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Analysis of offshore capelin catch rate data in NAFO Divs. 2J3KL for the period 1978-90

by

Peter A. Shelton, David W. Kulka and James E. Carscadden
Department of Fisheries and Oceans
PO Box 5667 St John's
Newfoundland A1C 5X1

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ABSTRACT

Capelin catch rate data in terms of catch per trawl for the commercial fishery in NAFO Divs. 2J3KL for the period 1978-90 were converted into density measurements using duration of haul and vessel towing speed. The resulting quantity was analysed for year, month and NAFO Division effects. Mean density in the fishing area increased over the early 1980s, levelled off in the mid 1980s and then decreased slightly in the late 1980s. There is a coherent seasonal trend in density with maximum density in October and density decreased from north to south through NAFO Divs. 2J, 3K and 3L. Year, month and division effects were all significant and together explained about 30% of the variance in catch rate in a multiple regression model. The year effect estimated by multiple regression differed only slightly from the annual mean of the logarithm of the density measurements derived from catch rates. There are unresolved statistical problems with the application of regression methods to catch rate data including significant interactions between year and month effects and between year and area effects. However, these problems do not detract from the use of the catch rate time series as an indicator of the general trend in an index of stock size.

RÉSUMÉ

On a converti les taux de prises de capelan par trait de la pêche commerciale pratiquée dans les divisions 2J3KL de l'OPANO de 1978 à 1990 en mesures de densité, en se fondant sur la durée des traits et sur la vitesse de trait des navires. On a analysé l'influence de l'année, du mois et de la division de l'OPANO visée sur les quantités obtenues. La densité moyenne dans la zone de pêche a augmenté au début des années 80, s'est stabilisée au milieu de cette décennie puis a diminué légèrement à la fin de celle-ci. Il existe une tendance saisonnière cohérente dans la densité, la densité maximale étant atteinte en octobre; de plus, la densité diminue du nord au sud dans les divisions 2J, 3K et 3L de l'OPANO. Il s'avère que l'année, le mois et la division ont des effets importants, qui, combinés, expliquent environ 30 p. 100 des écarts observés dans les taux de prises établis d'après un modèle à régression multiple. L'influence de l'année, estimée au moyen d'une régression multiple, ne diffère que légèrement de la moyenne annuelle du logarithme des mesures de densité dérivées des taux de prises. Certains problèmes statistiques demeurent irrésolus dans l'application des méthodes de régression aux données sur les taux de prises; il existe notamment des interactions importantes entre l'influence de l'année et celle du mois ainsi qu'entre celles de l'année et de la zone. Ces problèmes n'empêchent cependant pas l'utilisation de la série chronologique sur les taux de prises comme un indicateur de la tendance générale de l'indice de la grosseur d'un stock.

1. INTRODUCTION

There are 13,052 records in the Canadian Observer Program data base for capelin-directed trawls made by Russian mid-water trawlers in NAFO Divs. 2J, 3K, and 3L for the period 1978-90. If suitably analysed, these data may provide an index of population size over the time period. Such an index would be useful in stock assessments. We converted the data to g.m^{-2} using haul duration and average vessel towing speed, as recorded by the observer, and analysed this quantity for year, month and area effects. The advantage of using these units of density is that it allows direct comparison in future studies with densities measured in research hydroacoustic surveys. The method used to analyse the catch rate data and the results obtained are reported in this paper.

