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ESTIMATES OF GROWTH, MORTALITY, RECRUITMENT PATTERN AND MSY OF IMPORTANT RESOURCES FROM THE MAHARASHTRA COAST

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ABSTRACT

Based on the data collected from the year 1987 - 1991 the growth, mortality and recruitment pattern of eighteen species of fish, two species of cephalopods and four species of penaeid prawns have been presented in the present communication. The total mortality coefficient, (Z) varied from lowest of 1.20 for *O.cuvieri* to a highest of 10.78 for *P.stylifera*. The natural mortality coefficient, (M) varied from 0.52 for *T. thalassinus* to 3.44 for *S.crassicornis*.

The average annual yield of eighteen species of fish, four species of prawns and two species of cephalopods are 65,083, 38,404 and 11,373 tons as against the MSY of 83,023, 72,460 and 10,475 tons respectively. The MSY estimated for the total fish stock is 1,77,753t where as the present yield is 1,14,859t. This indicates that higher yield can be obtained by increasing the effort.

INTRODUCTION

The state of Maharashtra with a coastline of 720 km. and continental shelf of 89,096 sq.km. has rich potential for marine fisheries. The areas of potential fishing grounds in 0 to 50 m and 50-200 m depths are 2.55 and 10.48 million hectares respectively (Srinath *et al.,* 1987). It contributes about 16% of the total marine fish landings of India. The fishing and allied activities are very well developed in the state in general and Bombay in particular. The process of mechanization of fishing craft began in the early sixties and continued on increasing till mid eighties. The increase in the mechanization of the fishing fleet has however, slowed down. The number of units operating now at new Ferry Wharf and Sassoon Docks centres are about 600 and 450 respectively. The description of the craft, gear and area of operation of this fishing fleet has been described by Chakraborty *et al.* (1983). But the depth of operation of the commercial trawlers have increased from 40 to 70 m and the duration of fishing has also gone up from 3-4 days to 5-6 days.

In the present communication the length frequency data collected on various fish, penaeid prawns and cephalopods were used for growth, mortality, recruitment and estimation of maximum sustainable yield. The data cover fourteen genera of fish which includes eighteen species, two genera of cephalopods with as many species and three genera of prawns covering four species. The length frequency data of two species of perches *(Epinephelus diacanthus and Priacanthus hamrur)* and one species of sciaenid *(Pennahia macrophthalmus)* have been collected from Sassoon Docks as these three species are not represented in adequate quantities at New Ferry Wharf. Though, *Harpodon nehereus* and *Coilia dussumieri* are landed in appreciable quantity by trawlers, the major gear for these resources is "dol" net which is operated mainly in the inshore waters. Therefore, the length frequency data for these two species were collected from Satpati, one of the major "dol" net centre in Maharashtra. For rest of the species the data were collected from New Ferry Wharf.

The growth and mortality parameters form the basis in the stock assessment and formulating the management strategy of the resources. Although, information on these parameters of some of the species are available from Bombay waters, they are few and scattered. This is an attempt to bring out as much information in one place for better understanding of multispecies fishery in the region.

MATERIAL AND METHODS

Weekly length frequencies on various species were collected at the landing centres. In the present communication data collected for the years 1987-1991 have been used. The length frequencies were grouped in different length classes depending on the largest size recorded and this was raised for the day and subsequently for the month using the method of Sekharan (1962). The von Bertalanffy's (1938) growth parameters, the asymptotic length ($L\infty$) and growth cofficient (K) were estimated using ELEFAN programme developed by Gayanilo *et al.* (1988). The von Bertalanffy's equation is as follows.

$$Lt = L\infty - \{1-e^{-K(t-to)}\}$$

This programme does not produce an estimate of t_o.

The total mortality coefficient (Z) has been estimated by length-converted catch curve method of Pauly (1982) and the natural mortality coefficient was estimated mainly by Pauly's (1980) emperical formula which is as follows.

$$\text{Log } M = -0.0066+0.279*\text{Log } L\infty + 0.6543 \text{ Log } K+0.4634* \text{ Log } T$$

where $L\infty$ is in cm and temperature is in degree centigrade. The mean environmental temperature of 27.2°C was taken from Bapat *et al.* (1982). The recruitment pattern was worked out to assess the seasonality of recruitment of the stock investigated.

Fishing mortality coefficient `F" was computed by subtracting (M) from (Z) and the exploitation ratio was derived from the relation.

$$E = F/Z$$

The maximum sustainable yield (MSY) was estimated by Corten's (1974) formula and the calculations were done on a PC using ELEFAN II programme.

The summary of various parameters on growth, mortality and recruitment pattern obtained for all the species are given in Table 1 and the estimates of MSY, standing stock and annual and average yield for 1987-1991 period in Table 2.

RESULTS AND DISCUSSION

The total mortality coefficient (Z) varied from lowest of 1.20 for *O.cuvieri* (Fig.3) to the highest of 5.0 for *O.militaris* (Fig.17) amongst fish, 2.09 to 3.0 for *S.aculeata* and *L.duvaucelii* (Figs.20 & 21) amongst cephalopods and 3.82 for *M. monoceros* (female) (Fig.24) to 10.78 for *P.stylifera* (Male) (Fig.23) among prawns. The natural mortality coefficent (M) ranged from 0.52 (*A.thalassinus*) (Fig.16) to 3.44 (*S.crassicornis*) female) (Fig.28).

Out of eighteen species of fish stocks studied, eleven are optimaly exploited and seven are under-exploited (Figs. 1-19) The penaeid prawns appeared to be under-exploited where as cephalopods are optimally exploited (Figs. 20-29).

Fourteen species of fish analysed show recruitment in two pulses while a couple of species indicated recruitment in single pulse while rest of the two species it could not be resolved (Figs.1-18). Both the species of cephalopods indicated recruitment in two pulses. Among the penaeid prawns *P.stylifera* showed recruitment in one pulse and *M.monoceros* shows recruitment in two pulses. The recruitment pattern could not be resolved for *M.affinis* and *S.crassicornis* female shows recruitment in two pulses and male in one pulse. (Fig. 28 & 29).

The gear used is shrimp trawl and the effort is mainly directed towards catching of prawns. But in the last four to five years cephalopods have also gained economic importance. Because of this, a part of the effort is also directed towards catching of cephalopod resources. Recently, ribbonfish, because of its newly acquired export value, is also caught in good quantity.

It is to be noted that all the species of fish and cephalopods are landed as by-catch of the shrimp trawl. The occurence of by-catch raises a number of biological, economical and social questions. It

Table 1 : *Growth and mortality parameters of the species studied*

Name	L_∞	K	Z	M	F	E
Scoliodon laticaudus (female)	726	0.48	3.00	0.90	2.10	0.70
Scoliodon laticaudus (male)	740	0.63	3.00	0.90	2.10	0.70
Otolithes cuvieri	398	0.52	1.20	0.86	0.34	0.28
Johnieops vogleri	345	0.72	3.20	1.10	2.10	0.65
Johnius macrorhynus	350	0.75	4.10	1.20	2.90	0.70
Johnieops sina	240	0.80	6.56	1.60	4.96	0.75
Pennahia macrophthalamus	245	0.64	2.00	1.30	0.70	0.35
Nemipterus japonicus	335	0.65	2.80	1.10	1.70	0.60
Nemipterus mesoprion	286	0.71	3.44	1.40	2.04	0.65
Epinephelus diacanthus	502	0.61	1.50	1.12	0.40	0.26
Priacanthus hamrur	345.5	0.66	2.50	1.10	1.40	0.56
Saurida tumbil	600	0.51	2.80	1.00	1.80	0.64
Saurida undosquamis	421	0.51	2.52	1.10	1.42	0.56
Harpodon nehereus	413	0.73	3.10	1.53	1.57	0.51
Tachysurus caelatus	521	0.68	3.50	1.10	2.40	0.68
Tachysurus thalassinus	850	0.28	1.50	0.52	0.97	0.65
Osteogeneiosus militaris	600	0.65	5.00	1.10	3.90	0.78
Coilia dussumieri	230	1.20	7.05	3.00	4.00	0.57
Trichiurus lepturus	1480	0.40	2.62	0.75	1.87	0.71
Loligo duvaucelii	343	0.49	2.09	1.10	0.99	0.47
Sepia aculeata	297	0.56	3.40	1.10	2.30	0.67
Parapenaeopsis stylifera (female)	140.8	2.15	7.60	3.60	4.00	0.53
Parapenaeopsis stylifera (male)	119.2	1.45	10.78	2.96	7.82	0.73
Metapenaeus monoceros (female)	219.2	1.40	3.82	2.40	1.42	0.37
Metapenaeus monoceros (male)	180.5	1.35	4.50	2.50	2.00	0.44
Metapenaeus affinis (female)	188.8	1.47	6.78	2.58	4.20	0.62
Metapenaeus affinis (male)	151.5	1.50	4.60	2.78	1.12	0.40
Solenocera crassicornis (female)	139	2.00	10.36	3.44	6.92	0.67
Solenocera crassicornis (male)	92	1.50	6.00	3.20	3.60	0.53

L_∞ is in mm and K is annual

Table 2 : *Yield and stock parameters of fish, cephalopods and prawns*

Name	Yield	Lc/L∞	M/K	E	Emax	F	Y/F	MSY
Scoliodon laticaudus (female)	2349	0.77	1.87	0.70	1.0	2.10	1119	3356
Scoliodon laticaudus (male)	2150	0.46	1.42	0.70	0.66	2.10	1024	2024
Otolithes cuvieri	6063	0.40	1.65	0.28	0.61	0.34	17832	13209
Johnieops vogleri	6126	0.40	1.52	0.65	0.67	2.10	2917	6314
Johnius macrorhynus	4958	0.45	1.60	0.70	0.66	2.90	1709	4674
Johnieops sina	2118	0.60	2.00	0.75	1.00	4.96	427	2824
Pennahia macrophthalamus	1038	0.44	2.03	0.35	0.70	0.70	1483	2076
Nemipterus japonicus	1242	0.48	1.69	0.60	0.71	1.70	731	1470
Nemipterus mesoprion	962	0.49	1.97	0.65	0.75	2.04	472	1110
Epinephelus diacanthus	280	0.46	1.83	0.26	0.71	0.40	701	761
Priacanthus hamrur	283	0.56	1.66	0.56	0.83	1.40	202	606
Saurida tumbil	3193	0.43	1.97	0.64	0.68	1.80	1774	3388
Saurida undosquamis	171	0.47	2.15	0.56	0.77	1.42	120	236
Harpodon nehereus	37270	0.40	2.09	0.51	0.65	1.57	23739	47650
Tachysurus caelatus	453	0.71	1.61	0.68	1.00	2.40	189	666
Tachysurus thalassinus	1990	0.28	2.16	0.65	0.52	0.97	2051	1588
Osteogeneiosus militaris	2948	0.53	1.69	0.78	0.79	3.90	2268	3004
Coilia dussumieri	4793	0.64	2.22	0.57	1.00	4.00	2397	8715
Trichiurus lepturus	23965	0.44	1.87	0.71	0.68	1.87	12815	22986
Loligo duvaucelii	6125	0.29	2.26	0.47	0.53	0.99	6187	6895
Sepia aculeata	5248	0.30	1.96	0.67	0.53	2.30	2281	4143
Parapenaeopsis stylifera (female)	12320	0.64	1.67	0.53	1.00	4.00	3080	23245
Parapenaeopsis stylifera (male)	5646	0.72	2.04	0.73	1.00	7.82	722	7734
Metapenaeus monoceros (female)	4563	0.59	1.71	0.37	1.00	1.42	3213	12332
Metapenaeus monoceros (male)	1709	0.61	1.85	0.44	0.91	2.00	855	3519
Metapenaeus affinis (female)	6227	0.72	1.75	0.62	1.00	4.20	1483	10044
Metapenaeus affinis (male)	2876	0.79	1.85	0.40	1.00	1.12	1580	7190
Solenocera crassicornis (female)	4401	0.68	1.72	0.67	1.00	6.92	636	6569
Solenocera crassicornis (male)	662	0.71	2.13	0.53	1.00	3.60	184	1249

Lc = Length at first capture, Emax = Maximum exploitation rate, Y/F = Standing stock.

is noteworthy that though by-catch forms quantitatively a large constituent, economically it does not fetch good value. But though not very remunerative, their value is not altogether negligible. The value of minor species can make all the differences between a profitable and nonprofitable trip (Gulland, 1983).

The groupwise distribution of catch shows that fish forms 56.77%, prawns 33.4% and cephalopods 9.9%. Out of eighteen species of fish stocks studied eleven are optimally exploited whereas seven species are underexploited. The notable underexploited resources are *O. cuvieri, P. macrophthalamus, E. diacanthus, P. hamrur, S. laticaudus* (female), *C.dussumieri and T.caelatus.* Both the species of cephalopods appear to be optimally exploited. The four species of prawns which together constitute 76.3% of the penaeid prawns in Maharashtra appear to be underexploited.

The standing stocks of eighteen species of fish is 78,420 t, of two species of cephalopods is 8,468t and four species of prawns is 11,753t.

The present average yield of eighteen species of fish is 65,082t whereas the MSY is 83,023t thus giving scope of increasing the catch by 27.57%. The present yield of four species of prawns is 38,404t whereas the MSY is 72,460t giving a scope for increasing the catch by 88.67%. The present average yield of cephalopod is 11,373t and the MSY is estimated at 10,475t. The estimated MSY of total fish stock is 1,77,785t whereas the present yield is 1,14,859t. Therefore, there is a scope to increase the total fish catch by 54.78%.

The "dol' net is an important gear operated in the northern part of Maharashtra. Bombay duck *Harpodon nehereus* is the target species of "dol" net and *Coilia dussumieri* is one of the by-catch. The average yield of the former species was 37,270t whereas the MSY was 47,650t. *C.dussumieri* the average yield was 4,793t whereas the MSY was 8,715t. This species appears to be under exploited. Bombay duck shows a wide year to year fluctuation in the catches (Table 2) with 18,565t in 1991 to 25,222t in 1989 and 48,000t in 1990. Srinath *et al.* (1987) observed that catches by the dolnetters did not respond positively to the effort expended and any change in the effort may not have any impact on the landings. Khan (1989) also observed that the dol net fishery is labour intesive, the effort is regulated depending on the catch per haul. Due to economic reasons the fishing is suspended when the CPUE is very low.

Gulland (1975) suggested that if the `E' value is more than 0.5, the stock understudy appears to be overexploited. In the present study we find that in most of the species of fish, prawns and cephalopods the `E' is more than 0.5. In spite of that these species do not show any sign of overexploitation like drastic decline in catch and catch rate.

It can thus be stated that perhaps the concept of Eopt of 0.5 may not hold true in the tropics. It is also observed that all the species studied have in general a small standing stock and the Lc/L_∞ ratio is also very high. It is noteworthy that a small standing stock is able to generated a higher yield in the north west coast of India (Table 2). The chief reasons may be attributed to

a. Faster rate of growth.

b. Abundance of food supply.

c. Less abundance of predators like "Ghol", "Koth", "Dara" and "Karkara" and

d. Majority of species have protracted spawning which results in recruitment through out the year.

Jones and Banerji (1973) estimated that the potential yield of Maharashtra waters as 2.62 lakh tonnes. George *et al.* (1978) estimated the potential yield of north west coast off India as 8.43 lakh tonnes based on the rate of production. Antony Raja (1974) gave an estimate of 3.53 lakh tonnes in which 2.7 lakh tonnes obtainable from the 0-50m depth zone. Kalawar (1978) and Srinath *et al.* (1987) arrived at potential yield of 3.74 lakh tonnes. They also observed that the relationship between catch and efforts by trawlers was $C = 0.651f^{1.004}(r^2=0.9)$ and suggested that additional 60,000 tonnes of trawl catch are expected by increasing 40% of efforts at 1984 level. It was further suggested that the increase could be made in a phased manner. There were 1792 trawlers in operation in Maharashtra in1984 since then the numbers of tawlers have increased to 2118 in 1992-1993. Despite this increase in the number of trawlers in Maharashtra in the last eight years there is no decline in the total fish landings.

The present Lc/L_∞ for all the species taken together is 0.53 and the estimated exploitation ratio is 0.53 whereas using the relative yield per recruit model (Fig. 30) the estimated E max is 0.83 at which the projected yield (MSY) would be 1,77,785t. The present avrage yield is 1,14,859 (combined catch of all the species). The study indicates that at present none of the species studied is over exploited. Most of them are either optimally exploited or underexploited. The study thus indicates that the present fishing fleet could be safely be increased to 25% without having any adverse effect in the fishery.

