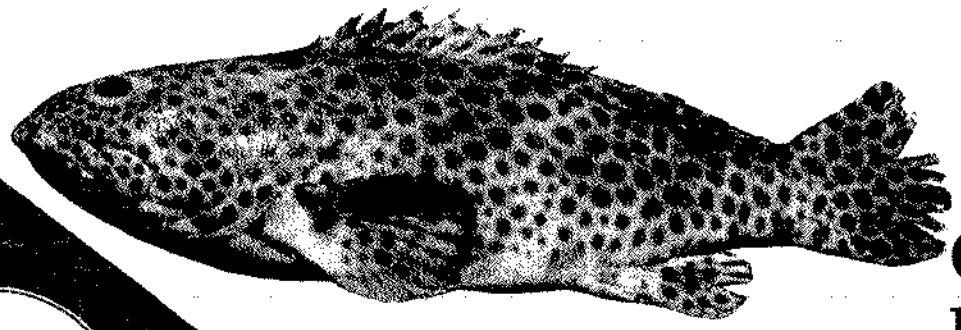

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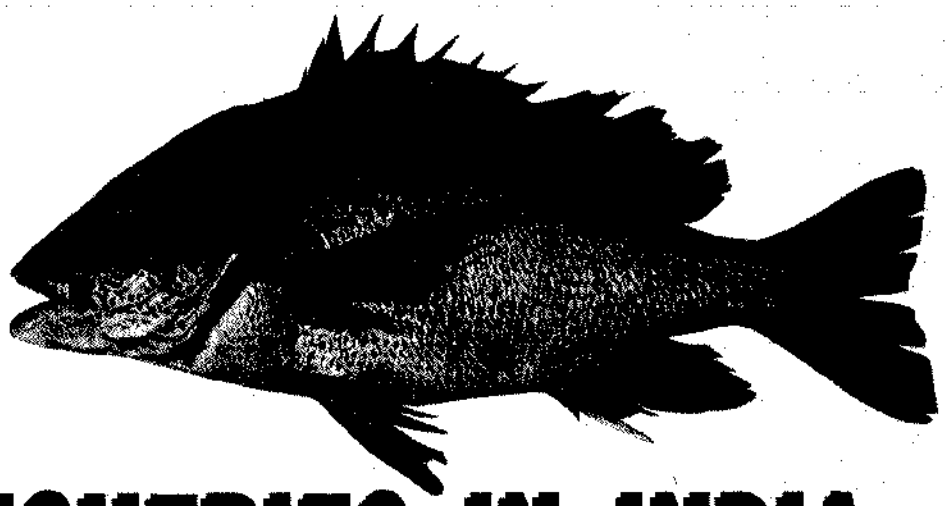

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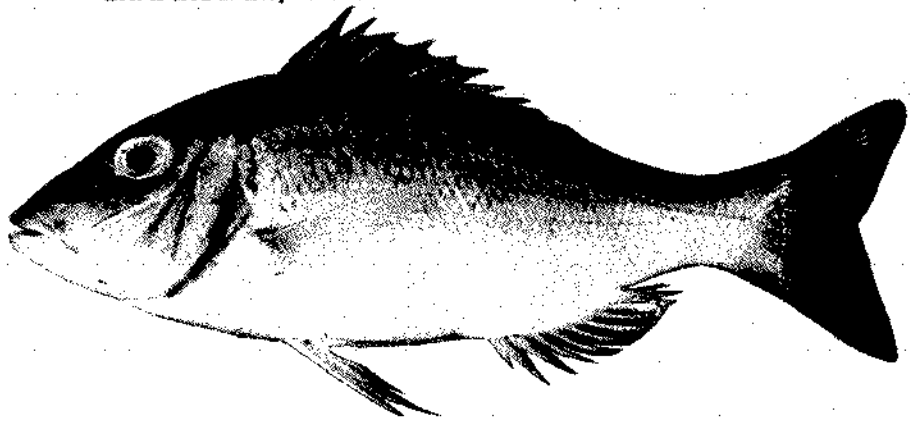

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THE FISHERY, BIOLOGY AND STOCK ASSESSMENT OF *NEMIPTERUS DELAGOAE* SMITH OFF TUTICORIN, GULF OF MANNAR