2. METHODS

The catch rate was converted from tons per trawl to g.m^{-2} by taking into account duration of haul and the average vessel towing speed during the haul, as recorded by the observer. All vessels involved in the fishery are Class 7 trawlers operating similar gear and a net opening width of 50m was assumed throughout. To analyse the density measure derived from catch rates, a multiplicative model was assumed (Robson 1966, Gavaris 1980) of the form

$$y_{ijkl} = \mu\alpha_i\beta_j\gamma_k e^{\varepsilon_{ijkl}}$$

where

y_{ijkl} = catch rate in terms of density for the l th trawl set and the i th year, the j th month and the k th division

μ = mean over all trawl sets

α_i = effect of year

β_j = effect of month

γ_k = effect of division

ε_{ikkl} = random normal error

This model was transformed into an additive linear model by taking logarithms, so that

$$\log y_{ijkl} = \log\mu + \log\alpha_i + \log\beta_j + \log\gamma_k + \varepsilon_{ijkl}$$

The choice of month and NAFO Division as factors in the analysis is an attempt to account for some of the within-year and spatial variability in catch rate that is assumed to occur. In the analysis the mean and standard error of the mean for log y over all trawl sets was first calculated for each year, month and division separately. Then the model specified above was fit to year, month and division together using PROC GLM (SAS 1990) with Type III sums of squares. Finally, interactions with year were examined. Conclusions were then drawn with respect to the utility of the time series as an index for capelin stock assessments.

3. RESULTS

The mean and standard error of the mean of log y by year, month and division are presented in Tables 1-3, and in Figs. 1 and 2. The annual means are well defined and values are generally higher in the late 1980s (Table 1, Fig. 1). The analysis of monthly means (Table 2, Fig. 2) suggests that there is a coherent seasonal trend in capelin density in the area fished, with peak density in October. Note that sample size is small for May, June, July and December (Table 2). The mean and standard error by NAFO Division (Table 3), shows that densities encountered by trawls decreased from north to south. Note that there is an order of magnitude decrease in the number of trawls going southwards from one division to the next.

The model of combined year, month and division effects had significant year, month and NAFO Division effects (Table 4) and accounted for 30% of the variance in log y. Parameter estimates (Fig. 3) follow a similar pattern to the annual mean log y (Fig. 1). The NAFO Div. effect is significant, but explains only a small amount of the variance in log y. A model of year, NAFO Division and the interaction between year and NAFO Division has significant year, NAFO and interaction terms (Table 5). Similarly, a model of year, month and the interaction between year and month has all terms significant (Table 6) This indicates that the effect of year on catch rate differs from division to division and from month to month. A plot of annual mean log y by division and month, where sufficient data exists (i.e. enough values among years to allow a plot), illustrates this (Figs. 4 and 5). Despite the existence of significant year-division and year-month interactions, the trends over years are basically similar. All suggest an increasing catch rate after 1979 with some levelling off or perhaps a decline over the mid to late 1980s. However, if the trends are examined in more detail different interpretations would be inferred from the individual plots over the last three years.

4 DISCUSSION

The analysis of capelin catch rate date for the offshore Russian fishery in NAFO Divs. 2J3KL shows that mean capelin density increased in the fishing area over the early 1980s, levelled off in the mid 1980s and perhaps decreased slightly in the late 1980s. There is a coherent seasonal trend in density with maximum density in October and density decreases from north to south through NAFO Divs. 2J, 3K and 3L. Analysis of variance of catch rate with year, month and NAFO Div. factors showed that about 30% of the variability in catch rate could be explained. In this model the year effect explained the largest proportion of the variability and the NAFO Div. effect only a small amount. Further analysis showed the interactions between year and NAFO Divisions and between year and month to be significant. Trends for those NAFO Divisions and months for which there are sufficient data show an increasing catch rate after 1979 and some levelling off or perhaps a decline over the mid to late 1980s. However, more detailed examination of the trend over the last three years shows considerable differences among divisions and months, as indicated by the interaction terms. Clearly the capelin catch rate data may be suitable for a general interpretation of trends in some index of the stock, but are unreliable with respect to more detailed information of year to year changes in the relative magnitude of this index.

Interaction problems, the fact that large sample size results in most effects appearing significant in the analysis and the fact that only a relatively small amount of the variability in catch rate is explained (Large 1992) suggest caution in making inferences from catch rate data. The interaction problem in particular may prohibit using the index of year effect as an index of density or abundance (Anon. 1981, Large 1992), particularly for distinguishing year to year effects. However, in the present case the overall pattern in the index appears to be reliably determined.

