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Population dynamics of big-eye croaker *Pennahia macrophthalmus* and blotched croaker *Nibea maculata* (Pisces/Perciformes/Sciaenidae) in the trawling grounds off Rameswaram island, east coast of India

P Jayasankar
Central Marine Fisheries Research Institute, Mandapam Regional Centre,
Mandapam Camp-623 520, Tamil Nadu, India
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Growth parameters of *P. macrophthalmus* and *N. maculata* were estimated. Estimated lengths on completion of I, II and III years were 173, 216 and 228 mm for *P. macrophthalmus* and 193, 253 and 273 mm for *N. maculata*. Total mortality rates (Z) ranged from 2.7 to 5.8 and from 3.35 to 5.91, while natural mortality (M) ranged from 1.84 to 2.38 and from 1.66 to 2.70, respectively for *P.* macrophthalmus and *N. maculata*. Length and age at first capture were 97 mm, 0.35 y and 124 mm, 0.48 y for the two species, which were less than the corresponding parameters at first maturity in both of them. Highest yield could be obtained when age at first capture was 0.45 in *P. macrophthalmus* and 0.60 in *N. maculata*.

In the region off Rameswaram (lat. 8°55'-9°20'N; long. 79°-79° 40'E), sciaenids are exploited almost exclusively by trawlers. Of the 9 commonly occurring species of croakers, *Pennahia macrophthalmus* (Bleeker) in the Palk Bay and *Nibea maculata* (Schneider) in the Gulf of Mannar are the dominant ones. No information is available on age and growth of these two species from Indian waters, hence present paper deals with aspects related to population dynamics based on the data collected during January 1988-December 1992.

Materials and Methods

Trawling grounds off Rameswaram island lie in the Palk Bay and Gulf of Mannar (Fig.1). About 80% of the trawler fleet operating here consists of 9.8 m-long boats fitted with Leyland engine (63-88 HP). This was taken as the standard unit. Until recently, trawlers operating off Palk Bay were doing night fishing (6 days/week) throughout the year, with few boats engaging in day fishing during January to August. Presently, in order to avoid clashes with traditional fishermen over fishing rights, trawl fishing is allowed only on three days/week, when they do 1 day and 1 night fishing. The trawlers operating off Gulf of Mannar engage in day fishing during May-September and 2 night and 1 day ('Voyage') fishing during October-April.

Data on catch and effort were collected for 10-20 days per month. Length measurements were made at weekly intervals. The catch and length data were raised for the day and subsequently for the month[1].

Growth in length was estimated by integrated method of Pauly[2]. The L_∞ (asymptotic length) was estimated by Ford-Walford plot and t_o (age of fish at zero length) by plotting $\text{Log}_e (L_\infty - L_t)$ against t. Since *N. maculata* exhibits allometric growth, growth in weight was also estimated to use in the computation of yield per recruit by Paulik & Gales[3] method. Length-weight relationship of *P. macrophthalmus* was calculated using the formula

$$\log W = \log a + b \log L$$

Length-weight relationship of *N. maculata* was reported earlier[4].

Instantaneous total mortality (Z) was estimated by 3 different methods: length-converted catch curve of Pauly[2], Ssentengo & Larkin[5] and Beverton & Holt[6]. Natural mortality (M) was estimated by four different methods: taking t_{max} as corresponding to L_{max} in the catch[7]; t_{max} corresponding to 95% of asymptotic length[2], t_{max} corresponding to the value obtained by substracting 0.5 cm from asymptotic length[8] and Pauly's emperical relationship[9]. In the last method, the value of T (temperature) was taken as 28.4°C based on an earlier observation made by the author in the Gulf of Mannar.

Length at first capture (l_c) was estimated by the method of Pauly[10]. The smallest length in the catch was taken as length at recruitment (l_r).

Exploitation rate (U) was estimated by the equation of Sekharan[7]. Total annual stock (Y/U) and average standing stock (Y/F) were estimated by

