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Distribution of Groundfish and Herring during the 1994
Cabot Strait Survey

by

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¹La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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Abstract

A groundfish survey was conducted in Cabot Strait (NAFO Division 4T to Unit Area 4Vsb) area from January 13-25, 1994. Distribution of catches for the survey for 6 species (cod, redfish, white hake, American plaice, witch flounder and Greenland halibut) of groundfish and herring are presented along with information from a survey conducted by Québec Region at the same time. For cod, two sets yielded more than one tonne but the remainder of the catches were largely less than 100 kg. Length distribution on a set by set basis for cod indicate some gradient in size with larger fish found to the south and smaller cod to the north. The distribution according to depth for herring, cod, white hake and redfish shows that these species had somewhat distinct preferred depth ranges. Herring were found in waters less than 5° C, redfish and the flatfish species in waters slightly above 5° C. The largest catch of cod was made at the highest bottom temperature observed. Distribution of many of the groundfish species appears to be continuous between area 4T and 4Vn in winter. For white hake, witch flounder and to some extent Greenland halibut (turbot), the current management units do not account for the winter distribution.

Résumé

Un relevé sur les poissons de fond a été effectué dans le Déroit de Cabot (Division 4T jusqu'à l'unité 4Vsb de l'OPANO) du 13 au 25 janvier 1994. La distribution des captures réalisées lors du relevé pour 6 espèces de poissons de fond (morue, sébaste, merluche blanche, plie canadienne, plie grise et flétan du Groenland) ainsi que pour le hareng sont présentées avec les informations du relevé mené par la Région du Québec à la même période. Pour la morue, deux traits ont donnés des captures de plus d'une tonne mais les captures des autres traits ont été généralement de moins de 100 kg. Les fréquences de tailles par trait pour la morue semblaient indiquer que les petits poissons se retrouvent au nord alors que les poissons de taille supérieure se retrouvent au sud. Le hareng, la morue, la merluche blanche et le sébaste semblent occuper des zones de profondeurs différentes. Le hareng a été retrouvé dans des eaux de moins de 5° C alors que le sébaste et les espèces de poissons plats se retrouvaient à des eaux de température légèrement supérieures à 5° C. La plus importante prise de morue a été réalisée à la plus haute température au fond observée. La distribution de plusieurs espèces de poissons de fond semblent être continue entre le 4T et le 4Vn en hiver. Pour la merluche blanche, la plie grise et jusqu'à un certain degré, pour le flétan du Groenland, les unités de gestion actuelles ne tiennent pas compte de la distribution hivernale.

I - Introduction

During the public audiences of the Fisheries Resource Conservation Council (FRCC) held during the summer of 1993, several representations were made by industry groups for more research in the winter distribution of groundfish in Cabot Strait. The area, at the entrance of the Gulf of St. Lawrence, is thought to be the overwintering area for the two cod stocks of the Gulf of St. Lawrence and Gulf of St. Lawrence redfish, and industry expressed concern that significant mixing between the various stocks may occur in the area. As a result, a groundfish survey was conducted in Cabot Strait from January 13-25 on board the research vessel *CSS Alfred Needler*. The objectives of this survey were to determine the distribution and relative abundance of groundfish species in the Cabot Strait area (primarily area 4Vn) during winter and to collect specimens for analyses related to the question of stock mixing in the Cabot Strait and Sydney Bight areas. It was made clear that the survey could not be used to determine trends in abundance of the stock at this time for 2 reasons:

- a) it was to be a single point and it is not known whether catchability in winter is comparable to the September survey conducted in the southern Gulf of St. Lawrence.
- b) the area is thought to be a mixing zone and it would be difficult to assign stock origin to the catches.

During the same period, the Québec Region was conducting their annual winter cod survey in the northern Gulf and northern section of Cabot Strait (4R, 4S, 3Pn, 3Ps, 4Vn) and the two surveys were coordinated to ensure that the entire area would be covered. The report presents the results of the winter survey in Cabot Strait and includes combined distribution maps of the two surveys. In addition to the distribution information, length frequencies, biomass estimates and depth and temperature preferences were examined.

II- Methods

Station selection followed a stratified random design. Strata in the Cabot Strait area from the stratification scheme by Halliday and Koeller (1981) for the southern Gulf of St. Lawrence and the Scotian Shelf were first used (436, 437, 438, 439, 440, 441, 442, part of 444, 446 and 459 - Figure 1) . For the Laurentian Channel area extending to the Newfoundland coast, the strata described by Pitt et al. (1981) with the additional strata added by Québec Region were used (304, 305, 802, 803, 407, 810, 415 - Figure 2) (Morin and Bernier 1992). The selection of stations for each strata was proportional to area except in the strata of depths of 100-200 fathoms where the number of stations was 1.5 to twice that according to strata area because observer information indicated that cod concentrations are usually in these depths.

As this was the first survey in winter with large coverage in the southern Cabot Strait, it was expected that not all strata could be fished depending upon ice conditions, however, stations were selected in these areas so as to delimit the distributions in case concentrations would be found.

During the survey, standard groundfish protocols used in Gulf Region surveys (Hurlbut and Clay 1990) were used. At each location, a standard 30-minute tow using an Atlantic Western IIA trawl (with 19 mm liner in lengthening piece and codend) was conducted. At each station, depth profiles of conductivity and temperature were done. The survey started at the northern end of the survey area and proceeded in a southerly direction to try to minimize problems with ice.

Ice was encountered as the vessel steamed north between St. Paul's Island and Cape Breton. Because of mechanical problems with the research vessel, it was decided early in the survey to cover the southern section of Cabot Strait (primarily area 4Vn). Stations in NAFO Divisions 4R and 3Pn had originally been planned but had to be dropped because of a lack of time. A survey was being conducted by the survey vessel *Gadus Atlantica* in these areas at the same time. In addition, stations in less than 200 m in 4T (strata 436 and 437) could not be fished due to the presence of ice. The presence of ice caused some disruptions during the survey; by January 21 some ice had even drifted as far south as 46° 30' N (off Sydney Harbour).

Besides the scientific staff from the Gulf Fisheries Centre, 3 fishermen (G. Savoie, Association des pêcheurs professionnels acadiens; E. Walters, P.E.I. Fishermen Association; and D. Amadio, Maritime Fishermen Union) were on board during the survey and participated in sampling operations.

Abundance estimates, mean numbers per tow, length frequency distributions and age composition were calculated using the standard formulas for stratified random sampling. Box and whisker plots were used to examine the set by set length frequencies. Depth and temperature preferences were investigated using cumulative distributions.

III- Results

During the survey, 72 tows were attempted, of which 71 were successful. The location of the stations is shown in Figure 3. During the survey, air temperature ranged between -10 C and -25 C (without the windchill) which caused some malfunctions in equipment (CTD, winches, etc). Only one day was lost due to high winds.

1) Oceanographic information

Bottom temperature in waters less than 100 m averaged 0.9° C, 2.0° C at depths between 100 and 200 m and 5.3° C in waters deeper than 200 m. Surface temperatures were in the range of -1.0 to 0.5° C. Salinity at 10 m was approximately 31.6 and 34.9 on the bottom in the middle of the Laurentian Channel.

2) Catches by species

For each species presented, the figures show the results of this survey in the top panel. In the bottom panel, data from the northern Gulf groundfish survey conducted on the *Gadus Atlantica* (Jan 8-28) are added to the plot to assist in the interpretation of the results. No adjustments were made for potential differences in fishing power between the two vessels.

Catches of cod (kg/standard tow) are shown in Figure 4. The largest catches during the survey were made on the slope of the Laurentian Channel in depths of 200 to 300 m where bottom temperatures were above 5° C. A large catch of 1011 kg made south of St. Paul's Island was composed primarily of juvenile cod (mode at 29 cm) while the large catch (1785 kg) made off Misaine Bank was composed of larger fish (mode at 43 cm). No large concentration were detected in the middle of the Laurentian Channel or in shallow waters (<150 m) in 4Vn. There appear to be smaller concentrations of cod in the middle of the Channel than on both sides consistent with previous observations for the two stocks.

Redfish catches tended to be largest in the southern section of the survey area (Figure 5) however, when the entire Cabot Strait is examined, the concentrations in 3Pn and 3Ps appear to be larger assuming that the fishing power for redfish are not too different for the two vessels.

White hake catches were almost entirely made in areas 4Vn and 4Vs in waters deeper than 200 m (Figure 6). The pattern of catches in the northern area of Cabot Strait appear to be consistent. Small catches realized inside the Gulf of St. Lawrence and larger catches in 3Pn.

Catches of American plaice (Figure 7), Greenland halibut (turbot) (Figure 8) and witch flounder (Figure 9) were made throughout the area surveyed. For these species, these results suggest a continuous distribution from 4S and 4T into area 4Vn in winter. Greenland halibut were predominantly found in the northern section of the survey area. Except for American plaice, catches of flatfish were predominantly made in waters deeper than 200 m. Thirteen Atlantic halibut were caught but no winter flounder and only a few yellowtail flounder were captured.

Amongst other species caught, herring concentrations were detected south of St. Paul's Island and around Misaine Bank in waters deeper than 125 m (Figure 10). Juvenile and adult herring were present in the catches. Herring were not caught in the Laurentian Channel in either surveys. Two infrequently-seen species were also caught during the survey. A female Greenland shark (*Somniosus microcephalus*) measuring 4 m in length was caught and released alive at station 11. One specimen of the deepsea angler (*Ceratias holboelli*) was caught at station 2.