5. REFERENCES

Anon. 1981. Report of the Ad Hoc Working Group on the Use of Effort Data in Assessments. ICES CM 1981/G:5, 65 pp.

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37:2272-2275.

Large, P.A. 1992. Use of a multiplicative model to estimate relative abundance from commercial CPUE data. ICES J. mar. Sci., 49:253-261.

Robson, D.S. 1966. Estimation of the relative fishing power of individual ships. ICNAF Res. Bull., 3:5-14.

Table 1. Number of records, mean logged catch rate (g.m^{-2}) and standard error of the mean for the Russian offshore capelin fishery in NAFO Divs. 2J3KL by year for the period 1978-90.

Yr	n	mean	std err
78	751	1.26302	0.041242
79	623	0.72096	0.055864
80	279	2.29116	0.076769
81	681	2.16053	0.032388
82	374	1.99122	0.044141
83	384	2.56177	0.050730
84	664	2.37942	0.034227
85	453	2.86356	0.030279
86	570	2.77446	0.030786
87	2509	2.94642	0.018476
88	587	2.52472	0.032941
89	1542	2.80755	0.021979
90	3703	2.69423	0.017124

Table 2. Number of records, mean logged catch rate (g.m^{-2}) and standard error of the mean for the Russian offshore capelin fishery in NAFO Divs. 2J3KL by month for the period 1978-90.

Mo	n	mean	std err
5	213	1.570	0.0637
6	47	1.671	0.0812
8	139	2.515	0.0878
9	3943	2.566	0.0177
10	5690	2.671	0.0134
11	2572	2.315	0.0258
12	516	1.689	0.0423

Table 3. Number of records, mean logged catch rate ($g.m^{-2}$) and standard error of the mean for the Russian offshore capelin fishery by NAFO Div. for the period 1978-90.

Div.	n	mean	std err
2J	11049	2.610	0.0103
3K	1811	2.013	0.0293
3L	260	1.592	0.0541

Table 4. Analysis of variance results for log y and explanatory factors year, month and NAFO Division. Type III sums of squares are given.

Source of variation	Sums of squares	Degrees of freedom	Mean square	F value	Pr>F
YEAR	3988.5	12	332.4	372.5	0.0001
MONTH	225.9	5	45.2	50.6	0.0001
NAFO	71.0	1	71.0	79.6	0.0001

Table 5. Analysis of variance results for log y and explanatory factors year and NAFO Division, and interaction between year and division. Type III sums of squares are given.

Source of variation	Sums of squares	Degrees of freedom	Mean square	F value	Pr>F
YEAR	1514.5	12	126.2	140.3	0.0001
NAFO	151.0	2	75.5	84.0	0.0001
YEAR-NAFO	135.9	6	22.7	25.3	0.0001

Table 6. Analysis of variance results for log y and explanatory factors year and month, and interaction between year and month. Type III sums of squares are given.

Source of variation	Sums of squares	Degrees of freedom	Mean square	F value	Pr>F
YEAR	1396.1	12	116.4	140.6	0.0001
MONTH	217.3	6	36.2	43.8	0.0001
YEAR-MONTH	939.8	31	30.3	36.6	0.0001

