based on a data set covering 56 "stocks" of teleosts fully documented in Table 1 of that paper.

Besides these models, the analysis of the data in our Table 1 led to simpler models of the form

$\log M = a + b_L L_\infty + b_k \log K$ ...3)

and

$\log M = a + b_w W_\infty + b_k \log K$ ...4)

which had been quantified and tested, and found to contain terms that were all significantly different from zero.

We ignored these results, and presented instead two models (equations (2) and (3) in Djabali et al. 1993) which had the same terms as the models of Pauly (1980) (i.e., equations (1) and (2)). We overlooked, however, the narrow range of our temperature data (for 13 to 19°C), which prevented the temperature-related terms (b_T) from being significantly different from zero. Moreover, the sign of our b_T estimates was negative.

The manner this was "corrected" further confused things (see D. Pauly's editorial, this issue). The results below document how the matter now stands.

Result and Discussion

Following discussion with Drs. Dino Levi (Instituto de Tecnologia della Pesca e del Pescato, Mazara del Vallo, Sicily, Italy) and D. Pauly, on the narrow range of our temperature estimates, we present here those of our empirical models that do not include a temperature term, and hence correspond to equations (3) and (4).

These models are

$\log_{10} M = 0.0278 - 0.1172 \log_{10} L_\infty + 0.5092 \log_{10} K$ ...5)

and

$\log_{10} M = -0.0656 - 0.0302 \log_{10} W_\infty + 0.5280 \log_{10} K$...6)

where M and K are expressed on an annual basis, and L_∞ is total length, in cm.

These multiple regressions have R^2 values of 0.82 and 0.81, respectively, slopes that are all significantly different from zero (F test, $P < 0.01$), and residuals that are normally distributed and independent (Durbin Watson test, $P < 0.01$).

These equations, and the tests that go with them thus confirm that, indeed, models can be derived which, as suggested by Arreguín-Sanchez (1990) allow "regional" estimation of M.

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Length-Based Estimates of Vital Statistics in Threadfin Bream (*Nemipterus japonicus*) from Bay of Bengal, Bangladesh

M.G. MUSTAFA

Abstract

ELEFAN 0, ELEFAN I and ELEFAN II were used to estimate vital statistics of *Nemipterus japonicus* from length-frequency data sampled along the coast of Bangladesh. The parameters L_∞ and K were estimated at 24.5 cm and 0.94·year^{-1}. The values of M and F were found to be 1.81 and 1.58·year^{-1}, respectively. The fish recruit to the fishery during May-June and September-October.

Introduction

Nemipterus japonicus is the most abundant among the few species of threadfin breams available in the deeper water of the Bay of Bengal, Bangladesh (Mustafa et al. 1987). This species lives in schools, generally close to the bottom, and accounts for about 4.4% of the total demersal biomass of which about 0.1% is from 0 to 20 m; 3.3% below 21-50 m; 15.2% below 51-80 m; and 81.4% in 81-100 m depth zones (Lamboeuf 1987). The importance of this species to the offshore fishery of Bangladesh has been stressed by several authors (Chowdhury et al. 1979; Mohiuddin et al. 1980; Saetre 1981; Quddus and Shafi 1983; White 1985; Mustafa et al. 1987; Lamboeuf 1987; Mustafa et al. 1992), although it is generally thrown overboard as trash fish, from offshore shrimp trawlers in Bangladesh.

Materials and Methods

Length-frequency samples used for this study were collected from February 1984 to October 1985 from Bangladesh coast (Fig. 1) during the course of demersal stock survey with *R.V. Anusandhan*; the net used was two-seam type high opening bottom trawl with a headrope length of 57.5 m. The mesh size at the cod end was 32 mm. Fork lengths at one cm interval for 2,926 specimens were measured on board immediately after the catch. Length-frequency data were pooled monthwise.

