http://journal.nafo.int
J. Northw. Atl. Fish. Sci., Vol. 6: 57-63

Reproductive Cycles of Redfishes (*Sebastes*) in Southern Newfoundland Waters

I-Hsun Ni and Wilfred Templeman
Fisheries Research Branch, Department of Fisheries and Oceans
Northwest Atlantic Fisheries Centre, P. O. Box 5667
St. John's, Newfoundland, Canada A1C 5X1

Abstract

Rapid field identification of *Sebastes mentella*, *S. fasciatus* and small *S. marinus* is difficult. Thus, redfish species are not distinguished for commercial statistics and the beaked redfishes usually not differentiated in biological sampling, the result being a lack of biological information by species. Knowledge of the ovoviviparous reproductive cycle of *Sebastes* sp. is important for species differentiation and stock discrimination. Investigations of sexual maturity and spawning in redfishes of southern Newfoundland waters (NAFO Division 3P) were carried out on the basis of 11,520 sex and maturity observations collected from 1957 to 1969. Stages of sexual maturity are described. Monthly changes of maturity condition and maturity factor indicated that beaked redfishes (*S. fasciatus*) spawned mainly in May/June and *S. marinus* probably spawned earlier.

Introduction

Morphological differences in Northwest Atlantic redfishes have been extensively described, but little is known about the biology of the different species due to confusion about redfish systematics in past decades. Three species of redfish have been reported (Templeman and Sandeman, 1957; Barsukov 1968). Identification of the two species of beaked redfishes (*Sebastes fasciatus* and *S. mentella*) and of small golden redfish (*S. marinus*) was difficult because most of the morphological characters overlapped (Barsukov, 1972; Barsukov and Zakharov, 1972; Litvinenko, 1974; Templeman, 1980; Ni, 1981a; Misra and Ni, 1983). Although the anatomical character of extrinsic gasbladder musculature is a good discriminator among the three forms (Hallacher, 1974; Litvinenko, 1980; Ni, 1981b; Power and Ni, 1982), dissection is very time-consuming and its use in field sampling is difficult. Also, the depth distributions of the three species overlap in some areas: on Flemish Cap (NAFO Div. 3M), and in waters off southern Labrador (Div. 2J), northeastern Newfoundland (Div. 3K) and southern Newfoundland (Div. 3P) (Ni, 1982, 1984; Ni and McKone, 1983). Thus, redfish species are not distinguished in fishery statistics, and the beaked redfishes are usually not differentiated in biological sampling, resulting in a lack of biological information by species. However, differences between species have been reported with respect to growth (Sandeman, 1969), larvae (Templeman, 1980) and size at sexual maturity (Ni and Sandeman, 1984). The questions have therefore been asked: Why are there three redfish species residing in the same area? Do these sympatric species have reproductive isolation? Three major processes in the reproductive cycle have been investigated for Northeast Atlantic redfishes (Magnûsson, 1955; Sorokin, 1958, 1961). These are mating when spermatozoa are transfered from male to female, fertilization of the eggs, and release of larvae (spawning).

For this paper, monthly variation in length frequencies, sex ratios, maturity condition and maturity factors of golden redfish (*S. marinus*) and beaked redfishes (*S. fasciatus* and *S. mentella* combined) were investigated from data collected in southern Newfoundland waters (Div. 3P). The study also involved size at maturity and variation in distribution of the species with depth. The reproduction cycle and its role in species and/or stock discrimination of redfishes are discussed.

Materials and Method

During 1957-69, 11,520 redfish specimens were collected from the otter-trawl catches of research vessels during daytime in southern Newfoundland waters (Fig. 1) at bottom depths to 578 m, in which 82% of the specimens were from 200-299 m. Sampling sites were

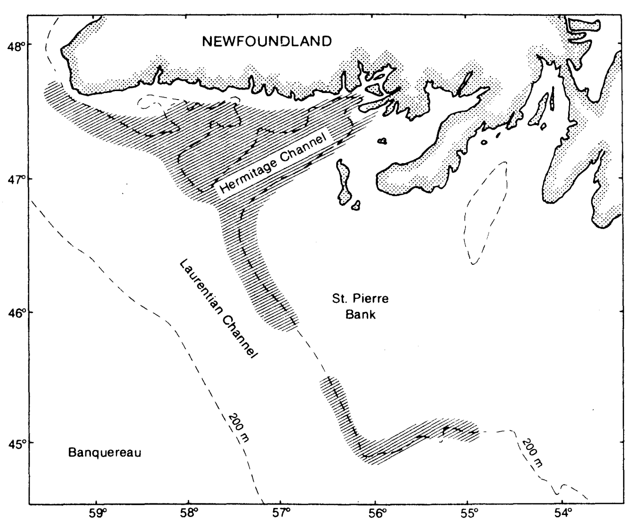

Fig. 1. Areas where redfish samples were collected off southern Newfoundland in 1957-69.

