Précis

Ce mémoire considère les relations réciproques existant entre diverses espèces de poissons en mer du Nord en utilisant les techniques de corrélation et de corrélations multiples.

On aboutit aux conclusions suivantes :

1. Il existe une corrélation positive entre les importances numériques de certaines classes d'une même année les unes avec les autres (c'est-à-dire entre les églefins et les merlans et entre les carrelets et les soles).

2. On note une corrélation négative de certaines séries les unes avec les autres (l'importance numérique d'une classe d'année d'églefins avec l'importance du cheptel de harengs, de même l'importance numérique d'une classe d'année de harengs avec un indice d'intrusion de l'eau du banc entre l'Islande et les îles Féroé dans le chenal entre les Féroé et les Shetland au cours de l'année précédente).

3. L'analyse de corrélation multiple ne révèle pas de rapports sous-jacents entre les variables si ce n'est ceux qui ont été découverts à l'aide de l'analyse de simple corrélation.

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SOME INTER-RELATIONS BETWEEN NORTH SEA FISH SPECIES

by

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Abstract

This paper considers inter-relations between various North Sea fish species using correlation and multiple correlation techniques.

It is concluded that:

1. certain year class strengths are positively correlated with each other (ie haddock with whiting and plaice with sole).

2. certain series are negatively correlated with each other (ie haddock year class strength with herring stock size, also herring year class strength with an index of the intrusion of Iceland/Faroe ridge water in the Faroe Shetland Channel in the preceding year).

3. multiple correlation analysis does not reveal underlying relationships between the variates other than those detected using simple correlation analysis.

Introduction

This paper investigates inter-relations between various North Sea fish species using correlation and multiple correlation techniques. Sets of data covering as many years as possible were selected for this purpose. They include year class strengths, stock size, growth and hydrographic data.

Basic Data

Period 1959-1974 (Table 1)

For the period 1959-1974, year class strength data are available for 8 North Sea species, ie haddock, whiting, Norway pout, cod, saithe, plaice, sole and herring. Table 1 gives millions of each of these species estimated from VPA. Also given are:-

1. estimates of haddock and herring stock size,

2. mean lengths of 2-group haddock in the period April-June. These provide indices of conditions for juvenile haddock during the 2 years preceding the production of each year class.

3. indices of the intrusion of Iceland/Faroe ridge water in the Faroe Shetland Channel (from Martin 1976). These provide a general measure of variations in hydrographic conditions.

Pre 1959 period (Table 2)

For some of the series, data are available for years prior to 1959, and these are given in Table 2. They include estimates of the year class strengths of haddock, whiting, plaice, sole and herring prior to 1959. Also shown are haddock and herring stock sizes, haddock mean lengths and indices of the intrusion of Iceland/Faroe ridge water. Each series is shown for as many years as possible. The longest series are for haddock and herring year class strengths which go back to 1918. Haddock and whiting year class strengths were based initially on catches per 10 hours fishing by Scottish research vessels. To make them comparable with the series in Table 1 these values were converted to millions of 1 year old fish, using the post 1958 relation between VPA estimates of year class strengths and Scottish research vessel catches.

Correlation coefficients (Period 1947-1974)

The period 1947-1974 is the longest period for which data are available for most of the variates. This period was therefore selected for initial investigation. The data available are for 9 variates, these being the year class strengths of haddock, whiting, plaice, sole and herring, and also haddock and herring stock sizes, haddock mean lengths, and indices of the intrusion of Iceland/Faroe ridge water.

Correlation coefficients were calculated between each of the 5 year class strengths and between each of these and the remaining variates. Because of the relatively large variations in some of the year class strengths, the year class strength indices were first converted to logarithms before correlation coefficients were calculated. The correlation coefficients were calculated both without displacement of variates and also with the variates displaced with respect to each other by 1, 2 and 3 years respectively. Multiple correlation coefficients were also calculated, using combination of both 3 variates and 4 variates at a time.

Table 3 shows the percentages of correlation coefficients that were statistically significant at the 5% level.

Without displacement of variates, there are 30 different combinations of each of the 5 year classes with each of the other 8 variates. Out of these 10 (ie 33%) were significant at the 5% level (Table 3A).

With displacement of variates, the percentages of correlations that were significant at the 5% level were: 8% when the variates were displaced one year with respect to each other; 13% when the variates were displaced 2 years; and 10% when the variates were displaced 3 years.

