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**ON THE GROWTH OF SOLE
IN THE NORTH SEA**

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Abstract

Changes in length at age, weight at age, condition factor and ovary weight of North Sea sole were investigated from Dutch market samples in the period 1957-1986. A considerable increase of length at age and condition factor and consequently weight at age in males and females were observed in the period 1965-1973. The increase in growth started in all age groups simultaneously. In the period after 1973 these parameters remained at a high level for age groups 3-7. Length- and weight at age in older animals show a further increase until 1986. The percentage of ovary weight has not changed significantly over the whole period. The surplus production has been calculated for an early and a recent period. A comparison has been made with the surplus production of North Sea plaice. From the differences between both production plots and differences in the migration behaviour of both species it is concluded that it is likely that the factor(s) responsible for the growth increase only occur in the southern North Sea.

Introduction

Changes in growth have been observed in many commercial species and many areas. In 1976 DE VEEN described significant changes in the biological parameters in the North Sea sole (*Solea solea* L.) observed in the years 1951-1973 and tried to relate them to changes in environmental factors. The only significant factors found were with fishing effort and with indices of the disturbance of bottom layers by active gears.

DE VEEN's paper was based on data from research vessel sampling for the years 1951-1965 and the annual sampling programmes in the Dutch fish markets in the years 1957-1973. He demonstrated a similar increase in growth in the period 1968-1973 in four sub-stocks and found no significant differences between the substocks in this period.

The Dutch fish market sampling programmes continued after 1973. The present paper reports on further developments of growth in the North Sea sole stock. No distinction has been made between sub-stocks. In order to compare the developments of the stock after 1973 with the period covered by DE VEEN the whole market sampling data base, for the period 1957-1986 was reanalysed.

Changes in length at age, weight at age, condition factors and gonad weight were studied on second quarter data only as in this period soles of all age groups aggregate in coastal waters for spawning and biological sampling was intensified in this period every year.

the data

Soles landed in the Dutch fish markets are gutted and are presented in 5 size categories. The biological sampling is based on this stratification. In each size category a number of fish are taken at random and sex, length, weight, gonad weight and maturity stage (females only) and age (otolith) were recorded. The sampled weights are raised to the total landings by size category for each quarter. In this way quarterly length distributions per age group are obtained for each category. Thereafter the categories were combined.

In the years before 1962 the Dutch fishery for sole in the North Sea was predominantly carried out with otter trawls. After 1961 the otter trawls were gradually replaced by beam trawls. Since 1969 the majority of the Dutch catch is landed by beam trawls. The market samples considered in this paper therefore originate from both type of gears.

In this paper only ages 2-14 were considered as older age groups occur infrequently in the the market samples.

Mean length at age were obtained as the average of the length distribution per age group weighted in each quarter.

The condition factor of each fish was calculated as $C = W/L^3$ where W is the life weight. A conversion factor gutted/life weight of 1.11 was applied in all years. A mean condition factor per age group was calculated as the average from all sampled fish.

Mean weight at age was calculated from the length distribution per age group and the mean condition factor of that age group and was weighted over catch numbers in the length distribution.

Ovary weights were determined in the second quarter only. In this paper only ovary weights of stage 4 and 5 in April were considered, because they represent pre-spawning fish with a seasonal maximum in average weight..

For the calculation of the surplus production of females the data were slightly modeled. Assuming no significant growth in length during spawning time, mean length at age in the second quarter were considered representative for the period just before spawning (end of the first quarter) and just after spawning (beginning of third quarter). Weight at age before ($W_{1,age}$) and after spawning ($W_{3,age}$) were calculated from a smoothed second quarter length at age, using the BERTALANFFY growth equation (in BEVERTON & HOLT, 1957), and first and third quarter condition factors. The total growth of an age group was calculated as the difference in weight before spawning and the weight of the preceding age group after spawning ($W_{1,age} - W_{3,age-1}$). The reproduction of the age group was estimated from the calculated pre-spawning weights ($W_{1,age}$) and the percentages of ovary weights (constants per age group) stages 4 and 5 in April. Both growth and reproduction were plotted against the mean weight $((W_{1,age} + W_{3,age-1})/2)$.

Results

Tables 1a and 1b give the numbers of fish sampled per age group in each year. The level of sampling was not the same each year. In the earliest years (1957-1961) sampling was rather poor. In 1962, 1969 and 1974 sampling was intensified in steps and in 1980 it was reduced again to its present level. The numbers sampled per age group each year depends also on year class strength. Therefore abundant year classes are better sampled than average and poor ones. Also, in general the younger age groups are better sampled because they occur in more than one size category in the fish market. Sometimes a size category contains only 1 year class. The oldest fish are predominantly found in the largest size class which contain many year classes.

The data for age 3 must be considered with caution, because this age group is not fully recruited in the fishery in the earlier years and might also be influenced by small changes in the used mesh size.

Tables 2a and 2b give the mean length at age in the 2nd quarter for males and females respectively. These data are plotted in Figure 1a and 1b. In these plots observations based on less than 3 fish are omitted because they are highly variable.

Length at age is variable, but at the same level in the years 1957-1965 in all age groups. The large fluctuations in the earlier years in the older age groups are mainly due to poor sampling. In the period after 1965 mean length at age starts to increase each year for all age groups simultaneously and in both sexes. This yearly increase in mean length at age stops around 1973 in the age groups 3-7 and the new higher level remains until 1986 except for 4 and 5 year old males where it tends to decrease again in the latter period. In age groups 8-14 the increase continues also after 1973 but is lower than in the previous period.

Weight at age data for the 2nd quarter are shown in tables 3a and 3b and figures 2a and 2b. Also here observations based on less than 3 fish are omitted in the plots. The trends in weight at age are similar as described for length at age.

Tables 4a and 4b show the condition factors per age group for both sexes. Figure 3 shows the condition factors for each age group in the 4 different quarters (averages over the period 1971-1986). The condition factors in females are higher than in males.

In females, the condition factor is lowest after spawning in the third quarter. It increases during the third, fourth and first quarter by somatic growth and the development of the ovaries. The seasonal pattern of changes in the condition factor of males is different from the females. The condition factors are lowest in the second and third quarter and highest in the fourth quarter. In contrast to the females they decrease in the first quarter.

Figure 4 shows the trends of the condition factors in the second quarter with time. Yearly fluctuations in the condition factors of males and females show a similar pattern. These fluctuations are probably caused by different growing conditions each year. However, also differences in the stratification of the samples in the second quarter might have influenced these fluctuations. In the period 1961-1971 the condition factors in both males and females increased continuously. After this period they remained at a more or less constant level, lower than in 1971 but higher than the period before the increase.

The percentage ovary weight of the total body weight (stages 4 and 5) in April shows some trends in time but has not changed over the whole period (figure 5). There are short periods with increasing and decreasing trends. In the periods 1966-1970 and 1973-1982 the

relative ovary weight decreases in all age groups. In the first period this decrease is much stronger (30-40%) than in the latter (10-15%). In the intermediate years there is a strong increase. The fluctuations in the years before 1969 are partly caused by poor sampling. Figure 5 shows that the percentage ovary weight increases with age.

Figure 6 shows the surplus production of females in the periods 1958-1962 and 1982-1986. The average annual growth (Y-axis) was plotted against the average weight of the fish during the year (X-axis). Each point represents an age group. The figure shows that the growth in all age groups group was higher in the latter period. The reproduction relative to the weight of the fish in both periods did not change.

Discussion

The annual growth of fish in weight results from an intake of energy by feeding. This energy is used for metabolic processes, increase in length, increase in condition factor and reproduction. Changes in growth can be described by changes in increase of length, condition factor and reproduction.

Within the considered years, a continuous increase of weight at age has been observed in male and female sole in the period 1965-1973 in all age groups simultaneously. In the period after 1973 no systematic changes in weight at age have been observed in ages 3-7. The weights in these age groups have remained fairly constant at the high 1973 level, except for 4 and 5 year old males which showed a gradually decrease until 1986. This decrease is not observed in females. In the period after 1973 the weights of age groups 8 and older continued to increase. The observed increase in weight at age results from an increase in length at age and an increase in the condition factor in the same period. DE VEEN (1976) mentions the period 1968-1973 in which the increase of growth occurred. From the available data it is difficult to determine the exact year in which it started because of the high annual fluctuation particularly in the first years.

The increase in weight at age from the earlier period (1958-1962) compared to the most recent period (1982-1986) for both males and females is about 54% for age groups 4-14. About 10% of the increase in weight is caused by the higher condition factor, the other 44% results from the increase in length.

The seasonal changes in condition factors are most pronounced in females as the development of the ovary, which amounts to about 6-12% of the total body weight in April, and the ripening of the eggs and spawning process take more energy than sperm production in males. The higher level of the condition factor in females is probably also related to a higher energy demand for reproduction. As most of the 2 year olds and some of the 3 and 4 year old females will not become mature (VAN BEEK, 1985), the seasonal change in condition factor for these age groups is less pronounced and the value is lower. The condition factors of males in the youngest age groups are not biased by the occurrence of immature fish, as was the case in females, because all males of age 2 and older are mature (unpublished data from 1985 April survey in the South Eastern North Sea).

In contrast to the females the condition factors of males decrease in the first quarter. The most likely explanation for this phenomena is that the loss weight is caused by the need of energy for metabolic processes in the first quarter. In females this loss is camouflaged by an increase of weight of the developing ovary and ripening of the eggs.

Egg production itself, has not been measured in the marked samples. However, changes in the egg production will be reflected in changes in the percentage ovary weight in spawning time. The decrease of the percentage ovary weight of the total body weight in the years 1966-1970 and the increase in the following years coincide with a period where overall growth in sole increases. Therefore it seems unlikely that those factors, responsible for the growth increase, are the same factors which influence the allocation of energy which will be used for reproduction. Over the whole period 1966-1986 the percentage ovary weight has not changed significantly and seems not related to the changes in the observed weights of the fish.

The fact that the increase in growth rate started in all age groups simultaneously suggests that an external factor, influencing the growth rate must be responsible. The effect of this factor has continued to increase until 1973. After 1973 this factor has not disappeared but the effects of it do not further increase the growth rate of sole. DE VEEN has attempted to correlate these changes with environmental factors such as the density of the sole stock, temperature in the growth season, eutrophication, and fishing effort. He found that of these factors significant correlations were only found with fishing effort and with indices of the disturbance of the bottom layers by active gears, in particular beam trawls. DE GROOT & APELDOORN (1971) studied the effects of beam trawling on the zoobenthos and demonstrated considerable damage to bottom organisms. DE VEEN suggests that the disturbance of bottom with tickler chains increase the availability of injured molluscs and polychaetes, which are the major food for soles.

