Population dynamics of *Nemipterus japonicus* (Bloch) in the trawling grounds off Cochin

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ABSTRACT

Population dynamics of *Nemipterus japonicus* (Bloch), the dominant species of threadfin breams fished off Cochin was studied during the period 2000-2002. *N. japonicus* was dominant during south-west monsoon and its spawning season extended from May to November. The estimated VBGF parameters were $L_\alpha = 318$ mm, $K = 0.69$ yr$^{-1}$ (males), and $L_\alpha = 265$ mm, $K = 0.77$ yr$^{-1}$ (females) indicating marked growth difference between the two sexes of *N. japonicus*. The study indicated that the present fishing effort along Cochin has reached an optimum level. The maximum yield in the present level of $F$ can be obtained by increasing the length at first capture by 177% of the present yield. The reduction in the cod-end mesh size unless stopped will lead to recruitment overfishing over a period of years.

Keywords: Fishery, Growth, *Nemipterus japonicus*, Population dynamics, Spawning

Introduction

The threadfin breams, comprising of about 6 species form an important fishery along the Kerala coast. Among the two species *Nemipterus japonicus* (Bloch) and *Nemipterus mesoprion* (Bleeker) landed at Cochin Fisheries Harbour, the former contributes about 41% to the total threadfin bream landings. Exploratory studies have revealed the presence of threadfin breams in the deeper waters (Silas, 1969; Nair and Reghu, 1990). Some information on the catch, effort and biology of *N. japonicus* from Cochin are available (Vinci, 1983; Nair and Jayaprakash, 1986; John, 1989; Murty *et al.*, 1992). However, this is the first attempt to study the differential growth rate of *N. japonicus* which have a bearing on the population dynamics of the stocks.

Materials and methods

Samples of *N. japonicus* were obtained at weekly intervals from the commercial trawlers operated off Cochin during 2000-2002. Samples were brought to the laboratory and data on total length, weight, sex and stages of maturity were collected and appropriately raised to the monthly catch estimates. Three hundred and seventy five female specimens in the length range of 70-240 mm with gravid and running maturity stages were considered for determining the spawning season. Growth parameters were estimated using the von Bertalanffy growth equation: $L_t = L_\alpha (1-e^{-K(t-t_0)})$ in FiSAT (Gayanilo *et al.*, 1988; Sparre and Venema, 1991). A total of 2418 fishes in the length range of 70-310 mm (total length) were used for estimation of growth parameters. The length at infinity ($L_\alpha$) values and their associated growth coefficient ($K$) values were selected using FiSAT.

The rate of total instantaneous mortality ($Z$) and exploitation ratio ($E$) was estimated from the length converted catch curve of Pauly (1983) using the total annual length frequency distribution of the catch. The natural mortality rate ($M$) was estimated using the equation of Pauly (1980) and for this purpose, the temperature in the fishing grounds was taken as 27 °C following Suseelan and Rajan (1989). The fishing mortality ($F$) was calculated as $F = Z - M$.

Estimation of exploitation ratio ($U$) was done using the equation (Beverton and Holt, 1957; Ricker, 1975):

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

The annual total stock ($Y/U$) and standing stock ($Y/F$) were estimated by taking the annual catch of the species ($Y$) during 2000-2002. The value of $Y/F$ thus obtained was taken as the biomass ($B$) during the exploited phase of the fishes in the trawling grounds.

Estimation of yield and biomass at different levels of $F$ and $t_0$ was made using Beverton and Holt’s (1957) yield per recruit analysis. The smallest length in the catch over the two-year period was taken as length at recruitment ($L_\gamma$). The length at first capture ($L_c$) was taken as equal to the length at recruitment. The values of $W_\alpha$ was estimated as 290 g from the length-weight relationship, the values of
was estimated as 0.2 taking 70 mm as the smallest length at recruitment \( (L_r) \) and \( t = 0.2 \) from \( L_c = 70 \text{ mm} \) for \( N. \text{japonicus} \). Estimation of yield at different values of \( F \) and length at first capture was calculated and presented in the form of a graph.

