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Meristic variation in golden redfish, *Sebastes marinus*, in the Northwest Atlantic

by

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ABSTRACT

The morphological differences among Northwest Atlantic redfishes have been somewhat confused in the past as all the morphological characters investigated overlapped. Meristic counts have been reported as the good discriminator between beaked redfishes, Sebastes mentella and S. fasciatus. However, the role of S. marinus in redfish classification is not clear. Meristic elements of 3612 vertebral, 1379 anal fin ray and dorsal fin ray counts were utilized to examine the meristic variation in S. marinus. X^2-test of independence of meristic frequencies showed no significant differences between sexes or among depth zones except a significant depth variation of anal fin ray and dorsal fin ray frequencies was observed on Flemish Cap. In comparison with beaked redfishes, S. marinus has less geographic variation and is similar to S. mentella in having 30 vertebral, 8 anal fin ray and 15 dorsal fin ray counts whereas S. fasciatus has 29, 7 and 14 respectively.

INTRODUCTION

The classification of Northwest Atlantic redfishes has always been a confusing topic. Templeman and Sandeman (1957) first described two varieties of redfish, marinus type and mentella type, in the Newfoundland area. This was further bewildered by the existence of a third redfish species, Sebastes fasciatus, as proposed by Barsukov (1968). In this study, I examine the vertebral, anal fin ray, and dorsal fin ray frequencies of S. marinus in the Northwest Atlantic and compare the meristic variation of S. marinus with that of S. mentella and S. fasciatus.

The morphological differences between S. marinus and S. mentella were recited by Templeman and Sandeman (1957) as well as Tempelman (1959): marinus type is found in shallower water (<300 m), is orange or yellowish red in color, has relatively small eyes, and the bony protrusion of the lower jaw is usually blunt and weakly developed whereas mentella type is in deep water with bright red colour, relatively large eyes, and a well-developed, long pointed chin. Barsukov (1972), Barsukov and Zakharov (1972), Litvinenko (1974, 1980), and Templeman (1980) were then described the morphological differences between S. mentella and S. fasciatus. Ni (1981a,b) supported the existence of S. fasciatus by listing a morphological guideline and concluded that meristics were good discriminators for separating the two beaked redfishes. Ni (1982) further exhibited the temporal, depth, and geographic variation of meristics in beaked redfishes and suggested that S. fasciatus occurs on the Nova Scotian shelf and Grand Bank whereas S. mentella is largely found in Baffin Bay, Labrador waters, and the Gulf of St. Lawrence. However, the role of S. marinus in the redfish classification is not clear since it is difficult to obtain enough specimens from the same depth and locality for the three species. In order to have an overall picture of meristic variation for all three redfish species, this research examines the sexual, depth and geographic variation of meristics in S. marinus and discusses the meristic differences among the three Northwest Atlantic redfishes.

MATERIALS AND METHODS

There were 3612 vertebrae, 1379 anal fin ray and dorsal fin ray counts collected from 1957 to 1969. The area sampled, covering the most northwest Atlantic, were NAFO Div 0-4X. S. marinus occurred very rarely in northern Labrador (Div. 2GH) in the Gulf of St. Lawrence (Div. 4ST), and on Nova

Scotia Shelf (Div. 4VWX), therefore no analysis could be conducted in these areas (Ni and McKone 1981). Sample sites were along the continental slope at bottom depths from 100 to 500 m. Data were broken down into <200 m, 200 to 299 m, 300 to 399 m and ≥400 m depth stratum for depth variation study.

Vertebral counts excluded urostyle. Anal fin ray counts were based on intermuscular bones connected with anal fin rays instead of anal fin rays.

Sexual and depth variation in each NAFO Division were examined separately by the method of Pearson χ^2-test or Yates' corrected χ^2 (if the table is 2X2). Geographic variation was examined by the patterns shown from the modes and mean values in the meristic frequency histograms.