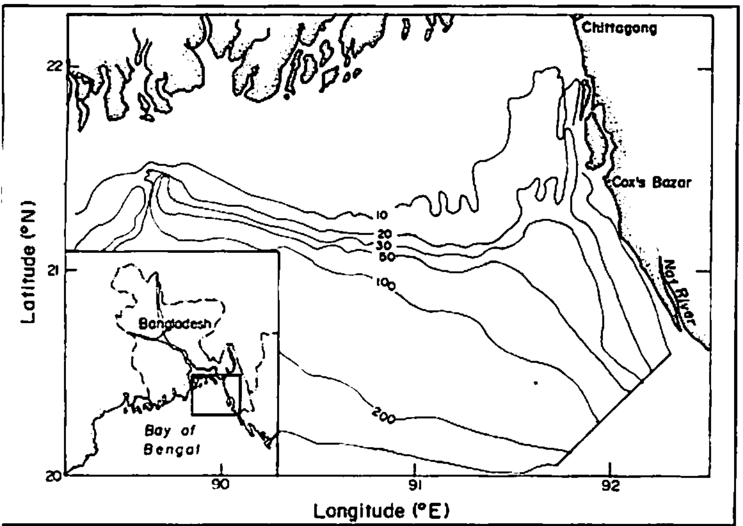

Fig. 1. ***Bay of Bengal, Bangladesh region.***

The ELEFAN I and II computer programs were used to estimate the population parameters of the threadfin bream (Pauly and David 1981; Saeger and Gayanilo 1986). The ELEFAN I routine used a preliminary estimate of L_∞ and Z/K, obtained by plotting $\bar{L}$ on L' (Wetherall 1986, as modified by Pauly 1986), i.e.,

$$\bar{L} - L' = a + bL' \quad ...1)$$

where $L_\infty = a/(-b)$

and $Z/K = (1+b)/-b$

where $\bar{L}$ is defined as the mean length, computed from L' upward, in a cumulated length-frequency sample representing a steady-state population, while L' is the limit of the first length class used in computing a value of $\bar{L}$.

The growth performance of threadfin bream populations in terms of length was compared using the index of Pauly and Munro (1984):

$$\phi' = \log_{10}K + 2\log_{10}L_\infty$$

Values of ϕ' obtained by various authors in the tropical IndoPacific region were used for comparison with the estimates obtained here. Total mortality (Z) was estimated from a length-converted catch curve.

Natural mortality (M) was estimated using the empirical relationship of Pauly (1980), i.e.,

$$\log_{10}M = -0.0066 - 0.279\log_{10}L_\infty + 0.6543\log_{10}K + 0.4634\log_{10}T \quad ...2)$$

where L_∞ (TL) is expressed in cm, and T (°C) is the mean annual environmental temperature (here taken as 28°C).

The estimate of F was obtained by subtraction of M from Z, and the exploitation ratio (E = F/Z) was then computed.

ELEFAN II was used to obtain a plot of probability of capture by length (Pauly 1984) by extrapolating the catch curve and calculating the number of fish that would have been caught, had it not been for selection effects (and incomplete recruitment).

A recruitment pattern was obtained by projection on the length axis of the available length-frequency data.

Relative-yield-per-recruit (Y/R) and biomass-per-recruit (B/R) were derived from the estimated growth parameter, probabilities of capture by length (Pauly and Soriano 1986) and estimates of M.

