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LENGTH AND AGE AT MATURITY OF NORWEGIAN SPRING-SPAWNING HERRING FOR
THE YEAR-CLASSES 1959-61 AND 1973-78.

by

Reidar Toresen
Institute of Marine Research
P.O. Box 1870, N-5011 Bergen, Norway

Abstract

The age and length at maturity is calculated for the six year-classes, 1973-78. The age at maturity is also calculated for the year-classes 1959-61. The two periods are characterized by great differences in stock abundance and recruitment. The proportion of mature herring in an age group is estimated as it's proportion in the spawning stock while maturing (at 3, 4 and 5 years) relative to it's proportion of mature fish in the spawning stock when fully recruited (mean proportion at 6, 7 and 8 years). The length at maturity for an age group is calculated as follows. The length distributions of the recruiting yearclasses while still maturing is back calculated from the length distribution of the fully recruited age group (at 6, 7 or 8 years). To find the length at maturity, the relative proportions of mature fish in the early age groups are used directly in these length distributions assuming the maturation to be length dependent. According to the growth rates of the different year-classes, the age at maturity vary from 3 to 5 years in the investigated period. However, the length at maturity is found to be fairly constant.

Introduction

It is a fairly well known phenomenon that the age at first spawning may vary quite considerable from one year-class to another. (ØSTVEDT 1958, DRAGESUND, HAMRE and ULLTANG 1980). In the seventies, when the stock of the Norwegian spring-spawning herring still was on a very low

level of abundance, the majority of the year-classes 1973 and 74 matured to spawn already at 3 years. The growth of these year-classes were very fast reflecting good environmental conditions and a minimum of competition from other year-classes. From earlier periods, the herring has been found to spawn at an older age, (ØSTVEDT 1958, ØSTVEDT 1965, JØRGENSEN 1979). In the fifties and early sixties the herring stock was on quite another level of abundance and the strength of the year-classes and the level of recruitment to the spawning stock was much higher than in the seventies. The strong yearclasses from this early period matured to spawn at 5 or 6 years which is found to be the age at maturity for most year-classes in the fifties and early sixties, (JØRGENSEN 1979). The aim of the present paper is to investigate selected year-classes from the two periods to find the age at first spawning (age at maturity). For the investigated year-classes in the seventies, the length at maturity is also calculated.

Material, methods and results

The herring stock in the seventies is divided in two components, one northern type and one southern type. These components are characterized by differences in the growth pattern, as the southern one is more fast growing. Maturity ogives are calculated for both components separately.

Age at maturity

When a year-class is fully recruited to the spawning stock the ratio between the number of individuals in this yearclass and the number in the older yearclasses is constant if total mortality (Z) by age group is constant.

In the samples taken from the spawning stock the ratio between the different year-classes may vary randomly from one year to another. No trend in this variance was detected and the proportions of each year-class in the spawning stock was calculated as follows:

$$p_i = \frac{N_i}{\sum_{i=1}^k N_i}$$

where p_i is the proportion of year-class i in the spawning stock, N_i is the number of fish in the samples from this year-class and k is the number of year-classes in the spawning stock that is fully recruited. The relative abundance of the fully recruited year-classes were then calculated as the mean of the age groups 6, 7, and 8 years (\bar{p}_i). The maturity ogive by year-class is then calculated as the proportions of the number of fish in the younger age groups to \bar{p}_i in samples of the spawning stock.

The results are shown in Table 1.

Length at maturity

When a year-class is partly recruited to the spawning stock, the mature component consists of the most fast-growing fish. The correspondance between fast-growing year-classes and early spawning indicate that the maturing of herring depends on the size of the fish rather than the age. Assuming a length dependent relationship a maturing length is defined as the length at which all fish in the year-class above that length are going to spawn. Knowing the maturing proportion by age (Table 1) this maturing length can be determined if the true length distribution by age is available. These distributions have to reflect the length distribution of all fish in the age groups and is established by back calculation from the otolith-zone distributions of the fully recruited year-classes. The body/otolith-radius relationship was fitted by least squares using standard regression procedures (BAILEY 1959, SNEDECOR and COCHRAN 1978), and the following equation used:

$$L_n = a + \frac{L_c - a}{R_c} R_n$$

where L_n is estimated length corresponding to measured otolith radius R_n of winter ring no. n , L_c and R_c are the fish length and otolith radius measured at capture, and a is the intercept of the L-axis estimated by the regression.

