Pauly, D. and Sann Aung. 1984. Population dynamics of some marine fishes of Burma. BUR/77/003/FAO Field Document No. 7, FAO, Rome, 22 p.

FI:DP/BUR/77/003
Field Document 7
November 1984

BURMA

POPULATION DYNAMICS OF SOME FISHES OF BURMA BASED ON LENGTH-FREQUENCY DATA

A report prepared for the

Marine fisheries resources survey and exploratory fishing project

by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1984

This report was prepared during the course of the project identified on the title page. The conclusions and recommendations given in the report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of the project.

ABSTRACT

The population dynamics (growth, mortality, gear selection, recruitment) of 3 species of marine fish (*Rastrelliger brachysoma*, *Polynemus indicus* and *Nemipterus japonicus*) are discussed, based on length-frequency data obtained - without rigorous sampling design - from 1966 to 1982 in Burmese marine waters.

The main methods of analysis used were the ELEFAN programs; the results obtained are in agreement with the present state of knowledge on the marine resources of Burma.

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1. INTRODUCTION

The Government of Burma, assisted by the United Nations Development Programme and the Food and Agriculture Organization of the United Nations, have been engaged in the Marine fisheries resources survey and exploratory fishing project (BUR/77/003), whose main purpose is to make an estimate of the marine fish biomass within Burma's EEZ, identify and map presently non-exploited fishing grounds, assist the Government in setting up a visit to survey the marine fishery resources, and train counterparts.

As part of the project operations, FAO assigned Mr D. Pauly as consultant (fish population dynamics) for 2 brief periods in August and December 1983 with the following terms of reference:

Under the supervision of the Team Leader and in close cooperation with the project staff and with Burmese counterparts, the consultant will:

- advise on the appropriate methodology to estimate the fish resources and their potential catches on the basis of data collected during the appraisal surveys, conducted by the project, and from the fisheries statistics;
- train Burmese counterparts in the methods of fish population dynamics studies, with emphasis on those which can be implemented in tropical waters.

This report presents some of the results of the analysis of length-frequency data of Burmese fish performed by the second author while on training at the International Center for Living Aquatic Resources Management (ICLARM), from 13 June to 6 October 1983, and also reassesses a preliminary analysis of some length-frequency data on Nemipterus japonicus, performed by the first author during his first visit to Burma in August 1983.

All length-frequency data presently available in Burma, whether collected by earlier investigators (e.g., Druzhinin, 1970, 1970a), or during the recent pelagic and demersal surveys have been collected more or less unsystematically, i.e., not on the basis of an explicit, pre-established sampling design.

Nevertheless, a number of useful inferences can be extracted from such data, as demonstrated here. It is hoped that, in the future, representative samples will be obtained by the Sea Fisheries Research and Survey Unit (SFRSU).

Results are presented for three species, the short-bodied mackerel Rastrelliger brachysoma, the Indian threadfin Polynemus indicus and the Japanese threadfin bream Nemipterus japonicus. For each species, a brief introduction is given which is followed by equally brief methods, results and discussion sections. A general discussion, covering all three species then follows.

2. POPULATION DYNAMICS OF RASTRELLIGER BRACHYSOMA

2.1 INTRODUCTION

The Indian mackerels (R. brachysoma and R. kanagurta) belong to the very few fish species of Burma whose biology has been studied and reported upon in the literature (Druzhinin, 1970, 1970a; Druzhinin and Tin Tin Myint, 1970; Naumov, 1971).

These studies yielded length-frequency data, of which those pertaining to R. brachysoma are analysed here to complement inferences drawn by earlier authors on the biology of this fish.

2.2 MATERIAL AND METHODS

The length-frequency data used here were collected by A.D. Druzhinin, Tin Tin Myint and their colleagues from June 1966 to September 1968, mostly at Mergui Observation Point, Mergui Archipelago, southern Burma, and stem from two nearby fishing grounds, the Barn Island area and the Marble Island area (see Fig. 1 in Druzhinin and Tin Tin Myint, 1970). The fish were caught by purse seines. For more details on sampling and fishing, see Druzhinin and Tin Tin Myint (1970) and Naumov (1971).

The method of analysis consisted first of reading the length-frequency data off Figure 10 in Druzhinin (1970a) (which is the same as Fig. 5 in Druzhinin 1970, only easier to read).

The data, which cover 3 years (1966 to 1968) are very uneven, with 1966 being represented by data from only 3 months, 1968 from 6 months and 1967 from 8 months (Table 1) none of which would seem by itself sufficient for growth and mortality analysis.

The length-frequency data from the same months but different years were therefore pooled, resulting in 10 months of an "average year" being covered by data.

The ELEFAN I program of Pauly and David (1981) was applied to the pooled length-frequency data to estimate the parameters L_∞ and K of the von Bertalanffy growth equation. The growth parameters were obtained in two steps. First, the growth parameters were estimated from the pooled length frequency data in Table 1; this resulted in preliminary estimates of L_∞ = 27 cm and K = 0.965 (see Fig 1A); then the ELEFAN II program was used to approximate the "resultant" curve of the purse seine used to obtain the length-frequency data at hand (see Fig. 2B) and the length-frequency data were corrected for selection effects. The final estimates of L_∞ and K derived, finally, by using ELEFAN I and the length-frequency data corrected for selection, were L_∞ = 27 cm and K = 1.6 (Table 2).

This procedure, which is a recent development in the application of the ELEFAN I and II programs (Pauly, MS.) was never applied before. As shown in Table 2, it results in improved growth parameter estimates.

Once L_∞ and K had been estimated, the ELEFAN II program was also applied to the pooled length-frequency data. The program does the following:

- combines single (e.g., monthly) samples into one single overall sample, and constructs a length-converted catch curve from it (for details on those procedures, see Pauly, 1982; and Pauly _et al._, 1981)
- obtains an approximation to a selection curve (or more precisely of the resultant of a recruitment and a selection curve) from the left, ascending side of the length converted catch curve (see Pauly _et al._, 1981)
- derives a preliminary estimate of M from the growth parameters L_∞ (in cm) and K, the mean environmental temperature (here 27°C), and the built-in empirical equation of Pauly (1980):

$$\log_{10}M = 0.0066 - 0.279\log_{10}L_\infty + 0.6543\log_{10}K + 0.4634\log_{10}T \quad \ldots (1)$$

- derives a "recruitment pattern", i.e., a graph representing the seasonality of fish entering the fishery from a projection of the available length-frequency data onto the time axis (Pauly, 1982; Pauly and Navaluna, 1983).

2.3 RESULTS

The growth parameters estimated from the length-frequency data, corrected for selection, are L_∞ = 27 cm, and K = 1.6; the growth curve is shown in Figure 1B, superimposed on the available pooled length-frequency data.

The length-converted catch curve (Fig. 2A) is remarkably straight, and suggests a total mortality (Z) of 11.90 (per annum), from which an estimated natural mortality (M) of 2.46 can be subtracted to obtain an estimated fishing mortality of F = 9.44, corresponding to a rather high exploitation rate (E = F/Z = 0.79).

The selection pattern (Fig. 2B) suggests a mean length at first capture of about 19.5 cm, which corresponds to a rather large fraction of L_∞ (c = 19.5/27 = 0.72).