This document would be useful to fishery biologists and management people in fishery and related industries as it covers the age, growth, mortality, recruitment pattern and MSY of most of the commercially important fish, cephalopods and prawns.

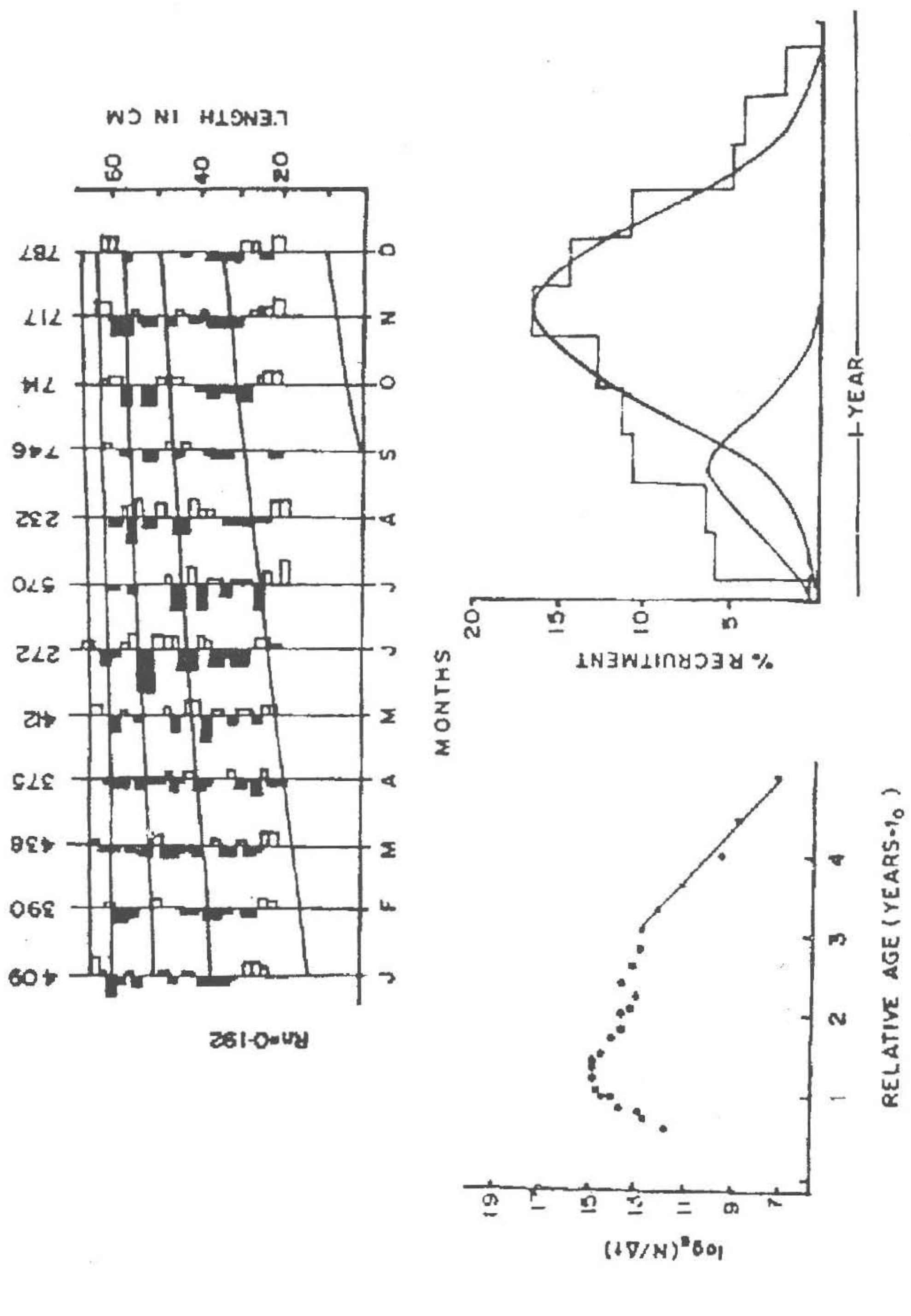

Fig. 1 : *Scoliodon laticaudus (Female) L∞=726mm, K=0.48, Z=3.0, Annual recruitment occured in two pulses.*

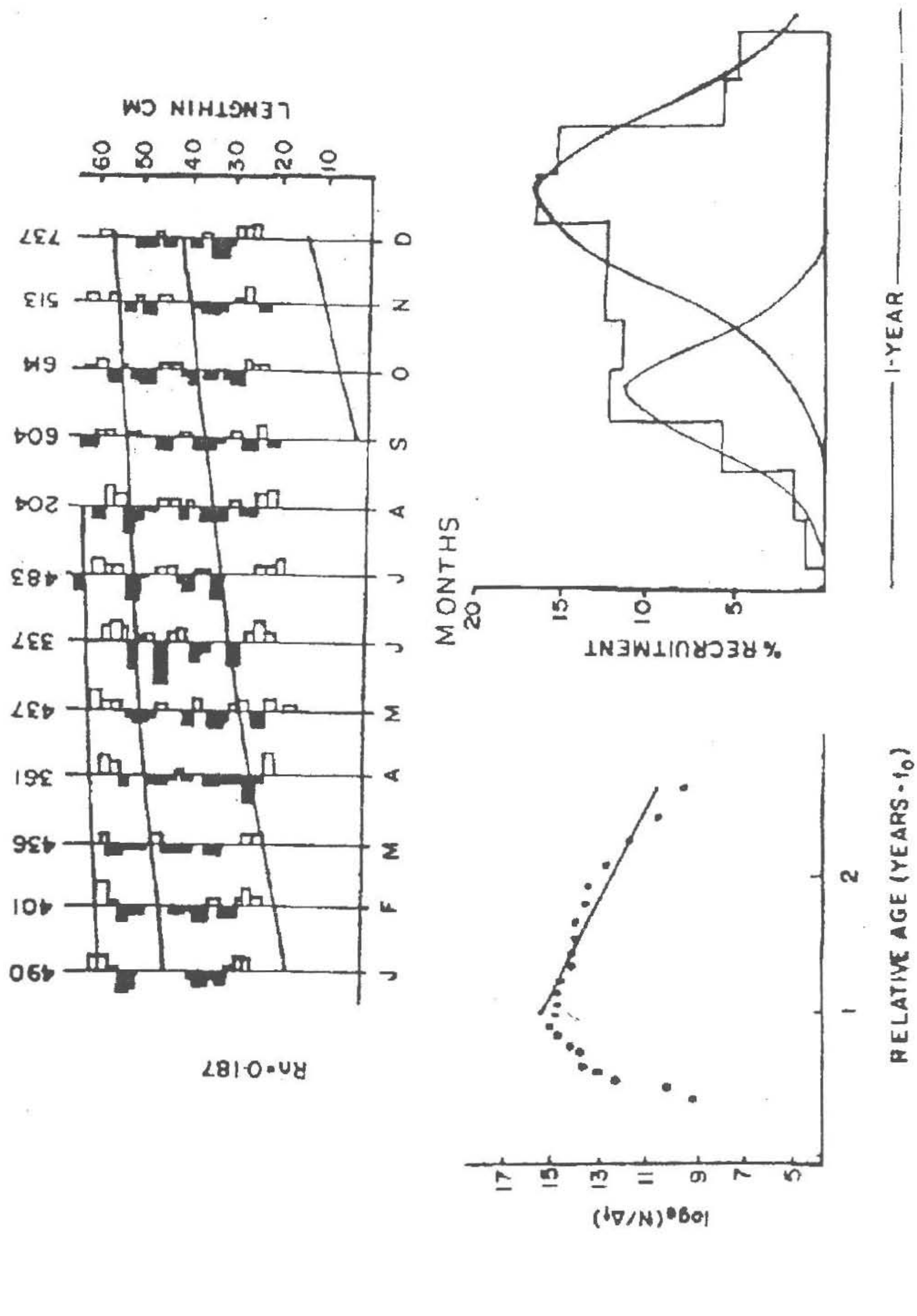

Fig. 2 : *Scoliodon laticaudus (Male) L∞=470mm, K=0.63, Z=3.0, Annual recruitment occured in two pulses.*

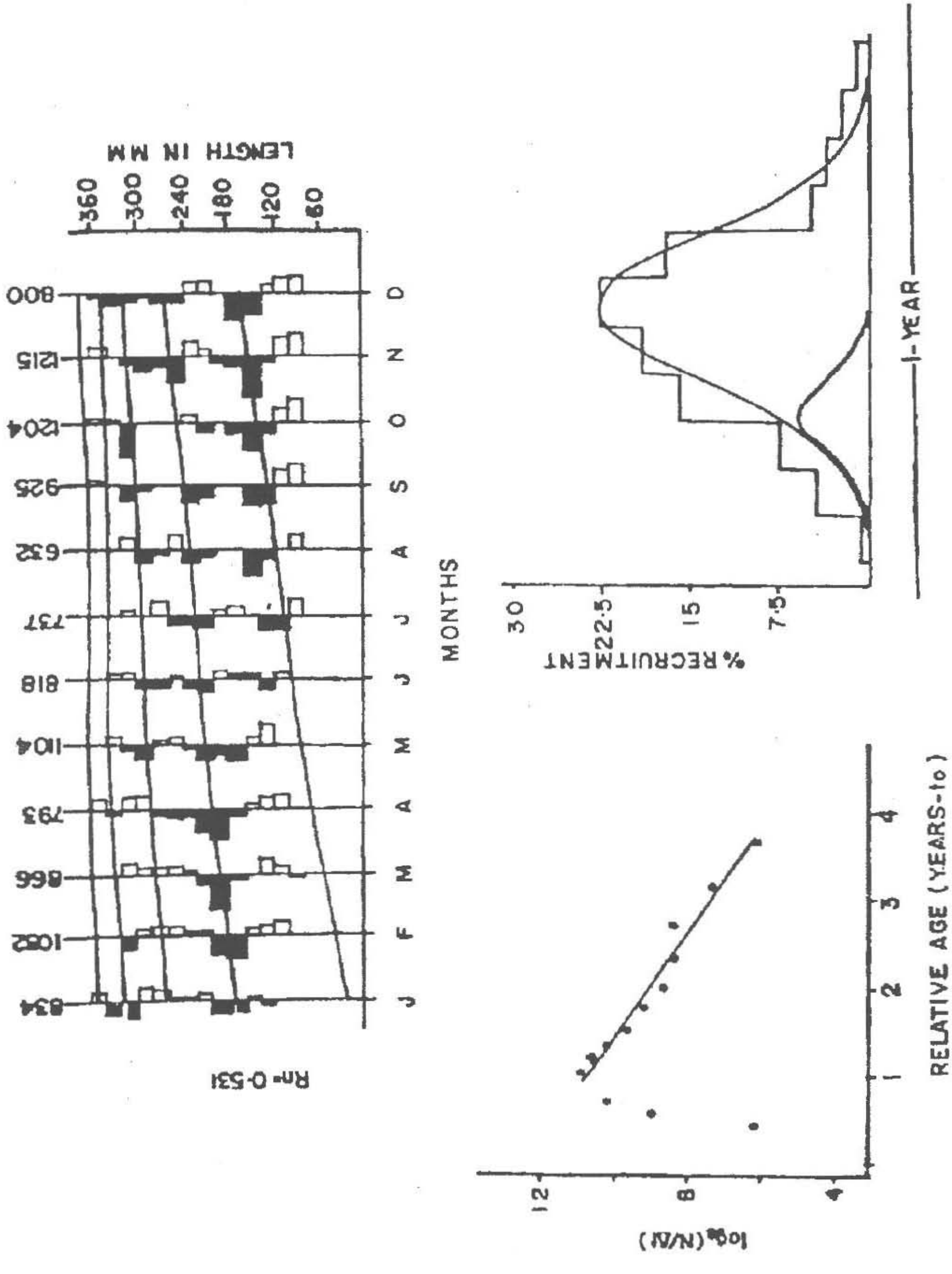

Fig. 3 : *Otolithes cuvieri L∞=398mm, K=0.52, Z=1.2, Annual recruitment in two pulses.*

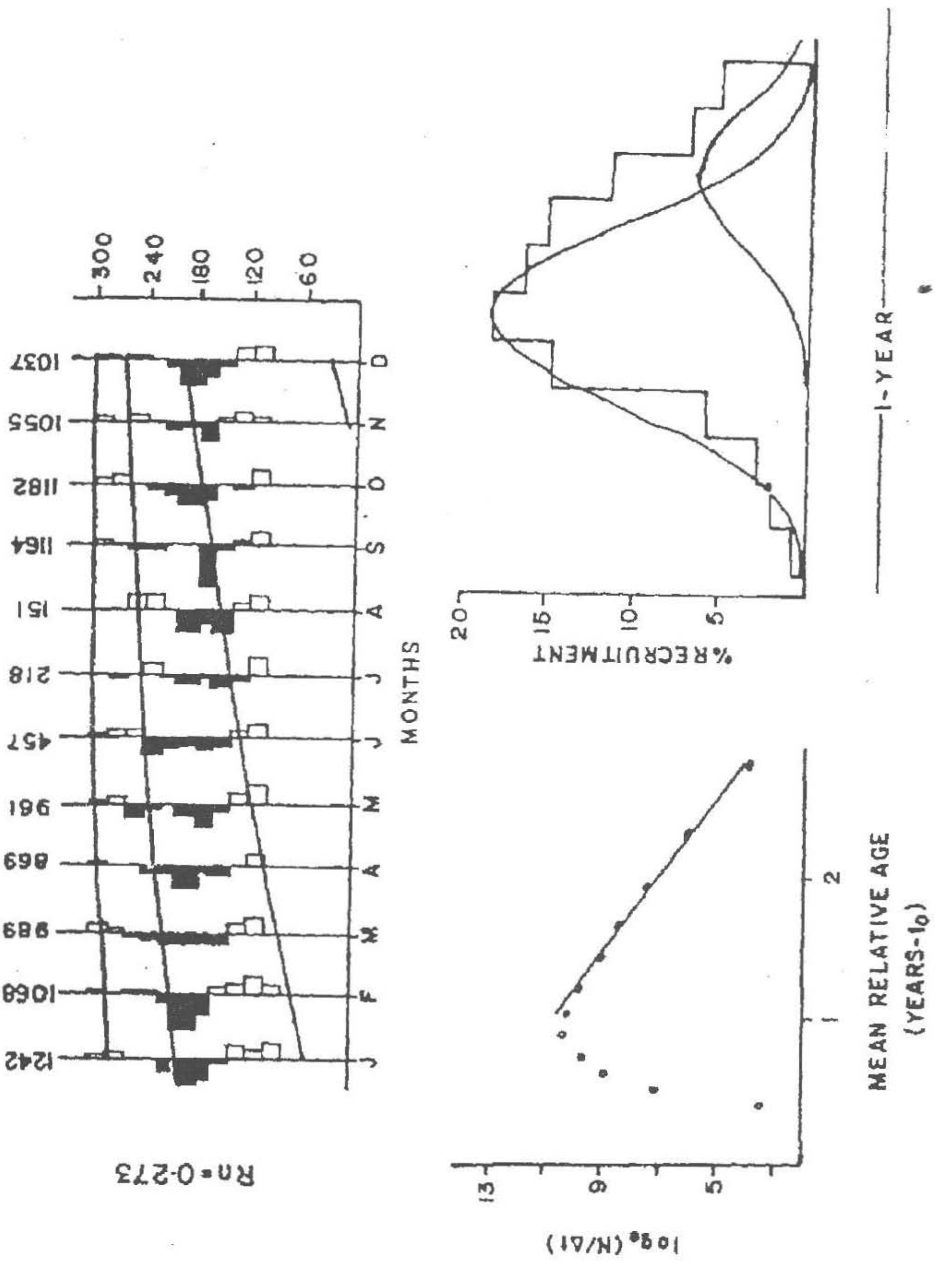

Fig. 4 : *Johnieops vogleri* $L\infty$=345mm, K=0.72, Z=3.2, Annual recruitment in two pulses.