3) Biomass estimates and mean catch per tow

Biomass estimates for the species discussed above are presented in Table 1. Cod, plaice and redfish were the main species caught during the survey. The largest concentrations of cod were found in waters between 100 and 200 fathoms while redfish catches were predominantly in waters deeper than 200 fathoms. Mean numbers per tow are shown in Figure 11. Values from the September groundfish survey in the southern Gulf are presented for comparative purposes. The mean number per tow for cod are similar to that observed in September (values unadjusted for Needler-Hammond depth differences - see Nielsen 1994 for details), however the confidence intervals are considerably larger in the winter survey. Coefficient of variation of the mean number per tow is lower for the flatfish species.

4) Length frequency distributions and age composition

Length frequency distributions of four common species are presented in Figure 12. For cod, the length frequency from the groundfish survey conducted in September 1993 in the southern Gulf of St. Lawrence is included in the graph. The two modes observed in the January survey (28 and 43 cm) appear to correspond to the modes observed in the September survey, once growth is accounted for. The relative height of the modes is opposite to that observed in September. This could be caused by recruitment of the first mode observed in September to the survey gear. However, much of the estimate of cod less than 35 cm in the January survey originates from one large set made south of St. Paul's Island. It should also be noted that cod catches from the January survey likely include fish from neighbouring stocks (e.g. 4VsW). Length frequencies for cod were also examined on a set by set basis. Sets where >30 cod and > 60 cod were caught were examined in relation to latitude. The plots indicate (Figure 13) that the median size of cod was generally greater than 45 cm in the southern part of the survey area and less than 45 cm in more northerly areas.

To compare the age composition in the January survey to that of September, one year was subtracted from the age readings of the January 1994 survey. The age composition of cod in the January 1994 survey was dominated by fish of the 1991 year-class (Figure 14 - see age 2 for 1994 minus 1), due in large part to the single set mentioned above. The mode during the September survey was at age 5 (1988 year-class).

For redfish, two modes were observed in the length frequency distributions, one mode at 15-17 cm corresponding to the 1988-1989 year-class and another at around 30-31 cm corresponding to the year classes of the early 1980's (Figure 12). Length frequencies for white hake indicate the presence of modes in the pre-recruited length ranges.

5) Depth and Temperature Preferences

The plot of cumulative catches by depth indicate that the flatfish species are found in a broader range of depths than the other species examined (Figure 15). Plaice were found in relatively shallower waters than turbot and witch. The four other species examined tend to show a narrower range in their distribution. The depth ranges between the 25 and 75 percentiles were approximately 150 to 200 m for herring, 200 to 250 m for cod, 250 to 400 m for white hake and over 400 m for redfish. Flatfish species and redfish were almost entirely found in temperatures of 5.0 to 5.5°C (Figure 16). Herring were found in waters less than 5°C while cod and white hake catches were made in warmer waters.

IV- Discussion

When data from the groundfish survey conducted in Cabot Strait in January are compared to those from the Québec Region survey, the previous notion of two areas of winter concentration (3Pn - 4Vn) for cod appears to be supported. It should be noted that the concentration in 3Pn extends to the deep waters of 4Vn. However, information from the International Observer Program from Scotia-Fundy indicate that the cod fishery in 4Vn was predominantly conducted on the southern edge of the Laurentian Channel (Chouinard et al. 1991). If significant catches were made in 4Vn along the 3Pn border, in the winter redfish fishery for example, these data indicate that they may be of northern Gulf of St. Lawrence origin. The origin of the concentrations found on Misaine Bank are unclear. Otolith samples collected from this area could serve to determine the stock origin of these catches if methods (e.g. otolith elemental analysis) under development prove to be successful.

Distribution of catches for witch, white hake and Greenland halibut indicate that, in all likelihood, the existing management units (4T hake, 4RS witch, and 4RST Greenland halibut) do not account fully for the winter distribution and that these should be redefined. For white hake, catches inside the Gulf of St. Lawrence were minimal. The absence of white hake in the Gulf of St. Lawrence suggests that the stock found there in the summer migrates to Sydney Bight in the winter. This information is consistent with migration patterns to the slope of the Laurentian Channel suggested by earlier studies (Kohler 1971; Clay 1991). It does appear that the movement out of the Gulf of St. Lawrence in winter is not limited to a few species but widespread to several species.

The length frequency distribution for cod in the southern part of Cabot Strait is consistent with that from the southern Gulf in the summer. The mode observed in the length frequency distribution in January may indicate that the 1991 year-class is larger than previously observed. It is noted however that a large portion of this estimate for that size class originates from one large set made south of St. Paul's Island. The 1994 September groundfish survey should provide more reliable information on the size of this year-class. The length frequency distribution of redfish is similar to that reported in 1993 (Morin and Bernier 1993).

The coefficient of variation (CV) of mean numbers per tow for cod are significantly larger in the winter survey than in the summer survey conducted in the southern Gulf. This pattern is also observed for other cod stocks (e.g. 3Pn, 4RS) where surveys are conducted in summer and winter. Cod appear to be more aggregated in the winter than in the summer. The precision of the estimates could likely be improved by using allocation schemes that account for the patchiness in the distribution (Gagnon 1991).

However, for other species such as the flatfish, white hake and redfish, a winter survey (assuming that the migration is completed) may provide as precise estimates as those from the summer surveys. For example, the CV for white hake was marginally lower than in the summer survey. The distribution of catches of these species indicate an even distribution in the Laurentian Channel.

Depth and temperature preferences may indicate adaptations to reduce competition for food (cod - white hake - redfish) or to avoid areas where large fluctuations in temperatures will occur. The apparent depth separation in the distribution for herring, cod, white hake and redfish is interesting from an ecological perspective and should be investigated further. Although cod appear not to be feeding in winter (Schwalme, unpublished), they are found in higher temperatures than in the southern Gulf of St. Lawrence in September. Page et al. (1994) also examined the associations of cod with temperature and depth in the summer in 4Vn and found them in shallower (<150 m) than observed in the present study. Similarly, in the southern Gulf of St. Lawrence, Tremblay and Sinclair (1985), found that the mean depth of occurrence for cod was less than 100 m. They also found that the mean temperature of occurrence did not exceed 5° C in the ten years of data examined (1971-1981). In this survey, largest catches were made at temperatures above 5° C. In the case of herring, the distribution in colder waters may be an effective way to avoid potential predators such as cod or white hake.

V- Acknowledgements

Thanks to Alain Fréchet for providing the catch information of the Québec Region winter survey in the northern Gulf of St. Lawrence and to the staff of Groundfish Section, Gulf Region and fishermen who participated in the groundfish survey in relatively cold conditions.

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Table 1 : Biomass estimates (t) by stratum for various species during the Cabot Strait winter survey (N197)

NAFO	Strata	Depth	Cod	Plaice	Witch	Greenland halbut	W. hake	Redfish	Herring
		(fathoms)							
4S	803*	>200	4024	1992	888	986	0	1401	0
4T	438	51-100	68	29	0	9	3	55	4
	439	100-200	528	376	17	183	22	105	9
	407	>200	1808	1347	1570	1359	0	419	0
4Vn	442	<50	76	0	0	0	0	34	22
	441	51-100	2941	250	1	34	166	64	399
	440	100-200	8598	1058	591	192	751	917	817
	415	>200	2175	3116	3431	2955	3173	11753	30
4Vs	444 *	51-100	1643	3650	121	361	37	344	761
	446 *	100-200	12463	735	368	7	1281	330	4
Total			34324	12553	6987	6086	5433	15422	2046