140 multiple correlations were calculated, using combinations of 3 variates at a time, and without displacement of variates. Of these 55% were significant at the 5% level.

280 multiple correlations were calculated, using combinations of 4 variates without displacement of variates. Of these 60% were significant at the 5% level.

Table 4A shows the 10 statistically significant correlations obtained without displacement of variates for the period 1947-1974.

These include significant correlations between:-

haddock and whiting year class strengths (positive)
plaice and sole year class strengths (positive)
haddock year class strength and herring stock size (negative)
haddock year class strength and the mean lengths of 2-group haddock in the year of spawning (positive).

Correlation coefficients (period 1959-1974)

The period 1959-1974 is the longest period for which data are available for all 12 variates (Table 1). Correlation coefficients were calculated between each of the 8 year class strength series and between each of these are the remaining variates.

Table 3 shows the percentages of correlation coefficients that were significant at the 5% level. These estimates range from 8% (for simple correlations with variates displaced 2 years) to 37% (for multiple correlations using 4 variates).

Table 4B shows the 13 significant (and 1 almost significant) correlations obtained out of 60 simple correlations without displacement of variates for the period 1959-1974.

These include:-

positive correlations between haddock, whiting and Norway pout year classes,
negative correlation between haddock year class strength and plaice and sole year classes and herring stock size
a positive correlation between plaice and sole year class strengths

Here again, it appears that considerably more than 5% of the correlations were significant at the 5% level.

Comparison of 1959-1974 correlations with pre 1959 correlations

Particular significance can be attached to those pairs of variates which happen to show statistically significant correlations for different and independent time periods. For those series which extended over a sufficiently long time period, correlations were therefore also calculated for the period before 1959 as well as for the period 1959-1974.

Taking the variates in pairs, only 5 pairs were found for which the correlation coefficients were statistically significant for both time periods.

Simple correlations: Details for these are given in Table 5.

1. Haddock and whiting year class strengths were found to be significantly correlated, both pre 1959 and also 1959-1974. These data are plotted in Figure 1.

2. Plaice and sole were also correlated significantly using both pre 1959 and 1959-1974 data separately.

3. With displacement of variates one year, only 1 pair of variates stood out as showing significant, or near significant correlations for both time periods, ie herring year class strength was found to be negatively correlated with the index of Iceland/Faroe ridge water in the preceding year. The correlation was significant at the 5% level for the pre 1959 period and for all years combined. For the 1959-1974 period the correlation coefficient was -0.44 which although not statistically significant, is quite close to the 5% level of significance.

4. Haddock year class strength is significantly and negatively correlated with herring stock size during the period 1959-1974 and for all years. The correlation for the pre 1959 period however is not significant (Table 5A).

5. Haddock year class strength is significantly and negatively correlated with herring year class strength 3 years previously both for the period pre 1959 and 1959-1974, as well as for the entire period (Table 5C).

For herring, in which there are relatively large variations in year class strengths, the stock of 3 year and older fish in any year is influenced to a large extent by year class strengths 3 years earlier. To a first approximation therefore, a correlation with herring stock size is much the same as a correlation with herring year class strengths 3 years earlier. Therefore, the correlations in 4. and 5. together, suggest that there could be a negative correlation between haddock year class strength and herring stock size.

Multiple correlations

Multiple correlations, using 3 and 4 variates, were also calculated for the period before 1959 as well as for the period 1959-1974.

In this analysis, it seemed appropriate also to confine attention only to those sets of data for which the various regression coefficients were all individually significant. With these restrictions, without displacement of variates, and using 3 variates, only one combination of variates was found for which the regression coefficients were both statistically significant and for both time periods.

This was the regression of haddock year class on whiting year class and haddock mean lengths. For this combination of variates the regression equation is $Y = -7.77 + 1.16\ X1 + 0.208\ X2$

where Y = ln (haddock year class strength) X1 = ln (whiting year class strength) X2 = mean length of 2-group haddock in the year of spawning.

The relationship between observed haddock year class strwngths and the predicted values obtained using this regression equation is shown in Fig. 2.

Using 4 variates and without displacement of variates, no combinations were statistically significant for both time periods separately.

Conclusions

A large number of correlations were calculated and it is to be expected that 5% of all correlations would prove to be statistically significant at the 5% level even if the populations were statistically uncorrelated. The analyses show however that considerably more than 5% of the correlations that were calculated were statistically significant at the 5% level.