TABLE 1. Maturity stages and descriptions of gonad condition for redfishes (*Sebastes*) from the southern Newfoundland area.

Maturity condition	Description
	Male
Immature	Testes translucent, string-like; width usually <1 mm (Ni and Sandeman, 1984).
Maturing	Testis width approximately 1.1–1.5 mm in area under study.[1]
Matured	Vas deferens approximately full of milt.
Partly spent	Some milt remaining in vas deferens; mating occurs during this stage.
Spent	No milt in vas deferens.
Resting	Slow recovery from spent condition.
Rematuring	Recovering from spent condition in previous year and maturing for breeding in current year.
	Female
Immature	Ovary tiny; ovarian wall transparent and delicate; eggs, if present usually less than 0.2–0.3 mm diameter; no evidence of old eye pigment or darker peritoneum (Ni and Sandeman, 1984).
Maturing	Ovary and eggs larger than immature condition, and developed to point where larvae expected to be produced in next spawning season; these fish may or may not have spawned before.
Matured	Eggs about 1.0–1.2 mm diameter, clearing and becoming loose in ovary, but no evidence of cell division.
Egg development	Early cell division to cell cap and neural fold stages.
Larval development	Development of larvae to stage of distinct eye pigment.
Hatching-hatched	Larvae well developed and 1–100% hatched, ranging from yolk-sac stage to larvae ready for extrusion.
Spawning	Partly spent, with some hundreds or thousands of larvae remaining.
Spawned	Extrusion of larvae completed; ovaries with old eye pigment and heavy pigmentation of peritoneum.
Recovering A	Recovering after spawning in same year, with or without old eye pigment, or maturing from the immature condition.
Recovering B	Recovering from previous year's spawning and maturing to spawn in current year.

[1] Applicable to the region from southwestern Grand Bank westward to Scotian Shelf and Gulf of St. Lawrence; in eastern Grand Bank and northern areas, redfish maturing when width of testis usually 1.5–2.0 mm.

in the deepwater channels and bays, primarily in Hermitage Bay and Coinnaigre Bay (77% of the specimens) but also in Hermitage Channel and Laurentian Channel. Identification of redfishes followed the criteria of Templeman and Sandeman (1957). It is possible that some small immature *S. marinus* (<20 cm) were classified as beaked redfish, but the former are generally quite scarce in Div. 3P relative to the abundance of beaked redfishes (Ni and McKone, 1983). Also, there is no bias in determining the reproductive cycle of beaked redfishes, because it was evaluated from mature fish only.

The specimens were measured as fork length to the nearest centimeter and weighed in grams. Gutted and gilled weights (after removal of viscera and gills) were also recorded, and gonad volumes (cm^3) were converted to weights (grams) by using a factor of 1.1. As a check on the visually-determined maturity stages (Table 1), the gonad weight as a percentage of the gutted and gilled weight of each fish was taken as the maturity factor.

Results

Monthly length frequencies and sex ratios

Except in March, the monthly length distributions of beaked redfishes (*S. fasciatus* and *S. mentella*) by 5 cm length groups (Fig. 2) indicate reasonably good representation of fish over the length range of 10–45 cm, with mean lengths varying irregularly from 25 to 32 cm. The March length frequency (mean 19 cm) was greatly influenced by samples of small fish from southwestern St. Pierre Bank. There were fewer males than females (ratios 0.71 to 0.93) in 9 months of the data series, the exceptions being in March, June and August (ratios 1.05 to 1.21). The overall sex ratio of males to females was 0.94.

For golden redfish (*S. marinus*), the monthly length distributions were quite variable and usually had dominant modal groups between 30 and 45 cm (Fig. 2). On the average, these fish were considerably larger than the beaked redfishes, with mean lengths varying from 35.4 to 42.6 cm. There was great variation in the sex ratio, with males being dominant in 6 months of the data series, greatly so in February and October. The overall sex ratio of males to females was 1.33.