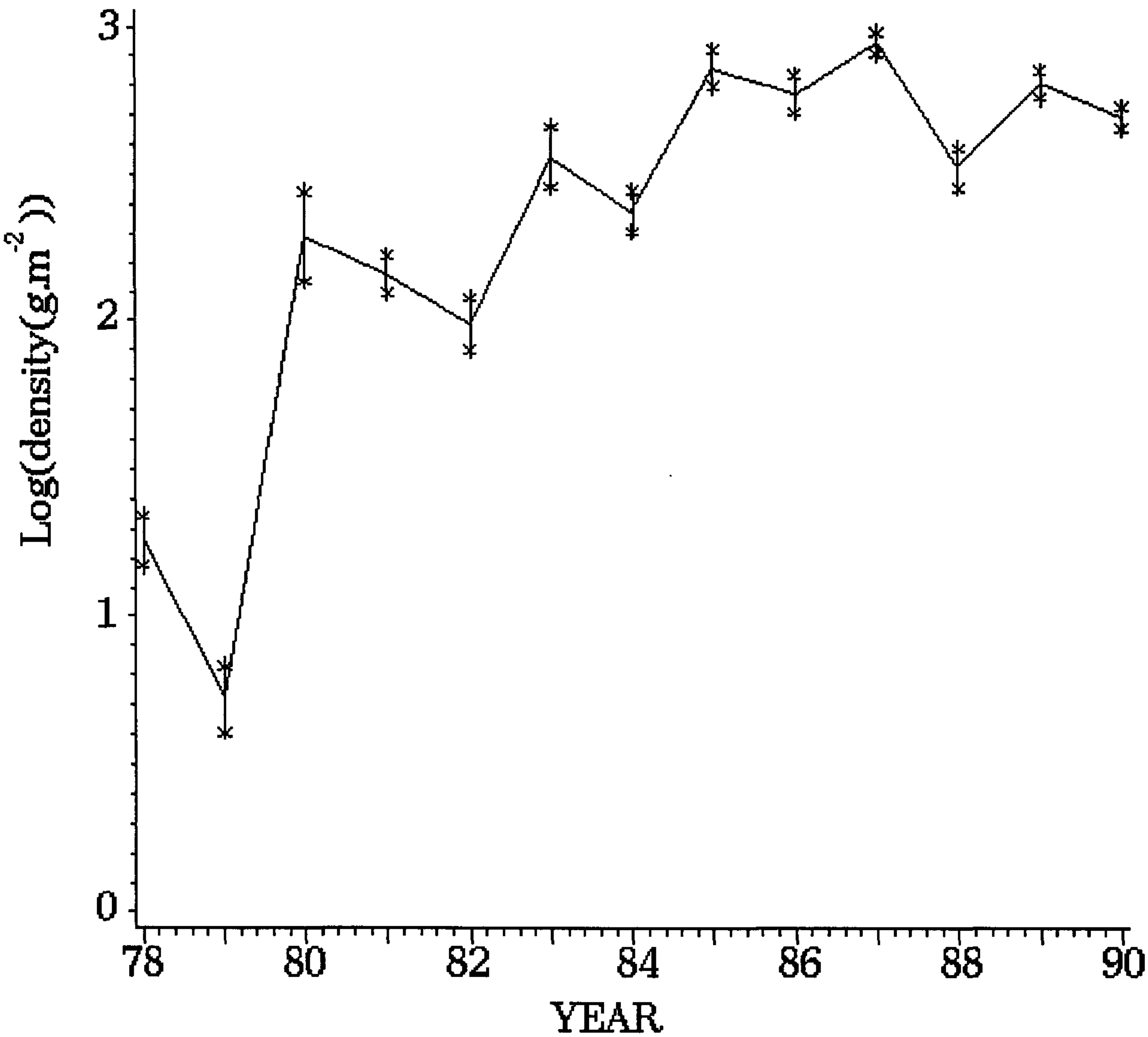

Fig. 1. Annual mean and two standard errors of the mean of the log of catch rate for the period 1978-90.

