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The Use of Vertebrae Frequencies to Indicate the Distribution of Sharp-beaked Redfish, *Sebastes mentella* and *S. Fasciatus*

by

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Introduction

A preliminary understanding of the distribution of sharp-beaked redfish Sebastes mentella and S. fasciatus, is important for the appropriate design of life history studies of each species and for determining component stocks. The separation of the two sharp-beaked redfish species is very time consuming and requires special skills. Therefore, a tentative method of using vertebrae frequencies to indicate their distributions is presented.

Although morphological differences of these two species were discussed by Barsukov (1972), Barsukov and Zakharov (1972), Litvinenko (1974), and Templeman (1980), the overlapping of morphological characters has made it very hard to distinguish sharp-beaked redfish in field studies. From the discriminant analysis of morphological characters, Ni (1981a,b) concluded that vertebrae number was one of the good discriminators between S. mentella and S. fasciatus. This has been elucidated by the numerous researchers listed in Table 1 who found that vertebrae count of S. fasciatus was most commonly 29 whereas that of S. mentella was 30.

The assumption was made that a) a vertebrae frequency distribution dominated by 29 indicated S. fasciatus as the predominant species, b) 30 indicated S. mentella and c) a combination of 29 and 30 indicated a mixture of the two redfish. In this study, the temporal, vertical and geographic variations of vertebrae of sharp-beaked redfish were evaluated.

Preliminay results of the distribution of sharp-beaked redfish obtained on the basis of vertebrae frequencies were: S. mentella dominated in the waters between Greenland and Baffin Island, in Labrador waters, in deep waters of Gulf of St. Lawrence and of all NAFO Subarea 3. S. fasciatus dominated on Nova Scotia shelf, in shallow waters of both Subarea 3 and Gulf of St. Lawrence. The common names of S. mentella and S. fasciatus are also discussed.

Materials and Methods

There were 33,301 specimens of vertebral counts collected from 1957 to 1968 by Templeman and Sandeman. The areas sampled, covering the whole Northwest Atlantic, were NAFO Divisions (with sample size) 0(599), 1(546), 2G(435), 2H(948), 2J(2377), 3K(1809), 3L(1743), 3M(1204), 3N(1229), 3O(1885), 3P(5838), 4R(5335), 4S(2465), 4T(2053), 4V(1061), 4W(2598), and 4X(1176). Data were then broken down into 100 m depth intervals (Table 2), since Barsukov (1972) and Templeman (1976) suggested that S. mentella were distributed in deeper waters than S. fasciatus. Sharp-beaked redfish were rarely found in shallow waters of less than 100 meters, therefore, data were combined into one <200 m depth zone. Urostyle was excluded in the vertebral counts in order to compare with Templeman's (1961) redfish vertebral studies based on data collected from 1947 to 1954.

Yearly and vertical variations were examined respectively by the method of χ^2-test of independence on vertebrae frequencies to identify cells (in the frequency table) or patterns of cells that contributed to a departure from independence. This was calculated in a stepwise manner by eliminating the cell that, when excluded, minimized the χ^2-test of independence performed on all cells. A sequence of cells of which contributed most to a significant difference could be drawn from the pattern of cells eliminated.

Geographic variations were examined by the patterns shown from the mode and the mean values in the vertebrae frequency histograms as well as by cluster analysis on vertebrae frequencies to display the dendrographic affinities among division-depth blocks.

Temporal Variations

Data for divisiondepth blocks in Table 2 were further broken down by year. A summary of the results of the χ^2-test, with the number of years data

used in the calculation, is shown in Table 3. No significant difference indicated that no yearly changes were found. Significant differences suggested that temporal variations were observed (i.e., a mixture of different types of vertebrae frequencies occurred). Divisions 2G and 2H did not have enough data to conduct the analysis and were excluded from the table.

The vertebrae frequencies were stable over time in the waters between Greenland and Baffin Island (Divisions 0 and 1). Vertebrae frequencies varied yearly in the shallow waters of 2J (<400 m) and of 3L (<500 m), but they were stable in deep waters. In Div. 3K a consistent pattern was only seen at the 500-599 m depth zone. On Flemish Cap, the unstable depth zone was 300-399 m; a significant difference for $\leq$ 600 m depth zone was due to the unusual frequencies from a small sample (n = 21). The unstable depth zone was 400-499 m in 3N. Vertebrae frequencies were stable at depths less than 500 m in Div. 30 while they fluctuated yearly in deep waters. On St. Pierre Bank (3P), vertebrae frequencies varied annually in the waters deeper than 200 m. In the Gulf of St. Lawrence, vertebrae frequencies varied yearly in the 200-299 m depth zone. There were occassional fluctuations in the < 200 m and at the 300-399 m depth zones. These inferences were drawn because no significant differences were found from the tests of 4R (7 years data), 4S (4 years data), and 4T (6 years data) by eliminating one year's data for both depth zones. On the Nova Scotian shelf, 4V showed no yearly variations in the shallow waters (< 400 m) while it varied in the deep waters; 4W and 4X displayed slight differences in yearly vertebrae frequencies in the shallow waters and in the deep waters, but they were stable in the medium depth zones (around 200-500 m).

Vertical Variations

In order to assess the variations among different depth zones for each division, data collected from different years were combined. Their percentage frequency histograms (Fig. 1), mean values (Table 4), and modes (Fig. 1 and Table 5) of vertebrae were evaluated. The vertebrae statistics for each NAFO Division are listed in Table 6. χ^2-statistics is also listed to show the independence of vertebrae frequencies with depth.