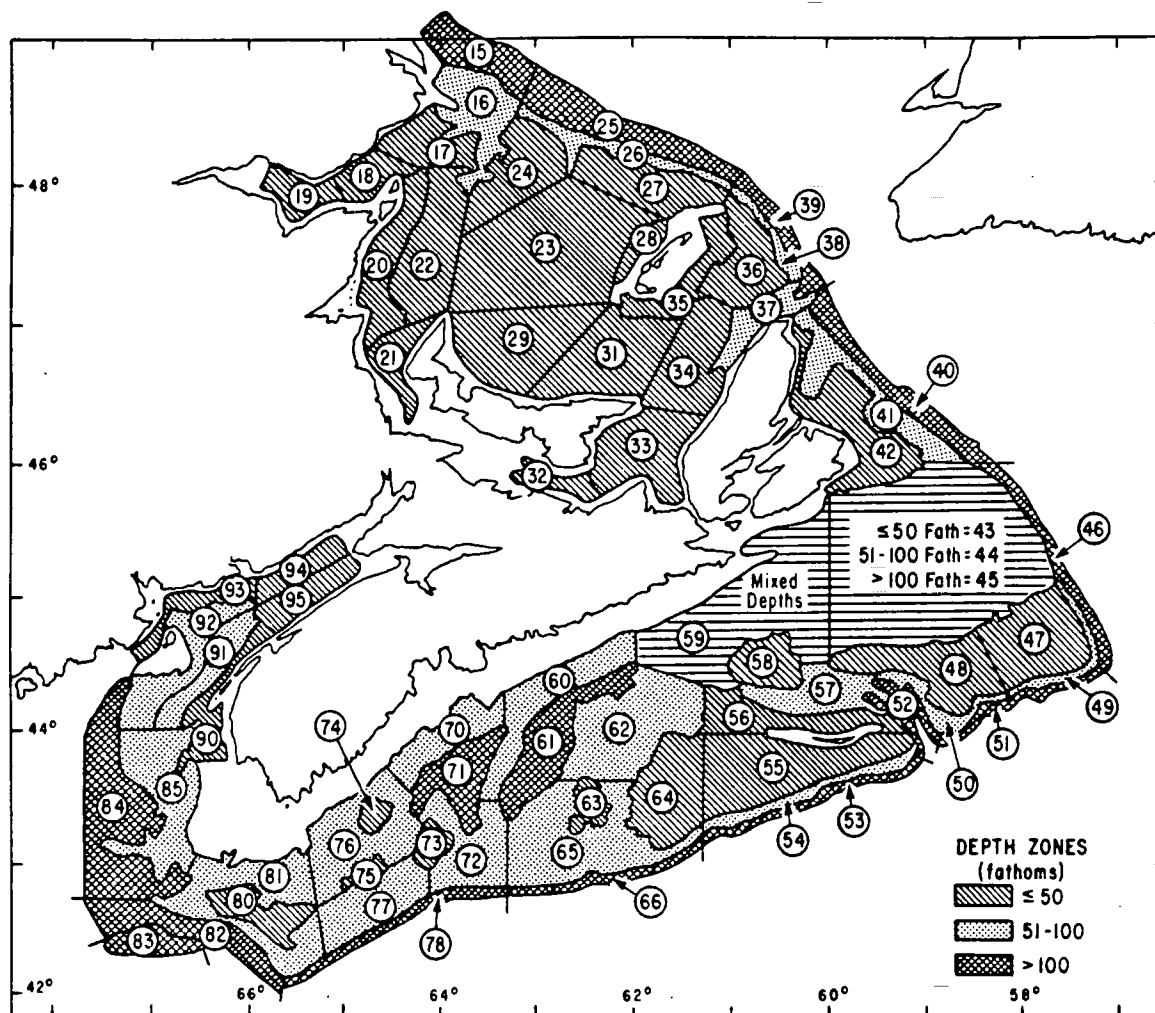


Figure 1. Stratification scheme for southern Gulf of St. Lawrence and Scotian Shelf groundfish surveys (from Halliday and Koeller 1981)

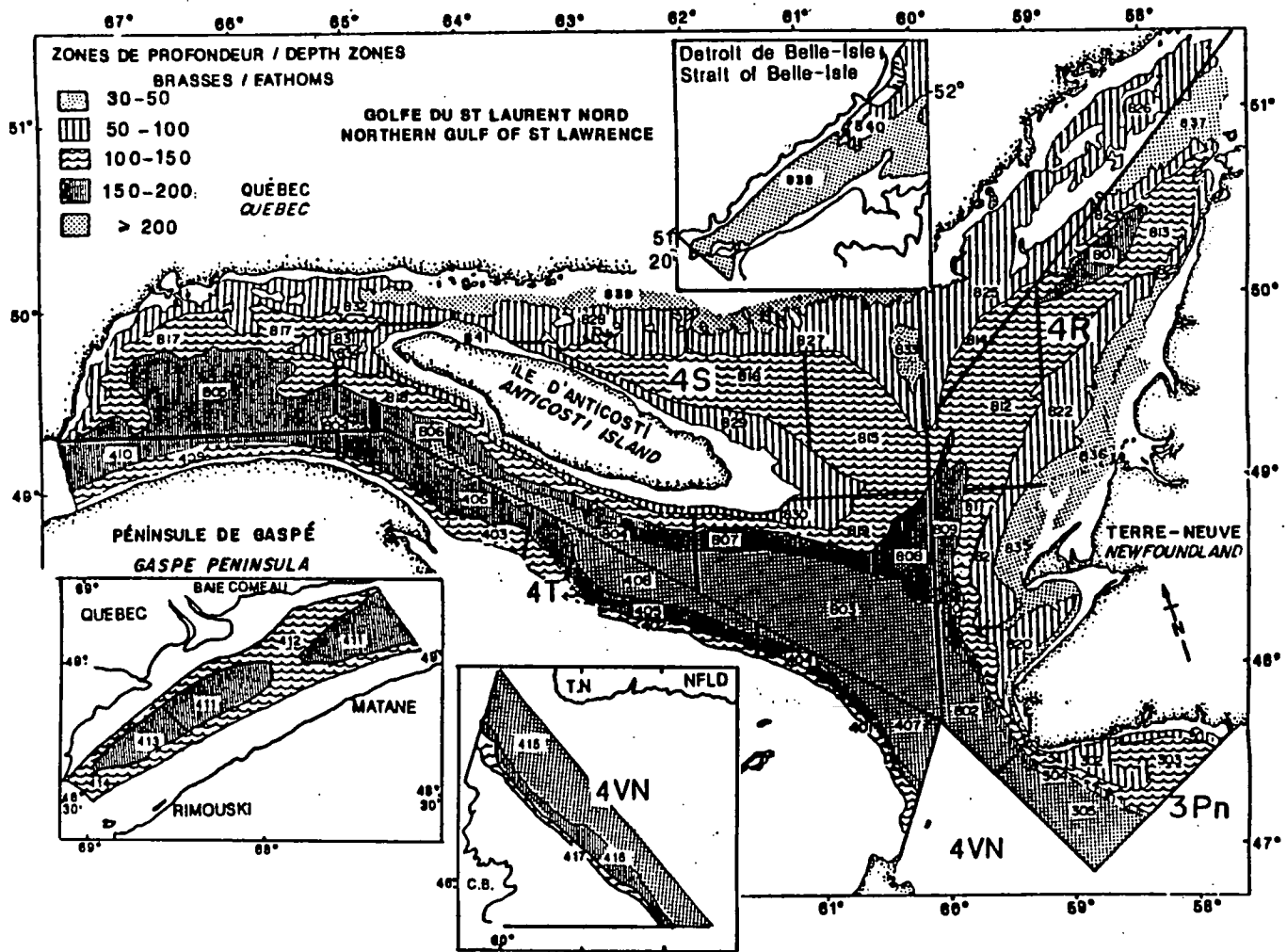


Figure 2 Stratification scheme for northern Gulf of St. Lawrence groundfish surveys (from Morin and Bernier 1993).

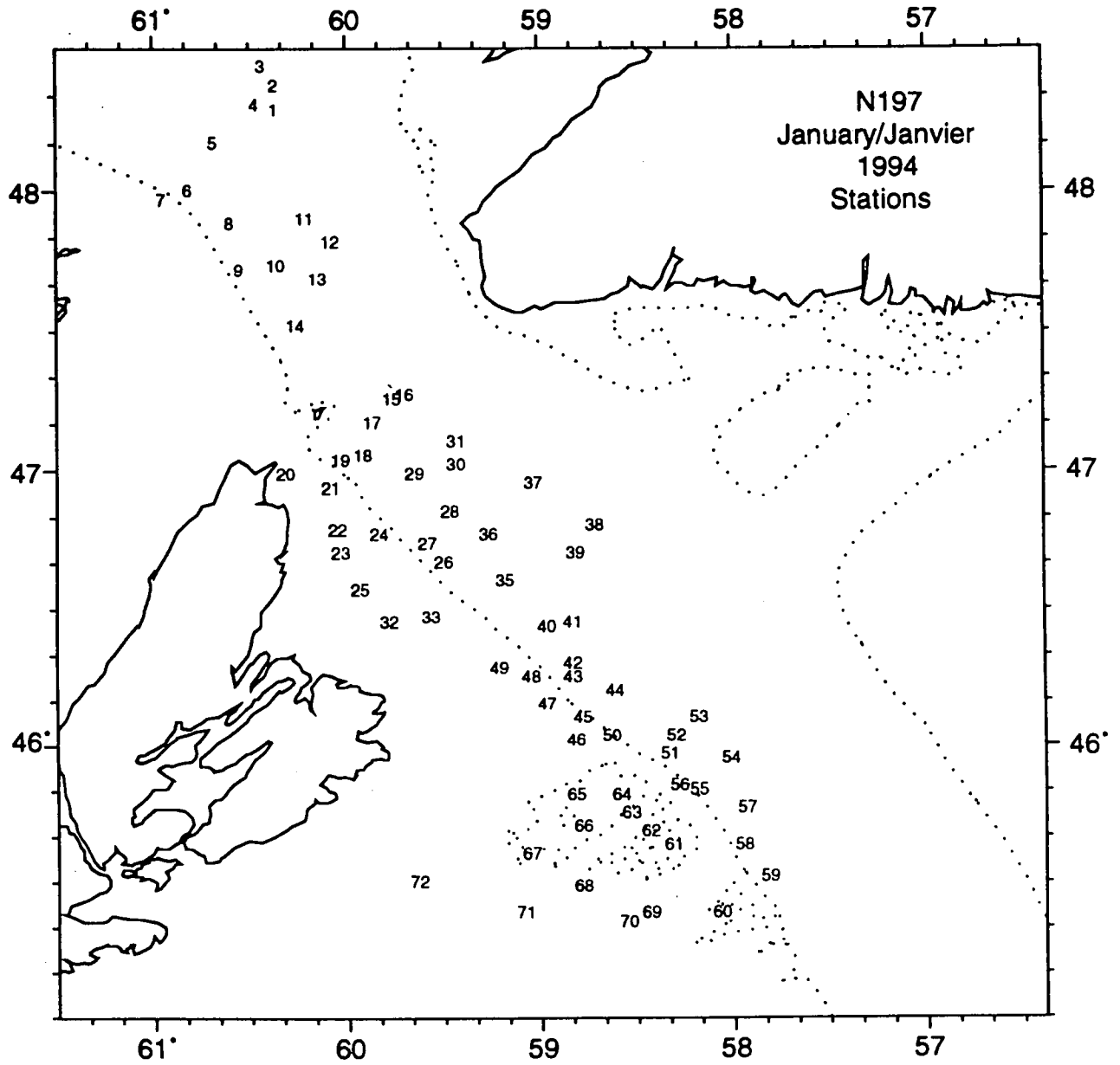


Figure 3. Location of the stations fished during the January 13-25, 1994 groundfish survey (N197) in Cabot Strait.

