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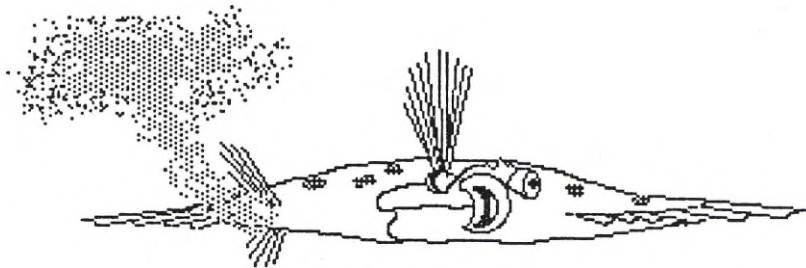




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THE GEOGRAPHICAL DISTRIBUTION, SIZE COMPOSITION AND
MATURITY STAGES OF PLAICE *PLEURONECTES PLATESSA* (L.)
DURING SPAWNING SEASON
IN THE SKAGERRAK
AND KATTEGAT

by
Mats Ulmestrand

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**(DEN GEOGRAFISKA UTBREDNINGEN, STORLEKSSAMMANSÄTTNINGEN
OCH LEKMOGNAD HOS RÖDSPOTTA *PLEURONECTES PLATESSA* (L.)
UNDER LEKPERIODEN I SKAGERRACK
OCH KATTEGATT)**

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SAMMANFATTNING.

Lekbeståndet av rödspotta har drastiskt minskat i Kattegatt under senare år och man antar att detta beror på minskad rekrytering. De senare årens rekrytering av rödspottor till Kattegatt beskrivs huvudsakligen istället komma från Skagerrak.

Sedan 1981 har data insamlats om storlekssammansättningen hos rödspottebestånden i Skagerrak och Kattegatt men eftersom definitionen och omfattningen av de olika rödspottebestånden i området är oklar, utökades provtagningarna inom den internationella bottenräkundersökningen (IBTS) under februari 1990 att även omfatta rödspottornas kön, lekmognad och åldersammansättning.

Resultaten från denna undersökning tyder på att Skagerrak har liten eller ingen betydelse som lekområde för rödspotta och att rekryteringen av rödspotta till Skagerrak och huvuddelen av Kattegatt sannolikt kommer från lekbestånden i Nordsjön.

ABSTRACT.

In the Kattegat the plaice spawning stock biomass has decreased drastically during recent years. It is supposed that the declining spawning stock is caused by decreasing recruitment and that the majority of recruits in the Kattegat originates from the Skagerrak. Data on the size composition of plaice was collected in the Skagerrak and Kattegat during bottom trawl surveys in February 1981 to 1992. Since 1990 the observations also cover the maturity stages and age composition. The results on the female maturity point to the insignificance of the Skagerrak and Kattegat as spawning areas for plaice during 1990-92 and it is suggested that the recruits of plaice in the Skagerrak and the major parts in the Kattegat during the same period are originated from a parental plaice stock in the North Sea.

INTRODUCTION.

The recruitment to a fish stock often shows a great variability between years resulting in a fluctuating size of the fishable stock. The variability in recruitment is generally much higher than the variability in spawning stock biomass and there is seldom found any correlation between spawning stock and recruitment (e.g. Saville and Schnack, 1981; Millner, 1984; Sissenwine, 1984). The relation between spawning stock and following recruitment is yet to be determined. The spawning potential in a stock is, however, an important factor in regulating the total number of egg produced.

The size of the spawning plaice stock in the Kattegat has drastically decreased from about 25000 t in the early 1970s to below 5000 t in recent years due to a decreasing recruitment. In the Skagerrak the spawning stock is fluctuating without trend (Anon., 1991). The plaice population in the Skagerrak and Kattegat area probably consists of overlapping local stocks recruited in the areas but also of plaice from the Belt Sea and probably also from the North Sea as a result of passive migration of eggs and larvae. The different age groups of plaice develop in different geographical areas and it is important to establish a clear definition on the difference between stocks. Simonsen et al. (1988) showed that the plaice in the northern Kattegat had a higher number of fin rays than those in the southern Kattegat. It was suggested that the higher number of fin rays in the northern part was caused by a mixing of Skagerrak and Kattegat plaice. As the Kattegat stock has declined, investigations on meristic characters (Simonsen et al., 1988) indicate that the Skagerrak stock component in the Kattegat has become dominant. The spawning areas for plaice are mentioned in (Anon., 1991) to be situated along the Danish Skagerrak coast and the Kattegat stock spawns in the deeper parts of southern and eastern Kattegat and in the northern Belt Sea. Tagging experiments indicate that there also may be a spawning migration to, and a compensatory drift of plaice larvae from adjacent areas like the North Sea (Molander, 1923; Jakobsson, 1982; Ulmestrand, 1989) and the Belt Sea (Blegvad, 1939). Because of the complex situation of overlapping and mixing of stocks it is not fully understood from which spawning group(s) the majority of recruits to the nursery areas in Skagerrak and Kattegat belong, as the egg and larvae are pelagic during the first two months and possibly transported long distances by the surface currents.

For many years the need for maturity data for the stocks of plaice in the Skagerrak-Kattegat area has been requested by the ICES' Division IIIa demersal stocks Working Group. Since 1990 the maturity stages of plaice have been documented during the International Bottom Trawl Survey (IBTS) performed by Sweden in the Skagerrak and Kattegat. This paper presents data on the composition of length, age and maturity in the plaice in Skagerrak and Kattegat and I also discuss the importance of the Skagerrak and Kattegat as spawning areas in comparison with other possibly contributing stocks.

MATERIAL AND METHODS.

The data on catches of plaice were collected in February during the International Young Fish Survey (IYFS) in 1981-89 and during the International Bottom Trawl Survey (IBTS) in 1990-92 with RV "Argos" (GOV-trawl; 16 mm mesh size, 30 min. duration at 4 knots). For each haul the length distribution of the plaice was recorded to the cm below. Since 1990 the sampling programme has been extended to include examination of sex, age and maturity stage of three fish from each cm group. All ages (otoliths) were read by the same person and the birthday of the plaice was set to 1 January. The maturity stages were visually determined according to the criteria presented in table 1. Plaice in stages 3 and 4 are considered as mature individuals.

Table 1. Maturity stages for males and females (modified from (Rijnsdorp 1989)).

Males:	1.	Immature.	Testis very small.
	2.	Ripening.	Testis bigger and grey.
	3.	Spawning.	Testis white. Milt running under pressure.
	4.	Spent.	Shrunken.
Females:	1.	Immature.	Lumen transparent, grey.
	2.	Ripening.	Colour orange, oocytes visible
	3.	Spawning.	Colour orange and hyaline eggs. Running under pressure.
	4.	Spent.	Ovary flabby and small.

