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Year-Class Strength of Northern Cod (2J3KL) and Southern Grand Banks Cod (3NO) Estimated from the Pelagic Juvenile Fish Survey in 1999.

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Abstract

The pelagic juvenile fish survey was carried out from August 23 to September 19, 1999 from southern Labrador to the southern Grand Bank, including the inshore areas of the northeast coast of Newfoundland (NAFO 2J3KLNO). Over the six years of the survey, abundance in 2J3KL declined from 1994 to 1996 and has increased since then. Abundance of pelagic juvenile Atlantic cod (*Gadus morhua*) was high in 1999, compared to surveys carried out 1994-1998, mostly as a result of high catches inshore. Similar to 1998, higher abundance in 1999 also resulted from relatively high abundance on the Grand Bank (3LNO). Higher abundance was observed on the Northern Grand Bank in 1999, in contrast to 1998, when higher abundance occurred in the southern portion. Abundance on the Northeast Newfoundland Shelf (2J3K) was low offshore while inshore it was the highest of any year. Catch rate inshore in 1999 was over 3x the previous high in 1994. Highest catch rates occurred in Conception Bay (3L) and Notre Dame Bay (3K) along the northeast coast of Newfoundland. Abundance in Trinity and Bonavista Bays was relatively low and almost no cod were found offshore in 2J3K. On the Grand Banks, juvenile cod were found throughout the surveyed area. As in 1998 juvenile cod on the Northern Grand Banks (3L) were larger than more northern areas (2J3K), although the difference in size in the two areas was not as great as in 1998. Cod in 3NO averaged 57.5 mm, while those in 3L (NGB) averaged 53.9 mm in length compared to mean lengths of 38.1 - 49.5 mm within the inshore bays. Condition factor was relatively high (1.73) in 1999, in contrast to 1998 when the lowest mean value (1.34) of any year was recorded. The relative condition factor was lower for 3NO than in 2J3KL. Mean growth rate was moderately high in relation to other years averaging 0.579 mm/day. Larval hatch dates ranged from early May which was relatively early compared to most years (except 1998) to early July. To the north, in 2J3KL, the production of young fish has increased in inshore areas and also on the Northern Grand Bank in 1999, but continues to be extremely low with no sign of recovery in the offshore areas. A relatively large year-class was measured on the southern Grand Bank for the second year in succession and appears to be a positive response by Atlantic cod to a warmer environment. There has been a general warming of oceanographic conditions throughout the period of the pelagic 0-group surveys.

Résumé

Le relevé des poissons juvéniles pélagiques a été effectué du 23 août au 19 septembre 1999, du sud du Labrador au sud du Grand Banc, y compris dans les zones côtières de la côte nord-est de Terre-Neuve (NAFO 2J3KLNO). Au cours des six années du relevé, l'abondance dans 2J3KL a décliné entre 1994 et 1996 et a augmenté depuis. L'abondance des morues de l'Atlantique juvéniles pélagiques (*Gadus morhua*) était élevée en 1999, comparativement à celle des relevés effectués de 1994 à 1998, ce qui est principalement attribuable au nombre élevé de prises dans les zones côtières. De même en 1998, l'abondance plus élevée en 1999 résultait aussi de l'abondance relativement élevée dans le Grand Banc (3LNO). Une abondance plus élevée a été observée au nord du Grand Banc en 1999, contrairement à 1998, alors que l'abondance plus élevée est survenue dans la partie sud. L'abondance dans le nord-est de la Plate-forme de Terre-Neuve (2J3K) était faible dans la zone hauturière tandis que dans la zone côtière elle était à son point le plus élevé pour toutes les années. En 1999, les taux de prise dans les zones côtières étaient de trois fois plus élevés que le sommet précédent de 1994. Les taux de prises les plus élevés ont eu lieu dans les baies de la Conception (3L) et de Notre Dame (3K) le long de la côte nord-est de Terre-Neuve. L'abondance dans les baies de Trinity et de Bonavista était relativement faible, et on a trouvé pratiquement aucune morue dans la zone hauturière 2J3K. Dans les Grands Bancs, des morues juvéniles ont été trouvées dans toute la zone du relevé. Comme c'était le cas en 1998, les morues juvéniles du nord des Grands Bancs (3L) étaient plus grandes que celles des zones plus nordiques (2J3K), bien que la différence dans la taille des deux zones n'était pas aussi marquée que celle de 1998. La taille moyenne des morues dans 3NO se situait autour de 57,5 mm, contre 53,9 mm dans 3L (NGB), comparativement aux tailles moyennes de 38,1- 49,5 mm à l'intérieur des baies côtières. Le coefficient de condition était relativement élevé (1,73) en 1999, comparativement à celui observé en 1998, lorsque la valeur moyenne la plus basse (1,34) a été enregistrée. Le coefficient de condition relatif était plus faible dans 3NO que dans 2J3KL. Le taux de croissance moyen était modérément élevé relativement à celui des autres années, avec une moyenne d'environ 0,579 mm/jour. Les dates des éclosions de larves allaient du début mai, ce qui est relativement tôt comparé à la plupart des autres années, (sauf pour 1998) au début juillet. Au nord, dans 2J3KL, la production de juvéniles a augmenté dans les zones côtières et aussi dans le nord du Grand Banc en 1999, mais continue à être extrêmement faible et ne montre aucun signe de rétablissement dans les zones hauturières. Une classe annuelle relativement grande a été recensée au sud du Grand Banc pour la deuxième année consécutive, ce qui semble attribuable à la réaction positive de la morue de l'Atlantique à un environnement plus chaud. On a noté un réchauffement général des conditions océanographiques au cours de la période des relevés des morues pélagiques du groupe d'âge 0.

Introduction

While recruitment in Atlantic cod (*Gadus morhua*) is usually established by the pelagic juvenile stage (Sundby et al. 1989, Assthorsson et al. 1994, Jakupsstovu and Reinert 1994), occasional failures to predict recruitment have resulted from over estimates, where relatively large year-classes of pelagic juveniles suffer high mortality during their demersal period of life, prior to recruitment at age three (Anon. 1995). With sufficiently long time series of data, indices of pelagic juvenile cod abundance can improve analytical predictions of recruitment (Anon. 1997). When predictions fail, we stand to measure important dynamics within cod stocks where mortality during the demersal juvenile stage is known to be density dependent (Myers and Caddigan 1993, Anderson and Gregory 1999). Measures of population abundance before and after the period of demersal juvenile mortality in one and two year old cod will provide direct estimates of predation mortality.

A research program to develop a multi-species, pre-recruit fish survey in the Newfoundland region was carried out during 1991-1993, as part of the northern Cod Science Program (Anderson and Dalley 1997). Beginning in 1994, a two-ship survey was initiated to measure pre-recruit abundance of cod and capelin (*Mallotus villosus*) from the southern Labrador Shelf to the southern Grand Bank (NAFO Divisions 2J3KLNO), including both inshore and offshore areas (Figure 1). A mid-water trawl (IYGPT) and plankton gear (bongo) were used to sample the upper water column for the abundance of pelagic juvenile fish. The surveys are carried out in August and September each year, timed to sample pelagic juvenile cod prior to settlement and to catch larval capelin following their release from beach and bottom sediments.