Only the specimens collected from the waters between Greenland and Baffin Island (Division 0 and 1) showed no significant differences of their vertebrae

frequencies with depth (Table 6). They consistently had high percentage of 30 vertebrae and were S. mentella (Fig. 1-1, Table 5). There was no indication that S. fasciatus existed in northern Labrador waters (2G and 2H) although the vertebrae frequencies exhibited significant differences with depth. This may be due to the small sample sizes from both deep and shallow water depth zones as well as the high percentage of 31 vertebrae in the shallow waters. All the other areas (Subarea 3 and 4) showed significant differences of vertebrae frequencies with depth which indicated strong vertical variations.

Geographic Variations

The homogeneity of vertebrae frequencies could be appraised from area to area by examining their mean values (Table 4), modes (Table 5), and histograms (Fig. 1) for all depth zones. In NAFO Divisions 0, 1, 2G, and 2H (Fig. 1-1), the vertebrae counts of 30 were dominant and S. mentella was the predominant species. There was no evidence of the existence of S. fasciatus in 2G or 2H. No data was available for waters less than 200 meters however.

The existence of S. fasciatus was indicated in Divisions 2J and 3K areas; 35.2% of the 494 specimens collected from the <200 m depth zone in 2J and 41% of the 1,345 specimens collected from <300 m depth zones had vertebrae count 29 (Table 5, Fig. 1-1). Deep waters in these areas were dominated by S. mentella.

A mixture of redfish was observed on Flemish Cap (3M). The sharp-beak redfish intermingled in shallow waters (<300 meters) and was dominated by S. mentella in deep waters (Table 5, Fig. 1-2).

On Grand Bank, S. fasciatus was predominant in shallow water and S. mentella was predominant in deep waters. The two sharp-beaked redfish species probably mixed at a depth of 400-499 meters in 3L and 3N, and in deeper waters (> 500 m) in 30 (Table 5, Fig. 1-2).

On St. Pierre Bank (3P), S. fasciatus was predominant in very shallow water (<200 m) whereas S. mentella was predominant in deep waters. They mixed at a wide range of depth zones (Table 5, Fig. 1-2).

In the Gulf of St. Lawrence (4RST areas), S. fasciatus was only found to dominate in water shallower than 200 meters; S. mentella dominated at deeper than 200 meters (Table 5, Fig. 1-2 and Fig. 1-3).

On the Nova Scotia Shelf (Division 4VWX), S. fasciatus was the predominant species. S. mentella may likely be present in waters deeper than 500 meters in these areas (Table 5, Fig. 1-3).

The mean values of each division-depth block, summarized in Table 4, offered a general indication of the distribution of sharp-beaked redfishes. Vertebrae means in the low 29's indicated that S. fasciatus was the predominant species whereas high 29's or 30's indicated that S. mentella was the predominant species. Mean values of about 29.4 to 29.7 suggested that a mixture of the two species occurred. These were found at 200-299 meters in Divisions 2J, 3K, 3M, 3P, 4R and 4S; at 300-399 meters In Division 3K, at 400-499 meters of 3LNO, and at depths greater than 500 meters in Divisions 3O and 4VWX.

Since the vertebral frequencies showed strong characteristics of either kurtosis or skewness, the modes of the vertebral frequency distribution should offer a better representation of the data and is shown in Table 5. If the second highest mode was more than 35%, it was also included in the table. Again, S. fasciatus with 29 vertebrae was located on the Nova Scotian Shelf; in shallow waters (<400 m) of NAFO Subarea 3; and in very shallow waters of Gulf of St. Lawrence. S. mentella with 30 vertebrae was found in the waters between Baffin Island and Greenland, Labrador, NAFO Subarea 3 (>300 m), Gulf of St. Lawrence (>200 m) and even the Nova Scotian Shelf (> 600 m).

The vertebrae statistics for all NAFO Divisions are listed in Table 6. These were calculated by excluding all the abnormal vertebrae (fused vertebrae). A clear geographic cline of vertebrae of sharp-beaked redfishes, from a high mean value in the north to a gradual reduction toward the south, was noted, exceptions being the Gulf of St. Lawrence (4RST) and Flemish Cap (3M). No particular characteristics of abnormal verterbae rate among areas were noted, except a peculiar high rate in 3K. The overall percentage of abnormal vertebrae for all areas was 0.52%.

Relatedness among Vertical-geographic Consideratons

Since significant vertical and geographic variations were demonstrated, a dendrographic closeness among division-depth blocks was calculated to better display the interrelationships. As shown in Fig. 2, division-depth blocks offered 5 different patterns and were clustered into groups. The first group showed a very high percentage of 30 vertebrae, with some varied slightly with 29 and 31 vertebrae, and were defined as S. mentella dominant areas. The second group also had relatively high percentage of vertebrae 30. This was proposed as an area where S. mentella was dominant, but the small portion of 29 vertebrae suggested that S. fasciatus might occassionally occur. The third group had a slightly higher percentage of 30 vertebrae than 29 vertebrae. This indicated a mixture of S. mentella and S. fasciatus in these areas. The fourth group exhibited a high percentage of 29 vertebrae and were considered to reflect S. fasciatus dominant areas. The last group had a slightly higher percentage of 29 than 30 vertebrae. This implied that the predominant species was S. fasciatus, however, S. mentella might occassionally occur. These clusters are clearly displayed in shaded form (Fig. 3).

Discussion

It is very important to have an understanding of the distribution of S. fasciatus and S. mentella before designing any biological studies. A preliminary solution for finding where they might be distributed can be quickly acquired by an analysis of the vertebrae frequency distribution.

