NAFO Sci. Coun. Studies, 21: 105–113

Spatial and Temporal Variability in Condition Factors of Divisions 2J and 3KL Cod (*Gadus morhua*)

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Abstract

Condition factors of cod (*Gadus morhua*) in NAFO Div. 2J and 3KL were determined using data from autumn research vessel surveys over the period 1977–92. Condition factors considered were: K_f = gutted weight/length^3 and K_1 = liver weight/length^3. Results indicated different trends in NAFO Divisions with those for Div. 2J and 3K declining in recent years, while there was an increase for those in Div. 3L. Regression analyses of condition factor with capelin biomass and/or temperature only indicated significant relationships with capelin biomass and K_f for ages 2–8 in Div. 2J, ages 3–9 in Div. 3K and age 4 in Div. 3L.

Key words: Cod, condition factors, Labrador, Newfoundland Area, surveys

Introduction

Assessment results have indicated that the cod (*Gadus morhua*) stock in Div. 2J and 3KL may have declined abruptly in recent years (Bishop *et al*., MS 1993) and that no single factor could be identified as the main cause (Anon., 1993). Groundfish research vessel surveys conducted by Canada during autumn suggest that declines in biomass and abundance have been more pronounced in the northern part of the stock area, particularly in Div. 2J. Some of the decline could be related to decreased growth rates and increased natural mortality. Changes in fish condition might provide insight as to their general health over time and the consequent influence on natural mortality. Information is presented in this paper relative to annual condition factors for cod from Div. 2J and 3KL along with their relationship with temperature, and the abundance of capelin which is an important food source to cod.

Data and Methods

Data used in the analyses were obtained from Canadian autumn research vessel surveys over the period 1977–92 in Div. 2J, 1978–92 in Div. 3K and 1981–92 in Div. 3L. Observations on fork length, gutted weights, and liver weights and volumes of cod were made both at sea and in the laboratory. For the latter, specimens were measured at sea, tagged and frozen, and subsequently thawed and examined. All cod were aged using standard techniques. Cod sampling was length-stratified with the general intention of collecting at least five cod per 3 cm length class per NAFO Division and year. Over the 1977–92 period a total of 10 466 specimens were examined for length, weight and age, with 10 394 of these having observations on liver volume and weight.

Condition factors to be described are defined as follows: Kf = Gutted weight(grams)/length^3 and Kl = liver weight/length^3. Gutted weights were used to avoid variation resulting from different feeding intensities. Observations on these lengths and weights covered the period 1947 to 1992 although coverage was incomplete during the early period. Observations on livers were of total volume and/or total weight. A regression analysis of liver weights and volumes indicated a close correspondence (liver weight = 1.000770 × liver volume). For the analyses weight values were used, either the values observed, or values calculated from the regression equation.

Condition factors (Kf and Kl) were determined for each NAFO Division and year, and by age for ages 3 to 11. The relationship of Kf and Kl to temperature and/or biomass of capelin in Div. 2J and 3K were also determined from linear regressions.

The model for the regression analyses was:

$$Kf = B0 + B1 \times \text{capelin biomass} + e$$

where B0 is the intercept

B1 is the slope

and e is the random error term

The temperature data used were the fourth quarter temperature anomalies from Station 27 at a depth of 175 m. Capelin biomass estimates were obtained from Miller (1992). The autumn 1992 estimate was provided by D. Miller, Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans (pers. comm.).

Results

The relationship of gutted weight to length^3 was examined using all length-weight data and was found to be consistent with an assumed linear relationship.

Mean condition factors (Kf and KI) at age for Div. 2J, 3K and 3L for the autumn surveys over the period 1977–92 are shown in Fig. 1–6. The Kf estimates for Div. 2J and 3K (Fig. 1–2) were observed to have a declining trend in recent years, commencing in 1989 for most ages. Values observed in Div.