The recruitment pattern (Fig. 2C) suggests that R. brachysoma is recruited twice a year off Burma with one of the recruitment pulses being much stronger than the other.

2.4 DISCUSSION

The growth parameters obtained here match those obtained by various authors working elsewhere on R. brachysoma. This match is not direct, however, since the value of L_∞ obtained here of 27 cm is higher than the values of 19-23 cm obtained by other authors working elsewhere in Southeast Asia and here the K of 1.6 is lower than their values ranging from 2.28 to 4.2 (see Table 2). The correspondence between the estimate here and the earlier estimate of the growth parameters of R. brachysoma can be established, however, by computing for each pair of growth parameter estimates, the value of Ø', defined as

$$\text{Ø}' = \log_{10}K + 2\log_{10}L_\infty \qquad \ldots (2)$$

which is adapted, assuming isometric length/weight relationship from the equation in Munro and Pauly (1983)

$$\text{Ø}' = \log_{10}K + 2/3\log W_\infty \qquad \ldots (3)$$

Values of Ø' are given in Table 2 for 6 stocks of R. brachysoma; as can be seen, the value from Burma corresponds to the other available values.

3. MORTALITY AND SELECTION OF POLYNEMUS INDICUS

3.1 INTRODUCTION

At least three species of threadfins occur off Burma, namely Polynemus heptadactylus, P. sextarius and P. indicus (Druzhinin and Phone Hlaing, 1972; Fischer and Whitehead, 1974; Strømme et al., 1981). Of these, P. indicus, the Indian threadfin, is the most abundant, especially in the Western Delta area and the Irrawaddy estuary (Sann Aung, personal observation), where it reaches a length of 145 cm, which is very close to the maximum length of 142 cm given in Fischer and Whitehead, 1974).

3.2 MATERIAL AND METHODS

Most of the length-frequency samples used here were obtained from 1979 to 1982 during the R/V DR FRIDTJOF NANSEN surveys, and from samples collected during the UNDP/FAO/PPFC fisheries project (BUR/003/77), while a few samples were obtained on board commercial vessels. Sampling was irregular and non-systematic. All samples stem from the Western Delta area. Altogether, 2 776 fish were measured.

The scanty nature of the available data, combined with the fact that P. indicus is a rather long-lived fish, precluded analysis of the available length-frequency data with ELEFAN I to estimate growth parameters. Instead, growth parameters published by Kagwade (1970) for a stock of P. indicus off the Eastern Indian coast (L_∞ = 150, K = 0.189) were used to construct a length-converted catch curve from the available length-frequency data.

Pooling of the available length-frequency data was done in two steps:

- at first, the available samples for 1979-1982 were simply added, by month irrespective of the year of sampling if they belonged to the same month (see Table 3)

- then the pooled monthly samples were pooled into a single summary sample by first converting all monthly samples into percentage samples, then adding them up after weighting them by the square root of their size. This procedure, suggested by Hans Lassen (Denmark Fish. Res. Inst., Charlottenlund, personal communication) is built into ELEFAN II and is applied everytime it is not possible to weight the samples by the biomass, or the by-catches.

The length-converted catch curve was then used to estimate Z and the pattern of selection/recruitment into the fishery using the appropriate routines of the ELEFAN II program. Natural mortality was estimated for equation (1); the value of M so obtained was subtracted from Z to obtain a preliminary estimate of F.

3.3 RESULTS

Figure 3A shows the length-converted catch curve for P. indicus in the Western Delta area of Burma, while Figure 3B shows the curve resulting from the interaction of a selection with a recruitment curve. The estimated values of Z, M, F and E (= F/Z) are 0.98, 0.37, 0.61 and 0.62 respectively, while the mean length at entry into the fishery was estimated to be 75.2 cm.

3.4 DISCUSSION

Although the quality of the length-frequency data at hand was poor and did not allow for a very detailed analysis, their combination with growth parameter estimates obtained elsewhere did produce a remarkably straight catch curve and a mortality estimate for Polynemus indicus which seem reasonable in view of the fact that the fish stocks of the Irrawaddy delta and Delta area are more strongly exploited - due to their abundance and closeness to Rangoon - than the other demersal resources off Burma (see account below on Nemipterus japonicus).

4. POPULATION DYNAMICS OF NEMIPTERUS JAPONICUS

4.1 INTRODUCTION

The Japanese threadfin bream, Nemipterus japonicus, is the most abundant nemipterid, and one of the most abundant resources of Burma (see Druzhinin and Phone Hlaing, 1972; Strømme et al., 1981).

Some information on the size distribution and the reproductive stages of N. japonicus caught in the Mergui Archipelago was presented in Druzhinin and Phone Hlaing (1972).

4.2 MATERIAL AND METHODS

Two different data sets were combined in the present analysis, and these are here discussed in sequence, with emphasis on the methods used for pooling samples:

(1) Data obtained during the R/V DR FRIDTJOF NANSEN surveys: these data which consist of catch (of Nemipterus japonicus) per haul and associated length-frequency samples (and/or weight of sample) were extracted from the 2 volumes of raw data sheets left at the SFRSU site after the surveys were completed.

For each trawl haul in which N. japonicus occurred in the catch, the following data were extracted:

(a) total catch per hour of N. japonicus

(b) size frequency distribution of catch or of sample (when available)

(c) number of N. japonicus caught (or number in sample when available)

(d) weight of N. japonicus in catch or sample, by length class (when available)

(e) mean trawling depth, in metres

The information in (a) to (e) was then used to:

- raise the sample of fish measured to catch per hour
- compute the mean weight of N. japonicus caught, and plot it against mean trawling depth
- compute the mean weight per length class (see Table 4)

The samples, raised to catch were then pooled, by area (Rakhine Coast, Delta Area, Northern and Southern Tenasserim Coast) and sampling month.

(2) Data obtained during the 1980 and 1981 demersal surveys: these data essentially resemble those obtained during the surveys of R/V DR FRIDTJOF NANSEN, except for the following features:

- sampling density (i.e., of length-frequency samples per trawl haul) was much less
- weight of samples per length class were not available

Here, the length-frequency samples were simply raised to catch per hour (i.e., apparent density) and pooled, by month and area.

The length-frequencies in (1) and (2) from 1979 to 1981 were then pooled by month and area, irrespective of the year, to obtain area samples more or less representative of the average population structure off Burma.

The analyses of the pooled data were performed with ELEFAN I and II and are presented separately for the Rakhine and Delta areas (Table 5) and the Northern plus Southern Tenasserim Coasts (Table 6); these two areas shall be referred to below as Northern and Southern Burma coast.

4.3 RESULTS

The growth parameters obtained using ELEFAN I for the Northern Burma coast from the data in Table 5 are similar to these obtained from the data in Table 6 for the Southern Burma coast, and to growth parameter estimates available in the literature (see Table 7).

The values of Z obtained from the two length-converted catch curves in Figure 4, pertaining to the Northern and Southern Burma Coast are very similar among themselves and also very close to the value of M that can be estimated from equation (1) and the appropriate growth parameters and temperature. This suggests a very low rate of exploitation for the stocks of N. japonicus off Burma during the period of 1979 to 1982.

