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Overview of 1996 Hydrographic Sampling Effort and Near-Bottom Water Temperature and Salinity Conditions During the Canadian Spring Research Vessel Groundfish Surveys Conducted on the eastern Scotian Shelf (4VsW) and Georges Bank (5Z)

by

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Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

ABSTRACT

Hydrographic sampling effort and near-bottom water temperatures and salinities from the 1987-96 Canadian research vessel spring groundfish, stratified random, bottom-trawl surveys are summarised. The surveys cover NAFO divisions 4VsW and 5Z. The timing of the surveys continues to be variable between years. Therefore, caution must be exercised in interpreting the hydrographic trends as climatic variability in the hydrography. In 1996, the surveys were conducted early, relative to previous years in the series. No samples were taken in 4VsW strata 411. The temperatures and salinities sampled in 1996 were near or above those observed in previous surveys.

RÉSUMÉ

Ce rapport résume les résultats des échantillonnages hydrographiques et des mesures de la température et de la salinité près du fond effectués dans le cadre de relevés stratifiés aléatoires au chalut de fond de poissons de fond menés au printemps par des navires de recherche canadiens de 1987 à 1996. Les relevés, qui couvraient les divisions 4VsW et 5Z de l'OPANO, ont été effectués à différents moments d'une année à l'autre. Il faut donc se garder d'interpréter trop rapidement les tendances hydrographiques comme un reflet de la variabilité du climat. En 1996, les relevés ont eu lieu tôt par rapport à ceux des années antérieures et aucun échantillon n'a été prélevé dans la strate 411 de la division 4VsW. Les valeurs de température et de salinité mesurées en 1996 étaient proches de celles qu'on avait mesurées lors des relevés précédents ou les dépassaient.

INTRODUCTION

The Canadian Department of Fisheries and Oceans conducts bottom-trawl surveys on an annual basis within NAFO unit areas 4VsW and 5Z as part of its approach for developing scientific advice on the status of groundfish resources. Water temperatures and salinities are measured during these surveys and are summarised on an annual basis (e.g. Page, Losier and McRuer 1994, 1995, 1996).

The intent of each summary has been to briefly describe the extent and nature of the hydrographic sampling effort and conditions within recent resource assessment surveys and to place these within the context of entire survey time series. In so doing, it is hoped that trends and anomalies in conditions and sampling procedures may be identified. The impact of these conditions, on estimates of the status of fisheries resources, is explored on a stock by stock basis during the Maritime Regional Assessment Process.

In this overview, we present a summary of sampling effort and the resulting estimates of water temperatures and salinities during the 1986-96 spring surveys conducted within 4VW and 5Z. The focus is on the near-bottom conditions in 1996 and how these compare to conditions encountered throughout the history of the survey series. The conditions during the summer surveys in 4VWX are described in a companion manuscript Page, Losier and McRuer (1997).

MATERIALS and METHODS

Data Sources

The hydrographic data summarised in this report were collected during the 1986-96 research vessel, spring groundfish bottom-trawl surveys conducted on the eastern Scotian Shelf, NAFO unit area 4VsW (Fig. 1), and on Georges Bank, unit area 5Z (Fig. 2). The surveys were conducted by the Canadian Department of Fisheries and Oceans using a stratified random design. The 4VsW and 5Z survey domains were divided into 11 and 8 strata, respectively. The strata boundaries were defined, primarily, on the basis of bottom depth and, secondarily, on the distribution of groundfish, mainly cod and haddock (Doubleday 1981). In 1996, survey N238 covered the eastern Scotian Shelf (4VsW) and N237 covered Georges Bank (5Z).

From 1986 to 1989, depth profiles of temperature and salinity were taken at standard hydrographic sampling depths (0,10,20,30,50,75,100,150 and 200 meters) at less than 25% of the sampling stations (Page, Losier and McRuer 1995). Surface temperatures were recorded with bucket thermometers and sub-surface temperatures with reversing thermometers. Salinities of water samples, taken from the surface bucket or subsurface water bottles, were measured with a laboratory salinometer.

From 1990-96, depth profiles of water temperatures and salinities were measured with a Seabird Model (SBE) 19 or 25 internally recording conductivity, temperature and depth (CTD) profiler (Page et al. 1995). In the most recent years profiles were taken at about 90% of the trawl stations (Page, Losier and McRuer 1996). An SBE 25 was used in 1996.