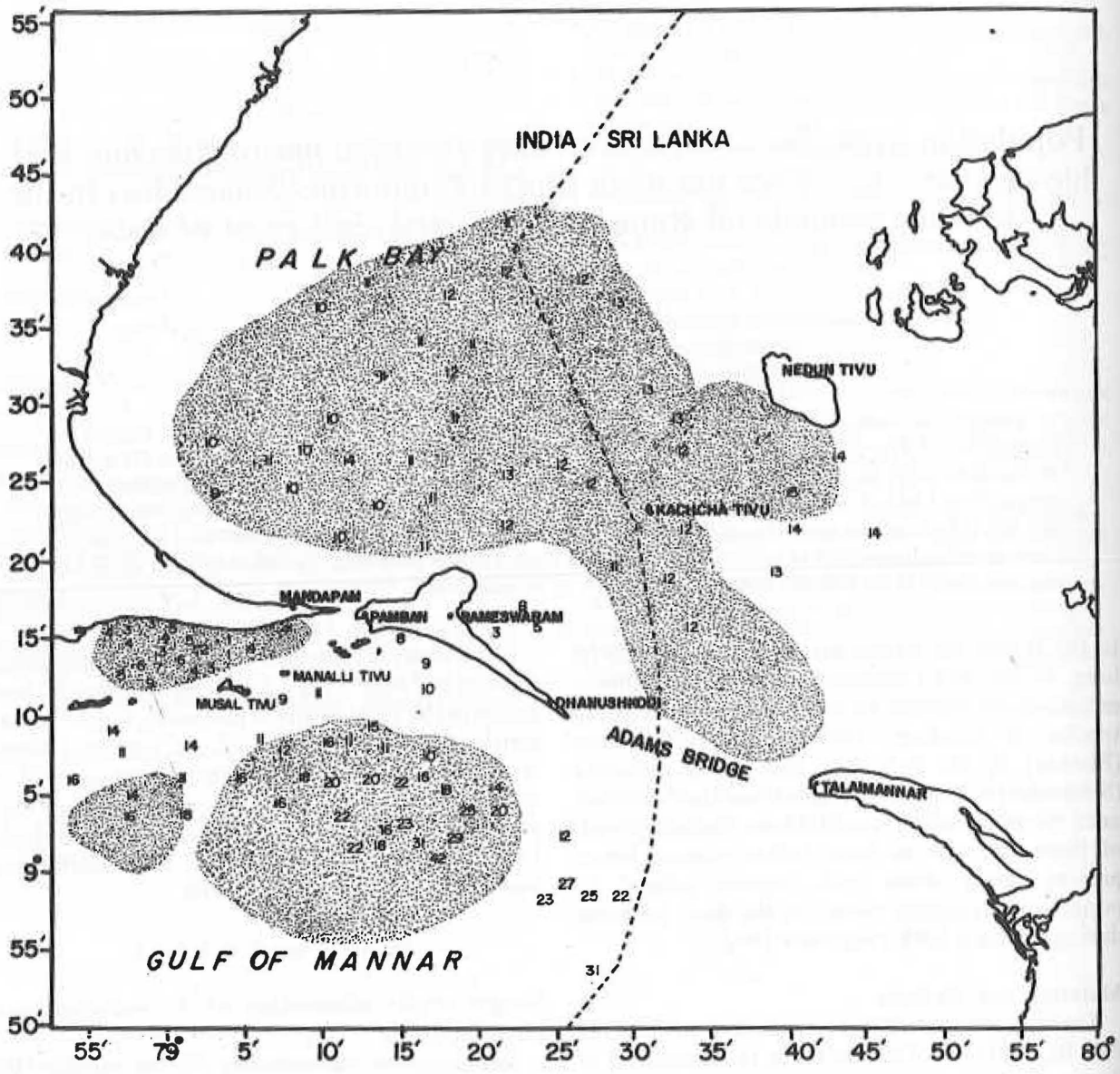

Fig. 1—Trawl fishing grounds in the Palk Bay and Gulf of Mannar off Rameswaram island (numerals indicate depth in m)

taking the average annual catches of the two species. The average standing stock thus obtained was considered as the average biomass (B) during the exploited phase of these species in the trawling grounds off Rameswaram.

Yield in weigtht (g) per recruit and relative yield per recruit were estimated by equations of Beverton & Holt[11,12]. Biomass per recruit and recruitment in numbers were estimated by the equation of Murty[13].

Results and Discussion

Length-weight relationship — A total of 294 specimens of *P. macrophthalmus*, measuring 67-210 mm in total length and weighing 4.6-118.3 g, were used to estimate regression equation of weight on length,

$$\log W = -4.8386 + 2.9890 \log L \ (r^2 = 0.96)$$

Growth is isometric ($t = 0.81$; $P > 0.01$). The results are comparable to the observation made in the same species collected from Andhra and Orissa coasts[14].