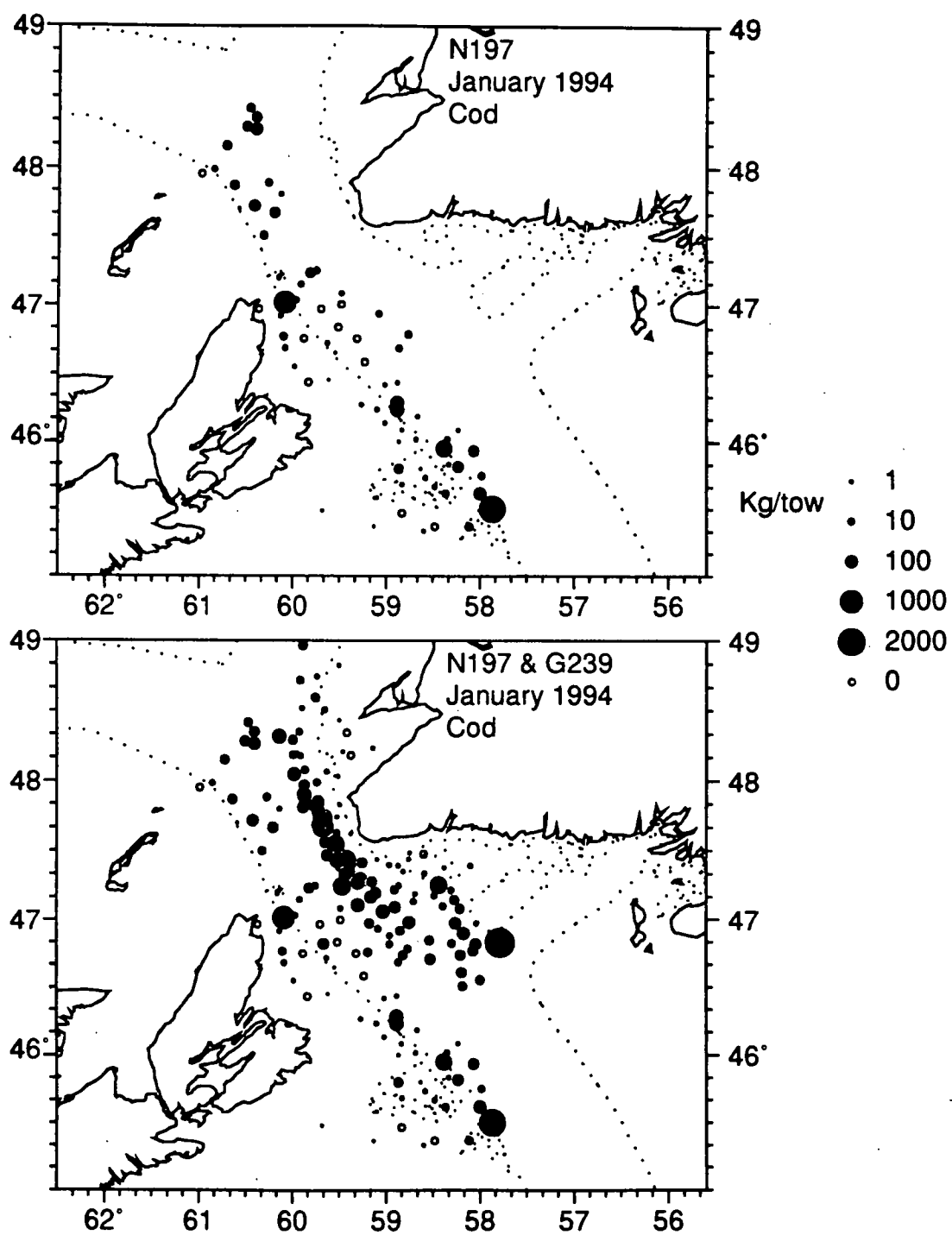


Figure 4. Catches of cod (kg/standard tow) during the January 13-25, 1994 groundfish survey (N197) in Cabot Strait (Bottom panel includes G239 survey results).

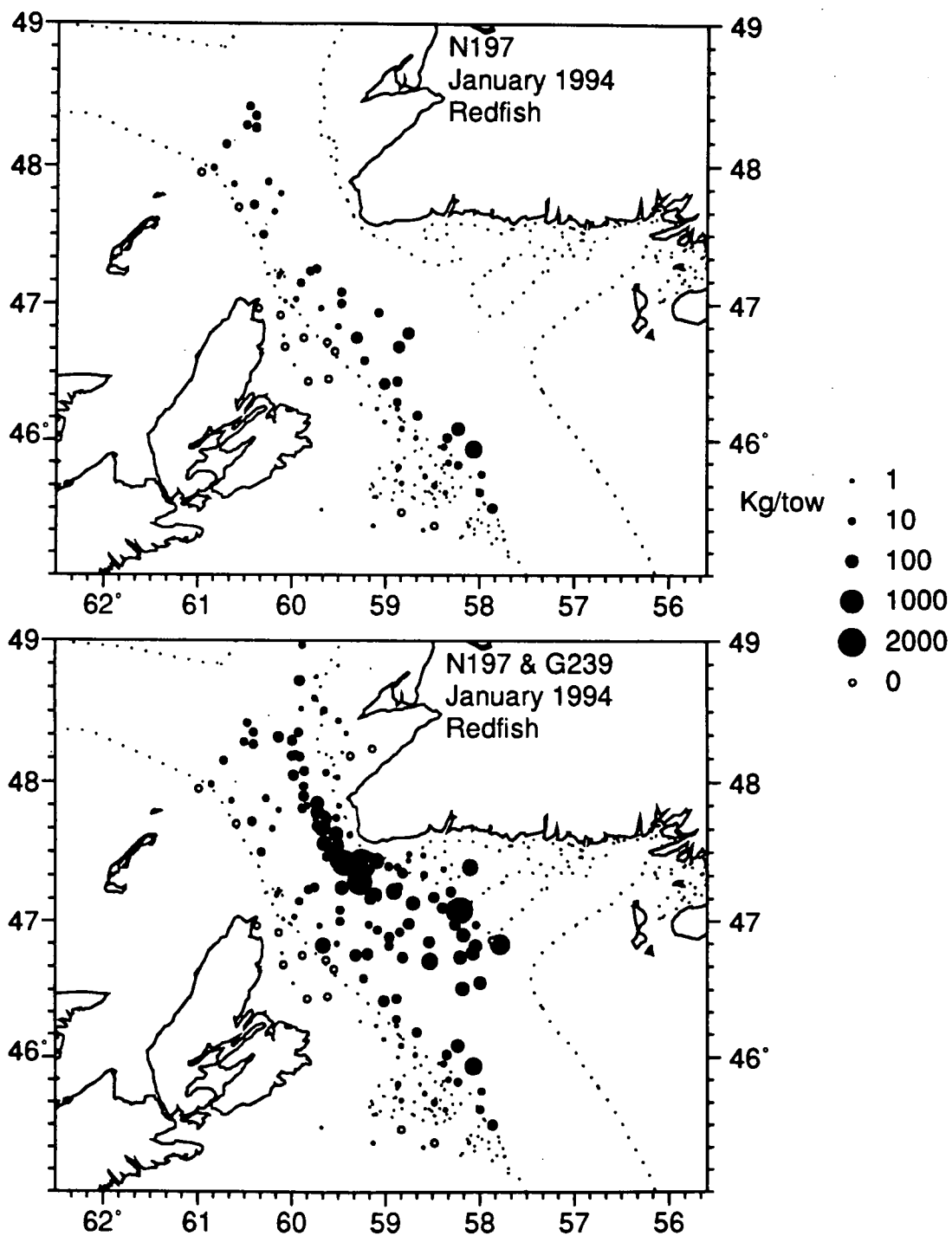


Figure 5. Catches of redfish (kg/standard tow) during the January 13-25, 1994 groundfish survey (N197) in Cabot Strait. (Bottom panel includes G239 survey results).

