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Reproductive cycles of redfishes in southern Newfoundland waters

by

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ABSTRACT

Information on the ovoviviparous reproductive cycle of Sebastes spp. is important for perceiving the sibling species differentiation and stock discrimination. There are 11,527 redfish maturity data collected between 1957 to 1969 from southern Newfoundland waters. Monthly changes of maturity condition and maturity factor indicated that beaked redfish spawned mainly in June and S. marinus probably spawned earlier. The large variation of sex ratio, peculiar monthly length frequencies, and unusual percentage of immature females suggested a possible migration of redfishes.

INTRODUCTION

Redfish stock assessment and management are often found unsatisfactory. This is because redfish species are not distinguished for commercial statistics and usually not differentiated in biological recording. Three redfish species were reported (Templeman and Sandeman 1957, Barsukov 1968) and their identification was difficult as most of the morphological characters investigated overlapped (Barsukov 1972, Barsukov and Zakharov 1972, Litvinenko 1974, Templeman 1980, Ni 1981b). Although the anatomical character of extrinsic gasbladder musculature is a good discriminator among three forms, Sebastes marinus, S. mentella and S. fasciatus (Litvinenko 1980, Ni 1981a, Power and Ni 1982), the dissection is very time-consuming which makes it difficult to apply in field sampling. Secondly, their distribution are mixed-up in some areas where three redfish species can be found in NAFO Div. 3M, 2J, 3K and 3P (Ni and McKone 1981, Ni 1982a and 1982b). Finally, their vital statistics, like growth and size at maturity, were found to be different among species (Sandeman 1969, Ni and Sandeman 1982).

The questions have then been asked: why are there three redfish species residing in the same area? What is the speciation mechanism? We approached this problem by examining the historical maturity data collected from southern Newfoundland waters to reveal the reproductive cycle for both S. marinus and beaked redfishes (S. fasciatus and S. mentella combined).

Three major processes in the redfish reproductive cycle were reported for northeastern redfish (Magnusson 1955, Sorokin 1958, 1961): these are mating (when spermatozoa are transferred from male to female), fertilization (when the ova are actually fertilized), and spawning (when the larvae are released). Little is known (Nikolskaya 1967, 1979) for Northwest Atlantic redfishes due to the confusion of redfish systematics and classification in past decades.

In this report, we investigated the length frequencies by month as well as depth, sex ratio, size at maturity, and monthly changes in maturity factors for both S. marinus and beaked redfishes. The reproductive cycle and its role in species and/or stock discrimination of redfishes were discussed.

MATERIALS AND METHODS

Collection of Samples

During 1957-69, 11,527 redfish specimens were collected from southern Newfoundland waters (Div. 3Ps and 3Pn) at bottom depths of 100 to 500 m. Primary sampling sites were in Hermitage Bay and Connaigre Bay, from which S. marinus as well as beaked redfishes could be collected.

Processing

All the specimens were measured to the nearest centimeter for fork length. Sex and maturity (Table 1) were determined and double checked on research boats for 9616 beaked redfishes (S. mentella and S. fasciatus) and 1860 golden redfish (S. marinus).

Additional examinations were conducted on some of the specimens at the laboratory. Body weight (gilled and gutted) was measured to the nearest gm. The gonad weight was measured by volume (cc) and then transformed to gm by a multiplication of 1.1.

RESULTS

Monthly Length Frequencies and Sex Ratio

The sex ratios from both beaked redfishes and S. marinus were examined monthly with length frequencies (Fig. 1). In the analysis, the fish have been grouped in 5 cm groups. The percentage length frequencies was calculated by separating sexes. Females were larger than males, particularly in S. marinus.

In beaked redfishes, there were more females than males. Exceptions were in March, June, and August. A large proportion of smaller beaked redfishes was noted in March as the larger size of fishes disappeared.

In S. marinus, large variations in sex ratios were observed. Males dominated in February (with relatively large sizes), October, July, January, April, and September. However, only 29% of the fish were male in December.

Depth Variation

Ni (1982) noted the depth distribution of the two species of beaked redfishes in southern Newfoundland waters: S. fasciatus dominated in the shallow waters whereas S. mentella were found in deep waters. Therefore, the length frequencies and sex ratios were then analyzed by depth, the proportion mature were also added to each length category except for S. marinus in shallow waters (<100 m) (Fig. 2). The numbers of male beaked redfishes were found to decrease with depth, as the sex ratios were reduced from 1.0 to 0.36, whereas the male S. marinus were dominant except in very shallow water (<100 m). The proportion mature in beaked redfishes was also found to increase with depth. It seemed no immature males of S. marinus could be recorded in this area.