Significant temporal and vertical variations of vertebrae frequencies showed strong division-depth characteristics except for the waters between Greenland and Baffin Island. Mixtures of different types of vertebrae frequencies, which could be reasoned by the no significant differences obtained by eliminating just one or two years data, varied in different depth zones for different areas. This intimated that different types of vertebrae patterns for sharp-beaked redfishes existed, and also, certain degree of vertical migration was inferred.

Although Ni (1981b) indicated that 68.7% of S. fasciatus had vertebrae counts of 29 and 31.3% of 30 while 99% of S. mentella had vertebrae equal to or greater than 30, the geographic variations of vertebrae of the two sharp-beaked redfishes should be considered in order to confirm their distribution.

However, the general patterns of vertebrae as 29 for S. fasciatus and counted as 30 for S. mentella were well recognized in Table 1, which covered almost the whole northwest Atlantic. It is, therefore, reasonabe to assume that the geographic variation of the vertebrae is not likely to be larger than the interspecies differences.

S. mentella were predominant in the waters between Baffin Island and Greenland, in Labrador waters, in deep waters of the Gulf of St. Lawrence (> 200 m), and of NAFO 3's Divisions (deeper than around 300-400 m), and in very deep waters of Nova Scotian Shelf (> 600 m). S. fasciatus were distributed on the Nova Scotian Banks (< 500 m), in shallow waters of NAFO Subarea 3 (<300-400 m) and in the very shallow waters of Gulf of St. Lawrence (< 200 m). Therefore, S. fasciatus should not be called the "Labrador redfish" as in the fourth edition of "A List of Common and Scientific Names of Fishes from the United States and Canada" (American Fisheries Society, special publication No. 12, 1980). I would support Barsukov (1972), Willim Eschmeyer and E. J. Sandeman suggestions to retain the common name "rosefish" for S. fasciatus as pointed out by Taning (1949). It is appropriate to use "deepwater redfish" for S. mentella since it is predominant in most of the deep waters of Northwest Atlantic although it can also be found in the shallow waters of Baffin Island, West Greenland and Labrador.

For the biological species concept (Mayr 1969) followers, who might still argue that the geographic variation of the vertebrae counts of the same species, this paper should be treated as vertical and geographic variations of vertebrae studies for sharp-beaked redfish. For the phenetic species concept (Sokal 1974) followers, these results would be a contribution to the preliminary understanding of the distribution of the two sharp-beaked redfishes species along with the redfishes distribution studies by Ni and McKone (1981). In either case, management of redfish should be seriously considered since the sharp-beaked redfishes had large vertical and geographic variations of vertebrae frequencies.

In conclusion, large vertical and geographic variations of vertebrae frequencies were observed in sharp-beaked redfishes. The indications were

that rosefish S. fasciatus were distributed in shallow waters and southern areas, whereas deepwater redfish S. mentella were predominant in deeper water and northern areas.

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Table 1. Mean values, modes, and sample sizes of vertebrae frequencies recorded in the literature for Sebastes mentella and S. fasciatus. Data were adjusted by excluding urostyle.

Species	$\bar{x}$	Mode	N	Location	Author
S. mentella	30.14	30	37	Barents Sea	Barsukov (1972)
	30.02	30	48	Banguereau, Flemish Cap, Grand Bank, and Iceland	Barsukov (1972)
	30.27	30	37	Iceland and Greenland	Barsukov (1972)
	30.17	30	253	Iceland	Barsukov and Zakharov (1972)
	29.99	30	146	West Greenland	Barsukov and Zakharov (1972)
	30.02	30	397	Baffin Island	Barsukov and Zakharov (1972)
	30.04	30	202	2J	Barsukov and Zakharov (1972)
	30.03	30	232	3K	Barsukov and Zakharov (1972)
	30.00	30	49	3M, 3P	Barsukov and Zakharov (1972)
	30.10	30	109	3O	Litvinenko (1974)
	30.03	30	100	3L	Ni (1981b)
S. fasciatus	29.19	29	41	Banguereau Flemish Cap, Grand Bank, and Iceland	Barsukov (1972)
	29.19	29	447	4W, 5Z	Barsukov and Zakharov (1972)
	29.12	29	455	3M, 3N, 3O, 3P	Barsukov and Zakharov (1972)
	29.36	29	228	3K, 2J	Barsukov and Zakharov (1972)
	29.05	29	124	3O	Litvinenko (1974)
	29.31	29	99	3L	Ni (1981b)

Table 2. Sample size of vertebrate of sharp-beaked redfish by NAFO Division and depth zone.

Depth range (meters)	NAFO Divisions																	Subtotal
	0	1	2G	2H	2J	3K	3L	3M	3N	3O	3P	4R	4S	4T	4V	4W	4X	
<200		99						1	86	649	540	1235	376	359	321	1070	557	5293
200-299			15	31	494	599	370	87	413	441	4822	3344	1707	1104	315	650	206	14598
300-399	206	175	145	425	883	746	645	389	427	359	388	645	323	537	126	332	140	6891
400-499	100	81	116	284	416	296	266	339	111	227		111	59	53	269	342	180	3250
500-599	264	176	146	192	394	96	404	249	168	93	88		-[a]	-	8	172	73	2523
≥600	29	15	13	16	190	72	58	139	24	116	-	-	-	-	22	32	20	746
Subtotal	599	546	435	948	2377	1809	1743	1204	1229	1885	5838	5335	2465	2053	1061	2598	1176	33301

[a] Depth not applicable

Table 3. Summary of chi-square test of independence of yearly variations of vertebrae frequencies for division-depth blocks.