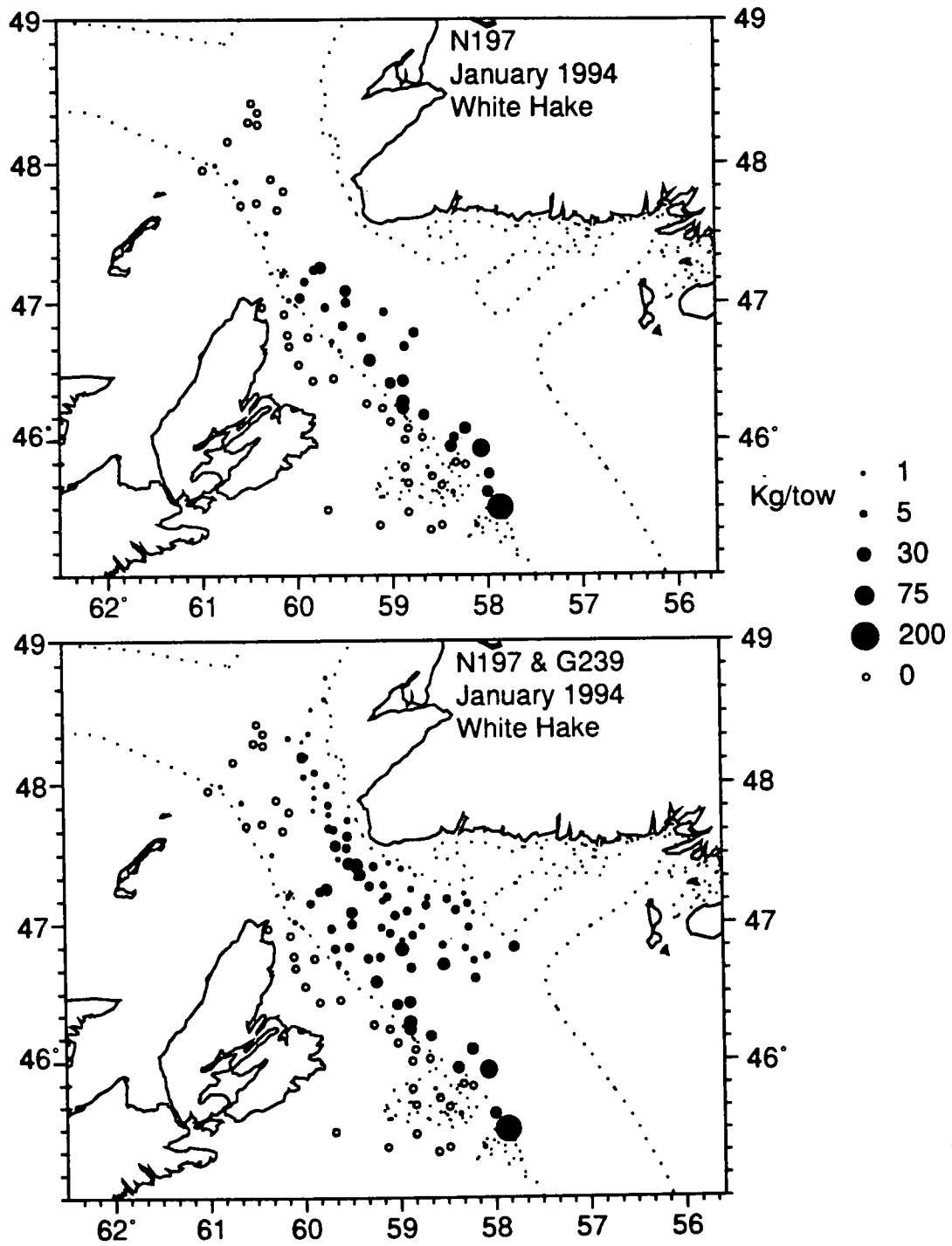


Figure 6. Catches of white hake (kg/standard tow) during the January 13-25, 1994 groundfish survey (N197) in Cabot Strait. (Bottom panel includes G239 survey results).

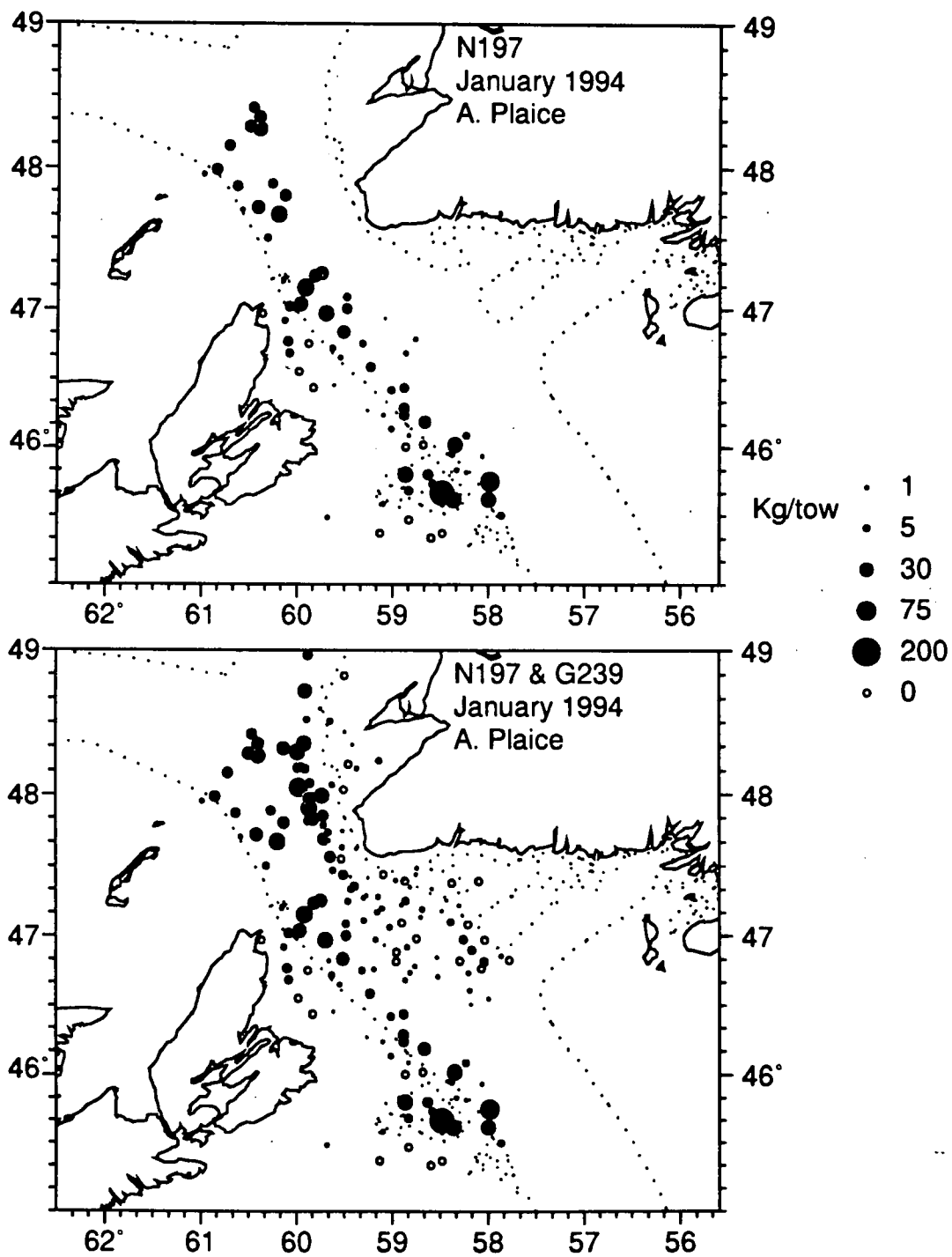


Figure 7.

Catches of American plaice (kg/standard tow) during the January 13-25, 1994 groundfish survey (N197) in Cabot Strait. (Bottom panel includes G239 survey results).