Variation in size and sex ratio with depth

Although most of the beaked redfishes were from the 200–299 m depth range, the length distributions showed a consistent increase in size with depth from a mean length of 20 cm in the shallowest depth zone to 34.6 cm in depths exceeding 400 m (Fig. 3). Over the same depth ranges, the modal size increased from

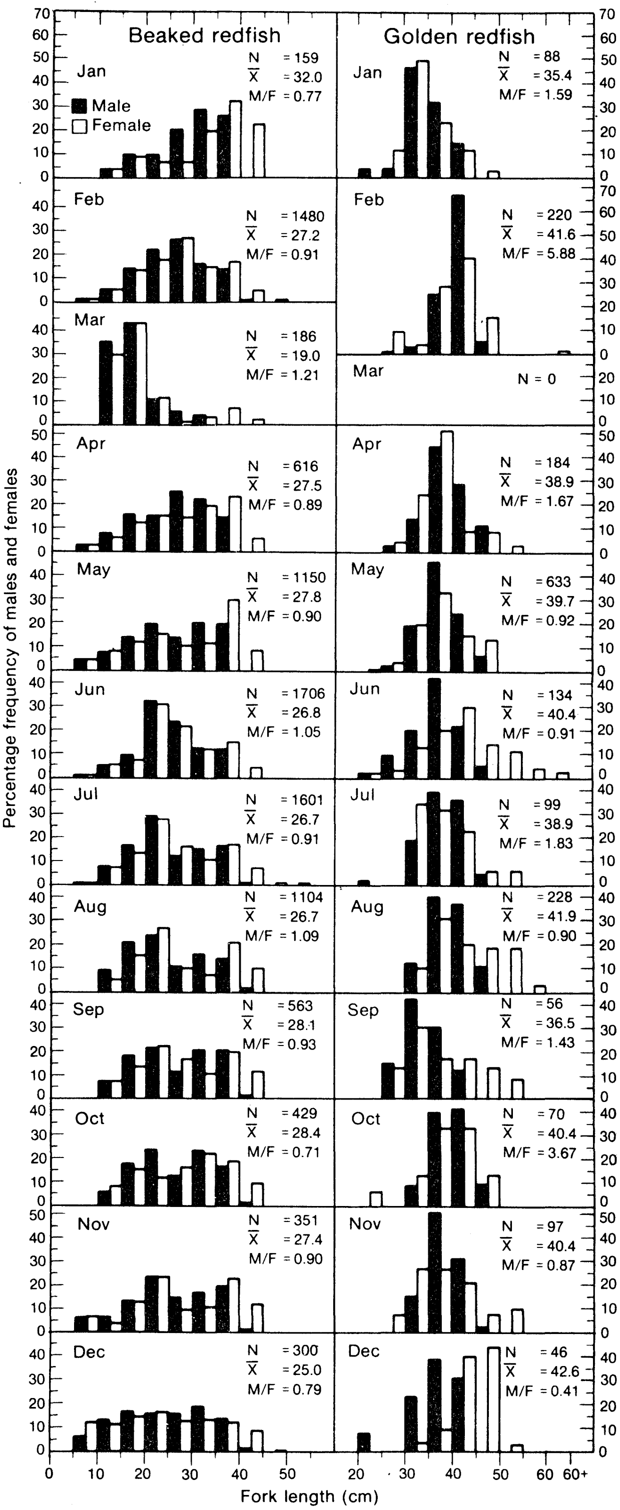

Fig. 2. Monthly length distributions of beaked and golden redfishes from southern Newfoundland waters.

15-19 to 30-34 cm for males and from 20-24 to 30-34 cm for females. The proportion of males decreased from about 50% in the samples from the shallowest depths to only 27.8% in those from the greatest depths,

