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Charlottenlund Slot - Denmark

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THE NORTH SEA HERRING

being the Report of the North Sea Working Group to the Herring Committee of ICES

CONTENTS

INTRODUCTION

Since 1955, catches of herring in the Southern Bight of the North Sea have declined. Consequently, the biology of the North Sea herring stocks has been examined thoroughly to find the causes of decline. It has been known for a long time (Johansen, 1924) that there was more than one main stock of autumn-spawning herring in the North Sea. The herring spawn off the Scottish north - east coast in August and September, in the region around the Dogger Bank in September and October, and in the Straits of Dover and the eastern English Channel in November and December. The differences in spawning time and spawning area might in themselves be considered enough to provide evidence of distinctness. However, it is also clear that herring from all three spawning groups mix on the feeding grounds between the Dogger Bank and the Shetland Islands.

A major problem facing the biologists was the identity of stocks. Therefore, in assessing the causes of the decline in the southern North Sea fisheries, the following major problems arose: (1) the identity of stocks and (2) the rate of mixing of fish of the different spawning groups in the feeding fisheries, so that fishing effort could be properly segregated to the different herring stocks. Only when these problems would be solved could good estimates of fishing mortality be made, and then estimates of natural mortality. Hence a rather complex procedure was needed to investigate the causes of failure.

During the 1950s a number of natural changes occurred, in growth, in the pattern of recruitment and in stock quantity. As might be expected, changes in the distribution of fisheries have taken place. Such changes have made the work of elucidating the causes difficult.

The terms of reference for the Working Group were (Procès-Verbal de la Réunion du CIEM, 1960):-

> That, in view of the serious state of many of the North Sea herring fisheries, a Working Group should be set up to meet for 6 days in Copenhagen at a suitable date, to make a detailed appraisal of all existing data on stock separation and identity for the North Sea herring populations and on the effects of fishing on these herring stocks. The findings should be reported to the Herring Committee at its annual meeting in 1961. All countries with herring fisheries in the North Sea should be invited to send participants to the meeting. Dr. D. H. Cushing has been nominated as Convenor for this Group.

The North Sea Herring Working Group met in Copenhagen (24-30 April 1961), Hamburg (30 April-5 May 1962), Copenhagen (30 September 1962) and Ijmuiden (28-29 March 1963). The following took part in the meetings (not all were present at all meetings) :

D. H. Cushing (Convenor)	England
A. C. Burd	
T. D. Iles	
J. A. Gulland	
K. Schubert	Federal Republic of Germany
G Krefft	
G. Hempel	
Mrs. E. Bohl	
A. Schumacher	

B. B. Parrish A. Saville I. G. Baxter	)	Scotland
J. J. Zijlstra K. H. Postuma	)	Holland
K. Popp Madsen K. P. Andersen	)	Denmark
J. Ancellin C. Nédelèc	)	France
Ch. Gilis	)	Belgium
S. S. Fedorov N. P. Birkov	)	U.S.S.R.

The Working Group studied three problems in the biology of the North Sea herring:-

(i) The identity of the stocks in the North Sea and English Channel;

(ii) estimates of stock size;

(iii) mixing of Southern Bight spawners (the Downs stock) in the northern and central North Sea feeding areas. Appendix I of this report gives a method of estimating the mixture, with some results; the method was developed by the Convenor.

The effect of fishing on the North Sea herring, one of the subjects mentioned in the terms of reference, was not examined by the Working Group before its work was terminated in March 1963. However, the question was examined in the work of the Herring Assessment Group (Anon., in press).

Figure I is a chart giving the place names referred to in the text.

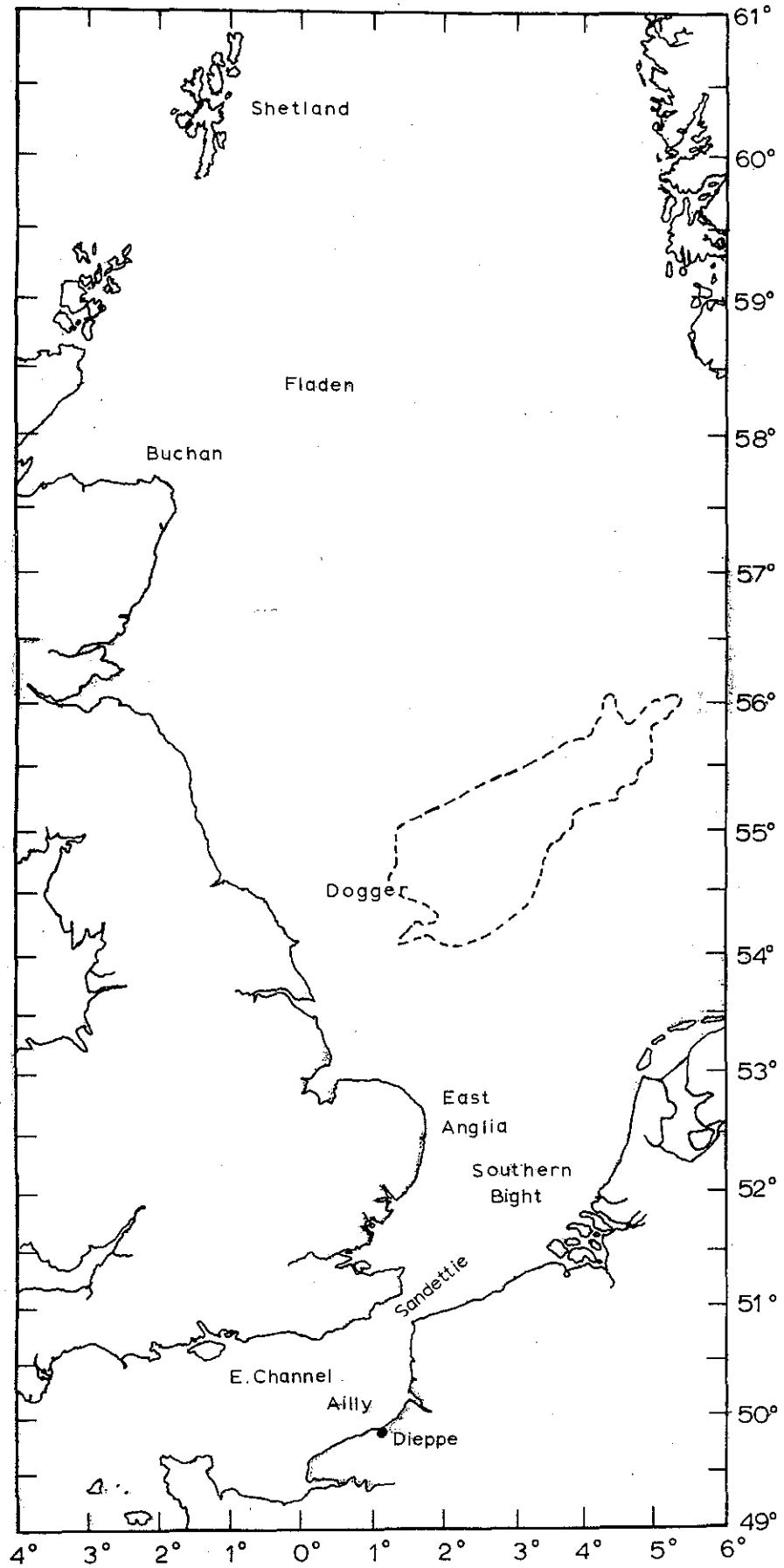

Figure 1 Chart showing positions of places named in the text

PART 1. The identity of the stocks in the North Sea and eastern English Channel

Biological and population characters of herring in the East Anglian fishery and in the southern (Sandettié and Eastern Channel i.e. the Downs fish), central (Dogger) and northern (Buchan) spawning areas were examined with a view to determining the homogeneity of the stocks in the Southern Bight and their relations with the central and northern spawning groups. For this purpose the following characters were examined:

1. Length for age;
2. l_1 ;
3. Otolith types;
4. Vertebral counts;
5. Maturity stages;
6. Mortality rates;
7. Age distributions;
8. Egg size.

1. Length for age

The mean lengths of three-to six-year-old Downs spawners sampled by French, Belgian and Dutch trawlers in the years 1945-61 are given in Table 1a; Table 1b gives mean lengths for age for different periods including the pre-war one; corresponding data for three- to eight-year-old Dogger (Dutch, trawl) and Buchan (Scottish, drift net) spawners are given in Tables 3 and 4 respectively. The values for four- and six-year-olds in each of these spawning groups are also given in Figures 2 and 3 respectively.

(a) Comparison between the East Anglian fishery and the fisheries on the southern spawning grounds (Table 1)

Data were available for comparison from different fisheries in the Southern Bight from 1932-59 (Tables 1a and 1b). The average deviations of the measurements for the various fisheries from the English East Anglian means are given in Table 2. In the period 1952-59 mean deviations from the East Anglian means of $\pm$ 3 mm were apparent in the various estimates of length for age in the ages three to six. The fact that the data comprised measurements of both fresh and "converted" salted herring (caught by drift net and trawl) and were made at varying times after capture when shrinkage may have taken place, could well explain these differences. However, prior to 1952 the English data gave means for the younger age groups consistently higher than those in comparable data from the other fisheries. This is probably due to the sampling methods used before 1955 (Burd, 1958). Ratios of length for age in catches per unit of effort of four-year-old to three-year-old herring were calculated for the French, Belgian and English data for the periods 1946-51 and 1952-59. Their mean values were as follows:-

	France	Belgium	England
1946-51	1.04	1.14	1.58
1952-59	0.59	0.49	0.54

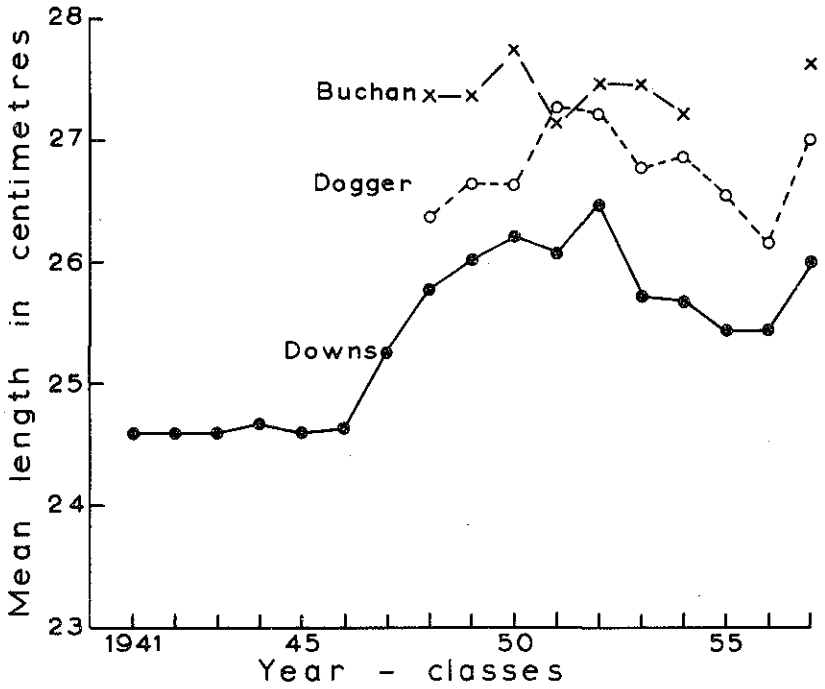

Figure 2 Mean length of four-year-old fish in the three spawning groups for a number of year-classes

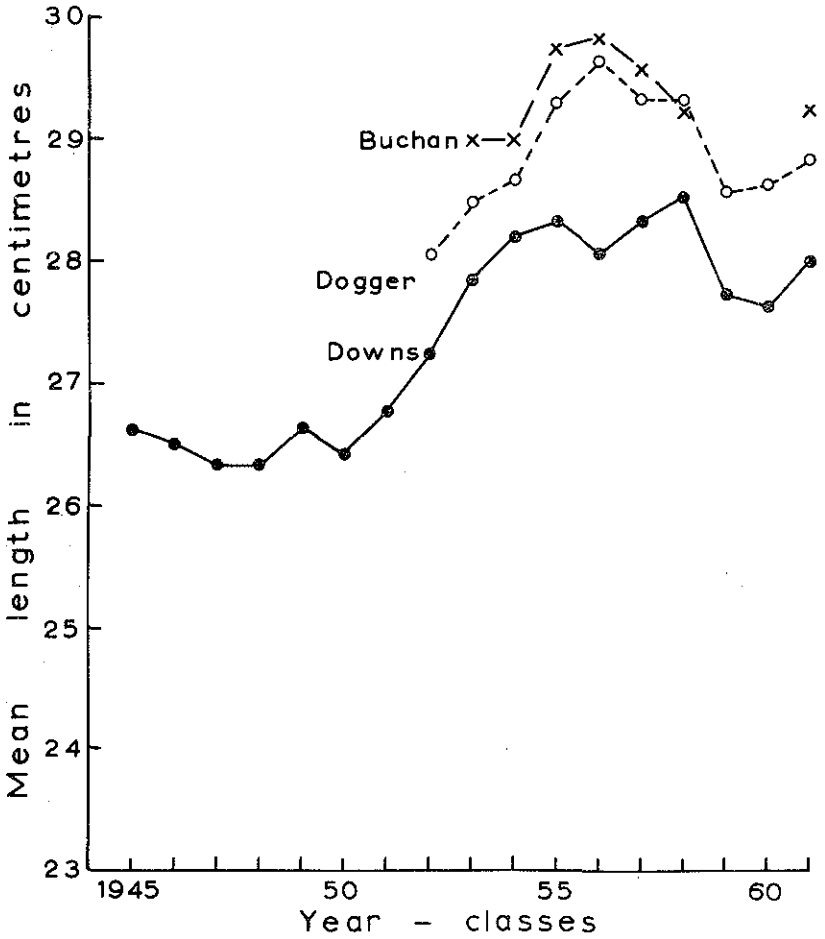

Figure 3 Mean length of six-year-old fish in the three spawning groups for a number of year-classes

The French and Belgian data show the same mean lengths for age; after 1952 the mean lengths for age were the same in all fisheries.

(b) Comparison between the different spawning communities (Tables 1, 3 and 4 and Figures 2 and 3)

These data show that:-

1. There were no consistent differences between the mean lengths for age of Sandettié and Ailly spawners.

2. The Downs (Ailly and Sandettié) mean lengths for age were consistently smaller than those of the Dogger spawners, by about 0.5-1.2 cm for the four- and six-year-old herring.

3. The Dogger mean lengths for age were again lower than those of the Buchan spawners; the range is up to about 1.1 cm in the data available.

2. l_1

The samples of l_1, given in Table 5, were taken from the East Anglian drift-net fishery and in the Belgian trawl and pelagic trawl fishery in the period 1944-57, from the Dutch Sandettié and Channel trawl fishery in the period 1948-57, from the Dutch Dogger trawl fishery in the period 1946-57, and lastly from the Scottish Buchan drift-net fishery in the period 1944-53.

(a) East Anglia-Southern Bight spawning communities

Using the English East Anglian l_1 distribution as standard the data from the Sandettié, Channel, and spent herring fisheries have been compared (Figure 4). It is felt that the differences in l_1 (East Anglian l_1 being 0.8 cm less in the mean) are certainly due partly to differences in technique (Anon., 1962 and Burd and Parnell 1962).

