STUDIES ON CERTAIN EXPLOITED MARINE FINFISH RESOURCES OF INDIA

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DECLARATION

I, V. Sriramachandra Murty hereby declare that the research papers incorporated in this thesis represent the bona fide research work carried out by me independantly and that they have not been previously submitted for any degree or diploma in this University or any other University in India or abroad.

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PREFACE

After completing the postgraduate education and securing M. Sc. degree in Zoology from the Vikram University, Ujjain, in March 1965, I joined the Central Marine Fisheries Research Institute (CMFRI), in September 1965. Since then, I have been carrying out research in marine fisheries of India excepting a short period of three years when I was engaged in research in freshwater fish. During 1970-'73, I was on leave to work for the Ph. D. degree at the Andhra University Postgraduate Centre, Guntur and I worked under the guidance of Professor S. Dutt. The Andhra University awarded the Ph.D. degree to me in 1974 for my thesis entitled "Studies on the Taxonomy of Fishes of the Family Cyprinidae and on some aspects of Biology of Barbus (Puntius) sarana (Hamilton-Buchanan, 1822) from lake Kolleru, Andhra Pradesh, India".

During the three-decade long career so far, I conducted researches in Taxonomy, Biology and Population dynamics of several finfish species with emphasis on demersal finfish, besides conducting researches on some shellfish resources also. Initially, the work was carried out at Mandapam Camp and later at Kakinada, both along the east coast of India. The results of researches conducted were published in different journals in India.

In 1976, a research project on biological characteristics of threadfin breams (Nemipterus spp) was initiated at the CMFRI and I took up the project as Principal Investigator;

this project was carried out from eight centres along the Indian coasts. In 1978, I took up the leadership of the project on silverbellies also which was implemented from four centres along the east coast of India. In addition to carrying out researches myself, I organised and coordinated the research programmes in these projects on a continual basis till 1989 when these were closed. Further, I was involved in the research projects relating to sciaenids and carangids during this period. Besides, I was associated with team research work. Such investigations included studies on stock assessment of threadfin breams and silverbellies on an all India basis and, the monsoon fisheries of threadfin breams along the west coast of India. As Principal Investigator and Team Leader of these projects, my contribution covered the collection and analysis of data, pooling and analysing the data collected from different centres by my colleagues, review of the work done, interpretation of data and the results and preparation of research papers for publication.

I was also involved in a short term programme of resources survey of Lakshadweep in 1987. This was an indicative Survey and covered ornamental fish resources, tuna live-bait resources and other finfish resources, among several other resources of the lagoons of Lakshadweep islands. In addition to my actual participation, the responsibility of collection of data by the first team, compilation of data collected by the colleagues in the second and third teams and their analysis and preparation of paper on ornamental fishes was given to me. Further, with the experience gained in working on the stock assessment of exploited resources and exposure to the various issues connected with marine fisheries management, I prepared papers on marine fisheries management also.

As a recognised guide of the Andhra University, I guided Ph.D. students. I was also appointed as an examiner for evaluation of Ph. D. thesis of Bombay University.

The submitted complex of thesis presents some of the papers published relating to the above mentioned groups of fish. The thesis is organised under four parts: Part I deals with papers on Taxonomy- new distributional records, nomenclatural issues and taxonomic revision. Part II deals with the results of studies on different aspects of biology, population parameters and stock assessment of different species of Nemipteridae, Leiognathidae, Sciaenidae and Carangidae. Part III embodies the results of studies in mixed fisheries assessments and the issues concerning such assessments. In Part IV, the papers pertaining to survey of ornamental fish resources of Lakshadweep and management of marine capture fisheries are included.

The research results of these papers formed original contribution in the field of marine fisheries and had considerably helped to enhance the knowledge on the taxonomy and dynamics of concerned populations which were essential prerequisites for formulation of measures for rational exploitation of the stocks and management of the resources. The results of the works refered to the limits of fish production through biological investigations and documented and drew attention to the implications of increased exploitation of the valuable fish groups contributing to the marine fish resources of India. Noting the constraints encountered in multispecies stock assessment in the tropical regions, they provided a perspective on the fishery assessment strategies in the current situation and addressed the issues in fisheries management. It is hoped that this humble contribution would kindle greater interest in comprehensive investigations on multispecies fish stock assessment for maintaining the fishery on a sustainable basis.

ACKNOWLEDGMENTS

During the past thirty years, I had the opportunity and privilege to work under the stalwarts of Fisheries Science in India: Dr. S. Jones, D. Sc., F.N.G.S., F.A.Sc., F.Z.S.I., F.M.B.A., Dr. S. Z. Qasim, Ph. D., D. Sc., F.A.Sc., F.M.B.A., F.N.A., Dr. E. G. Silas, Ph. D., D. Sc., F.M.B.A. and Dr. P. S. B. R. James, Ph. D., D. Sc., F.M.B.A., - the former Directors of CMFRI; they encouraged me and extended their whole-hearted support without which I could not have achieved what all I have, in my research profession. I am extremely gratefull to them. Dr. P. Vedavyasa Rao, Ph. D. F.M.B.A., who was the Director of CMFRI for about an year during 1994 -1995, not only suggested to me to submit the published papers for the award of D.Sc. degree but also continuously inspired and encouraged me to complete the same quickly; I owe a deep sense of gratitude to him. Dr. M. Devaraj, Ph. D., the present Director of CMFRI, permitted and encouraged me to submit this thesis; I am grateful to him for this kind gesture.

My colleagues at Mandapam Camp and at Kakinada, particularly Mr. P. Ramalingam, Technical Assistant at Kakinada, have helped me by extending their cooperation and assistance; I am thankful to all of them. Dr. N. R. Menon, Director, School of Marine Sciences and Dean, Faculty of Marine Sciences, Cochin University of Science and Technology, Cochin, Kindly extended his support on several occasions; I am thankful to him.

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10. Observations on some aspects of biology of silverbelly Leiognathus bindus (Valenciennes) from Kakinada. Indian J. Fish., 30(1): 61-68; 1983.

11. Studies on growth and population dynamics of the silverbelly Leiognathus bindus (Valenciennes) in the trawling grounds off Kakinada. Indian J. Fish., 33(3): 277-284; 1986.

12. Population characteristics of the silverbelly Leiognathus bindus (Valenciennes) along west Bengal coast. J. mar. biol. Ass. India, 28(1&2): 41-47; 1986 (1988).

13. Biology and population dynamics of the silverbelly, Secutor insidiator (Bloch) from Kakinada. J. mar. biol. Ass. India, 32(1&2): 10-24; 1990 (1991).

C. CROAKERS

14. Observations on some aspects of biology of the black croaker, Atrobucca nibe (Jordan and Thompson) from Kakinada. Indian J. Fish., 27(1&2): 66-75; 1980 (1981).

15. Observations on some aspects of biology of the croakers Johnius (Johnieops) dussumieri (Cuvier) and Johnius (Johnius) carutta Bloch from Kakinada. J. mar. biol. Ass. India, 21(1&2): 77-85; 1979 (1984).

16. Growth and yield per recruit of Johnius (Johnius) carutta Bloch in the trawling grounds off Kakinada. Indian J. Fish., 33 (2): 163-170; 1986.

17. Observations on some aspects of biology of *Johnius (Johnieops) vogleri* (Bleeker) and *Pennahia macrophthalmus* (Bleekr) in the Kakinada Region. *J. mar. biol. Ass. India*, 28 (1&2): 57-62; 1986 (1988).

D. CARANGIDS-SCAD

18. Observations on some aspects of biology and population dynamics of the scad *Decapterus russelli* (Ruppell) (Carangidae) in the trawling grounds off Kakinada. *J. mar. biol. Ass. India*, 33 (1&2): 396-408 ; 1991.

Part III Mixed Fisheries Assessment

19. Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada. *J. mar. biol. Ass. India*, 27 (1&2): 39-48; 1985 (1987).

20. Mixed fisheries assessment with reference to five important demersal fish species landed by shrimp trawlers at Kakinada. p 69-86; in: Venema, S.C. and N. P. van Zalinge (eds) *Contributions to Tropical Fish Stock Assessment in India*, Papers prepared by the participants at the FAO/DANIDA/ICAR National Follow-up Training Course on Fish Stock Assessment. FAO Rome, 157pp; 1989.

21. Stock assessment of threadfin breams (*Nemipterus* spp) of India. *Indian J. Fish.*, 39(1&2): 9-41; 1992 (1994).

22. Stock assessment of silverbellies of India with particular reference to Andhra Pradesh and Tamil Nadu. *Indian J. Fish.*, 39(1&2): 42-64; 1992 (1994)

Part IV Resources Survey and Management

23. Resources of ornamental fishes. *in*: Marine living resources of the union territory of Lakshadweep- an indicative survey with suggestions for development. *Bull. cent. mar. Fish. Res. Inst.*, 43: 46-64; 1989.

24. Present trends in marine fisheries management and catch forecasting. Paper presented at the International workshop on application of Satellite Remote Sensing for identifying and forecasting Potential Fishing Zones in Developing countries;Hyderabad, India, 7-11 December,1993. National Remote Sensing Agency, Department of Space, Hyderabad, India; Committee on Science and Technology in Developing countries of the International Council of Scientific Unions, Madras, India.

25. Complexities of Management of Inshore Fishery Resources of India. Fishing Chimes, 13(8): 5-9; 1993.

List of Research Papers Published by V. Sriramachandra Murty.

RESUMÉ OF RESEARCH WORK DONE

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INTRODUCTION

One of the most important objectives of research in capture fisheries is to understand the state of exploited stocks and to suggest possible options for rational exploitation, to ensure continued and sustained production of fish. To fulfill this, it is essential to understand the taxonomic identity of each species contributing to the fishery, its distribution in space and time, the various aspects of biology of the species that influence the fishery and enable making estimates of vital statistics and finally to estimate the parameters of growth, mortality and selection which are useful in stock assessment studies.

Organised research on marine fishery resources of India was started during late forties. During that period, the fishing used to be predominantly by artisanal craft and gear in the nearshore waters and the exploitation of each species was at a much-less-than-optimum level. During that period, the research efforts were mainly directed at describing the fisheries and in a few cases towards making preliminary studies on bionomics. The situation underwent tremendous change when mechanised fishing was introduced in sixties and then popularised. These and the location of lucrative fishing grounds in the inshore waters together with the development of an export trade of fish and fishery products, paved the way for excellent growth of the fishing industry and, consequently the total marine fish landings increased from around half-a-million tonnes in fifties to around 2.3 million tonnes in nineties. This development process not only brought to light several resources which were not exploited or, exploited only marginally prior to introduction of mechanised fishing, but also their vulnerability to increased fishing pressure, necessitating scientific management of the resources through a reliable information base particularly on fishing effort, catch, seasonal variations in availability and abundance in relation to changes in environment and on the biological characteristics of the exploited species.

There was considerable difficulty in identifying the species accurately, because, in a large number of families of marine fishes, several closely-resembling species existed. Besides, many species came to light after the publication of the "Fishes of India" by Day (1878). More recently, the delimitation of known species and introduction of nomenclatural changes have caused confusion and lead to use of incorrect scientific names or application of one name to more than one species. These have emphasised an urgent need for directed research in taxonomy of several exploited marine fish families.

In the case of many species, there was practically no information on aspects of biology such as food and feeding habits, spawning and fecundity, growth and migration which were essential prerequisites for understanding spawning habits and seasons, deleniating spawning grounds, estimating recruitment, understanding fluctuations in availability and abundance, studying dynamics of the populations. As the fishery was still in a developing stage untill about a decade-and-a-half back, the effect of exploitation was not felt in respect of many stocks. Consequently, due consideration was not given to the estimation of population parameters and to stock assessments. The need for developing expertise in this major area of research also, was therefore, not considered. It was only after the catches of major exploited stocks started declining, that the imperative need to reorient the efforts towards stock assessment and management was realised. Accordingly, through the steps taken by the CMFRI and the training programmes arranged and organised by the Food and Agricultural Organisation of the U.N. and the Danish International Development Agency jointly for the benefit of the fisheries Scientists in the tropical countries, that research work in fish stock assessment began receiving its due attention in India.

The author had the opportunity to carry out researches in taxonomy, biology and population dynamics of major exploited fish stocks such as threadfin breams, silverbellies, croakers, scad and others. The results of the studies, most of which happenned to be the first ones from the seas around India, contributed significantly to the enhancement of knowledge on the above aspects of the concerned fish species.

PART I TAXONOMY

1. On some interesting and new records of marine fishes from India.

This work reestablished the status of the two species of the family Drepanidae: *Drepane punctata* (Linnaeus, 1758) and *D. longimana* (Bloch and Schneider, 1801). Several authors treated them as synonymous, inspite of their distinctness established by Lele (1924). Utilising the material collected from Palk Bay and Gulf of Mannar and examining them for both morphological and anatomical characters, it was shown that the two species were indeed distinct and valid. A key to identify these two species was also given.

For the first time, the presence of barbels in 3-4 rows below the chin in smaller individuals of D. punctata and D. longimana was reported. It was also reported that these barbels disappear in larger fishes over 270mm in total length.

This paper also reported two species of fish, Stethojulis interrupta (Bleeker, 1851) and Platycephalus isacanthus (Cuvier, 1829) for the first time from Indian seas, along with detailed descriptions. Stethojulis interrupta (Bleeker) of the family Labridae was known from western and eastern parts of Indian Ocean; the single specimen collected from the Gulf of Mannar was the first report from the central Indian Ocean in general and from the Indian coastal waters in particular. Platycephalus isacanthus (Cuvier) (Family Platycephalidae) was known only from western Pacific and eastern Indian Ocean. The report from the Gulf of Mannar and Palk Bay was the first from India and Central Indian Ocean.

2. On the fishes of the family Platycephalidae of the seas around India.

A taxonomic revision of the family Platycephalidae was made. This was the first comprehensive taxonomic work on the family from India after Day (1878). Studying the fresh material collected from along the Indian coast, the collections available in the Zoological Survey of India, Calcutta and consulting the data on certain type specimens, a taxonomic revision of the family was attempted. In view of the confusion in assigning the species to their respective genera, some earlier authors (eg. de Beaufort and Briggs, 1962) preferred to include all the species under the single genus Platycephalus. This issue was examined in this work and the thirteen species were included under six genera tentatively. Detailed descriptions were given for the first time utilising the characters of ridges and spines on the head and keys for the identification of genera and species were given.

Of the thirteen species dealt with (against the seven species dealt with by Day, 1878), Wakiyus serratus (Cuvier, 1829) which was first described from Sri Lanka, was not reported from any where else in the world though a mention of its name, that too erroneously, was made from a few localities. The description in this paper, on the basis of material from Lakshadweep sea, was the first from the region, in addition to the first adequate description of the species after its original description in 1829.

Platycephalus carbunculus (Cuvier, 1829) was first described on the basis of a few specimens from off Bombay and subsequently there was no description of this species from any where else in the country. The material collected from the east coast of India, in the study, was the first report on its extended distribution from the east coast of India.

3. Nemipterus luteus (Schneider, 1801) (Nemipteridae,Pisces) the valid name for a threadfin bream from the Indo-Pacific region.

After a critical review of the literature, studying the data of type specimens of relevant nominal species and examining specimens collected from Kakinada, along the east coast of India, it was shown that Nemipterus luteus (Schneider,

1801) was the valid name for the species which was referred earlier as N. striatus (Valenciennes, 1830), N. filamentosus (Valenciennes, 1830), N. nematophorus (Bleeker, 1853 a) and N. macronemus (Gunther, 1859). A detailed description of the species was given for the first time from India.

4. Nemipterus mesoprion (Bleeker, 1853) (Nemipteridae,Pisces) a new record from the seas around India.

On the basis of collections made at Kakinada along the east coast of India, Nemipterus mesoprion (Bleeker, 1853 b) was first reported from the seas around India and adequate description was given. For the purpose of accurate identification of the species, the data of the holotype of the species in the Leiden Museum was consulted and the original and subsequent descriptions by Bleeker (1853 b, 1873, 1877) were also studied and details presented in the paper.

To distinguish this species from N. japonicus (Bloch), particularly in preserved condition, because colour is the most important character in threadfin breams, a comparison of N. mesoprion and N. japonicus was made and the differences explained to enable accurate identification of the two species.

PART II BIOLOGY AND POPULATION DYNAMICS

A. THREADFIN BREAMS

The threadfin breams (*Nemipterus* spp) which are exploited by trawlers are one of the major demersal finfish resources of India. In 1993, an estimated 86752 tonnes of threadfin breams were landed (Anon., 1994) which formed about 8.0% of total demersal fish landings and 4.0% of total marine fish landings of India. These fishes are known to be more abundant in relatively deeper waters of 100-200 m (Silas, 1969; Silas *et al.*, 1976; Zupanovic and Mohiuddeen, 1973; Philip and Joseph, 1988; John, 1989; Sudarsan *et al.*, 1990; Sivaprakasam *et al.*, 1991) and are known to move into relatively shallower inshore waters during certain periods (Banse, 1959; Nair and Jayaprakash, 1986) particularly along the west coast. Among the maritime states, Kerala accounted for maximum catch which formed about 52% of total threadfin bream catch, followed by Maharashtra (14%), Tamil Nadu (11%), Karnataka (9%), Gujarat (8%) and others. A total of six species contribute to the fishery of which *Nemipterus japonicus* and *N. mesoprion* are most abundant, constituting the bulk of threadfin bream landings. The other species: *N. tolu*, *N. delagoae*, *N. luteus* and *N. metopias* occur in the catches occasionally in small quantities.

5. Observations on some aspects of biology of threadfin bream *Nemipterus mesoprion* (Bleeker) from Kakinada.

After reporting the occurrence of *Nemipterus mesoprion* in the Indian seas and publishing a detailed description of the species from Kakinada (Murty, 1981), investigations on the biology of this species were carried out from Kakinada during January 1976-March 1980. This was the first original research work on the biology of *N. mesoprion* from the Indian Ocean region; the lone earlier report was from east Malaysia (Weber and Jothy, 1977), on the basis of survey data obtained during March 29-May 1, 1972. The length-weight relationship was calculated as Log W= -4.650901 + 2.877071 Log L. Examining 295 females of the length range 83-177 mm, the length at first maturity (50% maturity) was determined as 100 mm. By studying the ova diameter frequency distribution in mature and ripe ovaries, it was shown that *N. mesoprion* was a fractional spawner releasing the ova in two batches during the protracted spawning season. On the basis of occurrence of females in different stages of maturation during different months and taking into consideration only the fishes of and above length at first maturity, the spawning period was determined as December-April with peak during January in the sea off Kakinada.

Using the length data of 2386 specimens of the length range 32-215 mm and following the modal progression method, the growth of *N. mesoprion* was studied; the parameters of von Bertalanffy growth equation were estimated as as L_{∞}= 219 mm, K= 0.83248 per year and t_o= -0.256198 year. The life-span in the fishery was estimated as three years.

6. Observations on the fisheries of threadfin breams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) in the trawling grounds off Kakinada.

Using the data collected by the author during 1976-'79 from the landings of small commercial trawlers operating off Kakinada, the fishery of threadfin breams and biology of *Nemipterus japonicus* were studied. This was the first study in India on the basis of data collected from commercial vessels, the earlier studies in the country being based on data of exploratory vessels operating off Andhra-Orissa coasts (Krishnamoorthi, 1973), off Cochin (Vinci and Nair, 1975; Vinci, 1983) and off Mangalore (Kuthalingam, 1971).

During the study period, four species of threadfin breams contributed to the fishery. Nemipterus japonicus was the most dominant species supporting the fishery, followed by N. mesoprion, N. tolu and N. luteus. It was shown that November-May was the period of abundance of nemipterids in the trawling grounds off Kakinada.

The reproductive biology of N. japonicus was studied. The testes were small even in mature fishes and it was not possible to quantify them into different maturation stages. The ovaries were, however, classified into six stages of maturation on the basis of external appearance (size in relation to body cavity, colour, nature of intraovarian ova as seen by naked eye) and structure and size of intraovarian ova under microscope. Fully spent fish were never encountered. The length at first (50% maturity) maturity was estimated as 125 mm in females. Like N. mesoprion (Murty, 1982), N. japonicus was also shown to be a fractional spawner, spawning in two spawning acts during the spawning period. The nature of ova diameter frequency distribution in mature and ripe ovaries and the non-occurrence of spent or spent rematuring females (over 1000 females examined during 1976-'79 period) were shown to be suggestive that the females once reaching ripe stage would not revert to "stage II" (rematuring adults or spent recovering adults) as was generally believed to be the case in Indian marine fishes and in most temperate water fishes which were known to spawn during shorter periods, once a year. By considering females above length at first maturity and on the basis of frequency of occurrence of mature and ripe females in different months, the spawning was shown to extend from August to April with peaks during December and February. This conclusion was supported by the occurrence of smaller fishes in the 35-85 mm length range over extended periods.

For the first time in Indian marine fishes, an attempt to estimate total annual fecundity of a fractional spawner was made in the case of N. japonicus from off Kakinada. The total annual fecundity in fishes of 134-199 mm total length range was estimated as ranging from about 23000 to 139200. The relationship between total length and fecundity was estimated as $F= -116.56711 + 1.11909\ L$; ($r=0.83$) and between weight and fecundity as $F= -0.75615 + 1.11380\ W$; ($r= 0.92$).

The sex ratio showed predominance of males; the largest length of males was observed to be 285 mm and that of females to be 215 mm. The possibility of faster growth rate of males as suggested by Krishnamoorthi (1976) and Eggleston (1973) was recognised in this study also (see Qasim, 1966 also).

Using the length data of over 6600 specimens of the length range 35-285 mm collected during 1977-'79 and following the monthly progression of modes in the length frequency distribution, the growth rate was estimated. The von Bertallanffy parameters of growth were estimated as $L_\infty= 314$ mm, $K= 0.75$ per year and $t_0= -0.17$ year.

Differential growth rate between sexes was observed in threadfin breams (Eggleston, 1973) and a possibility of such a situation occurring in N. japonicus was also recognised in this study. Investigations made with scales and otoliths did not reveal growth checks of value in age determination in this species (some otolith sections were prepared when the author visited Lowestoft laboratory, U.K., but growth check of use were not discernible). As it was not possible to make length measurements of males and females separately in the field in the absence of external sexual dimorphism and in view of the practical difficulties in doing the work in the landing centre, the pooled data of males and females only were considered for estimating growth parameters.

7. Estimates of mortality, population size and yield per recruit of Nemipterus japonicus (Bloch) in the trawling grounds off Kakinada.

For the first time in India, the mortality rates and stock size of Nemipterus japonicus were estimated on the basis of data generated from commercially exploited populations; the earlier study by Krishnamoorthi (1978) was based on data from vessels conducting exploratory surveys. Using the length frequency data obtained during 1976-79 from commercial trawlers at Kakinada and the values of growth parameters estimated earlier (Murty, 1984 a), the mortality rates were estimated and stock size determined. The values of total mortality rate (Z), fishing mortality rate (F) and natural mortality rate (M) were estimated as 1.86, 0.72 and 1.14 respectively. It was shown that the exploitation of N. japonicus during the period did not have any adverse effect on the stock.

8. Further studies on the growth and yield per recruit of <u>Nemipterus japonicus</u> (Bloch) from the trawling grounds off Kakinada.

Having studied (Murty, 1984 a) the growth using the modal progression method and recognising the bottlenecks in reliably estimating the same using this method, another attempt to estimate the growth parameters of <u>Nemipterus japonicus</u> was made using the length data collected during 1980-'83 from off Kakinada and following the less subjective 'Integrated Method' of Pauly (1980 a). The mortality rates, length at first capture and yield per recruit were also estimated. The von Bertalanffy growth parameters estimated were L_{∞}= 339mm, K= 0.52 per year t_o= -0.16 year. The total (Z), natural (M) and fishing (F) mortality rates were estimated as 2.64, 1.11 and 1.53 respectively. The length at first capture (L_c) was estimated as 120 mm. The yield per recruit was estimated and it was shown that increased effort would result in decreased yield in the grounds under exploitation, if the cod end mesh size was not changed. It was also shown that yield could be increased if the cod end mesh size was increased by 70% without increasing the effort.

The various issues relating to estimation of parameters were discussed in detail and the need to update the estimates, whenever stock assessment was attempted, was indicated. The values estimated in this work were compared with the earlier estimates.

9. Present status of exploitation of fish and shellfish resources - Threadfin breams- Monsoon fisheries of west coast of India, prospects, problems and management.

/ As Principal Investigator of the project on threadfin breams, the author analysed the data collected by colleagues working at different centres along the west coast of India, interpretted the same, reviewed the literature and prepared the paper for publication. Additionally, the author was associated with the editorial work of the publication /

Due to the ban imposed by the government on trawling during monsoon period along the Indian west coast, particularly along the Kerala coast, the fishing industry expressed apprehensions on the validity of such a ban. As part of the Institute's efforts to examine whether such a ban was indeed necessary, the data on threadfin breams- a resource of considerable magnitude taken in large quantities during monsoon period by the trawlers- collected during 1984-'88 were analysed and the results reported in this paper.

The data on total catch, species composition, length composition of catch and maturity condition of fishes exploited during different seasons were examined critically. The study revealed that while the ban on trawling was not essential so far as threadfin breams were concerned, the need for continuous monitoring of the exploited stocks was emphasised because: the trawl fishery was multispecies in nature, the inshore grounds were known to be nursery grounds for many species of fin- and shellfish, the yields of threadfin breams in the inshore fishing grounds of 0-50 m depth range reached near optimum levels and because the cod end mesh size of trawl nets was reduced in the shrimp-oriented trawl fishery.

B. SILVERBELLIES

The silverbellies (Leiognathidae) are known to be abundant in shallower regions of the sea upto about 40 m depth (James, 1973; Pauly, 1977 a, b; Pillai and Dorairaj, 1985; Sudarsan *et al.*, 1988; Sivaprakasam *et al.*,1991) though they are known to occur in depths of 100-150 m also (Sudarsan *et al.*, 1988). An estimated 62304 tonnes of silverbellies were landed in India in 1993 (Anon., 1994) which formed 5.5% of total demersal fish catch and 2.7% of total marine fish landings of India. Maximum landings (71% of total silverbelly catch) of these fishes were obtained along Tamil Nadu coast, followed by Andhra Pradesh (9%), Kerala (8.4%), Karnataka (6.0%) and other maritime states. Though these fishes were taken by artisanal gear as well as trawl, the latter accounted for the bulk of the landings. Silverbellies were known to undertake diurnal vertical migrations (Venkatraman and Badrudeen, 1974; Murty, 1988) staying at the bottom during day time and rising to surface and subsurface watersduring night time. A total of about 20 species were known from india but only a few species: *Leiognathus jonesi*, *L. bindus*, *L. dussumieri*, *L. brevirostris* and *Secutor insidiator* contribute to the fishery significantly.

10. Observations on some aspects of biology of silverbelly *Leiognathus bindus* (Valenciennes) from Kakinada.

Leiognathus bindus was one of the most dominant components of silverbelly catches along east coast where no attempt to study the biology was made. The present paper from Kakinada was the first one from this coast as the single earlier work (Balan, 1967) from the country was from the west coast of India. The aspects of biology pertaining to maturation and spawning and length-weight relationship were presented in this paper.

The length at first maturity (50% maturity) was estimated as 80 mm. The ova diameter studies showed that L. bindus was a fractional spawner, each fish spawning twice during a year. The spawning period was found to be continuous throughout the year with peak during December-April. The length frequency distribution of the species in the fishery was presented. The length-weight relationship was calculated as:

$$\text{Log } W = -4.77709 + 2.96182 \text{ Log } L$$

11. Studies on the growth and population dynamics of silver-belly Leiognathus bindus (Valenciennes) in the trawling grounds off Kakinada.

After completing a study of the spawning biology of Leiognathus bindus (Murty, 1983 a), the von Bertalanffy growth parameters, mortality rates and yield per recruit were estimated utilising the length frequency data collected from the trawl landings at Kakinada during 1979-'81. This also happenned to be the first work from the east coast of India as Pauly and David's (1981) estimation of growth parameters using the data of Balan (1967), was from off Calicut (west coast). The growth parameters were estimated as L_{∞} = 158.4 mm, K = 0.58 per year and t_0= -0.024 year. The mortality rates were estimated as Z=5.2, M=1.5 and F=3.7. The study on yield per recruit indicated the need to increase the cod end mesh size by about 50% to be able to harvest the maximum yield without affecting the stock adversely.

12. Population characteristics of the silverbelly Leiognathus bindus (Valenciennes) along west Bengal coast.

This paper was based on the data collected during a midwater trawl survey conducted between long. 20^{o}- 21^{o} 03'N and lat. $87^{o}15'$ - $88^{o}55'$ E along the coast of west Bengal. The data on L. bindus during the survey showed that larger fish inhabit relatively deeper waters and, confirmed the earlier study of Venkatraman and Badrudeen (1974) that silver-bellies stay at bottom during day time and migrate to surface and subsurface waters during night. The length-weight relationship of the stock was estimated as Log W= -5.38217+3.28637 Log L. The mortality rates estimated showed that total mortality rate was equal to natural mortality rate indicating that there was no exploitation of this species in the region; this was supported by the landings also. It was suggested that maximum yield of this species could be obtained at a fishing mortality rate of 3.6 with the 42 mm cod end mesh size of trawl net.

13. Biology and population dynamics of the silverbelly Secutor insidiator (Bloch) from Kakinada.

In the silverbelly landings by commercial trawlers at Kakinada, Secutor insidiator was one of the most dominant species. On the basis of data collected during 1979-'83, a study on the biology and population dynamics of the exploited stock was made. This happenned to be the first report on the above aspects of the species from India; earlier, Pillai (1972), briefly dealt with the spawning habits and fecundity of this species from Tuticorin.

Maturation, spawning and sex ratio were studied and it was shown that this species spawned throughout the year with a peak during January-March in the sea off Kakinada. The length at 50% maturity was estimated as 90 mm. Though the maximum length of males and females was the same, females were predominant in larger lengths. The length-weight relationship was calculated as Log W= -5.73713 + 3.43654 Log L.

The von Bertalanffy growth parameters were estimated as L_{∞}= 123 mm, K= 1.2 per year and t_0= -0.01 year.

The total mortality rate was estimated using different methods and the value was taken as 6.1052. Similarly, the natural mortality rate was estimated by four different approaches as 1.8, 2.3, 2.4 and 2.6. The age at first capture was estimated as 0.86 year. Using all these values, the yield per recruit was estimated. The yield as a function of fishing mortality showed that it did not attain maximum within the values of F considered. The yield as a function of age at first capture (t_c) indicated the need to reduce the t_c from 0.86 to 0.70 year. The reduction in t_c was, however, not recommended because the same would result in increased exploitation of still smaller fishes which did not have any commercial value.

The difficulties encountered in the analysis of data for estimating growth parameters, mortality rates and yield were discussed.

C. CROAKERS

The fishes of the family Sciaenidae (croakers, jew fish) represented over thirty species in India, contributed significantly to the exploited demersal finfish resources of the country. In 1993, an estimated 161105 tonnes of croakers were landed along the Indian coast (Anon., 1994) which formed about 14% of total demersal fish catch and 7% of total marine fish landings of India. Maximum catches were obtained from Gujarat, followed by Maharashtra, Tamil Nadu, Orissa, Andhra Pradesh, Kerala and other maritime states. Of the species known from the country, Protonibea diacanthus, Otolithus cuvieri, Johnius vogleri, J. macrorhynus, J. aneus, J. sina, J. carutta and Atrobucca nibe were most abundant at different regions. Some species like P. diacanthus which used to form dominant components in the landings along north west coast of India, registered declining yields in recent years.

14. Observations on some aspects of biology of the black croaker Atrobucca nibe (Jordan and Thompson) from Kakinada.

The paper represented the second report on biology of Atrobucca nibe from anywhere in the world and the first one from Indian Ocean region in general and from the Indian coastal waters in particular; the only earlier report was from Japan (Matsui and Takai, 1951).

A. nibe formed a seasonal but major component in the multispecies (about 20 species from off Kakinada) sciaenid catches taken off Kakinada by trawlers: during 1975-'77, this species formed 27% of the average annual sciaenid catch of 1500 tonnes. The length-weight relationship was estimated as Log W = -5.524308 + 3.213476 Log L. The length at first maturity was estimated as 145 mm; through the study of ova diameter frequency distribution, it was shown that *A. nibe* spawned twice during the spawning period which extended from February to July in the sea off Kakinada.

15. Observations on some aspects of biology of the croakers *Johnius* (*Johnieops*) *dussumieri* (Cuvier) and *Johnius* (*Johnius*) *carutta* Bloch from Kakinada.

This paper was the first report on the biology of *J. dussumieri* and *J. carutta* (excepting the study on spawning of *J. carutta* by Rao, 1967) from the Indian seas. The length weight relationship, relative condition factor, length at first maturity, spawning habits and spawning seasons were determined. In *J. dussumieri*, the spawning season extended from March to August. The length at first maturity was estimated as 110 mm. The length-weight relationship was calculated as Log W = -4.84511 + 2.96347 Log L. The changes in relative condition factor were found to be associated with gonad cycle.

In *J. carutta*, the length at first maturity was found to be 155 mm. The spawning season extended from January to June. The length-weight relationship followed the equation Log W = -5.4389 + 3.2343 Log L.

16. Growth and yield per recruit of *Johnius* (*Johnius*) *carutta* Bloch in the trawling grounds off Kakinada.

After studying the maturation, spawning, length-weight relationship in *J. carutta* (Murty, 1984 b), the estimation of growth parameters, mortality rates and yield per recruit was made on the basis of data collected from trawl landings at Kakinada during 1980-'83. The parameters of growth were estimated as L_∞ = 333.3 mm, K = 0.44 per year and t_o= -0.0002 year; the mortality rates as Z = 5.07, M = 1.0 and F = 4.07. At the prevailing levels of t_c and F during 1980-83, the yield per recruit as a function of F had already declined. The yield per recruit as a function of t_c showed that Y_{max} could be obtained at t_c= 1.7. The study lead to the suggestion of the following options to maximise and then sustain the yield:

— to decrease the fishing effort by 51% without modifying the cod end mesh size,

— to increase the age at first capture by 50% (i.e. cod end mesh size) without changing the fishing effort, or

— to increase both effort and cod end mesh size of trawl net.

17. Observations on some aspects of biology of *Johnius* (*Johnieops*) *vogleri* (Bleeker) and *Pennahia macrophthalmus* (Bleeker) in the Kakinada region.

/ The author was responsible for planning the work, collection, analysis and interpretation of data and for preparing the paper for publication. The junior author rendered assistance in aquisition and analysis of data. /

Among the several species contributing to the sciaenid fishery by trawlers at Kakinada, *Johnius vogleri* and *Pennahia macrophthalmus* were important among others. From off Kakinada, there was no information on the biology of these species; in the case of *J. vogleri*, there was no information on the biology from east coast of India. The earlier studies were restricted to those by Rao (1967, 1983) in *P. macrophthalmus* from Visakhapatnam and by Muthiah (1983) in *J. vogleri* from off Bombay. The present paper dealt with the results of a study on the length-weight relationship and spawning biology. It was shown that these two species spawn in two batches during October/ November-June in the sea off Kakinada. The length at first maturity (50% maturity) was estimated as 147 mm in *P. macrophthalmus* and 190 mm in *J. vogleri*. The length-weight relationship was estimated as:

P. macrophthalmus: Log W = -4.63735 + 2.89703 Log L

J. vogleri: Log W = -5.08923 + 3.07931 Log L

D. CARANGIDS——SCAD

The fishes of the family Carangidae comprising of horse mackerels, scads, leather jackets and others, constitute an important pelagic finfish resource of India represented by nearly sixty species belonging to about16 genera. In 1993, an estimated 129064 tonnes of carangids were landed in India (Anon., 1994) which formed 11.3% of pelagic finfish catch and 5.6% of total marine fish landings of India. Of the different species, the scads represented by about four species contribute to over 46% of the carangid catches. *Decapterus russelli* is the most dominant species of the scads and is exploited in large quantities by trawlers during certain periods.

18. Observations on some aspects of biology and population dynamics of the scad *Decapterus russelli* (Ruppell) (Carangidae) in the trawling grounds off Kakinada.

In the catches of carangids landed by the trawlers at Kakinada, the scad, *Decapterus russelli* accounted for over 80% by weight of the carangid catch, with an estimated average annual catch of 1229 tonnes during 1979-83. In view of the lack of information on biological characteristics (excepting the work of Sreenivasan, 1982, 1983, 1984 from Vijhinjam along the south-west coast of India) and population dynamics of the exploited stocks along Indian coasts, an investigation into these aspects was made using the data collected during 1979-83.

The annual estimated catches and catch rates and seasonal variations in abundance were presented. D. russelli supported a seasonal fishery with major peak during January-May period and a minor peak in September.

The length-weight relationship followed the equation: Log W = -5.93433 + 3.40764 Log L. The von Bertalanffy growth parameters were estimated as L_{∞} = 232.3 mm, K = 1.08 per year and t_o = -0.08 year. The length and age at first maturity were assessed as 150 mm and 0.88 year respectively. The spawning period off Kakinada was determined as extending from December to August. The different mortality rates were estimated as Z = 6.65, M = 1.90 and F = 4.75. The yield per recruit analysis showed that if the age at first capture was above 0.6 year, the yield increased with increase in F without attaining maximum.

Studying the earlier literature on experimental fishing and taking into account the fishing practices, the possible reasons for the seasonal fishery of D. russelli were explained. The spawning season determined was explained to be realistic taking into account the earlier studies on exploratory and experimental fishing and larval and spawner surveys (Rao et al. 1977) and the review of Qasim (1973) on spawning of Indian marine fishes. The reasons for the difference in the estimated values of growth parameters given by Sreenivasan (1983) and this study were examined and explained, though it was expressly stated that these values could be different in different stocks of the same species and also innthe same stock between different periods (vide, Gulland, 1983) for various reasons.

In the estimation of natural mortality coefficient, the available methods, including the methods recently developed (Pauly, 1980 b, 1983; Alagaraja, 1984) were critically examined and finally the method adopted by Sekharan (1975) was followed with justification.

The problem of estimating length at first capture (L_c), in the absence of selection experiments, was discussed and justification deduced for the estimate obtained taking into account the known distribution pattern of the species and fishing practice. Yield per recruit analyses were, however, made using different values of L_c (and hence t_c) and the yield curves compared and the strategy of exploitation suggested noting the limitations.

PART III MIXED FISHERIES ASSESSMENT

19. Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada.

The Indian marine fisheries, like any comparable tropical marine fisheries, exploit a large number of species in any gear. The classical models of fish stock assessment of exploited stocks (Beverton and Holt, 1957) only deal with single species assessments. The author made a few single species stock assessments and found that though such assessments did provide useful insights into the state of the exploited, single species stocks, they did not help to palnning a strategy for rational exploitation and management of multispecies stocks. Besides, methods of assessing multispecies stocks in the tropical context were also not available. The author, therefore, attempted the multispecies stock assessment using the data obtained from trawl landings at Kakinada. This was the first attempt in India to do multispecies stock assessment and it primarily demonstrated the methodology using four demersal finfish species. The theoretical and practical issues, in making the assessment, were discussed in detail.

In the higher latitudes, particularly in the north sea, multispecies stock assessment model (Multispecies Virtual Population Analysis Model——MSVPA) was developed (Helgason and Gislason, 1979; Gislason and Helgason, 1985; Pope, 1979;

ICES, 1984, 1986, 1987; Gislason and Sparre, 1987) taking into account the species interactions, particularly in regard to mortality generated by predation, and following the age-based methodology. While this approach was still under trial, in the tropics, the age-based methodology could not be implemented because of the inability to determine the age of individual fish (even after the discovery of daily growth rings in the otoliths of tropical fishes, as this methodology was not successful in ageing fishes older than about one year —— see Gjosaeter et al., 1984). Necessarily, therefore, the length-based methodology appears to be the only answer to tropical fish stock assessment until a more efficient model is developed.

In the present paper, the methodology of multispecies assessment using the data of one speices of threadfin breams, one species of croakers and two species of silverbellies, using the Beverton-Holt model was demonstrated. It was also shown that with existing gear under operation, the effort had to be reduced by about 6% to ensure maximum yield of the four species or, the cod end mesh size had to be increased by about 28% without increasing or decreasing the effort. The latter option was explained to be the most desirable one as the lengths at first capture of the species were less than the lengths at 50% maturity.

20. Mixed fisheries assessment with reference to five important demersal fish species landed by shrimp trawlers at Kakinada.

After attempting an assessment of multispecies stocks in the tropical context, another assessment of five exploited species in the sea off Kakinada was attempted using the length-based Thompson and Bell analysis developed by Sparre (1985). This approach, similar in concept to the one attempted earlier (Murty, 1987 b), was also given primarily to demonstrate the methodology for assessment of a mixed fishery. Additionally, this approach considered pooling the values (prices) instead of the yields themselves so that it became more meaningful in the management. The theory of length-based Thompson and Bell (1934) model was also presented. This was the first stock assessment study of the kind in tropical waters and it was shown that this approach could be followed for the assessment of a large number of species exploited by the gear.

21. Stock assessment of threadfin breams (Nemipterus spp) of India.

> [As principal Investigator of the project and team leader, the author analysed the data supplied by colleagues from all centres and interpretted the same, reviewed the work done and prepared the paper for publication, in addition to generating data from Kakinada]

Though some isolated attempts on stock assessments were made, during different periods from different localities, of single species (Krishnamoorthi, 1978; Murty, 1983 b, 1987 a; Vivekanandan and James, 1986; Devaraj and Gulati, 1988; John, 1989; Kasim et al., 1989), concerted effort to study the population dynamics from all along the coast taking into account the principal species, was not made. This paper dealt with the mixed fisheries assessment of the threadfin breams

(Nemipterus japonicus and N. mesoprion) from east and west coasts of India. All necessary parameters were estimated, stock assessment made and optimal yield levels in the existing fishing grounds indicated. The various scientific issues relating to the assessments in the tropical context using length data were discussed, particularly the widely-differing values of growth parameters estimated using data of different years and the consequent difficulty in using a particular set of growth parameters for estimating mortality rates and yield. The choice of selecting two sets of values of growth parameters, the smallest and largest L_{∞} values and their related K values from among the several sets of reasonably satisfactory values obtained, for proceeding further with the assessments and then considering the average values of yields (of the two obtained using two sets of growth parameters) corresponding to each effort level (F-level) as representing the realistic estimates, was believed to be the best under the existing situation. Besides, the conflicting options for rational exploitation of different species in the same fishery were pointed out and the strategies to be followed, in the given option, were indicated.

22. Stock assessment of silverbellies of India with particular reference to Andhra Pradesh and Tamil Nadu.

[In addition to generating data from Kakinada, as Principal Investigator of the project and team leader, analysed the data from all four centres and interpretted the same, reviewed the work done and prepared the paper for publication.]

Though silverbellies were known to occur in the catches all along the Indian coast, about 80% of the silverbelly catch was landed from off Tamil Nadu and Andhra Pradesh; of these regions, Tamil Nadu's contribution was the highest forming 70% of silverbelly landings of India. Bulk of the silverbelly catch in the country was obtained from trawlers.

Of the species contributing to the fishery, *Leiognathus bindus* and *Secutor insidiator* were the most dominant along Andhra Pradesh and northern Tamil Nadu coasts and *L. jonesi* and *L. dussumieri* along southern Tamil Nadu coast.

Though work on stock assessment of silverbellies was carried out earlier (Venkatraman *et al.*, 1981; Murty, 1986, 1988, 1991 and Karthikeyan *et al.*, 1989), it was restricted to single species from restricted areas. To have an overall view of the status of the exploited silverbelly stocks from the region of greatest abundance in the country, two most dominant species (*L. bindus* and *S. insidiator*) from Andhra Pradesh and Northern Tamil Nadu and two other dominant species (*L. jonesi* and *L. dussumieri*) from southern Tamil Nadu were selected for the present assessment.

The available information on the biology of different species from different localities along the Indian coast was reviewed. Parameters of growth and mortality rates of the selected species were estimated. Stock assessment was done for each species separately from the regions and then mixed fisheries assessment was carried out. Along Andhra Pradesh, the effort level was found to be greater than the one yielding maximum catch in the existing fishing grounds; in northern Tamil Nadu, scope for marginally increasing the yield by increasing the effort was indicated. In southern Tamil Nadu also, scope for increasing the yield by increasing the effort was indicated. Regulation of cod end mesh of trawl net was also explained.

PART IV RESOURCES SURVEY AND MANAGEMENT

23. Resources of ornamental fishes of the Lakshadweep islands

[The resources survey was carried out by three teams covering thirteen islands. The author participated in the first team. The responsibility of analysing the data and preparation of paper on ornamental fishes was given to the author who analysed the data and prepared the paper for publication, using the data collected by the second and third teams also.]

In recent years, the demand for live ornamental fishes is increasing and a strong export market is developing. Though a comprehensive account of the fishes of Lakshadweep (Jones and Kumaran, 1980) was published, information on species available for exploitation, their relative abundance and the areas of abundance in the lagoons and reef flats of different islands was lacking. For the first time in the region, a survey was conducted during January-March 1987 in 13 islands of Lakshadweep, which resulted in collection of 139 species of ornamental fishes belonging to 33 families. Of these, it was shown, the fishes of the family Pomacentridae were the most dominant in terms of numerical abundance and number of species (22 species collected) followed by Labridae (21 species), Apogonidae (10 species), Mullidae (9 species), Chaetodontidae (8 species), Callyodontidae (6 species), Acanthuridae (6 species) and others. The number of species known from Lakshadweep region and the number of species common in the area were given. The distribution and abundance of different species of ornamental fishes in the reef flats and lagoons during the survey period were explained and a few suggestions for rational exploitation were made.

24. Present trends in marine fisheries management and catch forecasting.

[After discussion on the subject and the format of the paper, the responsibility of survey of literature, consolidation of information and preparation of the paper was taken by this author]

The Indian marine fisheries were facing a near crisis in that, the catches from the presently exploited inshore waters reached optimal levels in respect of majority of stocks and the region beyond 50 m depth in the Exclusive Economic Zone which was estimated to support a potential yield of 1.7 million tonnes, was yet to be exploited commercially. While technologies for increasing production from the seas were available and the investigations on several exploited stocks were carried out aiming at stock assessment, it was felt necessary to bringout a comprehensive account of the available methods of marine fisheries management and catch forecasting under the Indian context and to make suggestions on the future course of action to be taken. After describing the current marine fisheries scenario briefly, the various methods of short and long term forecasts of the yields, the management strategies and the information requirements were indicated.

25. Complexities of management of inshore fishery resources of India.

/ The author was involved in the preparation and finalisation of the paper. /

In the context of declining yields from the inshore fishing grounds along the Indian coast, the prevailing social and economic conditions of the resource users and the various complexities, controversies and conflicts among the different sectors of fishing industry in the country, the imperative need to enforce regulations and manage the fisheries was discussed. In consideration of the various issues, it was suggested that:

—— increased role might be provided to the local or regional fishing communities in the formulation of regulatory measures and their managerial responsibilities,

—— positive access might be ensured in favour of local fishing communities,

—— regulatory measures should be formulated with a strong conservation policy through careful regulation of fishing effort and restrictions on gears, and

—— a system of fishing within the regional management scheme transmuting the conflict to coexistence or even symbiosis might be incorporated in the management system.

REFERENCES

ALAGARAJA, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. Indian J. Fish., 31: 177-195.

ANONYMOUS. 1994. Annual Report 1993-'94. Central Marine Fisheries Research Institute, Cochin, 108 pp.

BALAN, V. 1967. Biology of the silverbelly Leiognathus bindus (Val.) of the Calicut coast. Indian J. Fish., 10: 118-134 (1963).

BANSE, K. 1959. On upwelling and bottom trawling off south west coast of India, J. mar. biol. Ass. India, 1: 33-49.

BEVERTON, R. J. H. AND S. J. HOLT. 1957. On the dynamics of exploited populations. Fishery Invest. ser. London, 19: 533 pp

BLEEKER, P. 1851. Bijdrage tot de kennis der ichthyologische fauna van de Banda-eilanden. Natuurk. Tijdschr. Ned.-Indie, 2: 225-261.

BLEEKER, P. 1853 a. Nieuwe tientallen diagnotische beschrijvingen van nieuwe of weining bekende vischsoorten van Sumatra. Natuurk. Tijdschr. Ned.- Indie, 5: 495-534.

BLEEKER, P. 1853 b. Diagnostiche beschrijvningen van nieuwe of weinig bekende vischsoorten van Batavia. Natuurk. Tijdschr. Ned.-Indie, 4: 255-256.

BLEEKER, P. 1873. Revision des especes de Dentex, Synagris, Gymnocranius. Verh. Akad. Amsterdam, 13: 23.

BLEEKER, P. 1877. Atlas Ichthyologique des Indes Orientales Neerlandaises publie sous les auspices du government colonial neerlandais. Amsterdam. 8: 456 pp, 41 pls.

BLOCH,M.E., AND J.G.SCHNEIDER. 1801. M.E.Blochii Systema Ichthyologiae iconibus ex illustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit, J.G.Schneider, Saxo Berolini, ix + 584 pp, 110 pls.

CUVIER, G. 1829. in: Cuvier, G. and A. Valenciennes. Histoire Naturelle de Poissons, 4: xxvi + 518 pp, Paris-Strasbourg.

DAY, F. 1878. Fishes of India, I: 778 pp, William Dawson & sons.

DE BEAUFORT, L. F. AND J. C. BRIGGS. 1962. The Fishes of the Indo-Australian Archipelago 11: 465 pp, E.J.Brill, Leiden.

DEVARAJ, M. AND D. GULATI. 1988. Assessment of the stock of the threadfin bream (Nemipterus japonicus) in the northwest continental shelf of India, in: M.Mohan Joseph (ed.) Proceedings of the first Indian Fisheries Forum, Asian Fisheries Society, Indian Branch, Mangalore; 159-164.

EGGLESTON, D. 1973. Patterns of biology in Nemipteridae. J. mar. biol. Ass. India, 14: 357-364 (1972).

GISLASON, H. AND T. HELGASON. 1985. Species interaction in assessment of fish stocks with special reference to the north sea. Dana, 5: 1-44.

GISLASON, H. AND P. SPARRE. 1987. Some theoretical aspects of the implementation of multispecies virtual population analysis in ICES. ICES C. M. 1987/G: 51.

GJOSAETER, J. P. P. DAYARATNE, O. A. BERGSTAD, H. GJOSAETER, M. I. SOUSA AND I. M. BECK. 1984. Ageing tropical fish by primary growth rings in their otoliths. FAO Fish. circ., (776): 54 pp.

GULLAND, J. A. 1983. Fish Stock Assessment: A manual of basic methods. FAO/Wiley Series on Food and Agriculture, 1: 223 pp.

GUNTHER, A. 1859. Catalogue of the Acanthopterygian fishes in the collections of the British Museum. 1: xxxi + 524 pp, London.

HELGASON, T. AND H. GISLASON. 1979. VPA-Analysis with species interactions due to predation. ICES C. M. 1979/G:52:10pp.

ICES. 1984. Report of the Ad hoc multispecies assessment working group. Copenhagen, 18-22 June, 1984, ICES C.M. 1984/Assess:20:99 pp.

ICES. 1986. Report of the Ad hoc multispecies assessment working group. Copenhagen, 13-19 November, 1985; ICES CM 1986/Assess: 9 : 141 pp.

ICES. 1987. Report of the Ad hoc multispecies working group. Copenhagen, 12-18 November, 1986; ICES C. M. 1987/ Assess: 9

JAMES, P. S. B. R. 1973. The fishery potential of silverbellies. Proceedings of the symposium of the Living resources of the seas around India, Spl. Pub. Cent. mar. Fish. Res. Inst., 439-444.

JOHN, M. E. 1989. Population dynamics and stock estimates of the threadfin bream (*Nemipterus japonicus*) off Kerala India: 45-62; in: Venema, S.C. and N. P. van Zalinge (eds). Contributions to tropical fish stock assessment in India, Papers prepared by the participants at the FAO/DANIDA/ICAR National Follow-up training course on fish stock assessment. FI:GCP/INT/392|DEN/1: 157 pp.

JONES, S. AND M. KUMARAN. 1980. Fishes of the Laccadive Archipelago. Nature conservation and aquatic sciences service, Santhinivas, Nanthencode, Trivandrum, 760 pp.

KARTHIKEYAN, M., N. G. K. PILLAI AND M. BADRUDEEN. 1989. Population dynamics of silverbelly *Leiognathus jonesi* James in the trawling grounds off Rameswaram. Indian J. Fish., 36: 103-106.

KASIM, H. M., K. M. S. AMEER HAMSA AND P. SAM BENNET. 1989. Present status of perch fishery resources in India and its prospects. in: National Symposium on Research and Development in Marine Fisheries, 16-18 September, 1987, Mandapam Camp. Bull. cent. mar. Fish. Res. Inst., 44: 226-237.

KRISHNAMOORTHI, B.1973. Biology of threadfin bream Nemipterus japonicus (Bloch). Indian J. Fish., 18: 1-21 (1971).

KRISHNAMOORTHI, B. 1976. A note on the size differences between males and females of Nemipterus japonicus (Bloch). Indian J. Fish., 21: 608-609 (1974).

KRISHNAMOORTHI, B. 1978. A note on the mortality rates and yield per recruit in Nemipterus japonicus (Bloch). Indian J. Fish., 23: 252-256 (1976).

KUTHALINGAM, M. D. K. 1971. Notes on some aspects of biology of Nemipterus japonicus (Bloch) with special reference to feeding behaviour. Indian J. Fish., 12: 500-506 (1965).

LELE, S. H. 1924. Studies on Bombay fish. 1. Revision of the genus Drepane Cuv. & Val. Proc. Asiat. Soc. Bengal, 20: 274-288.

LINNAEUS, C. 1758. Systema Naturae, 10th ed. Vol I: 824 pp; Nantes & Pisces: 230-338, London.

MATSUI, J. AND T. TAKAI. 1951. Ecological studies on the black croaker Nibea nibe (Jordan and Thompson). Contr. Shimonoseki Coll. Fish., 1951: 65-89.

MURTY, V. S. 1981. Nemipterus mesoprion (Bleeker, 1853) (Nemipteridae Pisces) a new record from the seas around India, Indian J. Fish., 25: 207-213 (1978).

MURTY, V. S. 1982. Observations on some aspects of biology of the threadfin bream Nemipterus mesoprion (Bleeker) from Kakinada along the east coast of India. Indian J. Fish., 28: 199-207 (1981).

MURTY, V. S. 1983a. Observations on some aspects of biology of the silverbelly, Leiognathus bindus (Valenciennes) from Kakinada. Indian J. Fish., 30: 61-68.

MURTY, V. S. 1983 b. Estimates of mortality, population size and yield per recruit of Nemipterus japonicus (Bloch) in the trawling grounds off Kakinada. Indian J. Fish., 30: 255-260.

MURTY, V. S. 1984 a. Observations on the fisheries of threadfin breams (Nemipteridae) and on the biology of Nemipterus japonicus (Bloch) from Kakinada. Indian J. Fish., 31: 1-18.

MURTY, V. S. 1984 b. Observations on some aspects of biology of the croakers Johnius (Johnieops) dussumieri (Cuvier) and Johnius (Johnius) carutta Bloch from Kakinada. J. mar. biol. Ass. India, 21: 77-85 (1979).

MURTY, V. S. 1986. Studies on the growth and population dynamics of silverbelly Leiognathus bindus (Valenciennes) in the trawling grounds off Kakinada. Indian J. Fish., 33: 277-284.

MURTY, V. S. 1987 a. Further studies on growth and yield per recruit of Nemipterus japonicus (Bloch) from the trawling grounds off Kakinada. Indian J. Fish., 34: 265-276.

MURTY, V. S. 1987 b. Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada. J. mar. biol. Ass. India, 27: 39-48 (1985).

MURTY, V. S. 1988. Population characteristics of the silverbelly Leiognathus bindus (Valenciennes) along west Bengal Coast. J. mar. biol. Ass. India, 28: 41-47 (1986).

MURTY, V. S. 1989. Mixed fisheries assessment with reference to five important demersal fish species landed by shrimp trawlers at Kakinada, 69-86. in: Venema, S.C. and N. P. van Zalinge (eds). Contributions to tropical fish stock Assessment in India, Papers prepared by the participants at the FAO/DANIDA/ICAR National Training Course on Fish Stock Assessment; Cochin, India, 2-28 November, 1987, FI, CGP/INT/392/DEN/1; 1989, 157 pp.

MURTY, V. S. 1991. Biology and population dynamics of the silverbelly Secutor insidiator (Bloch) from Kakinada. J. mar. Biol. Ass. India, 32: 10-24 (1990).

MUTHIAH, C. 1983. Study on the biology of Johnieops vogleri (Bleeker) of Bombay waters. Indian J. Fish., 29: 118-123 (1982).

NAIR, K. V. S. AND A. A. JAYAPRAKASH. 1986. A note on the monsoon fishery for threadfin breams off Cochin. Indian J. Fish., 33: 106-112.

PAULY, D. 1977 a. The Leiognathidae (Teleostei), their species stocks and fisheries in Indonesia with notes on biology of Leiognathus splendens (Cuvier). Mar. Res. Indonesia, 19: 73-93.

PAULY, D. 1977 b. The Leiognathidae (Teleostei): an hypothesis relating their mean depth of occurrence to the intensity of their countershading bioluminiscence. Mar. Res. Indonesia, 19: 137-146.

PAULY, D. 1980 a. A selection of simple methods for the assessment of tropical fish stocks. FAO Fish. Circ., 729: 54 pp.

PAULY, D. 1980 b. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. cons. int. Explor. Mer., 39: 175-192.

PAULY, D. 1982. Studying single species dynamics in a tropical multispecies context. in: Theory and Management of Tropical Fisheries, D. Pauly and G.I.Murphy (eds), ICLARM, ISIRO, 33-70.

PAULY, D. 1983. Some simple methods for the assessment of tropical fish stocks. FAO Fish. Tech. Pap., 234: 53 pp.

PAULY, D. AND N. DAVID. 1981. ELEFAN-I a BASIC programme for the objective extraction of growth parameters from length frequency data. Meeresforschung, 28: 205-211.

PHILIP, K.P. AND P.J. JOSEPH. 1988. Fishery resources of the offshore and deep sea waters of Karnataka and the fishing effort suggested for exploitation. in: I. Karunasagar and N.V.Sripathy (ed) Problems and prospects of marine fishing and fish processing in Karnataka. 179 pp. Forum of fishery professionals, Mangalore.

PILLAI, N. G. K. AND K. DORAIRAJ. 1985. Results of trawling survey by an Institutional boat _Cadalmin II_ in the Palk Bay and Gulf of Mannar, Mandapam during 1977-80. _Indian J. Fish._, 32: 123-132.

PILLAI, P. K. M. 1972. Fecundity and spawning habits of some silverbellies. _Indian J. Fish._, 19: 196-199.

POPE, J. C. 1979. A modified cohort analysis in which constant natural mortality is replaced by estimates of predation levels. ICES C. M. 1979/H:16: 7 pp.

QASIM, S. Z. 1966. Sex ratio in fish populations as a function of sexual difference in growth rate. _Curr. Sci._, 35: 140-142.

QASIM, S. Z. 1973. An apprisal of the studies on maturation and spawning in marine teleosts from Indian waters. _Indian J. Fish._, 20: 166-181.

RAO, K. V. N., M. KUMARAN AND J. SANKARASUBRAMANIAN. 1977. Resources of horse mackerel of the southwest coast of India. _Seafood Export J._, 9(8): 1-16.

RAO, T. A. 1967. Maturity and spawning habits of some sciaenids in offshore waters at Visakhapatnam. _Indian J. Fish._, 11: 121-126 (1964).

RAO, T. A. 1983. Length-weight relationship in _Pennahia macrophthalmus_ (Bloch). _Indian J. Fish._, 29: 263-266 (1982).

SEKHARAN, K. V. 1975. Estimates of the stocks of oil sardine and mackerel in the present fishing grounds off the west coast of India. _Indian J. Fish._, 21: 177-182 (1974).

SILAS, E. G. 1969. Exploratory fishing by _R.V. Varuna_. _Bull. cent. mar. Fish. Res. Inst._, 12: 1-86.

SILAS, E. G., S. K. DHARMARAJA AND K. RENGARAJAN. 1976. Exploited marine fisheries resources of India-A synoptic survey with comments on potential resources. _Bull. cent. mar. Fish. Res. Inst._, 27: 25 pp.

SIVAPRAKASAM, T. E., P.S. PARASURAMAN, PREMCHAND, S. A. RAJA-KUMAR AND G. NAGARAJAN. 1991. Marine fishery resources off the lower east coast of India. Bull. Fishery Surv. India, 21: 29 pp.

SPARRE, P. 1985. Introduction to tropical fish stock assessment. FAO Rome, Denmark Funds-in-Trust. FI: GCP/INT/392/DEN Manual 1: 338 pp.

SPARRE, P. 1987. Computer programmes for fish stock assessment. Length-based fish stock assessment (LFSA) for Apple II Computers. FAO Fish. Tech. Pap., (101) suppl., 2: 217 pp.

SREENIVASAN, P. V. 1982. Length-weight relationship in *Decapterus dayi* Wakiya. Indian J. Fish., 28: 283-286 (1981).

SREENIVASAN, P. V. 1983. Age and growth of the scad *Decapterus dayi* Wakiya. Indian J. Fish., 29: 144-150 (1982)

SREENIVASAN, P. V. 1984. Feeding biology of the scad *Decapterus dayi* Wakiya. J. mar. biol. Ass. India 21: 97-102 (1979).

SUDARSAN, D., T. E. SIVAPRAKASAM, V. S. SOMAVANSHI, M. E. JOHN, K. N. V. NAIR AND ANTONY JOSEPH. 1988. An apprisal of the marine fishery resources of the Indian Exclusive Economic Zone. Bull. Fishery Surv. India, 18: 85 pp.

SUDARSAN, D., M. E. JOHN AND A. JOSEPH. 1989. An assessment of the demersal stocks in the southwest coast of India with particular reference to the exploitable resources in outer continental shelf and slope. Bull. cent. mar. Fish. Res. Inst., 44, Part I: 266-272.

SUDARSAN, D., M. E. JOHN AND V. S. SOMAVANSHI. 1990. Marine fishery resources potential in the Indian Exclusive Economic Zone. Bull. Fishery Surv. India, 20: 27 pp.

THOMPSON,W.F. AND F. H. BELL. 1934. Biological studies of the halibut fishery 2. Effects of changes in intensity upon total yield and yield per unit of gear. Rep. Internat. Fish. (Pac. Halibut) comm., (8): 49 pp.

VALENCIENNES, G. 1830. in: Cuvier, G. and A. Valenciennes Histoire Naturelle de Poissons, 6: xxiv + 559 pp., Paris Strasburgh.

VALENCIENNES, G. 1833. in: Cuvier, G. and A. Valenciennes Histoire Naturelle de Poissons, 9: xxix + 512 pp;

VENKATRAMAN, G. AND M. BADRUDEEN. 1974. On the diurnal variations in the catches of silverbellies in Palk Bay. Indian J. Fish., 21: 254-265.

VENKATRAMAN, G., M. BADRUDEEN AND R. THIAGARAJAN. 1981. Population dynamics of silverbelly Leiognathus jonesi in Palk Bay. Indian J. Fish., 28: 65-86.

VINCI, G. K. 1983. Threadfin bream (Nemipterus) resources along the Kerala coast with notes on biology of Nemipterus japonicus. Indian J. Fish., 29: 37-49 (1982).

VINCI, G. K. AND AKK NAIR.1975. Length-weight relationship in the threadfin bream, Nemipterus japonicus along the Kerala coast. Indian J. Fish., 21: 299-302 (1974).

VIVEKANANDAN, E. AND D. B. JAMES. 1986. Population dynamics of Nemipterus japonicus (Bloch) in the trawling grounds off Madras. Indian J. Fish., 33: 145-154.

WEBER, M. AND L. F. DE BEAUFORT. 1936. The fishes of Indo-Australian Archipelago. 7: 607 pp, E.J. Brill, Leiden.

WEBER, W. AND A. A. JOTHY. 1977. Observations on the fish Nemipterus spp (Family Nemipteridae) in the coastal waters of east Malaysia. Arch. Fishwiss., 28 (2,3): 109-122.

ZUPANOVIC, S. AND S. Q. MOHIUDDIN. 1974. A survey of the fishery resources in the northern part of Arabian sea. J. mar. biol. Ass. India, 15 (2): 496-537 (1973)

PART I TAXONOMY

CONTRIBUTION 1

MURTY, V. SRIRAMACHANDRA. 1969. On some interesting and new records of marine fishes from India. J. mar. biol. Ass. India, 10(1): 126-132 (1968)

CONTRIBUTION 1

ON SOME INTERESTING AND NEW RECORDS OF MARINE FISHES FROM INDIA

J. Mar. biol. Ass. India, 1968, **10** (1): 126-132

ON SOME INTERESTING AND NEW RECORDS OF MARINE FISHES FROM INDIA*

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WHILE examining the fish landings by shore seines and trawl nets at various fishing centres along the Palk Bay and Gulf of Mannar in the vicinity of Mandapam the author came across several specimens of *Drepane longimana* (Bloch and Schneider) which is little known and *Drepane punctata* (Linnaeus) which was recognised as the only valid species of the genus *Drepane*. A study of these specimens has shown that these two species are distinct as shown by some authors (vide Text). A brief comparative account of these two species is given in this paper, along with a few remarks and key to distinguish the two species. The author has also been able to collect specimens of *Platycephalus isacanthus* Cuvier from the above catches, and a single specimen of *Stethojulis interrupta* (Bleeker) from the inshore waters of Gulf of Mannar caught in dragnet, whose occurrence, in Indian seas, is so far not known. Brief descriptions of these two species are also given in this paper.

Family: DREPANIDAE

Drepane longimana (Bloch and Schneider)

This species was first described by its authors from Tranquebar. Cuvier and Valenciennes (1831) studied the specimens of the genus *Drepane*, both morphologically and anatomically and distinguished the two species *D. longimana* (Bloch and Schneider) and *D. punctata* (Linnaeus). Cantor (1850) also recognised the two species as valid. But subsequently Günther (1860), Bleeker (1877) and Day (1878) recognised *D. punctata* only as the valid species. Lele (1924) revised the genus *Drepane* and established both anatomically and morphologically, the distinctness of the two species. However Weber and de Beaufort (1936) considered *D. punctata* as valid and relegated *D. longimana* to its synonymy. Smith (1949) believed that, the Genus *Drepane* consists ' possibly two species '. Herre (1953) pointed out the value of Lele's (*op. cit.*) work and stated that ' the dissection of numerous specimens in conjunction with a study of this paper showed that *D. longimana* is a valid species '. Munro (1955) refers only to *D. punctata* without any mention of the other species.

In spite of its common occurrence in trawl catches and first description from south-east coast of India and the latter revision of the genus *Drepane* by Lele, *D. longimana* is not well known especially in India. Since the species of the genus *Drepane* are commercially important, a brief comparative description is given along with a key to distinguish the two species.

* Published with the permission of the Director, Central Marine Fisheries Research Institute, Mandapam Camp.

Thirty specimens of both males and females of *D. longimana* (Plate I, A) ranging from 97-180* mm. in total length and fifty specimens of both sexes of *D. punctata* (Plate I, B) ranging from 88-502 mm. in total length collected during November 1965 to October 1966 have been examined in this study. It has been found that sexes are alike as regards the colour pattern, external form and other anatomical characters in both the species. The specimens are deposited in the Reference Collection Museum of Central Marine Fisheries Research Institute, *D. longimana* No. CMFRI-F79/506 and *D. punctata* No. CMFRI-F79/188a.

The meristic characters of both the species are given below.

D. longimana, D. VIII, 21-22 ; A. III, 17-19 ; P 1. 17 ; P 2. I, 5 ; L l. 50-55 ; Gill rakers 14-15.

D. punctata, D. IX, 21-22 ; A. III, 18-19 ; P l. 17 ; P 2. I. 5 ; L l. 50-55, Gill rakers 15-16.

The most important morphological and anatomical differences between the two species, which also agree with Lele's observations, are given in Table I and certain body proportions in per cent of total length are presented in Table II.

TABLE I

Morphological and anatomical differences between D. longimana *and* D. punctata

Character	*D. longimana*	*D. punctata*
I. MORPHOLOGICAL		
(*a*) Dorsal spines	Always 8. Radial between first two vertebrae supports the first dorsal spine only. 3rd spine longest.	Always 9. Radial between first two vertebrae supports the first two dorsal spines. 4th spine longest.
(*b*) Colour	4-9 vertical dark bands on each side or bands absent and body silvery.	Each side with 4-11 vertical rows of dark spots or with rows of spots with underlying bands or with both rows of spots and dark bands.
(*c*) Lateral line.	Makes a strong upward curve.	Makes a low symmetrical arch.
II. ANATOMICAL		
(*a*) Air-bladder.	Two short anterior and two long tubular posterior horns. About 15 short and variously branched caeca on each side. Three pairs of caeca on the inner margins of the posterior horns.	Two short anterior and two long tubular posterior horns. At each of the anterior corners two lateral caeca, the posterior long and sends out lateral flattened branches. A pair of caeca on the inner margins of the posterior horns.
(*b*) Pyloric caeca.	Three.	Two.
(*c*) Liver.	Bilobed, long and thin.	Bilobed, short and thick. The dorsal side is produced into irregular prominences.

* Since the manuscript was sent to press the author examined two specimens of *D. longimana* from Colachel (S.W. Coast of India), measuring 277 and 360 mm., and a single specimen of the same species 211 mm. long from Cape Comorin which agree in all details with the specimens of the lower size range of this species studied in this work.

TABLE II

Body proportions of D. longimana *and* D. punctata *in per cent of total length*
(Number of specimens in each case : 13)

S. No.	Morphometric character	*D. longimana* Range of T. L. 97-180 mm. (139.3 mm.)	*D. punctata* Range of T.L. 88-251 mm. (147.5 mm.)
1.	Height of body	66.00-70.75 (68.44)	65.33-75.00 (69.54)
2.	Length of head	24.32-28.88 (27.26)	24.56-30.09 (27.69)
3.	Length of caudal	21.17-25.77 (23.48)	21.05-26.21 (23.86)
4.	Length of Pectoral	42.26-49.08 (46.80)	44.80-51.39 (48.17)
5.	Diameter of eye	8.24-10.34 (8.93)	7.39-11.36 (9.25)

Parentheses indicate the mean.

From the above comparison it is clear that although the two species show overlapping body proportions they differ strikingly in the morphological and anatomical

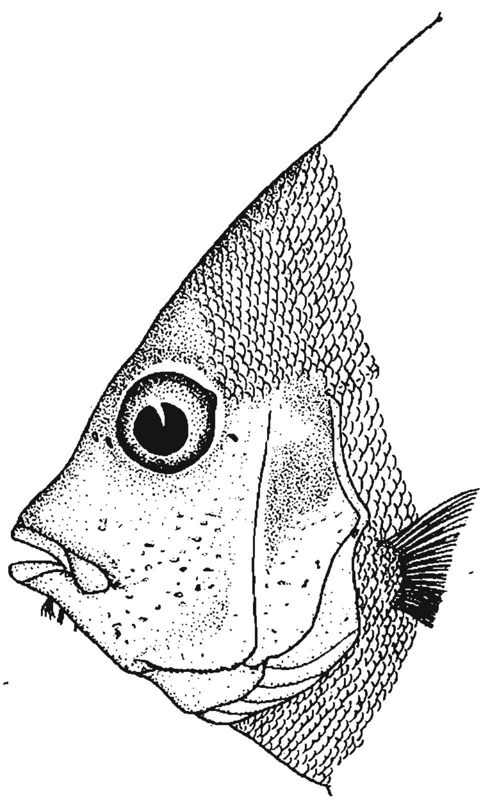

FIG. 1. Head of *Drepane punctata* (Linnaeus) (T.L. 133 mm.) showing the position of barbels.

characters mentioned. Based on the above differences a key to distinguish the two species is given below.

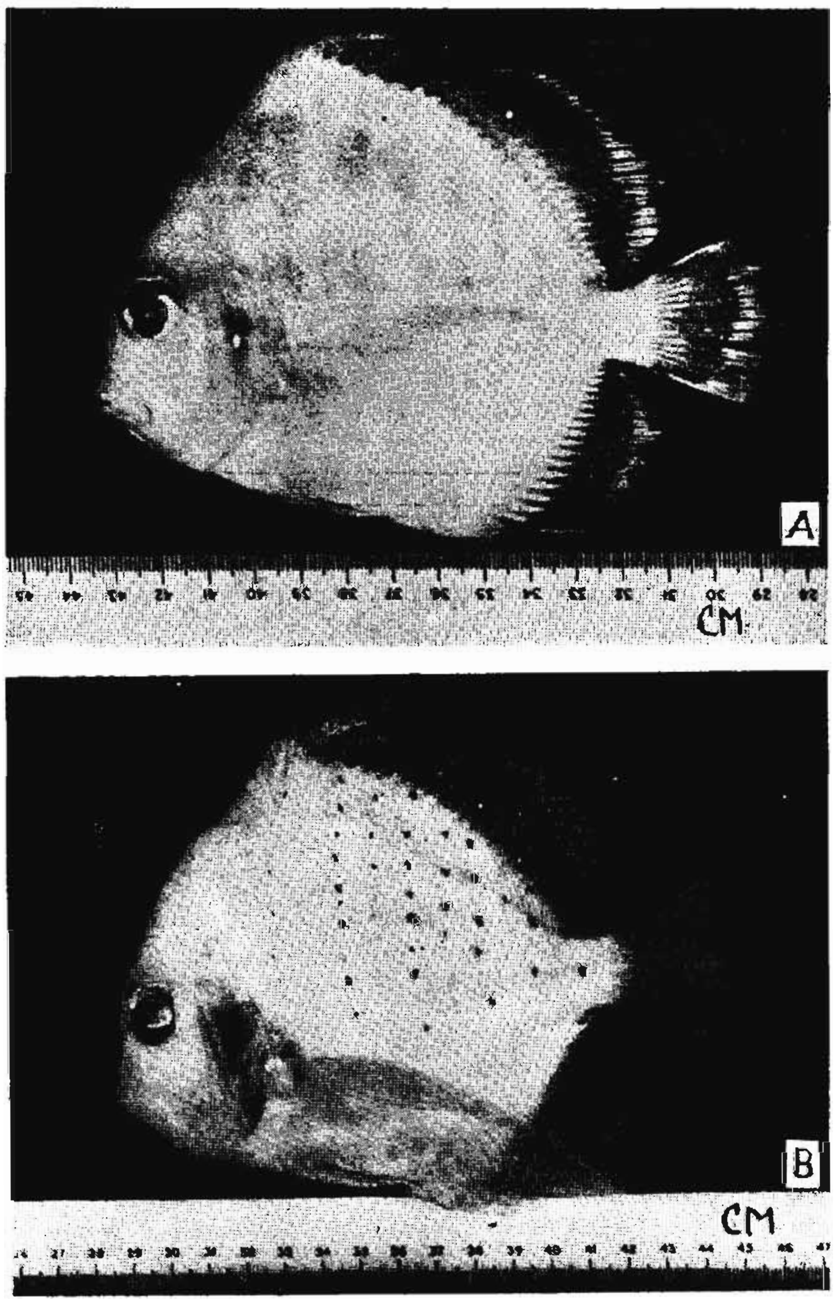

PLATE I, A. *Drepane longimana* (Bloch and Schneider). B. *Drepane punctata* (Linnaeus).

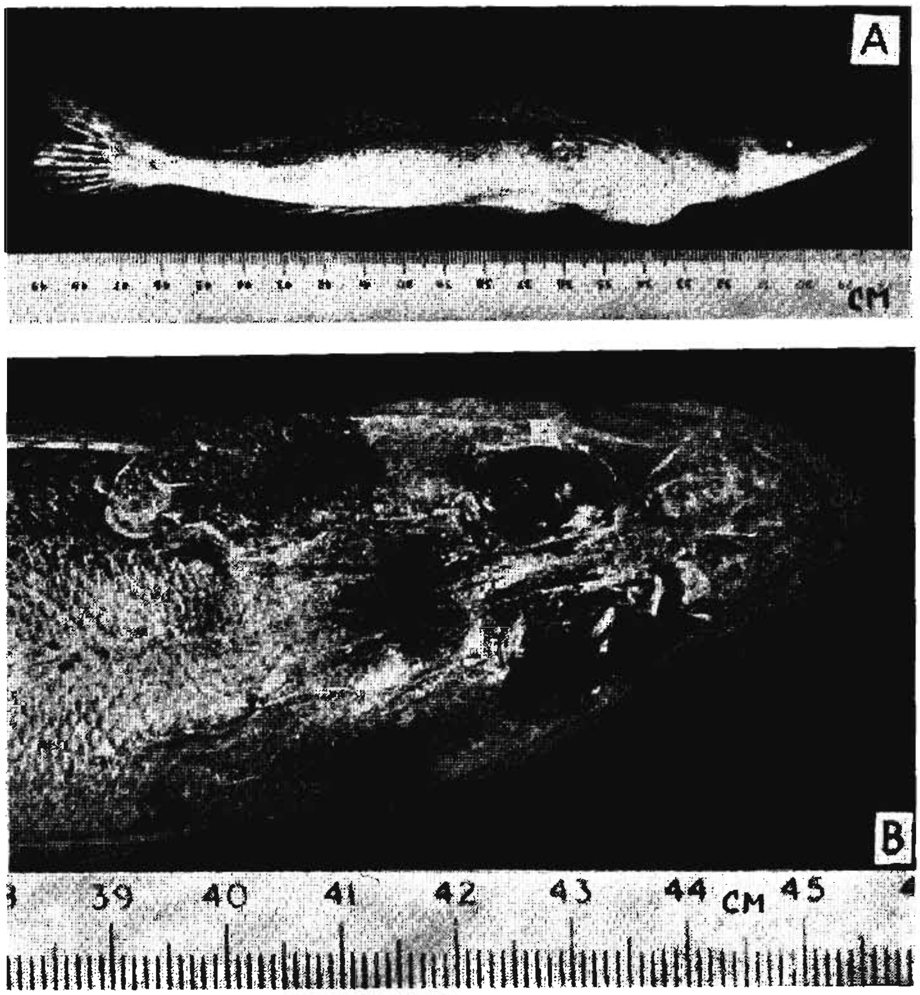

PLATE II. *Platycephalus isacanthus* Cuvier. A. Lateral view (note the subopercular flap). B. Dorsal view of head.

KEY TO THE SPECIES

1. Spinous dorsal with 9 spines, 4th spine longest ; vertical rows of dark spots with or without underlying black bands on sides ; pyloric caeca 2 .... *Drepane punctata*

2. Spinous dorsal with 8 spines, 3rd spine longest ; no dark spots ; with or without dark bands on sides ; pyloric caeca 3.......... *Drepane longimana*

Remarks : In this connection it may be worthwhile to mention the presence of small barbels (Fig. 1) measuring 3-5 mm in length, below the chin in both the species, which seem to have hitherto remained unnoticed by the earlier authors. These are arranged in 3-4 transverse rows ; those of the succeeding rows shorter than the preceding. In *D. punctata* their number varies from 2-10 and they appear to get reduced as the fish grows; and beyond 270 mm in total length, they are altogether absent. In *D. longimana* the number varies from 4-10 in all the specimens examined. The barbels are longer and thinner in *D. longimana* when compared to those of *D. punctata.*

Distribution : The distribution of *D. longimana* extends from the west and east coasts of Africa through Red Sea, seas of India to Australia and that of *D. punctata* from Red Sea and the east coast of Africa through seas of India to Australia.

Family : LABRIDAE

Stethoujlis interrupta (Bleeker) (Fig. 2)

Material : A single specimen from Gulf of Mannar near CMFRI jetty, 79 mm., deposited in the Reference Collection Museum of Central Marine Fisheries Research Institute No. CMFRI. F69/583.

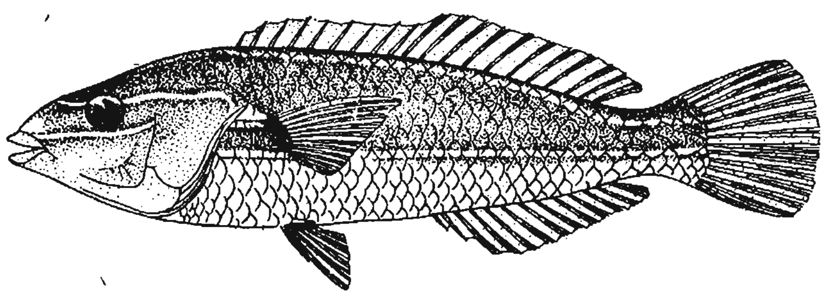

FIG. 2. *Stethojulis interrupta* (Bleeker) 79 mm.

D. IX, 11 ; A. III, 11 ; Pl. 14 ; P 2. I, 5 ; Ll. 28 ; Ltr. 2/1/9.

Height of body 3.8, length of head 2.7, length of pectoral 4.4, snout vent length 1.5 and snout to dorsal origin 2.7 in length without caudal and 4.6, 3.3, 5.6, 1.8 and 3.3 respectively in total length. Snout 3, eye 6 in length of head. Eye 2 in snout and 1.5 in interorbital space.

Head naked except near the occiput where the scales are small when compared to those on sides of body and scales on thorax slightly larger than those on sides of body. Mouth small, horizontal, teeth in jaws incisiviform in a single series with a well developed canine at the corner of the mouth. Lateral line continuous but bent obliquely after the 18th scale running on two scales and thereafter runs horizontally on 8 scales to the middle of caudal. Dorsal spines stiff and pungent. Pectorals about as long as head without snout.

Colour: In fresh condition reddish brown above and creamy below. The body with longitudinal red colour bands on sides. A longitudinal band, beginning from nape runs closely below the base of dorsal fin to the upper caudal rays. Another from middle of snout runs backward and downward through the upper border of eye to the dorsal edge of gill opening and ends just above the dark brown spot dorsal to the pectoral fin base ; another from tip of snout extends along lower edge of eye to the preopercular border ; a short band from gill opening to upper base of pectoral and below this another band runs parallel to this from gill opening to the anterior border of pectoral, interrupted here, but continues further after five scales to the middle of caudal. A dark blotch at pectoral axil. All the colour bands turn dull white on formalin preservation.

Distribution: Previously known from the Red Sea and east coast of Africa as far south as Bashee (cape province) and from Singapore, Indonesia, Coast of China, Philippines and New Guinea. The present report is the first from the central Indian Ocean.

Family : PLATYCEPHALIDAE

Platycephalus isacanthus Cuvier (Plate II, A)

Material: Thirty specimens from Palk Bay and Gulf of Mannar in the vicinity of Mandapam ranging from 144-211 mm T.L. Two specimens deposited in the Reference Collection Museum of Central Marine Fisheries Research Institute No. CMFRI. F. 144/573.

D. IX, 12 ; A. 12 ; P 1. 19-20 ; P 2. I, 5 ; L l. 55-57 ; Ltr. 8-10/1/14-17 ; Gill rakers 5-6.

Head 2.9-3.1 in standard length, 3.4-3.8 in total length. Height 7.4-10.1 in standard length 8.9-12.2 in total length. Body elongate dorsal side convex and ventral side flat. Head depressed (Plate II, B) its width 1.6-1.9 in its length. Maxilla reaching to below front border of eye. Eye 4.1-5.1 in head ; 1.2-1.6 in snout. The iris extending on the pupil is divided into a number of cirri. The supraorbital ridge serrated posteriorly with 6-9 small spines, the last one bigger than the preceding ones forming the beginning of the superior postorbital ridge. The superior postorbital ridge smooth ending in two small spines. The inferior postorbital ridge with 5-6 small spines, the last one somewhat larger than the others, terminating near the beginning of the lateral line. The suborbital ridge with a spine below the middle of eye, another below hind border of eye, and some times a third spine indistinct, at the base of the upper preopercular spine. Lateral line smooth, except for 4-5 anteriormost scales provided with small spines. A well developed triangular skinny flap present on the subopercle. The first dorsal spine about as long as eye ; the third spine longest. Pectorals rounded, length of pectoral 5.16-6.12 in standard length and 6.24-7.76 in total length. Ventrals not quite reaching anal. Caudal rounded.

Colour : In fresh condition reddish brown dorsally, light yellow ventrally. Dorsal spines and rays with small dark spots. Pectorals with small dark spots. Caudal with dark spots on rays as well as on membrane. Sometimes three to four broad dark brown cross bands on the upper side of the body which may disappear on preservation.

Distribution : The known distribution of the species extends westwards from Northern Australia and Waigeu through Philippines, Macao (South of Hong Kong) and Tourane (Viet Nam) to Singapore and the present record from the east coast of India is of interest.

Day (1878) described seven species of platycephalids from the seas around India. The description of the flat head given by him under the name *Platycephalus carbunculus* Cuvier and Valenciennes was found similar to that of *P, carbunculus* Cantor by Bleeker (1878) who described the same as a new species, *P. cantori. P. carbunculus* Valenciennes (1838) was reported from Bombay on the western coast of India, but Rao (1966) while giving a key to the known Indian species of *Platycephalus* in his paper '*Platycephalus bengalensis* sp. nov. from Bay of Bengal' did not include *P. carbunculus* Valenciennes. He included *P. pristiger* Cuvier and stated that it occurs in the Bay of Bengal off Waltair. Thus the number of species of *Platycephalus* (seven by Day including *P. cantori, P. carbunculus* Valenciennes, *P. bengalensis* Rao, *P. pristiger* Cuvier and *P. isacanthus* Cuvier) occurring in Indian seas becomes eleven.

SUMMARY

The distinctness of *Drepane longimana* (Bloch and Schneider) is corroborated, from the study of the specimens from Gulf of Mannar and Palk Bay. The occurrence of *Stethojulis interrupta* (Bleeker) and *Platycephalus isacanthus* Cuvier in the Indian seas (from the east coast of India) is reported for the first time.

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REFERENCES

BLEEKER, P. 1851. Bijdrage tot de kennis der ichthyologische fauna van de Banda-eilanden. *Nat. Tijdschr. Ned. Indie*, **2** : 252.

————. 1862. *Atlas Ichthyologique*. **1** : 133.

————. 1877. Revision des especes Insulindiennes De la Famile Des Chaetodontoides. *Verh. Akad. Amsterdam*, **17** : 21.

BLEEKER, P. 1878. Revision Des especes Insulindiennes Du Genre *Platycephalus*. *Ibid.*, **19** : 1-31.

BLOCH AND SCHENIDER. 1801. *Syst. Ichth.* : 229.

CANTOR, T. 1850. Catalogue of Malayan Fishes. *J. Asiat. Soc. Bengal*, **18** : 1021, 1143-1145 (1849).

CUVIER AND VALENCIENNES. 1829. *Hist. Nat. Poissons*, **4** : 246 Paris.

———. 1831. *Ibid.*, 7 : 129-136.

———. 1833. *Ibid.*, 9 : 461.

DAY, F. 1878. *The Fishes of India*. **2** : 116, 274-278. Barnard Quaritch, London.

GÜNTHER, A. 1860. Catalogue of acanthopterygian fishes in the collection of British Museum, **2** : 62-63.

HERRE, A. W. C. T. 1953. Check list of Philippine fishes. *Res. Rep. U.S. Fish. Wildl. Serv.*, **20** : 489.

LELE, S. H. 1924. Studies in Bombay fish. 1. Revision of the genus *Drepane* Cuv. & Val. *J. Proc. Asiat. Soc. Bengal*, **20** : 274-288.

LINNAEUS, C. 1785. *Systemma naturae* : 273. British Museum (N.H.) London.

MUNRO, IAN S. R. 1955. *The Marine and Fresh Water Fishes of Ceylon* : 169, Canberra.

RAO, V. VISWESWARA. 1966. *Platycephalus bengalensis* sp. nov. from Bay of Bengal. *Ann. Mag. Nat. Hist.*, Ser. 13, **9** : 123-127.

SMITH, J. L. B. 1949. *The Sea Fishes of Southern Africa*: 232, Central News Agency Ltd., S. Africa.

WEBER, M. AND DE BEAUFORT, L. F. 1935. *The Fishes of the Indo-Australian Archipelago*, **7** : 180-183. Leiden.

CONTRIBUTION 2

MURTY, V. SRIRAMACHANDRA. 1982. On the fishes of the family Platycephalidae of the seas around India.
<u>J. mar. biol. Ass. India</u>, 17 (3): 679-694 (1975).

J. mar. biol Ass. India, 1975, **17** (3): 679 - 694

ON THE FISHES OF THE FAMILY PLATYCEPHALIDAE OF THE SEAS AROUND INDIA*

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ABSTRACT

The fishes of the family Platycephalidae† popularly called "Flatheads" widely distributed in the Indio-Pacific region are of some commercial importance. Thirteen species of flatheads are so far Known to occur in the Indian Seas as reported by Day (1878), Munro (1955), de Beaufort and Briggs (1962) and others. As to their taxonomy, especially at their generic level, opinions vary among ichthyologists who studied the group. In view of their fishery importance along some parts of the Indian Coast and because of the paucity of any detailed information on the species, a comprehensive study of the group has been made, based on the collections made by the author from different parts of the Indian Coast and the material available in the Indian Museum, Calcutta. These have been compared with the descriptions of the type specimens available in the Museum National d 'Histoire Naturelle, Paris and Rijksmuseum van Natuurlijke Historie, Leiden. Detailed descriptions, distribution, synonymy and key to identification of genera and species of flatheads occuring along the Indian Coast are given in this paper.

INTRODUCTION

THE FISHES of the family Platycephalidae (flatheads or crocodile fishes) are distributed throughout the tropical Indo-West Pacific region. Day (1878) recorded seven species from the coasts of India and Ceylon. Munro (1955) recorded eight species from Ceylon; de Beaufort and Briggs (1962) described eight species as occurring in Indian Seas. Rao (1966) described a new species from Visakhapatnam and Murty (1969 a), George (1970) and Jones and Kumaran (1971) reported one species each as new records from the Indian Seas. Some species contribute significantly to the groundfish catches especially along the southwest coast of India.

As pointed out by Schultz (1960) it has been extremely difficult to make accurate identifications of these fishes because the available descriptions are inadequate; the cranial ridges and spines which are shown to be taxonomically important were not given due importance. Further, there is no up-to-date comprehensive information on these fishes from Indian Seas; the available keys for identification of species are either inadequate or do not include all the known species from the region.

Studies on this group from outside India include the works of Bleeker (1878), Jordan and Richardson (1908), Jordan and Hubbs (1925) and Matsubara and Ochiai (1905).

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† The platycephalids dealt with in this paper do not include members of the families Bembradidae, Bembridae and Parabembridae which have recently been incorporated in the family Platycephalidae by Greenwood *et al.* (1966).

In view of the fact that the available species descriptions are inadequate and the consequent difficulty in identifying them correctly, it was felt that a detailed account of these fishes from this region giving adequate descriptions based on examination of fresh material, key for identification and their distribution, is necessary to provide a basic reference for more comprehensive fishery biological studies of some of the species.

The present study deals with thirteen species that are known to occur in the seas around India. There is considerable confusion in assigning species to their respective genera. Some authors (de Beaufort and Briggs, 1962) preferred to include all the species under the genus *Platycephalus* Bloch. Schultz (1960) gave a tentative key to the genera. In the present paper an attenpt is made to assign the species to their respective genera; since there are several nominal genera and the type specimens of the type species could not be examined, the present arrangement can only be treated as tentative.

The author is thankful to Dr. S. Jones, former Director, Central Marine Fisheries Research Institute (CMFRI) for the encouragement and for the facilities and to Dr. E. G. Silas, Director, for going through the manuscript and offering suggestions for its improvement; late Dr. K.V. Sekharan and Mr. S. Reuben of the CMFRI Substation, Visakhapatnam; Mr. M. S. Muthu of CMFRI unit, Kakinada and Dr. K. C. George of CMFRI, Cochin have kindly sent material from their respective areas and the author is very much obliged to them for their help. The author is also thankful to the Director, Zoological Survey of India for permitting him to examine the collections of platycephalids in the Museum of Zoological Survey of India and to Dr. A. G. K. Menon, Superintending Zoologist, Zoological Survey of India for the help rendered. Thanks are due to Dr. J. Guibe of Museum National d'Histoire Naturelle, Paris and to Dr. Boeseman, Curator of fishes, Rijksmuseum van Natuurlijke Historie, Leiden for kindly sending data on certain Types. Dr. F. H. Talbot of the Australian Museum, Sydney, has kindly arranged to send some relevant literature.

Material and Methods

The specimens for this study were collected from Visakhapatnam, Kakinada, Madras, Pondicherry, Tuticorin and Mandapam on the east coast and Bombay, Cochin and Neendakara on the west coast. In addition to these, the collections of this family in the Zoological Survey of India, Calcutta (ZSI) and National Museum, Sri Lanka were also examined. Morphometric and meristic data of the relevant type specimens in the Museum National d'Histoire Naturelle, Paris and Rijksmuseum van Natuurlijke Historie, Leiden also have been utilised for comparison. In taking measurements, total length (TL) was measured from tip of snout to the tip of caudal fin and Standard length (SL) from tip of snout to base of caudal fine. Head length was taken from tip of snout to the posterior margin of the operculum and head width between the bases of the upper preopercular spines of the two sides. Eye diameter is the horizontal diameter of bony orbit. L. tr. includes the count of scales from origin of first dorsal obliquely backwards to lateral line, the one in the lateral line and from origin of anal obliquely forwards to lateral line. Vertical rows of scales above lateral line are counted from above the lateral line from its origin to the end at the base of caudal fin. The nomenclature of various ridges on head is taken from Schultz (1960). No attempt has been made to include all the synonyms under each species; only the original reference and all the references from the area under study are included. The species for which adequate descriptions are available from this region, are not described in this paper.

Speoimens of the species collected by the author and utilised in this study have been deposited in the Reference collection Museum of the Central Marine Fisheries Research Institute (Murty, 1969 b).

KEY TO GENERA OF PLATYCEPHALIDAE FROM INDIA

1. Teeth on vomer in a continuous crescent-shaped band .... *Platycephalus* Bloch

   Teeth on vomer separated medially into two subovate patches by deep edentulous furrow 2

2. Suborbital ridges finely serrate 3

   Suborbital ridges not finely serrate; with distant spines or entirely smooth......4

3. Preopercle with strong antrorse spine on lower side..*Rogadius* Jordan and Richardson

   No antrorse preopercular spine, preocular with 2–3 spines ....*Wakiyus* Jordan and Hubbs

4. Eye with a dermal cirrus (tentacle) ....*Thysanophrys* Ogilby

   Eye without a dermal cirrus 5

5. All lateral line scales spiny .... *Gramnoplites* Fowler

   Only first few scales or anterior half of lateral line spiny......*Suggrundus* Whitly

Genus: **Platycephalus** Bloch 1975

Platycephalus Bloch (1795). *Nat. Ausland Fische*, 9: 76 (Type species : *Platycephalus spathula* Bloch = *Callionymus indicus* Linnaeus).

Platycephalus indicus (Linnaeus)

Callionymus indicus Linnaeus (1758). *Syst. Nat. ed.* ,10: 250.
Platycephalus insidiator Day (1878). *Fish. India*, 276.
Thysanophrys indicus Munro (1955). *Marine and freshwater fishes of Ceylon*, 253. Misra, (1962). *Rec. Indian Mus.*, 57:304.
Platycephalus indicus de Beaufort and Briggs (1962). *Fish. Indo-Aust. Archipel.*, 11.

Material examined: 1 specimen 363 mm from Tuticorin (Gult of Mannar); 4 specimens 191, 207, 243, 312 mm from Mandapam (Palk Bay); 2 specimens 156, 188 mm from Athankarai Estuary (Palk Bay) 1 specimen 362 mm from Madras (Day's collection) ZSI No. 112–115; 1 specimen 180 mm from Chilka Lake ZSI F. 11086/1; 4 specimens 216, 166, 373, 386 mm from Akyab, ZSI Dup. Cat. Nos. 47, 272, 398, and F. 1510/1; 1 specimen 215 mm from Burma ZSI F. 12079/1; 1 specimen 175 mm from Namkhana ZSI F. 4981/2; 1 specimen 175 mm from Philippines, ZSI F. 4222/2.

Description: D. IX, 13; A. 13; 18–19; V. 1, 5; Ll. pored 61-74; Vertical rows of scales above lateral line 105-136; L. tr. 11-15/1/25-38; G. R. 2 + 1 + 5.

Head 3.04-3.85 in SL, 3.50-4.02 in TL, body depth 9.17-17.18 in SL, 10.58-19.63 in TL. head width 1.24-1.63 in its length. Eye 5.00-8.08 in head; 1.37-2.25 in snout, head strongly compressed, maxilla reaches to below middle of eye. Interorbital space rather flat and wide, 0.62-1.26 times wider than eye diameter. Teeth villiform, those on upper jaw at the symphysial region pointed, in a cresent shaped band on vomer and in two narrow longitudinal bands on palatines; some on vomer and palatines slightly pointed (on vomer the pointed teeth are at the end of the crescent). Ridges between nostrils smooth, run parallel backwards up to middle of interorbital space. A short but strong spine on anterior orbital rim. Supraorbital ridge completely smooth, superior postorbital ridge also smooth, but in large specimens with single spine posteriorly; inferior postorbital ridge with a spine anteriorly and with two to four spines posteriorly, last one longer and in line with lateral line. Suborbital ridge, smooth sometimes with single spine below hind border of eye. Two strong sub equal preopercular spines, upper one at an angle to suborbital ridge. Opercular ridges flat and smooth, lower ridge not very prominent. A prominent triangular subopercular flap present. Head completely scaly. First lateral line scale keeled. First dorsal spine short, second and third spines more or less of same length, nineth spine not connected with eighth one; first ray of soft dorsal longest. Pectoral more or less rounded, 6.00 to 7.31 in SL; 6.92–8.31 in TL. Pelvic sometimes reaches anal origin; 4.83-5.90 in SL; 5.80-6.75 in TL. Caudal truncate.

Colour: Brown above and pale yellow below. Sometimes two cross bands on posterior dorsal side. Pectoral, pelvic and dorsal fins spotted. Caudal yellowish with two oblique black bands with white borders.

Distribution: Extends westwards from coasts of New Guinea, Philippines, seas of Japan, through Celebes, Borneo, Java, Sumatra, Burma, Andaman Coasts of India, and Sri Lanka to east coast of Africa and the Red sea.

Remarks: Cantor (1850) and Matsubara and Ochiai (1955) reported ten dorsal spines in this species and according to them first spine is very small or rudimentary and hidden. All other authors have reported only eight spines in first dorsal fin. In all the present specimens the author counted only nine spines. First rudimentary (Cantor, 1850) or isolated reclining spine (Matsubara and Ochiai, 1955), however, could not be seen even with a lens.

Genus: **Rogadius** Jordan and Richardson

Rogadius Jordan and Richardson, 1908. *Proc. U. S. Nat. Mus.*, 33:630. Type species: *Platycephalus asper* Cuvier.

Rogadius pristiger (Cuvier) (Pl. I)

Platycephalus pristiger Cuvier (1829). *Hist. nat. Poiss.*, 4:260; de Beaufort and Briggs (1962). *Fish. Indo-Auster. Archipel.*, 11:139-140.

Regadius asper Munro (1955). *Marine and freshwater fishes of Ceylon*. 251. (*nec.* Cuvier)

Material excmined: 2 specimens 105 and 111 mm SL from Sri Lanka (collected at 34 fathoms) ZSI No. 11745; 3 specimens 97, 102 and 118 mm SL from off Ganjam Coast (Bay of Bengal) ZSI Nos. 12951, 12952, 12953; 1 specimen 56 mm SL from Andaman Sea (6 m) ZSI No. F. 424/2; 1 specimen 58 mm SL from Nicobar Island; ZSI No. F. 424/2; and 2 specimens 94 and 105 mm SL from Andaman Sea, ZSI F. 812/1 and 813/1.

[4]

Description: D. IX, 11; A. 11; p. 19-23; V. I, 5; Ll pored 52-54, vetical rows of scales above lateral line 54-58; L. tr. 6-7/1/20-21; G. R. 1 + 1 + 5-6.

Body depth 5.6-6.9, head 2.5-2.6 in SL. Head width 1.6-1.9, eye diameter 3.0-3.5 in head length, eye 1.0-1.1 in snout. Body width at the insertion of pelvics 5.00-5.60 in SL. Teeth in jaws villiform, on vomer in two distinct oval patches, on palatines in two narrow bands. Teeth on vomer and palatines pointed. Anterior nostril with a flap. Interorbital space narrow, 5.0-7.0 in eye diameter. Two completely serrated longitudinal parallel ridges between nostrils on both sides. A strong spine on anterior orbital rim. Supraorbital ridge smooth anteriorly, serrated posteriorly and continued to behind eye as superior postorbital ridge which also serrated ending in two spines. Anterior portion of inferior postorbital ridge serrated, posterior portion with two to three strong spines, last one in line with beginning of lateral line; suborbital ridge completely serrated ending in a long pre-opercular spine. Three to four spines below upper preopercular spine and a strong antrorse spine below. Opercle with two smooth ridges each ending in a spine. Opercle and preopercle with ctenoid scales. Lateral line smooth excepting anterior 4-6 scales which are spiny. First dorsal spine small, third spine longest equal to postorbital part of head. Pectoral rounded; pelvics reach anal origin.

Colour: Specimens preserved in alcohol brown above, light below. Spinous dorsal dark on distal half; rays of soft dorsal with faint longitudinal rows of spots. Pectorals with dark spots, pelvics and caudal dusky. Cross bands on body not clear.

Distribution: Known from Queensland, New Guinea, Philippines, Indonesia (Batjan), Ternate, Menado, Makassar, Lombok, Bali and Singapore in the Pacific; Andamans Islands, Sri Lanka, Visakhapatnam and Ganjam Coast (Bay of Bengal), Seychelles, Gulf of Oman and Gulf of Aden in the Indian Ocean.

Remarks: This species was described by Cuvier (1829) from Sri Lanka; Day (1878) did not include this species. To date there has not been published account of this species from the Indian Coasts except for a mention by Rao (1966). Hence the present description of this species happens to be the first from the Indian Coast.

Genus: **Wakiyus** Jordan and Hubbs, 1925

Wakiyus Jordan and Hubbs (1925). *Mem. carnegie Mus.*, 10:286 (Type species:*Platycephalus spinosus* Temmnick and Schlegel).
Sorsogona Herre (1934). *Fish. Zool. Mus. Stanford Univ.*, 1:67 (Type species *Sorsogona serrulata* Herre = *Platycephalus tuberculatus* Cuvier).

Key to Species of Genus Wakiyus from India

D. IX, 11; A. 11-12; ridges of head finely serrated, 21-22 anterior scales of lateral line spiny..*W. tuberculatus* (Cuvier)

D. IX, 12; A. 12; headridges serrated but destitute of spines; only 3-5 scales of the lateral line spiny ....*W. serratus* (Cuvier)

Wakiyus tuberculatus (Cuvier 1829) (Pl. II A, B)

Platycephalus tuberculatus Cuvier (1829). *Hist. nat. Poiss.*, 4: 258–259; Day (1878). *Fish. India.*, 275; de Beaufort and Briggs (1962). *Fish. Indo-Aust. Archipel.*, 11:142-143: Misra, (1962). *Rec. Indian Mus.*, 57:304.

Sorsogona serrulata Herre (1834). 67.
Suggrundus tuberculatus: Munro (1955). *Marine and freshwater fishes of Ceylon,* 252.

Material examined: 21 specimens ranging from 51-125 mm from Palk Bay and Gulf of Mannar near Mandapam; 3 specimens 105-124 mm from Madras; 3 specimens 72-81 mm from Pondicherry; 1 specimen 135 mm fιom Madras, ZSI No. 1856 (Day's collection); 1 specimen (length not recorded) ZSI No. 1857 Day's collection; and 1 specimen 94 mm from Sri Lanka, Ceylon National Museum No. F.M. 94.

Description: D. IX, 11; A. 11-12; P. 19-21; V. I, 5; Ll pored 52-56; vertical rows of scales above lateral line 53-59; L. tr. 5/1/13-16; G. R. 1 + 1 + 5-6.

Body depth 6.1-8.0 in SL, 7.2-9.6 in TL. Head 2.5-2.9 in SL, 3.11-3-46 in TL. Head width 1.35-1.77 in its length. Eye 3.37-4.40 in head, 1.00-1.40 in snout Interorbital space 3.2-5.0 in eye. Anterior nostril with a flap. Villiform teeth in jaws; in two oval patches on vomer and in two elongate bands on palatine. Some teeth on vomer and palatines pointed. Two longitudinal serrated ridges between nostrils. Two to four spines on anterior orbital rim; Supraorbital ridge completely serrated. Superior and inferior postorbital ridges denticulated former with last two spines slightly elongate and ending at origin of lateraline. Suborbital ridge finely serrate ending at base of strong preopercular spine which is short and not reached gill opening. Two to three smaller spines below upper preopercular spine. Lower opercular ridge finely serrated ending in a spine. 21-22 anterior scales of lateral line spiny. Opercle and preopercle scaly, rest of head naked. Some scales on opercle and preopercle tuberculate and small. First dorsal spine short, third spine longest as long as or just shorter than second ray of soft dorsal. Pectoral rounded, pelvics reach anal.

Colour: Brown above, light below. 2-5 broad transverse bands on upper side, region between pelvics and at anal origin pigmented black. Dorsal spines and rays with back spots. Pectorals and pelvics with black bands. Caudal black.

Distribution: Red Sea, coast of Natal, coasts of India, Singapore, Philippines and Queensland.

Remarks: Cuvier (1829) stated "La lingne laterale est presque aussi epineuse qu au *scaber*" but unlike in *scaber* the type of *tuberculatus* in the Paris Museum has only 25 spiny scales in lateral line, and in present specimens only anterior 21-22 scales of lateral line are spiny.

Cuvier (1829) gave a dorsal fin count of D. 9-1/11 and Day (1878) gave it as 1/7-8/11-12, but in all the specimens examined (including those of Day in the Indian Museum) the present author could count only 9 spines and 11 rays.

De Beaufort and Briggs (1962) considered *Sersogona serrulata* Herre as a doubtful synonym of *tuberculatus Cuvier.* In the present description it is considered as a synonym of *W. tuberculatus.* Schultz (1960) recognised *Sorsogona* Herre as a valid genus with *S. serrulata* as its type. However, since there are 2-4 preocular spines and suborbital ridge completely serrated in *tuberculatus*—the characters of *Wakiyus* Jordan and Hubbs (1925), genus *Sorsogona* Herre is considered as asynonym of *Wakiyus* Jordan and Hubbs. Ridge of lower opercular spine distinctly serrated in *tuberculatus.* This character alsofound in *serratus* belonging to *Wakiyus;* in *rodericensis* which is assigned to genus *Suggrundus* Whitly here, the author found this ridge spiny at least anteriorly. Hence it is felt that this character does not provide a 'decided gap' (Mayr, 1969) of generic significance.

Wakiyus serratus (Cuvier 1829)

Platycephalus serratus Cuvier (1829). *Hist. nat. Poiss.*, 4:259-260; Peters (1876). *Akad. Wiss. Berlin. Monatsb.*, 839 (1876); Day (1878), *Fish. India*, 276.
Suggrundus serratus: Munro (1955). *Marine and freshwater fishes of Ceylon*, 252.

Material examined: 6 specimens 115-124 mm from Laccadive Sea ZSI F. 896/1; 901/1-904/1 and F. 906/1.

Description: D. IX, 12; A. 12; P. 19-20; V. 1, 5; Ll pored 42-50; vertical rows of scales above lateral line 55-65; L. tr. 6/1/17-19; G. R. 1+1+7-8.

Body depth 5.8-6.7 in SL, 6.6-8.8 in TL. Head 2.6-2.7 in SL, 3.0-3.2 in TL. Head width 1.8-1.9 in its length. Eye 3.3-3.9 in head and equal to snout. Interorbital space 2.7-3.5 in eye diameter. Body subcylindrical and head depressed. Teeth in jaws villiform, a few pointed; those on vomer slightly pointed and curved, arranged in two oval patches; similar teeth on palatines in two longitudinal banks. Two longitudinal serrated ridges on either side of median line between nostrils, which extend back to interorbital space. Anterior orbital rim elevated, preocular with two to three spines. Supraorbital ridge and superior postorbital ridge serrated completely the latter ending in a spine. Inferior postorbital ridge serrated with two moderate spines posteriorly at beginning of lateral line. Suborbital ridge serrated completely ending at beginning of strong preopercular spine which is 1.9-2.2 in eye; 3 moderate spines below upper preopercular spine, no trace of an antrorse spine below. All serrated ridges are destitute of spines. Anterior part of lower opercular ridge serrated, posterior part smooth ending in a spine; upper ridge completely smooth. Opercle and preopercle scaly.

First dorsal spine short 1.3-1.6 in eye; third spine longest and 2.2-2.3 in head. Lateral line smooth except first 3-5 scales which are spiny.

Colour: Specimens preserved in alcohol - body brown above and light below; spinous dorsal with a dark blotch; second dorsal with dark spots on rays. Pectorals with dark irregular spots on rays; pelvics dark.

Distribution: First described from Sri Lanka (Trincomale) and subsequently recorded from New Ireland. The present description from the Laccadive Sea is first from the seas around India.

Remarks: Cuvier (1829) described this species from east coast of Sri Lanka and subsequently Peters (1876) reported it from New Ireland. There does not seem to be any other authentic record of this species from anywhere else. De Beaufort and Briggs (1962) did not include this species. None of the available descriptions is adequate for correct identification of the species.

The present specimens conform the description of Cuvier (1829) except that according to him there are 11 rays in anal fin whereas in all present specimens there are 12 rays. It appears that Cuvier had a doubt with regard to the presence of at least very small antrorse preopercular spine but in present specimens there is no trace of such a spine.

Genus: **Thysanophrys** Ogilby, 1889

Thysanophrys Ogilby (1889). *Proc. Linn. Soc. N. S. W.*, 23; 40. (Type species: *Platycephalus cirronasus* Richardson).

KEY TO SPECIES OF GENUS *THYSANOPHRYS* FROM INDIA

Anterior part of the supraorbital ridge smooth, posterior portion serrated; vertical rows of scales above lateral line 82–97........................*T. carbunculus*

supraorbital ridge completly serrated; vertical rows of scales above lateral lines about 68..*T. cantori.*

Thysanophrys carbunculus (Valenciennes) (Pl. II C)

Platycephalus carbunculus Valenciennes (1833). *Hist. nat. Poiss.*, 9: 461; De Beaufort and Briggs (1962). *Fish. Indo-Australian Archipel.*, 11.
Suggrundus carbunculus: Munro (1955). *Marine and freshwater fishes of Ceylon*, 253.

Material examined: 13 specimens 82-162 mm from Palk Bay and Gulf of Mannar near Mandapam; 1 specimen 102 mm from Bay of Bengal, ZSI F. 421/1; 6 specimens 77-139 mm SL from Arakan Coast (Burma), ZSI cat. 123.

Description: D. IX, 11-12; A. 12-13; P. 18-19; V. I. 5; Ll pored 51-55; vertical rows of scales above lateral line 82-97; L. tr. 9-11/1/25-29; G. R. 1+1+3–4.

Body depth 7.0-9.6 in SL; 9.1-10.1 in TL. Head 2.8-3.2 in SL; 3.4-3.9 in TL. Eye 3.4-4.2 head; 1.0-1.1 in snout. Teeth villiform, in two distinct oval patches on vomer, in two narrow bands on palatines. Maxillary reaches to below anterior border of pupil. Anterior nostril with a flap. A ridge on either side of median line between nostrils, bearing 1-2 spines. Anterior orbital rim with a short spine. Supraorbital ridge smooth anteriorly and serrated from above anterior border of pupil, serrations more prominent posteriorly; superior postorbital ridge with 3-4 spines, last one generally at a distance from others and slightly longer; inferior postorbital ridge with 5–6 spines, last one longer than others and in line with lateral line. Suborbital ridge with a spine at its beginning, one or two below middle of eye and three to four spines behind this, last one at the base of upper preopercular spine which is short, not reaching gill opening. Two small spines below upper preopercular spine. Opercle with two smooth ridges ending in spines. Opercle and preopercle scaly. A small simple tentacle on eye above middle of pupil. Lateral line smooth except for anterior 2-4 spiny scales. Subopercular flap not prominent.

First dorsal spine small, 2.00-2.30 in eye, third spine longest and equal to or slightly smaller than postorbital part of head. Pectoral rounded, 4.7-5.6 in SL; 5.7-6.7 in TL. Pelvics reach anal, 4.2-4.7 in SL; 5.1-5.6 in TL. Caudal rounded.

Colour: Body dark brown above and white below. Four broad dark brown bands on dorsal side: one near posterior end of spinous dorsal, another near beginning of second dorsal; third near posterior end of second dorsal and fourth one on caudal peduncle. These bands extend to sides also but divided into irregular blotches there. Two crossbands from eye over check, posterior broader than anterior, another band from preopercular angle below. Spinuous dorsal with abroad brown band distally; second dorsal and anal rays with brown spots. Pectoral with small spots on rays forming irregular crossbands. Pelvics with three or four rows of spots on rays and caudal with 4 cross bands.

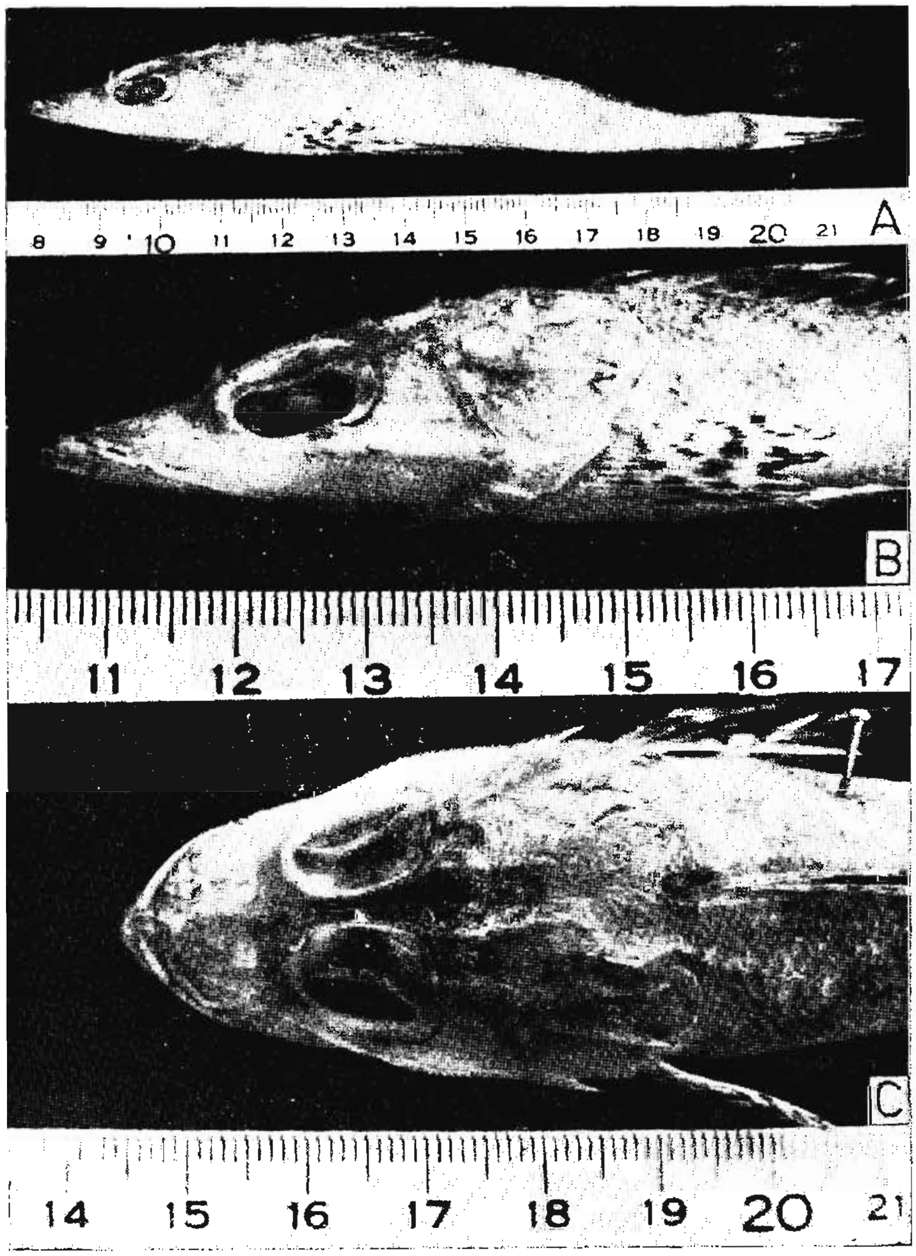

PLATE I. *Rogadius pristiger* (Guvier) - A. Lateral view, B. Anterior lateral side enlarged to show the antrorse preopercular spine and C. Dorsal side of head.

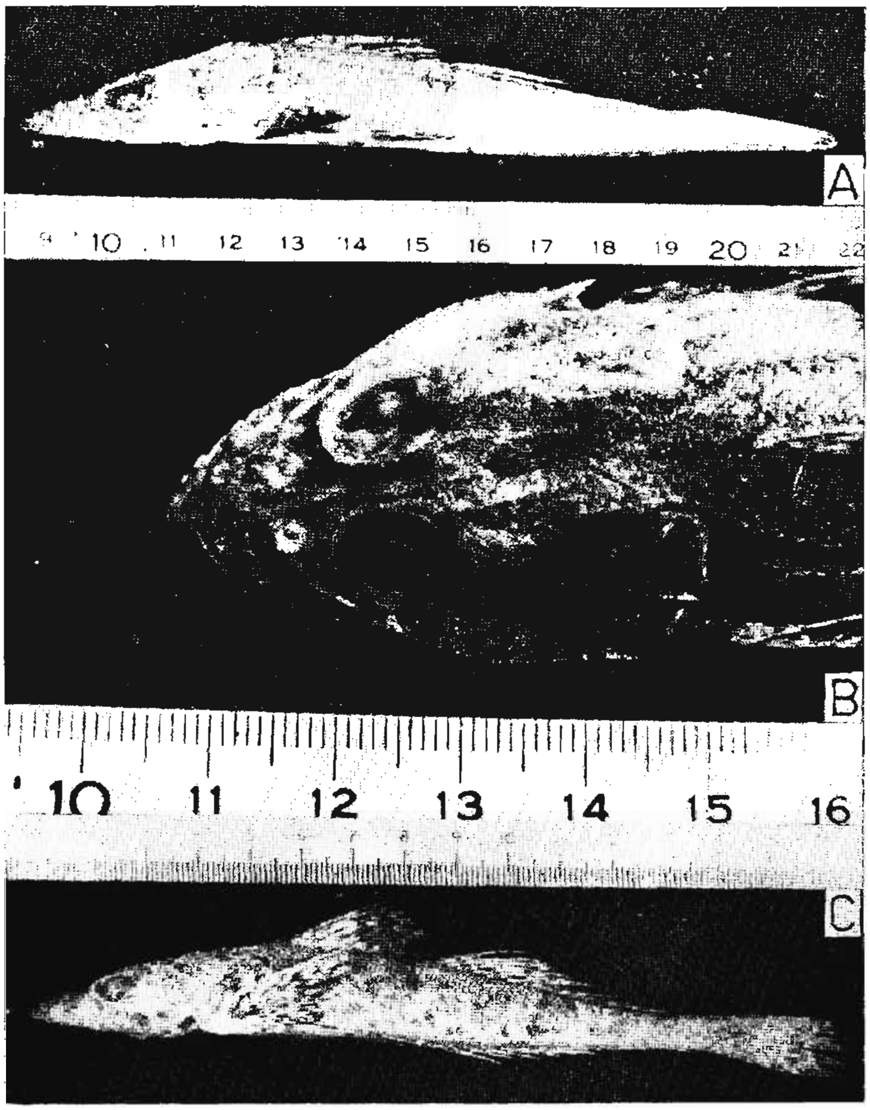

PLATE II A. *Wakiyus tuberculatus* (Cuvier) – lateral view, B. *W. tuberculatus* – dorsal view of head and C. *Thysanophrys carbunculus* (Valenciennes) – lateral view.

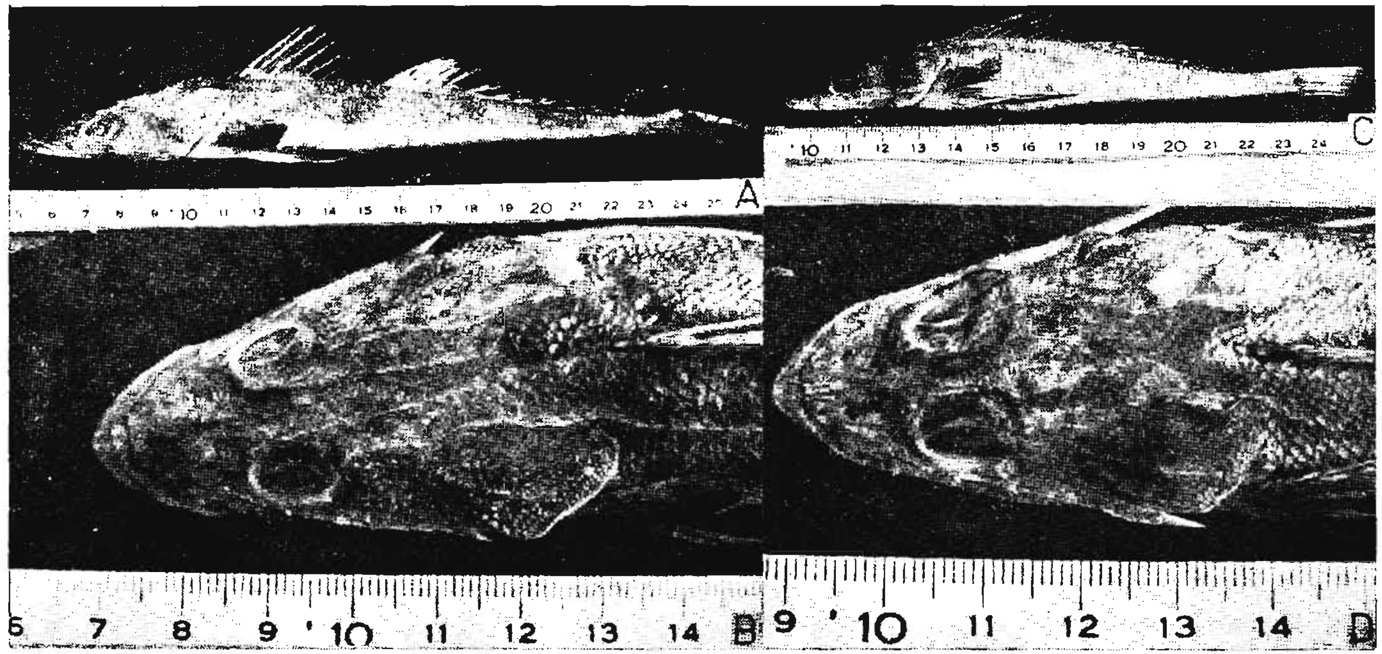

PLATE III A. *Grammoplites scaber* (Linnaeus) - lateral view, B. *G. scaber* - dorsal view of head, C. *Suggrundus rodericensis* (Cuvier) - lateral view and D. *S. rodericensis* - dorsal view of head.

