

GILLRAKER ANALYSIS OF THE INDO-PACIFIC CHUB MACKEREL,
RASTRELLIGER NEGLECTUS (VAN KAMPEN)

by

V. Hongskul
Research Biologist
Marine Fisheries Laboratory, Department of Fisheries,
Bangkok, Thailand

ABSTRACT

This paper presents the results of the analyses of the numbers of gillrakers and the lengths of the gillrakers of the Indo-Pacific mackerel (*Rastrelliger neglectus* van Kampen), in the Gulf of Thailand. It establishes the number of gillrakers and the positions of the longest gillraker of the mackerel. However, no definite conclusion can be drawn as to the distinct differences in the gillraker counts and in the lengths of the gillrakers of the fish sampled from various locations along the coast of the Gulf of Thailand.

INTRODUCTION

The Department of Fisheries has carried out the Indo-Pacific Mackerel Project in order to discover causes of the fluctuation in the yield of this resource since 1958 (Menasveta, 1965), but due to the limited budget for the mackerel research, the systematic study has actually been carried out since 1961. In this connection, it is essential that stock identification and population distribution be known.

The analysis of tagging experiments, spawning grounds, surveys, and other investigations indicate that there may exist more than one stock of mackerel, one inhabiting the Eastern coast the other inhabiting the Western coast, in the Gulf of Thailand. To test the hypothesis, a program utilizing morphometric measurements and meristic counts of selected physical characters of the species was initiated in 1964.

The separation of the fish may be based upon the differences in the complement of gillrakers of the fish. Several workers have reported evidence of difference within the fish population based on gillraker counts (Pritchard, 1945; Fukuhara and others, 1962 and Perry & Barrett, 1963).

The purpose of this study was to determine if discrete populations of chub mackerel in the Gulf of Thailand could be identified on the basis of consistent differences in gillraker analysis of this fish sampled from various locations along the coast of the Gulf.

MATERIALS AND METHODS

A. Sampling locations

In this study, the Gulf of Thailand was arbitrarily divided into four fisheries statistical areas: the inner gulf, the upper western coast, the lower western coast and the eastern coast respectively (Fig. 1). The materials were sampled monthly at random from each area in the year 1964. There were 491 chub mackerel (*R. neglectus*) as indicated in Table I.

TABLE I
LOCATIONS AND DATES OF COLLECTED FISH SAMPLES
IN THE STUDY OF CHUB MACKEREL'S GILLRAKER

Fisheries Area	No. of sample	Location (provinces)	Dates	Sample Size	Total
I	A	Samut-sakorn	Nov. 3, 1964	40	149
	B	Samut-sakorn	Dec. 3, 1964	40	
	C	Samut-sakorn	Dec. 5, 1964	29	
	D	Cholburi	Dec.29, 1964	40	
II	A	Chumphorn	Apr. 4, 1964	24	166
	B	Chumphorn	Apr. 8, 1964	20	
	C	Surajtani	June 9, 1964	32	
	D	Prachuab	Oct. 6, 1964	27	
	E	Chumphorn	Oct. 9, 1964	20	
	F	Chumphorn	Oct.10, 1964	23	
	G	Surajtani	Dec. 1, 1964	20	
IV	A	Trat	Oct.27, 1964	27	176
	B	Rayong	Oct.31, 1964	20	
	C	Trat	Nov.25, 1964	39	
	D	Trat	Nov.26, 1964	30	
	E	Trat	Nov.26, 1964	40	
	F	Trat	Nov.26, 1964	20	
Grand Total:					491

B. Examination of Gillrakers

The samples of the mackerel were preserved with 10% formaldehyde right after capture and taken to the laboratory for examination. Individual fish in each sample was measured for standard length and total length (dorsal extreme length) of the body. The 'Standard length' means the length from the tip of snout to the base of caudal peduncle, while the 'Total length' is the length from tip of snout to the end of the longest ray of the upper lobe of the caudal fin that moves to median axis. The measurements were made with a standard measuring - board and were recorded to the nearest millimeter.

After the measurements, the first left gillarch of an individual fish was removed (Fig. 2). Counting and measuring the length of each gillraker (Fig. 3) to nearest millimeter were made. In this study it was assumed that the bilateral variations in the number of gillrakers and their lengths were insignificant and may be disregarded. The gillrakers on the upper and lower branches of the left gillarch were examined separately by using the joint of these branches as origin (Fig. 4).

C. Statistical treatment of data

In order to study the general characteristics of the chub mackerel (*R. neglectus*) gillrakers, some statistical parameters of each sample were obtained (Table III using the analysis of variance outlined by Onate (1963) to indicate the intra-area and inter-area variations of the number of gillrakers.

This paper also presents relationships between the number and the lengths of gillrakers with the size of the fish.

RESULTS AND DISCUSSION

I. Number of gillrakers of the Indo-Pacific mackerel in the Gulf of Thailand

A. Number of gillrakers on the upper branch of the first gillarch

A total of 449 gillarches of the sampled fish was examined in order to determine the number of gillrakers on the upper branch of the gillarch (materials that had un-completed end were omitted).

TABLE II

GILLRAKER COUNTS OF THE SAMPLED
CHUB MACKEREL (*RASTRELLIGER NEGLECTUS*)

A. Number of gillrakers on the upper branch of the first gillarch.

Area	Number of gillrakers								Total
	15	16	17	18	19	20	21	22	
I	3	13	21	26	33	30	15	3	144
II	4	6	15	43	45	29	6	2	150
III	1	5	18	37	54	19	17	4	155
Total	8	24	54	106	132	78	38	9	499
Percentage	1.78	5.34	12.03	23.61	29.40	17.37	8.46	2.00	100

B. Number of gillrakers on the lower branch of the first gillarch of
R. neglectus.

Area	Number of gillrakers								Total
	32	33	34	35	36	37	38	39	
I	3	4	16	33	43	32	11	-	142
II	4	8	24	36	44	33	10	1	160
III	3	9	13	46	56	34	7	-	168
Total	10	21	53	115	143	99	28	1	470
Percentage	2.13	4.47	11.80	24.47	30.42	21.06	5.96	0.21	100

C. Total number of gillrakers on the first left gillarch of
R. neglectus.

Area	Number of gillrakers													Total
	47	48	49	50	51	52	53	54	55	56	57	58	59	
I	-	-	4	4	7	19	12	21	26	18	13	10	4	138
II	1	-	2	2	7	21	25	29	19	22	10	8	1	147
III	-	-	2	5	6	9	26	28	23	24	14	8	3	148
Total	1	-	8	11	20	49	63	78	68	64	37	26	8	433
Percentage	0.23	-	1.85	2.54	4.62	11.32	14.5	18	15.7	14.8	6.0	1.85	100	

TABLE III

AVERAGE NUMBERS OF GILLRAKERS OF
R. NEGLECTUS SAMPLED FROM DIFFERENT AREAS

Position	Sample Size	Number of gillrakers					
		Mode	Range		Standard error	c.v. (X) %	
			Mean	s.d.			
Upper Branch	I	144	19	18.6528	+ 1.6186	0.1349	0.7232
	II	150	19	18.6000	+ 1.3411	0.1095	0.5887
	IV	155	19	18.8258	+ 1.3682	0.2099	0.5838
Total	449	19	18.6949	+ 1.4448	0.0682	0.3647	
Lower Branch	I	142	36	35.7535	+ 1.3272	0.1114	0.3116
	II	160	36	35.6250	+ 1.2606	0.1123	0.3157
	IV	168	36	35.6250	+ 1.2606	0.0972	0.2720
Total	470	36	35.6404	+ 1.3353	0.0616	0.1728	
Total	I	138	55	54.3913	+ 2.3690	0.2017	0.3708
	II	146	54	54.1644	+ 2.0343	0.1684	0.3109
	IV	148	54	54.4594	+ 2.1233	0.1745	0.3204
Total	432	54	54.3380	+ 2.1749	0.1046	0.1925	

Table IIA, summarizes the results which indicate that the number of gillrakers on the upper branch of the first gillarch was between 15-22 but mostly 18-20. The average number of gillrakers of the fish sampled from various areas were nearly the same (Table III) and the modes were the same in the three areas (Fig. 5).