In this paper we report on the results of the 1999 survey for the northern (2J3KL) and southern Grand Banks cod stocks (3NO). We examine results of abundances, distributions, sizes (length, weight, condition), ages, growth rates and hatching dates of pelagic juvenile (0-group) Atlantic cod and compare these results to those of the 1994-1998 surveys. We discuss these results in terms of the production of cod from the existing populations and predictions of recruitment in these two stocks.

Materials and Methods

The surveys are designed to capture plankton (0.23-10 mm) and nekton (10-200 mm) across almost three orders of magnitude in size, as a broad-scale measure of these communities in late summer, following the spring and summer spawning periods. The surveys have been carried out in August and September each year (Table 1). The survey design is based on a systematic survey grid at 55 km (30 mm) station spacing. This design is equivalent to a systematic stratified sampling design, where the first station was selected randomly from one 55x55 km stratum (Snedcor and Cochrane 1967). Within the bays, stations were positioned approximately 55 km apart through the center of each bay.

The 1999 survey was carried out from August 23 until September 19, which was the latest of all years except for 1995, 4 days later than 1998 and the overall mean midday. A smaller number of stations were sampled in 1999, compared to previous surveys of comparable duration, due to mechanical problems problems with the south ship (Wilfred Templeman Trip 242).

At each station a SeaBird 25 CTD fitted with a fluorometer was lowered to a maximum depth of 500m followed by a plankton tow (0-100 m) and then a mid-water trawl (20-60 m). Plankton were sampled using a bongo sampler (61 cm, 0.232 mm mesh) towed at 1.25-1.5 m $^{s-1}$ using a double oblique haul 0-100 m with payout and retrieval rates of approximately 0.8 and 0.4 m $^{s-1}$, respectively. Beginning in 1996, 0.232 mm and 0.505 mm mesh nets were used on each side of the bongo sampler to measure invertebrate zooplankton and ichthyoplankton, respectively. The bongo sampler was instrumented and transmitted data in real time to the ship, including sampler speed, volume filtered, distance towed, sampling time, salinity, temperature and depth. The IYGPT (International Young Gadoids Pelagic Trawl) is a pelagic mid-water trawl designed to catch pelagic juvenile gadoids with an effective opening of approximately 10 m by 10 m, (Anderson and Dalley 1997). The IYGPT trawl was towed at 1.25-1.5 m/s for 30 minutes, slowly oscillating the head rope between 20-50 m depth through two complete cycles, such that the trawl sampled the 20-60 m depth stratum. The trawl depth and configuration were monitored using acoustic net sensors (Scanmar) to measure net depth, net opening, wing and door widths. For both samplers, the net performance data were used to estimate the volume of water (m^3) filtered during the tow to standardize catch rates.

The IYGPT trawl catches were processed at sea, identifying all fish to species level, where possible, and recording total length for fish species. Total lengths of pelagic juvenile (0-group) Atlantic cod were recorded at sea, prior to preservation in alcohol (1994) or frozen (1995). Total length was recorded again at the time of otolith extraction. Since the change in length over the period of preservation was small and not systematic, preserved lengths were used in all analyses. All other species were preserved in 5% buffered formalin. Total trawl wet weight was also estimated (g). In 1994 this weight included jellyfish, whereas in subsequent years jellyfish were weighed separately. Wet weight was also determined for the dominant species sorted from the catch. Squid were counted and weighed but not speciated. Samples of squid were preserved in formalin and returned to the laboratory for taxonomic identification.

Samples from one side of the bongo were sub-sampled at sea for identification and measurement of capelin and herring larvae, without replacement. Sorted samples were preserved in alcohol. The remainder of the sample was processed in the laboratory, following standard procedures for fish eggs and larvae (Smith and Richardson 1997). From the other bongo sample, the plankton was split into two equal halves using a Motoda plankton splitter. One half of this sample was divided into three size categories (< 1 mm, 1-2 mm, > 2 mm), dried for 24 h at 55-60°C and weighed to the nearest milligram. Selected zooplankton samples from 1994 (n=29) and 1995 (n=29) were processed for full taxonomic classification following standard laboratory procedures.

Atlantic cod were measured for total length, preserved frozen and returned to the laboratory where the otoliths (sagittae and lapillae) were removed, measured and mounted on microscope slides using "crystal bond". Otoliths were polished to their central plane using different grades of lapping film. In most cases lapillae were aged under a light microscope at magnifications of 400 to 1000 times with the assistance of an Optimus Image Analysis System. Replicate readings of daily rings were made to ensure consistency of the age estimates. When age estimates of replicate readings differed by more than 10% then the otolith was discarded. Samples for otolith age analyses were stratified across all length groups and for different geographic areas, when possible. Hatch date was estimated as the difference between the age of the fish subtracted from the date of capture. The hatching date frequency distribution was estimated by adjusting the age frequency distribution for a fixed mortality rate of 0.04/day, as ($N_{0j} = N_{1i}\, e^{-zt}$) where N_0 is the number at the time of hatching, N_1 is the number at the date of capture, z is the daily instantaneous mortality rate, and t is the age and i is the age group.

Dry weight (g) of cod was estimated from those specimens used for otolith extraction and age estimation. Prior to weighing, each specimen was measured for standard length and total length to the nearest millimetre. Each fish was placed on a tared weighing disc, weighed to the nearest 0.001 gram (wet weight) and then placed in a drying oven at 75°C for 24 hours. After drying, each fish was placed in a desiccator to cool and then re-weighed to the nearest 0.001 gram (dry weight).

An abundance index was developed based on a number of selected areas, following the method of Randa (1982) and described in Anderson et al. (1999). These Index Areas were chosen to represent different regions for inshore and offshore locations (Figure 1). The index is dependent on all stations being sampled within each area for a given year. When two or more areas have been sampled, an area weighted overall index of abundance can be derived. The basic index for a unit area is calculated for each area using the geometric mean abundance ($\log_e$ number $10^4 m^{-3}$) and the proportion of non-zero catches. An overall index for several commonly sampled areas can be estimated as the sum of the weighted Index Area values.