As a more rigorous test, it may be thought appropriate to pay attention only to those pairs of variates which were significantly correlated when calculated for different time periods. With this restriction it was found that comparatively few of the simple correlations were statistically significant. In the case of the multiple correlations it is also appropriate to consider only those combination variates for which each of the regression coefficients is individually significant. Only one combination of 3 variates and none using 4 variates were found to satisfy these conditions.

Although preliminary analyses suggested a relatively high degree of correlation among the variates, these more detailed considerations tend to restrict attention to just certain groups of variates.

The main conclusions appear to be:-

1. Certain pairs of variates appear to be positively correlated with each other ie (a) haddock and whiting year classes appear to be positively correlated with each other.
(b) plaice year classes appear to be positively correlated with sole year classes.

Positive correlations between groups of year classes suggests that recruitment could be influenced by general conditions, affecting the year class strengths of more than one species at a time.

2. Other pairs of variates appear to be negatively correlated
ie (a) haddock year class strength with herring stock size.
This is not inconsistent with suggestions made by Jones & Richards (1976) ie that during the 1960s, some North Sea gadoids might have benefitted from the food energy released by the reduction in the stocks of adult herring and mackerel.
(b) herring year class strength with the index of intrusion of Iceland Faroe ridge water in the preceding year.

3. In general, more significant correlation is not obtained by multiple correlation of the variates in 3's or 4's.

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Table 1 Post 1958 year class strengths and other data

Year	Year class strengths								Stock sizes			
	Haddock[1]	Whiting[1]	Norway pout[2]	Cod[3]	Saithe[4]	Plaice[5]	Sole[6]	Herring[7]	Haddock[8]	Herring[9]	Haddock lengths[10]	IFR index[11]
1959	234	575	107	31	36	567	40	2.1	238	18	(28.8)	52
60	152	414	28	31	50	466	58	16.0	356	13	29.0	40
1	638	916	182	88	84	379	14	7.2	310	12	32.1	41
2	3203	1562	142	68	178	394	17	8.7	223	8.1	32.0	20
3	70	387	7	149	156	127¼	552	10.9	570	15	28.0	29
4	115	682	19	146	167	376	115	5.6	2773	14	(25.0)	65
5	147	777	6	190	134	342	62	5.3	1779	13	22.9	77
6	767	977	(60)	173	366	316	62	7.6	1028	10	28.1	(59)
7	6296	2614	243	67	382	263	97	7.6	537	7.8	34.1	(40)
8	385	858	(6)	66	494	340	47	3.8	764	5.9	27.1	22
9	109	778	33	261	207	410	135	9.1	5183	4.6	24.0	31
70	974	829	112	321	203	320	39	7.1	2689	4.8	24.1	52
1	1510	1784	329	65	209	287	75	5.0	808	3.3	27.1	72
2	273	2343	17	128	238	699	84	2.2	938	3.5	27.1	67
3	1338	1667	122	136	934	480	61	5.9	1191	3.4	25.4	84
4	2050	2304	10	284	291	248	13	1.0	690	2.2	26.1	65

1) Millions of 1-group fish in sea from VPA - from Anon 1977/F:8
2) From Anon 1977/F:7 index of I-group abundance - value in brackets calculated using indices of 0-group abundance
3) From Anon 1976/F:9 and Anon 1977/F:8 - millions of fish aged 2 yrs - from VPA
4) From Anon 1974/F:2 and Anon 1977/F:3 - millions of fish aged 2 yrs from VPA
5) From Anon 1975/F:4, and 1977/F:5 - millions of fish aged 2 yrs - from VPA
6) From Anon 1976/F:4 and 1977/F:5 millions of fish aged 2 yrs from VPA
7) From Anon 1977/H:2 - 0-group nos x 10^{-9}
8) Millions of fish ≥ 3 yrs - from VPA
9) Nos of fish aged ≥ 3 yrs x 10^{-9} from Anon 1977/H:2
10) Mean lengths of 2-group haddock in period April-June - from Scottish research vessel samples - values in brackets by interpolation
11) Index of intrusion of Iceland/Faroe ridge water - from Martin 1976 - values in brackets by interpolation.