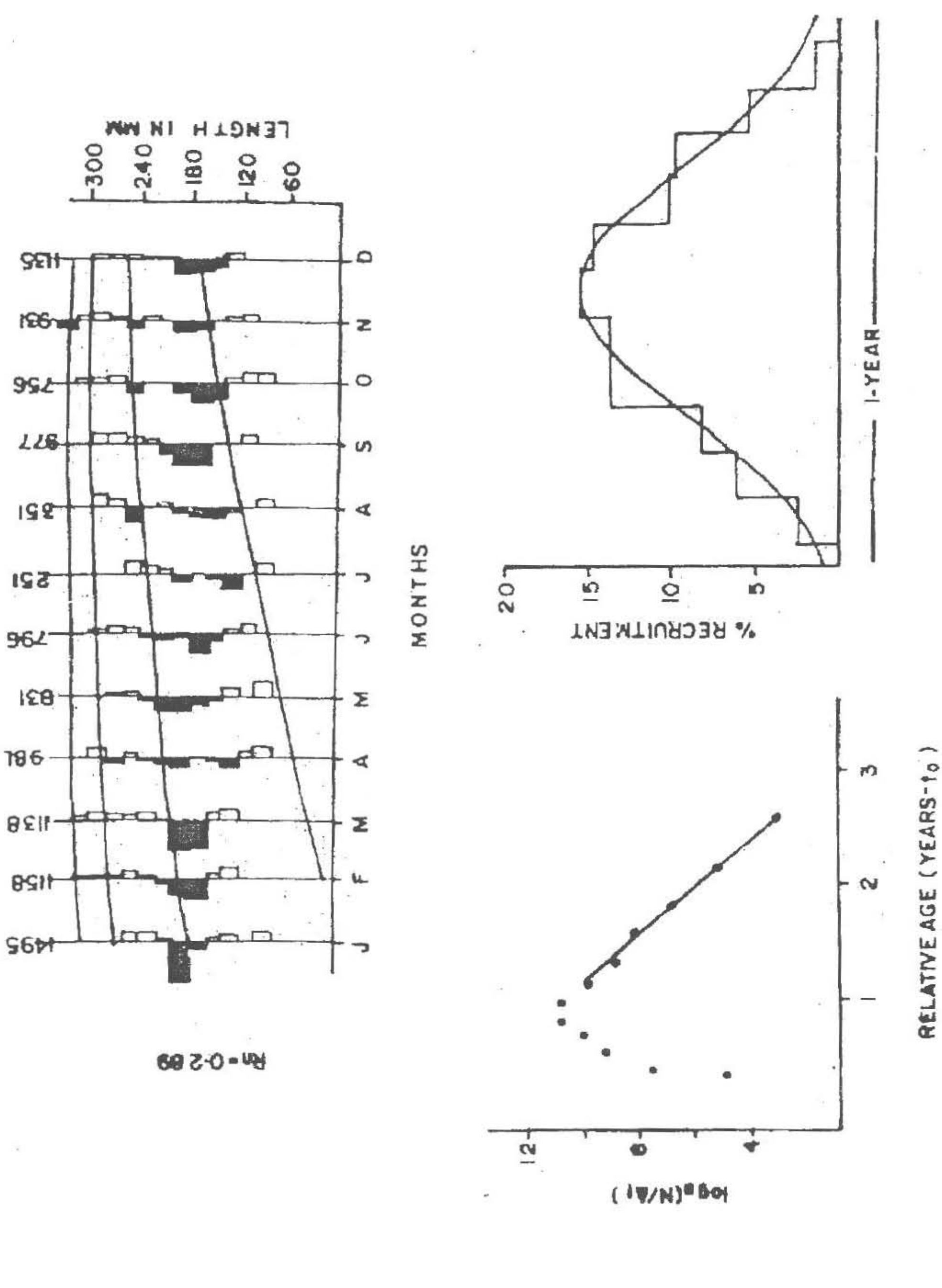

Fig. 5 : *Johnius macrorhynus* $L\infty$=350*mm*, *K*=0.75, *Z*=4.1, *Annual recruitment in one pulse.*

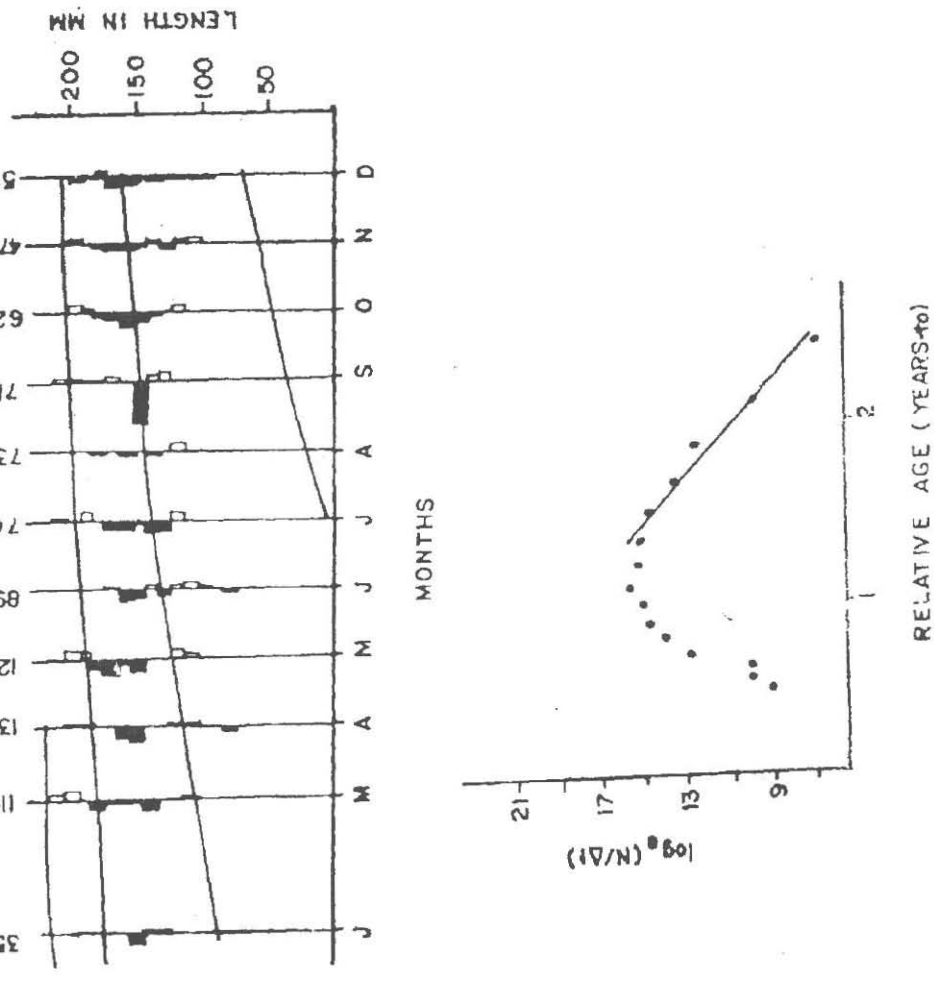

Fig. 6 : *Johnieops sina L∞=240mm, K=0.8, Z=6.56. The recruitment pattern could not be resolved.*

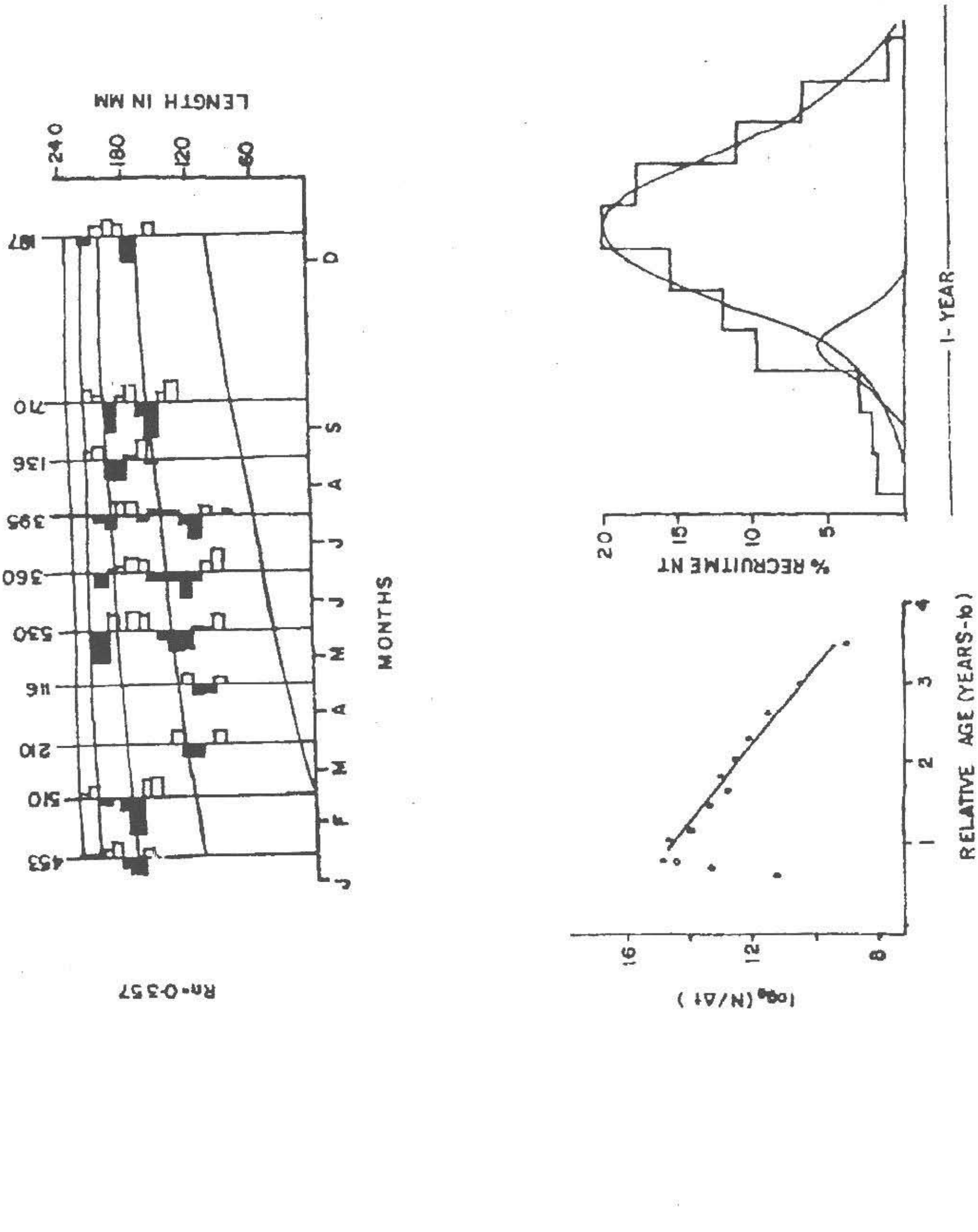

Fig. 7 : *Pennahia macrophthalamus* $L\infty$=245mm, K=0.64, Z=2.0. The recruitment in two pulses.

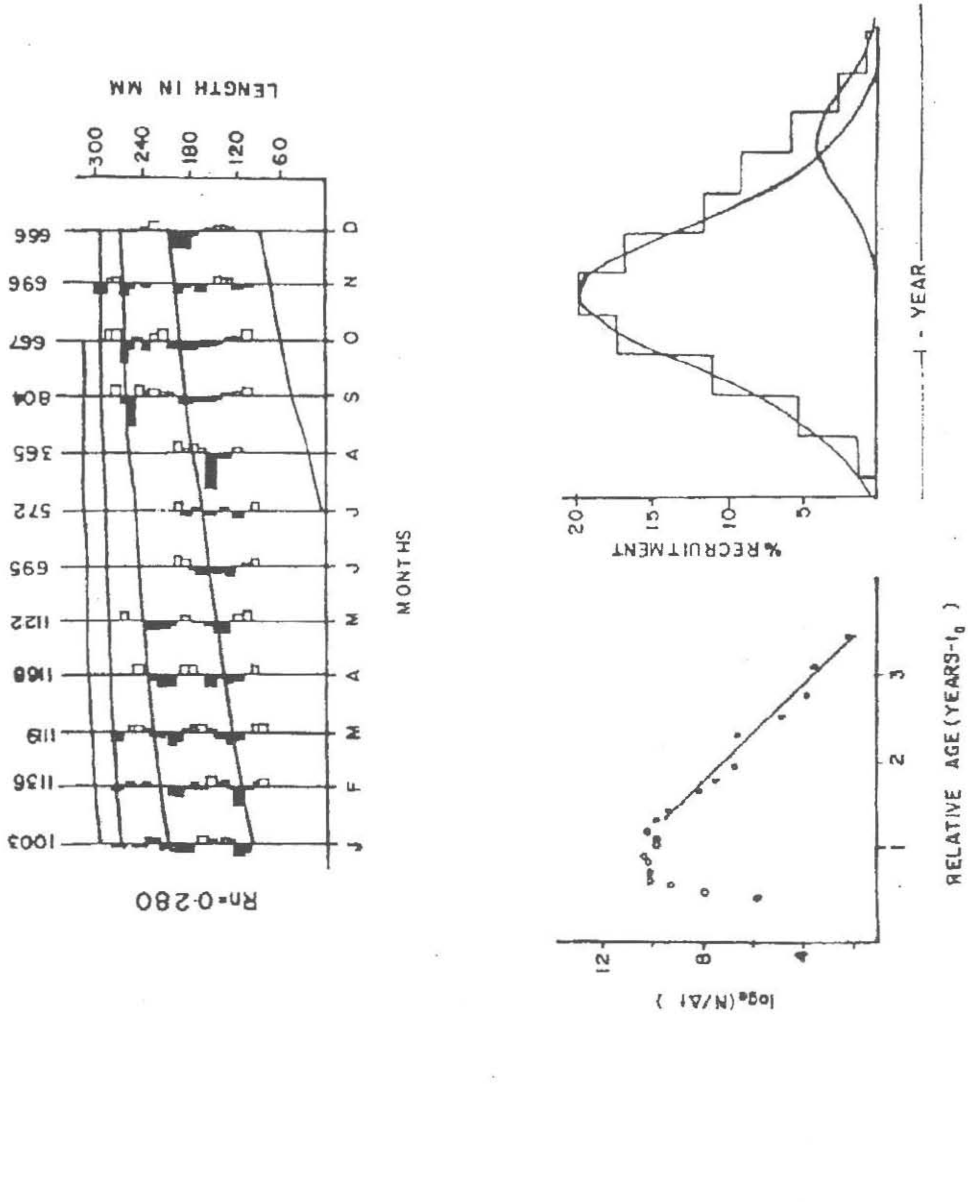

Fig. 8 : *Nemipterus japonicus* $L\infty=335mm$, $K=0.65$, $Z=2.8$. *Recruitment in two pulses.*

