. *Seasonal catfish production (t) in Kerala during 1984-88 and the average gearwise contribution*

Year	Premonsoon	Monsoon	Postmonsoon	Total
1984	2632	3046	4917	10595
1985	882	1233	3087	5202
1986	320	983	7277	8580
1987	162	2070	2359	4591
1988	362	3609	6017	9988
Average	871.6 (11.2%)	2188.2 (28.1%)	4731.4 (60.7%)	7791
Trawl net	258.0 (29.6%)	1483.6 (67.8%)	360.6 (7.6%)	
Gill net	190.2 (21.8%)	263.4 (12.5%)	994.4 (21.0%)	
Purse seine	50.6 (5.8%)	-	76.4 (1.6%)	
Hooks & Line	1.4 (0.2%)	-	745.4 (15.8%)	
Others	371.4 (42.6%)	431.2 (19.7%)	2554.6 (54.0%)	

Along the Kerala Coast, the exploitation of catfishes was carried out by mechanised gears such as trawl net, drift net, hooks and line and purse seine and by a wide variety of non-mechanised gears such as boat seine, gill net, handline, cast net, etc. The mechanised sector landed 56.5% of the total yield. During 1984-'88 period the annual average trawlnet yield was 27% of the all gear total catch followed by drift net (18.3%), hooks and line (9.6%) and purse seine (1.6%). Peak landing was in postmonsoon (60.7%) and monsoon and premonsoon contributed 28.1% and 11.2% respectively in the annual total production. More than 70% of the total trawl net catch of catfishes was realised in monsoon; whereas both in drift net and purse seine, the major landings are during postmonsoon with corresponding percentages of 69.9 and 60.2. There was no monsoon fishery for purse seiners, while drift net landed catfishes in monsoon (16.7%) and premonsoon (13.4%). More than 99% of the hooks and line landings took place in postmonsoon (Table 4).

Seasonal gearwise effort, catch and catch rate at different centres

Veraval : Catfishes were caught in trawl net and gill net with an annual average (1984-86) catch of 512.7 t and 278.4 t respectively; forming 0.84% of total trawl catch and 6.4% of total gill net landings. During premonsoon the average catfish catch by trawl net was 246.8 t (0.7% of total trawl catch) for an effort input of 21,774 units. In postmonsoon the average yield was 265,9 t (24,865 units effort) forming 1.1% of total trawl production. In monsoon season there was no trawling in the Veraval area. Both premonsoon and postmonsoon showed similar trend of catfish landings as well as rates of production (11.3 kg/unit in premonsoon and 10.7 kg/unit in postmonsoon).

The gill net catch also showed similar magnitudes of production in premonsoon and postmonsoon with averages of 128.5 t and 109.8 t respectively. Whereas, the monsoon period yielded only 40.1 t. In the total fish production of gill nets, catfishes formed 7.7% in premonsoon, 6.7% in monsoon and 5.3% in postmonsoon (Table 5). Though the yield was low in monsoon season, the catch rate was the highest (10.97 kg/unit) compared to premonsoon (10.04 kg/unit) and postmonsoon (8.09 kg/unit).

Monthly average production (trawl and gill net) trend showed the lowest (8.4 t) in July and the highest (130.6 t) in April with corresponding catch rates of 8.6 and 12.3 kg/unit. The highest rate of yield of 27.4 kg/unit effort was recorded in June. Catfish resource had high abundance in this area during November-April and June. Although the production in monsoon season was only 5.1% of annual total, the abundance during this season was estimated to be 29.1% of the annual total. This is indicative of the future possibilities to increase fishing pressure during monsoon.

Bombay : Catfish was landed by trawlers at Bombay with an annual average production of 3,535.8 t and accounted for 4.5% of the total fish catch by trawlers. Seasonal effort, catch and catch rate of catfishes at Bombay by trawlers are given in

TABLE 5. *Gearwise seasonal catfish catch, catch rate and total catch during 1984-86 at Veraval*

Season	Year	Trawl net		Drift net		Total
		C (t)	C/E (kg)	C (t)	C/E (kg)	C (t)
Premonsoon	1984	300.7	14.1	52.1	3.8	352.8
	1985	152.1	7.8	138.6	10.8	290.7
	1986	287.5	11.8	194.8	16.4	482.3
	Average	246.8	11.3	128.5	10.0	375.3
Monsoon	1984			3.8	9.0	3.8
	1985		No data	31.7	7.2	31.7
	1986			84.9	13.8	84.1
	Average			40.1	11.0	40.1
Postmonsoon	1984	213.3	8.5	152.8	9.4	366.1
	1985	357.3	15.9	79.6	6.9	436.9
	1986	227.1	8.4	96.8	7.5	323.9
	Average	265.9	10.7	109.8	8.1	375.7

Table 6. During premonsoon season the catch ranged from 764.1 t (1985) to 1,660.6 t (1986) with catch rates of 51 kg and 96.7 kg/unit effort respectively.The mean catch of premonsoon period was 1,345.5 t at a production rate of 81.9 kg/unit effort, when the resource accounted for 5.5% of the total fish yield of trawlers. In monsoon season, the production varied from 280.2 t (1985) to 438.3 t (1986) with catch rate of 50.2 and 67.3 kg/unit effort respectively. The average monsoon production was only 342.1 t (CPUE of 52.8 kg) and catfishes formed 3.6% of the total fish landed by trawlers. Peak landings were recorded during postmonsoon season with a mean yield of 1,848.2 t at a catch rate of 75.1 kg/unit effort and this group accounted for 3.9% of the total landings of trawlers. During 1984-88 period the postmonsoon landings varied from 1,270.7 t (1984) to 2,574 t (1988) with corresponding catch rates of 53.6 and 92.7 kg/unit effort. At Bombay, both production and abundance showed high values during premonsoon and postmonsoon seasons. More than 90% of total yield was realised during these seasons by exploiting 75% of the resource abundance, excerting 86% of the total fishing pressure.

Mangalore : Catfishes were harvested by purse seine, trawl net and drift net at Mangalore. They occurred in large quantities, during seasons of shoal movements, as incidental catch by purse seiners in

TABLE 6. *Seasonal trawl net catfish catch and catch rate at Bombay during 1984-88*

Season	Year	Catch (t)	C/E (kg)
Premonsoon	1984	1537.6	106.6
	1985	764.1	51.0
	1986	1660.6	96.7
	1987	1522.2	82.7
	1988	1243.2	72.3
	Average	1345.5	81.9
Monsoon	1984	287.4	45.3
	1985	280.2	50.2
	1986	438.3	67.3
	1987	281.9	47.1
	1988	422.5	53.1
	Average	342.1	52.8
Postmonsoon	1984	1270.7	53.6
	1985	1407.8	63.9
	1986	1808.5	76.8
	1987	2179.9	83.8
	1988	2574.1	92.7
	Average	1848.2	75.1

the area from Kaup to Kasaragod. As the Government of Karnataka had suspended mechanised fishing during June-August, there was no monsoon fishery by trawl net, purse seine and drift net. Therefore, the effort, catch and catch rate of catfishes at Mangalore during premonsoon and postmonsoon seasons alone are given in Table 7. In premonsoon season the catfish landing by purse seine ranged from nil catch in 1984-85 to 1,158.9 t in 1986-87. Catfishes accounted for 12.0% of the total fish catch by purse seines in premonsoon. The entire catch for this season was realised in February (79%) and March (21%). The catch rates were 71.1 kg/unit effort in 1985-'86 and 338.5 kg/unit effort in 1986-87 with a mean of 118 kg/unit effort. Peak catch rate of 642.9 kg was recorded in February, 1986. The trawler landings of catfishes fluctuated from 4.0 t in 1987-'88 to 215.5 t in 1984-85 with an average of 88 t in the premonsoon. Catfishes formed only about 1% of the total trawl catch and the catch rate ranged from 0.14 kg(1987-'88) to 9.2 kg/unit effort (1984-'85) with a mean of 3.3 kg/unit effort. About 81% of the trawler catfish catches of this season were landed in February and March. In premonsoon drift net landings varied from 0.3 t (1987-'88) to 7.3 t (1984- '85) with catch rates of 0.21 kg and 10.2 kg/unit effort respectively. The mean rate of production was 3.3 kg/unit effort. Catfishes accounted for 7.1% of the all fish total drift net landings during this season. Again, February and March produced 95% of the season's total catfish catch by this gear.

The catfish catch of purse seine fluctuated from 87.6 t (1984-'85) to 277.7 t (1987-'88) with a mean of 781.0 t during the postmonsoon season. The catch rate varied from 9.6 kg in 1984-'85 to 186.2 kg/unit effort in 1986-87 and the seasonal average was 81.4 kg/unit effort. In the total catfish production, the postmonsoon season landed 71.3% and the resource formed only 2.8% of the total fish catch by purse seine. The average catfish production of the season by trawl net was 83.8 t accounting for 48.9% of the annual total catfish landing. The postmonsoon production by this gear fluctuated from 7.8 t (1986-87) to 271.8 t (1984-'85) with corresponding catch rates of 0.5 and 10.4 kg/unit effort and the average was 4.3 kg/unit effort. In the total fish catch of trawlers, catfishes formed only 1.4% during postmonsoon season. In this season the drift gill netters caught an average of 17.5 t of catfishes and the yield varied from 11.6 t (1984-85) to 20.9 t (1987-88). The catch rate was 2.9 kg in 1984-85 and 7.0 kg in 1985-86 with a seasonal mean of 4.9 kg/unit effort. This resource accounted for 6% of the total fish yield by the gear. In the annual total gill net production of catfishes, the postmonsoon contributed 87%. The all gear catch was the highest during postmonsoon (66.8%) followed by premonsoon (31.4%). Similarly the rate of yield was 66.8% in postmonsoon and 33.2% in premonsoon at Mangalore.

Calicut : At Calicut catfishes were harvested mainly by hooks and line (67.0%), drift net (22.7%)

TABLE 7. *Seasonal, gearwise catfish catch, catch rate and all gear total catch at Mangalore during 1984-88*

Season	Year	Purse seine		Trawl net		Gill net	
		C (t)	C/E (kg)	C (t)	C/E (kg)	C (t)	C/E (kg)
Premonsoon	1984-85	-	-	215.5	9.2	7.3	10.2
	1985-86	98.0	71.1	38.1	4.4	0.5	1.5
	1986-87	1158.9	338.5	93.0	0.3	2.4	3.3
	1987-88	-	-	4.0	0.1	0.3	0.2
	Average	314.2	102.2	87.7	3.3	2.6	3.25
Monsoon	1984-88		No fishing				
Postmonsoon	1984-85	87.6	9.6	271.8	10.4	11.6	2.9
	1985-86	1045.4	91.6	22.1	1.4	16.7	7.0
	1986-87	1713.5	186.2	7.8	0.5	20.7	6.0
	1987-88	277.7	32.2	22.5	1.6	20.9	4.8
	Average	781.1	81.4	83.8	4.3	17.5	5.0

and trawl net (19.3). However, occasional bulk landings were also recorded by *Pattenkolli vala* during seasons of catfish shoal movements in the coastal surface waters. Gearwise, seasonal average (1979-85) catfish catch, effort and catch rate at Calicut is given in Table 8. Average monthly gearwise catch and catch per effort of catfishes are shown in Fig. 1.

During postmonsoon trawlers landed an average catch of 35.2 t with a catch rate of 9.4 kg/unit effort by expending 58.5% of the total annual trawler efforts. In this season, hooks and lines produced 83.0 t at a catch rate of 134.6 kg/unit effort, with an effort input of 38.9% of the total. The average production by drift net in this season was only 14.2 t with a production rate of 12.6 kg/unit effort. This catch was realised by a fishing pressure of 30.2% of the total annual drift net efforts.

In monsoon the trawler operation was almost negligible (about 1% of the total annual effort) and proportionately the catfish catch was also poor. The average hooks and line landing of this season was 18.5 t, but the catch rate was 121.8 kg/unit effort. This low production of less than 6% of the total annual landings was mainly due to less effort inputs in this season (8.3% of total annual efforts). Similarly, the drift net yield was only 8.5 t with a catch rate of 34.0 kg/unit effort. The low production (7.9% of annual total) was again due to poor fishing pressure (6.6%) in monsoon.

During postmonsoon season, the average trawl production was 13.1 t, accounting for 27.1% of the annual catch. The catch rate was 5.1 kg/unit effort realised by a fishing pressure of 40.6% of the annual total effort. This season yielded the highest catch in hooks and line (215.0 t) forming 67.9% of

TABLE 8. *Seasonal, gearwise catfish catch (t) and all gear total landing (t) and catch per effort (kg) at Calicut during 1979-85*

Season	Year	Trawl net	Drift net	Hooks & line	All gear combined	Total
Premonsoon	1979	92.1	39.6	94.1	225.8	35.6
	1980	100.9	7.6	130.2	246.7	35.1
	1981	5.3	9.4	102.5	117.2	28.8
	1982	2.6	9.5	42.3	54.4	11.1
	1983	43.8	14.4	63.7	121.9	22.5
	1984	-	5.7	73.5	79.2	48.0
	1985	-	13.1	66.7	79.8	35.0
	Average	34.9	14.2	83.0	130.3	29.0
Monsoon	1979	9.9	29.9	27.8	37.7	62.2
	1980		14.4	15.7	30.1	99.9
	1981		5.7	18.5	14.2	21.9
	1982		7.4	46.4	53.8	56.5
	1983		2.1	1.6	3.7	8.4
	1984		8.8	11.0	19.8	60.3
	1985		11.1	18.4	29.5	94.8
	Average		8.5	18	26.1	46.9
Postmonsoon	1979	25.9	119.0	218.4	363.3	80.1
	1980	72.0	195.4	324.8	592.8	72.4
	1981	6.0	96.2	238.7	340.9	67.6
	1982	1.7	45.9	123.8	171.4	51.2
	1983	3.3	31.3	260.2	296.8	79.6
	1984	-	39.2	176.5	215.7	73.8
	1985		80.9	120.6	201.5	56.5
	Average	15.5	86.8	209.0	316.8	52.60

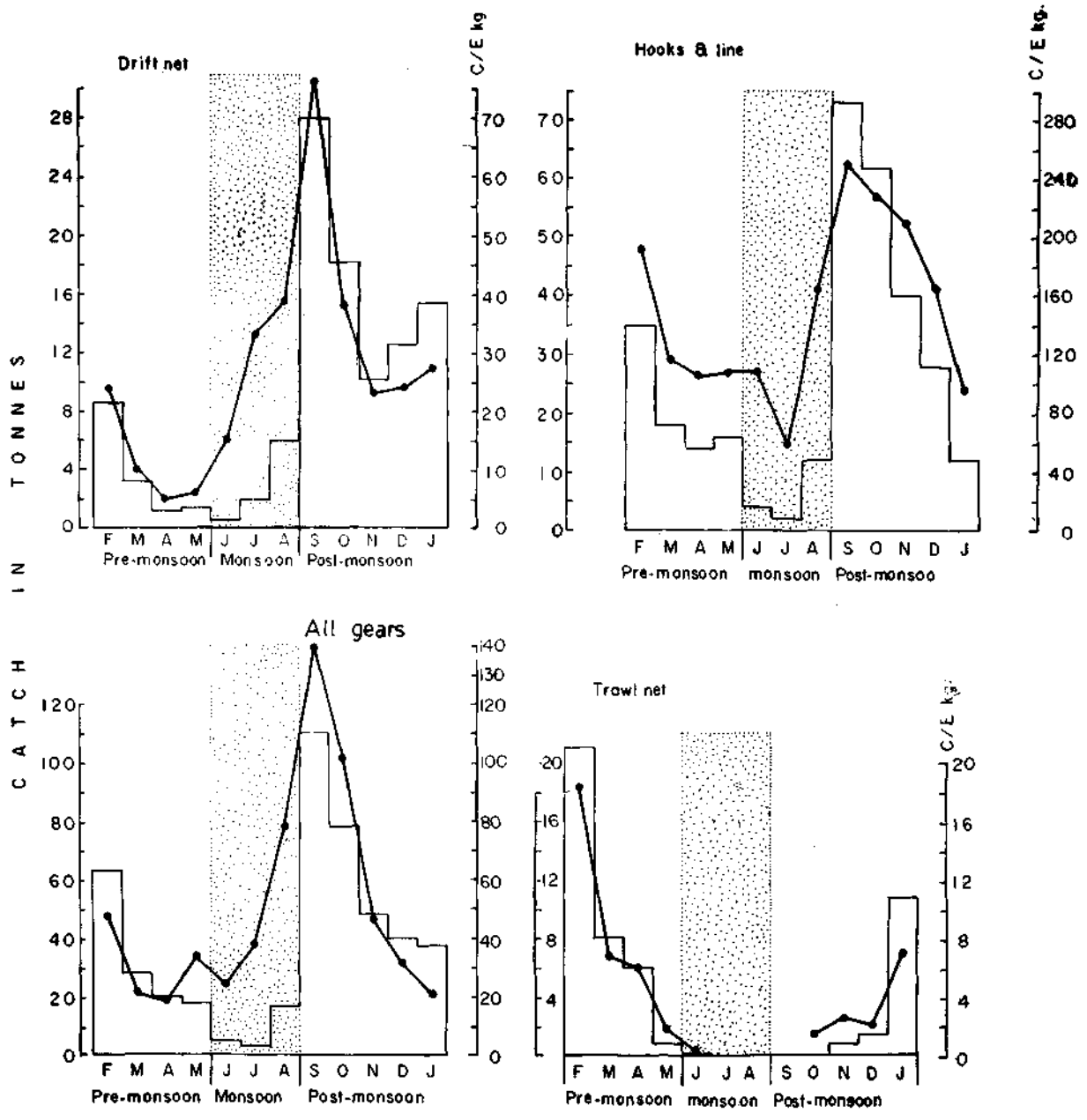

Fig. 1. Total and gearwise seasonal average catch and catch rate of catfishes at Calicut.

the annual production. The production rate was also highest, 204.2 kg/unit effort, in postmonsoon. The drift net landed 84.7 t at a catch rate of 35.7 kg/unit efforts and the production accounted for about 79% of the annual yield by the gear. All-gear total landings of catfishes showed peak yield in post-monsoon (67%) followed by premonsoon (27.5%) and the production rate was 52.6 kg and 29.0 kg/unit effort respectively. Although monsoon catch was only 5.5% of the annual total, the rate of production (46.9 kg/unit effort) was 36.5% of the total.

Cochin : Catfish resource was exploited by trawl net (59.9%), drift net (40.0%) and purse seines (0.1%) at Cochin with an annual average production of 816.5 t. Gearwise, seasonal average (1984-88) catch and catch rates are given in Table 9.

In premonsoon season the trawlers landed, on an average 47.5 t, accounting for 9.7% of the

annual production by the gear. The catch rate showed an average value of 2.6 kg/unit effort. The average drift net landing in this season was 2.8 t forming only 0.9% of the annual production and the production rate was only 0.65 kg/unit effort; whereas the purse seine produced only 0.4 t (94% of the total annual yield by the gear).

seine also landed negligible quantities of catfishes during postmonoon.

All gear combined production trends showed peak landing in monsoon (585.8 t) forming 71.7% of the total annual catch and the catch rate also attained the highest value (30.5 kg/unit effort) in

TABLE 9. *Seasonal, gearwise catfish catch (t) and catch rate (kg) of catfishes at Cochin during 1984-88*

Season	Year	Trawl net		Drift net		Purse seine		Total catch
Premonsoon	1984	237.5	12.4	8.2	2.0	-	-	245.6
	1985			5.6	1.0			6.6
	1986			0.2	0.04			0.2
	1987					2.0		2.0
Average		47.5	2.6	2.8	0.7	0.4		50.7
Monsoon	1984	299.0	21.9	181.1	25.8			480.1
	1985	301.4	59.5	195.7	27.8			497.2
	1986	307.8	20.7	263.7	38.5			571.5
	1987	538.2	29.8	106.9	15.3			695.1
	1988	728.8	80.1	6.5	0.9			735.3
Average		435.0	35.8	150.8	21.2			585.8
Postmonsoon	1984			152.5	17.1	0.1		152.6
	1985			142.4	20.9			142.4
	1986			355.0	13.2			355.0
	1987			43.5	9.3			70.1
	1988							
Average				173.3	24.2			150.0

During monsoon the production by drift net varied from 6.5 t (1988) to 263.7 t (1986) with a mean of 150.8 t, forming 46.1% of the annual total. The catch rate also correspondingly ranged from 0.9 kg (1988) to 38.5 kg (1986) with an average of 21.3 kg/unit effort. More than 50% of the all gear annual total catfish catch was realised by trawl net during monsoon (435.0 t), accounting for about 89% of the annual yield by the gear. The yield ranged from 279.0 t (1984) to 728.8 t (1988) with a progressive increasing trend at a mean catch rate of 35.8 kg/unit effort. The purse seine operation was banned during monsoon at Cochin.

Higher yields were realised during postmonsoon by drift nets. The seasonal production fluctuated from 43.5 t (1987) to 335.0 t (1986) with an average of 173.3 t at a catch rate of 24.2 kg/unit effort. In this season the trawlers landed 6.7 t at a catch rate of 0.6 kg/unit effort. Similarly the purse

this season. The postmonsoon was the next dominant season for catfishes with a production of 180.0 t (22.1%) at a CPUE of 10.1 kg/unit effort; whereas the premonsoon caught only 50.7 t (6.2%) with a rate of only 2.2 kg/unit effort. The average monthly CPUE at Cochin showed better abundance during June (53.6 kg/unit) to October (20.9 kg/unit effort). Catfish yield (71.7%) and abundance (71.3%) were the highest in monsoon and achieved by expending only 32.3% of the annual total effort input.

Gearwise, seasonal species composition at different centres

About 8 species of catfishes occurred in the commercial fisheries of the west coast all through the seasons. The estimated, all gear combined seasonal species composition in the west coast, based on data from representative centres, revealed

that in premonsoon, *Tachysurus dussumieri* was the most dominant species (32.4%), followed by *T. tenuispinis* (20.5%), *Osteogeneious militaris* (17.2%), *T. thalassinus* (14.8%), *T. serratus* (9.6%), *T. caelatus* (3.2%), *T. jella* (1.3%) and *T. sona* (1.2%), whereas in monsoon season, *T. thalassinus* formed the bulk of landings (42.4%) closely followed by *T. tenuispinis* (39.2%) and *T. dussumieri* (19.8%). The less abundant species caught in this season were *T. caelatus* (3.7%), *T. serratus* (1.6%), *O. militaris* (1.5%), *T. sona* (0.5%) and *T. jella* (0.3%). During postmonsoon, *T. tenuispinis* and *T. dussumieri* accounted for 28.3% and 28.2% respectively in the total catfish catch of the season, the other species were *T. thalassinus* (18.8%), *O. militaris* (9.5%) *T. caelatus* (4.6%), *T. serratus* (4.3%), *T. sona* (3.9%) and *T. jella* (2.4%).

Only 4 species such as *T. dussumieri, T. tenuispinis, T. thalassinus* and *T. serratus* were recorded from the coast of Kerala, Karnataka and Goa; whereas in Maharashtra and Gujarat 4 more species like *O. militaris, T. caelatus, T. sona* and *T. jella* contributed substantially to the catfish production.

In Gujarat, *T. dussumieri* was the most abundant species throughout the seasons. The next important species were *T. thalassinus* and *O. militaris* (pre and postmonsoon). *T. tenuispinis* (throughout the season) and *T. caelatus* (monsoon). The catfish landings of Maharashtra showed high catches of *T. dussumieri* throughout the seasons, followed by *O. militaris, T. thalassinus* and *T. tenuispinis*. *T. caelatus* was more abundant during monsoon and *T. sona* in postmonsoon. In Karnataka, *T. dussumieri* was accounted for peak production during premonsoon; whereas *T. tenuispinis* was the chief item in postmonsoon. *T. serratus* was common in premonsoon season, while *T. thalassinus* in postmonsoon. Along Kerala during the premonsoon period *T. tenuispinis* formed 48.5% of the total yield of the season, followed very closely by *T. dussumieri* (42.9%). On the contrary, in monsoon season *T. thalassinus* (48.5%) was the most common species followed by *T. tenuispinis* (44.3%). Almost a similar condition was found in postmonsoon, with major catch by *T. tenuispinis* (37.6%) and *T. thalassinus* (36.0%). *T. serratus* appeared in fair quantities during postmonsoon.

Veraval : In premonsoon season, the trawlers landed *T. dussumieri, T. thalassinus, O. militaris, T. tenuispinis* and *T. caelatus* in the decreasing order of production; whereas the postmonsoon contributed *T. tenuispinis, T. thalassinus, T. dussumieri* and *O. militaris* in 30.3, 25.7, 17.0 and 15.1% respectively in the total yield of the season. Gill net catch gave a different picture, in that *T. dussumieri* was the most dominant component during all seasons, with a percentage range of 53.6 - 74.6. The other important species was *T. tenuispinis*, but with better yield in premonsoon and monsoon seasons. *T. caelatus* formed about 1/3rd of the total production by gill net in monsoon.

Bombay : Eight species of catfishes appeared in trawl net catches of Bombay. On an annual average *T. dussumieri* (27%) was the major constituent followed by *T. thalassinus, O. militaris* and *T. tenuispinis* accounting for 18.5%, 18. 4% and 10.8% respectively in the total landing. Species such as *T. sona, T. jella* and *T. serratus* are less abundant in Bombay area, together constituted less than 20% of the annual total. Although all the species appeared in all seasons, the relative dominance varied from season to season. In premonsoon, the catch comprised mostly of *O. militaris* (28.6%), *T. dussumieri* (23.8%), *T. thalassinus* (18.3%) and *T. tenuispinis* (11.9%). During monsoon and postmonsoon seasons *T. dussumieri* was most abundant, followed by *T. thalassinus*. Species such as *T. tenuispinis* and *T. caelatus* were common; whereas *O. militaris* appeared in good quantities during postmonsoon.

Mangalore : All the 4 species viz. *T. dussumieri, T. thalassinus, T. tenuispinis* and *T. serratus* were caught from the coastal waters of Mangalore by purse seine, trawl net and drift net. All gears operate only during premonsoon and postmonsoon seasons. During premonsoon *T. serratus* was the dominant catch (82.7%) in purse seine, followed by *T. dussumieri* (17.3%); whereas in postmonsoon, *T. tenuispinis* (58.2%) was the chief item followed by *T. dussumieri* (30.1%) and the remainder by *T. thalassinus* and *T. serratus*. The trawl net catch showed a different condition, in that *T. tenuispinis* (84.8%) and *T. thalassinus* (15.4%) were the major species in premonsoon and a very similar trend of species composition was recorded in postmonsoon. The drift net landed *T. dussumieri* and *T. serratus* at 66.7 and 29.6% respectively in total yield during premonsoon. During postmonsoon *T. serratus* formed about 39% of the total catch and the other 3 species occurred in almost uniform percentages.

Calicut : Of the 4 species landed at Calicut, *T. tenuispinis* was the most dominant (52.6%) in all gear total catch followed by *T. dussumieri* (27.8%), *T. thalassinus* (12.9%) and *T. serratus* (6.7%). In premonsoon *T. dussumieri* formed 60.7% and *T. tenuispinis*. *T. serratus* and *T. thalassinus* accounted for 35.4%, 3.5% and 0.4% respectively. The abundant species of monsoon were *T. dussumieri* (40.8%) and *T. tenuispinis* (35.6%); whereas *T. serratus* and *T. thalassinus* formed 19% and 4.6% respectively. In postmonsoon *T. tenuispinis* ranked first (60.4%) in total yield of the season, while *T. thalassinus*, *T. dussumieri* and *T. serratus* accounted for 18.2%, 14.5% and 6.9% respectively. In hooks and line landings *T. dussumieri* (56.5%) and *T. tenuispinis* (35.2%) were the dominant species during premonsoon; *T. dussumieri* (37.7%), *T. tenuispinis* (29.3%) and *T. serratus* (20.8%) in monsoon and *T. tenuispinis* (59.9%) and *T. thalassinus* (24.4%) in postmonsoon.

Cochin : Catfishes were exploited by trawl net, drift net and purse seine at Cochin and the former two gears operate throughout the season, while the latter only during pre and postmonsoon seasons. The composition of catch by drift net in premonsoon indicated an average production of 57.0% by *T. serratus*, 36.4% by *T. dussumieri* and 6.6% by *T. thalassinus* in the seasonal total catfish catch. In monsoon, *T. tenuispinis* and *T. serratus* formed 37.3 and 36.8% respectively and *T. dussumieri* (14.0%) and *T. thalassinus* (11.9%) were the less abundant species in drift net. The catch composed of *T. thalassinus* (59.8%), *T. serratus* (23.4%), *T. dussumieri* (12.0%) and *T. tenuispinis* (4.8%) during postmonsoon. In trawl net, *T. tenuispinis* was the most abundant component (77.4%) followed by *T. thalassinus* (14.9%) and *T. dussumieri* (7.8%) during premonsoon; whereas the entire catch, consisted of *T. thalassinus* (57.9%) and *T. tenuispinis* (42.1%) in monsoon and *T. thalassinus* (100%) in postmonsoon. The purse seine landing was very negligible and composed of *T. dussumieri* in premonsoon period. All-gear seasonal percentage composition of different species of catfishes at Cochin are shown in Fig. 2.

Size composition in different seasons

Veraval : The length frequency distribution (1984-86) of *T. thalassinus*, *T. tenuispinis* and *T. caelatus* during premonsoon, monsoon and postmonsoon seasons are given in Fig. 3-5, separately for trawl net and gill net.

The size of *T. thalassinus* in trawl catch ranged from 160-540 mm during monsoon and 180-680 mm in postmonsoon with mean sizes of 403 mm and 373 mm respectively. In gill net the length varied from 340-520 mm (premonsoon) and 240-580 mm (postmonsoon) with mean sizes of 443 and 433 mm in pre and postmonsoon respectively (Fig. 3).

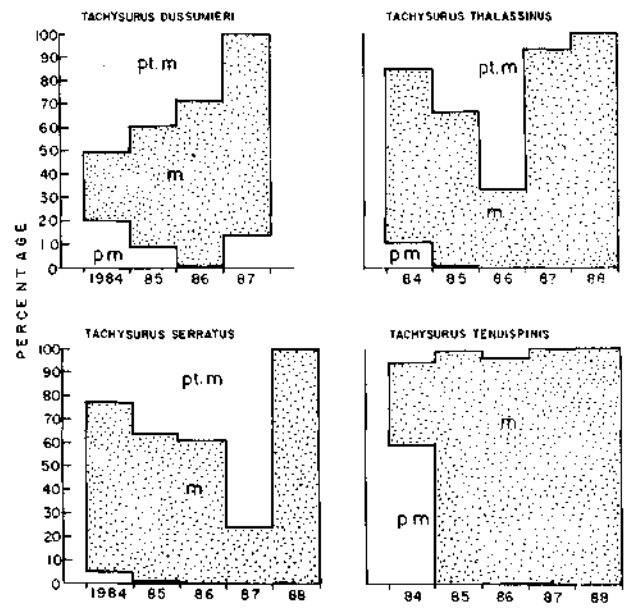

Fig. 2. Seasonal percentage composition of different species of catfishes during 1984-'88 at Cochin.

The length range of *T. tenuispinis* in trawl catch was 160-580 mm with a mean size of 354 mm in premonsoon and 140-580 mm with a mean size of 357 mm in postmonsoon. The premonsoon, monsoon and postmonsoon size ranges in gill net landings were 200-500 mm, 160-560 mm and 180-560 mm with mean sizes of 406, 448 and 366 mm respectively (Fig. 4).

In trawl catch, the size of *T. caelatus* fluctuated from 100-400 mm in premonsoon and 220-480 mm in postmonsoon with corresponding mean sizes of 271, 350 mm. In gill net, the length ranges were 320-480 (mean size of 308 mm) in premonsoon, 260-420 mm (335 mm) in monsoon and 320-380 mm (354 mm) in postmonsoon (Fig. 5).

Bombay : The length frequency distribution of *O. militaris* and *T. thalassinus* in trawl catches for the year 1987 and 1988 are given separately for premonsoon, monsoon and postmonsoon seasons in Fig. 6 and 7.

The length of *O. militaris* ranged from 160-420 mm in premonsoon with mean size of 265 mm (1987) and 310 mm (1988); in monsoon the mean sizes were 198 mm (1987) and 281 mm (1988). Larger size classes (160-540 mm) appeared in post-monsoon season with mean sizes of 265 mm (1987) and 295 mm (1988). The data indicated that recruitment took place in monsoon months at Bombay.

purse seine, drift net and trawl net are shown in Fig. 8 and 9.

The size of *T. dussumieri* caught by purse seine ranged from 500- 980 mm during premonsoon with mode at 720 mm and from 440-880 mm with modes at 640, 680 mm in drift net. During post-monsoon season the size varied from 340-1000 mm with modes at 640, 680 mm in drift net landings.

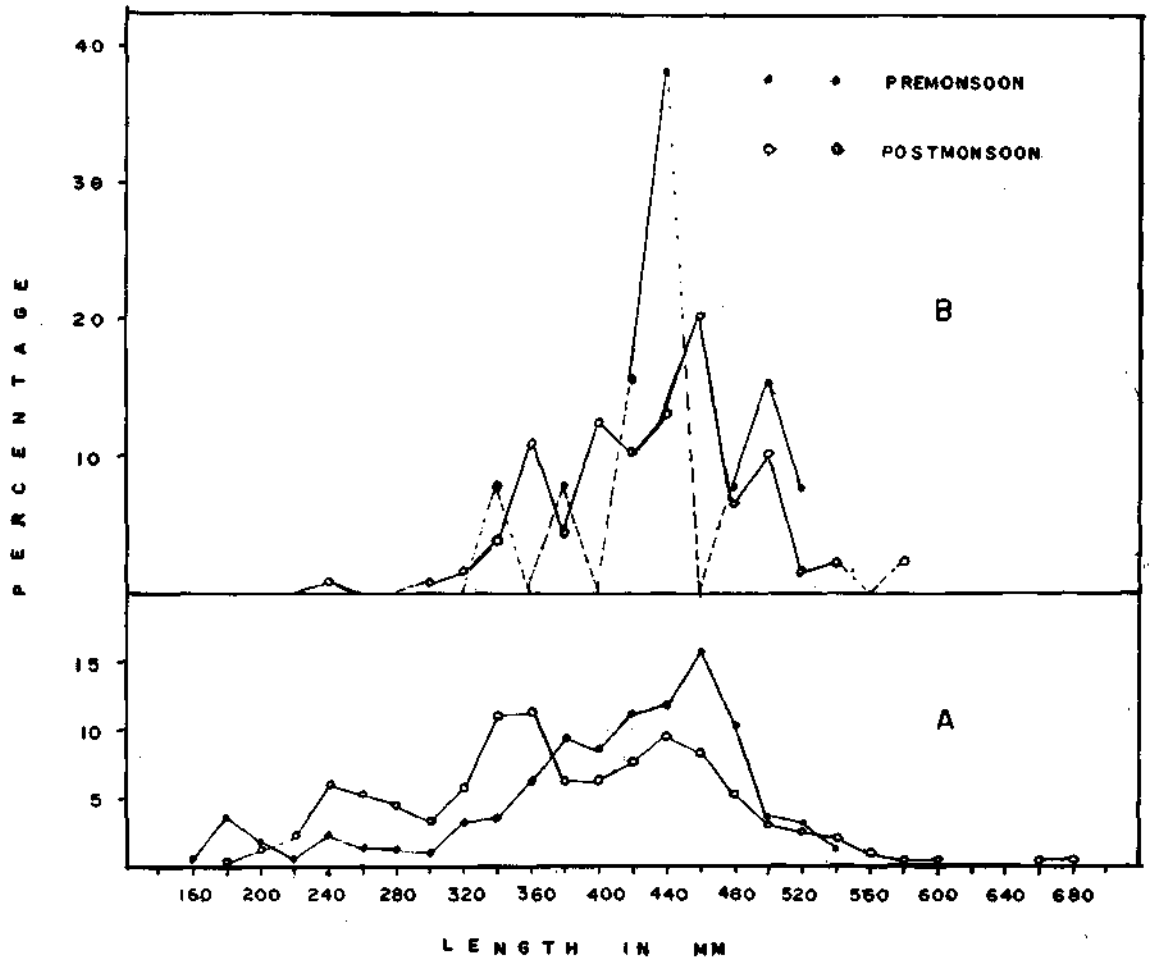

Fig. 3. Seasonal length frequency distribution of *T. thalassinus* (A - Trawl net, B - Gill net) at Veraval during 1984-88.

In premonsoon, the size range of *T. thalasi sinus* was 100-520 mm (mean size of 214 mm in 1987 and 297 mm in 1988), during monsoon the mean sizes were 214 mm (1987) and 229 mm (1988); whereas in postmonsoon larger sizes, 160-600 mm occurred in trawl with mean sizes of 292 mm (1987) and 300 mm (1988), when most of the spawning population aggregate the shallow grounds.

Mangalore : The seasonal length frequency distribution of *T. dussumieri* and *T. tenuispinis* landed by

In premonsoon season, the length of *T. tenuispinis* in trawl net ranged from 40-400 mm with the bulk of the landings in the length group 40 - 180 mm; whereas the sizes caught during postmonsoon included fishes of 40-520 mm. Juveniles (40-200 mm) were abundant in November-February with a model length of 60 mm. Fishes of the size 200-520 mm with a mode at 440 mm occurred in the purse seine landing of the premonsoon.

Calicut : In premonsoon and postmonsoon, adult *T. dussumieri* of age classes 5 and above dominated the landing both in drift net and hooks and line. Bulk of *T. thalassinus* landed in postmonsoon belong to age classes 3 and above. Hooks and line and drift net fishery for *T. serratus* comprised of size classes 700-1100 mm in monsoon and postmonsoon. *T. tenuispinis* was fully vulnerable to hooks and line and drift net by ages 3 and 4 in postmonsoon seasons.

Cochin : There was no appreciable variation in the length range of *T. dussumieri* caught during different seasons. Fishes of age 5 and above dominated the drift net catch of monsoon and postmonsoon. The size range of *T. thalassinus* was from 180-440 mm in trawl net during monsoon and from 300-820 mm in drift net during monsoon and postmonsoon. The length of *T. serratus* in drift net varied from 500-1140 mm during both monsoon and postmonsoon with major size classes of 700-900 mm in the fishery. Premonsoon and monsoon landed *T. tenuispinis* of sizes 180-420 mm. Large sizes of 220-500 mm appeared in the drift net during monsoon and postmonsoon months.

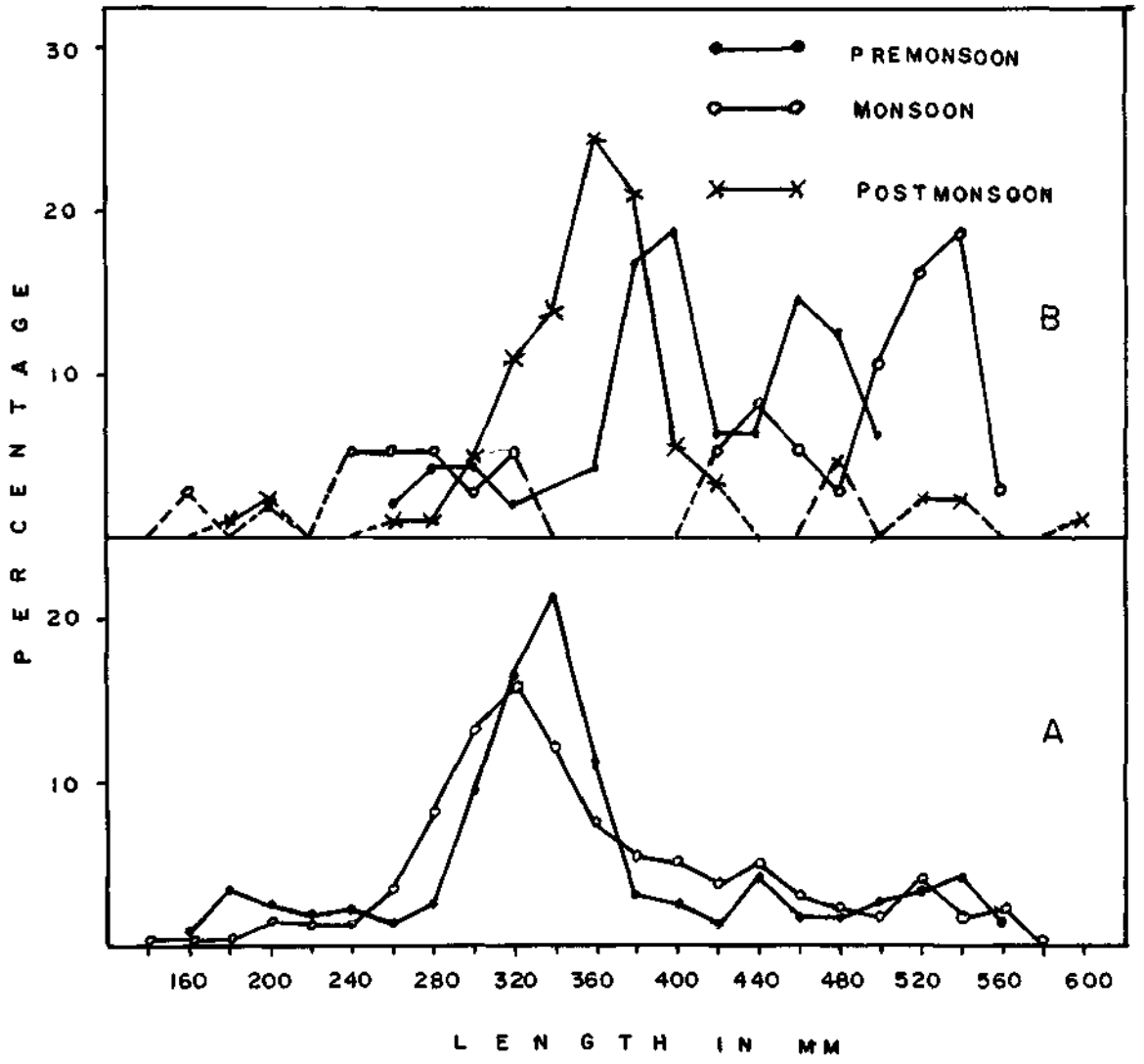

Fig. 4. Seasonal length frequency distribution of *T. tenuispinis* (A - Trawl net, B - Gill net) at veraval during 1984-88.

Spawning

All along the west coast the spawning seasons of catfishes were either premonsoon or postmonsoon. Generally the mature population moves towards the coastal waters during monsoon and spawning takes place by the end of monsoon, or in the beginning of postmonsoon (Anon., 1987).

The spawning season of *T. thalassinus* is postmonsoon all along the west coast. Ripe females and gestating males appeared in the catches during September-November months at all centres and in fairly high percentages at Mangalore, Calicut and Cochin.

T. tenuispinis spawn during premonsoon months of February-May along Veraval waters as evidenced by the appearance of ripe females of stages V and VI during March and April months with F:M ratio of 1.7:1. But this species spawns during postmonsoon months of September-November all along the southwest coast of India as evidenced by the occurrence of gestating male shoals in coastal waters off Mangalore and Calicut and ripe females off Cochin.

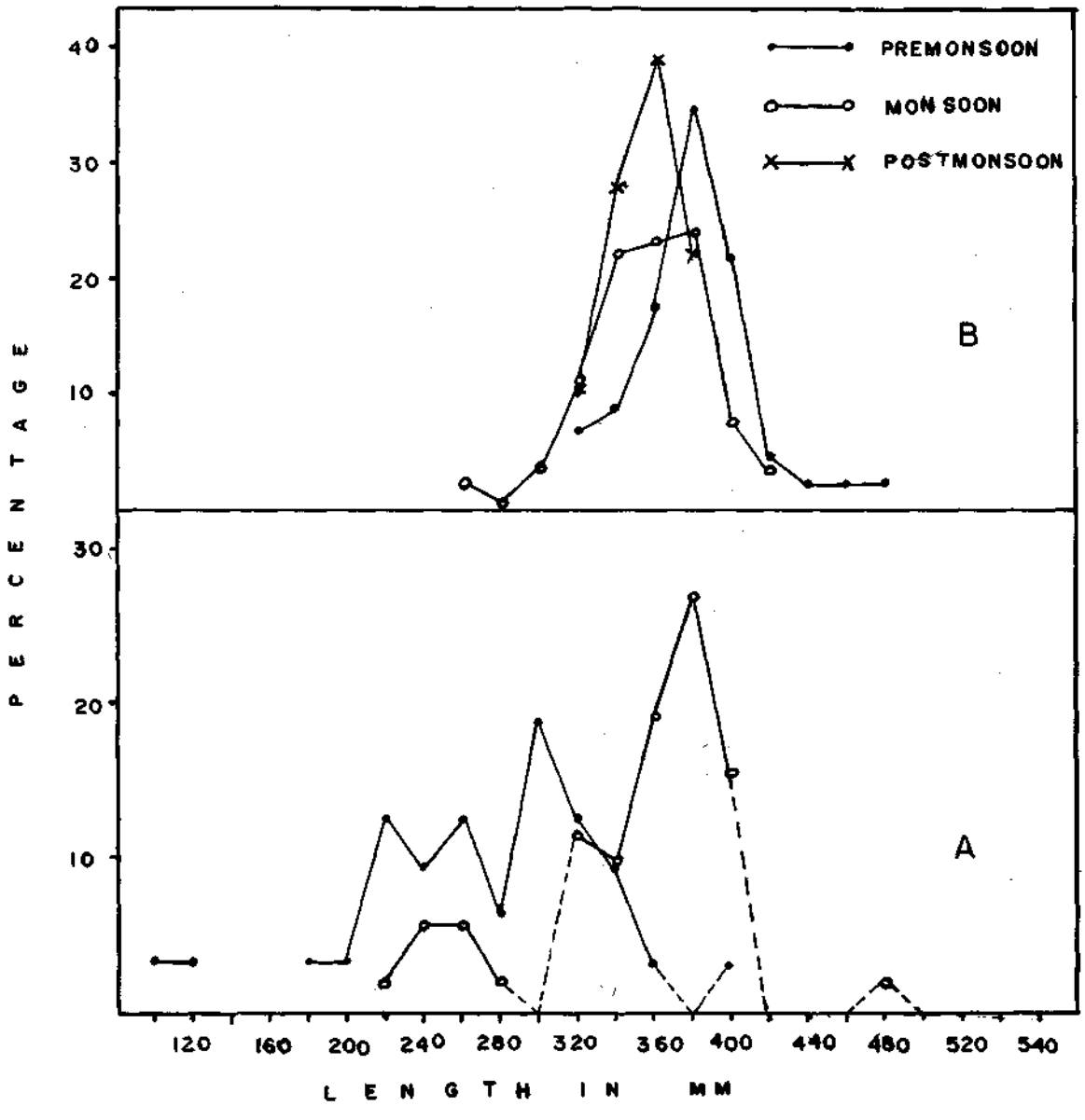

Fig. 5. Seasonal length frequency distribution of *T. caelatus* (A - Trawl net, B - Gill net) at Veraval during 1984-88.

Gestating male shoals of *T. dussumieri* appeared in shallow grounds during postmonsoon and premonsoon months of December-February at Mangalore. Spawners were also encountered in the catches of Calicut and Cochin during December-February.

The spawning season of *T. serratus* is postmonsoon months of September-December at

Mangalore,Calicut and Cochin. Shoals of gestating males are generally caught from Mangalore by purse seine during postmonsoon season. The soon season of January-April. Ripe females occurred in the catches during this season with a F:M ratio of 2:1.

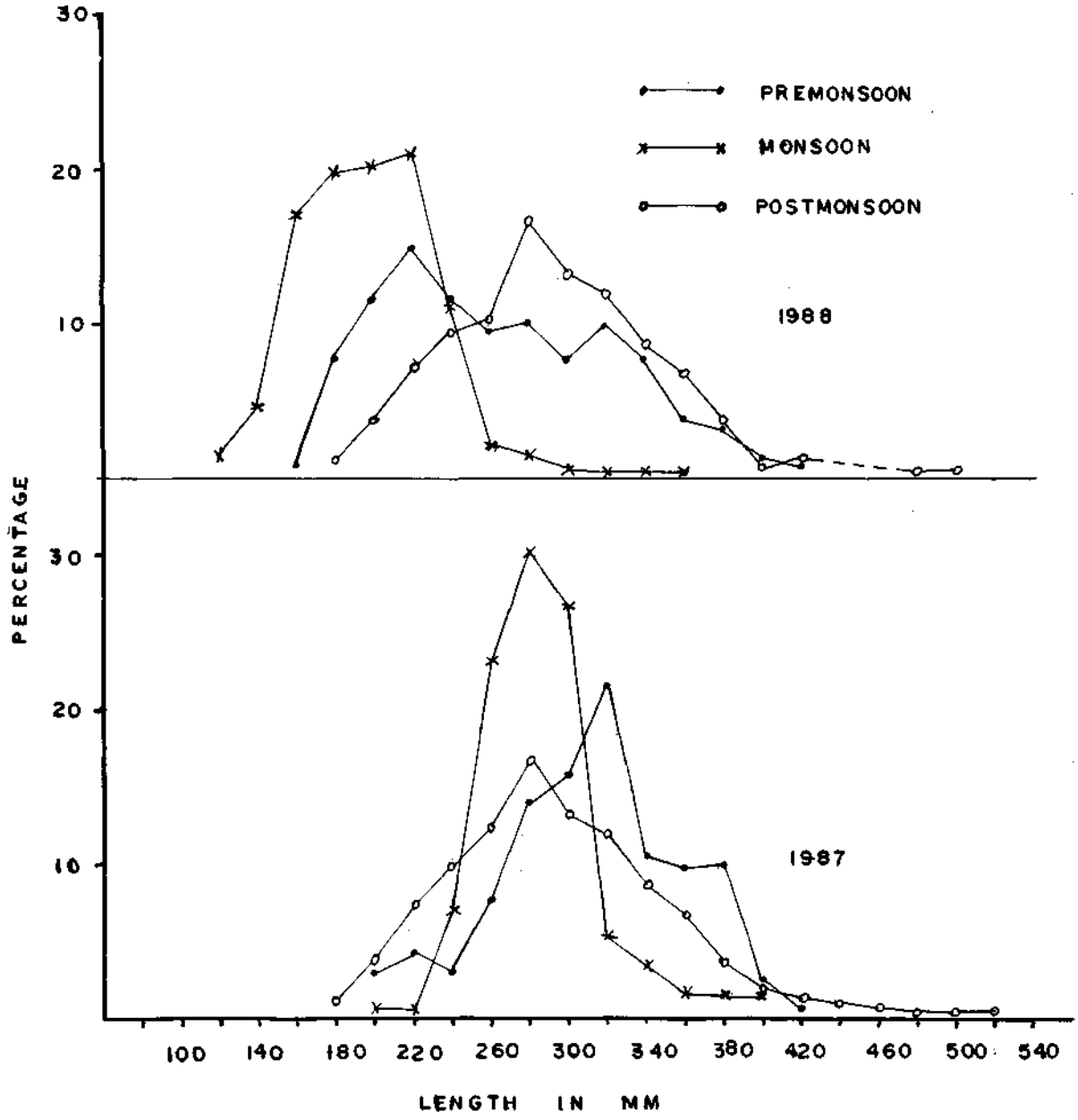

Fig. 6. Seasonal length frequency distribution of *O. militaris* at Bombay during 1987-88.

landings of this species by drift net and hooks and line at Cochin and Calicut recorded high percentage of ripe females during September-December months.

T. caelatus is a regular species of catfish landed at Veraval, which spawns in the premon-

Seasonal Abundance and Rainfall

An attempt was made to correlate the seasonal resource abundance with rainfall at Calicut and Cochin. At Calicut the catch rate was generally low during premonsoon and it varied

from 11.1 kg with a rainfall of 205 mm (1982) to 48.0 kg with 484 mm rainfall (1984). Whereas monsoon season recorded catch rates from 8.4 (1983) to 99.1 kg (1980) with corresponding rainfall of 1793 mm and 2745 mm. Similarly in postmonsoon the abundance fluctuated from 51.2 kg (1982) to 80.1 kg (1979) when rainfall was 456 mm and 460 mm respectively (Fig. 10). The intensity of rainfall indicated a strong positive correlation with the abundance (catch rate) of catfish. But the seasonal production trend showed poor landings during monsoon, although the resource is abundant in the fishing grounds. This is mainly due to low fishing pressure (5% of the total) during monsoon at Calicut.

The catfish production as well as CPUE showed a positive correlation with seasonal rainfall at Cochin also. The seasonal mean rainfall (1984-1988) was 422 mm (15.6%) in premonsoon, 1576 mm (58.1%) in monsoon and 714 mm (26.3%) in postmonsoon, the corresponding production was 50.7 t (6.2%), 585.8 t (71.7%) and 180.0 t (22.1%). The catch rate also showed a similar trend with 2.2 kg (5.1%), 30.5 kg (71.3%) and 10.1 kg (23.6%) during premonsoon, monsoon and postmonsoon seasons respectively (Fig. 11). The monthly catfish production and CPUE data of all the 4 species when superimposed over rainfall for a period of 5 years from 1984 to 1988 also showed positive correlation (Fig. 12).

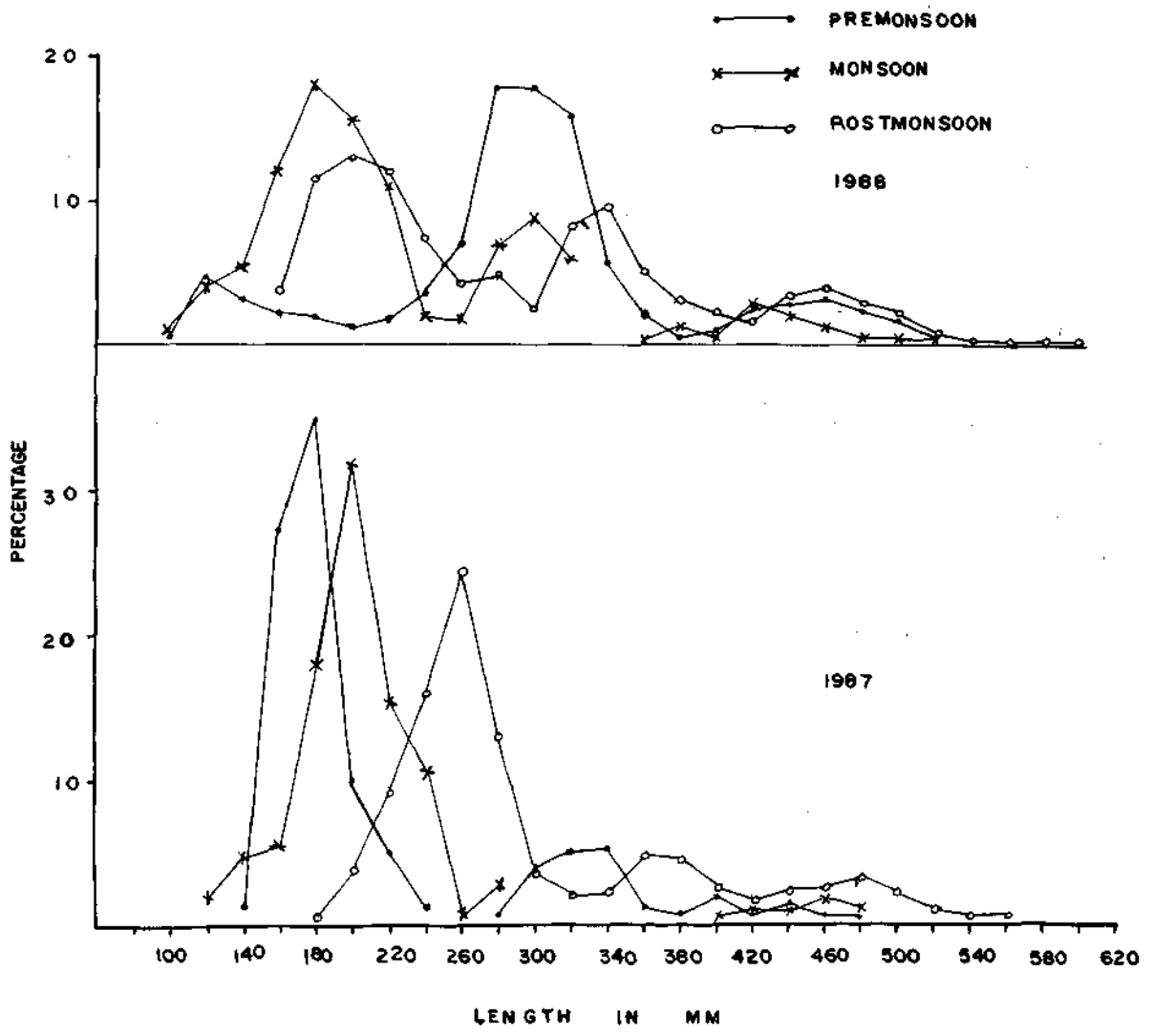

Fig. 7. Seasonal length frequency distribution of *T. thalassinus* of Bombay during 1987-88.

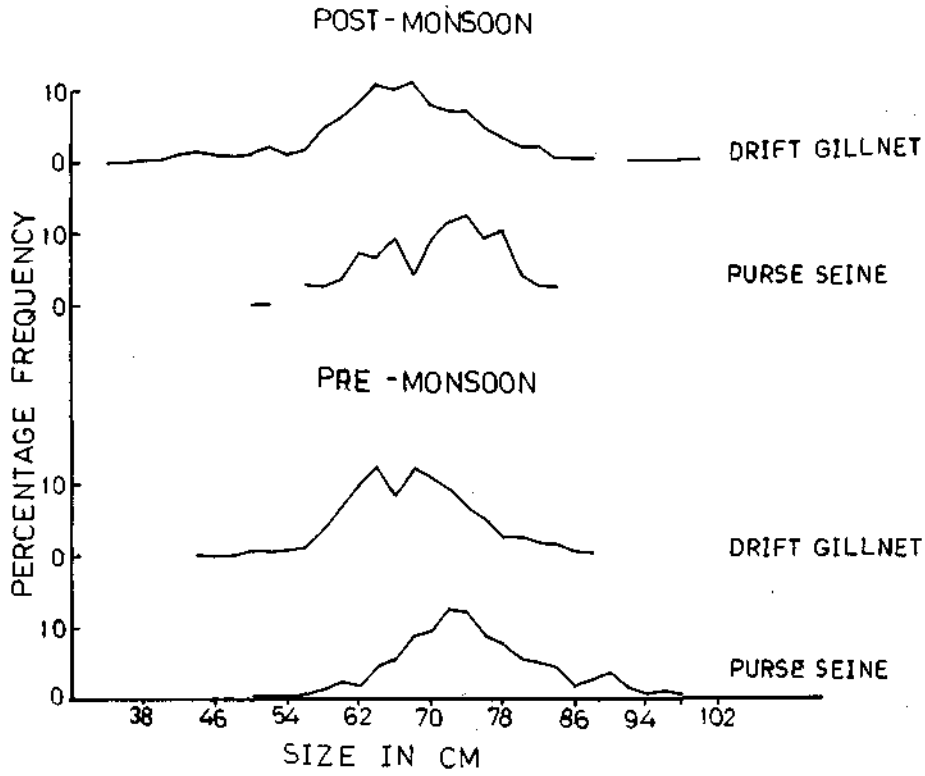

Fig. 8. Seasonal length frequency distribution of *T. dussumieri* in purse seine and drift gill net at Mangalore.

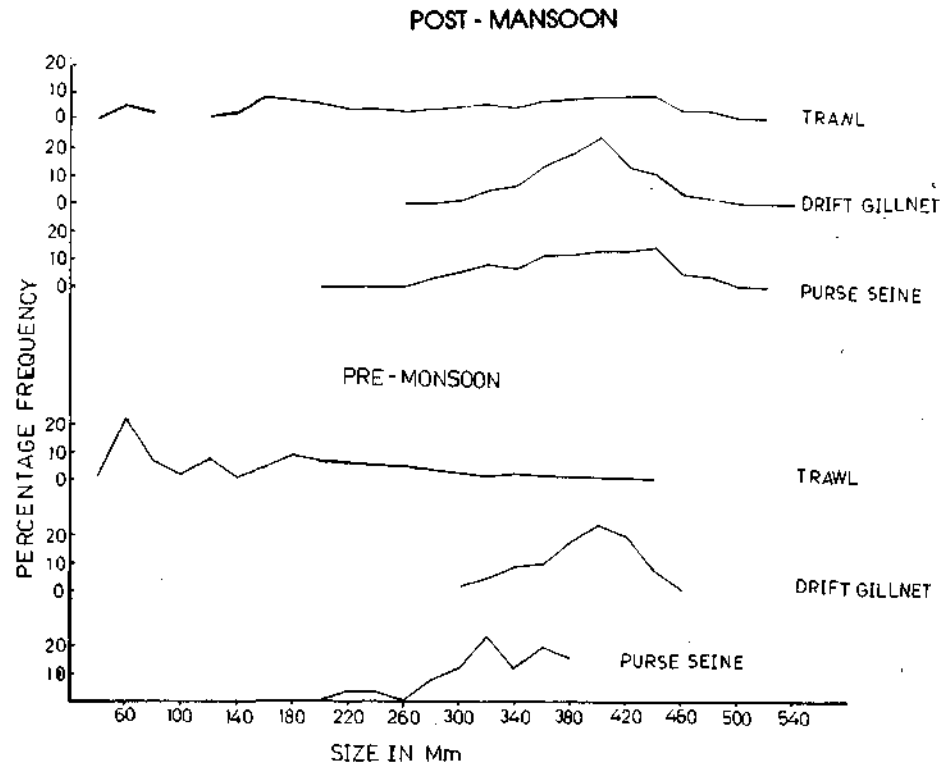

Fig. 9. Seasonal length frequency distribution of *T. tenuispinis* in trawl net, purse seine and drift gill net at Mangalore.

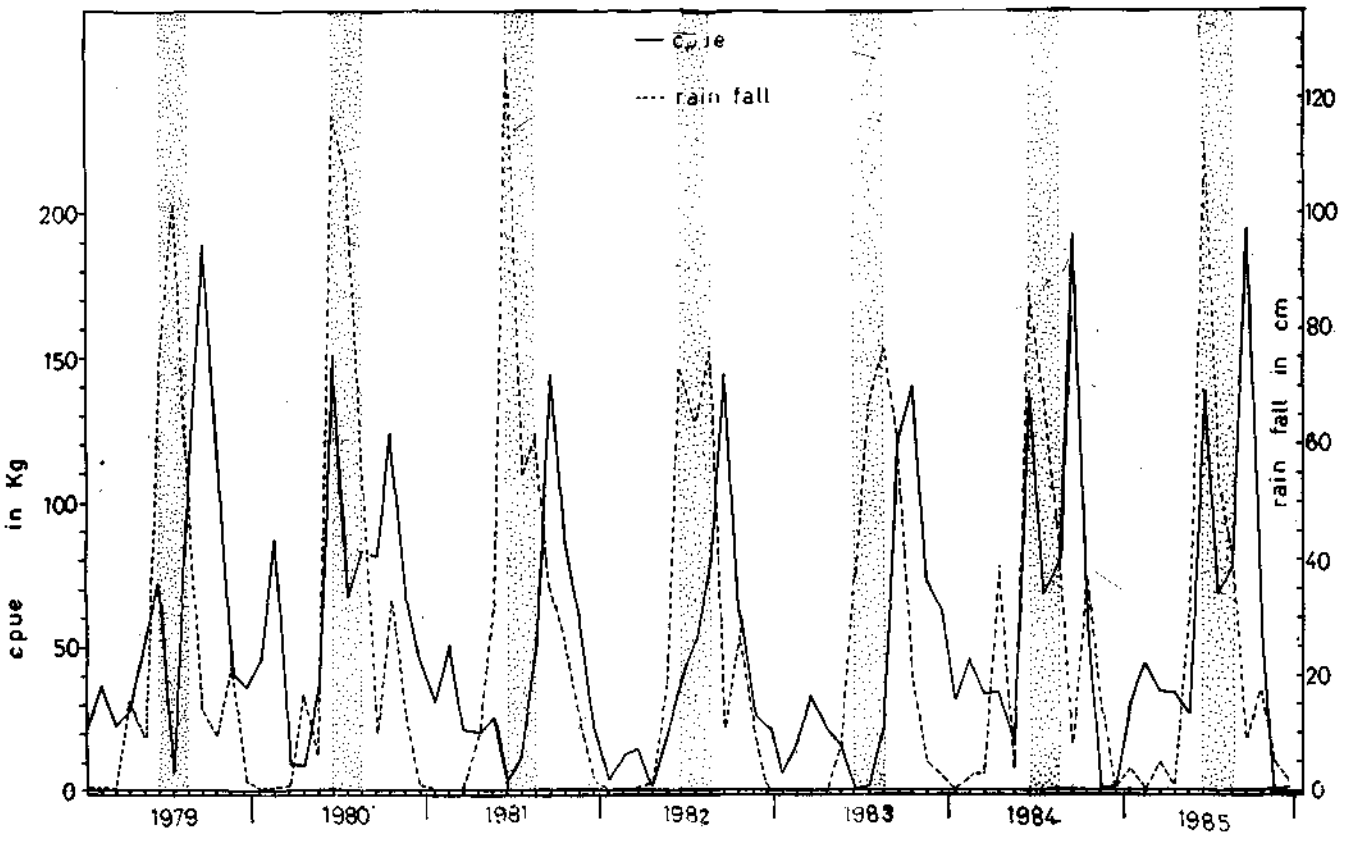

Fig. 10. Monthly catch per unit effort and rainfall at Calicut during 1979-85.