Age and growth — A total of 4903 specimens of *P. macrophthalmus* ranging in total length from 40 to 223 mm and 4277 specimens of *N. maculata* of length range 60-249 mm were measured during January 1990-December 1992. The monthly modal lengths

and the growth traced through them are shown in Fig.2. Plots of L_{t+1} against L_t as read off the different growth curves showed good positive correlation in both the species ($r^2 = 0.84$ for *P. macrophthalmus* and 0.85 for *N. maculata*). Estimates of L_∞, K and t_o were:

P. macrophthalmus : 233 mm, 1.26/y and −0.08;
N. maculata : 284 mm, 1.08/y and −0.05.

Parameters of growth in weight estimated for *N. maculata* were:

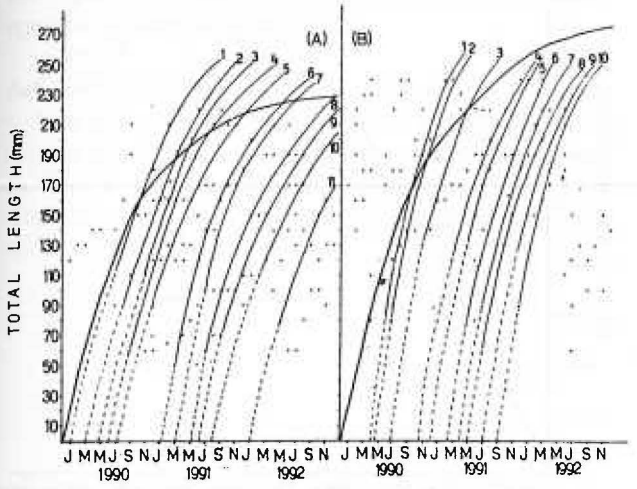

Fig. 2—Growth curves in *P. macrophthalmus* (A) and *N. maculata* (B) drawn through monthly modal lengths (numerals indicate growth curves, broken lines extend the growth curves from the lowest points to touch X-axis, the solid curves without broken line parts represent von Bertalanffy curves)

$\sqrt[3]{W_\infty} = 7.2389$, $K = 1.62$/y and $t_o = -0.08$

The reported L_∞ value of *P. macrophthalmus* in Malayasian waters[15] was 348 mm.

Lengths at the completion of I, II and III years were 173, 216 and 228 mm in *P. macrophthalmus*, while 193, 253 and 273 mm, respectively in *N. maculata*. Since the maximum length of the two species observed in the catches were 223 and 249 mm, the maximum age in the fishery worked out to 2.4 y for *P. macrophthalmus* and 1.9 y for *N. maculata*. Ingles & Pauly[16] reported L_∞ and K values of *P. macrophthalmus* in Manila Bay and San Miguel Bay in the Philippines as 26.5 cm, 1.4 and 20 cm, 0.6, respectively.

Mortality rates — Table 1 shows the estimated values of Z by different methods. In both methods of Ssentengo & Larkin[5] and Beverton & Holt[6], for the purpose of calculating mean length, only fishes measuring above the length at first capture (l_c) were considered. Tables 2 and 3 show the estimates of M obtained by four different methods. In the present study, M/K values for *P. macrophthalmus* were 1.46, 1.78, 1.89 and 1.53, while those for *N. maculata* were 2.13, 1.78, 2.50 and 1.54 in different methods employed to estimate M. Thus they are all within the known range of M/K ratios in fishes[17].

For the computation of yield, length frequency data for 1988-1992 were pooled and the estimates of Z obtained by Catch curve method[2] were used; 4.24 and 4.41, Z values, respectively for *P. macrophthalmus* and *N. maculata* (Fig.3). For the same purpose, values of M obtained by Pauly's method[9] were used (Tables 2 and 3).

Length and age at first capture — The l_c and t_c

Table 1—Estimated values of Z in *P. macrophthalmus* (Pm) and *N. maculata* (Nm) by different methods in different years

Method (ref.)	1988		1989		1990		1991		1992	
	Pm	Nm	Pm	Nm	Pm	Nm	Pm	Nm	Pm	Nm
Beverton & Holt[6]	2.73	3.35	2.75	4.00	2.70	3.59	2.81	3.72	2.78	5.09
Ssentengo & Larkin[5]	3.31	3.86	3.41	4.52	3.22	4.10	3.62	4.23	3.51	5.61
Pauly[2]	4.43	5.69	5.80	4.89	4.72	5.91	4.22	4.85	3.59	5.02

Table 2—Estimation of M following different methods and estimation of F, U, Y/U, Yw/R, B/R and R in *P. macrophthalmus* (Yw/R estimated by Beverton & Holt[11] method) (Z = 4.24; average annual catch = 237 tonnes)