Comparison of meristics between S. marinus and beaked redfishes (Ni 1982) were conducted with the BMDP3D program (Dixon et al. 1981) by the Levene's W-test for the variances and the appropriate t-test for the mean values. The group means of the three meristics could then be tested simultaneously by the multivariate Hotelling's T^2 and Mahalanobis D^2. This would be shown by a transformed F-statistics.

RESULTS

Vertebrae

The statistics for vertebrae in each NAFO Division are listed in Table 1. These were calculated by excluding the abnormal vertebrae (fused vertebrae). The χ^2-test of independence of vertebral frequencies for each NAFO Division showed no significant difference ($P>0.05$) between sexes (χ^2_s) or among depth zones (χ^2_d). The analysis was then conducted on data combined from all areas, no sexual variation was again obtained, however, a slight difference among depth zones was observed ($0.01>P>0.05$).

The geographic variation of vertebral frequencies could be appraised from area to area by examining their means and histograms for all NAFO Divisions (Fig. 1). No significant difference or geographic cline can be noted. They are all dominated by 30 vertebrae.

Anal Fin Rays

The anal fin ray percentage frequency histograms for each NAFO Division are shown in Fig. 2. The anal fin ray statistics are also calculated (Table 2). No sexual variation of anal fin rays was observed by the χ^2-test of independence for each NAFO Division or for all areas combined. No significant difference of anal fin ray frequencies among depth zones was obtained except for the specimens from Flemish Cap or from all areas combined.

A slight geographic cline of anal fin ray frequencies, from a high mean value in the north to a gradual reduction toward the south, was noted (Fig. 2 and Table 2). The mode of anal fin ray frequency distribution is dominated by 8 in most areas except west Greenland (Subarea 1) and Div. 3K, where anal fin rays of 8 and 9 were both equally observed.

Dorsal Fin Rays

The dorsal fin ray frequency histograms are shown in Fig. 3. The dorsal fin rays were dominated by 15 counts except Div. 2J and Div. 3O where 15 and 14 were both equally observed (Table 3). The sexual variation and depth variation of dorsal fin rays were similar to that of anal fin rays: no significant difference between sexes, or among depth was observed in most of the areas except for specimens from Flemish Cap or from all areas combined. Even the geographical cline resembled that of anal fin rays.

Comparison Between S. marinus and Beaked Redfishes

Significant differences were found between S. marinus and beaked redfishes in each of the three meristics by using Levene's test of variances and the appropriate t-test of the mean values, and also, with the three meristics combined by use of the transformed multivariate F-statistics (Table 4). The lack of significant differences shown in Subarea 1 and Div. 4R was due to the insufficient data of S. marinus. Only the variances of dorsal fin rays and anal fin rays showed no significant difference in all cases.

DISCUSSION

The meristics of S. marinus in the Northwest Atlantic were very stable: no sexual difference or depth variation in each NAFO Division, exceptions were the slight depth variation of anal fin rays and dorsal fin rays on Flemish Cap (Div. 3M). Geographic clines of anal fin ray and dorsal fin ray frequencies were contrary to the stable vertebral frequency (Table 1, 2, and 3). The significant differences among depth zones for combined data from all NAFO Divisions also implied a geographic variation of meristics in S. marinus. The area contributed the greatest difference was on Flemish Cap.

Barsukov and Zakharov (1972) first described the morphological differences among North Atlantic redfishes, however, they admitted that more intensive complex investigations were necessary for a definite solution to the redfish problem. In comparison with the temporal, depth, and geographic variation of meristics in beaked redfishes (Ni 1982), this study of sexual, depth, and geographic variation of meristics in S. marinus completed the overall meristic variation for the three Northwest Atlantic redfishes. It confirmed Baruskov and Zakharov's (1972) hypothesis on redfish meristics (not morphometrics): S. marinus is similar to S. mentella in having 30 vertebral (excluding urostyle), 8 anal fin ray, and 15 dorsal fin ray counts whereas S. fasciatus, having 29, 7, and 14 respectively, is similar to European redfish, S. viviparous (Table 5). It was also found that S. marinus has less variation in anal fin rays and dorsal fin rays than that of beaked redfishes, S. mentella and S. fasciatus.