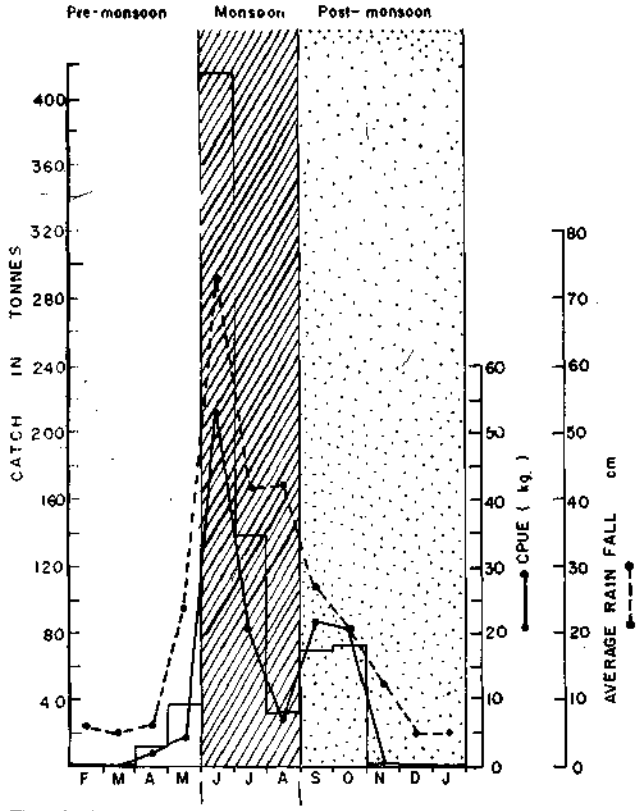

Fig. 11. Average seasonal catch, catch rate and rainfall at Cochin during 1984-88.

Discussion

More than 55% of the total annual catfish production of west coast is realised during premonsoon. The premonsoon season landed 35.6% of total catfish catch; whereas the monsoon contribution was only 9.2%. The low production in monsoon was attributed to poor fishing pressure during that season, especially along waters of Gujarat, Maharashtra and Karnataka owing to local/regional, legal/social restrictions of fishing operations in this season. A summary of the seasonal percentages of effort, yield and yield per effort; rainfall, major gears and the species composition are presented in Table 10.

At Veraval, the catfish production as well as resource abundance were maximum (47.5% and 42.1% respectively) in postmonsoon realised by expending 66.7% of the total effort inputs. Although considerable relation in the yields of premonsoon (47.4%) and monsoon (5.1%) was observed, the CPUE showed almost same intensity in both the seasons. The poor yield of monsoon was clearly due to low fishing pressure (by drift gill

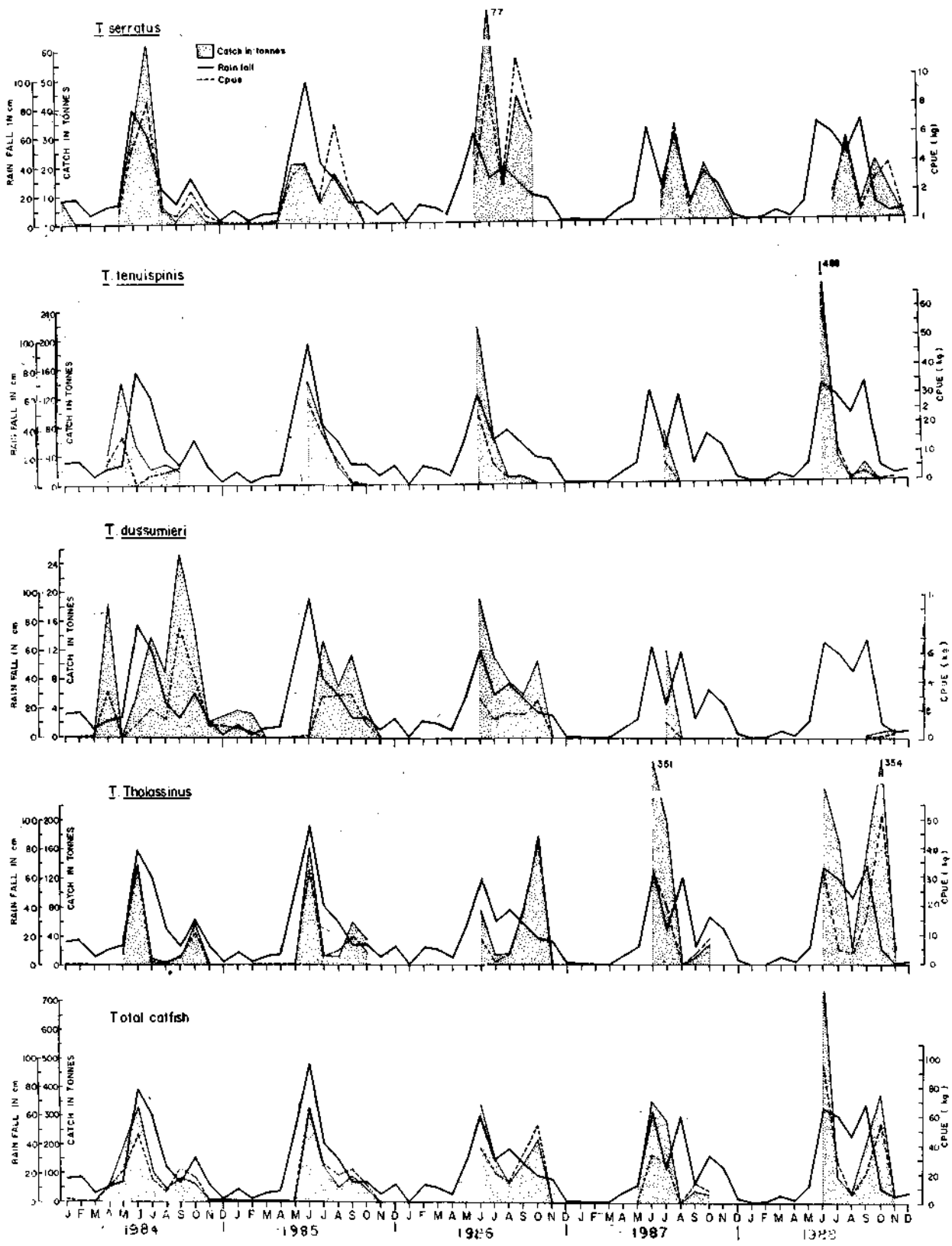

Fig. 12. Total catfish and specieswise catch, catch rate and rainfall at Cochin during 1984-88.

net). The data indicated that fishing effort of monsoon might be intensified to achieve increased harvest during monsoon. Throughout the seasons *T. dussumieri* was the most abundant species irrespective of the method of operation.

Catfish yield (52.3%) of Bombay by trawlers was almost proportional to the effort input (51.8%) during postmonsoon; similarly in premonsoon also the production and effort inputs were of same magnitude (34.6% and 38.1% respectively). The low production (9.6%) and abundance (25.2%) in monsoon showed the poor availability of catfishes in the fishing grounds off Bombay during the season. Invariably *T. dussumieri* was the dominant species in the trawl catches of Bombay.

TABLE 10. *Centrewise seasonal average (1984-86), effort (E), catfish yield (Yt) and yield rate (Y/E) and percentage with rainfall, gears and major species (Percentages in parenthesis)*

Season	E	%	Y(t)	%	Y/E	(%)	Rainfall (%)	Gear	Composition of major species
Veraval									
Premonsoon	36569	30.0	375.3	47.4	10.9	28.8		TR, DN	Td (49.3) Tt (14.3), Ttp (12.8) Om (10.2) Tc (2.8)
Monsoon	3655	3.3	40.1	5.1	11.0	29.1		DN	Td (53.8) Tc (30.4), Ttp (10.3), Om (1.2), Tt (0.9)
Postmonsoon	76660	66.7	375.7	47.5	15.9	42.1		TR, DN	Td (32.9), Ttp (23.9), Tt (20.8), Om (11.7) Tc (3.4)
Bombay									
Premonsoon	16437	34.6	1345.5	36.1	81.9	39.0		TR	Om (28.6), Td (23..8), Tt (18.3), Ttp (11.9), Tc (4.8) *T.sona* (2.5), Ts. (2.5)
Monsoon	6477	13.6	342.0	9.6	52.8	25.2		TR	Td (22.1), Tt (21.6), Ttp (18.8), Om (9.5) Tc (12.9) *T. sona* (3.3)
Postmonsoon	24613	51.8	1848.2	52.3	75.1	35.1		TR	Td (29.2), Tc (18.2), Om (15.1), Ttp (9.4), Tc (7.8), *T. sona* (7.1), Ts. (2.3)
Mangalore									
Premonsoon	30106	47.9	404.5	31.4	13.4	33.2	4.4	PS, DN, TR	Td (52.9), Ts (25.5), Ttp (18.3) Tt (3.3)
Monsoon	-	-	-	-	-	-	80.1	-	-
Postmonsoon	32707	52.1	882.3	68.6	27.0	66.8	15.5	PS, DN, TR	Ttp (60.0), Td (7.1), Tt (7.8), Ts (5.1)
Calicut									
Premonsoon	1500	40.6	130.3	27.5	29.0	22.6	9.0	H&L, DN, TR	Td (60.7), Ts (3.5), Ttp (35.4), Tt (0.4)
Monsoon	558	5.0	226.1	5.5	46.9	36.5	71.9	H&L, DN	Td (40.8), Ttp (35.6), Ts (19.0) Tt (4.6)
Postmonsoon	6023	54.4	316.8	67.0	52.6	40.9	19.1	H&L, DN, TR	Ttp (60.4), Tt (18.2), Td (14.5), Ts (6.9)
Cochin									
Premonsoon	20492	37.9	50.6	6.2	2.2	5.1	15.6	TR, DN, PS	Ttp (72.5), Tt (14.3), Td (10.1), Ts (3.1)
Monsoon	19198	32.2	583.8	71.7	30.5	71.3	58.1	TR, DN	Tt (46.1), Ttp (40.8), Ts (9.5), Td (3.6)
Postmonsoon	17810	29.9	180.0	22.1	10.1	23.6	26.3	TR, DN, PS	Tt (61.3), Ts (22.5), Td (11.6), Ttp (4.6)

Td - *Tachysurus dussumieri*, Tt - *Tachysurus thalassinus*, Ttp - *Tachysurus tenuispinis*, Tc - *Tachysurus caelatus*, Ts - *Tachysurus serratus*, Om - *Osteogeneiosus militaris*, Tr - Trawl net, DN - Drift net and PS - Purse seine.

About 68.6% of the total yield was realised in postmonsoon season at Mangalore by exerting 52.1% of total fishing pressure. The resource abundance accounted for 66.8% in this season and about 60% of which consisted of *T. tenuispinis*. Detailed analysis of data showed that a vast majority of the catch of *T. tenuispinis* belonged to spawning or brooding populations. Almost the entire catch of the species was caught by purse seine during September - October when shoals of ripe females and male congregate the inshore waters for breeding. Similar mass harvest of *T. dussumieri* took place in December-March period, when spawners accumulated the shallow breeding grounds off Mangalore - Malpe, as recorded during the premonsoon seasons of 1982, 1984-1987. James *et al.* (1989) estimated that about 64% of the annual average purse seine catfish catch was composed of gestating males of *T. tenuispinis* and *T. dussumieri*, with an annual average landing of 1905 t and 502 t, mostly in postmonsoon and premonsoon seasons respectively. Further it is reported that the egg/embryo/larval annual average fishing mortality was around 8.2 million (13.4 t) for *T. tenuispinis* in postmonsoon season and 1.6 million (6 t) for *T. dussumieri* in premonsoon from Karnataka waters. Such wanton destruction of eggs/embryos/larvae is not only economically wasteful, but also biologically harmful to future recruitment.

As the species were highly migratory, the impact of the egg/larval fish mortality at any one point is felt at all fishing centre along the course of their migration, as evidenced by their low rate of recruitment (James *et al.*, 1989). In addition to egg/embryo mortality by fishing, the nearshore trawling in premonsoon also damaged whatever new recruitment of *T. tenuispinis* by removing the juveniles and subadults from the feeding grounds. As the bulk of catchs are found in 50-80 m depth belt during monsoon season in this region (Rao *et al.*, 1977; Philip, 1986; James and Pillai, 1990), it is suggested that monsoon fishing may be intensified along the grounds off Kerala and Karnataka to achieve better harvests.

The high abundance of catfishes during monsoon and postmonsoon season along Calicut (36.5%) and Cochin (71.3%) areas, estimated from the present data (Table 10) agreed well with earlier findings based on acoustic survays by PFP (Rao *et al.*, 1977), resources survey by FSI (Philip, 1986) and fishery survey by FORV *Sagar Sampada* (James and Pillai, 1990). James *et al.* (1989) already showed a southward migration of catfishes during SW monsoon along waters off Kerala and Karnataka and the present data corroborated the earlier findings. The higher production of breeding/spawning fish in adult exploited population from shallow grounds of Kerala and Karnataka, gives a timely warning that exploitation of such stocks may bring about negative impacts on future recruitment. Therefore, in order to avoid any such negative effects on recruitment (1) catches must be organised to include exploitation at depths greater than 50 m by bottom and mid water trawling and purse seining, (2) exploitation by hooks and line should be encouraged and intensified in breeding grounds, as this gear spares juveniles and brooders/spawner (Menon *et al.*,1989) population of catfishes and (3) fishing pressure may be intensified during south-west monsoon especially in deeper waters at depths of 50-100 m.

Acknowledgemets

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References

Anon., 1987. Marine Catfish Resources of India. *Bull. Cent. Mar. Fish. Res. Inst.*, **40**: 1-94.

Dhulkhed, M. H., C. Muthiah, G. Syda Rao And N. S. Radhakrishnan 1982. The purse seine fishery of Mangalore (Karnataka). *Mar. Fish. Infor. Serv. T & E Ser.*, **37** : 1-7.

James, P. S. B. R., V. N. Bande, N. Gopinatha Menon and K. Balachandran 1989. The catfish resources of south-west coast of India : Prospects and Mangement problems. *Bull. Cent. Mar. Fish Res. Inst.*, **44** (1) : 78-94.

—— and V. Narayana Pillai 1990. Fishable concentrations of fishes and crustaceans in the offshore and deep sea areas of the Indian Exclusive Economic Zone based on observations made on board FORV *Sagar Sampada*. *Proc. Frist Workshop Sci. Result FORV Sagar Sampada*; pp. 201-213.

Menon, N. G., V. N. Bande and K. Balachandran 1989. Hooks and line fishery in North Kerala with particular reference to catfish resources. *J. mar. biol. Ass. India*, **31** (1 & 2) : 205-217.

Muthiah, C. and G. Syda Rao 1985. Occurrence of *Tachysurus*

dussumieri (Valenciennes) with incubating young ones off Mangalore. *Mar. Fish. Infor. Serv. T & E Ser.*, **61** : 14-15.

PHILIP, K. P. 1986. Fishery resources off the offshore and deep sea waters of Karnataka and the fishing effort suggested for exploitation. *In : Proc. Sem. on Problems and Prospects of marine fishing and fish processing in Karnataka. Forum of Fishery Professionals, Mangalore* (1986); pp. 28-35.

RAO, K. V. N., M. KUMARAN AND J. SANKARASUBRAMANIAM 1977. Resources of ribbonfishes and catfishes of the southwest coast of India. *Seafood Export J.*, **9** (11) : 9-26.

SILAS, E. G., P. PARAMESWARAN PILLAI, M. H. DHULKHED, C. MUTHIAH AND G. SYDA RAO 1980. Purse seine fishery - Imperative need for regulations. *Mar. Fish. Infor. Serv. T & E Ser.*, **24** : 1-9.

Bull. Cent. Mar. Fish. Res. Inst., 1992, 45 : 154 - 168

4. 8

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : THREADFIN BREAMS

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ABSTRACT

Threadfin breams, an important demersal fishery resource along the Indian west coast, are mainly exploited by small commercial trawlers in depths upto about 50 m. These fishes are more abundant in relatively deeper waters beyond 50 m and are known to move into shallower areas during monsoon period along southwest coast. Along Kerala Coast, maximum catches and catch rates are obtained during monsoon period. There is no significant trawling along Maharashtra and practically no trawling along Karnataka and Gujarat Coasts during monsoon period. Two species viz. *Nemipterus japonicus* and *N. mesoprion*, contribute to the fishery and along Kerala Coast, the latter species is the principal one during monsoon period and the former in other period. Along the coasts of other States in the west coast, the principal species is *N. japonicus* in all seasons. Fishes of larger lengths are caught in monsoon period and of smaller lengths in postmonsoon period at Cochin. At Bombay, the average length is highest during the postmonsoon and lowest during monsoon in *N. japonicus*. Nemipterids spawn over longer periods and in *N. japonicus* peak spawning takes place during monsoon at Cochin and Bombay, during postmonsoon at Veraval and partly during post and pre-monsoon periods at Mangalore. In *N. mesoprion*, peak spawning takes place during postmonsoon period at Cochin and Veraval and during monsoon period at Bombay.

The available information and data on distribution during different seasons, on various aspects of biology and on present exploitation of stocks of threadfin breams along the west coast are considered for a detailed discussion and suggestions on different management options are given.

INTRODUCTION

The fishes of the Family Nemipteridae, popularly called Threadfin breams (*Kilimeen* in Malayalam, *Madhumal meenu* in Kannada, Rani in Marathi, *Lal machala* in Gujarati) form an important component in the exploited demersal fishery resources of India. An estimated 67,677 tonnes of these fishes were landed in 1989 (CMFRI,1989; Anon., 1990) from Indian Seas, which formed 7.7% of total demersal fish landed and 3.0% of total marine fish landings of India. Though they are presently exploited in depths of about 50 m and less by the small commercial shrimp trawlers, the threadfin breams are more abundant in 75-100 m depth along the Indian west Coast (Silas, 1969) and in the depth range of 50-125 m in the north eastern Arabian Sea (Zupanovic and Mohiuddin, 1973). According to James *et al.* (1987), the threadfin breams constitute a promising resource having good potential for exploitation along both the coasts; according to them, further, large concentrations of these fishes are located in 75-225 m depth zone during February-May and in comparatively shallower waters during July-September. There are wide seasonal fluctuations in abundance of threadfin breams particularly in the trawling grounds of the eastern Arabian Sea. Along the southwest coast of India, in the trawling grounds off Sakthikulangara and Cochin, very heavy catchs are obtained during the monsoon months of June-August, the catches during this period accounting for over 80% by weight of total annual threadfin bream landings at these centres. For various reasons such as conflicts between the fishermen of artisanal gear and trawlers, apprehensions of over-fishing of spawners and destruction of spawns, particularly of some important pelagic fishes, caused by mechanised fishing during monsoon months and safety of fishermen, some States on the west coast of India have prohibited mechanised fishing during monsoon months. This has led to a great deal of resentment among trawler operators and exporters. According to them "the ban will not produce better catches after the ban period, but the stoppage of trawling will affect the future catches

also" (Anon., 1989). This being the background, it is considered desirable to critically examine the data on fishery and biology of dominant species of threadfin breams obtained from different centres along the Indian west coast to enable giving a suitable advice on whether a ban on mechanised fishing during monsoon season is necessary or not from the biological point of view.

Data Base

Bulk of the threadfin bream catch in India is obtained by trawlers and therefore the present study is based on data collected from trawler landings. Data on monthly effort (number of operations of boats), catch, species composition and biology of important species of threadfin breams from trawl landing centres at Cochin, Mangalore, Bombay and Veraval collected from February 1984 to August 1988 are utilised for the study. At Vizhinjam, small quantities of threadfin breams are landed by hooks and lines; the data from this centre however, are also included in the present study. Data on estimated quarterly effort and catch from six trawl landing centres along the west coast pertaining to the period January 1982-June 1988 are also examined. For the purpose of the present study, a year is considered under three periods; premonsoon period from February to May, monsoon from June to August and postmonsoon period from September to January.

Observations

Annual landings of threadfin breams at different centers : The estimated landings of threadfin breams at different centres (Table 1) during 1982-'87 show fluctuations over the period and maximum landings are obtained from the centres of Kerala Coast followed by those of Maharashtra, Gujarat and Karnataka. Excepting Vizhinjam, the landings from all centres are obtained by trawlers only. At Vizhinjam there is no trawling and threadfin breams are caught by Hooks and lines (used by motorised as well as nonmotorised crafts). It is interesting to note that though there is considerable effort of hooks and lines, during this period at Sakthikulangara, Cochin and Sassoon Docks, there is no catch of threadfin breams by this gear.

Quarterly estimated effort and catch : The data obtained from six centres along the west coast show : (a) At Sakthikulangara in Kerala (Fig. 1 A) the trawling effort and threadfin bream catch, are highest during third quarter (July-September) in all years. The catch and the effort during this quarter in different years form 81-85% and 29-38% of total threadfin bream catch and total trawling effort respectively in each year. Further, the nemipterid catch in the third quarter in different years shows increasing trend in succeeding years upto 1986 though similar trend is not there in effort. (b) At Cochin, also in Kerala (Fig. 1 B), the effort is maximum is second quarter (April-June); it forms 34-42% of annual effort in different years whereas the catch of nemipterids is the highest in third quarter (July-September) forming 70-86% of annual threadfin bream catch in each year. In 1985 however, the catch in second and third quarters is the same. (c) At Mangalore in Karnataka (Fig. 1 C), the effort is highest in first quarter (January-March) forming 42-55% of total annual effort in each year; it is lowest in third quarter (July-September) forming 0.2-2.4% of total annual effort in each year. The catch of threadfin breams is highest in first quarter (46- 65% of total annual catch) in 1984, 1986, 1987 and 1988 and in second quarter (April-June) (49-53 % of total annual catch) in 1983 and 1985. (d) At the New Ferry Wharf landing centre (Fig. 1 D) in Maharashtra (Bombay) the effort is maximum in fourth quarter (October-December) and minimum in third quarter, forming respectively 32-40% and 9-18% of the annual effort in different years. The nemipterid catch is highest in fourth quarter (conforming to effort) in 1982, 1984 and1986 forming 40-56% of total annual catch and in second

Table 1. *Estimated landings (tonnes) of threadfin breams at different centers along the west coast during different years*

Centre	1982	1983	1984	1985	1986	1987	Annual Average
Vizhinjam	-	-	118	210	264	350	235
Sakthi-kulangara	4830	5529	14256	20904	28668	14507	14782
Cochin	3505	1016	5222	1968	7076	4576	3894
Mangalore	-	1462	518	330	1881	2664	1371
Bombay							
New Ferry wharf	409	2150	1308	653	1262	1436	1203
Sassoon Docks	3287	2125	1687	1591	2580	2942	2369
Veraval	998	1015	2085	1739	4571	1015	1904

quarter forming 32-42% of total annual catch in 1983, 1985 and 1987. (e) At another centre in Maharashtra (Sassoon Docks at Bombay) (Fig. 1 E) the effort is highest (27-29% of annual effort) in fourth quarter in four years (1983, 1984, 1986 and 1987), first quarter in one year (1982) and in third quarter in yet another year (1985). The effort is minimum in second quarter (17-25% of annual effort) in all years; the catch, however, is highest in second quarter in all years excepting one (1984) when the same is highest in fourth quarter. (f) At Veraval in Gujarat (Fig. 1 F), the effort is minimum

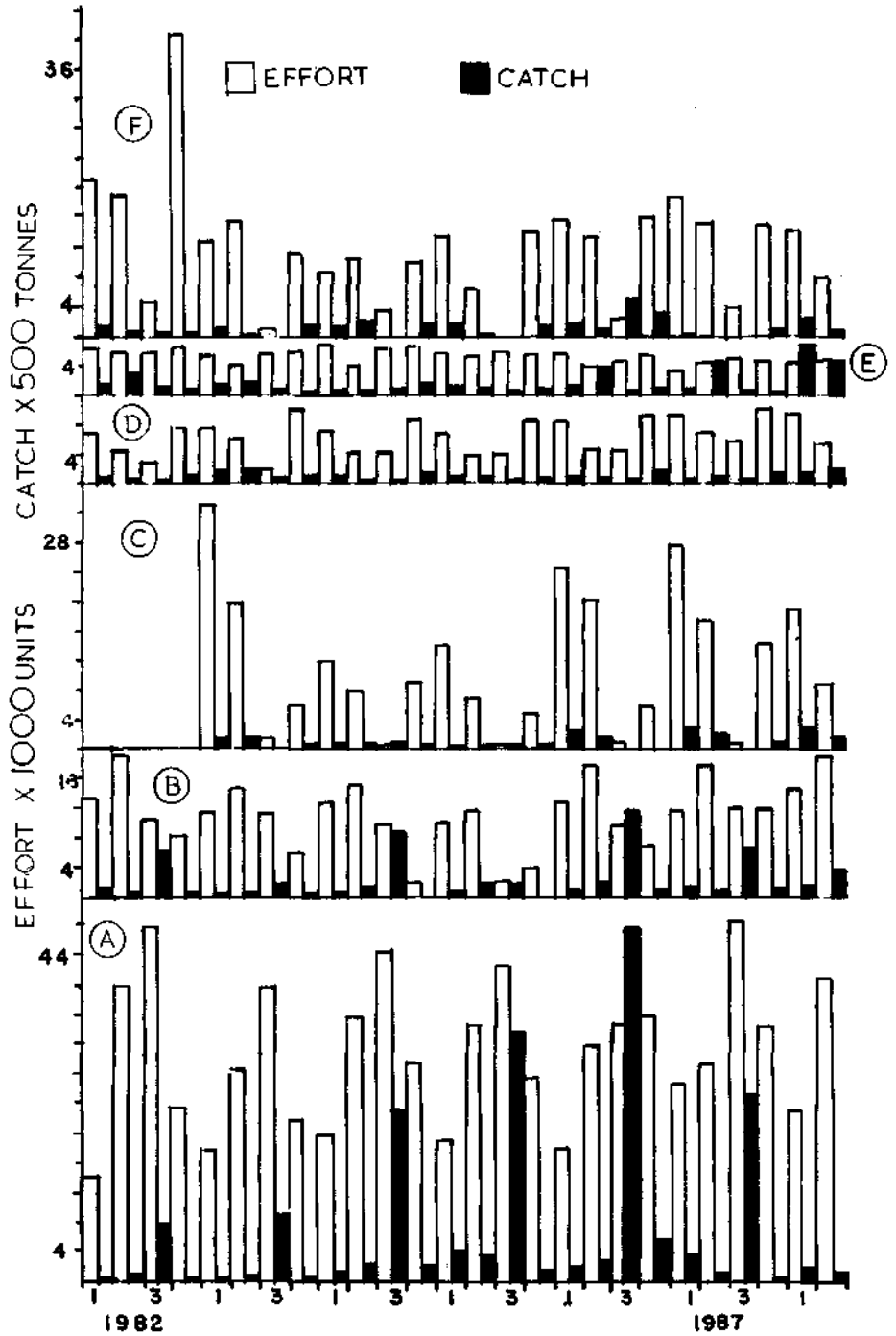

Fig. 1. Quarterly estimated effort and threadfin bream catch in different years at important trawl landing centres along the west coast of India. A. Sakthikulangara, B. Cochin, C. Mangalore, D. New Ferry Wharf, E. Sassoon Docks and F. Veraval.

in third quarter in all years forming 1-10% of the total annual effort in different years. In some years there is no fishing in third quarter and there are no landings of threadfin breams in third quarter of some other years. The peak period of catch is different in different years.

Along the west coast the monsoon period is June-August and 67% of this period falls under third quarter and 33% in second quarter in the quarterly effort and catch data mentioned above.

and March, July August 1988. Peak catches, however, are obtained (Fig. 2) in August-September 1984, July-September 1985, June-August 1986 and June-September 1987. Thus, though there are year to year variations in peak periods of effort and catch, the peaks in both of them in July-August are more or less consistent.

At Cochin (Fig. 3), maximum landings of threadfin breams are obtained during June, July or August in different years. The trawling is either

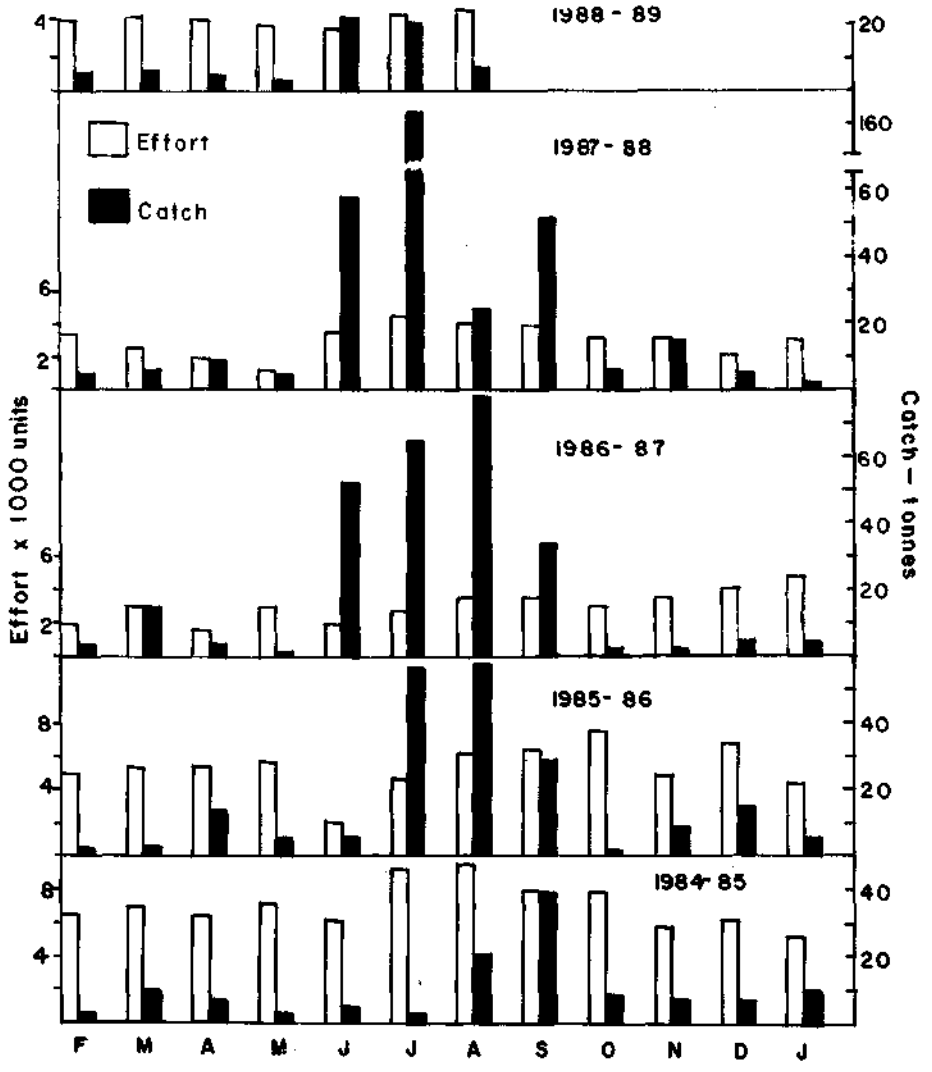

Fig. 2. Monthly estimated effort and catch of threadfin breams by hooks and lines at Vizhinjam during different years.

Monthly effort and catch at selected centers : At Vizhinjam, hooks and lines contribute to over 95% of threadfin bream landings and this gear is in operation round the year. Maximum effort is expended (Fig. 2) in July-August 1984, October 1985, December 1986, January, July, August 1987 very poor or absent during September-October. Though there is considerable trawling effort in November and December there is either no catch or the catch of nemipterids is very poor.

At Mangalore, there is no trawling during June-August period; there are no landings or poor

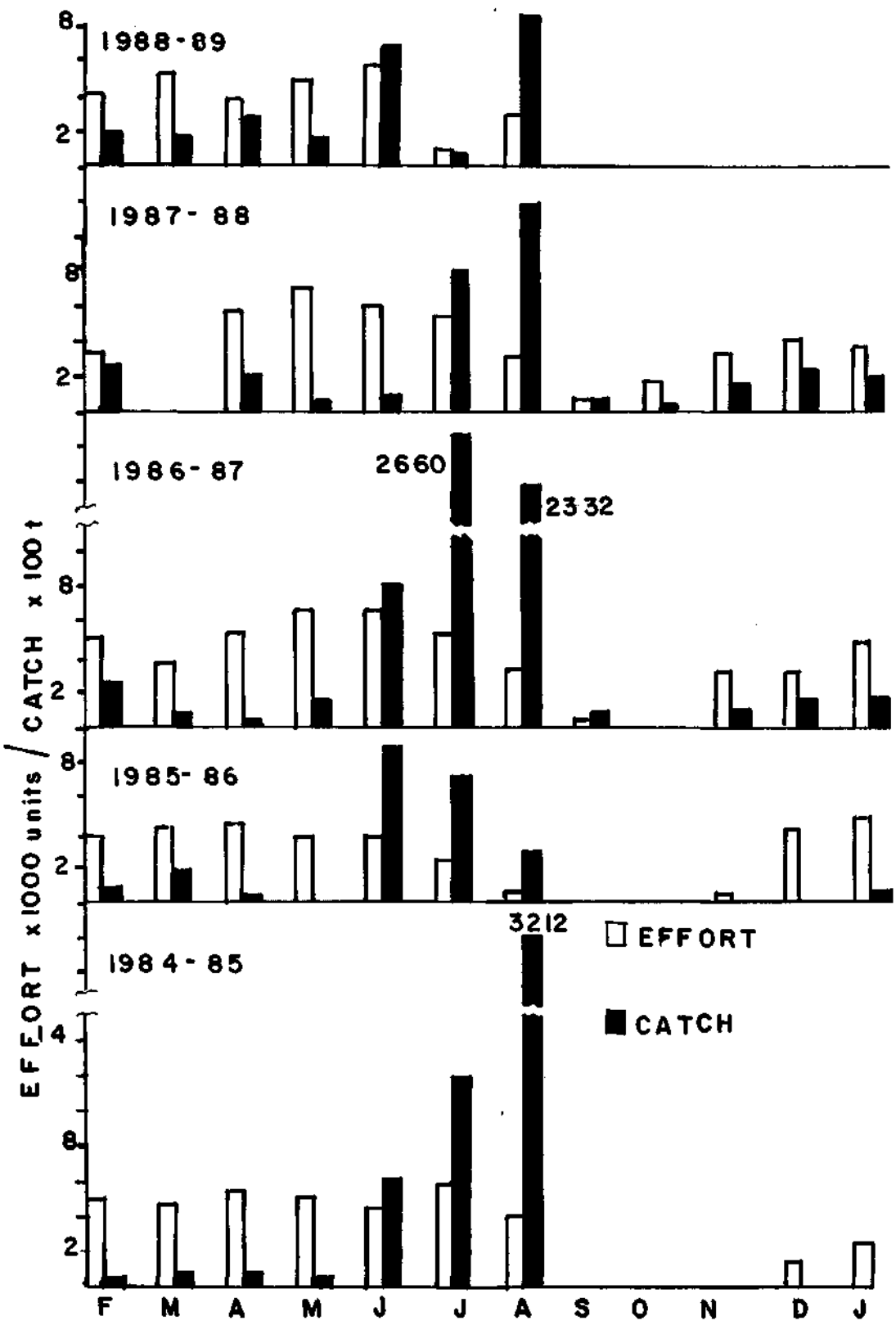

Fig. 3. Monthly estimated effort and catch of threadfin breams by trawlers at Cochin during different years.

landings during September and October and maximum catch of over 400 t is obtained in March and May.

At New Ferry wharf landing centre in Bombay (Fig. 4), the trawling effort and catch of nemipterids are very poor from June to August. Consistently good catches are obtained in October and in some years the catches are maximum in April. The effort is generally at its peak during September-December period.

At Veraval (Fig. 5), there is no trawling during June-August. Though the months of peak effort and catch are different in different years, generally the catch and effort are good during March, September and October.

breams is obtained in monsoon period of all years except 1984-'85 when the peak catch is obtained in postmonsoon period (Fig. 6). At Cochin (Fig. 7 A) the average effort is highest during premonsoon and lowest during postmonsoon except during 1985-86. The nemipterid catch, however, is the highest during monsoon forming 71-97% of total nemipterid catch obtained in each year. At Mangalore (Fig. 7 B) both the effort and catch are highest in premonsoon period and there is no fishing during monsoon. At Bombay (Fig. 7 C), the effort and catch are minimum during monsoon and maximum during postmonsoon. At Veraval (Fig. 7 D) there is no fishing in monsoon period and the effort as well as catch are higher in premonsoon in some years and in postmonsoon period in some other years.

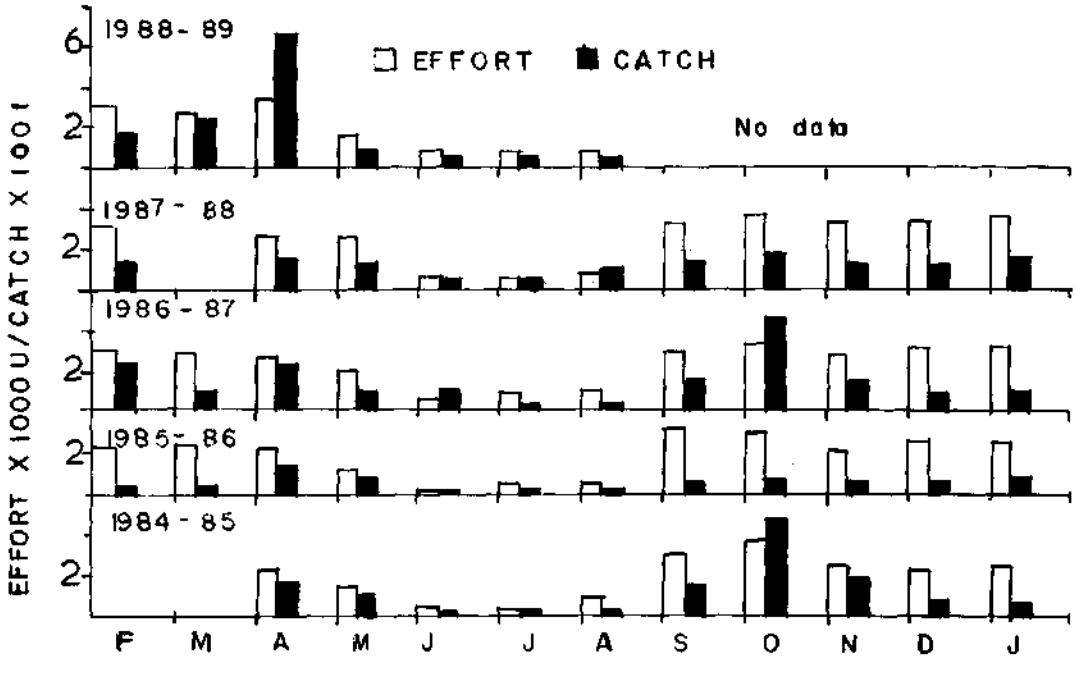

Fig. 4. Monthly estimated effort and catch of threadfin breams by trawlers at New Ferry Wharf (Bombay) during different years.

Seasonal variations in effort, catch and catch rates : As mentioned above, the premonsoon period consists of four months, the monsoon three months and the postmonsoon period five months. Therefore, for comparison of effort, catch and catch rates between different seasons as well as between the same season in different years, monthly average catch and effort in each season are calculated. At Vizhinjam, peak effort of hooks and lines is seen in monsoon period in two years (1984-85, 1987-'88) and in postmonsoon period in two years (1985-'86, 1986-'87) (Fig. 6), but peak catch of threadfin

The catch rates during the three seasons (Fig. 8) show that they are highest during monsoon period at Cochin and during premonsoon at Mangalore. There is no consistency in the periods of peak catch rates at Bombay and Veraval in different years. At Vizhinjam, peak catch rates are obtained in monsoon period in all years except in 1984-'85 when the same is obtained in postmonsoon period (Fig. 6).

The effort (Fig. 9) is highest during premonsoon period at Cochin, Mangalore and Veraval and

during postmonsoon period at Bombay. There is no fishing during monsoon at Mangalore and Veraval and the effort is lowest during this period at Bombay (Fig. 9).

the three seasons in different years (Fig. 10) shows that at Cochin, *N. mesoprion* is the most dominant species during monsoon period forming over 70% of threadfin bream landings in this period and

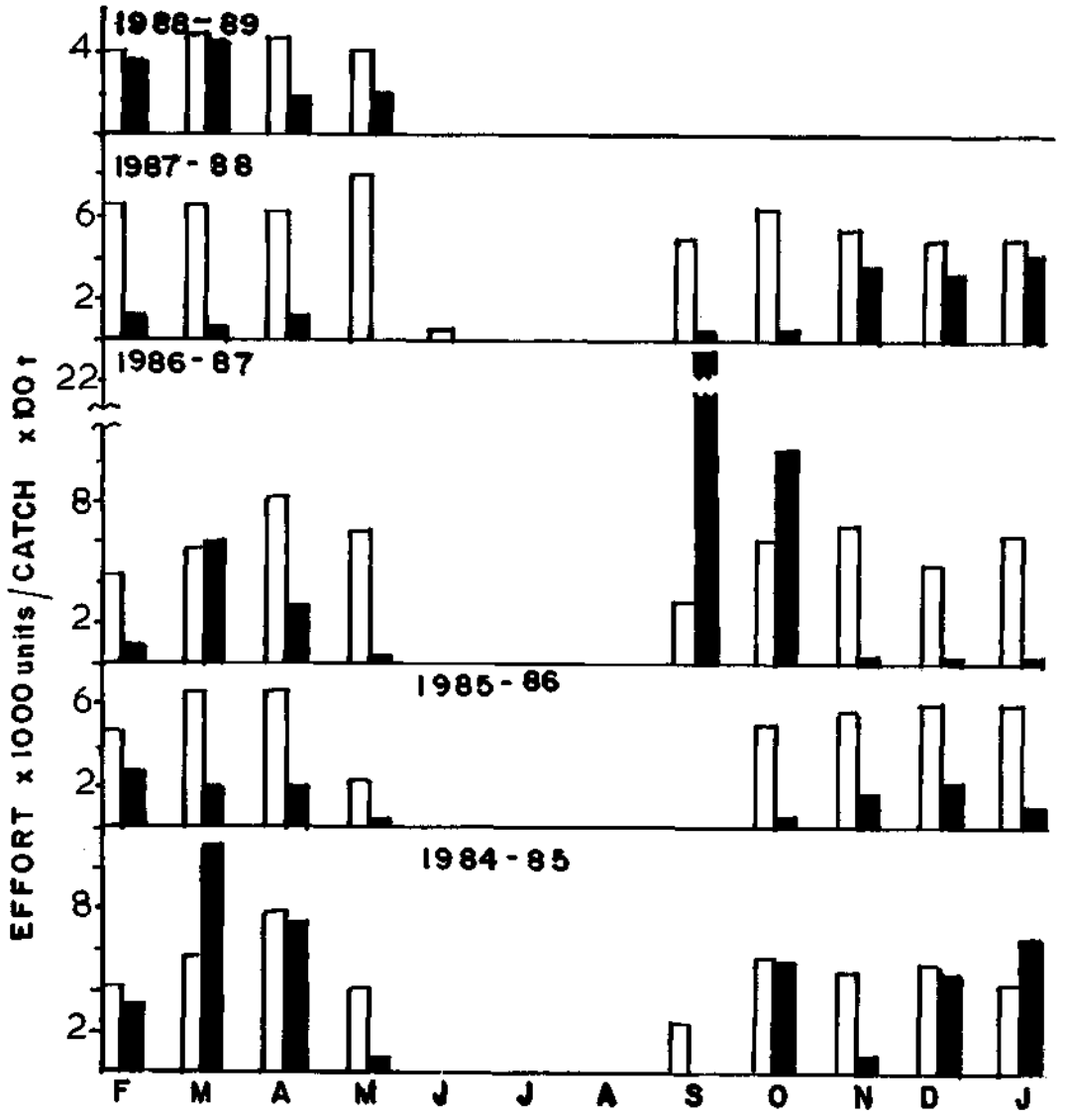

Fig. 5. Monthly estimated effort and catch of threadfin breams by trawlers at Veraval during different years.

Species Compositions

Along the west coast centres four species contribute to the fishery. These are *N. japonicus, N. mesoprion, N. delagoae* and *N. metopias*. Of these, *N. japonicus* and *N. mesoprion* are most dominant, together forming over 95% of threadfin bream landings. *N. delagoae* does not form any significant proportion in nemipterid catch and *N. metopias* is principally encountered at Vizhinjam only. The abundance of *N. japonicus* and *N. mesoprion* during about 55% of nemipterids obtained in the annual landings. *N. japonicus* is the dominant species during pre and postmonsoon seasons. The three species contributing to the fishery at Vizhinjam are *N. metopias, N. delagoae* and *N. japonicus*, the first one being the dominant. Peak catches are obtained in monsoon period and *N. metopias* forms about 95% of nemipterid catch during this period.

At Mangalore *N. japonicus* is the most dominant species in the premonsoon and postmon-

soon fishery although *N. mesoprion* is also caught in small quantities during the period.

At Bombay where the fishing during monsoon is very poor (Fig. 9), *N. japonicus* is the predominant species in all the seasons (Fig.10) forming about 70% of the threadfin bream catch. At Veraval there is no fishing during monsoon and *N. japonicus* is the most dominant species during both pre and postmonsoon periods forming around 80% of threadfin breams catch in each year.

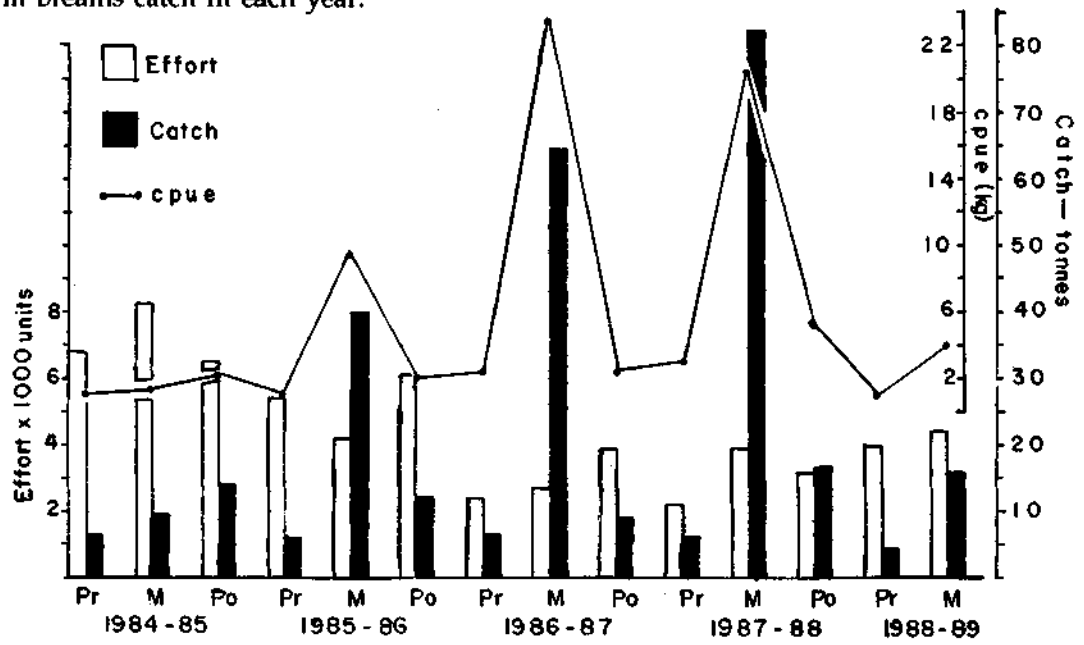

Fig. 6. Estimated effort, catch and catch per unit of effort of threadfin breams during premonsoon (Pr), monsoon (M) and postmonsoon (Po) seasons in different years at Vizhinjam.

It is thus clear that the monsoon fishery is largely supported by *N. mesoprion* at Cochin whereas at other centres the dominant species is *N. japonicus* during all seasons and at Vizhinjam the dominant species in monsoon is *N. metopias*.

Length Composition

The distribution pattern of length range and mean length of *N. japonicus* and *N. mesoprion* in the catch in each season during different years is depicted in Fig. 11 and 12 respectively.

N. japonicus : At Cochin, the length range of catch is 30-309 mm with variations during different seasons. Larger fishes are caught during monsoon in all years and the mean length is the highest (except during 1984-'85) during monsoon period; the mean length is lowest during postmonsoon period (Fig. 11). At Mangalore, the length range of the species in the catch is 60-289 mm. At Bombay, it is found to be 70-329 mm during the entire period; the mean lengths are (Fig. 11) the highest during postmonsoon period and the lowest in the monsoon months. At Veraval, the length range during the entire period is 30-309 mm; the average lengths are larger in premonsoon period during first two years and in the postmonsoon period during later period (Fig. 11).

N. mesoprion: At Cochin, as in the case of *N. japonicus*, the highest mean length is recorded in the monsoon period and the lowest during postmonsoon months, the length range in the catch in all years being 30-269 mm (Fig. 12). At Mangalore, the specimens in the length range of 70-205 mm constitute the fishery of pre and postmonsoon periods. At Bombay, the length range in the catch is 70-259 mm and there is no definite pattern in the distribution of mean lengths in different seasons during different years and the mean lengths show a very narrow range (Fig. 12). At Veraval, the length range in the catch is 40-299 mm; the highest mean lengths are at 168 mm during premonsoon period in 1984-'85 and at 139 mm during postmonsoon period in 1985-'86. In 1986-'87, the mean lengths are more or less same during both pre and postmonsoon periods, but larger fishes are caught in the latter period.

Spawning

It is known that the spawning period of nemipterid species of India is protracted and that these fishes are fractional spawners (Murty, 1982, 1984; Vivekanandan and James, 1986) like several other Indian marine fishes.

off Mangalore extends from November to April with peak during December-February. As there is no fishing here during monsoon there is no information on spawning during this period. In the sea off Bombay, mature adults are available round the year, but peak spawning appears to take place

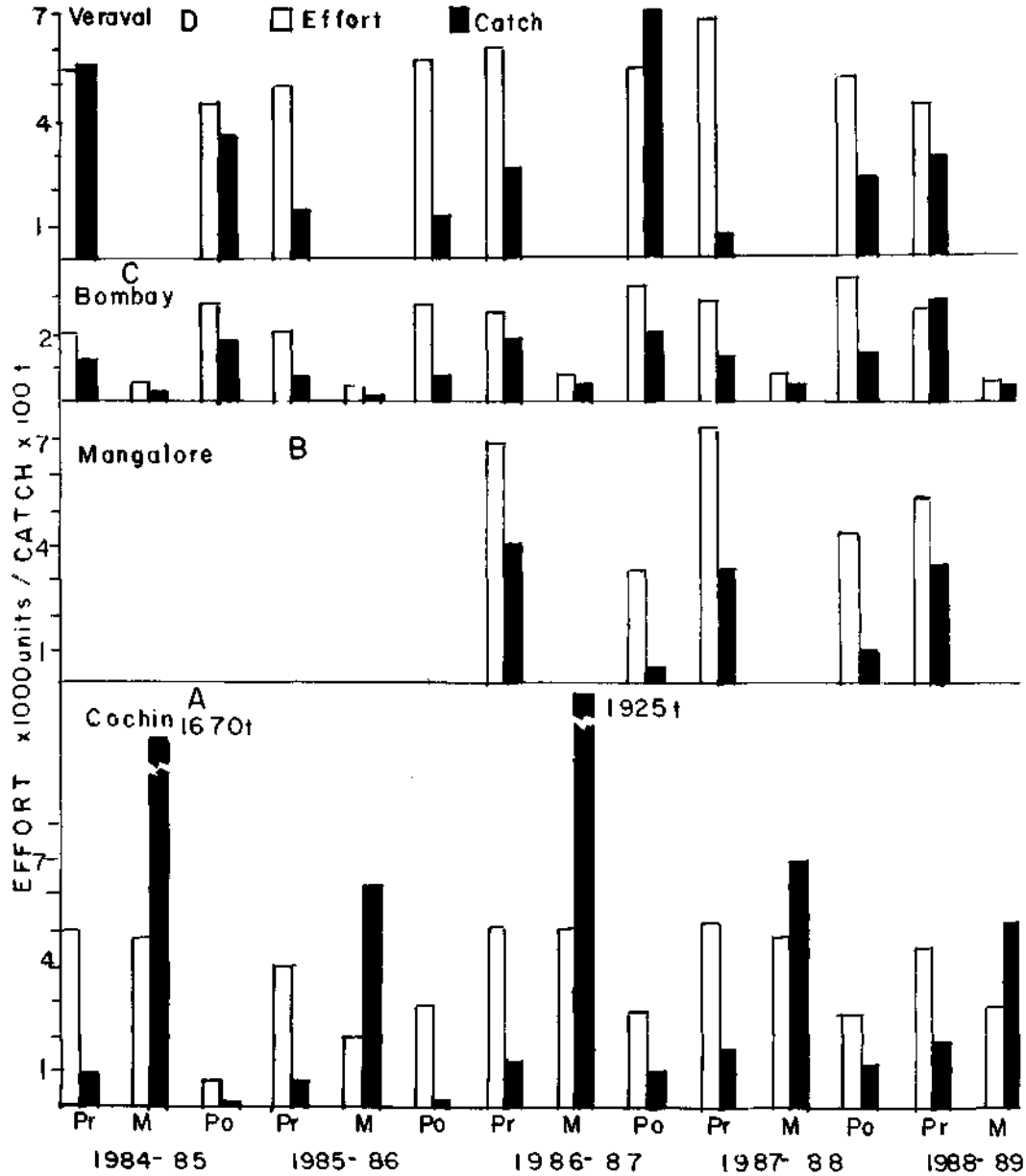

Fig. 7. Estimated effort and catch of threadfin breams during premonsoon (Pr), Monsoon (M) and Postmonsoon (Po) seasons in different years at different centres.

N. japonicus (Fig. 13) : At Cochin gravid adults are observed during monsoon and postmonsoon periods; peak spawning appears to take place in monsoon period. The spawning season in the sea during monsoon. At Veraval there is no fishing during monsoon and spawning appears to take place during pre and postmonsoon periods with peak during latter period.

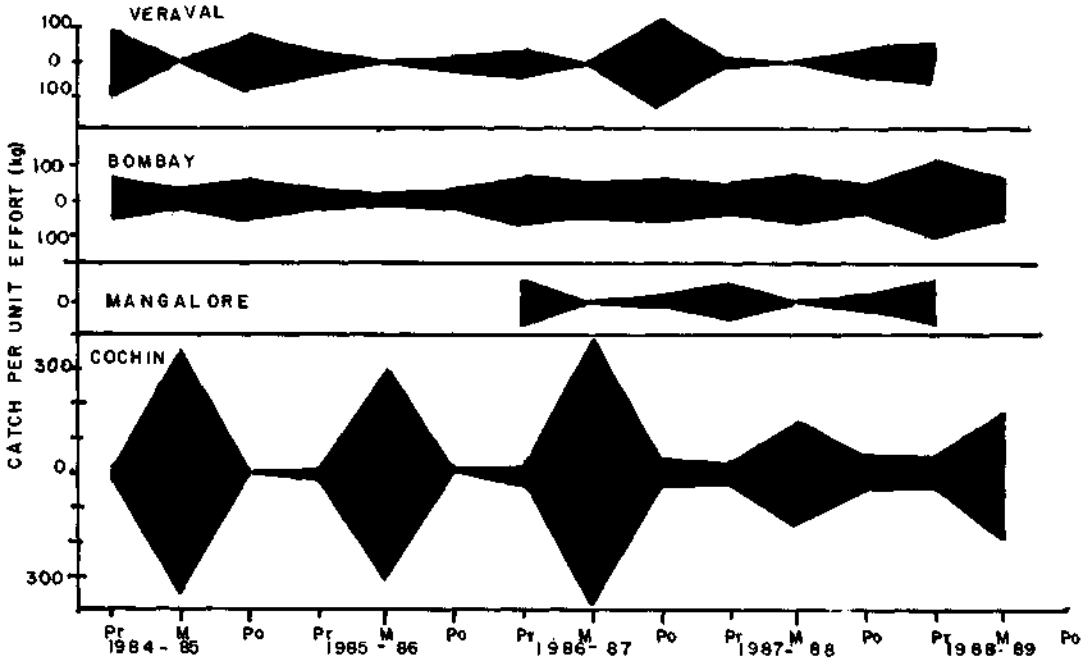

Fig. 8. Estimated catch rates of threadfin breams during different seasons in different years at different centres (Pr : Premonsoon, M : monsoon, Po : Postmonsoon).

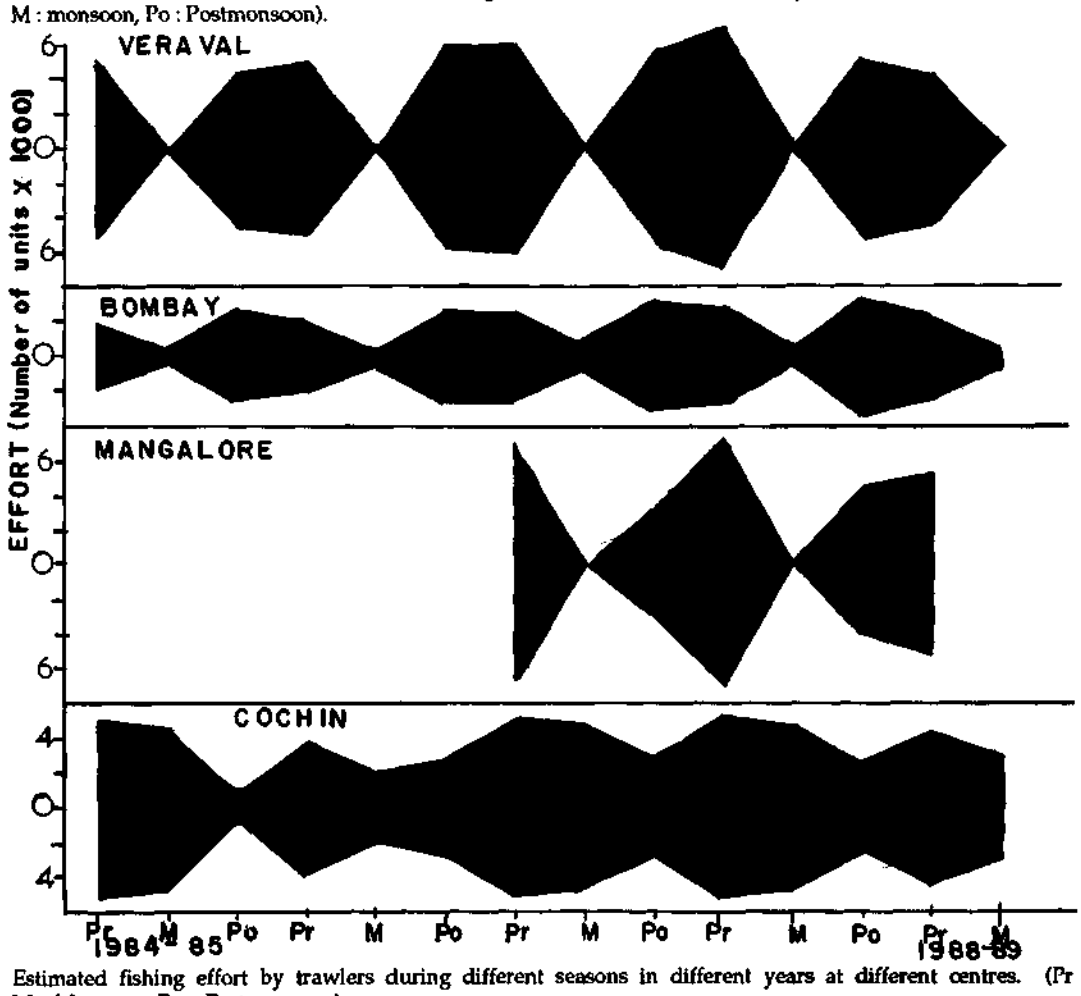

Fig. 9. Estimated fishing effort by trawlers during different seasons in different years at different centres. (Pr : Premonsoon, M : Monsoon, Po : Postmonsoon).

N. mesoprion (Fig. 13) : Off Cochin, this species spawns during monsoon and postmonsoon periods with peak in the latter period. In the sea off Bombay the spawning appears to take place round the year with a peak during monsoon period. At Veraval there is no information during monsoon; spawning takes place during pre and postmonsoon periods with peak during the latter period.

exploited stocks with varied success (Naamin, 1984; Garcia, 1986). Similarly, closure of selected trawling grounds is resorted to protect fish on spawning grounds, those migrating through areas of restricted extent where they are especially vulnerable to capture, to protect young fish on nursery grounds or to prevent or reduce conflicts between fishemen of artisanal and mechanised gears.

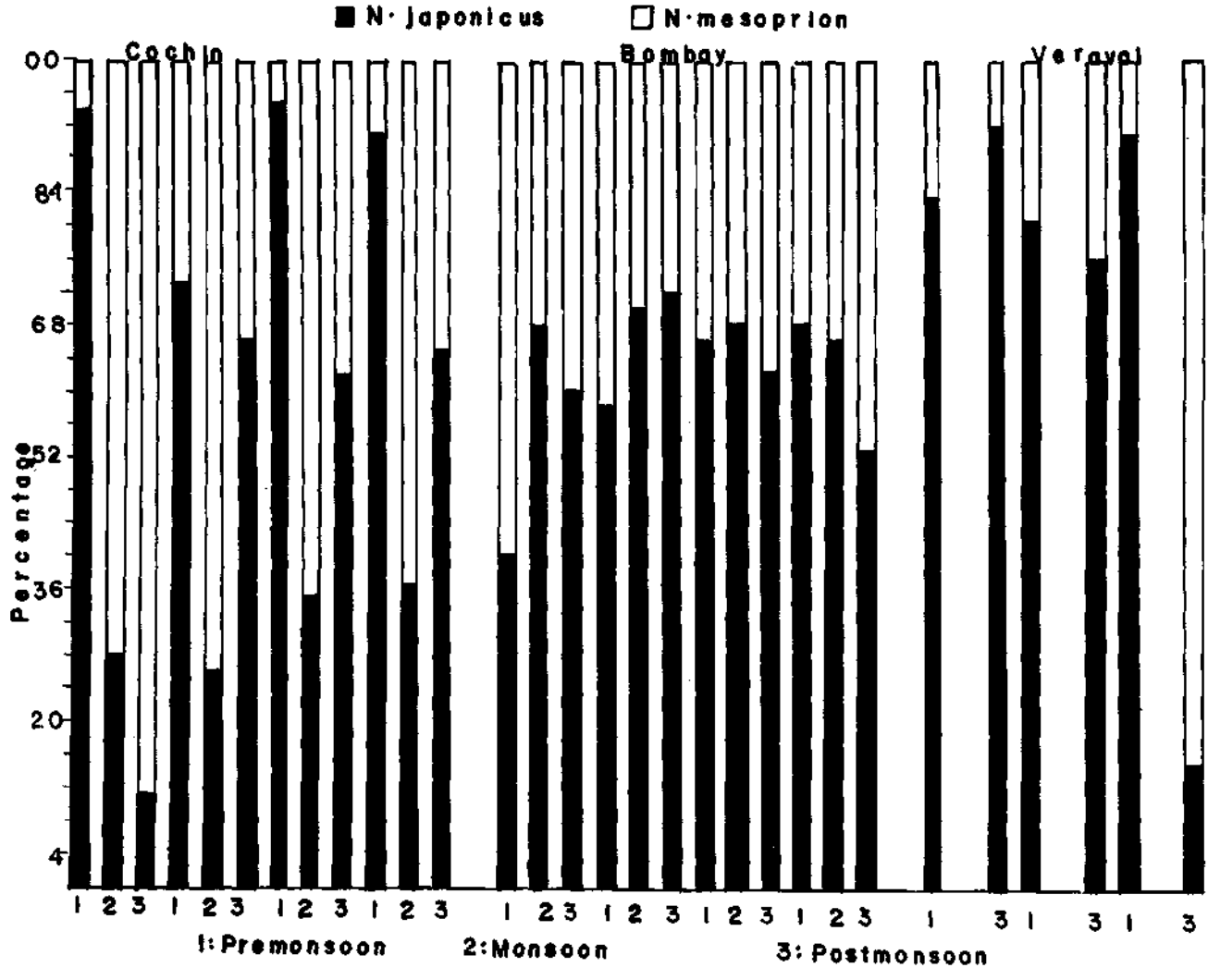

Fig. 10. Percentage composition of *N. japonicus* and *N. mesoprion* in each season in different years at different centres (two more species also occurred, but in very small quantities and therefore ignored in this graph).

