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Abundance and Growth Rate of Juvenile Redfish (Sebastes sp.) on Flemish Cap During the Period 1978-1985

by

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INTRODUCTION

A cooperative international program of research into the causes of variation in year-class strength of demersal fish has been conducted on Flemish Cap (47°N; 45°W) since 1978. The program has included quantitative surveys for larvae and adults, but has omitted special surveys for juveniles. Measures of the abundance of juveniles are necessary to provide an early indication of the fate of larvae and to monitor the survival of cohorts during the juvenile stage. This paper will provide estimates of the abundance of specific age-groups of redfish (Sebastes spp.) during the winters of 1978-85 as determined from catches during Canadian winter bottom-trawl surveys.

Power and Atkinson (MS 1986) provide population numbers at age estimated from these catches. They used the data which Atkinson (MS 1985) reported as mean catch at length per tow, but for some years they removed "sets that appeared to be anomalously high". The ages were based on interpretation of annuli in otoliths. As described by Lilly and Gavaris (1982), there are differences between the age reading and an interpretation of the annual progression of modes in length-frequencies.

The first inconsistency is the age of the juveniles when they are first caught in the winter surveys at a fork length of 7-8cm. They are aged primarily as 2-year-olds. If this is accurate, they are not captured as 1-year-olds in plankton gear and lined bottom-trawls, and they are not found in cod stomachs. On August 01 of their first year their average length is approximately 2cm (standard length) (Anderson, 1984), so in winter of the intermediate year they would have to be about 4-5cm. Even if this size would enable them to avoid capture by trawls, they would not be too small to be preyed upon by cod, which consume large numbers of hyperiids about 1 cm in length on Flemish Cap (Lilly, MS 1979) and have been found on the Grand Banks to consume capelin, a much slimmer species, at a length of 5-7cm (unpubl. data).

If, however, the 7-8cm redfish are 1-year-olds, their growth would be consistent with the size of age 0 redfish found elsewhere. For example, an isolated dominant group of redfish, assumed to be the 1971 year-class, was first recorded in a bottom-trawl survey in the Gulf of Maine in the autumn of 1971 at a modal length of 6cm (Mayo, et al., 1981). 0-group redfish collected in an IYGPT trawl in the Irminger Sea in August-September 1984 averaged 4.7 cm (SL) (Noskov and Romanchenko, MS 1985). Palsson (1983) reported that redfish 5-7cm in length were common prey of a broad size-range of cod off Iceland in October-November 1980. The author stated that these were 0-group redfish.

The second inconsistency is that the age reading indicates that three or four recent year-classes were relatively strong (Atkinson, MS 1985) whereas an interpretation of the length-frequencies is that there were only two very strong year-classes. In addition, the years of birth of the strong year-classes, as determined by age reading, move back in time as the fish get older.

This paper will provide an alternative to the application of age-length keys to the catch at age (Power & Atkinson MS 1986). Numbers and lengths at age will be estimated by fitting mixtures of normal distributions to the catch at length.

MATERIALS AND METHODS

Redfish were captured during stratified-random bottom-trawl surveys (Doubleday, 1981) of Flemish Cap by the chartered research stern trawler GADUS ATLANTICA during January-February of 1978 to 1985. An Engel high-rise otter trawl, with 29mm mesh liner in the codend, was towed at 3.5 knots (108 m/min) for 30 minutes at each fishing station. Redfish were measured as fork length to the nearest centimeter. Individuals less than 16cm were not sexed, but separate length frequencies were compiled for males and females 16 cm and longer. The number of redfish per length group on the Flemish Cap at the time of the survey was estimated by areal expansion of the stratified arithmetic mean number per length group per tow (Smith and Somerton, 1981), using strata defined in Doubleday (1981).

The number and mean length of juvenile redfish of specific ages on Flemish Cap in each year were estimated by fitting mixtures of normal distributions to the numbers at length (Macdonald and Pitcher, 1979; Macdonald and Green, MS 1985). In those years when most juvenile redfish were less than 16cm, all individuals of a given length were combined. In those years (1983-85) when large numbers of individuals longer than 15cm were caught, the unsexed individuals were evenly divided among males and females, and normal distributions were fitted to the numbers at length for males and females separately. Numbers of males and females at age were combined to provide total numbers at age. In two years (1978, 1980) the catches of juveniles were so small that numbers at age could not be estimated.

RESULTS

Growth rate

If one assumes that redfish caught in winter at a length of 7-8cm are 1-year-olds, then fitting mixtures of normal distributions to the numbers at length yields the mean lengths at age shown in Table 1. Redfish grow about 3.5cm per year between ages 1 and 4. The 1980 year-class appeared to grow only 2 cm between ages 4 and 5, but mean lengths estimated from 1985 data may be less accurate than those from earlier years because the 1980 and 1981 year-classes were merging into a single mode by 1985.

Year-class strength

The present analysis indicates that only the 1980 and 1981 year-classes were strong in the period 1974-1984 (Table 2). The relative strengths of other year-classes is difficult to assess because catches of all were very small, but the 1982 year-class appears stronger than the rest. The apparent increase in abundance of the 1980 and 1981 year-classes between ages 1 and 2 indicates that age 1 redfish are not fully recruited to the lined research trawl. There was high apparent mortality in both the 1980 and the 1981 year-classes between 1983 and 1984, and nil or negative mortality in both between 1984 and 1985. Such a pattern suggests that abundance from at least one of the surveys may be suspect. Perhaps abundances in 1984 are underestimated relative to other years.