The range of average number was approximately 18.69 + 1.44. This result is good because of the low standard error and the coefficient of variation.

The average number of gillrakers on the upper gillarch from area I could be compared with the results that were reported by Banasopit (1962) as follows:

	<u>Banasopit (1962)</u>	<u>Hongskul (1965)</u>
Sample size (Area I)	191	144
Number of gillrakers on the upper branch	17-22	15-22
- mostly	20	19
- average mean and range	19.597 + 0.062	18.6528 + 1.6186

There seems to be some slight difference which should be investigated in the future.

B. Number of gillrakers on the lower branch of the first gillarch

The result of 470 gillraker counts (Table IIB) showed that the number of gillrakers on the lower branch were approximately 32-39, mostly 36, which differed from the numbers reported previously by Rofen (1963).

Table III indicated that the average number was 35.64 + 1.33 by which the standard error was 0.0616 and the coefficient of variation was 0.1728%. In comparing with those reported by Holt (1959) and Banasopit (1962) the differences seem to be insignificant.

C. Total number of gillrakers

According to Table IIC, the result of 433 gillraker counts showed that the total number of gillrakers of *R. neglectus* was between 49 and 59, mostly 53-56. The average number from the three areas (Table III) was 54.33 + 2.17 which seemed to be good because of the low percentage of coefficient of variation.

In conclusion, total number of gillrakers of the Indo-Pacific chub mackerel (*Rastrelliger neglectus*) was approximately 53 - 56 (54 mostly), which divided into 18 - 20 (19 mostly) on the upper branch and 35 - 37 (36 mostly) on the lower branch of the first gillarch on the left side of the fish.

II. Intra-area Variations in the Number of Gillrakers

Besides the differences in the time and locations of the samples taken in this study, there may be some variations between samples within the same area that must be analysed before the evolution of the intra-areas variation.

A. Variation within Area I

The result of the analysis of variance on the numbers of gillrakers (lower branch) of the mackerel sampled from various locations within Area I indicated that there were highly significant differences within the samples (Table IV).

TABLE IV

ANALYSIS OF VARIANCE ON THE NUMBERS OF LOWER BRANCH'S GILLRAKERS
OF THE MACKEREL SAMPLED FROM VARIOUS LOCATIONS WITHIN AREA I

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-value
Total	141	248.3732	-	
Between-group	3	60.7378	20.2459	14.8899**
Within-group	138	187.6354	1.3597	

** P / 0.01

In order to find out the samples that caused highly significant difference within samples from Area I, the L.S.D. (Least Significant Difference) method was applied (Onate, 1963). The result showed the separation between the groups of samples within Area I, at 95% level of significance, as follows:

A B D C

It means that sample in Group B is not significantly different from Group A and D, but the sample of Group C differed from the others. The sample group C was removed from the total analyses within Area I and the analyses of the inter-area variation was conducted again. The result, showed some significant variation but at the 95% level, as shown in Table V.

TABLE V

ANALYSIS OF VARIANCE ON THE NUMBERS OF LOWER BRANCH'S GILLRAKERS
OF THE MACKEREL SAMPLED FROM VARIOUS LOCATIONS WITHIN AREA I
(SAMPLE GROUP C WAS REMOVED)

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-value
Total	114	126.7827	-	
Between-group	2	9.8881	4.9440	4.7369*
Within-group	112	116.8946	1.0437	

* P / 0.05

B. Variation within Area II

The result of the analysis of variance showed that there were significant difference within samples (Table VI).

TABLE VI

ANALYSIS OF VARIANCE ON THE NUMBERS OF LOWER BRANCH'S GILLRAKERS OF THE MACKEREL SAMPLED FROM VARIOUS LOCATIONS WITHIN AREA II

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-value
Total	159	321.1	-	
Between-group	6	32.7343	5.4557	2.8947*
Within-group	153	288.3657	1.8847	

* $P < 0.05$

By using L.S.D. method, it was found that the significant difference between samples within Area II was due to the sample group F :

C G E D B A F

When the sample group F was drawn out, the result of analysis of variance indicated that there were no more significant difference among sample (Table VII), on the other hand, the samples from Area II (group F was excluded) were homogeneous and could be used as the representative character of mackerel's gillraker of the Area II.

TABLE VII

ANALYSIS OF VARIANCE ON THE NUMBERS OF LOWER BRANCH'S GILLRAKERS OF THE MACKEREL SAMPLED FROM VARIOUS LOCATIONS WITHIN AREA II (GROUP F WAS REMOVED)

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-value
Total	136	248.5402	-	
Between-group	5	7.6545	1.5309	0.8325
Within-group	131	240.8857	1.8388	

Besides, the homogeneity in samples that were collected at different times and places indicate that, probably, the number of mackerel's gillraker does not vary with location and season within the same area.

C. Variation within Area IV

The result of analysis of variance showed that there were a significant difference in the number of lower branch's gillraker of mackerels from various places within Area IV (Table VIII).

TABLE VIII

ANALYSIS OF VARIANCE ON THE NUMBERS OF LOWER BRANCH'S GILLRAKERS OF THE MACKEREL SAMPLED FROM VARIOUS LOCATIONS WITHIN AREA IV

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-value
Total	167	265.38	-	
Between-group	5	20.27	4.0504	2.6794*
Within-group	162	245.11	1.5130	

* $P / 0.05$

In order to detect which groups of samples that contributed to the significant variation between group, L.S.D. method was again used to find out the separation within sample groups. The resulted relationship is as follows:

E F D C A B

It seemed that the samples from Area IV were separated into two groups, the minimum group which consists of A, B and C was drawn out from the analysis. The rest are proved, and as a result, there is no variation (Table IX).

TABLE IX

ANALYSIS OF VARIANCE ON THE NUMBERS OF LOWER BRANCH'S GILLRAKERS OF THE MACKEREL SAMPLED FROM VARIOUS LOCATIONS WITHIN AREA IV (GROUPS A, B AND C WERE REMOVED)

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-value
Total	120	181.24	-	
Between-group	3	6.27	2.0900	1.3975
Within-group	117	174.97	1.4955	

III. Inter-area Variations in the Number of Gillrakers

In order to find out the difference of the number of gillrakers among the fisheries areas, the variation of gillrakers in various areas had again been analyzed by means of the analysis of variance and the L.S.D. method. The representative data of each area was the sample groups that had been tested in section II. Table X indicates the significant variations in the numbers of gillrakers of the fish sampled from the four areas.

TABLE X

ANALYSIS OF VARIANCE ON THE NUMBERS OF LOWER BRANCH'S GILLRAKERS OF THE MACKEREL SAMPLED FROM VARIOUS AREAS

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-value
Total	372	562.89	-	
Between-group	2	30.14	15.07	10.4653**
Within-group	370	532.75	1.44	

** P / 0.01

The result of L.S.D. analysis showed that the number of gillrakers on the lower branch of the first gillarch of Area IV sample did not differ significantly from Area I and II, but in the later two areas there were a significant - difference as follows:

- a) An average number of gillrakers in Area I = 35.0435
- b) An average number of gillrakers in Area II = 35.7372
- c) An average number of gillrakers in Area IV = 35.8016

The average numbers of the lower branch's gillrakers were different from the total average in each area as indicated in Table III. This is because the numbers of the lower branch's gillrakers were selected from the sample groups that were major groups in each area which had been tested in Section II.