Depth range (meters)	NAFO Divisions[a]														
	0	1	2J	3K	3L	3M	3N	3O	3P	4R	4S	4T	4V	4W	4X
<200	-	-	-	-	-	-	ns (2)	ns (4)	ns (8)	***[b] (8)	*[b] (4)	***[b] (6)	ns (6)	*[b] (6)	*[b] (3)
200-299	-	-	***[b] (4)	*[b] (3)	*** (4)	ns (2)	* (3)	ns (2)	***[c] (8)	*** (8)	***[c] (5)	***[c] (6)	ns (3)	*[b] (3)	ns (3)
300-399	ns (2)	ns (2)	**[b] (3)	*** (2)	**[b] (4)	*** (2)	ns (3)	ns (3)	*** (4)	***[b] (7)	*[b] (4)	ns (5)	ns (2)	ns (3)	* (2)
400-499	ns (2)	ns (2)	ns (3)	* (2)	** (3)	ns (2)	*** (2)	ns (3)	-	ns (3)	ns (2)	ns (2)	** (2)	ns (3)	ns (4)
500-599	-	ns (2)	ns (3)	ns (2)	ns (4)	ns (2)	ns (2)	**[b] (3)	-	-	-	-	-	**[b] (3)	* (2)
≤600	-	ns (2)	ns (2)	* (2)	ns (3)	*** (2)	-	** (2)	-	-	-	-	-	ns (3)	*[b] (3)

[a] ns = no significant difference; * = significant difference at p = 0.05 level; ** = significant difference at p = 0.01 level; *** = significant difference at p = 0.001 level; number of years data for calculation are in brackets.

[b] no significant difference was found by eliminating only one year data.

[c] no significant difference was found by eliminating two years data.

Table 4. Mean value of vertebrae of sharp-beaked redfish by NAFO Division and depth zone.

Depth range (meters)	NAFO Divisions																
	0	1	2G	2H	2J	3K	3L	3M	3N	3O	3P	4R	4S	4T	4V	4W	4X
<200		30.03						(29.0)[a]	29.27	29.25	29.22	29.31	29.36	29.36	29.18	29.16	29.18
200-299			(30.07)	30.13	29.69	29.53	29.34	29.47	29.20	29.23	29.44	29.71	29.78	29.87	29.15	29.11	29.08
300-399	30.04	30.09	30.01	30.02	29.99	29.67	29.24	29.97	29.24	29.18	29.87	29.93	29.99	30.01	29.28	29.08	29.12
400-499	30.06	30.07	30.01	30.07	30.05	29.89	29.71	30.08	29.79	29.36		29.99	30.02	30.02	29.27	29.22	29.11
500-599	30.02	30.03	30.0	30.01	30.01	29.98	29.99	30.12	30.11	29.77	29.74		-[b]	-	(29.75)	29.48	29.08
≥600	(30.03)	(30.13)	(30.0)	(30.0)	30.0	29.83	29.98	30.09	(29.88)	29.53	-	-	-	-	(29.41)	29.84	(29.80)

[a]Sample size less than 30 indicated in parenthesis

[b] Depth not applicable

Table 5. The mode of vertebral frequency distribution of sharp-beaked redfish by NAFO Division and depth zone.

Depth range (meters)	NAFO Divisions																
	0	1	2G	2H	2J	3K	3L	3M	3N	3O	3P	4R	4S	4T	4V	4W	4X
<200		30						29	29	29	29	29	29	29,30[a]	29	29	29
200-299			30	30	30,29	30,29	29	29,30	29	29	29,30	30	30	30	29	29	29
300-399	30	30	30	30	30	30,29	29	30	29	29	30	30	30	30	29	29	29
400-499	30	30	30	30	30	30	30,29	30	30	29		30	30	30	29	29	29
500-599	30	30	30	30	30	30	30	30	30	30	30,29		-[b]	-	30	29,30	29
≥600	30	30	30	30	30	30	30	30	30	29,30	-	-	-	-	29,30	30	30

[a]The second figure where shown had a frequency of greater than 35%.

[b] Depth not applicable

Table 6. The vertebrae statistics of sharp-beaked redfishes for every NAFO Division. χ^2-test shows the independence of vertebrae frequencies with depth zones.

Depth range (meters)	NAFO Divisions																
	0	1	2G	2H	2J	3K	3L	3M	3N	3O	3P	4R	4S	4T	4V	4W	4X
N[a]	599	546	435	948	2377	1809	1743	1204	1229	1885	5838	5335	2465	2053	1061	2598	1176
$\bar{x}$	30.03	30.06	30.01	30.04	29.94	29.68	29.53	30.01	29.41	29.29	29.46	29.65	29.75	29.82	29.21	29.17	29.15
range	29-31	29-31	29-31	29-31	29-31	29-31	29-31	29-31	28-31	28-31	28-31	28-32	28-31	28-31	28-31	27-31	28-31
SD	0.2534	0.2713	0.2145	0.3262	0.3991	0.5126	0.5548	0.5034	0.5419	0.4858	0.5391	0.5395	0.5269	0.4959	0.4210	0.4063	0.3763
$SE_{\bar{x}}$	0.0104	0.0116	0.0103	0.0106	0.0082	0.0121	0.0133	0.0145	0.0155	0.0112	0.0071	0.0074	0.0106	0.0109	0.0129	0.080	0.0110
Number of abnormal vertebrae	5	1	3	7	6	25	15	6	8	7	34	21	12	6	5	9	3
Percentage of abnormal rate	0.83	0.18	0.68	0.73	0.25	1.36	0.85	0.50	0.65	0.37	0.58	0.39	0.48	0.29	0.47	0.35	0.25
χ^2	ns	ns	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***

a excluding abnormal vertebrae.