DISCUSSION

Growth rate

The growth rate of juvenile redfish, estimated by fitting a mixture of normal curves to the numbers caught at length, is very different from that obtained by applying age-length keys to the same numbers at length. If one assumes that juveniles caught at a length of 7-8cm in winter are 1-year-olds, then the redfish would appear to attain a length of about 20cm by winter of age 5 (Table 1). In contrast, the age reading yields an estimate of 12-14cm by age 5 (Power and Atkinson, MS 1986). The lengths at age estimated from the frequencies are similar to those reported by Sandeman (1969), who aged the otoliths of redfish caught on Flemish Cap in July 1956 and November 1958 (Templeman, 1976) and found that redfish attain a length of about 19-20 cm by late age 5. The lengths at age estimated in this paper are very close to those found for the 1971 year-class in the Gulf of Maine (Mayo, et al., 1981). This year-class was preceeded and followed by several years of poor recruitment, and could be clearly followed in length-frequencies from a length of 6cm in autumn 1971 to a length of about 20cm in spring 1976 (age 5).

Year-class strength

The abundance of individual year-classes at the juvenile stage, as estimated from the analysis of modes in the numbers at length, varied by several orders of magnitude among years (Table 2). During the period 1975-84 only the 1980 and 1981 year-classes were strong. Other year-classes, most notably that of 1982, may ultimately contribute to the fishery, but their contribution will be relatively small. This pattern of occasional strong year-classes interspersed among many much weaker year-classes fits the historical pattern of recruitment on

Flemish Cap (Templeman, 1976; Lilly 1980), and is a characteristic of redfish populations elsewhere, such as in the Gulf of Maine (Mayo, 1980). This pattern is strikingly different from that indicated by the age reading, which shows that there tend to be periods of several years of successful recruitment and periods of several years of poor recruitment (Atkinson, MS 1985).

Relative year-class strengths of larvae and juveniles

The abundance of redfish year-classes as juveniles may be compared with their abundance as larvae to provide some indication of the time at which year-class strength has been established. The first and major peak of extrusion of larvae on Flemish Cap occurs in the second half of April (Anderson, 1984; Penney and Evans, 1985). Anderson (1984) estimated the number of larvae from this cohort surviving on Julian day 214 (August 02) during each year in the period 1978-1982. In descending order of abundance, the years may be ranked as 1978, 1982, 1980, 1981, and 1979 (Table 3).

Abundances in years 1978, 1980, and 1982 were all an order of magnitude greater than in 1981, while larvae from the early cohort were not observed in July 1979. Only in 1979 and 1980 were the relative abundances in agreement with those found in the juvenile stage. The 1978 year-class was the largest at the larval stage, but at age 1 it was relatively small in the trawl survey and very abundant in cod stomachs (Lilly and Gavaris, 1982). By age 2 it had declined to very low levels in both. The 1979 year-class apparently suffered very high mortality at the larval stage after an apparently normal extrusion (Anderson, 1984), and remained at low abundance both in trawl surveys and in cod stomachs. The 1980 year-class was strong as larvae, and remained strong as juveniles. The 1981 year-class was at a relatively low abundance by mid-summer and had grown at a slower rate than the 1981 year-class (Penney and Evans, 1985), yet at the juvenile stage it was approximately as abundant as the 1980 year-class. The 1982 year-class was at high abundance as larvae, but only at relatively low abundance at age 1 in the trawl survey. Unlike the 1978 year-class, which was also relatively weak at age 1, the 1982 year-class has persisted at a measurable level for at least an additional two years.

One cannot determine from these data whether the lack of a clear relationship between the abundance of larvae and the abundance of juveniles is due to annual variation in mortality rates after August 2 or to error in the estimation of abundance of larvae or juveniles. More frequent ichthyoplankton surveys during summer and surveys for juveniles in autumn and winter may have helped to eliminate the latter possibility. Surveys for juveniles would also have prevented the uncertainty which now exists concerning the growth rate of juveniles.

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Table 1. Mean length (cm fork length) at age of juvenile redfish on Flemish Cap during the winters of 1978-85, as estimated by fitting normal distributions to population numbers at length estimated from bottom-trawl surveys. The mean of lengths for males and females is provided for 1983-85, when sexes were analyzed separately.

Age	1978	1979	1980	1981	1982	1983	1984	1985
1		7.5		7.5	7.6	7.3	8.3	
2		11.2			11.2	10.8	11.3	
3						14.6	14.4	
4							18.1	18.4
5								20.2

Table 2. Numbers (X 10^{-6}) of juvenile redfish on Flemish Cap in the winters of 1978-85 as estimated from catches in bottom-trawl surveys, and annual mortality rates calculated for the 1980 and 1981 year-classes.

Age	1978	1979	1980	1981	1982	1983	1984	1985
1	0	2.67	+[a]	56.00	108.57	5.90	5.22	0.03
2	+	1.92	+	0.18	394.09	267.48	8.46	0.80
3	+	+	+	0.64	0.64	380.04	16.58	5.23
4				0.66	+	1.40	64.05	53.30
5								63.98
Z_{1-2}					-1.95	-0.90		
Z_{2-3}						0.04	2.78	
Z_{3-4}							1.78	-1.17
Z_{4-5}								0.00

[a] + indicates that individuals of the appropriate size for a specified age were present, but there was no distinct mode, numbers were small, and there was no distinct mode of larger juveniles.

Table 3. Estimates of abundance (N X 10^{-6}) as larvae and juveniles for five year-classes of redfish on Flemish Cap. Abundances of larvae are from Anderson (1984) and abundances of juveniles are from Table 2.

Age		1978	1979	1980	1981	1982
0	(Aug. 02)	140000	0	59000	7900	87000
1	(winter)	3	+	56	109	6
2	"	+	+	394	267	8
3	"	+	+	380	16	5
4	"	+	1	64	53	