IV. The relationship between total body length and the number of gillrakers

In order to find out whether the numbers of gillrakers vary with the sizes of the chub mackerel, the relationship between the total body

length (LX) and the number of lower branch gillrakers had been studied by finding out the correlation coefficient (Snedecor, 1946) between these two factors. The calculated "r" value was 0.1126, having a significant value at 99% confidence level. However, r-value did not have significance at 95% confidence level on the other hand, there was no correlation between the numbers of gillrakers and the size of the fish.

V. The relationship between standard body length and the number of gillrakers

Several workers have reported the relationship between the standard body length (LB) and the number of gillrakers, for example, as a curvilinear relationship in the clupeoid (Perry & Barrett, 1963). In this study, the calculated coefficient of correlation (r) was 0.1316 ($P < 0.01$). It is, therefore, not definite in the case of mackerel that there is a positive relationship between the numbers of gillrakers and the size of the fish both in terms of the total length or standard length.

VI. The Lengths of the Indo-Pacific Mackerel

Each gillraker on the first left gillarch of the sampled fish was measured to the nearest millimeter. The following are the results of those measurements:

1. The average length of the upper branch gillrakers.

The first one (from the joint) was 1.30 centimetres.
The last one (the 21 or 22nd) was 0.15 centimetres.

2. The average length of the lower branch gillrakers.

The first one (from the joint) was 1.36 centimetres.
The longest one (in the middle) was 1.77 centimetres.
The last one (the 38th or 39th) was 0.15 centimetres.

(Average valuable of 96 samples from Area II).

In this investigation, we observed the graded lengths of the gillrakers. Starting from the last gillraker on the upper branch, the gillrakers became longer until the one in the middle of the lower branch because the longest. From then on, they became shorter and shorter until they were nearly as long as the beginning (Fig. 8).

In each gillarch, the positions of the longest gillrakers were between the 9th and 21st on the lower branch. In some gillarches, there were more than one longest gillraker. Because of this, the average position of the gillraker that has a maximum length was determined by finding out the frequency distribution of the position of maximum - length gillraker (Fig. 9). Statistical analysis showed that the average position was 15.77, 2.25 and the coefficient of variation in this case was 0.5872%. Hence this study shows that the longest gillraker may be located between gillraker numbers 13 and 18 on the lower branch of the gillarch in the Indo-Pacific mackerel.

VII. The relationship between the total body length and the maximum length of the gillraker

In order to study the variation of the maximum length of the gillraker with the size of the fish, the correlation coefficient of these two factors was computed. The result was that $r = 0.7030$, which was highly significant ($P < 0.01$). This showed that the longest gillrakers varied with the length of the mackerel under study.

However, when the maximum length of gillraker was plotted against the total body length, the curvilinear relationship was observed (Fig. 10).

To find out the characteristics of this relationship, both the length of the gillraker and the fish were expressed logarithmically so that the curvilinear relationship would be changed into a straight - line relationship in the form of $Y = a + bX$.

Where, $\text{Log } G = Y$ (G = the maximum length of gillraker)
 $\text{Log } L = X$ (L = the total body length of mackerel)
 $a = Y$ - intercept (when $X = 0$)
 and $b =$ the increasing rate of gillraker's length according to the increased size of body length, which was the slope of the regression line.

By using the least square method, the above equation could be established. The resulting estimates of the relation between total body length and the maximum length of gillraker are:

Area :	I	II	IV	Total
Sample size (N)	149	145	97	391
Correlation coefficient (r)	0.9020**	0.9113**	0.9785**	0.9410**
Y - intercept (a)	- 1.4066	- 1.3185	- 2.0454	- 1.6170
Slope (b)	1.3286	1.2612	1.8433	1.4991

** $P < 0.01$

Hence, the equation are:

A. Area I. $\text{Log } G = -1.4066 + 1.3286 \text{ Log } L$

or, $G = 0.0039 L^{1.3286}$

B. Area II. $\text{Log } G = -1.3185 + 1.2612 \text{ Log } L$

or, $G = 0.0048 L^{1.2612}$

C. Area IV. $\text{Log } G = -2.0454 + 1.8433 \text{ Log } L$

or, $G = 0.0009 L^{1.8433}$

D. Total Area

$\text{Log } G = -1.6170 + 1.4991 \text{ Log } L$

or, $G = 0.0024 L^{1.4991}$

From these equations, there seems to be some differences in the relation of the lengths of gillraker and of the fish among the sampled areas. However, distinct differences in the three areas studied still cannot be established at the present.

We are now in the process of collecting more samples systematically as regards both area and period. It is hoped that with more complete statistics on the subject, we can reach a better conclusion as to the stock or stocks of the Indo-Pacific Mackerel in the Gulf of Thailand in the future.

SUMMARY

The Department of Fisheries has laid out a program of investigation on the population of the Indo-Pacific mackerel, *Rastrelliger neglectus* (van Kampen), in the Gulf of Thailand. One of the research projects being carried out is to determine whether there exist heterogeneous populations of the species in the Gulf.

In this study analyses were made on the numbers of gillrakers and the lengths of the gillrakers of the fish sampled from various locations along the coast of the Gulf of Thailand. The results of this study showed:

1) The average number of gillrakers of a mackerel was 54.34 ± 2.17 , 18.69 ± 1.44 on the upper branch and 35.64 ± 1.33 on the lower branch of the first left gillarch.

2) The longest gillraker was located between gillrakers No. 9 and No. 21 on the lower branch of the arch.

3) There was a curvilinear relationship between the maximum length of the gillraker and the total length of the fish.

4) No definite conclusion can be drawn as to the differences between the numbers of gillrakers and the lengths of the gillrakers of the mackerel sampled from Area I, II and IV.

ACKNOWLEDGEMENTS

The author wish to express his sincere gratitude and appreciation to Mr. Sanan Ruamrak, Head of Fish Section, and to Dr. Deb Menasveta, Senior Fisheries Biologist of the Department of Fisheries, for his direct guidance and advice as to the planning of the study.

Thanks are also due to the technical staff members of the Fish Section, Division of Fisheries Investigations, who helped in the collection of basic data needed for this study.

REFERENCES

- Banasopit, T. (1962). Report on the gillraker examination of chub mackerel from the Inner Gulf of Thailand (In Thai). Unpublished report. Department of Fisheries, Bangkok.
- Berry, F.H. and I. Barrett (1963). Gillraker analysis and speciation in the thread herring genus *Opisthonema*. Inter-Amer. Trop. Tuna Com. Bull., 6(2): 113-153.
- Fukuhara, F.M. et al. (1962). Continental origin of red salmon as determined from morphological characters. Int. North Pac. Fish. Com., Bull., 8: 15-109.
- Holt, S.J. (1959). Report of the International Training Center on the Methodology and Techniques of a research on mackerel (*Rastrelliger*). FAO Report No. 1095.
- Menasveta, D. (1965). Program of Mackerel Investigations (In Thai). In Reports on Mackerel Investigations, 1963-1965. Contribution No. 4, Marine Fisheries Laboratory, Department of Fisheries, Bangkok, 1-13 pp.
- Odate, B.T. (1963). Statistics in Rice Research, Part I. IRRI, Laguna, Philippines.
- Pritchard, A.L. (1945). Counts of gillrakers and pyloric caeca in pink salmon. J. Fish. Res. B. Canada, 6(5): 392-398.
- Rofen, R.R. (1963). Handbook of the food fishes of the Gulf of Thailand. Scripps Inst. Oceano., SIO-Ref. 63-18: 30-34.
- Snedecor, G.W. (1946). Statistical Methods. Iowa State College Press, Iowa, U.S.A., 485 pp.