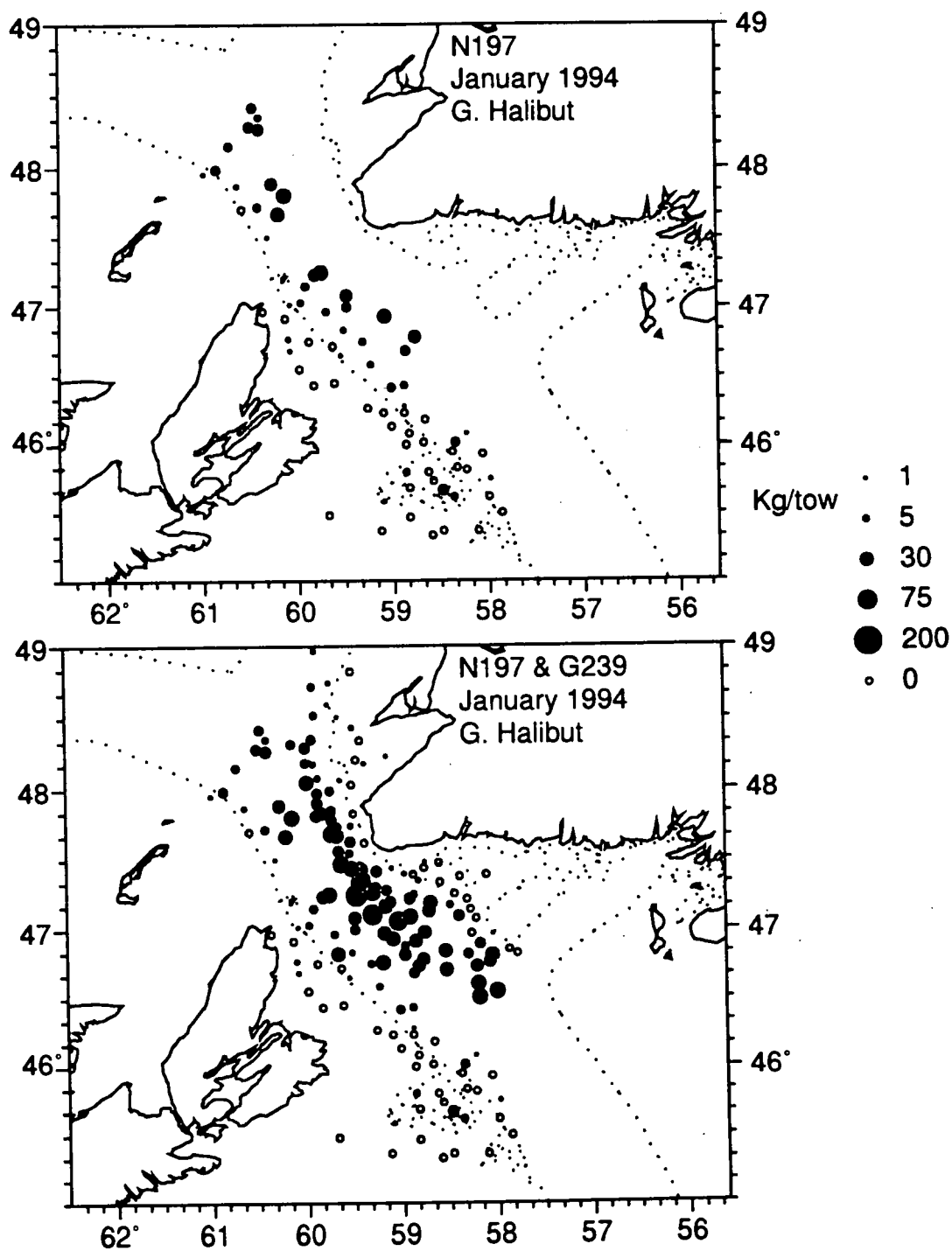


Figure 8. Catches of Greenland halibut (kg/standard tow) during the January 13-25, 1994 groundfish survey (N197) in Cabot Strait. (Bottom panel includes G239 survey results).

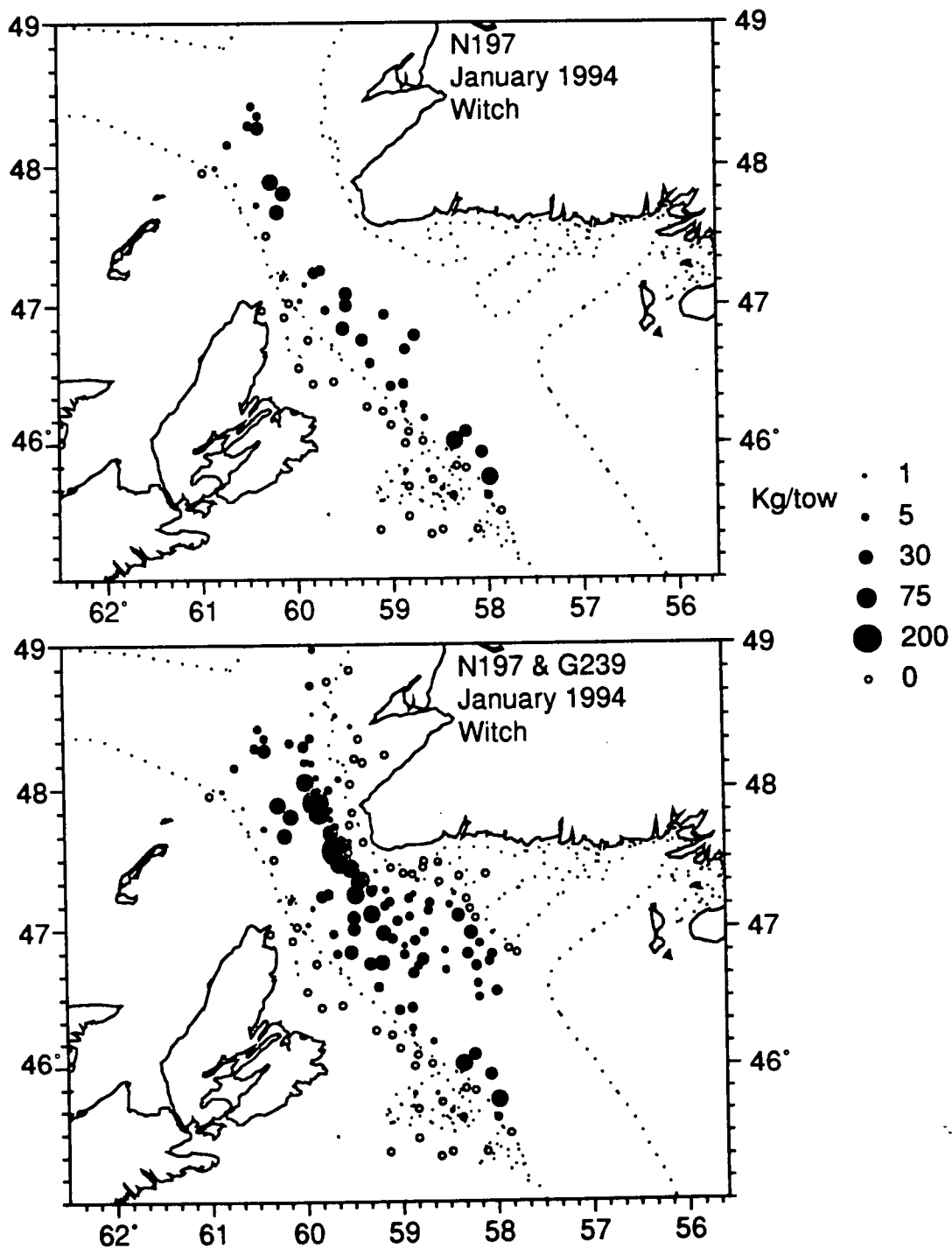


Figure 9.

Catches of witch flounder (kg/standard tow) during the January 13-25, 1994 groundfish survey (N197) in Cabot Strait. (Bottom panel includes G239 survey results).

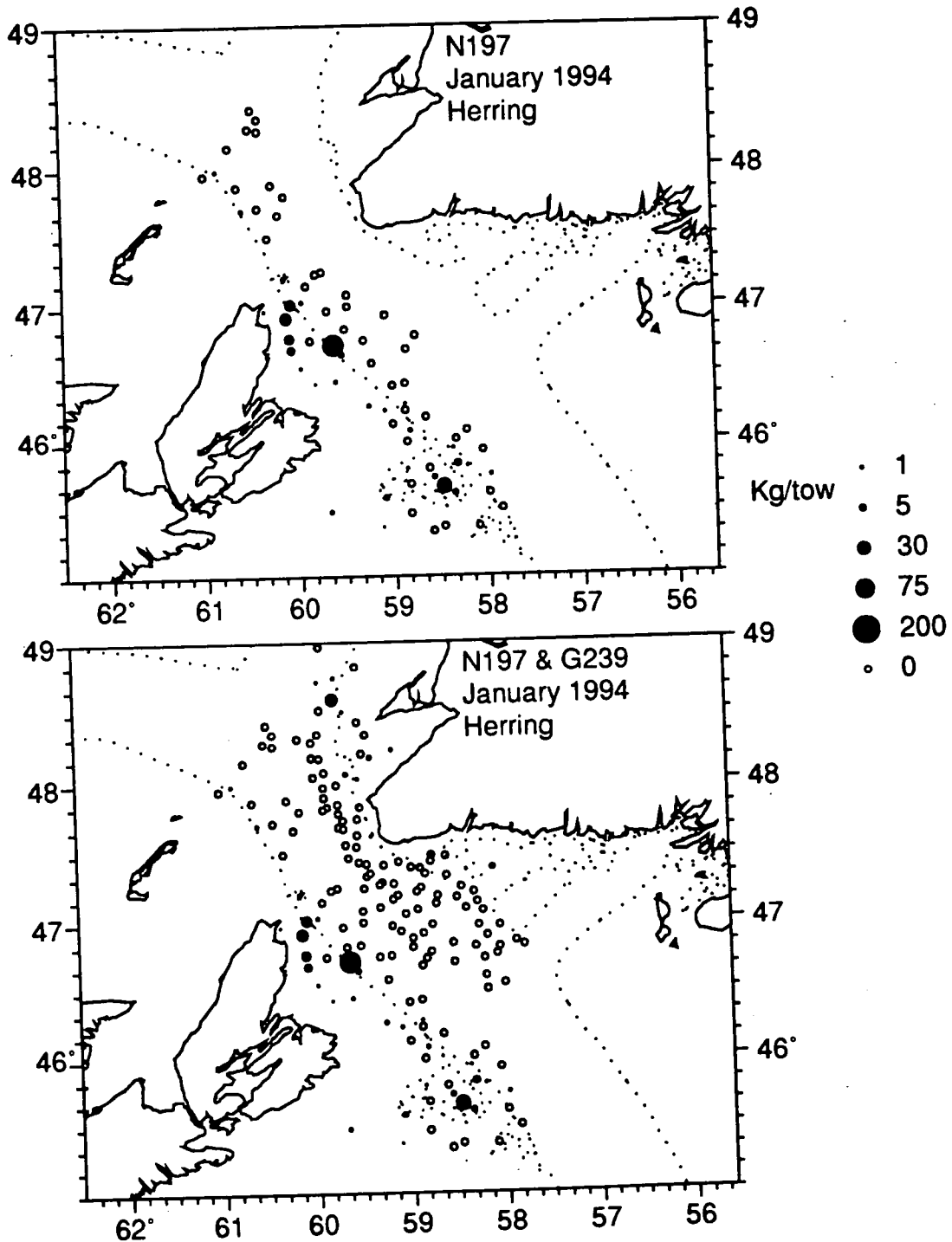


Figure 10. Catches of herring (kg/standard tow) during the January 13-25, 1994 groundfish survey (N197) in Cabot Strait. (Bottom panel includes G239 survey results).