No attempt was made to repeat these correlations. However, it must be considered that since 1971 beam trawl effort of Belgium and The Netherlands doubled and tripled respectively. Although some of the increase of effort is exerted to areas outside the distribution of sole, most of the increase is made on the sole fishing grounds. However, after 1973 no further increase in growth has only been observed in age groups 8 and older. It seems reasonable to assume that availability of food is a major factor in the growth increase. If disturbance of the bottom is a significant factor three possibilities remain; 1) The increase of effort after 1973 has exerted to areas where predominantly older soles occur. 2) Further increase in effort after 1973 does not increase the availability of food. 3) Taking in account the limits of other environmental factors, the growth parameters of sole have reached a biological limit in 1973 and the increase of weight at age in the years thereafter are caused by the cumulative effects of the period 1965-1973 with a superimposed maximum growth in the years after 1973. The first possibility does not seem likely. No information is available to verify the other two possibilities. Also natural changes in the abundance of zoobenthos, may be interfering with disturbance of the bottom, could be responsible for changes in the availability of food. However, time series of the abundance of zoobenthos are lacking.

In general, a great proportion of energy in young female soles, accumulated by feeding, is allocated to somatic growth. At older ages an increasing proportion is used for reproduction at the expense of somatic growth. This is demonstrated in figure 6. The surplus production plot (figure 6) shows the annual growth in two periods where weight at age was fairly stable. The period 1958-1962 is representative for the situation before the increase of growth occurred. The period 1982-1986 represents the situation after the major growth increase. As discussed above, the percentage of ovary weight did not change systematical during and after the growth increase (data were only available for the period 1966-1986) and it is assumed that that no changes occurred before 1966. The figure shows that the surplus production of sole has increased in small and large animals but that the amount of production used for the reproduction has not changed.

RIJNSDORP & VAN BEEK (1987) report on an increase of mean length at age in the late sixties and early seventies in young plaice. This increase did not occur in older plaice. They also present a comparable surplus production plots (figure 7) for the periods 1957-1965 and 1975-1980. In plaice the surplus production has increased in the latter period in smaller animals only and remained the same or showed a slight decrease in the larger animals.

They suggest that the differences between sole and plaice are possibly related to differences in the distribution of both species. The younger age groups of plaice are predominantly distributed on the same feeding grounds as sole in the Southern North Sea. Older plaice migrate in summer to feeding grounds in the Central and Northern North Sea, while older soles remain in the Southern North Sea. They suggest that the factor(s) responsible for the increase of growth in sole and plaice occur in the Southern North Sea and only that soles are exposed to these factors during their whole life and plaice only in their first years.

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table 1a North Sea Sole, males, numbers sampled at age in 2nd quarter

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
2									1	
3	6	11	9	8	19	6	10	19	3	102
4	11	20	15	17	5	77	14	54	16	2
5	3	33	21	12	9	17	124	50	18	1
6	6	11	18	19	8	18	22	164	9	14
7	23	6	3	18	16	11	20	26	56	5
8	5	20	10	6	11	9	9	18	7	53
9	2	10	14	2	3	7	8	9	2	2
10	32	5	2	8	2	1	3	4	3	10
11		23	5	3	6	4	5	4		3
12	1		10	2	4	6	5	2	4	5
13				11	5	4	3	5	2	3
14	1				7	3	2	4	3	1
total	90	139	107	106	95	163	225	359	124	201
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2		8	44	7	88	14	101	146	83	28
3	56	71	256	483	368	738	345	1309	1097	1198
4	239	152	81	108	291	144	400	314	508	568
5	6	222	168	26	98	129	76	608	104	240
6	2	2	410	55	27	35	46	156	249	57
7	11			289	56	8	17	121	46	113
8	4	10	5	3	205	28	19	61	43	26
9	30	2	22	3	4	208	35	38	31	20
10		23	2	22	3	6	125	30	15	15
11	4		42	5	25	3	2	228	6	17
12	3	4	1	57	3	24	5	8	143	10
13	2	1	8	4	43	4	14	6	5	16
14	4	2	3	9	3	65	2	24	5	5
total	361	497	1042	1071	1214	1406	1187	3049	2335	2313
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	234	140	22	9	74	10	15	13	1	1
3	487	948	1274	201	76	410	211	264	225	154
4	858	180	415	265	176	29	144	212	152	185
5	427	333	129	124	211	81	5	95	127	90
6	83	215	154	27	69	129	16	2	42	70
7	16	98	77	32	20	67	32	15	1	24
8	68	16	38	26	22	20	13	13	4	
9	32	44	13	8	24	20	7	12	12	6
10	14	10	22		5	18	6	4	2	4
11	8	9	9	6		5	16	4	2	4
12	13	4	6		4	7		4	3	4
13	2	6	6	2	4	8			2	2
14	72		5	1		1	8			3
total	2314	2003	2170	701	685	805	473	638	573	547

table 1b North Sea Sole, females, numbers sampled at age in 2nd quarter

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
2									10	
3	27	14	30	18	61	6	56	20	4	235
4	43	40	33	29	26	110	27	45	5	5
5	6	35	37	27	37	25	154	33	14	7
6	7	5	32	21	16	38	33	210	12	36
7	33	9	4	18	16	22	31	47	62	13
8	15	23	9	2	20	16	17	22	11	119
9	6	16	13	5	8	15	13	21	11	14
10	56	17	17	19	6	3	17	31	3	21
11	2	52	13	10	19	13	5	21	6	8
12	1	1	34	6	7	9	2	4	8	20
13	2	1	5	25	2	17	14	15	3	5
14	2	1	3	1	28	6	3	10		1
total	200	214	230	181	246	280	372	479	149	484
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	3	5	37	20	159	31	114	278	94	34
3	58	44	263	471	379	575	229	1434	113	1023
4	319	105	76	109	305	181	362	323	676	826
5	8	277	185	36	85	174	98	677	159	364
6	5	2	489	55	43	55	75	151	433	96
7	37	4	3	432	87	17	33	166	74	227
8	9	30	8	5	420	47	25	77	107	79
9	134	6	70	1	4	283	49	40	53	91
10	10	115	16	36	3	7	187	76	31	50
11	17	9	178	8	34	5	13	483	21	36
12	7	15	12	154	1	19	4	11	327	34
13	24	7	31	11	97	6	28	13	4	323
14	14	7	8	26	9	84	5	45	12	8
total	645	626	1376	1364	1626	1484	1222	3774	2104	3191
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	473	282	21	11	99	13	58	31	4	7
3	467	1062	1073	194	69	492	312	258	233	187
4	988	252	782	241	116	31	336	258	215	261
5	551	499	171	113	152	100	16	238	221	130
6	166	406	361	33	85	170	60	36	167	176
7	57	143	273	71	37	94	126	63	6	112
8	197	49	127	79	39	23	68	103	48	2
9	56	127	45	21	41	33	27	66	57	16
10	65	19	106	2	7	32	37	13	29	30
11	25	36	43	17	4	12	57	26	12	22
12	19	13	24	2	14	2	5	26	24	6
13	11	17	22	1	5	18	2	3	16	4
14	275	22	20	2	1	1	27	3	2	12
total	3350	2927	3068	787	669	1021	1131	1124	1034	965

table 2a North Sea Sole, males, length at age in 2nd quarter (cm)

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
2									24.5	
3	24.8	26.2	25.7	26.3	25.5	26.4	25.7	26.4	24.9	25.6
4	25.7	27.4	26.2	26.7	27.4	26.3	26.9	26.9	28.8	26.5
5	27.5	27.5	27.1	26.6	27.6	28.2	27.7	27.8	27.9	29.5
6	29.0	28.5	28.1	27.6	28.0	29.4	28.5	29.1	29.2	28.8
7	28.8	28.9	28.2	29.2	29.7	29.5	29.3	29.4	30.3	31.5
8	29.9	30.8	30.1	29.4	28.8	29.4	30.0	30.1	28.7	31.1
9	32.5	31.8	30.0	29.9	30.1	28.7	30.3	30.6	34.0	31.1
10	31.1	31.0	29.5	30.3	29.9	31.5	31.6	32.0	31.1	31.9
11		31.7	30.3	36.5	31.7	30.7	32.4	32.0		36.0
12	33.5		31.5	30.7	32.3	30.4	33.8	33.2	30.7	33.0
13				32.8	34.5	32.6	33.8	36.7	33.4	31.2
14	39.5				33.1	34.3	33.6	31.5	32.4	33.5
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2		24.2	25.0	24.6	24.9	25.2	25.2	25.2	25.2	25.4
3	25.9	26.1	26.2	27.3	27.3	27.6	27.8	27.3	27.2	27.2
4	28.1	28.0	28.1	28.9	29.7	29.9	30.3	30.2	29.4	29.4
5	29.5	29.6	29.7	30.5	31.2	32.1	31.4	31.7	31.7	30.6
6	32.8	28.8	30.4	31.4	30.9	33.2	33.0	32.7	32.7	33.4
7	30.9			32.3	32.8	33.6	32.8	34.4	34.0	33.7
8	29.8	32.5	31.0	33.2	32.9	33.6	32.9	33.8	35.0	33.3
9	31.2	33.5	32.1	33.2	34.9	34.2	32.5	34.7	34.4	34.5
10		32.7	32.7	33.8	33.2	34.5	33.4	34.3	34.4	35.7
11	30.7		33.7	35.6	34.4	38.0	37.1	35.0	32.1	35.8
12	30.3	33.4	36.5	34.0	35.7	34.9	34.5	36.0	35.1	36.9
13	34.8	40.5	32.7	34.8	35.4	35.8	33.5	36.7	37.0	34.8
14	33.1	35.2	33.2	33.3	35.8	35.9	37.2	35.1	33.1	34.8
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	25.2	25.1	26.3	25.5	25.2	24.5	25.1	25.0	24.5	24.5
3	27.6	27.0	27.3	27.1	27.6	26.8	26.6	26.8	26.7	26.3
4	29.7	30.0	29.5	30.2	29.9	29.7	29.1	28.8	28.0	27.9
5	31.2	31.4	31.7	31.5	31.5	30.6	30.3	30.6	29.8	29.4
6	31.8	32.4	32.6	32.2	32.4	32.3	32.2	33.5	31.3	30.9
7	34.1	33.1	33.2	34.1	33.4	33.0	33.3	32.6	35.5	33.1
8	33.8	33.5	33.5	35.4	34.4	33.6	33.1	35.8	35.0	
9	34.5	34.7	34.6	34.5	35.8	34.9	33.4	34.1	35.3	35.3
10	34.4	36.2	34.4		36.0	35.4	34.5	36.2	35.0	35.3
11	35.0	35.9	33.8	35.9		33.5	34.2	33.6	36.0	33.4
12	36.2	37.5	36.8		37.8	36.5		36.6	37.5	37.0
13	40.4	37.7	36.1	39.0	37.2	37.6			39.1	39.0
14	36.4		36.0	37.5		37.5	36.9			39.2

table 2b North Sea Sole, females, length at age in 2nd quarter (cm)