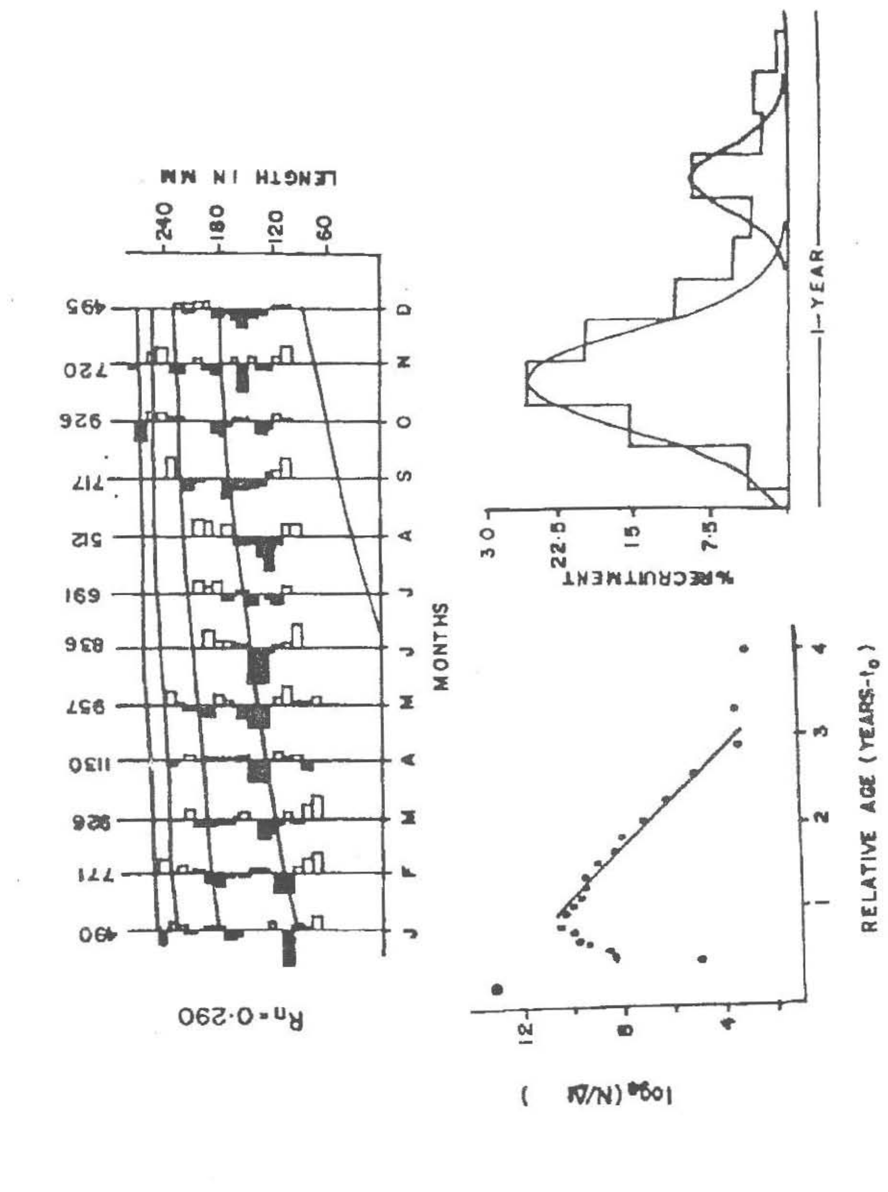

Fig. 9 : *Nemipterus mesoprion* $L\infty$*=286mm, K=0.71, Z=3.44. Recruitment in two pulses.*

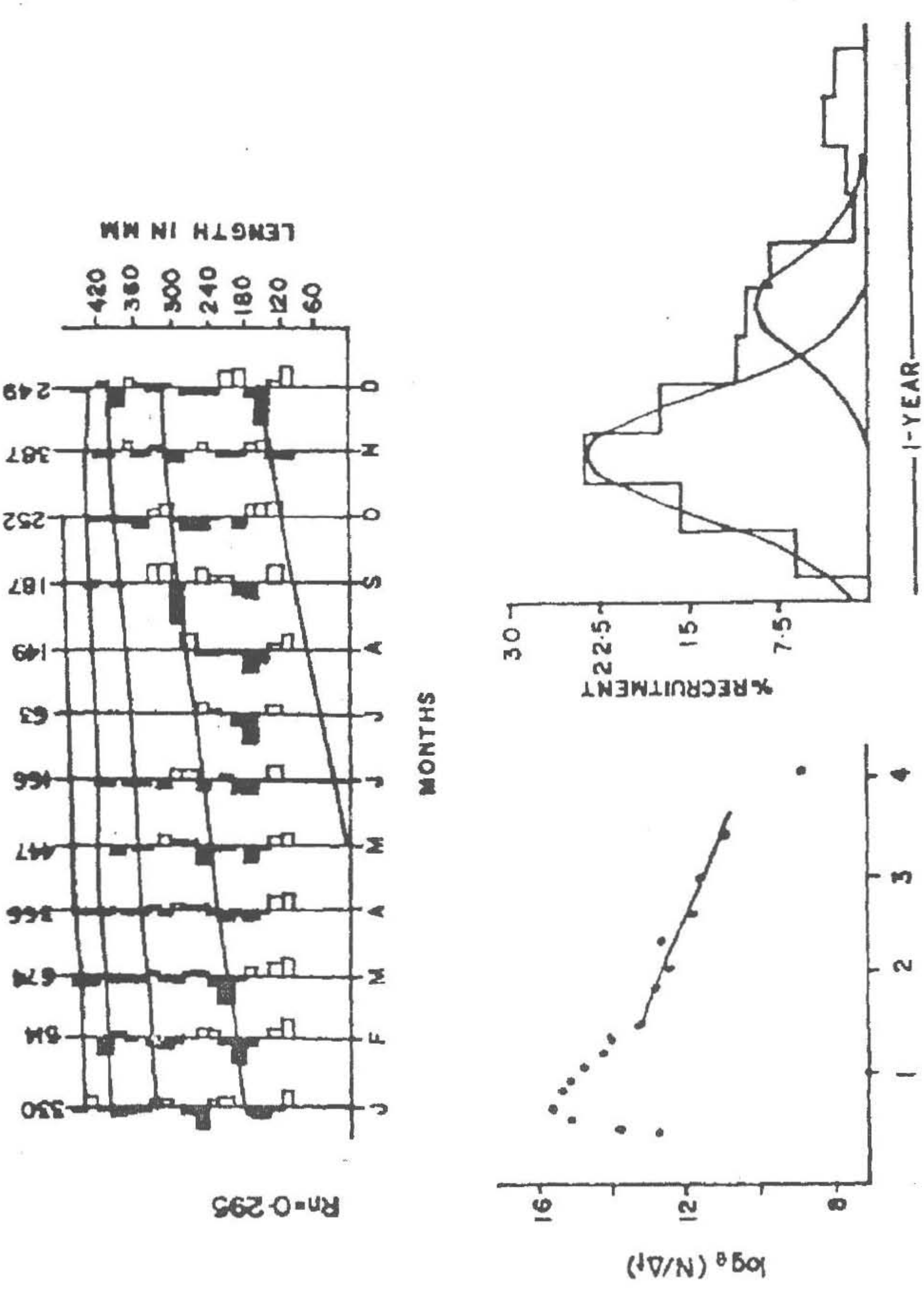

Fig. 10 : *Epinephelus diacanthus L∞=502mm, K=0.61, Z=1.5. Recruitment in two pulses.*

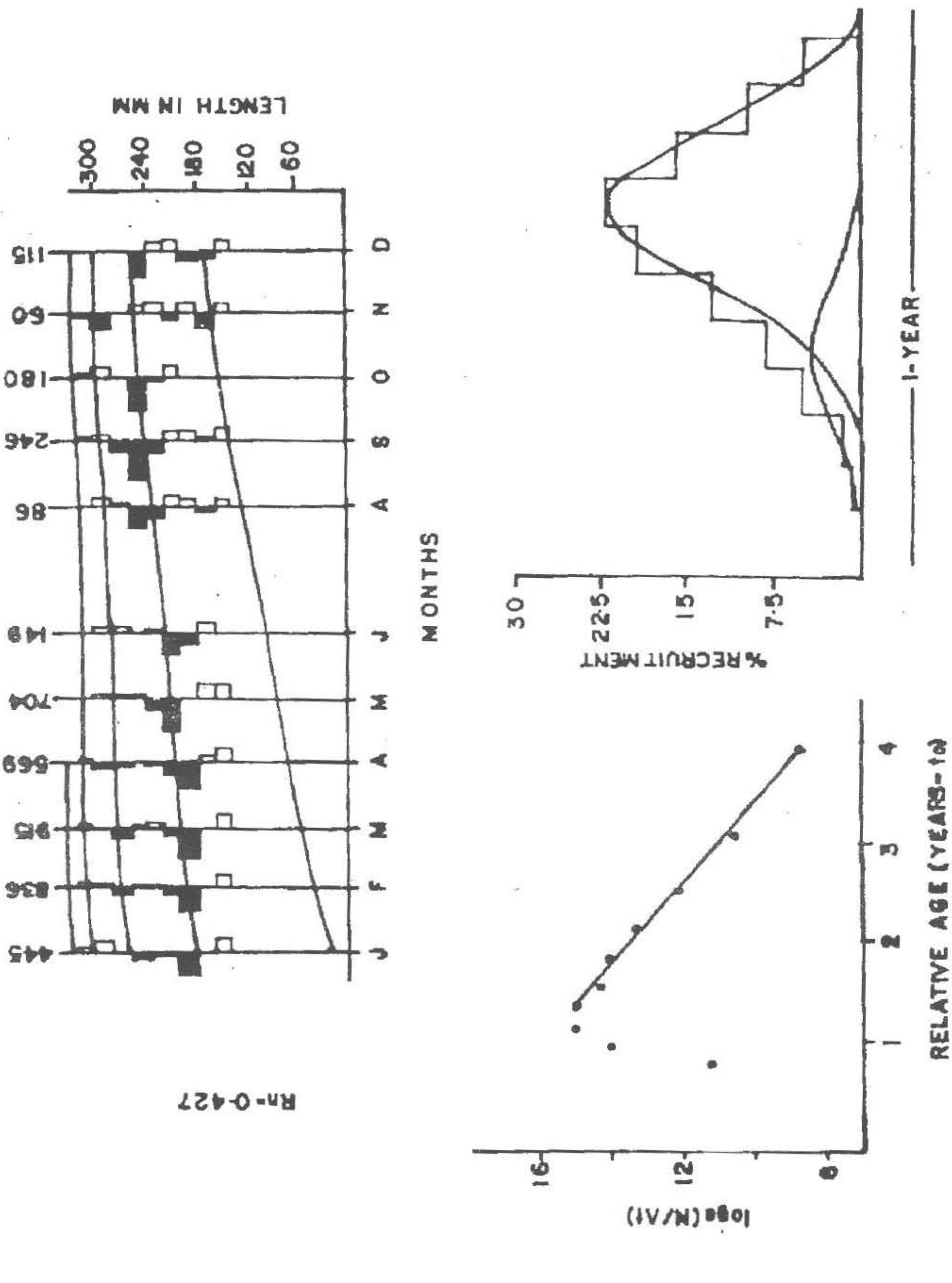

Fig. 11 : *Priacanthus hamrur* $L\infty$=345mm, K=0.66, Z=2.5. Recruitment occured in two pulses.

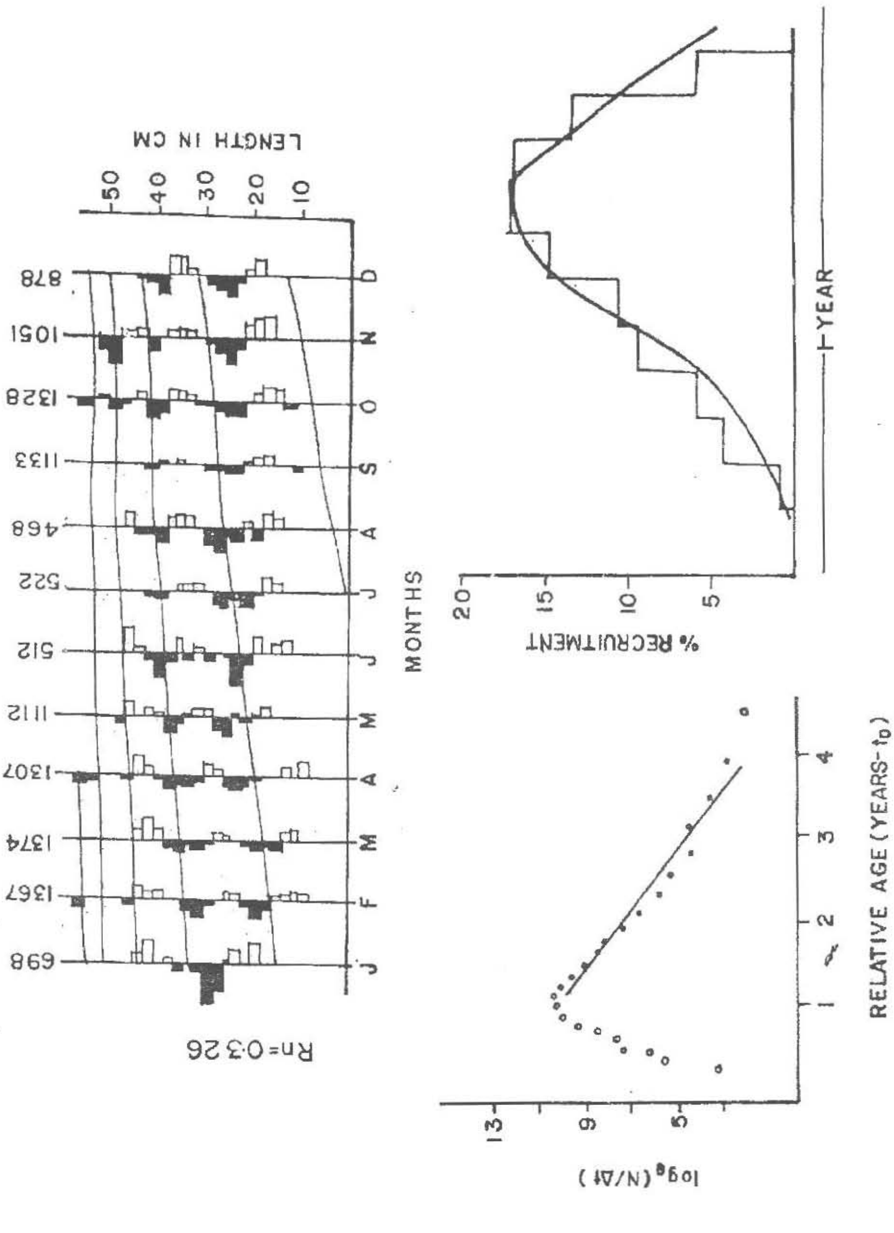

Fig. 12 : *Saurida tumbil* *L∞=600mm, K=0.51, Z=2.80. Recruitment in single pulse.*

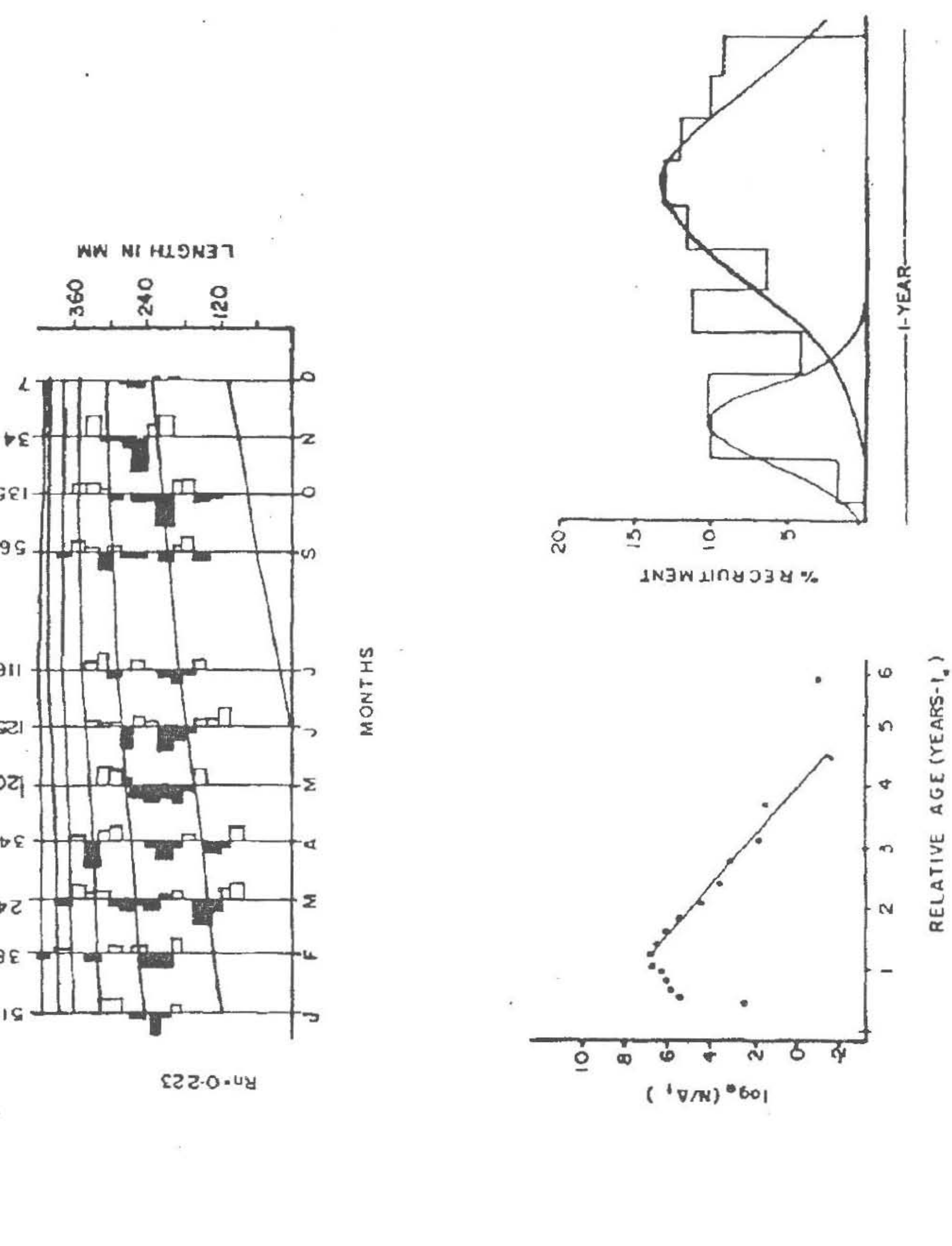

Fig. 13 : *Saurida undosquamis* $L\infty$=412*mm*, K=0.51, Z=2.52. *Recruitment pattern could not be resolved.*