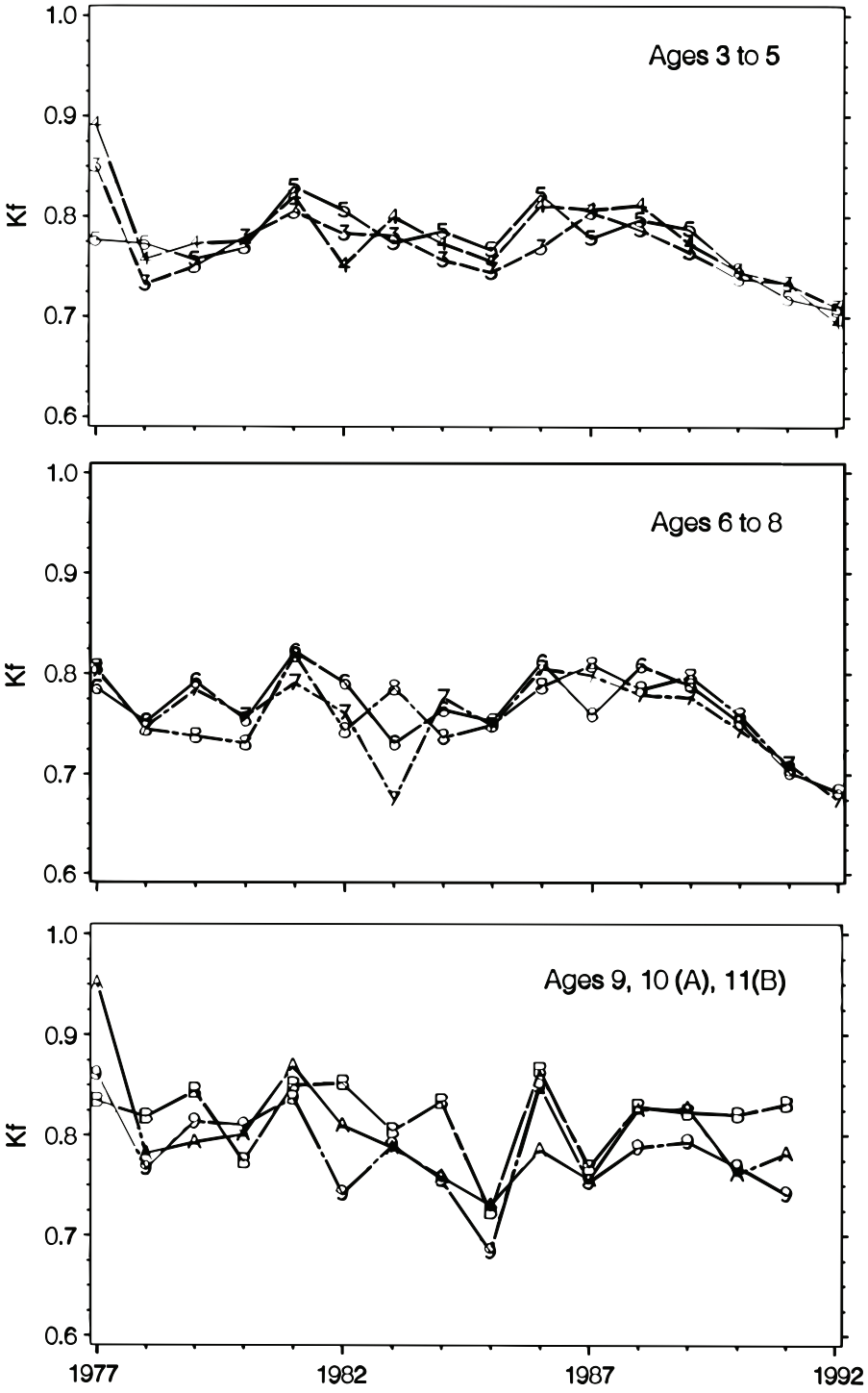

Fig. 1. Annual mean condition factor (Kf) by age and year for cod in Div. 2J.