Results and Discussion

Growth Parameters

The Wetherall plot is shown in Fig. 2. As might be seen, the points from 13 cm and above show a good linear relationship. The corresponding estimates of L_∞ and Z/K are 23.35 cm and 2.47, respectively. Subsequent analysis with ELEFAN I led to L_∞ = 24.5 cm and K = 0.94·year^{-1} (Fig. 3). The value of ϕ' for *N. japonicus* (ϕ'=2.75) is well within

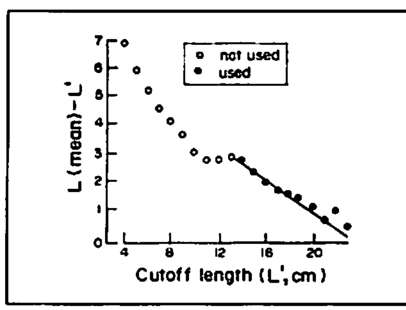

Fig. 2. ***Estimation of L_∞ and Z/K using the methods of Wetherall for* N. japonicus; *the estimated L_∞ = 23.35 cm and Z/K = 2.467.***

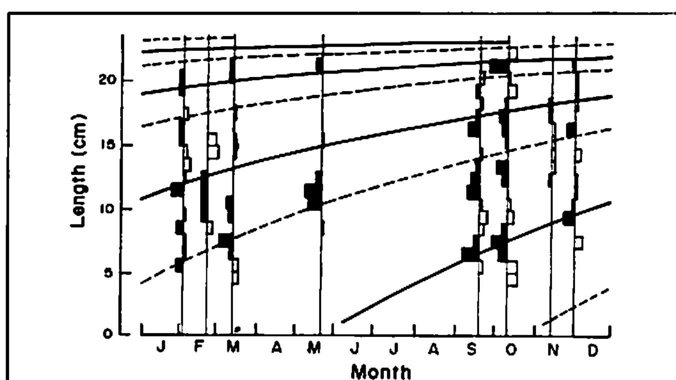

Fig. 3. ***Growth parameters of* Nemipterus japonicus *estimated by ELEFAN I (L_∞ = 24.5 cm and K = 0.94 year^{-1}).***

the range of 2.28-2.80 observed in this species (Table 1 and Fig. 4).

Mortality

The estimates of mortality rates M, F and Z are 0.78, 0.55 and 1.33·year^{-1}, respectively. Fig. 5 presents the catch curve

Table 1. Growth parameter estimates of *Nemipterus japonicus* in various areas of the IndoPacific region.

Area	L_∞	K	ϕ'	Remarks	Sources
India (Andra, Orissa)	30.5	0.314	2.47	1964-1965	Krishnamoorti (1971)
India	20.9	0.648	2.45	1965-1966	Krishnamoorti (1971)
India	30.3	0.294	2.43	1966-1967	Krishnamoorti (1971)
Hong Kong	34.1	0.190	2.34	Females	Lee (1975)
Hong Kong	38.2	0.130	2.28	Males	Lee (1975)
Northern Myanmar (Burma)	37.0	0.235	2.51	1979-1982	Pauly and Sann Aung (1984)
Southern Myanmar (Burma)	37.0	0.243	2.52	1979-1982	Pauly and Sann Aung (1984)
Manila Bay, Philippines	30.0	0.700	2.80	1978-1979	Ingles and Pauly (1984)
Carigara Bay, Philippines	23.5	0.730	2.61	1981-1983	Corpuz et al. (1985)
Samar Sea, Philippines	26.5	0.600	2.62	1981-1983	Corpuz et al. (1985)
Kedha State Pen., Malaysia	31.5	0.530	2.72	1985	Isa (1988)
Kedha State Pen., Malaysia	31.4	0.550	2.73	1985	Isa (1988)
Bangladesh (Bay of Bengal)	26.5	0.600	2.62	1979-1980	Humayun et al. (1989)
Pakistan	28.8	0.460	2.58	1983-1984	Iqbal (1991)
Bay of Bengal, Bangladesh	24.5	0.940	2.75	1984-1985	This study