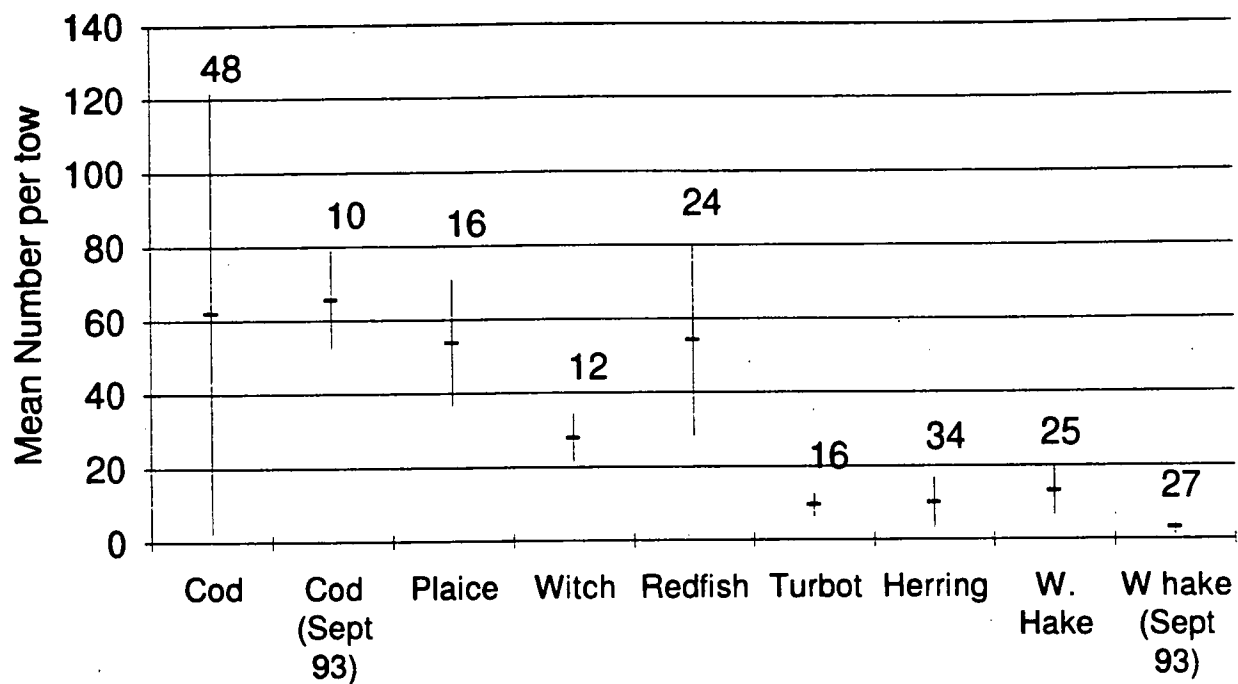


Figure 11. Mean numbers per tow (± 2 SD) for various species during the January groundfish survey in Cabot Strait. Values from the September 1993 survey for cod and white hake are provided for comparisons. Numbers correspond to coefficients of variation (%) of the estimates.

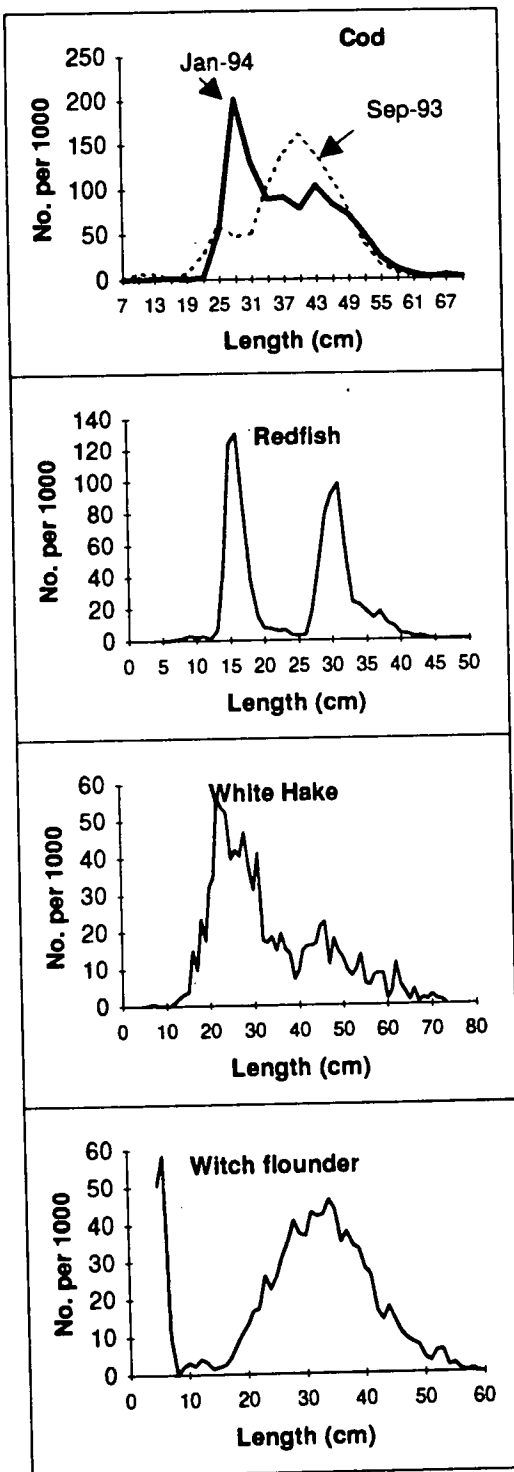


Figure 12. Length frequency distributions for cod, redfish, white hake and witch flounder during the 1994 groundfish survey in Cabot Strait.

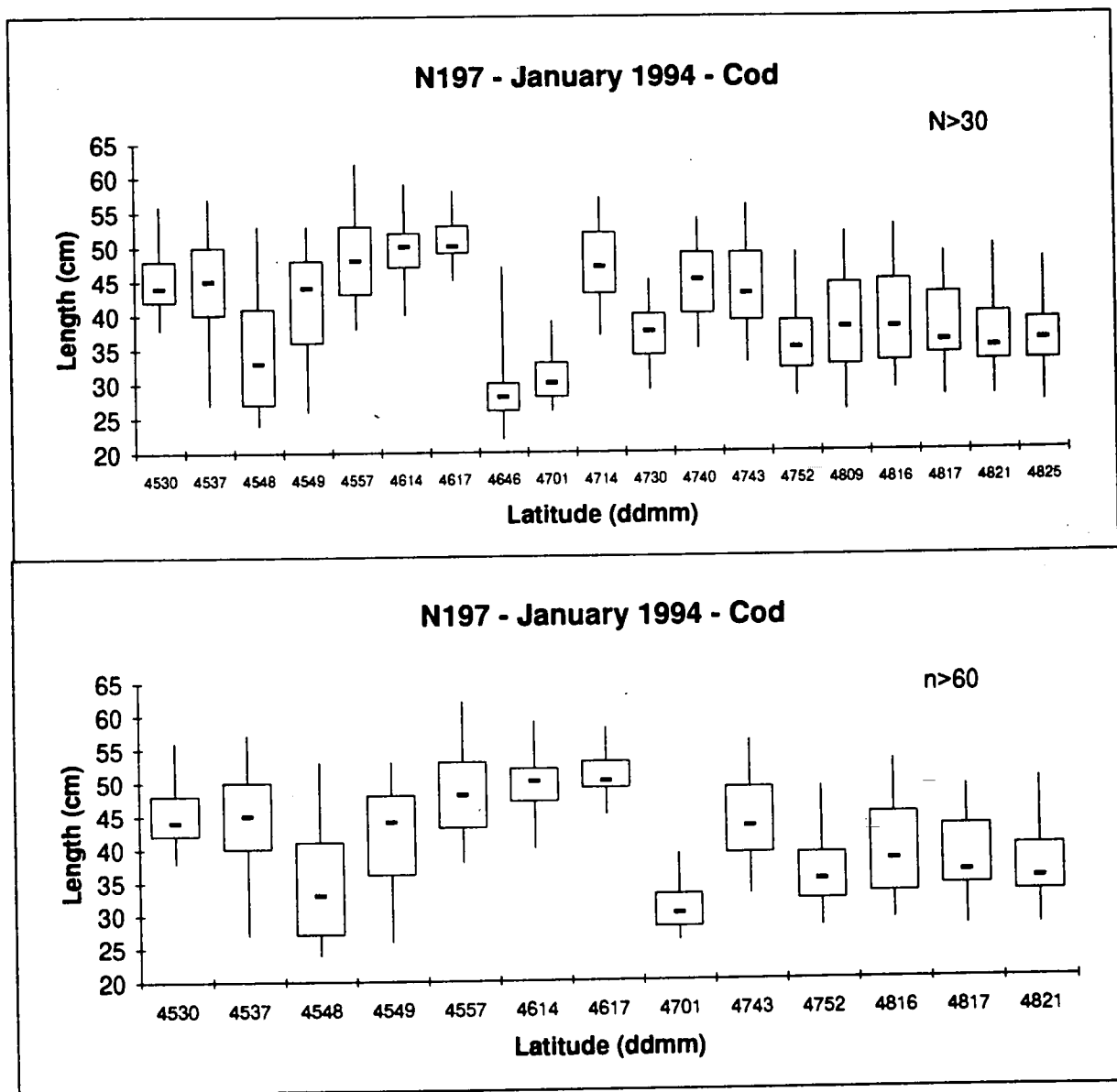


Figure 13. Set by set box and whisker plot from the most southerly to the most northerly station. The boxes delimit the 25 and 75 percentile, the end of the whiskers mark the 5 and 95 percentile and the dash is the median.