(b) Spawning communities (Table 5, Figures 4 and 5)

1. As with length for age, no consistent differences were shown between the mean l_1s of the Ailly and Sandettié spawners.

2. A consistent difference between the mean l_1s could be observed between the Dogger and Southern Bight (Ailly and Sandettié) spawning communities. The range of differences observed varied from 0.3 to 2.2 cm.

3. A consistent difference was observed between the mean l_1s of Dogger and Buchan spawners. Differences varied between 0 6-1.3 cm.

Between the 1948 and 1951 year-classes an increase in mean l_1, of the same order, took place in each of the spawning groups. The increases were:

1.7 cm (Buchan);

1.9 cm (Dogger);

1.7 cm (Downs).

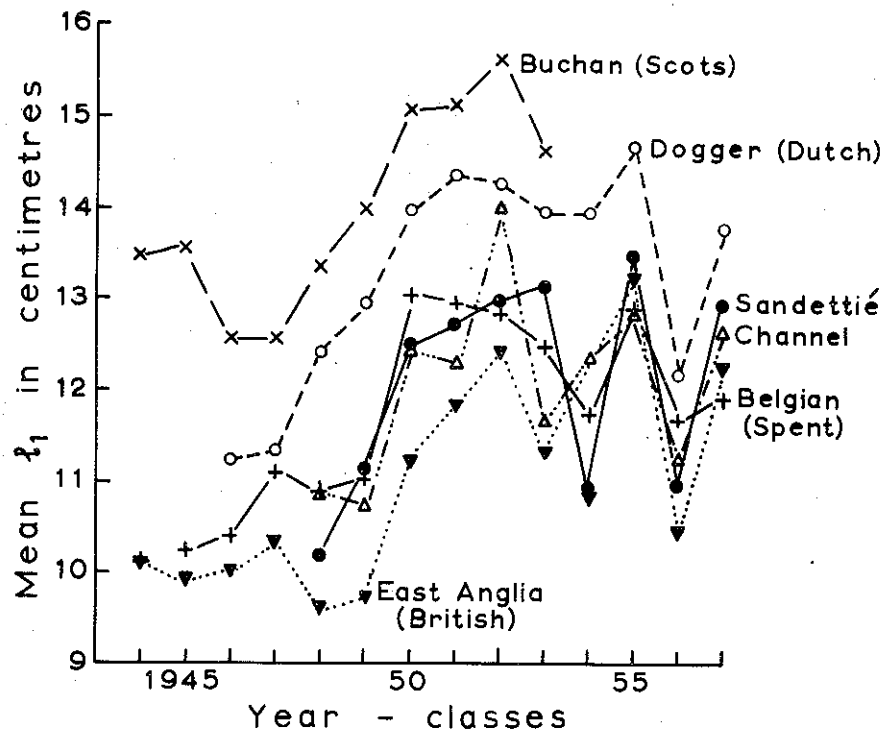

Figure 4 Mean l_1 values for the three spawning groups in a number of year-classes

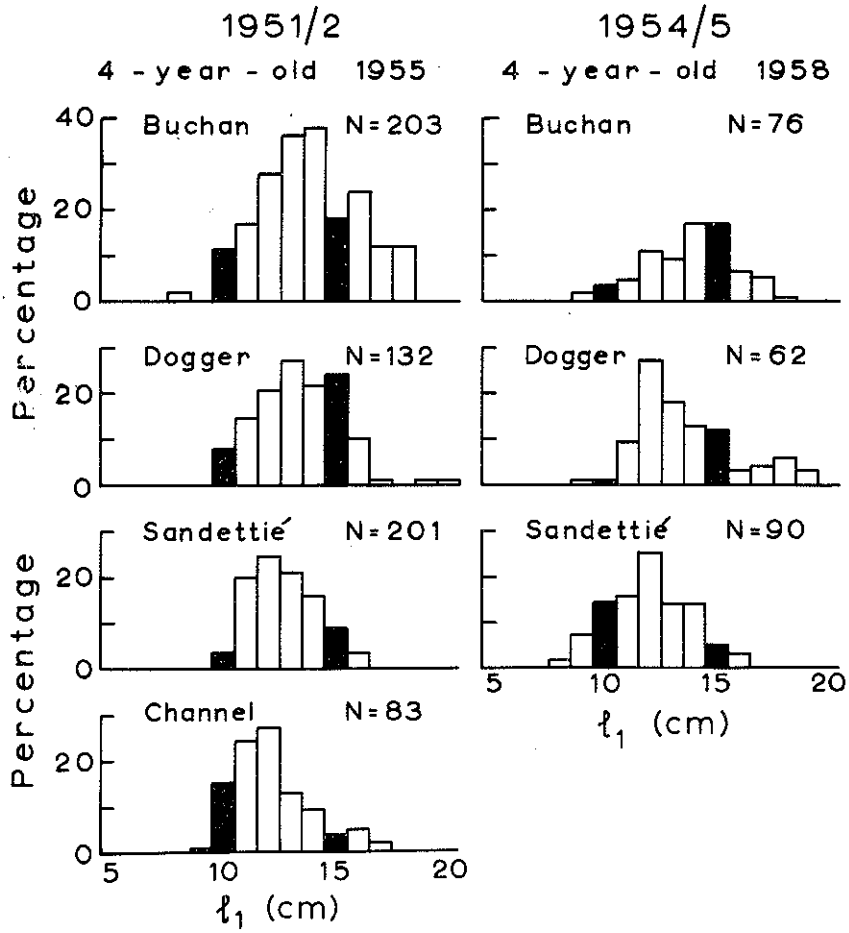

Figure 5 Distribution of l_1 in the three spawning groups for the 1951/2 and 1954/5 year-classes

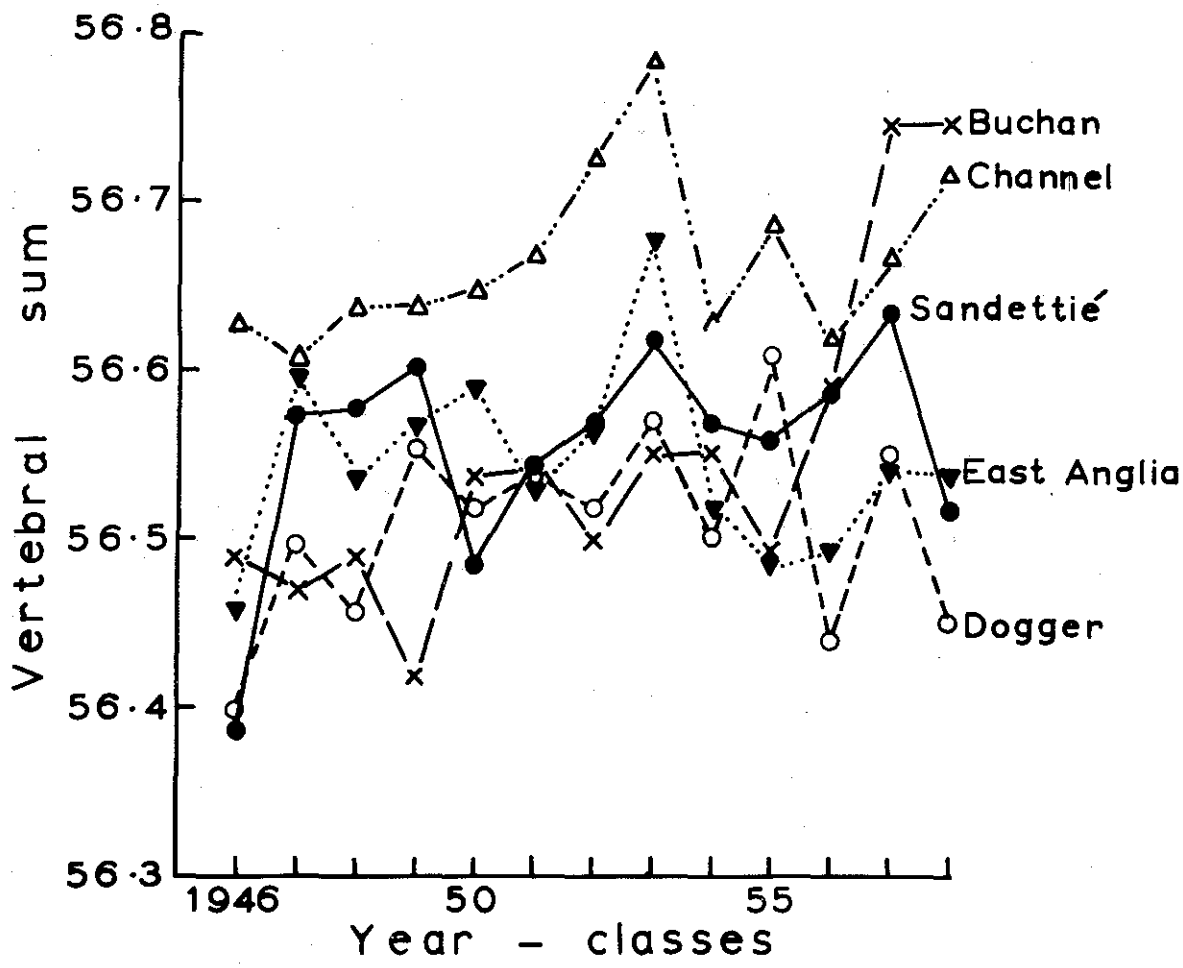

Figure 6 Mean vertebral sum of stage VI spawners in the three spawning groups for a number of year-classes

Further, the increased fluctuations within the year-classes after 1953 were of the same order and direction in the three groups.

Otolith types

In Table 6 are given the percentage of "narrow" otoliths in the Southern Bight and the Dogger in the period 1947-58, from Dutch and English data.

(a) East Anglia-Southern Bight spawning communities (Tables 6a and 6b)

Samples were available from East Anglia, Sandettié and the Channel. The proportions of narrow-type otoliths in these samples are given in Table 6; they show that (i) the proportions of narrows varied considerably between year-classes (Table 6a) and (ii) the percentages of narrows in the same year-class in the Sandettié and Channel were similar, but differed from those on the Dogger (Table 6b).

(b) Spawning communities (Table 6b)

1. The only data available for a split in the percentages of narrows of three- and four-year-old herring were Dutch material from Dogger, Sandettié and Ailly spawners. Complete sets of data for only the 1956 and 1957 year-classes were available. No decline in the percentages of narrows from three to four years of age was observed.

   For the year-classes 1952-58 there were 40% more narrows in the Dogger spawners than in the Downs spawners. No real differences in this respect exist between Sandettié and Channel spawners.

2. Relation of l_1 to percentages of narrows

   Referring to a paper of Zijlstra (1963), two phenomena in the relation between l_1 and otolith types on different spawning grounds can be observed:

   (i) Within a year-class of each spawning stock an increasing percentage of narrows with increasing l_1 can be observed;

   (ii) There is a decrease in the proportion of narrows within an l_1 cm group between Dogger and Downs spawners.

Vertebral counts (Tables 7 and 8, Figure 6)

In Table 7a are given the mean values of VS from the East Anglian drift-net fishery, the Channel trawl fishery and the pelagic trawl fishery in three periods, 1928-37, 1945-51 and 1952-59, from Belgian, Dutch, English, French and German data. The values for the months December, January and February in the Belgian pelagic trawl fishery are given in Table 7b in three periods, 1930-38, 1945-51 and 1951-60. In Table 7c are given values of VS by age for East Anglian, Sandettié and Channel samples.

For the five groups (Buchan, Dogger, Sandettié, Ailly and East Anglia) VS means by year-classes are given in Table 8a for the period 1946-58. In Table 8b these data are grouped into three periods, 1946-49, 1950-54 and 1955-58.

(a) East Anglia-Southern Bight fisheries

Mean vertebral counts for the East Anglian, Sandettié, Channel and Belgian spent herring fisheries were compared. The data, grouped into three periods (pre-1939, 1945-51 and 1952-59) and by month and age groups, are given in Tables 7a, 7b and 7c respectively. No large differences could be detected between periods in any area, but a consistent difference was seen between the the values obtained at Sandettie and in the Channel. In the Belgian spent fishery in the period 1945-51 intermediate values were obtained.

(b) Spawning communities

The mean vertebral counts for the Downs, Dogger and Buchan spawning groups are given in Tables 8a and 8b. Again they show consistent differences from the values obtained at Sandettié and in the Channel. The Channel (Ailly) counts are the highest of all the spawning communities, with the exception of the 1957 and 1958 year-classes in the Buchan spawners.

Comparing the mean values of the spawners arranged in groups of year-classes the following sequence of values appeared: in the period up to 1954 the Ailly fish have the highest values, followed by the Sandettié, Dogger and Buchan spawners. In the last period (1955-58) the values for Buchan spawners increased above the value of the Sandettié and Ailly spawners. According to the periods under observation (Table 8a) a small increase in the mean vertebral counts in all spawning communities can be observed, starting with the year-class 1950/51.

The observed differences between the Dutch and German vertebral counts for Dogger spawners may be due to differences in methods of sampling. As the Dutch material covers the whole spawning season and all spawning places fished, it is probably the more representative; for example, Zijlstra (1963) has shown a consistent decline in the mean vertebral counts within year-classes throughout the Dogger spawning season.

5. Maturity stages (Table 9)

Percentage maturity stage compositions in the English East Anglian fishery are given in Table 9 for the period 1947-60. They show that about 90% of the fish are in stages IV and V, with the exception of 1947 when 42% were in maturities VI, VII and II. In other years varying proportions of these later maturity stages occur, ranging from 2 to 16%.