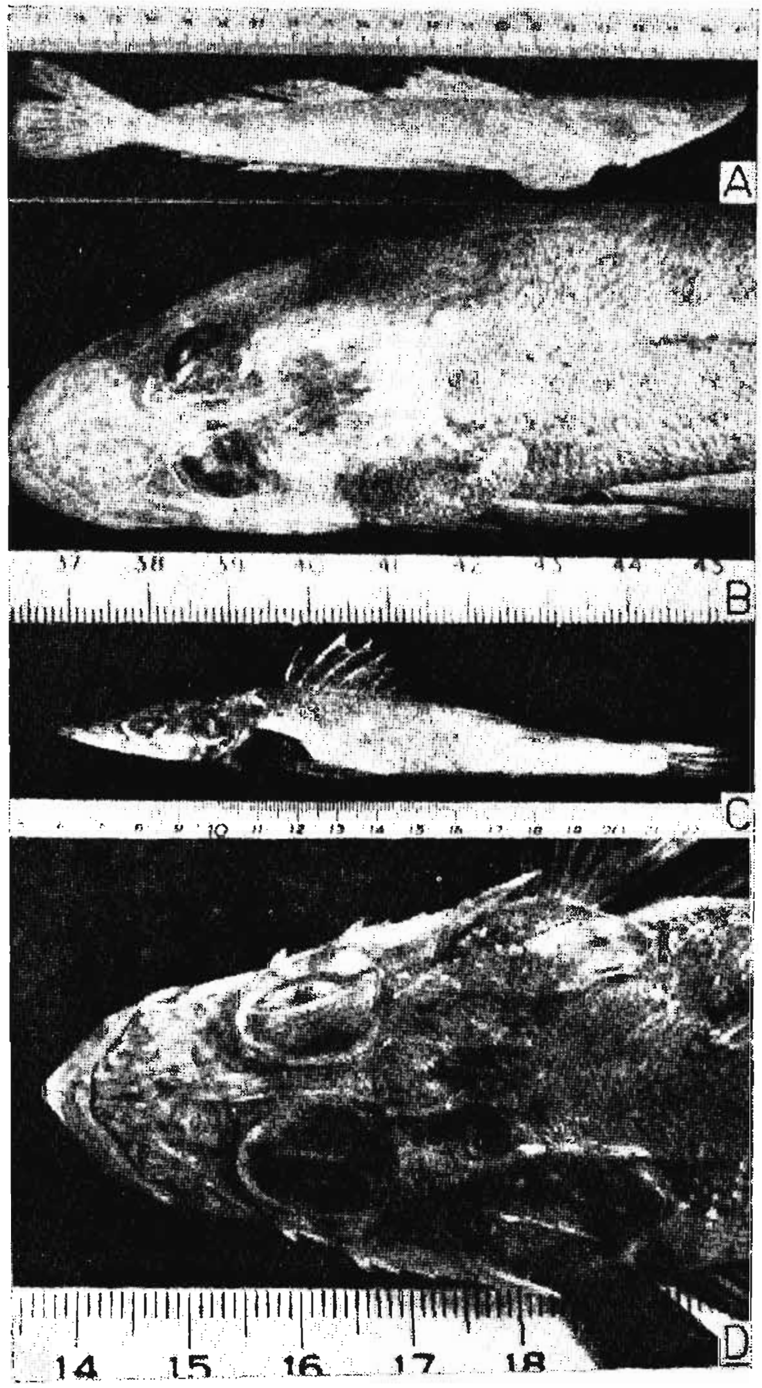

PLATE IV A. *Suggrundus isacanthus* (Cuvier) – lateral view, B. *S. isacanthus* – dorsal view of head, C. *S. bengalensis* (Rao) – lateral view and D. *S. benaglensis* – dorsal view of head.

Distribution: Known from Singapore, Bintang, Banka, Java, Borneo, Celebes, Aru Islands, Tonkin and Bombay.

Remarks: Valenciennes (1833) first described this species from Bombay. So far there is no other report of this species from Indian Coast; present report is the first from Bay of Bengal and south east coast of India. Also this happens to be the first record for coast of Burma (ZSI Cat. 123.)

Of twenty specimens of this species examined only two specimens (199 mm SL from Arakan Coast, and 115 mm SL from Mandapam) have 13 rays in the anal and one specimen (137 mm SL from Mandapam) has 12 rays in the second dorsal which are different from counts given by Valenciennes for this species (D. IX, 11; A. 12). None of the authors gave any range for these counts, but for Bleeker (1878) who gave "11 (12)" and "12 (13)" for second dorsal and anal respectively. However, present specimens agree with *carbunculus* Valenciennes in all other essential characters.

De Beaufort and Briggs (1962) did not include *carbunculus* described by Munro (1955) under synonmy of this species. The description given by Munro is inadequate to come to any conclusion since it does not give the essential characters: tentacle on eye, serrations on head ridges, etc.

Thysanophrys cantori Bleeker

Platycephalus cantori Bleeker, (1878). *Verh Akad. Amsterdam* (Revision *Platycephalus*), 19:26. De Beaufort and Briggs. *Fish. Indo-Australin Archipel.*, 11:149-151.
Platycephalus carbunculus: Cantor, 1849. *J. Asiatic Soc. Bengal,* 18: 1021; 1850. Valenciennes Day (1878). *Fish. India.* 278 *nec.* Valenciennes.
Platycephalus malabaricus: Günther. *Cat. Br. Mus*,. *II:* 181 (proparte) (*nec.* Cuvier).

Platycephalus carbunculus described by Cantor (1850) from Pinang was considered as a new species *P. cantori* by Bleeker (1878). Day (1878) followed Cantor in giving the description of what he called *P. carbunculus* Cuvier and Valenciennes and gave the distribution of this species as western coast of India to Malay Archipelago. De Beaufort and Briggs (1962) in a note under the description of *P. cantori* remarked that "It is not known whether Day saw the specimens of what he called *carbunculus* but his description resembles that of *carbunculus* of Cantor and hence referable to *cantori.*" They gave the distribution for this species as western coast of India, Madras and Pinnang.

The present author could not collect at least one specimen of this species from the Indian Coasts. It is possible that Day (1878) followed Cantor (1850) for the description of *carbunculus* and that on the basis of the report of *carbunculus* by Valenciennes from Bombay and that of Cantor from Pinang, gave the distribution as western coast of India to Malay Archipelago for his *Carbunculus* There is however no authentic report of *cantori* from India and its occurrence in the area is doubtful especially since "it is not known whether Day saw specimens of what he called *carbunculus*". Hence the occurrence of *cantori* from India needs confirmation.

Genus: **Grammoplites** Fowler, 1904

Grammoplites Fowler, 1904. *J. Acad. nat. Sci. Philadelphia,* 12:550. (Type species: *Cottus scaber* Linnaeus).

KEY TO SPECIES OF GENUS *GRAMMOPLITES* FROM INDIA

Upper preopercular spine long and strong reaching to gill opening; a black blotch posteriorly on the distal half of the spinous dorsal between 6th and 9th spines; the spines on the lateral line not very prominent especially posteriorly ....*Grammoplites maculipinna* (Regan)

Upper preopercular spine short not reaching gill opening, the distal half of spinous dorsal completely dark; the spines on the lateral line very prominent more so posteriorly...*Grammoplites scaber* (Linnaeus)

Grammoplites maculipinna (Regan) 1905

Platycephalus maculipinna Regan, 1905. *J. Bombay nat. Hist. Soc.*, 16: 318–324; George, 1970. *J. mar. biol. Ass. India*, 10: 355–356.
Thysanophrys scaber: Flower, 1928. *J. Bombay nat. Hist. Soc.*, 33: 117.

Material examined: 12 specimens 175-270 mm from Neendakara (Kerala Coast); 2 specimens 127 and 175 mm from Bombay 1 specimen 240 mm from Alleppey Coast, ZSI F. 5352/2.

Description: D. IX, 12-13; A. 13; P. 21-23; V. 1, 5; Ll pored 53-56; vertical rows of scales above lateral line 91-101; L. tr. 10-11/1/31-38; G. R. 1+1+6–7.

George (1970) gave a detailed description of this species.

Remarks: The specimens examined conform to the original description by Reagan (1905) in all characters; in only one specimen (175 mm from Bombay) the soft dorsal has 13 rays as against the count given by Regan (12) and in all the specimens examined by the present author.

Distribution: From Muscat (Gulf of Oman) through Bombay to Kerala Coast.

Grammoplites scaber Linnaeus (Pl. III A, B)

Cottus scaber Linnaeus (1785). *Syst. nat.*, ed. 10, 264.
Platycephalus scaber Day (1878). *Fish. India*, 275; De Beaufort and Briggs 1962. *Fish. Indo-Aust. Archipel.*, **11**: 140–142.
Grammoplites scaber Munro (1955). *Marine and fresh-water fishes of Ceylon*, 251.

Material examined: 10 specimens 105-182 mm from Palk Bay and Gulf of Mannar near Mandapam; 4 specimens 127-280 mm from Neendakara (Arabian Sea); 2 specimens 137, 180 mm from Madras; 2 specimens 152, 161 mm from Laccadives, ZSI F. 898/1, and 899/1; 3 specimens from Madras, ZSI 1858; ZSI 1852-55 (Day's collection); ZSI 1181/2 from Karaikal; ZSI F. 5146/2 from Cochin; ZSI F. 2208/1, 2210/1 from Orissa Coast; ZSI F. 532/2 from river Hooghly; ZSI 9121 from Pinang; ZSI 11217 from Orissa Coast; ZSI F. 1180/2 from Sankuppam and ZSI F. 1183/2 from Karaikal.

Description: D. IX, 12; A. 12-13; P. 19-22; V. I, 5; Ll pored 52-55; vertical rows of scales above lateral line 99-108; L. tr. 10-11/1/29-32; G. R. 1+1+4–6.

Body depth 9.33-13-87 in SL, 10.55-15.87 in TL. Length of head 2.97-3.42 in SL, 3.42-3.96 in TL. Head width 1.66-2.31 in its length; eye diameter 4.14-5.38 in head, 1-12-1.57 in snout. Interorbital space 1.80-3.50 in eye. Maxillary reaches to below middle of eye; anterior nostril with a flap. Teeth villiform in two distinct oval patches on vomer and in two elongate bands on platines. Ridges between anterior nostrils with a spine on each, between these two ridges from posterior part, two smooth ridges extend parallel upto anterior part of interorbital. A strong pointed spine on anterior orbital rim. Supraorbital ridge smooth in its anterior half, serrated posteriorly and continued as fan-like diverging low ridges, central one forming superior postorbital ridge which has 3-6 spines. Inferior postorbital ridge with 5 spines at its beginning; 3 spines below anterior half of eye, one spine below middle of eye, one spine below posterior border of eye and 2-3 spines behind it, last one at base of upper preopercular spine which is short and does not reach gill opening, 1.16-2.50 in eye and 6.16-10.00 in head length; two small spines below it. Opercle with two smooth ridges ending in spines. Opercle and preopercle scaly. First dorsal spine small, third spine longest and equal to or slightly smaller than first ray of second dorsal. Height of anal slightly less than that of second dorsal. Pectorals rounded 6.93-8.51 in SL, 7.93-9.65 in TL. Pelvics 4.94-5.68 in SL, 5.58-6.56 in TL. Caudal rounded. Lateral line completely spiny, spines strong and very prominent posteriorly.

Colour: Brown above and light below, about 4 dark vertical bands on dorsal side which extend to sides also. First dorsal with minute dark spots and black on distal half. Second dorsal, anal, caudal and pectoral with small spots; pelvic dark with minute black pigment spots.

Distribution: Coasts of Natal and Zululand, Madagascar, Reunion, coasts of India, Sri Lanka, Singapore, Sumatra, Nais, Banka, Java, Borneo, Celebes and Sulu Islands. Enters estuaries also.

Genus: **Suggrundus** Whitly

Suggrundus Whitly (1930). *Mem. Queesland Mus.*, 10:26 (Type species: *Platycephalus rudis* Günther = *Platycephalus meerdervoorti* Bleeker).

Key to Species of Genus *Suggrundus* from India

18-24 anterior scales of lateral line spiny............*Suggrundus rodericensis* (Cuvier)

Only 3-5 anterior scales of lateral line spiny vertical rows of scales above lateral line 62-67. D. IX, 11; suborbital ridge with 4-6 spines.........*Suggrundus malayanus* (Bleeker)

D. IX, 12; suborbital ridge with 3 spines..................*Suggrundus isacanthus* (Cuvier)

Vertical rows of scales above lateral line 72-81, no black spots on body, D. IX, 11; A. 12..*Suggrundus bengalensis* (Rao)

Vertical rows of scales above lateral line 92-109, several black spots on head and body, D. IX, 11-12; A. 11...........................*Suggrundus crocodilus* (Tilesius)

Suggrundus rodericensis (Cuvier) (Pl. III C, D)

Platycephalus rodericensis Cuvier (1829). *Hist. nat. Poiss.*, 4:253. De Beaufort and Briggs (1962). *Fish. Indo-Asutralian Archipel.*, 11:144-145.

Platycephalus timoriensis Cuvier (1829). *Hist. nat. Poiss.*, 4:254.

Platycephalus macracanthus Bleeker (1878). *Verh. Akad. Amsterdam*, 19, (Revision *Platycephalus*); 22-23. Day (1878). *Fish. India*, 276.

Platycephalus scaber Günther (1868). *Cat. Br. Mus*, 2: 187 *(nec.* Linnaeus).
Thysanophrys macracanthus Fowler (1929). *J. Bombay nat. Hist. Soc.*, 33:117.
Suggrundus macracanthus Munro (1955). *Marine and Freshwater fishes of Ceylon*, 252

Material examined: 9 specimens 184-212 mm from Visakhapatnam; 6 specimens 130-183 mm from Kakinada; 10 specimens 100-188 mm from Madras; 1 specimens 155 mm from Madras, ZSI F, 2351/2; 1 specimen 156 mm SL from Karachi, ZSI F. 422/2 and 1 specimen 160 mm from Porto Novo, ZSI F. 1179/2.

Description: D. IX, 12-13; A. 12-13; P. 21-23, V. I. 5; Ll pored 51-57; Vertical rows of scales above lateral line 78-93; L. tr. 7-10/1/17-20; G. R. 1+1+5–7.

Body depth 7.50-10.85 in SL, 8.85-12.57 in TL. Head 2.86-3.68 in SL, 3.40-4.31 in TL. Width of head 1.09-1.85 in its length. Eye 3.15-4.54 in head, 1.11-1.27 in snout. Interorbital 2.33-3.76 in eye. Maxillary reaches to below anterior part of eye. Teeth villiform in two oval patches on vomer and in two elongate bands on palatines. Two spines one on either side of median line between anterior nostrils. A strong spine on anterior orbital rim. Supraorbital ridge smooth anteriorly with 4-5 spines on posterior portion. Superior postorbital ridge with two spines, one immediately behind eye and another at end of ridge. Inferior postorbital ridge with 4-5 spines. Suborbital ridge with a spine at beginning, one below middle of eye and 2-4 behind this ending at base of long and strong preopercular spine which reaches gill opening. Two short spines below longest preopercular spine. Inferior opercular ridge with 4-5 spines anteriorly, remaining portion smooth ending in a spine. A triangular skin flap on subopercle. Head completely rugose, with scales on opercle and preopercle; otherwise head naked. 18-24 scales of lateral line spiny. First dorsal spine short; third spine longest as long as or slightly longer than longest ray of the second dorsal. Pectorals rounded 6.58-7.63 in SL; 7.64-9.09 in TL. Pelvics 4.68-5.72 in SL; 5.48-6.45 in TL. Caudal more or less rounded.

Colour: Body dark brown above and light below. Four faint cross bands - one near posterior region of spinous dorsal another near middle of second dorsal, a band near posterior side of second dorsal and a band on caudal peduncle. Spinous dorsal dark with small scattered black spots. Second dorsal with black spots on rays. Pectoral black with small spots on rays. Pelvics dus! y, anal pale, caudal black.

Distribution: Reunion, coats of India, Sri Lanka, Singapore, Ambon, Timor, Sulu Islands, Philippines and Formosa.

Remarks: Of 28 specimens examined, in only two of them (ZSI F. 2351/2 and 1179/2) there are 13 rays in the second dorsal fin. Type specimens of *rodericensis, timoriensis* and *macracanthus* have only 12 rays in second dorsal; all authors gave 12 rays consistantly for *rodericensis*. In two other specimens of *rodericensis* examined (196 and 202 mm from Visakhapatnam) there are 13 rays in anal whereas description and type specimens of *rodericensis* and *timoriensis* show only twelve rays. Type specimen of *macracanthus*, however, seems to have 13 rays in anal as also given by De Beaufort and Briggs (1962).

Suggrundus malayanus (Bleeker) 1853

Platycephalus malayanus Bleeker (1853). *Nat. Tij. Ned. Indie*, 5:498. *Verh. Akad. Amsterdam*, 19: 27-28; 1879. *Atlas Ichth.*, 9, tab, 419, fig. 2. De Beaufort and Briggs (1962). *Fish. Indo-Aust. Archipel.*, 11 : 152-153. Jones and Kumaran, 1971. *J. mar. biol. Ass. India*, 12:187-196.

Material examined: 9 specimens 64-169 mm from Kavarathi (Laccadives).

Description: D. IX, 11; A. 12; V. I, 5; Ll pored 52-56; vertical rows of scales above lateral line 62-67; L. tr. 8/1/28; G. R. 1 + 1 + 4-5.

The description is given by Jones and Kumaran (1971).

Distribution: Known from Queensland, New Guinea, Banda, Ambon, Philippines, Borneo and Java in the Pacific and from Padang (Sumatra) and Laccadives in the Indian Ocean.

Suggrundus isacanthus (Cuvier) 1829 (Pl. IV A, B)

Platycephalus isacanthus (Cuvier, 1829). *Hist. nat. Poiss.*, 4:246; Murty (1968). *J. mar. biol. Ass. India*, 10 (1): 126-132.

Material examined: 30 specimens ranging from 144-211 mm from Palk Bay and Gulf of Mannar on the southeast coast of India.

Description: D. IX, 12; A. 12; P. 19-20; V. 1,5; Ll pored 55-57; L. tr. 8-10/1/14-17; G. R. 1 + 1 + 3 - 4.

Distribution: West wards from Northern Australia and Waigeu through Philippines, Macao (south of Hong Kong) and Tourane (Vietnam) to Singapore and further west wards to the southeast coast of India (Mandapam).

Suggrundus bengalensis (Rao) 1966 (Pl. IV C, D)

Platycephalus bengalensis (Rao, 1966). *Ann. Mag. nat. His.*, Ser. 13; 9:123-127.

Material examined: 25 specimens 123-194 mm from Visakhapatnam and Kakinada 1 specimen 141 mm from Madras, 2 specimen (caudal fin broken) 89 mm S.L. from Tannesserim Coast of Burma.

Description: The following meristic data were taken (Table 1).

TABLE 1. *Meristic data of specimens from different localities*

Character	Localities		
	Visakhapatnam and Kakinada	Madras	Burma
Dorsal fin	IX, 11	IX, 11	IX, 11
Pectoral fin	19-20	19	19
Pelvic fin	1, 5	1, 5	1, 5
Anal fin	12	12	12
Ll pored	54-57	53	53
Vertical rows of scales above lateral line	77-83	81	81

Distribution: First recorded from Visakhapatnam. The present report extends the distribution southward to Madras and eastward to the Tanasserim Coast of Burma.

Remarks: The specimen of this species in the collections of Zoological Survey of India contains a label with the following details: *Platycephalus malayanus*

F. 423/2 off Tenasserim Coast of Burma "Endeavour" (Indian Survey) Sta. No. 396; 9-11-1911. Rao (1966) described this species for the first time on the basis of his collections from Visakhapatnam. Although the specimen from Burma was collected 55 years before the species was first described, the present report happens to be the first from Burma because the specimen was registered under a different name (*P. malayanus)* in the Zoological Survey of India.

Suggrundus crocodilus (Tilesius) 1812

Platycephalus crocodilus Tilesius, 1812. *Krusenstern's* Reise, Pl. 59, fig. 2.
Platycephalus punctatus Cuvier, 1829. *Hist. nat. Poiss.*, 4:243.
Platycephalus malabaricus Cuvier, 1829. *Ibid,* Day, 1865. *Fish Malabar,* 45.
Thysanophrys crocodilus Munro, 1955. *Marine and Freshwater fishes of Ceylon,* 253.

Material examined: 2 specimens 96, 189 mm from Tuticorin, 2 specimens 267, 268 mm from Visakhapatnam; 1 specimens 185 mm from Madras; 3 specimens 121, 241, 262 mm from Malabar (Day's collection) ZSI, Reg. No. 1849, 1850, 1851; 1 specimen 139 mm from Pillai Bay, Mergui Archipelago, ZSI No. 10946.

Description: D. IX, 11; A. 11; P. 18-22- V. I, 5; Ll. 54-58; vertical rows of scales above lateral line 92-109; L. tr. 11-13/1/24-33; G. R. 1 + 1 + 4-5.

Head length 2.91-3.16 in SL; 3.42-3.70 in TL; body depth 7.9-10.4 in SL, 9.25-12.1 in TL. Head width 1.66-2.18 in its length. Eye 3.84-4.85 in head; 1.22-1.50 in snout. Maxilla reaches to below anterior border of eye. Teeth villiform, arranged in two ovate patches on vomer and in two elongate narrow bands on palatines. Anterior nostril with a flap. Two spines between anterior nostrils. Two smooth ridges run parallel from between anterior nostrils upto beginning of interorbital space and then becomes indistinct. A strong spine on anterior orbital rim. Supraorbital ridges serrated posteriorly from behind middle of eye and end in a fan-like low radiating ridges behind eye and one of them on either side continued as superior postorbital ridge with a single spine. The inferior postorbital ridges with 5 spines each, last two elongate and last one ends at beginning of lateral line. Suborbital ridge with a spine in its begining, a spine below middle of eye and another below hind border of eye; behind this ridge is smooth, sometimes about three spines present ending in a long spine on preopercular angle. A single spine below this. Subopercular flap rather feeble. Opercle with two smooth ridges each ending in a spine. Preopercle and opercle scaly. 14-16 rows of scales before dorsal. First dorsal spine short and third spine longest; second dorsal higher than anal. Pectorals rounded 5.66-6.57 in SL, 6.61-7.65 in TL. Pelvics 4.25-5.34 in SL, 4.84-6.23 in TL.

Colour: Body reddish brown above, light below. Dorsal side of head and body with several black dots which extend to sides also. 2-3 broad dark bands on dorsal side. Outer three fourths of spinous dorsl black. Rays of soft dorsal with small black spots; pectoral rays with black spots which form irregular bands; pelvics black; anal whitish; caudal dark with two or three longitudinal black bands.

Distribution: The known distribution of this species extends from coasts of New Guinea westward through Japan, Philippines, Ambon, Timor, North Celebes, Borneo Java and Banka to Singapore in the Pacific and from Nias, Andaman Sea, coats of Sri Lanka and India, Madagascar, Natal and Zululand in the Indian Ocean.

Remarks: The present specimens conform to the original descriptions of *Platycephalus punctatus* Cuvier and *Platycephalus malabaricus* Cuvier in all respects but differ in the soft dorsal and anal fin rays. Counts of these fins for above two species as given by Cuvier 12 and 12 respectively whereas in all the present specimens 11 and 11. Day (1878) gave D. 1/8/12; A. 11-12, while there are 11 rays each in second dorsal and anal fins in specimen of his collection in the Zoological Survey of India.

All the meristic counts of the specimens in the present study agree with Matsubara and Ochiai (1955) but according to them the "interopercular flap" is absent which character they have utilised even to distinguish genera; in all the present specimens this flap *is* present though rather feeble.

Other than the thirteen species dealt with in the present paper the following twelve species (not so far recorded from the Indian Seas) are known to occur in the Indian Ocean region. No attempt was made to study the descriptions of these species so as to refer them to different genera; they are given under the generic name *Platycephalus*.

Platycephalus longiceps Cuvier (Singapore, Java, Delagoa bay, Mozambique, Zanzibar and Red Sea)
P. bataviensis Bleeker (Singapore)
P. sundaicus Bleeker (Singapore, Sumatra, Java)
P. boschei Bleeker (Singapore)
P. nematophthalmus Günther (Singapore, western Australia)
P. nigripinnis Regan (Muscat)
P. towensendi Regan (Karachi, Muscat)
P. subfasciatus Günther (Muscat)
P. pristis Peters (Mozambique)
P. grandideri Sauvage (Madagascar, Durban)
P. portuguesus Smith (Mozambique)
P. borboniensis Sauvage (Madagascar)

REFERENCES

BLEEKER, P. 1878. Revision Des espéćès Insulidiennes Du genre *Platycephalus*. *Verh. Akad. Amsterdam*, **19**:1-31.

CANTOR, T. 1850. Catalogue of Malayan Fishes. *J. Asiatic Soc.* Bengal, **18** (2) 983-1443.

DAY, F. 1878. *The Fishes of India*, **2**:274-278. Barnard Quaritch, London.

——— 1889. *The Fauna of British India including Ceylon and Burma, Fishes*, **2**:1-503.

DE BEAUFORT, L. F. AND J. C. BRIGGS 1962. *The Fishes of the Indo-Australian Archipelago*, **11**: 127-165. E. J. Brill [Ed.], Leiden.

FOWLER, H. W. 1904. A collection of fishes from Sumatra. *J. Acad. nat. Sci. Philadelphia*, **2** (12) 495-560.

GEORGE, K. C. 1970. Note on two species of flatheads (Platycephalidae : Pisces) from the trawl grounds of the southwest coast of India. *J. mar. biol. Ass. India*, **10** (2):187-196.

GREENWOOD, P. H., D. E. ROSEN, S. H. WEITZNAB, AND G. S. MYERS 1966. Phyletic studies of Teleostean fishes with a provisional classification to living forms. *Bull. Am. Mus. nat. Hist.*, **131**: 241-455.

JONES, S AND M. KUMARAN 1971. New records of fishes from the seas around India *J. mar. biol. Ass. India*, **12**: 187-196.

JORDAN, D. S. AND C. L. HUBBS 1925. Record of fishes obtained by David Star Jordan in Japan in 1922. *Mem. Carnegie Mus.*, **10**: 93-94.

——— AND R. E. RICHARDSON 1908. A review of flatheads, gurnards and other mail-checked fishes of the waters of Japan. *Proc. U. S. Nat. Mus.*, **33** (1581): 629-670.

MATSUBARA, A. AND K. OCHIAI 1955. A Revision of the Japanese fisbes of the family Platycephalidae (The Flatheads). *Mem. Coll. Agric. Kyoto Univ.*, Fish Ser., **68**, **4**: 1-109.

MAYER, E. 1969. *Principles of Systematic Zoology*, TMH Edition, 428 pp.

MUNRO, I. S. R. 1955. *The Marine and Freshwater Fishes of Ceylon*, 1-349.

MURTY, V. SRIRAMACHANDRA 1968. On some interesting and new records of marine fishes from India. *J. mar. biol. Ass. India*, **10** (1): 126-132.

———, 1969. Catalogue of fishes (excluding from the Laccadives) in the Reference Collections of the Central Marine Fisheries Research Institute. *Bull. cent. mar. Fish. Res. Inst.*, **10**: 1-36.

RAO, V. VISWESWARA 1964. *Platycephalus bengalensis* sp. nov. from Bay of Bengal. *Ann. Mag. nat. Hist.*, Ser. 13, **9**: 123-127.

SCHULTZ, L. P. 1960. Platycephalidae. In: *The Fishes of Marshall and Marianas Islands. Bull. U. S. Nat. Mus.*, 202; **3**: 45-62.

CONTRIBUTION 3

MURTY, V. SRIRAMACHANDRA. 1982. Nemipterus luteus (Schneider, 1801) (Nemipteridae Pisces) the valid name for a threadfin bream from the Indo-Pacific region. J. mar. biol. Ass. India, 19(2):107-114 (1977)

J. mar. biol. Ass. India, 1977, 19 (2) : 107 - 114

NEMIPTERUS LUTEUS (SCHNEIDER, 1801) (NEMIPTERIDAE, PISCES) THE VALID NAME FOR A THREADFIN BREAM FROM THE INDO-PACIFIC REGION

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ABSTRACT

Nemipterus luteus (Schneider, 1801) is shown to be the valid name for a threadfin bream from the Indo-west Pacific region and that *N. striatus* (Valenciennes, 1830), *N. filamentosus* (Valenciennes, 1830), *N. nematophorus* (Bleeker, 1853) and *N. macronemus* (Gunther, 1859) are its junior synonyms. A detailed description of this species, on the basis of specimens collected from Kakinada is given.

INTRODUCTION

DURING the course of investigations on the biology and fisheries of nemipterid fishes in the trawler catches off Kakinada (Lat. 16° 15′ N to 17° 10′N and Long. 82° 22′ to 82° 35′ E), the author collected several specimens of a *Nemipterus* species which agree with Day's (1875) description of *Synagris striatus* Jerdon, 1851 and also with the description of *Nemipterus nematophorus* (Bleeker) given by Weber and de Beaufort (1936). The fact that these two specific names were not treated as synonyms by these authors and neither of them had even referred to the other specific name, prompted the author to probe into their taxonomy. It has been found that these two species are junior synonyms of *Nemipterus luteus* (Schneider, 1801) and that the latter is the valid name for the specimens mentioned above. Most of the recent authors (Weber and de Beaufort, 1936; Fischer and Whitehead, 1974) recognise *N. nematophorus* (Bleeker, 1853) as valid, which is also shown to be a junior synonym of *N. luteus* in the present paper.

The name *Nemipterus luteus* has almost become a forgotten name (though the name is 'available' in the meaning of the Code) and some authors (Fisher and Whitehead, 1974) have even treated it as a doubtful species. The nomenclatorial status of this species is discussed and adequate description on the basis of specimens collected from off Kakinada, is presented in this paper.

I am thankful to Dr. M. Boeseman, Curator, Rijksmusseum van Natuurlijke Historie, Leiden for sending data on holotypes of *Dentex filamentosus* Valenciennes and *D. nematophorus* Bleeker. I am also thankful to Dr. Martine Desoutter of Museum National D' Histoire Naturelle, Paris for kindly sending data on the specimen of *Dentex luteus* Valenciennes and for sending relevant literature. Dr. P. K. Talwar, Superintending Zoologist, Zoological Survey of India, Calcutta has kindly sent the original description and figure of *C. lutea* Schneider; I am thankful to him for this help.

Historical Resume

Schneider (1801) described *Coryphaena lutea* on the basis of a specimen from Tranquebar. The description is very brief; the figure shows: D. X, 9; A. III, 7 and caniniform teeth in upper jaw.

Valenciennes (1830) described *Dentex luteus* from Pondicherry on the basis of a 7 inches long specimen. He described the species as: *suborbital very high, teeth decrease in size towards interior of the mouth in such a way that it is difficult to notice the canines which are eight in number. The scales are large and there are forty scales in the lateral line. Valenciennes (1830) considered *Coryphaena lutea* Schneider as a doubtful synonym of his *Dentex luteus* and stated:

"We have found this species in the Berlin Museum among fishes of Bloch. First he had confused this fish with his *Sparus japonicus* because we have seen it written as such by his own hands. However, he appears to have recognised it afterwards and it seems that the figure given by Bloch in tab 58 of the of edition of Schneider and also the short description on p. 297 under the name *Coryphaena lutea* were made after the same one. Some traces of reddishness could also be seen on this specimen which Bloch had mistaken for bands in his painting. His specimens more entire than ours shows that the third ray of caudal is prolonged into a filament. It is 7 inches long from the tip of snout to the end of caudal lobe; the caudal filament is one inch long.

Gunther (1859) recorded *Synagris luteus* (Cuv. and Val.) and treated *Coryphaena lutea* Schneider, as a doubtful synonym of it. He did not give the description of this species in detail except for a few meristic data and stating that "teeth nearly equal (Val)".

Day (1875) stated "There are two of Bloch's specimens marked *Dentex luteus* at Berlin; one evidently the skin from which Bl. Schn.'s figure has been taken, the artist not having reversed it whilst he had delineated the eye too small and the (?) elongated dorsal spines are broken. On the second specimen which has no elongated dorsal spine is Val's label, "C'est le vrai *C. lutea* Bl. Schn".

Valenciennes (1830) described *Dentex striatus* on the basis of an 8-inch long specimen from Tranquebar in the Berlin Museum (*fide:* Bauchot and Daget, 1972). He named the species as *striatus* following the unpublished manuscript description of *Coryphaena striata* by Bloch. He described the species as: suborbital very high, scales slightly longer, ciliated; the limb of preopercle strongly striated, the canines are feeble; the body with lontgitudinal lines. Caudal lobes in the specimen are not complete and so it is not possible to say whether they had filaments.

Jedon (1851) recorded *Dentex striatus* C. V. from Madras. He described only the colour of the species as: alternate longitudinal bands of rosy and yellow, dorsal purple beneath, yellow in the middle and rosy externally. Anal blended with pale rosy, others tinged with rosy.

*Here and elsewhere in this paper, the English translation of Valenciennes' French text is quoted.

Day (1875) described *Synagris striatus* (Jerdon) from Madras but figured species as *Synagris luteus* in plate VIII, figure 5. Among others, the description shows that there are 8 canines in the upper jaw, the vertical limb of preopercle serrated, the first two dorsal spines and upper caudal lobe are produced and filamentous. Day (1875) who stated that "Bl. Schn.'s figure (of *Coryphaena lutea*) is probably coloured from a description in which it was said to have been striated or banded; and instead of placing such longitudinally he has given them as vertical", treated *Coryphaena lutea* Schneider as a doubtful synonym of *Synagris striatus* (Jerdon).

Valenciennes (1830) described *Dentex filamentosus* from Surinam (Sumatra). The description shows that the first dorsal spine (actually the first two dorsal spines in the holotype), upper caudal lobe and pelvic ray are produced and filamentous; canines 8 in number, preopercular border finely serrated.

Bleeker (1853) described *Dentex nematophorus* from Padang (Sumatra). Gunther (1859), Weber and De Beaufort (1936) and Fisher and Whitehead (1974) described *Synagris* (or *Nemipterus*) *nematophorus* (Bleeker). These accounts among others, show that the first two dorsal spines and the upper caudal lobe are produced and filamentous and that there are canines in the upper jaw.

Gunther (1859) described *Synagris macronemus* from Surinam. He treated *Dentex filamentosus* Valenciennes, 1830, as a junior synonym of his *S. macronemus* apparently under the erroneous impression that the name *D. filamentosus* Valenciennes, 1830 was preoccupied by *Dentex filamentosus* Valenciennes 1841 *in*: Webb. and Berthelot, *Hist. nat. canaries. Ichthy.*, pl. 6, though the former has priority and the latter is a synonym of *Dentex gibbosus* (Rafinsque, 1810) (Vide, Bauchot and Daget, 1972) but at the same time stated that "It is not certain from the imperfect description of Valenciennes whether the fish *D. filamentosus* Valenciennes, 1830, should be referred to *Synagris* or to *Dentex*; according to the figure it has the habit of *Synagris* but the scales on the preoperculam are arranged in more than three series, as in *Dentex*". It has since been confirmed (Weber and De Beaufort, 1936) that there are only three rows of scales on preoperculum of the holotype of *Dentex filamentosus* Valenciennes, 1830 which is also the type species of the genus *Nemipterus* Swainson.

The important taxonomic characters of all the above species taken from the available descriptions and in some cases from types, are presented in Table 1.

Discussion

It is clear from the above that several earlier authors described *Nemipterus luteus* under five different specific names evidently being uncertain of the nomenclatorial status of the nominal species they described. This is because :

1. the original description of *Coryphaena lutea* Schneider is most inadequate
2. Bloch prepared a description of *Coryphaena striata* but never published it and deposited a specimen in the Berlin Museum under this unpublished name, and

3. the type specimen of *Coryphaena lutea* Schneider and the specimen labelled *C. striata* in the Berlin Museum are apparently damaged.

The earliest published account for the species under discussion is that of *Coryphaena lutea* Schneider, 1801. Since the efforts made by the present author to get the type specimen of this species in the Berlin Museum re-examined were not fruitful and since the original description (including the figure) is not adequate on whether the first two dorsal fin spines and upper caudal lobe are produced in this species (these two being the most important diagnostic characters), it is, however, inferred that the first two dorsal spines and the upper caudal lobe *were* produced and filamentous in the holotype because (1) Valenciennes (1830) stated that he came across a specimen of *C. lutea* in the Berlin Museum and that he believed that the description and figure of *C. lutea* Schneider were made after this specimen. He further stated that "...montre que le troisieme rayon la caudale se prolonge en un long filament" (the third ray of caudal is prolonged into a filament) in *C. lutea* Schneider in the Berlin Museum, and (2) Day (1875) stated that in a specimen marked *Dentex luteus* at Berlin Museum, "...from which Bl. Schn.'s figure (of *C. lutea*) has been taken", "...the (?) elongated dorsal spines are broken".

It is clear from the above statements that though Valenciennes examined the specimen in the Berlin Museum quite before Day had examined it, the former did not even notice the possibility of the first dorsal filaments being broken. Valenciennes only noticed the caudal filament and by the time Day examined this specimen, the caudal filament also was, perhaps, brokens

There is a specimen of *Dentex luteus* (examined by Valenciennes, 1830) in the Paris Museum, the data of which are presented in Table 1. This agrees well with *Coryphaena lutea* Schneider.

The description of *Dentex striatus* Valenciennes, 1830 (based on the specimen of Bloch: *Fide* Bauchot and Daget, 1972) is inadequate to relate it to *C. lutea* Schneider. The subsequent description of this species by Day (1875), however, shows the important characters clearly and this agree well with *C. lutea* Schneider.

The original description of *Dentex filamentosus* Valenciennes, 1830 shows, among others, that only the first dorsal spine is produced and filamentous. An examination of holotype of this species shows that the first two spines of dorsal are produced and filamentous, as against only one as described by Valenciennes (1830).

The data on the holotype of *Dentex nematophorus* Bleeker, 1853 (Table 1) indicates that it agrees closely with *C. lutea* Schneider, 1801.

The original description *Synagris macronemus* Gunther, agrees with *D. filamentosus* Valenciennes, 1830. Gunther (1859) obviously repeated the same mistake as Valenciennes (1830) in stating that only the first dorsal spine is produced. However, since he treated *D. filamentosus* of Valenciennes (1830) as a synonym of his *S. macronemus* it is believed that his *macronemus* also is a synonym of *Nemipterus luteus* (Schneider).

It is, thus, clear that *Dentex striatus* Valenciennes, *Dentex filamentosus* Valenciennes, *Dentex nematophorus* Bleeker and *Synagris macronemus* Gunther are junior synonyms of *Nemipterus luteus* (Schneider).

TABLE 1. *Comparison of* Coryphaena (= Nemipterus lutea *Schneider*) *and its synonyms*

Particulars	*C. lutea* Schneider, 1801	*D. luteus* Valenciennes, 1830	*D. filamentosus* Valenciennes, 1830	*D. striatus* Valenciennes, 1830	*S. striatus* Day, 1875	*N. nematophorus* Bleeker, 1853
Material	Original description and subsequent descriptions of type.	No. 8087 Paris Mus. specimen examined by Valenciennes.	Holotype No. 1018 Leiden Museum	Specimen in Berlin Mus. described by Valenciennes.	Description of Day, 1878	Holotype No. 5696 in Leiden Museum
Locality	Tranquebar	Pondicherry	Surinam (Sumatra)	Tranquebar	Madras	Padang (Sumatra)
Total length	180 mm	202 mm	305 mm including caudal filament	203 mm	—	208 mm including caudal filament
Dorsal fin	X, 9	X, 9	X, 9	—	X, 9	X, 9
Anal fin	III, 10 (III, 7 in fig.)	—	III, 7	—	III, 7	III, 7
Pectoral rays	17	17	17	—	17	17
Lateral line scales	—	—	47 or 48	—	48	48
L. tr.	—	—	3-1-10	—	$3\frac{1}{2}/10$	$3\frac{1}{2}$-1-$9\frac{1}{2}$
First two dorsal spines	The (?) elongated dorsal spines are broken (Day)	Filamentous	Produced, distally very close.	—	Produced & filamentous	Produced and filamentous
Upper caudal lobe	Third ray of caudal produced into a filament (Valenciennes)	Broken	With long filament	Broken	Produced and filamentous	Produced and filamentous
Canines	—	Present in upper jaw	Present in upper jaw, 3+3 on either side	Present in upper jaw, feeble	8 in upper jaw	Present in upper jaw
Hind border of preoperculum	—	—	—	Serrated	Serrated	almost denticulate

The name *Nemipterus luteus* (Schneider, 1801) cannot be suppressed on the ground that it is a *nomen oblittum* since Article 23 (b) which providse for this, is repealed (*vide* Declaration 43 in *Bull. Zool. Nomen.*, **27** (3 & 4) : 135-163, 1970).

A detailed description of *N. luteus* along with its synonyms is given below.

Nemipterus luteus (Schneider, 1801) (Fig. 1)

Coryphaena lutea Schneider, 1801, p. 297, tab. 58; Tranquebar.
Dentex luteus Valenciennes, 1830, p. 250; Pondicherry.
Dentex striatus Valenciennes, 1830, p. 252; Tranquebar.
Dentex filamentosus Valenciennes, 1830, p. 254; Surinam (Sumatra).
Dentex nematophorus Bleeker, 1853, p. 500; Padang (Sumatra).
Synagris macronemus Gunther, 1859, p. 380; Surinam.
Synagris striatus Day 1875, p. 90, Madras.
Synagris luteus Day, 1975, pl. VIII, fig. 5.
Nemipterus nematophorus Weber and De Beaufort, 1936, p. 366. Fisher and Whitehead, 1974.

Material examined : 20 specimens ranging from 140 to 216 mm TL* from Trawler catches of Kakinada.

Meristic data : D. X, 9; p. 16-18 (16 in 1, 17 in 18, 18 in 1; N : 20) ; V. I, 5; A. III, 7; L. 46-49 (46 in 5, 47 in 7, 48 in 6, 49 in 1; N: 19) ; L. tr. 4/1/9-10: G. R. 10-12 (10 in 2, 11 in 7, 12 in 8; N: 17).

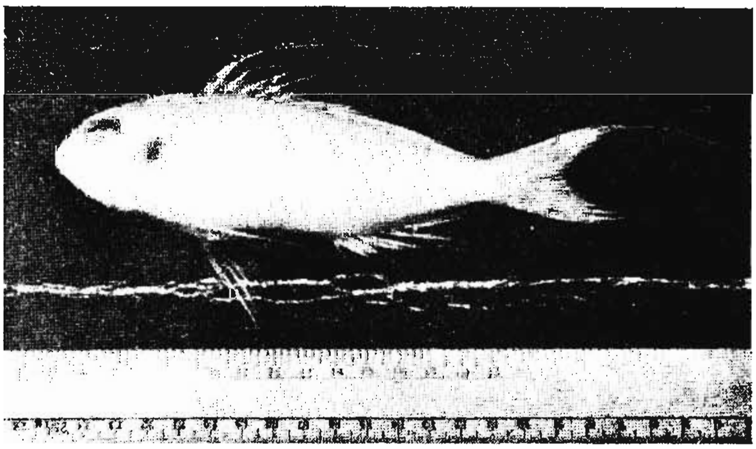

Fig. 1. *Nemipterus luteus* (Schneider, 1801).

Body proportions as percentage of standard length : Body depth at dorsal origin 30.1-34.1 (31.7)**, head length 32.0-35.8 (33.6), predorsal length 28.0-34.5 (33.3), prepelvic length 31.6-35.5 (33.4), preanal length

* Total length is measured from tip of snout to tip of lower caudal lobe.
** Values in paranthesis are mean values.

60.6-66.1 (63.9), length of dorsal fin base 50.5-57.5 (54.0), length of anal fin base 15.9.-21.2 (19.7), pectoral length 29.0-34.1 (32.0), pelvic length 27.3-32.9 (30.3), depth of caudal peduncle 10.3-12.2 (11.2).

Body proportions as percentage of head length : Depth of head behind preopercular border 78.8-90.0 (82.7) horizontal eye diameter 28.8-38.9 (32.7), snout length 23.7-31.6 (27.6), interorbital length 16.3-21.2 (18.9) height of suborbital 10.5-20.0 (15.0).

Other characters : Mouth termial, oblique; maxillary reaches to below anterior border of pupil. Teeth in several rows in both jaws; in upper jaw 3-4 canines on the outer row on either side, canines absent in lower jaw. Height of suborbital equal to about half vertical diameter of eye; suborbital surface rugose. Vertical border of preopercle finely serrated. Scales ctenoid; 3 rows of scales on preopercle. The first two dorsal spines are produced and filamentous, when folded they extend beyond posterior border of dorsal fin upto nearly base of caudal; spinous dorsal (excepting filaments) shorter than the soft, pectorals falcate, reach upto above 2nd or 3rd anal spine, the first ray of pelvic produced reaching 3rd anal spine, spinous anal shorter than soft portion. Caudal forked; the second branched ray of upper caudal lobe produced into a filament.

Colour : Body pink above and silvery below. A yellow blotch below lateral line near origin. A longitudinal band on either side of the base of dorsal fin with irridiscent shine. Similar band on lateral line. Three longitudinal yellow bands below lateral line but above pectoral base. One yellow band on either side, on ventrolateral sides. The two dorsal filaments and upper border of dorsal deep yellow; the remaining portion of dorsal fin pink. Pectoral and pelvic light pink. Anal pale with a longitudinal yellow band above middle of the fin. Caudal pink except the tips of upper rays in the upper lobe and the filament which are deep yellow.

Distribution : East coast of India, coasts of Sumatra, Borneo, north Celebes and Philippines.

Remarks : *Nemipterus luteus* occurs in the trawler catches off Kakinada in fair quantities when there is fishing at depths of over 55 metres. The peak period of abundance for this species at Kakinada is January-March. During 1976 an estimated 35.3 tonnes of this species where landed forming 6.7 % of the total nemipterid catches of the year.

REFERENCES

BAUCHOT, M. L. AND J. DAGET 1972. Catalogue critique des types de poissous du Museum national d' Histoire naturelle. *Bull. Mus Nat. Hist. Nat*, ser. 3, **24** : 99.

BLEEKER, P. 1853. Niewwe tientallen diagnotische beschrijving van nieuwe of Weining bekende Vischsoorten van Sumatra. *Natuurk. Tijdschr. Ned.-Indie* **5** : 500.

—— 1873. Revision des especes de *Dentex, Synagris, Gymnocranius. Verh. Akad. Amsterdam*, **13** : 23.

—— 1877. *Atlas Ichthyologique*, **7** : 90

DAY, F. 1875. *The fishes of India* (Ist part) : 1 - 168.

FISCHER, W. AND P. J. P. WHITEHEAD (Eds.) 1974. *FAO Species Identification sheets for fishery purposes.* Eastern Indian Ocean (Fishing area 57) and Western Central Pacific (Fishing area 71). Vol III, FAO, Rome.

GUNTHER, A. C. 1859. *Catalogue of fishes in the Britsh Museum,* **1** : 377 - 380.

JERDON, T. C. 1851. Ichthyological gleanings in Madras. *Madras J. Litt. Sci.,* **17** : 128 - 151.

SCHNEIDER 1801. *In* : Bloch and Schneider (Ed.) Systema Ichthyologiae.

VALENCIENNES, M. 1830. *In* : Cuvier, M. B. and M. Valenciennes. *Hist. Nat. Poiss.,* **6** : 559 pp, pls. 141 - 169. Reprinted 1969, A. Asher & Co., Amsterdam.

WEBER, M. AND L. F. DE BEAUFORT 1936. The fishes of Indo-Australian Archipelago, **7** : 1-607.

CONTRIBUTION 4

MURTY, V. SRIRAMACHANDRA. 1981. Nemipterus mesoprion (Bleeker, 1853) (Nemipteridae Pisces) a new record from the seas around India, Indian J. Fish., 25 (1&2): 207-213 (1978).

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NEMIPTERUS MESOPRION (BLEEKER 1853) (NEMIPTERIDAE PISCES) A NEW RECORD FROM THE SEAS AROUND INDIA

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ABSTRACT

Nemipterus mesoprion (Bleeker) is reported for the first time from the Indian seas. This species resembles *N. japonicus* (Bloch) closely but differs from it in colour, snout length, head length, height of suborbital bone and pelvic fin length. A description of the species is presented.

INTRODUCTION

During the course of investigations on the fishery and biology of nemipterid fishes in the trawler catches off Kakinada, the author collected specimens of *Nemipterus tolu* (Valenciennes), *N. japonicus* (Bloch) and *N. mesoprion* (Bleeker). The last named species has hitherto not been reported from the seas around India (*vide*: Day 1878, Weber and De Beaufort 1936, Munro 1955). Since the present report of *N. mesoprion* is the first from the Indian seas, a description of the same is presented here.

It is observed that *N. mesoprion* resembles *N. japonicus* very closely and in preserved condition it is difficult to distinguish between the two species with reasonable accuracy. An attempt is made in this paper to bring out those characters that would help distinguish these species.

MATERIAL AND METHODS

Specimens under study were collected from trawl catches off Kakinada from depths of 15-70 m. Colour and pigmentation were noted in fresh specimens, but detailed observations were made on specimens preserved in 5% formalin. The morphometric data are presented as percentage of standard length or head length. Frequency distribution of meristic characters is given in paranthesis following the range: eg. p. 16-18 (16 in 20, ...etc.) meaning 16 rays in 20 specimens and so on. Total length is measured from tip of snout to tip of lower caudal lobe.

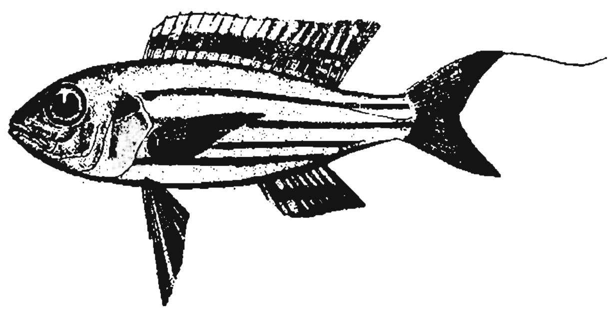

FIG. 1. *Nemipterus mesoprion* (Bleeker) 175 mm x 1½

NEMIPTERUS MESOPRION (Bleeker)

(Figure 1)

Dentex mesoprion Bleeker, Nat, Tijdschr. Ned. Indie, 1853, IV, 255 (Priaman)

Material examined: 30 specimens (18 males, 12 females) ranging from 101 to 185 mm total length.

Meristic Data:

D. X, 9; P. 16-18 (16 in 20, 17 in 9, 18 in 1); V. I, 5; A. III, 7; C. 17; Ll. 45-49 (45 in 3, 46 in 6, 47 in 11, 48 in 9, 49 in 1) L.tr. 3-3½|1|9.

Body Proportions:

a) *As percentage of standard length*: Total length 127.6-134.6 (131.8*), body depth 31.6-37.5 (33.6), head length 34.5-40.0 (37.5), predorsal length 31.5-36.4 (33.6), prepelvic length 32.5-36.9 (35.1), preanal length 62.5-70.5 (65.8), dorsal fin base length 50.0-57.3 (52.9), anal fin base length 16.9-21.8 (18.8), Pectoral length 32.4-39.0 (34.5), pelvic length 27.6-37.8 (31.6), least height of caudal peduncle 9.6-11.5 (10.3).

b) *As percentage of head length*: Head height (measured behind preopercular border) 71.1-85.2 (77.0), eye diameter 27.6-37.5 (32.1), snout length 20.8-28.3 (24.4), interorbital length 18.8-24.4 (21.6), height of suborbital bone 10.0-17.0 (13.3).

Other Characters

Mouth oblique, maxillary reaching to below anterior border of pupil, Teeth in jaws in several rows, pointed; upper jaw with 3-4 caniniform teeth anteriorly in each ramus, but such teeth are absent in lower jaw. Scales ctenoid; three rows of scales on preopercle. Height of suborbital nearly half of vertical diameter of eye. Hind border of preoperculum crenulate. Dorsal spines strong, first spine shortest, fourth to tenth more or less of same length; soft dorsal deeper than spinous one. First anal spine shortest, third longest. Soft anal less deep

* Figures in parantheses are mean values.

than soft dorsal; the last two rays of anal longer than the preceeding ones. Pectorals falcate, extend to above first or second anal ray. Pelvics with the first ray produced, reaching to first or second anal rays. The second branched ray of upper caudal lobe produced into a long filament the length of which is more than the caudal fin itself.

Colour (fresh): Body pink dorsally and on upper half of flanks, lower flanks and belly silvery. 3-4 longitudinal yellow bands on sides below lateral line; thick yellow longitudinal bands on the ventrolateral borders. Dorsal fin with closely packed yellow pigment dots on the lower threefourths of the fin forming a longitudinal yellow band which divides into 3 small bands on the last few rays; upper margin pink. A reddish blotch below lateral line near its origin. Pectoral pink; pelvic pink but with the first ray whitish all along its length. Anal whitish with a distinct narrow longitudinal yellow band in the middle. Caudal pink including the elongated filament on the upper lobe.

Distribution

Known from Sumatra (east and west coasts) and Singapore. The present report extends the range of distribution westwards towards the east coast of India.

Remarks

The present specimens agree well with the original description by Bleeker (1853), with the holotype and also with the description of Weber and De Beaufort (1936) in several characters (Table 1) but differ in the following: According to Bleeker (1853) and Weber and De Beaufort (1936) the height of suborbital is equal to vertical diameter of eye, whereas in the holotype and the specimens examined by the present author it is about half vertical diameter of eye. According to Weber and De Beaufort the hind border of preoperculum is denticulate but in the holotype and the present specimens it is crenulate. The tip of upper caudal lobe appears to be broken in the holotype (Dr. Boeseman in litt., *vide* Table 1); in the original description of this species Bleeker (1953) described the caudal fin as mutilated, presumably with the tips broken off ["valde emarginata lobis (ex parte abruptis)]. Therefore, in the subsequent descriptions (1873, 1977) Bleeker did not describe a produced upper caudal lobe in this species. Weber and De Beaufort (1936) stated that they examined "typical specimens" in Leiden Museum and that "In three specimens from Malacca the upper caudal lobe is produced into a long filament." These authors did not however state whether the upper caudal lobe is *not* produced in other specimens they examined (if at all). As stated above in all the present specimens, the second branched ray of the upper caudal lobe is produced into a filament. The description and figues of *N. mesoprion* presented by FAO (1974) clearly show that the upper caudal lobe is produced into a filament which is short; in the

TABLE 1. Nemipterus masoprion: *Comparison of specimens from Kakinada with the holotype and with the description by Weber and De Beaufort* (1936).

Sl.No.	Character	Specimens from Kakinada	* Holotype	Description of Weber and De Beaufort
1.	Dorsal fin count	x, 9	x, 9	x, 9
2.	Anal fin count	III, 7	III,7	III, 7
3.	Pectoral fin rays	16-18	16	16
4.	Lateral line scales	45-49	45	45-47
5.	L. tr.	3-3½|1-|9	3½|1|8 or 9	3-3½|1|11
6.	Standard length/head length	2.5-2.9	3.0	3.2-3.5
7.	Standard length/body depth	2.8-3.1	3.3	3.2-3.5
8.	Head length/eye	2.7-3.4	3.3	3.1-3.4
9.	Eye/Interorbital length	1.2-1.7	2.2	1.5-1.6
10.	Hind border of preopercle	Crenulate	Crenulate	Denticulate
11.	Canines	in upper jaw only	in upper jaw only	in upper Jaw only
12.	Suborbital height	equal to half of vertical diameter of eye orslightly less.	Slightly more than half of vertical diameter of eye.	Equal to vertical diameter of eye
13.	Upper caudal lobe produced	Produced in all specimens	Doubtful	Produced in three specimens from Malacca.

* Holotype No. 5684 of Leiden Museum, 94.5 mm Standard length; type locality: Priaman (Sumatra).

present specimens the filament is long and longer than the caudal fin. There is no difference in the length of caudal filament between sexes in the present specimens.

Colour is the most important character in distinguishing species of Nemipteridae (Eggleston 1973). The colour of *N. mesoprion* is described (FAO 1974) among other things as: head with yellow streaks from eye to middle of upper jaw, dorsal fin with a broad median yellow longitudinal band which sub-

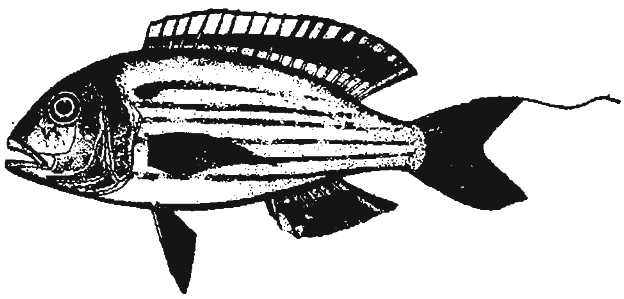

FIG. 2. *Nemipterus japonicus* (Bloch) 271 mm x 1.

divides towards tail into three yellow bands separated by blue lines. Pelvic fins pink with elongated first ray deep red; caudal fin reddish, median rays yellow, outer rays and filament red. In the present specimens yellow streaks on head absent, the median band on dorsal fin narrow anteriorly and broad posteriorly, it divides posteriorly into three bands; pelvic fin pink except the first elongated ray which is white; caudal fin pink including the median rays and the filament. The differences in the colour pattern may be due to differences in the habitat.

TABLE 2. *Distinguishing characters of* N. japonicus *and* N. mesoprion

Sl.No.	Characters	*N. japonicus*	*N. mesoprion*
1.	Head length	Equal to or less than body depth.	More than body depth
2.	Snout length	Equal to or more than horizontal eye diameter	Less than horizontal eye diameter
3.	Suborbital height	Equal to or slightly less than vertical eye diameter	About half of vertical eye diameter
4.	First pelvic ray	Not produced and does not reach anal origin.	Produced and reaches beyond anal origin up to 2nd anal ray.
5.	Colour:		
	a) on anal fin	A longitudinal yellow band near base with three irregular or broken yellow bands below.	Only one longitudinal yellow band in the middle.
	b) On upper caudal obel	Tip of upper caudal lobe and filament yellow.	Tip of upper caudal lobe and filament pink.

Among Indian Nemipteridae *N. mesoprion* resembles *N. japonicus* (Bloch) (fig. 2) in several characters and differs mainly in colour, but when preserved specimens are examined, colour is not of any value and one has to necessarily depend upon other characters most of which show overlap in distinguishing between the two species. The available description of these two species do not help in distinguishing them satisfactorily. An examination of 30 specimens of *N. japonicus* ranging from 92 to 280 mm in total length and comparison of these specimens with those of *N. mesoprion*, both collected from the trawler catches off Kakinada, have revealed differences in certain characters (Table 2) which are of use in distinguishing these species in fresh or in preserved condition.

To show the extent of variation in the relative proportions of head length, snout length, height of suborbital bone and pelivc fin length in each of these two species and to show differences in these characters between them, head length and pelvic fin length expressed as percentages of standard length are plotted against standard length and height of suborbital bone and snout length expressed as percentages of head length, against head length (figure 3). Though

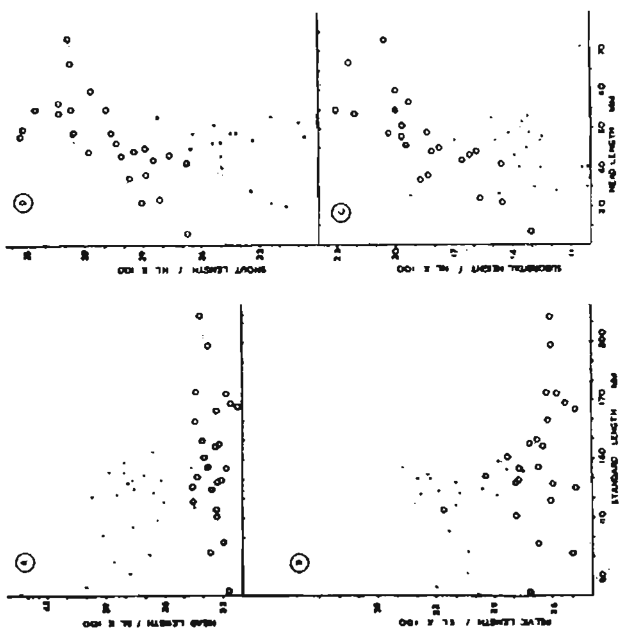

FIG. 3. A. Relationship between head length expressed as percentage of standard length and standard length; B. Relationship between pelvic fin length expressed as percentage of standard length and standard length; C. Relationship between height of suborbital bone expressed as percentage of head length and head length; D. Relationship between snout length expressed as percentage of head length and head length. *N. mesoprion* ● *N. japonicus* o

a definite relationship in the different body proportions with standard length or head length is not perceptible, it may be seen that:

1. head is relatively shorter in *N. japonicus* and relatively longer in *N. mesoprion*.
2. pelvic fin is relatively shorter in *N. japonicus* and relatively longer in *N. mesoprion*,
3. height of suborbital is relatively more in *N. japonicus* and relatively less in *N. mesoprion*, and
4. snout is relatively longer in *N. japonicus* and relatively shorter in *N. mesoprion*.

Acknowledgements

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References

Bleeker, P. 1853. Diagnostische beschrivningen van view of weining bekende vissch-soorten van Batavia. *Nat Tijdschr. Neder.-Indie*, IV: 255-256.

Bleeker, P. 1873. Revision des especes de *Dentex, Synagris, Gymnocranius. Verh. Akad. Amsterdam*, XIII: 30-31.

Bleeker, P. 1877. *Atlas Ichthyologique*. VIII: 92, Tab. 328, fig. 4.

Day, F. 1878. *Fishes of India*, 778 pp, William Dewson and Sons Ltd.

Eggleston, D. 1973. Patterns of Biology in the Nemipteridae. *J. mar. biol. Ass. India*, 14: 357-364. (1972).

Fao. 1974. *FAO species identification sheets for fishery purposes*, Eastern Indian Ocean fishing area 57 and Western Central Pacific Fishing area 71. Vol. III, FAO Rome.

Munro, I. S. R. 1955. *The Marine and Fresh-water fishes of Ceylon*. 169 pp. Canberra.

Weber, M. and L. F. De Beaufort. 1936. *The Fishes of Indo-Australian Archipelago*. 7: 607 pp., E. J. Brill, Leiden.

PART II BIOLOGY AND POPULATION DYNAMICS

A. THREADFIN BREAMS

CONTRIBUTION 5

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CONTRIBUTION 5

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OBSERVATIONS ON SOME ASPECTS OF BIOLOGY OF THREADFIN BREAM *NEMIPTERUS MESOPRION* (BLEEKER) FROM KAKINADA

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ABSTRACT

The length-weight relationship of *N. mesoprion* can be described by the equation log W = −4.650901 + 2.877071 log L. Females attain first maturity at a length of 100 mm. This species is a fractional spawner, releasing the ripe ova in two spawning acts during the single spawning season: December-April. It is estimated that the species attains 140, 185 and 205 mm at the completion of first, second and third years, respectively. The estimated growth parameters are: L_∞ = 219 mm, K = 0.83248 and t_0 = −0.256198 years.

INTRODUCTION

As part of investigations on the resource characteristics of threadfin breams, studies on the biology of *Nemipterus mesoprion* (Bleeker) were initiated at Kakinada in 1976. The species was first reported from India only in 1976 (Murty MS) and there is no published information on any aspect of biology of this species from India. This species forms a seasonal fishery at Kakinada and the data collected from the trawl catches during January 1976-March 1980 are utilised for the study.

MATERIAL AND METHODS

Samples were obtained at weekly intervals from the catches of trawlers operating off Kakinada. Since this species forms a seasonal fishery at Kakinada, samples were collected as and when it occurred in the catches. Samples were brought to the laboratory for data on total length,* weight, sex and stage of maturation. Data were taken from fresh specimens only. The length-weight relationship was calculated by the method of least squares using the formula $W = aL^n$ or $\log W = \log a + n \log L$ (Le Cren 1951), where W =weight in g, L = length in mm, a = a constant and n = exponent. While the maturation stages were allotted on the basis of macroscopic examination of fresh ovaries, ova-

* As the upper caudal lobe of this species is produced and some times the filament is broken, the total length is measured from the tip of snout to tip of lower caudal lobe.

diameter measurements were taken from ovaries preserved in 4% formalin. For measurement of ova diameters, small pieces from the middle of the ovaries were taken; the ova were teased out on a microslide and measured under a microscope with the help of an ocular micrometer at a set magnification where each micrometer division (md) is equal to 0.019 mm. In taking diameter measurements the procedure of Clark (1934) was followed.

Length-Weight Relationship

Th study is based on 295 females ranging from 83 mm and 9 g to 177 mm and 69 g and, 311 males ranging from 86 mm and 8 g to 197 mm and 106 g, collected during January 1976-March 1980. The relationship was calculated separately for the sexes and the equations are:

females : $\log W = -4.642866 + 2.87319 \log L$

males $W = -4.65377 + 2.87966 \log L$

The significance of difference between regression coefficients of males and females was tested by analysis of covariance (Table 1) following Snedecor and Cochran (1967). It is observed that the difference is not significant at 5% level. Hence the data of males and females were pooled and a single equation was calculated for the species from Kakinada which is:

$$\log W = -4.650901 + 2.877071 \log L.$$

TABLE 1. *Comparison of regression lines of Length-weight relationship of males and females of* N. mesoprion.

						Deviation from Regression		
	df	Σx^2	Σxy	Σy^2	Reg. Co-efficient	df	SS	MSS
Within								
Males	310	1.422756	4.097065	12.007835	2.87966	309	0.209648	
Females	294	1.207296	3.468791	10.304630	2.87319	293	0.338134	
						602	0.547782	0.000909
Pooled	604	2.630052	7.565856	22.312465	2.87669	603	0.547809	0.000908
		Differences between slopes				1	0.000027	0.000027
Between	1	0.333072	0.959265	2.762693				
Total	605	2.963124	8.525121	25.075158	2.877072	604	0.547771	
		Between adjusted means				1	0.000038	0.000038

Slopes F = 33.666, df = 602, 1 — Not significant at 5%

Elevations F = 23.89, df = 603, 1 — Not significant at 5%

Maturation and Spawning

As in the case of *N. japonicus* (Murty MS) the testis in *N. mesoprion* is very small even in mature fishes thus making it difficult to study the process of maturation in males. Hence, only females are considered for this purpose. A total of 295 females ranging from 83 to 177 mm were examined. The stages of maturation are fixed following those fixed for *N. japonicus* (Murty MS) from Kakinada.

i. *Length at first maturity*: Fishes in the stages III-VII of maturation are taken as mature for this purpose. The percentage-frequency distribution of mature females in each length group are shown in figure 1. Fishes above 90 mm showed mature ovaries. The data show that 50% of the fish are mature at 100 mm. Hence 100 mm is taken as the length at first maturity of female *N. mesoprion* at Kakinada. In this connection it may be mentioned that the smallest female with running ripe ovary obtained in the present study measured 110 mm.

ii. *Spawning*: The ova-diameter-frequency distribution in mature and ripe ovaries are presented in figure 2. It may be seen that the ova are distributed around two modes (Fig. 2; A & B) in mature ovaries (st. V): one mode at 0.152 mm (7-8 m.d.) and the other at 0.418 mm (21-22 m.d.); the former group constitutes maturing translucent ova and the latter constitutes mature opaque ova. In running ripe females (fig. 2, C & D) a group of ova are separated and form

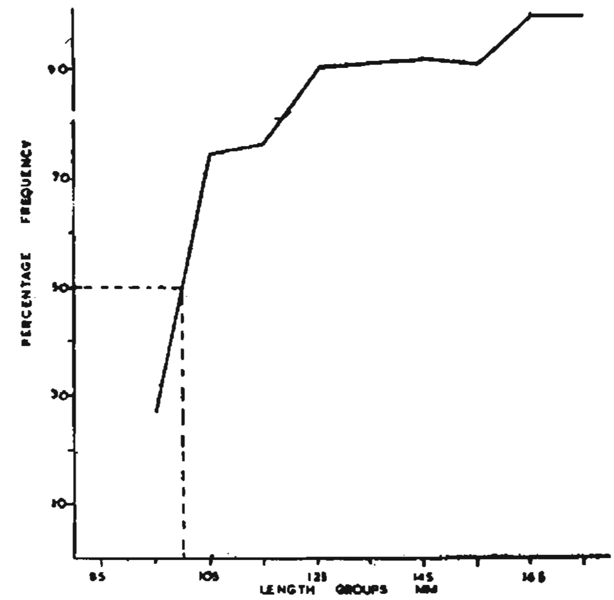

FIG. 1. Percentage-frequency distribution of mature female *N. mesoprion* in different length groups.

modes at 0.722 mm (37-38 m.d.) or 0.760 mm (39-40 m.d.). These constitute the ripe ova with translucent yolk and distinct oil globule. In fact, there is evidence of spawning being almost complete (fig. 2, D) by the poor representation of ripe ova in the ovary. Apparently, the mature ova forming a mode at 0.418

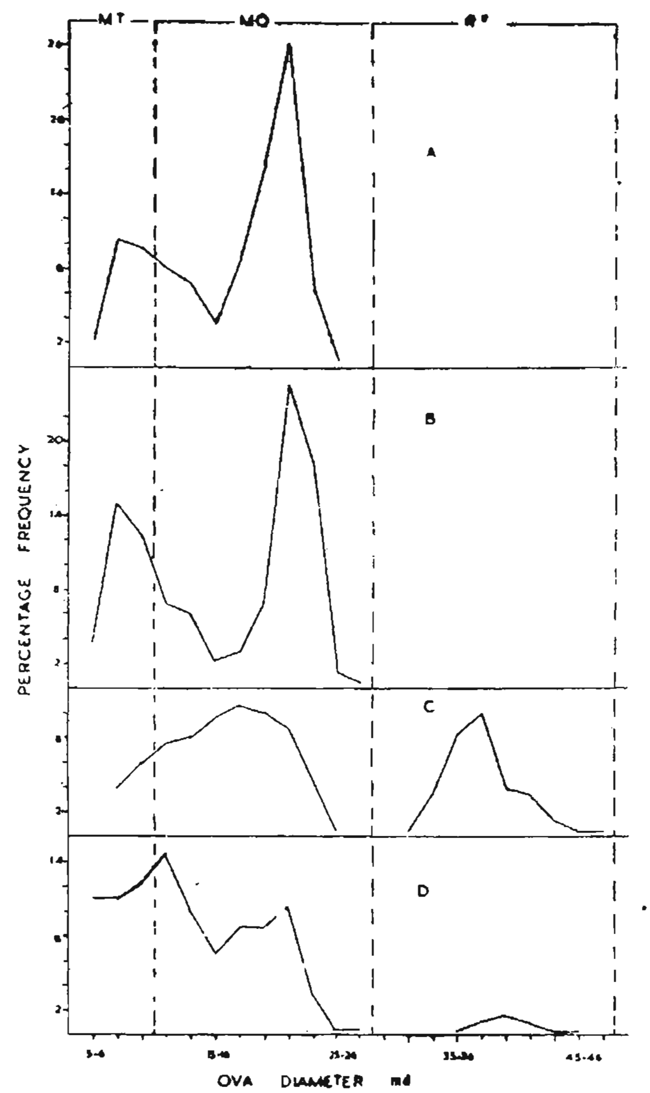

FIG. 2. Ova-diameter-frequecy distribution in mature and ripe ovaries of *N. mesoprion*: A & B. Mature ovaries (st V) collected on 12-1-79 and 7-11-79.

C & D. Ripe (st VI) ovaries collected on 12-1-79.

MT: Maturing translucent ova, MO: Mature opaque ova, RT: Ripe translucent ova with oil glubule.

mm in mature ovaries (fig. 2, A & B) have undergone the process of maturation and reached the modal diameters of 0.722 mm and 0.760 mm (Fig. 2 C & D) in ripe ovaries. In ripe ovaries (st. VI) a mode can also be seen in the mature opaque ova at 0.418 mm (21-22 m.d.) (Fig. 2, D) or at 0.342 mm (17-18 m.d.) (Fig. 2, C). These modes are the same as those representing mature ova in stage V (Fig. 2A & B). Since the time taken for the mature ova in stage V to become ripe (St. VI) and be released is generally short, it is reasonable to state that *N. mesoprion* is a fractional spawner releasing ripe ova in two batches during the single spawning season. A similar situation is obtained in a related species *N. japonicus* from Kakinada (Murty, MS).

For purpose of determining spawning season only females above the length at first maturity are taken into consideration. Since data are not available continuously in all months in different years, the data pertaining to the corresponding months of different years are pooled and the monthly percentage-frequency distribution of individuals in different stages of maturation are shown in Table 2. It is observed that fishes in stage V occur during February-March and November-December whereas those in ripe condition (St. VI) occur during January-March and December. Though the data are not quite adequate to determine the spawning season correctly it appears that this species spawns in the sea off Kakinada during December-April period with peak during January. The fact that ripe oozing females occur in the catches in considerable numbers during certain months indicates that *N. mesoprion* spawns in the present trawling ground off Kakinada.

TABLE 2. *Monthly percentage frequency distribution of adult females in different stages of maturation of* N. mesoprion.

Months	No. examined	II	III	IV	V	VI	VII
January	77	5.2	26.0	39.0	—	27.3	2.5
February	77	3.9	61.0	23.4	2.6	7.8	1.3
March	25	16.0	36.0	36.0	8.0	4.0	—
April	13	62.0	31.0	7.0	—	—	—
September	4	25.0	75.0	—	—	—	—
November	39	20.5	30.8	46.2	2.6	—	—
December	24	4.2	45.8	33.3	4.2	4.2	8.4

No data for May-August and October.

AGE AND GROWTH

For purpose of study of age and growth, data on the length-frequency distribution collected during January 1977-September 1980 are used. A total of 2386 specimens ranging from 32 to 215 mm were examined. The monthly length-frequency distribution of *N. mesoprion* in different years are shown in figure 3. It may be seen that data are available for only a few months in different years. This is mainly due to the fact that this species forms a seasonal fishery during

January-March and during other months it becomes scarce in the catches (Murty MS). Even during the short periods for which data are available, the modes in the monthly length-frequency distribution do not show clear-cut progression making the estimation of age difficult. However, an attempt is made here to estimate the growth rate and age by following the modal progression (wherever possible) during short intervals of one to four months. This has been done deliberately, in spite of the limitations involved because there is no information on age and growth of this species from India. It may be seen from figure 3, that

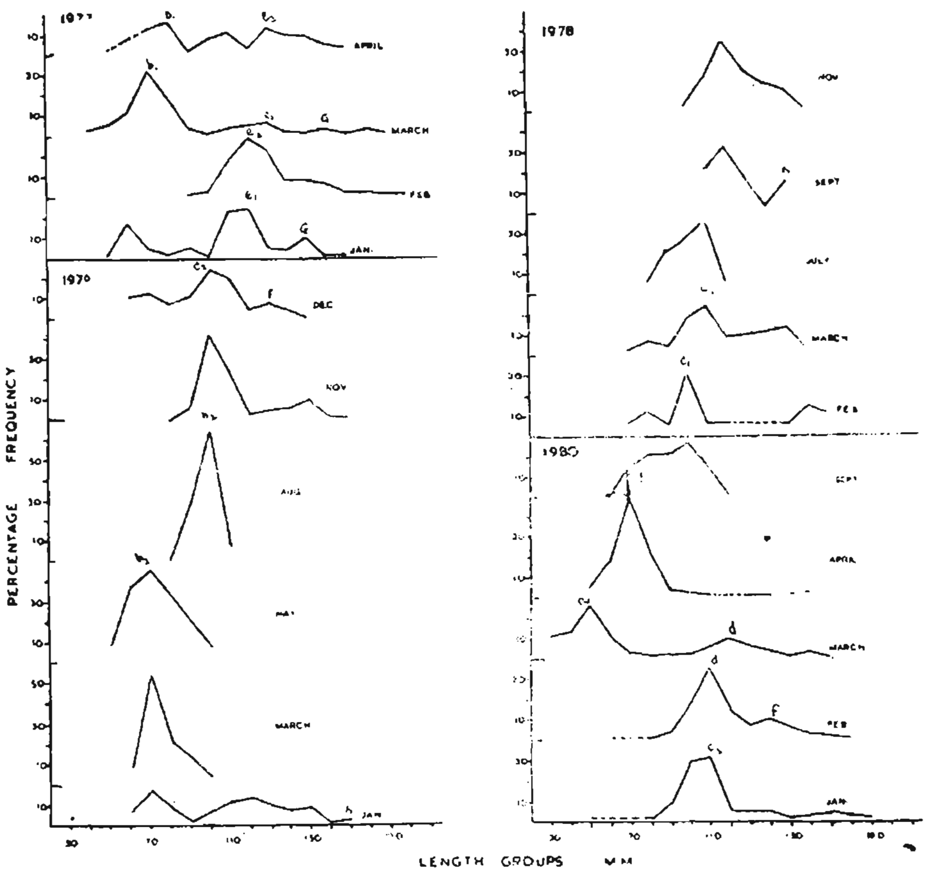

FIG. 3. Monthly length-frequency distribution of *N. mesoprion* in different years.

the mode (a) at 50 mm in March 80 can be traced to 70 mm in April 80 giving a growth of 20 mm in one month. The mode (b1) at 70 mm in March 77 is traceable to 80 mm in April 77 giving a growth rate of 10 mm per month; another mode (b2) also at 70 mm in May 79, can be traced to 100 mm in August 79, in three months, giving an average growth rate of 10 mm per month. The mode at 100 mm (c1) in February 78 can be traced to 110 mm in March 78; similarly, the mode at 100 mm (c1) in December 79 can be traced to

110 mm in January 80 thus giving a growth rate of 10 mm per month. The mode at 110 mm (d) in February 80 has progressed to 120 mm in March 80 with a growth rate of 10 mm per month. The mode (e1) at 120 mm in February 77 can be traced to 130 mm in March 77 and the mode (e2) at 120 mm in February 77 to 130 mm in April 77, thus giving a monthly growth rate of 5 mm. The mode at 130 mm in December 79 (f) is traceable to 140 mm in February 80 giving a growth of 10 mm in two months. Similarly the mode at 150 mm (g) in January 77 can be traced to 160 mm in March 77 giving a monthly growth rate of 5 mm and the mode (h) at 150 mm in september 78 is traceable to 170 mm in January 79 (in four months) with a growth rate of 5 mm per month. Beyond 170 mm, the modal progression is not traceable.

From the above observations it may be summarised that the monthly growth rates are 20 mm between 50 and 70 mm length, 10 mm between 70 and 120 mm, and 5 mm between 120 and 170 mm length. Since a growth of 20 mm is observed between 50 and 70 mm in one month, the fishes forming a mode at 50 mm can be reasonably taken as two months old (at a growth rate of 25 mm|month). It may thus be taken that *N. mesoprion* off Kakinada obtains a length of 140 mm at the completion of one year and 170 mm at the completion of one-and-half year.

Weber and Jothy (1977) believed that this species attains 50-60 mm, 125 mm and 156 mm at the completion of first, second and third years, respectively. The data for the above conclusions came from the survey of demersal fish resources carried out in the coastal waters of the South China sea bordering east Malaysia (Sarawak and Sabha) from 29th March to 1st May 1972. The length data of *N. mesoprion* obtained during the above period were analysed with the help of probability paper (Harding 1949, Cassie 1954) and the resultant normal distributions of different length groups were taken as belonging to different age groups. These authors, however, did not take the growth rate of the species into account nor did they have data over extended periods to facilitate the study of age and growth.

The von Bertalanffy equation for growth in length (Beverton and Holt 1957) which is of the form:

$$L_t = L\alpha\,(1 - e^{-K(t - t_o)})$$

Where $L\alpha$ = asymptotic length of the fish, L_t = length at age t, K = a constant equal to 1/3 of catabolic coefficient, t = age of fish and t_o = arbitrary origin of growth curve, was fitted to the age-length data of *N. mesoprion* from Kakinada.

The $L\alpha$ was estimated from the Ford-Walford plot (Food 1933, Walford 1946, Beverton and Holt 1957) of $L_t + 1$ against L_t on the basis of lengths attained at intervals of 3 months. The regression line (fig. 4) was fitted by the method of least squares. It is observed that the points are well represented by the straight line. The L∞ obtained is 219 mm which is close to the maximum length (215 mm) obtained in the trawler catches at Kakinada.

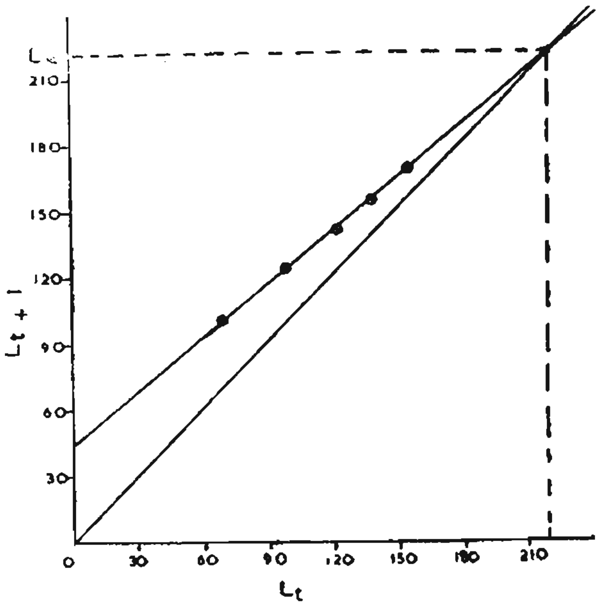

FIG. 4. Ford-Walford plot of growth in length of *N. mesoprion*.

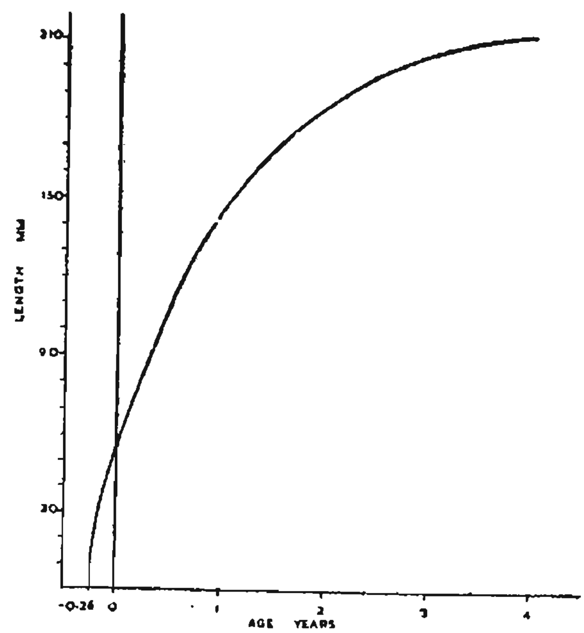

FIG. 5. Theoretical growth curve of *N. mesoprion*

The parameters K ahd t_o were eestimated from the equation (Beverton 1954) log e ($L\alpha$-L_t) = log e ($L\alpha + kt_o$) - K_t and values obtained are K = 0.83248 and t_o = −0.256198 years.

The lengths at different ages calculated from the von Bertalanffy growth equation are plotted in figure 5 which indicate that observed and calculated lengths at different ages agree closely and that *N. mesoprion* at Kakinada attains 140, 185 and 205 mm at the completion of first, second and third years respectively.

REFERENCES

BEVERTON, R. J. H. 1954. Notes on the use of theoritical models in the study of dynamics of exploited fish popuhations. *U.S. Fish. Lab Beaufort N.C. Misc. contr.*, 2: 159 pp.

BEVERTON, R. J. H. AND S. J. HOLT. 1957. On the dynamics of exploited fish populations. *Fish. Invest. Ser. London, Min. Agric. Fish U.K.* 2(19): 533 pp.

CASSIE, R. M. 1954. Some uses of probability paper in the nalysis of size frequency distributions. *Aust. J. Mar. Freshwater Res.* 5(3): 513-522.

CLARK, F. N. 1934. Maturity of the California Sardine (*Sardina caerulea*), determined by ova diameter measurements. *Fish. Bull. Calif. Div. Fish. Game*, 42: 49 pp.

FORD, E. 1933. An account of the Herring investigations conducted at Plymouth during the years 1924–1933. *J. mar. biol. Ass. U.K.*, 19: 305-384.

HARDING, J. P. 1949. The use of probability paper for the graphical analysis of polymodal frequency distributions. *J. mar. biol. Ass. U.K.*, 28: 141-153.

LE CREN, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the Perch (*Perca fluviatilis*). *J. anim. Ecol.*, 20: 201-219.

SNEDECOR, G. W. AND W. G. COCHRAN. 1967. *Statistical Methods.* Sixth Editiron Oxford and IBH publishing Co., New Delhi. 593 pp.

WALFORD, L. A. 1946. A new graphic method of describing the growth of animals. *Biol Bull Woods Hole*, 90: 141-147.

WEBER, W. AND A. A. JOTHY. 1977. Observations on the fish *Nemipterus* spp. (Family: Nemipteridae) in the coastal waters of east Malaysia. *Arch Fisch Wiss.*, 28 (2/3): 109-122.

CONTRIBUTION 6

MURTY, V. SRIRAMACHANDRA. 1984. Observations on the fisheries of threadfin breams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) from Kakinada. *Indian J. Fish.*, 31 (1): 1-18.

CONTRIBUTION 6

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OBSERVATIONS ON THE FISHERIES OF THREADFIN BREAMS (NEMIPTERIDAE) AND ON THE BIOLOGY OF *NEMIPTERUS JAPONICUS* (BLOCH) FROM KAKINADA

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ABSTRACT

Of the four species of threadfin breams occurring, *N. japonicus* is the most dominant at Kakinada. Peak landings are obtained during first and last quarters. There is significant difference in length-weight relationship of males and females. Peak values of Relative condition factor are associated with accumulation of fat. This species is a fractional spawner releasing the ripe ova in two batches during a protracted spawning season: August-April. The length at first maturity is estimated as 125 mm in females. The estimated fecundity ranges from 23049 to 139160 in fishes of 134-199 mm length; in this length range, there is linear relationship between length and fecundity and between weight and fecundity. Generally males outnumber females and attain larger length. *N. japonicus* attains 185 mm, 255 mm and 285 mm at the completion of the first, second and third years, respectively, at Kakinada. The various growth parameters are estimated as: $L_{\infty} = 314$ mm, $K = 0.75142$ and $t_0 = -0.17309$ years.

INTRODUCTION

Threadfin breams constitute an important portion of the demersal fish catches at Kakinada: an estimated 394 tonnes were landed by the trawlers during April 1968-December 1970, forming 9.7% of the total trawl catches (Muthu et al 1977). With increase in the fishing effort in recent years, the catches of these fishes increased considerably, though showed decline in 1978 and 1979. The present account deals with the fisheries of threadfin breams and biology of *N. Japonicus*.

MATERIAL AND METHODS

The study is based on data collected during 1976-1979. Estimates of monthly and annual effort and catches were made following Muthu et al (1977). Three types of boats were engaged in fishing in the area, using two-seam bottom trawl nets (see CMFRI 1981 for details). The effort (number of units) was standardised taking *Pomfret* (the total number of units of this boat is maximum in the fleet) as the standard unit, following the procedure of Gulland (1969). The catch rates (C/E) mentioned in this paper refer to catch per unit of standard effort.

Samples for the study were obtained at weekly intervals. Data on length,* weight, sex and stage of maturation were taken from fresh specimens. The length data obtained on each observation day were raised to the day's catch and these data were further raised to get monthly length composition of the catch. For the present study, these data were scaled down to percentages. The length-weight relationship and Relative condition factor were calculated following Le Cren (1951). Ova-diameter measurements were taken from formalin-preserved ovaries: small pieces from the middle of the ovaries were taken and all the ova in the piece were measured with the help of an ocular micrometer at a magnification where each micrometer division was equal to 0.019 mm, following the procedure of Clark (1934). Fecundity was estimated taking stage V ovaries.

FISHERIES

The catches of nemipterids were highest in 1977. In 1978 and 79 the catches were low, when both the effort (Table 1) and the catch rates were also in decline. The period from November to May was the season of abundance with peaks during January, March, May and December (fig. 1).

TABLE 1. *Estimated catches (kg), effort (standard units) and catch rates of Threadfin breams during* 1976-'79. (*Values in parantheses indicate percentage increase or decrease over each previous year*).

Particulars	1976	1977	1978	1979
Effort	33777	58450	53645	50125
		(+73.0)	(−8.2)	(−6.6)
Catch	527767	1336945	393361	271386
		(+153.3)	(−70.6)	(−31.0)
C/E	15.6	22.9	7.3	5.4

Four species of nemipterids contributed to the fishery. *N. japonicus* was the most dominant species contributing to over 50% (by weight) of nemipterid catches in most months, followed by *N. mesoprion, N. tolu* and *N. luteus* (Fig. 2). *N. mesoprion* formed a seasonal fishery, particularly during January-March. During certain years this species dominated over even *N. japonicus. N. tolu* occurred almost round the year, but in poor quantities. *N. luteus* was also represented by poor catches, but occurred in considerable quantities during January-March.

Determination of depthwise distribution of different species was not possible on the basis of the present data. According to Narayanappa et al (1968),

* Total length, measured from tip of snout to tip of lower caudal lobe.

Nemipterus spp. were predominent in depths beyond 50 m. The data on experimental trawling, by Satyanarayana et al (1972), also showed that threadfin breams were more abundant in the area beyond 50 m depth.

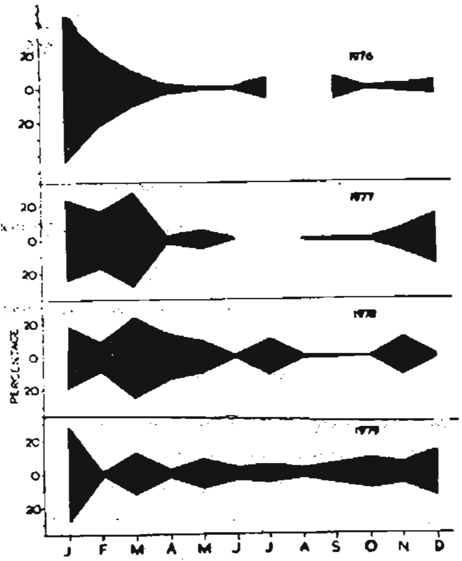

FIG. 1. Seasonal abundance of Threadfin breams during 1976-1979.

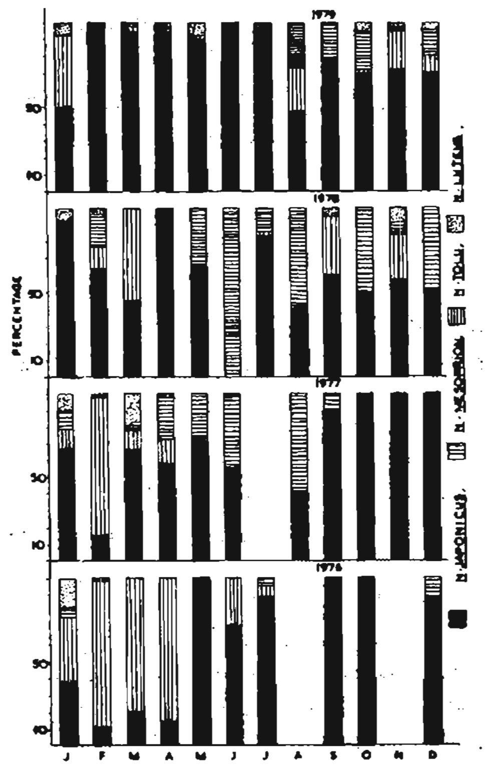

FIG. 2. Monthly percentage composition (by weight) of nemipterid species during 1976-1979.

Silas (1969) showed that, in the depth zone 75-100 m along the west coast, *N. japonicus* predominated in exploratory and experimental fishing operations, often forming 75% of the trawl catch. Zupanovic and Mohiuddin (1975) also reported similar abundance of this species in the 50-125 m depth zone along the northeastern Arabian sea.

BIOLOGY OF *Nemipterus japonicus*

Length-weight relationship

The study was based on 279 females ranging from 69 mm and 5 g to 218 mm and 139 g and 168 males ranging from 71 mm and 6 g to 251 mm and 184 g, collected during April 1976-March 1977. The relationship was calculated separately for the sexes and the equations obtained are:

Males: log W = -3.65045 + 2.43025 log L
Females: log W = -4.78737 + 2.95688 log L

The significance of difference between the Regression coefficients of sexes was tested by Analysis of covariance following Snedecor and Cochran (1967) (Table 2). The difference is significant at 5% level.

TABLE 2. *Comparison of Regression lines of length-weight relationship of males and females of* N. japonicus *from Kakinada.*

	Df	Σx^2	Σxy	Σy^2	Regression coefficient	Deviation from Regression Df	SS	MS
Within								
Males	167	2.77689	6.74856	20.03178	2.43025	166	3.63104	
Females	278	2.82427	8.35101	25.15722	2.95688	277	0.46435	
						443	4.09538	0.00924
Pooled	445	5.60116	15.09957	45.18900	2.69579	444	4.48368	
		Difference between slopes				1	0.38830	0.38830

Comparison of slopes: F = 42.02; Df = 1,443; Significant at 5% level.

Differences in length-weight relationship between sexes in nemipterid fishes are known; Eggleston (1970) recorded the difference in *N. virgatus* and Krishnamoorthi (1973) in the case of *N. japonicus* off Visakhapatnam. Vinci and Nair (1975) and Hoda (1981), however, did not find difference in the length-weight relationship of males and females of *N. japonicus* from Cochin on the west coast of India and from Pakistan coast, respectively.

Relative condition factor

The Relative condition factor (Kn) values of females were less than unity in January, April and June and more than unity in other months. In males, the values were more than unity in all the months. It was also observed that the Kn values of males were more than those of females in most months. Fat accumulation started in June, became heavy in August-October, and traces of it were present in November-December. During January-May there was no fat. The high Kn values in July-October (fig. 3) were thus due to fat accumulation.

For comparing the Kn values of different lengths, data of March-May 1977 only were considered, to eliminate any possible influence of different factors (e.g., maturation, fat accumulation, etc.) on Kn values. The Kn values of males up to 155 mm were less than those of females, but from 165 mm onward these values were more (fig. 4). In females, there was a peak at 75 mm, followed by a gradual fall till a minimum at 125 mm, increasing again to a peak at 145 mm; there was another fall at 165 mm and another peak at 195 mm.

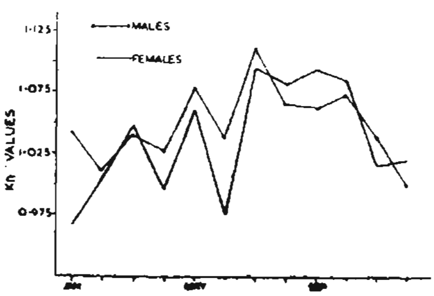

FIG. 3. Relative condition factor in *N. japonicus* in different months.

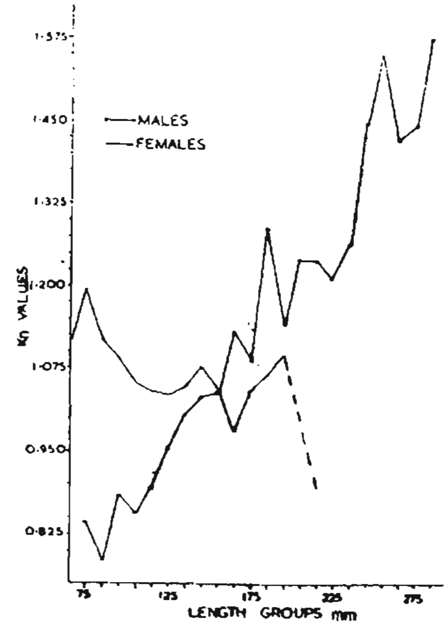

FIG. 4. Relative condition factor in *N. japonicus* in different length groups.

Maturation and spawning

Only females (1001 nos.) ranging from 65 to 215 mm in total length, collected during January 1977-December 1979, were considered for this study.

1. Stages of maturation: The following seven stages of maturation were recognised (arbitrarily) for females of *N. japonicus*,

Stage I (Immature): Ovary thin, narrow, cylindrical, occupying less than $\frac{1}{4}$ of body cavity length; pale translucent.

Stage II (maturing virgins): Ovary thin, narrow, cylindrical, occupying about $\frac{1}{4}$ of body cavity length, pale, translucent. Ova translucent, irregularly shaped, with slight yolk (spent-recovering adults were not encountered).

Stage III (maturing): Ovary occupies about $\frac{1}{2}$ the length of the body cavity, narrow, cylindrical and pale yellow. Blood capillaries not distinct, ova not clearly visible to naked eye; larger ova are opaque and smaller ones are translucent.

Stage IV (mature): Similar to that in stage III but with numerous blood capillaries. Majority of the ova are opaque and are visible to naked eye.

Stage V (gravid): Ovary occupies about ¾ the length of the body cavity, whitish, with numerous blood capillaries, ovarian wall thin; ova spherical, opaque with narrow translucent outer border.

Stage VI (ripe): Ovary occupies from ¾ to entire length of the body cavity, cream-coloured. Ripe ova, which are translucent and with a distinct oil globule, are already released into the lumen of the ovary; along with these ova are several mature (opaque) and maturing (translucent) ova. (In several instances, the ovary extended to about half the length of body cavity, with a few ripe and a majority of opaque ova. Obviously the majority of ripe ova were released. Such ovaries were also included under stage VI.)

Stage VII: Completely spawned ovary was never encountered.

2. *Length at first maturity*: Only females in stages III-VI were taken as mature for this purpose. The data of August-April (spawning period) alone were considered. Fishes of 100 mm and above showed mature gonads and there was an increase in the number of mature fishes with increase in length. About 50% of the fish were mature at a length of 125 mm (fig. 5). Hence this length was taken as the length at first maturity at Kakinada. According to Krishnamoorthi (1973), the length at first maturity of females of *N. japonicus* off Waltair was 165 mm.

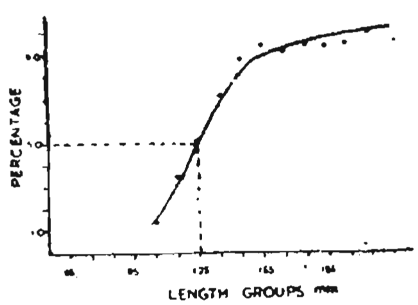

FIG. 5. Percentage-frequency distribution of mature females of *N. japonicus* in different length groups.

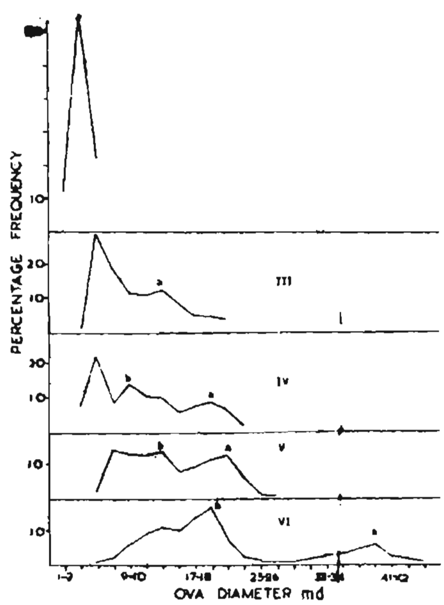

FIG. 6. Ova-diameter frequency distribution in ovaries of different stages of maturation in *N. Japonicus*.

3. *Spawning habits*: The ova were distributed around a modal value of 0.08 mm in stage II (fig. 6). In stage III, a batch of ova was released from the parent stock and formed a mode around 0.27 mm (mode 'a'). This mode progressed to 0.76 mm in stage VI. In stage IV, another batch of ova was released from the parent stock and it formed a mode around 0.19 mm (mode 'b'). This mode could be traced to 0.38 mm in stage VI. Two batches of ova were, thus, released from parent stock and underwent the process of maturation. While the ova at mode 'a' in stage VI were ripe and to be released, the ova at mode 'b' in stage VI were opaque and were yet to become ripe (figs. 6-7). Also the mode 'a' in stage V and mode 'b' in stage VI were more or less at the same diameter, indicating that the ova at mode 'b' in stage VI probably took the same

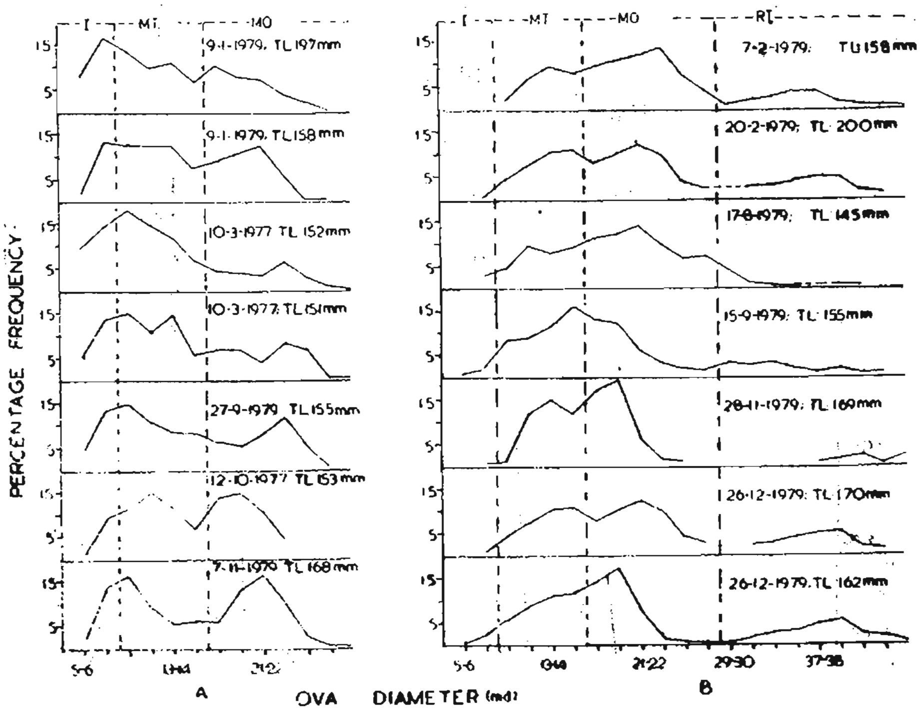

FIG. 7. Ova-diameter frequency distribution in (A) stage V and (B) stage VI ovaries collected during different months. Diameter ranges of Immature ova (I); Maturing translucent ova (MT); Mature opaque ova (MO), Ripe translucent ova with an oil globule (RT).

time to become ripe and spawned as the ova at mode 'a' in stage V. Thus, it appears that *N. japonicus* is a fractional spawner, releasing its ripe eggs in two batches during the spawning season. Eggleston (1973) and Dan (1980) have obtained similar results. The process of maturation also suggests that once the fish reaches stage VI and release the batch of ripe ova, it may revert to stage V and again undergo ripening and reach stage. VI. This is possible, because

TABLE 3. *Monthly percentage frequency distribution of adult females of* N. japonicus *in different stages of maturation (Data of* 1977-1979 *pooled).*

	No. of specimens examined	% of maturation stages				
		II	III	IV	V	VI
Jan	81	8.6	18.6	45.7	12.8	14.3
Feb	37	16.2	—	5.4	5.4	73.0
Mar	117	42.7	17.1	17.1	6.8	16.3
Apr	55	69.1	18.2	9.1	1.8	1.8
May	27	85.2	14.8	—	—	—
Jun	9	100.0	—	—	—	—
Jul	55	36.4	40.0	23.6	—	—
Aug	35	11.4	28.6	8.6	11.4	40.0
Sep	76	9.2	19.8	28.9	14.5	27.6
Oct	67	3.0	23.9	26.8	44.8	1.5
Nov	91	—	—	53.8	38.5	7.7
Dec	71	1.4	2.8	12.7	40.8	42.3

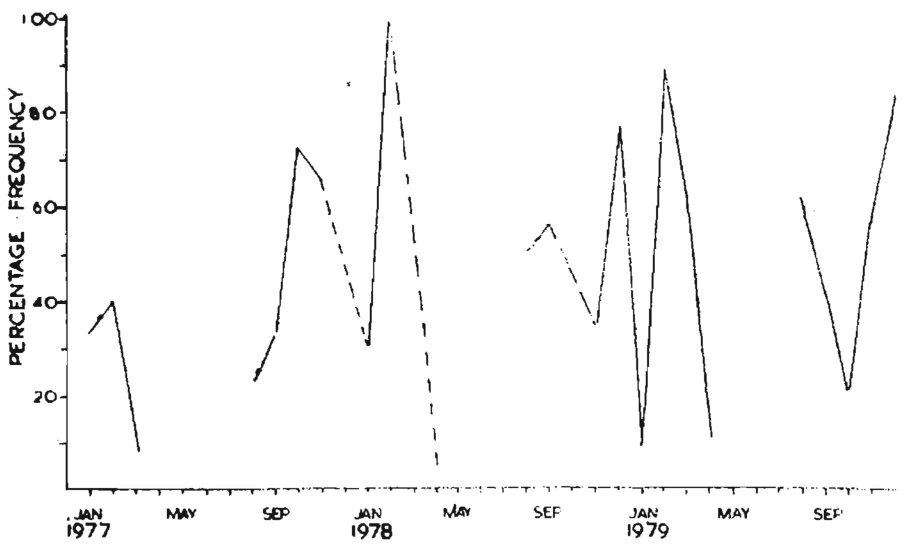

FIG. 8. Percentage-frequency distribution of gravid and ripe (st V + st VI) females of *N. japonicus* in different months.

the modal sizes of mature opaque ova in stage V and VI were more or les same. There was also a group of maturing translucent ova forming a mod (fig. 7) in stage V, which seem to mature and become opaque by the tim the ovary reached stage VI. Thus it appears that the ovary, on reaching stag VI, and releasing ripe ova, does not go back to stage II, as is generally known but only returns to stage V. Supporting evidence is available from the fact tha fully spawned and spent rematuring adults were never encountered in th catches. James and Baragi (1980) observed similar situation in some marin fishes of India.

4. *Spawning season*: For the purpose of determining the spawning period, onl individuals above the length at first maturity were taken into account.

Though there were differences in the occurrence and abundance of gravi and ripe females in different years the spawning season of *N. japonicus* at Kaki nada may be taken as extending from August to April (Table 3) with peak during February and December (fig. 8). The occurrence of juveniles of th length range 35-85 mm over an extended period (*vide infra*) supports thi conclusion.

Krishnamoorthi (1973) stated that *N. japonicus* spawns off Waltai during September-November, and Dan (1980) observed that this species spawn twice a year, during December-February and June-July, at Waltair. This specie in the south China sea spawns during May-October (Eggleston, 1973).

Fecundity

For estimating fecundity, 30 stage V ovaries, of fishes ranging from 134 to 199 mm TL (32 to 105 g weight), were taken. Since *N. japonicus* releases ripe ova in two batches, the fecundity estimates from stage V ovaries pertain to the first batch only. To facilitate estimation of the number of ova produced for the second batch, the total number of maturing-translucent (0.17-0.30 mm) and mature-opaque ova (0.31-0.57 mm), from the ova-diameter-frequency distribution of stage V and VI ovaries (Fig. 7A & B), were taken and their percentages determined (Table 4). While the percentage of mature-opaque ova in stage VI ovaries ranged from 51.5 to 69.7, with the average at 59.2, the percentage of mature-opaque ova in stage V ovaries ranged from 30.1 to 57.5, with the average at 45.4. Hence, the ratio of ova produced for the first spawning act to those for the second was taken as 45:55.

The first and second batch fecundities range from 10372 to 62622 and from 12677 to 76538, respectively, and the total annual fecundity from 23049 to 139160, in fishes ranging from 134 to 199 mm TL. The average values are given in table 5. Fecundity against total length as well as weight (fig. 9) of fish shows a linear relation. The equations obtained are:

a) $F = -116.56711 + 1.11909\ L$ and
b) $F = -0.75615 + 1.11380\ W$

TABLE 4. *Maturing translucent ova and mature opaque ova in ovaries of stages VI and V in* N. japonicus *(percentages)*.

Stage VI		Stage V	
Maturing-translucent ova	Mature-opaque ova	Maturing-translucent ova	Mature-opaque ova
46.8	53.2	55.8	44.2
30.3	69.7	54.6	45.4
45.3	54.7	69.9	30.1
48.5	51.5	58.5	41.5
39.2	60.8	53.2	46.8
34.1	65.9	50.4	49.6
41.5	58.5	42.5	57.5
Pooled			
40.8	59.2	54.6	45.4

Where F = total fecundity in thousand eggs, L = length in mm, and W = weight in grams. The Correlation coefficient (r) for both the equations are 0.83 and 0.92 respectively. According to Dan (1980) the average fecundity ranged from 13.9 to 58.4 thousand eggs in *N. japonicus*, with the range of 138 to 205 mm, from Waltair. The estimated fecundity for the first batch spawning in the present study agrees well with the fecundity estimates of Dan (1980)..

Sex ratio

Females outnumbered males in January, March and May-June 1977 and in January, March-July, September and November 1978 (Table 6). In 1979,

TABLE 5. *Estimated average batch fecundities and total fecundity in different length groups (cm) of* N. japonicus.

Average length (mm)	Average Wt. (g)	N	I Batch Average	II Batch Average	Average total fecundity
134*	32	1	10372*	12677*	23049*
146	44	5	25149	30738	55887
153	47	9	23064	28189	51253
163	59	5	30514	37294	67808
174	63	3	30152	36851	67003
183	79	5	35904	43883	79787
195	105	2	56064	68522	124586

* Actual values.

males outnumbered females in all months except August-December. The annual sex ratios, however, showed predominence of males in 1977 and 1979, whereas in 1978 the ratio was 1 : 1. A test of variance for homogeneity (Snedecor and Cochran 1967) of the sex ratio over a period of one year was applied for the data of the three years separately.

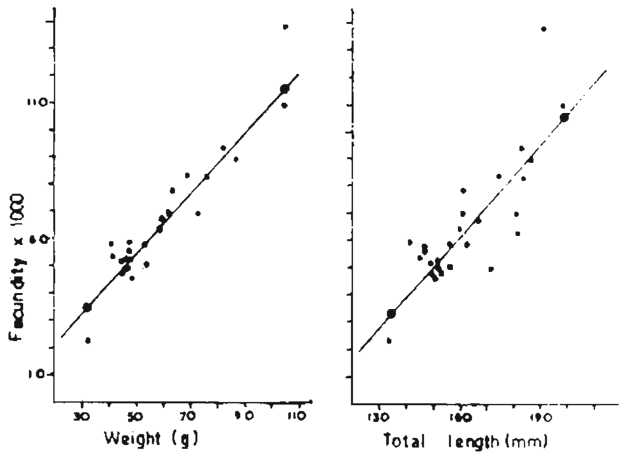

FIG. 9. Relation between fish weight and fecundity and between fish length and fecundity in *N. japonicus.*

At 5% probability level the χ^2 values for 1977 and 1978 showed that the observed differences in the monthly sex ratios were statistically significant, whereas they were not significant for 1979. In this connection, it may be noted that data were not available for all 12 months in 1977 and 78.

The data on the sex ratio in relation to length (Table 7) showed that in most length groups males outnumbered females and females were not represented in groups beyond 215 mm. Also the mean length of males in the catches was always greater than that of females. The present observation therefore supports that of Krishnamoorthi (1979) off Waltair that females were generally smaller in siize than males and males grew quicker and to a larger size.

Age and growth

A total of 6654 specimens, ranging from 35 to 285 mm, were measured for age and growth during the years 1977-1979 (figs 10-12). Mode 'f' at 65 mm in January 1977 could be traced to 85 mm in February 77, with a growth rate of 20 mm per month (fig. 10). Mode 'a' at 75 mm in April 1977 could be traced continuously to the mode at 275 mm in May 1978; the mode at 75 mm in April 1977 showed a progression up to 115 mm in June (2 months) at a growth rate of 20 mm per month; the mode at 115 mm in June 1977

TABLE 6. N. japonicus: *Proportion of females and sex ratio in monthly samples during* 1977-1979.

	N	Females	Proportion of females	M:F ratio	χ^2 test
1977					
Jan	63	39	0.619	1.0:1.6	
Feb	23	13	0.565	1.0:1.3	
Mar	131	83	0.634	1.0:1.7	
Apr	99	39	0.394	1.0:0.7	
May	72	40	0.556	1.0:1.3	χ^2=59.524
Jun	19	10	0.526	1.0:1.1	Df=9
Jul			— No data —		Significant
Aug	42	10	0.238	1.0:0.3	
Sep	92	27	0.293	1.0:0.4	
Oct	110	38	0.345	1.0:0.5	
Nov	85	26	0.306	1.0:0.4	
Dec			— No data —		
Pooled	736	325	0.442	1.0:0.8	
1978					
Jan	49	43	0.673	1.0:2.1	
Feb	43	19	0.442	1.0:0.8	χ^2 33.644
Mar	42	31	0.738	1.0:2.8	
Apr	144	55	0.382	1.0:0.6	
May	15	5	0.333	1.0:0.5	Df = 9
Jun			— No data —		
Jul	84	46	0.548	1.0:1.2	
Aug	9	2	0.222	1.0:0.3	Significant
Sep	25	14	0.560	1.0:1.3	
Oct			— No data —		
Nov	131	72	0.550	1.0:1.2	
Dec	43	16	0.372	1.0:0.6	
Pooled	585	293	0.501	1.0:1.0	
1979					
Jan	93	39	0.419	1.0:0.7	
Feb	100	47	0.470	1.0:0.9	
Mar	120	56	0.467	1.0:0.9	
Apr	50	16	0.320	1.0:0.5	χ^2=19.200
May	47	20	0.426	1.0:0.7	
Jun	20	8	0.400	1.0:0.7	Df = 11
Jul	24	11	0.458	1.0:0.8	
Aug	48	27	0.563	1.0:1.3	not significant
Sep	83	38	0.458	1.0:0.8	
Oct	90	36	0.400	1.0:0.7	
Nov	53	14	0.264	1.0:0.4	
Dec	134	71	0.530	1.0:1.1	
Pooled	862	383	0.444	1.0:0.8	

TABLE 7. N. japonicus: *Sex ratio in relation to length.*

Length groups (mm)	1977 M	1977 F	1978 M	1978 F	1979 M	1979 F	pooled 1977-79 M	pooled 1977-79 F
65	—	1	—	—	—	—	—	1
75	2	2	1	3	—	—	3	5
85	9	7	9	7	4	5	22	19
95	14	15	16	15	11	12	41	42
105	18	29	21	25	34	31	73	85
115	32	39	34	41	48	40	114	120
125	23	37	39	37	44	51	106	125
135	27	58	24	48	40	37	91	143
145	57	52	25	35	43	50	125	137
155	42	34	32	47	33	59	107	140
165	55	22	13	23	33	51	101	96
175	47	8	18	4	31	26	96	38
185	20	11	16	2	35	12	71	25
195	22	6	14	5	22	7	58	18
205	23	1	16	—	27	1	66	2
215	6	3	8	1	22	1	36	5
225	2	—	3	—	34	—	39	—
235	6	—	1	—	9	—	16	—
245	1	—	2	—	5	—	8	—
255	2	—	—	—	1	—	3	—
265	1	—	—	—	3	—	4	—
275	1	—	—	—	—	—	1	—
285	1	—	—	—	—	—	1	—
N	411	325	292	293	479	383	1182	1001
mean length (mm)	155.34	135.74	145.75	133.46	160.05	141.40	154.88	137.24
Sex ratio	1.26 : 1.00		1.00 : 1.00		1.25 : 1.00		1.18 : 1.00	

could be traced to 145 mm in August 1977 (2 months), with an average growth rate of 15 mm per month. The mode at 145 mm in August 1977 could be traced to 165 mm in October (2 months), with a growth rate of 10 mm per month. From 165 mm in October 1977 the growth was not traceable but this could be connected to the mode at 205 mm in March 1978 (fig. 11) (5 months) with an average growth rate of 8 mm per month. The mode at 205 mm in March 1978 was traced to 215 mm in May (2 months), with an average growth rate of 5 mm per month; this mode was not further traceable but the mode 'b' at 205 mm in November 1978 could be traced to 235 mm in May 1979 (in 6 months) (figs. 11 & 12), with an average growth rate of 5 mm per month. Similarly, the mode 'e' at 215 mm in January 1977 (fig. 10) could be traced to 235 mm in May (4 months), with an average growth rate of 5 mm per month. The progression of this mode was not traceable further. The mode 'c' at 245 mm in October 1979 was traceable to 255 mm in December 1979

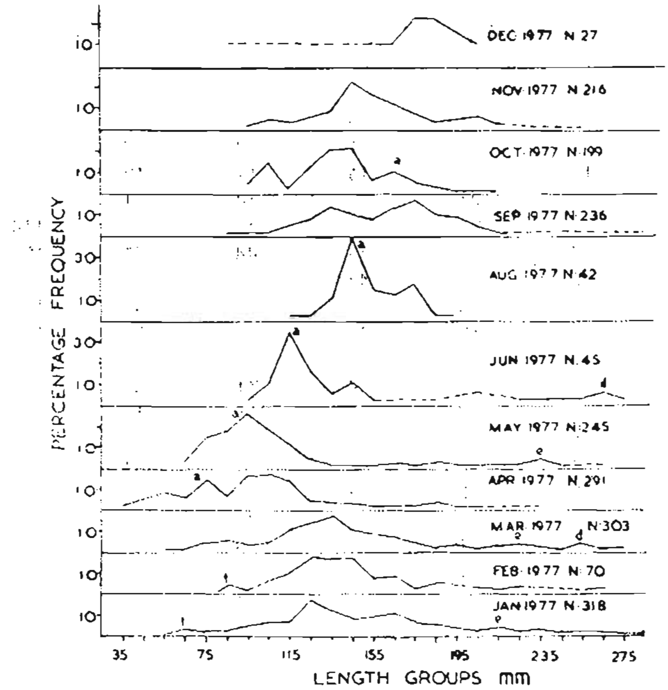

FIG. 10. Monthly length-frequency distribution of *N. japonicus* in 1977.

(2 months), with a monthly growth rate of 5 mm. Since the growth rate from 215 mm to 235 mm and from 245 mm to 255 mm was the same (5 mm| month), the same growth rate could be taken from 235 to 245 mm. The mode 'd' at 255 mm in March 1977 could be traced to 265 mm in June '77 (3 months), with an average growth rate of 3.3 mm per month.

Since the growth rates from 65 mm to 85 mm and from 75 mm to 115 mm were estimated at 20 mm per month, a still higher growth rate can be expected for fish up to 65 mm (the smallest modal length in the present study period was 65 mm, *vide* figs. 10-12) and an age of 3 months (at a growth rate of 21.7 mm per month) could be reasonably allotted to fish of 65 mm. On the basis of the estimated growth rates for different lengths, the lengths attained at different ages (months) are shown in figure 13A. The points on the graph are the modal lengths obtained from the data (figs. 10-12) and the curve indicates the authors interpretation of modal progression.

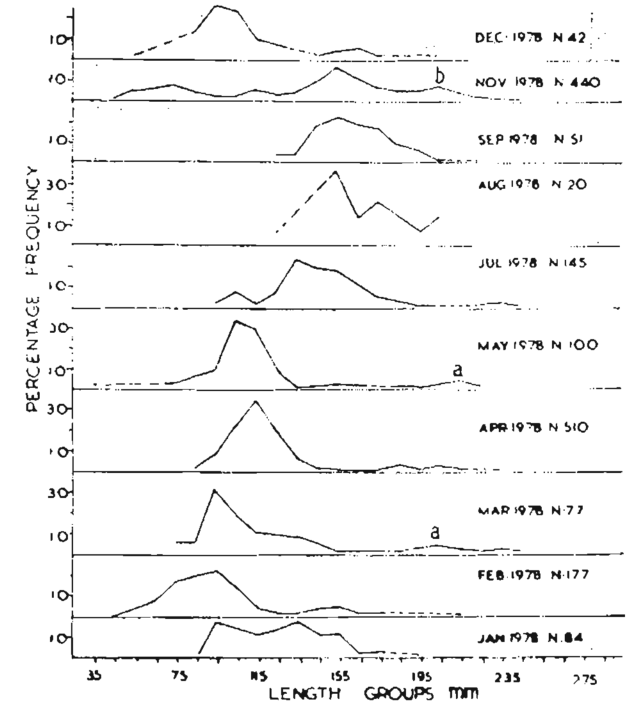

FIG. 11. Monthly length-frequency distribution of *N. japonicus* in 1978.

The von Bertalanffy equation for growth in length is of the form:

$$L_t = L\infty \left(1 - e^{-K(t-t_0)}\right)$$

The Ford-Walford plot (Beverton and Holt 1957; Ford 1933; Walford 1946) on the basis of lengths attained at intervals of 6 months is shown in figure 14. It was observed that the points were well represented by a straight line. The asymptotic length ($L\infty$) obtained in this study is 314 mm. The values of K and t_0 were estimated on annual basis from the relation:

$$\log_e(L\infty - l_t) = (\log_e L\infty + K\, t_0) - K_t$$

and the values obtained are K = 0.7514 and t_0 = −0.1731 year (fig. 15). The von Bertalanffy growth equation for *N. japonicus* from Kakinada can be written as:

$$L_t = 314\ \left(1 - e^{-0.7514\,(t+0.1731)}\right)$$

The lengths at different ages, calculated from the above growth equation (figure 13b), show that *N. japonicus* attains 185, 225 and 285 mm at the completion of first, second and third years respectively. Since the maximum length obtained in this study was 285 mm, the fishable life span is 3 years.

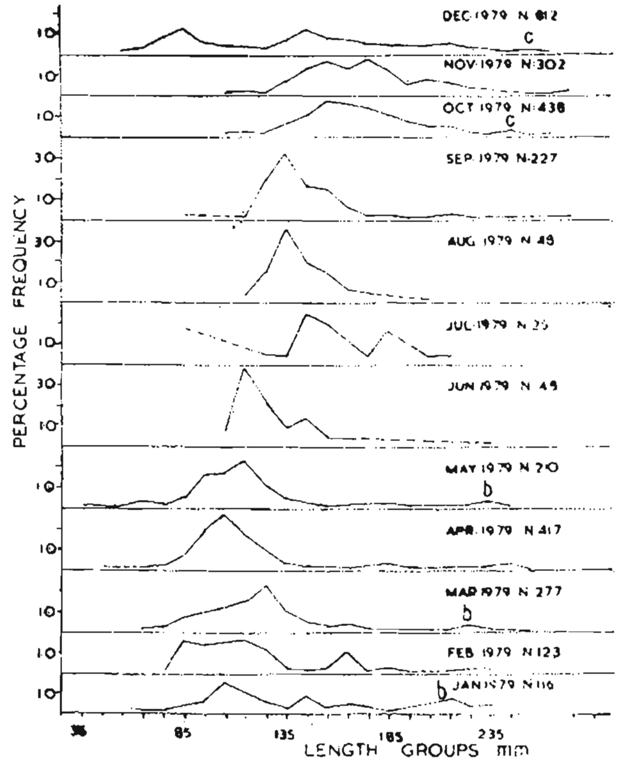

FIG 12. Monthly length-frequency distribution of *N. japonicus* in 1979.

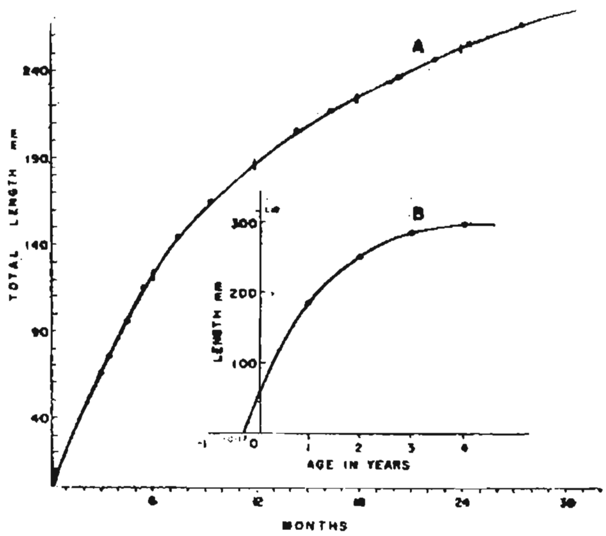

FIG. 13. A. Growth in length of *N. japonicus* on the basis of modal progression; B. Von-Bertalanffy growth curve.

According to Krishnamoorthi (1973) *N. japonicus* attains 150, 210 and 240 mm at the completion of first, second and third years, respectively, in the sea off Visakhapatnam. Ben Tuvia (1968) presented the length data of *N. japonicus* obtained during November-December 1957 from the Ethiopian coast and assumed that the modes obtained at 13 and 17 mm ac belonging to '0'

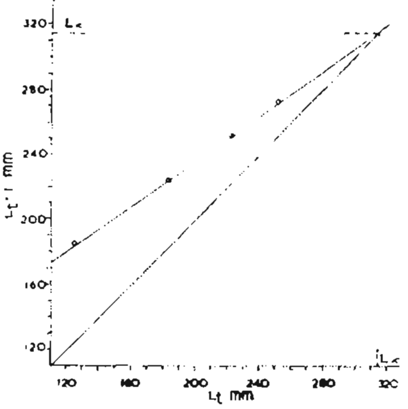

FIG. 14. Ford-Walford plot of growth of *N. japonicus*.

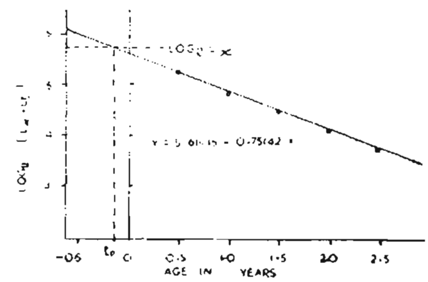

FIG. 15. Plot of $\log_e L_\infty - L_t$ against 't' to determine 'to' graphically.

and 'I' age group respectively. Eggleston (1973) and Fischer and Whitehead (1974) observed differential growth rate in sexes of *N. japonicus*. In the present study it was observed that males attain longer length than females (*vide* section on sex ratio), but it was not possible to determine the age and growth of sexes separately by length-frequency method. in the absence of external sexual dimorphism in this species.

REFERENCES

BEVERTON, R. J. H. 1954. Notes on the use of theoretical models in the study of the dynamics of exploited fish populations. *U. S. Fish. Lab. Beaufort. N. C., Misc., Contr.*, 2: 159 pp.

BEVERTON. R. J. H. AND S. J. HOLT. 1957. On the dynemics of exploited fish populations. *Fish. Invest Ser. London. Min. Agric. Fish.* 2 (19): 533 pp.