RESULTS.

Spatial distribution in the spawning period.

The density of plaice in numbers per trawling hour (sexes combined) per statistical square in February 1985-1992 for total catch (all sizes) and for plaice ≥ 27 cm are shown in figure 1. In February 1990 and 1992 high densities of undersized plaice (< 27 cm) were found in the hauls from shallow water (about 20 m) in eastern Kattegat. Plaice ≥ 27 cm are of commercial size and are dominating in the deeper areas. In the Norwegian deep the density is generally low.

Connection between the Skagerrak and Kattegat areas.

The correlation between catch rate (number per trawling hour) in Skagerrak and Kattegat for the period 1981 to 1992 shows that there is a close connection ($r^2 = 0,686$) between the areas (fig 2.). Severe conditions of hypoxia occurred in the south eastern Kattegat during autumn 1988 and several thousands of km^2 were affected. This environmental disturbance may have been caused a migration of plaice from that area and that the density was still low during the survey in February 1989. If we exclude the data point from 1989, which deviates from the correlation line, the correlation coefficient (r) increases to 0,92 which suggests a high correlation between Skagerrak and Kattegat plaice density.

Length- and age distribution.

The length composition of plaice (sexes combined) in the catches in February 1981-92 for Skagerrak and Kattegat are shown in figure 3 and the mean length for the same catches and period are shown in figure 4. The mean length in the average catch in Skagerrak and Kattegat shows a significant decrease during the period 1981-92 (Spearman rank coeff. $p=0,0092$ and $p=0,0046$ for Skagerrak and Kattegat respectively). The age composition in the catches is only determined for 1990-92 and shows no change in mean length per age group between the years 1990-92 which indicates that the decrease in mean length during this period (1991-92) is caused by a larger amount of younger age groups. During the period 1981-89 age data is lacking and it is not possible to determine whether there has been a decrease in growth or the stock has recruited a larger amount of younger age groups. The mean length dropped drastically in the

Kattegat between 1989 to 1990. The percental distribution of age classes for males and females in the catches during February 1990-91 shows that the males are dominated by 3 years old while the females are dominated by 4 years old individuals.

Sexual maturity.

The geographical distribution of percental proportion mature individuals per square is presented for February 1990-92 in fig. 5 for males and fig. 6 for females. Southern Kattegat shows the highest proportion of mature individuals in the catches for both males and females. This is most obvious for the females where up to 100% of the number analysed per square in 1991 were mature (fig 6). In the Skagerrak on the other hand the proportion of mature females is generally below 10% and in 1992 none of the analyzed females in the Skagerrak were mature. The occurrence of mature males shows a more random distribution in the whole Skagerrak and Kattegat area. During 1992 the proportion of mature males was much lower than in 1990 and 1991.

There was no difference in size of onset of sexual maturity between Skagerrak and Kattegat. Figure 8 shows that the males become mature at a smaller length and at an earlier age (fig. 7) than the females. The length at 50 % maturity (L_{50}) was about 40 cm for females and 35 cm for males in Skagerrak and Kattegat combined. In fig 9 the percentage maturity stage per age class 2 to 6+ is presented for males and females in the Skagerrak, Kattegat and areas combined. The Skagerrak females are dominated by immature or ripening fish for all age groups 2 to 6+ and the proportion of mature individuals is very small. In the Kattegat, female maturity increases with age and age group 5 has about 50% maturity.

DISCUSSION.

The spawning areas and nursery grounds for plaice are geographically separated. The majority of young stages (0-group) develop during their first year in estuaries and the very shallow coastal areas (Veer et al., 1990). As 1-group they begin to migrate to deeper coastal water (fishing grounds) and during the third year they appear more frequently on the fishing grounds. The mean size of plaice in Skagerrak-Kattegat trawl catches increases with increasing depth (Molander, 1944; Ulmestrand, 1990). As the trawl stations in the survey comprise the deeper (>20m) parts in Skagerrak and Kattegat, the length distribution presented in this paper shows only the larger length sizes of the total population. Bagge and Nielsen (1987) found that the yearly growth increment had a significantly decreasing trend in the Kattegat plaice during 1971 to 1985. As the Kattegat plaice is supposed to contain a Belt Sea component, a local Kattegat component and a Skagerrak component (Nielsen and Bagge, 1985), the observed change in growth could be explained by variations in the proportions of mixed components and especially the decreasing Belt Sea stock component (Anon., 1990) that is observed in the Kattegat. The change in growth could also be connected with the increasing duration and

numbers of periods with oxygen deficiency in the southern Kattegat bottom water during autumn (Engström and Fonselius, 1989). This investigation has shown a decrease in total length composition (sexes combined) of plaice during 1981 to 1992 and an increased amount of younger age groups in the catches from 1990 to 1992. No decrease in mean length at age was observed during the years of age data (1990-92). The increased amount of younger age groups probably results in a larger proportion of first time spawners (recruit spawners) in relation to repeat spawners. The smaller mean size in the Kattegat as compared to that in the Skagerrak during February 1992 is caused by a much larger amount of 2 year old fish in the Kattegat. The lesser mean depth in the Kattegat (23m) may be one reason for this region to have a higher importance as a nursery area in comparison with the Skagerrak.

The present results show that about 50% of the 2 year old males are mature and are probably recruit spawners. According to Rijnsdorp et al. (1991) a larger amount of recruit spawners may cause a higher reproductive variability than the density dependent variations in the absolute number of eggs produced. This means that in spite of a large amount of mature 2 year old plaice, the success in recruitment may have decreased because the number of spawning age groups are few resulting in deterioration in quality of the eggs. The size of a spawning stock is generally not correlated to the recruitment and the variability in recruitment is generally much higher than the variability in spawning stock biomass. If the reproductive success is lower for recruit spawners than for older fish, the increased amount of recruit spawners in the Kattegat, together with the declining Belt Sea component, may have caused the falling recruitment in the Kattegat. As the Kattegat stock has declined the major part of the recruitment of Kattegat is coming from the Skagerrak stock which spawns in the Skagerrak along the Danish coast (Anon., 1991). The present results showing small amount of mature females indicates that the Skagerrak has little or no importance as spawning area, even along the Danish Skagerrak coast, and that mature females remain in the southern Kattegat for spawning. As the density of plaice in this area generally is lower than in other parts of Kattegat and Skagerrak, there is probably not an active migration to this spawning area. In the Skagerrak the mature females seem to migrate from the investigated area at time of sexual maturity. The existence of old but immature females in the Skagerrak indicate that they may return again after spawning somewhere outside the area. The increase in per cent maturity for the males at about 20 cm length may indicate that some males start spawning one year earlier than the majority but it can also be a result of mixing of different stocks with different growth and length at first maturity.