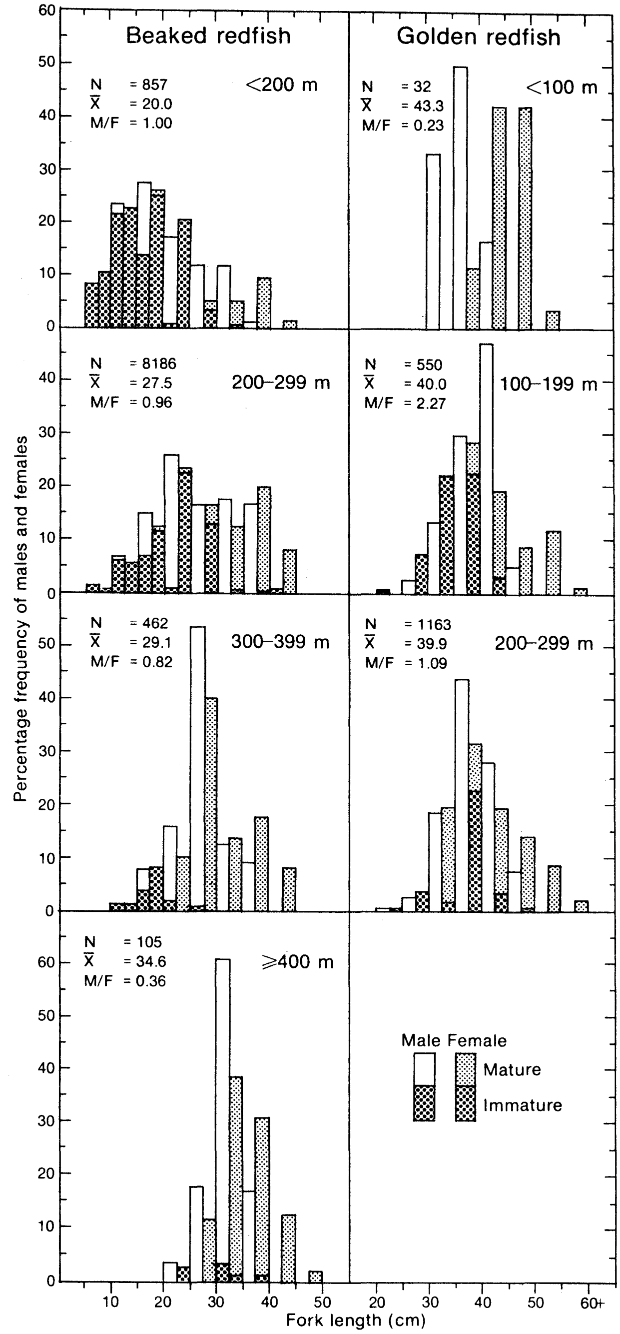

Fig. 3. Length distribution of beaked and golden redfishes by sex and proportion mature for various depth zones off southern Newfoundland. (Golden redfish from the <100 m depth zone were identified by sex only and not as immature or mature.)

but the number of specimens from the deepest zone was quite small. As would be expected with the trend in the length distributions, the proportion of mature beaked redfish increased with depth.

Nearly all of the golden redfish were from two depth zones with similar length distributions, and males were dominant except in the small sample from the shallowest depth zone.

TABLE 2. Monthly distribution of immature and mature beaked redfishes and percentages of mature fish in various stages by sex, from samples taken off southern Newfoundland, 1957–69. (N refers to number of specimens; + indicates <0.5%.)

	Maturity stages	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
						Males								
N	Immature	7	98	83	65	111	96	111	104	39	27	28	42	811
	Mature (unclass.)	—	329	6	102	244	425	139	264	31	—	1	9	1,550
	Mature (classified)[a]	62	266	13	121	186	350	511	208	201	155	137	86	2,291
	Total	69	693	102	288	541	871	761	576	271	177	166	137	4,652
%	Maturing	74	38	69	71	88	71	64	36	—	—	—	—	
	Matured	—	—	—	2	7	24	6	6	—	—	—	—	
	Partly spent	—	—	—	22	4	4	24	27	18	1	—	7	
	Spent	—	+	8	3	1	+	1	+	48	9	3	7	
	Resting	—	1	23	2	—	—	5	31	34	90	97	86	
	Rematuring	26	61	—	—	—	—	—	—	—	—	—	—	
						Females								
N	Immature	21	400	73	157	284	534	530	310	156	108	96	105	2,774
	Mature (unclass.)	—	5	—	25	32	3	—	2	—	—	—	8	75
	Mature (classified)[a]	69	367	11	142	286	293	303	215	135	139	88	57	2,105
	Total	90	772	84	324	602	830	833	527	291	247	184	170	4,954
%	Maturing	4	53	18	6	—	2	4	8	13	14	7	16	
	Matured	—	6	9	11	3	—	—	—	—	—	—	—	
	Eggs developing	—	19	—	32	12	1	—	—	—	—	—	—	
	Larvae developing	—	7	—	13	17	6	—	—	—	—	—	—	
	Hatching to hatched	—	—	28	13	25	19	1	—	—	—	—	—	
	Spawning	—	—	18	1	9	11	3	1	—	—	—	—	
	Spawned	—	—	18	21	31	36	39	2	3	—	—	—	
	Recovering A	—	—	9	—	2	25	53	89	84	86	93	84	
	Recovering B	96	15	—	3	1	—	—	—	—	—	—	—	

[a] Percentages of fish at different stages of maturity are based on the totals in these rows.

