INTERNATIONAL COUNCIL FOR THE
EXPLORATION OF THE SEA.

C.M. 1979 / H: 26
Pelagic Fish Committee

ABUNDANCE OF HERRING LARVAE IN THE DUTCH WADDEN SEA AS A POSSIBLE INDICATION OF RECRUITMENT STRENGTH.

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Introduction.

Each year from February to May, herring larvae migrate into the inshore brackish waters of the southern and eastern Central North Sea where they subsequently undergo metamorphosis. They arrive in several waves and in yearly fluctuating quantities.

Along the Dutch Coast a sampling programme for these larvae was started in 1967 (Postuma 1969). The first objective of this programme was to assess the importance of the Wadden Sea as a nusery area for herring. A second objective, which later gained more importance, was to investigate the possible relationship between the abundance of herring larvae entering the coastal waters, and the strength of the same year-class when it recruited after 2 1/2 years to the spawning grounds in the southern and central North Sea. If such a relationship could be demonstrated, a larval monitoring programme in coastal waters could provide a useful method for predicting yearclass strength at very early stage.

Larvae arriving in Dutch coastal waters in February and March generally have a higher mean length than those arriving in April and May. This difference in mean length is assumed to correspond to a difference in time of birth of the larvae. The larvae arriving in February and March have a mean length of approximately 40 mm, and they are assumed to have been born in September/October on the spawning grounds in the central North Sea (Longstone, Whitby, Flamborough, Dowsing). The smaller larvae arriving in April and May, with a mean length of approximately 30 mm, are assumed to have been born in December/January on the spawning grounds in the southern North Sea and English Channel (Sandettie, Vergoyer, Seine Bay). This hypothesis is based on the results of

German studies, in which the drift of herring larvae was followed from the spawning grounds in the central and southern North Sea towards the inshore nursery areas along the coasts of Denmark, Germany and The Netherlands. (Bückman 1950, Bückman and Hempel 1957). Figure 1 demonstrates the drift pattern of herring larvae born in the central and southern North Sea, as found during the German investigations. The drift route of larvae from the Dogger Bank area has been omitted, as no substantial spawning in this area has been reported since 1965.

This paper presents the results of the Dutch sampling programme during the period 1967-78. An attempt has been made to split the larvae sampled along the Dutch coast into central and southern North Sea larvae, and these different catagories of larvae have been compared to the recruitment of the same year-classes, after 2 1/2 year, to the different spawning grounds.

Methods and Material.

Sampling gear and method.

The sampling gear consisted of a plankton net with a circular mouth opening of 2 m. diameter. During the year 1967-69, the netting consisted of saran gauze with a mesh opening of 1,35 mm. The total length of the net was then 20 m. From 1970 onward, nylon "Monodur" netting with a mesh size of 1,40 mm was used, and the total length of the net was reduced to 14 m.

Figure 2 shows the rigging of the net. The net was fished on the tide from an anchored ship. The depth of the net was approximately 7 m, while the bottom depth at the sampling stations was about 15 m. Hauls were made both on the in- and outgoing tide, but only when the tidal current was more than 1 knot. Standard duration of the hauls was 45 minutes, except is cases when clogging of the net occurred by phytoplankton in large numbers of ctenophores. The volume of water filtered was measured by means of a flowmeter mounted in the mouth of the net. The catches of herring larvae were all converted to numbers per 10.000 m^3 water.

Sampling positions and frequency.

Regular sampling was carried out at 4 different stations, situated in two of the main inlets to the western Wadden Sea (fig. 1). The exact positions of the stations were:

buoy	T8	53°01'N	4°49'E
buoy	TM	52°59'N	4°48'E
buoy	VL5	53°19'N	5°09'E
buoy	WM5	53°18'N	5°14'E

Each year, a total number of 2-4 one week surveys were made in the period February-May. During each survey, the objective was to make 8 hauls at each of the 4 stations. A summary of all surveys carried out during the year 1967-78 is given in figure 3.

Results.

The results from the surveys have been grouped into half-monthly standard periods, in order to compare changes in abundance and length composition throughout the season and between years. Figure 4 shows mean length distributions for half-monthly periods during all the years 1967-78 combined. It is seen that larvae with a modal length of approximately 40 mm arrive in February/March, and these are followed by smaller larvae of 25-35 mm modal length arriving in March/April.

Separation of assumed central and southern North Sea larvae.

On the basis of the studies by Bückman (1950) and Bückman & Hempel (1957), it is assumed that the largest, first arriving larvae originate from the Central North Sea spawning grounds, and that the smaller larvae in March/April have been born in the English Channel. In figure 4, which is based on a combination of several year's data, the separation between the two groups of larvae is not always very clearly defined, but in the data for individual surveys, the split is generally very evident. Because the growth of the larvae is slightly different from year to year, it is difficult to use a fixed length criterium for splitting central and southern larvae in each year. Instead, the split between the two groups of larvae was made for each cruise separately, based on the length distribution of the larvae during that particular cruise (table 1).

Calculation of mean number per haul for each cruise.

Catches of herring larvae show a rather large within haul variance, at each sampling position due to the patchy distribution of the larvae. The variance between different sampling positions was even greater, which is probably caused by the fact that the larvae arrive in several "waves". One sampling position may be hit by such a "wave" of larvae during a certain cruise, while another position during the same cruise may show a very law abundance of larvae.

In order to calculate the mean number of larvae per haul for the entire cruise, forst the mean number per haul and its variance were calculated for each individual sampling position. Next, the stratified mean and its variance were calculated for the 4 sampling positions combined. TableII shows this procedure, applied to the assumed central North Sea larvae from all cruises, and table III. gives the same data for the assumed southern North Sea larvae. In these tables the various cruises have already been grouped in half monthly periods.

Calculation of abundance indices per year.