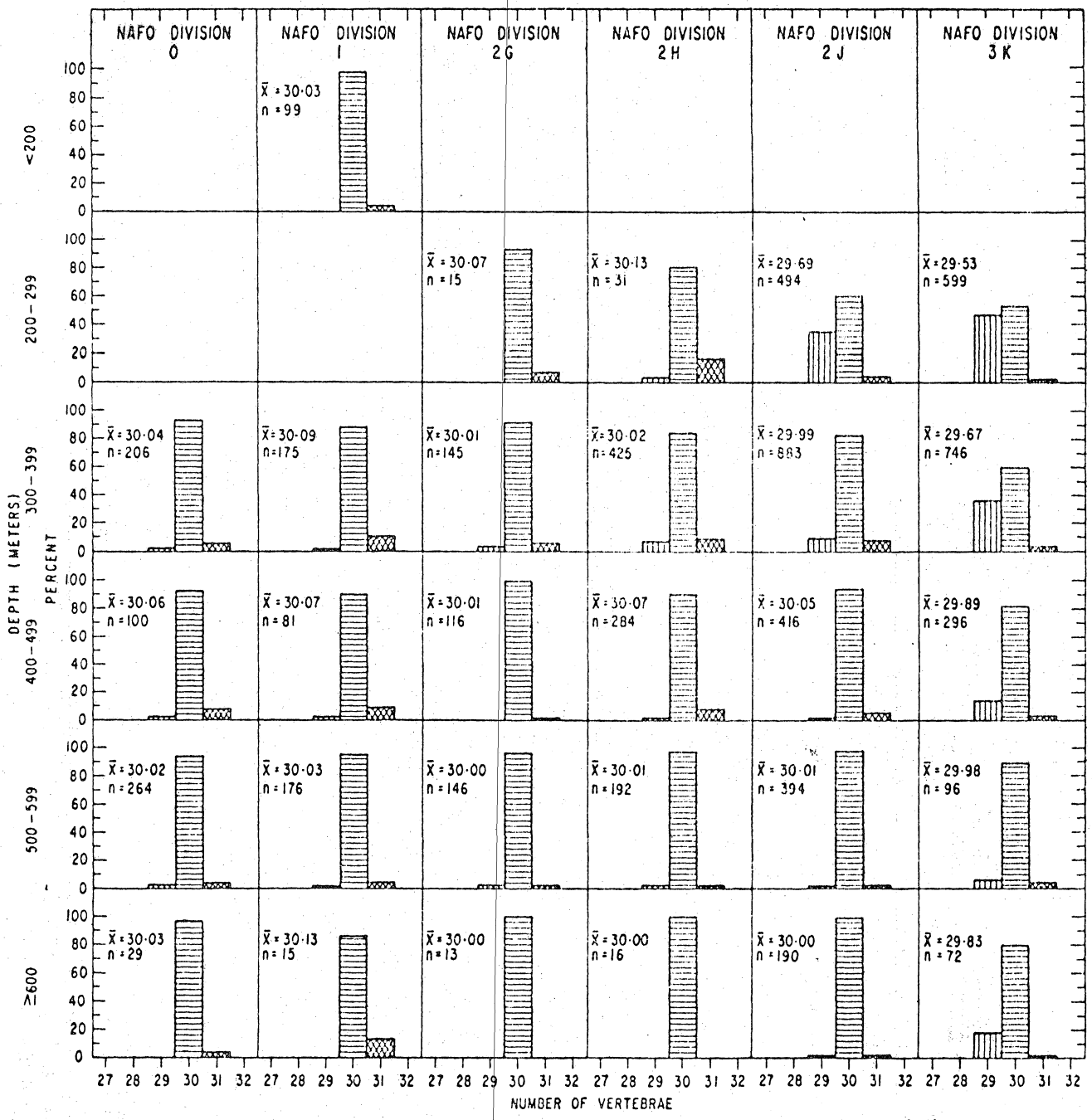

Fig. 1-1. Vertebrae frequency distribution by depth zone in NAFO divisions.