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ABSTRACT

Nemipterus delagoae is the dominant threadfin-bream landed at Tuticorin. An estimated 158.15 t and 226.9 t were landed by trawl net at the catch rate of 6.31 and 10.13 kg/unit in 1987 and 1988 respectively constituting on an average 3.6% of the total catch by trawl net. The peak period of fishing season is during September - December. The estimated growth parameters from length frequency data are $L\infty$ = 362.0 mm, K = 1.0586 (annual) and t_0 = -0.0087 yr. The sexwise length-weight relationship did not exhibit any significant difference and hence a common length-weight relationship is proposed. Fishes (25.6%), prawns (21.9%), crabs (14.3%) formed the dominant food items of this species in addition to brittle-stars, cuttlefishes, gastropods, bivalves, *Squilla*, polychaetes, alphids, isopods and amphipods. The natural mortality coefficient (M) is 1.625 and the average annual total mortality coefficient (Z) is 3.29 by trawl net. The yield per recruit studies indicate that the prevailing F *i.e.* 1.665 by trawl net which is well below the F_{max} which can produce the highest yield (Y_{max}) for the prevailing age at first capture 0.4687 yr for the M/K ratio 1.535. This indicate that the fishery of *N. delagoae* is not exposed to higher fishing pressure and there is scope for further increase in the fishing effort of trawl net.

INTRODUCTION

Among perches, threadfin-bream is considered as a commercially very important resource as this constitutes more than 50% of the total perch landings in India (Kasim *et al.*, 1989). The fishery and biology of different species of threadfin-breams have been studied by Krishnamoorthi (1971, 1973, 1976), Murty (1982, 1983, 1984), Muthiah and Krishna Pillai (1979) and Vinci and Kesavan Nair (1974). However, the fishery, biology and stock assessment of *Nemipterus delagoae* Smith is being reported from Tuticorin, Gulf of Mannar for the first time in India. The fishery of threadfin-breams in Tuticorin is sustained by mostly *Nemipterus delagoae* and the occurrence of other species was very much limited. The predominant occurrence, commercial and economic importance of *N. delagoae* have prompted to initiate a detailed study on this species at Tuticorin and the present account deals with the fishery by trawl net, some aspects of biology such as the length - weight relationship, food and feeding, maturity, age and growth, mortality rates, yield per recruitment and stock assessment of *N. delagoae*.

OBSERVATIONS

Due to non-maintenance of fishing log by the fishing units, weekly obsevations were made and data on the gearwise catch, effort and length frequency of *N. delagoae* were collected by sampling at random a minimum of 10% of the fishing units on each observation day. The length-weight relationship was studied by simple regression and co-variance analysis (Snedecor, 1961). To estimate the growth parameters initially the length frequency data were processed as per integrated method (Pauly, 1980) as shown in Fig. 1. Then the average size attained by this species in subsequent month was obtained as per George and Banerji (1968) from this figure and these data were used to obtain the $L\infty$, K and t_0 by the method of Alagarja (1984). The natural mortality coefficient (M) was estimated from the life span (T_{max}) according to Sekharan (1974), the total mortality coefficient (Z) by Beverton and Holt (1956) method, the gear selection factor by the catch curve method (Pauly, 1984) and the yield per recruitment by the method of Beverton and Holt (1957) simplified by Ricker (1958). The optimum

age of exploitation and potential yield per recruit were estimated as per Krishnan Kutty and Qasim (1968).

to higher effort expended (Table 1). The effort expended being not commensurate with better abundance of this species in most of the months

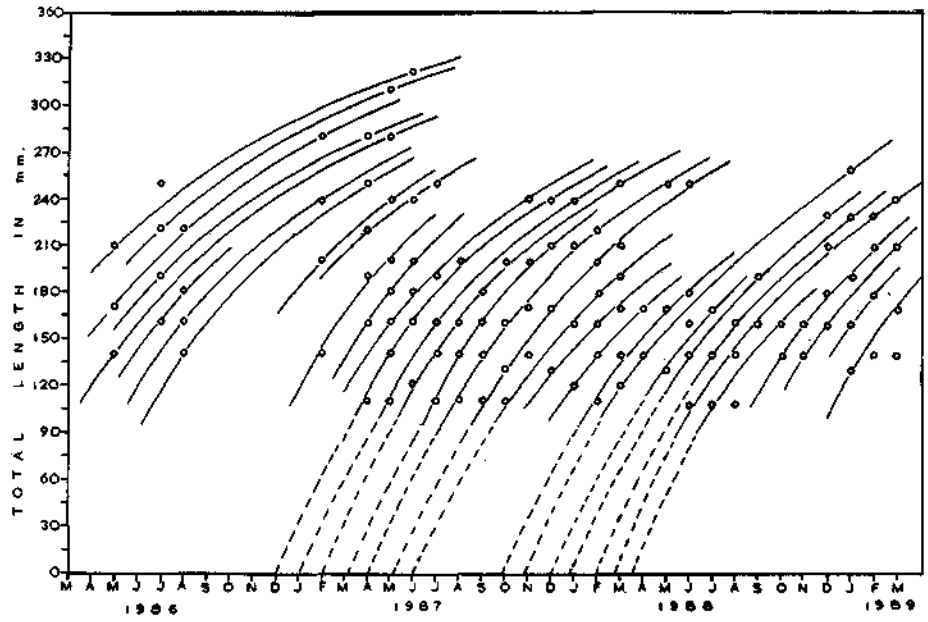

Fig. 1. Tracing the progression of different modes in relation to time and back tracing (broken lines) to find out the time of origin of different broods in *N. delagoae* as per the integrated method (Pauly, 1980).