6. Mortality rates

Instantaneous mortality rates were estimated from age-abundance data for the East Anglian and Channel fisheries. Their values for the periods 1946-51, 1952-59 and 1955-59 are given below:-

Period	Ages	East Anglian (English)	Sandettié and Channel combined (French)	East Anglia (Dutch)	Sandettié (Dutch)	Channel (Dutch)
1946-51	5-7	0.36	0.31			
1952-59	5-7	0.90	0.73			
1955-59	5-7	1.09	1.09	1.03	0.86	1.04

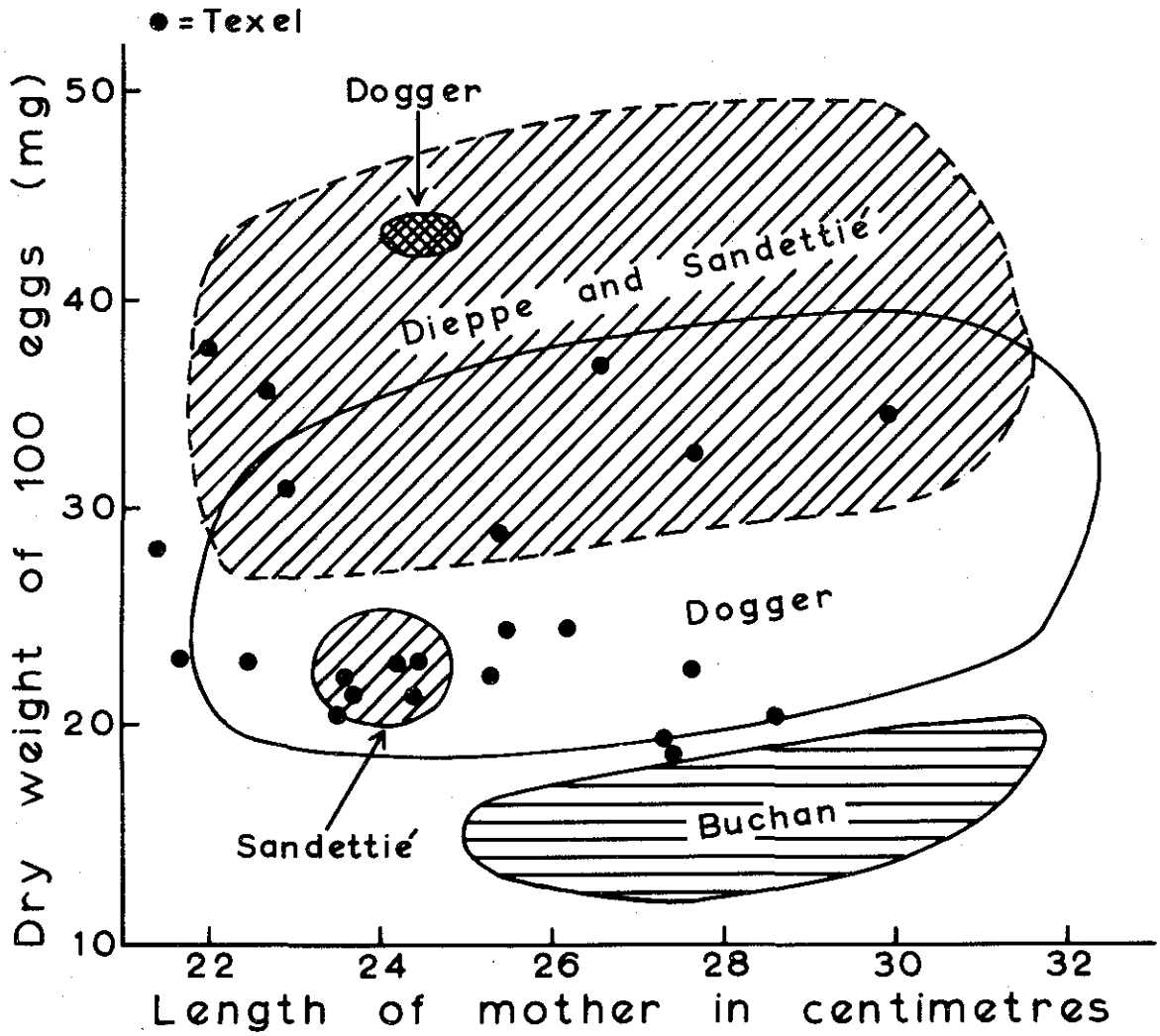

Figure 7 Relationship between dry weight of herring eggs and mean length of the mother in the three spawning groups

These estimates of mortality rate from the different sources are in reasonable agreement.

7. Percentage age distribution (Table 10)

Age-distribution data for the Sandettié and Ailly spawning fisheries were compared for year-class differences within the French, Belgian and Dutch data for the period 1952-61. They are given in Tables 10a and 10b, which show different dominant year-classes on the Sandettié and Ailly grounds; from this analysis the following year-classes (out of ten) appeared to be different on the two grounds:-

Dominant at Ailly		Dominant at Sandettié	
1947/48	(French and Dutch)	1946/47	(French)
1956/57	(French and Dutch)	1951/52	(French and Dutch)
		1955/56	(French and Dutch)

Otherwise the proportions of the other year-classes appeared to be similar in the two sets of data.

8. Egg size (Figure 7)

Measurements of dry weight of ripe eggs taken from a restricted number of females on the spawning grounds showed clear differences in egg size between Buchan herring and the groups spawning further southwards, in which the variability in egg size was much greater. On an average, the eggs of herring spawning in the Dieppe-Ailly area are the biggest. There was a considerable overlap in egg size between herring spawning on the Dogger, at Sandettié and in the English Channel.

9. Conclusions

(a) Southern Bight and eastern English Channel

Consistent differences were found between the mean vertebral counts of fish spawning at Sandettié and in the Channel. These differences were very consistent over the periods 1932-39 and 1946-59. Other characters examined were length for age, l_1, otolith types, age composition and mortality rates; for these no great differences were found between Sandettie and Channel. Growth characters and mortality rates varied in the same way between the spawning fisheries.

Comparing the pre-spawning and spent fisheries, trends in l_1, mean length for age and mortality rates were similar to those observed in the spawning fisheries. The vertebral-count data in the spent fishery point to the occurrence of fish from both spawning areas. This cannot be shown with the vertebral-count material available for the pre-spawning fisheries. As far as characters used in population dynamics are concerned (l_1, length for age, age composition and total mortality) the material is not inconsistent with similarity of the herring in all the fisheries in the Southern Bight area, but it must be stressed that differences in population probably exist between the Sandettie and Channel spawners.

For many purposes the fisheries in the Southern Bight and Eastern Channel can be regarded as exploiting the same stock unit.

(b) Spawning communities in the North Sea and eastern English Channel

Consistent differences were observed between the Downs (Sandettié and Ailly), Dogger and Buchan herring in mean l_1, mean length for age and otolith types. In the case of the vertebral counts differences were found between the different spawning groups (Buchan, Dogger, Sandettié and Ailly). The assumption of the existence of differences in character between spawning populations was strengthened by the material available.

Table 1a. Mean lengths for age (cm)

Downs herring (Stage VI-VII)

(French, Belgian and Dutch data)

Year	Age				
	3	4	5	6	
1945	22.73	24.63	25.86	26.58	French-Belgian data
1946	22.90	24.61	25.71	26.48	
1947	23.15	24.61	25.55	26.31	
1948	23.07	24.77	25.58	26.26	
1949	22.40	24.60	25.53	26.61	
1950	23.52	24.57	25.83	26.42	
1951	23.61	25.36	26.93	26.68	
1952	24.06	25.83	27.00	27.21	French-Belgian-Dutch data
1953	24.27	26.03	26.93	27.80	
1954	24.29	26.23	27.48	28.09	
1955	24.43	26.11	27.41	28.23	
1956	23.63	26.50	27.00	27.93	
1957	23.86	25.69	27.34	28.17	
1958	24.26	25.77	27.07	28.40	
1959	24.05	25.47	26.98	27.56	
1960	23.70	25.55	26.80	27.50	
1961	24.33	26.00	27.03	27.93	

Table 1b. Mean lengths (cm) of age-groups 3-7 of Downs herring

(Data of all countries combined)

Period	Age				
	3	4	5	6	7
1932-39	22.8	24.1	25.3	26.1	26.7
1946-51	23.4	25.0	25.9	26.7	27.1
1952-59	24.4	26.1	27.3	28.1	28.6

Table 2. Deviation of Southern Bight samples from the East Anglian mean lengths for age

(data of Table 1a)

Fishery	Mean deviation from East Anglian mean (mm)	Period
Dutch East Anglian (Drift net)	+ 0.4	1956-59
Dutch Sandettié (Trawl)	- 1.4	1953-59
Dutch Channel (Trawl)	- 1.7	1952-59
French "Spawning grounds" (Trawl)	- 2.9	1952-59
Belgian Spent (Pelagic trawl)	+ 3.3	1952-59
French "Spawning grounds" (Trawl)	- 6.1	1946-51
Belgian Spent (Pelagic trawl)	- 1.6	1946-51
French Sandettié (Trawl)	- 5.5	1933-37
French N. Somme (Trawl)	- 2.4	1933-37
French S. Somme (Trawl)	- 3.1	1933-37
Belgian Spent (Pelagic Trawl)	- 3.8	1932-39

Table 3. Mean lengths for age (cm)

Dogger spawners (Stage VI)

(Dutch data)

Year	Age						
	3	4	5	6	7	8	
1952	25.1	26.4	27.3	28.0	28.9	)	
1953	24.7	26.7	27.8	28.4	28.7	29.2)	(Stages V-VIII)
1954	25.2	26.7	28.2	28.6		29.3)	
1955	25.3	27.3	28.6	29.2	29.6	29.8	
1956	25.1	27.3	28.5	29.5	29.8	30.0	
1957	24.8	26.8	28.4	29.2	29.9	30.4	
1958	25.3	26.9	28.3	29.2	29.8	30.3	
1959	23.9	26.6	28.0	28.4	29.4	29.8	
1960	25.0	26.2	28.0	28.5	29.2	29.9	
1961	25.7	27.2	27.5	28.7	29.4	29.3	

Table 4. Mean lengths for age (cm)

Buchan spawners (Stages VI and VII)

Year	Age					
	3	4	5	6	7	8
1952	26.25	27.43	28.16			
1953	25.95	27.43	28.94	28.91	29.24	
1954	26.11	27.87	28.76	28.90	29.55	
1955	26.71	27.24	28.92	29.60	30.03	
1956	26.00	27.59	28.82	29.66	29.91	
1957	25.79	27.54	28.76	29.42	31.23	30.26
1958	25.50	27.28	28.63	29.10	29.50	30.00
1959	-	-	-	-	-	-
1960	-	-	-	-	-	-
1961	27.75	28.05	28.44	29.14	30.11	30.57

Table 5. Mean l_1 (cm) for Southern Bight and North Sea herring (four- to seven-year-olds)

Year-class	East Anglian pre-spawning (English data)	Belgian spent fishery (Belgian data)	Sandettié spawning (Dutch data)	Channel spawning (Dutch data)	Dogger spawning (Dutch data)	Buchan spawning (Scottish data)
1944	10.1	10.1	-	-	-	13.4
1945	9.9	10.2	-	-	-	13.5
1946	10.0	10.4	-	-	11.2	12.5
1947	10.3	11.1	-	-	11.3	12.5
1948	9.6	10.8	10.2	10.9	12.4	13.3
1949	9.7	11.0	11.1	10.7	12.9	13.9
1950	11.2	13.0	12.4	12.4	13.9	15.0
1951	11.8	12.9	12.7	12.3	14.3	15.0
1952	12.4	12.8	12.9	13.9	14.2	15.5
1953	11.3	12.4	13.1	11.6	13.9	14.5
1954	10.9	11.7	10.9	12.3	13.9	
1955	13.2	12.8	13.4	12.8	14.6	
1956	10.4	11.6	10.9	11.2	12.1	
1957	12.2	11.8	12.9	12.6	13.7	

Table 6a. Otolith types for East Anglia

(Combined English and Dutch data)

Year-class (ages used 3 and 4 years)	Otolith type (% narrows)
1947	22
1948	7
1949	11
1950	45
1951	58
1952	55
1953	43
1954	17
1955	70
1956	25
1957	27

Table 6b. Otolith types for the three spawning communities Dogger, Sandettie and Channel (as percentage narrows, ages 3 and 4)

(Dutch data)

Year-class	Dogger		Sandettie		Channel	
	3	4	3	4	3	4
1952	81	82				
1953	79		37		49	
1954	62		15		19	
1955	90		69	85		68
1956	70	63	36	17	24	25
1957	61	68	26	52	28	57
1958	79		50		55	
Mean	75		39		35	

Table 7a. Mean vertebral counts from the East Anglian drift-net fishery, by area and period [1]

Area	Method of fishing	1928-1937	1945-1951	1952-1959
Sandettié[2]	Trawl	56.56 (F)	56.57 (F)	56.54 (F) 56.53 (G) 56.56 (D)
Channel	Trawl	56.64 (F)	56.65 (F)	56.64 (F) 56.63 (G) 56.67 (D)
East Anglian region	Drift net	-	56.51 (E)	56.54 (E) 56.59 (G)
Belgian spent fishery	Trawl	56.57 (B)	56.59 (B)	56.58 (B)

1) The averages given are averages of mean vertebral counts.
2) B = Belgian data; D = Dutch data; E = English data; F = French data; G = German data.

Table 7b. Mean vertebral counts by month - Belgian spent fishery

Period	December	January	February
1930-1938	56.53	56.60	56.56
1945-1951	56.55	56.60	56.62
1951-1960	56.60	56.59	56.61

Table 7c. Mean vertebral counts by age

Year-class	Age		
	3	4	5
East Anglian fishery (English data)			
1943-1947	56.47	56.53	56.52
1949-1955	56.53	56.55	56.54
Sandettié fishery (Dutch data)			
1950-1956	56.56	56.57	
1950-1955	56.56	56.55	56.58
Channel fishery (Dutch data)			
1949-1953	56.67	56.65	
1949-1952	56.66	56.63	56.70

Table 8a. Mean vertebral counts in the spawning communities by year-classes (Stage VI fish only)

Year-class	Buchan	Dogger	Sandettié	Ailly	East Anglian
1946/47	56.49	56.40	56.39	56.63	56.46
1947/48	56.47	56.50	56.58	56.61	56.60
1948/49	56.49	56.46	56.58	56.64	56.54
1949/50	56.42	56.56	56.61	56.64	56.57
1950/51	56.54	56.52	56.49	56.65	56.59
1951/52	56.54	56.54	56.55	56.67	56.53
1952/53	56.50	56.52	56.57	56.73	56.57
1953/54	56.55	56.57	56.62	56.79	56.68
1954/55	56.55	56.50	56.57	56.63	56.52
1955/56	56.49	56.61	56.56	56.69	56.49
1956/57	56.59	56.44	56.59	56.62	56.49
1957/58	56.75	56.55	56.64	56.67	56.54
1958/59	56.75	56.45	56.52	56.72	56.54

Table 8b. Mean vertebral counts in groups of year-classes (Stage VI)

Year-class	Buchan	Dogger	Sandettie	Ailly
1946/47-1949/50	56.47	56.48	56.54	56.63
1950/51-1954/55	56.54	56.54	56.56	56.69
1955/56-1958/59	56.63	56.51	56.58	56.58

Table 9. Percentage maturity stage compositions for East Anglian fishery

(English data)

Year	Stages VI, VII and II		Stages IV and V	
	three-year-olds	All fish	three-year-olds	All fish
1947	19	42	81	58
1948	15	15	80	84
1949	9	6	89	94
1950	5	5	92	94
1951	10	5	85	91
1952	9	9	83	88
1953	2	3	95	94
1954	8	5	89	92
1955	7	5	91	94
1956	7	7	89	90
1957	9	10	88	88
1958	16	11	83	88
1959	5	7	93	92
1960	15	16	85	83

Table 10. Mean % age distributions of Sandettié and Ailly spawners

(French, Belgian and Dutch data combined)

A. Sandettié

Year	1+	2+	3+	4+	5+	6+	7+	8+
1952	0.6	36.6	15.4	12.3	13.0	8.3	5.5	7.9
1953	0.1	41.7	18.3	9.7	10.1	10.4	5.7	3.4
1954	0.2	50.1	21.8	8.5	4.9	4.3	5.0	5.1
1955	0.1	29.0	34.2	13.8	5.9	4.8	4.1	7.5
1956	0.4	52.3	13.9	12.1	7.6	4.5	2.6	6.4
1957	2.1	62.9	23.8	4.4	3.0	1.4	0.7	1.6
1958	0.6	41.7	37.8	12.3	2.9	2.2	1.5	1.1
1959	1.2	73.5	15.1	5.9	2.8	0.6	0.5	0.3
1960	5.3	63.0	26.1	3.1	1.8	0.3	0.2	0.1
1961	0.7	73.1	19.5	5.9	0.5	0.3	0.1	-

B. Ailly

1952	-	20.5	16.7	18.6	13.0	13.5	5.0	12.4
1953	-	33.2	26.3	8.4	13.2	7.0	6.3	5.4
1954	-	28.1	25.6	12.3	8.4	11.6	7.1	6.5
1955	-	25.9	20.2	18.2	15.9	6.8	5.4	7.7
1956	0.1	52.3	15.2	7.8	12.2	5.8	2.5	4.3
1957	0.7	61.4	28.3	3.6	2.5	1.4	1.4	0.6
1958	0.8	25.5	46.1	18.8	3.9	3.1	1.1	1.1
1959	1.7	80.6	6.4	6.6	2.3	0.9	0.9	0.5
1960	0.8	45.9	44.6	3.2	3.1	1.5	0.5	0.5
1961	0.3	74.0	14.6	10.2	0.3	0.4	0.3	-

Part II. Estimates of stock size

The discussions of the Working Group in 1961 and also during the Herring Symposium (1961; the report was published in 1963 as Vol. 154 of Rapp. Cons. Explor. Mer) stressed the desirability of estimates of the relative sizes of the main stocks of herring in the North Sea. Therefore the Working Group examined the methods and assumptions used in estimating relative stock sizes and in checking the comparability of the results.