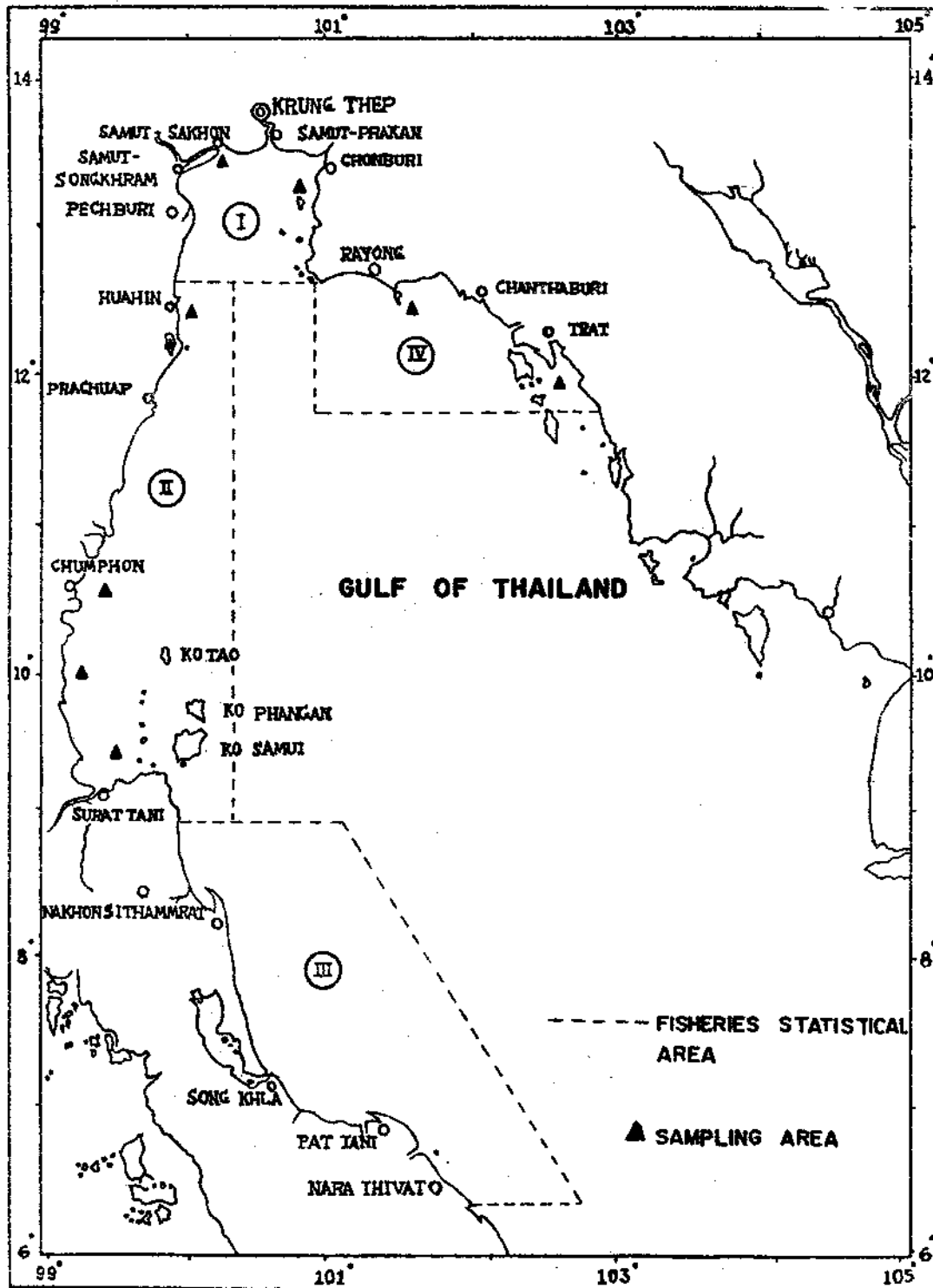


FIG 1 SAMPLING AREAS UNDER STUDY IN THE GULF OF THAILAND



Fig. 2. Gillarch and Gillrakers of *Rastrelliger neglectus* (3 X)

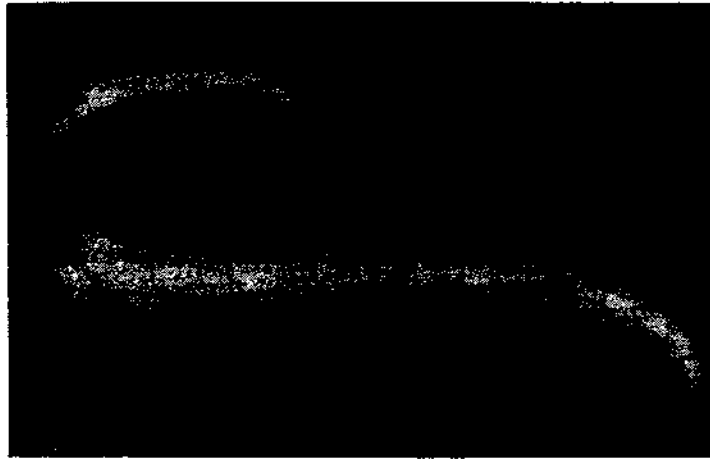


Fig. 3. Gillrakers of *R. neglectus* (8 X)