FISHERY

Annual landing of threadfin-breams is estimated to be 158.15 t and 226.9 t in 1987 and 1988 by trawlers and the annual catch rate was 6.31 kg and 10.13 kg per unit respectively (Table 1). On an average the threadfin-breams constituted 3.6% of the total catch by trawl net in a year. As indicated by the monthly catch rate, the abundance of threadfin-bream was good during January - March and August - December in both the years. However, the effort input decreased while the abundance increased during January - March 1987 registering a decline in the catch whereas during August - December 1987 the effort input increased from 1250 units to 3250 units when the abundance was also good which resulted in better landings during September - December. Almost similar trend was observed in 1988 also with an exception that the effort input did not coincide with better abundance during November and December 1988 whereas the catch was good during these two months due to better abundance. Though the catch rate was low (3.88 Kg/unit) in June 1988, the landing was good due during 1987 - '88 was mainly due to the reason that the trawl fishery is not aimed at exploiting *Nemipterus* alone, but some other resources also. Hence the deviation from the usual expolitation strategy *i.e.* when the abundance is more, effort is also increased to realise more catches.

BIOLOGY

Age and Growth : A sample of 4087 specimens of *Nemipterus delagoae* were measured from both trawl net and hook and line landings for length frequency studies in which 2296 were studied from trawl net landings during 1986 - 1988 and 1791 specimens from hook and line during 1987 - '88. Combined length frequency data base was used for age and growth studies as this resource is being exploited from the same ground by these two gears. The average size attained by *Nemipterus delagoae* in subsequent months, derived from Fig. 1 were plotted against respective month on an arthmatic graph and a curve was fitted through the plots by free hand as shown in Fig. 2. This curve may be considered as an empirical growth curve of this species.

As per this growth curve, this species attains 87, 155, 205, 241, 268.5, 291 and 309 mm in 0.25, 0.5, 0.75, 1.0, 1.25, 1.5 and 1.75 years respectively. Based on this growth data the growth parameters have been estimated to be $L\infty$ = 362 mm, K = 1.0586 (annual) and t_0 = -0.0087 yr by Alagaraja (1984) method.

According to von Bertlanffy growth equation, $1_t = 362\ (1\text{-}e^{-1.0586\ (t\ +\ 0.0087)})$, this species is estimated to grow 237.6, 318.8 and 347.0 mm in 1st, 2nd and 3rd year. The life span (T_{max}) of this may be 2.83 years as per the relation T_{max} = 3/K (Pauly, 1980). The fishery of *Nemipterus delagoae* is sustained by mostly one year old

TABLE 1. *Estimated fishing effort (units), catch (kg) and Catch per effort (kg) of* Nemipterus delagoae *by trawl nets at Tuticorin Fishing Harbour during 1987 and 1988*

	1987			1988		
	E	C	C/E	E	C	C/E
January	1430	7757	5.42	2250	18800	8.36
February	828	5302	6.40	1540	13970	9.07
March	754	6049	8.02	1620	22275	13.75
April	1820	6240	3.42	1456	9750	6.69
May	1690	8540	5.05	2262	9672	4.27
June	2252	2300	1.02	2600	10088	3.88
July	2530	4007	1.58	1950	17592	9.02
August	1250	7205	5.62	1820	28470	15.64
September	2470	28340	11.47	2236	33690	15.06
October	2700	28850	10.68	2522	31161	12.35
November	3000	19688	6.56	1612	16367	10.15
December	3250	34060	10.48	1134	15120	13.33
Total	23974	158158	-	23002	226955	-
Mean	1998	13180	6.31	1917	18913	10.13

TABLE 2. *Monthly percentage frequency of the intensity of feeding of* N. delagoae *caught by trawl nets and hooks and lines during 1987 and 1988*

	Gorged	Full	3/4 Full	½ Full	¼ Full	Little	Empty
January	10.27	10.27	12.50	6.25	13.39	6.25	41.07
February	-	18.60	10.53	25.09	15.27	2.63	27.90
March	12.70	14.29	22.22	28.97	9.13	-	12.70
April	11.44	16.67	5.56	2.94	2.94	46.08	14.38
May	33.34	22.92	6.25	6.25	25.00	6.25	-
June	-	38.89	-	27.78	5.56	5.56	22.22
July	-	24.09	10.00	15.00	4.55	5.00	41.36
August	19.30	29.89	2.18	6.52	10.87	-	31.25
September	31.25	39.59	8.34	8.34	12.50	-	-
October	10.53	42.11	10.53	26.32	10.53	-	-
November	6.25	6.25	18.75	25.00	12.50	18.75	12.50
December	-	6.25	-	12.50	12.50	12.50	56.25
Mean	11.26	22.49	8.91	15.91	11.23	8.59	21.64

individuals and to a limited extent by two year old individuals in trawl net and hooks and line.