Figure 5 shows the combined selection patterns and recruitment patterns of N. japonicus from the Northern and Southern Burma coast.

The length-weight relationship derived from the data in Table 4 is

$$W = 0.0105L^{3.06} \qquad \ldots (4)$$

while the mean condition factor (c.f. = $W\ 100/L^3$ = 1.241

Figure 6 presents a double logarithmic plot of mean fish weight against fishing depth. As might be seen, no relationship is apparent, all sizes occurring - more or less - at all depths.

4.4 DISCUSSION

The length-frequency data used here, although obtained without rigorous sampling design, yielded estimates of growth parameters for Nemipterus japonicus similar to those in the literature, as well as estimates of total mortality compatible with the available information on the state of exploitation of the Burmese demersal stocks (see 5. General Discussion).

The wealth of data collected during the R/V DR FRIDTJOF NANSEN surveys allowed, moreover, to derive a length-weight relationship that will be useful in subsequent studies of N. japonicus and to infer the lack of a direct relationship between depth and mean fish weight in N. japonicus off Burma.

This latter phenomenon is of considerable interest because it differs from the pattern usually found in nemipterids (see e.g., Weber and Jothy 1977) and suggests the existence of a mechanism which prevents the establishment of such a size/depth gradient along the Burma coast.

Such a mechanism could be the "shoreward movement of the (oxygen-poor) bottom water on the shelf with corresponding upwelling in near shore areas during spring" (Strømme et al., 1981). However, more research will be needed on this phenomenon and its effects on the demersal fishes to test this.

5. GENERAL DISCUSSION

Although based on data not specifically collected for the kind of detailed analysis to which they were subjected, the results here are encouraging with regard to rapidly obtaining the information needed to assess the fish stocks off Burma.

Thus, in the cases of Rastrelliger brachysoma and Nemipterus japonicus, growth parameters were obtained which compare very well with those obtained elsewhere by other authors.

In the case of R. brachysoma, this result was achieved, however, only after correcting the available length-frequency data for selection effects. The correction used, which rests on the assumption of a sigmoid-shaped selection (or resultant) curve (such as generally occurs with trawl and purse seine) and which does not require mesh selection experiments, is a new development in the use of the ELEFAN programs with length-frequency data. It will be discussed in more detail in a future paper (Pauly, MS.); at present, it suffices to mention that correcting for selection effects, when inferring growth from length-frequency data, seems most appropriate when a narrow range of lengths are covered by the available length-frequency data - as illustrated here by the data on R. brachysoma.

Assessing the validity of the total, natural and fishing mortality estimates presented here is quite difficult. It is realized that the various procedures used here to pool and aggregate data cannot entirely offset the fact that the data used were not collected in the fashion that would have ensured representativeness.

On the other hand, it is obvious that overall the results obtained here do correspond with what could reasonably have been expected.

Thus, the catch curve for R. brachysoma suggests a rather high mortality and exploitation rate, reflective of the intensive, but localized, purse seine fishery from small pelagics that operated in the late sixties and early seventies in the Mergui Archipelago (Naumov, 1971) (although the possibility cannot be dismissed that the high apparent total mortality of R. brachysoma reported here is actually an artefact, caused, for example, by emigration of large fish from the fishing grounds).

Similarly, the high total mortality and exploitation rate of the Indian threadfin, Polynemus indicus, reflects the fact that this fish - which is one of the few marine fish actually sought after in Burma - is exploited rather intensively in its relatively small area of occurrence.

The mortality and exploitation rate estimates for N. japonicus, which are based on data from the whole Burma coast, are extremely low, e.g., the estimated values of Z are close to the mean estimate of M in nemipterids of Weber and Jothy (1977) and are thus in agreement with what is known of the present state (low) of exploitation of the overall demersal stock off Burma.

The recruitment patterns of R. brachysoma and N. japonicus, finally, suggest the occurrence of two pulses of recruitment per year, as reported from other areas of Southeast Asia (Pauly and Navaluna, 1983).

Overall, the results confirm that a large number of useful inferences can be drawn from length-frequency data, provided care is taken to ensure representativeness and that appropriate methods are used for their analysis.

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Table 1

LENGTH-FREQUENCY SAMPLES AVAILABLE FOR THE STUDY OF *RASTRELLIGER BRACHYSOMA* FROM THE MERGUI ARCHIPELAGO, 1966-1968 (FROM DRUZHININ, 1970a; NUMBERS INDICATE SAMPLE SIZES)

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
Year													
1966	-	-	-	-	-	-	-	105	-	507	100	-	712
1967	-	395	417	-	927	287	116	178	384	800	-	-	3 504
1968	-	852	100	199	1 235	488	-	-	400	-	-	-	3 774
Total	-	1 247	517	199	2162	775	116	283	784	1 307	100	-	7 490

Table 2

GROWTH PARAMETERS OF *RASTRELLIGER BRACHYSOMA* IN VARIOUS AREAS OF SOUTHEAST ASIA[a/]

Area	L_∞	K	ϕ'	Remarks	Author
Inner Gulf of Thailand	20.9	3.38	3.17		Hongskul (1974)[b/]
Inner Gulf of Thailand	20.9	4.2	3.26		Somjaiwong *et al.*, 1972[b/]
Gulf of Thailand (10°N, 100°E)	20	3.53	3.15	January brood	Sucondharman *et al.*, 1970[b/]
Gulf of Thailand (10°N, 100°E)	19.6	4.14	3.2	July brood	Sucondharman *et al.*, 1970[b/]
Indonesia (Tanjung Satai)	22.9	2.28	3.08		Sudjastani (1974)
Burma Coast	27	(0.965)	(2.84)	Data not corrected for selection effects	Present study
Burma Coast	27	1.6	3.07	Data corrected for selection effects	Present study

a/ All growth parameter estimates based on analysis of length-frequency data; also note that *R. brachysoma* reaches a length of 24-25 cm in Southeast Asia

b/ These authors refer to *R. brachysoma* as *R. neglectus*, a junior synonym

Table 3

LENGTH-FREQUENCY DATA USED FOR ESTIMATING Z AND THE SELECTION CURVE IN INDIAN THREADFINS (*POLYNEMUS INDICUS*) CAUGHT IN THE DELTA AREA, BURMA COAST (SEE TEXT FOR METHODS USED TO POOL L/F DATA)

Median of length class (in cm)	January	February	March	August	October	December
15	-	-	2	-	2	-
25	-	-	21	-	21	-
35	16	-	26	-	26	-
45	84	-	20	12	18	-
55	244	-	28	55	21	5
65	331	-	28	76	17	10
75	399	1	11	95	10	-
85	543	16	30	58	23	2
95	327	19	17	15	5	4
105	54	1	6	5	3	-
115	27	-	7	3	-	-
125	24	1	1	-	-	-
135	5	-	-	-	-	-
145	1	-	-	-	-	-
Total	2 055	38	197	319	146	21

Table 4

DATA USED FOR DERIVING THE LENGTH-WEIGHT RELATIONSHIP OF *NEMIPTERUS JAPONICUS* OFF BURMA (FROM SAMPLES COLLECTED DURING THE SURVEYS OF R/V *DR FRIDTJOF NANSEN*; DASHES INDICATE VALUES THAT WERE PROBABLY ERRONEOUS AND THEREFORE OMITTED)