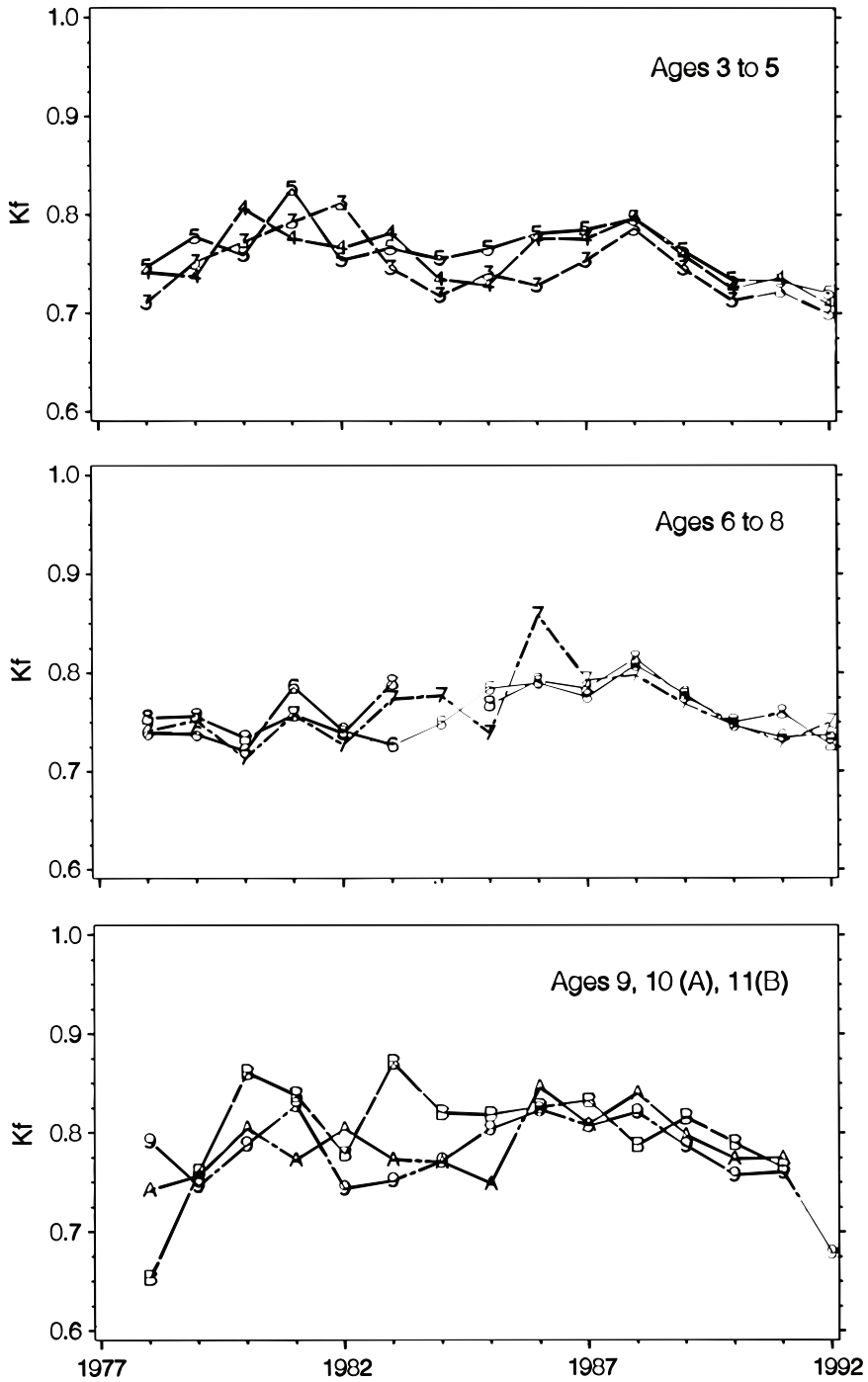

Fig. 2. Annual mean condition factor (Kf) by age and year for cod in Div. 3K.

3L did not indicate a trend although most ages showed an increase from 1991 to 1992 (Fig. 3).

Division 2J cod KI estimates had similarly declined since 1989 (Fig. 4–6), with those for ages 6–8 being substantial from 1990 to 1991. A persistent decline was not evident for Div. 3K. Those for ages 5 and older generally increased in 1992.

In Div. 2J current levels for both condition factors were the lowest in the time series. This was not the case for most ages in Div. 3K.