Maturity condition

Analysis of the maturity data for beaked redfishes and golden redfish resulted in a general separation of the individual records into three categories by sex: immature, mature without further information on gonad condition (unclassified), and mature with additional information (classified). The last category was further separated into six stages for males and nine stages for females, the percentages of which are given in Table 2 for beaked redfishes and Table 3 for golden redfish. For both species, the unclassified mature category had much higher proportions of males than females.

Immature male beaked redfishes were observed in all months, and, apart from the unusually high proportion in March (81%), their frequency ranged from 10% in January to 31% in December, the overall average being 17% (Table 2). The maturing stage was noted consistently from January to August and the matured stage from April to August with a peak in June. Partly spent testes were observed mainly in July–September, and the spent stage was dominant in September. Apart from the abnormal observation in March, the percentages of male gonads in the resting and recovering stage increased from 5% in July to values exceeding 85% in October–December, and many were rematuring in January and February for the next breeding season.

Immature female beaked redfishes occurred much more frequently than males (Table 2), ranging mainly from 44% in October to 64% in June with an exceptionally low value in January (23%) and a high value in March (87%), the overall average being 56%. The maturing stage was dominant in February, and developing eggs were observed in February–May (except in the small March sample of only 11 adults). Fertilization would have taken place during this period. The stage of larval development within the eggs was observed during February–June, and hatching evidently occurred during March–June. Spawning began in March and the extrusion of larvae was almost completed by July. High percentages of ovaries in the resting and recovering condition were observed from July to January of the next year.

For golden redfish (*S. marinus*), interpretation of the reproductive cycle was difficult due to insufficient monthly data, particularly in March and December (Table 3). For males, the pattern of maturation was generally similar to that for beaked redfishes, but the process in females occurred earlier than in

TABLE 3. Monthly distributions of immature and mature golden redfish and percentages of mature fish in various stages by sex, from samples taken off southern Newfoundland, 1957–69. (N refers to number of specimens.)

	Maturity stages	Jan	Feb	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
	Males												
N	Immature	—	1	—	—	—	—	1	—	—	—	1	3
	Mature (unclass.)	—	132	5	119	12	1	52	—	2	4	1	328
	Mature (classified)[a]	53	54	110	187	53	63	55	33	53	41	3	705
	Total	53	187	115	306	65	64	108	33	55	45	5	1,036
%	Maturing	57	2	96	97	70	38	2	—	—	—	—	
	Matured	—	—	1	1	28	33	13	—	—	—	—	
	Partly spent	—	—	—	—	2	21	67	18	—	46	—	
	Spent	—	—	2	2	—	—	4	—	—	5	—	
	Resting	—	—	1	—	—	8	14	82	100	49	100	
	Rematuring	43	98	—	—	—	—	—	—	—	—	—	
	Females												
N	Immature	30	13	53	179	23	20	40	10	6	22	1	397
	Mature (unclass.)	—	—	2	2	—	—	1	—	—	—	—	5
	Mature (classified)[a]	3	19	14	150	46	15	79	13	9	30	—	378
	Total	33	32	69	331	69	35	120	23	15	52	1	780
%	Maturing	33	10	—	4	2	27	15	69	44	63		
	Matured	—	—	—	—	—	—	—	—	—	—		
	Eggs developing	—	37	7	—	—	—	—	—	—	—		
	Larvae developing	—	48	—	1	—	—	—	—	—	—		
	Hatching to hatched	—	—	43	11	—	—	—	—	—	—		
	Spawning	—	—	21	10	4	—	—	—	—	—		
	Spawned	—	5	29	71	50	13	6	8	—	—		
	Recovering A	—	—	—	2	44	60	79	23	56	37		
	Recovering B	67	—	—	1	—	—	—	—	—	—		

[a] Percentages of fish at different stages of maturity are based on the totals in these rows.

beaked redfishes, as indicated by the higher percentages of developing eggs and larvae in February, hatching in April and spawning in April–May, compared to May–June in beaked redfishes (omitting the March data for only 11 fish).