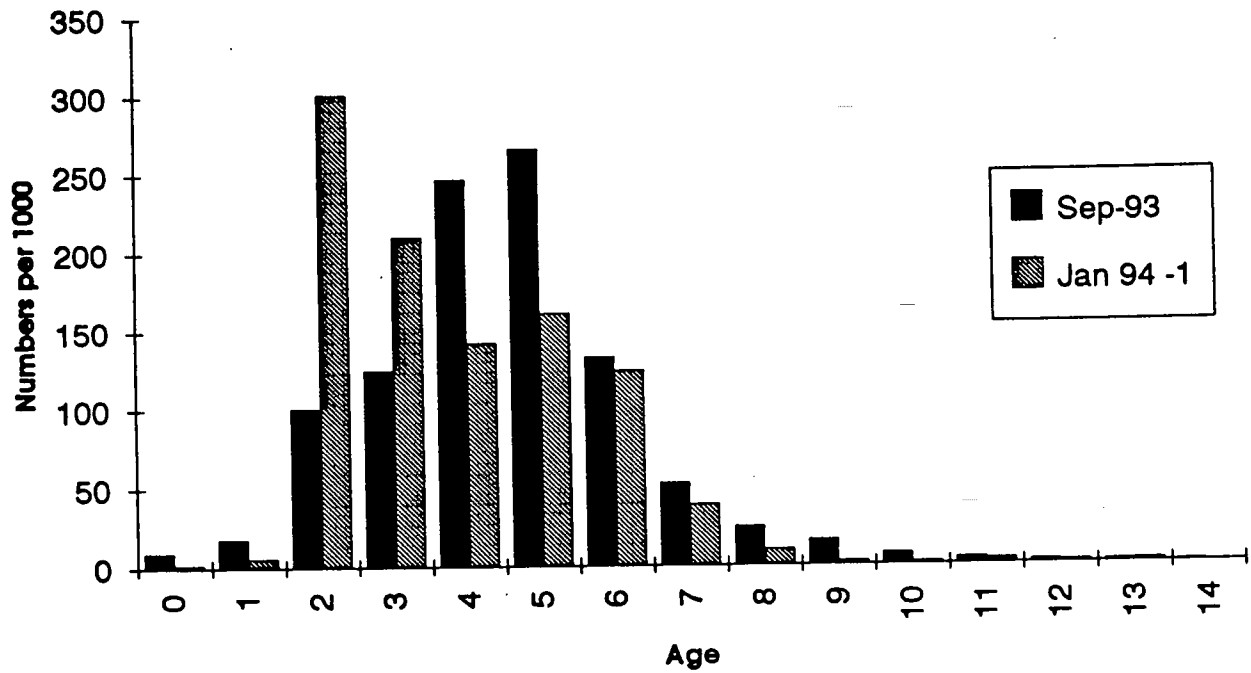


Figure 14. Age composition of cod caught during the 1994 January survey in Cabot Strait (hatched lines) and the September groundfish survey (solid). Note: one year was subtracted from the January 1994 ages for comparison purposes.

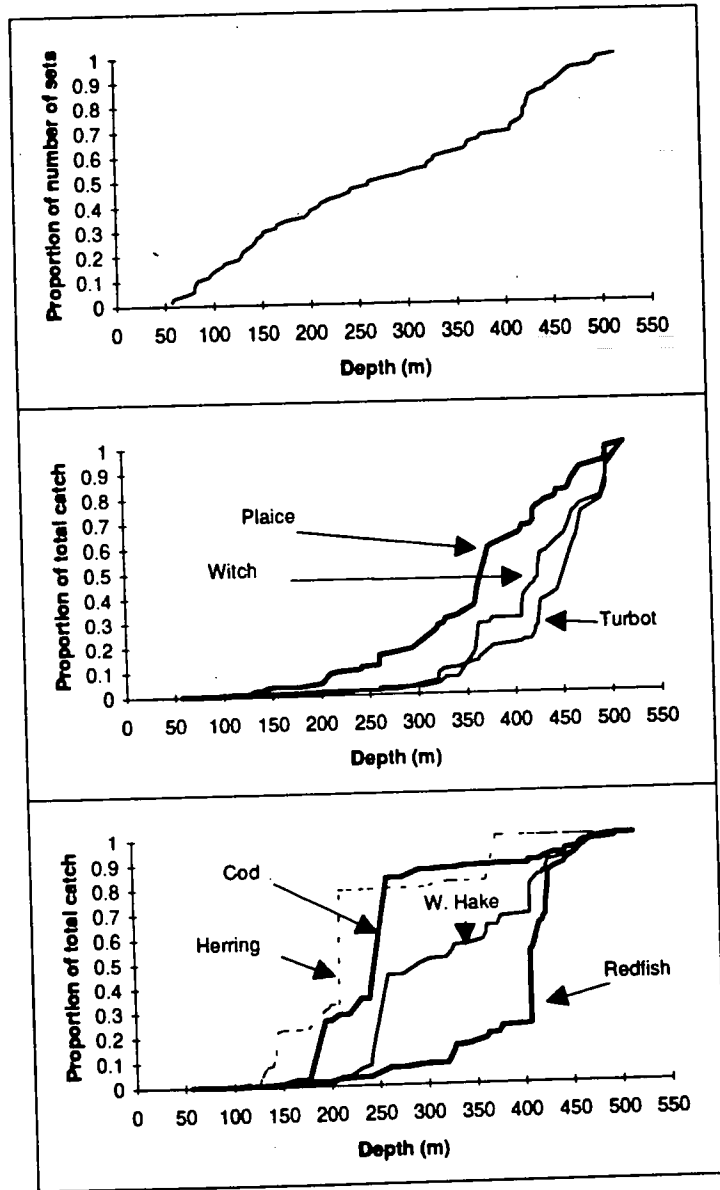


Figure 15. Cumulative distribution of sets (top panel), flatfish catches (mid-panel) and catches of cod, herring, redfish and white hake according to depth.

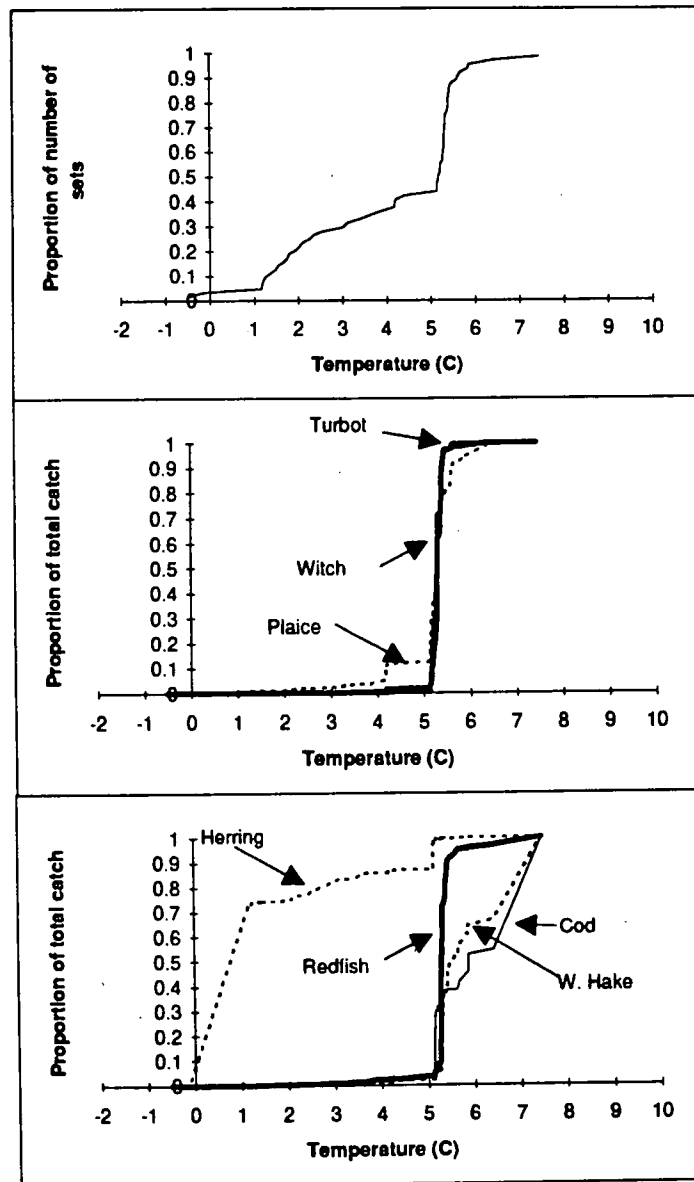


Figure 16. Cumulative distribution of sets (top panel), flatfish catches (mid-panel) and catches of cod, herring, redfish and white hake according to temperature.