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GROWTH IN THE NORWEGIAN SPRING-SPAWNING HERRING FOR THE YEAR-CLASSES 1950-1960 AND 1973-1983

by

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Abstract

Two periods with great differences in year-class abundance and recruitment where chosen for growth studies. In the first period the mean year-class strength at 3 years was 6 790 x 10^6 individuals while in the second period the average recruitment at age 3 was 436 x 10^6. The growth in each year-class, as observed by the length and weight at age, is compared to the year-class strengths in the two periods in question. Variations in growth is observed and before maturation, strong year-classes has remarkable less growth both in length and weight than weak year-classes. The latter period in question is therefore characterized by far better growth in these early years of life than the former. After maturation however, the difference in growth between the two periods is far less distinct.

Introduction

After the great reduction in the abundance of the Norwegian spring spawning herring in the late sixties, the growth as observed by the length at age and weight at age increased significantly, (JØRGENSEN 1979). At the same time, the adult stock totally changed it´s migration pattern as it ceased migrating into the Norwegian Sea after spawning, (DRAGESUND, HAMRE and ULLTANG 1980). Since 1970 the distribution has been limited to the fjords of the western and northern Norway (except for the 1983 year-class). The observed change in growth and maturation is explained by the severe reduction of the abundance of the stock as observed in other herring stocks, (JAKOBSSON and HALLDORSSON 1984). However, this change in growth is not necessarily density dependent.

It should be noted that growth in the Norwegian spring spawners is extremely variable, depending strongly on the area in which they spend their adolescent phase. Herring located off Finnmark and in the Barents Sea during the adolescent phase have a markedly slower growth than those found off the coast between Møre and Lofoten. As the maturing prosess is dependent on the length rather than the age in the herring (TORESEN 1986), the parts of the stock spending their first years of life south of Lofoten mature earlier than those found further to the north or in the Barents Sea. Accordingly, immature herring older than three years are scarce south of Lofoten, whereas off Finnmark herring in the adolescent stage are common up to four years of age. This pattern is probably independent on the size of the year-classes. What is most certainly dependent on the year-class strength is the relative abundance of the stock in the different areas and the growth within these areas.

Since the recruitment to this stock is so variable, it is of great importance in the assessment that the prediction of growth is correct, and it is therefore valuable to know the mechanisms that govern the growth.

In this paper different aspects of growth in the Norwegian spring spawners are enlightened especially with respect to the question of growth and year-class abundance. Two periods with quite significant differences in abundance, recruitment and growth are chosen for this purpose.

Material and methods

The immature part of the stock is treated separately from the adults because the biological samples from the two parts of the stock are not taken in the same period of the year. The samples from the spawning stock are taken during the spawning in spring while the samples from the immatures are taken during autumn.

The immatures

Growth, as expressed by the mean length at age in the autumn (Sept-Nov) is studied within 4 regions along the Norwegian coast (Fig. 1). Average values of length at age for the full periods are compared between the regions. The 1983 year-class is treated seperately because it is a very strong one showing a tendency to a level of growth which is similar to that in the fifties.

The material from the fifties is very poor, as no systematic sampling of the juvenile part of the stock was carried out at that time. No weight at age data are present.

The adults

The geographical regions are here cut down to one, the main spawning grounds in area 07 (Fig 1). Sampling is done during spawning in spring (Feb-Apr). Mean values of length at age each year in the two periods are held up against spawning stock abundance. In addition, the mean length at age for each year-class is compared to the year-class strength at three years. Further on, growth as expressed by length increments in the age intervall from 5-10 years is compared between the periods and the mean length at age for all year-classes in each period are compared in a plot.

At last, the growth as expressed by the weight at age relationship is discussed briefly.

Results and discussions

The immatures

The observed data of length at age for the two periods in four areas along the norwegian coast are shown in Table 1 a-d. The data given are mean values of all samples of young herring from September till November each year. The mean values of length at age might have been effected by the time the samples are taken in the autumn. However, the growth during these months is marginal and it is assumed that the growth for the season is finished. As can be seen from the tables, the data from the fifties and early sixties is very poor. However, treated together, the few samples present give an idea of the growth level in the full period.

Comparing the length at age within the two periods but between the different regions show a clear trend of increasing growth when moving from north to south along the coast (Table 1 a-d). This fenomenon is earlier described by DRAGESUND (1970), and is probably related to environmental conditions. The length distribution of the 0-group herring may be similar all along the coast, but a difference in length at age is initiated very soon and this difference increases through the years. This feature results in earlier maturation of the components of the stock spending the adolescence further to the south than those found in the north or in the Barents Sea, as the maturation prosess is related to growth rather than to age. The recruitment to the spawning stock is therefore largely dependent on the geographical distribution of the year-classes in the early stages of life.

