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ORIGIN, MIGRATION AND SPAWNING OF SOUTHERN NORTH SEA MACKEREL WITH RESPECT TO THE OVERSPILL OF WESTERN MACKEREL TO THE NORTH SEA STOCK

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Summary

Southern North Sea mackerel (Scomber scombrus L.) seems to be offspring of the Western stock and not of the North Sea stock. This conclusion is based on age composition comparisons, tagging experiments, the presence of the parasite Grillotia (Cestoda) and the low infestation by Anisakis (Nematoda) in these mackerel. The southern North Sea mackerel follows each year the same migration routes from western overwintering areas through the southern North Sea to the central North Sea without feeding in the northern North Sea as distinct from the North Sea and Western Mackerel.

The following hypothesis was formulated: The southern North Sea mackerel are spawning in the central North Sea together with the North Sea Mackerel. Offspring of the eggs, spawned by southern North Sea mackerel, will probably recruit to the North Sea Mackerel stock and not to the southern North Sea mackerel, which are getting recruits from the western areas.

The very low recruitment and fishery caused a fast decrease of the North Sea stock. However, the overspill of recruits from the Western stock to the North Sea stock, via the southern North Sea, will act as a natural buffer against a total collapse of the North Sea Mackerel stock.

Introduction

Mackerel (Scomber scombrus L.) from the Northeast Atlantic north of 43° N, belong to two stocks: a North Sea stock inhabiting ICES Divisions IVa, IVb, IVc, IIIa, IIa and the northern part of

VIa, and a Western stock ranging over ICES Sub-areas VII and VIII and over ICES Divisions VIa, IVa and IIa. The two stocks mix in the northern North Sea during the summer feeding season and in recent years also during the overwintering period in ICES Divisions IIa, IVa and VIa. The spawning areas are completely separated.

The spawning biomass of the Western Mackerel stock was decreased in recent years (to 1.8 million tonnes in 1984), but it is still 12 times larger than the spawning biomass of the North Sea stock (160 thousand tonnes in 1984). The latter has been producing low recruitment for many years and often recruitment was even too low to compensate losses by natural mortality (Anon., 1985). A total collapse of the North Sea Mackerel stock seems inevitable unless a good year class appears in the near future. The causes of the decline are uncertain, but environmental changes might be responsible for the downward trend. It has been recommended to stop fishing on North Sea Mackerel (Anon., 1985), but this advice is hard to implement because of the mixing with the Western Mackerel. The Western Mackerel distribution has been shifted in recent years to northern areas, where both stocks mix for a prolonged period of time (Anon., 1986). During the feeding season the adult fish of both stocks remain in the northern North Sea, while during the last two winters (1984/85 and 1985/86) the adult Western Mackerel was overwintering in Division VIa north and Division IVa. Thus the adult fish of both stocks remain in the northern areas for about 8 months. Closure of these northern areas for the fishery would protect the North Sea Mackerel, but would also adversely affect the fishery on Western Mackerel.

The small quantities of mackerel caught in the southern North Sea have always been allocated to the North Sea stock for the purpose of assessment, but tagging data indicated that the southern North Sea mackerel could be part of the Western stock (Anon., 1981). From a study on parasites (Grillotia), MacKenzie and Mehl (1984) concluded that the mackerel population of the southern North Sea may originate from the western nursery areas.

The origin, migration and spawning of the southern North Sea mackerel is investigated in this paper by a comparison of age compositions, parasites studies, tagging, maturity studies, L1 studies and mean length at age comparisons. Two species of parasites (biological tags) of mackerel have been investigated:

<u>Grillotia angeli</u> (Cestode) : infects the 1- and 2-year old mackerel (second intermediate host) during the juvenile period. This parasite occurs to the southwest of Britain; its distribution is determined largely by the distribution of the definitive host - the monkfish (MacKenzie, 1981; MacKenzie, Smith and Williams, 1984). The first intermediate host is unknown. This parasite may be used as an indication of the area where mackerel have spent their juvenile period: mackerel that have grown up to the southwest of Britain carry the parasite, whereas mackerel originating from the central and northeren North Sea are not infected (MacKenzie, 1981; MacKenzie and Mehl, 1984).

<u>Anisakis simplex</u> (Nematode) : infects the mackerel (second intermediate host) during the feeding period, when they are eating Euphausids (first intermediate hosts) (Smith, 1971). This parasite indicates whether the mackerel migrates to feeding areas with a high percentage of infected Euphausids. The main final host of Anisakis are Cetaceans (van Banning, 1978).

This study on the origin and migration has been made especially to investigate a possible overspill of Western Mackerel through the southern North Sea to the North Sea Mackerel stock. Such an overspill could maintain a certain egg production in the central North Sea from which the North Sea stock might eventually recover.

Material and Methods

An analysis of the maturity stages of mackerel in ICES Division IVc has been carried out by estimating the maturity stage composition in percentages in April, May and June in 1977-1985 from the Dutch market sampling programme (table I). The maturity stages used are described in Eltink (1984).

The age compositions of the North Sea and the Western Mackerel stock by year were obtained from Virtual Population Analysis (VPA) (Anon., 1985), while the age compostions of the southern North Sea mackerel were obtained from the Dutch market sampling programme. Number of otoliths read are given in table II.