The results from tagging experiments of juvenile plaice in the Skagerrak suggests a stationary behaviour until onset of sexual maturity when a westerly migration of adult plaice takes place to the western Skagerrak and the North Sea (Molander, 1923; Jakobsson, 1982; Ulmestrand, unpubl.). Recent larval investigations (P-O. Larsson, pers. comm.) has shown a transport of gadoid larvae and eggs from the North Sea through the central Skagerrak towards the Swedish west coast where it splits into components; one going north to the Skagerrak, the other going

south in the Kattegat. It seems probable that the transport of plaice larvae is similar.

The conclusions drawn from these considerations point to the insignificance of the Skagerrak and Kattegat as spawning areas for plaice during 1990-92 and that the recruits of plaice in the Skagerrak and the major parts in the Kattegat during the same period are originated from a parental plaice stock in the North Sea.

ACKNOWLEDGEMENT.

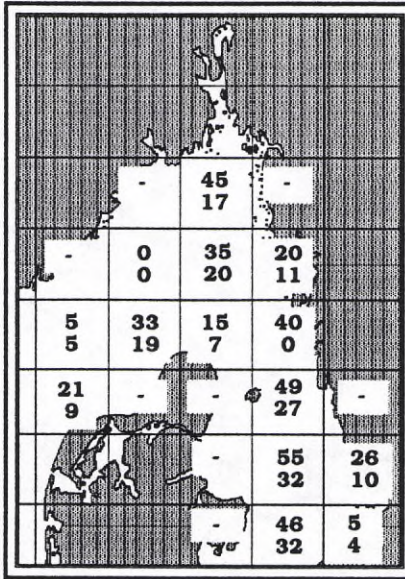
I gratefully thank Barbara Johnsson who has read the otholiths and established the ages of the plaice. Financial support was given by the Sven and Brita Rahmns foundation and the Institute of Marine Research in Lysekil.

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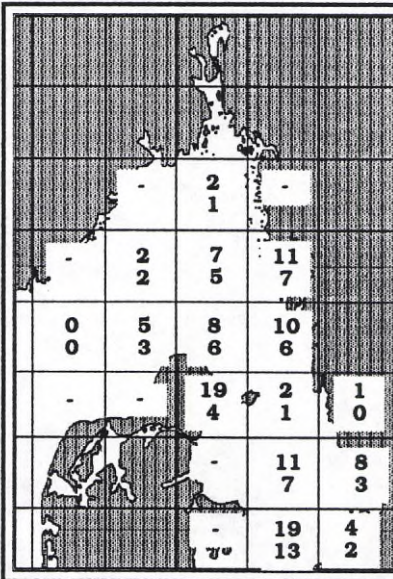
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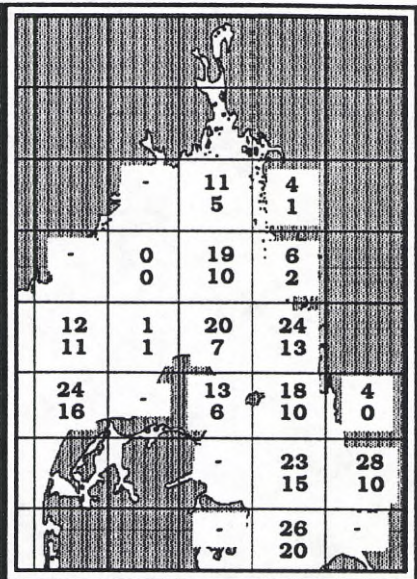
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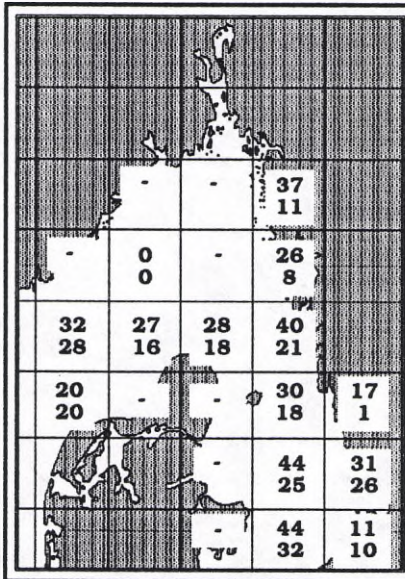
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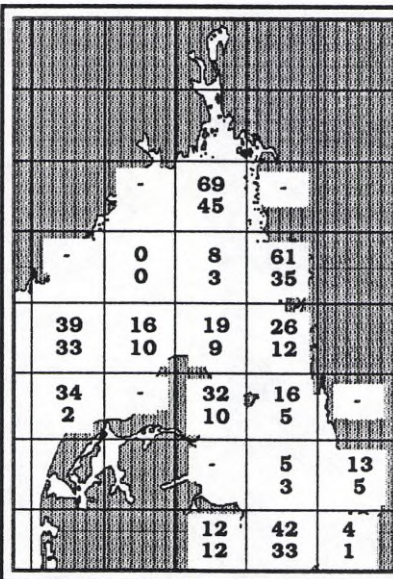
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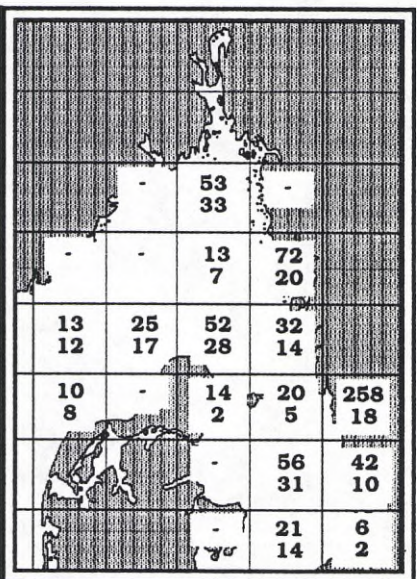
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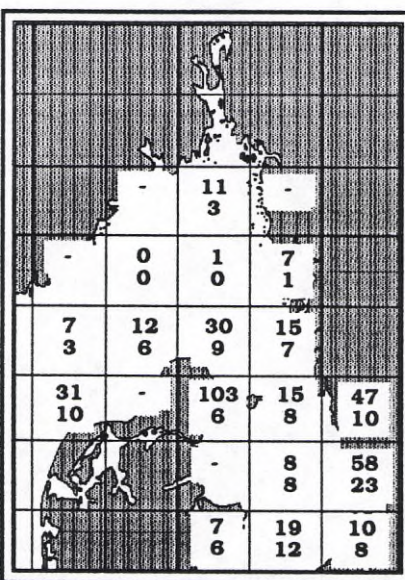
1989



1990



1991



1992

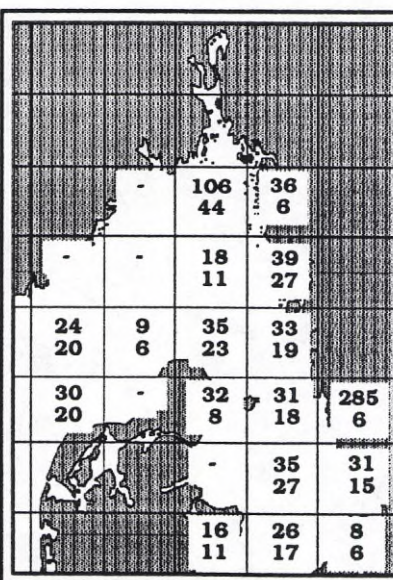


Figure 1. Catch in number per trawling hour for total catch (upper figure) and plaice ≥ 27 cm (lower figure) per statistical square during February 1985-92.