With regard to the common name of S. marinus, the Northwest Atlantic Fisheries Organization (NAFO) uses "golden redfish", by referring to the color of orange red or golden red, instead of "ocean perch" or "redfish" as in the 4th edition of "A list of common and scientific names of fishes from the United States and Canada" (AFS 1980). This single vernacular name is more proper since it follows the principles governing selection of common names.

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Table 1. The vertebrae statistics of Sebastes marinus by NAFO Division. The probability of χ^2-test shows the independence of vertebral frequencies between sexes (χ^2_s) and among depths (χ^2_d).

	NAFO Divisions										
Statistics	0	1	2J	3K	3M	3L	3N	3Ø	3P	4R	Total
N[a]	13	131	885	322	650	56	109	48	1374	23	3611[b]
$\bar{x}$	30.0	29.97	30.04	30.01	30.07	30.16	30.05	30.02	30.05	30.04	30.04
Range	30	29-30	29-31	29-31	29-31	20-31	29-31	29-31	29-31	29-31	29-31
Mode	30	30	30	30	30	30	30	30	30	30	30
$SE_{\bar{x}}$	0	0.0149	0.0091	0.0128	0.0110	0.0494	0.0239	0.0476	0.0070	0.0772	0.0045
Percentage of abnormal Vertebrae	0	0.76	0.79	0.62	0.31	3.57	0	0	0.36	0	0.53
$P(\chi^2_s)$	-[c]	1.0[d]	0.4419	0.6337	0.3592	0.3762[d]	0.1838	0.0767	0.4090	0.06	0.7399
$P(\chi^2_d)$	-	0.5822	0.2131	0.7087	0.7050	0.8318	0.8939	0.5934	0.1785	-	0.0386[e]

[a]: excluding abnormal vertebrae.

[b]: excluding one specimen from Div. 2H.

[c]: data has less than two rows or two columns, no statistics can be computed.

[d]: Yates' corrected p value for the 2X2 table.

[e]: significant differences at p = 0.05 level.

Table 2. The anal fin ray statistics of Sebastes marinus by NAFO Division. The probability of χ^2-test shows the independence of anal fin ray frequencies between sexes (χ^2_s) and among depths (χ^2_d).

	NAFO Divisions										
Statistics	0	1	2J	3K	3M	3L	3N	3Ø	3P	4R	Total
N	13	130	399	34	81	24	91	42	560	4	1379
$\bar{x}$	8.69	8.42	8.22	8.50	8.30	8.21	8.23	8.24	8.21	8.0	8.25
Range	8-9	7-10	7-10	8-9	7-10	7-9	7-10	7-9	7-10	7-9	7-10
Mode	9	8,9[a]	8	8,9[a]	8	8	8	8	8	8	8
$SE_{\bar{x}}$	0.1331	0.0482	0.0290	0.0875	0.0667	0.1041	0.0608	0.0818	0.0237	0.4100	0.0183
$P(\chi^2_s)$	0.9621[b]	0.6994	0.8269	0.4803b	0.2953	0.3955	0.5178	0.6665	0.4002	-	0.4576
$P(\chi^2_d)$	-[c]	0.3031	0.6770	-	0.0033[d]	0.8330	0.5493	0.7534	0.2695	-	0.000[d]

[a]: The second figure where shown had a frequency of greater than 40%.

[b]: Yates' corrected p value for the 2 X 2 table.

[c]: data has less than two rows or two columns, no statistics can be computed.

[d]: significant difference at p = 0.01 level.