1. Comparison of estimates of larval abundance from Downs, Dogger and Buchan spawning

The estimates of larval abundances produced by Bridger (1959) and Chandler (unpublished) for Downs herring and by Saville (unpublished) for Buchan herring differ to a very great extent. The number of larvae produced in the north were about thirty to forty times higher than in the south. Zijlstra (1963) estimated that Dogger larvae were about ten times more abundant than the Downs larvae. In an attempt to correct the larval data to a relationship which seemed to be more probable, Cushing recalled Bridger's (1960) hypothesis of the unviability of the progeny of three- and four-year-old Downs spawners. The Working Group reconsidered the biological and statistical basis for that hypothesis. When the date for 1959 and 1961, treated in the same way as Bridger's original data, were incorporated in Bridger's regression the hypothesis failed statistically. The Working Group also produced a new refined set of data on larval abundance and spawning potential of the stock. This new set is based on the total abundance of larvae in the Southern Bight in mid-January. The relationship between the abundance of larvae in January in the Southern Bight and the total larval production of Downs herring will differ from year to year due to differences in spawning time, larval mortality and hydrographical factors such as water movements and temperature. It is probably, however, a more reliable index of annual variations in larval production than the sum of a variable number of estimates at different times within a spawning season. The estimate of the spawning potential is based on the number of herring (maturity stages III to V/VI) per unit effort caught in the East Anglian fishery. The data derived in this way show a correlation between stock size and larval abundance (Table 11). The negative intercept was nearly the same as that described by Bridger (1960). As with Bridger's results, the intercept was not signigicantly different from zero and therefore cannot be considered as a basis for any far-reaching conclusions.

Bearing in mind the differences in the biotic and abiotic environment it was considered that the mortality rate of Buchan larvae may be different from that of the Downs larvae. Furthermore, the age-distribution, the rate of dispersion, and the sampling methods used were not the same in the north and in the south. Therefore, the Working Group was of the opinion that at least in the present state of our sampling a comparison of stock size by means of figures on larval abundance should be treated with great caution.

In spite of the lack of a statistical significance for Bridger's hypothesis its biological basis has been reconsidered in the light of experimental work recently done on Downs herring (Blaxter and Hempel, 1963). The following items have been investigated:

(a) Parental effect

Parental effects reducing considerably the chances of survival of the

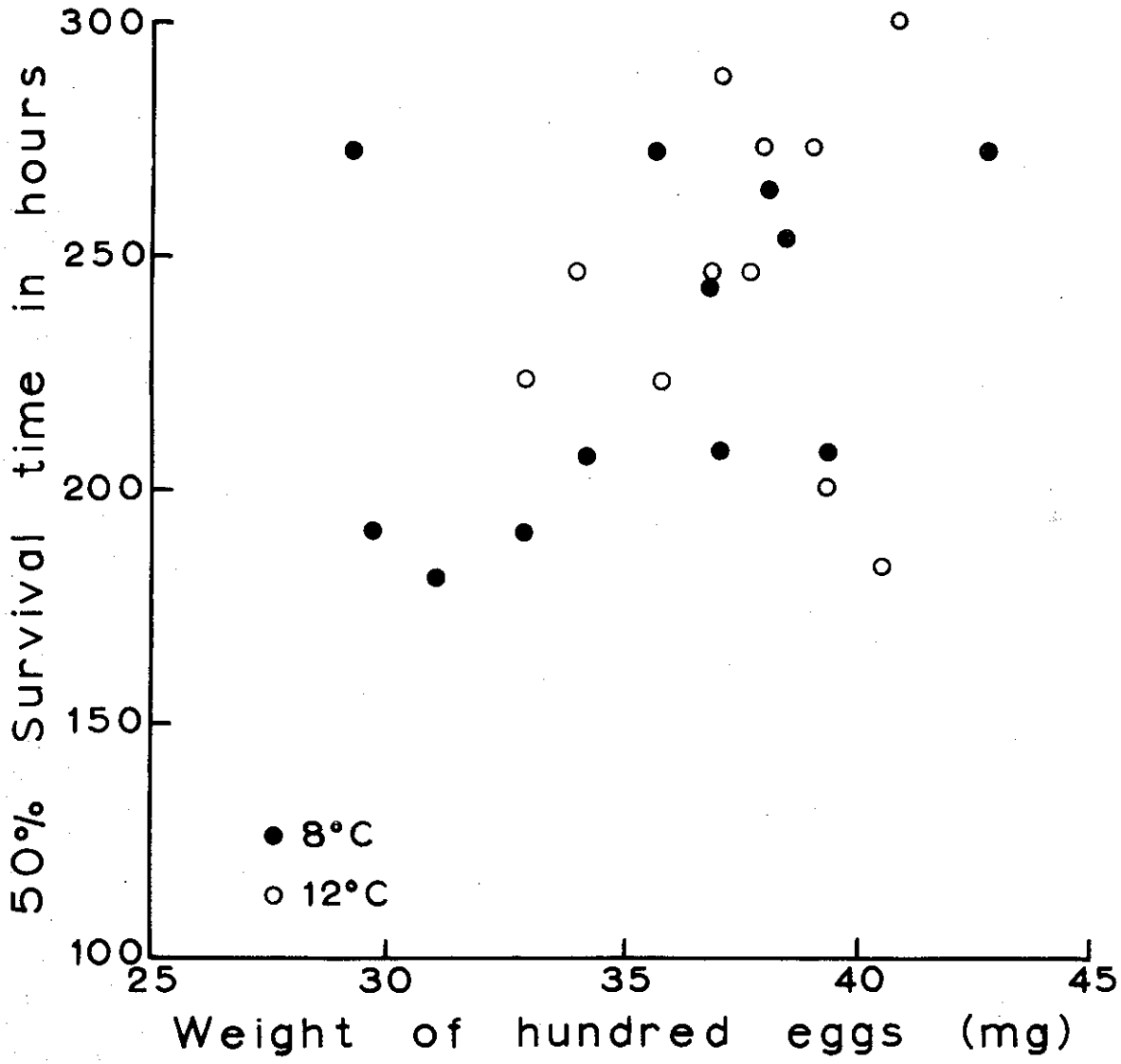

Figure 8 Dependence of survival time of larvae on egg weight

progeny of young spawners have not been found. The following factors were considered:

(i) Differences in egg size. At Sandettié and Dieppe there is no striking increase in egg size with age of the parent fish (Table 12); on average, eggs of recruit spawners are 9% lighter than those of older fish.

(ii) Differences in the quality of eggs. Until now only the content of fat and water for a small number of herring has been measured. No obvious relationship of size and quality of eggs to fat content or condition factor of the mother was detectable. For reliable results far more analyses are needed.

(iii) Differences in the fertilizability. In the experiment eggs and sperm of recruits proved to be fully fertilizable.

(iv) Survival time of starved larvae. The results of the experiments on Downs eggs and larvae were not very consistent. Figure 8 suggests an increase of lifespan with egg size, but it is not statistically significant. Blaxter and Hempel (1963) summarised the results of comparative rearing of eggs of old fish and of recruit spawners as follows: average maximum dry weight of larvae (attained on the yolk) will be 0.16 mg for larvae from recruit spawners, as compared with 0.17 mg for larvae from older fish. The "point of no return" will be reached one day earlier in larvae spawned from recruits.

(b) External factors

Externally-caused differences in viability between the offspring of young and old herring within a spawning community can only arise if differences in time and/or area of hatching are consistent. This does not seem to be true for the spawning of Downs herring. A difference in spawning time between younger and older fish at Sandettié and in the Channel, if it exists at all, is not so pronounced as has been assumed by Bridger (1961). Actual data on the distribution of age-groups with time on spawning grounds would be of great value.

Nevertheless, the Working Group gave some consideration to changes in the environment during the season.

(i) Differences in temperature

The eggs of fish spawning early in the season incubate and hatch at a higher temperature than those of later spawners. Comparative survival experiments at $8^{\circ}C$ and $12^{\circ}C$ showed that the mean survival time in terms of day-degrees tends to be about the same in both temperatures or to be a little longer in warmer water.

(ii) Differences in light intensity

Herring larvae do not feed in darkness. Larvae hatching at the end of November meet the shortest days of the year at the time when they should start feeding. The spawning season of Downs fish, however, is not long enough to result in large differences in day-length.

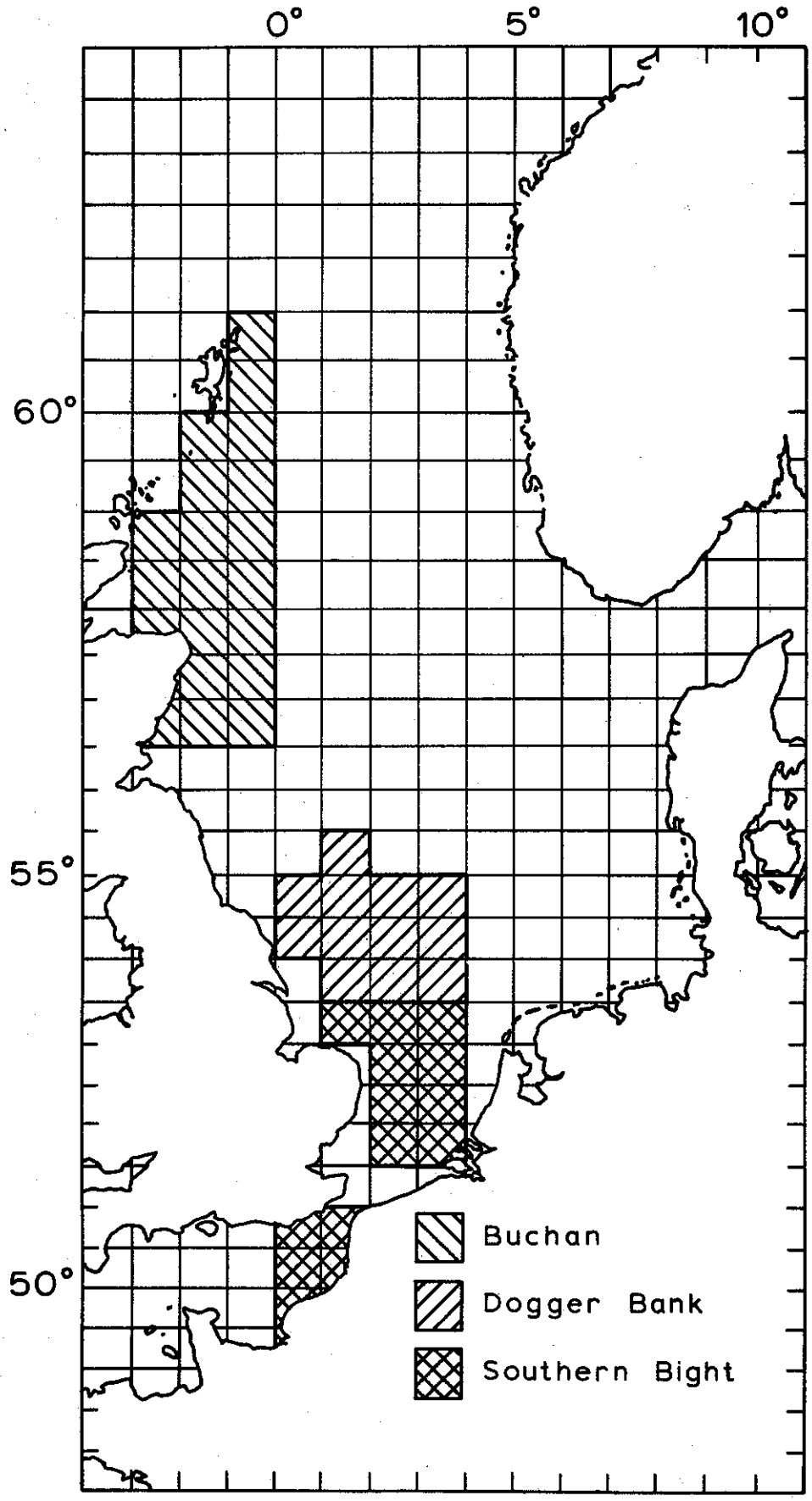

Figure 9 "Assembly areas" for fish in maturity stage V, used in estimating stock sizes in the three spawning groups

(iii) Differences in food supply

In 1961/62 food organisms were several times more abundant at the end of November than in January (Williamson, personal communication).

(iv) Differences in the abundance of predators

In 1961/62 predators such as large Sagitta and Pleurobrachia were found to be more abundant in November/December than in January. It would be useful to find out whether spent herring are important predators on young herring larvae in the Southern Bight.

Summing up, no biological evidence has been produced to suggest that the viability of larvae from recruit spawners should be remarkably less than that of larvae from older spawners. It may be mentioned that there were large numbers of larvae in 1961 in the south, derived mainly from recruit spawners. It would be interesting to follow up the future fate of that progeny.

The Working Group recommends that since sampling in the Southern Bight seems to provide a method of detecting large-scale changes in spawning potential, for that purpose one cruise covering the whole area of distribution at a fixed time after the main spawning might give results more comparable between years. Better information on the actual spawning time on the different spawning grounds in different years would be very valuable in this context.

Estimate of stock size from abundance of recruits

(a) Method $\overline{P}_N = \frac{R}{Z} \cdot (1 - e^{-Z\lambda})$

where $\overline{P}_N$ is the average stock size;

R is the recruitment in absolute numbers;

Z is the instantaneous coefficient of total mortality;

λ is the duration of the fishable lifespan in years.

Estimates were made for groups of years for which there were adequate data, using mean values of the parameters for the periods considered.

(b) Methods of estimation of parameters

(i) Recruitment

This was estimated as the density of recruits multiplied by the relative sizes of the assembly areas of ripening fish.