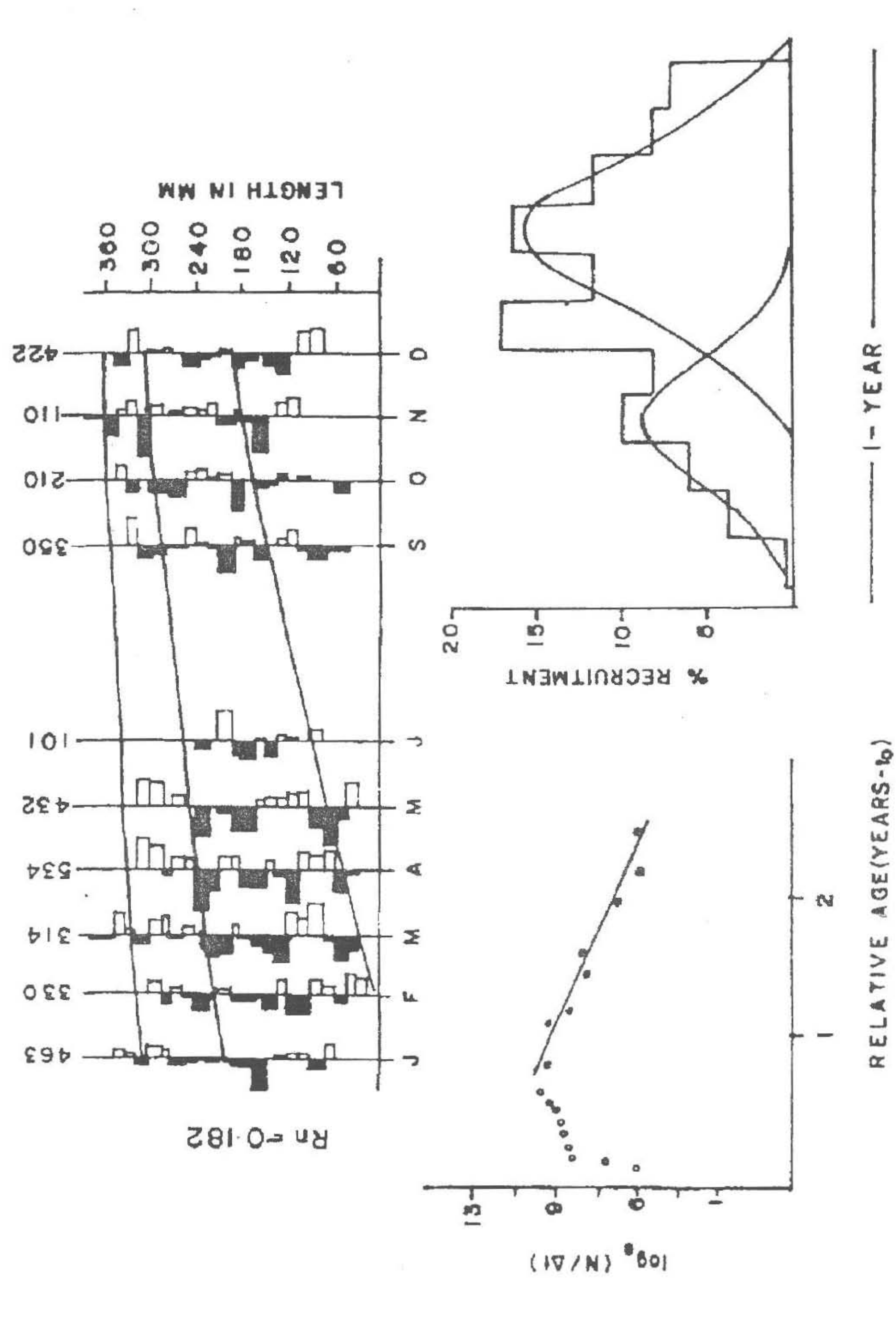

Fig. 14 : *Harpodon nehereus* L_∞=413mm, K=0.73, Z=3.1. Recruitment in two distinct pulses.

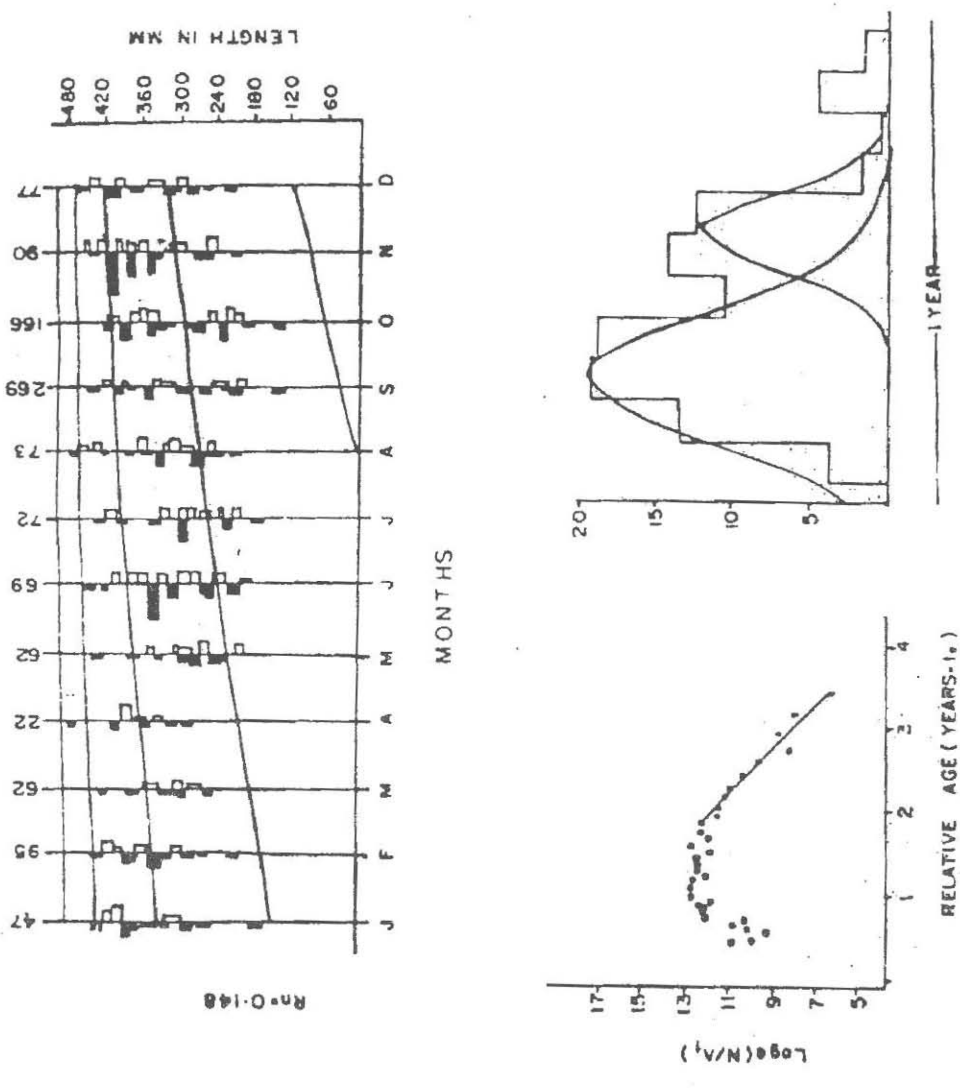

Fig. 15 : *Trachysurus caelatus* L_∞ = 521mm, K = 0.68, Z = 3.5. Recruitment in two pulses.

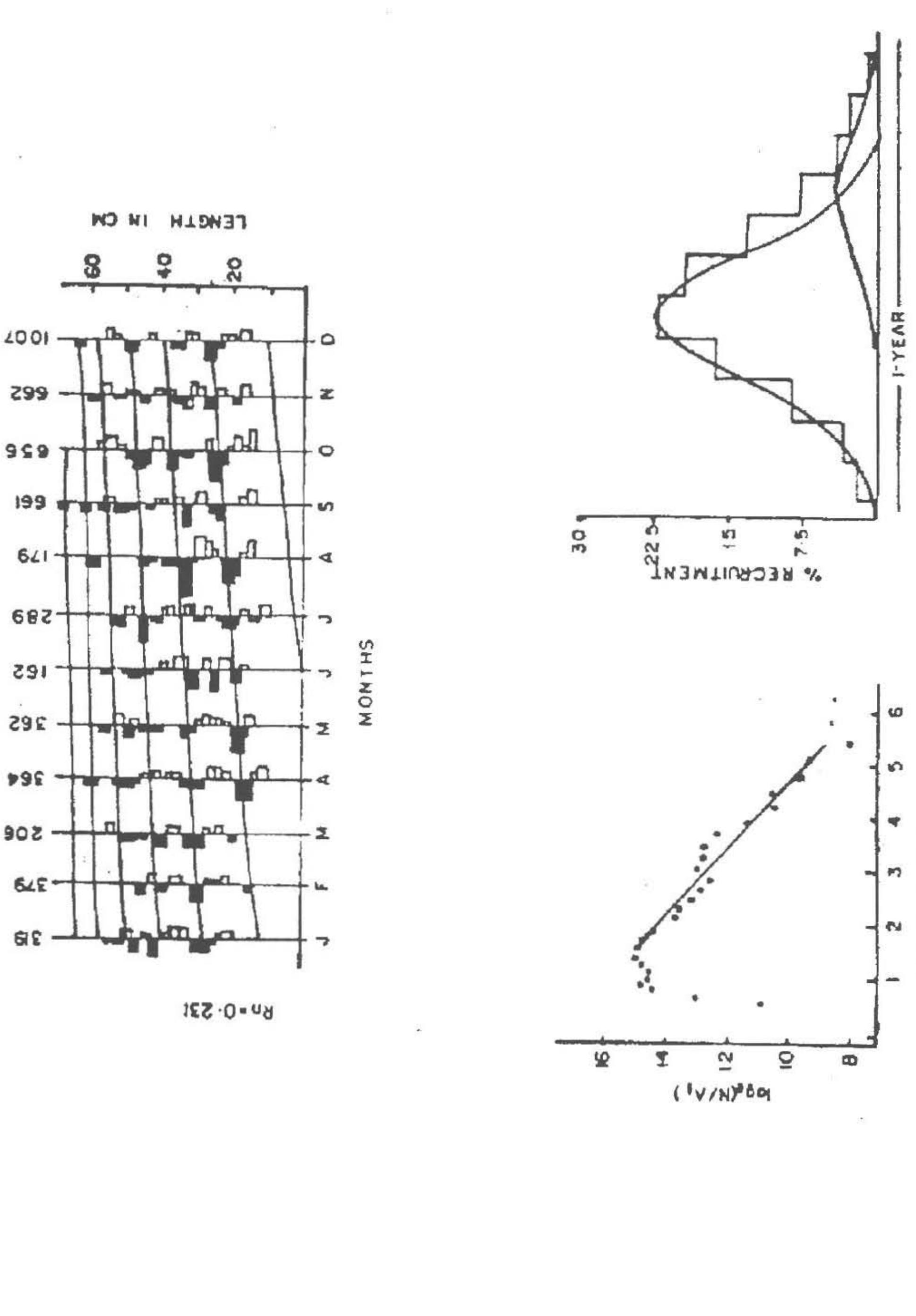

Fig.16 : *Trachysurus thalassinus* $L\infty = 850mm$, $K = 0.24$, $Z = 1.5$. Recruitment in two distinct pulses.

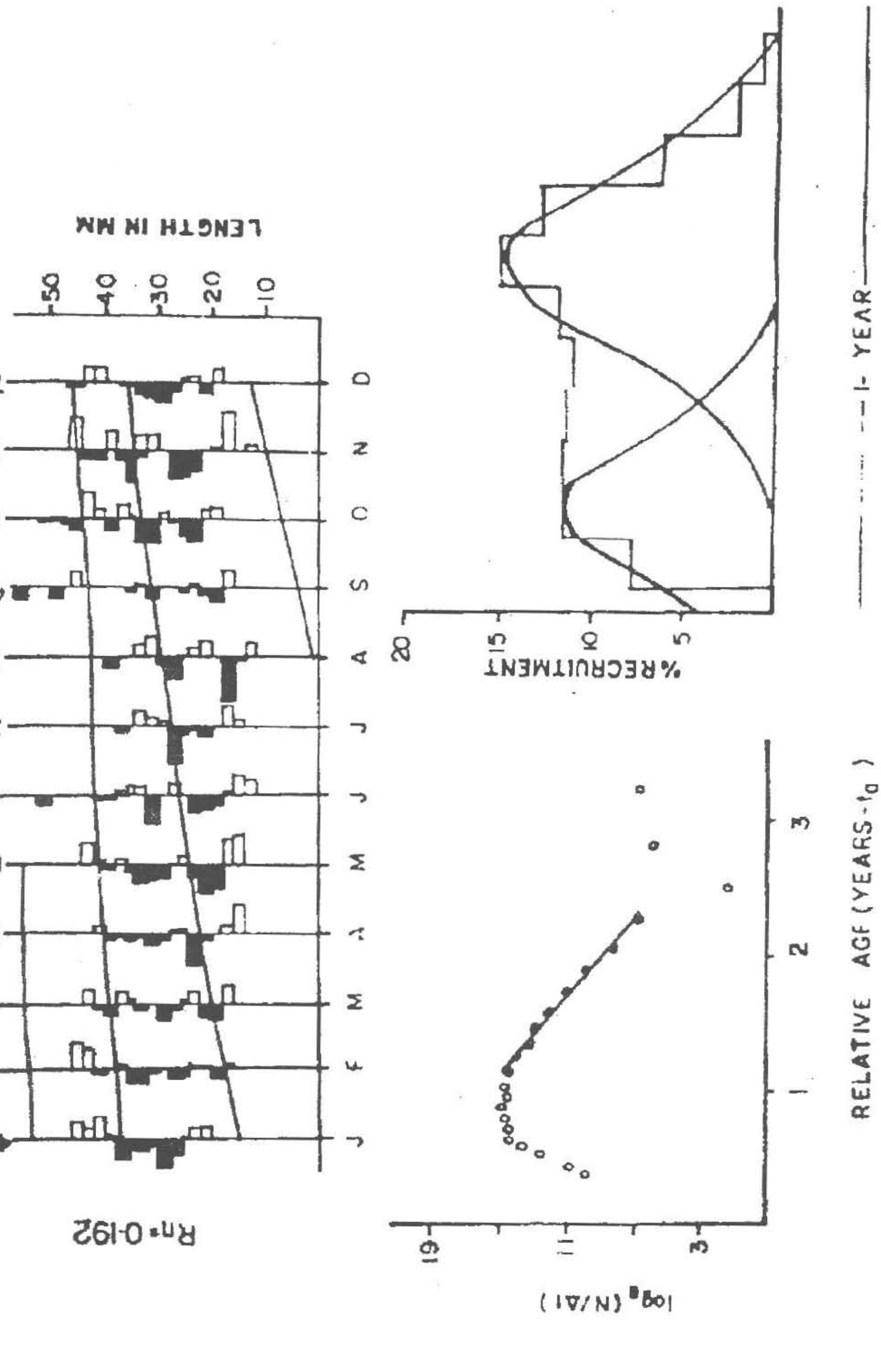

Fig. 17 : *Osteogeneiosus militarias* L_∞ = 600mm, K = 0.65, Z = 5.0. Recruitment in two pulses.