In most years, not all half-monthly periods have been sufficiently sampled to calculated an integrated total abundance for the whole sampling period. Therefore, only the abundance figures during the peak of the immigration season were used as an index of larval influx. For larvae from the central North Sea, this peak season was defined as the period from 15 March - 15 April. The first half of March was omitted because in many years no data were available for this period. Larvae from the southern North Sea reach their highest abundance in the period 15 March - 30 April. The abundance during missed half-monthly periods was estimated by using the ratio between neighbouring periods in years with complete sampling. Yearly abundance indices were calculated as the mean of the half-monthly periods during the peak immigration season. Tables IV and V show these calculations for central and southern North Sea larvae.

Comparison between larval abundance and subsequent recruitment.

The objective of the larvae monitoring programme was to find out whether a relationship existed between the abundance of central and southern North Sea larvae in Dutch coastal waters, and the strength of the same year-class when it recruited as 3 year-olds to the spawning population.

Estimates of recruitment strength for the individual spawning stocks in the central and southern North Sea were based on the data published by Corten (1978). In this paper, stock sizes in weight were calculated for individual herring stocks, using the results from the ICES herring larval surveys (surveys for newly hatched larvae on the spawning grounds). By applying the percentage age composition of samples of spawning herring, which were obtained from these spawning stocks, a relative index for the number of 3 year-olds in each year can be calculated. For the purpose of this report, Corten's data from 1978 were expanded with data from one additional year. Percentage age compositions and numbers per kg were taken from the routine market sampling programme at the Ymuiden laboratory.

Table VI and figure 5 show the indices of recruitment strength in the central and southern North Sea, compared with the abundance indices of the corresponding larvae in the Wadden Sea. A spearman rank correlation test was applied to these figures, and the correlation coefficients found for the central and southern North Sea were 0,63 and 0,53 respectively. These correlations, although positive and rather high, are not significant at the 5% level ($r_s > 0{,}67$).

Discussion.

Although the abundance of herring larvae, measured by means of anchored plankton nets, does not show a significant correlation with the strength of the same year-class as adult herring, it seems advisable to continue the larval monitoring programme for at least some more years. The correlations obtained so far look rather promising, and there are some reasons to believe that the addition of a few extra years might eventually result in a significant correlation.

Firstly, the surveys in the earlier years were made at rather irregular times, and there was no complete coverage of the main immigration period in several years. These missed sampling periods, although corrected for as well as possible, may have caused inaccuracies in our estimate of larval abundance. In the second place, the range of larval abundances (and recruitment strengths) was rather small over the period investigated. This of course was due to the depleted state of the herring stocks in the areas concerned. If some good year-classes would appear in future, this might add some values at the other end of the range, thereby showing more clearly the relationship between larval abundance and recruitment.

A possible cause of error in the larval abundance estimates, however, which is hard to avoid or correct for, is the limitation of the sampling area. It is possible that the drift pattern of the larvae is slightly different from year to year, and that each time a different proportion of the larvae born at the various spawning grounds, will end up in the western Wadden Sea. If these differences in yearly drift pattern are really pronounced, they could strongly effect the abundance of herring larvae in the Wadden Sea. In this case, the abundance of larvae in the Wadden Sea would not only depend on the actual size of the year-class at the moment, but also on the specific distribution of the year-class during that particular year. The variable drift pattern would thus introduce a large source of variance, and the correlation between larval abundance in the Wadden Sea and recruitment strength might never become significant.

There is also a possibility that the year-classes will sustain a high and variable mortality between the ages of 1/2 and 3 years. In that case, the abundances of 1/2 and 3 year-olds will never show a good correlation, no matter how accurate the abundance estimates may be.

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TABLE I - Mean length distributions per survey (in numbers per 10 000 m³) and split in central and southern North Sea larvae.