Station: $\bar{L}$ (cm)	301 n/w	277 n/w	322 n/w	321 n/w	215 n/w	213 n/w	204 n/w	203 n/w	202 n/w	185 n/w	183 n/w	180 n/w	175 n/w	160 n/w	153 n/w	152 n/w	147 n/w	142 n/w	139 n/w	Σw	Σn	$\bar{W}$ (g)
9.5														8/0.14					18/0.20	0.34	26	13.1
10.5														15/0.28	–				15/0.20	0.48	30	16.0
11.5						2/0.05				–		8/0.2		40/0.78	6/0.08	5/0.14	14/0.31	12/0.33	72/1.28	3.17	159	19.9
12.5						5/0.16			2/0.03	–		16/0.44		76/1.85	20/0.42	20/0.52	5/0.13		90/2.04	5.59	234	23.9
13.5						3/0.1			3/0.09	96/2.57		11/0.32	12/0.32	47/1.34	28/0.77	31/0.97	16/0.53		81/2.17	9.18	328	28.0
14.5	1/0.041	1/0.05				2/0.09		–	3/0.10	57/1.83	9/0.33	17/0.67	10/0.34	13/0.54	22/0.71	24/0.93	14/0.53	14/0.65	40/1.55	8.361	227	36.8
15.5	1/0.055	4/0.15			3/0.17	11/0.55		–	5/0.25	45/1.73	14/0.72	12/0.55	27/1.19	15/0.43	12/0.44	15/0.72	14/0.65		12/0.47	8.075	190	42.5
16.5		7/0.35	–		2/0.12	1/0.06		7/0.46	4/0.23	5/0.23	9/0.59	21/1.20	6/0.37	–	–	2/0.14	4/0.23	23/1.38	5/0.24	5.60	96	58.3
17.5		3/0.27			3/0.24	5/0.35		4/0.36	2/0.13	11/0.63	13/0.85	9/0.62	13/0.89		2/0.11	3/0.23	2/0.13		3/0.17	4.98	73	68.2
18.5	2/0.16	7/0.55		–	2/0.15	1/0.1		3/0.31	7/0.50	18/1.19	10/0.84	7/0.77	10/0.80		5/0.37			12/1.10		6.84	84	81.4
19.5	7/0.62	7/0.60			4/0.42	2/0.2		5/0.53	9/0.80	8/0.62	4/0.40	11/1.24	13/1.22		4/0.35					7.00	74	94.6
20.5	3/0.31	7/0.75	6/0.74	4/0.58	4/0.49			2/0.30	12/1.20		5/0.57	14/1.55	4/0.47		8/0.84			6/0.74		8.54	75	114
21.5	5/0.58	7/0.85		2/0.30	6/0.77	6/0.81	1/0.12	7/0.95	12/1.53	1/0.10	4/0.54	8/1.10	7/0.94		2/0.24			5/0.7		9.53	73	130
22.5	2/0.26	6/0.80	2/0.26	1/0.17	3/0.43	2/0.32	2/0.28	5/0.78	6/0.87		2/0.33	11/1.68	5/0.68		1/0.13					6.99	48	146
23.5	1/0.16	1/0.15		6/0.98	6/1.03	5/0.81		6/1.05	–		2/0.43	7/1.23	4/0.68		1/0.15					6.67	39	171
24.5		2/0.35			10/1.82	5/1.0	2/0.32	5/1.01	5/0.90			12/2.45	1/0.19							8.04	42	191
25.5		–		1/0.22	7/1.46	4/0.8	1/0.19	7/1.46	6/1.17		5/1.11	6/1.28			1/0.21					7.90	38	208
26.5		1/0.35	1/0.35		10/2.40	3/0.7	2/0.46	1/0.30				6/1.43			1/0.22					6.210	25	248
27.5		2/0.75	1/0.37	1/0.31	3/1.27	1/0.3														3.00	8	375
28.5					4/1.10	5/1.45	1/0.24													2.79	10	279
29.5					2/0.63	2/0.62														1.25	4	312
30.5					2/0.72															0.72	2	360
32.5					3/1.35															1.35	3	450
35.5					1/0.55															0.55	1	550

n = number
w = weight (kg)

Table 5

POOLED LENGTH-FREQUENCY DATA OF *NEMIPTERUS JAPONICUS*, 1979-1982
(RAKHINE COAST AND DELTA AREA, SEE TEXT)

Median of length class (in cm)	March	April	May	August	September	October	November
5	-	-	-	-	-	-	2
7	-	-	-	-	-	-	12
9	434	146	-	-	-	-	24
11	3 305	4 092	-	-	-	78	19
13	14 709	4 205	-	3	-	202	280
15	9 354	2 574	-	15	3	208	619
17	1 621	141	68	25	23	160	411
19	643	64	238	57	68	80	351
21	477	110	306	64	3	173	92
23	250	30	1 190	105	5	73	83
25	119	7	612	63	-	34	43
27	39	9	306	50	-	20	13
29	-	-	-	28	-	-	26
31	-	-	-	27	-	-	-
33	-	-	-	18	-	-	-
35	-	-	-	-	-	-	-
Total	30 951	11 378	2 720	455	130	1 028	1 980

Table 6

POOLED LENGTH-FREQUENCY DATA OF *NEMIPTERUS JAPONICUS*, 1979-1982
(NORTHERN AND SOUTHERN TENASSERIM COAST, SEE TEXT)

Median of length class (in cm)	March	April	August	October	November	December
11	10	-	-	4	32	-
13	129	-	3	116	346	-
15	132	-	15	120	900	84
17	238	-	25	141	478	98
19	99	96	68	190	490	98
21	208	90	85	222	413	49
23	121	84	123	72	276	56
25	172	30	84	7	35	49
27	36	-	64	3	18	7
29	42	-	45	-	-	-
31	-	-	28	-	-	-
33	2	-	18	-	-	-
35	1	-	-	-	-	-
Total	1 190	300	558	875	2 988	441

Table 7

GROWTH PARAMETERS OF *NEMIPTERUS JAPONICUS* IN VARIOUS AREAS OF THE INDO-PACIFIC[a]

Area	L_{∞}	K	Ø'	Remarks	Author
India (Andhra-Orissa)	30.5	0.314	2.47	1964–1965	Krishnamoorthi (1971)
India (Andhra-Orissa)	20.9	0.648	2.45	1955–1966 "draught period"	Krishnamoorthi (1971)
India (Andhra-Orissa)	30.7	0.294	2.44	1966–1967	Krishnamoorthi (1971)
Hong Kong	34.1	0.19	2.34	females	Lee (1973)
Hong Kong	38.2	0.13	2.27	males	Lee (1973)
Northern Borneo	28.9	0.47	2.59	based on data in Weber and Jothy (1977)	Pauly (1978)
Northern Burma	37.0	0.235	2.51	based on data in Table 5	this study
Southern Burma	37.0	0.243	2.52	based on data in Table 6	this study

a/ All growth parameter estimates based on analysis of length-frequency data, except those of Lee (1973), which are based on aging through scales and otoliths