Maturity Condition

The maturity condition, as described in Table 1, was examined monthly for both beaked redfishes (Table 2) and S. marinus (Table 3). Immature and mature are the general terms. For some specimens, mature condition was further determined for 6 stages for males and 8 stages for females. Interpretation of maturity stages should be cautious for S. marinus which did not have sufficient sample size.

In male beaked redfishes, immatures were noted mainly from February to August. Very few immature males were found in January. Maturing stage for males started from May and concentrated in June and July. There were 61% of matured stage noted in June. Spending stage mainly occurred in July and lasted to August and September. Spent stage dominated in September (71%). Male beaked redfish were resting and recovering mainly from October to November and were rematuring for the next breeding season in February and January.

For female beaked redfishes, About 50 to 60 percent of them were in immature stages all year round, except a very low immature percentage in January (21%) and a very high ratio in March (87%). Maturing stage dominated in February. Eggs were clearing and becoming loose in the ovary from February to April. This would be the time for fertilization. Cleavage of eggs developed from February to May. Larvae were developing in April and were hatched in April, May and June. Spawning started probably from April, was at its peak in June and was almost over by July. This was evidenced by the larvae extruded stage occurred mainly in June and July. Resting, recovering and rematuring were noted from July onwards.

For S. marinus, interpretation of the reproductive cycle was difficult due to insufficient monthly data. A similar pattern to beaked redfishes was generally noted. However, almost all mature female S. marinus were spawning or spent in May, which is about one month earlier than that of beaked redfishes, but only small numbers were examined, especially in June.

Size at Maturity

The size at maturity was defined where 50% of fish were in mature stage. The logistic model was applied to calculate the mature proportion versus fork length as described in Ni and Sandeman (1982). The sizes at maturity for males and females were determined as 18.56 cm and 29.61 cm respectively in beaked redfishes, and also as 16.95 cm and 40.32 cm respectively in S. marinus (Fig. 3). This is similar to the size at maturity of 20 cm for males and 30 cm for females reported by Sandeman (1969) for mentella type redfish in Hemitage Bay. The ages of maturity are about 6 yr and 10-12 yr respectively.

Maturity Factor

The maturity factor is defined as the gonad weight divided by body weight of fish and expressed in percentage. In order to reduce the variability introduced by the fullness of stomach, we utilize the gutted and gilled weight of fish instead of total body weight for calculating maturity factor. The monthly changes in maturity factor were exhibited in histograms comparing beaked redfishes and S. marinus (Fig. 4). It was then displayed by the mean values of maturity factor with its 95% confidence limits for specimens larger than the size at maturity for both groups (Fig. 5).

In beaked redfishes, increasing size of testes was noticed commencing in February. Testes grew to the maximum size in April and May, and then started to decrease in June. The smallest maturity factor was observed in December. The ovaries were expanding gradually from August. Large ovaries were noted in some of the specimens in December and then reach the maximum maturity factor in April and May. A sharp decrease in ovarian size was noted from May to June.

A similar pattern to that of beaked redfishes was noted in S. marinus. It seemed that there are not very many females of S. marinus with large gonads in southern Newfoundland waters. The significant differences in maturity factor between the two groups were for females, especially from January to May.

DISCUSSION

Redfish have very complicated species and stock structures. Morphologically, they are similar to each other. Geographically, they sometimes distribute in different depths in the same area. In terms of life history the ovoviviparous fishes differ from the oviparous fishes in the sense of a great reduction of their number of eggs. The redfishes are, however, an exception: a fully grown pregnant female of S. marinus is estimated to have about 150,000 (Magnusson 1955). This may greatly with regard to population biomass, which were highly fluctuated (Parsons 1976). The comprehension of the reproductive cycle of redfishes could then be attributed to the understanding of species differentiation and stock discrimination. Based on spawning season and sites, we can investigate the environmental factors, which make them different, and trace the pelagic larvae. In so doing, we can then explore the controlling factors for redfish distribution and biomass fluctuation.