BEN TUVIA, A. 1968. Report on the fisheries investigations of the Israel South Red Sea Expedition 1962. *Bull. Sea Fish. Res. Stn. Haifa*, 52, 21-55.

CLARK, F. N. 1934. Maturity of the California sardine (*Sardina caerulea*), determined by ova-diameter measurements. *Fish. Bull. Calif. Div. Fish. Game*, 42:49 pp.

CMFRI. 1981. Commercial trawl fisheries off Kakinada during 1969-1978. *Mar. Fish. infor. Serv. T & E Ser. No.* 31:1-6.

DAN, S. S. 1980. Intra ovarian studies and fecundity in *Nemipterus japonicus* (Bloch) *Indian J. Fish.*, 24: 48-55 (1977).

EGGLESTON, D. 1970. Biology of *Nemipterus virgatus* in the northern part of the South China Sea. *in*: Marr, J. C. (Ed.). 'The *Kuroshi;* A symposium on the Japan current.' 417-424.

EGGLESTON, D. 1973. Patterns of biology in nemipteridae, *J. mar. biol. Ass. India*, 14: 357-364 (1972).

FORD, E. 1933. An account of the herring investigations conducted at Plymouth during the years 1924-1933. *J. mar. biol. Ass. U. K.*, 19: 305-384.

GULLAND, J. A. 1969. Manual of methods for fish stock assessment part. I. Fish population Analysis. *FAO Manuals in Fisheries Science* No. 4: 154 pp.

HODA, S. M. S. 1981. Length-weight and volume relationship in the threadfin bream, *Nemipterus japonicus* from the Pakistan Coast. *J. mar. biol. Ass. India* 18: 421-430 (1976).

JAMES, P. S. B. R. AND V. K. BARAGI. 1980. Ovary as an indicator of frequency of spawning in fishes. *Proc. Indian natn. Sci. Acad.*, B 46: 479-489.

KRISHNAMOORTHI, B. 1973. Biology of the threadfin bream, *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 18: 1-21 (1971).

KRISHNAMOORTHI, B. 1976. A note on the size difference between males and females of *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 21: 608-609 (1974).

LE CREN, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*) *J. Anim. Ecol.*, 20: 201-219.

MUTHU, M. S., K. A. NARASIMHAM, G. SUDHAKARA RAO, Y. APPANNA SASTRY AND P. RAMALINGAM. 1977. On the commercial trawl fisheries off Kakinada during 1967-70. *Indian J. Fish.*, 22: 171-186 (1975).

NARAYANAPPA, G., D. A. N. RAJU AND A. V. V. SATYANARAYANA. 1968. Certain observations on the otter trawl operations carried out in the inshore and deep waters off Kakinada. *Proc. Indo-Pacific Fish. Coun.*, 13 (III): 450-455.

SATYANARAYANA, A. V. V., G. NARAYANAPPA AND D. A. N. RAJU. 1972. On the comparative fishing experiments with a four-seam and a two-seam trawls on the east coast. *Fish. Technol.*, 9 (2): 169-179.

SILAS, E. G. 1969. Exploratory fishing by R. V. Varuna. *Bull. Cent mar. Fish. Res. Inst.*, 12: 1-86.

SNEDECOR. G. W. AND W. G. COCHRAN. 1967. *Stastistical Methods*. Sixth Edition. Oxford & IBH Publishing Co., New Delhi. 593 pp.

VINCI. G. K. AND A. K. K. NAIR. 1975. Length-weight relationship in the threadfin bream, *Nemipterus japonicus*, along the Kerala coast. *Indian J. Fish.*, 21: 299-302 1974).

WALFORD, L. A. 1946. A new graphic method of describing the growth of animals. *Biol. Bull. Woods Hole*, 90: 141-147.

ZUPANOVIC S. AND S. Q. MOHIUDDIN. 1976. A survey of the fishery resources in the northeastern part of the Arabian sea. *J. mar. biol. Ass. India*, 15: 469-537.

CONTRIBUTION 7

MURTY, V. SRIRAMACHANDRA. 1983. Estimates of mortality, population size and yield per recruit of *Nemipterus japonicus* (Bloch) in the trawling grounds off Kakinada. *Indian J. Fish.*, 30 (2): 255-260.

CONTRIBUTION 7

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ESTIMATES OF MORTALITY, POPULATION SIZE AND YIELD PER RECRUIT OF *NEMIPTERUS JAPONICUS* (BLOCH) IN THE TRAWLING GROUNDS OFF KAKINADA

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ABSTRACT

The mortality rates of *N. japonicus* are estimated from annual age composition of fish caught by trawlers. The estimated values are $Z = 1.86$, $F = 0.72$ and $M = 1.14$. The exploitation rate (U) is estimated at 0.33 and the total annual stock at 1181 tonnes. The yield curve shows that the fishing mortality can be increased from the present level of 0.72 to 1.75 to get increased yield.

INTRODUCTION

For rational management of fisheries resources a knowledge of various mortality rates (total, natural and fishing) of fish populations is necessary apart from the knowledge on various aspects of biology of the concerned species. In an earlier paper (Murty MS), the author presented the details of some aspects of biology of *N. japonicus* from Kakinada. The present paper deals with the mortality rates, population size and yield per recruit of this species in the trawling grounds off Kakinada.

The account is based on the data collected during 1976-79 from the trawlers operating off Kakinada. The methods of collecting data on catch and effort are given in the earlier paper (Murthy, MS). The length data collected on each observation day was raised to the day's catch and the monthly length composition of the catch was obtained by raising the pooled days' catch to the month's catch. The monthly data were pooled to get the annual length composition of the catch (i.e. the number of fish caught in each length group).

In the region off Kakinada (16° 35′-17° 25′ N Lat. and 82° 20′-82° 55′ E long.), *N. japonicus* is caught almost exclusively by trawlers, though it occurs in stray numbers in the catches of the indigenous gear operating in the same area. Hence, the fishing mortality can be taken as having been generated by trawlers only.

OBSERVATIONS AND RESULTS

Estimation of Mortality rates: Fishes of the length range 35-285 mm occur in the catches. A preliminary analysis of data on length composition of the catch indicated that fishes of the length range 35-75 mm are not fully recruited to the fishery. According to Ricker (1975), it is impossible to find out anything definite about the actual mortality rate of fishes which are not fully vulnerable to the gear, because representative samples of these lengths cannot be obtained. It is apparently for these reasons that Gulland (1977) states, "....that it is both simpler, and in many ways more realistic to omit fish below some chosen size (or age) from most of the analyses." (p. 77). In the present study, hence, only fishes of and above 85 mm are taken into account for estimating mortality rates.

Estimates of total Mortality are obtained by using the equation:

$$\log_e Nt = \log_e N_O - Zt$$

Where Nt = number of fishes in differet age groups; t = age of fish, N_o = number of fish when t = 0 and Z = total instantaneous mortality rate. Estimate of 'Z' are obtained separately (by the catch curve) for each year using the age groups represented in the catch of that year. For this purpose, the length composition of the catch is converted into age composition on the basis of age determined earlier (Murty MS), and the numbers of fish in each age group are scaled down to number of fish per 100 units of effort since the effort expended in different years was different.

The annual age composition of catch in different years is shown in Table 1 and the values of 'Z' for different years are shown in Table 2. It may be seen that the 'Z' values range from 1.58 to 2.03 in different years, with an average value of 1.86.

TABLE 1. *Number of fish in each age group (catch per* 100 *units effort) and their natural logarithms in* N. japonicus *during different years.*

Age groups	1976 C/E	1976 $\log_e$ C/E	1977 C/E	1977 $\log_e$ C/E	1978 C/E	1978 $\log_e$ C/E	1979 C/E	1979 $\log_e$ C/E
0	8515	9.0496	23056	10.0458	18203	9.8091	6784	8.8224
I	3410	8.1345	10005	9.2103	1338	7.1989	1627	7.3944
II	645	6.4693	1514	7.3225	312	5.7430	634	6.4521
III	77	4.3438	94	4.5433	—	—	12	2.4849

TABLE 2. *Estimated effort and 'Z' values during different years.*

Year	Effort (units)	'Z'
1976	33777	1.57826
1977	58450	1.83953
1978	53645	2.03305
1979	50125	1.99548
	Average	1.86158

Natural mortality rate (M) is estimated from the relation: Z = M + qf following Gulland (1969) and Ricker (1975), where, q = catchability co-efficient, and f = fishing effort. A plot of 'Z' against fishing effort is shown in figure 1. The estimated value of natural mortality is 1.14177 (value of Y-intercept in fig. 1). According to Gulland (1969), "A fish which approaches its ultimate length quickly — i.e., has a high value of K — is likely to have a high natural mortality, whereas a fish that grows slowly (a low K) is likely also to have a low M." (p. 70). The K value obtained for *N. japonicus* from Kakinada is 0.75142 (Murthy MS), and the high natural mortality rate obtained now (M = 1.14177) is in conformity with the theoretical concept outlined by Gulland (1969). In this connection it may be mentioned that, according to Krishnamoorthi (1978), the natural mortality rate of this species off Visakhapatnam is 0.5037, which is very low when compared to that from Kakinada. However, Krishnamoorthi (1978) did not take age composition of catch into account for estimating mortality rates. Fishing mortality rate (F) for the 1976-79 period is estimated as 0.71981.

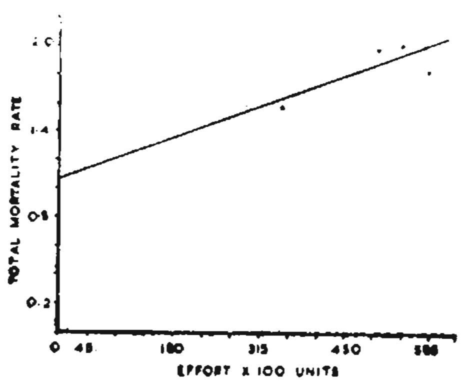

FIG. 1. Plot of instantaneous total mortality rate (Z) against fishing effort.

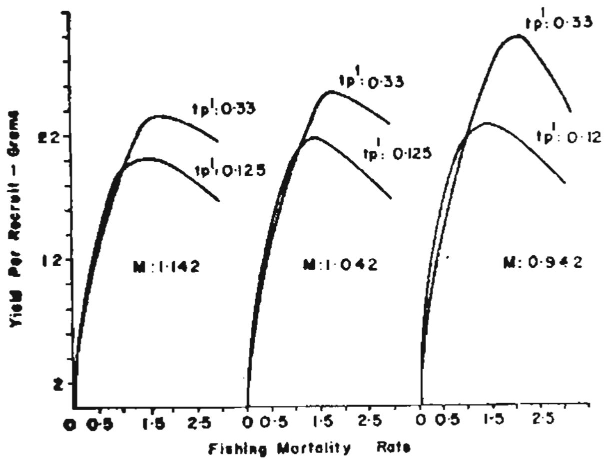

FIG. 2. Yield per recruit (YW/R) in relation to fishing mortality (F) at fixed ages of exploitation (Tpl) and natural mortalities (M).

Estimation of poulation size: The estimates of exploitation rate (U) are made using the equation:

$$U = \frac{F}{F+M}\left(1-e^{-(F+M)}\right)$$

(Beverton and Holt 1957; Ricker 1975), and, from this, the total annual stock (Y/U) and average standing stock (Y/F) are estimated (Y = annual estimated catch).

The exploitation rate (U) is calculated, keeping the value of Z constant, at 1.862 (The 1976-79 average value) and using different values of 'F'. The details are shown in table 3.

TABLE 3. *Stock estimates of* N. japonicus *based on different values of 'F'.*

Z	F	F|Z	U	*Y|U (kg)	*Y|F (kg)
1.862	0.42	0.2256	0.191	2022539	919774
	0.52	0.2793	0.236	1636885	742894
	0.62	0.3330	0.281	1374751	623073
	0.72	0.3867	0.327	1181361	536535
	0.82	0.4403	0.372	1038454	471104
	0.92	0.4941	0.417	926391	419897
	1.02	0.5478	0.463	834352	378730

* Y = The estimated annual average catch of *N. japonicus* for 1976-79 period is 386305 kg.

The estimated catches of *N. japonicus* at Kakinada range from 196 t, in 1979, to 862 t, in 1977, with an annual average of 386 t, for the four year period 1976-79. Since the maximum estimated landings of this species in any one year were at 862 t, the average annual stock should be above 900 t. This means that the value of F against Z = 1.862 can be at 0.92 (Table 3). It is observed that the present 'F' is at 0.72, and it may be concluded that the present trawling effort will not have any adverse affects on the stocks of *N. japonicus*.

Estimation of yield per recruit: The yield-in-weight per recruit (YW/R) was calculated from the equation of Beverton and Holt (Beverton 1953) as modified by Jones (1957), which states:

$$YW = \frac{F}{K} R' W\infty \, e^{Z(t_{p1} - t_o)} \left\{ \beta(XPQ) - \beta(X_1PQ) \right\} \quad \ldots.(1)$$

Where K, t_o and $W\infty$ are the parameters in Bertalanffy's growth equation, R' = number of recruits entering the fishery and t_{p1} = age at which fish become fully exploitable. The parameters for incomplete Beta function (Pearson 1948) are X, X_1, P and Q where $X = e^{-K(t_{p1} - t_o)}$, $X_1 = e^{-K(t_\lambda - t_o)}$, $P = \frac{Z}{K}$ and, Q = one + exponent in the length weight relationship. In the above equation (1), R' = $Re^{-M(t_{p1} - t_p)}$ where R = number of fish first entering the fishing ground, The above yield equation can be rewritten as given below, after accounting for natural mortality during pre-exploited phase and by dividing both sides by R (Krishnan Kutty and Qasim 1967):

$$\frac{YW}{R} = \frac{F}{K} W_{\infty}\, e^{Z(t_p l - t_0) - M(t_p l - t_p)} \left\{ \beta\,(XPQ) - \beta\,(X_1PQ) \right\} \quad \ldots\ldots(2)$$

The parameters of von Bertalanffy's growth equation for *N. japonicus* from Kakinada were estimated as $K = 0.75$, $t_0 = -0.17$ and $W = 320$ g (Murty MS); it was shown that maximum age attained (t) in the population is 3 years.

The yield per recruit at natural mortalities (M) 1.142, 1.042 and 0.942 and at two different ages of exploitation ($t_p l$), against fishing mortality rate (F), are shown in figure 2. Since in the present work M is estimated as 1.142, it was felt reasonable to consider lower values of M as given above for calculation of yield per recruit, because the life span of the fish being 3 years a value higher than 1.142 for M is not expected: the value of M estimated on the basis of life span is at 1.0 (assuming that about 95% of the fish would die before they attain 3 years of age if they are not subjected to exploitation).

In the present work, the age of exploitation of the population ($t_p l$) is estimated at 0.33 year, according to the growth rate and age determined earlier (Murty MS). Since the commercial trawlers are engaged in fishing almost exclusively for prawns (Silas et al 1976), and since there is reduction in the cod-end mesh size of trawl nets at Kakinada (Rao et al 1980), to facilitate catching even smaller prawns which have a lucrative market, it is felt that the industry will not increase the cod-end mesh size in the coming few years. Hence, there is no possibility of getting an increased age of exploitation for *N. japonicus* from the present 0.33 year. Keeping this point in mind, the yield per recruit is calculated taking the present age of entry (t_p) of *N. japonicus* into the fishing ground as the age at recruitment to the fishery (i.e., $t_p l = t_p$) and also taking the present age at recruitment. (fig. 2).

It is observed (fig. 2) that, at $t_p l = 0.125$ and at different M values, maximum YW/R is reached at $F = 1.50$ and decreased thereafter with further increase in F. When $t_p l = 0.33$ and at different values of M, maximum yield is obtained at $F = 1.75$ (fig. 2). It is also observed that, with decreasing M, the yield per recruit is increasing.

Since the value of M obtained for the period of investigation is at 1.142, and the present F is estimated at 0.72, there is scope for increasing the yield of *N. japonicus* from the present fishing ground by increasing the fishing effort and without changing the cod-end mesh size. As stated above, even if there will be change in the mesh size, it will only be towards decreasing it, and even then the yield can be increased by increasing the effort (i.e., at t_p 1 = 0.125, vide fig. 2).

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REFERENCES

BEVERTON, R. J. H. 1953. Some observations on the principles of fishery regulations. *J. Cons. int. Explor. Mer.*, 19: 56-68.

BEVERTON, R. J. H. AND S. J. HOLT. 1957. On the dynamics of exploited fish populations. *Fishery Invest. London, Series* 2, 19: 553 pp.

GULLAND, J. A. 1969. Manual of methods for fish stock assessment. Part I., Fish population analysis. *FAO Manuals in Fisheries Science*. No. 4: 154 pp.

GULLAND, J. A. 1977. The Analysis of data and development of models. *In*: Gulland, J. A. (Ed.). *Fish population dynamics*. John Wiley and Sons, London, 372 pp.

JONES, R. 1957. A much simplified version of the fish yield equuation. *Joint meeting of /CNAF ICES/FAO, Document* No. 21, 8 pp.

KRISHNAMOORTHI, B. 1978. A note on the mortality rates and yield per recruit in *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 23: 252-256 (1976).

KRISHNANKUTTY, M. AND S. Z. QASIM. 1967. Theoretical yield studies on the large-scaled tongue sole, *Cynoglossus macrolepidotus* (Bleeker), from the Arabian sea. *Bull. Nat. Inst. Sci. India*, 38: 864-875.

PEARSON, K. 1948. *Tables of Incomplete Beta-Function*. "Biometrica" office, University college, London.

RAO, G. SUDHAKARA, C. SUSSELAN AND S. LALITHADEVI. 1980. Impact of mesh size reduction of trawl nets on the prawn fishery of Kakinada in Andhra Pradesh, *Mar. Fish. Infor. Serv. T & E Ser.* 21: 1-6.

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. fish. Res. Bd. Canada*, 191: 382 pp.

SILAS, E. G., S. K. DHARMARAJA AND K. RENGARAJAN. 1976. Exploited marine fishery resources of India—a synoptic survey with comments on potential resources. *Bull. Cent. mar. Fish. Res. Inst.*, 27: 25 pp.

CONTRIBUTION 8

MURTY, V. SRIRAMACHANDRA. 1987. Further studies on the growth and yield per recruit of *Nemipterus japonicus* (Bloch) in the trawling grounds off Kakinada. *Indian J. Fish.*, 34 (3): 265-276.

CONTRIBUTION 8

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FURTHER STUDIES ON THE GROWTH AND YIELD PER RECRUIT OF *NEMIPTERUS JAPONICUS* (BLOCH) FROM THE TRAWLING GROUNDS OFF KAKINADA

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ABSTRACT

On the basis of data on *N. japonicus* from trawl landings at Kakinada, the von Bertalanffy parameters of growth in length are estimated as L_∞ 339 mm, $K = 0.52$ per year and $t_0 = -0.16$ year. The mortality rates are estimated as $Z = 2.64$, $M = 1.11$ and F 1.53. The length at first capture is estimated as 120 mm. The yield per recruit analysis shows that increase in effort from the present level results in reduced yield from the present fishing ground if the cod end mesh size is not increased.

INTRODUCTION

Nemipterus japonicus (Bloch) is the most dominant species in the nemipterid landings along both coasts of India and some information is available on various aspects of biology and population dynamics of this species from Visakhapatnam (Krishnamoorthi 1973, 1976, 1978; Dan 1980) and on biology and fishery from Cochin (Vinci and Nair 1975; Vinci 1983). On the basis of data collected during 1976-79 from the landings of small commercial trawlers at Kakinada, the author (Murty 1983, 1984) reported on various aspects of biology and yield per recruit of this species. The results of the study using the data collected during 1980-83 on the growth and population dynamics of *N. japonicus* in the trawling grounds off Kakinada are presented in this paper.

MATERIAL AND METHODS

Data on effort and catch were collected from the trawlers for 18-20 days in each month; these data were weighted to get monthly estimates of effort, catch and species composition. Boats of three different sizes are engaged in trawling in this region (see CMFRI, 1981, for details) and the effort (no. of units as well as trawling hours) was standardised taking *Pomfret* as the standard effort and all demersal groups together were considered as one species for this purpose. The length data of *N. japonicus* collected on each observation day (at weekly intervals) were weighted to get the day's and then the month's length composition of estimated catch. The length data were grouped into 10 mm-class intervals and the mid points in these groups were considered to study the growth. Parameters of growth in length were estimated following the 'integrated method' of Pauly (1980) and using the well-known von Bertalanffy growth equation:

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

Eestimates of L_∞ and K were obtained using Ford-Walford plot (Ford 1933, Walford 1946) as adapted by Manzer and Taylor (1947); the growth data of *N. japonicus* of different lengths at intervals of six months were used for the purpose.

Instantaneous rate of total mortality (Z) was estimated using the data of annual length-frequency distribution of catch and following:

1. the length-converted catch curve method of Pauly (1982),
2. Cumulative catch curve method of Jones and van Zalinge (1981) and
3. Beverton and Holt (1956) method.

The coefficient of natural mortality (M) was estimated using the relation $Z = M + qf$ where q is the catchability coefficient and f the fishing effort. It was also estimated using the equation of Pauly (1980):

$$\text{Log } M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$$

where L_∞ is in cm, K per year and T in °C. For the purpose of this equation the value of T was taken as 27.2°C from Ganapati and Murty (1954) and La Fond (1958).

Length at first capture (L_c) was estimated following the method given by Pauly (1984).

The yield in weight per recruit was estimated from the equation of Beverton and Holt (1957).

Estimation of Growth Parameters

The monthly modal lengths of *N. japonicus* during January 1980-December 1983 and the growth traced through them are shown in figure 1. While drawing the growth curves, the points that are likely to fall in a curve were joined first and then the curve was extended further both upwards and downwards. A total of nine curves, each of them passing through several modal points, were thus drawn (Fig. 1). The lengths attained at intervals of six months, starting from the smallest modal length in each curve, were read from these growth curves for estimating L_∞ and K using 'Manzer-Taylor plot'. (Fig. 2). From the origins of

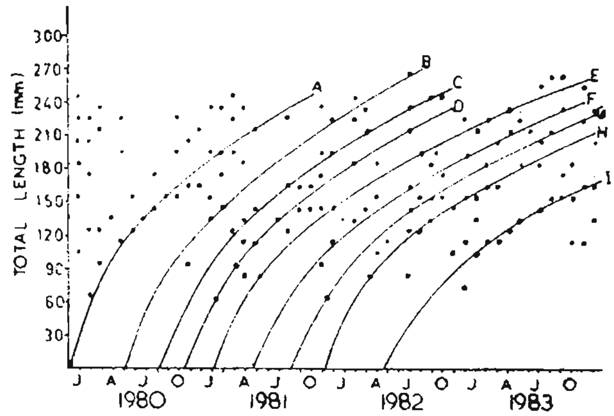

FIG. 1. Estimation of growth in length through growth curves in *N japonicus*.

the curves D and G (Fig. 1), the age of smallest modal length at 65 mm was read as three months and, taking this into account, the lengths at successive half years were estimated using values of slope and elevation of Manzer-Taylor plot, for purpose of estimating t_0 (Fig. 3). The von Bertalanffy parameters of growth in length were, thus, estimated as L_∞ = 339 mm, K = 0.52 per year and t_0 = —0.16 year. Since the maximum length observed in the catches is 305 mm, the life-span of *N. japonicus* in the trawling grounds is 4.26 years.

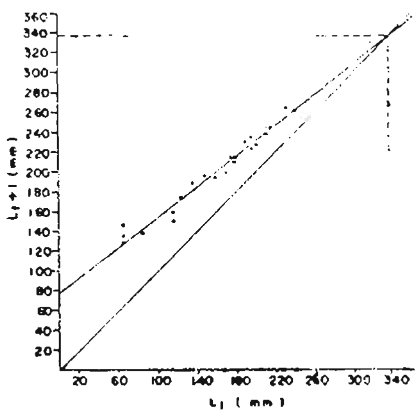

FIG. 2. Manzer and Taylor plot in *N. japonicus*.

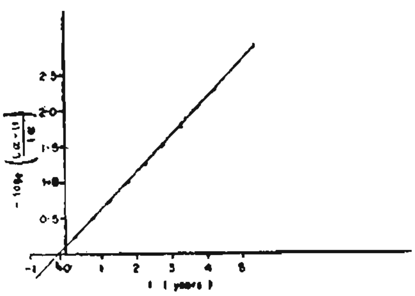

FIG. 3. Estimation of t_0 in *N. japonicus*.

Estimation of Mortality Rates

Total mortality rate (Z): The points that represent the straight descending part of the length-converted catch curve (Fig. 4) and the points that fall in a straight line of cumulative catch curve (Fig. 5) were taken into account to estimate the total mortality rate. For Beverton-Holt method, the mean length was calculated taking fish of and above length at first capture.

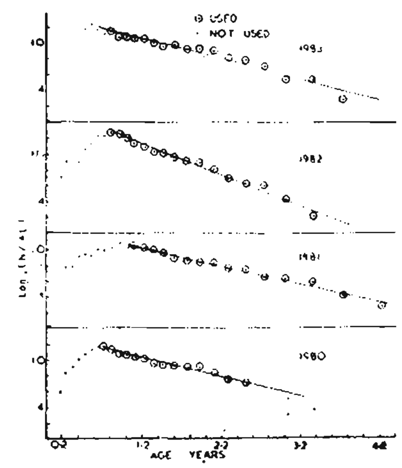

FIG. 4. Estimation of Z of *N. japonicus* by length-converted catch curve.

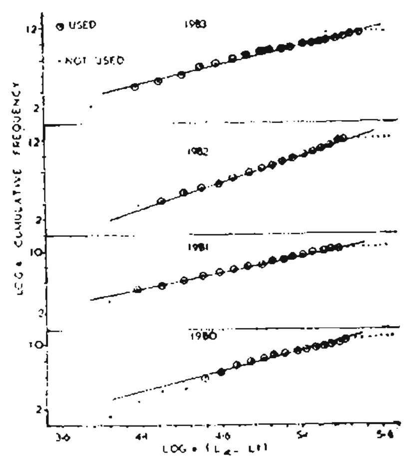

FIG. 5. Estimation of Z of *N. japonicus by* cummulative catch curve.

The estimated values of Z by different methods during different years (Table 1) show that, in any one year, the values obtained by different methods are in close agreement; the average of the values obtained by different methods during different years at 2.64 was taken as Z during the four-year period.

TABLE 1. N. japonicus: *Estimated values of Z by different methods in different years. (The estimated catches of this species during different years are also shown)*

Methods of	1980	1981	1982	1983	Average
Pauly	2.2964	2.2571	3.8364	2.5427	2.7332
Jones and van Zalinge	2.5606	2.0901	3.4288	2.4281	2.6269
Beverton and Holt	2.2027	2.1450	3.6742	2.2402	2.5655
Average	2.3532	2.1641	3.6465	2.4037	2.6419
Estimated catches of *N. japonicus*	261	201	632	365	364.8

Natural mortality rate (M): An attempt was made to estimate the value of M with the help of regression of Z against effort. For this purpose, the values of Z obtained by different methods were used separately and the effort was taken as number of units as well as trawling hours. The estimated values of M are negative in all cases indicating that they are unrealistic.

Using the formula of Pauly (1980), the M value was calculated as 1.11. Assuming the value of t_{max} in the population to be the one in the unexpoited phase and also assuming that 99% of the fish by numbers would die by the time they reach this age in an unexploited phase (Sekharan 1975), the M value can be estimated as 1.08 which is almost the same as that obtained by Pauly's formula. For the present study this value was taken as 1.11.

The various mortality rates in *N. japonicus* during the period of study, thus, are:

$Z = 2.64$, $M = 1.11$, $F = 1.53$

ESTIMATION OF LENGTH AT FIRST CAPTURE

The data on length composition of catch of the four years were pooled (because the mesh size of the gear was the same during different years) and a length-converted catch curve was obtained to estimate Z value for this purpose and also to obtain an estimate of the number of fish in the first length class that is fully selected — i.e. the estimated number of fish corresponding to the first point in the straight descending portion of the length-converted catch curve (number of fish against the 135 mm group in table 2). Using these two values and also the value of M obtained above, the length at first capture was estimated as 120 mm (Table 2 and Fig. 6).

Using the data in table 2 and varying the values of M, several values of L_c were obtained to see whether they would be different. For different values of M ranging from 0.1103 to 5.0 and 25.0, the estimated values of L_c are not quite different (Fig. 7).

ESTIMATION OF YIELD PER RECRUIT

The value of W_∞ corresponding to L_∞ was calculated as 389.7 g. The smallest length in the catch at 50 mm was taken as the length at recruitment whose age (t_r) is 0.15 year. The age at first capture (t_c) is 0.68 year on the basis of the estimated value of length at first capture.

The yield in weight per recruit (YW|R) with the value of M at 1.11 and with five values of t_c ranging from 0.43 to 0.77 (corresponding to L_c ranging from 90 to 130 mm) against F (Fig. 8A) shows that for higher values of t_c, maximum YW|R is obtainedat greater values of F, and that the YW|R is greater

TABLE 2. *Derivation of selection curve of* N. japonicus *caught by trawlers at Kakinada (Data of 1980-83 pooled).*

Mid points of 10 mm length classes	Numbers caught (Ni)	mid point to mid point	Mortality I (M Z)	Mortality II (means)	Numbers available (Ni|Pi)	$Ni\frac{P}{(Ni\|Pi)}$	Cumulative P
45	(0)		M=1.1103		—	(0)	(0)
		—		—			
55	101		1.2978		179564	0.00056	0.00056
		0.069		1.3916			
65	1027		1.4853		163124	0.00629	0.00685
		0.0715		1.5791			
75	5348		1.6728		145708	0.03670	0.04355
		0.0742		1.7666			
85	6139		1.8603		127807	0.04803	0.09158
		0.0773		1.9541			
95	15711		2.0478		109889	0.14297	0.23455
		0.0804		2.1416			
105	27968		2.2353		92507	0.30233	0.53688
		0.0840		2.3291			
115	38884		2.4228		76069	0.51117	1.04805
		0.0879		2.5166			
125	36620		2.6103		60973	0.60059	1.64864
		0.0920		2.7041			
135	*(47544)		(2.7978)		*(47544)	(1.00000)	2.64864

* Camputed from the equation of the length-converted catch curve.

when tc is higher. Under the current value of tc (0.68), the yield per recruit attains its maximum when F is 1.6 and declines slowly thereafter with further in crease in F. It may be noted that the present F is 1.53.

The yield per recruit as a function of tc under the present rate of fishing mortality (Fig. 8B) shows that maximum YW|R is attained when tc is 1.1 and with increase in tc thereafter the yield per recruit declines.

DISCUSSION

The models dealing with fish stock assessment assume the growth pattern, natural mortality and recruitment in a species to be constant. However, according to Gulland (1923, p. 165), "This is obviously not true; in a year of good food supply, growth is likely to be unusually good, while in unfavourable years

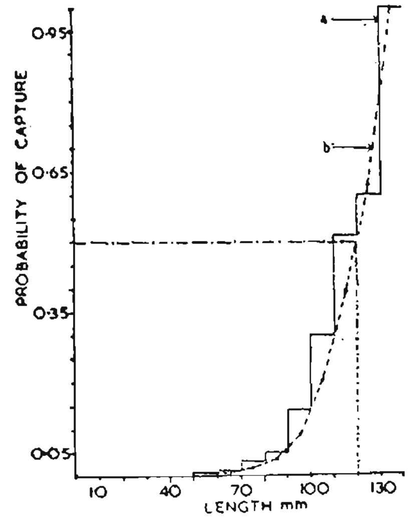

FIG. 6. a. Results of division of numbers caught by numbers available, representing selection pattern and b. cumulative curve to estimate the length at first capture, in *N. japonicus*.

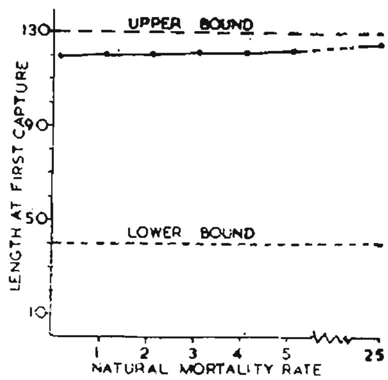

FIG. 7. Results of analysis of sensitivity of Lc estimates to changes in natural mortality input in *N. japonicus*.

natural mortality may be high". On the basis of the data obtained during 1976-79 at Kakinada, the parameters of von Bertalanffy growth equation were estimated as: L_∞ 314 mm, K = 0.75 per year and t_0 = — 0.17 year (Murty 1984) whereas in the present study from the same area, these parameters were estimated as 339 mm, 0.52 per year and —0.16 year respectively. In the earlier study, growth was estimated by following (for shorter intervals) the modes in the monthly length frequency distribution in the succeeding months whereas in the present study, the integrated methods of Pauly (1980) was followed. While the observed differences (though not very great) in the methods used, it is also possible that the growth rate has really changed; whatever may be the reasons for the differences in the estimated values of parameters, the fact that there are differences between them (assuming of course, that the methods used give reliable results) indicates the need for updating the parameter estimates, whenever attempts at stock assessment are made.

are likely to be due to differences

The values of total mortality coefficient (Z) obtained by different methods (Table 1) in any one year are close to each other. The choice of taking the average (at 2.64) of the values obtained by all methods of all four years to represent the Z during the four-year period can therefore be taken as reasonable. The estimated values of Z (Table 1) during 1982 are much greater than those

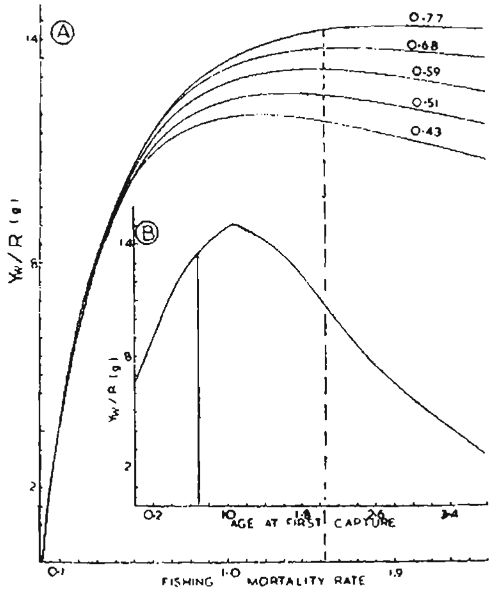

FIG. 8. Yield per recruit of *N. japonicus*: A. as a function of fishing mortality rate (numerals indicate the age at first capture and the broken vertical line the present fishing mortality rate). B. as a function of age at first capture (vertical line indicates the present age at first capture).

of the other three years: the average during this year is 3.65 whereas during the other three years the averages range from 2.16 to 2.40. The estimated catches of *N. japonicus* during 1982 were 632 tonnes — the highest during the four-year period — whereas the same during the other three ranged from 201 to 365 tonnes (Table 1).

It is known that the estimation of coefficient of natural mortality in exploited populations is difficult (Cushing 1981). It is particularly difficult in the case of tropical demersal fisheries which exploit a large number of species simultaneously, with the result, information on effective effort with reference to a particular species cannot be obtained. Hence the regression of Z (of a particular species) against multispecies effort is likely to result in unrealistic values of M including negative ones (Ricker 1975, Pauly 1982). Obviously because of this reason, the values of M obtained by regression in the present study are negative and naturally the M|K value is less than unity, whereas this ratio in fishes is known to range from 1 to 2.5. (Beverton and Holt 1959). The value (1.11) obtained by using the formula of Pauly gives an M|K value which is within the above range; for this reason and for reasons mentioned above, this value was taken as M in the population of *N. japonicus* at Kakinada. In the earlier work, however, the author (Murty 1983) obtained an M value of 1.14 on the basis of regression of Z on multispecies effort which is almost the same (obviously accidentally) as that obtained by using the Pauly's formula in the present work. With the parameters of growth estimated earlier (Murty 1984, *vide supra*) and with the Pauly's formula, the M value can be calculated as 1.44 which is slightly more than the one obtained in the present study. It may be mentioned in this connection that the author has also studied (Murty 1986a, b) the growth and mortalities of sciaenid and silverbelly species from Kakinada and realiable estimates of M could not be obtained by the regression of Z on effort.

Length at first capture (L_c) is an important parameter in yield equation and has to be estimated through selection experiments, for each type of gear separately. In the absence of such a study, some authors have resorted to selecting a value arbitrarily (Krishnamoorthi 1978) or to considering the smallest modal length (Banerji and George 1967; Murty 1983) in the monthly samples as the L_c. If the value of L_c (and hence t_c) is taken like this for computing yield, the yield curve cannot be taken as representing a true situation because, even when the same values of M and F are used, the values of yield per recruit will be different when t_c is different; further, the value of F against which Y_{max} is attained can also be different when different values of t_c are considered. This is evident from the present study also (Fig 8.A). Thus any arbitrariness in considering the L_c values is likely to result in incorrect advice for the management of a resource. Pauly (1984) developed a method with the help of which "the selection curve of the gear can be inferred from the shape of the ascending arm of a length-converted catch curve and the growth parameters" (p. 17), if the natural mortality rate is known. Further according to him (p. 19), "the values of L_c obtained through this method are indeed close to those obtained from selection experiments" in Mediterranean hakes and sardines. However, three assumptons have to be fulfilled for the estimate by this method to be accurate (Pauly 1984). One of them is that the gear in question is a trawl or a gear where it is only the smaller fish that are selected against. Obviously, this assumption is fulfilled in the present work. In *N. japonicus,* the fact that gravid and ripe fish occur in the trawling ground in considerable numbers during the spawning period August-April and that smaller fish of the length range 35-85 mm also occur in the fishing ground (Murty 1984) suggest that spawning takes place in the usual fishing ground and this ground itself serves as nursery area also. Hence, there is no question of smaller fish reaching the fishing ground from a separate nursery ground (recruitment) in this species, as opposed to penaeid prawns or some temperate fish species. Hence the smallest fish caught can be safely taken as fully recruited, thus fulfilling the second assumption also. The third assumption is that the M value used for fish below the smallest recruited length and the mortalities generated by interpolation between M and the Z value of the fully selected fish are accurate. This assumption was verified using sensitivity analysis and it was observed (Fig. 7) that the Lc is not very sensitive to changes in the input value of M.

The yield per recruit analysis shows that any increase in effort (F) in the present fishing ground will result in reduced yield, if the present cod end mesh size is retained (Fig. 8A); if the cod end mesh size is increased, effort can also be increased to get increased yield (Fig. 8A) or even if the effort is not increased, increasd yield can still be obtained by increasing the cod end mesh size (Fig. 8B). The length at first maturity in this species is 120 mm (Murty 1984). Since the length at first capture is also 120 mm, increasing the cod end mesh size will be beneficial in the sense that there will not be any problem of recruitment overfishing brought about by continuous removal of prospective spawners.

The private trawlers at Kakinada fish in depths up to 50 m most of the time and go up to 80 m depth only during certain months of the year (November-February). During these latter months the catches are generally good (Murty 1984). Further, it is known (Silas 1969; Zupanovic and Mohiuddin 1975) that *N. japonicus* is abundant in 75-125 m depth zone. Hence there is need to fish in such depths at Kakinada to get higher yield of this species.

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REFERENCES

BEVERTON, R. J. H. AND S. J. HOLT. 1957. On the dynamics of exploited fish populations *Fish. Invest. Ser. London., Min. Agric. Fish.*, (19): 533 pp.

BEVERTON, R. J. H. AND S. J. HOLT. 1959. A review of Life spans and mortality rates of fish in nature and their relation to growth and other physiological characteristics. Ciba Foundation Colloquia on ageing. G. E. W. Wolsenholny and M.O.'. Connor. (Ed.) *The life span of animals*, 5: 142-147.

CMFRI. 1981. Commercial trawl fisheries off Kakinada during 1969-1978. *Mar. Fish. Infor. Serv. T & E Ser.*, (31): 1-6. (Central Marine Fisheries Research Institute, Cochin).

CUSHING, D. H. 1981. *Fisheries Biology: A study in population dynamics*. Second edition. The university of Wisconsin press, 295 pp.

DAN, S. S. 1980. Intra ovarian studies and fecundity in *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 24: 48-55 (1977).

FORD, E. 1933. An account of the herring investigations conducted at plymouth during the years 1924-1933. *J. mar. biol. Ass. U.K.*, 19: 305-384.

GANAPATI, P. N. AND V. S. R. MURTHY. 1954. Salinity and temperature variations of the surface waters off Visakhapatnam Coast. *Andhra Univ. Mem. Oceanogr.* I: 125-142.

GULLAND, J. A. 1983. *Fish stock Assessment: A Manual of Basic Methods,* John Wiley and Sons, 223 pp.

JONES, R. AND P. N. VAN ZALINGE. 1981. Estimation of mortality rate and population size of shrimps in Kuwait Waters. *Kuwait Bull. Mar. Sci.*, 2: 273-288.

KRISHNAMOORTHI, B. 1973. Biology of the threadfinbream, *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 18: 1-21 (1971).

KRISHNAMOORTHI, B. 1976. A note on the size differences between males and females of *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 21: 608-609 (1974).

KRISHNAMOORTHI, B. 1978. A note on the mortality rates and yield per recruit in *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 23: 252-256 (1976).

LA FOND, E. C. 1958. Seasonal cycle of sea surface temperature and salinity along the east coast of India. *Andhra Univ. Mem. Oceanogr.* II: 12-21.

MANZER, J. I. AND F. H. C. TAYLOR. 1947. The rate of growth in lemon sole in the straight of Georgia. *Prog Rep. Fish. Res. Board Pacific Coast Stn.*, (72): 24-27.

MURTY, V. SRIRAMACHANDRA. 1983. Estimates of mortality, population size and yield per recruit of *Nemipterus japonicus* (Bloch) in the trawling grounds off Kakinada. *Indian J. Fish.*, 30: 255-260.

MURTY, V. SRIRAMACHANDRA. 1984. Observatiions on the fisheries of threadfin breams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) from Kakinada. *Indian J. Fish.*, 31: 1-18.

MURTY, V. SRIRAMACHANDRA. 1986a. Growth and yield per recruit of *Johnius (Johnius) carutta* Bloch in the trawling grounds off Kakinada. *Indian J. Fish.*, 33: 163-170.

MURTY, V. SRIRAMACHANDRA. 1986b. Studies on growth and population dynamics of the silverbelly *Leiognathus bindus* (Valenciennes) in the trawling grounds off Kakinada. *Indian J. Fish.*, 33: 277-284.

PAULY, D. 1980. A selection of simple methods of for assessment of tropical fish stocks. *FAO. Fish. Circ.* (729): 54 pp.

PAULY, D. 1982. Studying single-species context. pp 33-70; *In*: Pauly, D. and G. I. Murphy (eds.) *Theory and management of tropical fisheries.* ICLARM Conference Proc. 9, 360 pp. ICLARM, Philippines and CSIRO Australia.

PAULY, D. 1984. Length-converted catch curves: A powerful tool for Fisheries Research in the tropics. Part II. *Fishbyte*, 2(1): 17-19.

RICKER, W. E. 1975. Computation and Interpretation of Biological statistics of Fish populations. *Bull. Fish. Res. Board. Can.* 191: 382 pp.

SILAS, E. G. 1969. Exploratory Fishing by R. V. Varuna. *Bull. Cent. mar. Fish. Res. Inst.*, 12:1-86.

VINCI, G K. 1983. Threadfinbream (*Nemipterus*) resources along the Kerala coast with notes on biology of *Nemipterus japonicus*. *Indian J. Fish.*, 29: 37-49 (1982).

VINCI, G. K. AND A. K. K. NAIR. 1975. Length-weight relationship in the threadfin bream, *Nemipterus japonicus*, along the Kerala coast. *Indian J. Fish.*, 21: 299-302 (1974).

WALFORD, L. A. 1946. A new graphic method of describing the growth of animals. *Biol. Bull. Woods Hole*, 90: 141-147.

ZUPANOVIC, S. AND S. K. MOHIUDDIN. 1976. A survey of the fishery resources in the north eastern part of the Arabian sea. *J. mar. biol. Ass. India*. 15: 469-537.

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4. 8

PRESENT STATUS OF EXPLOITATION OF FISH AND SHELLFISH RESOURCES : THREADFIN BREAMS·

V. SRIRAMACHANDRA MURTY, K. V. SOMASEKHARAN NAIR, P. A. THOMAS, S. LAZARUS, S. K. CHAKRABORTY, S. G. RAJE, C. GOPAL, P. U. ZACHARIA AND A. K. VELAYUDHAN

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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., 1988). 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

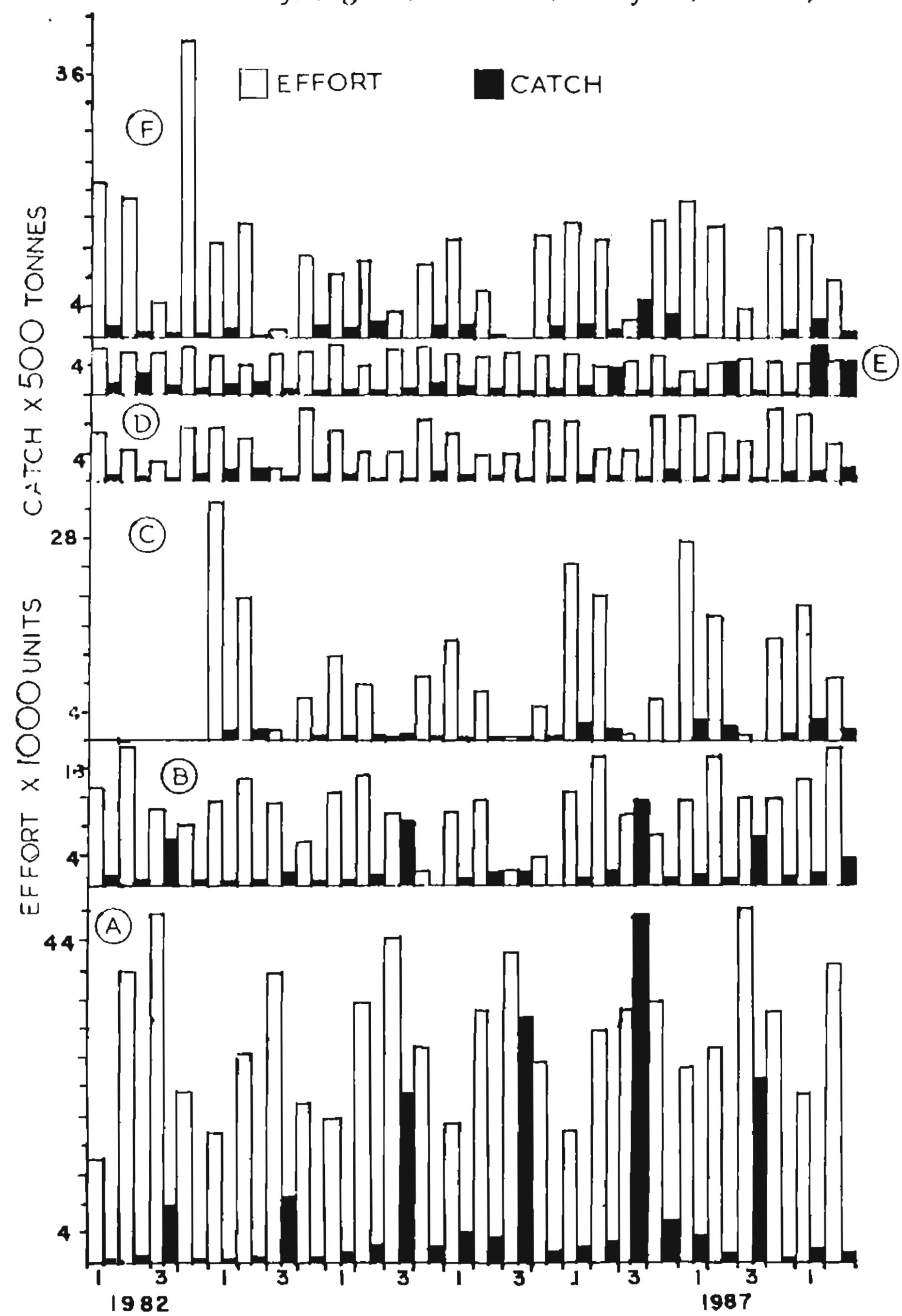

Fig. 1. Quarterly estimated effort and threadfin bream catch in different years at important trawl landing centres along the west coast of India. A. Sakthikulangara, B. Cochin, C. Mangalore, D. New Ferry Wharf, E. Sassoon Docks and F. Veraval.

in third quarter in all years forming [illegible]-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

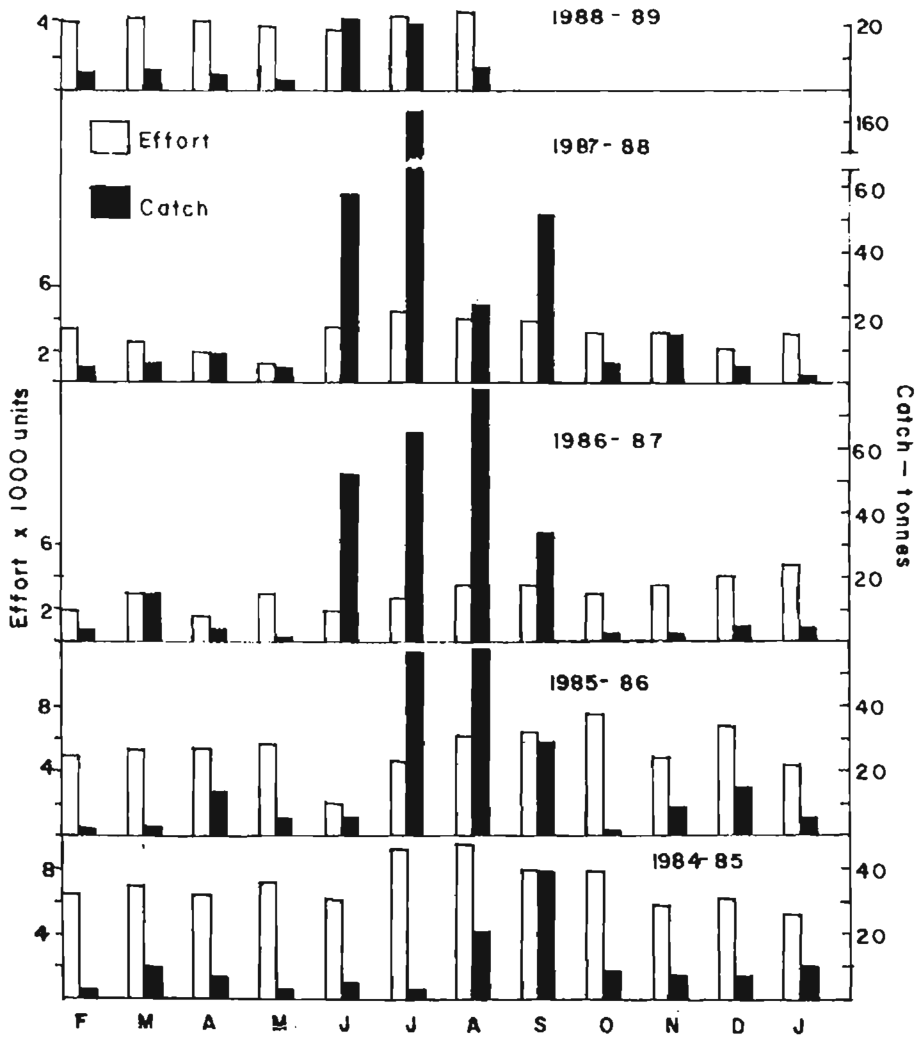

Fig. 2. Monthly estimated effort and catch of threadfin breams by hooks and lines at Vizhinjam during different years.

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

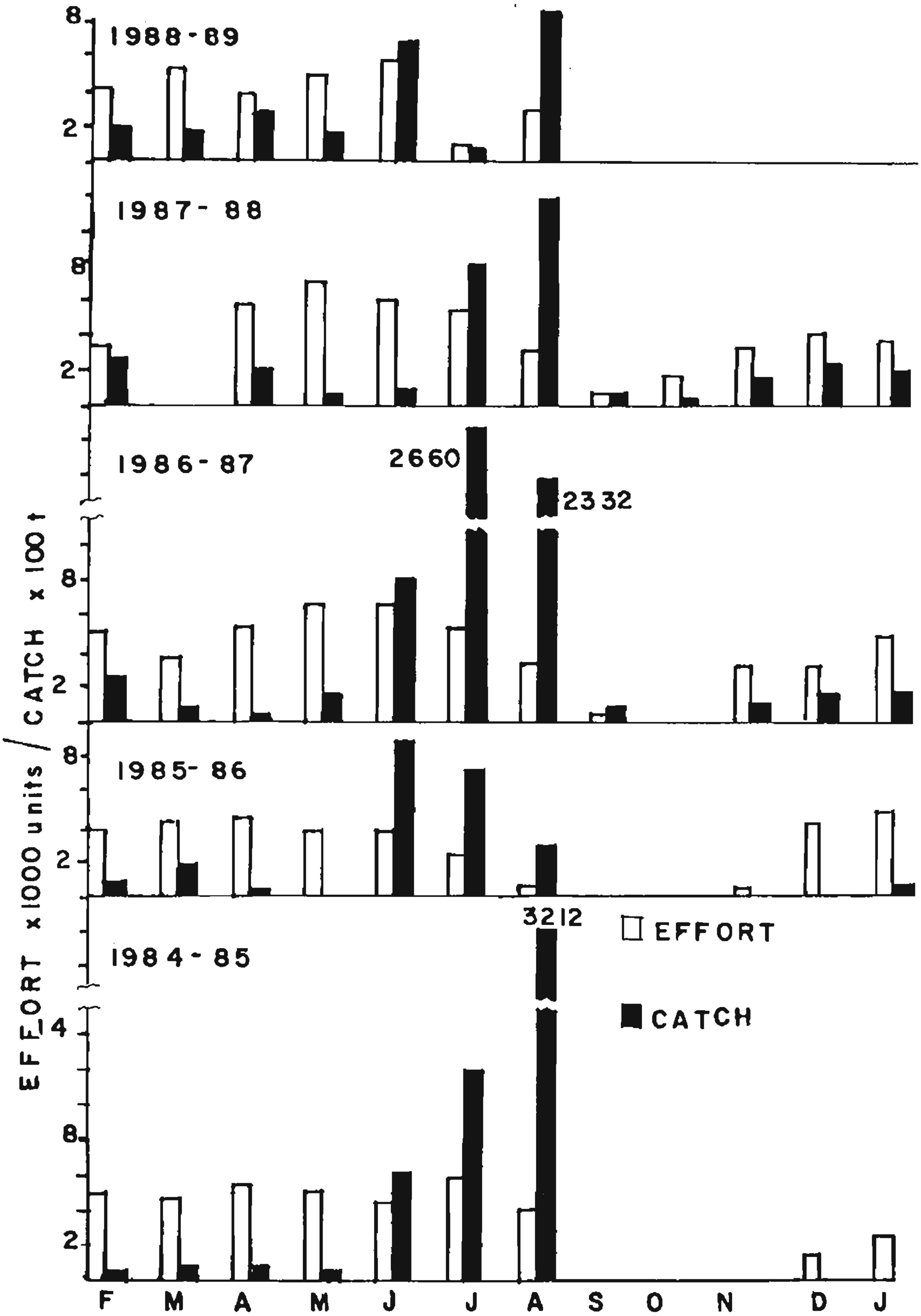

Fig. 3. Monthly estimated effort and catch of threadfin breams by trawlers at Cochin during different years.

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. The average catch of threadfin 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.

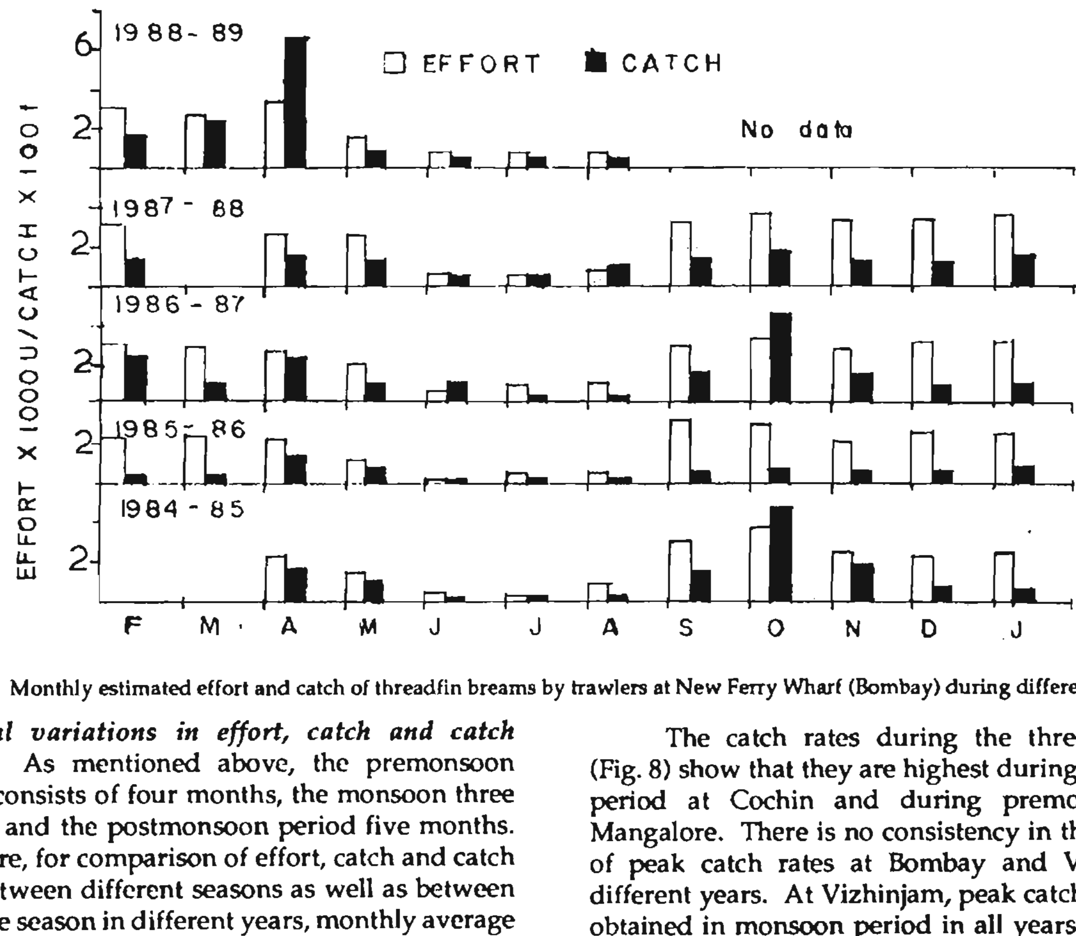

Fig. 4. Monthly estimated effort and catch of threadfin breams by trawlers at New Ferry Wharf (Bombay) during different years.

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

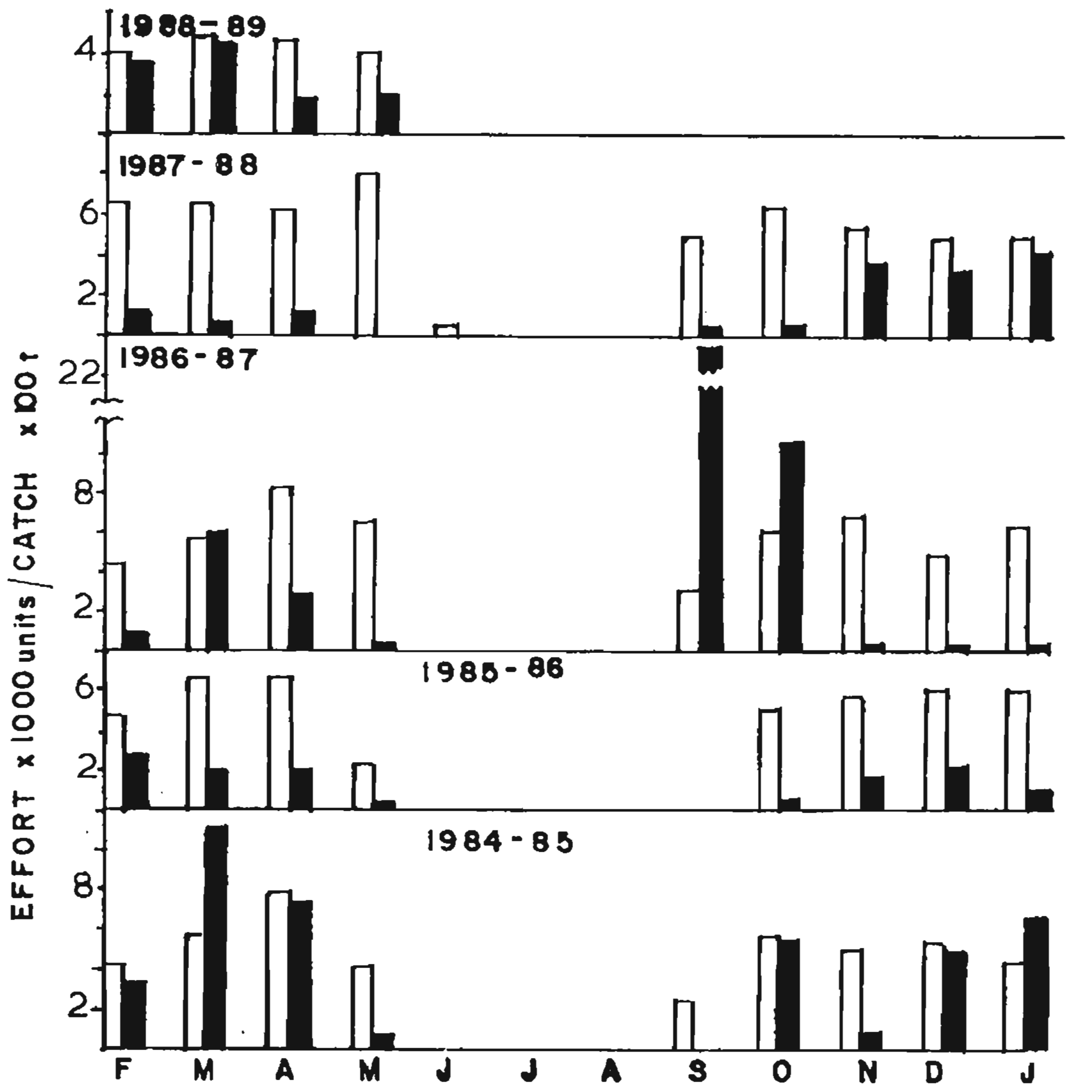

Fig. 5. Monthly estimated effort and catch of threadfin breams by trawlers at Veraval during different years.

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.

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

At Mangalore *N. japonicus* is the most dominant species in the premonsoon and postmonsoon 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.

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).

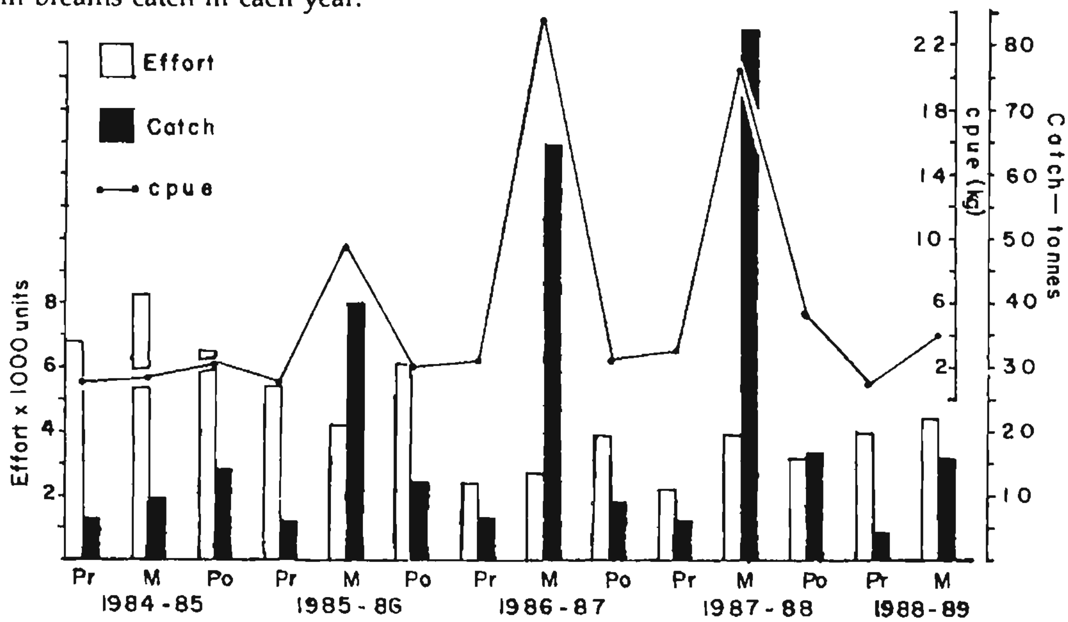

Fig. 6. Estimated effort, catch and catch per unit of effort of threadfin breams during premonsoon (Pr), monsoon (M) and postmonsoon (Po) seasons in different years at Vizhinjam.

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

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

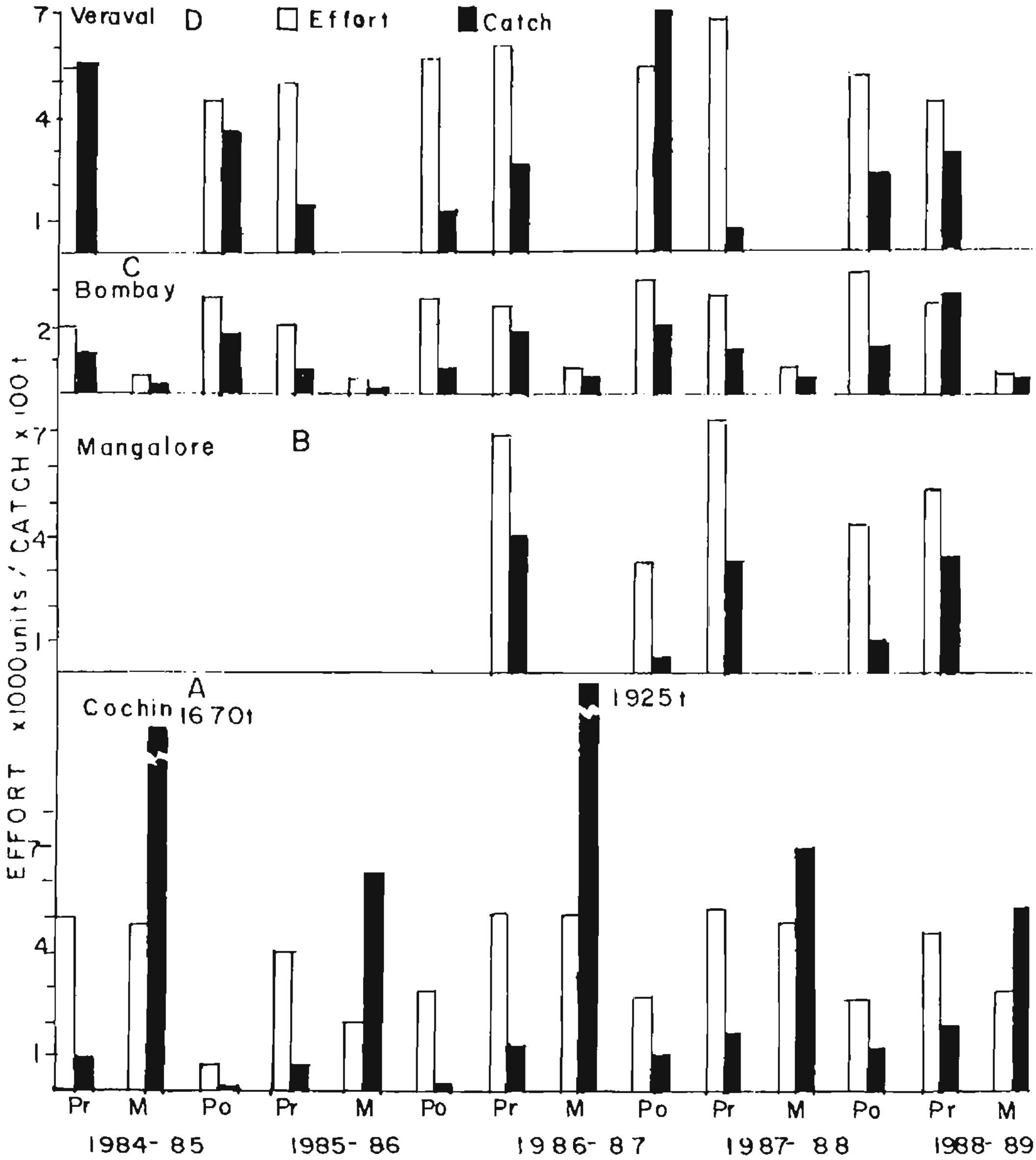

Fig. 7. Estimated effort and catch of threadfin breams during premonsoon (Pr), Monsoon (M) and Postmonsoon (Po) seasons in different years at different centres.

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.

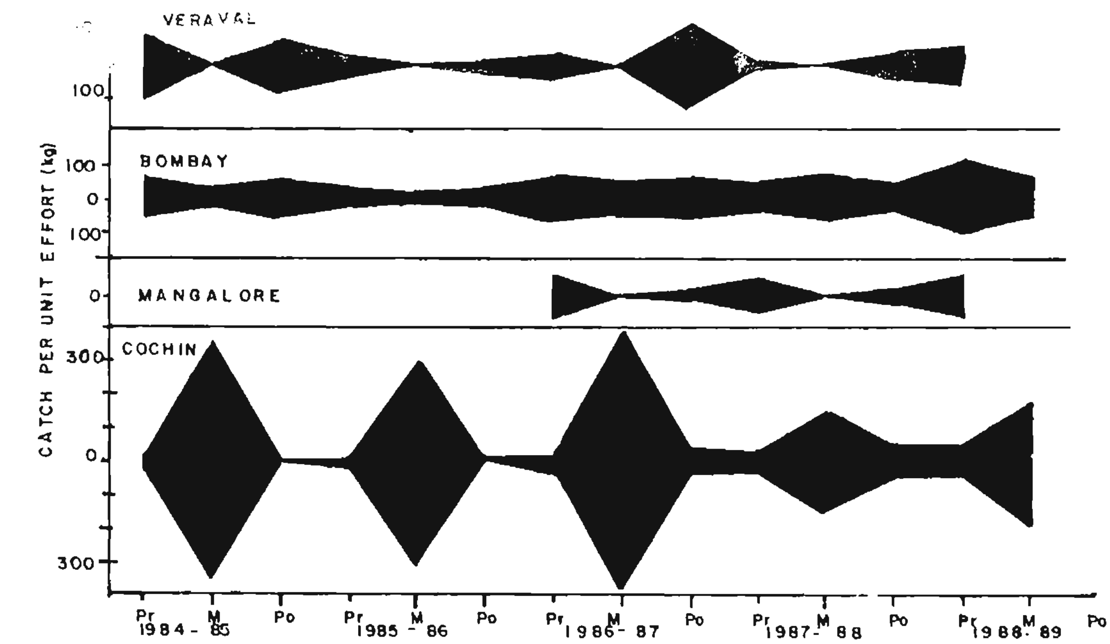

Fig. 8. Estimated catch rates of threadfin breams during different seasons in different years at different centres (Pr : Premonsoon, M : monsoon, Po : Postmonsoon).

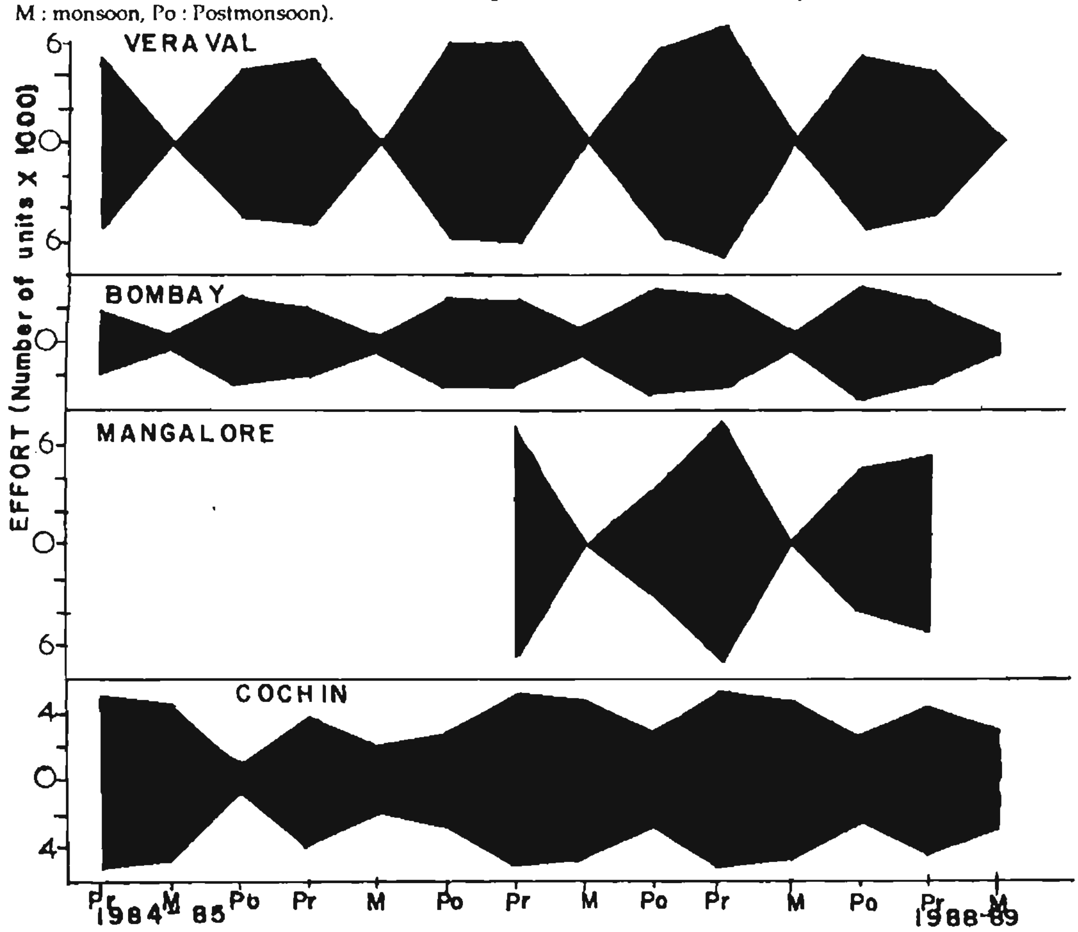

Fig. 9. Estimated fishing effort by trawlers during different seasons in different years at different centres. (Pr : Premonsoon, M : Monsoon, Po : Postmonsoon).

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.

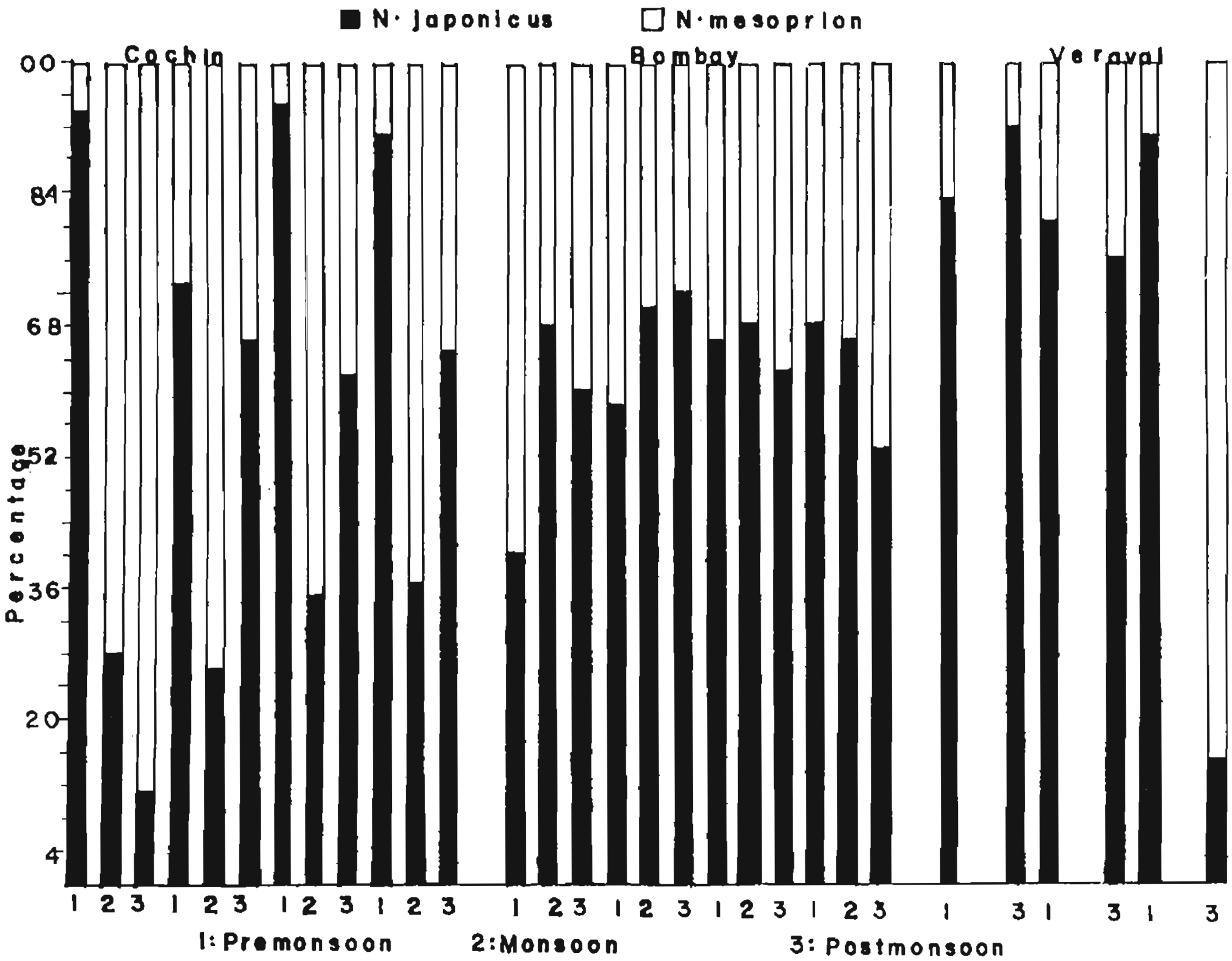

Fig. 10. Percentage composition of *N. japonicus* and *N. mesoprion* in each season in different years at different centres (two more species also occurred, but in very small quantities and therefore ignored in this graph).

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 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.

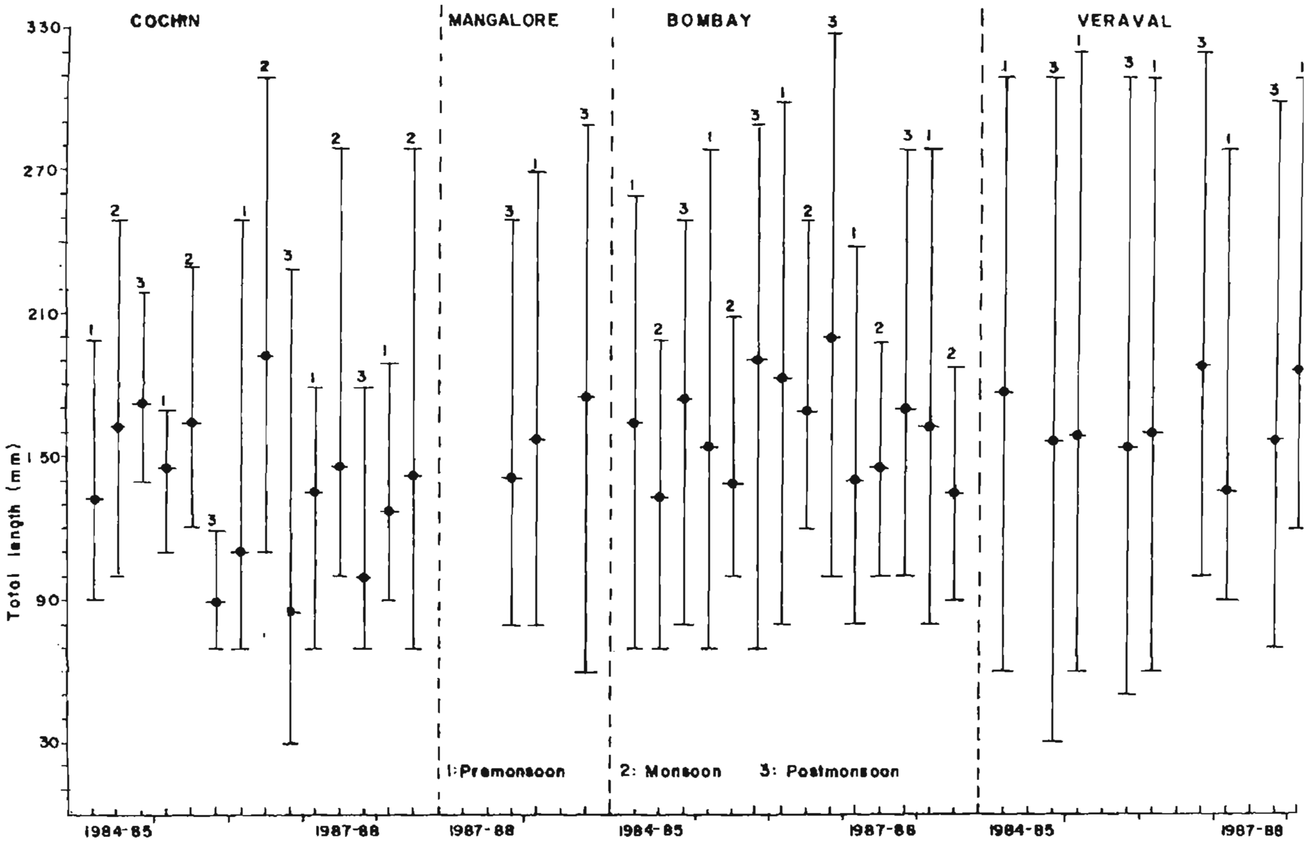

Fig. 11. Length range and mean length of *N. japonicus* during different seasons in each year at different centres (The vertical line shows the length range and the closed circle with a small horizontal line on the vertical line, the mean length).

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

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".

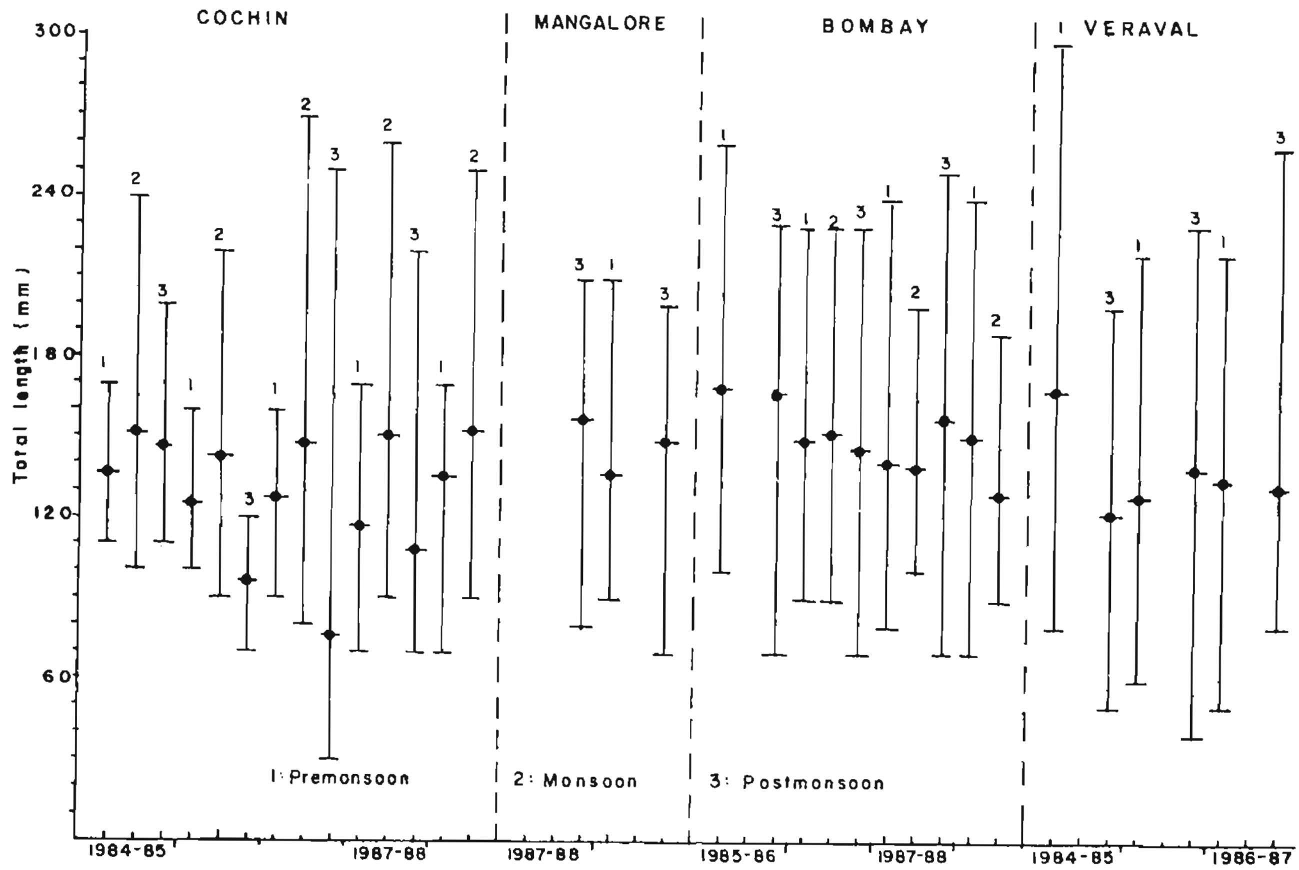

Fig. 12. Length range and mean length of *N. mesoprion* during different seasons in each year at different centres (The vertical line shows the length range and the closed circle with a small horizontal line on the vertical line, the mean length).

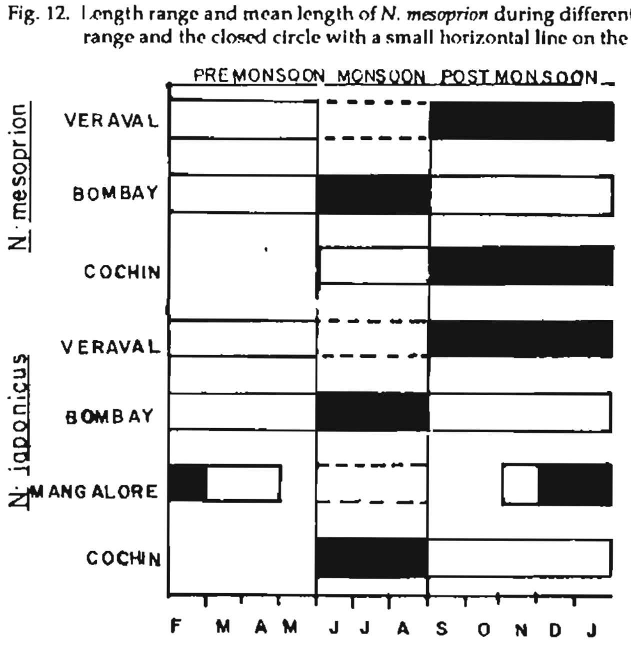

Fig. 13. Spawning periods and peak spawning periods of *N. japonicus* and *N. mesoprion* at different centres (Peak spawning period indicated by black bars; bars with broken lines indicate absence of fishing).

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.

B. SILVERBELLIES

CONTRIBUTION 10

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OBSERVATIONS ON SOME ASPECTS OF BIOLOGY OF SILVERBELLY *LEIOGNATHUS BINDUS* (VALENCIENNES) FROM KAKINADA

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ABSTRACT

The length-weight relationship of *Leiognathus bindus* can be described by the equation log W = —4.77709 + 2.96182 log L. The length at first maturity is estimated as 80 mm. This species is a fractional spawner and appears to release the ova in at least two spawning acts during the course of one year; it appears to spawn in almost all months, with a peak during December-February. Based on length-frequency distribution, the species attain 65 and 90 mm at the completion of first and second year respectively.

INTRODUCTION

Along the Andhra coast, an estimated annual average of 4073 tonnes of silverbellies landed during the 11-year period 1969-79 (CMFRI 1980), forming 9.5% of all India silverbelly catches. The studies on the resource characteristics of silverbellies were taken up at Kakinada in 1979, as part of investigations on the major demersal fisheries resources, and the present paper deals with some aspects of the biology of *Leiognathus bindus,* which is one of the important species in regard to abundance, in the trawl catches at Kakinada. Reports dealing with biology of silverbellies in general are a few from India (Arora 1951; Kuthalingam 1958; James and Badrudeen 1975) and, but for the paper of Balan (1967), there is no information on the biology of *L. bindus.*

MATERIAL AND METHODS

The study is based on the data collected during the years 1979 and 1980. Samples were obtained at weekly intervals from the catches of commercial trawlers. On each observation day, samples of all silverbellies were collected from 3-4 boats for species composition and biology. The length data on *L. bindus* obtained on each observation day were raised to the day's catch and these were further raised to get monthly length composition of the estimated catch. It is only on the basis of these data that the estimation of age and growth rate were made. For detailed biology the specimens were examined in fresh condition; the data on weight of each fish were taken to 0.5 g accuracy. The various maturation stages were fixed arbitrarily following those fixed for *L. brevirostris* by James and Badrudeen (1975). Ova-diameter measurments were made from ovaries fixed in 4% formalin, following the procedure of Clark (1934). From each ovary about 300 ova were measured at a magnification, at which 10 md equals 0.097 mm. The length-weight relationship was calculated by the method of least squares using the formula $W = aL^n$ or $\log W = \log a + n \log L$, where W = weight in grams, L = length in mm, a = a constant and n = exponent.

Length-Weight Relationship

The study is based on 183 males ranging from 54 to 113 mm length and from 2 to 24 g weight and 182 females ranging from 56 to 122 mm length and from 2 to 38 g weight. The relationship was calculated separately for sexes and the equations are:

Males: $\log W = -4.74861 + 2.94179 \log L$

Females: $\log W + -4.81952 + 2.98912 \log L$

The significance of difference between the regression coefficients of sexes was tested by analysis of covariance following Snedecor and Cochran (1967), and the results are given in Table 1. It is observed that the difference is not signicant at 5% level. Hence the data of sexes were pooled and a single equation was calculated for the species from Kakinada which is:

$$\log W = -4.77709 + 2.96182 \log L$$

In the parabolic form the equation can be written as $W = 0.0000167 \cdot L^{2.96182}$. According to Balan (1967), the equation for the length-weight relationship of this species from Calicut is $W = 0.00002452L^{2.8641}$.

TABLE 1. *Comparison of regression lines of length-weight relationship of males and females of* L. bindus *from Kakinada.*

	df	Σx^2	Σxy	Σy^2	Reg. co-efficient	Deviation from Reg. df	SS	MSS
Within								
Males	182	0.99866	2.93786	11.44379	2.94179	181	2.80119	
Females	181	0.70836	2.11739	8.76149	2.98912	180	2.43230	
						361	5.23349	0.01449
Pooled	363	1.70702	5.05525	20.20528	2.96144	362	5.23442	0.01445
		Difference between slopes				1	0.00093	0.00093
Between	1	0.00002	0.00072	0.04198				
Total	364	1.70704	5.05597	20.24726	2.96182	363	5.27231	
		Between adjusted means				1	0.03789	0.03789

Comparison of slopes $F = 0.1449|0.00093 = 15.58$, Df = 361,1

Comparison of elvation $F = 0.0389|0.01445 = 2.622$, Df = 1,362

Maturation and Spawning

The study is based on 540 specimens (288 males and 252 females) ranging from 60 to 122 mm total length.

Length at first maturity: For the purpose of determining the minimum length at first maturity only females were considered, and fishes in stages III-VI of maturation were considered as mature. The data of the two years were pooled. The percentage of the mature fish in relation to immature fish in different lengths are given in figure 1. It is observed that mature fish occur from 72 mm and that until a length of 102 mm the percentage of mature individuals show gradual increase. Above 102 mm all are mature. It may be seen that at a length of 80 mm, 50% of the fish are mature and this length is taken as the length at first maturity of *L. bindus* from the sea off Kakinada. It may be stated in this connection that according to Balan (1967), the length at fiirst maturity of this species at Calicut is 87 mm, almost the same.

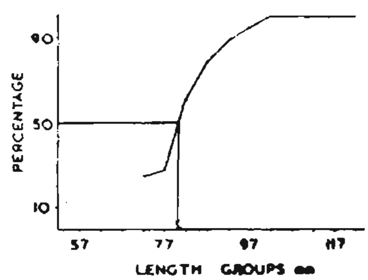

FIG. 1. Percentage-frequency distribution of mature female. *L. bindus* in relation to immature females in different length groups.

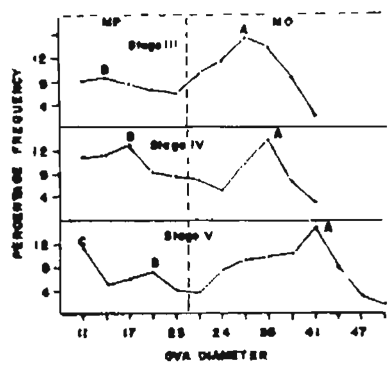

FIG. 2 *L. bindus*: ova-diameter-frequency distribution in ovaries of Stages III-V of maturation. MP : Maturing partially opaque ova, MO = Mature opaque ova.

Spawning: For purpose of detremining the spawning season only females above the length at first maturity were taken into account. The frequency distribution of females in stages II-VI of maturation during 1979 and 80 and in the data of two years pooled are shown in Table 2. It is observed that fishes in stage IV of maturation occurred during March, May, September, November and December 1979 and January, March, July and August 1980.. StageVI females occurred only in small numbers in January and July 1980. On the basis of the occurrence of fishes in stages IV-VI of maturation in different months, it appears that in the sea off Kakinada *L. bindus* spawns in almost all months with a peak during December-February. Supporting evidence is obtained from the length-frequency distribution: smaller fishes in the length range 15-34 mm occur in the catches in almost all months (fig. 3).

It may be stated in this connection that mature *L. bindus* were recorded throughout the year wih peak during February-April at Madras (CMFRI 1978).

TABLE 2. L. bindus: *frequency disritibution of adult females in different stages of maturation* (Data of 1979 and 1980 pooled).

Months	No. of females examined	No of females above length at Ist maturity.	% of maturation stages II	III	IV	V	VI
January	43	33	—	33.3	51.5	9.1	6.1
February	49	33	18.2	66.7	15.1	—	—
March	19	5	20.0	20.0	50.0	—	—
April	7	5	100.0	—	—	—	—
May	11	6	16.7	50.0	33.3	—	—
June	4	3	100.0	—	—	—	—
July	10	9	—	55.5	33.3	—	11.1
August	12	12	16.7	58.3	16.7	8.3	—
September	32	31	9.7	45.2	45.2	—	—
October	23	17	52.9	47.1	—	—	—
November	7	7	—	—	14.3	85.7	—
December	35	25	12.0	44.0	20.0	24.0	—

According to Balan (1967) the spawning season of *L. bindus* at Calicut is very short, extending from December to February only.

The ova-diameter frequency in ovaries of stages III-V of maturation are presented in figure 2. Three types of ova are present in the ovaries of stages III-V: one representing immature stock with the diameter extending up to 9 md; these ova are translucent with irregular shapes with the nucleus clearly visible and with yolk in some only. These ova were not considered for measurement of diameters. The second group represents the maturing ova, the diameter ranging from 10 to 24 md; these ova are more or less spherical and partially opaque heavily yolked and nucleus not visible. The third group represents the mature ova with diameter ranging from 25 to 51 md; these are spherical and opaque with yolk deposition complete. These ova in stage V show the distinct peri-vitelline space.

It is observed (fig. 2) that there are two modes in the diameter-frequency dstribution in stage III: one at 32 md (mode a) and the other at 14 md (mode b). These modes show progression to 35 md and 17 md in stage IV respectively and 41 md and 20 md in stage V ovary. The ova forming a mode at 41 md in stage V may be released in one batch after a short time since they are already mature. The ova forming a mode at 20 md in stage V have already undergone about half the maturation process, and they may take only less than half the time required for the immature ova to undergo the process of maturation and release, since it is generally known that the growth of ova in maturing condition is faster than those in immature condition.

In stage V, a new mode appeared (mode c) at 11md; these ova forming the early maturing. This mode is almost the same as that at 14 md (mode b) in stage III, which indicates that this mode reaches to about 20 md by the time the ova forming a mode at 20 md in the same ovary reach about 32 md. This situation indicates a possibility that once the ovary reaches stage VI (ripe) it may revert back to stage III and again undergo ripening and reach stage VI. It may be mentioned in this connection that James and Baragi (1980) have indicated that in some fishes the ovary after attaining stage VI (ripe) and releasing a batch of ova may revert to stage V, IV or III. It may be questioned as to how stage VI ovary reverts back to stage III after releasing a batch of ova instead of to stage II as is genearlly known in fishes. The ova forming a mode at 41 md in stage V may further increase in size by the time the ovary passes on to stage VI and the ova forming a mode at 20 md in stage V may grow further and pass on to a modal size of 32 md — the modal diameter of mature opaque ova in stage III (fig 2) — judging from the progression of ova in different modes in stages III-V. Thus, it appears that *L. bindus* in Kakinada is a fractional spawner releasing the ripe ova in at least two batches in the course of one year. Balan (1967), however, states that each adult female releases the ripe ova in one spawning act during a short spawning season at Calicut. The conclusions made here get support from the occurrence of stage IV females in almost all months (Table 2) and also from the similar observations made at Madras (CMFRI 1978).

LENGTH-FREQUENCY DISTRIBUTION

Data on length-frequency distribution collected during the years 1979 and 1980 were used. A total of 5626 specimens ranging from 17 to 122 mm were measured. The monthly length-frequency distribution is presented in figure 3. It is observed that the modes in the length-frequency ditribution do not show regular monthly progression and in some consecutive months the distribution shows modes at the same length. There are, however, some modes whose progression could be traced for shorter periods ranging from one to five months. An attempt is made to estimate the growth rate and age on the basis of the progression of these modes. It may be seen from figure 3 that there is a mode (a) at 32 mm in December 1979 which can be traced to 37 mm in January 80. This can be further traced to 57 mm in May 80. Thus a growth of 25 mm is obtained in 5 months from December 79 to May 80 at a rate of 5 mm per month. The modes at 47 mm (b & c) in September 79 and February 80 can be traced to 52 mm in October 79 and March 80 respectively, which also give a monthly growth of 5 mm. There is a mode (d) at 52 mm in August 79 which can be traced to 57 mm in September 79; this mode can be further traced to

62 mm in November 70. Thus a monthly growth of 5 mm is observed between 52 and 57 mm and 2.5 mm between 57 mm and 62 mm. The mode (e) at 57 mm in September 80 can be traced to 62 mm in November 80 which gives a growth of 5 mm in two months. Similarly the mode (f) at 57 mm in March 79 has shown a growth of 5 mm in months and reached 62 mm in May 79. The progression of

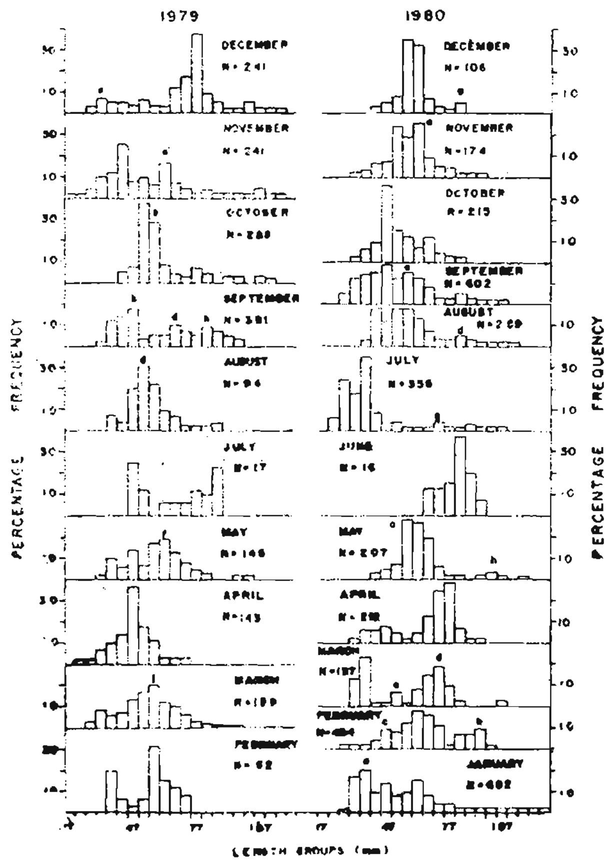

FIG. 3. Monthly length-frequency distribution of *L. bindus* during 1979 and 1980.

mode at 62 mm (d) in November 79 can be traced to 72 mm in March 80 (4 months) giving a monthly growth of 2. 5 mm; this can be further traced to 82 mm in August 80 (5 months from March) which shows an average growth of 2 mm per month. Similarly the mode (g) at 72 mm in July 80 can be traced to 82 mm in December 80 giving a growth of 10 mm in five months with an average monthly growth of 2 mm. The mode at 82 mm in September 79 (h) can be traced to 92 mm in February 80 which gives a monthly growth rate of 2 mm; this mode can be further traced to 97 mm in May 1980 with a growth of 5 mm (1.66 mm|month) in three months.

It can be inferred from the above observations that in the sea off Kakinada *L. bindus* grows at an average monthy rate of 5 mm between 32 and 57 mm length, 2·5 mm between 57 and 72 mm length, 2 mm between 72 and 92 mm length and 1.7 mm between 92 and 97 mm. The growth is not traceable beyond 97 mm though fishes up to 122 mm length are recorded in the catches. Since a growth rate of 5 mm per month is obtained from 32 to 57 mm and since a reduced growth rate is observed from 57 mm onwards, the smallest modal length obtained in the present study at 32 mm (from which growth rate could be traced) can be reasonably taken as 4 months old with an average growth of 8 mm per month. It may thus be stated that *L. bindus* attains average length of 65 mm at the completion of first year and 90 mm at the completion of second year in the sea off Kakinada. It may be mentioned here that the catches of *L. bindus* at Madras range from 33 to 124 mm length and it appears that the species attains 70 mm at the completion of first year (CMFRI 1978). Balan (1967) studied the length-frequency distribution of *L. bindus* in the catches obtained at Calicut during 1956-1959. Though he did not arrive at any conclusion regarding growth rate and age he stated that ". . . . there is an overall increase in the size of the fish from 50 mm in April to 90 mm in November i.e., showing a growth of 40 mm in the course of 7 months each year (in 1957 and 1958) in general."

James and Badrudeen (1975) studied the length-frequency disribution of *Leiognathus brevirostris* from southeast coast of India. According to them the fish grows at a uniform rate of 5 mm per month throughout its life and attains 60 mm and 120 mm at the completion of first and second years respectively. It is possible that the longevity of *L. bindus* is more than two years because the estimated average length at the completion of second year of life at Kakinada is 90 mm and because the maximum length recorded is 120 mm. In view of these observations and also since growth rate could not be traced beyond 97 mm (which is 28 months old), the estimation of growth parameters has not been attempted for fear of getting erroneous results.

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References

Arora, H. L. 1951. A contribution to the biology of the silverbelly, *Leiognathus splendens* (Cuv.). *Sec. II, Proc. Indo-Pacific Fish. Counc.*, 1-6.

Balan, V. 1967. Biology of the silverbelly, *Leiognathus bindus* (Val.) of the Calicut Coast. *Indian J. Fish.*, *10A*: 118-134 (1963).

Clark, F. N. 1934. Maturity of the California sardine (*Sardina caerulea*), determined by ova diameter measurements. *Fish. Bull., Calif. Div. Fish Game*, 42 :49 pp.

CMFRI. 1978. *Annual Report* 1978. Central Marine Fisheries Research Institute, Cochin. 151 pp.

CMFRI. 1980. Trends in total Marine Fish production in India-1979. *Mar. Fish. Infor. Serv. T and Ser.*, No. 22: 1-19.

JAMES, P. S. B. R. AND M. BADRUDEEN. 1975. Biology and fishery of *Leiognathus brevirostris* (valenciennes) from the Palk Bay and the Gulf of Mannar. *Indian J. Mar. Sci.*, 4 : 50-59.

JAMES, P. S. B. R. AND VIJAYAKUMAR M. BARAGI. 1980. Ovary as an indicator of frequency of spawning in fishes. *Proc. Indian natn. Sci. Acad.* B 46: 476-489.

KUTHALINGAM, M. D. K. 1958. The food and feedng habits of some young silverbellies. *J. Mad. Univ.*, 28: 13-22.

SNEDECOR, G. W. AND W. G. COCHRAN. 1967. *Statistical Methods*. Sixth Edition. Oxford and IBH Publishing Company Delhi. 593 pp.

CONTRIBUTION 11

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CONTRIBUTION 11

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STUDIES ON THE GROWTH AND POPULATION DYNAMICS OF SILVERBELLY *LEIOGNATHUS BINDUS* (VALENCIENNES) IN THE TRAWLING GROUNDS OFF KAKINADA

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ABSTRACT

Leiognathus bindus attains average lengths of 72, 110 and 132 mm at the completion of first, second and third years, respectively. The parameters of von Bertalanffy growth equation are estimated as: L_∞ = 158.4 mm, K = 0.58 per year and t_0 = —0.024 year. Instantaneous rates of mortality are estimated as Z = 5.2, M = 1.5 and F = 3.7. The yield per recruit analysis shows that the yield of *L. bindus* can be increased by increasing the cod-end mesh size of trawl nets.

INTRODUCTION

Among the silverbellies landed by private trawlers at Kakinada, *L. bindus* is the most abundant species forming about 41% by weight. Aspects of biology of this species were studied earlier (Murty 1983). The present paper gives the results of investigations on age and growth, mortality rates and stock assessment of this species on the basis of data collected from private trawlers during 1979-81.

MATERIAL AND METHODS

Based on samples collected at weekly intervals, data on species composition of silverbellies and lengths of *L. bindus* were obtained on each observation day. These were raised to the day's catch, and were further raised to get monthly estimates of cath of different species and length composition in the catch. From these data, annual estimates of species composition and length composition of catch were obtained.

Growth and age were estimated from the modal progression in the monthly length-frequency distribution of catch. Parameters of growth in length were estimated using the von Bertalanffy growth equation, which is of the form:

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

where L_∞ = asymptotic length of fish, L_t = length at age 't', K = growth coefficient and t_0 = arbitrary origin of growth curve.

Instantaneous rate of total mortality (Z) was estimated using the equation of Beverton and Holt (1956):

$$Z = K(L_\infty - \bar{l}) / (\bar{l} - l_c)$$

where l_c is the length at first capture and $\bar{l}$ is the average length of fishes including and above l_c.

Estimate of instantaneous rate of natural mortality (M) was obtained using the equation of Pauly (1980):

$$\text{Log } M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$$

where L_∞ is in cm, K per year and T in °C. Value of temperature was taken as 27.2°C from Ganapati and Murthy (1954) and La Fond (1958). The value of M was also estimated taking the life-span of the species into account.

The yield in weight per recruit (YW|R) was calculated from the equation of Beverton and Holt (1957):

$$YW/R = Fe^{-M(t_c - t_r)} W_\infty \left(\frac{1}{Z} - \frac{3S}{Z+K} + \frac{3S^2}{Z+2K} - \frac{S^3}{Z+3K} \right)$$

where $S = e^{-K(t_c - t_0)}$, t_c = age at first capture, t_r = age at recruitment and W_∞, K and t_0 are parameters of von Bertalanffy growth equation.

Growth and Age

A total of 7452 specimens ranging from 17 to 129 mm were measured during February 1979-December 1981. The data (Fig. 1) did not show progression of modes over a period of several successive months to facilitate determination of growth. Nevertheless, a few modes (Fig. 1) whose progression can be traced for periods ranging from 2 to 5 months are present. A mode at 32 mm in December 79 can be traced to 37 mm in January 80, giving a monthly growth of 5 mm (Fig. 1). Three modes at 37 mm in February 79, May 79 and July 80 can be traced respectively to 47 mm in April 79, 52 mm in August 79 and 47 mm in September 80, showing an average growth of 5 mm per month. Further, the modes at 47 mm in September 79, February 80, October 80 and February 81 have shifted respectively to 52 mm in October 79, 52 mm in March 80, 57 mm in December 80 and 57 mm in April 81 again all the modes showing an average monthly growth of 5 mm. The mode at 52 mm in November 79 has shifted to 72 mm in March 80 and another mode at 57 mm in August 80 has shifted to 67 mm in October 80, showing, once more, a monthly growth of 5 mm. It is therefore clear that the monthly growth rate is about 5

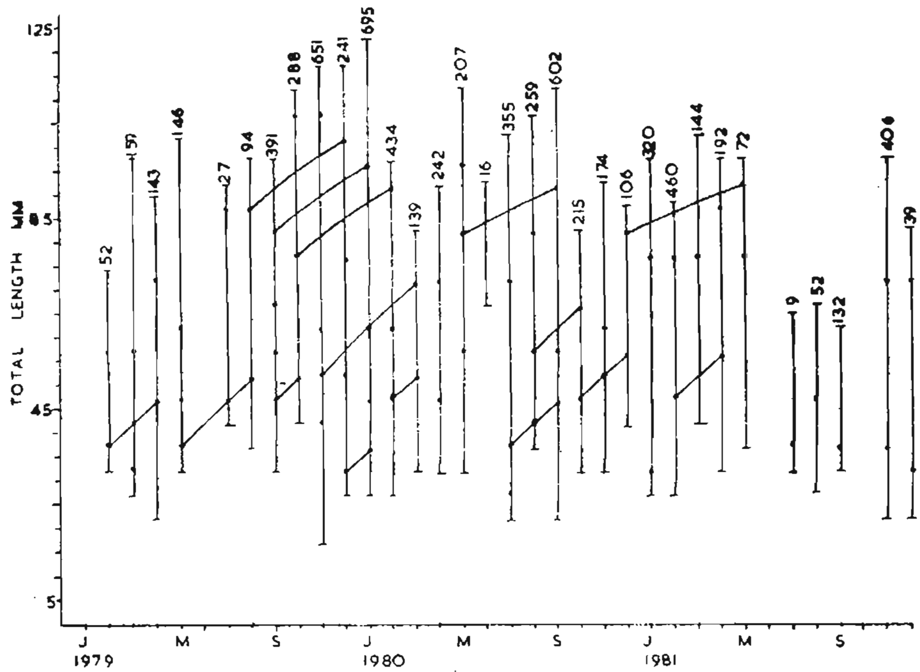

FIG. 1. Length range and modal lengths in *L. bindus* and their progression in different months during 1979-'81 (vertical lines show the length range, the points indicate the modal lengths and numerals indicate sample size).

mm in fish ranging from 32 to 72 mm length. The mode at 77 mm in October 79 is traceable to 92 mm in February 80 showing a growth of 15 mm in 4 months, with a monthly average of 3.75 mm. Similarly, the mode at 82 mm in September 79 has progressed to 97 mm in January 80 again showing a monthly growth of 3.75 mm. Two modes at 82 mm in May and December 80 have shifted to 92 mm in September 80 and May 81, respectively, giving an average monthly growth of 2.5 and 2 mm. The mode at 87 mm in August 79 has shifted to 102 mm in December 79 in four months, giving a monthly growth of 3.75 mm. Thus, the modal progression between 77 and 102 mm length has given three different monthly growth rates: 3.75 mm in 3 cases, 2.5 mm in one case and 2.0 mm in one case. Hence the average of these values was taken as the monthly growth between 77 mm and 102 mm length.

Since a monthly growth of 5 mm between 32 and 72 mm length and 3.1 mm between 77 and 102 mm length were observed, fish with the smallest modal length at 32 mm (from which growth could be traced) can be reasonably taken as 4 months old with an average monthly growth of 8 mm.

The Ford-Walford plot (Ford 1933, Walford 1946) of l_{t+1} against l_t on the basis of lengths attained at intervals of 3 months (Fig. 2) shows that

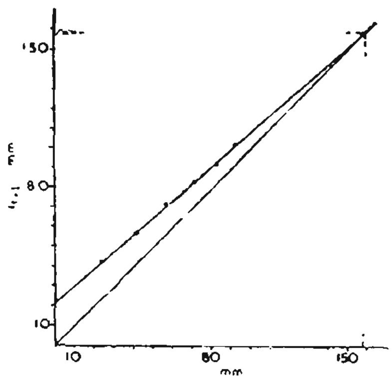

FIG. 2. Ford-Walford plot in *L. bindus*.

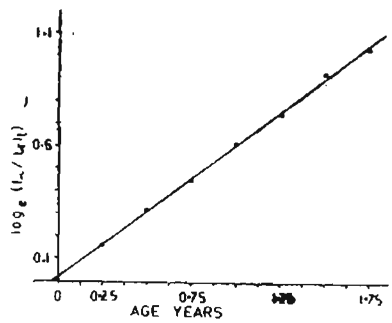

FIG. 3. Estimation of t_0 graphically.

the points are well represented by the straight line. The L_∞ was estimated at 158.4 mm and K per year at 0.58. The value of t_0 was estimated (Fig. 3) as —0.024 year. The calculated lengths of *L. bindus* at Kakinada are 72, 110 and 132 mm at the completion of first, second and third years of life respectively (Fig. 4). Since the maximum length recorded in the present study is 129 mm, the maximum age works out to 2.9 years.

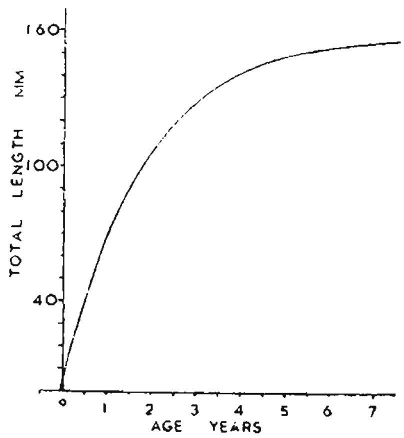

FIG. 4. von Bertalanffy growth curve of *L. bindus*.

Mortality Rates

The monthly length-frequency distribution (Fig. 1) shows that the smallest modal length in any year is at 32 mm. However, the annual length composition of the catch during the period shows dominant mode at 57 mm. Hence this length was taken as length at first capture (Lc). The estimated values of Z in different years (Table 1) varied from 4.4 to 6.0 with an average of 5.2.

TABLE 1. *Estimated values of length at first capture* (l_c) *mean length* ($\bar{l}$) *and total mortality rate* (Z) *during different years in* L. bindus.

Particulars	1979	1980	1981
l_c (mm)	57	57	57
$\bar{l}$ (mm)	65.9	68.9	67.1
Z	6.0281	4.3622	5.2423

The value of M was estimated as 1.5 on the basis of the equation of Pauly (1980). If it is assumed that there is no exploitation and that 99% of this species by numbers die by the time they attain the maximum age of 2.9 years, the M value can be calculated as 1.6 (Ln 100 $\div$ 2.9), which is almost the same as the one obtained by Pauly's formula. The M value is taken as 1.5 and the average F during the period works out to 3.7.

YIELD PER RECRUIT

The value of W_∞ was estimated at 54.7 g on the basis of length-weight relationship and L_∞. Taking 57 mm as l_c, the value of t_c was estimated as 0.75 year. The smallest fish in the catch measured 17 mm. Hence this length was taken as length at recruitment (Lr) whose age (tr) was estimated as 0.18 year.

The yield per recruit as a function of fishing mortality rate was calculated taking four values of t_c ranging from 0.59 to 1.13. (Fig. 5) representing l_c values ranging from 47 to 77 mm. It is observed that with tc at 0.59 the yield increases to a maximum at F = 2.0 and then declines with further increases to a maximum at F = 2.0 and then declines with further increase in F. With tc at 0.75 (the present value) and 0.93 the value of yield per recruit is maximum at F = 3.0 and 4.5 respectively and show decline with further increase in F. With t_c at 1.13, the yield per recruit increases with increased F and does not show any fall. It is also observed that yield per recruit is greater for higher values of tc (Fig. 5). The yield curves show that under the current value of F (3.7) and tc (0.75) the yield per recruit already showed a decline and further increase in F will result in further decline of yield.

The yield per recruit as a function of t_c shows that maximum yield can be obtained at tc = 1.1 (Fig. 6) with F at 3.7 (present value) indicating that yield can be maximised by increasing the age at first capture (i.e., by increase of codend mesh size) without further increasing the effort.

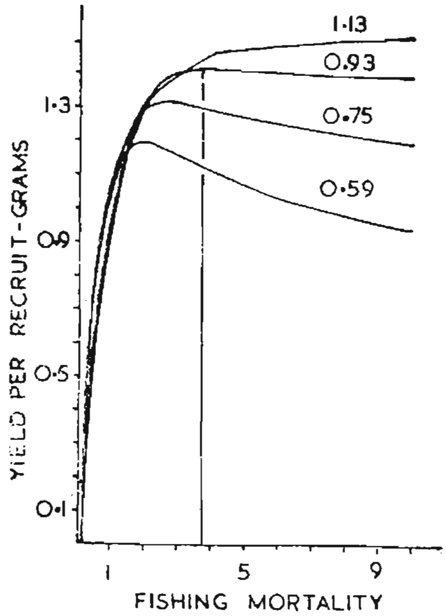

FIG. 5. Yield per recruit (YW|R) of *L. bindus* in relation to Fishing mortality rate (The vertical line indicates the present F). Numerals indicate the values of age at first capture.

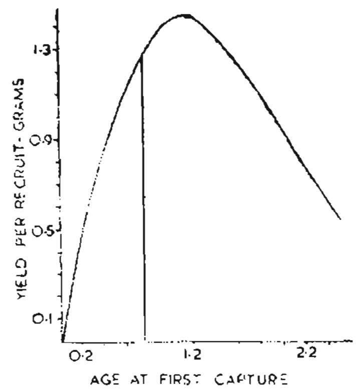

FIG. 6. Yield per recruit of *L. bindus* in relation to age at first capture. (The vertical line indicates the present tc).

Discussion

It is well known that estimation of growth and age of tropical fishes is difficult for a variety of reasons. Since in the present study there is no clear-cut progression of modes in the length-frequency distribution in each successive month in a year (Fig. 1), the modal progression during shorter intervals was taken into account, assuming that the modes considered belong to the same brood, and the parameters of growth obtained in the study seem to be realistic because the estimated value of L_∞ at 158.4 mm is close to the maximum recorded length of the species: at Madras the maximum length recorded is 155 mm (CMFRI, 1977) though the maximum length recorded during the study period at Kakinada is only 129 mm. The estimated values of K and M obtained also show that the M|K value is just about the upper limit of the range known for fishes (Beverton and Holt 1959). Pauly and David (1981), however, estimated the values of L_∞ and K in *L. bindus* on the basis of data from Calicut (of Balan, 1967) as 12.2 cm and 1.3 per year, respectively.

An attempt to estimate M on the basis of regression of Z on effort did not prove successful probably because, the fishery being a multispecies one.

effective effort for the species under consideration could not be obtained. Hence the value obtained by using the formula of Pauly (1980) was taken.

The regression coefficient in the length-weight relationship of *L. bindus* from Kakinada (2.96182; Murty 1983) was tested against the theoretical value of 3 by t-test and it was found that the observed value was not significantly different from 3. Hence the results of yield-per-recruit study, using Beverton-Holt equation, (which takes growth to be isometric) can be taken as reliable even to arrive at etimates of absolute yield.

The yield curves (Fig. 5) show that the value of F, where the fall in the yield per recruit occurs, is greater if t_c is greater, indicating that there is a possibility of growth overfishing under lower values of t_c and that higher yield can be obtained by increasing t_c. When t_c is 1.13, hte yield curve does not show a fall with increased F. It was shown earlier (Murty, 1983) that *L. bindus* attains first maturity at 80 mm (1.19 year). Thus, it appears that increasing t_c up to age at first maturity will not only result in increased yield out also give scope for increasing the effort. This is possible because increasing t_c up to age at first maturity will not hamper the reproduction by removing prospective spawners, thus averting recruitment overfishing also. In *L. bindus* at Kakinada, hence, increasing the cod-end mesh size of trawl nets results in higher yields without adversely affecting the stock.

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REFERENCES

*BALAN, V. 1967. Biology of the silverbelly, *Leiognathus bindus* (Val.) of the Calicut coast. *Indian J. Fish.*, 10: 118-134. (1964).

BEVERTON, R. J. H. AND S. J. HOLT. 1956. A review of the methods for estimating rates in Exploited fish populations, special reference to sources of bias in catch sampling. *Rapp. P-V. Reun. Cons. Perm int. Explor. Mer.*, 140(1): 67-83.

BEVERTON, R. J. H. AND S. J. HOLT. 1957. On the dynamics of exploited fish populations. *Fishery Invest. London, Ser.* 2, 19: 533 pp.

BEVERTON, R. J. H. AND S. J. HOLT. 1959. A review of lifespans and mortality rates of fish in nature and their relation to growth and other physiological characteristics. *In*: Ciba Foundation Colloquia on ageing. G. E. W. Wolsenholme and M. O'Connor (Eds.). *The life-span of animals*, 5: 142-177.

CMFRI. 1977. *Annual Report* 1977. Central Marine Fisheries Research Institute Cochin. 148 pp.

FORD, E. 1933. An account of the herring investigations conducted at Plymouth during the years 1924-1933. *J. mar. biol. Ass. U.K.*, 19: 305-384.

GANAPATI, P. N. AND V. S. R. MURTHY. 1954. Salinity and temperature variations of the surface waters off Visakhapatnam coast. *Andhra. Univ. Mem. Oceanogr.*, I: 125-142.

LAFOND, E. C. 1958. Seasonal Cycle of sea surface temperatures and salinities along the east coast of India. *Andhra Univ. Mem. Oceanogr.*, II: 12-21.

MURTY, V. SRIRAMACHANDRA. 1983. Observations on some aspects of biology of the silverbelly, *Leiognathus bindus* (Valenciennes) from Kakinada. *Indian J. Fish.*, 30: 61-58.

PAULY, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. int. Explors Mer.*, 39: 175-192.

PAULY, D. AND N. DAVID. 1981. ELEFAN 1, a BASIC program for the objective extraction of growth prarameters from length frequency data. *Meeresforsch*, 28: 295-211.

WALFORD, L. A. 1946. A new graphic method of describing the growth of animals. *Biol. Bull. Woodshole*, 90: 141-147.

CONTRIBUTION 12

MURTY, V. SRIRAMACHANDRA. 1988. Population characteristics of the silverbelly *Leiognathus bindus* (Valenciennes) along west Bengal coast. *J. mar. biol. Ass. India*, 28 (1&2): 41-47 (1986).

CONTRIBUTION 12

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POPULATION CHARACTERISTICS OF THE SILVERBELLY *LEIOGNATHUS BINDUS* (VALENCIENNES) ALONG WEST BENGAL COAST

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ABSTRACT

Leiognathus bindus occurs 6-15 m above sea bottom during night time in areas of depths ranging from 21 to 35 m. There is good correlation between depth of occurrence and mean length of this species. The length-weight relationship in the sea off West Bengal can be described by the equation log W = -5.38217 + 3.28637 log L. The selection length for the 22 mm cod end mesh size is 42 mm. It appears that *L. bindus* in the sea off West Bengal belongs to a virgin stock and the estimated value of Z at 1.02 can be taken as M for the species. The yield per recruit analysis shows that higher yield can be obtained at a cod end mesh size of 42 mm with a maximum F of 3.2.

INTRODUCTION

IN FEBRUARY 1985, the Research Vessel *R. V. Skipjack* of the Central Marine Fisheries Research Institute conducted a survey in the region between 20°-21° 03'N and 87° 15' - 88° 55'E along the coast of West Bengal using a midwater trawl. *Leiognathus bindus* (family Leiognathidae) was one of the most dominant species in the catches. Since there is no information on this species from along West Bengal Coast, an account of biology and population dynamics of this species is given in this paper.

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MATERIAL AND METHODS

R. V. Skipjack operated a mid water trawl 141.5 m long (including the leg) with a cod end mesh size of 22 mm, in the sea off West Bengal during 21. 2. 1985 - 25. 2. 1985. One-hour hauls were taken at each station at a trawling speed of 3.5 kn in a total of 16 stations (Fig. 1). At each station, the depth (echo depth and year depth) was recorded along with all relevant particulars. Fishing was conducted both during day and night. The catch at each station was separated into constituent species and then all relevant data were recorded. In *L. bindus* all the specimens caught were measured: in cases where the catches were larger, a sample of fishes was measured and then weighted to the catch. Some specimens were preserved in formalin and brought to the laboratory for further studies. The length data were grouped into 5 mm- class intervals. For length-weight relationship the preserved specimens were measured to the nearest mm and 0.5 g and the relationship was calculated using the formula: log W = log a + b log L (Le Cren, 1951). Maturation stages were fixed following Murty (1984). The total mortality rate was estimated following Beverton and Holt (1956) method; for this purpose the data on length composition of catch at all stations were pooled. Natural mortality rate (M) was estimated assuming that 99% of the fish by numbers would die if there is no exploitation, by the time they attain maximum age (t_{max})

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and by taking t_{max} as corresponding to L_{max} in the catch (Sekharan, 1975) or to L_{∞} - 0.50 cm (Alagaraja, 1984) or to 95% of L_{∞} Pauly, 1983). Length at first capture (L_c) was estimated following Jones (1976): L_c = SF X MS where SF is the selection factor and MS the cod-end mesh size. SF was estimated using the depth ratio (standard length/maximum body depth) of the species and the nomogram given by Pauly (1983).

