STATEMENT

This is to certify that the thesis entitled "Some Studies on the Biology of Nemipterids of Goa Coast" *is my original contribution and that the same has not been submitted on any previous occasions for any other degree or diploma of this University or any other University/ Institute. To the best of my knowledge the present study is the first comprehensive study of its kind from the area mentioned. The literature related to the problem investigated has been cited. Due acknowledgements also have been made wherever facilities and suggestions have been availed of.*

S. K. Naik

Date: 4th August 2000

SOME STUDIES ON THE BIOLOGY OF NEMIPTERIDS OF GOA COAST

THESIS SUBMITTED TO THE GOA UNIVERSITY
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BY

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This is to certify that
1. All the corrections have been incorporated.
2. This is the final copy which can be deposited in the library of the university as the record copy.

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CERTIFICATE

This is to certify that the thesis entitled "Some studies on the biology of nemipterids of Goa coast" submitted by Mr. S. K. Naik, for the Award of the Degree of Doctor of Philosophy in Zoology (Faculty of Life Sciences and Environment) Goa University, Taleigao Plateau, is a record of research work done by him during the period of study in the Department of Zoology, Faculty Of Life Sciences and Environment, Goa University, Goa under my supervision and guidance. The thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or any other similar titles.

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CONTENTS

1. INTRODUCTION

Among the aquatic animals fish occupy a prominent place. They are richly diverse, numerically abundant, widely distributed and occupy the position of higher tropic levels making them the most important living beings in the aquatic system. Fish get a large area of planet to live-in especially the large stretches of open waters, sea and oceans. As the marine ecosystem is the largest of earth's habitat it was believed that fish wealth was bountiful and the fishery resources unlimited.

Life in the ocean is influenced by various long term and short-term changes in the dynamic ecosystem. Though the ocean is a single continuous phase of aquatic environment, it is not a homogeneous medium. The physical and chemical properties of the ocean vary from region to region and season to season. The interaction between seawater, atmosphere and the exchange of energy is a vital aspect of the coastal waters. The *in situ* changes in the ocean affect the production of plankton, which form the food material for fish. The fluctuation in various hydrographic features has profound influence on the distribution of fishes. Further, the conditions in the aquatic environment and their changes influence the spawning, recruitment, survival and growth of fish.

Though the tropics encompass 50% of the global waters, they have only 30% of world's continental shelf. The higher temperatures of tropical waters enable the life forms to occupy every niche available, which should have resulted in very highly productive fishery in the tropical region. However, this region contributes to only about 10% of the global fish production. The tropical fishes are very sensitive to modern fishing methods/practices. Use of advanced harvesting technology, not keeping pace with natural growth rate has put fishery in tropical waters into various management problems/conflicts, as in many other parts of the world (Devaraj, 1983; Gulland, 1971; 1988a; 1988b; Pauly, 1988).

The coastal resources in the Indian waters, which were targets for traditional and small-scale fishing sector have been under severe fishing pressure. The resources that were away from the shallow coastal waters remained unutilised, initially due to non-availability of technology to harvest them, and later due to lack of resource details/information such as fish composition and distribution. Because of consumer's hesitance to accept unconventional and unfamiliar fishes and non availability of ready markets, the deep sea resources did not get the patronage of traditional fish markets. The pressure on the near shore waters was expected to be eased when the offshore resources were harvested and the fish eating community started accepting the same. Indian Government agencies like Integrated Fisheries Project (IFP) and Fishery Survey of India (FSI) identified many offshore resources like bull's eye, Indian drift fish, perches and threadfin breams. Threadfin breams is one such resource that has wide distribution along the Indian continental shelf, but not harvested as more economically profitable fishery resources were available in the coastal regions.

The members of the family Nemipteridae are coastal demersal fishes known to be distributed in tropical and sub-tropical regions. The principal regions supporting the nemipterid fishery around the world are Mediterranean, Red Sea, Arabian Sea, Bay of Bengal, west coast of Malay Peninsula, Singapore, Sumatra, Borneo, North Celebes, South China Sea, Philippines, southern Japan and Australian waters. In India, although they are distributed along both east as well as west coast, they form a major deep sea fishery resource along the south-west coast, constituting about 2% of the marine fish production of the country (Anon, 1995).

The fishes with white meat, which are known for their nutritive value are used mostly in fresh or salted and dried condition by the Indian consumers. The textured meat of *N. japonicus* has a high protein content and all essential amino-acids (Nair *et al.*, 1988) and hence can be used as convalescent food. The meat of the fish is also used in preparation of value added products which are popular in the far east countries like Korea and Japan. Its frozen minced meat can be preserved for long period without any reduction in quality. The paste prepared out of this fish can be preserved for 26 weeks (Yaligar *et al.*, 1993). Many of the successful studies (Sudhakaran and Sudhakara, 1985; Raj and Chandrasekhar, 1986; Ng *et al.*, 1987; Shamasunder *et al.*, 1987; Shenoy *et al.*, 1988; Joseph *et al.*, 1989; Toyohara *et al.*, 1990; Yu Sy, 1990; Lee *et al.*, 1990; Verma and Srikar, 1994) on utilization of the threadfin meat only, or along with other fish meat for preparation of value added products has increased demand for the fish. Therefore, a resource that was once treated as a bye-catch, became target fishery in most parts of its geographical distribution. Indian fishers also harvested this resource, distributed abundantly along the country's maritime belt.

The threadfin breams in Goa were found to occur along with the other fishery resources from the demersal region (Rao and Dorairaj, 1968; Dawan, 1971; Prabhu and Dawan, 1986) in the trawl catches. Vijayakumaran and Naik (1990) observed that the nemipterids formed the largest single resource in waters more than 100 m deep, and second largest in 50 –100 m depth range. These fishes locally known as 'Rane' had no consumer acceptance and were not harvested by Goan fishing community. Scarcity of hitherto commercially important fishes in coastal waters made some of the enterprising trawl owners to harvest 'Rane' fish, which were initially sold in Kerala, Tamil Nadu and interior Karnataka. As the meat of threadfin was suitable in preparation of fish paste products, the meat picking factories in Ratnagiri started buying the fish from the landing centers in Goa. As the returns were encouraging, the fishery was established along Goa coast.

Fish biologists in the world over have been documenting various biological aspects of fish with an over all aim of determining the interplay a given fish species has with its living and nonliving environment. A detailed literature search suggests that there is an absence of any systematic studies on the biology and fisheries of nemipterids along the Goa coast, although they were actively harvested along the coast. Knowledge of the biological aspects of the species contributing any fishery of importance is a primary requirement for its judicial exploitation. Hence, it was felt that there is a strong need for investigating the biological information of this important resource. Therefore, the present work was planned to document the biology of some of the prominent species of nemipterids contributing the fishery along the Goa coast. The study was to cover length-weight relationship, relative condition factor, food and feeding habits, maturity, sex ratio, reproduction, growth, and the stock parameters.

2. REVIEW OF LITERATURE

The members of the family Nemipteridae commonly known as threadfin breams, whiptail breams, monocle breams, dwarf monocle and coral breams constitute about 64 species. They inhabit in the shallow coral reef to deeper shelf areas living in the demersal regions ranging from sandy to muddy bottoms. These fishes may remain solitary or form schools in the sea and exhibit no territorial preference (Russell, 1990a).

The available literatures suggest that most of the studies on nemipterids are limited to the commonly occurring species. The distribution of the nemipterids is patchy, with the exception of *Nemipterus japonicus, N. zysron, Parascolopsis eriomma* and *Scolopsis vosmeri.* Therefore, the biological information is also patchy, and most of the works are from southeast Asian countries bordering west pacific region.

Most of the works on nemipterids from our coasts are on their taxonomy, distribution and utilisation using advanced processing technology. Though some biological studies have been carried out on the threadfin breams like *N. japonicus, N. mesoprion, N. delagoae, N. tolu* and *N. peronii,* most of them are confined to the species from the east coast, south west coast and north west coast. Thus the information is patchy with gaps especially with respect to the population from the central west coast. Moreover, in some cases the very validity of their identification is doubtful due to the in-built uncertainties and fluidity in taxonomic characters adopted for the group.

2.1. Taxonomy

The members of the family Nemipteridae are all marine belonging to order Perciformes. They belong to super family Sparoidea, which includes other families like Sparidae (porgies), Lethrinidae (emperor fishes) and Centracanthidae (picarels). Akazaki (1962) and Johnson (1980) have discussed relationship of the sparoid fishes. Johnson (*op.cit.*) is of the opinion that nemipertids are more closely related to lethrinids than any other sparoides. Some of the recent works (Jordan, 1923; Berg, 1940; Gosline, 1971; Lindbergh, 1971; Greenwood *et al.,* 1974; Nelson, 1984 and 1994) have reduced the variations in the general classification of the fishes. In the most commonly followed classification, the threadfin breams belong to Super Class: Teleostomi; Class: Osteichthyes; Sub Class: Actinoptrygii; Order: Perciformes; Sub Order: Percoidei; Super Family: Sparoidea; Family: Nemipteridae. The generic name *Nemipterus* was given by Swainson (1839), while Günther (1859) gave the name *Synagris.*

Threadfin breams in Indian waters were first documented by Day (1875-77) under genus *Synagris* Günther (family: Percidae), which were earlier placed under a different genus *Dentex* Cuvier and Valenciennes. Munro (1955) recorded only 4 species from the Gulf of Mannar and Sri

Lanka and placed them under family Nemipteridae of Suborder Percoidei and order Perciformes. Talwar and Kacker (1984) listed 8 species of Genus *Nemipterus* and 17 species of Genus *Scolopsis* under the family Nemipteridae.

Nelson (1994) described 62 species of nemipterids under four Genera Viz. *Nemipterus* (Swainson), *Scolopsis* (Cuvier) *Parascolopsis* (Cuvier) *Pentapodus* (Quay and Gaimard) and Scaevius (Whitley). *Pentapodus* was placed under nemipterids following Johnson (1975, 1980), though formerly it was isolated in a separate family Pentapodidae. Weber and Beaufort (1936) placed all the species occurring in Indo- Australian Archipelago under sub-family Nemiptirinae. They included Genera 1) *Scolopsis* Cuvier, 2) *Gnathodentex* Bleeker, 3) *Monotaxis* Bennett 4) *Nemipterus* Swainson, 5) *Pentapus* Cuvier and Valenciennes, 6) *Gymnocranius* Klunzinger and 7) *Symphorus* Günther. Under Genus *Scolopsis* they described 16 species and under Genus *Nemipterus* 20 species.

Taxonomy

Nemipterids are considered to be one of the taxonomically difficult groups. Fowler (1904, 1931, 1933 and 1943), Weber and Beaufort (1936) and Akazaki (1959 and 1962) previously reviewed taxonomic status of these fishes. Nevertheless, the confusion continues. Fowler (1972) has reported 7 species under genus *Nemipterus* from the Chinese waters. The reviews of *Nemipterus* species of Thailand (Wongratana, 1972, 1974), Taiwan (Lee, 1986) and western Indian Ocean (Russell, 1986) have attempted to solve some of the taxonomic problems. In spite of these efforts, identification and systematics of these fishes is full of confusion. Many species of nemipterids are similar in morphology, hence colour differences separate the taxa (Eggleston, 1973) making the identification of preserved specimen difficult. The descriptions of species under family Nemipteridae were revised to reduce the confusion in identification, and the work is still in progress. Hence, the FAO species catalogue for the nemipterid species of the world (Russell, 1990a) which is a product of on going revision of the family Nemipteridae is not complete (Russell personal communication).

Russell (1991a) described a new species *N. thosaporni* previously identified as *N. marginatus*. In addition, he re-described *N. marginatus* (Val.), *N. mesoprion* (Bleeker) and *N. nematopus* (Bleeker) from west pacific region and Southern Japan to Indonesia. Russell (1991b) established the validity of *N. furcosus* (val.) which was hitherto wrongly identified as *N. peronii* (Val.) and re-described as a senior Synonym of *N. tolu* (Val.).

The nemipterids from Indian waters so far recorded are placed under genera *Nemipterus* (Swainson), *Scolopsis* (Cuvier), and *Parascolopsis*

(Boulenger). The species of these genera recorded from Indian waters are given below.

Species of the genus *Nemipterus* recorded from Indian waters.

1. *Nemipterus japonicus* (Bloch, 1791); *Sparus japonicus* Bloch, 1791, Naturges. Ausländ. Fisches., 5: 110.

   Synonyms: *Dentex blochii* Bleeker (1851c); *Synagris japonicus* Day 1875-77 in Day (1889); *Nemipterus japonicus* (Bloch) in Talwar and Kacker (1984)

2. *Nemipterus bipunctatus* (Ehrenberg, 1830); *Dentex bipunctatus* Ehrenberg in C. &V., 1830b. Hist. Nat. poiss.,6: 247 (Dejedda, Red Sea)

   Synonyms: *Synagris bleekeri* (Day, 1875 - 77) in Day (1889); *Nemipterus mulloides* Smith (1939)(Preoccupied); *Nemipterus delagoae* Smith (1941); *N. delagoae* in Fisher and Bianchi (1984) *Nemipterus bleekeri* (Day, 1875-77) in Talwar and Kacker (1984); mostly reported as *N. bleekeri* in Indian waters. Reported as *N. delagoae* (Smith) of Quillon, south west coast of India by Rajagopalan *et al.*, (1975), from Waltair by Rao & Rao (1981b) and along Cochin waters by John and Hameed (1983).

3. *Nemipterus marginatus* (Valenciennes, 1830) *Dentex marginatus* Valenciennes in C. &V., 1830b., Hist. Nat. poiss.,6: 245 (Vanicolo; Java) .

Reported first time in India by Shameem and Rao (1997) as *Nemipterus marginatus* (Valenciennes, 1830)

4. *Nemipterus nematophorus* (Bleeker, 1853) *Nemipterus nematophorus* (Bleeker, 1853, Nat. Tijdschr. Ned.-Indië 5: 500 (Padang, Sumatra).

Synonyms: *Dentex filamentosus* Valenciennes in C. and V. 1830b, *Synagris macronemus* Günther (1859), *Cantharus filamentosus* Rüppell. Reported as *N. luteus* (Schneider, 1801) in Talwar and Kacker (1984). Murty (1977) however considered *N. luteus* Schneider as a valid name. The priority status of Synonym is not yet clear.

5. *Nemipterus peronii* (Valenciennes, 1830). *Dentex peronii* Valenciennes, in C.V., 1830b, Hist. nat. poiss., 6:245,pl.154 (no type locality).

Synonyms: - *Dentex tolu* Valenciennes in C. and V. (1830b); *Synagris tolu* (Day, 1875); *Dentex Mulloides* Bleeker (1852); reported as *Nemipterus tolu* Valenciennes in Talwar and Kacker (1984). *N. peronii,* (Valenciennes, 1830) was reported from Tuticorin waters (Rao & Rao, 1986a) and along Cochin waters John and Hameed (1983).

6. *Nemipterus zysron* (Bleeker, 1856-57): *Dentex zysron* Bleeker, 1857, Nat. Tijdschr. Ned. – Indie. 12: 219 (Nias).

Synonyms: *Dentex metopias* Bleeker (1857). Mostly reported as *N. metopias* Fisher and Whitehead (1974) Fisher and Bianchi (1984) but *N. zysron* has priority (Russell, 1990a). Along Indian coast, Indira (1981), Madanmohan and Gopakumar (1981) reported occurrence of *N. metopias.*

7. *Nemipterus randalli* Russell (1986): *Nemipterus randalli* Russell, 1986, Senckenberg. Biol. 67: 23, fig. 2 (Persian Gulf; Red Sea; Gulf of Aden; Zanzibar; Seychelles; Madagascar; Pakistan; India). This species was described by Russell while reviewing the Nemipterid fishes of the world. There is no general agreement on this description. According to him the fishes hitherto recorded as *N.mesoprion* (Bleeker, 1853) in Indian waters are wrongly identified so. Mishra and Krishnan (1992) have recorded *N. randalli* from Andaman waters.

8. *Nemipterus mesoprion* (Bleeker, 1853): *Dentex mesoprion* Bleeker, 1853a, Nat. Tijdschr. Ned. –Indië , 4: 255 (Priaman, Sumatra). *Nemipterus mesoprion*: Weber and Beauport, 1936. The species does not have a caudal filament (Russell, 1990a, 1991a). However, Indian workers have been recording *N.mesoprion* following the description given with the first report of the species by Murthy (1978). But, according to

Russell (1986) the species occurring in west cost of India is *Nemipterus randalli.*

9. *Nemipterus hexodon* (Quay & Gaimard, 1824): *Dentex hexodon* Quoy & Gaimard, 1824, Voy. "Uranie", Zool.,: 301 (Timor). Synonyms: *Dentex (Synagris) notatus* Day (1870); Reported as *Nemipterus hexodon* (Quay & Gaimard, 1824) in Talwar and Kacker (1984).

10. *Nemipterus furcosus* (Valenciennes, 1830) a valid Species (Russell, 1991b) may be occurring in Indian waters if wrongly identified as *N. peronii,*) *Dentex furcosus* Valenciennes in C. and V. 1830b Hist. Nat. poiss., 6: 245, (Trincomalee Srilanka) pl.154. Synonyms: *Dentex upeneoides* Bleeker (1852c). Reported along Sri Lankan waters by Munro (1955).

Species of the genus *Parascolopsis* recorded from Indian waters

1. *Parascolopsis aspinosa* (Rao & Rao, 1981); *Scolopsis aspinosa* Rao and Rao, 1981, Proc. Kon. Ned. Akad. Wetensch., Ser. C, 84:134, Fig.1,3 (Waltair, India). Synonym: *Parascolopsis jonesi* Talwar (1986).

2. *Parascolopsis boesemani* (Rao & Rao, 1981); *Scolopsis boesemani* Rao & Rao, 1981, Proc. Kon. Ned. Akad. Wetensch., Ser. C, 84: 139, fig.2, 4 (Waltair, India).

3. *Parascolopsis townsendi* (Boulenger, 1901): *Parascolopsis townsendi* Boulenger, 1901, Ann. Mag. Nat. Hist.,(7) 7: 262, pl. 6(Gulf of Oman).

4. *Parascolopsis inermis* (Schlegel, 1843): *Scolopsis inermis* Schlegel in Temminck & Schlegel, 1843, Fauna Japonica: 63, pl. 28, fig.1 (Japan). Talwar and Kacker (1984) are of the opinion that the distribution of the species is doubtful.

The taxonomic status of the members of genus *Scolopsis* Cuvier (1815) occurring in Indian waters was first dealt by Rao and Rao (1981a) who placed them under *Scolopsis* Cuvier, 1815, which included the species of *Parascolopsis* also.

Species of the genus *Scolopsis* recorded from Indian waters

1. *Scolopsis vosmeri* (Bloch, 1792); *Anthias vosmeri Bloch, 1792,* Naturges. Ausländ. Fische, 6:120, pl. 321 (Japan Sea). Synonyms: *Anthias japonicus* Bloch (1793).

2. *Scolopsis ciliatus* (Lacépède, 1802): *Holocentrus ciliatus* Lacépède, 1802, Hist. nat. poiss., 4: 333 (no locality given) ; *Scolopsis ciliatus* (Day, 1889) from Port Blair Andaman.

Representatives of Genus *Pentapodus* (Quoy and Gaimard, 1824) are mostly found in the West Pacific region (Russell, 1990a), their distribution in Indian waters is yet to be recorded.

The genus *Scaevius* Whitley, 1947 is represented by a single species *Scaevius milii* (Bory de Saint- Vincent, 1823) in the northwestern Australian waters; and is not known from Indian waters.

2.2. Length-weight relationship and relative condition factor

The length-weight relationships of different species of nemipterids from waters around India and other parts of the world are available. In Indian waters, Krishnamoorthi (1971) observed that a single equation was not possible as there was significant difference in the regression equations of males and females of *N. japonicus*. He gave the equation for males as $W = 0.001752\ L^{2.0769}$ and for females, $W = 0.0000183\ L^{2.9423}$. Vinci and Nair (1974) gave common length-weight relationship of *N. japonicus* along Kerala coast as $\log W = -5.4793 + 2.8487 \log L$. They also suggested that the regression equation of both sexes of the species of Kerala, differed from that of Andhra and Orissa due to difference in stock.

The length-weight relationship of *N. mesoprion* of Kakinada region was worked out by Murty (1981) in the form of a common equation, $\log W = -4.650901 + 2.877071 \log L$. Murty (1984) observed that difference of the regression coefficients between sexes in the case of *N. japonicus* of Kakinada region was significant. He derived the equation for male, $\log W = - 3.65045 + 2.43025 \log L$ and for female, $\log W = - 4.78137 + 2.95688 \log L$. In fishes with lengths lesser than 155 mm, the K_n value for males was always higher than that for females. For *N. mesoprion* in Chennai region the length-weight equation for males was log W = -4.7926 + 2.9692 log L and for females was log W = 3.0602 + 2.1570 log L which differed significantly (Vivekanandan and James, 1984). Acharya and Dwivedi (1980-81) have worked out the length-weight relationship of *N. japonicus* from the Bombay region as log W = -4.4516 + 2.8069 log L for males and log W = -5.0034 + 3.0634 log L for females. In *N. japonicus* from the trawl of grounds of Chennai the length-weight relationship among males and females did not differ significantly. The pooled equation was log W = -4.8665 + 2.9661 log L (Vivekanandan and James, 1984).

Lee (1973) gave length-weight equation for *N. japonicus* from Hong Kong region as W = 0.0176 $L^{3.0246}$ for males and W = 0.0147 $L^{3.0939}$ for females. Hoda (1976) found that among the *N. japonicus* of Pakistan coast the length-weight relationship between sexes did not differ significantly and proposed a combined equation, log W = -6.875413 + 3.090598 log L. He also computed the condition 'K' for both the sexes. Gopal and Vivekanandan (1991) have reported that the length-weight relationship between sexes of *N. japonicus* of Veraval region did not differ significantly. The combined equation proposed by them was log W = -4.2570 + 2.7488 log L. Along the Kochi region (John and Hameed, 1994) the length-weight relationship for *N. japonicus* was log W = - 4.3794 + 2.7831 log L and that for females was log W = - 4.8315 + 2.9881 log L. The regression equation for males of *N. mesoprion* was log W = - 4.4430 + 2.7983 log L and for females was log W = - 4.6385 + 2.8873 log L. For both the species, the exponent value 'b' for males and females was less than 3. The regression equations between sexes differed significantly among *N. japonicus* but among *N. mesoprion,* difference was not significant. Hence they proposed a combined equation log W = - 4.5641 + 2.8163 log L for *N. mesoprion.* Raje (1996) found that there was no significant difference in length-weight relation between males and females of *N. mesoprion* from Veraval region. Therefore the combined equation was log W = -10.7134 + 2.9124 log L. He also reported that the peak condition of females was up to March and that for males upto April. Length-weight relation for *N. japonicus* along Kuwait waters (Samuel, 1990) was log W = 0.02448 + 2.78952 log L for males and log W = 0.01123 + 3.0399 log L for females. The K_n value had 3 peaks suggesting two spawning periods.

Madanmohan and Velayudhan (1984) observed that in the case of *N. delagoae* from Vizhinjam Kerala, the equation for males was log W = -4.894391+ 2.969385 log L and for females, log W = -4.675841+2.881551 log L. The difference between the regression equations for males and females was not significant. Therefore the combined equation derived by them was log W = -4.891125 +2.972582 log L.

2.3. Food and feeding

Most of the earlier studies on the food and feeding habits of nemipterids were of generalized/gross nature and did not provide details. In the first ever report (Anon, 1960) the most common food items of *N. japonicus* obtained from the southern part of the Indian coast were recorded as prawns, polychaetes and small fish. Food habits of *N. japonicus* from trawl catches along Mangalore shore did not differ between seasons (Kuthalingam, 1965), but differed among those caught from different depths. The food of the fish from 10-20 m depth mainly consisted of *Metapenaeus dobsonii* and *Parapaenopsis stylifera* along with polychaetes, foraminiferans, and fishes. Among them the prawn *M. dobsonii* (35%) dominated. In slightly deeper waters of 20-30 m depth, *Parapaenopsis stylifera* formed the bulk (40%) of the food. At 30-40 m depth, besides crustaceans teleosts were included in the diet while at 40-50 m, cannibalism was observed. George *et al.* (1968) reported that *N. japonicus* off Kochi consumed crustaceans, predominantly amphipods. They were considered to be active predators possibly by sight (Krishnamoorthi, 1971), feeding substantially on crustaceans, mulluscs, annelids and echinoderms. *N. japonicus* from shallow waters were reported to feed on mostly prawns and those from deeper waters on fish and crabs (Vivekanandan, 1990). *Squilla*, crab prawns, teleosts, cephalopods, amphipods, polychaetes, were encountered in the order dominance in the gut of *N. japonicus* caught off Visakhapatnam (Rao and Rao, 1991). Their feeding intensity was recorded to be the highest between March to November and lowest during December and February. Off Bombay coast (Acharya *et al.*, 1994) also the *N. japonicus* were found to feed on bottom mainly on crustaceans, fishes polychaetes and salps.

Rao (1989) observed that the food of *N. mesoprion* from the Andhra coast was mainly crustaceans such as young prawns, crabs and squilla and so also teleosts. Along Gujarat coast, *N. mesoprion* was found to feed on crustaceans, fishes, molluscs and annelids in the order of preference (Raje, 1996).

The *N. delagoae* off Tutukkudi fed predominately on fishes, prawns and crabs (Hamsa *et al.,* 1994). They also fed on brittle star, cuttle fishes, gastropods, bivalves, squilla, polychaetes, alphids, isopods and amphipodes. *N. delagoae* (Smith) from Vizinjam (Madanmohan and Velayudhan, 1984) consumed crustaceans (74.5%) mainly prawns, crabs and *Squilla.* They also fed on fishes such as *Stolephorus* sp., *Saurida, Trichiurus* sp., *Platycephalus* sp., *Thryssa* and molluscs, such as Octopus, *Sepia and* mussels.

N. bathybius, N. japonicus, N. virgatus from Hong Kong waters (Eggleston, 1972) were reported to be active predators feeding during day time and hunting by sight. Adults among them fed mainly on crustaceans, fishes and cephalopods. Range of food items narrowed down as they grew and the prey size increased. Cephalopods crustaceans, polychaetes and lamellibranchs formed the bulk of the diet of *N. virgatus, N. bathybius* and *N. japonicus* respectively. The *Nemipterus tolu* of the South China Sea was an active carnivore, day light feeder, feeding on fishes, crustaceans, mollucs and polychaetes. Stomach contents of bigger fish varied less than that of smaller fish (Said *et al.*, 1983). *N. japonicus* of Daya Bay, China fed mainly on benthos and small zooplankton (Zhuang, 1990). Feeding of *N. peronii*, along northwest Australia was observed to be during day (Sainsbury and Whitelaw, 1984). *N. furcosus* from gulf of Carpentaria , Australia showed seasonal differences in food habits (Salini *et al.* 1994). In a related species *N. nemurus* from South-China Sea, crustaceans dominated the food composition (Daud and Taha, 1986).

2.4 Reproduction

The first ever report on the reproduction of nemipterids from Indian waters was on that of *N. japonicus* (Anon, 1960). They were reported to begin to attain maturity from September and move to deeper waters beyond 50m along Mangalore coast after attainment of sexual maturity (Kuthalingam, 1965). He also suggested that breeding took place during January or February. According to Krishnamoorthi (1971), *N. japonicus* along the east coast spawns for the first time on attainment of 160 to 179 mm total length, and second time on attainment of 222 mm total length. In *N. japonicus* additional growth of upper region of caudal fin in males, nearly one and half time more than that of females was treated as secondary sexual character (Nammalwar, 1973). Along the east coast, *N. japonicus* was found to breed twice a year - December – February and June – July, and the fishes ranging in total length from 132 to 209 mm had a fecundity of 10.5 to 80.8 thousand (Dan, 1977). Along Kakinada, *N. japonicus* was observed to be a fractional spawner releasing the ova in two batches during the protracted spawning season extending from August to April. The species at Kakinada attained first maturity when they were 125 mm long and had a fecundity of 23,094 to 1,39,160 while in the size range of 134 to 199 mm (Murty, 1984). Off Mumbai, *N. japonicus* spawned from August to November with a peak during October (Acharya and Dwivedi, 1980-81). The occurrence of low catch of running *N. japonicus* along Kuwait in deeper waters through out the year (Samuel, 1986) suggests that they also move to deeper waters for breeding as observed along Mangalore coast. Gonadal maturation in *N. japonicus* off Visakhapatnam (Rao and Rao, 1991) is between August and October. Further, *N. japonicus* with ripe ovaries were observed offthe coast of Visakhapatnam from January to April, wherein the males outnumbered the females. Along Madras coast

(Vivekanandan and James, 1986) *N. japonicus* matured at 145 mm total length and had an extended spawning period from June to March with a peak between December to March. Acharya (1990) recorded July to December as the breeding season off Mumbai coast with a peak during November to December. Vivekanandan (1990) observed that mature females of *N. japonicus* were in a larger number in deeper waters of Tamil Nadu and South Andhra Pradesh.

N. mesoprion were found to attain sexual maturity when 100 mm long, and were recorded to be fractional spawners releasing ova in two batches during a single spawning season extending from December to April (Murty, 1981). The males outnumbered the females in *N. mesoprion* landed at Visakhapatnam (Rao, 1989). Along Veraval, the sex ratio for *N. mesoprion* was 2.57:1 (Raje, 1996). The females of the fishes attained first maturity at 134 mm and the fecundity ranged from 50,344 to 64,369 in fishes of size ranging from 104 to 198 mm. They are also known to spawn from September to March with a first peak in September and second peak in November-December.

Sex ratio, maturity and spawning season for *N. delagoae* off Mumbai were recorded by Muthiah and Pillai (1979). The females achieved first maturity when they were 135 mm long. The sex ratio was 1:1.01 and the fecundity ranged from 5,578 to 93,948 with a high correlation with length, body weight and weight of gonad. Along Vizhinjam these fishes spawned twice a year with a peak during September to June (Madanmohan and Velayudhan, 1986). The size at first maturity was between 164 to 170 mm, and the annual fecundity ranged from 86,184 to 4,97,230, which increased with increase in both length as well as weight.

The histological examinations of gonads of *Scolopsis monogramma, S. taeniopterus, S. bilineatus* exhibited protogynus hermaphroditism (Young and Martin, 1985). In *N. peronii* and *Pentapodus porous*, the evidence suggested the occurrence of hermaphroditism. They observed that the size related skewness in *S. monogramma, S. taeniopterus* and *S. bilineatus* was a result of protogynus hermaphroditism and not sexually differentiated growth rates. *N. peronii* of northwest shelf of Australia was found to have ripe eggs throughout the year, the proportion of ripe eggs was highest in November and December (Sainsbury and Whitelaw, 1984). The *N. tolu* from the trawl grounds of the South China Sea was found to have two prolonged spawning periods one from November to February and another starting from May/June (Said *et al.*, 1983). Along Hong Kong waters, Eggleston (1972) studied the spawning habits of three species *N. japonicus, N. virgatus* and *N. bathybius*. Spawning of *N. virgatus* was around the islands in the northern part of South China Sea (Zhang and Lee, 1980). While surveying the ichthyoplanktons of Daya Bay, China, Wang (1990) observed a large number of eggs of *N. virgatus and N. japonicus,* abundance of which decreased during summer. He also carried out studies on the hatching and larval development of these fishes. In the northern part of south China sea, spawning season of *N. virgatus* was observed to be from April to June (Zhang, 1986).

2.5 Age, growth, stock and population dynamics

Age and growth details of fish form an important input for stock assessment studies. In the earliest recorded work on growth, the Japanese threadfin bream *N. japonicus* had the modal size of 120 – 130 mm in September-December which advanced to 140 mm by January- March (Anon, 1960). Along South Sea coast, Israel (Ben –Tuvia, 1968) *N. japonicus* measuring up to 130 mm were of '0'-year class and those measuring 170 mm were of one-year class.

In *N. virgatus* of the South China Sea, males grew faster than females (Eggleston, 1970) resulting in size difference between them. At Visakhapatnam, *N. japonicus* is reported to grow to an average size of 150 mm, 210 mm, 240 mm at the end of 1^{st}, 2^{nd} and 3^{rd} years respectively (Krishnamoorthi, 1971). Eggleston (1972) suggested that growth curves for males and females of Nemipterids should be plotted separately as the growth rate of male and females of *N. Virgatus, N. bathybius* and *N. japonicus* differed. Males and females of *N. japonicus* caught by Hong Kong vessels were found to have maximum length of 311 mm and 357 mm and maximum age of 7 and 8 years respectively (Lee, 1973). Krishnamoorthi (1974) observed size differences between the sexes of *N. japonicus* along Visakhapatnam, the females being generally smaller. Krishnamoorthi (1976) worked out yield per recruit in weight (Y_w/R) and in number (Y_n/R) for the stocks of *N. japonicus* off Andhra Pradesh coast and opined that the stocks were under exploited, as the rate of exploitation ('E') was only 0.3. In *N. vigratus* off Persian Gulf and Arabian Sea the formation of growth check was once a year which is considered to be associated with spawning (Nekrasov, 1979). Age determination using the otolith of *N. virgatus* was carried out by Kao and Liu (1979), wherein a single growth check was noticed by May in the population from South China Sea and by June in that from East China Sea. They observed that males grew faster. The parameters of von- Bertalanffy's growth formula (VBGF) in East China Sea were L_∞ = 31.26 cm, K = 0.3216, t_o = -0.8998 for females and L_∞ = 41.37 cm K = 0.3026, t_o = -0.2663 for males. For fishes in South China Sea, females had L_∞ = 27.98 cm, K = 0.4404, t_o = -0.8135 and males had, L_∞ = 34.18 cm, K = 0.4474, t_o = -0.2016.

In Indian waters, Acharya and Dwivedi (1980-81) observed difference in the growth rates among males and females of *N. japonicus* along Mumbai coast. They further observed that *N. japonicus* on an average grows at the rate of 12.91 mm per month and attains a size of 155 mm in the first year and later, grows at a rate of 5 mm per month and attains a size of 211.5 mm in the second year. *N. Japonicus* attained a length 136 mm, 186 mm and 230 mm by the end of 1^{st}, 2^{nd} and 3^{rd} year respectively along the Kerala coast (Vinci, 1982). *N. mesoprion* along Kakinada attained 140 mm, 185 mm, and 205 mm at the end of 1^{st}, 2^{nd} and 3^{rd} year respectively (Murty, 1981). The values of VBGF obtained by him were L_∞ = 219 mm, K = 0.83248 and t_o = -0.256198. *N. japonicus* along Kakinada coast had an estimated total mortality (Z) of 1.86, fishing mortality (F) of 0.72, natural mortality (M) of 1.14 and the exploitation rate (U) of 0.33 (Murty, 1983). The estimated total annual stock was 1181 tons. The yield per recruit (Y/R) curve showed that the Fishing mortality 'F' could be increased from 0.72 to 1.75. These fishes attained 185 mm, 255 mm, 285 mm on completion of first, second and third year respectively (Murty, 1984), and their growth parameters were L_∞ = 314 mm, K = 0.75142, t_o = -0.173909 Year. The growth of males and females differed significantly in the case of *N. peronii* from north west coast of Australia (Sainsbury and Whitelaw, 1984). Along the Madras coast *N. japonicus* had L_∞ of 305 mm, K =1.004, t_o = 0.2257 Y, M = 2.5254 and F = 0.4599. The annual stock (2300 tons) and standing crop (731 tons) were higher than the estimated landings which suggested that increased effort can be put for increasing the total production (Vivekanandan and James, 1986). The growth checks on the scales of *N. japonicus* landed at Visakhapatnam were biannual, one during January – March when feeding was poor and another during August – October due to gonadal maturation and spawning (Rao and Rao, 1986b). The maximum age of fish in the commercial landings estimated by them by using the scales was three years.

Growth and mortality parameters observed for *N. japonicus* of Kakinada trawl ground were, K = 0.52 per Year, L_∞ = 339 mm, t_o = -0.16 Year, M = 1.11, F =1.53, Z = 2.64 (Murty, 1987a). The estimated length at first capture (L_c) of the fish was 120 mm and he recommended for an increased effort (F). The average recommended F for *N. japonicus* and *N. mesoprion* along Kakinada was 1.95 and 2.7 respectively (Murty, 1987b). Using two different methods John (1987) obtained values of L_∞ = 303 mm, 326 mm; K = 0.4 and t_0 = 0.7 Year for *N. japonicus* along Kerala coast. At an estimated value of Z = 1.37 per Year, the maximum sustainable yield (MSY) of nemipterids above 80 mm along Kerala coast was 27000 t, slightly higher than the catch level of the period. According to Devaraj and Gulati (1988), *N. japonicus* from Mumbai region attained an average length of 150 mm, 250 mm and 280 mm in 1st, 2nd and 3rd year respectively. Their estimated average annual yield of 6600 tons at F = 0.3504 for 1983-84 was far less than the MSY level of 11,887 tons available from the inshore waters. The average standing stock of *N. japonicus* along Gujarat was 419634 tons, Maharastra 64555 tons and Karnataka 38,621 tons. Along Mangalore regions the estimated L_∞ was 33 cm, K = 1.0 yr^{-1} , M=1.87 and Z = 5.65 with the E of 0.68. (Zacharia, 1998).

Along the Malaysian waters *N. japonicus* had L_∞ = 314 mm, K = 0.55 per Year, Z = 3.72, M =1.21, F = 2.51 (Isa, 1986). Along Bangladesh (Khan and Mustafa, 1989), *N. japonicus* had L_∞ = 20.14 cm and K =1.06 per Year and the rate of exploitation was estimated to be 0.47. The *N. mesoprion* landed at Visakhapatnam measuring 70-140 mm in length were found to grow at the rate of 10 mm per month (Rao, 1989). The growth parameters of *N. japonicus* for males and female was given by Samuel (1990) as L_∞ = 303, 265 mm; K = 0.542, 0.595; t_0 = 0.19, 0.03 respectively. He also observed that the males grew faster than females. Along the northern Arabian Sea the stock parameters of *N. japonicus* were studied by Iqbal (1991a), using length based stock assessment technique, ELEFAN. Three species along east coast *viz. N. mesoprion, N. tolu* and *N. delagoae* had K values of 1.080, 0.828 and 0.761 respectively and the corresponding L_∞ Values were 207 mm, 282 mm and 271 mm respectively (Vivekanandan, 1991). Murty *et al.,* (1992a) recorded increase of Threadfin landings from 22247 tons (1980-83) to 48100 tons (1984-88) with a maximum landing of 60000 tons during 1986.

Estimated growth parameters from length data of *N. delagoae* landed at Tutukkudi were, L_∞ = 362 mm and K = 1.0586 per year and t_o =0.007 year (Hamsa *et al.,* 1994). They also found that the average annual total mortality coefficient Z for the species by trawl net was 3.29, with natural mortality coefficient (M) 1.625. Yield per recruitment (Y_r) indicated that the fishing mortality (F = 1.665) was below F_{max} for age at first capture (t_c) of 0.4687 years. The recorded M/K ratio was 1.535. The estimated VBGF parameters for *N. japonicus* of Bangladesh region using ELEFAN technique were L_∞ = 245 mm and K = 0.94; and the natural mortality coefficient M = 1.81 and F = 1.58 (Mustafa, 1994). Along the north west Coast of India *N. japonicus* from Mumbai region grew to 193, 281 and 322mm at the end of 1st, 2nd and 3rd year (Chakraborty, 1995). The VBGF parameters were L_∞ = 356 mm, K = 0.75576, t_0 = 0.03358254. The total, natural and fishing mortality were respectively 3.58, 1.53 and 2.03, while the exploitation rate and exploitation ratios were 0.54 and 0.56. Compared to the yield of 1645 tons during the study period under reference, estimated total stock and standing stocks were 3047 tons and 810 tons respectively.

2.6. Distribution and fishery

The members of the family Nemipteridae are marine, distributed along the Indo-Pacific regions. Most species of the genus *Nemipterus* inhabit muddy and sandy bottom in coastal inshore as well as offshore shelf waters, some in depths ranging upto 300 m. The species of *Parascolopsis* occur in mud or sand bottom, but are mainly in deeper waters upto a depth of 400 m. Species of *Scolopsis* and *Scaevius* inhabit relatively shallow waters on muddy or sandy bottom closer to coral reefs. *Pentapodus* are benthic, free swimming in regions closer to reefs. The threadfin breams (*Nemipterus* spp.), whiptail breams (*Pentapodus* spp.), monocle breams (*Scolopsis* spp.) and the dwarf monocle breams (*Parascolopsis*. spp.), constitute multi species catch of the trawl gear. The monocle breams and the dwarf monocle breams are of little importance in fishery. The *Scolopsis* spp. is caught for aquarium trade, the *Parascolopsis* spp. are occasionally caught by the fishermen along with other deep-water resources. The whiptail breams are of artisan fisheries, occasionally taken by recreational fisheries. Only the members of genus *Nemipterus* come in the multi-species catch, often two or three species caught together.

2.6.1. Global distribution and the fishery

The distribution of the members of family Nemipteridae are limited to tropical and sub tropical Indo-West Pacific region. There is no record of their occurrence in Eastern Pacific. The report of their occurrence in Atlantic was an error, and that at Mediterranean Sea is yet to be confirmed (Russell, 1990a). The three genera: *Nemipterus, Scolopsis* and *Parascolopsis* are widely distributed throughout the Indo- West Pacific region. Whereas the genus *Pentapodus* is restricted to west Pacific. The genus *Scaevius* is endemic to northern Australia. The landings of nemipterids are not systematically reported, hence the landing statistics of these fishes are inadequate. According to the catch statistics compiled by FAO, the fishing area 71 lands the highest quantity followed by areas 61 and 57.

Zupanovic and Mohiuddin (1976) reported abundance of *N. japonicus* along the northeastern Arabian Sea in the 50-125 m depth zone. Nemipterids formed 5.3% of demersal community in the Malaysian shallow waters (Chan and Liew 1986). In the Malaysian EEZ, nemipterid species formed one of the important by-catch (Mohamed 1986). In another study 9.7% of the overall catch of demersal survey yielded threadfins constituting eight species, (Said *et al.,* 1986) of which *N. nemurus* was most abundant. This group was second in abundance after Lutjanidae (Mohamed *et al.,* 1986). Along South China Sea, the Nemipterids formed the third largest commercially important resource (Mohsin *et al.,* 1987). Threadfins formed a small resource along Arabian Gulf (El-Sedfy *et al.,* 1987). Along Pakistan waters, *N. metopias* formed one of the important constituents of trawl catch during the northeast monsoon period (Iqbal, 1991b).

2.6.2 Distribution and Fishery along the Indian Coast

Nemipterids were identified for the first time in India by Day (1878) who also recorded their distribution. Banse (1959) observed that, off Kochi, *N. japonicus* were available when the oxygen content was above 0.25 to 0.50 mlL^{-1}. *N. japonicus* were first reported from the southern coast (Anon, 1960) and later along Mangalore coast (Kuthalingam, 1965). Krishnamoorthi (1973) observed that the peak abundance of *N. japonicus* along Andhra coast was from January to April coinciding with the upwelling period. Silas *et al.* (1976) reported existence of the rich nemipterid resource on the continental shelf beyond 50 m depth, especially in the 75-100 m belt, often-forming 75% of the trawl catches along different parts of the Indian coast. Along Kakinada, they were found to form about 9.7% of total trawl catch (Muthu *et al.*, 1977). Murty (1984) recorded that 50% of nemipterid landings at Kakinada was constituted by *N. japonicus*, followed by *N. mesoprion, N. tolu,* and *N. luteus. N. japonicus* are found all along the Indian coast including Andaman waters. Nemipterids was one of the important resources available for exploitation during the 1980's (Joseph, 1986). At Sassoon Dock, Mumbai, which is one of the major landing centers of northwest coast, the landing of threadfins started during 1970's (Pillai, 1986). These were projected as one of the important resources from the deep-water region (Sudarsan *et al.*, 1988). *N. japonicus* and *N. mesoprion* were the two dominant species representing the threadfin breams in the trawl catch in the region. Dwarf monocle bream (*Parascolopsis*) was also caught with the threadfin breams in the deeper waters in small quantity. Vivekanandan (1990) reported that *N. japonicus* were dominant in shallow waters while *N. mesoprion* (*N. randalli?*) was dominant in the deeper waters. Reuben *et al.,* (1989), while assessing the demersal resource between 1961- 1985, along northeast coast of India observed that threadfin breams were under exploited in the region. Nair and Jayaprakash (1986) observed that *N. mesoprion* and *N. japonicus* were dominant in the catch from 35-40 m depth off Kochi during monsoon. Kasim *et al.,* (1988), based on the landing figures reported that threadfin breams formed 50% of the perch resources. In the trawling grounds at 10-80 m depth between Lat.17° and 18° N. along the east coast of India the nemipterids formed about 14.7% of the catch (Shastry and Chandrasekhar, 1986). Landing along Waltair comprised of *N. mesoprion* measuring 70 to 140 mm (Rao, 1989). Along the Karnataka coast, major part of demersal resource consisted of threadfin breams (Biradar, 1987). Murty *et al.* (1992) observed that *N. japonicus* and *N. mesoprion* formed two important species in the fishery along Kerala State. Sudarsan (1993) opined that quantitatively nemipterids were one of the most important marine resources of India. The results of survey conducted on board FORV Sagar

Sampada (Kunjipalu, 1990; Nair and Reghu, 1990; Nair *et al.*, 1996; Sivakami, 1990; Panicker *et al.*, 1993; Bensam *et al.*, 1996, and Menon *et al.*, 1996) also revealed the abundance of Nemipterids in the deep waters along our coast, especially in the southwest sector.

3. MATERIAL AND METHODS

3.1. Material

The samples of *Nemipterus mesoprion, Nemipterus japonicus* and *Parascolopsis aspinosa* were collected from the survey vessels of Fishery Survey of India, viz. M. F. V. *Matsya Shakti* and M. F. V. *Matsya Vishwa,* based at Mormugao. Samples were also collected from the landing centers at Betim jetty at weekly intervals and on a few occasions at Vasco-da-Gama. The samples were collected for two years from February 1996 to January 1998.

Nemipterus japonicus

The present study is based on a total of 2182 individuals ranging from 83 mm to 261 mm in total length and comprising of 1005 males, 1009 females and 168 indeterminates.

Nemipterus mesoprion

The study is based on 3400 individuals ranging from 80 mm to 271 mm in total length and comprising of 1919 males, 1345 females and 136 indeterminates.

Parascolopsis aspinosa

The study is based on 511 individuals ranging in size from 90 mm to 207 mm in total length and comprising 239 males and 272 females.

The rare specimens examined during this study included

One specimen of *Parascolopsis eriomma*, a spent female with a total length of 240 mm and weight of 201 gms. This specimen was collected from the central west coast of India on board M. F. V. *Matsya Vishwa*. The sample came from 145 m depth in the demersal trawl.