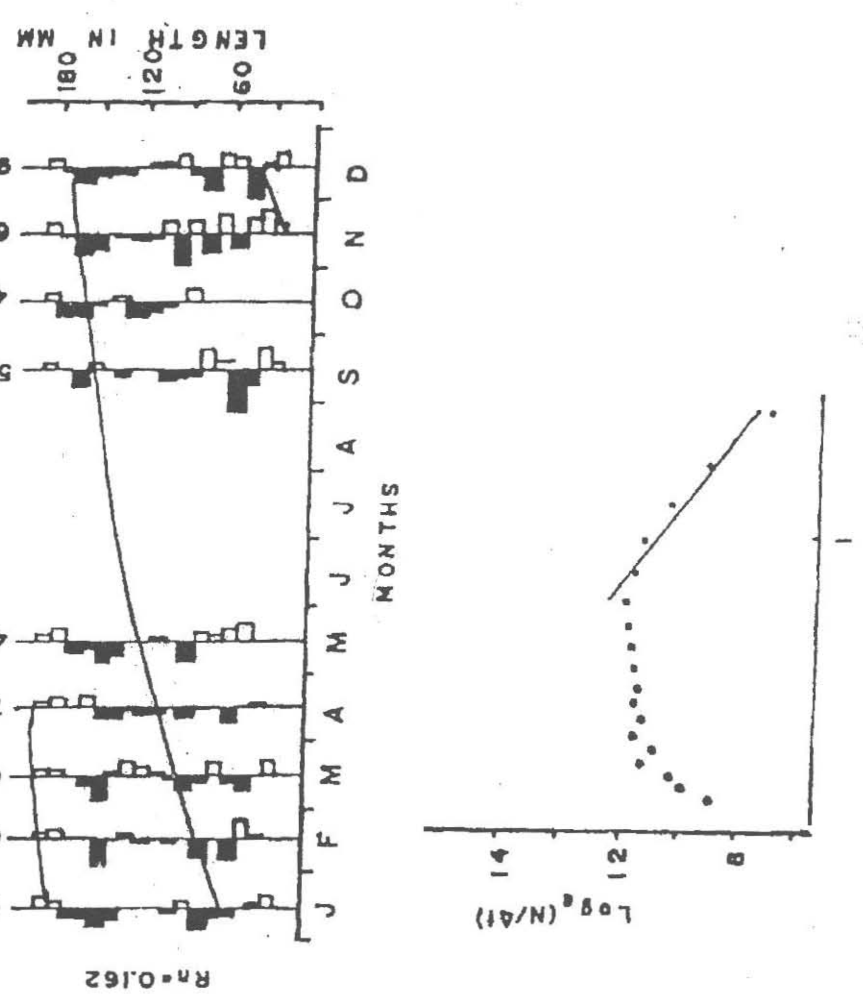

Fig. 18 : *Coilia dussumieri* $L\infty = 230mm$, $K = 1.2$, $Z = 3.6$. *Recruitment pattern of this species could not be resolved.*

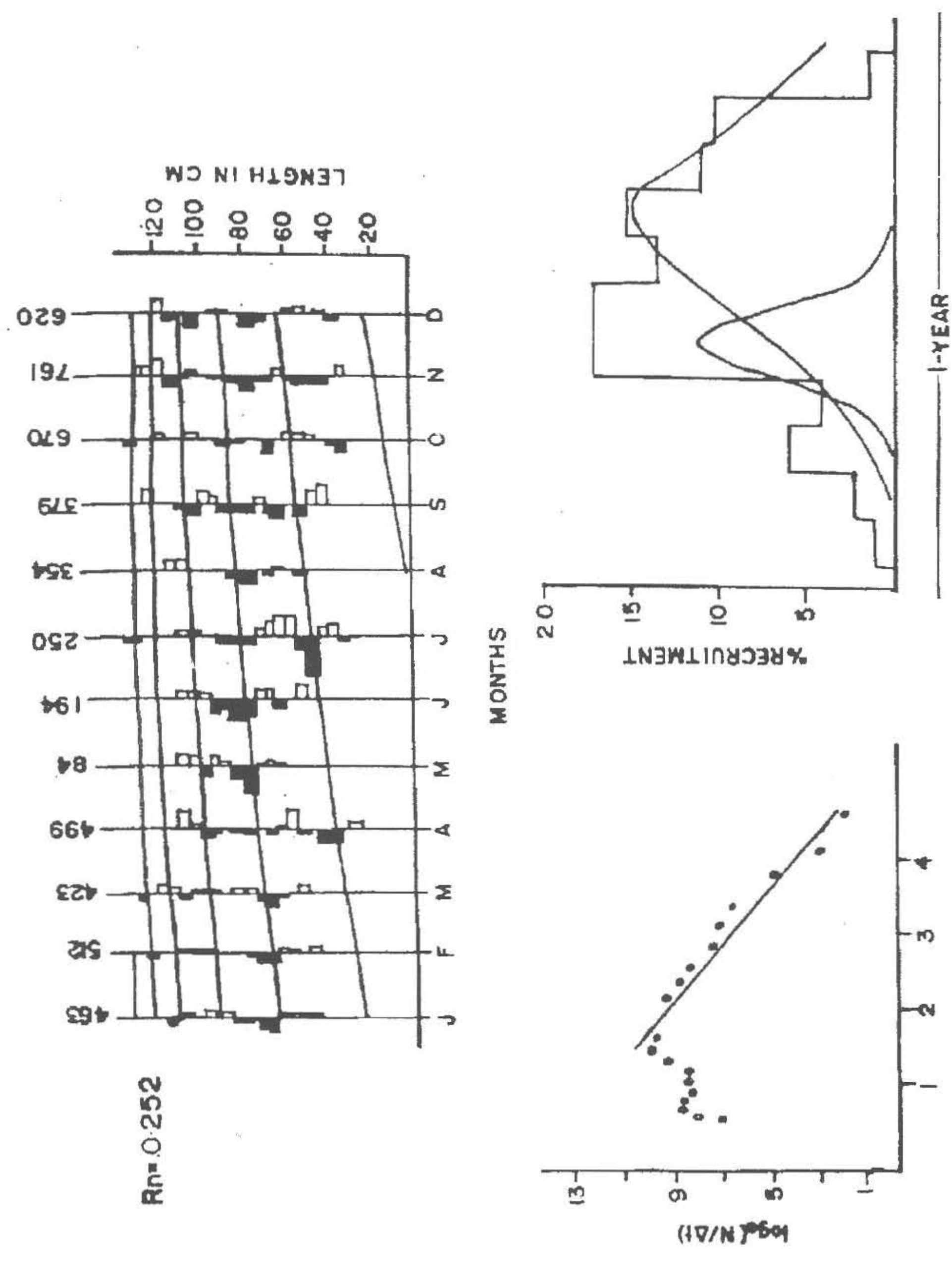

Fig. 19 : *Trichiurus lepturus* L_∞ = 1480mm, K = 0.4, Z = 2.62, Recruitment occured in two pulses.

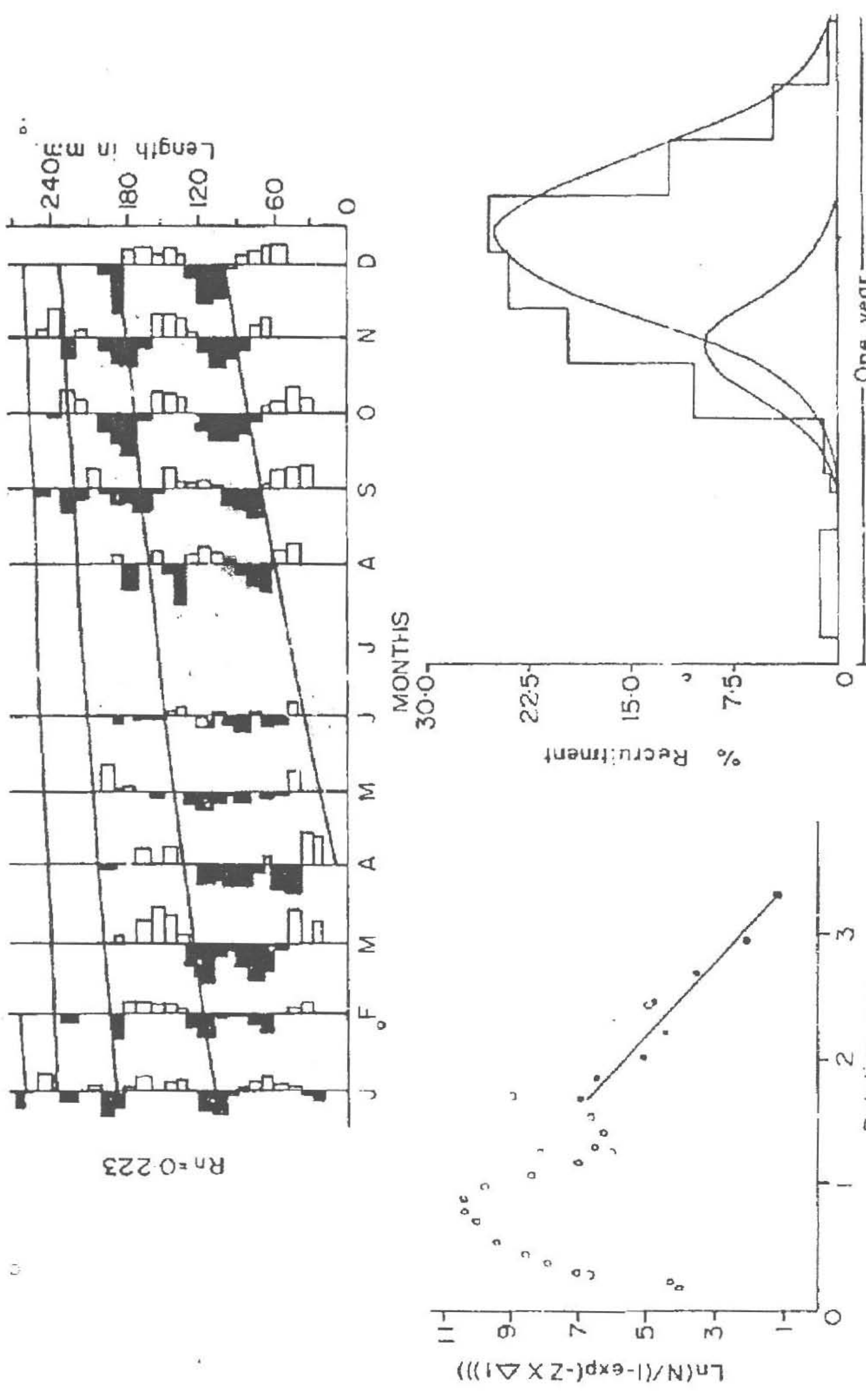

Fig. 20 : *Loligo duvaucelii.* $L\infty = 343mm$, $K = 0.49$, $Z = 2.09$. *Recruitment occured in two pulses.*

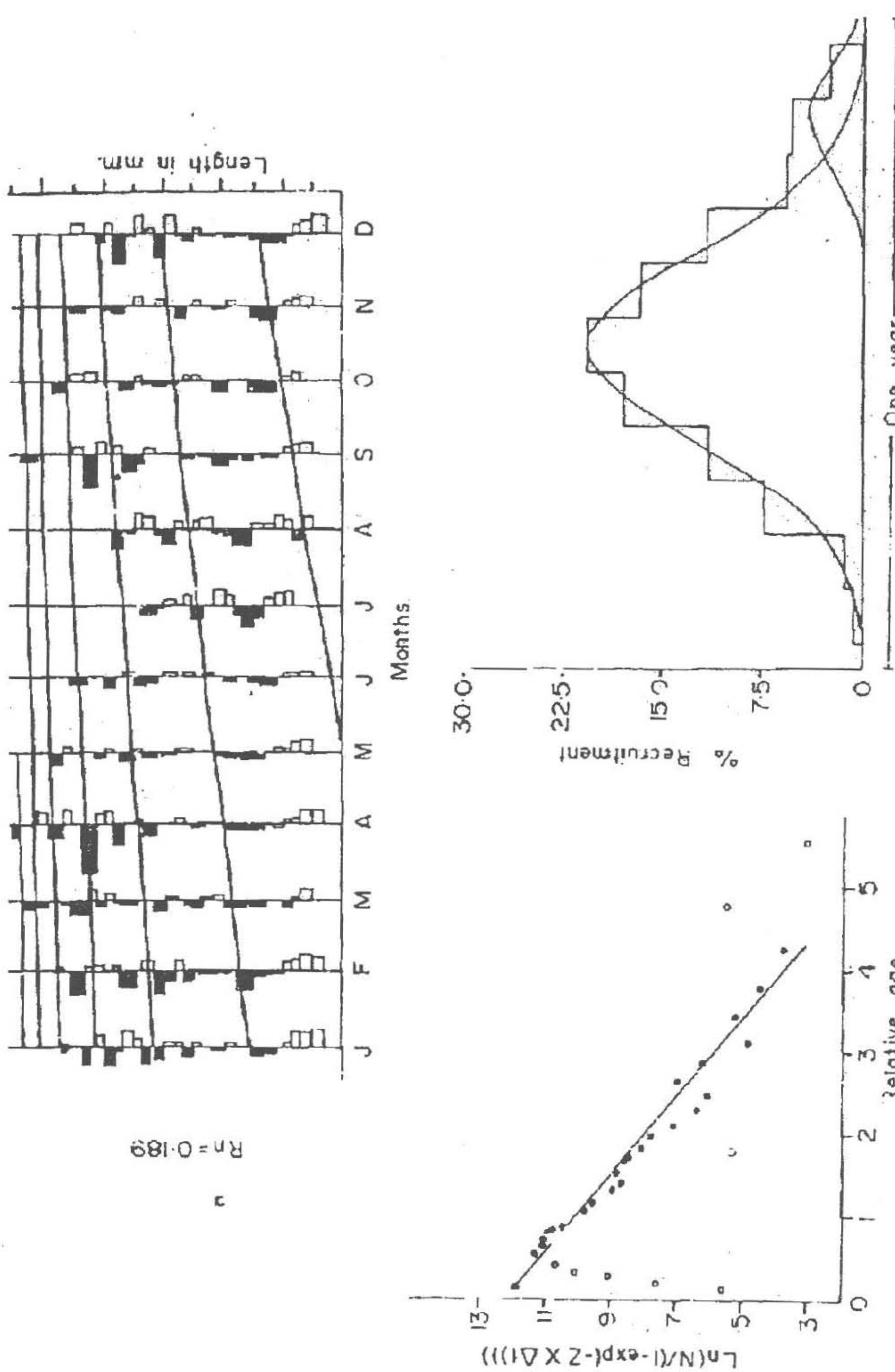

Fig. 21 : *Sepia aculeata.* $L\infty$ = 297mm, K = 0.56, Z = 3.4. Recruitment in two pulses.