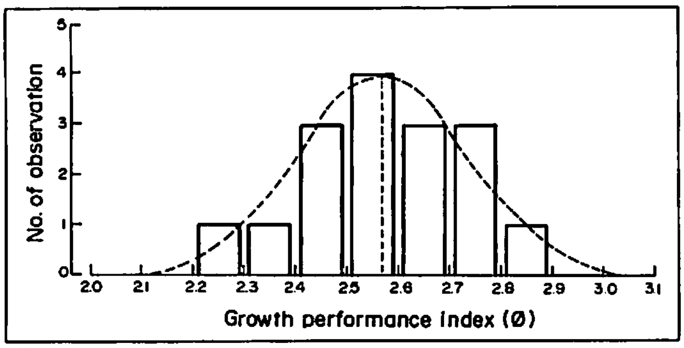

Fig. 4. ***Frequency distribution of 15 values of the growth performance index (ϕ') of* N. japonicus *with superimposed normal distribution ($\bar{x}$ = 2.57 ± 0.086, s.d. = 0.16).***

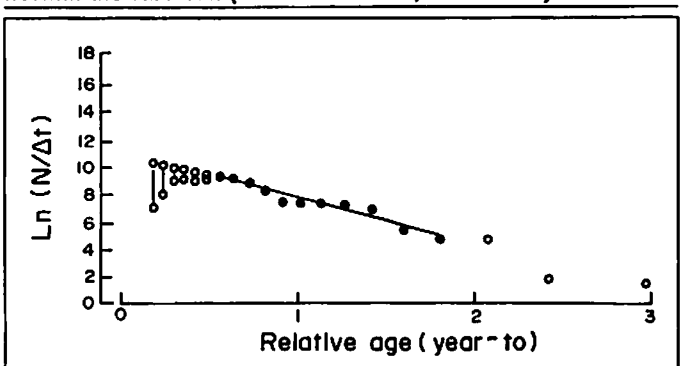

Fig. 5. ***Length-converted catch curve of* Nemipterus japonicus *off Bangladesh.***

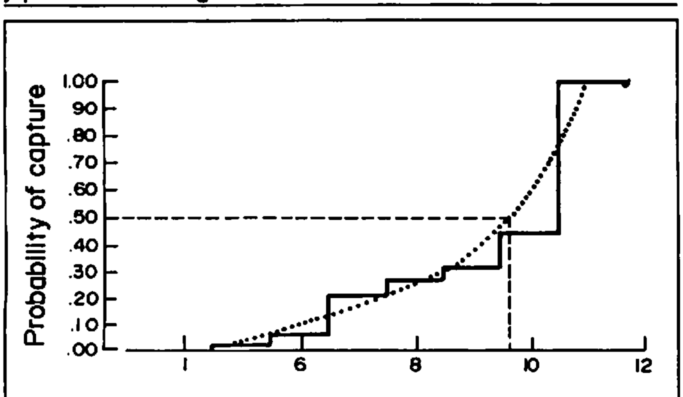

Fig. 6. ***Selection pattern of* Nemipterus japonicus *off Bangladesh.***

utilized in the estimation of Z. Black dots represent the points used in calculating Z through least squares linear regression, while open dots represent the points either not fully recruited or close L_∞ and hence discarded from the calculation. A good fit for the descending right hand limb of the catch curve was obtained, with a correlation coefficient of r = 0.928.

Selection Pattern

Fig. 6 shows the selection (or more precisely: resultant) curve derived from the length-converted catch curve. This provided an estimate of L_{50} = 9.6 cm.

Recruitment Pattern

The recruitment pattern determined through ELEFAN II (Fig. 7) suggests that annual recruitment consists of two uneven seasonal pulses, in May-June and September-October. This is in agreement with Pauly and Navaluna (1983) who reported two pulses of recruitment of *N. japonicus*·year^{-1} in Southeast Asia.

Yield-per-Recruit and Biomass-per-Recruit

Yield-per-recruit and biomass-per-recruit were determined as functions of L_{50}/L_∞ and M/K, respectively. Fig. 8 shows that the present exploitation rate (E = 0.41) is lower than that which generates maximum yield-per-recruit (E_{max} = 0.62).