Two female specimen of *Parascolopsis boesemani* caught in a demersal trawl on 28.8.1998 by M. F. V. *Matsya Vishwa*, of Goa (Lat. 14° 58' N Long 73° 14' E) from the depth between 110-115 m. The first specimen was of 107.5 mm in total length (TL), 82.5 mm in standard length (SL). The second specimen was 133 mm in TL, 108 mm in SL, and was captured from the same locality as the holotype.

3.2. Methods

3.2.1. Taxonomy

The specimens were deep-frozen before they were brought to the shore for examination. The colour and pigmentation was observed in fresh condition after thawing. All measurements were taken using vernier calipers to the nearest 0.1 mm. All the measurements and counts were made following the methods adopted by Russell and Golani (1993).

3.2.2. Laboratory Observations

Samples of *N. japonicus, N. mesoprion* and *P. aspinosa* were brought to the laboratory and the data on length, weight, sex, stages of maturity, weight of gonads and the gut contents were recorded for each specimen. The total length - the length of fish from the tip of snout to the tip of lower lobe of caudal fin in the case of *N. japonicus* and *N. mesoprion;* to the upper lobe in the case of *P. aspinosa* was measured to the nearest mm. The weight was recorded to the nearest 0.5 g. Fish were cut open, the sex and the stages of maturity were noted. Gonads were dissected out and weighed to the nearest 0.01 g using an electronic microbalance. Stomachs and ovaries were preserved in 5% neutral formalin for further analyses.

3.2.3. Length-Weight Relationship

The parabolic equation $W = aL^b$ (Le Cren, 1951) representing the length-weight relationship was used which can be written in the linear form of the type $Y = A + bX$ where $Y = \log W$, $A = \log a$ and $X = \log L$. The regression analysis was carried out in stages. The regression statistics was first computed for each sex separately. To test whether the regression coefficient 'b' computed for each sex was significantly different from a parabolic value of b = 3, t-test (t_s = b-3 /SE_b) was carried out where, 'b' is the regression coefficient and SE_b is the standard error estimate of the regression coefficient.

The regression coefficients computed for each sex were tested for significant difference by analysis of covariance (Snedecor and Cochran, 1967) to see if common (pooled) regression coefficient can be computed for each species.

A common (pooled) regression equation was arrived at when the regression lines between males and females did not significantly differ.

3.2.4. Relative condition factor (K_n)

The data used for length-weight relationship was also utilized for calculating the relative condition factor. The expected weight ' $\hat{W}$ ' was calculated from the equation for length-weight relationship suggested by Le Cren (1951). In order to find out the relation, if any, between spawning seasons and relative condition factor, monthly mean values were calculated for males and females separately for the whole period of study (February 1996 to January 1998) to analyze the fluctuation in the relative condition factor. To study the fluctuations if any in the relative condition factor with length of the fish, K_n values calculated for individual fish were grouped into

10 mm size groups and the average values were calculated for each size group.

3.2.5 Food and feeding habits

For studying the food and feeding habits 2014 specimen of *N. japonicus,* 3264 specimen of *N. mesoprion* and 511 specimen of *P. aspinosa* were used. For qualitative and quantitative analysis 810 guts of *N. japonicus,* 946 guts of *N. mesoprion* and 203 guts of *P. aspinosa* were used.

Qualitative analysis

Qualitative analysis consisted of identification of the entire organism in the stomach contents. The stomach contents were emptied into a petri dish and each food item identified. The identification of different organisms was usually done upto the generic level and whenever possible up to the species level, depending on the state of digestion. Identification of individual items even to the generic level was not always possible due to the semi-digested condition and the advanced state of digestion of food inside the stomach. Hence, such food items were broadly categorized as remains of crustacea, fish or miscellaneous matters.

Quantitative analysis

Quantitative analysis was carried out by using volumetric and occurrence method (Hynes, 1950; Pillay, 1952). The volume of food item was measured by displacement method and weight was recorded by using the micro-electronic balance with an accuracy of 0.001mg.

Frequency of occurrence of food items, volumetric and gravimetric percentage of the same in the pooled gut contents was calculated for assessing the importance of different prey items. Overall importance of each prey was assessed using the index of relative importance (IRI) suggested by Pinkas *et al.* (1971).

IRI = F (N + W)

Where, F = Percentage of frequency of occurrence

N = Percentage number and

W = Percentage weight.

Food in relation to length and maturity of fish was studied by tabulating the percentage occurrence of different food items by weight against size.

Feeding intensity

Feeding intensities during various months and in relation to the size of the fish were studied by the degrees of fullness of the stomachs. The fullness of the stomach was classified as ' gorged' when the stomach was swollen with food, and the walls of the stomach fully stretched in size; 'full' when the distention of stomach wall was not visible but food content appeared fully packed, '¾ full', '½ full', '¼ full', depending on the relative fullness and space occupied by the stomach contents. Stomachs were designated 'trace' when the contents were lesser than '¼ full' containing traces of food, and 'empty'. Fish with the gorged and full stomachs were considered to have been feeding actively, those with '¾ full' and '½ full' were considered to have been feeding moderately, while '¼ full' and 'little' were considered to denote poor feeding activity. Food in relation to size of the fish was studied by tabulating percentage occurrence of each food item against the size of the fish.

3.2.6. Reproduction

Gross examination of gonads

The length, weight, sex and stage of maturity of individual fish during each month were noted. The ovaries were removed and preserved in 5% neutral formalin for further study.

Maturity stages

Maturity stages of females were classified based on macroscopic appearance of the ovaries and microscopic characteristics of ova. In males, maturity stages were classified based on macroscopic appearance of testes. The macroscopic observations were based on fresh material, whereas, the microscopic observations were made on 5% formalin preserved material.

The scheme of classifications of maturity into 7 stages used in the present study was the one given by (ICES) followed by Dan (1977) for *N. japonicus* and Murthy (1981) for *N. mesoprion*. Similar classification was followed for the *P. aspinosa*.

Growth of ova

To study the growth of ova, diameter of intra-ovarian eggs were measured and the growth was traced with the development stages of the gonad. For this study, small pieces of ovaries from the anterior, middle and posterior regions were cut and then ova teased out on to a glass slide. Diameters of ova were measured by calibrated ocular micrometer mounted on the eyepiece of a compound microscope. About 600-800 ova were measured from each gonad and these were grouped into class width of 3 ocular divisions (o.d) and frequency polygons were drawn for all stages of maturity for the purpose of studying the progression of growth of ova from one stage to another.

Gonado-somatic index

For calculating the gonado-somatic index (GSI), the weight of individual fish was noted and the gonads were removed carefully and weighed in a microbalance after removing the excess moisture using a blotting paper. The GSI was calculated using the formula, gonad weight x

10^3/fish weight (June, 1953; Yuen, 1955; James, 1967). The average values of the GSI were plotted against months.

Fecundity

Formalin preserved ovaries of the V stage were utilized for fecundity estimations. The excess moisture was drained out and the ovaries were weighed to the nearest mg. A small sample from each ovary was removed and weighed to the nearest 0.001mg. The numbers of matured and maturing ova in the sample were counted. These numbers were extrapolated to the total weight of the ovary. The number of mature and the maturing ova formed the fecundity of two batch of eggs released (Murty, 1984; Murty *et al.*, 1992) by *N. japonicus* and *N. mesoprion.* Similar method was followed to *P. aspinosa,* as during the course of study the development of ova to maturity in this species was found similar to *Nemipterus* spp.

Fecundity in relation to length, weight and gonad weight

The log-linear relationships i.e. fecundity with length of fish, weight of fish and ovary weight were calculated by using least square methods. The correlation coefficient ' r ' was calculated to test the significant relationship if any between the paired variables.

Size at first maturity

The size at first maturity was determined by (a) plotting cumulative percentage of mature (stage III and above) fishes against size. Size at first maturity was determined for males and females separately. In addition to this method increase of relative condition factor K_n with respect to size of fish (Hart, 1946), was used to determine the size at first maturity.

Sex -ratio

Sex ratios were studied with respect to months and size groups of fish. Sex ratios were tested for significant difference (H_0 = 50:50) by employing Chi-square test.

3.2.7. Growth, mortality and exploitation

Age and rate of growth of the fishes are traditionally determined by use of growth checks on the scales. In the present study the length frequency data were analysed to trace the growth over relative age.

Estimation of growth parameters

Length based studies were made to estimate the growth parameters using the samples collected from February 1996 to January 1998. The fish were grouped together as all the samples were obtained from a single type of gear, the trawl net, which formed the most important gear for nemipterids along Goa coast. Length frequency data was first computed by grouping them in to 10mm-class width. These data formed the basis for calculation of growth rate as well as relative age of fish. For this purpose the computer software FiSAT FAO-ICLARM - Stock Assessment Tools; ver. 1.0; (Gayanilo *et al.*, 1996) was used.

A rough estimate of the growth parameter (L_∞) was initially made using the modified Wetherall plot (Wetherall *et al.*, 1987). Initial values of L_∞ for all stocks were obtained by plotting $\bar{L} - L'$ on L' (Wetherall, 1986 as modified by Pauly 1986), i.e.,

$$\bar{L} - L' = a + bL'$$

Where $L_\infty = a/-b$, and $Z/K = (1+b)/-b$

$\bar{L}$ is defined here as the mean length, computed from L' upward, in a given length-frequency sample, while L' is the limit of the first length class used in computing a value of $\bar{L}$.

The values obtained were used to facilitate the estimation of the parameters L_∞ and K of the von Bertalanffy growth formula (VBGF) through ELEFAN 1 (Pauly and David, 1981; Pauly, 1986) routine of the FiSAT program. Based on this, the automatic search routine and response surface analyses were run to get the best estimates of L_∞ and K.

Growth equation

The von Bertalanffy growth formula (von-Bertalanffy, 1938; 1957) was used to describe the growth. The growth equation (VBGF) by length in the following form

$$L_t = L_\infty[1-e^{-K(t-t_o)}]$$

(Where,

L_t = Length at age 't'

L_∞ = asymptotic length

K = catabolic growth coefficient

t_o = age at zero length).

was fitted for the relative age-length data obtained by the methods described earlier.

The seasonally oscillating growth curve was proposed (Longhurst and Pauly 1987; Somers, 1988; Soriano and Pauly, 1989) where **C,** is the constant expressing the amplitude of growth oscillations and $\mathbf{t_s}$ is the onset of sinusoid oscillations with respect to $t_o = 0$. Seasonal oscillations in growth are caused by temperature fluctuations, and slight seasonal fluctuations of temperature such as that occurring in the tropics are sufficient to generate seasonally oscillating growth curves. This form of VBGF equation can be written as

$$L_t = L_\infty\left(1-e^{-K(t-t_o)) + CK/2^{\pi} \sin 2^{\pi}(t-t_o)}\right)$$

This form has not been used in the present study to reduce the subjectivity in the estimates caused by uncertain inputs.

The L_∞ and K values thus obtained were used to estimate total mortality (Z), following the catch curve method. The natural mortality coefficient (M) was estimated by applying Pauly`s (1980) empirical formula.

Estimation of mortality rates

The death process affected by natural causes and fishing, constitutes mortality. It is expressed as total mortality rate or instantaneous total mortality rate and denoted by the symbol 'Z'.

Natural mortality is mainly due to predation, including cannibalism and other factors such as disease, parasitic infection, starvation, old age and environmental conditions acting independently. It is expressed as instantaneous rate of natural mortality and denoted conventionally as 'M'.

Fishing mortality depends on the fishing activity and is expressed as instantaneous rate of fishing mortality (F), which is assumed to be directly proportional to the fishing effort (f).

For the estimation of instantaneous mortality rate (Z), a number of methods like Beverton and Holt (1956), Alagaraja (1984), length converted catch curve (Pauly, 1983b) and modified Wetherall *et al.*, (1987) method are in vogue.

Instantaneous rate of total mortality (Z)

The estimate of instantaneous rate of total mortality 'Z' by the length converted catch curve method described by Pauly (1983, 1984a, 1984b) was followed in the present study. This is also known as the linearised length converted catch curve method.

To make the catch curve usable for length data the following equation,

$$\ln C(t, t + \Delta t) / \Delta t = c - Z^{*}(t + \Delta t/2)$$

is to be replaced by length (L's) in place of ages (t's). By making use of inverse von-Bertalanffy equation shown below,

$$t(L) = t_0 - 1/K * \ln(1 - L/L_\infty)$$

the time taken for the average fish to grow from length L1 (lower limit) to L2 (upper limit) and the age interval mid-points are derived for making use of the equation given below.

$$\ln\{C(L1, L2)/\Delta t(L1, L2)\} = c - Z * t\{(L1 + L2)/2\}$$

where C= numbers caught in each length class, Δt = time taken to grow from lower limit (L1) to upper limit (L2) in each length class. Then the equation becomes linear where,

y is, $\ln\{C(L1, L2)/\Delta t(L1, L2)\}$ and

x is, $t\{(L1 + L2)/2\}$.

This has the form of Y= a+bx where the slope (b) is the '-Z' of the equation. Hence the negative value of the slope gives the value of total mortality, 'Z'.

Natural mortality (M) estimates

In nature, natural mortality rates vary according to the stage of life of the fish. Maximum mortality rate occurs in the early juvenile stages and during advanced age. In general, natural mortality remains constant when the longevity of the species in natural conditions remains relatively constant. Further, shorter longevity, higher is the natural mortality rate. This is especially so among tropical fishes.

Natural mortality rate 'M' is generally difficult to measure. The problems related to the estimation of 'M' have been discussed by many authors. Mortality is linked directly to longevity (Tanaka, 1960; Holt, 1965; Cushing, 1968; Sekharan, 1976; Pauly, 1980a; Alagaraja, 1984) and indirectly to growth coefficient 'K' (Beverton and Holt, 1959 and Srinath, 1998). It is also related to other growth parameters like L_∞ and W_∞ (Sparre *et al.,* 1989), maturity (Rikhter and Efanov, 1976), and gonad weight (Gunderson and Dygert, 1988). Several simple methods are available to estimate mortality based on the above principles. Some of these methods are widely in use while the others may become popular in future. The best and perhaps the most reliable method for the estimation of natural mortality is that of regressing 'Z' against effort. Generally in the tropical multi-species, multi-gear system the apportionment of effort for a particular species is difficult. Moreover, in the present study, data is available for only two years. This method requires time series data for a number of years. The natural mortality coefficient is generally determined by employing Cushing's (1968) formula, Pauly's (1980), Srinath's (1998) empirical formula and by Rikhter and Efanov's (1976) method. In the present study natural mortality 'M' was estimated by Pauly's (1980a) empirical formula .

Pauly's empirical formula

Generally, most of the biological processes take place faster at higher temperatures within certain limits. Hence, one could imagine the natural mortality to be related to the environmental temperature of the actual fishing ground and their growth coefficient and asymptotic length. Based on this principle, Pauly (1980a) proposed the formula

$$\text{Log } 10M = -0.0066 - 0.279 \log 10 L_\infty + 0.6543 \log 10 K + 0.4634 \log 10 T$$

Where, M = the instantaneous rate of mortality per year,

L_∞ = asymptotic length in cm,

K = annual growth coefficient and

T = average annual sea surface temperature in degree Celsius.

Along the Goa coast, the mean annual temperature around 10 m depths was between 24.4 to 28.4°C (Ansari *et al.*, 1977) and at around 100 m it varied from 24.5 to 25.6°C (Harkantra and Parulekar, 1981). The annual average demersal temperature off Goa coast between 30-50 m ranged between 27- 28°C and, between 50-150 m ranged between 23-28°C (Rameshbabu *et al.*, 1980, Naidu *et al.*, 1999). Therefore the annual average habitat temperature of *P. aspinosa* and for *N. mesoprion* was taken as 24°C and 25°C respectively. For *N. japonicus*, which is mainly a shallow water resident the annual average habitat temperature was 28.5° C (Vivekanandan, 1990)

Fishing mortality estimates :-

The instantaneous fishing mortality rate (F) was estimated from the relationship:

$Z = F + M$, therefore $F = Z - M$

Resource distribution and fishery

The data on fishery resource and details of sampling was obtained from the Fishery Survey of India. The period of data used for analysis was from 1989 to 1999 for shallow water (30-50 m) and from 1983 to 1999 for deeper waters. The average catch rates for the different months were computed for further analysis.

Vessel and gear

The data collected on board survey vessels attached to the Mormugao Zonal base of Fishery Survey of India *viz.* M. F. V. *Matsya Shakti* and M. F. V. *Matsya Vishwa* was used for this study. Both the survey vessels are built with same specification and used identical gears for survey. The major specification of vessel and gear is given in table below.

Length Over All (LOA)	Gross Registered Tonnage (GRT)	Brake Horse Power (BHP)	Endurance (Days)	Fishing gear type	
				Fish Trawl	Shrimp Trawl
36.5 m	312	760	20 days	27 m	42 m

The data was segregated to three depth zones as below. The sampling effort put to collect data from the three depth zones is also given in the same table.

Depth zones	Depth range (m)	Fishing effort (hrs.)
Zone -I	Upto-50	527.16 (1989 to 98)
Zone- II	51 –100	1997.74 (1983 to 98)
Zone –III	101-200	1157.50 (1983 to 98)

For the time series analysis, the monthly catch data was regrouped to different seasons depending on the fishing activity in the area of study. As the onset of monsoon makes a large change in the quality of sea water in the demersal region the first three months of monsoon (June – August) were taken as monsoon months. The three months following monsoon phase, when the demersal region gets warmed is treated as post monsoon (September to December) period. The demersal fishing along Goa coast begins around August - September in shallow waters and later in the deeper waters. The winter months of December, January and February are placed together leaving the summer months of March, April and May to make the last trimester before the onset of monsoon. The quarters separated based on the fishing activity is given below.

Season I. (Winter)	December, January and February
Season II. (Summer)	March, April and May
Season III. (Monsoon)	June, July and August
Season IV.(Post- monsoon)	September, October and November.

Four seasons were identified with reference to the fishing season. To identify the trend in catch, trend lines were fitted on to the graph by plotting the moving averages (five quarters).

Estimation of the biomass and potential yield

The monthly catch data on the nemipterids for the period from December 1996 to December 1998 collected by the survey vessels M. F. V. *Matsya Vishwa* and M. F. V. *Matsya Shakti* was used for the study. The data was regrouped to each of the depth zones classified above. The zone wise effort is given below.

Depth Zones	Depth Range (m)	Fishing Effort (Hrs.)
Zone –I	Up to 50	127.25
Zone –II	51-100	168.666
Zone –III	101-200	120.25

The catch per unit effort (CPUE) was calculated for all nemipterids for different months. The average catch rates were computed for three bathymetric zones from 1996 to 1998, which was used to calculate the biomass by swept area method. Average density for each zone was calculated assuming 40% of head rope as effective width of sweep, the area swept in one hour is calculated as below.

$$Sa = .4*(HR/1000)*Vs*1.852$$

Where,

Sa = Swept area;

HR = Head rope Length;

Vs = Vessel speed (in nautical miles) while trawling.

The density of fish (kg/km^2) is calculated by the formula shown below, assuming that only 50% of the fishes in the path are caught in the net.

Di = CPH/(Sa*c)

Where,

Di	=	Density of fish (kg/Sq.Km)
CPH	=	Catch in Kg. per hour
Sa	=	Swept area in one hour in Sq. Km.
c	=	Catchability coefficient,

The catchability coefficient was assumed to be 0.5 (Vijayakumaran and Naik, 1990, 1991.)

The MSY was computed following the generalised version of Gulland's estimator proposed by Cadima (in Troadec, 1977) which has the form:

$$MSY = 0.5 * Z * \bar{B}.$$

Where, $\bar{B}$ is average annual biomass and Z is the total mortality. The average Z of two species viz. *N. mesoprion* and *N. japonicus* was used for computation.

The fish landing figures estimated by the Directorate of Fisheries, Government of Goa were used in the analysis of fish stocks.

4. RESULTS

4.1. SYSTEMATICS

During the period of study, five species belonging to the Family Nemipteridae were identified along the Goa coast. Two species belonged to genus, *Nemipterus, viz. N. japonicus* and *N. mesoprion,* and three belonged to genus, *Parascolopsis, viz. P. aspinosa, P. eriomma* and *P. boesemani.* The systematic position of the nemipterids is presented below.

Systematic position of Nemipteridae :

Class	: Osteichthyes
Sub Class	: Teleostomi
Super Order	: Acanthopterygii
Order	: Perciformes
Sub order	: Percoidei
Family	: Nemipteridae

Characters of taxonomic importance :

Body is oblong and compressed slightly, terminal mouth, with rows of small conical teeth and a few canines in front and none on palate and vomer. Dorsal fin continuous, with 10 spines and 8-11 soft rays. Anal fin with 3 spines and 5-8 soft rays. Pelvic fin with 1 spine and 5 soft rays. A medium sized auxiliary scale present above each pelvic fin. Pelvic and upper lobe of caudal often with filamentous rays. Caudal forked. Head naked, scales beginning above the eyes. Cheeks often with 3-4 rows of scales. Scales on body ctenoid and deciduous.

Key to genera.

Suborbital scaly or naked, spines weak or absent, Posterior margin of the sub-orbital smooth, finely serrate, or with a few small denticulations, posterior margin of pre-opercle finely denticulate or smooth, canine teeth in jaws absent, or present only anteriorly in upper jaw. Scales on top of head reaching forward to or in front of middle of eyes. Temporal parts of head scaled.

1. Posterior margin of sub-orbital without spine; 3 transverse scale rows on pre-opercle: ....*Nemipterus.*
2. Posterior margin of sub-orbital spine weak or absent; no canine teeth on jaws; 4-6 transverse scales on preopercle; second anal spine longer and robust than third spine... ....*Parascolopsis.*

Genus: *Nemipterus* Swainson, 1839:

Nemipterus Swainson, 1839, Nat. Hist. animals, 2, Fishes; 223. Type species: *Dentex filamentosus* Valenciennes in C. & V. (1830b), by original designation. Synonyms: *Spondylisoma* Cantor, 1850; *Synagris* Güinther, 1859

Description:

These are small to medium sized fishes with slender or moderately deep, laterally compressed body, covered with ctenoid scales, scales on top of head reaching to a level of middle of eye. Pre-opercle scaly with 3 transverse scales, flange naked. Teeth small and conical or villiform, some species with small pointed or re-curved canine teeth anteriorly. Single dorsal, 10 spines and 9 soft rays. Anal fin with 3 spines and 7 soft rays. Pectoral fin short to moderately long, with 2 un-branched and 13 to 16 branched rays. Pelvic short or long with 1 spine and 5 soft rays. Caudal fin forked upper lobe rounded, pointed, may be produced to form filamentous extension. Colour variable, usually with pink and yellow shades or lines.

Key to species

1. Upper lobe of caudal fin filamentous and yellow in colour, Dorsal fin membrane having a median band which widens posteriorly, anal fin membrane with reticulate pattern. Pelvic short and pectoral fin very long **N. japonicus**
2. Upper lobe of caudal fin filamentous and red in colour, Dorsal fin with reticulate pattern, anal fin membrane with a median yellow band. Pelvic and pectoral fin very long **N. mesoprion**

1. Nemipterus japonicus (Bloch 1791): Plate I, Fig. 1

Sparus japonicus Bloch, 1791, Naturges. Ausländ. Fisches., 5: 110.

Synonyms: *Dentex blochii* Bleeker (1851c). *Synagris japonicus* Day 1875 in Day (1889); *Nemipterus japonicus* (Bloch) in Talwar and Kacker (1984)

Description:

D X, 9; P ii, 16; A III, 7; C 18, Ll 43-48, Ltr. 3/10 ½ gill rakers 14– 17

Body depth 2.7 to 3.5 in SL; snout length equal to or greater than diameter of eye; diameter of eye 3.2 to 4.4 in HL; eye above the level of the line connecting the tip of the snout and upper base of the pectoral fin; interorbital width 1.0 to 1.9 in eye; suborbital depth 1.0 to 1.9 in eye diameter; pre-opercle naked about 1.1 to 2.0 in scaly width; pectoral fin very long, 1.0 to 1.3 in head length, reaching to or just beyond the level of origin of the anal fin; pelvic fin moderately long, 1.2 to 1.6 in head length reaching to or just beyond anus; caudal fin moderately forked, upper lobe slightly longer than lower and produced into a short or moderately long filament; four or five pairs of small re-curved canines anteriorly in upper jaw.

Colour:- Body pinkish on upper part, paler and becoming silvery below; a golden sheen appear on top of the head behind the eye; 11-12 pale golden yellow strips from behind the head to caudal fin. A bright orange red blotch below the origin of the lateral line; dorsal fin rosy with orange margin and a broad pale lemon stripe near the base of the fin, narrow anteriorly and widening on posterior part of the fin; anal fin milky white with faint wavy lines forming reticulate pattern; pectoral fin translucent pink, pelvic pale pink, caudal fin pink, tip of the upper lobe and the filament bright yellow.

2. *Nemipterus mesoprion* (Bleeker, 1853): Plate I, Fig. 2

Dentex mesoprion Bleeker, 1853a, Nat. Tijdschr. Ned. -Indië 4:255 (Priaman, Sumatra). *Nemipterus mesoprion*: Weber and Beauport, 1936. *Synagris mesoprion Fowler, 1938.*

Description:

D X, 9; P ii, 16; A III, 7; C 18, Ll 40-45 Ltr 3/10 ½ gill rakers 12- 15

Body slender, depth of the body 3.2 to 3.5 in SL; snout length about diameter of eye; eye diameter is about the 2.7 to 3.7 in head length; eye above the level of line connecting the tip of the snout and upper base of the pectoral fin; interorbital width 1.4 to 2.0 in eye; suborbital depth 1.7 to 4.0 in eye diameter; pre-opercle naked with 1.2 to 3.0 in scaly width; pectoral and pelvic fins very long, reaching to or just beyond level of origin of anal fin; pectoral fin 1.0 to 1.4 in head length, pelvic fin 0.9 to 1.4 in head length; caudal fin forked, upper rays produced into long filament; 3 to 4 pairs small re-curved canines anteriorly in upper jaw.

Colour:- Upper body and head rosy, silvery below; head with yellow streaks from eye to below nostrils and from eye to middle of upper jaw; 2 broad pale yellow lines along flanks; a red spot below the origin of the lateral line; dorsal fin pale bluish, closely packed yellow pigmented marking making a reticulate pattern on lower three fourth of the margin edged with red; anal fin pale bluish with a narrow yellow median stripe; caudal fin pink, caudal filament moderately long and reddish; pelvic fin whitish; pectoral fin transparent; peritoneum pink.

Genus: *Parascolopsis* Boulenger, 1901

Parascolopsis Boulenger, 1901, Ann. Mag. nat. Hist., (7) 7: 262. Type species *Parascolopsis townsendi* Boulenger, 1901, by monotype.

Description:-

Small fishes laterally compressed body. Villiform teeth in tapering band in both jaws. Canine teeth absent. Gill rakers short and stubby 8-19 in first arch. Second anal spine usually longer and more robust than the first and third. Pectoral long and with 2 un-branched and 12-15 branched rays. And pelvic fin long to moderately long with one spine and 5 soft rays. Anal with 3 spines and 7 soft rays. Scales on top of the head reaching forward to the level of middle of the eye or posterior nostrils. Suborbital naked, posterior margins smooth. Preopercle scaly with 4 or 5 transverse rows, lower limb naked or scaly, posterior margin serrated. Upper margin of preopercle with small flat embedded spine. Lateral line scales 34-40, usually 2½ to 5 transverse scales above the lateral line. They are bright coloured fishes, usually red, rosy, orange, with yellow or silver markings.

Key to species.

1. Dorsal with a black blotch between 7-10 spine, posterior margin of suborbital smooth or few tiny spines....... ***P. aspinosa***
2. Dorsal with a blood red blotch between 5-10 spine, posterior and anterior margin of suborbital finely denticulated..... ***P. boesemani***
3. Dorsal no blotch, body with a median yellow stripe, Gill rakers 17-18, suborbital and maxilla naked......... ***P. eriomma***

1. Parascolopsis aspinosa (Rao and Rao1981) Plate II Fig. 1

Parascolopsis aspinosa. (Rao and Rao1981) Proc. Kon. Akad. Wetensch., Ser. C, 84:134, Fig. 1,3 (Waltair, India). Synonym: *Parascolopsis jonesi* Talwar (1986)

Description:

D X, 9; P ii, 14-15; A III,7; C 18, Ll 35- 36, Ltr 3/10 ½ gill rakers–10-11.

Body moderately deep 2.46 to 2.98 in SL, head 3.1-3.9 (3.3) in SL, head length lesser than body depth, depth 0.8-0.92 (0.84) in head, snout short and less than eye diameter bluntly rounded 4.76-5.81 (5.7) in head, eye 2.48-2.82 (2.71) in head, diameter of the eye is greater than snout length 0.39-0.67 (0.48) in snout, interorbital width 0.92-1.1 (1.0) in eye; sub-orbital narrow, least depth is 2.16-2.62 (2.53) in eye. Dorsal fin length 1.7-2.12 (1.9) in SL, 5th dorsal ray longest 0.98-1.04 (1.03) times length of longest spine (4th dorsal spine). Anal fin length 5.1-5.82 (5.53) in SL. first anal spine 1.67-1.93 (1.83) in second, second 1.31-1.67 (1.45) in 3rd. Pectoral fin moderately long, reaching to the level of vent and 0.98-1.26 (1.1) in head. Pelvic fin moderately long, reaching to level of vent 1.30-1.54 (1.43) in head. Pectorals 1.12-1.45 (1.3) in pelvic.

Colour:- Body is rosy orange. Four saddles reddish in colour on the back and 2 on the caudal peduncle. The suborbital and pre-opercle edge is silvery- yellow. A black blotch at the base of the dorsal fin lying between eighth spine and the first ray. Dorsal fin has orange edge, anal fin rosy pectoral fin golden yellow.

2. Parascolopsis eriomma (Jordan & Richardson, 1909) Plate III, Fig. 1

Scolopsis eriomma 1909: Mem. Carnegie mus. 4:188, pl. 70 (Formosa; Ceylon)

Description:

D X, 9; P ii, 16; A III, 7; C 18, Ll 36, Ltr 3/10 ½ gill rakers – 17

Body moderately deep 2.76 in SL, head 3.3 in SL, head length lesser than body depth, depth 0.84 in head, snout short, bluntly rounded 5.7 in head, eye 2.71 in head, diameter of the eye greater than snout length 0.48 in snout, interorbital width 1.0 in eye; suborbital narrow, least depth is 2.53 in eye. Dorsal fin length 1.9 in SL, 5^{th} dorsal ray longest 1.03 times length of longest spine (4^{th} dorsal spine). Anal fin length 5.53 in SL. first anal spine 1.83 in second, second 1.45 in 3^{rd}. Pectoral fin moderately long, reaching to level of vent and 1.1 in head. Pelvic fin moderately long, reaching to level of vent 1.43 in head. Pectorals 1.3 in pelvic.

Mouth rather small, snout short, maxillary reaching beyond the anterior margin of the pupil. Jaw teeth villiform. Scales on top of head extending forward to mid-pupil; snout naked; suborbital naked, with small spine at the upper corner and fine denticulation at posterior margin. Premaxilla naked, pre-opercle with 5 transverse scale rows and broad naked flange. Posterior margin of preopercle finely denticulate. Dorsal fin emarginate, caudal fin slightly forked, gill rakers spatulate compressed with 9 spines at distal margin.

Colour:- Body rosy with orange tinge, pale below lateral line. Golden yellow strip clearly marked at the mid posterior margin of pupil to the margin of the eye, which appear diffused into the preopercle and opercle in the form of a trace of indistinctive yellowish band which further continues up to the beginning of caudal peduncle. Preopercle and opercle with yellow reflections. Dorsal fin pink, spinous margin indistinct red. Caudal fin rosy pink, lower lobe pale yellow. Anal and pelvic fin milky white with light yellow shade, pectorals translucent yellow.

3. Parascolopsis boesemani (Rao & Rao 1981) Plate III, Fig. 2.

Scolopsis boesemani Rao & Rao 1981; Proc. Kon. Akad. Wetensch., Ser. C, 84:139,fig. 2,4 (Waltair, India)

Description:

D X, 9; A III, 7; P 16; Ll 39/41; Ltr 3 / 14; gill rakers 9.

Body moderately deep (2.7 – 2.5) in SL. Head (2.5 – 2.4) in SL. Head length is more than (0.9 -1.0 times) or equal to body depth. Snout short, rounded (5.4 - 5.2) in head length; eye (3.6 - 3.2) in head length; snout length lesser than eye diameter (1.5 to 1.6) in eye; Dorsal fin length (2.3 - 2.0) in SL. Inter-orbital width (1.1 - 1.3) times in eye; sub-orbital shallow least depth (4.8 - 4.8) times in eye; fourth or fifth dorsal spine usually longest, and (1.9 - 2.3) times length of first dorsal spine; 2^{nd} through fifth dorsal rays longest, (1.1 - 1.2) times length of longest dorsal spine, anal fin length (7.2 - 6.6) in SL; First anal spine (1.6 - 1.9) times in second; Second anal spine (1.0 - 1.0) times in third; pectoral fin long, reaching upto or beyond level of vent, (1.4 to 1.4) times in head; pelvic fins moderately long, not reaching to the level of vent (2.0 to 1.7) times in head;

Mouth moderate, maxillary reaching to about level of anterior margin of pupil. Jaw teeth villiform in narrow tapering bands in both jaws. Upper jaw with a series of small curved canines decreasing in size posteriorly on either side forming narrow band of teeth. However, lower jaw also has a band of teeth on either side but slightly smaller compared to teeth in upper jaw. Scales on top of head extending forward between eyes to about the level of posterior margin of pupil. Pre-opercle with 5 transverse rows of scales, its lower links naked.

Colour:- When fresh, the body of the fish is rosy pink, two greenish golden yellow bands run the entire length of the body. The upper stripe starts from the margin of eye (upper) reaching to the caudal fin base. The lower band starts from the base of the pectoral fin to the base of the caudal fin. Colour of the (i) Pelvic fin is pinkish orange in the anterior, milky white in the posterior, (ii) pectoral golden yellow at the base with pinkish periphery, (iii) Dorsal fin spinous region membrane cloudy at the notch with the red spot starting from 6^{th} spine extending upto the 10^{th} spine bordered with golden yellow pigmentation. A small pale blood red spot not very conspicuous, present between 1^{st} to 3^{rd} soft ray. Soft ray pinkish at the periphery. (iv) Light red blotch covering spinous portion and 2^{nd} soft ray of the anal fin. Anal fin is milky white. (v) Caudal fin is light pink in colour with red blotch in the center paling towards the lower portion. Body is orange red with three dark orange bands. 1^{st} band is in front of 1^{st} dorsal, 2^{nd} from the orange blotch of dorsal fin to the anal fin merging with the colour of the anal fin membrane. 3rd from the end of dorsal fin to the end of the anal fin covering half of the caudal peduncle.

Colour when preserved in formaldehyde: - Pale brown below lateral line and darker above, three dark blackish brown strips running parallel to the body below lateral line, paler towards the ventral side. Three bands across the body visible as blotches on the 1st stripe, which is darkest of the three stripes.

In Table 1 the description of *P. boesemani* (Rao & Rao) is compared with specimens collected off Goa and other red spot parascolopsis.

4.2. LENGTH - WEIGHT RELATIONSHIP AND RELATIVE CONDITION FACTOR

Length - weight relationship

The length-weight relationship of *N. japonicus, N. mesoprion* and *P. aspinosa* were studied (Le Cren, 1951) by plotting the parameters to find their fit. The plots are depicted in Figs. 1 to 5. The relationship was linearised by log transformation, and the fit is given within the corresponding figures. The log values of length-weight were distributed in a straight line in the form Y = a + bx. Therefore the length- weight relationship were fitted by least- square method using the transformed parameters. In order to understand these aspects the length-weight relationship of *N. japonicus, N. mesoprion* and *P. aspinosa* were fitted. The regression lines of males and females of these species were tested for significant difference by analysis of co-variance and the results are presented in Tables 2, 3 and 4. The length weight relationship were fitted by least- square method separately for males and females of the three species and the results are given below.

Nemipterus japonicus

The length-weight relationships for two sexes are;

For males: Log W = -1.8757222469+3.005113817 * log L

$$\text{Or } W = 0.013313049*L^{3.005113817} \quad (r = 0.968024931)$$

The slope of the regression line was not significantly different from

H_o: $\beta = 3$, ($t = 0.208326255$, $\alpha = 0.05$, d. f. = 1004)

For females: Log W = -1.752262272+2.914780905* log L

$$\text{Or } W = 0.017690403L^{2.914780905} \quad (r = 0.979720945)$$

The slope of the regression line was not significantly different from

H_o: $\beta = 3$, ($t = 0.869342103$, $\alpha = 0.05$, d. f. = 1008).

The result of analysis of co-variance (Table 2) revealed that there was significant difference between the regression lines of males and females. Hence, a common length-weight equation could not be derived.

Nemipterus mesoprion

The length-weight relationships for two sexes are;

For males: Log W = -1.8883675264+3.001251561 * log L

Or $W = 0.013071479*L^{3.001251561}$ (r = 0.979742796)

The slope of the regression line was not significantly different from

H_o: $\beta = 3$, (t = 0.089338864, $\alpha = 0.05$, d. f. = 1345).

For females: Log W = -1.956219703+3.06475081* log L

Or $W = 0.011060641L^{3.06475081}$ (r = 0.968063077)

The slope of the regression line was significantly different from

H_o: $\beta = 3$, (t = 2.99080443, $\alpha = 0.05$, d. f. = 1919).

The result of analysis of co-variance (Table 3) revealed that there was significant difference between the regression lines of males and females. Hence, a common length-weight equation could not be drawn.

Parascolopsis aspinosa.

The length-weight relationships for two sexes are;

For males: Log W = -1.647925706+2.872986425 * log L

Or $W = 0.022494394*L^{2.872986425}$ (r = 0.966525818)

The slope of the regression line was significantly different from

H_o: $\beta = 3$, (t = 2.56324875, $\alpha = 0.05$, d. f. = 238).

For females: Log W = -1.758971955+2.973939837* log L

Or $W = 0.017419193L^{2.973939837}$ (r = 0.97540234)

The slope of the regression line was not significantly different from

H_o: $\beta = 3$, (t = 2.223946547, α = 0.05, d. f. = 271)

The analysis of co-variance (Table 4) revealed that there was no significant difference between the regression lines of males and females of the species (F = 2.501153963, α = 0.025, d. f. = 1, 507). Hence, a common length-weight equation could be proposed as below.

$$\text{Log } W = -1.708799286 + 2.928029294 * \log L$$

$$\text{Or } W = 0.019552429 * L^{2.928029294} \quad (r = 0.957860062).$$

The Slope of the regression line was not significantly different from

H_o: $\beta = 3$, (t = 2.223946547, α = 0.05, d. f. = 509).

Relative condition factor (K_n)

The relative condition factor was computed separately for males and females of each species by making use of their respective length-weight relationship. The average K_n values of both males and females for different months and different length classes were plotted for the three species separately.

Seasonal variation in K_n

Nemipterus japonicus

The computed values were plotted against respective months and are given in Fig. 6. The mean condition of the *N. japonicus* most of the time remained closer to 1. Among males, the K_n ranged from 0.814399 to 1.205307 and among the females it ranged from 0.911349 to 1.245196. The general trends in changes of K_n values of both sexes were similar. K_n for females were higher during most part of the year. In both sexes K_n remained more than unity during December to April.

Nemipterus mesoprion

The computed average for K_n value is provided in Fig. 7. The values of K_n ranged from 0.9219608 to 1.0313607 among the males and from 0.91141 to 1.0968156 among the females. The values of K_n among males increased from April and remained high until August, which were reduced by the end of monsoon period. Later the increase registered from November remained until April, however high values were observed only unto January. Among females, similar trend was seen with minor variations during some months. The condition remained higher from January until May and remained lower during monsoon months. After monsoon the condition improved from November and remained better until April. During the post monsoon months the condition remained close to unity.

Parascolopsis aspinosa

The monthly changes in the K_n value is given in Fig. 8. The data available on this resource is discontinuous. The values varied from 0.9282 to 1.1375981 for males and 0.9226716 to 1.139634 for females. The condition of females remained higher than that of males.

Size dependent fluctuation in K_n

Nemipterus japonicus

The variation in K_n with respect to body length is shown in Fig. 9. Among the males, the K_n ranged from 0.837003 to 1.073868 and among females from 0.890524 to 1.26171. Average K_n was closer to 1.0 and it was higher than unity in males up to the class interval 130 - 139 mm and among females from 150 - 159 mm to 190 - 199 mm. Among the smaller fishes, the K_n was closer to 1. The males beyond 180-189 mm class and females of the class interval beyond 200 – 209 mm had K_n values lower than 1.0. A reduction of K_n values of both males and females with the increase in size was a noticeable trend.

Nemipterus mesoprion

The size dependent fluctuation among the *N. mesoprion* is depicted in Figure 10. The relative condition factor ranged from 0.758591 to 1.024815 and among females it ranged from 0.913817 to 1.054491. Among the smaller males, the condition was higher than that of the bigger ones, and in males above 210 - 219 mm class the value of condition factor was lower than 1. Among the females, the condition increased in relation to size, but beyond 180 -189 mm the relative condition reduced. In both the sexes an increase in K_n between 90 - 99 mm and 110 - 119 mm; 140 -149 mm to 180 -189 mm; and around the class of 200 - 290 mm was seen, thus forming three separate peaks.

Parascolopsis aspinosa

The variation in K_n of the species in different length groups is presented in Fig. 11. The relative condition factor among the males ranged from 0.97457 to 1.14932 and among females from 0.977624 to 1.0616812. Highest K_n values were recorded for males of 190 - 199 mm size class. In most of the sizes, the males had higher K_n values than females. The values of K_n decreased from smaller size to larger fishes of about 130 - 139 mm, later the K_n increased as they grew further. This trend was noticed upto the biggest size recorded.

4.3. Food and Feeding

Qualitative and quantitative analysis

For studying the food habits, guts of 710 specimen of *N. japonicus,* 946 specimen of *N. mesoprion* and 203 specimen of *P. aspinosa* were analysed. Among *N. japonicus, N. mesoprion* and *P. aspinosa,* 59.8 %, 65.3 % and 60.3 % of guts were empty respectively. The qualitative and quantitative analysis of food is provided in tables 5-7.

The gut content analysis indicated that the crustaceans and fish formed the main food of these species. The other food items like polychaetes and molluscs, were also found in considerable quantities in the guts. At times bivalves, gastropods, echinoderms were also encountered. In *N. japonicus,* crustaceans, fishes, molluscs, polychaetes and miscellaneous matters formed 46.3, 36.4, 10.7, 6.1 and 0.5 percent of the gut content respectively. While, in *N. mesoprion* percentage of gut content constituted by crustaceans, fishes, molluscs, polychaetes and miscellaneous matters was 42.8, 36.2, 10.6, 8.2 and 2.2 respectively.

In the case of *P. aspinosa,* crustaceans formed 43.7%, fishes 33.4%, molluscs 17.3% and the miscellaneous items 0.7%, of the gut content.

Nemipterus japonicus:-

The stomachs most frequently contained crabs (17.7%) followed by Squilla (16.3%). Fish remains constituted next important constituent of the gut contents. Among the fishes, *Stolephorus* was most common. Polychaete worms were often encountered in the guts. The numerical, volumetric and gravimetric percentages of the food items found are presented in table 5. It can be seen that all the methods converged to indicate identical importance to various food items. Index of Relative Importance (IRI) of crustacean was 5773 where as that of fishes was 1791.

Nemipterus mesoprion:-

Food items found in the guts of *N. mesoprion* are given in the table 6. As in *N. japonicus*, most commonly encountered food was crustaceans followed by fishes. Among the crustaceans, prawns occurred more frequently, followed by amphipods. Among the fishes, *Stolephorus* dominated followed by *Saurida* sp. However polychaete worms and cephalopods were less frequent. The importance of the food items assessed by their numerical abundance, volumetric and gravimetric percentages are presented in the table 7. The Index of relative importance ascribed highest rating to crustaceans (5570) followed by fishes (1679).

Parascolopsis aspinosa

The food of this deep-water species was predominantly formed by crustaceans, as in the case of other nemipterids. Amphipods and prawns were the most frequently encountered food items. Guts with fish remains were also encountered frequently. The food of the *P. aspinosa* was not different from the other two nemipterids. The IRI score of crustaceans was 6921 and that of fishes was 1733.

Food composition during different months

The food items found in the stomachs of the three species investigated, in terms of gravimetric percentage are provided in table 8-10. Crustaceans followed by fishes were recorded in the stomachs of the species studied, during all the months. Crustacean appendages, cephalopod tentacles, heads and other remains of fishes, and worms were the important constituents of the food found in the stomachs.

Nemipterus japonicus :-

The month wise composition of food recorded from the guts of *N. japonicus* is provided in tables 8a and 8b. Crustaceans formed the major food of this species throughout the year. Highest percentage of crustaceans was found during February 97 (80.5%), March 97 (76.7%), January 98 (64.6%) and October 96 (56.2%). Among the crustaceans, prawns dominated the food during February 96 (46.1%), February 97 (36.2%) and January 98 (38.2%). Amphipods were dominant during May 97 (43.5). Fishes were mainly found in the guts during April 96 (41.8%) and December 96 (36.6%) while Cephalopods were dominant during November 96 (30.4%).

Nemipterus mesoprion :-

The food of this species was also comprised mainly of crustaceans. Amphipods were dominant in food during March 96 (44.6%), April 96 (34.6%) and December 96 (31.4%). Prawns formed major component of food during most of the months, especially during September 97 (48.1%), April 97 (38.3%), February 96 (36.4%), September 96 (34.4). Fishes were encountered in food during most of the year. The juveniles formed the bulk, while the guts were also found with heads of larger fishes. Fishes were common in food especially during November 96, 97 and August 96.

Parascolopsis aspinosa :-

The monthly variations in the food of monocle breams were not different from those of threadfin breams. Crustaceans formed the main food item dominated by Amphipods during January 97 (75%), prawns during December 97 (70.5%), October 97 (40.3%), and crabs during September 96 (48.2%), September 97 (62.8%). Fish and fish remains were encountered during April, September and December while cephalopods were encountered during September and October.

Food in relation to size.

The percentage composition of food items in fishes of various length classes of *N. japonicus, N. mesoprion* and *P. aspinosa* are given in tables 11-13.

Nemipterus japonicus:-

The smaller *N. japonicus* mostly fed on crustaceans. The fishes upto the size of 119 mm fed mainly on prawns and crabs. Stomachs with fish-remains were also observed in this group though in small quantity. Crabs formed 60.4% of food in fishes of 120-129 mm class and 55.5% in those of 180-189 mm class. Squilla formed the highest percentage (48.4) of gut content in the fishes of 160-169 mm class. The other important group, the fishes formed largest component of food in 170-179 mm class. Generally larger *N. japonicus* contained fishes in their stomachs.