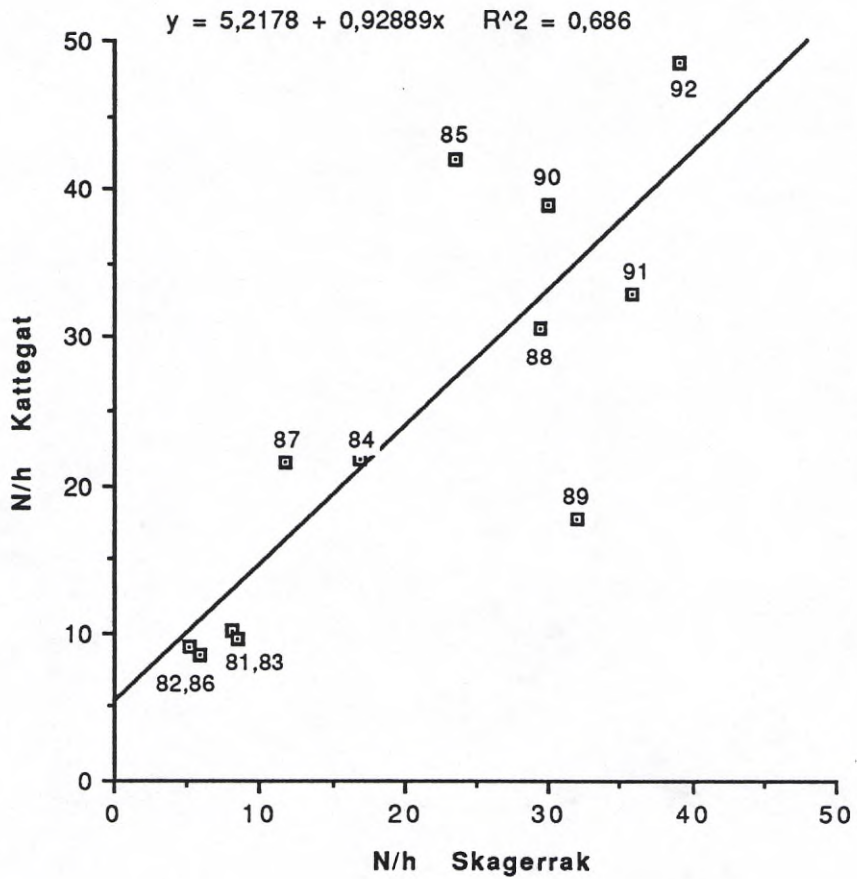


Figure 2.
 Correlation of catch of plaice per unit of effort (N/h) between Skagerrak and Kattegat during February for the years 1981-92.

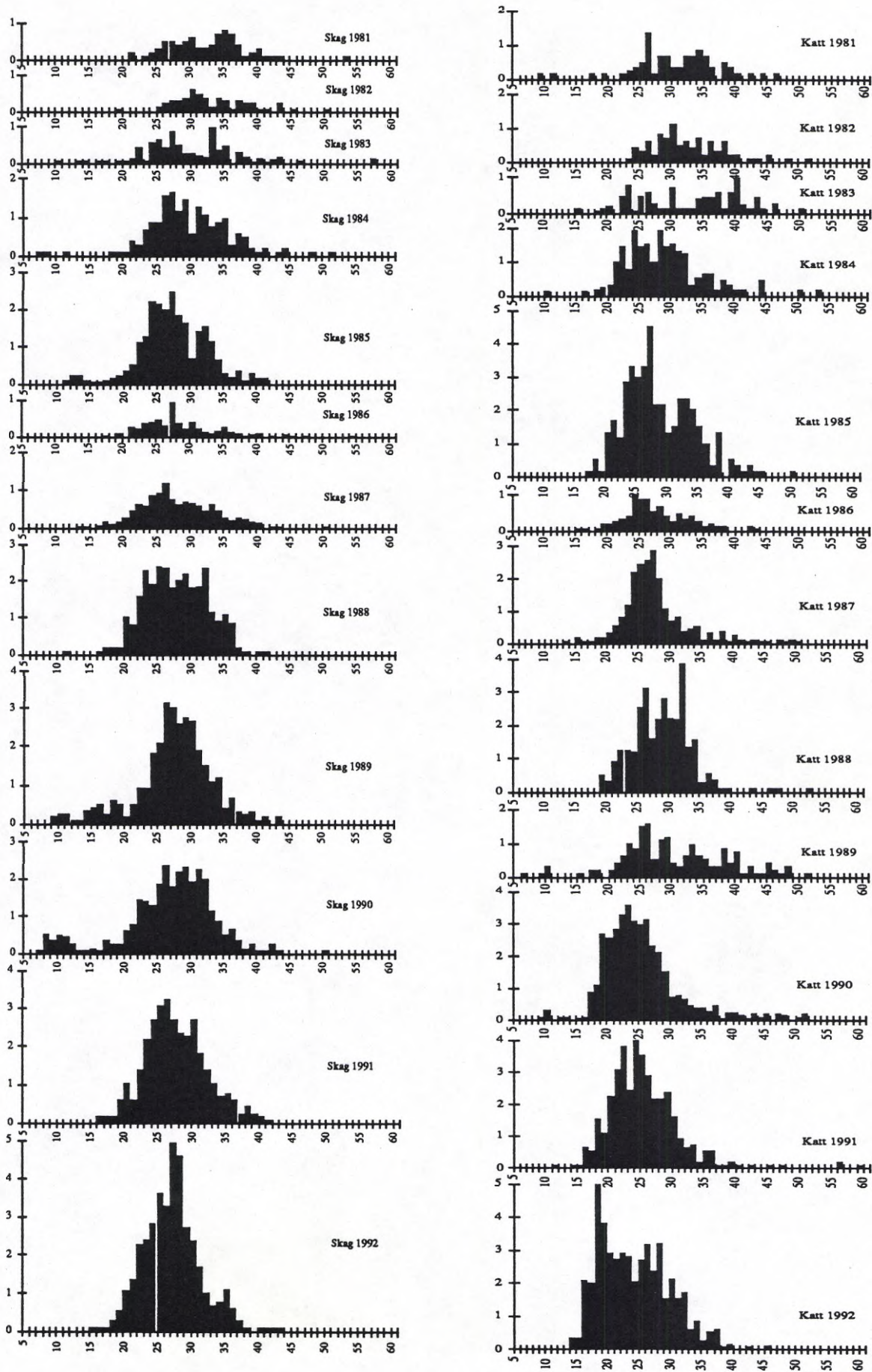


Figure 3. Length distribution of plaice in catches from the Skagerrak (left) and the Kattegat (right) during February 1981-92.