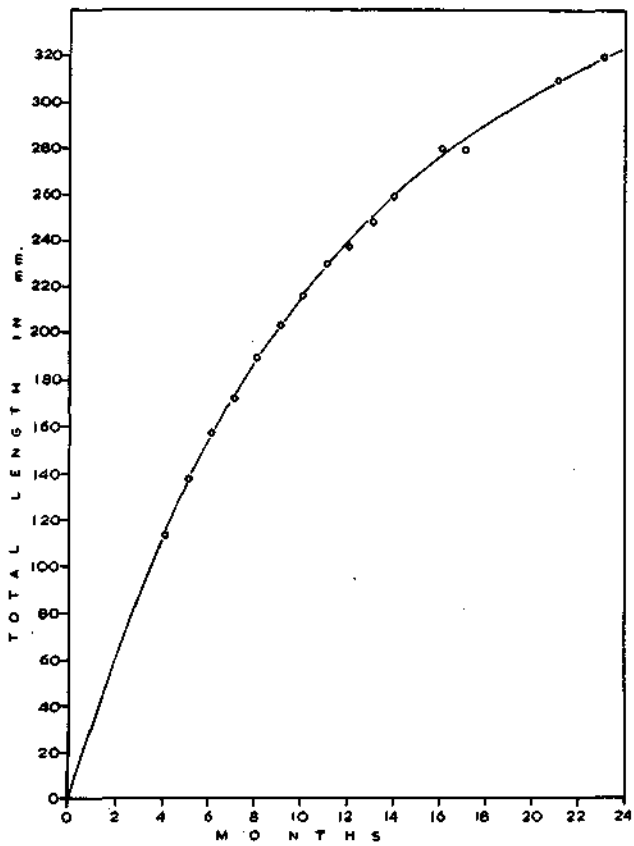

Fig. 2. Empirical growth curve of *N. delagoae* obtained by plotting the average size attained by this species against respective months.

Length - weight relationship : The sexwise length-weight relationship may be described by the equations :

Male : log W = -5.6909 + 3.3249 Log L (r = 9327) and

Female : Log W = -4.9269 + 2.9962 Log L (r = 0.9569)

However, the analysis of covariance carried out to test the difference in significance between the values of regression coefficient (b) for male and female has yielded an F ratio 2.54, f = 1.255 indicating that there is no significant difference in the length weight relationship between male and female. Therefore, a combined equation Log w = -5.0547 + 3.0508 Log L (r = 0.9088) is proposed to describe the length-weight relationship of *N. delagoae*. Muthiah and Krishna Pillai (1979) have also suggested a single equation to describe the length-weight relationship of this species from Bombay waters on the west coast as there was no significance in the length-weight relationship of male and female.

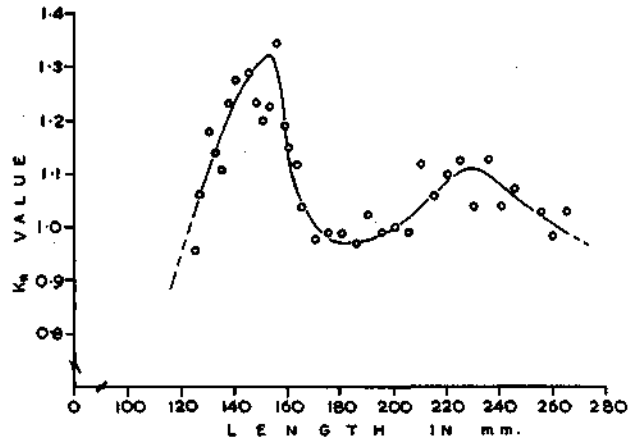

Fig. 3. Variation in the relative condition factor (K_n) in relation to different size ranges in *N. delagoae* in Tuticorin waters.