Absolute abundance of pelagic juvenile cod offshore (Figure 1) was based on the standardized catch rates at each station, as

$$N_1 = \sum_{i=1}^{k} q \cdot A C_i \cdot D_i$$

where N_1 is the absolute number of cod offshore, q is the trawl catchability, A is the area represented by each station (2.92×10^9 m^2), C_i is the density of cod estimated at each station (m^{-3}), D_i is the maximum tow depth (m), and i represents the number of stations sampled offshore. For all inshore areas (Figure 1), absolute abundance was estimated, as

$$N_2 = \sum_{j=1}^{m} q \cdot B_j \cdot \sum_{i=1}^{k} E_i \cdot D_i$$

where N_2 is the absolute abundance inshore, q is the trawl catchability, B_j is the total area of each inshore area (m^2), E_i is the mean density of cod for all stations sampled within each inshore area (m^{-3}), D_i is the mean maximum tow depth (m), i represents the number of stations within each inshore area, and j represents the inshore areas. The inshore areas were estimated using a high-resolution shoreline to define the inner boundary, while the outer boundary was defined arbitrarily to include an outer extension of each bay onto the adjacent shelf. Area was estimated using Surfer (1997). Total abundance for the entire stock area, 2J3KL, was simply N_1+N_2. Trawl catchability was estimated for an IYGPT by Koslow et al. (1997), where $q = 0.14$. Catchability for nekton typically ranges from 0.1 to 0.25 (Sundby et al. 1989, Koslow et al. 1997).

Results

Abundance

There has been an increase in abundance each year since 1996 for northern cod (2J3KL) following a trend of decreasing abundance from 1994-1996 (Figure 2). The greatest rate of increase in abundance occurred between 1998 and 1999. Although abundance increased in 1996 and 1997 both years remained lower than 1994 and 1995. The large increase in abundance in 2J3KL in 1999 was influenced mainly by increased catches inshore, but also the relatively high abundance on the Northern Grand Bank (3L). In 1998 we rationalized (due to their larger mean size) that fish on NGB were a direct extension of the abundant fish distribution observed throughout the southern Grand Bank (3NO). In 1999, however, mean size of fish on NGB was smaller than that of SGB indicating that they were probably not an extension of the distribution of fish to the south.

Inshore abundance in 1999 ranked highest, approximately 6x higher than 1998 and 3x higher than 1994, which ranked second (Table 2).

Offshore in 2J3K (Index Areas: ISN, ISS, BIBI, FIBI), the abundance of pelagic juvenile cod has varied logarithmically. Highest abundance occurred in 1994 whereas 1999 ranked second, mostly as a result of relatively high abundance off southern Labrador (ISN). Abundances among the remaining three years were relatively low, with 1996 ranking lowest. Except for 1994, there has been almost no production of juvenile cod offshore in 2J3K (BIBI and FIBI, Table 2).

On the southern Grand Bank (3NO), there was a significant increase in abundance in 1998 compared to the previous four years (Figure 2, Table 2). In 1999 abundance decreased compared to 1998 but remained 3x greater than the previous high of 1994, when we observed cod distributed over a small but continuous area of the southern Grand Bank (Anderson et al. 1998). In 1999 abundance was ~3 times that measured in 1998 (Table 2).

Considering that there was such a large increase in abundance of pelagic 0-group cod in 1999, using the Index Area method (Randa 1982), we compared other methods of calculating the index (Figure 3). Using the arithmetic mean of each index area, rather than the geometric mean, indicates higher variation of the index over the 6-year time series, and a much higher value (>2x) for the 1999 index compared to other years. The increase in abundance in 1999 over 1998 is also much greater using the arithmetic mean. Likewise, if absolute abundance was calculated, the increase in 1999 over 1998 is exemplified compared with the geometric mean of the Index Area method (Figure 3).

Distributions

Inshore for the 2J3KL stock area, pelagic juvenile cod were distributed throughout the large inshore bays with highest mean catch rates occurring in Conception Bay and Notre Dame Bay but were less abundantly distributed in Trinity and Bonavista Bays, occurring primarily at the heads of the bays (Figure 4). Offshore, cod extended further north on the northern Grand Bank than in 1998 and the distribution was continuous with that of the inshore. Notably, pelagic cod were relatively abundant on the coast of southern Labrador.

On the southern Grand Bank (3NO), cod were distributed throughout the surveyed area, although abundance declined to zero values at the southwestern extent of the survey (Figure 4). Abundance was highest within the central portion of the southern Grand Banks. Cod were abundant at the western edge of the surveyed area and the extent to which these distributions continued into the adjacent St. Pierre stock area (3Ps) remains unknown.

Compared other survey years, overall distribution in 1999 was extensive (Figure 5), extending from the most southern to most northern latitudes sampled, being distributed throughout the Grand Banks, inshore, and inner Northeast Shelf. However, distribution in the offshore portion of the Northeast Newfoundland Shelf in 1999 was negligible. The most extensive distribution on the NE Newfoundland shelf occurred in 1994 and decreased to negligible catches in 1996, remaining quite restricted on the shelf since.

Length, Weight and Relative Condition

Overall mean length of all cod measured in 1999 (47.9 mm) was ~9.5 mm smaller than in 1998, which was higher than any of the previous years, averaging 57.4 mm; compared to 39.3-45.3 mm in 1994-1997. The length frequency distribution extended from 33 - 94 mm (Figure 4). The situation in 1999 was different from 1998 in that fish on the southern Grand Bank were less numerous and 5.2 mm smaller than in 1998. To the north, within the inshore bays, cod averaged 38.1-49.5 mm in length. Overall, fish in the northern part of the surveyed area (2J3K) averaged 46 mm compared to 57 mm in the south (3NO); a difference of 11 mm compared to a difference of 18 mm in 1998.

Fish weight increased exponentially with length (Figure 6), as in previous years, (Anderson et al. 1999). On average, fish in 3NO weighed less at a given length than fish in 2J3KL. This may be related to poorer feeding conditions resulting from lower zooplankton biomass on the southern Grand Bank compared to more northern areas. (Dalley et al. 2000)

Relative fish condition, measured as Fulton's K, was 1.73 in 1998 (Table 4). This is the second highest measure of condition observed during the period 1995-1998 when condition ranged from 1.34-1.78.

Age and Growth

For the entire surveyed area, 2J3KLNO, estimates of daily age indicate pelagic juvenile cod were relatively old averaging 82.1 days of age in 1999 (Table 3). Mean age ranked second only to 1998 when age was approximately 12 days older than the previous high. Mean age was also relative old in 1994 when cod averaged 80 days while in 1995-1997 they averaged 65-69 days. Growth rate averaged 0.579 mm d^{-1} in 1999, which was in the range of that measured in previous years (Table 3).

Hatching and Spawning Times

Larval hatch date estimates ranged from early-mid May to early July (Figure 5). These dates started approximately 2 weeks later, and extended later, than in 1998 when the earliest estimated hatch dates of the time series occurred. In 1999 peak hatching occurred around mid June as opposed to 1998 when peak hatching occurred in late May to early June. There is evidence from the earlier mode occurring in mid May that 2 spawning periods may have occurred in 1999.