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
2									24.7	
3	25.8	26.9	26.2	26.8	26.3	25.5	26.1	25.8	28.1	26.8
4	28.5	29.3	28.7	29.4	29.4	29.5	29.0	30.1	29.1	26.1
5	29.5	31.9	32.1	31.4	31.3	32.3	31.7	32.5	31.2	35.3
6	32.5	33.4	33.6	33.5	31.4	33.6	33.1	33.3	32.3	35.4
7	33.7	34.3	34.3	34.7	33.5	34.6	34.4	33.7	34.3	36.2
8	36.2	35.3	34.5	37.8	35.1	34.7	36.1	34.6	34.8	36.1
9	35.3	37.0	35.8	39.5	32.7	37.3	35.9	35.6	38.4	36.8
10	38.3	37.1	37.6	37.9	36.7	38.1	36.6	37.5	37.7	37.4
11	38.8	37.9	38.2	38.0	37.3	36.9	38.2	36.3	36.5	41.5
12	39.5	40.5	38.6	37.6	36.8	40.2	40.5	38.6	40.6	39.8
13	39.9	37.5	35.6	39.9	42.1	38.4	40.2	38.1	36.0	42.3
14	44.4	41.5	41.1	37.5	37.0	41.1	39.3	38.1		38.5
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	28.3	24.7	25.1	25.0	24.9	25.3	25.4	25.1	25.5	25.4
3	27.4	27.8	27.8	28.9	28.7	29.2	29.9	29.8	29.1	29.1
4	31.1	32.1	31.7	32.2	32.8	33.0	33.9	34.0	33.7	33.1
5	38.8	34.1	34.0	34.7	34.6	36.2	35.8	36.6	36.4	35.9
6	36.1	31.6	35.3	35.8	36.3	37.5	38.1	37.8	37.9	37.7
7	36.8	39.9	37.5	37.0	37.1	39.0	38.9	38.9	39.9	39.1
8	37.6	38.4	37.7	38.8	38.2	38.6	40.2	42.3	40.3	38.9
9	37.5	38.9	38.2	37.5	37.4	40.0	40.5	40.9	41.6	41.4
10	36.5	39.3	38.3	39.3	41.9	37.5	40.4	42.6	43.3	42.3
11	38.2	40.5	39.3	39.0	39.2	36.7	40.6	41.8	41.6	41.4
12	39.1	40.7	38.7	40.2		41.0	41.3	41.3	42.4	42.9
13	39.7	40.4	41.4	42.4	40.8	41.0	42.0	41.3	42.7	41.8
14	40.9	41.7	40.5	41.3	41.5	41.9	41.5	40.7	43.4	42.1
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	25.5	25.1	25.2	26.1	24.7	24.3	24.9	25.0	24.2	24.9
3	29.3	29.6	29.7	28.6	28.5	28.5	28.8	29.2	28.2	28.6
4	32.9	33.6	33.2	33.5	32.7	32.3	32.4	33.0	32.4	33.0
5	35.9	35.4	35.8	35.3	36.1	35.9	34.7	35.3	34.8	36.1
6	37.1	37.7	37.5	38.2	37.2	38.3	37.6	35.3	36.4	37.6
7	38.3	38.9	38.8	39.1	39.1	38.9	39.7	37.7	38.1	39.1
8	39.5	39.9	40.1	39.8	40.3	40.9	39.9	41.0	40.2	
9	40.7	41.1	41.1	41.5	40.3	41.9	42.1	41.2	42.7	41.9
10	41.1	42.3	41.4	37.7	41.5	42.1	42.1	43.1	42.1	42.9
11	40.8	43.2	43.7	43.6	40.5	42.1	42.7	42.5	42.5	42.8
12	43.4	44.1	41.7	41.5	41.9	42.5	41.8	44.2	43.1	44.3
13	42.5	41.6	44.7	46.5	42.5	44.0	39.4	41.0	43.4	44.8
14	42.6	44.6	44.6	46.5	48.5	46.5	43.8	46.4	44.3	45.2

table 3a North Sea Sole, males, weight at age in 2nd quarter (kilogrammes)

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
2									0.122	
3	0.137	0.151	0.143	0.144	0.137	0.148	0.142	0.164	0.133	0.145
4	0.145	0.170	0.157	0.158	0.166	0.146	0.163	0.167	0.226	0.160
5	0.167	0.174	0.165	0.161	0.175	0.185	0.175	0.181	0.196	0.244
6	0.206	0.193	0.191	0.179	0.179	0.236	0.195	0.217	0.224	0.206
7	0.197	0.224	0.211	0.209	0.226	0.220	0.216	0.214	0.254	0.287
8	0.220	0.249	0.237	0.210	0.195	0.216	0.230	0.234	0.220	0.277
9	0.327	0.290	0.236	0.258	0.225	0.197	0.241	0.263	0.367	0.256
10	0.267	0.287	0.205	0.246	0.207	0.277	0.276	0.290	0.318	0.303
11		0.295	0.251	0.435	0.271	0.236	0.278	0.282		0.404
12	0.299		0.280	0.262	0.287	0.246	0.334	0.380	0.291	0.330
13				0.343	0.384	0.323	0.345	0.418	0.377	0.282
14	0.555				0.307	0.360	0.283	0.259	0.333	0.322
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2		0.119	0.136	0.135	0.151	0.156	0.145	0.142	0.146	0.140
3	0.144	0.151	0.153	0.178	0.190	0.196	0.195	0.185	0.180	0.176
4	0.184	0.187	0.194	0.216	0.253	0.252	0.251	0.253	0.230	0.228
5	0.213	0.223	0.234	0.253	0.301	0.317	0.282	0.293	0.290	0.262
6	0.355	0.217	0.255	0.276	0.279	0.352	0.333	0.323	0.320	0.342
7	0.267			0.311	0.341	0.375	0.322	0.376	0.362	0.349
8	0.223	0.286	0.256	0.352	0.344	0.359	0.328	0.364	0.395	0.350
9	0.268	0.339	0.298	0.360	0.406	0.385	0.306	0.401	0.375	0.387
10		0.308	0.318	0.369	0.403	0.383	0.342	0.383	0.365	0.408
11	0.258		0.355	0.405	0.401	0.560	0.472	0.396	0.292	0.420
12	0.268	0.333	0.422	0.365	0.423	0.403	0.365	0.426	0.407	0.434
13	0.388	0.521	0.342	0.388	0.429	0.411	0.346	0.487	0.466	0.395
14	0.323	0.323	0.340	0.375	0.454	0.457	0.493	0.398	0.364	0.406
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	0.140	0.135	0.155	0.142	0.140	0.130	0.136	0.129	0.125	0.130
3	0.185	0.171	0.176	0.178	0.190	0.168	0.163	0.164	0.162	0.159
4	0.233	0.244	0.224	0.246	0.248	0.234	0.218	0.206	0.189	0.192
5	0.272	0.278	0.285	0.284	0.284	0.266	0.261	0.253	0.235	0.227
6	0.293	0.317	0.312	0.301	0.331	0.314	0.311	0.364	0.275	0.281
7	0.368	0.341	0.339	0.376	0.364	0.326	0.333	0.326	0.398	0.337
8	0.353	0.349	0.356	0.406	0.389	0.341	0.334	0.403	0.401	
9	0.378	0.390	0.390	0.383	0.436	0.417	0.354	0.370	0.409	0.454
10	0.355	0.450	0.367		0.457	0.395	0.395	0.482	0.417	0.428
11	0.384	0.442	0.374	0.403		0.369	0.390	0.360	0.443	0.400
12	0.468	0.501	0.483		0.541	0.473		0.467	0.484	0.506
13	0.584	0.506	0.449	0.558	0.466	0.523			0.582	0.557
14	0.440		0.479	0.440		0.430	0.499			0.600

table 3b North Sea Sole, females, weight at age in 2nd quarter (kilogrammes)