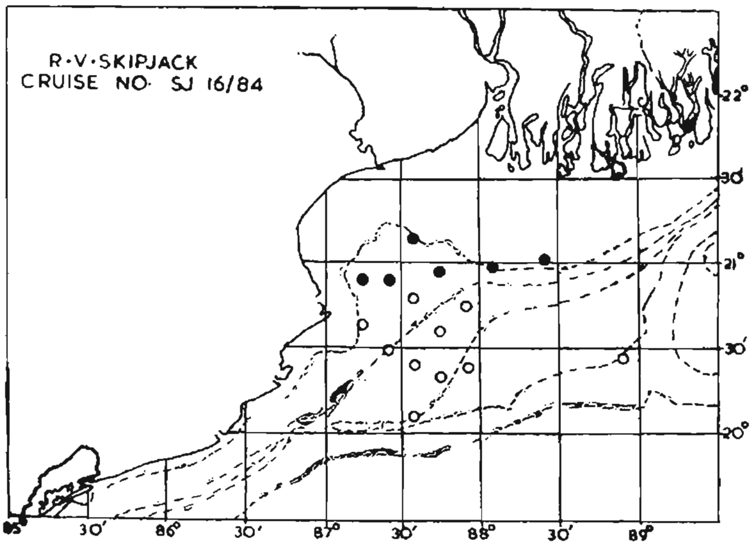

Fig. 1. Coast of West Bengal. Fishing stations are indicated by rcicles and closed circles indicate stations where *L. bindus* was caught.

Distribution and Biology

Distribution: A total of 16 hauls was taken at 16 stations (Fig. 1). *Leiognathus bindus* was caught only in six stations and a total of 18.6 kg forming 13.5% of total catch in all 16 stations was obtained (Table 1). Fishing was conducted in areas having bottom depths ranging from 21 to 150 m and the depth of the gear ranging from 12 to 68 m. *L. bindus* occurred in the catches at gear depths ranging from 12 to 23 m (6-15 m above sea bottom having the depth range 21-35 m). Though fishing was conducted both during day and night, *L. bindus* was caught only during night time or during early morning time before dawn (Table 1). Only small quantities of another silverbelly (*Secutor ruconius*) were caught.

A plot of mean length (of all the fishes caught at each station) of *L. bindus* against the gear depth (Fig. 2) shows that there is a significant correlation between the two (n=6; r=0.79) suggesting that larger fishes live in relatively deeper waters. The relation can be described by the regression:

$$ML = -27.0428 + 5.8778 D$$

Where ML is mean length in mm and D is gear depth in m.

Length composition of catch: A total of 1908 specimens was caught and 234 specimens were measured. The total length at different stations varied from 20 to 135 mm (Fig. 3) with modal lengths at 47 and 102 mm.

Sex ratio and Maturity: A total of 163 specimens ranging from 87 mm to 118 mm was

relationship was calculated separately for males and females and the regressions are:

males : $\log W = -4.69562 + 2.94611 \log L;\ r^2 = 0.80$

TABLE 1. *Details of fishing stations and catches*

St. No.	Depth (m) of bottom	Depth (m) of gear	Time of fishing (Hrs)	Total catch (kg)	Silverbelly catch (kg)	Catch os *L. binduf* (kg)
1	21	12	0130–0230	25.86	1.00	0.10
5	150	60	1815–1915	1.00	-	-
11	25	18	0510–0610	13.19	2.00	1.35
12	53	32	0930–1030	1.25	-	-
13	98	45	1325–1425	0.05	-	-
15	94	50	1850–1950	0.66	-	
16	58	36	2200–2300	0.65	-	-
17	35	20	0035–0135	2.28	2.10	2.10
18	26	20	0510–0610	27.39	0.13	0.13
19	35	25	0800–0900	3.78	-	-
20	53	35	1145–1245	0.10	-	-
21	89	68	1540–1640	-	-	-
22	44	32	1840–1940	34.10	0.20	-
23	33	23	2200–2300	17.33	15.00	15.00
24	27	21	0110–0210	8.20	0.28	0.08
25	34	29	0425–0525	2.70	-	-
			Total:	138.54	20.71	18.76

Note: The numbers of the stations where only hydrographic data were collected are not listed here.

examined; of these 86 were females and the rest males. Among females 87.2% were in stage IV and 12.8% in stage V.

Length - weight relationship: Data of the 163 specimens mentioned above were used. The

Females : $\log W = -5.70966 + 3.44844 \log L;\ r^2 = 0.83$

Analysis of covariance (Table 2) does not reject the identicality of regression lines at 5% level of significance The data of males and females were therefore pooled and regression for the species was fitted:

$$\log W = -5.38217 + 3.28637 \log L; \; r^2 = 0.82$$

The t-test (Pauly, 1984) was applied to test whether the regression coefficient is significantly different from 3. At df = n-2, the $\hat{t}$ value shows that the regression coefficient is not significantly different from 3 at 1% level.

Estimation of L_c: The depth ratio was calculated as 1.85 and using this value, the SF value was read as 1.9 from the nomogram of Pauly (1983). Taking the cod end mesh size of the gear at 22 mm, the L_c value was calculated as 42 mm. The L_c in the present study was taken as 40 mm being the lower limit of the length class 40-44 mm.

TABLE 2. *Analysis of Covariance to test the significance of difference between regression lines of sexes in the length-weight relationship of* L. bindus

Source of variation	Df	Deviation from Regression SS	MS
Due to regression within sexes	159	0.187204	0.001177
Due to difference between regression coefficients	1	0.004361	0.004361
Residual due to regression pooled within	160	0.191565	0.001197
Difference between adjusted means	1	0.000006	0.000006
Total	161	0.191571	

Comparison of slopes F=3.71, df=1,159; NS

Comparison of elevations F=0.005, df=1,160; NS.

TABLE 3. *Estimated values of M obtained by different methods along with the values of L_{max} and t_{max}* in L. bindus

Method of	L_{max} (mm)	t_{max} (year)	M	M/K
Sekharan (1975)	135	3.27	1.41	2.43
Pauly (1983)	150.48	5.14	0.90	1.55
Alagaraja (1984)	153.4	5.93	0.78	1.34
Pauly (1980)	–	–	1.50	2.59

Estimation of total mortality rate (*Z*): Murty (1986) estimated the von Bertalanffy growth parameters of this species as $L_\infty = 158.4$ mm, $K=0.58$ per year and $t_0 = -0.024$ year from off Kakinada along the coast of Andhra Pradesh. Taking these values for the stock along West Bengal Coast and taking L_c as 40 mm ($\bar{L}$ value was calculated taking fishes above 40 mm TL), the value of Z was estimated as 1.02.

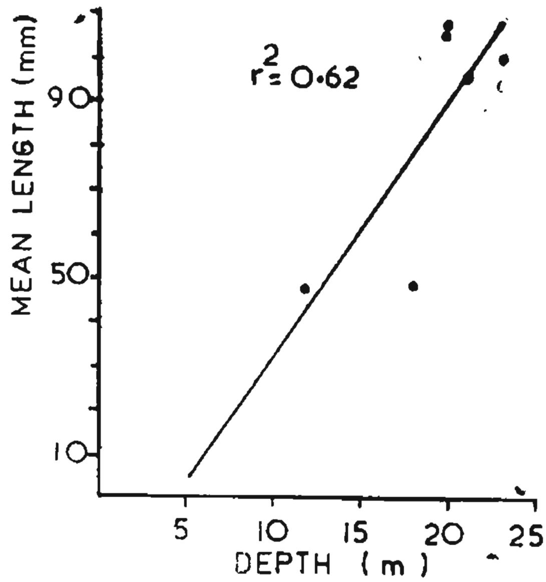

Fig. 2. Relationship between mean length of *L. binds* against fishing depth.

Estimation of natural mortality rate (M): The values of M obtained by different methods are shown in Table 3 along with the value obtained by Murty (1986) following Pauly's (1980) equation. In the present study M value was taken as 1.02 which is also the Z value.

Estimation of yield per recruit: The growth parameter estimates were taken from Murty (1986). The W_∞ value was calculated taking the L_∞ value and the length - weight relationship. The smallest length in the catch at 20 mm was taken as Lr and its age (t_r) is 0.2 year. Taking the value of M at 1.02 and taking different values of L_c corresponding to different

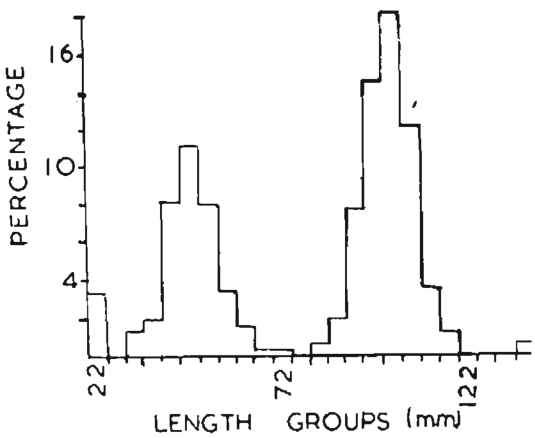

Fig. 3. Length frequency distribution of *L. bindus* (Data pooled from all stations).

cod end mesh sizes, the yield per recruit (Yw/R), was calculated. The Yw/R as a function of F (Fig. 4) shows that Yw/R is higher if t_c is higher and reaches maximum at greater values of F when t_c is greater. It is also clear that if t_c is 1.19 (cod - end mesh size 42 mm), maximum Yw/R is obtained at F=3.2.

Discussion

Balan (1967) stated that in *L. bindus*, "very good catches are reported to be procured during foggy nights and also during the dark phase of the moon when the shoals reveal their presence by luminescence in the surface and sub-surface waters". Venkatraman and Badrudeen (1975) showed that silverbellies "stay at the bottom during day time and a good portion of these migrates from there and rises to surface and sub-surface waters at night.". The present observations (Table 1) are in conformity with those of the above authors. There is justification, therefore, in using the present data from midwater trawl catches for a study of population dynamics of *L. bindus*.

Along the West Bengal Coast which has a length of 600 km, an average catch of 13,634 tonnes during 1976-'81 (CMFRI, 1982), of all fish forming 1.0% in the total marine fish catch of India, are landed annually. The annual average catch of siverbellies (during the above period) in this state was estimated at 110 tonnes (CMFRI, 1982) which forms 0.2% of all India silverbelly catch and 0.8% in total landings in West Bengal State. It is thus clear that marine fisheries resources in general are underexploited in West Bengal and *L. bindus* in the region can be treated as belonging to a virgin stock. This latter aspect is particularly clear from the estimate of instantaneous rate of total mortality : off Kakinada, the author (Murty, 1986) estimated the Z value of this species as 5.2 during 1979-'81 whereas in the present study (in 1985), it is estimated as 1.02 only. This latter value is much less than the value of M estimated by Sekharan's (1975) and Pauly's (1980) methods and is only slightly more than the M values obtained by Pauly's (1983) and Alagaraja's(1984) methods. It is thus clear that there is virtually no fishing mortality for this species off the West Bengal Coast. Since there is presently no way of obtaining an objective estimate of M particularly for the exploited stocks of

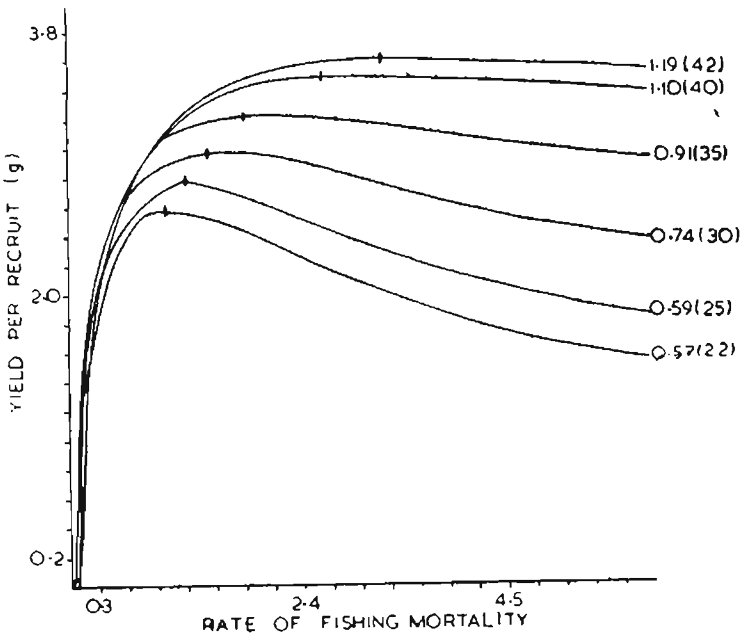

Fig. 4. Yield per recruit of *L. bindus* as a function of fishing mortality rate. Numerals indicate the values of age at first capture in years; those in parentheses are the corresponding values of cod end mesh size in millimetres.

tropical fishes (Cushing, 1981; Alagaraja, 1984), the present estimate of M = 1.02 for *L. bindus* can well be taken as the M value for those stocks of this species which are well-exploited.

The stock of *L. bindus* along West Bengal Coast, like any other species in tropical multispecies fisheries, can only be exploited along with several other demersal species in the region. The yield per recruit analysis (Fig. 4) of *L. bindus*, may therefore appear as having academic value only. While it may be so at present, the results of the analysis provide an idea of the best strategy for rational exploitation of the species and will be useful in future when similar information on all other demersal species in the region, becomes available.

REFERENCES

ALAGARAJA, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian J. Fish.*, **31** (2): 177-208.

BALAN, V. 1967. Biology of the silverbelly *Leiognathus bindus* (Val.) of the Calicut Coast. *Ibid.*, **10** A: 118-134 (1963).

BEVERTON, R. J. H. AND S. J. HOLT 1956. A review of methods for estimating mortality rates in exploited populations with special reference to sources of bias in catch sampling. *Rap. p. v. Reun. Cons. perm. int. Explor. Mer.*, **140** (1): 67-83.

——— AND ——— 1957. On the dynamics of exploited fish populations. *Fishery Invest., London Ser.* (2), **19**: 1-533.

CMFRI 1982. Trends in marine fish production in India - 1981. *Mar. Fish. Infor. Serv. T & E. Ser.*, **41**: 1-33.

CUSHING, D. H. 1981. *Fisheries biology: A study in population dynamics.* The University of Wisconsin Press, Second Edition, 295 pp.

JONES, R. 1976. Mesh regulation in the demersal fisheries of South China Sea area. *South China sea fisheries development programme, Manila, SCS/76/WP/* 35: 75 pp.

LE CREN, E. D. 1951. Length-weight relationship and seasonal cycle in gonad weight and condition of the perch (*Perca fluviatilis*). *J. anim. Ecol.*, **20**: 201-219.

MURTY, V. SRIRAMACHANDRA 1984. Observations on some aspects of biology of silverbelly *Leiognathus bindus* (Valenciennes) from Kakinada. *Indian J. Fish.*, **30** (1): 61-68 (1983).

——— 1986. Studies on the growth and population dynamics of the silverbelly *Leiognathus bindus* (Valenciennes) in the trawling grounds off Kakinada. *Ibid.*, **33** (3):

PAULY, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. int Explor. Mer.*, **39**: 175-192.

——— 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. pap.* **(234)**: 52 pp.

——— 1984. Fish population dynamics in tropical. waters : a manual for use with programmable calculators. *ICLARM Studies and Reviews*, **8**: 325 pp.

SEKHARAN, K. V. 1975. Estimates of the stocks of oil sardine and mackerel in the present fishing off the West Coast of India. *Indian J. Fish.*, **21** (1): 177-182 (1974).

VENKATRAMAN, G. AND M. BADRUDEEN 1975. On the diurnal variation in the catches of silverbellies in Palk Bay. *Ibid.*, **21** (1): 254-265 (1974).

CONTRIBUTION 13

MURTY, V. SRIRAMACHANDRA. 1991. Biology and population dynamics of the silverbelly *Secutor insidiator* (Bloch) from Kakinada. *J. mar. biol. Ass. India*, 32 (1&2): 10-24 (1990).

CONTRIBUTION 13

BIOLOGY AND POPULATION DYNAMICS OF THE SILVERBELLY *SECUTOR INSIDIATOR* (BLOCH) FROM KAKINADA

J. mar. biol. Ass. India, 1990, **32** (1 & 2) : 10-24

BIOLOGY AND POPULATION DYNAMICS OF THE SILVERBELLY *SECUTOR INSIDIATOR* (BLOCH) FROM KAKINADA

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ABSTRACT

The biology and population dynamics of *Secutor insidiator* from the trawling grounds off Kakinada were studied. The estimated length at first maturity is 90 mm and the spawning season is protracted with a peak during January-March period. The von Bertalanffy parameters of growth in length are estimated as L_{∞} = 123 mm, K=1.2 per year and t_0=0.01 year. The estimated lengths on the completion of first and second years are 86 and 112 mm respectively. The length-weight relationship can be described by the equation : log W(g)= —5.73713+3.43654 log L (mm). The instantaneous rate of total mortality during the period is estimated as 6.1 and the values of natural mortality rate, by different methods, are estimated as ranging from 1.8 to 2.6. Length and age at first capture are 80 mm and 0.87 year respectively. Under the present value of t_c, yield increases with increased F without reaching a maximum ; highest yield, however, can be obtained at t_c ranging from 0.5 to 0.7 with the present Z and different value of M considered.

INTRODUCTION

SILVERBELLIES or slipmouths (Family : Leiognathidae) are exploited in considerable quantities and form one of the major demersal fishery reasources of India. Though some information on the fisheries and biology of silverbellies from India is available (Arora, 1951 ; Balan, 1967 ; James, 1973 ; James and Badrudeen, 1975 ; 1982 ; Venkataraman and Badrudeen, 1974 ; Venkataraman *et al*., 1982 ; Annam and Dharmaraja, 1982 ; Murty, 1983), there is no information on the biology of *Secutor insidiator* from the Indian Coast, excepting a brief account on spawning from Tuticorin (Pillai, 1972). Since this is one of the most dominant species in the trawl catches at Kakinada, a detailed study of its biology was taken up in 1979 and the results are presented in this paper. An attempt is also made to estimate the mortality rates and yield of this species from the trawling grounds off Kakinada.

The author is grateful to Dr. E. G. Silas, former Director and Dr. P. S. B. R. James, present Director of CMFRI for encouragement and to Mr. C. Mukundan for suggesting improvements in the manuscript.

MATERIAL AND METHODS

The study is based on data collected during 1979-83 from the catches of the commercial trawlers operating off Kakinada. Data on catch and effort were collected for 18-20 days in a month. Samples for studies on the species composition and biology were collected at weekly intervals. The data on species composition of siverbellies and length of *S. insidiator* collected on each observation day were weighted to get the day's and then the monthly estimates.

Three types of boats are operated in the area under study (CMFRI, 1981). As the

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Pomfret-Royya category of boats is most dominant in the fleet (CMFRI, 1981), this was considered as the standard unit and effort standardisation was made following Gulland (1969), by considering all the demersal group landed as one group since the trawl fishery is a multispecies one.

For biological studies the specimens in fresh condition were examined. Maturation stages were fixed following Murty (1983). Only females were considered for estimating length at first maturity and spawning. Fishes in stages IV-VI of maturation were taken as mature for estimating length at first maturity and fishes of and above length at first maturity only were considered to determine spawning season.

To examine whether the monthly sex ratio is 1 : 1 or not, the chi-square test was applied. A test of variance for homogeneity (Snedecor and Cochran, 1967) was used to find whether the sex ratio over a period of one year is uniform.

The length data were grouped into 5 mm class intervals and the mid points in these groups were considered to study growth. Parameters of growth in length were estimated by the 'integrated method' of Pauly (1980 a) and using the well-known von Bertalanffy equation for growth :

$$Lt = L\infty(1-e^{-K}(t-t_o)$$

Estimates of $L\infty$ and K were obtained using the Ford-Walford plot (Ford, 1933 ; Walford, 1946) as adapted by Manzer and Taylor (1947).

Since Beverton-Holt yield equation assumes growth in weight with length to be isometric, computation of yield following this method results in erroneous estimates of absolute yield in species in which growth in weight with length does not follow cube law. Hence, Paulik and Gales (1964, as cited by Clark 1978) have recommended that 'a von Bertalanffy curve be fitted to the cube root of weight at each age and this fictitious length schedule used in computations [of yield] by the method of Beverton and Holt'. Hence, in the present study, the parameters of growth in weight were also estimated : the values of lengths at half yearly intervals, obtained by the integrated method were converted into weights at ages with the help of the length-weight relationship and the cube roots of these values were taken for fitting the von Bertalanffy equation.

Weight of each fish was taken to an accuracy of 0.5 g. The length-weight relationship was calculated with the help of the formula : log W=log $a+b$ Log L, where W=weight of fish in grams, L=total length in mm, a=a constant and b=exponent (Le Cren, 1951).

Instantaneous rate of total mortality (Z) was estimated by length-converted catch curve method of Pauly (1982), cumulative catch curve method of Jones (1981) and Jones and van Zalinge (1981), Ssentongo and Larkin (1973) method and Beverton and Holt (1956) method.

The estimation of natural mortality rate (M) was attempted by the relation : $Z=M+qf$ where q is the catchability coefficient and f=fishing effort, but the plot of Z against effort showed that the points are not well-represented by a straight line. The value of M, therefore, was estimated assuming that 99% of the fish by numbers would die, if there was no exploitation, by the time they attained t_{max} and by taking t_{max} as corresponding to L_{max} in the catch (Sekharan, 1976), or to $L\infty$-0.5 cm (Alagaraja, 1984) or to 95% of $L\infty$ (Pauly, 1983). It was also estimated with the help of the empirical relationship (Puly, 1980 b) :

log M=−0.0066-0.279 log $L\infty$+0.6543 log K+0.4634 log T where $L\infty$ is in cm, K per year and T is mean water temperature in °C. For the purpose of this equation the value of T

was taken as 27.2°C from Ganapati and Murthy (1954) and La Fond (1958). Length at first capture (L_c) was estimated following Navaluna (1982).

Exploitation rate (U) was estimated by the equation of Sekharan (1976) and the total annual stock (Y/U) and average standing crop (Y/F) were estimated by taking the average annual catch of the species (Y) during 1979-'83. The value of Y/F thus obtained was taken as the average biomass (B) during the exploited phase of the species in the trawling grounds.

The yield in weight per recruit (g) was estimated from the equation of Beverton and Holt (1957). Since growth in weight with length in *S. insidiator* is not isometric, yield per recruit was also estimated following the method recommended by Paulik and Gales (1964).

The biomass per recruit (B/R) was estimated from the formula : $B/R = (YW/R)/F$ and recruitment in numbers (R) was estimated by the relation $R = B/\ (B/R)$. Since the estimation of biomass was made under the present level of fishing mortality rate (considering different values of M) and age at first capture, recruitment was also estimated taking these values into account. The values of recruitment thus obtained were assumed to be constant.

The expected yield at different levels of fishing mortality was estimated by the relation : yield in weight = Recruitment (Nos) X yield in weight per recruit (g).

Maturation, Spawning and Sex Ratio

Length at first maturity : The data of the three-year period (1980-'82) were pooled for the purpose. Fishes of 72 mm and above showed mature gonads and the percentage of mature fish in each length group showed increase with increased length. It was observed that at 92 mm length, about 50% of the fish were mature. Hence the lower limit of this length group at 90 mm was taken as the length at first maturity at Kakinada.

Spawning : Fishes in stages III-V of maturation occurred in almost all months (Fig. 1). The percentage of gravid and ripe (St. V+VI) adults in different months (Fig. 2) shows that the spawning season of *S. insidiator* is protracted running almost throughout the year, with a peak during January-March period.

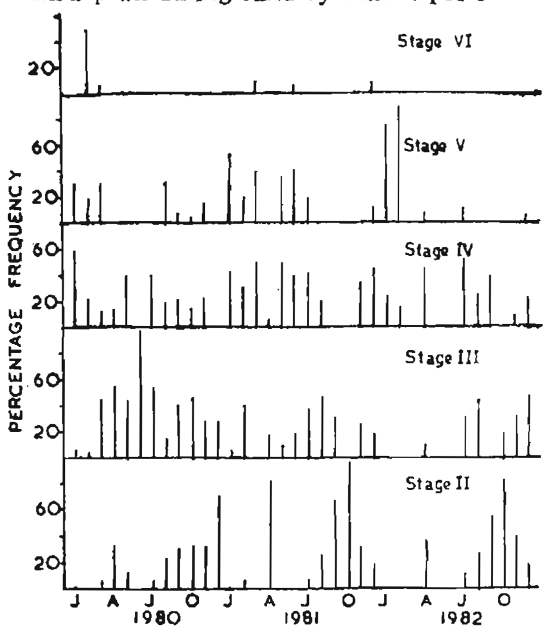

FIG. 1. Monthly percentage frequency distribution of ovaries of *S. insidiator* in each stage of maturation during 1980-82.

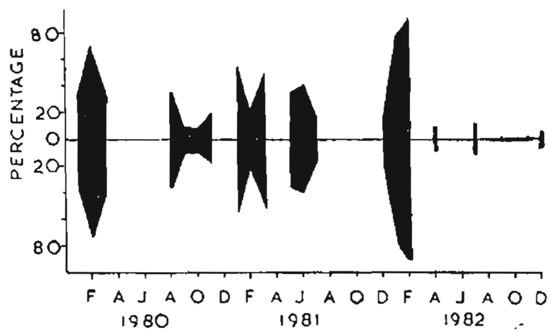

FIG. 2. Percentage composition of gravid and ripe females (St. V+VI) of *S. insidiator* in the total number of adult females examined in each month during 1980-82.

Sex ratio: 1374 specimens (606 males, 768 females) ranging from 72 to 112 mm were examined. Females outnumbered males in majority of the months (Table 1) while the reverse was true in January, June and October 1980; April, September and October 1981 and January, September and November 1982. In the annual total, females outnumbered males in all years.

At 5% probability level, the ratios are not significantly different from 1 : 1 in all months except February 1980, May and December1981 and July 1982 (Table 1). The test of variance for homogeneity of sex ratio (Table 2) reveals that the X^2 values are significant at 5% in 1980 and 1981, but in 1982 it is not significant. It may be noted that data were available only for 9 months in 1982. It was felt that the non-uniform nature of sex ratio in 1980 and 1981 could be due to greater predominance of females in one or two months as mentioned above. When the test of variance for homogeneity was applied after eliminating the data of those months (February 1980, May and December 1981) where the sex ratio was significantly different from 1 : 1, the chi-square value did not show significant difference.

TABLE 1. *Monthly sex ratio in* S. insidiator

	1980		1981		1982	
	♂	♀	♂	♀	♂	♀
January ..	28	24	24	30	12	10
February ..	7*	28*	43	55	7	14
March ..	24	24	10	12	—	—
April ..	7	13	23	20	16	16
May ..	27	44	5*	24*	—	—
June ..	10	5	12	17	—	—
July ..	8	17	18	21	28*	49*
August ..	13	13	9	11	13	20
September ..	32	41	10	7	7	6
October ..	34	20	7	6	7	10
November ..	46	46	44	44	20	17
December ..	7	16	17*	45*	31	43
Pooled ..	243	291	222	292	141	185

* Sex ratio significantly different from 1: 1 at 5%.

TABLE 2. *Test of variance for homogeneity of sex ratio in* S. insidiator

Year	Df	χ^2
1980 ..	11	27.83*
1981 ..	11	20.13*
1982 ..	8	6.23
1980-1982 Pooled ..	32	55.13*

* Significant at 5%.

The data on sex ratio in different length groups (Table 3) showed predominance of males upto 87 mm group and of females from and above 92 mm. The mean lengths of fishes in the sexes over the period did not show marked differences.

ESTIMATION OF GROWTH PARAMETERS

The monthly modal lengths during 1979-83 are plotted in Fig. 3. While drawing the

TABLE 3. *Sex ratio in different length groups of S. insidiator**

Length groups(mm)	N	♂	♀
72	4	50.0	50.0
77	19	57.9	42.1
82	45	66.7	33.3
87	173	58.4	41.6
92	347	46.1	53.9
97	255	36.5	63.5
102	150	35.3	64.7
107	47	27.6	72.4
112	8	25.0	75.0
Pooled	1048	44.3	55.6
Mean length (mm)	—	92.5	95.0

* Data of 1980 and 1981 only were considered

growth curves, the points that were likely to fall in a curve were joined first and then the curve was extended further both upwards and downwards. The curves thus drawn are parallel to each other. The lengths attained at intervals of six months were read off these growth curves for purpose of estimating the growth parameters : the smallest modal length in a curve was taken as the initial length (Lt) and from there, the curve was marked at an interval of six months (irrespective of occurrence of a modal point at that point) and the length at that point was taken as length attained after six months (L_t+1) and so on for estimation of $L\infty$ and K (Fig. 4). The smallest modal length in the growth curves was 47 mm in July 1982 (Curve *K*, Fig. 3) whose age was read off as 6 months from the origin of the curve.

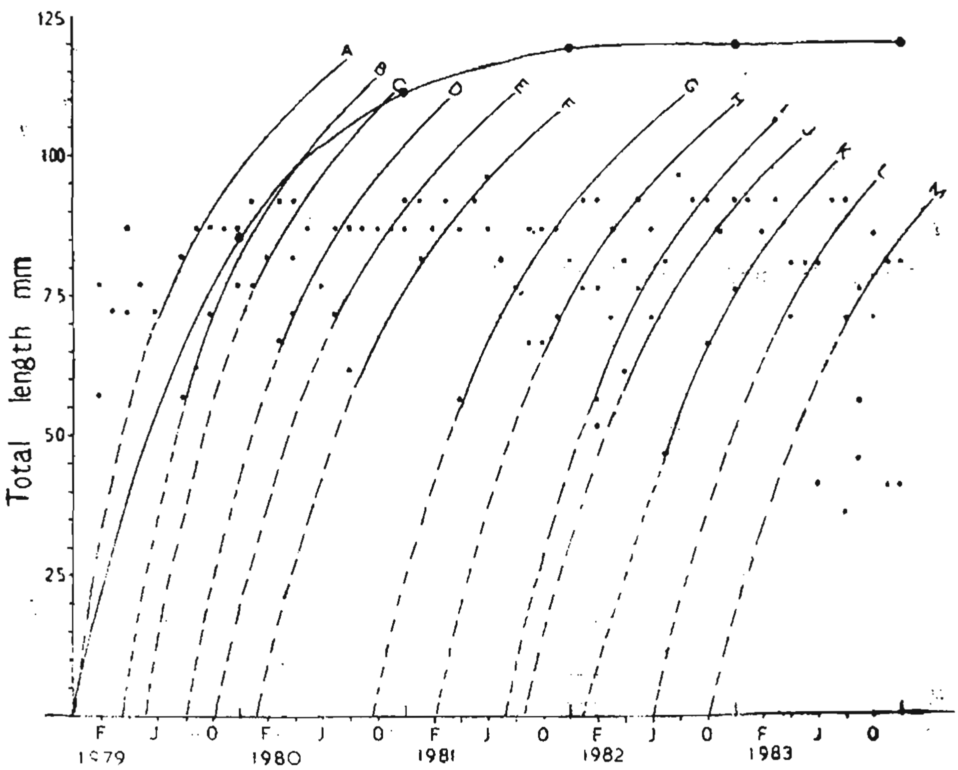

FIG. 3. Monthly modal lengths and growth curves drawn through them in *S. insidiator* (Integrated method of Pauly 1980 a). The von Bertalanffy growth curve is also shown.

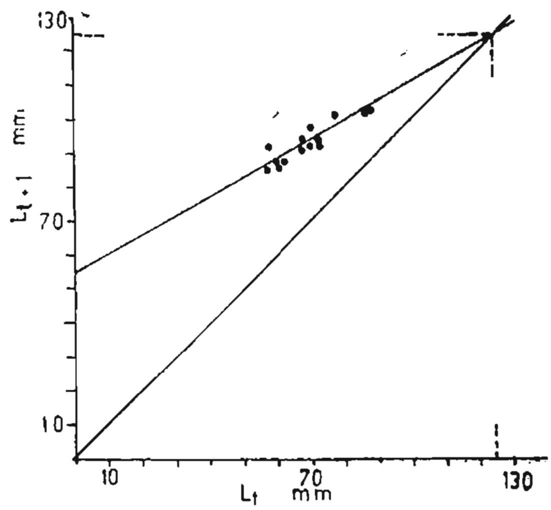

Fig. 4. Ford-Walford plot of growth in length obtained by integrated method in *S. insidiator*.

Taking this length, the length, at successive half years were estimated using the Ford-Walford relation, for purpose of estimating t_o. The estimated values of parameters are shown in Table 4.

TABLE 4. *Parameters of growth and mean lengths (mm) at ages in* S. insidiator

Particulars		Growth in length	Growth in weight
L_∞ (mm)/W_∞ (g)	..	123	3.07764*
K (per year)	..	1.20	1.11
t_o (year)	..	—0.01	—0.07
Length at 1 year	..	86	—
Length at 2 years	..	112	—
Length at 3 years	..	120	—

* $\sqrt[3]{W_\infty}$

Since the maximum length recorded during the study period was 117 mm, the maximum age of the species in the fishing ground works out to 2.5 years.

Estimation of parameters of growth in weight : The estimated values of parameters are given in Table 4. The cube root value of W_∞ is 3.07764 ; this value was used in yield studies following Paulik and Gales (1964) and Clark (1978).

Length-Weight Relationship

Data from 253 males ranging from 57 to 109 mm and from 2 to 19 g and 264 females ranging from 62 to 114 mm and from 3 to 22 g were used for this study. The relationship for fishes in the sexes separately are :

Males : Log $W = -5.62499 + 3.37829$ Log L ($r = 0.96$)

Females : Log $W = -5.86469 + 3.50201$ log L ($r = 0.89$)

The values of slope and elevation of males and females when tested by analysis of covariance (Table 5) did not show significant difference at 5% level. The data of both sexes were, hence, pooled and the relationship for the species from Kakinada was calculated as :

log $W = -5.73713 + 3.43654$ log L ($r = 0.93$).

The value of the regression coefficient was tested against the theoretical value of 3 by the t-test and it was found that it differed significantly. Hence growth in weight with length in *S. insidiator* is not isometric.

Mortality Rates

Total mortality rate : A plot of log e ($N/\Delta t$) against 't' for different years is shown in Fig. 5. Only those points which represented the straight descending part of the catch curve were considered for estimation of Z. Similarly in the cumulative catch curve method (Fig. 6), those points which represented a straight line were used. The departure from linearity at either end in the above graphs (Fig. 5 and 6) is likely to be due to non-representativeness of smaller individuals in the catches, resulting from incomplete recruitment of fish in these

TABLE 5. *Analysis of Covariance to test the significance of difference between regression lines of sexes in the length-weight relationship of* S. insidiator

Source of variation	Df	Deviation from regression Sum of squares	Mean squares
Due to regression within sexes ..	513	2.024169	0.003946
Due to difference between regression coefficients	1	0.003972	0.003972
Residual due to regression pooled within	514	2.028141	0.003946
Difference between adjustmented means	1	0.000801	0.000801
Total: ..	515	2.028942	

Comparison of slopes : F=1.0066, df 1,513 : not significant.
Comparison of elevations : F=0.2029, df 1,514 ; not significant.

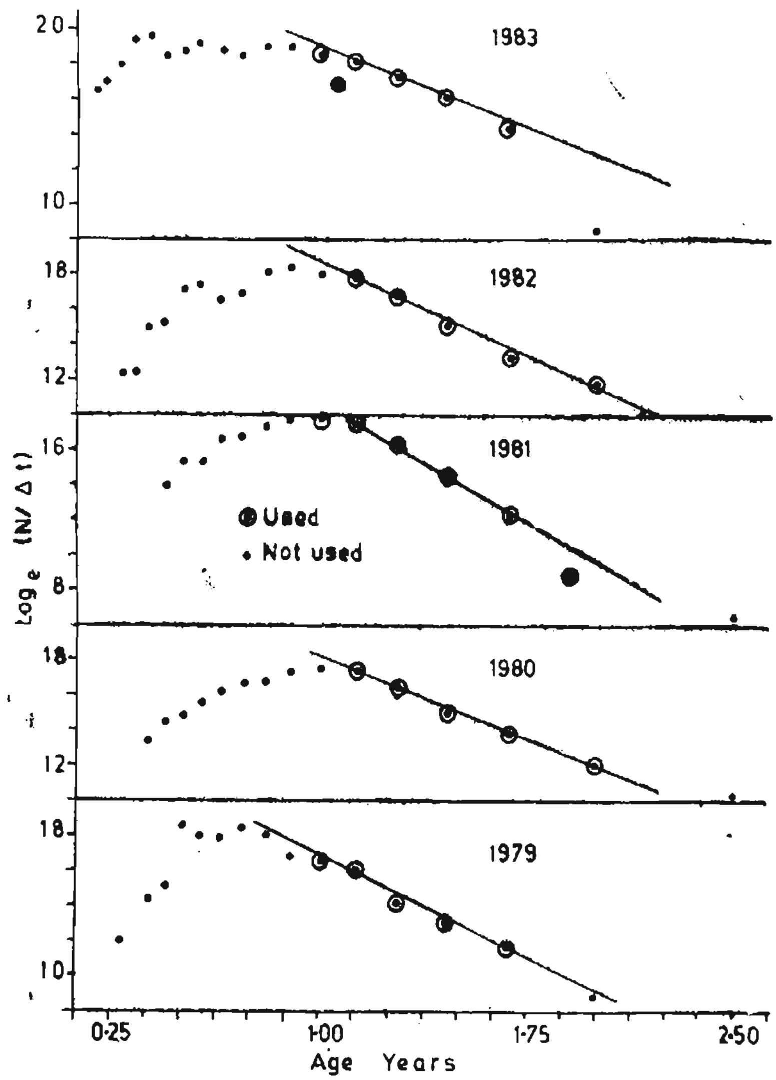

FIG. 5. Estimation of Z by length-converted catch curve method of Pauly (1982) in S. *insidiator*.

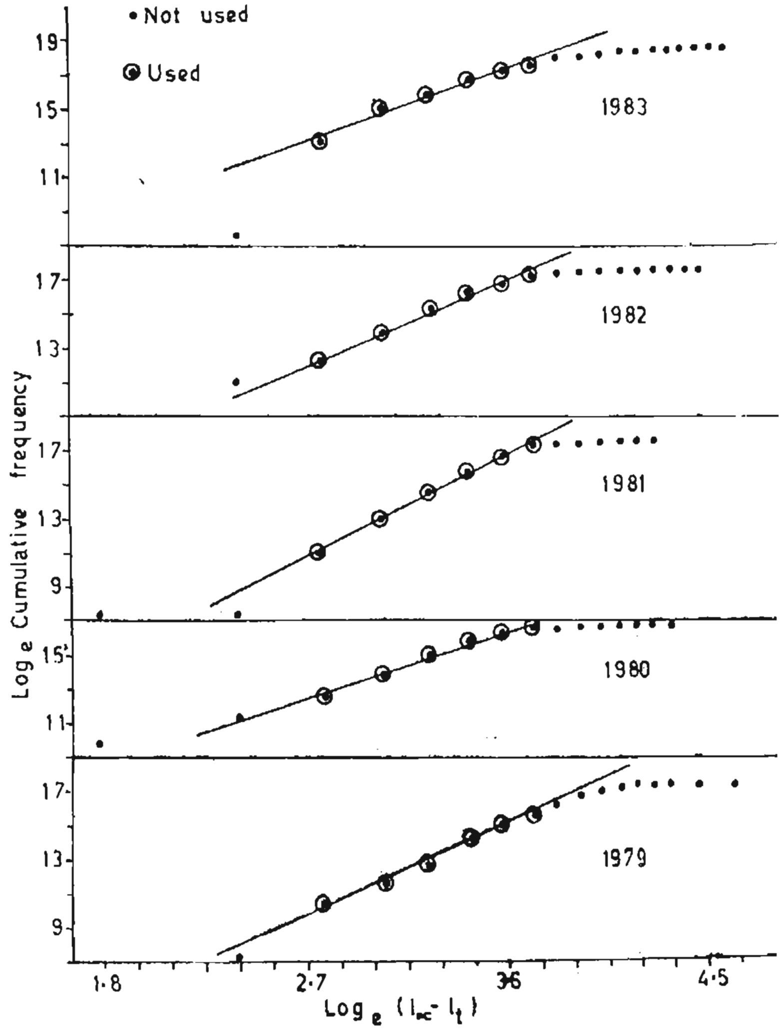

FIG. 6. Estimation of Z by cumulative catch curve method in *S. insidiator*.

lengths and of the larger individuals due to the variations in growth rates (Jones, 1981) or due to the possible over-estimation of age of these individuals (Pauly, 1983). The estimated values of Z by different methods (Table 6) show that the values obtained by Pauly's method for each year are the highest and those obtained by Beverton-Holt method are the lowest. The average (Z=6.1) of all these values for all years was taken as the total mortality rate during the period (Table 6).

Natural mortality rate : The estimates obtained by different methods are shown in Table 7. It may be noted that except the value by Sekharan's method, all the values are more or less the same.

SELECTION PATTERN

The selection pattern (Fig. 7) shows that the mesh sizes used during different years are not much different ; the 50% selection length

TABLE 6. *Estimated values of Z in* S. insidiator *by different methods in different years*

Year		Pauly's method	Cumulative catch curve method	Ssentongo-Larkin method	Beverton-Holt method	Average
1979	..	8.0329	7.0856	6.6093	6.0274	6.9388
1980	..	6.1908	5.1765	4.5160	3.9425	4.9565
1981	..	9.1357	8.0029	5.7397	5.1606	7.0097
1982	..	7.1845	6.4493	5.4458	4.8678	5.9869
1983	..	6.2143	5.8505	5.5254	4.9471	5.6343
Average	..	7.3516	6.5130	5.5672	4.9891	6.1052

TABLE 7. *Estimation of M Following different methods and estimation of F, U, Y/U, Y/F, Yw/R, B/R and R in* S. insidiator (Z=6.1 and annual average catch : 331 t)

Method of estimation of M		M	F	U	Y/U (t)	Y/F (t)	YW/R (g)	B/R (g)	Recruitment (Nos)
Sekharan, 1976	..	1.8	4.3	0.70	473	77	0.19671	0.045746	1682704499
Alagaraja, 1984	..	2.3	3.8	0.62	534	87	0.124975	0.032889	2648453890
Pauly, 1983	..	2.4	3.7	0.61	543	89	0.113915	0.030788	2905673370
Pauly, 1980 b	..	2.6	3.5	0.57	581	95	0.094432	0.026981	3505161135

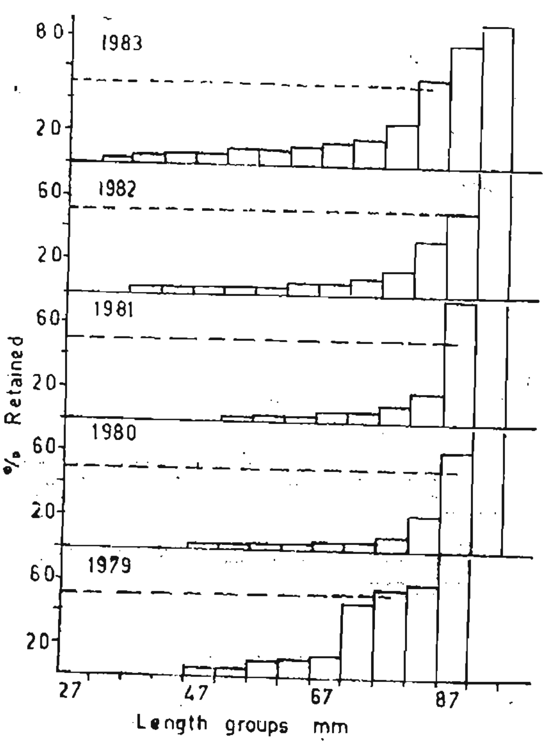

FIG. 7. Selection pattern in *S. insidiator*.

ranges from 77 to 87 mm in different years and their average works out to 84 mm. Hence the lower limit of this length class (80-84 mm) was taken as length at first capture (L_c) whose estimated age (t_c) is 0.86 year.

CATCHES OF SILVERBELLIES

The estimated catches of silverbellies and *S. insidiator* during the period 1979-83 (Table 8) show continuous increase in successive years and an annual average of 904 tonnes of silverbellies was landed at Kakinada, with 331 tonnes of *S. insidiator*, contributing to about 37% of silverbelly landings.

EXPLOITATION RATE AND STOCK SIZE

Taking the Z value as 6.1 and different values of M, the exploitation rate (U) was estimated as ranging from 0.57 to 0.70 (Table 7). The corresponding values of total annual stock (Y/U) and average standing crop (Y/F) are also shown in Table 7.

TABLE : 8 *Estimated effort (Trawling hours) and catch (tonnes) of Silverbellies in different years*

Year		Effort	Total Silverbelly catch	% of *S. insidiator* in silverbelly catch
1979	..	396864	535	34.3
1980	..	322655	569	29.5
1981	..	384436	605	41.7
1982	..	459599	969	33.4
1983	..	328461	1843	39.3
Average	..	378403	904	36.6

Estimation of Yield Per Recruit

Beverton and Holt method : The value of $W\infty$ corresponding to $L\infty$ was calculated as 28 g on the basis of the length-weight relationship ; the value of t_r was estimated as 0.2 taking 27 mm (the smallest length in the catch) as the length at recruitment. As stated earlier, 80 mm was taken as length at first capture, whose estimated age (t_c) is 0.87 year.

The yield in weight per recruit taking all possible values of M as given in Table 7 and 3 values of t_c at 0.69, 0.87 and 1.09 corresponding to L_c values of 70, 80 and 90 mm respectively (Fig. 8 a-c) against F, show that yield

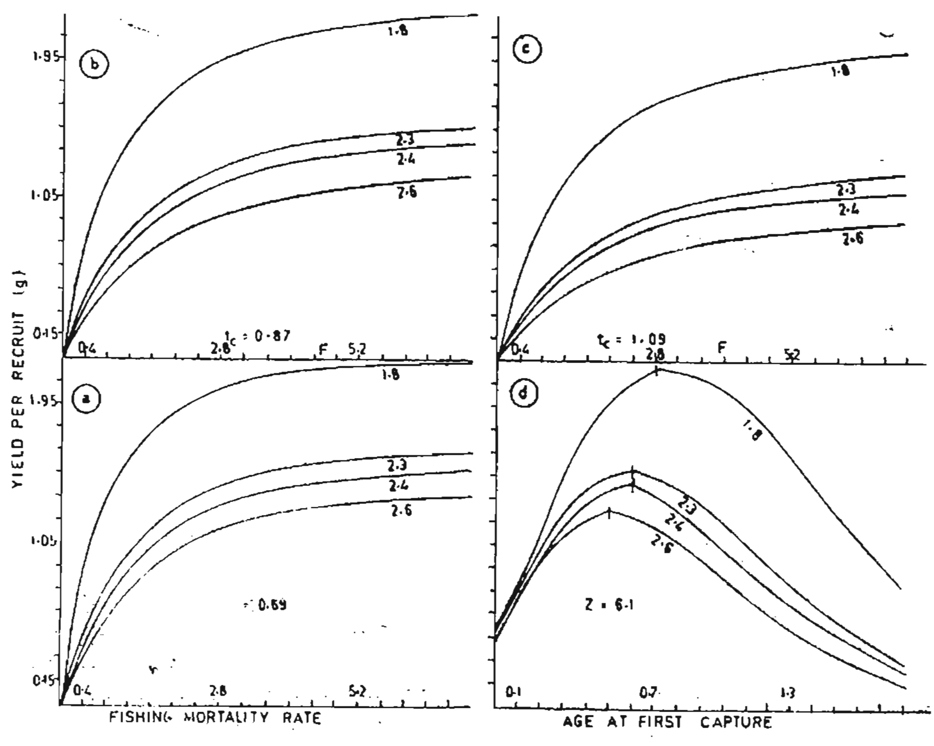

FIG. 8 a-c. Yield per recruit as a function of fishing mortality rate in *S. insidiator* under different values of t_c and M (Numerals refer to different values of M) and d. Yield per recruit as a function of age at first capture in *S. insidiator* with Z at 6.1 and different values of M (Numerals refer to M values).

per recruit increases with increased F without reaching a maximum ; the curves also show that yield per recruit increases by decreasing the age at first capture.

The yield per recruit as a function of age at first capture (Fig. 8 d) with the present value of Z at 6.1 and different values of M shows that maximum yield per recruit can be obtained at t_c=0.5 if M is 2.6 ; at 0.6 if M is 2.3 or 2.4 and at 0.7 if M is 1.8. The observations, thus, suggest that the cod end mesh size has to be reduced because the present estimated value of t_c=0.87.

Paulik and Gales method : The curves of yield per recruit against F (Fig. 9) taking the present value of t_c at 0.76, corresponding to

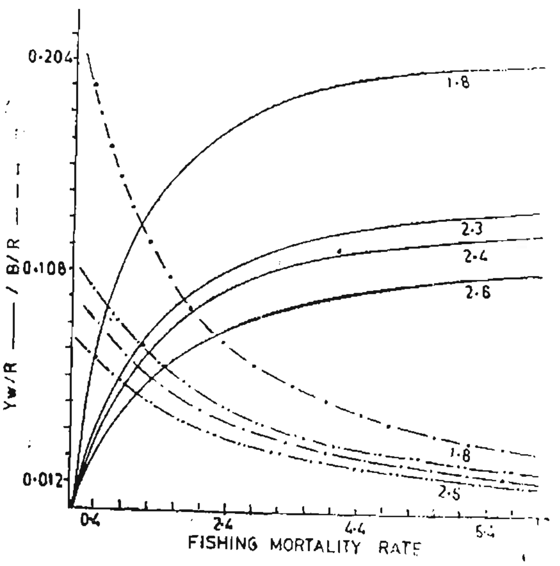

Fig. 9. Yield per recruit and Biomass per recruit as functions of fishing mortality in *S. insidiator* following Paulik and Gales method. (Numerals refer to M. values.)

the cube root of weight of fishes of the present L_c value of 80 mm, show trends comparable to those obtained by assuming isometric growth (Fig. 8 b) though the absolute values of yield per recruit are different.

Estimation of Recruitment and Yield

Recruitment and yield were estimated taking YW/R values obtained by Paulik and Gales (1964) method.

At the present values of t_c and Z and taking different values of M the estimates of yield per recruit, biomass per recruit and recruitment were obtained (Table 7). The expected yield (Fig. 10) at different levels of fishing mortality with the present cod end mesh size

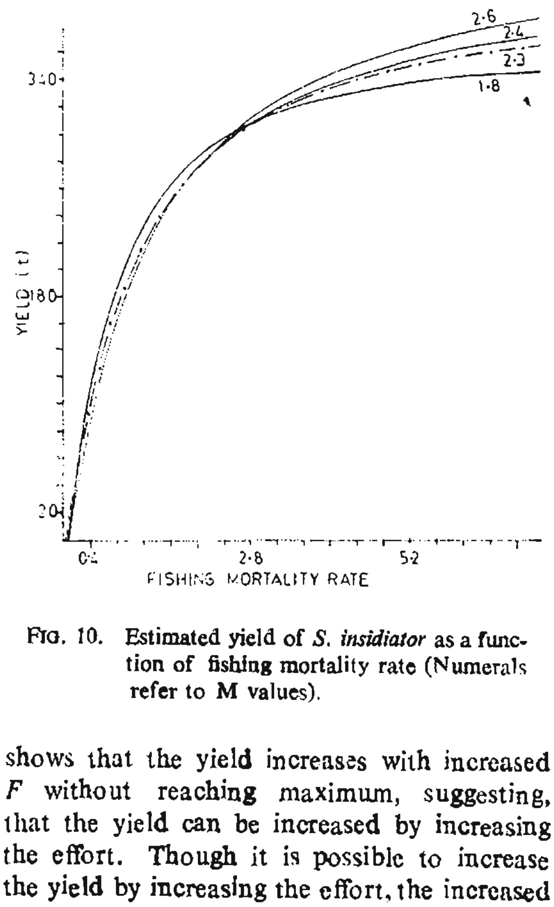

Fig. 10. Estimated yield of *S. insidiator* as a function of fishing mortality rate (Numerals refer to M values).

shows that the yield increases with increased F without reaching maximum, suggesting, that the yield can be increased by increasing the effort. Though it is possible to increase the yield by increasing the effort, the increased yield will not be remunerative because, for example, when M=2.6, a yield of 115% of the present can be obtained by expending an effort equivalent to 200% of the present (*i.e.*) only 15% increase in catch with 100% increase in effort (Fig. 11). On the other hand, if the effort is 97% of the present (*i.e.* if decreased by 3%) the yield will be 99% of the present (*i.e.* a decline of 1% only in the catch). For economic reasons, therefore, the effort should not be increased.

DISCUSSION

The study on spawning shows that *S. insidiator* spawns throughout the year with a possible peak during January-March. Pillai (1972) examined the ova-diameter frequency

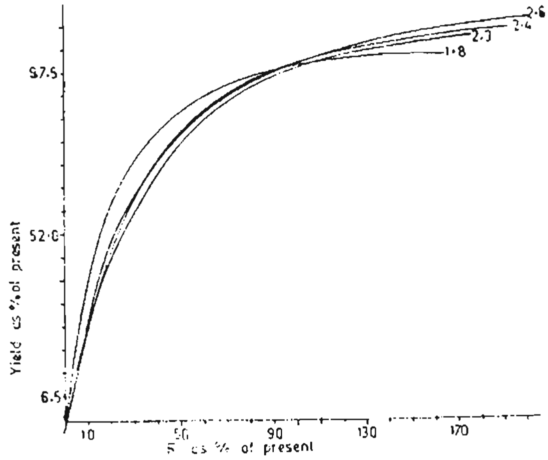

FIG. 11. Yield of *S. insidiator* as per cent of present against F which is also as per cent of present (Numerals refer to M values).

distribution from ovaries of mature adults of this species from Tuticorin during April-June 1970 and stated that the species spawns more than once in a year and that the spawning season is protracted. According to James and Badrudeen (1975), *Leiognathus brevirostris* spawns throughout the year in the Palk Bay and Gulf of Mannar near Mandapam with peaks during May-June and October-November. It was tentatively concluded that *L. dussumieri* in the sea off Mandapam spawns during April-May and November-December (James and Badrudeen, 1982) According to Murty (1983), *L. bindus* spawns almost throughout the year in the sea off Kakinada. Thus, the Indian silverbellies spawn round the year with one or two peaks.

Though the predominance of females in certain months and in the larger length groups may suggest a faster growth rate in females (Qasim, 1966), the growth rate in both the sexes may be taken as the same because : the departure in the sex ratio from 1 : 1 is restricted only to one or two months in different years (Table 1) and both sexes are represented in all length-groups (Table 3). It appears, therefore, that the estimated length at first maturity for females (90 mm) can be taken for the species as a whole. On the basis of the growth parameters, the age at first maturity for the species becomes 1.09 years.

The predominance of females above the length at first maturity suggests a possibility of greater natural mortality rate in males after attaining first maturity. Supporting evidence, however, is not available to corroborate this view.

The estimated values of parameters of growth in length of *S. insidiator* in the present study appear to be realistic when compared to those of other silverbelly species (Table 9) from different localities, except *L. equulus* which is the largest known silverbelly species (maximum recorded length from India 242 mm, James, 1973) and *L. jonesi*. It appears that Venkataraman *et al.* (1982) underestimated the growth rate of *L. jonesi* because the values of M and K at 2.28 and 0.528 respectively lead to an M/K value of 4.3 which is very much beyond the range (1-2.5) known in fishes (Beverton and Holt, 1959); similarly in the case of *L. bindus* from Calicut the value of $L\infty$ obtained (122 mm, Pauly and David, 1981), appears to be an underestimate since the maximum known length of this species from India is 155 mm (CMFRI, 1977) and also since it is known that the fish 'will not grow' beyond $L\infty$ (Gulland, 1983).

An examination of values of Z estimated by different methods reveals that the value obtained by Pauly's method is the highest followed by Cumulative catch curve, Ssentongo-Larkin and Beverton-Holt methods (Table 6). According to Pauly (1983) the equation of Ssentongo and Larkin 'Produces estimates of Z which are higher than those obtained using equation' of Beverton and Holt, and Per Sparre (*in litt.* to Dr. Pauly, 1983) suggests that Ssentongo-Larkin equation is 'biassed upward'. There is, thus, an indication that the Beverton-Holt equation is *not* a biassed one. There is no indication in the literature whether the other two methods (Pauly's and Jones and van Zalinge's) are not biassed and presently it is not possible to explain the disparity between the Z values obtained; hence it was preferred to consider the average value.

Though the value of Z at 6.1, considered in the present work, appears to be very high, it could be a reasonable estimate because, the bulk of silverbellies (including *S. insidiator*) occur in shallow waters (Pauly, 1977) where intensive trawling takes place for prawns, thus resulting in high fishing mortality. Further, since the maximum length and life-span are observed to be small, mortality due to predation and other natural causes could also be very high, which too would have contributed to a greater Z.

Since the trawl fishery is a multispecies one, apportioning of fishing effort with reference to a particular species is not possible (Pauly, 1983) and apparently this resulted in the lack of good correlation between effort and Z. The M values obtained by different methods are close to each other except the one obtained by Sekharan's method (Table 7); the M/K value in all the four cases is within the known range in fishes. In this connection it is worthwhile to quote Cushing (1981): '.... a precise separation of fishing and natural mortality remains inaccessible, and yet is one of the central problems of fisheries research.'

TABLE: 9 *Parametres of von Bertalanffy growth formula of different species of silverbellies*

Species	Locality	Source	$L\infty$ mm	K per year	t_0 year
S. insidiator	Kakinada	Present work	123.0	1.20	—0.01
L. bindus	Calicut	Pauly & David, 1981	122.0	1.30	—
L. jonesi	Mandapam	Venkataraman *et al.*, 1982	161.2	0.53	0.111
L. splendens	Philippines	Pauly, 1983	143.0	1.04	—
L. equulus	Madagascar	Pauly, 1983	212.0	1.75	—

The yield per recruit analysis at the three values of t_c against F (Fig. 8 a-c and 10) and the yield per recruit against t_c (Fig. 8 d) show that maximum yield can be obtained by increasing F greatly, but with a maximum to of 0.7 only, thus indicating that t_c has to be reduced from the present 0.87 (thus reduction in mesh size) and that F can be increased to get higher yield. Decreasing the mesh size results in increased production of smaller fishes. Since the adult size of the fish under study is itself a small one, the increase in yield so obtained will not be of consequence to the industry. Further, the present age at first capture is close to the age at first maturity and it is not desirable to have the age first capture less than the age at first maturity, as otherwise the fishery takes away prospective spawners and increased effort in such a situation can result in the collapse of the fishery due to recruitment overfishing (Ursin, 1984) at certain higher effort level. Since at higher values of t_c also, the yield did not show a fall with increase in *F*, it is desirable to have the current t_c retained, if not increased a little, to avoid possible fall in the stock size and to get increased yield of *S. insidiator* by increasing the effort. The analysis has also shown that though theoretically it is possible to increase yield by increasing effort increased effort will not be remunerative (Fig. 11).

Since the trawl fishery is a multispecies one, regulation of effort including mesh regulation has to take into account other species taken by the fishery, as otherwise any change in the number of units or mesh size is likely to result in the loss of a particular resource for the fishery or in overexploitation of another resource. Still, such a study as the present one on the yield of any one component species is not an exercise in futility, for it must be stressed, in addition to enabling an understanding of the state of a particular single species resource in a multispecies fishery, such studies when conducted an all or most of the dominant species, will help in arriving at more meaningful decisions for the management of a multispecies fishery.

References

Alagaraja, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian J. Fish.*, **31** : 177-195.

Annam, V. P. and S. K. Dharmaraja 1982. Trends in the catch of silverbellies by mechanised boats in Tamil Nadu during 1971-75. *Indian J. Fish.*, **28** : 86-95 (1981).

Arora, H. L. 1951. A contribution to the biology of the silverbelly *Leiognathus splendens* (Cuv.). *Proc. Indo-Pacif. Fish. Coun.* 3rd Meeting, Madras, Sec. III : 75-80.

Balan, V. 1967. Biology of the silverbelly *Leiognathus bindus* (Val.) of the Calicut Coast. *Indian J. Fish.*, **10** : 118-134 (1963).

Beverton, R. J. H. and S. J. Holt 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. *Rap. p-v. Reun. Cons. Perm. int. Explor. Mer.*, **140** (1) : 67-83.

——— and ——— 1957. On the Dynamics of Exploited Fish Populations. *Fishery Invest., London*, **19** : (2) 533 pp.

——— and ——— 1959. A review of life-spans and mortality rates of fish in nature and their relation to growth and other physiological characteristics. Ciba Foundation Colloquia on ageing. *In* : G. E. W. Wolsenholmy and M. O. Connor (Ed.) *The life-span of animals*, **5** : 142-177.

Clark, W. G. 1978. Dynamic pool models. *In* : Models for Fish stock assessment. *FAO Fish. Circ.* **701** : 17-30.

CMFRI 1977. *Annual report.* Central Marine Fisheries Research Institute, Cochin. 148 pp.

——— 1981. Commercial trawl fisheries off Kakinada during 1969-1978. *Mar. Fish. Infor. Ser.* T. & E. Ser., **31** : 1-6.

Cushing, D. H. 1981. *Fisheries Biology : A study in population Dynamics.* Second Edition. The University of Wisconsin Press, 295 pp.

Ford, E. 1933. An account of herring investigations conducted at Plymouth during the years 1924-1933. *J. Mar. Biol. Ass. U.K.*, **19** : 305-384.

Ganapathi, P. N. and V. S. R. Murthy 1954. Salinity and temperature variations of the surface waters off Visakhapatnam Coast. *Andhra Univ. Mem. Oceanogr.*, **1** : 125-142.

Gulland, J. A. 1969. Manual of Methods for fish stock assessment. Part I. Fish Population analysis. *FAO Man. Fish. Sci.*, **4** : 154 pp.

——— 1983. *Fish stock assessment : A manual of basic methods.* FAO/Wiley Series on food and Agriculture, **1** : 223 pp.

James, P. S. B. R. 1973. The fishery potential of silverbellies. *Proc. Symp. Living. Resources of the seas around India*, Spl. Pub. Central Marine Fisheries Research Institute, Cochin. pp. 493-444.

——— and M. Badrudeen 1975. Biology and fishery of *Leiognathus brevirostris* (Val.) from Palk Bay and Gulf of Mannar. *Indian J. Mar. Sci.*, **4** : 50-59.

——— AND ——— 1982. Biology and fishery of silverbelly *Leiognathus dussumieri* (Valenciennes) from Gulf of Mannar. *Indian J. Fish.*, **28**: 154-182 (1981).

JONES, R. 1981. The use of length composition data in fish stock assessment (with notes on VPA and Cohort analysis). *FAO Fish. Circ.*, **734**: 60 pp.

——— AND P. N. VAN ZALINGE. 1981. Estimation of mortality rate and population size of shrimps in Kuwait waters. *Kuwait Bull. Mar. Sci.*, **2**: 273-288.

LA FOND, E. C. 1958. Seasonal cycle of sea surface temperature and salinity along the east coast of India. *Andhra Univ. Mem. Oceanogr.*, **2**: 12-21.

LE CREN, E. D. 1951. Length-weight relationship and seasonal cycle in gonad weight and condition of the perch (*Perca fluviatilis*). *J. Anim. Ecol.*, **20**: 201-219.

*MANZER, J. I. AND F. H. C. TAYLOR 1947. The rate of growth in lemon sole in the Strait of Georgia. *Prog. Rep. Fish Res. Board Pac. Coast Stn.*, **72**: 24-27.

MURTY, V. SRIRAMACHANDRA 1983. Observations on some aspects of biology of the silverbelly *Leiognathus bindus* (Valenciennes) from Kakinada. *Indian J. Fish.* **30**: 61-68.

NAVALUNA, N. A. 1982. Morphometrics, biology and population dynamics of the Croaker fish *Otolithes ruber*. *In*: Pauly D. and A. N. Mines (Ed.) *Small scale fisheries of San Miguel Bay, Philippines: biology and stock assessment. ICLARM Technical Reports*, **7**: 124 pp.

*PAULIK, G. J. AND L. E. GALES 1964. Allometric growth and Beverton-Holt yield equation. *Trans. Amer. Fish. Soc.*, **93**: 369-381.

PAULY, D. 1977. The Leiognathidae (Teleostei): their species, stocks and fisheries in Indonesia, with notes on the biology of *Leiognathus splendens* (Cuvier). *Marine Research in Indonesia*, **19**: 73-93.

——— 1980 a. A selection of simple methods for the assessment of tropical fish stocks. *FAO Fish. Circ.*, **729**: 54 pp.

——— 1980 b. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. cons. int. Explor. Mer.*, **39**: 175-192.

* Not referred to in original.

——— 1982. Studying single-species dynamics in a tropical multispecies context. *In*: D. Pauly and G. I. Murphy (Ed.) *Theory and management of tropical fisheries*. ICLARM conference Proc. **9**, 360 pp. ICLARM, Manila; Philippines and CSIRO, Cronulla, Australia.

——— 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. Pap.*, **234**: 52 pp.

——— AND N. DAVID 1981. ELEFAN I, a BASIC program for the objective extraction of growth parameters from length frequency data. *Meeresforsch.*, **28**: 205-211.

PILLAI, P. K., MAHADEVAN 1972. Fecundity and spawning habits of some silverbellies. *Indian J. Fish.* **19**: 196-199.

QASIM, S. Z. 1966. Sex ratio in Fish populations as a function of sexual difference in growth rate. *Curr. Sci.*, **35**: 140-142.

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Bd. Canada*, **191**: 382 pp.

SEKHARAN, K. V. 1976. Estimates of stocks of oil sardine and mackerel in the fishing grounds off the west coast of India. *Indian J. Fish.*, **21**: 177-182 (1974).

SNEDECOR, G. W. AND W. G. COCHRAN 1967. *Statistical Methods.* Sixth Edition, Oxford and IBH Publishing Co., New Delhi, 593 pp.

SSENTONGO, G. W. AND P. A. LARKIN 1973. Some simple methods of estimating mortality rates of exploited fish populations. *J. Fish. Res. Bd. Canada*, **30**: 695-698.

VENKATARAMAN, G. AND M. BADRUDEEN 1974. On the diurnal variation in the catches of silverbellies in Palk Bay. *Indian J. Fish.*, **21**: 254-265.

———, ——— AND R. THIAGARAJAN 1982. Population dynamics of silverbelly *Leiognathus jonesi* in Palk Bay. *Ibid.*, **28**: 65-86 (1981).

URSIN, E. 1984. The tropical, the temperate and the Arctic seas as media for fish production. *Dana*, **4**: 43-60.

WALFORD, L. A. 1946. A new graphic method of describing the growth of animals. *Biol. Bull. Woodshole*, **90**: 141-147.

C. CROAKERS

CONTRIBUTION 14

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OBSERVATIONS ON SOME ASPECTS OF BIOLOGY OF THE BLACK CROAKER *ATROBUCCA NIBE* (JORDAN AND THOMPSON) FROM KAKINADA

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ABSTRACT

Observations on some aspects of biology of *Atrobucca nibe* are made from Kakinada. The length-weight relationship is described by the equation log W = −5.524308 + 3.213476 log L. The fluctuations in relative condition factor appear to be associated with fluctuations in gonad cycle. Individuals release ova in two batches during the spawning season which extends from Febuary to July in the area. The length at first maturity is estimated at 145 mm. The sex ratio indicates predominance of males in most months and length groups.

INTRODUCTION

The fishes of the family Sciaenidae form fisheries of considerable magnitude along Indian coasts; off Kakinada (16.15'-17.10' N Lat. and 82.22'-35' E long), an estimated 603.1 tonnes of these fishes were landed by the trawlers during April 1968-December 1970 (Muthu et al 1975). The catches of these fishes have been increasing with increased intensity of trawl fishing and during 1976 alone, an estmated 873.1 tonnes of these fishes were landed (CMFRI, 1976) from this area. The fishery is a multispecies one and *Atrobucca nibe* supports a rich fishery at Kakinada.

Though there is considerable information on the biology of sciaenid fishes from different localities along the Indian coasts (Rao 1967, Annigeri 1967, Rao K. V. S. 1968, Kutty 1968, Devadoss 1972), there is practically no information on the biology of *A. nibe* from any where in the world except for the work of Matsui and Takai (1951) from Japanese waters. The present paper gives information on some aspects of biology of this species from the trawler catches landed at Kakinada during the years 1975-1977.

MATERIAL AND METHODS

The samples were obtained from the trawler landings at weekly intervals. In the laboratory, the constituent species were separated and data taken on each species. For biological studies, data on length, weight, sex, stages of maturation and relative fullness of the stomachs were taken. Always the data from fresh specimens only were taken. The length-weight relationship was calculated by the method of least squares using the formula $W = a L^n$ or $\log W = \log a + n \log L$ where W = weight in grams, L = length in mm, a = a constant and n = exponent. The relative condition factor (Kn) was calculated using the formula $Kn = W/\hat{W}$ (Le Cren 1951), where W = observed individual weight and $\hat{W}$ = weight calculated from the length-weight relationship for each length. The colour and general appearance of the gonads were noted in fresh condition and ova diameter measurements were taken from formalin-preserved ovaries. In taking the diameter measurements the procedure of Clark (1934) was followed. From each ovary about 400 ova were measured at a magnification where 1 md equals 0.014 mm. Spawning season is determined on the basis of the data on females only.

As *A. nibe* occurs in the catches seasonally, the biological data of corresponding months in different years were pooled for purpose of the present study.

Length-Weight relationship

The data of 125 females ranging from 122 to 235 mm length and from 14 to 136 g weight and 164 males ranging from 94 to 218 mm length and from 6 to 109 g weight, were used to calculate the length-weight relationship. The equations for both the sexes are:

Males: $\log W = -5.571216 + 3.234755 \log L$

Females: $\log W = -5.461329 + 3.185315 \text{ Log } L$

The regression coefficient of males and females were compared by analysis of covariance following Snedecor and Cochran (1967). The results (Table 1) show that there is no significant difference both in the slopes and in the elevations between sexes. Hence the data of sexes were pooled and a common relationship calculated (fig. 1) which can be expressed by the equation:

$\text{Log } W = -5.524308 + 3.213476 \log L.$

Relative condition factor

The values of relative condition factor calculated separately for each fish were added up and the mean for each month and for each length group obtained.

It is seen that Kn values in May, June and September are higher than the weighted average; whereas in other months the values are lower (fig. 2). It is also evident that the Kn value is minimum in March and maximum in September. As stated elsewhere in this paper (vide infra), the spawning season for *A. nibe* is February-July. The generally low values during January-April may perhaps be due to the peak activity of ripening of gonads and consequent spawning stress.

TABLE. 1. *Comparison of Regression lines of the length-weight relationship of* A. nibe.

	df	Σx^2	Σxy	Σy^2	*Reg coefficient*	*Deviation from regression df*	*s.s.*	*M.S.*
Within								
Females	124	0.294305	0.93745	3.20119	3.185315	123	0.215110	0.0017488
Males	163	0.478141	0.54667	5.38772	3.234755	162	0.384623	0.0023742
						285	0.5997733	0.0021043
Pooled (within)	287	0.772446	2.484123	8.58892	3.215918	286	0.600178	0.0020985
			difference between slopes			1	0.000445	0.000445
Between	1	0.068986	0.21979	0.70027				
Total	288	0.841432	2.70392	9.28919		287	0.600195	
			between adjusted means			1	0.000017	0.000017

Comparison of slopes: F = 4.728764; df = 285, 1; F at 5% = 254; not significant

Comparison of elevations: F = 123.441176; df = 286, 1; F at 5% = not significant

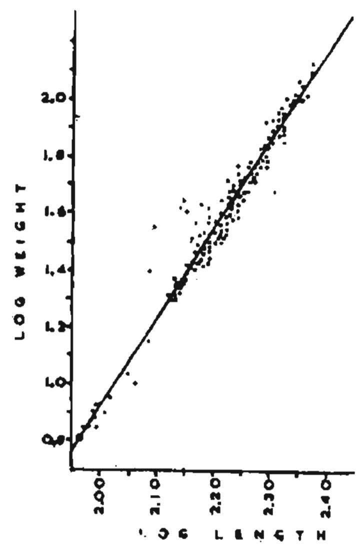

FIG. 1. Length-weight relationship in *A. nibe*

The Kn values in different lengths (fig. 3) show steep decline till 120-129 mm and thereafter show increase till 140-149 mm. *A. nibe* attains sexual maturity for the first time when the fish is 145 mm and the peak Kn value at this length may be associated with maturity. The Kn values show decline after 140-149 mm and reach another peak at 200-209 mm group. Extending the previous suggestion, it is possible that individuals of *A. nibe* attain maturity for the second time when they attain a length of 200-209 mm. A similar conclusion was drawn in the case of *Nemipterus japonicus* by Krishnamoorthi (1971).

Maturation and Spawning

The study is based on 357 specimens (224 males and 133 females) ranging from 994 to 235 mm in length.

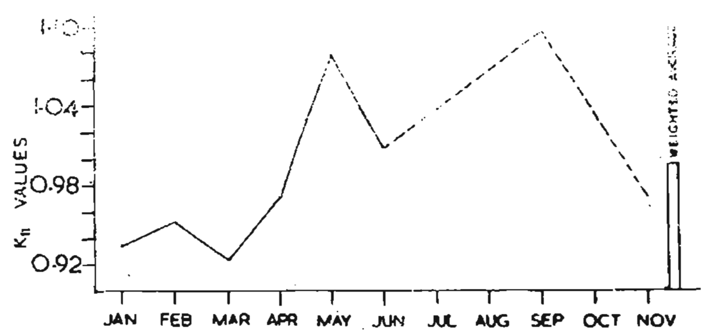

FIG. 2. Relative codition factor in different months in *A. nibe*.

Stage of maturation: The following stages of maturation are recognised in females of *A. nibe*:

Stage I (immature): Ovary thin, occupying less than half the length of body cavity; ova minute, irregularly-shaped, transparent, without yolk and with clearly visible nucleus. Ova range from 0.02 to 0.13 mm in diameter.

Stage II (maturing virgins): Ovary thin, occupying about half the length of body cavity, whitish; yolk deposition initiated in most ova which are translucent. Ova diameter ranges from 0.02 to 0.26 mm.

Stage III (maturing): Ovary yellow occupying about ¾ of the length of body cavity; ova visible to naked eye; majority of ova translucent, but opaque ova also are present. Maximum diameter at 0.60 mm.

Stage IV (ripening): Ovary pale yellow occupying almost the entire length of body cavity; ovarian wall thin, ova distinctly visible to naked eye; majority of ova are opaque with the maximum diameter at 0.73 mm.

Stage V (ripe): Ovary distended, occupying the entire length of body cavity; ova translucent with a distinct oil globule. Maximum ova diameter upto 1.03 mm. The diameter of the oil globule ranges from 0.19 to 0.26 mm.

Stage Va (Partially spawned): Same as stage V but the ovary does not occupy entire length of body cavity. Ripe, translucent ova with oil globule are present but majority are opaque.

Stage VI (spent): Not encountered in the samples.

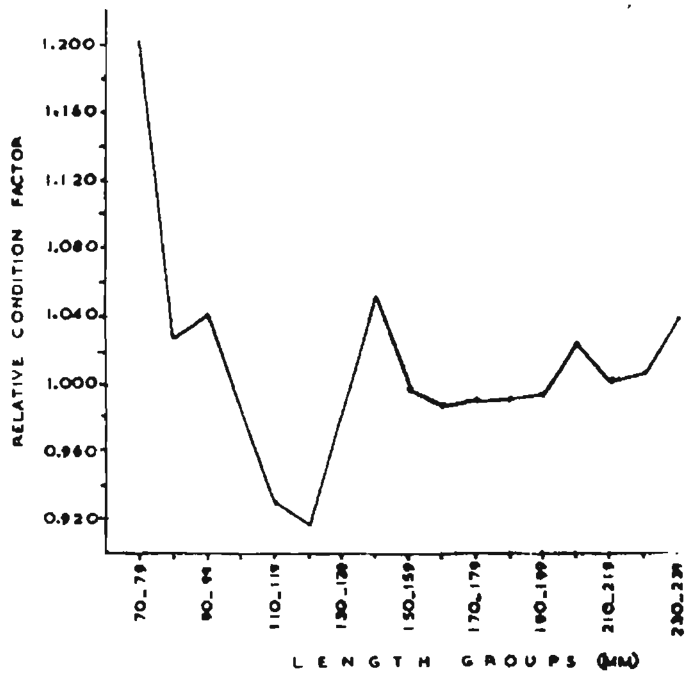

FIG. 3. Relative condition factor in different length goups in *A. nibe*

Males are recognised as immature, maturing and mature only, on the basis of macroscopic examination of fresh testes.

Length at first maturity: For the purpose of determining the minimum length at first maturity, maturing, ripening and ripe (stage III-V) females and mature males were taken into account. The percentage of these mature fish in relation to immature fish in different lengths are presented in figure 4. It may be seen that untill a lentgh of 200 mm, the percentage of mature individuals show progressive increase and that in specimens above this length, all are mature. On the basis of these observations, it may be concluded that *A. nibe* mature first at the length of 145 mm (50% mature).

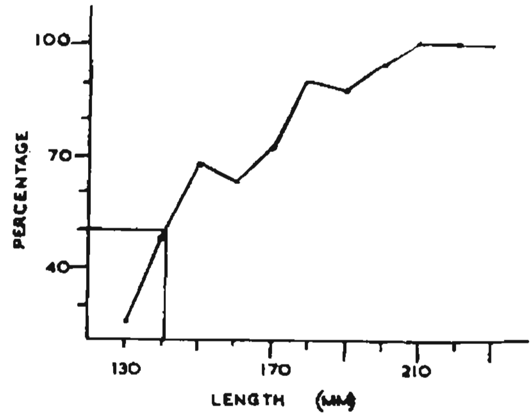

FIG. 4. Frequency distribution of mature individuals in different length groups of *A. nibe*.

Spawning: The ova diameter frequency distribution in ovaries of stages II, III, IV and V of maturation are presented in firure 5. It may be noted that there is only one mode at 5 md in the diameter frequency distribution in ovary of stage II of maturation. In stage III, a new mode appeared at 32 md. In stage IV, there are two modes in addition to the one at 11 md: one at 32 md and the other at 41 md in the dameter frequency distributian of mature ova. Obviously, certain fast growing ova have got separated from the batch of ova that formed a single mode at 32 md in stage III, by the time the ovary passed on to stage IV. In stage V, the ripe translucent ova got separated from other ova and formed a mode at 59 md. This mode must have resulted by the further

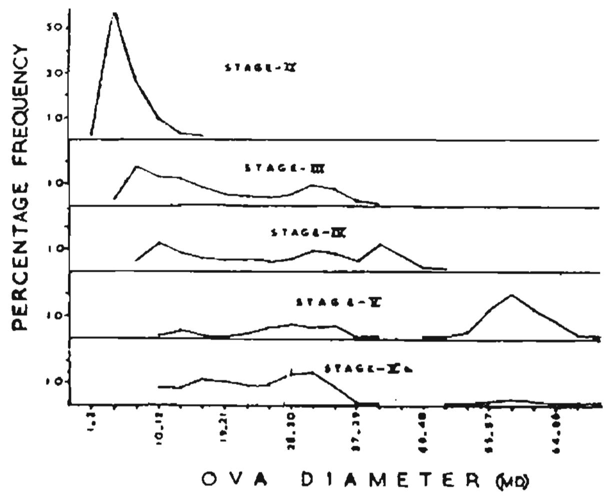

FIG. 5. Ova diameter frequency distribution in ovaries of diffeent stages of maturation in *A. nibe*.

growth of ova that formed a mode at 41 md in the dameter frequency distribution of ovary in stage IV. There is another mode at 29 md in the diameter frequency distribution of stage V ovary. In the partially spawned stage Va ovary, the ripe translucent ova form a minor mode at 59 md while the majority of the ova are opaque forming a mode at 32 md.

The fact that: 1) there are two closer modes in the diameter frequency distribution of mature ova in ovary of stage IV, 2) there are two modes one each in the mature and ripe ova in the ovary in stage V and 3) a partially-spawed stage occurs with a major mode at 32 md and a minor mode at 59 md indicate a possibility that each adult female of *A. nibe* spawns twice during a single but extended spawning season. The evidence is not strong enough to believe that there may be two distinct spawning seasons in a year because the batch of ova that are destined to be released in the second batch are already

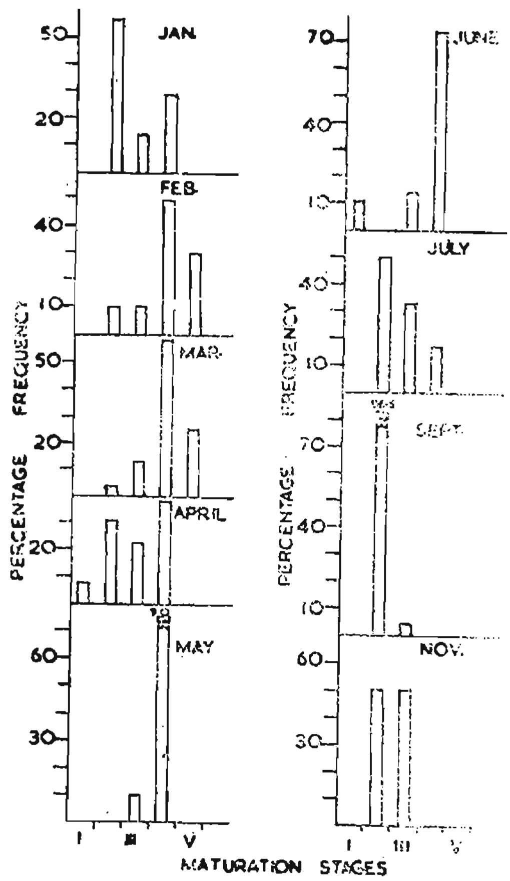

FIG. 6. Frequency distribution of different stages of maturation in different months in females of *A. nibe*

mature and opaque and have reached a modal diameter of 32 md in stage Va (fig. 5) and judging from the sequence of maturation process, it may not take more time for these ova to become ripe and be realeased. Similar conclusions were drawn in the case of ***Pseudosciaena diacanthus*** (Rao, KVS. 1968) and ***Johnius dussumieri*** (Devadoss, 1972). In other sciaenid species studied: ***Otolithus argenteus*** (Annigeri 1967), ***Pseudosciaena aneus*** and ***P. bleekeri*** (Rao, T. A. 1967) and ***Otolithus ruber*** (Devadoss 1972) the ripe ova are stated to be released in only one spawning act.

The frequency distribution of maturation stages in females in different months are presented in figure 6. It may be seen that felales with ripe ovaries (stages V nda Va) occur in the catches during February and March but fishes with ripening ovaries (stage IV) occur in several months from January to July. Further, the ripening females dominate others during February-June period.

The occurrence of running ripe females during February-March and the occurrence of ripening females in large numbers during February-June period indicate that *A. nibe* spawns during February-July period in th sea off Kakinada. It may be stated in this connection that according to Matsui and Takai (1951; as cited by Trewavas 1977), this species "probably" spawns "during the period April-June" in shallow waters between China and Japan. The spawning seasons of other sciaenid species from India are determined as June-August in *P. diacanthus* off Bombay (Rao, K. V. S. 1968), October-January in *O. argenteus* in the sea off Mangalore (Annigeri 1967), February-May in *P. bleekeri* and January-April in *J. carutta* off Waltair (Rao, T. A. 1967) and July-October in *O. ruber* and June-September in *J. dussumieri* of Bombay (Devadoss 1972).

TABLE 2. *Sex ratio in different months in* A. nibe.

Months	*No. of fish examined*	*Percentage of males*	*Percentage of females*
January	31	77.4	22.6
February	46	78.2	21.8
March	43	44.2	55.8
April	37	64.9	35.1
May	26	57.7	42.3
June	38	18.4	81.6
July	25	76.0	24.0
August	No data	——	——
September	68	57.4	42.6
October	No data	——	——
November	43	95.3	4.7
December	No data	——	——
Pooled	357	63.7	37.3

TABLE 3. *Sex ratio in different length groups of* A. nibe

Length groups (mm)	*No. of fish examined*	*Percentage of males*	*Percentage of females*
140-149	24	83.3	16.7
150-159	52	75.0	16.7
160-169	75	64.0	36.0
180-189	48	58.3	41.7
170-179	71	59.2	40.8
190-199	28	42.9	57.1
200-209	19	42.1	57.9
210-219	11	54.5	45.5
220-229	7	28.6	71.4

SEX RATIO

The sex ratio in different months and in different length groups are presented in Tables 2 and 3 respectively. It may be seen that males outnumber females in all months except March and June (Table 2). Similarly, males dominate females in all length group upto 189 mm. The preponderance of males in the catches in different months and in different length groups upto 189 mm and the general preponderance of females from and above 190 mm is noteworthy and may indicate differential growth rate of sexes as shown by Qasim (1966) in some freshwater fishes of India.

REFERENCES

ANNIGERI, G. G. 1967. Maturation of the intraovarian eggs and the spawning periodicities in a few fishes of Mangalore. *Indian J. Fish.*, 10: 23-32 (1963).

CLARK, F. N. 1934. Maturity of the California sardine (*Sardina caerulea*), *Calif. Div. Fish Game*, 42: 49 pp.

CMFRI. 1976. *Annual Report for* 1976. Central Marine Fisheries Research Institute, Cochin, 123 pp.

DEVADOSS, P. 1972. Maturity and spawning in *Otolithus ruber* (Schn.) and *Johnius dussumieri* (C. & V.). *Indian J. Fish.*, 16: 117-128 (1969).

KRISHNAMOORTHI, B. 1971. Biology of the threadfin Bream, *Nemipteus japonicus* (Bloch) *Indian J. Fish.*, 18: 1-21.

KUTTY, M. N. 1968. A note on the biology of the 'koth' *Otolithoides brunneus* (Day). *J. mar. biol. Ass. India*, 9: 197-198.

LE CREN, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*perca fluviatilis*). *J. Anim. Ecol.*, 20: 201-219.

MATSUI, J. AND T. TAKAI. 1951. Ecological studies on the black croaker, *Nibea nibe* (Jordan & Thompson). *Contr. Shimonoseki Coll. Fish.*, 1951: 65-89.

MUTHU, M. S., K. A. NARASIMHAM, G. S. RAO, Y. A. SASTRY AND P. RAMALINGAM. 1975. The commercial trawl fisheries off Kakinada during 1967-70. *Indian J. Fish.*, 22: 171-186.

QASIM, S. Z. 1966. Sex ratio in fish populations as a function of sexual difference in growth rate. *Curr. Sci.*, 35: 140-142.

RAO, K. V. S. 1968. Some aspects of biology of 'Ghol' *Pseudosciaena diacanthus* (Lacepade). *Indian J. Fish.*, 10: 413-459 (1963).

RAO, T. A. 1967. Maturity and spawning habits of some sciaenids in offshore waters at Visakhapatnam. *Indian J. Fish.*, 11: 121-126 (1964).

SNEDECOR, G. W. AND W. G. CODHRAN. 1967. *Statistical Methods.* Sixth Edition, Oxford and IBH publishing Co., New Delhi, 593 pp.

TREWAVAS, E. 1977. The sciaenid fishes (croakers ordrums) of the Indo-west-Pacific. *Trans. Zool. Soc. Lond.* 33: 253-541.

CONTRIBUTION 15

MURTY, V. SRIRAMACHANDRA. 1984. Observations on some aspects of biology of the croakers *Johnius* (*Johnieops*) *dussumieri* (Cuvier) and *Johnius* (*Johnius*) *carutta* Bloch from Kakinada. *J. mar. biol. Ass. India*, 21 (1&2): 77-85 (1979).

CONTRIBUTION 15

J. mar. biol. Ass. India, 1979, **21** (1 & 2) : 77-85

OBSERVATIONS ON SOME ASPECTS OF BIOLOGY OF THE CROAKERS *JOHNIUS (JOHNIEOPS) DUSSUMIERI* (CUVIER) AND *JOHNIUS (JOHNIUS) CARUTTA* BLOCH FROM KAKINADA

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ABSTRACT

Observations on some aspects of biology of *Johnius dussumieri* and *J. carutta* are made from trawler catches of Kakinada. It is shown that *J. dussumieri* spawns during March-August period. This species attains first maturity at a total length of 110 mm. There is a predominance of females in larger length groups. The length-weight relationship of *J. dussumieri* follows the equation log w = -4.84511 + 2.96347 log L. The fluctuations in relative condition factor seem to be related to gonad cycle.

Individuals of *J. carutta* attain first maturity at a total length of 155 mm. This species is a fractional spawner releasing the ripe ova in two spawning acts during the single spawning season which appears to extend from January to June. In this species also, as in *J. dussumieri*, there is a predominance of females in larger lengths. The length-weight relationship in *J. carutta* is calculated to be log W = -5.43389+ 3.23343 log L.

INTRODUCTION

AMONG the demersal catches landed by the small trawlers at Kakinada, sciaenids rank second in abundance being next to prawns and among the fish catch these fishes rank first (Muthu *et al.*, 1977). In regard to the species abundance, *Johnius dussumieri* and *J. carutta* are among the important species in the sciaenid catches off Kakinada. Considerable information is available on the biology of sciaenid fishes from different regions on the Indian Coasts but there is no information on the biology of *Johnius dussumieri*** and excepting the work of Rao (1967) on the spawning, there is no information on the biology of *J. carutta* from India. An attempt is, therefore, made to present the details of some aspects of biology of these two species from Kakinada on the basis of the data collected from the small trawlers during January 1975-December 1977.

I am thankful to Mr. K. V. Narayana Rao. Head of Fishery Biology Division and Mr, T. Tholasilingam of my Institute for going through the manuscript and offering suggestions for its improvement. I am also thankful to Mr. T. Jacob for the advice in statistical treatment.

MATERIAL AND METHODS

The material for the present study was obtained at weekly intervals from the private trawler landings at the Kakinada Fishing Harbour. On each observation day, random samples of all species of sciaenids were collected from 4-5 boats for studies on species composition and different aspects of biology. The pooled samples were brought to the laboratory and data on length, weight, sex and stages of maturation were taken on fresh specimens of important species and gonads were preserved in 4% formalin for detailed studies. Since the sciaenid fishery is a multispecies one (about 17 species at Kakinada), the samples collected (each about 2-3 kg) consist of different species. Another feature of sciaenid fishery at Kakinada is that none of the species occurs throughout

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** The species referred to as *Johnius dussumieri* by Sawant (1963) and Devadoss (1973) is referrable to either *Johnius elongatus* or *Johnieops macrorhynus* Mohan (Mohan, 1975).

the year in the catches (CMFRI, 1976). Consequently, relatively few numbers of each species could be examined each month and hence the data of corresponding months of the three-year period were pooled for purpose of the present study.

The colour and general appearance of the gonads were noted in fresh condition and ova diameter measurements were taken from preserved ovaries. In taking the diameter measurements the procedure of Clark (1934) was followed. In each ovary about 300 ova were measured at a magnification where each micrometer division is equal to 0.014 mm. For classification of maturation stages, the procedure followed earlier for *Atrobucca nibe* (Murty, 1981) was employed. The spawning season is determined on the basis of data of females only.

The length-weight relationship was calculated by the method of least squares using the formula $W = a\ L^n$ or $\log W = \log a + n \log L$, where W = weight in grams, L = length in mm, a = a constant and n = exponent. The relative condition factor (Kn) was calculated using the formula $Kn = W/\hat{W}$ (Le Cren, 1951), where W = observed individual weight and $\hat{W}$ = weight calculated from the length - weight relationship for each length.

BIOLOGY OF *JOHNIUS (JOHNIEOPS) DUSSUMIERI*

Maturation and Spawning

The study is based on 326 specimens (176 females and 150 males) ranging from 81 to 168 mm total length.

For determining the minimum length at first maturity, maturing, ripening and ripe (stages III-V) females and mature males were taken into account. The percentage frequency distribution of these individuals in different length groups in relation to immature fish are presented in Fig. 1. Specimens of 100 mm and above only showed mature gonads. It may

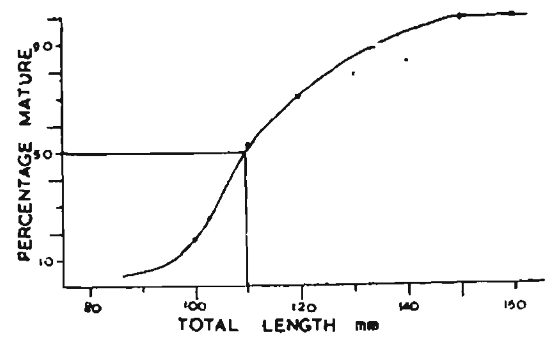

Fig. 1. Percentage frequency distribution of mature individuals in different length groups of *J. dussumieri*.

be seen from the figure that there is a progressive increase of mature fish along with increase in length. All individuals above 150 mm are mature. The data show that 50% of fish are mature (Fig. 1) at a length of about 110 mm.

The ova diameter frequency distribution in ovaries in stages III, IV and V of maturation is presented in Fig. 2. It is seen that there are two modes (a, b) in the diameter frequency distribution in all three stages. In stage III, the mode (b) at 13–15 md group consists of early maturing translucent ova, whereas the other mode (*a*) at 25–27 md group consists of opaque ova. In stage IV these modes have shifted to 22–24 md and 43–45 md groups respectively. While some of the ova in mode '*b*' are translucent, all the ova in mode '*a*' are opaque and are separate from the capsules. In stage V (Ripe), these modes have further shifted to 28–30 md and 49–51 md groups. While the ova in the mode *b* are all opaque, those in the mode *a* are translucent with vacuolated yolk and with a distinct oil globule ranging in diameter from 8 to 11 md.

The process of maturation and ripening indicated that the ova at mode '*a*' in stage III attained a growth of 24 md by the time the ovary reached ripe stage (V) and that the ova in mode *'b'* in stage III attained a growth of 15 md, by the time the ovary became ripe. The ova diameter frequency distribution in different stages of maturation indicates that the ova may be released in two spawning acts.

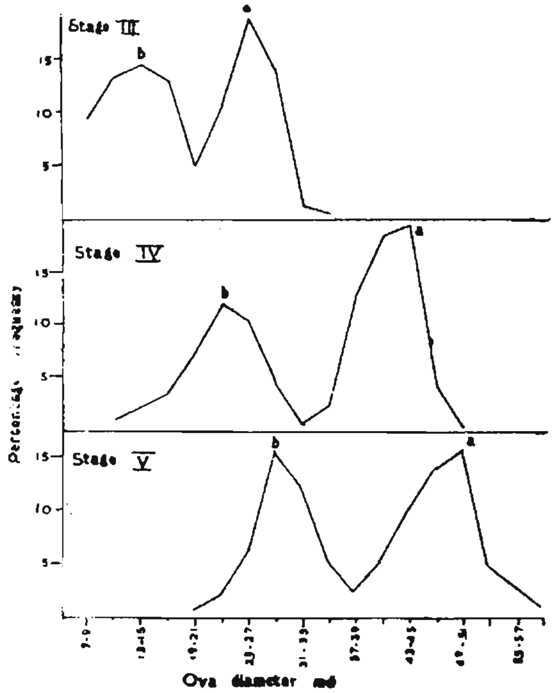

Fig. 2. Ova diameter frequency distribution in ovaries of different stages of maturation in *J. dussumieri*.

Table 1 shows the percentage frequency distribution of maturation stages in females in different months. It may be seen that ripe females (st. V) occurred during March–June period with greater abundance in May. Females in prespawning stage (st. IV) occurred during February-July period with peak in June. March-August is, therefore, considered to be the spawning season of *J. dussumieri* at Kakinada. The details of sex ratio in different months are presented in Table 2. It may be seen that females dominated males during February–July (except April) and November. The sex ratio in different lengths is given in Table 3; males dominated females upto a length of 119 mm whereas in all larger lengths females dominated.

Length-weight relationship

The data of 144 females ranging from 81 to 168 mm total length and from 6 to 59 g weight and 132 males ranging from 85 to 168 mm TL and from 7 to 61 g weight were used to calculate the length-weight relationship. The relationships for males and females were calculated separately and equations are:

Males: $\text{Log } W = -4.67244 + 2.88164 \log L$; ($r = 0.96$)

Females: $\text{Log } W = -5.06076 + 3.06496 \log L$; ($r = 0.95$)

The regression coefficients of sexes were compared by analysis of covariance following Snedecor and Cochran (1967). Since there is no significant difference both in the slopes and in the elevations (Table 4), the data of sexes were pooled and a common relationship calculated which can be expressed by the equation:

$$\log W = -4.84511 + 2.96347 \log L; \ (r = 0.95)$$

Relative condition factor

The values of relative condition factor (Kn) calculated separately for each fish were added up and the mean for each month calculated. It is seen from Fig. 3 that the Kn value is minimum in June and maximum in September. It is also noted that the Kn values during March–July period are low. As in the case of *Atrobucca nibe* (Murty, 1981), in this species also, majority of fish (84%) had either evorted or empty stomachs and hence the possibility of food intake influencing Kn values could not be ascertained.

TABLE 1. *Percentage frequency distribution of different maturation stages in females of* J. dussumieri *in different months*

Months	N	Stages of maturation I	II	III	IV	V
January	13	—	100.0	—	—	—
February	17	—	5.9	82.4	11.7	—
March	38	—	—	73.7	23.7	2.6
April	26	—	19.2	46.1	30.8	3.9
May	45	—	2.2	24.4	26.7	46.7
June	10	—	—	30.0	60.0	10.0
July	6	—	50.0	16.7	33.3	—
August	15	26.7	60.0	13.3	—	—
September	3	—	100.0	—	—	—
October		— No	data —			
November	5	100.0	—	—	—	—
December	14	35.7	64.3	—	—	—

TABLE 2. *Percentage sex ratio in different months in* J. dussumieri *and* J. carutta (P:150)

Months	*J. dussumieri* N	Male : Female	*J. carutta* N	Male : Female
January	29	25.2 : 44.8	82	50.0 : 50.0
February	29	20.7 : 79.3	45	51.1 : 48.9
March	32	37.5 : 62.5	62	41.9 : 58.1
April	57	54.4 : 45.6		No data
May	88	48.9 : 51.1	2	50.0 : 50.0
June	14	28.6 : 71.4		No data
July	6	33.3 : 66.7	10	90.0 : 10.0
August	31	58.1 : 41.9	94	56.4 : 43.6
September	5	40.0 : 60.0	22	36.4 : 63.6
October	No data		24	45.8 : 54.2
November	6	16.7 : 83.3	13	23.1 : 76.9
December	29	51.7 : 48.3	51	33.3 : 66.7

TABLE 3. *Percentage sex ratio in different length groups in* J. dussumieri *and* J. carutta

Length groups (mm)	*J. dussumieri* N	Male : Female	*J. carutta* N	Male : Female
80– 89	3	66.7 : 33.3	2	50.0 : 50.0
90– 99	4	75.0 : 25.0	2	100.0 : —
100–109	35	62.9 : 37.1	8	100.0 : —
110–119	64	56.3 : 43.7	24	58.3 : 41.7
120–129	89	39.3 : 60.7	57	56.1 : 43.9
130–139	78	43.6 : 56.4	62	56.5 : 43.5
140–149	31	32.3 : 67.7	65	41.5 : 58.5
150–159	11	45.5 : 54.5	74	43.2 : 56.8
160–169	11	27.3 : 72.7	48	37.5 : 62.5
170–179	—	—	41	51.2 : 48.8
180–189	—	—	33	33.3 : 66.7
190–199	—	—	11	9.1 : 90.9
200–209	—	—	1	100.0 : —
210–219	—	—	3	— : 100.0

For purpose of comparison of Kn values of different lengths, data of April and May only were considered because it is desirable for such comparison that data are collected during a reasonably short period (Lagler, 1952), so that the possibility of different factors (eg. maturation, fat deposition etc.) affecting Kn values in different months or seasons can be eliminated. The months April and May are selected because most of the length groups are represented in these two months.

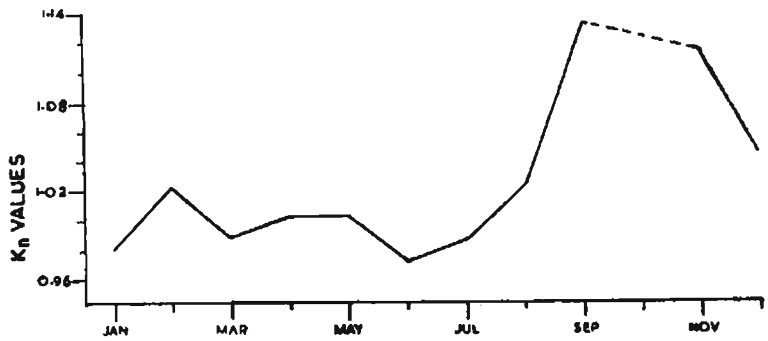

Fig. 3. Relative condition factor of *J. dussumieri* in different months.

Kn value is maximum in 80 mm group (Fig. 4). After that length there is a fall in the Kn value and it reached a peak at 110 mm group. As shown earlier, *J. dussumieri* matures first at a length of 110 mm. Again the Kn values showed a fall and increased gradually till 140 mm. It is possible that majority of the individuals mature for the second time when they are 140 mm.

Biology of *Johnius (Johnius) carutta*

Maturation and spawning

The study is based on 403 specimens (190 males and 213 females) ranging from 84 to 215 mm TL.

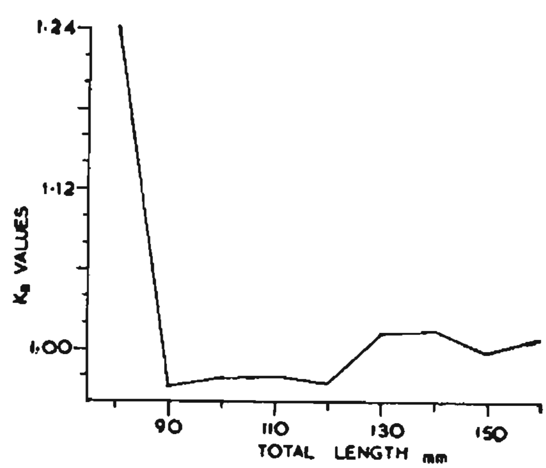

Fig. 4. Relative condition factor of *J. dussumieri* in different length groups.

Females of stages III–V of maturation and mature males were considered for the purpose of determining size at first maturity. The percentage frequency distribution of these fishes in relation to immature fish in different length groups are presented in Fig. 5. There is a gradual increase of mature specimens till 190 mm and, above this length all are mature. Since 50% of the individuals were mature at 155 mm, this length is taken as the minimum length at first maturity. The ova diameter frequency distribution in ovaries of stages III, IV and Va of maturation are presented in Fig. 6. There are two modes one at 15–16 md and

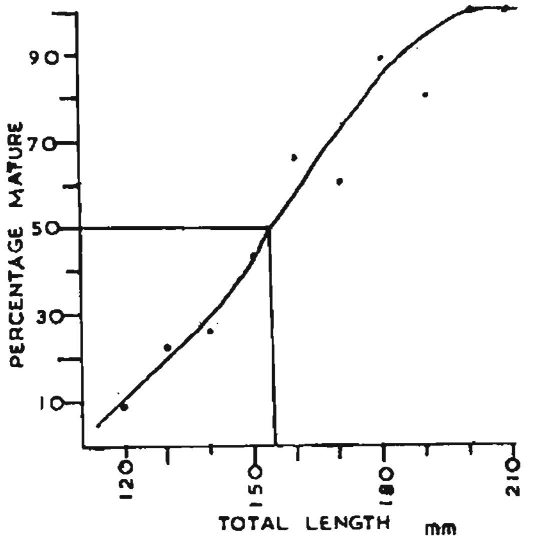

Fig. 5. Percentage frequency distribution of mature fishes in different length groups of *J. carutta.*

the other at 25–26 md group in the diameter frequency distribution of ovary in stage III.

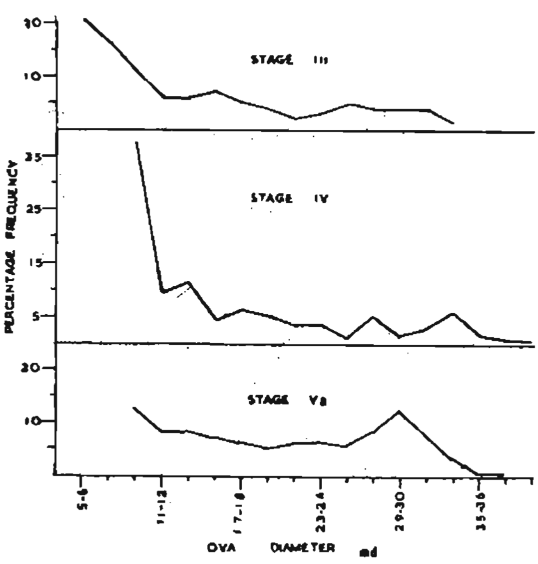

Fig. 6. Ova diameter frequency distribution in ovaries of different stages of maturation in *J. carutta.*

While the first mode consists of immature translucent ova, the second mode consists mostly of opaque ova. In stage IV, in addition to the immature and early maturing ova, there are two modes at 27–28 md and 33–34 md groups in the mature ova. The latter mode (at 33–34 md) may be the result of faster growth of a group of ova forming a mode at 25–26 md group in stage III. Fishes with fully ripe, stage V ovaries were not encountered in the samples. In stage Va (partially spawned) there is only one mode at 29–30 md groups in the diameter frequency distribution of mature ova. Though some of the larger ova were translucent (ripe ova) with an oil globule, majority of them were opaque. In this connection, it may be stated that stage Va ovary does not occupy the entire length of body cavity indicating that some ova were already released.

The fact that there are two modes in the diameter frequency distribution of mature ova in stage IV ovary and that there is only one mode in mature group of ova in the ovary of stage Va, indicate that *J. carutta* is a fractional spawner releasing ripe ova in two batches during the single spawning season. The absence of a second mode in the frequency distribution of mature ova in stage Va ovary, unlike in that of stage IV and the presence of a few ripe ova in stage Va ovary, support this conclusion. Rao (1967) observed a similar situation in mature ovaries and stated that only one batch of mature ova was likely to be released in the 'ensuing spawning season.' His data clearly show that mature individuals occur during November-March period which indicated a single spawning season and the second batch of ova in mature ovaries may not remain till next spawning season since they were already mature.

The frequency distribution of maturation stages in females is presented in Table 5. It is seen that mature individuals (stage IV) occurred from January to May and partially spawned individuals during January. During July–December period only immature and maturing individuals occurred. It thus appears that *J. carutta* spawns off Kakinada during January–June period. According to Rao (1967) this species spawns off Visakhapatnam during January–April period.

The details of se ratio in different months are presented in Table 2. It is observed that the sexes are distributed more or less in 1:1 ratio during January–May period; incidentally, this happens to be the spawning season for this species. During July–August there is a predominance of males and during September–

TABLE 4. *Analysis of Covariance to test the significance of differences/between regression lines of sexes in the length-weight relationship of* J. dussumieri

Sources of variation	Deviation from regression df	sum of squares	Mean squares
due to regression within sexes	272	0.68029	0.00250
difference between regression coefficients	1	0.00621	0.00621
residuals due to regression-pooled within	273	0.68650	0.00252
difference between adjusted means	1	0.00090	0.00090
Total	274	0.68740	

Comparison of slopes	F = 2.484, df 1,272 NS
Comparison of elevation	F = 0.357, df 1,273 NS

TABLE 5. *Percentage frequency distribution of different maturation stages in females of* J. carutta *in different months* (P:152)

Months	N	Stages of maturation I	II	III	IV	Va
January	40	5.0	77.5	5.0	7.5	5.0
February	23	—	13.0	74.0	13.0	—
March	36	—	—	80.0	19.5	—
April			No data			
May	1	—	—	—	100.0	—
June			No data			
July	1	100.0	—	—	—	—
August	41	53.7	46.3	—	—	—
September	14	—	100.0	—	—	—
October	13	38.5	61.5	—	—	—
November	10	80.0	20.0	—	—	—
December	34	11.8	76.5	11.8	—	—

TABLE 6. *Analysis of covariance to test the significance of differences/between regression lines of sexes in the length-weight relationship of* J. carutta (P:153)

Sources of variation	Deviation from regression df	sum of squares	Mean squares
Due to regression within sexes	350	0.34203	0.00098
difference between regression coefficients	1	0.00013	0.00013
residuals due to regression-pooled within	351	0.34216	0.00097
difference between adjusted means	1	0.00061	0.00061
Total	352	0.34277	

Comparison of slopes	F = 0.133 df 1,350 NS
Comparison of elevation	F = 0.629 df 1,351 NS

December period, there is a predominance of females. The sex ratio in different length groups is given in Table 3. It is seen that upto a length of 139 mm there is predominance of males and after this length females dominated.

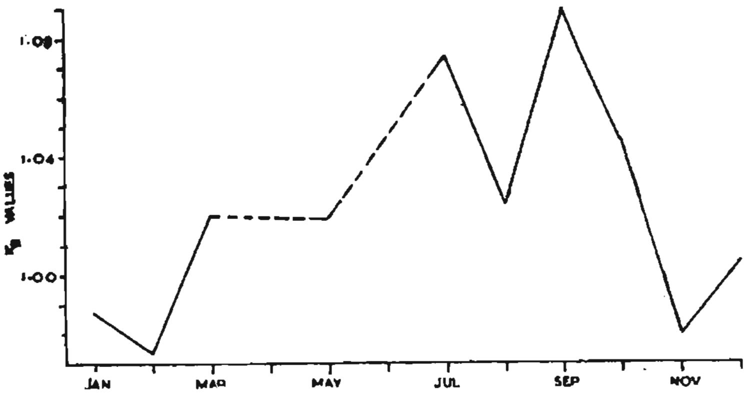

Fig. 7. Relative condition factor of *J. carutta* in different months.

Length-weight relationship

The data of 163 males ranging from 86 to 200 mm length and 5 to 94 g weight and 191 females ranging from 84 to 216 mm length and 6 to 133 g weight were used to calculate the length-weight relationship. The equations were obtained separately for sexes and they are:

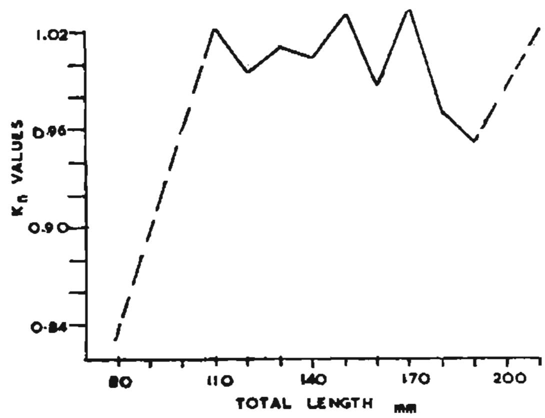

Fig. 8. Relative condition factor of *J. carutta* in different length groups.

Males: $\log W = -5.41602 + 3.22584 \log L$; ($r = 0.99$)

Females: $\log W = -5.46190 + 3.24570 \log L$; ($r = 0.99$)

The regression coefficients of sexes were compared by Analysis of Covariance. The results (Table 6) show that there is no significant difference both in slopes and elevations. Hence, data of sexes were pooled and a common relationship was calculated:

$$\log W = -5.43389 + 3.23343 \log L.; \quad (r = 0.99)$$

Relative condition factor

The values of Kn during different months are presented in Fig. 7. It is seen that the values during January-March and May were low. It has been shown earlier that the spawning season for this species is January-June and the low Kn values during this period (no data for April and June) may be associated with spawning. It was observed that there was building up of fat in the body cavity during July-October period and the high Kn values during these months may be associated with this.

For reasons cited elsewhere in this paper, the Kn values in different length groups during November and December 1976 were taken to compare the values of different lengths (Fig. 8) because most of the length groups occurred during these two months. Though the fluctuations in Kn values in different lengths do not clearly show any relationship with spawning, it may be noted that high Kn values occurred in 150–159, 170–179 and 210–219 mm length groups.

REFERENCES

CLARK, F. N. 1934. Maturity of the California sardine *(Sardina caerulea)*. *California Div. Fish. Game*, **42**: 1-49.

CMFRI. 1976. *Annual Report for* 1976. Central Marine Fisheries Research Institute, Cochin. 123 pp.

DEVADOSS, P. 1969. Maturity and spawning in *Otolithus ruber* (Schn.) and *Johnius dussumieri* (C & V). *Indian J. Fish.*, **16**: 117-128.

LAGLER, K. F. 1952. *Freshwater Fishery Biology.* W. M. C. Brown Company, IOWA, 421 pp.

LE CREN, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch *(Perca fluviatilis)*. *J. Anim. Ecol.*, **20**: 201-219.

LAL MOHAN, R. S. 1975. Two new species of Sciaenid fishes *Johnius elongatus* and *Johnieops macrorhynus* from India. *Matsya*, **1**: 19-25.

MURTY, V. SRIRAMACHANDRA 1980. Observations on the biology of the black croaker *Atrobucca nibe* (Jordan and Thompson) from Kakinada. *Indian J. Fish.*, **27**: 66-75.

MUTHU, M. S., K. A. NARASIMHAM, G. SUDHAKARA RAO, Y. APPANNA SASTRY AND P. RAMALINGAM 1977. On the commercial trawl fisheries off Kakinada during 1967–70. *Ibid.*, **22**: 171-186.

RAO, T. APPA 1967. Maturity and spawning habits of some sciaenids in offshore waters at Visakhapatnam. *Ibid.*, **11**: 121-126.

*SAWANT, V. V. 1963. A study on a sciaenid *Johnius dussumieri* (C & V). *Ph. D. Thesis, University of Bombay.*

SNEDECOR, G. W. AND W. G. COCHRAN 1967. *Statistical methods.* Oxford and IBH publishing Co., New Delhi. Sixth Edition, 593 pp.

*Not referred to in original.

CONTRIBUTION 16

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CONTRIBUTION 16

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GROWTH AND YIELD PER RECRUIT OF *JOHNIUS* (*JOHNIUS*) *CARUTTA* BLOCH IN THE TRAWLING GROUNDS OFF KAKINADA

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ABSTRACT

The growth of *J. carutta* can be described by the von Bertalanffy growth formula, with parameter values: L_{∞} = 333.3 mm; K = 0.44 per year; and t_0 = —0.0002 year. The Instantaneous rates of mortality are estimated at Z = 5.07, M = 1.0 and F = 4.07. The Yield per recruit analysis shows that the yield can be increased by increasing the cod-end mesh size of the trawl nets.

INTRODUCTION

Among the sciaenids landed by commercial trawlers at Kakinada, *Johnius* (*Johnius*) *carutta* Bloch is one of the most dominant species. In an earlier paper, Murty (1984) has considered some aspects of biology of this species. The present paper deals with the estimation of growth parameters, mortality and Yield per recruit on the basis of data collected from commercial trawlers during 1980-83.

Among the past attempts to estimate age and growth of sciaenids from India, those which have estimated the parameters of growth are confined to two species, namely *Pseudosciaena diacanthus* (K. S. Rao 1971, K. V. S. Rao 1961, 1971a, 1971b) and *Otolithoides brunneus* (Kutty 1961, Jayaprakash 1978) from the west coast of India. There is practically no information on age and growth of *J. carutta* from anywhere along the Indian coast. Further, except for the work of Rao, K. V. S. (1971b) on mortality and Yield per recruit of *P. dicanthus* from Bombay, there is no information on the population dynamics of any sciaenid species of India.

MATERIAL AND METHODS

Data on catch and effort from the commercial trawlers were obtained for 18-20 days in a month and samples for biological studies were collected at weekly intervals. Data on length-frequency distribution collected on all the observation days in a month were weighted to get the monthly length-frequency distribution in the catch.

The length-data were grouped into 10 mm-class intervals and the mid-point in each group was taken to study growth. Growth in length was estimated using the integrated method of Pauly (1980a) drawing growth curves passing through several modes in the monthly length-frequency distribution. The von Bertalanffy equation for growth in length:

$$L_t = L_\infty \left[1-e^{-K(t-t_0)} \right],$$

where L_∞ is asymptotic length, K is growth coefficient and t_0 is origin of growth curve, was used to estimate parameters of growth. Estimates of L_∞ and K were made using the relation:

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

and t_0 was estimated using the relation:

$$-\log_e \left(\frac{L_\infty - L_t}{L_\infty} \right) = -Kt_0 + Kt$$

Instantaneous rate of total mortality (Z) was estimated by the length-converted catch-curve method of Pauly (1982) using the relation: $\log_e (N/\Delta t) = a + bt$, where Δt is the time taken to grow from the lower limit to the upper limit of each length class, N = numbers caught in each length group, a = y-axis intercept, b = Z with sign changed and t = age of midpoint of each length group.

The natural mortality rate (M) was estimated using the relation Z = M + qf, where q is catchability coefficient and f the fishing effort, and also using the equation of Pauly (1980b):

$$\text{Log } M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T,$$

where L_∞ is in cm, K per year and T in °C. The value of T was taken as 27.2°C from Ganapati and Murthy (1954) and La Fond (1958).

The yield in weight per recruit (YW|R) was estimated from the equation of Beverton and Holt (1957):

$$YW/R = F\, e^{-M(t_c - t_r)}\, W_\infty \left(\frac{1}{Z} - \frac{3S}{Z+K} + \frac{3S^2}{Z+2K} - \frac{S^3}{Z+3K} \right)$$

where $S = e^{-K(t_c - t_0)}$, t_c = age at first capture and t_r = age at recruitment to the fishing ground.

Estimation of Growth Parameters

In total, 8540 specimens ranging from 75 to 225 mm were measured during 1980-83. The monthly length-frequency distribution in *J. carutta* (Fig. 1) showed that modal lengths in different months varied from 95 to 215 mm. While drawing the growth curves, the modal lengths which were likely to fall in a curve were joined first and then the line was extended both upwards and downwards to complete the curve. Six growth curves (A-F; Fig. 1) were identi-

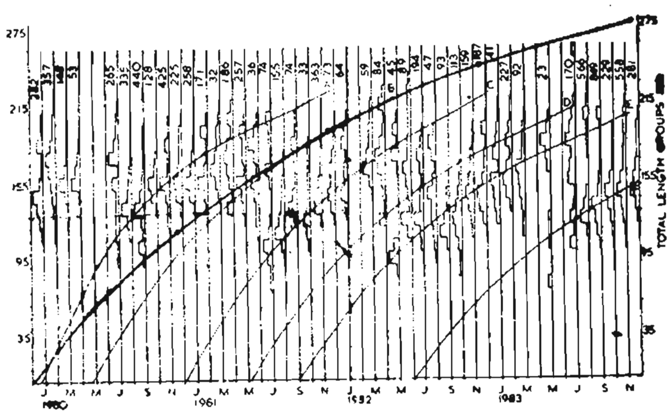

FIG. 1. Monthly length-frequency distribution of *J. carutta* showing the growth traced by growth curves. The von Bertalanffy growth curve is shown by thick line (Numerals indicate the number of specimens measured in each month).

fied in the data of the 4-year period and they were of the same shape. For studying the growth, the smallest modal length in a curve was taken as the starting point (shown by small dots in Fig. 1) and from there the curve was marked at intervals of six months and the lengths attained at half-yearly intervals were taken. Care was however taken to include in the analysis the portion of growth curves only when there was a mode between two half-year intervals or beyond. The values thus taken (Table 1) were used to estimate the parameters of von Bertalanffy growth equation.

A plot of L_{t+1} against L_t as read off the different growth curves showed that the observed points were wall-represented by the straight line ($r^2 = 0.97$). From the value of the slope ($= e^{-K}$) of the regression, the value of K was estimated as 0.22 per half year and then as 0.44 per year. The estimated value of L_∞ was 333.3 mm. The value of t_0 was estimated as -0.0002 year.

The estimated lengths of *J. carutta* at the completion of I, II, III and IV years were 119, 195, 244 and 276 mm, respectively (Fig. 1). Since the maximum length observed in the catch was 255 mm, the maximum age in the fishery worked out to 3.3 years.

TABLE 1. *Details of lengths (mm) read off different growth curves in figure 1 at intervals of 6 months.*

Curve	Initial length	Length at six months	Length at 12 months	Length at 18 months
A	135	181	215	—
B	142	183	215	—
C	100	150	188	—
D	125	165	193	—
E	95	140	175	201
F	121	157	—	—

ESTIMATION OF MORTALITY RATES

Total mortality rate (Z): The points that represented the straight, descending part of the length-converted catch curve (Fig. 2) were taken into account for estimating total mortality rates. The estimated values of Z during different years and the average worked out are as follows:

	Z
1980	5.0589
1981	4.4247
1982	5.6504
1983	5.1651
Average	5.0748

Estimation of natural mortality rate (M): A plot of Z against effort (Fig. 3) showed that there was good correlation (r^2 0.80) between effort and Z with the estimated value of M at 2.05 and q at 0.000059533. But the above value of M gave M|K value of 4.66, a value much beyond the range (1.0-2.5) known in fishes (Beverton and Holt 1959). This value, thus appearing to be an over-estimate, was considered to be unrealistic and, therefore, the value of M estimated by the formula of Pauly, being 1.0 with M|K at 2.3, was taken.

Fishing mortality rate: The present fishing mortality rate, derived from the values of Z and M estimated above, was 4.07.

ESTIMATION OF YIELD PER RECRUIT

Using the length-weight relationship (Murty 1984) of the species and the L_∞ value obtained, the value of W_∞ was estimated to be 529 g. The

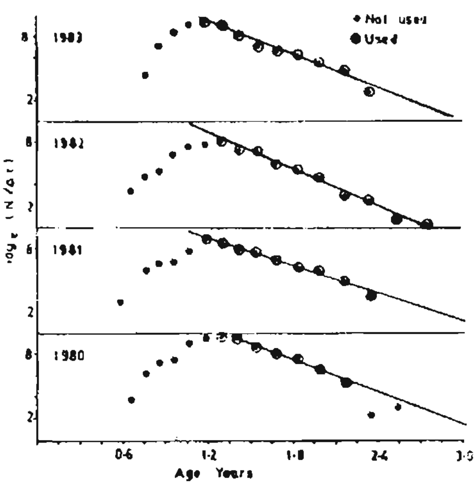

FIG. 2. Estimation of 'Z' by length-converted catch curve method in *J. carutta*.

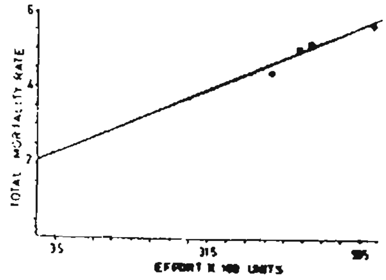

FIG. 3. Plot of Z against effort to estimate M in *J. carutta*.

smallest fish observed in the catch was 70 mm and therefore the age, estimated of it, i.e., 0.536 year, was taken as the age at recruitment (t_r). The annual length-frequency distribution of catch during the 4-year period showed the smallest mode at 135 mm and, hence, 130 mm (lower limit of 135 mm-group) was taken as the length at first capture. The t_c was calculated as 1.123 years.

The Yield per recruit with M at 1.0 and the five values of t_c ranging from 1.014 to 1.486, respectively representing t_c values at 120, 130, 140, 150 and 160 mm (Fig. 4A), showed that the Yield per recruit increased with increased t_c . It was also observed that, with t_c at 1.014, the Yield per recruit reached its maximum (20.6 g) when F was 1.6, and then on slowly decreased with further increase in F. With t_c at 1.123 (present value), the Yield per recruit reached its maximum (21.5 g) when F was 2.0. With the t_c values at 1.238 and 1.359, maximum Yield per recruit (22.3 and 23.1 g, respectively) was at F = 2.4 and 3.0, respectively. With t_c at 1.486, the yield increased with increasing F and reached maximum (23.7 g) when F was 4 and decreased slowly with further increase in F. Thus, the Yield per recruit not only increased with greater values of t_c, but also reached its maximum at higher values of F if t_c was higher. The estimated values of present F and t_c were 4.07 and 1.123, respectively; and the Yield per recruit had already shown a decline.

The Yield per recruit with M at 1.0 and F at 4.07, as a function of age at first capture (Fig. 4B), showed that it increased, reaching maximum (24.1 g) at t_c 1.7, and declined with further increase in t_c .