Size at maturity

The transition from immature to mature condition in redfishes occurred over ranges of size in the form of cumulative normal frequency distributions or sigmoid curves, which were different for each sex and species. To facilitate comparison of such data, it is usual to determine the sizes at which 50% of the fish are mature. These values were calculated from the curves which resulted from fitting the logistic model to the proportions of mature fish by size-group (Fig. 4), according to the procedure of Ni and Sandeman (1984). For beaked redfishes, the mean lengths at 50% maturity were 18.6 and 29.6 cm for males and females respectively. For golden redfish, there were too few small males to calculate a maturity curve, but the mean length at 50% maturity for females was 40.3 cm. The sizes at 50% maturity for beaked redfishes were similar to those estiamted by Sandeman (1969) for samples from Hermitage Bay, where the 50% maturity lengths for males and females were 20 and 30 cm respectively and the corresponding ages were 6 and 10–12 years.

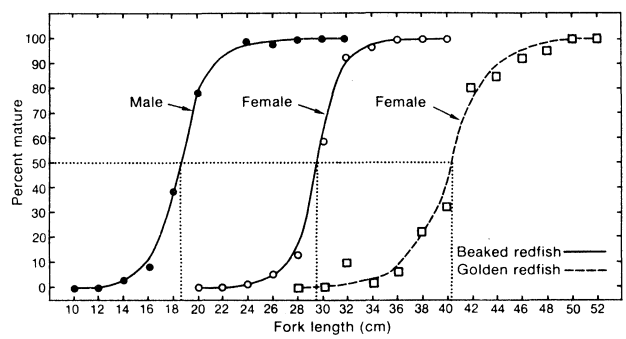

Fig. 4. Maturity curves for beaked and golden redfishes showing the mean length at 50% maturity by sex. (Data for male golden redfish insufficient to calculate a maturity curve.)

Maturity factor

Monthly variations in mean values of the maturity factor (gonad weight as percent of gutted and gilled weight of fish) for beaked redfishes and golden redfish (excluding immature specimens) are shown in Fig. 5. In beaked redfishes, the relative size of testes increased from the lowest value in December to a maximum in May and declined gradually thereafter to a minimum level in October which persisted until January. The relative size of ovaries also increased during the winter to a peak in May, but this increase actually began in October of the preceding year after the rapid

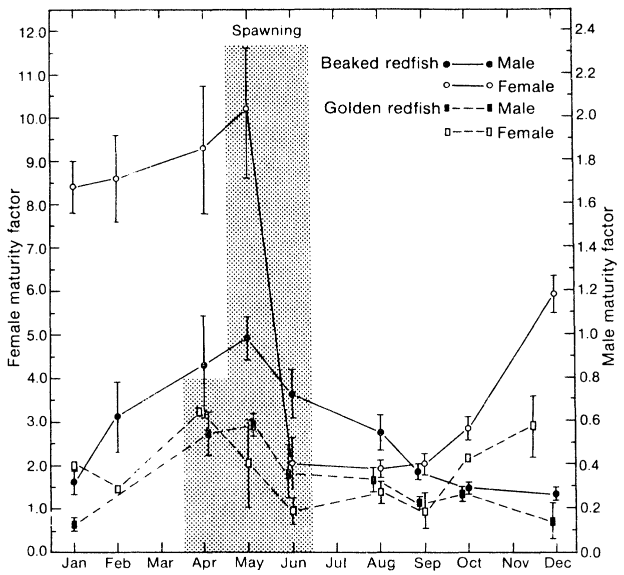

Fig. 5. Seasonal trends in maturity factor (mean and 95% confidence interval) by sex for beaked and golden redfishes, excluding data for immature specimens.

decline to a minimum level in June which persisted until September.

Similar but less variable patterns were evident for golden redfish except that the peak for females occurred about a month earlier than that for beaked redfishes. Few female golden redfish with large gonads were sampled in southern Newfoundland waters, and, consequently, the greatest differences in maturity were for females of the two redfish types, especially from December to May.

Discussion

The species and stock structures of Northwest Atlantic redfishes are very complicated because two or three species, which are not easily recognizable in field studies, may occur in the same area. Consequently, knowledge of the reproductive cycles of the three redfish species, particularly if spawning occurs in different depths and at different times, would be useful in understanding their ecological relationships, because larval survival of the different species would be influenced by different environmental factors such as temperature, currents, plankton blooms, etc. Such factors could then be studied with a view to understanding the mechanisms which cause fluctuations in distribution and abundance of the species.