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
2									0.146	
3	0.150	0.175	0.163	0.172	0.151	0.147	0.152	0.158	0.225	0.172
4	0.207	0.223	0.216	0.237	0.217	0.235	0.209	0.264	0.230	0.146
5	0.239	0.298	0.305	0.290	0.271	0.330	0.293	0.335	0.296	0.408
6	0.318	0.356	0.362	0.359	0.281	0.374	0.326	0.359	0.328	0.450
7	0.349	0.379	0.415	0.389	0.325	0.390	0.378	0.370	0.409	0.479
8	0.469	0.444	0.382	0.507	0.396	0.407	0.438	0.422	0.421	0.477
9	0.445	0.527	0.454	0.616	0.321	0.489	0.421	0.457	0.586	0.485
10	0.528	0.515	0.508	0.530	0.445	0.587	0.485	0.505	0.591	0.537
11	0.602	0.566	0.589	0.552	0.484	0.508	0.571	0.454	0.461	0.770
12	0.589	0.610	0.570	0.517	0.450	0.650	0.616	0.567	0.754	0.667
13	0.587	0.433	0.413	0.670	0.785	0.557	0.639	0.499	0.454	0.785
14	0.876	0.566	0.598	0.466	0.506	0.689	0.655	0.551		0.555
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	0.205	0.125	0.137	0.138	0.150	0.156	0.152	0.149	0.155	0.145
3	0.188	0.197	0.197	0.223	0.243	0.251	0.265	0.262	0.239	0.231
4	0.285	0.318	0.314	0.334	0.375	0.380	0.400	0.407	0.395	0.371
5	0.269	0.385	0.399	0.402	0.437	0.513	0.479	0.511	0.501	0.477
6	0.464	0.342	0.452	0.463	0.512	0.556	0.577	0.548	0.552	0.550
7	0.502	0.629	0.569	0.513	0.546	0.627	0.593	0.612	0.635	0.624
8	0.506	0.570	0.569	0.573	0.582	0.628	0.668	0.785	0.683	0.611
9	0.523	0.559	0.584	0.455	0.573	0.674	0.688	0.703	0.755	0.748
10	0.462	0.591	0.580	0.612	0.753	0.582	0.676	0.827	0.828	0.832
11	0.505	0.748	0.607	0.580	0.620	0.547	0.713	0.747	0.748	0.736
12	0.607	0.666	0.589	0.658	1.255	0.736	0.614	0.709	0.793	0.810
13	0.584	0.678	0.708	0.784	0.710	0.622	0.775	0.676	0.788	0.769
14	0.692	0.711	0.733	0.720	0.721	0.792	0.755	0.662	0.843	0.731
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	0.152	0.142	0.144	0.173	0.139	0.131	0.139	0.132	0.122	0.135
3	0.240	0.251	0.252	0.223	0.222	0.222	0.228	0.230	0.210	0.225
4	0.340	0.383	0.375	0.384	0.370	0.347	0.340	0.359	0.347	0.369
5	0.473	0.454	0.483	0.458	0.490	0.497	0.413	0.459	0.443	0.503
6	0.525	0.567	0.554	0.568	0.529	0.586	0.552	0.486	0.512	0.581
7	0.582	0.645	0.641	0.610	0.612	0.609	0.646	0.586	0.569	0.640
8	0.608	0.688	0.726	0.645	0.703	0.747	0.672	0.742	0.733	0.527
9	0.664	0.729	0.764	0.779	0.718	0.767	0.791	0.755	0.834	0.808
10	0.702	0.777	0.773	0.506	0.761	0.787	0.804	0.830	0.766	0.872
11	0.388	0.860	0.934	0.924	0.693	0.757	0.833	0.868	0.833	0.878
12	0.806	0.985	0.809	0.823	0.805	0.845	0.774	0.946	0.876	0.858
13	0.729	0.688	0.961	1.037	0.781	0.909	0.732	0.861	0.849	1.016
14	0.759	0.952	0.917	1.244	1.335	0.833	0.842	1.017	0.930	1.062

table 4a North Sea Sole, males, mean condition factor at age in 2nd quarter (*10-5)

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
2									830	
3	897	832	842	789	823	799	836	877	866	854
4	849	808	867	826	805	805	827	858	946	857
5	789	827	827	850	824	822	814	837	894	951
6	836	818	850	839	809	914	824	869	891	848
7	818	921	927	832	852	845	851	838	905	917
8	820	839	862	815	800	844	831	850	901	909
9	954	890	867	967	798	822	850	910	934	849
10	871	943	800	876	776	888	863	864	1044	932
11		905	873	897	843	809	807	858		840
12	797		889	878	849	866	854	1006	982	896
13				964	926	944	883	836	1007	930
14	901				834	885	741	820	974	856
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2		833	870	897	964	967	893	888	905	859
3	819	842	845	862	927	923	901	908	891	867
4	825	843	864	888	949	930	893	920	899	894
5	826	848	884	879	977	946	895	918	908	910
6	1002	898	888	884	928	949	917	923	914	918
7	896			913	954	960	903	934	918	910
8	835	826	849	920	951	938	910	927	918	948
9	871	901	878	983	951	950	882	961	915	947
10		870	866	944	1101	933	907	918	920	880
11	860		922	888	972	1023	910	927	874	916
12	922	882	867	918	920	935	876	905	942	861
13	915	785	973	904	954	889	909	916	924	932
14	882	729	907	999	987	976	954	931	993	965
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	868	850	858	866	868	880	846	816	853	883
3	880	867	862	889	901	867	867	841	849	869
4	890	905	870	893	922	879	884	852	853	875
5	891	899	893	901	802	928	941	875	878	884
6	913	934	897	900	916	932	937	965	888	929
7	918	940	920	948	979	898	905	913	891	820
8	921	932	939	920	950	892	932	875	932	
9	926	944	930	941	947	976	959	920	921	1023
10	863	946	904		971	916	965	1003	969	960
11	887	967	950	892		974	973	914	942	1048
12	987	905	968		1005	970		956	918	996
13	885	943	948	944	898	988			975	938
14	910		1026	821		821	987			999

table 4b North Sea Sole, females, mean condition factor at age in 2nd quarter (cm)

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
2		800		900		1004	1067		988	
3	911	917	860	965	847	932	947	979	1087	929
4	948	971	923	1003	913	981	979	1020	1073	959
5	1018	985	979	1019	953	1010	999	1042	1087	1004
6	1049	1037	967	1091	952	1016	977	1051	1136	1069
7	1006	1016	1036	1104	1036	1054	992	1054	1115	1117
8	1035	1071	1043	1065	1013	1094	1069	1094	1154	1030
9	1029	1102	1075	1039	1048	1084	1010	1097	1135	1009
10	1066	989	1087	1086	1103	1092	990	1035	1195	1112
11	1072	1089	1086	1142	1013	997	1029	981	1288	1006
12	1241		1078	1119	1048	977	978	1012	1054	1143
13	854		1117	1061	1066	1028	1019	942	1242	1205
14	1243	966			1055	991	982	909	1230	1087
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2			903	981	1011		1024	929	914	931
3	908	953	909	979	1018	1017	1034	1001	975	999
4	967	1065	994	1087	1086	1078	1122	1086	1080	1113
5		1085	1060	1125	1103	1153	1135	1098	1096	1146
6	1000	1187	1066	1102	1184	1157	1133	1114	1126	1164
7	1097			1125	1169	1135	1132	1132	1157	1134
8	1111	1158	1071	1041	1167	1255	1155	1179	1169	1145
9	1029		1015			1301	1241	1263	1183	1202
10	1061	1111	989	1116	1070	1219	1154	1154	1108	1117
11	1054	1159	1057		1200	1196		1158	1211	1194
12	1122	1205	994	1082			1164	1240	1181	1220
13	1027		968		1102	1294	1192			1163
14		1172	1030	1070			1243	1224	1143	1116
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	932	917	906		933	886	902	946	903	922
3	977	1014	999	1016	999	988	996	994	971	996
4	1051	1115	1090	1119	1148	1088	1092	1077	1083	1075
5	1104	1135	1135	1172	1158	1181	1118	1106	1100	1115
6	1135	1172	1152	1167	1154	1172	1187	1150	1138	1139
7	1159	1211	1167	1128	1209	1163	1138	1136	1291	1126
8	1110	1276	1167	1204	1151	1185	1186	1147	1150	1137
9	1063	1170	1204	1180	1243	1139	1191	1154	1177	1138
10	1141	1298	1190		1193	1181	1204	1154	1180	1133
11	1038	1171	1092	1141	1341	1155	1168	1161	1177	1168
12	1101	1301	1147		1153	1173	1087	1169	1174	1121
13	1236	1184	1111	1082	1157	1107	1153	1393	1152	1149
14	1143	1206	1044			1160	1194	935	1145	1099

Fig 1a N.S. Sole, length at age males

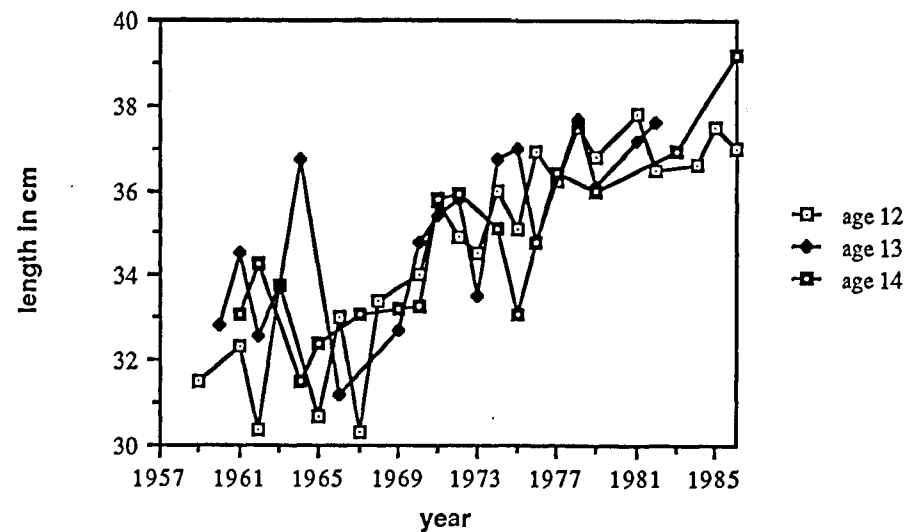
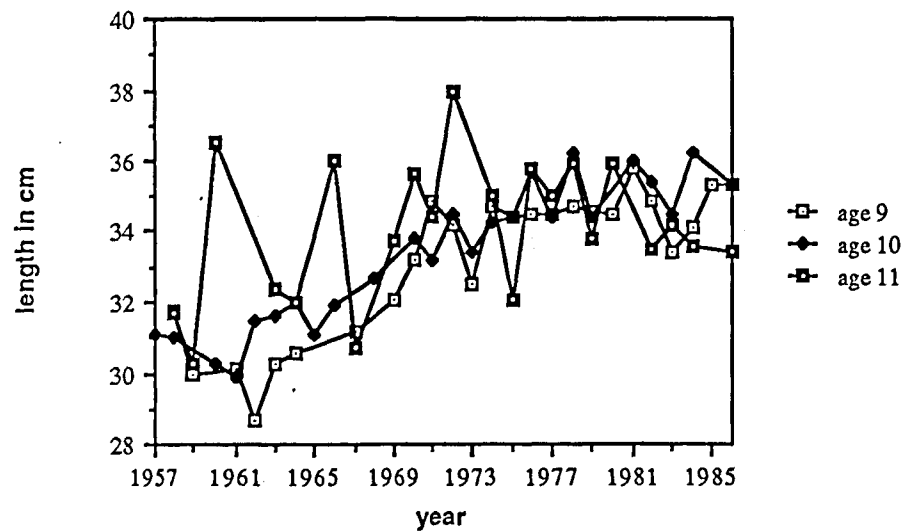
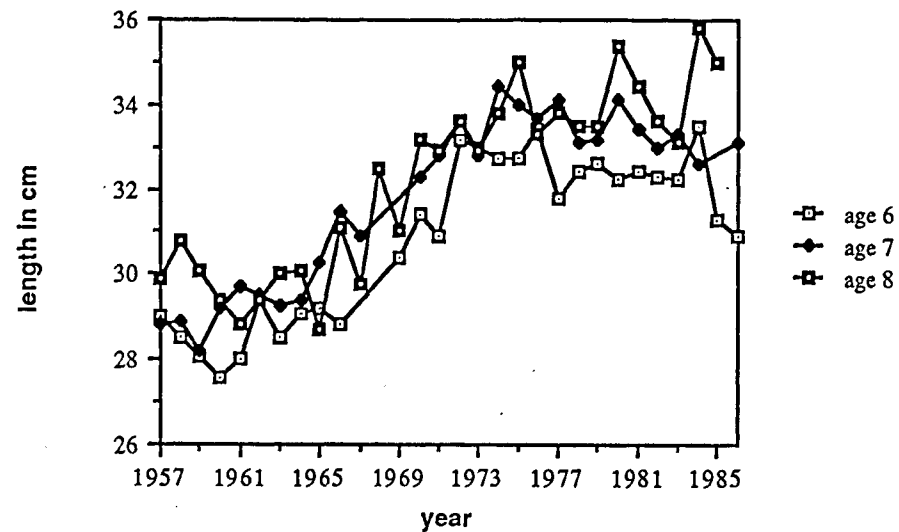
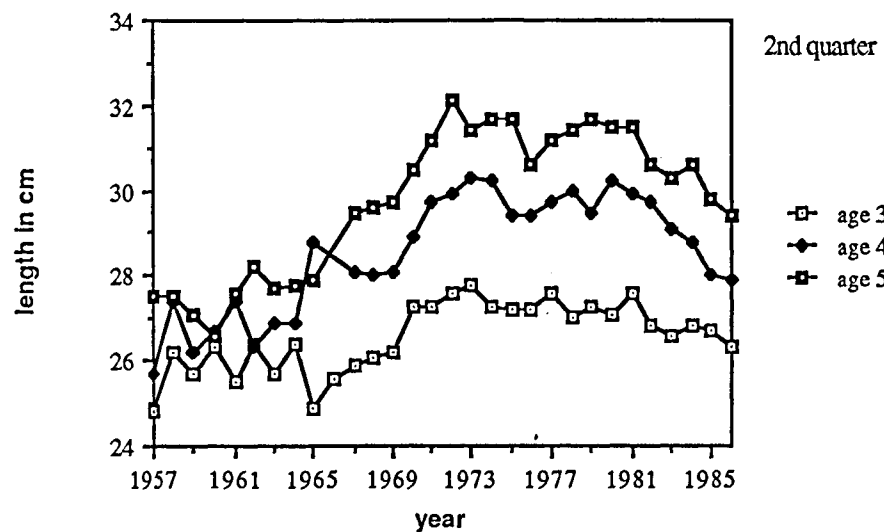