Nemipterus mesoprion:-

Crustaceans formed the common food of *N. mesoprion* in all the length classes. Prawns were often found in the fishes of all the sizes. The smaller ones mostly fed on amphipods, the highest being 88.3% in 80-89 mm size class, followed by 42.4% in 100-199 mm size class. Prawns formed the highest (40.8%) component of food in 220-229 mm class. Above 220 mm size class the food was predominantly formed of fishes; smaller ones fed on Ribbon fishes while larger ones fed on Lizard fishes. Anchovies formed 24.9% and 23.8% of food of 120-139 mm class and 110-119 mm class respectively. Although cephalopods, were found occasionally in the food, no size specific preference could be ascribed.

Parascolopsis aspinosa:-

The presence of crustacean remains were noticed in fishes of most of the length classes, encompassing almost 98% of stomachs containing food. Only prawns were found in the stomachs of fishes in 90-109 mm class. In the larger fishes though prawns remained important dietary component, crabs were not uncommon. Cephalopods though found occasionally formed 24.2% of food in 170-179 mm length class. Fishes were not very common in food. Highest percentage of fishes was recorded in 170-179 mm length class.

Feeding intensity

Feeding intensity in relation to calendar months

The percentage occurrences of stomachs in various degrees of fullness during different months are given in tables 14 -16 for the three species under investigation.

Nemipterus japonicus :-

More actively fed fishes were found during February 96, April 96 and March 96. During December and January, also the percentage of actively fed fishes was fairly high. The moderately fed fishes were found more in number during October 96, October 97, May 96 and April 96. Empty stomachs were encountered during all the months. Their percentage was highest during November 96 (88%). More than 70% of empty stomachs were encountered during March 96, January 97, February 97, November 97 and December 97.

Nemipterus mesoprion :-

Most actively fed individuals of this species were found during August 96, followed by March 96 and January 97. High percentage of moderately fed fishes was encountered during May 97, August 96, September 96 and December 96. Highest percentage of empty stomachs was recorded during October 97 and November 96, which were more than 80%. During February 96, March 97, April 97, November 97 and December 97 more than 70% of the guts were found to be empty.

Parascolopsis aspinosa:-

The data available do not give any clear picture of the feeding variations through months. With the available information, December 97 was the only month, when active feeding was recorded. During September 97, moderate feeding was registered. About 70% of the stomachs were always empty during all the months wherein samples could be obtained.

Feeding intensity in relation to size

The percentage occurrences of stomachs in various degree of fullness in different length classes are given in tables 17-19

Nemipterus japonicus :-

Fishes of size 120-129 mm fed most actively, followed by those of size 110-119 mm and 100-109 mm. Moderately fed individuals were in 90-180 mm size class. Highest number of moderately fed individuals were in the larger size groups followed by 90-190 mm class. Nevertheless, the highest percentage of empty stomachs was also registered among the larger fishes. Among the fishes above 130-139 mm size class more than 50% were found to have empty stomachs. Highest percentage of fishes with empty stomachs was encountered in 220–229 mm class.

Nemipterus mesoprion:-

The high percentage of actively fed fishes were found in 140-149 mm and 210-219 mm class. The moderately fed fishes were encountered mainly in the small size range especially below 170-179 mm length class. More than 75% of stomachs were seen empty in 190-199 mm, 240-249 mm, 120-129 mm and 100-109 mm size classes.

Parascolopsis aspinosa :-

Most active feeding was registered in 110-119 mm class followed by 130-139 mm class. The moderately fed fishes were found in the decreasing order amidst 180-189 mm, 190-199 mm, 160-169 mm, 170-179 mm and 150-159 mm size classes. More than 50% of stomachs were empty in most of the size classes.

4.4. REPRODUCTION

The result of studies on, maturity, spawning, fecundity and sex ratio are presented below.

4.4.1. Maturity

Classification of maturity stages:

The description of the maturity stages following the scales of classification recommended by ICES is given below. The diameter of ova is given in ocular divisions (o.d.) for easier understanding of progression of their frequency modes. Actual diameters in mm is also given in the parenthesis wherever necessary.

Maturity stages of *N. japonicus*

Stage I – Immature

The ovaries appeared very small, narrow, cylindrical and pale translucent in colour; occupy less than ¼ th of the body cavity. Ova were small, transparent and having distinct nucleus, no yolk deposition, colorless, not visible to naked eye. The ova range from 1 to 8 o.d. (0.0097 to 0.0777 mm). The largest numbers of ova were between 2 and 3 o.d. (0.0194 to 0.0292 mm).

The testes appeared very small thread like, and were faint to light yellow in colour when fresh.

Stage II – Maturing virgin

The ovaries of the stage were slightly larger, pale and translucent. They occupied less than ¼ th of the body cavity. Ova were small, transparent still, though yolk deposition had started. The central region was semi-transparent. The size of ova ranged from 1 to 15 o.d. (0.0097 to 0.1458 mm). The group of largest number of ova formed a mode at 5 o.d.

(0.0486 mm.)

The testes appeared slightly larger, semi-transparent, pale, white in colour occupying less than ¼ th of body cavity.

Stage III – Early mature

Ovaries were fairly large, cylindrical and pale yellow in colour, occupying not more than ¼ th of the body cavity, capillaries were not distinct. The ova were round in shape and some smaller ones were still translucent. The largest group of ova ranged between 4 to 14 o.d. (0.0398 – 0.1361 mm). A second mode was formed by the largest ova at 17 o.d. (0.1652 mm).

The testes looked thicker, flatter and tended to be wider than those of previous stage. They occupied more than ¼ th of the body cavity. The volume of the testes increased at this stage and appeared whitish in colour.

Stage IV – Late mature

Ovaries appeared large, pale yellow in colour, numerous blood capillaries were visible, occupied more than ½ of the body cavity. Most of the ova were opaque and yolky, and were visible to the naked eye. Majority of ova ranged in size from 25 to 51 o.d. (0.2430 - 0.4956 mm). Most of the largest group of ova were at 41 o.d. (0.3985 mm) and the mode was formed between 36 and 45 o.d. (0.3499 – 0.4373 mm).

The testis at this stage also increased in size and appeared thicker and wider and occupied less than ½ the length of body cavity. They were dull white in colour.

Stage V – Matured

The ovaries were grown to large size occupying about ¾ th of body cavity, the colour of the ovary tending to white and the blood capillaries were numerous, the ovarian wall thin. The ova were large, burst free from the follicle, partly transparent, often a translucent outer border was visible. Majority of the ova ranged from 25 to 51 o.d. (0.2430 -0.4956 mm). The largest group of ova was at 34 - 48 o.d. (0.3304 - 0.4665 mm) and the mode was formed at 41 o.d. (0.3985 mm).

The testis of this stage appeared thicker and wider occupying about ½ the length of the body cavity. The colour was dull white.

Stage VI - Ripe

Ovaries were greatly enlarged occupying ¾ th to entire body cavity, creamy white in colour. Ova were free from lumen, large and fully transparent with deposition of one or more oil globules. Most of the ova were between 31 and 51 o.d. (0.3013 - 0.4956 mm) and the largest recorded size was 66 o.d. (0.6414 mm). A mode at ova diameter of 41 o.d. (0.3985 mm) and a second smaller one at 49 o.d. (0.4762 mm) were seen.

Testes of this stage were undistinguishable from those of previous stage except that a small quantity of milt oozed out with slight pressure on the abdomen.

Stage VII - Spent

The ovaries appeared flabby flaccid and flat. The colour was dull brown with blood shot. There were few residual ova, which were very large, ranging from 8 to 68 o.d. (0.777 - 0.6608 mm) with a mode formed between 7 and 14 o.d. (0.680 - 0.136 mm).

The testis were flabby, flat and appeared shrunken to ribbon shape with blackish brown colour.

Maturity stages of *N. mesoprion*:-

Stage I – Immature

The ovaries were very small, narrow cylindrical and pale translucent in colour. They occupied less than ¼ th of the body cavity. Ova were transparent, small with distinct nucleus. They are colourless and not visible to the naked eye. The ova range from 2 to 7 o.d. (0.0194 to 0.0680 mm). The largest numbers of ova were between 2 and 5 o.d. (0.0194 to 0.0486 mm), and the largest group was of 2 o.d. (0.0194 mm).

Testis appeared small occupying less than ¼ th the length of the body cavity, more wider than long, appeared white in colour

Stage II – Maturing virgin

The ovaries of this stage were slightly larger, pale and translucent.

Ovaries still occupied less than ¼ th the length of the body cavity. Ova were small, transparent, though yolk deposition had started. The size of ova range from 1 to 15 o.d. (0.0.0097 to 0.1458 mm). The group of largest number of ova formed a mode at 5 - 9 o.d. (0.0486 – 0.0875 mm).

The testes appeared slightly wider, semi-transparent, pale white in colour, occupied less than ¼ th the body cavity.

Stage III – Early mature

Ovaries were fairly large, cylindrical and pale yellow in colour, occupying more than ¼ th of the body cavity. Capillaries were not distinct. The ova were round in shape, larger ones were opaque, and smaller ones were still translucent. The size of ova ranged between 2 and 27 o.d. (0.0194 – 0.2624 mm). The largest group of ova was between 3 and 23 o.d. (0.0292 to 0.2235 mm) and a second was between17 and 20 o.d. (0.1652 - 0.1944 mm).

The testes were thicker, flatter and tended to be wider than those of previous stage. Occupied more than ¼ th of the body cavity. The volume of the testes increased at this stage and they were whitish in colour.

Stage IV – Late mature

Ovaries appeared large, occupying more than ½ the body cavity. They were pale yellow in colour and numerous blood capillaries were visible. Fully yolky opaque ova contained within the follicles were visible to naked eye. Most of the ova ranged in size from 12 to 47 o. d. (0.1166 – 0.4568 mm). The mode of the largest group of ova was at 41 o.d. (0.3985 mm). Smaller modes were visible at 29 and 11 o.d. (0.2818 and 0.1069 mm)

The testis at this stage also increased in size and appeared thicker and wider and occupied nearly ½ the length of body cavity. They were dull whitish in colour.

Stage V - Matured

Ovaries were large in size occupying about ¾ th of body cavity. The colour of the ovaries was tending to white and the blood capillaries were numerous. The ovarian wall was thin. The ova were large, burst free from the follicle, partly transparent, often a translucent outer border was visible. The size of the ova varied from 5 to 55 o.d. (0.486 -0.5345). The largest group of ova had mode at 41 o.d. (mean - 0.202 mm).

The testis of this stage appeared thicker and wider occupying about ½ of the body cavity. The colour was dull white.

Stage VI - Ripe

Ovaries were greatly enlarged, occupying ¾ th to entire body cavity, light yellow to creamy white in colour. Ova were free in the lumen, large and fully transparent with deposition of one or more oil globules. The size of the ova varied from 8 to 89 o.d. (0.0777 - 0.8649 mm). The largest group of ova formed a mode at 41 o.d. (0.3985 mm). The most advanced ova were between 56 and 58 o.d. (0.5442 - 0.5637 mm).

Testis of this stage were undistinguishable from those of previous stage except that milt oozed out when slight pressure was applied on the abdomen.

Stage VIIa - Partially Spent

The ovaries appeared flabby flaccid and flat. The colour was dull brown with blood shot. Size of ova ranged from 5 to 46 o.d. (0.389 - 0.447 mm), few residual ova, which were very large measuring upto 90 o.d. (0.8746 mm) were still present. A mode of matured ova was formed at 41 o.d. (0.3985 mm). This stage looked similar to stage VII on gross examination. However, it appeared similar to stage IV in terms of composition of ova on the basis of their diameter. The presence of very large ova could differentiate them from stage IV.

The testis were flabby, flat and appeared shrunken to ribbon shape, and were blackish brown in colour.

Stage VIIb - Fully Spent

The ovaries appeared flabby flaccid and flat. The colour was dull brown with blood shot. No residual ova were present. Size of ova ranged from 2 to 43 o.d. (0.0194 - 0.4179 mm). Largest group of ova formed a mode at 17 o.d. (0.1652 mm) roughly corresponding to ova at stage III, rarely encountered.

Maturity stages of *P. aspinosa*

Stage I – Immature

The ovaries appeared very small, narrow, cylindrical and pale translucent in colour. Occupying less than ¼ th of the body cavity. Ova were small, transparent and having distinct nucleus. There was no yolk deposition and hence were colorless. They were not visible to the naked eye. Ova ranged from 2 to 11 o.d. (0.0194 - 0.1069 mm). The largest numbers of ova were between 3 and 6 o.d. (0.0292 - 0.0583 mm).
The testes appeared very small thread like and were yellowish in colour when fresh.

Stage II – Maturing virgin

The ovaries in this stage were slightly larger, pale and translucent. The occupied less than ¼ th of the length of the body cavity. Ova were small, transparent and yolk deposition had started. The ova were semi-transparent centrally. The size ranged from 4 to 17 o.d. (0.0389 - 0.1652 mm). The group of largest number of ova was between 3 and 9 o.d. (0.0293 -0.0875 mm) and formed a mode at 5 o.d. (0.486 mm).

The testes appeared slightly larger, semi-transparent, pale white in colour, occupying less than ¼ th of the body cavity.

Stage III – Early mature

Ovaries were fairly large, cylindrical and pale yellow, occupying more than ¼ th of the body cavity, the ova were round, larger ones were not fully opaque and smaller were still translucent. The size of ova ranged between 2 and 24 o.d. (0.0194 - 0.2332 mm). The mode of the largest group of ova was at 6 o.d. (0.0583 mm), but the second mode at18 o.d. (0.1749 mm) represented the stage.

The testes were thicker, flatter and tended to be wider than those of the previous stage. They occupied more than ¼ th of the body cavity. The volume of the testes had increased and they were nearly whitish in colour.

Stage IV – Late mature

Ovaries appeared large, occupying more than ½ the body cavity. They were pale yellow in colour with numerous blood capillaries. Most of the ova were opaque and fully yolky, contained within the follicles. They were visible to the naked eye. The ova ranged in size from 8 to 47 o.d. (0.0389 -0.4568 mm). The mode of the largest group of ova was at 41 o.d. (0.3985 mm).

The testis at this stage also increased in size and appeared thicker and wider and occupied less than ½ the length of the body cavity. They appeared dull whitish in colour.

Stage V - Matured

Ovaries were large, occupying about ¾ th of the body cavity. Colour of the ovaries at his stage was white, and the blood capillaries were numerous. The ovarian wall was thin. The ova were large and free from the follicle. A few transparent ova were seen, often a translucent outer boarder was visible. The size of the ova varied from 5 to 56 o.d. (0.0486 - 0.5442 mm). The largest group of ova was at 41 o.d. (0.3985 mm).

The testes of this stage appeared thicker and wider occupying about ½ of the body cavity. The colour is dull white

Stage VI - Ripe

Ovaries were greatly enlarged occupying ¾ th to entire body cavity. They were creamy white in colour. Ova were free in the lumen. They were large and fully transparent with deposition of one or more oil globules. The size of the ova varied from 5 to 65 o.d. (0.0486 - 0.6317 mm). The largest group of ova was of 41 o.d. (0.3985 mm). A group of ova had further grown to form most advanced ones lying in the range of 50 to 65 o.d. (0.4859 - 0.6317 mm).

Testes of this stage were undistinguishable from those of previous stage except that milt oozed out when slight pressure was put on the abdomen.

Stage VII - Spent

The ovaries appeared flaccid and flat. The colour was dull brown with blood shot. There were few very large residual ova. The size of ova ranged from 4 to 45 o.d. (0.0389 - 0.4373 mm) with a mode formed at 8 o.d. (0.0777 mm). Few large ova of diameter around 41 o.d. (0.3985 mm) were still seen.

The testes were flabby, flat appeared shrunken to ribbon shape. They were blackish brown in colour.

Development of ova to maturity:

For the species under investigation the description of development of ova in typical stages of maturity are given below. The composition was plotted as percentage frequency as depicted in Figs. 12 to 14.

Nemipterus japonicus

In stage I, the ova size ranged from 1 to 8 o.d., with majority of them in the size range of 4 to 6 o.d.. The size of ova in stage II was from 1 to 15 o.d. and the withdrawal of ova from stage I partial, with a mode at 5 o.d. In stage, III the mature ova were well separated from the immature ova with a mode at 18 o.d. and the maximum size of ova was 20 o.d.. The mode at 20 o.d. shifted to 41 o.d. in stage IV that had the maximum size of 51 o.d.. The gravid ova of stage V were almost similar to those from the stage IV. The maximum diameter of ova had increased to 59 o.d.. The running stage ova were semi-transparent and greatly enlarged, the diameter of which ranged from 47 to 69 o.d. with a small peak at 63 o.d..

Nemipterus mesoprion

The development of the ova in this species of Nemipteridae was not much different from that of *N. japonicus*. In stage I, the range of ova was from 1 to 7 o.d., with majority of ova forming a mode at 2 - 5 o.d.. The diameter of most of the ova was 0.0194 mm. In stage II the ova had advanced in growth, but were not fully separated from those of stage I. The ova ranged from 1 to 15 o.d., size of most of ova being 0.0681 mm. In stage III a group of ova were separated, which had an average diameter of 19 o.d. (0.1846 mm). In stage IV the matured ova formed a peak at 41 o.d., with maximum diameter of 47 o.d. (0.4568 mm). In stage V, ova formed a peak at 41 o.d. (0.3985 mm) with maximum size of ova being 0.60254 (62 o.d.). The ova of stage VI were with o.d. more than 55 (0.5345 mm). The maximum recorded o.d. was 89 (0.8649 mm). In stage VIIa which is a partially spent stage, only few large ova remained, but the peak was at 41 o.d. which remained through stage V and VI. At stage VIIb, the advanced ova with the diameter of 41 o.d. were all released

Parascolopsis aspinosa

In stage I, the ova of 3 o.d. (0.0292 mm) were numerous and the maximum o.d. was 11 (0.0194 mm). In stage II the mode shifted to o.d. 7 to

9 with maximum size of ova being 15 o.d. (0.1458). The number of ova in the lower diameters were more. When the gonad matured to stage III, though immature transparent ova were encountered, the opaque ova of between 13 and 18 o.d. also started to appear. The maximum size of matured ova was 20 o.d. (0.1944 mm). Even at this stage the number of ova of smaller diameter were more. When the gonad matured to the stage IV, there was a prounced change in the ova diameter, with the largest group forming a mode at 41 o.d. (0.3985 mm). The maximum size attained by ova was 47 o.d.. These ova formed the stock of ova, which remained through stage V, and VI. When the ovaries advanced to stage V, the number of ova of larger diameter increased but they were not separated from the stock. At stage VI, a group of ova of 50 - 65 o.d. (0.4859 - 0.6317 mm) was present. In the spent gonads, the ova of all lower stages were present but larger ova were less in number.

4.4.2. Spawning habits

Frequency of Spawning

Nemipterus japonicus

The formation of modes in the ova diameter frequency is given in Fig. 12. Separation of a batch of ova that were matured in stage III was clearly visible. The matured ova at stage IV were a very distinct group forming largest numbers. The stage V ova did not form any distinct mode, they were very close to those of stage IV in size. In the stage VI, the ripe ova were forming a distinct group. The difference between the ova diameter of stage IV and V was very small, and the presence of a small mode before stage IV eggs was noticed.

Nemipterus mesoprion

The frequency polygon of ova diameter of the various maturity stage of *N. mesoprion* is provided in Fig. 13. The progress in diameter of ova from early stages to the advanced stages of maturity and movement of modes of frequency polygon can be seen clearly. In the first stage to third stage, most of the ova were of smaller diameter. However, the ova of the stage IV forming mode were very large in number. At this stage, there was a small group of ova that was immediately following the largest group. Stage V was not much different from stage IV except that a small group of ova had grown larger in diameter which did not form a distinct mode. However, the group showed a distinct mode at stage VI with the ova of stage IV still forming the largest group.

Parascolopsis aspinosa

The progression of modes of ova diameter (Fig. 14) at different stages of maturity did not differ widely from other two species presented above. The ova diameter of maturity stages upto III was quite small. Nevertheless, the ova of stage IV were distinct and well separated from the ova of stage II and III. The mode of stage IV remained through stage V and VI. In stage VI, a small group of ova was seen separated from those in stage V. Presence of a small group of ova just preceding the group forming the IV stage and, maintenance of stage IV through the V and VI stage was distinctly seen.

Spawning season.

The percentage occurrence of maturity stages in different months tabulated to identify the breeding seasons of these fishes are presented in Tables, 20 – 25.

Nemipterus japonicus

The percentage occurrence of different maturity stages of males and females of the species are presented in Tables 20 and 21. During most part of the year, fishes with gonads at early stages of maturity were commonly found. During most of the fishing season, fishes with advanced maturity stages of gonads were found. Fish samples collected during October to April contained fishes in advanced maturity stages. Most of the small fishes caught during April were in the stage II and I. Occurrence of different stages of maturity did not follow any seasonality.

Nemipterus mesoprion

Percentage occurrence of different maturity stages of *N. mesoprion* is given in Tables 22 and 23. During most part of the investigation, fishes in advanced stages V, VI and VII were observed. The conditions during monsoon was not clear, no samples could be obtained during July, and only a single sample each could be collected during June and August. However a slump in breeding activity before monsoon (April in 1996 and March in 1997) and after monsoon (November - December 1997 and October - November 1996). The breeding activity is twice separated forming a breeding period between November - December to March - April with a short break.

Parascolopsis aspinosa

The percentage occurrence of different maturity stages of the fishes in different month is given in Tables 24 and 25. The limited number of samples available from September, October, November, December and April were found to have specimens in an advanced stage of maturity. The specimens with gonads beyond maturity stage V were available between September to April. In the absence of adequate samples through all the months of a year, though a confirmed breeding season cannot be made out, there is a broad indication that the breeding period was from September to March.

4.4.3. Size at first maturity

Relationship between the size of the fish and maturity

The computed results of percentage occurrence of maturity stages in different size groups for the fishes are presented in Tables 26- 31. Fishes in stages III and above were treated as matured.

Nemipterus japonicus

From Tables 26 and 27 it can be seen that fishes below 70 - 79 mm class could not be separated by sex. Among the fishes, which could be separated as males and females, the mature gonads were encountered from 90 - 99 mm class. Among the males the percentage of matured members increased with increase in length. In 130 - 139 mm class and 140 - 149 mm class the percentage of mature fish was closer to 50. But in the 150 - 159 mm class and beyond, most of them were mature with a very small percentage of immature fishes. It can be seen that the size at first maturity of males is between 140 - 159 mm total length. Among females a small number of fishes of total length of 100 - 109 mm were mature. Only in the class of 130 - 139 mm, more than 50% of fishes were mature, indicating that this class can be considered as the size at first maturity for females of *N. japonicus.*

Nemipterus mesoprion

In Tables 28 and 29, the percentage occurrence of matured males and females of *N. mesoprion* is given. In the size range below 100 mm mature males were encountered in the species. The percentage of mature males increased with increase in size, but only in the class 140 - 149 mm, more than 50% of individuals were mature. The size group below 100 mm also had mature females. Their number increased only beyond 120 mm. By the time they reached 130 -139 mm class, the majority of individual were mature.

Parascolopsis aspinosa

In Tables 30 and 31, the percentage occurrences of matured males and females of the species are given. Matured males were encountered in the size range below 100 mm. Nearly 40% of fishes belonging to 100 - 109 mm classes were mature. In the class 110 – 119 mm class more than 50% of the individuals were mature. Among the females, in 100 -109 mm class more than 50% of the individuals were mature.

Size at first maturity determined by cumulative percentage frequency of matured fish.

Nemipterus japonicus

1005 males and 1009 females of *N. japonicus* were examined for the study. The cumulative percentage frequency plot of mature fishes at different length groups are presented in Figs.15 and 16. It can be seen in the graph that the males matured at 155 mm and females at 137 mm.

Nemipterus mesoprion

The cumulative percentage frequency plot of matured fishes of the species is given in Figs. 17 and 18. The length at first maturity for males is 145 mm while that for females 137 mm.

Parascolopsis aspinosa

The length at first maturity obtained by plotting the cumulative percentage frequency is given in Figs. 19 and 20. The males achieved first maturity at 118 mm and female did so at 116 mm.

Size at first maturity determined from relative condition factor.

Due to the biological changes in the fish before the start of breeding activity, an increase in weight is noticed. This fattening of the fish is reflected in an increase in the K_n value. The Length-K_n value plot of three species is given in Figs. 9 –11.

Nemipterus japonicus

It can be seen that in Fig. 9 the K_n values of both males and females decreased with the increase in length. The initial increase in K_n for male was in 90 - 99 mm class and that for females was in 130 - 139 mm class. The increase in K_n though was prominent at 90 - 99 mm class, the second increase around 150 - 159 mm class seems to indicate the size at first maturity of male. Among the females, the increase in K_n at around 130 -139 mm class indicated the size at first maturity.

Nemipterus mesoprion

The K_n values of both males and females (Fig. 10) increased from the lowest length and decreased latter. The second increase for males was at 130 -139 mm class and for females at 140 -149 mm class. Therefore the size at first maturity of males is between 130 – 139 mm and for females, it is between 140 – 149 mm.

Parascolopsis aspinosa

The K_n value of male and female of *P. aspinosa* (Fig. 11) showed decrease from the lowest size captured. There was an increase in K_n among males in 120 -129 mm class and among females in 130 -139 mm class. Therefore, the size at first maturity of males is between 120 - 129 mm and females between 130 - 139 mm.

4.4.4. Gonado-somatic index (GSI)

The average gonado-somatic index (GSI) calculated for fish, grouped into sex and arranged over months is given in Figs. 21 - 23.

Nemipterus japonicus

The monthly variation in the GSI of this species is given in Fig. 21. It may be seen that the GSI varied widely from 1.1160 to 22.0590 among males and from 1.8598 to 40.2444 among females. In all the months the GSI of females were higher than the males. The GSI peaks in the case of females were during February , December, April and August in descending order. Similarly the peaks of males were observed during February, March, January and September. However the fluctuations in GSI of males and females were closely similar.

Nemipterus mesoprion

The GSI was always higher in females than males (Fig. 22). GSI was highest during December 1997, followed by November 1997 reflecting occurrence of more mature females during these months. The period between September and December normally had high GSI. A drop in GSI during February 1996 and March 1997 and lower K_n towards January 1998 showed lower activity in the preceding months.

Parascolopsis aspinosa

The monthly variation of GSI of *P. aspinosa* is given in Fig. 23. The graphic representation of GSI of males and females indicated higher GSI for females. GSI of the females were high from July to February.

4.4.5. Fecundity

As all the three species investigated appeared to spawn in batches, the maturing and matured opaque ova were counted to estimate the fecundity.

The fishes in stage V were used for estimation of ova and the diameter of ova of stages V and IV were measured. The estimated fecundity for the three species is given separately. The estimated fecundity of *N. japonicus* is given in Table 32. The fecundity ranged from 8,046 to 92,456. The estimated fecundity of *N. mesoprion* (Table 33) ranged from 14,454 to 52,638 and that of *P. aspinosa* (Table 34) ranged from 10,922 to 62 992.

Relation between fecundity and total length of fish

Nemipterus japonicus

A linear relationship was discernible between the logarithmic value of fecundity (Y) and logarithmic value of total length (X) (Fig. 24a). The relationship between log fecundity and log length was found to be;

$Y = -0.514814 + 3.90439X$.

The correlation coefficient 'r' calculated for the logarithmic value of the two variables was 0.437584, which was found to be significant at $P < 0.05$.

Nemipterus mesoprion

When logarithmic value of fecundity (Y) of *N. mesoprion* was plotted against logarithmic value of total length (X), a linear relationship between the two variables was noticed (Fig. 25a). The relationship between log fecundity and log length was found to be;

$Y = 2.61162 + 21.5172X$.

The correlation coefficient 'r' calculated for the logarithmic value of the two variables was 0.159054 which was not found to be significant at P >

0.05.

Parascolopsis aspinosa

When logarithmic value of fecundity (Y) of *P. aspinosa* was plotted against logarithmic value of total length (X), it showed a linear relationship between the two variables (Fig. 26a). The relationship between log fecundity and log length was found to be;

Y = 4.20078 +1.05583X.

The correlation coefficient 'r' calculated for the logarithmic value of the two variables was 0.88612, which was found to be significant at P < 0.001.

Relation between fecundity and weight of fish

Nemipterus japonicus:

The relationship between log fecundity (Y) and log weight (X) of *N. japonicus* was linear as can be seen in the Fig. 24b. The linear relationship was found to be:

Y = 2.19293 + 1.119152X

The correlation coefficient 'r' between log fecundity and log weight of fish 0.585246 was highly significant at P > 0.01.

Nemipterus mesoprion

The relationship between log fecundity (Y) and log weight (X) of *N. mesoprion* was linear as seen in Fig. 25b. The linear relationship was found to be:

$Y = 3.30067 + 0.620912X.$

The correlation coefficient 'r' between log fecundity and log weight of fish 0.159054 was not significant at $P < 0.1$.

Parascolopsis aspinosa

The linear relationship between log fecundity (Y) and log weight (X) (Fig. 26b) of *P. aspinosa* ($Y = 0.088027 + 2.070212X$) did not have a significant ($P > 0.05$) correlation coefficient ($r = 0.448552$).

Relationship between gonad weight and fecundity

Nemipterus japonicus

The logarithmic values of fecundity (Y) plotted against logarithmic values of gonad weight (X) of *N. japonicus* (Fig. 24c) indicated a linear relationship in the form:

$Y = 3.98837 + 1.08442X$

The correlation coefficient 'r' calculated from the log value of the variables was 0.736951, which was highly significant ($P < 0.05$).

Nemipterus mesoprion

The logarithmic values of fecundity (Y) when plotted against logarithmic values of gonad weight (X) of *N. mesoprion* (Fig. 25c), indicated a linear relationship in the form:

Y = 4.30328 + 0.771663X

The correlation coefficient 'r' calculated from the log value of the variables was found to be 0.718618 which is highly significant at $P < 0.001$).

Parascolopsis aspinosa

The logarithmic values of fecundity (Y) when plotted against logarithmic values of gonad weight (X) of *P. aspinosa* (Fig. 26c) indicated a linear relationship in the form of:

Y = 2.04515 + 2.12865X

The correlation coefficient 'r' calculated from the log value of the variables was found to be 0.645693 which is highly significant ($P < 0.001$).

4.4.6. Sex ratio

Wide ranges in size of fishes were examined to study the sex ratio. The ratio was computed separately for each month as well as for different size groups of all three species (Tables 35 - 40). Significance of ratio was tested (χ^2 test) and the results are provided with respect to months, lengths and for pooled data. The result of test of homogeneity is also given in the respective tables.

Nemipterus japonicus

Out of 2014 specimens of *N. japonicus* examined 1005 were males and 1009 were females. The sex ratio was 1: 1.004, in favor of females. However, the ratio was not significantly different (χ^2 = 0.007944, α = 0.05).

The monthly sex ratio (Table 35) was significantly different during February 1996, May 1996, November 1996, December 1996, May 1997 and November 1997. During November 1996 and 1997 males dominated and during February 1996 and May 1997 females dominated. There was no significant homogeneity of sexes in different months (χ^2 = 139.1095, d.f. 16, α = 0.5).

Similar studies to identify the sex ratio in different lengths (Table 36) showed that only at size classes 90 - 99 mm, 110 - 119 mm and 220 - 229 mm the sex ratio was significantly different. The sexes were found to be distributed homogeneously (χ^2 = 30.0744, d.f. = 18, α = 0.05).

Nemipterus mesoprion

Out of 3261 specimen examined, 1919 were males and 1342 were females showing numerical dominance of males. The sex ratio worked out to be 1 : 0.699, which is significantly (χ^2 = 100.94, α = 0.05) in favor of males.

The result of month-wise analysis of sex ratio (Table 37) suggested that distribution of sexes are not homogeneous (χ^2 = 187.176, d.f. $_{(n-2)}$ = 17, α = 0.05). During most months, the ratio was significantly different from H_0 = 1:1 except April 1996 in May 1996 and May 1997.

It was observed that the lengthwise (Table 38) distribution of sexes were also not homogenous (χ^2 = 89.67518, d.f $_{(n-2)}$ = 18, α = 0.05). Most of the length groups had significantly different sex ratios. The sex ratio was favorable to females in smaller size groups and in favor of males in larger size groups. Among the fishes beyond 240 mm, only males were encountered. The sex ratio distribution in different length classes was not homogeneous. (χ^2 = 89.6751841, d.f. $_{(n-2)}$ = 18, α = 0.05)

Parascolopsis aspinosa

The sex ratio worked out for 511 specimen of this species had 139 males and 272 females. The sex ratio of 1:1.1381 was in favor of females, but was not statistically significant (χ^2 = 2.13112, α = 0.05).

Only during September 1997 and October 1997 the ratio was significant (Table 39) and during both these months females dominated. Homogeneity of sexes was also different from H_0 = 1:1. (χ^2 = 26.8478, d.f $_{(n-2)}$ = 8, α = 0.05).

With reference to length class (Table 40) the 110 - 119 mm class only had a sex ratio that was significantly different. There was significant homogeneity of sexes in different size groups (χ^2 = 10.493888 d.f. $_{(n-2)}$ = 11, α =0.05).

4.5. GROWTH, MORTALITY AND EXPLOITATION

4.5.1. Growth

As the length-weight relationship between males and females of *N.*

japonicus and *N. mesoprion* differed significantly the growth parameters L_∞ and K were estimated separately for males and females of these species. The estimated growth parameters using FiSAT for males, females and pooled lot of *N. japonicus* and those of *N. mesoprion* are given in Figs. 27 – 29 and Figs. 30 – 32, respectively. The growth curve for *P. aspinosa* is given in Fig. 33.

Length based techniques used in FiSAT computes only the L_∞ and K, the most important VBGF parameters. The value of 't_0' is taken as '0' for other computations. The estimated L_∞ for males of *N. japonicus* was 295 mm and the growth rate K was 1.2. The L_∞ for females was 285 mm and K was 1.0. The estimated L_∞ of all individuals pooled was 300 mm and the growth coefficient K was 1.00. Similarly, the L_∞ values of males, females and both sexes combined for *N. mesoprion* were 288 mm, 282 mm and 285 mm respectively, and respective growth coefficients were 0.7, 1.0 and 0.8. In the case of *P. aspinosa,* a single equation for both males and females was possible, the estimated L_∞ value was 217 mm and K was 0.67.

4.5.2. Mortality rates

Average mortality rates were obtained for both the years by pooling the data to respective months. The results of mortality rates *i.e.* .Z, M and F are provided in Table 41 for all three species. The mortality rates were separately estimated for each sex in the case of *N. mesoprion* and *N. japonicus* since their length-weight relationship differed significantly. As the sexes cannot be separated by external morphology, these estimates may be of less practical utility. Hence, a pooled estimation was thought necessary and more appropriate. Moreover, the data of indeterminates could also be added to the data when the frequencies were pooled. Therefore, pooled data of both sexes were used to enhance the practical utility of the estimates and the combined results are presented in Table 41. As the growth-rates between sex were not different in *P. aspinosa,* the mortality rates were estimated treating the males and females as a single homogenous group. The estimation of mortality rates for males, females and pooled data of *N. japonicus* using length converted catch curve are presented in Figs. 34 – 36. Similarly the mortality details of *N. mesoprion* and those of the estimates of *P. aspinosa* are provided in Figs. 37 – 39 and Figs. 40, respectively. The figures also give the L' - a length for which all fish of that length and larger are under full exploitation. Other mortality parameters like Z, M and F as well as exploitation rate E are also given in the figures.

4.5.3. Exploitation rate

The exploitation rate (E) and exploitation ratio (U) are provided in Table 41. The calculated 'E' was highest for *N. japonicus* (0.78) and lowest for *P. aspinosa* (0.43). *N. mesoprion* was exploited at 0.59. It was clearly evident that males and females of the nemipterids had dissimilar exploitation rates.

4.6. FISHERY

In Table 42, the annual marine landing of Goa state are provided from 1985 - 1999. The landings varied from 29,927 tons (1986) to 1,00,922 tons (1993). Annual landings were 92737 tons during the year 1996 and 9,1277 tons during 1997, which corresponded to the first and second year of the study period. The annual landings were reduced during the year 1998 substantially. The landing of threadfin breams were 2098 and 4648 tons respectively for the year 1996 and 1997. The landing figures for 1998 were 864 tons and for 1999 they were 404 tons, showing a reduction in the landings.

Distribution pattern with depth

The depth distribution of two major species contributing the fishery is given in Table 43a. A total of 167 fishing stations were selected between January 1989 and January 1998 for this analysis, of which 100 stations were in the 35 - 60 m depth zone, while 67 were in the 80 - 135 m depth zone. *N. japonicus* was encountered in 79.0 % of the hauls made in shallow waters while *N. mesoprion* was found only in 33.0 % of the shallow water stations. In shallow waters, catches of *N. japonicus* were 1.95 times more than those of *N. mesoprion.*

In deeper waters, frequency of occurrence of *N. japonicus* was lower than that of *N. mesoprion.* In 66 out of the 67 stations (98.5%) *N. mesoprion* was recorded. The catch of *N. mesoprion* was 4.73 times higher than that of *N. japonicus,* forming about 82% of the catch of threadfins from the zone. Therefore, along this coast the former can be treated as a shallow water and the latter a deep-water species.

Density of the two major species of nemipterids is given in Table 43b for the three depth zones. The density was highest (291.3Kg/Km^2) in the deepest zone of 101 - 200 m, followed by that in 51 - 100 m (14.4Kg/Km^2) and least in the zone with a depth lesser than 50 m (6.6. Kg/Km^2)

Changes in the catch rates of the threadfins of Goa coast

The combined quarterly catch rates of the two major species (*N. mesoprion* and *N. japonicus)* are given in Figs. 41 - 43. The running average (5 points) of the quarterly catch rate can also be used to trace the trend.

In shallow waters below 50 m, there were occasional high catch rates coinciding with the fishing seasons. The trend showed (Fig. 41) steady increase upto the beginning of 1994. Later the trend decreased without any instance of high catch rate. Though the catch rates were near to nil during 1995 and 1996, there was an improvement later, but the catch rates did not reach the earlier levels. The trend graph also depicted the same, the negative slope started from the year 1993.

In the medium depth range (51–100 m) the catch rates increased from the year 1983 (Fig. 42) registering a record peak in the year 1989. The catch rates decreased thereafter reaching lowest level during 1994 to 1996. An increase in the catch rates has been noticed from the year 1997. The trend graph also showed a similar pattern. There was an increase in catch rate from 1983, which remained so until 85 - 86 season, later the trend showed decline upto the year 1997. The trend in the later years showed increase in the catch rate but the increase was not significant compared with that of earlier period.

The catch rate of deep-water regions of the Goa coast is given in Fig 43. The catch rates in the deeper waters oscillated widely, recording a highest quarterly average of 672 kg/hr. during 1990. In the beginning, the catch rates were low, which increased steadily upto the year 1990. However, from the year 1990 the catch rates reduced year after year. During the late 90s catch rates were very poor, making fishing for the resource in the zone an unprofitable exercise. In the moving average graph, it may be seen that a low catch trend prevailing during the initial years showed a steady increase from 1985 to 1989. After 1989, a continuously declining trend has been noticed and it is yet to show a perceptible improvement.

Biomass and maximum sustainable yield (MSY)

The biomass estimated by swept area method is given in the Table 43b. The estimated biomass of threadfin breams from Goa coast is a total of 22.8 tons from waters below 50 m, 66.7 tons from those between 51 - 100 m and 488.7 tons from waters at 101 - 200 m depths. This amounts to 934.2 tons of average biomass from the coast. If 50% of the biomass is available for harvesting, about 467.1 tons of threadfins were the harvestable resource available during the study period. From this estimated annual average biomass, the harvestable resource that was estimated for study period by using the Gadima's estimator was 2,372 tons.

Table 1. Comparison of important taxonomic characters of Red Spot Parascolopsis species hitherto known and the specimens collected from Goa, India.

	P. boesemani	*P. rufomaculatus*	*P. baranesi*	This collection of specimens
Fin formula	X 9; P ii 14, Ll. 36/37.	X 9; P ii 14, Ll. 35/37.	X 9; P ii 14, Ll. 39; A III 7.	X 9; P ii 14, Ll. 39/41; A III 7.
Pectoral	Long, reaching beyond the level of anus	Moderately long, reaching to, or just short of level of vent	Moderately long, reaching to or just short of level of vent	Moderately long reaching beyond the level of vent.
Pelvic fin	Pelvic long reaching beyond level of anus	Pelvic short	Pelvic short, not reaching the level of vent	Pelvic short, not reaching the level of vent
Scales on head	Reaching forward to the level of posterior nostril.	Reaching forward to between middle of eye	Reaching forward to the level of posterior nostril.	Reaching forward to the level of posterior nostril.
Body colour	Rosy yellow	Body pinkish, Pearly white below	Body pale pink Silvery below mid lateral line.	Rosy pink
Bands on body	Three pale rosy saddles on body and one on caudal fin peduncle.	No vertical bars	Traces of three vertical bars on upper half of the body	Three dark orange bands 1st in front of dorsal fin, 2nd from the middle of the dorsal fin and the 3rd on the caudal peduncle

Table 2. Comparison between the regression lines of males and females of *Nemipterus japonicus*.

	d.f	SSq x	SSQ y	SSQ xy	*Regression coefficient*	*Deviation from regression*			
						d.f	*S.S*	*M.S.S*	
Within									
Males	1004	7.241744134	69.78995255	21.7622675978	3.0051141265	1003	4.3918547652	0.0043787186	
Females	1008	8.542171527	75.6093156	24.8985576205	2.9147808073	1007	3.0354777213	0.0030143771	
		Deviation from Regression				2010	7.4273324865	*0.0036951903*	**MSSR**
Pooled **W**	2012	15.78391566	145.3992682	46.6608252184	2.9562262128	2011	7.4593135314	*0.0037092559*	**MSSP**
		Difference between the slopes				1	0.0319810449	*0.0319810449*	**MSSE**
Between **B**	1	0.220258436	0.935276604	0.4538750506					
Within and Between **(W+B)**	2013	16.0041741	146.3345448	47.1147002690	2.9439007589	2012	7.6335428798	0.0037940074	
		Between adjusted means				1	0.1742293485	*0.1742293485*	**MSSA**

Comparison of slope

MSSE/MSSR = 8.621957101*

Comparison of elevation

MSSA/MSSP = 46.97150995*

* Significant at 5% level

Table 3. Comparison between the regression lines of males and females of *Nemipterus mesoprion*..

	d.f	SSQ *x*	SSQ *y*	SSQ *xy*	*Regression coefficient*	*Deviation from regression*			
						d.f	*S.S*	*M.S.S*	
Within									
Males	1918	12.36767988	116.05640160	37.11851854	3.00125142	1917	4.65440017	0.00242796	
Females	1344	8.51289053	85.32181676	26.08988879	3.06475089	1343	5.36280699	0.00399316	
		Deviation from individual regression				3260	10.01720716	0.00307276	**MSSR**
Pooled **W**	3262	20.88057041	201.37821840	63.20840562	3.02713979	3261	10.03750580	0.00307806	**MSSP**
		Difference between slopes				1	0.02033342	0.02033342	**MSSE**
Between **B**	1	0.76102551	1.96479040	0.68527938					
Within and Between **(W+B)**	3263	21.11954928	203.34300880	63.89364601	3.02533189	3262	10.05328547	0.00307887	
		Between adjusted means				1	0.01574489	0.01574489	**MSSA**

Comparison of slope:

MSSE/MSSR = 0.020333420/0.003072763 = 6.617308266*,

Comparison of elevation:

MSSA/MSSP = 0.01574489/0.003078056 = 5.115205831*,

*Significant at 5% level: Not significant at 1% level

Table 4. Comparison between the regression lines of males and females of *Parascolopsis aspinosa*..

	d.f	SSQ *x*	SSQ *y*	SSQ *xy*	*Regression coefficient*	*Deviation from regression*			
						d.f	*S.S*	*M.S.S*	
Within									
Males	238	0.872593187	7.709984165	2.506948381	2.872996303	237	0.507555498	0.00141584	
Females	271	1.113161289	10.34796329	3.31047472	2.973939837	270	0.502810695	0.001862262	
		Deviation from regression				507	1.010366193	0.001992833	**MSR**
Pooled **W**	509	1.985751476	18.05794746	5.817423083	2.929582656	508	1.015326644	0.001998674	**MSSP**
		Difference between slopes				1	0.004984264	0.004984264	**MSSE**
Between **B**	1	0.018500832	3.141088400						
Within and Between **(W+B)**	510	2.004252308	18.19903586	5.86850947	2.928029294	509	1.015868221		
		Between adjusted means				1	0.000541577	0.000541577	**MSSA**

Comparison of slope:

MSSE/MSSR = .0049844264/0.001992786 =2.501153963*

Comparison elevation:

MSSA /MSSP = 0.00541577/.001998674 = 2.709681519*

* not significant at 5% level

Table 5. Relative importance of food items of *Nemipterus japonicus.*

Food items	Frequency of occurrence	Numerical Percentage	Volumetric Percentage	Gravimetric Percentage	Index of Relative Importance (IRI)
Crustaceans	55.3	58.1	56.3	46.3	5773.2
Amphipods	2.6	3.6	4.8	3.4	18.2
Prawns	9.4	14.1	12.3	9.2	219.0
Crabs	17.7	12.8	15.1	12.6	449.6
Squilla	16.3	15.6	12.6	10.8	430.3
Lobster	--	--	--	--	--
Crustacean remains	9.3	12.0	11.5	10.3	207.4
Pisces	30.1	23.1	26.8	36.4	1791.0
Trichiurus sp	1.6	1.0	2.3	5.2	9.9
Saurida sp	2.8	1.9	4.1	8.1	280
Stoliphorus sp	11.6	14.2	8.1	10.2	283.04
Fish remains (Head)	14.1	6.0	12.3	12.9	266.5
Cephalopods	8.2	9.4	9.3	10.7	164.8
Loligo	1.6	1.5	1.2	2.3	6.1
Sepia	1.3	2.1	2.9	2.8	6.4
Octopus	0.0	0.0	--	--	--
Cephalopod appendage	6.3	6.8	5.2	5.6	78.1
Annelids	10.1	8.3	7.2	6.1	145.4
Polychaetes	7.4	6.2	5.3	4.8	81.4
Other worms	2.7	1.1	1.9	1.3	6.4
Miscellaneous	3.8	1.1	0.4	0.5	6.1

Table 6. Relative importance of food items of *Nemipterus mesoprion*..