**Results and discussion**

**Spawning season**

Ripe fishes (stage IV) were observed from May to November with highest abundance during July-August, indicating the peak spawning season. Earlier studies have indicated that peak spawning was during June-January off Cochin (Vinci, 1983), December-May along Andhra coast (Krishnamoorthi, 1973b; Dan, 1980), August-April off Kakinada (Murty, 1984), June-March off Chennai (Vivekanandan and James, 1986), November-May off Mangalore (Murty et al., 1992) and September-April off Mumbai (Raje, 2002).

**Growth parameters**

The estimated VBGF parameters of length at infinity \( (L_\alpha) \) and growth coefficient \( (K) \) of \( N. \text{japonicus} \) (male, female and pooled) for the period 2000-2002 indicated difference between the two sexes (Table 1). The parameters of growth estimated by earlier workers using different methods show that the values of \( L_\alpha \) ranged from 23.5 to 38.2 cm and \( K \) from 0.12 to 1.00 yr\(^{-1}\) (John, 1989; Murty et al., 1992; Zacharia, 1998). The values obtained in the present study are well within the ranges known for this species. Sainsbury and Whitelaw (1984) estimated von Bertalanffy growth curve of \( N. \text{peronii} \) from Australia and inferred that the growth parameters of sexually differentiated individuals differ significantly. Granada et al. (2004) obtained von Bertalanffy equation for males and females and they were significantly different showing that males grew faster than females in \( N. \text{bathybicus} \) off Japan.

**Age and growth**

The analysis of the data for males and females were done separately to study variation in growth. The length and weight attained by male and female along the same period were different (Fig. 1). Age and growth attained by \( N. \text{japonicus} \) from different localities are given in Table 2. The difference in growth of males and females of \( N. \text{japonicus} \) observed in the present study can be compared with the earlier studies which reported differential growth with males attaining larger length than females (Eggleston, 1972; Krishnamoorthi, 1976; Amorncharoju and Boonwanich, 1982; Murty, 1984). Differential growth in this species in seas off Kuwait has also been reported (Samuel, 1990).

The estimated total mortality (\( Z \)), fishing mortality (\( F \)) and natural mortality (\( M \)) of \( N. \text{japonicus} \) for the period 200-2002 showed difference in males and females (Table 1). The results obtained by catch curve method were taken for the stock assessment studies. The fishing mortality obtained in the present study ranged from 0.59 to 1.28 (male) while for female it ranged from 0.73 to 1.98.
Population dynamics of *Nemipterus japonicus*

The estimated natural mortality (M) was 1.3 which was comparable with those reported by earlier workers where the values ranged from 0.50 to 2.52 (Krishnamoorthi, 1978a; Murty, 1983, 1984, 1987; Vivekanandan and James, 1986; Devaraj and Gulati, 1988; John, 1989; Murty et al., 1992; Zacharia, 1998).

**Stock assessment of *N. japonicus***

During the period 2000-2002, an estimated 1383 t of threadfin breams were landed at Cochin of which *N. japonicus* formed 40.7%. The total stock (Y/U) in the fishing ground fluctuated from 1336 (2000) to 1665 t (2002) and the average was 1058 t while the standing stock (Y/F) ranged from 380 (2000) to 508 t (2002) with a mean of 140 t (Table 3). The average estimated catch was 563 t and estimated fishing mortality (F) was 1.87 landed by 4849 units of multiday trawlers (MDT) and 5749 units of single day trawlers (SDT). The catch per unit effort (CPUE) and catch per hour (CPH) for MDT were 115 kg unit⁻¹ and 4 kg h⁻¹ while that for SDT were 98 kg unit⁻¹ and 14 kg h⁻¹ respectively. The present fishing effort along Cochin has presently reached the optimum level and further increase in catches from the present fishing grounds is unlikely. Recent estimate on the potential of threadfin bream landings of Kerala coast shows a difference of +3805 t from the annual average yield and suggests a reduction in the number of units for the sustainable yield of the resources (Sathianandan et al., 2008).