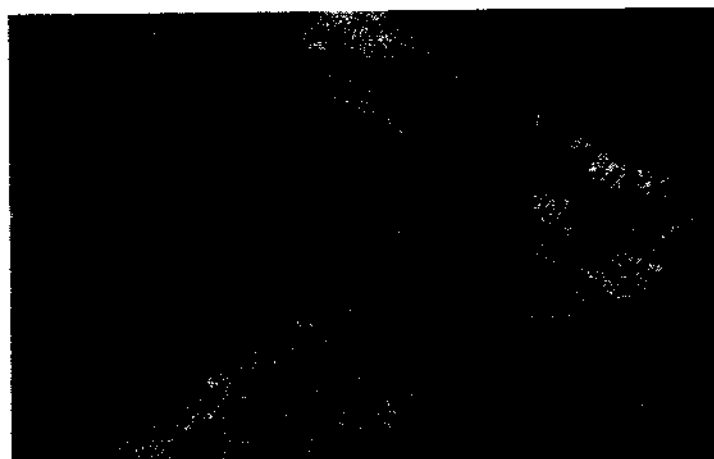
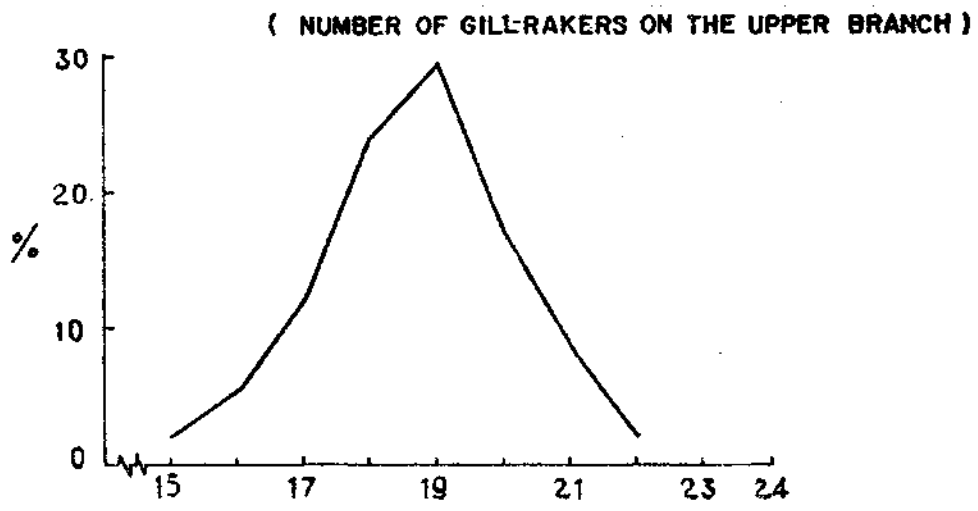
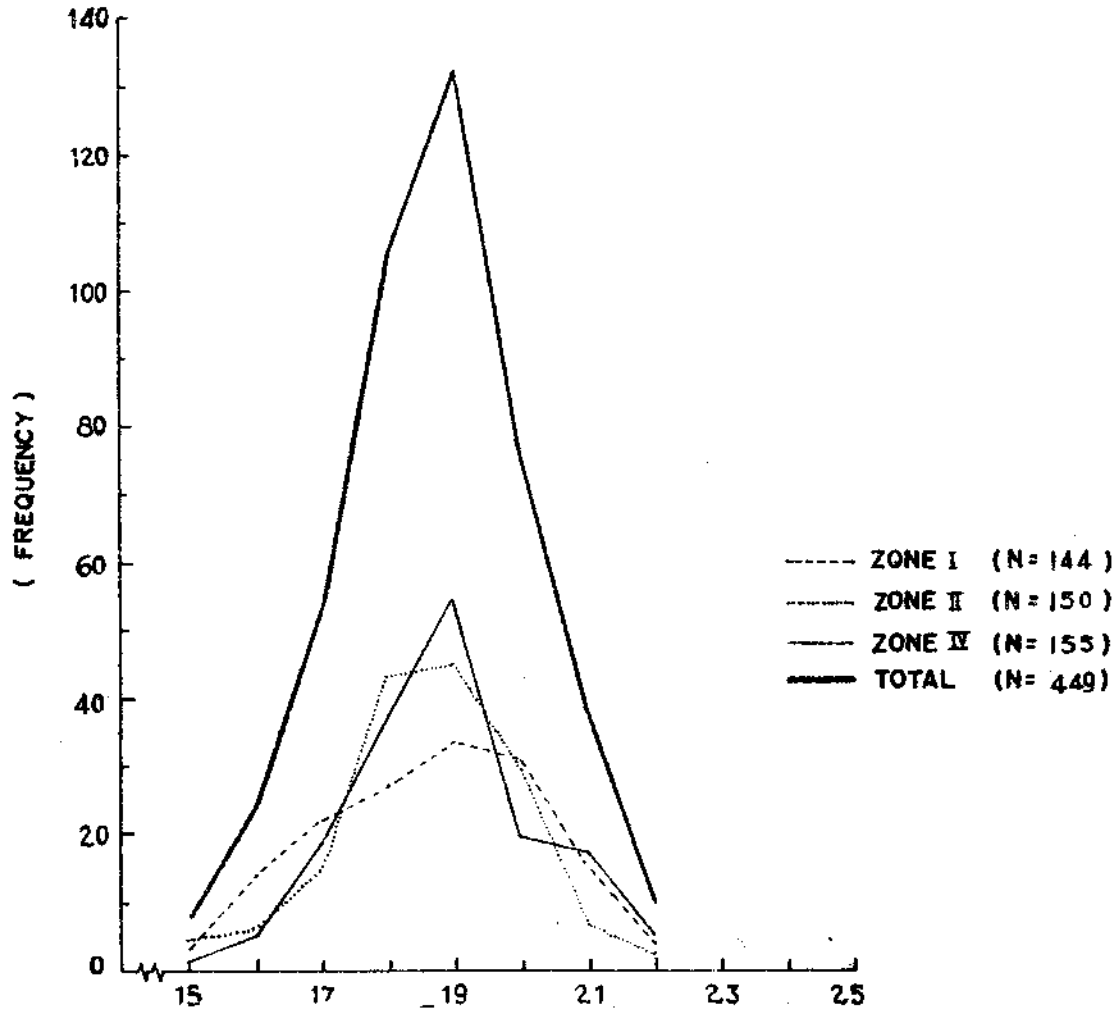


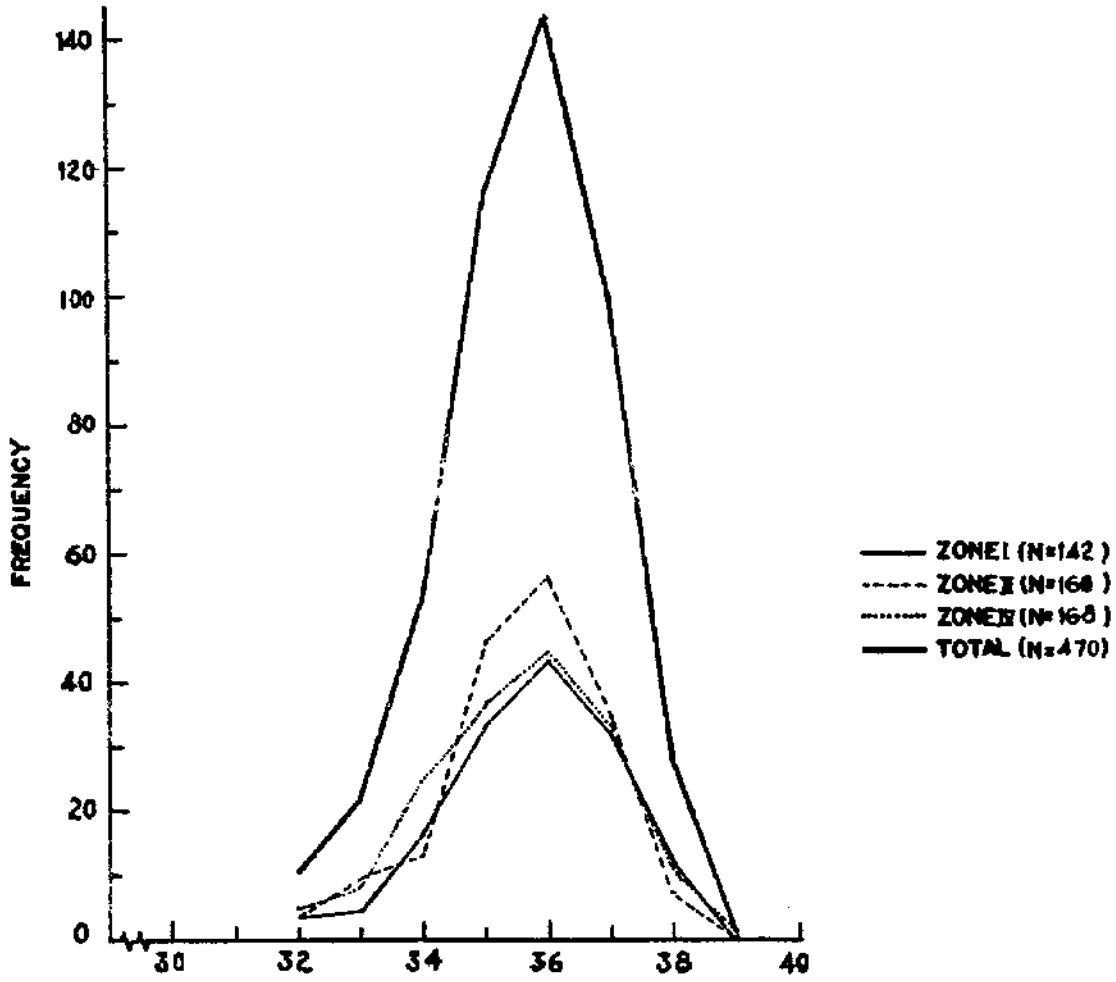
Fig. 4. Joint of Gillarch between upper and lower branches (10 X)