Table 3. The dorsal fin ray statistics of Sebastes marinus by NAFO Division. The probability of χ^2-test shows the independence of dorsal fin ray frequencies between sexes (χ^2_s) and among depths (χ^2_d).

	NAFO Divisions										
Statistics	0	1	2J	3K	3M	3L	3N	3Ø	3P	4R	Total
N	13	132	398	34	81	24	91	42	559	4	1379
$\bar{x}$	15.08	14.95	14.58	15.03	14.89	14.79	14.59	14.57	14.62	14.25	14.67
Range	15-16	14-16	13-17	14-16	13-16	14-16	13-16	13-16	13-17	14-15	13-17
Mode	15	15	15,14[a]	15	15	15		15,14[a]	15	14	15
$SE_{\bar{x}}$	0.0777	0.0444	0.0351	0.0669	0.0789	0.1470	0.0639	0.0972	0.0292	0.25	0.0183
$P(\chi^2_s)$	0.8050[b]	0.0547	0.8570	0.3221	0.1698	0.3222	0.6881	0.7585	0.3232	1.0[b]	0.3313
$P(\chi^2_d)$	1.0[b]	0.7978	0.7573	-[c]	0.0082[d]	0.1498	0.8205	0.4909	0.9139	-	0.000[d]

[a]: The second figure where shown had a frequency of greater than 40%.

[b]: Yates' corrected p value for 2X2 table.

[c]: data has less than two rows or two columsn, no statistics are computed.

[d]: Significant difference at p = 0.01 level.

Table 4. Comparison of meristics between beaked redfishes and Sebastes marinus. Levene's w-tests of variances, the appropriate t-test and the multivariate F-statistics are p at 0.05 (*), 0.01 (**), and 0.001 (***) significant levels.

NAFO Division	Vertebrae		Anal fin rays		Dorsal fin rays		All three meristics
	w-test	t-test	w-test	t-test	w-test	t-test	Multivariate F
0	(ns)[a]	(ns)	(*)	(ns)	(***)	(***)	(ns)
1	**	***	ns	*	***	***	***
2J	***	***	***	***	ns	***	***
3K	***	***	***	***	-[b]	-	-
3M	***	*	***	***	***	***	***
3L	***	***	***	**	ns	***	***
3N	***	***	***	***	ns	***	***
3O	***	***	ns	***	ns	***	***
3P	***	***	***	***	***	***	***
4R	***	***	(ns)	(ns)	(ns)	(ns)	(ns)

[a]: small sample size of S. marinus.

[b]: lack of specimens of beaked redfishes.

Table 5. Samples sizes, mean values, and modes of meristics frequencies of North Atlantic redfishes recorded in the literature for (A) Sebastes marinus (B) S. mentella, (C) S. fasciatus and (D) S. viviparus. Abbreviations for locality are NAFO Divisions.