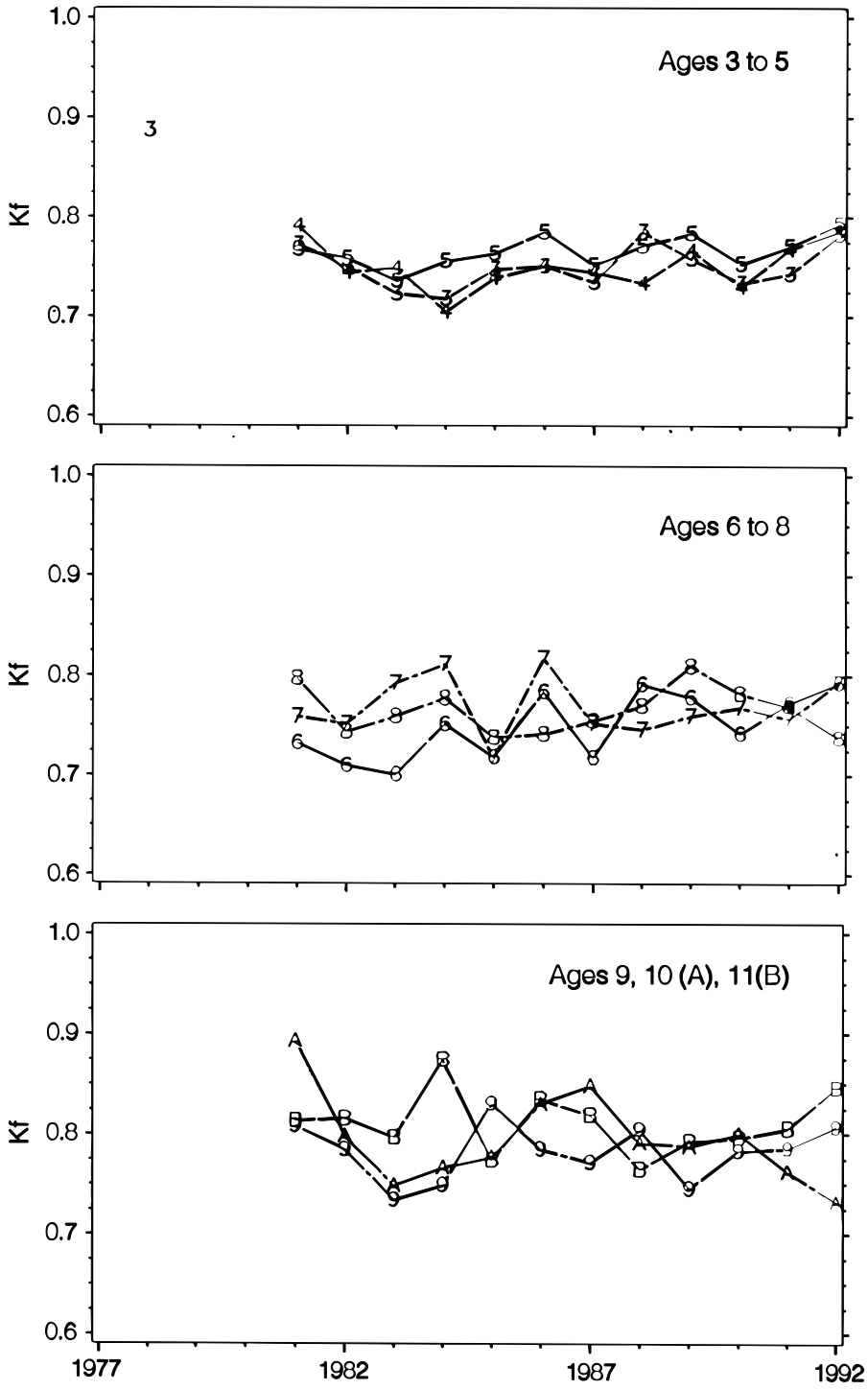

Fig. 3. Annual mean condition factor (Kf) by age and year for cod in Div. 3L.

The KI values for Div. 3L were observed to have an increasing trend since 1987 for ages 3–8, and since 1988 for ages 9–11. The pattern in Div. 3L was generally opposed to those in Div. 2J and 3K.

Condition factor data at age were analyzed to determine possible changes with year-class for the 1972–90 year-classes. The data (Kf) for Div. 2J only are presented in Fig. 7(A–D). Year-classes from