From a study of gasbladder musculature (Power and Ni 1982) and biochemical systematics (Payne and Ni 1982), it was suggested that S. fasciatus is the predominant species, in southern Newfoundland waters. Although the percentage of 8 anal fin rays for S. fasciatus was found greater than on northeastern Grand Bank (Ni 1981b).

The reproductive cycle of beaked redfishes, as indicated by the monthly changes of maturity conditions and maturity factor, was that fertilization of eggs was probably in February to April, and spawning was found from April to July and mainly in June. It also suggested that S. marinus spawned earlier than beaked redfishes. Magnusson (1955) pointed out that the large, white, soft and easily injured testes, as observed in May and June, had no mature spermatozoa. He concluded that the maximum size of the testis in European redfish, as shown by the histological studies, was neither in the period of copulation nor in the period of sperm maturity. He indicated that the testes had become somewhat yellowish in September and the copulation started in October and lasted to January when testes were thinner and the vas deferens was completely filled with spermatozoa. This probably could not be observed on research boats as pressure changes on the testes as well as the vas deferens could force sperm out of the body. In future, histological studies for testes and ovary of Northwest Atlantic redfishes should be carried out.

The peculiar length frequencies observed in March for beaked redfishes and in February for S. marinus, the large variation of sex ratio, especially for S. marinus, the unusual percentage of immature females of beaked redfishes in January and March, and the significant difference of maturity factors between beaked redfishes and S. marinus from January to May all indicated the possible migration of redfishes.

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Table 1. Gonad condition criteria applied to Sebastes specimens in southern Newfoundland (NAFO Div. 3Ps and 3Pn)

Code	Condition	Description
	MALES	
10	Immature	Testes like a translucent string, width less than 1 mm approximately.
20	Mature	
21	Maturing	Testes approximately bigger than 1.1 mm-1.5 mm.
22	Matured	Milt in vas deferens
23,24	Spending	Partly spent, old milt in vas deferens
25	Spent	Mating would be expected
26,27	Resting	Recovering after spent in the same year
28	Rematuring	Recovering for year after spending year and rematuring for next breeding season
	FEMALE	
50	Immature	Ovary relatively tiny. If eggs present, ovarian wall clear, transparent and delicate. Eggs usually less than 0.2-0.3 mm in diameter. No evidence of old eye pigment or darker peritoneum.
60	Mature	
61,62,65	Maturing	Egg and ovary are larger in size beyond the immature to the point where it is expected that the fish will produce larvae at the next spawning season they may or may not have spawned before.
66,67	Matured	Eggs about 1 to 1.2 mm in diameter, clearing and becoming loose in ovary, with no evidence of cell division or formation of larvae.
70,71,72,73	Egg developing	Prelarval stage, early cell division to cell cap stage and neural fold stage.
74,75,76	Larvae developing	Early larva in egg, to the stage with eye pigment distinct
77,78,79,80	Hatching to hatched	Larvae well developed and 1-100% hatched, yolk sac protruding when hatched to used up and ready for extrusion.
81,82,83	Spawning	Partly spent, old larvae remain
84,85	Spawned	Larvae extruded
63	Recovering A	Recovering after spawning in the same year, with or without old eye pigment, or maturing from immature.
87,88,64	Recovering B	Recovering from previous year spawning and rematuring for present year, or maturing from immature.

Table 2. Observed frequencies of monthly maturity conditions in beaked redfishes

Maturity condition	January	February	March	April	May	June	July	August	September	October	November	December	Total # sampled
MALE													
IMMATUI0	7	98	83	65	111	96	111	104	39	27	28	42	811
MATURE20	0	329	6	102	244	425	139	264	31	0	1	9	1350
MATURE21	46	102	9	86	165	245	326	74	0	0	0	0	1053
MATPMI22	0	0	0	2	13	89	29	13	0	0	0	0	146
SPEN2324	0	0	0	27	7	15	125	56	36	1	0	6	273
SPENTP25	0	1	1	4	1	1	6	1	96	14	4	6	135
MATU2627	0	2	3	2	0	0	25	64	69	135	133	74	507
SPLMAP28	16	161	0	0	0	0	0	0	0	0	0	0	177
FEMALE													
FIMMAT50	21	400	73	157	284	534	530	310	156	108	96	105	2774
FMATUR60	0	5	0	25	32	3	0	2	0	0	0	8	75
MA616265	13	196	2	8	0	5	11	16	18	19	6	9	293
MATU6667	0	24	1	16	9	0	0	0	0	0	0	0	50
70717273	0	69	0	45	35	2	0	0	0	0	0	0	151
LA747576	0	25	0	19	48	17	0	0	0	0	0	0	101
77787980	0	0	3	18	73	57	5	0	0	0	0	0	156
SP818283	0	0	2	2	27	33	9	3	0	0	0	0	76
SPE08485	0	0	2	30	88	105	118	4	4	0	0	0	351
SPENTP63	0	0	1	0	4	74	160	192	113	120	82	48	794
SP878864	66	53	0	4	2	0	0	0	0	0	0	0	125
TOTAL	159	1465	186	612	1143	1701	1594	1103	562	424	350	307	9606