The CTD deployment protocol was as follows. The CTD was attached to a hydrographic wire spooled on a variable speed hydraulic winch. Each CTD profile was taken by lowering the instrument to approximately 10m below the sea surface and allowing it to equilibrate with ambient conditions for about 5 minutes. At some stations a water bottle equipped with a reversing thermometer was triggered at the end of this period to obtain water samples and temperatures for later calibration of the CTD temperature and salinity sensors. After the equilibration period the instrument was raised to just below the sea surface and then lowered to within a few meters of the bottom at a drop rate of approximately 30-40 $m \cdot min^{-1}$. If calibration samples were not taken at the initial equilibration depth the instrument was raised approximately 5-10m off the bottom, and a water bottle equipped with a reversing thermometer was triggered at the end of a 5 minute waiting period to obtain water samples and temperatures for later calibration of the CTD. The CTD was then recovered and stored on deck. Sea surface temperatures were also measured at each station with an electronic thermometer. Subsequent to the survey a laboratory salinometer was used to obtain salinities from the water samples. When a CTD was not available for use, due to malfunction or extreme weather, standard hydrographic profiles (described above) were taken with reversing thermometers attached to water bottles and/or an XBT profile was taken.

Data Analyses

All CTD temperature and salinity profiles have been edited using a combination of quantitative and visual techniques, including range checks, despiking routines and density inversion algorithms. In most cases, only the down profiles are used. An up profile may be used in rare occasions if the editing indicates it is more reliable than the down profile.

The edited data is stored in GSHYD, the hydrographic component of the Maritimes Region Scotian Shelf-Gulf of Maine-Bay of Fundy groundfish ORACLE database. In this database, all measurements made within 20 meters of the bottom are designated as bottom samples. These are referred to as "near-bottom" conditions in this report.

RESULTS

4VsW Sampling

Mean and 1996

In 1996, sampling was conducted from 3-10 March (consecutive days 63-70) during survey N238. CTD profiles were obtained from all strata except 411 (Fig. 1). As in previous years, sampling stations within some strata (e.g. 408-10) were not widely distributed throughout the strata.

The maximum CTD profile depths in the survey series ranged from <50m to >300m. The distribution of near-bottom depths varied between strata (Fig. 1 & 3). In 1996, the depths sampled were within previous limits. In several of the strata (e.g. 401, 405-8, 410) the sampling tended to be restricted to a narrower and shallower depth range than in previous years.

Historical Context: Temporal Trends

Historically, the surveys have been conducted between 27 February (consecutive day 58) and 29 March (consecutive day 88; Fig. 4). A strong trend toward earlier sampling dates exists. Sampling in 1994 and 1995 was 26 days earlier than in 1987. The sampling dates in 1996, 3-10 March, were some of the earliest in the series.

4VsW Near-Bottom Temperatures

Means and 1996

The overall range of near-bottom temperatures within the survey domain, and during the complete survey time period (1986-96), is approximately -1°C to 12°C (Fig. 5). The range of temperatures differs considerably between strata. In some strata the range is only a few degrees, whereas in others, it is >10°C. The near-bottom temperatures in 1996 ranged from 0.8 to 9.1°C. These were often above the 1986-95 strata medians but within previously observed limits (Fig. 5).

The geographic distribution of the 1996 temperatures (Fig. 7) is similar to that of the long-term (1987-90) strata mean temperatures (Fig. 8). The lowest temperatures (<2°C) occurred on the eastern Scotian Shelf and the highest temperatures (>8°C) occurred on the central shelf. Temperatures throughout the remainder of the survey domain were between 2° and 8°C.

The strata mean temperatures were near or above the 1987-90 means (Fig.9). This is also indicated by the cumulative frequency distributions of the area unweighted temperatures (Fig. 13).

Historical Context: Temporal Patterns

The time series of area unweighted temperature percentiles is shown in Fig. 15. With the exception of 1994, the temperatures have remained relatively stable over the 1987-96 period. In 1996 the distribution of temperatures is skewed toward higher temperatures that in 1995 and most other years.

A somewhat different time trend is indicated by the time series of stratified mean temperatures (Fig. 17). In these series, the temperatures tend to increase marginally in both 4Vs and 4W since 1990-91.

The strata specific time series of temperatures are shown in Fig. 18. The pattern of increasing temperatures indicated by the stratified means is clearly evident in strata 401, 408-9. There is little trend in the temperatures from several of the other strata.

4VsW Near-Bottom Salinities

Means and 1996

The overall range of near-bottom salinities within the survey domain, and during the complete survey time period (1986-96), is approximately 31.5 to 35psu (Fig 6). With the exception of strata 401, where the range is reduced, the range is somewhat similar between strata.