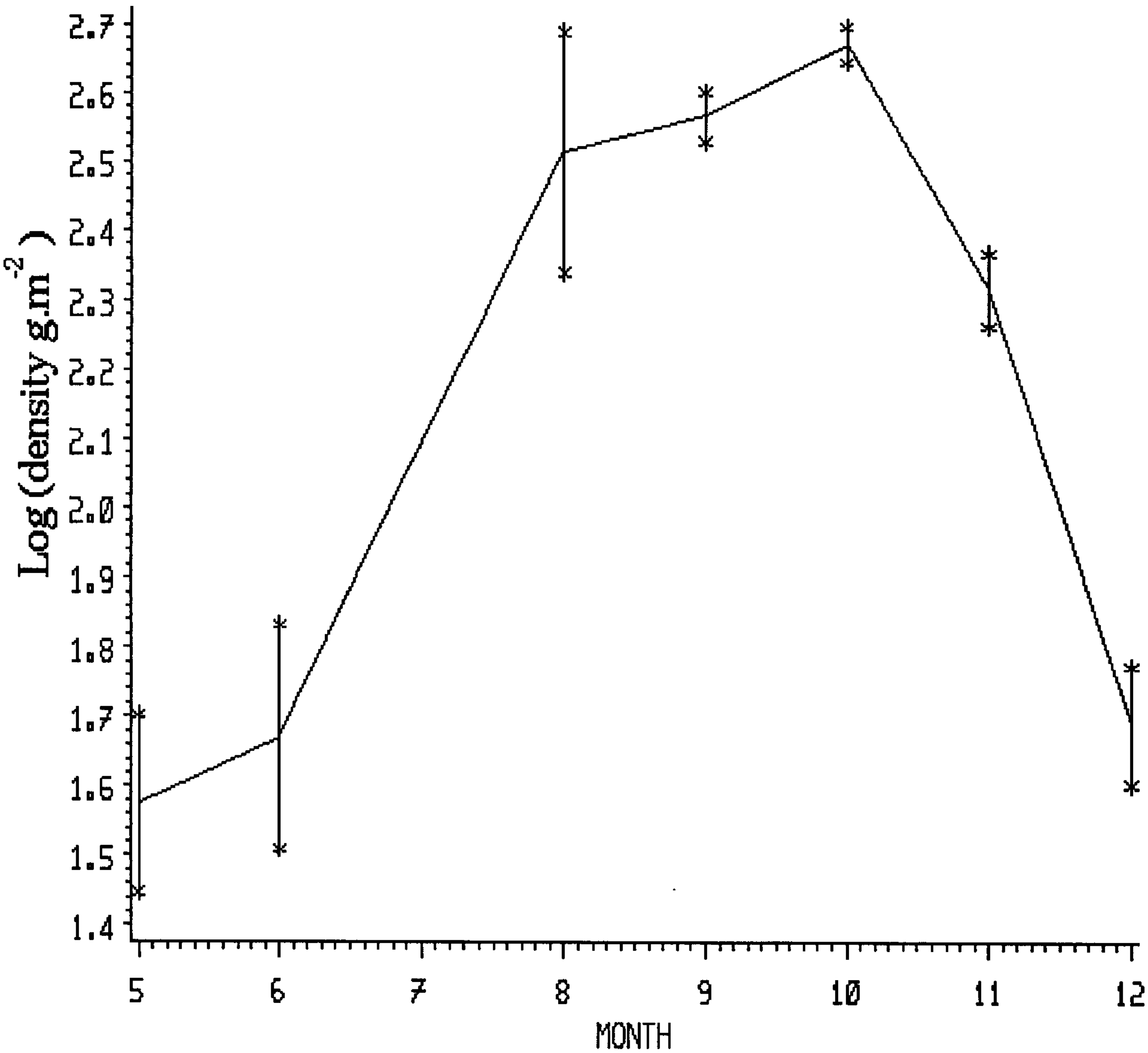

Fig. 2. Monthly mean and two standard errors of the mean of the log of catch rate for the period 1978-90.