The difference in growth between the two periods are studied by comparing the average length at age values for each period and region. Figure 2. a-d shows the plots of length at age in the four regions in each period. The 1983 year-class is plotted separately. In all the regions, growth is far better in the seventies than in the fifties. As the plots clearly show, the growth rate is also higher in this latter period leading to greater differences in length at age through the years. This higher growth also leads to maturation at a much younger age for the year-classes in the seventies, which was observed down to 3 years.

Is this large difference in growth between these two periods density dependent? The annual recruitment was at a much higher level in the fifties than in the seventies. The mean year-class strength at 3 years was 6 790 x 10^6 individuals in the fifties, while in the seventies this number was reduced to 436 x 10^6. However, it is a fact that big year-classes of Norwegian spring-spawning herring has quite another geographical distribution than small ones. Weak year-classes spend more or less entirely the adolescence in the fjords along the coast. The relative distribution of each year-class in the different regions is determined at the 0-group stage. Abundant year-classes also distribute in the fjords, but at a certain level of abundance, the 0-group herring also get distributed in the open watermasses of the

Barents Sea. The mechanism governing this distribution pattern is not yet known. However, the conditions for high growth rates are less favourable in the open watermasses of the oceans than in the fjords along the coast, where the temperature is higher and the density of zooplankton is greater. The density of herring in the fjords for these big year-classes is still much higher than for small year-classes, probably leading to reduced growth due to higher density. In this way, we have two main reasons for reduced growth in big year-classes of Norwegian spring-spawners; density dependent growth in the fjords and reduced growth due to distribution in the open watermasses of the Barents Sea. The latter factor is a secondary effect of high density but the reduced growth is not density dependent itself.

The adults

Length at age

The observed data of mean length at age for the two periods at the spawning grounds in Area 07 is shown in Table 3. All samples taken in the actual time, February - April, are present in the material.

Mean length at age per year in the two periods and spawning stock abundance is shown in Fig. 3, a and b. The spawning stock decreases from a level of about 10 mill tonnes in 1957 till about 3 mill tonnes in 1965 and further to nearly zero in 1969. Through these years, the growth, as expressed by the mean length at age per year, show an increasing trend throughout the fifties. In the beginning of the sixties however, the growth suddenly start to fall shown by the low values of mean length at age for the year-classes 1958-59 and 60. The correlation between this pattern of growth and the stock abundance is not very clear because the change of growth pattern differs from one age-group to another. In fact, it is obvious that the growth pattern changes in correspondance with the year-class strength rather than the stock abundance.

Figure 4 shows the mean length at age per year-class and the corresponding year-class strength in the two periods. It is clear, from the plot that there is a positive correlation between the length at age for the different year-classes and the year-class abundance. The overall growth pattern shows an increasing trend untill 1957. The 1958 year-class has far less growth than the two or three older year-classes and this decreasing tendency to growth continue for the 1959 year-class flattening out for the 1960 year-class. This pattern is set before the herring mature. As shown in Fig. 4, the pattern is clear at 4 years, smoothening a little untill the age of ten. The observed drop in growth for the weak 1958 year-class is most certainly caused by interactions between this year-class and the very strong 1959 year-class.

In the second period, only weak year-classes occur, except for the 1983 year-class which is comparable to strong year-classes in the fifties. It is difficult to draw any conclusions from the appearing growth pattern. However there is a tendency to decreasing values of length at age throughout the years, (Fig. 3 b). This decrease might have been effected by the increase in the abundance of the total stock. However, a clear drop in growth is observed for the strong 1983 year-class.

Comparing the curves of mean length at age by year-class between the two periods in Figure 4 gives an impression of better growth in the seventies than in the fifties. However, the better growth is restricted to the immature part of the stock only, as the mean length increments for the age intervall 5-10 years is higher in the former period than in the latter, 5.87 and 5.08 cm respectively. The length increment in the age intervall 5-10 years for the year-classes with lowest values of length at 4 years is much higher than for year-classes with high values of mean length at 4. This fenomenon is earlier described by WATKIN (1927), and ØSTVEDT (1958) and JAKOBSSON & HALLDORSON (1984) has described this for Atlanto-scandian herring. It leads to less variation in length within the same year-class as the fish grow older.