The geographic distribution of the 1996 salinities (Fig. 7,10) is similar to that of the long-term (1987-90) strata mean salinities (Fig. 8). The lowest salinities occurred on the eastern Scotian Shelf and the highest occurred on the central shelf and shelf edge regions. The 1996 strata mean salinities were near or above the 1987-90 means (Fig.8). The cumulative frequency distributions of the area unweighted salinities (Fig.14) indicate a similar general pattern. However, they also suggest the occurrence of 33-34 psu water was relatively low in 1996.

Historical Context: Temporal Patterns

The time series of area unweighted salinity percentiles is shown in Fig.16. The salinities have remained relatively stable over the 1987-96 period. The time trend in the time series of stratified mean salinities (Fig. 17) indicates relatively constant conditions in 4W and a slight decrease in salinities during the early 1990's in 4Vs. Time trends are not evident in most of the strata specific time series (Fig. 19).

5Z Sampling

Mean and 1996

In 1996, sampling was conducted from 20-29 February (consecutive days 51-60) during survey N237. CTD profiles were obtained from all strata (Fig. 2). As in previous years, sampling stations within some strata (e.g. 5Z7-8) were not widely distributed throughout the strata.

The maximum CTD sample depths in the survey series ranged from <50m to >200m. The distribution of near-bottom depths varied between strata (Fig. 3). In 1996, the depths sampled were, for the most part, consistent with previous years.

Historical Context: Temporal Trends

The surveys have been conducted between from 13 February to 18 March (consecutive days 44-77, Fig. 4). As in the 4VsW surveys the timing of the surveys has varied considerably between years. In 1991, sampling began on 13 Feb, whereas in 1987 it began on 10 March, 25 days earlier than in 1987. The sampling dates in 1996 were near the middle of the previous dates in the series.

5Z Near-Bottom Temperatures

Means and 1996

The overall range of near-bottom temperatures within the survey domain, and during the complete survey time period (1987-96), is approximately 3°C to 14°C (Fig. 5). The range of temperatures differs considerably between strata. In some strata the range is only a few degrees, whereas in others, it is >10°C. The near-bottom temperatures in 1996 ranged from 3.6 to 8.8°C. These were mainly near the middle of the previously observed limits (Fig. 5).

The geographic distribution of the 1996 temperatures (Fig. 7,11) is similar to that of the long-term (1987-90) strata mean temperatures (Fig.8). The lowest temperatures (<6°C) occurred on top of Georges Bank and the highest temperatures occurred along the bank edge in the deeper water. With the exception of strata 5Z8, the strata mean temperatures were near the 1987-90 means (Fig. 11). However, the mean for stratum 5Z8 is based on only one observation. The cumulative frequency distributions of the area unweighted temperatures (Fig. 13) also indicates that the temperatures sampled in 1996 were near normal.

Historical Context: Temporal Patterns

The time series of area unweighted temperature percentiles is shown in Fig. 15. The temperatures rose from 1987-91, decreased until 1993, increased in 1994 and have remained relatively constant since then. In 1996, the distribution of temperatures is near the long-term normal. The time series of stratified mean temperatures (Fig. 17) shows interannual variability, but relatively little trend. Several of the strata specific time series of temperatures (Fig. 18) show the decrease in area unweighted temperature during the early 1990's.

5Z Near-Bottom Salinities

Means and 1996

The overall range of near-bottom salinities within the survey domain, and during the complete survey time period (1986-96), is approximately 31.0 to 35.5psu (Fig. 6). The range is somewhat less in the strata on top of the bank (5Z2-7). The bank edge strata have the largest ranges (5Z1, 5Z8).

The geographic distribution of the 1996 salinities (Fig. 7,12) is similar to that of the long-term (1987-90) strata mean salinities (Fig. 8). The lowest salinities occurred on top of Georges Bank and the highest occurred along the bank edges. The 1996 strata mean salinities were near or below the 1987-90 means (Fig.12). This is also indicated by the cumulative frequency distributions of the area unweighted salinities (Fig. 14). The negative anomaly, in strata 5Z8, is based on only one observation. The 1996 intrusion of low salinity water onto the northeast peak may be indicative of a cross-over of Scotian Shelf water from the Browns bank area (Fig. 7).

Historical Context: Temporal Patterns

The time series of area unweighted salinity percentiles is shown in Fig. 16. The median salinities have undulated over the 1987-96 period, with maxima in 1990 and 1995 and minima in 1988 and 1993. The time trend in the time series of stratified mean salinities (Fig. 17) indicates similar fluctuations, although the minima and maxima occur in 1988, 1992 and 1990, 1995 respectively. These trends are also evident in several of the strata specific time series of salinities (Fig. 19).