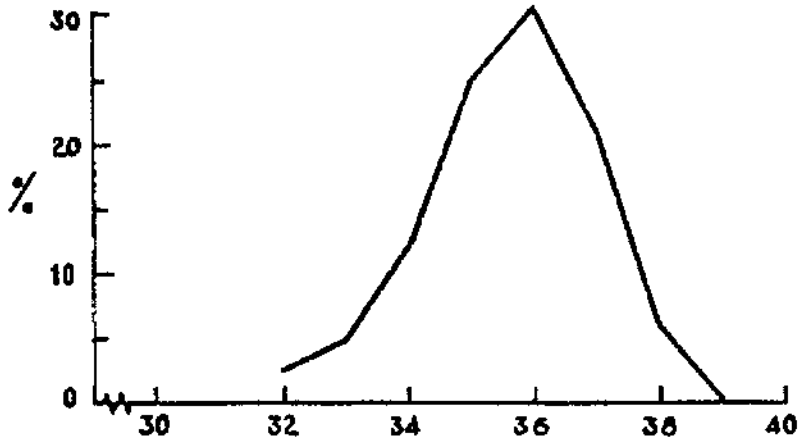
(NUMBER OF GILL-RAKERS ON THE UPPER BRANCH)

(NUMBER OF GILL-RAKERS ON THE UPPER BRANCH)

FIG.5 FREQUENCY DISTRIBUTION OF THE NUMBER OF GILL-RAKERS ON THE UPPER BRANCH OF THE FIRST GILLARCH



(NUMBER OF GILLRAKERS ON THE LOWER BRANCH)



(NUMBER OF GILLRAKERS ON THE LOWER BRANCH)

