DFO Atlantic Fisheries Research Document 95/135

MPO Pêches de l'Atlantique Document de recherche 95/135

RESULTS OF THE DECEMBER JUVENILE HERRING SURVEYS FROM 1991 TO 1994, AND AN OVERVIEW OF SOME OTHER JUVENILE INDICES

by

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ABSTRACT

In 1991, a December stratified-random bottom trawl survey was initiated, covering selected areas which were known or thought to harbour juvenile herring in the southern Gulf of St. Lawrence. The numbers of juveniles by region indicate that the north area of the southern Gulf had the largest proportion of spring and fall-spawned juveniles for all years. The catch-at-age suggests that the 1991 spring year-class was above average in numbers. The most consistent and promising monitoring using the December juvenile herring survey is that of the spring-spawned cohorts. Other juvenile herring indices were also examined. From the annual September groundfish surveys, since 1988, the juvenile herring catch-at-age in daytime trawl sets enabled the calculation of a standardised mean catch per tow. Also from the annual groundfish survey data, the mean length at age, for juveniles of ages 0 spring and 1 fall, was determined and extracted from the length-frequency distributions to generate a mean catch for the years 1984 to 1993. A SAS GLM procedure was used to compare the groundfish survey juvenile indices with other fishery-based indices, including the 1994 4T herring assessment fall spawners population numbers. There were no significant correlations between the two groundfish survey indices and indices based on fishery data for the spring-spawned juveniles. However, the fall-spawned 2 year-old juveniles from the north area of the southern Gulf did correlate with 4TVn ADAPT fall population numbers at age. Finally, seven different fishery-independent juvenile herring abundance indices were used in a paired comparison between indices. The comparison that resulted in significant correlation was from the acoustic versus groundfish survey indices, for age 1 spring-spawned and age 2 fall-spawned numbers.

RESUME

Depuis 1991, un relevé aléatoire stratifié au chalut de fond a lieu en décembre dans le sud du golfe Saint-Laurent afin d'inventorier l'abondance de harengs juvéniles dans des régions de distribution connues ou plausibles. Le nombre de juvéniles du printemps et d'automne inventoriés est plus élevé dans la région nord du sud du golfe Saint-Laurent. D'après les prises-à-l'âge, la classe-d'âge du printemps 1991 serait au-dessus de la moyenne en nombre. Le relevé de décembre s'est avéré efficace pour échantillonner les juvéniles nés le printemps. D'autres indices d'abondance furent aussi examinés. À partir des relevés annuels de poissons de fond en septembre, une analyse des prises-à-l'âge depuis 1988, ainsi que des distributions de fréquence-longueurs entre 1984 et 1993 sur les harengs juvéniles d'âge 0 du printemps et d'âge 1 d'automne, a permis l'élaboration de deux indices d'abondance. Ces indices furent comparés en utilisant des procédures GLM de SAS à d'autres indices provenant de la pêcherie, incluant les nombres-à-l'âge générés dans l'évaluation annuelle du stock de hareng dans le sud du golfe. Aucune corrélation significative existait entre les indices provenant du relevé de septembre et ceux de la pêcherie pour les juvéniles du printemps. Cependant, les résultats étaient significatifs entre l'indice des juvéniles d'automne d'âge 2 provenant des relevés de poissons de fond et les nombres-à-l'âge des frayeurs d'automne provenant de l'analyse virtuelle de population. De plus, une comparaison jumelée entre sept indices d'abondance indépendant de la pêcherie a démontré qu'il y avait des relations significatives entre les indices provenant des relevés acoustiques et du poisson de fond pour les nombres de juvéniles de printemps d'âge 1 et les juvéniles d'automne d'âge 2.

INTRODUCTION

In the southern Gulf of St. Lawrence (NAFO Division 4T) the major portion of the Atlantic herring population spawns either in the spring or in the fall. Wide fluctuations in recruitment are evident by dominating year-classes in both seasons (Claytor et al. 1995). At present we have no measure of pre-recruit abundance for either spawning group.

This paper summarises the results of the December juvenile herring surveys held from 1991 to 1994. Included are a description of survey design and procedures, as well as an annual description of results, catch rates and composition. Finally, an overview of other possible juvenile indices available and a comparison between indices are presented.

PART A: DECEMBER JUVENILE HERRING SURVEYS

INTRODUCTION

The juvenile herring program was initiated with systematic searches in promising areas within the southern Gulf of St. Lawrence. In December 1988, a survey was conducted in Chaleur Bay using hydroacoustic gear and a midwater trawl, but with limited success. A comparative survey in late November 1990 in Chaleur Bay between two vessels, one using a midwater trawl and the other a bottom trawl, showed that the bottom-trawl was more successful in capturing juvenile herring.

In 1991, a stratified-random bottom trawl survey design was initiated. The objectives of these surveys was to obtain a stratified catch rate of juvenile herring in the southern Gulf in order to determine abundance indices, specific to season of birth and age, that could be used as an index of pre-recruitment in the stock assessment process.

METHODS

Survey Design

A random-stratified survey design, similar to the annual groundfish surveys, covered selected areas of the southern Gulf. Areas which were known or thought to harbour juvenile herring were divided into depth-specific strata (Fig. 1). These strata were further subdivided into major sampling units of about 115 km^2. The number of stations fished in each stratum was determined proportionally to the stratum area. Up until 1993, fishing stations were located at approximately the centre of the major sampling units. In 1994, each major sampling unit was further subdivided into ten minor units, and one was selected randomly as the start of the fishing station.

Survey Procedure

From 1991 to 1993, the survey was conducted with the research vessel E.E. Prince using a Yankee 36 bottom trawl lined with 1.9 cm mesh in the codend. In 1994, the Alfred Needler was used as the survey vessel with a Western IIA trawl. No direct comparison of the catchability between these two vessels using the same or different gear has been done. However, during annual groundfish surveys, comparisons were done in 1985 between the E.E. Prince and the Lady Hammond with the Yankee 36 bottom trawl, and in 1992 between the Alfred Needler and Lady Hammond, both using a Western IIA bottom trawl (Nielsen, 1994). Overall, no significant differences were detected between these paired sets comparisons for herring catch. Nevertheless, there could be some bottom depth-related differences in catchability between vessels as seen in other species (Nielsen, pers. comm.).

The 1991 survey began with a day/night comparison of the bottom trawl's fishing efficiency, with the conclusion that fishing efficiency was greater during daytime hours (Table 1). Protocol was then established as daytime (07:00-17:00) bottom trawling for 30 minutes at a speed of 3.5 knots at selected stations. At the end of each set, a CTD profile was done.

Biological Sampling

In all the surveys, the total weight of herring caught in each tow was taken. A random subsample of up to 300 fish from each tow were measured (total length) to the nearest 0.5 cm. All fish, or a stratified subsample (of 3 individuals per 0.5-cm length interval) were frozen and brought to the laboratories where total weight, age, season of birth, sex, and gonad weight and maturity stage of individual herring were determined. Age was determined by counting the number of annuli on otoliths, and season of birth was assigned by evaluating otolith shape and size characteristics (Messieh 1972).

Catch Data

A calculation of the mean number of juvenile herring per tow by stratum was done. Herring of less than 25 cm total length were considered juveniles, based on fishery and research length-at-age data indicating that herring of less than 25 cm are immatures of ages 0 to 2 years. All valid tows that were cut short, but at least 20 minutes in duration, were standardised to represent a 30 minute tow.

The surface covered by a 30 minute tow was estimated by taking into consideration trawl width, vessel speed and distance towed, as indicated on the station cards. In 1994, the surface area covered during a standard 30 minute tow was taken from groundfish survey estimations (Hurlbut and Clay, 1990). Once the surface covered by tow was known, the number of juvenile herring per km^2 and for the whole stratum area could be determined.

Catch-at-age

Catch-at-age matrices were constructed by NAFO unit area and season of birth, using SAS procedures with age-length keys applied to length-frequency data. For comparative purposes and to superimpose these NAFO areas (Fig. 2) on our juvenile herring strata (Fig. 1), the southern Gulf was divided into two areas. The NORTH area includes NAFO unit areas 4Tm, 4Tn, and 4Tl, and our juvenile survey strata A to G. The SOUTH area includes NAFO unit areas 4Tg and 4Th as well as our strata H to J. Once the proportions at age for each area and season of birth were obtained using age-length keys, they were applied to the number of juveniles per area from our survey catch data.

RESULTS

1991 Survey

The day/night bottom trawling comparison results are presented in Table 1. The number of juvenile herring per set (Fig. 3) indicate that the areas of greater catches were west and central Chaleur, as well as east P.E.I.

The vast majority of samples were spring-spawned juveniles, with the age 0's at a mean length of 13.6 cm (Table 2). This corresponds to the peak juvenile percentage seen in the length-frequencies of both north and south areas (Fig. 5). The north area showed a wider range of juvenile sizes from age 0 falls to age 2's, plus larger young adult herring.

1992 Survey

The number of juvenile herring per set shows no area of major catches (Fig. 3), and catch rates are less than the other years in the time series. The majority of samples taken were spring-spawned juveniles (Table 2). The numbers were spread more evenly between ages and areas, with the most numerous age-groups being the 0 spring at a mean length of 14.6 cm and the age 1 springs at 19.8 cm.

The north area had the most widespread percentage length-frequency distribution (Fig. 5), with a peak number of juveniles at 20 cm corresponding to the age-1 spring group, and a smaller peak of age-1 falls at 16 cm. In the south area, the age 0 spring group predominates with a mean length of 14.6 cm.

1993 Survey

The 1993 numbers of juveniles per set (Fig. 4) indicate two poles of concentration; one in the west and central Chaleur Bay, and the second in the eastern part of Northumbertland Strait. The mean length at age numbers by season (Table 2) of the juvenile samples taken showed a predominance of spring juveniles, spread evenly between ages 0, 1 and 2. The mean length for the age 0 spring juveniles was 11.6 cm, the lowest value in the time series. Age-1 spring spawners had a mean length of 19.5 cm and age 2 spring at 23.8 cm. There was also a large number of age 2 fall juveniles at mean length of 21.3 cm.

The north area had predominantly older ages 1 spring and 2's spring and fall (>19 cm) as seen in the percentages at length (Fig. 5). The south area samples contained mostly age-0 spring juveniles between 8 and 15 cms.

1994 Survey

The 1994 survey had the largest catches of juveniles per set of the four years (Fig. 4). Large numbers were present in central Chaleur Bay, Shediac valley, eastern Northumberland Strait and PEI. The mean lengths-at-age (Table 2) indicate large proportions of age 0 and 1 spring juveniles, with mean lengths of 12.5 and 16.9 cm respectively. There were also some fall juveniles age 0 at 7.2cm, age 1 at 14.6cm and age 2 at 21.4cm. Fall juveniles were more abundant than previous years.