Food items	Frequency of occurrence %	Numerical Percentage	Volumetric Percentage	Gravimetric Percentage	Index of Relative Importance (IRI)
Crustaceans	52.5	63.3	48.2	42.8	5570
Amphipods	12.6	19.3	13.2	12.1	395.6
Prawns	17.3	16.1	17.0	18.5	598.6
Crabs	8.6	9.2	6.8	6.3	133.3
Squilla	3.4	4.1	4.1	3.6	26.2
Lobster	1.2	0.5	0.8	0.6	1.3
Crustacean remains	9.4	14.1	6.3	2.3	154.2
Pisces	29.3	21.1	32.4	36.2	167.89
Trichiurus sp	2.8	4.3	6.7	9.8	39.5
Saurida sp	9.8	3.8	4.5	7.1	106.8
Stolephorus sp	11.1	10.2	10.6	10.1	225.3
Fish remains	5.6	2.8	8.6	9.2	67.2
Cephalopods	7.8	5.6	8.3	10.6	126.4
Loligo	3.1	2.5	3.4	3.8	19.8
Sepia	2.4	2.1	2.7	3.3	12.9
Octopus	0.4	0.2	0.4	0.8	0.4
Cephalopod appendage	1.9	0.7	2.0	2.7	6.5
Annelids	8.2	6.2	8.5	8.2	118.1
Polychaetes	6.1	3.3	4.8	4.2	45.8
Other worms	2.1	2.9	3.7	4.0	14.5
Miscellaneous	2.2	3.8	2.6	2.2	13.2

Table 7. Relative importance of food items of *Parascolopsis aspinosa*..

Food items	Frequency of Occurrence	Numerical Percentage	Volumetric Percentage	Gravimetric Percentage	Index of Relative Importance (IRI)
Crustaceans	62.3	67.4	55.4	43.7	6921.5
Amphipods	15.8	21.2	12.6	8.3	466
Prawns	16.8	15.1	17.9	12.4	462
Crabs	13.1	14.4	15.1	18.3	428
Squilla	2.3	1.2	3.2	1.8	6.9
Lobster	3.8	5.8	2.7	0.9	25.5
Crustacean remains	10.5	9.7	3.9	2.0	122.9
Pisces	33.2	18.8	24.6	33.4	1733.0
Trichiurus sp	1.2	0.7	2.8	4.3	6.0
Saurida sp	7.6	1.3	3.7	6.8	61.6
Stolephorus sp	--	--	--	--	--
Fish remains	24.4	16.8	18.1	22.3	958.9
Cephalopods	14.2	8.1	13.2	17.3	360.7
Loligo	1.7	1.2	1.1	2.4	6.1
Sepia	2.0	1.0	2.2	2.5	7.0
Octopus	1.2	0.8	2.0	2.1	3.5
Cephalopod appendage	9.3	5.1	7.9	10.3	143.2
Annelids	8.2	5.3	6.2	4.9	83.6
Polychaetes	6.3	4.1	4.6	3.8	54.8
Other worms	1.9	1.2	1.6	1.1	4.4
Miscellaneous	3.8	0.4	0.6	0.7	4.2

Table 8a. Percentage composition (by weight) of food items recorded during different months in the stomach of *Nemipterus japonicus* (96-97).

Food items	Feb 96	Mar	Apr	May	Jun *	Jul *	Aug *	Sep	Oct	Nov	Dec	Jan 97
Crustaceans												
Amphipods			23.4	27.3					23.6			
Prawns	46.1	35.8		8.5				37.9	28.9	11.6	43.1	18.3
Crabs	2.2	28.2		3.6						13.8		6.4
Squilla	20.3			2.1							3.6	11.4
Lobster										7.6		2.1
Crustacean remains		12.7	10.3	1.3				62.1	3.7		8.1	20.3
Pisces												
Trichiurus sp	13.4										3.2	
Saurida sp									3.4			14.2
Stolephorus ap			18.6	14.8						7.9	33.8	
Fish remains	11.9		23.2	21.6					11.6	13.3	12.3	6.1
Cephalopods												
Loligo				20.8					14.6	12.1		8.3
Sepia										18.3		3.4
Octopus												
Cephalopod remains	6.1	18.3	8.3						10.3			
Annelids												
Polychaetes			12.8						4.7			6.1
Other Worms		5.0	3.3							6.7		3.4
Miscel. matters											7.3	

* No samples

Table 8b. Percentage composition (by weight) of food items recorded during different months in the stomach of *Nemipterus japonicus* (97-98).

Food items	Feb 97	Mar	Apr	May	Jun *	Jul *	Aug *	Sep *	Oct	Nov	Dec	Jan 98
Crustaceans												
Amphipods	11.6	12.1	25.3	43.5					20.4	16.3	10.4	6.8
Prawns	36.2	16.3	7.3	1.3						12.6		38.2
Crabs	2.1		12.1	2.1					17.3	8.4	6.3	
Squilla	16.3	2.4		6.8						3.1	12.4	13.3
Lobster											1.2	6.3
Crustacean remains	14.3	22.3	0.6									
Pisces												
Trichiurus sp				6.1						22.1	6.5	16.6
Saurida sp				18.2						8.3	6.1	
Stolephorus sp												
Fish remains			28.3	6.3					13.6	17.4		
Cephalopods												
Loligo		3.4	11.0	1.2					18.1			4.4
Sepia		6.7	8.4							8.5		
Octopus	2.4		3.6	6.4								
Cephalopod remains	16.3	6.1							25.6	1	23.5	10.6
Annelids												
Polychaetes		7.2	3.4	8.1						2.3	10.2	3.8
Annelids												
Miscel. maters	10.3								5.0			

* No samples

Table 9a. Percentage composition (by weight) of food items recorded during different months in the stomach of *Nemipterus mesoprion* (96-97).

Food items	Feb 96	Mar	Apr	May	Jun *	Jul *	Aug	Sep	Oct	Nov	Dec	Jan 97
Crustaceans												
Amphipods	10.8	44.6	34.6				12.0	3.3		16.3	31.4	18.3
Prawns	36.4	5.4		31.4			4.7	34.4	30.8	3.2	22.3	16.7
Crabs	3.6	11.3	6.8				12.3	8.2		17.4	6.2	6.1
Squilla	6.6		19.3	18.3			11.6		12.3	7.8		23.8
Lobster								10.6				6.9
Crustacean remains	9.2		14.8	12.9			13.2	16.7	12.6	23.4		
Pisces												
Trichiurus sp			13.0								12.2	18.2
Saurida sp				16.0			18.3		19.5	6.3	6.1	
Stolephorus sp												
Fish remains	16.3	11.2	10.5	21.4							14.7	
Cephalopods							3.9	20.0	10.2	22.2		
Loligo	6.8											
Sepia			12.2									
Octopus	2.1									3.4		6.2
Cephalopod remains	8.2	9.9					6.4	6.8				
Annelids												
Polychaetes		10.3					18.6					
Other worms												
Miscel. matters		7.3	3.0	3.3					14.6		7.1	3.8

* No samples

Table 9b. Percentage composition (by weight) of food items recorded during different months in the stomach of *Nemipterus mesoprion* (97-98).

Food items	Feb 97	Mar	Apr	May	Jun *	Jul *	Aug *	Sep	Oct	Nov	Dec	Jan 98
Crustaceans												
Amphipods	10	28.7		11.2				10.3		16.5	18.6	10.2
Prawns	25.3		38.3					48.1	26.3	19.1	20.3	14.5
Crabs	3.8		12.2	3.4					6.8	18.9	4.6	12.9
Squilla	6.1	8.1		6.4				2.3	11.3			22.7
Lobster										7.1	21.3	
Crustacean remains	12.1	26.8	24.3	6.1				12.6	25.9	8.4		
Pisces											7.7	
Trichiurus sp	16.4											18.6
Saurida sp				28.3							8.6	
Stolephorus sp				10.2								
Fish remains	14.6	7.4	14.1	7.3				18.3	12.6	20.8		12.7
Cephalopods												
Loligo		11.2							3.8		6.3	
Sepia		3.4										
Octopus		8.6								8.9		
Cephalopod remains			11.3					6.8	8.7			0.9
Annelids												
Polychaetes	10.2	5.8		27.1								7.5
Other worms												
Miscel. matters	1.5							1.8	4.6	0.3	12.6	

* No samples

Table 10a. Percentage composition (by weight) of food items recorded during different months in the stomach of *Parascolopsis aspinosa* (96-97).

Food items	Feb 96	Mar *	Apr	May *	Jun *	Jul *	Aug *	Sep	Oct *	Nov *	Dec *	Jan 97
Crustaceans												
Amphipoda			25.5					30.3				75.1
Prawns			32.6					--				
Crabs			6.1					48.2				20.5
Squilla												
Lobster			12.4									
Crustacean remains												
Pisces												
Trichiurus sp												
Saurida sp												
Stolephorus sp												
Fish remains			13.2					14.2				
Cephalopods												
Loligo												
Sepia												
Octopus												
Cephalopod remains								7.3				
Annelids												
Polychaetes												
Other worms												
Miscel. matters			10.2									

* No samples

Table 10b. Percentage composition (by weight) of food items recorded during different months in the stomach of *Parascolopsis aspinosa* (97-98).

Food items	Feb 97	Mar	Apr *	May	Jun *	Jul *	Aug *	Sep	Oct	Nov	Dec	Jan 98
Crustaceans												
Amphipods				32.1								
Prawns									40.3		70.5	
Crabs		100		28.6				62.8	29.6		2.8	
Squilla												
Lobster								23.5		16.5		
Crustacean remains	100			18.4							4.5	
Pisces												
Trichiurus sp												
Saurida sp												
Stolephorus sp												
Fish remains											14.7	
Cephalopods												
Loligo									17.1			
Sepia								13.7	23			
Octopus												
Cephalopod remains												
Annelids												
Polychaetes				14.6							7.5	
Other worms												
Miscel. matters				6.3								

* No samples

Table 11. Percentage occurrence of food items (by weight) of *Nemipterus japonicus* in different length classes.

Length class	Amphipods	Prawns	Crabs	Squilla	Ribbon fish	Saurida	Anchovies	Cephalopods	Fish remains	Crustacean remains	Worms, Molusc remains.
80-89		60.8	-	-	-	-	-	-	-	39.2	
90-99	3.5	31.5	11.11	18.6	-	-	-	-	21.2	5.4	6.5
100-109			8.6	6.0			23.6		8.3	4.4	7.5
110-119	28.4	41.6	11.7			14.8		9.3	2.8	8.2	1.6
120-129	3.3	23.2	60.4					2.6	8.6	4.5	2.0
130-139	16.8	18.6	12.6		6.2		16.8	4.6	23.2	11.6	8.4
140-149				39.3	2.1	6.2		7.2	18.7	6.6	12.4
150-159	8.4	8.2	22.9					1.6	18.4	7.3	
160-169	3.4	41.4	3.6	48.4	1.6			22.8	8.6	9.6	
170-179	2.6	2.8	43.4	6.8			14.8		30.6	2.8	
180-189	1.0		55.5				8.2	6.3	7.4	14.6	8.0
190-199				7.1		18.9			65.6		
200-209		23.1	11				83.0		3.8	12.1	
210-219	3.6		28.8				61.6				
220-229		10.8		16.1					71.6		12.3
230-239									0.8	7.9	
240-249		91.3	100								
250-259				100							
260-269											

Table 12. Percentage occurrence of food items (by weight) of *Nemipterus mesoprion* in different length classes.

Length classes	Amphipods	Prawns	Crabs	Squilla	Ribbon fish	Saurida	Anchovies	Cephalopods	Fish remains	Crustacea. remains	Molusc. remains	Miscel.
80-89	88.3									11.7		
90-99		22.4	43.6	33.9								
100-109	42.4	16.8	7.8				3.6	22.7			0.4	6.3
110-119	14.6	32.4	14.8		0.2		23.8			14.2		
120-129		11.6	10.3	18.1	6.3	24.6		17.7	9.7		0.7	
130-139	8.0	11.6		6.1		10.6	24.9		18.6	10.7	8.1	1.44
140-149	24.0	22.3		22.3	16.4			5.6	7.3		2.1	
150-159	6.3	18.4	30.2	6.6			18.4	0.8	11.1	8.2		
160-169	3.3	22.1	16.2	14.2	1.0	6.3	6.8	8.8	12.6	6.2	9.8	2.4
170-179	16.8	12.3	1.6	32.2	12.6			14.2			0.6	0.3
180-189	8.2	6.2	44.3	6.1		14.6		8.8	9.2	2.0		0.6
190-199	13.3	12.1	23.2	04.2			13.1		12.6	14.1	6.8	0.6
200-209	10.6	32.3		10.6	3.0	20.2		0.9	12.6	8.2	1.0	
210-219		40.8	0.8	26.8		08.3	13.3	10.0				
220-229	30.6		6.3						40.2	22.9		
230-239		26.0				18.2		41.2	14.6			
240-249									100			
250-259									62.0	38.0		
260-269		1.00										
270-279												

Table 13. Percentage occurrence of food items (by weight) of *Parascolopsis aspinosa* in different length classes.

Length class	Ampipods	Prawns	Crabs	Squilla	Ribbon fish	Saurida	Anchovies	Cephalopods	Fish remains	Crustaca. remains	Molusc. apendages	Worms	Misc
80-89													
90-99		100											
100-109		100											
110-119	20.2	30.6	8.8	1.6	4.3	2.2		10.9		21.1	6.5	0.1	4.8
120-129	8.4	14.6	26.2	6.2		3.7	6.3		10.8	8.1	5.4	1.1	1.1
130-139	22.1	28.2	14.3	1.8			14.2	10.3		3.3	3.5	2.1	0.2
140-149	14.4	23.4		10.2	3.6			11.7	14.4	14.7	7.1	0.1	0.4
150-159	43.0	12.1	12.3			13.1			0.6	12.6		6.2	
160-169		18.7	20.2	16.7	8.6					27.1	8.6	0.1	
170-179	12.6	30.6	14.8					24.2	8.8	2.2		6.8	
180-189		23.8	45.6							30.6			
190-199		100											
200-209													
210-219			100										

Table 14. Feeding intensity during different months among *Nemipterus japonicus* from February 1996 to January 1998.

Months	Number of fishes	Feeding Intensity						
		G	F	¾	½	¼	T	E
1996 Feb.	151	4.64	33.77	3.31	11.26	11.92	0	35.10
Mar.	37	8.11	8.11	-	8.11	2.70	2.70	70.27
Apr.	53	5.66	13.21	9.43	11.32	-	5.66	54.72
May.	105	4.76	2.86	11.43	12.38	3.81	2.86	61.90
Jun.	*	--	--	--	--	--	--	--
Jul.	*	--	--	--	--	--	--	--
Aug.	*	--	--	--	--	--	--	--
Sep.	5	0	0	0	20	20	0	60
Oct.	30	0	40	13.33	13.33	0	0	33.33
Nov.	164	0.61	3.66	1.83	3.05	1.83	0.61	88.41
Dec.	57	3.51	10.53	7.02	14.04	0	1.75	63.16
1997 Jan.	190	2.11	7.89	2.63	7.37	4.74	2.11	73.16
Feb.	143	2.10	9.09	6.99	7.69	2.10	0.90	70.63
Mar.	22	0	9.09	4.55	0	18.18	9.09	59.09
Apr.	127	3.15	7087	3.15	15.75	7.87	0	62.20
May.	194	6.19	4.64	6.19	10.82	12.37	0	59.79
Jun.	*	--	--	--	--	--	--	--
Jul.	*	--	--	--	--	--	--	--
Aug.	*	--	--	--	--	--	--	--
Sep.	*	--	--	--	--	--	--	--
Oct.	33	6.06	6.06	15.15	15.15	6.06	0	51.52
Nov.	171	-	4.09	2.34	9.94	7.02	0	76.61
Dec.	134	0.75	9.70	2.99	5.22	8.21	0	73.13
1998 Jan.	398	6.53	12.06	7.04	16.08	10.55	11.81	35.93

Table 15. Feeding intensity among *Nemipterus mesoprion* from February 1996 to January 1999.

Months	Number of fishes	Feeding Intensity						
		G	F	¾	½	¼	T	E
1996 Feb.	226	0.44	4.42	1.33	5.31	3.54	-	76.11
Mar.	134	2.24	20.9	0.75	10.45	6.72	-	61.94
Apr.	160	3.75	7.5	1.88	10.63	5.63	5.00	65.63
May.	75	-	8.00	6.67	4.00	12.00	10.67	58.67
Jun.	-	-	-	-	-	-	-	-
Jul.	-	-	-	-	-	-	-	-
Aug.	149	14.77	32.21	12.75	8.05	0.67	0.67	30.87
Sep.	113	2.65	4.42	3.54	14.16	30.97	20.35	23.87
Oct.	96	1.04	14.58	4.17	7.29	2.08	9.38	61.46
Nov.	151	--	5.3	1.99	5.3	4.64	-	82.78
Dec.	230	1.3	17.39	2.17	12.17	2.17	11.74	53.04
1997 Jan.	218	5.50	11.93	3.21	5.50	1.83	7.34	64.68
Feb.	228	2.19	7.46	3.51	14.47	10.53	3.95	57.89
Mar.	222	3.15	4.50	1.80	5.41	6.31	0.45	78.38
Apr.	61	4.92	3.28	-	4.92	8.20	-	78.69
May.	124	4.84	12.10	2.42	24.19	0.81	0.81	54.84
Jun.	-	-	-	-	-	--	-	-
Jul.	-	-	-	-	-	-	-	-
Aug.	-	-	-	-	-	-	-	-
Sep.	156	1.92	3.85	2.56	10.26	14.10	5.13	62.18
Oct.	155	5.81	0.65	-	3.23	1.94	5.16	83.23
Nov.	261	6.13	4.21	3.07	2.68	6.13	2.68	75.10
Dec.	259	0.39	6.56	2.32	5.02	6.18	1.54	77.99
1998 Jan.	246	-	5.28	0.81	3.66	3.66	-	86.59

Table 16. Feeding intensity among *Parascolopsis aspinosa* from February 1996 to January 1998.

Months	Number	Feeding Intensity						
		G	Full	¾	½	¼	Trace	Empty
1996 Feb.	*	-	-	-	-	-	-	-
Mar.	*	-	-	-	-	-	-	-
Apr.	120	-	3.33	7.5	8.33	5.83	2.5	72.50
May.	*	-	-	-	-	-	-	-
Jun.	*	-	-	-	-	-	-	-
Jul.	*	-	-	-	-	-	-	-
Aug.	*	-	-	-	-	-	-	-
Sep.	30	6.67	3.33	3.33	10.00	-	-	76.67
Oct.	*	-	-	-	-	-	-	-
Nov.	*	-	-	-	-	-	-	-
Dec.	*	-	-	-	-	-	-	-
1997 Jan.	5	20	-	-	20	20	-	40
Feb.	5	20	-	-	-	-	-	80
Mar.	1	100	-	-	-	-	-	-
Apr.	*	-	-	-	-	-	-	-
May.	91	1.10	4.4	5.49	15.38	3.3	1.1	69.23
Jun.	*	-	-	-	-	-	-	-
Jul.	*	-	-	-	-	-	-	-
Aug.	*	-	-	-	-	-	-	-
Sep.	26	-	3.85	7.69	11.54	3.85	-	73.08
Oct.	23	8.70	3.43	-	8.70	47.83	-	69.57
Nov.	68	2.94	10.29	-	2.94	16.18	-	67.65
Dec.	142	1.41	14.79	6.34	14.08	7.75	3.52	52.11
1998 Jan.	*	-	-	-	-	-	-	-

Table 17. Feeding intensity in various length classes of *Nemipterus japonicus.*

Length classes	Number of fishes	Maturity Stages						
		G	F	¾	½	¼	T	E
70-79	*	*	*	*	*	*	*	*
80-89	2	-	-	50.00	50.00	-	---	-
90-99	29	-	-	13.79	6.90	6.90	-	72.41
100-109	96	-	1.04	4.17	11.46	6.25	1.04	76.04
110-119	153	2.61	5.23	3.92	9.80	3.92	5.23	69.28
120-129	264	2.65	3.41	1.52	4.17	9.47	3.03	75.76
130-139	360	3.61	5.56	1.94	8.61	11.11	3.61	65.56
140-149	408	4.90	12.50	4.17	7.60	9.07	3.68	58.09
150-159	415	3.61	8.19	2.89	6.75	11.57	3.61	64.10
160-169	439	0.91	8.43	4.33	9.79	7.06	7.06	62.41
170-179	403	2.48	3.72	2.23	9.93	10.92	2.98	67.74
180-189	254	2.76	11.02	1.97	8.27	5.91	2.76	67.32
190-199	185	3.24	4.86	1.08	7.57	5.95	2.16	75.14
200-209	104	2.88	13.46	2.88	9.62	12.50	0.90	57.69
210-219	59	8.47	11.86		5.08	11.86	5.08	57.63
220-229	40	2.50	12.50	-	2.50	12.50	-	70.00
230-239	34	2.94	17.65	-	5.88	2.94	2.94	67.65
240-249	12	-	16.67	-	8.33	-	-	75.00
250-259	5	-	20.00	-	20.00	0	-	60.00
260-269	1	-	100	-	-	-	-	0
270-279	1	-	-	-	-	-	-	100

Table 18. Feeding intensity of various length classes of *Nemipterus mesoprion.*

Length classes	Number of fishes	Maturity Stages						
		G	F	¾	½	¼	T	E
70-79	*	*	*	*	*	*	*	*
80-89	2	-	-	50.00	50.00	-	-	-
90-99	29	-	-	13.79	6.90	6.90	-	72.41
100-109	96	-	1.04	4.17	11.46	6.25	1.04	76.04
110-119	153	2.61	5.23	3.92	9.80	3.92	5.23	69.28
120-129	264	2.65	3.41	1.52	4.17	9.47	3.03	75.76
130-139	360	3.61	5.56	1.94	8.61	11.11	3.61	65.56
140-149	408	4.90	12.50	4.17	7.60	9.07	3.68	58.09
150-159	415	3.61	8.19	2.89	6.75	11.57	3.61	64.10
160-169	439	0.91	8.43	4.33	9.79	7.06	7.06	62.41
170-179	403	2.48	3.72	2.23	9.93	10.92	2.98	67.74
180-189	254	2.76	11.02	1.97	8.27	5.91	2.76	67.32
190-199	185	3.24	4.86	1.08	7.57	5.95	2.16	75.14
200-209	104	2.88	13.46	2.88	9.62	12.50	0.90	57.69
210-219	59	8.47	11.86	-	5.08	11.86	5.08	57.63
220-229	40	2.50	12.50	-	2.50	12.50	-	70.00
230-239	34	2.94	17.65	-	5.88	2.94	2.94	67.65
240-249	12	-	16.67	-	8.33	-	-	75.00
250-259	5	-	20.00	-	20.00	0	-	60.00
260-269	1	-	100	-	-	-	-	0
270-279	1	-	-	-	-	-	-	100

Table 19. Feeding intensity of various length classes of *Parascolopsis aspinosa.*

Length classes	Number of fishes	Maturity Stages						
		G	F	¾	½	¼	T	E
70-79	-	-	-	-	-	-	-	-
80-89	-	-	-	-	-	-	-	-
90-99	4	25.00	-	-	-	-	-	75.00
100-109	16	-	-	6.25	-	18.75	-	75.00
110-119	59	1.69	18.64	3.39	6.78	10.17	-	59.32
120-129	101	2.97	5.94	6.93	2.97	16.83	0.99	63.37
130-139	94	7.45	9.57	2.13	8.51	5.32	1.06	65.96
140-149	104	1.92	7.69	5.77	9.62	2.88	-	72.12
150-159	58	-	1.72	3.45	18.97	8.62	-	67.24
160-169	37	2.70	0	5.41	10.81	2.70	-	78.38
170-179	27	-	3.70	14.81	14.81	-	-	66.67
180-189	7	14.29	-	14.29	14.29	-	-	57.14
190-199	2	-	-	50.00	-	-	-	50.00
200-209	0	0	0	0	0	0	0	0
210-219	1	-	-	50.00	-	-	-	50.00

Table 20. Percentage occurrence of males in *Nemipterus japonicus* during different stages of maturity from February 1996 to January 1998.

Months	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
1996 Feb.	63	36.51	31.16	19.05	11.11	3.17	--	--
Mar.	20	--	55.00	35.00	5.00	5.00	--	--
Apr.	20	35.00	55.00	10	--	--	--	--
May	38	65.79	21.05	13.16	--	--	--	--
Jun.	--	--	--	--	--	--	--	--
Jul.	--	--	--	--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Sep.	4	25	25	25	25	--	--	--
Oct.	15	20	13.33	40.00	26.66	--	--	--
Nov.	124	81	14.52	75	9.68	--	--	--
Dec.	37	--	10.81	83.78	2.70	2.70	--	--
1997 Jan.	101	17.82	69.31	3.96	4.95	--	3.96	.99
Feb.	79	36.71	44.30	12.66	3.80	1.27	--	1.27
Mar.	15	60	13.33	20	6.67	--	--	--
Apr.	60	53.33	30	16.67	--	--	--	--
May.	42	45.24	47.02	7.14	--	--	--	--
Jun.	--	--	--	--	--	--	--	--
Jul.	--	--	--	--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Sep.	--	--	--	--	--	--	--	--
Oct.	17	6.25	75	18.75	6.25	--	--	--
Nov.	105	40	43	11.43	2.86	1.90	--	--
Dec.	77	35.06	31.17	23.38	7.79	1.3	--	1.3
1998 Jan.	184	71.74	5.98	7.07	7.61	7.07	--	0.54

Table 21. Percentage occurrence of females in *Nemipterus japonicus* during different stages of maturity from February 1996 to January 1998.

Months	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
1996 Feb.	88	39.77	15.91	28.41	4.55	2.27	--	9.09
Mar.	17	17.65	--	41.18	35.29	--	--	5.88
Apr.	33	21.21	57.58	18.18	--	3.03	--	--
May	67	17.91	49.25	23.88	1.49	--	--	--
Jun.	--	--	--	--	--	--	--	--
Jul.	--	--	--	--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Sep.	1	--	--	--	100	--	--	--
Oct.	15	46.67	20	26.67	6.67	--	--	--
Nov.	38	--	18.42	60.53	15.79	2.63	2.63	--
Dec.	20	15	20	50	10	5	--	--
1997 Jan.	87	34.48	5.75	2.30	32.18	22.99	--	2.30
Feb.	64	26.56	28.13	21.88	15.63	6.25	--	1.50
Mar.	7	57	--	29	14	--	--	--
Apr.	67	70.15	13.43	10.45	--	5.97	--	--
May	152	34.21	53.29	12.5	--	--	--	--
Jun.	--	--	--	--	--	--	--	--
Jul.				--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Sep.	--	--	--	--	--	--	--	--
Oct.	16	--	37.5	50	12.5	12.5	--	--
Nov.	66	7.58	40.91	34.85	16.67	16.67	--	--
Dec.	57	56.14	7.02	21.05	8.77	7.02	7.02	4.2
1998 Jan.	214	79.44	--	0.93	1.4	1.4	--	4.21

Table 22. Percentage occurrence of males in *Nemipterus mesoprion* during different stages of maturity from February 1996 to January 1998.

Months	Number of fishes	Maturity stages						
		I	II	III	IV	V	VI	VII
1996 Feb.	136	6.62	46.32	33.09	5.15	6.62	2.21	--
Mar.	83	8.43	56.63	19.28	10.84	4.82	--	--
Apr.	73	41.10	49.32	9.59	--	--	--	--
May	43	65.12	13.95	16.28	4.65	--	--	--
Jun.	--	--	--	--	--	--	--	--
Jul.	--	--	--	--	--	--	--	--
Aug.	57	5.26	52.63	40.35	1.75	--	--	--
Sep.	65	10.77	43.08	38.46	4.62	--	--	--
Oct.	33	15.15	54.55	33.33	--	--	--	--
Nov.	56	19.64	53.57	26.79	--	--	--	--
Dec.	160	23.13	46.88	20.63	7.50	0.63	--	1.25
1997 Jan.	127	10.24	52.76	29.13	5.51	2.36	--	--
Feb.	138	3.62	55.80	34.78	2.90	--	--	2.90
Mar.	125	6.40	78.40	13.60	0.80	--	--	0.80
Apr.	32	3.13	84.38	9.38	3.13	--	--	--
May	93	5.38	37.63	47.31	6.45	3.23	1.08	-
Jun.	--	--	--	--	--	--	--	--
Jul	--	--	--	--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Sep.	79	16.46	46.84	24.05	7.59	5.06	--	--
Oct.	89	6.74	52.81	26.97	10.11	3.37	--	--
Nov.	213	0.94	2.82	59.15	10.8	26.24	--	--
Dec.	173	2.89	9.83	63.58	19.65	2.85	--	1.16
1998 Jan.	144	10.42	41.67	38.19	6.25	--	2.85	0.69

Table. 23. Percentage occurrence of females in *Nemipterus mesoprion* during different stages of maturity from February 1996 to January 1998.

Months	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
1996 Feb.	90	3.33	11.11	22.22	11.11	44.44	7.77	--
Mar.	51	3.92	17.65	52.94	19.61	3.92	--	1.96
Apr.	87	26.44	33.33	32.18	5.57	2.30	--	--
May	32	9.38	37.50	53.13	--	--	--	--
Jun.	--	--	--	--	--	--	--	--
Jul.	--	--	--	--	--	--	--	--
Aug.	92	1.09	50.00	38.04	4.35	4.35	--	2.17
Sep.	48	8.33	14.58	50.00	18.75	4.17	--	4.17
Oct.	63	1.59	11.11	44.44	42.86	--	--	--
Nov.	95	13.68	16.84	64.21	4.21	--	--	1.05
Dec.	70	7.14	25.71	37.14	25.71	1.43	1.43	1.43
1997 Jan.	91	2.20	24.18	51.65	12.09	5.49	1.10	3.30
Feb.	90	5.56	30.00	45.56	13.33	3.33	2.32	--
Mar.	97	7.22	24.74	49.48	18.56	--	--	--
Apr.	29	-	13.79	34.48	48.28	3.45	--	--
May	21	4.76	14.29	23.81	4.76	42.86	9.52	
Jun.	--	--	--	--	--	--	--	--
Jul.	--	--	--	--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Sep.	77	6.49	24.68	46.75	10.39	6.49	5.19	--
Oct.	66	16.67	27.27	39.39	15.15	1.52	--	--
Nov.	48	4.17	4.17	50.00	41.67	--	--	--
Dec.	86	2.33	6.98	34.88	36.05	19.77	--	--
1998 Jan.	102	8.82	36.22	23.53	2.59	8.82	1.96	--

Table. 24. Percentage occurrence of males in *Parascolopsis aspinosa* during different stages of maturity from February 1996 January 1998.

Months	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
1996 Feb.	--	--	--	--	--	--	--	--
Mar.	--	--	--	--	--	--	--	--
Apr.	68	4.41	19.12	36.76	20.59	13.24	--	5.88
May	--	--	--	--	--	--	--	--
Jun.	--	--	--	--	--	--	--	--
Jul.	--	--	--	--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Sep.	12	--	8.33	24.99	41.67	16.67	8.33	--
Oct.	--	--	--	--	--	--	--	--
Nov.	--	--	--	--	--	--	--	--
Dec.	--	--	--	--	--	--	--	--
1997 Jan.	3	--	--	--	66.66	33.33	--	--
Feb.	2	--	--	--	--	100	--	--
Mar.	1	--	--	--	100	--	--	--
Apr.	--	--	--	--	--	--	--	--
May	37	--	70.27	10.81	8.11	10.81	--	--
Jun.	--	--	--	--	--	--	--	--
Jul.	--	--	--	--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Sep.	3	--	33.33	66.67	--	--	--	--
Oct.	6	--	--	33.33	50.00	16.67	--	--
Nov.	33	--	42.42	36.36	5.03	--	18.18	--
Dec.	74	--	18.92	48.68	20.27	6.76	5.41	5.41
1998 Jan.	--	--	--	--	--	--	--	--

Table 25. Percentage occurrence of females in *Parascolopsis aspinosa* during different stages of maturity from February 1996 to January 1998.

Months	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
1996 Feb.	--	--	--	--	--	--	--	--
Mar.	--	--	--	--	--	--	--	--
Apr.	52	7.69	11.54	23.08	26.92	3.85	3.85	--
May	--	--	--	--	--	--	--	--
Jun.	--	--	--	--	--	--	--	--
Jul.	--	--	--	--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Sep.	18	--	27.78	38.89	16.67	11.11	5.56	--
Oct.	--	--	--	--	--	--	--	--
Nov.	--	--	--	--	--	--	--	--
Dec.	--	--	--	--	--	--	--	--
1997 Jan.	2	--	--	--	100	--	--	--
Feb.	3	--	--	66.67	33.33	--	--	--
Mar.	--	--	--	--	--	--	--	--
Apr.	--	--	--	--	--	--	--	--
May	54	1.85	20.37	29.63	42.59	5.56	--	--
Jun.	--	--	1	--	--	--	--	--
Jul.	--	--	1	--	--	--	--	--
Aug.	--	--	1	--	--	--	--	--
Sep.	23	8.70	8.70	52.17	13.04	13.04	4.35	--
Oct.	17	--	--	17.65	58.82	11.76	11.76	--
Nov.	35	--	34.29	57.14	5.71	--	2.86	--
Dec.	68	--	20.59	52.9	16.18	7.35	--	2.94
1998 Jan.	--	--	--	--	--	--	--	--

Table 26. Percentage occurrence of males in *Nemipterus japonicus* during different stages of maturity in various length classes.

Length (mm) class	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
80-89	1	100	--	--	--	--	--	--
90-99	12	75	16.67	8.33	--	--	--	--
100-109	46	58.70	17.39	23.91	--	--	--	--
110-119	153	33.99	38.56	27.45	--	--	--	--
120-129	117	13.68	40.17	45.30	0.85	--	--	--
130-139	82	17.07	30.49	39.02	13.23	--	--	--
140-149	93	4.30	33.33	53.76	8.60	--	--	--
150-159	90	3.13	15.63	30.21	34.38	10.42	--	--
160-169	112	2.68	12.50	66.07	17.80	5.36	--	0.89
170-179	126	3.17	22.22	45.24	24.60	1.59	--	3.17
180-189	71	8.45	19.72	47.89	19.72	4.23	1.41	--
190-199	24	8.33	29.17	33.33	8.33	20.83	--	--
200-209	25	--	48.00	48.00	4.00	--	--	--
210-219	9	--	66.67	22.22	11.11	--	--	--
220-229	14	--	7.14	50.00	28.57	7.14	7.14	--
230-239	15	--	40.00	53.33	6.67	--	--	--
240-249	9	--	11.11	44.44	33.33	11.11	--	--
250-259	4	--	25	75	--	--	--	--
260-269	2	--	50	50	--	--	--	--

Table 27. Percentage occurrence of females in *Nemipterus japonicus* during different stages of maturity in various length classes.

Length classes (mm)	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
70-79	1	--	100	--	--	--	--	--
80-89	2	--	100	--	--	--	--	--
90-99	27	96.30	3.70	--	--	--	--	--
100-109	56	66.07	14.29	19.64	--	--	--	--
110-119	197	37.06	34.52	26.40	2.03	--	--	--
120-129	122	50.82	18.85	28.69	1.64	--	--	--
130-139	104	12.50	31.73	45.19	7.69	2.88	--	--
140-149	76	--	11.84	35.53	38.16	13.16	--	1.32
150-159	80	--	2.50	26.25	38.25	31.25	1.25	--
160-169	109	--	--	27.52	64.22	7.34	--	7.34
170-179	108	--	--	6.48	37.96	51.85	--	1.85
180-189	62	--	1.61	16.13	74.19	4.48	3.23	--
190-199	21	--	--	4.76	38.10	47.62	4.76	4.76
200-209	16	--	--	12.50	18.75	37.5	25.00	6.25
210-219	9	--	11.11	55.56	22.22	11.11	--	--
220-229	4	--	--	25	50	25	--	--
230-239	8	--	--	50	25	12.5	--	12.5
240-249	3	--	--	66.67	33.33	--	--	--
250-259	4	--	--	25	50	25	--	--

Table 28. Percentage occurrence of males in *Nemipterus mesoprion* during different stages of maturity in various length classes.

Length class (mm)	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
80-89	1	100	--	--	--	--	--	--
90-99	9	55.55	33.33	11.11	--	--	--	--
100-109	47	34.04	38.30	27.66	--	--	--	--
110-119	74	14.86	54.05	27.03	4.05	--	--	--
120-129	145	12.41	46.90	30.04	10.34	--	--	--
130-139	206	1.94	59.71	25.73	12.62	--	--	--
140-149	236	2.12	40.68	47.46	8.90	0.85	--	--
150-159	250	--	17.60	66.80	8.80	1.60	1.60	3.60
160-169	269	0.74	14.13	56.13	25.65	0.37	1.12	1.86
170-179	241	0.41	37.34	47.30	7.47	4.98	2.49	--
180-189	135	6.67	12.59	56.30	18.52	5.93	--	--
190-199	106	--	47.17	33.02	13.21	4.72	--	1.89
200-209	73	--	9.59	71.23	10.96	8.22	--	--
210-219	44	--	--	27.27	40.91	20.45	4.55	6.82
220-229	36	--	22.22	36.11	38.89	2.78	--	--
230-239	28	--	28.57	39.29	25.00	--	--	7.14
240-249	12	--	8.33	41.67	33.33	16.33	--	--
250-259	5	--	--	40.00	60.00	--	--	--
260-269	1	--	--	1.00	--	--	--	--
270-279	1	--	--	1.00	--	--	--	--

Table 29. Percentage occurrence of females in *Nemipterus mesoprion* during different stages of maturity in various length classes.

Length classes (mm)	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
80-89	1	--	100	--	--	--	--	--
90-99	20	80	15	15	--	--	--	--
100-109	49	57.14	26.53	16.33	--	--	--	--
110-119	79	41.77	32.91	24.05	1.27	--	--	--
120-129	119	5.88	62.18	28.57	3.36	--	--	--
130-139	154	2.60	14.94	53.90	24.68	3.90	--	--
140-149	172	1.16	16.86	58.14	16.28	5.81	--	1.74
150-159	165	1.21	11.52	44.85	21.21	13.94	1.82	5.45
160-169	170	--	15.29	25.29	35.88	15.29	7.65	0.59
170-179	162	--	--	32.10	45.06	22.22	0.62	--
180-189	119	--	8.4	17.65	11.76	39.50	16.81	5.88
190-199	79	--	--	32.91	17.72	39.24	5.06	5.06
200-209	31	--	--	6.45	41.94	22.58	29.03	--
210-219	15	--	--	6.67	46.67	33.33	--	13.33
220-229	4	--	--	25	25	25	25	--
230-239	6	--	--	16.67	33.33	16.67	--	16.67
240-249	--	--	--	--	--	--	--	--
250-259	--	--	--	--	--	--	--	--

Table 30. Percentage occurrence of males in *Parascolopsis aspinosa* during different stages of maturity in different length classes.

Length class (mm)	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
80-89	--	--	--	--	--	--	--	--
90-99	2	--	50	50	--	--	--	--
100-109	5	20	40	40	--	--	--	--
110-119	21	9.52	33.33	52.38	4.76	--	--	--
120-129	42	2.38	4.76	54.76	21.43	--	--	16.66
130-139	50	--	22.00	30	46	2	--	--
140-149	48	--	6.25	58.33	29.16	4.16	--	2.08
150-159	30	--	20.06	63.33	16.61	--	--	--
160-169	22	--	31.82	50.00	18.18	--	--	--
170-179	14	--	14.29	35.71	50.00	--	--	--
180-189	3	--	--	66.66	33.33	--	--	--
190-199	1	--	--	--	100	--	--	--
200-209	--	--	--	--	--	--	--	--
210-219	1	--	--	--	100	--	--	--

Table 31. Percentage occurrence of females in *Parascolopsis aspinosa* during different stages of maturity in various length classes.

Length class (mm)	Number of fishes	Maturity Stages						
		I	II	III	IV	V	VI	VII
80-89	--	--	--	--	--	--	--	--
90-99	2	--	100	--	--	--	--	--
100-109	11	9.09	54.54	27.27	--	--	--	--
110-119	38	5.26	18.42	50.00	26.32	--	--	--
120-129	59	1.69	33.90	47.46	16.95	--	--	--
130-139	44	--	38.64	29.55	15.91	15.91	--	--
140-149	56	--	23.21	53.57	10.71	10.71	--	--
150-159	28	--	--	14.29	32.14	32.14	17.86	3.57
160-169	15	--	--	20.00	46.66	26.66	--	6.66
170-179	13	--	--	15.39	46.15	30.77	7.69	--
180-189	4	--	--	--	75	25	--	--
190-199	1	--	--	--	100	--	--	--
200-209	--	--	--	--	--	--	--	--
210-219	1	--	--	--	--	100	--	--
220-229	--	--	--	--	--	--	--	--
230-239	--	--	--	--	--	--	--	--
240-249	1	--	--	--	--	100	--	--
250-259	--	--	--	--	--	--	--	--
260-269	--	--	--	--	--	--	--	--

Table 32. Fecundity of *Nemipterus japonicus* in relation to length, weight and gonad weight.

Sl.No.	Length (Cm)	Weight (g)	Gonad weight (g)	Fecundity
1	20	115.5	4.2	64053
2	18.5	63.5	1.96	11829
3	21.2	116	3.63	51063
4	17.6	58	3.93	41819
5	17.4	67.5	1.44	28065
6	17.2	68	2.2	25906
7	19	95	2.07	24140
8	12.3	23	0.78	8046
9	18.2	85.5	1.89	21382
10	20.4	110.5	3.25	59537
11	22	122	5.24	58418
12	19.4	107	3.34	32742
13	18	87.5	2.19	26354
14	18.7	92	2.92	29212
15	19.8	96.5	2.16	38426
16	19	95	1.86	36214
17	22.2	120.4	5.65	72915
18	20.3	111.8	3.328	54548
19	18.9	94.3	3.32	45326
20	17.2	65.3	1.68	31257
21	21.5	129	11.3	89357
22	20.9	133	12.7	92457
23	25	145	2.08	25624

Table 33. Fecundity of *Nemipterus mesoprion* in relation to length, weight and gonad weight

Sl.No.	Length (cm)	Weight (g)	Gonad weight (g)	Fecundity
1	15.5	48	3.64	42440
2	13.1	55	1.26	22201
3	12.7	74	1.01	14454
4	14.7	67	1.19	25232
5	19.2	92	1.26	24763
6	18.5	85.5	1.88	38404
7	17	74.5	2.32	43409
8	16.5	78.5	1.05	20396
9	20.1	119	2.96	42802
10	19	97.5	2.35	32261
11	18	77.5	1.22	29543
12	18.5	103	2.45	45025
13	18.4	84	1.55	31235
14	16.6	79.5	1.19	25232
15	18	94.5	2.17	34859
16	20.1	119	3.62	52638
17	18.5	89	1.18	30458
18	20.5	121	2.94	51369
19	16.5	61	1.44	29517
20	17.5	79	1.52	38129

Table 34. Fecundity of *Parascolopsis aspinosa* in relation to length, weight and gonad weight.

Sl. No.	Total length (cm)	Weight (g)	Gonad weight (g)	Fecundity
1	11.2	23	0.95	12390
2	11.3	25	0.82	10922
3	12	28.5	1.14	16589
4	12.1	28	1.26	19378
5	12.4	32	1.97	26762
6	12.4	32	1.97	38960
7	12.4	38	1.57	33096
8	12.6	34	1.83	48014
9	13	39	1.6	23682
10	13.1	36.5	1.57	22863
11	13.2	36.5	1.17	19062
12	13.7	43.5	1.54	28413
13	13.8	48	3.46	58358
14	15.9	62	3.27	43218
15	15.9	64	3.17	55628
16	16	80	3.43	51312
17	17.1	88	3.18	62992
18	17.2	84	1.02	26876
19	17.4	100.5	3.32	51905
20	17.8	109	2.05	43260
21	19	84	3.67	53415

Table 35. Test of significance (χ^2) of difference in observed sex ratio of *Nemipterus japonicus* in different months.

Months	Total numbers	Males		Females		χ^2 Values
		Number	Percentage	Number	Percentage	
1996 Feb.	151	63	41.72	88	58.28	4.1391*
Mar.	37	20	54.05	17	45.95	0.2432
Apr.	53	20	37.74	33	62.26	3.1887
May	105	38	36.19	67	63.81	8.0095*
Jun.	-					
Jul.	-					
Aug.	-					
Sep.	5	4	80.00	1	20.00	1.8000
Oct.	30	15	50.00	15	50.00	0
Nov.	164	126	76.83	38	23.27	47.2195*
Dec.	57	37	64.91	20	35.09	5.0702*
1997 Jan.	190	103	54.20	87	45.79	1.3474
Feb.	143	79	55.24	64	44.76	1.5734
Mar.	22	15	68.18	7	31.82	2.9091
Apr.	127	60	47.24	67	52.76	0.3858
May	194	42	21.65	152	78.35	62.3711*
Jun.	-					
Jul.	-					
Aug.	-					
Sep.	-					
Oct.	33	17	51.52	16	48.48	0.1142
Nov.	171	105	61.40	66	36.60	8.8947*
Dec.	134	77	57.46	57	42.54	2.2613
1998 Jan.	398	184	46.23	214	53.77	1.7157
Total	2014	1005	49.93	1009	50.07	0.0079

Test of dependence: $\chi^2 = (\Sigma nipi\text{-}NP)*(1/pq)$

χ^2 = 139.1095*, d. f, $_{18-2}$=16 χ^2 tab = 26.296

* Significant at α = .05

Table 36. Test of significance (χ^2) of observed difference in sex ratio of *Nemipterus japonicus* in different size groups.

Size groups	Total number	Males	Percentage males	Females	Percentage females	χ^2 value
70-79	1	-	0	1	100	--
80-89	3	1	33.33	2	66.66	0.3333
90-99	39	12	30.77	27	69.23	5.7692
100-109	102	46	45.10	56	54.90	0.9803
110-119	350	153	43.71	197	56.29	5.5314
120-129	239	117	48.95	122	51.05	0.1046
130-139	186	82	44.09	104	55.91	2.6021
140-149	169	93	55.03	76	44.97	1.7101
150-159	170	90	52.94	80	47.06	0.5882
160-169	221	112	50.68	109	49.32	0.0407
170-179	234	126	53.85	108	46.15	1.3846
180-189	133	71	53.38	62	46.62	0.6090
190-199	45	24	53.33	21	46.66	0.2
200-209	41	25	60.98	16	39.02	1.9786
210-219	18	9	50.00	9	50.00	--
220-229	18	14	77.77	4	22.22	5.5556
230-239	23	15	65.22	8	34.78	1.500
240-249	12	9	75.00	3	25.00	3.00
250-259	8	4	50.00	4	50.00	--
260-269	2	2	100.00	--	0.00	--
Total	2014	1005	49.93	1009	50.07	.0079

χ^2 Test of dependence $\chi^{2=(\Sigma nipi-NP)*(1/pq)}$

χ^2 = 30.074366, df, $_{20\text{-}2}$=18 χ^2 tab =28.869 cal> tab H_0 rejected

3.84 α = .05

* Significant at α = .05

Table 37. Test of significance (χ^2) of observed difference in sex ratio of *Nemipterus mesoprion* in different months.