Investigations on the parasites Grillotia and Anisakis have been carried out on mackerel samples from catches taken in 1982-1984. Mackerel examined for Grillotia were sampled from catches in the southern North Sea (ICES Division IVc n= 157) and in ICES Division IVb close to the Dutch coast (n=95). Mackerel examined for Anisakis were sampled from catches in the southern North Sea (ICES Division IVc n=331), from catches in the northern North Sea (ICES Division IVa n=244) and from catches in the western areas (ICES Sub-area VII: n= 825) as shown in table III. From the fish samples in 1982 and 1983, the number of Anisakis and Grillotia parasites in mackerel were estimated by examining the intestines. In 1984 only the number of Anisakis were estimated by the peptic digestion method (Roskam, 1966), which can not be used for Grillotia. The number of fish examined, the prevalence (percentage of fish infected) and the abundance (total number of Anisakis found divided by the total number of examined fish) have been estimated by age group. In order to normalize the distribution a log-tranformation has been applied to the number of Anisakis per mackerel: $100 * \log(N + 1)$
The mean and the standard deviation have been calculated from the log-transformed data (table III). The 95% confidence limits of the abundance by age group were set at two times the standard error of the mean (figure 2).

The mean length at age in the second quarter in 1979-1984 was estimated from the Dutch market sampling programme for ICES

Division VIIj (spawning area of the Western Mackerel), for Division IVc, and for Division IVa (east of 0°W) + IVb.

Results

The maturity stages of the southern North Sea mackerel in April, May and June indicate that these fish are maturing and that spawning is in process, or will commence soon (table I). The most frequent maturity stage is 4 in April, 5 in May and 6 in June. But even in June at peak spawning time in the North Sea the percentage of maturity stage 6 mackerel is still low (36%).

Age compositions of the North Sea and Western Mackerel stock are shown in table II and figure 1 together with the age compositions of the southern North Sea mackerel. Year class 1969 is very dominant in the North Sea stock, but is of average strength for the Western stock and for the southern North Sea mackerel.

The prevalence of Grillotia in mackerel from the southern North Sea was 2.5% (4/157) and in mackerel from the IVb along the Dutch coast 5.3% (5/95). For both areas combined 3.6% (9/252). The occurence of Grillotia indicates that these fish are from western nurseries to the southwest of Britain.

The lowest prevalence and abundance of Anisakis in mackerel is found in the southern North Sea mackerel and the highest for the northern North Sea Mackerel (table III and figure 2). The abundance of Anisakis in southern North Sea mackerel of all age groups is about as low as juvenile Western fish, which do not migrate to the feeding area in the northern North Sea. The prevalence and abundance of Anisakis in southern North Sea mackerel is lower than for the North Sea Mackerel and the Western Mackerel for all age groups.

The mean length at age data of southern North Sea mackerel show more agreement with Western Mackerel (Division VIIj) than with North Sea Mackerel (Division IVa east of 0°W and Division IVb) at least over age groups 4 - 8 as is shown in figure 3. The mean length at age of the 2- and 3-year olds of southern North Sea mackerel seem relatively high.

Discussion

Fishery pattern

The migration of mackerel through the southern North Sea had been observed in the beginning of this century and not just since the decline of the North Sea stock. At that time mackerel was mainly caught in the southern North Sea during two periods: a spring peak in the second quarter and an autumn peak in September and October as shown in table IV (revised after Ehrenbaum, 1913). Mackerel still migrate through the southern

North Sea at the same two times every year, which is reflected by the monthly catches in this area.

Maturity stages

Even in June the percentage of southern North Sea mackerel in maturity stage 6 is still relatively low (36%) compared with the spawning areas of the Western (Eltink, 1984) and North Sea stocks, indicating that these mackerel are still on their way to their spawning grounds (table V). The southern North Sea is not an important spawning area (Johnson and Dawson, 1975; Johnson, 1977; Iversen, 1981). In the beginning of June 1980 there was only a very low spawning activity in the southern North Sea compared with the central North Sea (Iversen, 1981). It is assumed that most of the southern North Sea mackerel will spawn in the central North Sea. The maturity stage of southern North Sea mackerel shows that these fish do not belong to the population that has spawned or still is spawning in the Celtic Sea or the Bay of Biscay.

Tagging experiments

Results from tagging experiments in the southern North Sea show evidence that southern North Sea mackerel migrate into the English Channel. Eight recaptures from a release of 593 mackerel tagged with spaghetti tags are shown in figure 4. Three of these tags were recaptured off Cornwall during winter, another three recaptured off Brittany and two of them were recaptured in the Norwegian Deep (Zijlstra and Postuma, 1966). 75 % of the tagged mackerel seemed to be of Western origin. Tagging experiments in the eastern English Channel off Newhaven in June and September-October 1966 (Bolster, 1966) demonstrated migrations from the eastern English Channel to the North Sea in summer and autumn (recaptures in June, July, August and October) and to the western English Channel in winter (recaptures in January) as is shown in figure 5 (after Lowings, 1981). These tagging data and the above described fishery pattern support the assumption that most of the southern North Sea mackerel overwinter in the English Channel and that they migrate through the southern North Sea to the central North Sea for spawning.

Age compositions

The age compositions of table II and figure 1 indicate that the southern North Sea mackerel show more agreement with the Western stock than with the North Sea stock. The 1969 year class, which is very strong in the North Sea stock, but only average in the Western stock, is also average in the southern North Sea. This indicates that the southern North Sea mackerel is offspring from the Western stock.

Parasites as biological tags

The southern North Sea mackerel is about equally infected with Grillotia compared as the mackerel from ICES Sub-area VII (table V after MacKenzie and Mehl, 1984) and has therefore been spending the juvenile period or a part of it in the English Channel (MacKenzie and Mehl, 1984). The investigation of Grillotia in mackerel samples taken in the southern North Sea in 1982 and 1983 shows a prevalence of 2.5%. This percentage is low, because it is calculated for all age groups (no age determinations) and could therefore not be corrected for the drop in prevalence in Sub-area VII from 13.8 % to 1.2 % in year class 1978 and later (MacKenzie and Mehl, 1984). These investigations together with the data of table V indicate that these southern North Sea mackerel have been spending at least part of their juvenile phase in Sub-area VII.