Table 2 Pre 1959 year class strengths and other data

	Year class strengths					stock sizes			
	Haddock[1]	Whiting[1]	Plaice[2]	Sole[2]	Herring[3]	Haddock[4]	Herring[5]	Haddock lengths[6]	IFR index[7]
1918	270				6.9				
1919	300				6.2				
1920	540				5.2				
1921	130				6.6				
1922	75				6.2				68
1923	700				3.1				80
1924	340				6.8				72
1925	280				3.0				48
1926	500		271		4.2	2921	12	26.4	53
1927	170		317		7.5	2126	14	25.8	61
1928	900		746		7.2	1967	12	24.2	20
1929	230		252		9.5	1736	11	26.2	44
1930	160		92		3.9	3160	13	22.7	(53)
1931	500	3000	90	17	7.5	1486	14	24.7	62
1932	170	1700	259	179	8.0	1216	18	25.6	55
1933	250	1000	130	8	10.8	1494	17	25.2	60
1934	140	1300	244	14	11.0	677	18	27.4	73
1935	600	1900		25	2.6	487	19	27.6	48
1936	140	1700		63		236	19	28.3	45
1937	120	800		50		1025	19	25.8	48
1938	230	400		68		958	16	24.8	58
1945	600	1500	417	36	7.8				
1946	60	500	378	20	7.0	1275		28.4	74
1947	120	800	413	378	4.6	1327	18	25.1	80
1948	210	1200	312	51	4.1	665	16	24.4	64
1949	180	1200	345	106	5.5	482	17	27.0	57
1950	170	700	332	152	7.0	578	16	25.4	52
1951	600	900	264	59	7.6	612	(14)	26.4	36
1952	370	2000	328	36	8.9	339	13	26.1	56
1953	400	1000	341	83	8.0	598	13	26.9	47
1954	450	900	392	95	7.5	1150	13	26.1	75
1955	500	800	242	72	4.8	1256	14	27.9	49
1956	50	500	340	113	21.4	1037	12	26.9	64
1957	75	550	541	107	5.5	2203	11	25.7	82
1958	368	370	579	347	7.6	949	9	28.7	60

Footnotes

1) Millions of 1-group fish - based on Scottish research vessel catches per 10 hrs fishing
2) Millions of 2-group fish - from Holden (1975)
3) Nos of 0-group fish $\times 10^{-9}$ - from Burd (1975)
4) Nos of fish $\geq$ 2 yrs per 10 hours fishing by Scottish research vessels
5) Nos of fish aged $\geq$ 3 yrs $\times 10^{-9}$ from Burd (1975) - value in brackets by interpolation
6) Mean lengths of 2-group haddock in period April-June from Scottish research vessel samples
7) Index of intrusion of Iceland/Faroe ridge water - from Martin (Personal communication) - value in brackets by interpolation.

Table 3

Percentage of correlation that were significant at the 5% level

	1947-1974		1959-1974	
	No of correlations	%	No of correlations	%
A. Simple correlations (2 variates only)				
without displacement of variates	30	33	60	22
variates displaced 1 year	40	8	88	10
" " 2 "	40	13	88	8
" " 3 "	40	10	88	10
B. Multiple correlations (3 variates)				
without displacement of variates	140	55	440	31
C. Multiple correlations (4 variates)				
without displacement of variates	280	60	1 320	37

Table 4

Correlation coefficient significant at the 5% level - No displacement of variates

A. Period 1947-1974

	Year Classes					Stock Size			
	Haddock	Whiting	Plaice	Sole	Herring	Haddock size	Herring stock	Haddock length	IFR index
Haddock	-	0.70	-0.45	-0.54	-	-	-0.53	0.50	-
Whiting	-	-	-0.43	0.49	-0.43	-	-0.48	-	-
Plaice	-	-	-	0.48	-	-	-	-	-
Sole	-	-	-	-	-	-	-	-	-
Herring YC	-	-	-	-		-	-	-	-

B. Period 1959-1974

	Year Classes								Stock Size			
Year Classes	Haddock	Whiting	N pout	Saithe	Cod	Plaice	Sole	Herring	Haddock stock	Herring stock	Haddock length	IFR index
Haddock		0.79*	0.63**	-	-	-0.61*	-0.54*	-	-	-0.52*	0.49*[1)]	-
Whiting	-		-	0.59*	-	-	-	-0.52*	-	-0.73**	-	-
N pout	-	-		-	-	-	-	-	-	-	0.50*	-
Saithe	-	-	-		-	-	-	-	-	-0.71**	-	-
Cod	-	-	-	-		-	-	-	0.64*	-	-0.67**	-
Plaice	-	-	-	-	-		0.58*	-	-	-	-	-
Sole	-	-	-	-	-	-		-	-	-	-	-
Herring	-	-	-	-	-	-	-		-	-	-	-