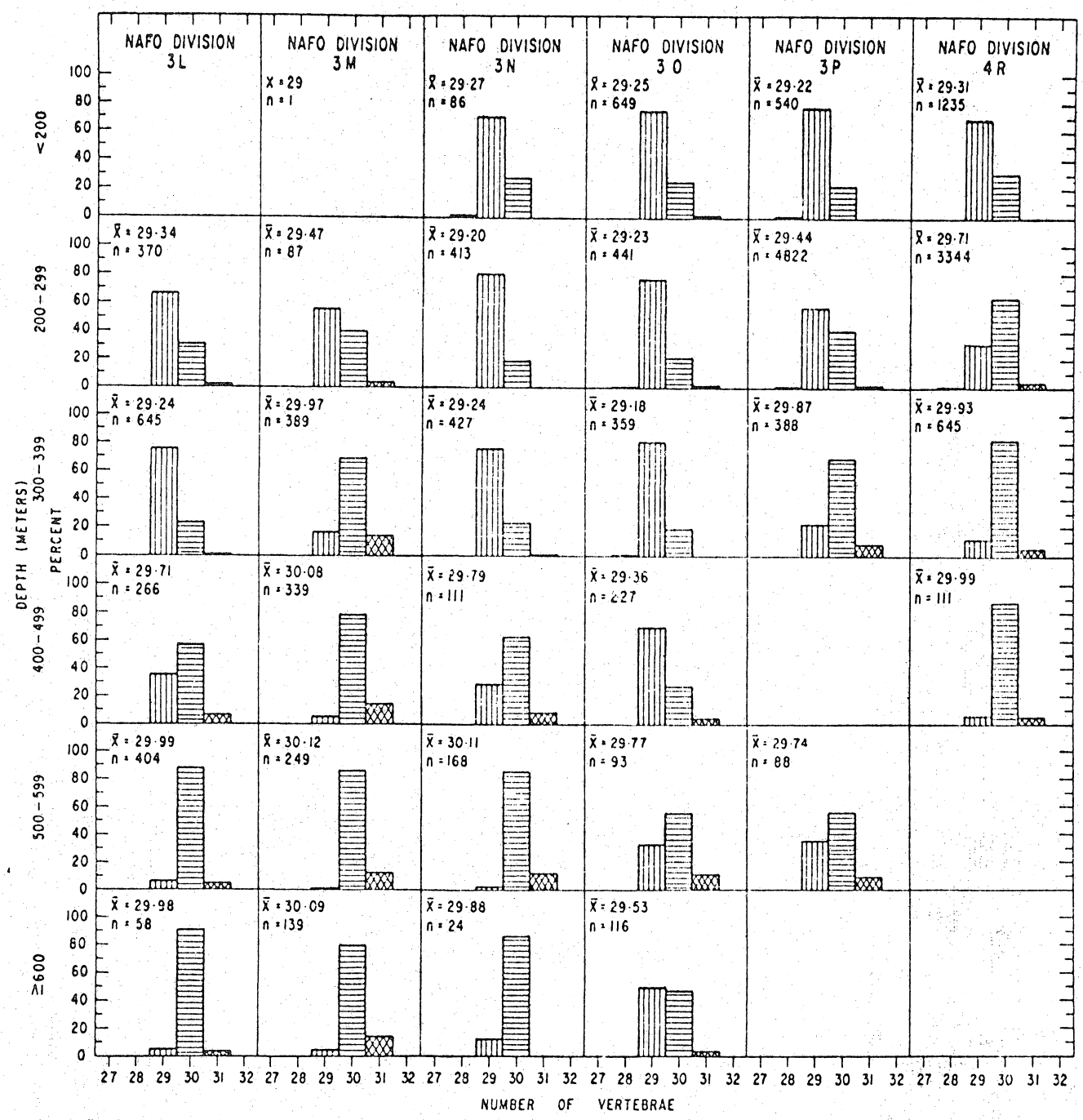
NAFO DIVISION 3L
NAFO DIVISION 3M
NAFO DIVISION 3N
NAFO DIVISION 3O
NAFO DIVISION 3P
NAFO DIVISION 4R
DEPTH (METERS)
< 200
200 – 299
300 – 399
400 – 499
500 – 599
≥ 600
PERCENT
NUMBER OF VERTEBRAE
X̄ = 29
n = 1
X̄ = 29·27
n = 86
X̄ = 29·25
n = 649
X̄ = 29·22
n = 540
X̄ = 29·31
n = 1235
X̄ = 29·34
n = 370
X̄ = 29·47
n = 87
X̄ = 29·20
n = 413
X̄ = 29·23
n = 441
X̄ = 29·44
n = 4822
X̄ = 29·71
n = 3344
X̄ = 29·24
n = 645
X̄ = 29·97
n = 389
X̄ = 29·24
n = 427
X̄ = 29·18
n = 359
X̄ = 29·87
n = 388
X̄ = 29·93
n = 645
X̄ = 29·71
n = 266
X̄ = 30·08
n = 339
X̄ = 29·79
n = 111
X̄ = 29·36
n = 227
X̄ = 29·99
n = 111
X̄ = 29·99
n = 404
X̄ = 30·12
n = 249
X̄ = 30·11
n = 168
X̄ = 29·77
n = 93
X̄ = 29·74
n = 88
X̄ = 29·98
n = 58
X̄ = 30·09
n = 139
X̄ = 29·88
n = 24
X̄ = 29·53
n = 116

Fig. 1-2.