Discussion

Closure of certain areas in the sea for fishing and banning fishing during certain seasons are among the important and wellknown methods of management of exploited resources. In the tropics, total or seasonal bans on trawling are known to have been implemented for rebuilding the

The neritic areas in the sea are known to be nursery grounds for a great majority of fishes. According to Rounsefell (1975), though this "area is small in comparison to the area of the waters overlying the deeper ocean, it is the scene of greater share of the world's fisheries and this ranks high in importance" and Garcia (1986) states that "... in most tropical areas, the fish production originates

in the littoral areas where fingerlings become benthic before starting to migrate towards deeper water, growing in size and decreasing in numerical abundance". According to Nagabhushanam (1971), the juveniles of larger fishes which inhabit deeper waters, are most abundant in the shallower regions less than 20 m forming 70% of total catch from within this area. James and Adolph (1971) also made similar observations. In the case of threadfin breams, particularly *N. japonicus*, Nagabhushanam (1971) and Nair and Jayaprakash (1986) observed larger fish in deeper waters and smaller fish in shallower regions. Weber and Jothy (1977) and Pauly and Mortosubroto (1980) found in the nemipterid fishes of South China Sea, a positive correlation between size of fish and depth in which they are caught indicating again that the larger fishes inhabit deeper waters and the smaller fish the shallower regions. The mean lengths of *N. japonicus* and *N. mesoprion* off Cochin are larger during monsoon months (Fig. 11 and 12); this apparently is due to the movement of relatively larger fish from relatively deeper water into shallower areas due to upwelling (*vide infra*). Thus the littoral areas serve as nursery grounds for majority of fish including threadfin breams. Therefore trawling in these areas (even with nets having larger cod end mesh size) destroys large number of young fish which congregate in these areas. Rounsefell (1975) states that closure of such areas is an effective way to prevent destruction of young fish. Further, an undesirable consequence of indiscriminate trawling in the nursery grounds is that, in the long run, the fish become progressively smaller and exploitation tends to be limited to shallower inshore regions as relatively deeper waters do not offer scope for any viable activity. These considerations prompt enforcement of ban on trawling in shallow inshore areas.

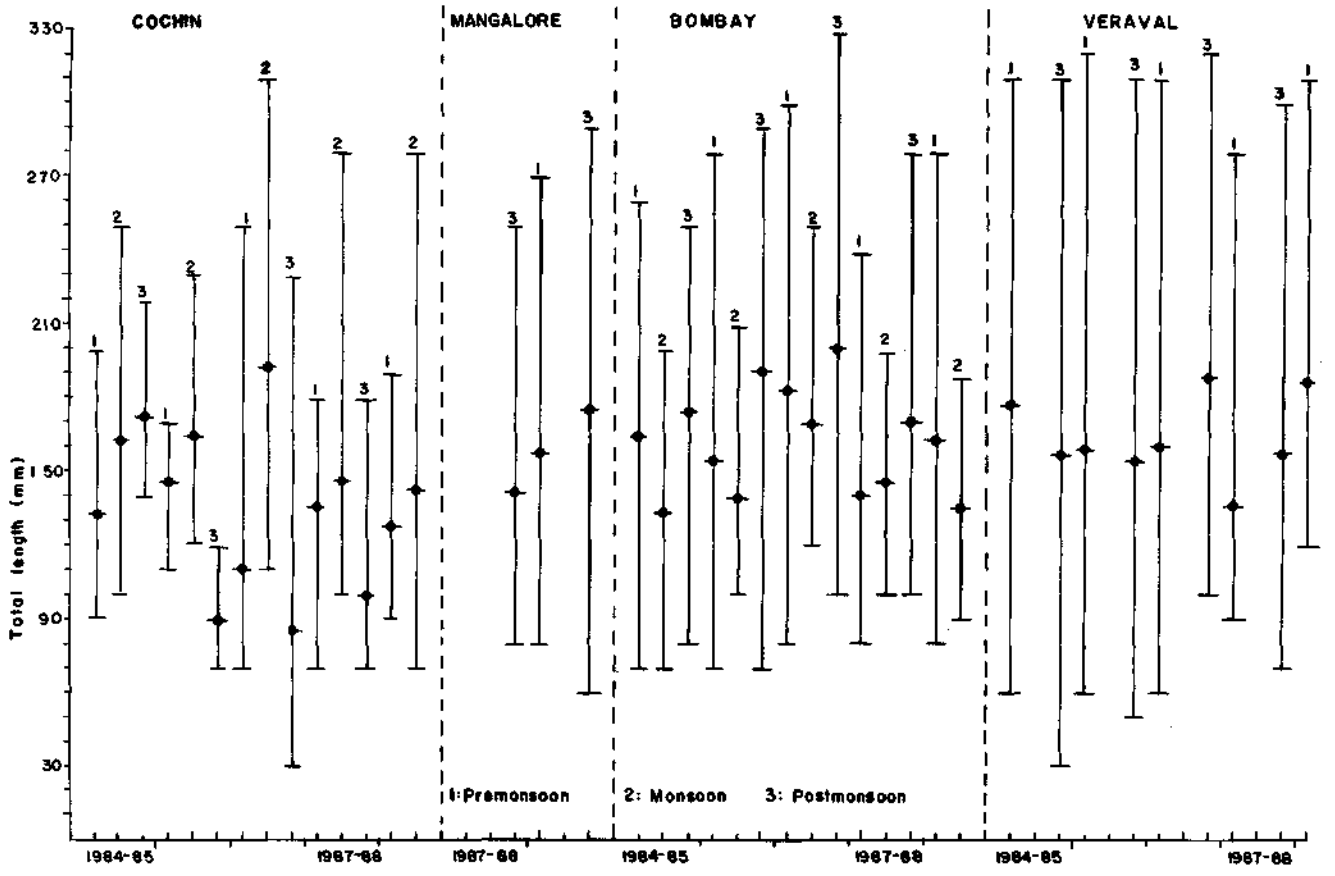

Fig. 11. Length range and mean length of *N. japonicus* during different seasons in each year at different centres (The vertical line shows the length range and the closed circle with a small horizontal line on the vertical line, the mean length).

Implementation of closed seasons in the tropical waters is also an established method of management of resources. According to Garcia (1986), closed seasons "are easily enforceable and, if implemented at the appropriate time of the year, usually produce good results".

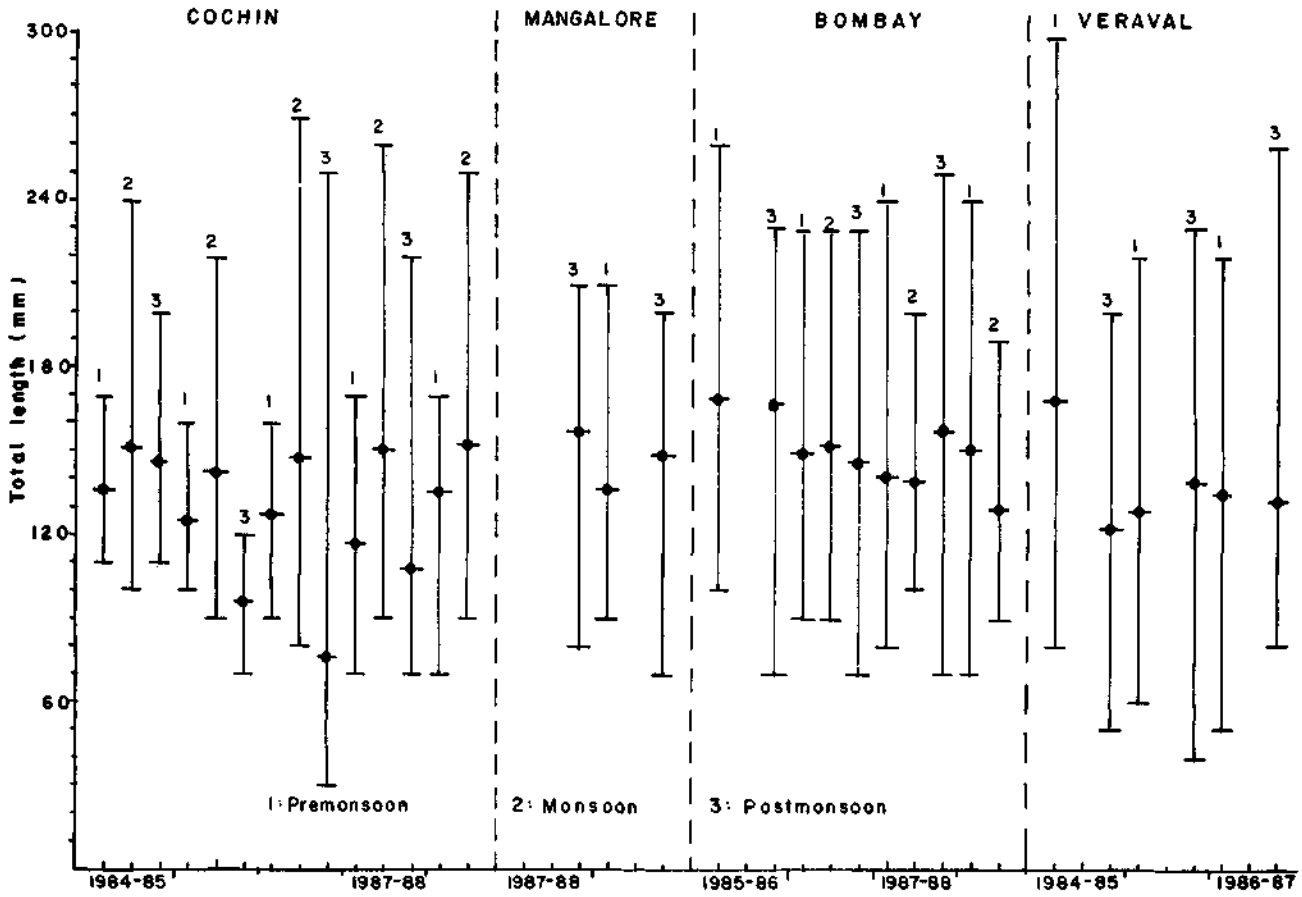

Fig. 12. Length range and mean length of *N. mesoprion* during different seasons in each year at different centres (The vertical line shows the length range and the closed circle with a small horizontal line on the vertical line, the mean length).

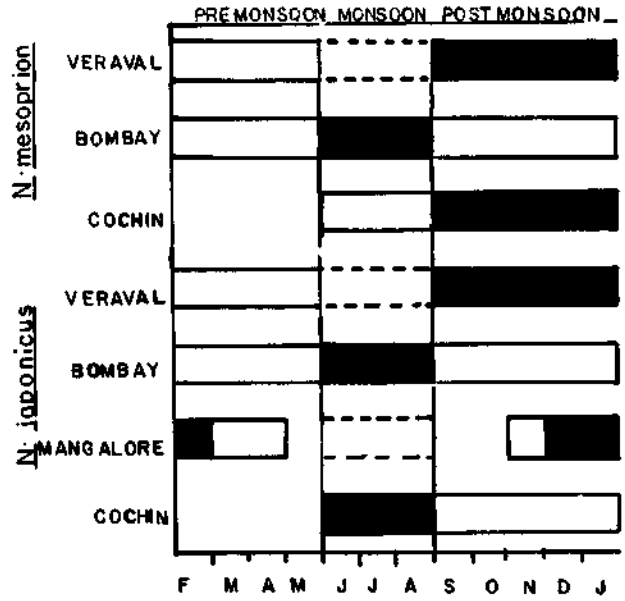

Fig. 13. Spawning periods and peak spawning periods of *N. japonicus* and *N. mesoprion* at different centres (Peak spawning period indicated by black bars; bars with broken lines indicate absence of fishing).

According to Banse (1959) strong upwelling takes place "from 8° to at least 15° N" during the whole southwest monsoon season along the west coast. Further, Banse (1959) observed "towards north the upwelling certainly reaches 15° and perhaps 18° N . . .". According to Rao and Ramamirtham (1976), upwelling takes place in the region between Kanyakumari and Karwar during monsoon period. Thus, upwelling region extends from off Kanyakumari to off southern Maharashtra. This upwelling influences the distribution of demersal fish population along the southwest coast of India (Banse, 1959; Nair and Jayaprakash, 1986). As stated elsewhere in this paper, the threadfin breams are more abundant in relatively deeper waters along the west coast and move into shallower depths of 35-40 m during monsoon to avoid oxygen deficient areas (Nair and Jayaprakash, 1986). Thus the threadfin breams are available in large quantities in intermediate depth zones during

monsoon. The upwelling off Karnataka Coast also is likely to result in such abundance of nemipterids, but there is no fishing in this region during monsoon.

Along Maharashtra Coast the fishing is poor and so also the catches and catch rates (Fig. 4, 8, 9). If there is any movement of threadfin breams into the fishing grounds during monsoon period as comparable to the one off Kerala Coast, one would expect the catch per unit of effort during monsoon to be very high here also, whereas the same is actually less than that in the other periods, indicating poor abundance of threadfin breams in the fishing grounds during monsoon. There is no trawling along Gujarat Coast during monsoon period.

It has been shown that *Nemipterus japonicus* and *N. mesoprion* are the two species that contribute to the bulk of the catches and *N. mesoprion* is most dominant at Cochin during the monsoon period (Fig. 10) and its contribution is very poor during other periods. A similar distribution can be expected along Karnataka Coast also, because of the upwelling in that region during monsoon.

It is known that Indian threadfin breams are fractional spawners having extended spawning periods (Murty, 1982, 1984; Vivekanandan and James, 1986). In the sea off Cochin, *N. japonicus* and *N. mesoprion* spawn during monsoon and postmonsoon periods with peaks during monsoon in the former and during postmonsoon in the latter species (Fig. 13). Since *N. mesoprion* is the principal species during monsoon (Fig. 10), there may not be any problem of recruitment overfishing for threadfin breams off Cochin, because of trawling during monsoon period. The information from Mangalore is rather inadequate. Off Bombay, spawning takes place in all the three periods (Fig. 13) with peak during monsoon in both the species. As the exploitation is very poor (Fig. 4 and 9) during monsoon there is no cause for concern. In the sea off Veraval, both the species spawn during pre and postmonsoon periods with peak during postmonsoon period (Fig. 13). Though there is no fishing during monsoon, there is every reason to expect spawning to take place during monsoon also. It is not possible to state anything about the impact of trawling during monsoon on stocks of threadfin breams off Gujarat as there is no information on distribution pattern of threadfin breams during different seasons and there is also no fishing during monsoon, along this coast. However, "most species in Indian waters, with the exception of a few inwhich seasonal breeding has been clearly established, are continuous breeders . . . " (Qasim, 1973). This is a positive feature and there does not seem to be any cause for concern about recruitment overfishing [provided the condition that the length at first capture (L_c) is maintained above or close to the length at first maturity, is met], because of trawling during a particular season (monsoon).

Seasonal trawling bans in overfished areas are known to give useful results as in the case of demersal fishes along the coast of Cyprus (Garcia, 1986). There is no trawling along Karnataka and Gujarat Coasts during monsoon period and the poor fishing activity during this period along Maharashtra does not offer any scope for concern on whether monsoon trawling should be permitted or not. Along Kerala, the considerable activity during monsoon can be the cause for concern, but the poor exploitation of threadfin breams during pre and postmonsoon months and fractional spawning habits and protracted spawning periods in these fishes can nullify any (if at all) adverse effect of fishing during monsoon on the stock of threadfin breams. This, however, should not lead to complaisance among managers of fisheries resources because :

1. The Indian marine fishes as also the threadfin breams, spawn over extended periods and the inshore areas are nursery grounds for majority of fishes and continued trawling in the littoral waters can lead to undesirable consequences,
2. as in the case of majority of Indian marine fisheries resources, the yields of threadfin breams also have reached levels where further increase in the same does not seem to be possible from the presently fished areas;
3. the demand for even smaller shrimps in the lucrative export markets has led, in almost all areas, to the reduction of the cod end mesh size of trawl nets, the consequence of which is the reduction in length at first capture (L_c). This in its turn can cause recruitment overfishing and collapse of demersal resources over a period of years.

Though the data on hand do not indicate adverse effects of trawling during monsoon on the stocks of the threadfin breams along west coast, closed season for trawling during monsoon can still be considered for implementation, because, in addition to the above reasons, it is known that such a practice will help rebuild the exploited stocks (most of which have almost reached a level where additional production from the present grounds is not possible) and prevent clashes between fishermen of artisanal and mechanised gears.

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References

Anon., 1989. The seafood exporters of India : Face to Face with a calamity. *Seafood Exp. J.*, **21** (8) : 3.

——, 1990. *Annual report 1989-90*. CMFRI, Cochin, 95 pp.

Banse, K. 1959. On upwelling and bottom trawling off the southwest coast of India. *J. mar. biol. Ass. India*, 1 : 33-49.

CMFRI 1989. Marine Fish Production in India - 1985-86. *Mar. Fish. Infor. Serv. T & E Ser.*, **91** : 1-32.

Garcia, S. 1986. Seasonal trawling bans can be very successful in heavily overfished areas : The "Cyprus effect". *Fishbyte*, **4** (1) : 7-12.

James, P. S. B. R. and Clement Adolph 1971. Observations on trawl fishing in the Palk Bay and Gulf of Mannar in the vicinity of Mandapam. *Indian J. Fish.*, 12 : 530-545 (1965).

——, K. Alagarswami, K. V. Narayana Rao, M. S. Muthu, M. S. Rajagopalan, K. Alagaraja and C. Mukundan 1987. Potential Marine Fishery Resources of India. *CMFRI Spl. Pub.*, **30** : 44-74.

Murty, V. Sriramachandra 1982. Observations on some aspects of Biology of threadfin bream *Nemipterus mesoprion* (Bleeker) from Kakinada. *Indian J. Fish.*, **28** : 199-207.

—— 1984. Observations on the fisheries of Threadfin breams (Nemipteridae) and on the Biology of *Nemipterus japonicus* (Bloch) from Kakinada. *Ibid.*, 31 : 1-18.

Naamin, N. 1984. The banning of trawl fishing in Indonesia. Paper presented at the FAO/Australia workshop on management of penaeid shrimps/prawns in the Asia-Pacific regions. *Mimeo Rept.*, 19 pp.

Nagabhushanam, A. K. 1971. A survey of the offshore demersal fisheries of the Andhra and Orissa Coasts, with special reference to the biological data collected during 1960. *Indian J. Fish.*, **13** : 359-379.

Nair, K. V. Somasekharan and A. A. Jayaprakash 1986. A note on the monsoon fishery for threadfin breams off Cochin. *Ibid.*, **33** : 106-112.

Pauly, D. and P. Mortosubroto 1980. The population dynamics of *Nemipterus marginatus* (Cuvier and Val.) off western Kalimantan, South China Sea. *Fish. Biol.*, **17** : 263-273.

Qasim, S. Z. 1973. An apprisal of the studies on maturation and spawning in marine teleosts from the Indian waters. *Indian J. Fish.*, **20** : 166-181.

Rao, D. S. and C. P. Ramamirtham 1976. Seasonal variations in the hydrographic features along the west coast of India. *Ibid.*, **21** : 514-524.

Rounsefell, G. A. 1975. *Ecology, utilization and management of marine fisheries*. The C. V. Mosby Company, Saint Louis. 516 pp.

Silas, E. G. 1969. Exploratory fishing by R. V. *Varuna*. *Bull. Cent. Mar. Fish. Res. Inst.*, **12** : 1-86.

Vivekanandan, E. and D. B. James 1986. Population dynamics of *Nemipterus japonicus* (Bloch) in the trawling grounds off Madras. *Indian J. Fish.*, **12** : 145-154.

Weber, A. and A. A. Jothy 1977. Observation on the fish *Nemipterus* spp. (Family : Nemipteridae) in the coastal waters of East Malaysia. *Arch. Fish. Wise.*, **28** (1) : 9-122.

Zupanovic, S. and S. Q. Mohiuddin 1973. A survey of the fishery resources in the northern part of the Arabian Sea. *J. mar. biol. Ass. India*, **15** : 496-537.

Bull. Cent. Mar. Fish. Res. Inst., 1992, 45 : 169 - 181

4. 9

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : CROAKERS

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Abstract

The monthly as well as seasonal fluctuations in the landings of sciaenids obtained by trawlers and gill nets operated from Veraval, Bombay, Cochin and Calicut landing centres during the period 1984-88 are studied. From Veraval, Bombay and Calicut centres, the catches during the postmonsoon period are better than the premonsoon and monsoon periods, while from Cochin, sciaenid landings during the premonsoon period are more than the monsoon and postmonsoon periods.

At Veraval, peak landings are recorded during February, April and May (premonsoon). *Otolithes cuvieri, Johnius vogleri, J. glaucus, J. dussumieri, O. ruber, O. biauritus* and *Protonibea diacanthus* contributed to the catches. During premonsoon, *O. cuvieri,* mainly of 1 and 2 year age groups, support the fishery. In the postmonsoon fishery, however, juveniles dominate the catch. *J. glaucus* and *O. cuvieri* spawn during the postmonsoon and premonsoon seasons, while *J. vogleri,* spawns during monsoon and postmonsoon seasons. The size at first maturity for *O. cuvieri* and *J. vogleri* is found to be 160 and 168 mm respectively.

At New Ferry Wharf and Sassoon Dock, bulk of the sciaenid landings are recorded during the postmonsoon. *J. macrorhynus, J. vogleri* and *O. cuvieri* contribute to the fishery in all the seasons, but during the monsoon months *N. semiluctosa, D. russelli, P. marcrophthalmus* are also obtained. Juveniles of *J. macrorhynus* are recorded during monsoon. The size at first maturity for *J. macrorhynus* is 160 mm, for *J. vogleri* 159 mm and in *O. cuvieri* 170 mm. *J. macrorhynus, J. vogleri* and *O. cuvieri* at this region are found to breed during monsoon and postmonsoon seasons.

At Cochin, major portion of the catch is registered during the premonsoon, but higher catch rates are recorded during November - December. *J. sina* mainly of 1-year group contributes to the fishery during monsoon, while *K. axillaris* and *O. ruber* of 1-year group during the postmonsoon. The peak spawning season for *J. sina, O. cuvieri* and *K. axillaris* is during premonsoon and postmonsoon.

At Calicut, during 1984-88, there was an increasing trend in the annual landings of sciaenids, However, the CPUE values during 1985-88 showed a decreasing trend.

The abundance of sciaenids in different seasons are correlated with the upwelling and other physical parameters such as oxygen and temperature. Feasibility of monsoon fishing for sciaenids is discussed.

Introduction

Sciaenid fishes, popularly known as Jew fishes or croakers or drummers, form an important group among the exploited marine fishery resources of India. With an estimated average annual production of 102,900 tonnes during 1985-89, they rank sixth in terms of magnitude of the catch in the total marine fish production of the country. They are caught through out year by a variety of gears such as trawl nets, shore seines, boat seines, gill nets and hooks and lines. Often, the population exploited during monsoon months at certain centres is found contributed by smaller specimens. Exploitation of such population, it is apprehended, may adversely affect the sciaenid stocks in the long perspective of time. In this paper, an attempt is, therefore, made to present their fishery characteristics during different seasons, with particular reference to the effect of fishing during monsoon on the resources. For the study, each calender year has been divided into three seasons - premonsoon (February - May), monsoon (June - August), postmonsoon (September - January) periods.

Data Base

Data were collected from private trawlers operating from Veraval, Bombay, Calicut and Cochin bases on effort, catch and speices composition. The length data of the dominant species were processed to find the variation in size during premonsoon, monsoon, postmoon periods.

Observations

Veraval

The commercial trawlers (14 m OAL, fitted with 87-93 H. P. engines) operate shrimp trawl nets, having cod end mesh size of 15-20 mm. These boats conduct daily fishing at a depth of 20-60 m between Mongrol and Diu. Some of the boats conduct fishing for 3-4 days in the distant areas between Jafarabad in the south and Madhavapur in the north. After monsoon season, fishing generally starts by the middle of September and ends in May. However, the boats with outboard and inboard motors operate gill nets throughout the year.

Catch and effort : Monthly variation of sciaenid catches as well as effort from the trawlers during the period 1984-88 is given in Table 1. It is seen that during February-May, peak landings occurred either in February or March. In the remaining period, catches varied from year to year, but generally, October-November was the period when peak landings were recorded. Excepting in 1984, CPUE values showed decreasing trend in the fishery, during February-May. In the postmonsoon fishery, however, the maximum values were recorded during October-December. The seasonwise catch distribution of sciaenids during premonsoon, monsoon and postmonsoon months is depicted in Fig. 1. The premonsoon period was moderately productive with higher catch being realised in 1984 and lower in 1987. During monsoon, the sciaenid catch in trawlers was generally insignificant except in June 1986 and 1987 when a small quantity estimated at 0.4 and 0.9 t respectively was landed. The most productive season for sciaenid fishery at Veraval was the postmonsoon period. Among the different years, highest catch during this season was registered in 1984 and the lowest in 1985.

Monthly variation of sciaenid catches together with effort from the gill nets during the period 1984-88 is given in Table 2. Peak landings were in May and January in 1984-85; February, April and January in 1985-86; February, May and January in 1986-87; March and October in 1987-88 and in May during 1988. During 1984-85, the trends in CPUE values fluctuated with minimum value in February and maximum in March. During 1985-86, maximum value was recorded in April and minimum in August. In 1986-87, maximum values were in February and May and minimum in September and November. During 1987-88, maximum and

Table 1. *Estimated monthly effort (units), catch (tonnes) and catch rates (kg) of sciaenids landed by trawlers at Veraval during 1984-88*

Month	1984-85			1985-86			1986-87			1987-88			1988		
Season	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE
February	3977	760.4	191	4396	1289.0	293	4295	1012.5	236	6561	623.9	95	3942	750.5	190
March	5640	2190.6	388	6394	961.8	150	5518	1409.6	256	6334	435.2	69	4968	1070.7	216
April	7713	1620.3	210	6685	945.1	141	8119	648.0	80	6140	357.9	58	4787	514.4	108
May	4090	690.4	169	2125	54.0	25	6460	321.0	50	8093	388.1	48	3904	248.0	64
June	-	-	-	-	-	-	35	0.4	12	366	9.9	27	-	-	-
July	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
August	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	2114	438.6	208	-	-	-	2982	617.9	207	4715	722.9	153			
October	5500	1508.2	274	4825	692.3	144	6069	767.4	126	6309	1305.2	207			
November	4527	1097.5	242	5503	1059.2	193	6786	1020.1	150	5200	927.9	178			
December	5494	2285.8	416	6081	794.7	131	4763	291.6	61	4478	683.3	153			
January	4245	760.7	179	6062	745.5	123	6390	820.7	128	4866	1156.7	238			
Total	43300	11352.5	262	42071	6541.6	155	51417	6909.2	134	53062	6611.0	125			
Premonsoon	21420	5261.7	246	19600	3249.9	166	24392	3391.1	139	27128	1805.0	66	17601	2583.6	147
Monsoon	-	-	-	-	-	-	35	0.4	12	366	9.9	27	-	-	-
Postmonsoon	21880	6090.8	278	22471	3291.7	147	26990	3517.7	130	25568	4796.0	188			

minimum values were recorded in March and October respectively. During February-May of 1988, CPUE values showed an increasing trend, in June-August of the same year, although they were at higher levels, decreased from 21 kg/unit in June to 11 kg/unit in August. During September - January of 1984-85, 1985-86, the CPUE values showed increasing trend with the highest value in January.

Abundance of sciaenid catch in gill net fishery during premonsoon, monsoon and postmonsoon seasons is shown in Fig. 1. The gill net catches in the premonsoon period in different years showed an increasing trend from 1984 to 1986. In 1987, it decreased only to increase again in 1988. In the monsoon months (June-August) of 1984, the total catch of sciaenids was only 0.3 t. In the subsequent years, it increased gradually to reach the highest catch of 67.5 t in 1988 monson season. Although the sciaenid catch in the postmonsoon period was lower than those in the same period of 1985-86, 1986-87 and 1987-88, it was 150.6 t in 1984-85 when the estimated catch in the premonsoon months was only 81.4 t.

Species composition : The important species contributing to the catches at this centre are *Otolithus cuvieri, Johnius vogleri, Johnius glaucus, J. dussumieri, O. biauritus* and *Protonibea diacanthus*. The percentage contribution of sciaenids in the total catches in the trawlers and gill nets and species composition are shown in Figs.1, 3 and 4 respectively. The percentage contribution of sciaenids in the total fish catch was more during September - December in each year than in the other months. The species such as *O. cuvieri, J. glaucus* and *J. vogleri* were abundant during this period. In the monsoon period, in the gill nets, *P. diacanthus, O. cuvieri* and *O. ruber* mainly contributed to the fishery.

Spawning season : The spawning habits of *J. glaucus, O. cuvieri* and *J. vogleri* were studied by Rao (1985 a, b, c). The spawning period of *J. glaucus* was during December - April and from November - April for *O. cuvieri*. *J. vogleri* exhibited two spawning seasons, one during June-July and the other from october to December.

Size distribution : The size distribution of *O. cuvieri* obtained by trawl nets in different seasons during 1984-85 is given in Table 3. During the premonsoon, fishes of size range 125-365 mm, consisting of mainly 1 and 2 year groups, contributed to the fishery while during the postmonsoon seasons, particularly in October and November, juveniles and smaller fishes of size range 75-115 mm, along with adults (0, 1, 2 year) supported the fishery.

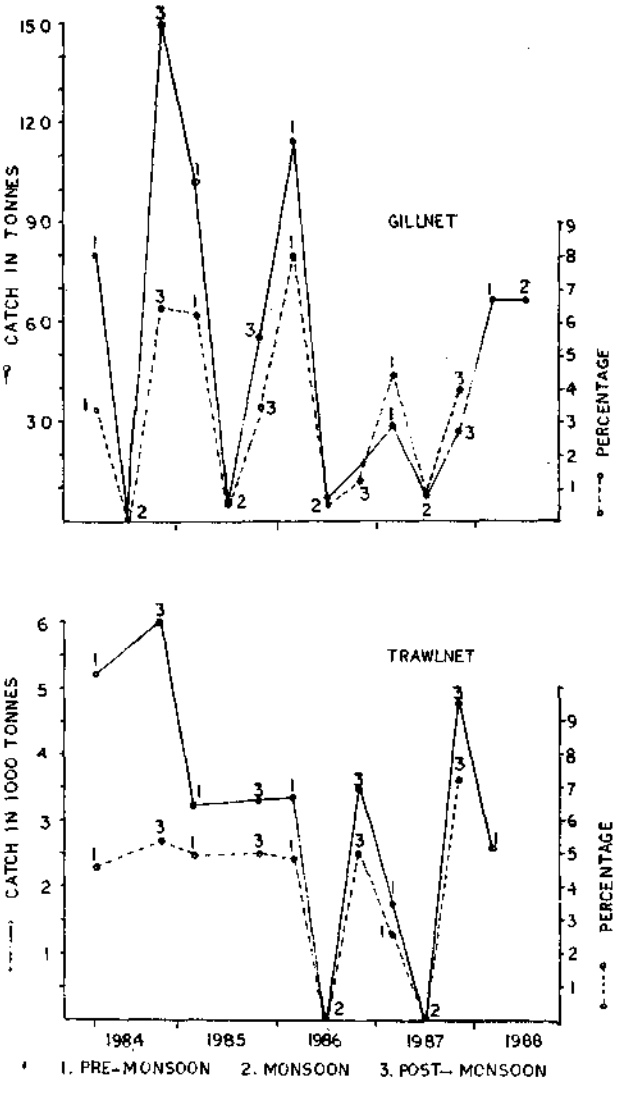

Fig. 1. Seasonal abundance of sciaenids from the trawlers and gill nets during 1984-88 at Veraval.

Size at first maturity : From the maturity studies made by Rao (1984), it was inferred that *O. cuvieri* and *J. vogleri* attain first maturity at 160 mm and 168 mm respectively.

Bombay

About 400 mechanised vessels for New Ferry Wharf and 350 boats from Sassoon Dock (10.5 m

TABLE 2. *Estimated monthly effort (units), catch (tonnes) and catch rates (kg) of sciaenids landed by gill nets at Veraval during 1984-88*

Month	1984-85			1985-86			1986-87			1987-88			1988		
Season	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE
February	3069	7.4	2	2817	38.2	14	3494	44.2	13	1861	7.9	4	3118	11.5	4
March	4182	14.0	3	3374	19.8	6	2437	4.0	2	3417	10.7	3	2662	9.6	4
April	3125	9.3	3	3717	38.9	11	2522	23.1	9	2967	4.7	2	2882	19.3	7
May	3226	50.7	16	2987	6.9	2	3436	45.0	13	3040	6.8	2	3200	27.1	9
June	12	-	-	860	2.5	3	460	4.8	10	1586	5.9	4	1665	34.4	21
July	92	-	-	588	0.7	1	2257	3.8	2	1962	-	-	369	3.9	10
August	316	0.3	1	2964	0.4	0.1	-	-	-	1976	3.0	2	2633	29.2	11
September	2481	6.0	2	2203	0.8	0.3	1988	0.2	0.1	2475	5.8	2			
October	2394	13.3	6	1837	0.6	0.4	2743	5.7	2	3447	2.0	0.6			
November	3194	30.8	10	2791	12.3	4	3048	0.1	0.1	2874	6.2	2			
December	3387	40.6	12	2674	13.1	5	2083	0.6	0.3	3107	5.6	2			
January	4790	59.9	13	2015	30.0	15	3074	11.5	37	1662	7.9	5			
Total	30268	232.3	8	28837	164.2	6	27542	143.1	5	3.374	66.5	2			
Premonsoon	13602	81.4	6	12895	103.8	8	11889	116.3	10	11285	30.1	3	11862	67.5	6
Monsoon	420	0.3	1	4412	3.6	1	2717	8.6	3	5524	8.9	2	4667	67.5	15
Postmonsoon	16246	150.6	9	11530	56.8	5	12936	18.2	1	13565	27.5	2			

TABLE 3. *Size range and modal lengths of O. cuvieri obtained by trawl nets at Veraval in different seasons during 1984-88*

Season	1984-85		1985-86		1986-87		1987-88	
month	Size range	Modal lengths	size range	Modal lengths	Size range	Modal lengths	Size range	Modal lengths
Premonsoon								
February	125 - 305	155, 205 & 265	155 - 235	185	115 - 365	175 & 295	125 - 205	155 & 175
March	125 - 315	175 & 275	155-325	195	125 - 285	175 & 245	165 - 295	175, 215 & 285
April	145 - 215	175	125 - 365	225, 295 & 325	-	-	-	-
May	175 - 305	215	215 - 325	245 & 295	-	-	-	-
Monsoon								
June	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-
Postmonsoon								
September	185 - 335	235	-	-	185 - 325	235 & 295	-	-
October	105 - 345	135 & 175	75 - 325	145 & 255	115 - 275	195 & 265	-	-
November	105 - 345	185 & 265	105 - 345	145, 165 & 265	105 - 325	135 & 185, 255	-	-
December	115 - 335	155	125 - 325	185, 205 & 255	105 - 345	135 & 305		
January	145 - 355	185 & 275	115 - 315	145	95 - 165	115	115 - 365	135, 255 & 285

OAL, 80-100 H.P. and 4 t fish hold capacity) are employed in the fishery at this region. From New Ferry Wharf, generally, boats go for fishing for 40-60 hrs duration in the fishing grounds extending from Ratnagiri in the south to Dahanu in the north

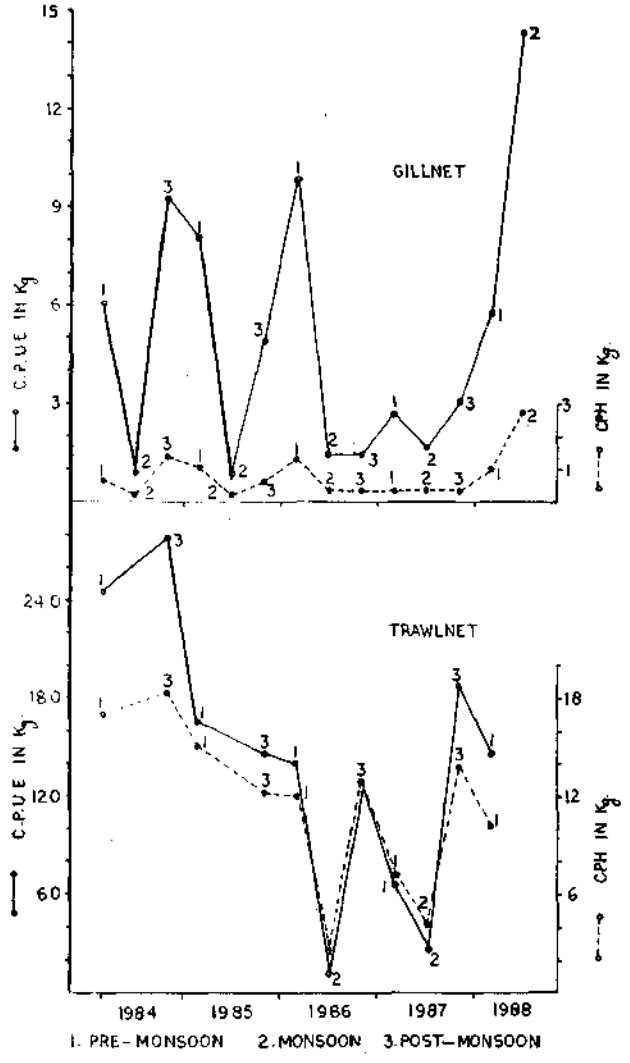

Fig. 2. Seasonal variation of catch per unit effort and catch per hour (kg/hr) values of sciaenids from the trawlers and gill nets during 1984-88 at veraval.

upto a depth 70 m, some of the boats go upto Gujarat Coast. Commonly otter trawl nets of length between 16 and 23 m with cod end mesh size of 20 mm are used. The fishing activity during the monsoon period at the New Ferry Wharf is found to be lean while at Sassoon Dock, it is carried out throughout the year.

Catch and effort : The monthwise catch and catch per unit of effort in respect of sciaenids from the New Ferry Wharf for the period 1984-88 is given in Table 4. In 1984-85, the catches during March-May showed a decreasing trend. With the onset of monsoon in June, the landings declined steeply and remained low upto August. After the monsoon in September, the catches improved considerably and were comparatively high. However, a decreasing trend was observed from October '84 to January '85. Catch per unit values also showed similar trends. In 1985-86, the trends in the catch and catch rates were similar to those of 1984-85, while in 1986-87, the production during February-April showed a decreasing trend and in September-January, a fluctuation between 403 t and 180 t. In 1987-88, the monthly catches during February-September fluctuated, but from October to January showed decreasing trend. Similar fluctuating trends were also seen in the catches of 1988 also. The trends in the CPUE values were more or less same as catch trends.

The monthly variation of catch and rates of sciaenids from Sassoon Dock for the period 1984-88 is given in Table 5.

The peak landings at this centre were recorded usually in February and November while the CPUE values showed wide fluctuations.

Seasonal variation of catch and CPUE values for the period 1984 - 88 from the New Ferry Wharf and Sassoon Dock are given in Tables 4 and 5 respectively. It is seen that both at N. F. Wharf and Sassoon Dock higher landings were registered in the postmonsoon period followed by premonsoon and monsoon periods. Similar trends were observed in the CPUE values also during all the years excepting during 1984-85.

Species composition : Species composition of sciaenids for different seasons during 1984-85 is given in Table 6. Ten species contributed to the fishery, of which *J. macrorhynus*, *J. vogleri* and *O. cuvieri* supported over 70% of the total sciaenid catches at N. F. Wharf in all the seasons. However, during monsoon months *N. semiluctuosa*, *D. russelli* and *P. macrophthalmus* were also found. *J. sina* which was the dominant species till 1986 was replaced by *J. elongatus*.

Size distribution : Size distribution of *J. macrorhynus*, *J. vogleri* and *O. cuvieri* in different seasons shows that during the monsoon season, only smaller fishes of less than 140 mm of

TABLE 4. *Estimated monthly effort (units), catch (tonnes) and catch rates (kg) of sciaenids landed by trawl nets at New Ferry Wharf Jetty during 1984-88*

Month/*Season*	1984-85 Units	Catch	CPUE	1985-86 Units	Catch	CPUE	1986-87 Units	Catch	CPUE	1987-88 Units	Catch	CPUE	1988 Units	Catch	CPUE
February	2338	2630	113	2187	311.3	142	2904	340.5	117	3001	568.6	190	3002	308.3	106
March	2487	319.9	129	2300	382.4	166	2712	290.4	107	3176	558.0	176	2672	314.6	118
April	2208	238.3	108	2195	281.5	128	2638	377.4	143	2762	440.0	159	3143	504.4	161
May	1490	135.7	91	1252	157.0	126	1989	317.3	160	2594	418.8	161	1446	65.3	45
June	310	14.2	46	290	14.1	48	597	69.6	117	595	63.0	106	630	49.6	79
July	279	7.6	27	503	17.5	35	735	70.5	96	477	82.9	174	460	54.3	118
August	877	64.3	73	523	52.9	101	875	135.5	155	837	201.5	241	586	65.3	111
September	3025	447.5	148	3113	300.4	97	2967	668.8	225	3243	673.7	208	-	-	-
October	3627	802.4	221	3025	548.7	181	3451	1389.8	403	3775	895.5	237	-	-	-
November	2455	563.0	229	2271	391.6	172	2782	1115.4	401	3459	723.3	209	-	-	-
December	2142	405.0	189	2633	194.6	74	3116	561.9	180	3379	656.2	194	-	-	-
January	2373	312.2	132	2411	296.4	123	3206	649.3	203	3503	532.4	152	-	-	-
Total	23611	3573.1	151	22703	2948.8	130	27972	5986.4	214	30601	5813.9	189	-	-	-
Premonsoon	8523	956.9	113	7934	1132.6	143	10243	1325.6	129	11533	1685.4	146	10263	1202.6	117
Monsoon	1466	86.1	59	1316	84.5	64	2207	275.6	125	1909	347.4	182	1676	169.2	101
Postmonsoon	13622	2530.1	186	13453	1731.7	129	15522	4385.2	283	17359	3481.1	201	-	-	-

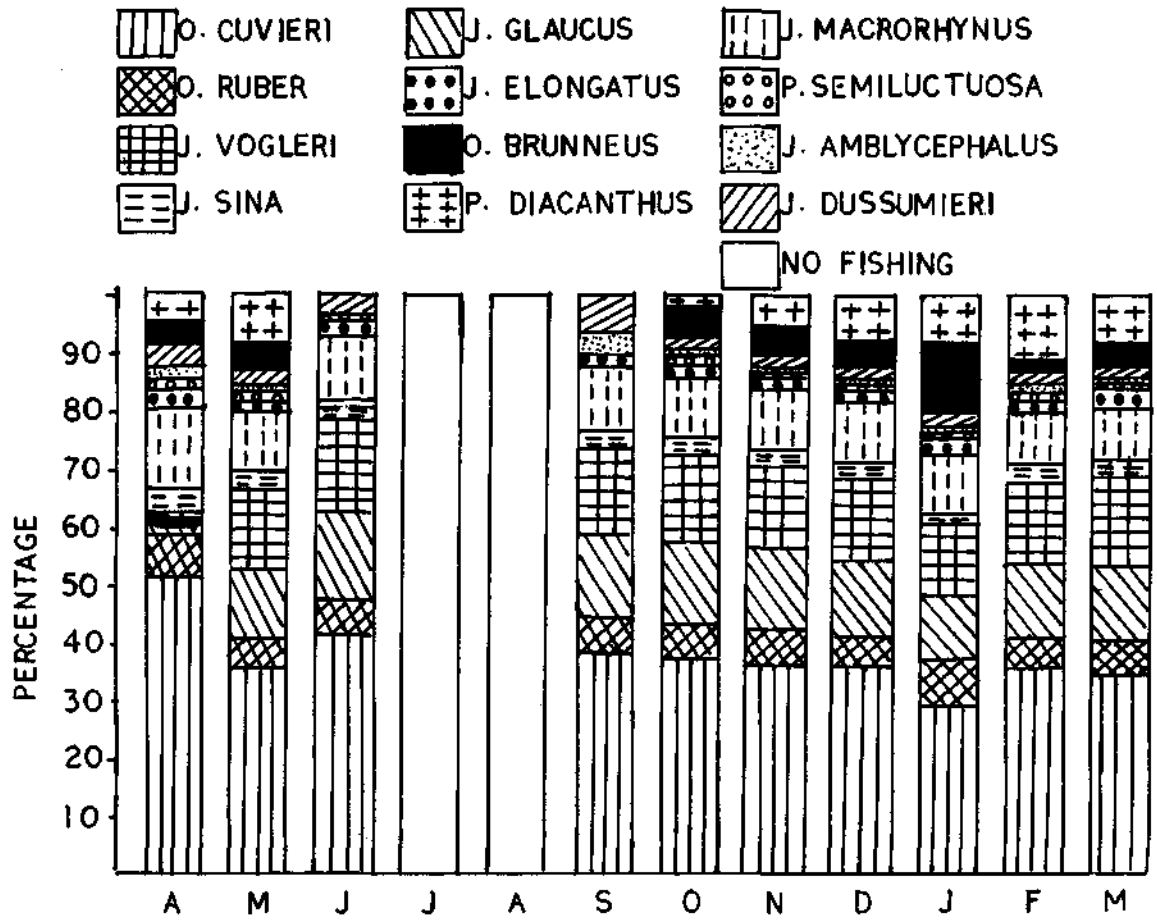

Fig. 3. Species composition of sciaenids from the trawlers during 1984-88 at veraval.

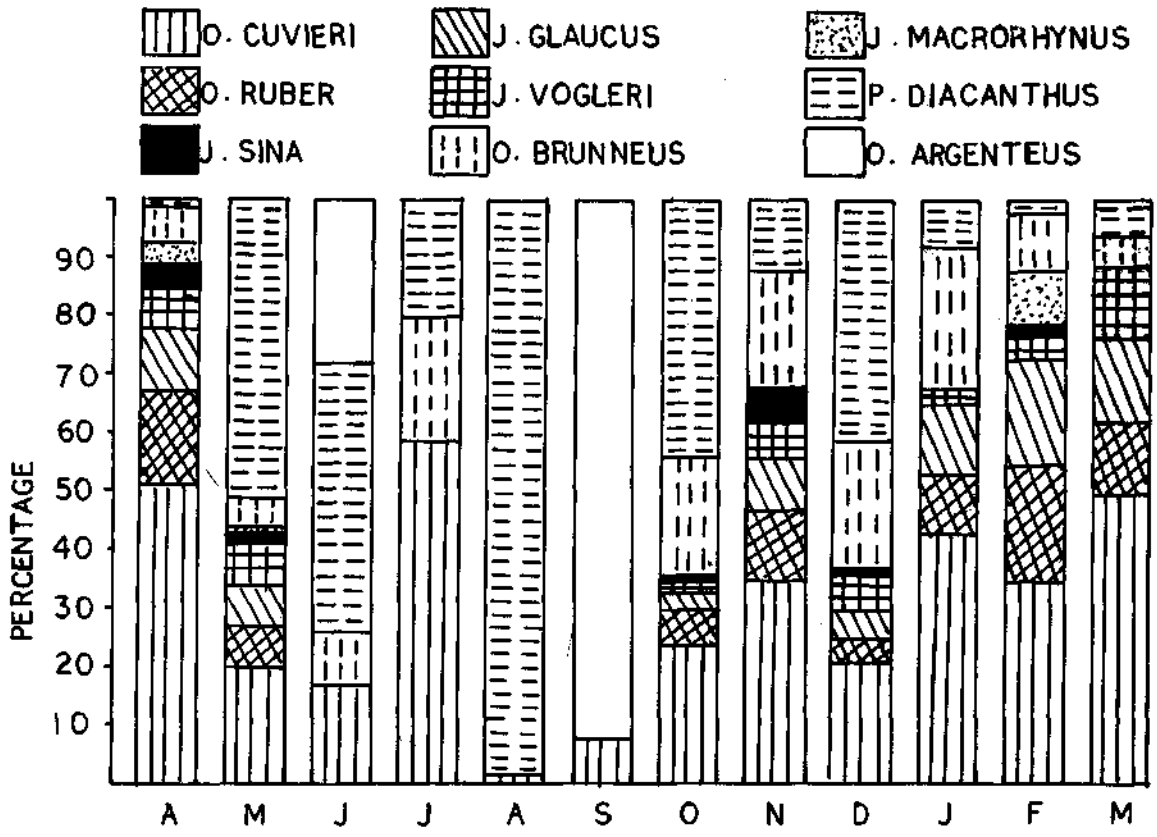

Fig. 4. Species composition of sciaenids from the gill nets during 1984-88 at veraval.

TABLE 5. *Estimated monthly effort (units), catch (tonnes) and catch rates (kg) of sciaenids landed by trawl nets at Sasoon Dock (Bombay) during 1984-88*

	1984-85			1985-86			1986-87			1987-88			1988		
Month/*Season*	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE
February	1510	73.3	49	1897	137.2	72	2051	279.6	136	1515	162.0	107	1618	158.9	98
March	1412	92.1	65	1594	158.6	100	1689	178.8	106	1260	147.8	117	1605	129.7	81
April	1156	72.3	63	2025	134.6	67	1453	159.6	110	1376	113.6	83	1733	109.6	63
May	1829	147.8	81	1538	183.2	90	1741	151.1	87	1802	129.4	72	1977	142.3	72
June	1156	82.8	72	673	105.6	157	969	77.1	80	1115	111.5	100	1687	140.9	84
July	1819	111.9	62	1727	114.5	66	1686	141.1	84	1565	125.7	80	2006	203.2	101
August	1903	108.8	57	1869	195.5	105	1648	159.8	97	1528	101.3	66	2586	213.2	83
September	2173	137.1	63	1880	242.4	129	1642	1689.1	103	1743	145.9	84	-	-	-
October	2276	194.9	86	1439	312.3	217	1776	212.5	120	1359	157.6	116	-	-	-
November	1967	249.6	127	1590	262.5	165	1776	212.5	120	1359	157.6	116	-	-	-
December	1822	195.3	107	1699	230.4	136	1866	249.8	122	1868	2276	122	-	-	-
January	1824	162.3	89	1927	344.1	178	1884	224.2	119	1833	265.9	145	-	-	-
Total	23611	3573.1	151	22703	2948.8	130	27972	5986.4	214	30801	5813.9	189	-	-	-
Premonsoon	5907	385.5	65	7054	613.6	87	6934	769.1	111	5953	552.8	93	6933	540.5	78
Monsoon	4878	303.5	62	4269	415.6	97	4303	378.0	88	4208	338.8	81	6279	557.3	89
Postmonsoon	10062	939.2	93	8545	1391.7	163	8908	1119.7	126	8644	1077.5	125	-	-	-

TABLE 6. *Species composition of sciaenids (tonnes) in differnet seasons at New Ferry Wharf during 1984-88 (Average Values) (Figures in parenthesis indicate individual percentage in total scianid catches)*

Month	*J. macrorhynus*	*J. vogleri*	*O. cuvieri*	*O. ruber*	*J. dussumieri*	*J. elongatus*	*N. semiluctosa*	*D. russelli*	*J. sina*	*P. macrophthalmus*	Total
Premonsoon											
February	71.0 (26.9)	53.7 (20.3)	52.0 (19.7)	11.6 (4.4)	21.6 (8.2)	9.5 (3.6)	6.6 (2.5)	-	21.0 (7.9)	17.1 (6.5)	264.1
March	74.7 (25.3)	57.8 (19.6)	75.8 (25.7)	7.7 (2.6)	10.8 (3.7)	16.4 (5.6)	3.1 (1.1)	0.3 (0.1)	34.5 (11.7)	13.6 (4.6)	294.7
April	77.3 (21.9)	82.6 (23.4)	62.3 (17.6)	22.9 (6.5)	22.8 (6.5)	7.4 (2.1)	14.7 (4.2)	-	32.1 (9.1)	30.8 (8.7)	352.9
May	43.2 (20.8)	41.9 (20.2)	50.2 (24.2)	15.0 (7.2)	15.4 (7.4)	7.6 (3.6)	10.8 (5.2)	0.3 (0.1)	13.7 (6.6)	9.7 (4.7)	207.8
Total	266.2 (23.8)	236.0 (21.0)	240.3 (21.5)	57.2 (5.1)	70.6 (6.3)	40.9 (3.7)	35.2 (3.1)	0.6 (0.1)	101.3 (9.0)	71.2 (6.4)	1119.5
Monsoon											
June	9.4 (21.70	7.7 (17.9)	8.3 (19.2)	0.3 (0.7)	4.8 (11.2)	0.3 (0.6)	1.5 (3.4)	0.7 91.6)	5.4 (12.5)	4.8 (11.2)	
July	11.0 (23.0)	10.1 (21.0)	11.7 (24.4)	0.9 (1.8)	1.7 (3.6)	0.6 (1.3)	2.0 (4.1)	1.4 (2.9)	4.9 (10.2)	3.7 (7.7)	48.0
August	20.5 (20.3)	17.9 (17.8)	25.0 (24.8)	-	7.4 (7.3)	5.3 (5.3)	7.3 (7.3)	3.4 (3.4)	9.3 (9.2)	4.7 (4.6)	100.8
Total	40.9 ((21.3)	35.7 (18.6)	45.0 (23.4)	1.2 (0.6)	13.9 (7.3)	6.2 (3.3)	10.8 (5.6)	5.5 (2.8)	19.6 (10.2)	13.2 (6.9)	192.0
Postmonsoon											
September	133.5 (24.3)	130.6 (23.8)	113.9 (20.7)	44.8 (8.1)	54.4 (9.9)	14.0 (2.5)	8.4 (1.5)	8.4 (1.5)	16.8 (3.1)	25.2 (4.6)	550.0
October	220.4 (25.5)	209.9 (24.3)	185.7 (21.5)	28.8 (3.3)	37.7 (4.4)	-	37.4 (4.4)	17.4 (2.0)	97.7 (11.3)	28.6 (3.3)	863.6
November	139.7 (21.0)	163.4 (2.4.5)	117.8 (17.7)	59.6 (9.0)	37.2 (5.6)	990 (1.3)	14.1 (2.1)	18.8 (2.8)	69.8 (10.5)	36.9 (5.5)	
December	111.2 (24.4)	119.9 (26.4)	98.0 (21.6)	30.4 (6.7)	18.1 (4.0)	8.2 (1.8)	-	4.9 (1.1)	37.9 (8.3)	25.9 (5.7)	454.5
January	81.5 (21.8)	114.7 (30.7)	93.5 (25.0)	17.0 (4.5)	18.0 (4.8)	13.3 (3.6)	6.7 91.8)	-	21.1 (5.7)	7.8 (2.1)	373.6
Total	686.3 (23.6)	738,5 (25.4)	608.9 (20.9)	180.6 (6.2)	165.4 (5.7)	44.5 (1.5)	66.6 (2.3)	49.5 (1.7)	243.3 (8.4)	124.4 (4.3)	2908.0
* Grand total	993.4 (23.5)	1010.2 (23.9)	894.2 (21.2)	239.0 (5.7)	249.9 (5.90	91.6 (2.2)	112.6 (2.7)	55.6 (1.3)	364.2 (8.6)	208.8 (5.0)	4219.5

* Total for 3 seasons (Premonsoon, Monsoon and Postmonsoon).

J. macrorhynus were recorded, while adults of *J. macrorhynus, J. vogleri* and *O. cuvieri* contributed to the fishery during other seasons.

Size at first maturity : From the maturity studies conducted on three important species, Chakraborty (1988) showed that in *J. macrorhynus*, the size at first maturity is 160 mm, for *J. vogleri* and *O. cuvieri* the sizes are found to be 159 mm and 170 mm respectively. Muthiah (1982) observed that *J. vogleri* attained maturity at 159 mm.

Spawning : Chakraborty (1988) indicated that ripe specimens of *J. macrorhynus* were found during June-August and November-December and spent ones during June-July and November-December. Ripe and spent specimens of *J. vogleri* were observed during June - July and November - December. For *O. cuvieri*, ripe females were encountered during May - July and November - December and spent ones during June-July and in December. He further indicated the possibility of two breeding seasons - one during monsoon period and other during postmonsoon period.

Cochin

The commercial trawlers based at this centre are of 28-32′ OAL and generally operate within 45-50 m depth region. Undertaking daily fishing they take 2-3 hauls each of about 2 hours duration and return to the landing centre in the evening.

Catch and effort : The estimated fishing effort, catch and catch rates of sciaenids for the period 1984-85 to 1988-89 are given in Table 7. During 1984-85, the effort increased from 4561 units in February to 5050 units in May, while in the other months it fluctuated from 1010 to 4916. As in 1984-85, the effort in 1985 - 86 showed increasing trend from February to April and again from November to January. The catches were also seen fluctuating in all the years except during November-December of 1984-85, 1985- 86; September-January of 1987-88 when it showed an increasing trend.

The seasonal variation of effort, catch and catch rates of sciaenids for the period 1984-88 is given in Table 7. During 1984-88, the average annual estimated effort was 39404 units. Maximum effort (46943 u) was expended during 1987-88 and minimum of 30344 u in 1985-86. Maximum number of trawlers was operated during premonsoon (Average : 18,600 u) forming more than 47% of the annual trawling effort. It was observed that the effort expended during the monsoon was moderate, while the number of units operated during the postmonsoon period was comparatively less (9105 u) forming 23% of the annual effort.

The average annual landings of sciaenids was about 616 t during the period 1984-88. The annual sciaenid catches increased from 390.6 (1984-85) to 717.6 t (1987-88). During 1984-85, peak landings were obtained during premonsoon period followed by monsoon period. In 1985-86, 468 t of sciaenids which formed 81.6% of annual sciaenid catches were obtained during premonsoon period while during postmonsoon and monsoon seasons, they contributed to 13.4% and 5.0% respectively. During 1986-87 bulk of the catches were obtained during premonsoon period (40.2%) followed by postmonsoon (30.3%) and monsoon periods (29.6%). But during 1987-88, 46.7% of sciaenid catches were realised during the postmonsoon. This was followed by monsoon when 34.2% of sciaenid catches were obtained. Thus better catches were landed during the premonsoon period (about 49.3%) followed by monsoon (30.1%) and postmonsoon (20.6%) periods.

As in the case of catches, the catch rates ranged from 10 kg/u (1984- 85) to 19 kg/u (1985-86) with an average value of 15.6 kg/u. It was during the postmonsoon period of 1984-85, highest catch rate (31.9 kg/u) followed by monsoon (4.7 kg/u) and premonsoon (4.7 kg/u) was registered. During 1985-86 highest catch rate was recorded in premonsoon(30.3 kg/u) followed by postmonsoon (8.9 kg/u) and monsoon period (4.7 kg/u). Again during 1986-87 and 1987-88 the highest catch rate was observed in postmonsoon followed by monsoon and premonsoon periods. In general, the postmonsoon period recorded highest catch rates, followed by premonsoon and monsoon periods.

Species composition : Different species that contributed to the fishery are given in Table 8. In 1986-87, during the premonsoon period, *J. sina* (63.4%) was the principal species supporting the fishery, besides *O. ruber* (15%) and *K. axillaris* (14.4%). In the monsoon period, *J. sina* was the predominant species constituting 85.5% of the catches while *O. cuvieri* and *K. axillaris* contributed to 9.5% and 2% respectively. During the postmonsoon period, *K. axillaris* formed 73% while *J. sina* 21.9%. Thus

TABLE 7. *Estimated monthly effort (units), catch (tonnes) and catch rates (kg) of sciaenids landed by trawl nets at Cochin during 1984-88*

	1984-85			1985-86			1986-87			1987-88			1988		
Month/*Season*	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE
February	4561	53.0	12	3512	105.4	30	4919	71,3	14	3259	40.0	12	4146	126.6	31
March	4565	56.6	12	4025	148.2	37	3553	40.2	11	3980	28.8	7	5141	117.1	23
April	4779	22.1	5	4327	102.1	24	5184	59.6	12	5554	38.6	7	3730	104.0	28
May	5050	31.1	6	3594	113.0	31	6681	102.2	15	6900	28.7	4	4895	206.0	42
June	4373	9.1	2	3531	26.3	7	6585	198.8	30	6081	121.0	20	5445	55.0	10
July	4916	17.3	4	2320	1.2	1	5218	2.4	0.4	5372	122.0	23	772	6.0	8
August	3803	-	-	359	0.2	1	3115	-	-	2984	3.0	1	2629	39.0	15
September	-	-	-	-	-	-	235	-	-	390	3.0	7	-	-	-
October	-	-	-	-	-	-	-	-	-	1676	18.3	11	-	-	-
November	1010	25.5	25	234	3.8	16	3109	11.9	4	3298	55.6	17	-	-	-
December	2652	48.1	18	3852	27.2	7	2889	135.6	0.5	3820	103.9	27	-	-	-
January	2332	79.7	34	4590	46.4	10	4683	57.9	12	3629	154.7	43	-	-	-
Total	38041	390.6	10	30344	573.8	19	46171	679.9	15	46943	717.6	15	-	-	-
Premonsoon	18955	162.8	9	15458	468.7	30	20337	273.3	13	19693	136.1	7	17912	553.7	31
Monsoon	13092	26.4	2	6210	27.7	5	14918	201.2	13	14437	246.0	17	8846	100.0	11
Postmonsoon	5994	153.3	26	8676	77.4	9	10916	205.4	19	12813	335.5	26	-	-	-

TABLE 8. *The estimated species composition by weight of sciaenids (tonnes) at cochin during 1986-89 (percentage in parenthesis)*

	J. sina	*J. dussumieri*	*O. ruber*	*O. cuvieri*	*K. axillaris*	*J. carutta*	*J. macrorhynus*	Others
1986-87								
Pre monsoon	165	-	41	6	39	14	8	-
	(60.4)	-	(15.0)	(2.2)	(14.4)	(5.1)	(2.9)	
Monsoon	171	-	6	19	4	-	-	-
	(85.5)		(3.0)	(9.5)	(2.0)			
Postmonsoon	45	-	5	-	150	5	-	-
		(21.90	(2.4)		(73.3)	(2.4)		
1987-88								
Premonsoon	86	-	19	7	9	12	1	2
	(63.2)		(14.2)	(5.1)	(6.6)	(8.8)	(0.7)	(1.4)
Monsoon	177	16	31	4	6	6	1	1
	(72.8)	(6.5)	(13.5)	(1.6)	(2.4)	(2.4)	(0.4)	(0.4)
Postmonsoon	102	47	73	1	45	60	-	4
	(30.7)	(14.1)	(22.2)	(0.3)	(13.5)	(18.0)		(1.2)
1988-89								
Premonsoon	270	35	84	18	84	57	3	2
	(48.8)	(6.3)	(15.2)	(3.3)	(15.2)	(10.4)	(0.5)	(0.3)
Monsoon	68	2	10	1	13	-	-	1
	(71.5)	(2.1)	(10.5)	(1.0)	(13.9)			(1.0)
Average								
Premonsoon	174	12	48	10	44	28	4	1
	(54.2)	(3.7)	914.9)	(3.1)	(13.7)	(8.9)	(1.2)	(0.3)
Monsoon	139	6	16	8	8	2	1	1
	(76.7)	(3.3)	(8.8)	(4.4)	(4.4)	(1.9)	(0.6)	(0.6)
Postmonsoon	73	24	39	1	98	33	0	2
	(27.0)	(8.8)	(14.4)	(0.3)	(36.7)	(12.2)		(0.6)

it is seen that *J. sina* mainly contributed to the catches both during the premonsoon and monsoon periods while *O. ruber* occupied the second position during the postmonsoon period.

Size composition : In 1986-87, in the premonsoon months *J. sina* of 125-135 mm along with the juveniles (75-90 mm) dominated the catch while in the monsoon period, the fishes with dominant modal size at 130 mm contributed to the fishery. Similar size distribution pattern was observed in the fishery of 87-88. In 1988-89, *J. sina* of modal length 100, 115 and 130 mm, and during the monsoon one year old fish of 130 mm modal size contributed to the fishery. Thus during the period under review, it is seen that fishes of the size range 110-140 mm dominated the catches both during premonsoon and monsoon periods while during the postmonsoon period juveniles also contributed to the fishery.

Maturity : The seasonal abundance of mature fishes of *J. sina* during premonsoon, monsoon and postmonsoon seasons for the period 1986-87 to 1987-88 is given in the Table 9. The percentage occurrence of gravid and spent fishes in different seasons indicated prolonged spawning nature of the species.

Calicut

At Calicut, trawlers are operated throughout the year excepting during June-September. The catch details of sciaenids landed by trawlers in different years are given in Table 10. The total effort expended in 1984-85 was 3646. There was an increasing trend from 3597 to 4418 in the subsequent years although the catch as well as CPUE values showed decreasing trend except in 1987-88.