Locality	Vertebrae[a]			Anal fin rays			Dorsal fin rays			Author
	N	Mean	Mode	N	Mean	Mode	N	Mean	Mode	
(A) S. marinus										
Iceland and W. Greenland	21	29.57	30	26	8.12	8	42	14.43	14,15	Barsukov and Zatharov (1972)
2J,3K, 3O	66	29.92	30	66	8.39	8				Barsukov and Zakharov (1972)
Barents Sea	22	29.91	30	244	7.92	8	56	14.54	15	Barsukov and Zakharov (1972)
(B) S. mentella										
Barents Sea	37	30.14	30	137	8.49	8	80	14.29	14	Barsukov and Zakharov (1972)
Iceland and Greenland	37	30.27	30	42	8.72	9				Barsukov (1972)
Iceland	253	30.17	30	282	8.49	9	34	14.65	15	Barsukov and Zakharov (1972)
West Greenland	146	29.99	30	235	8.53	9	57	14.53	15	Barsukov and Zakharov (1972)
West Greenland	546	30.06	30	591	8.55	9	591	14.57	15	Ni (1982)
Baffin Island	397	30.02	30	326	8.54	9	153	14.59	15	Barsukov and Zakharov (1972)
Baffin Island	599	30.03	30	771	8.51	9	771	14.59	15	Ni (1982)
2G	435	30.01	30	825	8.53	9	468	14.56	15	Ni (1982)
2H	948	30.04	30	1282	8.57	9	983	14.59	15	Ni (1982)
2J	202	30.04	30	203	8.61	9				Barsukov and Zakharov (1972)
3K	232	30.03	30	233	8.51	9				Barsukov and Zakharov (1972)
3L	100	30.03	30	100	8.62	8	100	14.67	15	Ni (1981 b)
3O	109	30.10	30	297	8.94	9	42	14.61	14	Litvinenko (1974)
3M, 3P	49	30.00	30	48	8.37	8				Barsukov and Zakharov (1972)
Flemish Cap and Banquereau	48	30.02	30	48	8.40	8				Barsukov (1972)
4R[b]	5335	29.65	30	2205	7.90	8	1482	13.98	14	Ni (1982)
4R[b]	2465	29.75	30	1588	7.93	8	759	14.06	14	Ni (1982)
4R[b]	2053	28.82	30	522	8.10	8	219	14.09	14	Ni (1982)
(C) S. fasciatus										
2J, 3K	228	29.36	29	232[c]	7.63	8	96[c]	13.79	14	Barsukov and Zakharov (1972)
3L	99	29.31	29	100	7.02	7	100	13.62	14	Ni (1981 b)

Table 5. (Cont'd.)

Locality	Vertebrae N	Vertebrae Mean	Vertebrae Mode	Anal fin rays N	Anal fin rays Mean	Anal fin rays Mode	Dorsal fin rays N	Dorsal fin rays Mean	Dorsal fin rays Mode	Author
3L[d]	1743	29.53	29	1850	7.82	7	1658	13.99	14	Ni (1982)
3N[d]	1229	29.41	29	1279	7.58	7	1274	13.92	14	Ni (1982)
3O[d]	1885	29.29	29	1993	7.32	7	1693	13.76	14	Ni (1982)
3O	124	29.05	29	124	7.22	7	84	13.63	14	Litvinenko (1974)
3M, 3N, 3O, 3P	455	29.12	29	455	7.27	7	196[e]	13.67	14	Barsukov and Zakharov (1972)
4W, 5Z[a]	447	29.19	29	489	7.22	7	106[f]	13.73	14	Barsukov and Zakharov (1972)
4V[d]	1061	29.21	29	1239	7.50	7	952	13.69	14	Ni (1982)
4W[d]	2598	29.17	29	1608	7.27	7	1607	13.69	14	Ni (1982)
4X[d]	1176	29.15	29	1013	7.24	7	1014	13.61	14	Ni (1982)
(D) S. viviparus										
Rockall Bank	48	29.00	29	50	6.80	7				Barsukov and Zakharov (1972)
Coast of Norway	60	29.00	29	88	7.02	7	84	13.42	13	Barsukov and Zakharov (1972)
Iceland	113	29.00	29	87	6.97	7	47	13.85	14	Barsukov and Zakharov (1972)

[a]: data were adjusted by excluding urostyle.

[b]: mixing with small amount of S. fasciatus from shallow waters.

[c]: from 3K only.

d: mixing with small amount of S. mentella from deep waters.

[e]: from 3O, 3P only.

[f]: from 4W only.