Table 3. Observed frequencies of monthly maturity conditions in Sebastes marinus.

Maturity condition	January	February	March	April	May	June	July	August	September	October	November	December	Total # sampled
MALE													
IMMATUI0	0	1	0	0	0	0	0	1	0	0	0	1	3
MATURE20	0	132	0	5	118	12	1	52	0	2	4	1	327
MATURE21	30	1	0	106	182	37	24	1	0	0	0	0	381
MATPMI22	0	0	0	1	2	15	21	7	0	0	0	0	46
SPEN2324	0	0	0	0	0	1	13	37	6	0	19	0	76
SPENTP25	0	0	0	2	3	0	0	2	0	0	2	0	9
MATU2627	0	0	0	0	0	0	5	8	27	53	20	3	117
SPLMAP28	23	53	0	0	0	0	0	0	0	0	0	0	76
FEMALE													
FIMMAT50	30	13	0	53	179	23	20	40	10	6	22	1	397
FMATUR60	0	0	0	2	2	0	0	1	0	0	0	0	5
MA616265	1	2	0	0	6	1	4	12	9	4	19	0	58
MATU6667	0	0	0	0	0	0	0	0	0	0	0	0	0
70717273	0	7	0	1	0	0	0	0	0	0	0	0	7
LA747576	0	9	0	0	1	0	0	0	0	0	0	0	10
77787980	0	0	0	6	17	0	0	0	0	0	0	0	23
SP818283	0	0	0	3	16	2	0	0	0	0	0	0	21
SPE08485	0	1	0	4	105	23	2	5	1	0	0	0	141
SPENTP63	0	0	0	0	3	20	9	62	3	6	11	0	114
SP878864	2	0	0	0	1	0	0	0	0	0	0	0	3
TOTAL	86	219	0	184	635	134	99	228	56	70	97	6	1814