Months	Total numbers	males		females		χ^2 Values
		Numbers	Percentage	Numbers	Percentage	
1996 Feb.	226	136	60.18	90	39.82	9.3628*
Mar.	134	83	61.94	51	38.06	7.6418*
Apr.	160	73	45.63	87	54.37	1.2251
May	75	43	57.33	32	45.45	1.6133
Jun.	-	-		-		-
Jul.	-	-		-		-
Aug.	149	57	38.60	92	61.74	8.2215*
Sep.	110	65	59.09	48	40.91	8.7091*
Oct.	96	33	34.38	63	65.62	9.3753*
Nov.	151	56	37.09	95	62.91	10.0728*
Dec.	230	160	69.57	70	30.43	35.2174*
1997 Jan.	218	127	58.26	91	41.74	5.9450*
Feb.	228	138	60.53	90	39.47	10.1053*
Mar.	222	125	56.30	97	43.70	3.5315*
Apr.	61	32	52.46	29	47.54	.1475
May	124	93	75.00	21	25.00	31.0001*
Jun.		-		-		-
Jul.		-		-		-
Aug.		-		-		-
Sep.	156	79	50.64	77	49.36	.0286
Oct.	155	89	57.42	66	42.58	3.4129
Nov.	261	213	81.61	48	18.39	104.3103*
Dec.	259	173	66.80	86	33.20	29.2239*
1998 Jan.	246	144	58.54	102	41.46	7.1707*
Total	3261	1919	58.85	1345	41.15	102.0941*

χ^2 Test of dependence: $\chi^2 = (\Sigma nipi - NP)*(1/pq)$

$\chi^2 = 187.17655$; (df, $_{(19-2)}$ χ^2 tab=.84; α = .05)

* Significant at α = .05

Table 38. Test of significance (χ^2)of observed difference in sex ratio of *Nemipterus mesoprion* in different size groups.

Length class (mm)	Total number	Males		Females		χ^2 value
		Number	Percentage	Number	Percentage	
80-89	2	1	50	1	50	0.0000
90-99	29	9	31.03	20	68.97	4.1724*
100-109	96	47	48.96	49	51.04	0.0417
110-119	153	74	48.37	79	51.63	0.1634
120-129	264	145	54.92	119	45.08	2.5606*
130-139	360	206	57.22	154	42.78	7.5111*
140-149	408	236	58.13	172	41.87	10.0392*
150-159	415	250	60.24	165	39.76	17.4096*
160-169	439	269	61.26	170	38.74	22.3257*
170-179	403	241	59.80	162	40.20	15.4864
180-189	254	135	53.15	119	46.85	1.0079*
190-199	185	106	57.30	79	42.70	3.9405*
200-209	104	73	70.19	31	29.81	16.9615*
210-219	59	44	74.58	15	25.42	15.5172*
220-229	40	36	90.00	4	10.00	25.6000*
230-239	34	28	82.35	6	17.65	14.2353*
240-249	12	12	100	0	0	12.0000*
250-259	5	5	100	0	0	5.0000
260-269	1	1	100	0	0	1
270-279	1	1	100	0	0	1
Total	3264	1919	58.85	1345	41.15	100.9424*

χ^2Test of dependence$\chi^{2=(\Sigma n_i p_i - NP)*(1/pq)}$

χ^2 = 89.67518216, df$_{,n-2=18)}$ χ^2tab = 28.869 $\propto$ = .05

* Significant at $\propto$ = .05

Table 39. Test of significance (χ^2) of observed difference in sex ratio of *Parascolopsis aspinosa* in different months.

Months	Total numbers	Males		Females		χ^2 Values
		Numbers	Percentage	Number	Percentage	
1996 Feb.	-	-				
Mar.	-	-				
Apr.	120	68	56.67	52	43.33	2.1333
May	-					
Jun.	-					
Jul.	-					
Aug.	-					
Sep.	30	12	40	18	60	1.2
Oct.	-					
Nov.	-					
Dec.	-					
1997 Jan.	5	3	60	2	40	.2
Feb.	5	2	40	3	60	.2
Mar.	1	1	100	0		-
Apr.	-	-		-		
May	91	37	40.66	54	59.34	3.17
Jun.	-			-		
Jul.	-			-		
Aug.	-			-		
Sep.	26	3	11.54	23	88.46	15.3846*
Oct.	23	6	26.09	17	73.91	5.2609*
Nov.	68	33	48.53	35	51.47	.0588
Dec.	142	74	52.11	68	47.89	0.2535
1998 Jan.	-	-				
Total	511	239	46.77	272	53.23	2.1311

χ^2Test of dependence: $\chi^{2=(\Sigma nipi-NP)*(1/pq)}$

χ^2= 26.84784442; χ^2tab 15.507;(df, $_{(10-2)}$;= $\propto$ = .05)

* Significant at $\propto$ = .05

Table 40. Test of significance (χ^2) on observed difference in sex ratio of *Parascolopsis aspinosa* in different size groups.

Length groups	Total number	Males		females		Chi-square (χ^2) value
		number	Percentage	number	Percentage	
90-99	4	2	50	2	50	0
100-109	16	5	31.25	11	68.75	2.25
110-119	59	21	35.59	38	64.41	4.8983*
120-129	101	42	41.58	59	58.42	2.8614
130-139	94	50	53.19	44	46.81	0.3830
140-149	104	48	46.15	56	53.85	0.6154
150-159	58	30	51.72	28	48.28	0.0690
160-169	37	22	59.46	15	40.54	1.3243
170-179	27	14	51.85	13	49.15	0.0370
180-189	7	3	42.86	4	57.14	0.1429
190-199	2	1	50	1	50	0
200-209	0	0		0		-
210-219	2	1	50	1	50	0
Total	511	239	46.77	272	53.23	2.1311

χ^2Test of dependence: $\chi^2 = (\Sigma nipi - NP) * (1/pq)$

χ^2= 10.4938877,

χ^2 tab=19.675 ; (d.f, $_{(13-2)}$ χ^2 cal < χ^2 tab Accept H_0)

* Significant at $\propto$ = .05

Table. 41. Growth and Mortality coefficients of three nemipterid species occurring along the Goa coast.

Species	Sex	Asymptotic length L_∞	Growth Coef. K	Total mortality coef. 'Z'	Natural mortality coef. 'M'	Fishing mortality coef. 'F'	Exploitation ratio 'E'	Exploitation rate 'U'	Survival Rate 'S'	exploitation cut of length L'
N. japonicus	Males	29.5	1.20	6.54	2.04	4.50	0.69	0.99885	0.00115	11
	Females	28.5	1.00	3.49	1.83	1.66	0.48	0.96950	0.03050	11
	Combined	30.0	1.00	6.60	1.80	4.80	0.73	0.99864	0.00136	12
N. mesoprion	Males	28.8	0.70	2.89	1.36	1.53	0.53	0.94442	0.05576	15
	Females	28.2	0.70	3.9	1.37	2.53	0.65	0.99090	0.00909	15
	Combined	28.5	0.80	3.56	1.49	2.12	0.58	0.97295	0.02705	15
P. aspinosa	Combined	21.7	0.67	2.45	1.40	1.05	0.43	0.91371	0.08629	13

Table. 42. Annual marine landing of fish and threadfin breams ('Rane') of Goa state from 1985 to 1999*

Year	Marine fish	Threadfin breams
1985	39,926	720
1986	29,927	1,295
1987	33,068	1,899
1988	40,713	39
1989	54,550	19
1990	53,179	3
1991	75,623	12
1992	96,333	8
1993	1,00,922	5
1994	95,840	25
1995	81,856	4,956
1996	92,737	2,098
1997	91,277	4,648
1998	67236	864
1999		404

* Source Department of Fisheries, Government of Goa.

Table 43a. Distribution of two major resource of nemipterids along the Goa coast

Depth zone	Total Stations		*N. japonicus*	*N. mesoprion*	Ratio Higher/ lower
Shallow water (35-80m)	100	Frequency	79 (79%)	32 (32%)	2.469
		Weight	503 (66%)	258 (34%)	1.950
Deeper waters (80-135m)	67	Frequency	17 (25%)	66 (98.5%)	3.882
		Weight	1686 (18%)	7970 (82%)	4.727

Table 43b. Effort, catch rate and density of two major species of nemipterids in three depth zones along the Goa coast from December 1995 to March 1998

Depth range (m)	Gear	Effort (hrs.)	Catch/hour (Kg)	Density (Kg/Km^2)	Area (Km^2)	Biomass (Kg)
30-50	27m fish trawl	177.25	0.462623	6.608377	3445	22,766
50-100	27m fish trawl	168.666	1.0079051	14.39749	4635	66,732
100-200	47m Shrimp trawl	120.25	20.390852	291.2745	2900	8,44,696

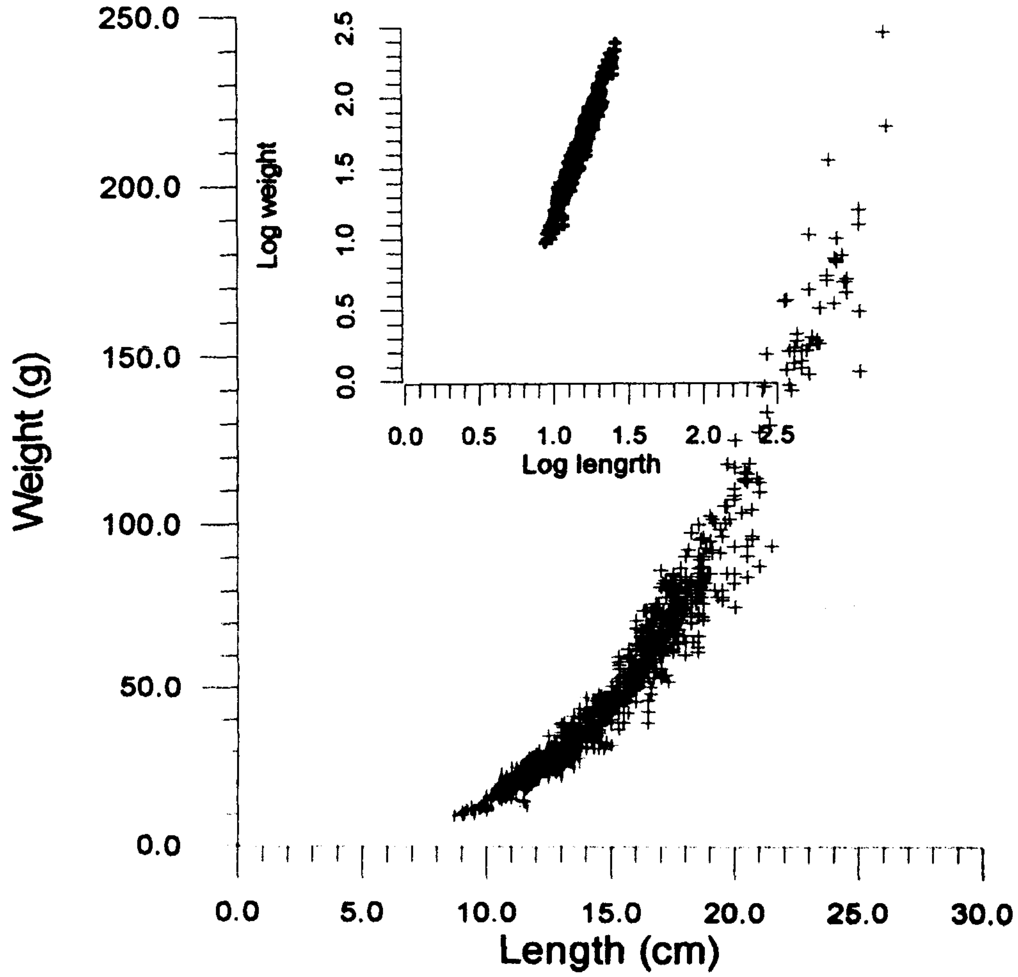

Fig. 1. Length-weight relationship in males of *Nemipterus japonicus*.

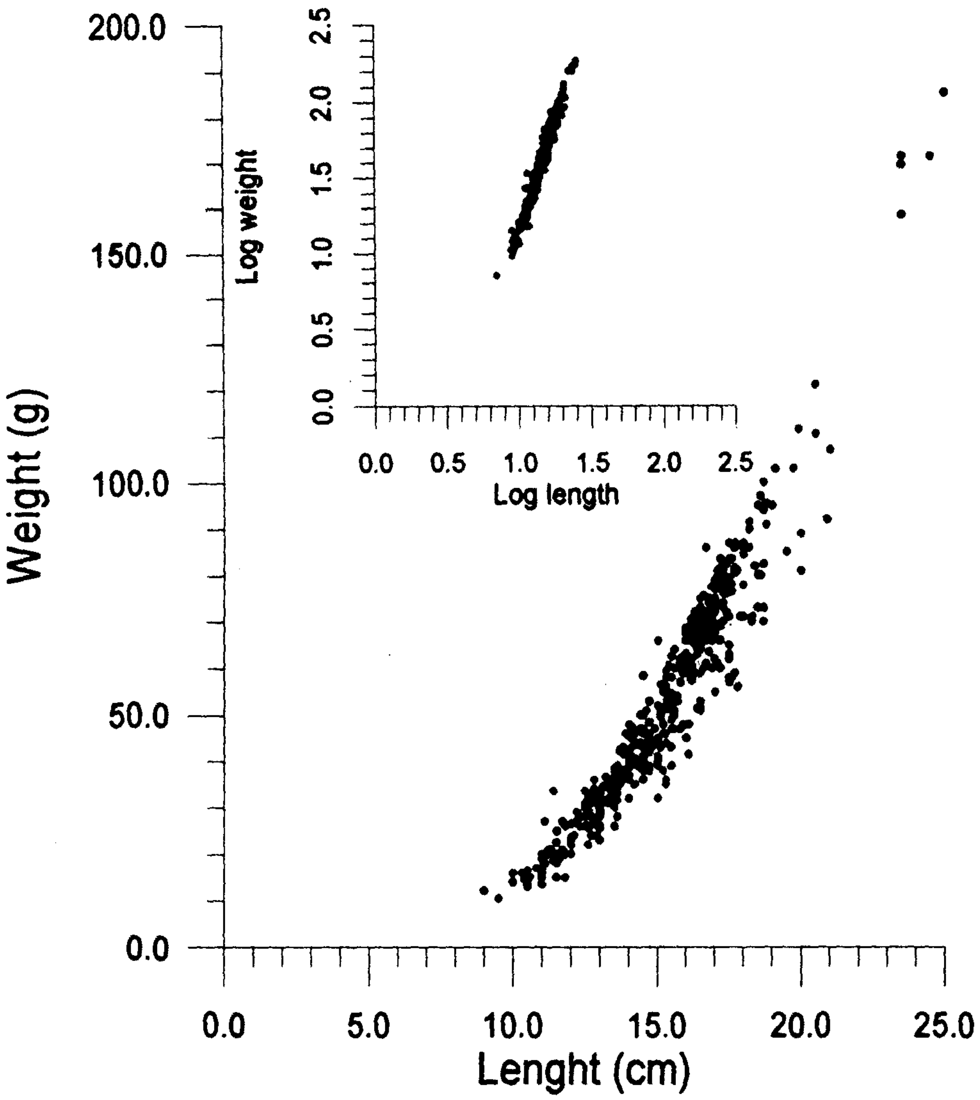

Fig. 2. Length-weight relationship in females of *Nemipterus japonicus.*

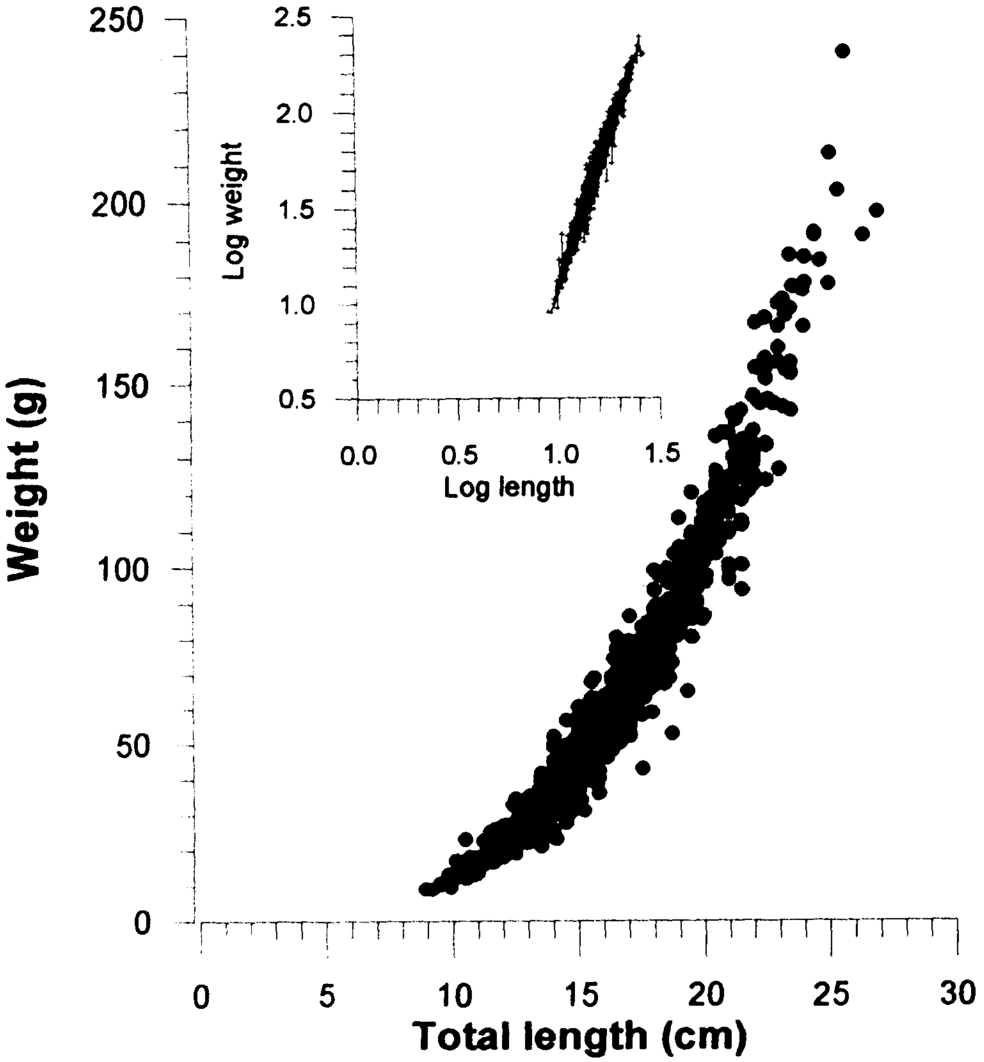

Fig. 3. Length-weight relationship in males of *Nemipterus mesoprion*.

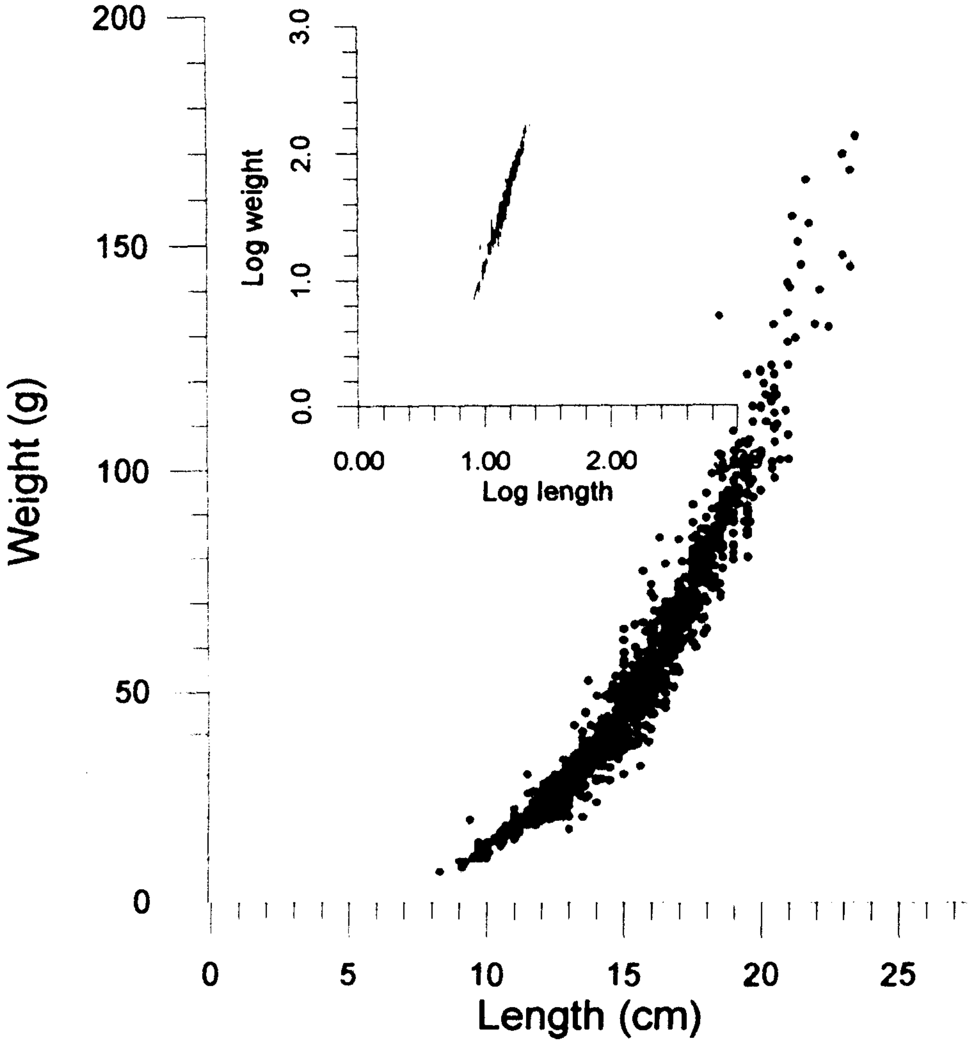

Fig. 4. Length-weight relationship in females of *Nemipterus mesoprion.*

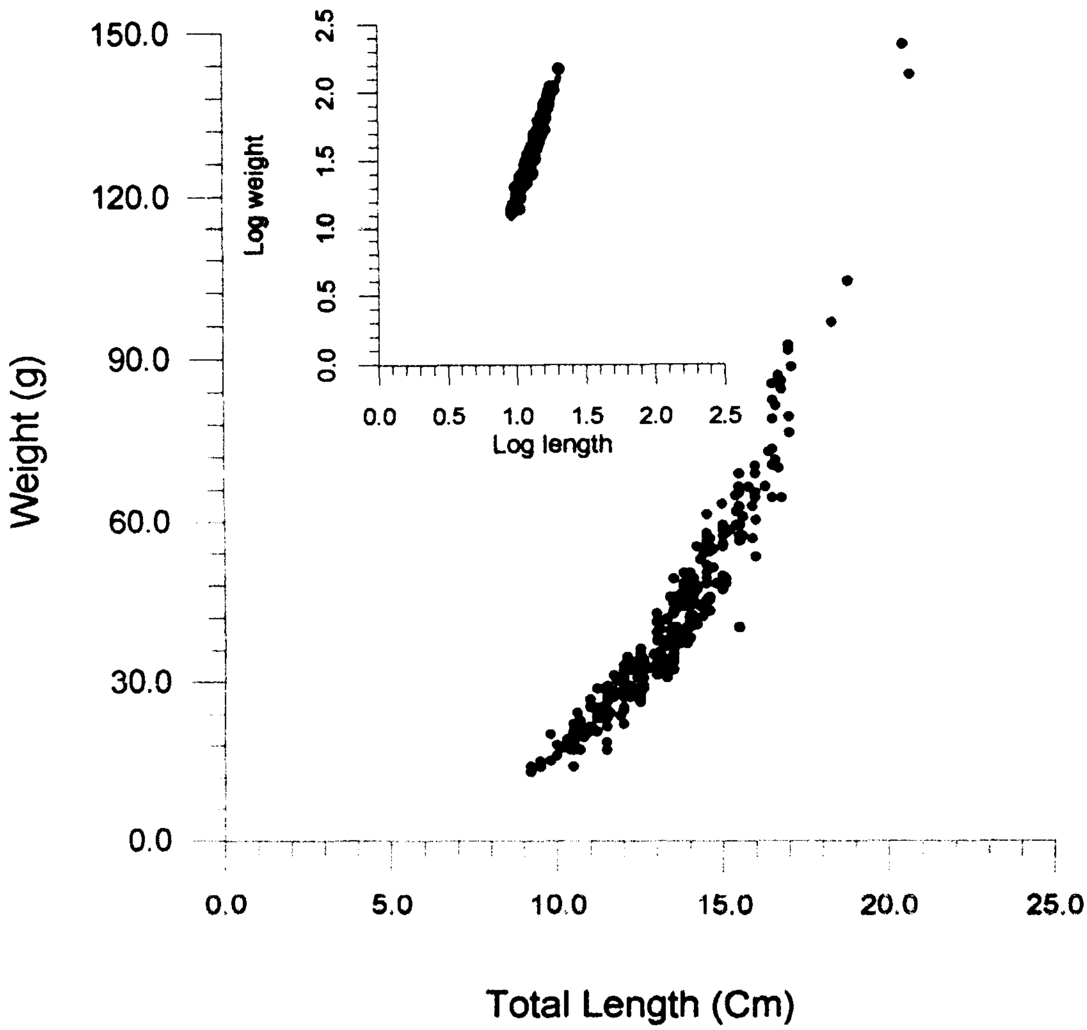

Fig. 5 Length-weight relationship in *Parascolopsis aspinosa*

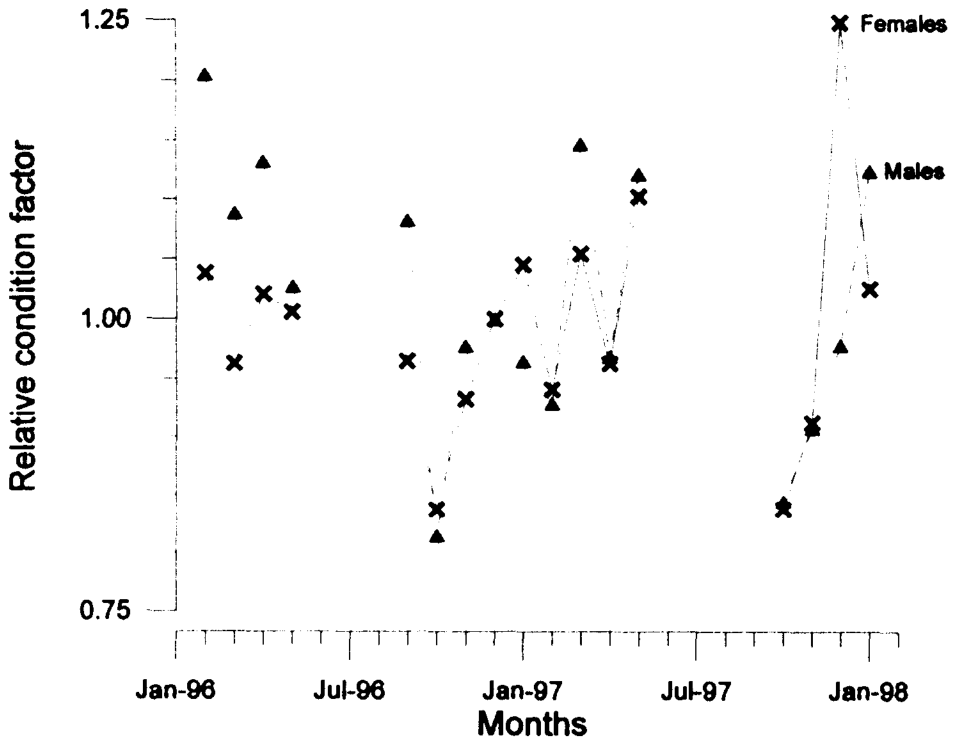

Fig. 6. Average relative condition factor of *Nemipterus japonicus* from February 1996 to January 1998

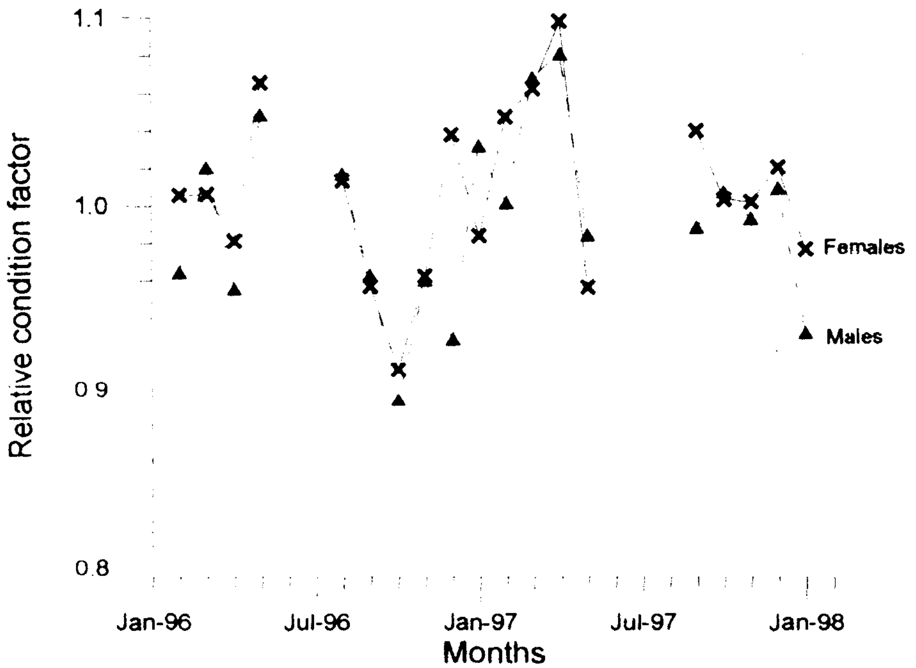

Fig. 7. Average relative condition factor of Nemipterus mesoprion from February 1996 to January 1998

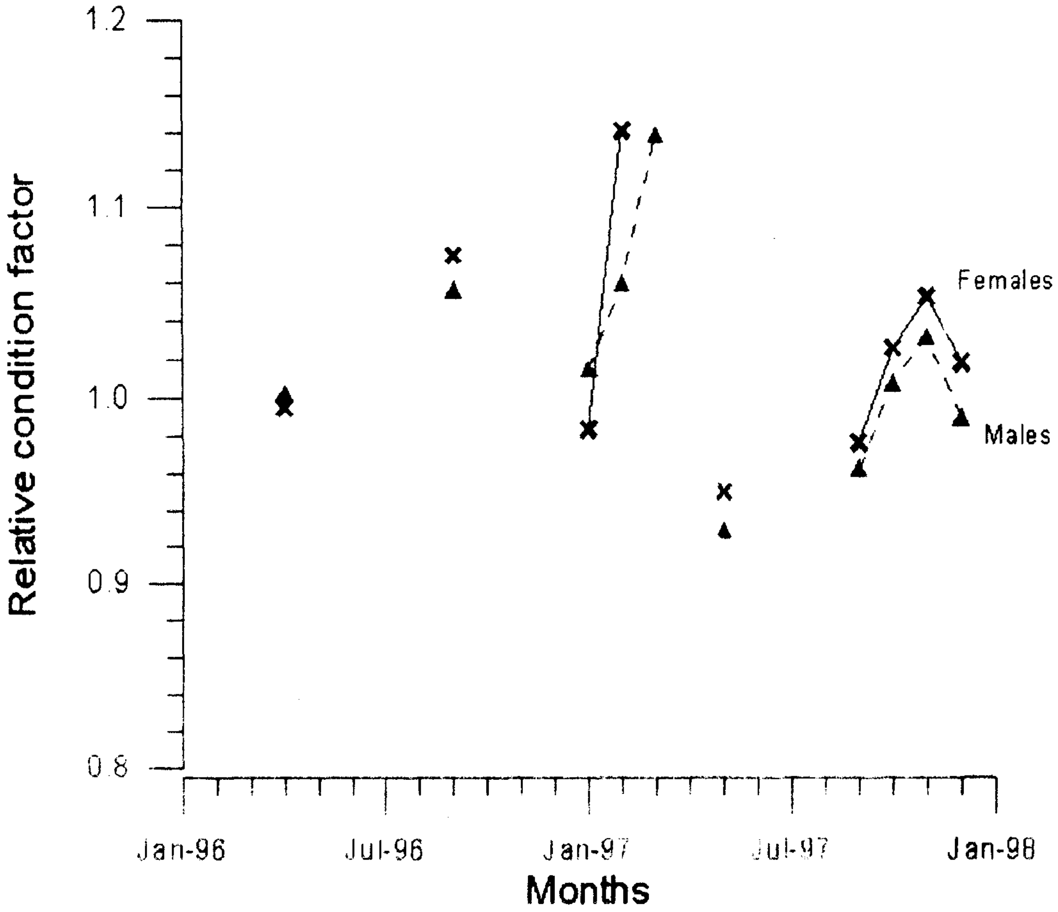

Fig. 8. Average relative condition factor of *Parascolopsis aspinosa* from February 1996 to January 1998.

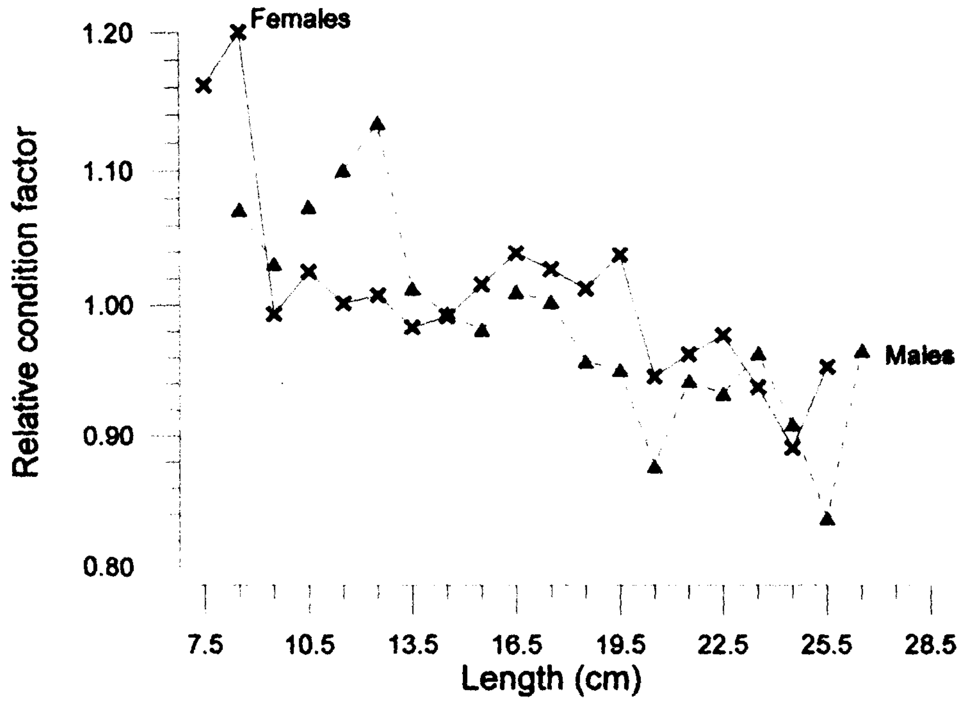

Fig. 9. Average relative condition factor of Nemipterus japonicus at different length groups

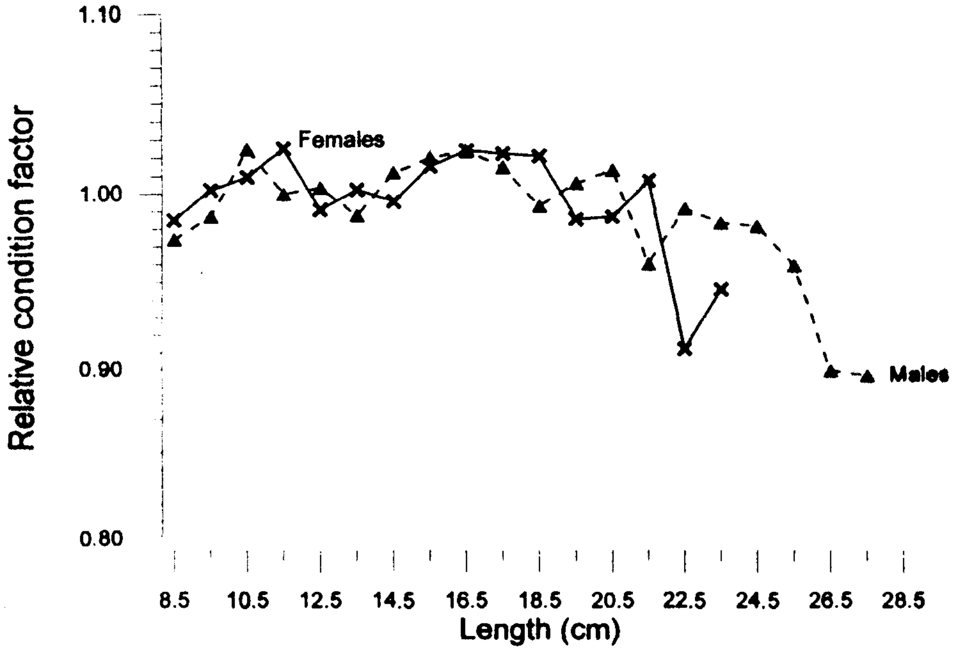

Fig. 10. Average condition factor of Nemipterus mesoprion at different length groups

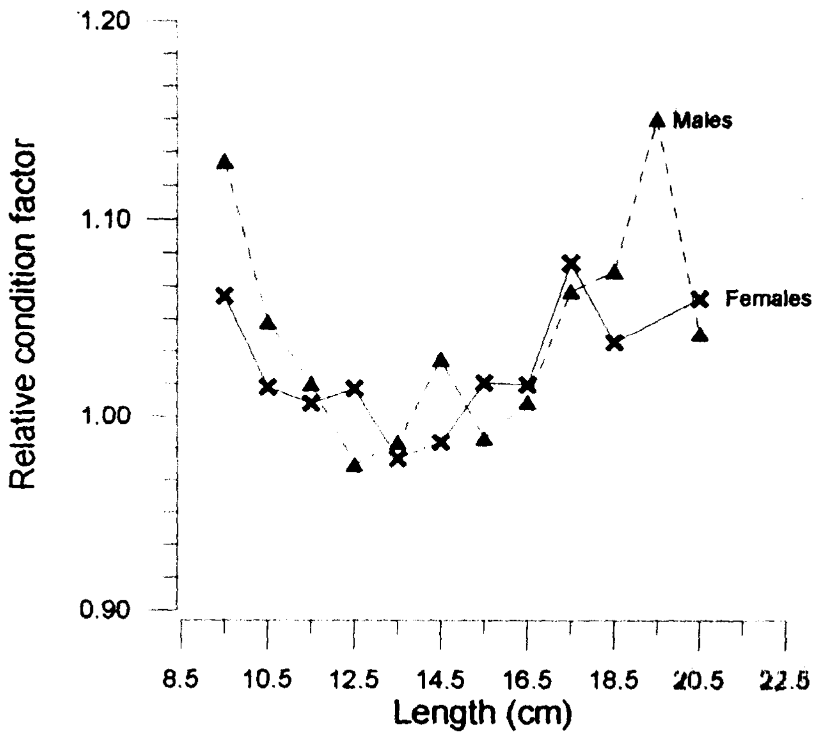

Fig. 11. Average relative condition factor of Parascolopsis aspinosa at different length groups

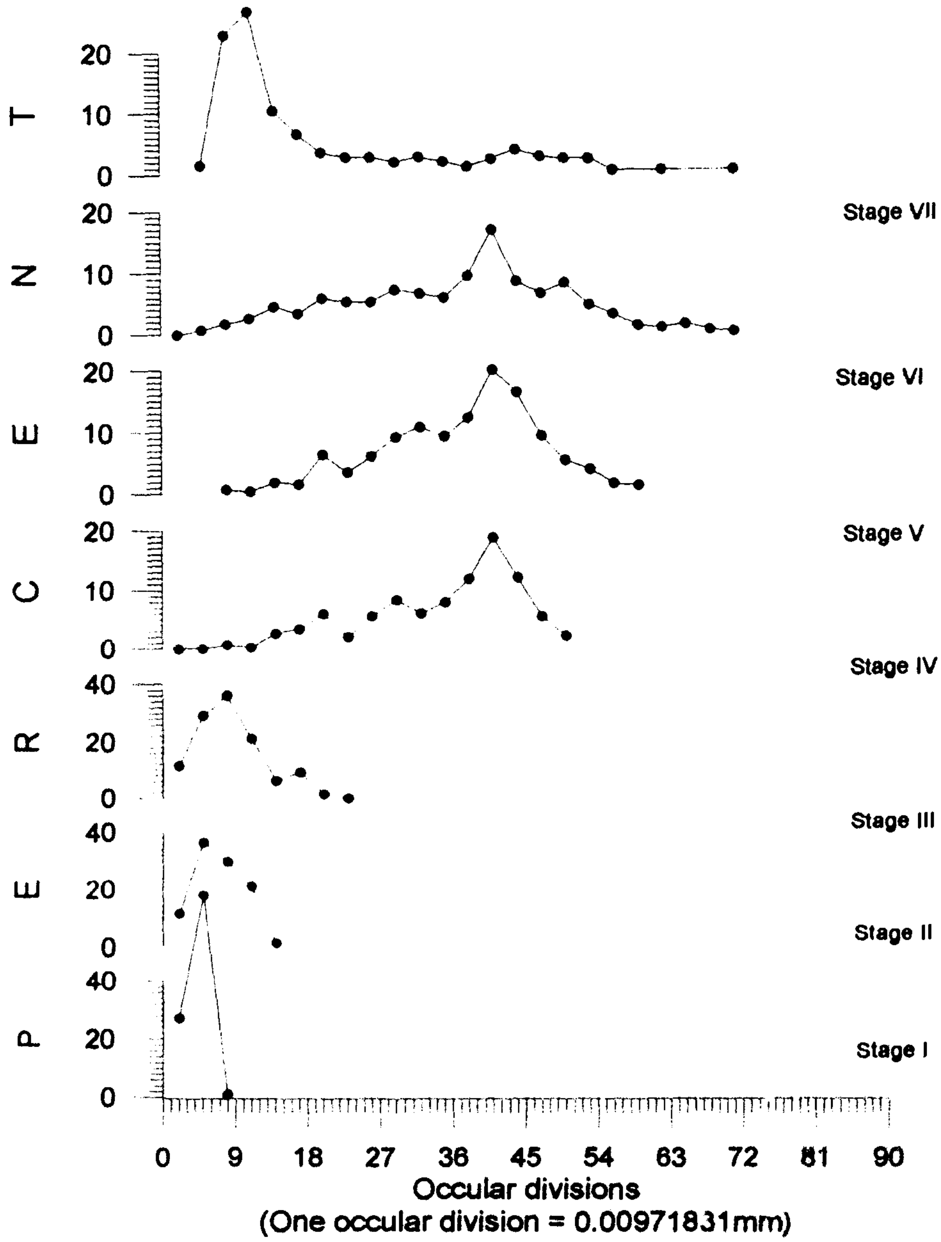

Fig.12. Ova diameter frequency polygons of Nemipterus japonicus in various stages of maturity.

