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Distribution and recruitment of demersal cod (ages 0+, 1+ and 2+) in the coastal zone, NAFO Divisions 3K and 3L

by

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Abstract

Research carried out under the Northern Cod Science Program (Methven, unpublished) showed that 0-group and 1-group cod currently (1992 onward) concentrate in coastal areas, with highest densities at depths of 4-7 m. Lower densities occurred at greater depths. 0-group cod are also concentrated in time, arriving in coastal nursery areas as distinct and predictable pulses in April-June, mid-August, mid-October, and possibly late December-January. Surveys were made during the October recruitment pulse at depths with maximum density by setting seines at 10-20 metres then hauling them shoreward. Analysis of the 1959-1964 and 1992-1994 data showed that a statistically significant recruitment signal was detectable based on regression of length group 2 (LG2) against length group 1 (LG1) fish, and regression of LG1 fish against length group 0 (LG0) fish. Based on these equations, the predicted density of LG1 cod for 1995 is 1.5 times that of 1994; the predicted density of LG2 fish is 1.6 times that of 1994. Because 0-group juveniles are now confined to coastal habitats, we expect that the recruitment signal currently evident in the coastal surveys will carry over to the entire stock, regardless of whether this signal carried through to the stock in the past.

Résumé

Des recherches effectuées dans le cadre du Programme de recherche scientifique sur la morue du nord (Methven, inédit) ont permis de montrer que les morues des groupes 0 et 1 se concentraient actuellement (à partir de 1992) dans les régions côtières, les plus grandes densités étant notées aux profondeurs de 4 à 7 m. Des concentrations, moins importantes, étaient aussi décelées à plus grande profondeur. Les morues du groupe 0 se concentraient aussi à certaines périodes. Elles arrivaient dans les aires de croissance côtières sous formes de vagues distinctes et prévisibles, d'avril à juin, à la mi-août, à la mi-octobre et, peut-être, à la fin de décembre et en janvier. Des relevés ont été effectués pendant la vague de recrutement d'octobre aux profondeurs de densité maximale en mouillant des sennes à des profondeurs de 10 à 20 mètres qui étaient ensuite halés vers la côte. L'analyse des données des périodes 1959-1964 et 1992-1994 a montré qu'il était possible de déceler un signal de recrutement statistiquement significatif par régression des poissons du groupe de longueur 2 (GL2) sur ceux du groupe de longueur 1 (GL1) et régression des poissons du groupe de longueur 1 (GL1) sur ceux du groupe de longueur 0 (GL0). Ces équations indiquent une densité prévue de morues GL1 en 1995 de 1,5 fois plus importante que celle de 1994 et une valeur correspondante de 1,6 fois pour les morues GL2. Les juvéniles du groupe 0 étant restreints aux habitats côtiers, nous croyons que le signal de recrutement actuellement décelé par les relevés côtiers se répercutera sur l'ensemble du stock, indépendamment qu'un tel phénomène se soit produit ou non par le passé.

Research carried out under the Northern Cod Science Program (Methven, unpublished) showed that 0-group and 1-group cod currently (1992 onward) concentrate in coastal areas, with highest densities at depths of 4-7 m. Lower densities occurred at greater depths. 0-group cod are also concentrated in time, arriving in coastal nursery areas as distinct and predictable pulses in April-June, mid-August, mid-October, and possibly late December-January.

Surveys were made during the October recruitment pulse at depths with maximum density by setting seines at 10-20 metres then hauling them shoreward. From 1959-1964 approximately 45 sites were sampled from St. Mary's Bay in the south to Notre Dame Bay in the north (Lear et al. 1980). Fish were collected with a 25 m seine (9 mm stretched mesh in the codend liner). Fish were assigned to three length groups: LG0 (Standard Length < 97 mm) corresponding to age 0+; LG1 (SL = 97-192 mm) corresponding to age 1+; and LG2 (SL $\geq$ 193) corresponding to age 2+. The survey was resumed in 1992, using the same sites and methods. Catches for the 1959-1964 and 1992-1994 surveys are reported as mean number per haul, based on two hauls at each site. Details are reported elsewhere (Methven, unpublished; Ings et al, submitted; Schneider et al, submitted NCSP).