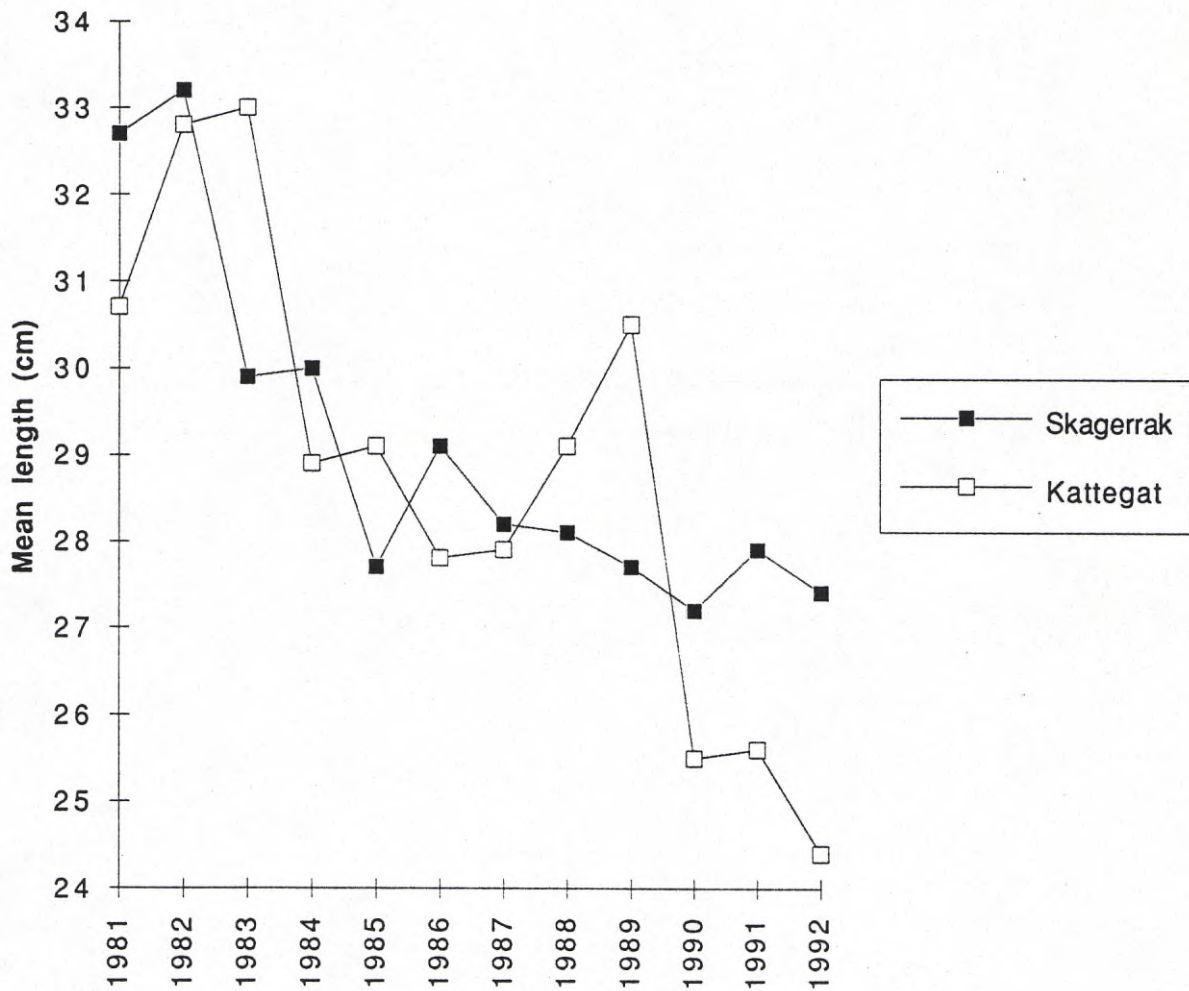
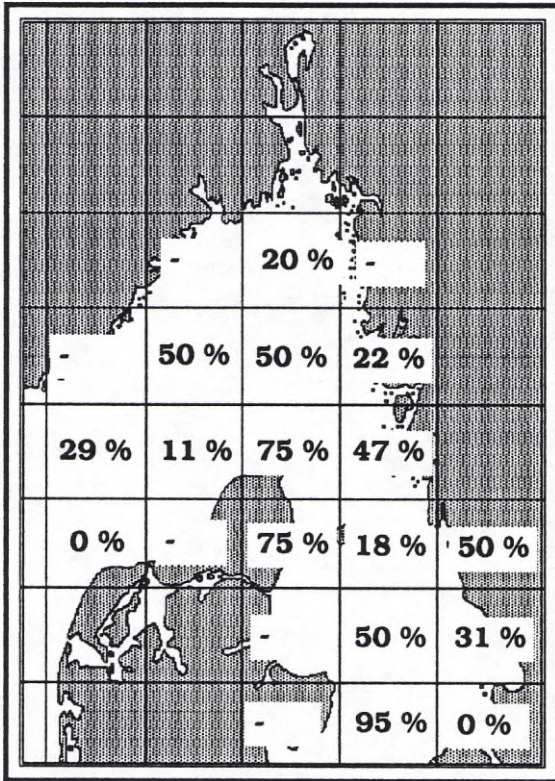
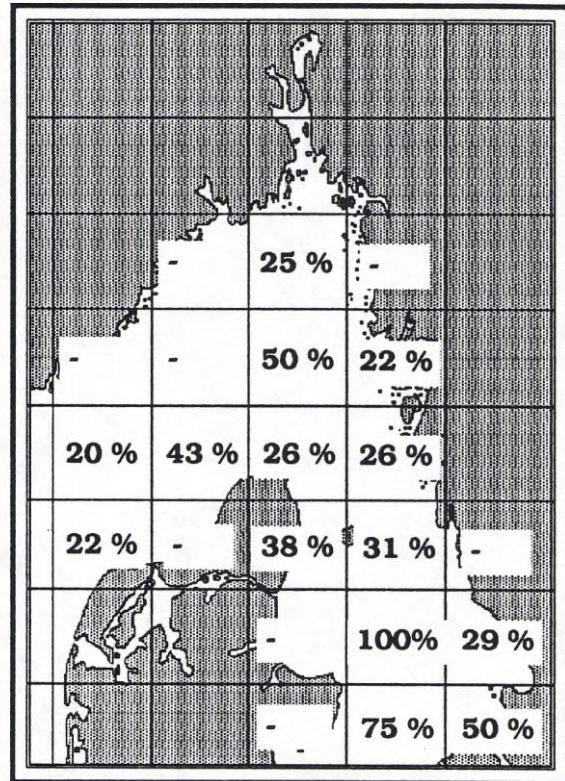


Figure 4. Mean length in plaice catches from Skagerrak and Kattegat during February 1981-92.