In the 1994 length-frequencies percentages (Fig. 5), small age 0 fall juveniles between 5 and 11 cms. were found. The biggest peak values in the south were a combination of age 0 spring and 1 falls, between 12 and 16 cm. The north area had a wide length-frequency distribution with all juvenile ages present.

Catch Rates

A summary by stratum, including depths, area, the number and proportion of sets with juvenile herring, the mean number of juveniles per set as well as the estimated number of juveniles by km^2 are given in Table 3. The 1994 survey has the highest numbers of juveniles and percent of sets containing juveniles. The lowest estimated numbers were from the 1992 survey. Central Chaleur was the stratum with the highest number of juveniles for all years except 1992. The variance among strata by year was estimated, the highest variance being in 1992, and the lowest in 1991. The deeper east Chaleur stratum (40-60 fathoms) yielded less juveniles than the shallower strata.

The total estimated number of juveniles per stratum and area is found in Table 4. These numbers illustrate the large inter-year variations, where the largest estimated total number of juveniles (in 1994) was a 20-fold increase from the lowest estimate (in 1992). The total by region indicates that the largest proportion of juveniles were found in the north, and more specifically the Chaleur Bay portion.

Catch-at-age

The catch-at-age matrix of proportions at age applied to the numbers of juveniles by region resulted in numbers at age and biomass at age by area. The biomass at age was obtained by multiplying the numbers at age by the mean weight at that age. Table 5 gives the spring-born number of juveniles and biomass at age by area. By far, the north area had the largest proportion of spring juveniles by age for all years. The proportion of the total estimated numbers by year of spring juveniles varied from a high of 96.3% in 1991 to 66.3% in 1994. The percentage of numbers-at-age of spring-spawned juveniles (Fig. 6) indicated that the north area sampled ages 0 to 2 in various proportions, while the south area mainly sampled age 0's.

The fall juvenile numbers and biomass at age are summarised in Table 6. Again, the north area had the largest proportion of fall juveniles by age for all years. The numbers and total biomass, as well as the proportion of the total estimated numbers by year, have increased in the last two years of the survey. The percentage of numbers-at-age of fall-spawned juveniles (Fig. 7) showed that age 2's are more abundantly sampled in the north area and overall in the southern Gulf, while a larger percentage of age 1's are sampled in the south area.

Temperature and Salinity

Temperature versus depth and salinity profiles by stratum were plotted for the 1993 survey (Appendix 1). Temperatures in the north area of Chaleur and Miscou varied from 0.5 to 3°C, while in the south area strata of Northumberland Strait and east PEI, water temperatures were warmer, between 2 and 5.2°C. The salinity values on the practical salinity scale ranged from 26 to 32.

DISCUSSION

The results of four years of data from the December juvenile herring surveys have shown the possibilities of this survey in developing an index of pre-recruits into the fishery. That is particularly the case for the spring-spawned juveniles, which comprised as much as 96% of numbers caught in 1991 and make up 66% of the catch in 1994. Furthermore, it is the only source effectively sampling the spring-spawned age 0's in the southern Gulf of St. Lawrence.

The catch-at-age and percentage of numbers-at-age of spring-spawned juveniles from the December juvenile surveys (Table 5, Fig. 6) suggest that the 1991 spring year-class was above average, being the highest proportion of numbers at age 0 in 1991, at age 1 in 1992, and at age 2 in 1993. This corroborates with the percentage numbers-at-age observed during the October acoustic survey (LeBlanc et al. 1995). The acoustic percentages showed that the spring-spawned 1991 year-class represented 23.9% of the catch in 1992 as age 1's, 60.6% in 1993 as age 2's, and 42% in 1994 as age 3's (Fig. 8).

The acoustic survey uses a midwater trawl that does not consistently sample juveniles of age 0. It could be that age 0 spring-spawned herring juveniles are not found with the older herring in October. We were not able to apply statistical comparisons between these two juvenile indices due to the short time series.

The small proportion of fall-spawned juveniles in our samples was unexpected since fall spawners constitute the main component of the 4T herring stock (Claytor et al. 1995). The proportion of numbers at age were minimal in 1991 and 1992, but they increased over the next two years of the survey. Some areas of the southern Gulf such as northern PEI and around the Magdelene Islands have yet to be adequately surveyed and may harbour large aggregations of fall-spawned juveniles.

The most consistent and promising monitoring by the December juvenile herring survey is that of the spring-spawned cohorts, which in itself could greatly improve our confidence in assessing the status of the southern Gulf's spring stock.

PART B: OTHER JUVENILE HERRING INDICES

September Groundfish Survey

The annual September groundfish survey has been collecting length-frequency data on herring for several years. Juvenile herring (< 25cm) catches and length-frequencies in daytime trawl sets were collected since 1984. However, no biological samples of juvenile herring were collected until 1988, and were minimal until 1990.

With the biological details on age, season of birth and area, catch-at-age keys were constructed with the RVAN software procedures (Clay, 1989). This resulted in a mean catch per tow by age for each groundfish survey stratum. For comparative purposes, we superimposed these groundfish strata to cover NAFO unit areas of the southern Gulf. This resulted into two areas; the NORTH area includes NAFO unit areas 4Tm, 4Tn, 4Tl and the SOUTH includes NAFO 4Tg and 4Th. A standardised mean catch per tow by age and season of birth was then computed for the north and south areas.

Using SAS procedures, we also determined the mean length at age for juveniles from the biological samples. This showed that the youngest age-groups were separable by size. Only two age-groups could be separated with confidence limits (mean + 2SD) which did not overlap with other ages; these are the age 0 spring and age 1 fall groups. Having determined these mean lengths with confidence intervals, we then took the length-frequency distributions from 1984 to 1993 and determined, for the two age-groups in each of the two areas, the mean catch per tow from sets which contained juvenile herring.

Despite the short time series, a SAS GLM procedure was used to compare the above indices to fishery based data. The spring juvenile indices were compared with the spring index gillnetter and Escuminac landings-by-day data indices, both taken from the 1994 4T herring assessment (Claytor et al. 1995). For the fall juvenile indices, the same procedures were applied using the fishery-based fall spawner population numbers in the 4T herring assessment.

Comparison Between Indices

Seven different fishery independent indices were used for a paired index comparison. The analysis was done by year, age, season of birth and area, using SAS GLM procedures, recognising that this type of analysis is premature because of the limited degrees of freedom.

The indices used were:

- -JSN December Juvenile Survey numbers at age
- -JSB December Juvenile Survey biomass at age
- -ASP October Acoustic Survey proportions at age
- -ASB October Acoustic Survey biomass at age
- -GSR September Groundfish Survey RVAN standardised catch
- -GSN September Groundfish Survey catch per tow
- -FB Aug-Sept Fisherman's Bank Spawning Bed Survey (egg volume)

RESULTS

September Groundfish Survey

There was no significant correlation between the two groundfish survey indices for the spring-spawned juveniles and either the index gillnetter or the Escuminac indices (Table 7). The fall-spawned 2 year-old juveniles from the north area of the RVAN estimate significantly correlated with ages 2 to 4 from the 4TVn ADAPT matrix of population numbers.

The scatter and residual plots of the GLM procedures (Appendix 2) for the three significant correlations show standardised residual plots with outliers unduly influencing the fitted line. As our time series increases with future surveys, we will be able to verify the influence of these outliers on the fit.

Paired Comparison Between Indices

The paired correlations between different fishery-independent juvenile herring abundance indices that resulted in significant correlation were from the acoustic versus groundfish surveys, for age 1 spring-spawned and 2 fall-spawned numbers (Table 8). The number of observations is minimal, since most of the indices have a 4 or 5 year span. Also, age 0 comparisons were highly restricted since only the December juvenile survey had numbers at age for consecutive years, these years not matching with other indices.

DISCUSSION

All of the juvenile indices used have low numbers of observations which currently limit our evaluation of their potential as indices of pre-recruits.

The groundfish survey index has the longest time series presently available, and has shown some correlation for fall-spawned 2 year-olds with the fishery-based population numbers from ADAPT. However, no relation could be detected for the spring groups. The same analysis with fishery-based data was tried with the acoustic survey proportions and biomass-at-age, but no correlation was found for the juvenile age-groups (LeBlanc et al. 1995). All other indices have even shorter time series which do not permit a comparison with present fishery-based 4T assessment indices or population numbers.

The paired correlation analysis between fishery-independent indices revealed significant correlations between acoustic and groundfish survey indices for certain age categories, with a strict minimum number of observations. These results are therefore encouraging and support the continuation of these data series.

Most of the analyses that proved significant were of fall-spawned juveniles of the older age 2 group. The spring juveniles of age-groups 0 and ,to a lesser extent, age-group 1, were less abundant or observed sporadically in the groundfish and acoustic surveys. These inconsistent occurrences could reflect real differences in geographic and/or vertical distribution of these age groups at that time of year, or could be explained by gear selectivity, sampling intensity or other factors affecting catchability. For these spring-spawned ages, the most promising index appears to be the December juvenile herring survey, which has consistently sampled spring juveniles of ages 0 to 2 for the past four years.

ACKNOWLEDGEMENTS

Sincere thanks go to Clarence Bourque and Colin MacDougall who did the laboratory work and ageing of collected samples. Thanks are also due to Ross Claytor for his suggestions and advice and Lorraine LeBlanc for helping with the Fig.s. Finally, thanks to all the Ship's Branch personnel who participated in the December juvenile herring surveys.

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Table 1. Day/night fishing comparison with the E.E. Prince's Yankee 36 bottom trawl during 30 minute tows at 3.5 knots in western Chaleur Bay, December 1991.
Comparaison jour/nuit de l'efficacité de pêche du chalut à panneaux Yankee 36 abord du E.E. Prince pour des traits de 30 minutes à 3.5 noeuds, décembre 1991.

Site	No. of juvenile herring caught Day tow	Night tow
48•02'N 66•05'W	83	0
47•50'N 65•41'W	51	0
47•56'N 65•05'W	6	0
48•18'N 64•40'W	0	0
47•57'N 65•44'W	28	5
48•02'N 65•44'W	31	9
48•03'N 65•57'W	127	0
47•58'N 65•54'W	5	0

Table 2. Mean length (cm) at age by area of FALL and SPRING born juvenile herring from the December juvenile herrinig survey samples, 1991 - 1994.
Longueur moyenne (cm) à l' âge des harengs juvéniles d'AUTOMNE et de PRINTEMPS par région provenant des échantillons du relevé de harengs juvéniles de décembre, 1991 - 1994.