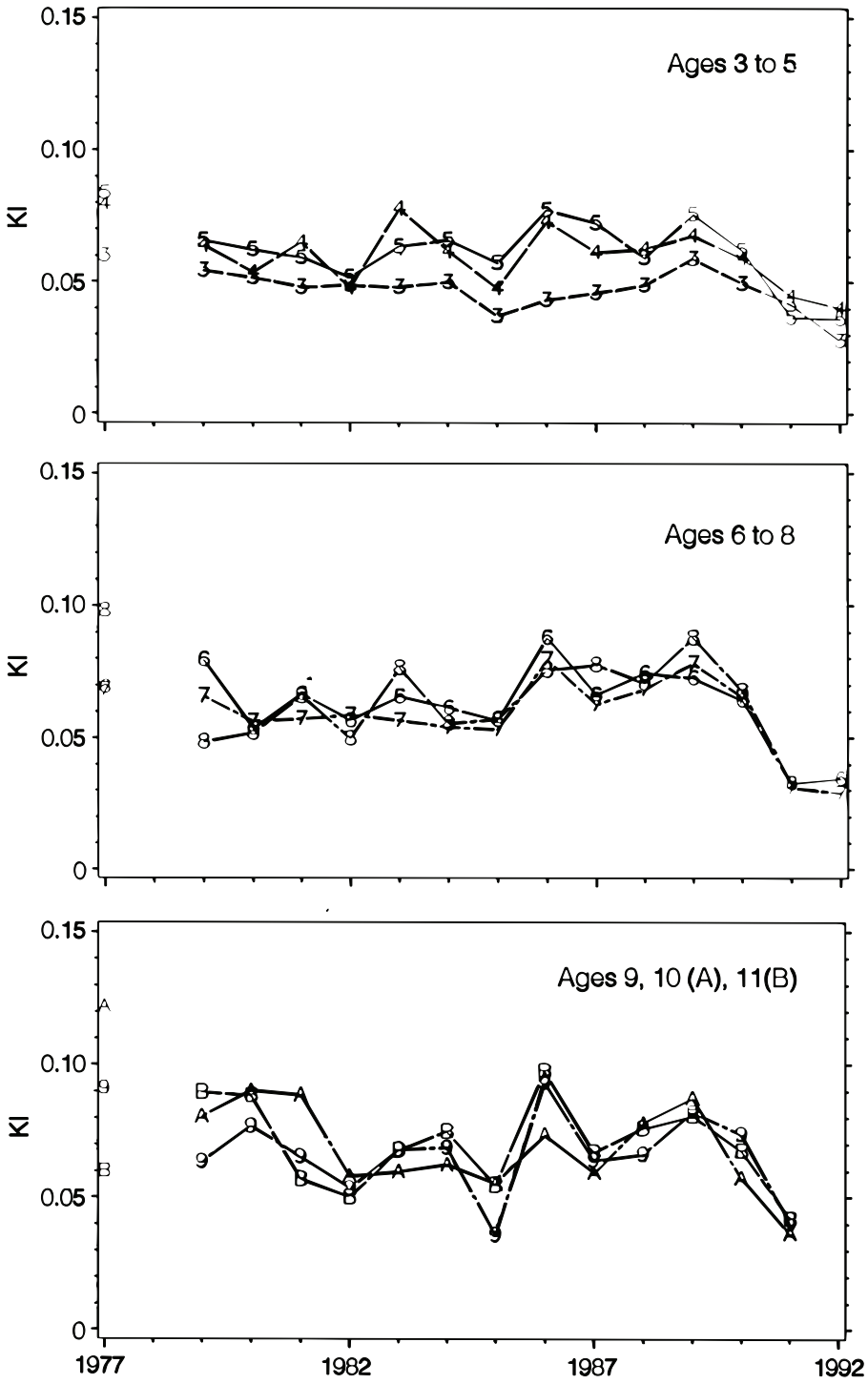

Fig. 4. Annual mean liver condition factor (K1) by age and year for cod in Div. 2J.

1972–81 did not indicate major trends other than a slight increase with age (Fig. 7A and B). The data appears to suggest that the declines observed (Fig. 7C and D) are year rather than year-class effects.

Regression analyses were conducted comparing mean annual Divisional condition factors by age with Station 27 temperature data and/or capelin biomass (Fig. 8–9). The model with capelin biomass