The southern North Sea mackerel are much less infected with Anisakis than the Western and North Sea Mackerel, because these southern North Sea mackerel never feed on euphausids in the northern North Sea (figure 2). They may therefore be considered as a seperate group, which migrates up and down the southern North Sea each year.

The assumption that the southern North Sea mackerel has been born and has been spending part of their juvenile phase in Sub-area VII is mainly based on the occurrence of Grillotia in these mackerel and the average strength of the 1969 year class as distinct from the great strength of this year class in the North Sea Mackerel. In addition the low Anisakis infestation confirms that the southern North Sea mackerel is not mixing with the North Sea mackerel on its feeding grounds and is migrating as a seperate group of which the growth characteristics differ from the North Sea Mackerel (this is confirmed in the following sections mean length at age and L1).

Mean length at age

The mean length at age of mackerel in the second quarter in 1979-1984 was estimated in ICES Division VIIj, in Division IVc and in Division IVa (east of 0°W) + IVb. The mean length at age data of southern North Sea mackerel show more agreement with Western Mackerel than with North Sea Mackerel as is shown in figure 3. The relatively high mean length of 2- and 3-year old mackerel in the southern North Sea is probably caused by the maturing of only the larger fish of these age groups, which migrate north for spawning, while the smaller fish of those age groups remain probably in the juvenile areas for another year.

L1

L1 estimated from mackerel samples taken in May 1979 shows a decrease in May 1979 from the Celtic Sea to the northern North Sea and to the southern North Sea (Dawson, 1983). The lowest L1 for the southern North Sea mackerel indicates that this group of mackerel does not randomly mix with Western or North Sea Mackerel, but retains its identity as a seperate group. When mixing of the southern North Sea mackerel with Western and North Sea Mackerel would have occurrred, then the southern North Sea mackerel would have had an intermediate L1 instead of the lowest L1.

When all areas are tested against the Norwegian Deep, two groups of mackerel can be distinguished: a) one in the North Sea and English Channel, comprising all the fish from the west of Scotland southward through the North Sea to Lyme Bay b) the other group consisting of all fish found west of the British Isles from the west of Scotland down to southern Biscay (Dawson, 1983). This supports the assumption that fish in the English Channel and the southern North Sea are the same group of fish just prior to spawning. However, it also suggests that the North Sea Mackerel is belonging to this group, which is not in agreement with the results presented above. Dawson (1983) ascribes the differences in L1 primairily to differences in spawning time, but it is possible that L1 in mainly related to water temperature and food availability. 0-group mackerel, which has an eastern distribution in the English Channel, might grow up under less favourable conditions than the more western 0-group, which would result in a lower L1 for the eastern juveniles. These eastern English Channel 0-group could later become southern North Sea mackerel.

Hypothesis: origin and migration of southern North Sea Mackerel

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Based on the observations above, the following hypothesis may be formulated:

> The southern North Sea mackerel is offspring of the Western Mackerel stock. This offspring is moving as 0-group into the English Channel and spends its juvenile phase in the English Channel and southern North Sea. After having migrated to the southern North Sea once, they continue to do so. When they reach maturity, they migrate again through the southern North Sea to spawn in the central North Sea. Offspring of the eggs, spawned by southern North Sea mackerel in the spawning area of the North Sea Mackerel, will probably recruit to the North Sea Mackerel stock.

Therefore, the southern North Sea mackerel will keep spawning in the North Sea even if the the North Sea Mackerel stock itself would have disappeared completely. All the southern North Sea mackerel should therefore be considered as an overspill from the Western Mackerel stock to the North Sea Mackerel stock.

Due to a shift in the western juvenile distribution to northern areas (Anon., 1986), an overspill of Western Mackerel to North Sea Mackerel might also be possible from Division VIa to IVa, which possibly could be caused by juveniles growing up in waters to the north and west of Scotland recruiting to the North Sea stock.

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Table I. Maturity stage composition (%) in April, May and June of mackerel in ICES Division IVc in 1977-1985.

Maturity stage		April %	May %	June %
immature	1	-	-	-
immature	2	5	4	2
	3	20	14	6
	4	38	18	6
spawning	5	26	38	27
spent	6	6	18	36
	7	-	7	19
	8	5	1	1
Total		100%	100%	100%
n		125	595	225

Table II. Age compositions in percentage of the North Sea stock (VPA), of the Western stock (VPA) and of the Dutch catches in the southern North Sea.

NORTH SEA MACKEREL STOCK in percentage (VPA: Anon., 1985) * = year class 69

age	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
1	0.2	4.2	34.8	31.4	18.8	11.7	2.0	8.2	12.5	19.2	14.6	6.1
2	5.1	37.7	24.3	16.2	11.2	2.2	10.5	14.0	19.5	13.8	6.0	11.2
3	42.3	24.5	12.1	9.2	2.1	10.9	16.5	18.0	13.9	5.1	10.9	8.9
4	24.0	11.0	5.9	1.6	9.3	14.7	18.4	12.0	4.6	9.6	7.8	50.0*
5	9.9	5.1	1.1	6.4	11.9	16.2	11.0	4.5	8.2	6.1	41.8*	10.7
6	4.8	0.9	3.6	7.5	11.9	9.3	4.9	7.4	5.1	31.6*	8.5	4.0
7	0.9	2.9	3.9	7.2	7.4	4.9	7.4	4.7	24.7*	6.5	3.0	3.8
8	2.4	3.2	3.7	4.6	4.3	6.8	3.5	21.5*	5.7	2.6	3.3	2.4
9	2.6	2.8	2.4	2.3	5.5	2.2	17.5*	4.8	1.8	2.6	1.3	0.2
10	2.4	2.0	1.2	3.1	1.9	14.6*	3.6	1.6	2.0	1.2	0.2	0.0
11+	5.3	5.7	7.0	10.6	15.7	6.3	4.6	3.3	1.9	1.8	2.6	2.7