Period	Year	Number of hauls	Mean number per 10 000 m³	Length in millimeters <25	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	>48
				North Sea Larvae											Central North Sea Larvae														
2nd h FEB	1967	3	-																										
	1968	7	61.3												2.4	0.3	0.7	0.7	5.0	1.7	10.7	11.6	3.8	10.1	8.1	2.3	0.7	2.9	0.3
	1969	15	2.9													0.2	-	0.3	0.2	0.1	0.4	0.3	0.7	0.4	0.1	-	-	-	0.2
	1970	28	-																										
	1975	32	5.6		0.0	-	-	0.0	0.4	0.1	0.1	0.4	0.2	0.1	0.1	0.2	-	0.4	0.5	0.1	0.9	0.5	0.7	0.5	0.3	-	0.1		
1st h MAR.	1972	31	76.0							0.1	-	0.1	0.3	0.2	0.8	0.9	2.4	5.9	8.1	9.0	12.3	10.0	12.7	6.5	4.1	1.6	0.9	0.1	
	1975	32	9.1	0.0	0.1	0.0	0.3	0.4	0.3	0.4	0.6	1.1	1.3	1.9	1.0	0.3	0.3	0.4	0.1	0.0	0.2	0.0	0.2	0.1	0.0	0.1	0.0		
	1976	32	11.7											0.0	0.3	0.2	0.3	0.3	0.5	1.1	1.2	1.0	1.6	1.2	2.3	0.7	0.4	0.6	
	1977	32	0.6						0.1	0.0	0.1	0.0	0.3	0.1	0.0	0.0													
2nd h MAR.	1968	35	106.6	0.4	-	0.3	0.2	0.1	0.7	1.3	0.2	1.3	1.4	3.0	6.6	6.8	8.0	12.7	11.7	14.3	10.8	13.5	6.4	2.6	3.1	0.6	0.3	0.3	
	1970	30	48.4	3.0	1.7	2.6	3.5	3.9	1.8	1.1	1.9	2.1	1.0	0.3	0.1	-	0.4	0.9	0.6	1.5	2.0	3.9	3.2	2.2	2.6	3.5	2.1	1.6	0.9
	1971	25	247.0	3.6	3.2	9.5	7.8	16.3	7.1	16.2	7.8	8.2	8.7	9.7	5.7	8.6	4.8	10.3	8.2	13.4	6.3	15.4	16.4	12.0	24.0	7.4	7.4	5.1	3.9
	1973	31	121.2	8.5	12.9	17.4	24.2	25.4	12.7	9.9	5.8	3.3	0.8	0.3	-	-	-	0.0											
	1974	35	93.6	5.7	2.5	5.4	5.3	8.8	9.3	7.8	9.9	16.1	11.9	6.7	2.0	2.0	0.2												
	1976	23	7.9															0.1	0.5	0.7	0.7	1.3	1.4	1.8	1.0	0.2	0.2		
	1977	32	33.1					0.1	-	-	0.1	0.4	2.3	6.0	11.4	5.3	5.1	1.6	0.5	0.2	0.1								
	1978	28	0.7				0.0	0.0	-	-	-	-	-	-	0.1	-	-	0.1	0.1	0.2	0.1	0.1	0.0						
1st h APR.	1967	20	86.8	8.8	3.3	3.5	3.7	5.2	3.0	7.3	5.8	10.0	8.8	4.6	5.1	4.6	2.8	4.2	1.5	0.9	0.4	0.3	0.6	0.2	1.0	0.4	0.1	0.2	0.5
	1969	13	461.2					2.8	0.6	2.7	0.8	5.4	6.9	3.3	9.7	12.9	15.6	23.7	29.4	78.7	51.9	64.2	51.2	25.8	31.2	14.6	7.5	13.9	8.4
	1972	10	147.5		1.7	1.1	3.9	6.8	9.0	6.5	7.8	4.7	1.4	2.8	1.9	1.0	1.3	5.2	3.1	8.8	11.3	12.0	13.4	7.3	11.0	10.5	8.3	6.7	
	1975	32	71.5	0.3	0.1	0.1	0.5	1.6	1.7	2.9	2.9	4.8	9.1	6.7	6.8	7.0	9.0	7.6	3.3	3.2	0.9	0.9	1.1	0.3	0.1	0.2	0.2	0.2	
	1976	32	4.9						0.2	0.2	0.4	0.4	0.3	0.4	0.6	0.3	0.4	0.3	0.1	0.2	0.3	0.1	-	-	0.2	0.4	0.1		
	1978	32	65.5	3.2	3.6	6.3	11.5	12.3	10.5	6.9	4.2	3.2	1.2	1.2	0.0	0.3	0.6	0.2	0.1	-	-	0.1	0.0	0.1	-	-	-	0.0	
2nd h APR:	1970	5	1028.1	46.5	56.8	102.2	102.9	110.0	67.6	122.8	90.2	104.3	74.8	30.2	33.4	17.2	16.7	5.4	6.0	1.1	5.4	19.5	5.4	7.0	2.7				
	1971	24	271.5		0.1	-	3.5	0.5	0.3	22.2	17.4	12.1	39.6	14.5	17.9	41.9	50.8	26.4	6.9	14.6	-	2.8							
	1972	32	141.9			0.2	0.7	2.6	2.1	6.8	10.9	22.4	19.1	22.0	15.9	14.5	6.9	6.3	6.2	3.5	0.7	0.4	0.4	0.3					
	1973	19	24.4			0.2	5.1	5.4	7.3	19.0	29.6	31.5	39.6	42.9	21.6	16.4	5.2	0.6											
	1974	27	474.8		1.4	3.0	4.3	14.7	48.3	59.5	59.9	85.2	66.2	52.4	36.6	24.2	12.2	4.3	2.5	0.1									
	1977	32	10.8											0.2	0.6	1.1	0.6	1.4	1.2	1.8	1.1	1.1	1.0	0.2	0.1	-	0.2	-	0.2
	1978	29	104.6	0.5	1.0	2.5	3.3	9.3	11.0	12.1	15.0	15.2	13.6	7.9	5.8	2.5	2.3	1.4	0.6	-	0.6	-	0.0	-	-	-	0.0		
1st h MAY	1967	27	80.2		2.1	1.5	4.9	3.7	5.0	5.8	6.3	10.0	9.1	9.7	5.8	6.2	5.6	2.2	1.7	0.4	-	0.2							
	1974	32	53.2				0.1	0.2	0.2	0.3	0.1	7.1	10.3	9.0	8.7	5.2	0.1	4.2	2.7	1.3	2.6	1.1							
	1975	32	0.0																										
2nd h MAY	1971	17	-																										
	1973	27	0.2															0.1	0.1	-	0.0								

Table II - Mean number of larvae per sampling position and stratified mean for each cruise : Central North Sea larvae.