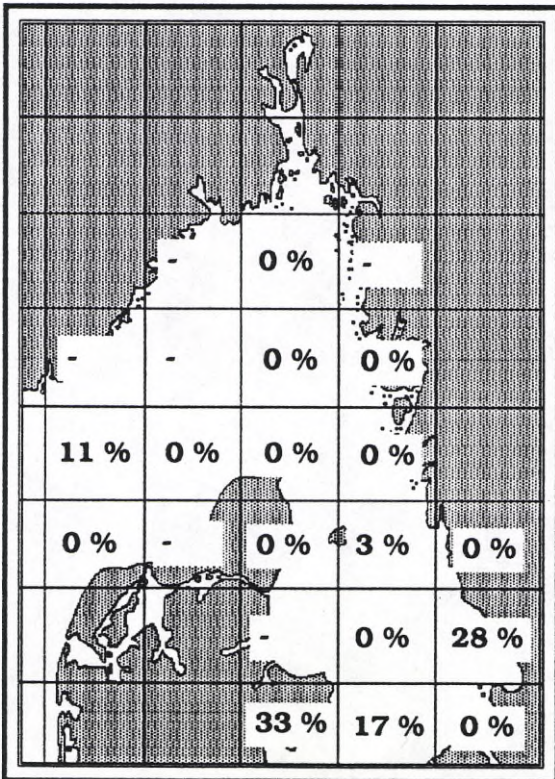
1990, Males



1991, Males



1992, Males



1990-92, Males

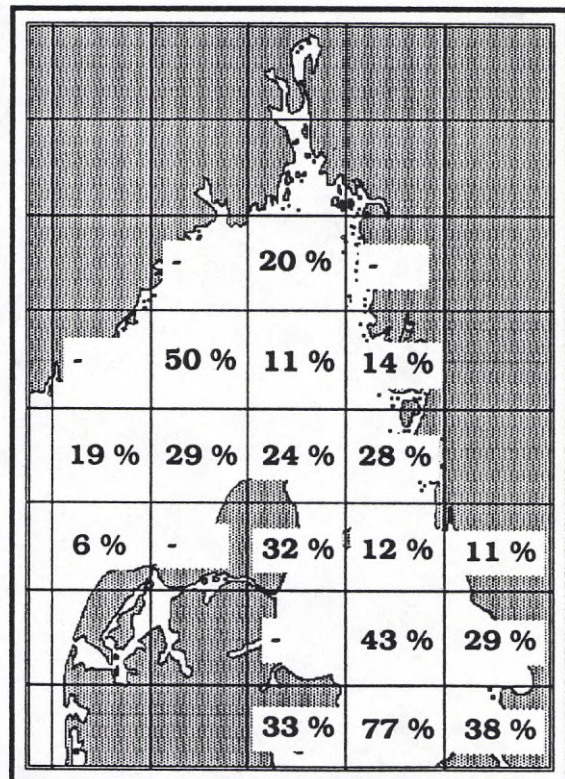
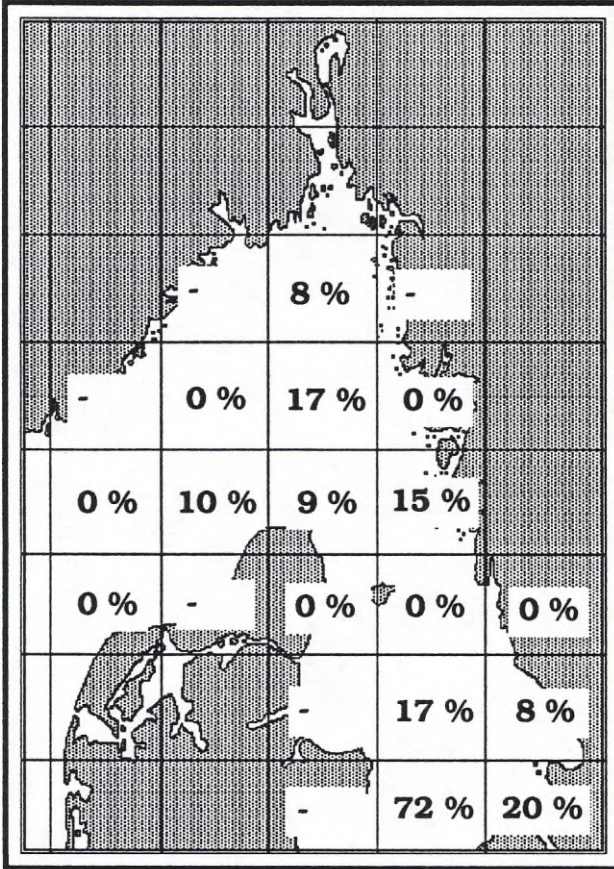
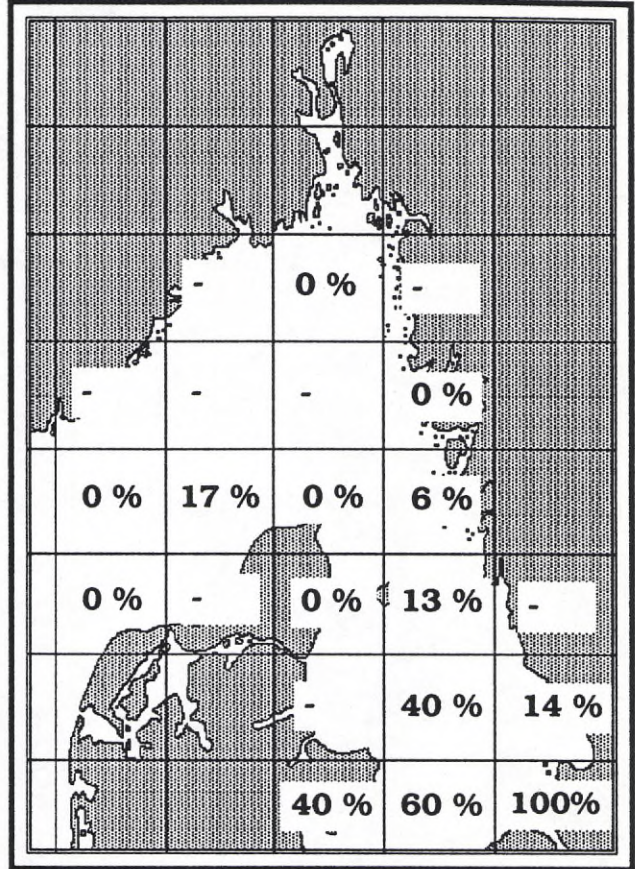


Figure 5. Proportion mature males per statistical square during February 1990, 1991, 1992 and 1990-92.