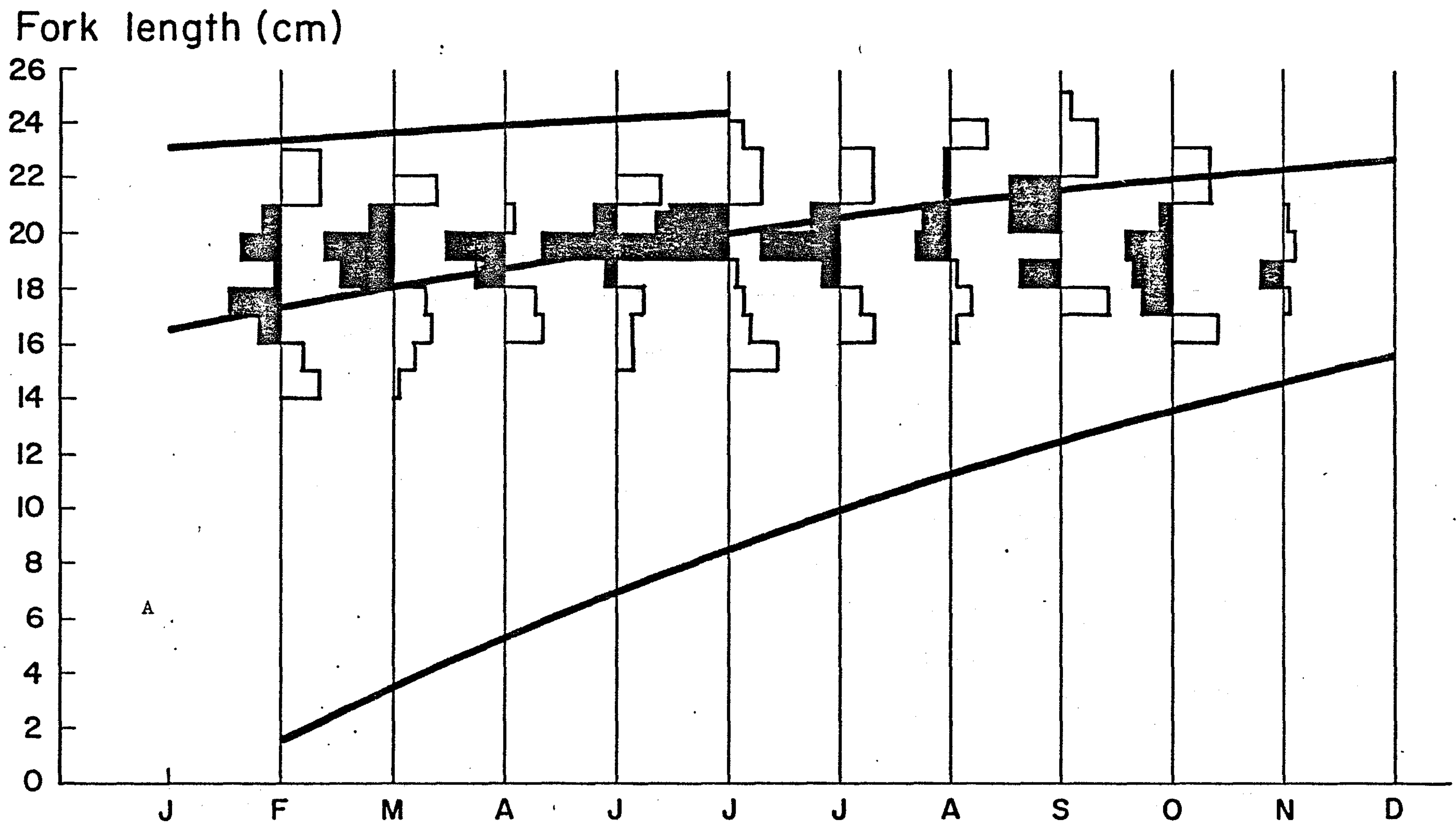


Fig. 1A. Growth of Rastrelliger brachysoma as estimated by ELEFAN I from data not corrected for selection (see also Table 2 and text).