It may be difficult to obtain representative samples of redfish for an analysis of monthly changes in maturity condition and maturity factor, such as that presented in this paper, because of large variations in size composition and sex ratio of samples, as well as in species composition, of catches from different depths in the same area. Such analyses require broad-scale coverage of the area under study in all months of the year with the largest possible number of samples, because sampling bias is reduced as the number of samples is increased. The present study involved the analysis of data for beaked redfishes from at least 145 otter-trawl sets with an average of 66 specimens per set and for golden redfish from more than 198 sets with an average of about 9 specimens per set. The scarcity of golden redfish over a sufficiently wide range of size hampered the calculation of an average size at maturity for males.

The monthly changes in maturity condition and maturity factor indicated that fertilization of eggs probably occurred from February to April and spawning from April to July (mainly May–June) in beaked redfishes, whereas spawning of golden redfish occurred somewhat earlier. Templeman (1976) reported that redfish spawning on Flemish Cap extends from March to July or August with the earlier spawning in deeper water. In the area from Flemish Cap to southern Labrador, Templeman (1980) observed that spawning *S. mentella* females appear to live deeper and extrude larvae earlier than *S. fasciatus* and *S. marinus*. Ni (1982), from an analysis of vertebral and anal-fin ray numbers, concluded that *S. fasciatus* was the dominant species at shallow depths (<300 m) with *S. mentella* at greater depths in Div. 3P with considerable mixing at 300–400 m. Since most (94%) of the beaked redfish specimens in the present study were from depths less than 300 m (Fig. 3), it is most likely that they were mainly *S. fasciatus*. However, the relatively high percentage of partly spent males in April and the higher-than anticipated percentages of spawning and spawned females in March (Table 2) indicate that some of these beaked redfish spawned early in the year. Interestingly, these early spawning specimens were all from Hermitage Channel, which is close to the deeper Laurentian Channel, and probably were *S. mentella*. It is possible, therefore, that the spawning sequence of the three species in southern Newfoundland waters (Div. 3P) is *S. mentella*, *S. marinus* and *S. fasciatus*.

Magnûsson (1955) pointed out that the large white testes of males in May and June had no spermatozoa, and he concluded, from histological studies, that the maximum size of the testes in European redfishes was neither in the period of copulation nor in the period of sperm maturity. He indicated that the testes become somewhat yellowish in September and that copulation started in October and lasted until January in some individuals. In Newfoundland waters, the whitish, plump testes of spring become smaller as milt passes to the vasa differentia, usually beginning in some males in June–July, and most of the testes of larger mature males are in a shrunken, brownish condition often with tiny white sperm patches, from July–August to November. In the early months of this condition, the testes are spent but the vasa differentia (and the fish) are not spent. In the later months, the testes may show some gradual recovery, especially at the edges of smaller testes, but the vasa differentia contain milt. By December, some of the larger testes still have the brown spent appearance with some milt in the vasa differentia, whereas others, especially smaller testes, are pinkish grey, the change in color beginning at the edges, and there is no milt in the vasa differentia. Copulation likely occurs during the same period as indicated above by Magnûsson (1955) for Northeast Atlantic redfish.

Because the pressure change in bringing redfish from deepwater to the surface could force some of the sperm out of the testes and vas differens, the maturity factor for males, as determined from the ratio of gonad weight to body weight, may not be a good indicator of the time when milt is released. Future work on the reproductive cycle of redfishes in the Northwest Atlantic should involve histological studies of testes and ovaries.

Acknowledgements

We are grateful to E. J. Sandeman for the privilege of using some of his data and for his critical review of the manuscript, to E. M. LeGrow and redfish technical staff for their help in collecting and compiling the data, to C. E. Bourgeois and D. J. Power for assembling the tables and illustrations, and to D. B. Atkinson, D. G. Parsons and A. T. Pinhorn for their comments.

References

BARSUKOV, V. V. 1968. The systematic relationship of redfishes of the genus *Sebastes* of the Northwest Atlantic. *Doklady Akad. Nauk SSSR*, **183**: 479–482. (Transl. from Russian in Dokl. Biol. Sci., 183: 734–737.

1972. Systematics of the Atlantic redfishes. *Tr., PINRO*, **28**: 128–142. (Fish. Res. Board Can. Transl. Ser., No. 2531, 1973.)