Catch and effort : The monthly variation of catches and catch rates during the period 1984-88 is given in Table 10. No definite trends can be observed either in the catches or catch rates in any year. Seasonal variation of sciaenids in different years (Fig. 5 & 6) showed that during premonsoon period the catches ranged from 1.7 t (1988) to 12.3 t (1985). Similar trend was seen in CPU values with mini-

TABLE 9. *Sex ratio and the gonadial condition of the females of* Johnieops sina *for the period 1986-87 to 1988-89*

Sex ratio/maturity		Season: Premonsoon No.	%	Monsoon No.	%	Postmonsson No.	%
Male		144	47.2	110	41.9	119	52.6
Females		161	52.8	152	58.1	152	47.4
Immature	I	16	9.9	35	23.0	10	9.3
	II	22	13.7	20	13.1	31	28.9
Resting	II	5	3.1	30	19.7	21	10.6
Developing	III-IV	58	36.0	13	8.5	18	16.8
Gravid	V-VI	28	17.4	29	19.0	12	11.2
Spent	VII	32	19.9	25	16.7	15	14.2
Total		305		262		226	

TABLE 10. *Estimated monthly effort (units), catch (tonnes) and catch rates (kg) of sciaenids landed by trawl nets at Calicut during 1984-88*

	1984-85			1985-86			1986-87			1987-88			1988		
Month/*Season*	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE	Units	Catch	CPUE
February	457	4.2	9	628	4.6	7	580	4.0	7	4009	4.9	5	414	1.3	3
March	305	2.5	8	764	7.2	9	700	2.6	4	555	0.7	1	128	0.3	3
April	412	0.9	2	460	0.4	0.9	505	3.1	6	197	0.4	2	8	0.02	3
May	638	0.3	0.5	212	0.1	0.5	332	0.04	0.1	547	0.6	1	49	-	-
June	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	352	0.6	2	-	-	-	-	-	-	-	-	-	-	-	-
November	483	7.6	16	403	2.2	5	192	1.6	9	463	0.6	1	-	-	-
December	358	0.03	0.1	477	5.9	12	665	5.9	9	938	14.9	16	-	-	-
January	641	22.1	35	653	7.2	11	1046	5.0	5	709	14.6	21	-	-	-
Total	3646	38.2	10	3597	27.6	8	4029	22.2	6	4418	36.7	8	-	-	-
Premonsoon	1812	7.9	4	2064	12.3	6	2117	9.74	5	2308	6.6	3	599	1.62	3
Monsoon	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-
Postmonsoon	30.33	16	1533	15.3	10	1903	12.5	7	2110	30.1	14	-	-	-	-

mum of 2.8 kg/u and maximum of 5.9 kg/u 1988 and 1985 respectively. During June-September, no trawlers were operated as the fishing was suspended during these months. The catches during the postmonsoon period in general were comparatively better than the premonsoon period. However during 1984-85 to 1986-87 the catches decreased from 30.4 to 12.6 t, but subsequently increased to 30.1 t. The catch and catch rates followed a similar trend as the maximum CPU of 16.6 kg/u and minimum of 6.6 kg/u were recorded in 1984 and 1986 respectively. Further a secondary peak of 14.3 kg/u was recorded in 1987.

Discussion

Maximum catches as well as highest CPUE values were recorded in 1984-85 and during the subsequent years they decreased. It was also seen that total catches of 'all fishes' was also maximum during 1984-85. The catches from gill nets were comparatively less, but they contributed to the fishery to a great extent during monsoon. In the gill nets, as in the case of trawlers, during 1984-85 to 1987-88, the sciaenid catches as well as CPUE values decreased gradually, but higher landings were recorded generally during February, April and May. The percentage composition of different species of sciaenids in the monsoon season varied from the other seasons since larger species such as *P. diacanthus* and *O. biauritus* contributed to the gill net catches to greater extent.

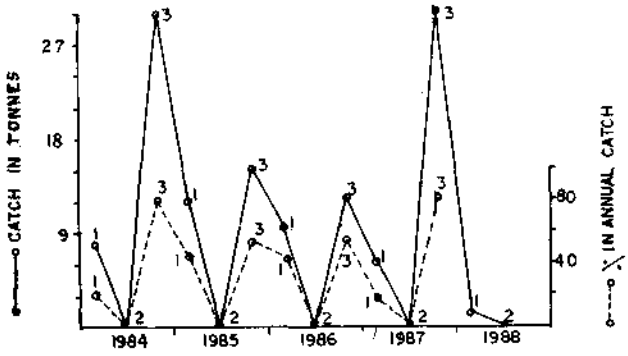

Fig. 5. Seasonal variation of sciaenid catches at Calicut during 1984-88.

At Bombay, New Ferry Wharf landing centre contributed to 65% of total sciaenid catches. Higher catch rates were also observed at this centre. From Sasoon Dock, as in N. F. Wharf, bulk of the landings were obtained during postmonsoon. This might be due to the fact that after the monsoon when normal conditions in the sea prevail, the number of trawlers and the effort expended is increased leading to higher yield of sciaenids particularly during November-December.

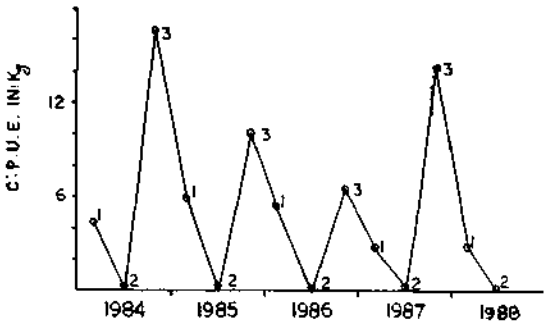

Fig. 6. Seasonal variation of catch per unit effort values (CPUE) of sciaenids during 1984-88 at Calicut.

It is reported that along the Bombay Coast, peak spawning season for the major species of sciaenids is during the monsoon period. Thus there is every possibility that high percentage of ripe and mature fish would be caught if trawling is conducted during monsoon period particularly with shrimp trawl net. Further some species like *D. russelli* and *N. semiluctosa* are seasonal and occur only during the monsoon. Besides, higher percentage of immature sciaenids are also caught during the monsoon months. It is, advisable that the fishes below the size of first maturity are not exploited so as to give them a chance to grow and breed to contribute to the process of recruitment.

At Cochin the bulk of the landings were recorded during the premonsoon period followed by postmonsoon and monsoon seasons. However, the highest catch rates were noticed during the postmonsoon period particularly during November-December. *J. sina* mainly of 1-year age group contributed to the fishery during monsoon. During the postmonsoon, *K. axillaris* and *O. ruber* dominated the catches. The peak spawning period for the common species of sciaenids was found to be during premonsoon and postmonsoon seasons and shrimp trawling operations during the monsoon was opined to be not adversely effecting the spawning stock. The abundance of sciaenids and rainfall at Cochin did not show any relationship between them.

From the exploratory surveys conducted along the Kerala Coast, it is known that during the

monsoon *J. sina, O. cuvieri* and *K. axillaris* occur in inshore areas where the shrimp trawlers conduct fishing for prawns, threadfin breams and lizard-fishes. Although fishing during monsoon along this coast appears to be profitable, it must be ensured that the trawling should be restricted beyond 20 m depth as envisaged in the Kerala Marine Fishing Act so as to avoid conflicts with the local fishermen who operate artisanal gears. It may be noted that the artisanal fishing sector which contributes to about 2110 t or 25.7% of annual sciaenid catches of the State conducts fishing during monsoon within 20 m depth zone.

Along the Karnataka, Maharashtra and Gujarat Coasts, the fishing activity by trawlers during monsoon months is generally lean. However, at Veraval some fishing operations by gill nets in the nearshore waters are seen during this season.

It is now well known that the upwelling and associated environmental factors during the latter half of the premonsoon and monsoon months affect the distribution of the demersal resources in the continental shelf regions, along the west coast of India by pushing some of the stocks to offshore waters and some close to the shore. After the south-west monsoon when normal, sea conditions set in, the demersal fishes reappear and colonise the usual fishing grounds (Banse, 1959, 1968; Carruthers, 1959). Besides this physico-biological phenomenon, the cessation of trawling during the monsoon would greatly help for the conservation of the spawning and juvenile population of several demersal fishes.

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REFERENCES

BANSE, K. 1959. On upwelling and bottom trawling off south-west coast of India. *J. mar. biol. Ass. India*, 1 (1) : 33-49.

—— 1968. Hydrography of the Arabian Sea shelf of India and Pakistan and effects on demersal fish. *Deep Sea Res.*, 1 (1) : 45 - 79.

CARRUTHERS, J. N. 1959. Shorewards upslope of layer of minimum oxygen off Bombay : Its influence on marine biology, especially fisheries. *Nature, London*, 183 : 1084 - 1087.

CHAKRABORTY, SUSHANT K. 1988. *A study on the sciaenids of Bombay waters*. Ph. D. Thesis, University of Bombay.

RAO, T. APPA 1985 a. Maturation and fecundity in *Sciaena glauca* (Day). *J. mar. biol. Ass. India*, 27 (1 & 2) : 183 -185.

—— 1985 b. Observations on some aspects of biology of *Otolithus cuvieri* (Trewavas) from Veraval. *Ibid.*, 27 (1 & 2) : 186 - 188.

—— 1986. A note on the spawning habit and fecundity of *Johnius vogleri* (Bleeker) from Veraval Coast. *Ibid.*, 28 (1 & 2) : 216 - 218.

Bull. Cent. Mar. Fish. Res. Inst., 1992, **45** : 182 - 196

4. 10

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : LIZARDFISHES

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Abstract

The lizardfish fishery of the different maritime States along the west coast during monsoon is compared with the premonsoon and postmonsoon seasons. In Kerala the catch rate of lizardfishes was the highest during monsoon, while in Karnataka and Goa the peak catch rates were during premonsoon, followed by postmonsoon. In Maharashtra the most productive period was postmonsoon with the catch rates being the lowest during premonsoon and moderate during monsoon. In Gujarat the catch rates were almost equal during pre and postmonsoon seasons, there being no landings during monsoon. The lizardfish fishery at Cochin was supported mainly by *Saurida tumbil* (50.9%) and *S. undosquamis* (48.5%) with negligible quantities of *Trachinocephalus myops*. During premonsoon, the fishery was constituted almost exclusively by *S. undosquamis*. The dominant species in monsoon was *S. tumbil*, while in postmonsoon *S. undosquamis* predominated. The catch rate of *S. tumbil* in the inshore area indicated some correlation with the intensity of monsoon, while no such correlation could be observed for *S. undosquamis*. The peak spawning season of *S. undosquamis* appeared to be pre and postmonsoon months, while *S. tumbil* exhibited a prolonged breeding season and the fact that only a part of the lizardfish stock was available for exploitation during monsoon ruled out the possibility of monsoon trawling seriously affecting the spawning potential of the resource. At Bombay *S. tumbil* was the only dominant species occurring in all the seasons. The biological investigations of *S. tumbil* suggested that spawning took place in postmonsoon period and only 6.7% of the females had developing ovaries in monsoon. During monsoon only 5.7% of the fishes were below the minimum size of maturity and the sex ratio showed predominance of males. The recruitment of young ones was seen during premonsoon period. The fishing of S. tumbil in monsoon therefore did not seem to pose recruitment and growth overfishing problems causing depletion of the stock.

Introduction

The lizardfishes constituted mainly by *Saurida tumbil* and *S. undosquamis* form an important constituent of the demersal fishery resources exploited by small mechanised trawlers along the west coast of India. The average all India annual production of lizardfishes for the period 1975-84 was 11,476 tonnes. The average annual landings from the west coast was 8,849 t, forming 77% of the all India catch (Anon., 1986).

The lizardfishes are caught mainly by mechanised shrimp trawlers. As these trawlers operate within 50 m depth in the coastal waters where the traditional fishermen also fish, clashes have been frequent. To prevent the unhealthy competition between traditional and mechanised sector leading to clashes, most of the maritime States have enacted legislations demarcating the deeper areas for mechanised fishing and shallow inshore areas for the traditional sector. However, due to the lucrative catch and price offered to the penaeid prawns by exporters, increasing number of trawlers undetake fishing operations during June - August period in States like Kerala inspite of inclement weather conditions prevailing during this period. On account of this, the fishermen operating traditional gears have been expressing a strong feeling that these trawlers fishing in monsoon months, adversely affect the stocks of demersal fishes resulting in poor catch returns in the recent years as compared to the fish production in the past when trawling operations remained suspended during monsoon months. It is in this context, the present investigations are undertaken to examine whether the monsoon fishing has any effect on the fishery for lizardfishes in order to indicate a broad strategy that may be adopted by the government and the fishing industry for the rational exploitation of the resource.

The earlier reported works on the biology of lizardfishes in Indian waters included the studies by Annigeri (1963), Kuthalingam (1959), Rao (1983) and Dighe (1977). The information available on the spatial and seasonal distribution of the lizardfish resources is limited to the works of Joseph (1980),

Sulochanan and John (1988), Sudarsan *et al.* (1988, 1989) and Nair and Reghu (1990).

Data Base

The data collected on catch and effort of lizardfishes by the Fisheries Resources Assessment Division of the Central Marine Fisheries Research Institute (CMFRI) during 1984 - 1988 were utilised for the present study to understand the annual and seasonal fluctuations of the fishery in the different maritime States of the west coast. In order to compare the monsoon fishery with the other seasons the fishing period was divided into pre-monsoon (February-May), monsoon (June-August) and postmonsoon (September-January). At Cochin the species composition, size, sex and maturity condition of *Saurida tumbil* and *S. undosquamis* were collected regularly during 1984-88. The data on monthly lizardfish landings were examined with reference to the rainfall data to see whether any relationship existed between these parameters.

Observations

Fishery characteristics

Annual production : Kerala ranked first in the production of lizardfishes, the average estimated annual landing for the period 1971-88 being 5,863 t forming more than 64% of the total lizardfish catch of the west coast (Table 1). Though there were wide fluctuations in annual landings, the fishery showed an increasing trend from 1,395 t in 1971 to 11,294 t in 1975. There was, however, a drastic decline in the production to 99 t in 1976, only to increase again to 5,169 t in 1977. The production stabilised between 5000 - 7,000 t during 1978-82. The highest catch of 13,336 t was recorded in 1988.

Karnataka contributed to only 7.1% (630 t) of the total lizardfish production on the west coast. Exhibiting wide fluctuations in annual catches, no definite trend in the production pattern of lizardfishes in the State was observed. During nineteen seventies, the catch varied from nil to negligible quantities in most of the years, the maximum catch recorded being only 385 t in 1977. The landings, which fluctuated between 148 and 1,364 t in the early eighties, increased to 2,672 t in 1987 and 2,911 t in 1988.

The lizardfish fishery in Goa was relatively poor till 1974. It, however, showed an increasing trend in the subsequent years with the production ranging from 25 t (1977) to 736 t (1984). The mean annual production was 308 t.

Table 1. *Annual Lizardfish landings in different maritime States along the west coast of India during 1971-1987*

Year	Kerala	Karnataka	Goa	Maharashtra	Gujarat	Total
1971	1395	351	-	148	-	1,894
1972	1426	18	-	577	1169	3190
1973	1136	-	-	987	563	2686
1974	8839	3	1	637	1546	110266
1975	11294	75	151	218	1267	13005
1976	99	187	25	1089	2797	4197
1977	5169	385	239	1135	42	6970
1978	6246	92	279	1815	82	8514
1979	5326	155	104	2374	6	7965
1980	7080	508	199	1057	85	8929
1981	5691	148	707	1308	110	7964
1982	5480	250	403	1160	807	8100
1983	5456	1364	540	3236	627	11233
1984	6322	591	736	2170	1619	11438
1985	6205	479	447	1883	1007	10021
1986	6594	1153	724	2875	227	11573
1987	5196	2672	640	1777	470	10755
1988	13336	2911	245	2388	554	19434
Average for 1971-1988	5683	630	307	1491	721	8827
Percentage	64.4	7.1	3.4	16.9	8.2	

During 1971-1988, Maharashtra contributed, on an average, 1,491 t forming 16.89% of the total lizardfish production along the west coast. Though the fishery was characterised by fluctuations in annual landings, it indicated an upward trend, the catch increasing from 148 t (1971) to 2,386 t (1988). The highest landing of 3,236 t was recorded in 1983.

The average estimated annul landings in Gujarat was 721 t which formed 8.2% of the lizardfish landings of the west coast. The fishery which had been comparatively good during 1972 - 1976 dwindled drastically to 42 t in 1977 and generally remained low till 1981. The catch increased to 807 t in 1982, reached 1,619 t in 1984 and again to 226 t in 1986. Thereafter a revival of the fishing was seen in 1987 and 1988.

Gearwise landings : The gearwise analysis of lizardfish landings for the period 1984-88 (Table 2) showed that they were caught predominantly by mechanised trawls, contributing to 97.5% of the total catch in Kerala, 99.9% in Karnataka, 98.3% in Maharashtra and 99.2% in Gujarat. In Goa, the landings were exclusively by trawls. The contribution from gears such as hooks and line, gill net and boat seine accounted for 2.5% of the total lizardfish catch in Kerala, while in Karnataka only stray catches were recorded in purse seine and gillnets. In Gujarat and Maharashtra small quantities were caught by gillnets.

Seasonwise landings : The seasonwise distribution of effort (boat trip), catch (t), catch rate (kg/boat trip), seasonwise percentage in annual lizardfish landings and the percentage of lizardfishes in total trawl catch in different States of the west coast are given in Tables 3 - 7. It is seen that in Kerala during premonsoon period the average catch was 2,294 in 1988. The average catch rate was 10.4 kg/bt and the percentage of lizardfishes was 5.1% of the total trawl landings. About 31.2% of the annual lizardfish catch was obtained during this period. During the monsoon period, the average catch was 2,654 t which ranged from 1,648 t in 1987 to 4,959 t in 1988. The average catch rate was 37.7 kg/bt which ranged from 26 kg/bt (1984) to 49.1 kg/bt (1988). The monsoon period contributed more than 36.1% of the total annual lizardfish landings. In postmonsoon period the average catch was 2,392 t fluctuating from 1107 t (1985) to 3,897 t (1988). The average catch rate was 10.8 kg/bt, the percentage contribution for the period being 32.6% of the annual lizardfish landings. Thus, the monsoon period could be considered as the most productive period in Kerala when the mean catch rate of lizardfishes was higher than that in the premonsoon and postmonsoon seasons (Table 3).

In Karnataka (Table 4) the premonsoon period was the most productive season when more than 63% of the annual lizardfish catch was landed, the balance being obtained during the postmonsoon months. There was no landing during monsoon, the average trawling effort expended being only 2.4% of the annual effort. During premonsoon the average catch was 1,134 t which fluctuated from 383 t in 1985 to 2,080 t in 1988. The average catch rate for the period was 11.4 kg/bt. During postmonsoon period the average catch was 667 t at a catch rate of 6.3 kg/bt and the catch

TABLE 2. *Gearwise catch (tonnes) of lizardfishes in different maritime States of the west coast during 1984-88*

Year	Trawl net	Hooks & line	Gill net	Boat seine	Purse seine	Others	Total
Kerala							
1984	6099	158	58	-	-	7	6322
1985	6075	32	68	4	-	24	6203
1986	6447	131	6	10	-	-	6594
1987	5076	93	24	3	-	-	5196
1988	13001	87	168	-	-	80	13336
Average	7340	100	65	3	-	22	7530
Percentage	97.47	1.34	0.86	0.04		0.29	
Karnataka							
1984	591	-	-	-	-	-	591
1985	479	-	-	-	-	-	479
1986	1149	-	-	-	4	-	1153
1986	2669	-	1	-	1	1	2672
1987	2908	-	-	-	2	1	2911
Average	1559	-	0.2	-	1.4	0.4	1,561
Percentage	99.88		0.03		0.06	0.03	
Goa							
1984	736	-	-	-	-	-	736
1985	447	-	-	-	-	-	447
1986	724	-	-	-	-	-	724
1987	640	-	-	-	-	-	640
1988	245	-	-	-	-	-	245
Average	558	-	-	-	-	-	558
Percentage	100.0	-	-	-	-	-	
Maharashtra							
1984	1,955	-	42	-	-	-	1997
1985	1883	-	-	-	-	-	1883
1986	2875	-	-	-	-	-	2875
1987	1634	-	143	-	-	-	1777
1988	2388	-	-	-	-	-	2388
Average	2147	-	37	-	-	-	2184
Percentage	98.31	-	1.69	-	-	-	
Gujarat							
1984	1,613	-	6	-	-	-	1619
1985	992	-	15	-	-	-	1007
1986	227	-	-	-	-	-	227
1987	463	-	7	-	-	-	470
1988	554	-	-	-	-	-	554
Average	770	-	6	-	-	-	776
Percentage	99.22		0.78				

TABLE 3. *Seasonwise effort and catch particulars of lizardfishes caught by mechanised trawls in Kerala during 1984-88*

Year/ Season	Effort (boat trips)	Catch (tonnes)	Catch rate (kg/unit)	Percentage of lizardfish in annual catch	Percentage of lizardfishes in total trawl catch
Premonsoon					
1984	132,565	1,522	11.4	24.9	5.8
1985	159,515	2,568	16.1	42.3	7.8
1986	192,098	1,969	10.2	30.5	5.8
1987	276,120	1,264	4.6	24.9	2.1
1988	336,995	4,145	12.3	31.9	5.9
Average	219,458	2,294	10.5	31.3	5.1
Monsoon					
1984	65,616	1,711	26.1	28.1	4.6
1985	59,417	2,400	40.4	39.5	6.5
1986	64,740	2,554	39.5	39.6	5.4
1987	60,931	1,648	27.1	32.5	4.5
1988	100,891	4,959	49.2	38.1	10.4
Average	70,319	2,654	37.7	36.2	6.5
Postmonsoon					
1984	100,371	2,866	28.5	47.0	10.2
1985	162,584	1,107	6.8	18.2	3.8
1986	150,999	1,924	12.7	29.9	5.2
1987	251,988	2,164	8.6	42.6	4.5
1988	437,376	3,897	8.9	29.9	4.6
Average	220,663	2,392	10.8	32.6	5.3

during the period, fluctuating from 96 t in 1985 to 1,430 t in 1987.

In Goa, the seasonal fishing trend reflected the pattern in Karnataka, with the premonsoon season contributing to 66.1% of the annual lizardfish catch, while the postmonsoon period contributed to the rest. There was no landing during monsoon when the trawling effort was very low forming only 6.9% of the annual trawling effort. During the premonsoon period the average catch was 340 t at a mean catch rate of 6.9 kg/bt. During postmonsoon, the catch fluctuated from 31 t (1988) to 477 t (1986), at an average catch of 139 t, there being no landings in 1984 and 1985. The average catch rate for the period was 5.8 kg/bt which fluctuated from 5.1 kg/bt in 1988 to 6.8 kg/bt in 1986 (Table 5).

In Maharashtra (Table 6) the average landing was highest in postmonsoon (37.1%) followed by premonsoon (25.4%) and lowest during monsoon (14.5%). The average lizardfish production for the period 1984-88 during January - March in Maharashtra was estimated to be 491 t, the production being the lowest in 1984 and the highest in 1986. The catch rate fluctuated from 1.8 kg/bt in 1988 to 11.68 kg/bt in 1986, with an average of 4.7 kg/bt. During premonsoon, the average landing was 546 t at an average catch rate of 5.6 kg/bt. The maximum catch occurred in 1988 (1,110 t) and the minimum in 1985 (260 t). The average production was lowest during monsoon (312 t), which seemed to be mainly due to the lower trawling effort expended during the period. However, the catch rate realised during the period was comparatively high (8.2 kg/bt). The production ranged from 145 t in 1984 to 427 t in 1987, while the minimum and maximum catch rates were recorded in 1988 and 1986 respectively. The postmonsoon period was the most productive period recording the highest mean catch (1021 t) and catch rates (8.7 kg/bt). The maximum catch was recorded in

TABLE 4. *Seasonwise effort and catch particulars of lizardfishes caught by mechanised trawls in Karnataka during 1984-88*

Year/ Season	Effort (boat trips)	Catch (tonnes)	Catch rate (kg/unit)	Percentage of lizardfish in annual catch	Percentage of lizardfishes in total trawl catch
Premonsoon					
1985	75,764	383	5.1	79.9	2.8
1986	105,192	834	7.9	72.6	2.7
1987	127,988	1239	9.7	46.4	2.3
1988	86,696	2080	23.9	71.5	4.8
Average	98,910	1134	11.4	62.9	3.2
Monsoon					
1985	752	-	-	-	-
1986	3,346	-	-	-	-
1987	8,720	-	-	-	-
1988	7,279	-	-	-	-
Average	5,024	-	-	-	-
Postmonsoon					
1985	67,233	96	1.4	20.1	0.6
1986	70.243	315	4.5	27.4	1.1
1987	177,474	1430	8.1	53.6	2.8
1988	108,248	828	7.7	37.1	2.1
Average	105,799	667	6.3	37.1	2.1

1988 (1478 t), while the minimum occurred in 1987 (437 t). The catch rates, however, showed a decreasing trend from 17.5 kg/bt (1984) to 5.3 kg/bt (1988).

TABLE 5. *Seasonwise effort and catch particulars of lizardfishes caught by mechanised trawlers in Goa during 1984-88*

Year/ season	Effort (boat trips)	Catch (tonnes)	Catch rate (kg/unit)	Percentage of lizardfish in annual catch	Percentage of lizardfishes in total trawl catch
Premonsoon					
1984	-	-	-	-	-
1985	56,018	447	7.9	100.0	2.5
1986	34,678	247	7.1	34.1	1.4
1987	59,424	471	7.9	73.6	2.6
1988	45,089	194	4.3	79.2	0.9
Average	48,802	340	6.9	66.1	1.8
Monsoon					
1984	17,028	-	-	-	-
1985	2,635	-	-	-	-
1986	6,286	-	-	-	-
1987	2,844	-	-	-	-
1988	2,530	-	-	-	-
Average	6,265	-	-	-	-
Postmonsoon					
1984	36,329	-	-	-	-
1985	30,178	-	-	-	-
1986	70,006	477	6.8	65.8	1.8
1987	32,820	169	5.2	26.4	1.4
1988	9,947	51	5.1	20.8	14.
Average	35,856	139	3.9	33.9	0.7

In Gujarat, the lizardfish production was almost of the same magnitude during premonsoon and postmonsoon period, there being no landing during monsoon. During premonsoon the catch ranged from 39 t in 1987 to 985 t in 1988 at an average of 382 t. The average catch rate was 9.2 kg/bt fluctuating from 0.8 kg/bt (1987) to 21.8 kg/bt in (1988). During postmonsoon the average production was 388 t at an average catch rate of 9 kg/bt (Table 7).

Fishing at selected centres

Cochin : The estimated annual effort, catch and catch per unit of lizardfishes for the period 1984-85 to 1987-88 are presented in Table 8. The trawling effort expended was found to be lowest in 1985-86 (30,044 bt) and highest in 1987-88 (46,762 bt), the average annual trawling effort expended for the period being 39,404 units. The total estimated average annual production of lizardfishes for the period 1984-88 was 507 t. Though there was a slight decline in the catch during 1985-86, it increased from 318 t in 1984-85 to 776 t in 1987-88. The annual catch rate also had been showing an increasing trend from 7.28 kg/bt in 1985-86 to 16.59 kg/bt in 1987-88.

TABLE 6. *Seasonwise effort and catch particulars of lizardfishes caught by mechanised trawlers in Maharashtra during 1984-88*

Year/ Season	Effort (boat trips)	Catch (tonnes)	Catch rate (kg/unit)	Percentage of lizardfish in annual catch	Percentage of lizardfishes in total trawl catch
January - March					
984	30,537	315	10.3	16.1	1.2
1985	40,170	418	10.4	22.2	1.6
1986	76,776	897	11.7	31.2	2.2
1987	9,319	332	3.5	20.3	0.7
1988	281,536	495	1.8	20.7	0.7
Average	104,667	491	4.7	22.9	1.2
April - June					
1984	31,848	446	14.0	11.8	3.1
1985	30,.733	260	8.5	13.8	0.9
1986	62,981	476	7.6	16.6	1.4
1987	51,353	438	8.6	26.8	1.6
1988	303,766	1110	3.7	46.4	1.3
Average	96,136	546	5.7	25.4	1.5
July - September					
1984	16,922	145	8.6	7.4	0.7
1985	16,656	213	12.8	11.3	1.3
1986	16,599	353	21.3	12.2	1.5
1987	26,706	427	16.0	26.1	1.9
1988	114,453	425	3.7	17.8	1.4
Average	38,267	312	8.2	14.5	1.5
October - December					
1984	59,780	1049	17.5	53.7	2.2
1985	89,076	992	11.1	52.7	1.1
1986	90,492	1149	12.7	39.9	2.2
1987	72,186	437	6.1	26.8	0.9
1988	278,477	1478	5.3	15.1	0.9
Average	118,002	1021	8.7	37.2	1.8

TABLE 7. *Seasonwise effort and catch particulars of lizardfishes caught by mechanised trawlers in Gujarat during 1984-88*

Year/ Season	Effort (boat trips)	Catch (tonnes)	Catch rate (kg/unit)	Percentage of lizardfish in annual catch	Percentage of lizardfishes in total trawl catch
Premonsoon					
1984	45,143	985	21.8	61.1	2.1
1985	31,757	466	14.7	46.9	1.1
1986	48,806	143	2.9	62.9	0.2
1987	47,610	39	0.8	8.4	0.1
1988	34,093	277	8.1	50.0	0.8
Average	41,481	382	9.2	49.6	0.8
Monsoon					
1984	547	-	-	-	-
1985	1,582	-	-	-	-
1986	276	-	-	-	-
1987	1,874	-	-	-	-
1988	1,241	-	-	-	-
Average	1,104	-	-	-	-
Postmonsoon					
1984	44,913	628	14.0	38.9	1.1
1985	54,217	526	9.7	53.0	0.7
1986	37,383	84	2.2	37.0	
1987	44,088	424	9.6	91.5	0.8
1988	34,100	277	8.1	50.0	0.5
Average	42,940	388	9.0	50.4	0.7

The seasonal distribution of trawling effort, catch and catch rates of lizardfishes for the period 1984-85 to 1987-88 are presented in Table 10. During premonsoon period the average catch of lizardfishes at Cochin was 175 t forming 24.3% of the total annual lizardfish catch for an average fishing effort of 18,600 bt. The average catch rate during the period was 9.41 kg/bt. The catch fluctuated from 21 t at a catch rate of 1.38 kg/bt in 1985 to 682 t at a catch rate of 31.85 kg/bt in 1988. During monsoon season, an average 450 t forming 62.5% of the total annual lizardfish catch were landed. The total catch of lizardfishes was the highest during the monsoon of 1988 (796 t), while the lowest catch was recorded in the monsoon of 1985 (191 t). However the contribution of monsoon fishery to the total annual lizardfish landings was found to be higher during 1984 and 1986, forming 89.2% and 87.2% of the annual landings respectively, when the premonsoon and postmonsoon fishery were poor. The average fishing effort during the period was 11,699 units. The average catch rate was 38.48 kg/bt, the highest among all seasons, which had been showing an increasing trend from 19.83 kg/bt in 1984 to 89.9 kg/bt in 1988. In postmonsoon period the average production was 119.8 t for a mean fishing effort of 11, 844 bt and the catch rate of 10.6 kg /bt. Thus when compared with premonsoon and postmonsoon seasons the catch as well as catch rates of lizardfishes in monsoon season were found to be considerably higher.

TABLE 8. *Annual effort and catch particulars of lizardfishes at Cochin during 1984-88*

Year	Effort (Boat trip)	Catch (kg)	Catch rate (kg/boat trip)
1984	38,190	318,400	8.33
1985	30,038	219,000	7.28
1986	46,171	713,000	15.44
1987	46,762	776,000	16.59
1988	49,764	1699,000	34.15
Average	42,183	744.8	17.65

The lizardfish fishery at this Centre was supported mainly by *Saurida tumbil* (50.9%) and *S. undosquamis* (48.5%) with negligible quantities of *Trachinocephalus myops* (Table 12). During the premonsoon months the fishery was constituted almost exclusively by *S. undosquamis* forming 96 and 83.7% of the catch in 1987 and 1988 respectively. *S. tumbil* was the main component species exploited during monsoon. *S. undosquamis* was not landed during the monsoon months in 1986, while in 1987 it formed 0.1% of the total lizardfish catch during this period. However its share increased to 45.9% in 1988. On an average, during postmonsoon period, the contribution of *S. tumbil* and *S. undosquamis* was 49.3% and 50.6% respectively.

Bombay : The average annual catch of lizardfishes at Sassoon Dock and New Ferry wharf landing centres together by the trawlers was 1,876 t at a catch rate of 39.6 kg/bt (Table 9). The lizardfishes formed 2.3% of the total fish landings.

During premonsoon period, the average catch of lizardfishes was 641.1 t which fluctuated from 420.8 t in 1985 to 1,206 t in 1988. The average catch rate during this period was 39.4 kg/bt (Table 11). During monsoon season, the average

TABLE 9. *Annual effort and catch particulars of lizardfishes in trawl catches at Bombay during 1984-88*

Year	Effort (Boat trip)	Catch (kg)	Catch rate (kg/boat trip)
1984	44,512	1209,594	27.17
2985	42,590	1086,215	29.50
1986	47,231	2038,033	43.15
1987	49,480	1493,610	30.18
1988	52,918	3551,035	67.15
Average	47,346	1875,697	39.61

catch was 150. 6 t , varying from 34.4 t in 1984 to 256.4 t in 1988 at an average catch rate of 23.3 kg/bt. In the postmonsoon period the average catch was 1083.9 t and it fluctuated from 544.6 t in 1985 to 2,008. 6 t in 1988. The average catch rate was 44.04 kg/bt being the highest among all the seasons. Thus, this period was found to be the best period for lizardfish fishery registering 47.2% and 10.5% higher catch rate than in the monsoon and premonsoon seasons respectively. When compared with postmonsoon and premonsoon seasons the catch as well as the catch rates of lizardfishes in monsoon season were 7.2 and 4.3 times lesser and 89.3% and 69.5% lower respectively.

TABLE 10. *Seasonwise effort and catch particulars of lizardfishes in trawl catches at Cochin during 1984-88*

Year/ Season	Effort (Boat trip)	Catch (kg)	Catch rate (kg/boat trip)
Premonsoon			
1984	19,786	33,000	1.65
1985	15,458	21,000	1.38
1986	20,337	32,000	1.55
1987	19,510	108,000	5.54
1988	17,912	682,000	31.35
Average	18,600	175,200	9.41
Monsoon			
1984	14,378	285,000	19.83
1985	5,910	191,000	32.25
1986	14,918	534,000	35.78
1987	14,447	445,000	30.78
1988	8,846	796,000	89.91
Average	11,699	450,200	38.48
Postmonsoon			
1984	4,026	400	0.09
1985	8,670	7,000	0.79
1986	10,916	147,000	13.51
1987	12,805	223,000	17.42
1988	23,006	221,800	9.64
Average	11,844	119,840	10.08

Four species of lizardfishes viz. *Saurida tumbil, saurida undosquamis, Synodus indicus* and *Trachinocephalus myops* were found in the trawl catches of the Bombay waters. The catch composition of the four species in different seasons during 1987 and 1988 is given in Table 13. Among these species , only *S. undosquamis* occurred in all the seasons in both the years, *S. indicus* and *T. myops* occurred in monsoon period with negligible percentage of 0.08 and 0.72 in 1987 and 0.06 and 0.19 in 1988 respectively.

TABLE 11. *Seasonwise effort and catch particulars of lizardfishes in trawl catches at Bombay during 1984-88*

Year	Effort (Boat trip)	Catch (kg)	Catch rate (kg/boat trip)
Premonsoon			
1984	14,439	439,712	30.45
1985	14,988	420,888	28.08
1986	17,177	515,540	30.01
1987	17,486	543,370	31.07
1988	17,190	1286,031	74.81
Average	16,256	641,108	39.43
Monsoon			
1984	6,344	54,387	8.57
1985	5,585	120,653	21.60
1986	6,510	109,190	16.77
1987	5,991	212,492	35.47
1988	7,955	256,422	32.33
Average	6,477	150,629	23.26
Postmonsoon			
1984	23,729	715,495	30.15
1985	22,017	544,674	24.74
1986	23,544	1413,303	60.03
1987	26,003	737,748	20.37
1988	27,773	2008,582	72.32
Average	24,613	1083,960	44.04

Biology

Length composition

Saurida undosquamis : With the dominant modal size at 145 mm (Fig. 1) exclusively supported the fishery at Cochin in the premonsoon months in 1986. There was no landing of this species during monsoon, while the postmonsoon fishery was composed mainly of fishes with modes at 145 and 195 mm. In 1987, the premonsoon fishery was good consisting mainly of fishes with modes at 155 and 183 mm. The monsoon and postmonsoon fishing season was very poor. In 1988, the fishery was very good during premonsoon and monsoon when the dominant size modes were at 125, 175 and 245 mm in the former period and at 145, 165, 195 and 225 mm in the latter season.

Table 12. *Seasonwise species composition of lizardfishes in trawl catches at Cochin during 1986-88*

Year/*Season*	*S. tumbil*	*S. undosquamis*	*T. myops*
Premonsoon			
1986	-	-	-
1987	4,000 (3.9)	98,000 (96.1)	
1988	101,000 (16.5)	519,000 (83.7)	-
Average	52,500 (14.5)	308,500 (85.5)	
Monsoon			
1986	534,000 (100.0)	-	-
1987	432,000 (97.0)	1,000 (0.1)	12,000 (2.9)
1988	427,000 (53.6)	366,000 (46.0)	3,000 (0.4)
Average	464,300 (78.4)	122,300 (20.8)	5,000 (0.8)
Postmonsoon			
1986	75,000 (50.6)	73,000 (49.4)	-
1987	52,000 (22.8)	176,000 (77.2)	-
1988	160,600 (77.3)	46,500 (22.4)	600 (0.3)
Average	95,800 (49.3)	98,500 (50.6)	200 (0.1)

Figures in paranathesis indicate percentage.

During 1986-87, the successful monsoon fishery was supported by *S. tumbil* with modes at 265, 285 and 325 mm (Fig. 2). In the postmonsoon months the fishery, however, was composed of fishes with relatively smaller sizes at 145, 185 and 255 mm. During the premonsoon of 1987 the fishery was very poor. The monsoon fishery was composed of fishes with modes at 205, 275, 315 and 385 mm, while that of postmonsoon period by the juveniles at 205 mm modal size. In 1988, the fishery in the premonsoon season was contributed by fishes with modes at 185 and 195 mm while the monsoon fishery was supported by larger fishes with modes at 295 and 305 mm.

The seasonwise size distribution of *S. tumbil* at Bombay for the period 1987 and 1988 is given in Fig. 3. During permonsoon periods of 1987 and 1988, the size of the fish ranged from 90 to 470 mm and 90 to 440 mm respectively with mean size at 287. 3 mm in 1987 and 250.8 mm in 1988. During monsoon the size range of *S. tumbil* was from 160 to 440 mm in 1987 and 180 to 450 mm in 1988 with mean sizes at 268.1 mm and 266.6mm respectively. In the postmonsoon period the size range was 190-490 mm in 1987 and 190- 420 mm in 1988 with mean sizes at 289.3 mm and 259.3 mm in the two years respectively. The occurrence of small specimens in the size range of 90-210 mm (modal sizes 120 mm, 110 mm) in the premonsoon periods of 1987 and 1988, suggest recruitment in this period.

Spawning : The seasonal distribution of mature, ripe and spent *S. undosquamis* and *S. tumbil* at Cochin during premonsoon, monsoon and post-monsoon periods is given in Table 14. During the monsoon season *S. undosquamis* was composed almost exclusively of immature fish. The spawning season of the species was found to be prolonged as indicated by the continued occurrence of spawning and spent fish during the premonsoon and post-monsoon months.

S. tumbil spawns almost throughout the year. However, the percentage of gravid and spent fish in the fishery was found to be higher during monsoon as compared to premonsoon and post-monsoon seasons. In Bombay waters, 98.85% of females of *S. tumbil* had their ovaries in immature/resting phase in the premonsoon period, whereas 93.3% in the monsoon and 44.6% in postmonsoon period (Table 15). There was an increasing trend in the percentage of developing ovaries from 1.17% in premonsoon to 6.67% in monsoon and 31.1% in postmonsoon seasons. The mature and gravid

TABLE 13. *Seasonwise species composition of lizardfishes in trawl catches (kg) at Bombay during 1987-88*

Year	*S. tumbil*	*S. undosquamis*	*Sy. indicus*	*T. myops*
Premonsoon				
1984	526,634 (96.2)	6,955 (1.3)	5,434 (1.0)	4,347 (0.8)
1988	1270,598 (98.8)	11,831 (0.9)	-	3,602 (0.3)
Average	898,616 (98.3)	8,393 (0.9)	2,717 (0.3)	3,975 (0.5)
Monsoon				
1987	210,261 (98.9)	1,169 (0.6)	170 (0.1)	892 (0.4)
1988	254,935 (99.4)	846 (0.3)	154 (0.1)	487 (0.2)
Average	232,598 (99.2)	1,008 (0.4)	162 (0.1)	690 (0.3)
Postmonsoon				
2987	737,453 (99.9)	295 (0.1)	-	-
1988	1990,304 (99.1)	18,078 (0.9)	-	-
Average	1363,878 (99.3)	9,186 (0.7)	-	-

Figures in paranthesis indicate percentage.

TABLE 14. *Sex ratio and the gonadial condition of the females of* Saurida undosquamis *and* S. tumbil *at cochin during 1986-88*

Sex ratio/maturity	Premonsoon No.	%	Monsoon No.	%	Postmonsson No.	%
S. undosquamis						
Male	61	37.4	1	20.0	85	49.1
Female	102	62.6	4	80.0	88	50.9
Immature/resting	51	50.0	4	100.0	13	14.9
Developing	24	23.5	-	-	7	8.0
Gravid	-	-	-	-	6	6.9
spent	27	26.5	-	-	62	70.2
S. tumbil						
Male	15	46.8	19	44.1	82	62.2
Female	17	53.2	136	55.9	50	37.8
Immature/resting	5	29.4	12	8.7	15	30.0
Developing	-	-	10	7.2	1	2.0
Gravid	2	11.8	7	5.1	8	16.0
Spent	10	58.8	107	79.0	26	52.0

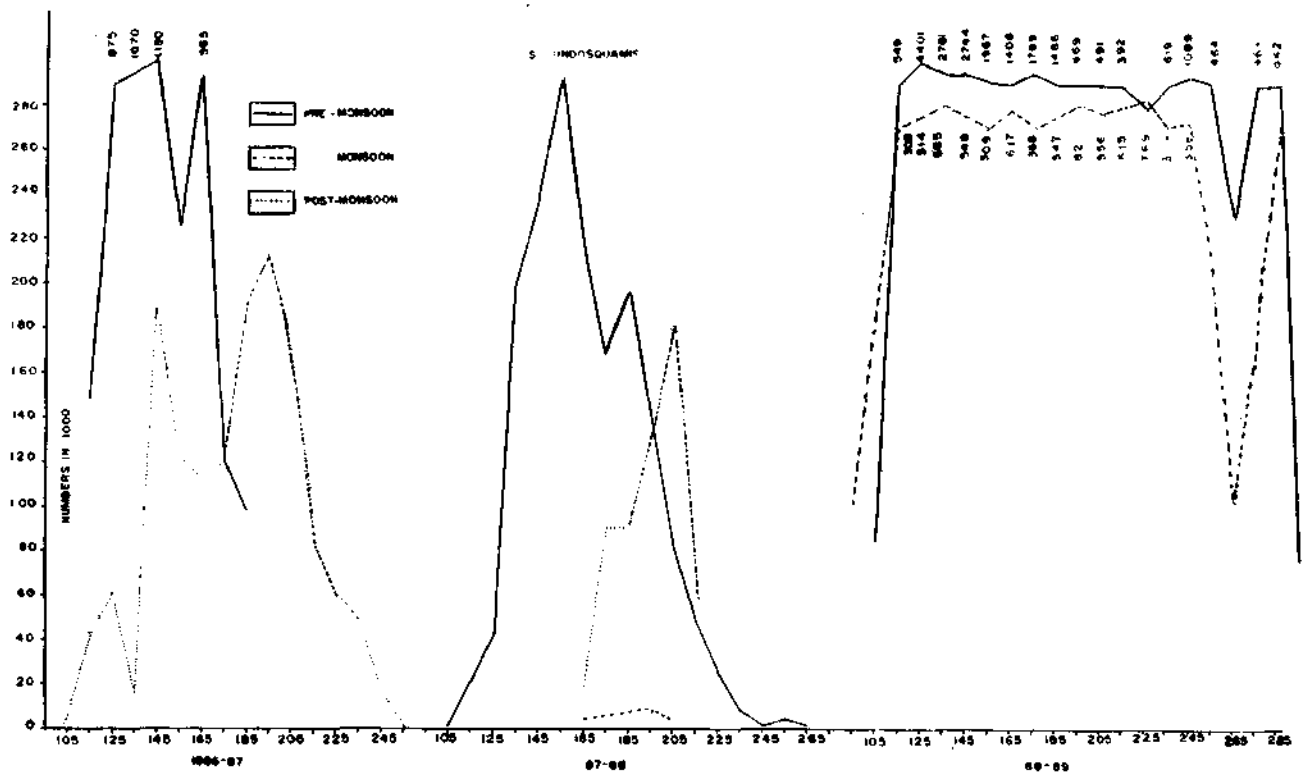

Fig. 1. Seasonwise size distribution of *Saurida undosquamis* in trawl catches at Cochin during 1986-88.

females were found only in postmonsoon period indicating that the spawning of *S. tumbil* occurs in postmonsoon period at Bombay.

The minimum size at maturity for *S. tumbil* in Bombay waters is 208 mm (Dighe, 1977). The percentage of fishes below the minimum size of maturity was 24.3 in the premonsoon, 5.7 in monsoon and 2.5 in the postmonsoon periods. The sex ratio showed dominance of males in all the three seasons.

Relationship between rainfall and lizardfish fishery

The rainfall data for the period 1984-88 are plotted against the catch and catch rates of lizardfishes at Cochin to see whether any relationship exists between the fishery and the intensity of monsoon (Fig. 4). The monthly lizardfish catch showed an increase with the onset of monsoon with very high landings in June, the trend continuing upto August during most of the years. The catches

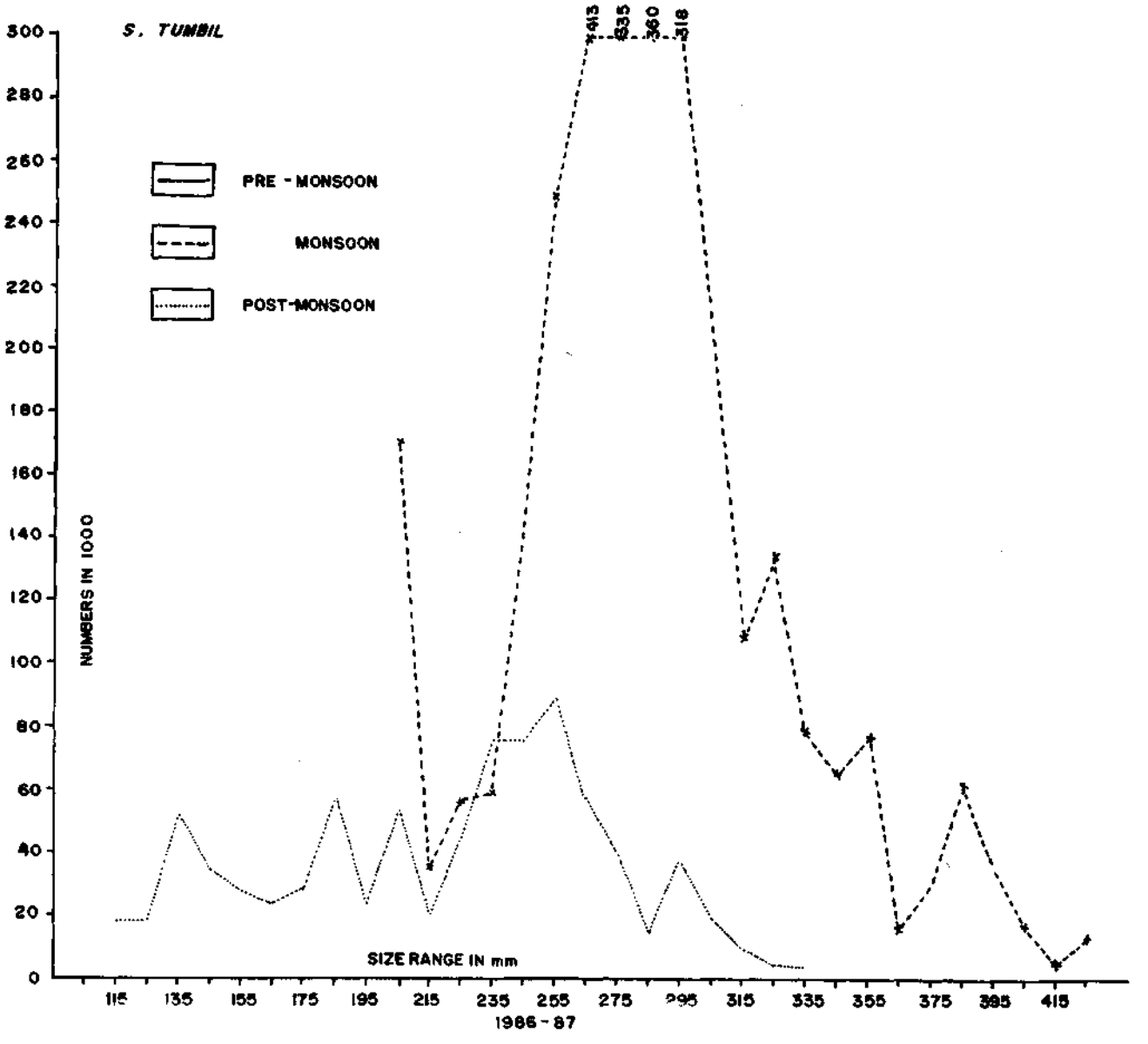

Fig. 2 a. Seasonwise size distribution of *Saurida tumbil* in trawl catches at Cochin during 1986-88.

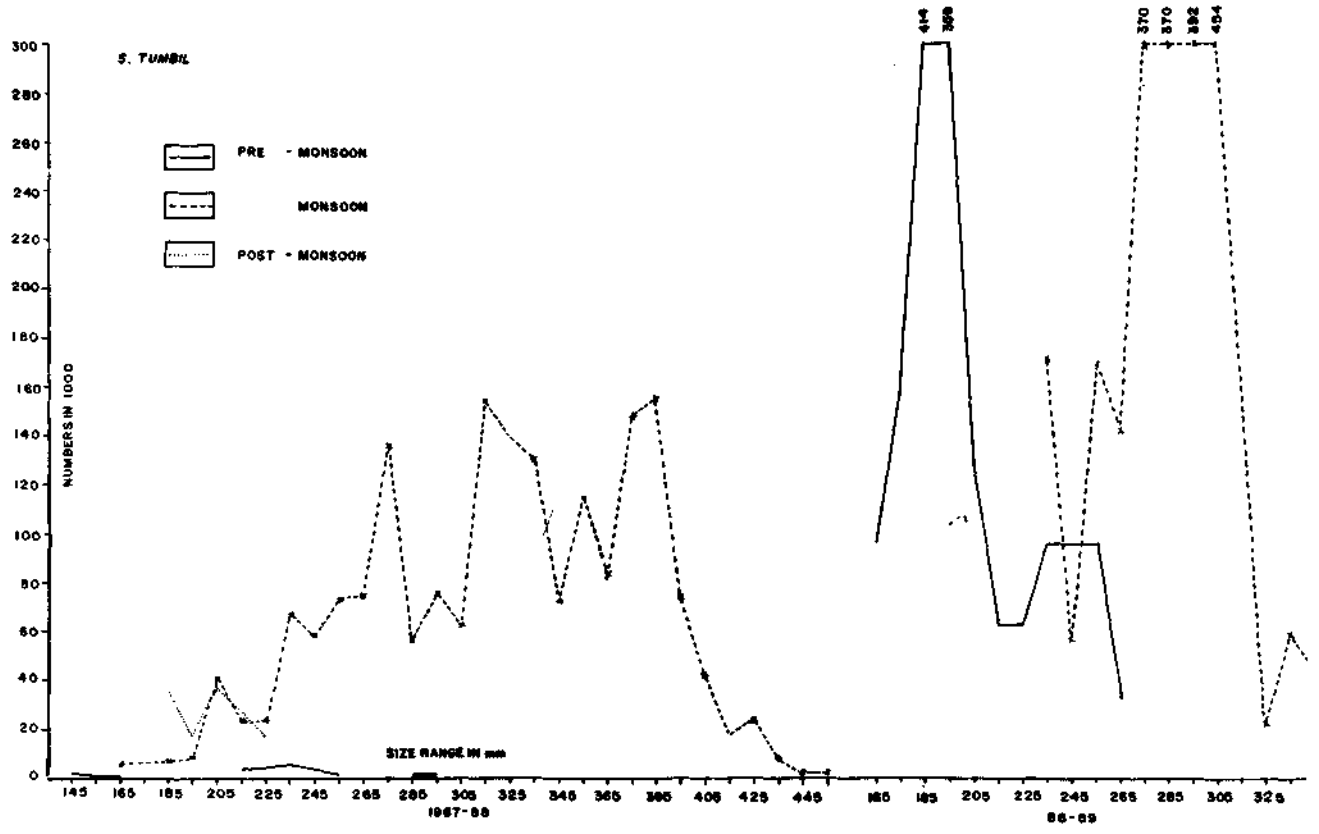

Fig. 2 b. Seasonwise size distribution of *Saurida tumbil* in trawl catches at Cochin during 1986-88.

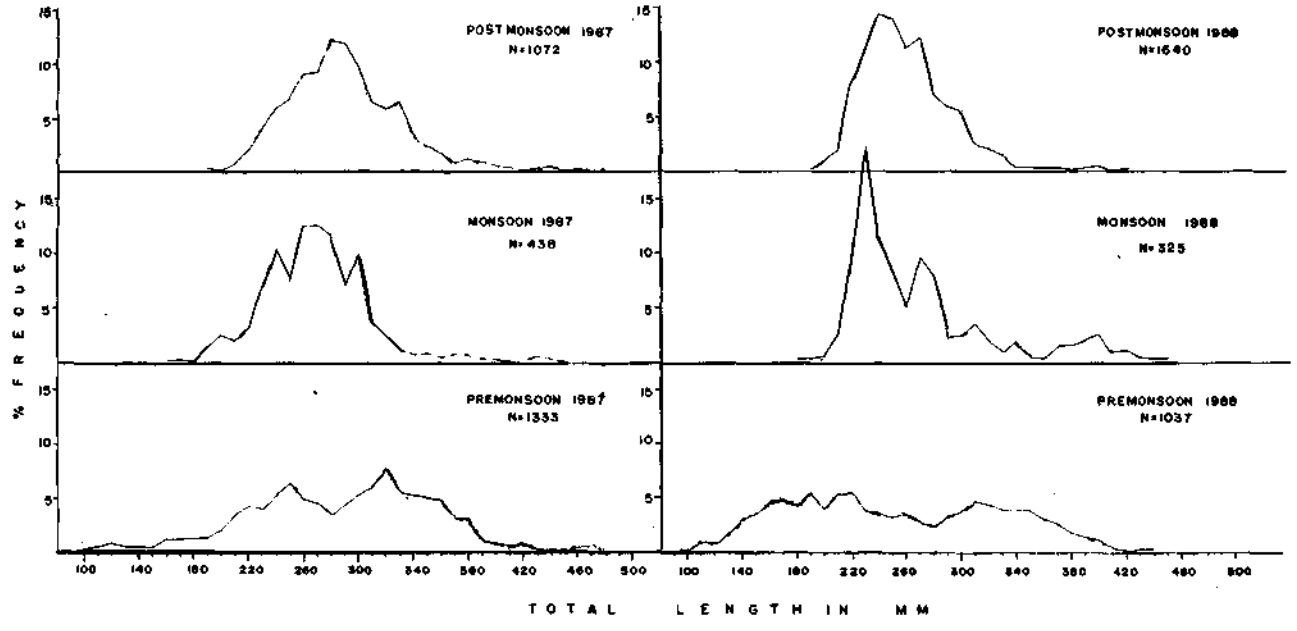

Fig. 3. Seasonwise size distribution of *Saurida tumbil* in trawl catches at Bombay during 1987-88.

were negligible in the premonsoon and postmonsoon periods of 1984, 1985 and 1986. In 1987 the fishery was comparatively better during the premonsoon and postmonsoon months with peak catches during monsoon.

In June 1985 the lizardfish catch was only 117 t, though the monsoon was rather vigorous with rainfall of 963 and 414 mm in June and July. In 1986, inspite of poor rainfall (610 and 296 mm in June and July respectively) the fishery was good, the landings being 158 and 205 t. Similarly very high catch rates for lizardfishes were observed when the monsoon was poor and *vice versa*. Thus no positive or negative correlation could be discerned between absolute monthly rainfall in a

TABLE 15. *Seasonwise sex ratio and maturity stages of females of* Saurida tumbil *in trawl catches at Bombay during 1987-88*

Season	Males Nos.	Females Nos.	Sex ratio Males: Females	Female maturty stages Immature/ resting	Developing	Mature/ gravid
Premonsoon	109	86	1:.79	85 (98.8)	1 (1.2)	-
Monsoon	73	45	1:0.62	42 (93.3)	3 (6.7)	-
Postmonsoon	96	74	1:.77	33 (44.6)	23 (31.1)	18 (24.3)

Figures in paranthesis indicate percentage.

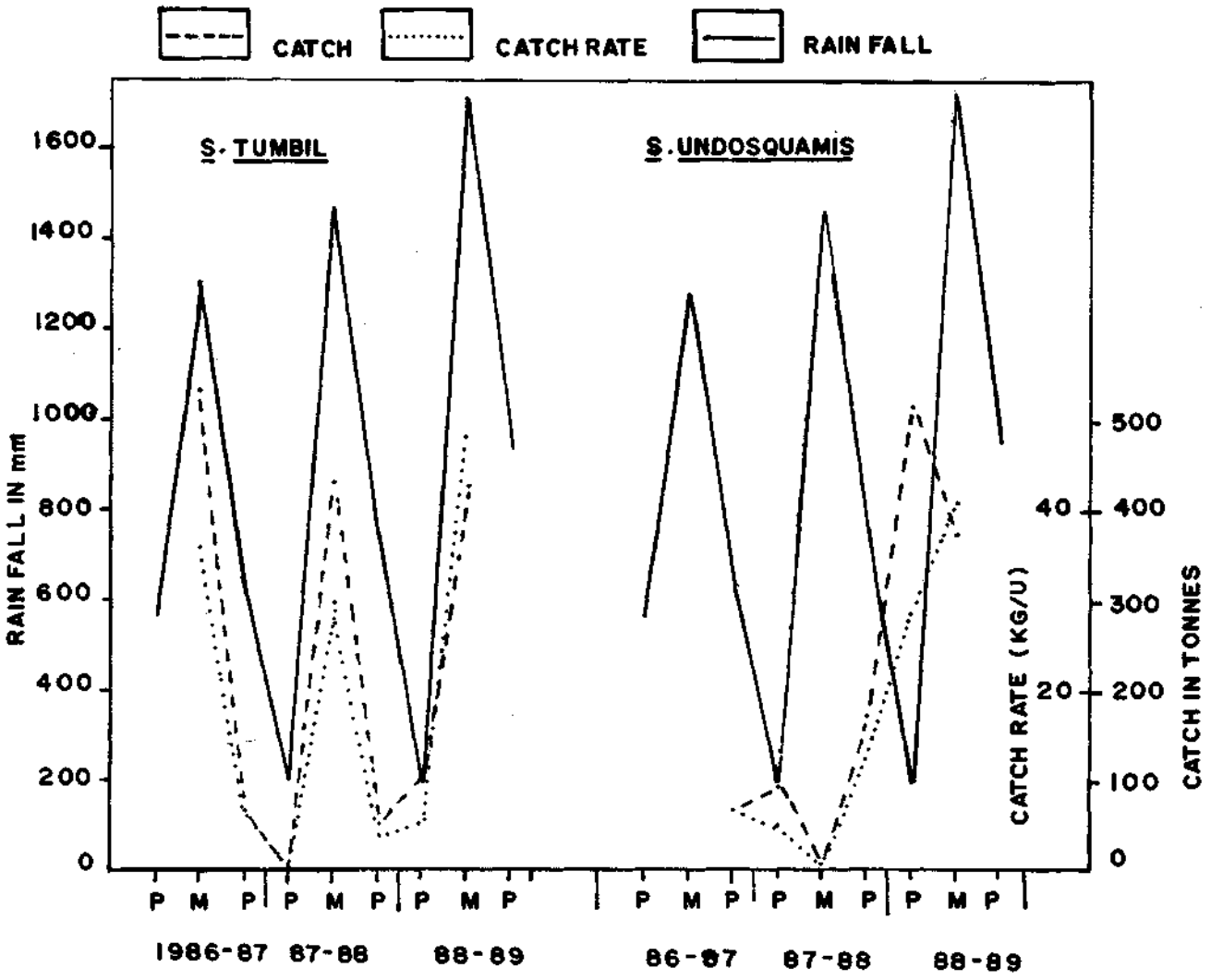

Fig. 4. Total and specieswise catch and catch rates of lizardfishes in relation to rainfall in different months at Cochin during 1984-88.

particular year and the catch and catch rates of lizardfishes.

The relationship between monthly rainfall and catch and catch rates of the important component species of lizardfishes *viz., Saurida tumbil* and *S. undosquamis* is given in Fig. 4. The landings of *S. tumbil* were the maximum in the months of July (1986 and 1987) immediately following the peak monsoon rainfall in June, the total catch of the species exhibiting some degree of positive correlation with monsoon. In 1988 the peak catch rates occurred in August, coinciding with the highest monthly landings for the year, whereas in 1986 and 1987 the catch rates were found to be the highest in September, which was characterised by very poor landings. The catch and catch rates of *S. undosquamis* were the maximum in May during all the years and showed no positive or negative correlation with monsoon.

The relationship between rainfall and the catch trend of *S. tumbil* and *S. undosquamis* during premonsoon, monsoon and postmonsoon periods of 1986 to 1988 is analysed. The rainfall had been the lowest in 1986 the highest in 1988. The abundance of *S. tumbil* as indicated by catch rate, was the lowest in the monsoon of 1987, when the rainrall was moderate, In 1986 the catch was higher at 35.8 kg/bt, though the rainfall was comparatively less than that in the monsoon of 1987. However, the catch rate for the species was found to be the highest in the monsoon of 1988, when the monsoon was also at its maximum intensity indicating that some correlation exists in most of the years between the catch rate and rainfall. The main fishing seasons for *S. undosquamis* were the premonsoon and postmonsoon months and the abundance of the resource was not showing any correlation with the intensity of rainfall in a particular year.

Discussion

The upwelling starts in the southern regions first and extends northwards with the onset of southwest monsoon (Ramamirtham and Rao, 1974; James *et al.*, 1987; Ramamitham and Jayaraman, 1960). Jayaraman and Gogate (1957) showed the presence of oxygen deficient, highly saline, cold waters off Bombay during southwest monsoon due to upwelling. Along the Maharashtra Coast, the upwelling continues upto December off Bombay, though with less intensity (Rao *et al.*, 1972). Patil *et al.* (1962) reported that the stable summer conditions of the shelf waters along the Gujarat Coast gradually progress towards unstable conditions with the onset of southwest monsoon. The presence of oxygen deficient bottom waters brought about by upwelling during monsoon is reported to result in disapperance of demersal fishes as the fishes try to escape the oxygen poor colder waters by either migrating to the offshore surface waters or towards the shore (Banse, 1959; Carruthers *et al.*, 1959). Probably due to the varying effect of upwelling on the lizardfish resource along west coast the seasonwise abundance of the resource in the inshore coastal waters differs between different maritime States. Monsoon is the most productive season in Kerala, while in Karnataka and Goa there is no catch during monsoon months due to negligible fishing effort, the most productive season being premonsoon. In Maharashtra inspite of comparatively high catch rates the production is poor during monsoon due to reduced fishing effort, the most productive period being the postmonsoon. In Gujarat, the lizardfish production is almost equal during the premonsoon and postmonsoon periods, there being no fishery in monsoon period. In Kerala during monsoon the demersal stock of lizardfishes consisting mainly of *S. tumbil* is seen to concentrate at 20-45 m depth zone and is exploited by 28- 32' shrimp trawlers. In the postmonsoon and premonsoon seasons, *S. tumbil* population seems to dissipate and randomly distributed. In Bombay, the fall in the catch rate of lizardfishes during monsoon by 89.3% and 69.5% as compared to that in the postmonsoon and premonsoon periods respectively supports the view reported by Banse (1959).

The exploratory trawling operations of Fishery Survey of India vessels indicated the availabi-lity of lizardfishes in the entire shelf area of the west coast with highest average catch of 10.8 kg/hr from Wadge Bank and 3.9 kg/hr from northwest coast with the highest concentration in 100-200 m depth zone (Joseph and John, 1986). The proportion of lizardfishes seems to be the highest off Cochin at 60-79 m depth. The potential yield of the resource along southwest coast was estimated to be 4,100 t, 2900 to, 1700 t and 500 t in the 0-50 m, 50-100 m 100-200 m and 200-500 m depth strata respectively, the potential yield for the entire depth range being 9,200 t (Sudarsan *et al.*, 1989). The standing stock for the entire depth range estimated by them was 12,900 t. Nair and Reghu (1989) based

on the demersal trawling operations of FORV *Sagar Sampada* observed that lizardfishes, composed mainly of *Saurida tumbil* and *S. undosquamis*, were the most abundant at Wadge Bank (68.9 kg/hr) followed by southwest and northwest zones. However, in the bottom trawl catches of M. T. *Muraena* in the EEZ of the northwest coast lizardfishes accounted for only a small percentage of the groundfish catch. Nearly 80% of the catch was recorded from 91-125 and 126-360 m depth ranges with catch rates at 5.91 and 5.69 kg/hr respectively (Bapat *et al.*, 1982).