Age compositions in percentage of Dutch CATCHES in ICES Division IVc * = year class 69

age	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
1	1.4	1.7	10.0	10.0	36.8	22.0	0	1.9	35.8	34.2	6.9	3.2
2	2.2	7.9	11.0	13.9	22.2	0.6	0	19.5	11.5	15.9	15.7	32.2
3	10.0	5.6	12.5	13.5	0.5	28.9	14.5	9.9	13.9	5.5	15.0	8.6
4	9.2	7.3	12.1	1.8	13.8	13.8	18.8	14.4	5.6	15.1	13.0	17.6*
5	7.1	9.7	2.5	17.3	6.1	10.0	5.9	3.8	8.7	7.4	25.1*	16.5
6	6.0	1.7	17.5	15.7	2.4	6.2	3.8	12.6	3.0	8.1*	12.4	5.0
7	2.1	10.4	7.7	3.4	5.0	2.7	6.4	6.8	6.5*	7.7	2.3	7.3
8	14.9	9.2	3.8	4.8	1.1	5.8	4.8	9.9*	6.7	1.2	6.3	3.4
9	4.8	5.4	5.9	1.9	3.1	1.9	19.7*	12.4	1.0	1.9	0.5	2.0
10	9.5	10.8	0.4	5.8	1.1	2.2*	10.5	2.9	3.2	1.0	0.6	1.1
11+	32.8	30.3	16.7	11.9	7.8	6.0	15.6	5.8	4.2	2.0	2.3	3.2
Otoliths	475	325	275	300	425	500	191	400	496	747	400	399

WESTERN MACKEREL STOCK in percentage (VPA: Anon., 1985) * = year class 69

age	1984	1983	1982	1981	1980	1979
1	2.5	4.6	28.4	26.9	32.8	20.8
2	5.4	30.6	19.9	25.8	15.2	3.2
3	30.8	19.1	17.6	10.4	2.3	18.3
4	19.2	16.1	7.0	1.5	11.6	13.5
5	16.0	6.4	1.0	7.7	9.0	8.6
6	6.7	1.0	5.1	6.2	5.8	9.6
7	1.0	4.7	4.0	4.2	6.6	3.2
8	5.0	3.6	2.8	4.8	2.2	8.3
9	3.8	2.5	3.1	1.6	6.0	2.7
10	2.6	2.9	1.0	4.4	1.8	3.3*
11+	7.1	8.5	10.1	6.5	6.7	8.4

Table III. The number of mackerel examined, the prevalence + abundance of Anisakis in mackerel and the mean + standard deviation of the log-transformed data in 1982-1984 in ICES Sub-area VII and ICES Divisions IVc and IVa by age group.

W = Western Mackerel (ICES Sub-areas VII)
SN= southern North Sea mackerel (ICES Division IVc)
N = North Sea Mackerel (ICES Division IVa)

	number of fish examined			prevalence			abundance			100 * $^{10}\log$(Anisakis + 1)			
AGE	W	SN	N	W	SN	N	W	SN	N	W	SN	N	
2	67	19	6	55	21	83	2.6	0.4	17.8	34.4	9.8	108.3	mean
										39.1	20.1	57.2	sdev
3	252	64	81	73	33	68	5.8	0.8	7.1	58.1	15.6	57.7	mean
										46.3	26.3	52.5	sdev
4	198	43	48	86	54	94	11.5	3.9	19.1	80.8	36.5	105.9	mean
										50.7	44.6	48.4	sdev
5	111	31	31	95	61	90	12.3	6.5	25.6	88.1	45.5	116.0	mean
										48.2	52.8	57.9	sdev
6	38	19	8	95	53	100	16.5	3.8	53.5	102.7	39.6	148.6	mean
										45.2	48.0	60.6	sdev
7	18	11	3	94	73	100	35.0	6.3	21.7	114.6	59.1	134.5	mean
										64.4	51.3	11.5	sdev
8	25	31	11	92	58	91	14.4	4.9	39.6	92.9	39.2	141.4	mean
										51.6	49.6	55.8	sdev
9	27	15	9	100	67	100	12.8	4.8	95.8	92.6	50.3	181.8	mean
										43.0	47.2	38.5	sdev
10	21	22	8	100	86	100	12.7	6.4	45.5	100.6	64.4	160.0	mean
										34.8	44.2	25.6	sdev
11+	68	76	39	93	72	97	13.2	5.2	30.3	89.9	53.1	127.3	mean
										47.5	46.3	45.8	sdev
total	825	331	244										

Table IV. Historical catches of mackerel by the Netherlands, England and Germany in kg. (Revised after Ehrenbaum, 1913)

Month	J	F	M	A	M	J	J	A	S	O	N	D
Netherlands 1906 - 1910	1395	1950	780	4080	26820	21435	6600	8325	121530	45915	15870	2985
England 1906 - 1910 Southern North Sea	102	305	1676	24943	76403	46685	18694	24841	96520	46888	29820	3759
Germany	25	-	508	433	14217	4213	389	673	4397	4183	412	385
Number of ships	1	-	1	5	93	69	30	19	28	17	16	2
Catch per ship 1908 - 1910 Southern North Sea	25	-	508	87	153	61	13	35	157	246	26	193