Figure 5 show the plots of mean length at age for all year year-classes in the two periods. The plot illustrates the higher values of mean length at age in the seventies than in the fifties and the difference is constant in the whole age intervall 5-10 years. The Figures 2 and 5 compared shows very well that the differences in growth in length is initiated early in life, before maturation.

Weight at age

Table 2 shows the mean weight at age each year for the two periods. These data show exactly the same pattern of growth as the growth of length data did (Fig. 4 and 5). There is a more or less constant difference of 35-60 g between the mean weight at age values for the age groups in the two periods. These differences follows the length at age differences and varies randomly during the age intervall 5-10 years.

Management considerations

Without any doubt, there is a relationship between year-class abundance and growth. The reduced growth due to high abundance might be density dependent in certain areas, but in most cases, it is most certainly due to dispersion of young herring in areas with lower consentrations of food particles and lower temperatures.

The reduced growth leads to later maturation because the maturation is size dependent rather than age dependent. The recruitment of large year-classes to the spawning stock therefore tend to be delayed compared to the recruitment of small year-classes. This delay may be 2-3 years or even more. The recruitment to the fishery will also be later for larger year-classes than for less abundant year-classes since the fishery is regulated by a minimum landing size regulation. If the prediction of growth is not thoroughly evaluated in the assessment work, the delay in recruitment may lead to an over-exploitation of the older year-classes in the stock. Since the TAC is given in weight rather than number of individuals, a reduced growth also may lead to a general over-exploitation of the stock.

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Table 1 a. Mean length at age.

AREA 04

Year	Age 0	1	2	3	4
1950				19.4	21.1
51				20.8	
52			19.8	23.3	
53			17.6		24.0
54				23.4	
55			22.3		
56			20.7		
57		16.5	16.8		
58	10.8	15.6			
59	12.1				
60					
Mean	11.45	16.40	19.44	21.73	22.55
1973		17.1	23.5	28.7	31.5
74	9.9			29.8	
75			26.8		
76	9.9				
77					
78			23.3		
79		16.9			
80	10.9	17.4	22.8	27.5	32.2
81				29.0	
82	9.0	18.0	24.2	28.4	30.8
83	9.6	16.6	20.5	23.6	
Mean	9.93	17.35	24.12	28.68	31.50

Table 1 b. Mean length at age.

AREA 05

	Age				
Year	0	1	2	3	4
1950			22.2		
51			19.0		
52		17.4		21.7	
53			19.3	24.4	
54		18.2	21.6		
55		18.8			
56			19.6	23.5	
57		14.5			
58	10.9	18.4			
59					
60					
Mean	10.9	17.55	20.34	23.20	
1973		19.2	25.2	29.7	33.2
74	13.5	22.6	29.2	32.4	34.1
75		21.2	29.0		
76	12.6	16.8	28.2		
77		20.2			
78	9.8	19.4	23.3		30.4
79	10.3	18.2		28.5	32.4
80	12.2		24.7	29.5	34.2
81			28.2	31.3	32.7
82	9.7	18.5	24.4	29.3	31.5
83	9.6	19.4	21.9	24.3	29.3
Mean	11.35	19.51	26.53	30.12	32.64

Table 1 c. Mean length at age.

AREA 06

	Age				
Year	0	1	2	3	4
1950			22.3		
51		17.2			
52					
53				23.0	
54			21.7		
55		19.2			
56					
57		17.1			
58	12.1				
59	12.7	17.6			
60	9.7				
Mean	11.50	17.78	22.00	23.00	
1973		21.1	28.5	31.0	33.2
74	13.6	25.4	28.9	31.7	
75		22.7	27.5		32.0
76	11.2	19.4	26.4	31.0	33.5
77	10.8	21.3	27.0	31.5	33.2
78	10.4	18.9	25.7	28.2	31.6
79	10.7	14.1	22.2	28.7	33.1
80	9.5	15.3	21.4	28.2	31.8
81		14.4	27.0		
82	11.4	22.8	23.9	28.7	
83	9.3	18.8	24.3	26.3	
Mean	11.09	19.54	25.85	29.88	32.63

Table 1 d. Mean length at age.