Fig 1b N.S. Sole, length at age females

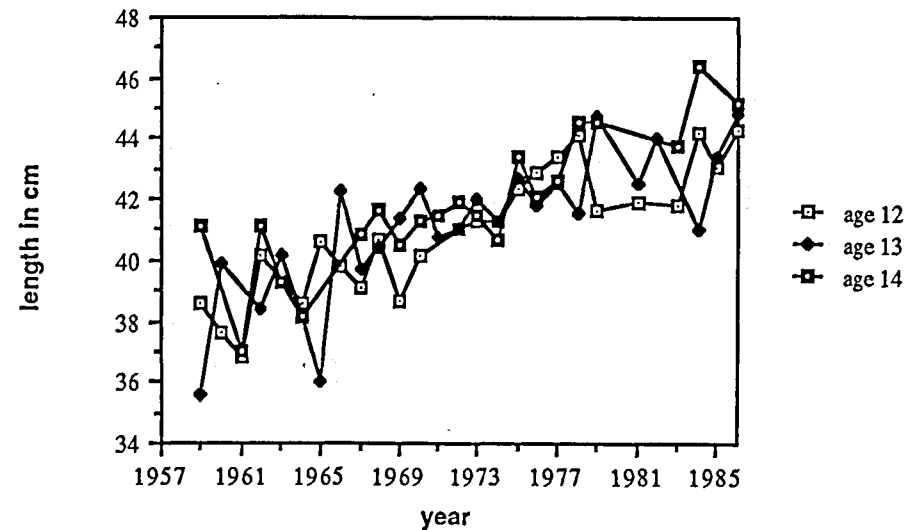
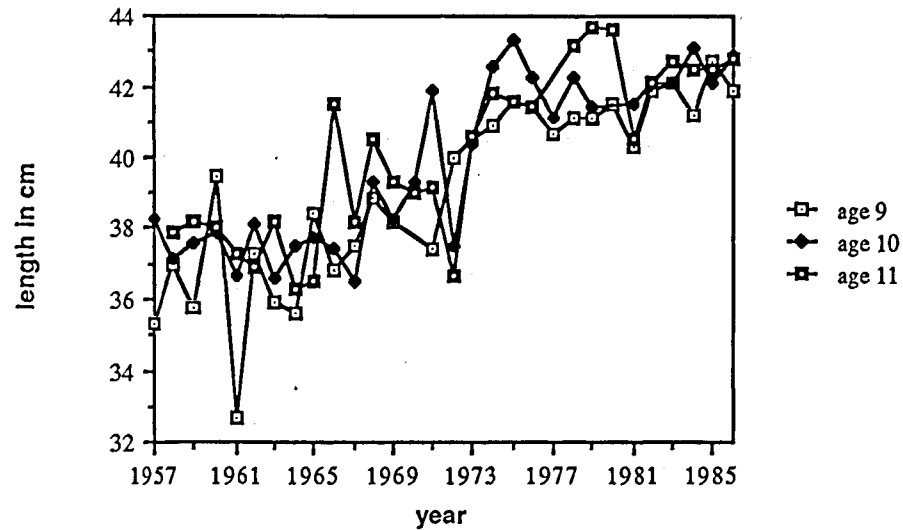
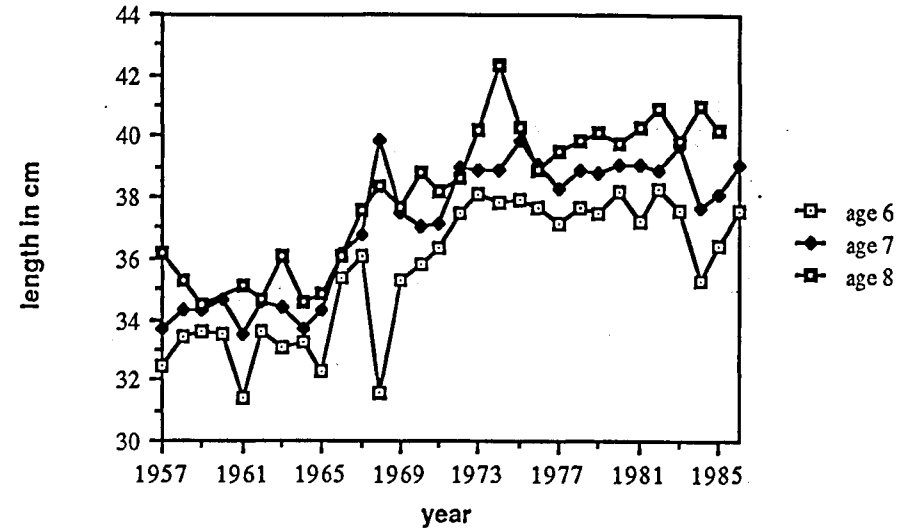
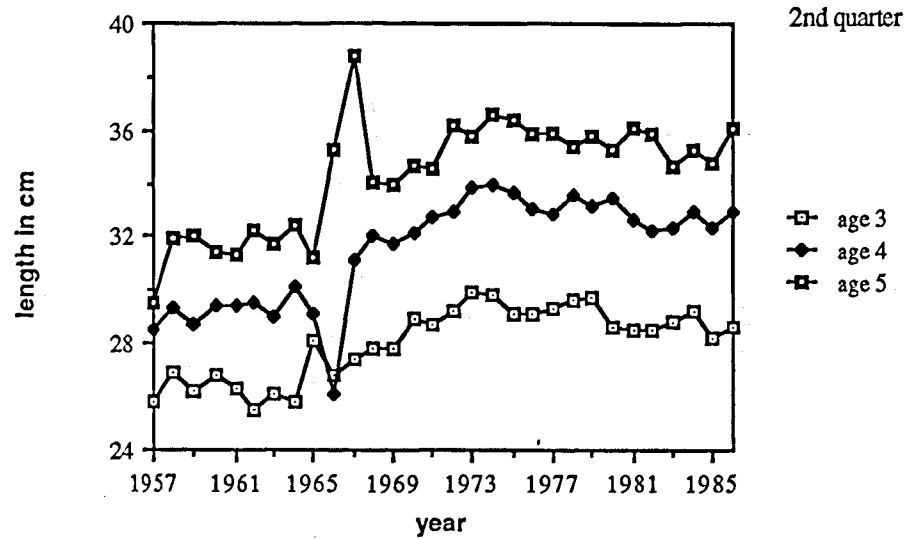