Discussion

In 1999 overall abundance of pelagic 0-group cod was higher than any other year, mostly as a result of higher abundance inshore, and also on the northern Grand Banks. Distribution was also a broader than any previous survey, being continuous over the whole north-south range, from the coast of southern Labrador, to the southern Grand Banks. For the second year in succession there was relatively high abundance on the Grand Banks (3LNO). The relatively large size of fish on NGB compared to SGB in 1998 was used as a basis to conclude that fish on NGB were a direct extension of successful spawning on the southern Grand Banks, which had dispersed to the north. This is not as clear in 1999. Since fish were not larger on the northern portion of the Grand Banks as they were in 1998, it is unlikely they are a direct extension of fish on the southern portion. On the other hand, mean size on the northern portion is only 4.4 – 6.4 mm larger than those in Trinity and Conception Bays, suggesting there may be a mixture of fish on the northern Grand Bank from the two different spawning areas.

Although the abundance index for 1999 was high compared to other years, examination of the arithmetic mean and absolute abundance methods indicated that the geometric mean method was relatively conservative in examining annual differences. Therefore, we conclude that there was a significant increase in the abundance of juvenile cod in 2J3KL in 1999.

Annual production of juvenile fish within the inshore portion of the northern cod stock area (2J3KL) was high in 1999; ~3x higher than the previous high measured in 1994. The most significant concentration of cod occurred in Conception Bay and Notre Dame Bays. Bonavista Bay had the lowest abundance of any of the large bays in 1999. The production of juvenile cod offshore remained extremely low, indicating as in 1998 very little successful spawning occurred offshore in 1999. It appears the high abundance observed in 2J3KL in 1999 originated from inshore spawning.

There has been an increase in the production of juvenile cod seven years after the implementation of a fishing moratorium The production, however, appears confined to the inshore. Based on our indices of year-class abundance the increase has occurred throughout the inshore, and not from traditional major spawning areas offshore on the Northeast Newfoundland and southern Labrador Shelves.

Ocean temperatures in the upper 170 m have been increasing since 1991 and recently temperatures have been at or above the historical mean (Colbourne 2000). During recent years there has an increase in zooplankton biomass and nekton biomass throughout the survey area (Dalley et al., 2000). Both capelin (*Mallotus villosus*) and Arctic cod (*Boreogadus saida*) have responded to these warmer temperatures by increasing and decreasing annual year-class abundance, respectively, during the 1990's (Dalley et al. 2000). Redfish, American plaice and sandlance, plus species common to the Grand Banks as hake, haddock, and witch flounder have also increased in abundance. Over the same period the combined abundance of several northern species has declined.

These changes indicate that the ocean environment has changed from the cold water regime of the early 1990's to a warmer water regime characteristic of previous years. In general, a warmer ocean climate should favour the survival of cod eggs and larvae (deYoung and Rose 1993).

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Table 1. Summary of Pelagic Juvenile Fish Surveys conducted, 1994-1999. Bongo-bongo plankton sampler; IYGPT-International Young Gadoids Pelagic Trawl. DoY—refers to the calendar day of the year; Start, End and mid refer to the starting, ending and middle day of the year for each survey. The numbers below each gear type list the number of stations sampled each year by each gear type.

Year	Ship-Trip	Dates	DoY Start	DoY End	DoY Mid	Bongo	IYGPT
1994	TEM157/GAD247	22 Aug-3 Sep	234	246	241	99	99
1995	TEM175/TEL018	5 Sep-22 Sep	248	264	257	139	139
1996	TEM193/TEL034	19 Aug-6 Sep	231	249	241	147	147
1997	TEM210/TEL050	11 Aug-29 Aug	233	241	233	148	148
1998	TEM226/TEL069	24 Aug-10 Sep	236	253	244	132	132
1999	TEM242/TEL081	23 Aug-19 Sep	234	261	248	129	127

Table 2. Abundance indices (log_e transformed) estimated for pelagic juvenile Atlantic cod (*Gadus morhua*) for the different Index Areas sampled each year, 1994-1999. SUM IN=sum of all weighted Index Area values for the commonly sampled inshore areas (shaded); SUM OFF=sum of all weighted Index Area values for the commonly sampled offshore areas (shaded); TOTAL = the sum of SUM IN + SUM OFF. For individual area identifications refer to Figure 1.

Area	1994	1995	1996	1997	1998	1999
			Inshore			
CB	**0.29**	**1.22**	**0.00**	**0.20**	**0.45**	**28.51**
TB	**0.87**	**0.43**	**0.00**	**0.12**	**0.39**	**2.55**
BB	**3.86**	**1.52**	**0.42**	**3.12**		**2.92**
NDB	**5.86**	**12.69**	**0.00**	**2.80**	**7.02**	**12.36**
WB	**7.09**	**1.03**	**3.49**	**1.25**	**1.51**	**8.27**
SUM IN	**17.97**	**16.89**	**3.91**	**7.49**	**9.37**	**54.61**
			Offshore			
HB		0.20	0.00	0.00	0.00	1.61
ISN		**0.98**	**0.00**	**0.00**	**0.34**	**7.46**
ISS	**16.55**	**2.20**	**0.23**	**1.86**	**1.50**	**3.13**
BIBI	**14.33**	**0.22**	**0.00**	**0.22**	**0.20**	**0.00**
FIBI	**4.83**	**0.43**	**0.00**	**0.89**	**0.00**	**0.65**
NGB	**0.34**	**0.55**	**0.00**	**0.34**	**4.33**	**11.5**
SA	0.30		0.00			6.61
SGB (3NO)	**3.05**	**0.38**	**1.13**	**0.68**	**14.54**	**9.20**
NOSE			0.00	0.00	1.20	
SUM OFF	**39.10**	**4.76**	**1.36**	**3.99**	**20.91**	**31.94**
2J3KL	**54.02**	**21.27**	**4.14**	**10.80**	**15.74**	**77.35**
TOTAL	**57.07**	**21.65**	**5.27**	**11.48**	**30.28**	**86.55**

Table 3. Summary of daily ages, total lengths (mm) and growth rates (MM d^{-1}) measured for pelagic juvenile cod (*Gadus morhua*) sampled each year, 1994-1999.

		Age			Length		
Year	n	Mean	Min	Max	Mean	Min	Max
1994	103	80.4	58	121	45.4	31.5	86
1995	100	68.5	48	96	45.8	30	69.5
1996	37	69.4	48	104	39.5	23.5	59.5
1997	84	65.1	41	84	38.5	23.5	51.5
1998	97	92.5	47	131	56.2	29	81
1999	105	82.1	54	119	51.2	32	94

		Growth Rates				
Year	n	Mean	Min	Max	Std Dev	CV
1994	103	0.520	0.391	0.682	0.055	10.6
1995	100	0.618	0.465	0.789	0.069	11.2
1996	37	0.521	0.389	0.674	0.064	12.3
1997	84	0.540	0.404	0.690	0.065	12.1
1998	97	0.569	0.422	0.732	0.065	11.5
1999	98	0.579	0.406	0.853	0.075	13.0

Table 4. Relative condition of cod, measured as Fulton's K, for the cod subsample selected for ageing and growth.