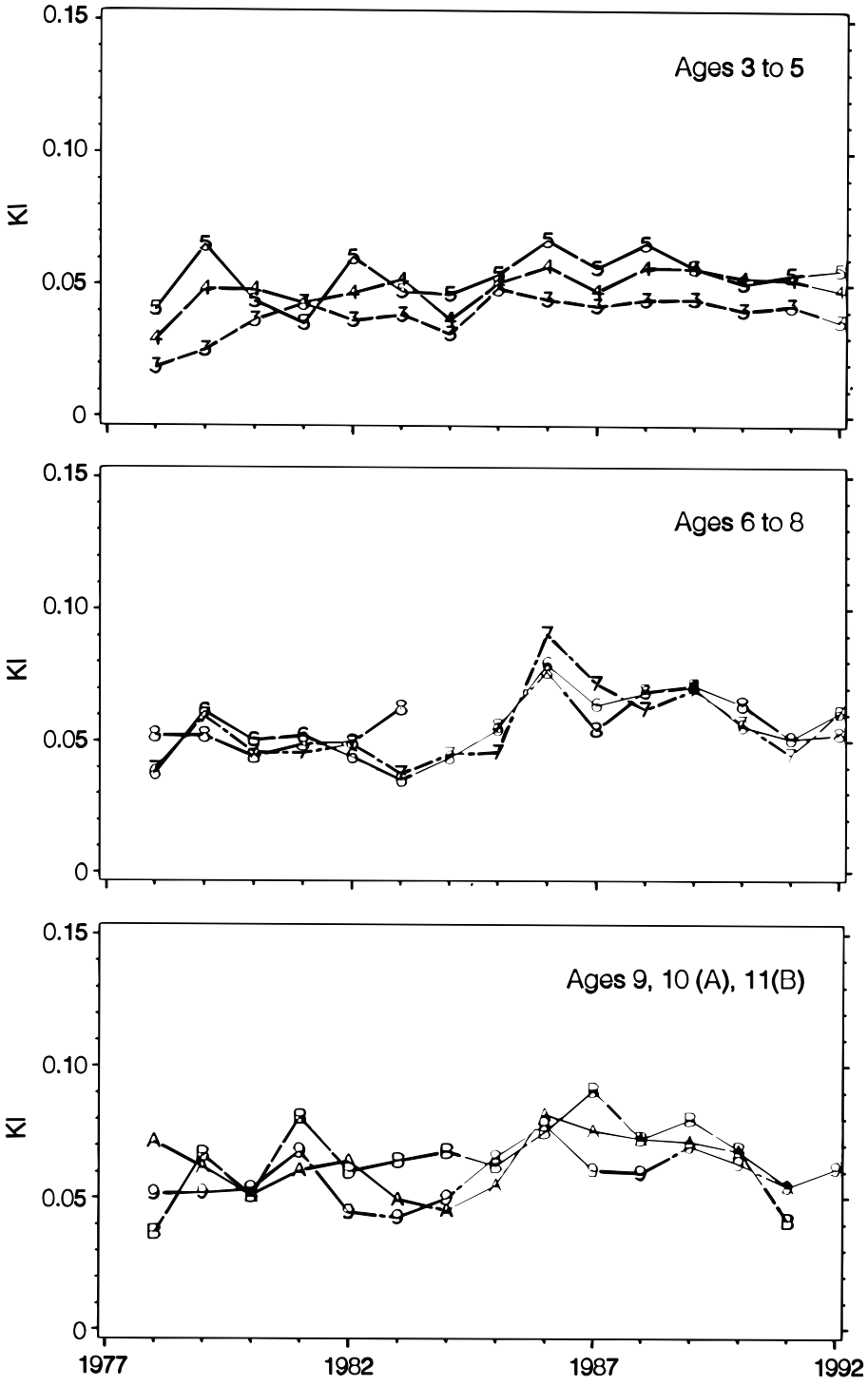

Fig. 5. Annual mean liver condition factor (K1) by age and year for cod in Div. 3K.

and Kf indicated significant relationships for ages 2–8 in Div. 2J, ages 3–9 in Div. 3K, but only for age 4 in Div. 3L (Table 1). Relationships were not as good using temperature as the independent variable, with the exception of an increase in the number of significant relationships in Div. 3L. Inclusion of both temperature and capelin biomass in the model did not improve the relationships.

TABLE 1. Results of regression analyses of mean annual condition factor (Kf) at age with Div. 2J and 3K capelin biomass. (Model: mean Kf = BO + B1xcapelin biomass + e)

Div.	Age	DF	B0	B1	P-value	R2
2J	1	7	0.67390	–0.00087	0.9657	0.0003
2J	2	10	0.71134	0.01698	0.0240	0.4495
2J	3	10	0.73333	0.02238	0.0193	0.4730
2J	4	10	0.73795	0.02524	0.0423	0.3831
2J	5	10	0.73121	0.04404	0.0074	0.5680
2J	6	10	0.72912	0.03700	0.0112	0.5286
2J	7	10	0.73625	0.02370	0.0353	0.4048
2J	8	9	0.75173	0.02266	0.0348	0.4459
2J	9	9	0.76112	0.01774	0.1853	0.2079
2J	10	9	0.75958	0.03163	0.0703	0.3526
2J	11	9	0.81517	0.00031	0.9870	0.0000
2J	12	9	0.80916	0.00078	0.9625	0.0003
2J	13	9	0.84196	0.01640	0.5112	0.0558
2J	14	4	0.79617	0.03320	0.4662	0.1877
2J	15	4	0.85618	0.01566	0.6543	0.0756
2J	16	3	0.76548	0.09897	0.3049	0.4831
2J	17	3	0.94111	–0.07145	0.2100	0.6241
2J	18	1	0.39941	0.32504	–	1.0000
3K	0	1	1.48363	–0.25965	–	1.0000
3K	1	8	0.72809	–0.01718	0.6798	0.0258
3K	2	10	0.72637	–0.00575	0.4913	0.0541
3K	3	10	0.71129	0.02630	0.0041	0.6184
3K	4	10	0.72977	0.01814	0.0409	0.3872
3K	5	10	0.73014	0.02378	0.0077	0.5646
3K	6	10	0.74026	0.02775	0.0007	0.7408
3K	7	10	0.74465	0.01588	0.0731	0.3137
3K	8	9	0.75456	0.01519	0.0432	0.4187
3K	9	10	0.76501	0.02013	0.0575	0.3447
3K	10	9	0.77546	0.01591	0.1643	0.2266
3K	11	9	0.81674	–0.00084	0.9525	0.0005
3K	12	9	0.79982	0.01928	0.1610	0.2297
3K	13	8	0.82190	–0.00016	0.9931	0.0000
3K	14	8	0.84997	0.00489	0.8127	0.0086
3K	15	8	0.85594	–0.07153	0.0946	0.3479
3K	16	7	0.82085	0.02393	0.3823	0.1290
3K	17	3	0.78545	0.14534	0.1254	0.7649
3K	18	2	0.82477	0.03752	0.6914	0.2172
3K	19	1	0.95452	–0.10305	–	1.0000
3K	20	1	1.00859	–0.21718	–	1.0000
3L	1	5	0.63739	0.00132	0.7225	0.0350
3L	2	10	0.72448	–0.00293	0.4576	0.0627
3L	3	10	0.75837	–0.00309	0.2007	0.1748
3L	4	10	0.76587	–0.00523	0.0296	0.4253
3L	5	10	0.77453	–0.00285	0.1444	0.2211
3L	6	10	0.77302	–0.00421	0.2236	0.1595
3L	7	10	0.77594	–0.00159	0.5398	0.0432
3L	8	10	0.75759	0.00332	0.1010	0.2705
3L	9	10	0.77352	0.00184	0.5035	0.0512
3L	10	10	0.76308	0.00614	0.0279	0.4324
3L	11	10	0.812388	–0.00299	0.3648	0.0919
3L	12	9	0.801500	0.00434	0.3551	0.1075
3L	13	9	0.839550	–0.00284	0.5109	0.0559
3L	14	6	0.845248	–0.00216	0.7489	0.0224
3L	15	6	0.773501	0.00743	0.2860	0.2219
3L	16	6	0.779060	0.01883	0.0498	0.5700
3L	17	4	0.878129	–0.03706	0.0994	0.6499
3L	18	1	0.802294	0.02104	–	1.0000
3L	20	1	0.972780	–0.56030	–	1.0000