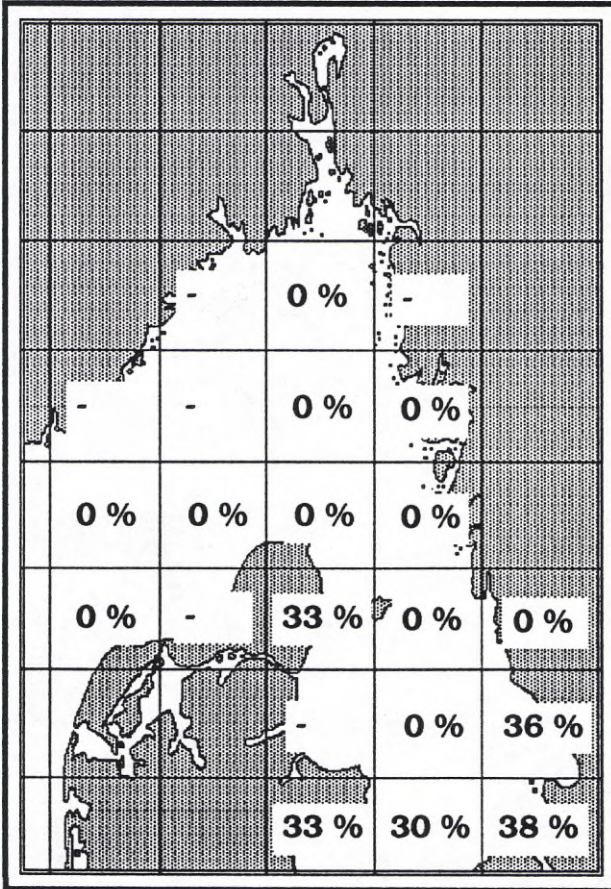
1990, Females



1991, Females



1992, Females



1990-92, Females

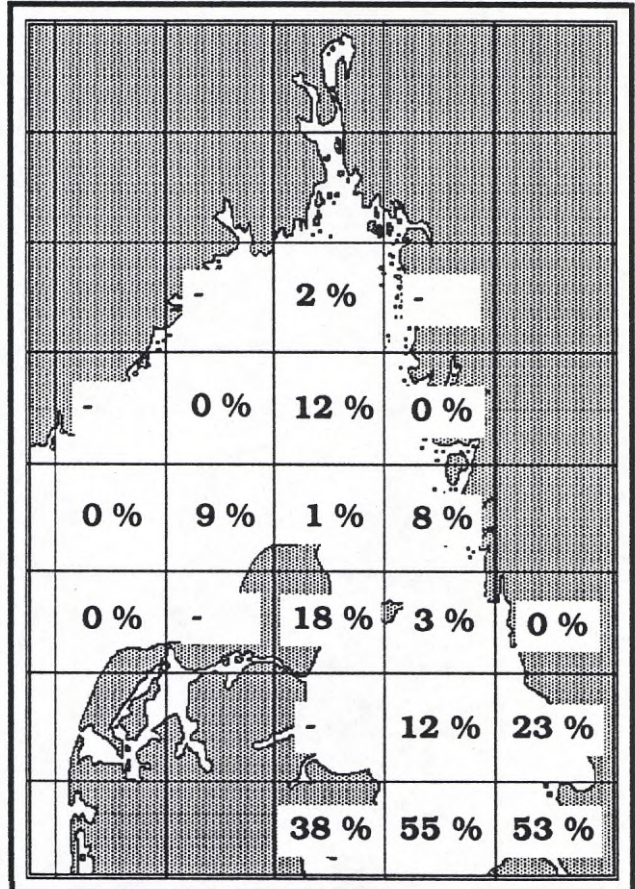


Figure 6. Proportion mature females per statistical square during February 1990, 1991, 1992 and 1990-92.