Season of birth: FALL		AREA								
		NORTH (4Tl, 4Tm, 4Tn)			SOUTH (4Tg, 4Th)			4T		
Year	AGE	N	Mean Length	SD	N	Mean Length	SD	N	Mean Length	SD
1991	0	-	-	-	3	8.5	0.5	3	8.5	0.5
	1	15	16.1	1.3	-	-	-	15	16.1	1.3
	2	2	23.0	0.7	-	-	-	2	23.0	0.7
1992	0	-	-	-	-	-	-	-	-	-
	1	11	16.3	1.2	3	14.5	1.0	14	15.9	1.4
	2	17	21.4	1.4	2	21.0	2.1	19	21.3	1.4
1993	0	-	-	-	3	6.3	0.3	3	6.3	0.3
	1	18	15.0	1.5	3	12.7	4.2	21	14.7	2.1
	2	100	21.4	1.2	1	14.0	-	101	21.3	1.4
1994	0	22	7.4	0.7	11	6.9	0.9	33	7.2	0.8
	1	94	14.9	1.5	43	14.1	1.2	137	14.6	1.4
	2	96	21.5	1.7	1	15.0	-	97	21.4	1.8

Season of birth: SPRING		AREA								
		NORTH (4Tl, 4Tm, 4Tn)			SOUTH (4Tg, 4Th)			4T		
Year	AGE	N	Mean Length	SD	N	Mean Length	SD	N	Mean Length	SD
1991	0	335	13.6	1.9	77	13.1	1.4	412	13.6	1.8
	1	39	20.7	2.2	2	13.5	0.7	41	20.3	2.6
	2	75	24.5	2.4	-	-	-	75	24.5	2.4
1992	0	73	14.6	2.2	54	14.7	1.2	127	14.6	1.9
	1	80	20.0	1.8	18	18.5	1.8	98	19.8	1.9
	2	36	22.2	2.2	13	25.0	2.0	49	22.9	2.5
1993	0	76	13.0	2.2	127	10.8	1.9	203	11.6	2.3
	1	162	20.0	1.3	12	13.3	0.9	174	19.5	2.2
	2	152	23.8	1.7	1	22.0	-	153	23.8	1.7
1994	0	198	12.2	1.9	134	12.8	1.8	332	12.5	1.9
	1	128	17.7	3.3	38	14.3	1.7	166	16.9	3.4
	2	71	22.2	1.8	-	-	-	71	22.2	1.8

Table 3. Stratum depth, area, number and proportion of sets with juvenile herring, mean number per set and km², December juvenile herring surveys, 1991 - 1994.
Profondeur et surface des strates, nombre et proportion de traits avec harengs juvéniles, nombre moyen par trait et par km², relevés de harengs juvéniles, 1991 - 1994.

STRATUM	STRATUM DEPTH fathoms	AREA (km2)	NUMBER OF SETS	% OF SETS WITH JUV. HERRING	JUV. HERRING MEAN NUMBER PER SET	S.E.	JUV. HERRING NUMBER PER km2
1991							
A. WEST CHALEUR	6 - 20	838	8	88	45	15.2	1324
B. CHALEUR INSHORE	6 - 20	731	2	50	22	21.2	647
C. CENTRAL CHALEUR	20 - 40	1397	4	100	131	75.0	3853
D. EAST CHALEUR	40 - 60	1050	0	--	--	--	--
E. MISCOU INS. & WEST PEI	6 - 20	3368	2	100	11	0.0	324
F. MISCOU OFFSHORE	20 - 40	2739	3	67	25	13.3	735
G. KOUCHIBOUGUAC	6 - 20	1099	1	100	53	--	1559
H. NORTHUMBERLAND	6 - 20	3501	0	--	--	--	--
I. EAST PEI INSHORE	6 - 20	925	6	100	53	21.2	1559
J. EAST PEI OFFSHORE	20 - 40	3295	0	--	--	--	--
surface sampled = 0.034km2			n = 26		CV = 0.24		
1992							
A. WEST CHALEUR	6 - 20	838	4	75	5.3	2.1	151
B. CHALEUR INSHORE	6 - 20	731	2	50	26	26.2	743
C. CENTRAL CHALEUR	20 - 40	1397	6	83	12	4.5	343
D. EAST CHALEUR	40 - 60	1050	2	0	0	--	0
E. MISCOU INS. & WEST PEI	6 - 20	3368	7	29	0.1	0.2	3
F. MISCOU OFFSHORE	20 - 40	2739	6	67	30	23.7	857
G. KOUCHIBOUGUAC	6 - 20	1099	2	0	0	--	0
H. NORTHUMBERLAND	6 - 20	3501	2	50	4.5	4.5	129
I. EAST PEI INSHORE	6 - 20	925	4	100	28	22.5	800
J. EAST PEI OFFSHORE	20 - 40	3295	9	78	3	1.3	86
surface sampled = 0.035km2			n = 44		CV = 0.39		
1993							
A. WEST CHALEUR	6 - 20	838	4	100	22.5	9.4	598
B. CHALEUR INSHORE	6 - 20	731	3	67	83.3	42.4	2215
C. CENTRAL CHALEUR	20 - 40	1397	6	100	258.5	136.8	6875
D. EAST CHALEUR	40 - 60	1050	3	100	11.3	8.8	301
E. MISCOU INS. & WEST PEI	6 - 20	3368	8	38	1.4	0.8	37
F. MISCOU OFFSHORE	20 - 40	2739	6	17	0.3	0.3	8
G. KOUCHIBOUGUAC	6 - 20	1099	3	0	0	--	0
H. NORTHUMBERLAND	6 - 20	3501	6	50	35.3	21.5	939
I. EAST PEI INSHORE	6 - 20	925	5	80	4.6	3.4	122
J. EAST PEI OFFSHORE	20 - 40	3295	7	43	0.6	0.3	16
surface sampled = 0.0376km2			n = 51		CV = 0.35		
1994							
A. WEST CHALEUR	6 - 20	838	4	100	315	85.7	7683
B. CHALEUR INSHORE	6 - 20	731	3	67	271	118.9	6610
C. CENTRAL CHALEUR	20 - 40	1397	6	83	1734	866.7	42293
D. EAST CHALEUR	40 - 60	1050	3	33	1	0.8	24
E. MISCOU INS. & WEST PEI	6 - 20	3368	8	75	48	26.7	1171
F. MISCOU OFFSHORE	20 - 40	2739	6	100	282	107.0	6878
G. KOUCHIBOUGUAC	6 - 20	1099	5	60	165	140.4	4024
H. NORTHUMBERLAND	6 - 20	3501	7	86	66	44.1	1610
I. EAST PEI INSHORE	6 - 20	925	3	100	60	20.3	1463
J. EAST PEI OFFSHORE	20 - 40	3295	7	86	39	28.0	951
surface sampled = 0.041km2			n = 52		CV = 0.30		

Table 4. Total number of juvenile herring per stratum and region, December juvenile surveys, 1991 - 1994.
Nombre total de harengs juvéniles par strate et région, relevés de harengs juvéniles, décembre 1991 - 1994.

REGION / STRATUM	DEPTH fathoms	AREA (km2)	NUMBER MAJ OR UNITS	NUMBER PER YEAR 1991	1992	1993	1994
NORTH							
A. WEST CHALEUR	6 - 20	838	8	1111580	126898	501463	6438354
B. CHALEUR INSHORE	6 - 20	731	7	462250	543036	1619476	4831910
C. CENTRAL CHALEUR	20 - 40	1397	13	5366093	478968	9604375	59083321
D. EAST CHALEUR	40 - 60	1050	9	----	0	315559	25200
E. MISCOU INS. & WEST PEI	6 - 20	3368	30	1089649	9622	125404	3943928
F. MISCOU OFFSHORE	20 - 40	2739	26	2013975	2363361	21854	18838842
G. KOUCHIBOUGUAC	6 - 20	1099	11	1713172	0	0	4422376
NORTH Total		11222		11756719	3521885	12188131	97583931
SOUTH							
H. NORTHUMBERLAND	6 - 20	3501	31	----	450130	3286843	5636610
I. EAST PEI INSHORE	6 - 20	925	8	1450080	740012	113165	1353275
J. EAST PEI OFFSHORE	20 - 40	3295	29	----	282429	52580	3133545
SOUTH Total		7721		1450080	1472571	3452588	10123430
TOTAL		18943		13206799	4994456	15640719	107707361

Table 5. Estimated numbers and biomass at age for SPRING-born juveniles, by area, December juvenile herring surveys, 1991 - 1994.
Nombres et biomasse à l'âge estimés des harengs juvéniles du PRINTEMPS, par région, relevés de harengs juvéniles, décembre 1991-1994.

Season of birth: SPRING

ESTIMATED NUMBERS AT AGE

	AGE	1991	1992	1993	1994
NORTH (4Tm,4Tn,4Tl)	0	5201626	889636	1014850	19263761
	1	907846	1473703	3153907	30745553
	2	5176978	735919	5094223	13420241
NORTH Total		11286450	3099259	9262980	63429555
SOUTH (4Tg,4Th)	0	1415244	1070793	2976365	6037995
	1	20335	205112	200016	1854946
	2	0	64135	0	3335
SOUTH Total		1435579	1340040	3176381	7896275
4T Total		12722029	4439298	12439361	71325831

ESTIMATED BIOMASS AT AGE (T)

	AGE	1991	1992	1993	1994
NORTH (4Tm,4Tn,4Tl)	0	104.553	20.729	20.906	377.57
	1	62.641	102.422	201.535	1654.111
	2	651.781	74.181	552.214	964.915
NORTH Total		818.976	197.332	774.654	2996.596
SOUTH (4Tg,4Th)	0	25.474	23.557	33.633	118.345
	1	0.409	9.189	4.06	41.922
	2	0	6.106	0	0.24
SOUTH Total		25.883	38.852	37.693	160.507
4T Total		844.859	236.184	812.348	3157.102
SPRING percent by number		96.3	88.9	79.6	66.3

Table 6. Estimated numbers and biomass at age for FALL-born juveniles, by area, December juvenile herring surveys, 1991 - 1994.
Nombres et biomasse à l'âge estimés des harengs juvéniles d'AUTOMNE, par région, relevés de harengs juvéniles, décembre 1991-1994.

Season of birth: FALL

ESTIMATED NUMBERS AT AGE					
NORTH (4Tm,4Tn,4Tl)	AGE	1991	1992	1993	1994
	0	298127	0	0	464415
	1	20784	150334	348123	11938183
	2	151358	272292	2577029	21751778
NORTH Total		470269	422626	2925151	34154376
SOUTH (4Tg,4Th)	0	10875	0	9833	239128
	1	3626	90876	259488	1937435
	2	0	41655	6887	50591
SOUTH Total		14501	132531	276207	2227155
4T Total		484770	555158	3201358	36381530

ESTIMATED BIOMASS AT AGE (T)					
NORTH (4Tm,4Tn,4Tl)	AGE	1991	1992	1993	1994
	0	8.884	0	0	1.393
	1	1.478	4.57	8.947	306.811
	2	19.813	19.796	196.37	1646.61
NORTH Total		30.175	24.366	205.316	1954.814
SOUTH (4Tg,4Th)	0	0.036	0	0.018	0.574
	1	0.058	1.908	6.954	42.43
	2	0	2.924	0.129	2.024
SOUTH Total		0.094	4.833	7.101	45.027
4T Total		30.269	29.198	212.418	1999.841
FALL percentage by number		3.7	11.1	20.4	33.7

Table 7. September groundfish survey juvenile herring indices comparison with SPRING index gillnetters and Escuminac co-ordination program and FALL spawners population estimates from ADAPT.
Comparaison entre indices de harengs juvéniles des relevés de poissons de fond et les indices provenant des pêcheurs repères et du programme de co-ordination d'Escuminac le PRINTEMPS et les estimés de population ADAPT à l'AUTOMNE.