	Year				
	1995	1996	1997	1998	1999
Average	1.78	1.63	1.61	1.34	1.73
n	63	59	120	109	120
Std Dev	0.230	0.223	0.215	0.124	0.208
Minimum	1.24	1.14	0.91	1.06	1.11
Maximum	2.39	2.17	2.12	1.67	2.26

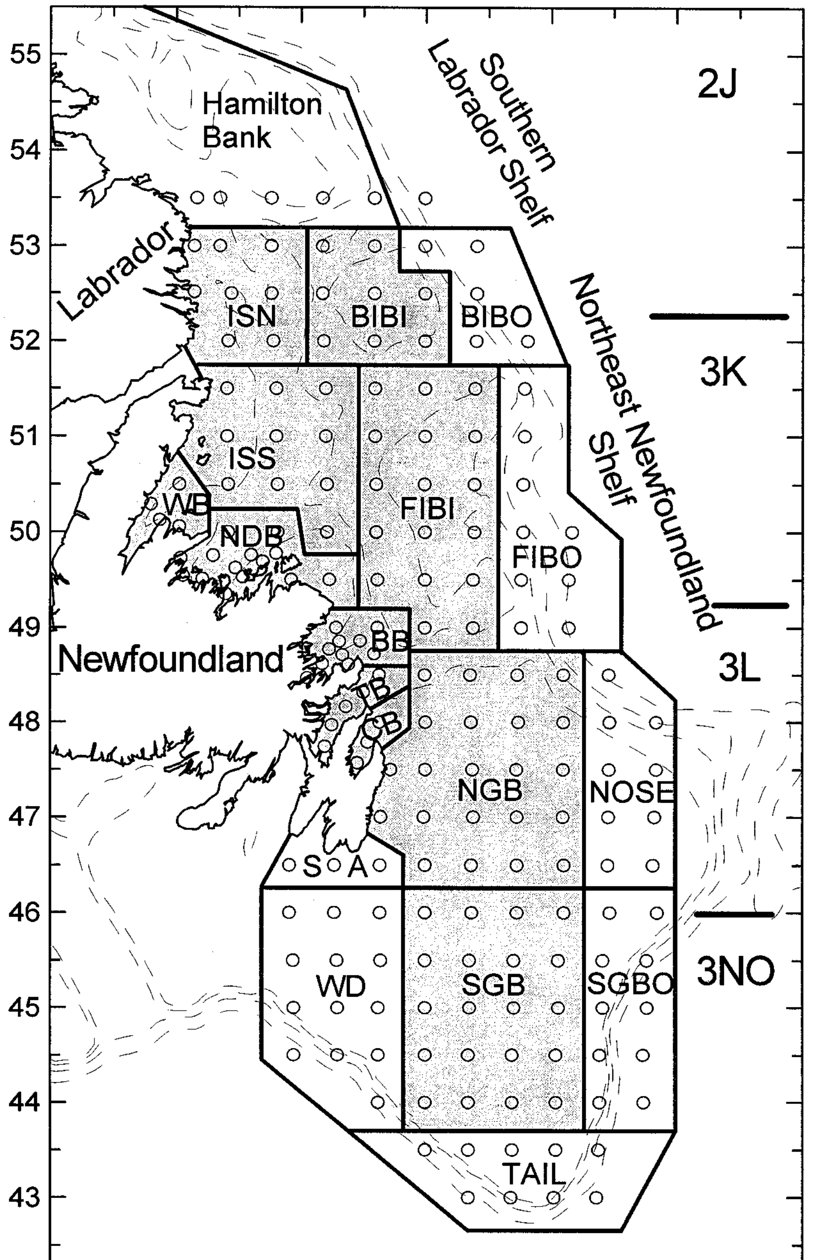

Figure 1. Pelagic juvenile fish survey area, showing sampling locations, 'o', and Index areas. The shaded areas represent the Index areas used in the calculation of annual abundance indices.

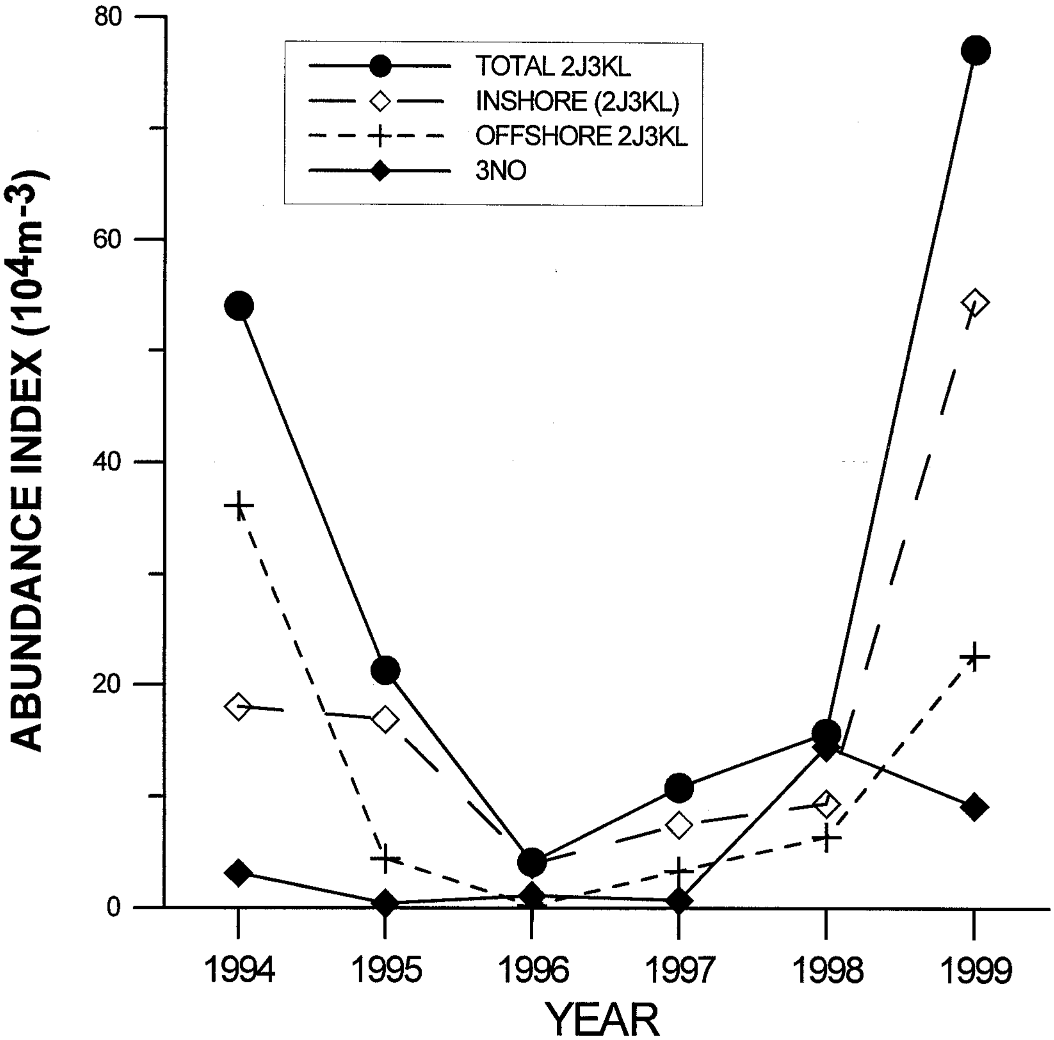

Figure 2. Pelagic juvenile Atlantic cod (*Gadus morhua*) abundance indices for northern cod (2J3KL) inshore, offshore and total areas, and southern Grand Banks cod (3NO), 1994 – 1999.