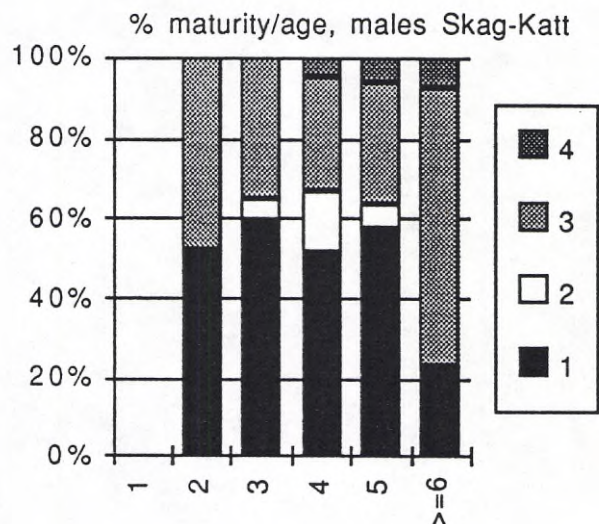
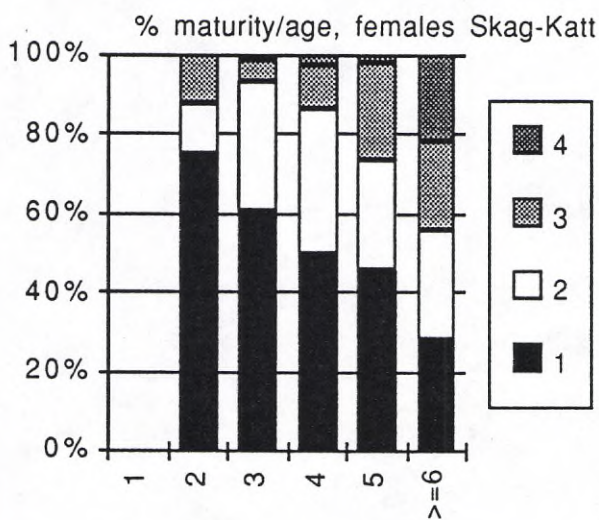
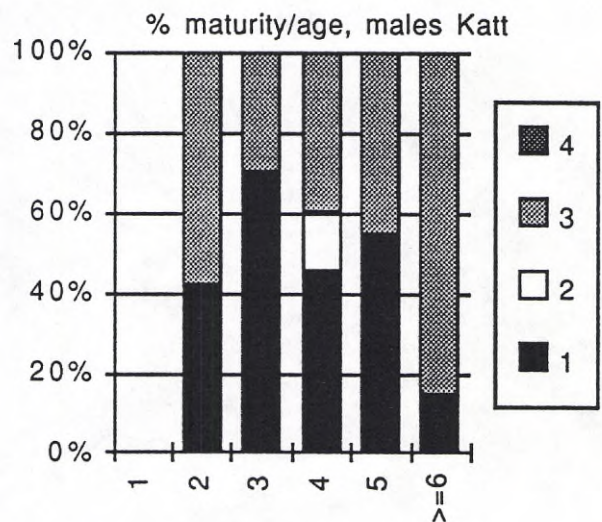
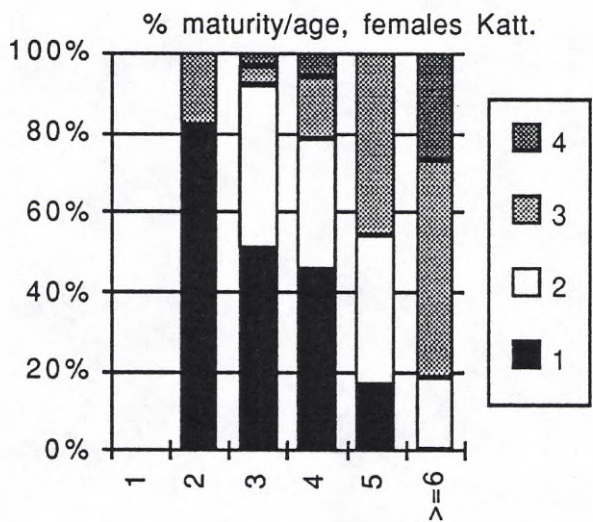
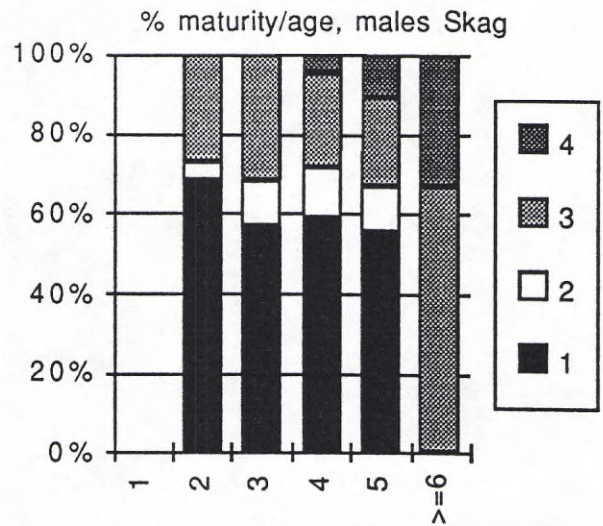
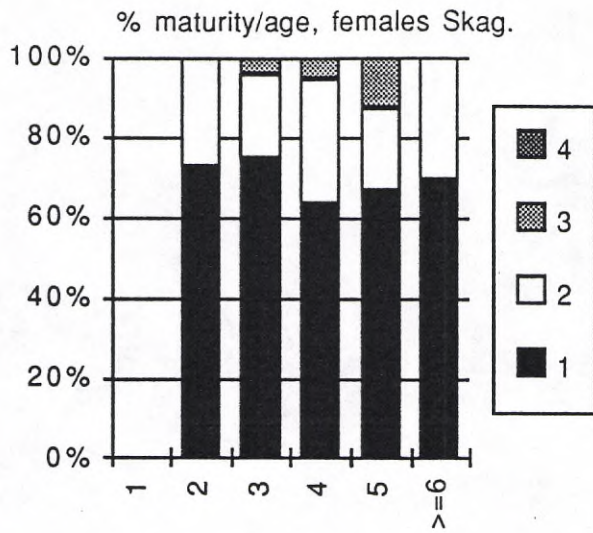


Figure 7. Percentage maturity during February 1990-92 in relation to age group for females (left) and males (right) in the Skagerrak, Kattegat and areas combined.

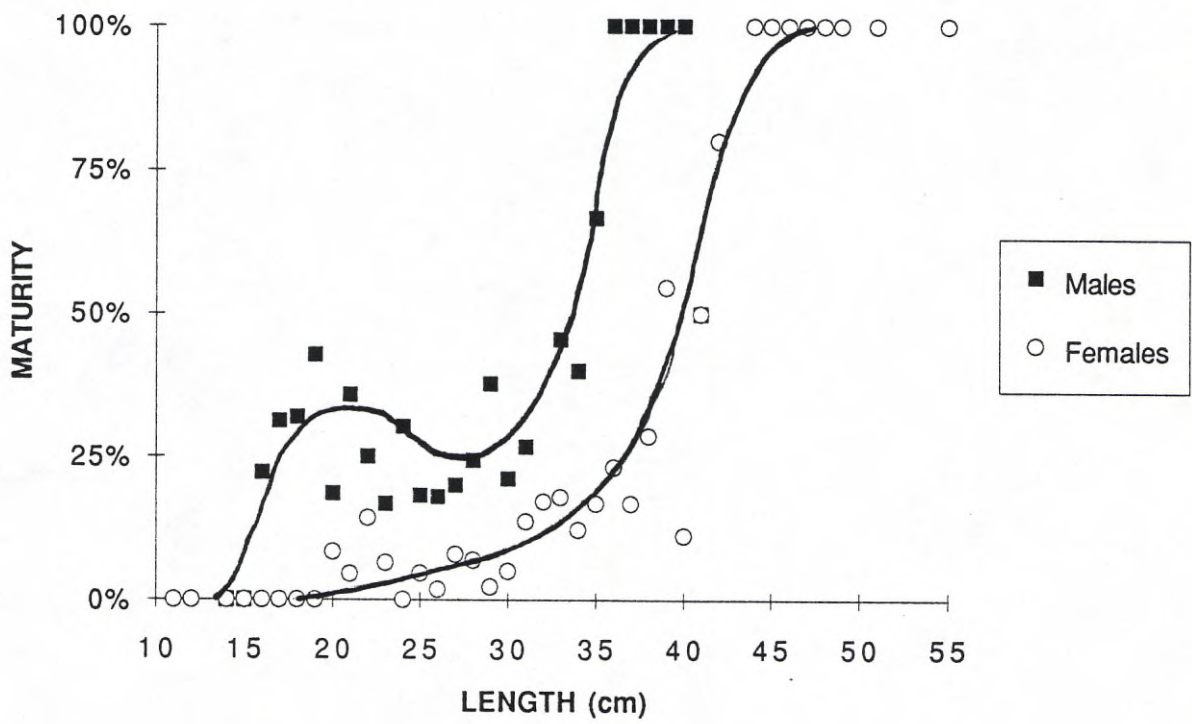


Figure 8. Percentage of mature plaice in relation to length in male and female during February 1990-92. Lines drawn by eye.