Method	M	F	U	Y/U (t)	Y/F (t)	Yw/R (g)	B/R (g)	Recruitment in numbers
Sekharan[7]	1.84	2.40	0.56	423	99	10.52	4.38	22602740
Pauly[9]	2.24	2.00	0.46	515	119	7.84	3.92	30357143
Pauly[2]	2.38	1.86	0.43	551	127	7.29	3.92	32397959
Alagaraja[8]	1.93	2.31	0.54	439	103	9.87	4.27	24121780

M = Natural mortality, F = Fishing mortality, U = Exploitation rate, Y/U = Total annual stock, Y/F = Average standing stock, Yw/R = Yield-per-recruit, B/R = Biomass per recruit, R = Recruitment

Table 3—Estimation of M following different methods and estimation of F, U, Y/U, Yw/R, B/R and R in *N. maculata* (Yw/R estimated by Paulik & Gales[3] method) (Z = 4.41; average annual catch = 41 tonnes)

Method	M	F	U	Y/U (t)	Y/F (t)	Yw/R (g)	B/R (g)	Recruitment in numbers
Sekharan[7]	2.30	2.11	0.47	87	19	0.445192	0.2109914	90051064
Pauly[9]	1.92	2.49	0.56	73	16	0.562562	0.2259283	70818928
Pauly[2]	2.70	1.71	0.38	108	24	0.335731	0.1963340	122240670
Alagaraja[8]	1.66	2.75	0.62	66	15	0.655806	0.2367531	63357143

M = Natural mortality, F = Fishing mortality, U = Exploitation rate, Y/U = Total annual stock, Y/F = Average standing stock, Yw/R = Yield-per-recruit, B/R = Biomass per recruit, R = Recruitment

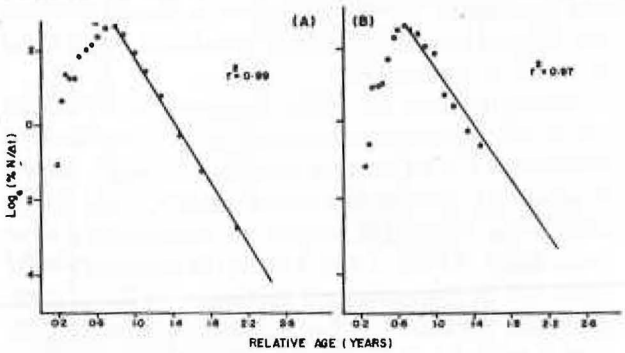

Fig. 3—Estimation of Z by length-converted catch curve method in *P. macrophthalmus* (A) and *N. maculata* (B) (solid circles indicate points used and hollow circles points unused in the estimation of Z)

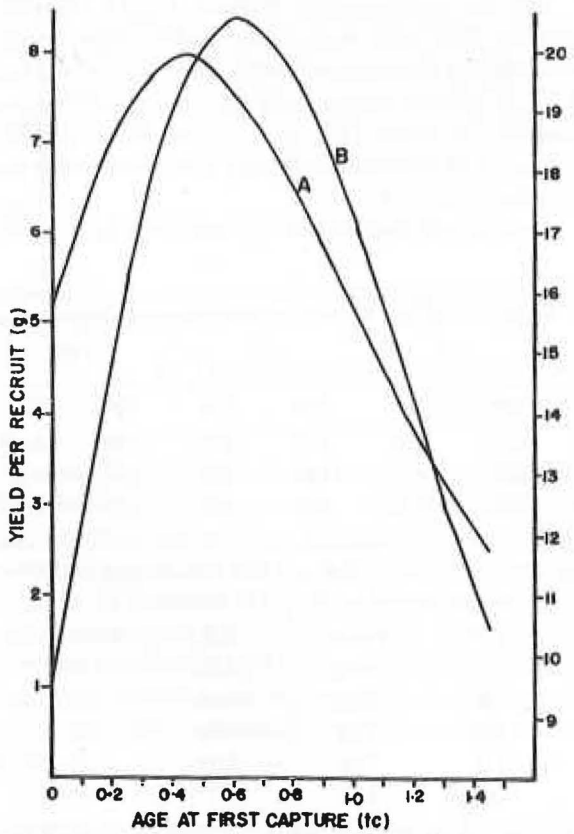

Fig. 4—Yield-per-recruit as function of age at first capture in *P. macrophthalmus* (A) and *N. maculata* (B)