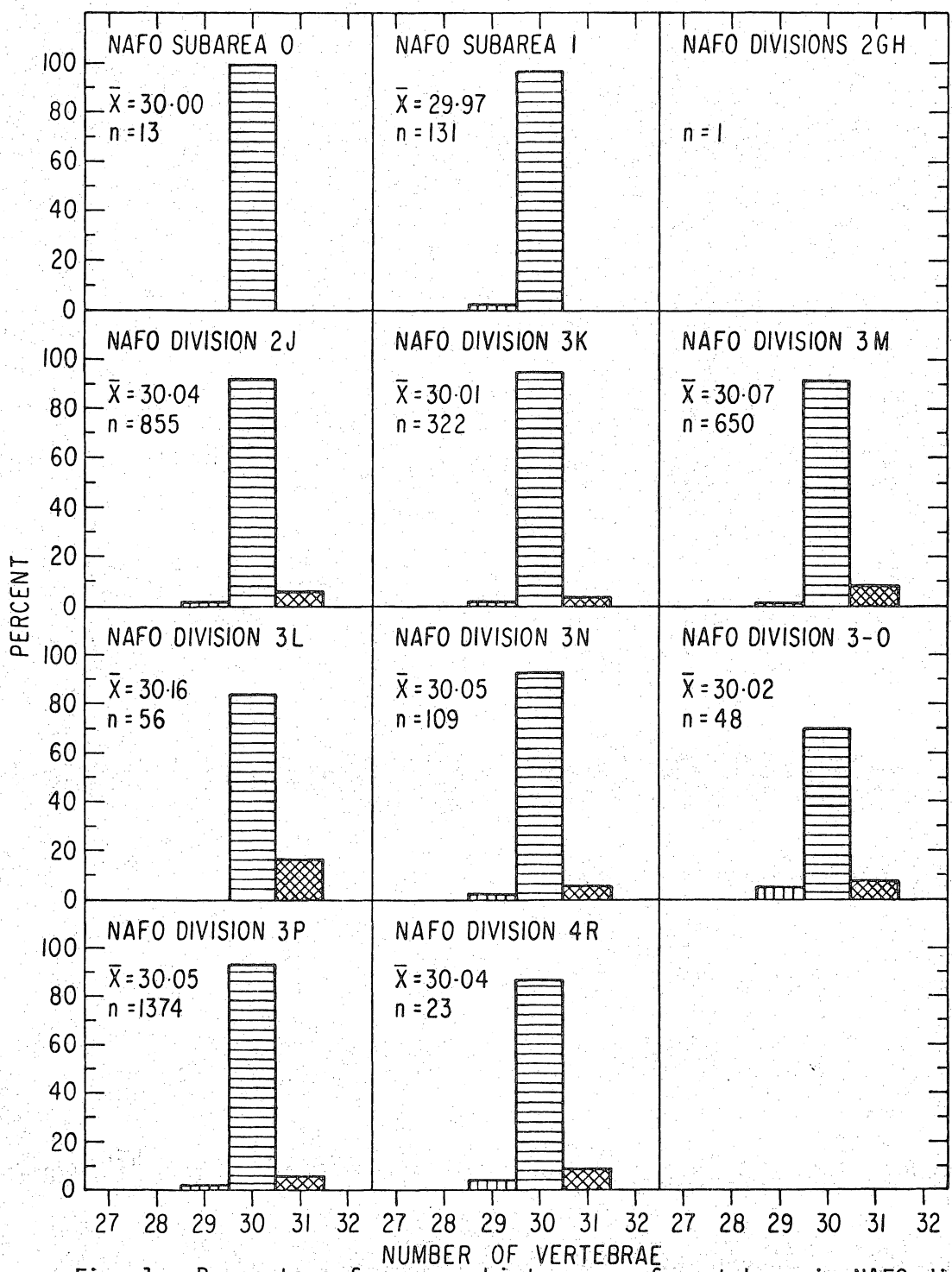

Fig. 1. Percentage frequency histograms of vertebrae in NAFO divisions.