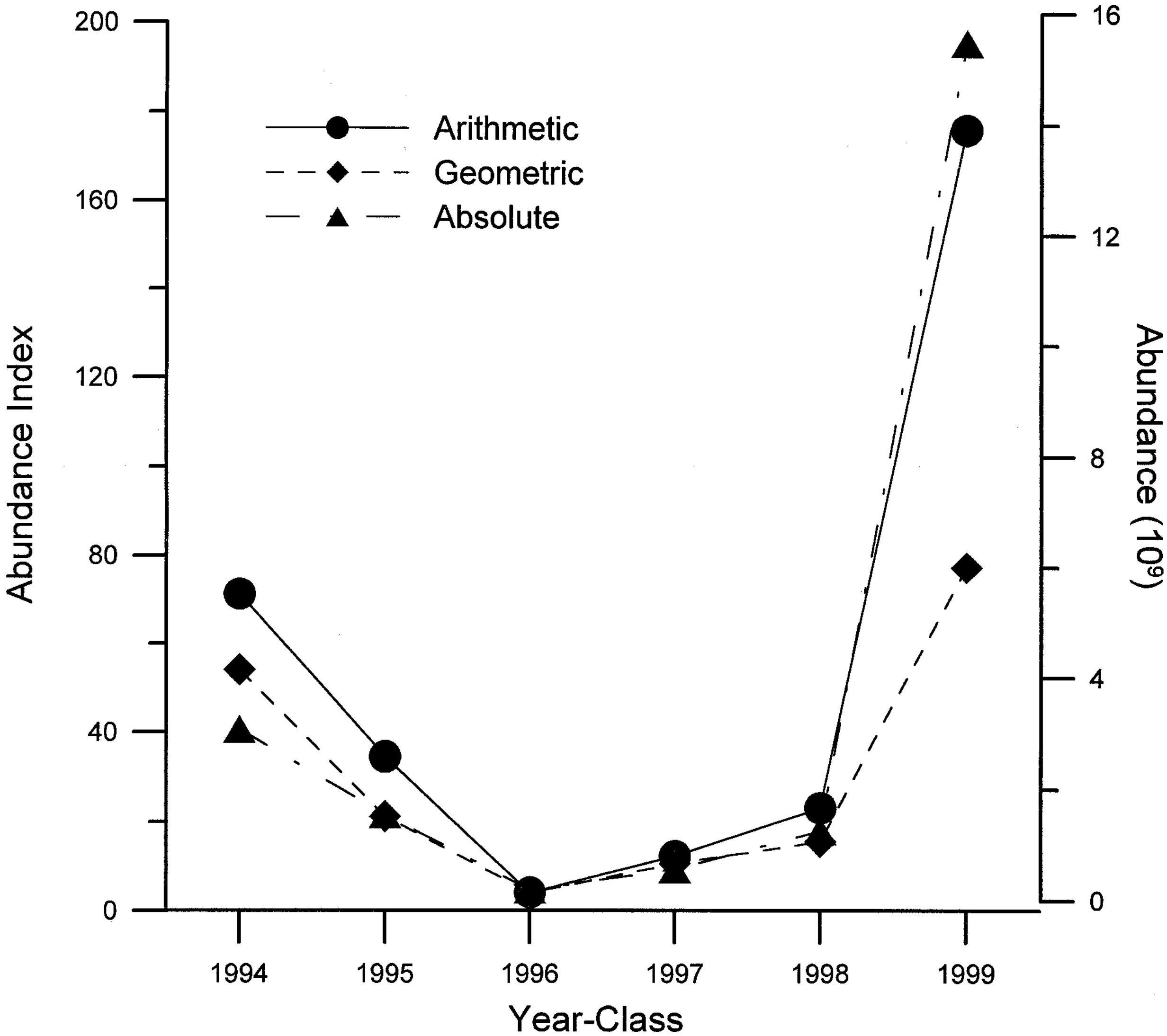

Figure 3. Comparison of the Index Area method using geometric mean, arithmetic mean, and absolute abundance estimates for pelagic 0-group cod, derived from surveys carried out in NAFO Divisions 2J3KL, 1994 – 1999.