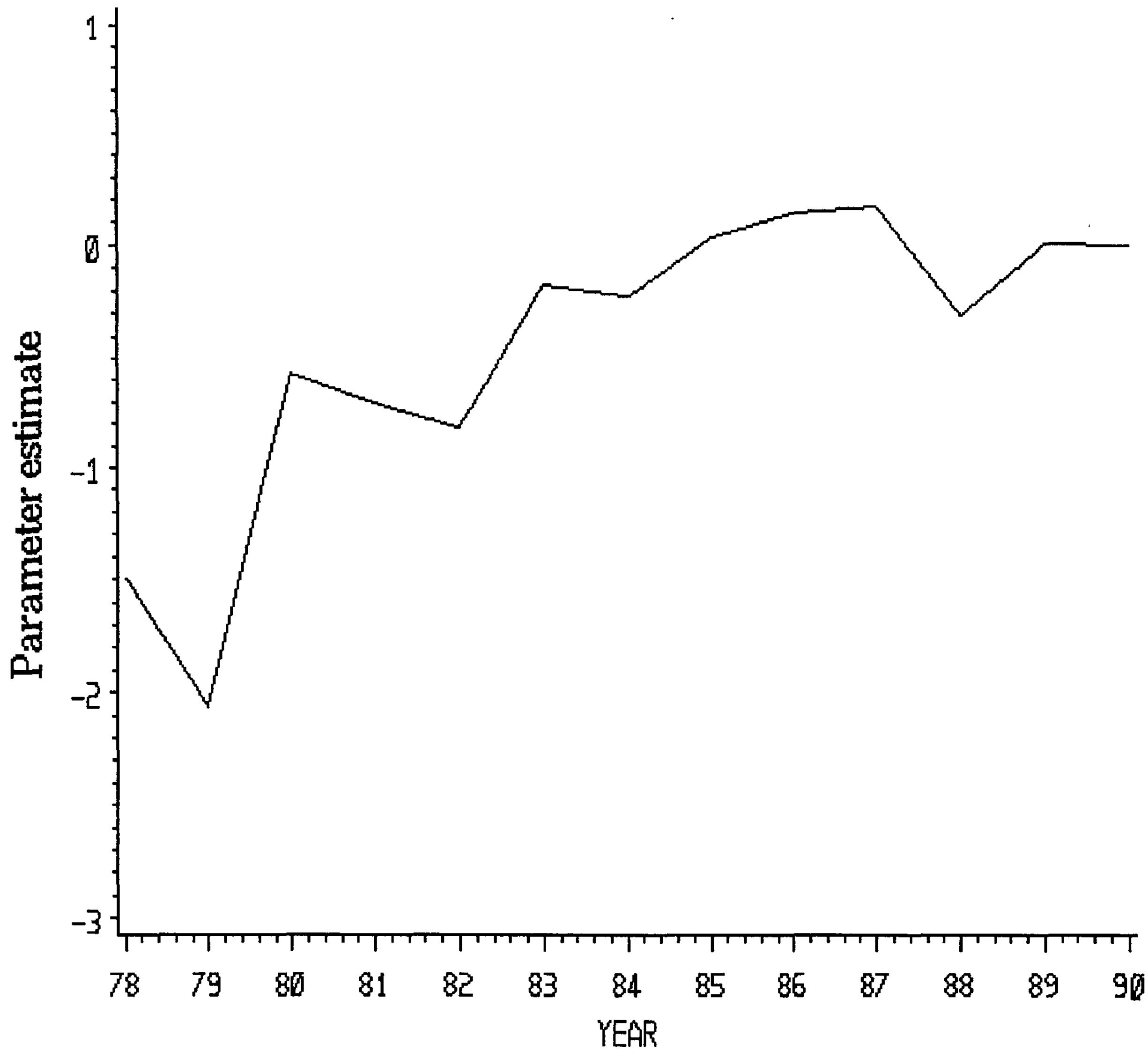

Fig. 3. The year effect estimated by analysis of variance of the log of catch rate from a model including year, month and NAFO Division effects.