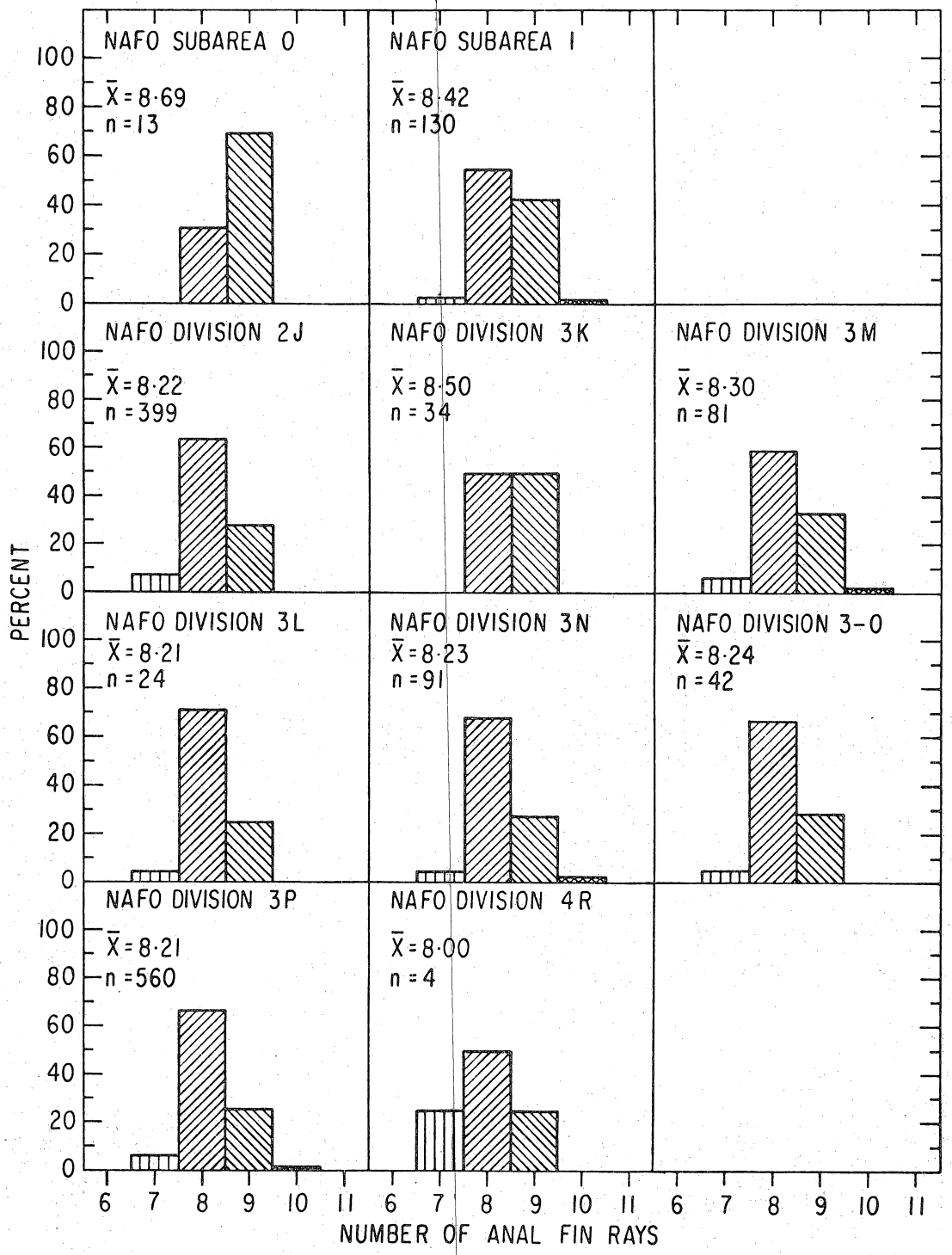

Fig. 2. Percentage frequency histograms of anal fin rays in NAFO divisions.