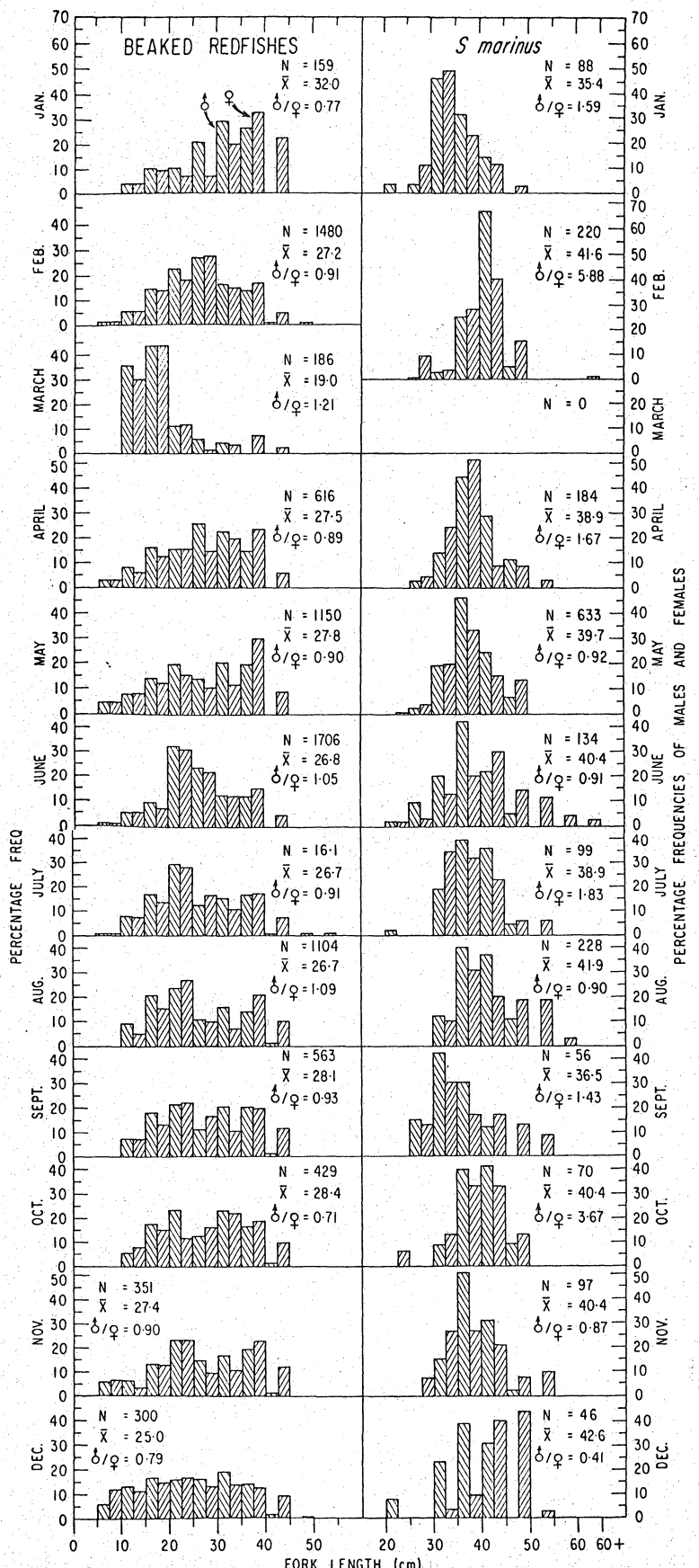

Fig. 1. Monthly length frequency distribution by sex in beaked redfishes and S. marinus