Data from the 1959-1964 and 1992-1994 coastal surveys were used to investigate whether a recruitment signal could be detected. Regression of LG1 abundances on LG0 abundances resulted in residuals that were not normal so re-analysis was carried out using an non-normal error structure (Gamma distribution) according to the generalized linear model (McCullagh and Nelder 1989). The result of this analysis was a significant regression of LG1 on LG0 abundances (likelihood ratio test, Δdeviance = 4.59 due to adding regression parameter, df = 1, p = 0.032 computed from a X^2 distribution). When LG2 was regressed against LG1 the residuals were again non-normal. Re-analysis with a gamma error structure resulted in no significant recruitment signal (likelihood ratio test, Δdeviance = 1.884, df = 1, p = 0.28 calculated from X^2 distribution). A more powerful test arises when the two analyses are combined (Δdeviance = 6.474, df = 2, p = 0.04). A recruitment signal from one year to the next, on a ratio scale, was detectable when two successive years were used.

It was of interest to investigate whether the sensitivity of the analysis could be increased by restricting the analysis to frequently visited sites, thus reducing effects of spatial variability. Table 1 shows the catches for sites sampled in 4 out of 5 years (1960-64). Years 1992-1994 were omitted from the analysis so that a model based on the first 5 years could be tested against data not used in constructing the regression model. The regression of LG1 on LG0 catch was strongly significant ($F_{1,3}$ = 33.84, p = 0.01) with acceptable residuals. The regression of LG2 on LG1 catches was also strongly significant ($F_{1,3}$ = 450.3, p < 0.001) again with acceptable residuals.

An iterative weighting algorithm was then used to estimate the parameters of the following equations:

$$LG1 = \beta_{0\text{->}1}\ LG0$$

$$LG2 = \beta_{1\text{->}2}\ LG1$$

$\beta_{0\text{->}1}$ is the product of two quantities, the loss due to natural mortality $e^{-\mu t}$ during t = 1 year, and the ratio of catchabilities of LG1 and LG0 fish α_1/α_0. $\beta_{1\text{->}2}$ is the product of the loss due to natural mortality $e^{-\mu t}$ during t = 1 year, and ratio of catchabilities of LG2 and LG1 fish α_2/α_1. The estimates for the two composite parameters were

$\beta_{0->1}$ = 0.7984 se = 0.1112

$\beta_{1->2}$ = 0.02019 se = 0.00061

The predictions from these equations for 1993 and 1994 were acceptable for LG1 but not for LG2 (Table 2). The underestimate of LG2 catches based on the 1959-1964 model is due either to a rise in the ratio of catchability α_2/α_1 or to a drop in mortality in recent years, compared to thirty years ago.

Re-analysis of the data collected by Alistair Fleming showed that a recruitment signal was more readily detected with a small number of consistently positioned hauls than with a larger number of hauls that varied in location. Based on these sites, the density of LG0, LG1, and LG2 fish per seine haul in 1994 was greater than in 1992 and 1993 (Table 1). Figure 1 shows 95% confidence intervals for these estimates. The changes in catch per unit area (ca. 16 m by 50 m) observed from 1992-1994 were similar to changes in catch per unit effort from surveys covering all of the shelf area in 3K and 3L (Figure 2). Catch per unit area was greater in Trinity and Bonavista Bay than further north or south (Figure 3).

The predicted density of LG1 cod for 1995 is 16/haul, 1.5 times that of 1994 (Table 2). The predicted density of LG2 cod for 1995 is 0.33/haul, 1.6 times that of 1994 (Table 2).

The recruitment signal from coastal juveniles did not carry through to the entire stock in the 1960s, a situation that cannot be extrapolated to currently low stock conditions. The 1992 and 1993 year classes at ages 0 and 1 were confined almost entirely to coastal waters (Dalley and Anderson, NCSP symposium). Coastal nursery areas are at present the only known source of demersal stage recruits to adult cod stocks. Because 0-group juveniles are now confined to coastal habitats, we expect that the recruitment signal currently evident in the coastal surveys will carry over to the entire stock, regardless of whether this signal carried through to the stock in the past.

References

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Table 1. Average count per haul at Fleming sites sampled at least 4 times in 5 years.