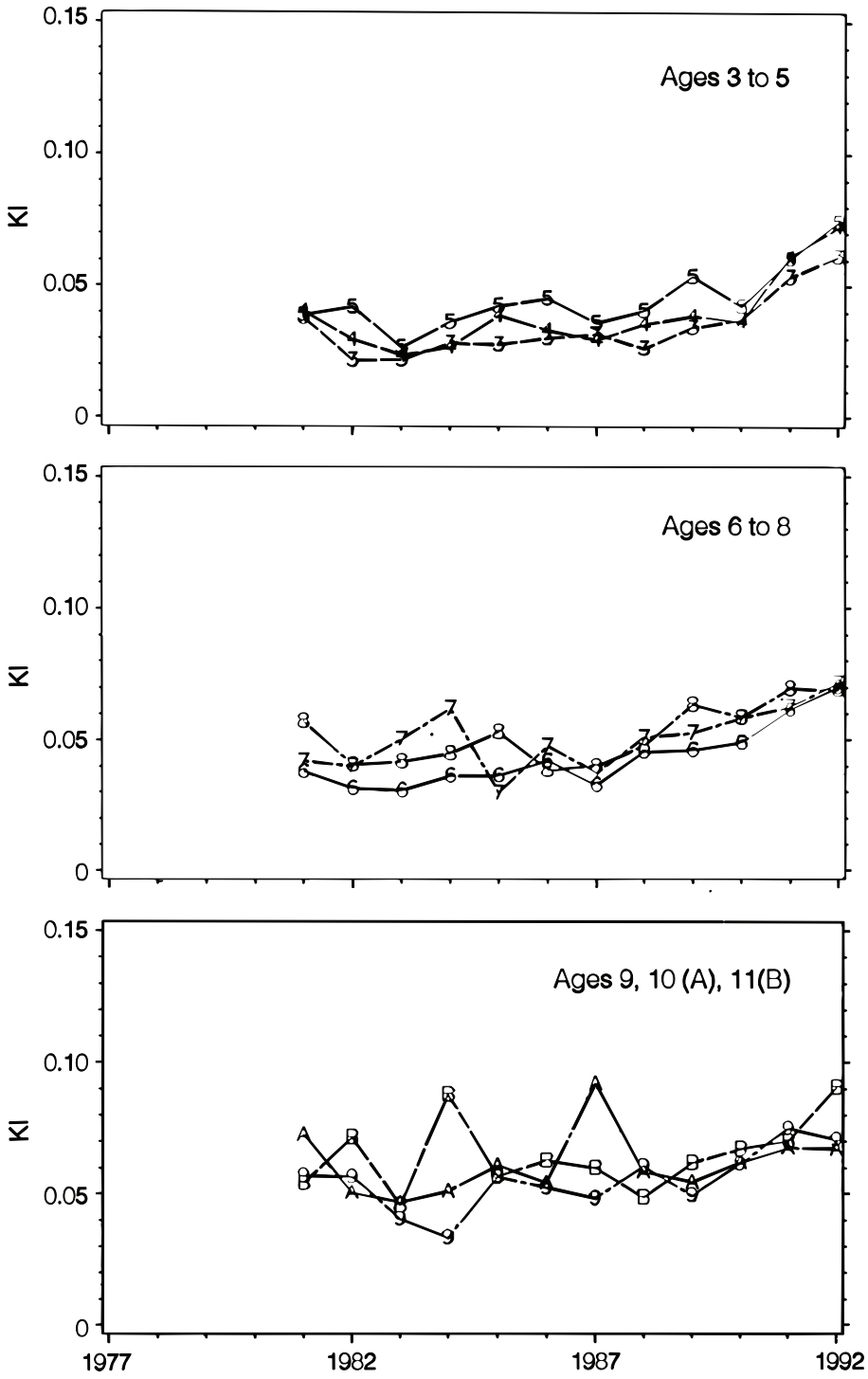

Fig. 6. Annual mean liver condition factor (K1) by age and year for cod in Div. 3L.

Similar analyses using KI produced very few significant relationships at age.