AREA 07

	Age				
Year	0	1	2	3	4
1950					
51		15.8			
52			20.3		
53			20.4		
54		17.7	25.6		
55		19.7			
56					
57		15.2			
58	11.9				
59					
60	11.6				
Mean	11.75	17.10	22.10		
1973		23.6	29.6	32.0	33.3
74		24.9	30.2	32.3	33.9
75	13.1	18.1	28.9	32.0	34.0
76	12.3	20.9	29.2	32.7	33.9
77	10.8	19.8	29.3	31.5	33.2
78	11.3	24.1	27.1	29.6	32.2
79	9.2	20.3	26.9	30.6	32.7
80	15.6	21.2	27.0	28.5	32.8
81	12.6		27.8	31.8	32.3
82		22.3	28.0	30.7	32.3
83		22.0	28.1	27.8	30.3
Mean	12.13	21.69	28.40	31.17	33.06

Table 2. Mean length at age in the spawning stock

	Age						
Year	4	5	6	7	8	9	10
1950	28.7	30.2	31.2	31.5	32.7	33.4	34.1
51	29.4	31.0	31.5	32.7	33.8	34.5	34.8
52	29.7	31.6	32.4	33.4	33.8	34.8	35.2
53	26.2	30.7	32.0	33.2	34.2	34.8	35.7
54	30.0	30.9	32.9	33.9	34.4	35.5	36.0
55	29.9	32.3	33.6	34.1	35.2	36.1	36.4
56		32.7	33.5	34.2	35.5	35.7	36.1
57	31.3	33.2	34.1	34.8	35.7	36.0	36.7
58	30.8	32.0	32.8	34.2	34.4	34.4	34.8
59	29.4	30.6	31.5	32.3	33.6	34.4	34.9
60	29.2	29.8	31.2	32.9	34.0	34.6	35.0
Mean	29.46	31.36	32.43	33.38	34.30	34.93	35.43
1973	31.6	33.3	35.0	36.0	36.4	37.0	37.4
74	32.2	34.1	35.5	36.3	36.7	37.7	37.6
75	32.8	34.5	35.2	35.6	37.2	37.1	37.8
76	32.3	33.8	35.1	36.4	36.7	37.2	37.6
77	33.3	33.3	34.8	36.0	36.9	37.1	36.9
78	30.0	32.8	34.3	35.6	36.2	36.1	
79	31.3	33.3	34.6	35.3	35.6		
80	30.9	32.4	33.5	34.7			
81	30.7	32.5	33.4				
82	30.9	32.3					
83	28.6						
Mean	31.60	33.23	34.60	35.74	36.53	37.03	37.46

Table 3. Weight at age in the spawning stock.

	Age						
Year	4	5	6	7	8	9	10
1950	181	213	249	262	293	303	314
51	195	245	272	295	308	321	322
52	208	268	292	307	306	323	334
53	136	242	260	288	304	326	334
54	234	252	284	302	320	327	350
55	221	265	291	313	328	354	370
56		251	300	301	359		369
57	229	294	293	317		354	
58	219	253	264		306	323	383
59	187	211	235	249	294	288	319
60	192	197	222	270	277	309	325
Mean	200.2	244.6	269.3	290.4	309.5	322.8	342.0
1973	231	298	369	385	391	385	430
74	267	338	366	379	361	418	380
75	282	340	347	322	438	366	390
76	262	299	321	386	371	398	384
77	278	262	338	347	382	375	330
78	181	274	307	347	350	321	
79	235	278	313	327	286		
80	234	238	275	275			
81	212	260	250				
82	213	224					
83	151						
Mean;	239.5	281.1	320.6	346.0	368.4	377.2	382.8
Diff;	39.3	36.5	51.3	55.6	58.9	54.4	40.8