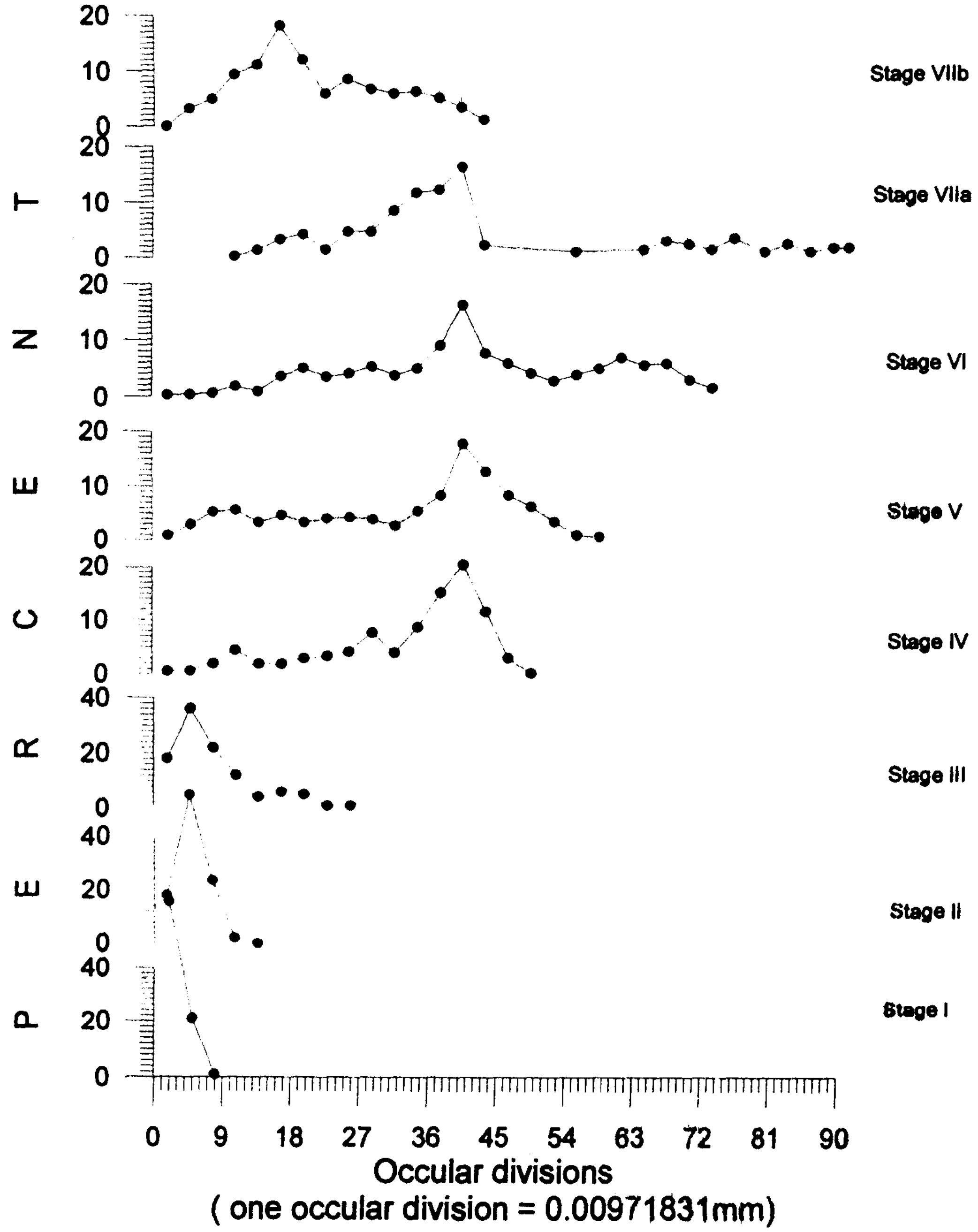

Fig. 13. Ova diameter frequency polygon of *Nemipterus mesoprion* in various stages of maturity

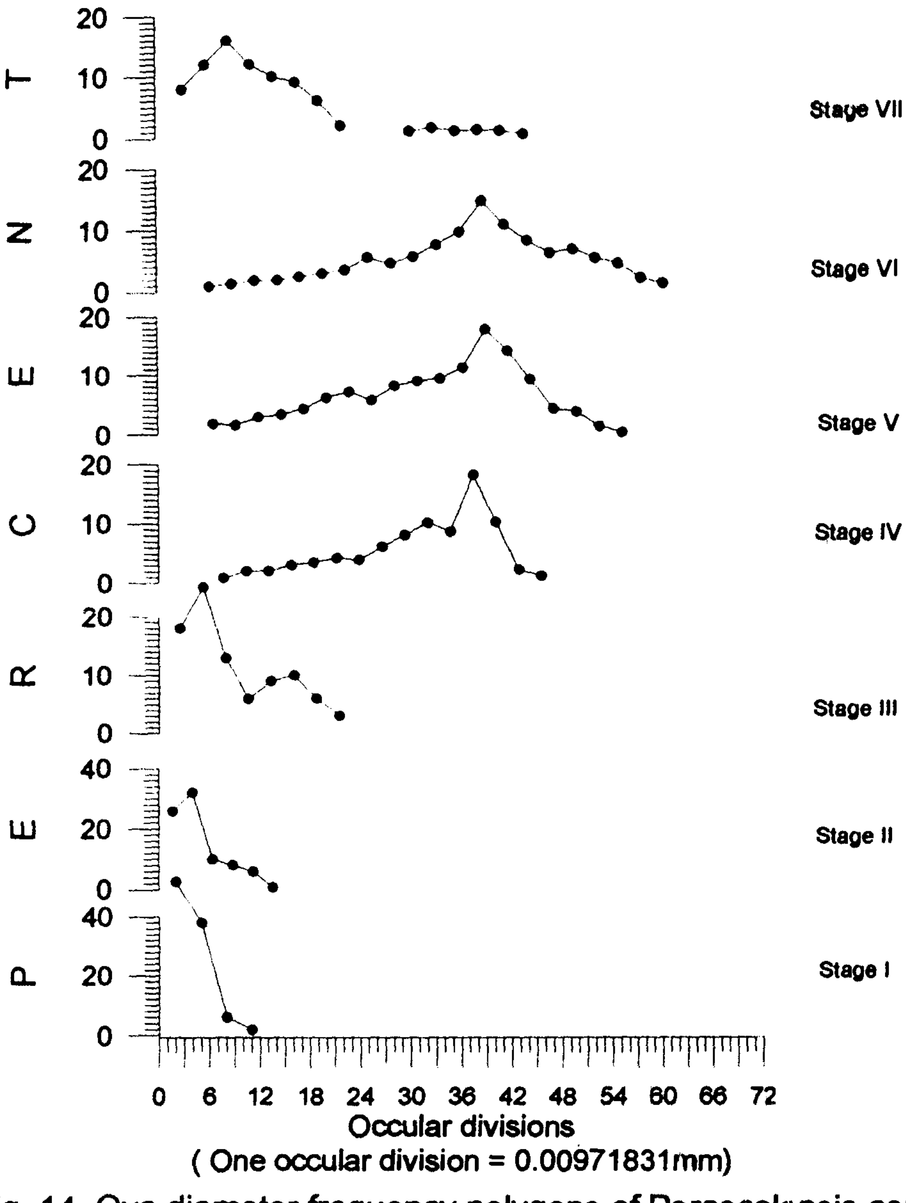

Fig. 14. Ova diameter frequency polygons of Parascolopsis aspinosa in various stages of maturity.

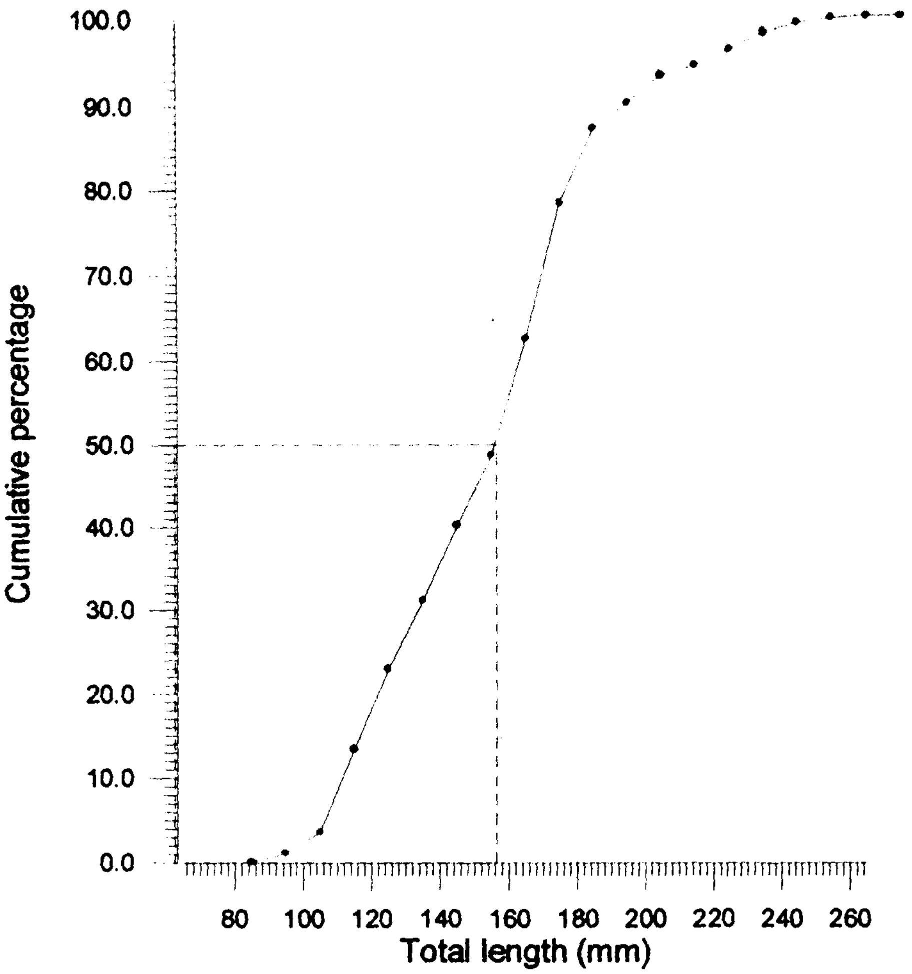

Fig. 15. Estimation of size at first maturity among males of Nemipterus japonicus.

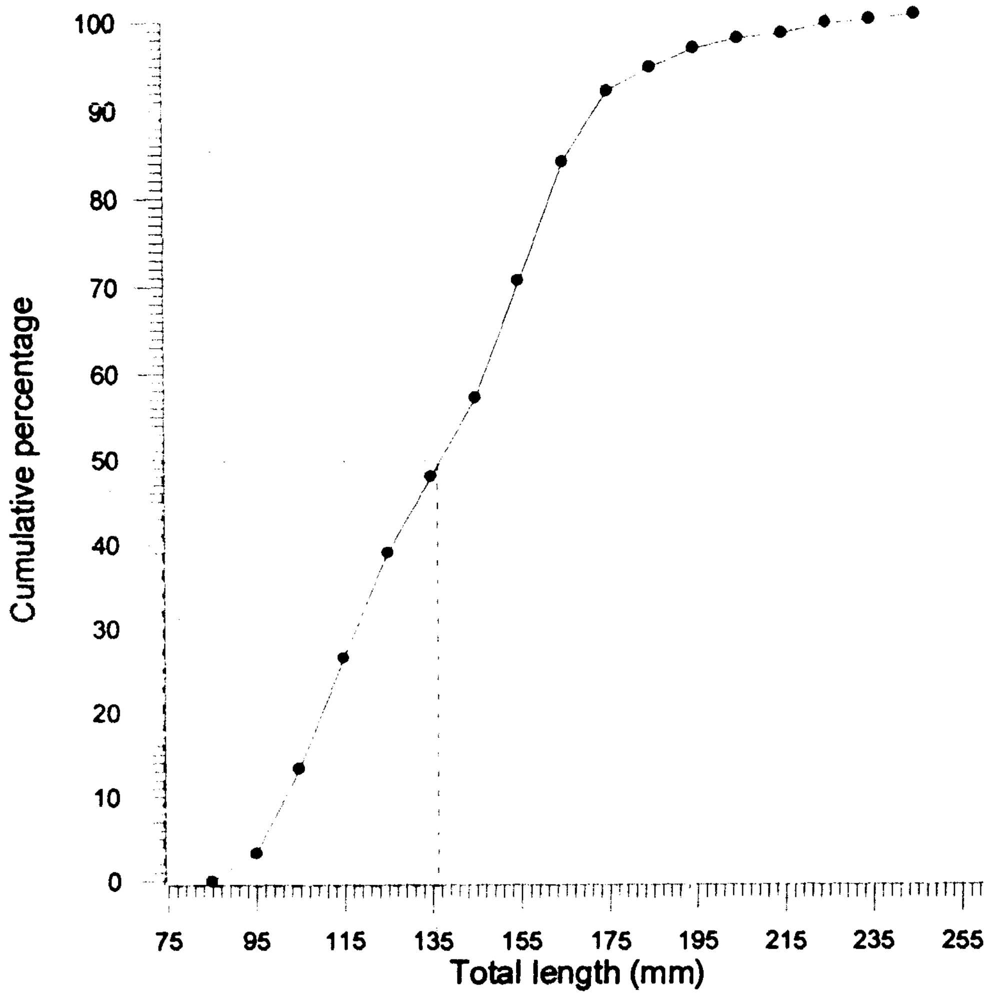

Fig. 16. Estimationof size at first maturity among females of <u>Nemipterus japonicus</u>

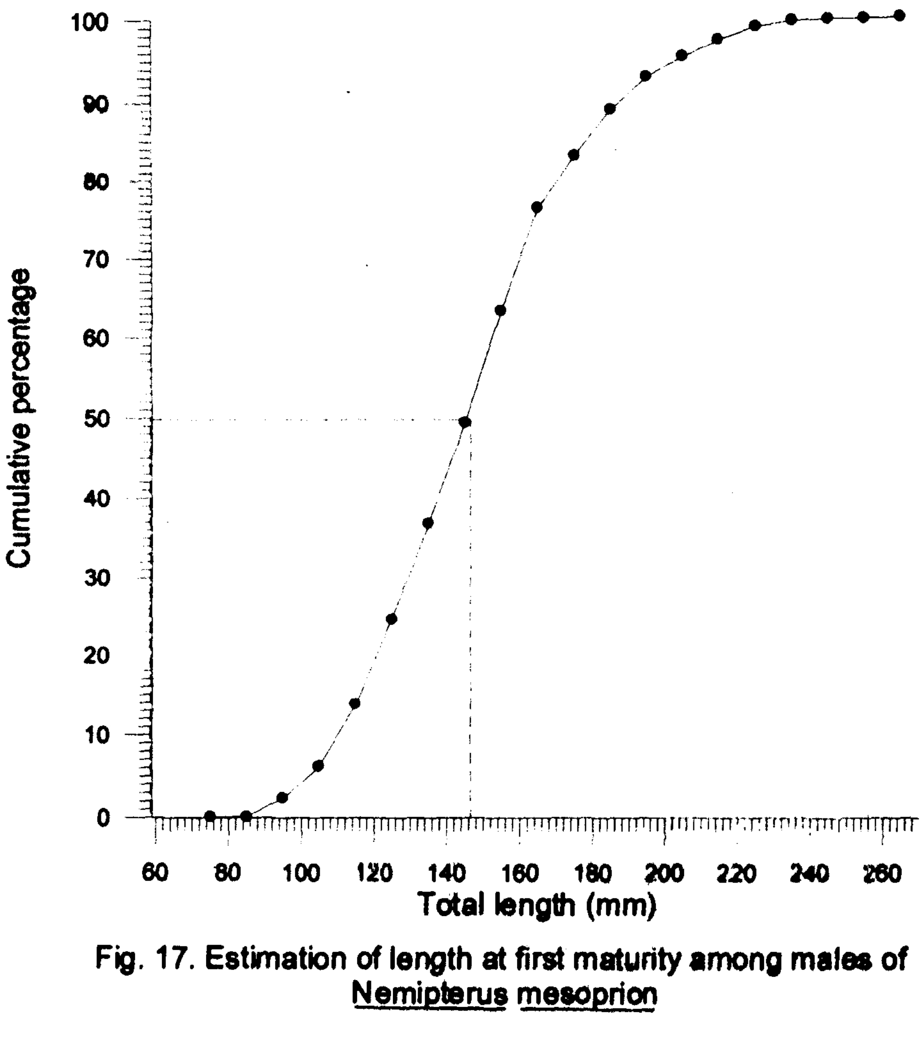

Fig. 17. Estimation of length at first maturity among males of *Nemipterus mesoprion*

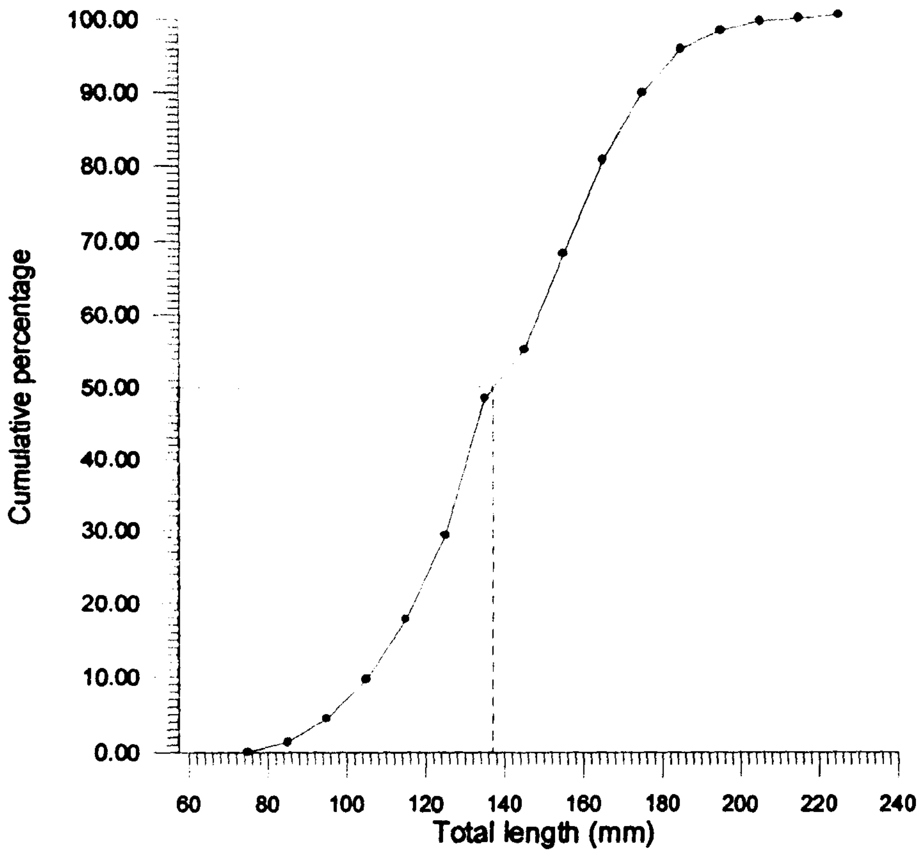

Fig. 18. Estimation of length at first maturity among females of <u>Nemipterus mesoprion</u>

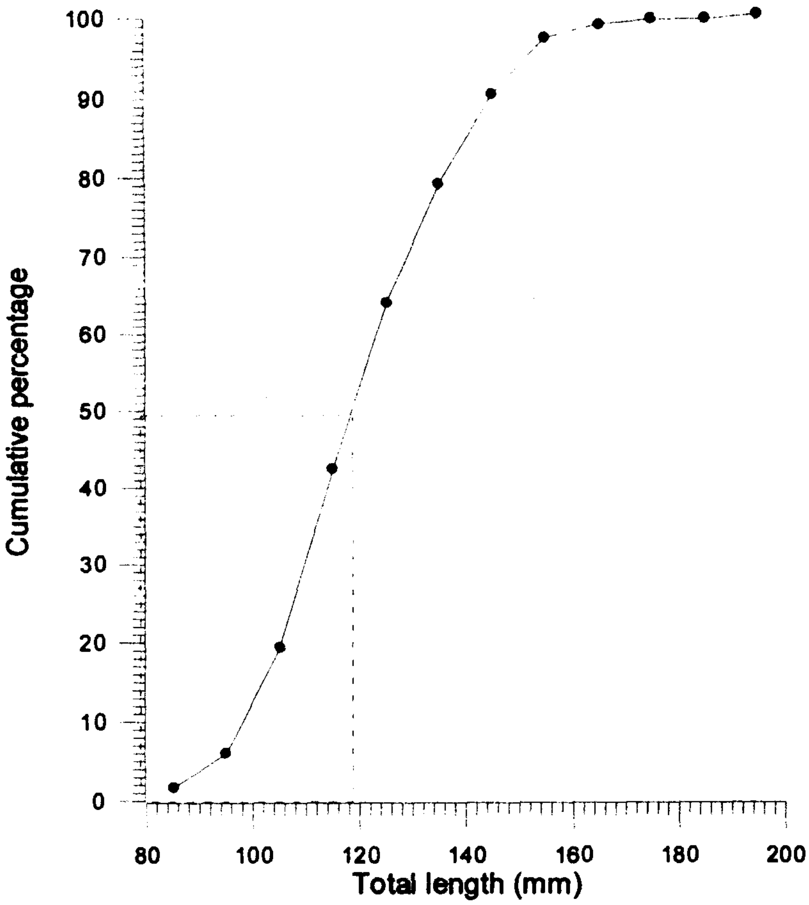

Fig. 19. Estimationof length at first maturity among males of *Parascolopsis aspinosa*

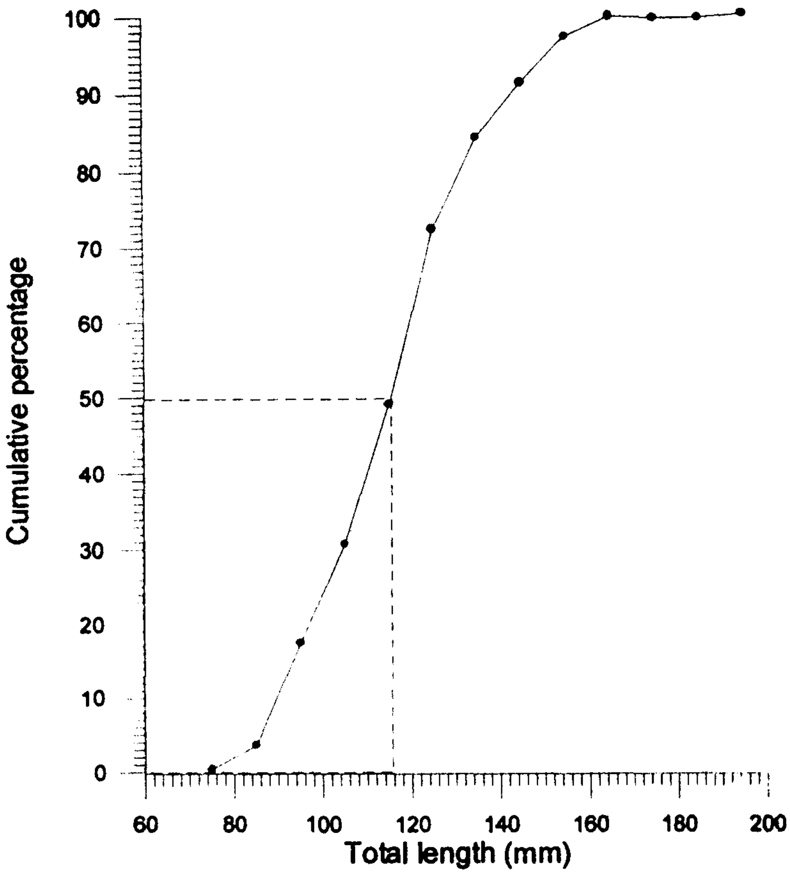

Fig. 20. Estimation of length at first maturity among females of <u>Parascolopsis aspinosa</u>

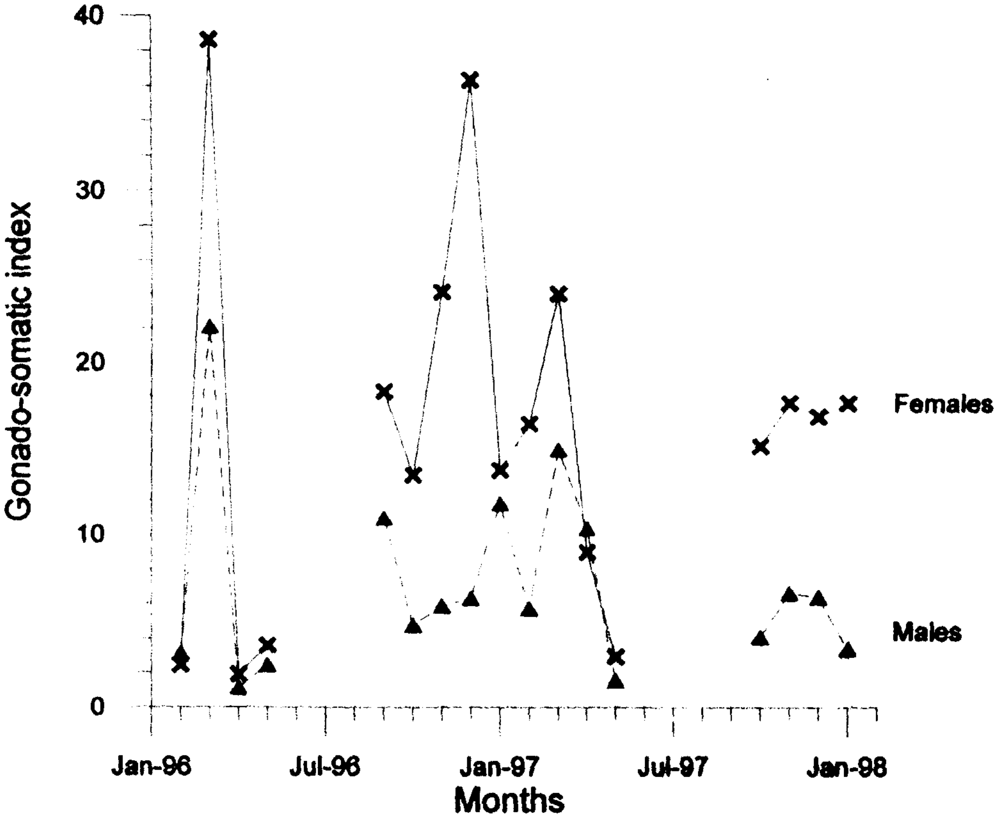

Fig. 21. Monthly variation in the gonado-somatic index in Nemipterus japonicus

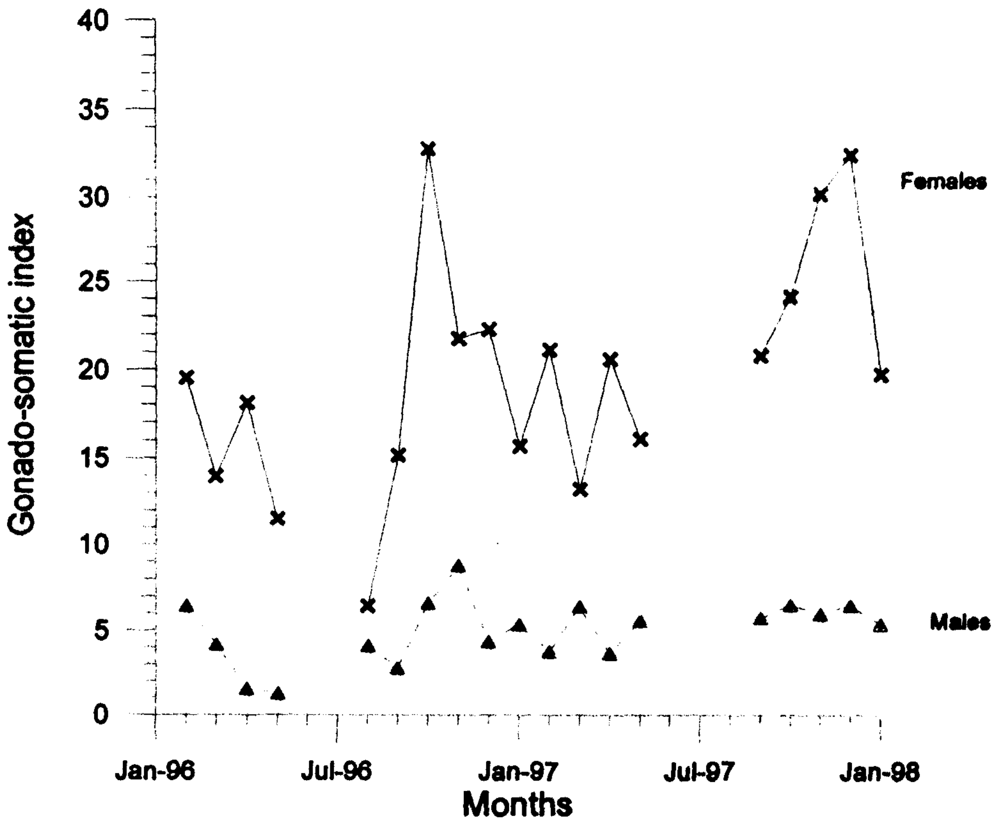

Fig. 22. Monthly variation in the gonado-somatic index in <u>Nemipterus</u> <u>mesoprion</u>

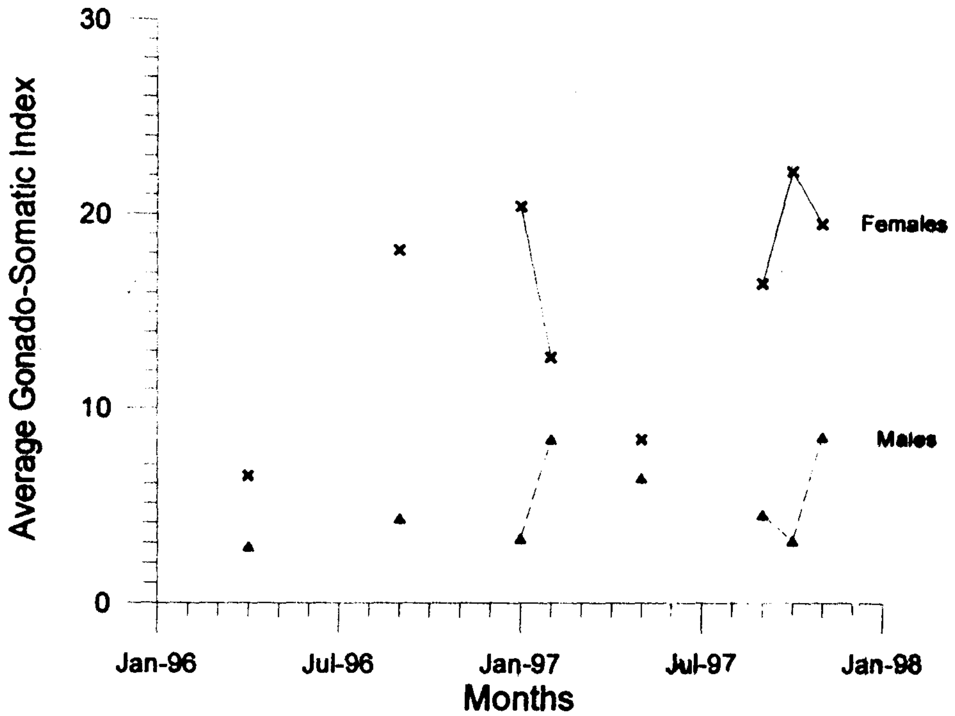

Fig. 23. Monthly variation in the gonado-somatic index in <u>Parascolopsis aspinosa</u>

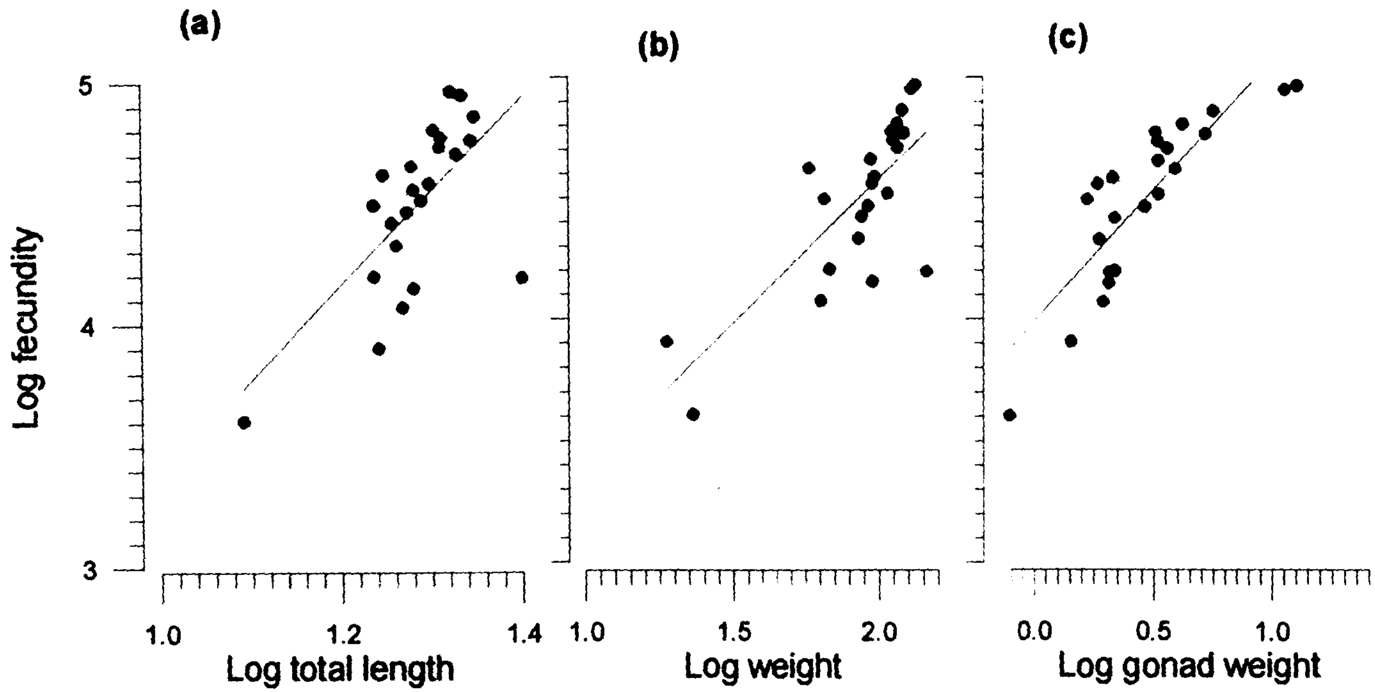

Fig. 24. Logarithmic relationships between a) Total length and fecundity
b) Body weight and fecundity c) Gonad weight and fecundity.
in Nemipterus japonicus

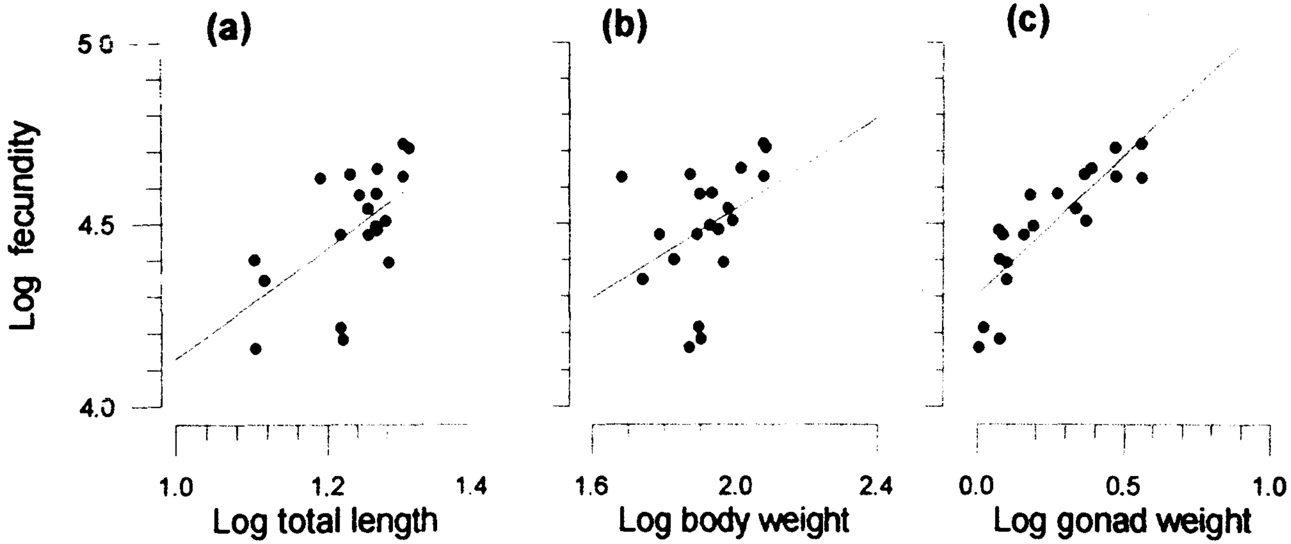

Fig. 25. Logarithmic relationships between a) Total length and fecundity b) Body weight and fecundity c) Gonad weight and fecundity in *Nemipterus mesoprion*

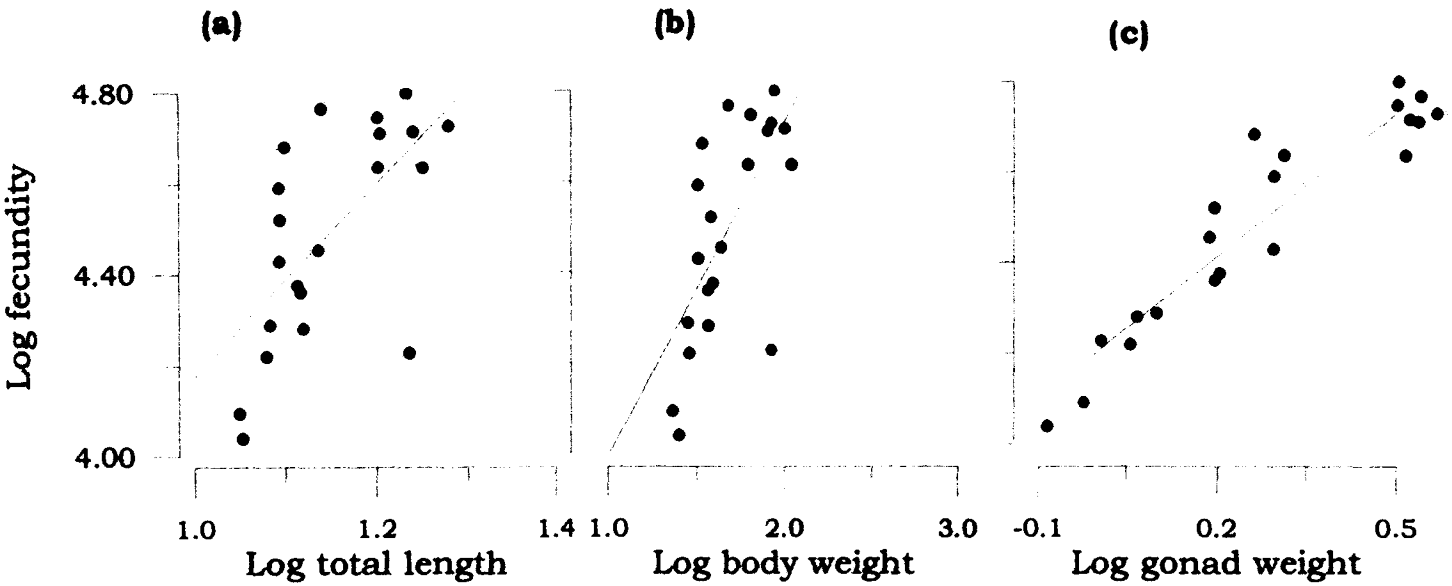

Fig. 26. a) Logarithmic relationship betweevn a) Total length and fecundity
b) Body weight and fecundity c) Gonad weight and fecundity
in *Parascolopsis aspinosa*

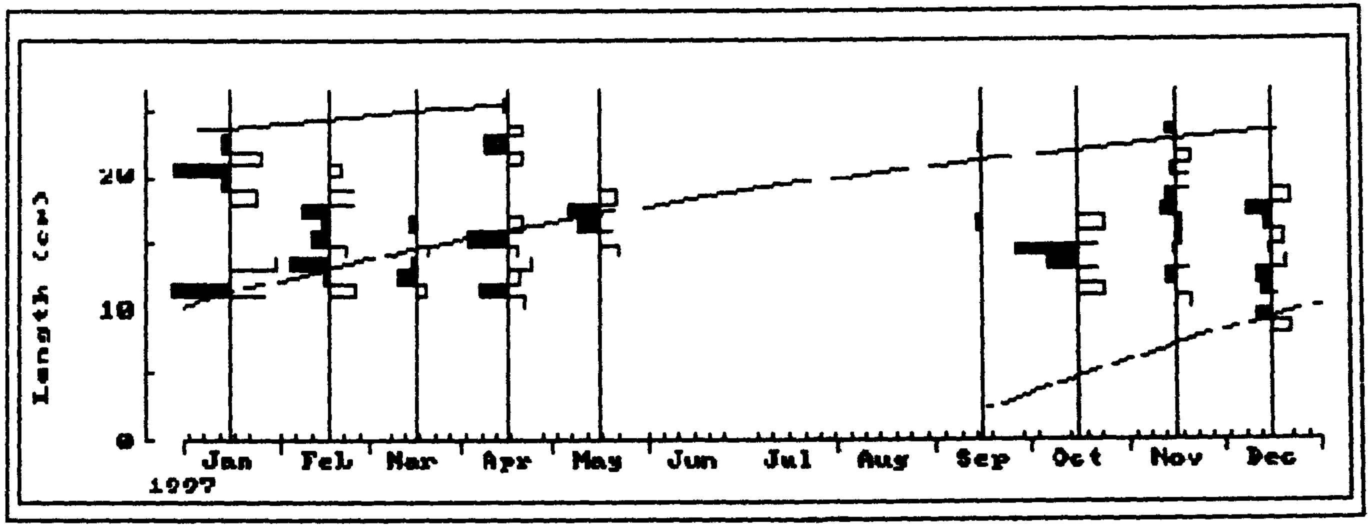

Fig. 27. Restructured length frequency and growth curve of male *Nemipterus japonicus*

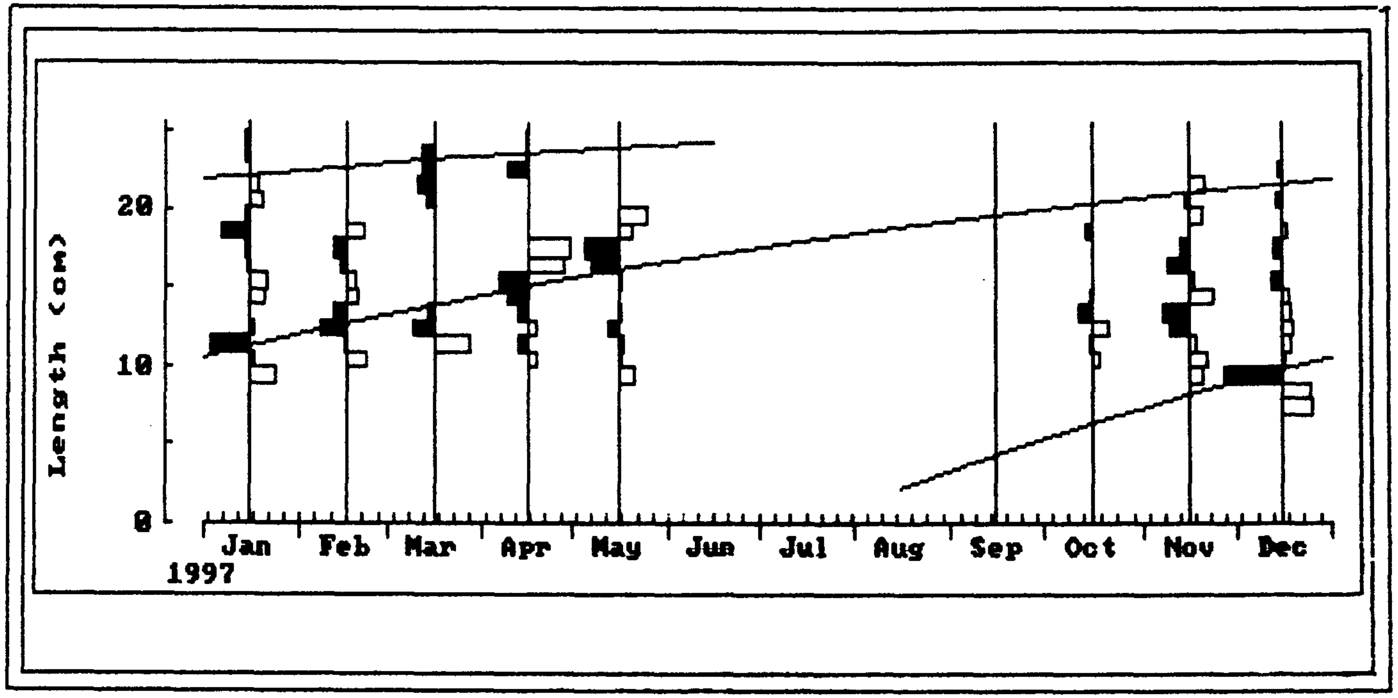

Fig. 28. Restructured length frequency and growth curve of female *Nemipterus japonicus*

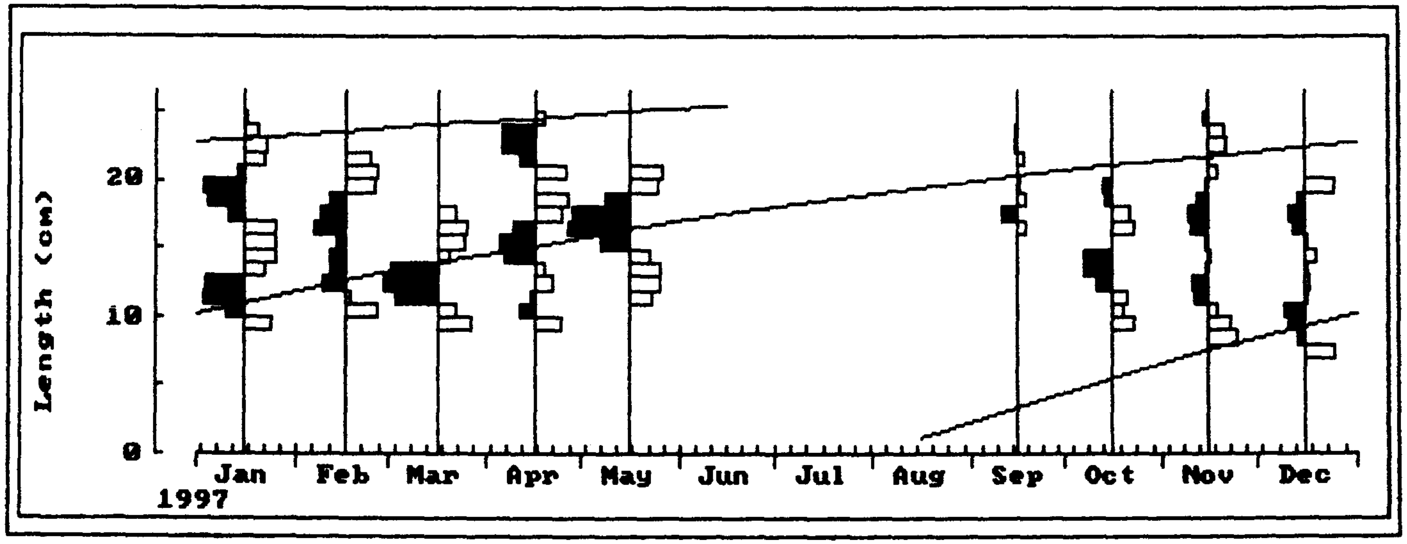

Fig. 29. Restructured length frequency and growth curve of *Nemipterus japonicus* pooled irrespective of sex

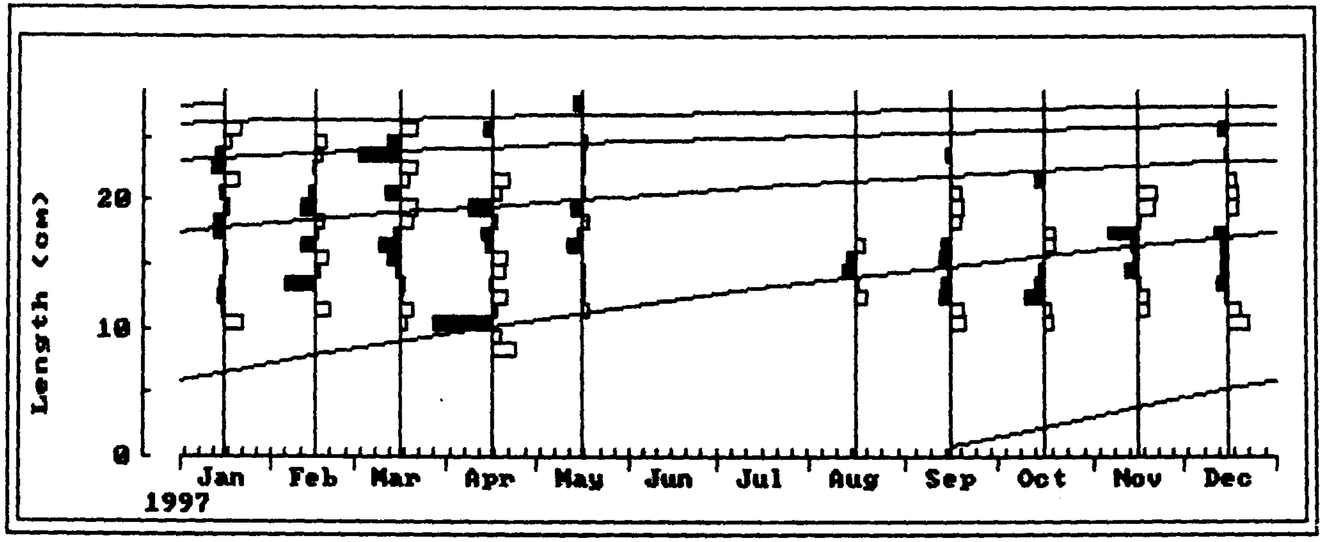

Fig. 30. Restructured length frequency and growth curve of male *Nemipterus mesoprion*.