Downs

Figures of recruit density from drift-net catches were derived from catches of all maturity stages in the East Anglian fishery. Twelve statistical squares were used to describe the assembly area, as shown in Figure 9.

Dogger

Figures of recruit density at three years of age were derived from Dutch trawl catches of stage-VI fish; by rough inspection no partial recruitment was observed in the age-distributions from 1956-61. Twelve statistical squares were used to describe the assembly area, as shown in Figure 9.

Buchan

Partial recruitment was observed in the Buchan age-distributions from Scottish drift-net catches and so the sum of the three- and four-year-old fish in density of year-classes was used. It was thought by the Scottish workers that the densities underestimated the abundances, due to the nature of the fishery. Eighteen statistical squares were used (see Figure 9) to describe the assembly area.

(ii) Effort

The East Anglian fishery and the Buchan spawning fishery are drift-net fisheries, whereas the Dogger fishery is a trawl fishery. Therefore a trawl/drift-net factor is necessary. Comparing German trawl catch per unit effort at Sandettié with drift-net catch per unit effort (English drifters) from 1951-54, the factor was 2.5; comparing Dutch trawl catches per unit effort on the Dogger with Dutch lugger catches per unit effort, the factor was 2.05 (2.74 x 0.75, because the Dutch use 120 nets per boat and the English and Scots use 90 nets) from 1956-60; comparing German trawl catch per unit effort the factor was 2.76. The vulnerability of herring in stage VI, however, may be different from that in other maturity stages.

(iii) Mortality estimates (Z)

Downs: Z_{5-7} from East Anglian fishery.

Dogger: Z calculated from ratio of all ages in year n to all ages except three in year n + 1.

Buchan: Z calculated from annual survival rates (Parrish and Craig 1963).

The mortality rates in the Buchan fishery and in East Anglia were highly variable.

(iv) The fishable lifespan (λ)

λ was taken as eight years in the Buchan and Dogger fisheries and as five years in the Downs fisheries; so t_λ = 11 in Buchan and Dogger, but t_λ = 8 in the Downs fisheries.

(c) Results

Results of these abundance estimates are given in Table 13. Any estimate of abundance obtained in this way is dubious because the herring is a pelagic species exploited by a seasonal fishery; all densities may be affected by availability differences. However, all estimates for the three stocks lie within an order of magnitude. The Dogger stock is probably underestimated relative to the others because only three-year-old fish in

stage VI were used rather than part of stage V and all stages VI and VII. The Buchan stock is overestimated by the measure of partial recruitment used and underestimated in density. The three areas used are arbitrarily chosen as areas in which fish in ripe maturity stages are found, i.e. as estimates, although poor ones, of the stock areas. The best estimate in Table 13 (in the quality of material used) is that of 1955-59. This shows that the Buchan stock is larger than either the Downs or Dogger stock.

Abundance estimates by means of the Blϕden stock and Blϕden catch

Using the stock data derived from the Blϕden tagging experiment Cushing estimated the size of Downs stock relative to the other groups of North Sea herring, assuming that the proportions of the different stocks in the North Sea were the same as in the Blϕden fishery. On the basis of the first tagging experiment (Aasen et al., 1961) and the total catch related to this, he calculated the Downs to be about 1/3 to 1/2 of the total stock; the second tagging experiment, treated in the same way, would give a somewhat lower proportion of Downs fish. It should be pointed out that the estimate of the proportion is very sensitive to small changes in the values of F. The main assumptions in these calculations are:

1. that the Blϕden population, as sampled by the tagging experiment, is the only source of recruits to the Downs stock;

2. that there are no other nursery grounds in the North Sea where mainly Buchan and/or Dogger herring are found;

3. that there is no segregation in time or space between different components of the Blϕden population;

4. that the fishing mortality on the Blϕden ground as calculated from the Blϕden tagging experiment is the same for the three stocks.

None of these assumptions can be substantiated in the present state of our knowledge. A provisional examination of them revealed that at least in some years young herring are found west of the Dogger. In addition Danish catches show that in the Skagerrak a group of young herring (presumably Bank herring) is present, which is about one quarter as large as the Blϕden population.

Bearing in mind the limitations outlined above, these results also point to the abundance of the three stocks lying within an order of magnitude.

The Working Group felt that an appropriate working up of material from the young herring surveys and of the Blϕden material should be done before any reliable calculation of the proportions of the three stocks can be derived.

General conclusions

The Working Group felt that the data available were inadequate to reach reliable estimates of relative stock sizes of North Sea herring by any of the methods described. All of them point to the three stocks being within the same order of magnitude, the Downs stock being smaller than at least the Buchan one during the late fifties.

Table 11

Abundance (minimum estimate) of herring larvae in mid-January in the Southern Bight, and spawning potential of Downs herring estimated from the catch per unit effort in the East Anglian fishery of fish in maturity stages III to V/VI

Year	Larval abundance	Spawning potential	Total larval production (larvae/day x 10^{-9}) estimated by Bridger (1959) and Chandler (unpubl.)
1946/47	450	-	38.0
1947/48	950	10.0	45.4
1950/51	300	14.9	20.4
1951/52	300	14.0	18.4
1955/56	100	6.2	6.4
1956/57	55	7.1	4.6
1957/58	12	5.6	1.2
1958/59	63	3.7	6.2
1959/60	8	4.3	3.1
1960/61	16	2.4	14.0
1961/62	56	5.2	32.6 (provisional figure)

Table 12

Average dry weight of eggs (in mg per 100 eggs) in relation to age of parent fish

Area	Age 3		Age 4		Age 5		Age 6	
	Wt	n	Wt	n	Wt	n	Wt	n
Buchan	16.0	5	15.7	10	15.3	25	17.1	8
Dogger	26.2	35	26.8	5	27.2	10	29.1	8
Texel	25.5	19	27.7	4				
Sandettié	34.0	36	36.3	11	42.3	2	36.8	1
Dieppe	38.8	21	38.2	12	38.2	12	40.3	5

Table 13

Abundance estimates for the three main stocks of North Sea herring. Figures in brackets allow for abundance of herring in the Shetland area

Year	Buchan	Dogger	Southern Bight
1930-38	66.4 (46.8)	-	290.4
1946-60	-	-	447.6
1949-52	129.6 (356.4)	-	-
1950-55	-	-	182.4
1955-59	237.6 (167.4)	124.5	132.0
1958-61	408.6 (390.6)	361.4	249.4*

* This figure includes the year-class 1958 sampled in 1961-2; as estimate of stock in the summers of 1959, 1960 and 1961, this estimate is biassed upwards.

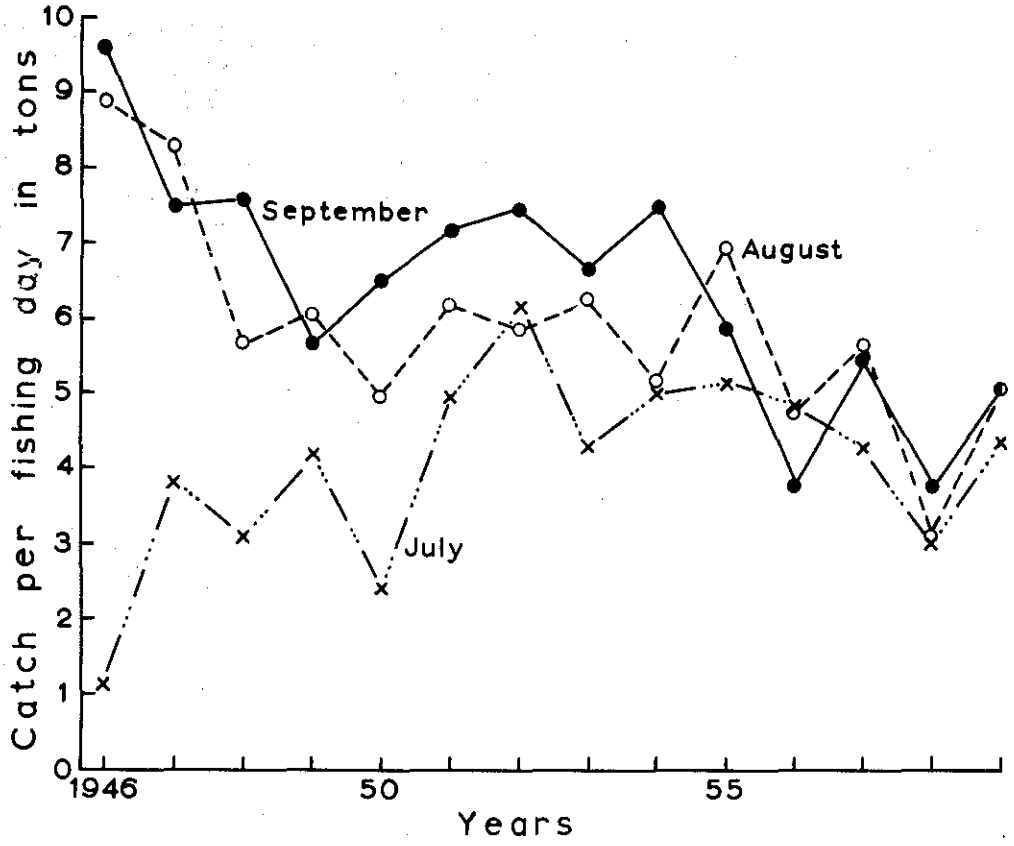

Figure 10 German trawl catches/fishing day on the Fladen ground in July, August and September

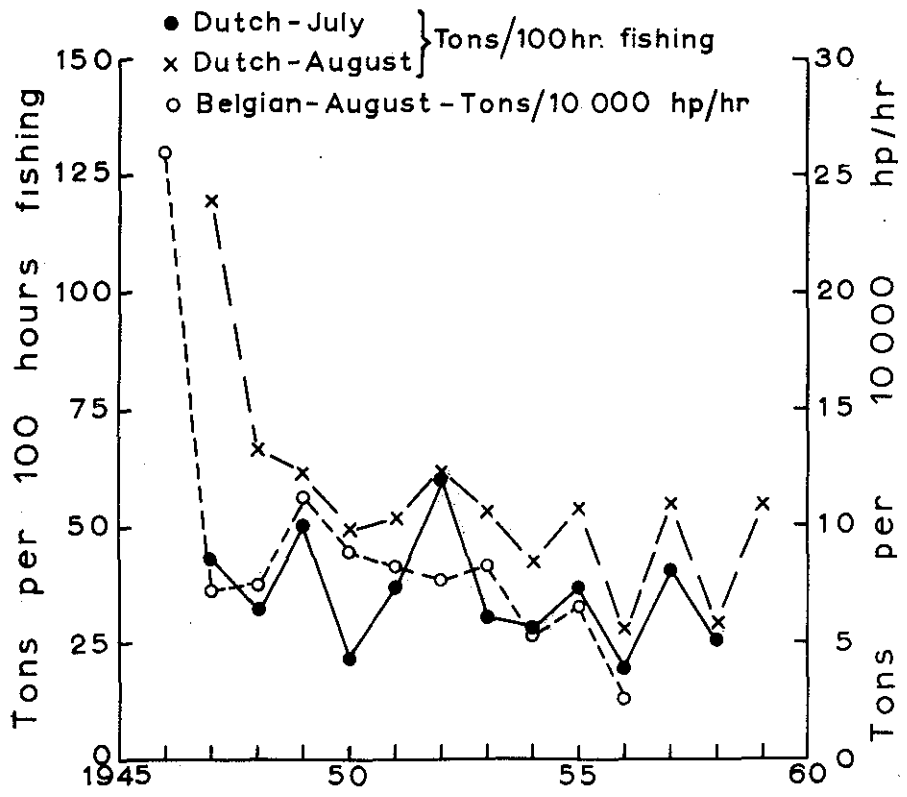

Figure 11 Dutch and Belgian trawl catches/unit effort in July and August

PART III. Mixing of Southern Bight spawners in the northern North Sea feeding areas

The Working Group considered further the problem of the mixing of northern, central and southern North Sea spawners on the northern North Sea feeding grounds in the light of (a) data presented at the first meeting of the Working Group;(b) information contained in contributions to the Herring Symposium and other publications; (c) new data on the composition and biological characters of herring sampled in the Fladen area.

1. Evidence from changes in catch per unit effort of German, Dutch and Belgian trawl and Scottish drift-net fisheries and from age-compositions of catches

The Working Group first examined the post-war changes in the catch per unit effort in the German trawl fishery at Fladen on a monthly basis. The catch, effort and catch per unit effort in each of the months June-October, for the years 1946-61, are given in Tables 14 and 14a; the two estimates of effort are:-

(a) the fishing days of German trawlers, unadjusted for changes in fishing power;

(b) the same data, weighted by fishing power factors, derived by Lundbeck (1962).

The catch per unit effort estimates using the adjusted effort data are given in Figure 10.

Both sets of estimates show that, although for all months combined there was a marked increase in catch per unit effort between 1950-1952, the monthly data show that this change took place mainly in July and September. The main fishery in August showed no marked upward trend during the period 1948-1955, but fluctuated about a mean of 6 tons/day (adjusted effort), and thereafter declined.

The catch and effort data show that in the years up to 1952, the July fishery was a relatively small one, yielding only 10-15% of the August catches; after 1952, however, the July catches increased and averaged about 50% of the August ones. It is possible, therefore, that the increase in catch per unit effort in the July fishery after 1950 was at least partly the result of a general expansion of the fishery in this month. It should, however, be noted that the high catch per unit effort in 1951 occurred with a very low fishing effort. For September also, the fishing effort decreased to a low level during the period of increasing catch per unit effort in the years 1949-1952.

In Figure 11 are given the data of catch per unit effort for the months of July and August in post-war years for the Dutch and Belgian trawl fisheries in the northern North Sea (sub-area B in tabulations of Past Time herring statistics - Statistical News Letter, No. 11A). The Dutch July and August data in 1950-1952 show the same general changes as in the German fishery, viz:-

(a) the main changes occurred in the July fishery;

(b) the catch per unit effort rose from a low 1950 value to a peak in 1952, and decreased again in 1953;

(c) the changes in the August values were smaller, but trending upwards after 1950 to a peak in 1952.

The Belgian catch per unit effort shows no increases over this period, but declined slowly between 1949 and 1953.

From the data available, therefore, it seems that, for the main part of the Fladen fishing season in August, changes in total stock abundance over the years 1950-1955 were small. However, in July the changes seem to have been greater; relative to the preceding and succeeding years, total abundance appeared low in 1950, and it then built up rapidly to a peak in 1952, followed by a general downward trend.

Unfortunately, age-composition data for the Fladen catches in the period up to 1953 are scanty; only limited sampling of the German and Belgian fisheries was undertaken in these years. However, the available data for this area and for the Dogger, Buchan spawning (Aug. - Sept.) and East Anglian fisheries are given for the years 1949-1955 in Table 15.

The most striking feature of the Fladen age compositions over the period of change, revealed by both the German and Belgian data, was their relatively high average age, and the appearance in 1952 of a large percentage of fish older than 8. Similar relatively high proportions of the older age groups were also recorded in the samples from the Buchan pre-spawning and spawning fisheries during this period (Parrish and Craig 1963). In 1951 and 1952 the older age groups appeared in September (Scottish data), and in 1953 and 1954 they appeared in August and September (German data).