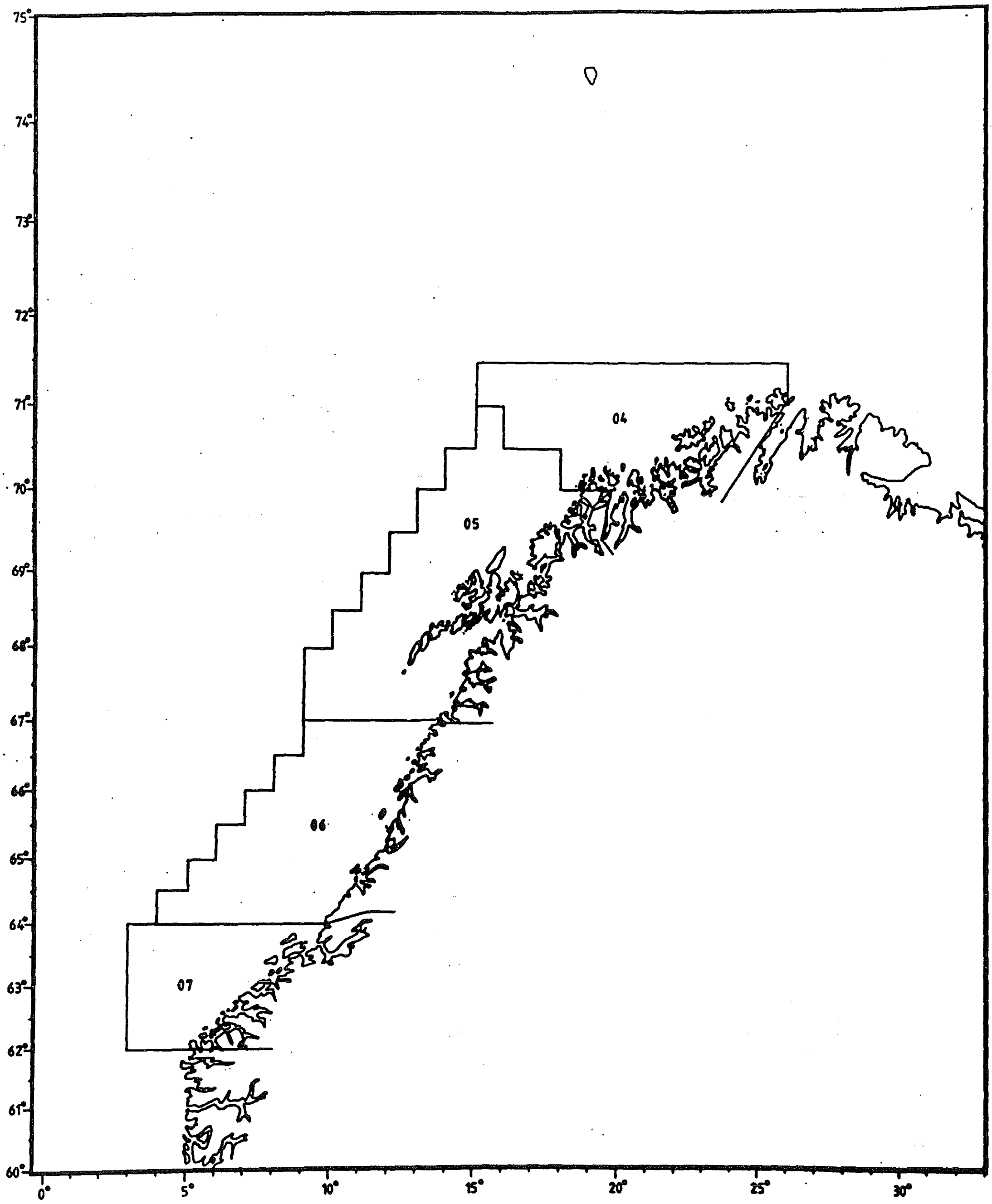


Figure 1. The areas in which growth is studied.