Fig 2a N.S. Sole, weight at age males

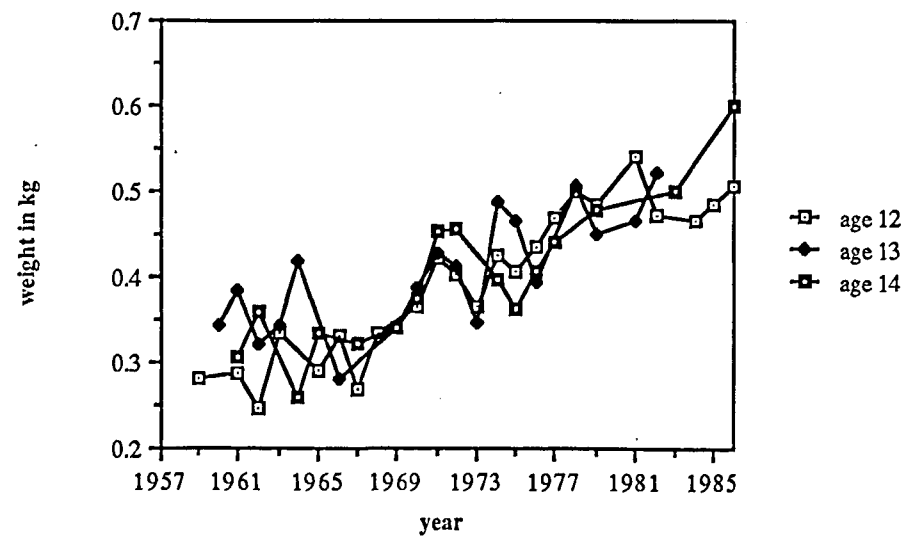
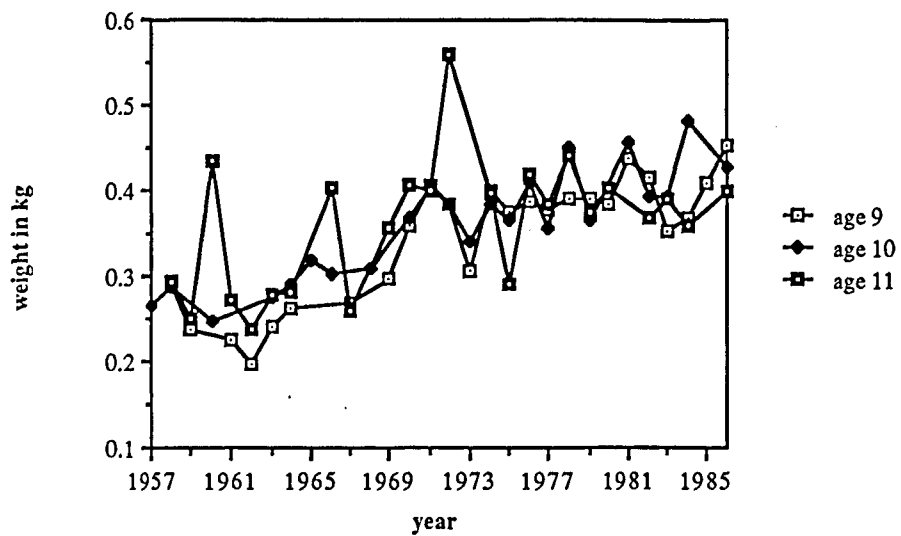
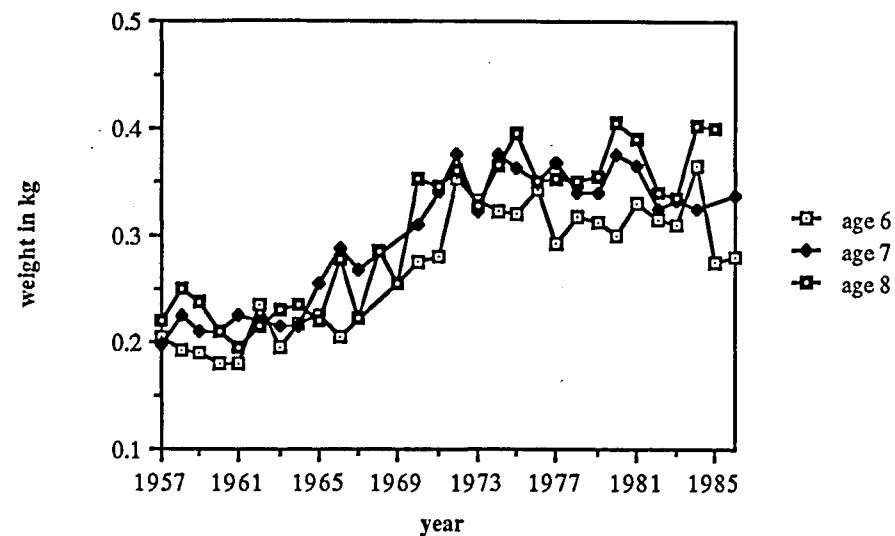
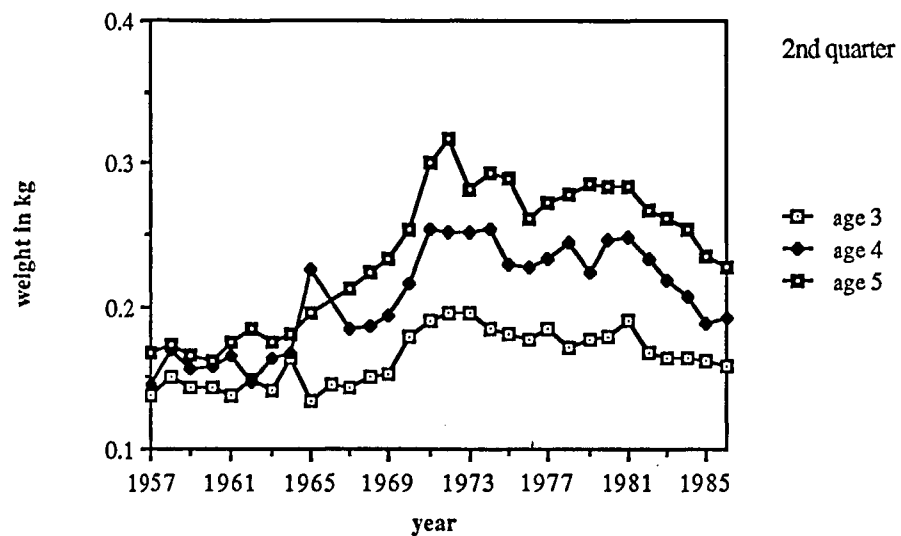


Fig 2b N.S. Sole, weight at age females

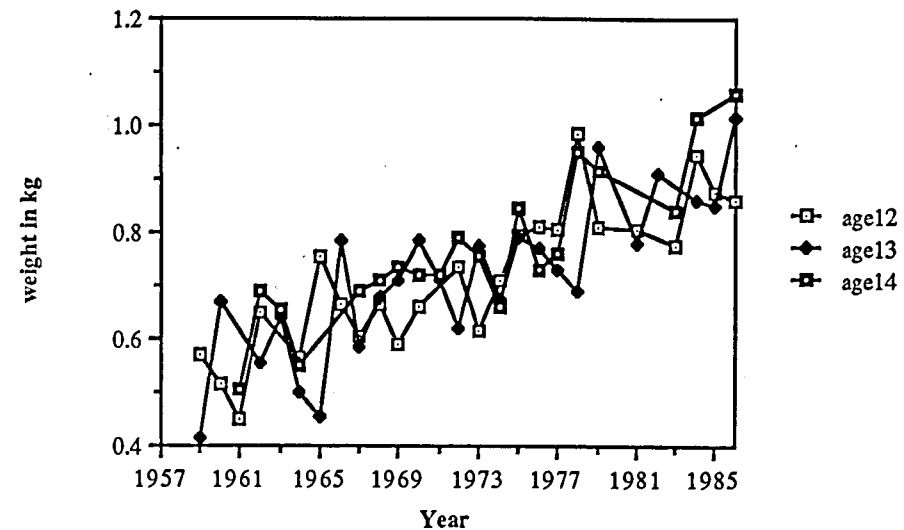
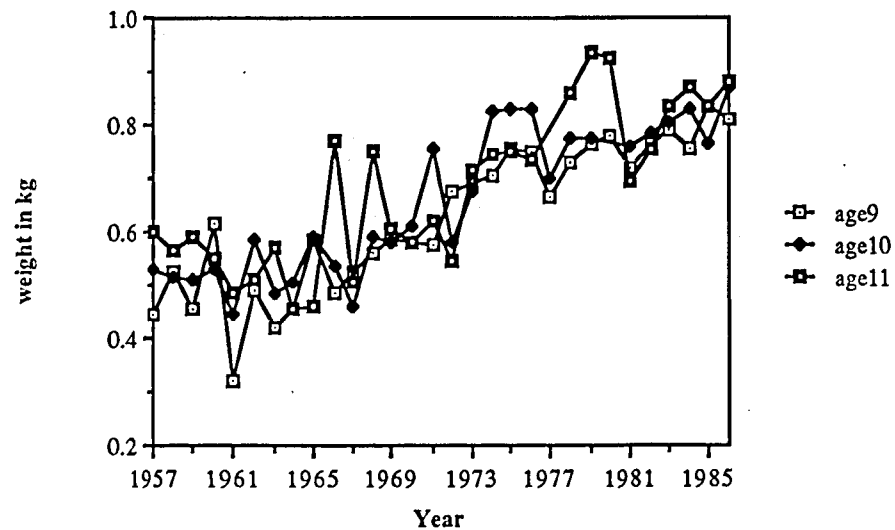
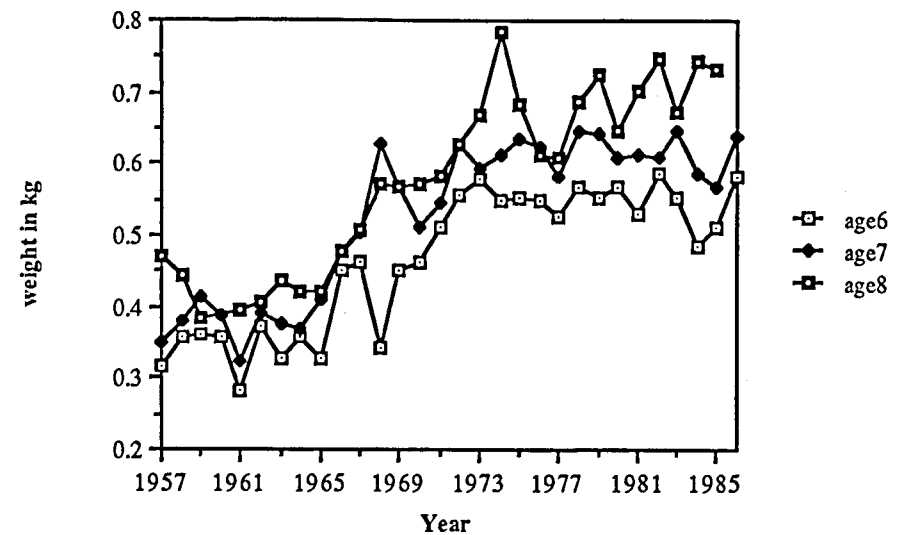
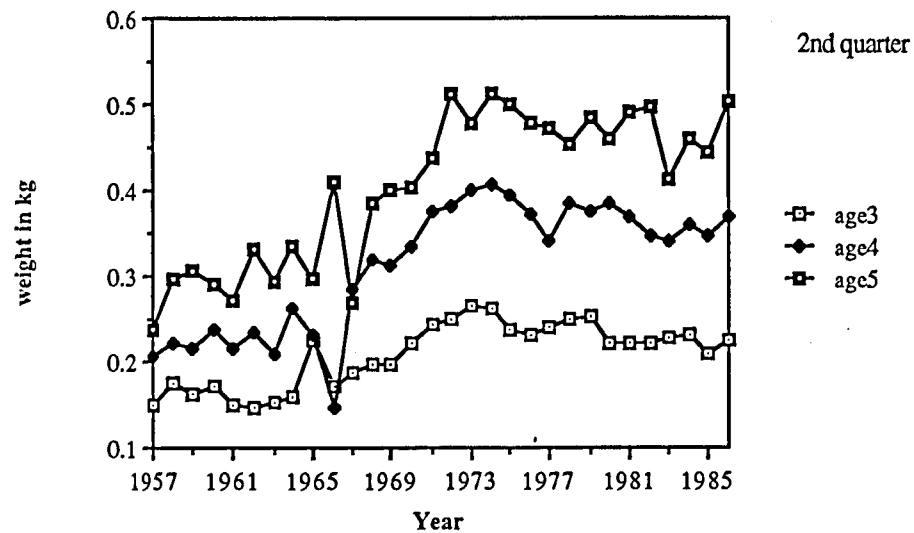
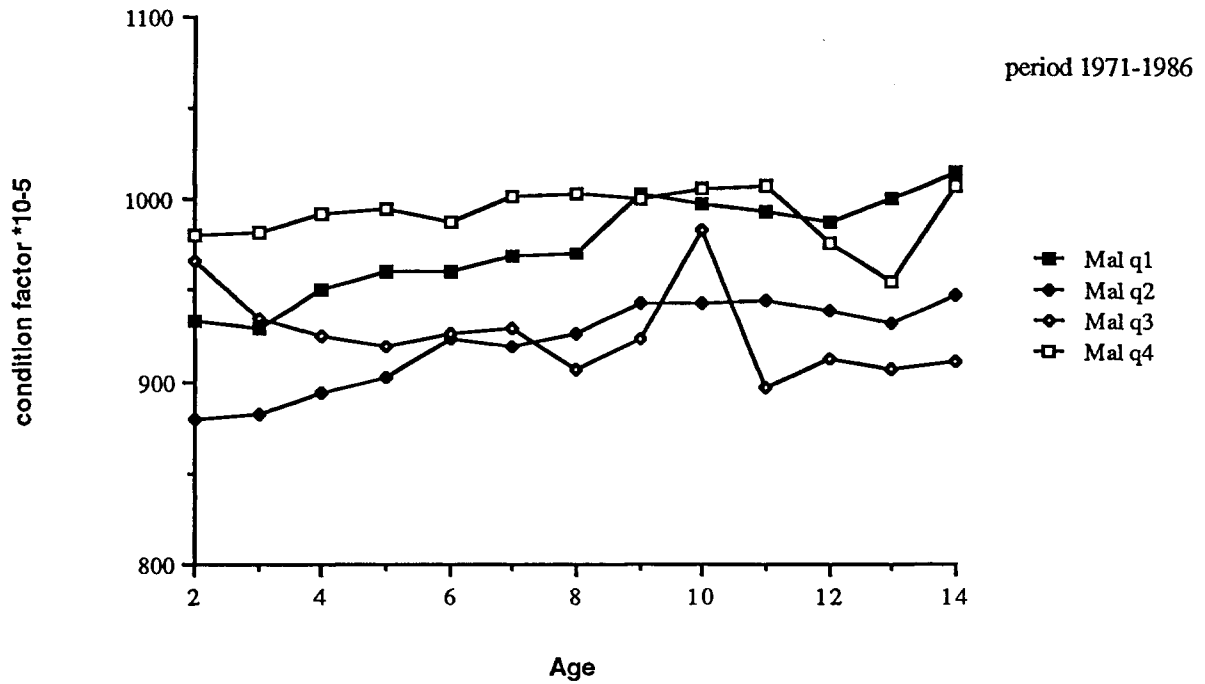