The average annual production of lizardfishes from the southwest coast comprising Kerala, Karnataka and Goa for the period 1984-88 is 9,772 t against an estimated annual potential of 9,200 t. The annual yield of lizardfishes for the entire west coast is estimated at 12,712 t against a potential yield of 12,300 t. In average annual yield of lizardfishes has thus been found to be higher than the estimated potential yield of the resource from the west coast. In 1988 the annual catch increased to 19,434 t. This high annual catch against potential yield clearly indicates that the MSY estimates of lizardfishes (Sudarsan *et al.*, 1989) are apparently gross underestimates. The seasonal migration of lizardfishes, mainly of *S. tumbil*, from deeper waters leading to their concentration in inshore fishing grounds during monsoon especially along the Kerala Coast also might not have been properly evaluated.

Joseph *et al.* (1987) recorded maximum catch and catch rates for lizardfishes at 46 - 73 m depths in the second and third quarters while in the fourth quarter the maximum occurred at 73-120 m depth. The depthwise seasonal distribution of lizardfishes showed that in the Wadge Bank and southwest coast the resource was the maximum in 41-60 and 61-80 m depth ranges during April - June closely followed by July-September, while in October-December the greatest abundance was at 101-150 m. However, in the northwest, the abundance in the shallower waters was the highest during October-December (Nair and Reghu, 1989). The same trend has been noticed in the catch trend of lizardfishes in the commercial fisheries at Cochin and Bombay. At Cochin the monsoon period contributes more than 80% of *S. tumbil* landings, while more than 78% of *S. undosquamis* catch is obtained during premonsoon and postmonsoon periods. The surveys conducted by FORV *Sagar Sampada* have shown that the lizardfish resource of the southwest coast is composed mainly of (1) *S. tumbil* - the concentration of which is usually higher in deeper waters beyond 40 m during most part of the year and (2) *S. undosquamis* - the concentration of which is higher in comparatively shallower waters.

In order to understand the effect of fishing on lizardfish resources during monsoon two aspects namely, recruitment overfishing due to excessive removal of spawning stock that is responsible for the future recruitment and the growth overfishing due to large scale capturing of juvenile fishes which would grow in due course and add to the biomass are examined. The spawning season of *S. tumbil* in Kerala is prolonged, while the spawning of *S. undosquamis* is more intense during premonsoon and postmonsoon seasons. Since only a part of the stock becomes vulnerable to monsoon trawling, the fear of monsoon trawling being deleterious to the stock is unfounded. At Bombay the spawning period of *S. tumbil* is during postmonsoon period which is further supported by the appearance of young recruits in the premonsoon season that immediately follows it. Dighe (1977) also reported that *S. tumbil* exhibits breeding period from January. During monsoon only 6.7% of the females have developing ovaries, the rest having their ovaries in immature/resting state. ***Thus, capturing of lizardfish stock in monsoon does not appear to be detrimental to the stock causing recruitment overfishing problem.***

The lizardfish fishery along the Kerala Coast seems to be supported by two distinct stocks of *S. tumbil* - an inshore resident stock and an offshore migrant stock that enters the coastal waters during monsoon. At Cochin the premonsoon and postmonsoon fishery is supported mainly by juveniles with modes at 145 to 205 mm, while the monsoon fishery is composed of fishes with modes at high size groups. At Bombay the juveniles of *S. tumbil* in the fishing grounds are observed during premonsoon period when 24.3% of the catch consists of juveniles, whereas in monsoon their representation is only 5.7% of the total catch. Thus, fishing in monsoon may not cause growth overfishing problem since the proportion of juveniles removed from the stock is relatively less.

In the maritime States of the west coast, bottom trawling is generally carried out by commercial shrimp trawlers primarily for prawns. However, in Kerala, there is directed fishing by

mechanised boats for finfish resources during monsoon. Among the finfish resources exploited, lizardfishes form a significant part of the catch. During this period due to the non-availability/ scarcity of pelagics such as sardine, mackerel and carangids, lizardfishes fetch higher prices (Rs. 4/- to Rs. 5/- per kg) as compared to the other seasons (less than Rs. 2/- per kg). Moreover the fishery is mainly supported by *S. tumbil* which has got better consumer acceptance. It is felt that better price for the catch can be obtained if the fish is supplied to the consumer in a more fresh condition. ***Since lizardfish is a resource exclusively harvested by mechanised trawlers, the question of any conflict with the traditional sector does not crop up. It may therefore be concluded that fishing in monsoon is not deleterious to the stock of lizardfishes in general and S. tumbil in particluar.***

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REFERENCES

ANNIGERI, G. G. 1963. Maturation of the intraovarian eggs and spawning periodicities in a few fishes off Mangalore based on ova diameter measurements. *Indian J. Fish.*, **10** A (1) : 23-32.

ANON., 1986. Marine fish production in India - 1983-84 and 1984-85. *Mar. Fish. Infor. Serv. T and E. Ser.*, **67** : 1-78.

BANSE, K. 1959. On upwelling and bottom trawling off the southwest coast of India. *J. mar. biol. Ass. India*, **1** : 33-49.

BAPAT, S. V., V. M. DESHMUKH, B. KRISHNAMOORTHI, C. MUTHIAH, P. V. KAGWADE, C. P. RAMAMIRTHAM, K. J. MATHEW, S. KRISHNA PILLAI AND C. MUKUNDAN 1982. Fishery resources of the Exclusive Economic Zone of the northwest coast of India. *Bull. Cent. Mar. Fish. Res. Inst.*, **33** : 1-86.

CARRUTHERS, J. N., S. S. GOGATE, J. R. NAIDU AND T. LAEVASTU 1959. Shoreward upslope of the layer of minimum oxygen of Bombay, especially fisheries. *Nature*, **183** : 1084-1087.

DIGHE, J. P. 1977. A study of lizardfish *Saurida tumbil* (Bloch). Ph.D. Thesis, Univ. of Bombay, 205 pp.

JAMES, P. S. B. R., D. S. RAO AND G. S. D. SELVARAJ 1987. A resume of marine biological and oceanographic research by the Central Marine Fisheries Research Institute, Cochin, India. *J. mar. biol. Ass. India*, **25** : 158-189.

JAYARAMAN, R. AND S. S. GOGATE 1957. Salinity and temperature variations in the surface waters of the Arabian Sea off Bombay and Saurashtra Coast. *Proc. Indian Acad. Sci.*, **45** (B) : 152-164.

JOSEPH, K. M. 1980. Comparative study of the demersal fishery resources of the Indian waters as assessed by 17.5 m trawlers. *Bull. Expl. Fish. Proj.*, **10** : 50 p.

—— AND M. E. JOHN 1986. Potential marine fishery resources. *Seminar on Potential Marine Fishery resources*. 29 p.

——, P. SULOCHANAN, M. E. JOHN, V. S. SOMAVANSHI, K. N. V. NAIR AND ANTONY JOSEPH 1987. Demersal fishery resources of Wadge Bank. *Bull. Fish. Surv. India*, **12** : 52 pp.

KUTHALINGAM, M. D. K. 1959. *Saurida tumbil* (Bloch) : Development and feeding habits. *J. Zool. Soc. India*, **1** (2) : 115-129.

NAIR, K. V. SOMASEKHARAN AND R. REGHU 1990. Studies on the threadfin-bream and lizardfish resources in the Exclusive Economic Zone of India based on the demersal trawling operations of FORV *Sagar Sampada*. *Proc. First Workshop Scient. Resul. FORV* Sagar Sampada, *5-7 June, 1989*, pp. 239-255.

PATIL, M. R., C. P. RAMAMIRTHAM, P. UDAYAVARMA AND C. P. ARAVINDAKSHAN NAIR 1962. Hydrography of the west coast of India during the premonsoon period of the year 1962. Part I. Shelf waters of Maharahtra and southwest Saurashtra Coasts. *J. mar. biol. Ass. India*, **6** (1) : 151-166.

RAMAMIRTHAM, C. P. AND R. JAYARAMAN 1960. Hydrographical features of the continental shelf waters off Cochin during the year 1958 and 1959. *Ibid.*, **2** (2) : 199-207.

—— AND D. S. RAO 1974. On upwelling along the west coast of India. *Ibid.*, **15** (1) : 306-317.

RAO, D. SADANANDA, N. P. KUNHIKRISHNAN AND R. VASANTHAKUMAR 1972. Hydrological features of the Arabian Sea off the northern and central west coast of India, during 1964 winter. *Indian J. Fish.*, **16** (1 & 2) : 1-13.

RAO, K. VENKATASUBBA 1983. Maturation and spawning of lizardfishes (*Saurida* spp.) from northwestern part of Bay of Bengal. *Ibid.*, **30** (1) : 152-164.

SUDARSAN, D., T. E. SIVAPRAKASAM, V. S. SOMAVANSHI, M. E. JOHN, K. N. V. NAIR AND ANTONY JOSEPH 1988. An appraisal of the marine fishery resources of the Indian Exclusive Economic Zone. *Bull. Fish. Surv. India*, **18** : 85 pp.

——, M. E. JOHN AND ANTONY JOSEPH 1989. An assessment of the demersal stocks in the southwest coast of India with particular reference to the exploitable resource in the outer continental shelf and slope. *Bull. Cent. Mar. Fish. Res. Inst.*, **44** : 266-272.

SULOCHANAN, P. AND M. E. JOHN 1988. Offshore deep sea and oceanic resources off Kerala Coast. *Bull. Fish. Surv. India.*, **16** : 27-48.

Bull. Cent. Mar. Fish. Res. Inst., 1992, 45 : 197 - 204

4. 11

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : FLATFISHES AND FLATHEADS

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ABSTRACT

The present paper deals with the fishery of flatfishes and flatheads along the west coast of India. Among flatfishes, the malabar role *Cynoglossus macrostomus* contributes significantly to the catch; *Psettodes erumei* also forms a fishery along Maharashtra and Gujarat Coasts. Among flatheads *Platycephalus maculipinna* contributes to the fishery. These two resources are mainly exploited by trawl. It is found that both the species are continuous spawners, with peak spawning taking place during September - November period. In both the groups the one year old fish contributes to the fishery. The major peaks of fishing are either immediately after the onset of monsoon or postmonsoon months.

INTRODUCTION

Among the demersal fishes of India, flatfishes and flatheads occupy a significant place. The annual average catch of flatfishes in the country is estimated at 36,000 t which forms 4.5% of the total fish catch (CMFRI, 1989). Tholasilingam *et al.* (1973) stated that from shallow and intermediate depths along the southwest coast, flatfishes and flatheads formed important constituents. West coast contributes 80-90% of the total marine flatfishes landed in the country. Rao (1967) states that the region between Mulki in South Kanara and Quilon in Kerala is important for sole fishery. Seshappa (1973) comments that the sole fishery along the west coast has always been an inshore fishery. The fishing cruises of many vessels have not yielded catches of any mentionable magnitude from deeper waters. The flatfish fishery of the west coast is dealt with in the present paper; in the case of flatheads, the data from Cochin and Calicut only are considered, for want of data from other centres.

Though about 91 species of flatfishes are known from the Indian waters, only a few species contribute considerably to the fishery. Sehappa (1973) states that only *Cynoglossus macrostomus*, contributes to a regular fisheryin Kerala and Kanataka Coasts, though a few others such as *C. dubius*, *Pseudorhombus* spp. and *Psettodes erumei* occur occasionally in the fishery.

Though a few species occur in stray numbers in the catches, *Platycephalus maculipinna* is the only species that contributes to the flathead fishery of trawlers.

DATA BASE

Data collected during February 1984-August 1988, from small private trawlers are presented in this paper. Sampling was carried out every week. To estimate the monthly catch, the average weight of catch per unit, on observation days was multiplied by the number of units in operation on that day and the total for all observation days was raised to the total number of actual fishing days in that particular month. Data from artisanal gear were also made use of on certain occasions, whenever it was required to substantiate certain findings. For the present study, a year is divided into Monsoon (June-August), Postmonsoon (September-January) and Premonsoon (February- May) seasons.

OBSERVATIONS

General fishery characteristics

Craft and gear: Small mechanised trawlers of size less than 14 m are the main craft employed in the fishery in the 20-50 m depth along the west coast, although non-mechanised country crafts are also employed in certain parts. It is estimated that there are about 7684 commercial trawlers operating along the entire west coast. The trawl nets operated from these mechanised boats have a cod end mesh size of about 18-25 mm. Indigenous gears employed especially along the Kerala Coast are the different types of seine nets like boat seines and shore seines

and a few drag nets are also used seasonally. Along the Malabar Coast 57.4% of the total flatfish were landed by trawl nets and the rest by indigenous gears. Among indigenous gears, the bulk of the catch was by *Paithu vala* (boat seines) and the rest by *Nethal vala, Pattan kolli vala* and *Chooda vala.*

Flatfish Fishery

Of the total production of 42,651 t of flatfishes in the country during the year 1984 (CMFRI, 1989), 89% was contributed by the west coast. Rao (1967) states that on the west coast, the soles are next in importance only to oilsardine, mackerel and shrimp fisheries in the magnitude of catch. The production trend in recent years shows that the catches are higher along the southwest coast and lower towards the northwest coast (Table 1). Rao (1967) states that the region between Mulki in South Kanara and Quilon in Kerala is important for sole fishery. The present study shows that maximum production comes from the Kerala Coast, which accounts for 40% of the total sole catches from the west coast. Karnataka contributes on the average 25%, Goa 10.7%, Maharashtra 17% and Gujarat 8.9%.

Kerala : Kerala contributed forty percent of the total flatfish catches of the west coast of India. During 1983-84 period, an average quantity of 15,400 t of these fish were landed in Kerala (Jacob *et al.*, 1987) forming about 4% of the State's total fish landings. But in the subsequent years, there was a decline in the landings; in 1985, the catch was 11,203 t forming 3.5% of the total catch. During 1986 and 1987 also the fishery was still on a declining note, with catches of 9,226 t and 10,115 t. But during 1988, there was an overall improvement in the landings of all finfish resources including flatfish along the Kerala Coast.

The Malabar Coast in Kerala in well known for the flatfish fishery. It contributed on an average 7.08% of the total finfish catch at Calicut. The most predominent species contributing to the sole fishery is the malabar sole *Cynoglossus macrostomus*, locally known as *manthal*. Studies on this species from this area were initiated in 1952 by Bhimachar and Venkataraman and continued by Seshappa and Bhimachar (1955), George (1958), Rao (1967) and Seshappa (1964, 1973). The Sole landings at Calicut during 1984 were 641.4 t, which declined to 260.4 t and 115.1 t in 1985 and 1986 respectively. In 1987, the catches showed an improvement to 243.6 t. But again in 1988, the catch declined (Table 6). On the Malabar Coast there is no gear that catches the flatfish exclusively or throughout the year (Table 7). Trawl nets gave the maximum landings during postmonsoon. Two special features of this fishery along this region are that there are wide fluctuations in the annual yield and that the commercial landings occur mostly within two or three months, immediately after monsoon. At Puthiappa near Calicut, soles were landed by trawl nets. Peak landings occurred during postmonsoon. During 1984-88 soles formed 15.9% of the total finfish catch (Table 6).

At Cochin, the flatfishes form about 4% of the total fish production. They are landed throughout

Table 1. *Statewise catch (tonnes) and percentage (in brackets) of flatfishes along the west coast during 1984-88*

	Kerala			Karnataka			Goa			Maharashtra			Gujarat		
	Premon-soon	Monsoon	Post-monsoon	Premon-soon	Monsoon	Post-monsoon	Premon-soon	Monsoon	Post-monsoon	Premon-soon	Monsoon	Post-monsoon	Premon-soon	Monsoon	Post-monsoon
1984	-	-	-	-	-	-	-	-	-	1074	129	3697	5527	-	1656
	-	-	-	-	-	-	-	-	-	(1.3)	(0.89)	(1.69)	(6.0)	-	(1.14)
1985	3674	3442	4087	1177	27	2575	1662	7	913	1788	201	2740	2308	-	936
	(3.77)	(3.87)	(2.71)	(4.37)	(1.87)	(2.5)	(4.73)	(0.22)	(3.55)	91.74)	(1.5)	(1.29)	(2.17)	-	(0.68)
1986	1774	1527	5925	2205	2147	2671	1736	103	606	2349	169	2588	793	-	1100
	(2.17)	(1.43)	(3.25)	(3.98)	(3.17)	(2.19)	(8.5)	(3.090	91.9)	(1.83)	(0.95)	(1.52)	(0.7)	-	(0.94)
1987	4330	2409	3376	1058	157	3881	587	10	1782	2091	272	3477	181	5	1160
	(4.96)	(2.47)	(2.85)	(1.53)	(4.15)	(2.42)	(3.1)	(2.9)	(3.81)	(1.97)	(1.590	(2.206)	91.8)	-	(1.08)
1988	4188	1598	6869	1923	35	2121	849	15	4989	1693	109	-	691	-	
	(4.49)	(1.36)	(2.43)	(2.46)	(0.68)	(1.76)	(3.92)	(4.02)	(5.75)	(132)	(0.77)	-	(1.15)	-	

the year by trawlers. During the period 1984-88, the landing of flatfishes was fairly good (Table 3). In 1984, the peak landings were in the month of February and a second one was noticed in June. Unlike the flatfish fishery on the Malabar Coast, landings were very much less during postmonsoon, but on the contrary, the fishery was fairly good during premonsoon and monsoon months. The peak landing was during the month of February and a second peak was noticed in June. In 1985 also, though the fishery of flatfishes showed a decline; a similar trend was observed with a major peak in March and another in June. In 1986, the flatfish fishery, especially the malabar sole fishery showed a two fold increase over the previous year. Fairly high catches of *C. macrostomus* were obtained during the period March-August; about 90% of the total flatfishes, were landed during this period. The peak landing was in the month of July. Again in 1987, the fishery showed an increasing trend; 89% of the total catch of flatfishes was landed during premonsoon and monsoon months. The catch was very poor during postmonsoon (Table 3). But by December the fishery was seen to have picked up again. In 1988 also, the flatfish fishery was fairly good. The major peak was during May and a minor peak was found during November.

Tholasilingam *et al.* (1968) stated that 3% of the ground fish catch off Cochin was comprised of soles; with a peak catch during December and another in April-May. According to Seshappa (1973), the commercial catches of Malabar sole at Calicut were obtained within two-three months immediately after the southwest monsoon, in large shoals at the surface and midwaters of the inshore sea. But this state of affairs was not observed in the Cochin area. The reason might be attributed to the changes in the method of fishing in the more recent times. Trawling became the more viable method for exploiting the ground fish resources. Before the introduction of trawlers, the shoaling behaviour of the fish was made use of for exploitation. The Malabar sole being a bottom dweller, feeds actively on amphipods, small polychaetes and lamellibranchs. During upwelling, the bottom mud is churned up and fish move to surface areas which are abundant in food, hence this shoaling behaviour could be attributed to be a feeding migration.

The flatfish fishery in relation to the intensity of rainfall was studied at Cochin. During 1985, 1986 and 1987, the catch rate had a direct correlation with the intensity of rainfall; the catch rate was fairly high during monsoon months. The intensity of rainfall was quite high during this period in 1986 and 1987, but in 1988, on the contrary during premonsoon months when rainfall was minimum, the catch rate was highest (Table 5).

Another interesting observation in the flatfish fishery exploited by trawlers at Cochin, over the years 1984 to 1988 was that the peak catch occurred mostly during the month of June, although in some years, there seems to be a slight shift in this period of peak landing. During 1984 and 1985, the peak was in June, but in 1986, the maximum catch was in July, whereas in 1987 the peak landing was again in June. In 1988, the month of peak landing was slightly earlier in May. However the flatfish fishery seemed to attain a peak only after the monsoon had set in along this coast.

Karnataka : The average estimated annual landing of flatfishes in Karnataka was 2.7% of the total fish catch in the State. Trawl nets were the main gear employed in the sole fishery here; except during the monsoon months when trawling was very less. During the premonsoon of 1985, 1177 t of soles were landed in the State whereas during monsoon period, the catch was a very negligible quantity of 27 t. In the postmonsoon months of 1985, trawlers brought 2575 t of soles. During the premonsoon months of 1986, 2205 t of soles were landed, which was 3.99% of the total fish catch of the State. Unlike the previous year, during the monsoon months of 1986, fairly good catch of 2147 t was landed by non-mechanised gears which formed 31.8% of the total fish catch during the season. In the postmonsoon months the catch was 2671 t by trawlers forming only 2.2% of the total fish catch. During the months February-May 1987, the sole fishery was comparatively poor in Karnataka forming only 1.5% of the total fish catch. During the monsoon months also the fishery was rather poor, but in the postmonsoon months 3881 t of soles were landed from trawlers. The sole fishery in Karnataka showed a decline throughout 1988. In the premonsoon months only 1923 t of flatfishes were landed, followed by 2121 t during postmonsoon period. During monsoon period the catches were negligible.

Goa : In Goa the sole fishery was mainly a trawl exploited one. Fishing activities using trawlers were less during the monsoon months. Goa contributed roughly 3100 t of flatfishes annually.

During the premonsoon months of 1985, 1662 t of flatfishes were landed with CPUE of 0.024 kg. The sole fishery was practically nil during monsoon period; in the postmonsoon again only 913 t of flatfishes were landed. In the succeeding year also the premonsoon months yielded better catch than other periods of the year. During 1987, the fishery was comparatively good only during the postmonsoon. The flatfish fishery was poor during monsoon months along the Goa Coast in the 1984-88 period. It was fairly good during premonsoon period of 1985 and 1986. But in 1984 and 1985 the season of higher catch and catch rate was postmonsoon.

premonsoon and postmonsoon, *Psettodes erumei* contributed 10-15% of the total flatfish catch.

Gujarat : Along the Gujarat Coast, flatfish fishery during the monsoon months was practically nil. During the period 1984-88 the flatfish production during premonsoon months was more than that of the postmonsoon. During monsoon months trawling operations were less than 5% of those of premonsoon period. During 1984, 5527 t of flatfishes were landed in the premonsoon and 1956 t in the postmonsoon. There was no catch in the monsoon. In the following year, 2308 t and 926 t of flatfishes were landed during premonsoon and

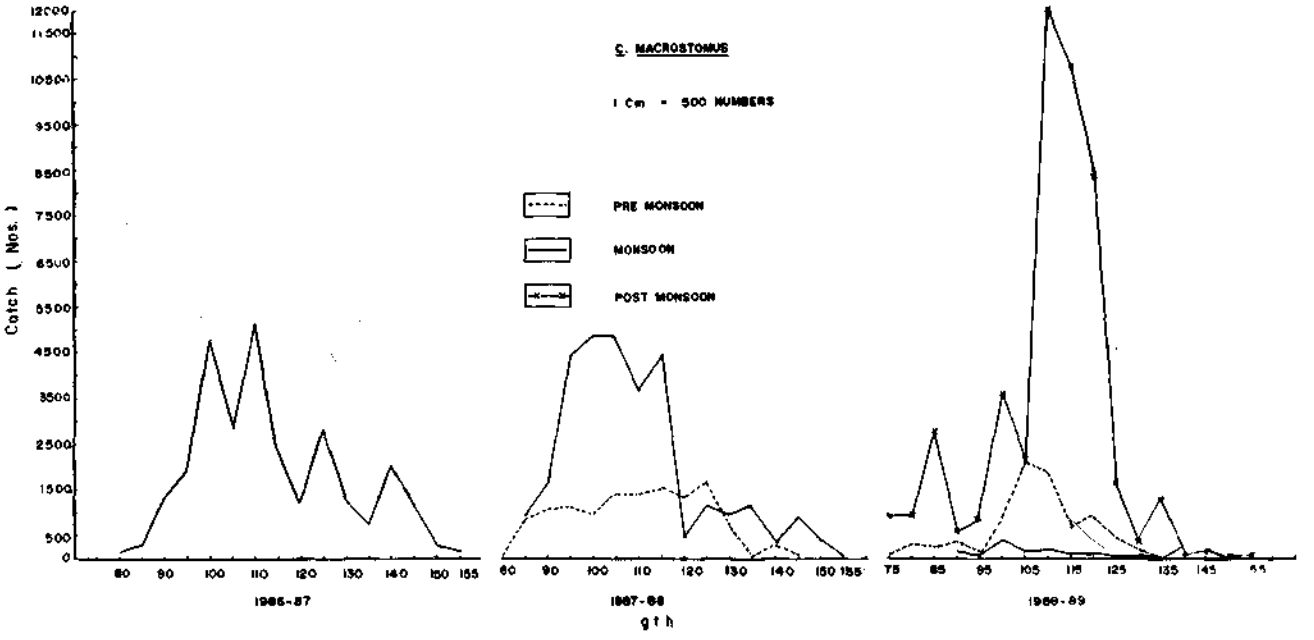

Fig. 1. Size distribution of *C. macrostomus* during premonsoon, monsoon and postmonsoon in the five year period 1984-88.

Maharashtra : Along the Maharashtra Coast also, fishing operations during monsoon period were much less, almost one-fourth that of the other months. Flatfish catch during monsoon for 1984-88 was very poor compared to the postmonsoon and premonsoon catches. During the postmonsoon months 3243 t of flatfishes were landed. In the premonsoon period of 1985 the flatfish landings were 1728 t; in the monsoon months it was only 198 t, but during postmonsoon the flatfish catch was about 2414 t. On an average the flatfish catch was only 1.3% of the total fish catch in the State. During 1986, the catch during premonsoon was slightly more than that of postmonsoon season. While it was the reverse in the succeeding years of 1987 and 1988. On the Maharashtra Coast, during postmonsoon respectively. In 1986, 793 t were landed during premonsoon and 1100 t in the postmonsoon. In 1987 also there was not much increase in the catch, being 1381 t and 1160 t during premonsoon and postmonsoon respectively. On an average the flatfishes contributed to 0.9 to 1.5% of total fish catch in the State. *Psettodes erumei* contributed to 10-15% of the total flatfish catch in the Gujarat Coast.

Species composition

Although Norman (1927, 1928) described 91 species of flatfishes from Indian waters, only a few species contribute to the fishery. The bulk of the catch (about 90%) was constituted by *Cynoglossus macrostomus*, particularly in Kerala and Karnataka

Coasts. A few other species such as *C. dubius, C. macrolepidotus, C. lingua, Pseudorhombus* spp. and *Psettodes erumei* also occurred occasionally in the fishery.

Length composition

Along Cochin area, during premonsoon months *C. macrostomus* fishery was constituted by fishes in the size range 75-152 mm (Fig. 1). Fishes of smaller size were more in the fishery during February and March, but they were not predominant during monsoon period. During 1984-88, the mode in this season varied from 115 mm to 120 mm. Again in December-January, smaller fishes occurred in plenty in the fishery, their size ranged from 41 to 129 mm. In December, 75% of them were juveniles, with a mode of 65 mm. During November-December these were caught in fairly good quantity, the catch rate being upto 5 kg in the boat seines operating very near the shore upto a depth of 10 m.

The size frequency data of *C. macrostomus* at Cochin show that females have a higher upper size limit than males. Also females tend to grow at a faster rate than males. This is in conformity with the observation on *C. macrostomus* at Calicut (Seshappa and Bhimachar, 1955). At Puthiappa on the Calicut Coast *C. macrostomus* ranged in size from 55 to 154 mm.

Maturity and spawning

According to Seshappa (1955) spawning of Malabar sole starts by about October at Calicut and extends upto the premonsoon months. However, at Cochin gravid and spent adults were encountered in appreciable quantities in September. Some spawning activity was also observed in April-May. Young ones were (65 mm modal group) generally observed during November-January, very close to shore and exploited by cast net.

Fishery of Flatheads

The flatheads are also a nearshore demersal resource occurring along the west coast. Tholasilingam *et al.* (1968) reported that these contributed to about 10% by weight of the miscellaneous fish component of the trawl catches at Cochin. The flathead fishery on the west coast has not been studied much except the work of Kuthalingam (1972) from off Mangalore. During 1984 a total of 208.5 t of flatheads landed at Cochin. The maximum landings (147 t) were in the premonsoon months. The lean period for the flathead fishery was the postmonsoon months with the catch as low as 9.9 t. The flathead fishery was on a decline in the succeeding years of 1985, 1986 and 1987. During 1985, the premonsoon catch was 15.0 t and in the monsoon it was 9.7 t and a total of 5.1 t of flatheads were landed in the postmonsoon months. In 1986 also, the flathead fishery showed a declining trend, with the total catch at 71 t. The bulk of the catch came during premonsoon and monsoon months. The maximum landing of 26.9 t was in August this year (Table 2). During 1987, a total of 81.5 t of flatheads only were landed at Cochin. Of this 27.8 t were landed during the monsoon period and 38.4 t in the premonsoon months. In the postmonsoon season, the flathead fishery was found to be rather poor as was seen in the previous years. But in 1988, the situation changed and a total of 322.1 t of flatheads were landed at Cochin. The catch during premonsoon months was 239 t and during monsoon season 63.4 t were caught. As observed in the previous years, the fishery declined as the monsoon advanced. The maximum catch (106.4 t) was observed in May.

Table 2. *Monthly catch (Kg) of flatheads at Cochin during 1985-88*

Month	1985	1986	1987	1988
January	-	-	1892	1174
February	-	8000	16596	24177
March	-	7000	18928	36543
April	-	-	-	71867
May	-	30067	3376	106428
June	-	6939	25635	51078
July	546	6683	406	3308
August	9210	26983	1812	9027
September	-	352	227	5575
October	-	-	-	10921
November	2932	-	5853	803
December	3225	-	6861	1204
Total	15913	86024	81586	322105

At Cochin, over the period of five years, the major peaks in the flathead fishery were observed during the monsoon and premonsoon months; the fishery was poor during the postmonsoon period (Table 4). Tholasilingam *et al.* (1973) stated that off

Cochin *Platycephalus* sp., *Nemipterus japonicus* and *Otolithus* sp. were abundant in the shallow and intermediate depths during January - March.

TABLE 3. *Estimated catch (Kg) of* Cynoglossus macrostomus *during premonsoon, monsoon and postmonsoon, during 1984-88 at Cochin*

	1984	1985	1986	1987	1988
Premonsoon	147,457.49	65,247.	71,548.63	152,373.1	224,213.77
Monsoon	60,176.8	40,718	255,437.2	245,294.4	39,827.4
Postmonsoon	876.64	6,875.7	56,049.9	15,213.69	133,400.77

At Calicut the flathead fishery constituted on an average of 0.11% of total landings during 1984-88 period with the maximum landings in 1986. A maximum of 73.9% of the flathead landings occurred during premonsoon period with catch per effort at 1.28 kg. The entire catch consisted of

TABLE 4. *Estimated catch (Kg) of* Platycephelus maculipinna *at Cochin during premonsoon, monsoon and postmonsoon, during 1985-88*

	1985	1986	1987	1988
Premonsoon	15,000	30,067	38,900	238,950
Monsoon	9,756	40,605	27,853	63,413
Postmonsoon	5,157	2,244	14,114	18,503

Platycephalus scaber. Out of the 85 t of flatheads landed at Puthiappa at Calicut, 77.5% were landed during premonsoon with a CPUE of 7.6 kg and the rest of the catch landed in the postmonsoon. Here the peak catch was in the month of March. A single species *viz.*, *P. scaber* constituted the catch (Table 6).

TABLE 5. *Catch rate (%) of Malabar sole with intensity of rainfall in brackets at Cochin during premonsoon, monsoon and post-monsoon months*

	1984	1985	1986	1987	1988
Premonsoon	59.33 (17.29)	31.61 (23.81)	13.69 22.85)	33.79 (8.09)	50.20 (6.89)
Monsoon	20.54 (53.33)	61.36 (29.54)	75.03 (51.44)	60.61 (60.76)	13.96 (59.34)
Postmonsoon	20.05 (23.83)	7.02 (16.55)	11.83 (25.71)	5.60 (31.05)	35.84 (33.27)

During 1985 and 1986, the fishery at Cochin was good during monsoon months, when the quantum of rainfall was also quite good. But during the succeeding years, the fishery did not show positive correlation with the rainfall.

TABLE 6. *Flatfish and flathead landings at Calicut during 1984 to 1988*

Year	Total catch (t)	flat fishes (t)	%	flatheads (t)	%
1984	7417.8	641.4	8.7	6.7	0.09
1985	3750.4	260.4	6.9	1.5	0.04
1986	2288.4	115.1	5.0	0.4	0.10
1987	3147.6	243.6	7.7	4.1	0.13
1988 (upto Aug.)	248.4	78.0	31.4	Nil	Nil

Sex ratio and maturity

At Cochin, females of *P. maculipinna* predominated in the fishery in all the months except in June 1988, when the male : female ratio was 3:2. During premonsoon months, the predominant maturity stages were III and IV, more than 50% were mature fish. The presence of fishes in stage VII, in the fishery at least in stray numbers in all the months indicated prolonged or continuous spawning in this species. During the monsoon months, stages VII as well as stages II and III predominated in the fishery. However, in August, the most frequently occurring stages were V and VI in females, the ova were fully ripe and the ovaries

TABLE 7. *Percentage of flatfish landings in different gears at Calicut during 1984-'88*

Gear	Premonsoon	Monsoon	Postmonsoon
Trawl net	85.26	-	70.99
Paithu vala	14.73	-	10.19
Chooda vala	0.01	71.22	0.27
Mathichala vala	-	20.86	0.06
Ailachala vala	-	-	3.26
Nethal vala	-	7.91	-
Patten Kolli vala	-	-	15.23

in oozing stage. Males were also in advanced stages of maturity of IV and V. Again in October also, the same condition prevailed and stages V, VI and VII predominated. 70% of specimens in the samples were either in oozing stage or partly spent condition. Quite a good number of juveniles and immature fish occur in the fishery during October-December. In January, though spawning takes place to a less extent, spent fish as well as fishes in stages II and III occurred in the fishery.

Length composition

The principal modes in the length frequency distribution of *P. maculipinna* in different months during 1985-88 ranged from 170 mm to 250 mm. During monsoon season, the modes were at 180-230 mm in different years; in the premonsoon at 190-250 mm and in postmonsoon at 195-230 mm (Fig. 2).

only when the fishes were shoaling in the surface and subsurface waters, but inefficient to capture them when they were at the bottom. In recent years, trawling was made possible almost throughout the year, except during monsoon, when mechanised trawling was suspended for sometime.

Although the spawning in the Malabar sole was throughout the year, the months of peak spawning were found to be postmonsoon months extending upto the premonsoon. During February-March small fishes and juveniles were more in the fishery. But in the monsoon period the size ranged from 98 to 146 mm and the predominant modes were at 115 and 120 mm. Again in the succeeding December - January also, smaller fishes occurred in plenty in the fishery; their size ranging from 41 to 129 mm with the mode at 65 mm.

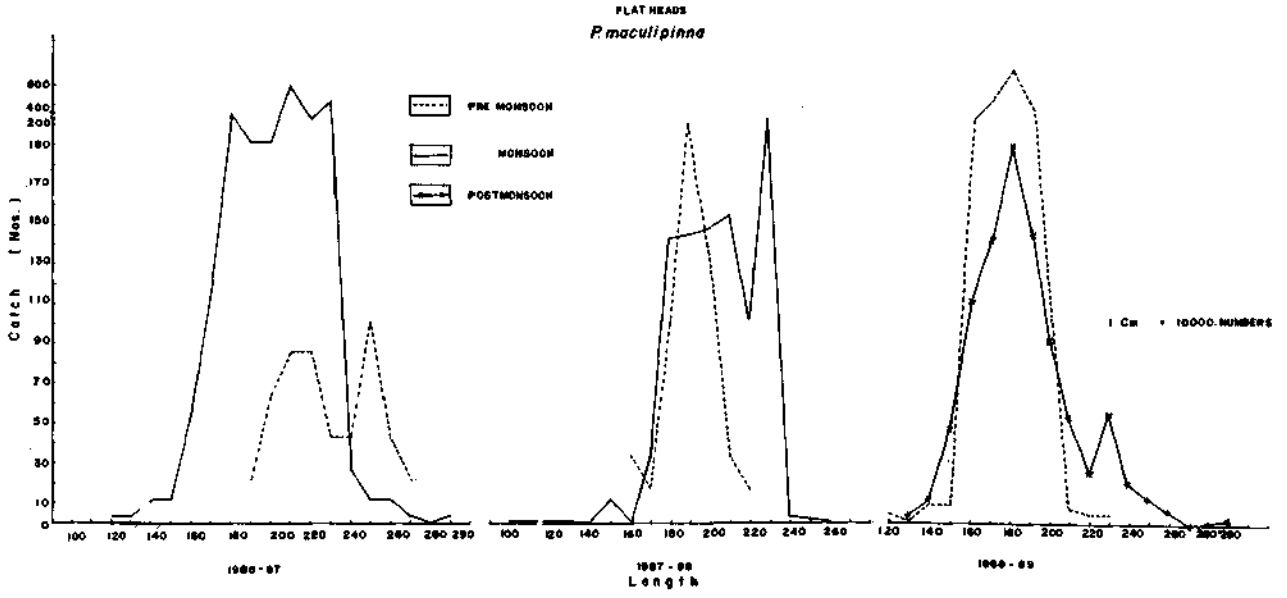

Fig. 2. Size distribution of *P. maculipinna* during premonsoon, monsoon and postmonsoon in the five year period 1984-88.

Discussion

According to Seshappa (1973) the Malabar sole fishery in the Calicut Coast was a postmonsoon fishery with the maximum landings in September, though the landings gradually declined. He also reported a very high catch of soles in the pre-monsoon months with the juveniles dominating. With the introduction of mechanisation in the early sixties, the pattern of the fishery underwent a change, earlier, the gears employed were effective

The flatheads also spawn mostly during the postmonsoon months of August - October. During monsoon months, they are predominantly in stages II and III. In the case of soles and flatheads along the west coast, the fishes belonging to the one year old constitute the fishery. Juveniles and young ones of flatfishes are mainly caught during December-January and those of flatheads during premonsoon months. ***It is found that during premonsoon and monsoon, these two resources are available in the inshore grounds in fairly good concentrations and the monsoon fishing does not affect the stocks.***

References

BHIMACHAR, B. S. AND G. VENKATARAMAN 1952. A preliminary study of the fish population along the Malabar Coast. *Proc. Nat. Inst. Sci. India*, **18** B (6) : 627-655.

CMFRI 1989. Marine Fish Production in India 1985-86. *Mar. Fish. Infor. Serv. T & E Ser.*, **91** : 1-32.

GEORGE, P. C. 1958. Sole fisheries. *Fisheries of the west coast of India. Central Marine Fisheries Research Station, Mandapam Camp*, pp. 51-54.

JACOB T., V. RAJENDRAN, P. K. MAHADEVAN PILLAI, JOSEPH ANDREWS AND U. K. SATHYAVAN 1987. An appraisal of the marine fisheries in Kerala. *CMFRI Sp. Publ.*, 33.

KUTHALINGAM, M. D. K. 1972. Observations on the fishery and biology of *Grammoplites scaber*. *Indian J. Fish.*, **17** (1 & 2) : 97-104.

NORMAN, J. R. 1927. The flatfishes (Heterosomata) of India with a list of species in the Indian Museum Part I. *Rec. Indian Museum*, **29** (I) : 7-48.

——, 1928. The Flatfishes (Heterosomata) of India with a list of species in the Indian Museum Part II. *Ibid.*, **30** (2) : 173-215.

RAO, K. V. N. 1967. The Flatfishes. *Souvenir, 20th Anniversary of CMFRI*, pp. 62-66.

SESHAPPA, G. 1964. Length frequency studies on the Malabar sole *Cynoglossus semifasciatus* Day. *Indian J. Fish.*, **11** (1) : 533-546.

——, 1973. The flatfish resources of the west coast of India. *Proc. Symp. Living Resources of the seas around India, CMFRI Spl. Publ.*, pp. 470-482.

—— AND B. S. BHIMACHAR 1955. Studies on the fishery and biology of the Malabar sole *Cynoglossus semifasciatus* Day. *Indian J. Fish.*, **2** (1) : 180-230.

THOLASILINGAM, T., G. VENKATARAMAN AND K. N. KRISHNAKARTHA 1968. A study of the fishery and estimation of relative abundance of ground fish off Cochin. *Ibid.*, **11** (2) : 709-714.

——, K. C. GEORGE, M. G. DAYANANDAN, P. KARUNAKARANA NAIR AND K. NANDAKUMARAN 1973. Exploratory trawl fishing and ground fish resources along the Kerala Coast and adjacent waters. *Proc. Symp. Living Resources of the seas around India, CMFRI Spl. Pub.*, pp. 241-257.

Bull. Cent. Mar. Fish. Res. Inst., 1992, 45 : 205 - 225

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PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : PRAWNS

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ABSTRACT

The Prawn fishery of the west coast of India is reviewed with particular reference to monsoon season and related management problems based on observations at Cochin, Calicut, Mangalore and Bombay. With an estimated average annual production of about 25,000 tonnes for the period 1984-88, the monsoon season contributes only 15% to the total prawn landings of this coast. While shrimp trawling remains almost completely suspended in most of the centres during this period, it is very active at Cochin and Sakthikulangara in Kerala Coast and moderately active in Bombay Coast. In Kerala, monsoon trawling is mainly targetted for *Parapenaeopsis stylifera* ('Karikkadi') which occupies relatively deeper waters during July-August. At Cochin, nearly 50% of the annual catch of trawlers is recorded during monsoon, with peak landings in July. In the traditional sector, though the prawn catch has considerably diminished in Cochin and neighbouring areas in recent years, the State as a whole witnessed tremendous increase in prawn production as a result of the introduction of ring seines. This fishery is chiefly supported by *Penaeus indicus* and *Metapenaeus dobsoni* which migrate to nearshore waters as a result of environmental changes taking place during monsoon season. As the contribution of 'Karikkadi' in this fishery is rather negligible, it appears that there is no clash of interest as far as exploitation of shrimp resource is concerned during the monsoon season. **As 'Karikkadi' is mainly concentrating in the offshore waters and the trawl catch does not contain an alarming proportion of breeding population, shrimp fishing in the deeper waters beyond the 30 m depth line would be advantageous to the fishery during this season.**

In the Mangalore Coast, a lucrative coastal fishery exists for prawns in the traditional sector during the monsoon period when large quantities of *M. dobsoni are* caught by 'Matabala' (a type of ring seine). Biological observations have shown that majority of the female prawns caught during this period are larger sizes far above the minimum size of attainment of maturity. As these prawns would have already spawned many times and are approaching their maximum size, it is felt desirable to exploit them and avoid natural mortality due to senility.

The monsoon trawl fishery of Bombay waters is largely supported by *P. stylifera, M. affinis* and *M. monoceros,* whose peak breeding is observed outside the monsoon season. Hence this fishery does not seem to adversely affect the breeding stock. It is, however, observed that the mean sizes of *P. stylifera* and *M. affinis* fall considerably during the early part of the monsoon season due to heavy recruitment of younger population into the fishery. If these undersized prawns are allowed to grow by observing a closed season for a short period of one or two months during June/July, it is hoped that the prawns would attain larger sizes and improve the quality of catch in the following months and enhance the economic returns of the fishermen. Possibility of increasing prawn production by extending commercial shrimp trawling in the offshore waters during the monsoon season is also pointed out.

INTRODUCTION

Among the various marine fishery resources of the west coast of India, prawns occupy a prominent position on account of its high export value. The tremedous development that has taken place in the capture fisheries along this coast during the past 3-4 decades was mainly due to the growing demand for shrimps in the overseas markets. Until about 1970, even after the advent of mechanised fishing outside the traditional fishing grounds prompted by the encouraging results of exploratory surveys, the commercial shrimp trawling prevailed only during the fair seasons extending from about September/October to May/June. The fishing activities during the monsoon season were relatively poor, being undertaken only by the indigenous craft and gears in the shallow coastal waters. The mechanised fishing, particularly shrimp trawling, remained totally suspended throughout the monsoon period due to rough weather conditions and other operational difficulties.

The fishermen of Kerala set an example in venturing the rough seas during the monsoon period for shrimp trawling by about early seventies from two centres, *viz.* Sakthikulangara (Quilon) and Cochin, where infrastructure facilities had developed for the operation of mechanised vessels. The State witnessed steady increase in prawn production during the subsequent few years and soon reached a level of stagnation. In other maritime States of the west coast, monsoon trawling commenced only very late and an attempt in this direction was made by Maharashtra to a limited extent.

In Kerala where monsoon trawling became a regular practice for exploiting prawns, many socio-economic problems began to crop-up as a result of the alleged encroachment of trawlers in the domain of the traditional sector. Outbreak of conflicts between these two sectors engaged in fishing in more or less the same fishing ground and trying to share common resources has become a regular feature in the State and also to a smaller extent in Maharashtra. It is also argued by the traditional fishermen that shrimp trawling in coastal waters during monsoon period is detrimental to the fishery wealth as well as to the coastal ecology. This has even led to the imposition of ban on trawling during the monsoon period in the last few years along the Kerala Coast. As monsoon trawling in the other parts of the west coast is likely to catch up momentum, similar situation may arise there also in future.

Many workers have attempted to study the prawn fishery of this coast and furnished information on the biology and fishery characteristics of important species from different centres. In Kerala, most of the studies carried out have been from Cochin and its neighbouring areas. Among the earlier works dealing with the fishery and biology of prawns of this coast, the studies of Panikkar (1937), Menon (1951, 1953, 1955, 1957), Panikkar and Menon (1955) and George (1960, 1961) are noteworthy. George *et al.* (1963) have provided a detailed account of the offshore prawn fishery of the area based on the catches of the Government of India trawlers operating from 1956 to 1963. Subsequent studies made by George and George (1964), Banerji and George (1967), George and Rao (1967); George *et al.* (1968), Rao (1968, 1972), Mohamed (1973), Kurup and Rao (1974), and Suseelan and Rajan (1989) have considerably augmented our knowledge of the fishery and population characteristics of prawns of the area. Alagaraja *et al.* (1986) have carried out stock assessment of important species at Cochin and Sakthikulangara based on the trawl catches of 1981-82 period. The prawn fishery of Karnataka Coast has been studied mainly from Mangalore and neighbouring centres (Ramamurthy, 1972 a; Ramamurthy and Sukumaran, 1984; Sukumaran (1987). Sukumaran *et al.* (1988) have dealt with the indigenous prawn fishery of Mangalore area during monsoon, while George *et al.* (1988) evaluated the present status of shrimp trawling and its impact on shrimp stocks of the entre Karnataka Coast. The distribution, fishery, species composition and biology of important species in Bombay waters have been elucidated by many workers, of which the contributions of Rajan *et al.* (1982), Aravindakshan and Karbhari (1983), Chakraborty *et al.* (1983), and Sukumaran and Rajan (1986) are some of the recent ones. Information on the prawn fishery of Gujarat Coast are derived mainly from the studies of Rao and Kasim (1985) from Veraval and Ramamurthy (1967), Deshmukh (1975) and Rao (1983) from Kutch region.

Apart from various regional investigations mentioned above, Silas *et al.* (1984) have made a general appraisal of the prawn fishery of the entire west coast, assessing the potential stocks at important centres. More recently, Suseelan and Rajan (1991) reviewed the coastal prawn fishery of this coast through low energy fishing methods and pointed out measures for improving the earnings of the traditional fishing sector.

Besides the investigations carried out from the sea, a number of studies have also been undertaken on the biology and exploitation of prawns from the estuaries and backwaters which serve as nursery grounds for many species of marine prawns contributing to the fishery. Some of the important contributions in this regard are the works of Suseelan and Kathirvel (1979, 1982) from Ashtamudi Backwater; Menon (1954), Gopinath (1955), Menon and Raman (1961) and George (1974) from Cochin Backwater and connected prawn filtration fields, and of Ramamurthy (1972) and Sukumaran and Nandakumar (1983) from Mangalore Estuary.

In the present paper, an attempt is made to assess the prawn fishery and connected manage-

ment problems of the west coast of India with particular reference to monsoon season.

Data Base

The gearwise catch and effort data of prawns taken from the Fishery Resources Assessment Division of CMFRI and the biological data collected by random sampling of commercial catches at Cochin, Calicut, Mangalore and Bombay during the period 1984-'88 formed the data base for this study. At Cochin, the catch and effort statistics and biological data were collected from trawlers operating from Cochin Fisheries Harbour and indigenous gears operating in the coastal waters of Ernakulam District (Sy. Zone 5). In the case of the indigenous fishery, detailed biological observations were made from three landing centres, namely Puthuvyppu, Narakkal and Fort Cochin during the monsoon season of 1988. At Calicut, the data were collected from Vellayil, where trawl net was the main gear used except during the monsoon period when the indigenous gears alone were operated. At Mangalore also, trawl net was the most important gear employed in the fishery except during the monsoon season when its operation was totally suspended. The data for trawl fishery were recorded from Mangalore bunder and indigenous fishery ('Matabala') from Ullal and Panambur Harbour. At Bombay, the data on trawl fishery were collected from two landing centres *viz.*, New Ferry Wharf and Sassoon Dock.

The prawn samples drawn from the commercial catches were analysed for species composition, size, sex and maturity condition of important species. The size refers to total length of the prawn. For size frequency and mean size analysis, the length measurements were grouped into 5 mm class intervals. The catch, effort and biological data collected from each of the centres were compiled seasonwise dividing the year into premonsoon (February-May), monsoon (June-August) and postmonsoon (September-January) seasons.

Observations

Craft and gear and fishing grounds

The shrimp fishing grounds on the west coast of India are spread over two diverse geographical regions - the southwest region comprishing of the coasts of Kerla, Karnataka and Goa and the northwest region comprising of the coasts of Maharashtra and Gujarat - where the physical Characteristics of the coastsal waters differ considerably from each other. While the southwest coast experiences strong upwelling and the consequent environmental changes during the monsoon seasons, the northwest region is characterised by strong tidal currents and a much wider continental shelf. The fishing craft and gears operating in these two regions are also suited to the prevailing physical conditions of the sea. George and Suseelan (1980) have described the distribution of different types of gears operated and their prawn production in different maritime States of this coast. In general, the indigenous fishery is based primarily on a few varieties of active gears on the southwest coast and passive gears on the northwest coast. Three major types of gears *viz.*, seine nets, fixed bag nets and gill nets are operated with the help of mechanised as well as nonmechanised country crafts such as catamarans, canoes and plank-built boats. On the southwest coast, the traditional gears (boat seines and shore seines) and the newly introduced mini purse seines ('ring seines' in Kerala and 'Matabala' in South Karnataka) are operated commonly, the later two types being intensively used during the southwest monsoon period in the coastal waters. In Kerala, the ring seines have almost replaced the boat seines locally called 'Thanguvala ', which was the principal gear used in the well known Mudbank ('*Chaakara*') fishery for ages. The 'Matabala' has turned out to be the most important gear operated now by the artisanal fishermen along Mangalore Coast during July-September. In the northwest coast, the important gears employed in the traditional sector are fixed bag nets/stake nets, which are operated against the flow of tide. The large version of these nets called 'Dol' nets are operated only during the nonmonsoon periods, while the smaller stake nets alone are used during the monsoon period in shallow coastal waters and creeks. Bottom-set gill nets made of synthetic twine are widely used along the west coast in the inshore waters, particularly during monsoon season. In certain areas of the southwest coast, as in the coast of Trivandrum District in Kerala, the regular single layered gillnets are being replaced by the tripple-walled trammel net popularly known as 'Disco vala' or 'Disco net' (Joel and Ebenezer, 1985). This net is operated upto a depth of about 35 m, with peak fishing activities during the southwest monsoon period. Another innovative gear that has been introduced in the coastal fishery in recent years is

the 'mini trawl' operated by motorised country craft without any winch facility. These nets have cod-end mesh sizes varying from 14 to 20 mm and are increasingly operated along the Kerala Coast during non-monsoon period.

Trawl nets of various designs and sizes operated by small mechanised vessels (8-14 m) are the most important gear used for exploiting prawns along this coast. Four-seam or two-seam shrimp trawls of 12-28 m headrope length having cod-end mesh sizes of 20-25 mm are operated. The fishing ground extends upto about 60 - 70 m depth. In general, the trawling season commences by about September and lasts till the end of May or some times middle of June, the operations being totally suspended during the monsoon period. In Kerala, however, shrimp trawling is most active during the southwest monsoon season at Cochin and Sakthikulangara. At Cochin, the trawl fishing during non-monsoon period is mainly restricted to the coastal waters upto about 25 m depth, while during the southwest monsoon period (June-August) the vessels gradually move out to deeper waters and operate between 30 and 60 m depth. In Maharashtra also shrimp trawling is practised during monsoon period in a smaller scale from Bombay. Here, the fishing is carried out in comparatively deeper waters (30-70 m) during non-monsoon months, whereas during monsoon period the trawling operations are confined to nearshore areas within 30-40 m depths for relatively shorter durations in each fishing trips.

General trend of prawn production

In the total marine prawn production of India, which amounted to an average of 1,97,000 t for the period 1984-'88, the west coast accounted for about 1,64,000 t forming 83 %. The annual prawn landings recorded during the 5-year period under study along with their percentages in the All-India prawn landings of the respective years are as follows :

Year	West coast prawn landings in tonnes	% in All-India prawn landings
1984	149179	77.7
1985	161788	85.6
1986	175343	83.3
1987	160973	84.4
1988	171805	84.8

Maharashtra accounted for about 52.7 % of this fishery, followed by Kerala 27.0 %, Gujarat 13.5 %, Karnataka 4.0 % and Goa 2.8%. Gearwise analysis of the catch data (Table 1) has indicated that, as much as 57% of the prawn catch of the entire west coast was contributed by the trawl sector and the remaining 43% by the artisanal sector. It is all the more striking to note that the trawlers registered nearly 80 to 100% of the prawn landings in the maritime States of the southwest region, Karnataka and Goa having contributed always the highest percentages (88.5-99.7%). As far the northwest region, the catch contribution of both the sectors of fishing was more or less equal, Gujarat registering slightly higher catches by trawlers (55.5%) than the artisanal gears (44.5%) and Maharashtra in the reverse order.

A perusal of Table 2, which summarises the seasonwise analysis of catch, would reveal that about 85% of the prawn landing was recorded during the non-monsoon period and only 15% during the monsoon period. In Gujarat, a meagre catch of about 4% recorded during the monsoon period was almost exclusively contributed by indigenous gears. Maharashtra registered an average production of over 9000 t during the monsoon season, which formed 9% of the total prawn landings of the State. This was mainly contributed by the trawlers operating from Bombay Coast. In Goa and Karnataka, 12-13% of the annual prawn catch was landed during the monsoon season. A significant portion of this catch in Karnataka was contributed by the artisanal gears, particularly 'Matabala'. The highest production of prawns during the monsoon season was recorded along the Kerala Coast, with an average landing of nearly 16,000 t (33.6%). This was mainly due to the heavy catches in trawl and boat seines/ring seines in all the years except in 1987. A remarkable increase in prawn catch of the traditional sector during monsoon season as a result of increased fishing by ring seines is a noteworthy change that has taken place in Kerala's marine capture fisheries in the last two-three years if the data after 1988 are also considered. In 1988, about 8500 t out of the total 18,000 t landed by the traditional sector was recorded during the monsoon season, which was mainly caught by both ring seines and boat seines. In 1989, the monsoon season recorded the maximum catch of 13,000 t out of the total 17,900 t landed by this sector, which was obtained chiefly

in ring seines. The gillnet/trammel net also contributed substantially to the monsoon fishery of the State.

TABLE 1. *Statewise and sectorwise prawn landings and percentage of west coast of India 1984-'88*

	States	Trawl sector (t)	(%)	Indigenous sector* (t)	(%)	Total (t)
1984	Gujarat	10680	55.1	8704	44.9	19384
	Maharashtra	36024	43.3	47140	56.7	83164
	Goa	4634	95.5	219	4.5	4853
	Karnataka	5000	90.7	511	9.3	5511
	Kerala	24971	68.8	11296	31.2	36267
	Total	81309	54.5	67870	45.5	149179
1985	Gujarat	9402	47.4	10446	52.6	19848
	Maharashtra	37759	35.3	69214	64.7	106973
	Goa	3451	98.7	45	1.3	3496
	Karnataka	4512	98..4	72	1.6	4584
	Kerala	23438	87.2	3449	12.8	26887
	Total	78562	48.6	83226	51.4	161788
1986	Gujarat	11389	46.8	12954	53.2	24343
	Maharashtra	40612	39.2	63116	60.8	103728
	Goa	4631	98.6	64	1.4	4695
	Karnataka	4912	92.9	373	7.1	5285
	Kerala	25124	67.4	12168	32.6	37292
	Total	86668	49.4	88675	50.6	175343
1987	Gujarat	17342	75.7	5565	24.3	22907
	Maharashtra	36237	51.9	33535	48.1	69772
	Goa	5776	99.7	19	0.3	5795
	Karnataka	8821	94.1	553	5.9	9374
	Kerala	47427	89.3	5698	10.7	53125
	Total	115603	71.8	45370	28.2	160973
1988	Gujarat	12364	52.1	1137	47.9	23738
	Maharashtra	28203	41.6	39553	58.4	67756
	Goa	3939	99.4	24	0.6	3963
	Karnataka	7690	88.5	1000	11.5	8690
	Kerala	54407	80.4	13251	19.6	67658
	Total	106603	62.0	65202	38.0	171805
Average	Gujarat	12235.4	55.5	9808.6	44.5	22044
	Maharashtra	35767.0	41.5	50511.6	58.5	86279
	Goa	4486.2	98.4	74.2	1.6	4560
	Karnataka	6187.0	92.5	501.8	7.5	6689
	Kerala	35073.4	79.3	9172.4	20.7	44246
	Total	93749	57.2	70068.6	42.8	163818

* Includes the occasional catches of prawns recorded in purse-seines also.

Centrewise catch, effort and catch rates

Cochin : Trawl fishery : The seasonwise break-up of prawn landings at Cochin Fisheries Harbour is shown in Table 3. The average annual prawn landings amounted to 2908 t of which nearly 50% (1432 t) was registered during the monsoon period and rest during the non-monsoon period. The contributions of premonsoon and postmonsoon seasons worked out to 38% and 12% respectively. In the average annual fishing effort of 42802 boat trips expended on the fishery, 13724 boat trips (32%) were performed during the monsoon period yielding the highest CPUE of 91 kg/boat trip. Though the effort expended during the premonsoon season was much higher (44%) than in the monsoon season the catch rate was only 61 kg/boat trip. Postmonsoon recorded the lowest CPUE of 35 kg/boat trip.

TABLE 2. *Average catch contributions (%) of monsoon and non-monsoon seasons to the total prawn landings of west coast, 1984-'88*

States	Monsoon	Non-monsoon	
		Premonsoon	Postmonsoon
Gujarat	4.2	41.9	53.9
Maharashtra	9.0	33.6	57.4
Goa	12.1	45.1	42.9
Karnataka	13.0	44.6	42.6
Kerala	33.6	35.6	30.8
West coast Total	15.4	39.3	45.3

The annual trend in prawn production during the monsoon season indicated that the fishery was relatively poor in 1984 and 1985 seasons when greater portion of the catch (57-67%) was obtained during the premonsoon season. In the subsequent two years the catch as well as CPUE steadily increased to reach a maximum of 2575 t and 144.5 kg/boat trip in 1987 season contributing the bulk (61.7%) to the fishery of that year. In 1988 season a drop in the catch as well as CPUE was noticed in spite of a substantial increase in fishing effort.

Within the monsoon season the peak of the fishery varied between the months, the maximum frequency of peak landings having been recorded in July (Table 4). In all the years, except in 1988, over 90% of the monsoon catch was registered during June-July period. In 1988 season, which was characterised by a peak in August, exceptionally high CPUE (135.8 kg) was recorded.

TABLE 3. *Prawn landings (t), fishing effort (boat trips) and CPUE (kg) by shrimp trawlers during monsoon and non-monsoon periods at Cochin Fisheries Harbour, 1984-'85 to 1988*

Year	Particulars	Monsoon (June-August)	Non-monsoon		Annual (Feb.-Jan.)
			Premonsoon (Feb.-May)	Postmonsoon (Sep.-Jan.)	
1984-'85	Catch	883.3	1353.1	158.6	2395
	No. of boat trips	14815	19787	3812	38414
	Catch/boat trip	59.6	68.4	41.6	62.3
1985-'86	Catch	181.6	1049.9	327.1	1558.6
	No. of boat trips	6229	15458	8641	30328
	Catch/boat trip	292.	67.9	37.9	51.4
1986-'87	Catch	2087.1	1101.4	321.4	3509.9
	No. of boat trips	16031	19175	11195	46401
	Catch/boat trips	130.2	57.4	28.7	75.6
1987-'88	Catch	2575.2	1012.0	582.7	4169.9
	No. of boat trips	17819	20115	18133	56067
	Catch/boat trips	144.5	50.3	32.1	74.4
1988	Catch	1295.8	1326.6		
	No. of boat trips	18097	18387		
	Catch/boat trips	71.6	72.2		

Indigenous fishery : The role of indigenous gears in harvesting prawns from the sea has considerably diminished over the years as is evident from the poor landings in the traditional sector. An active fishery by indigenous gears continues to exist only in Cochin Backwater and the adjacent paddy-cum-prawn culture fields where juvenile prawns are exploited in large quantities. In the sea, prawns are caught occasionally in a variety of traditional gears such as boat seines, ring seines, gillnets, cast nets, stake nets (off Cochin Barmouth) and mini trawls operated from motorised as well as non-motorised country crafts very close to the shore (< 10 m depth).

TABLE 4. *Monthly trends in production of prawns (t), number of boat trips and catch/boat trip (kg) by shrimp trawlers at Cochin Fisheries Harbour during the monsoon period 1984-'88 (Monthly percentage of catch in parenthesis)*

Year	Particulars	June	July	August
1984	Catch	193.6 (21.9)	640.9 (72.6)	48.8 (5.5)
	No. of boat trips	4726	5850	4239
	Catch/boat trip	41.0	109.6	11.5
1985	Catch	96.4 (53.1)	82.0 (45.1)	3.2 (1.8)
	No. of boat trips	3531	2320	378
	Catch/boat trip	27.3	35.3	8.5
1986	Catch	367.0 (17.56)	1516.9 (72.7)	203.2 (9.7)
	No. of boat trips	6371 6028	3632	
	Catch/boat trip	57.6 251.6	55.9	
1987	Catch	912.8 (35.4)	1513.7 (58.8)	148.7 (5.8)
	No. of boat trips	6276 5687	5856	
	Catch/boat trip	145.4 266.2	25.4	
1988	Catch	454.1 (35.0)	298.0 (23.0)	543.7 (42.0)
	No. of boat trips	10855	3238	4004
	Catch/boat trip	41.8	92.0	135.8

Analysis of the catch of indigenous gears operating in the coastal waters of Ernakulam District (Table 5) indicated an annual average production of about 180 t of prawns of which over 50% was landed during the monsoon season. Greater portion of this catch was recorded in June when the coastal waters experience environmental changes due to upwelling resulting in shoreward migration of some of the species of prawns which are eventually caught by indigenous gears. Of the non-monsoon periods, the postmonsoon season recorded better catch (32.6%) than the premonsoon season (15.7%). Boat seines (64%) and gill nets (18%) together accounted for about 82% of the total indigenous fishery.

TABLE 5. *Prawn landings (t) by indigenous gears in different seasons from the inshore waters of Ernakulam District, 1984-'88*

Year	Monsoon	Non-monsoon		Annual
		Premonsoon	Postmonsoon	
1984	46	23	196	265
1985	150	1	80	231
1986	-	-	-	-
1987	223	114	11	348
1988	37	-	-	37

Calicut : Trawl fishery : Shrimp trawlers operated only during the non-monsoon period except in 1986 when some fishing was attempted during monsoon (June) period also. Table 6 shows the catch, effort and catch rates recorded in this fishery. The average annual prawn landings during the non-monsoon period worked out to 240.7 t with an average catch rate of 29.6 kg/unit. During premonsoon period, the average annual catch was estimated at 91.3 t which formed about 38% of the total prawn catch by trawlers. The CPUE was estimated at 27.8 kg. During postmonsoon period, the average annual catch and catch rate were estimated at 147.4 t and 31.8 kg respectively. The peak landing and highest CPUE of this season were recorded in January and November respectively.

The monsoon trawling conducted in 1986 yielded about 10 t of prawns with a high catch rate of 47 kg/boat.