Feeding intensity : In all 273 stomachs of *N. delagoae* have been examined to study the food and feeding of this species. The intensity of feeding was determined for each fish based on the distension of its stomach and the amount of food contained in the stomach was classified by eye estimation as gorged, full, 3/4 full, 1/2 full, 1/4 full, little and empty (Pillay, 1952). The total and individual volume of different food and their number of occurrence were recorded qualitatively. The monthwise percentage frequency of the intensity of feeding (Table 2) indicates that this species appears to be an active feeder as the gorged, full and 3/4 full individuals constituted 11.26%, 22.49% and 8.91% respectively and fishes with empty stomach were only 21.64%. Further, it is observed that this species exhibits active feeding particularly during March - May and August - October (Table 2). There appears to be no relation between the intensity of feeding and size of the fish except that fishes with empty stomach were available in all sizes except in 250 - 269 mm, the gorged and full stomach fishes were observed from 140 - 249 mm and the gorged stomach in 260 - 269 mm also. In general the feeding intensity was observed to be better to some extent in higher size ranges. The average volume of stomach in various degrees of fullness varied between 4.11 ml in gorged, 1.52 ml in full, 1.06 ml in 3/4 full, 0.91 ml in 1/2 full, 0.55 ml in 1/4 full and 0.2 ml in little (Table 3).

Food composition : The qualitative analysis of food reveals that the diet of *N. delagoae* is constituted by prawns, crabs, fish, brittle stars, cuttlefish, bivalves, gastropods, *Squilla* spp., polychaetes, alphids, isopods and amphipods in which the first three items have been recorded to be the most dominant items constituting on an average 21.9%, 14.3% and 25.6% respectively and these 3 items occurred in all the months in the diet of this species (Table 4). The occurrence of brittle star was observed in all the months except in January, July, August and December and of cuttlefish also in all the months except in January, May and October - December. The rest of the items have occurred higly irregular manner (Table 4). The percentage occurrence of different food items in the stomachs of different size ranges of *N. delagoae* indicates that the bivalves, gastropods, *Squilla* spp., polychaetes, alphids, isopods and amphipods occurred mostly in lower size ranges from 130 - 199 mm whereas the other items occurred in almost all the size ranges and perhaps more in the higher size ranges.

Index of preponderance : The degree of preference of different food items by *N. delagoae* has been studied by estimating the 'index of preponderance' as per the method of Natarajan and Jhingran (1961). It is clearly discernible from the index of preponderance that the order of preference of different food items by *N. delagoae* is fishes such as *Stolephorus* spp., *Leiognathus* spp., young ones of different perches and clupeids (37.02), prawns constituted by *Metapenaeus* spp., *Penaeus indicus*, etc. (30.8), juvenile crabs of *Charybdis, Portunus pelagicus* and spider crab (15.4), brittle star mostly Amphiurids (10.4), cuttlefish *i.e. Sepia* spp. (1.03), followed by *Squilla* spp. (0.5), gastropods and bivalves (0.3), amphipods (0.03), isopods (0.02), alphids (0.02) and polychaetes (0.01). Animal flesh (2.9) and partially or fully digested matter (1.7) which could not be related to any of the above said food items were also present.

Stages of maturity : Immature specimens belonging stage I occurred throughout the year

TABLE 3. *Percentage frequency occurrence of stomachs in various degrees of fullness and the average volume of food per fish of different size ranges in* N. delagoae *caught by trawl nets and hooks and lines during 1987 and 1988*

Size group (TL/mm)	Number of stomachs observed in degrees of fullness						
	Gorged	Full	3/4 Full	½ Full	¼ Full	Little	Empty
120 - 129	-	-	-	-	-	50.00	50.00
130 -	-	-	18.18	27.27	9.10	18.18	27.27
140 -	5.88	23.53	11.76	23.53	5.88	11.76	17.65
150 -	10.71	25.00	10.71	28.57	10.71	7.14	7.14
160 -	5.56	30.56	8.33	11.11	11.11	16.67	16.67
170 -	5.88	20.59	11.76	17.56	11.76	8.82	23.53
180 -	4.76	38.10	11.90	14.29	14.29	-	16.67
190 -	18.42	15.79	7.89	10.53	10.53	15.79	21.05
200 -	13.33	13.33	20.00	20.00	13.33	-	20.00
210 -	8.33	33.33	-	8.33	8.33	-	41.67
220 -	33.33	13.33	-	20.00	6.67	-	26.67
230 -	12.50	37.50	12.50	-	25.00	-	12.50
240 -	36.36	27.27	-	-	-	18.18	18.18
250 -	-	-	-	100.00	-	-	-
260 - 269	50.00	-	-	-	50.00	-	-
Mean	13.67	18.56	7.54	18.75	11.78	9.77	19.93
Average volume of food per fish in ml	4.11	1.52	1.06	0.91	0.55	0.20	0.00

in highest percentage followed by stage II specimens in almost all the months except in January. Females with developing ovaries (stage III) occurred during January - April and July-October and females with developed ovaries (stage IV) were observed in March - April and also during July - August. Specimens with ripening ovaries (stage V) occurred in February, March and July and females with fully ripened ovaries (stage VI) were observed in February, August, October and December. There appears to be two spawning seasons in a year - the first one in July and August and the second one, may be a prolonged one from October to February (Table 5). This is being supported by the occurrence of young ones in the trawl net catches (Fig. 1).