FIG. 6 FREQUENCY DISTRIBUTION OF THE NUMBER OF GILLRAKERS ON THE LOWER BRANCH OF THE FIRST GILL ARCH

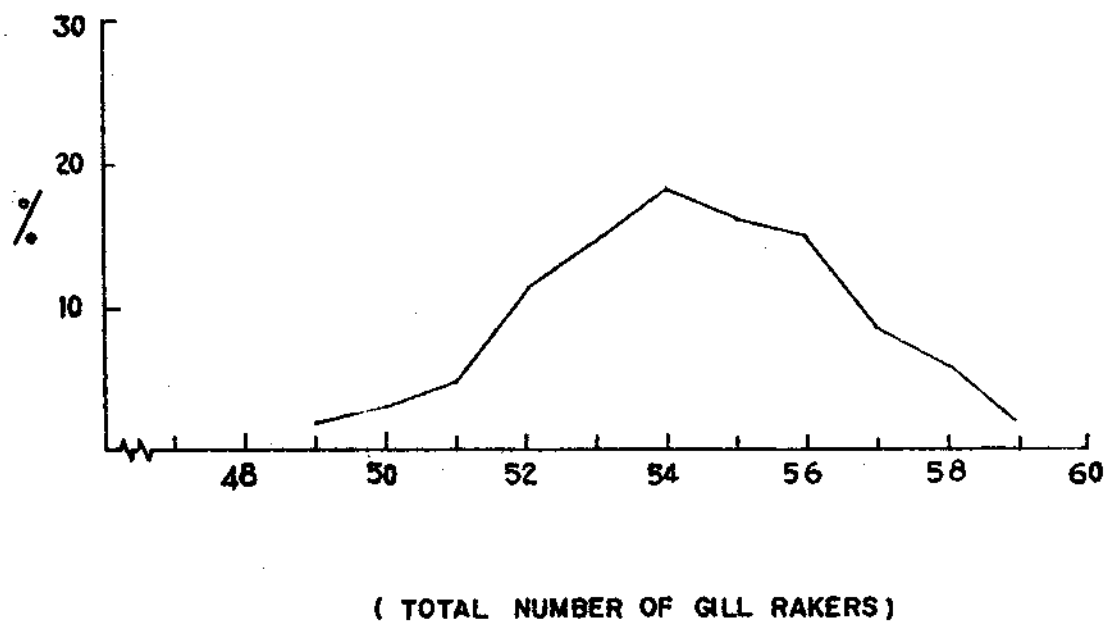
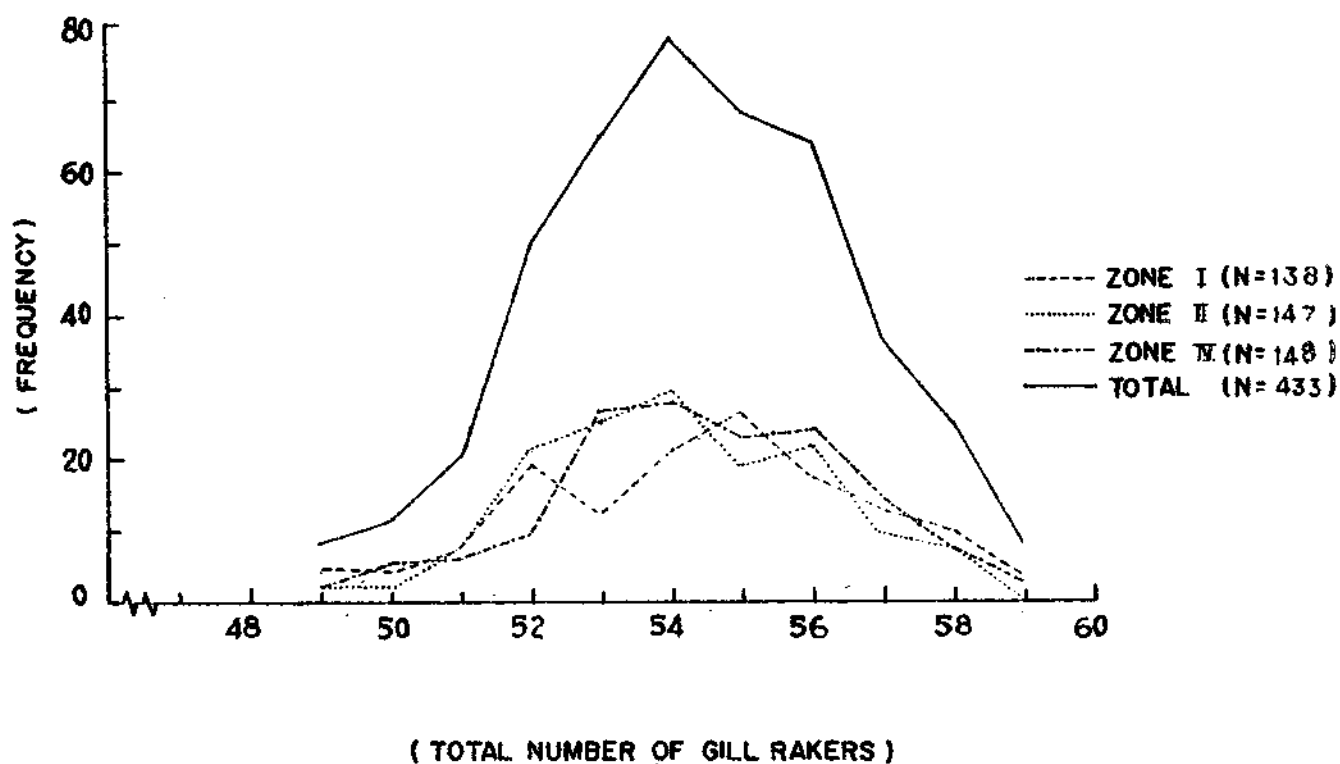
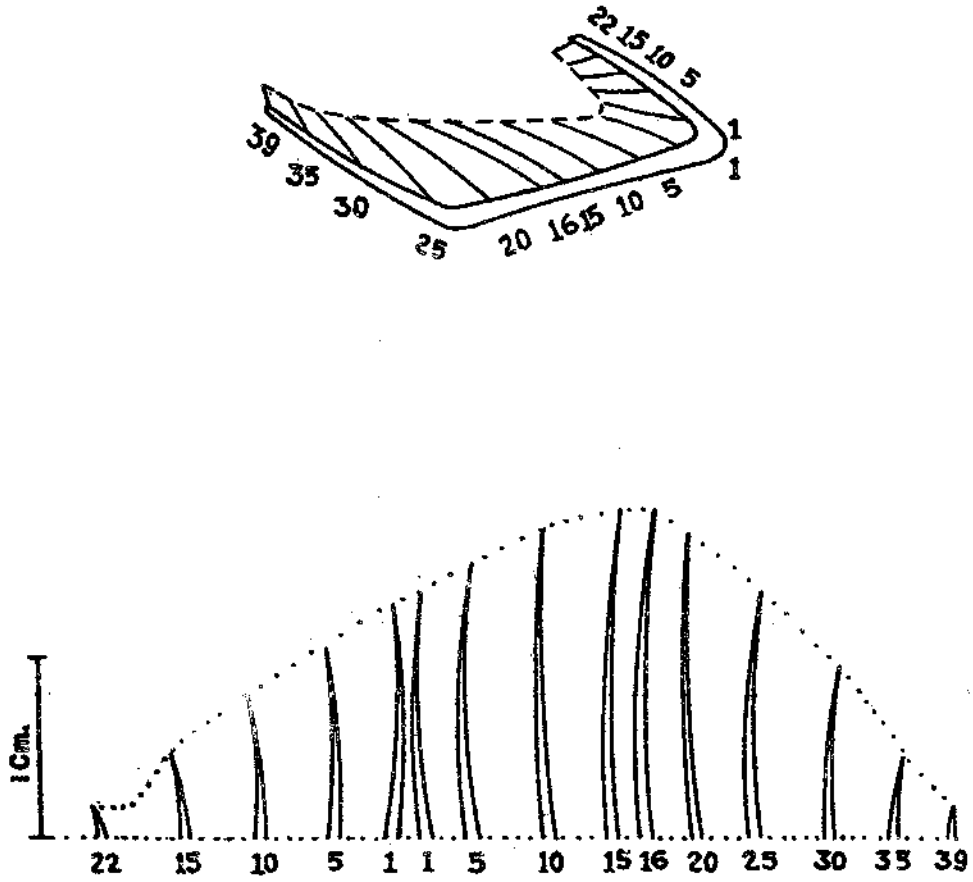
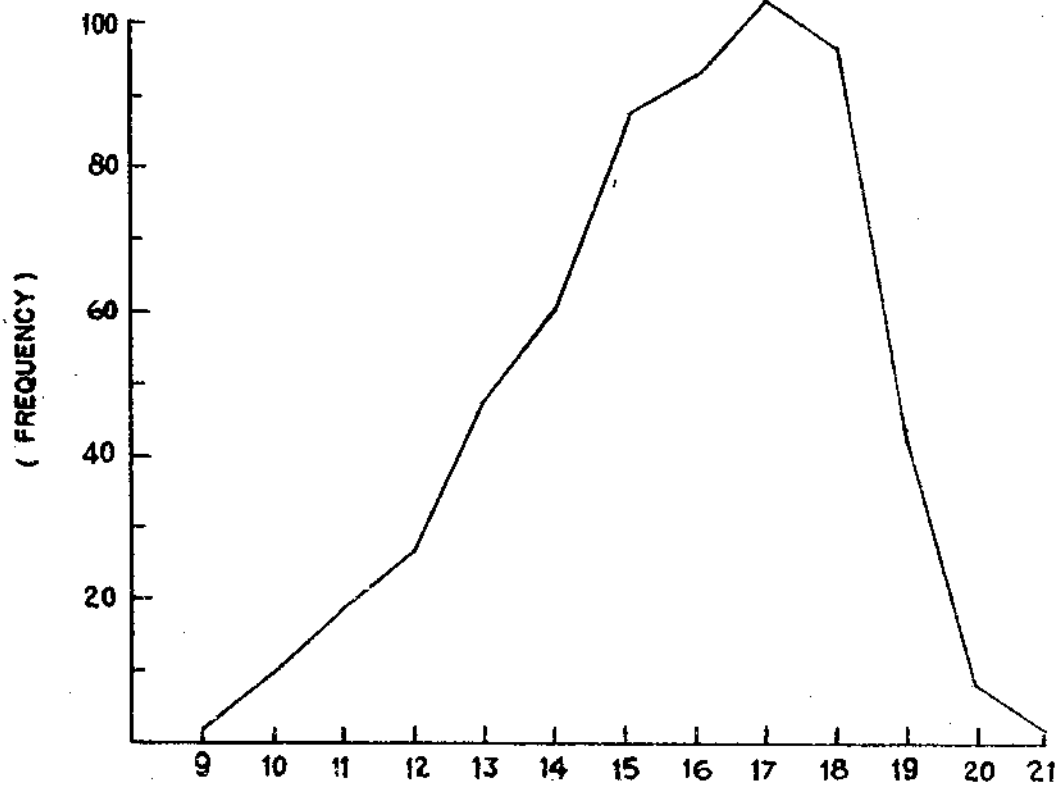


