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RECRUITMENT TRENDS IN THE LOBSTER FISHERY OF BERWICKSHIRE (S.E. SCOTLAND) FROM 1955 TO 1979

by

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Abstract

More than half of the lobsters landed in the Berwickshire creel fishery are sexually immature and this had led to fears that recruitment to this stock might be limited by the size of the spawning stock.

Cohort analysis has been applied to length composition data for the periods 1955-8, 1960-4, 1965-9, 1970-4 and 1975-9. The results suggest that recruitment has declined steadily since 1960-4. The biomass of the female spawning stock fell sharply in 1965-9 since when it has shown a small recovery. The time series is too short for conclusions to be drawn about a possible stock/recruitment relationship. A conservative (protective) management strategy is nevertheless indicated.

Résumé

Plus de la moitié des homards amenés à la pêcherie par casier de Berwickshire sont pas mûr sexuellement, et ce fait a occasionné crainte que le recrutement à cette lignée peut être limité par le nombre du stock en frai.

On a fait une analyse sur les données de composition du longueur pour les périodes 1955-9, 1960-4, 1965-9, 1970-4 et 1975-9. Les résultats suggèrent une baisse soutenus de recrutement depuis 1960-4. La biomasse des femelles en frai descendait nettement en 1965-9, depuis lors il a montré un recouvrement mince. L'échelle du temps est trop court de nous permettre de prendre des conclusions sur un rapport possible entre le stock/recrutement. Néanmoins on peut indiquer une stratégie de direction conservateur protecteur.

Introduction

The reports of the ICES Homarus Working Group (Anon., 1977 and 1979) have drawn attention to the dangers of recruitment failure in a number of the lobster (*Homarus gammarus* and *Homarus americanus*) stocks in the ICES area. One stock which gives cause for concern is off Berwickshire in south-east Scotland. The fishery in this area has a long history of intensive exploitation (Shelton et al., 1978; Thomas, 1965), so much so that more than half of the lobsters landed are sexually immature. On the assumption that most of the recruitment to this stock is derived from parents inhabiting the same area, the possibility that recruitment might be limited by the size of the spawning stock is self-evident. Until a method can be found for determining the age of lobsters, there is no way of investigating this possibility on a year-to-year basis. However, although it is not yet possible to relate individual year-classes to their presumed parent stocks, it is possible, by applying the technique of cohort analysis to length composition data (Jones, 1974), to investigate recruitment trends within a long time series. The same technique can be used to estimate the mean biomass of the female spawning stock. It is therefore possible to compare an estimate of recruitment for one period with an estimate of the female spawning stock biomass in an appropriate earlier period.

The main drawback of the method is the necessity to combine the catch length composition data for several years to reduce biases introduced by short-term changes in recruitment (Jones, 1974). It was felt that in this assessment the most appropriate period to use would be one of five years. This is about the minimum period to have a useful damping effect upon short-term fluctuations in recruitment. Five years is also a likely mean age for the smallest, fully-recruited size group (a carapace length of 80-89mm) so appropriate comparisons should be possible between mean recruitment in one quinquennium and the biomass of the female spawning stock in the previous quinquennium.

The data series upon which this paper is based extends from 1951 to 1979. It is complete with the exception of 1959, for which year no catch length composition data are available for this fishery.

Methods

1. Cohort analysis

Cohort analyses on mean catch length composition data are liable to give mis-leading results unless the pattern and rate of exploitation have remained reasonably stable over the period represented by the mean values. This was not so in 1951, when the minimum legal landing size was increased (Shelton et al., 1978) nor in the years immediately following. The earliest period on which a cohort analysis could usefully be attempted was 1955-8. The four subsequent quinquennia were also analysed. The period, 1965-9, presented a potential problem in that in 1965 the ban on the landing of berried lobsters was rescinded. However, the regulation had been so completely evaded that the short-term effects of cancelling it were not detectable in the landing statistics. It was therefore possible to include the 1965-9 quinquennium in the series of analyses.