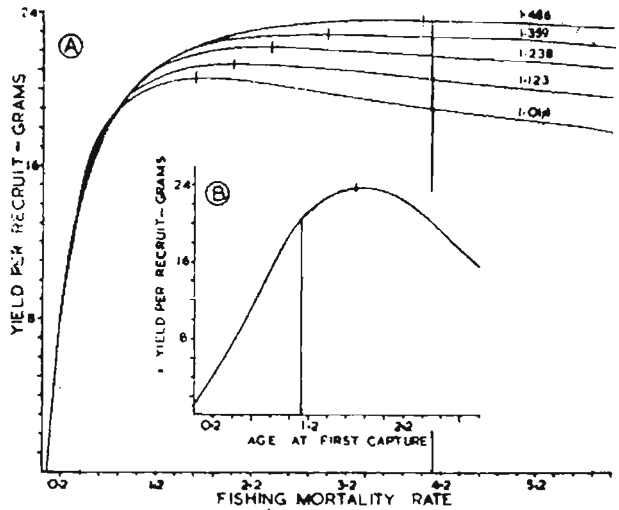

FIG. 4. A. Yield per recruit as a function of fishing mortality in *J. carutta.* The numerals indicate the tc values and the vertical line the present F. B. Yield per recruit as a function of age at first capture in *J. carutta.* The vertical line shows the present tc. (The small vertical lines on the curves in A and B indicate maximum YW|R values).

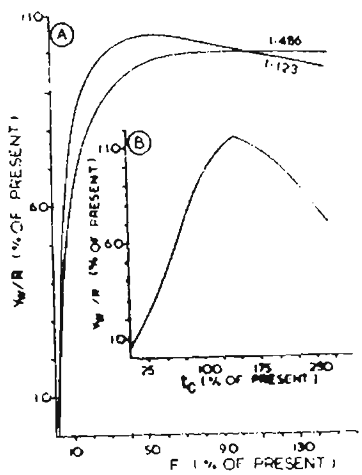

FIG. 5. Yield per recruit (as percent of present value), as A. function of fishing mortality (also as percent of present value), for two values of age at first capture. B. function at first capture (also as percent of present value).

It was observed (Fig. 5A) that if the fishing mortality rate was about 49% of the present value (of 4.07) and tc was 1.123, the Yield per recruit was 104.3% of the present value, and if the F was about 98% of the present value and tc 1.486, the Yield per recruit was about same as the present value (see also fig. 4A). It was also observed (Fig. 5B) that if the tc was 151% of the present value (1.123) and F was at 4.07 (also the present value), the Yield per recruit was 117% of the present value (Fig. 5B). It was thus clear that higher Yield per recruit could be obtained by one of the following:

i: decreasing the fishing mortality to 49% of the present value (by decreasing the fishing effort) without changing the cod-end mesh size

ii: increasing the age at first capture to 150% of the present value (by increasing the cod-end mesh size) without changing the fishing effort

iii: increasing both effort and cod-end mesh size.

DISCUSSION

The study of growth in *Johnius carutta* is rendered difficult by the entry into the fishery of several broods over an extended period, and estimation of growth by following the modal progression in successive months is likely to lead to erroneous results, because there is no evidence to show that the modes interconnected really belong to the same brood. According to Pauly (1980a), however, the integrated method makes it quite hard to trace "wrong" growth curves, and the parameters obtained from such curves will describe the growth of at least the exploited part of a population well enough for most purposes.

Estimation of M of a particular species in a multi-species fishery by regression of Z on effort is not likely to lead to reliable results because of lack of knowledge on the effective effort for the species under consideration. It is perhaps for this reason that, though the correlation is good (Fig. 3), the M value obtained by the regression method is very much higher, particularly when viewed against the estimated growth parameters. The value obtained using the equation given by Pauly (1980b) appears to be a reasonable one for reasons mentioned above.

The yield per recruit analysis shows that under the current values of F (4.07) and tc (1.123) the yield has already shown decline, and that maximum yield can be obtained by reducing the effort to about 49% of the present. It also shows that greater YW|R is obtained at higher F for greater tc, which indicates that the yield can be maximised by increasing the cod-end mesh size without further increasing the effort (Figs 4 and 5).

In an earlier study (Murty 1984) the author had shown that the length at 50% maturity of this species was 155 mm and whose age was 1.422 years. In the present study the tc is at 1.123 years (lc = 130 m). Thus the need is apparent to increase the cod-end mesh size to get tc value above 1.4 years, so that the fish will get at least one chance to spawn before being caught in large numbers and it will help avert the possibility of recruitment overfishing at higher levels of F.

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REFERENCES

BEVERTON, R. J. H. AND S. J. HOLT. 1957. On the dynamics of exploited fish populations. *Fishery Invest. London*. Ser. 2, 19: 533 pp.

BEVERTON, R. J. H. AND S. J. HOLT. 1959. A review of the lifespans and mortality rates of fish in nature and their relation to growth and other physiological characteristics. Ciba foundation Colloquia on ageing. G. E. W. Wolsenholmy and M.O.' Connor (Eds.). *The life-span of animals*, 5: 142-177.

GANAPATI, P. N. AND V. S. R. MURTHY. 1954. Saiilinity and temperature variations of the surface waters off Visakhapatnam coast. *Andhra Univ. Mem. Oceanogr.*, 1: 125-142.

JAYAPRAKASH, A. A. 1978 Age and growth of juveniles of 'Koth' *Otolithoides brunneus* (Day) in Bombay waters. *Indian J. Fish.*, 23: 86-96 (1976).

KUTTY, M. N. 1961. Scales and otoliths of 'Koth' *Otolithoides brunneus* (Day) as age indicators. *Indian J. Fish.*, 8: 145-151.

LA FOND, E. C. 1958. Seasonal cycle of sea surface temperature and salinity along the east coast of India. *Andhra Univ. Mem. Oceanogr.*, II: 12-21.

MURTY, V. SRIRAMACHANDRA. 1984. Observations on some aspects of biology of the Croakers *Johnius (Johnieops) dussumieri* (Cuvier) and *Johnius (Johnius) carutta* Bloch from Kakinada. *J. mar. biol. Ass. India* 21(1 & 2): 77-85 (1979).

PAULY, D. 1980a. A selection of simple methods for the assessment of tropical fish stocks. *FAO Fish. Circ.* 729: 54 pp.

PAULY, D. 1980b. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. cons. int. Explor. Mer.* 39: 175-192.

PAULY, D. 1982. Studying single-species dynamics in a tropical multispecies context. pp. 33-70, *In*: Pauly, D and G. I. Murphy (Eds.) *Theory and Management of tropical fisheries*, ICLARM Conference proc. 9, 360 pp., ICLARM, Manila, Philipines and CSIRO. Cronulla, Australia.

RAO, K. S. 1971. Studies on the scales of *Pseudosciaena diacanthus* (Lacepede) for estimating growth parameters. *Indian J. Fish.*, 15: 127-144 (1968).

RAO, K. V. S. 1961. Studies on age determination of (Ghol' *Pseudosciaena diacanthus* (Lacepede) by means of scales and Otoliths. *Indian J. Fish.*, 8: 121-125.

RAO, K. V. S. 1971a. Age and growth of Ghol *Pseudosciaena diacanthus* (Lacepede) in Bombay and Saurashtra waters. *Indian J. Fish.*, 13: 251-292 (1966).

RAO, K. V. S. 1971b. Estimates of mortality and yield per recruit of Ghol *Pseudosciaena diacanthus* (Lacepede). *Indian J. Fish.*, 15: 88-98 (1968).

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MURTY, V. SRIRAMACHANDRA AND P. RAMALINGAM. 1988. Observations on some aspects of biology of *Johnius (Johnieops) vogleri* (Bleeker) and *Pennahia macrophthalmus* (Bleeker) in the Kakinada region. *J. mar. biol. Ass. India*, 28 (1&2): 57-62 (1986).

CONTRIBUTION 17

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OBSERVATIONS ON SOME ASPECTS OF BIOLOGY OF *JOHNIUS* (*JOHNIEOPS*) *VOGLERI* (BLEEKER) AND *PENNAHIA MACROPHTHALMUS* (BLEEKER) IN THE KAKINADA REGION

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ABSTRACT

The length-weight relationship in *J. vogleri* and *P. macrophthalmus* can be described by the equations log W=-5.08923+3.07931 log L and log W=-4.63735+2.89703 log L respectively. The length at first maturity in *J. vogleri* is estimated as 190 mm and in *P. macrophthalmus* as 147 mm. These two species appear to spawn atleast twice in a year during protracted spawning periods: November-June in *J. vogleri* and October - June in *P. macrophthalmus*.

INTRODUCTION

AMONG the demersal fishes landed by the private trawlers at Kakinada, the sciaenids constitute the most dominant group. Though 18 species contribute to the fishery, only a few are dominant. The present paper gives an account of length-weight relationship and spawning in *Johnius vogleri* and *Pennnahia macrophthalmus* on the basis of data collected from the landings of private trawlers during 1975-1979. Though considerable information is available on the biology of sciaenid from India, in the case of *J. vogleri* the only account available is from Bombay (Muthiah, 1983) and *P. macrophthalmus* from Visakhapatnam (Rao, 1967, 1983).

MATERIAL AND METHODS

Samples were collected at weekly intervals from the landings of private trawlers. Data on length, weight, sex and stage of maturation were taken from fresh specimens and ova diameters were taken from formalin-preserved ovaries. Ova diameters were measured following the procedure of Clark (1934); in each ovary a minimum of 300 ova were measured at a magnification where 1 mm = 59 divisions of occular micrometer. The gonads were classified into seven stages of maturation. Length - weight relationship was calculated following Le Cren (1951) using the formula log W = log a+b log L.

LENGTH - WEIGHT RELATIONSHIP

In *J. vogleri*, the study is based on 132 males ranging from 94 to 234 mm length and from 10 to 138 g weight and 144 females ranging from 99 to 238 mm length and from 11 to 145 g weight. The relationship was calculated separately for sexes and equations are:

Males: $\log W = -5.01103 + 3.04169 \log L$; $r^2 = 0.99$

Females: $\log W = -5.13942 + 3.10374 \log L$; $r^2 = 0.99$.

In *P. macrophthalmus*, a total of 90 males ranging from 98 to 222 mm length and from 15 to 148 g weight and 100 females ranging from 91 to 219 mm length and from 12 to 140 g weight was used for the calculation of

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the relationship. The equations for sexes separately are:

Males: $\log W = -4.56767 + 2.86347 \log L$; $r^2 = 0.94$.

Females: $\log W = -4.70991 + 2.931936 \log L$; $r^2 = 0.98$.

The differences between the regression lines of males and females of these two species were tested by analysis of covariance following Snedecor and Cochran (1969). It was found (Table 1) that the differences are not significant at 5% level. The data of males and females were, therefore, pooled and relationships for the two species obtained (Fig. 1). The equations for the species are:

J. vogleri: $\log W = -5.08923 + 3.07931 \log L$; $r^2 = 0.99$.

P. macrophthalmus: $\log W = -4.63735 + 2.89703 \log L$; $r^2 = 0.96$.

The t-test (Pauly, 1984) was applied to see whether the values of regression coefficient (b) in the above equations were significantly different from 3; it was observed that the b values are not significantly different from 3; hence growth in weight with length in these two species can be taken as isometric.

Length at First Maturity

For determining the length at first maturity, only females were considered and fishes in stages IV-VI of maturation were taken as

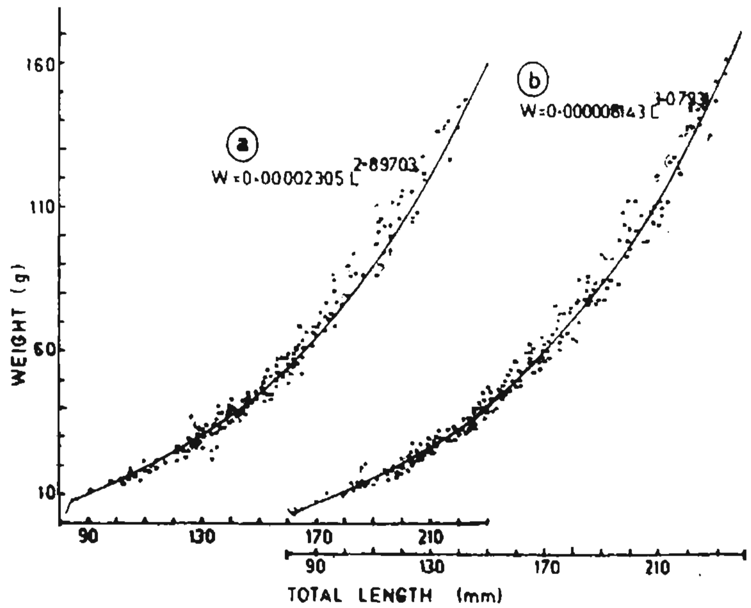

Fig. 1. Length-weight relationship in: a. *P. macrophthalmus* and b. *J. vogleri*.

TABLE 1. *Analysis of Covariance to test significance of differences between regression lines of sexes in the length-weight relationships of* J. vogleri *and* P. macrophthalmus

Source of variation	df	*J. vogleri* Deviation from regression SS	MS	df	*P. macrophthalmus* Deviation from regression SS	M
Due to regression within sexes	272	0.308146	0.001133	186	0.419714	0.002257
Difference between regression coefficients	1	0.002205	0.002205	1	0.001514	0.001514
Residuals due to regression pooled within	273	0.310351	0.001137	187	0.421228	0.002253
Difference between adjusted means	1	0.003591	0.003591	1	0.002483	0.002483
Total	274	0.313942		188	0.423711	

Comparison of slopes F=1.95, df=1,272; NS., F=0.67, df=1,186; NS

Comparison of elevations F=3.16, df=1,273 NS., F=1.10, df=1,187; NS

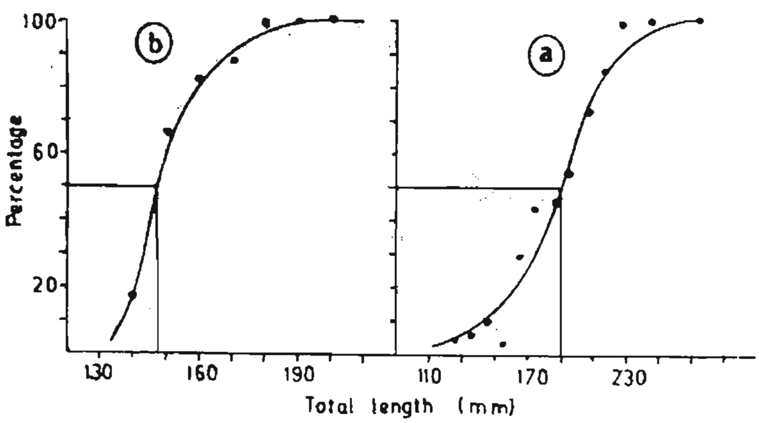

Fig. 2. Percentage of mature females in the total numbers of females examined in each length group in : a. *J. vogleri* and b. *P. macrophthalmus.*

mature (Fishes with fully spent ovaries - stage VII - were not encountered in the samples). The total lengths were grouped into 10 mm class intervals.

In *J. vogleri,* the smallest mature female was observed in 120-129 mm group. The percentage of mature females in each length group (Fig. 2 a) shows that 50% of fishes were mature at 190 mm; hence this length was taken as length at first maturity.

In *P. macrophthalmus* (Fig 2 b), the percentage of mature fish in each length group indicates that 50% are mature at 147 mm; hence this length can be taken as length at first maturity.

lucent maturing ova and the other group (mode b) consists of mature, opaque ova. In stage VI the above two groups are present with more or less same modal diameters; there is another group consisting of ripe ova with distinct oil globules. The above observations indicate that each adult female spawns at least twice during the course of one year.

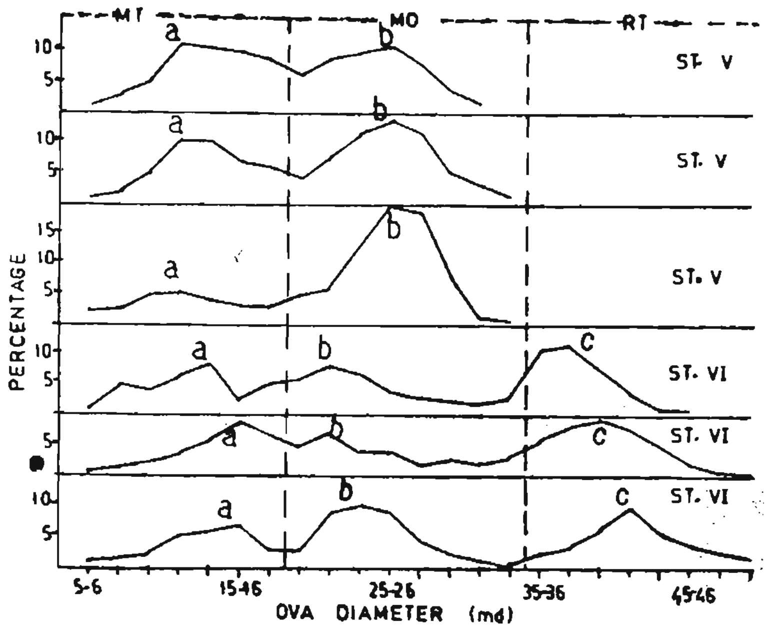

Fig. 3. Ova diameter frequency distribution in mature and ripe ovaries of *J. vogleri* (diameter ranges of : maturing translucent ova MT; mature opaque ova MO; ripe translucent ova RT).

SPAWNING

The ova diameter frequency distribution in gravid (St. V) and ripe (St. VI) ovaries of *J. vogleri* (Fig. 3) shows that two groups of ova (in addition to immature ova measuring upto 4 md which were not considered in the present study) are present in stage V ovaries. One group (mode a) consists of yolked, trans-

In *P. macrophthalmus*, fishes with ripe ovaries were not available in the samples, therefore only those with stage V ovaries were considered. The ova diameter frequency distribution (ova measuring upto 4 md were not considered in this species also) in stage V ovaries (Fig. 4) in this species shows a situation similar to that in *J. vogleri* indicating similar spawning habits.

For purpose of determining spawning season only females of and above length at first maturity were considered and data of corresponding months of different years pooled. In *J. vogleri* fishes in stage IV of maturation occurred in almost all the months and the proportion of gravid and ripe adults in each shows that spawning takes place from November to June with maximum spawning activity during May-June. In *P. macrophthalmus*, fishes with stage V ovaries (fishes with ripe ovaries were not encountered in samples) occurred during September, November, December and February-May (Fig 5) indicating that spawning takes place during October-June. It is thus clear that spawning season in these two species is more or less the same and that it is protracted. The study of ova diameter frequency distribution (Fig. 4 & 5) lends support to this conclusion.

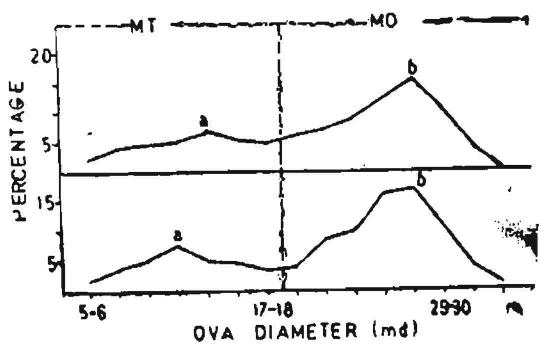

Fig. 4. Ova diameter frequency distribution in mature ovaries of *P. macrophthalmus* (Abbreviations as in Fig. 3).

DISCUSSION

Muthiah (1983) calculated the length-weight relationship separately for males and females of *J. vogleri* from Bombay, but did not calculate the relationship for the species as a whole nor did he state that the regression coefficients are significantly different. The values of regression coefficient (b=3.2861 males; 3.2808 females) of males and females from Bombay appear to be different from those of sexes of this species, from Kakinada. The value of 'b' for *P. macrophthalmus* from Visakhapatnam (Rao, 1983), however, is close to the one obtained from Kakinada. The above authors did not test whether the growth is isometric in these species; however the fact that the values of b are not significantly different from 3 in the two species from Kakinada shows that Beverton-Holt (1957) yield equation can be used in yield studies without any modification.

In *J. vogleri*, Muthiah (1983) estimated the length at first maturity as 159 mm whereas the same estimated from Kakinada is larger (190 mm). In the ova diameter frequency distribution in ripe ovaries of *J. vogleri* from Bombay, Muthiah (1983) observed a situation comparable to that observed from Kakinada (Fig. 3), but stated that "the spawning in this species seem to be restricted to a short period with an indication of second spawning, the duration in between being short". He, however, observed mature (st. IV) fish throughout the year, but stated that *J. vogleri* spawns twice a year during June-July and October-November. The ova diameter frequency distribution

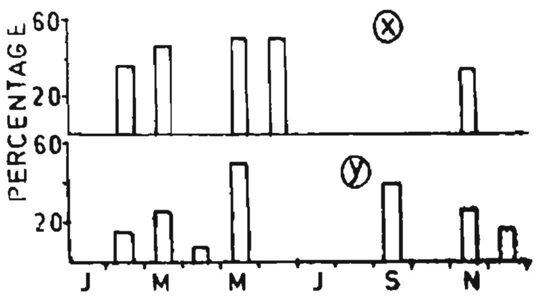

Fig. 5. Monthly percentage of gravid and ripe females in the total number of adult females examined each month: x. *J. vogleri* and y. *P. macrophthalmus*.

(Fig. 3) in *J. vogleri* from Kakinada shows that the maturing translucent ova and mature opaque ova have more or less the same modal values in stage V and VI ovaries. This indicates that by the time the mature opaque ova in stage V reach ripe stage the maturing translucent ova in the same ovary become mature and opaque. This further suggests that after the ovary reaches stage VI and spawns the batch of ripe ova, it reverts to stage V and again reaches ripe stage and this process continues (James and Baragi, 1980). The ova diameter frequency distribution in *P. macrophthalmus* also suggests a similar conclusion. Rao (1967) however stated that *Pseudosciaena aneus* (= *Pennahia macrophthalmus*) spawns only once a year during December - March. The present observations show that both *J. vogleri* and *P. macrophthalmus* have more or less the same spawning period and that the periods are protracted.

References

Beverton, R. J. H. and S. J. Holt 1957. On the dynamics of exploited fish populations. *Fish. Invest. Ser.* II, **19**: 1-533.

Clark, F. N. 1934. Maturity of the California sardine (*Sardina caerulea*), determined by ova diameter measurements. *Calif. Div. Fish. Game Fish. Bull.*, **42**: 1-49.

James, P. S. B. R. and V. M. Baragi 1980. Ovary as an indicator of frequency of spawning in fishes. *Proc. Indian natn. Sci, Acad.*, B **46** (4): 479-489.

Le Cren, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*) *J. anim. Ecol.*, **20**: 201-219.

Muthiah, C. 1983. Study on the biology of *Johnieops vogleri* (Bleeker) of Bombay waters. *Indian J. Fish.*, **29**: 118-113 (1982).

Pauly, D. 1984. Fish Population dynamics in tropical waters : a manual for use with programmable calculators. *ICLARM studies and Reviews*, **8**: 325 pp.

Rao, T. Appa 1967. Maturity and spawning habits of some sciaenids in offshore waters at Visakhapatnam. *Indian J. Fish.*, **11**: 121-126 (1964).

——— 1983. Length-weight relationship in *Pennahia macrophthalmus* (Bloch). *Ibid.*, **29**: 263-266 (1982).

Snedecor, G. W. and W. G. Cochran 1967. *Statistical Methods.* Oxward and IBH publishing Co. New Delhi, Sixth edition, 593 pp.

D. CARANGIDS——SCAD

CONTRIBUTION 18

MURTY, V. SRIRAMACHANDRA. 1991. Observations on some aspects of biology and population dynamics of the scad *Decapterus russelli* (Ruppell) (Carangidae) in the trawling grounds off Kakinada. *J. mar. biol. Ass. India*, 33 (1&2): 396-408.

CONTRIBUTION 18

OBSERVATIONS ON SOME ASPECTS OF BIOLOGY AND POPULATION DYNAMICS OF THE SCAD *DECAPTERUS RUSSELLI* (RUPPELL) (CARANGIDAE) IN THE TRAWLING GROUNDS OFF KAKINADA*

J. mar. biol. Ass. India, 1991, **33** (1 & 2) : 396-408

OBSERVATIONS ON SOME ASPECTS OF BIOLOGY AND POPULATION DYNAMICS OF THE SCAD *DECAPTERUS RUSSELLI* (RUPPELL) (CARANGIDAE) IN THE TRAWLING GROUNDS OFF KAKINADA*

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ABSTRACT

Decapterus russelli (Ruppell)[2] is abundant in relatively deeper waters and forms 80-90% of carangid catches by trawlers. The von Bertalanffy growth parameters are estimated as L_∞ = 232.3 mm, K = 1.08 per year and t_0 = —0.08 year. The length-weight relationship can be described by the equation log W (g) = —5.93433+3.40764 log L (mm). The length and age at first maturity are estimated as 150 mm and 0.88 year respectively. This species spawns off Kakinada during December-August. The different mortality rates are estimated as Z = 6.65, M = 1.90 and F = 4.75 and the length and age at first capture as 158 mm and 0.98 year respectively. The yield per recruit analysis shows that: with t_c above 0.6 the Y_w/R increases with increased F without reaching maximum. The highest Yw/R, however, is obtained with tc at 0.6 only.

INTRODUCTION

THE FISHES of the family carangidae are an important group of exploited pelagic resources of India; an estimated average annual carangid catch of 38,685 tonnes was landed during 1981 and 1982 (CMFRI, 1982 ; 1983) forming 2.8% of the total marine landings of the country. Though this family is represented by about 50 species in Indian seas, only a few contribute to the fisheries at different places and *D. russelli* is the most dominant carangid landed by trawlers at Kakinada: an estimated annual average of 1229 t were landed during July 1979-June 1983 forming 83% of all carangids landed. Excepting the work of Sreenivasan (1982, 1983, 1984) from Vizhinjam, there is no information on the biology of *D. russelli* from India. The present paper deals with some aspects of biology and population dynamics of *D. russelli* on the basis of data obtained from commercial shrimp trawlers at Kakinada during July 1979-June 1983.

The author is grateful to Dr. P.S.B.R. James, Director, CMFR Institute for encouragement. He is thankful to Mr. M. Srinath for his suggestions on statistical analysis and to Mr. P. Ramalingam for assisting in the field as well as in the laboratory.

MATERIAL AND METHODS

Data on effort and catch were collected for about 18 days each month and samples for biological study were obtained at weekly intervals. The data obtained on each observation day were weighted to get the

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[2] Smith-Vaniz (1984) considered *Decapterus dayi* Wakiya as a junior synonym of *D. russelli* (Ruppell).

estimates for that day and the pooled days' estimates were weighted to get monthly estimated effort, catch and length composition of catch. The length data were grouped into 5 mm class intervals and the mid points of these groups were considered for estimation of growth. The parameters of von Bertalanffy growth equation were estimated using the monthly length frequency data obtained during March 1979-February 1983 and following the integrated method of Pauly (1980 a). The length-weight relationship was calculated following Le Cren (1951) using the formula log W = log a + b log L, where W = weight in grams, L = total length in mm, 'a' a constant and 'b' the exponent. The specimens were examined in fresh condition; each fish was measured and weighed to an accuracy of 1 mm and 0.5 g respectively. The stages of maturation were fixed following Kagwade (1971) and Sreenivasan (1981). Ova diameter measurements were taken from ovaries fixed in 4% formalin following the procedure of Clark (1934). From each ovary about 300 ova were measured using an ocular micrometer at a magnification where each micrometer divisi n (md) was eq al to 0.017 mm. The instantaneous rate of total mortality (Z) was estimated following the length-converted catch curve method of Pauly (1982). The natural mortality rate (M) was estimated assuming that 99% of fish by numbers would die if there was no exploitation by the time they attained t_{max} and by taking t_{max} as corresponding to L_{max} in the catch (Sekharan, 1975), or to $L\infty$ - 0.50 cm (Alagaraja, 1984) or to 95% of $L\infty$ (Pauly, 1983). The value of M was also obtained using the equation of Pauly (1980 b), taking the average water temperature as 27.2°C following Ganapati and Murthy (1954) and LaFond (1958). The length at first capture was estimated following Pauly (1984 a) and the yield in weight per recruit by following Beverton and Holt (1957) method.

TABLE 1. *Estimated annual effort and catches (t) of all carangids and* Decapterus russelli *by private trawlers at Kakinada (Values in parantheses show % increase or decrease over each previous year)*

Years	Effort		All carangid catch	Catch of *D. russelli*	% of *D. russelli* in all carangid catch
	Units	Tr. Hrs.			
1979-80	47,948	3,41,997	442	350	79.2
1980-81 ..	40,294 (—16.0)	3,29,179 (—3.7)	1,003 (+126.9)	900 (+157.1)	89.7
1981-82	50,462 (+25.2)	4,45,794 (+35.4)	1,652 (+64.7)	1,360 (+51.1)	82.3
1982-83	48,550 (—3.8)	3,19,864 (—28.2)	2,823 (+70.9)	2,305 (+69.5)	81.7

CATCHES AND EFFORT

The estimated annual catches of carangids by trawlers at Kakinada varied from 442 t in 1979-80 to 2,823 t in 1982-83 (Table 1); though there were fluctuations in the effort in different years, the catches showed considerable increase in succeeding years. The seasonal variations in the catches of carangids showed (Fig. 1) that peak periods of abundance varied during different years: there were major peaks during February 1982, 1983;

April 1980 or May 1981. A minor peak in abundance was observed during September 1979 and 1980. *Decapterus russelli* was the most dominant species in the catches and formed about 80-90% of carangid catches during different years (Table 1), though it contributed to the fishery significantly only during certain months particularly during January-April (Fig. 2).

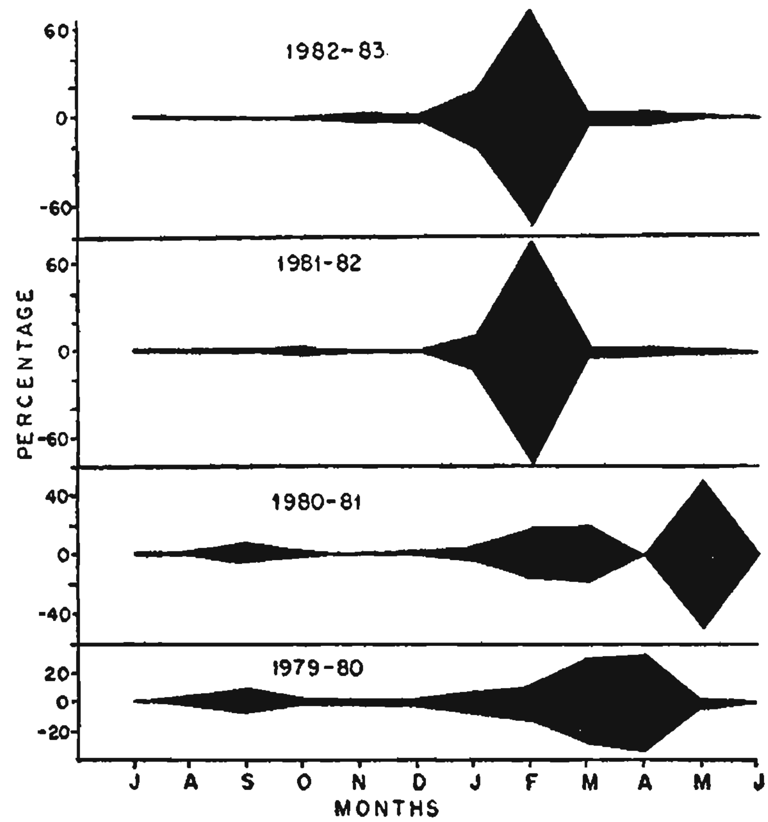

Fig. 1. Estimated monthly percentage of carangids in the total catch of each year.

Growth Parameters

A total of 8,984 specimens of the length range 52-217 mm were measured. The monthly modal lengths and growth curves drawn through majority of them are shown in Fig. 3 ; it may be seen that the curves are more or less parallel. The lengths attained at intervals of six months starting from the smallest modal length in each curve were read off these curves : in each curve, only the portion between the smallest and largest modal lengths was taken ; sometimes to enable reading the growth for 6 month period the portion of the curve slightly beyond the largest modal length was also taken. The values thus taken from all the curves were used to estimate the parameters of von Bertalanffy equation.

A plot of L_{t+1} against L_t (similar to that of Manzer and Taylor, 1947) shows that the observed points are well represented (Fig. 4) by the straight line ($r^2=0.89$). From this relation, the values of $L\infty$ and K were estimated as 232.3 mm and 1.08 per year respectively.

From the origin of the curve D (Fig. 3), the age of the smallest modal length at 67 mm was read as three months and taking this into account, the lengths at successive half years were estimated using the constants of the above regression for estimating t_0 (Fig. 5) ; the value was estimated as —0.08 year.

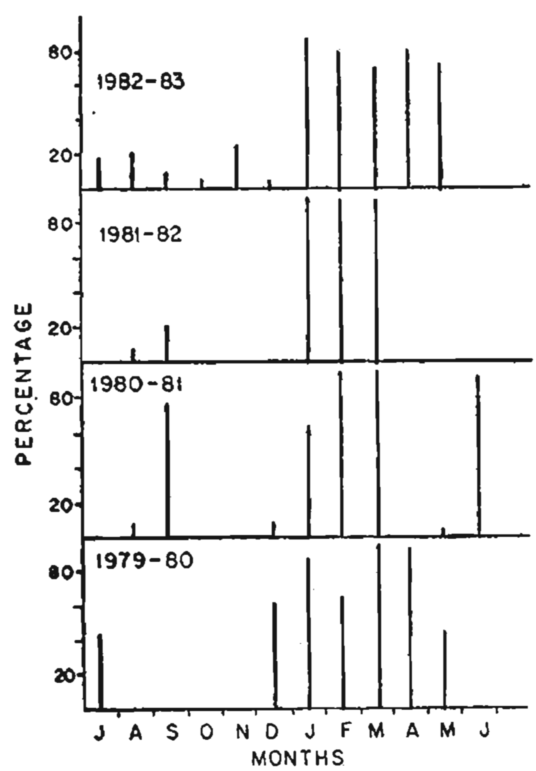

Fig. 2. Monthly percentage composition of *D. russelli* in the carangid catches of each month.

The estimated lengths at the completion of I, II and III years are 160, 208 and 224 mm respectively (Fig. 3). The maximum recorded length at Kakinada was 217 mm (age 2.4 years).

Length-Weight Relationship

Data of 267 females ranging from 132 to 201 mm in total length and from 19 to 87 g weight and 325 males ranging from 120 to 205 mm and 15 to 89 g were considered. The equations obtained for each sex were :

Females : $\log W = -5.97804 + 3.42534 \log L$ ($r^2 = 0.92$)

Males : $\log W = -5.88927 + 3.38898 \log L$ ($r^2 = 0.86$)

The analysis of covariance (Snedecor and Cochran, 1967) showed that the differences between regression coefficients and Y-intercepts of sexes were not significant at 5% level. Hence the data of sexes were pooled and the relationship for the species was calculated as :

$$\log W = -5.93433 + 3.40764 \log L \ (r^2 = 0.90)$$

The value of regression coefficient was tested against the theoretical value of 3 by the t-test ; it was significantly different from 3.

Maturation and Spawning

Length and age at first maturity : Only females were considered and individuals in stages III-VII of maturation were taken as mature. Fishes of 135 mm and above showed mature ovaries. On the basis of the percentage of mature fishes in each length group, length at first maturity could be taken as 150 mm (Fig. 6) whose age could be calculated as 0.88 year.

Spawning habits : Three specimens each of stages IV and V and one each of stages VI and VII were examined for ova diameter frequency distribution. Three types of ova were recognised in ovaries in stages IV and V, the first one representing immature ova with the diameter extending upto 4 md and the second one representing maturing ova with the diameters ranging from 5 to 18 md. The former were transparent and irregularly-shaped with the nucleus clearly visible and the latter were more or less spherical, yolked, translucent and the nucleus was not clearly visible. For the present study, ova upto 6 md were not considered as they were of no consequence in interpreting the periodicity of spawning. The third group Fig. 7) represented the mature ova with the diameters ranging from 19 to 32 md; these ova were spherical and opaque. In stage VI, in addition to the above, there was another group (Fig. 7) which represented the ripe translucent ova with a distinct oil globule; these ova were spherical and ranged from 33 to 48 md and the diameter of the oil globule ranged from 9 to 11 md.

The ova diameter frequency distribution in ovaries of different stages of maturation (Fig. 7) showed that the mode at 11-12 md in stage IV remained stationery in stage V, but in stage VI it had shifted to 17-18 md; the ova in this group were mature opaque and maturing. The mode at 23-24 md in stage IV had shifted to 27-28 md in stage V and then to 39-40 md in stage VI. In stage VII, in addition to the modes in maturing ova, there were two minor modes one each in mature opaque ova and ripe translucent ova. The situation therefore, indicates that the species probably spawns twice in a season in the sea off Kakinada.

Spawning season: Only females of and above the length at first maturity were considered. The frequency distribution of females in different stages of maturation (Table 2) suggests that *D. russelli* in the sea off Kakinada spawns during December-June the period sometimes extending upto August.

Mortality Rates

Total mortality rate: During 1982-83 the data were not available for several months, hence the data of this year were not used. Through the length-converted catch curves (Fig. 8), the values of Z were estimated to range from 4.78 to 8.75 with the average at 6.65.

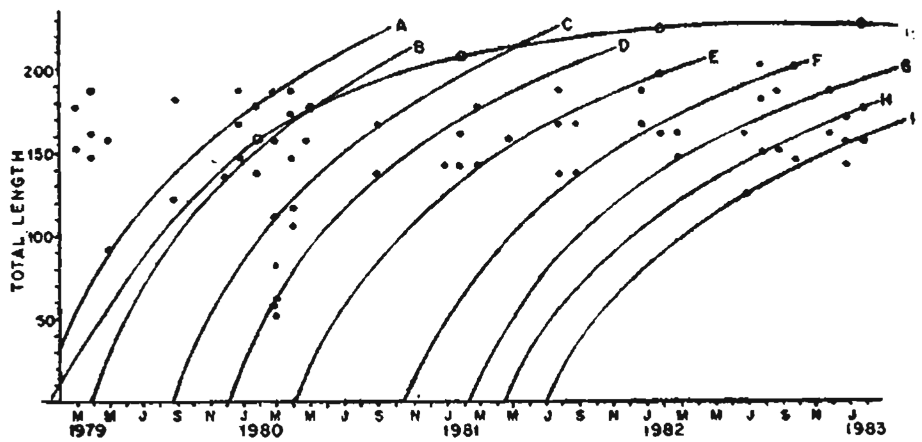

Fig. 3. Growth curves in *D. russelli* to estimate growth. The VBG curve is also shown.

Natural and fishing mortality rates: The values of M estimated by following different approaches are shown in Table 3. In the present study, however, the M value obtained by Sekharan's (1975) method at 1.90 was considered. Since the average total mortality during the period was estimated as 6.65, the present F value became 4.75.

Estimation of Length at First Capture

Since the gear operated was the same with the same cod end mesh size in all the three years, the data of these three years were pooled and a length converted catch curve was obtained to estimate the number of fish in the first length class that was fully selected (*i.e.*) the estimated number of fish corresponding to the first point in the straight descending portion of the length-converted catch curve. Taking this value, and the M value at 1.90, the length at first capture (L_c) was estimated as 158 mm (Fig. 9); the t_c could therefore be calculated as 0.98 year.

Yield per Recruit

The smallest length in the catch (52 mm) was taken as the length at recruitment (L_r) and its age at 0.15 year as t_r. The value of W_∞ was calculated as 134.4 g taking the value of L_∞ and the length-weight relationship.

The yield in weight per recruit (Y_w/R), at $M = 1.9$ and five values of t_c corresponding to L_c values of 108, 118, 128, 148 and 158 mm (Fig. 10) against F showed that, within the range of F values considered :

1. With t_c ranging from 0.50 to 0.66, the Y_w/R was greater if t_c was greater and attained maximum at greater values of F if t_c was greater ; there was however no maximum if t_c was 0.66.
2. With t_c above 0.66, the Y_w/R increased with increased F without attaining a maximum.

The Y_w/R as a function of t_c with the present F (Fig. 11) showed that maximum Y_w/R was obtained with t_c at only 0.6, whereas the present t_c was 0.98.

It is thus clear that highest yield of *D. russelli*, with the present F or by increasing the same, can be obtained only if the t_c is 0.6. It is also clear, however, that yield can still be increased from the present level, without decreasing t_c, but by increasing the effort, though the yield will be less than when t_c is 0.6.

Table 2. *Gonadal condition of adult females of* D. russelli *in different months (data of all years pooled)*

Months	Females examined (No)	% of maturation stages II	III+IV	V+VI	VII
July	—	—	—	—	—
August	22	86.4	4.5	4.5	4.5
September	6	100.0	—	—	—
October	13	100.0	—	—	—
November	—	—	—	—	—
December	41	80.5	14.6	4.9	—
January	157	44.6	32.5	20.3	2.5
February	198	1.0	40.9	54.5	3.5
March ..	46	15.2	69.6	13.0	2.2
April ..	9	55.5	45.5	—	—
May ..	19	63.1	36.9	—	—
June ..	—	—	—	—	—

Discussion

The trawling experiments in the sea off Kakinada in the depth range 5-100 m by Narayanappa *et al.* (1968), Satyanarayana *et al.* (1972) and Satyanarayana and Narayanappa (1972) have shown that *Decapterus* spp. are abundant beyond 50 m depth. According to Muthu *et al.* (1977), the abundance of these fishes during February-April off Kakinada may be due to possible upwelling in the region. On the basis of data of 10 year period (1969-'79) it was shown (CMFRI, 1981) that *Decapterus* spp. are abundant in the catches during January-March at Kakinada. The greater returns of *D. russelli* during January-April, as observed in the present study, may be because the boats conduct fishing in the relatively deeper waters during this period.

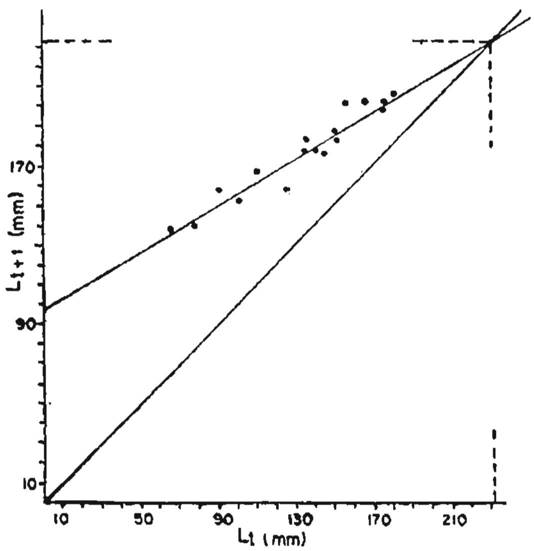

Fig. 4. Plot of L_{t+1} against L_t in *D. russelli* a intervals of 6 months.

It is known (Qasim, 1973) that spawning in majority of Indian marine fishes is prolonged lasting 7-9 months in a year and the present observation on *D. russelli* are in agreement with this. The conclusion on spawning period as December-August is in conformity with the observations of Rao *et al.* (1977) along the Indian west coast : they observed scads with ripe and running ovaries during October-August. The ova diameter frequency distribution in mature and ripe ovaries (Fig. 7) indicates that spawning takes place in two batches during a season. The growth curves (Fig. 3) show that 2-3 broods are recruited to the fishery in different years indicating that ova are also released in 2-3 spawnings a year. Though the data on hand do not give evidence of spawning in three batches in a year, the observations of Rao *et al.* (1977) show that the scad spawns over an 'extended period with two or three peaks in an year'.

TABLE 3. *Estimated values of M obtained by different methods along with the values of L_{max} and t_{max} in* D. russelli *at Kakinada*

Method adopted		L_{max} (mm)	t_{max} (years)	M
Sekharan (1975)	In the catch:	217	2.4	1.9
Alagaraja (1984)	$L\infty$-5 mm:	227.3	3.5	1.3
Pauly (1983)	95% $L\infty$:	220.7	2.7	1.7
Pauly (1980 b)	—		—	2.0

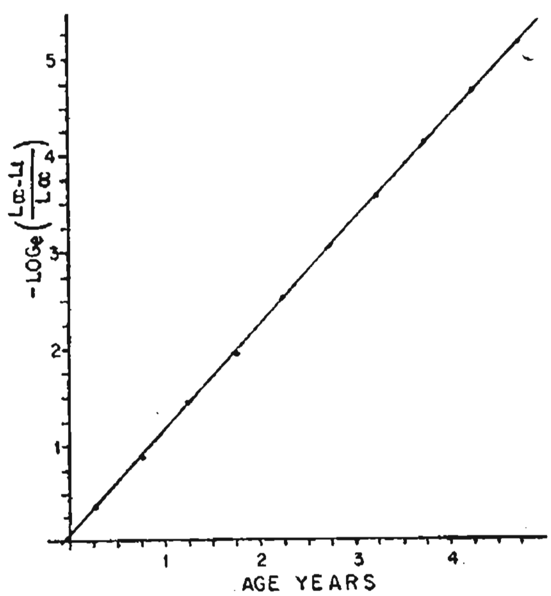

Fig. 5. Estimation of t_0 in *D. russelli*.

From Vizhinjam along the southwest coast, Sreenivasan (1983) estimated the growth parameters of *D. dayi* (=*D. russelli*) as $L\infty = 260$ mm fork length (288 mm TL*), K=0.74 per year and $t_0 = -0.13$ year whereas the same

* Sreenivasan (1983) considered fork length only; the total length was calculated from TL-FL relationship given by him.

from Kakinada were estimated as 232.3 mm TL, 1.08 per year and -0.08 year respectively. The length range and maximum length at Vizhinjam (20-219 mm FL or 21-243 mm TL and 271 mm FL or 300 mm TL) are greater than those at Kakinada (52-217 mm TL and 217 mm TL); these differences appear to be responsible for the differences in the estimated values of growth parameters though such

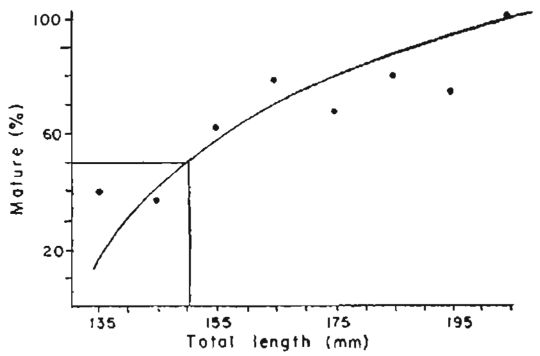

Fig. 6. Percentage of matured individuals of *D. russelli* in each length group.

differences in growth parameter estimates can also occur (for various reasons) in different stocks of the same species and during different periods in the same stock. Further, the non availability of data in some months (Fig. 2, 3) and the narrow length range in the catch in most months (probably because of size specific shoaling behaviour) which resulted in the data having over 90% of the modal values between 100 and 200 mm (Fig. 3) only, could also possibly have lead to the differences in the growth parameter values.

According to Munro and Pauly (1983) the frequency distribution of the values of ϕ ($\phi = \log K + 0.67 \log W_\infty$) of a particular species from different areas produces normal distribution and that the growth parameter estimates pertaining to a species of a particular area have to be checked, if the ϕ value from that region does not fit into the already known range of normal distribution (obviously assuming that the ϕ values producing the normal distribution have *indeed* resulted from reliable growth estimates). In the case of *D. dayi* (=*D. russelli*) from Vizhinjam, the ϕ value can be calculated as 1.6 (taking different parameter values from Sreenivasan 1982, 1983) and the one from Kakinada as 1.5 which are close to each other.

It is well-known that estimation of natural mortality rate in exploited fish populations is difficult (Cushing, 1981; Alagaraja, 1984). In the absence of knowledge of effective effort pertaining to a particular species in a multispecies fishery, it is not possible to estimate M with the help of the regression of Z against effort. It is also clear (Fig. 8) that Z showed an increasing trend over different years though such a trend is not present in the effort (Table 1) which is due to the fact that the effort is not effective effort for the species. In the present study, the M value was estimated following different approaches (Table 3). In the Sekharan's (1975) method, the value of t_{max} in a virgin stock is required (Sekharan, 1975; however, considered t_{max} in the catch) and this value is not available for the stock of *D. russelli* at Kakinada. Though Alagaraja (1984) suggested that maximum length in a population (to calculate t_{max} value in a 'virgin stock, and to estimate M) could be taken as L_∞ —0.50 cm, the reasons for doing so were not mentioned; it is also not known whether this can be done uniformly for all species having widely varying L_∞ values. Pauly (1983) suggested that L_{max} could be taken as 95% of L_∞ following Taylor (1962). It is, therefore, clear that all these approaches are subjective. Recently Alagaraja *et al.* (1986) estimated M in shrimps 'Assuming that when X% of L_∞ is reached by fish X% of mortality takes place, one gets $M/K = 1$ for all X'. Though these authors have not stated, it is also necessary to assume $t_0 = 0$, as otherwise M/K is not always equal to 1. This approach however, presupposes $M/K = 1$ (which means $M = K$)

whereas the M/K in fishes is known to range from 1 to 2.5 (Beverton and Holt, 1959). The equation of Pauly (1980 b) does not require assumptions or adjustments as above, but according to Pauly (1984 b), the value obtained by this equation 'may be biassed upward in the case of strongly schooling fishes' and therefore this approach cannot be followed in *D. russelli* which is known to form schools. Under the circumstances it is not possible to state which of the methods considered here gives the most satisfactory estimate of M for the species under consideration. The M value obtained by Sekharan's method (Table 3) was taken into account in this study, because the maximum length in the catch was considered as L_{max} without any adjustment; the value obtained this way is only slightly less than that obtained by Pauly's (1980 b) equation and slightly more than that obtained by Pauly's (1983) method (Table 3). The value obtained by Alagaraja's method is, however much smaller than those obtained by other methods.

The value of L_c at 158 mm as obtained by following Pauly's (1984) method was used in the present study. Taking the depth ratio (standard length/maximum body depth) of this species from Kakinada (as 4.2) and using the nomogram given by Pauly (1983), the selection factor of *D. russelli* can be read as 2.5. Using the cod end mesh size of the gear under use (average 15.6 mm), the L_c value can be calculated as 39 mm which is less than even the length of the smallest fish caught (52 mm). The L_c obtained by the Pauly's (1984) method is therefore much greater than the theoretically possible value. It may be mentioned in this

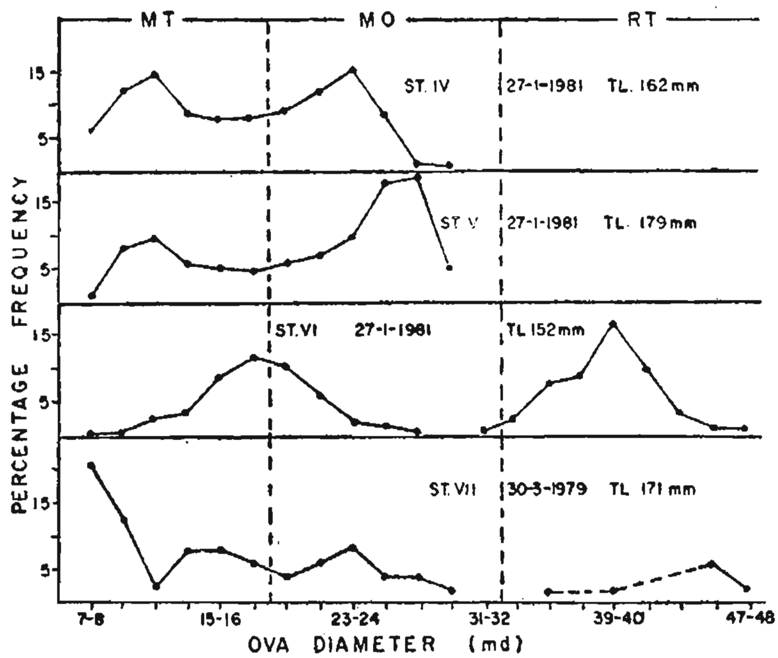

Fig. 7. Ova diameter frequency distribution in ovaries of different stages of maturation. MT, MO and RT indicate the diameter range of maturing translucent ova, mature opaque ova and ripe translucent ova respectively.

connection, that fishing being prawn-biassed, the effort is not uniformly distributed in the fishing grounds and this can result in the non-representativeness in the catches, of the lengths in the populations of finfishes i.e. fishes of in the Lc values shown above. It may be argued that since *Decapterus* spp. are pelagic, catches by bottom trawl are not representative of the population. It may not hold good, because the resources surveys conducted by

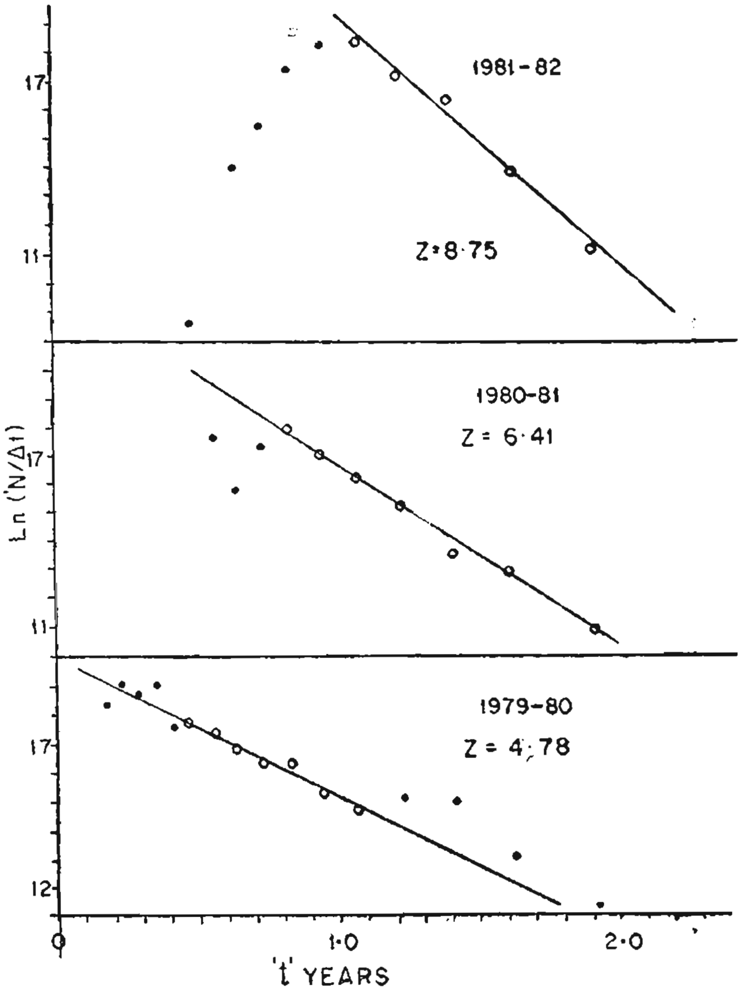

Fig. 8. Length-converted catch curves in *D. russelli* during different years.

certain smaller lengths are not available in areas where fishing activity is concentrated, as otherwise one would expect smaller fishes (smaller than the smallest fish caught) to be retained in the gear in large numbers since the cod end mesh size is very small. This could probably be the reason for the wide difference Rao *et al.* (1977) clearly show that the scads are distributed in dense vertically extended schools at or near the bottom during day and ascend to surface layers at night ; according to Lowe-McConnel (1977) also, the neritic pelagic fishes like the scad, have the habit of forming demersal shoals congregating near bottom depressions by day and moving up to feed at night. It may noted that the trawlers at Kakinada conduct fishing during day time.

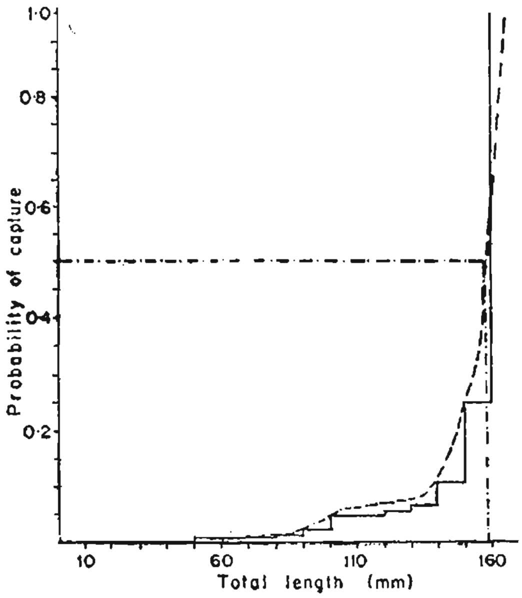

Fig. 9. Estimation of length at first capture (Lc) in *D. russelli* by trawlers at Kakinada.

The non availability of smaller fishes in the presently fished areas could probably be due to the fact that ***Decapterus*** spp. are more abundant beyond 50 m depth (*Vide* supra) or, as already observed by Rao *et al.* (1977), the current system is such that young scad probably cannot enter the fishing grounds to be captured. The data of different years also show that fishes of the length range 52-89 mm were caught only during 1979-80 and not in other years. Since it is known (Fig. 10) that tc determines the shape of the yield curve, there is need to determine Lc of *D. russelli* by experimental fishing using commercial gear in areas where it occurs in abundance for any realistic advice on optimum mesh size.

The yield per recruit analysis shows that there is need to decrease the present cod end mesh size and then to increase effort to get increased Yw/R (Fig. 10, 11). In view of the uncertainty, as shown above in the estimated

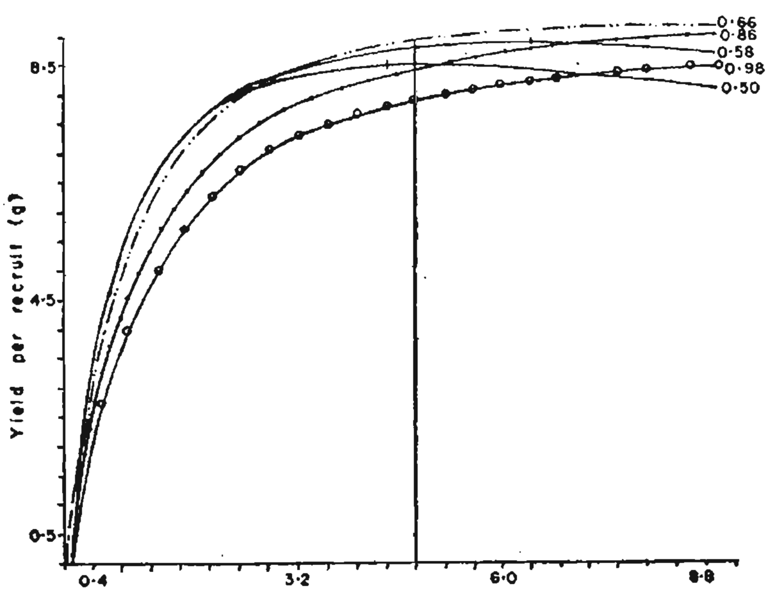

Fig. 10. Yield in weight per recruit as a function of fishing mortality rate in *D. russelli*. The numerals pertain to ages at first capture and the vertical line the present F.

value of L_c in the present study, this regulation should not be implemented. The data of different years show that the smallest modal lengths (excluding the fishes of the length range 52-89 mm caught only during 1979-80) are at 102 and 107 mm. If the average of these two values at 105 mm is taken as the present L_c the present t_c works out to 0.48 year which is almost the same as one of the t_c values (=0.50) considered (Fig. 10). In this case the Y_w/R reaches the maximum at F=4.4 and then declines slowly with increased F, thus indicating that the effort has to be decreased (present F=4.75). The Y_w/R as a function of t_c (Fig. 11) shows that maximum Y_w/R is obtained at t_c=0.6. If the present t_c is indeed 0.5 (as mentioned above) there is scope to increase the cod end mesh size to get increased and sustained yield. Further, (1) since the length at first maturity and L_c are at 150 mm and 158 mm respectively, reduction in mesh size will affect the recruitment adversely and should not be recommended; (2) since the Y_w/R does not attain maximum with increased F at higher levels of t_c (Fig. 10), there is no harm to the stock even if the mesh size is increased. Finally it may be pointed out that whichever may be the optimum mesh size for *D. russelli*, any regulation of mesh size or effort has to take into consideration the possible effect of such regulation on other species since the trawl fishery is a multispecies one.

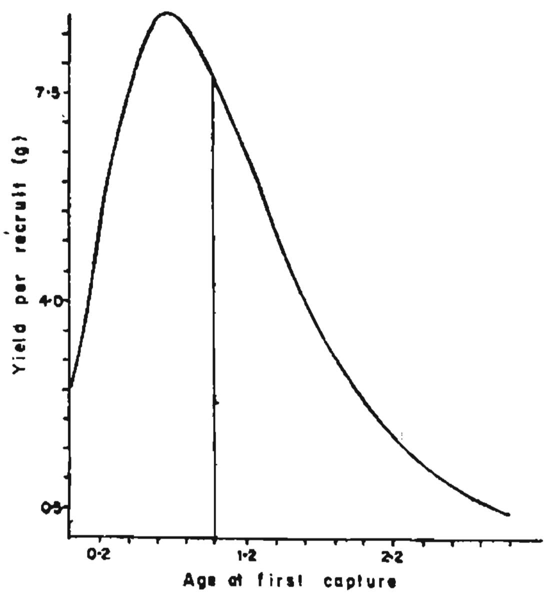

Fig. 11. Yield in weight per recruit as a function of age at first capture. The vertical line indicates the present age at first capture.

REFERENCES

ALAGARAJA, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian J. Fish.*, 31 (2).

———, M. J. GEORGE, K. NARAYANAKURUP AND C. SUSEELAN 1986. Yield-per recruit analyses on *Parapenaeopsis stylifera* and *Metapenaeus dobsoni* from Kerala State, India. *J. Appl. Ichthyol.*, 2 : 1-11.

BEVERTON, R. J. H. AND S. J. HOLT 1957. On the dynamics of exploited fish populations. *Fishery Invest. London*, (2) 19 : 533 pp.

——— AND ——— 1959. A review of lifespans and mortality rates of fish in nature and their relation to growth and other physiological characteristics. Ciba Foundation Colloquia on ageing. *In* : G. E.W. Wolsenholmy and M. O'Connor (Ed.) *The lifespan of animals*, 5 : 142-177.

CLARK, F. N. 1934. Maturity of the California Sardine (*Sardina caerulea*). *California Div. Fish., Game*, 42 : 1-49.

CMFRI 1981. Commercial trawl fisheries off Kakinada during 1969-1978. *Mar. Fish. Infor. Serv. T & E Ser.*, 31 : 1-6.

——— 1982. Trends in marine Fish production in India—1981. *Ibid.*, 4 : 1-33.

——— 1983. Trends in marine Fish production in India—1982-'83. *Ibid.*, 52 : 1-21.

CUSHING, D. H. 1981. *Fisheries biology : A study in population dynamics*. The University of Wisconsin Press, 2nd Edition, 295 pp.

GANAPATI, P. N. AND V. S. R. MURTY 1954. Salinity and temperature variations of the surface waters off Visakhapatnam Coast. *Andhra Univ. Mem. Oceanogr.*, 1 : 125-142.

KAGWADE, V. N. 1971. Maturation and spawning of the horse mackerel *Caranx kalla* (Cuv & val). *Indian J. Fish.*, 15 : 207-220 (1968).

LAFOND, E. C. 1958. Seasonal cycle of sea surface temperature and salinity along the east coast of India. *Andhra Univ. Mem. Oceanogr.*, 2 : 12-21.

LECREN, E. D. 1951. Length-weight relationship and seasonal cycle in gonad weight and condition of the perch (*Perca fluviatilis*). *J. Anim. Ecol.*, 20 : 201-219.

LOWE-MCCONNELL, R. H. 1977. *Ecology of fishes in the tropical waters.* The Institute of Biology's Studies in Biology. Edward Arnold ; London, 76 : 1-64.

*MANZER, J. I. AND F. H. C. TAYLOR 1947. The rate of growth in lemon sole in the strait of Georgia. *Prog. Rep. Fish. Res. Board Pac. Coast. Stn.*, 72 : 24-27.

MUNRO, J. L. AND D. PAULY 1983. A simple method for comparing growth of fishes and invertebrates. *Fishbyte*, 1 (1) : 5-6.

MUTHU, M. S., K. A. NARASIMHAM, G. SUDHAKARA RAO, Y. APPANNASASTRY AND P. RAMALINGAM 1977. On the commercial trawl fisheries off Kakinada during 1967-70. *Indian J. Fish.*, 22 : 171-186 (1975).

NARAYANAPPA, G., D. A. N. RAJU AND A. V. V. SATYANARAYANA 1968. Certain observations on the otter trawl operations carried out in the inshore and deep waters off Kakinada. *Proc. Indo-Pacific Fish. Counc.*, 13 (3) : 450-455.

PAULY, D. 1980 a. A selection of simple methods for the assessment of tropical fish stocks. *FAO Fish. Circ.*, 729 : 54 pp.

——— 1980 b. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. int. Explor. Mer.*, 39 : 175-192.

——— 1982. Studying single species dynamics in a tropical multispecies context. *In :* D. Pauly and G. I. Murphy (Ed.) *Theory and management of tropical fisheries.* ICLARM conference proc., 9 : 360 pp. ICLARM, Manila : Philippines and CSIRO, Cronulla : Australia, 33-70.

——— 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. pap.*, 234 : 52 pp.

——— 1984 a. Length-converted catch curves : a powerful tool for fisheries research in the tropics — Part II. *Fishbyte*, 2 (1) : 17-19.

——— 1984 b. Fish population dynamics in tropical waters : a manual for use with programmable calculators. *ICLARM studies and Reviews*, 8 : 325 pp.

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

RAO, K. V. N., M. KUMARAN AND J. SANKARASUBRAMANIAN 1977. Resources of horse mackerel off the southwest coast of India. *Seafood Export J.*, 9 (8) : 1-16.

SATYANARAYANA, A. V. V. AND G. NARAYANAPPA 1972. A review of experimental trawling from small and medium sized mechanised vessels off Kakinada. *Fish. Technol.*, 9 : 97-103.

———, ——— AND D. A. N. RAJU 1972. On the comparative experiments with a four-beam and two-beam trawls on the east coast. *Fish. Technol.*, 9 : 169-179.

SEKHARAN, K. V. 1975. Estimates of the stocks of oilsardine and mackerel in the present fishing grounds off the west coast of India. *Indian J. Fish.*, 21 (1) : 177-182 (1974)

SMITH-VANIZ, W. F. 1984. Carangidae. *In :* W. Fischer and G. Bianchi (Ed.) *FAO species identification sheets for fishery purposes.* Western Indian Ocean (Fishing area 51), 1.

SNEDECOR, G. W. AND W. G. COCHRAN 1967. *Statistical Methods.* Oxford and IBH publishing Co., New Delhi, Sixth edition. 593 pp.

SREENIVASAN, P. V. 1981. Observations on the fishery and biology of *Megalaspis cordyla* (Linnaeus) at Vizhinjam. *Indian. J. Fish.*, 25 : 122-140 (1978).

——— 1982. Length-weight relationship in *Decapterus dayi* Wakiya. *Ibid.*, 28 : 283-286 (1981).

——— 1983. Age and growth of the scad *Decapterus dayi* Wakiya. *Ibid.*, 29 : 144-150 (1982).

——— 1984. Feeding biology of the scad *Decapterus dayi* Wakiya. *J. mar. biol. Ass. India*, 21 : 97-102 (1979).

*TAYLOR, C. C. 1962. Growth equation with metabolic parameters. *J. cons. int. Explor. Mer.*, 27 : 270-286.

* Not referred to in original.

PART III MIXED FISHERIES ASSESSMENT

CONTRIBUTION 19

MURTY, V. SRIRAMACHANDRA. 1987. Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada. J. mar. biol. Ass. India, 27 (1&2): 39-48 (1985).

J. mar. biol. Ass. India, 1985, **27** (1 & 2) : 39-48

CONTRIBUTION 19

MULTISPECIES STOCK ASSESSMENT WITH PARTICULAR REFERENCE TO MAJOR DEMERSAL FISH SPECIES IN THE TRAWLING GROUNDS OFF KAKINADA

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ABSTRACT

On the basis of data of four dominant demersal finfish species landed by trawlers at Kakinada, the method of multispecies stock assessment using the Beverton and Holt model is described and the problems involved are discussed. It is shown that with the present gear in use, the effort has to be reduced by about 6% to get MSY or with the present effort unchanged, the cod end mesh size has to be increased by 28% to get MSY. The latter option is considered to be the best because the present lengths at first capture are less than the lengths at first maturity, a situation that, if allowed to continue, can lead to recruitment overfishing.

INTRODUCTION

THE TROPICAL marine fisheries, particularly those exploiting demersal resources, take several species belonging to different genera and families having different maximum lengths, growth characteristics, mortality rates, *etc.* For various reasons— both biological and non-biological—the estimation of important parameters of individual species in these areas is still difficult, though methods to obtain reasonably accurate estimates have recently been developed (Pauly, 1980 a, 1980 b, 1980 c, 1982, 1983 ; Pauly and David 1981 ; Jones, 1981 ; Jones and van Zalinge, 1981 ; Srinath and Alagaraja, 1982 ; Alagaraja, 1984). The available methods for stock assessment of exploited fish populations fall under two main categories : the surplus production (Schaefer, 1954) and the analytic (Beverton and Holt, 1957) models. In the former, all the species together are treated as one species and the data required are only effort and catch for over a number of years. Though this model appears to be good for stock assessment of tropical multispecies fisheries, it has the significant draw back that it 'is ostensibly empirical with no theoretical basis.' (Larkin, 1982) and, 'real fish stocks do not fit the simple models '; besides, the curve of catch as a function of effort usually does not have such a sharply defined maximum as the parabola corresponding to the simplest assumption nor does the maximum always occur ' tidily at half the unexploited population ' (Gulland, 1983). Further, ' what we gain in simplicity with the surplus production models has the cost of a number of assumptions on the dynamics of fish stocks, which may be (and nearly always are) impossible to justify ' (Sparre, 1985). On the other hand, the analytic model, which takes into account the growth, mortality, *etc.* of a particular species stock, has a major advantage of the ' existence of an established body of theory and methods for dealing with single species ' (Larkin, 1982). However, since several species are exploited by several gears in the tropical seas like those of India, single species assessments do not generate meaningful

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management options. So far as the author is aware, there has not been any attempt to assess multispecies stocks using analytic models excepting Munro (1983) who considered the problem in general terms and Mennes (1985) who attempted stock assessment of sparid species off western Sahara region using his (Mennes, 1983) computer programmes. From India, there has been practically no attempt in this regard.

Among the demersal fin fishes landed by private trawlers at Kakinada, sciaenid, leiognathid and nemipterid fishes are most dominant and *Johnius carutta*, *Leiognathus bindus*, *Secutor insidiator* and *Nemipterus japonicus* are most dominant in these three groups. The present paper describes the method of assessing multispecies stocks, taking into account the above four species. Studies on the biology, mortality rates and yield per recruit of these four species were made earlier (Murty, 1983 a, b, 1984 a, b, MSS).

The author is thankful to Dr. P. S. B. R. James, Director, CMFRI for the encouragement and to Mr. C. Mukundan, Head of Demersal Fisheries Division, CMFRI for the useful criticism. Thanks are due to Mr. P. Ramalingam for the assistance in the collection and analysis of data.

MATERIAL AND METHODS

Catch and effort : Data were collected from the landings of private trawlers operating off Kakinada (Lat. 16°35'-17°25' N ; Long. 82°20'-83°10' E). Boats of three different sizes operate in the region (CMFRI, 1981). Since the *Pomfret-Royya* category is the most dominant one, the effort (units as well as trawling hours) put in by this category was taken as standard effort and all the demersal groups landed were together considered as one group for standardising the effort. The data on effort and catch were collected for about 18 days each month and samples for biological study were collected at weekly intervals. The data of each observation day were given weightages to ultimately obtain monthly estimates.

Estimation of parameters : Parameters of growth in length were estimated earlier (Murty, MSS) using the data of 1980-'83 and the integrated method of Pauly (1980 a) in *N. japonicus*, *J. carutta* and *S. insidiator* whereas in *L. bindus* they were estimated using the data of 1979-'81 and following the modal progression method. For estimating all other parameters and yield, the data of 1980-'83 only were used.

The coefficient of total mortality (Z) was estimated following the length-converted catch curve method of Pauly (1982) ; the average of the four-year period was taken as the present value. The coefficient of natural mortality (M) was calculated using Pauly's formula (1980 b) taking the average water temperature as 27.2° C and K per year.

The length at first capture (L_c) was estimated following Pauly (1984) and the smallest length in the catch was taken as length at recruitment (Lr).

Yield-per-recruit : The yield in weight per recruit (Yw/R) was calculated using the well-known Beverton and Holt (1957) yield equation. In each species the value of W_∞ was calculated with the help of Length-weight relationship and the estimated value of L_∞.

Multispecies assessment : The values of the catchability coefficient (q=F/E) were calculated following Ricker (1975) and Pauly (1980 c), taking into account the present value of fishing mortality rate (F) of each species and the present average annual effort (E). The resultant values were used to derive values of F : taking a set of values of effort, values of F for each species corresponding to the same effort were calculated (F=Eq). The F values thus obtained were used to calculate Yw/R in each species ; this enables plotting of yield per recruit against effort instead of against F.

For each species, the selection factors (SF) of the gear under operation were calculated as SF=present L_c/present cod end mesh size (Jones, 1976). The cod end meshes (stretched) were found to vary from 15 to 20 mm with the average at 15.6 mm, hence this was taken as the present cod end mesh size. A set of values of cod end mesh sizes (MS) were taken L_c values for each species corresponding to these mesh sizes were calculated as L_c=SF X MS. These L_c values were converted into t_c and the t_c values thus obtained were used to calculate Yw/R, thus providing to plot Yw/R against mesh size instead of against t_c.

In each species, the present values of F and Yw/R were taken and the present biomass per recruit (B/R) was calculated as Yw/R÷F. The average biomass (B) of each species in the fishing ground was calculated as Y/F where Y is the annual average catch of a particular species and F the present value of that species. From these values, the recruitment (R) was calculated as B÷B/R and the resultant value was taken as constant. In each species, the Yw/R values at different levels of effort or mesh size were multiplied by the R value of that species to enable to obtain yield. The yield values of all species corresponding to a particular effort level or cod end mesh size were pooled to get a yield curve common to all species as a function of effort or mesh size.

The values of effort or mesh size against which maximum yield is obtained were considered as those giving maximum sustainable yield (MSY).

Observations and Results

Catches: The demersal component in the catch during the period under study (1980-83) formed about 66% of the total trawl catch. Sciaenids, silverbellies and threadfinbreams together contributed about 2670 tonnes (annual average, Table 1) forming about 18.5% of total trawl catch and 28.1% of total demersal catch. An estimated annual average of 1,313 tonnes of the four species under consideration were landed, together forming about 50% of the above three groups. Except *S. insidiator*, the catches of which showed an increasing trend in successive years irrespective of fluctuations in effort (Table 1), there is no clear trend in the landings of the other three species.

Table 1. *Particulars of catches (tonnes) of different groups and species and the effort during different years by private trawlers at Kakinada.*

	1980	1981	1982	1983	Average
Total trawl catch	9,911	9,275	16,554	21,857	14,399
Catch of demersal groups	7,155	6,928	9,854	14,053	9,498
Catch of sciaenids, silver-bellies and threadfin breams	2,348	1,641	2,712	3,977	2,670
N. japonicus	261	201	632	365	365
J. carutta	410	132	60	167	192
L. bindus	269	246	428	612	389
S. insidiator	168	252	323	725	367
Standard effort					
No. of units ..	48,144	42,954	62,000	50,450	50,887
Trawling hours ..	3,22,655	3,84,436	4,59,599	3,28,461	3,73,788

Parameters of yield equation : The estimated values of different parameters are shown in Table 2. It is observed that in all four species, the lengths at first capture are smaller than those at first maturity.

Estimation of yield : The yield in weight as a function of effort (Fig. 1) shows that MSY is obtained at different effort levels in different species with the present gear in use ; in *S. insidiator*, however, there is no maximum in the yield. In *L. bindus* and *J. carutta*, the present effort is greater than the one that gives MSY whereas in *N. japonicus* it is slightly less. The pooled yield curve of all species, however, shows (Fig. 1) that there is scope to increase effort to get MSY, but to get the same, the effort should be 128% of the present and the yield will only be 100.6% of the present (Fig. 2). Further, this increase in yield is obviously only due to increase in yield of *S. insidiator*—a smaller species (Table 2) whereas there is bound to be a decline if the effort is increased in the yield of the other three species (Fig. 1), two of which attain greater lengths (Table 2).

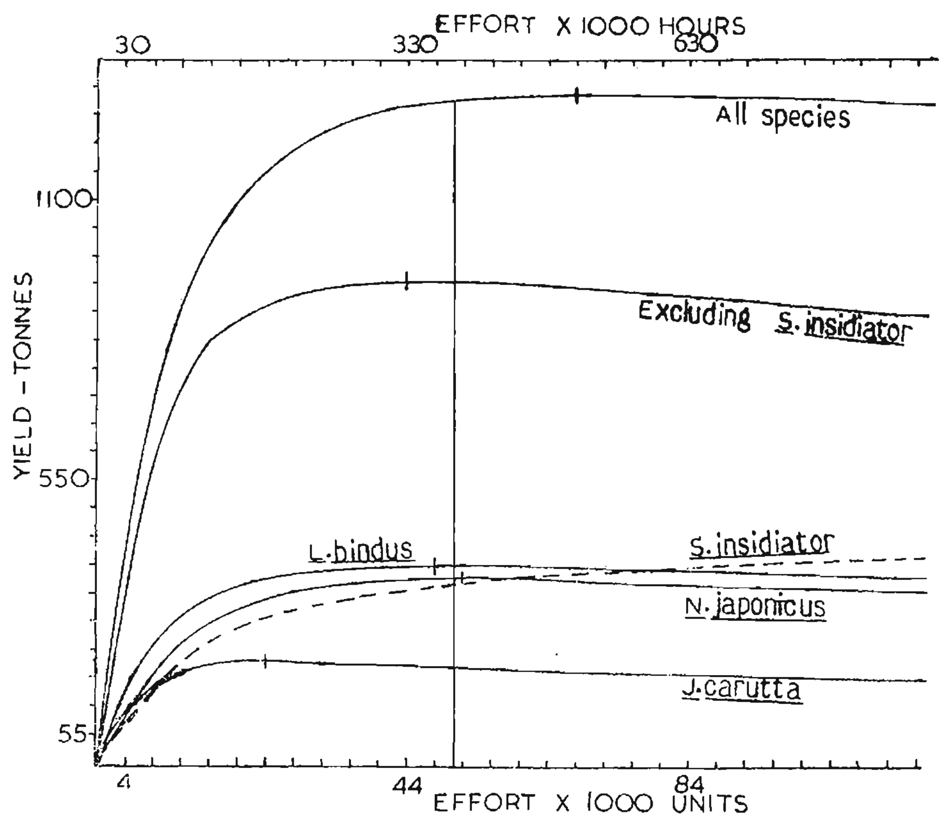

FIG. 1. Yield as a function of fishing effort with the present gear. The smaller vertical lines on each curve indicate the MSY and the bigger vertical line the present effort.

If *S. insidiator* is ignored, the MSY of the other three species together can be obtained at an effort level slightly less than (88% of the present) the present one (Fig 1 and 2). Since decrease in effort does not result in any harm to the resource of *S. insidiator*, decreasing the same slightly will ensure sustained returns of these commercially valuable species.

The yield as a function of cod end mesh size (Fig. 3) with the present rates of mortality (Table 3) operating, shows that for all species except *S. insidiator*, the present mesh size is much less than that which gives MSY. In all the four species together, the MSY is obtained at a mesh size slightly less than the present one, *i.e.* at about 96% of the present mesh size (Fig. 4)—this situation, again, is brought about by *S. insidiator*. If this species is ignored, the mesh size can be increased to about 135% of the present, to get over 110% of the present yield of the other three species (Fig. 4).

It was also observed (Murty, MSS) in the cases of *N. japonicus*, *J. carutta* and *L. bindus* that the effort giving maximum yield is greater if the age at first capture is increased. For the management of the resources of these species (ignoring *S. insidiator* for reasons explained above) thus, the following options are available.

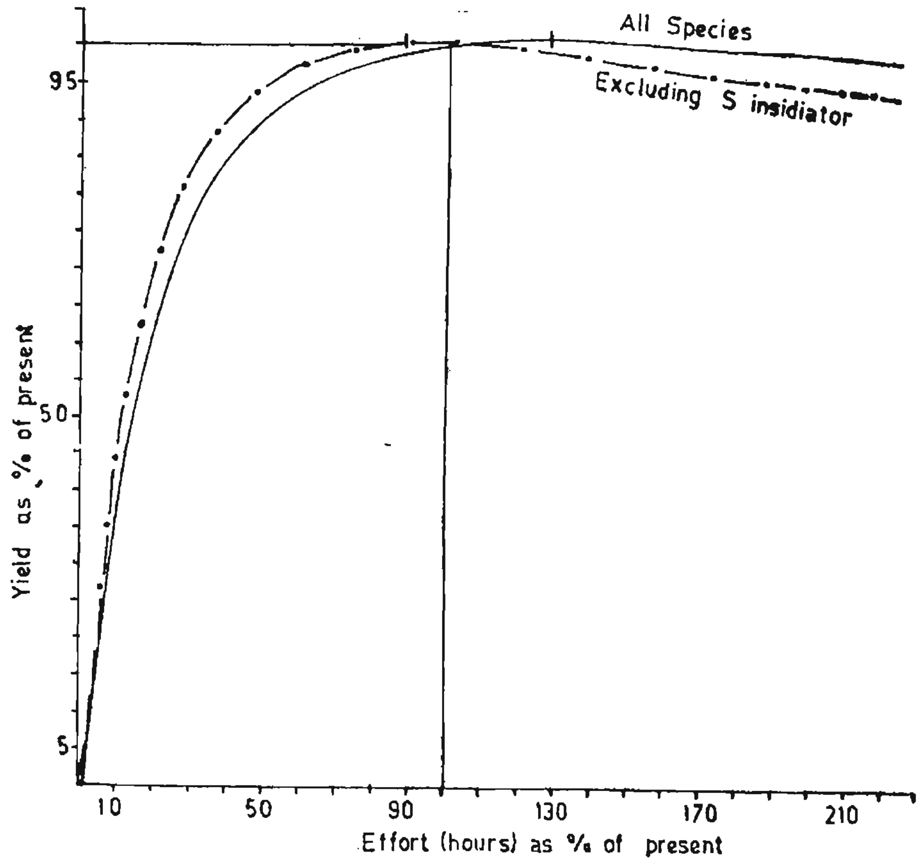

FIG. 2. Yield as percentage of present against effort-also as percentage of present. The smaller vertical lines indicate maximum values and the horizontal and vertical lines the present values.

(*i*) to decrease the present effort by about 6% and to retain the present cod end mesh size ;

(ii) to increase the cod end mesh size about 20 mm and to retain the present effort, or

(iii) to increase both cod end mesh size and effort.

Of these, the second one appears to be better because, while giving sustained yields, this measure will also ensure adequate recruitment.

Discussion

Among the available methods of estimating natural mortality rate of exploited populations because of lack of knowledge of effective effort in respect of a particular species and, because it is also known that any attempt to relate multispecies effort to Z of a particular species may, not only result in unrealistic estimates but in certain cases negative values also (Ricker, 1975; Pauly, 1982). Though the

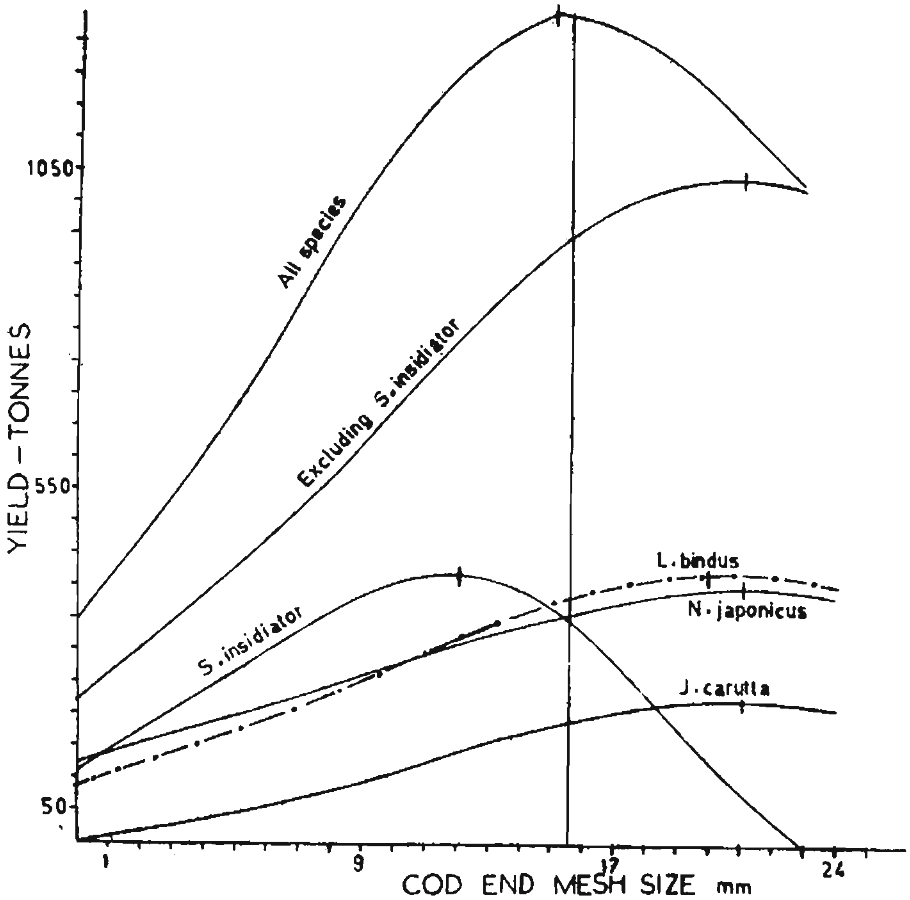

FIG. 3. Yield as a function of cod end mesh size with the present effort unchanged. The smaller vertical lines indicate MSY and bigger vertical line the present cod end mesh size.

the one in which the changes in total mortality are related to changes in fishing effort using the equation Z=M+qf (Beverton and Holt, 1957) gives an accurate estimate in addition to giving an estimate of catchability coefficient. This was not possible in the present work equation of Pauly (1980 b) helps in estimating a reasonably reliable value of M, the value of the other constant in the above equation — the q — has to be estimated through some other method. Pauly (1980 c) states that the method of obtaining this as a ratio of fishing mortality rate of a particular species and effort (even a multispecies one), ' can now be used as a routine method, since it is easier to estimate M than to estimate q '. Although it may appear that the q value thus obtained cannot be regarded as realistic for the same reason as pointed out above, it is believed that in multispecies assessments, this approach, which takes into account the catchabilities of all species, can be followed with reasonable justification because :

(*a*) ' each unit of fishing gear will generate a certain amount of mortality in each species in the fishery (defined as the ' catchability ' q) (Munro, 1983).

(*b*) estimate of M and hence of F for each species can be obtained without taking the multispecies effort into account and

(*c*) values of *q* of different species can be derived using the same effort value.

It must be accepted, however, that this is all that can be done under the prevailing situation and there is need to develop methods to obtain more reliable estimates of M and q in tropical multispecies fisheries.

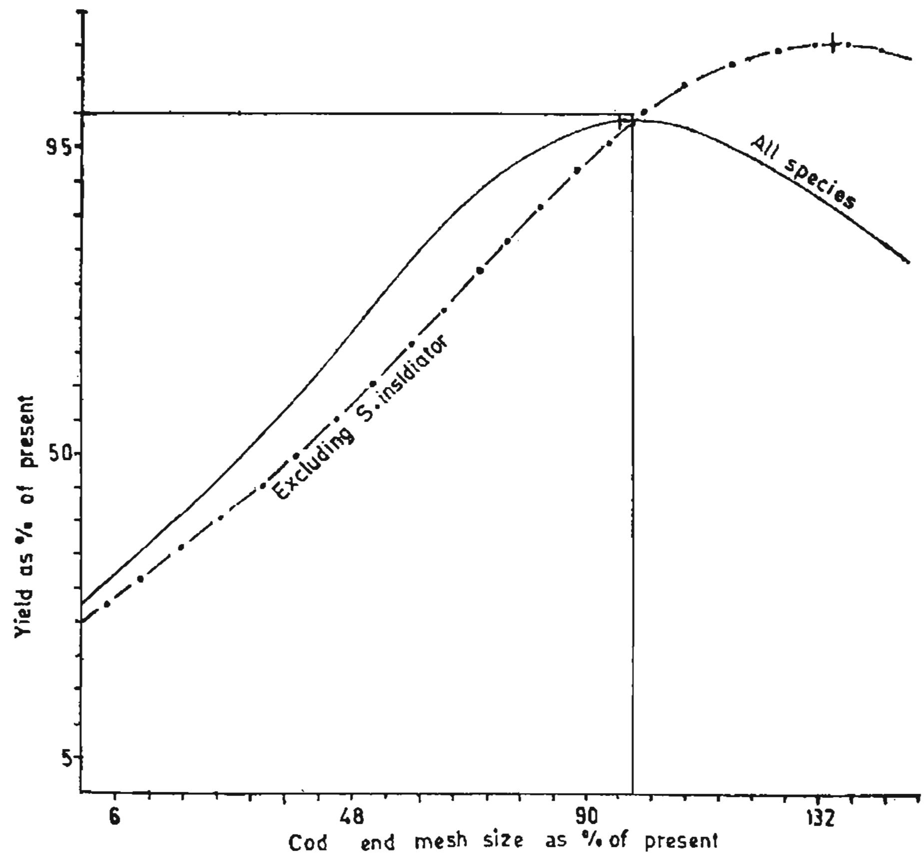

Fig. 4. Yield as percentage of present against cod and mesh size — also as percent of present. The horizontal and vertical lines indicate the present values.

The reliability of the estimated values of Yw/R and recruitment in the present work (*vide supra*) can be questioned on two counts :

The Yw/R was estimated following Beverton-Holt yield equation which assumes growth in weight with length to be isometric, whereas the situation in three of the four species considered, is not so (in *L. bindus*, however, the ' b ' value in length-weight relationship is *not* significantly different from 3) and therefore the estimated values of Yw/R and hence R cannot be taken as exact.

In answer to this, it may be stated that while the value of W∞ taken is exact (*vide supra*), only for a part of the computation of Yw R, the exponent value of length-weight relationship (*b*) was, perforce, taken as 3. Even the method of Jones (1957) which is supposed to take into account the exact value of ' b ' and hence give accurate values of Yw/R, does not do so because in the available tables of incomplete Beta function such as those of Wilimovsky and Wicklund (1963), the differences between successive entries are large and linear interpolation is not accurate (Clark, 1978) and hence, it is not possible to use the exact value of b. Therefore, it appears that the use of Beverton-Holt yield equation, under the assumption of isometric growth, is the only alternative (however disagreeable it may be) if one cannot calculate yield using a computer. Further since the important objective of the present study is to examine whether any regulatory measure in respect of effort or mesh size is necessary, it is believed that the method followed gives the desired results. It may be mentioned in this connection, that Clark (1978) has clearly shown that both the methods of calculating Yw R (original as well as the modified versions of Beverton-Holt model) will produce the same regulatory recommendation.

One of the prerequisites in estimation of Yw/R by Beverton-Holt method and R by the equation B÷B/R is the requirement of steady state condition which is difficult to verify and which is ' patently false ' (Murphy, 1982). However, Murphy (1982) states that ' Nevertheless, even if recognised to be in error the methods do provide useful first estimates and insights into what is taking place '. Further, since the species considered here, like majority of tropical marine fishes, are short-lived and the fishable life-spans are still shorter (Table 2), it is believed that there is justification (Pauly, 1982) in making estimates as above.

According to Jones (1976), the selection factors for fish tend to range from about 2 to 6 and once the selection factor is determined for a given species and a particular cod end mesh size, it can be used to calculate L_c for a given mesh size or *vice versa*. From the Gulf of Thailand, the selection factor was estimated as 3.2 for both *N. japonicus* and *J. carutta* (Isarankura, 1966 ; Jones, 1976) with the help of a trawl net having a cod end mesh size of 40 mm. In the present work, since selection experiments were not conducted, the L_c values were estimated following Pauly (1984) and from these values (Table 2) and the cod end mesh size at Kakinada, the selection factors of the above two species were calculated as 7.7 and 8.3 respectively (3.7 in *L. bindus* and 5.1 in *S. insidiator*) which are not only beyond the range given by Jones (1976) but are also much greater than the values for these species estimated from Gulf of Thailand. If the selection factor of 3.2 is taken for *N. japonicus* and *J. carutta*, the L_c values are estimable at 50 mm from Kakinada whereas the data show that the lengths at recruitment (L_r) of these two species were 50 and 70 mm respectively and an L_c of 50 mm (50% retention length) cannot be regarded as realistic. Since the S.F. values of these two species from Kakinada are not comparable to those obtained from Gulf of Thailand, the validity of the estimated values of L_c in the present work may become questionable in view of the smaller cod end mesh size, though all possible care was taken to obtain adequate data and the most recent and acceptable method was followed to estimate L_c. It may be stated that the present situation has arisen probably because of prawn-biassed trawling which is restricted to areas 'supposed' to be rich in prawns and where smaller individuals of *N. japonicus* and *J. carutta* are probably not available to be retained in the gear.

The combined curve of yield of the four species against effort (Fig. 1) indicates that the effort can be increased substantially to get maximum yield without any fear of adversely affecting the stocks, though in respect of three species (*N. japonicus*, *J. carutta* and *L. bindus*) together (Fig. 1), the effort can only be slightly less than the present one to enable getting sustainable yield. This contradicting situation has come about because the yield of *S. insidiator* increases with increased effort without reaching a maximum (Fig. 1). The estimated values of L_c in all the four species are smaller than the lengths at first maturity (Table 2), which means that the fish are prevented from spawning at least once before they are caught in large numbers. In *S. insidiator*, the present cod end mesh size is much greater than the one that gives maximum yield (Fig. 3). In the light of what has been stated above, increased mesh size may not effect the stock of this species adversely though it may result in decrease in yield. Since the largest size of this species is itself small, decrease in mesh size may result in increased yield brought about by the yield of still smaller fish which are not of considerable value to the industry. In regard to the other three species, the present mesh size will not only result in decreased yield but is likely to result in recruitment overfishing of these three species; the latter is true in the case of *S. insidiator* also. There is therefore, need to increase the present mesh

TABLE 2. *Estimated values of different parameters in the four species.* (All lengths in mm, weight in g, ages in years, K-per year and mortality rates on annual basis)

Parameters		*N. japonicus*	*J. carutta*	*L. bindus*	*S. insidiator*
L_∞	..	339.0	333.3	158.4	123.0
$^*W_\infty$	..	389.7	529.0	54.7	28.0
K	..	0.52	0.44	0.58	1.20
t_0	..	—0.16	—0.0002	—0.024	—0.01
Z	..	2.7	5.1	4.4	7.2
M	..	1.1	1.0	1.5	2.6
F	..	1.6	4.1	2.9	4.6
L_r	..	50	70	17	27
L_c	..	120	130	57	80
L_m	..	125	155	80	90
L_{max}	..	305	255	142	117
t_r	..	0.15	0.54	0.17	0.20
t_c	..	0.68	1.12	0.75	0.87
t_m	..	0.72	1.42	1.19	1.09
t_{max}	..	4.26	3.29	3.89	2.51
$(t_{max}-t_c)$	..	3.58	2.17	3.14	1.64

* Calculated from length-weight relationship and L_∞.

size to 20 mm (Fig. 3) to get sustained yield though it may result in some loss of *S. insidiator* for the fishery. In this connection, one can argue that increase in numerical strength of this species in the sea brought about by increase in mesh size can result in greater competition for food particularly in earlier stages (since most tropical fishes spawn almost round the year) and thus can cause depletion of the preferred species in the long run (Gulland, 1982). It is also possible that the increased numbers of *S. insidiator* thus available in the sea (at least some) may be consumed by predators inhabiting the same area. It may, however, be stated that management of multispecies resources requires a knowledge of possible interactions between species and attempts at understanding them are wanting in India. Though it is recognised that interspecies interactions do occur, it is not clear whether they exert such an influence on the stocks that ignoring them would lead to erroneous results (Larkin, 1982).

Though the present study did not take all the species in the fishery into account, it is believed that the results of the same can be taken to indicate how the other demersal species in the region *might* respond to exploitation because, since the four species considered have widely differing maximum lengths (Table 2) which are comparable to a majority of the other demersal species in the region, it is perhaps reasonable to assume (at least until information on all species becomes available) that the growth and mortality rates of the other species in the fishing ground are also comparable to those of the species considered.

References

ALAGARAJA, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian J. Fish.*, **31** (2) : 208.

BEVERTON, R. J. H. AND S. J. HOLT 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. *Rap. p. v. Reun. Cons. perm. int. Explor. Mer.*, **140** (1) : 67-83.

——— AND ——— 1957. On the dynamics of exploited fish populations. *Fishery Invest., London Ser.* (2), **19** : 1-533.

CLARK, W. G. 1978. Dynamic pool models. *In* : Models for fish stock assessment. *FAO Fish. Circ.*, **701** : 17-30.

CMFRI 1981. Commercial trawl fisheries off Kakinada during 1969-1978. *Mar. Fish. Infor. Serv. T. & E. Ser.*, (**31**) : 1-6.

GULLAND, J. A. 1982. The management of tropical mutispecies fisheries. pp. 287-298. *In* : D. Pauly and G. I. Murphy (Ed.) *Theory and management of tropical fisheries*. ICLARM conference proceedings, **9** : 360 pp.

——— 1983. *Fish stock assessment : A Manual of basic methods*. FAO/Wiley series on food and agriculture, **1** : 223 pp.

*ISARANKURA, A. P. 1966. Size selection of some commercially important species of Gulf of Thailand demersal fish by otter trawl cod end mesh size of 4 cm. *Rep. Mar. Fish. Lab., Bangkok*.

JONES, R. 1957. A much simplified version of the fish yield equation. *Contribution to the Joint Scientific Meeting of ICNAF/ICES and FAO, Document No.* : **21** : 8 pp.

——— 1976. *Mesh regulation in the Demersal Fisheries of South China Sea Area*. South China Sea Fisheries Development Programme, Manila. SCS/76/WP/35 : 75 pp.

——— 1981. The use of length composition data in fish stock assessment (with notes on VPA and Cohort analysis). *FAO Fish. Circ.*, **734** : 60 pp.

——— AND P. N. VAN ZALINGE 1981. Estimation of mortality rate and population size of shrimps in Kuwait waters. *Kuwait Bull. Mar. Sci.*, **2** : 273-288.

LARKIN, P. A. 1982. Directions for future research in tropical multispecies fisheries. *In* : D. Pauly and G. I. Murphy (Ed.) *Theory and management of tropical fisheries*. *ICLARM Conference Proceedings*, **9** : 360 pp.

*MENNES, F. 1983. Descriptions, examples, tests, printouts, plots and listings of programs which process the data of bottom trawl surveys of south-Morocco ; 231 pp (Mimeo).

——— 1985. Multispecies assessment of fish stocks off the Western Sahara region with emphasis on the family sparidae. *Fishbyte*, **3** (3) : 5-10.

MUNRO, J. L. 1983. A cost-effective data acquisition system for assessment and management of tropical multispecies, multi-gear fisheries. *Ibid.*, **1** (1) : 7-11.

MURPHY, G. I. 1982. Recruitment of tropical fishes pp : 141-148. *In* : D. Pauly and G. I. Murphy (Ed.) *Theory and management of tropical fisheries* ICLARM Conference proceedings, **9** : 360 pp.

MURTY, V. SRIRAMACHANDRA 1983 a. Observations in some aspects of biology of silverbelly *Leiognathus bindus* (Valenciennes) from Kakinada. *Indian J. Fish.*, **30** (1) : 61-68.

——— 1983 b. Estimates of mortality, population size and yield per recruit of *Nemipterus japonicus* (Bloch) in the trawling grounds off Kakinada. *Ibid.*, **30** (2) : 255-260.

——— 1984 a. Observations on the fisheries of thread finbreams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) from Kakinada. *Ibid.*, **31** (1) : 1-18.

——— 1984 b. Observations on some aspects of biology of the croakers *Johnius (Johnieops) dussumieri* (Cuvier) and *Johnius (Johnius) carutta* Bloch from Kakinada. *J. mar. biol. Ass. India*, **21** (1 & 2) : 77-85 (1979).

——— (in press). Growth and yield per recruit of *Johnius (Johnius) carutta* Bloch in the trawling grounds off Kakinada. *Indian J. Fish.*, **33** (2).

——— (MS). Studies on the growth and population dynamics of the silverbelly *Leiognathus bindus* (Valenciennes) in the trawling grounds off Kakinada.

——— (MS). A study of the biology and population dynamics of the silverbelly *Secutor insidiator* (Bloch) from Kakinada.

——— (MS). Further studies on the growth and yield per recruit of *Nemipterus japonicus* (Bloch) from the trawling grounds off Kakinada.

PAULY, D. 1980 a. A selection of simple methods for assessment of tropical fish stocks. *FAO Fish. Circ.*, **729** : 54 pp.

——— 1980 b. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. cons. int. Explor. Mer.*, **39** : (2) : 175-192.

——— 1980 c. A new methodology for rapidly acquiring basic information on tropical fish stocks : Growth, mortality and stock recruitment relationships. *In* : S. Saila and P. Roedel (Ed.) *Stock assessment for tropical small scale fisheries. Proc. Intern. Workshop* Sept. 19-21 (1979). Univ. Rhode Island, Intern. Center Mar. Res. Development. 198 pp.

——— 1982. Studying single species dynamics in a tropical multispecies context. *In* : D. Pauly and G. I. Murphy (Ed.) *Theory and management of tropical fisheries.* ICLARM conference proceedings, **9** : 360 pp.

——— 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. Pap.*, **234** : 52 pp.

——— 1984. Length-converted catch curves : A powerful tool for fisheries research in the tropics (Part II). *Fishbyte*, **2** : (1) : 17-19.

——— AND N. DAVID 1981. ELEFAN, 1, a basic programme for the objective extraction of growth parameters from length frequency data. *Meeresforsch.*, **28** : 205-211.

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Bd. Canada*, **191** : 382 pp.

SCHAEFER, M. B. 1954. Some aspects of the dynamics of populations important of the management of marine fisheries. *Bull. I-ATTC.*, **1** (12) : 25-56.

SPARRE, P. 1985. Introduction to tropical fish stock assessment. *Denmark Funds-in-trust. FI : GCP/INT/392/DEN Manual*, **1** : 338 pp.

SRINATH, M. AND K. ALAGARAJA 1982. A method of estimation of mortality rates from length samples. *Indian J. Fish.*, **28** : 183-188 (1981).

*WILIMOVSKY, N. J. AND E. C. WICKLUND 1963. *Tables of the incomplete Beta function for the calculation of Fish population yield.* University of British Columbia Vancouver, B.C., 291 pp.

* Not referred to in original.

CONTRIBUTION 20

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CONTRIBUTIONS TO TROPICAL FISH STOCK ASSESSMENT IN INDIA

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MIXED FISHERIES ASSESSMENT WITH REFERENCE TO FIVE IMPORTANT DEMERSAL FISH SPECIES LANDED BY SHRIMP TRAWLERS AT KAKINADA

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ABSTRACT

Data collected on five species in the by-catch of shrimp trawlers at Kakinada (Andra Pradesh) during 1984-86 are used for a length based cohort analysis and Thompson and Bell assessments. An assessment of this mixed fishery is also carried out. The methods used are described in detail and problems involved in estimating the important parameters to assess mixed trawl fisheries are discussed. Growth parameters and mortality estimates for Nemipterus japonicus, N. mesoprion, Johnius carutta, Leiognathus bindus and Secutor insidiator were taken from published work on resources off Kakinada.

1 INTRODUCTION

In the trawl catches at Kakinada, some fishes of the families Nemipteridae, Sciaenidae and Leiognathidae are very important. They constituted over 20% of the total average annual trawl catch of 19,525 tonnes during 1984-86. Various aspects of the biology of the dominant species in these groups Nemipterus japonicus, N. mesoprion, Johnius carutta, Leiognathus bindus and Secutor insidiator, were studied earlier. The mortality rates and yield per recruit of four of the above species were estimated on the basis of data collected up to 1983 (Murty 1982; 1983; 1983a; 1984; 1984 a; 1986; 1986 a). However, studies pertaining to mixed fisheries assessments which help in regulating the fishing effort and mesh size of the nets effectively, are lacking. An attempt is made in this paper to assess the resources of the above five species together on the basis of data collected during 1984-1986. For the mixed fisheries assessment to be meaningful, it is necessary to take into account the majority of the species, particularly the more valuable species like shrimps. As the present study does not take into account the shrimps, it should be considered as a beginning for a more detailed study.

1.1 Description of the fishery

Small shrimp trawlers started operating off Kakinada in 1964. The industry has expanded substantially, particularly due to the lucrative export value of shrimps. During 1984-86, an average of about 120 boats was in operation. The length of the trawlers ranges from 9 to 11 m. The trawl gear is made of synthetic monofilament twine of 0.5-1.0 mm diameter, and it has a codend mesh size of about 1.6 cm. Fishing is conducted at depths ranging from 5 to 80 m but mainly in the 5-50 m depth range. Several species contribute to the fishery and data are regularly collected for 40 species or species groups. Shrimps, sciaenids, silverbellies, nemipterids, ribbon fish, scads, drift fish and lizard fish are the more abundant groups (Muthu et al., 1977 and CMFRI, 1981). From year to year there are varia-

Species	Price
N. japonicus	Rs. 3 upto 12 cm and Rs. 6 beyond
N. mesoprion	Rs. 3 all lengths
J. carutta	Rs. 3 all lengths
L. bindus	Re. 1 all lengths
S. insidiator	Re. 1 all lengths

Table 2 Estimated effort (trawling hours), total catch (t) and the catches of some particular groups and species during 1984-86 at Kakinada by the commercial trawlers

Years	Effort	Total catch	Catches by group			Catches by species				
			Nemip-terids	Sciae-nids	Silver-bellies	N.japo-nicus	N.meso-prion	J.carut-ta	L.bindus	S.insi-diator
1984	310367	17679	1060	1234	1725	398	583	129	1047	310
1985	330456	18451	548	1513	1677	186	319	105	870	367
1986	368532	22445	685	1472	1906	202	438	46	453	658
Average	336452	19525	764	1406	1769	262	447	93	790	445
% in average total catch			3.9	7.2	9.1	1.3	2.3	0.5	4.0	2.3
% in the catch of the group			-	-	-	34.3	58.5	6.6	44.7	25.2

tions in the abundance of the different groups, within the year, though, the maximum catch is obtained from December to March in most years. The boats land the entire catch without discarding, because also the trash fish has some value as poultry feed, manure etc. Some prices of fish at the landing centre are presented in Table 1.

The estimated total annual effort and the catch of the different groups considered in this paper are shown in Table 2.

1.2 Notes on biology

Estimated values of the von Bertalanffy growth parameters, length and age at first maturity, natural mortality (M) and L_{max} of the five species under study are given in Table 3.

Information on the biology of *N. japonicus* from different centres in India other than Kakinada is available in the works of Krishnamoorthi (1973, 1976), Dan (1980), Vivekanandan and James (1986), Vinci and Nair (1975) and Vinci (1983). It has been shown that this species is a fractional spawner. The spawning period off Kakinada is from August to April (Murty, 1984). Further north (Andhra Pradesh-Orissa) this species spawns during September-November and further south, off Madras during June-March. For *N. mesoprion*, the spawning period was determined as December-April. Also this species is a fractional spawner (Murty, 1982). For *Johnius carutta*, the information on biology is restricted to the accounts of Rao (1967) and Murty (1984 a, 1986). This species is also a fractional spawner with a spawning period from January to June. For *Leiognathus bindus* the available data show that the spawning season is during December-February off the southwest coast (Balan, 1967) whereas the study of material at Kakinada shows that this is a fractional spawner and that it spawns almost throughout the year (Murty, 1983). For *Secutor insidiator* Pillai (1972) showed that this is a fractional spawner with a protracted spawning period. Murty (MS) showed that this species spawns almost throughout the year.

1.3 Data base

During 1984-1986 data were collected on the landings of the small commercial trawlers operating off Kakinada (16°35'-17°25' N, 82°20'-83°10' E). Data on effort and the landings by family groups were collected on about 18 days in a month and samples for biological studies were obtained on 6-8 days in a month. Excepting silverbellies, length data were collected at the landing place for all species. The data on effort, catch, species composition and length composition collected on each observation day were weighted following Alagaraja (1984) to get monthly estimates. The monthly estimates were pooled to get annual estimates.

Parameters of growth estimated earlier using the integrated method of Pauly (1983) in *N. japonicus*, *J. carutta* and *S. insidiator* and following the modal progression method in *L. bindus* and *N. mesoprion* (Murty, 1982; 1986, 1986 a, 1987, MS) were used in the present study. The natural mortality range was estimated using Pauly's (1980) formula; for this purpose the average water temperature was taken as 27.2° C from the works of Ganapati and Murthy (1954) and La Fond (1958).

2 METHODS

Yield and biomass estimates were made using a micro computer with the help of the LFSA package, Sparre (1987). An assessment of the mixed fishery was made based on length frequencies, using the length-converted Thompson and Bell analysis developed by Sparre (1985). For easy reference the theory and method are described below.

Table 3 Estimated values of growth parameters (L_∞, K, t_o), natural mortality rate (M), lengths and ages of first maturity (Lm, tm) and maximum lengths (L_{max}) for five species based on research in India

Species	L_∞ (cm)	K (per year)	t_o (year)	M (per year)	L_m (cm)	t_m (years)	L_{max} (cm)	Region	Source	Method of estimation of growth parameters
Nemipterus japonicus	30.5	0.3141	-1.1079	0.5037	16.5	1.4	35.0	Andhra-Orissa coast	Krishnamoorthi (1973,1978)	Modal progression
- " -	29.0	0.6244	0.1439	-	-	-	30.5	Visakha-patnam	Rao and Rao (1986)	Scale studies *)
- " -	31.4	0.7514	-0.1731	1.1418	12.5	0.5	28.5	Kakinada	Murty (1983a, 1984	Modal progression
- " -	33.9	0.52	-0.16	1.1	12.5	0.72	30.5	Kakinada	Murty (1987)	Integrated method
- " -	30.5	1.004	0.2257	2.5254	14.5	0.87	30.1	Madras	Vivekanandan and James (1986)	Integrated method
N. mesoprion	21.9	0.83	-0.26	1.7	12.0	0.7	21.5	Kakinada	Murty (1982)	Modal progression
Johnius carutta	33.3	0.44	0	1.0	15.5	1.4	25.5	Kakinada	Murty (1984a, 1986	Integrated Method
Leiognathus bindus	15.8	0.58	-0.024	1.5	8.0	1.2	14.2	Kakinada	Murty (1983, 1986a)	Modal progression
	12.2	1.3	-	-	8.7	1.0	-	Calicut	Balan (1967)	
Secutor insidiator	12.3	1.2	-0.01	2.6	9.0	1.1	11.7	Kakinada	Murty (in press)	Integrated method

*) Rao and Rao (1986) estimated growth parameters through the Gompertz growth equation

2.1 Theory of length-based Thompson and Bell model

The Thompson and Bell model (1934) is an age-structured model for prediction of catch and stock size for a given fishing pattern (the array of fishing mortalities by age group). The model used here (Sparre, 1985) is the length-structured parallel of the Thompson and Bell model.

The starting point is Jones' length-converted cohort analysis:

$$X(L1,L2) = ((L_\infty - L1)/(L_\infty - L2))^{M/2K} \quad (1)$$
$$N(L1) = (N(L2)\ X(L1,L2) + C(L1,L2)\ X(L1,L2) \quad (2)$$
$$F/Z = C(L1,L2)/(N(L1) - N(L2)) \quad (3)$$
$$F = M\ (F/Z)/(1 - F/Z)$$

where L_∞ is the asymptotic length. K the curvature parameter and (L1,L2) the (lower limit, upper limit) of the length class considered, N is stock number, C is number caught, F is fishing mortality, M is natural mortality and Z is total mortality, (for further details see Jones (1984) or Sparre (1985).

The forward projection of the length based cohort analysis is named "length converted Thompson and Bell" analysis (Sparre, 1985) It takes the fishing mortalities by length group and the recruitment (number in smallest length group) as inputs and calculates the number caught and the stock numbers.

To turn Eqs. 1 to 3 into "forward projection", Eq. (3) is rewritten:

$$C(L1,L2) = (F/Z) * (N(L1) - N(L2)) \quad (4)$$

which inserted into Eq. (2) gives:

$$N(L1) = (N(L2)\ X(L1,L2) + (F/Z)\ (N(L1) - N(L2)))\ X(L1,L2)$$

Solving this equation with respect to N(L2) gives:

$$N(L2) = N(L1)*(1/X(L1,L2) - F/Z)\ /\ (X(L1,L2) - F/Z) \quad (5)$$

Eqs. (4) and (5) form the "forward version" of length converted cohort analysis.

In its simplest form, the length converted Thompson and Bell analysis uses the F-array estimated in cohort analysis as the reference F-array and assesses the effect of raising (reducing) all F's by a certain factor.

In the general case where all F-values are raised (or reduced) by the factor XX the general step becomes:

$$N(li+1) = N(li) * (1/X(Li,Li+1)-E(Li,Li+1))/(X(Li,Li+1)-E(Li,Li+1))$$

where

$$E(Li,Li+1) = XX * F(Li,Li+1)/Z(Li,Li+1)$$
$$Z(Li,Li+1) = XX * F(Li,Li+1) + M$$
$$C(Li,Li+1) = XX * F(Li,Li+1) * (N(Li)-N(Li+1))/Z(Li,Li+1)$$

The yield (catch in weight) in length group i is:

$$YIELD(Li,Li+1) = C(Li,Li+1) * W(Li,Li+1)$$

where W(Li,Li+1) is the mean weight of fish of lengths between Li and Li+1. It may be calculated from:

$$W(Li,Li+1) = a * (Li\hat{\ }b + Li+1\hat{\ }b)/2$$

where a and b are the parameters in the length-weight relationship.

The value of the yield is given by:

VALUE(Li,Li+1) = YIELD(Li,Li+1) * PRICE(Li,Li+1)

where

PRICE(Li,Li+1) is the kg price of fish between lengths Li and Li+1.

The mean number of survivors in length group i is:

NMEAN(Li,Li+1) = (N(Li) - N(Li+1))/Z(Li,Li+1)

and the corresponding mean biomass is

BIOM(Li,Li+1) = NMEAN(Li,Li+1) * W(Li,Li+1)

The prediction made by the length converted Thompson and Bell analysis is a prediction of the average long term catches, assuming recruitment to remain constant.

2.2 Assessment of mixed fisheries based on length frequencies

In the present case the kg prices differ between species and between size categories within some species. Therefore it is not correct to treat each species separately and subsequently sum the results in terms of yield. Before a summation makes sense the yields must be converted into units of value.

Moreover, even if yields are converted into values it is still not possible to sum the results of single species assessments. It will usually be so that the effort level which for one species gives the maximum sustainable economic yield (MSE), will not be at that level for the other species.

The approach suggested below combines all species in the estimation of MSE. The computational procedure of the assessment of a mixed fishery based on length frequency data works as follows:

a) Perform a single species length converted cohort analysis on each species separately. This gives estimates of the current fishing pattern for each species.

b) Perform separate length converted Thompson and Bell yield analysis on each species. Use the same F-factor for the fishing patterns of each species. Sum the values of the yields of all the species.

c) Use the sum of values to determine the optimum effort level.

The assumption behind this approach is that when the fishing mortality on one species is increased, that on the other species will automatically be increased also by the same relative amount. The above suggested computational procedure involves a large number of calculations and is greatly facilitated by the use of a computer. The LFSA-package (Sparre, 1987) with the program "MIXFISH" was used.

3 RESULTS

3.1 Length based cohort analysis

The raised annual length frequencies of the three years (1984-86) were pooled and the annual average frequencies were obtained as inputs for cohort analysis. The other input parameters are given in Table 4. The data of 1980-83 were earlier analysed for estimation of mortalities (Murty, 1986, 1986 a, 1987, MS) and F/Z values were found to range from 0.6 to 0.8. The terminal F/Z values for length cohort analysis were guessed (Table 4) on the basis of these values. The results of the cohort analysis on the five species are shown in Figures 1 to 5.

For N. japonicus (Fig. 1), F shows an increase to a maximum of 1.95 at 22.5 cm which is followed by a decline. The average F for fully recruited fishes (L>= 13.5) was 1.1.

For N. mesoprion (Fig. 2) F increased to 3.68 at 11.5 cm, then decreased to 1.1 at 14.5 cm and then increased again. The average F for fully recruited lengths (L>= 11.5) was 2.7.

For J. carutta (Fig. 3) F increased with increasing length to 17.5 cm and from there onwards was relatively stable. The average F for fully recruited fish (L>= 16.5) was 3.6.

For L. bindus (Fig. 4) F increased to a maximum of 4.5 at 8 cm and then showed a decline, after which they were more or less constant at around 3.5. The average F for fully recruited fish (L>= 6.75) was 3.4.

For S. insidiator (Fig. 5) F in different length groups showed an increase from a minimum of 0.1 to a maximum of 3.9, with increasing length. The average F for fully recruited fish (L>= 9.25) was 3.6.

Table 4 Input parameters for the length converted cohort analyses given in Figs. 1-5 *)

Parameters	N.japonicus	N.mesoprion	J.carutta	L.bindus	S. insidator
L_∞ (cm)	33.9	21.9	33.3	15.84	12.3
	(30)	(18.5)	(24.5)	(13.0)	(11.0)
K per year	0.52	0.83	0.44	0.58	1.20
	(0.71)	(1.20)	(0.85)	(1.00)	(1.79)
M per year	1.1	1.7	1.0	1.5	2.6
	(1.4)	(2.27)	(1.68)	(2.22)	(3.41)
Terminal F/Z	0.50	0.68	0.78	0.68	0.6
q in $W = qL^b$ (g, cm)	0.0287	0.0168	0.0063	0.0153	0.0050
b in $W = qL^b$	2.702	2.877	3.233	2.962	3.437

*) Values for L_∞, K and M were taken from Table 3, while those in brackets are the parameters used for an alternative assessment presented in Fig. 7.