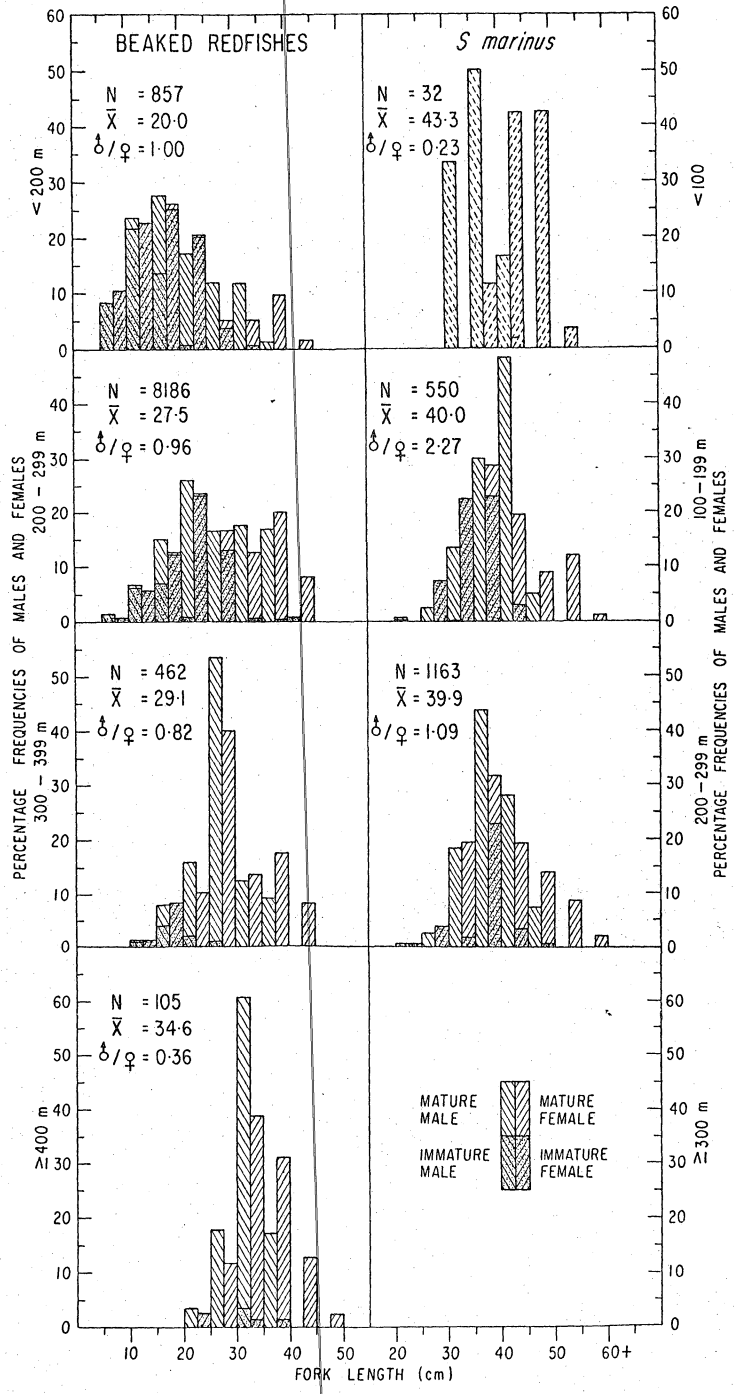

Fig. 2. Length frequency distribution and proportion mature by sex at different depth stratum in beaked redfishes and S. marinus.

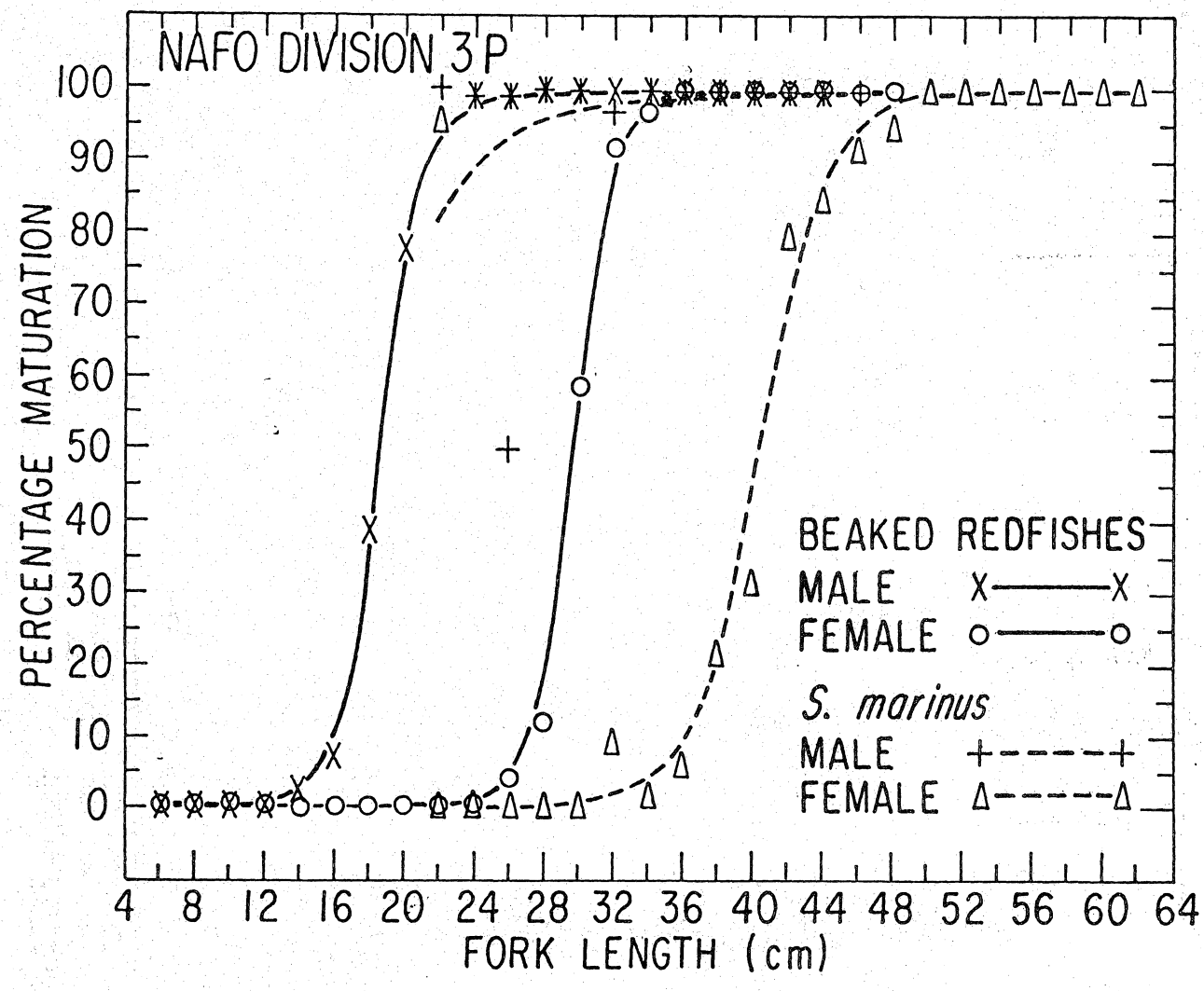

Fig. 3 The proportion mature versus fork length by sex in beaked redfishes and S. marinus