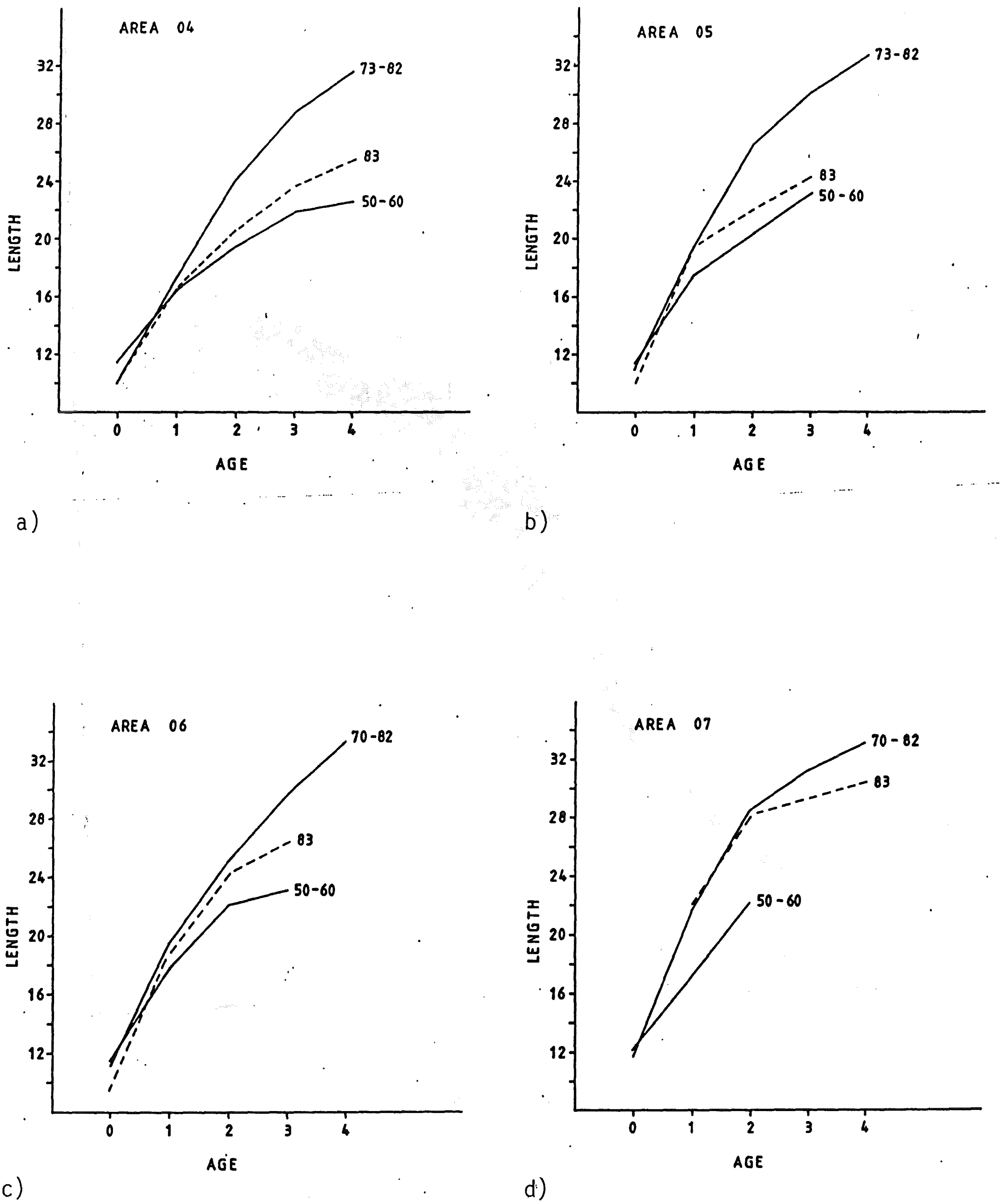
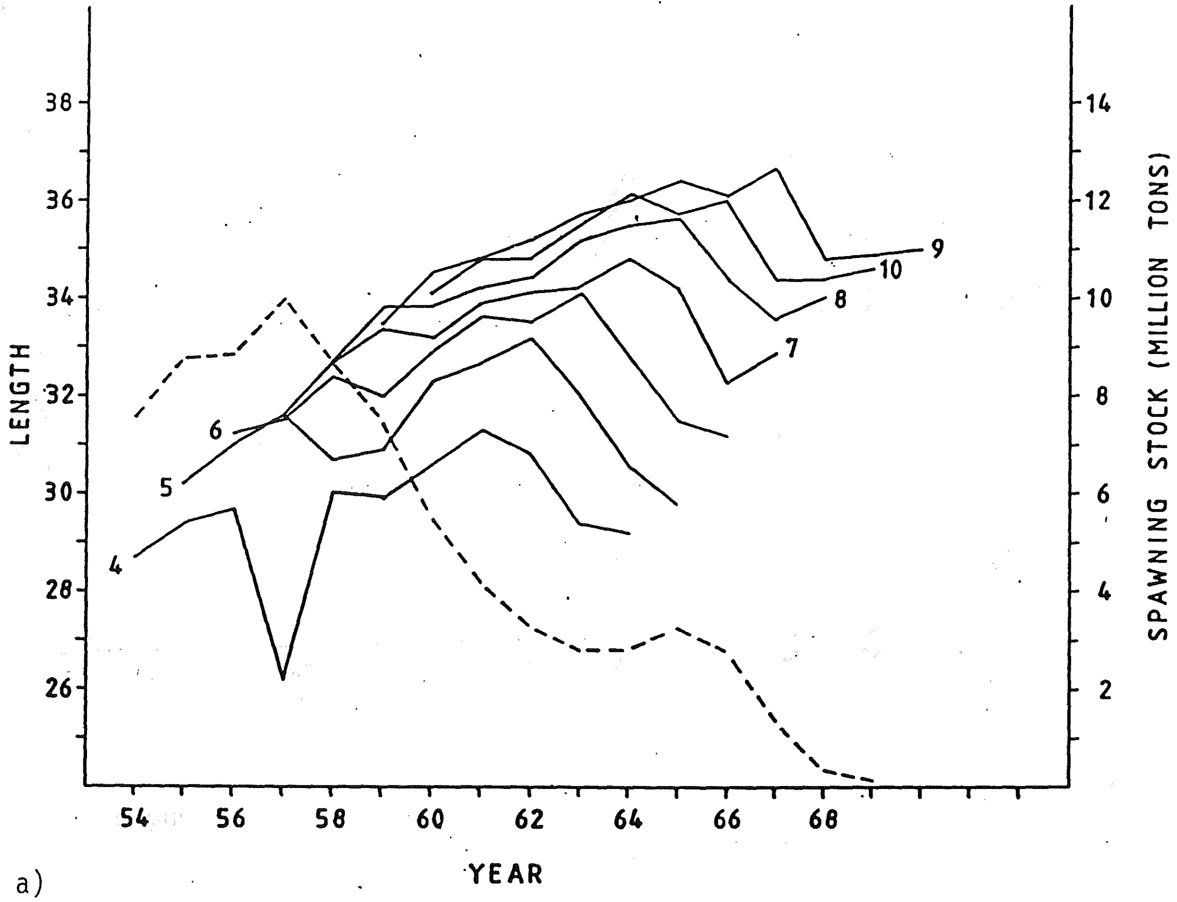