Fig. 9 finally shows a complete yield-per-recruit isopleths

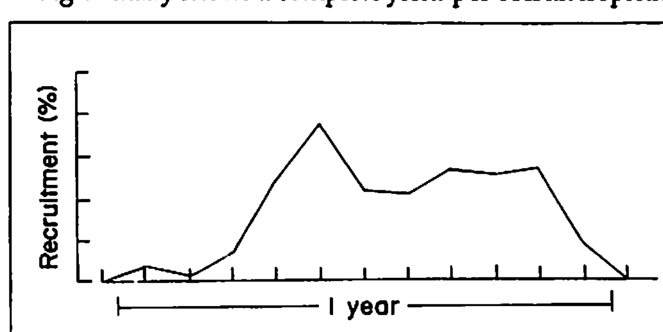

Fig. 7. ***Recruitment pattern of* Nemipterus japonicus.**

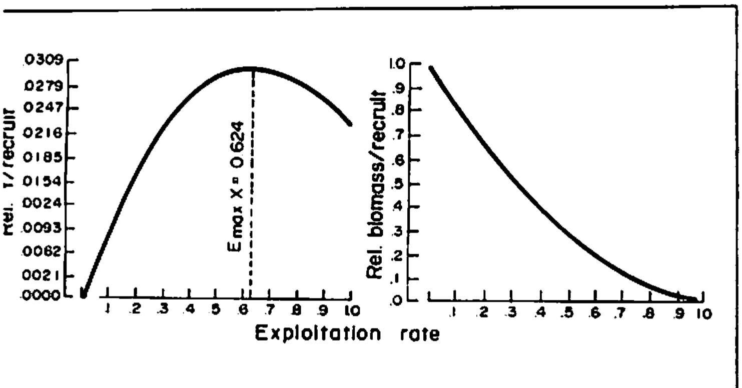

Fig. 8. ***Relative yield per recruit and relative biomass per recruit of* Nemipterus japonicus *(Lc/L$_\infty$ = 0.77, M/K = 2.08).***

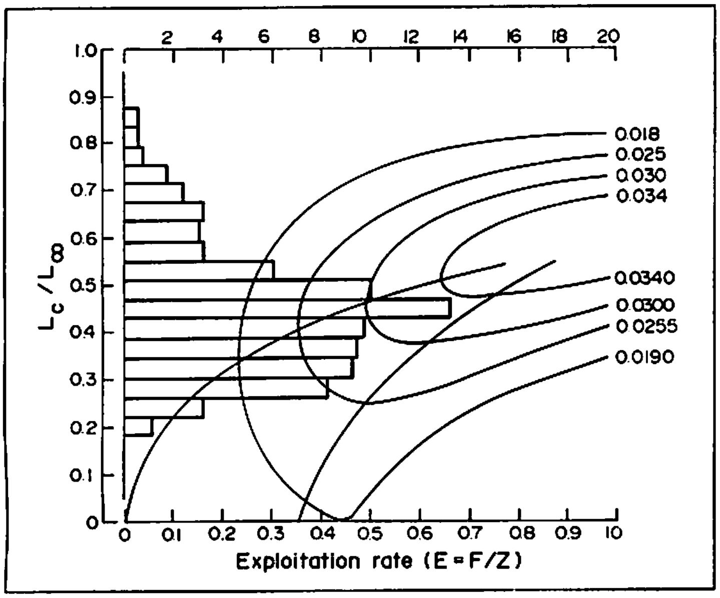

Fig. 9. ***Yield per recruit isopleths diagram of* Nemipterus japonicus *and % frequency distribution of catch.***

diagram. This indicates that yield-per-recruit could be increased over the present situation, by simultaneously increasing L_{50} and E.

As *N. japonicus* is harvested as a (small) component of a multispecies complex, studies such as presented here cannot provide direct inputs to management. However, these results may be indicative of the overall state of the stock; this can be verified by performing similar analyses on several species.

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