TABLE 6. *Prawn landings (t), fishing effort (boat trips) and CPUE (kg) by shrimp trawlers during monsoon and non-monsoon periods at Calicut, 1984-'85-1988*

Year	Particulars	Monsoon	Non-monsoon		Annual
			Premon-soon	Postmon-soon	
1984-'85	Catch	-	88.1	90.9	179.0
	No. of boat trips	-	1926	2844	4770
	Catch/boat trip	-	45.7	32.0	37.5
1985-'86	Catch	-	104.8	33.7	138.7
	No. of boat trips	-	2142	1024	3166
	Catch/boat trip	-	48.9	32.9	43.8
1986-'87	Catch	9.9	69.7	60.2	139.8
	No. of boat trips	210	2223	2052	4485
	Catch/boat trip	47.0	31.3	29.3	31.2
1987-'88	Catch	-	21.6	317.0	338.6
	No. of boat trips	-	974	12038	13012
	Catch/boat trip	-	22.2	26.3	26.0
1988	Catch	-	172.2	235.4	407.7
	No. of boat trips	-	9205	6073	15278
	Catch/boat trip	-	18.7	38.8	26.7

Indigenous fishery : Producing an average annual catch of about 65 t, the indigenous sector enjoyed a minor fishery throughout the year, with peak fishing activities during the southwest monsoon period (Table 7). The annual production, however, was found to be quite unsteady as observed at Cochin. During the monsoon season, which accounted for over 56 t (86%) on an average, the fishery maintained a regular pattern although the catches widely fluctuated (16-88 kg) in different years. The highest catch of 88.5 t was recorded in 1986 and the lowest in 1988. A number of gears such as boat seines ('Nethalvala' and 'Pattenkollivala'), gill nets ('Ayilachalavala' and 'Mathichalavala'), mini trawls ('Paithuvala') and cast nets were used, of which boat seines were the most important gear operated during the monsoon period.

Mangalore : Being the premier prawn fishing centre of Karnataka, Mangalore registered about 35% of the total prawn landing of the State, which was exploited by trawlers, indigenous gears and to a small extent by purse-seines. The maximum catch of 2560 t of prawns by all the gears was recorded in 1987-88 and the minimum of 1982 t in 1985-'86, the annual average being 2302 t (Table 8). Of this, the non-monsoon period contributed 97.9% and the share of monsoon period was only 2.1%.

TABLE 7. *Prawn landings (t), Fishing effort (units) and CPUE (kg) by indigenous gears during monsoon and non-monsoon periods at Calicut, 1984-'85-1988*

Year	Particulars	Monsoon	Non-monsoon		Annual
			Premon-soon	Postmon-soon	
1984-'85	Catch	70.7	13.7	2.8	87.2
	No. of units	6195	492	1110	7797
	Catch/unit	11.4	27.8	2.5	11.2
1985-'86	Catch	34.6	-	-	34.6
	No. of units	3188	-	-	3188
	Catch/unit	10.8	-	-	10.8
1986-'87	Catch	88.5	-	17.5	106.0
	No. of units	7923	-	1175	9098
	Catch/unit	11.2	-	14.9	11.7
1987-'88	Catch	73.3	0.7	-	74.0
	No. of units	3402	45	-	3447
	Catch/unit	21.5	15.6	-	21.5
1988	Catch	16.1	0.2	1.5	17.9
	No. of boat trips	1390	273	163	1826
	Catch/boat trip	11.6	0.7	9.2	9.8

Trawl fishery : There was virtually no trawl fishing at this centre during the monsoon period. A gearwise analysis of the data revealed that the shrimp trawls contributed to the bulk of the prawn catch (96.4%) obtained during the non-monsoon period. The maximum catch of 2534.6 t was obtained in 1987-88 and the minimum of 1918.8 t in 1985-86 (Table 9). The average annual catch by this gear amounted to 2218.1 t. The catch rate was relatively high in 1985-86 (6.4 kg/hr) when the total catch was the lowest and it was minimum in 1987-88 (5.4 kg/hr) when the total catch was the highest.

TABLE 8. *Seasonwise prawn landings (t) by all gears at Mangalore during 1984-'85 to 1987-'88*

Years	Monsoon	Non-monsoon		Total
		Premonsoon	Postmonsoon	
1984-'85	-	1117.2	1437.2	2554.4
1985-'86	63.1	1471.2	447.6	1981.9
1986-'87	116.7	1497.3	496.5	2110.5
1987-'88	16.9	1356.0	1186.8	2559.7
Average	49.2	1360.4	892.0	2301.6
%	2.1	59.1	38.8	

Purse-seine fishery : During the non-monsoon period, prawns were caught occasionally in purse-seines in large quantities. The annual catch estimated for this gear ranged from 8.2 t in 1987-88 to 112.0 t in 1984-85.

TABLE 9. *Prawn landings (t), fishing effort (hrs.) and CPUE (kg) by shrimp trawlers during non-monsoon period at Mangalore, 1984-'85—1987-'88 (No trawling during monsoon season)*

Year	Particulars	Pre monsoon & Post monsoon (Annual)
1984-'85	Annual catch	2442.4
	Effort	393935
	Catch/hr	6.2
1985-'86	Annual catch	1918.8
	Effort	299813
	Catch/hr	6.4
1986-'87	Annual catch	1976.9
	Effort	313794
	Catch/hr	6.3
1987-'88	Annual catch	2534.6
	Effort	46
	Catch/hr	5.4

Indigenous fishery : The prawn fishery along Mangalore Coast during monsoon season was largely dependent on the weather conditions and availability of shoals of prawns. Due to this, there has not been any consistency in this fishery. The 'matabala' fishery of the monsoon period exhibited a highly varying production trend (Table 10). At Ullal, the maximum, minimum and average annual catches of prawns were 110.6 t (1986), 11.9 t (1988) and 40.2 t respectively. The highest catch rate of 517.4 kg/unit was obtained in 1985, while the lowest (33.6 kg/unit) was observed in 1988. At Panambur Harbour, the maximum, minimum and average catches were 14.8 t (1988), 0.1 t (1987) and 4.5 t respectively. The catch rate was highest during 1986 (27.3 kg/unit), whereas, it was the lowest during 1987 (0.1 kg/unit). When the fisheries of both the observation centres were combined, the maximum catch (116.7 t) as well as CPUE (229.7 kg/unit) were recorded during 1986.

TABLE 10. *Prawn landings (t), effort (units) and CPUE (kg) of prawns by 'Matabala' during monsoon season at Mangalore, 1985-'88 (Fisheris of Ullal and Panambur harbour combined)*

Particulars	1985	1986	1987	1988
Catch	63.1	116.7	16.9	26.8
Effort	277	508	1265	1510
CPUE	227.8	229.7	13.4	17.7

Bombay : *Trawl fishery* : Monitoring of the penaeid prawn landings of shrimp trawlers at New Ferry Wharf showed a year-round fishery yielding an annual production ranging from 8553 t in 1985-86 to 11870 t in 1984-85 (Table 11), with an average annual catch of 10,112 t. During the premonsoon period, the prawn catch varied from 2137 t in 1988 to 4853 t in 1986 and the catch rate fluctuated from 5.8 kg/hr in 1988 to 13.1 kg/hr in 1986. The monsoon period recorded the lowest catch, evidently due to the lesser amount of fishing effort expended, but the catch rates were the highest in all the years. During this period, the catch varied from 406 t in 1985 to 1191 t in 1984 and the catch rate fluctuated from 25.7 kg to 67.7 kg/hr in the same years respectively. During the postmonsoon period, the catch varied from 5581 t in 1985 to 8330 t in 1984 and the catch rate fluctuated from 10.9 kg/hr in 1987 to 19.1 kg/hr in 1984. Month-wise trend in CPUE for the years 1984-88 (Fig. 1) showed a remarkable increase during August-September period in all the years.

TABLE 11. *Penaeid prawn landings (t), fishing effort (hrs.) and CPUE (kg) by shrimp trawlers during monsoon and non-monsoon periods at New Ferry Wharf, Bombay during 1984-1988*

Year	Particulars	Monsoon	Non-monsoon		Annual
			Premon-soon	Postmon-soon	
1984-'85	Catch	1191.4	2348.6	8330.1	11870.1
	Effort	17592	306828	435904	760324
	Catch/hr	67.7	7.7	19.1	15.6
1985-'86	Catch	405.8	2566.7	5580.9	8553.4
	Effort	15792	285624	430496	731912
	Catch/hr	25.7	8.9	12.9	11.7
1986-'87	Catch	936.9	4852.9	5867.4	11656.8
	Effort	26484	368748	496704	891936
	Catch/hr	35.4	13.2	11.8	13.1
1987-'88	Catch	758.9	2505.9	6037.3	9302.1
	Effort	21396	415188	555488	992072
	Catch/hr	35.5	6.0	10.9	9.4
1988	Catch	585.1	2137.4	-	
	Effort	20112	369252	-	
	Catch/hr	29.1	5.8	-	

At Sassoon Dock also the trawl fishery continued throughout the year, with relatively less fishing operations during the monsoon season. The annual catch of penaeid prawns varied from 9000 to 13000 t.

Species Composition

The prawn fishery of the west coast of India is represented by atleast 30 species belonging to the penaeid (24 species) and nonpenaeid (6 species) groups. Of these, 18 species of penaeids such as *Metapenaeus affinis, M. brevicornis, M. dobsoni, M. kutchensis, M. monoceros, Metapenaeopsis stridulans, Parapenaeopsis hardwickii, P. sculptilis, P. stylifera, Penaeus canaliculatus, P. indicus, P. japonicus, P. merguiensis, P. monodon, P. semisulcatus, P. penicillatus, Solenocera crassicornis* and *Trachypenaeus curvirostris* and 5 species of nonpenaeids such as *Acetes indicus, A. johni, Exopalaemon styliferus, Nematopalaemon tenuipes* and *Exhippolysmata ensirostris* support the regular fishery of mechanised and nonmechanised units. The species composition of the landings vary considerably in the southern and northern regions of the coast and also in different gears and seasons. In general, the trawl fishery of northwest region is predominantly supported by the penaeid prawns *M. affinis, M. monoceros, M. brevicornis, M. kutchensis, P. stylifera, P. hardwickii, P. sculptilis, P. penicillatus, S. crassicornis* and *M. stridulans*. The nonpenaeids *Acetes indicus, N. tenuipes* and *E. ensirostris* are the major constituents of the landings of indigenous gears such as 'Dol' nets which operate in relatively shallower areas. In the upper part of the southwest region (Goa-North Karnataka) the fishery is mainly based on *P. merguiensis, M. affinis, M. monoceros* and *P. stylifera*, while on the South Karnataka and

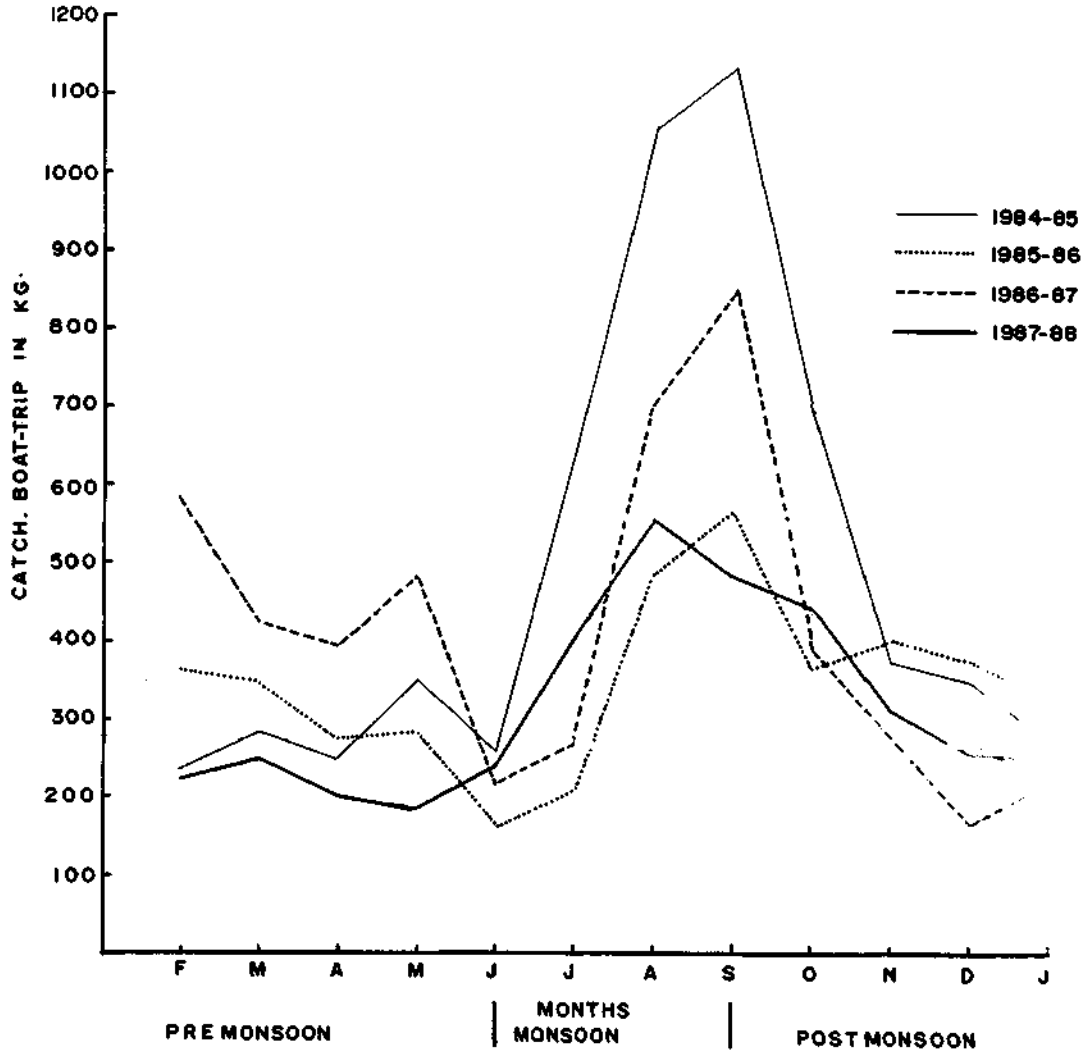

Fig. 1. Monthwise catch-per-boat trip (Kg) of penaeid prawns during 1984-85 to 1987-88 at New Ferry Wharf, Bombay.

Kerala Coasts is mainly constitued by *P. stylifera, M. dobsoni, M. monoceros, M. affinis* and *P. indicus.* Species like *P. semisulcatus, P. canaliculatus, T. curvirostris* and *M. stridulans* are also caught occasionally in large quantities by trawlers operating from Quilon and Cochin during the non-monsoon months.

The species composition and its variations noticed at the different observation centres were as follows.

In the trawl fishery at Cochin, though several species were encountered, only four namely *P. indicus* ('Naran'), *M. dobsoni* ('Poovalan'), *M. monoceros* ('Choodan') and *P. stylifera* ('Karikkadi') formed the main components. Their percentage composition in different seasons of the year is shown in Table 12. The dominant species in the catch exhibited marked variations during the monsoon and non-monsoon periods. During the monsoon season *P. stylifera* formed the bulk of the fishery (80-98 %) in all the five years of study. The mean percentage values for the various species during this period were *P. stylifera* 89.7 %, *M. monoceros* 5.4 %, *M. dobsoni*, 3.6 % and *P. indicus* 0.8 %. In fact *P. stylifera* accounted almost the entire catch when the fishery was at its peak, while the other species occurred in sizeable proportions only in the beginning of the season. *M. dobsoni* dominated in the fishery during the premonsoon (45.0 %) and postmonsoon (69.5 %) periods. The indigenous fishery (Table 13) was chiefly supported by *P. indicus, M. dobsoni* and *P. stylifera* in the order of their abundance. The most characteristic feature noticed in this fishery during the monsoon season was that *P. indicus* accounted as much as 91.3% of the catch which was mainly harvested by boat-seines and gill nets. During the premonsoon period *M. dobsoni* (82%) dominated in the fishery, whereas in the postmonsoon period both *P. indicus* (46.7%) and *M. dobsoni* (37.2%) accounted for the bulk of the fishery. It is interesting to note that the catch of 'Karikkadi' (*P. stylifera*) in the indigenous fishery was rather negligible during the monsoon season when compared to its absolute predominance and high catch rates in the trawl fishery.

At Calicut, the trawl fishery of non-monsoon period depicted more or less the same pattern as observed at Cochin Fisheries Harbour as regards catch composition. The fishery was mainly supported by *P. stylifera, M. dobsoni* and *P. indicus* along with small quantities of *M. affinis, M. monoceros* and others. *P. stylifera* contributed to the bulk of the catch, with percentages ranging between 64 and 79. While this species generally

TABLE 12. *Seasonwise percentage composition of important species in the prawn landings by shrimp trawlers at Cochin Fisheries Harbour, 1984-88*

Season	Year	*P. indicus*	*M. dobsoni*	*M. monoceros*	*P. stylifera*	Other prawns
PrM	1984	6.6	28.6	2.9	60.4	1.5
	1985	14.0	60.5	1.2	23.3	1.0
	1986	14.4	43.1	4.9	36.8	0.8
	1987	3.8	50.3	5.4	39.9	0.6
	1988	4.1	42.0	18.3	31.1	4.5
M	1984	-	-	10.2	89.3	0.5
	1985	0.2	4.0	3.0	92.4	0.4
	1986	0.8	0.3	0.7	98.1	0.1
	1987	1.9	5.7	2.9	89.1	0.4
	1988	1.3	8.2	10.3	79.7	0.5
PtM	1984-'85	22.7	62.3	2.5	10.6	1.9
	1985-'86	11.8	82.5	0.6	4.9	0.2
	1986-'87	5.6	86.8	3.3	3.9	0.4
	1987-'88	3.8	46.3	10.5	38.8	0.6

PrM = Premonsoon; M = Monsoon; PtM = Postmonsoon.

TABLE 13. *Seasonwise species compositon of prawn catch (t) of indigenous gears from the inshore waters of Ernakulam District, 1984-'88*

Season	Year	*P. indicus*	*M. dobsoni*	*P. stylifera*	Other species	Total
PrM	1984	23	-	-	-	23
	1985	-	1	-	-	1
	1986	-	-	-	-	-
	1987	-	112	1	1	114
	1988	-	-	-	-	-
M	1984	46	-	-	-	46
	1985	147	3	-	-	150
	1986	-	-	-	-	-
	1987	193	28	-	2	223
	1988	30	2	5	-	37
PtM	1984	132	30	34	-	196
	1985	-	76	4	-	80
	1986	-	-	-	-	-
	1987	2	1	7	1	11

PrM = Premonsoon; M = Monsoon; PtM = Postmonsoon.

dominated in the fishery during the premonsoon period, the postmonsoon catch was mainly supported by *M. dobsoni* (Fig. 2). During 1984, '85 and '86, the former accounted for 79, 72 and 64% of the catch respectively during the premonsoon period, while in 1987 and '88 the same species dominated during the postmonsoon season with percentage contributions of 79 and 60 respectively. *P. indicus* occurred in the fishery at the rate of 6 to 22% during premonsoon and 2 to 10% during postmonsoon periods. During the monsoon season of 1986 when trawlers operated in the beginning of June, *P. stylifera* accounted for over 80% and *M. dobsoni* the rest. The indigenous fishery was mainly based on *M. dobsoni* which contributed over 75% of the annual catch. During the monsoon period its percentage was as high as 80-97 (Fig. 3). Among the other species, *P. indicus* (5.5%) and *P. stylifera* (4.5%) were common. During the premonsoon season, the indigenous gears caught mainly *P. stylifera*, whereas in the postmonsoon season the fishery was chiefly supported by both *M. dobsoni* and *P. stylifera*. In September, however, *P. indicus* was the only species represented in this fishery.

At Mangalore, the trawl fishery of the non-monsoon period was mainly constituted by *P. stylifera, M. dobsoni, M. monoceros* and *P. indicus* in the order of abundance. During the premonsoon season *M. dobsoni, M. monoceros* and *P. indicus* were relatively more represented in the fishery than in postmonsoon season. The species occurred in the 'Matabala' fishery of monsoon period were *M. dobsoni, P. indicus, P. stylifera* and *M. affinis* of which *M. dobsoni* was the dominant one contributing to 93 % at Ullal and 97 % at Panambur Harbour.

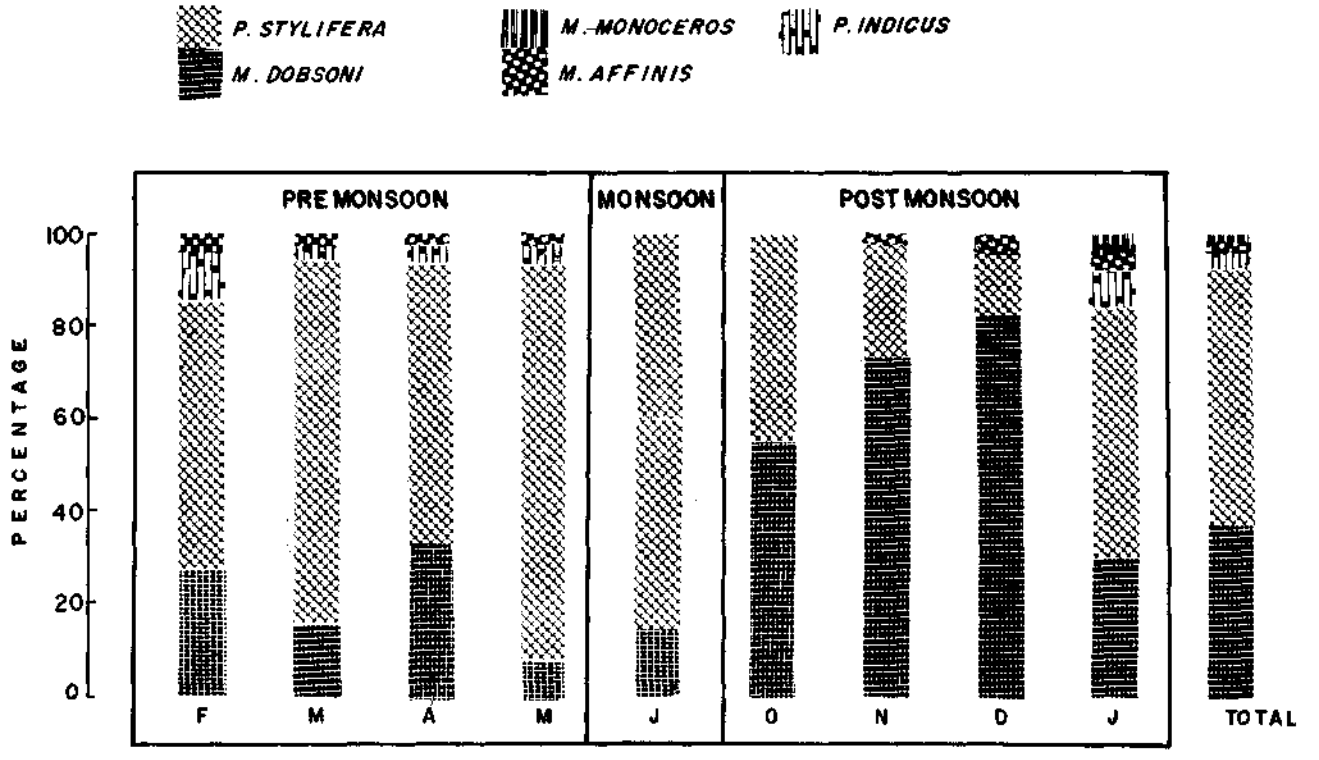

Fig. 2. Monthly/seasonal and annual average species composition of trawl catches at Calicut, 1984-88.

At Bombay, the catch composition of the trawl fishery at New Ferry Wharf and Sassoon Dock was more or less similar. At New Ferry Wharf, the penaeid prawns *P. penicillatus, M. affinis, M. monoceros, M. brevicornis, M. kutchensis, P. stylifera, P. hardwickii, S. crassicornis* and *M. stridulans* contributed to the commercial landings. Table 14 shows the specieswise catch, catch rate and percentage composition of important species during the different seasons of 1984-88 period. During the monsoon period, *P. stylifera* was the dominant

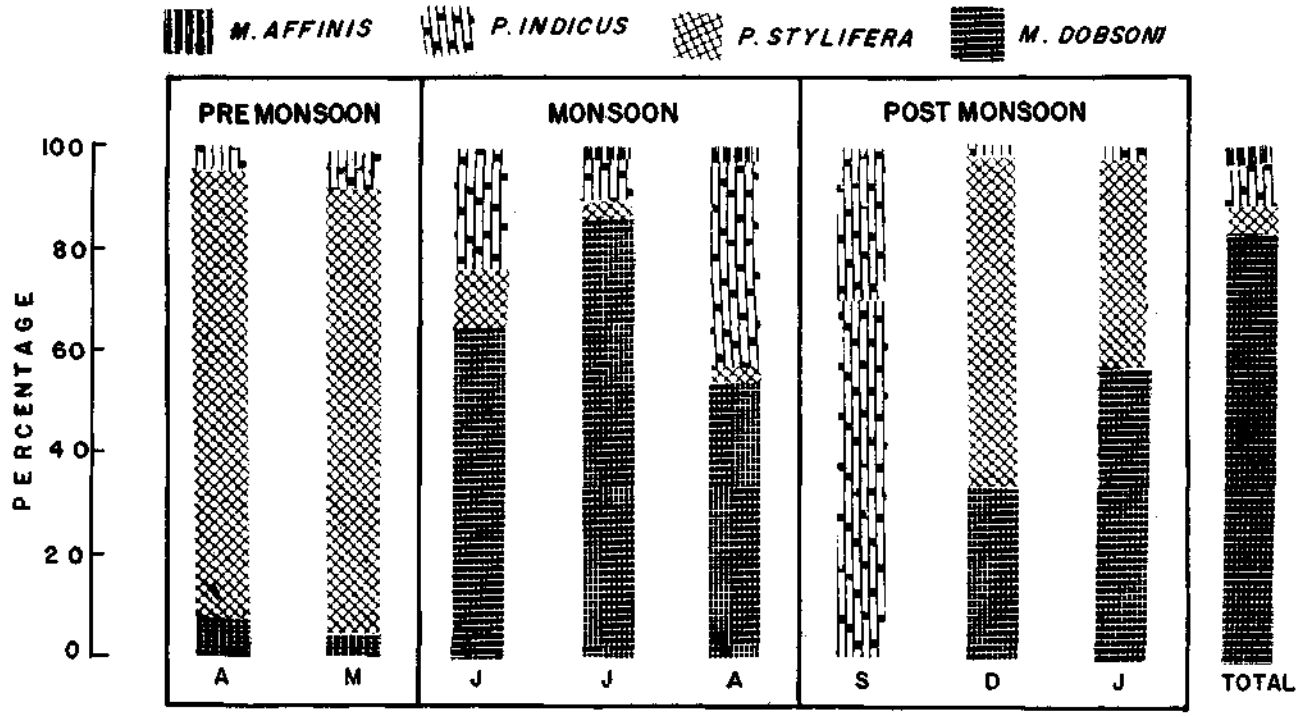

Fig. 3. Monthly/seasonal and annual average species composition of prawn catch by indigenous gears at Calicut, 1984-88.

species forming about 41 % followed by *M. affinis* and *M. monoceros* contributing 24% and 15% respectively. Thus, these three species together formed the bulk of the penaeid prawn landings. During the postmonsoon season, *P. stylifera* again dominated the catch (43%). In addition *M. affinis*, *M. monoceros*, *S. crassicornis* and *M. stridulans* also formed sizeable percentage during this period. The premonsoon period was, however, dominated by *S. crassicorins* forming one-third of the total penaeid prawn catch, followed by *P. stylifera* contributing 22%. *M. kutchensis* (2-3%) and *P. hardwickii* (2-4%) formed minor fisheries in the non-monsoon period.

Biological Considerations

Size composition and sex ratios : At Cochin, the size of *P. stylifera* in the trawl fishery ranged from 36 to 100 mm for male and 37 to 125 mm for female, the bulk of the fishery being contributed by the size groups 66-85 mm and 66-95 mm for the two sexes respectively. There was no marked variation in the size compoistion of the species in different seasons of the year. The monthly size frequency distribution for the monsoon season of different years is shown in Fig. 4. In general, the peak production

Table 14. *Seasonwise catch (kg), catch rate (kg/hr) and % composition of penaeid prawns during the years 1984-88 at New Ferry Wharf, Bombay*

	Premonsoon	Monsoon	Postmonsoon
Penaeus spp.	115,,769 (0.332) 4.02%	34,996 (1.726) 4.51%	326,245 (0.680) 5.05%
Metapenaeus affinis	342,770 (0.982) 11.89%	185,571 (9.152) 23.93%	929,119 (1.937) 14.40%
Metapenaeus monoceros	286,559 (0.821) 9.94%	119,524 (5.895) 15.41%	549,390 (1.145) 8.51%
Metapenaeus kutchensis	57,490 (0.165) 1.99%	-	176,112 (0.367) 2.73%
Metapenaeus brevicornis	180,075 (0.516) 6.25%	28,415 (1.401) 3.66%	292,119 (0.609) 4.53%
Parapenaeopsis stylifera	628,479 (1.800) 21.80%	315,216 (15.547) 40.64%	2768,652 (5.772) 42.90%
Parapenaeopsis hardwickii	119,591 (0.343) 4.15%	-	155,332 (0.324) 2.41%
Solenocera crassicornis	974,955 (2.793) 33.83%	61,496 (3.033) 7.93%	676,592 (1.410) 10.48%
Metapenaeopsis stiridulans	170,364 (0.488) 5.91%	27,156 (1.339) 3.50%	530,389 (1.106) 8.22%
Other penaeid prawns	6,258 (0.018) 0.22%	3,239 (0.160) 0.42%	49,992 (0.104) 0.77%

of the species during June and July was characterised by greater abundance of younger population. The modal size of males during this period were at 71-75 mm in most of the years when the catches were high except in July 1987 when the mode was at 81-85 mm. In females, the mode generally fell within the range of 71-75 mm and 81-85 mm except in July 1987 when a higher mode at 91-95 mm was also seen. In August, the 'Karikkadi' stock was found to be mainly composed of larger size groups for both sexes during the years 1986 to 1988 when the fishery was much better than in the previous years. The modal size during these years was invariably at 81-85 mm for males, whereas in females two principal modes - one at 81-85 mm and the other at 91-95 mm, were observed. In order to understand the proportion of undersized prawns in the fishery, which were generally discarded by the industry, the length frequency data of 1986-1988 period were pooled into two categories namely, 'discards' (< 65 mm) and 'commercial sizes' (> 65 mm) seasonwise and the results are presented in Table 15. The percentage of discards in the annual catch amounted to 16.2% in 1986-87 and 18.3% in 1987-88 periods. In the total discards about 70- 90% was recorded during the monsoon season. Examination of monthwise data reveals that the peak of discards in the fishery occurred in June and July. The important size group of *M. dobsoni* was 66-100 mm in the month of June when it appeared in the fishery in fair quantities.

In the indigenous fishery observed at puthuvyppu, Narakkal and Fort Cochin, *P. indicus* had a size range of 71-155 mm for males and 76-170 mm for females. The modal sizes were between 136 and 145 mm for both sexes throughout the monsoon period except in June when the males had mode at 121-125 mm. *M. dobsoni* was represented in the size range 51-105 mm with mode at 86-90 mm for females. Though the contribution of *P. stylifera* in the indigenous fishery was insignificant, detailed biological data were collected whenever catches were encountered for comparison with the trawl fishery. Fig. 5 gives an overall picture of the size composition of the species in different gears including trawl nets during the monsoon season. It can be seen that the size of the prawns caught by the non-selective indigenous gears (cast nets, stake net and boat seines) operating in the shallow coastal waters was much larger than the size constituting the trawl fishery. The major size groups in the indigenous gears were 81-100 mm for males and 91-110 mm for females, whereas in the trawl fishery they were 71-85 mm and 71-95 mm for the two sexes respectively, when the data for the entire period of study were combined. Studying the coastal shrimp fishery by indigenous gears at Narakkal, George (1961) also observed the modal length of the species attaining the maximum (86-90 mm) by August-September.

In the trawl fishery, the distribution of sexes for *P. stylifera* during the monsoon period was characterised by dominance of females whose percentage in the catch ranged mostly between 51 and 72. The maximum disparity was noticed in August when larger size groups accounted for the bulk of the fishery. During the permonsoon and postmonsoon seasons also females were generally more in the catch than males. The overall sex ratio for *M. dobsoni* was more or less 50:50. In the indigenous fishery *P. indicus* catch showed greater proportion of males (51-65%), while in *M. dobsoni* only females were encountered. The sex ratio of *P. stylifera* was in favour of females (61-70%) in all the gears operated during the monsoon period.

At Calicut, the size range of *M. dobsoni* in the trawl fishery of non-monsoon season was 36-100 mm for males and 36-120 mm for females. The bulk of the catch was constituted by 56-95 mm size group. Fresh recruitment into the fishery was noticed during the premonosoon season. In the case of *P. stylifera*, the size range was 31-105 mm for males and 31-130 mm for females, the bulk of the fishery being composed of the size group 66-95 mm. In the indigenous fishery of monsoon period, *M. dobsoni* was chiefly represented by the size group 71-110 mm and *P. indicus* by the size group 110-140 mm. The former species showed dominance of males over females throughout this season, while in the latter, males outnumbered females in the beginning of the southwest monsoon period and as the season advanced the females became more numerous than males in the fishery.

At Mangalore, the trawl fishery of *M. dobsoni* was mainly constituted by prawns in the size range 61-90 mm for males and 61-110 mm for females, while the major size groups of *P. stylifera* were 56-95 mm for males and 61-110 mm for females. In the 'Matabala' fishery, *M. dobsoni* catch was supported by relatively large sized prawns, ranging in size from 68 to 98 mm, with mode at 88 mm in

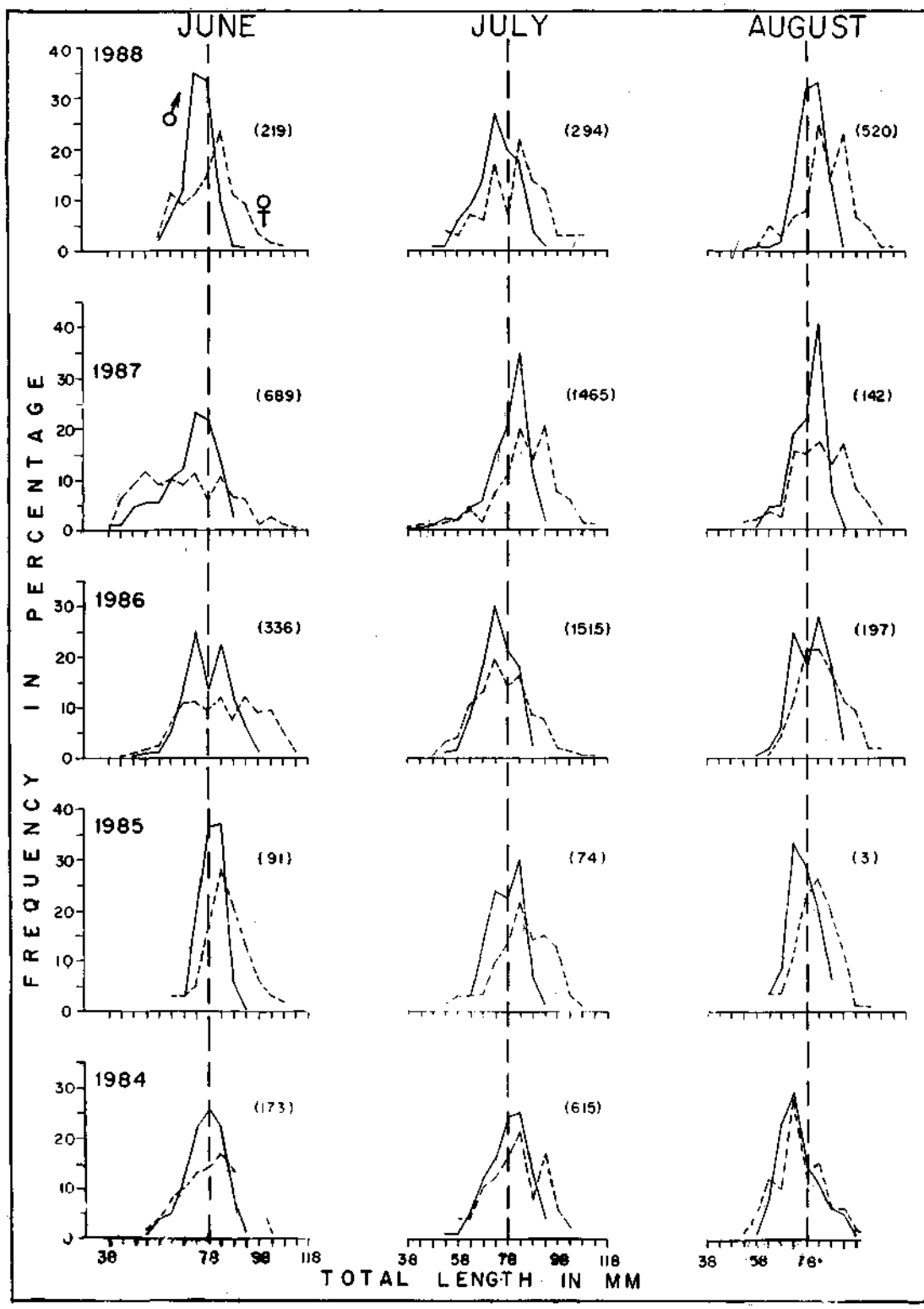

Fig. 4. Monthly size frequency distribution of *P. stylifera* in the trawl fishery at Cochin Fisheries Harbour during monsoon season. Figures in bracket indicate estimated total catch of the species in tonnes by trawlers. The broken line against 78 mm length is to indicate the changing pattern of major size groups in the fishery with the progress of season.

males and from 58 to 118 mm with modes at 93 mm, 98 mm and 108 mm in females. Males were in excess of females at both the centres of observation.

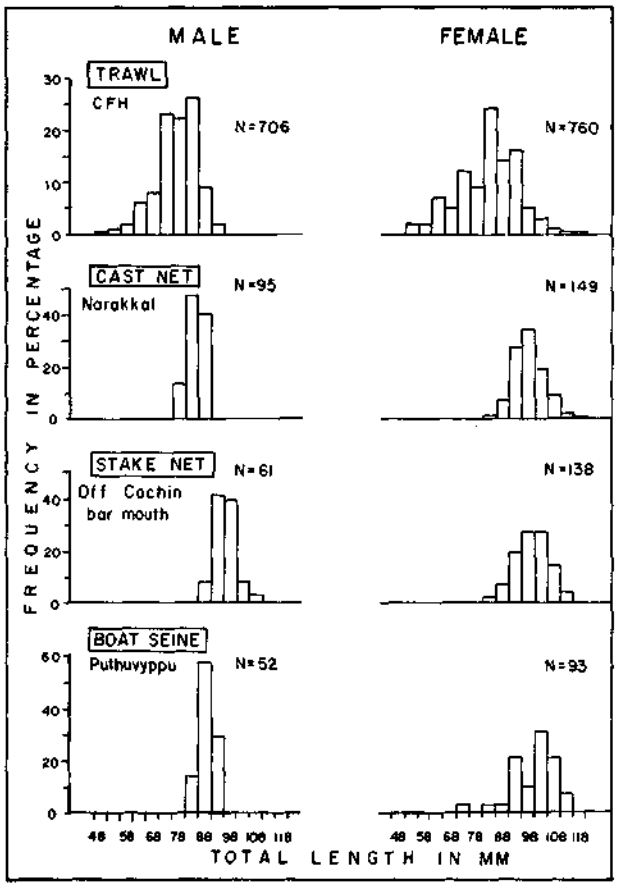

Fig. 5. Size composition of *P. stylifera* in the catches of different gears during monsoon season.

The monthly mean size distribution of important species at New Ferry Wharf at Bombay (Fig. 6) showed that, in the case of *P. stylifera* and *M. affinis*, there was considerable fall in mean sizes of both male and female during monsoon season, particularly in June and July. In *M. monoceros* and *S. crassicornis*, a similar fall in mean size was noticed during the postmonsoon season. The female prawns were found to be less abundant in the fishery during monsoon period in the case of *P. stylifera*, *M. affinis* and *S. crassicornis*, whereas they were more in *M. monoceros* and *M. brevicornis*.

Spawning Stock

In the trawl fishery at Cochin, the abundance of females of *P. stylifera* in spawning condition (maturity stages III and IV) was the least during the monsoon period (5.3-18.1%) as compared to the premonsoon (27.2-44.5%) and postmonsoon (32.4-61.9%) fisheries (Fig. 7). In the indigenous gears, on the other hand, the proportion of spawners was considerably higher than in the trawl catches during the monsoon period. The relative abundance of spawning population in the fishery of different gears is shown in Fig. 8. While the overall

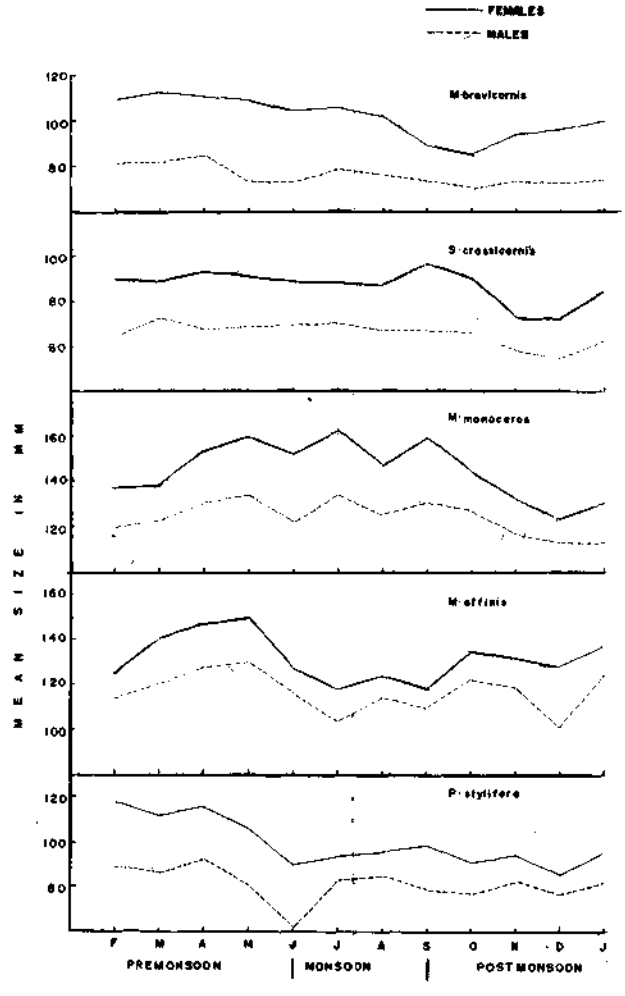

Fig. 6. Monthwise distribution of mean sizes of important species of penaeid prawns in the fishery at New Ferry Wharf, Bombay.

percentages of mature females in the trawl fishery was only 12, it was as high as 39 in stake nets, 42 in boat seines and 55 in cast nets operating in the shallow coastal waters. In the case of *P. indicus* caught by indigenous gears during the monsoon period spawners were totally absent. At Calicut, mature females of *M. dobsoni* and *P. stylifera* occurred in the trawl fishery almost through out the year in varying percentages (1-48%) with peaks

during March-May and November-January for both the species. During the monsoon period, the percentage of spawning population of *M. dobsoni* in the indigenous fishery ranged from 11 to 28. In the Mangalore Coast, the trawler catches showed peak abundance of spawners during January-May for *M. dobsoni* January-April for *P. stylifera* and February-April for *M. monoceros*. *P. indicus* recorded spawning peaks in April, October and January. In the 'Matabala' fishery of monsoon season, *M. dobsoni* showed 14-18% of females in mature

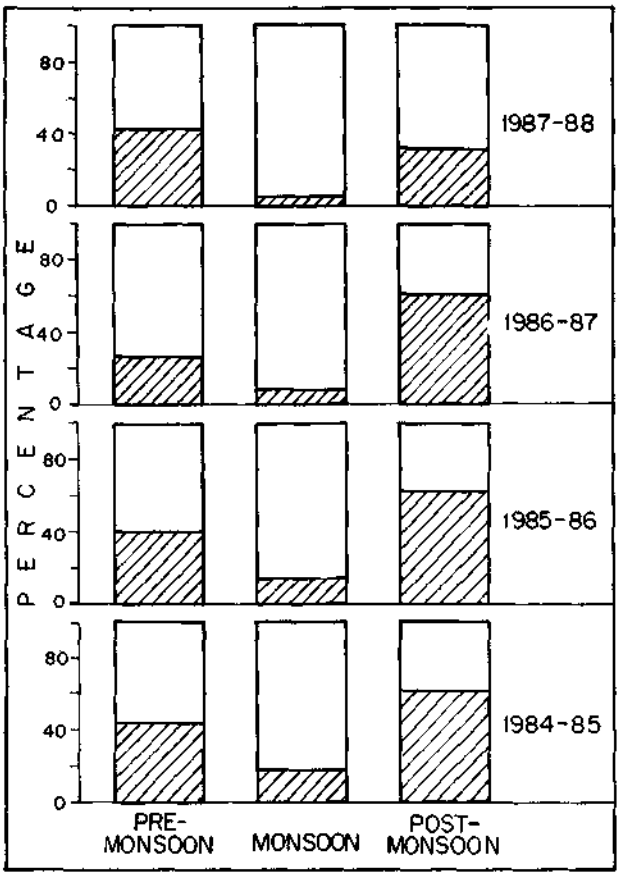

Fig. 7. Sesonal abundance of spawning population (shaded) of *P. stylifera* in the trawl fishery at Cochin Fisheries Harbour.

condition and 6-16% in spent or spent recovering stages, suggesting active spawning of the species during July-August in the coastal waters. In the case of *P. stylifera*, however, fully mature females were not encountered in this fishery. Seasonwise percentage distribution of mature females of penaeid prawns at New Ferry Wharf (Fig. 9) indicated relatively less breeding activities during monsoon season as compared to other seasons in Bombay waters for *P. stylifera*, *M. affinis*, *S. crassicornis* and *M. brevicornis*. *P. stylifera* and *M. monoceros* showed peak breeding during the premonsoon period and *P. hardwickii* during monsoon period.

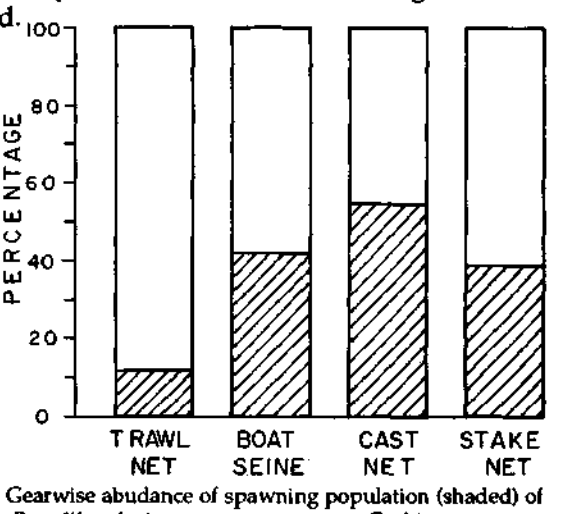

Fig. 8. Gearwise abudance of spawning population (shaded) of *P. stylifera* during monsoon season at Cochin.

Discussion

It is well known that changes in bottom hydrography brought about by upwelling during monsoon have significant effect on the demersal fisheries of the west coast of India. Upwelling is reported to occur throughout the west coast of India, although its origin, intensity and duration in a particular year vary between the southern and northern regions of the coast (Jayaraman and Gogate, 1957; Banse, 1959. Carruthers *et al.*, 1959; Anon., 1976; Murty, 1981). In the southwest coast, the upwelling commences during the premonsoon period and continues throughout the southwest monsoon season with its maximum intensity during August/Setpember (Anon., 1976). Banse (1959) reports that, as the low-oxygen layer ascends on to the shelf waters as a result of upwelling, a band of shelf bed along the southwest coast is overlayed by badly aerated water. The demersal fish and prawns abandon this portion of the shelf and migrate either to the deeper or to the shallow areas of the shelf. As a result of this shifting of fish and prawn stock from the usual fishing grounds, it is inferred that bottom trawling is profitable only in the deeper water beyond 35 m depth and occasionally in very shallow water during the southwest monsoon period. Recent experimental shrimp trawling conducted in the shelf waters off Cochin (Suseelan *et al.*, 1989) yielded added evidences in support of the above findings (Banse, 1959; Murty, 1981) on changes of shrimp stocks during the different

fishing seasons. It is observed that during the non-monsoon season (September/October to May) most of the stocks of *P. stylifera* occupy the coastal waters within 20 m depth line. With the commencement of southwest monsoon and the consequent changes in environmental conditions, the prawns leave the inshore areas in large numbers to the deeper zones. They remain mostly in the 20-40 m depth zone during June and in the 40- 60 m depth zone during July and August/September. A small population of 'Karikkadi', however, exists very close to the shore during the monsoon period, which is predominantly constituted by adult prawns in spawning condition. Menon (1958) states that on the Malabar Coast, from June to August, fishermen frequently catch prawns with cast nets, *i.e.* in quite shallow water, because the shoals come near the shore at this time of the year. All these observations point to the fact that the monsoon and the consequent upwelling bring about tremendous changes in the distribution and abundance of prawns (also fish) along the southwest coast. These changes of stocks in the fishing grounds have considerable relevance in the exploitation and management of the resource during the monsoon period.

In the northwest coast, the upwelling is observed to occur in Bombay region with a different origin (Jayaraman and Gogate, 1957). Here, the offshore winds during the northeast monsoon favours local upwelling during October/November. As a result of this, demersal fish migrate to shallower areas during the northeast monsoon period inorder to escape the lethal low oxygen condition of upwelled waters (Carruthers *et al.*, 1959). The present study reveals that a shore ward concentration occurs in the case of prawns also as the catches of prawns were very high during late monsoon and early postmonsoon period (August-September). The percentage of prawns in trawl catches during monsoon is found to be higher than in the postmonsoon and premonsoon periods.

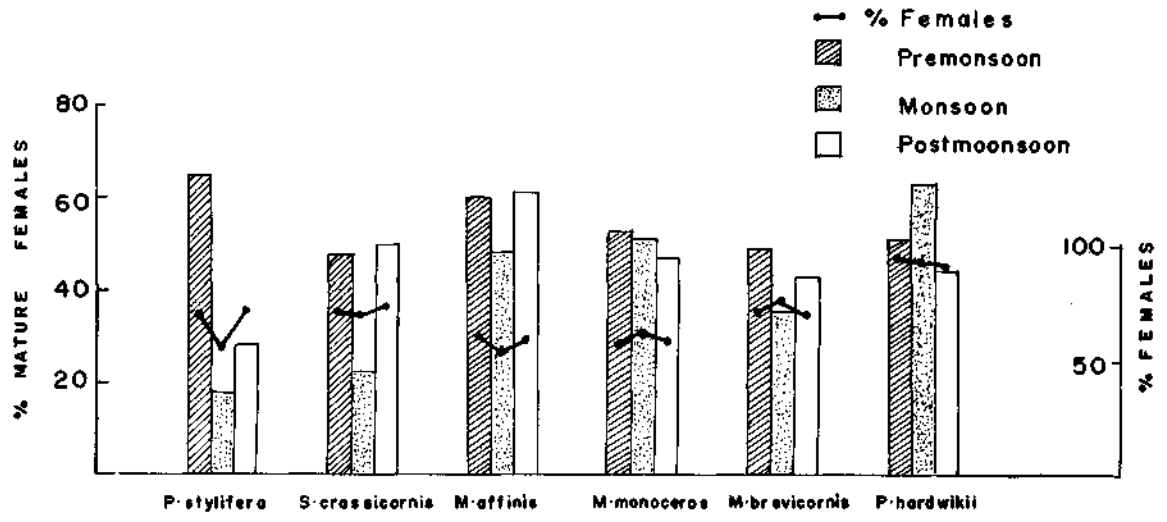

Fig. 9. Percentage distribution of mature females of important penaeid prawns in the fishery during monsoon and non-monsoon seasons at New Ferry Wharf, Bombay.

The present analysis of available data on the shrimp fisheries at different observation centres reveals the following facts which deserve attention in the context of management of the fishery during the monsoon period.

At Cochin, the prawn landings of the monsoon period is almost entirely through the contribution of shrimp trawlers whose area of operation is quite different from the area exploited by the traditional fishermen. This is because of the peculiar behaviour of *P. stylifera* which migrate in large numbers to the deeper waters during the monsoon period (June-August) as a result of changes in the environmental conditions of the inshore areas. The fact that the abundance of spawners in the trawl fishery is very low during the monsoon season as compared to other seasons of the year precludes the possibility of offshore migration of the species for breeding purpose. In

fact the usual breeding ground of *P. stylifera* is considered to be the coastal waters within about 22 m depth (Menon, 1953) and even during the monsoon season the small population of the species lingering very close to the shore and being caught sporadically in the indigenous gears (Suseelan *et al.*, 1989), contains a high percentage of spawners. The minor fishery that is existing in the traditional sector is chiefly supported by other species that tend to migrate shoreward with the commencement of monsoon. ***Thus, apparently there is no clash of interest as far as the exploitation of shrimp resource is concerned during the monsoon season.***

Taking into account the crucial role played by 'Karikkadi' in earning foreign exchange worth several millions of rupees during the monsoon period, it is imperative that this resource has to be exploited at the appropriate time. The only possible way of achieving this is by shrimp trawling since the indigenous gears cannot harvest 'Karikkadi' from the deeper waters. Opinion is expressed from certain quarters that if 'Karikkadi' is not exploited during the monsoon period by shrimp trawlers, will it be available to the indigenous fishery in the nearshore waters after the monsoon is over ? Though direct evidences are lacking to fully rule out this possibility there are indications to presume that the species may not return to the coastal waters and unless they are fished out they may perish due to prolonged exposure to the unfavourable hydrographic conditions prevailing in the offshore waters.

Analysing the catch data of FORV *Sagar Sampada*, Suseelan *et al.* (1990) observed the occurrence of 'Karikkadi' in varying densities in the offshore waters upto 53 m depth during the southwest monsoon period almost as a continuous belt between Quilon and Marmagoa. This would indicate that the offshore migration of 'Karikkadi' stock is taking place throughout the southwest coast during the monsoon season. But its fishery at the northern centres like Calicut, Mangalore, etc. where monsoon trawling is non-existent, becomes active only by November or December. Even at Cochin and Sakthikulangara in Kerala, it is observed that the postmonsoon fishery for 'Karikkadi' is preceded by a lean period of one or two months when the catch includes mainly fresh recruits which are much smaller than the dominant sizes constituting the trawl catches of August (Fig. 4). Studying the coastal shrimp fishery of Cochin (Narakkal) and Alleppey region, George (1961) also observed that after August-September the larger size groups disappear from the catches and the smaller groups become dominant. All these indirectly suggest that the offshore population of 'Karikkadi' may not return to contribute to the coastal fishery after the cessation of monsoon. However, a detailed study is needed to arrive at a definite conlcusion in this regard.

That the prawn production in the artisanal sector has considerably declined over the years is evident from the available catch statistics. According to George (1961) an active fishery prevailed at Cochin in late fifties with peak catches during July-September when the fishery was mainly supported by *M. dobsoni* (65-99%). *P. stylifera*, though formed second in abundance in the fishery, was prominent only in the postmonsoon period. Present analysis of the catch data (Table 13) indicates that the production of *M. dobsoni* in the artisanal sector has gone down drastically over the past several years. It is now relegated to a secondary position by *P. indicus*. The decline in catch could have been the cumulative effect of many attributes, such as constant fishing pressure in the coastal waters by shrimp trawlers, destruction of young ones and other man-made activities in the nursery grounds of important species. Unlike *P. stylifera* which spends its entire life in the sea, species like *M. dobsoni* and *P. indicus* face commercial fishing in both the environments, adults in the sea and juveniles in estuaries and backwaters. The extensive backwater system of Vembanad Lake has been the grazing field for thousands of traditional fishermen for 'Thelli' the juvenile of *M. dobsoni*, from time immemorial. Added to this, many man-made changes in these nursery areas and other destructive processes on the juvenile population (Suseelan, 1987) would have caused far-reaching effects on the stock leading to gradual decline in the coastal fishery. In the inshore sea also, indiscriminate capture of undersized prawns and heavy exploitation of the spawning population of *P. stylifera* and *M. dobsoni* by shrimp trawlers during the non-monsoon period would have adversely affected this population. More recently the operation of 'mini trawl', which has mesh sizes as small as 14 mm at cod end, is increasingly practised along the coastal waters of Kerala by motorised country crafts. This is highly detrimental to the fishery,

since the catch includes an alarming proportion of juvenile prawns.

At Calicut and Mangalore, the prawn fishery is least active during the monsoon season due to the suspension of trawl fishing. In the artisanal sector, however, fairly good catches of prawns are recorded on certain occasions, which are mainly constituted by larger size groups of *M. dobsoni*. This species is also found to breed actively in the coastal waters during the southwest monsoon period. The capture of large quantities of *M. dobsoni* with ripe ovaries by 'Matabala' during monsoon period has been alleged to cause depletion of the resource in Mangalore Coast. The present observations have shown that the modal lengths of the monsoon catch are at 88 mm in males and 93 mm, 98 mm and 108 mm in females, which are much higher than the minimum sizes at first maturity of the species. As most of these prawns would have already spawned two/three times and are approaching their maximum size it may be desirable to exploit them and avoid natural mortality due to senility. ***Therefore, imposing any restriction on the exploitation of this valuable resource from the point of view of conservation needs careful consideration.***

The monsoon trawl fishery of Bombay waters is largely supported by *P. stylifera*, *M. affinis* and *M. monoceros* which together constitute more than 80% of the total penaeid prawn fishery of the area. Though these species breed throughout the year, peak breeding is observed outside the monsoon season. Further, the lowest mean sizes recorded for the females of these species during monsoon period are 89.8 mm for *P. stylifera*, 117.5 mm for *M. affinis* and 144.6 mm for *M. monoceros*, which would indicate that the prawns caught during this season are well above their estimated minimum sizes at first maturity (George, 1967; Rao, 1967). ***Hence, monsoon fishing does not seem to adversely affect the breeding stock.*** The mean sizes of prawns show considerable fall during monsoon in the case of *P. stylifera* and *M. affinis*, whereas *M. monoceros* shows an upward trend. This fall in mean size may be attributed to heavy recruitment resulting from the peak breeding activity during the premonsoon period. Removal of such undersized prawns in monsoon period may result in growth overfishing as well as lower returns to the fishermen. If these undersized prawns are allowed to grow during early monsoon period by observing a closed season for a short period by about June/July, the prawns would grow to larger sizes and improve the quality of catch in the following months and thereby enhance the economic returns of the fishermen. At present, monsoon trawling in Bombay waters is restricted to the inshore areas within 30-40 m depth and it does not pose any management problem as the operation of 'dol' nets, the major gear of the traditional sector, is totally suspended. Recent bottom trawling surveys conducted in the offshore waters (Anon., 1989) have revealed that large concentrations of *P. stylifera* exist along with other species of prawns between 60 and 85 m depth in the area on latitude 18°N. **This indicates that there is scope for increasing the production of penaeid prawns in this region during monsoon period by extending commercial trawling operations to deeper waters.**

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References

Alagaraja, K., M. J. George, K. N. Kurup and C. Suseelan 1986. Yield-per recruit analyses on *Parapenaepsis stylifera* and *Metapenaeus dobsoni* from Kerala State, India. *J. Appl. Ichthyol.*, 2 : 1-11.

Aravindakshan, M. and J. P. Karbhari 1983. New penaeid prawn resources showing up along Maharashtra Coast. *Mar. Fish. Infor. Serv. T & E Ser.*, 53 : 20-23.

Anonymous 1976. Physical oceanography of the southwest coast of India based on the investigations of the UNDP/FAO Pelagic Fishery Project. *Progress Report UNDP/FAO Pelagic Fishery Project (IND 69/593)*, 16 : 1-18.

—— 1989. New shrimp grounds off Bombay Coast. *Fishing Chimes*, 8 (11) : p. 37.

Banerji, S. K. and M. J. George 1967. Size distribution and growth of *Metapenaeus dobsoni* (Miers) and their effect on the trawler catches off Kerala. *Proc. Symp. on Crustacea*, MBAI, 634-648.

Banse, K. 1959. On upwelling and bottom-trawling off the southwest coast of India. *J. mar. biol. Ass. India*, 1 (1) : 33- 49.

Carruthers, J. N., S. S. Gogate, J. R. Naidu and T. Levastu 1959.

Shoreward upslope of the layer of minimum oxygen off Bombay : Its influence on marine biology, especially fisheries. *Nature*, **183** : 1084-1087.

CHAKRABORTY, S. K., V. D. DESHMUKH, V. KUBER AND S. RAMAMURTHY 1983. By-catch of shrimp trawlers in greater Bombay. *Mar. Fish, Infor. Serv. T & E Ser.*, **54** : 7-15.

DESHMUKH, V. M. 1975. A note on the prawn fishery in the Gulf of Kutch during 1962-63. *Indian J. Fish.*, **22** (1 & 2) : 265-269.

GEORGE, K. V. 1974. Some aspects of prawn culture in the seasonal and perennial fields of Vypeen Island. *Ibid.*, **21** (1) : 1-19.

GEORGE, M. J. 1960. Notes on the bionomics of the prawn *Metapenaeus monoceros* Fabricius. *Ibid.*, **6** (2) : 268-279.

—— 1961. Studies on the prawn fishery of Cochin and Alleppey Coast. *Ibid.*, **8** (1) : 75-95.

—— 1967. A synopsis of biological data on penaeid prawn *Metapenaeus monoceros* (Fabricius, 1978). *FAO World Scientific Conference on the Biology and Culture of Shrimps and Prawns. Mexico* 12-24 June, 1967.

—— AND P. VEDAVYASA RAO 1967. Distribution of sex ratios of penaeid prawns in the trawl fishery of Cochin. *Proc. Symp. on Crustacea, MBAI*, **2** : 698-700.

—— AND C. SUSEELAN 1980. Changing pattern of prawn production in small scale fisheries of India. *Proc. Indo-Pacif. Fish. Counc.*, 19th Sess, pp. 402-425.

——, K. RAMAN AND P. K. NAIR 1963. Observations on the offshore prawn fishery of Cochin. *Indian J. Fish.*, **10** A (2) : 460-499.

——, S. K. BANERJI AND K. H. MOHAMED 1968. Size distribution and movement of the commercial prawns of the southwest coast of India. *FAO Fish. Rep.*, **57** (2) : 265-284.

——, K. ALGARAJA, K. K. SUKUMARAN, G. NANDAKUMAR, S. RAMAMURTHY AND K. Y. TELANG 1988. The present status of shrimp trawling and its impact on shrimp stocks of Karnataka Coast. *Proc. Sem. Problems and Prospects of marine fishing and fish processing in Karnataka.* Forum of Fishery Professionals, Mangalore, pp. 1-14.

GEORGE, P. C. AND M. J. GEORGE 1964. On the location of a possible spawning area for the penaeid prawn *Metapenaeus monoceros* Fabricius off Cochin. *Curr. Sci.*, **33** (8) : 215-252.

GOPINATH, K. 1955. Prawn culture in the rice fields of Travancore - Cochin, India. *Proc. Indo-Pacif. Fish. Counc., 6th Sess.*, **18** (3) : 419-424.

JAYARAMAN, R. AND S. S. GOGATE 1957. Salinity and temperature variations in the surface waters of the Arabian Sea off Bombay and Saurashtra Coasts. *Proc. Indian Acad. Sci.*, B **45** : 151-164.

JOEL, J. J. AND I. P. EBENEZER 1985. The Disco Valai. *Mar. Fish. Infor. Ser. T & E Ser.*, **63** : 8-10.

KURUP, N. S. AND P. V. RAO 1974. Population characteristics and exploitation of the important marine prawns of Ambalapuzha, Kerala. *Indian J. Fish.*, **21** (1) : 183-210.

MENON, M. K. 1951. The life history and bionomics of an Indian penaeid prawn *Metapenaeus dobsoni* Miers. *Proc. Indo-Pacific Fish. Counc.*, 3rd meeting, Sec II : 80-93.

—— 1953. Notes on the bionomics and fishery of the prawn *Parapenaeopsis stylifera* (M. Edw.) on the Malabar Coast. *J. Zool. Soc. India*, **5** (1) : 153-162.

—— 1954. On the paddy field prawn fishery of Travancore - Cochin and an experiment in prawn culture. *Proc. Indo-Pacific Fish. Coun.*, Sec. II : 131-135.

—— 1955. Notes on the bionomics and fishery of the prawn *Metapenaeus dobsoni* Miers on the Southwest Coast of India. *Indian J. Fish.*, **2**(1) : 41-56.

—— 1957. Contribution to the biology of penaied prawns of the southwest coast of India. I. Sex ratio and movements. *Ibid.*, **4** (1): 62-74.

—— 1958. Prawn fisheries. *In*: 'Fisheries of the west coast of India' Mandapam Camp, India, pp. 45-50.

—— AND K. RAMAN 1961. Observations on the prawn fishery of the Cochin Backwaters with special reference to the stake net catches. *Indian J. Fish.*, **8** (1): 1-23.

MOHAMED, K. H. 1973. Penaeid prawn resources of India. *Proc. Symp. Living Resources of the Seas around India. CMFRI*, pp. 548- 556.