Cohort analyses upon mean catch length composition data also require the values of the von Bertalanffy parameter, L_∞ , the ratio $\frac{M}{K}$, the exploitation rate, $\frac{F}{Z}$, for the largest animals in the catch, and the characteristics of the length/weight relationship.

The values of the growth parameters used were

	L_∞	K
Male	209	0.0913
Female	168	0.1088

These values were derived from recent tagging experiments by MAFF scientists in the nearby Yorkshire lobster fishery (Anon., 1979).

A value of 0.1, the value currently in use by the ICES *Homarus* Working Group, was used as the coefficient of natural mortality. This is compatible with estimates derived from tagging experiments by Thomas (1955a and b) in the Berwickshire fishery and with the results of tagging experiments currently in progress in the adjacent fishery in Fife.

An exploitation rate ($\frac{F}{Z}$) of 0.9 for the largest lobsters in the catch was used throughout. The carapace length/weight relationships used were

$$\text{Males} \quad W = 0.000207\ L^{3.26}$$

$$\text{Females} \quad W = 0.00105\ L^{2.89}$$

where W = the weight in g. and L = carapace length in mm.

Recruitment was calculated as the numbers in the sea of male and female lobsters which attain a carapace length of 80-89mm. This was compared with the biomass of the female spawning stock (all female lobsters with a carapace length of 90mm of more), the biomass of the total female stock and with mean catch per unit effort (catch in Kg. per 100 creel hauls). In each instance the comparison was with the previous quinquennium.

2. Catch and fishing effort data

Weather permitting, the lobster fishing season in Berwickshire lasts for some nine months, beginning in April and ending in December. Catch rates are greatest in late summer and autumn when sea temperatures are comparatively high and when freshly-moulted and therefore hungry lobsters form a high proportion of the population. Except where stated, the catch per unit effort values given in Table 1 are mean values based upon the whole nine months fishing season. Prior to 1963, catch/effort data were collected during routine visits to the fishery in spring and autumn. From 1963, catch/effort data have been obtained from the monthly returns of two fishermen/observers. Results are expressed as mean catch (in Kg) per 100 creel hauls. Total annual effort (in 1 000's of creel hauls) was derived from annual catches. The annual numbers of boats active in the fishery provides a second measure of fishing effort. However, since the participation of many of these vessels was part-time and sporadic, their numbers provide only a crude and unreliable guide to total fishing effort.

Results and discussion

1. Fishing effort

Fishing effort, as measured by the numbers of creels hauled (Table 1) has fluctuated about a mean of 475×10^3 (standard deviation = 122×10^3).

Taken at their face value, the fishing effort estimates for the 1950s suggest that fishing effort remained relatively low throughout the decade. However, the later 1950s were poorly documented and, because for some years the fishing effort estimates were calculated from catch per unit effort data collected during the months of September and October, a period when catches are normally high, the period of harder fishing which is shown in Table 1 as beginning in 1961, and lasting four years, undoubtedly began some years earlier. The later 1960s and early 1970s were marked by a return to the less intensive fishing of the early part of the previous decade. A second period of more intensive fishing took place from 1974-8, a period when continental demand for Scottish lobsters was especially strong.

Cohort analyses on length composition data are based upon the assumption that the length compositions represent equilibrium conditions. When, as in this fishery, there have been fluctuations in fishing effort, this ideal is not attained and time lag effects may bias the calculated values of numbers, and instantaneous rates of fishing mortality at length. It is clear from inspecting Table 1 that the fluctuations in fishing effort in the Berwickshire lobster fishery are sufficiently large in extent and duration to cause biases which should be borne in mind when interpreting the results of the cohort analyses.