Season of Birth: SPRING / PRINTEMPS — Procedure: SAS GLM

DEPENDENT VARIABLE	AGE	AREA	INDEPENDENT VARIABLE	AGE	AREA	df	r	Pr>F
Catch per tow	0	S*	Index Gillnetter	2	4T	6	0.15	NS
Catch per tow	0	S	Index Gillnetter	3	4T	5	0.15	NS
Catch per tow	0	S	Escuminac	2	S	4	0.31	NS
RVAN	0	S	Index Gillnetter	2	4T	4	0.37	NS
RVAN	0	S	Escuminac	2	S	4	0.33	NS

Season of birth: FALL / AUTOMNE

DEPENDENT VARIABLE	AGE	AREA	INDEPENDENT VARIABLE	AGE	AREA	df	r	Pr>F
Catch per tow	1	S	ADAPT	2	4T	7	0.28	NS
RVAN	1	S	ADAPT	2	4T	4	0.3	NS
RVAN	1	S	ADAPT	3	4T	4	0.3	NS
RVAN	2	N*	ADAPT	2	4T	5	0.98	0.0008
RVAN	2	N	ADAPT	3	4T	5	0.98	0.0008
RVAN	2	N	ADAPT	4	4T	4	0.98	0.002
RVAN	2	S	ADAPT	2	4T	5	0.24	NS
RVAN	2	S	ADAPT	3	4T	5	0.24	NS
RVAN	2	S	ADAPT	4	4T	4	0.43	NS

* N = North * S = South

Table 8. Paired correlation analysis of juvenile herring fishery-independent abundance indices in the southern Gulf of St. Lawrence, by age, season of birth and area. Analyse jumelée de correlation entre les indices d'abondance du hareng juvenile indépendants de la pêcherie du sud du Golfe du Saint-Laurent, par âge, saison et région.

INDICES AVAILABLE	AGE PER INDEX AUTUMN	SPRING	AREA	YEARS OF DATA
JSN (Juvenile survey numbers)	0 - 2	0 - 2	N S T	1991 - 1994
JSB (Juvenile survey biomass)	0 - 2	0 - 2	N S T	1991 - 1994
ASP (Acoustic survey percents)	1 - 2	1 - 2	N T	1990 - 1994
ASB (Acoustic survey biomass)	1 - 2	0 - 2	N T	1990 - 1994
GSR (Groundfish survey, RVAN)	1 - 2	0 - 2	N T	1988 - 1993
GSN (Groundfish survey numbers)	1	0	S T	1984 - 1993
FB (Fisherman's bank)	0	-	S	1985 - 1994

PAIRED CORRELATION ANALYSIS PERFORMED

JSN * ASP, ASB, GSR, GSN, FB

JSB * ASP, ASB, GSR, GSN, FB

ASP * GSR, GSN, FB

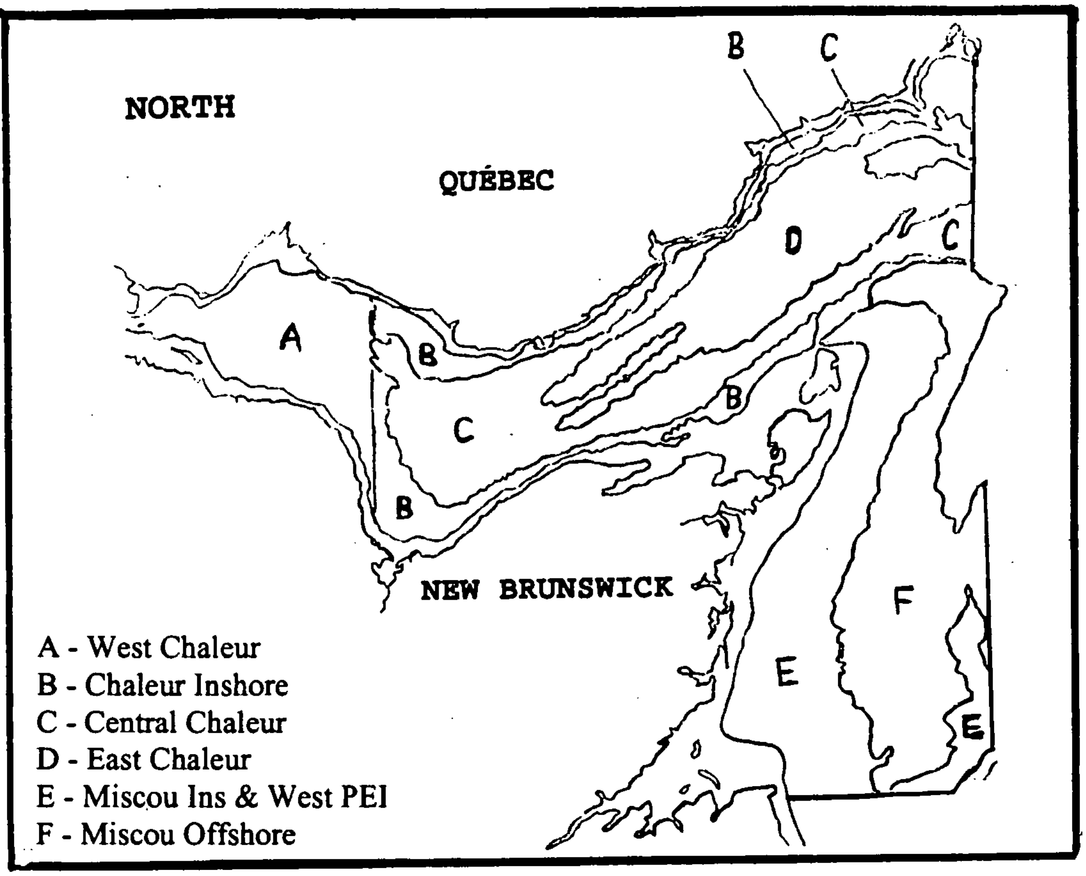
ASB * GSR, GSN, FB

GSR * GSC, FB

SIGNIFICANT RESULTS

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	GROUP (age/season of birth)	REGION	df	r	Pr > F
ASB	GSR	2A	N	3	0.9	0.003
ASP	GSR	2A	N	3	0.9	0.001
ASB	GSR	1P	N	3	0.9	0.0002

N = NORTH S = SOUTH T = NAFO AREA 4T



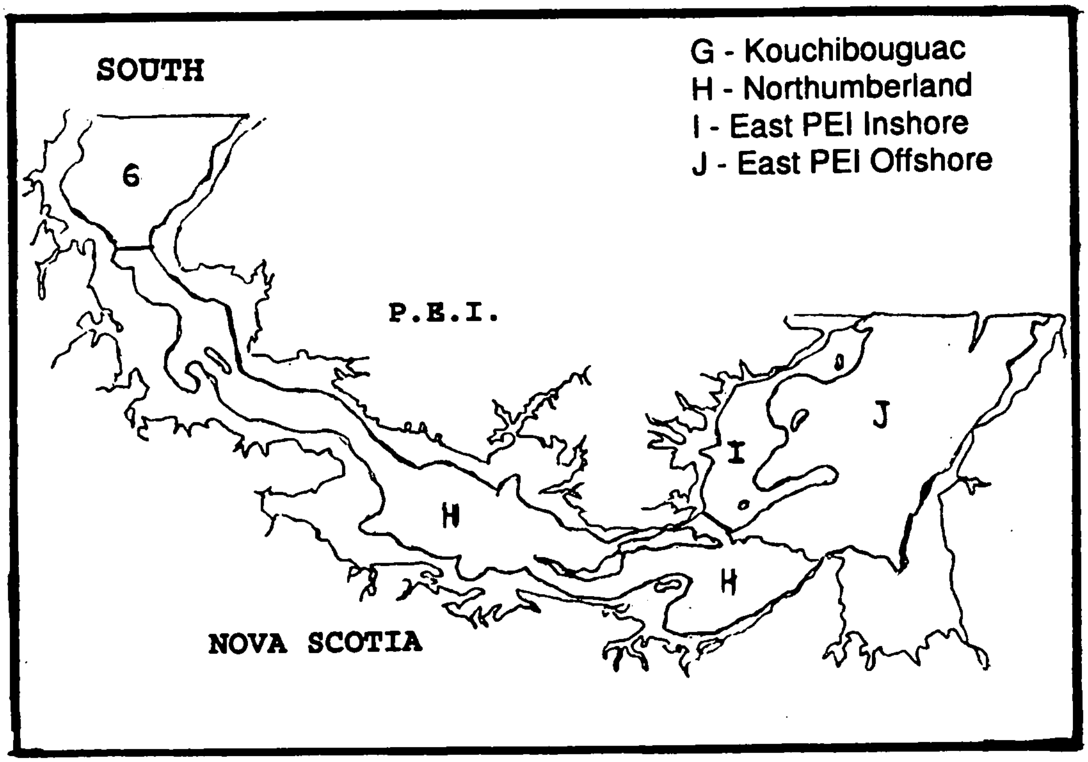


Fig. 1. December herring juvenile survey north and south strata in the southern Gulf of St. Lawrence. Strates pour les régions nord et sud du golfe du Saint-Laurent utilisées lors des relevés de harengs juvéniles de décembre.