MURTY, A. V. S. 1981. Observations of coastal-water upwelling around India. *In* : J Light Hill and Pearce (Ed.) *'Monsoon Dynamics'*. Cambridge Univ. Press, 35 pp.

PANIKKAR, N. K. 1937. The pawn industry of the Malabar Coast. *J. Bombay nat. Hist. Soc.*, **39** (2) : 343-353.

—— AND M. K. MENON 1955. Prawn fisheries of India. *Proc. Indo-Pacific Fish. Counc.*, **6** (2&3) : 328-346.

RAJAN, K. N., K. K. SUKUMARAN AND S. KRISHNA PILLAI 1982. On 'Dol' net prawn fishery of Bombay during 1966-76. *Indian J. Fish.*, **29** (1&2) : 29-36.

RAMAMURTHY, S. 1967. On the prawn fishery of the Gulf of Kutch. *Proc. Symp. Curstacea, MBAI*, **4**: 1424-1436.

——1972 a. Trawl fisheries of the South Kanara Coast during 1967- 70. *Indian J. Fish.*, **19**: 54-59.

—— 1972 b. Observations on the prawn fishery of the Mangalore Estuary on the southwest coast of India. *Ibid.*, **19** (1 & 2): 143-155.

—— AND K. K. SUKUMARAN 1984. Observations on the prawn fishery of Mangalore Coast during 1970-1980. *Ibid.*, **31** (1): 100-107.

RAO, G. SUDHAKARA 1983. Observations on the seasonal prawn fishery of the Little Rann of Kutch during 1980. *Ibid.*, **30** (1): 124-134.

—— AND H. MOHAMAD KASIM 1985. On the commercial trawl fishery off Veraval during 1979-1982. *Ibid.*, 33 : 296-308.

RAO, P. VEDAVYASA 1967. Maturation and spawning of the penaeid prawns of the southwest coast of India. *FAO World Scientific Conference on the Biology and Culture of Shrimps and Prawns*, Mexico 12-14 June, 1967, 17 p.

—— 1968. Maturation and spawning of the penaeid prawns of the southwest coast of India. *FAO Fish. Rep.*, 57 (2): 285-302.

—— 1972. Seasonal abundance of larvae and postlarvae of the commercially important penaeid prawns in the inshore waters of Cochin. *Indian J. Fish.*, 19 : 86-96.

SILAS, E. G., M. J. GEORGE AND T. JACOB 1984. A review of shrimp fisheries of India : A scientific basis for the management of the resource. *In* : J. A. Gulland and B. J. Rothschild (Ed.) *Penaeid shrimps - thier biology and management*. Fishing News Books Ltd., Farnham, Surrey, England, pp. 83-103.

SUKUMARAN, K. K. 1987. Monsoon prawn fishery by indigenous gears along the Mangalore Coast. *Mar. Fish. Infor. Serv. T & E Ser.*, 76 : 1-4.

—— AND G. NANDAKUMAR 1983. A potential new resource of prawn from the Karnataka Coast. *Ibid.*, 54 : 16-17.

—— AND K. N. RAJAN 1986. On the biology of the penaied *Parapenaeopsis sculptilis* (Heller) in the Bombay area. *Indian J. Fish.*, 33 (4) : 440-449.

——, ALLI C. GUPTA, UMA S. BHAT, D. NAGARAJA, H. RAMACHANDRA, O. THIPPESWAMY AND Y. MUNIYAPPA 1988. Monsoon prawn fishery by 'Matabala' along the Mangalore Coast - A critical study. *Mar. Fish. Infor. Serv. T & E Ser.*, 82 : 23-28.

SUSEELAN, C. 1987. Impact of environmental changes and human interference on the prawn fishery resources. *Ibid.*, 73 : 1-5.

—— AND M. KATHIRVEL 1979. A good nursery ground for tiger prawns located in Kerala. *Ibid.*, 12 : 8-9.

—— AND —— 1982. A study on the prawns of Ashtamudi Backwater in Kerala with special reference to penaeids. *Indian J. Fish.*, 29 (1 & 2) : 71-78.

—— AND K. N. RAJAN 1989. Stock assessment of the Kiddi shrimp (*Parapenaeopsis stylifera*) off Cochin, India. Contributions to tropical fish stock assessment in India. Papers prepared by the participants at the FAO/DANIDA/ICAR National Follow-up Training Course in Fish Stock Assessment. Cochin, India from 2 to 28 November 1987. FI: GCP/INT/392/DEN/1, 1989, 157 p.

—— AND ——1991. Marine prawn production in low energy fishing sector of Indian Coast - Present trend and future prospects. Paper presented at the *'National Workshop on Low Energy Fishing'* organised by society of Fisheries Technologists (India), Kochi-29.

——, —— AND G. NANDAKUMAR 1989. The Karikkadi fishery of Kerala. *Mar. Fish. Infor. Serv. T & E Ser.*, 102 : 4-8.

——, G. NANDAKUMAR AND K. N. RAJAN 1990. Results of bottom trawling by FORV *Sagar Sampada* with special reference to catch and abundance of edible crustaceans. *Proc. First Workshop Scient. Resul. FORV Sagar Sampada*, 5-7 June, 1989. pp. 337-346.

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PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : SQUID AND CUTTLEFISH

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Abstract

A great bulk of the cephalopods exploited in India, mostly as by-catch, is landed on the west coast with the three maritime States of Kerala, Maharashtra and Gujarat accounting for the lion's share. Over 70% of this is obtained in trawl, while the rest is taken in artisanal fisheries, besides some exclusive fisheries of localised nature. During February 1984 to August 1988, on the west coast as a whole, the post-monsoon season (September-February) is the best period for cephalopod landings accounting for an average of 63% of the annual production, while premonsoon season (February-May) is the next productive and the monsoon season (June-August) is the least. Fishery in the monsoon season is active only at Vizhinjam with the opearation of large number of artisinal gear; however the cephalopod catch is much less than in other seasons. *Loligo duvauceli* is the single species that constitutes the squid fishery on the west coast, while *Sepia pharaonsis* and *Sepia aculeata* mainly form the cuttlefish fishery. There is no significant variation in size range or maturity conditions of the component species of squid and cuttlefish in relation to the seasons. The possible effect of fishing during monsoon on cephalopod resources is discussed.

Introduction

Cephalopods, which have gained great importance in recent years due to the increasing demand (next only to shrimp) in the export trade, are obtained as by-catch in good quantities in trawl fishing; also a small portion is taken in many types of indigenous gear. The present production has crossed the 50,000 t mark. About three-fourths of this is taken on the west coast, with three maritime States - Kerale, Maharashtra and Gujarat accounting for the lion's share. At present no special gear is exclusively used for the capture of cephalopods, except for a type of hand-jig (anchor hook) which is employed for obtaining cuttlefish at Vizhinjam, the Japanese hand-jig for squid in the Palk Bay area and the spear for the octopus fishing in Minicoy. Though cephalopods are caught throughout the year, there are striking seasonal variations in the catches.

Observations on the fishery characteristics at different centres (Vizhinjam, Cochin, Mangalore, Bombay and Veraval) more or less reflect the nature of the cephalopod fishery of the west coast as a whole. However, there are certain variations in the craft and gear employed, catch and effort, seasonal abundance and species composition. For example, the fishery at Vizhinjam is peculiar in that there is no trawling or other mechanised fishing, but only artisanal fishery. On the other hand, it is by trawling that most of the fishing is done at all other centres. This paper deals with the cephalopod fishery as a whole and at different centres based on the data collected for the period 1984-88 and attempts to examine whether there is any effect of fishing during the monsoon period on the stock of cephalopods, species and size composition, and other related aspects.

Data Base

The catch and effort data on cephalopds presented here in respect of the maritime States of the west coast (Kerala, Karnataka, Goa, Maharashtra and Gujarat) were obtained from the Fishery Resources Assessment Division of CMFRI. These data pertain to the period (1985-88) (upto August) and include the Statewise, seasonwise fishing effort, cephalopod and total catch by gear, except in the case of Maharashtra for which gearwise data were not available.

Apart from these, the data pertaining to the local fishery, environmental parameters for the period 1984-88 (upto August) were collected at different centres. At all centres the catch and effort data collected at random on fixed days were raised

to each day's total, and the total for all the observation days to the month to arrive on the monthly estimates. Biological studies were based on specimens taken by random sampling. The length of squid and cuttlefish refers always to the dorsal mantle length (DML) which is the standard measurement for all cephalopods. The seasons recognised are the premonsoon (February-May), the monsoon (June-August) and the postmonsoon (September-January).

Observations

West coast

From the gearwise data for the period February 1985 to August 1988, it was observed that over 77% of the total cephalopod catch was taken by trawl net and the rest by many other types of gears like boat-seine, drift gillnet, hooks and line, shore seine, *dol* (fixed bag net) and ring seine. Trawl was operated in all the States; a variety of indigenous gears (boat seine, shore seine, hooks and line, drift/gill net and ring seine) was used in Kerala. In Maharashtra and Gujarat the *dol* net took very small quantities of cephalopods.

Of the total cephalopods landed on the west coast, an average of 63% was taken during the postmonsoon season, 29% during the premonsoon season and 8% during the monsoon season. Fig. 1 shows the seasonwise landings on the west coast during the years 1985-87; in the year 1988, as the postmonsoon season was not originally included in the study, the average catch for the postmonsoon seasons of the three previous years is shown for comparison. In all the years the catches during the postmonsoon seasons were the highest, accounting for 54-71% of the annual landings and the lowest catches during the monsoon seasons, ranging from 3% to 18%.

Fig. 2 shows the seasonwise fishing effort by trawl, the cephalopod catch by trawl and the catch by all the other categories of gear put together in respect of the maritime States except Maharashtra. The fishing effort by other categories of gear is not shown, as it was by more than one type of gear in small numbers. There were also no data for the postmonsoon period of 1988. In Kerala the cephalopod catch by trawl during the postmonsoon seasons in all the years was the highest, though the fishing effort was slightly more during the premonsoon season. But in the case of other categories of gear, the catch in the postmonsoon season of 1986 was much higher (7,175 t) than that by trawls (5,096 t). This was due to the very good catches obtained in boat seine (5,446 t), shore seine (993 t) and hooks and line (579 t), owing to the unusual incursion of squid into the inshore waters during the season, especially in the southern parts of the State where the artisanal gear operating closer to the shore were more in operation than trawls. The fishing effort by trawl as well as artisanal gear was minimum during the monsoon seasons.

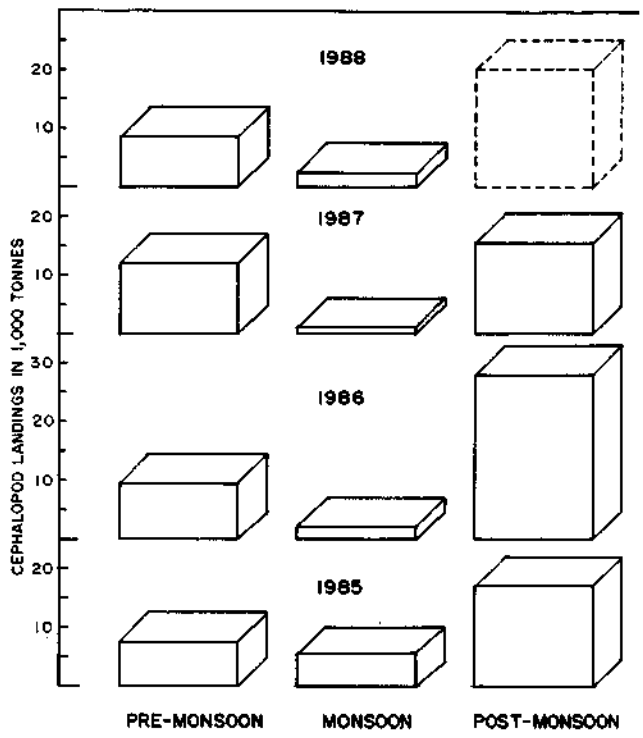

Fig. 1. Seasonwise landings of cephalopods on the west coast of India. Since the landings during postmonsoon season of 1988 were not originally included, the average of preceeding three years' postmonsoon seasons is shown for comparison.

More or less similar trend was noticed in Karnataka and Goa, but variation in fishing effort and cephalopod catch during premonsoon and postmonsoon seasons was not as pronounced as in Kerala. Both effort and catch were uniformly low during the monsoon seasons.

In Gujarat, the fishing effort by trawlers during each of the premonsoon and postmonsoon seasons was low when compared to other States. But the corresponding cephalopod catches were

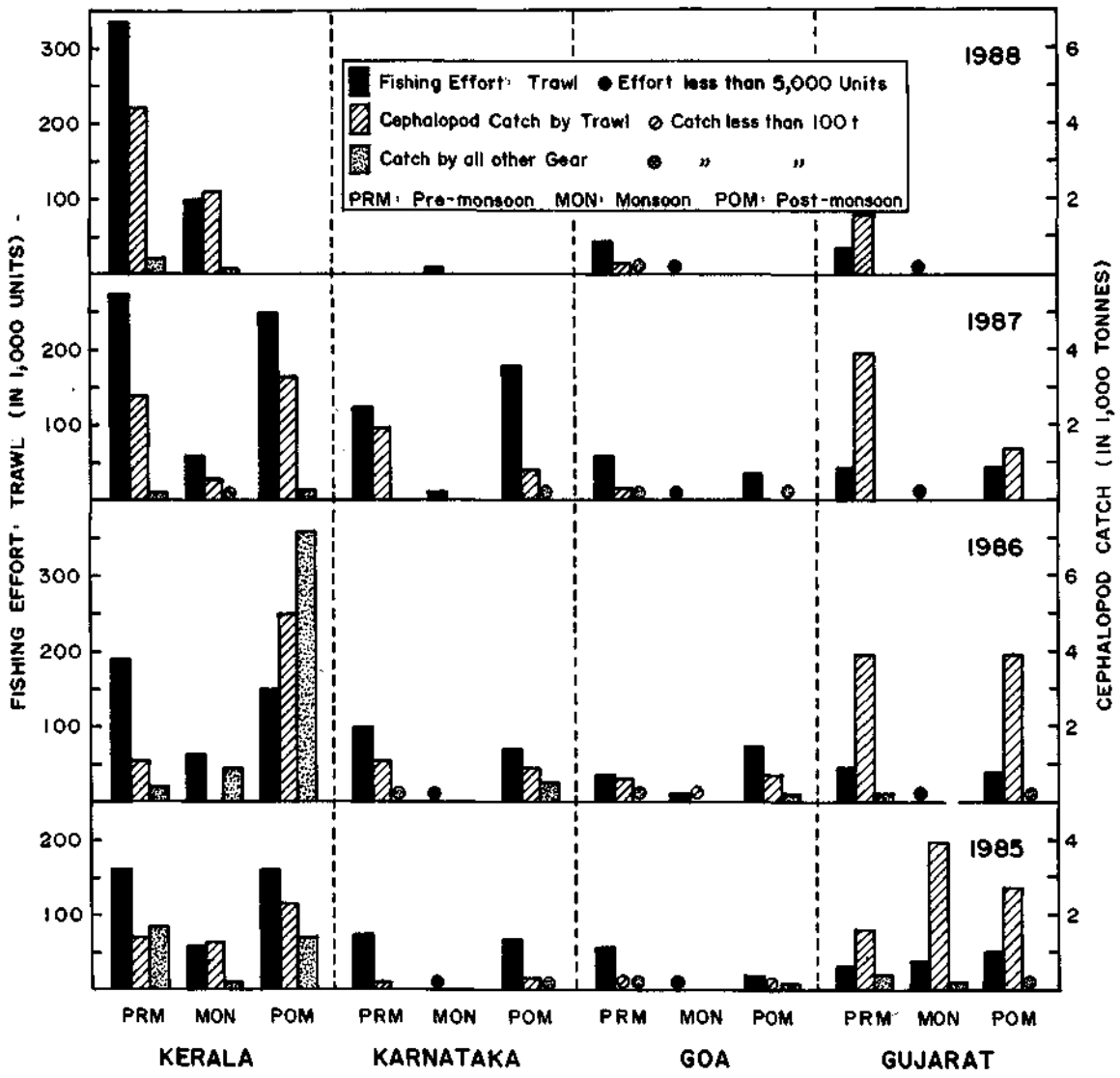

Fig. 2. Statewise, seasonwise fishing effort by trawl and cephalopod catch by trawl and by all other gears. Gearwise data for Maharashtra not available.

high. In 1985, the postmonsoon catch was higher than that in the postmonsoon, but in 1986 it was almost equal and in 1987, the premonsoon catch was much higher (3,852 t) than in the postmonsoon. Trawling operations and the catch were the minimum during the monsoon seasons in most years, but in 1985, the effort was slightly more than that in the premonsoon and the catch was much higher, 3,901 t by trawl and 152 t by other types of gear.

The seasonwise landings of cephalopods in Maharashtra are given in Table 1. Here also the landings during the postmonsoon seasons were the highest, with the least during the monsoon seasons. The postmonsoon catches in this State were much higher than those in Kerala during 1985 and 1987, but in 1986 the catch in Kerala was slightly higher, 12,271 t as against 10,047 t in Maharashtra.

TABLE 1. *Seasonwise cephalopod landings (tonnes) in Maharashtra for the years 1985-88 (Postmonsoon season of 1988 not included)*

Season	1985	1986	1987	1988
Premonsoon	2,327	2,426	3,016	1,870
Monsoon	59	118	112	187
Postmonsoon	10,349	10,047	9,550	-

Vizhinjam

The cephalopod catch at Vizhinjam was composed of three species *viz.*, the squids *Loligo duvauceli* Orbigny and *Doryteuthis sibogae* Adam and the cuttlefish *Sepia pharaonis* Ehrenberg. Besides these species, stray occurrence of squids *Doryteuthis singhalensis* (Ortman) and *Sepioteuthis lessoniana* Lesson and the cuttlefish *Sepia aculeata* (Orbigny) and *Sepiella inermis* (Orbigny) has been noticed; none of these species formed any fishery, except for *Sepioteuthis lessoniana* which was occasionally taken in small quantites.

Annual catch trend : In 1984 (February 1984 to January 1985) the total cephalopod catch was 267 t, but during the next year it increased to 532 t. In 1986 there was a bumper catch of 1,752 t of cephalopods and this was more than thrice the highest annual landings ever recorded at Vizhinjam. Such a peak was due to the sudden spurt in the squid catch throughout the southern part of the southwest coast of India in September that year. This was followed by a dismal fall in the catch next year with a total of only 37 t, the lowest record of annual cephalopod landings.

Monthly catch trend : The average monthly catch data for five years from February 1984 to August 1988 (Table 2) show that squids were landed in all the months. In the case of cuttlefish, the peak landings were in October-November with the catch coming down towards the end of the year or the beginning months of the next year. There were absolutely no landings of cuttlefish from May to July.

TABLE 2. *Average monthly squid and cuttlefish landings (tonnes) at Vizhinjam during 1984-1988*

Month	Squid	Cuttlefish	Total
February	10.9	1.8	12.7
March	16.3	3.5	19.8
April	0.1	0.5	0.6
May	3.0	-	3.0
June	4.4	-	4.4
July	1.1	-	1.1
August	122.8	0.8	123.6
September	352.7	11.8	364.5
October	4.6	33.9	38.5
November	0.1	20.5	20.6
December	26.2	14.1	40.3
January	0.8	6.4	7.2

Seasonal catch trend : During the period of observation as a whole, the cephalopod catch was the maximum (74%) in the postmonsoon period, followed by the monsoon period (20%) and premonsoon period (6%). In 1987 and 1988, the fishery itself was very poor to show any seasonal trend; however, the catches in the premonsoon were slightly better than in other season (Fig. 3). In 1985 the catch in the monsoon season dominated, but in the remaining two years (1984 and 1986) the postmonsoon landngs were the highest (78% and 80% respectively). It was also seen from Fig. 3 that the catches were always less in monsoon periods than in postmonsoon periods; annually they varied between 4% in 1988 and 45% in 1985.

Gearwise seasonal catch trend : (i) *Shore seine* : Of 1,985 units operated, the minimum (76) was during the monsoon peropd. There was no operation of shore seine during the monsoon months in some years. The maximum effort (1,052 units) was put in during the postmonsoon seasons as also the maximum catch (1.4 t). The average CPUE ranged from 1 kg in the premonsoon to 1.4 kg in the monsoon (Table 3).

(ii) *Boat seine* : About 82% of the total cephalopod landings and 94% of the squid landings at Vizhinjam were contributed by boat seine. Bulk of the squid catch by this gear (60%) came during the postmonsoon season, though only 19% of the fishing effort was put in; the CPUE was very high 56.2 kg. In the postmonsoon of 1986 the CPUE was as high as 127.1 kg (Table 3). More effort (75%) was put in during the monosoon season, but the catch was only 29%. Both effort and catch were the minimum in the premonsoon period.

Fig. 4 shows the fishing effort and cephalopod catch in each season of the year in respect of boat seine, and hooks and line; shore seine is not represented here as both effort and catch were very small. The boat seine effort was more in the monsoon season of all the years, but the catch was significant in the postmonsoon season of 1984 and 1986; 1,314 t of squids obtained during the latter year was the highest recorded so far at Vizhinjam. Only in 1985 and also in 1987 to avery small extent, the catch during the monsoon season was slightly higher than in the other seasons. In 1988 the premonsoon catch was much better than the catches in the corresponding seasons of other years, while the contribution of the monsoon season was negligible.

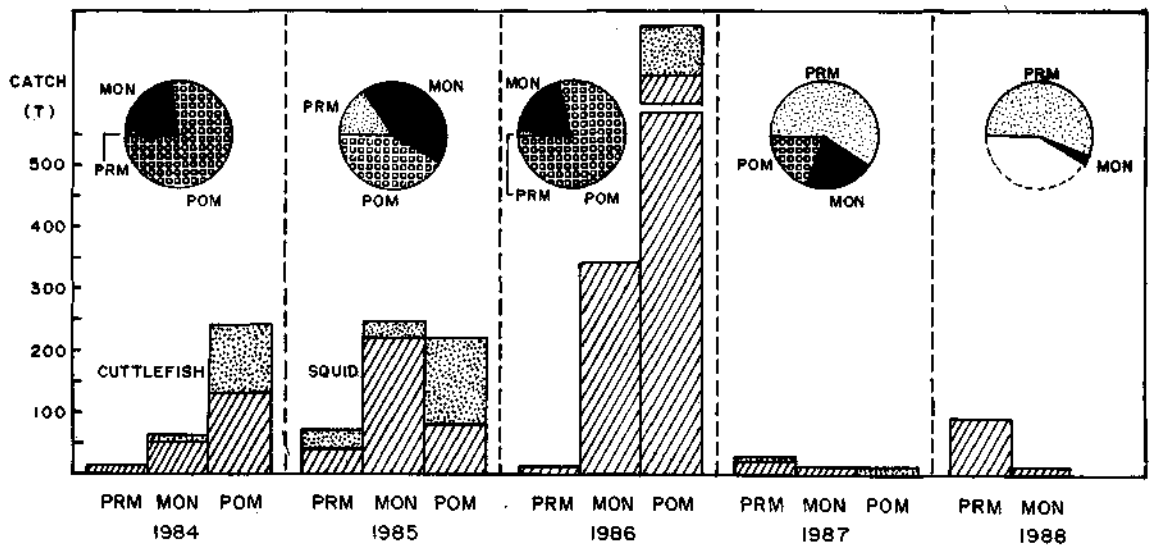

Fig. 3. Squid and cuttlefish landings at Vizhinjam during the premonsoon (PRM), monsoon (MON) and postmonsoon (POM) seasons of 1984-88. The pie-diagrams show the relative seasonal landings.

TABLE 3. *Gearwise catch per unit effort (kg) during premonsoon, monsoon and postmonsoon seasons of 1984-'88 at Vizhinjam*

	Premonsoon			Monsoon			Postmonsoon		
Year	SS	BS	HL	SS	BS	HL	SS	BS	HL
1984	0.3	0.1	0.1	1.7	2.6	0.1	3.3	22.3	3.1
1985	2.6	11.2	1.6	-	8.8	1.1	0.6	7.5	5.0
1986	1.4	1.0	N.C.	-	15.8	N.C.	1.2	127.1	4.2
1987	0.5	4.3	1.1	0.1	0.3	0.1	0.2	N.C.	0.4
1988	0.5	16.5	2.8	N.C.	0.1	N.C.	-Not included-		
Average	1.0	6.9	1.1	1.4	5.9	0.2	1.3	56.2	3.4

SS : Shore seine; BS : Boat seine; HL : hooks and line;
- : no operation of gear; N. C. : no catch.

(iii) *Hooks and line* : This gear accounted for 18% of the total cephalopod catch. Unlike the boat seine, the effort was the minimum during the monsoon season in all the years. In the other two seasons the effort varied from 14,786 to 32,649. The catch was minimum during the monsoon seasons. In the postmosoon seasons the hooks and line catch of cephalopod was high during the first three years varying from 95 t (1986) to 101 t (1984) and the bulk (88%) of the catch was cuttlefish. The fishery was moderate in the premonsoon seasons of 1985 (36 t), 1987 (19 t) and 1988 (63 t) and the catch was

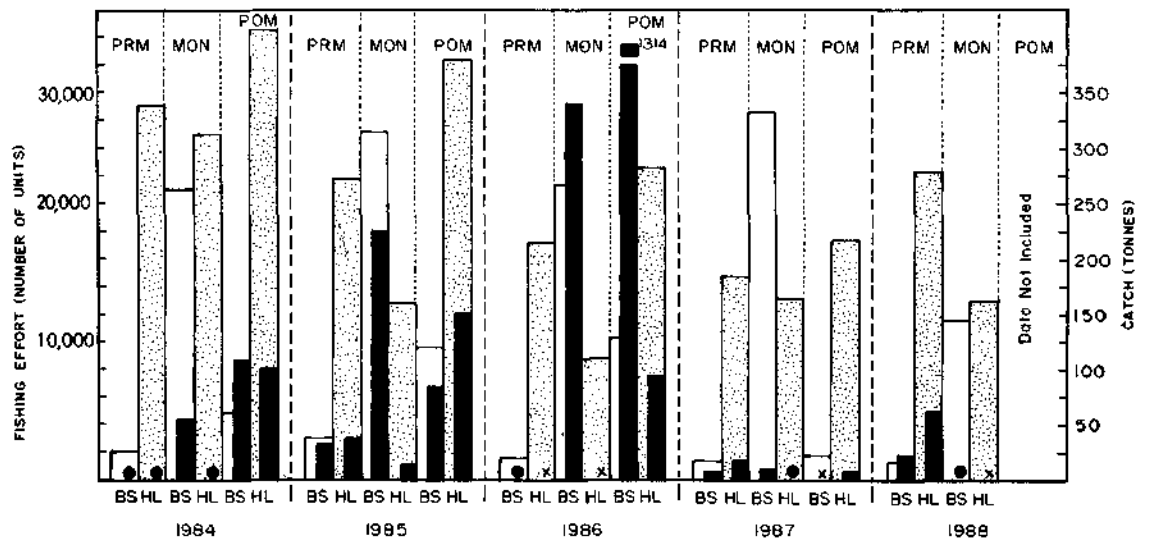

Fig. 4. Fishing effort (in number of units operated) and cephalopod catch (shaded bars) in respect of boat seine (BS) and hooks and line (HL) at Vizhinjam during the premonsoon (PRM), monsoon (MON) and postmonsoon (POM) seasons of 1984-88. O : catch less than 5 tonnes; X : no catch.

composed of 75% of squids and 25% of cuttlefish. The CPUE was low during the premonsoon and monsoon seasons of all the years, but in the post-monsoon seasons the values were better, with the average of 3.4 kg.

There was progressive mechanisation of the fishing craft for operation of the hooks and line through the years. In 1984 the ratio of fishing effort of non-mechanised craft to mechanised craft was 1 : 0.2, which has increased to 1 : 4.9 in 1987. The corresponding ratios of the cephalopod catches were 1 : 0.4 and 1 : 5.4, indicating that there was increased returns for the fishing effort expended from mechanised craft.

Catch composition

Fig. 5 shows the relative abundance of the squids *Loligo duvauceli* and *Doryteuthis sibogae* and the cuttlefish *Sepia pharaonis* in different seasons. The landings of *Loligo duvauceli* were the lowest, less than 2 t, in the premonsoon periods of the first four years and there was no catch in 1988. The catches were much better in the monsoon seasons (8-341 t), but the highest seasonal catch of 1,314 t was in the postmonsoon period of 1986. This was due to the bumper catches in September that year when there was unusual large scale shoreward migration of schools of squids. As a whole, about three-fourths of the catch of this squid were taken in the postmonsoon period and almost the rest in the monsoon period, with very insignificant catch in the premonsoon season.

Doryteuthis sibogae was landed in all the pre-monsoon periods in all the years with the catch varying from 1 to 85 t. There was no fishery in the monsoon months except in 1985. In the postmon-soon period of 1984 there was a good catch of 96 t, but in subsequent two years the catches were very insignificant. As a whole, the fishery was minimum (7%) during the monsoon season and maximum (57%) during the premonsoon period.

The cuttlefish *Sepia pharaonis* showed a trend different from those of the squids. Bulk of the catch (75%) was taken during the postmonsoon, followed by the landings in the premonsoon (26%); in the monsoon season there was either no catch or the catches were less than 2 t.

Catch and rainfall

In general it is observed that higher catches were obtained when there was low rainfall (Fig. 6 A). For example in December 1984 the catch was 110 t and the rainfall 3 mm. In August 1983 there was a catch of 216 t and in September 1986 the catch was 1,314 t. The rainfall in the two months was 62 mm and 78 mm respectively. The maximum rainfall of 539 mm was recorded in June 1988 but there was no cephalopod catch. In June 1985 the rainfall recorded was 424 mm and the catch 19 t; in October 1987 the rainfall was 415 mm whereas the catch was only 6 t.

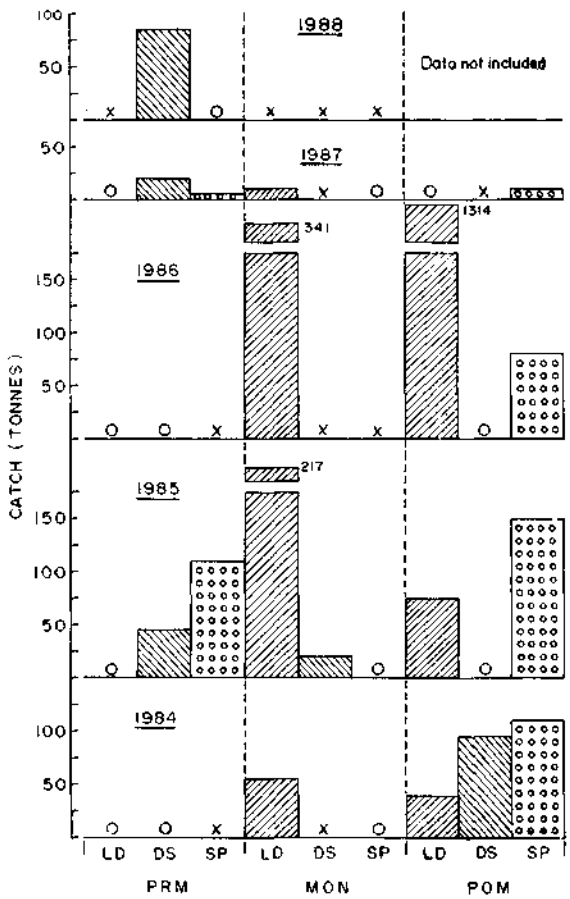

Fig. 5. Relative abundance of the squids *Loligo duvauceli* (LD) and *Doryteuthis sibogae* (DS), and cuttlefish *Sepia pharaonis* (SP) during the premonsoon (PRM), monsoon (MON) and postmonsoon (POM) seasons of 1984-88.

Fig. 6 B shows the cephalopod catch in relation to the seasonal rainfall for the 5 years. Except in 1984 and 1987, the maximum rainfall was in the monsoon season, followed by that in the post-monsoon (which also includes the northeast mon-

soon); in 1984 the premonsoon total was 730 mm and in 1987 the rainfall during the postmonsoon was very high (1,109 mm). The monthly trend mentioned earlier is reflected in the seasons as a whole in that the catch was more with less rainfall.

Size composition

Loligo duvauceli : The size of males ranged from 20 mm to 330 mm; females had a smaller size range, 30-230 mm (Fig. 7). From the monsoon season of 1984 to the postmonsoon of 1985, a large number of length groups (40-50 mm to 320-330 mm) were represented in the catch, but afterwards the size range became smaller. Upto the premonsoon period of 1986 the fishery was supported by adult squid above 110 mm which is the size at maturity for both the sexes. The same pattern was repeated during the monsoon season of 1988. The bumper catch during the postmonsoon season of 1986 was supported by squid with modal sizes of 145 mm (males) 155 mm (females). In the monsoon season of 1987 immature and mature squid were in almost equal proportion. In the premonsoon and postmonsoon period of 1987 juveniles constituted the fishery.

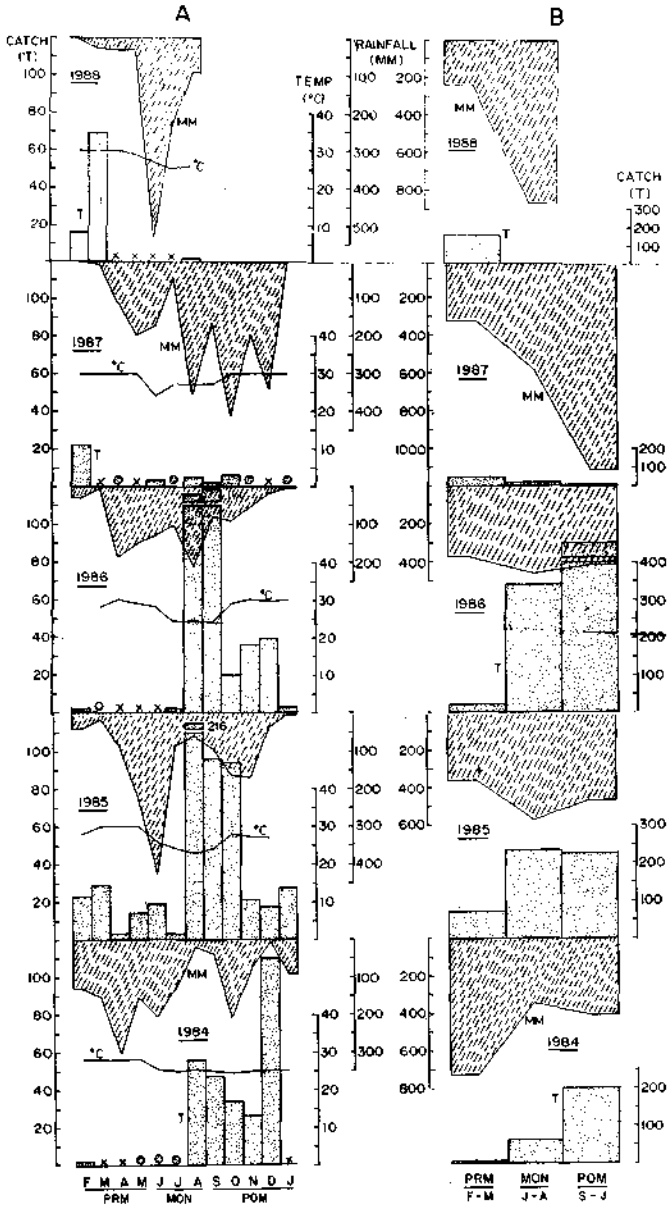

Fig. 6 A. Monthly rainfall, seawater temperature and cephalopod catch during 1984-88 and B. Seasonal rainfall and cephalopod catch. PRM : Premonsoon; MON : monsoon; POM : postmonsoon, O : catch less than 2 tonnes; X : no catch.

Doryteuthis sibogae : Males of this squid had a size range of 30-240 mm and females a smaller size range within 30-220 mm (Fig. 7). The fishery in general was supported by adult squid above 90 mm [According to Silas *et al.* (1986) the size at first maturity of male is 97 mm and that of female 84 mm]. Only in the premonsoon period of 1986 the juveniles constituted the fishery; in the postmonsoon of 1984 and premonsoon and postmonsoon of 1985 also they formed part of the landings.

Sepia pharaonis : As in the case of squids, the cuttlefish *Sepia pharaonis* also had a wide length range from 130 mm to 360 mm, which was also the range for male; the females were smaller, 130-290 mm (Fig. 7). In all the seasons when cuttlefish was landed, almost the entire catch was composed of adult individuals larger than 145 mm which was the size at first maturity for males (160 mm for females). Most of the male cuttlefish that formed the bulk of the catch were 250 mm and above and females larger than 200 mm.

Cochin

Premonsoon season : The estimated average cephalopod production (Table 4) during the season amounted to 257 t taken at a catch rate (CPUE) of 13.9 kg per trawler day. The monthly average landings varied from 40 t in February to 94 t in May with catch rates varying from 10.1 kg to 17.3 kg. Cephalopod contribution to all-fish production was 5%. The catch during May was higher than that in other months, contributing 36.6% to the season's total. The catch, effort and CPUE showed an increasing trend from February to May.

Squid, solely represented by *L. duvauceli* was dominant (79.7%) in the landings. Its catch increased from 27 t in February to 79 t in May. Among the cuttlefish, *S. pharaonis* which is commercially the most important species, accounted for 33.6%; the contribution by other species was : *S. elliptica* 28.7%, *S. aculeata* 20.5% and *Sepiella inermis* 17.2%. Cuttlefish landings were poor during February.

The size of males of *L. duvauceli* ranged from 30 to 250 mm and that of females from 30 to

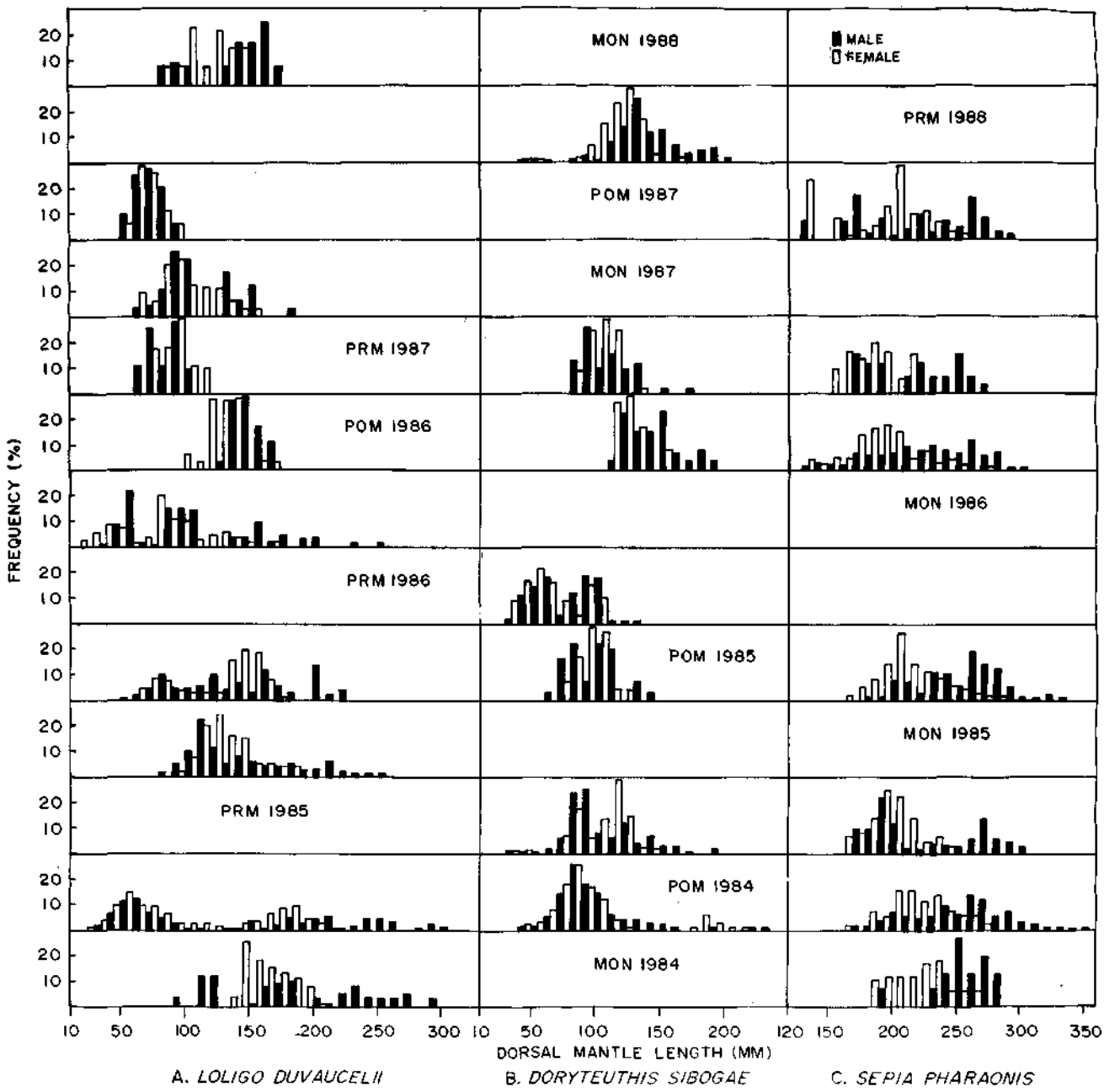

Fig. 7. Size composition of component species of cephalopods by premonsoon (PRM), monsoon (MON) and postmonsoon (POM) seasons of 1984-88, shaded bars : males; open bars : females.

190 mm. The fishery was mostly supported by squid in the size range of 60-150 mm. Sexes were almost equally represented during the season. Squid with maturing gonads were generally dominant, with mature and running gonads occurring in lesser numbers.

Monsoon season : The average landings during the season were estimated at 187 t, with a catch rate of 13.2 kg (Table 5). Though the catch rate was more or less the same as that during the premonsoon season, the catch and effort had decreased by 27.3% and 23.7% respectively. The landings ranged from 31 t in July to 106 t in June with their catch rates varying from 6.8 kg to 17.2 kg. About 57% of the season's production came in June. During the monsoon period the cephalopod contribution to all-fish production was just over 2%.

With a catch of 147 t, the cuttlefish accounted for 79% of the total cephalopod landings. Cuttlefish landings ranged from 28 t July to 80 t in June.

TABLE 4. *Catch (tonnes), fishing effort (trawler days), CPUE (kg) and species composition of cephalopods during premonsoon season at Cochin (Average for 1984-'88)*

	Feb.	Mar.	Apr.	May	Total
Loligo duvauceli	26.8	49.6	49.7	78.7	204.8
Sepia pharaonis	5.1	3.2	4.5	4.8	17.6
Sepia aculeata	2.0	1.3	3.7	3.8	10.8
Sepia elliptica	4.5	2.3	4.6	3.7	15.1
Sepiella inermis	1.6	1.6	2.6	3.3	9.1
Total squids	26.8	49.6	49.7	78.7	204.8
Total cuttlefish	13.2	8.4	15.4	15.6	52.6
Total cephalopods	40.0	58.0	65.1	94.3	257.4
Fishing effort	3,939	4,373	4,792	5,429	18,533
CPUE	10.1	13.2	13.6	17.3	13.9

S. pharaonis (55.9%), *S. aculeata* (32%), *S. elliptica* (11.4%) and *S. inermis* (less than 1%) constituted the cuttlefish landings. *L. duvauceli* contributed 99.4% to the squid production (39 t) and the rest by *Doryteuthis singhalensis*. The latter species was observed in the landings at Cochin for the first time during August 1988.

The size range of *L. duvauceli* was 30 mm to 260 mm for males and 40 mm to 180 mm for females. Squid in the size groups 60-150 mm supported the fishery. During this period also the gonadial conditions of the squid were almost similar to those observed during the premonsoon period.

Postmonsoon season : During this season 213 t of cephalopods were landed with a CPUE of 20.2 kg (Table 6). The production varied from 7 t in September to 110 t in November. Cephalopods contributed 7% to all-fsih landings. The effort spent during September and October was 247 and 560 trawler days, but it increased to a maximum of 4,268 in January. The monthly catch rates varied from 11 kg in January to 54.3 kg in November. The fishing effort during this season decreased by 43% from the premonsoon period and by 25% from the monsoon period.

Cuttlefish *S. pharaonis* (44.6%), *S. aculeata* (28.9%), *S. elliptica* (22.5%) and *Sepiella inermis* (4.0%) were dominat in the catches contributing 55% to cephalopod production. The squid *L. duvauceli* accounted for the rest of the catch. Squid landings were comparatively more during December and January.

TABLE 5. *Catch (tonnes), fishing effort (trawler days), CPUE (kg) and species composition of cephalopods during monsoon season at Cochin (Average for 1984-'88)*

	June	July	August	Total
Loligo duvauceli	26.7	3.0	9.7	39.4
Doryteuthis singhalensis	-	-	0.2	0.2
Sepia pharaonis	50.1	12.3	20.0	82.4
Sepia aculeata	26.7	9.4	11.0	47.1
Sepia elliptica	2.2	5.5	9.0	16.7
Sepiella inermis	0.7	0.4	-	1.1
Total squids	26.7	3.0	9.9	39.6
total cuttlefish	79.7	27.6	40.0	147.3
Total cephalopods	106.4	30.6	49.9	186.9
Fishing effort	6,177	4,472	3,488	14,137
CPUE	17.2	6.8	14.3	13.2

The size ranges of males and females of *L. duvauceli* were 30-290 mm and 30-190 mm respectively. There was not much variation either in the size groups supporting the fishery or in the maturity conditions of the gonads from the earlier two seasons.

Mangalore

Species composition : The cephalopod fishery at Mangalore was constituted by squid represented by a single species *Loligo duvauceli* and the cuttlefish composed of *Sepia aculeata* and *Sepia pharaonis*, besides other species in very small numbers. The specieswise relative abundance during different seasons of 1984-88 is given in Table 7.

TABLE 6. *Catch (tonnes), fishing effort (trawler days), CPUE (kg) and species composition of cephalopods during postmonsoon season at Cochin (Average for 1984-'88)*

	Sep.	Oct.	Nov.	Dec.	Jan.	Total
Loligo duvauceli	0.7	4.2	29.1	27.4	35.6	97.0
Sepia pharaonis	2.7	1.3	37.2	5.9	4.8	51.9
Sepia aculeata	1.7	0.7	26.5	3.5	1.2	33.6
Sepia elliptica	1.4	0.8	15.9	3.5	4.6	26.2
Sepiella inermis	0.1	0.4	1.4	2.1	0.7	4.7
Total squids	0.7	4.2	29.1	27.4	35.6	97.0
Total cuttlefish	5.9	3.2	81.0	15.0	11.3	116.4
total cephalopods	6.6	7.4	110.1	42.4	46.9	213.4
Fishing effort	247	560	2,029	3,446	4,268	10,550
CPUE	26.5	13.1	54.3	12.3	11.0	20.2

Premonsoon season : During this period the cephalopod catches varied from 290 t in 1985 to 875 t 1987 (Table 8). The cephalopod contribution to the total catch ranged between 4.7% in 1984 and 8.7% in 1986. The CPUE varied from 11.1 kg in 1985 to 30.3 kg in 1987. The squid *Loligo duvauceli* was the most dominant species forming about 90% of the total cephalopods in 1984 to 95% in 1987. *Sepia aculeata* was the dominant cuttlefish, contributing to 2-10%. *Sepia pharaonis* was observed in the premonsoon catches during 1986 and 1987, contributing 5% and 3% respectively during the above two years. On an average, the contribution of cephalopods during premonsoon period was 6.2%, with a CPUE of 21.6 kg.

Monsoon season : There was no fishing during monsoon period. However, fishing was conducted in the first week of June in 1987 due to late onset of monsoon. During this period the cephalopod catch was negligible (Table 8).

Postmonsoon season : During this period the cephalopod catch varied from 167 t in 1986 to 342 t in 1984, while the CPUE ranged from 10.4 kg in 1986, to 20.9 kg in 1985 (Table 8). The contribution of cephalopods to the total catch varied between 3.1% in 1987 and 9.5% in 1985. The catches of *Loligo duvauceli* ranged from 147 t in 1986 to 226 t 1987, forming 55-88% of the total cephalopods taken in the postmonsoon seasons (Table 7). The catches of cuttlefish ranged from 20 t in 1986 to 153 t in 1984

TABLE 7. *Seasonal specieswise cephalopod landings (tonnes) at Mangalore during 1984-87*

	1984	1985	1986	1987
Premonsoon				
Loligo duvauceli	338	262	661	829
Sepia aculeata	40	26	62	21
Sepia pharaonis	-	-	35	25
Others	-	2	-	-
Total	378	290	758	875
Monsoon				
Loligo duvauceli	-	-	-	(*)
Sepia aculeata	-	-	-	-
Sepia pharaonis	-	-	-	-
Total	-	-	-	(*)
Postmonsoon				
Loligo duvauceli	189	213	147	226
Sepia aculeata	146	84	15	45
Sepia pharaonis	2	8	5	3
Others	5	8	-	-
Total	342	313	167	274
Annual				
Loligo duvauceli	527	475	808	1,055
Sepia aculeata	186	110	77	66
Sepia pharaonis	2	8	40	28
Others	5	10	-	-
Total	720	603	925	1,149

(*) Catch negligible

forming 12-45%. *Sepia aculeata* and *Sepia pharaonis* were the important species, besides *Sepiella inermis* in very small quantity. On an average the cephalopods formed 4.5% of the total trawl landings during the postmonsoon period with a catch rate of 14.4 kg. The contribution of *Loligo duvauceli* was 70.8%, *Sepia aculeata* 26.5% *Sepia pharanis* 2% and *Sepiella inermis* 0.7% February, 1984 to August, 1988.

TABLE 8. *Monthly and seasonal cephalopod landings (tonnes) and seasonal effort (number of boats per day), CPUE (kg) and percentage of cephalopods in total landings at Mangalore during 1984-87*

Month	1984	1985	1986	1987
Premonsoon				
February	88	107	208	167
March	112	48	408	261
April	78	79	119	343
May	100	56	23	104
Total	378	290	758	875
Effort	23,433	26,198	27,942	28,919
CPUE	16.2	11.1	27.1	30.3
Percentage	4.7	6.2	8.7	7.1
Monsoon				
June	-	-	-	(*)
July	-	-	-	-
August	-	-	-	-
Total	-	-	-	(*)
Effort	-	-	-	100
CPUE	-	-	-	0.2
Percentage	-	-	-	0.4
Postmonsoon				
September	-	-	-	-
October	5	1	-	-
November	44	41	(*)	35
December	144	162	47	125
January	149	109	119	114
Total	342	313	167	274
Effort	24m266	14,992	15,019	45,290
CPUE	14.1	20.9	10.4	13.1
Percentage	4.9	9.5	3.3	3.1

* Catch negligible

Bombay

The total cephalopod landings in the 5-year period amounted to 42,137 tonnes forming 10.4% of all-fish catch.

Monthwise catch : The monthly catch, CPUE and percentage of cephalopod in all-fish catch are shown in Fig. 8. The catch was 22 tonnes in July and it gradually increased in subsequent months, reaching 3,707 tonnes in December. The CPUE was the lowest (10 kg) in July and the highest (800 kg) in December. The same trend was observed in the percentage of cephalopods in all-fish catch also. In all the three monsoon months catches were poor. From February to August the catches were mainly dominated by squid, whereas from September to January, cuttlefish dominated.

Seasonal catch trend : The fishing effort, catch, CPUE and percentage of cephalopods during the premonsoon, monsoon and postmonsoon seasons of 1984-88 are given in Table 9.

Premonsoon season : The catch of cephalopods varied from 1,303 t in 1984 to 2,676 t in 1987 with an average of 2,118 t. The CPUE ranged from 90 kg in 1984 to 153 kg in 1987 with an average of 130 kg. The cephalopod catch was composed of 69.5% of squid and 30.5% of cuttlefish. The highest CPUE (67 kg) of cuttlefish was reocrded in 1988 and that of squid (79 kg) in 1984. During the premonsoon season cephalopods formed 7% of the total fish catch.

Monsoon season : The catch of cephalopods varied from 51 t in 1984 to 277 t in 1988. The CPUE was the highest (35 kg) in 1988 and the lowest (9 kg) in 1985. The average catch and CPUE were 139 t and 21 kg respectively. Squids dominated in the catch with 64.3%. The percentage of cephalopods in total fish catch for the season as a whole was very low (1.4%).

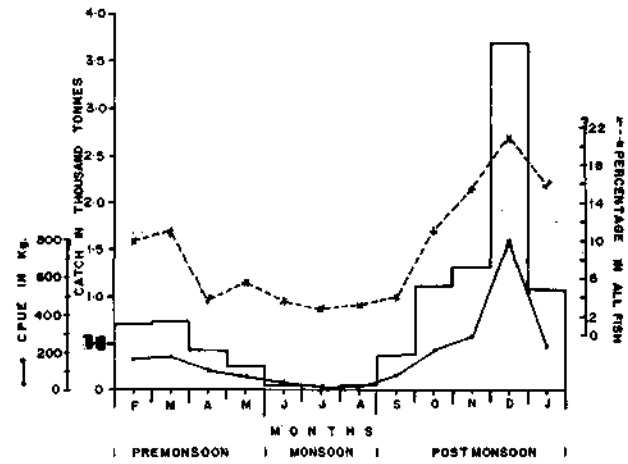

Fig. 8. Monthly catch (tonnes) and CPUE (kg) of cephalopods and their percentage in all-fish catch at Bombay (Pooled data for 1984-'88).

Postmonsoon season : The period in all the years was the best for cephalopod fishery. The catch varied from 4,727 t in 1984 to 8,899 t in 1987 with an average of 7,727 t. The highest CPUE (397 kg) was

TABLE 9. *Seasonwise fishing effort and catch particulars of cephalopods at Bombay during 1984-'88 (Fishing effort in number of units, catch in tonnes and CPUE in kg)*

Years	Units	Squids	% of squid in cephalopod	CPUE	Cuttle fish	% of cuttle-fish in cephalopod	CPUE	cephalopod	CPUE	% of cephalopod in all fish	All fish
Premonsoon (February-May)											
1984	14,480	1,033	79.3	71	270	20.7	19	1,303	90	2.7	48,944
1985	14,983	1,733	73.5	115	626	26.5	42	2,359	157	11.5	20,558
1986	17,305	1,640	74.2	95	570	25.8	33	2,210	127	7.3	30,162
1987	17,486	2,070	77.4	118	606	22.6	35	2,676	153	10.8	24,777
1988	17,190	890	43.5	52	1,155	56.5	67	2,045	119	7.3	27,900
Average	16,290	1,473	69.5	90	645	30.5	40	2,118	130	7.0	30,468
Monsoon (June-August)											
1984	6,344	69	72.1	11	27	27.9	4	96	15	0.9	9,972
1985	5,585	27	52.6	5	24	47.4	4	51	9	0.7	6,965
1986	6,510	84	66.2	13	43	33.8	6	127	20	1.3	9,837
1987	6,077	78	54.1	13	67	45.9	11	145	24	1.6	9,041
1988	7,955	189	68.2	24	88	31.8	11	277	35	2.2	12,423
Average	6,494	89	64.3	14	50	35.7	8	139	21	1.4	9,648
Postmonsoon (September-January)											
1984	23,719	1,073	22.7	45	3,654	77.3	154	4,727	199	11.6	40,707
1985	22,157	857	9.7	39	7,947	90.3	359	8,804	397	22.1	39,810
1986	24,434	2,520	29.9	103	5,900	70.1	241	8,420	345	11.0	76,592
1987	26,003	980	11.0	38	7,919	89.0	305	8,899	342	18.8	48,183
Average	24,078	1,357	17.6	56	6,355	82.4	264	7,712	320	15.0	51,323

obtained in 1985 with the lowest (199 kg) in 1984 which was much higher than the highest value in other seasons. The average CPUE was 320 kg. Cuttlefish catch was higher (82%) than that of squids (18%). The cephalopods accounted for 15% of the all-fish catch during this season, which was the highest for all seasons.

Species composition

Loligo duvauceli was the only species that formed the squid fishery. The squids were more abundant in premonsoon months than in other seasons and the seasonal average CPUE was 90 kg. Postmonsoon months recorded a CPUE of 56 kg and the lowest value of 14 kg in the monsoon period. The length of *Loligo duvauceli* ranged from 20 to 319 mm, with 90-99 mm and 180-189 mm as the two prominent modal size groups. During monsoon months 50-219 mm size squids were netted. The sex ratio was 1 : 1. Mature females were common from January to May and spawning females occurred along with mature ones from September to November.

Cuttlefish were mainly landed during post-monsoon period with an average CPUE of 264 kg. The lowest CPUE (8 kg) was in monsoon season, while it was 40 kg during the premonsoon season.

Sepia aculeata : The size of this cuttlefish ranged from 30 to 249 mm with two prominent modal groups of 100-109 mm and 180-189 mm. The male : female ratio was 3 : 2. Mature and spawning individuals have been observed during February-March and September-November periods.

Sepia pharaonis : This is a less abundant, but larger cuttlefish. The size ranged from 150 to 359 mm. The common modal size groups were 240-249 mm and 290-299 mm. Smaller individuals were not represented in the catches.

Veraval

Monthly and seasonal catch trend : The monthwise and seasonwise total cephalopod landings at Veraval, their CPUE and percentage in total fish

landings are given in Table 10. It could be noted that in general the average catch of cephalopod was more during the postmonsoon period, with alomst 36% increase over the premonsoon period. There was concomitant increase in the CPUE also. The average CPUE during the premonsoon period was 3.9 kg whereas it was 4.4 kg during the postmonsoon. During the premonsoon period the cephalopod catch ranged from 427 t in 1984 to 1,535 t in 1987, whereas in the postmonsoon period the range was from 934 t in 1987 to 2,136 t in 1986. Although there was steady increase in the annual cephalopod landings from 1984 onwards, a sharp peak of 2,136 t during the postmonsoon period of 1986 and a sudden decline to 984 t during the corresponding period of subsequent year could be noted. The CPUE of cephalopods during the premonsoon season ranged from 1.4 kg in 1984 to 6 kg in 1987; in the postmonsoon season the range was from 2.8 kg in 1987 to 7.5 kg in 1986.

Species composition

The cephalopod fishery at Veraval was constituted by one species of squid *(Loligo duvauceli)* and one species of cuttlefish *(Sepia elliptica.)* The specieswise monthly and seasonal landings and CPUE are given in Table 11. It was seen that the squid and the cuttlefish had definite seasonal abundance. In the premonsoon of all the years the squid catches were much higher than the cuttlefish, accounting for about 90% of the total cephalopod landings during that period. The reverse was the trend during the postmonsoon; cuttlefish formed over 70% of the entire cephalopod catch.

Length frequency : The length frequencies of *Loligo duvauceli* for the premonsoon and postmonsoon period of 1986 and 1987, showed that the dorsal mantle length ranged from 30 mm to 280 mm, but majority of the squid were less than 150 mm in length. During the premonsoon period, the main mode was at 120 mm in 1986, 90 mm in 1987 and 110 mm in 1988. In the case of postmonsoon, the modes were almost identical, 70 mm in 1986 and 80 mm in 1987. Squids of larger lengths occurred in very small numbers. The length of *Sepia elliptica* ranged from 20 mm to 140 mm, but most of them were between 40 mm and 100 mm. In the premonsoon season of 1986 the cuttlefish had a modal size of 50 mm, while it was 60 mm in 1987 and 1988. In the postmonsoon seasons of 1986 and 1987, the important modes were at 80 mm and 60 mm respectively.

TABLE 10. *Monthly and seasonal cephalopod landings (tonnes) and percentage (in paranthesis) in total landings at Veraval during 1984-87*

	1984	1985	1986	1987	1988
Premonsoon					
February	97 (2.0)	350 (6.7)	212 (6.5)	761 (19.2)	182 (4.4)
March	178 (1.1)	258 (5.4)	387 (4.8)	580 (1.6)	543 (8.0)
April	110 (0.9)	192 (6.6)	361 (6.4)	162 (4.6)	250 (5.0)
May	42 ((0.8)	3 (0.3)	40 (1.0)	31	260 (6.2)
Total	427 (1.1)	803 (5.7)	1000 (4.8)	1535 910.4)	1,235 (6.1)
CPUE	1.4	3.7	3.6	6.0	4.8
Monsoon					
June					
July			No Landings		
August					
Postmonsoon					
September	3 (0.3)	-	416	8 (0.4)	
October	402 (6.1)	90 (1.6)	946	245 (3.7)	
November	114 (2.5)	401 (6.0)	95	328 (6.1)	
December	349 (3.4)	362 (8.1)	252	242 (6.5)	
January	391 (7.5)	197 (4.6)	427	161 (2.9)	
Total	1,259 (4.5)	1,0-50 (5.0)	2,136 (9.4)	984 (4.1)	
CPUE	3.5	3.9	7.5	2.8	

DISCUSSION

From the foregoing account it was seen that cephalopods were obtained as by-catch mainly in trawl fishing aimed at fish and prawns. However, they were caught exclusively in anchor-hooking for cuttlefish at Vizhinjam, hand-jigging for squid in the Palk Bay and spearing for octopus in Minicoy. The great bulk of the all-India cephalopod catch was taken on the west coast. According to Silas *et al.* (1986) the west coast contribution of cephalopod, during the period 1968-75 was 41-81% annually and during the subsequent years it was as high as 84-94% with an average of 89%.

TABLE 11. *Specieswise monthly and seasonal cephalopod landings (tonnes) at Veraval; the seasonal CPUE (kg) is also given*

	1984		1985		1986		1987		1988	
	sq	cf	sq	cf	sq	cf	sq	cf	sq	cf
Premonsoon										
February	73	24	304	46	197	15	723	39	171	11
March	156	22	229	29	237	50	553	27	531	12
April	100	10	167	25	333	28	139	23	230	20
May	34	8	3	*	32	8	256	5	206	54
Total	363	64	703	100	899	101	1,441	94	1138	97
CPUE	1.2	0.2	3.3	0.5	3.2	0.4	5.7	0.4	4.4	0.4
Monsoon										
June										
July					No landings					
August										
Postmonsoon										
September	3	*	-	-	32	384	3	5		
October	43	359	28	62	15	931	118	127		
November	11	103	208	193	29	66	100	228		
December	53	296	129	233	26	226	48	194		
January	123	268	105	92	324	103	122	39		
Total	233	1,026	470	580	426	1,710	391	593		
CPUE	0.7	2.8	1.7	2.1	1.5	6.0	1.1	1.7		

Sq : Squid, cf : Cuttlefish,
* catch less than 1 tonne

The postmonsoon was the best period for cephalopod landings on the west coast (Fig. 1). An average of 63% of the annual catch was taken in this period within the range of 54-71% annually. The period of least abundance was the monsoon season when the landings formed an average of 8% of the total within a range of 3-18% annually.

The most important gear by which the cephalopods were landed was trawl, accounting for over 77% of the total catch. During the period 1973-77, trawls contributed 31-80% of the annual cephalopod catch, the rest having been shared by shore seine, boat seine, hooks and line and *dol* net (Silas *et al.*, 1986). In all the States the fishing effort by trawl and the cephalopod landings during the monsoon season were uniformly low when compared to other seasons, except in Gujarat, where the highest seasonal cephalopod catch in 1985 was obtained in the monsoon season (Fig. 2). This was due to the minimum fishing activity during the monsoon. Another reason that could be attributed was the ban on trawling during certain period in the monsoon season in some areas. Such a ban was not in force for other types of gear which continued to operate during the monsoon season especially in Kerala, though in lesser number than in other seasons. Kerala's higher catches during monsoon seasons when compared to other States was due to this; moreover there was no ban on trawling till 1989.

The fishery trend on the west coast in relation to the three seasons was more or less reflected by the fishery characteristic observed at different centres. At all the centres except Cochin the postmonsoon season was the best period for cephalopods and in Cochin it was the premonsoon season.

While the fishing activity was at its minimum during the monsoon seasons at other centres, it was active at Vizhinjam with many fishing units from nearby fishing villages shifting to this place for safe launching. Since trawling was not practised here, other types of gear such as boat seine and hooks and line were operated in good nunbers. However, the cephalopod catch was minimum indicating that they were not available in the fishing grounds during the monsoon season. During the postmonsoon seasons they were obtained in good quantities. This shows that they migrate to the fishing grounds during postmonsoon period making them available for exploitation.

Loligo duvauceli was the single species that almost constituted the squid fishery of India. This species was landed all along the coast. Studies indicated that mature squid were present throughout the year and the size groups that supported the fishery were more or less the same during all the seasons (Silas *et al.*, 1986). At Vizhinjam the fishery in most of the seasons was supported by adult squid above 110 mm. Only in the premonsoon and postmonsoon seasons of 1987 the juveniles contributed to the bulk of the fishery, whereas in the monsoon season of the same year, juvenile and mature squid were in almost equal proportions. At Cochin, the fishery in all seasons was supported by squid in the size range of 60-150 mm with maturing and mature gonads. For Mangalore and Bombay centres there was no information on this aspect. At Veraval a large number of length groups within 40-250 mm were represented during all the premon-

soon and postmonsoon seasons; no squid was obtained during the monsoon period (Table 12).