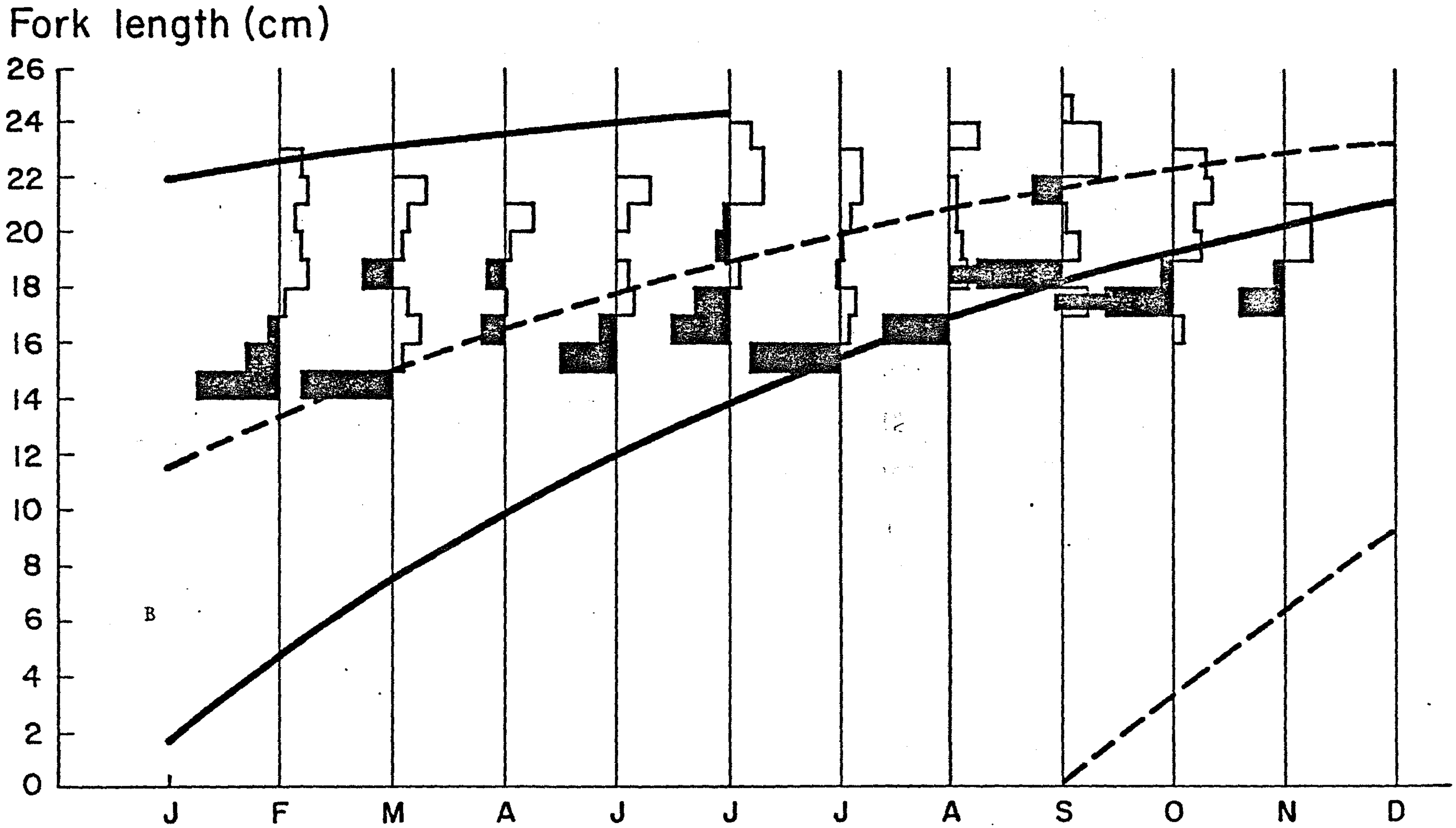
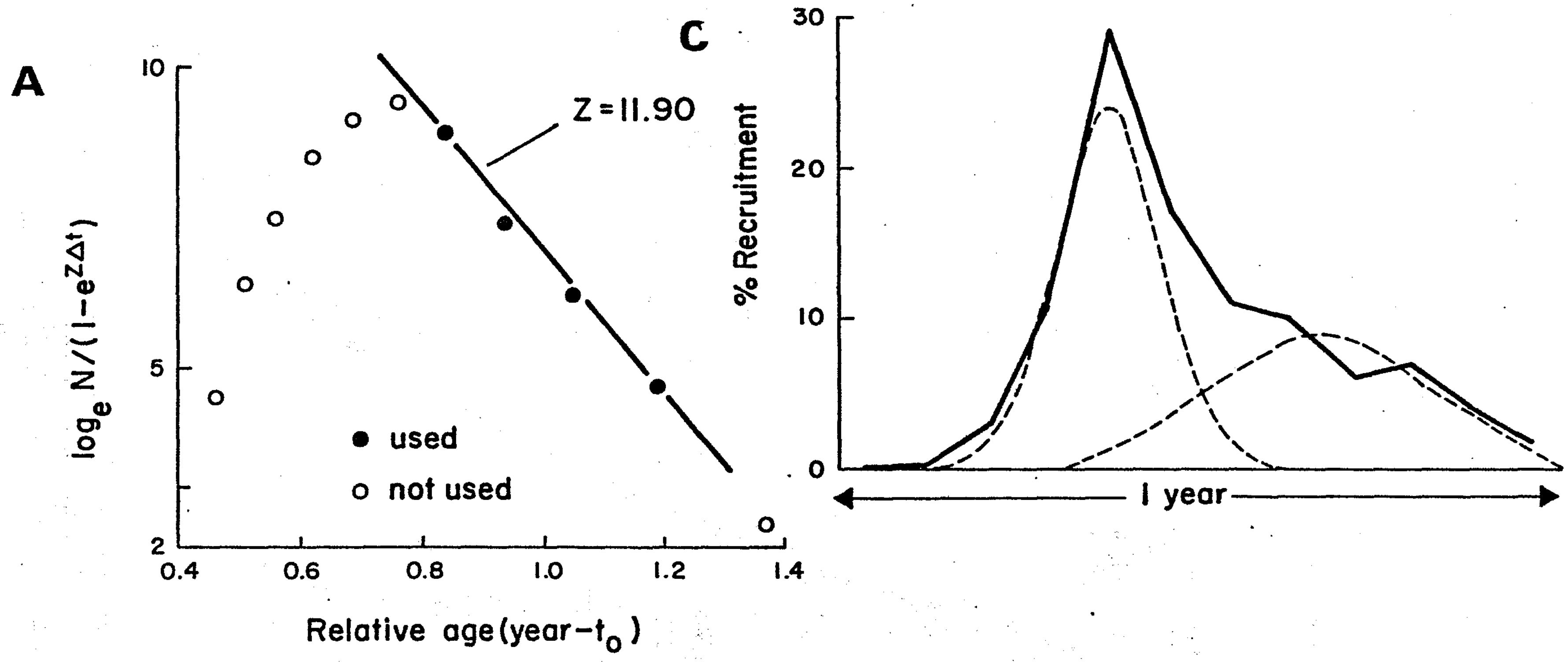


Fig. 1B. Growth of Rastrelliger brachysoma as estimated by ELEFAN I from data corrected for selection (see also Table 2 and text).



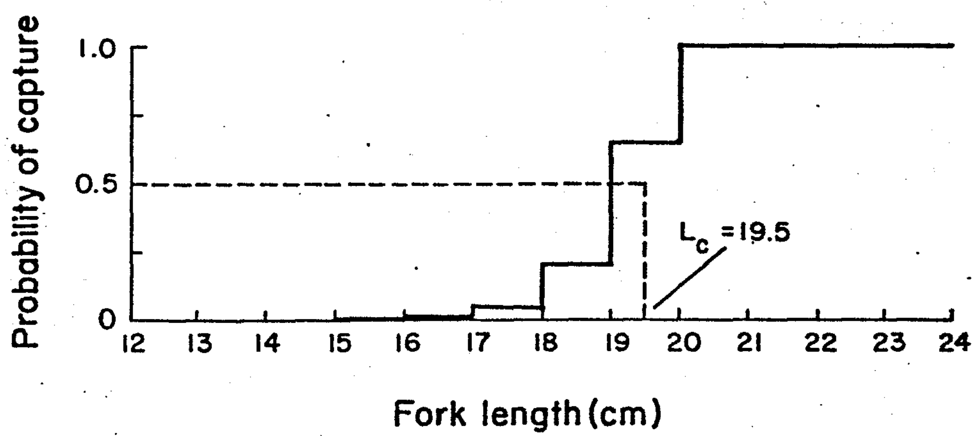


Fig. 2A. Length-converted catch curve.
B. Selection pattern (resultant curve).
C. Recruitment pattern for Rastrelliger brachysoma caught with purse seines in the Mergui Archipelago, Burma, 1966 to 1968. Note high apparent total mortality ($Z = 11.9$) and mean length at first capture ($L_c = 19.5$) and biannual pulses of recruitment