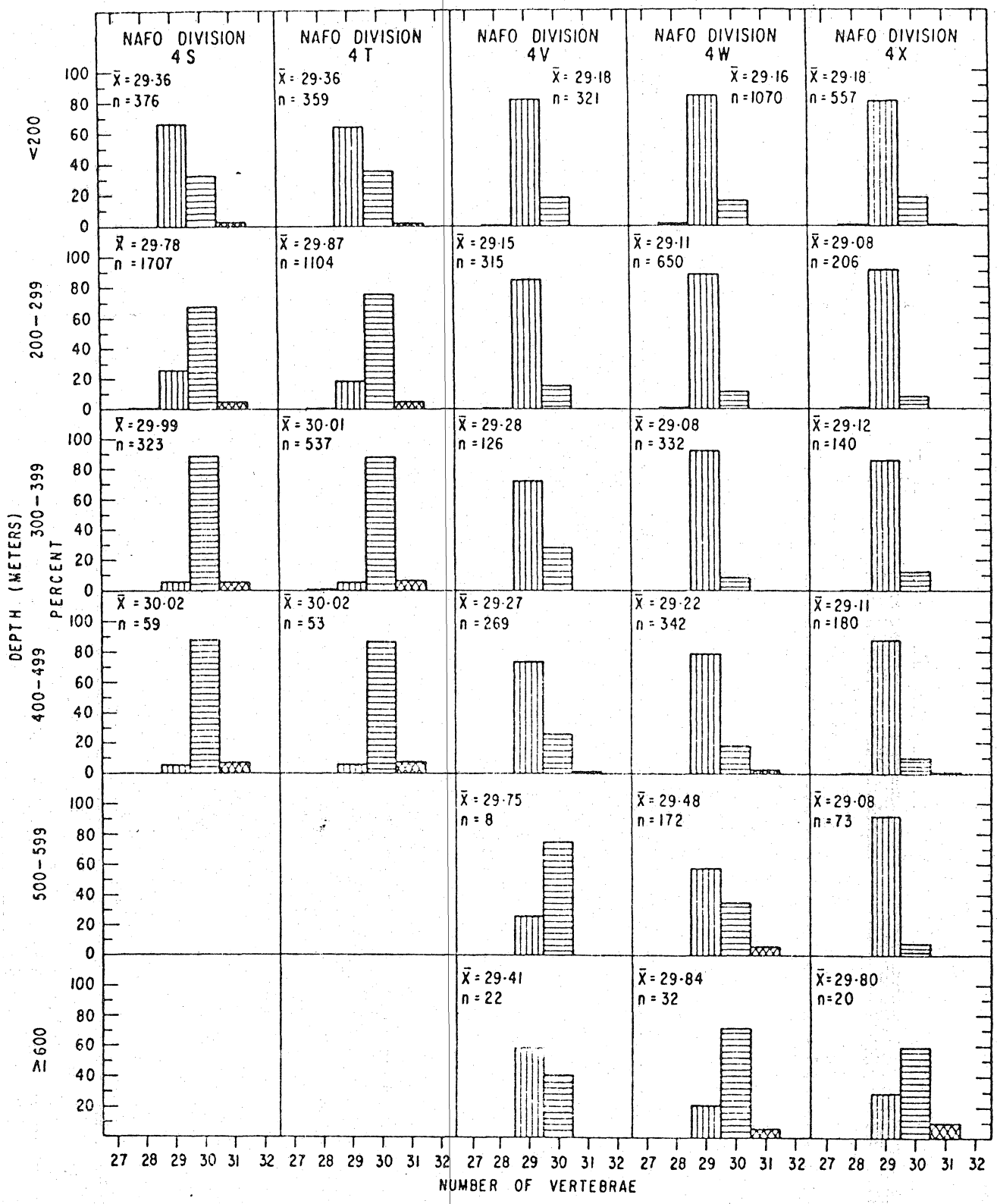
NAFO DIVISION 4S
NAFO DIVISION 4T
NAFO DIVISION 4V
NAFO DIVISION 4W
NAFO DIVISION 4X
X̄ = 29·36 n = 376
X̄ = 29·36 n = 359
X̄ = 29·18 n = 321
X̄ = 29·16 n = 1070
X̄ = 29·18 n = 557
X̄ = 29·78 n = 1707
X̄ = 29·87 n = 1104
X̄ = 29·15 n = 315
X̄ = 29·11 n = 650
X̄ = 29·08 n = 206
X̄ = 29·99 n = 323
X̄ = 30·01 n = 537
X̄ = 29·28 n = 126
X̄ = 29·08 n = 332
X̄ = 29·12 n = 140
X̄ = 30·02 n = 59
X̄ = 30·02 n = 53
X̄ = 29·27 n = 269
X̄ = 29·22 n = 342
X̄ = 29·11 n = 180
X̄ = 29·75 n = 8
X̄ = 29·48 n = 172
X̄ = 29·08 n = 73
X̄ = 29·41 n = 22
X̄ = 29·84 n = 32
X̄ = 29·80 n = 20
DEPTH (METERS)
<200
200–299
300–399
400–499
500–599
≥600
PERCENT
0 20 40 60 80 100
27 28 29 30 31 32
NUMBER OF VERTEBRAE

Fig. 1-3.