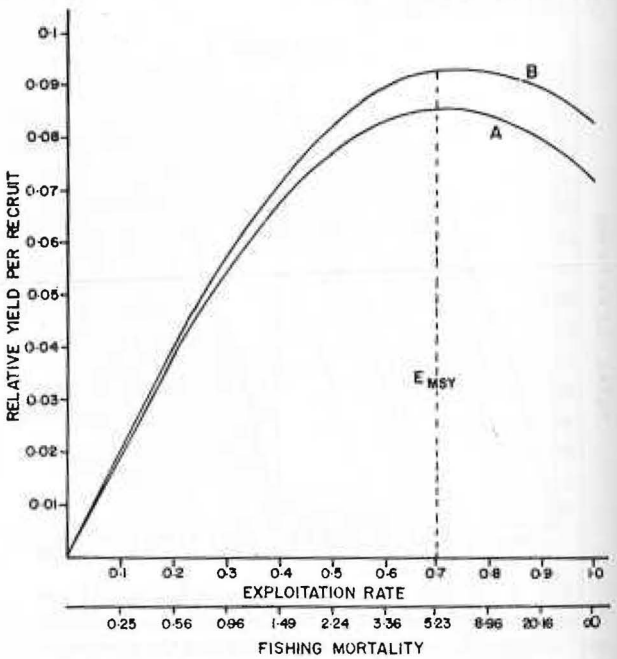

Fig. 5—Relative yield per recruit as function of Exploitation rate and Fishing mortality in *P. macrophthalmus* (A) and *N. maculata* (B)

values were 97 mm/0.35y and 124 mm/0.48y, respectively for *P. macrophthalmus* and *N. maculata*.

Population size and yield per recruit — Values of exploitation rates, total annual stock, average standing stock, yield per recruit, biomass per recruit and recruitment numbers of the two species are given in Tables 2 and 3. On the basis of length-weight relationship, the values of W_∞ corresponding to L_∞ were calculated as 166 and 360 g in *P. macrophthalmus* and *N. maculata*, respectively. Estimated length and age at recruitment were 40 mm/0.07 y and 60 mm/0.17 y.

Yield-per-recruit is maximised when t_c is 0.45 y in *P. macrophthalmus* and 0.6 y in *N. maculata* (Fig. 4). Since the present t_c values of the two species are 0.35 and 0.48 y, there is scope for further increase in yield by increasing the codend mesh size (presently 20 mm) of the trawl net. Further, in both the species, the age at first capture was less than that at first maturity. The

age at first maturity is 0.6 (males) and 0.72 (females) in *P. macrophthalmus*[18], while 0.77 (males) and 0.93 (females) in *N. maculata*[4]. Increasing the present codend mesh size would give atleast one chance to the fish to spawn before being caught in great numbers.

Figure 5 is suggestive of scope for further increase in effort to maximise the yield since present exploitation rates (0.46 and 0.56) are below E_{MSY} (0.7) in both the species.

Both species of sciaenids studied here form only a minor portion of the multispecies complex exploited by trawling. Present results may not provide meaningful management options of the trawl fishery. However, the utility of such data to understand the state of a particular species resource among the other species cannot be overlooked.

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References

1 Sekharan K V, *Indian J Fish*, 9A (1967) 679.
2 Pauly D, *FAO Fish Tech Pap*, 234 (1983) pp.52.
3 Paulik G J & Gales L E, *Trans Amer Fish Soc*, 93 (1964) 369.
4 Jayasankar P, *Indian J Fish*, 36 (1989) 299.
5 Ssentengo G W & Larkin P A, *J Fish Res Bd Canada*, 30 (1973) 695.
6 Beverton R J H &Holt S J, *Rap Pv Reun Cons Perm Int Explor Mer*, 140 (1956) 67.
7 Sekharan K V, *Indian J Fish*, 21 (1976) 177.
8 Alagaraja K, *Indian J Fish*, 31 (1984) 208.
9 Pauly D, *J Cons Int Explor Mer*, 39 (1980) 175.
10 Pauly D, *ICLARM Fishbyte*, 2 (1984) 17.
11 Beverton R J H & Holt S J, *Fish Invest Lond Ser*, 19 (1957) 533.
12 Beverton R J H & Holt S J, *FAO Fish Tech Pap*, 38 (1966) pp.49.
13 Murty V S, *J Mar Biol Ass India*, 32 (1990) 10.
14 Rao P A, *Indian J Fish*, 29 (1982) 263.
15 Ahmad B A, *FAO Fish Rep*, 389 (1988) 141.
16 Ingles J & Pauly D, *ICLARM Tech Rep*, 13 (1984) pp. 127.
17 Beverton R J H & Holt S J, in *Ciba Foundation Colloquia on Ageing*, edited by G E W Wolsenholmy & M O Connor, (CIBA) 1959, 142.
18 Gandhi V, *Indian J Fish*, 29 (1982) 79.