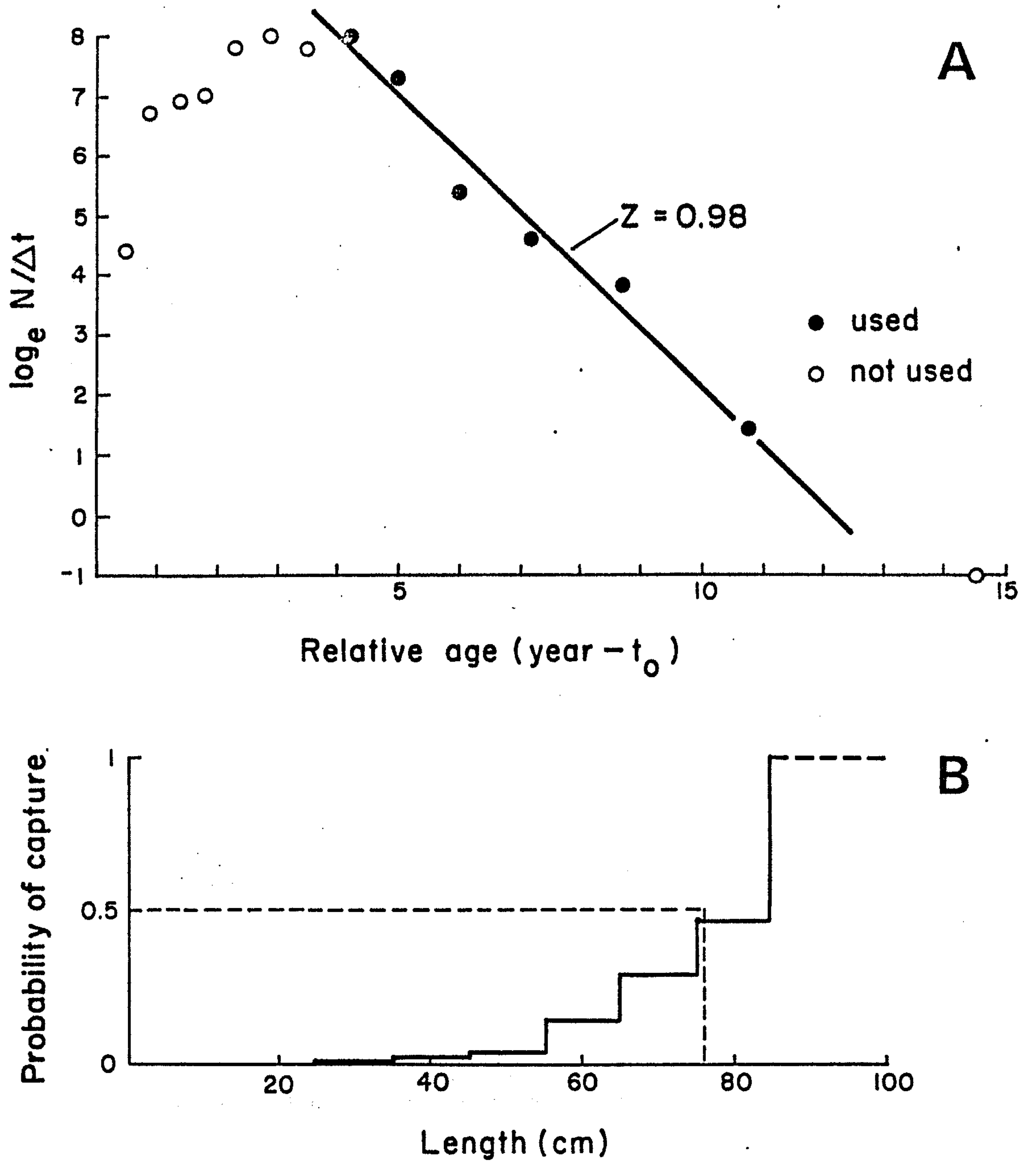


Fig. 3A. Length-converted catch curve.
B. Resultant curve (selection x recruitment)for <u>Polynemus indicus</u> caught in the Delta area, Burma Coast. The estimated mean size at first capture is 75.2 cm.

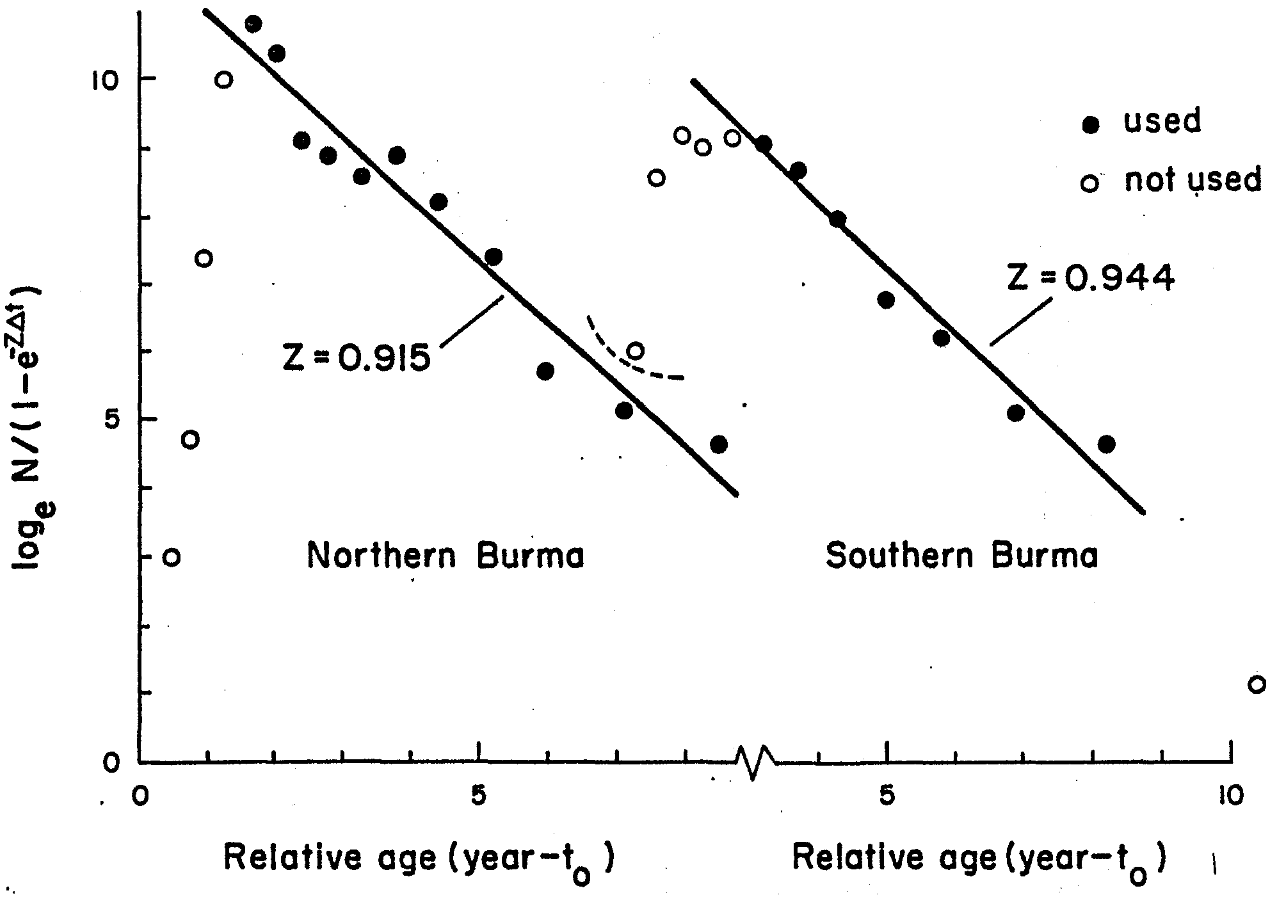


Fig. 4 Length-converted catch curves of <u>Nemipterus japonicus</u> off the coast of Burma. Note similarity of estimates of total mortality for Northern and Southern Burma.