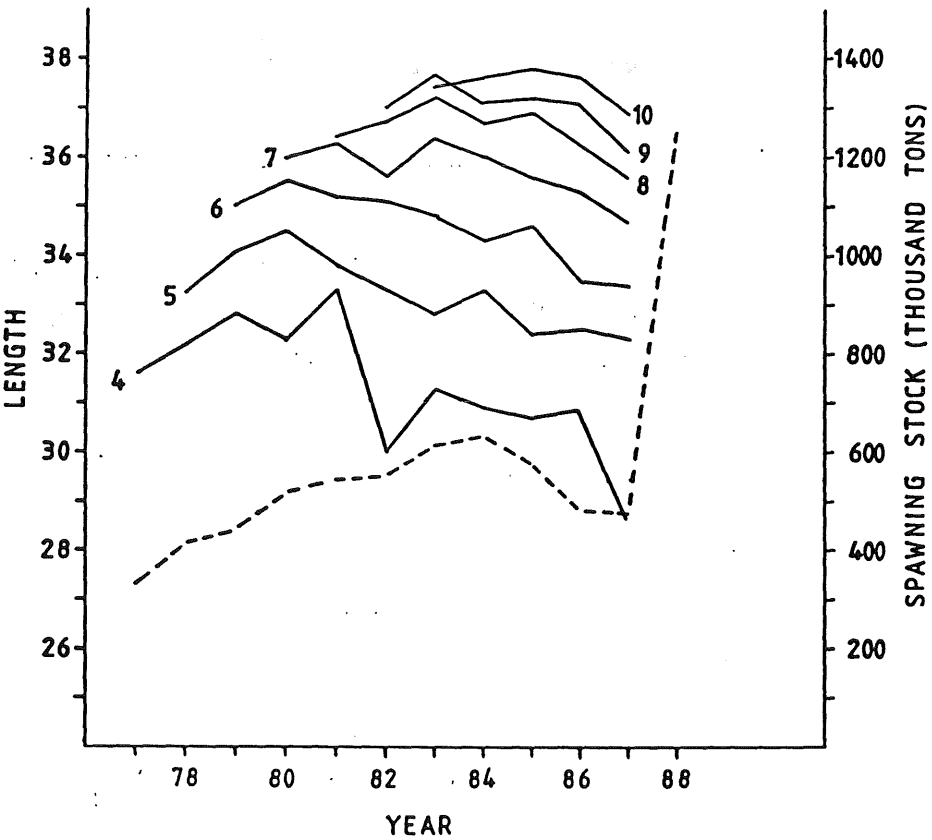