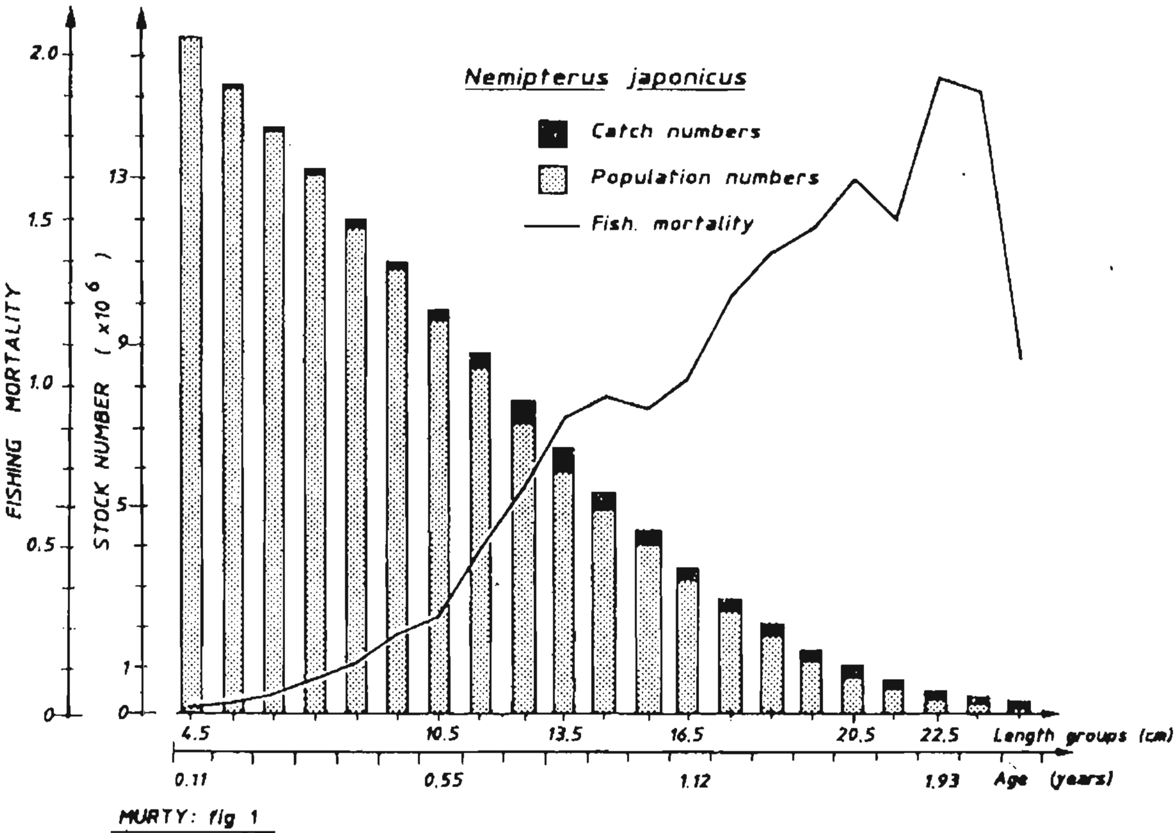

Fig. 1 Length cohort analysis of Nemipterus japonicus at Kakinada, 1984-1986. Mean F = 1.1

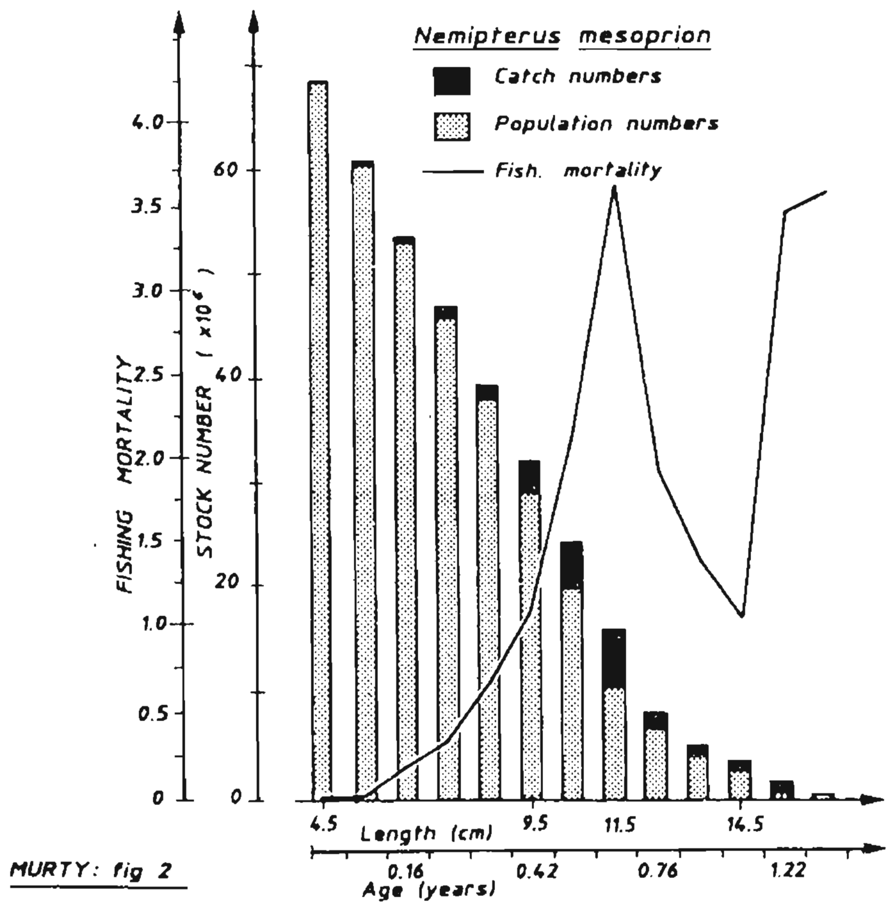

Fig. 2 Length cohort analysis of Nemipterus mesoprion at Kakinada, 1985-1986. Mean F = 2.7

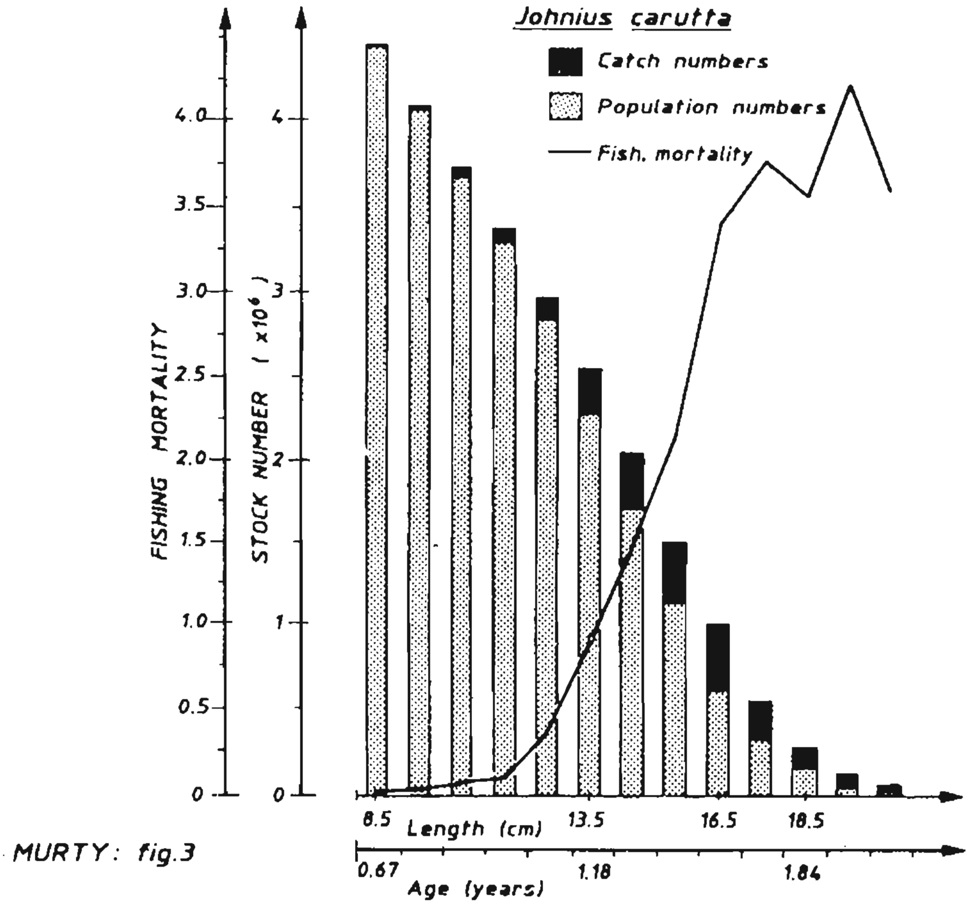

Fig. 3 Length cohort analysis of Johnius carutta at Kakinada, 1984-1986. Mean F = 3.6

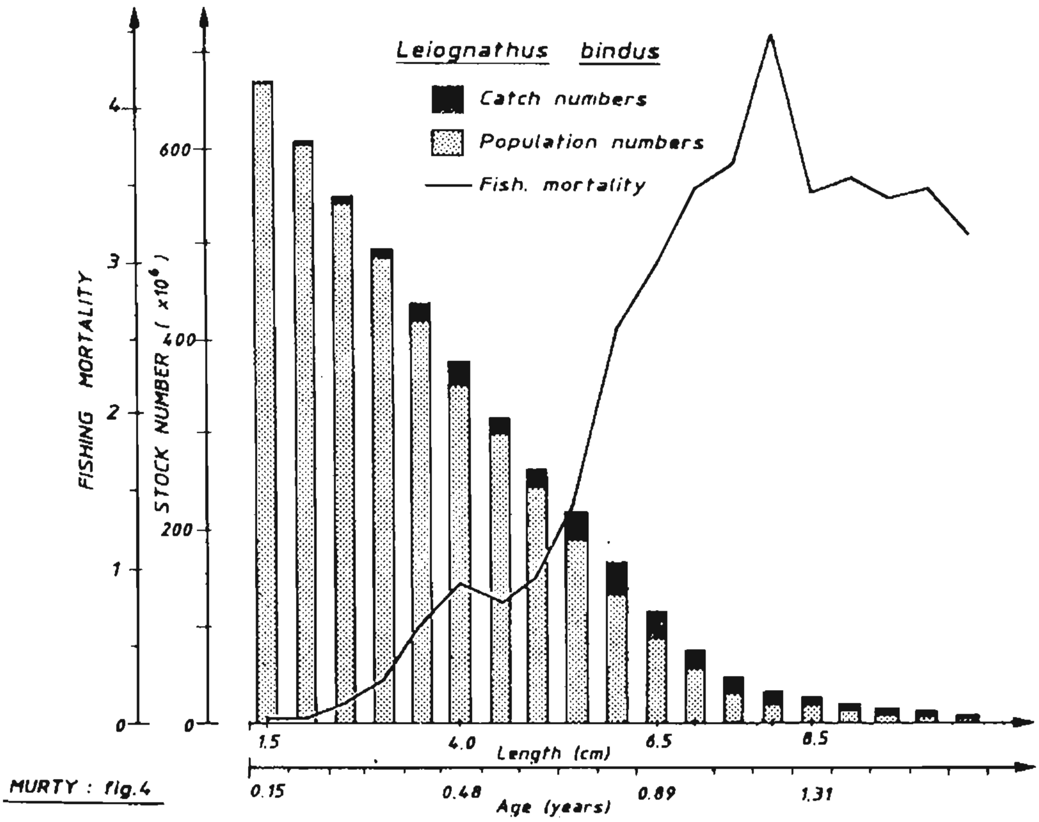

Fig. 4 Length cohort analysis of Leiognathus bindus at Kakinada, 1984-1986. Mean F = 3.4

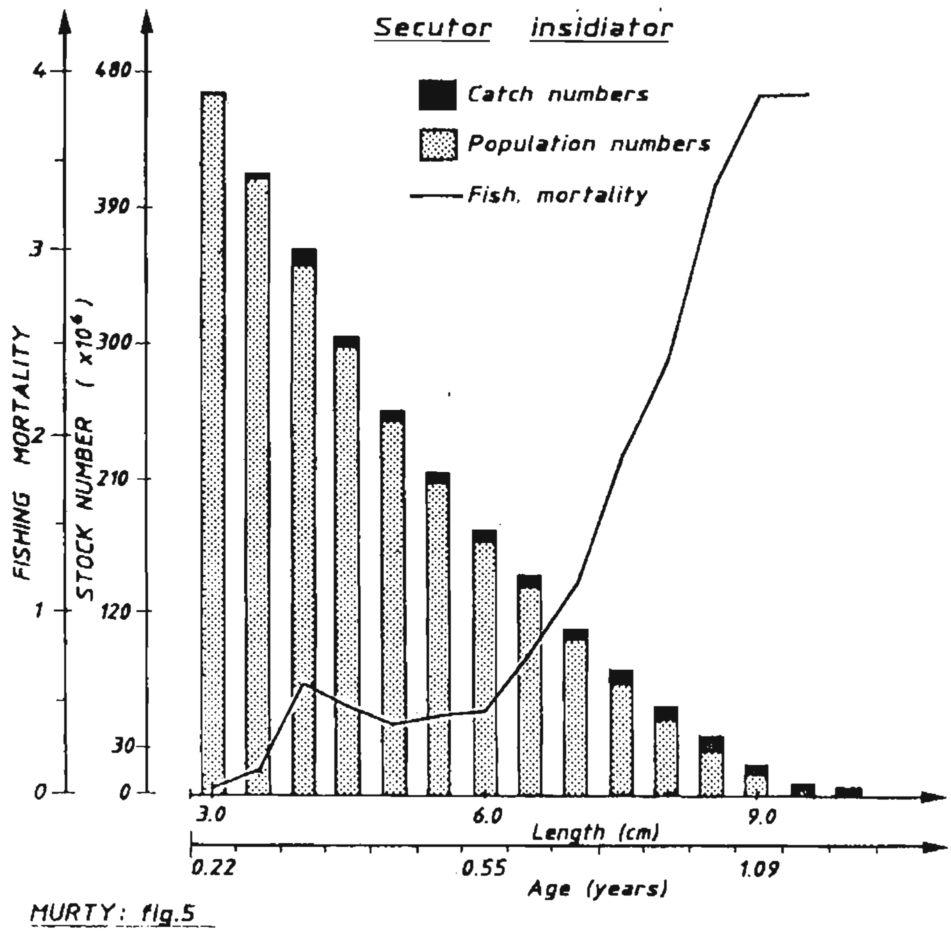

Fig. 5 Length cohort analysis of Secutor insidiator at Kakinada, 1984-1986. Mean F = 3.6

3.2 Length based Thompson and Bell analysis by species

To assess the conflicts between management strategies for individual stocks usually inherent in a mixed fishery, predictions were made for each stock separately. The conflicting results of this exercise can be summarized.

For N. japonicus, the maximum sustainable yield (MSY) of 254 t can be obtained by increasing the effort by 40% (Fig. 6). The maximum sustainable economic yield (MSE) can be obtained however, by increasing the effort by 20% only (Table 5). Furthermore, the 40% increase in effort will result in only 1% increase in yield which indicates that the catch per unit of effort will be reduced drastically.

For N. mesoprion (Table 6), the results indicate that the effort can be increased by 80% to get the MSY as well as the MSE (Fig. 6). Also in this case 80% effort increase will only result in a 1.8% increase in yield and will therefore not be remunerative.

For J. carutta (Table 7), the present effort is at optimum level (Fig. 6).

For L. bindus, the Thompson and Bell long term forecast (Table 8) shows that the present effort is 40% more than the one giving the MSY (Fig. 6) thus suggesting a need for a reduction in effort.

For S. insidiator, on the other hand, the analysis (Table 9) shows that the effort can be increased by 140% to get the MSY but the increase in yield will only be 6%.

3.3 Mixed fisheries assessment

The assessment of individual species has indicated that the present effort is optimal for one species only, it can be increased considerably in the case of three species and should be reduced for one species. The mixed fisheries assessment (Table 15) shows, on the other hand, that the MSE of all the five species together can be obtained by increasing the effort by about 19%. This suggestion should only be considered in the light of similar studies on shrimps and other valuable species.

It may be stated here that any gain or loss in yield should be considered together with a corresponding change in CPUE (which can be taken as roughly proportional to the biomass as calculated by the Thompson and Bell analysis).

Table 5 Thompson and Bell long term forecast of *N. japonicus* at Kakinada

XX factor	Yield (t)	Mean biomass (t)	Value (000 Rs)
0.0	0	725	0
0.2	126	539	751
0.4	191	423	1132
0.6	225	346	1325
0.8	243	293	1420
1.0	251	255	1460
1.2	254	226	1470 MSE
1.4	254 MSY	204	1463
1.6	253	186	1447
1.8	250	171	1425
2.0	248	159	1400
2.2	244	149	1374
2.4	241	140	1348
2.6	238	132	1322
2.8	235	125	1296
3.0	232	119	1271

Table 6 Thompson and Bell long term forecast of *N. mesoprion* at Kakinada

XX factor	Yield (t)	Mean biomass (t)	Value (000 Rs)
0.0	0	707	0
0.2	175	539	526
0.4	272	430	817
0.6	327	356	982
0.8	359	303	1077
1.0	377	264	1131
1.2	386	234	1160
1.4	391	212	1175
1.6	393	194	1181
1.8	393 MSY	179	1181 MSE
2.0	392	167	1178
2.2	390	158	1172
2.4	388	149	1165
2.6	386	142	1158
2.8	383	137	1150
3.0	380	131	1142

Table 7 Thompson and Bell long term forecast of *J. carutta* at Kakinada

XX factor	Yield (t)	Mean biomass (t)	Value (000 Rs)
0.0	0	231	0
0.2	56	148	168
0.4	78	107	234
0.6	86	85	260
0.8	89	71	268
1.0	90 MSY	62	270 MSY
1.2	89	56	268
1.4	88	52	265
1.6	87	49	262
1.8	86	46	259
2.0	85	44	256
2.2	84	42	253
2.4	83	41	250
2.6	82	39	247
2.8	81	38	245
3.0	81	37	243

Table 8 Thompson and Bell long term forecast of *L. bindus* at Kakinada

XX factor	Yield (t)	Mean biomass (t)	Value (000 Rs)
0.0	0	1854	0
0.2	587	1115	587
0.4	768	768	768
0.6	815 MSY	583	815 MSE
0.8	814	473	814
1.0	796	402	796
1.2	774	352	774
1.4	751	315	751
1.6	728	287	728
1.8	707	264	707
2.0	688	245	688
2.2	670	229	670
2.4	653	215	653
2.6	638	204	638
2.8	623	193	623
3.0	610	184	610

Table 9 Thompson and Bell long term forecast of *S. insidiator* at Kakinada

XX factor	Yield (t)	Mean biomass (t)	Value (000 Rs)
0.0	0	631	0
0.2	197	519	197
0.4	304	448	304
0.6	366	398	366
0.8	404	361	404
1.0	429	331	429
1.2	445	307	445
1.4	456	287	456
1.6	463	270	463
1.8	468	255	468
2.0	470	242	470
2.2	471	231	471
2.4	472 MSY	220	472 MSE
2.6	471	211	471
2.8	470	202	470
3.0	469	194	469

Table 10 Thompson and Bell long term forecast all species combined at Kakinada

XX factor	Yield (t)	Mean biomass (t)	Value (000 Rs)
0.0	0	4151	0
0.2	1143	2862	2231
0.4	1615	2179	3257
0.6	1821	1770	3750
0.8	1911	1503	3986
1.0	1945	1316	4089
1.2	1951	1178	4120 MSE
1.4	1942	1071	4113
1.6	1926	987	4083
1.8	1907	917	4042
2.0	1885	859	3993
2.2	1862	810	3942
2.4	1839	767	3890
2.6	1817	730	3838
2.8	1795	697	3786
3.0	1773	668	3736

4 DISCUSSION

An assessment of the mixed trawl fishery off Kakinada based on length frequencies has been attempted for the fish component of this fishery. Ideally shrimp, the most important component, should have been included. Data for this component, however, was not available to the author. The assessment presented here is thus not complete. The present paper should therefore be considered primarily as a presentation of a methodology for assessment of a mixed fishery rather than an actual assessment of the Kakinada demersal trawl fishery.

When making single species assessments for the components of a mixed fishery the management implications found for individual components may be conflicting. In the present study such conflicts were found, e.g. MSY for N. japonicus corresponded to a 40 percent increase in effort, whereas effort at MSY for L. bindus should be reduced by 40 percent (see Fig. 6).

The assumed simplest solution was chosen here, namely to convert the biomass of different species into a common unit. By doing so the gain from increasing effort for N. japonicus can be weighted against the loss for L. bindus.

Although an increase in yield and value is achieved with an increase in effort the implication need not to be that an effort increase is advisable. The yield and the value curves should always be considered in conjunction with the CPUE curve, since an increase in effort always results in a decrease of CPUE. The question to be addressed is whether the increase in yield is so big that it can justify the decrease in CPUE.

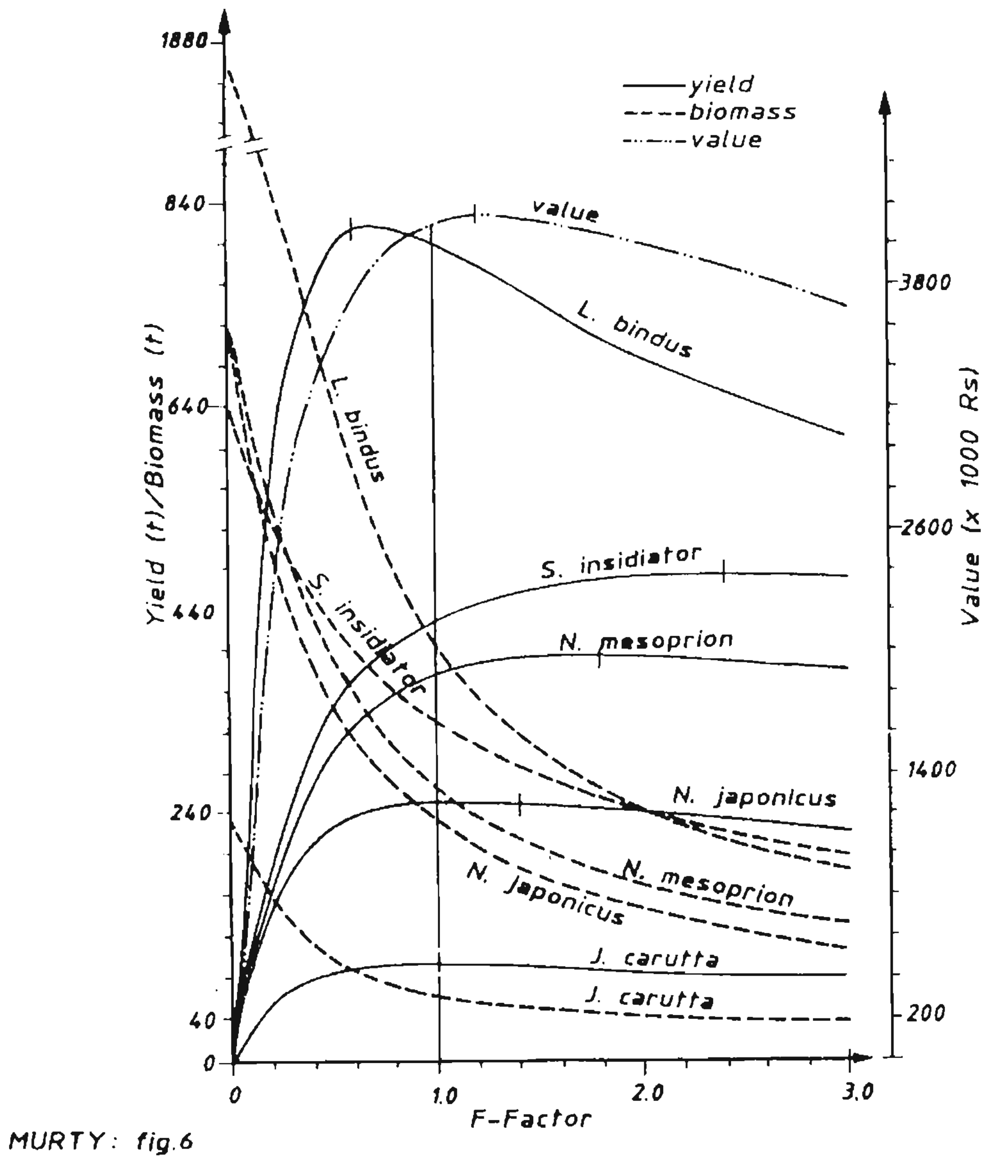

Fig. 6 Estimation of yield and biomass by length based Thompson and Bell method for different species and mixed fisheries assessment. (Small vertical lines on curves show the Fmsy and Fmse (value) levels, vertical line at X-Factor 1.0 shows the present effort level)

In the present analysis no explicit estimate of the CPUE was made. However, the estimated average stock biomass can be used as an index for CPUE. The above mentioned considerations apply in particular to many tropical fish species, for which the yield curves are flat-topped or in some cases have no maximum.

The present analysis is composed of a number elements all of which could form the basis for a lengthy discussion, however, only those aspects pertaining to the mixed fisheries will be considered in detail.

In particular the estimation of growth parameters and its implications for the cohort analysis presented here could be discussed in the light of the following aspects:

a) In addition to catch statistics, assessment of exploited fishery resources requires information on various aspects of biology and behaviour of the populations, in particular their distribution in space and time, spawning periods and recruitment.

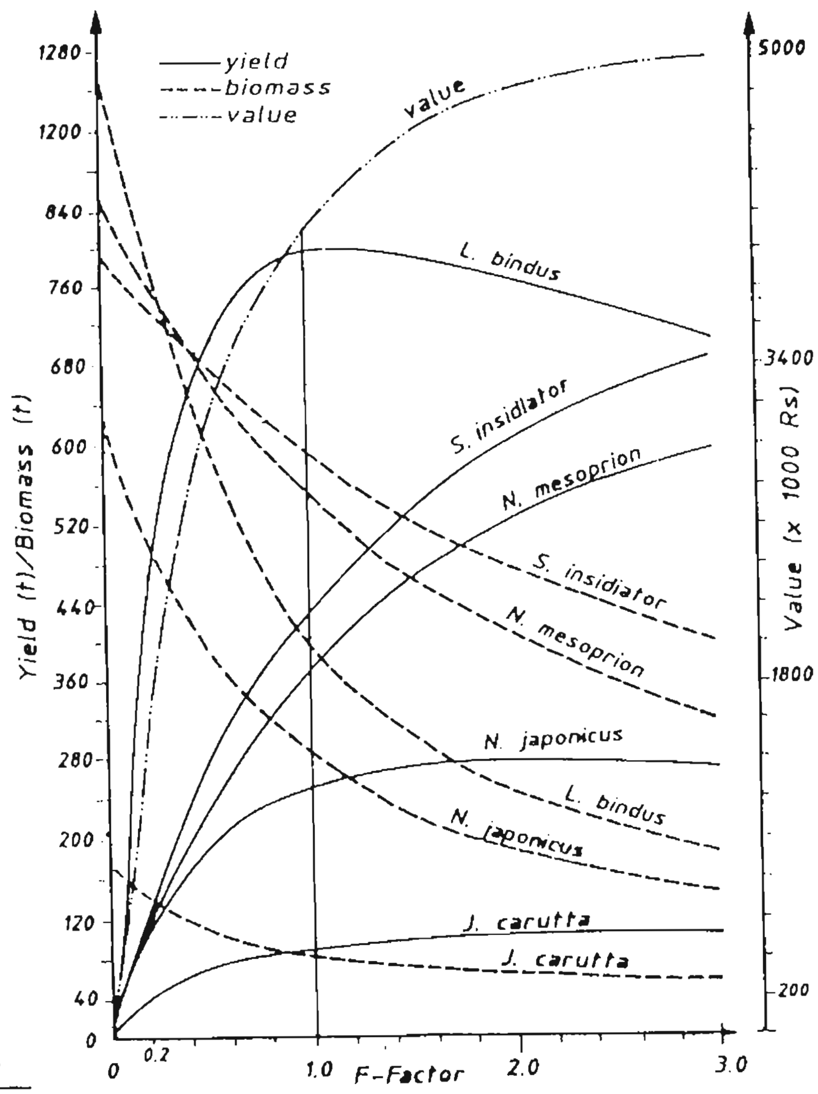

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Fig. 7 Estimation of yield and biomass by length based Thompson and Bell method for different species and mixed fisheries assessment, using arbitrarily selected lower values of L_∞ with compatable K values. (Small vertical lines show Fmsy levels, and the vertical line at X-Factor 1.0 the present effort level)

b) Information on the selectivity of the gear may be essential for a successful assessment.

The above mentioned features may have had an impact on the estimates of the growth parameters used in the present study (Table 4), which might represent overestimates of L_∞ and underestimates of K.

The fishing patterns estimated by cohort analysis (Tables 5-9 and Figures 1-5) show fishing mortalities increasing rapidly with the length of the fish. There is no straight forward explanation of this result. One explanation is that the L_∞'s are overestimated, as lower values of L_∞ would make the slopes of the F-curves less pronounced and make them resemble more the sigmoid selection ogive expected for trawls. An alternative explanation is that fishing mortality is mixed with the effect of migration out of the fishing grounds.

To assess the impact of changed growth parameters on the mixed fisheries assessment a set of alternative growth parameters were worked out. The L_∞'s were reduced arbitrarily and the K's subsequently modified accordingly. These parameters are presented as the figures in brackets in Table 4. Based on this alternative set of growth parameters, the entire assessment exercise was repeated and the result is summarized in Fig. 7.

It is believed that Fig. 6 represents the best possible assessment of the mixed fishery. Fig. 7 is given here primarily to illustrate the evaluation of the sensitivity of the results relative to the growth parameters and the natural mortality. It is noticed that the reduction of L_∞ and the related increase of K and M produce higher estimates of the MSY and MSE.

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5 REFERENCES

Alagaraja, K., 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. Indian J.Fish., 31:177-208

Balan, V., 1967. Biology of the silverbelly, *Leiognathus bindus* (Val.) of the Calicut coast. Indian J.Fish., 10(1963):118-34

Banse, K., 1959. On upwelling and bottom trawling off the south west coast of India. J.Mar.Biol.Assoc.India, 1:33-49

CMFRI (Central Marine Fisheries Research Institute), 1981. Commercial trawl fisheries off Kakinada during 1969-78. Mar.Fish.Inf.Serv.Tech. Ext.Ser., (31):1-6

Dan, S.S., 1980. Intraovarian studies and fecundity in *Nemipterus japonicus* (Bloch). Indian J.Fish., 24(1977):48-55

Ganapathi, P.N. and V.S.R. Murty, 1954. Salinity and temperature variations of the surface waters off Visakhapatnam coast. Andhra Univ.Mem. Oceanogr., 1:125-42

James, P.S.B.R., 1973. The fishery potential of silver-bellies. In Proceedings of Symposium on the living resources of the seas around India. Cochin, Central Marine Fisheries Research Institute, pp. 439-44

Jones, R., 1976. Mesh regulation in the demersal fisheries of South China Sea area. Manila, South China Sea Fisheries Development and Coordinating Programme, SCS/76/WP/34:35 p.

____________, 1984. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis). FAO Fish.Tech.Pap., (256):118 p.

Krishnamoorthi, B., 1973. Biology of the threadfin bream Nemipterus japonicus (Bloch). Indian J.Fish., 18(1971):1-21

____________, 1976. A note on the size difference between males and females of Nemipterus japonicus (Bloch). Indian J.Fish., 21(1974): 608-9

____________, 1978. A note on the mortality rates and yield per recruit in Nemipterus japonicus (Bloch). Indian J.Fish., 23(1976):252-6

La Fond, E.C., 1958. Seasonal cycle of sea surface temperature and salinity along the east coast of India. Andhra Univ.Mem.Oceanogr., (2):12-21

Murty, V.S., 1982. Observations on some aspects of biology of threadfin bream Nemipterus mesoprion (Bleeker) from Kakinada. Indian J.Fish., 28(1981):199-207

____________, 1983. Observations on some aspects of biology of silverbelly Leiognathus bindus (Valenciennes) from Kakinada. Indian J.Fish., 30: 61-88

____________, 1983a. Estimates of mortality population size and yield per recruit of Nemipterus japonicus (Bloch) in the trawling grounds off Kakinada. Indian J.Fish., 30:255-60

____________, 1984. Observations on the fisheries of threadfin breams (Nemipteridae) and on the biology of Nemipterus japonicus (Bloch) from Kakinada. Indian J.Fish., 31:1-18

Murty, V.S., 1984a. Observations on some aspects of biology of the croakers Johnius (Johnieops) dussumieri (Cuvier) and Johnius (Johnius) carutta (Bloch) from Kakinada. J.Mar.Biol.Assoc.India, 21(1979):77-85

____________, 1986. Growth and yield per recruit of Johnius (Johnius) carutta (Bloch) in the trawling grounds off Kakinada. Indian J.Fish., 33:163-70

____________, 1986a. Studies on the growth and population dynamics of silverbelly Leiognathus bindus (Valenciennes) in the trawling grounds off Kakinada. Indian J.Fish., 33:277-84

____________, 1987. Further studies on the growth and yield per recruit of Nemipterus japonicus (Bloch) from the trawling grounds off Kakinada. Indian J.Fish., 34

____________, (MS). A study of the biology and population dynamics of the silverbelly, Secutor insidiator (Bloch) from Kakinada. Submitted for publication in J.Mar.Biol.Assoc.India

Muthu M.S. et al., 1977. On the commercial trawl fisheries off Kakinada during 1967-70. Indian J.Fish., 22(1975):171-86

Nair, K.V.S. and A.A. Jayaprakash, 1986. A note on the monsoon fishery for threadfin breams off Cochin. Indian J.Fish., 33:106-12

Narayanappa, G., D.A.N. Raju and A.V.V. Satyanarayana, 1968. Certain observations on the otter trawl operations carried out in the inshore and deep waters off Kakinada. Proc.IPFC, 13(3):450-5

Pauly, D., 1977. The Leiognathidae (Teleostei): their species, stocks and fisheries in Indonesia with notes on biology of Leiognatus splendens (Cuvier). Mar.Res.Indones., (19):73-93

___________, 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J.Cons.CIEM, 39:175-92

___________, 1983. A selection of simple methods for the assessment of tropical fish stocks. FAO Fish.Tech.Pap., (234):52 p. Issued also in French and Spanish

Pauly, D. and N. David, 1981. ELEFAN I. A BASIC programme for the objective extraction of growth parameters from length frequency data. Meeresforschung, 28:205-11

Pillai, P.K.M., 1972. Fecundity and spawning habits of some silverbellies. Indian J.Fish., 19:196-99

Rao, D.M. and K.S. Rao, 1986. Studies on the age determination and growth of Nemipterus japonicus (Bloch) off Visakhapatnam. Indian J.Fish., 33:426-39

Rao, T.A., 1967. Maturity and spawning habits of some sciaenids in offshore waters at Visakhapatnam. Indian J.Fish., 11:121-6

Satyanarayana, A.V.V. and G. Narayanappa, 1972. A review of experimental trawling from small and medium sized mechanised vessels off Kakinada. Fish.Technol.Soc.Fish.Technol.,Cochin, 9:97-103

Satyanarayana, A.V.V., G. Narayanappa and D.A.N. Raju, 1972. On the comparative experiments with a four-seam and two-seam trawls on the east coast. Fish.Technol.Soc.Fish.Technol., Cochin, 9:169-79

Silas, E.G., 1969. Exploratory fishing by R.V. Varuna. Bull.Cent.Mar.Fish. Res.Inst.Cochin, 12:1-86

Sparre, P., 1985. Introduction to tropical fish stock assessment. Rome, FAO, Denmark Funds-in-Trust, FI:GCP/INT/392/DEN, Manual 1:338 p.

___________, 1987. Computer programs for fish stock assessment. Length-based fish stock assessment (LFSA) for Apple II computers. FAO Fish. Tech.Pap., (101) Suppl. 2:217 p.

Thompson, W.F. and F.H. Bell, 1934. Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon total yield and yield per unit of gear. Rep.Int.Fish.(Pac.Halibut)Comm., (8):49 p.

Vinci, G.K., 1983. Threadfin bream (Nemipterus) resources along the Kerala coast with notes on biology of Nemipterus japonicus. Indian J.Fish., 29(1982):37-49

Vinci, G.K. and A.K.K. Nair, 1975. Length-weight relationship in the threadfin bream, Nemipterus japonicus along the Kerala coast. Indian J.Fish., 21(1974):299-302

Vivekanandan, E. and D.B. James, 1986. Population dynamics of Nemipterus japonicus (Bloch) in the trawling grounds off Madras. Indian J.Fish., 33:145-54

Zupanovic, S. and S.Q. Mohiudiin, 1976. A survey of the fishery resources in the north eastern part of the Arabian Sea. J.Mar.Biol.Assoc.India, 15:469-537

CONTRIBUTION 21

MURTY, V. SRIRAMACHANDRA, T. APPARAO, M. SRINATH, E. VIVEKANANDAN, K. V. SOMASEKHARAN NAIR, S. K. CHAKRABORTY, S. G. RAJE AND P.U. ZACHARIA. 1994. Stock assessment of threadfin breams (Nemipterus spp) of India. Indian J. Fish., 39 (1&2): 9-41 (1992).

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Stock assessment of threadfin breams (*Nemipterus* spp.) of India

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ABSTRACT

The annual average estimated landing of threadfin breams in India during 1980–83 was 22 247 tonnes which increased to 48 100 tonnes during 1984–88; a maximum of about 60 000 tonnes landed in 1986. Over 90% of threadfin bream catch in the country was obtained by commercial trawlers. Among the maritime states of India, Kerala contributed maximum (52%) to the nemipterid landings, followed by Maharashtra (13.6%), Tamil Nadu and Pondicherry (11.2%), Karnataka and Goa (8.8%), Gujarat (7.8%), Andhra Pradesh (5.5%) and Orissa (1.1%). Though a total of six nemipterid species contributed to the fishery in different states, only two species viz *Nemipterus japonicus* and *N. mesoprion* contributed significantly; the former was most abundant in Tamil Nadu - Pondicherry, Karnataka - Goa, Maharashtra and Gujarat and the latter in Andhra and Kerala. Periods of peak abundance were January–March in Andhra Pradesh, Karnataka-Goa, and Gujarat whereas April–June in Maharashtra and July–September in Tamil Nadu - Pondicherry and Kerala. The parameters of growth and mortality were estimated. The results of stock assessment from each state show that though there is scope to increase the effort by 40%–100% to get MSY from the fishing grounds, the increase in yield will be marginal (1%–12%). There is need to increase the cod end mesh size of trawl net (or length at first capture L_c) by 10–30% to get MSY. The maximum possible yield of *N. japonicus* and *N. mesoprion* from the fishing grounds along east coast (Andhra Pradesh, Tamil Nadu and Pondicherry) is around 5 000 tonnes and along west coast between 43 000 tonnes and 46 000 tonnes. These are close to the yields in 1984–88. The problems in stock assessment and different options for management of fisheries are discussed.

The threadfin breams are one of the most dominant components among the demersal fisheries resources of India being exploited by small commercial trawlers up to depths of about 50–60 m all along Indian coast. An estimated 67 677 tonnes of these fishes were landed in 1989 (Anonymous 1990) from Indian seas which formed 7.7% of total demersal fish and 3.0% of total marine fish landings of India. Though six species occur in the catches, only two species, *Nemipterus japonicus* (Bloch) and *N. mesoprion* (Bleeker) are most abundant and contribute to bulk of threadfin breams catches.

Considerable work on the distribution, taxonomy, biology and fisheries of threadfin breams was done from different regions along Indian coasts (Banse 1959; Narayanappa *et al.* 1968; Silas 1969; Kuthalingam 1971; Satyanarayana *et al.* 1972; Krishnamoorthi 1973a, 1973b; Vinci and Nair 1975; Silas *et al.* 1976; Rajagopalan *et al.* 1977; Dan 1980; CMFRI 1981; Indra 1981; Madanmohan and Gopakumar 1981; Murty 1981, 1982a, 1982b,

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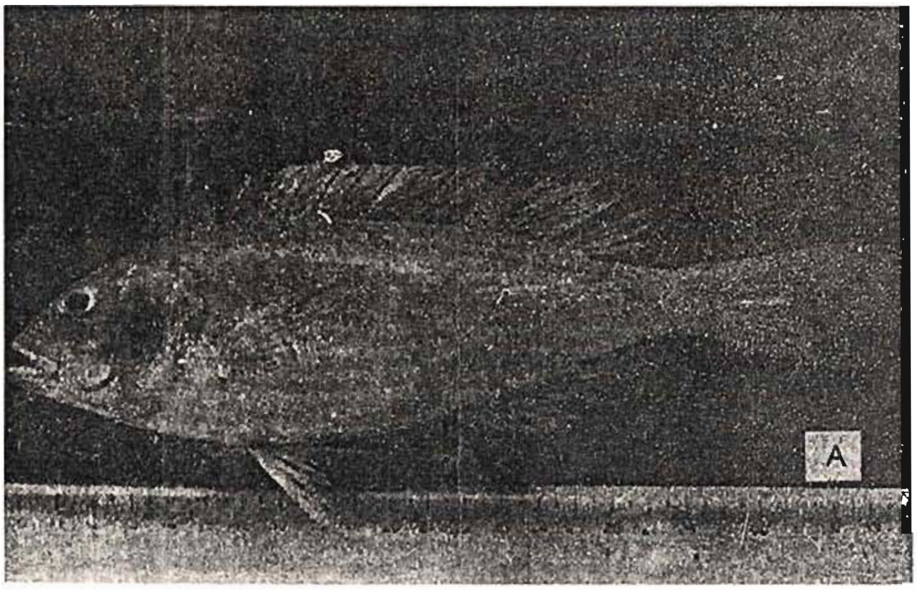
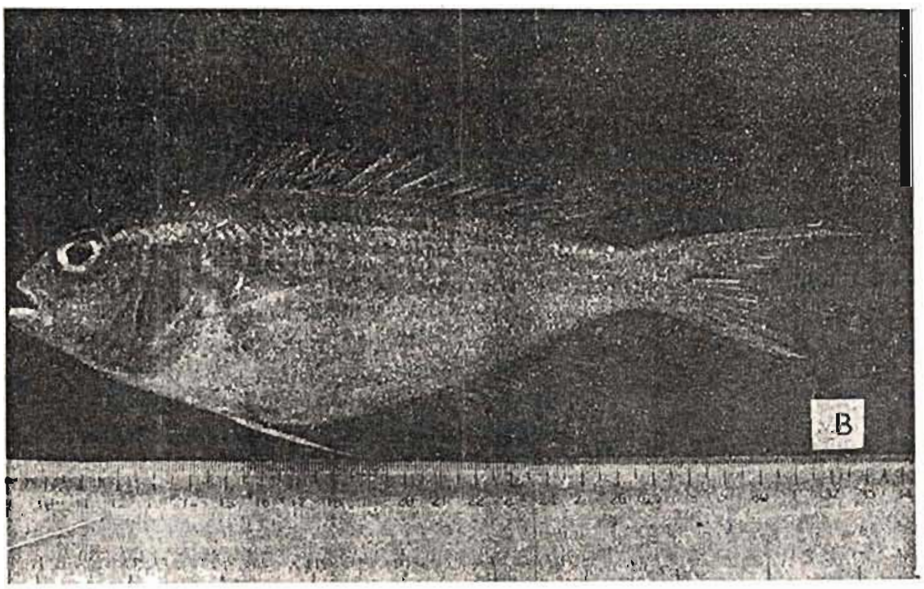


A. *Nemipterus japonicus.*



B. *Nemipterus mesoprion.*

1984; Rao 1981; Rao and Rao 1981, 1983, 1986; Vinci 1983; Acharya and Dwivedi 1984; Madanmohan and Velayudhan 1984; Muthiah and Pillai 1984; Nair and Jayaprakash 1986; Vivekanandan and James 1986, 1987; Vivekanandan 1990; James *et al.* 1987; Reuben *et al.* 1989; Rao 1989 and Nair and Reghu 1990). Detailed studies on stock assessment of threadfin breams were also made (Krishnamoorthi 1973a; Murty, 1983, 1987a, 1987b, 1989; Vivekanandan and James 1986; Devaraj and Gulati 1988; John 1989; Kasim *et al.* 1989), but they were restricted to analyses of data from particular trawl landing centres or of data from research/exploratory vessel from particular areas. These studies are, to a large extent, not able to meet the requirements of agencies engaged in management of fisheries. Therefore, concerted efforts were made to examine the data collected on dominant species of threadfin breams from over wider areas off the Indian coast for stock assessment and the results are presented in this paper.

MATERIALS AND METHODS

Detailed data on species composition, length composition of catch, and biology of dominant species collected from the trawl landing centres at Visakhapatnam, Kakinada and Madras along east coast; and Cochin, Mangalore, Bombay and Veraval along west coast during 1984–88, were considered. The Fisheries Resources Assessment Division of the Central Marine Fisheries Research Institute collects effort and catch data in the country through a well-designed Stratified Multistage Random Sampling Scheme and makes estimates of districtwise and gearwise effort, and districtwise, gearwise and group/specieswise production. These data were also taken for the present study. Two species (*Nemipterus japonicus* and *N. mesoprion*) were selected for the study.

Species composition and length frequency distribution: At each of the seven above mentioned trawl landing centres, data were collected for 4–8 days every month. In some cases, data on species composition and length composition were collected at the landing place and in others the samples were brought to the laboratory. Biological data were collected from samples brought to the laboratory. Total length, measured from tip of snout to tip of lower caudal lobe, was considered for length frequency and other studies. The data on species composition and length composition collected on each observation day were first weighted to the estimated total catch of the group (threadfin breams) and the species respectively, obtained on that day and then such estimates in a month were pooled and then raised to the estimated catch of the month following the procedure of Alagaraja (1984). The monthly estimates were pooled to get quarterly and annual estimates. The data obtained at the observation centre were suitably weighted to get estimates for each state. As the data on production were available in the form of quarterly estimates, the monthly estimates from each centre pooled for each quarter (I quarter: January-March, II quarter: April–June and so on for four quarters) were weighted to get quarterwise and statewise estimates. In the states where detailed data were collected at single centres only, the centre's data were raised to the data of states: thus the data collected at Madras, Cochin, Mangalore, Bombay and Veraval were raised respectively to the data on catches of Tamil Nadu - Pondicherry, Kerala, Karnataka - Goa, Maharashtra and Gujarat. However, in the case of Andhra Pradesh, detailed data were available from two centres : Visakhapatnam and Kakinada. In this case, the data obtained at Visakhapatnam were raised to the catches obtained in the northern districts of Srikakulam, Vijayanagaram and Visakhapatnam together and those obtained at Kakinada were raised to the total catch obtained in the remaining coastal districts (East Godavary, West Godavary, Krishna, Guntur, Prakasam and Nellore) of the state. Stock assessment was done separately for these two sets and then pooled to get estimates for the state of Andhra Pradesh.

Biology: The results of detailed studies on length-weight relationship, food and feeding habits, maturation, spawning, sex ratio and fecundity carried out at different centres were taken from published work.

Estimation of von Bertalanffy growth parameters: The length data were grouped into 10 mm-class intervals. The parameters of growth in length were estimated following the ELEFAN method (Pauly and David 1981, Gayanilo *et al.* 1988): the growth parameters were estimated using the monthly length frequency distribution of each year (from 1984 to 1988) separately from each of the seven centres. In the data of each year, different starting lengths and 'samples' were used and best fit values were taken. Thus, 1–3 estimates of growth parameters in each year from each centre were obtained. Of all such estimates in all the years, the smallest and largest lengths at infinity (L_∞) values and their associated growth coefficient (K) values were selected from each centre for all further studies. The estimates thus obtained were compared with those available in the literature from India and outside.

Mortality rates: The instantaneous total mortality rate (Z) was estimated using length-converted catch curve method (Pauly 1982), using the pooled data of all the five years and the LFSA package of Sparre (1987). The instantaneous natural mortality rate (M) was estimated using the empirical formula of Pauly (1980) and then the fishing mortality rate (F) was obtained as Z-M.

Lengths at recruitment and first capture: The midpoint of the smallest length group in the catch during the five-year period was taken as length at recruitment (L_r). The length corresponding to the first value in the descending limb of the length-converted catch curve was taken as an estimate of the length at first capture (L_c).

Yield and biomass: The raised annual length frequencies of catch of each species from each state were pooled for all the years (1984–88) and annual average values obtained; these were used as input for the study. Estimation of yield and biomass at different fishing effort levels was made, using length-converted Thompson and Bell (1934) analysis (Sparre 1985, Murty 1989) with the help of the programme MIXFISH of the LFSA package of Sparre (1987). The estimates of yield and biomass were made separately using the two sets of growth parameters (as mentioned above) and their average corresponding to each effort level was taken. These values were considered for the purpose of present study. The assessment of *N. japonicus* and *N. mesoprion* was done separately and then together from each maritime state.

For studying the effects of changes in the cod end mesh size, the following procedure was adopted.

1. For each species, the present L_c values were converted into present t_c values using VBG parameters (t_0 is taken as 0).
2. The present t_c values in the species were decreased and increased by same factor (as 10%, 20% . . . 120% . . . 200% of present t_c).
3. Using these t_c values, the present F and other required parameters, the Beverton - Holt (1957) yield-per-recruit analysis was made. This resulted in yield-mesh curve for each species.
4. Taking the value of yield-per-recruit (Y_w/R) at current F and t_c and the value of annual average yield of the species, the

recruitment in numbers R = Y/(Y/R) was estimated.

5. The Y_w/R at each t_c in each species as obtained at 3 above was weighted by the value of R (obtained as in 4 above) to obtain values of yield in weight at different t_c (i.e. percentages of present t_c) values.
6. The values of yield at different t_c values (i.e. percentage of present t_c) for the two species were pooled to get yield mesh curve for the two species together.

The estimates were made separately using the two sets of growth parameters. The average values of yield corresponding to each t_c level, for the two sets of estimates, were taken for the present study.

Similar analyses were made separately for each maritime state.

RESULTS

Fishery

Though the exploitation of threadfin breams was confined to relatively shallower areas, the results of exploratory and experimental fishing (trawling) showed that these fishes were more abundant in depths beyond 50 m (particularly in the 100–200 m depth zone) (Silas 1969; Zupanovic and Mohiuddin 1973; Silas *et al.* 1976, James *et al.* 1987, Philip and Joseph 1988, John 1989, Sudarsan *et al.* 1990, Vivekanandan 1990, Vijayakumaran and Philip 1991, Sivaprakasam *et al.* 1991) and known to move into relatively shallower areas of the depth range 35–40 m during certain seasons (Banse 1959, Nair and Jayaprakash 1986). It is for this reason that threadfin bream catch in different states of India was obtained mainly by trawlers only and not by other gears.

In Andhra Pradesh, commercial trawlers of three different sizes (ranging from 10 to 11.4 m O A L) operated in the depth range 5–50 m during greater part of the year and during November–February in depths extending up to 80 m. Most of the boats returned the same day after fishing but some boats stayed in the sea and conducted fishing for 2–4 days and then returned. Shrimp trawl with cod end mesh size of 15–20 mm was operated by all the boats. In Tamil Nadu, the small vessels (9.8–11 m OAL) operated shrimp trawl with cod end mesh size ranging from 15 to 18 mm. In this state, some boats conducted daytime fishing and some night fishing in different depths up to 50 m. In Kerala also, the trawlers operated shrimp trawl in the 5–50 m depth zone; some returned to the base every day while some returned after 3–4 days. In Karnataka, however, boats of varying lengths of 6.7–15.0 m OAL operated in the depths extending up to 70 m; the smaller-sized boats used shrimp trawl with cod end mesh size of 18–20 mm and conducted fishing during day time whereas the bigger ones conducted stay fishing up to 4 days using shrimp trawl of 25–28 mm cod end mesh size during nights and with fish trawl of 30–40 mm cod end mesh size during day time. In Maharashtra, boats of 13.5 m length operated shrimp trawl in depths extending up to 60 m; these boats stayed in the sea for 2–3 days and after fishing for about 36 hours returned to the base. In Gujarat also, the commercial trawlers (14 m OAL) used shrimp trawl with cod end mesh size of 15–20 mm; trawling was conducted in 20–70 m depth zone and most of the boats conducted fishing and returned the same day whereas a few boats returned after 3–4 days of fishing.

All-India catches: The landings of threadfin breams increased considerably during 1980–88, consistent with increased effort. The average annual landing of threadfin breams during 1980–83 was 22 247 tonnes whereas the same during 1984–88 was 48 104 tonnes. Starting from about 22 600 tonnes in 1980 the landings showed considerable increase (except a minor decline in 1981) over

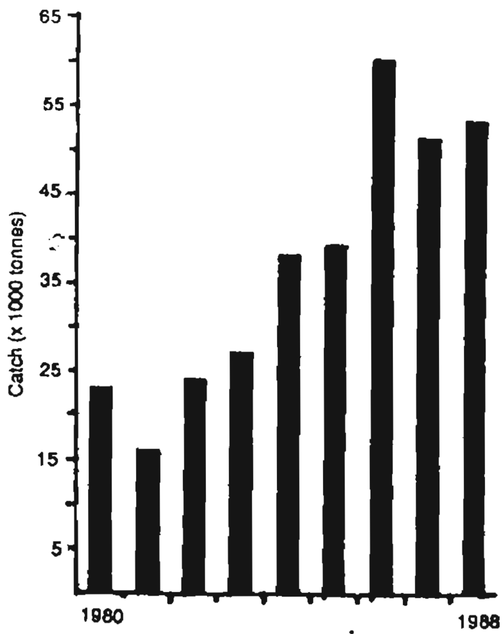


Fig. 1. Estimated annual landings of threadfin breams in India during 1980–88.

the years and reached a maximum of over 60 000 tonnes in 1986, the catches declined to about 50 600 tonnes in 1987 but in 1988 they increased to over 53 000 tonnes (Fig. 1).

Statewise catch effort and catch rates: Among the maritime states and union territories, West Bengal did not contribute to threadfin bream landings. Among the remaining, Kerala contributed the maximum (52%) of all India nemipterid catch, followed by Maharashtra (13.6%), Tamil Nadu - Pondicherry (11.2%), Karnataka - Goa (8.8%), Gujarat (7.8%), Andhra Pradesh (5.5%) and Orissa (1.1%). The total landings in each state along with the catches and catch rates by trawl are dealt with here.

ANDHRA PRADESH: During 1980–88 the estimated landings from *all gears* varied from about 1 130 tonnes in 1988 to about 3 000 tonnes in 1983, with the annual average during this period at 2 030 tonnes. The catch increased from 1980 till 1983 but from 1984 it fluctuated.

Major trawling in this state took place off Visakhapatnam and Kakinada. The trawling effort in the state during 1981–88 ranged from 98 200 to 124 000 boat-days (Fig. 2) with an annual average of 112 450. The nemipterid landings varied from a minimum of 1 100 tonnes in 1988 to a maximum of 2 800 tonnes in 1983 with an annual average of about 2 000 tonnes. During the period, two peaks in the landings, one in 1983 and the other in 1987, were observed. The catch per unit effort in different years varied from about 11 kg in 1988 to 23 kg in 1983. There were two peaks in catch rates also, in 1983 and 1987, in conformity with those in catches.

TAMIL NADU AND PONDICHERRY: The estimated annual landings of threadfin breams by *all gears* during 1980–88 ranged from 2 100 tonnes to 6 800 tonnes with the annual average at 4 100 tonnes. There were two peaks, one in 1982 and the other in 1987.

Major trawling took place off Madras, Cuddalore, Nagapattanam, Mandapam, Rameswaram, Tuticorin, Pondicherry and Karaikal and the total trawling effort varied from 412 000 to 558 000 boat-days (Fig. 2) with the annual average at 487 500. At all the

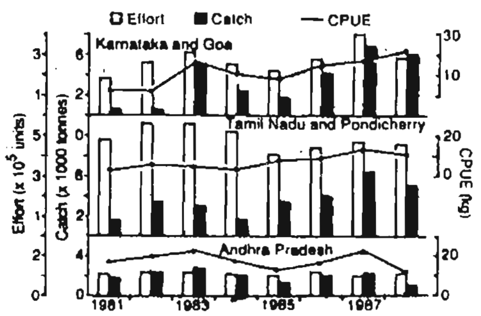


Fig. 2. Estimated effort, catch and catch rates of threadfin breams by trawlers during 1981–88 in Andhra Pradesh; Tamil Nadu and Pondicherry; and Karnataka and Goa.

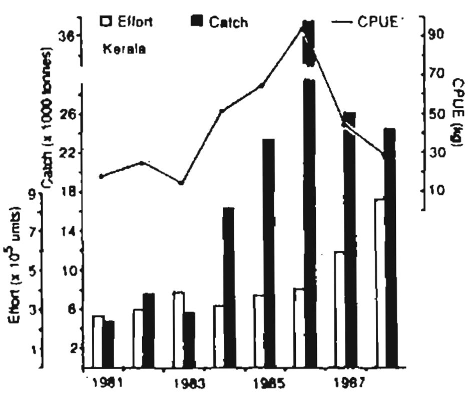


Fig. 3. Estimated effort, catch and catch rates of threadfin breams by trawlers during 1981–88 in Kerala.

trawl landing centres, threadfin breams were landed in considerable quantities but at Mandapam and Rameswaram the landings were negligible. The estimated annual landings of threadfin breams by trawlers during 1981–88 varied from 1 500 tonnes to 6 400 tonnes (Fig. 2) with the annual average at 3 600 tonnes. The catch per unit of effort varied between 3 kg and 13 kg. During 1981–88 the peaks in effort, catch and catch rate were more or less in the same periods (Fig. 2).

KARNATAKA AND GOA: An estimated annual average of 3 200 tonnes of nemipterids were landed with the yearly estimated catches by *all gears* varying from a minimum of 700 tonnes to a maximum of 6 800 tonnes during 1980–88. Starting from 1980, the landings increased slowly, but suddenly showed a fivefold increase in 1983. The landings declined in 1984 and 85 and showed increase in 1986 and the maximum catch of 6 800 tonnes was obtained in 1987.

There was considerable trawling along Karnataka-Goa coast and the trawling effort ranged from 179 000 boat-days to 397 000 boat-days in different years (Fig. 2) during 1981–88, with an annual average of 271 000 boat-days. The estimated threadfin bream catch from trawlers varied from about 600 to 6 700 tonnes with an annual average of 3 400 tonnes during 1981–88. The catch per unit of effort varied from 2 to 22 kg in different years. The effort and catch showed more or less similar trends but the catch rate in 1988 was the highest though the effort and catch were less than in some previous years.

KERALA: The yearly estimated threadfin bream landings by *all gears* in this state ranged from 6 400 tonnes to 38 000 tonnes with the annual average at 19 000 tonnes.

Apart from the two major fishing harbours at Cochin and Sakthikulangara, mechanized boats operated all along the coastline and the estimated annual trawling effort varied from 268 000 to 863 000 boat-days in different years during 1981–88 (Fig. 3). The catch of nemipterids by trawlers varied from abut 4 900 tonnes in 1981 to 37 500 tonnes in 1986 with an average of 18 300 tonnes. The catch per unit of effort varied from 14 to 93 kg. It is clear that over the years, the catches and catch rates showed considerable increase. It could also be seen that the effort variation among different years was not as significant as among landings of the threadfin breams by trawlers (Fig. 3).

MAHARASHTRA: In this state, the estimated annual threadfin bream landings by *all gears* varied from about 2 200 to 12 300 tonnes. Starting from 1980, the landings increased with a peak in 1983; the landings showed decline in 1984 and 1985 and increased further with highest landings in 1988.

The annual trawling effort varied from 73 000 to 245 000 boat-days (Fig. 4) with an average of 174 000. The estimated threadfin bream landings during the same period varied from 2 100 to 12 300 tonnes with an annual average of 5 100 tonnes. The catch rates fluctuated between 14 and 54 kg. The trawling effort and catch showed more or less same trend over the period as also the catch rates.

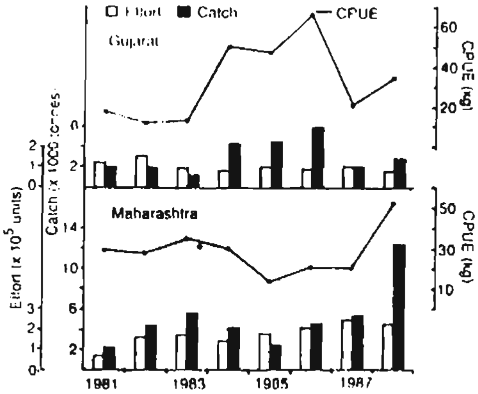


Fig. 4. Estimated effort, catch and catch rates of threadfin breams by trawlers during 1981–88 in Maharashtra and Gujarat.

GUJARAT: The annual trawling effort varied from 82 000 to 149 000 boat-days (Fig. 4) with an annual average of 101 000 boat-days. The nemipterid catch ranged from 1 200 to 5 900 tonnes with an average of 31 000 tonnes. The catch per unit of effort ranged from 12 to 67 kg. The period 1984–86 recorded good annual catches from trawls with highest in 1986. The catch rates by trawls showed increasing trend up to 1986.

Species composition: A total of six species, *Nemipterus japonicus, N. mesoprion, N. tolu, N. delagoae, N. luteus* and *N. metopias*, contributed to the fishery along Indian coast during the period. Of these, the first two species contributed to the fishery significantly all along the coast whereas the others occurred in the catches occasionally in small quantities. The last mentioned species contributed to the fishery in small quantities along southern Tamil Nadu and Kerala regions only.

In Andhra Pradesh five species (excepting *N. metopias*) contributed to the fishery and *N. japonicus* and *N. mesoprion* together formed over 90% of nemipterid catch. Along Tamil Nadu and Pondicherry also the same five species occurred in the catches; here also, the above two species formed the bulk of the catches and the other three species formed about 40% of nemipterid catch. In Kerala, *N. japonicus, N. mesoprion* and *N. metopias* occurred in the catches but the first two species together formed about 99% of threadfin bream catch. In Karnataka-Goa and Maharashtra only two species (*N. japonicus* and *N. mesoprion*) contributed to the fishery. In Gujarat, in addition to the above two species, *N. delagoae* also occurred in the catches but in very small quantities forming about 2.0% of threadfin bream catches.

It is thus clear that only two species are of any importance to the fishery. Of these, *N. mesoprion* is more dominant in Andhra Pradesh and Kerala and *N. japonicus* in the remaining states.

Seasonal variations: The data on estimated catches in each month were pooled for periods of three successive months from January (4 quarters) and were then converted into percentages in each year. These values are shown in Fig. 5 for each state separately for the years from 1985 to 1988. Though there were slight variations in the periods of peak landings within each state, the first quarter appeared to be the peak period in Andhra Pradesh, Karnataka and Goa, and Gujarat, second quarter in Maharashtra and third quarter in Tamil Nadu and Kerala. While there was trawling round the year along east coast, there was no fishing along Karnataka and Gujarat on the west coast, and only very poor fishing in Maharashtra during monsoon (June–August) months. In Kerala, however, there was trawling during monsoon also and major portion of threadfin bream catch was obtained during this period.

Biology

Considerable work on various aspects of biology of different species of threadfin

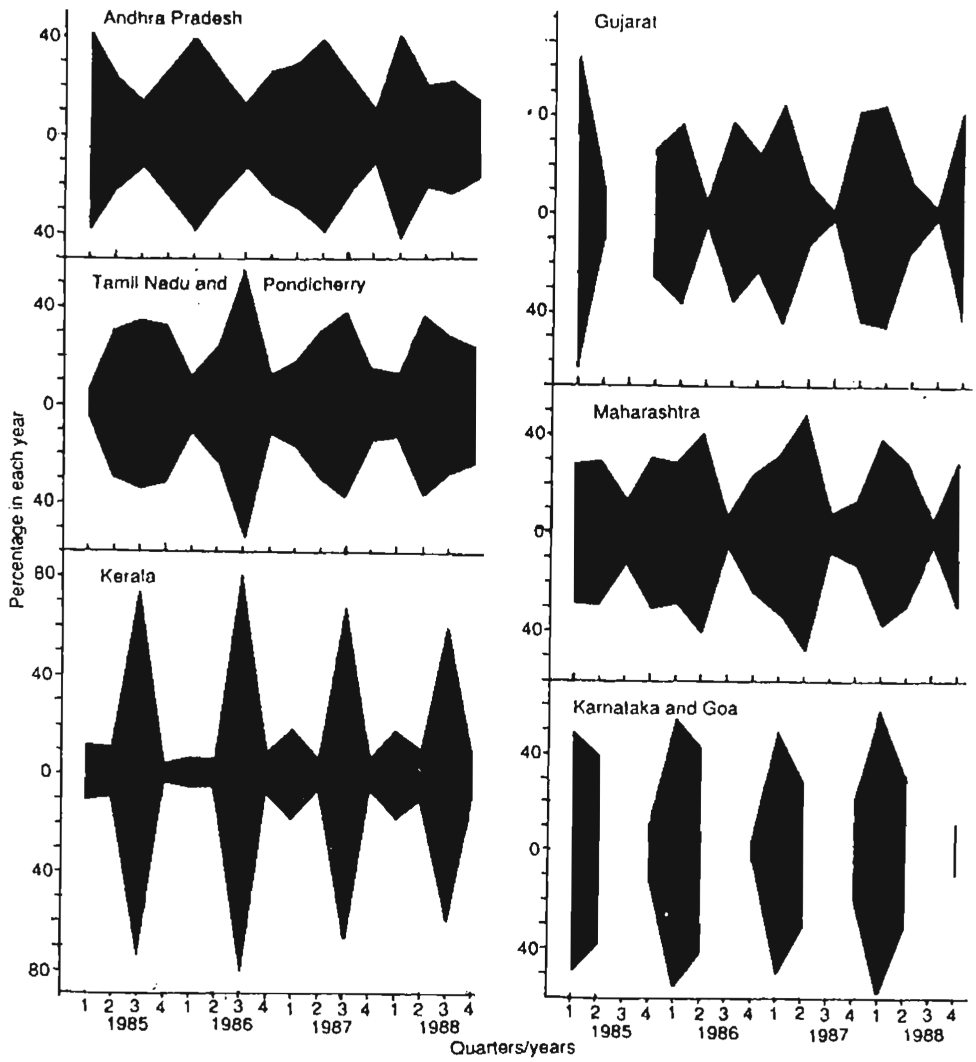


Fig. 5. Quarterly variation in catches of threadfin breams in different years in Andhra Pradesh; Tamil Nadu and Pondicherry; Kerala; Karnataka and Goa; Maharashtra; and Gujarat. 1. January–March 2. April–June 3. July–September 4. October–December.

breams was carried out on the basis of data collected from particular centres along Indian coasts. The results are briefly given below in the case of *N. japonicus* and *N. mesoprion*.

Nemipterus japonicus

FOOD: According to Krishnamoorthi (1973b), the chief items of food of this species from off Andhra-Orissa coasts are *Squilla*, crabs, carried prawns, squids and fishes in the order of dominance; this species is a bottom feeder.

LENGTH AT FIRST MATURITY: From off Andhra-Orissa coast, Krishnamoorthi (1973b) studied the data obtained by exploratory fishing vessels and taking females in stages V and VI of maturation as mature, determined the length at first maturity of the species as 165 mm. Based on data from commercial trawlers from off Kakinada, Murty (1984) determined the length at first maturity as 125 mm; for this purpose he considered the data of spawning season only and took females of stages III–VI as mature. From off Madras, Vivekanandan and James (1986) estimated the length at first maturity as 145 mm on considerations similar to those of Murty (1984).

SPAWNING: The data of Krishnamoorthi (1973b) showed that fishes in stage IV of maturation were available from August to March with peaks in September–October and January–February; stage V fish occurred from September to February and stage VI (Ripe) from September to November. According to the author, September–November is the "probable" period of spawning in the sea off north Andhra and Orissa coasts.

Dan (1980) used a part of the material and data of Krishnamoorthi (1973b); he examined 38 ovaries of fish of length range 130–209 mm collected during November–February (4 months) of 1965-66. According to him "the fish breeds over a short and definite period from December to February. Since about three months time is necessary for the second mode [in the ova diameter frequency distribution] to become ready for spawning, it appears that the fish may breed for a second time in June–July period". However, looking at the data on ova diameters presented and the above conclusions, one would conclude that the second batch will be released after three months starting from March since the first batch is released starting from December. This means that the second batch of ova will be released during March–May period. Since the first batch is released during December–February, the spawning period becomes continuous from December to May, each fish releasing the ripe ova in two spawning acts.

Murty (1984) studied the gross structure of ova of different diameters and the ova diameter frequency distribution in several ovaries of different stages of maturation and concluded that *N. japonicus* was a fractional spawner releasing the ripe eggs in two spawning acts during August–April in the sea off Kakinada. In the sea off Madras (Vivekanandan and James 1986), the spawning season was determined as June–March with peak during December–March. From off Cochin, the study by Vinci (1983) and the present data showed that spawning in *N. japonicus* takes place during June–January with peak during June–August (monsoon). From the findings of Kuthalingam (1971) and the present data, it appeared that off Mangalore the spawning period extended from November to May with peak during November–February. Off Bombay, mature and spent fish occured almost throughout the year but their proportion was highest during monsoon months (June–August). Off Veraval, spawning appeared to take place during October–April with peak during October–December.

FECUNDITY: Dan (1980) examined 38 ovaries and estimated the fecundity as ranging from 13 900 to 58 400 in fishes of 135 to 205 mm in total length. The author knew that this species spawns in two batches but did not consider this fact for estimating fecundity. The estimates given, therefore, are to be taken as 'batch fecundity' estimates only.

Murty (1984) estimated the total annual fecundity (two batches together) as ranging from 23 000 to 139 200 in fishes of the length range 134–199 mm. Two relationships obtained were:

$$F = -116.56711 + 1.11909\,L;\ R^2 = 0.69$$
$$F = -0.75615 + 1.11380\,W;\ R^2 = 0.85$$

where F, fecundity; L, total length (mm); and W, total weight of fish (g)

SEX RATIO: According to Krishnamoorthi (1976) and Murty (1984) males were predominant in almost all lengths and beyond 215 mm there were no females; the mean length of males was always greater than that of females.

Nemipterus mesoprion

FOOD: According to Rao (1989) this species is carnivorous subsisting mainly on crustaceans and teleosts. Among the former, small prawns, stomatopods and crabs were dominant.

MATURATION AND SPAWNING: The length at first maturity was estimated in females as 100 mm (Murty 1982a). This species is also a fractional spawner spawning in two batches during the season which off Kakinada extended from December to April with peak in January (Murty 1982a).

Though results of investigations from other centres on spawning in *N. mesoprion* were not published, the available data indicated that off Cochin spawning takes place during June–September with peak in June. Along the Bombay coast mature and spent fish occur almost throughout the year with peak during June–August. Off Veraval there was no trawling during June–August, the proportion of mature and gravid fish in each month showed that spawning in this region takes place during October–March with peak during December–February.

Stock assessment

For this study, only *N. japonicus* and *N. mesoprion* were considered as these two species contributed over 90% of threadfin bream catches.

Growth parameters: The smallest and largest L_∞ values and their associated K values pertaining to the two species are shown in Tables 1 and 2. The corresponding length frequency data (restructured) with the growth curves are shown in figures 6–13. The values of L_∞ and K of *N. japonicus* from all the centres in both the sets (Table 1) varied from 305 to 351 mm and from 0.40 to 0.70/year respectively. While the maximum recorded length (L_{max}) in India is 350 mm (Krishnamoorthi 1973b), the L_{max} values observed at different centres (Table 1) are close to the estimated values of L_∞. Further, the values of L_∞ and K in each set from different centres are closer. The growth parameters estimated by earlier workers (Table 3) from the Indo-Pacific region show wider range in both L_∞ (235–382 mm) and K (0.12–1.00/year).

In *N. mesoprion*, the values of L_∞ and K from different centres vary from 222 to 297 mm and from 0.405 to 0.84/year (Table 2) respectively and the L_{max} observed at different centres are close to L_∞ values considered. The values of lower L_∞ from different centres are more or less close to each other but in higher L_∞, the range is slightly larger.

Mortality rates: Taking the two sets of growth parameters (Tables 1 & 2), the total mortality rates were estimated using the length converted catch curve. The Z values obtained by using each set of parameters from different centres varied from 1.80 to 3.02 (lower parameters) and 2.12 to 3.39 (higher parameters) in *N. japonicus* (Table 1) and from 2.01 to 3.76 (lower parameters) and 2.25 to 5.37 (higher parameters) in *N. mesoprion* (Table 2) (Here and elsewhere in the text the estimates obtained by using smallest L_∞ and related K are referred to as having been ob-

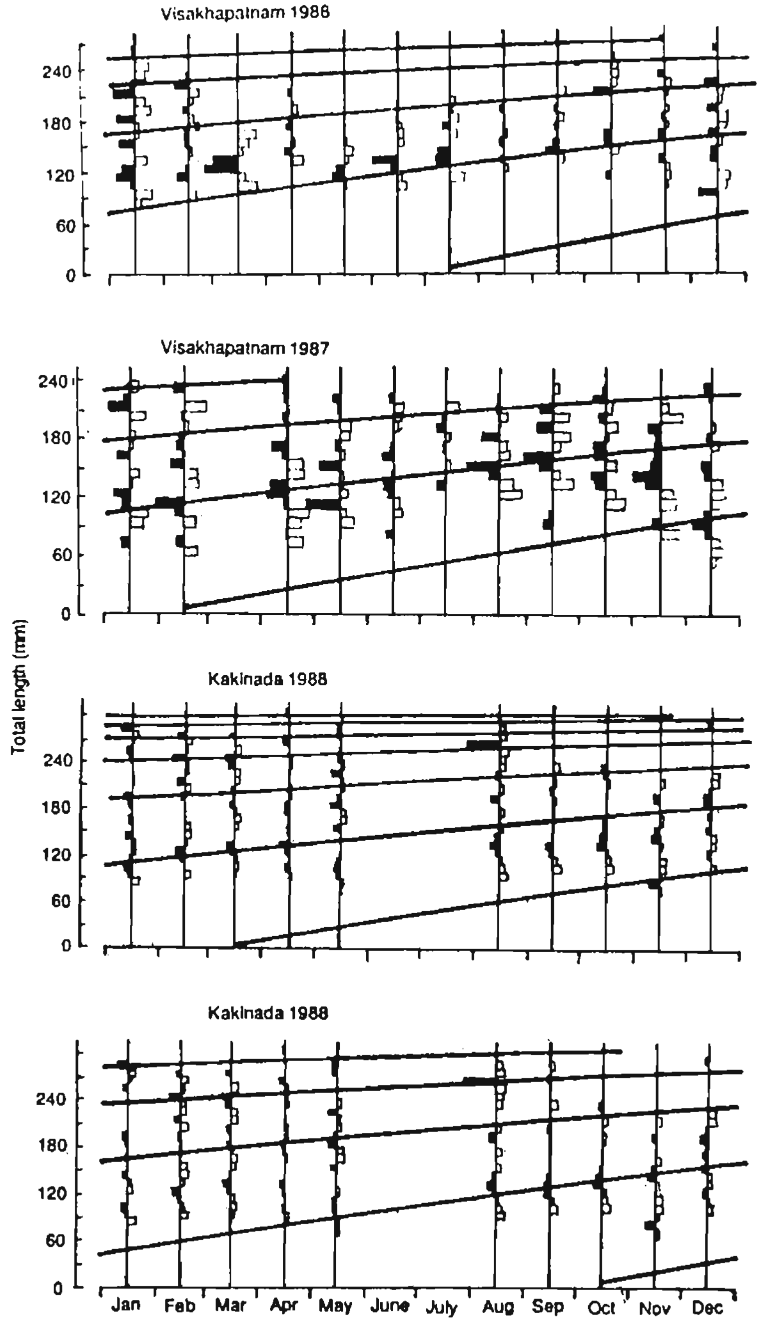


Fig. 6. Restructured length frequency data (ELEFAN I) and growth curves of *Nemipterus japonicus*. Visakhapatnam 1986 : L_∞ = 305 mm, K=0.52 per year, SS=9, SL=145 mm; Visakhapatnam 1987 : L_∞ = 335 mm, K=0.40 per year, SS=2, SL=115 mm; Kakinada 1988: L_∞ = 315 mm, K=0.51 per year, SS=2, SL=120 mm; Kakinada 1988: L_∞ = 351 mm, K=0.49 per year, SS=6, SL=125 mm.

Table 1. Estimated values of growth parameters, mortality rates, ages at recruitment and first capture, and other parameters used in the assessment of *Nemipterus japonicus* from different centres

	Parameters	Visakha-patnam	Kakinada	Madras	Cochin	Mangalore	Bombay	Veraval
	l_{max}	350	315	295	305	285	325	345
Lower L_∞ and	L_∞	305	315	305	323	323	320	320
related K	K	0.52	0.51	0.62	0.70	0.43	0.56	0.60
	M	1.14	1.12	1.28	1.37	0.99	1.18	1.23
	Z	2.29	1.80	2.14	3.02	2.72	1.95	2.70
	F	1.15	0.68	0.86	1.77	1.81	0.77	1.47
	t_c	1.06	0.99	0.60	0.41	1.14	0.88	1.10
	t_r	0.23	0.30	0.32	0.16	0.52	0.48	0.19
	Terminal F/Z	0.548	0.500	0.500	0.624	0.683	0.500	0.500
Higher L_∞ and	L_∞	335	351	350	350	–	350	345
related K	K	0.40	0.49	0.58	0.68	–	0.50	0.55
	M	0.94	1.06	1.18	1.30	–	1.07	1.14
	Z	2.12	2.16	2.92	3.39	–	2.16	3.05
	F	1.18	1.10	1.74	2.19	–	1.09	1.91
	t_c	1.22	0.89	0.58	0.38	–	0.88	1.10
	t_r	0.28	0.28	0.29	0.15	–	0.48	0.19
	Terminal F/Z	0.676	0.500	0.500	0.770	–	0.500	0.500
	log a	–4.2441	–4.2441	–4.8665	4.4793	4.4793	–5.5272	–5.5272
	b	2.702	2.702	2.9661	2.8487	2.8487	3.2839	3.2839

All lengths are in mm, weights in grams and ages in years; log a and b are the constants of length-weight relationship.

tained from "lower parameters" and similarly for largest L_∞ and K from "higher parameters"). The estimated value of M from different centres in *N. japonicus* ranged as 0.99–1.37 with lower parameters and 0.94–1.30 with higher parameters (Table 1). In *N. mesoprion* the range of M values was 1.02–1.59 with lower parameters and 1.12–1.67 with higher parameters (Table 2).

Length-based Thompson and Bell analysis: The results pertaining to each maritime state are presented first followed by those of east coast and west coast and then all India.

ANDHRA PRADESH: In *N. japonicus* the yield increases with increased effort and reaches a maximum of 617 tonnes at 160% of the present effort. In *N. mesoprion*, maximum yield of 1 023 tonnes can be obtained at 140% of the present effort. In both the species together the highest yield of 1 636 tonnes each be obtained at 140% of the present effort (Fig. 14.A). Thus the effort should be increased by 40% to get MSY. The present yield of these two species is 1 600 tonnes and a maximum increase of 2% in the yield can be attained from the present fishing grounds through increasing the effort by 40%. This means a drastic reduction in catch per unit effort as also indicated by low biomass values at this effort level (Fig. 14.A).

TAMIL NADU - PONDICHERRY: In this region, maximum yield of 1 850 tonnes can be obtained at 140% of present effort in *N.*

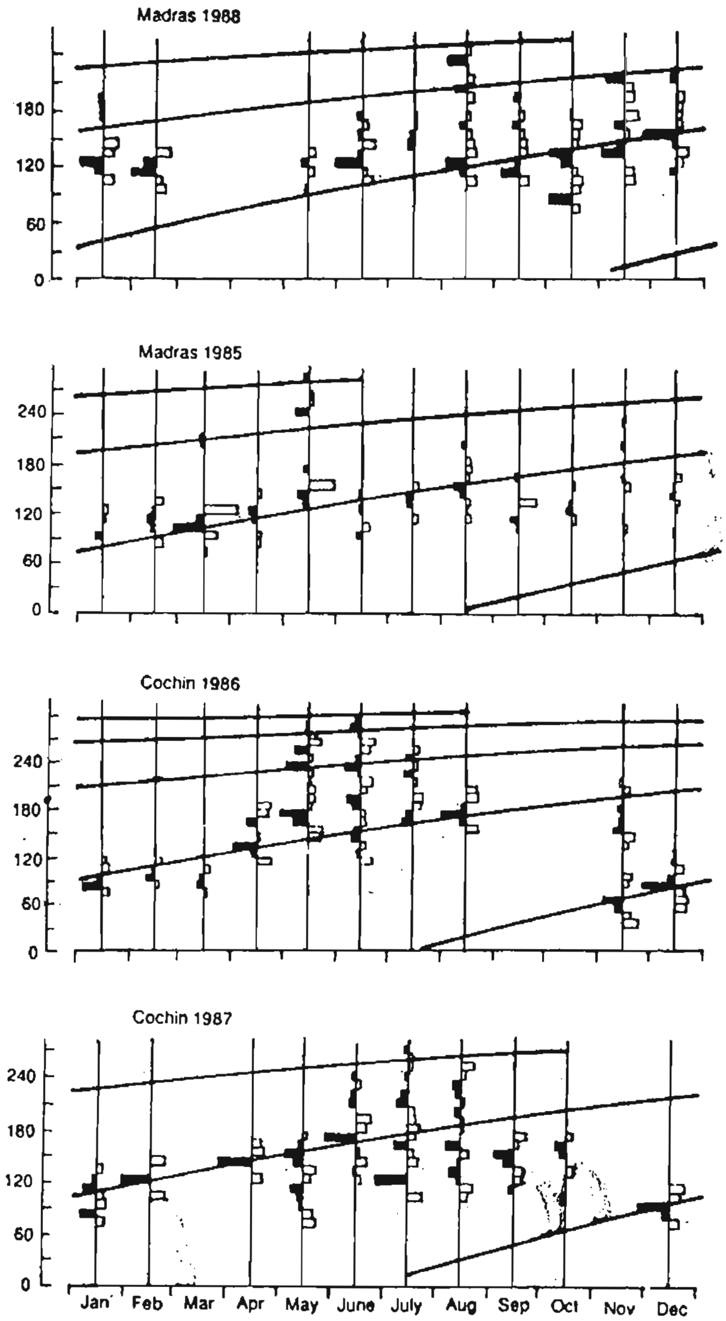


Fig. 7. Restructured length frequency data (ELEFAN 1) and growth curves of *Nemipterus japonicus*. Madras 1988: L_∞ = 305 mm, K=0.62 per year, SS=6, SL=120 mm; Madras 1985: L_∞ = 350 mm, K=0.58 per year, SS=3, SL=105 fnm; Cochin 1986: L_∞ = 323 mm, K=0.70 per year, SS=4, SL=135 mm; Cochin 1987: L_∞ = 350 mm, K=0.68 per year, SS=2, SL=125 mm.

Table 2. Estimated values of growth parameters, mortality rates, ages at recruitment and first capture and other parameters used in the assessment of *Nemipterus mesoprion* from different centres

	Parameters	Visakha-patnam	Kakinada	Madras	Cochin	Mangalore	Bombay	Veraval
	L_{max}	229	215	195	265	205	255	295
Lower L_∞ and	L_∞	240	225	223	244	222	246	255
related K	K	0.65	0.76	0.61	0.62	0.74	0.77	0.405
	M	1.41	1.59	1.38	1.36	1.57	1.56	1.02
	Z	3.76	2.91	2.01	2.04	2.28	2.21	2.09
	F	2.35	1.32	0.63	0.68	0.71	0.65	1.07
	t_c	1.13	0.62	1.11	1.30	0.99	0.92	1.76
	t_r	0.24	0.29	0.46	0.25	0.47	0.47	0.36
	Terminal F/Z	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Higher L_∞ and	L_∞	267	255	238	273	260	288	297
related K	K	0.72	0.465	0.84	0.51	0.60	0.58	0.65
	M	1.47	1.12	1.67	1.36	1.31	1.24	1.33
	Z	5.37	2.47	3.39	2.25	2.88	2.57	5.06
	F	3.90	1.35	1.72	1.09	1.57	1.33	3.73
	t_c	0.88	0.94	0.79	1.34	1.03	1.04	0.89
	t_r	0.19	0.42	0.31	0.27	0.48	0.52	0.19
	Terminal F/Z	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	log a	−4.650917	−4.650917	−4.79260	−4.83784	−4.83784	−4.25225	−4.25225
	b	2.87707	2.87707	2.9692	2.9840	2.9840	2.89912	2.89912

All lengths are in mm, weights in grams and ages in years; log a and b are constants of length-weight relationships.

japonicus. In *N. mesoprion* and in both the species together, the yield increases with increased effort up to 200% of present (Fig. 15.A) and the yields are 1 670 tonnes and 3 470 tonnes respectively. The increase in yield of the two species will be only 7% with 100% increase in effort. Thus, the increase in effort can result in decline of catch per unit effort from the present fishing grounds.

KERALA: The MSY of *N. japonicus* corresponds to 11 900 tonnes at 60% of the present effort. In *N. mesoprion* and in both the species together, the yield increases to 23 230 tonnes and 31 125 tonnes respectively at 200% of present effort (Fig. 16.A). Thus there is scope to increase yield of *N. mesoprion* and 36% increase in yield can be obtained through increasing the effort by 100%. However, at this effort level, the increase in yield of both the species together will be only 12%. Though this means a decline in catch per unit effort, the yield of *N. mesoprion* can still be increased by suitably deploying the effort in the grounds during monsoon. It may be noted that threadfin breams are principal group in the fishing grounds at depths of 30–40 m during monsoon period (Nair and Jayaprakash 1986, Murty *et al.* 1992).

KARNATAKA-GOA: In this region the MSY of *N. japonicus* corresponds to 80% of present effort whereas the yield increases with increased effort up to 200% of present effort in *N. mesoprion*. In both the species together

Table 3. Von Bertalanffy growth parameters and mortality rates estimated by different authors from different localities in the Indo-Pacific region for *Nemipterus japonicus* and *N. mesoprion*

Locality	L_∞ (mm)	K per year	t_0 (year)	Z	M	F	L_{max} (mm)	Method of estimation of growth parameters	Source
				Nemipterus japonicus					
Andhra - Orissa coast	305	0.3141	−1.1079	0.5166	0.5037	0.0129	350	Modal progression	Krishnamoorthi 1973a
Visakhapatnam	290	0.6244	0.1439				305	Scale studies	Rao and Rao 1986
Kakinada	314	0.7514	−0.1731	1.86	1.14	0.72	285	Modal progression	Murty 1983, 1984
"	339	0.52	−0.16	2.64	1.11	1.53	305	Integrated method	Murty 1987a
Madras	305	1.004	0.2257	2.9853	2.5254	0.4599	301	Integrated method	Vivekanandan and James 1986
Cochin	302	0.47	−0.27	1.37	1.0	0.37	315	Model progression	John 1989
"	326	0.51	–	–	–		315	ELEFAN	John 1989
Maharashtra-Gujarat	298	0.8214	−0.0426	1.6690	1.3186	0.3504	285	Modal progression	Devaraj and Gulati 1988
Kuwait Male	303	0.542	0.19	–				Otoliths	Samuel 1991
Female	265	0.595	0.03	–				"	
Sexes pooled	277	0.580	0.10	0.84				"	
Aden	291	0.31	0.05	0.67				Scales	Edwards *et al.* 1985
Hong Kong (Female)	341	0.190	–	1.32				Scales & otoliths	Lee 1975
" " (Male)	382	0.130	–	1.43				Scales & otoliths	Lee 1975
Manila Bay-Philippines	300	0.70	–	3.31	1.41	1.90			Ingles and Pauly 1984
Carigara Bay-Philippines	235	0.73	–	2.49	1.52	0.98			Corpuz *et al.* 1985
Samar sea-Philippines	265	0.60	–	2.09	1.29	0.80			Corpuz *et al.* 1985
Java sea	235	0.7	–	2.17	1.53	0.64		ELEFAN	Dwiponggo *et al.* 1986
Gulf of Thailand (Male)	–	0.160	–	-	5.48	-			Amornchairojkul and Boonwanich 1982
" (Female)	–	0.121	–						
Peninsula of Malaysia	315	0.530	–	4.02	1.18	2.84		ELEFAN	Isa 1988
"	314	0.550	–	3.72	1.21	2.51		ELEFAN	Isa 1988
Northern Burma	370	0.235	–	0.92				ELEFAN	Pauly and Aung Sann 1984
Southern Burma	370	0.243	–	0.94				ELEFAN	Pauly and Aung Sann 1984
Northern Borneo	289	0.470	–	2.28					Weber and Jothy 1977
				Nemipterus mesoprion					
Kakinada	219	0.83	−0.256					Modal progression	Murty 1982
Java sea	215	0.80		3.25	1.73	1.54		ELEFAN	Dwiponggo *et al.* 1986

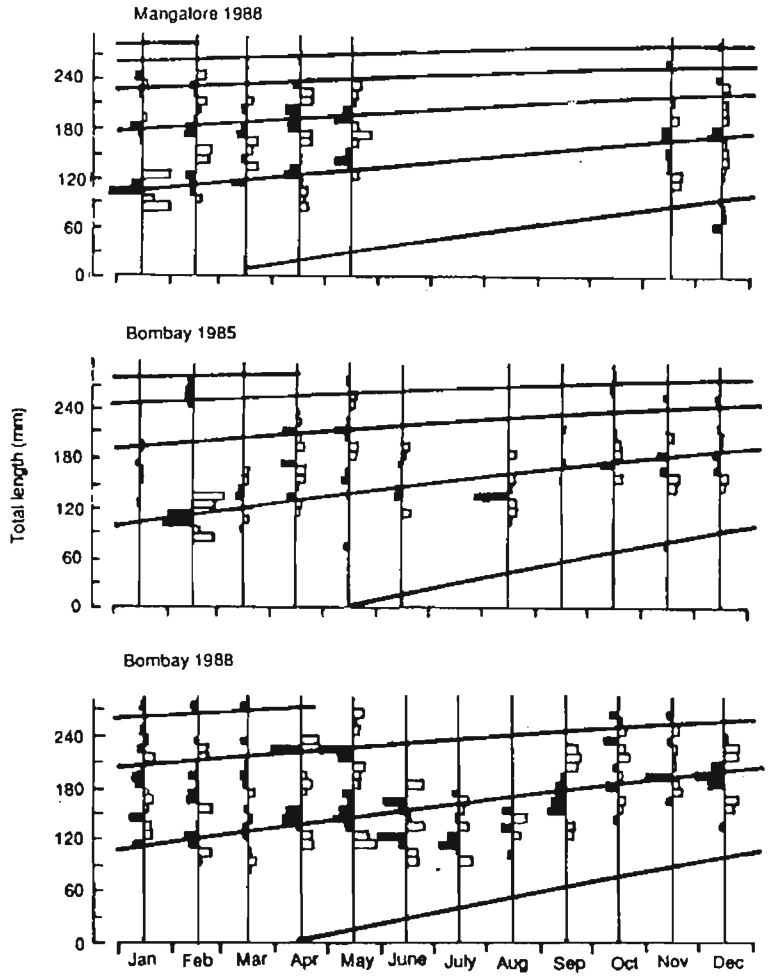


Fig. 8. Restructured length frequency data (ELEFAN 1) and growth curves of *Nemipterus japonicus*. Mangalore 1988: L_∞ = 323 mm, K=0.43 per year, SS=1, SL=105 mm; Bombay 1985: L_∞ = 320 mm, K=0.56 per year, SS=4, SL=130 mm; Bombay 1988: L_∞ = 350 mm, K=0.50 per year, SS=1, SL=115 mm.

MSY corresponds to 140% of the present effort (Fig. 17.A). The increase in yield at this effort level will only be about 1%, indicating a drastic decline in CPUE.

MAHARASHTRA: In *N. japonicus* the MSY corresponds to 140% of present effort whereas in *N. mesoprion* the yield increases up to 200% of present effort. In both the species also maximum yield corresponds to 200% of present effort (Fig. 18.A); the increase in yield is, however, 9% only.

GUJARAT: In this region the MSY of *N. japonicus* corresponds to 160% of present effort and in *N. mesoprion* the yield increases up to 200% of present effort. In the two species together the MSY corresponds to 180% of

Table 4. Yield (tonnes) of *Nemipterus japonicus*, *N. mesoprion* and both the species together along east coast, west coast and both the coasts combined at different levels of effort

Effort as per cent of present	East coast *Nemipterus japonicus*	East coast *Nemipterus mesoprion*	East coast Both species	West coast *Nemipterus japonicus*	West coast *Nemipterus mesoprion*	West coast Both species	All India *Nemipterus japonicus*	All India *Nemipterus mesoprion*	All India Both species
20 (−80)	1 253 (−48.1)	1 169 (−51.9)	2 422 (−50.1)	16 220 (−20.6)	7 206 (−67.2)	23 426 (−44.7)	17 473 (−23.5)	8 375 (−65.7)	25 848 (−45.3)
40 (−60)	1 860 (−23.0)	1 757 (−27.8)	3 617 (−25.4)	20 157 (−1.3)	12 425 (−43.4)	32 582 (−23.1)	22 017 (−3.6)	14 182 (−41.8)	36 199 (−23.3)
60 (−40)	2 172 (−10.1)	2 091 (−14.1)	4 263 (−12.1)	21 014 (+2.9)	16 384 (−25.4)	37 396 (−11.7)	23 186 (+1.5)	18 473 (−24.2)	41 659 (−11.8)
80 (−20)	2 334 (−3.4)	2 298 (−5.5)	4 632 (−4.5)	20 887 (+2.3)	19 472 (−11.3)	40 359 (−4.7)	23 221 (+1.7)	21 770 (−10.7)	44 991 (−4.7)
100 (Present) (0)	2 417 (0)	2 433 (0)	4 850 (0)	2 420 (0)	21 951 (0)	43 271 (0)	22 837 (0)	24 384 (0)	47 221 (0)
120 (+20)	2 453 (+1.5)	2 524 (+3.7)	4 977 (+2.6)	19 842 (−2.8)	23 928 (+9.0)	43 770 (+3.3)	22 295 (−2.4)	26 452 (+8.5)	48 747 (+3.2)
140 (+40)	2 463 (+1.9)	2 587 (+6.3)	5 050 (+4.1)	19 245 (−5.8)	25 557 (+16.4)	44 802 (+5.7)	21 708 (−4.9)	28 144 (+15.4)	49 852 (+5.6)
160 (+60)	2 455 (+1.9)	2 628 (+8.0)	5 083 (+4.8)	18 665 (−8.6)	26 899 (+22.5)	45 564 (+7.5)	21 120 (−7.5)	29 527 (+21.1)	50 647 (+7.3)
180 (+80)	2 439 (+0.9)	2 658 (+9.2)	5 097 (+5.1)	18 117 (−11.3)	28 012 (+27.6)	46 129 (+8.9)	20 556 (−10.0)	30 670 (+25.8)	51 226 (+8.5)
200 (+100)	2 416 (−0.04)	2 677 (+10.0)	5 093 (+5.0)	17 605 (−13.8)	28 938 (+31.8)	46 544 (+9.8)	20 021 (−12.3)	31 615 (+29.7)	51 636 (+9.3)

Highest values underlined; values in parentheses indicate percentage increase or decrease over present values.

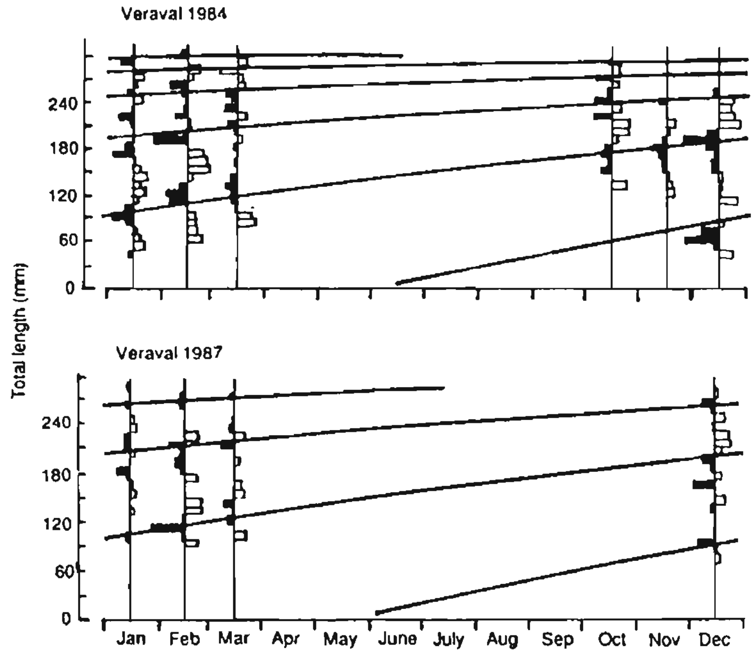


Fig. 9. Restructured length frequency data (ELEFAN 1) and growth curves of *Nemipterus japonicus*. Veraval 1984: L_∞ = 320 mm, K=0.60 per year, SS=1, SL=100 mm; Veraval 1987: L_∞ = 345 mm, K=0.55 per year, SS=4, SL=200 mm.

present effort (Fig. 19,A). The total yield of the two species (at 3 900 tonnes) at 180% of present effort gives only 5% increase in yield, thus suggesting decline in catch per unit effort.

EAST COAST OF INDIA: The results of stock assessment off east coast (except Orissa and West Bengal) of *N. japonicus* showed that MSY is obtained at 140% of the present effort (Table 4). In *N. mesoprion* the yield increases with increased effort up to 200%. In both the species together MSY is obtained at 180% of present effort. At this effort level, increase in the yield of *N. japonicus* will be 1%, in *N. mesoprion* 9%, and in both the species together 5%, over the present yield.

WEST COAST OF INDIA: In *N. japonicus* the yield is maximum at 60% of the present effort whereas in *N. mesoprion* the same is at 200% (Table 4). In both the species together the yield is maximum at 200% of the present effort. At this effort level, however, there will be 14% decline in the yield of *N. japonicus* though 32% increase in the yield of *N. mesoprion* and thus about 10% increase in the yield of both the species together over the yield at the present effort level.

ASSESSMENT ON ALL-INDIA BASIS: In *N. japonicus* the MSY corresponds to 80% of present effort whereas the yield increase continues till 200% of the present effort in *N. mesoprion* and both the species together. By increasing the effort by 100% the yield of *N. japonicus* decreases by 12.3% (Table 4). In *N. mesoprion* the yield increases by about 30% and, by 9% in both the species. Thus the

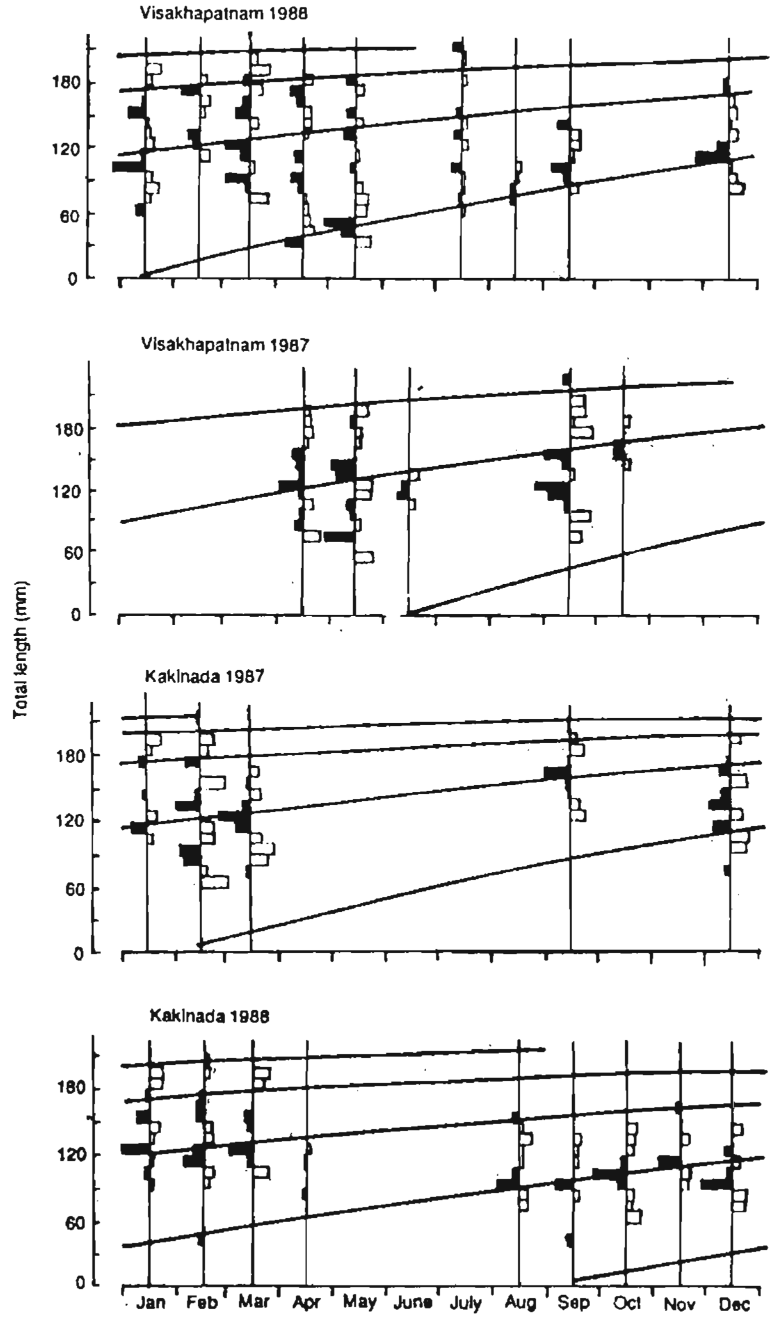


Fig. 10. Restructured length frequency data (ELEFAN 1) and growth curves of *Nemipterus mesoprion*. Visakhapatnam 1988: L_∞ = 240 mm, K=0.65 per year, SS=5, SL=50 mm; Visakhapatnam 1987: L_∞ = 267 mm, K=0.72 per year, SS=2, SL=130 mm; Kakinada 1987: L_∞ = 225 mm, K=0.76 per year, SS=5, SL=110 mm; Kakinada 1988: L_∞ = 255 mm, K=0.465 per year, SS=2, SL=50 mm.

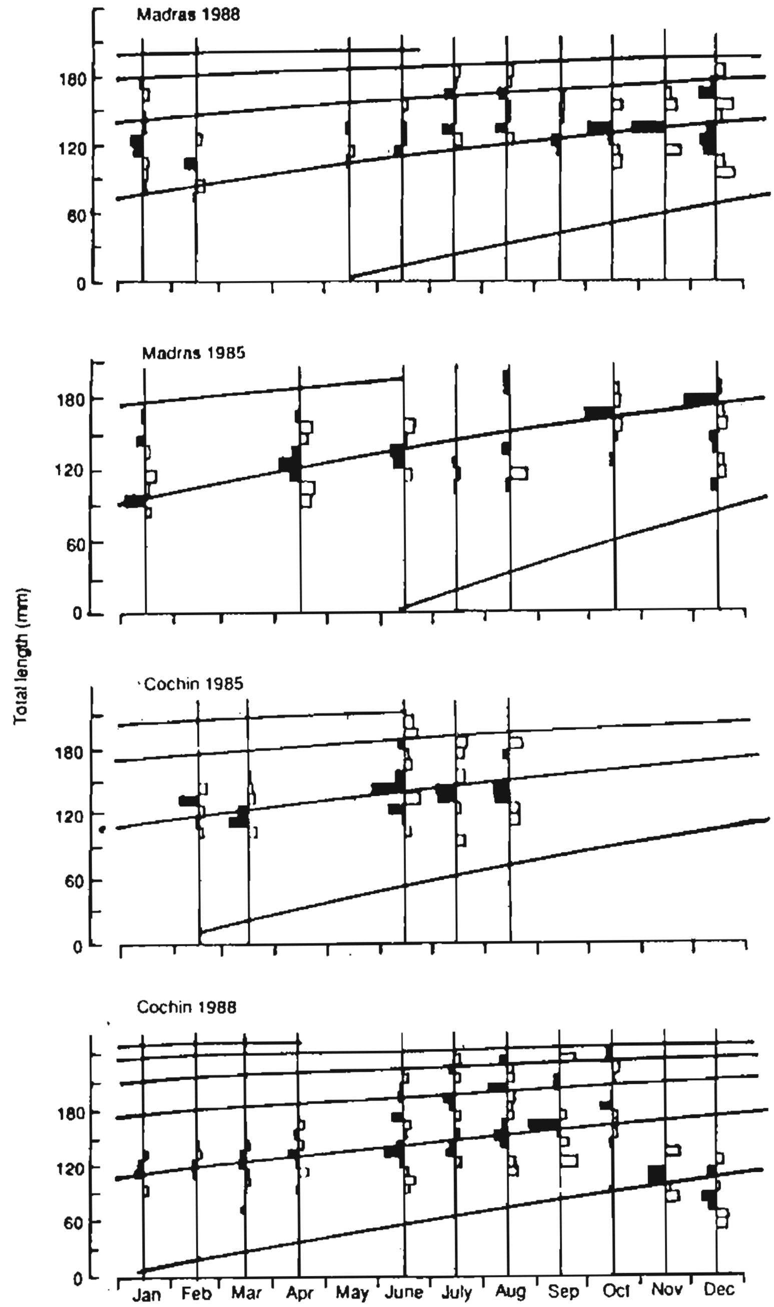


Fig. 11. Restructured length frequency data (ELEFAN I) and growth curves of *Nemipterus mesoprion*. Madras 1988: L_∞ = 223 mm, K=0.61 per year, SS=4, SL=110 mm; Madras 1985: L_∞ = 238 mm, K=0.84 per year, SS=1, SL=95 mm; Cochin 1985: L_∞ = 244 mm, K=0.62 per year, SS=2, SL = 125 mm; Cochin 1988: L_∞ = 273 mm, K=0.51 per year, SS=7, SL=155 mm.

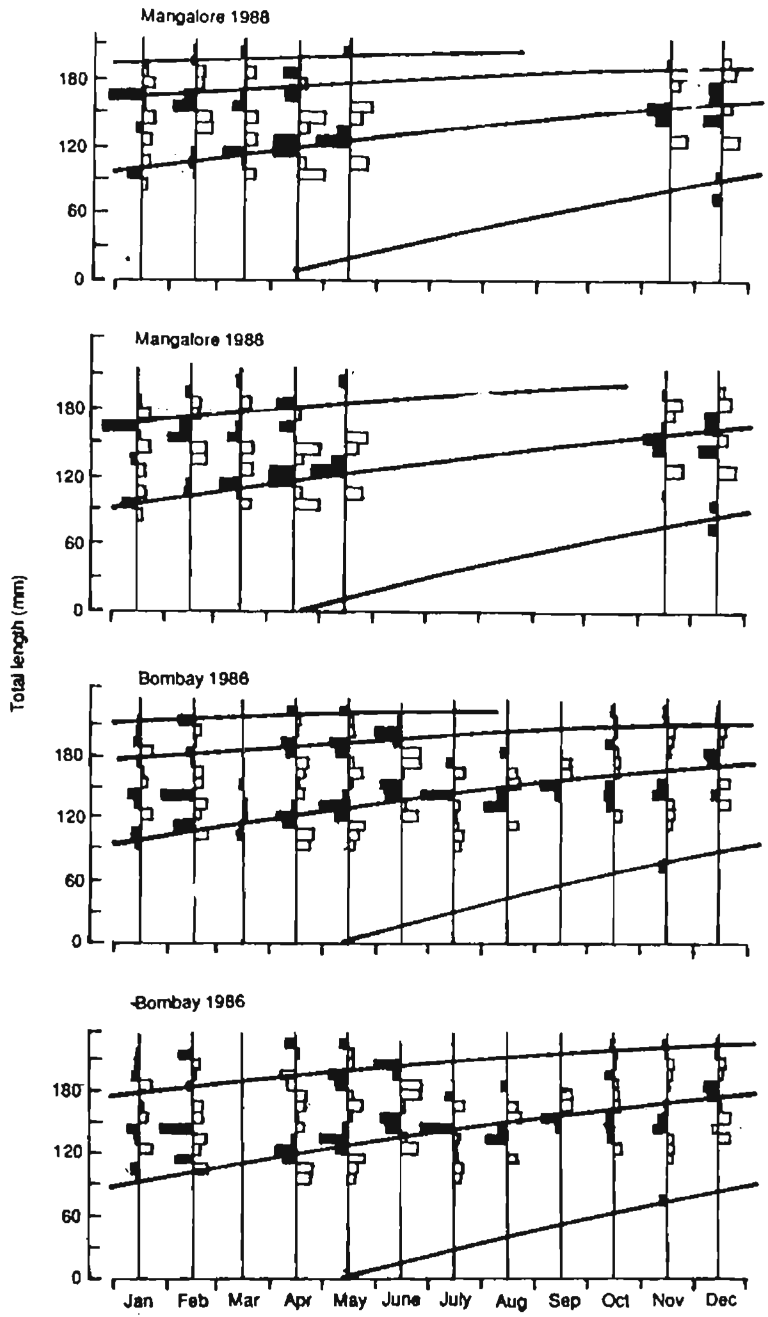


Fig. 12. Restructured length frequency data (ELEFAN 1) and growth curves of *Nemipterus mesoprion*. Mangalore 1988: L_∞ = 222 mm, K=0.74 per year, SS=7, SL=160 mm; Mangalore 1988: L_∞ = 260 mm, K=0.60 per year, SS=1, SL=95 mm; Bombay 1986: L_∞ = 246 mm, K=0.77 per year, SS=2, SL=110 mm; Bombay 1986: L_∞ = 288 mm, K=0.58 per year, SS=11, SL=75 mm.

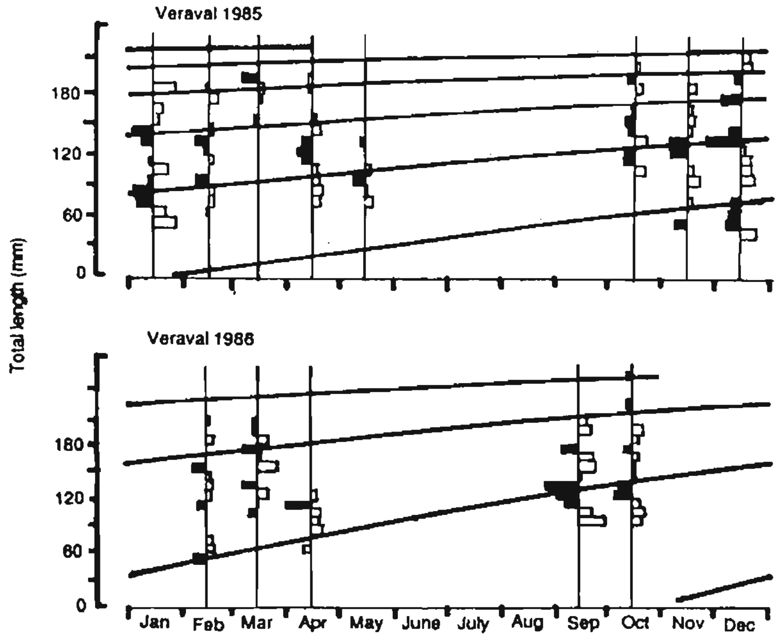


Fig. 13. Restructured length frequency data (ELEFAN 1) in *Nemipterus mesoprion*. Veraval 1985: L_∞ = 255 mm, K=0.405 per year, SS=1, SL=85 mm; Veraval 1986: L_∞ = 297 mm, K=0.65 per year, SS=1, SL=55 mm.

present effort is beyond the one that corresponds to MSY of *N. japonicus* along west coast and both the coasts together. However, the present effort is less than that which gives MSY in *N. japonicus* along east coast; in *N. mesoprion* along both coasts; and in both the species together along both the coasts.

Yield assessment with reference to cod end mesh size of trawl: In Andhra Pradesh (Fig. 14.B) for both the species, the assessment shows that there is need to increase the age at first capture by 10%. In Tamil Nadu-Pondicherry (Fig. 15.B), for *N. japonicus* there is need to increase the cod end mesh size of trawl net by 80% to harvest the MSY whereas for *N. mesoprion* the same has to be decreased by 20%; for both the species together, maximum yield is obtained by increasing the age at first capture by 20%. In Kerala (Fig. 16.B), the yield is maximum at 200% of present t_c for *N. japonicus* and at only 70% of the present t_c for *N. mesoprion*. For both the species together, the yield is maximum at 90% of present t_c thus indicating that 10% decrease in cod end mesh size is necessary. In Karnataka and Goa (Fig. 17.B) the MSY is obtained at 140% of present t_c for *N. japonicus* whereas the same can be taken at 80% of the present t_c for *N. mesoprion*. The highest yield of the two species together can be harvested at 130% of the present t_c. In Maharashtra the present t_c of *N. japonicus* is 20% smaller than the one that gives MSY whereas the same is 20% larger in *N. mesoprion*. In the

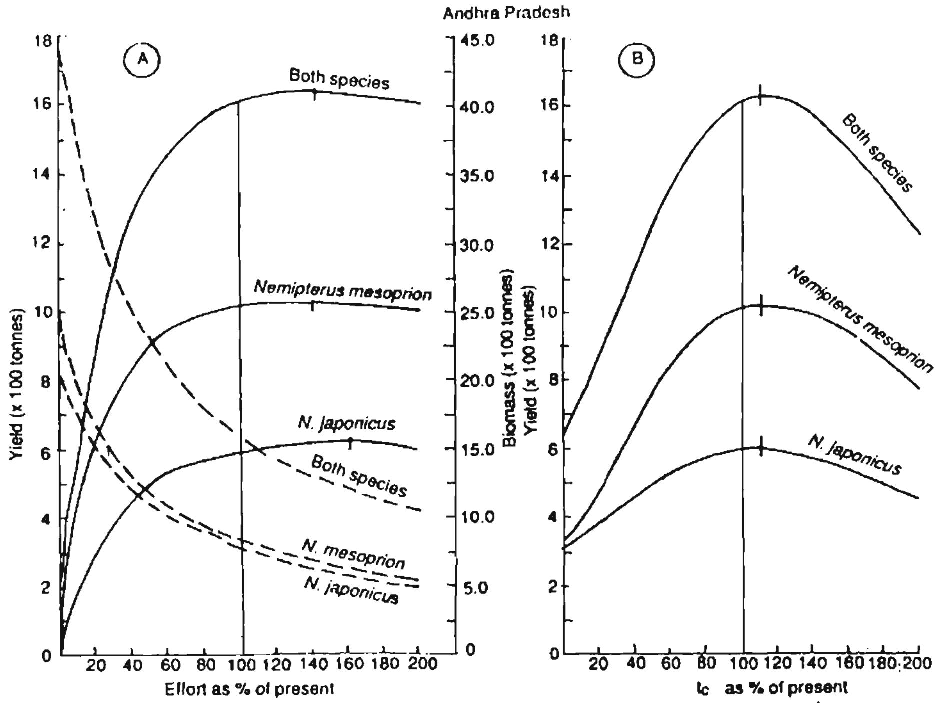


Fig. 14. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Andhra Pradesh (small vertical lines on the curves indicate MSY and the long vertical line the current effort level and yield). B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) (small vertical lines indicate MSY and the long vertical line the current t_c and yield).

two species together the yield is maximum at the present level of t_c (Fig. 18.B) indicating that there is no need to change the present cod end mesh size. In Gujarat (Fig. 19.B), the MSY corresponds to the present t_c in both the species.

The analysis thus shows that except in Kerala, there is need to either increase the cod end mesh size of trawl net by 10–30% or to maintain the currently used mesh size. In Kerala, however, the analysis shows that there is need to decrease the cod end mesh size by 10%; as the increase in yield is only 0.3% by this regulation, the present cod end mesh size has no adverse effect on the stocks.

DISCUSSION

The present assessment is based on the data collected from seven centres along Indian coasts. Only two species were considered because these two species form over 90% of threadfin bream catches and the results of assessment of these two species are believed to reflect the situation in the threadfin breams as a whole.

It is essential in a study of this kind, to first ensure whether a species from all along the coast line belongs to one unit stock or not. There is, however, no information on this aspect except in *N. japonicus* from east coast (Rao and Rao 1983) which is not conclusive.

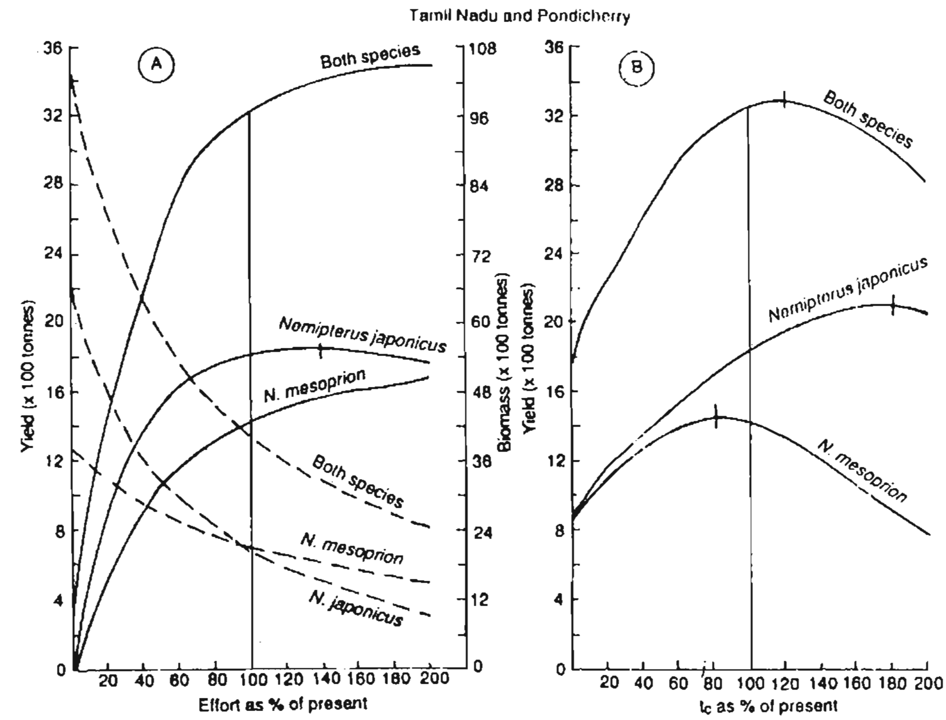


Fig. 15. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present) in Tamil Nadu and Pondicherry. B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Tamil Nadu and Pondicherry.

As data were obtained from centres in different maritime states and as the management of the fishery is within the purview of the administration of different maritime states of India, the estimation of growth parameters and resource assessment was done for stocks of each state separately. Yield estimates for the country as a whole, however, were also made.

The estimation of parameters of growth and mortality using the length-based methods is beset with problems and there is criticism against almost every available method which uses length frequency data as input. It was decided to use the ELEFAN method for extracting the growth parameters and then to compare the results with those already available. It was, however, found difficult to arrive to *a* set of *true* growth parameters because, in each year's data from any centre, 2–3 seemingly 'best estimates' of growth parameters were obtained. Therefore, the smallest and largest values of L_∞ and their related K from among the sets of values from each centre were, perforce, selected and stock assessment was done separately using both the sets of parameters. The average yield values corresponding to each effort level were taken. This was done under the belief that the true values fall somewhere between the ranges considered and the stock assessment thus made

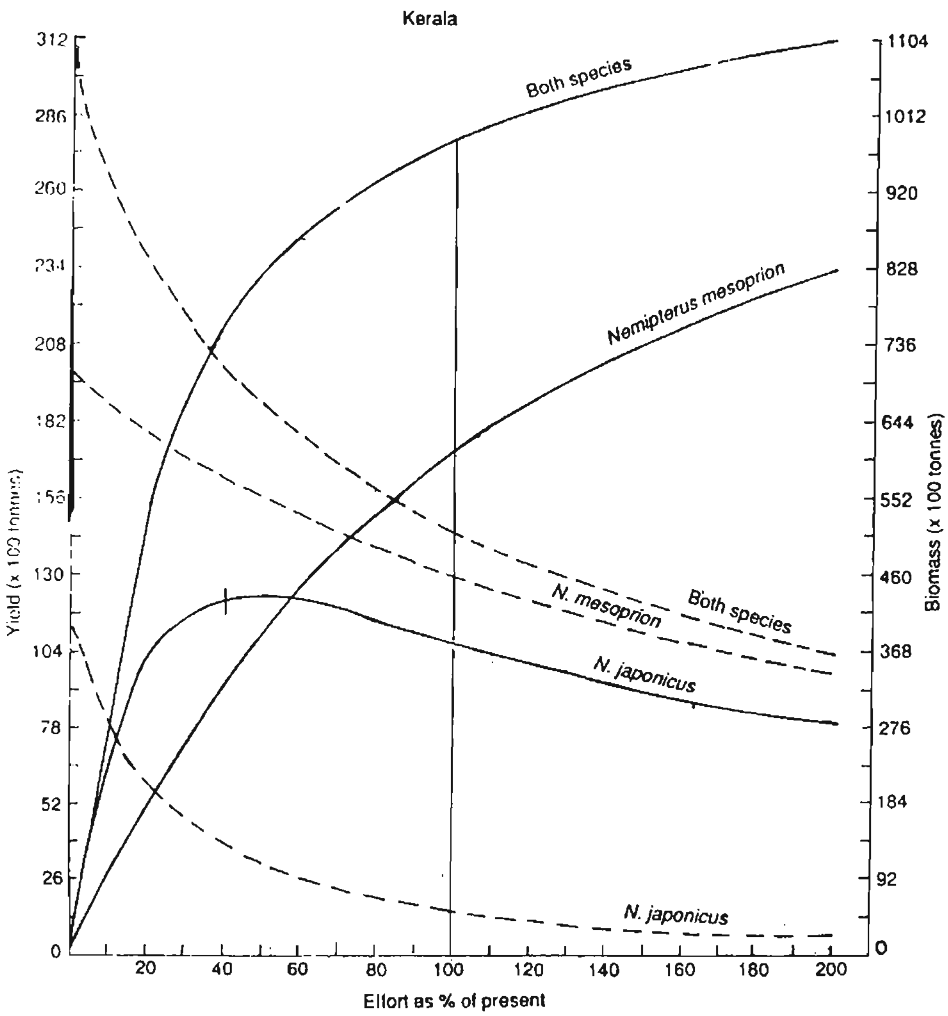


Fig. 16A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Kerala.

would hopefully lead to more meaningful conclusions. This was also done to account for possible uncertainties associated with the procedures of estimation of parameters and the consequent uncertainties in the conclusions arrived at on the basis of only one set of parameters.

A comparison of the growth parameters and mortality rates estimated (Tables 1, 2) with those available in the literature (Table 3) showed that they were in close agreement with those obtained earlier from India and, barring a few from other areas in the Indo-Pacific region also.

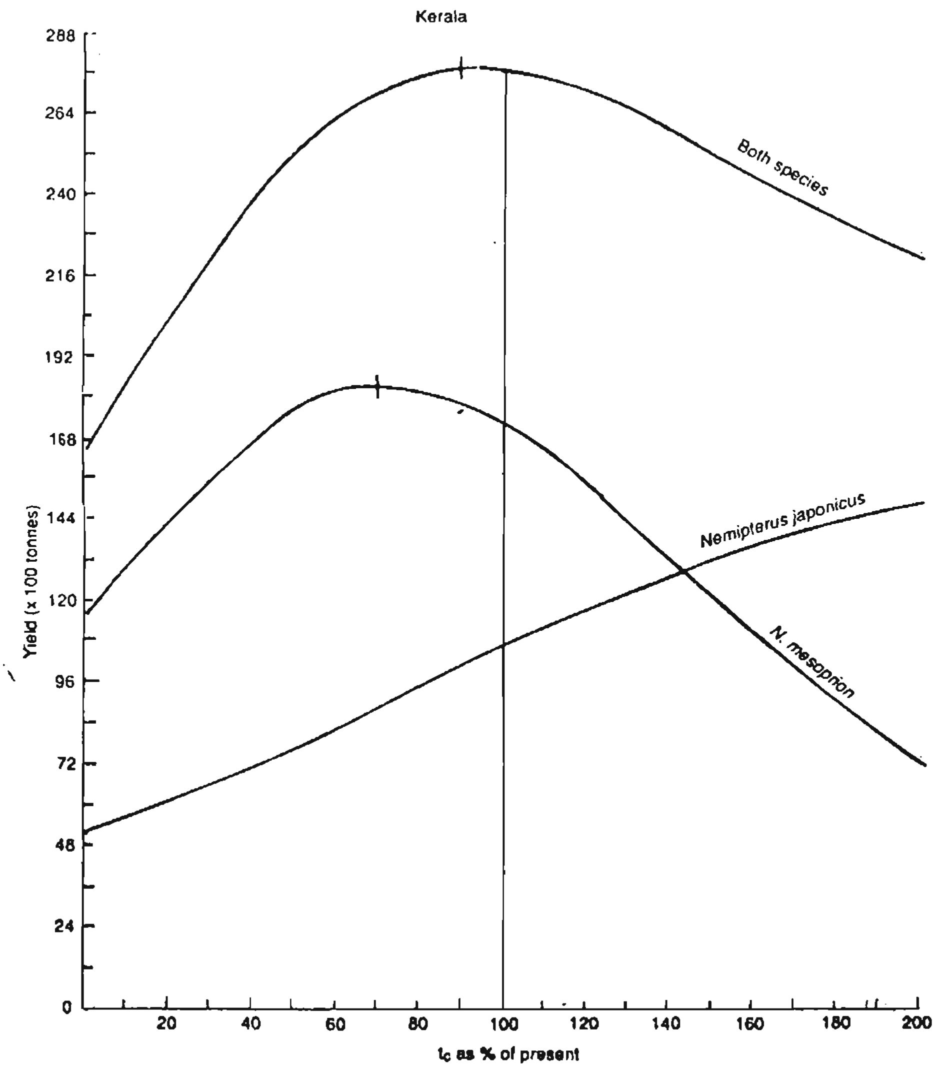


Fig. 16B. Yield of *Nemipterus japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Kerala.

The Thompson and Bell long-term forecast of yield gave conflicting management options for individual species (Fig 14–19). In one species the present effort was greater than that giving MSY and in the other, smaller, thus making it difficult to formulate regulatory measures. Such conflicting options are not uncommon while dealing with assessment of single species stocks in a mixed fishery because the growth and natural mor-

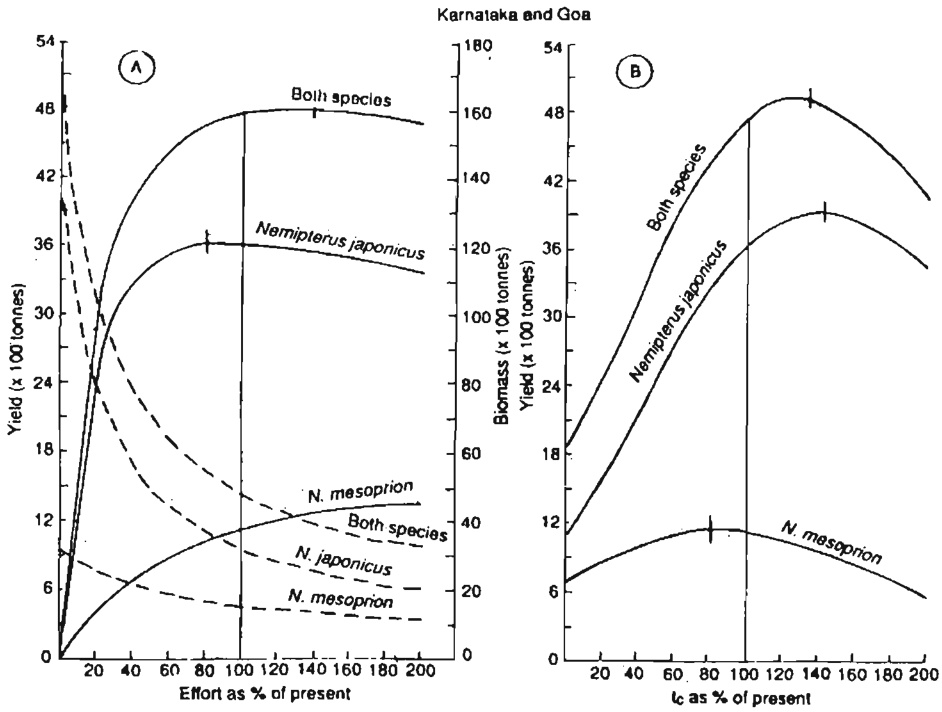


Fig. 17. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Karnataka and Goa. B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Karnataka and Goa.

tality rates are different in different species and there is no knowledge of the effective effort for any one species in the fishery. The simplest solution to such situations is mixed fisheries assessment which gives maximum yield and the corresponding effort level for all the species together in the fishery, that is, the effort which gives maximum yield (or value) of all the species in the mixed fishery together has to be taken into account for resource management. It may so happen, however, that such an option results in reduction in yield of species whose economic value may be greater. Such a reduction (some times drastic) in yield of species (by exceeding F_{msy} of these species) caused by increasing the effort to get MSY of the required species together is likely to be viewed seriously in the context of over-fishing of those species. It is believed that such a fear need not be entertained in multispecies or mixed fisheries because even if the yield of one species crosses the MSY level because of increased effort, the same gets stabilized at particular stabilized effort level according to steady state assumption. As long as the yield of other species in the fishery is increased the total yield will automatically increase and there is no biological wastage. The management decisions, however, often depend upon the economic returns of a fishery. Then the simplest option is to stabilize the effort which gives MSY of economically important

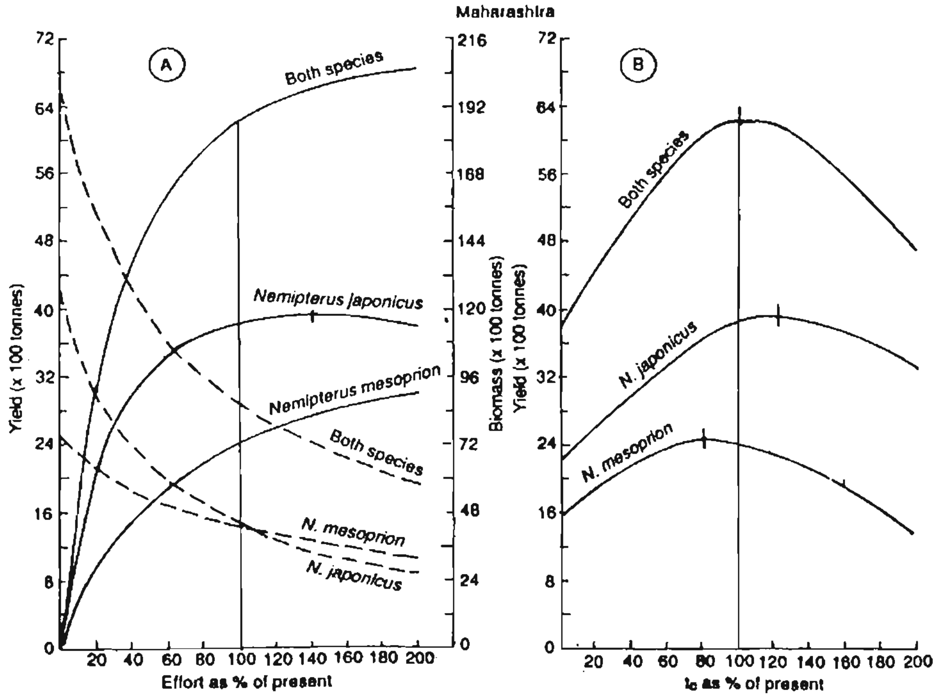


Fig. 18. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Maharashtra. B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Maharashtra.

species. This of course can result in biological wastage because certain species may be underexploited. While there is presently no solution to this problem, a sound knowledge of the biological interactions between species contributing to the mixed fishery is essential to understand the dynamics of the species better and to effectively formulate regulatory measures.