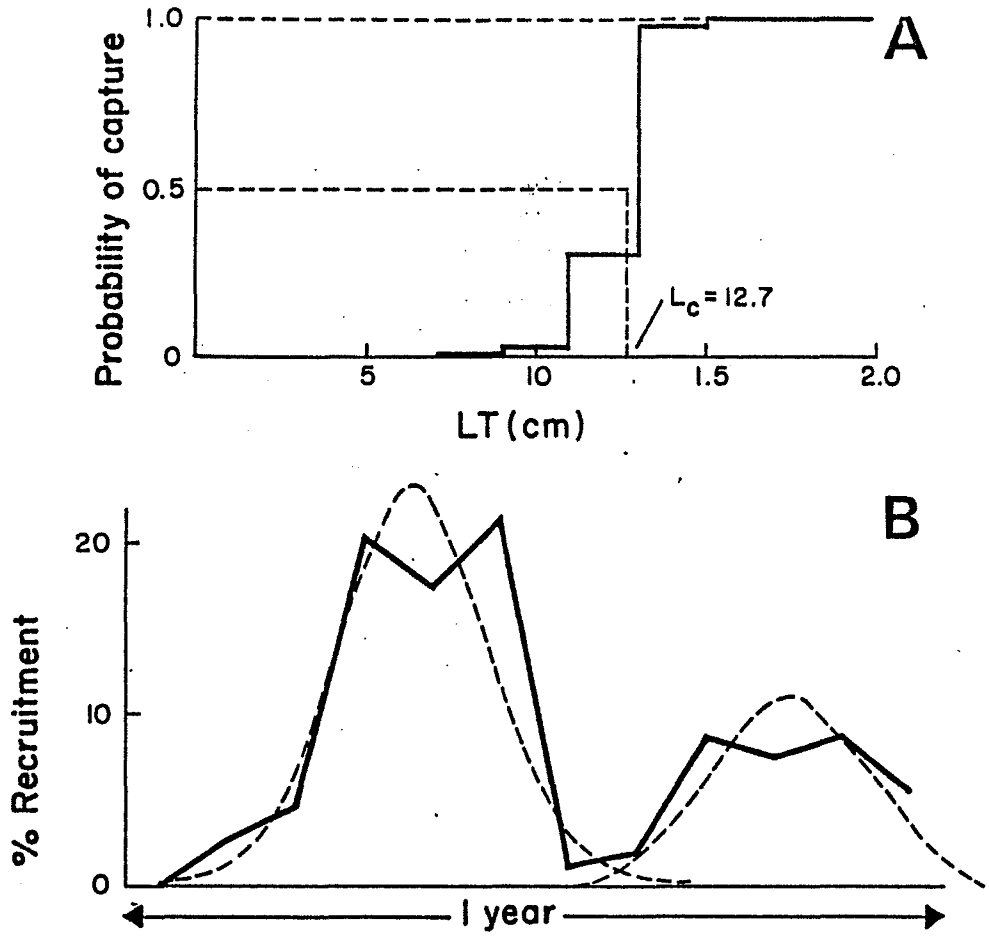


Fig. 5A. Selection pattern (resultant curve) of Nemipterus japonicus off Burma, with estimated mean length at first capture = 12.7 cm.

B. Recruitment pattern of Nemipterus japonicus off Burma. Note marked separation of the two pulses of recruitment

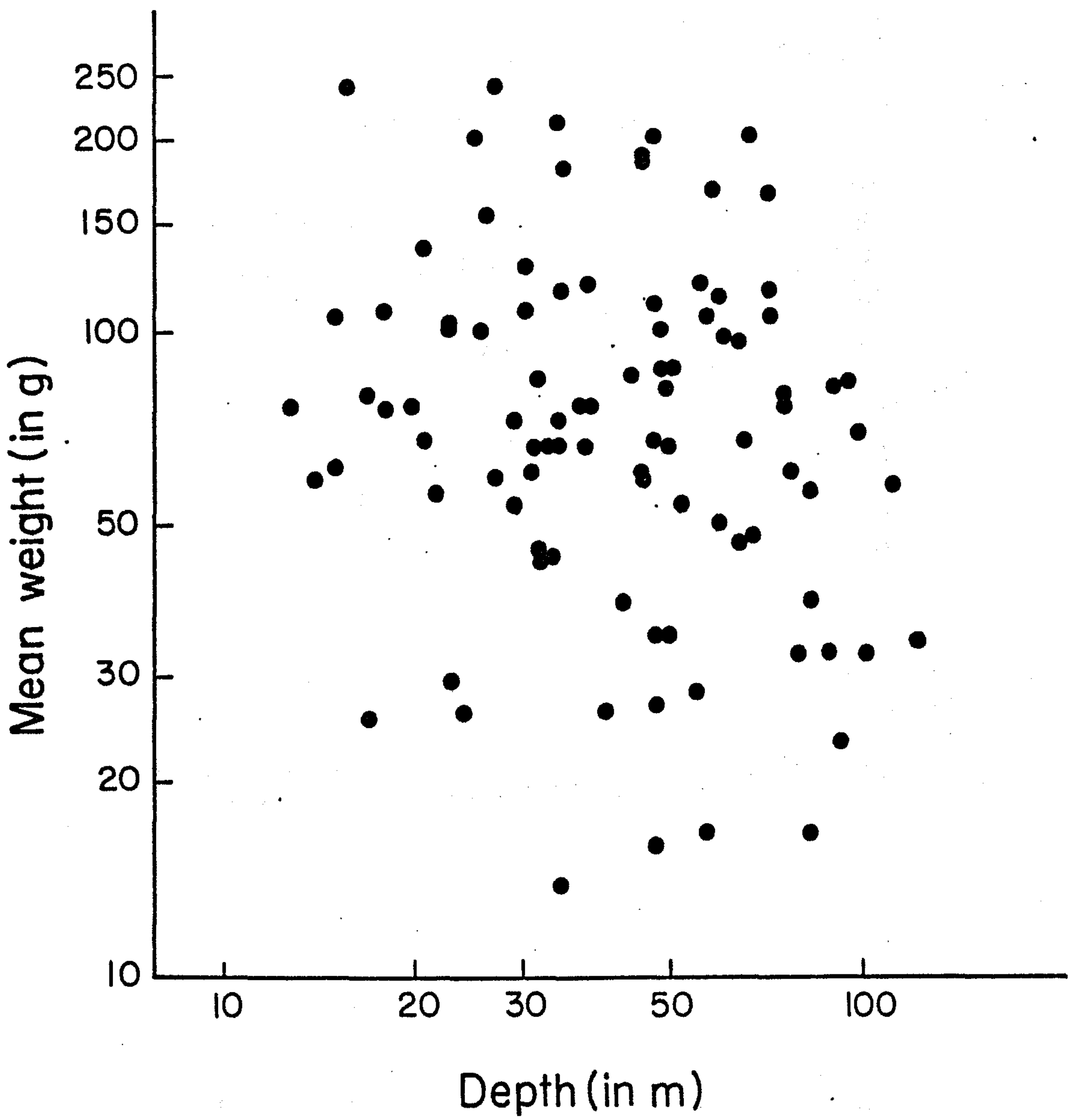


Fig. 6 Plot of log mean body weight of Nemipterus japonicus on log sampling depth. Based on data obtained during the 1979 and 1980 surveys of the R/V "Dr. Fridtjof Nansen" off Burma. Note lack of any direct relationship between body weight and depth.