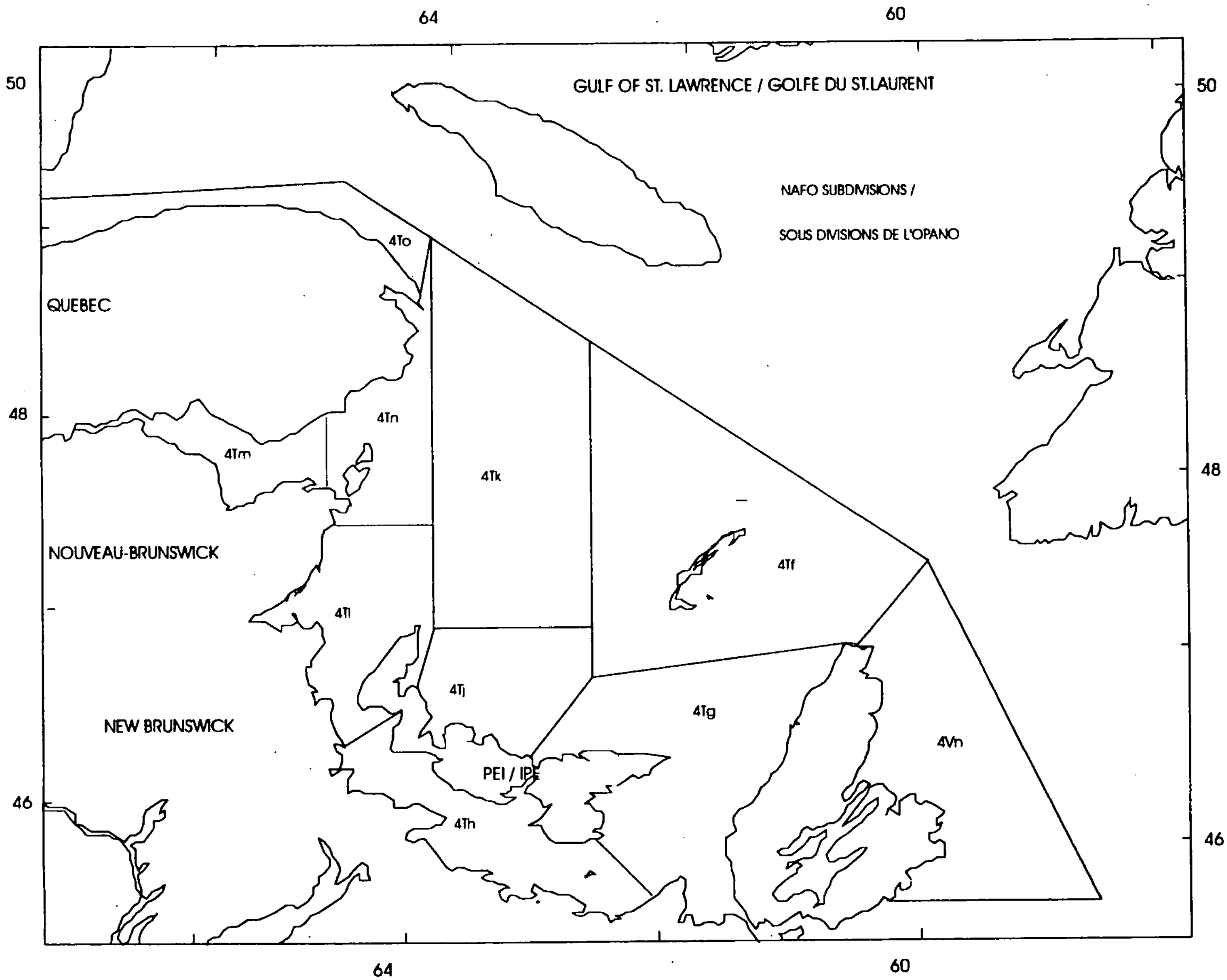


Fig. 2. Northwest Atlantic Fisheries Organisation (NAFO) subdivisions in the southern Gulf of St. Lawrence.
Sous-divisions de l'OPANO dans le sud du golfe du Saint-Laurent.

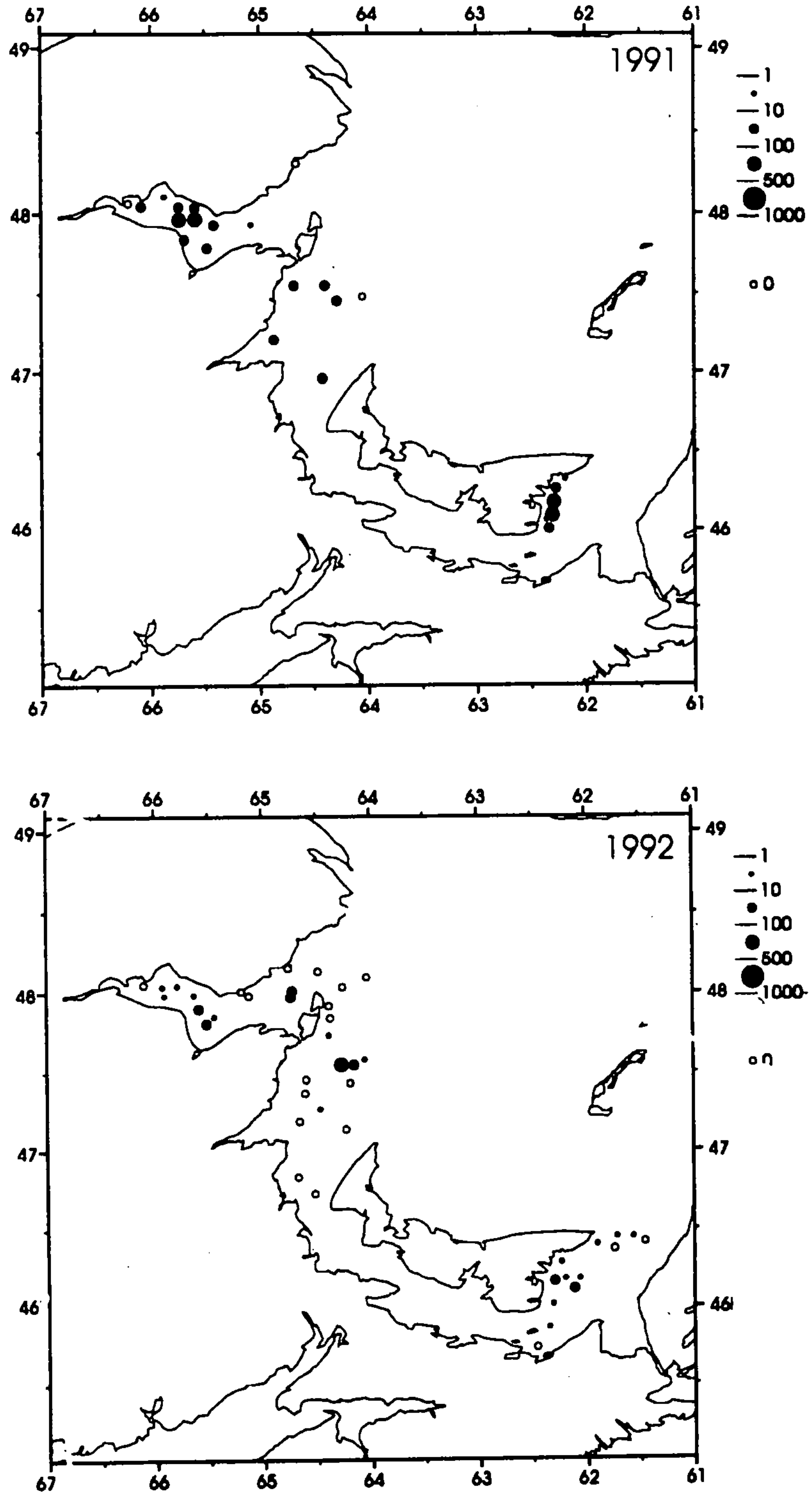


Fig. 3. Juvenile herring survey numbers per set, December 1991 and 1992.
Nombre de harengs juvéniles par trait, relevés de décembre 1991 et 1992.

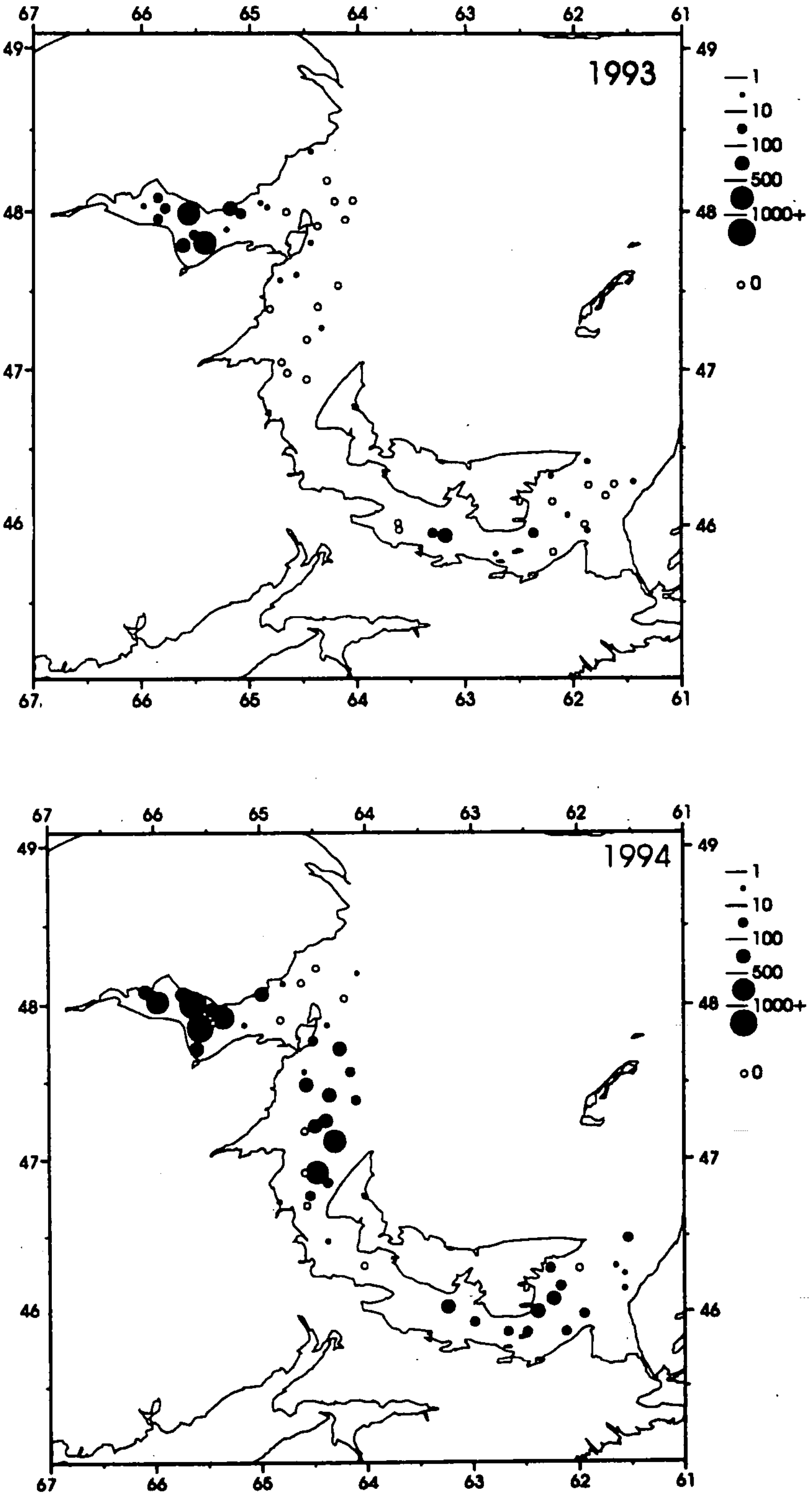


Fig. 4. Juvenile herring survey numbers per set, December 1993 and 1994.
Nombre de harengs juvéniles par trait, relevés de décembre 1993 et 1994.