It seems, therefore, that despite rather wide variations in the data in the period 1950-1952 there was an increase in the abundance and/or accessibility of the older age groups on the northern North Sea feeding grounds and that the change in catch per unit effort was probably partly due to this. Since these age groups did not appear prominently in the Southern Bight catches, but were more prominent in the Buchan spawning area, it seems that the rise in catch per unit effort of the Fladen and north-western North Sea fisheries between 1950-1952, in September at least, was due to an increase in the abundance or accessibility of northern North Sea spawners, rather than an increase in the mixing of Southern Bight spawners on the northern feeding grounds. The increase in catch per unit effort in July 1951, because of lack of data, cannot be specified to a particular spawning stock.

2. Maturity stages

The Working Group examined maturity-stage data for the German fishery at Fladen in the years 1953-1960 (Table 16), the Buchan pre-spawning fishery in June and July, and the Belgian fishery in the north-western North Sea (Table 17*). Unfortunately, no German data for the Fladen area are available for the years 1950-1952.

The most striking features of these data are as follows:-

(a) In July, the percentage of maturity stages II and III, for all age groups combined in the German material for Fladen, fluctuated widely during the period 1953-1960, but showed no obvious trend. High values were recorded in 1955 and 1959, which were years when strong year-classes recruited to the north-western North Sea fisheries.

* Sampling in most years, in August.

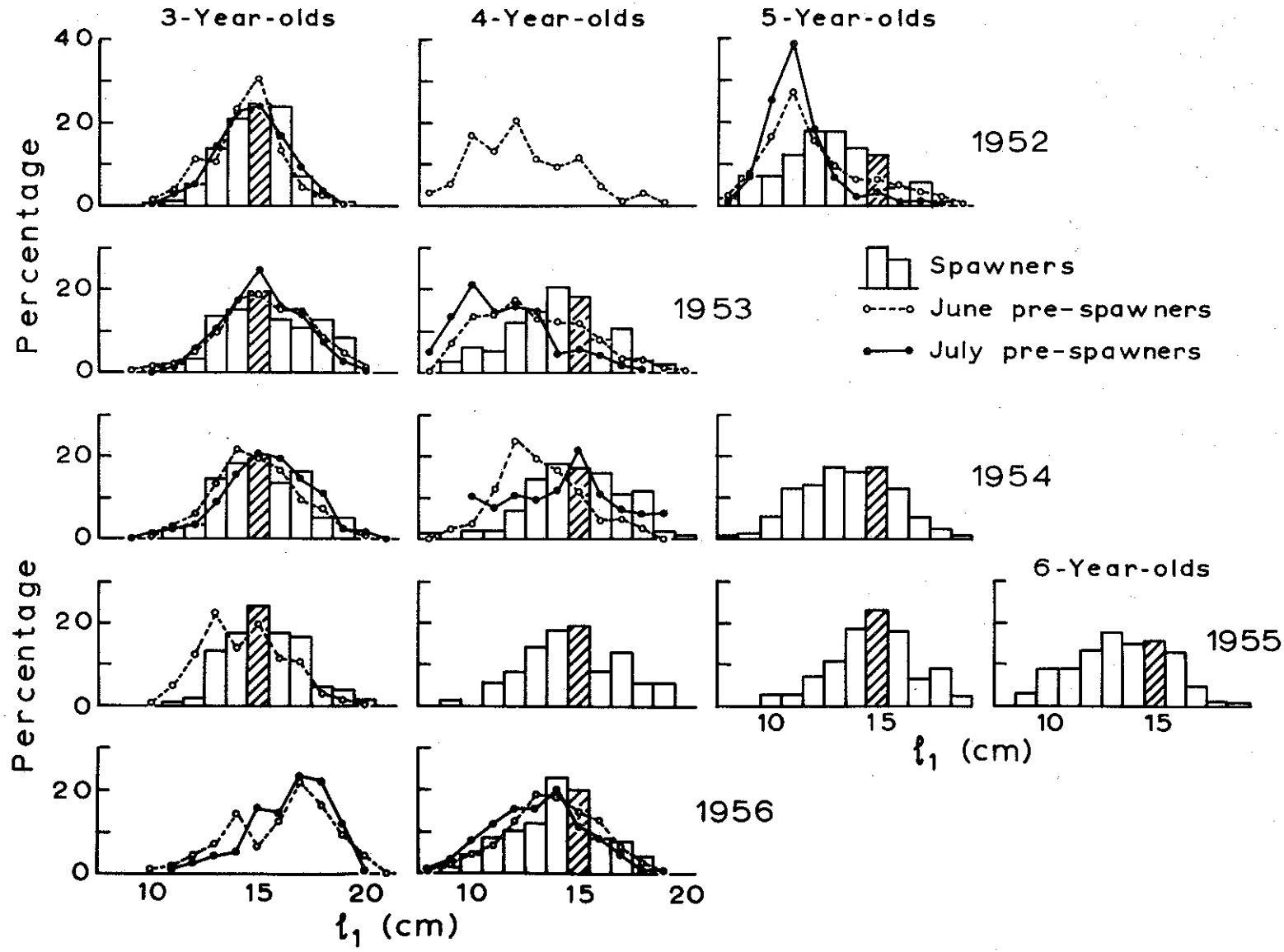

Figure 12 l_1 distributions of Buchan spawners and pre-spawners

(b) The percentages of these maturity stages in the Fladen material in August decreased sharply after 1957, and stages IV and V increased.

(c) The Belgian data (Table 17) show wide fluctuations in the proportions of maturity stage III in the years 1946-1957. High values were recorded in 1950, 1951 and 1954, but in other years the values were low. The proportion of stage IV increased after 1949, but decreased again in 1957. The proportion of stage V was low in the years of high stage III values (1950, 1951 and 1954), but otherwise showed no trends during the period.

(d) In the Buchan samples, in August, the proportion of stages II and III increased after 1956. This is in contrast to the changes in the German Fladen data.

On the assumption that stages II and III in June and July are late spawners, the German data provide no evidence of a major trend in the extent of mixing of late-spawning herring on the Fladen in June and July during the years 1953-60. Similarly, no major trends can be detected up to 1959 in the Buchan area in June. However, the sharp decrease after 1957 in the proportions of stage III fish at Fladen in August suggests that there has been either an increase in the rate of maturation or a decrease in the degree of mixing of a late-spawning component.

The Working Group considers that until more is known about the rates of maturation of the main herring groups, spawning at different times in the North Sea, and about the factors governing them, little reliance can be placed on maturity-stage data, in estimating mixing rates. Note was taken of the results of Iles (1964), which suggest that the main difference between the maturation cycles of the early (Bank) and late (Downs) spawners in the North Sea may be in the duration of stage V, and that their passage through the earlier stages may take place at about the same time. On this basis fish in maturity stages II and III in June and July may belong to any of the spawning groups in the North Sea.

It is strongly recommended that all herring workers in the ICES area should examine their maturity data for as many herring stocks as possible, in order to determine more clearly the course of the maturation cycles in different herring groups, and the factors governing them. The possible importance of associated fat and endocrine studies is stressed.

3. l_1 distributions

The Working Group examined l_1 data for Buchan pre-spawners (maturity stages II and III in June and July) and spawners in the years 1952-1955 and 1958. The l_1 distributions for those age groups for which sufficient data were available are given in Figure 12.

These data show that:-

(a) The l_1 distributions of a year-class of Buchan spawners tend to decrease somewhat with age.

(b) The l_1 distributions of the three-year-old recruit pre-spawners in June and July are similar to those of the three-year-old Buchan spawners, corresponding to them in general form, mode and range.

(c) The l_1's of older pre-spawners are smaller than those of the three-year-olds, and conform less closely with those of the spawners, in showing a relatively higher proportion of smaller l_1's.

These results suggest that, while a major part of the three-year-old recruit pre-spawning stock in the Buchan area in June and July may be Buchan spawners in that year, amongst the older age-groups there is an admixture of smaller l_1 fish, which spawn in other areas. Therefore, the Working Group also compared the l_1 distributions of the pre-spawners with those of Dogger and Southern Bight spawners, the l_1's of which are known to be smaller, on average, than those of Buchan spawners of the same age. This comparison showed that there was a relatively small degree of overlap of the l_1 distributions of the three-year-old pre-spawners in maturity stages II and III with the Southern Bight spawners, especially in the years 1952-54, but a larger one between those of the older age groups. The overlap with Dogger spawners was also relatively small amongst the three-year-olds in 1952 and 1953, but large amongst the older age-groups. Unfortunately, owing to the close similarity between the l_1 distributions of Dogger and Southern Bight spawners, it was not possible to determine from these data to which of these spawning groups the main body of low l_1 fish, amongst the Buchan pre-spawners, belonged.

German Fladen l_1 data for all age groups combined, for the years 1953-1959, were also examined. The means for fish for different maturity stages are given in Table 18. Again, these data point to the presence of substantial numbers of fish with low l_1's, comparable with the Dogger and/or Southern Bight values, but as with the Buchan data it is not possible to determine to which of these groups they belonged.

Mean length for age

In Table 19 are given the mean lengths of age groups 3-6, in maturity stages II and III in June and July, amongst Buchan pre-spawners in the years 1952-1960, and the corresponding values for Buchan, Dogger and Southern Bight spawners. The values for Buchan pre-spawners in maturity stages IV and V, and for Fladen fish in all maturity stages, are also given for some years.

It is evident from these data that the mean lengths of the three- and four-year-old pre-spawners tended to be higher than those of the Southern Bight spawners and lower than those of the Dogger and Buchan spawners. Those of the five- and six-year-olds, based on much smaller numbers, showed less consistent differences, some being slightly smaller and some slightly larger than in the case of the Southern Bight spawners.

Owing to uncertainty concerning the growth of herring between June-July and the spawning times in the North Sea, the Working Group was unable to arrive at any firm conclusions regarding the use of these data as evidence of mixing of Southern Bight spawners amongst the north-western North Sea pre-spawners.

Vertebral counts

The mean vertebral counts of Buchan pre-spawners in maturity stages II and III in June and July in the years 1952-1960, and of Buchan, Dogger and Southern Bight spawners (East Anglian data for all maturity stages), are given

in Table 20. These data exhibit wide variations in the values for the pre-spawners between year-classes, age-groups and months, and in their similarities to the values for the three spawning groups.

The Working Group was unable to draw any conclusions regarding the mixing of spawning groups from these data, although it notes that an increase in mean V.S. among Buchan spawners after 1956 is not reflected in the V.S. data for the pre-spawners, either in June or July.

For the older age-groups, however, the vertebral counts were rather high and more similar to those of Downs fish, whereas there is no indication that the values were lower in July than in June.

6. k_2's (keel-scale counts)

German data for year-classes sampled on the Fladen ground in 1958-60, and for Dogger, Sandettié and Channel spawners for a number of year-classes, together with Scottish data for the Buchan spawners of the 1956 year-class, were examined by the Working Group. These are given in Table 21.

The most striking values were those for the 1956 and 1957 year-classes, which gave very low values for all maturity stages at Fladen, differing markedly from those of other year-classes sampled. Similar low values were also revealed by the 1956 year-class amongst Buchan spawners and pre-spawners, but not in the Dogger or Southern Bight spawners of this year-class. These data therefore suggest that both in 1959 and 1960 the main body of pre-spawners of the 1956 year-class, in all maturity stages, in both the Fladen and the north-western North Sea were Buchan spawners, with only a very small admixture of Dogger or Southern Bight spawners. Unfortunately, owing to the absence of k_2 data for other year-classes from the Buchan area and the similarity between the ranges of values of Dogger and Southern Bight spawners, it is not possible to determine the significance of the values for other year-classes sampled at Fladen, but it is evident that the values for the 1952 and 1955 year-classes are close to the range of values for the Channel spawners, while the 1953 and 1954 year-classes fall mostly within the Dogger range.

In view of the very marked difference between the k_2 values of the northern and southern North Sea components of the strong 1956 year-class, the importance of this character in studies on mixing of this and perhaps other year-classes was stressed, and it was recommended that a detailed study of this character should be made throughout the lifespan of the 1956 year-class in all parts of the North Sea.

7. Tagging

In Table 22 are given the Dogger recaptures of herring tagged in the Buchan area in the years 1948-1953. These data show that highest percentage recaptures were obtained from May liberations and the lowest from July liberations. This suggests that there may be a change in the "composition" of the pre-spawning Buchan population between May and July.

8. Fecundity

The results of fecundity studies of herring in low maturity stages,

undertaken by Baxter (1963) in the northern North Sea in 1961, were noted. These showed that in both the Buchan and Fladen areas, for most of the herring in maturity stages III and IV in July and August, the estimated fecundities were similar to the high level of the Buchan spawning group (estimated from fish in stage V). These data support the evidence from k_2 counts, for the 1956 year-class, that the main body of pre-spawners in the northern North Sea in 1961 belonged to the northern spawning group.

The possible importance of this "character" in studies of mixing of the spawning groups in the pre-spawning feeding fisheries was noted, and it was recommended that it be included in future studies of mixing of spawning groups in the North Sea.

General conclusions

With the data at its disposal, the Working Group was unable to arrive at estimates of the degree of mixing of the major spawning groups in the northern feeding areas or of changes in them during the last decade. However, the following tentative conclusions were drawn:

(a) In the years since 1951, most of the three-year-old pre-spawning recruits in the north-western North Sea (Buchan area) have subsequently spawned on the northern (Buchan) or Dogger spawning grounds, and only few in the Southern Bight.

(b) Amongst the older pre-spawners in the north-western North Sea the Southern Bight spawning group may have been larger.

(c) Since 1958, the total proportion of Southern Bight spawners both amongst the north-western North Sea and the Fladen pre-spawners has probably not exceeded 10%.

The Working Group stresses the need for further investigations of the mixing of spawning groups during the pre-spawning phase in the North Sea, with special reference to:

(i) The extension of the estimation of fecundity of fish in maturity stages III, IV and V. (Attention should also be given to the possibility of estimating fecundities of fish in maturity stages I-III and II.)

(ii) The inclusion of k_2 as a routine racial character in all parts of the North Sea.

(iii) The possibility of undertaking extensive tagging experiments in known or suspected mixing areas (e.g. Fladen, Gut, Buchan, Dogger, East Anglia).

(iv) The further study of the maturation cycles in North Sea and other spawning groups.