Year	N_{haul}	Count per haul			N_{sites}
		LG0	LG1	LG2	
1959	12	178	5.17	1.50	6
1960	24	41.1	135	0.0833	12
1961	36	8.78	36.5	2.78	18
1962	38	20.2	7.16	0.605	19
1963	38	20.0	50.9	0.237	19
1964	30	5.73	36.5	0.967	60
1992		9.60	3.95		
1993		13.0	9.99	0.233	
1994		19.8	16.5	0.937	

N_{haul} = number of hauls.
N_{sites} = number of sites.

Table 2. Observed and predicted catches in 1993, 1994, and 1995 based on equation from 1959-1964.

	Observed	Predicted
1993		
LG1	9.99	7.66
LG2	0.233	0.0798
1994		
LG1	16.5	10.4
LG2	0.937	0.202
1995		
LG1		15.8
LG2		0.333

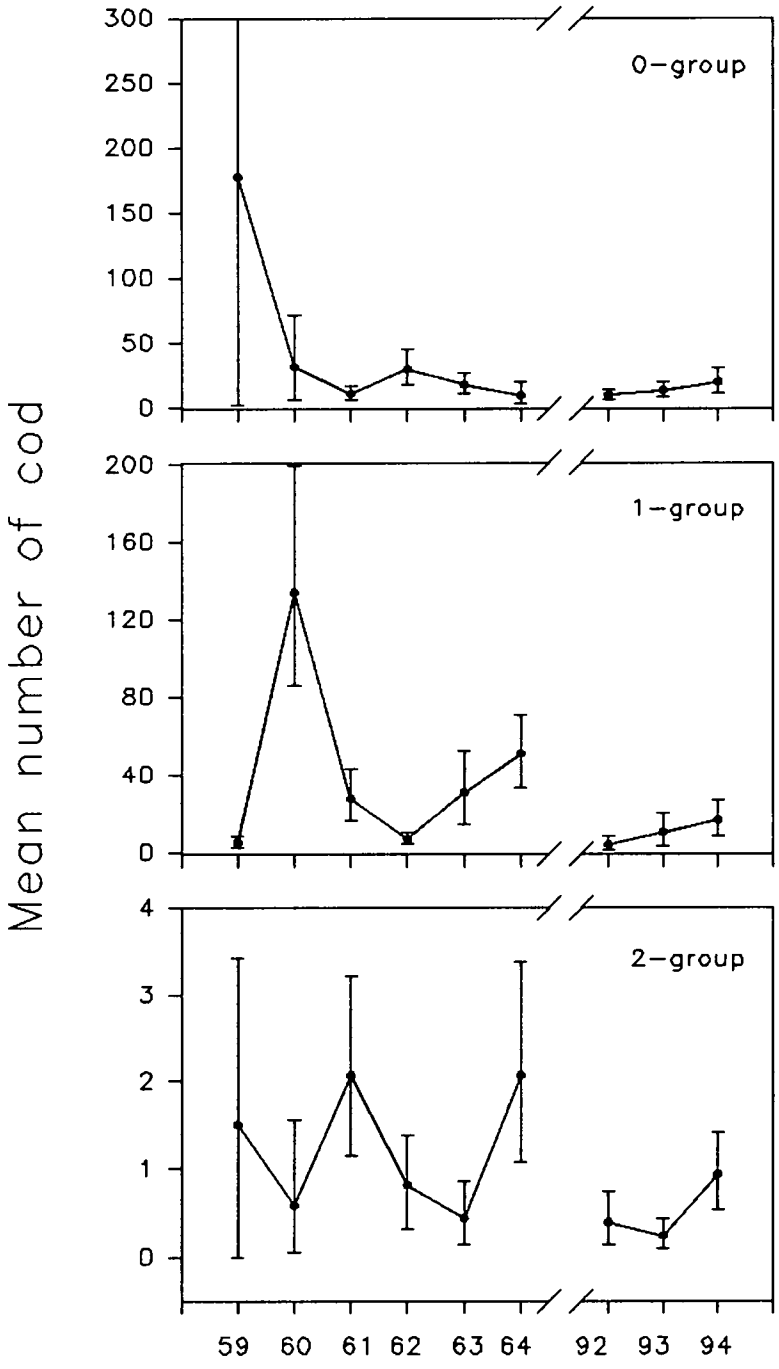

Figure 1. Mean number of cod caught in first two seine hauls at coastal sites from St. Mary's Bay to western Notre Dame Bay. Repeated resampling (bootstrap) methods were used to compute 95% confidence limits.