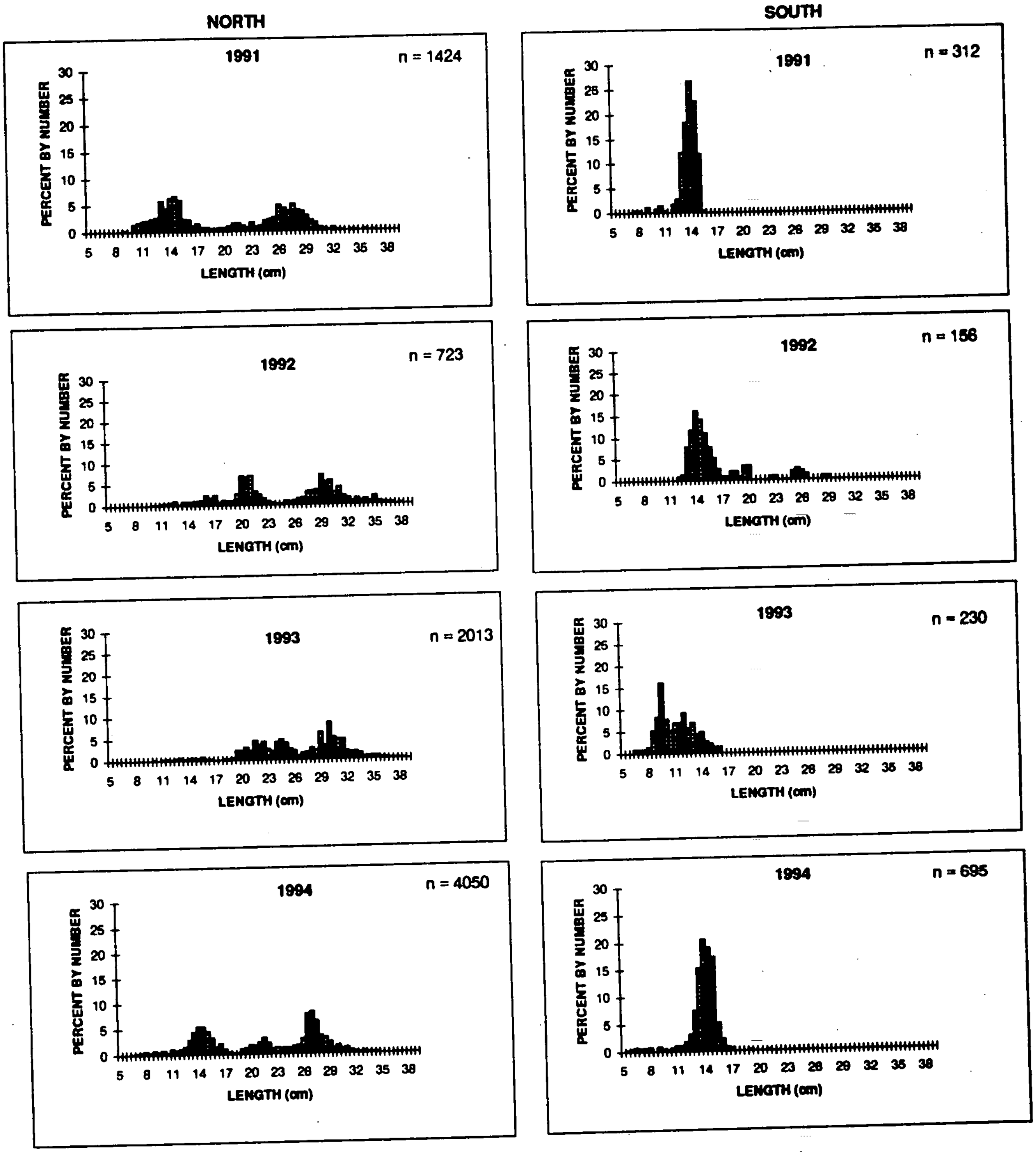
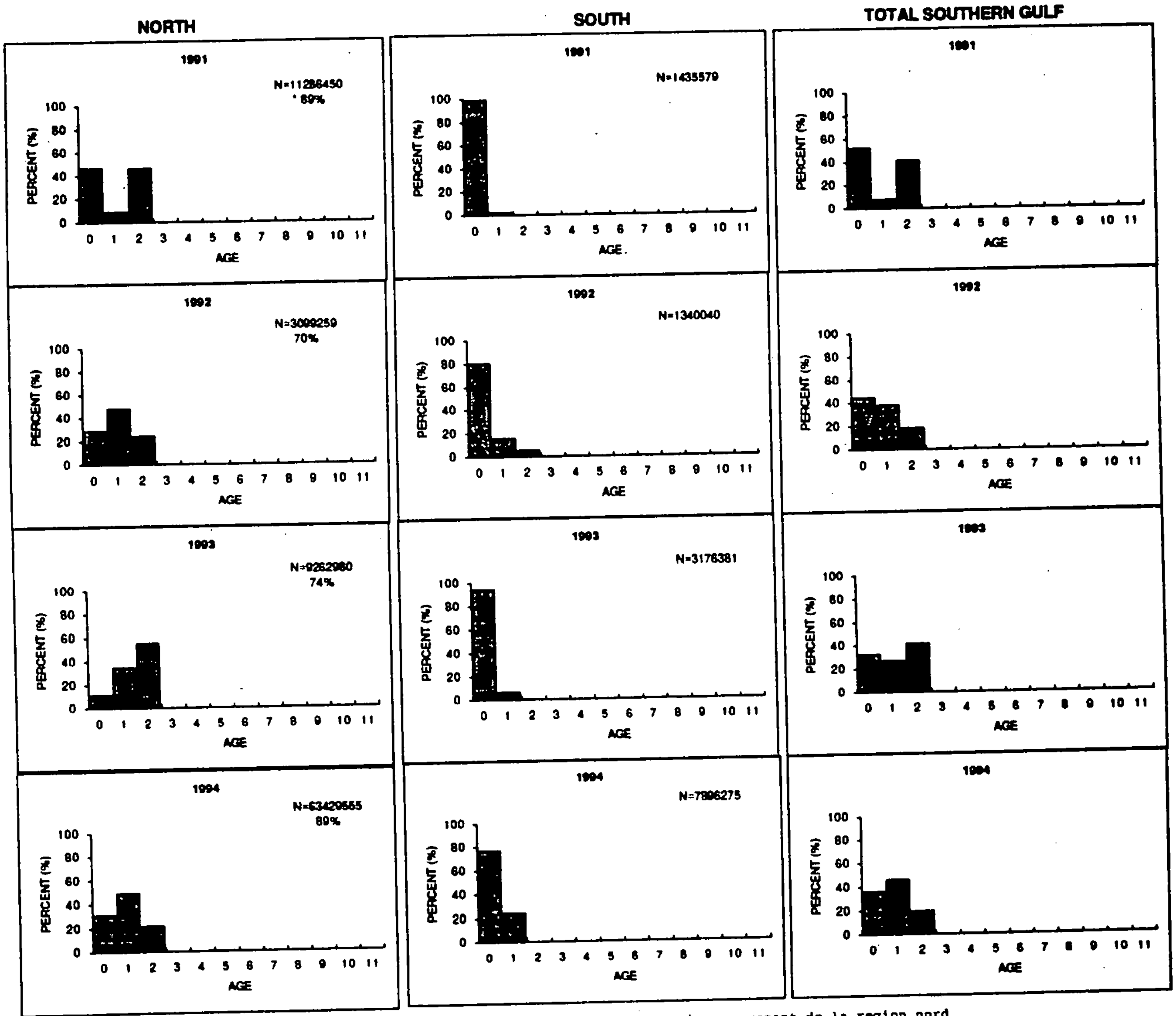
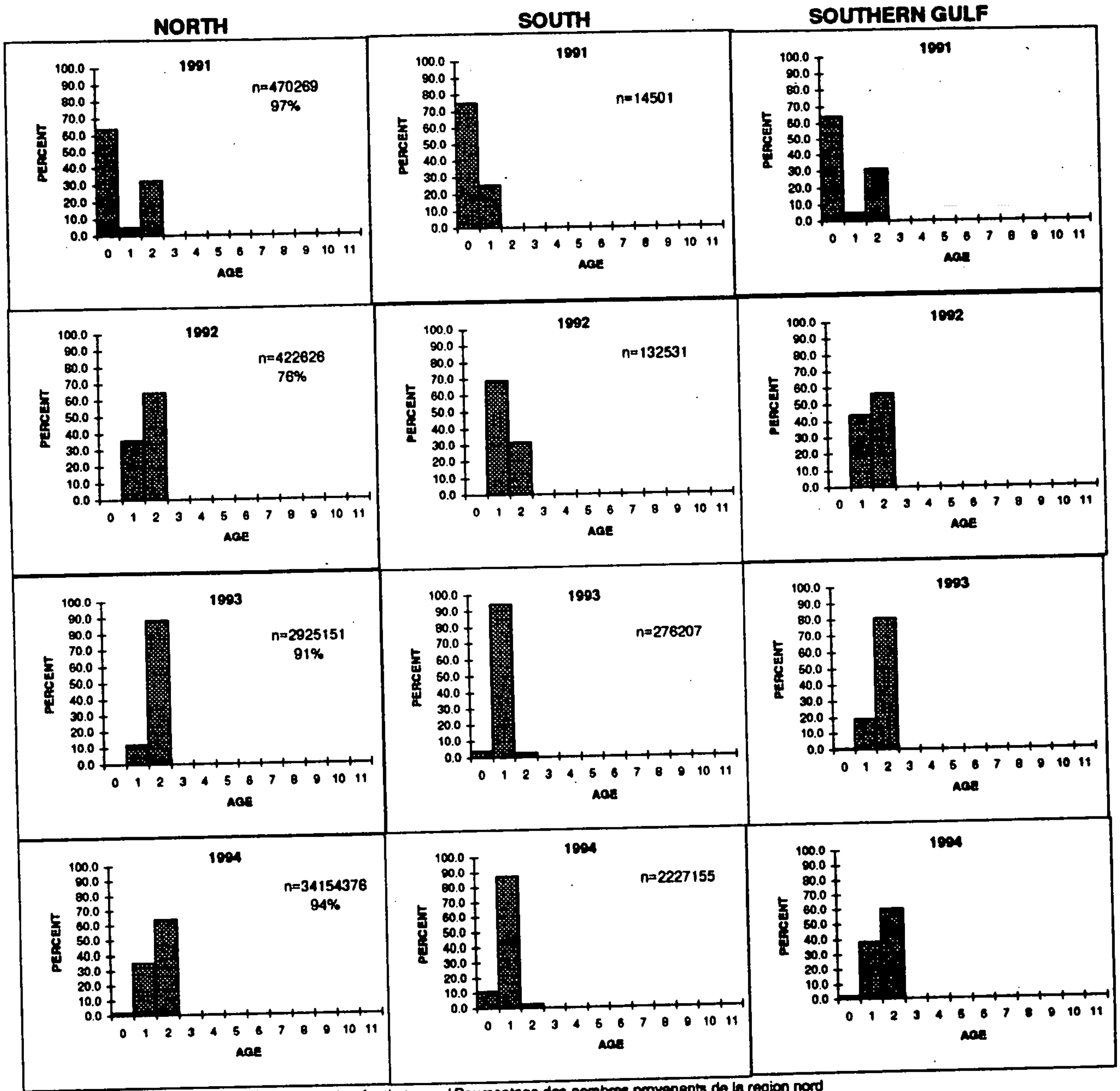


Fig. 5. Length-frequency distribution by area from December juvenile herring surveys.
Distribution de fréquence-longueurs par région, relevés de harengs juvéniles de décembre.