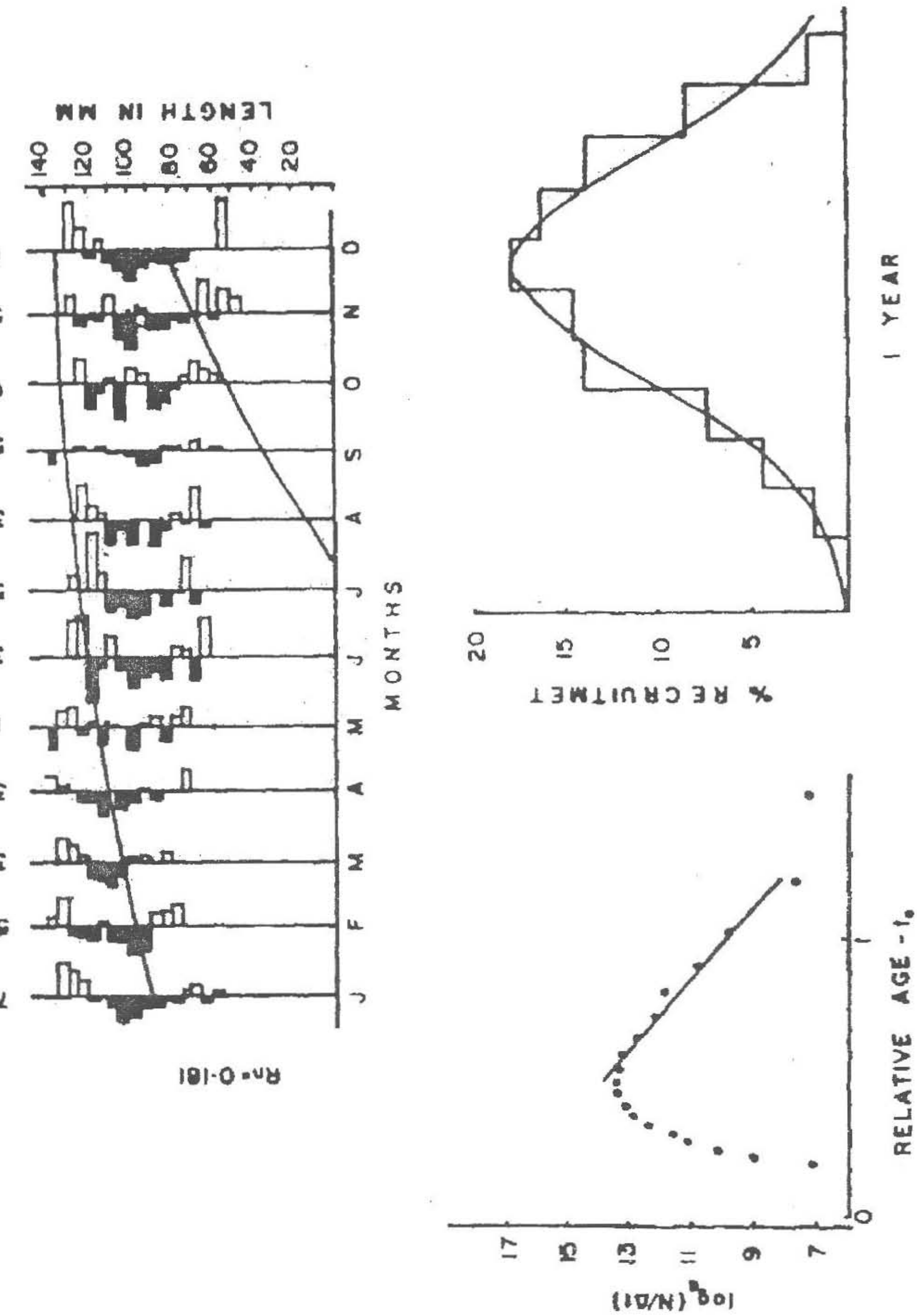

Fig. 22 : *Parapeneopsis stylifera (Female)* $L\infty = 140.8mm$, $K = 2.15$, $Z = 7.6$. *Recruitment occured in two pulses.*

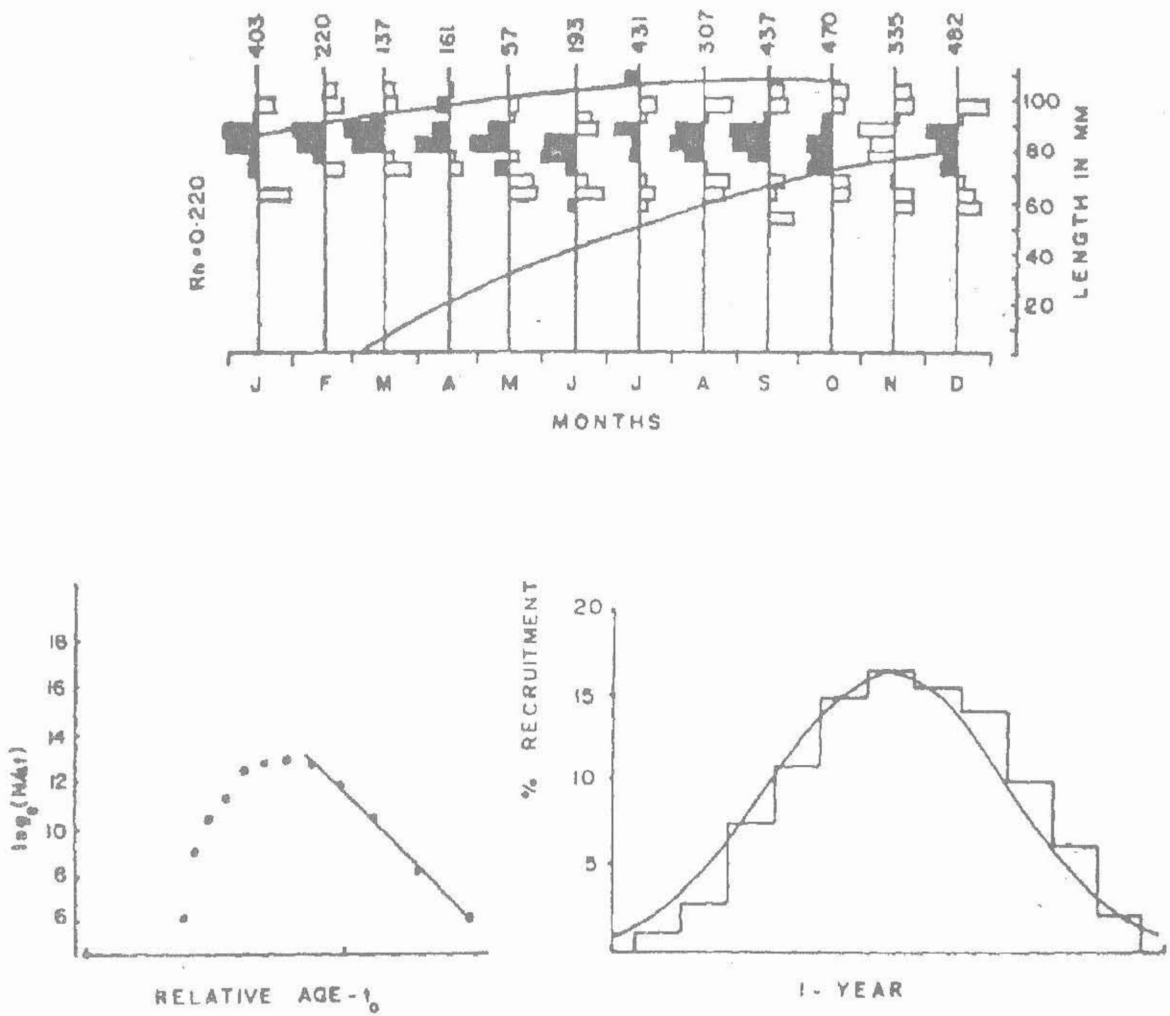

Fig. 23 : *Parapeneopsis stylifera (Male)* $L\infty$ *= 119.2mm, K = 1.45, Z = 10.78. Recruitment occured in two pulses.*

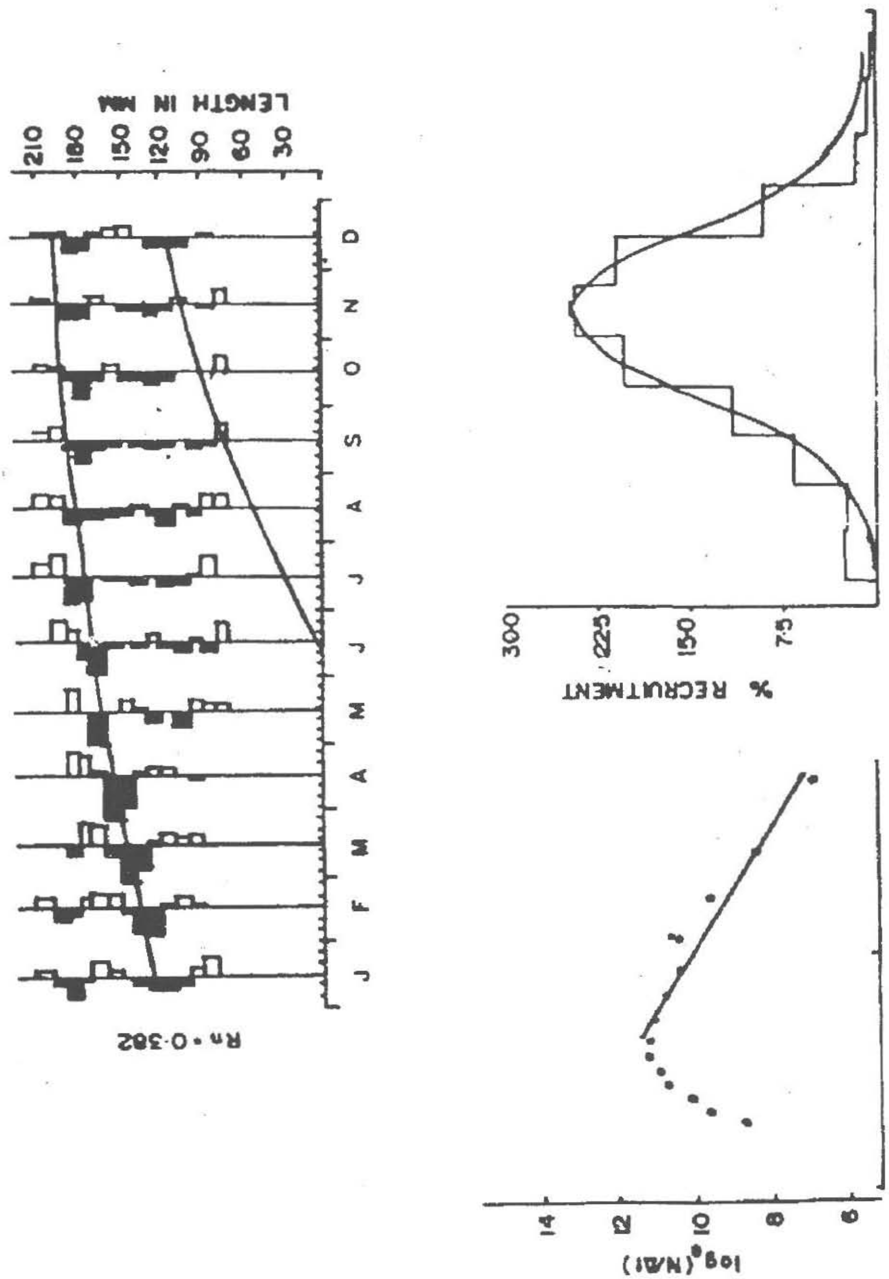

Fig. 24 : *Metapenaeus monoceros (Female)* $L_\infty = 219.2mm$, $K = 1.4$, $Z = 3.82$. *Recruitment in two pulses.*

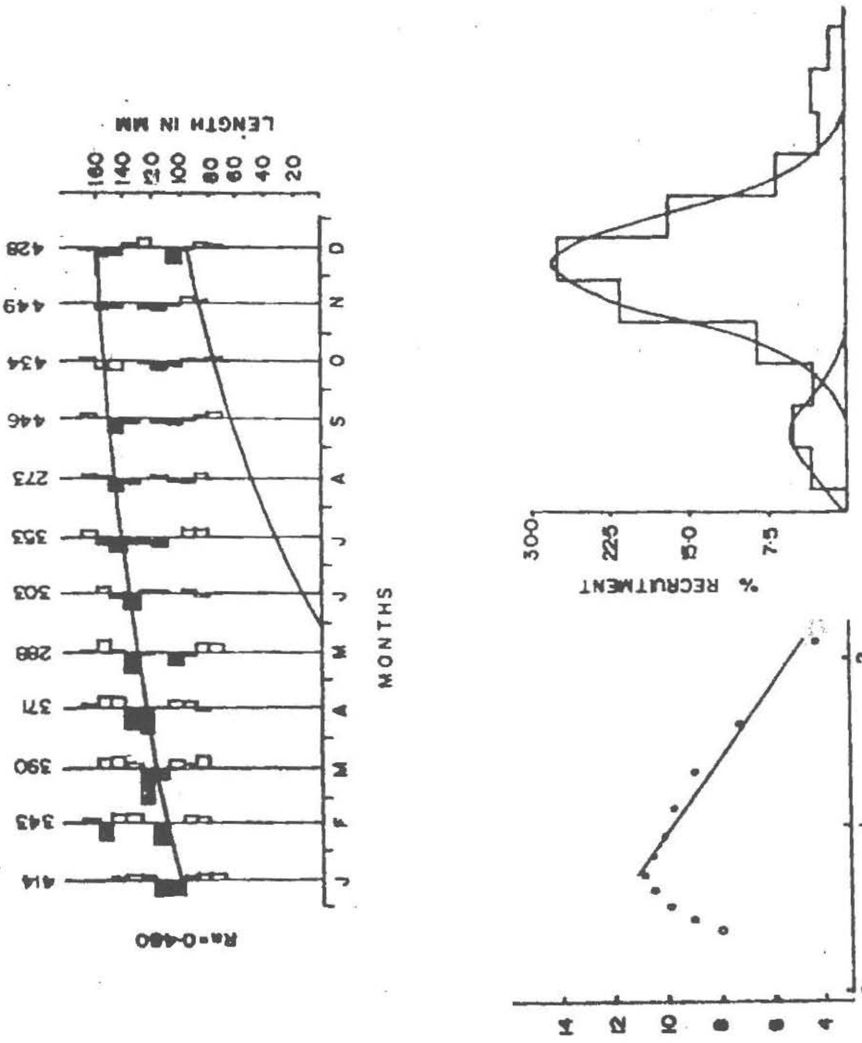

Fig. 25 : *Metapenaeus monoceros (Male)* $L_\infty = 180.5mm$, $K = 1.35$, $Z = 4.5$. *Recruitment in one pulse.*

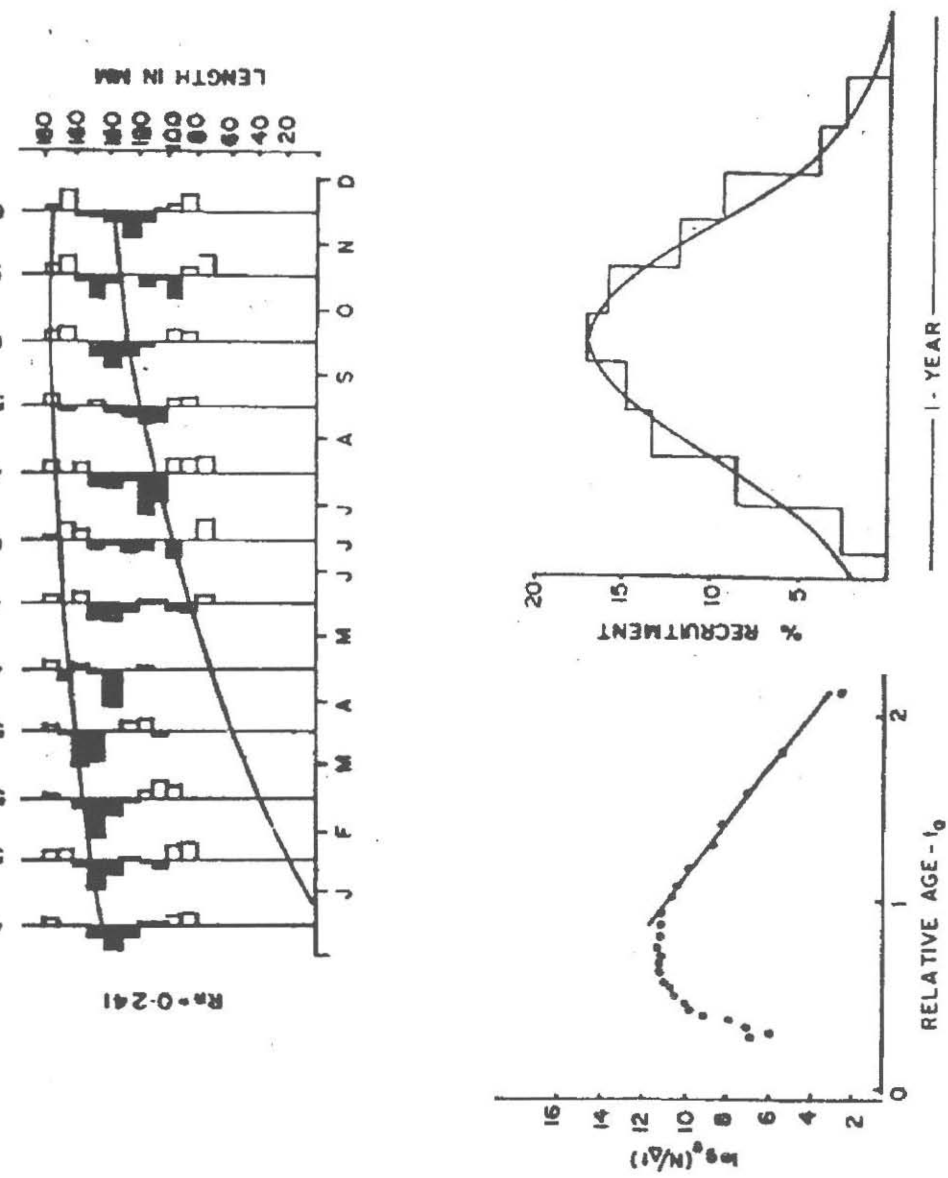

Fig. 26 : *Metapenaeus affinis (Female)* $L\infty$ = 188.8*mm*, *K* = 1.47, *Z* = 6.78. *Recruitment pattern could not be resolved*