Table V. Prevalence of G. angeli in mackerel caught in different ICES Sub-areas and Divisions (MacKenzie and Mehl, 1984).
N = total number examined n = number infected Prev = percentage prevalence

		IIa	IIIa	IVa	IVb	IVc	VIa south of 58 N	VIa north of 58 N	VII	VIII	IX
Year classes	N	210	64	1102	315	228	200	1611	952	201	1
1977 and	n	9	1	45	5	25	16	92	131	15	0
earlier	Prev	4.3	1.6	4.1	1.6	11.0	8.0	5.7	13.8	7.5	0

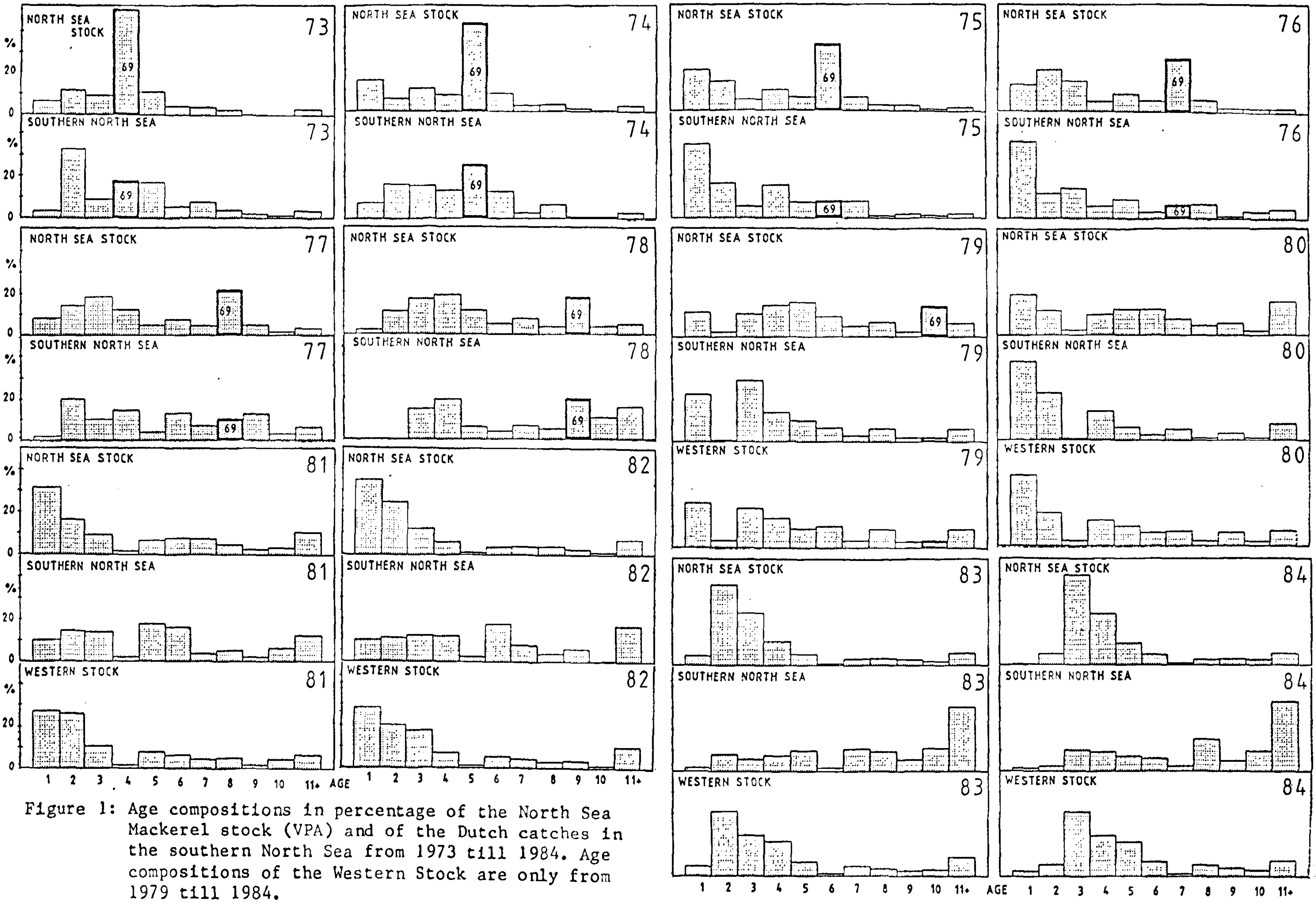

Figure 1: Age compositions in percentage of the North Sea Mackerel stock (VPA) and of the Dutch catches in the southern North Sea from 1973 till 1984. Age compositions of the Western Stock are only from 1979 till 1984.