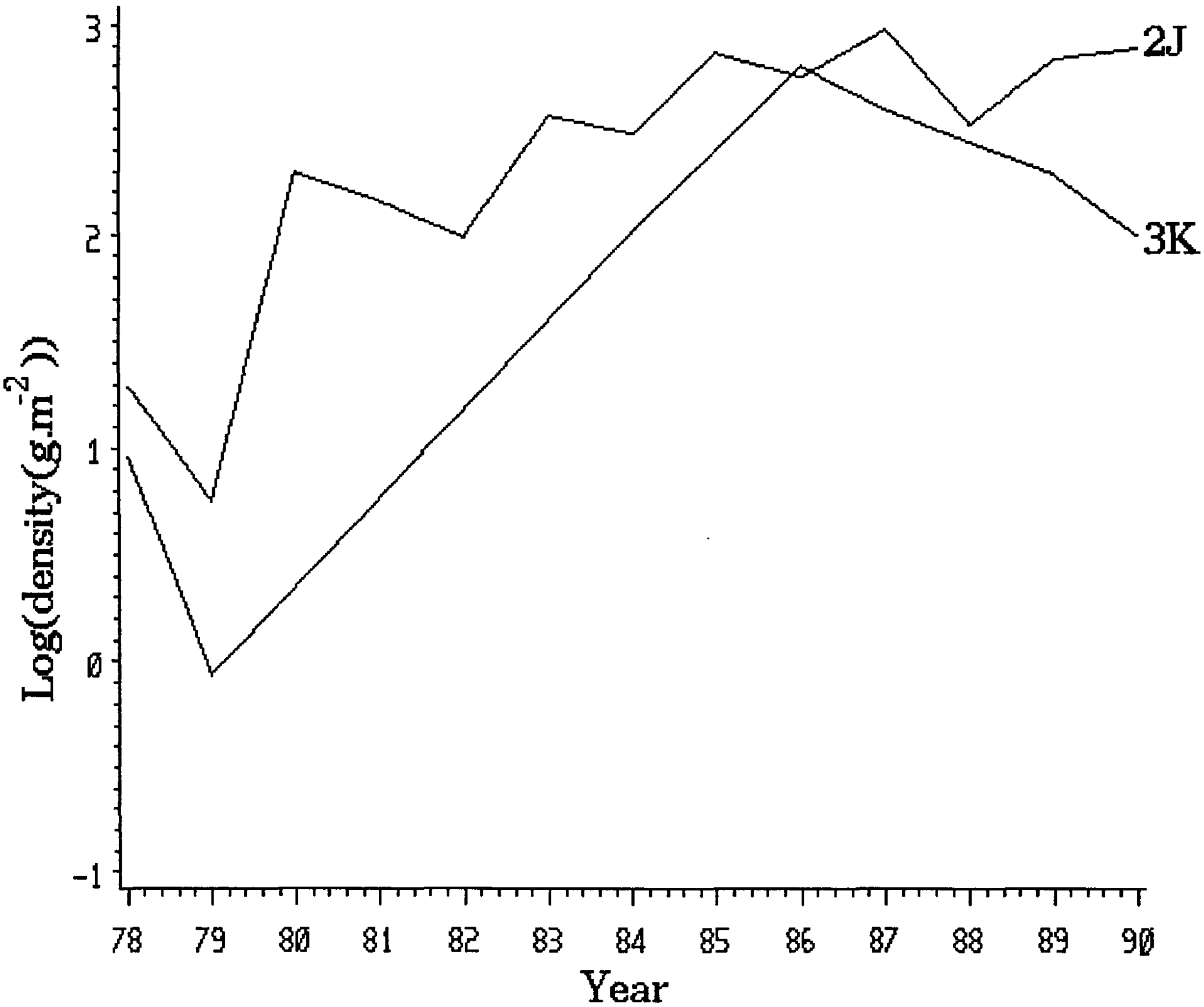

Fig. 5. The annual mean log of catch rate for NAFO Divisions 2J and 3K plotted separately.