2. Cohort analyses

The mean percentage length compositions of the lobsters landed in the Berwickshire fishery over the five periods covered by this paper are shown in Table 2. This table and Table 3, which lists the numbers (in thousands) of lobsters landed by sex and carapace length group, show that catches have been dominated throughout by small, recently-recruited individuals. The estimated numbers (in thousands) of lobsters attaining each carapace length group in the sea are listed in Table 4. Recruitment reached an apparent peak of 727×10^3 lobsters in the 80-89mm carapace length group in 1960-4. Recruitment has declined continuously since so that by 1975-9 it had fallen to 291×10^3 lobsters. The corresponding array of fishing mortality coefficients is given in Table 5. F values are moderate to high throughout. Comparison of this table with Table 1 shows that the periods when fishing effort was greatest do not correspond with the periods when calculated F values were highest. This is largely due to time lag effects of the kind referred to earlier, which are inherent in the method of analysis. It is considered that these biases are not great enough to invalidate the main conclusion that there has been a decline in recruitment over recent quinquennia. It is interesting to note that a similar decline in recruitment was evident when the catches of recruits per unit of fishing effort were calculated. This was possible from 1960-4 onwards and gave the following results (expressed in numbers of recruits per 100 creel hauls).

1960-4	-	11.6
1965-9	-	14.6
1970-4	-	11.1
1975-9	-	5.8

By using C.P.U.E. as an index of recruitment it can be seen that the decline is not evident until 1970-4.

More caution is needed in comparing indices of recruitment in one quinquennium with the decline in the female (spawning and total) stock in the immediately previous quinquennium (Table 6). All that can be said is that the biomass of the female stock was markedly less in the last three quinquennia than in the previous two and that this is especially true of the larger females which comprise the spawning stock. It is, perhaps, a hopeful sign that the female stock has not shown a continuous decline but appears to have stabilised at a new lower level. There is, of course, insufficient evidence to conclude that the decline in recruitment is a direct consequence of the smaller size of the female spawning stock. However, the results of this paper could reasonably be interpreted as an indication that all is not well with the Berwickshire lobster fishery and that the case for a conservative (protective) management strategy, already justified in terms of yield per recruit (Shelton *et al.*, 1978), is strengthened still further.

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Table 1

Summary of catch and fishing effort data in the Berwickshire lobster fishery 1951-1979.

Year	Catch in tonnes	Catch in kg per 100 creels hauled	No. of creels hauled x 10^{-3}	No. of boats
1951	32	9.1	349	32
1952	30	7.3	414	N.A.
1953	46	10.4	439	34
1954	47	14.5	326	31
1955	52	N.A.	N.A.	36
1956	56	N.A.	N.A.	33
1957	56	13.6*	413*	30
1958	59	13.8	428	31
1959	72	26.8*	268*	33
1960	73	15.9*	458*	34
1961	94	11.4	825	30
1962	55	8.6	642	29
1963	56	8.6	649	27
1964	52	8.1	648	32
1965	43	9.6	447	37
1966	36	8.4	434	35
1967	53	10.7	492	36
1968	42	8.8	473	39
1969	33	6.8	483	41
1970	38	9.2	416	43
1971	38	8.6**	445**	42
1972	33	11.8	281	45
1973	33	7.1	460	28
1974	31	5.9	533	29
1975	22	4.9	453	29
1976	24	3.9	625	22
1977	31	6.0	522	31
1978	33	6.5	512	35
1979	26	6.9	N.A.	N.A.

* Data based on September and October only.

** Data based on July-December only.

Table 2

Mean percentage length compositions of lobsters landed by carapace length group (CLmm) in the periods shown. Note that lobsters falling within the 70-79mm carapace length group were not recorded until 1965.

Period	1955-8*		1960-4		1965-69		1970-74		1975-9	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
CLmm										
150	-	-	-	-	-	-	-	-	<0.1	-
140	<0.1	-	-	<0.1	<0.1	-	<0.1	<0.1	0.1	<0.1
130	0.5	0.3	0.3	0.4	<0.1	<0.1	0.2	<0.1	0.5	0.2
120	1.4	1.1	1.6	1.3	0.3	0.2	0.5	0.1	1.5	0.5
110	3.9	4.6	3.8	3.5	1.5	1.0	2.9	0.7	4.9	3.2
100	10.6	12.3	9.6	9.0	5.3	3.7	7.6	4.2	10.0	9.8
90	34.3	33.3	27.7	26.2	22.5	19.8	23.3	21.0	24.1	26.7
80	49.3	48.3	57.1	59.6	66.7	68.1	60.6	65.8	54.8	52.9
70	N.A.	N.A.	N.A.	N.A.	3.6	7.2	4.9	8.2	4.0	6.6

Table 3

Numbers (x 10^{-3}) of lobsters landed by carapace length group (CLmm) in the periods shown.