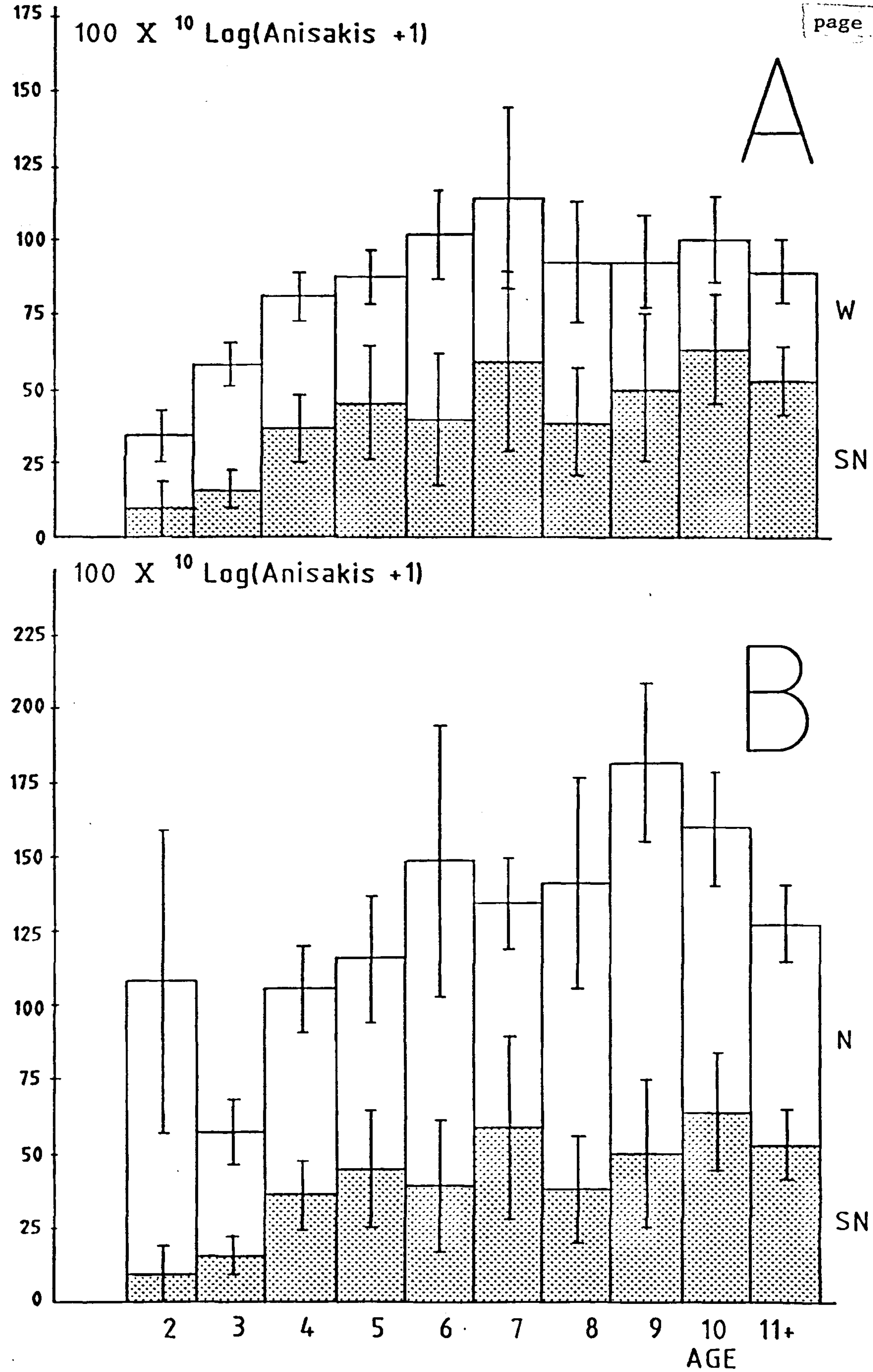

Figure 2: The abundance (log-transformed) of Anisakis in the southern North Sea mackerel (SN) compared with the Western Mackerel (W) in figure 2A and compared with the North Sea Mackerel (N) in figure 2B. The vertical lines indicate the 95% confidence limits.