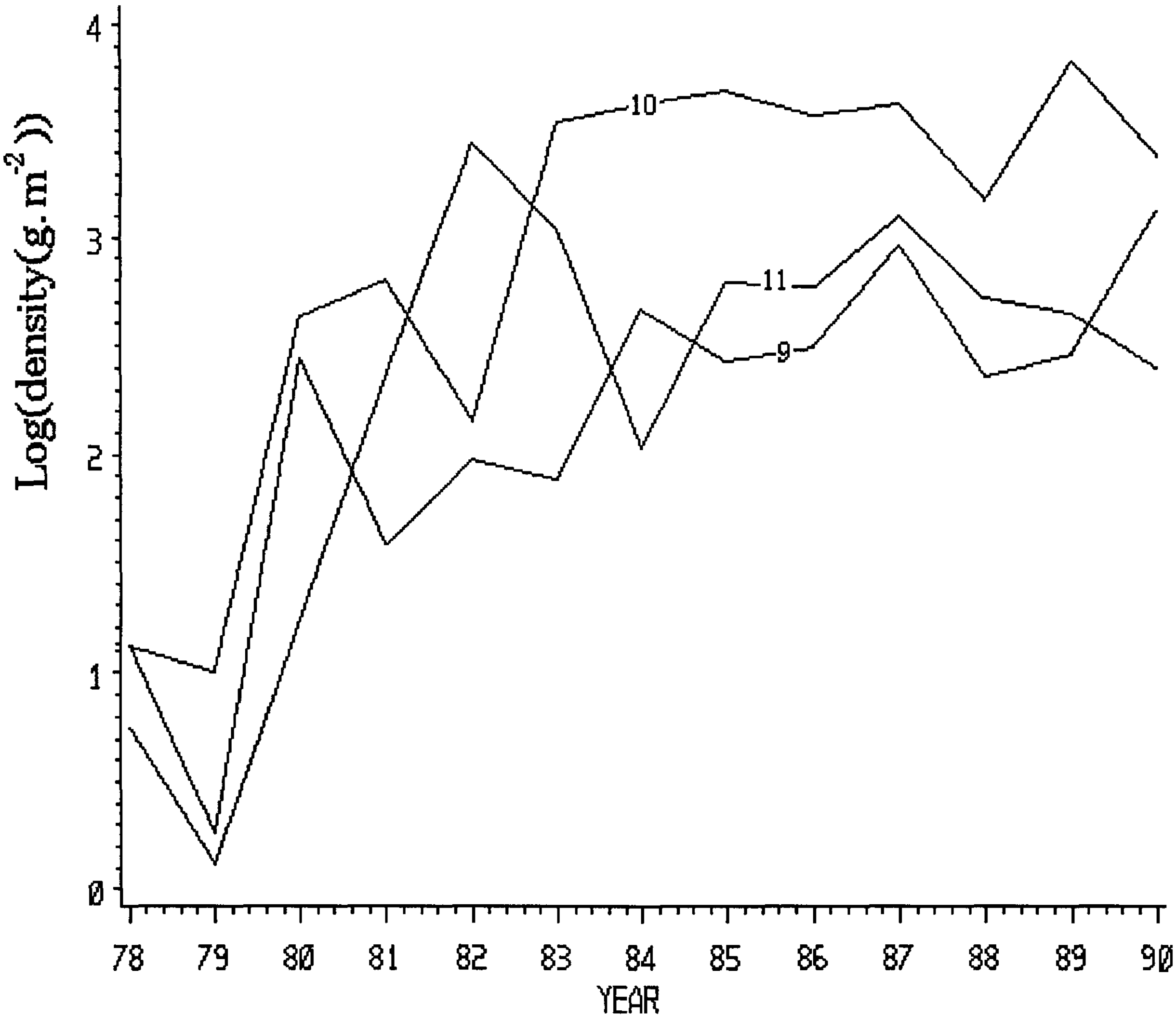

Fig. 5. The annual mean log of catch rate by month for the three months with sufficient data.