The assessment of the two species of threadfin breams (Figs 14–19), on the basis of the present knowledge, indicated that maximum yield of the two species together can be taken through increasing the effort by 40%–100% in different states and in the country as a whole. The increase in yield, however, will only be 2%–12% and will not be proportional to increased effort leading to reduction in catch per unit effort. It, therefore, appears that in the present fishing grounds, there is no scope for increasing effort to increase the yield of threadfin breams. However, the threadfin breams are known to be more abundant in the relatively deeper areas of the sea beyond the present grounds and yield can be substantially increased by deploying the additional effort beyond 50 m depth. It has been estimated that vast potential of these fishes exists beyond 50 m depth (125 000 tonnes of perches of which threadfin breams is a dominant component, Anonymous 1991). Moreover, off Kerala coast (Fig. 5C), it is known that peak landings are obtained during July-September mainly due to movement of threadfin breams into shallower areas to avoid oxygen deficient waters in the

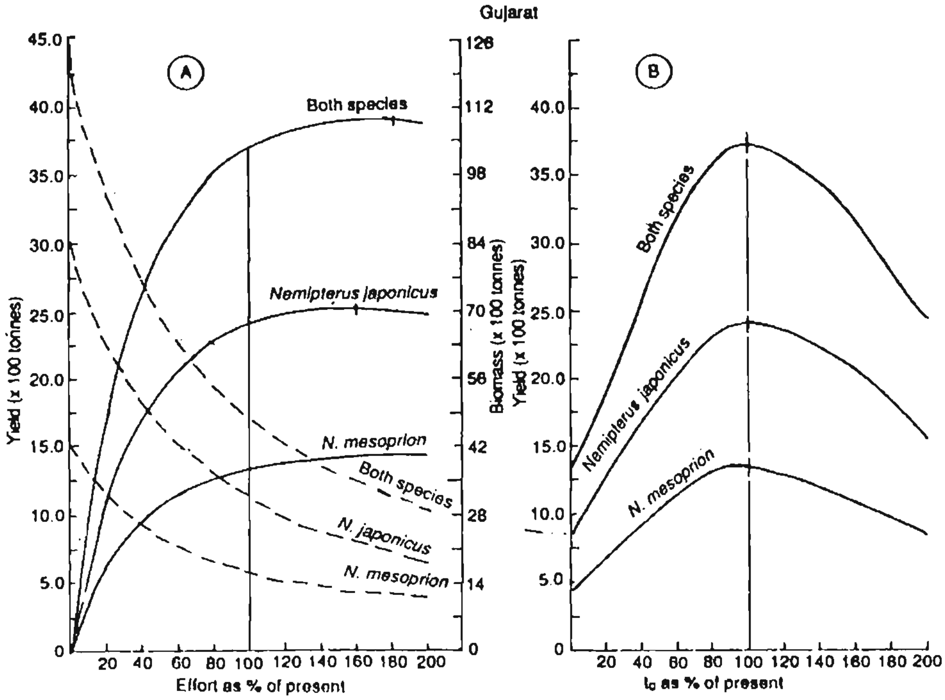


Fig. 19. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Gujarat. B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Gujarat.

deeper waters (Banse 1959). Hence suitable deployment of trawlers during the monsoon period is likely to result in substantial increase in the landings of threadfin breams off Kerala.

The assessment of yield as a function of cod end mesh size (Figs 14–19) showed that there is need to increase the same in all states except Kerala. It is known that smaller cod end mesh sizes in trawl fisheries can lead to recruitment overfishing and adversely affect the exploited stocks in the long run and, therefore, efforts to regulate the mesh size by suggesting at least 20% increase, will help improve the threadfin bream stocks in the presently fished grounds.

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REFERENCES

Acharya P and Dwivedi S N. 1984. Condition factor and length-weight relationship of *Nemipterus japonicus* (Bloch) off Bombay coast. *Journal of Indian Fisheries Association* 10 & 11 : 37–44.

Alagaraja K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian Journal of Fisheries* 31 : 177–95.

Amornchairojkul S and Boonwanich T. 1982. Growth and mortality of *Nemipterus japonicus* off the west coast of Gulf of Thailand (Chumpornko Samui), 1981. *Technical Report, Demersal Fisheries Unit, Marine Fisheries Division*, Bangkok (7/2525). 12 pp.

Anonymous. 1990. *Annual Report 1989-90*. Central Marine Fisheries Research Institute, Kochi, 95 pp.

Anonymous 1991. *Report of the Working Group on Revalidation of the Potential Marine Fisheries Resources of Exclusive Economic Zone of India*. Ministry of Agriculture, Govt. of India, New Delhi.

Banse K. 1959. On upwelling and bottom trawling off the south west coast of India. *Journal of Marine Biological Association of India* 1 : 33–49.

Beverton R J H and Holt S J. 1957. On the dynamics of exploited fish populations. *Fishery Investigation Series, London* 19 : 533.

CMFRI. 1981. Commercial trawl fisheries off Kakinada during 1969–1978. *Marine Fisheries Information Service, Technical and Extension Series* 31 : 1–6.

Corpuz A, Saeger J and Sambilay V. 1985. Population parameters of commercially important fishes in Philippine waters. Department of Marine Fisheries, University of Philippines in the Visayas. *Technical Report No. 6*. 99 pp.

Dan S S. 1980. Intra ovarian studies and fecundity in *Nemipterus japonicus* (Bloch). *Indian Journal of Fisheries* 24 : 48–55.

Devaraj M and Deepak Gulati. 1988. Assessment of the stock of the threadfin bream (*Nemipterus japonicus*) in the northwest continental shelf of India. (Ed.) Mohan Joseph M. *The First Indian Fisheries Forum Proceedings*. Asian Fisheries Society, Indian Branch, Mangalore, pp xv + 494.

Dwiponggo A, Hariati T, Banon S, Palomares M L and Pauly D. 1986. Growth, mortality and recruitments of commercially important fishes and penaeid shrimps in Indonesian waters. *ICLARM Technical Report No. 17*, 91 pp.

Edwards R R C, Bakader A and Shabeer S. 1985. Growth, mortality, age composition and fisheries yields of fish from the Gulf of Aden. *Journal of Fish Biology* 27 : 13–21.

Gayanilo F C Jr, Soriano M and Pauly D. 1988. A draft guide to the COMPLEAT ELEFAN. *ICLARM Software Project* 2. 65 pp.

Ingles J and Pauly D. 1984. An atlas of the growth, mortality and recruitment of the Philippines fishes. *ICLARM Technical Report 13*, 127 pp.

Isa M B M. 1988. Population dynamics of *Nemipterus japonicus* (Pisces: Nemipteridae) off Kedah State, Malaysia. *Contributions to Tropical Fisheries Biology*, pp 126–40. (Eds) Venema S, Moller J Christenseon and Pauly D. Papers by the participants of FAO/DANIDA follow-up training courses in stock assessment in the tropics. FAO/fish. Rep (389), 519 pp.

Indra T J. 1981. A note on the occurrence of *Nemipterus metopias* (Bleeker) from Madras coast. *Indian Journal of Fisheries* 28 : 290–91.

James P S B R, Alagarswamy K, Narayana Rao K V, Muthu M S, Rajagopalan M S, Alagaraja K and Mukundan C. 1987. Potential Marine Fishery Resources of India. *CMFRI Special Publication* 30 : 44–74.

John M E. 1989. Population dynamics and stock estimates of the threadfin bream (*Nemipterus japonicus*) off Kerala, India. *Contributions to Tropical Fish Stock Assessment in India*. pp 45–62. (Eds). Venema S C and Van Zalinge N P. Papers prepared by the participants at the FAO/DANIDA/ICAR National follow up training course on fish stock assessment. FI: OCP/INT/392/DEN/1: 157 pp.

Kasim H Md, Ameer Hamsa K M S and Sam Bennet P. 1989. Present status of perch fishery resources in India and its prospects. National Symposium on Research and Development in Marine Fisheries, Mandapam Camp, 16-18 September, 1987. *Bulletin of Central Marine Fisheries Research Institute* 44 : 226–37.

Krishnamoorthi B. 1973a. An assessment of *Nemipterus* fishery of Andhra-Orissa coasts based on exploratory fishing. Proceedings of the Symposium on Living Resources of the Seas around India, 1968. *CMFRI Special Publications*. pp 496–516.

Krishnamoorthi B. 1973b. Biology of threadfin bream, *Nemipterus japonicus* (Bloch). *Indian Journal of Fisheries* 18 : 1–21.

Krishnamoorthi B. 1976. A note on the size difference between males and females of *Nemipterus japonicus* (Bloch). *Indian Journal of Fisheries* 23 : 252–56.

Kuthalingam M D K. 1971. Notes on some aspects of the fishery and biology of *Nemipterus japonicus* (Bloch) with special reference to feeding behaviour. *Indian Journal of Fisheries* 12 : 500–06.

Lee C K C. 1975. Exploitation of *Nemipterus japonicus* (Bloch) by Hong Kong Vessels in 1972-73. *Papers presented in Special Symposium on Marine Science* held by Pacific Sciences Assn. in December 1973, Hongkong. (Ed.) Morton B. pp 48–52.

Madanmohan and Gopakumar G. 1981. On the occurrence of *Nemipterus metopias* (Bleeker) (Nemipteridae, Pisces) from the south west coast of India. *Indian Journal of Fisheries* 28 (1&2) : 280–82.

Madanmohan and Velayudhan A K. 1984. A few observations on the taxonomy and biology of *Nemipterus delagoae* Smith from Vizhinjam. *Indian Journal of Fisheries* 31 : 113–21.

Murty V S. 1981. *Nemipterus mesoprion* (Bleeker, 1953) (Nemipteidae, Pisces) a new record from the seas around India. *Indian Journal of Fisheries* 25 : 207–13.

Murty V S. 1982a. Observations on some aspects of biology of the threadfin bream *Nemipterus mesoprion* (Bleeker) from Kakinada along the east coast of India. *Indian Journal of Fisheries* 28 : 199–207.

Murty V S. 1982b. *Nemipterus luteus* (Schneider, 1801) (Nemipteridae, Pisces), the valid name for a threadfin bream from the Indo-Pacific region. *Journal of Marine Biological Association of India* 19 (1) : 107–14.

Murty V S. 1983. Estimates of Mortality, population size and yield per recruit of *Nemipterus japonicus* (Bloch) in the trawling grounds off Kakinada. *Indian Journal of Fisheries* 30 : 255–60.

Murty V S. 1984. Observations on the fisheries of threadfin breams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) from Kakinada. *Indian Journal of Fisheries* 31 : 1–18.

Murty V S. 1987a. Further studies on growth and yield per recruit of *Nemipterus japonicus* (Bloch) from the trawling grounds off Kakinada. *Indian Journal of Fisheries* 34 : 265–76.

Murty V S. 1987b. Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada. *Journal of Marine Biological Association of India*. 27 : 39–48.

Murty V S. 1989. Mixed fisheries assessment with reference to five important demersal fish species landed by shrimp trawlers at Kakinada. *Contributions to Tropical Fish Stock Assessment in India*. (Eds) Venema S C and Van Zalinge N P. pp 69–86. Papers prepared by the participants at the FAO/DANIDA/ICAR National training course on fish stock assessment, Cochin 2-28 Nov. 1987. FI: GCP/INT/392/DEN/1:1989, 157 p.

Murty V S, Nair K V S, Thomas P A, Lazarus S, Chakraborty S K, Raje S G, Gopal C, Zacharia P U and Velayudhan A K. 1992. Present status of exploitation of fish and shellfish resources: Threadfin breams. Monsoon Fisheries of the west coast of India: Prospects, Problems and Management. (Eds). Rao P V, Murty V S and Rengarajan K. *Bulletin of Central Marine Fisheries Research Institute* 45 : 154–68.

Muthiah C and Krishna Pillai S. 1984. A new distributional record of *Nemipterus delagoae* smith from Bombay waters with notes on its biology. *Journal of Marine Biological Association of India* 21 : 174–78.

Nair K V S and Reghu R. 1990. Studies on the threadfin bream and the lizard fish resources in the exclusive economic zone of India based on the demersal trawling operations of FORV *Sagar Sampada*. *Proceedings of the First Workshop on Scientific Result of FORV Sagar Sampada*, 5-7 June 1989, pp 239–55.

Nair K V S and Jayaprakash A A. 1986. A note on the monsoon fishery for threadfin breams off Cochin. *Indian Journal of Fisheries* 33 : 106–12.

Narayanappa G, Raju D A N and Satyanarayan A V V. 1968. Certain observations on the otter trawl operations carried out in the inshore and deeper waters off Kakinada. *Proceedings of the Indo-Pacific Fisheries Council* 13 (III). pp 450–55.

Pauly D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 1975 fish stocks. *Journal du conseil* 39 : 175–92.

Pauly D. 1982. Studying single species dynamics in a tropical multispecies context. Theory and Management of Tropical Fisheries. (Eds) Pauly D and Murphy G I. *ICLARM Conference Proceedings*. No. 9. 360 pp.

Pauly D and David N. 1981. ELEFAN 1, a Basic programme for the objective extraction of growth parameters from length frequency data. *Meeresforschung* 28 : 205–11.

Pauly D and Aung Sann. 1984. *Population Dynamics of Some Fishes of Burma Based on Length Frequency Resources Survey and Exploratory Fishing Projects*. FI: DP/BUR/77/003 Field Dec. 7, FAO, Rome.

Philip K P and Joseph P J. 1988. Fishery Resources of the offshore and deep sea waters of Karnataka and the fishing effort suggested for exploitation. *Problems and Prospects of Marine Fishing and Fish Processing in Karnataka*. 179 pp. (Eds) Karunasagar I and Sripathy N V. Forum of Fishery Professionals, Mangalore.

Rajagopalan M, Karuppusamy P and Regunathan A. 1977. *Nemipterus delagoae* Smith (Nemipteridae: Pisces) a new record from the Indian seas. *Indian Journal of Fisheries* 22 : 274–76.

Rao D M. 1981. 'Studies on the biology and biometry of the threadfin bream *nemipterus japonicus* (Bloch) with observations on the nemipterid fishery off Visakhapatnam (Bay of Bengal).' Ph. D. thesis, Andhra University, 224 pp.

Rao D M and Rao K S. 1983. Biometric comparison of *Nemipterus japonicus* (Bloch). Populations along the east coast of India. *Proceedings of the Indian Academy of Sciences (Animal Sciences)* 92 (5) : 351–60.

Rao D M and Rao K S. 1986. Studies on the age determination and growth of *Nemipterus japonicus* (Bloch) off Visakhapatnam. *Indian Journal of Fisheries* 33 : 426–39.

Rao K S and Rao D M. 1981. On the occurrence of *Nemipterus delagoae* Smith (Nemipteridae, Pisces) off Waltair. *Matsya* 7 : 84–85.

Rao T A. 1989. Fisheries of threadfin breams at Waltair with notes on some aspects of biology of *Nemipterus mesoprion* (Bleeker). *Journal of Marine Biological Association of India* 31 : 103–09.

Reuben S, Sudhakara Rao G, Luther G, Rao T A, Radhakrishna K, Sastry Y A and Radhakrishna G. 1989. An assessment of bottom-trawl fishery resources of the north east coast of India. *Bulletin of Central Marine Fisheries Research Institute* 44 : 59–77.

Samuel M. 1991. Biology, age, growth and population dynamics of threadfin bream *Nemipterus japonicus*. *Indian Journal of Fisheries* 32 : 66–76.

Satyanarayana A V V, Narayanappa G and Raju D A N. 1972. On the comparative fishing experiments with a four-seam and a two-seam trawls on the east coast. *Fishery Technology* 9 : 169–79.

Silas E G. 1969. Exploratory fishing by R V Varuna. *Bulletin of Central Marine Fisheries Research Institute* 12 : 1–86.

Silas E G, Dhamaraja S K and Rengarajan K. 1976. Exploited marine fishery resources of India. A synoptic survey with comments on potential resources. *Bulletin of Central Marine Fisheries Research Institute* 27 : 25 pp.

Sivaprakasam T E, Parasuraman P S, Premchand, Rajkumar S A and Nagarajan G. 1991. Marine fishery resources off the lower east coast of India. *Bulletin of Fishery Survey of India* 21 : 29.

Sparre P. 1985. *Introduction to Tropical Fish Stock Assessment*. FAO. Rome. Denmark Funds-in-trust. FI; GCP/INT/392/DEN Manual 1.338 pp.

Sparre P. 1987. Computer programmes for fish stock assessment. Length based fish stock assessment (LFSA) for Apple II computers. *FAO Fisheries Technical Paper* 101 (Suppl 2). 217 pp.

Sudarsan D, John M E and Somavanshi V S. 1990. Marine fishery resources potential in the Indian exclusive economic zone. *Bulletin of Fishery Survey of India* 20 : 27.

Thompson W F and Bell F H. 1934. Biological statistics of the halibut fishery 2. Effect of changes in intensity upon total yield and yield per unit of gear. *Reports International Fisheries (Pac. Halibut) Commission* 8 : 49 pp.

Vijaykumaran K and Philip K P. 1991. Demersal Fishery Resources of the north Kerala, Karnataka and Konkan coasts. *Journal of Marine Biological Association of India* 32 : 177–86.

Vinci G K. 1983. Threadfin bream (*Nemipterus*) resources along the Kerala coast with notes on biology of *Nemipterus japonicus*. *Indian Journal of Fisheries* 29 : 37–49.

Vinci G K and Nair A K K. 1975. Length-weight relationship in the threadfin bream, *Nemipterus japonicus* along the Kerala coast. *Indian Journal of Fisheries* 21 : 299–302.

Vivekanandan E. 1990. Distribution pattern of threadfin breams along Tamil Nadu and south Andhra coasts. *Indian Journal of Fisheries* 37 : 269–80.

Vivekanandan E and James D B. 1986. Population dynamics of *Nemipterus japonicus* (Bloch) in the trawling grounds off Madras. *Indian Journal of Fisheries* 33 : 145–54.

Vivekanandan E and James D B. 1987. Length-weight relationship in four species of threadfin breams from Madras. *Journal of Marine Biological Association of India* 26 ; 132–35.

Zupanovic S and Mohiuddin S Q. 1973. A survey of the fishery resources in the north eastern part of the Arabian sea. *Journal of Marine Biological Association of India* 15 (2) : 496–537.

CONTRIBUTION 22

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CONTRIBUTION 22

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Stock assessment of silverbellies of India with particular reference to Andhra Pradesh and Tamil Nadu

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ABSTRACT

Along Indian coasts, the silverbellies are exploited by trawl and artisanal gears but bulk of the landings are obtained by trawls which operate up to 50 m depth. During 1979–83, the estimated annual average silverbelly landings were 69 000 tonnes, whereas during 1984–88 these were 62 000 tonnes. Maximum silverbelly landings were obtained in Tamil Nadu which contributed 70.5% of total all-India silverbelly landings followed by Andhra Pradesh (9%), Kerala (8.4%), Karnataka (6%) and other states (6.1%). Out of 20 species of silverbellies, known to occur in the seas around India, *Leiognathus bindus* and *Secutor insidiator* were most dominant along Andhra Pradesh and northern Tamil Nadu coasts, together contributing to 64% and 55% respectively of silverbelly landings. Along southern Tamil Nadu, *L. jonesi* and *L. dussumieri* were most dominant together forming about 60% of silverbelly catch in the region.

The available information on the biology of different species from several localities along Indian coast was reviewed. Parameters of growth and mortality of dominant species were estimated. Stock assessment was made separately for *L. bindus* and *S. insidiator* and then mixed fisheries assessment made for these two species combined from Andhra Pradesh and northern Tamil Nadu. From southern Tamil Nadu coast, stock assessment was made for *L. jonesi* and *L. dussumieri* separately and combined. Along Andhra Pradesh coast, the effort level was found greater than the one yielding MSY in the existing fishing grounds. In northern Tamil Nadu there was scope to increase the fishing effort to get MSY. In southern Tamil Nadu yield can be increased by about 1.5% through increasing the effort by 40%. The assessment of yield of *L. bindus* and *S. insidiator* in relation to cod end mesh size of trawl along Andhra Pradesh showed the need to reduce the cod end mesh size by about 40%. In northern Tamil Nadu also more or less similar situation existed. In southern Tamil Nadu, the MSY corresponded to the existing cod end mesh size and, therefore, did not warrant any change in the latter.

The fishes of the family Leiognathidae, popularly called as silverbellies or ponyfishes, are among the important demersal fishes contributing to the fisheries along Indo-west Pacific region. Though these are small and are considered as trash fish at certain places, the quantities landed make them important both from fishery and management point of view. Silverbellies are known to be more abundant in shallower regions in the sea (James 1973; Pauly 1977a, b; Pillai and Dorairaj 1985; Sudarsan *et al.* 1988; Sivaprakasam *et al.* 1991) up to about 40 m depth though they are available in depths of 100–150 m also (Sudarsan *et al.* 1988). These fishes are known to undertake diurnal vertical migrations staying at the bottom during day time and moving up to surface and subsurface waters during nights (Venkatraman and Badrudeen 1974, Murty

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1986b). A lot of work has been done on various aspects of these fishes as evidenced by two bibliographies exclusively on these fishes (Pauly and Pauly 1981, James *et al.* 1992). In India an estimated 53 876 tonnes of silverbellies landed during 1990 (Anonymous 1991) which formed 5.7% of the total demersal fish and 2.5% of total marine fish landings.

Total 20 species of silverbellies are known from India and a lot of work on distribution, taxonomy, biology and fishery has been done (Arora 1952; Balan 1967; James, 1967, 1969, 1973, 1975, 1986; Pillai 1972; Venkatraman and Badrudeen 1974; James and Badrudeen 1975, 1981, 1986, 1991; Rani Singh and Talwar 1978a, 1978b; Annam and Dharmaraja 1981; Kurup and Samuel 1983; Murty 1983, 1991; Jayabalan 1985, 1986, 1988a, 1988b; Jayabalan and Ramamoorthy 1985a, 1985b, 1985c, 1986; Pillai and Dorairaj 1985; Vivekanandan and Krishnamoorthy 1985; James *et al.* 1987; Reuben *et al.* 1989 and Srinath 1989). Population dynamics of dominant species from particular localities have also been studied (Venkatraman *et al.* 1981; Murty 1985, 1986a, 1986b, 1991 and Karthikeyan *et al.* 1989). An attempt is made here to study the dynamics of the exploited silverbelly resources making use of data obtained during 1984-88 on dominant species of the group from Andhra Pradesh and Tamil Nadu coasts. The results are presented in this paper.

MATERIALS AND METHODS

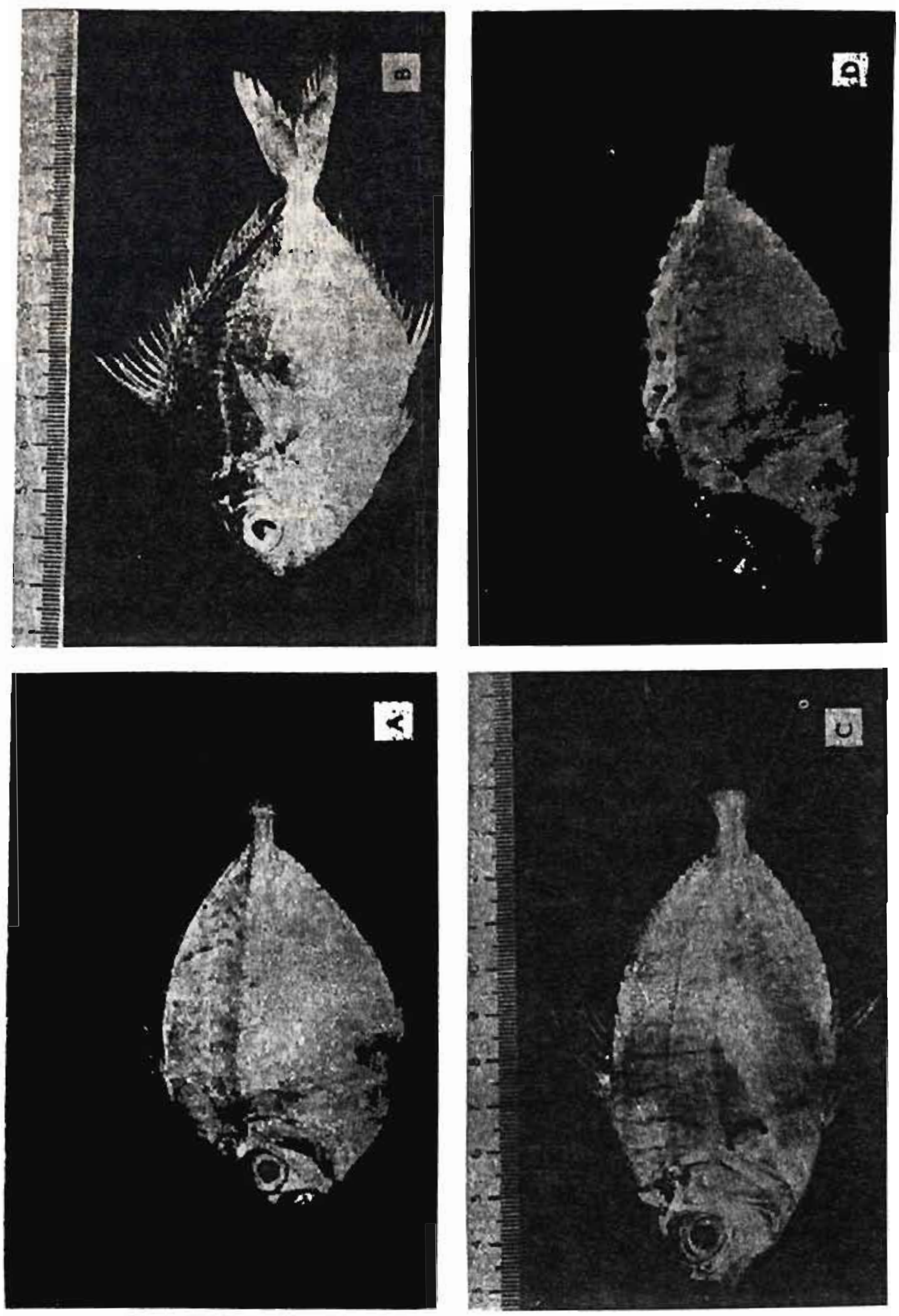
Data obtained from trawl landings only were considered. Bulk of the silverbelly landings in India were obtained from Tamil Nadu–Pondicherry and Andhra Pradesh and considerable data were generated from this region. The stock assessment in the present study was, therefore, restricted to this region.

The estimates of districtwise and gearwise effort and districtwise, gearwise and groupwise/specieswise landings made by the Central Marine Fisheries Research Institute for the years 1984–88 were used for the present study. Further, the estimates of catch for each maritime state pertaining to the period 1979–88 were also used.

Detailed data on effort and catch were collected for 18 days in a month and on species composition, length composition and biology of dominant species for 4–8 days every month from the trawl landing centres at Visakhapatnam, Kakinada, Madras and Mandapam. These data of 1984–88 formed the major input for this study.

For stock assessment, *Leiognathus bindus* and *Secutor insidiator* from Andhra Pradesh and northern Tamil Nadu–Pondicherry; and *L. jonesi* and *L. dussumieri* from southern Tamil Nadu were selected because these species were most dominant in these regions and determined the success or failure of silverbelly fishery in the respective areas.

Species composition and length frequency distribution: At each of the above four trawl landing centres, samples were collected from different boats and brought to the laboratory for taking data on species composition, length composition and biology. Total length was considered for length frequency and other studies. The data on species composition and length composition collected on each observation day were first weighted respectively to the estimated total catch of the group and species obtained on that day and such estimates in a month were pooled and then raised to the estimated catch of the month as per Alagaraja (1984). The monthly estimates were pooled to get quarterly and annual estimates. To obtain estimates of total catch (weight) of each species as well as catch (numbers) at length also of each species, the data obtained at the observation centres were suitably weighted to get estimates for each



A. *Leiognathus bindus*. B. *L. jonesi*. C. *L. dussumieri*. D. *Secutor insidiator*.

state. As the data on production from each district were available in the form of quarterly estimates, the monthly estimates from each observation centre pooled for each quarter (January–March: I quarter, April–June: II quarter, July–September: III quarter, October–December: IV quarter) were weighted to get quarterly estimates. For this purpose, the data obtained at Visakhapatnam were raised to those obtained in the northern districts of Srikakulam, Vijayanagaram and Visakhapatnam together, and those from Kakinada to the data obtained in the remaining coastal districts (East Godavary, West Godavary, Krishna, Guntur, Prakasam and Nellore) of Andhra Pradesh (Fig. 1). The former is referred as northern Andhra Pradesh and the latter as southern Andhra Pradesh. In Tamil Nadu–Pondicherry (Fig. 2), the data obtained at Madras were weighted to those of Madras, Chengalpattu, South Arcot and Pondicherry together and those obtained at Mandapam (Mandapam, Pamban and Rameswaram) to the ones from the southern coastal districts of Thanjavur, Pudukkottai, Ramanathapuram (presently Muthuramalingam and Ramanathapuram), Tirunelveli (presently Chidambaranar and Kattabomman) and Kanyakumari. These two areas are referred to as northern Tamil Nadu (A in Fig.2) and southern Tamil Nadu (B in Fig. 2) respectively. Stock assessment was done separately with these sets of data. For Andhra Pradesh, the two estimates were pooled to get estimates for the state because the species dealt with from the two regions were the same. For Tamil Nadu-Pondicherry, however, the species dealt with were not same from the two centres as the dominant species were different in the two regions. The estimates obtained, therefore, were treated separately.

Biology: The results of detailed studies made on aspects of biology of particular species were taken from published work.

Estimation of von Bertalanffy growth parameters: The parameters of growth in length were estimated following the ELEFAN method (Pauly and David 1981, Gayanilo *et al.* 1988); the estimates were made using the monthly length frequency distribution of catch of the species, separately from each of the four centres. In the data of each year, different starting lengths and 'samples' were used and best fit values were taken. Thus, 2-4 sets of growth parameters in each year from each centre were obtained for each species. Of all such estimates in all the five years, the smallest and largest L_∞ values and their associated K values were selected from each centre for all further studies. The results obtained by using the largest L_∞ and its associated K were referred to as having been obtained by using 'higher parameters' and those obtained by using the smallest L_∞ and its associated K by 'lower parameters'.

Mortality rates: The estimates of instantaneous total mortality rate (Z) were made using length-converted catch curve method (Pauly 1982) using the data of all the five years pooled and the LFSA package of Sparre

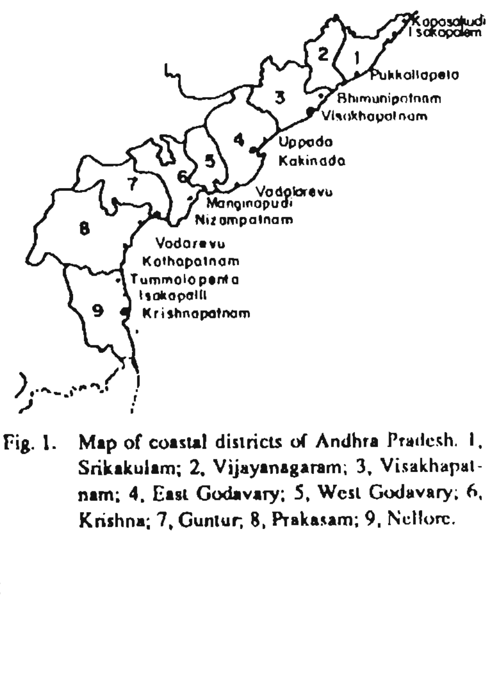


Fig. 1. Map of coastal districts of Andhra Pradesh. 1, Srikakulam; 2, Vijayanagaram; 3, Visakhapatnam; 4, East Godavary; 5, West Godavary; 6, Krishna; 7, Guntur; 8, Prakasam; 9, Nellore.

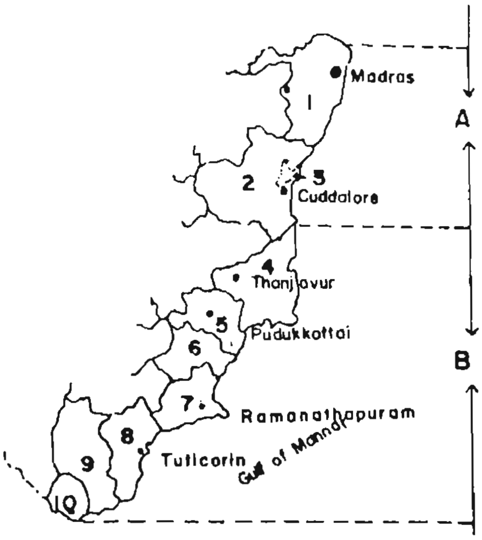


Fig. 2. Map of coastal districts of Tamil Nadu and Pondicherry. 1, Chengalpattu and Madras; 2, South Arcot; 3, Pondicherry (U.T.); 4, Thanjavur; 5, Pudukkottai; 6, Muthuramalingam; 7, Ramanathapuram; 8, Chidambaranar; 9, Kattabomman; 10, Kanyakumari.

(1987). The natural mortality rate (M) was estimated using the empirical formula of Pauly (1980) and then the fishing mortality (F) as Z–M. For each species from each centre estimates of mortality rates were made separately using both the sets of growth parameters.

Lengths at recruitment and first capture: The mid point of the smallest length group in the catch during the five-year period was taken as length at recruitment (L_r). The lengths corresponding to the first values in the descending limbs of the length-converted catch curves (with both the sets of growth parameters separately) were taken as lengths at first capture (L_c).

Yield and biomass: The data on catch (numbers) at length of each species at each centre weighted to total catch of the species of the region(north Andhra, south Andhra, north Tamil Nadu, south Tamil Nadu) in each year were pooled for the five years (1984–88) and average annual values obtained; these were used as input for the study. Yield and biomass at different effort levels were estimated by the length-converted Thompson and Bell (1934) analysis (Sparre 1985, Murty 1989) and the programme MIXFISH of LFSA package of Sparre (1987). In each species, the yield and biomass at different effort levels were first estimated separately using the statistics obtained with the help of 'lower' and 'higher' growth parameters. The average of the values corresponding to each effort level were then obtained and were considered in this study.

The assessment of different species was done separately and combined from each region of Andhra Pradesh and Tamil Nadu.

Yield and cod end mesh size: Trawl data alone were considered for this purpose. For studying the effects of changes in cod end mesh size on the yield, the following procedure was adopted using the data of each region in Andhra Pradesh and Tamil Nadu-Pondicherry:

a. For each species the present t_c values (corresponding to L_c values as stated above) were taken. These values in each species were decreased and increased by the same factor (as 10%, 20%,. . . . . . . 150% . . . . 200% of present t_c).
b. Using these resultant t_c values, the present F and other required parameter values, the Beverton-Holt (1957) yield-per-recruit (Y_w/R) analysis was made.
c. Taking the value of yield-per-recruit (Y_w/R) at current F and t_c and the value of annual average yield of the species during 1984–88, the recruitment in numbers (R = Y + Y/R) was estimated.
d. The Y_w/R at each t_c in each species as obtained at 'b' above, was weighted by

the value of R obtained in 'c' above to obtain values of yield in weight at different t_c values (i.e. percentage of present t_c).

e. In each species, the yield corresponding to different t_c levels was first estimated separately using the statistics obtained with 'lower' and 'higher' growth parameters and averages of yield corresponding to each t_c level were then obtained and used for this study.

f. The values of yield at different t_c levels for different species in each region were pooled to get the combined yield-mesh curves for the species considered.

The results pertaining to the two regions in Andhra Pradesh were pooled and those pertaining to northern Tamil Nadu-Pondicherry and southern Tamil Nadu were treated separately for reasons stated earlier.

RESULTS

Fishery

Along Indian coasts, the silverbellies are exploited by trawl and a variety of artisanal gears such as shore seine, boat seine, gillnet, etc. However, these fishes are caught in large quantities by trawls which are operated in shallower regions up to 50 m depth.

All-India silverbelly catch: The landings in India during 1979–88 (Fig. 3) showed that they ranged from about 53 000 tonnes (1985) to 92 000 tonnes (1983). During the first half of 1979–88 period, the average annual landings were estimated at 69 000 tonnes whereas during the second half of this period the same was 62 000 tonnes. Though the fluctuations in the annual landings were not very large (except 1983), with the annual average during 1979–88 at 69 000 tonnes, the landings showed a declining trend. In fact, in 1989 and 1990, the annual silverbelly landings in India were estimated as 49 000 tonnes and 54 000 tonnes respectively (Anonymous 1991).

Catches in different states: The silverbelly landings in different maritime states and union territories during the decade 1979–88 showed that maximum landings were obtained in Tamil Nadu (70.5%) followed by Andhra Pradesh (9%), Kerala (8.4%), Karnataka (6%) and others. The maximum estimated landings in any year were about 62 000 tonnes in Tamil Nadu in 1983, followed by 11 500 tonnes in Karnataka in 1986, 9 900 tonnes in Andhra Pradesh in 1981, and others (Table 1). Thus the southeast and southwest coasts contribute to over 90% of silverbelly landings in India.

Districtwise landings: In Andhra Pradesh (Fig. 4.A), maximum silverbelly production was obtained in Srikakulam district with annual average of 2 100 tonnes during 1986–88 forming 35% of total silverbelly landings in Andhra Pradesh. This was followed by East Godavary (1 645 tonnes, 27.7%), Nellore (992 tonnes, 16.7%), Visakhapatnam (709 tonnes, 11.9%), Prakasam (234 tonnes, 3.9%), Guntur (170 tonnes, 2.9%), Vijayanagaram (51 tonnes, 0.9%), West Godavary (23 tonnes, 0.4%)

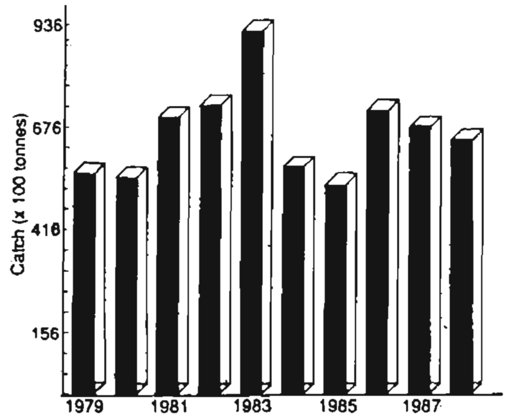


Fig. 3. Estimated annual landings of silverbellies in India during 1979–1988.

Table 1. Estimated landings (tonnes) of silverbellies in different maritime states and union territories of India during 1979–88

Years	West Bengal	Orissa	Andhra Pradesh	Tamil Nadu	Pondi-cherry	Kerala	Karna-taka	Goa	Mahara-shtra	Gujarat	Anda-mans	Total
1979	96	1 108	3 585	43 083	746	3 597	156	881	724	–	78	54 054
1980	34	707	3 832	38 237	681	4 148	4 713	1 727	406	–	102	54 587
1981	–	733	9 856	50 942	975	2 826	1 638	2 075	129	–	275	69 449
1982	24	1 133	5 132	52 577	538	8 730	2 417	1 011	169	–	937	72 668
1983	75	587	8 154	62 116	1 763	9 511	7 024	1 342	929	37	195	91 733
1984	95	363	5 035	39 912	924	3 911	3 355	1 669	1 016	456	381	57 118
1985	399	708	5 348	37 410	1 359	3 419	2 518	764	62	357	381	52 725
1986	179	211	5 392	44 515	1 095	6 029	11 541	1 445	144	57	742	71 350
1987	81	428	8 904	46 276	871	6 027	2 314	860	195	151	643	66 750
1988	20	469	3 505	46 790	329	6 522	2 615	1 664	273	1 094	476	63 757
Annual average	100	645	5 874	46 186	928	5 472	3 829	1 344	405	215	421	65 419

and Krishna (20 tonnes, 0.3%) districts. In Srikakulam and Vijayanagaram there was no trawling and maximum silverbelly production was obtained by boat seine followed by shore seine and other artisanal gears. In West Godavary the trawl landing was almost nil and shore seine landed the bulk of silverbelly catch. In Prakasam district, trawls contributed to about 40% of silverbelly production and in all the remaining districts the contribution of trawl to the production of these fishes ranged from 61% to 93%. In Andhra Pradesh as a whole, the trawl accounted for 47% of silverbelly landings and the remaining by other gears.

In Tamil Nadu (including Pondicherry) (Fig. 4.B), Ramanathapuram (presently Muthuramalingam and Ramanathapuram districts, Fig. 2) contributed to bulk of silverbelly landings with annual average of 17 323 tonnes during 1986–88 forming 45% of silverbelly landings in Tamil Nadu–Pondicherry. This was followed by Pudukkottai (10 650 tonnes, 27.5%), Thanjavur (5 216 tonnes, 13.5%), Tirunelveli (presently Chidambaranar and Kattabomman districts, Fig.2) (5 211 tonnes, 13.4%), South Arcot (3 150 tonnes, 8.1%), Madras (2 913 tonnes, 7.5%), Chengalpattu (1 075 tonnes, 2.8%), and Kanyakumari (352 tonnes, 0.9%) districts and Pondicherry (749 tonnes, 1.9%). In all the districts except Chengalpattu, there were considerable landings by trawlers and the contribution of trawl to total silverbelly production ranged from 77% to 99.5%; in Kanyakumari district, however, the trawlers contributed to only 25% of silverbelly landings. In northern Tamil Nadu, the trawl catch formed about 80% of total silverbelly catch and in southern Tamil Nadu it was 96%.

Trawl fishery: In Andhra Pradesh, commercial trawlers of three different sizes rang-

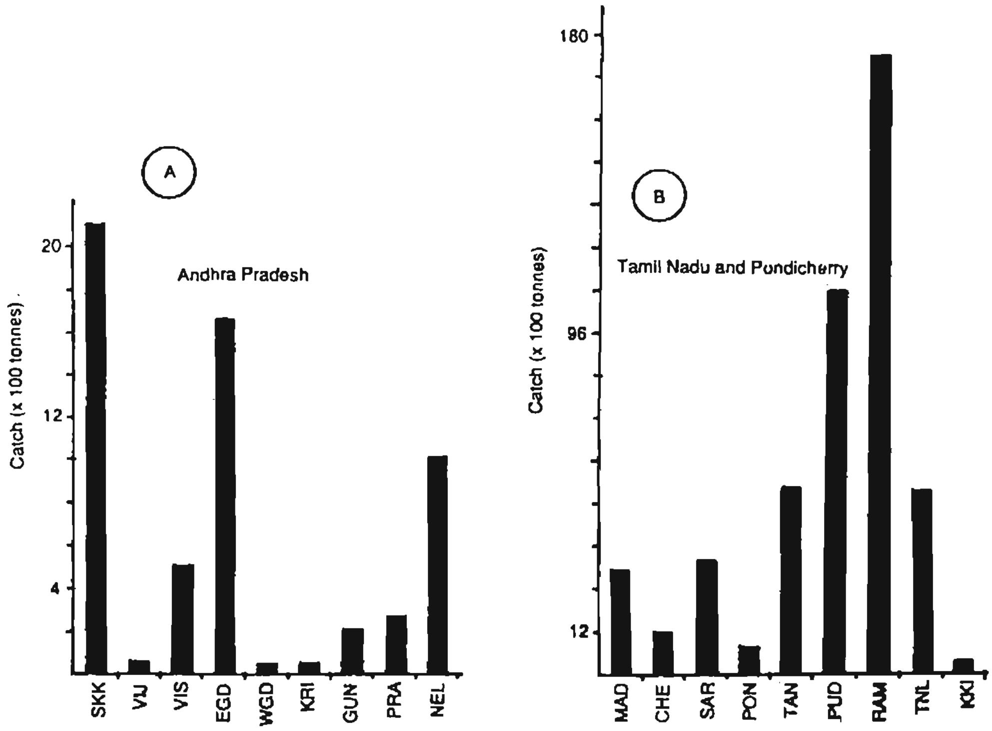


Fig. 4. Average districtwise landings of silverbellies during 1986–88. A. In Andhra Pradesh (SKK: Srikakulam, VIJ: Vijayanagaram, VIS: Visakhapatnam, EGD: East Godavary; WGD: West Godavary, KRI: Krishna, GUN: Guntur, PRA: Prakasam, and NEL: Nellore district). B. In Tamil Nadu–Pondicherry [MAD: Madras, CHE: Chengalpattu, SAR: South Arcot, PON: Pondicherry, TAN: Thanjavur, PUD: Pudukkottai, RAM: Ramanathapuram (presently Muthuramalingam and Ramanathapuram), TNL: Tirunelveli (presently Chidambaranar and Kattabomman), and KKI: Kanyakumari districts].

ing from 10 to 11.4 m OAL operated in the depth range 5–50 m during greater part of the year and during November–February in depths extending up to 80 m. Most of the boats returned the same day but some conducted fishing continuously for 2–4 days. Shrimp trawl with cod end mesh size of 15–20 mm was operated by all these boats. Silverbelly was considered as a 'trash' fish and used mostly in poultry feed.

In Tamil Nadu–Pondicherry, the trawlers (9.8–11.0 m OAL) operated shrimp trawl with a cod end mesh size ranging from 15 to 25 mm. In the northern districts, fishing was mostly conducted during day time up to depths of about 50 m. In the southern districts particularly along Ramanathapuram coast both night and day fishing was carried out regularly up to depths of about 40 m. In this region silverbelly was used for human consumption and a small quantity was reduced to fish meal.

Seasonal variation in silverbelly landings: The quarterly catch estimates (as percentage of each year) from the northern Andhra Pradesh, southern Andhra Pradesh, northern Tamil Nadu and southern Tamil Nadu during 1985–88 are shown in Fig. 5.

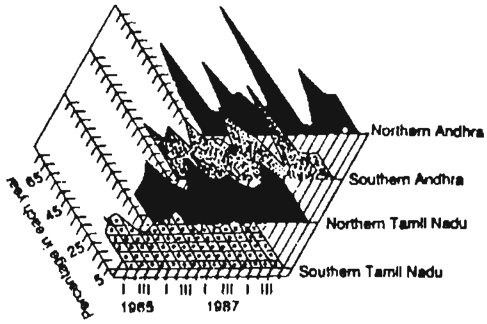


Fig. 5. Seasonal (quarterly) variations in catches of silverbellies.

There were year to year variations in periods of peak landings in the four regions. However, the second quarter was the peak period in northern Andhra Pradesh, first quarter in southern Andhra Pradesh and third or fourth quarter in both the regions of Tamil Nadu.

Species composition: Out of 20 species of silverbellies known to occur in the Indian seas (James and Badrudeen 1991) most of them occur in varying proportions in the Palk Bay and Gulf of Mannar along southern Tamil Nadu coast. Off the coasts of Andhra Pradesh and northern Tamil Nadu, 9–12 species contribute to the fishery. Along Andhra Pradesh coast, *Leiognathus bindus* was the most dominant species forming 40% of silverbelly catch followed by *Secutor insidiator* (24%); all other species together formed the rest (36%). Along northern Tamil Nadu coast also these two species were most dominant together forming about 55% of silverbelly catch; among these two, *S. insidiator* was more abundant. These two species occurred along southern Tamil Nadu coast also but in negligible quantities. In this area *L. jonesi* was the most dominant species forming 44% of silverbelly catch. The other important species was *L. dussumieri* which formed about 15% of silverbelly catch followed by other species. *L. dussumieri* occurred along Andhra and northern Tamil Nadu also, but in small quantities. *L. jonesi*, however, is known from the southern Tamil Nadu coast only.

Biology

Various aspects of biology of different species were studied from different localities along Andhra Pradesh and Tamil Nadu and on one species (*Leiognathus bindus*) from Kerala. The results are briefly given below for each species.

Leiognathus bindus: According to Balan (1967), this fish spawns off Calicut in relatively deeper waters during December–February. The length at first maturity was estimated as 87 mm and fecundity as ranging from 4 950 to 7 735 in fishes of the length range 98–114 mm. Copepods were the most dominant food item followed by polychaetes, cladocerans, larval bivalves and larval crustanceans; phytoplankton occurred in stomachs frequently during monsoon period.

From Kakinada, Murty (1983) reported that this species is a fractional spawner releasing the ova in at least two spawning acts during the course of one year; this species spawns almost throughout the year with a peak during December–February. The length at first maturity was estimated to be 80 mm.

According to James and Badrudeen (1986) the spawning is continuous in batches over prolonged period along southeast coast of India.

This species exhibits sexual dimorphism. The males have a black spot under the pectoral fin near its base which is absent in females (Jayabalan and Ramamoorthi 1985a).

Leiognathus dussumieri: According to James and Badrudeen (1981), this species releases the ova in batches during shorter periods and spawns in the Gulf of Mannar during April–May and November–December.

The length at first maturity was estimated at 78 mm in males and 83 mm in females. The maximum length recorded was 161 mm.

According to Pillai (1972), this species spawns off Tuticorin during prolonged period. The fecundity was estimated to range from 5 400 to 32 500 with an average of 14 300.

Leiognathus brevirostris: In the Palk Bay and Gulf of Mannar this species spawns throughout the year with peaks during May–June and October–November (James and Badrudeen 1975). The lengths at first maturity were estimated as 68 mm in males and 63 mm in females and fecundity 3 650–16 240 in fishes of the length 106–132 mm. The maximum recorded length was 142 mm. Diatoms, copepods, *Lucifer*, nematodes and polychaetes were important food items.

Leiognathus jonesi: James (1986) gave a detailed account of the biology of this species from Palk Bay and Gulf of Mannar. It was concluded that spawning takes place throughout the year with individual fish spawning at least twice in a year; the prolonged spawning period was also indicated by the occurrence of smaller fish of the length range 14–39 mm round the year. Length at first maturity was determined at 70 mm in males and 75 mm in females. Fecundity was estimated to range from about 700 to 39 800 in fishes of the fork length range 65–104 mm. Maximum length recorded was 152 mm. The most important food items were *Pleurosigma, Triceratium, Coscinodiscus*, nematodes, copepods and foraminiferans.

Leiognathus splendens: From Porto Novo, Jayabalan (1986) reported that spawning takes place almost throughout the year with two peaks during April–May and October–December. Length at first maturity was estimated as 89–90 mm in males and 89–94 mm in females. The relationship between fecundity and total length was determined as:

$$\text{Log } F = -7.4897 + 6.6970 \log L$$

and between fecundity and fish weight as

$$\text{Log } F = 0.8056 + 2.3838 \log W.$$

According to James and Badrudeen (1986), this species spawns in batches in quick succession over a short period.

Secutor insidiator: Pillai (1972) estimated the fecundity from Gulf of Mannar as ranging from about 7 250 to 15 700 with an average of 10 620.

According to Jayabalan and Ramamoorthi (1985b), this species spawns during March–April and July–November in the sea off Porto Novo. The length at first maturity in males was estimated as 79–82.5 mm and in females as 81–82.5 mm. The relation between fecundity and total length was determined as:

$$\text{Log } F = -5.2479 + 4.50 \log L$$

and between fecundity and total weight as:

$$\text{Log } F = 2.3155 + 1.3806 \log W.$$

Murty (1991) reporting on the biology of *S. insidiator* from Kakinada stated that the spawning is throughout the year with a peak during January–March. There was predominance of males up to 87 mm group and of females above this length group. The maximum length in the fishery was 117 mm and length at first maturity of females was estimated as 90 mm.

Gazza minuta: Pillai (1972) estimated the fecundity as ranging from about 7 950 to 28 430 with an average of 13 530 in the Gulf of Mannar.

From Porto Novo, Jayabalan (1988b) determined the spawning period as August-February. The length at first maturity in males was estimated as 99 mm and in females as 102 mm. Fecundity was estimated as ranging from about 11 650 to 26 750 in 15 fishes of the length range 110–114 mm.

The results, therefore, show that silverbellies are fractional spawners spawning throughout the year with one or two peaks or over longer durations each year; the estimates

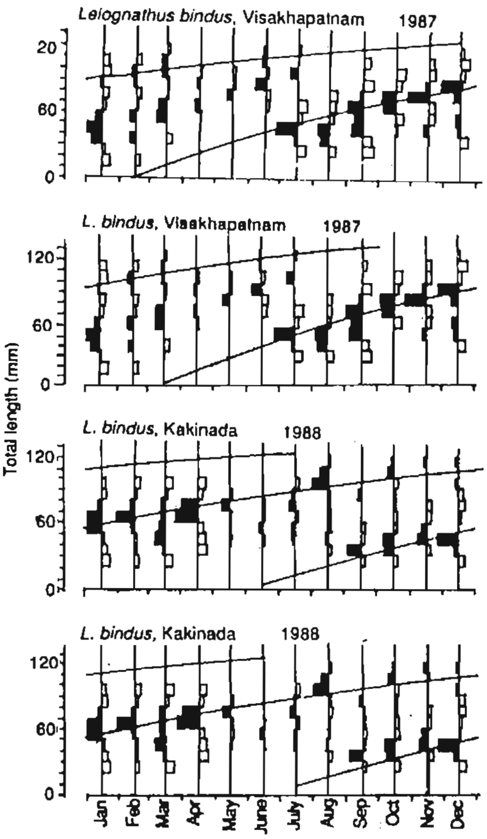


Fig. 6. Restructured length frequency data (ELEFAN 1) and growth curves of *Leiognathus bindus*. Visakhapatnam 1987: L_∞ = 151 mm, K = 0.95 per year, SS=9, SL=65 mm; Visakhapatnam 1987: L_∞ = 163 mm, K=0.95 per year, SS=7, SL=45 mm; Kakinada 1988: L_∞=154 mm, K=0.77 per year, SS=9, SL=30 mm; Kakinada 1988: L_∞=165 mm, K=0.70 per year, SS=10, SL=100 mm.

Stock assessment

Growth parameters: The smallest and largest L_∞ values and their associated K values of the four species under study along with the corresponding Phi values (Pauly and Munro 1984) are shown in Table 2; the corresponding length frequency (restructured) data with growth curves are shown in figures 6–9. In *L. bindus* (Table 2), the estimated of length at first maturity are within 63–102 mm with majority of the values falling in the length 80–95 mm; these fishes are mainly zooplankton feeders; and though some estimates of fecundity are made; in view of the fractional spawning habits in these fishes, the estimates cannot be taken as total annual fecundity, and can at best be referred to as batch fecundities.

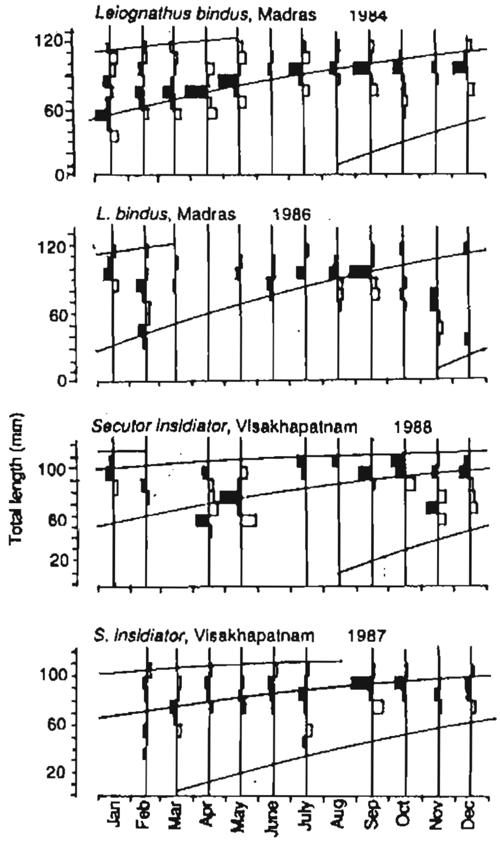


Fig. 7. Restructured length frequency data (ELEFAN 1) and growth curves of *Leiognathus bindus*. Madras 1984: L_∞=153 mm, K=0.90 per year, SS=1, SL=55 mm; Madras 1986: L_∞=167 mm, K=0.96 per year, SS=8, SL=90 mm. *Secutor insidiator*. Visakhapatnam 1988: L_∞=120 mm, K=1.2 per year, SS=7, SL=90 mm; Visakhapatnam 1987: L_∞=130 mm, K=0.85 per year, SS=7, SL=95 mm.

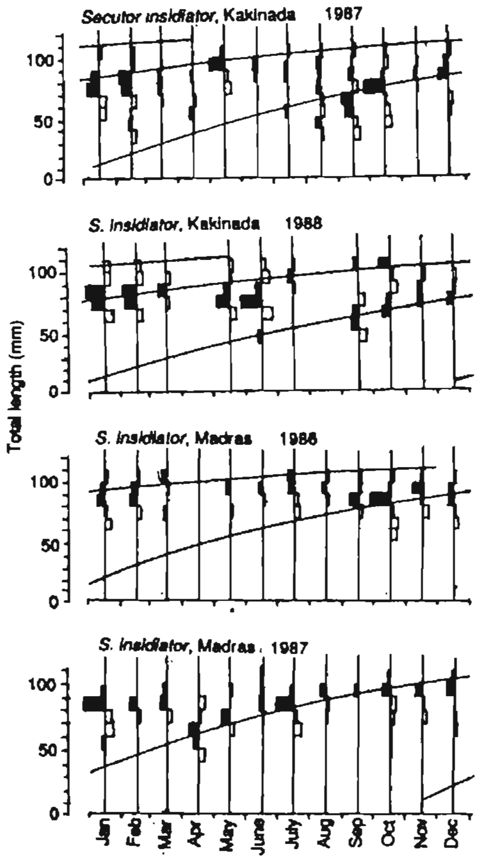


Fig. 8. Restructured length frequency data (ELEFAN 1) and growth curves of *Secutor insidiator*. Kakinada 1987: L_∞ = 125 mm, K = 1.06 per year, SS = 1, SL = 85 mm; Kakinada 1988: L_∞ = 130 mm, K = 0.85 per year, SS = 7, SL = 65 mm; Madras 1986: L_∞ = 125.5 mm, K = 1.22 per year, SS = 9, SL = 80 mm; Madras 1987: L_∞ = 138 mm, K = 1.30 per year, SS = 4, SL = 65 mm.

values of L_∞ and K in both the sets ranged from 151 mm to 167 mm and from 0.70 to 0.96 respectively. The maximum known length of this species was 155 mm (Anonymous 1977) from Madras. The estimated values within each set (lower or higher) were found to be close to each other. The values estimated earlier by Murty (1986a) were closer to the values of this study but those estimated from Calicut (Pauly and David 1981), Samar sea (Silvestre 1986) and Java sea (Dwiponggo *et al.*, 1986) were different: the values of L_∞ were much smaller (Tables 2 and 3).

In *L. jonesi* (Table 2), the L_∞ values were slightly larger than L_{max} known. While the

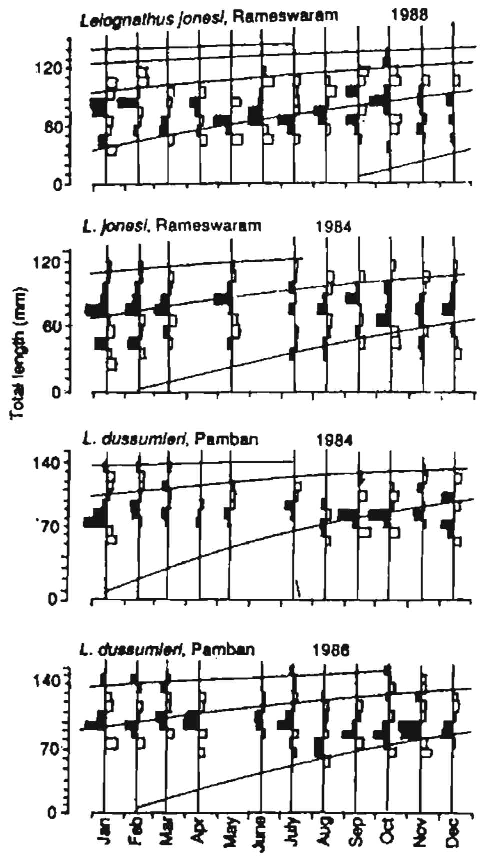


Fig. 9. Restructured length frequency data (ELEFAN 1) and growth curves of *Leiognathus jonesi*. Rameswaram 1988: L_∞= 155 mm, K=0.70 per year, SS=3, SL=50 mm; Rameswaram 1984: L_∞= 160 mm, K=0.6 per year, SS=1, SL=70 mm. *Leiognathus dussumieri*. Pamban 1984: L_∞ = 162 mm, K=1.2 per year, SS=7, SL=85 mm; Pamban 1986: L_∞= 175 mm, K=0.80 per year, SS=7, SL=60 mm.

Table 2. Estimated values of growth parameters, mortality rates, lengths and ages at entry and first capture of different species of silverbelly as used in the present study (the ϕ values are also shown)

Species	Locality	L_{max}	Log a	b	L_∞	K	Z	M	F	t_r	t_c	ϕ (phi)	M/K
					Lower L_∞ and related K and other parameters								
Leiognathus bindus	Visakhapatnam	130	–4.77709	2.96182	151	0.95	4.14	2.05	2.09	0.087	0.275	2.34	2.16
	Kakinada	142	–4.77709	2.96182	154	0.77	5.26	1.78	3.48	0.152	0.412	2.26	2.31
	Madras	155	–4.77709	2.96182	153	0.90	5.22	1.98	3.24	0.172	1.022	2.32	2.20
L. jonesi	Rameswaram	152	–5.20211	3.2167	155	0.70	5.36	1.67	3.69	0.330	0.961	2.23	2.38
L. dussumieri	Pamban	161	–5.02993	3.1136	162	1.20	6.70	2.35	4.35	0.250	0.630	2.50	1.96
Secutor insidiator	Visakhapatnam	119	–5.73713	3.43654	120	1.20	4.88	2.55	2.33	0.258	1.052	2.24	2.13
	Kakinada	117	–5.73713	3.43654	125	1.06	4.69	2.33	2.36	0.279	1.100	2.22	2.20
	Madras	120	–5.73713	3.43654	125.5	1.22	5.67	2.55	3.12	0.334	1.011	2.28	2.09
					Higher L_∞ and related K and other parameters								
L. bindus	Visakhapatnam	Same as above			163	0.95	4.72	2.01	2.61	0.080	0.257	2.40	2.12
	Kakinada	"			165	0.70	5.43	1.64	3.79	0.155	0.412	2.28	2.34
	Madras	"			167	0.96	7.44	2.01	5.43	0.147	0.814	2.43	2.09
L. jonesi	Rameswaram	"			160	0.60	4.95	1.50	3.45	0.372	1.076	2.19	2.50
L. dussumieri	Pamban	"			175	0.80	5.46	1.76	3.70	0.343	0.851	2.39	2.20
S. insidiator	Visakhapatnam	"			130	0.85	5.28	1.99	3.29	0.332	1.310	2.16	2.34
	Kakinada	"			130	0.85	4.36	1.99	2.37	0.332	1.291	2.16	2.34
	Madras	"			138	1.30	8.72	2.59	6.13	0.279	0.810	2.39	1.99

Note: All lengths in mm, weights in grams and ages in years. The Z values are those obtained by length-converted catch curve method; Log a and b are constants of length-weight relationship.

ϕ values are calculated following Pauly and Munro 1984.

estimates of Venkatraman *et al.* (1981) were close to the estimates of this study, those obtained by Karthikeyan *et al.* (1989) were not so (Table 3); the L_∞ was much smaller than these estimates.

In *L. dussumieri* the L_∞ was closer to the L_{max} (Table 2).

In *S. insidiator* the estimates obtained were close to each other (Table 2). The lone earlier estimate (Murty 1991) was closer to the present estimated values (Tables 2 and 3).

Mortality rates: Taking the two sets of parameters (Table 2), the total mortality rates were estimated using the length-converted catch curve. In *L. bindus*, the estimated values of Z varied from 4.14 to 5.26 under 'lower parameters' and from 4.72 to 7.44 under 'higher parameters' (Table 2). In *L. jonesi*, the Z values were 4.95 and 5.36 under 'higher' and 'lower' parameters respectively. In *L. dussumieri*, they were 5.46 and 6.70 (Table 2). In *S. insidiator* under 'lower parameters', the Z values varied from 4.69 to 5.67 and from 4.36 to 8.72 under 'higher parameters' at different centres (Table 2).

The estimated values of natural mortality rate (M), under both the sets of parameters ranged from 1.64 to 2.05 in *L. bindus*, from 1.50 to 1.67 in *L. jonesi*, from 1.76 to 2.35 in *L. dussumieri* and from 1.99 to 2.59 in *S. insidiator*. The M/K values (Table 2) in all the cases showed that they were well within the range of 1.0–2.5 (Beverton and Holt 1959) known in fishes.

Effort and yield: In Andhra Pradesh, maximum yield of about 2 500 tonnes of *L. bindus* is obtainable at 60% of the present effort whereas the yield of *S. insidiator* increases to 1 560 tonnes at 200% of present effort. The mixed fisheries assessment of these two species showed that maximum yield of 3 700 tonnes will be obtained at 80% of the present effort (Fig. 10.A). The present estimated yield of these two species is 3 680 tonnes. Hence, the increase in yield by decreasing the effort by 20% will not be significant.

In northern Tamil Nadu (Fig. 11.A), the maximum yield of 1 860 tonnes of *L. bindus* corresponds to 120% of present effort. In *S. insidiator* the yield increases to about 2 270 tonnes at 200% of present effort. The combined yield of these two species increases to 4 100 tonnes at 200% of present effort. The present yield of these two species is estimated to be 3 930 tonnes. Thus, a 100% increase in effort can result in about 4% increase in yield.

In southern Tamil Nadu (Fig. 12) the yield of *L. dussumieri* increases to 5 720 tonnes at 200% of present effort whereas the MSY of 16 500 tonnes of *L. jonesi* corresponds to 120% of present effort. The maximum combined yield of 22 100 tonnes of these two species corresponds to 140% of present effort. The estimated yield of these species during the study period was 21 800 tonnes. Thus a 20% increase in effort will result in about 1.3% increase in yield of the two species and 40% increase in effort will increase the yield by about 1.5%.

Cod end mesh size of trawl and yield: In Andhra Pradesh, the yield of *L. bindus* increases up to 200% of present t_c. In *S. insidiator*, on the other hand the MSY corresponds to 60% of the present t_c (Fig. 10.B). The situation thus, shows that under the current effort level there is need to reduce the cod end mesh size by 40% to get MSY of one species and to increase the same by at least 100% for another species. The combined maximum yield of the two species, however, corresponds to 60% of present t_c. This implies that the present cod end mesh size which is already small (15–20 cm) has to be reduced further by 40% (to 9–12 mm). This reduction can only result in 1–6% increase in yield.

Table 3. Parameters of growth, mortality, lengths and ages at entry and first capture of different silverbelly species from Indo-Pacific region

Species	Area/Locality	Source	L_∞ (mm)	K (per year)	t_0 (year)	L_r (mm)	t_r (year)	L_c (mm)	t_c	Z	M	F	ø
Leiognathus bindus	Kakinada, India	Murty 1986	158.4	0.58	–0.024	17	0.18	57.0	0.75	5.20	1.50	3.7	2.16
	Samar sea	Silvestre 1986	121.0	0.98	0	–	–	–	–	4.28	2.21	2.07	2.16
	Java	Dwiponggo *et al.* 1986	125.0	1.38	0	–	–	50.3	–	8.84	2.83	–	2.33
	Calicut, India	Pauly and David 1981	122.0	1.3	–	–	–	–	–	–	–	–	2.29
L. jonesi	Mandapam, India	Venkataraman *et al.* 1981	161.20	0.528	0.111	–	–	48	0.56	3.20	2.28	0.92	2.14
	Mandapam, India	Karthikeyan *et al.* 1989	146.62	0.917	0	15	–	–	–	5.26	1.25	4.01	2.29
L. splendens	Porto Novo, India	Jayabalan 1988 a	170.00	0.3259	–1.4159								1.97
	Samar sea	Silvestre 1986	131.00	0.90	0					3.13	2.02	1.11	2.19
	Java	Dwiponggo *et al.* 1986	145.00	1.25	0			96.5	–	4.64	2.55	2.09	2.42
	"	"	169.00	1.10	0			62.3	–	4.00	2.25	1.75	2.50
	"	"	167.00	0.90	0			62.3	–	3.27	1.98	1.25	2.40
L. equulus	Samar sea	Silvestre 1986	240.00	0.56	0	–	–	–	–	2.20	1.26	0.94	2.51
	Java	Dwiponggo *et al.* 1986	215.00	1.50	0	–	–	134.0	–	5.68	2.50	3.10	2.84
L. elongatus	Malaysia	Chan and Liew 1986	135.00	0.80	0	–	–			3.10	1.80	1.30	2.16
L. leuciscus	Samar sea	Silvestre 1986	137.00	0.93	0	–	–	–	–	3.86	2.12	1.74	2.24
	Java	Dwiponggo *et al.* 1986	135.00	1.80	0	–	–	47.6		6.15	3.31	2.84	2.52

Table 3 (*Contd*)

Species	Area/Locality	Source	L_∞ (mm)	K (per year)	t_0 (year)	L_r (mm)	t_r (year)	L_c (mm)	t_c (year)	Z	M	F	ϕ
L. brevirostris	Java	Dwiponggo *et al.* 1986	120.00	0.95	0	-	-	71.0	-	2.79	2.20	0.59	2.14
Secutor insidiator	Kakinada, India	Murty 1991	123.00	1.20	-0.01	27.00	0.20	80.0	0.86	6.10	2.60	3.50	2.26
S. ruconius	Java	Dwiponggo *et al.* 1986	90.00	2.20	0	-	-	36.0	-	8.91	4.22	4.69	2.25
	Java	- do -	83.00	1.45	0		-	49.0	-	8.86	3.29	5.57	2.00
Gazza minuta	Porto Novo	Jayabalan and Ramamurthi 1986	160.00	0.8649	-0.2316	-	-	-	-	-	-	-	2.34

In northern Tamil Nadu (Fig. 11. B) the MSY corresponds to 80% of present t_c for *L. bindus* and to 60% of present t_c for *S. insidiator*. The combined maximum yield of these two species corresponds to 60% of present t_c. Here also, the implication is reduction in cod end mesh size by 40% which results in 13% increase in yield.

In southern Tamil Nadu (Fig. 13) the MSY of the two species corresponds to present t_c only suggesting that under the present effort level and in the present fishing grounds, mesh regulation is not necessary.

DISCUSSION

Two species (*L. bindus* and *S. insidiator*) were considered for the study from Andhra Pradesh and northern Tamil Nadu coasts and two other species (*L. jonesi* and *L. dussumieri*) from southern Tamil Nadu. As these species formed about 60% by weight of silverbelly catches in the respective regions, assessment of these species could be taken as nearly reflecting the situation in the silverbelly fisheries of the regions.

The problems in arriving at realistic estimates of growth parameters and the consequent need to take into account at least two sets of growth parameters (lowest and highest L_∞ and related K) from among many sets of values estimated and the types of conflicting management options one would encounter in mixed fisheries assessments, have been discussed in the paper on threadfin breams in this issue. As these are common to most of the multi-species/mixed fisheries, they are not dealt with here.

By the very abundance of silverbellies, both in terms of number of species as well as quantities landed, and the species dominant in the fishery, the southern Tamil Nadu is distinct and requires separate treatment for

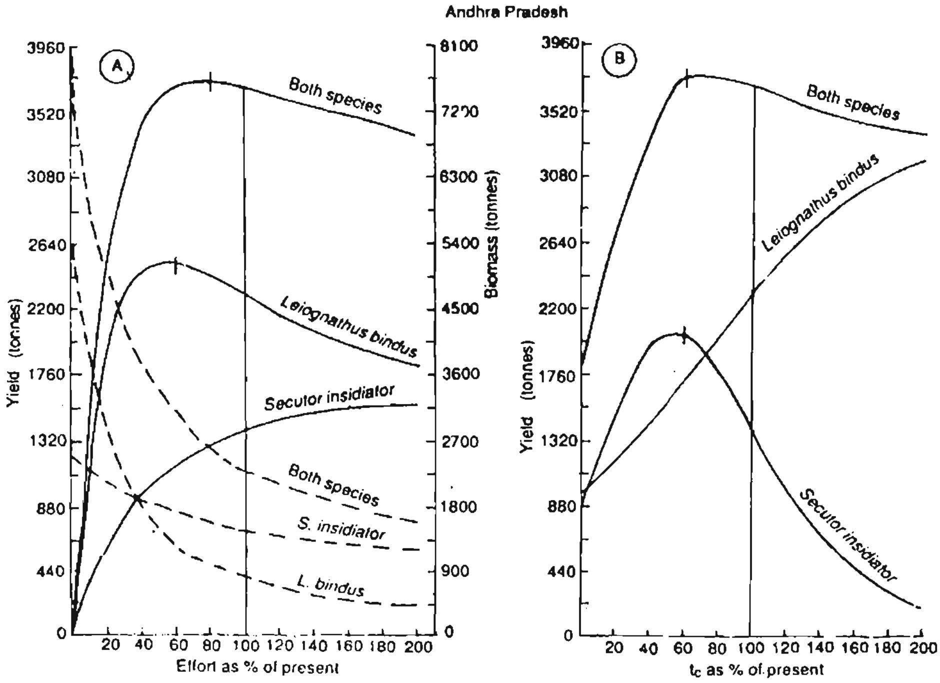


Fig. 10. Yield of *Leiognathus bindus* and *Secutor insidiator* from Andhra Pradesh. A. At different effort levels expressed as percentage of present effort. B. At different t_c levels expressed as percentage of present t_c (the small vertical lines on the curves indicate MSY in the present fishing ground and the long vertical lines the current effort or t_c levels and yields).

fisheries management. Northern Tamil Nadu and Andhra Pradesh, however, do not show greater difference with regard to the species composition and dominant species. The assessments were, however, treated separately for the three regions due to the above reasons and mainly because the fisheries management is within the administrative control of maritime states.

The Thompson and Bell long-term forecast in Andhra Pradesh indicated the need to decrease the present effort level for one species and increase the same for another species in the same fishery to get MSY (Fig. 10.A). In northern Tamil Nadu (Fig. 11.A), situation was that increased effort was required to harvest MSY but the levels of effort required to get the same were different in both the species. In southern Tamil Nadu, in both the species (Fig. 12), increased effort was necessary to get MSY but at different maximum levels. The combined assessment of the two species (in each region) lead to a still different situation in that the effort corresponding to maximum combined yield was different from the effort corresponding to MSY of constituent species. A more or less similar situation was seen in case of yield-mesh curves of the species from the three regions making the task of formulating effective management measures difficult. If all other species in the mixed fishery are also

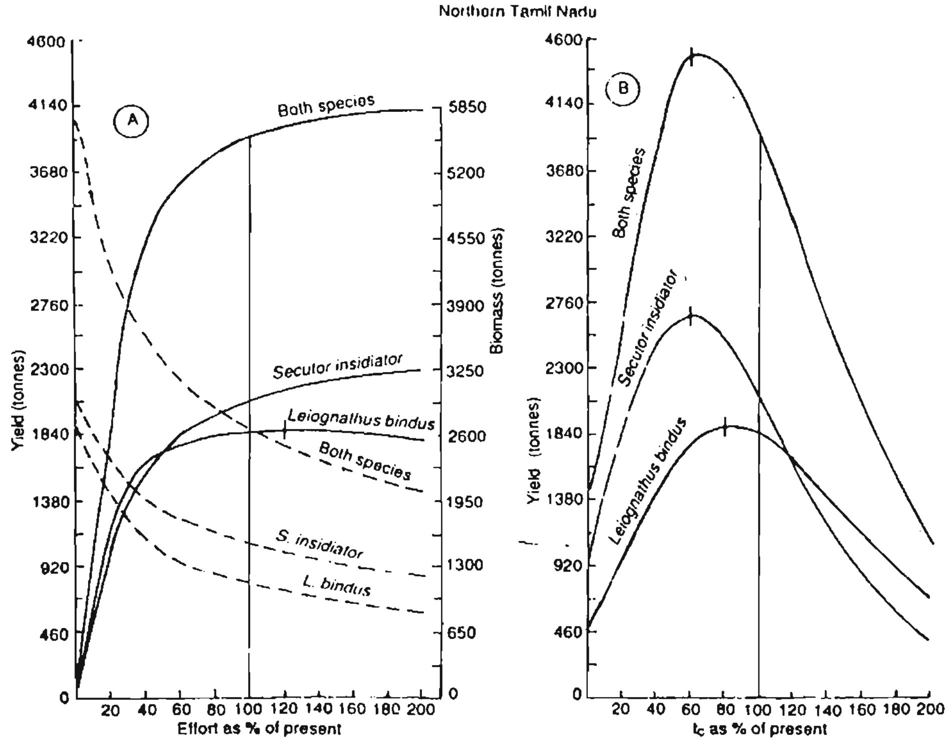


Fig. 11. Yield of *Leiognathus bindus* and *Secutor insidiator* from northern Tamil Nadu. A. At different effort levels expressed as percentage of present effort. B. At different t_c levels expressed as percentage of present t_c.

considered, the situation will only become more complex. This is the real problem faced in fisheries resources management particularly in tropical countries like India. While knowledge of the biological interactions between species contributing to the multi-species/mixed fisheries is essential for effectively formulating regulatory measures, on the basis of available knowledge, the only option appears to be fit is to regulate the effort at a level where MSY (or MSE) of the most economically important species is obtained. As long as the effort is stabilized at a required level (in the well-defined fishing grounds), the yield of all the species including the targetted species, also gets stabilized as long as the steady state assumption is fulfilled. Thus the importance of stock assessment lies in making available strategies for regulating fisheries of several species stocks so that the fishery managers can select the strategy most required for the industry. In the case of silverbelly resources considered here, the present effort can be maintained in the present fishing grounds, because in cases where increase in effort to get MSY is warranted, the increase in yield will be very marginal and can result in reduction in catch rates. Only in Andhra Pradesh there is need to decrease the effort by about 20%; here also the increase in yield and catch rates is not significant warranting such a reduction in effort. Though the analysis in certain instances indicated the need to reduce cod end mesh size of trawl net, particularly in

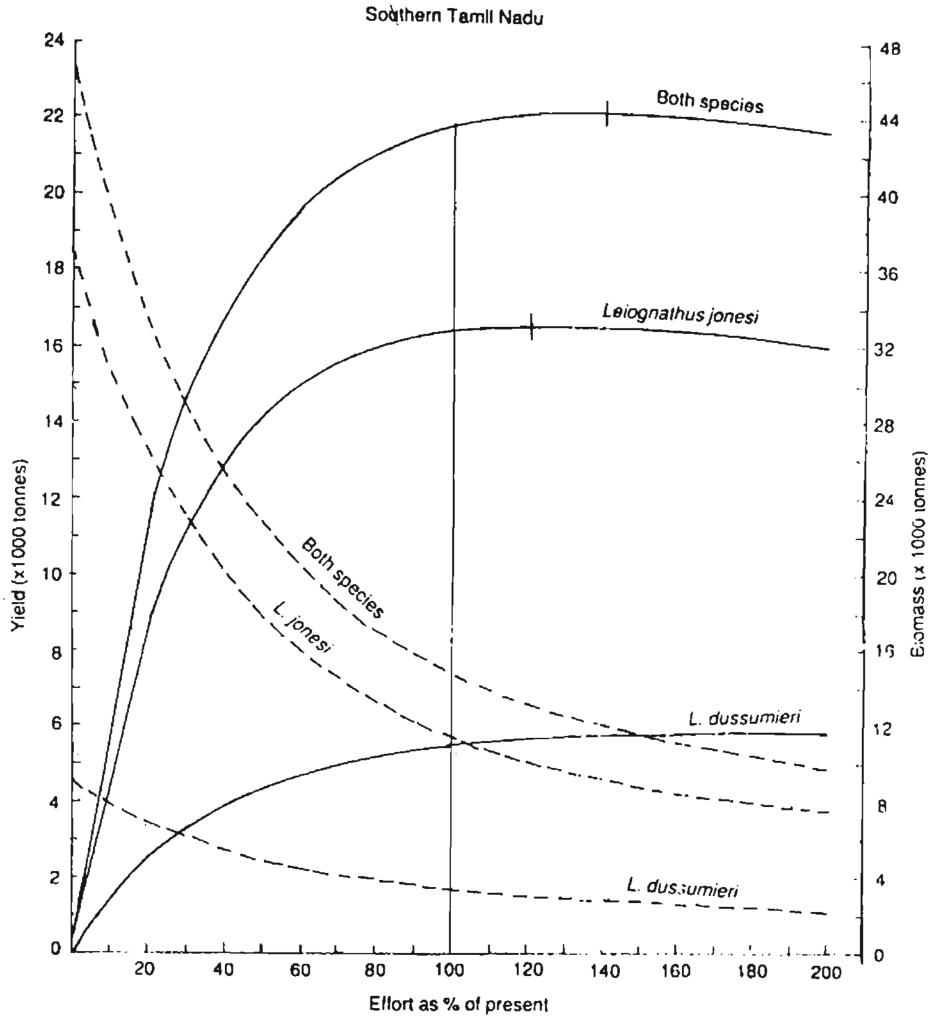


Fig. 12. Yield of *Leiognathus jonesi* and *L. dussumieri* at different effort levels expressed as percentage of present effort in southern Tamil Nadu.

northern Tamil Nadu, such a regulation will not result in substantial increase in yield and even if so, the contribution will be from much smaller fish (of the already small, considered as trash fish) not valued by the industry in any significant manner.

It is known that silverbellies are predominantly inhabitants of shallower regions where active fishing both by mechanized and non-mechanized gears is taking place. Considerable caution is necessary before any effort increase in the present fishing grounds is thought of because of its possible impact on other resources. Moreover, silverbelly landings are showing declining trends in recent years.

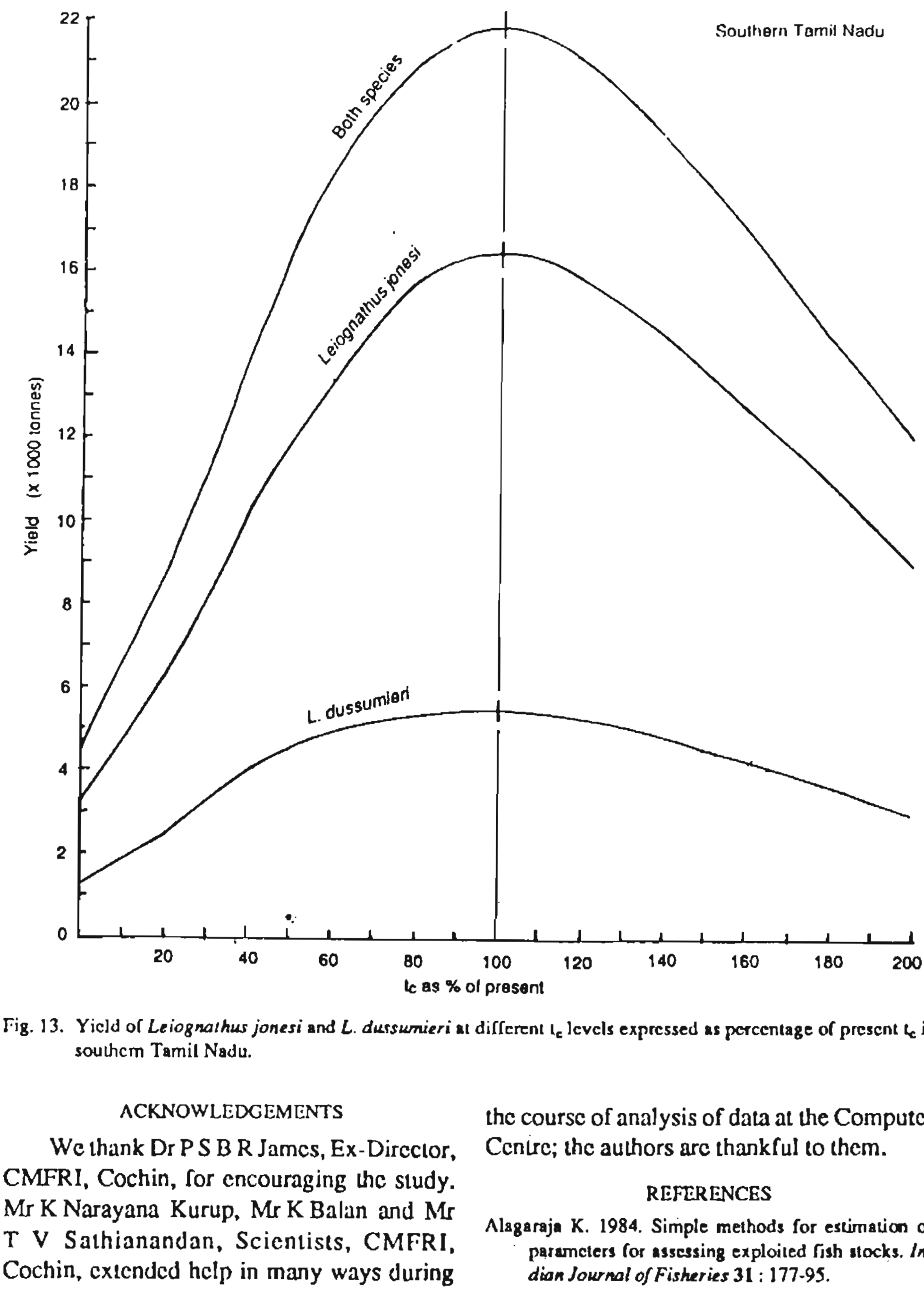


Fig. 13. Yield of *Leiognathus jonesi* and *L. dussumieri* at different t_c levels expressed as percentage of present t_c in southern Tamil Nadu.

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REFERENCES

Alagaraja K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian Journal of Fisheries* 31 : 177-95.

Annam V P and Dharmaraja S K. 1981. Trends in the catch of silverbellies by mechanized boats in Tamil Nadu during 1971-75. *Indian Journal of Fisheries* 28 (1 & 2) : 87-95.

Anonymous. 1977. *Annual Report 1977*. Central Marine Fisheries Research Institute, Cochin, 148 pp.

Anonymous. 1991. *Annual Report 1990-91*. Central Marine Fisheries Research Institute, ICAR, Cochin, 111 pp.

Arora H L. 1952. Contribution to the biology of the silverbelly *Leiognathus splendens* Cuv. *Proceedings of Indo-Pacific Fisheries Council* 3, Technical Paper 4, pp. 75-80.

Balan V. 1967. Biology of silverbelly, *Leiognathus bindus* (Val.) of the Calicut coast. *Indian Journal of Fisheries* 10(1) : 118-34.

Beverton R J H and Holt S J. 1957. On the dynamics of exploited fish populations. *Fishery Investigation Series, London* 19 : 533.

Beverton R J H and Holt S J. 1959. A review of life-spans and mortality rates of fish in nature and their relation to growth and other physiological characteristics. Ciba foundation colloquia on ageing. *The Life-span of Animals*. 5.pp 142-77. (Ed.) Wolsenholmy G E W and Conor M O.

Chan E H and Liew H C. 1986. Characteristics of an exploited tropical shallow water demersal fish community in Malaysia. *The First Asian Fisheries Forum*. pp 349-52. (Eds) Maclean J L, Dizon L B and Hosillos L V. Asian Fisheries Society, Manila, Philippines. 727 pp.

Dwiponggo A, Hariati T, Banon S, Palmares M L and Pauly D. 1986. Growth, mortality and recruitments of commercially important fishes and penaeid shrimps in Indonesian waters. *ICLARM Technical Report* 17 : 91 pp.

Gayanilo F C Jr, Soriano M and Pauly D. 1988. A draft guide to COMPLEAT ELEFAN. *ICLARM Software Project* 2 : 65 pp.

James P S B R. 1967. *Leiognathus leuciscus* (Gunther) and *Leiognathus smithursti* (Ramsay and Ogilby) (Family Leiognathidae : Pisces) - Two new records from the Indian seas. *Journal of Marine Biological Association of India* 9(2) : 300-02.

James P S B R. 1969. A new species of silverbelly *Leiognathus jonesi* (Family Leiognathidae : Pisces) from the Indian seas. *Journal of Marine Biological Association of India* 11 (1 & 2) : 316-19.

James P S B R. 1973. The fishery potential of silverbellies. The proceedings of Symposium of Living Resources of the Seas around India. *CMFRI Special Publication*. pp 439-44.

James P S B R. 1975. A systematic review of the fishes of the family Leiognathidae. *Journal of Marine Biological Association of India* 17(1) : 138-72.

James P S B R. 1986. Biology and fishery of *Leiognathus jonesi* James from the Palk Bay and Gulf of Mannar. *Recent Advances in Marine Biology*. pp 29–101. (Ed.) James P S B R. Today and Tomorrow publishers, New Delhi.

James P S B R and Badrudeen M. 1975. Biology and fishery of *Leiognathus brevirostris* (Valenciennes) from the Palk Bay and Gulf of Mannar. *Indian Journal of Marine Sciences* 4 : 50-59.

James P S B R and Badrudeen M. 1981. Biology and fishery of silverbelly *Leiognathus dussumieri* (Valenciennes) from Gulf of Mannar. *Indian Journal of Fisheries* 28(1 & 2) : 154-82.

James P S B R and Badrudeen M. 1986. Studies on maturation and spawning of the fishes of the family Leiognathidae from the seas around India. *Indian Journal of Fisheries* 33(1) : 1-26.

James P S B R and Badrudeen M. 1991. A new species of silverbelly *Leiognathus striatus* (Family Leiognathidae : Pisces) from the Gulf of Mannar India and redescription of *Leiognathus fasciatus* (Lacepede). *Journal of Marine Biological Association of India* 32 (1 & 2) : 217-26.

James P S B R, Alagarswamy K, Rao K V N, Muthu M S, Rajagopalan M S, Alagaraja K and Mukundan C. 1987. Potential Marine Fishery Resources of India. *CMFRI Special Publication* No. 30. pp. 44-74.

James P S B R, Badrudeen M and Edwin Joseph V. 1992. An annotated bibliography of the silverbellies. (Pisces : family Leiognathidae) *CMFRI Special Publication* No. 50. 220 pp.

Jayabalan N. 1985. A new species of silverbelly, *Gazza shettyi* (Pisces : Leiognathidae) from the Bay of Bengal. *Matsya* 11 : 42-45.

Jayabalan N. 1986. Reproductive biology of silverbelly *Leiognathus splendens* (Cuvier) at Porto Novo. *Indian Journal of Fisheries* 33(2) : 171-79.

Jayabalan, N. 1988a. Age and growth of the ponyfish, *Leiognathus splendens* (Cuvier) caught off Porto Novo coast. *The first Indian Fisheries Forum Proceedings*. (Ed.) Mohan Joseph M. Asian Fisheries Society, Indian Branch, Mangalore, pp XV + 494.

Jayabalan N. 1988 b. Reproductive biology of the ponyfish *Gazza minuta* (Bloch) from Porto Novo, east coast of India. *Indian Journal of Marine Sciences* 17(1) : 51-54.

Jayabalan N and Ramamoorthi K. 1985 a. Sexual dimorphism in the ponyfish *Leiognathus bindus* (Val.). *Current Science* 54 (22) : 1191-92.

Jayabalan N and Ramamoorthi K. 1985 b. Maturation and spawning of silverbelly *Secutor insidiator* from Porto Novo coast. *Indian Journal of Marine Sciences* 14 : 105-09.

Jayabalan N and Ramamoorthi K. 1985 c. Food and feeding habits of the silverbelly *Gazza minuta* (Bloch) in Porto Novo waters. *Indian Journal of Marine Sciences* 14 : 110-12.

Jayabalan N and Ramamoorthi K. 1986. Determination of age and growth in the toothed ponyfish *Gazza minuta* (Bloch) from Porto Novo. *Mahasagar* 19 (3) : 217-20.

Karthikeyan M, Pillai N G K and Badrudeen M. 1989. Population dynamics of silverbelly *Leiognathus jonesi* James in the trawling grounds off Rameswaram. *Indian Journal of Fisheries* 36(2) : 103-06.

Kurup B Madhusoodana and Samuel C T. 1983. Systematics and distribution of fishes of the family Leiognathidae (Pisces) of the Vembanad Lake, Kerala. *Records of Zoological Survey of India* 80 (3 & 4) : 387-411.

Murty V S. 1983. Observations on some aspects of biology of silverbelly *Leiognathus bindus* (Valenciennes) from Kakinada. *Indian Journal of Fisheries* 30 (1) : 61-68.

Murty V S. 1985. Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada. *Journal of Marine Biological Association of India* 27 (1 & 2) : 39-48.

Murty V S. 1986 a. Studies on growth and population dynamics of silverbelly *Leiognathus bindus* (Valenciennes) in the trawling grounds off Kakinada. *Indian Journal of Fisheries* 33 (3) : 277-84.

Murty V S. 1986 b. Population characteristics of the silverbelly *Leiognathus bindus* (Valenciennes) along West Bengal coast. *Journal of Marine Biological Association of India* 28 (1 & 2) : 41-47.

Murty V S 1989. Mixed fisheries assessment with reference to five important demersal fish species landed by shrimp trawlers at Kakinada. pp. 69-86. *Contributions to Tropical Fish Stock Assessment in India.* (Eds) Venema S C and Van Zalinge P N. Paper prepared by the participants at the FAO/DANIDA/ICAR National training course on fish stock assessment: Cochin, India, 2-28 Nov. 1987. FI: GCP/INT/392/DEN/1: 1989, 157 pp.

Murty V S. 1991. Biology and population dynamics of the silverbelly *Secutor insidiator* (Bloch) from Kakinada. *Journal of Marine Biological Association of India* 32 (1 & 2) : 10-24.

Pauly D. 1977 a. The Leiognathidae (Teleostei), their species, stocks and fisheries in Indonesia with notes on biology of *Leiognathus splendens* (Cuvier). *Marine Research in Indonesia* 19 : 79-93.

Pauly D. 1977 b. The Leiognathidae (Teleostei) : A hypothesis relating their mean depth of occurrence to the intensity of their countershading bioluminiscence. *Marine Research in Indonesia* 19 : 137-46.

Pauly D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *Journal du Conseil* 39(3) : 175-92.

Pauly D. 1982. Studying single-species dynamics in a tropical multi-species context. *Theory and Management of Tropical Fisheries*. pp 33-70. (Eds) Pauly D and Murphy C I. ICLARM, ISIRO.

Pauly D and David N. 1981. ELEFAN-I a BASIC programme for the objective extraction of growth parameters from length frequency data. *Meeresforschung* 28 : 205-11.

Pauly D and Pauly S W. 1981. *An Annotated Bibliography of Slipmouths* (Pisces : Leiognathidae). ICLARM, Manila (Philippines), 62 pp.

Pauly D and Munro J J. 1984. Once more on the comparison of growth in fish and invertebrates. *Fishbyte* 2(1) : 21.

Pillai N G K and Dorairaj K. 1985. Results of trawling survey by an Institutional boat Cadalmin II in the Palk Bay of Gulf of Mannar, Mandapam, during 1977-80. *Indian Journal of Fisheries* 32 (1) : 123-32.

Pillai P K Mahadevan. 1972. Fecundity and spawning habits of some silverbellies. *Indian Journal of Fisheries* 19 : 196-99.

Rani Singh and Talwar P K. 1978 a. Species of silverbelly, *Leiognathus indicus*, Pisces : Leiognathidae (From the Bay of Bengal). *Bulletin of Zoological Survey of India* 1(3) : 275-77.

Rani Singh and Talwar P K. 1978 b. On the little known ponyfish *Gazza achlamys* Jordan and Starks (Pisces : Leiognathidae) in the Indian waters. *Current Science* 47 (23) : 930-31.

Reuben S, Sudhakararao G, Luther G, Apparao T, Radhakrishna K, Appanna Sastry Y and Radhakrishna G. 1989. An assessment of the bottom trawl fishery resources of the northeast coast of India. *Bulletin of Central Marine Fisheries Research Institute* 44 (Part I) : 59-77.

Silvestre G T. 1986. Yield-per-Recruit Analysis of Ten Demersal fish species from the samar sea, Philippines. pp 501-504. *Proceedings of First Asian Fisheries Forum, Manila, Philippines.* 727 pp. (Eds) Maclean J L, Dizon L B and Hosillos L V.

Sivaprakasam T E, Parasuraman P S, Premchand, Rajakumar S A and Nagarajan G. 1991. Marine fishery resources off the lower east coast of India. *Bulletin of Fishery Survey of India* 21 : 29.

Sparre P. 1985. *Introduction to Tropical Fish Stock Assessment.* Denmark Funds-in-Trust, F I: GCP/INT/392/DEN Manual 1. 338 pp, FAO.

Sparre, P. 1987. Computer programme for fish stock assessment. Length based fish stock assessment (LFSA) for Apple II Computers. *FAO Fisheries Technical Paper* (101) Suppl. 2 : 217 pp.

Srinath M. 1989. Trend of the major exploited marine fishery resources of India during 1961-85. *Bulletin of Central Marine Fisheries Research Institute* 44 (Part I) : 272-83.

Sudarsan D, Sivaprakasam T E, Somavanshi V S, John M E, Nair K N V and Joseph Antony. 1988. An appraisal of the marine fishery resources of the Indian Exclusive Economic Zone. *Bulletin of Fishery Survey of India* 18 : 85.

Thompson W F and Bell F H. 1934. Biological studies of the halibut fishery. 2. Effect of changes in intensity upon total yield and yield per unit of gear. *Report of International Fisheries (Pacific Halibut) Commission* (8). 49 pp.

Venkatraman G and Badrudeen M. 1974. On the diurnal variation in the catches of silverbellies in Palk Bay. *Indian Journal of Fisheries* 21(1) : 254-65.

Venkatraman G, Badrudeen M and Thiagarajan R. 1981. Population dynamics of the silverbelly *Leiognathus jonesi* in Palk Bay. *Indian Journal of Fisheries* 28 (1 & 2) : 65-86.

Vivekanandan E and Krishnamoorthi B. 1985. Estimated resources of demersal fisheries of north Tamil Nadu south Andhra Pradesh coasts based on exploratory surveys. *Harvest and Post Harvest Technology of Fish.* (Eds) Ravindran K, Nair N V, Perigreen P A, Madhavan P, Pillai A G, Panicker P A and Thomas Mary. pp. 69-76. Society of Fishery Technologists (India), Cochin.

PART IV RESOURCES SURVEY AND MANAGEMENT

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An Indicative Survey With Suggestions For Development

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CONTENTS

6. RESOURCES OF ORNAMENTAL FISHES

V. Sriramachandra Murthy, M. Kumaran and R. S. Lalmohan

INTRODUCTION

Among the fishes of Lakshadweep islands, those of ornamental value (aquarium fishes) are very abundant: of the 601 species of marine fishes belonging to 126 families reported from these islands (Jones and Kumaran, 1980), at least 300 species belonging to over 40 families are ornamental fishes. In addition to the taxonomic account of fishes of Lakshadweep islands by Jones and Kumaran (1980), information on ornamental fishes of these islands is restricted to the works of Pillai *et al.* (1983), Madan Mohan *et al* (1986). and Kumaran and Gopakumar (1986). There is, however, no information on the relative abundance or areas of abundance of different species of ornamental fishes from different islands. There is considerable demand for live ornamental fishes in several countries (Tomey 1985, 1986) and the present export market price of each fish, depending on the species, ranges from Rs. 16.10 to Rs. 272.25 with an average of Rs. 90.60 in Netherlands and from Rs. 4.96 to Rs. 148 with an average of Rs. 34.85 in South East Asian Countries. In West Germany, each specimen of some of the species of ornamental fishes from India can fetch from Rs. 99 to Rs. 810 (Anon 1986). In view of the demand for the ornamental fishes and the possible earning of foreign exchange through export of live ornamental fishes and also in view of the lack of adequate information on distribution and abundance of different species in different islands, a survey was conducted during January-March 1987 and the results with reference to ornamental fishes are presented here.

MATERIAL AND METHODS

The survey was conducted by three teams as follows:

I team: Chetlat, Kiltan, Kadmat and Amini islands during 5.1.1987-6.2.1987.

II team: Bitra, Thinnakara, Bangaram and Agatti islands during 9.2.1987-25.2.1987.

III team: Androth, Kavaratti, Suheli, Kalpeni and Minicoy during 6.3.1987-1.4.1987.

In all the islands the fishes were collected using drag net, encircling net and cast net. In the lagoons, the collections were made by encircling nets Fig. 15 A-D and those in the reef flats with drag nets Fig. 15. E : the drag net was laid in a semicircular fashion on the flats in suitable areas and stones were placed in the net to provide hiding space for fishes; the fishes were driven into the net from the open end and then the net was hauled. Every effort was made to collect all the species available in the area. Cast net was also operated on the reef flats during low tide periods ; the net was laid over a big stone and then the stone was moved several times or lifted up, the fishes underneath the stone get entangled in the net and thus caught. Observations on the distribution and abundance of ornamental fishes were also made visually and through underwater surveys in deeper areas of the lagoons.

Collections were made from the lagoons and reef flats by dividing them into arbitrary zones so that representative samples of the species inhabiting the "zones" could be collected, Each zone was intensively studied: specimens were collected from different areas in each "zone" to get a general picture of distribution and abundance of different groups of fishes in the lagoons and reef flats. After collection, the fishes were taken to the shore, identified in fresh condition, photographs taken and then preserved in 5% formalin. All the collections were brought to the main land.

ORNAMENTAL FISHES OF LAKSHADWEEP ISLANDS

Jones and Kumaran (1980) recorded about 300 species of ornamental fishes belonging to over 40 families (Fig. 1). The most dominant group is Labridae with 45 species, followed by Pomacentridae (35), Apogonidae (22), Muraenidae (22) Serranidae (21), Blenniidae (20),

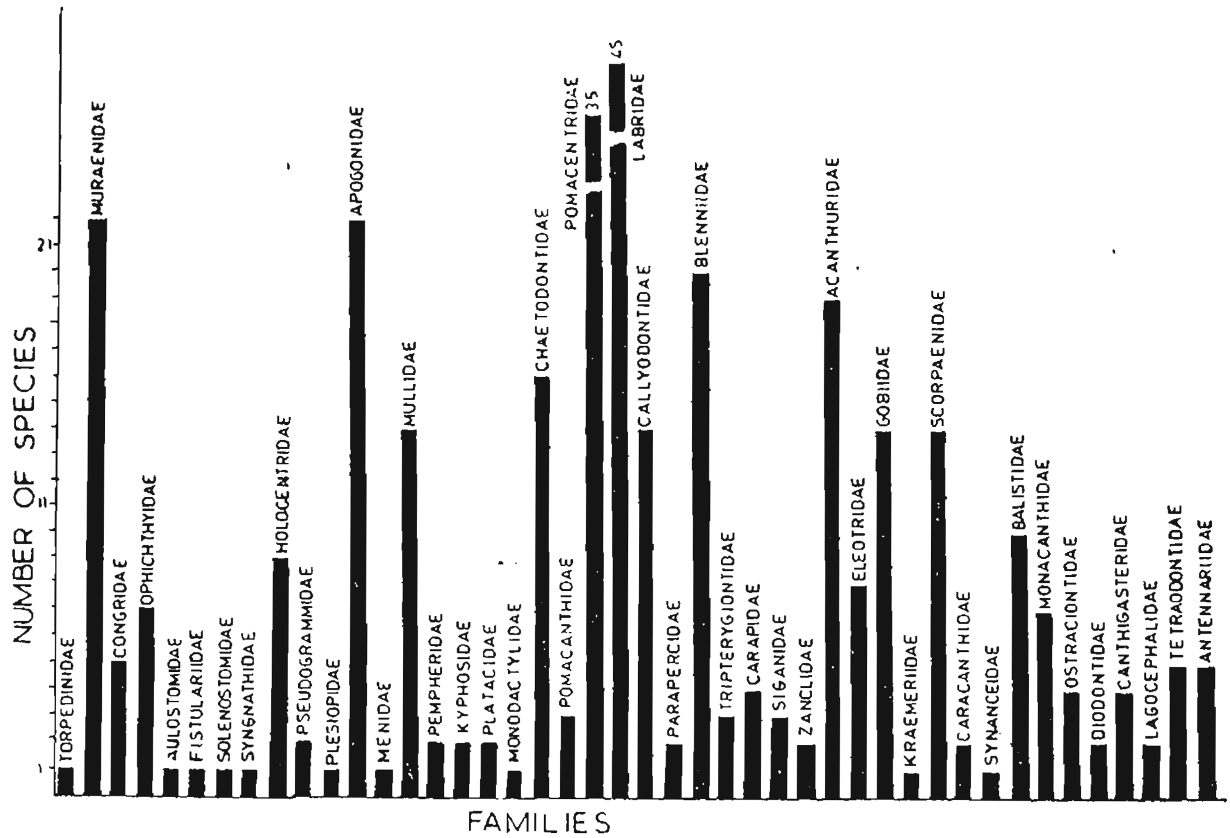

Fig. 1. Number of species of ornamental fishes in each family reported from the Lakshadweep islands.

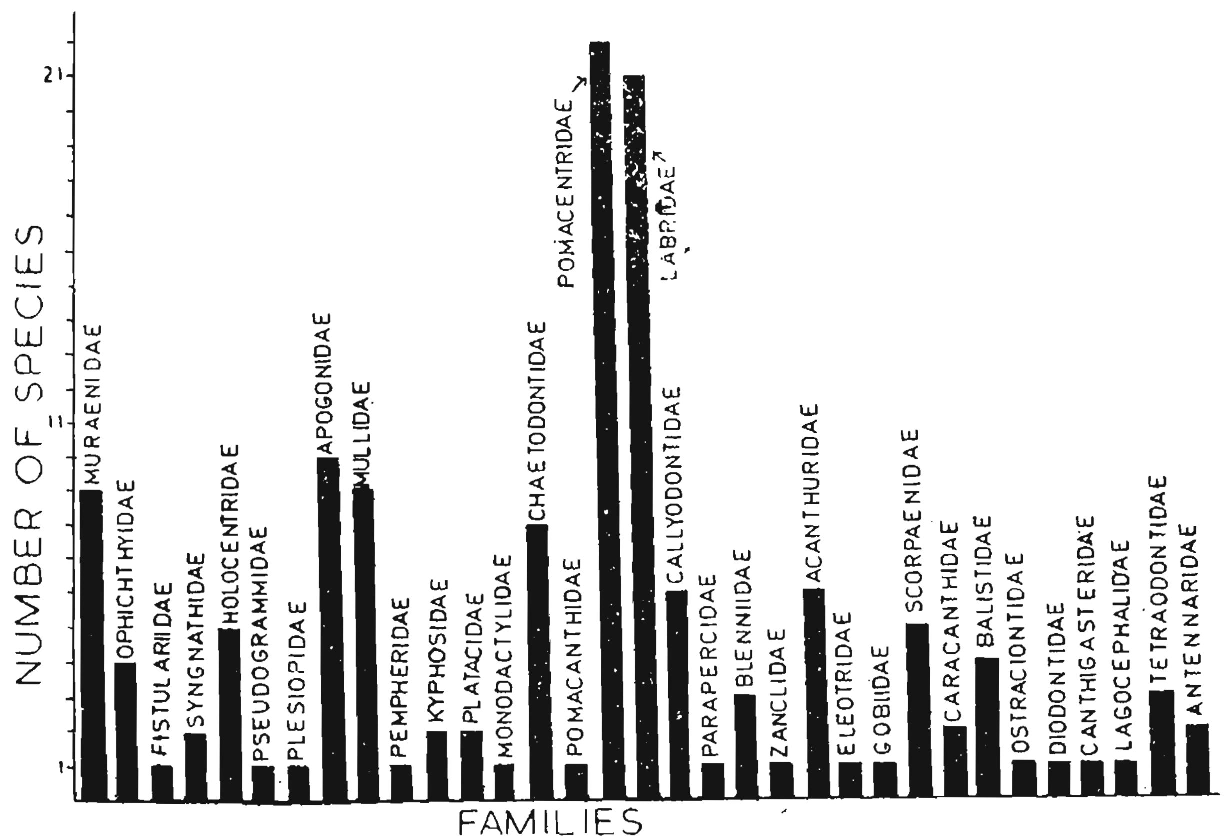

Fig. 2. Number of species of ornamental fishes in each family collected from the Lakshadweep islands during January-March 1987.

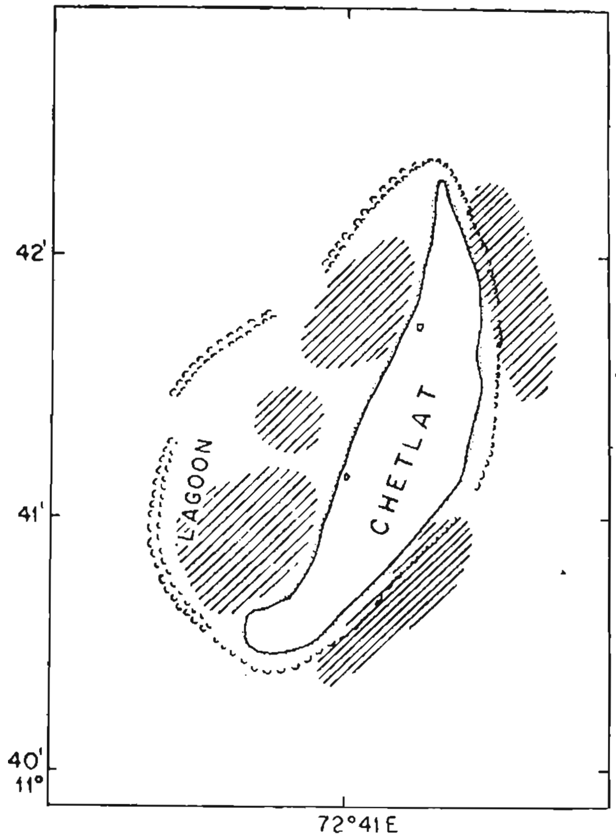

Fig. 3. Map of Chetlat island showing the distribution by shaded areas, of ornamental fishes.

Acanthuridae (19), Chaetodontidae (16), Mullidae (14) Callyo dontidae (14), Gobiidae (14), Scorpaenidae (14), Balistidae (10), Holocentridae (9) and others. The above 14 families are

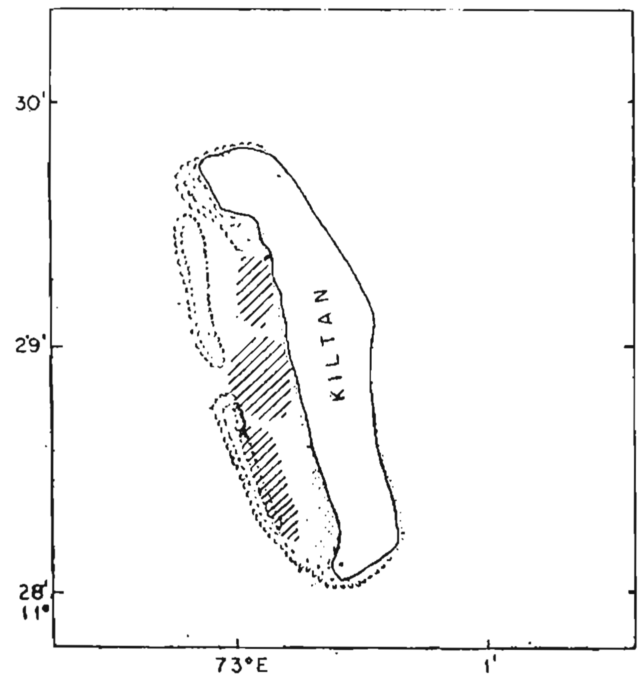

Fig. 4. Map of Kiltan Island showing the distribution, by shaded areas, of ornamental fishes.

represented by 275 species which form about 76% of the total ornamental fish species known from the Lakshadweep islands. In terms of value the fishes of the families Chaetodontidae, Pomacanthidae, Acanthuridae, Holocentridae, Pomacentridae, Balistidae, Labridae and Scorpaenidae are very important (see Anon 1986) these families comprise of 151 species forming 41.8% of total number of ornamental fish species known from the islands.

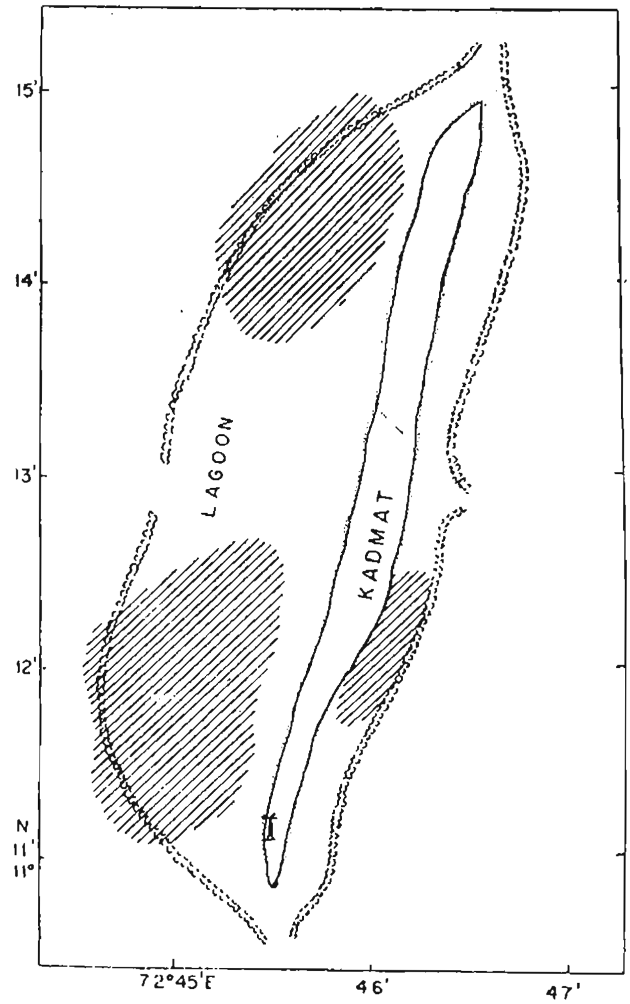

Fig. 5. Map of Kadamat island showing the distribution, by shaded areas, of ornamental fishes.

DISTRIBUTION AND ABUNDANCE OF ORNAMENTAL FISHES

During the three-month survey, a total of 139 species belonging to 33 families were collected from different islands (Fig 2). Among them, the fishes of the family Pomacentridae are most dominant (22 species) followed by Labridae (21), Apogonidae (10), Mullidae (9), Muraenidae (9) Chaetodontidae (8), Callyodontidae (6), Acanthuridae (6) and others; the species of these eight familiies together con-

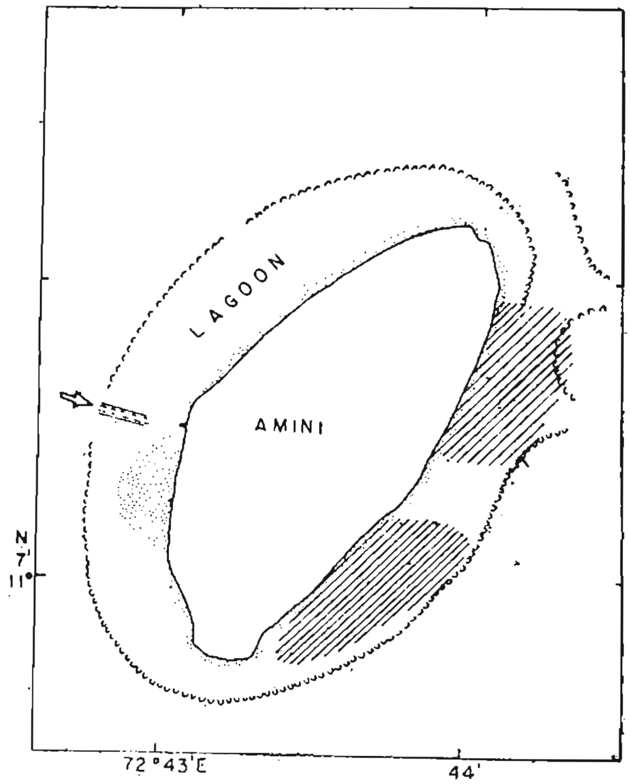

Fig. 6. Map of Amini island showing the distribution, by shaded areas, of ornamental fishes.

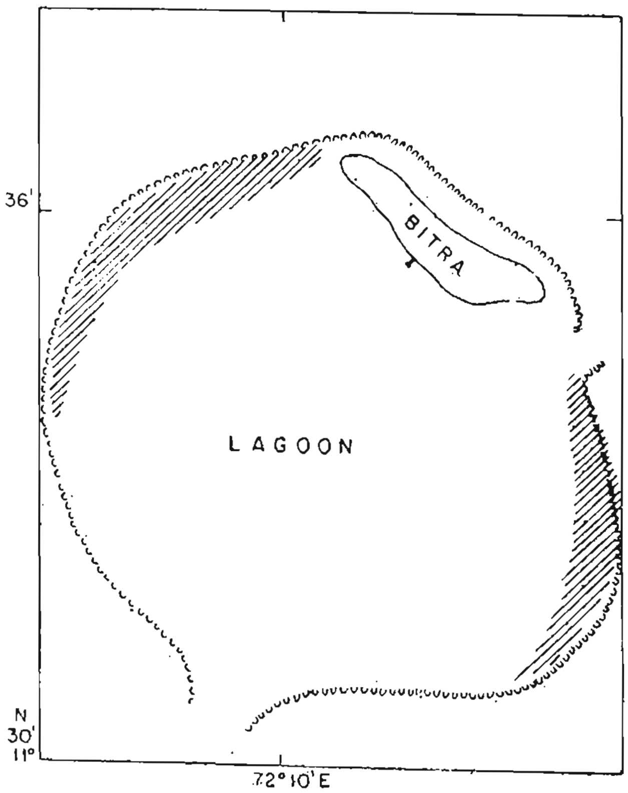

Fig. 7. Map of Bitra island showing the distribution of ornamental fishes.

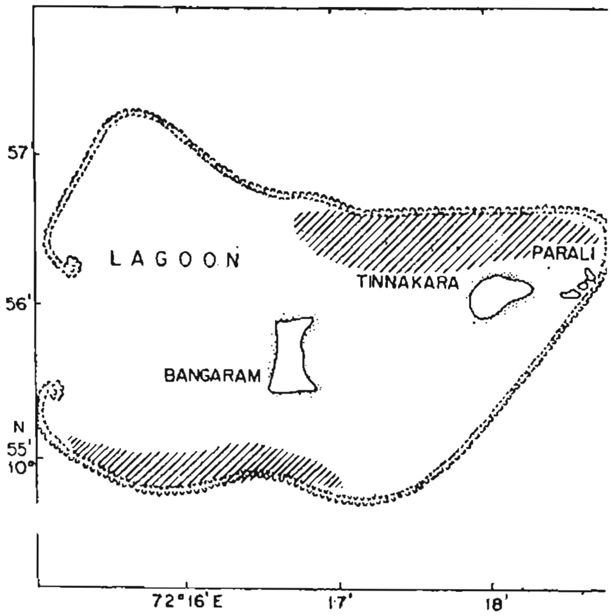

Fig. 8. Map of Tinnakara and Bangaram islands showing the distribution of ornamental fishes.

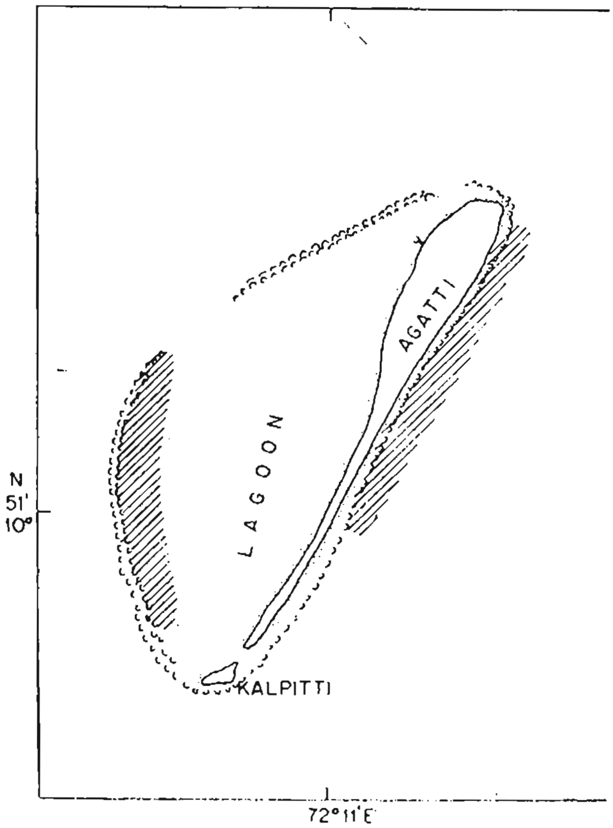

Fig. 9. Map of Agatti and Kalpitti islands showing the distribution of ornamental fishes.

stitute about 64% of all ornamental fish species collected.

The distribution and abundance of different species of ornamental fishes in the reef flats and

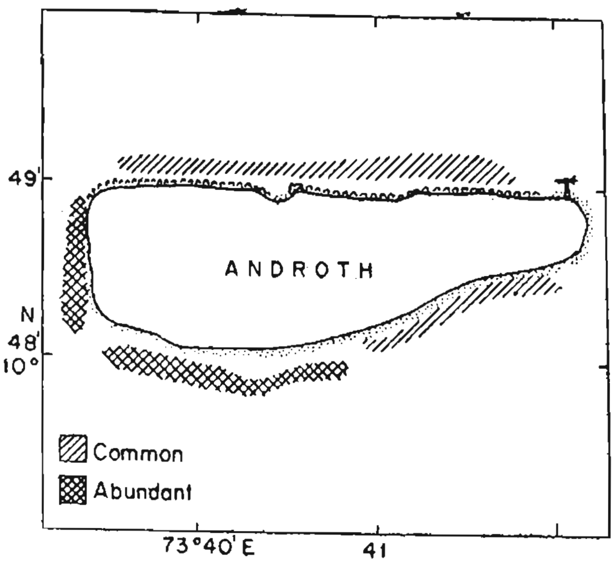

Fig. 10. Map of Androth island showing the distribution of ornamental fishes.

lagoons of different islands are shown in table 1 and in Figures 3-14 (the areas of abundance of ornamental fishes are shown by shaded areas).

1. *Chetlat*: At this island, pomacentrids are most dominant followed by acanthurids,

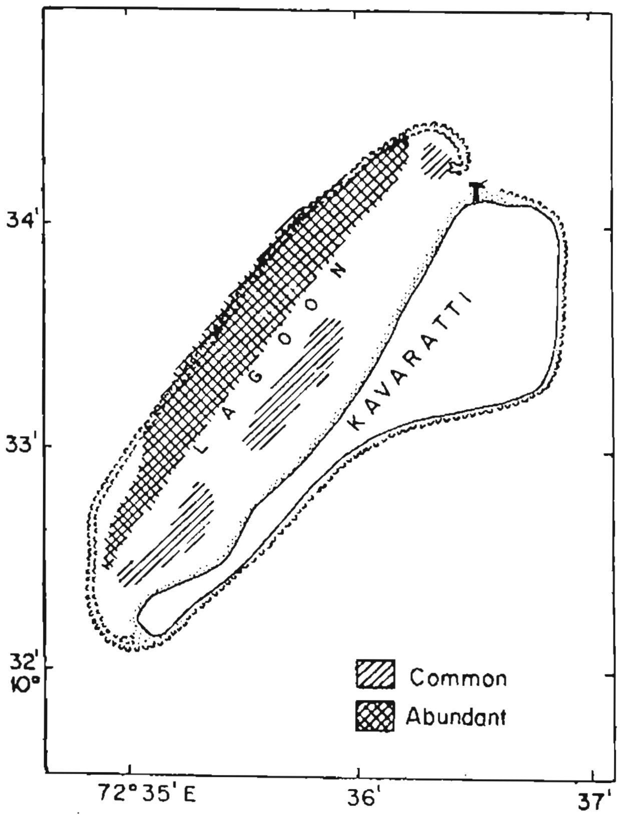

Fig. 11. Map of Kavaratti island showing the distribution of ornamental fishes.

apogonids and holocentrids. Pomacentridae are abundant both in the lagoon and reef flat, acanthurids in the reef flat and Holocentridae and Apogonidae are abundant in the lagoon.