BARSUKOV, V. V., and G. P. ZAKHAROV. 1972. Morphological and biological characteristics of the American redfish. *Tr., PINRO*, **28**: 143–173. (Fish. Res. Board Can. Transl. Ser., No. 2488, 1973.)

HALLACHER, L. E. 1974. The comparative morphology of extrinsic gasbladder musculature n the scorpionfish genus *Sebastes* (Pisces: Scorpaenidae). *Proc. Calif. Acad. Sci.*, Ser. 4, **40**(3): 59–86.

LITVINENKO, N. I. 1974. Coloration and other morphological characters distinguishing juvenile *Sebastes fasciatus* from juvenile *S. mentella* (Scorpaenidae). *J. Ichthyol.*, **14**: 591–595.

1980. The structure, function and origin of the drumming muscles in the North Atlantic perches of the genus *Sebastes* (Scorpaenidae). *J. Ichthyol.*, **20**: 89–98.

MAGNÛSSON, J. 1955. Microscopical anatomical investigations on reproduction in redfish (*Sebastes marinus* Linne.). *Z. Zellforsch.*, **43**: 121–167. (Fish. Res. Board Can. Transl. Ser., No. 138, 1958.)

MISRA, R. K., and I-H. NI. 1983. Distinguishing beaked redfishes (*Sebastes mentella* and *S. fasciatus*) by discriminant analysis (with covariance) and multivariate analysis of covariance. *Can. J. Fish. Aquat. Sci.*, **40**: 1507–1511.

NI, I-H. 1981a. Numerical classification of sharp-beaked redfishes, *Sebastes mentella* and *S. fasciatus*, from northeastern Grand Bank. *Can. J. Fish. Aquat. Sci.*, **38**: 873–879.

1981b. Separation of sharp-beaked redfishes, *Sebastes fasciatus* and *S. mentella*, from northwestern Grand Bank by the morphology of extrinsic gasbladder musculature. *J. Northw. Atl. Fish. Sci.*, **2**: 7–12.

1982. Meristic variation in beaked redfishes, *Sebastes mentella* and *S. fasciatus*, in the Northwest Atlantic. *Can. J. Fish. Aquat. Sci.*, **39**: 1664–1685.

1984. Meristic variation in golden redfish, *Sebastes marinus*, compared to beaked redfishes of the Northwest Atlantic. *J. Northw. Atl. Fish. Sci.*, **5**: 65–70.

NI, I-H, and W. D. McKONE. 1983. Distribution and concentration of redfishes in Newfoundland and Labrador waters. *NAFO Sci. Coun. Studies*, **6**: 7–14.

NI, I-H, and E. J. SANDEMAN. 1984. Size at maturity for Northwest Atlantic redfishes (*Sebastes*). *Can. J. Fish. Aquat. Sci.*, **41**: 1753–1762.

POWER, D. J., and I-H. NI. 1982. Morphology of the extrinsic gasbladder musculature in the golden redfish, *Sebastes marinus*. *J. Northw. Atl. Fish. Sci.*, **3**: 165–168.

SANDEMAN, E. J. 1969. Age determination and growth rates of redfish, *Sebastes* sp., from selected areas around Newfoundland. *ICNAF Res. Bull.*, **6**: 79–106.

SOROKIN, V. P. 1958. Biology of reproduction of the redfishes (*Sebastes marinus* L. and *Sebastes mentella* Travin) in the Barents and Norwegian Seas. *Tr. Soveshch. Probl. Biol. Vnutr. Vod*, **8**: 158–170. (Fish Res. Board Can. Transl. Ser., No. 308, 1960.)

1961. The redfish, gametogenesis and migrations of the *Sebastes marinus* (L.) and *Sebastes mentella* Travin. *ICNAF Spec. Publ.*, **3**: 245–250.

TEMPLEMAN, W. 1976. Biological and oceanographic background of Flemish Cap as an area for research on the reasons for year-class success and failure in cod and redfish. *ICNAF Res. Bull.*, **12**: 91–117.

1980. Incidence of subcaudal melanophores in pre-extrusion larvae of redfish species in the Newfoundland-Labrador area. *J. Northw. Atl. Fish. Sci.*, **1**: 7–19.

TEMPLEMAN, W., and E. J. SANDEMAN. 1957. Two varieties of redfish in the Newfoundland area. *Fish. Res. Board Can. Atlant. Prog. Rep.*, **66**: 20–23.