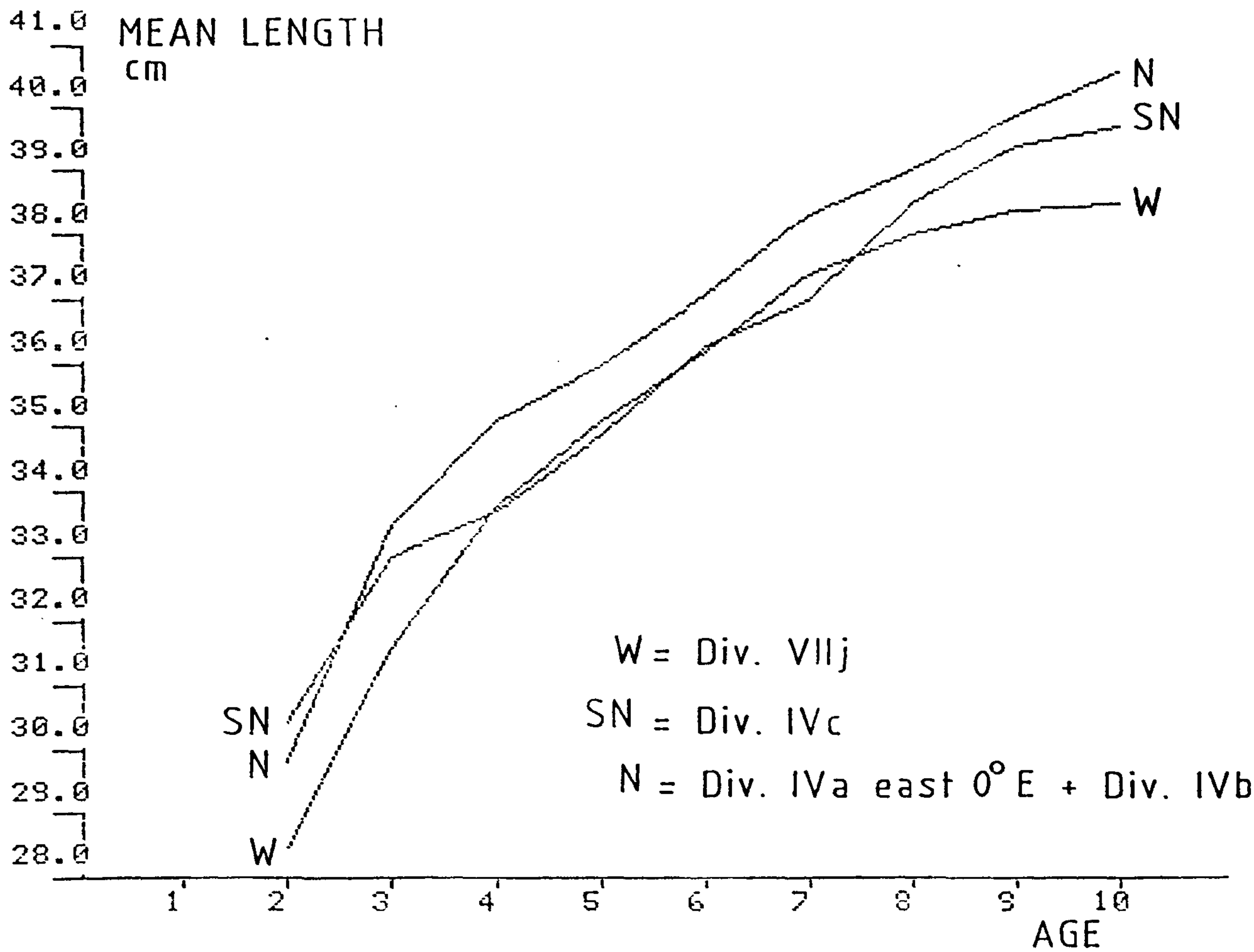

Figure 3: The mean length at age of mackerel in the second quarter in 1979 - 1984 in ICES Division VIIj (W), ICES Division IVc (SN) and ICES Division IVb + IVa east of 0° W (N).

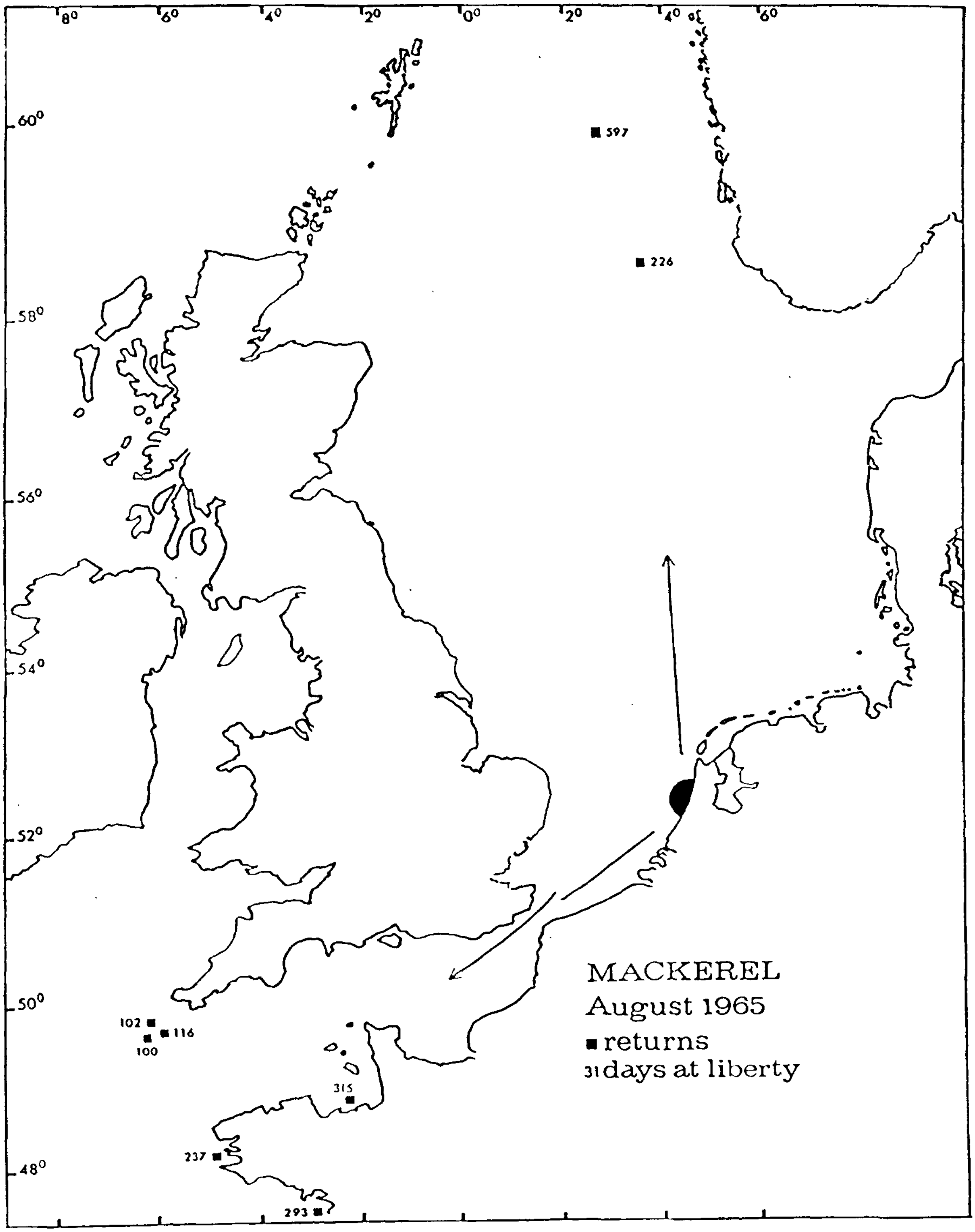

Figure 4: Tagging area and recaptures of the experiment in the summer 1965 along the Dutch coast (Zijlstra and Postuma, 1966).