2. *Kiltan*: At this island Pomacentridae, Labridae, Holocentridae and Acanthuridae are abundant. Of these pomacentrids are more abundant in the lagoon whereas Labrids in the reef flat.

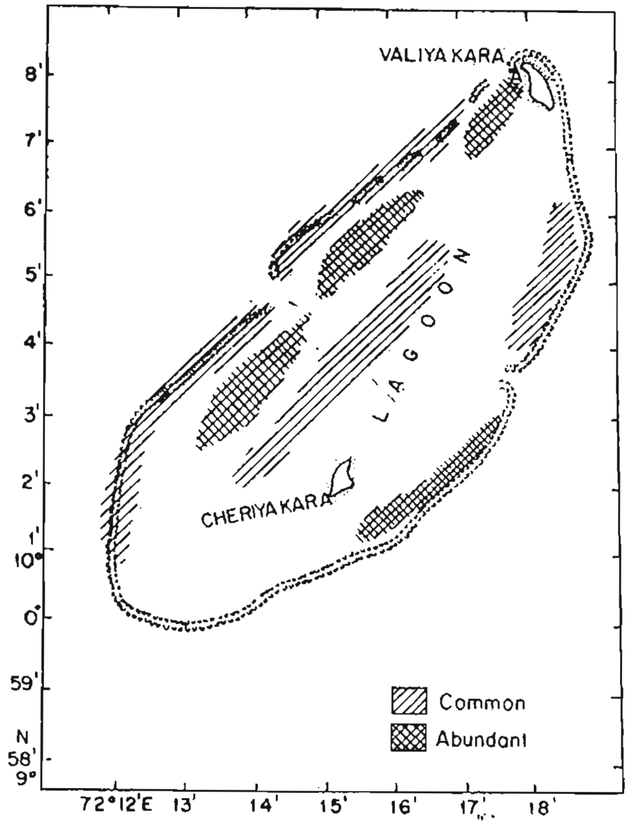

Fig. 12. Map of Suheliper showing the distribution of ornamental fishes.

3. *Kadmat*: At this island also, pomacentrids are more abundant followed by labrids, holocentrids, and blenniids, the former two groups being more abundant in the reef flat.

4. *Amini*: Only two families, Pomacentridae and Labridae are abundant in this island, both in the reef flat. Eels of the family Muraenidae are common in the reef flats of this island.

5. *Bitra*: Labridae, and Scorpaenidae are most abundant in the reef flat. Only one species each of the first two families is abundant in the lagoon whereas scorpaenids were not seen in the lagoon.

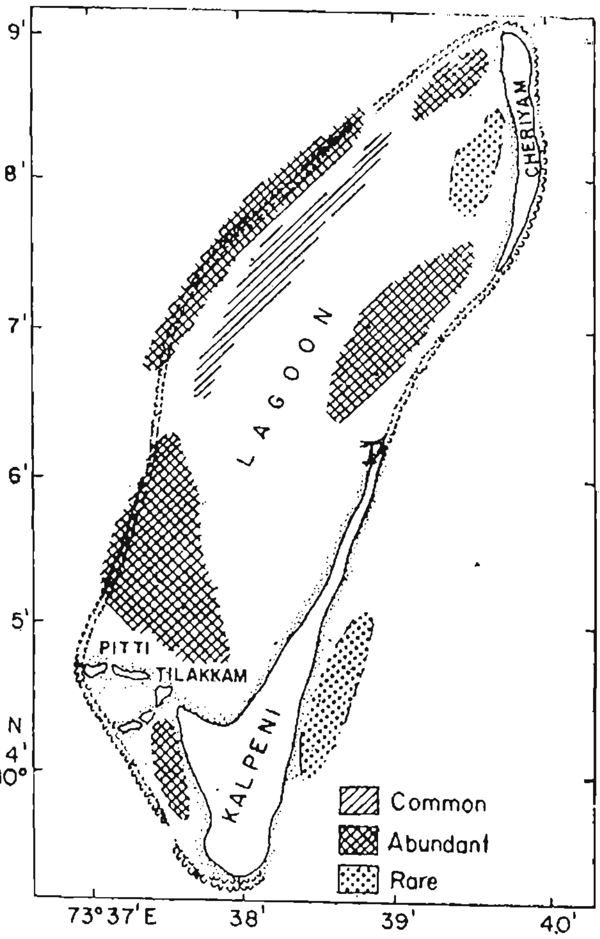

Fig. 13. Map of Kalpeni island showing the distribution of ornamental fishes.

6. *Thinnakara*: Pomacentridae, Mullidae Labridae and Acanthuridae are abundant in this island: three species of Pomacentridae, 2 each of Mullidae and Acanthuridae are abundant in the lagoon whereas two species each of the above four families are abundant in the reef flat.

7. *Bangaram*: Pomacentridae, Labridae, Chaetodontidae, Mullidae, and Balistidae are abundant in this island; except pomacentridae, the fishes of all the above families are abundant in the reefs.

8. *Agati*: Pomacentrds are the most abundant group here followed by Labridae, Scorpaenidae and others. In all these cases, reef flat is richer in ornamental fishes than the lagoon.

9. *Androth*: Only two species of pomacentridae and one species of Labridae are abundant in the reef flat.

10. *Kavaratti*: Only Labridae and Acanthuridae are abundant, particularly on the reef flat of this island.

11. *Suheli*: Labrids and apogonids are abundant in this island.

12. *Kalpeni*: Labridae is the only abundant group here both in the lagoon and reef flat.

13. *Minicoy*: Pomacentridae, Labridae and Acanthuridae are abundant both in the reef flat and lagoon of this island.

The above observations show the following:

a. In 9 of the 13 islands surveyed, there are more number of ornamental fish species in the reef flats than in the lagoons, though some species are abundant in the lagoon and some in the reef flat, in almost all the islands reef flat is richer in ornamental fishes than the lagoon.

b. Species of Pomacentridae and Labridae are not only more in number but they are also abundant in almost all the islands.

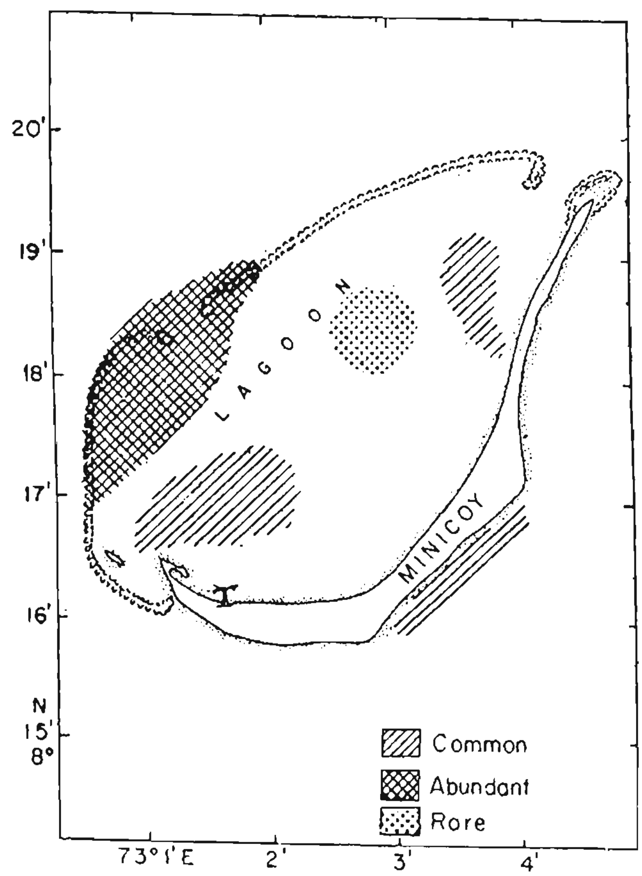

Fig. 14. Map of Minicoy island showing the distribution of ornamental fishes.

Fig. 15. A-D. Collection of fishes using encircling net in the lagoons. The drag net used in collection of fish in the reef flat.

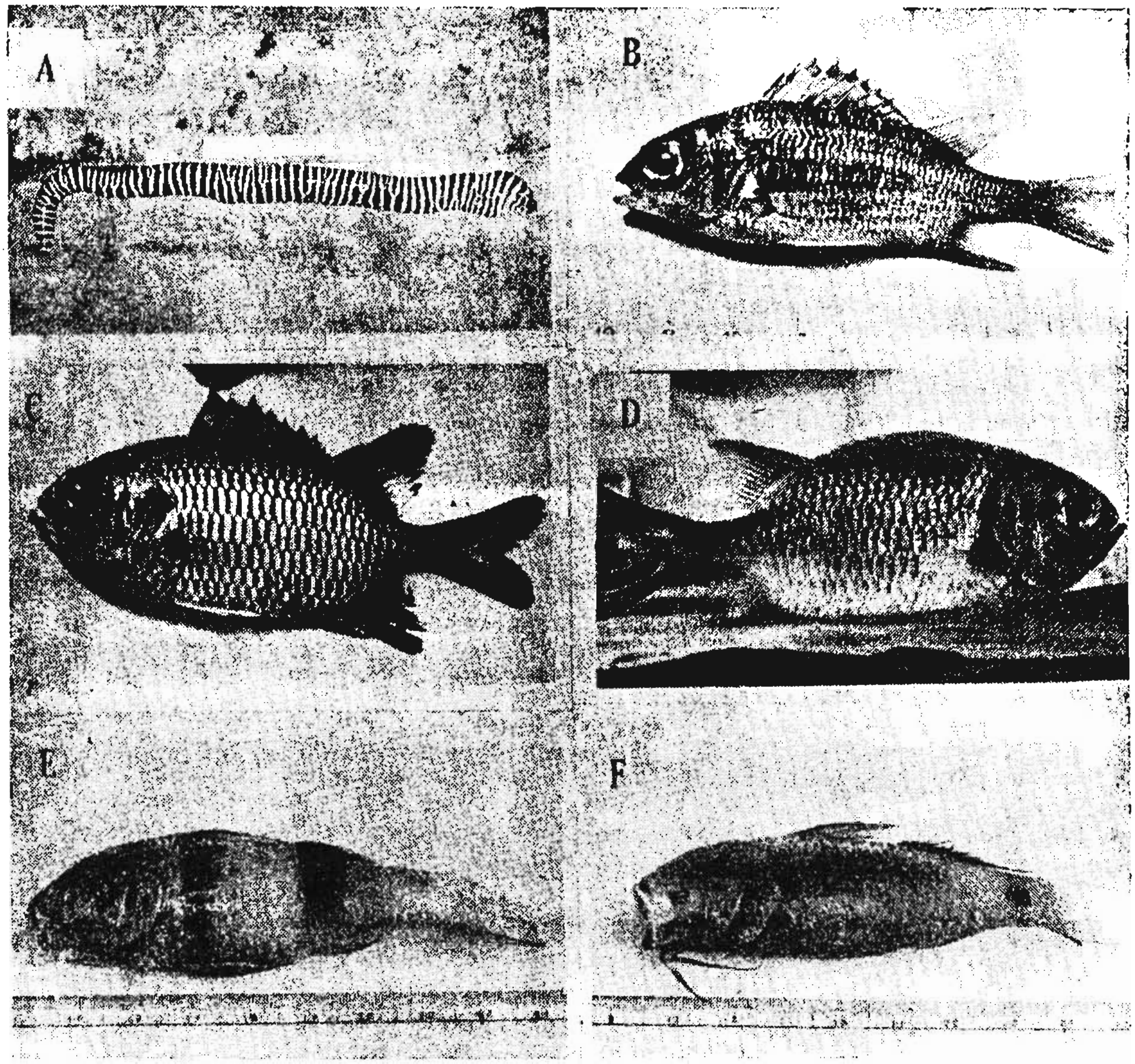

Fig. 16. *A. Echidna zebra*, *B. Holocentrus diadema*, *C. Myripristis adustus* *D. M. murdjan*, *E. Parupeneus bifasciatus*, *F. P. macronemus*

c. Agati and Bitra have very rich resources of ornamental fishes as revealed by the total number and abundance of species followed by the group of four islands Kadmat, Chetlat, Kiltan and Amini. Agatti and Androth respectively are the richest and poorest islands in regard to the abundance of ornamental fish species. It is also clear that the western and northern group of islands are rich in ornamental fishes.

d. The abundant species are : *Abudefduf sordidus, A. sexfasciatus, A. cingulum, A. biocellatus, A. uniocellatus, A. xanthozona, A. zonatus, A. glaucus, Chromis caeruleus, C. ternatensis, C. chrysurus*,, *Dascyllus aruanus, Halichoeres scapularis, Stethojulis axillaris, S. strigiventer, S. albovittata, Thalassoma hardwickii, Labroides dimidiatus, Acanthurus triostegus, A. lineatus, Holocentrus diadema, Ostorhynchus novemfasciatus, O. endekataenia, Archamia fucata, Chaetodon auriga, Aspidcnotus tractus, Mulloidichthys samoensis, M. auriflamma, Pterois volitns Dendrochirus zebra, Rhineacanthus aculeatus* and *R rectangulus*. All these fishes range in length from 2.5 cm to 22.0 cm. Some species of ornamental fishes collected from different islands are shown in Figs. 16-21.

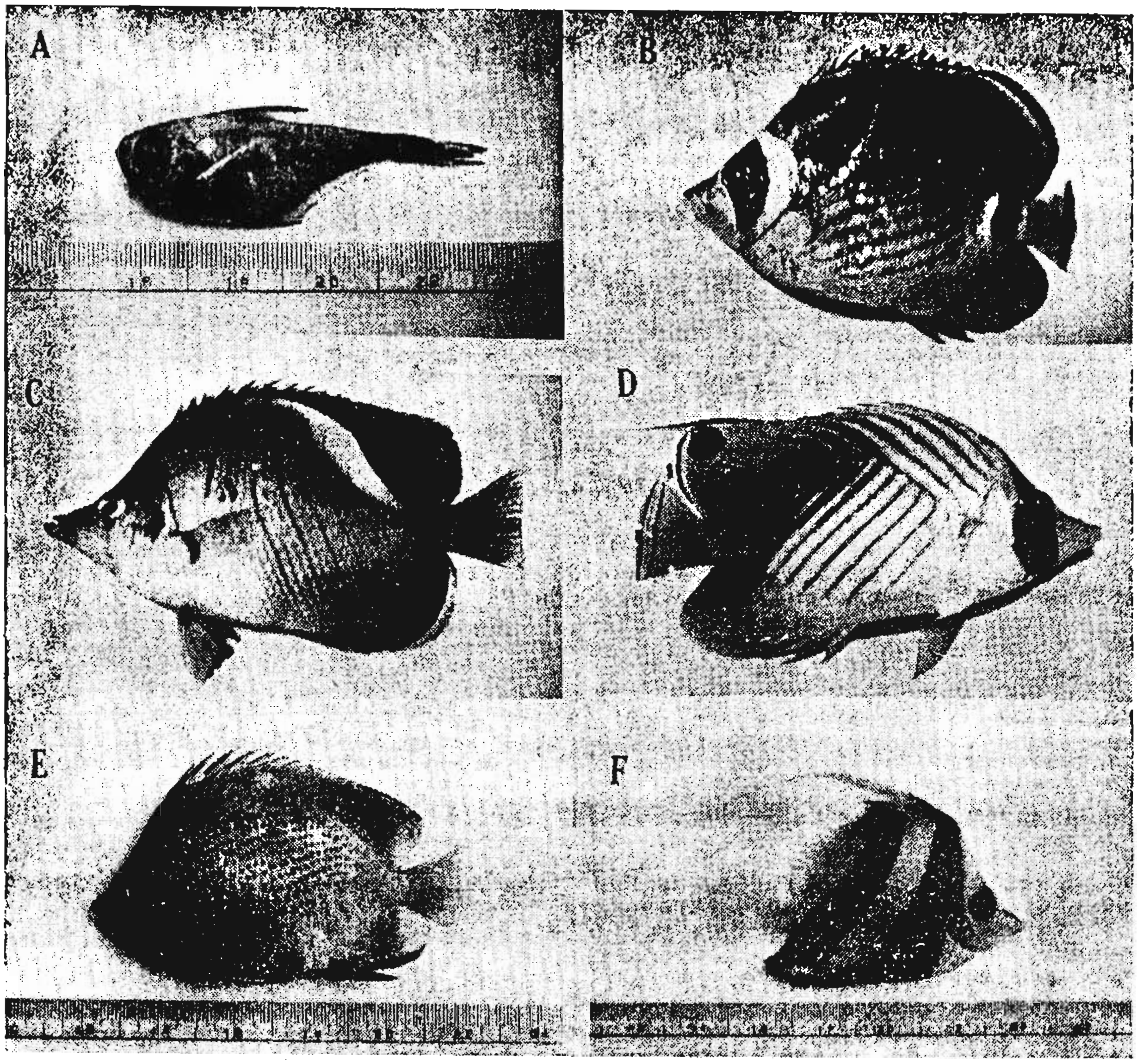

Fig. 17. *A. Pempheris owalensis, B. Chaetodon lunula, C. C. xanthocephalus D. C. auriga, E. C. citrinellus, F. Heniochus acuminatus*

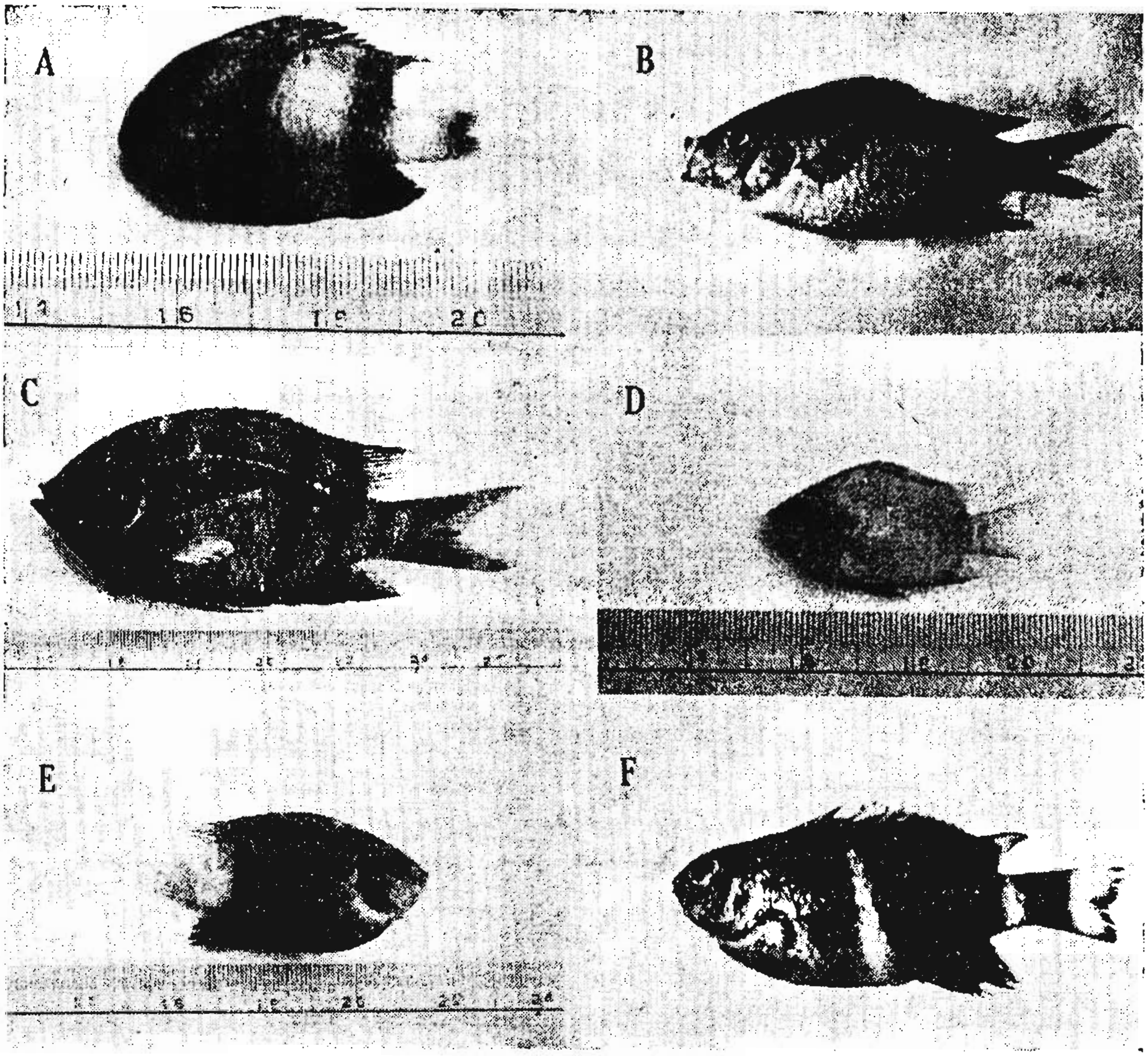

Fig. 18. *A. Dascyllus aruanus, B. Chromis caeruleus, C. Abudefduf saxatilis D. A. sordidus, E. A. dickii, F. A. xanthozona*

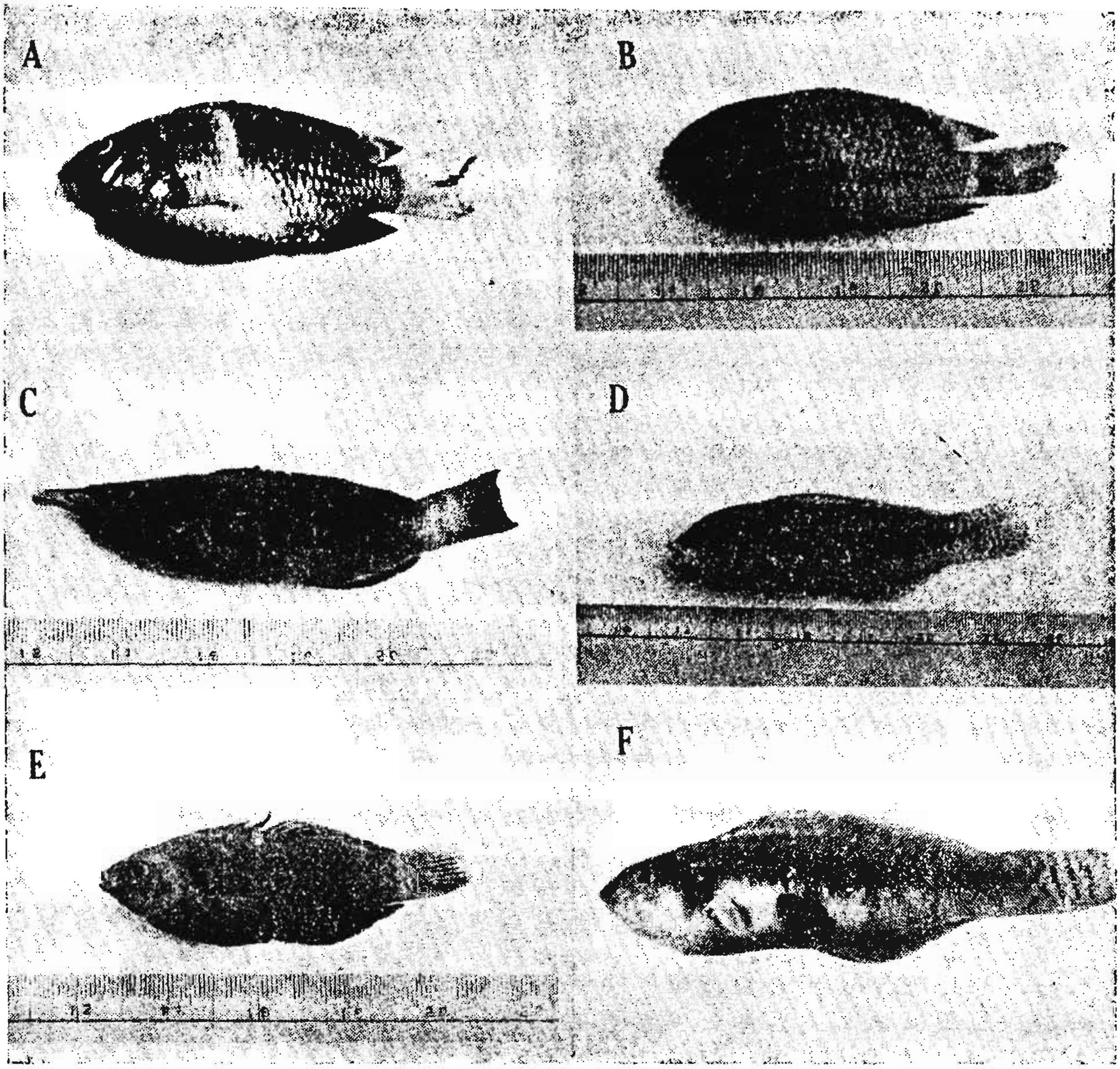

Fig. 19. *A. Abudefduf biocellatus*, *B. A. glaucus*, *C. Gomphosus vartus* *D. Halichoeres capularis*, *E. H. notopsis*, *F. H. kawarin*

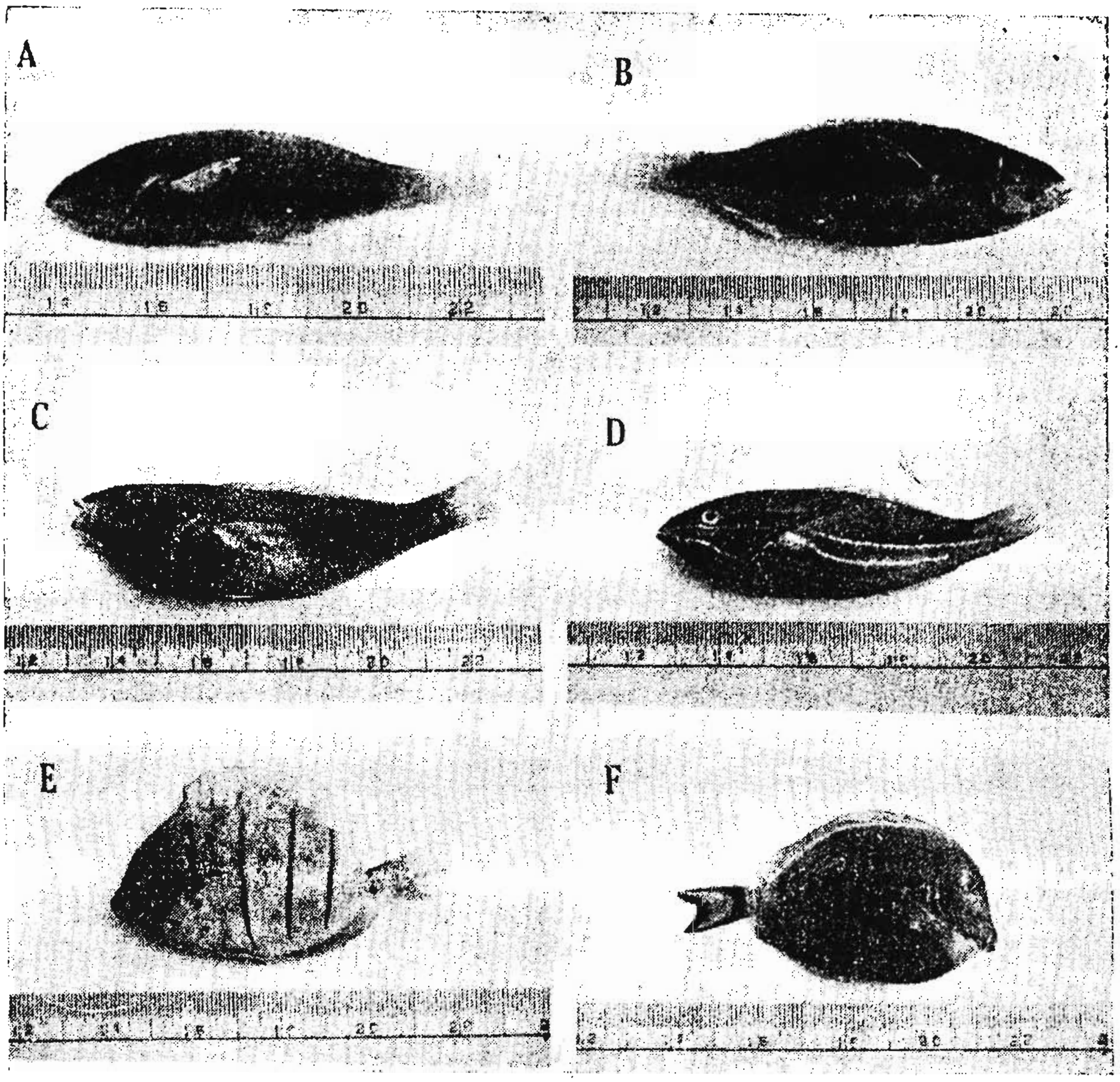

Fig. 20. *A. Stethojulis axillaris, B. S. phaekadopleur, C. S. Strigiventer S. albovittata, E. Acanthurus triostegus, F. A. leucosternon*

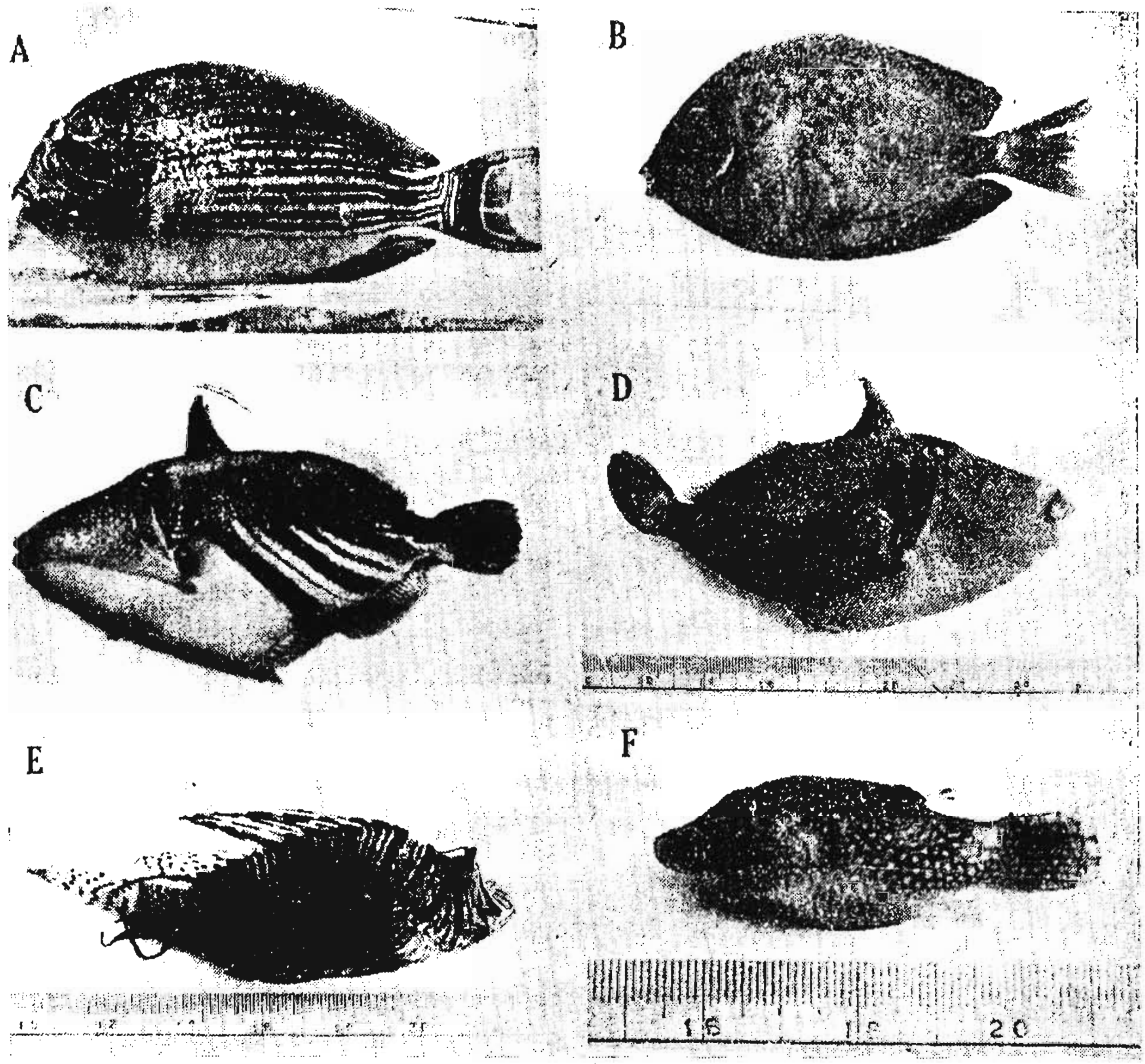

Fig. 21. *A. Acanthurus lineatus*, *B. A. matoides*, *C. Rhineacanthus aculeatus* *D. D. R. rectangulus*, *E Pterois volitans*, *F. Canthigaster margaritatus*

HABITAT OF IMPORTANT GROUPS

It is observed that labrids and callyodontids are abundant in areas where sea grass is abundant; thus the reef flat along the eastern side of Amini these fishes are very abundant. Pomacentrids, particularly *Chromis caeruleus* and *Dascyllus aruanus* and some labrids are abundant in the lagoons where corals are abundant. Lagoons with sandy bottom are generally poor in ornamental fishes but goat fishes are available in considerable quantities during night time particularly in Kadmat and Chetlat. Ornamental fish fauna is also poor along the near-shore sandy portions of the lagoons. The reef flats are particularly rich in pomacentrids, serranids, holocentrids, acanthurids and in some islands labrids. The different species of eels are residents of crevices in the reef flats. Pomacentrids represented by *Abudefduf sordius*, *A. saxatilis*, *A. sexfasciatus* and *A. glaucus* and chaetodontids, ostraciontids, canthigasterids and some acanthurids are abundant in areas under the Jettys and in areas protected by large rocks.

TABLE 1: *List of ornamental fishes with information on relative abundance of each of them in the reef flats and lagoons of different islands.*

Sl. No.	Family	Species	Chetlát	Kiltan	Kad-mat	Amini	Bitra	Thin-nakara	Ban-garam	Agatti	And-roth	Kava-ratti	Suheli	Kalpe-ni	Mini-coy
1	Muraenidae	*Echidna zebra*	X	—	—	—	—	—	—	—	—	—	—	—	—
2		*E. nebulosa*	—	—	—	XX	X	—	X	XX	—	X	X	—	—
3		*E. polyzona*	—	—	—	—	X	—	—		—	—	—	—	—
4		*Uropterygius marmoratus*	—	—	—	—	—	—	—	—	—	—	X	—	—
5		*Gymnothorax pictus*	XXX	—	—	X	XXX	X	X	X	X	X	X	—	—
6		*G. pseudothyrsoidea*	—	—	—	XX	—	—	—	—	—	—	—	—	—
7		*G. pictus*	—	—	—	—	—	—	—	—	—	—	—	—	—
8		*G. fimbriatus*	—	—	—	—	XXX	XX	X	XXX	—	X	X	—	—
9		*G. petelli*	—	—	—	—	X	—	X	—	—	—	—	—	—
10	*Ophichthyidae*	*Myrichthys colubrinus*	—	—	—	—	X	—	—	X	—	—	—	—	—
11		*M. maculosus*	—	—	—	—	—	—	—	—	—	—	—	—	—
12		*Callechelys melanotaenia*	—	—	—	—	—	—	—	—	—	—	X	—	—
13		*Leiuranus semicinctus*	—	—	—	—	—	—	—	—	—	XX	XX	—	—
14	Fistulariidae	*Fistularia petimba*	—	—	XXX	—	X	XX	XXX	XXX					
15	Syngnathidae	*Choeroichthys sculptus*	—	—	—	—	X	X	XX	XX	—	—	—	—	—
16		*C. intestiualis*	—	—	—	—	XX	X	X	X	—	—	—	—	—
17	Holacentridae	*Holocentrus sammara*	XX	—	—	—	XX	—	X	XXX	—	—	—	XX	X
18		*H. diadema*	XXX	XXX	XX	X	—	—	—	—	—	—	—	—	X
19		*H. lacteoguttatum*	—	—	—	—	—	—	—	—	XX	—	—	—	—
20		*Myripristis adustus*	—	XX	—	X	—	—	—	—	—	—	—	—	—
21		*M. murdjan*	XX	—	XX	—	XX	XX	X	XX	—	—	—	—	—
22	Pseudogrammdae	*Pseudogramma polyacanthus*	—	—	—	—	X	X	XX	—	—	—	—	—	—
23	*Plesiopidae*	*Plesiops caeruleolineatus*	XX	—	X	—	XX	—	X	XX	—	—	—	—	—
24	Apogonidae	*Pristiapogon fraenatus*	XX	—	—	—	—	—	—	—	—	—	—	—	—
25		*P. snyderi*	—	—	—	—	—	—	—	—	—	—	X	—	—
26		*Ostorhynchus savayensis*	XX	—	—	—	—	—	—	—	—	—	—	—	—
27		*O. novemfasciatus*	XXX	—	—	XX	—	—	—	—	—	—	XX	X	—
28		*O. endakataenia*	—	—	—	—	XX	—	X	XXX	—	—	—	—	—

Sl. No.	Family	Species	Chetlat	Kiltan	Kad-mat	Amini	Bitra	Thinna-kara	Ban-garam	Agatti	Androth	Kava-ratti	Suheli	Kal-peni	Mini-coy
29		*O. moluccensis*	—	—	—	—	—	—	—	—	—	x	x	—	—
30		*Archamia fucata*	—	—	xxx	—	—	—	—	xx	—	—	—	—	—
31		*Apogon leptacanthus*	—	—	—	—	xx	x	xx	xx	—	—	—	—	—
32		*Cheilodepterus lachneri*	—	—	—	—	x	—	—	—	—	—	—	—	—
33		*Paramia quinquelineata*	—	—	—	—	—	—	—	—	—	—	xx	—	—
34	Mullidae	*Upeneus tragula*	—	—	—	—	x	xx	xxx	xxx	—	—	—	—	—
35		*U. vittatus*	—	—	—	—	—	xx	xx	x	—	—	—	—	—
36		*U. arge*	—	—	—	—	—	xx	—	x	—	—	—	—	—
37		*Mulloidichthys samoensis*	—	—	xxx	—	—	—	—	—	—	—	—	—	xx
38		*M, auriflama*	xxx	xxx	xxx	—	—	xx	—	xx	—	—	—	—	—
39		*Parupeneus barberinus*	xx	xx	xx	xx	xx	x	x	x	—	—	xx	x	—
40		*P. bifasciatus*	—	—	xx	x	—	—	—	—	—	—	—	—	—
41		*P. trifasciatus*	—	—	—	—	xxx	—	—	x	—	—	—	—	—
42		*P. macronemus*	—	—	xxx	—	—	—	x	xx	—	—	—	—	—
43	Pempheridae	*Pempheris oualensis*	—	—	—	xx	—	—	—	—	—	—	—	—	—
44	Kyphosidae	*Kyphosus cinerascens*	—	—	—	—	—	x	x	—	—	—	—	—	—
45		*K. raigiensis*	—	—	—	—	x	—	x	—	—	—	—	—	—
46	Platacidae	*Platax orbicularis*	—	—	—	—	xxx	—	—	xxx	—	—	—	—	—
47		*P. tiera*	—	—	—	—	xxx	—	x	xx	—	—	—	—	—
48	Monodactylidae	*Monodactylus argenteus*	—	—	—	—	xx	—	—	x	—		—	—	—
49	Chaetodentidae	*Chaetodon lunula*	—	xx	—	—	—	—	—	—	—	—	—	—	—
50		*C. citrinellus*	—	xx	xx	—	—	—	—	—	—	—	—	—	—
51		*C. xanthocephalus*	—	xx	—	—	—	—	—	—	—	—	—	—	—
52		*C. auriga*	—	xx	—	x	xx	—	xx	xxx	x	x	—	—	—
53		*C. melanotus*	—	—	—	—	—	—	—	—	x	x	—	—	—
54		*C, meyeri*	—	—	—	—	—	—	xx	x	—	—	—	—	—
55		*C. trifasciatus*	—	—	—	—	—	—	—	xx	—	—	—	—	—
56		*Heniochus acuminatus*	—	xx	—	—	—	—	—	—	—	—	—	—	—
57	Pomacanthidae	*Pomacanthodes semicirculatus*	—	—	—	—	x	—	xx	—	—	—	—	—	—
58	Pomacentridae	*Amphiprion nigrepes*	—	—	—	—	—	—	x	x	—	—	—	—	—
59		*Lepidozygous tapeinosoma*	—	—	—	—	—	—	xx	xx	—	—	—	—	—
60		*Dascyllus aruanus*	xxx	xxx	xx	—	xxx	xx	x	xxx	—	—	—	xx	xxx

Sl. No.	Family	Species	Chetlat	Kiltan	Kad-mat	Amini	Bitra	Thinna-kara	Ban-garam	Agatti	Androth	Kava-ratti	Suheli	Kal-peni	Mini-coy
61		*D. trimaculatus*	—	—	—	—	—	xx	xx	—	—	—	—		x
62		*D. reticulatus*	—	—	—	—	—	—	—	—	—	—	—	—	xx
63		*Chromis chrysurus*	—	xxx	—	—	—	—	x	xxx	xx	—	—	—	—
64		*C. caeruleus*	xx	xxx	xxx	—	xxx	xxx	xxx	xxx	xx	—	—	—	—
65		*C. ternatensis*	—	—	—	—	xxx	x	xxx	xxx	xxx	—	—	—	—
66		*Pomacentrus nigricans*	x	—	xxx	—	—	—	—	xx	—	—	—	—	—
67		*P. littoralis*	—	—	—	x	x	—	—	xx	—	—	—	—	—
68		*Abudefduf saxatilis*	—	xx	xx	xx	—	—	—	—	—	—	—	—	—
69		*A. sexfasciatus*	xxx	xxx	—	—	—	—	—	xx	—	—	—	—	—
70		*A. sodidus*	xxx	xx	—	—	—	—	—	—	—	—	—	—	—
71		*A. septemfasciatus*	xx	—	xx	—	—	—	—	—	—	—	xx	—	—
72		*A. cingulum*	xxx	—	—	—	x	—	x	—	—	—	—	—	—
73		*A. dickii*	—	—	xx	—	—	—	—	—	—	—	—	—	—
74		*A. biocellatus*	xxx	—	—	—	—	—	—	—	x	—	—	—	—
75		*A. uniocellatus*	xxx	xx	xxx	x	—	—	—	—	—	—	—	x	x
76		*A. xanthozone*	xxx	—	—	—	—	—	—	—	x	—	—	—	—
77		*A. zonatus*	xxx	—	xx	xx	xx	x	—	—	x	—	—	—	—
78		*A. glaucus*	xxx	xxx	xxx	xx	—	—	—	—	x	—	—	—	—
79		*A. bengalensis*	—	—	—	—	—	—	—	—	x	—	—	—	—
80	Labridal	*Gomphosus varius*	—	xx	—	—	—	—	xx	x	—		—	—	—
81		*G. caeruleus*	—	—	—	—	x	—	—	x	—	—	—	—	—
82		*Cheilio inermis*	—	—	—	—	—	—	—	—	—	xx	—	—	—
83		*Halichoeres scapularis*	xxx	—	—	—	—	x	xx	—	—	—	—	xx	x
84		*H. notopsis*	—	xx	—		—	—	—	—	—	—	—	—	—
85		*H. kawarin*	—	—	xx	xx	x	x	xx	—	—	—	—	—	—
86		*H. centriquadrus*	—	—	—	—	—	—	—	—	—	xx	—	xx	—
87		*Stethojulis axillaris*	xxx	xxx	xx	xxx	xx	xx	x	xx	—	xx	xx	xx	—
88		*S. strigivener*	—	—	xxx	xxx	—	—	—	—	—	—	—	—	—
89		*S. trilineata*	—	xx	—	—	—	—	—	—	—	—	—	—	—
90		*S. albovittata*	xxx	xx	xx	—	—	—	—	—	—	—	—	xx	—

Sl. No.	Family	Species	Chetlat	Kiltan	Kad-mat	Amini	Bitra	Thin-nakara	Ban-garam	Agatti	And-roth	Kava-ratti	Suheli	Kalpe-ni	Mini-coy
91		*S. phaekadopleura*	—	—	—	—	XX	X	—	X	—	—	—	—	X
92		*Thalassoma amblycephalus*	—	—	XX	—	—	—	—	—	—	—	XX	—	—
93		*T. hardwicki*	—	—	—	—	XX	XX	X	XXX	—	—	—	—	—
94		*T. quinquivittata*	—	—	—	—	—	—	—	—	—	—	—	XX	—
95		*Labroides dimieiatus*	—	—	—	—	X	X	—	XX	XX	XXX	XX	XXX	XX
96		*Macropharyngodon meligris*	—	—	—	—	XX	XX	—	X	—	—	—	—	—
97		*Cheilinus chlorurus*	—	—	—	—	XX	—	X	—	—	—	—	—	—
98		*C. trilobatus*	—	—	—	—	—	X	—	XX	—	X	—	XX	X
99		*Cymolutes lecluse*	—	—	—	—	—	—	XX	X	—	—	—	—	—
100		*Novaculichthys taeniourus*	—	—	—	—	—	—	—	—	—	—	—	X	—
101	Callyodontidae	*Cryptotomus spinidens*	—	—	—	—	—	—	—	XX	—	—	—	—	—
102		*Callyodon taeniurus*	—	—	—	—	—	XX	XX	XX	—	—	—	X	—
103		*C. harid*	—	—	XX	—	—	—	—	—	—	—	—	—	—
104		*C. bataxiensis*	—	XX	XX	—	—	—	—	—	—	—	—	—	—
105		*C. sexvittatus*	X	—	—	—	—	—	—	—	—	—	—	—	—
106		*C. ghobban*	—	—	—	—	—	—	—	—	—	X	—	—	—
107	Parapercidae	*Parapercis hexophthalma*	—	—	—	—	—	—	—	—	—	XX	—	—	—
108	Blennidae	*Aspidonotus tractus*	—	—	XXX	—	XX	X	—	—	—	—	—	—	—
109		*Petroscirtes pindae*	—	—	XX	—	—	—	—	—	—	—	—	—	—
110		*Istiblennius edentulus*	XX	XX	XX	—	—	—	—	—	—	—	X	—	—
111	Zanclidae	*Zanclus cornutus*	—	—	—	—	—	—	—	—	X	X	—	XX	X
112	Acanthuiidae	*Ctenochaetus strigosus*	—	XX	—	—	—	—	—	—	—	—	—	—	—
113		*Acanthurus triostegus*	XXX	XXX	XXX	XX	XX	XX	X	XXX	X	XX	X	X	X
114		*A. leucosternon*	X	—	—	—	—	XX	X	—	X	XX	X	X	XX
115		*A. lineatus*	XX	XX	XXX	X	—	—	—	—	—	—	—	—	—
116		*A. matoides*	—	XX	—	—	—	—	—	—	—	—	—	—	—
117		*A. elongatus*	XX	—	—	—	—	—	—	—	—	—	—	—	—
118	Electridae	*Electroides sexguttatus.*	—	XX	—	—	—	—	—	—	—	—	XX	—	—
119	Gobiidae	*Acentrogobius ornatus*	—	XX	—	—	—	—	—	—	—	—	—	—	—
120	Scorpaenidae	*Pterois volitans*	—	—	xx	x	xx	—	—	xxx	—	—	—	—	—

Sl. No.	Family	Species P. antennate	Che-llat	Kittan	Kad-mat	Amini	Bitra	Thinna-kara	Banga-ram	Agatti	And-roth	Kava-ratti	Suheli	Kal-peni	Mini-Coy
121		*Scorpaenodes guamensis*	—	—	—	—	xx	—	—	x	—	—	—	—	—
122		*Dendrochirus zebra*	—	—	—	—	x	xx	x	xx	—	—	—	—	—
123		*Sebastapistes strongia*	—	—	—	—	xx	x	x	xxx	—	—	—	—	—
124		*Caracanthus unipinnus*	—	—	—	x	—	—	—	—	—	—	—	—	—
125	Caracanthidae	*C. maculatus*	—	—	—	—	—	—	—	—	—	—	—	xx	—
126		*Rhineacanthus aculeatus*	—	—	—	—	—	—	—	—	—	—	—	xx	—
127	Balistidae	*R. rectangulus*	x	—	—	x	—	x	xxx	xx	—	xxx	xxx	xxx	xx
128		*Balistoides viridescens*	xx	—	—	—	xx	x	xx	xxx	—	—	—	—	—
129		*Melichthys niger*	—	—	—	—	—	—	—	—	—	—	—	xx	—
130		*Ostracion tuberculatus*	—	—	—	—	—	—	—	—	—	—	xx	—	—
131	Ostracanthidae	*Lophodiodon calori*	—	xx	—	—	—	—	—	—	—	—	—	—	—
132	Diodontidae	*Canthigaster margaritotus*	x	xx	—	x	xx	xx	x	xx	—	—	—	—	—
133	Canthigasteridae	*Sphoeroides hypselogeneion*	—	x	x	—	—	—	—	—	—	—	—	—	—
134	Lagocephalidae	*Tetraodon nigropunctatus*	xxx	—	—	—	—	—	—	—	—	—	—	—	—
135	Tetrandontidae	*T. meleagris*	—	—	—	xx	x	—	—	—	—	—	—	—	—
136		*T. hispidus*	—	—	—	xx	x	x	x	—	—	—	—	—	—
137		*Antennarius chironectes*	—	—	—	—	—	—	—	—	—	—	x	—	—
138	Antennaridae	*A. coccineus*	—	—	—	—	—	—	—	—	—	—	xx	—	—

XXX : Abundant; XX : Common: K : Rare - not seen

REMARKS

The survey as mentioned above was conducted during a short period of three months and thirteen islands were covered during the survey. The results are very useful for an appraisal of the availability of different species of ornamental fishes in different islands and for planing a comprehensive future research on the resources of ornamental fishes of different islands. The data collected, however, are not sufficient for estimation of resource potential of these fishes. In this connection the following points need consideration:

i. The Information on population characteristics is restricted to one or two species that too from Minicoy only. There is also no information on seasonal variations of important species. There is therefore need to study various aspects of biology of dominant species of ornamental fishes from different islands to enable a detailed study of stock assessment of these fishes. Initially, the study should be undertaken for at least two years to enable advice on the exploitation pattern.

ii. Presently the exploitation of ornamental fishes is only on a sustenance basis and there is no organised exploitation for commercial purpose. Since the ornamental fishes are associated with corals and associated fauna and flora in the islands, any exploitation on a commercial scale can result in destruction of the environment which in turn can also eventually affect the fish populations inhabiting these areas. Further, since the areas are easily accessible, the exploitation of reef fishes is likely to quickly lead to depletion of stocks and therefore utmost caution has to be exercised before planning exploitation and export trade of ornamental fishes. Fishing with traps is suitable for ornamental fishes; this is not likely to lead to destruction of habitat and therefore can be encouraged. However exploitation of ornamental fish species from the lagoons and reef flats can be undertaken on a smaller scale, and the same should be closely monitored.

REFERENCES

ANNON. 1986. Report on the training mission on ornamental fish export to the Netherlands. Marine Products Export Development Authority, Cochin. 24 pp.

JONES, S and M. KUMARAN. 1980. *Fishes of the Laccadive Archipelago.* The Nature Conservation and Aquatic Sciences Service, Trivandrum. 760 pp.

KUMARAN, M and G. GOPAKUMAR. 1986. Potential resources of fishes other than tuna in Lakshadweep. *Mar Fish. Infor. Serv. T & E. Ser.*, 68 : 41-45.

MADAN MOHAN, C. S. GOPINADHA PILLAI and K. K. KUNHIKOYA. 1986. Biology of the blue puller, *Chromis caeruleus* (Cuvier), from the Minocoy atoll. *Indian J. Fish.*, 33 (4) : 457-470.

PILLAI, C. S. GOPINADHA, MADAN MOHAN AND K. K. KUNHI KOYA. 1983. On an unusual massive recruitment of the reef fish *Ctenochaetus strigosus* (Bennet) Perciformes : Acanthuridae) to the Minicoy atoll and its significance. *Indian J. Fish.*, 30 (2) 261-268.

TOMEY, W. A. 1985. Survey in the Union Territory of Lakshadweep, the Bombay and Madras area: Promotion of export trade Indian ornamental fishes from marine as well as freshwater origin and ornamental plants. Report to CBI., the Netherlands and the Marine Products Export Development Authority, Cochin.

TOMEY, W. A. 1986. Promotion of Export trade Indian ornamental fishes from Marine as well as freshwater origin and aquatic plants for the aquarium industry: The pilot project : Conclusions and recomendations. Report on the project results to CBI/MPEDA.

CONTRIBUTION 24

RADHAKRISHNA, K. AND V. SRIRAMACHANDRA MURTY. 1993.
Present trends in marine fisheries management and catch forecasting. Paper presented at the International workshop on application of satellite remote sensing for identifying and forecasting potential fishing zones in developing countries; Hyderabad, India, 7-11 December, 1993. National Remote sensing agency, Department of space, Hyderabad India; Committee on Science and Technology in Developing countries of the International Council of Scientific Unions, Madras, India, 20 pp.

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INTERNATIONAL WORKSHOP
ON

APPLICATION OF SATELLITE REMOTE SENSING FOR IDENTIFYING AND FORECASTING POTENTIAL FISHING ZONES IN DEVELOPING COUNTRIES

HYDERABAD, INDIA 7 - 11 DECEMBER, 1993

LECTURE NOTES

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COMMITTEE ON SCIENCE AND TECHNOLOGY IN DEVELOPING COUNTRIES OF THE INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS (COSTED / ICSU), MADRAS, INDIA

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PRESENT TRENDS IN MARINE FISHERIES MANAGEMENT AND CATCH FORECASTING

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ABSTRACT

Marine fish catch forecasting is made on a short term or long term basis for purposes of exploitation and management. Among the short term forecasts, two approaches need serious consideration in India: 1. to improve the methods of understanding the influence of environmental characteristics on the abundance or availability of fish in different areas in different periods and to make the forecasts of the same, 2. to make analysis of time series catch data (ARIMA models) to make forecasts of catch in the next year or in a particular period during next year. There is some evidence of suitability of these approaches to Indian marine fisheries but attempts aiming at comprehensive studies should be made.

In the area of long term forecasts, considerable work is done in India on single species assessments but in the context of multispecies, multigear nature of Indian marine fisheries, assessments of all species together in a mixed fishery are urgently required for effective managements of fisheries.

INTRODUCTION

India, with a long coastline, is one of the major marine fish producing countries and occupies 7th position in the world in regard to the quantity of fish harvested. Of the total of 3.84 million tonnes harvested in 1990-91, 2.3 million tonnes forming about 60% of the total fish production is contributed by the marine capture sector. The exploitation of marine fishes has so far been restricted to about 50-60m depth. The declaration of Exclusive Economic Zone (EEZ) in 1977 for exploration, exploitation and utilization of the living resources in the sea upto 200 nautical miles from the shore has given exclusive rights to the country to formulate its policies for the development and use of the fisheries resources in an area of 2017900 sq. km. This extended jurisdiction, provides a challenge for a new and improved basis for rational exploitation and utilisation of the resources and to enhance opportunities for fisheries

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to play a greater role in increasing food production so as to help minimise protein malnutrition and contribute to the betterment of the socioeconomic conditions of the poorest sections of the population. Though it is nearly one and half decades since this extended jurisdiction has become available to the country, for various reasons (including shrimp-oriented development of the marine fishery), the progress in the exploitation of the resources in the entire EEZ region has not been satisfactory and the fishery has only been taking the resource available in the inner continental shelf up to about 50 m depth. Only a small number of larger vessels have been introduced to exploit the resources in the relatively deeper waters. By and large the resources available in the areas beyond 50m depth still remain unexploited. The situation, hence, calls for a reassessment of the strategies and policies for marine fisheries development and management in India.

From the presently exploited regions in the Indian seas, vast information on craft and gear, state-wise and species-wise production and on various aspects of biology of constituent major fish and shell fish species is gathered. Based on such information, attempts at stock assessment of some species from particular regions and at the development of mathematical models and methods for estimation of parameters are made (Alagaraja 1983, 1984; Alagaraja and Srinath, 1981, 1987; Alagaraja et al. 1982, 1986, 1988; Annigeri 1972, 1987; Chakraborthy 1989; Dan 1982, Devaraj and Gulati 1988; James et al. 1989; Karthikeyan et al. 1989; Kasim 1987, Kasim et al. 1981, Kasim and Hamsa 1989; Krishnamoorthi 1978, 1980; Krishnamoorthi and Jagdish 1986; Kurup and Rao 1975; Lalithadevi 1986, 1987; Murty 1983, 1985, 1986a, 1986b, 1987, 1988, 1989, 1990, 1991; Narasimham 1983, 1987, 1988; Nair 1972; Ramamurthy et al 1981; Rao 1971; Reuben et al, 1989; Sekharan 1975; Silas et al 1985a, 1985b; Silas and Pillai 1985; Srinath 1986; Srinath and Alagaraja 1982; Sudarsan et al 1990; Sukumaran 1983; Vivekanandan and Krishnamoorthi 1985; Vivekanandan and James 1986; Venkatraman et al 1982; Yohannan 1983). However, in view of the various problems involved in the acquisition of data and estimation of parameters, the progress in this direction aiming at a plausible advice to the industry has only been fragmentary. Moreover, in the context of multigear multispecies nature of the tropical marine fisheries like those of India, steps to make assessments to advise the industry or developmental agencies on the required measures are but very scanty. Though some assessments of mixed fisheries are attempted (Murthy, 1985,1989), they have been only preliminary and detailed assessments on, for example, management of artisanal fisheries of trawl fisheries of a maritime state or the country are not attempted. In the context of management of fisheries resources, major thrust has been on possible measures to regulate the effort or mesh size of the gear with reference to particular species in the mixed fisheries and attempts at forecasting the catches or the abundance of stocks in the fishing grounds are not made in any serious manner, except a few preliminary studies (Noble and Sathianandan 1991 and Sathianandan and Srinath MS). The present paper attempts at giving an overview of the marine fisheries scenario in India with notes on current trends in catch forecasting.

MARINE FISHERIES OF INDIA :

Fishing and Landings: The fishing in the Indian seas, restricted as it was, to the use of artisanal gear and craft in the nearshore waters during forties has improved vastly later by introducing and popularising mechanised vessels with trawl nets. By seventies, purse seines were introduced along the west coast (first in Goa and later in Karnataka and Kerala). This development has resulted in increase in the area of fishing and increase in the production of demersal resources along both the coasts and pelagic resources along the west coast. With increasing demand for fish and with improved technologies, the indigenous craft are motorised to reach fishing grounds quickly and to operate drift/gill nets, hooks and lines, ring seines etc. Presently about 1,68,100 traditional non-mechanised craft, 15,300 motorised indigenous craft and 22,900 mechanised craft are engaged in marine fishing in the country. All these operate in the inner continental shelf upto about 50m depth and during 1988-1992 an estimated annual average of 2.15 million tonnes of marine fish are landed in the country. Maximum catches are obtained from off Kerala which contributes about 27% of total catch followed by Gujarat, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Goa, Orissa, West Bengal, Pondicherry, Andaman and Lakshadweep Islands (table 1).

Prawns form the most dominant component in the marine landings in India followed by oil sardine, other clupeoids, mackerel, carangids, croakers, Bombay duck, perches (predominantly threadfin breams), ribbon fish, anchovies, catfish etc. (Table 2).

Potential yield : Based on the researches on primary and secondary production, survey by exploratory fishing and the data on exploited stocks, the potential yield in the presently fished grounds upto 50m depth along both coasts of India is estimated as 2.21 million tonnes (Anon 1991) (Table 1). Of this, the maximum quantity is available off Kerala coast with an estimated 571317 tonnes forming 25.8% of the total country's potential. Next in importance is Tamilnadu (16.3%) followed by Maharashtra (16.1%), Gujarat (13.3%), Karnataka (12.2%), Andhra Pradesh (6.4%) and others (Table 1). The present landings (Average of 1990, 1991 and 1992: 2.23 million tonnes), clearly show that there is not much scope to increase from these areas.

The potential yield of the resources in the EEZ beyond 50m depth is estimated as 1.69 million tonnes (Anon 1991) and this region is virtually unexploited. The potential of pelagic resources is estimated at 10.4 lakh tonnes of which about 4 lakh tonnes is available in the 50-100m depth zone, 3.42 lakh tonnes in the 100-200m depth zone and 2.95 lakh tonnes beyond 200m depth zone. The major components are carangids, coastal and oceanic tunas, ribbonfish, pelagic sharks and mackerel which have considerable value for export as well as for domestic consumption.

The potential yield of demersal resources is estimated as 4.2 lakh tonnes in the 50-100m depth range, 2.0 lakh tonnes in the 100-200m depth range and 0.3 lakh tonnes in the depths beyond 200m in the EEZ. The major constituents of the demersal resources in the 50-200m depth zone are thread-fin breams, catfish, bull's eye, croakers and lizard fish.

The above information thus leads to the following considerations:

-increase in production can be achieved only by deploying additional effort in the depths beyond 50m as there is not much scope to increase production from the presently exploited grounds, the strategy in this area should be for a sound and pragmatic management with forecasts of maximum sustainable yield of individual species stock and all the stocks together and, to regulate the effort to harvest the MSY.

FORECASTING AND MANAGEMENT

Fish being a dynamic aquatic resource, the ability to forecast the catches or variations in the seasonal abundance of the stocks in different areas assumes great importance in the development and management of fisheries of exploited stocks. Principally two types viz; 1.Short term and 2. Long term forecasts are recognised (Shepherd 1988).

SHORT TERM FORECAST

Short term forecasts of catch are required for management of fisheries, for setting total allowable catches in a year and to guide the industry on the likely catches or catch rates. In these assessments, forecasts of catch, catch rates, stock size, level of effort required and immediate effects of measures such as mesh regulation or closed season are made (Shepherd, 1988). These largely depend upon the current state of the stock and the likely changes in the stock in the near future. Short term forecasts are made using different approaches: 1. analytical approach (virtual population analysis - VPA), 2. analysis of time series data on catch, 3. influence of environment on the availability or abundances, 4. changes in fishing pattern and 5. remote sensing and PFZs.

1. Analytical approach :

The virtual population analysis (Gulland 1965; Murphy 1965; Pope 1972), is a procedure for determining how many individuals there must have been in the sea to account for a known catch as well as natural losses. This analysis which also helps a forecast of the catch next year, can be carried out with data on, among others, catch-at-age and an estimate of recruitment of the stock in question. However, in Indian marine fishes, techniques for ageing individuals are not yet developed and therefore data on catch-at-age are not available. Similarly an estimate of recruitment too is not possible on the basis of available data. Hence short term forecast using VPA cannot be made for Indian marine fisheries. This technique is used in higher latitudes, particularly in the North Sea to forecast the catch next year and allocating quotes to different fleets.

2. Analysis of time-series data :

Though analytical methods such as VPA take several factors into account and lead to better predictions of catch and catch rates, they are time-consuming and demand extensive data. This has lead to development of simpler methods that are less demanding on data and still yield reasonably acceptable results for forecasting catch and biomass. Among these, time-series methods employing ARIMA (Auto Regressive Integrated Moving Average) models (Box and Jenkins 1976; Saila et al. 1980; Mendelssohn 1981; Stocker and Hilborn 1981) are helpful in catch forecasting. For example in the case of Pilchard from Greek waters, Stergiou (1989) applied ARIMA model to the monthly catch data of 17 years and found that the mean error was 14.6% or 12% (with two equations). About the forecast value of the catch and the actual estimated catch (after one year) the author remarked that "ARIMA procedures are capable of describing and forecasting the complex dynamics of the Greek pilchard fishery which have hitherto been regarded as difficult to predict....". In the case of sardine and anchovy in the Eastern Mediterranean, Stergiou (1991) applied Vector Auto Regressive Model to the catch data of these two species, obtained during 1964-87 and stated that the model "produced accurate and unbiased fits and forecasts".

In India forecasting using ARIMA models have been made only recently; Nobel and Santhiandan (1991) analysed the annual catch data of mackerel of the period 1950-1989 and found that ARIMA (1,0,0) to be suitable for forecasting. The catch predictions by this method "hinted at 10 years cycle but seemed to lack seasonal term". Sathianandan and Srinath (MS) analysed the annual data, for the period 1950-91, of total catch and catches of three important groups: penaeid prawns, silver bellies and cat fish. They found that ARIMA (2,2,1) to be suitable for predicting total landings. ARIMA (1,2,1) for penaeid prawn landings and ARIMA (3,2,1) for cat fish and silver belly landings. Thus, forecasting using ARIMA models is still in its beginning in India; as the basic requirement is only the annual estimate of catch for over a long period, say a few decades, it is imperative that further studies on the efficacy of ARIMA models to Indian situated are made in a big way to be able to attempt catch forecasting using these methods.

3. Environmental influence on abundance :

Certain environmental parameters as limiting factors on the availability of stocks for exploitation is well known and the study of environmental factors for the prediction of availability or abundance of fish stocks in the fishing grounds is gaining momentum. According to Banse (1959,1968), the deoxygenation of the near-bottom water during the period of upwelling, results in regular disappearance of demersal fishes and in unprofitable trawling in a belt between the aerated water nearshore and the relatively new bottom water in the outershelf off Cochin. He (Banse, 1959) observed that Oxygen concentrations of 0.25-0.50 ml/l were critical for Nemipterus japonicus. Further, Banse (1968) stated that the drop of Oxygen content to Zero in near-bottom waters off Bombay and Calicut "suggests that there may possibly be a vast area in the outer shelf (and perhaps also in the middle shelf) approximately from Cochin to Karachi that is devoid of commercially exploitable concentrations of demersal fishes during southwest monsoon. The fishes very likely disappear before the oxygen has completely vanished". During the post monsoon period also, the near-bottom areas are known to be devoid of fishes because poorly aerated water persists on the shelf between Bombay and Karachi (Carruthers et al 1959; Doe 1965).

The threadfin breams which are more abundant in the 100-200m depth zone (Silas 1969, Silas et al. 1976, Vijayakumaran and Philip 1991, Sudarsan et al. 1990) are known to move into relatively shallower depths of 35-40m during the southwest monsoon period to avoid oxygen deficient layers in deeper waters (Nair and Jayaprakash, 1986). This enables exploitation of this resource from relatively shallower areas during monsoon period which during other periods is available only beyond, a good fishery exists for this resource off Kerala during July-September.

Along the central east coast also, a similar situation of the so-called "cold water fishes" (eg. Psenes sp) moving into nearshore waters from deeper waters during upwelling in April-May has been observed (Reuben et al. 1989). Thus, oxygen-deficient layers in near-bottom areas of deeper waters and upwelling indicate disappearance of demersal fishes from deeper waters and their abundance in inshore areas.

In the case of oil sardine, Longhurst and Wooster (1990) showed that the success of recruitment is related to sea level prior to onset of monsoon. According to them, the sea level just prior to monsoon, indicates remote forcing of upwelling (other than the wind driven upwelling that occurs during monsoon) and "Unusually early remote forcing (of this upwelling) appears to inhibit subsequent recruitment, perhaps through exclusion of spawning fish from the neretic zone by oxygen-deficient upwelled water. Critically studying the data on oil sardine landings and sea level during 1900-1987, these authors could establish a relationship between sea level just prior to the onset of monsoon and the recruitment to the oil sardine fishery towards the end of summer monsoon.

A peculiar phenomenon, known as "mudbanks" or chakara (in Malayalam language) occurs along southwest coast particularly along Kerala coast. Though the origin and nature of dissipation of these mudbanks are not fully understood, their formation enables a good fishery to develop in the coastal area during the peak southwest monsoon period. The waters of mudbank are very calm compared to the very turbulent conditions prevailing outside these areas during the same period. This calmness facilitates operation of artisanal craft and gear which are brought from several distant places (Silas, 1984). Several species of shrimp and finfish particularly Metapenaeus dobsoni, Penaeus indicus, Sardinella longiceps, Leiognathus spp, Stolephorus spp are known to be abundant in the mudbank regions (Regunathan et al., 1984) and support a very lucrative fishery.

On the basis of fishery data for ten years from the mudbank and non mudbank regions of Kerala, Regunathan et al. (1984) made the following observations:

1. The abundance of some species in the mudbanks during July-August is not an exclusive feature for the mudbank alone but such abundance is seen all along the coast during southwest monsoon because, along with good catches in the mudbank region, similar catches are also obtained from non mudbank regions on days when weather is suitable for operation in the inshore waters.

2. During monsoon, the current is southerly and fish moving in schools in northerly direction (swimming against the current), pass through the mudbanks and contribute to the catches there. The composition of catch in the mudbank area shows variation on a daily basis indicating that different shoals move, one after the other on different days, into the bank area and support fishery.

Thus, whatever may be the reason for a lucrative fishery in the mudbanks during southwest monsoon period, the mere formation of the banks makes the area calm (unlike the rough weather conditions in the non bank areas) and facilitates operation of cannoes and harvest bumper catches of fin and shell fish which cannot be obtained otherwise. Therefore mudbank formation serves as an indicator of a good fishery during monsoon period.

4. **Change in fishing pattern**: Regulation of fishing by implementing closed season or closed area is a major short-term management strategy. In the tropics, annual or seasonal bans on trawling are known to have been implemented for rebuilding exploited stocks (Naamin 1984, Garcia 1986). Similarly, ban on bottom trawling in certain instances is resorted to, to protect ripe running fish on spawning grounds and to protect young fish on nursery grounds. In recent years, trawling bans are implemented along Indian west coast particularly along Kerala coast during monsoon period because 1. due to rough sea conditions during the monsoon period, the fishing by artisanal gear is restricted to nearshore waters whereas the trawlers operate in the waters which are accessible to artisanal fishermen during fair season and exploit shrimp, and 2. the traditional fishermen believe that trawling during monsoon results in the destruction of spawners of important fishes and affect the recruitment adversely. According to James (1992), the studies made so far do not indicate any adverse effect of trawling during monsoon on various stocks. He, however recommended, among others, that 1. urgent steps should be taken to regulate the number of ring seines and their further entry into the fishery; as this gear catches appreciable quantities of young fish, it was also recommended that the mesh size of this gear should be increased to not less than 35mm and, 2. bottom trawling during monsoon is allowed strictly only beyond territorial waters all along west coast, perhaps to prevent possible growth overfishing in the nursery grounds by the first measure and to prevent clashes between fishermen of mechanised and artisanal gears by the second measure.

5. **Remote Sensing and potential fishing zones**

Identification of potential fishing zones (PFZs) using Sea Surface Temperature (SST) data derived from Satellite imageries and forecasting the same are receiving attention. The data from the Thermal infrared sensor of the satellite are processed at the National Remote Sensing Agency (NRSA) to retrieve information on SST which is used to locate thermal boundaries, upwelling areas and eddies where maximum pelagic fish populations are found to occur (Narendra Nath et al., 1992). The data on the thermal imageries obtained by the satellite are transformed onto scaled base maps to obtained maps showing PFZs. These maps are transmitted by FAX to fishermen associations and to maritime-state fisheries departments; where FAX facility is not available, the information on the exact location of the PFZ is sent by Telex/Telegram also.

The forecasting of PFZ initiated on an experimental basis in 1991 along Karnataka coast has been extended to coasts of all maritime states including Lakshadweep and Andamans. Along Karnataka coast, in one instance, the fish catch was reported to be 71.4 t from 102 boats from the PFZ where as only 52.4 t from 192 boats from other areas.

In another instance along Karnataka coast, it was observed that the catch per unit effort at the PFZ was more than twice that obtained from other areas (Narendra Nath et al., 1992).

The data on PFZs provided by NRSA are being increasingly made use of by the fishing industry; from Orissa coast during February-April 1992, it was reported that the catch in more than 80% of the cases was " above average or very good" in the PFZs when compared to other ares (Narendra Nath et al. 1992). Similar encouraging reports were also obtained from some other areas.

It is thus clear that the Satellite derived SST values can be utilized to forecast potential fishing zones not only to help fishermen save time searching productive grounds but also help increase production with less effort.

LONG TERM FORECAST

A long term forecast such as estimating maximum sustainable yield (MSY) depends on the factors such as recruitment, growth, mortality etc. which maintain the stock in the long run. Such an assessment is relevant to the strategy of management and is generally a part of an attempt to determine some long term goals or targets for management. It may involve estimation of fishing mortality (or the fishing effort) consistent with MSY or a minimum tolerable stock size to avoid the undue risk of stock collapse. Long term forecasts can be divided into two: 1. macro and 2. micro analytical models and the most common valuable result of these assessments is an estimate of the maximum quantity that can be harvested annually, year after year. In practice, however, the greatest possible yield may not be taken because greater economic benefit can often be obtained by taking slightly less catch at considerably less cost or because the greatest theoretically achieved yield requires an impracticable combination of a high level of fishing and strictly controlled selectivity of fish of the right size (Gulland 1983).

MACROANALYTIC MODELS :

These models also called as production models, do not consider the events such as recruitment, growth, mortality in a population. They take into account the population biomass, the catch, the fishing effort (in terms of boat-days, number of units etc.) and the natural rate of increase in the population. In these models (eg. Schaefer 1954) all the species together are treated as one and the data required are only effort and catch over a number of years and the assessment leads to an estimate of MSY and the effort required to take it. Though this is very simple for assessment of stocks, the assumptions on the dynamics of the stocks cannot be fulfilled (Larking 1982, Gulland 1983, Sparre 1985) and therefore this model is of limited value. It can be used only as a first approximation, when data on various stock parameters of constituent species are not available, to be above to provide a provisional advice on the maximum quantity that can be taken and the effort required for the same.

MICROANALYTIC MODELS

As opposed to the macroanalytic models, the microanalytic models consider the various events in the stock such as recruitment, growth and natural mortality. The most widely used model is that of Beverton and Holt (1957 which is based on the assumptions that recruitment, growth and rate of natural mortality are constant. In the absence of techniques for determining age of individuals on a routine basis, methods of estimation of parameters of growth and mortality using length frequency data are developed in the tropics (Pauly 1980 Pauly and David 1981, Jones 1984, Gayanilo et al. 1988, Sparre 1987). In many stocks, recruitment is found to be highly variable and these variations are found to be independent of adult stock being determined mainly by environmental factors. Beverton and Hold (1957), therefore, developed a method of estimation yield-per-recruit, taking into account the growth parameters, natural and fishing mortality rates and selectivity of the gear and this method has become very popular in tropical countries to make assessments. Mainly two types of assessments viz; yield per recruit as a function of fishing mortality rate and as a function of age at first capture are made which lead to an advice on the pattern of fishing effort that will give the greatest yield from the fish that is recruited.

The Beverton and Holt model deals with single species stocks and therefore advice on the effort or mesh regulation in a multi species fishery is not possible. It however, leads to an understanding of the state of single species stocks in a multispecies fishery. Of the several studies on pelagic and demersal fin fish and shrimp species made in India using microanalytic models (vide supra), in majority of the cases the fishing mortality is found to be close to the one that gives maximum yield and in the case of trawl, the cod end mesh size is found to be smaller indicating that additional fishing pressure in the currently fished grounds will not lead to any further increase in production and that the cod end mesh size of trawl has to be increased. However, since all these assessments are based on individual species in a mixed fishery, a proper advice to the managers or the industry on the effort or mesh regulation has not been possible. There is therefore urgent need to develop methods of multispecies stock assessment to be able to manage the exploited marine fisheries resources effectively.

Table 1: Marine Fish landings and potential yield in different maritime state of India from the presently fished areas in the 0-50m depth range.

States / U.T.	Landings (t) (1988-92 average	% in the all India total	Catchable potential (t)	% in the all India total
West Bengal	48,934	2.3	23,916	1.1
Orissa	50,096	2.3	55,023	2.5
Andhra Pradesh	1,27,190	5.9	1,41,563	6.4
Tamil Nadu	3,21,769	15.0	3,59,677	16.3
Pondicherry	12,931	0.6	19,706	0.9
Kerala	5,80,825	27.1	5,71,317	25.8
Karnataka	1,93,444	9.0	2,70,146	12.2
Goa	89,899	4.2	1,08,522	4.9
Maharashtra	3,47,022	16.2	3,56,043	16.1
Gujarat	3,52,879	16.5	2,93,929	13.3
Andaman & Nicobar Islands	13,324	0.6		
Lakshadweep Islands	6,809	0.3		
	21,45,122		22,09,842	

Table 2 : Estimates of present yield and potential yield of different groups in the 0-50m depth range of potential yield beyond 50m depth.

Resource	Present yield ('000 t) 1990	1991	1992	Potential yield ('000 t) in 0-50m depth	Potential yield ('000 t) beyond 50m depth
Elasmobranchs	51	51	62	65	103
Eels	5	7	7	7	-
Cat fish	38	39	36	60	63
Oil Sardine	261	177	104	191	-
Other Sardines	77	86	93	96	-
Anchovies	59	86	81	53	-
Other Clupeoids	136	188	191	196	14
Bombay Duck	130	136	127	104	-
Lizard Fish	25	28	29	27	21
Perches	121	103	114	114	125
Sciaenids	119	146	162	120	22
Ribbon Fish	74	95	111	95	216
Carangids	142	169	190	143	304
Silverbellies	54	52	51	82	4
Pomfrets	40	42	34	42	12
Mackerel	184	114	134	162	62
Seer fish	30	37	43	42	-
Tunas	52	36	42	37	451
Flat Fish	30	37	63	38	-
Penaeid Prawn	165	190	187	178	-
Non Penaeid Prawn	80	101	91	54	-
Cephalopods	56	65	89	50	21
Others	233	255	244	254	272
TOTAL	2162	2240	2285	2210	1690

REFERENCES

Alagaraja, K. 1983, Mathematical models in Fish Stock assessment, J.mar.biol.Ass.India 25(1&2):142-157

Alagaraja, K. 1984, Simple methods for estimation of parameters for assessing exploited fish stocks, Indian J. fish. 31(2): 177-194.

Alagaraja, K. and M. Srinath, 1981, Marine Fish Landings in India - Estimates and precision, India J. Fish., 27(1&2):155-160.

Alagaraja, K. and M. Srinath, 1987, Assessment of the resources of important species of cat fishes, in: Marine cat fish resources of India, Exploitation and prospects, Bull.Cent.Mar.Fish.Res.Inst., 4070-87

Alagaraja, K., K.N. Kurup, M. Srinath and G. Balakrishnan, 1982, Analyses of Marine fish landings in India - A new approach, CMFRI spl. pub. 10:42-pp.

Alagaraja, K., M.J. George, K. Narayana Kurup and C. Suseelan, 1986 yield - per - recruit analyses on Parapenaeopsis stylifera and Metapenaeus dobsoni from Kerala state, Indian J. Appl. Ichthiol, 2:1-11.

Alagaraja, K., C.Suseelan and M.S.Muthu, 1988, Mesh selectivity studies for management of marine fishery resources in India. J.Mar.Bio.Ass.India, 28:202-212.

Annigeri, G.G., 1972, Estimation of mortality rates of the oil sardine Sarinella longiceps val. Indian J. Fish. 18: 109-113.

Annigeri, G.G.. 1987, Estimates of yield-per-recruit and stock of lesser sardines Sardinella gibbosa (Bleeker) and S. Dayi Regan, in the Karwar waters, west coast of India, J. Mar.Biol. Ass.India, 42(1&2): 175-182.

Anon, 1991, Report of the working group on revalidation of the potential marine Fisheries Resources of Exclusive Economic Zone of India, Ministry of Agriculture, Department of Agriculture and Cooperation, Govt. of India, February, 1991.

Banse, K. 1959, On upwelling and bottom trawling off the south west coast of India, J.mar.biol.Ass.India, 1:33-49.

Banse, K. 1968, Hydrography of the Arabian sea shelf of India and Pakistan and effects on demersal fisheries, Deep-sea Res., 15:45-79.

Beverton, R.J.H. and S.J. Holt, 1957, on the dynamics of exploited fish populations. Fishery Invest.Ser.London, Ministry of Agr.Fish. 19:533pp.

Box, G.E.P. and G.M. Jenkings, 1976, Time series analysis, forecasting and control, Holden-Day, San Francisco, 575pp.

Carruthers, J.N., S.S. Gogate, J.R. Naidu and T. Laevatsu, 1959, Shore wards upslope of the layer of minimum oxygen off Bombay: it influence on marine biology, especially fisheries, Nature London, 183 (4668): 1084-1087.

Chakraborty, S.K. 1989, Population dynamics of Otolithes cuvieri (Trewavas) off Bombay waters. In: National symp.Res.Dev.Mar.Fish. Mandapam Camp. 16-18 Sept. 1987 Bull.Cent.Mar.Fish.Res.Inst. 44:238-244.

Dan, S.S. 1982. Mortality rates in yield per recruit of cat fish Tachysurus tenuispinis (Day). Indian J. Fish., 28:41-46.

Devaraja, M. and D. Gulati, 1988, Assessment of the stock of the threadfinbream (Nemipterus japonicus) in the north west continental shelf of India. In. M.Mohan Joseph (ed.) Proceedings of the Indian Fisheries Forum. Asian Fisheries Society, :Indian Branch, Mangalore 159-164.

Doe, L.A.E. 1965, Physical conditions on the shelf near Karachi during the post monsoonal calm, 1964, Ocean Sci. Ocean Engg., 1: 278-292.

Garcia, S. 1986, Seasonal trawling bans can be very successful in heavily overfished areas: The " Cyprus effect", Fishbyte 4(1):7-12.

Gayanilo, F.C. Jr., M. Soriano and D. Pauly, 1988, A draft guide to the complete Elefan. ICLARM Software project, 2: 65pp.

Gulland, J.A. 1965, Estimation of mortality rates Annex to Arctic Fisheries working group report ICES, CM DOC No. 3 (mimeo).

Gulland, J.A. 1983, Fish Stock Assessment - manual of Basic methods. Joh Wiley & Sons. 223pp.

James, P.S.B.R. 1992, Impact of Fishing along the west coast of India during southwest monsoon period on the Finfish and Shellfish resources and the associated management considerations. In: Rao, P.V., V.S.Murthy, and K. Rengarajan (eds). Monsoon Fisheries of the west coast of India - prospects, problems and management. Bull. cent. mar. fish. Res.Inst., 45:251-259.

James, P.S.B.R., K. Alagarswamy, K.V.N. 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.

Jensen, A.L. 1976, Time series analysis and forecasting of Atlantic menhaden catch, Chesapeake Sci., 17:305-307.

Jensen, A.L. 1985, Time series analysis and the forecasting of Menhaden catch and CPUE, North American J. Fish Management 5: 78-85.

Jones, R. 1984, Assessing the effect of changes in exploitation pattern using length composition data (with notes on VPA and cohort Analysis). FAO.Fish.Tech pap. 256: 118 pp.

Karthikeyan, M., N.G.K. Pillai and M. Badrudeen, 1989. Population dynamics of silverbelly Leiognathus jonesi James in the trawling grounds of Rameswaram, Indian J. Fish 36(2): 103-106.

Kasim, H.M. 1987, Population dynamics of the squid Loligo duvaucelii D'orbigny (Cephalopoda) in Saurashtra Waters, J.Mar.biol.Ass. India. 27(1&2): 103-112.

Kasim, H.M. and K.M.S. Ameer Hamsa, 1989, On the Fishery and population dynamics of seer fish Scomberomorus commerson (lacepede) off Tuticorin, Bull.cent.Mar.Fish.Res.Inst. 44:46-53.

Kasim, H.M. K.M.S. Ameer Hamsa and P. Sam Bennet, 1989, Present status of perch fishery resources in India and its prospects. Bull cent. Mar. Fish Res. Inst., 44:226-237.

Krishnamoorthy, B. 1978, A note on mortality rates and yield per recruit in Nemipterus japonicus (Bloch). Indian J. Fish., 23(1&2): 252-256.

Krishnamoorthy, B. 1978, Maximum equilibrium yields of Demersal Fisheries based on Exploratory trawling. Indian J. Fish. 23(1&2): 76-82.

Krishnamoorthy, B and I. Jagdish, 1986, Biology and population dynamics of the grey dogshark Rhizoprionodon acutus (Ruppell) in Madras waters, Indian J.Fish., 33(4): 371-385.

Kurup, N.S. and P.V. Rao, 1975, Population characteristics and exploitation of the important marine prawns of Ambalapuzha, Kerala, Indian J. Fish., 21: 183-210.

Lalitha Devi, S. 1986, Growth and population dynamics of the Indian white Prawn Penaeus inducus (H.M. Edwards) from Kakinada. proc. Indian Acad. Sci. 95B(5): 629-639.

Lalitha Devi, S. 1987, Growth and population dynamics of three penaeid prawns in the trawling grounds off Kakinada, Indian J. Fish., 34(3): 245-264.

Larkin, P.A. 1982, Directions for future Research in tropical multispecies fisheries. In: D.Pauly and G.J. Murphy (ed). Theory and management of tropical fisheries; ICLARM Conference proceedings, 9: 360 pp.

Longhurst, A.R. and W.S. Wooster, 1990, Abundance of oil sardine (Sardinella longiceps) and upwelling on the south west coast of India, Can.J. Fish Aquat. Sci., 41: 2-19.

Mendelssohn, R. 1980, Using Box-Jenkins models to forecast fishery dynamics: Identification, estimation and checking Fish. Bull.U.S. 78: 887-896.

Montgomery, D.C. and L.A. Johnson, 1976, Forecasting and time series analysis Mc Graw-Hill Book co., New York, 183pp.

Murphy, G.I. 1965, A solution to catch equation, J.Fish.REs.Bd.Can., 22(1):191-202.

Murty, V.S. 1983, Estimates of mortality. Population size and yield per recruit of Nemipterus japonicus (Bloch) in the trawling grounds off Kakinada. Indian J. Fish. 30: 255-260.

Murty, V.S. 1985, Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada, J.Mar.Biol.Ass.India, 27:39-48.

Murty, V.S. 1986a, Growth and yield per recruit of Johnius (Johnius) carutta Bloch in the trawling grounds off Kakinada, Indian J. Fish., 33(2): 163-170.

Murty, V.S., 1986b, Studies on growth and population dynamics of silverbelly Leiognathus bindus (Valenciennes) in the trawling grounds off Kakinada, Indian J. Fish., 33(3) 277-284.

Murty, V.S. 1987, Further studies on the growth and yield per recruit of Neipterus japonicus (Bloch) from the trawling grounds off Kakinda, Indian J. Fish., 34(3): 265-276.

Murty, V.S. 1988, Population characteristics of the Silverbelly Leiognathus bindus (Valenchiennes) along West Bengal coast. J.mar.biol.Ass.India., 28: 41-47.

Murty, V.S. 1989, Mixed fisheries assessment with reference to five important demersal fish species landed by shrimp trawlers at Kakinda, 69-76. In: Venema, S.C. and N.P. Vazalinge (ed). 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, 2-28 Nov., 1987, FI: GCP/INT/392/DEN 1: 157 pp.

Murty, V.S. 1990, Biology and population dynamics of the silverbelly Secutor insidator (Bloch) from Kakinda. j.mar.biol.Ass.India., 32: 10-24.

Murty, V.S. 1991, Observations on some aspects of biology and population dynamics of the scad Decapterus russelli (Ruppell) (Carangidae) in the trawling grounds of Kakinda. J.mar.biol.Ass.India, 33(1&2): 396-408.

Maamin, N. 1984, The banning of trawl fishing in Indonesia. Paper presented at the FAO/Australia workshop on management of penaeid shri9mps/prawns in the Asia-Pacific Region, Mimeo Rept. 19 pp.

Narasimham, K.A. 1983. On Fishery, mortality rates and yield per recruit of Ribbonfish Trichiurus lepturus Linnaeus, Indian J. Fish. 30(1): 99-109.

Narasimham, K.A. 1987, Fishery and population dynamics of the windowpane oyster, Placenta placenta (linnaeus) from Kakinada Bay, Indian J. Fish., 34(3): 277-282.

Narasimha, K.A. 1988, Fishery and population dynamics of the Blood clam, Anadara granosa (linnaeus) in the Kakinada Bay. Bull cent. Mar.Fish.Inst., 42:130-135.

Nair, K.V.S. and A.A. Jayaprakash, 1986, A note on monsoon fishery for threadfin bream off Cochin, Indian J.Fisk., 33: 106-112.

Narendranath, A. M.V. Rao, K.H. Rao, D.E. Nathaniel, T.V. Ramana, T.D. Suhasini, G. Venugopal and D. Jogendranath, 1992, Satellite forecasting for marine Fishery resources exploitation along Indian coast, Interface 3(4): 1-3.

Noble, A. and T.V. Sathianandan, 1991. Trend analysis in all India mackerel catches using ARIMA model. Indian J. Fish., 38(2): 119-122.

Pauly, D. 1980, On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 Fist Stocks, J. Cons.int.Explor.Mer. 39: 175-192.

Pauly, D. and N. David, 1981, ELEFAN I-A BASIC programme for the objective extraction of growth parameters from length frequency data. Meeresforschung, 28: 205-211.

Pope, J.G. 1972, An investigation of the accuracy of virtual population analysis using cohort analysis, Res. Bull ICNAF, (9): 65-74.

Ramamurty, S., G.G. Annigeri and N.S. Kurup, 1981, Resource assessment of the penaeid prawn Metapenaeus dobsoni (Miers) along Mangalore coast. India J. Fish., 25(1&2):52-66.

Rao, K.V.S., 1971, Estimates of mortality and yield per recruit of 'Ghol', Pseudosciaena diacanthus (Lacepede). Indian J.Fish., 15(1&2): 88-98.

Regunathan, A., K.J. Mathew, D.S. Rao, C.P. Gopinathan, N. Surendranatha Kurup and A.V.S. Murty, 1984, Fish and Fisheries of mudbanks, 60-71, in: Kartha, K.N.R. (ed). Coastal Zone Management - Mudbanks of Kerala Coast, Bull.cent.mar.Fish.REs.Inst., 31:i-vi, 74pp.

Reuben, S., G.S. Rao, G. Luther, T. Appa Rao, K. Radhakrishna, Y.A. Sastry and G. Radhakrishnan, 1989, An Assessment of the bottom-trawl fishery resources of the north east coast of India, Bull.cent.Mar.Fish.Rest.Inst., 44:59-77.

Saila S.B., M. Wighbout and R.J. Lermit, 1980, Comparison of some time series models for the analysis of fisheries data, J.Cons.int.Explor.Mer., 39: 44-52.

Sathianandan, T.V. and M. Srinath (MS), Time series analysis of marine fish landings in India.

Schaefer, M.B. 1954, Some aspects of the dynamics of populations important to the management of marine fisheries, Bull.I-ATTC 1:25-56.

Sekharan, K.V. 1975, Estimates of the stocks of oil sardine and mackerel in the present fishing grounds off the west coast of India. Indian J.Fish., 21(1): 177-182.

Shepherd, J.G. 1988, Fish Stock Assessment and their data requirements 35-62, In: JA. Gulland (ed). Fish population Dynamics (second edition) John Wiley and Sons Ltd.

Silas, E.G. 1969, Exploratory Fishing by R.V. Varuna, Bull.Cent.Mar.Fish.Res.Inst., 12:86 pp.

Silas E.G. 1984, Foreword, in: Kartha, K.N.K. (ed). Coastal zone Management-Mudbanks of Kerala coast. Bull.cent.mar.Fish.Res.Inst., 31: i-vi, 74pp.

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: 25pp

Silas E.G. and P.P. Pillai, 1985, Fishery, Biology and population dynamics of tunas and seer fishes - an update for India, proc. 8th sess. I.O.F.C., Colombo, 24pp.

Silas, E.G., P.P. Pillai, M. Srinath, A.A. Jayaprakash, C. Muthaiah, V. Balan, T.M. Yohannan, PON Siraimeetan, Madan Mohan, P. Livingston, KK. Kunhikoya, MA. Pillai and P.S.S. Sarma, 1985a, Population dynamics of tunas: stock assessment, Bull.cent.mar.fish.res.inst., 36: 20-27.

Silas E.G., M.M. Meiyappan, R. Sarvesan, K. Prabhakaran Nair, M. Srinath and K.S. Rao, 1885b, Stock assessment, squids and cuttle fish at selected centres, Bull.cent.mar.fish.res.inst., 37: 71-79.

Srinath, M. and K. Alagaraja, 1982, A method of estimation of mortality rates from length samples, Indian J.Fish., 28(1&2): 183-188.

Stergiou, K.I. 1989, Modelling and forecasting the fishery for pilchard (Sardine pilchardus) in Greek waters using Arima time-series models, J.Cons.int.explor.Mer., 46:16-23.

Stergiou, K.I. 1991, Describing and forecasting the sardineanchovy complex in the eastern Mediterranean using vector Auto Regressions, Fish.Res., 11: 127-141.

Stocker, M. and R. Hilborn, 1981, Short term forecasting in marine fish stocks, Can.J.Fish Aquat.Sci., 38: 1247-1254.

Sudarsan, D., M.E. John, and V.S. Somavanshi, 1990, Marine Fishery Resource potential in the INdian Exclusive Economic Zone, Bull.Fish.Surv.India, 20: 27pp

Van Winkle, W., B.L. Kirk and B.W. Rust, 1979, Periodicities in Atlantic coast stripped bass (Morone saxatilis) commercial fisheries data, J.Fish.Res.Bd.Can., 36: 54-62.

Venkataraman, G., M. Badrudeen and R. Thyagarajan, 1982, Population dynamics of silverbelly Leiognathus jonesi in Palk Bay, Indian J.Fish, 28 (1&2): 65-86.

Vijayakumaran, K. and K.P. Philip, 1991, Demersal fishery resources of the north Kerala, Karnataka and Konkan coasts, J.Mar.Biol.Ass.India, 32: 177-186.

Vevekannandan, E. and B. Krishnamoorthi, 1985, Estimated resources of demersal Fisheries off North Tamilnadu-South Andhra coasts based on Exploratory Surveys, In: K. Ravindran et al. (ed). Harvest and post-harvest technology of Fish: 69-76, Soc.Fish.Tech.India, Cochin.

Vivekanandan, E. and D.B. James, 1986, Population dynamics of Nemipterus japonicus (Bloch) in the trawling grounds off Madras, Indian J. Fish., 33(2)145-154.

Yohannan, T., 1983, Population dynamics of Indian mackerel based on data from Mangalore during 1967-1975, Indian J. Fish., 29(1&2): 50-62.

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Complexities of Management of inshore Fishery Resources of India

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The management of coastal fishery resources of India, accommodating the technological changes, socio-economic objectives, interaction of different users of the resources and other activities which influence the fisheries, has been a matter of great concern for the policy makers, planners, scientists and maritime State Fisheries Departments in the last decade. It appears to dominate the scene in the current decade as well. A review of the present state of the inshore fisheries by Experts has concluded that the catchable potential of different groups of fishes in the 0-50 m depth zone, estimated at 2.21 million tonnes, is very close to the present production level of almost the same quantity. Added to this depressing note, the fishing technological developments, which are perceived as panacea for augmenting production and economic gains, have given rise to the formation of sectoral groups among the fishing communities exploiting the resource, and the consequent social and professional conflicts. The various controversies and complexities of these issues are discussed here in an attempt to help in the development of a balanced management strategy in consideration of the administrative, social, economic resource conservation, technological and political objectives.

The Beginnings and Growth Thereafter

The emphasis on the marine fisheries development of India at the start of the planning process in the fifties and sixties has been on the introduction of mechanised fishing vessels, improved gears and gear material. The location of lucrative shrimp grounds in the inshore waters, establishment of an export trade for shrimps and its accelerated expansion, gave a fillip to the progressive addition of mechanised fishing vessels and popularisation of bottom trawling, which co-existed with the traditional fishing, exploiting the same resources almost in the same area. These activities were supported by modern methods of handling, processing, preservation and utilisation of the catch, and establishment of other onshore infrastructural facilities with considerable financial aids and subsidies. During 1970-80, the marine fishing activities expanded rapidly harvesting the resources upto about 50 m depth zone in the Continental Shelf.

In the early seventies, purse-seines were introduced on the South-West coast for the exploitation of pelagic fishes. The pattern of fishing also changed from single day fishing to stay-over fishing. Since the last decade, motorisation of country craft got momentum, and employing these craft, gears such as ring seines and "minitrawls" were used for fishing in the inshore waters. These inputs have helped the marine fish production of India to increase steadily to the level of two million tonnes by the turn of the last decade.

Fishing Pressure and Chasing Crisis

As the catching capacity of the fishing units increased but confined to a narrow belt of 0-50/60 m depth zone in the Continental Shelf, and the competition among the resource users for maximising their share of opportunities to step up harvests, the exploitation pressure on the stocks in these grounds increased. Several studies made on the production trend and the fishing effort put in to realise the production, and the studies made on the population characteristics of the important individual fish and shellfish stocks constituting the fisheries, have indicated that increased effort in these grounds may not produce enhanced yield or proportionate increase in production as the exploitation has reached the optimum or near optimum level. This is particularly so in respect of the shrimp fishery, which due to its value and importance in the export trade, is playing a pivotal role in stoking the aspirations and also precipitating a crisis in the Indian marine fishing industry.

Juvenile Exploitation : Besides the difficulties of resource sustainability, the increase in number of fishing fleet, use of least selective fishing gears having relatively small mesh size, the changing pattern of fishing methods and the increasing competition to catch as much quantity as possible to realise better economic returns, resulted in the catch of considerable quantities of juveniles. Large quantities of juvenile fishes and prawns, are also caught from the estuaries and backwaters. The increased catch of juveniles of potentially high commercial value fishes has brought intense pressure on the resources.

Neglect of By - Catch

Similarly, the trawl fishery of our country is, by and large, interested in exploiting only the shrimps and a large quantity (about 75-90% of trawl catch) of fishes and other shellfishes is landed as by-catch. This by-catch is not properly cared for and often, discarded to facilitate proper preservation and landing of shrimps. According to one estimate, about 1,30,000 t of by-catch were discarded in the north-east coast of India alone by the large trawlers in 1988. Such huge discards in the sea pose severe problems for the resource scientists to get a correct and reliable picture of the species composition, seasonal variation, biology of the constituent species in the catch, estimation of natural and fishing mortality rates and other population characteristics of the exploited resources. Besides, in the critical situation of protein fish food supply shortage the country cannot afford wastage of fish biomass in this way. This, coupled with the lack of involvement of the fishing industry in generation of data on exploited stocks places severe constraints on the fisheries managers.

Modules in Fishery Resource Management

Recognising the adverse effects of the above activities on the resources over the years, and the urgent need to maintain a sustainable resource base and stock conservation, the management strategy advocated for adoption in this zone has been towards the management of resources that are over-exploited or have reached the optimum level of exploitation. The management measures discussed and suggested in this context are : i) regulation of fishing effort and catch limitation, mainly of the shrimps, ii) restriction of fishing gears which exploit the juveniles in the inshore waters, estuaries and backwaters, iii) mesh size regulation of fishing gears such as trawl nets, purse-seines and ring seines, and iv) closed fishing season and areas.

Catch limitation : catch limitation and control of fishing effort are among the most common methods used in the management of fisheries, particularly in their developed state. This technique is based on estimations of Maximum Sustainable Yield (MSY) and determination of Total allowable Catch (TAC) indicating the quantum of catch that could be taken annually without disturbing the replenishment ability of the stock and, the optimum effort needed to exploit this quantum of catch. However, as the estimations of MSY and maximum effort are dependent on a number of variables and the quality of the commercial catch and effort data used for the estimation, the management strategy based on this technique is often criticised for being too narrow in its objectives.

Similarly, the changing seasonal pattern of the fishery as well as the fishing methods, rapid generation of improved gears and ineffective system of surveillance are the other problems of its practical application. Besides, the regulation of fishing effort is difficult in the context of multigear and multispecies nature of the fishery and the competitive attitude of the resource users, enjoying common property rights of fishing. It is observed that for species which have short life span and exhibit intense recruitment variability, it is difficult to base the management strategy on catch quotas. This strategy would also attract opposition from economic and political angles. In view of these complexities, although this management technique should receive further consideration for dealing with excess fishing effort, its practical success cannot be achieved in the present situation, and perhaps, continuous education of the resource users on the deleterious effects of excess fishing effort on resources needs to be undertaken before its application.

Young Fish Conservation : Restrictions on the exploitation of juveniles of commercially important fishes and shellfishes in the inshore waters, estuaries and backwaters to conserve the stocks are in application in the coastal fishery of the country. Licensing of fishing gears such as stake nets and Chinese dip nets in the estuarine/backwater fisheries of Kerala is in force. Similarly, the operation of gears during high tides is also prohibited.

These measures are meant to protect certain life stages of the exploited stocks, mainly the shrimps, that spend a part of the life cycle in these ecosystems. Their implementation, however, has not been successful mainly due to the socio-economic constraints. The estuarine fisheries contribute significantly not only to the sustenance of the fisher population living on the banks of these water bodies, but also offers gainful employment opportunities. The increasing demand for even tiny shrimps and the absence of regulations on the minimum size of species for capture as well as for export, have prompted the use of several hundreds of unlicenced gears along with the licenced gears. Further, the exploitation of smaller individuals of certain culturable species such as Penaeus monodon and P.indicus for purpose of seed in certain parts of the Indian Coast is causing concern to the already existing problem of over-exploitation of shrimps in the nursery ground. In respect of shrimps, there is one school, however, which believes that exploitation of juvenile prawns in the estuaries and backwaters is the best way of utilisation of the resource because all the juveniles which enter the estuaries as larvae may not return to the sea even in the absence of fishing due to heavy natural mortality during post-larval and juvenile phases. In any case this unrestricted exploitation has led to the necessity of controlling the fishing to ensure safeguarding of the resource without sacrificing the social and economic benefits. The regulation of this practice, therefore, cannot be achieved immediately, unless an alternate workable policy for rehabilitation of the affected fishermen in gainful fishery related avocations is incorporated in the management strategy recommended for the purpose.

Mesh regulation and gear selectivity : Mesh size regulation for the capture of marine fishes has been one of the traditional methods of conservation and management of fisheries resources used in several parts of the world. The use of nets with large mesh size would permit the escapement of juvenile fishes enabling them to grow to larger size, mature and contribute to the maintenance of spawning biomass. It is also observed that by allowing the fish to grow to larger size, the market value of the catch would be improved and growth overfishing averted. As the fishing effort in the marine fishery of the country increased, the catch distribution among the fishing units dwindled, and consequently, the resource users started reducing the mesh size of the net to catch even small fish in more numbers which gradually resulted in the reduction of size of the fish or in catching greater proportion of small-sized fish and shrimps. Over the years, the cod-end mesh size of the shrimp trawl nets was reduced from 25 mm to 8-20 mm and that of purse-seine from 10/18 mm to 7/15 mm. Studies carried out on mesh selectivity in relation to populations of shrimps exploited from the inshore waters of the country have shown that there is an urgent necessity for increasing the cod-end mesh size of shrimp trawl nets to atleast 30 mm to save the stocks from the danger of over-exploitation. However, in recommending an appropriate mesh size of the net, there should be a realistic relationship between the size of the fish and the performance of the fishing gear used to catch the fish. Further, in the operation of demersal trawling and purse-seining, often large quantities of fish are caught which virtually seal off the net meshes resulting in the retention of undersized fish. For a multispecies fishery of the type prevailing in our waters, selection of gear by mesh size would be difficult. From the investment point of view, a regulation based on mesh size will not be appreciated by the fishermen as they may have to sacrifice the present nets incurring loss and requiring additional investment for the new nets. Nevertheless, studies carried out have indicated that it is worthwhile to encourage adoption of more selective gears for stabilised harvest of the resource, although the benefits are slow to be realised. Recently, the UK Government has insisted that square meshed panels with a cod-end mesh size of 75 mm shall be used for trawl nets, as it permits greater escapement of juvenile fish than the normal mesh nets.

Closed seasons and areas : Closed season, as a fishery management technique, is well known in many parts of the world. For example, in UK, closed season is practised to protect Salmon and Coarse fish breeding stocks. Similarly, in some of the world penaeid shrimp fisheries such as in Gulf of California, it is used for the protection of spawning stock. Besides helping in the protection of breeding stocks or juveniles in the nursery grounds, it also limits the fishery at certain level of the total catch. Closed fishing season for shrimps is observed at present in India during April-June by the larger trawlers operating from Visakhapatnam on the east-coast. As this is a voluntary action, no problem is encountered at present. Otherwise, the main constraints of this system would be, when the fishing season changes it would adversely affect the industry as the vessels and the crew may have to be laid off for longer period. Consequently, the supply of raw material would fluctuate.

Conflicts : The system of fisheries management through fishing zone demarcation (Territorial use of Rights in Fisheries) is a recent thinking in India. As the fishing activities by the traditional and the mechanised fishing vessel operators in the inshore fishing grounds increased, competition to maximise the rent from the resource ensued. This has gradually led to conflicts between the two sectors for the control of the fishing grounds. Similarly, as the mechanised fishing vessel operators could harvest the resource more effectively than the traditional fishermen, the social and economic status between them widened and this imbalance caused dissatisfaction among the traditional fishermen. This conflict between the two sectors, often becoming violent, necessitated safeguarding the interest of the Small-scale and Medium-scale fishermen.

Fishing Zone : The management policy which has been adopted to tackle this problem has been the demarcation of fishing zone for the operation of different types of fishing vessels in the inshore fishing ground. Accordingly, certain regions of the inshore area based either on distance from the shore or on bathymetric disposition, are set apart exclusively for the operation of traditional fishing units; the mechanised fishing vessels are prohibited from operation in this zone. However, the demarcation of fishing zone is found to vary from state to state and often, within the same state, as in Kerala. This arbitrary nature of fishing zone demarcation and the pressure of increased fishing effort, technical modernisation and exploitation based on common property principle, form formidable obstacles for the success of this system of management. Besides, its strict enforcement is beset with practical difficulties mainly due to inadequate facilities and resource with the implementing/enforcing agencies. Nevertheless, the management of fisheries through the Territorial Use Rights has elsewhere shown that it is possible to achieve a balance among the administrative, social, economic, resource conservation systems and technological & political objectives, whenever it is organised by the resource users entirely by their own inputs without much of external regulations.

Monsoon Trawling conflicts : In the complexity of issues causing the conflicts between the traditional and mechanised fishing sectors, the monsoon fishing practised in certain states, particularly in Kerala since the last decade, has become a critical issue of controversy. Opposition to monsoon fishing comes from (i) the mechanized fishing vessels sharing the resources in the inshore waters normally held for the traditional fishing, (ii) fears of possible adverse affects of monsoon fishing on the resource against the already deepening crisis of resource availability and consequently, the urgent need for conservation of the resource, (iii) acute competition for the harvest of shrimps available in the inshore waters and (iv) the widening economic imbalance between the sectors. At the same time, one school believes that the monsoon fishing would help better utilisation of the resources such as shrimps which otherwise may not be available for exploitation if not harvested when available during the monsoon period. The dilemma whether this problem can be successfully accommodated within a management policy which seeks to place the stock conservation at the top without unduly restricting the utilisation of the resource or risking serious dislocation of the fishing industry, has been a matter of great concern for several Committees and Commissions appointed by the Government of Kerala to go into the issue of trawling during the monsoon period. After considerable deliberations on the subject, it was decided to ban bottom trawling in the territorial waters of the State during June-August. Although this is implemented since 1988, with relaxation in certain areas and duration, the controversy still persists and a workable solution to the conflicts does not seem to have been worked out.

Remarks and Conclusions

It will be clear from the preceding paragraphs that none of the management measures adopted in the country can be considered as successful. Is it due to the failure of planning system or setting up of rational, non-conflicting developmental objectives ? One is tempted to believe that the policy of introduction of mechanised fishing vessels and their addition year after year in the context of common use right system for exploitation has resulted in an imbalance between the emphasis of fisheries development for maximising production and economic components and the need to maintain a sustainable resource base with adequate stock conservation measures. In this context, catch limitation and control of fishing effort are the most effective ways to manage the fisheries and conserve the stocks. But in practice, it is difficult to maintain the fishing effort at desired level. The new technologies (fishing capacity of vessels, engine size, gear dimensions, improvised gears, methods of operation) would effect the catching process often yielding higher catch and leading to increased level of fishing effort beyond that which gives MSY. Similarly, implementation of catch limitation requires accurate and reliable data both from the biological observations and commercial fisheries sources. Although a very reliable method of sampling the commercial landings, within the overall limitations of Governmental set-up, availability of funds and adequate number of trained personnel is in vogue at the Central Marine Fisheries Research Institute, the sampling system without the involvement of fishing vessel operators gives room for one to doubt the validity of conclusions drawn from these data. If the fishing industry furnishes all the relevant data in a prescribed format to the Data Centre of the Institute at the end of each cruise, that will go a long way not only in understanding many things which are hitherto not understood well but also in the proper management of the fisheries. Further, catch limitation/fishing effort are set for individual species stocks, whereas, the gears catch not just one species but several species, thereby making it difficult to uniformly apply the catch-limitation based management system in such multispecies fishery. TAC should be fixed for the multispecies groups taking into account the bio-economic considerations. The problems of management by mesh regulation and closed seasons have already been indicated. In the context of discarding fish by-catch by trawlers appropriate method of collecting the same would play a significant role in the better utilisation of this protein rich resource.

Thus, practical implementation of management policy in coastal fisheries is a complex and a difficult task. It is generally observed that the Government formulates the regulatory and legislative measures to safeguard the resource or for resolving the issue affecting the fisheries and force the resource users to abide by or adopt these regulations. However, the resource users try to break the regulations to stay in the business. This poor relationship between the regulations and the users has given rise to many of the unwanted and destructive features leading to the failure of implementation of the regulations. As observed "Experience, when resource sharing becomes an issue, has shown that unless all parties agree to a rational system for sharing, sooner or later the debate ends up in court. If this happens, expensive court cases replace fisheries management, expensive lawyers replace fisheries managers and fishers, the resource suffers and nobody wins". In consideration of these, several administrators and fishery managers now assert that the resource users organisations must play an active role in policy making and be made responsible for its implementation. This strategy would also result in fewer social, political and conservation-led problems that are to be addressed by the Government. In fact, such strategies/tactics have helped to reduce/redress several of the controversies encountered in the purse-seine fisheries of Karnataka and the mechanised fisheries in certain areas of Tamil Nadu.

Against the background of heavy fishing pressure in the inshore fisheries of the country, its impact on sustainability of resource and deepening conflicts among the resources users, the policy to be evolved should meet the requirements of conservation of stocks taking into account the social and economic background and the livelihood of the local communities dependent on fisheries. Accordingly, the appropriate management system that could be considered may

- provide increased role to the local or regional fishing communities in the formulation of regulatory measures and their managerial responsibility;
- ensure positive access in favour of local fishing communities;
- formulate regulatory measures with a strong conservation policy through careful regulation of fishing effort and restrictions on gears; and
- incorporate a system of fishing zones within the regional management scheme transmuting the conflict to co-existance or even symbiosis.

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LIST OF RESEARCH PAPERS PUBLISHED
BY
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1. MURTY,V.SRIRAMACHANDRA.1967. Notes on hyperostosis in the fish *Drepane punctata* (Linnaeus).*J.mar.biol.Ass.India*, 9:323-326.

2. MURTY,V.SRIRAMACHANDRA. 1969. On some interesting and new records of marine fishes from India. *J. mar. biol. Ass. India*, 10: 126-132 (1968).

3. MURTY,V.SRIRAMACHANDRA. 1969. Catalogue of fishes (excluding from the laccadives) in the Reference collection of the Central Marine Fisheries Research Institute. *Bull. Cent. mar. Fish. Res. Inst.*, 10:36 pp.

4. MURTY,V.SRIRAMACHANDRA. 1972. On a specimen of *Caranx carangus* Bloch (carangidae, Pisces) without a pelvic fin. *J. mar. biol. Ass. India*, 14:884-885.

5. MURTY,V.SRIRAMACHANDRA. 1975. Studies on the maturation, spawning, fecundity and sex ratio in *Barbus (Puntius) sarana* (Hamilton-Buchanan) from lake Kolleru, Andhra Pradesh. *Fish. Technol.*, 12: 131-144.

6. MURTY,V.SRIRAMACHANDRA. 1976. Studies on growth checks on the scales of *Barbus (Puntius) sarana* (Hamilton-Buchanan) from lake Kolleru, Andhra Pradesh with comments on growth checks reported on some hard parts of Indian fishes. *Proc. Indian Acad. Sci.*, 83 B: 85-102.

7. MURTY,V.SRIRAMACHANDRA. 1976. On the length-weight relationship and relative condition factor in *Barbus (Puntius) sarana* (Halmilton-Buchanan) from the lake Kolleru, Andhra Pradesh. *Mem. Sôc. Zool. Guntur*, 1: 96-102.

8. MURTY,V.SRIRAMACHANDRA. 1976. Note on the natural pearl in *Placenta placenta* (Linnaeus). *Indian. J. Fish.*, 23: 243-246.

9. MURTY,V.SRIRAMACHANDRA. 1977. Taxonomic studies on the fishes of the family Cyprinidae from lake Kolleru, Andhra Pradesh. *Proc. Indian Acad. Sci.*, 85B: 107-146.

10. MURTY,V.SRIRAMACHANDRA. 1981. *Nemipterus mesoprion* (Bleeker) (Nemipteridae, Pisces) a new record from the seas around India. *Indian J. Fish.*, 25: 207-213 (1978).

11. MURTY,V.SRIRAMACHANDRA. 1981. Observations on the biology of black croaker, *Atrobucca nibe* (Jordon and Thompson) from Kakinada. *Indian J. Fish.*, 27: 66-75 (1980).

12. MURTY,V.SRIRAMACHANDRA. 1982. *Nemipterus luteus* (Schneider,1801) (Nemipteridae, Pisces) the valid name for a threadfin bream from the Indo-Pacific region. *J. mar. biol. Ass. India*, 19: 107-114 (1977).

13. MURTY,V.SRIRAMACHANDRA. 1982. Observations on some aspects of biology of threadfin bream *Nemipterus mesoprion* (Bleeker) from Kakinada . *Indian J. Fish.*, 28: 199-207 (1981).

14. MURTY,V.SRIRAMACHANDRA. 1982. On the fishes of the family Platycephalidae of the seas around India. *J. mar. biol. Ass. India*, 17: 679-694 (1975).

15. MURTY,V.SRIRAMACHANDRA. 1983. Observations on some aspects of biology of the silverbelly *Leiognathus bindus* (Valenciennes) from Kakinada. *Indian J. Fish.*, 30: 61-69.

16. MURTY,V.SRIRAMACHANDRA. 1983. Estimates of mortality, population size and yield per recruit of *Nemipterus japonicus* (Bloch) in the trawling grounds off Kakinada. *Indian J. Fish.*, 30: 255-260.

17. MURTY,V.SRIRAMACHANDRA. 1984. Observations on the fisheries of threadfin breams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) from Kakinada. *Indian J. Fish.*, 31: 1-18.

18. MURTY,V.SRIRAMACHANDRA. 1984. Observations on the biology of the croakers *Johnius (Johneiops) dussumieri* (Cuvier) and *Johnius (Johnius) carutta* Bloch from Kakinada. *J. mar. biol. Ass. India*, 21: 77-85 (1979).

19. MURTY,V.SRIRAMACHANDRA. 1986. The threadfin bream resources. *R&D series for Marine Fishery Resource Management.* No.8: 4pp, CMFRI, Cochin.

20. MURTY,V.SRIRAMACHANDRA. 1986. Growth and yield per recruit of *Johnius (Johnius) carutta* Bloch in the trawling grounds off Kakinada. *Indian J. Fish.*, 33: 163-170.

21. MURTY,V.SRIRAMACHANDRA. 1986. Studies on the growth and population dynamics of silverbelly *Leiognathus bindus* (Valenciennes) in the trawling grounds off Kakinada. *Indian J. Fish.*, 33: 277-284.

22. MURTY,V.SRIRAMACHANDRA. 1987. Further studies on the growth and yield per recruit of *Nemipterus japonicus* (Bloch) from the trawling grounds off Kakinada. *Indian J. Fish.*, 34: 265-276.

23. MURTY,V.SRIRAMACHANDRA. 1987. Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada. *J. mar. biol. Ass. India*, 27: 39-48 (1985).

24. MURTY,V.SRIRAMACHANDRA. 1988. Population characteristics of the silverbelly *Leiognathus bindus* (Valenciennes) along the West Bengal coast. *J. mar. biol. Ass. India*, 28: 41-47 (1986).

25. MURTY,V.SRIRAMACHANDRA. 1989. Mixed Fisheries Assessment with reference to five important demersal fish resources landed by the shrimp trawlers at Kakinada, p69-86 in: Venema,S.C. and N.P. van Zalinge (eds). *Contributions to the tropical fish stock assessment in India*. Papers prepared by participants at the FAO/DANIDA/ICAR National followup training course in fish stock assessment, Cochin, India, 2 -28 November 1987. FI:

26. MURTY,V.SRIRAMACHANDRA. 1991. Biology and population dynamics of the silverbelly *Secutor insidiator* (Bloch) from Kakinada. *J. mar. biol. Ass. India*, 32: 10-24 (1990).

27. MURTY,V.SRIRAMACHANDRA. 1991. Observations on some aspects of biology and population dynamics of scad, *Decapterus russelli* (Ruppell) (Carangidae) in the trawling grounds off Kakinada. *J. mar. biol. Ass. India*, 33: 396-408.

28. MURTY,V.SRIRAMACHANDRA. 1994. Contribution of CMFRI to research and development in marine fisheries of Andhra Pradesh. Central Marine Fisheries Research Institute, Cochin, India, 26pp.

29. MURTY,V.SRIRAMACHANDRA,D.C.V.EASTERSON,A.B.FERNANDO,K.K.APPUKUTTAN and K.M.S.AMEER HAMSA. 1968. Bibliography of marine fisheries and oceanography of Indian ocean 1962-1967. *Bull. cent. mar. Fish. Res. Inst.* 1: 208pp.

30. MURTY, V.SRIRAMACHANDRA, D.C.V.EASTERSON, A.B.FERNANDO. 1969. Bibliography of Indian Ocean 1968 (with suppliment for 1962-1967). *Bull. cent. mar. Fish. Res. Inst.* 5: 146pp.

31. MURTY, V.SRIRAMACHANDRA, K.A.NARASIMHAM and W.VENUGOPALAM. 1979. Survey of window - pane oyster *(Placenta placenta)* resources in the Kakinada bay. *Indian J. Fish*, 26: 125-132.

32. MURTY, V.SRIRAMACHANDRA AND N.G.MENON. 1986. The silverbelly resources. *R&D series for Marine Fishery Resource Management.* No.7: 3pp. CMFRI, Cochin.

33. MURTY,V.SRIRAMACHANDRA AND P.RAMALINGAM. 1988. Observations on some aspects of biology of *Johnius (Johneiops) vogleri* (Bleeker) and *Pennahia macrophthalmus* (Bleeker) in the Kakinada region. *J. mar. biol. Ass. India*, 28: 57-62 (1986).

34. MURTY,V.SRIRAMACHANDRA, M.K.BANDYOPADHYAY AND P.RAMALINGAM. 1988. Marine fish calendar V.Kakinada. *Mar. Fish. Infor. Serv. Tech & Extn. Ser.*, 83: 1-17.

35. MURTY,V.SRIRAMACHANDRA, M.KUMARAN AND R.S.LALMOHAN. 1989.Resources of ornamental fishes. *in*: Marine Living Resources of the Union Teritory of Lakshadweep - An indicative survey with suggestions for development. *Bull. cent. mar. Fish. Res. Inst.*, 43: 46-64.

36. MURTY,V.SRIRAMACHANDRA, K.V.S.NAIR, P.A.THOMAS, S.LAZARUS, S.K.CHAKRABORTHY, S.G.RAJE, C.GOPAL, P.U.ZACHARIA AND A.K.VELAYUDHAN. 1992. Persent status of exploitation of fish and shellfish resources - Threadfin breams. *in*: RAO.P.V., V.SRIRAMACHANDRA MURTY AND K.RENGARAJAN (eds). Monsoon Fisheries of the West Coast if India - Prospects, Problems and Management. *Bull. cent. mar. Fish. Res. Inst.*, 43: 154-168.

37. MURTY,V.SRIRAMACHANDRA, R.S.LALMOHAN AND G.GOPAKUMAR. 1994. Marine Ornamental Fish Resources of India, Department of Environment and Forests, Government of India, New Delhi.

38. MURTY,V.SRIRAMACHANDRA, T.APPRA RAO, M.SRINATH, E.VIVEKANANDAN, S.K.CHAKRABORTHY, S.G.RAJE AND P.U.ZACHARIA. 1994. Stock Assessment of Threadfin breams *(Nemipterus spp)* of India. *Indian J. Fish.*, 39: 9-41 (1992).

39. MURTY,V.SRIRAMACHANDRA, M.SRINATH, P.LIVINGSTON, Y.APPANNA SASTRY AND S.SRINIVASA RENGAN. 1994. Stock Assessment of Silverbellies of India with particular reference to Andhra Pradesh and Tamil Nadu. *Indian J. Fish.*, 39: 42-64 (1992).

40. MURTY,V.SRIRAMACHANDRA AND P.RAMALINGAM.(in Press).Characteristics of exploited stock of *Nibea maculata* (Schneider)(Sciaenidae) as revealed by trawl landings at Kakinada. *J. mar. biol. Ass. India*, 37:

41. MURTY,V.SRIRAMACHANDRA AND P.VEDAVYASA RAO. (in Press). Marine Fishery Resources of India - present status and management concerns. *Spl. pub.* CMFRI, Cochin.

42. RAJAPANDIAN, M.E. AND V.SRIRAMACHANDRA MURTY. 1966. On the occurrence of spotted threadfin *Polynemus microstoma* Bleeker in the Gulf of Mannar. *J. mar. biol. Ass. India.* 8: 365-367.

43. DUTT,S. AND V.SRIRAMACHANDRA MURTY. 1971. On the fishes of the genus *Cirrhinus* Cuvier (Family Cyprinidae) from lake Kolleru, Andhra Pradesh. *Bull. Dept. mar. biol. Oceanogr. Univ. Cochin*, 5: 39-48.

44. KUTHALINGAM,M.D.K., G.LUTHER, P.LIVINGSTON AND V.SRIRAMACHANDRA MURTY. 1973. Further occurrences of the whale shark *Rhincodon typus* Smith in the Indian Coastal waters. *Indian J. Fish.*, 20: 646-651.

45. DUTT,S. AND V.SRIRAMACHANDRA MURTY. 1976. On the Fish and Fisheries of lake Kolleru, Andhra Pradesh. *Mem. Soc. Zool. Guntur*, 1: 17-27.

46. DUTT,S. AND V.SRIRAMACHANDRAMURTY. 1976. Remarks on some diagnostic characters used in the taxonomic studies on the cyprinid fishes with special reference to those of lake Kolleru, Andhra Pradesh. *Mem. Soc. Zool. Guntur*, 1: 70-75.

47. RAO,G.S., K.A.NARASIMHAM AND V.SRIRAMACHANDRA MURTY. 1988. Pwawn culture in salt pans in East Godavari District (Andhra Pradesh). *J. mar. biol. Ass. India*, 30: 151-156.

48. KUMARAN,M., P.P.PILLAI, R.S.LALMOHAN, V.SRIRAMACHANDRA MURTY AND G.GOPAKUMAR. 1989. Live-bait resources and development. *in:* Marine Living Resources of the Union Territory of Lakshadweep - An indicative survey with suggestions for development. *Bull. cent. mar. Fish. Res. Inst.*, 43: 39-45.

49. KUMARAN,M., R.S.LALMOHAN, V.SRIRAMACHANDRA MURTY. 1989. Other Finfish Resources. in: Marine Living Resources of the Union Territory of Lakshadweep - An indicative survey with suggestions for development. *Bull. cent. mar. Fish. Res. Inst.*, 43: 65-72.

50. RAO,T.A., R.S.LALMOHAN, S.K.CHAKRABORTHY, V.SRIRAMACHANDRA MURTY, K.V.S.NAIR, E.VIVEKANANDAN AND S.G.RAJE. 1994. Stock assessment of sciaenid resources of India. *Indian J. Fish.*, 39: 85-103 (1992).

51. RAO,P.VEDAVYASA AND V.SRIRAMACHANDRA MURTY. 1993. Complexities of Management of inshore fishery resources of India. *Fishing Chinnes*, 13 (8): 5-9.

52. RADHAKRISHNA, K. AND V.SRIRAMACHANDRA MURTY. 1993. Present trends in marine fisheries management and catch forecasting. Paper presented at the International Workshop on Remote Sensing applications to Fisheries, 7-9 December 1993; NRSA, Hyderabad, 20pp.

53. JAMES,P.S.B.R. AND V.SRIRAMACHANDRA MURTY. 1993. Groupers and Snappers of India - their distribution, exploitation and biology. Paper presented at the International Workshop on Tropical Groupers and Snappers; Campeche, Mexico; 26-29 October 1993.

54. JAMES,P.S.B.R., K.A. NARASIMHAM AND V.SRIRAMACHANDRA MURTY. 1994. Technology for improving Marine Fishery Production *in:* D.L.DEB (ed). *Sustaining crop and animal productivity.* p261-283; Associated Publishing company, New Delhi.