Period	1955-8*		1960-4		1965-9		1970-4		1975-9	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
CLmm										
150	-	-	-	-	-	-	-	-	<0.1	-
140	0.2	-	-	<0.1	<0.1	-	<0.1	<0.1	0.1	<0.1
130	1	0.7	0.8	1	0.1	0.2	0.3	<0.1	0.6	0.3
120	3	3	5	4	0.6	0.6	0.9	0.2	2	0.7
110	8	10	12	12	3	3	5	1	6	4
100	23	28	30	30	12	10	13	8	13	14
90	73	75	85	87	49	56	41	42	31	38
80	105	109	176	197	145	192	105	131	68	75
70	N.A.	N.A.	N.A.	N.A.	8	20	8	16	5	9

* Data for 1959 not available

Table 4
Estimated number (x 10^{-3}) of lobsters attaining each carapace length group (CLmm) in the sea derived by cohort analysis from catch length composition data for the periods shown.

Period	1955-58		1960-64		1965-69		1970-74		1975-79	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
CLmm										
150	-	-	-	-	-	-	-	-	<0.1	-
140	0.2	-	-	<0.1	<0.1	-	<0.1	<0.1	0.3	<0.1
130	1	0.8	0.9	2	0.2	0.3	0.5	0.2	1	0.1
120	5	4	6	7	0.9	0.9	1	0.5	3	1
110	14	16	19	20	4	4	7	2	10	7
100	39	48	53	56	17	16	22	11	25	23
90	120	135	147	155	70	78	67	57	59	66
80	241	265	345	382	229	290	184	202	138	153
70	N.A.	N.A.	N.A.	N.A.	257	341	208	240	155	178

Table 5
Fishing mortality coefficients for each carapace length group (CLmm) derived by cohort analysis, from catch length composition data for the periods shown.

Period	1955-8		1960-4		1965-9		1970-4		1975-9	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
CLmm										
140	-	-	-	-	-	-	-	-	0.43	-
130	0.98	-	-	-	0.76	-	0.84	0.21	0.69	0.42
120	0.74	0.55	1.08	0.51	0.89	0.46	0.70	0.27	0.72	0.36
110	0.76	0.64	0.79	0.51	1.06	0.66	1.05	0.64	0.81	0.67
100	0.81	0.61	0.78	0.55	1.04	0.73	0.88	0.89	0.70	0.68
90	0.96	0.67	0.89	0.67	1.18	0.98	0.96	1.00	0.76	0.70
80	0.66	0.50	0.81	0.68	1.11	0.97	0.96	0.94	0.80	0.63
70	-	-	-	-	0.04	0.07	0.05	0.08	0.04	0.06

Table 6
Summary of recruitment, spawning and total female stock biomasses and mean C.P.U.E. for the periods shown.

Period	No. of recruits x 10^{-3}			Biomass of female stock (kg x 10^{-3})		Mean C.P.U.E. (kg/100 creel hauls)
	Male	Female	Total	Spawning (>89 CLmm)	Total (>79 CLmm)	
1955-9	301	331	632	151	259	16.8
1960-4	345	382	727	148	263	10.3
1965-9	229	290	519	40	137	8.9
1970-4	184	202	386	34	100	8.0
1975-9	138	153	291	58	111	5.3

Note that the recruitment and biomass values shown for 1955-9 were estimated by applying a raising factor of 1.25 to the 1955-8 values and that the mean C.P.U.E. values for the first two quinquennia are overestimates (See Table 1).