Year	Date	T8			TM			VL			WM			Stratified mean		
		M	s^2	N	M	s^2	N	M	s^2	N	M	s^2	N	M	$\bar{S}$	N
1967	27/02-03/03	-	-	2	-	-	1							-	-	3
1967	03/04-08/04	0.9	2	8	13.2	183	4	-		5	-	-	3	3.5		20
1967	08/05-12/05	-	-	11				-		10	-	-	5	-	-	26
1968	26/02-01/03	61.6	5525	5				60.9	227	2				61.3	17.5	7
1968	25/03-29/03	107.6	6885	17				101.6	6212	11	95.8	17516	7	101.7	19.6	35
1969	24/02-28/02	4.7	21	5	-	-	4	3.1	20	6				2.6	0.9	15
1969	31/03-02/04	488.4	68368	6	784.8	38137	3	115.1	4919	4				462.8	53.1	13
1970	23/02-27/02	-	-	9	-	-	3	-	-	12	-	-	4	-	-	28
1970	16/03-20/03	25.8	1128	8	1.8	15	11	72.9	2870	7	6.3	21	4	26.7	5.9	30
1970	26/04-28/04	-	-	2							66.8	7156	3	33.4	24.4	5
1971	23/03-26/03	43.7	1895	8	-	-	5	223.5	190122	10	-	-	2	66.8	34.7	25
1971	19/04-23/04	-	-	7	-	-	8	-	-	6	-	-	3	-	-	24
1971	18/05-19/05	-	-	5	-	-	4	-	-	4	-	-	4	-	-	17
1972	13/03-17/03	91.8	5208	7	67.1	4047	8	74.9	380	8	71.1	1002	8	76.2	9.4	31
1972	04/04-07/04	82.8	2966	4	97.7	4016	4	103.3	62	2				94.6	14.0	10
1972	24/04-28/04	-	-	8	-	-	8	-	-	10	-	-	6	-	-	32
1973	19/03-23/03	-	-	5	-	-	10	0.1	0	9	-	-	7	0.0	0.0	31
1973	16/04-18/04	-	-	6				-	-	7	-	-	6	-	-	19
1973	14/05-18/05	-	-	6	-	-	4	-	-	8	-	-	9	-	-	27
1974	18/03-21/03	-	-	6	-	-	10	-	-	8	-	-	11	-	-	35
1974	16/04-18/04	-	-	7	-	-	8	-	-	6	-	-	6	-	-	27
1974	06/05-10/05	-	-	8	-	-	8	-	-	8	-	-	8	-	-	32
1975	24/02-28/02	2.3	11	8	2.0	25	8	6.2	45	8	6.1	74	8	4.2	1.1	32
1975	03/03-07/03	4.2	32	8	-	-	8	0.9	4	8	0.7	4	8	1.5	0.6	32
1975	01/04-07/04	1.4	3	8	2.2	17	8	7.4	36	8	1.7	4	8	3.2	0.7	32
1975	12/05-15/05	-	-	8	-	-	8	-	-	8	-	-	8	-	-	32
1976	08/03-11/03	15.6	72	8	10.2	79	8	6.5	49	8	14.0	261	8	11.6	1.9	32
1976	15/03-19/03	7.8	117	23										7.8	2.3	23
1976	05/04-08/04	-	-	8	2.9	25	8	-	-	8	-	-	8	0.7	0.4	32
1977	07/03-10/03	-	-	8	-	-	8	-	-	8	-	-	8	-	-	32
1977	29/03-31/03	-	-	8	-	-	8	-	-	8	-	-	8	-	-	32
1977	20/04-28/04	-	-	8	-	-	8	-	-	8	-	-	8	-	-	32
1978	20/03-23/03	0.5	2	8	-	-	4	0.4	1	8	0.9	2	8	0.5	0.2	28
1978	03/04-06/04	0.2	0	8	-	-	8	0.6	1	8	-	-	8	0.2	0.1	32
1978	18/04-21/04	-	-	7	-	-	8	-	-	7	-	-	7	-	-	29

Table III - Mean number of larvae per sampling position and stratified mean for each cruise: Southern North Sea larvae.

Year	Date	T8			TM			VL			WM			Stratified mean		
		M	s^2	N	M	s^2	N	M	s^2	N	M	s^2	N	M	S	N
1967	27/02-03/03	-	-	2	-	-	1							-	-	3
1967	03/04-08/04	59.0	2293	8	119.6	15661	4	66.9	4037	5	111.6	8534	3	89.3	22.2	20
1967	08/05-12/05	77.8	32657	11				106.6	41576	10	31.5	1192	5	72.0	28.6	26
1968	26/02-01/03	-	-	5				-	-	2				-	-	7
1968	25/03-29/03	4.8	146	17				0.4	2	11	4.1	21	7	3.1	1.1	35
1969	24/02-28/02	-	-	5	-	-	4	-	-	6				-	-	15
1969	31/03-02/04	32.2	1118	6	16.8	843	3	1.9	15	4				17.0	7.2	13
1970	23/02-27/02	-	-	9	-	-	3	-	-	12	-	-	4	-	-	28
1970	16/03-20/03	32.5	1367	8	7.7	54	11	32.3	601	7	31.0	776	4	25.9	5.3	30
1970	26/04-28/04	1259.0	1696114	2							807.9	305354	3	1033.5	487.3	5
1971	23/03-26/03	140.6	119287	8	11.2	117	5	140.1	24380	10	7.1	994	2	74.8	33.4	25
1971	19/04-23/04	374.0	235494	7	49.4	6045	8	572.1	206592	6	24.9	1206	3	255.1	65.8	24
1971	18/05-19/05	-	-	5	-	-	4	-	-	4	-	-	4	-	-	17
1972	13/03-17/03	-	-	7	0.2	0	8	1.0	1	8	0.6	2	8	0.5	0.2	31
1972	04/04-07/04	82.7	.2668	4	3.8	8	4	69.4	722	2				52.0	10.7	10
1972	24/04-28/04	51.2	1261	8	95.4	18195	8	31.8	2444	10	507.4	807272	6	171.5	92.6	32
1973	19/03-23/03	315.7	79200	5	14.3	683	10	157.6	37340	9	55.5	2429	7	135.8	35.7	31
1973	16/04-18/0	506.8	94939	6				127.8	11018	7	54.7	1639	6	229.8	44.3	19
1973	14/05-18/05	-	-	6	1.3	1	4	0.1	0	8	-	-	9	0.4	0.1	27
1974	18/03-21/03	82.4	4056	6	57.3	2141	10	166.3	4091	8	80.0	19159	11	96.5	14.0	35
1974	16/04-18/04	403.7	289228	7	223.4	143672	8	699.5	67589	6	668.6	414632	6	498.8	93.4	27
1974	06/05-10/05	0.9	5	8	209.2	91835	8	2.9	28	8	0.3	1	8	53.3	26.8	32
1975	24/02-28/02	0.8	1	8	2.7	17	8	1.6	3	8	0.8	3	8	1.5	0.4	32
1975	03/03-07/03	8.3	215	8	1.3	5	8	11.6	90	8	9.7	274	8	7.7	2.1	32
1975	01/04-07/04	19.8	176	8	58.4	2515	8	120.6	2717	8	75.4	3492	8	68.6	8.3	32
1975	12/05-15/05	-	-	8	-	-	8	0.2	0	8	-	-	8	0.1	0.0	32
1976	08/03-11/03	-	-	8	-	-	8	-	-	8	-	-	8	-	-	32
1976	15/03-19/03	-	-	23										-	-	23
1976	05/04-08/04	2.3	3	8	13.2	515	8	1.3	4	8	-	-	8	4.2	2.0	32
1977	07/03-10/03	-	-	8	-	-	8	2.5	12	8	-	-	8	0.6	0.3	32
1977	29/03-31/03	1.3	5	8	41.2	9144	8	48.4	3123	8	41.6	754	8	33.1	10.1	32
1977	20/04-28/04	12.1	89	8	3.9	9	8	26.2	639	8	1.0	2	8	10.8	2.4	32
1978	20/03-23/03	0.3	0	8	-	-	4	-	-	8	0.1	0	8	0.1	0.1	28
1978	03/04-06/04	0.4	0	8	12.4	115	8	85.3	2694	8	162.8	5809	8	65.2	8.2	32
1978	18/04-21/04	12.2	157	7	39.8	1437	8	293.3	19085	7	82.7	4312	7	107.0	14.9	29