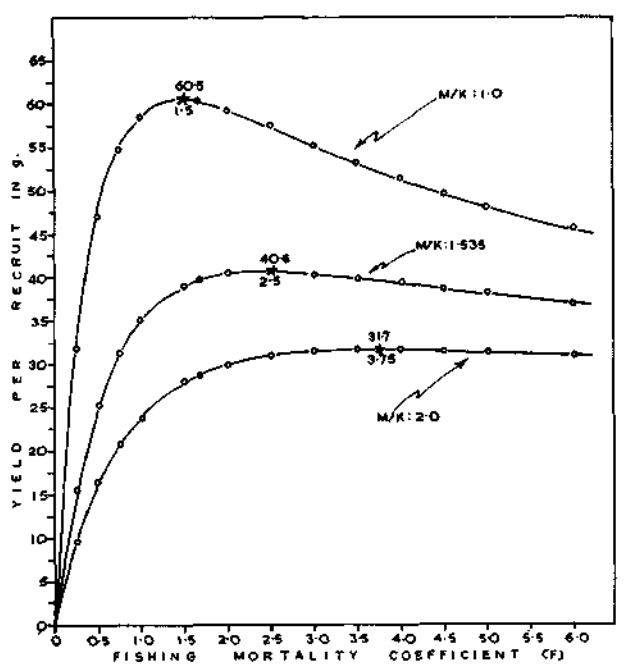

Fig. 4. Yield per recruitment (Y=W/R) in g of *N. delagoae* at different fishing mortality coefficients (F) for the prevailing age at first capture and for 3 different M/K ratios with their respective Y_{max} and F_{max}. The prevailing F is indicated by closed circles.

Size at first maturity : The occurrence of different stages of maturity in different size ranges (Table 6) reveals that the specimens measuring upto 140 mm were all immature and mature specimens were observed in size ranges above 150 mm suggesting that size at first maturity may be above this size. The relative condition factor (K_n) estimated from the relation

TABLE 4. *Monthly percentage occurrence of food components in* N. delagoae *caught by trawl nets, and hooks and lines during 1987 and 1988*

	Size Group (TL/mm)	No of fishes	Prawn and prawn append-ages	Crab and crab append-ages	Fish and fish remains	Brittle-star	Cuttle-fish	Molluscs (with shellbhits)	*Squilla* spp.	Poly-chaete	Alphid	Isopod	Amphi-pod	Animal flesh	Partly/ fully digested matter
January	134 - 245	23	21.67	26.05	28.56	-	-	4.41	-	-	0.44	0.88	-	0.88	17.11
February	140 - 240	34	40.53	18.80	12.67	0.79	8.06	4.07	3.23	-	-	0.33	-	8.26	3.10
March	150 - 256	23	28.03	34.40	5.39	4.17	7.92	6.03	-	-	-	-	-	10.53	3.54
April	140 - 228	26	20.31	6.79	38.00	3.66	3.57	-	-	-	-	-	-	3.57	24.11
May	153 - 265	14	58.33	9.81	15.49	1.77	-	0.59	10.33	0.30	-	-	-	3.39	-
June	129 - 210	18	33.64	10.71	34.14	13.93	0.71	-	-	-	-	0.43	-	-	6.43
July	135 - 217	21	4.17	5.00	41.67	-	32.50	-	-	-	-	-	-	16.67	-
August	142 - 232	31	25.55	37.43	23.95	-	8.92	-	-	-	-	-	-	-	4.17
September	135 - 265	32	2.86	5.00	39.79	22.40	1.88	5.84	0.21	1.67	-	-	-	10.17	10.21
October	155 - 199	19	16.05	13.84	22.11	4.74	-	5.63	4.21	1.32	0.53	0.26	-	18.68	12.63
November	138 - 204	16	2.14	20.93	17.14	8.57	-	2.86	2.50	-	4.28	-	4.21	7.86	29.50
December	128 - 216	16	20.41	8.16	35.71	-	-	-	-	-	-	-	-	23.47	12.24

$K_n = w/\hat{w}$ where W is the observed weight and $\hat{W}$ is the calculated weight of a specimen

a highly pronounced first one around 150 mm and another near 230 mm. The initial peak may