Fig 3 North Sea Sole condtion factor, males



North Sea Sole, females

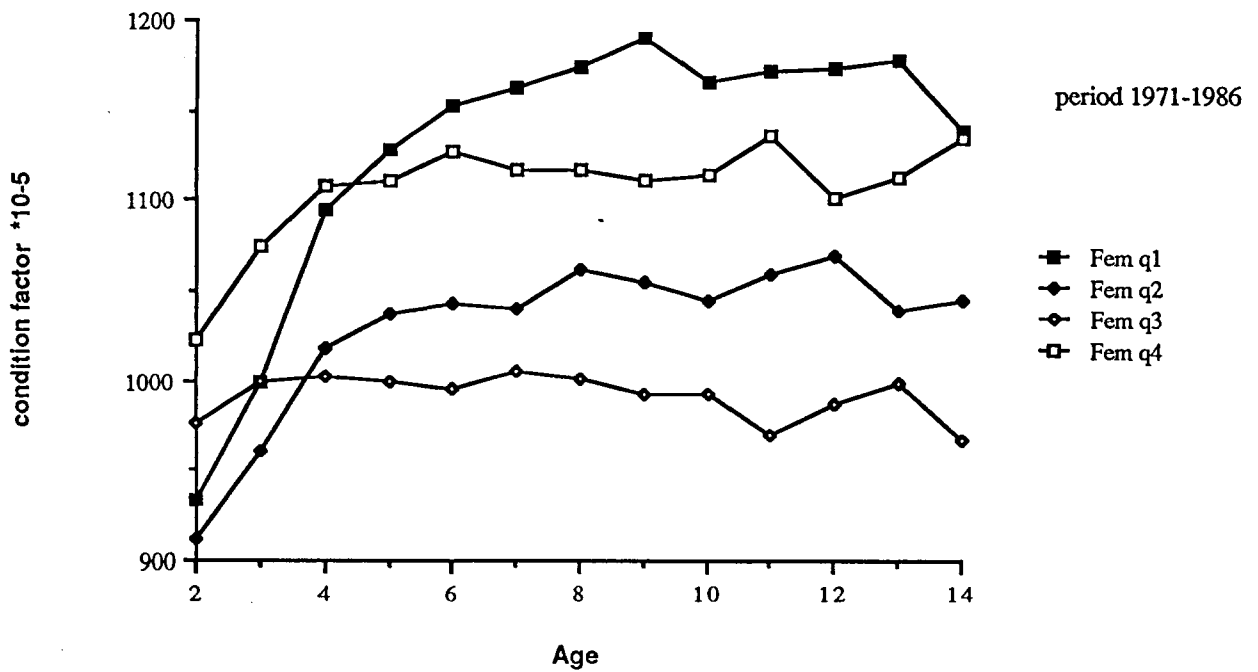


Fig 4 North Sea sole, condition factor

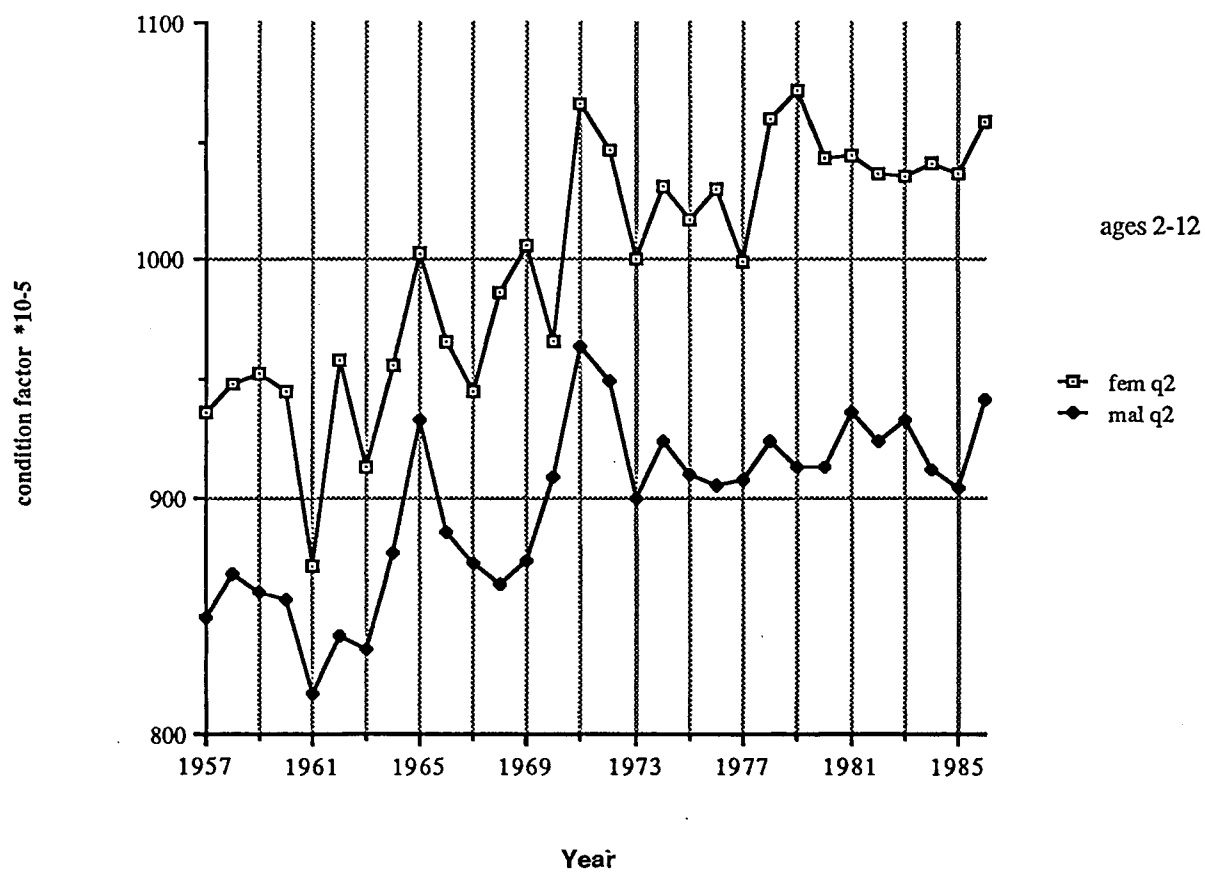


Fig 5 N.S. Sole females, gonad weight