Table IV - Mean number of larvae per half-monthly period and average value for the peak immigration season, Central North Sea larvae. Number of larvae per 10 000 m3

	FEB	MARCH		APRIL		MAY		average for peak immigration period
	2e half	1st half	2nd half	1st half	2nd half	1st half	2nd half	
			peak immigration period					
1967	0		1.2*	3.5		0		2.4
1968	61.3		101.7	308.0*				204.9
1969	2.6		152.8*	462.8				307.8
1970	0		26.7	80.9*	33.4			53.8
1971			66.8	202.3*	0		0	134.6
1972			76.2	94.6	0			85.4
1973			0	0*	0		0	0
1974			0	0*	0	0		0
1975	4.2	1.5	1.1*	3.2				2.2
1976		11.6	7.8	0.7				4.3
1977		0	0	0*	0			0
1978			0.5	0.2	0			0.4
MEAN			31.1	94.2				

*) estimated by using the average ratio between neighbouring periods.

Table VI - Abundance of central and southern North Sea larvae in the Wadden Sea compared to recruitment in the corresponding spawning populations.

	Central North Sea		Southern North Sea	
year-class	abundance 1/2 year old	abundance 3 year old	abundance 1/2 year	abundance 3 year old
1966	2.4	2.2	253.1	19.1
1967	204.9	20.6	10.6	5.9
1968	307.8	17.3	54.8	0.4
1969	53.8	3.2	384.1	9.2
1970	134.6	73.8	131.3	7.2
1971	85.4	61.3	74.7	0.6
1972	0	3.5	154.8	1.1
1973	0	3.0	230.2	0.7
1974	2.2	19.3	194.4	2.3
1975	4.3		10.7	
1976	0		21.5	
1977	0.4		57.4	

Table V - Mean number of larvae per half-monthly period and average value for the peak immigration season, Southern North Sea larvae. Numbers of larvae per 10 000 m^3.

	FEB	MARCH		APRIL		MAY		
	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	average for peak immigration period
			peak immigration period					
1967	0		74.3*	89.3	595.6*	72.0		253.1
1968	0		3.1	3.7*	24.9*			10.6
1969	0		14.1*	17.0	113.4*			54.8
1970	0		25.9	93.0*	1033.5			384.1
1971			74.8	64.1	255.1		0	131.3
1972			0.5	52.0	171.5			74.7
1973			135.8	98.8	229.8		0.4	154.8
1974			96.5	95.4	498.8	53.3		230.2
1975	1.5	7.7	57.1	68.6	457.6*	0.1		194.4
1976		0	0	4.2	28.0*			10.7
1977		0.6	33.1	20.7	10.8			21.5
1978			0.1	65.2	107.0			57.4
MEAN			41.1	49.4	339.5			

*) estimated by using the average ratio between neighbouring periods.