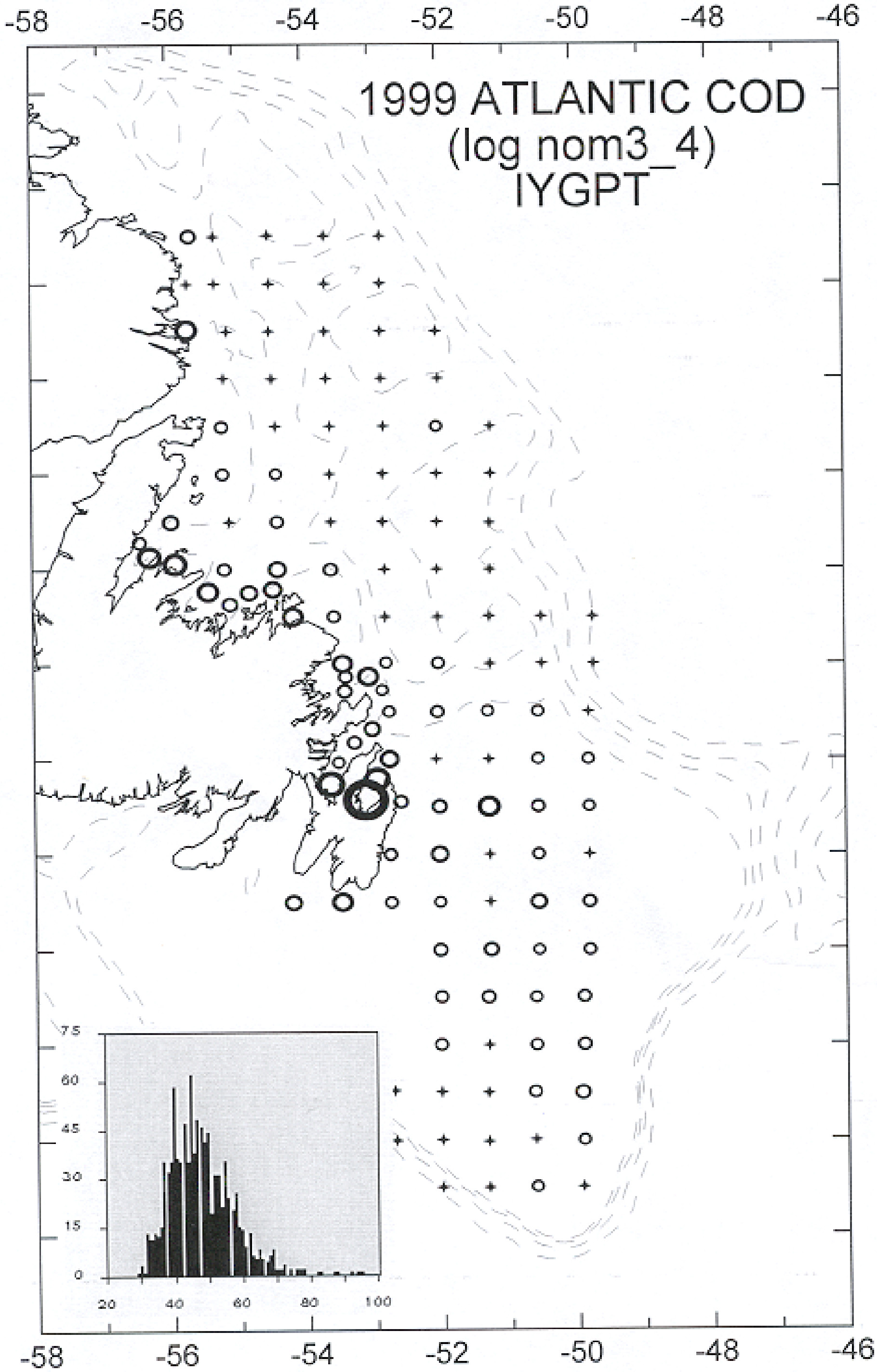

Figure 4. Distribution of pelagic juvenile Atlantic cod (*Gadus morhua*) in 1999. The expanding symbols represent abundance ($\log_{10}$ number/10,000 m^3). The '+' symbols represent stations where cod were **not** caught. The length frequency distribution of animals captured is plotted in the embedded graph.

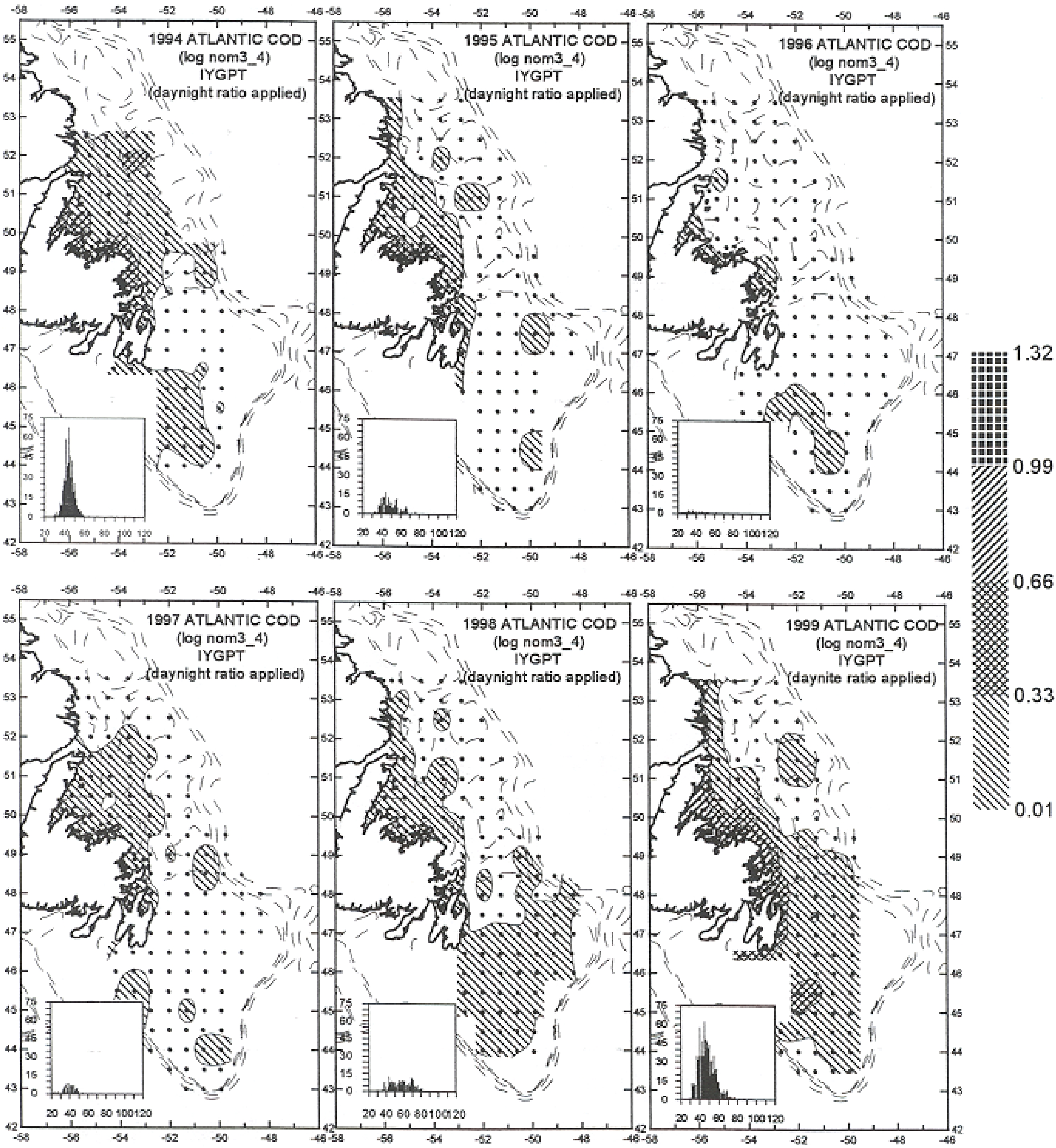

Figure 5. Comparison of pelagic 0-group Atlantic cod distribution determined from surveys carried out in NAFO Divisions 2J3KLNO, 1994 - 1999.