Figure 2 a - d. Plots of length at age in the four regions in the two periods.



a)



b)

Figure 3 a and b. Mean length at age per year and spawning stock abundance.

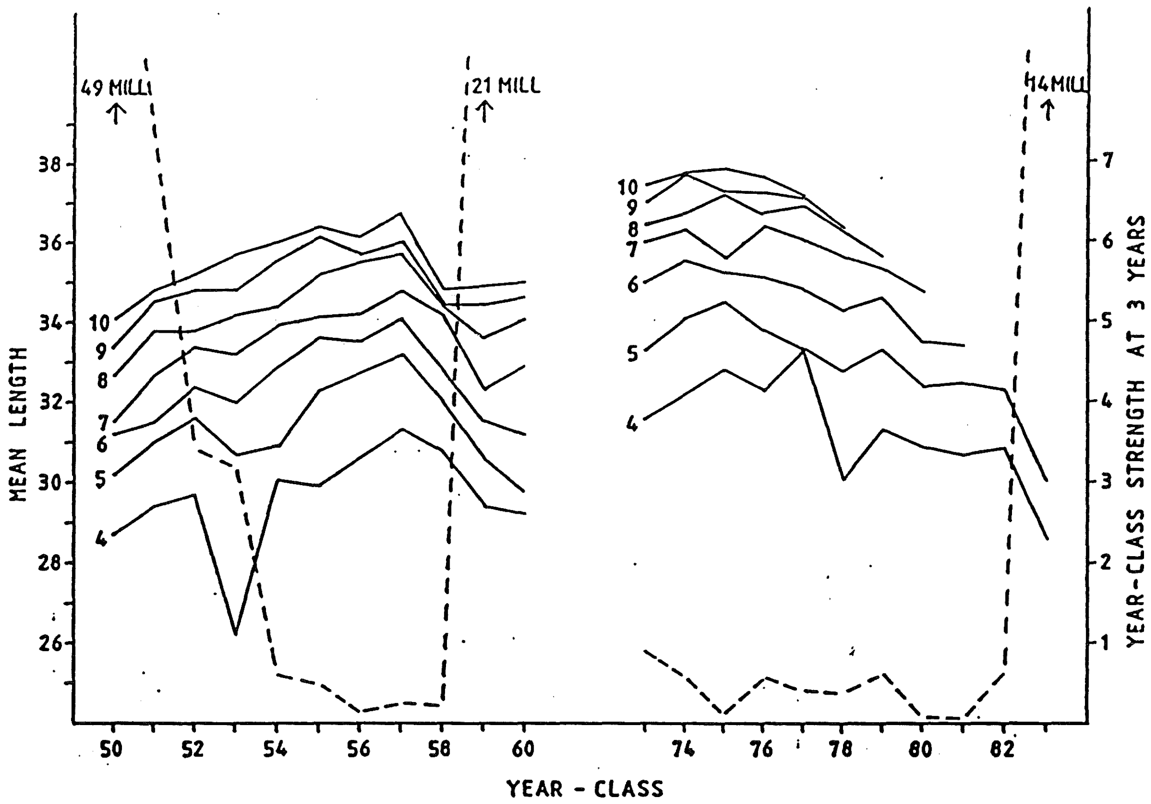


Figure 4. Mean length at age per year-class and year-class strength at three years in the two periods.

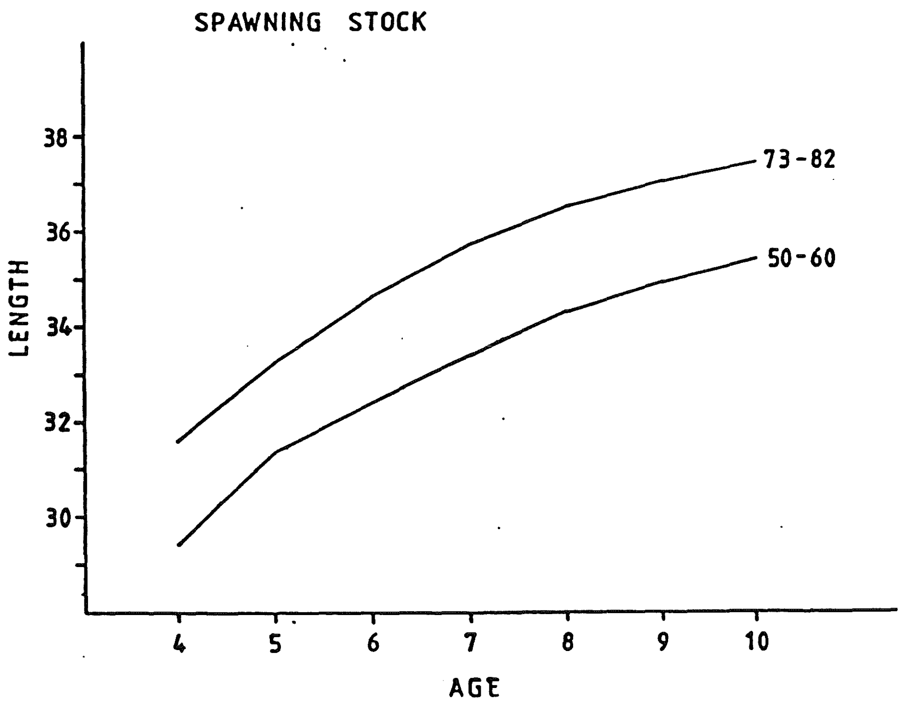


Figure 5. Mean length at age for all year-classes in the two periods.