Table 14. Statistics of catch, fishing effort and catch per unit effort for the German herring trawl fishery 1946-1961 - by results

Year	June			July			August			September			October			Total (all months)		
	Catch	Effort[1]	C/E	C	E	C/E	C	E	C/E	C	E	C/E	C	E	C/E	C	E	C/E
1946	-	-	-	243	111	2.2	17,777	970	18.3	2,109	107	18.7	457	46	9.9	20,828	1,271	16.4
					226	1.1		1,989	8.9		221	9.5		94	4.9		2,606	8.0
1947	-	-	-	1,624	198	8.2	29,473	1,632	18.1	14,763	906	16.3	780	74	10.5	48,053	3,137	15.3
					430	3.8		3,541	8.3		1,966	7.5		161	4.8		6,808	7.1
1948	-	-	-	3,405	494	6.9	30,457	2,354	12.9	13,777	801	17.2	32	18	1.8	48,293	3,939	12.3
					1,112	3.1		5,297	5.7		1,802	7.6		41	0.8		8,864	5.4
1949	-	-	-	6,289	648	9.7	21,540	1,525	14.1	7,366	550	13.4	32	8	4.0	39,593	3,667	10.8
					1,510	4.2		3,553	6.1		1,282	5.7		19	1.7		8,545	4.6
1950*	38	11	3.5	6,176	1,036	6.0	26,876	2,185	12.3	4,280	269	15.9	-	-	-	37,370	3,501	10.7
		27	1.4		2,549	2.4		5,375	5.0		662	6.5					8,613	4.3
1951*	-	-	-	3,999	310	12.9	30,939	1,946	15.9	2,360	128	18.4	647	23	28.1	38,513	2,472	15.6
					800	5.0		5,021	6.2		330	7.2		59	11.0		6,378	6.0
1952*	-	-	-	15,504	927	16.7	18,887	1,199	15.8	2,346	117	20.1	530	35	15.1	37,267	2,248	16.4
					2,484	6.2		3,213	5.9		314	7.5		94	5.6		6,105	6.1
1953	-	-	-	10,794	899	12.3	34,406	1,965	17.5	5,413	292	18.5	-	-	-	50,613	3,156	16.2
					2,499	4.3		5,463	6.3		812	6.7					8,774	5.8
1954	90	9	10.0	14,763	1,025	14.2	30,896	2,061	14.8	3,517	163	21.6	765	39	19.6	50,031	3,294	15.0
		26	3.5		2,962	5.0		5,956	5.2		471	7.5		113	6.8		9,528	5.3
1955	883	89	9.8	23,482	1,499	16.2	49,371	2,367	20.8	31,118	1,771	19.1	97	17	5.8	104,951	5,743	18.8
		266	3.3		4,482	5.2		7,077	7.0		5,295	5.9		51	1.9		17,171	6.1
1956	1,520	133	11.4	16,979	1,410	12.0	33,578	2,235	15.0	17,827	1,512	12.1	683	45	15.3	70,587	5,335	13.4
		415	3.7		3,499	4.8		6,973	4.8		4,717	3.8		140	4.9		16,645	4.2
1957	1,535	183	8.6	17,641	1,342	13.2	35,850	2,075	17.0	19,035	1,133	17.0	2,867	199	17.0	76,023	4,950	15.5
		554	2.8		4,066	4.3		6,287	5.7		3,433	5.5		603	4.8		14,998	5.1

(continued overleaf)

Table 14. (cont'd)

Year	June			July			August			September			October			Total (all months)		
	Catch	Effort	C/E	C	E	C/E	C	E	C/E	C	E	C/E	C	E	C/E	C	E	C/E
1958	1,058	193	5.5	10,506	1,167	9.0	16,644	1,795	9.3	16,050	1,408	12.2	3,840	418	9.7	48,646	5,094	9.7
		587	1.8		3,548	3.0		5,457	3.1		4,280	3.8		1,271	3.0		15,487	3.1
1959	1,200	156	7.8	16,777	1,241	13.7	29,360	1,865	16.3	22,316	1,405	16.6	5,268	515	12.7	75,386	5,439	15.0
		476	2.5		3,785	4.4		5,688	5.2		4,285	5.2		1,571	3.4		16,589	4.5
1960	490	122	4.4	6,600	666	10.2	16,667	1,401	12.5	6,355	602	10.4	2,146	189	10.5	32,638	3,029	11.2
		-	-		-	-		-	-		-	-		-	-		-	-
1961	-	-	-	2,792	261	10.7	6,440	681	9.7	740	62	22.2	40	8	5.9	10,012	1,012	10.2
		-	-		-	-		-	-		-	-		-	-		-	-

1) Upper figures are days fishing uncorrected for changes in fishing power; lower figures are fishing days adjusted for fishing power.

*) In these three years there were substantial additional quantities of herring landed from mixed trips to the Fladen, Gut and Dogger. These are given in Table 14A.

Table 14A. German statistics. Mixed catches Fladen, Gut and Dogger 1950-1952

Year	June			July			August			September			October			Total (all months)		
	Catch	Effort	C/E	C	E	C/E	C	E	C/E	C	E	C/E	C	E	C/E	C	E	C/E
1950	-	-	-	196	54	3.5	10,859	904	12.1	13,786	1,069	13.0	4,791	439	10.9	30,214	2,558	11.9
1951	-	-	-	754	99	6.0	12,762	894	14.2	24,825	1,468	16.9	634	346	18.2	47,303	3,168	15.2
1952	-	-	-	496	30	16.5	15,959	995	16.0	11,805	666	17.7	1,152	102	11.3	59,486	3,788	15.7

Table 15. Percentage age-composition in four fisheries: Buchan, Fladen, Dogger, East Anglia.

			Age							
			2	3	4	5	6	7	8	8+
1949	Buchan	Aug.-Sep.		2.2	5.8	21.4	15.0	21.4	16.9	10.6
		July	1.0	44.9	35.7	9.2	3.1	1.0	3.1	2.0
	Fladen; German	Aug.		17.4	27.2	23.1	16.9	7.2	4.6	3.6
		Sep.			7.1	18.4	16.3	26.5	30.6	1.0
	Belgian			1.1	3.4	11.3	12.8	18.5	20.8	32.1
	Dogger; German		2.0	38.0	19.0	9.0	10.0	7.0	7.0	8.0
	East Anglia			18.5	39.3	17.1	8.4	11.5	2.6	2.6
1950	Buchan	Aug.-Sep.		12.2	8.7	8.3	10.4	9.6	13.0	37.2
	Fladen; German				1.1	12.2	19.7	31.9	18.6	16.5
	Belgian			15.5	33.0	8.2	6.2	8.2	14.4	14.5
	Dogger; German			11.0	32.0	21.0	12.0	7.0	8.0	21.0
	East Anglia			18.4	30.8	23.8	11.5	5.6	6.3	3.6
1951	Buchan	Aug.-Sep.		8.6	20.0	15.0	5.8	11.0	10.0	28.2
	Fladen; German				1.4	14.9	10.8	18.9	33.7	20.2
	Belgian			2.4	10.6	20.0	20.0	15.3	9.4	22.3
	Dogger; German			4.0	20.0	37.0	17.0	5.0	3.0	14.0
	East Anglia			17.4	24.6	25.7	15.8	7.5	3.8	5.2
1952	Buchan	Aug.-Sep.		19.9	10.9	18.0	10.2	3.7	7.1	31.4
	Fladen; German			1.0	7.0	8.0	15.0	13.0	15.0	41.0
	Belgian			0.9	6.7	8.4	15.1	12.6	15.1	42.2
	Dogger; German			18.0	17.0	15.0	22.0	13.0	4.0	11.0
	Belgian			14.6	14.8	13.5	20.1	12.6	6.2	18.2
	Dutch			33.9	30.1	12.1	17.8	3.0	1.8	1.4
	East Anglia			34.2	16.4	14.9	18.0	9.2	3.5	3.8
1953	Buchan	Aug.-Sep.		23.2	26.9	6.8	12.0	6.4	2.5	20.7
	Fladen; German	July	1.8	22.9	26.5	11.5	11.3	12.4	4.5	9.0
		Aug.	1.9	21.1	16.8	11.4	10.3	10.8	8.8	19.0
		Sep.	3.7	27.5	15.3	11.6	9.5	12.7	6.9	12.7
	Belgian			9.1	21.0	12.4	12.0	13.9	5.7	25.9
	Dogger; German			9.0	21.0	12.0	12.0	14.0	6.0	26.0
	Dutch			26.9	22.4	11.1	5.3	19.2	3.2	11.8
	East Anglia		0.5	52.5	20.7	8.6	5.6	6.3	3.5	3.3
1954	Buchan	Aug.-Sep.		19.6	18.2	23.1	5.8	9.8	5.3	18.1
	Fladen; German	July		17.1	21.9	26.1	12.2	8.8	5.4	8.1
		Aug.		11.8	18.4	19.6	7.8	11.1	12.6	18.8
		Sep.	3.2	26.9	20.4	10.8	6.5	7.5	10.8	14.0
	Belgian		4.6	23.5	26.7	12.9	6.4	8.3	7.4	10.2
	Dogger; German		1.0	14.0	40.0	16.7	10.0	3.3	10.0	5.0
	Belgian		1.4	14.0	26.1	16.6	8.8	6.8	9.6	16.7
	Dutch			70.7	12.1	7.3	2.9	0.2	3.8	2.9
	East Anglia		1.6	41.1	29.8	12.0	4.5	4.3	3.4	3.3

(continued overleaf)

TABLE 15 (Cont'd)

			Age							
			2	3	4	5	6	7	8	8+
	Buchan	Aug.-Sep.		33.2	18.3	12.5	14.2	4.2	5.2	12.4
	Fladen; German	July		68.4	22.5	6.1	2.0	1.0	-	-
		Sep.		55.6	33.3	8.3	2.8	-	-	-
1955	Dogger; German			32.5	20.0	14.5	9.5	8.5	8.4	6.6
	Belgian			18.1	19.4	8.0	11.7	7.3	6.9	28.6
	Dutch		0.1	48.3	12.2	4.6	5.6	4.3	3.3	21.3
	East Anglia		0.1	37.2	28.7	16.1	8.6	3.0	2.7	3.6

Table 16. Maturity - stage composition of German trawl samples (All ages combined) Fladen 1953-1960

		Maturity stage							
		I	II	III	IV	V	VI	VII	VII/II
	June	17.6	38.7	24.5	12.9	6.3	-	-	-
1953	July	9.4	19.2	25.3	18.6	27.4	0.5	-	-
	August	8.9	4.2	20.0	26.0	40.0	0.2	0.2	0.5
	June	38.3	29.9	24.9	6.9	-	-	-	-
1954	July	18.6	18.0	22.4	32.3	8.4	-	-	0.3
	August	7.3	8.8	15.5	20.5	42.5	1.0	4.2	0.5
	June	11.0	39.0	32.0	14.0	3.0	-	-	1.0
1955	July	19.0	36.0	34.0	8.0	3.0	-	-	-
	August	5.3	12.1	11.9	28.6	27.7	-	5.9	8.5
	June	52.0	3.0	36.0	9.0	-	-	-	-
1956	July	6.5	19.0	38.0	25.5	11.0	-	-	-
	August	19.6	13.7	23.5	19.6	23.5	-	-	-
	June	4.0	16.0	39.0	40.0	1.0	-	-	-
1957	July	14.4	6.6	31.3	29.9	17.8	-	-	-
	August	13.0	6.5	13.5	31.0	25.0	-	2.0	9.0
	June	6.0	24.0	58.0	12.0	-	-	-	-
1958	July	3.2	4.0	31.5	35.7	25.4	-	-	0.2
	August	1.0	5.0	5.3	64.9	19.1	-	1.0	3.7
	June	-	-	-	-	-	-	-	-
1959	July	10.8	13.0	46.8	28.2	1.2	-	-	-
	August	12.0	0.5	5.5	24.0	52.0	-	5.0	1.0
	June	-	-	-	-	-	-	-	-
1960	July	26.7	2.5	25.8	44.6	0.2	-	-	0.2
	August	3.4	5.7	2.3	39.1	47.2	-	-	2.3

Table 17. Percentages of maturity stages III, IV and V at Fladen 1946-1957: Belgian data

(No data for the years 1955 and 1956)

	Maturity stage		
	III	IV	V
1946	9.3	22.9	58.0
1947	12.8	30.2	38.4
1948	10.8	23.5	49.2
1949	6.1	16.4	54.4
1950	37.9	34.6	23.9
1951	27.7	38.7	26.8
1952	10.5	32.5	51.0
1953	6.5	31.4	45.9
1954	21.2	41.8	30.5
1957	7.3	18.9	48.0

Table 18. Mean l_1's (cm), for all age-groups combined, for the years 1953-59: German Fladen data

	June	July		June and July			August		
	II + III	II + III	IV	II + III	IV	V	II + III + IV	IV	V
1953	11.33 (196)	11.47 (200)	12.33 (62)	-	-	-	10.76 (25)	-	11.87 (15)
1954	11.90 (157)	12.00 (12)	12.57 (23)	-	-	-	-	12.18 (11)	12.81 (21)
1955	11.73 (33)	-	-	-	-	-	11.75	-	-
1956	11.55 (20)	12.24 (41)	13.17 (18)	-	-	-	12.09 (11)	-	-
1957	-	-	-	12.38 (24)	12.61 (23)	14.13 (15)	-	13.79 (14)	-
1958	-	-	-	11.82 (22)	13.77 (13)	-	-	13.79 (14)	-
1959	-	13.27 (41)	14.52 (23)	-	-	-	-	-	13.45 (20)

Figures in brackets are numbers of observations.

Table 19. Mean length for age (cm) for: Buchan pre-spawners

Buchan, Dogger and Southern Bight spawners; Fladen pre-spawners

	Age 3					
	Buchan pre-spawners Stages II + III	Buchan spawners	Dogger spawners	Southern Bight spawners	Buchan pre-spawners Stages IV	V
June						
1952	24.6(373)	26.3(55)	25.1(157)	24.1		
1953	24.8(284)	26.0(180)	24.7(234)	24.8		
1954	24.8(378)	26.1(133)	25.2(295)	24.3		
1955	24.3(723)	26.7(283)	25.3(233)	24.4	25.5	-
1956	-	26.0(167)	25.1(149)	23.6	25.9	-
1957	24.1(811)	25.8(74)	24.8(228)	23.9		
1958	24.6(223)	25.5(12)	25.3(40)	24.3	-	-
1959	24.1(1568)	-	23.9(618)	24.1		
1960	24.3(560)	-	25.0(70)	23.7		
1961		27.8(25)	25.7(672)	24.3		
July						
1952	25.2(287)	26.3	25.1	24.1		
1953	24.7(520)	26.0	24.7	24.3		
1954	24.7(603)	26.1	25.2	24.3		
1955	24.7(670)	26.7	25.3	24.4	24.4	25.9
1956		26.0	25.1	23.6	25.6	26.2
1957	24.5(1496)	25.8	24.8	23.9		
1958	24.8(226)	25.5	25.3	24.3	25.9	-
1959	24.7(1451)		23.9	24.1		
1960	24.7(742)		25.0	23.7		
1961		27.8	25.7	24.3		
Fladen						
1952	26.5					
1953	24.1					
1954	23.7					
1957	24.6					

Figures in brackets are numbers of observations

(continued overleaf)

Table 19 (cont'd)