Otolith-radius measurements are available for the year-classes in the seventies only, and the back-calculated length frequency distribution by age, year-class and components is shown in Figure 1. The calculated maturing length by age corresponding to the estimated \bar{p}_i is given in Table 2. The maturing length by year-class is given as the mean of the maturing lengths by age weighted by the proportion of the year-class maturing for the first time at this age.

The variance in these results reflect the variance in the age at maturity for the year-classes and the components. The smallest value of length at maturity, 26.5 cm, is calculated for the northern component of the 1973 year-class maturing at 3 years. Else, the maturing length by age is slightly longer in the northern component than in the southern one. The mean length at maturity for fish maturing at 3, 4 and 5 years were 29.3, 30.1 and 31.7 cm respectively for the southern component, and 29.6, 30.5 and 31.9 cm for the northern component. In the year-classes 1973-75, all fish in the southern component matured to spawn at 5 years, while in the northern component the age at fully recruitment were 6 years for the same year-classes, reflecting the higher growth rate in the southern component than in the northern. The difference in the maturing lengths between the age groups may be explained by the non-continuity of the maturation process, as it only takes place once a year, interrupted by a period of growth. The maturing length for the period, 29.96 cm, is calculated as the mean of the weighted mean values by year-class.

These findings are consistent with results from investigations on the maturation of herring in earlier periods. In the thirties, Runnstrøm found the mean maturing length to be 28-29 cm. (RUNNSTRØM 1936). For the period 1946-1962, Østvedt calculated the mean maturing length to be 30.9 cm. (ØSTVEDT 1964). Compared to the great variation of the age at first spawning, the maturing length is fairly constant, irrespective of the period investigated.

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Table 1. The portions of the recruiting year-classes being mature to spawn.

Southern component

Year-class	Age						
	2	3	4	5	6	7	8
1973	0.0	0.56	0.93	1.04	1.00	1.00	0.92
1974	0.0	0.96	0.98	1.04	1.02	0.83	1.13
1975	0.0	0.24	0.83	1.05	0.55	1.21	-
1976	0.0	0.27	1.00	0.82	1.05	0.91	1.05
1977	0.0	0.38	0.70	0.87	0.73	1.16	1.13
1978	0.0	0.02	0.50	0.69	1.04	0.97	

Northern component

Year-class	Age						
	2	3	4	5	6	7	8
1973	0.0	0.67	0.85	0.94	0.99	1.00	1.01
1974	0.0	0.50	0.82	0.87	1.05	0.87	1.10
1975	0.0	0.02	0.41	0.89	0.91	0.50	
1976	0.0	0.01	1.12	1.32	0.91	1.16	0.96
1977	0.0	0.13	0.38	0.52	0.68	1.17	1.05
1978	0.0	0.03	0.45	0.68	0.90	1.04	

Both components

Year-class	Age						
	2	3	4	5	6	7	8
1959	0.0	0.02	0.25	0.78	0.94	1.02	1.05
1960	0.0	0.08	0.22	0.37	0.85	1.05	1.08
1961	0.0	0.04	0.35	0.68	0.94	0.94	1.10

Table 2. Maturing lengths corresponding to the calculated maturity ogives for the year-classes 1973-78.