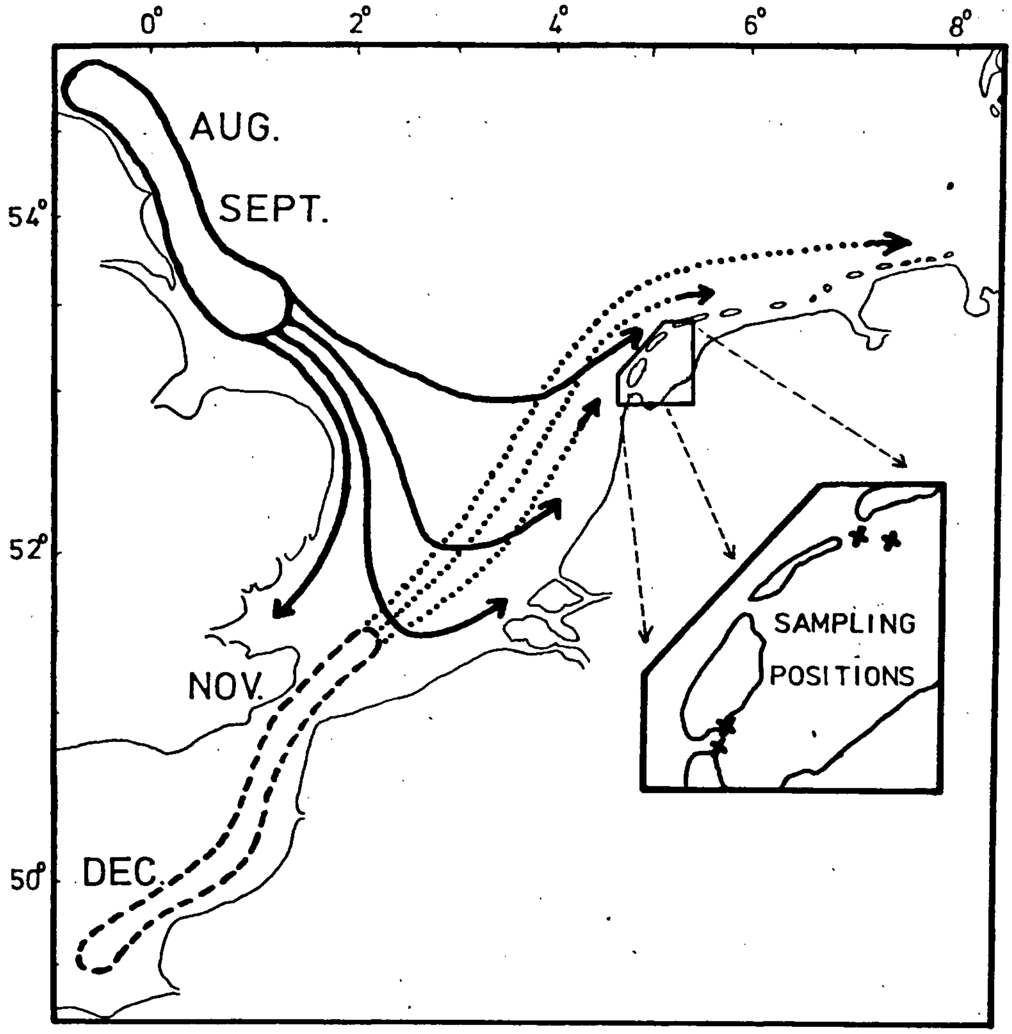

fig. 1. Drift routes of herring larvae born in the central and southern North Sea.
Adapted from Buckman (1950).

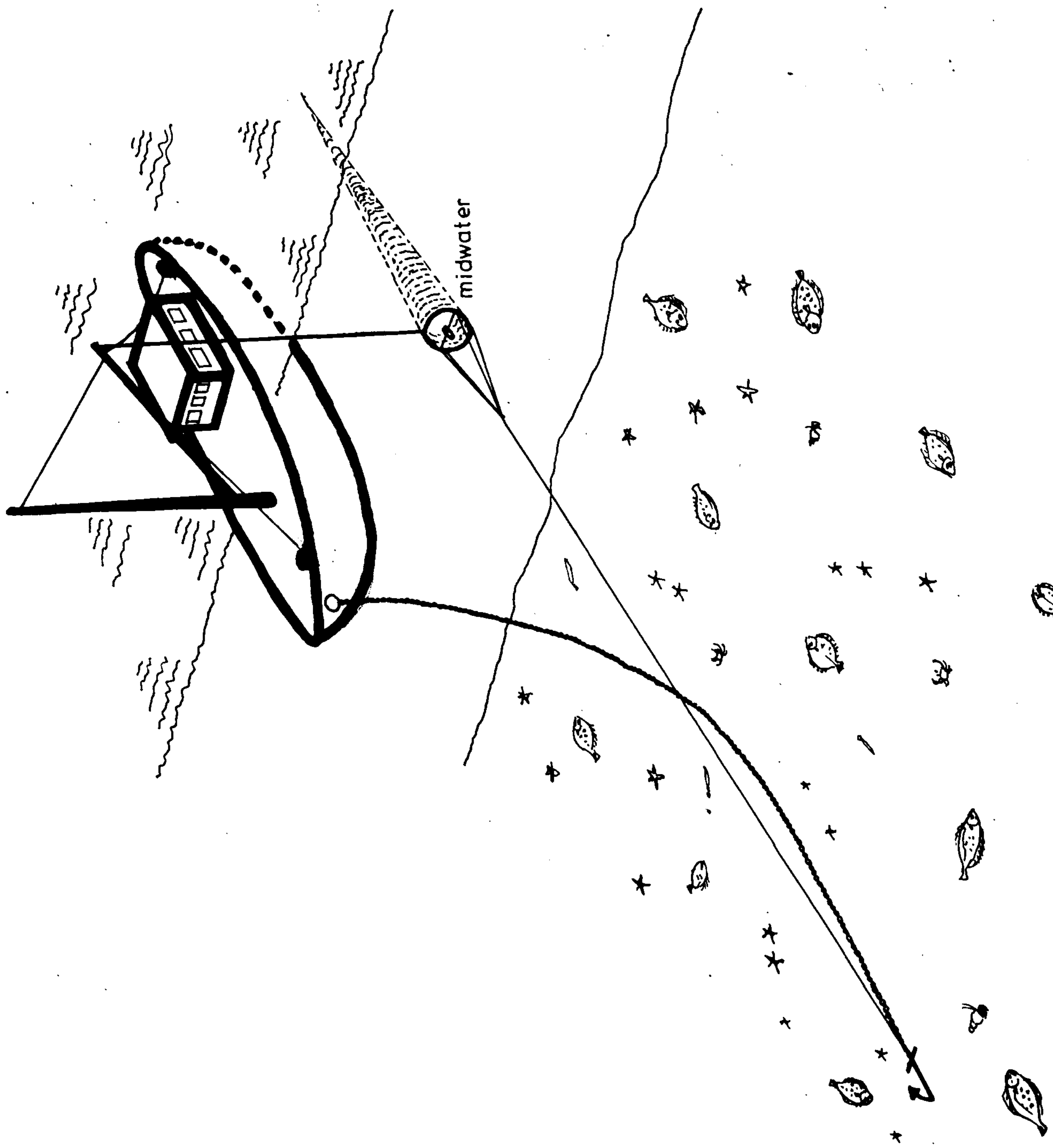

fig. 2. Rigging of the anchored plankton net.