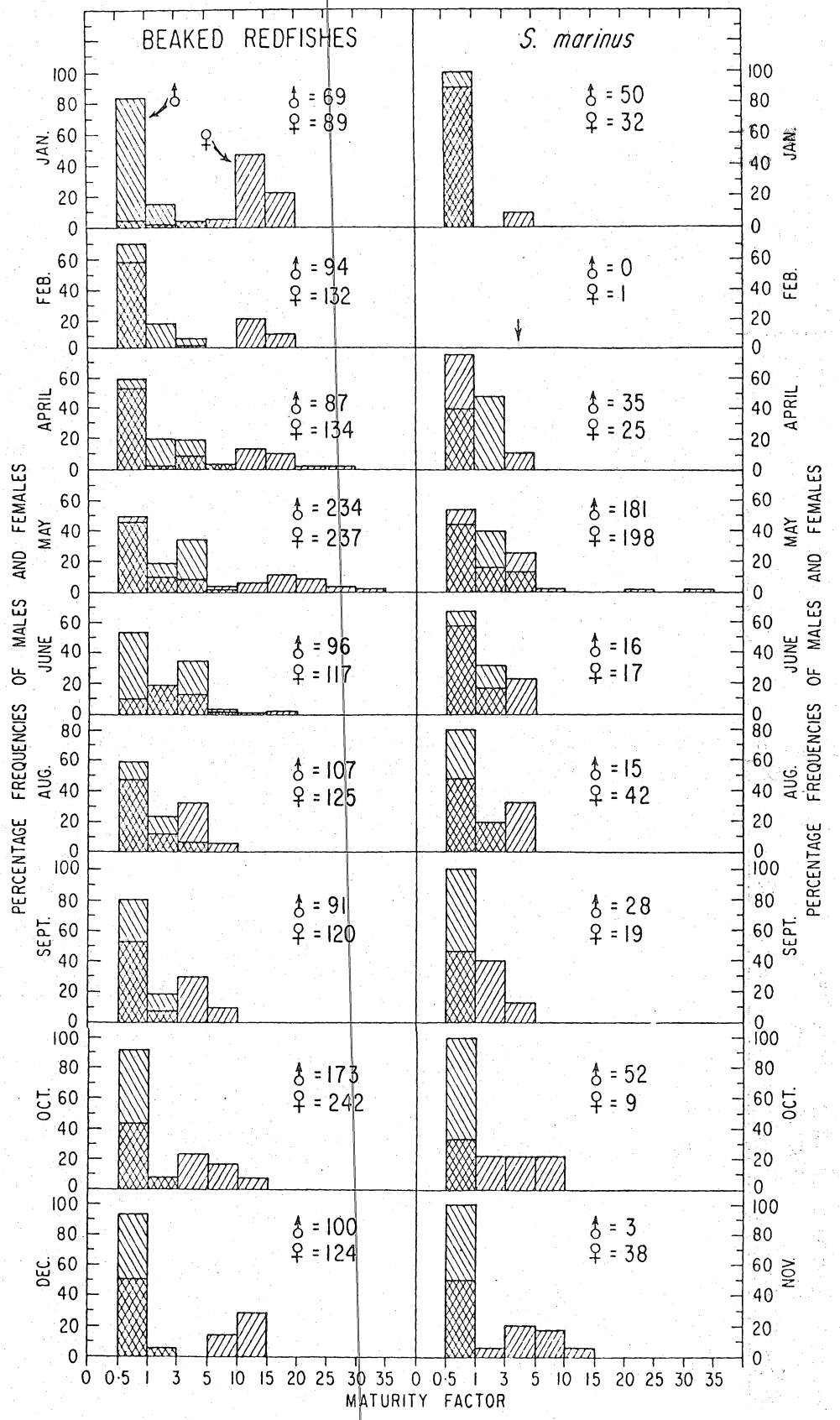

Fig. 4. Monthly frequencies of maturity factor by sex in beaked redfishes and S. marinus.