TABLE 5. *Percentage frequency distribution of maturity stages in* N. delagoae *landed at Tuticorin by trawl nets, and hooks and lines during 1987 and 1988*

	No. of fishes examined	Maturity Stages (Females)					
		I	II	III	IV	V	VI
January	21	52.4	-	47.6	-	-	-
February	34	41.2	23.5	23.5	-	5.9	5.9
March	22	36.4	31.8	13.6	9.1	9.1	-
April	23	65.2	17.4	13.0	4.4	-	-
May	9	77.8	22.2	-	-	-	-
June	17	47.1	52.9	-	-	-	-
July	13	46.2	30.8	7.7	7.7	7.7	-
August	28	42.9	28.6	17.9	3.6	-	7.1
September	28	50.0	42.9	7.1	-	-	-
October	17	52.9	35.3	5.9	-	-	11.8
November	4	50.0	50.0	-	-	-	-
December	11	18.2	63.6	-	-	-	18.2

TABLE 6. *Percentage frequency distribution of maturity stages in different size groups in* N. delagoae *landed at Tuticorin by trawl nets, and hooks and lines during 1987 and 1988*

Size range (TL/mm)	No. of fish examined	Maturity Stages (Females)					
		I	II	III	IV	V	VI
120 - 129	2	50.0	50.0	-	-	-	-
130 -	9	55.6	11.1	33.3	-	-	-
140 -	12	66.7	16.7	16.7	-	-	-
150 -	25	44.0	44.0	8.0	4.0	-	-
160 -	33	42.4	48.5	6.1	-	-	3.0
170 -	34	38.2	32.4	17.7	2.9	-	8.8
180 -	34	35.3	26.5	17.7	5.9	5.9	8.8
190 -	25	56.0	16.0	16.0	4.0	4.0	4.0
200 -	11	72.7	-	18.2	-	9.1	-
210 -	8	87.5	12.5	-	-	-	-
220 -	11	54.6	18.2	18.2	-	9.0	-
230 -	8	62.5	25.0	12.5	-	-	-
240 -	11	27.2	54.6	18.2	-	-	-
250 -	2	-	100.0	-	-	-	-
260 - 269	2	50.0	-	50.0	-	-	-
Total	227	108	68	33	5	5	8
%	-	47.6	30.0	14.5	2.2	2.2	3.5

measuring particular size, were plotted against respective sizes (Fig. 3) exhibits two peaks *i.e.* be taken as to reflect the attaining of maturity by this species for the first time. Further,

running specimens were observed to occur in the size range 160 - 169 mm onwards. Therefore the minimum size at first maturity may be around

F_{max} which can produce the highest yield (Y_{max}) are 1.5, 2.5 and 3.75 for M/K ratios 1.0, 1.535 and 2.0 respectively in which the F_{max} of the

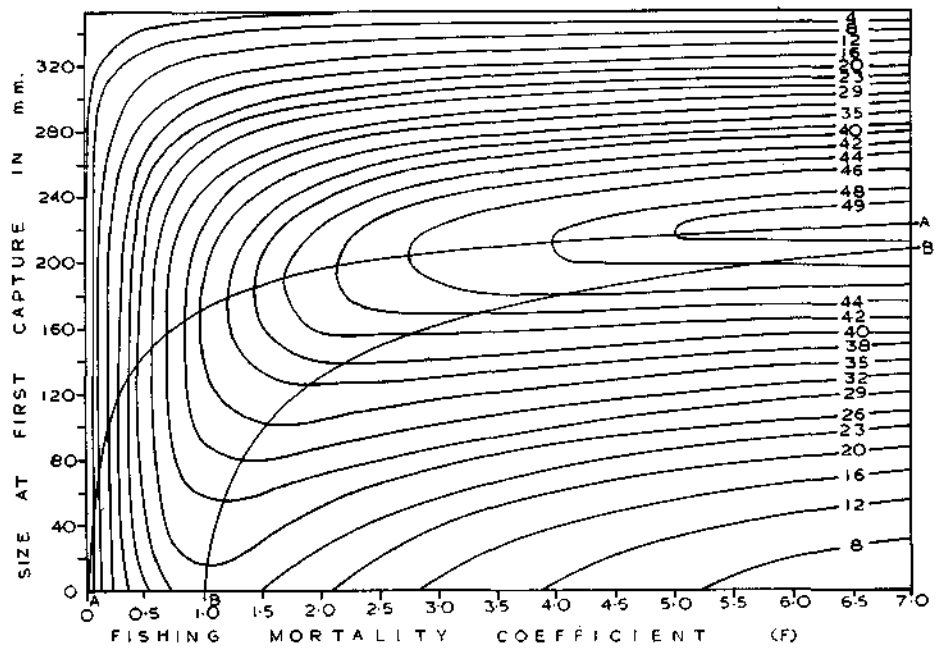

Fig. 5. Isopleth diagram of yield per recruit in g of *N. delagoae* population in Tuticorin waters. The eumetric fishing curve (line A - A), maximum sustainable yield curve (line B - B) and potential yield per recruit are indicated.