Southern component

Year-class	Age			Weighted mean
	3	4	5	
1973	29.2	29.5		29.32
1974	27.2	29.6		27.25
1975	30.2	30.8		30.63
1976	29.6			29.60
1977	28.8	30.4	31.5	29.92
1978	30.5	30.2	31.9	30.68
Means	29.3	30.1	31.7	29.57

Northern component

Year-class	Age			Weighted mean
	3	4	5	
1973	26.5	28.8	30.7	27.34
1974	29.0	30.8	32.2	29.85
1975	31.8	31.5	31.8	31.67
1976	31.3			31.30
1977	29.6	31.5	33.0	31.43
1978	29.3	30.0	31.7	30.54
Means	29.6	30.5	31.9	30.36

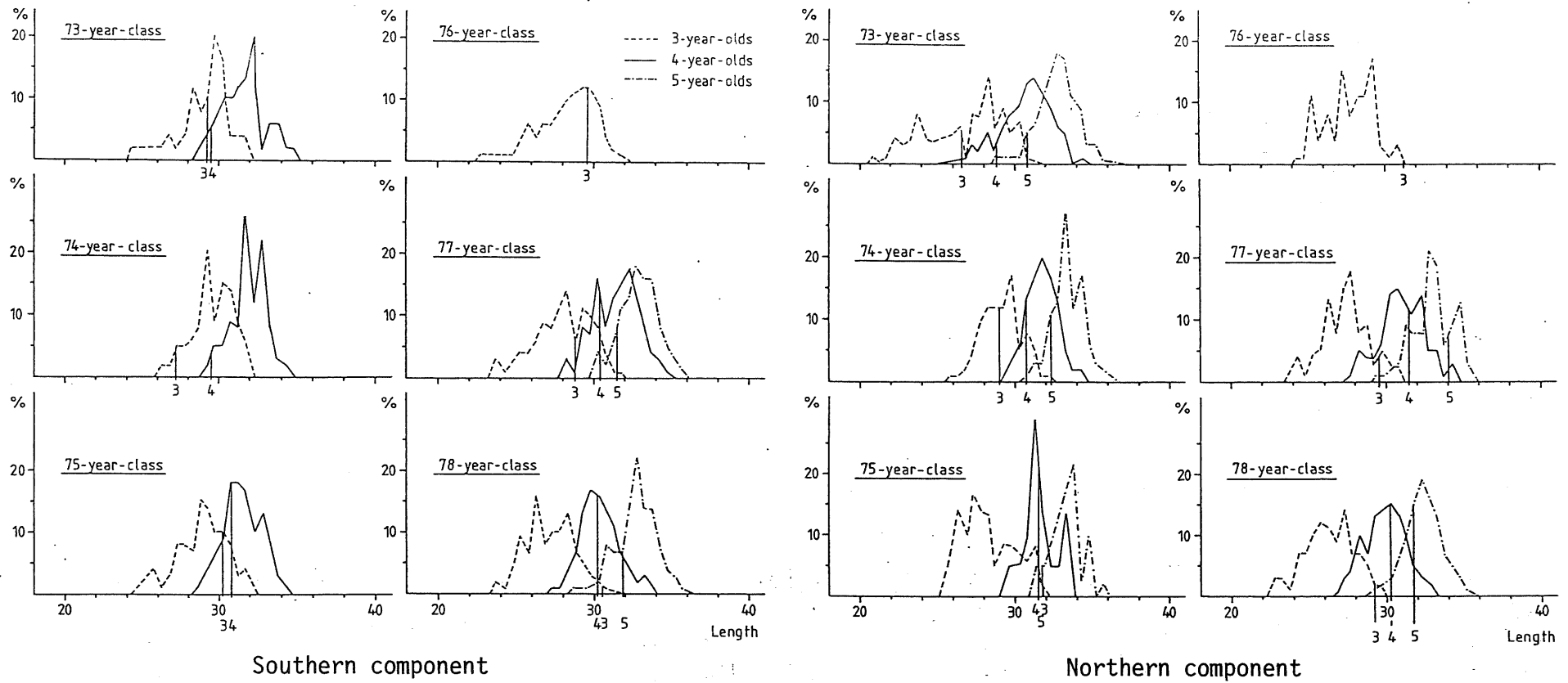


Figure 1. Back-calculated length frequency distributions by component, year-class and age. The maturing lengths corresponding to the estimated \bar{p}_i are also given.