% = north area percent of total number for that year/Pourcentage en nombre provenant de la region nord

Fig. 6. SPRING-spawned percentage of numbers-at-age by area, December juvenile herring surveys.
Pourcentage de nombres-à-l'âge des harengs juvéniles du PRINTEMPS, relevés de décembre.



% = north area percent of total number for that year / Pourcentage des nombres provenants de la region nord

Fig. 7. FALL-spawned percentage numbers-at-age by area, December juvenile herring surveys. Pourcentage des nombres-à-l'âge des harengs juvéniles d'AUTOMNE, relevés de décembre.

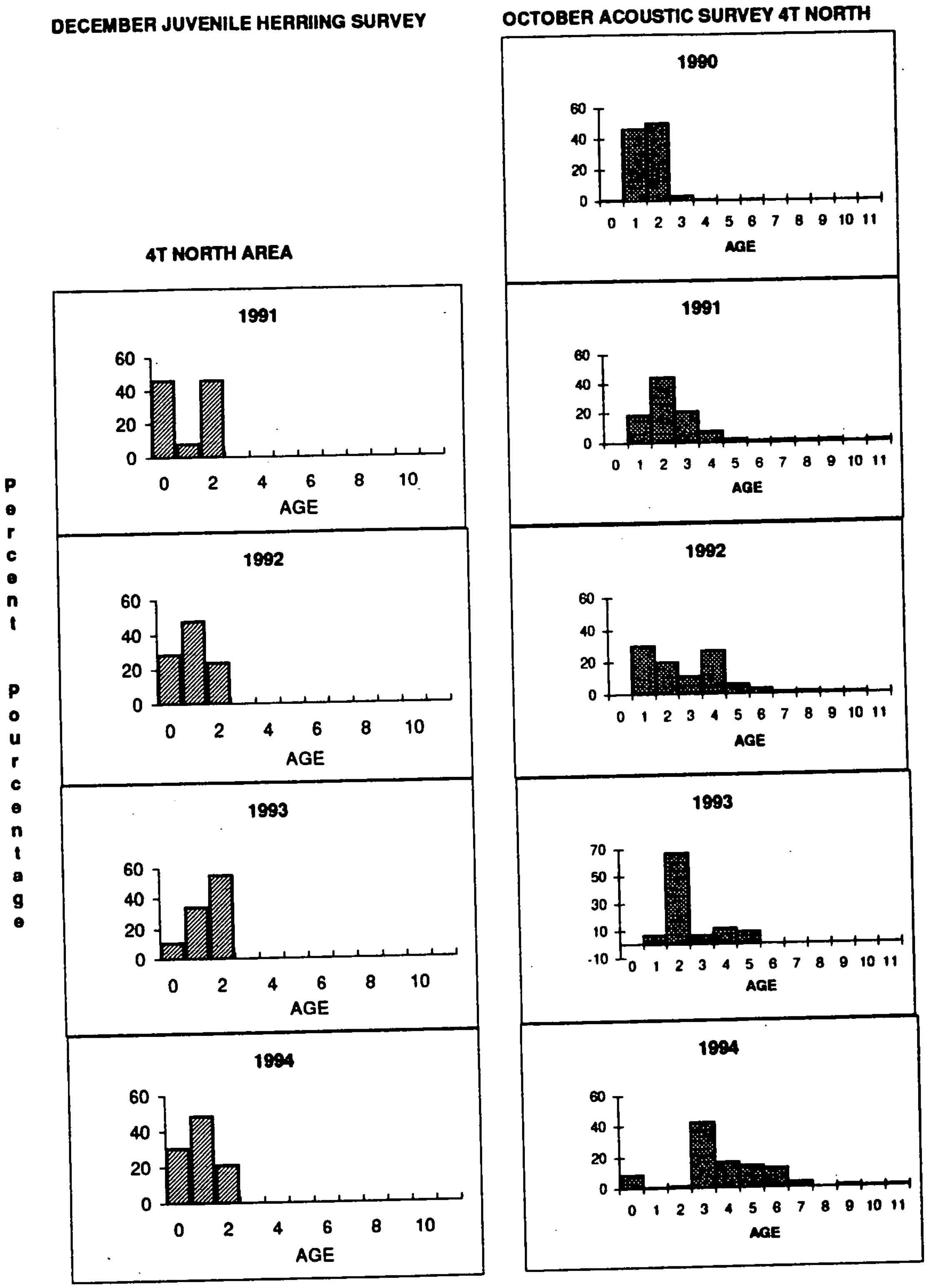
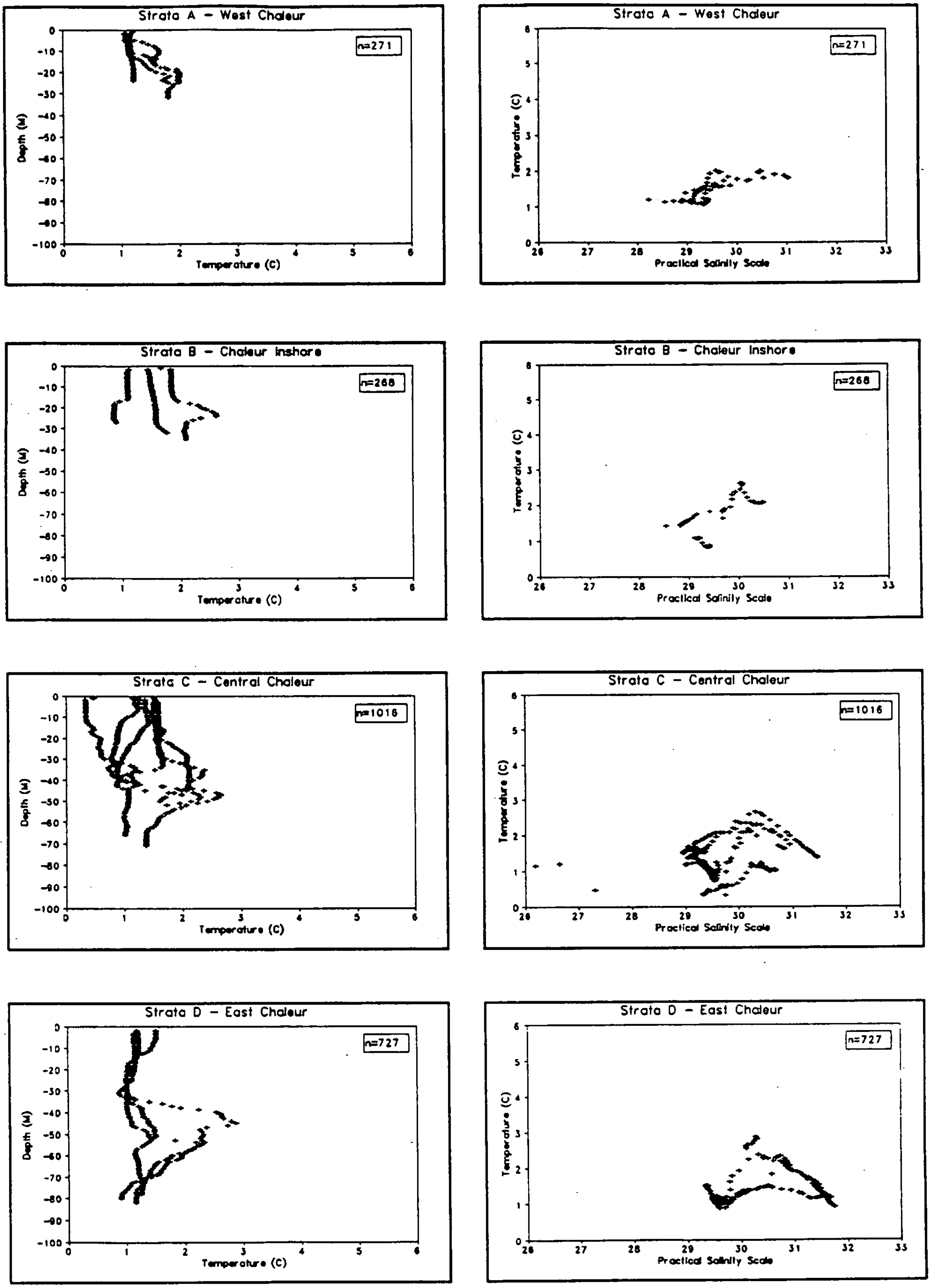
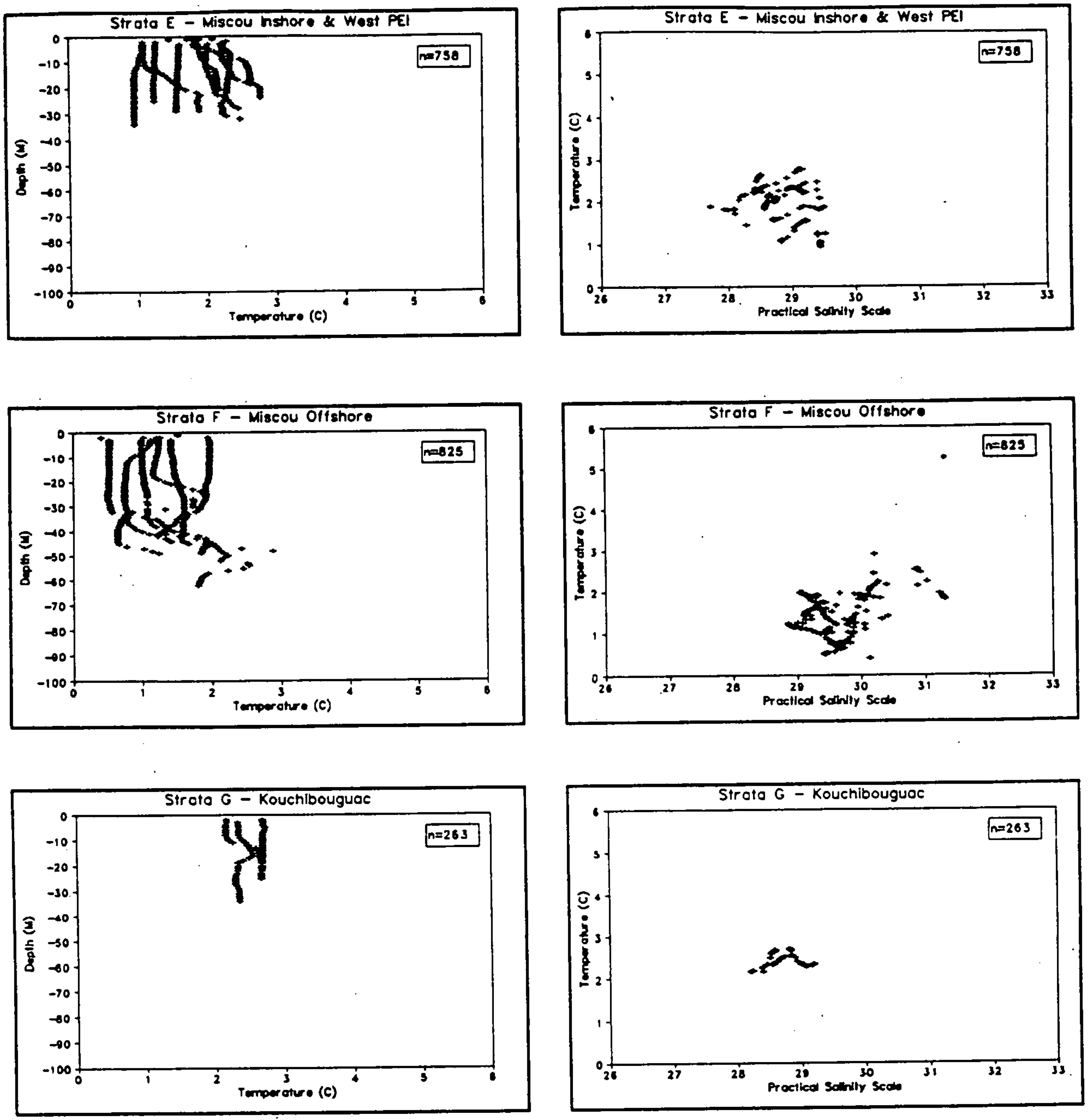