1) Very close to 5% level of significance

Table 5

Correlation Coefficients
Pre 1959 and 1959-1974 periods

A. No displacement of variates

Period / Groups	Pre 1959	1959-1974	All years
Haddock YC/whiting YC	0.56*	0.79**	0.74**
Plaice/sole	0.77**	0.58**	0.61**
Haddock YC/herring stock	-0.20 NS	-0.52*	-0.53**

B. Variates displaced one year

HerringYC/IrR index	-0.52*	-0.44 NS	-0.38*

C. Variates displaced 3 years

HaddockYC/herring YC	-0.47*	-0.66*	-0.35*

NS Not significant
YC Year class

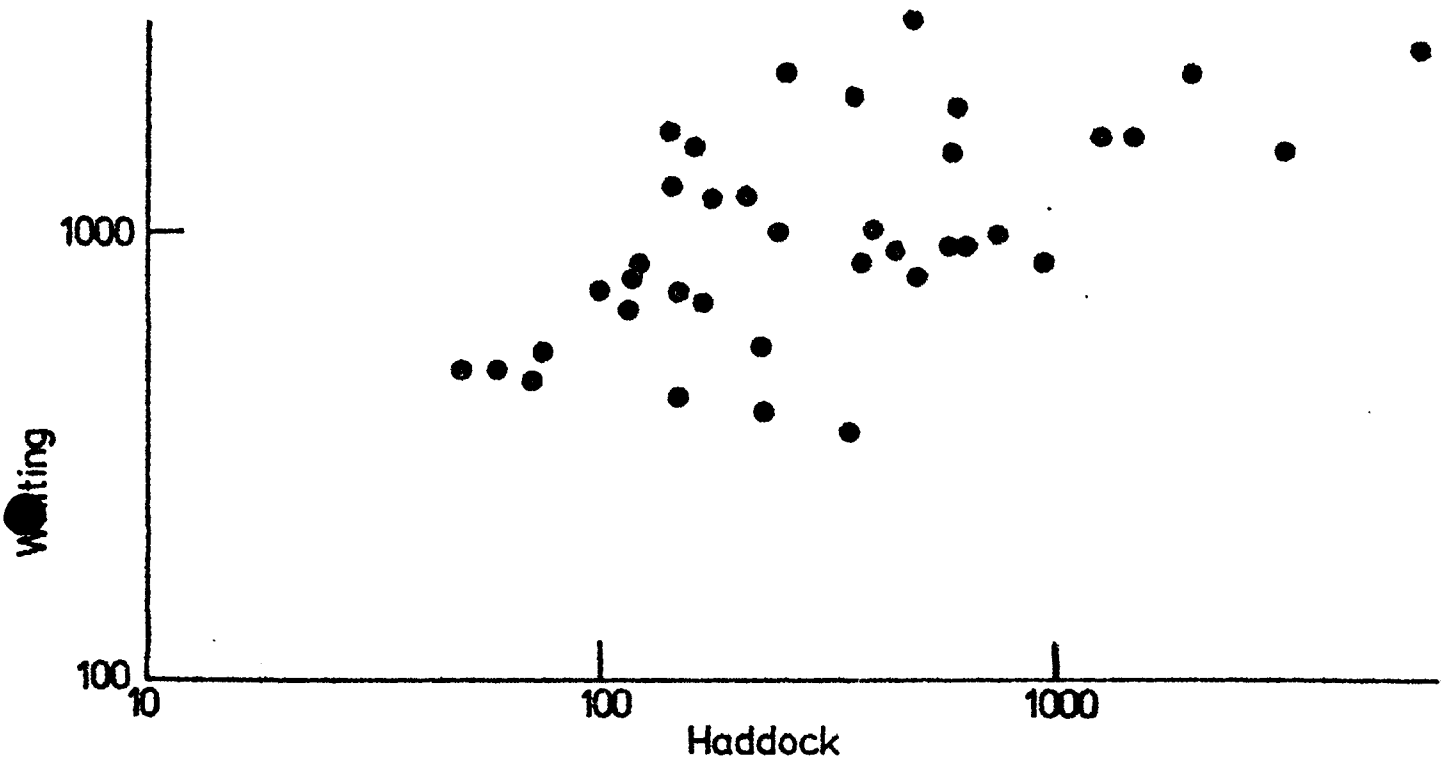

Figure 1. Relation between haddock and whiting year class strengths

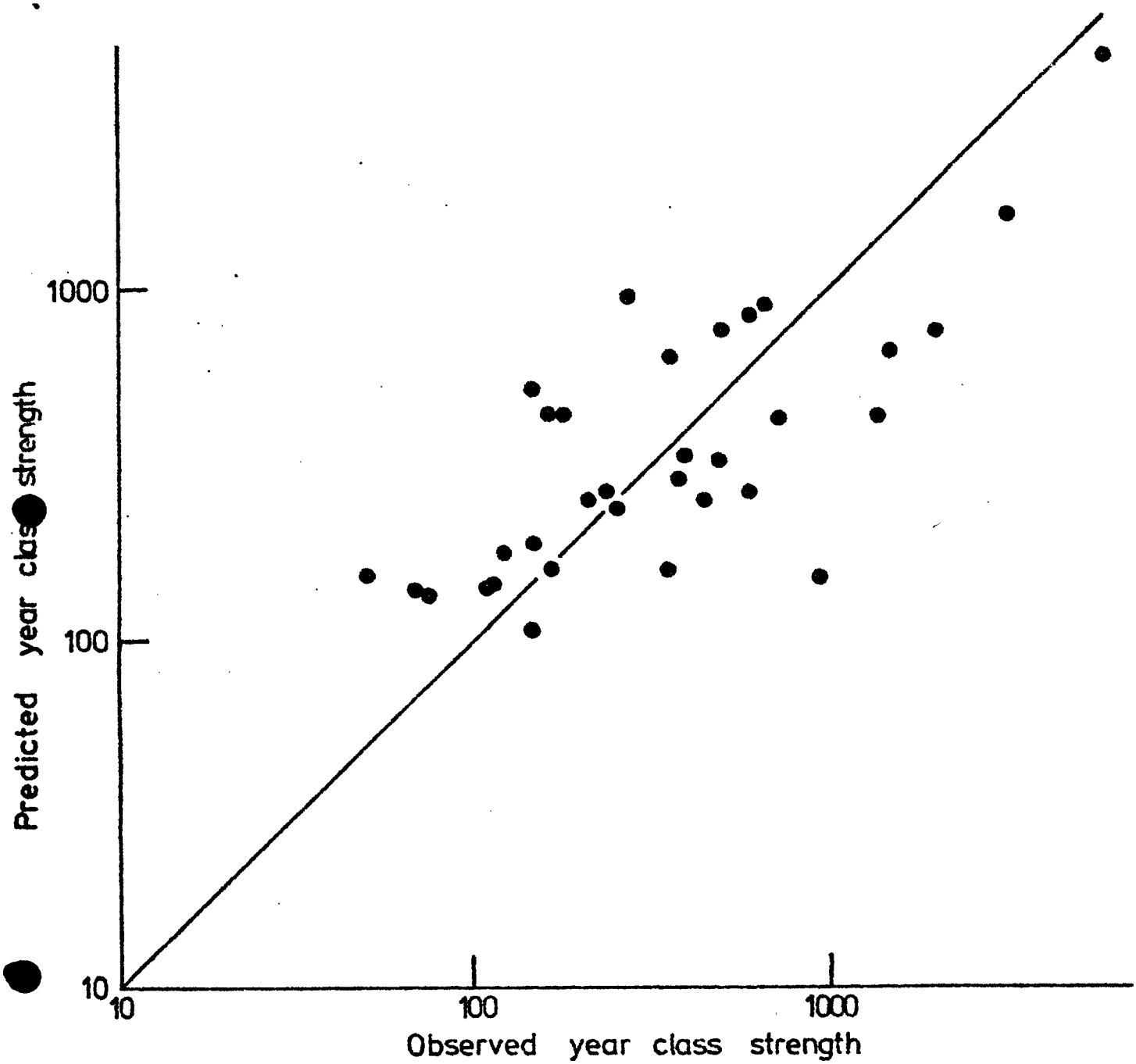

Figure 2. Relation between predicted and observed haddock year class strengths using multiple regression of haddock year class strength on whiting year class strength and haddock mean lengths.