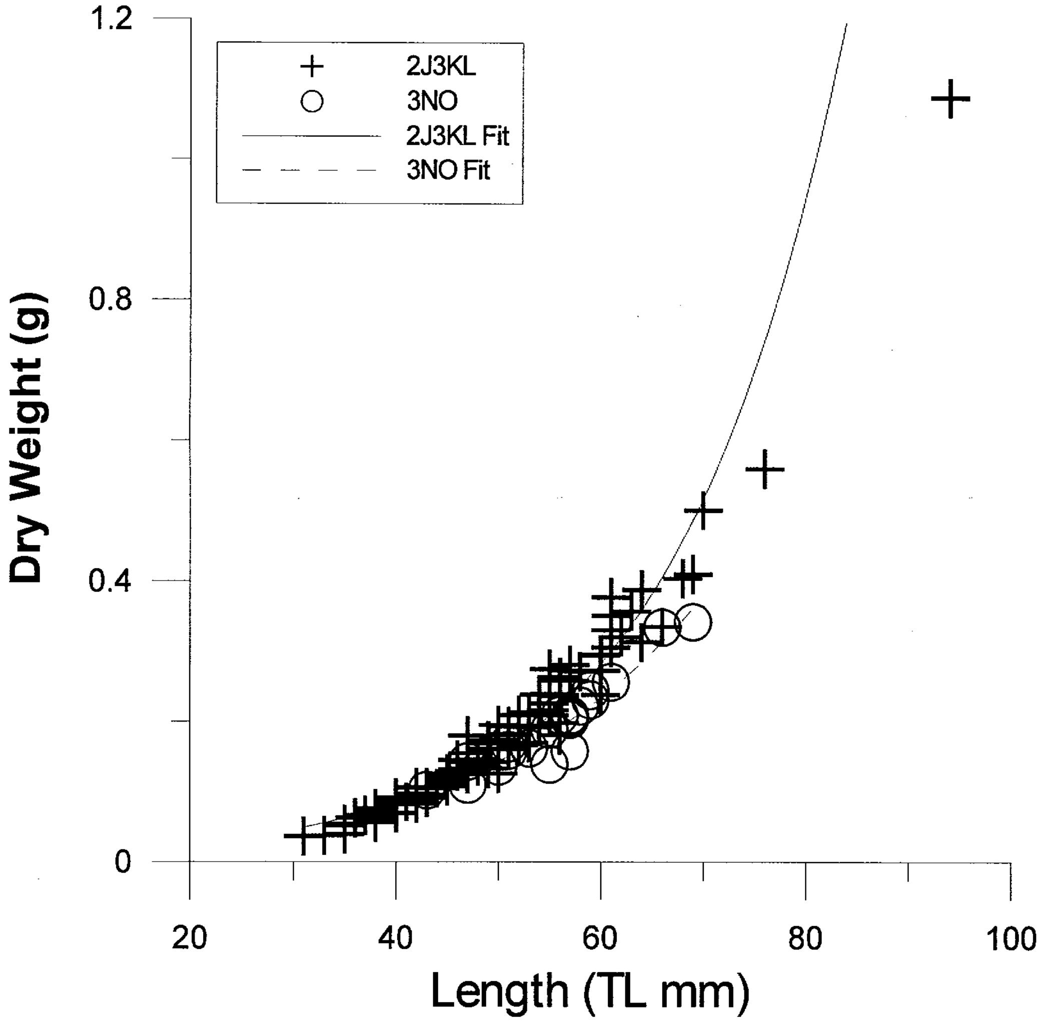

Figure 6. Length-dry weight relationship for pelagic juvenile northern cod (2J3KL) and southern Grand Banks cod (3NO) during the 1999 pelagic 0-group survey.

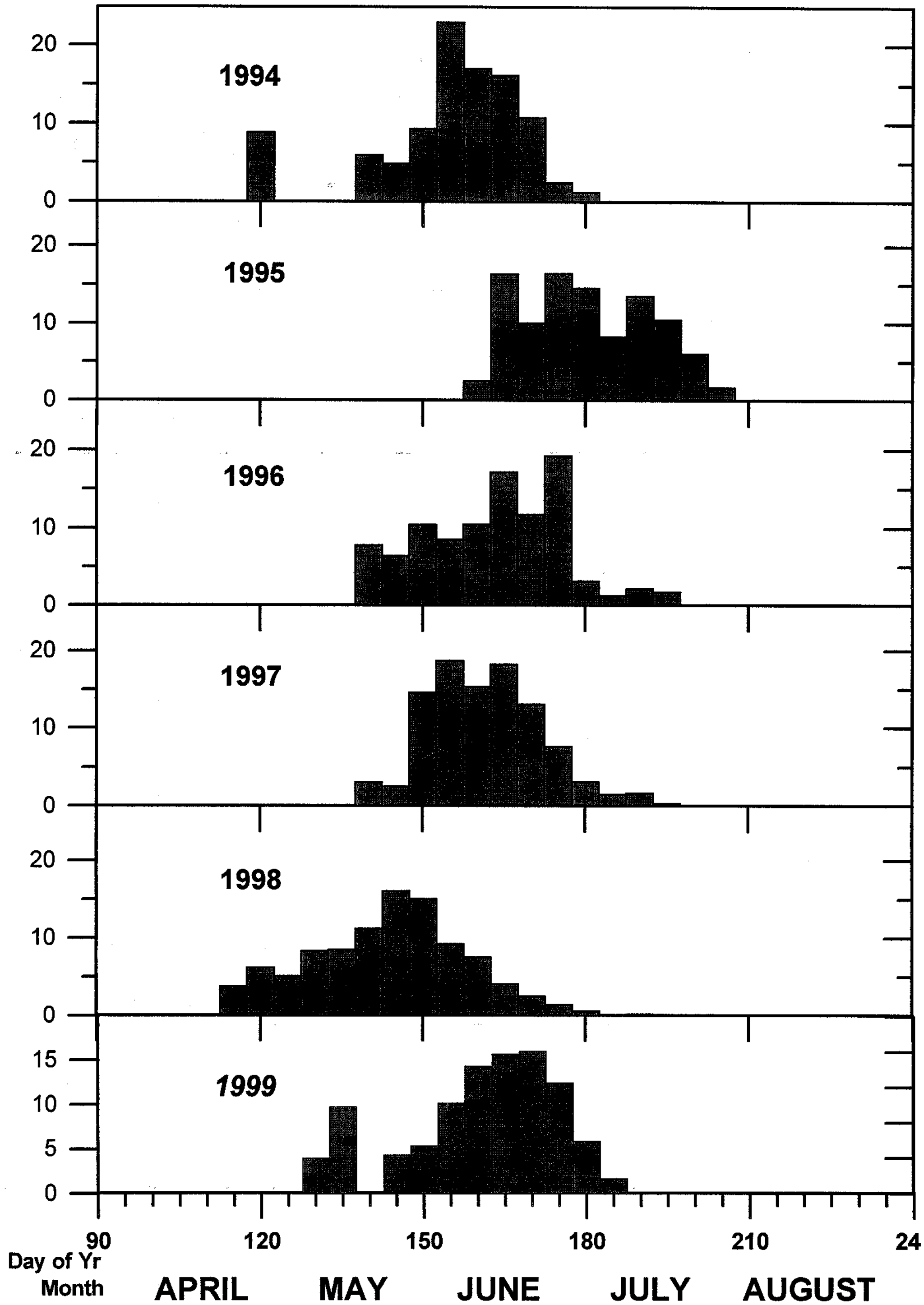

Figure 7. Larval hatch dates adjusted for 4% daily mortality and summarized in 5 day periods estimated from the ages of pelagic juvenile cod sampled each year, 1994-1999.