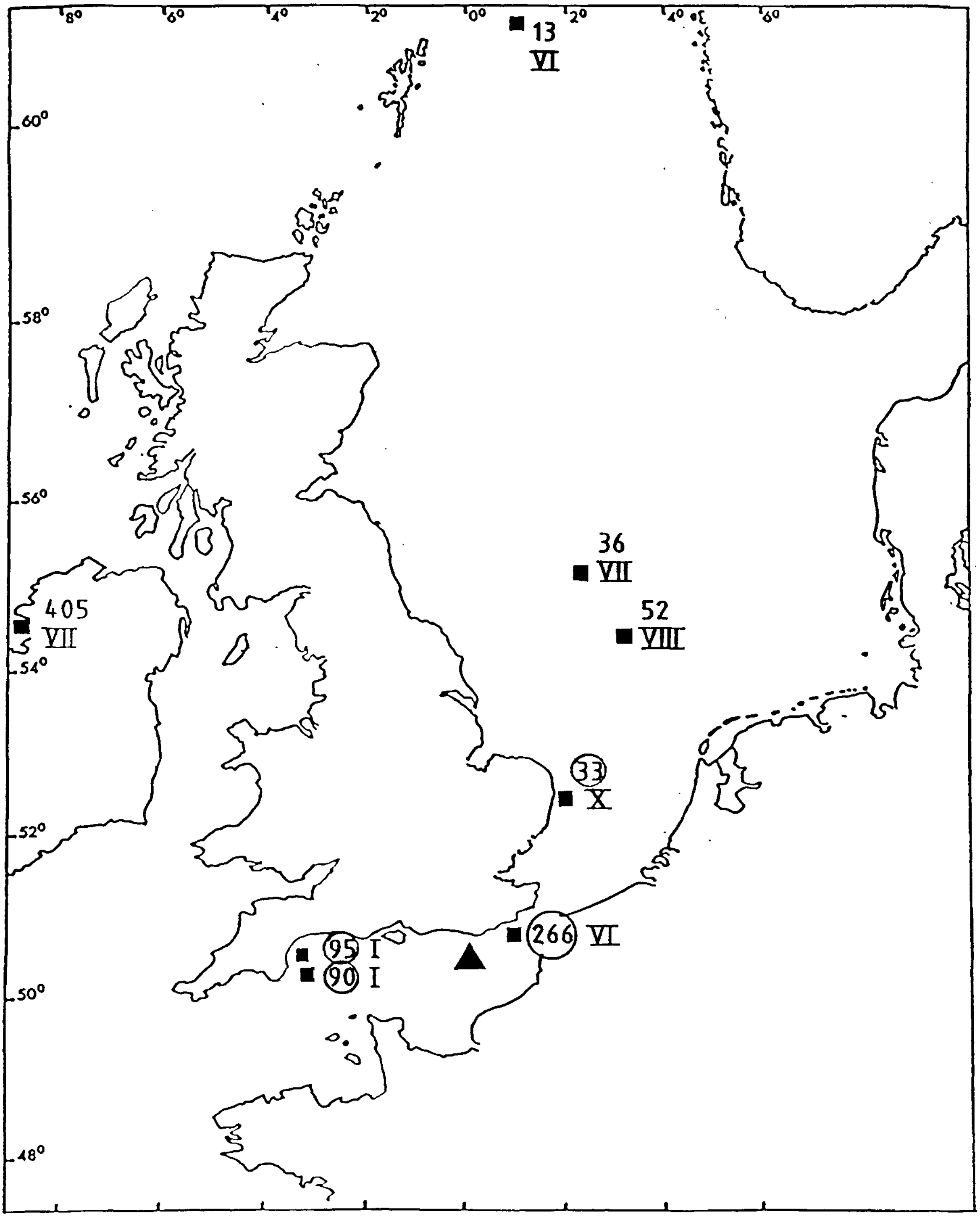

Figure 5: Recaptures of mackerel tagged off Newhaven in June 1966 and September-October 1966 (encircled). The tagging area is indicated by a black triangle, the month of recapture by Roman numurals and days at liberty by Arabic numurals (Bolster, 1966).

Résumé

Le maquereau du sud de la Mer du Nord (**Scomber scombrus L.**) semble issu du stock de l'ouest plutôt que de celui de la Mer du Nord. Ceci est basé sur des comparaisons de structures démographiques, des expériences de marquage, la présence du parasite Grillotia (Cestode) et le faible taux d'infestation par Anisakis (Nématode) chez ce maquereau. Le maquereau du sud de la Mer du Nord suit chaque année les mêmes trajets migratoires entre les zones d'hivernage de l'ouest au travers du sud de la Mer du Nord vers le centre de la Mer du Nord sans s'alimenter dans la partie septentrionale de la Mer du Nord se distinguant en cela des maquereaux de Mer du Nord et de l'ouest.

L'hypothèse suivante est formulée: Le maquereau du sud de la Mer du Nord pond dans le centre de la Mer du Nord en même temps que le maquereau de Mer du Nord. Les jeunes issus des pontes du maquereau du sud de la Mer du Nord contribueront probablement au recrutement du stock de Mer du Nord et non à celui de la population du sud de la Mer du Nord qui reçoit des recrues du stock de l'ouest.

Le très faible niveau du recrutement et la pêche ont entraîné une diminution rapide du stock de Mer du Nord. Cependant l'apport au stock de Mer du Nord de recrues provenant du stock de l'ouest doit agir comme un palliatif naturel à l'effondrement total du stock de Mer du Nord.