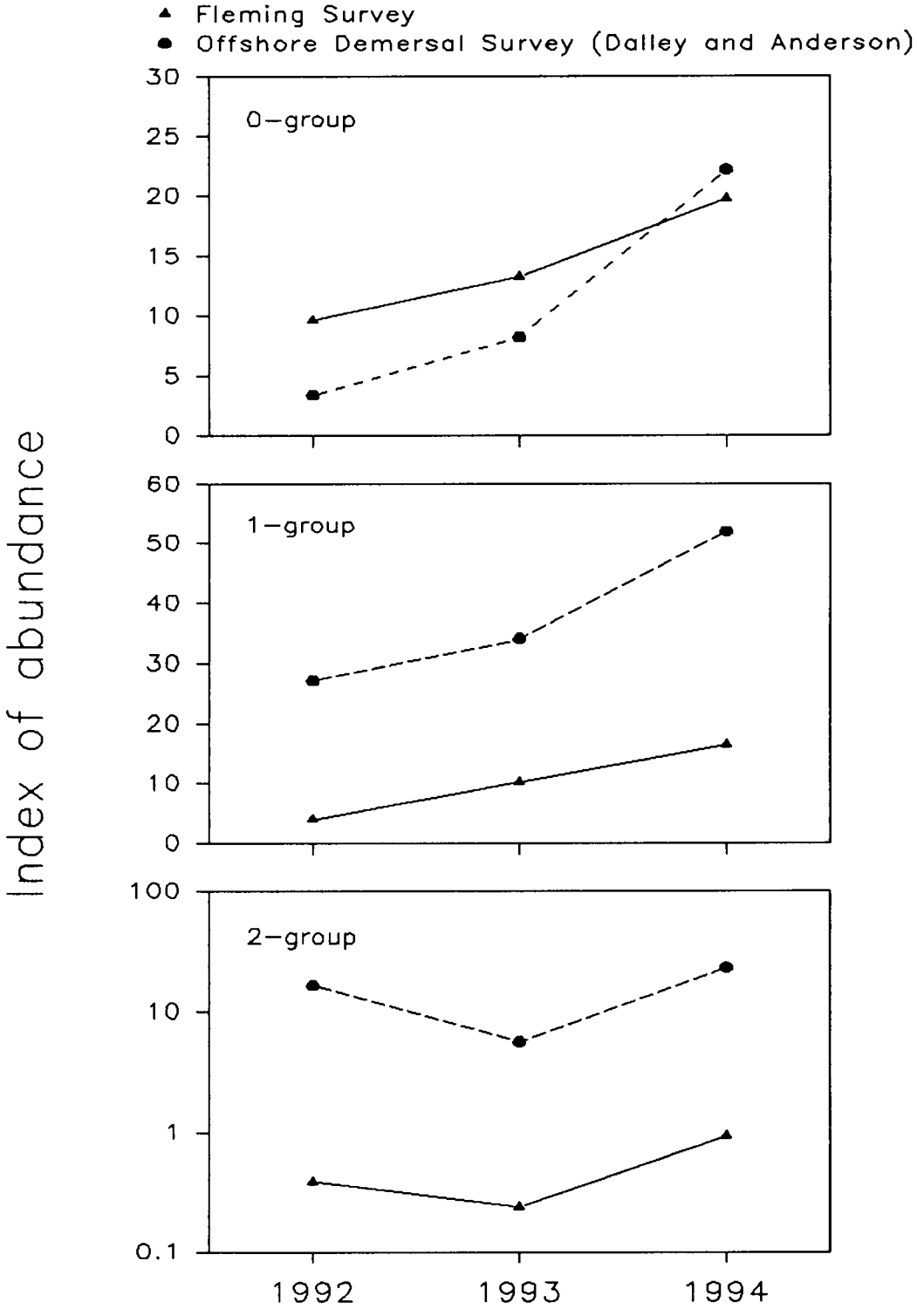

Figure 2. Comparison of coastal zone juvenile survey results (depth ≈ 0-20 m) with nearshore/offshore survey (depth > 50 m).

Figure 3. Catches of demersal juvenile cod in the coastal zone, from St. Mary's Bay to western Notre Dame Bay.