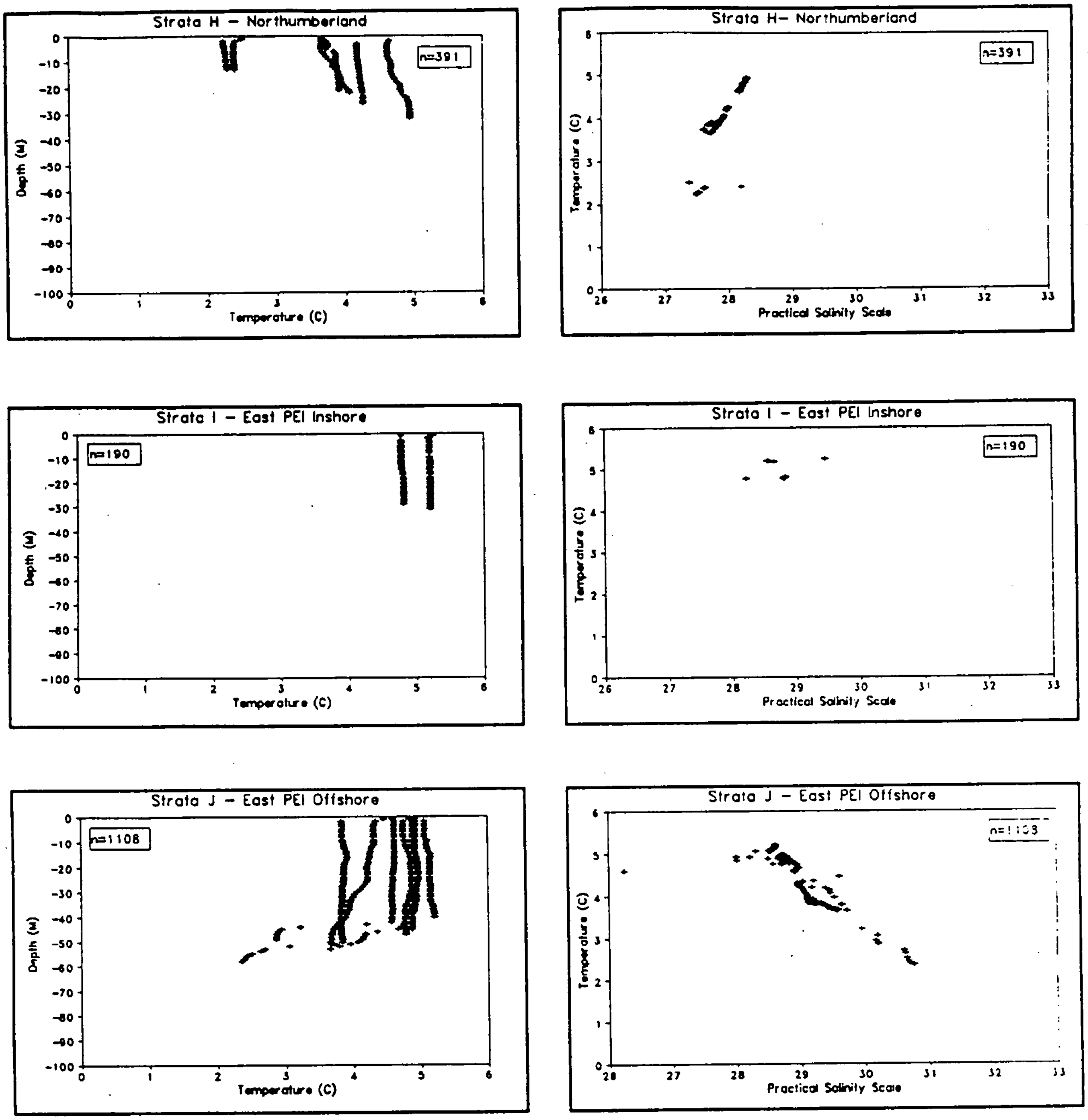
Fig. 8. SPRING-born juvenile herring percentage numbers at age comparison between Dec. juvenile and Oct. acoustic surveys.
Comparaison du pourcentage de nombre à l'âge de harengs juvéniles du PRINTEMPS provenant des relevés de juvéniles (déc) et acoustiques (oct).



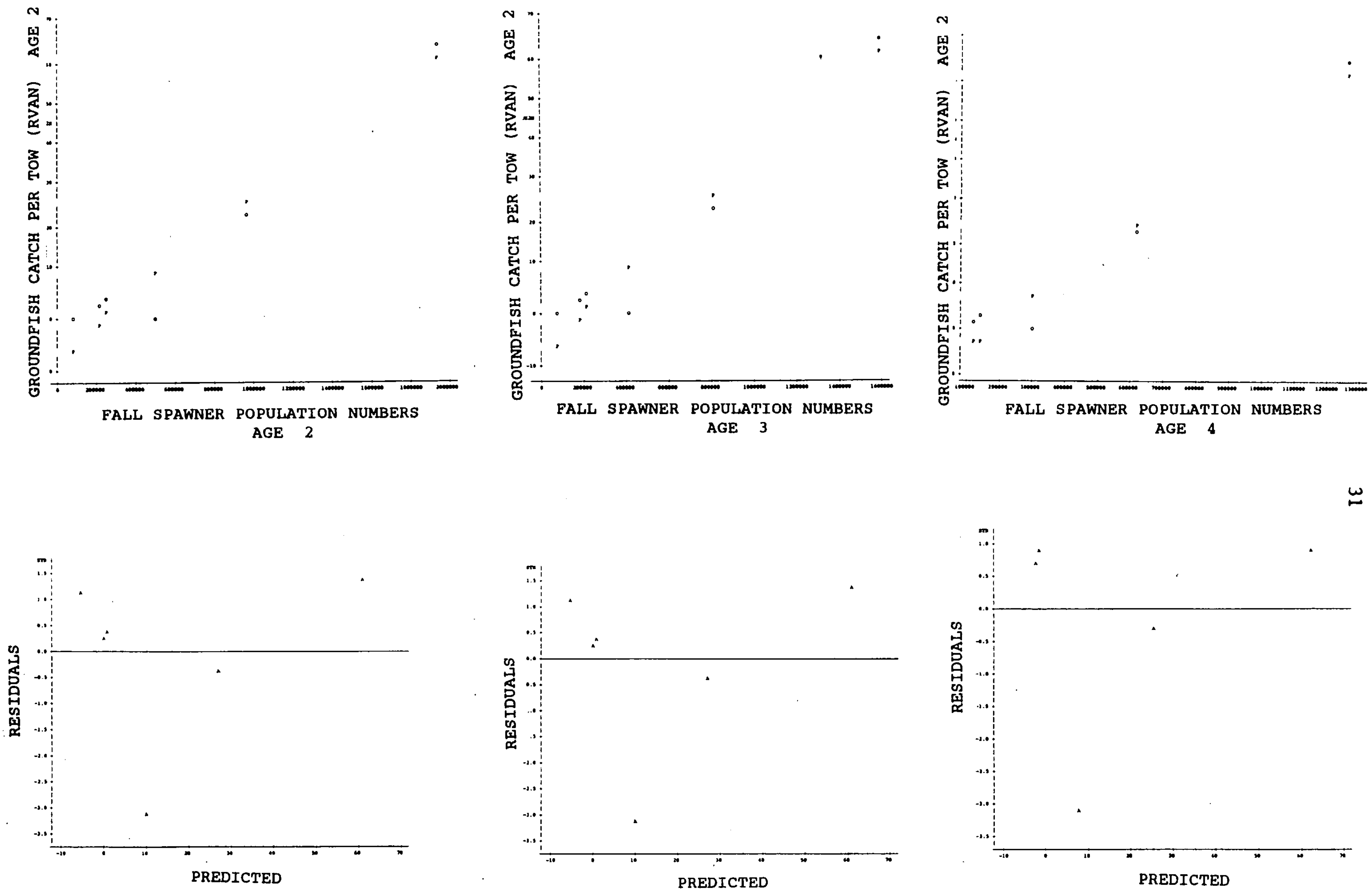
Appendix 1a. Combined depth, temperature and salinity data, Chaleur Bay strata, 1993.
Données de profondeur, température et salinité, strates de la baie des Chaleurs, 1993.



Appendix 1b. Combined 1993 depth, temperature and salinity, Miscou and Kouchibouguac strata.
Données de profondeur, température et salinité, strates de Miscou et Kouchibouguac, 1993.



Appendix 1c. Combined depth, temperature and salinity data, Northumberland Strait and east P.E.I. strata, 1993.
Données de profondeur, température et salinité, strates du détroit de Northumberland et de l'est de l'I.P.É., 1993.



Appendix 2. Scatter and residual plots of SAS GLM procedures on groundfish survey standardized catch-per-tow numbers (RVAN) compared to FALL spawner population numbers (ADAPT) (Table 7). Régressions linéaires (SAS GLM) entre les prises par trait standardisées provenant des relevés de poissons de fond et des nombre de géniteurs d'AUTOMNE issus de la matrice ADAPT (Tableau 7).