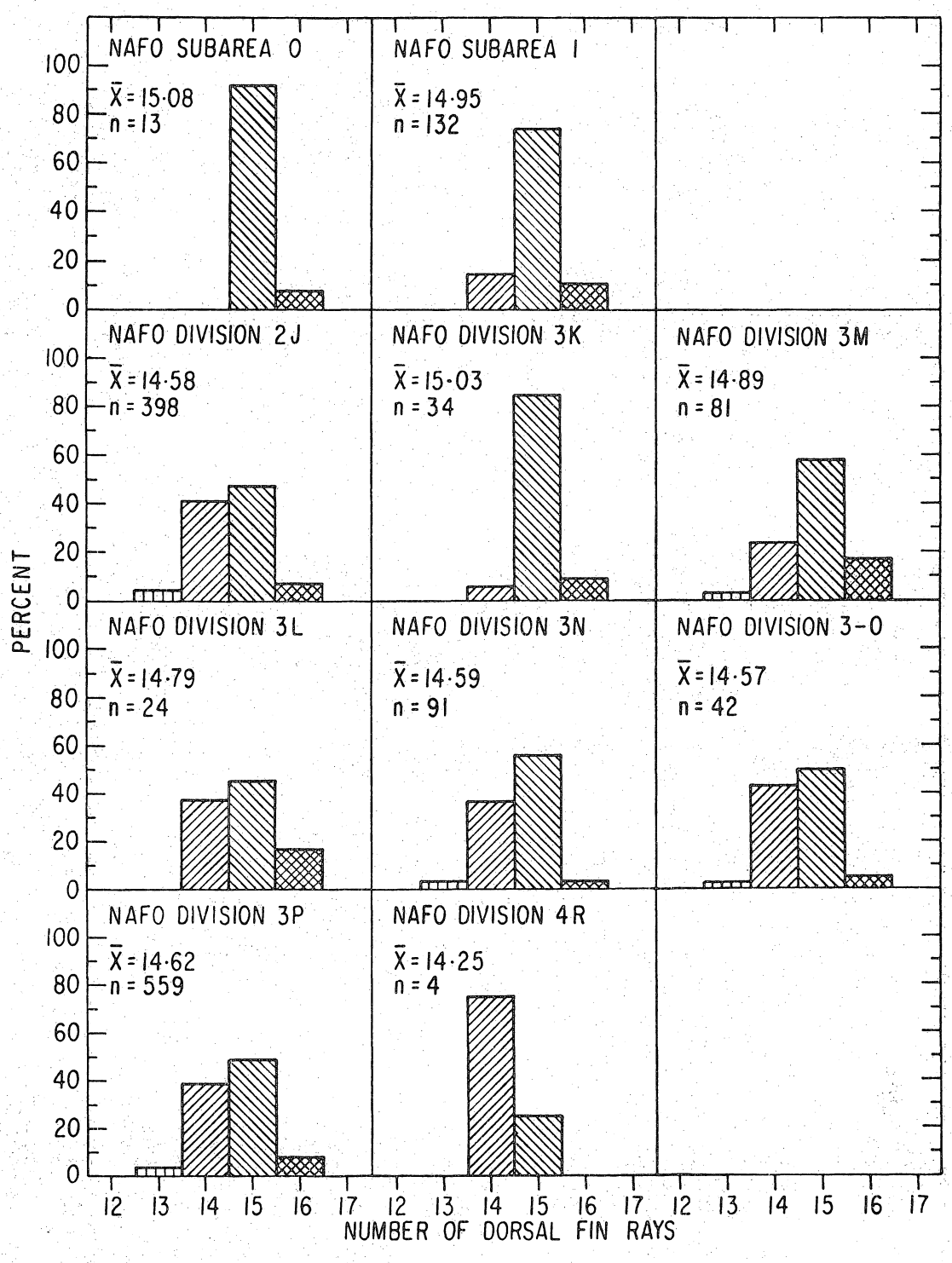

Fig. 3. Percentage frequency histograms of dorsal fin rays in NAFO Divisions