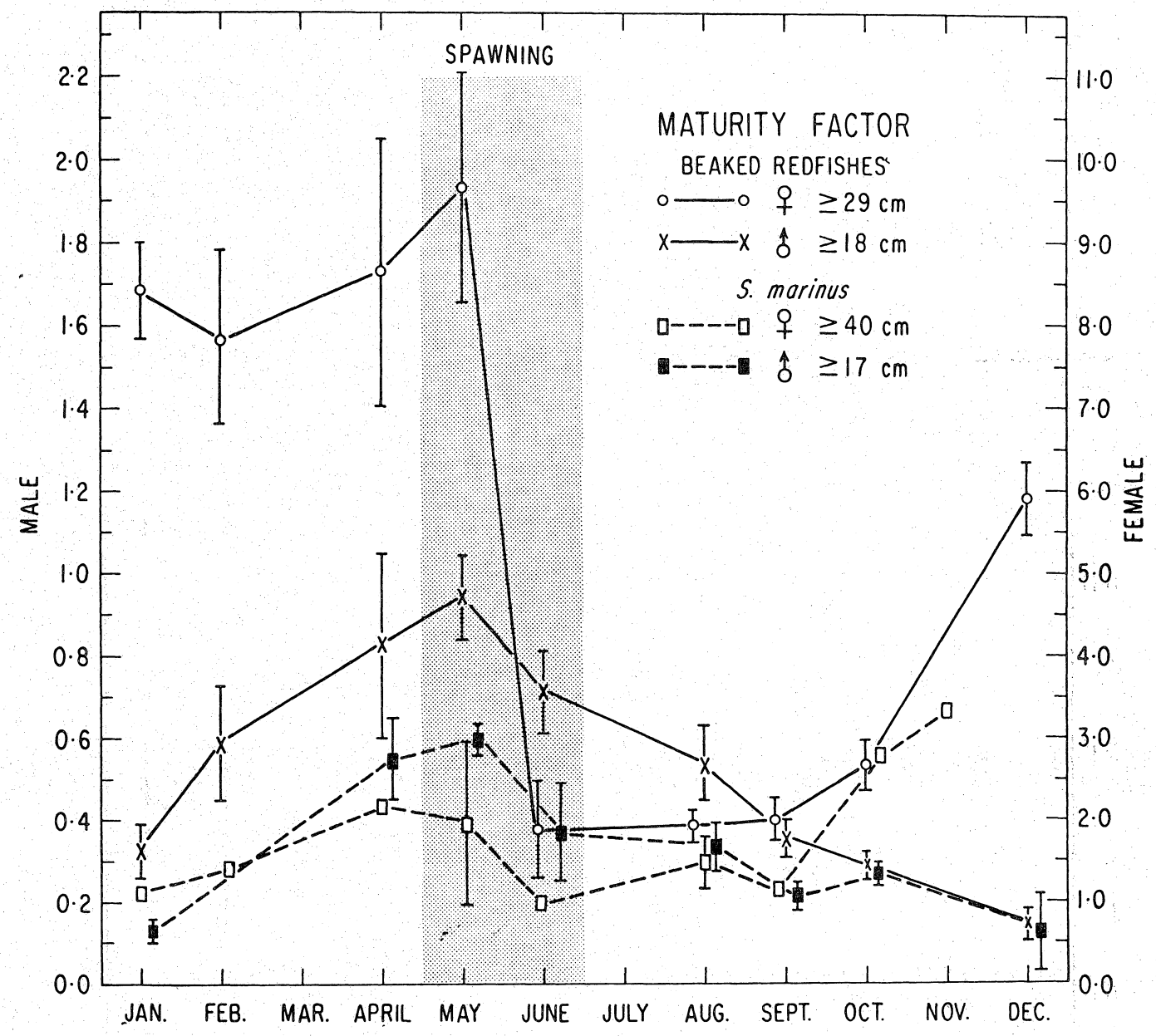

Fig. 5. Monthly changes of maturity factor by sex in beaked redfishes and S. marinus for specimens larger than size at maturity. Vertical bars are mean values with 95% confidence limits, absent if the standard error are too large due to small sample size.