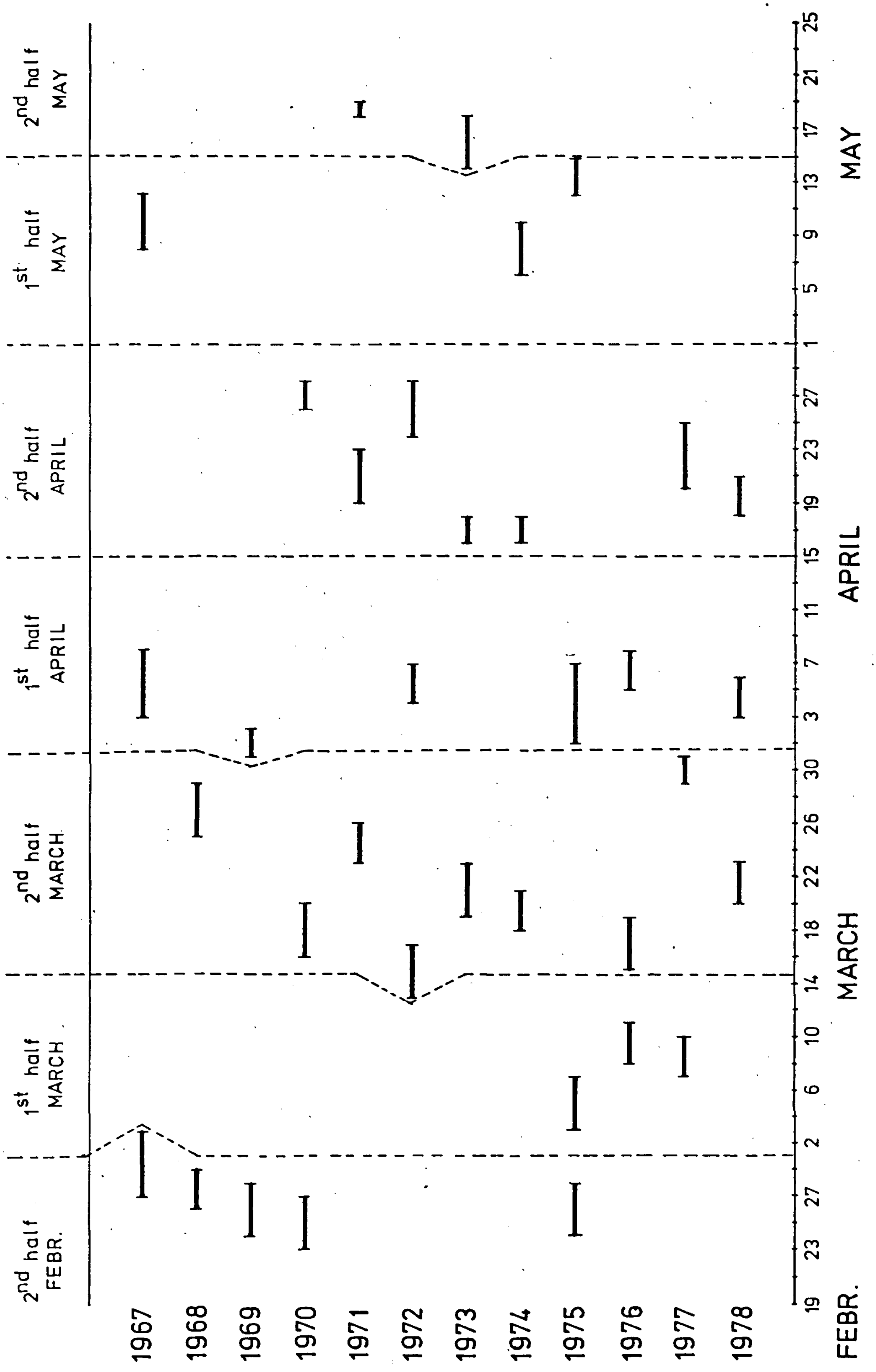

fig. 3. Diagram of all surveys in the period 1967-78 and their allocation to half-monthly periods.