Apart from *Loligo duvauceli*, *Doryteuthis sibogae* contributed to the squid fishing at Vizhinjam to a small extent. This squid was caught only during the premonsoon and postmonsoon seasons.

The cuttlefish fishery was mainly constituted by two species *Sepia pharaonis* and *Sepia aculeata*. At Vizhinjam, *Sepia pharaonis* formed the fishery mostly during the postmonsoon seasons; only in one year there was catch during the monsoon season. Since the anchor-hooks were found to be highly selective, only medium and large sized cuttlefish were caught, without affecting the juvenile populations. At Cochin, the cuttlefish fishery was mostly constituted by *Sepia pharaonis* and *Sepia aculeata* and supported by less important species such as *Sepia elliptica* and *Sepiella inermis*. At Mangalore, *Sepia aculeata* was the dominant species followed by *Sepia pharaonis*. At Bombay the highest cuttlefish catches came in postmonsoon seasons of all the years with the high average catch rate of 264 kg (Table 9). *Sepia aculeata* was the dominant species with modal sizes of 105 mm and 185 mm; *Sepia pharaonis* was less abundant, but had larger size, with the modal lengths of 245 mm and 295 mm. At Veraval, none of these cuttlefish was available and the fishery was constituted by a single species *Sepia elliptica*, which was much smaller and less commercially important.

The rainfall data available were restricted to Vizhinjam and Veraval. At Vizhinjam, the monsoon rainfall seemed to have no direct relation with the cephalopod fishery. During the months and seasons of very high rainfall, there were either no cephalopod catches or the catches were small (Fig. 6). At Veraval, an increase in cephalopod catch was observed after good monsoon. The observations of Nair *et al.* (1987) suggested that the postmonsoon period was biologically more productive with high zooplankton population. However, it is yet to be studied how this aspect is related to cephalopod abundance.

The sea surface temperature was comparatively lower in the postmonsoon period. Temperature has been attributed as one of the factors for the distribution and migration of each species of cephalopod, which in turn is helpful for their commercial exploitation (Young, 1972; Okutani and Murata, 1983). Although the temperature preferences of cuttlefish and squid occurring in the Indian waters are not understood, high catches of cephalopods during the postmonsoon period indicate their probable preference of lower temperature in those periods.

Since trawling is not done in Vizhinjam area at present, there is no controversy over trawling in monsoon season. There is also no conflict at this centre between the non-mechanised and mechanised sectors (mechanisation is limited to propulsion of craft). In general there is good and congenial atmosphere, in spite of some recent conflicts between the Vizhinjam fishermen and those from elsewhere over their alleged encroachment. **The present study showed that there is no adverse effect on the cephalopod stock due to fishing in monsoon season.** On the other hand, the catch can be increased by operating artisanal gear during this season as being done at Vizhinjam at present.

As cephalopods appear to be opportunistic animals capable of rapidly expanding their population size to occupy niches left unoccupied by the depletion of other resources (Caddy, 1983) and as the present level of exploitation as by-catch is considered to be very nominal, the depletion of their stock through increased fishing activity does not seem to be a possibility.

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References

Caddy, J. F. 1983. The cephalopods : factors relevant to their population dynamics and to the assessment and management of world cephalopod resources. *FAO Fish. Tech. Pap.*, 321 : 416-452.

Nair, R. Vijayalakshmi, K. Govindan, S. H. Gajbhiye and N. M. Lodh 1987. Biological observations off Sutrapada, Veraval (Gujarat). *Advances in Aquatic Biology and Fisheries, Prof. N. Balakrishnan Nair Felicitation Volume.* pp. 225-238.

OKUTANI, T. AND M. MURATA 1983. A review of the biology of oceanic squid *Onychoteuthis borealijaponica*. *Mem. Natl. Mus. Victoria*, 44 : 189-195.

SILAS, E. G., K. SATYANARAYANA RAO, R. SARVESAN, K. PRABHAKARAN NAIR, KUBER VIDYASAGAR, M. M. MEIYAPPAN, Y. APPANNA SASTRY AND B. NARAYANA RAO 1986 a. Some aspects of the biology of squids. *In* : E. G. Silas (Ed.) *Cephalopod Bionomics, Fisheries and Resources of the Exclusive Economic Zone of India*. *Bull. Cent. Mar. Fish. Res. Inst.*, 37 : 38-48.

——, K. PRABHAKARAN NAIR, R. SARVESAN, K. SATYANARAYANA RAO, M. M. MEIYAPPAN, KUBER VIDYASAGAR, P. V. SREENIVASAN, D. SIVALINGAM, K. BALAN AND B. NARAYANA RAO 1986 b. Cephalopod production in India and constituent maritime States. *Ibid.*, pp. 80-87.

YOUNG, R. E. 1972. The systematics and areal distribution of pelagic cephalopods from the sea off Southern California. *Smithsonian Contri. Zool.*, 97 : 1-159.

Bull. Cent. Mar. Fish. Res. Inst., 1992, 45 : 242 - 250

SOCIO-ECONOMIC ASPECTS OF THE MONSOON FISHERIES OF THE WEST COAST OF INDIA

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Abstract

Along the west coast, fishing operation during monsoon period (June - August) as a family occupation, is only at a subsistence level except for trawlers and gillnetters at a few centres. The number of mechanised units under operation during monsoon is reduced to about 10% of the total units and non-mechanised including motorised crafts to 25%. The household income during monsoon is very low and consequently fishermen become permanent debters. During monsoon the level of employment is reduced to about 20%. Consumer has to pay very high price for fish and the producer (fisherman) does not get his due share in consumer's rupee. Socio-economic studies conducted in a number of villages along the west coast indicate that in the present coastal rural set-up it is rather difficult to impose a complete ban on the monsoon fishery. It would further aggravate the poor economic situation in fishing villages. To overcome the problems faced by fishermen, especially of artisanal sector, it is suggested to (1) constitute a public agency to purchase fish at a minimum price whenever there is glut at the landing centre and distribute throughout the year and at interior places, (2) provide adequate finance at reasonable terms and conditions through co-operatives and (3) extend all facilities for developing prawn farming as well as integrated fish-crop-livestock farming.

Introduction

Of the average annual marine fish production of 1.6 million tonnes in India about 70% is landed along the west coast. However, the fishery of the west coast is characterised by distinct seasonality. Southwest monsoon period (June - August) is a lean season for fishing and allied activities, throughout the west coast. Postmonsoon season (September - January) is generally more productive and more than 60% of the total catch along the west coast is landed during this period. Due to the seasonal nature of the fishery, major portion of the annual income of a fisherman household is earned within a period of 3 to 5 months. This situation not only affects the living condition of fisherfolk, but also the fishery developmental schemes. The poverty of the artisanal fishermen is mainly attributed to this seasonality. Since there is not much fishing activity during monsoon and in the absence of any alternate employment opportunity, the artisanal fishermen have to depend on money lenders or fish traders to tide over this lean season which ultimately keeps them under perpetual indebtedness and consequently under poverty. Hence, it is essential to investigate the problems of mosoon fishery especially its social and economic implications. In this report an attempt has been made to analyse these problems on the basis of the socio-economic studies conducted by the Central Marine Fisheries Research Institute (CMFRI) at a number of villages along the west coast.

Data Base

The data available in the reports of the socio-economic studies conducted by the CMFRI at selected fishing villages along the west coast since 1985, have been used for the preparation of this paper. Information has also been collected from the State fishery departments, certain fishery organisations and in some cases, through direct observation at the landing centres.

Observations and Discussion

Socio-economic aspects

Gujarat and Maharashtra

Majority of the fishermen population is illiterate in Maharashtra. Among the literates most of them have only primary education. Literacy position is better in the villages located near the towns. Literacy is more among males than females. In Gujarat, coastal villages, literacy is slightly higher than in Maharashtra.

Both in Maharashtra and Gujarat the family size in fishermen villages is about 7. The difference in family size is significant between the villages in Maharashtra and non-significant in Gujarat. It is because some of the tribal villages in Maharashtra Coast are very backward and others are advanced.

About 55% of fishermen population is found to be working in Maharashtra. About 44% of the population has fishing and allied activities as main occupation. Earning population in Gujarat fishermen villages is 52%. About 47% of the fishermen has fishery as main occupation.

Fishing is traditionally conducted by *Mahadev* Kolis (Scheduled Tribe) and *Kolis* (Backward community) in the most of the fishing villages of Maharashtra and by *Machhi* and *Kharwas* (Backward communities) in Gujarat. Women participation in fishery is more in Maharashtra as compared to Gujarat. In many fishermen villages cooperatives are working successfully. The Cooperative societies are providing fishing tackle, loan and diesel and also helping fishermen in marketing the catch.

Goa

There are 61 fishing villages and 54 landing centres in Goa. There are about 8000 fishermen households in the State with a population of about 48,000. The average size of the fishermen family is 6.

About 26% of the fishermen population is literate. 22% of the population is engaged in actual fishing.

About 700 trawlers, 120 purse seiners and 400 gillnetters are under operation in the State.

Karnataka

Along Karnataka Coast there are 147 fishing villages, 77 in South Kanara and 70 in North Kanara Districts. There are about 20,000 fishermen households in the State with a population of about 1.35 lakhs.

The average size of the fishermen family is 7.2. About one-fourth of the population is literate.

22% of the fishermen in the State is engaged in actual fishing activities.

Fishing activities along Karnataka Coast is now dominated by mechanised fishing units which include fishing craft fitted with inboard and outboard engines. More than 80% of the catch is accounted for by mechanised fishing. Recently the number of small trawlers and gillnetters has been very much increased. The traditional Rampani gear has almost disappeared due to the large scale introduction of purse seiners. In the indigenous sector a remarkable development is the large scale introduction of outboard motors which resulted in the emergence of comparatively efficient gears such as *Mattubala* and ring seine.

Along Karnataka Coast a fisherman who works in a purse seine unit for wages, on an average gets Rs. 65 per day of operation, in trawlers Rs. 50 and in gillnetters Rs. 45. The worker of *Mattubala* and ring seine operation earns about Rs. 55 per day of operation.

Kerala

Total fishermen population in Kerala is about 8 lakhs. The average size of the family is 6. Literates constitute 30% of the fishermen population. About 20% of the total fishermen is engaged in fishing in the sea. For 80% of them, fishing is a full time occupation.

There are about 4500 mechanised fishing craft fitted with more than 30 HP engines. About 50% of them is owned by fishermen families. Trawlers constitute 75% of these crafts. Others are gillnetters with the exception of about 20 purse seiners.

Besides these mechanised units about 30,000 non-mechanised craft are under operation in this State. The recent major development in the artisanal sector of marine fishery of the State is the large scale motorisation of country craft using outboard engines. At present more than 50% of the country craft are fitted with outboard engines mostly 12 HP motors. Maximum catches of the motorised craft are found during monsoon (June-August) and postmonsoon (September-December) seasons. Net operating income of a fisherman family owning motorised craft with boat seine, per day of operation works out at Rs. 350/- which includes imputed family labour also; in respect of gillnet, it is Rs. 90 and Hook and line, Rs. 250/-. A fisherman who is engaged in fishing in other's

boats for wages, gets an average amount of Rs. 75 in catamaran - hook and line unit, Rs. 50 in canoe - hook and line unit, Rs. 35 in boat seine and Rs. 40 in gillnet units. A worker in small trawler gets about Rs. 60 and purse seine about Rs. 80 per day of operation.

Fishing activities and employment pattern during monsoon

Gujarat : Gujarat has the longest coastline of about 1260 Km covering mainly 9 coastal districts. It has the widest continental shelf area covering about 1.6 lakhs sq. km. There are about 180 fishing villages with a marine fishermen population of about 1.65 lakhs. About 3,000 mechanised and 4,000 non-mechanised craft are in operation in the State. Trawlnet, gillnet, bagnet and longlines are the important gears used for fishing.

Plank-built boats (*Hodi*) numbering 250-300 are operated for catching the penaeid prawn *Metapenaeus kutchensis*. Besides the bagnet, dragnet locally known as *Gheti* which is dragged by two fishermen is also used for capturing prawns in Surajbari area. In certain years the production of prawns used to touch 2000 tonnes. An involvement of 2000-3000 fishermen was noted in monsoon fishing in Little *Rann* of Kutch in an area of about 1200 sq. km. In July the prawn catch decreases, but a good fishing for *Hilsa* spp. is observed for about a fortnight. When the intensity of monsoon decreases, it becomes an ideal estuarine environment for juveniles of prawns to migrate into the area.

In Jamnagar District, the plank-built boat (*Hodi*) and dugout canoe (*Eklakadi*) are operated during monsoon. Small mesh size gillnets (*Jali*) are employed to entangle mainly *Mugil cephalus* and *Sillago sihama*. About 20% of fishermen are engaged in monsoon fishing. Landings of 60-80 t of fish per year is recorded. The fishing is confined to creeks, marshy lands and nearshore areas. The fish is in good demand locally and also transported to Ahmedabad, Baroda and Surat for marketing.

Bhavanagar District has two centres : Machuva and Katput where fishermen collect gobiids from the exposed mudbeds in low tide period. No craft or gear is used as the practice is only hand picking. Sometimes traps (*Phans*) are used as contrivance for the capture of big sized gobiids. About 150 persons including men, women and children are engaged during monsoon and 8-10 t of fish is landed every year. It is considered as only a subsistence fishery.

In Kheda (or Kaira) District the main centres are Cambay (Khambhat) and Dahewan where plank-built boats are operated during monsoon season. The stake net (*Gholwa*) is operated at the opening of Mahisagar River and gillnet (*Jal*) at the upper reaches of the river. Nearly 50-60 fishermen go for fishing and catch is limited to 8-10 t. The monsoon fishery is mainly of subsistence nature.

In Bharuch (or Broach) District, at the centres, Kavi and Sarod on the bank of Mahisagar River and Bhadhbut and Mansot on the bank of Narmada, 200-300 fishermen conduct fishing during monsoon. Stake nets and gillnets are operated and the craft used is plank-built boat. The catch is estimated at 30-50 t. The fishing is only at subsistence level and almost similar to that of Kheda District. At Kavi and Sarod centres, bagnets (*Gholwa*) are also used.

In Surat District moderate fishing activities are observed during monsoon. Mainly gillnets and stake nets (*Gholwa*) are operated. *Gholwa* fishing is mainly a subsistence type, but gillnet fishing for *Hilsa illisha* (Chakshi) is on commercial basis fetching good returns to fishermen. A production of about 80 t of fish is estimated during monsoon and 700-800 fishermen are engaged in fishing. In Valsad District mechanised plank-built boats (*Machwa*) and non-mechanised dugout canoes (*Hodi*) operate stake nets (*Gholwa or Kadhia*). About 2000 fishermen are involved in monsoon fishing and the catch is estimated at about 80 t. The fishing is carried out in creek regions only. Some of the fishermen fish with their mechanised plank-built boats upto Hansot village in the mouth of major river Narmada and carry out *Hilsa ilisha* fishing during monsoon period. The fishing is carried out by gillnet and is highly rewarding for fishermen.

There is no report of monsoon fishing in Junagadh and Amreli Districts. Generally boats are not operated during rough weather. Fishing is poor and confined to creek areas. Nowhere commercial fishing has been noticed in these districts.

Maharashtra

Maharashtra with coastline of about 720 km, ranks second among the maritime States of India in

respect of marine fish landings. The State has 5 coastal districts and 2.32 lakhs marine fishermen. There are about 4,560 mechanised boats mainly operating bagnet, trawlnet, gillnet, long-line and purse seine. Non-mechanised boats numbering about 7,900 include both plank-built and dugout canoes (tonys).

In Thane District, generally, non-mechanised boats operate stake nets, called "Bokshi" and gillnets called "Jali" for fishing in creeks and nearshore waters. About 1,000 fishermen in this district go for fishing in monsoon and 40 - 50 t of catch having 15 - 20% of *ghol* (*Pseudoscianea diacanthus*) is available during the period of three months.

In Greater Bombay District, about 2,000 fishermen are engaged in fishing during monsoon and the catch availability is 150 - 200 t. The operation of the stake net and the gillnet is restricted to the creek regions. The trawlers (80 - 100 in number) operate in open sea, but return daily to the landing centres. Trawlers have good income at some of the centres though a great risk is involved in operation in rough waters.

In Raigad District 180-200 fishermen are fishing during monsoon and the estimated output of 15-20 t of fish is observed. Dugout canoes, tony and plank-built boat (*Machwa* or *Hodi*), all non-mechanised, are operating stake nets (Bokshi) and gill nets in the creek. It is mainly a subsistence level of fishery.

In Ratnagiri District the stake nets (Bokshi) operate in creek region, whereas, gill nets (Jali) operate in nearshore waters. The monsoon fishing is in existence at Bankot, Kelshi, Veldur, Navanagar, Dhopave, Anjanvel, Jambhari, Raigad, Sakhar-Jaigad, Golap-pawas and Ratnagiri centres either at subsistence or at commercial level. Tony and out-riggered plank-built boats (*Machwa*) are used for fishing. Total number of fishermen is about 500 and about 30 t of fish is landed during monsoon. The fishing is carried-out in creek and inshore region only.

In Sindhudurg District, monsoon fishing is generally observed in creek regions. Catfish, mullets, non-penaeid prawns and clupeoids form the catch. Out-riggered plank-built boats, both motorised (IBM and OBM) and non-motorised operate stake net and gillnet (*Nahichi Jaal*) and the catch is about 25 t of fish and equal quantity of prawns in monsoon season.

Goa

Goa has a coastline of about 110 km and shelf area of about 10,000 sq. km. There are 46 landing centres scattered all over the coast and equal number of fishing villages. The marine fishermen population of Goa is about 20,000. The number of mechanised boats exceeds 300 whereas non-mechanised boats are about 6 times of mechanised boats. Trawlnet, gillnets, purse seines, hook & line and shore seine are important gears used for fishing in the State.

At some of the centres like Panaji, Cartalni, Ribander, Aldona, Vascodagama, Mopusa and Bethem there is trawl fishing during monsoon. There are about 150 trawlers in Goa and some of them operate during monsoon. Other nets operated in creek and nearshore waters include gillnet operated with out-riggered OBM boats and Rampani. Some stake nets (*Gholwa*) also operated with non-motorised boats.

In the northwest coast of India during fair season, generally, contracted labourers form crew on mechanised boats and each labourer is paid Rs. 400-700 per month excluding food and other personal expenses on-board. The contract labourers go back to their native place during monsoon season. Only local persons including owners of the boats are engaged in monsoon fishing and share the catch and operating expenditure since a few boats are under operation. Sometimes, even 50% of the required strength of crew is forced to operate a unit since the fishing is very occasional during monsoon. In non-monsoon season 6-9 persons on trawlers, mechanised gillnetters and dolnetters and 3 - 5 persons on OBM units and non-mechanised units form the crew. Generally, on mechanised units during postmonsoon, a fishing trip consists of 3-6 days duration whereas it is only one day during monsoon season for all types of units. In northwest coast, 50-60% of total fishermen form working population, of which 10-20% has non-fishery occupation. Those men and women who are engaged in fishing and allied activities, are found fully engaged during non-monsoon season. Of working population 30-40% are active fishermen. Fishery allied activities include fish trading, processing/curing, transportation, loading/unloading, net

splicing/repairing, boat building/repairing, etc. Fisherwomen have important role in fish trading and curing in northwest coast. During monsoon hardly 10% of the working population is able to get employment in fishing and fishery related work. Repair and maintenance of craft, gear and engine and net making are the major fishery related activities prevailing in monsoon. Some fisherwomen are engaged in making mats and baskets, especially in tribal fishing villages. Finding it difficult to get even non-fishery work for subsistence during monsoon, fishermen take loan either from the fish traders or from the money lenders.

Based on the socio-economic survey in northwest, it was found that the number of fishing days in a year ranged from 200 to 244 for different types of units. During monsoon the number of fishing days ranged from 20 to 40 for different types of units at different centres. The number of fishing days was more for the category of gear owners as compared to mechanised and non-mechanised units. Of the annual catch, 12% is landed during monsoon at the centres where there is monsoon fishing obtaining 15% of annual gross revenue. Of the annual recurring expenditure, 15% is incurred during monsoon period. For mechanised units the net annual income was found to be about Rs. 12,000 and the contribution of monsoon was about 5%. Of net annual income for non-mechanised units (Rs. 4000 - 5000) 7% was obtained during monsoon. For other groups, the monsoon accounted for about 4% of annual net fishing income.

At a few centres in northwest coast the trawl nets operate during monsoon season usually with one trip a day. Trawl fishery is not regular in this season. About 600 kg of catch was obtained per trip for a trawler during monsoon. On an average an amount of Rs. 2,200 is incurred as recurring expenditure per trip. The gross returns averaged at Rs. 4,700/- per trip resulting in a net operational income of Rs. 2,500. Hardly 10% of trawlers operate during monsoon. Having 25-30 trips during monsoon (June-August), a trawl unit on an average earns Rs. 70,000 over operational expenses. Against this an earning of about Rs. 2.5 lakhs was calculated in fair season. The major repairs/maintenance and fixed cost were not taken into account for the calculation of the operational income.

The gillnet fishing is observed all along the northwest coast (including Goa) during monsoon with mechanised boats, non-machanised boats and country craft fitted with OBE. For mechanised gillnetters 25-35 fishing days were observed during monsoon whereas total duration of fishing was observed for about 220 days a year. About 11% of the annual catch and 12% of the gross fishery income was obtained during monsoon. For non-mechanised units the number of fishing days ranged from 35-40 during monsoon and the annual fishing days ranged from 200 to 235. About 13% of total catch and 16% of annual income accrued during monsoon. Of annual net operational income (Rs. 80,000) of a mechanised gillnetter about 11% is earned during monsoon. For non-mechanised boats the net fishery income of a unit during monsoon is about Rs. 500/-. For a country craft fitted with OBE the gross annual income is calculated at about Rs. 30,000 and the net operational income is about Rs. 8,000.

Dolnet operation is limited to a few centres during monsoon. It is smaller in size as compared to that used in fair season and is operated in creeks and inshore waters.

From June to August the *Bokshi* operation is limited for a period of about 20 days. About 8% of annual catch was landed during monsoon fetching a revenue of Rs. 3000 and for non-mechanised units Rs. 1800/-. An amount of about Rs. 800/- is earned over operational cost during monsoon in a *Bokshi* unit.

Besides the three main gears mentioned above, other gears under operation during monsoon season include hook & line, traps, *Rampani* and dragnet (*Pagadia*) operated at a subsistence level of fishing in the creek areas. This type of fishery is carried out for about 40 days during monsoon to obtain an income of about Rs. 1500/- for a unit over a period of three months. Since there is no need of craft for this type of fishing, the net revenue is found to be about 50% of the gross revenue. Fishing by hand picking does not incur any expenditure other than labour. In non-monsoon period the average income of these fishermen is the range of Rs. 3000-4000/- per family in different regions.

Karnataka

Karnataka has a coastline of 270 km and a shelf area of 25,000 sq. km. The State's contribution to national marine fish production is about 10%.

Fishing is almost confined to near-shore areas and the major contribution to the State's total landings is from oilsardine and mackerel. The fishermen population is estimated to be about 1.25 lakhs inhabiting in about 150 fishing villages. About 2000 mechanised country crafts are under operation along this coast. Till recently fishing operation was mainly carried out by traditional fishing units, the types of craft commonly used were rampani boats, dug out canoes and out-rigger boats and the gears used were rampani, small shore seines, gillnets, drift nets and hook & line. By mid seventies mechanised craft and gears started dominating the marine fishery sector, with the result, rampani, the major traditional gear which used to contribute more than 60% of the total catch has almost disappeared from the Karnataka Coast.

About 70% of the annual catch and 65% of the annual income of both mechanised and non-mechanised units along Karnataka Coast are accounted during postmonsoon season (September - January). During monsoon period (June - August) there is no mechanised fishing along Karnataka Coast. For non-mechanised units including the OBM units about one fourth of the annual income is earned during monsoon season and the lean period is premonsoon (February - May). The contribution of monsoon catch of non-mechanised units to total annual catch is only around 20%, whereas the contribution of income is at about 30% because of the higher prices fetched for different species during this period.

For *Mattubala* operating with OBM, about 60% of the annual revenue is earned during postmonsoon and the remaining during monsoon period. When *Mattubala* was introduced around 1985-86, its operation was confined to monsoon season when there was no mechanised fishing. However, later *Mattubala* fishing has been extended to postmonsoon also since it is found to be much more profitable. There is no operation of *Mattubala* during premonsoon. The average gross revenue per trip during postmonsoon during 1987-88 was about Rs. 4,000 as against Rs. 1,300 during monsoon period. Cost per kg of fish is much higher during monsoon as the catch per unit of effort (CPUE) is very low. Even cost per trip was higher during monsoon.

The contribution of premonsoon to the annual income is highly fluctuating. As in the case of monsoon and postmonsoon there is not any definite trend in the catch as well as in the income during this period.

For purse seines, about 80% of the annual income is earned during postmonsoon. The average revenue per day of operation is also much higher (Usually more than double) than that of premonsoon period. The only gear which shows a better performance during premonsoon as compared to other seasons is trawlnet. During 1987-88 about 55% of the annual income of trawler was earned during premonsoon. The revenue per trip during this period also was about 50% higher than postmonsoon period. Gillnet (mechanised and motorised) operation is mostly confined to post-monsoon season. However gillnet operation by OBM has been recently started during monsoon season.

Along Karnataka Coast, during monsoon there is no mechanised trawl or purse seine fishing at all. Since more than 15,000 fishermen are engaged in mechanised fishing and most of them are only wage earners, it is a difficult task to provide all of them employment during monsoon either in fishery sector or in any other sector that too during a period when overall employment opportunities are comparatively less. The recently introduced *Mattubala* is essentially for monsoon operation and it is estimated that about 50% of the usual workers in mechanised fishing get employment in *Mattubala, Kairampani* and gillnets.

In traditional sector, because of the recent introduction of motorisation of country crafts, employment potential has been much improved. About 10,000 artisanal fishing units are under operation along the Karnataka Coast. Since most of these units are not fully engaged throughout the year, only about 20,000 fishermen are estimated to be employed in this sector at a time. In the absence of mechanised fishing during monsoon only less than 50% of the artisanal fishermen are employed that too at sub-subsistence level.

Kerala

Kerala Coastline is about 600 km. The State occupies the foremost position in marine fish production in India, accounting for almost a quarter of total marine fish landings of the country. Marine fishing using traditional gears like boat seines, shore seines, stake nets and Chinese dipnets is an

age old occupation of the coastal fishermen. Mechanisation was started in the late fifties by Indo-Norwegian Project first at Quilon. A major technological development namely the shift from cotton to synthetic nylon nets took place during early sixties. Trawl fishery was introduced on an industrial footing by mid-sixties. Commercial purse seining started by late seventies confined only to Cochin area without further expansion. Motorisation of country craft began in early eighties and its development at present is too fast. Kerala's fishermen population is about 7 lakhs and there are 304 fishing villages along the coastal area.

Kerala contributed more than 50% of the country's export earnings from marine products mainly consisting of prawns, especially penaeid group which is a major component of prawn landings in Kerala. More than 50% of this earning is contributed by monsoon catch because of the heavy landings at Sakthikulangara during this period.

The trawlers earn maximum income during monsoon season. The revenue per trip during monsoon is much higher than that in other season. It is mainly because of the *Karikkadi* fishery during monsoon at Sakthikulangara areas and a few other centres.

Only about 45 purse seines are operating at Cochin Fisheries Harbour. About 80% of the annual revenue of purse seiners is earned during postmonsoon period.

For drift gillnets also maximum earning is accounted for postmonsoon period. Catch rate and average revenue per trip is also highest during postmonsoon period.

The socio-economic studies conducted in the selected villages along the west coast revealed that the majority of the fisermen families, mainly those who depend on the traditional way of fishing for their livelihood finds it difficult to tide over the monsoon period which is cahracterised by slack fishing activities. However along Kerala Coast there are some centres where fishing activity specially artisanal fishing is brisk. Poonthura fishing village in the Trivandrum region is one such centre where fishing is carried out throughout the year whereas at many other centres in this region fishing remains suspended during monsoon months as the artisanal fishermen find it difficult to launch their catamarans through the breakers. Catamaran is the major fishing unit under operation in this area. Catamarans operate mainly either hook and line or gillnet. During the period 1985-86, the average catch per day of operation worked out at 11 kg during premonsoon (February-May) and 81 kg during monsoon (June-August). The average gross revenue per day of operation worked out at Rs. 98 during premonsoon, Rs. 298 during monsoon and Rs. 92 during postmonsoon. Out of the annual income of Rs. 38,000 for a catamaran unit about 50% was earned during the 3 months of monsoon. However the corresponding catch was about 60%. Value realised per kg of fish was less during monsoon than other seasons. It was Rs. 8 per kg during premonsoon, Rs. 4 during monsoon and Rs. 5 during postmonsoon. It is actually a sort of exploitation of the situation by middlemen or traders. Along the west coast, especially Kerala Coast, monsoon is a lean season and generally fish prices are ruling high. However fishermen at certain centres where monsoon fishery is active, cannot take the advantage of overall scarcity of landings, because of the abundance in monsoon catch at these centres which helps the traders to pull down the price. But at interior markets prices will be higher than those during other seasons and traders can take full advantage out of it. The lower level of average value realised per kg of fish during monsoon may also be due to the occurrence of cheaper variety of fishes more in the catch. Catamaran operating gillnets also showed the same trend. About 50% of its annual revenue is obtained during the monsoon period. For motorised canoe postmonsoon is the peak season and about 55% of the annual income is earned during this period. The average value realised per kg of fish is minimum (Rs. 5.53) during postmonsoon and maximum during premonsoon (Rs. 6.63). Average catch per unit per day of operation does not show much variation between postmonsoon (85 kg) and monsoon periods (74 kg).

About 1.5 lakh fishermen are engaged in actual fishing along Kerala Coast and about 1 lakh people are engaged in all other fishery allied activities. About 20,000 fishermen are engaged in mechanised fishing, of that 70% are in trawlers. The only fishing unit which earns about 50% of its annual income during monsoon period is the trawler. Hence, as compared to Karnataka Coast employment situation of those engaged in mecha-

nised fishing in Kerala is not much affected during the monsoon season. But due to rough weather non-mechanised fishing is restricted only to few centres. For traditional fishermen it is almost a fishing holiday and most of them take loans to tide over this season. Due to the reduction in fish landings during monsoon the freezing plants, ice factories and other processing units cannot work to the full capacity and the workers in these units have to face full or partial reduction in employment as well as wages.

Monsoon fishing and its socio-economic implication

Except commercial trawl and gillnet fishing at few centres, near about subsistence level of fishing is noticed in northwest coast during monsoon. Economic evaluation of fishing operations shows that monsoon fishing provides a surplus revenue over operational expenditure for different types of craft and gears. It accounts for about 20% of total annual revenue for different types of units. At a few centres trawl fishing is somewhat profitable along northwest coast, but hardly 10% of the units are operating during monsoon. Since boats are not insured against the risk involved in fishing during rough sea, only new and good conditioned units operate during monsoon. In most of the mechanised units contracted labourers are engaged during fair season (September-May) and during the monsoon period the family members and people from different units join to operate. Generally, catch and operating expenses are shared by the crew members.

There is no significant conflict specially in monsoon fishing between mechanised, OBM units and non-mechanised units throughout the northwest coast. Since there is no intensive fishing by a particular type of unit or a gear no conflict is arising over the issue of encroachment of area of operation between different groups of fishermen.

The socio-economic factors do not warrant the imposition of blanket ban on monsoon fishing unless it has got adverse biological effects on the stock. The fishermen in general have to depend on fish traders and money lenders for loan during monsoon due to the insufficient income. Those, who can manage fishing during rough weather, even though at subsistence level will be in a position to employ themselves during monsoon.

Along southwest coast, generally, postmonsoon is the peak season for all types of fishery activities and monsoon is a lean period. In Karnataka there is no mechanised fishing during monsoon period. Along Kerala and Tamil Nadu Coasts during monsoon there is intensive fishing both by trawlers and non-mechanised units including motorised crafts at certain centres. Premonsoon is almost a lean season throughout this region except for trawlers. Trawler is the only type of fishing unit which earns about 50% of its annual income only during the monsoon period. For all other types of units as a whole, less than 20% of the annual income is earned during monsoon period.

The socio-economic studies conducted in the selected villages of this region indicated that the seasonality of the fishery considerably affects the living condition of the fishermen in many ways which can be summarised as follows :

1. The major portion of the fishing income is received during few months mostly during postmonsoon period. Since the fishermen are not in the habit of saving and in most of the cases income is not sufficient to cover day to day expenses and for repayment of loan, they are forced to take further loans during lean season.

2. They produce a commodity which is highly perishable and due to the absence of storage facilities, marketing, co-operative societies or even proper regulated markets, they dispose off their catch at the terms of local traders.

3. They are employed only during few months in a year because of the seasonality of the fishery. There is no alternate employment opportunity in the coastal areas. Most of the fishermen especially those who are engaged in active fishing, are not skilled in attending any other work. Generally they do not want to leave their villages. Even if some of them move out, it is only for fishing. Hence due to seasonality of marine fishing, a number of mandays is wasted in the fishing villages which could be planned to divert for some productive purposes.

4. Since fishing is concentrated to a limited period it is difficult to set up permanent regulated markets at the primary (landing centre) level itself and also the marketing infrastructure.

5. The capacity of processing units, ice factories, curing yards and other infrastructure

facilities cannot be fully utilised, so it is difficult to establish such facilities at most of the landing centres.

No doubt, monsoon is a nightmare for fishermen of west cost and it creates tension and uncertainty among them. It is highly essential to focus attention on the practical problems encountered by the fishermen due to the onslaught of southwest monsoon and to evolve ways and means to overcome them.

Suggestions

1. Throughout the west coast the major problem for fishermen during the monsoon is loss of fishing days due bad weather. There is no alternate employment opportunity during this period. Hence it is essential to find out alternate employment potential. For the coastal area the most suitable scheme is the devlopment of brackishwater aquaculture. Other intergrated projects can also be formulated with proper institutional arrangement for the sustained supply of required inputs.

2. Since the quantity of fish produced during monsoon is very low it reduces the average household income of the fisherfolk and consumers do not get sufficient quantity of fish at reasonable price. It provides opportunity to middlemen to exploit the situation to their own benefit. The major step, to be taken to overcome this, is the proper distribution of the fish produced during peak season. This can be done only by establishing adequate storage and processing facilities at all major landing centres. Usually there will be glut in the market during peak season atleast for some species every year. In such cases the fishermen dispose off the fish at throw-away price. This can be avoided by establishing a public agency to purchase the fish at minimum support price and the fish can be disposed off during monsoon after the required processing. Such an agency must arrange adequate distribuion system so that the fish can be transported and marketed at interior places. This will help the producer to get a remunerative price and the consumer, the fish at a reasonable price.

3. During monsoon the fishermen face difficulties not only in actual fishing operation, but also in landing the catch. Most of the rural landing centres do not have proper jetty facilities. At many centres fishing can be done even in monsoon if properly designed jetties are constructed.

4. Along the west coast, extensive waterlogged areas suitable for prawn farming are available. With adequate technical and financial support from the public agencies, these areas can be fully utilised for prawn fish farming so that more employment potential can be created for the marine fishermen who are unemployed or underemployed during the lean season for capture fishery.

5. The major problem along coastal rural area is the absence of economic activities other than fishing even during the peak season. A number of household ancillary industries such as net making and repairing, making of baskets, coir products, processing, curing and preparation of value added products have very good scope for providing employment to marine fishermen throughout the year.

6. Another major problem during monsoon is the credit requirement of fishermen families. Most of these families depend on money lenders, fish traders or boat owners for loans to tide over the monsoon soason. Since it happens every year they cannot escape from the clutches of these middlemen who in effect keep them in poverty. The only way to save them from this situation is to formulate credit facilities through institutional financing with appropriate terms and conditions. In the present socio-economic frame work of our coastal rural sector the most suitable organisation for this purpose is the co-operative society of fishermen. Though it is considered as a failure in some States including Kerala and Tamil Nadu, its success has already been proved in Gujarat, Maharashtra and Karnataka to a certain extent. Even in these States, the co-operative movement among fishermen has not come up to the level of expectation, because the involvement of ordinary fishermen is only partial. Hence steps should be taken for full involvement of all fishermen to make the co-operative movement a success.

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IMPACT OF FISHING ALONG THE WEST COAST OF INDIA DURING SOUTHWEST MONSOON PERIOD ON THE FINFISH AND SHELLFISH RESOURCES AND THE ASSOCIATED MANAGEMENT CONSIDERATIONS

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ABSTRACT

Based on the informations presented in the preceding sections on oceanography, productivity of the eastern Arabian Sea and the fisheries and biological characteristics of the resources along the west coast of India during different seasons particularly in the monsoon and the informations collected by CMFRI over the period of 45 years; the impact of fishing during monsoon months on (i) the fishery resources, (ii) interaction between the artisanal and the mechanised fishing sectors exploiting the resources, (iii) complexities of multispecies - multigear fisheries in the inshore waters and (iv) their possible resource management options are analysed critically, discussed and recommendations suggested/ formulated.

It is clearly found that the management of fisheries cannot be considered only a matter concerning administration or biology or resource assessment, but as an integrated approach taking into account sociological, economical and developmental objectives and priorities as well.

The papers presented in the preceding sections have dealt with the oceanographic and productivity features of the continental shelf waters of the eastern Arabian Sea and the fisheries and biological characteristics of the important species/ groups exploited during different seasons along the west coast with particular reference to the monsoon season. In this section the impact of fishing during monsoon months on the resources, interaction between the artisanal and the mechanised fishing sectors exploiting the resources, complexities of multispecies - multigear fisheries in the inshore waters and their possible resource management options are discussed.

The west coast of India with a coastline of about 3400 km and covering an area of 0.86 million square kilometres of the Exclusive Economic Zone, contributes to 1.29 million tonnes of marine fish production out of the total estimated all India marine fish production of 1.78 million t (1985-89). In consideration of the general topographical features, physical nature of the sea, nature of the sea bottom, distribution pattern of the species, their abundance and fishery characteristics, the coast can be broadly divided into two : the northwest coast comprising of the maritime States of Gujarat and Maharashtra and the southwest coast covering Goa, Karnataka, Kerala and west coast of Tamil Nadu. The continental shelf of the northwest coast particularly off Gujarat slopes gradually and very much wider than the Maharashtra Coast. In the southwest coast the shelf is relatively narrow. Nevertheless, some of the most productive fishing grounds supporting the rich fisheries of Indian mackerel, oilsardine and penaeid prawns are located here.

Evolution of the marine fisheries of the west coast of India

The evolution of marine fisheries of the west coast of India is well documented (Chopra, 1951; Jones, 1958; Rao, 1973; Alagaraja *et al.*, 1982; Alagaraja, 1987; Silas *et al.*, 1976, 1986; Jacob *et al.*, 1987; Kurup *et al.*, 1987; Srinath *et al.*, 1987; Balan *et al.*, 1987) and during this process four periods are distinguished. Prior to Independence and immediately after that upto about 1950, the fishing was carried out at subsistence level with the indigenous craft employing gears such as cast nets, small seines and traps operated rather close to the shore. The production was low and was mainly used for daily subsistence. No real fish markets existed.

In the second period from about 1950 to 1970, along with the traditional fishery, small mechanised vessels with bottom trawl nets were introduced. The establishment of an export market for

shrimps and its accelerated expansion gave a fillip to progressive addition of mechanised vessels and popularisation of bottom trawling, although, initially, the traditional fishermen were hesitant to accept the mechanised fishing. Another noteworthy development during the period was the introduction of synthetic gear material replacing the cotton fibre. As these new gears and new boats were fishing almost in the same area, the fisheries resources became one of common property exploited both by traditional and mechanised sectors. The marine fish production during this period increased from 292,071 t in 1950 to 811,940 t in 1970.

The third period from about 1970 to 1980 witnessed rapid expansion of the fishery in the inshore waters. Besides, purse seines for the exploitation of pelagic fishes were introduced on the southwest coast. The introduction of this gear resulted not only in the abandonment of the large beach seines the *Rampan* nets along the Karnataka Coast, but also increasing competition between the traditional and purse seine operators for the exploitation of pelagic resources, the main stay of fisheries of this region. The pattern of fishing also changed from single day fishing to stay over fishing for more than a day, the cod end mesh size of the trawl nets was reduced to catch relatively smaller sized prawns, fishing during monsoon with gears such as gill nets and small purse seines in addition to trawlers came into practice. This increasing fishing effort resulted in the catch fluctuating at a level about the maximum catch. And at certain centres where large number of trawlers and fishing activity are concentrated, the prawn fishery showed a declining trend indicating the sign of overexploitation of the stocks. As more fishing units are employed in the fishery and with improved processing and marketing facilities, the average annual production increased from 584,420 t during 1960-69 to 924,850 t during 1970-79 decade.

The major development in the marine fisheries sector during the period 1980-90 has been the rapid increase of motorisation of country craft which was first started in Gujarat, but soon became popular and extended to the southern States of Kerala and Karnataka. Employing these crafts, a new gear simulating a smaller version of the purse seine with local modification and called variously as *Mattabala* in Karnataka, the ring seine in Kerala and disco net in some other places was introduced into the capture fisheries to catch fishes in the columnar and surface waters. These units were employed initially during the monsoon season when trawl nets and purse seines were not operated in large scale. Becoming popular, their number increased rapidly as exemplified in Kerala where the ring seines increased from a mere 748 in 1986 to 2400 in 1989. These developments and the continued fishing effort although helped to increase the production from 855,000 t in 1980 to 1,700,000 t in 1987, the traditional fishery was affected.

Reasons for conflicts between traditional and mechanised fishing sectors

As elsewhere in the world, the exploitation of the marine fishery resources in India, is carried out on a common property basis there being no restrictions or limitation on the entry of fishing units. In the earlier phase, the mechanised fishery soon after its introduction and the traditional fishery co-existed for some time exploiting the resources from almost the same ground without much problem. With the discovery of lucrative fishing grounds for prawns, growing export trade and attracted by the higher profitability on investment, more and more numbers were added year after year taking advantages of institutional credit and liberal subsidies extended to the sector. This rapid expansion gradually lead to a struggle for the control of the inshore fishing grounds by the different sectors. Srivastava *et al.* (1986) made an excellent study on the impact of mechanisation on small fishermen and the salient features of their observations are :

1. the pattern of mechanisation and its pace were different in different States;
2. the ownership of mechanised craft between the actual fishermen and non-fishermen was also varying from State to State (for example in Gujarat the share of non-fishermen owning mechanised craft was 15.21% while in Karnataka, it was 46.51% (1980). Here a large number of mechanised boats were on partnership basis).
3. the introduction of purse seine in Karnataka has resulted in the disappearance of the *Rampan* nets and in the total shift in the catch composition, employment pattern and income;

4. in general, the fish production accelerated due to mechanisation, the growth rate of production increased from 1.50% during premechanisation (1956-69) to 2.32% during post-mechanisation period;

5. mechanisation has helped to enhance the demersal fish production, but in the case of pelagics there has not been appreciable increase and in certain cases, the production has decelerated or shown negative growth rate;

6. the mechanisation has contributed to reduction in seasonal variation in total landings in Gujarat or reduced fluctuations in the catch as in Karnataka;

7. as the purse seines are operated mainly for pelagics and since several of the traditional gears such as boat-seines, gillnets and shore-seines are also employed to catch these resources, it is observed that purse seines are competing, but the trawlers are complimentary with occasional conflicts whenever they operate in shallow waters causing damages to nets and boats of traditional fishermen;

8. in the socio-economic front, while the mechanisation of craft has not resulted in higher education or literacy rate, mechanised boat owners, as could be expected, possess assets of higher value than the non-mechanised groups and live in extended household with larger family size. Similarly, the crew in mechanised craft earned much higher income than those in the non-mechanised sector and greater disparity in income and ownership is observed as per capita per household is higher.

Besides the above, the impact of mechanisation is also observed on the indebtedenss of traditional fishermen more on boat onwers to tide over the difficult days, price realisation of the catch and disappearance of certain village industries like that producing cotton yarns for the nets.

Therefore, the major factors for bringing about the conflicts between the two groups are (1) for the control of fishing grounds and (2) widening social and economic disparity. These were futher made use of by certain vested interests for their advantage. Thus the introduction of modern technologies of fishing was not inappropriate *per se*, but has unwittingly lead to social conflicts and economic disruption of traditional fishing community.

The studies carried out by the Central Marine Fisheries Research Institute have shown that the fishing effort by small mechanised vessels has increased appreciably over the years contributing to 262,954, 113,809, 32,400, 286,496 and 205,586 tonnes in Kerala, Karnataka, Goa, Maharashtra and Gujarat respectively in 1984 as against the contribution from the nonmechanised sectors respectively at 129,939, 13,187, 4100, 19,789 and 45,004 tonnes. Further the results of stock assessment studies at the Institute on the major exploited resources have shown that the present production has reached near MSY levels or in some cases, crossed the MSY level in the present fishing grounds. This, together with the problem of availability of opportunities for equitable and sustainable harvest for the different groups can also bring about conflicts among them.

Monsoon fisheries

While the conflicts due to the above factors have been occurring occasionally and resolved amicably at the local level, the fishing during monsoon, in recent years, has assumed great controversy requiring its resolution at the State level. It is feared that sooner or later it may even assume a nation level problem. This controversy stems principally from the encroachment of the territorial waters demarcated for traditional fishermen, by the mechanised fishing vessel operators to catch prawns and fishes that occur in the area. Due to the rough sea conditions during monsoon period the fishing activities of traditional fishermen are restricted to close to the shore. Further, with less efficient craft and gear they could harvest the resources that are fishable by these units. Consequently their income from fishing occupation gets reduced considerable and thus they get caught in a poor economic trap. At the same time, the mechanised fishing operators are able to harvest the resource with the efficient trawl net and increase their wealth. Further, in the context of fluctuating trend of fish production, the traditional fishermen believe that continuous sweeping of fishing grounds by the trawl nets disturbs the bottom habitat of fishes. They also believe that trawling during monsoon results in the destruction of spawning

populations of commercially important resources, thus adversely affecting the subsequent recruitment. This undue resource sharing, sociological and economical manifestations have brought about the conflict between the artisanal and mechanised sectors.

While the resource papers in Chapter 4 have dealt with the characteristics of the fisheries and resources during different seasons, certain important features of the monsoon fishing along the west coast are discussed here.

The monsoon fishery is carried out at present at a significant level in Kerala, at a moderate level in Karnataka and to a lesser extent in Goa, Maharashtra and Gujarat. In Gujarat there is no trawling during monsoon; the principal gear used in this season is the gillnet and the catch is mainly composed of elasmobranchs, wolf herring, shad, croakers, penaeid prawns, seerfish and others. The average production from the monsoon fishery is 5300 t as against 223,000 t during other seasons during 1984-1988. Over the years, the share of monsoon fish landings in the total landings of the State has been varying from 5 to 8.5%. As the exploitation during monsoon period in this State is not significant, there does not seem to be any cause for concern on the possible ill effects of fishing during monsoon on the resources.

The monsoon fishery of Maharashtra contributes to about 5-10% of the annual marine fish production of the State and over the years, the share of monsoon landings in the total landings has been showing an increasing trend. The principal gears employed in the monsoon fishery are trawlnets, Gill net and dol net. The trawling effort during the period is very poor, forming about 12% of the total annual trawling effort. The important species contributing to the fishery are penaeid prawns, Bombay-duck, non-penaeid prawns and croakers. As in Gujarat, no detrimental effect on the resources due to fishing during monsoon has been observed.

In Goa, of about 53,000 t landed annually (1984-88) the monsoon period contributes about 3000 t. Although there is not much of information on the biology of the resources exploited off this coast, adverse effect of monsoon fishing is not reported.

In Karnataka fishing by mechanised vessels and purse seiners is suspended from June to August. The principal gear used in the monsoon fishery are *Mattabala*, shore seines and gillnets. The *Mattabala* in the fishery started from mid-eighties and are operated using the motorised craft. The number of these units has been progressively increasing since 1986. Penaeid prawns constitute the principal species group caught by this net. The marine fish production in the monsoon period in the State accounts for about 2.7% of annual fish catch. The relatively low catches during the monsoon period and the available biological information on major constituent species indicate that the present monsoon fishing does not affect the stocks adversely.

The monsoon fishery of Kerala has been the subject matter of considerable discussion in view of the serious conflicts occurring between the traditional and mechanised sector for the past few years. The different Committees/Commissions appointed by the Government of Kerala to examine and report the marine fisheries problems including fishing during monsoon have analysed the characteristics of the resources exploited during the monsoon season and have endeavoured to discuss its impact on the resources. As mentioned earlier, monsoon fishing is carried out more vigorously in this State than in other States of the west coast. The share of fish production produced during the monsoon season amounts to 30% of the total annual fish production in this State. The monsoon fishery is mainly contributed by the landings of trawl nets, drift gill nets and ring seines. The major component in the State's catch during monsoon is penaeid prawns, which form about 50% of the annual penaeid prawn catch. Among finfishes, perches (mainly threadfin-bream), sciaenids, lizardfish, ribbonfish and in some years, catfish and whitebait are the important components in the catch during the third quarter.

At Sakthikulangara, the trawlers land maximum catch in the third quarter which forms over 50% of the year's catch by this gear. The dominant groups contributing to the fishery are penaeid prawns (mainly *P. stylifera*), perches, lizardfishes and flatfishes. At Cochin also the peak landings forming 50% of the total annual catch by trawlers are obtained in third quarter; the dominant groups during this period are perches, lizardfish and penaeid prawns.

This unique nature of heavy landings during monsoon period along the Kerala Coast, though there is no proportional or significant increase in the effort during this period, is mainly governed by the movement in large concentrations of certain resources into and beyond the fishing grounds. During premonsoon and postmonsoon periods, the commercially important demersal finfishes and shrimps are distributed in the area upto 50 m depth zone. Certain fishes such as threadfin-breams, however, are more abundant in depth beyond 50 m particularly in the 100-150 m depth zone. During the monsoon period, due to the influence of upwelling, some portions of populations of certain demersal finfishes and shrimps (*Metapenaeus dobsoni*) move to nearshore waters, while some others (*Parapenaeopsis stylifera* among shrimps) move to relatively deeper waters of 35-60 m depth range. Similarly, the threadfin breams move into relatively shallower areas of 35-40 m depth range during monsoon. The monsoon fishery of Kerala thus appears to depend upon the above mentioned movements of certain populations. Although there has been substantial overall increase in recent years in the landings of exploited finfish resources and a declining trend in the landings of *P. stylifera* during the monsoon periods, the year to year fluctuations in production appear to be dependent on the intensity of upwelling and consequent movement of the constituent populations into and beyond the fishing grounds.

One of the most important biological characteristics which determines the success of a fishery in a particular year is spawning and corollary recruitment. It is therefore highly relevant to have an adequate understanding of this phenomenon to appreciate the dynamics of the exploited populations and their management. It is well known that the environment plays a significant role in triggering the maturation and spawning. In tropical marine finfishes and shellfishes, spawning is generally protracted and fractional spawning is common. It appears to be true in respect of the commercial finfishes and prawns of the west coast of India on the basis of available information (Table 1). While most of the species spawn during monsoon months they also spawn during other periods of the year with varied intensities. Though the occurrence of one of the peak periods of spawning during monsoon months appears to be a matter of concern, the fact that the spawning is continuous over longer periods and that fractional spawning occurs, suggest that the apprehensions that exploitation during monsoon period adversely affects spawning and consequent recruitment do not appear to be well-founded. In fact, this positive feature of continuous spawning coupled with faster growth rate appears to be a built-in mechanism against over exploitation in tropical marine fishes like those of India.

The progressive decline in the mean length of exploited species is one of the indications of overexploitation. In the context of management of exploited resources controls on indiscriminate exploitation of juveniles assume significance because, if proper controls/regulatory measures are not undertaken, the fishery is likely to face the problem of growth overfishing. In the present context of monsoon fishery along the west coast, the data on various resources show that juveniles are caught not only during monsoon period, but also in other periods. Therefore, the exploitation of juveniles is not restricted to monsoon period only.

As stated above, the protracted spawning and recruitment in different pulses help in the protection of the stock from being overexploited. However, the studies on stock assessment in most cases reveal that the lengths at first capture of most of the exploited stocks are smaller and most cases smaller than lengths at first maturity. This is particularly the result of reduction in the cod end mesh size of trawl nets. The maximum sustainable yield in several species corresponds to larger values of lengths at first capture. Therefore, to ensure MSY of the exploited stocks, juvenile exploitation should be restricted. Further, it is known that the nearshore waters serve as nursery grounds for majority of fish and prawn species and it is essential to regulate fishing particularly with least selective dynamic gears such as trawls and ring seines in these areas.

Management considerations

The management of fisheries in India is governed by the rules and regulations formulated under the Indian Fisheries Act 1897 and later under the Marine Fishing Resolution Bill demarcating the fishing zones in 1978. The Government of India in 1977 enacted the Exclusive Economic Zone Act extending her rights to explore, exploit and utilize the living and non-living resources available in

TABLE 1. *Spawning seasons of marine finfish and shellfish along the west coast*

Species	Locality/Area	Spawing season
Rastrelliger kanagurta	West coast	June-Aug.; Oct.-Dec., Mar.-July; Oct.
Sardinella longiceps	West coast	June-Nov.
	"	June-Sep.
	Karwar	June-Dec.
	Mangalore	May-Oct.
	Calicut	May-Oct.
	Vizhinjam	May-Aug.
S. fimbrita	Karwar	Jan.-Apr.
Thrissocles mystax	Calicut	Feb.-May; Sep.-Jan.
Nematalosa nasus	Mangalore	Oct.-Nov.
Opisthopterus tardoore	Karwar	Feb.-Aug.
Auxis thazard	Vizhinjam	Apr.-Sep.
	Cochin	Oct.-Dec.
Euthynnus affinis	Vizhinjam	Apr.-Sep.
	Cochin	Oct.-Mar.
Katsuwonus pelamis	Minicoy	Feb.-July
Sarda orientalis	Vizhinjam	Apr.-Sep.
Nemipterus japonicus	Cochin	June-Jan.
	Mangalore	Nov.-Apr.
	Bombay	Jan.-Dec.
	Veraval	Feb.-May; Sep.-Jan.
N. mesoprion	Cochin	June-Jan.
	Bombay	Throughout the year peak : June-Aug.
	Veraval	Feb.-May; Sep.-Jan.
Cynoglossus semifaciatus	Calicut	Feb.-May; Oct.-Jan.
Psettodes erumei	Bombay	Sep.-Oct.
Leiognathus bindus	Calicut	Feb.-Apr.
Sillago sihama	Karwar	Aug.-Feb.
Saurida tumbil	Karwar	Oct.-Jan.
Harpadon nehereus	Bombay	Apr.-July; Nov.-Dec.
Caranx kalla	Calicut	May-June; Dec.-Jan.
Tachysurus thalassinus	Cochin	Sep.-Jan.
T. dussumieri	Cochin	Dec.-Feb.
	Calicut	"
	Mangalore	"
T. tenuispinis	Cochin	Sep.-May.
	Calicut	"
	Mangalore	"
	Veraval	Feb.-May.
T. serratus	Cochin	Sep.-Dec.
	Calicut	"
	Mangalore	"
T. caelatus	Veraval	Jan.-Apr.
Protonibea diacanthus	Bombay	June-Sep.
Otolithus argenteus	Mangalore	Oct.-Jan.
O. cuvieri	Cochin	Feb.-May; Sep.-Jan.
	Veraval	Feb.-May; Sep.-Jan.
	Bombay	May-July; Nov.-Dec.
Johnius glaucus	Veraval	Feb.-May; Sep.-Jan.
J. vogleri	Bombay	June-July; Nov.-Dec.
	Veraval	June-Aug.; Sep.-Jan.
J. sina	Cochin	Jan.-Dec.
J. macrorhynus	Bombay	June-July; Nov.-Dec.
K. axillaris	Cochin	Feb.-May; Sep.-Jan.
Pseudosciaena coibor	Calicut	May-Aug.
Polynemus heptadactylus	Bombay	Mar.-June; Aug.-Nov.
Penaeus indcus	SW coast	Throughout the year; peaks : Oct.-Nov.; May- June
Metapenaeus dobsoni	SW coast	Throughout the year; peaks : Oct.-Dec.; Apr.-May
M. affinis	NW coast	Throughout the year; peaks : Sep.-Jan.; Feb.-May
M. monoceros	SW coast	Throughout the year; peaks : July-Aug.; Nov.-Dec.
	NW coast	Throughout the year; peaks : Feb.-Aug.
Parapenaeopsis stylifera	SW coast	Throughout the year; peaks : Nov.-Dec.; Mar.-Apr.
	NW coast	Throughout the year; peaks : Feb.-May.
P. hardwickii	NW coast	Throughout the year; peaks : June-Aug.
Solenocera crassicornis	NW coast	Throughout the year; peaks : Sep.-Jan.

200 n. m zone from the shore. As the development of the marine fisheries in the territorial waters extending upto 12 n. m from the shore is a State subject, the different maritime States formulated their own rules and regulations for the management of the resources.

The regulatory measures formulated under the above Acts and Regulations, by and large, cover prohibition of destruction of resources by explosives and poisonous means and by destructive gears. The other regulatory measures include regulation of fishing in the nursery areas where juveniles are concentrated; indiscriminate fishing or catching of breeders in their migratory phase and leasing/licensing system of fishing rights, particularly in the inland waters. In the marine region, the regulatory measure that has been adopted as an administrative approach to the management of fisheries is the demarcation of fishing zones aimed at mainly safeguarding the interests of small-scale and medium-scale fisheries. The other management solutions discussed and advocated are : (1) regulation of fishing effort for exploiting the resources, particularly the shrimp resource which is a single critical resource and center of most of the controversies and conflicts in the country; (2) restriction of number of fishing gears which exploit the juvenile phase in the backwaters, estuaries and shallow inshore waters through licensing, (3) mesh size regulation, (4) minimum legal length for capture and (5) closed seasons and areas. Among these, although the licencing of fishing gears engaged in the juvenile fishery is in force through regulation as in Kerala, its implementation has not been successful mainly due to socio-economic constraints, particularly lack of alternative employment opportunities for fishermen. Similarly, mesh size regulation could not be enforced due to multispecies, multigear nature of the fisheries and again, the socio-economic reasons.

The crucial problem of conflicts in the monsoon fisheries of Kerala was discussed by several committees and commissions appointed for the purpose. After considerable deliberations and detailed analyses of the pattern of the fisheries, information available on the resources and other related social and economical implications, it was decided to ban trawling in the territorial waters of the State during June-August and this has been implemented since 1988 with relaxation in certain areas and varied total duration. One of the Commissions (Kalawar Commission) appointed to examine this issue recommended regulation of effort to 1145 trawling boats during this period with the trawl cod end mesh size not less than 35 mm. However, the arguments for banning of trawling and extending into total banning of fishing during this period and against this regulatory measure are being continued.

The main objective of regulatory management of fishery resources is to ensure maximum sustainable yield or maximum sustainable economic yield. However, while considering the regulatory management tools, it is essential to consider the socio-economic conditions and employment opportunities of fishermen belonging to different economic and ethnic groups so that these measures could be implemented ensuring maximum benefit and safeguarding their interest eventhough the total objective of that regulatory measure or the fishery output may suffer. In such a situation, the classical management tools such as limiting the effort, regulation of entry by gear type and closed seasons or areas may not be totally acceptable unless alternative opportunities for their livelihood and basic needs are ensured or created. The failure of the total implementation of the present regulatory measure of banning of trawling to the satisfaction of different sectors appears to center around this crucial point, although the data available on the resource exploitation and cognate argument of adverse effects of trawling on spawning population and juvenile exploitation do not advocate total banning of trawling in the fishing grounds. Nevertheless in consideration of the conservation of the resource and unrestricted exploitation of juveniles, it has become imperative to stress viable management measures. In this context, confining trawling to beyond territorial waters during monsoon and restriction of additions of ring seines with increased mesh sizes as recommended is strongly supported.

As the success of implementation of regulatory measures largely depends on the involvement of the fishermen, it is necessary to take this aspect into consideration. It is observed that the self regulation formulated by fihsermen themselves as in the case of management of purse seine operation in Karnataka, sharing of day and night fishing between the artisanal and mechanised sectors in Tamil Nadu have been successful in the conflict

management. Such a conflict management system with the total involvement of fishermen, adminstrators, politicians and others should work effectivley as against the exclusively administrative approach as being followed now. It is therefore clear that the management of fisheries cannot be considered only a matter concerning administration or biology or resource assessment, but as an integrated approach taking into account the sociological, economical and development objectives and priorities as well.

Suggestions and Recommendations

1. The monsoon fisheries of the west coast of India is dealt with in the background of its environment, resources exploited, interactions between different fisheries and fishing interests.

2. In the light of the data now available on the exploited resources and their characteristics, **it is observed that monsoon fishing, by and large, does not adversely affect any of the resources.** However, further information base is necessary for a comprehensive conclusion on this and therefore, continuous monitoring of the resources and directed research on the gaps in our knowledge on the distribution pattern, movements, effects of exploitation on the dominant groups such as *P. stylifera* and threadfin-breams supporting the monsoon fisheries are necessary.

3. At present the controversy is confined to bottom trawling during monsoon within the territorial waters. The rapid increase of ring seines and similar gears witnessed during the recent years would sooner or later assume the status of another controversy as the ill effects of exploitation by these gears during monsoon have greater deleterious effect on the resources than trawling. **It is therefore recommended that urgent steps should be taken to regulate the number of ring seines and their further entry into the fisheries.** As this gear catches appreciable quantities of young fish, **it is suggested to increase the mesh size to not less than 35 mm.**

4. In consideration of the urgent necessity of conservation of the resources and since there is no effective regulatory measure under operation to safeguard the resources in the sea and in the context of improvement of the habitat, **it is recommended that bottom trawling during monsoon is allowed strictly only beyond territorial waters all along the west coast.** As comprehensive and stringent regulation of monsoon fishery is not possible due to a number of socio-economic and political reasons, total ban of all fishing during monsoon may not be advocated.

5. The success of regulatory measures depend upon their effective implementation. To achieve this, the involvement of the fishermen, along with the political will is the prime requisite particularly in the background of socio-economic milieu prevailing in the country. Considering this vital aspect, **it is suggested that voluntary self regulation by the fishermen and other interested groups as successfully practised at present in the regulation of purse seine operation in Karnataka and mechanised fishing vessel operation in certain areas of Tamil Nadu may be adopted.**

References

Alagaraja, K. 1987. A brief appraisal of marine fisheries in India. *Proc. Nat. Symp on Research and Development in marine fisheries, Bull. Cent. Mar. Fish. Res. Inst.*, **44** (1) : 36-41 (1989).

——, K. Narayana Kurup, M. Srinath and G. Balakrishnan 1982. Analysis of marine fish landings in India - A new approach. *CMFRI Spl. Publ.*, **10** : 1-42.

Balan, K., P. Sivaraman, K. P. George and M. Ramachandran 1987. An appraisal of the marine fisheries of Gujarat. *Ibid.*, **38** : 1- 53.

Chopra, B. N. (Ed.) 1951. *Handbook of Indian Fisheries. Prepared for the third metting of the Indo-Pacific Fisheries Council, Madras, February 1951.* 129 pp.

JACOB, T., V. RAJENDRAN, P. K. MAHADEVAN PILLAI, JOSEPH ANDREWS AND U. K. SATYAVAN 1987. An appraisal of the Marine Fisheries of Kerala. *CMFRI Spl. Publ.*, 35 : 1-42.

JONES, S. (Ed.) 1958. *Fisheries of the west coast of India*. 125 pp.

KURUP, K. NARAYANA, G. KRISHNANKUTTY NAIR, V. P. ANNAM, ABHA KHANT, M. R. BEENA AND LATHA KHAMBADKAR 1987. An appraisal of the Marine Fisheries of Karnataka and Goa. *CMFRI Spl. Publ.*, 36 : 1-104.

RAO, K. VIRABHADRA 1973. Distribution pattern of the major exploited marine fishery resources of India. *Proc. Symp. Living Resources of the Seas around India, Special Publication, CMFRI*; pp. 18-101.

SILAS, E. G., S. K. DHARMARAJA AND K. RENGARAJAN 1976. Exploited Marine Fishery Resources of India - A synoptic survey with comments on potential resources. *Bull. Cent. Mar. Fish. Res. Inst.*, 27 : 1-25.

——, T. JACOB, K. ALAGARAJA AND K. BALAN 1986. Exploitation of marine fisheries resources and its contribution to Indian economy. *CMFRI Spl. Publ.*, 29 : 1-32.

SRINATH, M., VARGHESE JACOB, A. KANAKKAN, P. T. MANI AND J. B. KARBHARI 1987. An appraisal of the marine fisheries - Maharashtra. *Ibid.*, 37 : 1-46.

SRIVASTAVA, U. K., M. DHARMA REDDY, B. SUBRAMANYAN AND V. K. GUPTA 1986. Impact of mechanization on small fishermen. Centre of Management, in Agriculture. Indian Institute of Management, Ahmedabad. Concept Publishing Company, New Delhi, *Monograph Series* 114 : 499 pp.