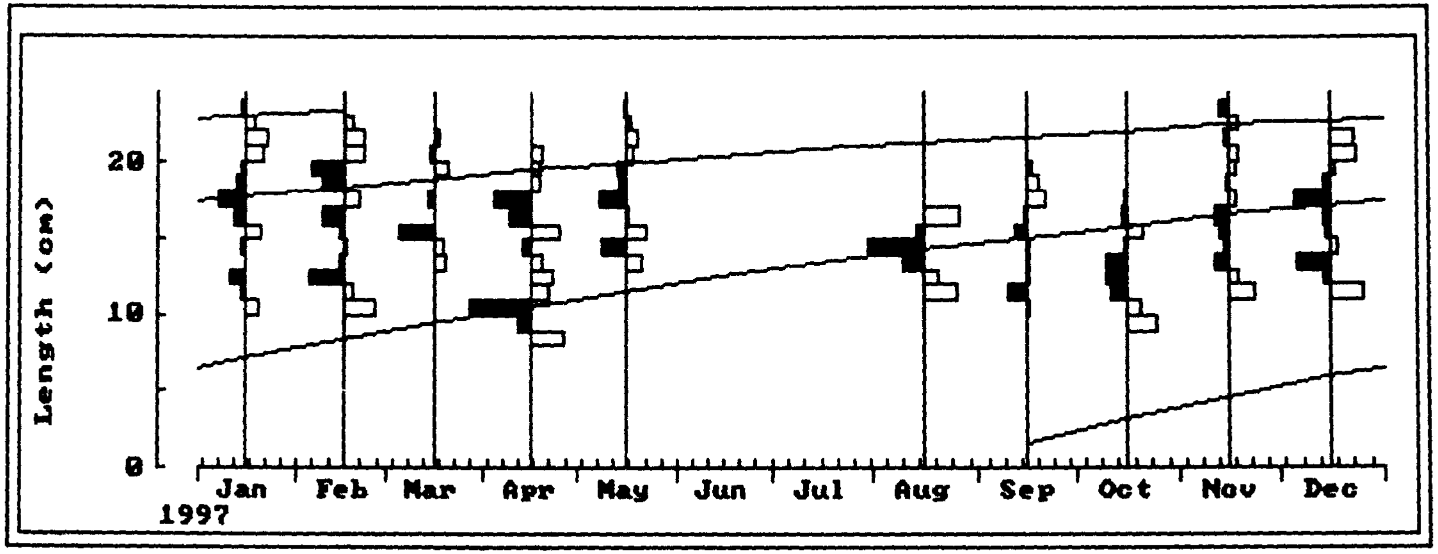

Fig. 31. Restructured length frequency and growth curve of female *Nemipterus mesoprion*.

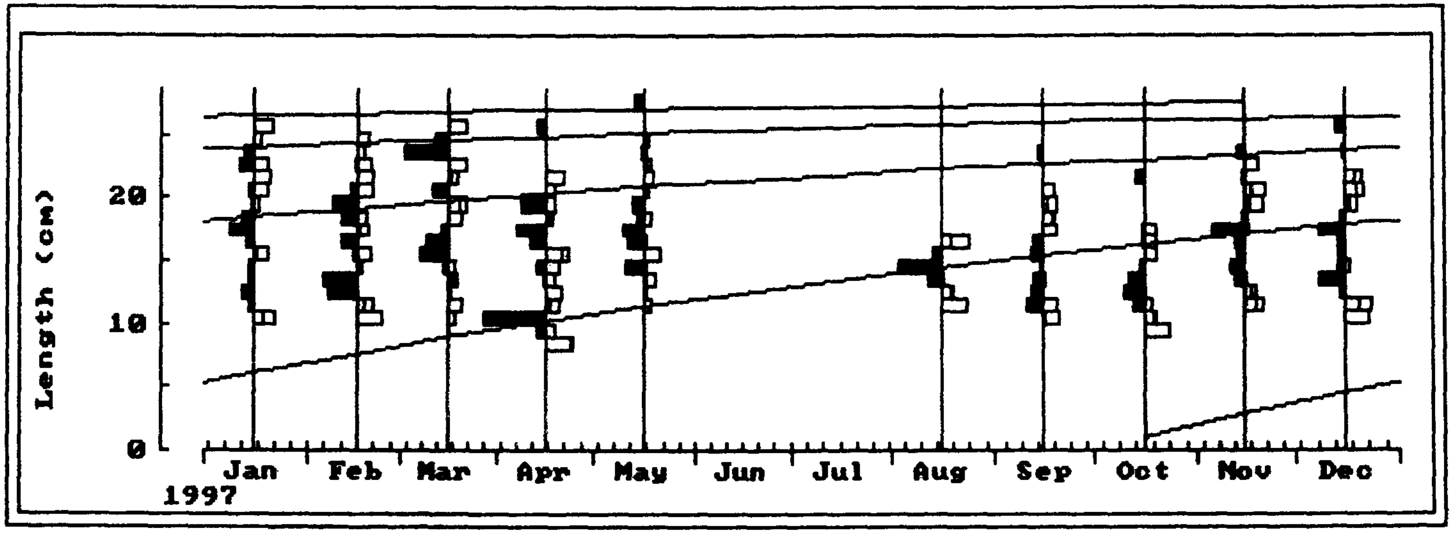

Fig. 32. Restructured length frequency and growth curve of *Nemipterus mesoprion* pooled irrespective of sex.

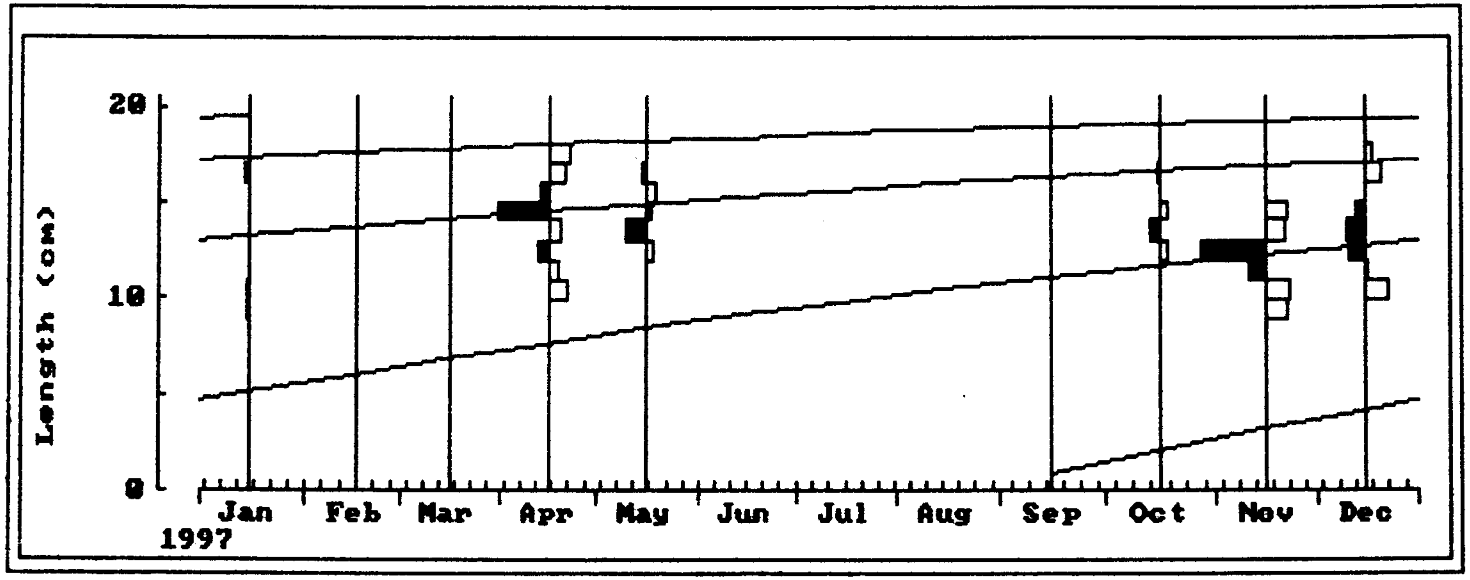

Fig. 33. Restructured length frequency and growth curve of *Parascolopsis aspinosa.*

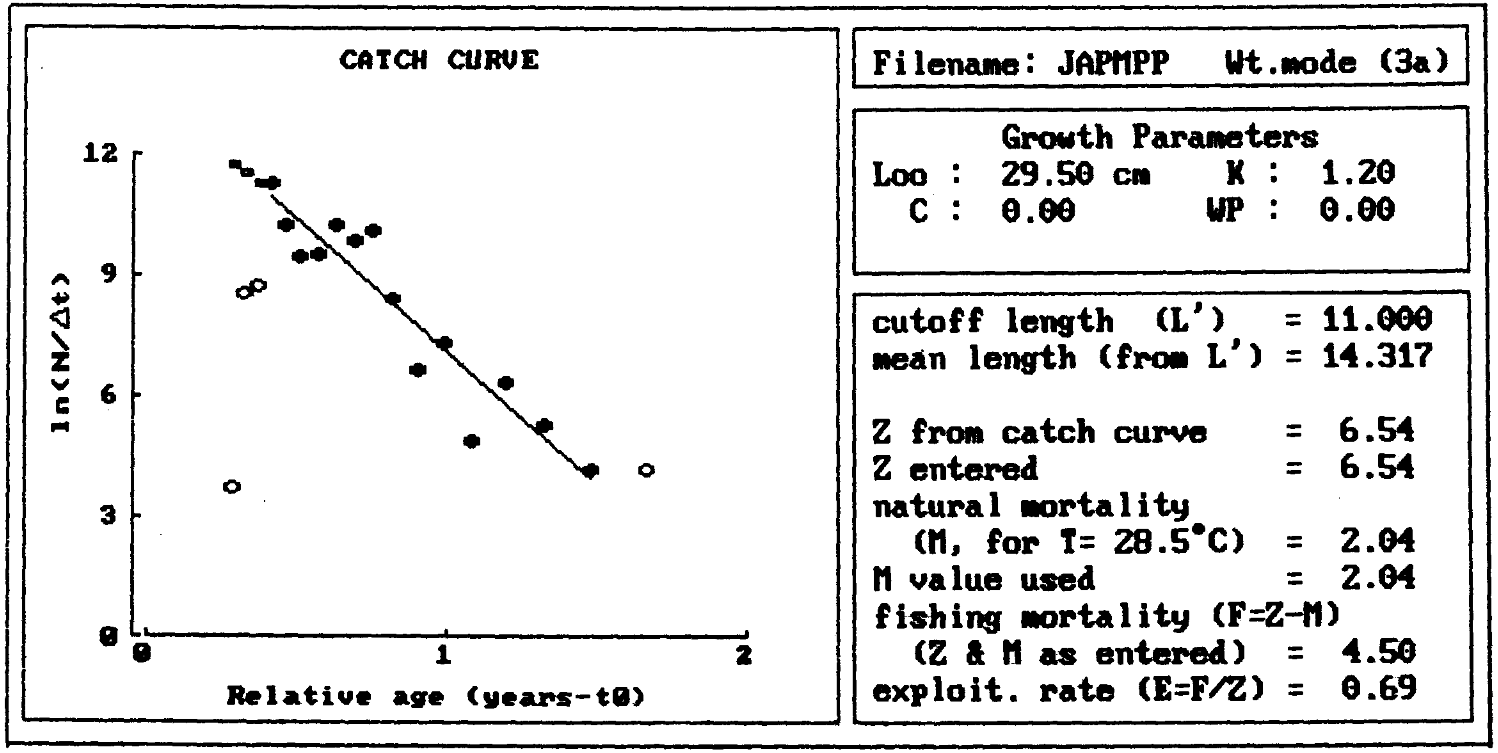

Fig. 34. Length converted catch-curve and instantaneous coefficients of total mortality Z, natural mortality M, fishing mortality F and exploitation rate of male *Nemipterus japonicus*.

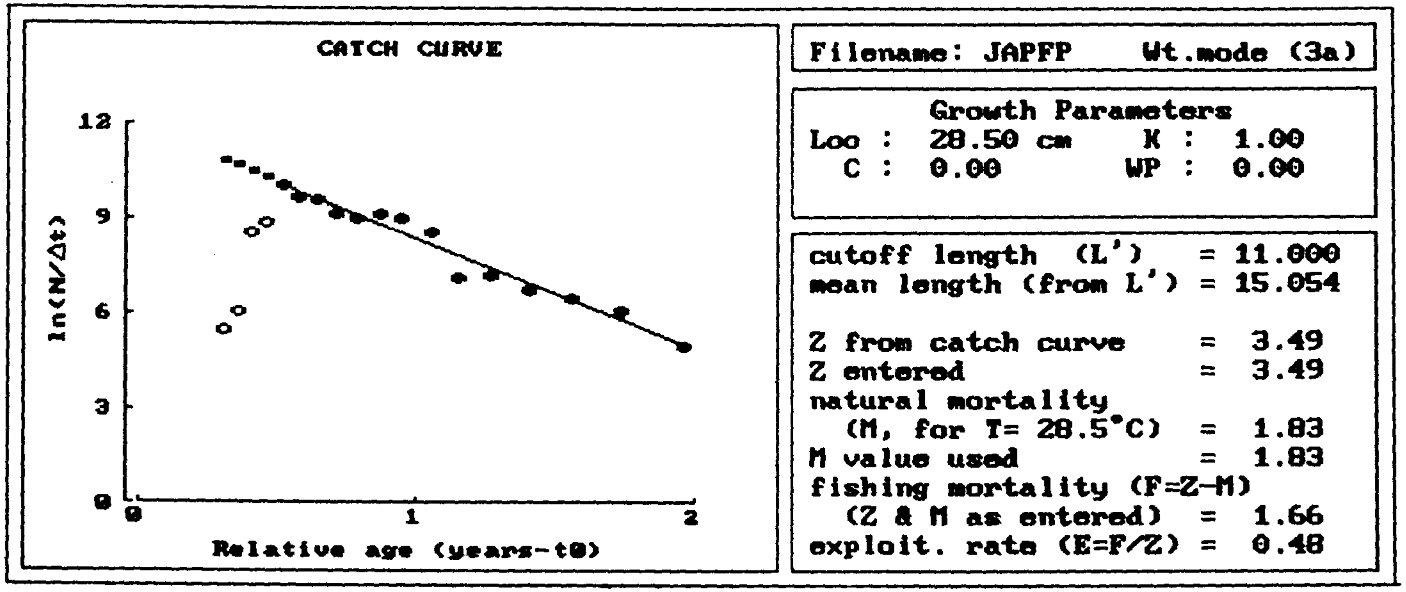

Fig. 35. Length converted catch-curve and instantaneous coefficients of total mortality Z, natural mortality M, fishing mortality F and exploitation rate of male *Nemipterus japonicus*.

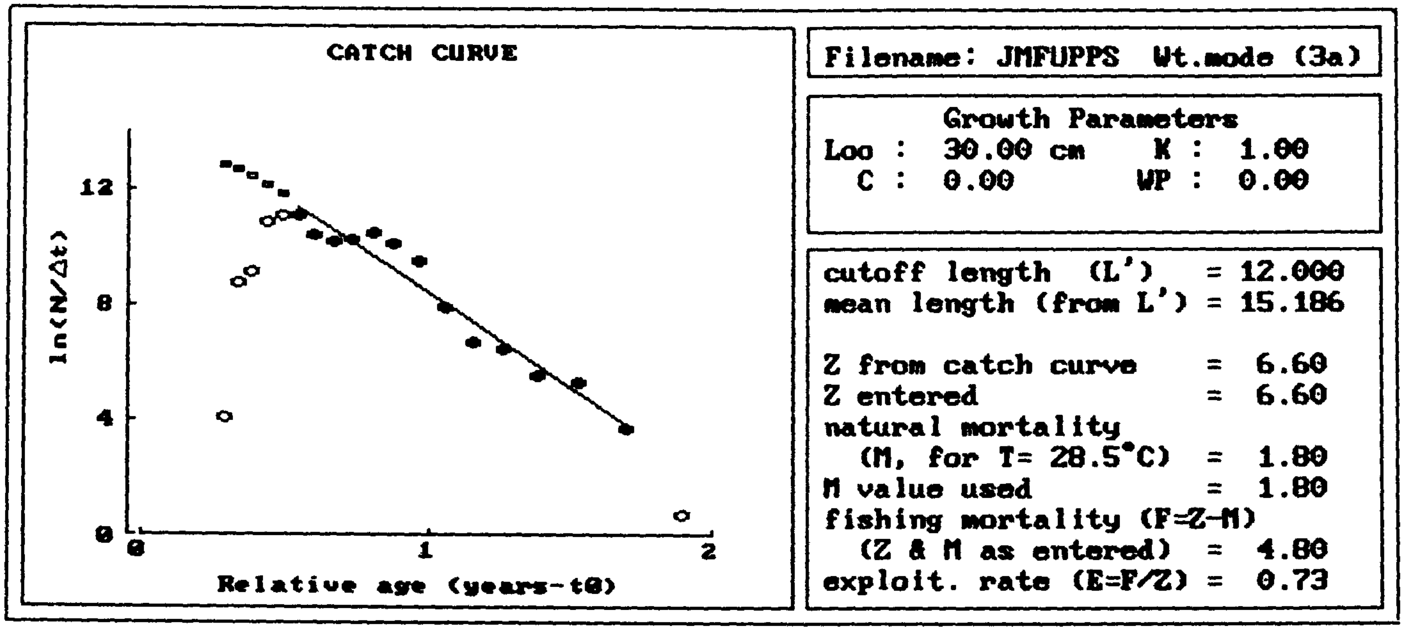

Fig. 36. Length converted catch-curve and instantaneous coefficients of total mortality Z, natural mortality M, fishing mortality F and exploitation rate of *Nemipterus japonicus* pooled irrespective of sex.

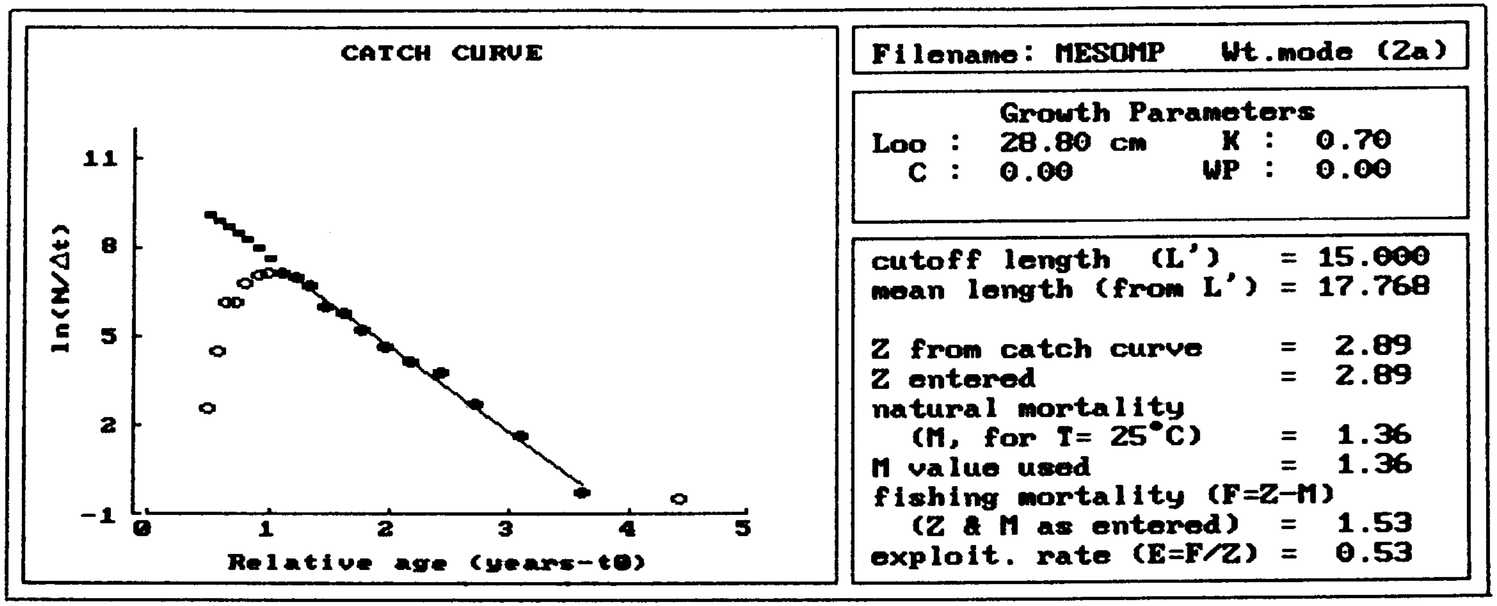

Fig. 37. Length converted catch-curve and instantaneous coefficients of total mortality Z, natural mortality M, fishing mortality F and exploitation rate of male *Nemipterus mesoprion*.

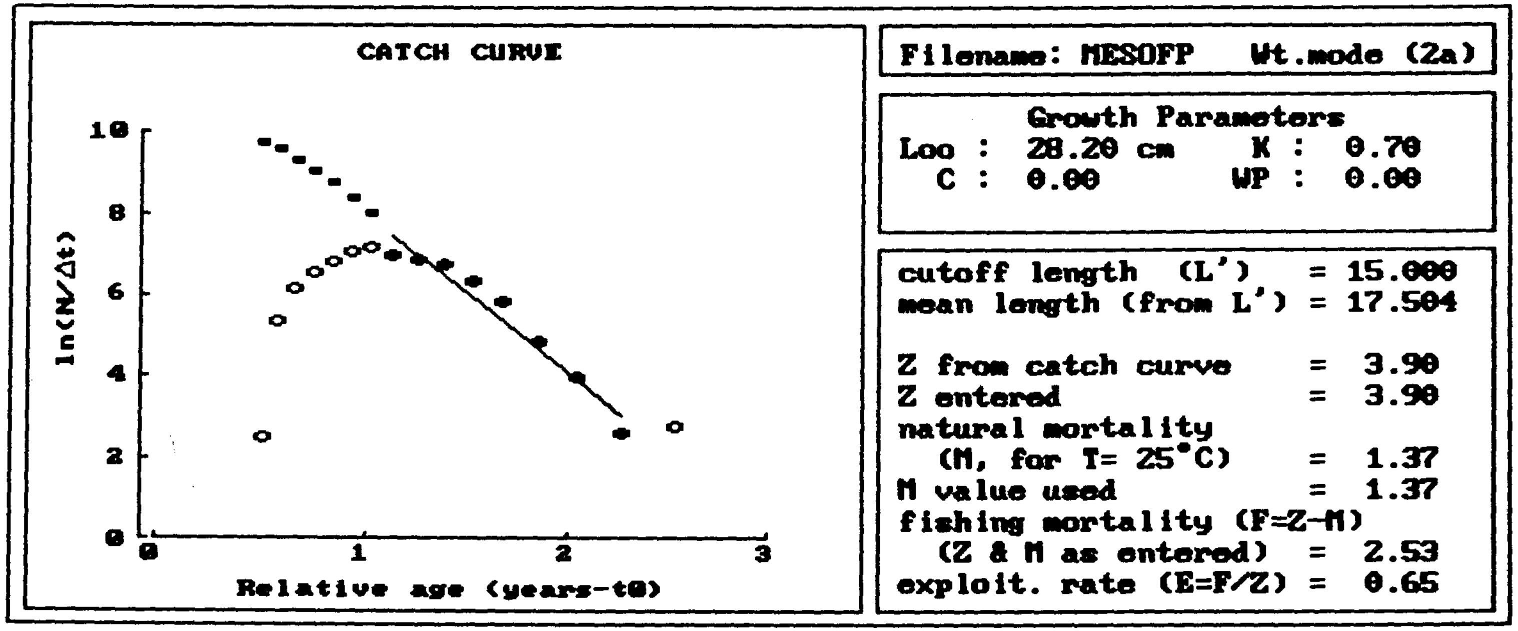

Fig. 38. Length converted catch-curve and instantaneous coefficients of total mortality Z, natural mortality M, fishing mortality F and exploitation rate of female *Nemipterus mesoprion* .

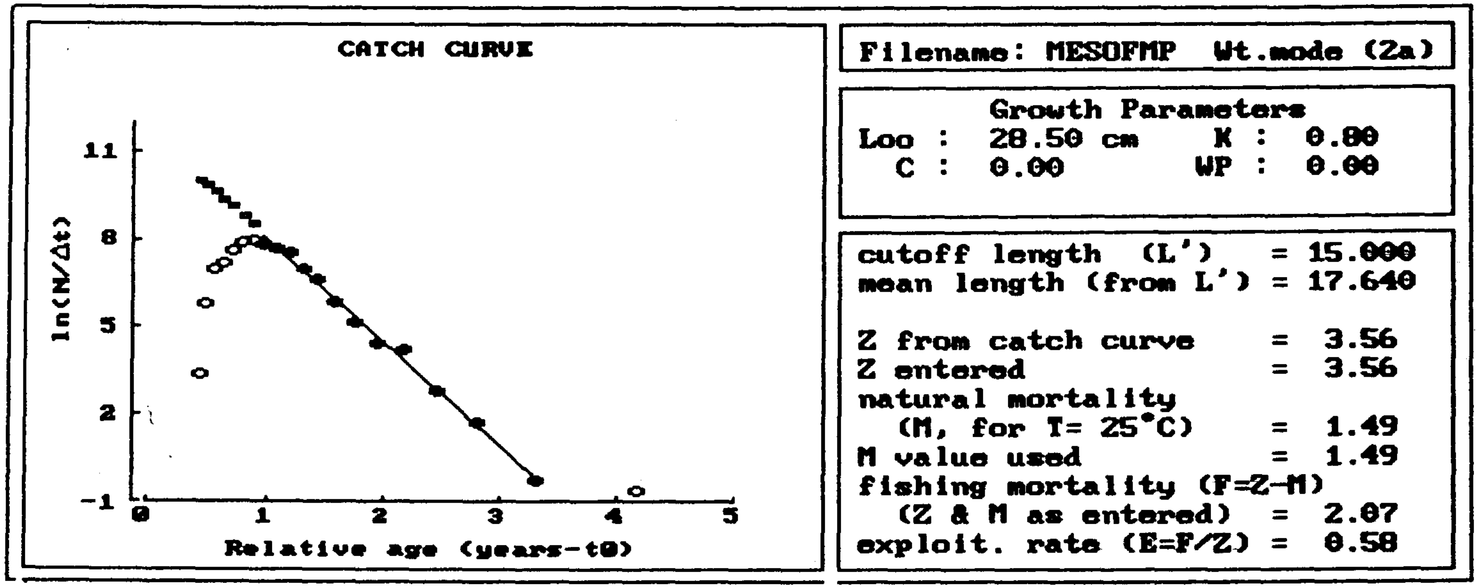

Fig. 39. Length converted catch-curve and instantaneous coefficients of total mortality Z, natural mortality M, fishing mortality F and exploitation rate of *Nemipterus mesoprion*, pooled irrespective of sex

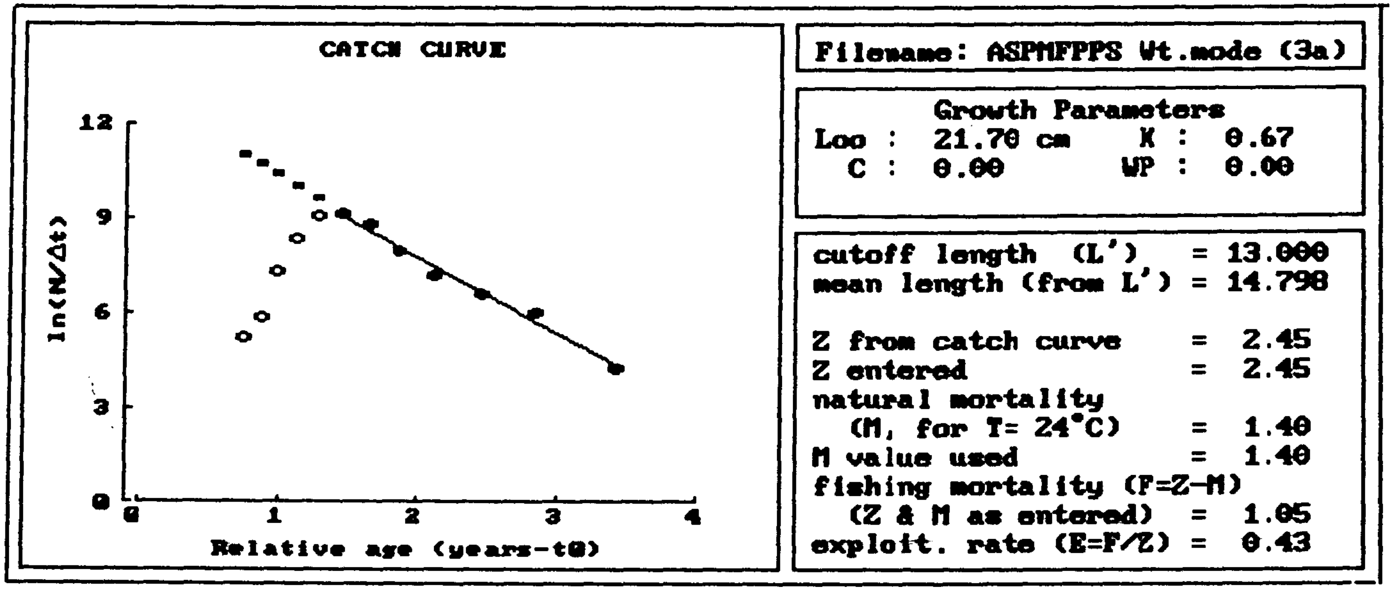

Fig.40. Length converted catch-curve and instantaneous coefficients of total mortality Z, natural mortality M, Fishing mortality F and exploitation rate of *Parascolopsis aspinosa*.

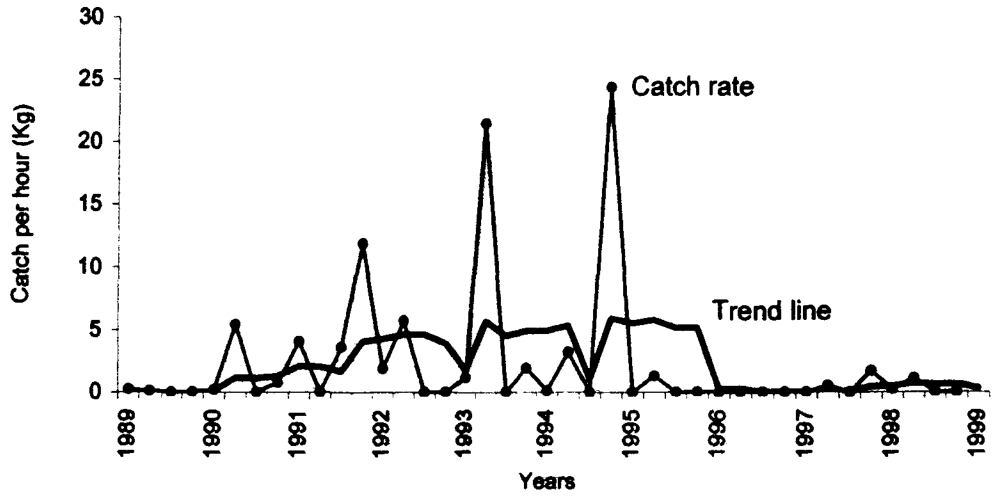

Fig. 41. Catch rates of nemipterids recorded from 30 to 50 m depth along Goa coast between 1989 and 1999

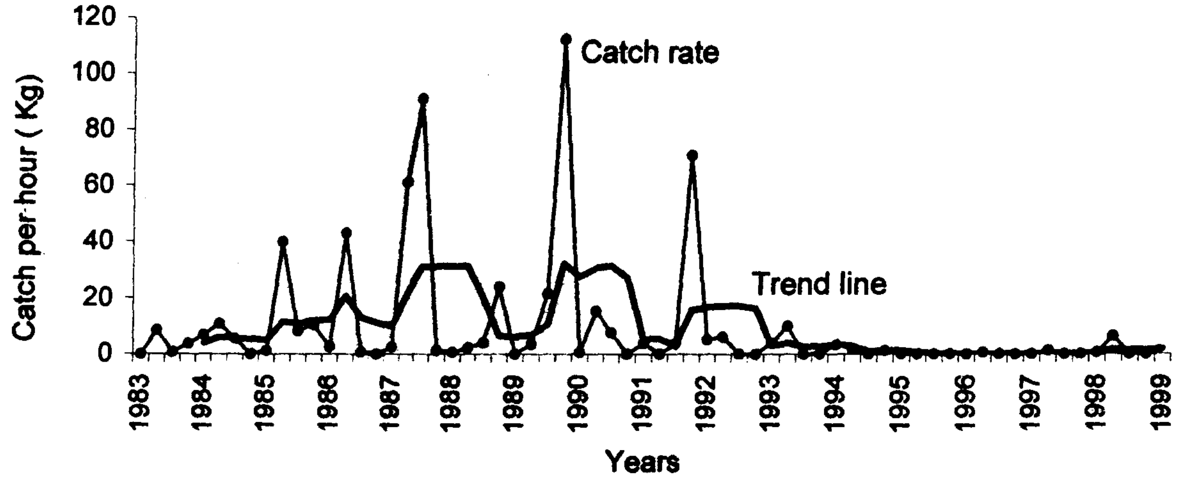

Fig. 42. Catch rate of nemipterids recorded from 51 to 100 m depth along Goa coast between 1983 to 1999

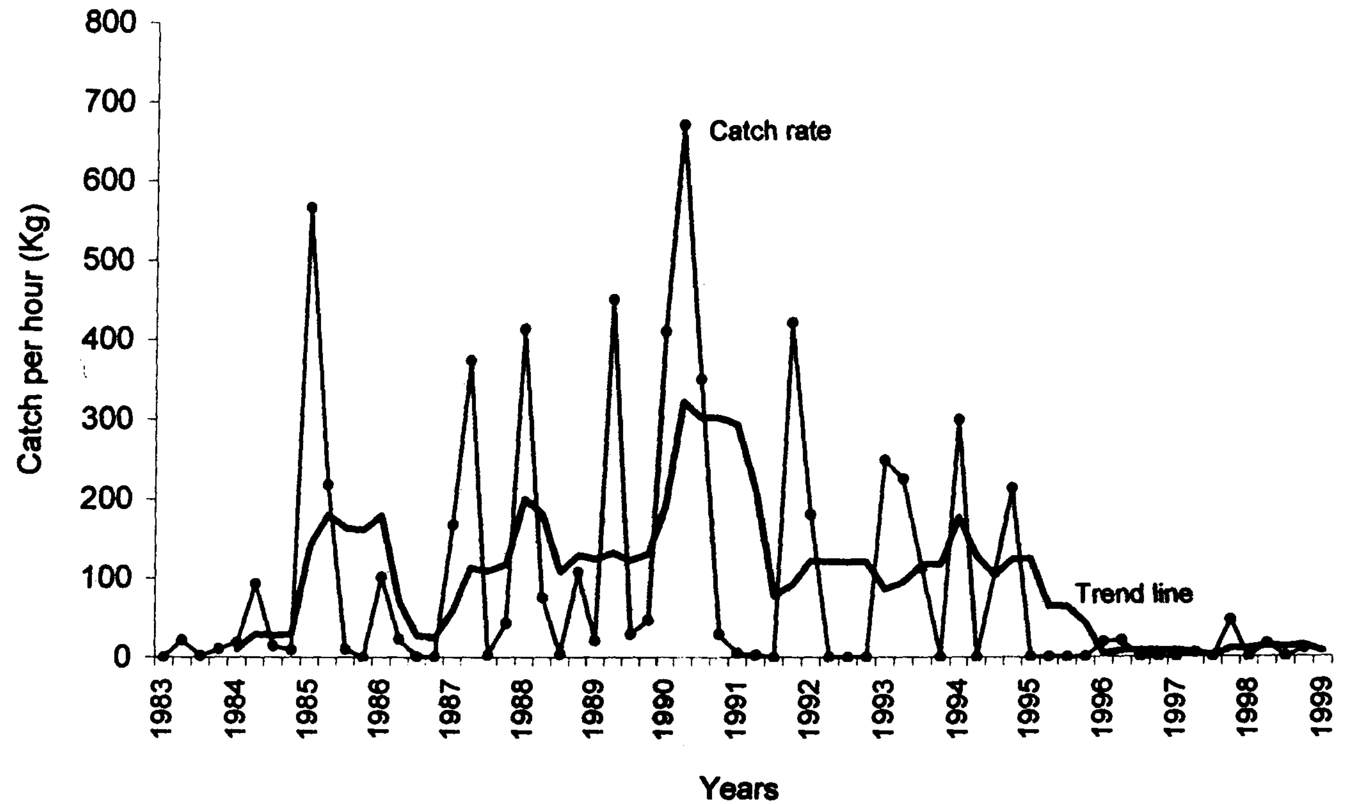

Fig. 43. Catch rates of nemipterids recorded from 101 to 200 m depths along Goa coast between 1983 to 1999

PLATE II

Fig. 1. *Parascolopsis aspinosa*

PLATE I

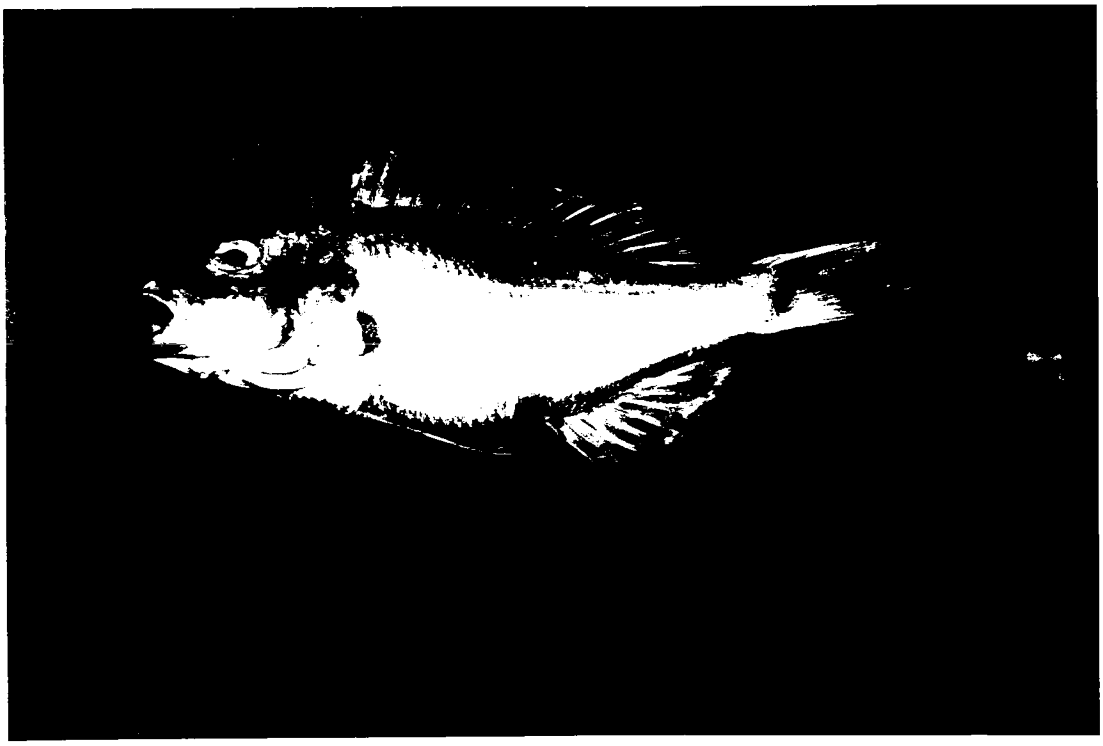

Fig. 1. *Nemipterus japonicus*

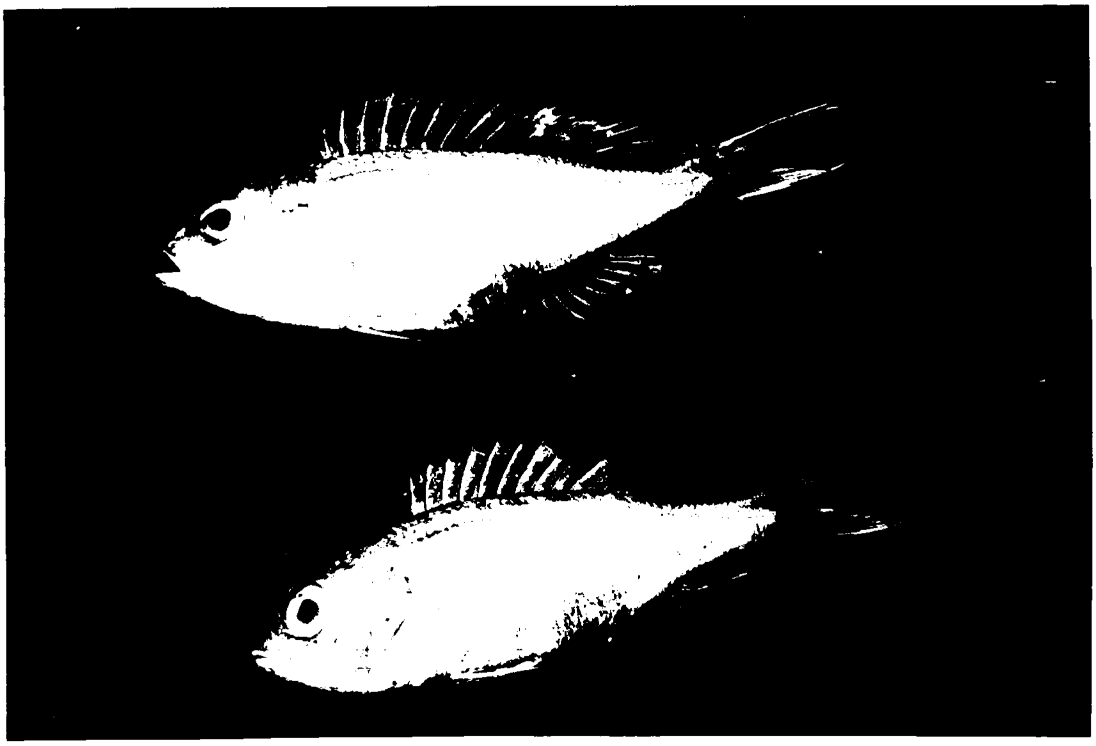

Fig. 2. *Nemipterus mesoprion*

PLATE III

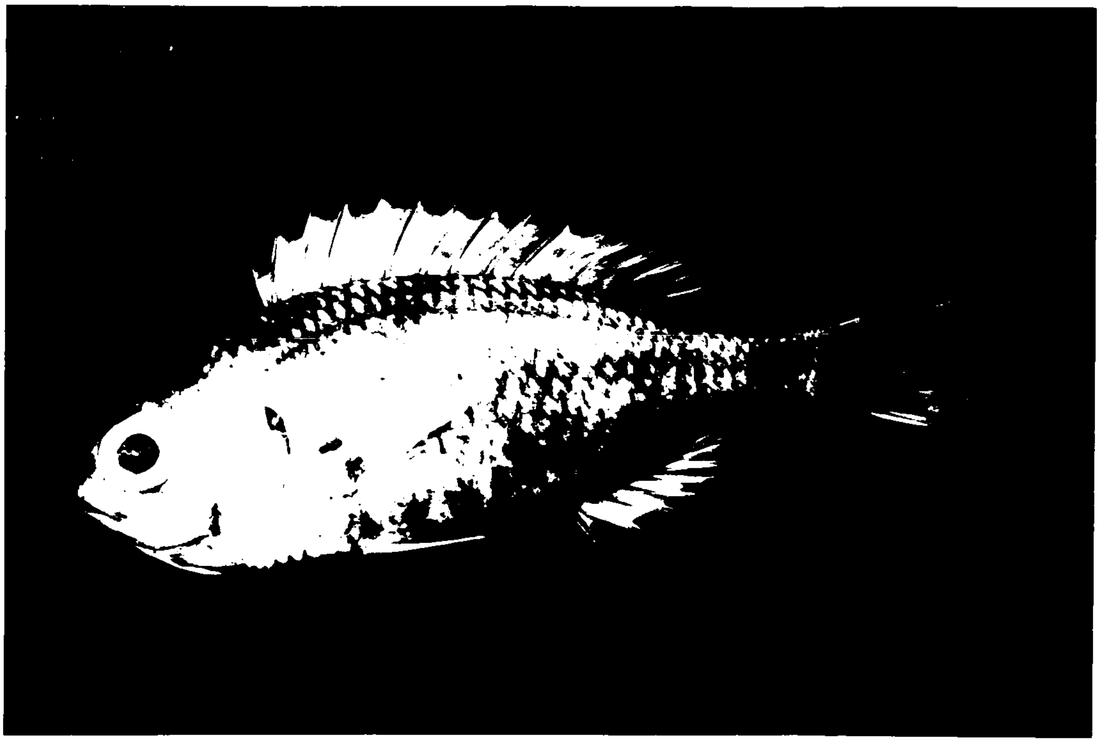

Fig. 1. *Parascolopsis eriomma*

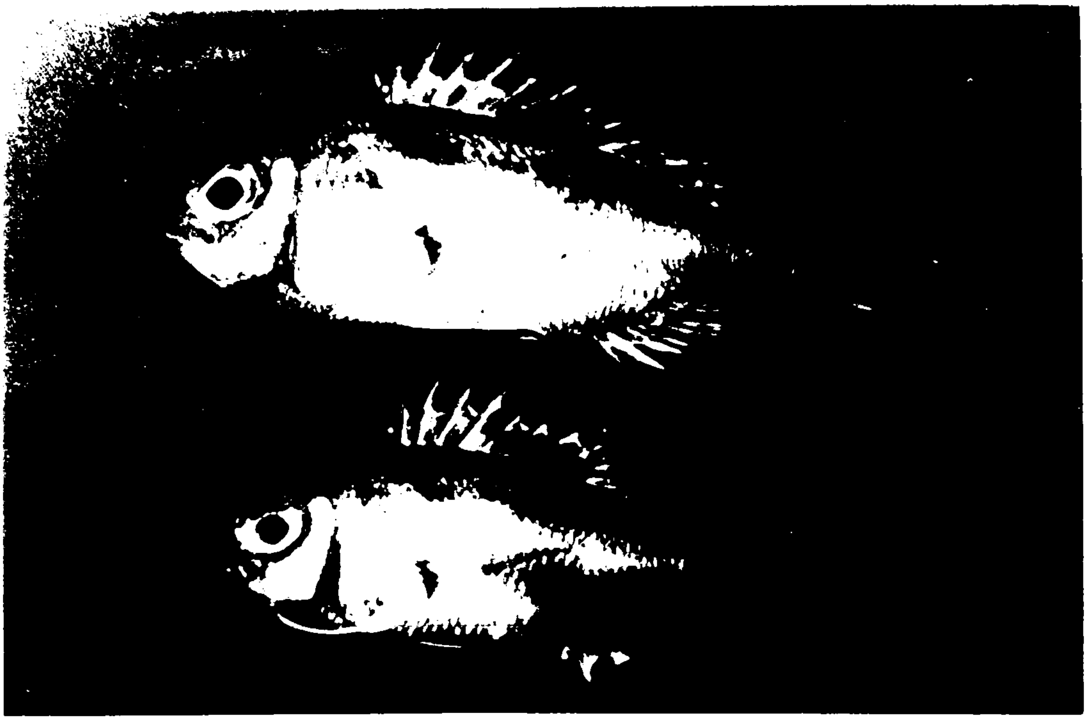

Fig. 2. *Parascolopsis boesemani*

5. DISCUSSION

Systematics of the Nemipterids

Genus: *Nemipterus* Swainson, 1839

Out of the 27 species so far identified under the genus *Nemipterus,* only 10 have been recorded along the Indian coast (Russell, 1990a). Among them only two species viz. *Nemipterus japonicus* (Bloch, 1791) and *Nemipterus mesoprion* (Bleeker, 1853) were identified from the Goa coast during the present study.