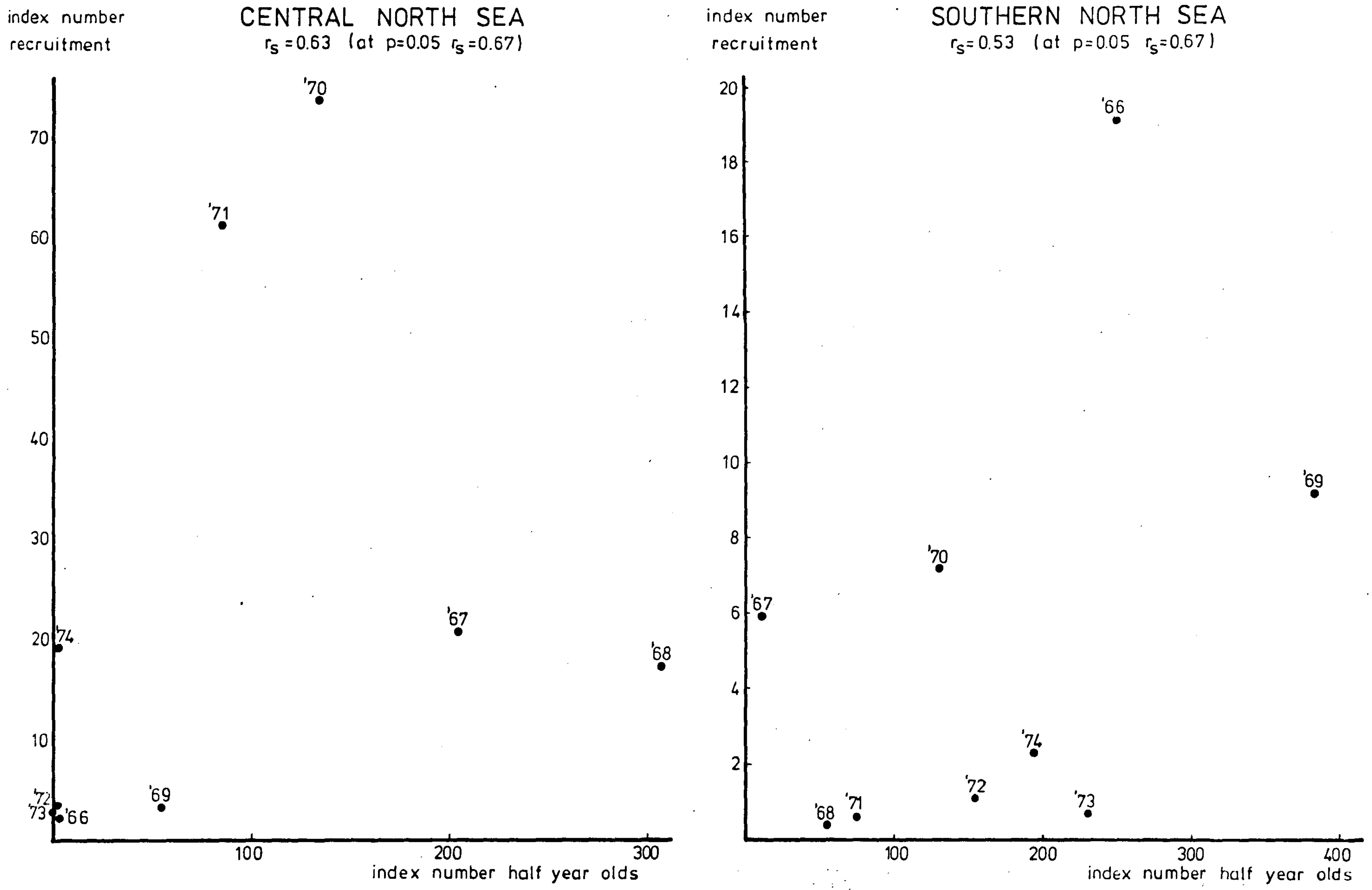

fig. 5. Relationship between abundance of 1/2 year-old herring in the Wadden Sea and recruitment to adult populations of the same year class.

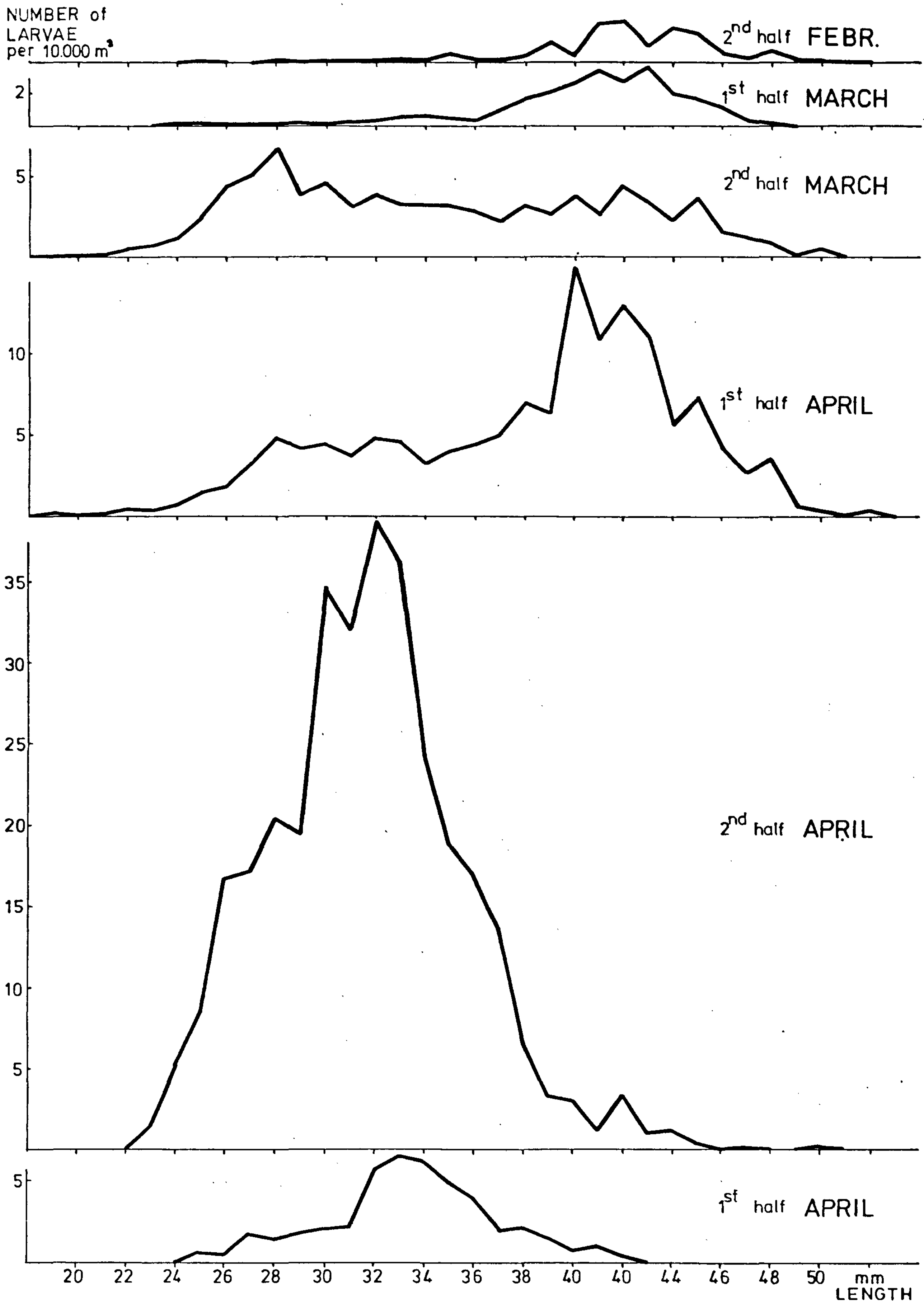

fig. 4. Length distributions of herring larvae sampled in different half-monthly periods. Mean values for all surveys in the years 1967-78.