	Age 4				
	Buchan pre-spawners Stages II + III	Buchan spawners	Dogger spawners	Southern Bight spawners	Buchan pre-spawners Stages IV V
June					
1952	25.8(169)	27.4(51)	26.4(170)	25.8	
1953	26.0(315)	27.4(209)	26.7(240)	26.0	
1954	26.7(136)	27.9(207)	26.7(53)	26.2	
1955	26.6(188)	27.2(201)	27.3(90)	26.1	27.2 -
1956	-	27.6(361)	27.3(380)	26.5	26.8 -
1957	26.2(207)	27.5(79)	26.8(119)	25.7	
1958	26.2(822)	27.3(81)	26.9(231)	25.8	26.7 -
1959	26.2(65)	-	26.6(268)	25.5	
1960	25.4(818)	-	26.2(479)	25.6	
1961	-	28.1(29)	27.1(61)	26.0	
July					
1952	26.3(187)	27.4	26.4	25.8	
1953	25.9(287)	27.4	26.7	26.0	
1954	26.2(156)	27.9	26.7	26.2	
1955	26.4(105)	27.2	27.3	26.1	27.6 27.7
1956		25.6	27.3	26.5	27.3 27.6
1957	26.2(287)	27.5	26.8	25.7	
1958	26.4(450)	27.3	26.9	25.8	27.0 27.2
1959	26.0(57)		26.6	25.5	
1960	25.5(649)		26.2	25.6	
1961		28.1	27.1	26.0	
Fladen					
1952	27.4				
1953	25.7				
1954	26.0				
1957	26.6				

Figures in brackets are numbers of observations

(continued overleaf)

Table 19 (cont'd)

	Age 5				
	Buchan pre-spawners Stages II + III	Buchan spawners	Dogger spawners	Southern Bight spawners	Buchan pre-spawners Stages IV V
June					
1952	26.5(132)	28.2(156)	27.3(6)	27.0	
1953	26.8(91)	29.0(68)	27.8(122)	26.9	
1954	27.4(55)	29.0(259)	28.2(25)	27.5	
1955	26.9(27)	28.9(163)	28.6(33)	27.4	28.7 -
1956	-	28.8(174)	28.5(115)	27.0	- -
1957	27.5(73)	28.8(77)	28.4(295)	27.3	
1958	27.5(145)	28.6(63)	28.3(21)	27.1	27.9 -
1959	26.9(19)	-	28.0(72)	27.0	
1960	26.8(18)	-	28.0(105)	26.8	
1961	-	28.4(197)	27.5(732)	27.0	
July					
1952	26.8(178)	28.2	27.3	27.0	
1953	26.7(69)	29.0	27.8	26.9	
1954	27.2(62)	29.0	28.2	27.5	
1955	27.0(21)	28.9	28.6	27.4	28.5 28.9
1956		28.8	28.5	27.0	28.4 28.7
1957	27.6(56)	28.8	28.4	27.3	
1958	27.6(64)	28.6	28.3	24.1	28.1 28.3
1959	27.0(9)		28.0	27.0	
1960	26.5(10)		28.0	26.8	
1961		28.4	27.5	27.0	
Fladen					
1952	27.8				
1953	27.4				
1954	27.7				
1957	28.1				

Figures in brackets are numbers of observations

(continued overleaf)

Table 19. (cont'd)

	Age 6				
	Buchan pre-spawners Stages II + III	Buchan spawners	Dogger spawners	Southern Bight spawners	Buchan pre-spawners Stages IV V
June					
1952	26.8(119)		28.0(104)	27.2	
1953	27.8(42)	28.9(134)	28.4(58)	27.8	
1954	28.0(20)	28.9(72)	28.6(10)	28.1	
1955	28.8(25)	29.6(142)	29.2(50)	28.2	- -
1956	-	29.7(38)	29.5(35)	27.9	27.7 -
1957	28.9(7)	29.4(58)	29.2(74)	28.2	
1958	28.4(129)	29.1(37)	29.2(27)	28.4	- -
1959	28.0(2)		28.4(55)	27.6	
1960	28.0(8)		28.5(32)	27.5	
1961		29.1(14)	28.7(67)	27.9	
July					
1952	27.1(208)		28.0	27.2	
1953	27.4(36)	28.9	28.4	27.8	
1954	27.7(25)	28.9	28.6	28.1	
1955	28.3(5)	29.6	29.2	28.2	- 29.6
1956		29.7	29.5	27.9	28.7 29.5
1957	27.9(11)	29.4	29.2	28.2	
1958	28.6(44)	29.1	29.2	28.4	28.6 29.3
1959			28.4	27.6	
1960	27.0(1)		28.5	27.5	
1961		29.1	28.7	27.9	
Fladen					
1952	28.0				
1953	28.7				
1954	28.1				
1957	28.9				

Figures in brackets are numbers of observations

Table 20. Mean VS for Buchan pre-spawners and for Buchan, Dogger and Southern Bight (East Anglian data) spawners

			Age				
			3	4	5	6	7
Buchan pre-spawners (Stages II + III)	June	1952	56.48(366)	56.32(158)	56.50(127)	56.36(116)	56.59(43)
		53	56.55(277)	56.49(305)	56.49(88)	56.45(41)	56.63(57)
		54	56.59(371)	56.56(135)	56.49(53)	56.53(23)	56.51(15)
		55	56.46(709)	56.64(168)	56.69(16)	56.67(24)	56.14(7)
		56					
		57	56.55(329)	56.48(98)	56.55(42)	55.98(5)	56.39(8)
		58					
		59	56.53(1057)	56.41(54)	56.06(14)	(56.00((2))	(56.00((1))
		60	56.54(133)	56.44(203)	(56.00((1))	(56.00((2))	-
	July	1952	56.45(282)	56.58(181)	56.57(173)	56.55(202)	56.70(87)
		53	56.53(506)	56.56(283)	56.44(69)	56.89(34)	56.45(42)
		54	56.44(555)	56.52(151)	56.50(62)	56.59(25)	56.68(10)
		55	56.43(757)	56.46(108)	56.61(20)	56.40(5)	(56.00((2))
		56	-	-	-	-	-
		57	56.50(834)	56.57(144)	56.36(29)	(56.83((6))	-
		58	-	-	-	-	-
		59	56.49(708)	56.67(55)	(56.60((5))	-	-
		60	56.50(151)	56.38(222)	-	-	-
	Buchan spawners	1952	56.45(117)	56.46(74)	56.42(168)	-	-
		53	56.53(235)	56.39(272)	56.44(99)	56.45(173)	56.48(101)
		54	56.46(189)	56.58(264)	56.42(372)	56.53(89)	56.50(181)
		55	56.41(478)	56.52(311)	56.58(230)	56.43(243)	56.44(71)
		56	56.48(171)	56.40(355)	56.57(155)	56.45(128)	56.48(75)
		57	56.57(158)	56.57(95)	56.53(184)	56.51(78)	56.40(38)
		58	56.28(29)	56.50(111)	56.48(89)	56.53(51)	56.61(18)
		59	56.59(269)	56.86(14)	56.45(33)	56.61(28)	56.62(37)
		60	56.57(57)	56.58(104)	-	-	-
Dogger	Stages V-VIII	1952	56.64(157)	56.56(170)	56.62(66)	56.45(104)	56.35(203)
		53	56.51(234)	56.60(240)	56.38(122)	56.50(58)	56.49(210)
		54	56.52(295)	56.51(53)	56.68(25)	56.40(10)	-
		55	56.53(233)	56.52(90)	56.42(33)	56.54(50)	56.41(46)
	Stage VI	56	56.54(149)	56.56(380)	56.60(115)	56.69(35)	56.44(70)
		57	56.49(228)	56.71(119)	56.48(295)	56.57(74)	56.79(28)
		58	56.56(40)	56.30(23)	56.76(21)	56.56(27)	56.88(8)
		59	56.54(618)	56.67(268)	56.42(72)	56.38(55)	56.51(108)
		60	56.41(70)	56.44(497)	56.60(105)	56.66(32)	56.68(19)
	East Anglia all Stages	1952	56.54	56.54	56.58	56.55	56.63
		53	56.54	56.60	56.59	56.62	-
		54	56.53	56.57	56.51	-	56.50
		55	56.57	56.57	56.51	56.61	-
		56	56.56	56.66	56.60	56.71	-
		57	56.55	56.45	56.42	56.65	-
		58	56.42	56.49	56.57	-	-
		59	56.51	56.49	56.47	-	-
		60	56.56	56.52	-	-	-
		61	56.54	-	-	-	-

Figures in brackets are numbers of observations. Where the VS and the number of observations are both within brackets, e.g. (56.00(1)), this draws attention to the fact that the number of observations is small.

Table 21. Mean k_2's for Fladen (year-classes 1952-57 in 1958-60), Sandettié (year-classes 1949-56 in 1953-59); north-western North Sea (year-class 1956 in 1960); Dogger and Channel (range of values for year-classes 1953-57 in 1955-59).

FLADEN (German data)

	Year - class					
Maturity Stage	1952	1953	1954	1955	1956	1957
II + III + IV	14.73	14.61	14.65	14.84	14.24	14.28
V + VI + VII + VII / II	14.78	14.72	14.58	14.56	14.23	-

SANDETTIÉ (German data)

	Year - class							
Maturity Stage	1949	1950	1951	1952	1953	1954	1955	1956
VI	15.04 (23)	14.89 (64)	14.91 (70)	15.09 (44)	15.08 (124)	14.80 (134)	14.99 (121)	14.75 (59)

DOGGER & CHANNEL (German data)

Maturity Stage	Area	
	Dogger	Channel
VI	14.61-14.70	14.69-14.86

NW. NORTH SEA (1956 year-class in 1960) (Scottish data)

Maturity Stage	June	July	Aug.-Sep.
II + III	14.07 (304)	14.15 (192)	
IV + V		14.14 (198)	14.14 (212)
VI + VII			14.23 (124)

Table 22. Dogger recaptures from Buchan liberations in May-July 1948-53

		No. liberated	No. recaptured
1948-50	May	2,265	1
	June	-	-
	July	1,482	1
1951	May	1,458	7
	June	1,703	3
	July	-	-
1952	May	2,764	6
	June	3,087	4
	July	1,930	1
1953	May	3,995	3
	June	1,418	1
	July	1,229	1
All years	May	10,482	17 (0.16%)
	June	6,208	8 (0.13%)
	July	4,641	3 (0.07%)

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APPENDIX I

A method for estimating the proportions of the Downs stock in the mixed fisheries in the northern and central North Sea

D. H. Cushing

There is some evidence that fish of the Downs stock are found in the summer feeding fisheries in the northern and central North Sea (Wood, 1930, 1937; Krefft, 1954; Cushing, 1959; Burd, in Burd and Cushing, 1962). There are three mixed fisheries in the northern North Sea in summer and early autumn: the Buchan pre-spawning fishery, the Shetland fishery and the Fladen fishery. In the central North Sea there is a series of fisheries in which Downs fish are found: Farne Deep, North-east Bank, Gut, Whitby, Bayman's Hole, Brucey's Garden, and on the Dogger Bank itself.

The method used is to correlate catches/effort of age-groups in the Downs stock (as represented by the East Anglian fishery) with those in a mixed fishery. The correlation estimates the mixing of the spawning fish in the mixed fishery, and the year-class correlation between the two groups. It can be shown that there is no year-class correlation between the three spawning groups (Buchan, Dogger and Downs).

In order to use the catches/effort of all age-groups, thus increasing the quantity of information, factors were calculated correcting for mortality between age-groups and for abundance between years. There is an array of stock densities, y, by age and by years, in one fishery:-

the row $_1y_3$, $_1y_4$ ..... $_1y_{n_1}$ represents the first year's densities by age, n_1 being the last age-group;

the column $_1y_3$, $_2y_3$ ..... $_{n_2}y_3$ represents the densities of three-year-old fish by years, n_2 being the number of years.

Mean densities are calculated for each row and each column:-

$_1\bar{y}$, $_2\bar{y}$ ..... $_{n_2}\bar{y}$ represent mean densitites for each year;

$\bar{y}_3$, $\bar{y}_4$ ..... $\bar{y}_{n_1}$ " " " " " age.

The overall mean density is $\bar{y}$.

The correction factor for mortality is, for example, for three-year-olds: $\bar{y}/\bar{y}_3$.

The correction factor for abundance is, for example, for the first year: $\bar{y}/_1\bar{y}$.

Each item is corrected by two factors, one for mortality and one for abundance: for example, for three-year-olds in the first year:-

$$_1y_3,\ \bar{y}/\bar{y}_3,\ \bar{y}/_1\bar{y}.$$

In this way differences between age-groups due to mortality are minimized, as are differences between years due to secular trends in abundance.

There is an array representing the stock densities in the mixed fishery, y, and an array representing those in the unmixed fishery, x, for the same period of years and for the same set of ages. The pairs of stock densities, corrected for mortality and abundance, are correlated. The two regressions, $y = a + bx$

and $x = a' + b'y$, are calculated. The estimate of mixing is given by $(1 - a'/\bar{x})100$. In all cases, no difference was found between the sums of squares, taken individually, and the total sums of squares. So it is unlikely that the regression using all the data was biassed by any single regression for one age-group. This is really a test of the possibly biassing effects of the correction factors.

There are two possible sources of error in this procedure. The first is a bias found when the shape of an age distribution changes markedly over a time period, as, for example, during the recruitment change of 1950-52. The effect is to make, for example, $\bar{y}_3$ and $_1\bar{y}$ larger than they should be and so the corrected age distribution becomes doubly biassed. The presence of this bias can be found in the corrected terms in detecting a significant trend with time in an age-group. In general, the bias has been eliminated by separating the series before the recruitment change from that after it.

The possible second error is that perhaps the corrected data, being derived from catches/effort, are not normally distributed. In samples of corrected data from the East Anglian fishery, the Buchan spawning fishery, the Belgian Dogger fishery, the Shetland fishery and the Fladen fishery, no correlation between mean and variance was found. So no transformation was necessary.

A full analysis of the results will be given in a forthcoming paper. They are as follows:-

Appendix Table 1

Proportions of the three spawning groups in the mixed fisheries

A. Three northern fisheries, before 1950

	Buchan spawners	East Anglia
Buchan pre-spawners	40.0%	43.9%
Shetland	27.9%	-
Fladen	-	29.5%

Note: Dogger spawners are excluded from this analysis because there are no data on the Dogger spawning fishery available before 1949.

B. Three northern fisheries, after 1950

	Buchan spawners	East Anglia	Dogger spawners
Buchan pre-spawners	52.7%	4.9%	49.8%
Shetland	71.6%	-	12.0%
Fladen	48.8%	-	48.1%

C. The general Dogger fishery, 1930-1958

	1930-1950	1949-1958
East Anglia	29.4%	-
October Dogger	-	36.0%

Note: the blanks in the table mean that the correlation between the single stock and the mixed stock was not significantly different from zero and that no estimate of the proportion of the single stock in the mixed stock could be made.

A second form of analysis was used by correlating the catches/effort in different maturity stages (y) with catches/effort in the East Anglian fishery, as recruits or middle-aged fish (x). The proportion of the single stock in the mixed fishery is given in this case by $(1 - a/\bar{y})100$. No correction factors were used. The results for the Fladen ground are given in Appendix Table 2.

Appendix Table 2

Proportions of the three spawning groups on the Fladen ground, from the analysis of maturity stages

		1932-1954	1955-1959	1932-1959
East Anglia	Recruits	24.2%	-	22.4%
	Middle-aged fish	25.6%	-	-
Buchan Spawners	Recruits	-	48.2%	13.3%
	Middle-aged fish	-	-	-
October Dogger	Recruits	-	-	-
	Middle-aged fish	36.9%	28.1%	-

In the forthcoming paper referred to above the results of the two methods are compared.

LIST OF FIGURES

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