Table 1. Population parameters of *Nemipterus japonicus* from Cochin during 2000-2002

<table>
<thead>
<tr>
<th>Year</th>
<th>( L_{\alpha} ) (mm)</th>
<th>K</th>
<th>Catch curve method</th>
<th>Jones/van Zalinge plot</th>
<th>Beverton and Holt model</th>
<th>M</th>
<th>F</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>247</td>
<td>1.020</td>
<td>2.430</td>
<td>1.776</td>
<td>2.108</td>
<td>1.3</td>
<td>1.13</td>
<td>0.47</td>
</tr>
<tr>
<td>2001</td>
<td>308</td>
<td>0.816</td>
<td>1.890</td>
<td>2.099</td>
<td>1.949</td>
<td>1.3</td>
<td>0.59</td>
<td>0.31</td>
</tr>
<tr>
<td>2002</td>
<td>338</td>
<td>0.700</td>
<td>2.580</td>
<td>3.246</td>
<td>2.450</td>
<td>1.3</td>
<td>1.28</td>
<td>0.50</td>
</tr>
<tr>
<td>Pooled</td>
<td>316</td>
<td>0.690</td>
<td>2.320</td>
<td>3.158</td>
<td>2.020</td>
<td>1.3</td>
<td>1.02</td>
<td>0.44</td>
</tr>
<tr>
<td>Female</td>
<td>2000</td>
<td>265</td>
<td>1.008</td>
<td>3.280</td>
<td>3.203</td>
<td>3.12</td>
<td>1.3</td>
<td>1.98</td>
</tr>
<tr>
<td>2001</td>
<td>230</td>
<td>1.000</td>
<td>2.030</td>
<td>1.816</td>
<td>2.250</td>
<td>1.3</td>
<td>0.73</td>
<td>0.36</td>
</tr>
<tr>
<td>2002</td>
<td>241</td>
<td>0.750</td>
<td>3.120</td>
<td>3.962</td>
<td>3.036</td>
<td>1.3</td>
<td>1.82</td>
<td>0.80</td>
</tr>
<tr>
<td>Pooled</td>
<td>243</td>
<td>0.770</td>
<td>2.060</td>
<td>2.605</td>
<td>2.020</td>
<td>1.3</td>
<td>0.76</td>
<td>0.37</td>
</tr>
<tr>
<td>Pooled</td>
<td>2000</td>
<td>257</td>
<td>1.300</td>
<td>3.210</td>
<td>2.225</td>
<td>2.754</td>
<td>1.3</td>
<td>1.91</td>
</tr>
<tr>
<td>2001</td>
<td>304</td>
<td>1.220</td>
<td>5.090</td>
<td>3.226</td>
<td>4.890</td>
<td>1.3</td>
<td>3.79</td>
<td>0.74</td>
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<tr>
<td>2002</td>
<td>328</td>
<td>0.900</td>
<td>2.900</td>
<td>2.842</td>
<td>2.781</td>
<td>1.3</td>
<td>1.60</td>
<td>0.55</td>
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<tr>
<td>Pooled</td>
<td>325</td>
<td>0.795</td>
<td>3.350</td>
<td>3.858</td>
<td>3.040</td>
<td>1.3</td>
<td>1.87</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Table 2. Comparison of age and growth attained by *N. japonicus* from different localities

<table>
<thead>
<tr>
<th>Location</th>
<th>Growth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 year</td>
</tr>
<tr>
<td>Veraval</td>
<td>188</td>
</tr>
<tr>
<td>Cochin</td>
<td>136</td>
</tr>
<tr>
<td>Chennai</td>
<td>165</td>
</tr>
<tr>
<td>Kakinada</td>
<td>185</td>
</tr>
<tr>
<td>Visakapatnam</td>
<td>123</td>
</tr>
<tr>
<td>Andhra-Orissa coast</td>
<td>150</td>
</tr>
<tr>
<td>Cochin (miae)</td>
<td>181</td>
</tr>
<tr>
<td>Cochin (female)</td>
<td>159</td>
</tr>
</tbody>
</table>

Table 3. Yield, total stock and standing stock of *N. japonicus* off Cochin during 2000-2002