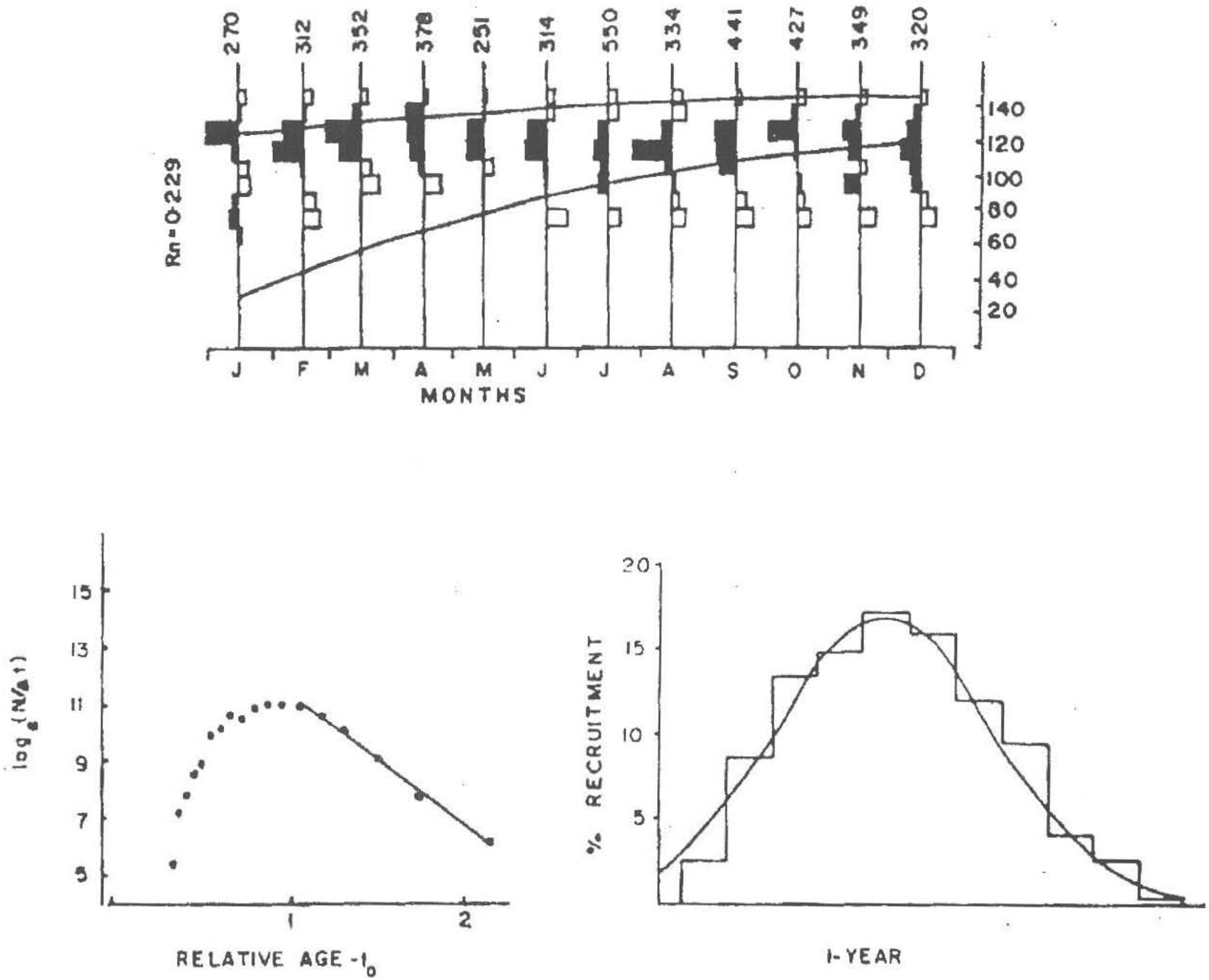

Fig. 27 : *Metapenaeus affinis (Male) L∞ = 151.55mm, K = 1.5, Z = 4.6. Recruitment pattern could not be resolved.*

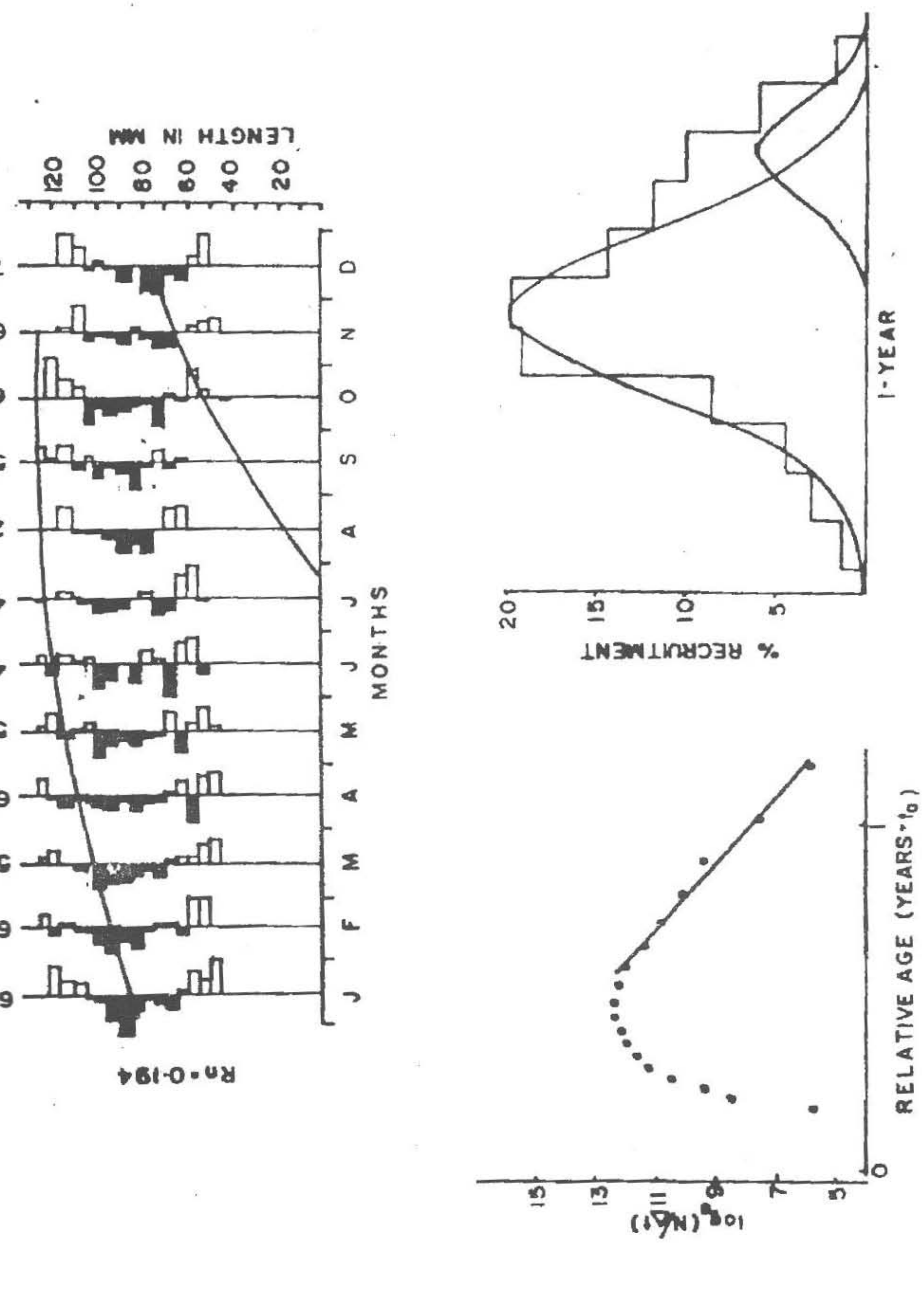

Fig. 28 : *Solenocera crassicornis (Female)* $L\infty = 139mm$, $K = 2.0$, $Z = 10.36$. *Recruitment occured in two distinct pulses.*

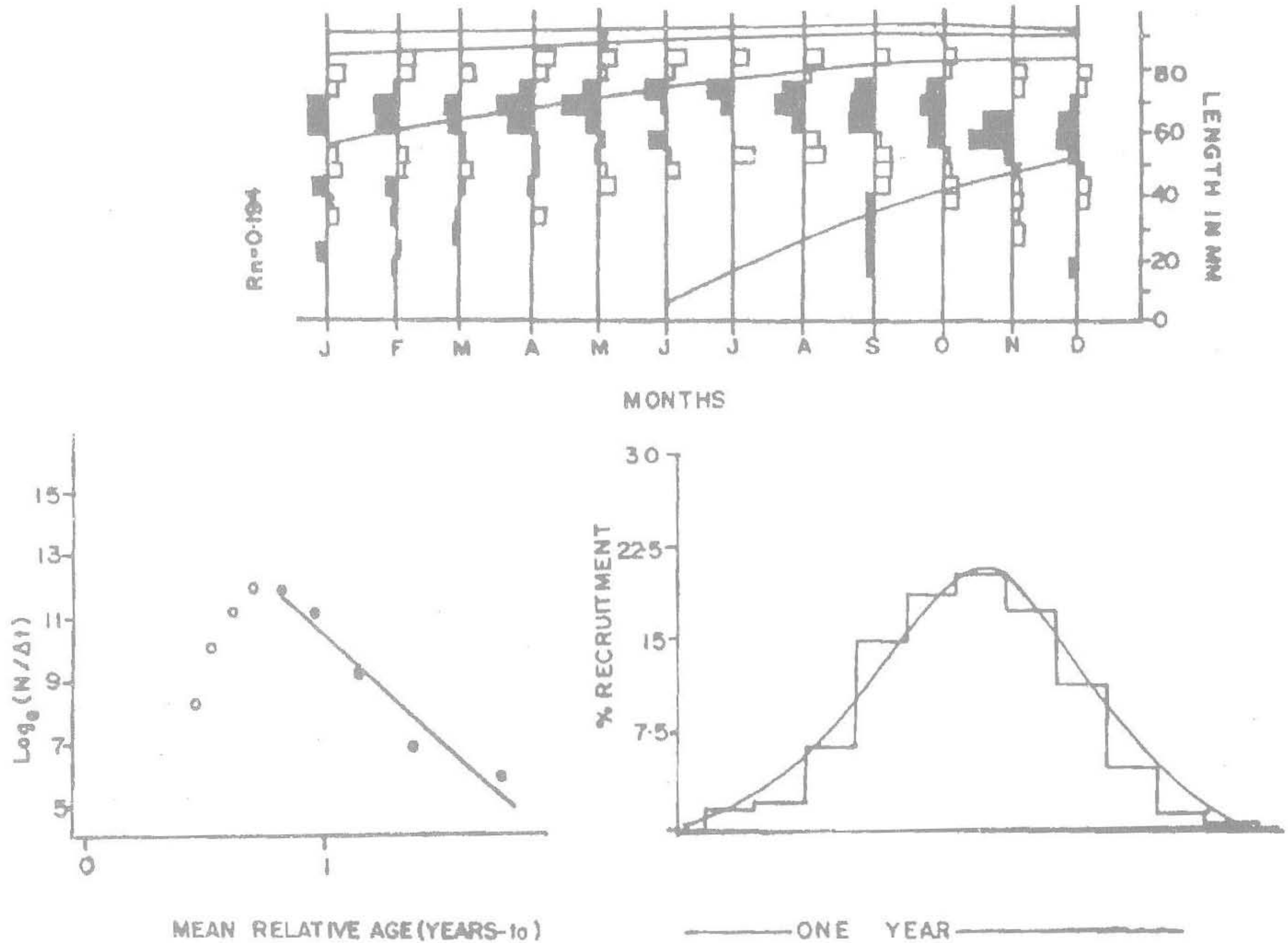

Fig. 29 : *Solenocera crassicornis (Male)* $L\infty$ *= 92mm, K = 1.5, Z = 6.8.*
Recruitment occured in one pulse.

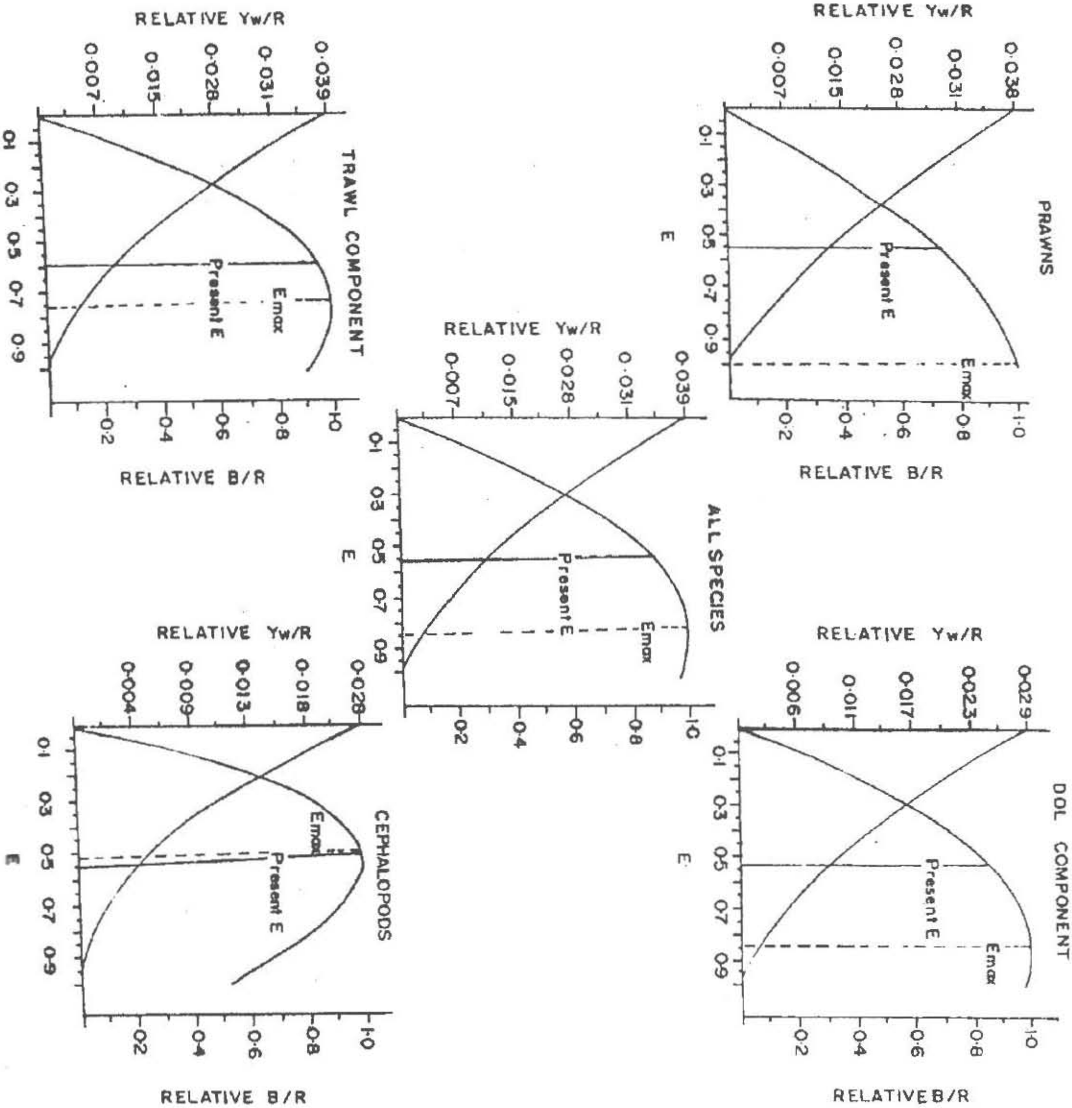

Fig. 30 : *Relative yield per recruit (Yw/R) and biomass per recruit (B/R) against exploitation rate.*

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