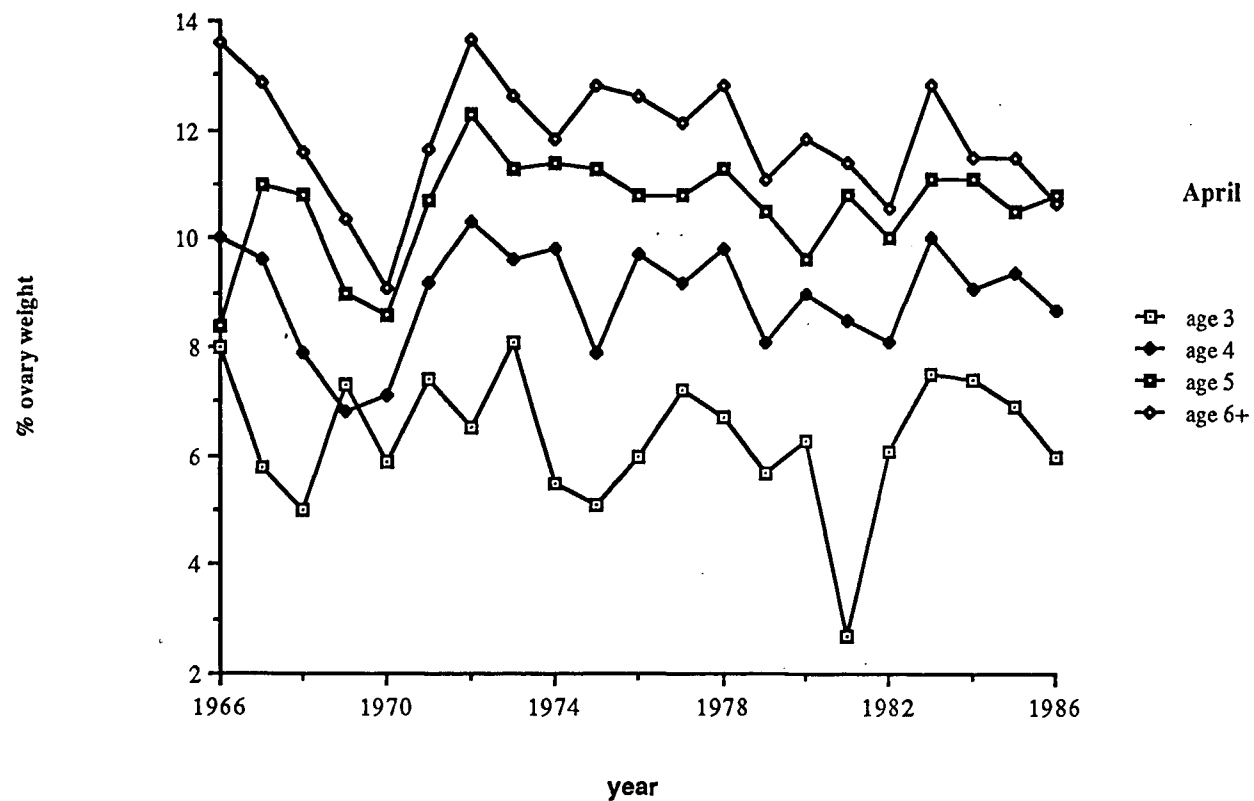


Fig 6 North Sea Sole, females

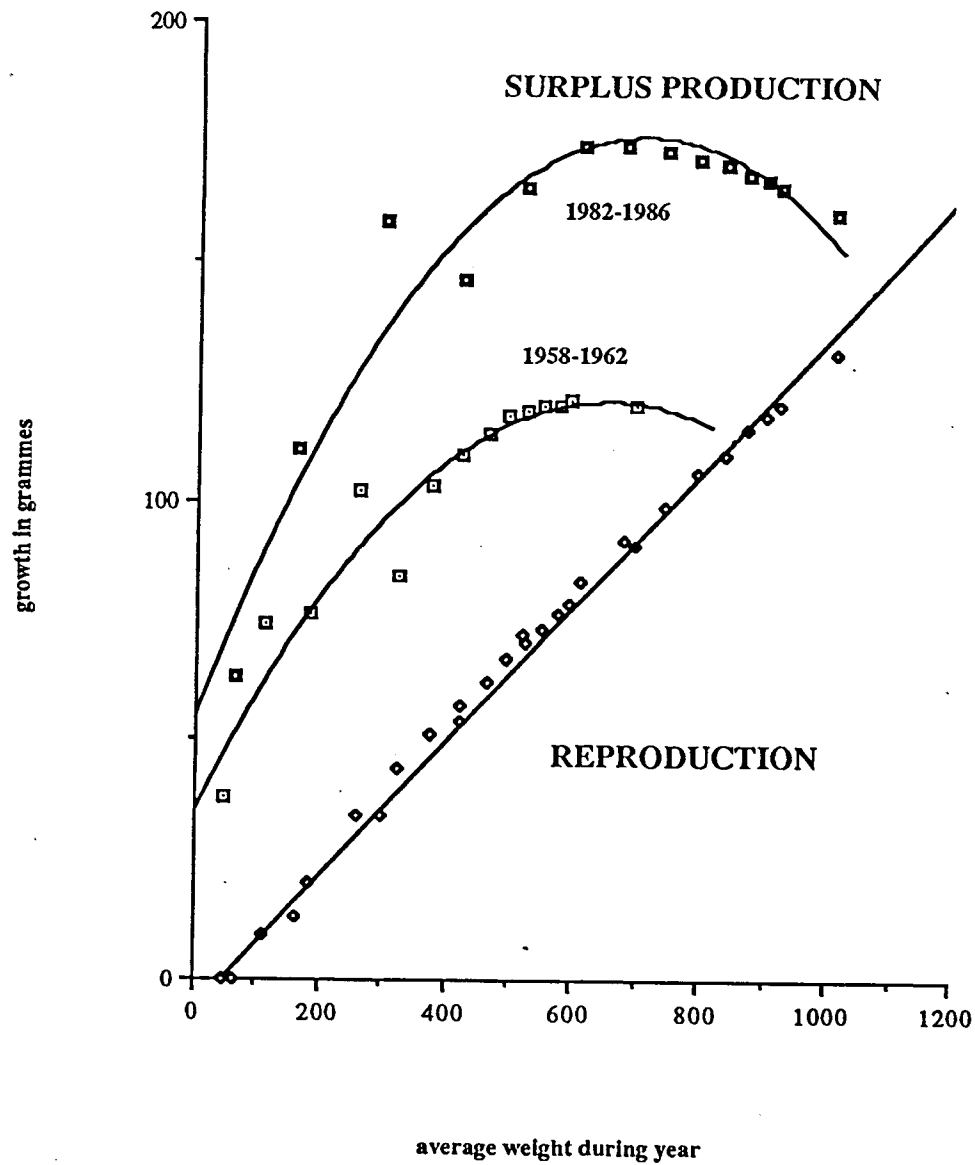
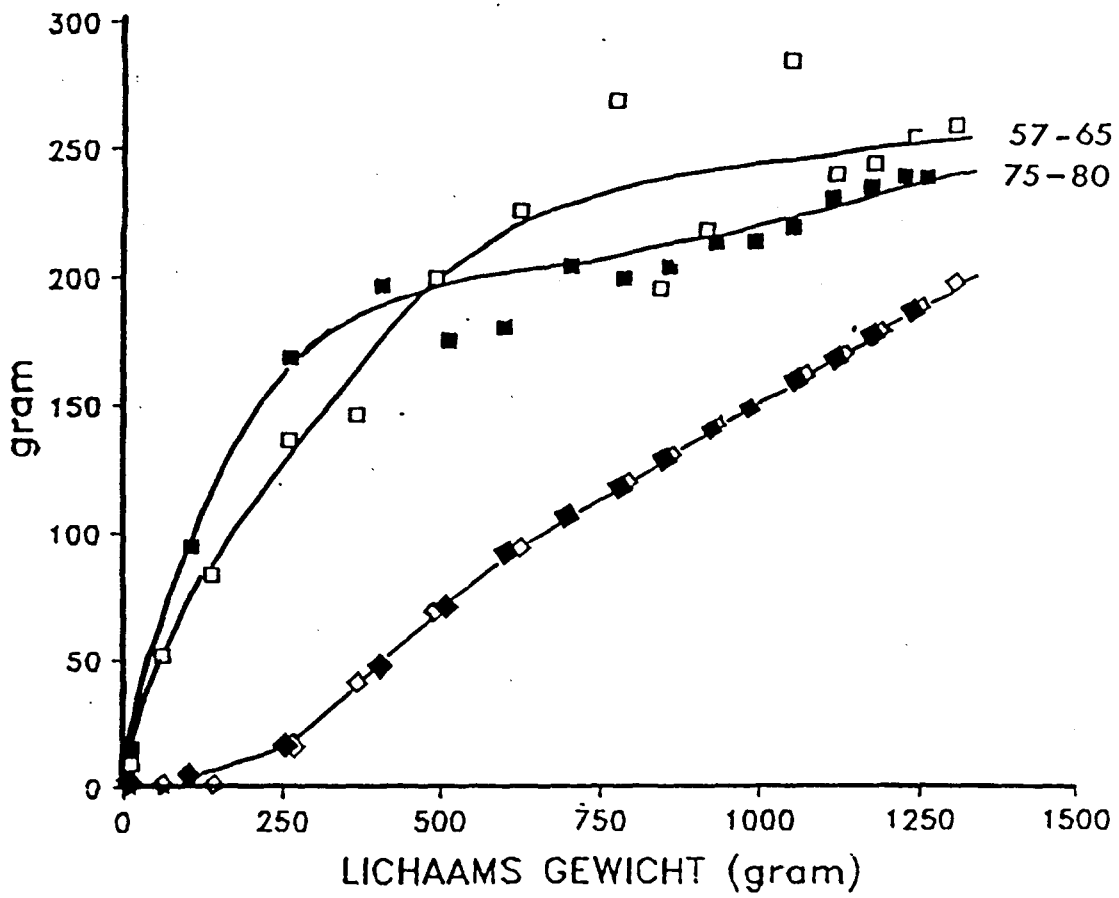


Fig 7 North Sea Plaice, females



Surplus production of North Sea Plaice, from RIJNSDORP & VAN BEEK, 1987