<table>
<thead>
<tr>
<th>Year</th>
<th>Catch (Y) (t)</th>
<th>F</th>
<th>M</th>
<th>Z</th>
<th>U</th>
<th>Total stock (Y/U)</th>
<th>Standing stock (Y/F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>725</td>
<td>1.91</td>
<td>1.3</td>
<td>3.21</td>
<td>0.542632</td>
<td>1336</td>
<td>380</td>
</tr>
<tr>
<td>2001</td>
<td>503</td>
<td>3.79</td>
<td>1.3</td>
<td>5.09</td>
<td>0.632110</td>
<td>796</td>
<td>133</td>
</tr>
<tr>
<td>2002</td>
<td>844</td>
<td>1.60</td>
<td>1.3</td>
<td>2.90</td>
<td>0.509918</td>
<td>1655</td>
<td>528</td>
</tr>
<tr>
<td>Mean</td>
<td>563</td>
<td>1.87</td>
<td>1.3</td>
<td>3.17</td>
<td>0.531933</td>
<td>1058</td>
<td>301</td>
</tr>
</tbody>
</table>
Yield per recruit

The yield per recruit for different values of F keeping the values of $t_1$ (0.58) and M (1.3) as constant shows that $Y_w/R$ increases with F reaching maximum of 12.65 g and corresponding B/R was 5.75 g for *N. japonicus* (Fig. 2).

![Graph showing yield per recruit](image)

Fig. 2. Yield per recruit (g) and biomass per recruit (g) in *N. japonicus* (current F and $Y_w/R$ are shown by small vertical arrow)

Yield assessment with reference to F

In both male and female of *N. japonicus*, the maximum yield corresponds to 536 t at 100% of the present effort. Thus there is no scope for increasing the yield from the current level of effort from the present fishing grounds. Murty *et al.* (2003) reported that MSY of *N. japonicus* corresponds to 60% of the present effort. During the last decade, the MSY showed an increase of 40% and reached up to 100% of the present effort. This may be due to the increase of multiday fishery of *N. japonicus* from deeper waters and expansion of fishing grounds to deeper waters.

Yield assessment with reference to $L_c$

In the case of *N. japonicus*, male and female combined, maximum yield corresponds to 844 t at 240% of the present $t_c$ (177% of $L_c$) and the yield will be 167% of the present yield (Fig. 3). The maximum yield in the present level of F will be obtained by increasing the length at first capture to 177% of the present and the recommended $L_c$ value for the MSY is 123 mm. This can be achieved by increasing the cod end mesh size from the present level of 15-20 mm to 35-40 mm, which will yield better catches. Murty *et al.* (1992) estimated the maximum yield of *N. japonicus* at 200% of present $t_c$. The present values are little above the earlier results and indicate an increase of length at first capture from the present will yield better.

![Graph showing yield vs. length at capture](image)

Fig. 3. Estimated yield of *N. japonicus* as function of different length at capture as expressed as percentage of present yield

Threadfin breams, spawn over extended periods and the inshore areas serve as nursery grounds for the species. Continued trawling in littoral waters can lead to undesirable consequences and the yield of threadfin breams also have reached levels where further increase in the same does not seem to be possible from the present fishing grounds (Murty *et al.*, 2003). The reduction of the cod-end mesh size of trawl nets can result in the reduction of lengths at first capture, $L_w$ which will in turn cause recruitment overfishing over a period of years (Murty *et al.*, 2003). One of the studies along the Karnataka coast inferred that the present yield could be increased to the MSY level by increasing the effort by 10% whereas the MSE would be at 80% of the present fishing effort (Zacharia, 1998). The abundance of threadfin breams (640 kg h$^{-1}$) in exploratory surveys (Vinci, 1983) and higher catch rates (235-718 kg unit$^{-1}$) during monsoon (Nair and Jayaprakash, 1986) are the two positive factors of the fishery. The decrease in cod end mesh size (Murty *et al.*, 1992), removal of spawning population and observed localization of the fishery very near to river systems owing to large scale discharge of nutrients from rivers (Krishnamoorthi, 1973 b) are the major negative factors of the fishery. The observed growth differences of male and female *N. japonicus* add to the complexity of management of the fishery. Comparing the earlier stock assessments (John, 1989; Murty *et al.*, 2003) with the results of the present study, it appears that the resources are not showing any considerable increase, even though the actual fishing effort and area of fishing operation have expanded, which indicates the need for scientific management for this important resource along the Kerala coast. If the fishery continues with the present F, there is every chance for decline of the catch of threadfin breams from the present trawling grounds.