Discussion

The condition factors presented suggest that there were different trends by Division. There has been a decline in recent years in Div. 2J and 3K but the effect was more pronounced in Div. 2J, while Div. 3L showed an increasing trend in KI values. Some of the decline in Kf in Div. 2J may be related to capelin biomass, which is a main food species for cod. Studies on the Northeast arctic cod stock

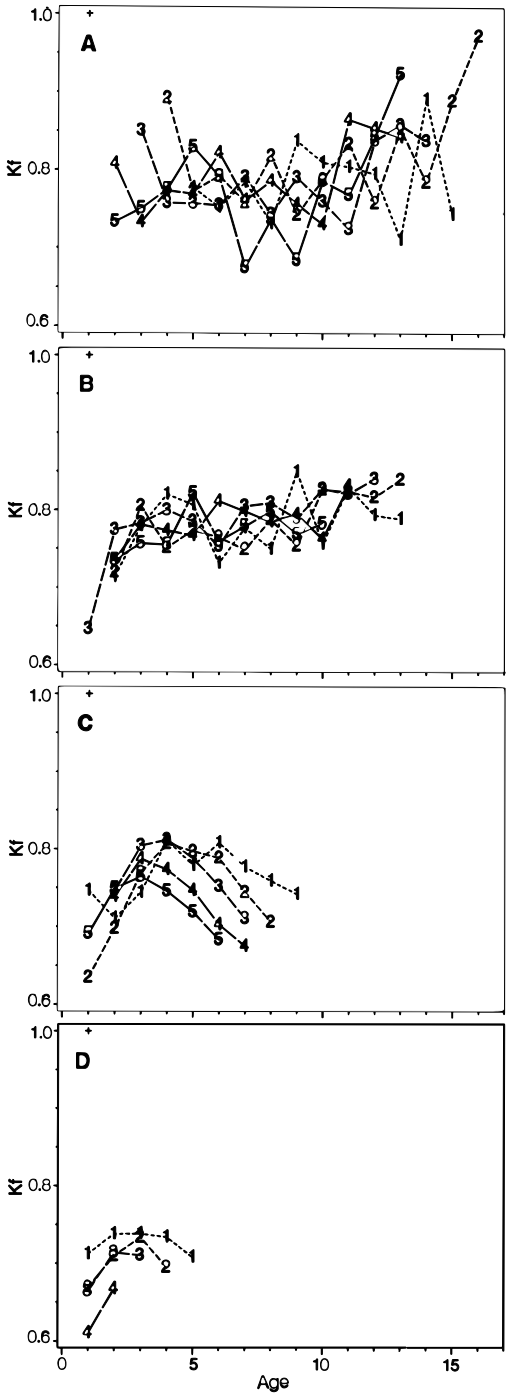

Fig. 7. Annual mean condition factor (Kf) at age and by year-class for Div. 2J cod. (**A**) Year-classes 1972(1) to 1976(5), (**B**) Year-classes 1977(1) to 1981(5), (**C**) Year-classes 1982(1) to 1986(5), (**D**) Year-classes 1987(1) to 1991(5).

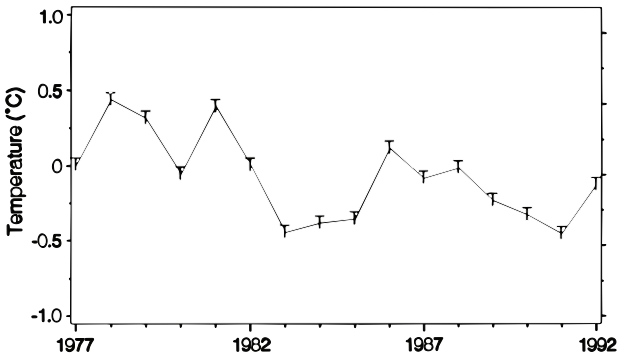

Fig. 8. Station 27 autumn temperature anomaly (°C) for Quarter 4 at a depth of 175 m.

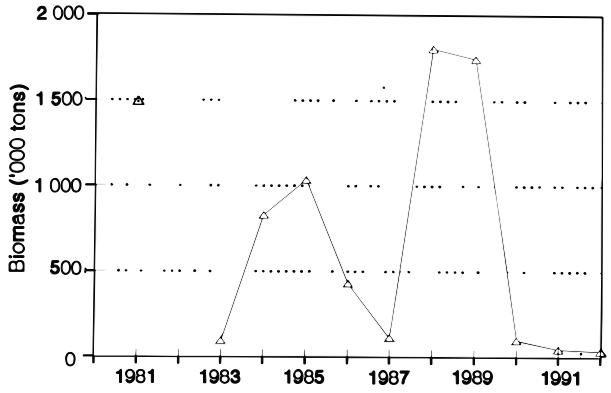

Fig. 9. Total capelin biomass (ages 1–5) from autumn acoustic surveys in Div. 2J and 3K.

(Jorgensen, 1992) suggest that reduced growth and condition factor(Kf) in the late-1980s was a direct result of a sharp decline in the capelin stock.

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