Nemipterus japonicus (Bloch, 1791)

This species was perhaps the first one brought to the shore by Indian fishers before *N. mesoprion* was known to the taxonomists. The bright colour of the body and bright yellow on the lower abdomen is a characteristic feature of the species. As there is no confusion among the taxonomists regarding the descriptions of the species, there is a general agreement on the taxonomic status of the species. The species has long filamentous caudal fin and hence most easily identified. It closely resembles *N. mesoprion* but the striking difference is the colour of caudal fin filament. In *N. japonicus* the filament is yellow whereas it is red in the case of *N. mesoprion.*

Nemipterus mesoprion (Bleeker, 1853)

The specimen collected during the study agree in most respect with the description given by Murty (1978), Talwar and Kacker (1984) except the colour pattern of the dorsal fin. The lower half of the dorsal fin membrane had reticulate patterns of yellow pigment. In addition, the anal fin had only one pale yellow longitudinal streak. The blotch on the origin of the lateral line was pinkish unlike the reddish blotch described by Murty (1978). Moreover, the lateral line scales were 40-45 and caudal filament was longer which differed from the description given by Talwar and Kacker (1984).

According to the description by Russell (1990a), upper lobe of caudal fin is not filamentous in *N. mesoprion*. After examining the holotype, the species was re-described by Russell (1991a) to reduce the confusion in identifying the similar looking nemipterids. However, the description of *Nemipterus randalli* given by Russell (1986) fits to the species usually referred as *N. mesoprion* occurring in the waters of Goa. However, in India the fishery biologists have been using the name *N. mesoprion* following Murty (1978), who reported this species for the first time in our waters along the east coast. In the present work also, the nomenclature adopted in the first report of this species in Indian waters has been followed.

Genus: *Parascolopsis* Boulenger, 1901.

The genus *Parascolopsis* Boulenger, 1901 was erected for a new deep-water fish, *P. townsendi* from the Gulf of Oman. The genus remained monotype, until Fowler (1931) placed two *Scolopsis* species *S. eriomma* Jordan and Richardson, and *S. inermis* (Temminck and Schlegel) under *Parascolopsis* at sub generic level. The later workers (Munro, 1955; Nelson, 1984; Russell, 1990a) also accepted the change. Out of the 11 species of *Parascolopsis* recorded in Indian and Pacific Ocean regions, six species viz. *P. aspinosa* (Rao & Rao, 1980); *P. boesemani* (Rao & Rao, 1981a); *P. eriomma* (Jordan & Richardson, 1909); *P. inermis* (Schlegel, 1843); *P. townsendi* (Boulenger, 1901); *P. capitinis* (Russell, 1996) and *P. baranesi* (Russell & Golani, 1993) are known to occur along the Indian peninsula.

Parascolopsis aspinosa (Rao & Rao, 1981)

This is a species first described by Rao and Rao (1981a) from the east coast of India as *Scolopsis aspinosa*. This species was also reported from the southwest coast of India as *Parascolopsis jonesi* Talwar (1986). Russell (1990a) considered it as a junior synonym of *P. aspinosa*. Talwar (1986) had not recorded the pale reddish saddles on back and caudal peduncle of this species. In the Goa region, the saddle is strong on the back and visible strongly below the lateral line and the belly.

Parascolopsis eriomma (Jordan & Richardson, 1909)

Fisher and Bianchi (1984) had showed the distribution of this species along the west coast of India. However, according to Russell (1990a) it has not been previously recorded from the west coast of India. There is no other record of this species along the Indian Coast although it has been recorded from Srilanka (Russell, 1996). Therefore, this is the first report of this species from not only Goan waters but also from the west coast of India.

Parascolopsis boesemani (Rao & Rao, 1981)

The specimens collected of the west coast differed from the first description of the species. The colour pattern has been now recorded in detail. The present collection differed from first description in having a short pelvic fin that does not surpass the vent (as against longer pelvic), and in having three bands on the body (as against four as described by Rao & Rao, 1981a). The fish also had a closer resemblance to *P. baranesi* except that it had longer pectorals reaching beyond the vent. The body colour was denser in the *P. boesemani* collected from the area of study when compared to the newly described species *P. baranesi* (Russell, 1992), and the bands were distinct on the lower half of the body. As all other descriptions agreed with the original description of *P. boesemani*, a re-description was made with additional information available during this study without resorting to designate it as a new species. A comparison of the species collected now with the first description of species and other red-spot *Parascolopsis* given in Table 1 shows that a revision of these red spot *Parascolopsis* is necessary.

Length-weight relationship

In both males and females of *N. japonicus*, the weight increased at a rate which was not significantly different from the cube of the length, showing an isometric growth pattern. However, the difference between the slope and elevation showed that the length and weight of males and females are not homogenous. Therefore, single regression equation to the length-weight relationship cannot be drawn. A single equation could not be drawn for both sexes of *N. japonicus* from Andhra-Orissa coast (Krishnamoorthi, 1971) and from Kakinada coast (Murty, 1984). Along the Kerala coast (Vinci and Nair, 1974) the regression coefficient (2.8487) was significantly different suggesting that the cubic law does not hold good for *N. japonicus* along Kerala coast. In those waters, the females had greater chances of reaching more than one weight for a given length. Along Tamilnadu Coast, the length-weight relationship was homogenous among males and females (Vivekanandan and James, 1986). Similarly, along Kochi (John and Hameed, 1994) and Veraval (Gopal and Vivekanandan, 1991) also the length–weight relationship among males and females was homogenous. The length-weight relationships between the sexes of the species along Hong Kong (Lee, 1986) and Pakistan Coast (Hoda, 1976) also were not different. But in the Kuwait waters, the regression coefficient 'b' was found to be more than 3 among the females.

In the case of the other threadfin-bream, *N. mesoprion*, the pattern of length-weight relationship between males and females was also similar to those of *N. japonicus*. A growth pattern showing significant difference between sexes was also noticed. The finding differs from that recorded for the same species along Kakinada Coast (Murty, 1982), where the length-weight relationship were homogenous, but is in agreement with similar findings by Vivekanandan and James (1984) along the coast of Tamilnadu.

However, in all these studies the regression value 'b' was not significantly different from 3. In contrast to this, the length-weight relationship did not differ significantly between the sexes in the studies made by John and Hameed (1994), but regression coefficient was less than 3. In the northwestern part, along the Veraval Coast (Raje, 1996), the length-weight relations were not homogenous between sexes. Along the southern part of west coast, the fishes had homogenous length-weight relation between sexes but along the northern part of west coast including Goa, the relationship is significantly different between the sexes.

Among the dwarf monocle breams, the relationship is established for the first time through this study. As the regression coefficient was significantly different from '3' among the males, and not so among females, it may be concluded that this species has a different growth pattern among the sexes. Nevertheless, the difference was not large enough to be statistically significant. As the slopes as well as elevation were not significantly different, a common equation could also be obtained to explain the length-weight relationship among males and females. In this common equation, the regression coefficient was however significantly different from '3' showing that these fishes followed an allometric growth pattern.

A well-popularized concept is that the weight (W) of fish varies as the cube of the length (L) i.e. $W = CL^3$ where 'C' forms another constant. However, since the other two dimensions - breadth (depth) and height of fish is not the same as length, or do not change at the same rate as the change in length, this law had an inherent defect. Since most species change their shape as they grow, value of the exponent differs significantly from '3' (Martin, 1949). Moreover, as the specific gravity and shape of the fish is different from a perfect cube, the cubic law does not hold good (Rounsefell and Everhart, 1953). Therefore, the length-weight relationship assumes a form of parabolic equation in the form $W = aL^n$ where the 'a' and 'n' are the components, which can be, estimated empirically by lenearising the equation. This parabolic equation then follows $W = aL^b$ where 'a' is the intercept and 'b', the slope. Beverton and Holt (1957) were of the opinion that variation from the isometric growth is rare. Hence, fishes are less likely to have 'b' value different from '3'.

Among the other species of the nemipterids *N. virgatus* along the northern part of South China Sea (Eggleston, 1970), *N. peronii* along northwest Australia (Sainsbury and Whitelaw, 1984), *N. delagoae* along Tuticorin waters (Hamsa *et al.*, 1994) had significantly different regression lines for males and females, whereas in the case of *N. delagoae* along Mumbai (Muthiah and Pillai, 1979), *N. delagoae* along Vizhinjam, Kerala (Madanmohan and Velayudhan, 1984) and *N. tolu*, *N. delagoae* and *N. lueteus* along Madras (Vivekanandan and James, 1986), the length-weight relationship did not differ significantly between sexes.

Therefore the differences in the regression equation between sexes appears to depend on species as well as on the locality they inhabit. Growth being one of the important deciding factors, species, sex, locality, body shape, food intake, availability of food, biological or environmental stress, presence or absence of conducive and/or adverse factors for growth either singularly or in combination will determine the growth of an individual fish; and hence the length-weight relationship.

Relative condition factor

The seasonal changes in ponderal index are correlated to maturity and spawning (Hart, 1946; Murrow, 1951). However, additional food content also could add to the weight of a fish and hence to the ponderal index. Ponderal index (Hile, 1936) which was widely used to compute the condition of fish,was not suited for fishes which did not follow cube law of growth. Therefore, calculation of relative condition factor K_n (Le Cren, 1951) using the length-weight relationship was suggested. Computation of relative condition factor also eliminates the error added to the index by age, sex, feeding intensity and selection in sampling.

The change in K_n among *N. japonicus* during different months indicated that from November to May the condition of fish is high for both the sexes. The higher K_n values during the period are more pronounced among females. During monsoon and immediate post monsoon months, the condition is lower, which indicated the condition after breeding. The increase in K_n value from the last few post-monsoon months appear to be due to increase in body weight before breeding season. Murty (1984) had observed that in *N. japonicus* from Kakinada, conditions of males were higher than females and suggested that the peak values of K_n were associated with accumulation of fat.

Among the males of *N. mesoprion,* the condition remained higher than '1' from January to April and among the females from December to April. Lower K_n during monsoon and its increase from post monsoon months is a trend seen in both sexes. A similar trend of increased K_n upto March for males and upto April for females was noticed in the population of species along Veraval (Raje, 1996). Decreasing K_n before and during the monsoon and, increased K_n from post monsoon months can be noticed as a trend in the changes of K_n. This trend is due to the breeding period after the monsoon period.

Among the *P. aspinosa,* for a larger part of the year the relative condition remained high for both the sexes. From January to April and September to December, the K_n showed a general increase. The general trend is increase in K_n after February-March. This coincides with the breeding season of the fish.

The changes in K_n values in different length classes have been noticed to depict a different trend. Among the *N. japonicus* of smaller length, the K_n value was higher than '1'. As fishes grew larger K_n values reduced below '1'. This may be due to weight increase not being proportional to increase in length and K_n curve having three modes, as observed at Kakinada (Murty, 1984). But the length groups in which K_n formed the peaks were different in Goan region indicating the difference in the growth pattern. A similar trend was seen in the case of *N. mesoprion.* But in *P. aspinosa,* in both, the smaller as well as the larger fishes the K_n value was higher than '1'. The high K_n value of the small sized fishes reduced with the increase in length and became less than '1'. The lowest value was for the length class between 130 to 149 mm. In later lengths, the K_n increased as the size increased. This trend of decrease in K_n with increase in length until it attains the lowest value and the recuperation of K_n with further increase in length must be the result of changes in K_n in relation to breeding activity among the mature fishes.

Variation in the K_n of different size groups and during different months gives an idea of the condition of fish during different stages of its life. The fluctuations in condition of fish has been observed to be closely related to their sexual cycle while the change in K_n value is due to the change in the gonadal weight (Le Cren, 1951; Pillay, 1958; Devaraj, 1973). The point of inflection on the curve showing the decreased K_n with increased length is good indication of the length at which the sexual maturity started (Pillay, 1958; Narasimham, 1970; Bhat, 1970; Parulekar and Bal, 1971; Devaraj, 1973). Major inflection in *N. japonicus* was around 135 mm in females and 155 mm among males; while in *N. mesoprion* it was at 135 mm among males 125 mm among females. Similarly in *P. aspinosa* the inflection was at 125 mm and 135 mm for males and females respectively indicated the length at first maturity. These values were slightly different from the values obtained from the cumulative plot of matured fishes. This indicates that K_n plot also can be utilized to trace the size at first maturity.

Food and feeding habits.

While investigating the biology of fish, considerable attention has been traditionally given to the food and feeding habits. Availability of the food of choice at different stages of life, especially in the early phase is vital. The variations in the food habits are reflection of the biological adaptation and food requirement of the fishes. In an open ecosystem like oceans, the complexity of the food web among the fishes is often not known correctly due to inadequate understanding of the food habits and feeding behavior through their life cycle.

The food of the nemipterids consisted of mainly crustaceans contributed by Amphipods, prawns, crabs, squilla and lobsters on rare occasions. The presence of crustacean appendages and especially their large carapace indicate that they prefer crunchy food items. Even in the case of fishes found in the guts, heads of large fishes, which could not be identified was a common item. This supports the view that these fishes prefer animals with exoskeleton. However presence of cephalopod tentacles, young ones of squids and cuttle fish shows that in such events any food available is consumed including polychaete worms and bivalves. The food of the three species investigated showed similarity in the composition. The preference for crustaceans by *N. japonicus* and *N. mesoprion* has been earlier recorded by Krishnamoorthy (1971) and Rao and Rao (1991) along Visakhapatnam; and Vivekanandan (1990) along Tamilnadu in the east coast. Similar findings have been reported by Kuthalingam (1965) along Mangalore coast, George *et al.* (1968) along Kochi waters, Acharya *et al.*, 1994 along Bombay coast and Raje (1996) along Veraval region of the north west coast. The findings regarding the feeding habit in terms of food preference in the case of nemipterids along Goa coast are in conformity with the earlier reports cited above. Fish were found to form the second most important group of food items of nemipterids in the course of present investigations also, as was observed in the investigations cited above. In the related species like *N. delagoae* along Vizhinjam (Madanmohan and Velayudhan, 1984) and in *N. bathybius*, (Eggleston, 1972) from Hong Kong waters, preference for crustaceans in the diet has been noticed, which indicates that nemipterids in general have preference for crustaceans over the other food items.

All the three methods of food analysis - numerical, gravimetric, and volumetric, procedures showed that the food of nemipterids mainly consisted of crustaceans followed by teleosts. These methods individually give the importance of food item based on the single attribute measured. Therefore, comparisons of the importance of food items were made by using the index of relative importance (IRI). Though there was no appreciable change in the hierarchy of preferred food items by computing the IRI, a proper comparison of food preference was ensured by the technique.

The feeding intensities of the fishes were found to vary from season to season and from size class to size class. Presence of large number of empty stomachs is a common phenomenon in these fishes caught by trawl nets. This may be to a greater extent due to crowding and struggling of fishes in the net while the net is dragged along the bottom, and to lesser extent due to the act of pressure and weight on the abdomen when the net is hauled up. Moreover, a short time-gap between the feeding and capture is more important so as to find food in the gut is not digested. This ensures proper identification of food items and proper execution of the methods prescribed for the analysis of food habits.

The feeding habits of fishes can be inferred from the food items found in the guts. From the type of food found in the stomachs of these fishes, most of the food items were found to be originating from the demersal region. Some of the fish larvae and fish heads in the stomachs suggests that the feeding may also be from the off-bottom region. Since none of the guts contained detritus or plant matter, it appears that these are active predators feeding by sight, probably during day time as suggested for fishes in Hong Kong waters (Eggleston, 1972). They also appear to be aggressive feeders, as on many occasions carapace of large prawns, heads of large fishes and tentacles of cephalopods are often seen. These fishes seem to attack the prey item and swallow the smaller prey items. In the case of larger items whatever comes in a single bite seems to be taken in. In such cases they appear to be attacking the prey from the front. This in turn indicates that they feed by sight.

Reproduction

Most of the fishes have been known to show some periodicity in reproduction. If there was a periodicity in spawning in a species, all mature fishes collected at any given time are expected to belong to the same stage of maturity (Clark, 1934). Therefore, a clear classification of the maturity stages in a species becomes a primary requirement. The researchers engaged in reproductive biology of fishes have presented different maturity scales (Bull, 1928; Wood, 1930; Clark, 1934; Matsui, 1950; Bagenal, 1957; Fairbridge, 1951). Number of stages classified range from 4 (Matsui, 1950) to 12 (Clark, 1934). Some authors have given alphabetic orders, some numerical orders and some even have subdivided the stages to accommodate intermediary stages. The International

Council for the Exploration of the Seas (ICES) has adopted VII stage classification of Wood (1930) which was followed in the present study. Indian workers have been mostly following the ICES scales as far as feasible and some have been using the same with modifications [Prabhu, 1956; Radhakrishna, 1957; Sheshappa and Bhimachar, 1955; Thomas, 1969; Kagwade, 1970; Antony Raja, 1966). Qasim (1973) suggested that reproductive condition of tropical and sub-tropical fishes could be classified only into 5 stages. However, according to him, simple 3-stage classification- immature, mature and ripe was adequate.

In the case of *Nemipterus japonicus* only 4 stages of classification of the gonads were followed by Acharya (1990), where as Dan (1977) followed a 7-stage classification. However in the present study ICES scales could be adopted with relative ease in females of *N. japonicus* when compared with males of the species and both the sexes of other two species studied.

Fishes has been found to exhibit four type of spawning habits (Hickling and Rutenberg, 1936; de Jong, 1940; James, 1967; Neelakantan *et al.*, 1989). The 'first' group includes those having short spawning once in a season. In these fishes, the mature ovaries have two distinct modes of ova, the mature and the immature, distinctly separated from each other. In the 'second' group of fishes, spawning takes place only once but for a longer period. In these fishes, the range of size of the matured ova will be approximately half the total range in size of ova. The 'third' group of fishes are expected to spawn twice in a season whose mature group of ovaries contain, in addition to the mature ova another group immediately following it, which has undergone about half the maturation process. The 'fourth' group of fishes spawned intermittently over a long period. In the ovaries of such fishes the successive batch of ova are not sharply differentiated, indicating that the maturation is a continuous process. The ova diameter frequency of the three species had similar polygon formation indicating similar breeding habits. The most advanced ova were followed by a stock of ova that have undergone half the maturation process. Therefore, these fishes can be considered to be spawning twice a year.

Spawning season

The temporal distribution of maturity stages of the three fishes showed that a sample collected on a particular day contained at least three stages which increased to 5 in some months (Table 20-25). The occurrence of the fishes in different maturity stages suggested that most number of fishes in advanced gonadal maturity were found during December, January and February. Similar condition, was observed along Mangalore (Kuthalingam, 1965) during December and January. Occurrence of immature specimen of *N. japonicus* of size class less than

80 mm in shallow waters during April along Goa suggests that breading might have already taken place prior to April. The young one's in the catch were sexually separable but lesser than one-year-old. They may be belonging to a spawning batch earlier to December-January period, again suggesting longer breeding period. Fishes with various maturity stages like mature and ripe were encountered between October to May, which also suggests a longer breeding period. Acharya (1990) also recorded long breeding period for *N. japonicus* along Mumbai. Similar observations were made on *N. japonicus* of Veraval (Raje and Vivekanandan 1991) and along Madras (Vivekanandan and James, 1986). Occurrence of mature fishes throughout the year is observed in majority of tropical marine fishes (James and Baragi, 1980) as maturation is a continuous process among the fishes of the region.

Breeding period of *N. mesoprion* also followed the similar pattern with gonads of various stages of maturity occurring during most part of the year. The gonads, which appeared spent by gross examination, were often observed to contain fairly large number of ova of diameter 41 o.d. of stage IV. This is a clear indication that the fishes might be spawning in two batches in a breeding season. However, in some unfavorable conditions these ova may be reabsorbed. In the case of *P. aspinosa,* though the temporal samples were limited, a broad agreement with the other two members of Nemipteridae studied in detail was discernible.

From the percentage occurrence of mature fishes in different length classes, *N. japonicus* female were found to have been matured earlier in contrast to males of both *N. mesoprion* and *P. aspinosa*. Among the males of *N. japonicus* individuals upto 80 mm were observed to be only in maturity stage I but females were in stage II. The last class of females in maturity stage I was 140 -149 mm but males as large as 190 -199 mm were found in stage I. Similarly, in *N. mesoprion* females upto 150 -159 mm class and males upto 180 -189 mm class were in stage I. Such differences were not noticed in *P. aspinosa*. This condition of larger males occurring in early maturity stages may also be due to protogynus hermaphroditism, though the evidences are not conclusive.

Sex ratio

The simple ratio between males and females in the population of any length class or a month could be 1:1. However, the ratio often very significantly. The differences in observed sex ratio of a fish are attributed to many factors like - differential fishing (Kisteven, 1942) and difference in growth rate (Qasim, 1966). The dominance of males among *N. macrodon* (Fairbridge, 1951) was attributed to maturity related migration. The author had suggested that the males matured first and moved to main trawling ground followed by females, which matured at larger size. This reflected that in higher sizes females dominated. The observed difference in sex ratio may also be due to various reasons like, i) actual difference in composition of sex in the population, ii) segregation of sexes during various periods due to difference in size, age and maturity, iii) selectivity of the gear due to the difference in morphological and physiological activity, iv) difference in natural mortality, v) difference in fishing mortality and, vi) spawning activity.

The sex ratio of *N. japonicus* significantly varied during February, May and December 1996 as well as May and November 1997. During this period males dominated on three occasions and females on two occasions. This shows that there are no large-scale differences in sex ratio among the species. Contrary to this the sex ratio in *N. mesoprion* was significantly different during 14 months with males dominating during 11 months and females dominating during 3 months. The ratio of males was very high during November to March. The sex ratio of *P. aspinosa* during different months was in favor of females. The observed difference in the monthly sex ratio was significant in *N. japonicus, N. mesoprion* and *P. aspinosa* and they were not homogeneously distributed. Such findings were recorded in *N. japonicus* (Krishnamoorthi 1974) from Visakhapatnam.

The data on length based sex ratio in different size ranges showed that among *N. japonicus, N. mesoprion* and *P. aspinosa*, there is a size related skew in the sex ratio. The dominance of females in smaller size classes and males in larger size classes is a common phenomenon among these fishes. *N. japonicus* of size class 130-139 mm, *N. mesoprion* of 110-119 mm and *P. aspinosa* of 140-149 mm class were dominated by females. In other size classes other than those cited above the males dominated in all the species. The finding is in agreement with that of Murty (1984) who reported absence of females beyond 215 mm. Size related skew was observed along Visakhapatnam for *N. japonicus* by Krishnamoorthi (1976) who suggested change of sex among the threadfins. According to him, one fraction of the population behaves first as male, while the other fraction behaves as females first and the rest do not change sex. Young and Martin (1985) have observed protogynus hermaphroditism by histological examinations in related species namely, *N. peronii, Scolopsis monogramma, S. taeniopterus* and *S. bilineatus.* They suggested that the size-related skew was not due to sexually differentiated growth. Therefore, the observed difference in sex ratio of the three-nemipterid species in this study might be due to the difference in their biological aspects. However, the present work does not provide any conclusive evidence though there are strong indications of protogynus hermaphroditism.

Fecundity

The production potential of fish can be indicated by the fecundity of a fish. Fecundity is generally determined as the number of mature ova in the ovary. A clear separation of ripe ova (Hickling and Rutenberg, 1936) makes fecundity estimate easier. In fishes that release ova in batches, estimation of fecundity from the advanced stock of eggs only form batch fecundity. While estimating the fecundity of *N. japonicus* which is a batch spawner, counting of the opaque, maturing and translucent ova of stage V was adopted in estimating fecundity of these species (Murty, 1984). In the present study a similar method was adopted, covering the ova of two batches. The range of fecundity of *N. japonicus* was 8,046 – 89,357, while that of *N. mesoprion,* 14,454 - 52638 and *P. aspinosa,* 10,922 – 62,992. This variation in their fecundity depended on size of the fish and various other factors, which may destine the fecund. The relationship of fecundity between the length, weight and the gonad weight have been dealt by different equations (Clark, 1934; Simpson, 1951; Mac Gregger, 1957). Logarithmic transformation has been followed by Dan (1977) and Beganel (1957). The purpose of estimating a relationship between fecundity and length or body weight or gonad height is to see the most retrievable estimator of fecundity. Though it has been established that gonad weight is the best estimator (Hickling, 1940; Kusuma, 1983; Qasim and Qayyam, 1963), Bagenal (1957) suggested length as a quicker estimator, and the fecundity to gonad weight relationship as non-linear, but a straight line where logarithm values are plotted. Fish weight and ovary weight based estimations led to minimum standard error in freshwater fish (Qasim and Quayyam, 1963), whereas in the case of *Johnius belangerii* (Kusuma, 1983) ovary weight happened to be the best estimator with minimum standard error. In the present work, in all three species the highest correlation was between gonad weight and fecundity which confirms the observation in most of the works cited above.

Gonado Somatic Index

GSI values of males are normally lower than those of females during most of the period. The changes in gonad weight in seasonally breeding fishes depend on the maturity stages. The changes are more pronounced in females, and the cyclic changes are indicative of spawning season (Qasim, 1973). Relative ovary weight was found more suitable to explain the stock of maturity in tuna (June, 1953; Yuen, 1955). An increase in GSI followed by a decrease later suggests the breeding period.

Among the nemipterids of Goa region, fluctuations in GSI were noticed. The increase in GSI among *N. japonicus* which started from post-monsoon months peaked during December-January. The GSI began reducing towards monsoon months. Similarly the GSI of *N. mesoprion* increased from August to peak during October-November, decreasing during January and increasing again in later months. Such differentiations were not clear among *P. aspinosa*. Presence of three peaks during the breeding season between the monsoon months reflects batch spawning in the former two species. Increased GSI in *P. aspinosa* during September-November 1997 and September and January 1996 denotes its breeding season. The GSI remained highest during the peak spawning of fishes in Indian waters (Pillay, 1958; Jayaprakash *et al.*, 1979; Kusuma, 1983; Jayabalan, 1986). In the present study also, GSI increased during the maturation process and peaked during the spawning season. This is clearly marked in *N. japonicus, N. mesoprion* and *P. aspinosa*. Higher GSI among females is a commonly observed phenomenon (Neelakantan, 1981; Jayabalan, 1986).

Growth, mortality and exploitation

The dynamics of a fish population has been a subject of discussion and various views were put forth from as early as 18th century. The first modern theory was formulated by Ber (1854) followed by many other investigators like Danilevskii (1862) and Petersen (1895, 1900). The exploitation of fish and related complexity led to the establishment of the International Council of Exploration for Sea (ICES) in 1902 to investigate and formulate theories on fish population dynamics. Some of the important contributions to the subject during the early 20th century were those of Baranov (1918), Russell (1931, 1939), Chugunov (1935), Graham (1935, 1939), Thomson (1937) and Ricker (1940, 1944). Some of the notable critical reviews on the subject are Nikolskii (1950,1953,1965), Beverton and Holt (1957), Thomson (1959), Paloheimo (1961), Gulland (1965, 1969), Ricker (1958), Holden (1974) and Powel (1979). Among the number of contributions in recent years, those of Caddy (1980), Pope (1980), Jones and Zalinge (1981), Gulland (1983, 1988), Jones (1984), Garcia (1985) and Cushing (1988) are very valuable.

Most of the methods used in estimating the vital parameters of any fish stock have been developed in temperate waters. The methods heavily depend on the aging of the 'year class' or 'cohorts'. Therefore, identification of the fish stock by their age became primary requirement for any work related to a fish stock. In temperate waters, the age reading has been easily done from the growth checks on the hard parts of the body like scales, otolith, vertebrae and spines. Moreover, they usually spawned once in a year for a short period making it easy to distinguish the year class or the cohorts.

The tropical fish stock assessment studies gained momentum in the recent years mainly through the works of Pauly (1979, 1980, 1980a, 1981, 1982, 1982a, 1983, 1983a 1984, 1984a and 1987); Pauly and David

(1981); Garcia and Le Reste (1981); Devaraj (1982,1983); Sanders *et al.*, (1984a, 1984b); Alagaraja (1984); Pauly and Morgan (1987); Sparre (1987b, 1991) and Sparre and Venema (1992).

In tropical waters, one of the most serious limitations is lack of appropriate method for age determination. The annual temperature cycle in tropical waters does not leave any remarkable imprint of the growth spurts or growth checks on the hard part of the fish. Moreover, most species are multi-spawners or have a protracted spawning making it difficult to trace various broods in the fishery. The seasonality is though less pronounced in tropics, wind induced (monsoon) changes in the ocean conditions bring some seasonality making it possible to detect the existence of cohorts through analysis of length frequency.

Estimation of L_∞ and K, the two most important parameters of VBGF, require the input - age. But in the ELEFAN I routine of FiSAT L_∞ and K can be obtained by maintaining the highest ESP/ASP ratio. The L_∞ value of 300 mm estimated for *N. japonicus* in the course of the present study is marginally lower than the estimated L_∞ for the species at Kakinada (Murty, 1987a), Mumbai (Chakraborty, 1995), Malaysian waters (Isa, 1988), Kerala coast (John, 1988), Chennai (Vivekanandan and James, 1986), Veraval (Gopal and Vivekanandan, 1991), Mangalore (Zacharia, 1998) and Kuwait waters (Samuel, 1990). However, the value was higher than that reported in the Bangladesh waters (Khan and Mustafa, 1989). Similarly, the K values ' 1.00' obtained in the present study was more than the estimates made by all the studies cited above except for that off Chennai.

The estimated L_∞ value of 285 mm for *N. mesoprion* is higher than that obtained off Chennai (Vivekanandan, 1991), Kakinada (Murty, 1982), Veraval and other centers like Kochi, Mangalore and Visakhapatnam (Murty *et al.,* 1992). In most of the centers, L_∞ was between 238 to 273 mm but the L_∞ of 288 mm at Bombay and 295 mm at Veraval were higher than the L_∞ estimate in this study. The L_∞ values in the east coast are lower than those from west coast, especially along the northwest coast. Similarly, the K value for this species was lower than that obtained at Kakinada (Murty, 1982), and more than the estimates by Murty *et al.* (1992) for different centers mentioned above.

The estimated L_∞ of *P. aspinosa* during this study was 217 mm. This is an estimate made for the first time for this species. As the body shape is different from the other two species and the L_{max} was only 207 mm, these values cannot be compared with other members of the family Nemipteridae. The estimated K during this study was 0.67, which is comparable with the values of other Nemipterids.

The total mortality coefficient estimations made, by using the length converted catch curve for *N. mesoprion* (3.61) and for *N. japonicus* (6.6) show a very wide difference in their mortality rates. The mortality coefficients like 1.86 and 2.67 recorded for *N. japonicus* at Kakinada (Murty, 1983, 1987a), 2.98 at Chennai (Vivekanandan, 1986), 1.37 at Kochi (John, 1987), 5.01 to 6.22 at Mangalore (Zacharia, 1998) are lower than the present estimation of 6.6. Along the Malaysian waters (Isa, 1988) also, the value was reported to be only 3.72. Though the values quoted from other works are of the eighties, the high value of total mortality obtained during the present study may be a result of heavy fishing. The values of mortality obtained by Murty *et al.* (1992) for different centers along the east and west coast were lower than the present estimate. The total mortality rate of *N. mesoprion* obtained during this study was 3.61 for the combined data of both sexes. The total mortality values for *N. mesoprion* at different centers (Murty *et al.,* 1992) were lower but in some of the centers they were as high as 5.37 as in Visakhapatnam. Mortality estimation (2.4) made for *P. aspinosa* is quite low. This happens to be a non-target species that is not accessible to coastal trawlers.

The exploitation ratio 'E' and Exploitation rate 'U' was highest for *N. japonicus* followed by those of *N. mesoprion.* Exploitation rate estimated for *N. japonicus* along the Goa coast is marginally higher than estimated average 'E' of 0.68 at Mangalore (Zacharia, 1998). For the non-target species *P. aspinosa* the values were lower, probably indicating fairly lower exploitation levels. Growth and mortality are among the important aspects of the fish population, which are governed by their adaptation to environment. Fishing activity reduces the population size and interferes with the adaptive relation of the fish species to its environment. The nemipterids that were once treated as by-catch are now a target fishery. The total mortality as well as the exploitation rates are high for the *N. japonicus* as well as for *N. mesoprion*.

Fishery

Goa has a very large population of fish eaters and every village can be considered as a fish-landing center. There are about 87 fishing villages out of which 47 are engaged in marine fishing. The marine fish landing centers for the mechanized sector are Panaji, Vasco-da-Gama, Cortalim, Katbona and Chapora. Though there are good estimated landing figures for marine fishes, the published information on the availability of threadfin breams from Goa coast is limited. Among the marine fishes landed, the landings of the sardines are the highest followed by mackerels. The Japanese threadfin breams form on an average 2.3% of the total marine landing and hence are ranked 5th by quantity.

The earliest literature available on the distribution of this resource is from the results of exploratory fishing by Government of India Vessels (Rao and Dorairaj, 1968). But they have not dwelled on the availability of threadfin breams though recorded catch was up to 5kg hr^{-1} in shallow waters, and 41-55 kg hr^{-1} in deeper waters. Further some of the works carried out on the fishery resources of Goa coast (Dhavan, 1971; Prabhu and Dhavan, 1974) also did not deal with this resource. Vijayakumaran and Philip (1990), Vijayakumaran and Naik (1990) reported the occurrence of this resource based on the data collected during the survey conducted by FSI in these waters.

The depth distribution of the nemipterid resource recorded in the present study suggests that the *N. mesoprion* is mainly a deep-water resource but is also found in shallower waters, whereas *N. japonicus* is a shallow water resource, which is also found in deep waters. Similar observation was made by Vivekanandan (1990) for the threadfins of the Tamilnadu coast. By quantity and catch rate *N. mesoprion* formed larger resource than the other species. The catch rate of threadfins was the highest along the Goa coast in deeper waters (20.39kg hr^{-1}.) followed by that at 51-100 m depth. The catch rate recorded by Vijayakumaran and Naik (op. cit.) was 154.81kg/hr in 101-200 m depth zone followed by 2.6 kg/hr in 51-100 m depth zone. The findings indicate that the resource status has changed during the intervening period to such an extent that the average catch rates have dropped to very low levels. The trend is also seen in the moving average plot. It is evident that, the decrease in the catch rate coincided with the period after 1990-91, when harvesting of the resource was initiated. The trend also depicts the same. From the year 1983 until 1989-90, the fishery was under initial stage of exploitation, as depicted by a steady catch rate. From the year of initial exploitation starting from the fishing season of 1990-91 the catch rates showed reduction in the trend which is a common phenomenon observed in an unexploited/under exploited resource. However, the decline in the catch rate during later years must be due to the increase in number of boats harvesting the resource. The threadfin breams landed along Goa coast showed a decrease from the year 1995. Though there was a slight recovery during the year 1997, in the latter years the decrease is sharp and alarming. As the resource probably was not able to replenish the stock compensating with the rate of exploitation the yield also decreased from year to year. This was clearly seen from the year 1997-1999 where in the landings reduced from 4,648 tons to 404 tons. Though the decline was certain, no management measures were taken, to control the quantity and the size of fish harvested. Since there is a continuous demand for this fish from the factories, which pick the meat for exporting it to

Southeast Asian countries, the resource will remain under fishing pressure until an alternative resource is available or the renewable resource is judiciously harvested. Although the commercial fishing for nemipterids began during the early nineties along the Goa coast, it is clear from the present study that there is a gradual decline in the CPUE and the nemipterid stocks which seems to be sensitive to fishing pressure.

SUMMARY AND RECOMMENDATIONS

The present study deals with fishery biology and stock assessment of the nemipterids along the Goa coast. These fishes known as threadfin breams and pink perch are referred in local language as Rani nee Rane. They are not popular among the fish eating community in Goa, but form an important fishery as most of the harvest caters the 'surimi' plants and consumers in Kerala and Tamilnadu. Though there are some reports on the occurrence of nemipterids along the Goa coast, studies on the biology of the resource were totally lacking until the present work was undertaken. Need for understanding the biology and the stock assessment of nemipterids was greatly felt, as commercial scale exploitation of the resource had already started during the last decade of 21st century and there were no records on the biology of any of the species contributing the fishery.

A review of literature suggested that work on the biological aspect of the nemipterids were mainly concentrated on the east coast especially off Andhra Pradesh and Tamilnadu states. Along the west coast, most of the works were limited to southern coast of Kerala state and northern part of Maharastra and Gujarat coast. Except limited works off Mangalore region, there were no detailed studies on the resource from the central west coast of India. Absence of any biological studies along Goa coast which is an important part of Central West Coast of India was glaring.

Description of nemipterids occurring along Goa coast

Along the Goa coast two major species contribute to the fishery namely *Nemipterus japonicus* and *N. mesoprion.* The former is more in the inner continental shelf and the latter is more on the outer continental shelf. One more member of family Nemipteridae representing the genus *Parascolopsis* viz. *P. aspinosa* was also found harvested from the outer continental shelf. Two more species of *Parascolopsis,* namely *P. boesemani* and *P. eriomma* were reported for the first time along the west coast of India during the course of present study. A description of the three species occurring along the Goa coast is given in detail to delimit the taxonomic description and systematic position of the fishes studied.

Length-weight relations

Length-weight relations of the three species were computed and the difference between sexes was also tested. Length-weight relations in *N. japonicus* and *N. mesoprion* differed significantly between sexes.

The length-weight relationships for two sexes of *N. japonicus* are;

For males: $\text{Log } W = -1.8757222469 + 3.005113817 * \log L$

$$\text{Or } W = 0.013313049 * L^{3.005113817} \quad (r = 0.968024931)$$

The slope of the regression line was not significantly different from

H_o: $\beta = 3$ (t = 0.208326255 α=0.05, d. f. 1004)

For females: Log W =-1.752262272+2.914780905* log L

Or W= 0.017690403$L^{2.914780905}$ (r = 0.979720945)

The slope of the regression line was not significantly different from

H_o: $\beta = 3$ (t = 0.869342103 α= 0.05 d. f. 1008)

The result of analysis of co-variance revealed that there was significant difference between the regression lines of males and females. Hence, a common length-weight equation could not be derived.

The length-weight relationships for two sexes of *N. mesoprion* are;

For males: Log W = -1.8883675264+3.001251561* log L

Or W = 0.013071479*$L^{3.001251561}$ (r = 0.979742796)

The slope of the regression line was not significantly different from

H_o: $\beta = 3$ (t = 0.089338864,α = 0. 05, d. f. 1345)

For females: Log W =-1.956219703+3.06475081* log L

Or W = 0.011060641*$L^{3.06475081}$ (r = 0.968063077)

The slope of the regression line was significantly different from

H_o: $\beta = 3$ (t = 2.99080443 α= 0.05 d. f. 1919)

The result of analysis of co-variance revealed that there was significant difference between the regression lines of males and females. Hence, a common length-weight equation could not be derived.

The length-weight relationships for two sexes of *P. aspinosa* are;

For males: Log W=-1.647925706+2.872986425 * log L

Or W= 0.022494394*L $^{2.872986425}$ (r = 0.966525818)

The slope of the regression line was significantly different from

H_o: β = 3 (t = 2.56324875 α= 0.05 d. f. 238)

For females: Log W=-1.758971955+2.973939837* log L

Or W= 0.017419193L$^{2.973939837}$ (r = 0.97540234)

The slope of the regression line was not significantly different from

H_o: β = 3 (t = 2.223946547 α= 0.05 d. f. 271)

The analysis of co-variance revealed that there was no significant difference between the regression lines of males and females the species (F = 2.501153963, α = 0.025, d. f. 1, 507). Hence, a common length-weight equation could be proposed as shown below.

Log W=-1.708799286+2.928029294 * log L

Or W= 0.019552429*L $^{2.928029294}$ (r = 0.957860062).

The slope of the regression line was not significantly different from

H_o: β = 3, (t = 2.223946547 α= 0.05 d. f. 509).

Relative condition factor

The relative condition factor of the fishes were computed to see the well being of the fishes. The change in K_n among *N. japonicus* was observed to increase after the monsoon months for both the males and females. This increase in condition is attributed to the ensuing breeding season. The size related changes in K_n was found to show a steady decrease from the smaller lengths. The relative condition factor of *N. mesoprion* also showed an increase after the monsoon months as in the case of *N. japonicus*. The size related fluctuation in this species showed an increase in the initial length classes but as the fish grew larger the value reduced. The K_n value of the dwarf monocle bream also increased after the monsoon months as seen in the other two species. The lengthwise change in the condition of fish however differed from the other two species. The values decreased from smallest length group caught, but increased later as the fish grew to the largest size.

Food and feeding

Food and feeding of the three species were studied based on the gut content analysis of the specimen collected. The feeding was observed to be poor most of the time as many empty stomachs were encountered. From the guts examined the food habits of these fishes showed some similarity. All the 3 species were found to prefer crustaceans in most of the seasons and length classes. Prawns formed one of the major food items which were commonly found in the guts of these species. The deep sea lobsters were also found in the guts of *N. mesoprion* and *P. aspinosa*. Fishes formed the second most important food. Among the fishes young ones of ribbon fish, lizard fish and *Stolephorus* were found especially in the guts of *N. mesoprion* and *N. japonicus*. Often, only heads of larger fishes were found in the guts of *N. mesoprion* and to a lesser extent in the guts of *N. japonicus*. Cephalopods like cuttle fishes, squids and sometimes octopuses were also encountered in the guts of all the three species. The polychaete worms were found in the guts of the *N. japonicus* and *N. mesoprion*.

Reproduction

The maturity stages of these fishes were classified based on the recommendations of International Council of Exploration of Sea (ICES) so as to facilitate easy comparison with similar works. The ova diameter studies to trace the maturation process indicated similarity among the three species. In the matured fishes a stock of egg having a diameter of 0.3985 mm was found to remain in large numbers even in the gonads which were partially spent.

The breeding season of the fishes was found to commence from November – December and extend till onset of monsoon, with the peak activities during January in the case of *N. japonicus*, and during December to March in the case of *N. mesoprion*. No conclusive evidences were available on the breeding season of *P. aspinosa*. The breeding habits of these fishes indicated that they were batch spawners, releasing the ova in two batches. The fecundity (based on the two batches of ova) of these fishes were estimated. It ranged from 8,046 - 89,357 for *N. japonicus*, 14454 -52638 for *N. mesoprion* and 10922 - 6292 for *P. aspinosa*. In all the three species the log relationship of fecundity with body weight and length of the fish were not significant whereas fecundity and weight of gonads was found to have highly significant correlation.

There was sex-related skewness in the length frequency of *N. japonicus* and *N. mesoprion*. Most of the smaller fishes were females while the larger ones were males in *N. mesoprion*. Fishes beyond 230 -239 mm class were all males. Similarly in fishes of sizes more than 130 -139 mm class the proportion of males was more. Such a difference could not be noticed in *P. aspinosa*.

Stock parameters

The estimated value of L_∞ and K using length based studies was made following the ELEFAN I routine of FiSAT separately for both the sexes and for the combined length frequency data. The respective values for *N. japonicus* are 295 mm, 1.2 for males, 285 mm and 1.0 for females and for the pooled data, L_∞ was 300 mm and K was 1.0. Similarly, for *N. mesoprion* the L_∞ values were 288 mm for males, 282 mm for females and 285 mm for pooled population; K was respectively 0.7, 1.0 and 0.8. The L_∞ and K value for *P. aspinosa* was respectively 217 mm and 0.67. The mortality estimates were made by deriving total mortality (Z) using the length converted catch curve and natural mortality (N) by applying Pauly's empirical equation. The fishing mortality and the exploitation ratios were estimated to assess the stock status. The total mortality rate of *N. japonicus* was 6.54, 3.49, 6.6 respectively for males, females and pooled data. Similarly the 'N' values for the 3 groups of the species were 2.04, 1.83, 1.80. The exploitation ratio of the stock was 0.73 which is slightly on the higher side. Similarly the values of 'Z' and 'N' for the 3 groups of *N. mesoprion* were 2.89, 3.9, 3.56 and 1.36, 1.37 and 1.49 respectively. The exploitation ratio for *N. mesoprion* was 0.58. In the case of *P. aspinosa* the 'M' 'Z' and 'E' were 2.45, 1.40 and 0.43 respectively.

Fishery

Among the three species, *N. japonicus* was found to be more frequent in shallow waters (< 60 m depth) than *N. mesoprion* which was more frequently found in deeper waters (> 80 m depth). The proportion by weight of *N. japonicus* in the shallow water was 1.95 times that of the *N. mesoprion*. In deeper waters *N. mesoprion* was 4.73 times that of *N. japonicus*.

Changes of the average quarterly catch rates in the three depth zones (zone I: 30-50 m; zone II: 51-100 m; zone III: 101-200 m) were studied to trace the trends in the stock of nemipterids in the Goa coast.

The simple five quarterly moving average plotted on the quarterly average catch rate from 1983 (from 1989 in the case of zone I) showed that there was an initial increase in the average catch rate. The catch rates in the zone II and III decreased from the year 1990 and decreased from the year 1996 in the case of zone I.

The estimated maximum sustainable rate in the three depth zones during 1996 to 1998 was 3272 tons. The harvest of the resource during the period touched to 4648 tons which later decreased to 864 tons during 1998 and 404 tons during 1999 which indicated that the resources was harvested beyond sustainable level.

Recommendations

To ensure that the nemipterid resource is harvested judiciously some strategy to reduce the fishing effort is desired. A definitive strategy of allowing the harvest of only a portion of standing stock need be implemented during the next decade. Although this study does not recommend a limit for exploitation, it is strongly felt that such steps are safer from the viewpoint of long term management and conservation strategy for nemipterids and maintaining sustainable yield.

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