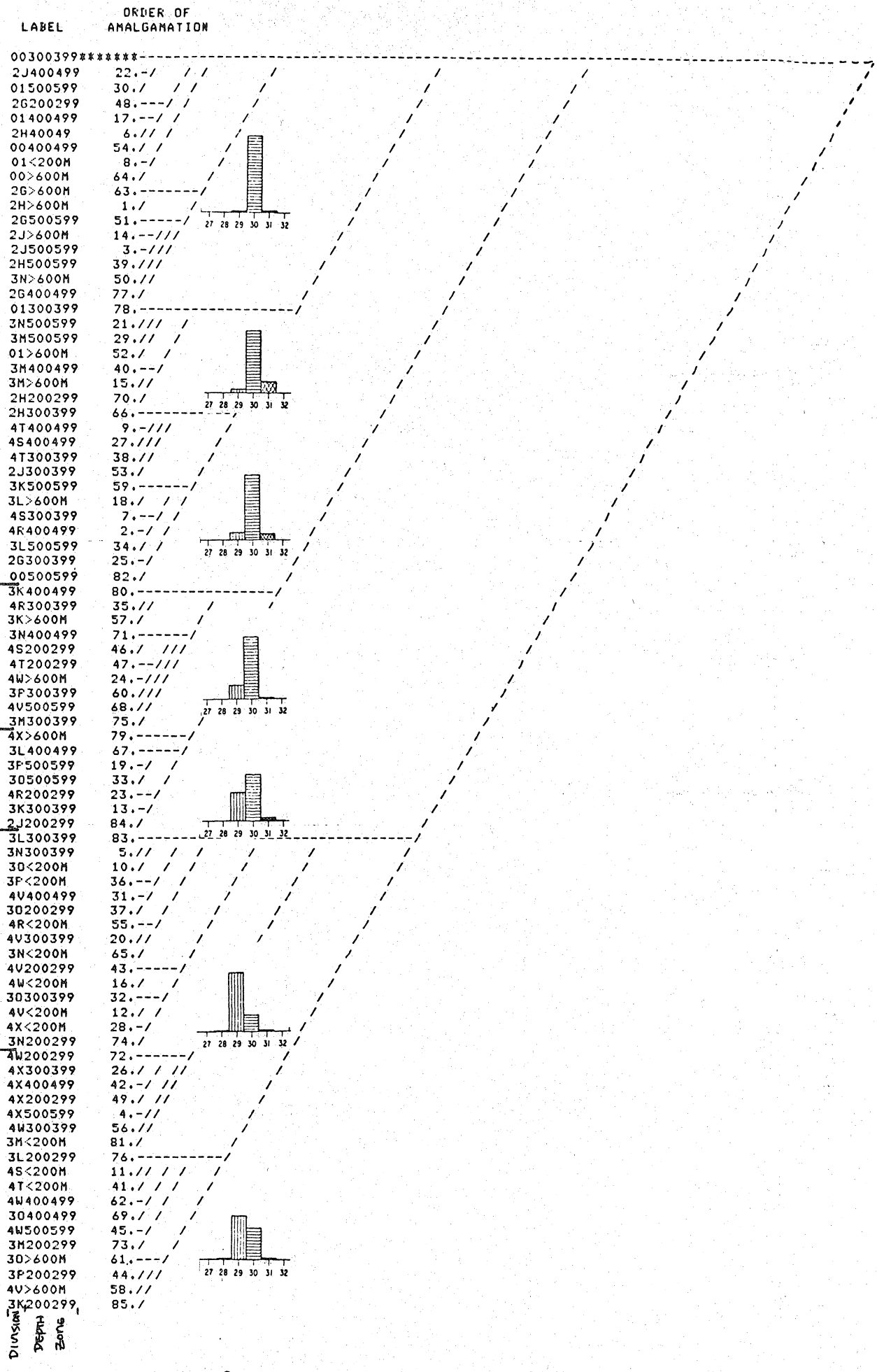

Fig. 2. CLUSTER ANALYSIS OF REDFISH VERTEBRAE FREQUENCIES

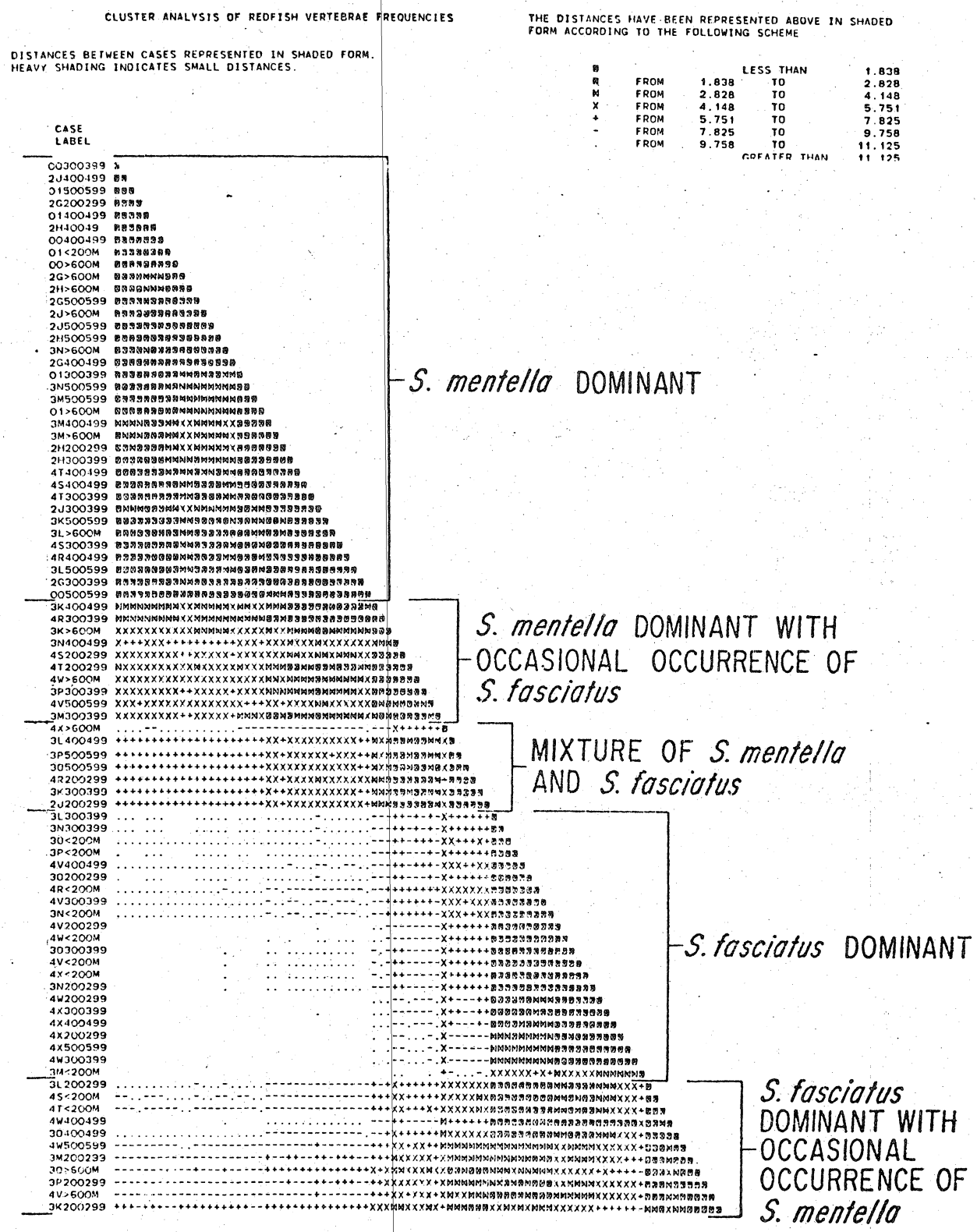

Fig. 3. Clusters of vertebrae frequencies.