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Population dynamics of *Nemipterus japonicus*

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CONTENTS

1  
Sahar Fahmy Mehanna and Fahmy I. El-Gammal Growth and population dynamics of the cuttlefish Sepia savignyi Blanchinville in the Gulf of Suez, Red Sea

7  
K. K. Joshi Population dynamics of Nemipterus japonicus (Bloch) in the trawling grounds off Cochin

13  
A. John Chembian Description of spawning ground and egg capsules of the batoid Raja miraletus Linnaeus, 1758 in the Wadge Bank, along the south-west coast of India

17  
E. M. Abdussamad, N. G. K. Pillai, H. Mohamed Kasim, O. M. M. J. Habeeb Mohamed and K. Jeyabalan Fishery, biology and population characteristics of the Indian mackerel, Rastrelliger kanagurta (Cuvier) exploited along the Tuticorin coast

23  
G. Syda Rao, Rani Mary George, M. K. Anil, K. N. Sakeela, S. Jasmine, H. Jose Kingsly and G. Hanumanta Rao Cage culture of the spiny lobster Panulirus homarus (Linnaeus) at Vizhinjam, Trivandrum along the south-west coast of India

31  
Molly Varghese and L. Krishnan Reproductive potential of the rotifer, Brachionus rotundiformis Tschugunoff in relation to salinity, feed type and feed concentration

39  
G. Syda Rao, Phalgungi Pattnaik and Biswajit Dash Comparative regeneration of excised mantle tissue in one year and seven year old Indian pearl oyster, Pinctada fucata (Gould) grown under land-based culture system

45  
D. Bhatnagar, Imelda-Joseph and R. Paul Raj Amylase and acid protease production by solid-state fermentation using Aspergillus niger from mangrove swamp

53  
N. Suja and P. Mutthiah Variations in gross biochemical composition in relation to the gametogenic cycle of the baby clam, Marcia opina (Gmelin), from two geographically separated areas

61  
E. F. Shamsan And Z. A. Ansari Biochemical composition and caloric content in the sand whiting Sillago sihama (Forsskal), from Zuari Estuary, Goa

65  
H. M. Palitha Kithsiri, Prakash Sharma, S. G. Syeddain Zaidi, A. K. Pal and G. Venkateshwarlu Growth and reproductive performance of female guppy, Poecilia reticulata (Peters) fed diets with different nutrient levels

73  
N. B. P. Nanda, P. C. Das, J. K. Jena and P. K. Sahoo Changes in selected haematological and enzymatic parameters of Heteropneustes fossilis exposed to sub-lethal toxicity of rotenone

81  
T. G. Manojkumar and B. Madhusoodana Kurup Age and growth of the Carnatic carp, Puntius carnaticus (Jerdon, 1849) from Chalakudy River, Kerala

87  
Anjali Baishya, Aparna Dutta and Sabitry Bordoloi Morphometry and length-weight relationship of Amblypharyngodon mola (Hamilton-Buchanan, 1822)

93  
Serena Agnes Karodt and C. K. Radhakrishnan Seasonal variations in the gut contents of Arius arius Hamilton from Cochin backwaters

97  
Shubhadeep Ghosh, Debasis Sasmal and T. Jawahar Abraham Microcosm evaluation of indigenous microflora of traditional shrimp farming system as bioremediators

103  
S. Ahamad Ali, C. Gopal, J. V. Ramana, B. Sampoornam, C. Arul Vasu, T. Vaithheeswaran and P. Selvakumar Evaluation of selected binders in a ring-die pellet mill for processing shrimp feed pellets

107  
Instructions for Authors

Indexed/Abstracted in: Aquatic Sciences and Fisheries Abstracts, Biological Abstracts, BIOSIS Previews, CAB Abstracts, Fish and Fisheries Worldwide (NISC), Science Citation Index Expanded, SCOPUS and Zoological Records