FIG. 7 FREQUENCY DISTRIBUTION OF THE TOTAL NUMBER OF GILL RAKERS ON THE FIRST GILL ARCH

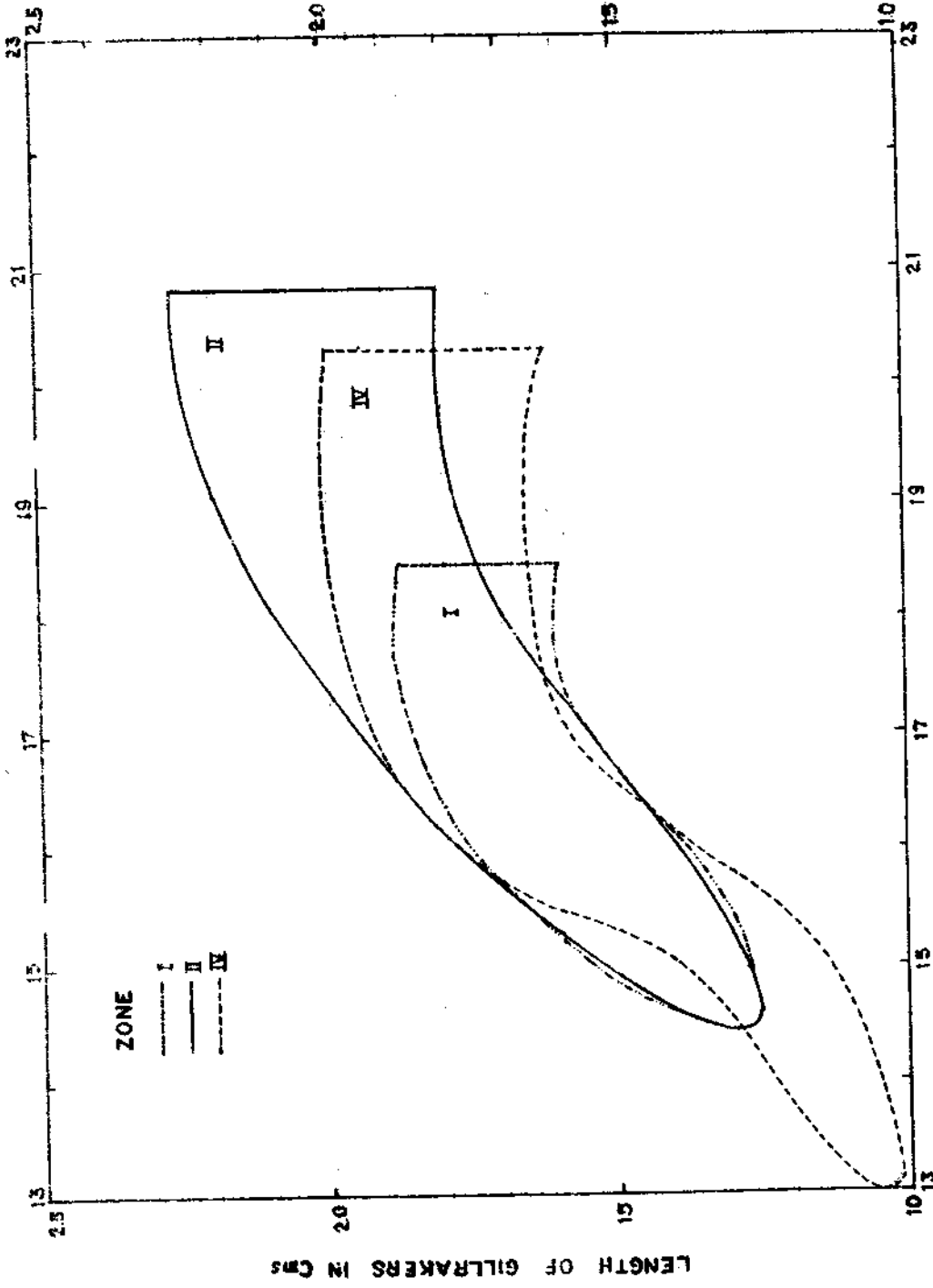


**FIG. 8 LENGTHS OF GILLRAKERS AT VARIOUS POSITIONS
ON THE GILLARCH**



POSITION OF THE MAXIMUM-LENGTH OF GILLRAKERS
ON THE LOWER ARCH

FIG. 9 POSITION OF THE MAXIMUM-LENGTH OF GILLRAKERS
ON THE LOWER BRANCH OF THE FIRST GILL ARCH



TOTAL LENGTH IN cms.

FIG. 10 THE RELATIONSHIP BETWEEN TOTAL LENGTH AND MAXIMUM LENGTH OF GILLRAKERS OF R. NEGLECTUS SAMPLING FROM VARIOUS FISHING ZONES IN THE GULF OF THAILAND

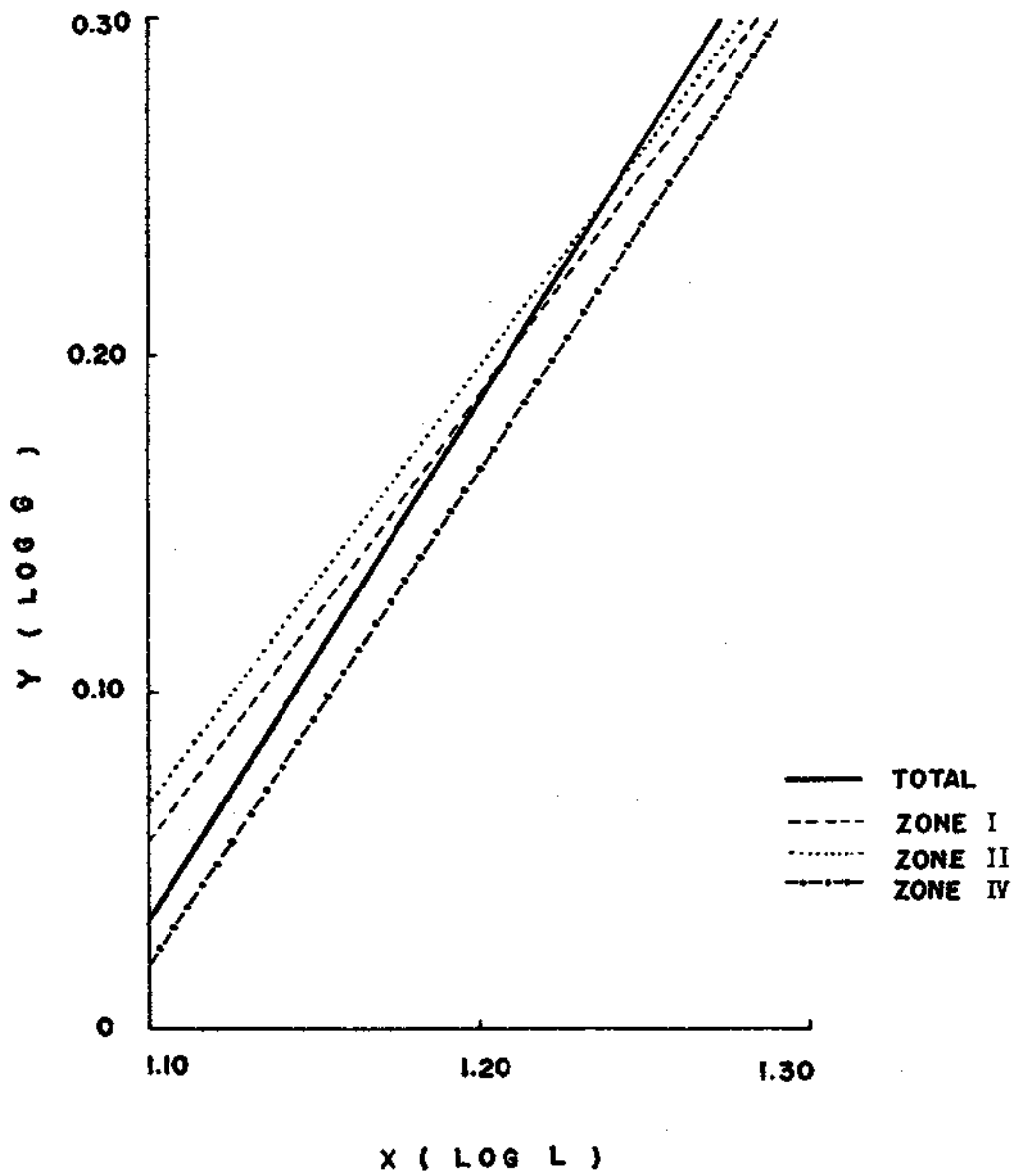


FIG. 11 REGRESSION LINES REPRESENT THE RELATIONSHIP BETWEEN TOTAL LENGTH AND THE MAXIMUM LENGTH OF GILLRAKERS OF R. NEGLECTUS SAMPLING FROM VARIOUS FISHING ZONES IN THE GULF OF THAILAND