160 - 169 mm. Occurrence of two peaks at 150 mm and 230 mm in the K_n value indicates that this species may spawn twice in its life span.

Population Dynamics

Mortality rates : The natural mortality coefficient (M) is estimated to be 1.625 and the annual total mortality coefficient (Z) is 3.11 and 3.49 by trawl net in 1987 and 1988 respectively. The fishing mortality coefficient (F) is estimated to be 1.48 and 1.87 in 1987 and 1988 by trawl net. The annual average Z and F by trawl net is 3.29 and 1.665 respectively.

Exploitation rate : The exploitation rate (U) estimated from the relation $U=F/Z\ (1-e^{-z})$ is 0.46 and 0.52 in 1987 and 1988 by trawl net. The annual average exploitation rate by trawl net is 0.49.

Yield per recruitment : The yield per recruitment estimated for the prevailing average age at first capture (0.4687 yr) and M/K ratio 1.0, 1.535 and 2.0 (Fig. 4) indicate that the latter two M/K ratios are higher than the prevailing F by trawl net 1.665. This indicates a scope for further increase in the fishing effort by trawl net.

The yield isopleth drawn from the estimates of yield per recruitment by varying the age at first capture and fishing mortality coefficient for the prevailing M/K ratio 1.535 is given in Fig. 5 wherein the line A - A indicates the eumetric fishing curve and line B - B the maximum sustainable yield curve. The optimum age of exploitation is estimated to be 1.0251 yr and the potential yield per recruit 49.8 g which is indicated in the yield isopleth diagram where both the eumetric fishing curve and MSY curve tend to meet.

Stock Assessment : The annual standing stock is estimated to be 343.9 and 436.5 t in 1987 and 1988 in the trawling grounds off Tuticorin and the average is 390.2 t. The average standing stock is estimated to be 106.9 and 121.4 t in 1987 and 1988 and the average is 114.2 t.

Maximum sustainable yield (MSY) : This can be estimated from the relation MSY = M x 0.5 x B, where M is the natural mortality coefficient and B is the annual standing stock. The average MSY is estimated to be 317.0 t.

DISCUSSION

Among threadfin-breams, the growth of *N. delagoae* is estimated to be faster than the growth of *N. japonicus* (Krishnamoorthi, 1971; Murty, 1984; Kasim *et al.*, 1989). The K value obtained for *N. delagoae* is 1.0586 whereas Krishnamoorthi (1971) has reported a K value of 0.2941 to 0.648 for *N. japonicus* from Andhra Coast, Murty's (1984) estimate was 0.75142 from Kakinada waters and Kasim *et al.* (1989) have estimated the K to be 0.8606 for *N. japonicus*. Owing to its ability to grow faster than *N. japonicus*, this species attains 237.6, 318.8 and 347.0 mm in 1st, 2nd and 3rd year respectively. The food and feeding studies reveal that this species is a voracious carnivore and it actively feeds on fishes, crustaceans, molluscs and echinoderms unlike *N. japonicus* which feeds mainly on crustaceans, molluscs, annelids and echinoderms (Krishnamoorthi, 1971). There appears to be similarity in maturity and spawning of this species and *N. japonicus* as the minimum size at maturity is around 160 - 169 mm for both species and this species also spawns for the second time when it attains 230 mm as in the case of *N. japonicus* (Krishnamoorthi, 1971). However, there appears to be two spawning seasons, the first one in July and August and the second, a prolonged one from October to February.

The exploitation rates generated by trawl net are lower than the optimum exploitation rate and it roughly indicates that *N. delagoae* is under exploited. The yield per recruitment in weight also shows that the F_{max} which can generate the highest yield (Y_{max}) is higher than the present F for the prevailing M/K ratio 1.535 and above, indicating that there is scope for further increase in the effort of trawl net which can enhance the production of *N. delagoae*. The age at first capture by trawl net is 0.4687 per year which is lower than the optimum age of exploitation *i.e.* 1.0251 yr and even at this prevailing low age at first capture *N. delagoae* is exposed to low fishing pressure. Similar state of under exploitation has been reported for *N. japonicus* by Krishnamoorthi, (1976), Murty (1983) and Kasim *et al.* (1989) suggesting that, in general, there is scope for increasing the production of threadfin-breams by increased effort input.

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