DISCUSSION

The Canadian bottom-trawl research vessel spring survey program began relatively recently, in 1986. Unfortunately, the timing of the surveys has been very variable. The start date of the surveys has differed by approximately 3 weeks. Because of this and the stratified random allocation of set locations, the patterns and trends in temperatures and salinities observed during the surveys cannot be considered as reliable indicators of climate change. However, they are indicators of the trends in the hydrographic conditions that were sampled. As such, they may be related to inter-annual variations in estimates of fish distribution and abundance. This possibility has been suggested by several authors (e.g. Pinhorn and Halliday 1985). Some recent examinations of relationships include Page et al. (1994) and Smith et al. (1994) who have examined the associations between cod and haddock abundance and sampling depth, water temperature and salinity. Smith, Perry and Fanning (1991) have shown that during the 1979 to 1988 period inter-annual changes in the proportion of 4VW bottom waters identified as Cold Intermediate Layer (CIL) water coincide with changes in the estimated abundance of 4VsW cod (Smith et al. 1991). When the proportion of the CIL is large (small), and hence, the temperatures are relatively cool (warm), the estimate of cod abundance is relatively low (high). The suggested trends in temperatures may, therefore, be associated with changes in the distribution and abundance of cod within at least the 4VW area. This connection has been explored more fully by Smith and Page (1996). The connection with haddock has been explored by Smith and Page (1994). The possibility of a relationship between temperature and herring was explored by Stephenson et al. 1995.

Acknowledgements

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REFERENCES CITED

DOUBLEDAY, W.G. (ed.) 1981. Manual on groundfish surveys in the Northwest Atlantic. NAFO Scientific Council Studies, No. 2, 55p.

PAGE, F.H., R. J. LOSIER and J. McRUER. 1996. Overview of near-bottom water temperature and salinity conditions observed during the groundfish research vessel surveys conducted within the Scotia-Fundy Region, NAFO areas 4VWX and 5Z. DFO Atlantic Fisheries Research Document 96/20.

PAGE, F.H., R. J. LOSIER and J. McRUER. 1995. Overview of Temperature and Salinity Conditions within NAFO areas 4VWX and 5Z, during Canadian 1994 Groundfish Research Vessel Surveys. DFO Atlantic Fisheries Research Document 95/138, 63p.

PAGE, F.H., R. J. LOSIER and J. McRUER. 1994. Overview of Temperature and Salinity Conditions within NAFO areas 4VWX and 5Z, during Canadian 1993 Groundfish Research Vessel Surveys. DFO Atlantic Fisheries Research Document 94/94, 53p

PAGE, F.H., R. J. LOSIER, S. SMITH and K. HATT 1994. Associations between cod and temperature, salinity and depth within the Canadian groundfish bottom trawl surveys (1970-93) conducted within NAFO divisions 4VWX and 5Z. Can. Tech. Rept. Fish. Aquat. Sci. 1958: vii + 160 p.

PINHORN, A.T. and R.G. HALLIDAY. 1985. A framework for identifying fisheries management problems associated with the influence of environmental factors on distribution and migration of marine species. NAFO Sci. Coun. Studies, 8: 83-92.

SMITH, S., R. J. LOSIER, F.H. PAGE, and K. HATT 1994. Associations between haddock and temperature, salinity and depth within the Canadian groundfish bottom trawl surveys (1970-93) conducted within NAFO divisions 4VWX and 5Z. Can. Tech. Rept. Fish. Aquat. Sci. 1959: vi + 70 p.

SMITH, S.J. and F.H. PAGE 1996. Associations between Atlantic cod (*Gadus morhua*) and hydrographic variables: Implications for the management of the 4VsW cod stock. ICES J. mar. Sci., 53: 597-614

SMITH, S.J. and F.H. PAGE 1994. Implications of temperature and haddock associations on survey abundance trends. DFO Atl. Fish. Res. Doc. 94/21:34p.

SMITH, S.J., R.I. PERRY and L.P. FANNING 1991 Relationships between water mass characteristics and estimates of fish population abundance from trawl surveys. Env. Monitor. and Assess., 17: 227-245

STEPHENSON, R.L., M.J. POWER, J.B. SOCHASKY, F.J. FIFE, G.D. MELVIN, S. GAVARIS, T.D. ILES and F. PAGE 1995 Evaluation of the stock status of 4WX herring. DFO Atl. Fish. Res. Doc. 95/83.

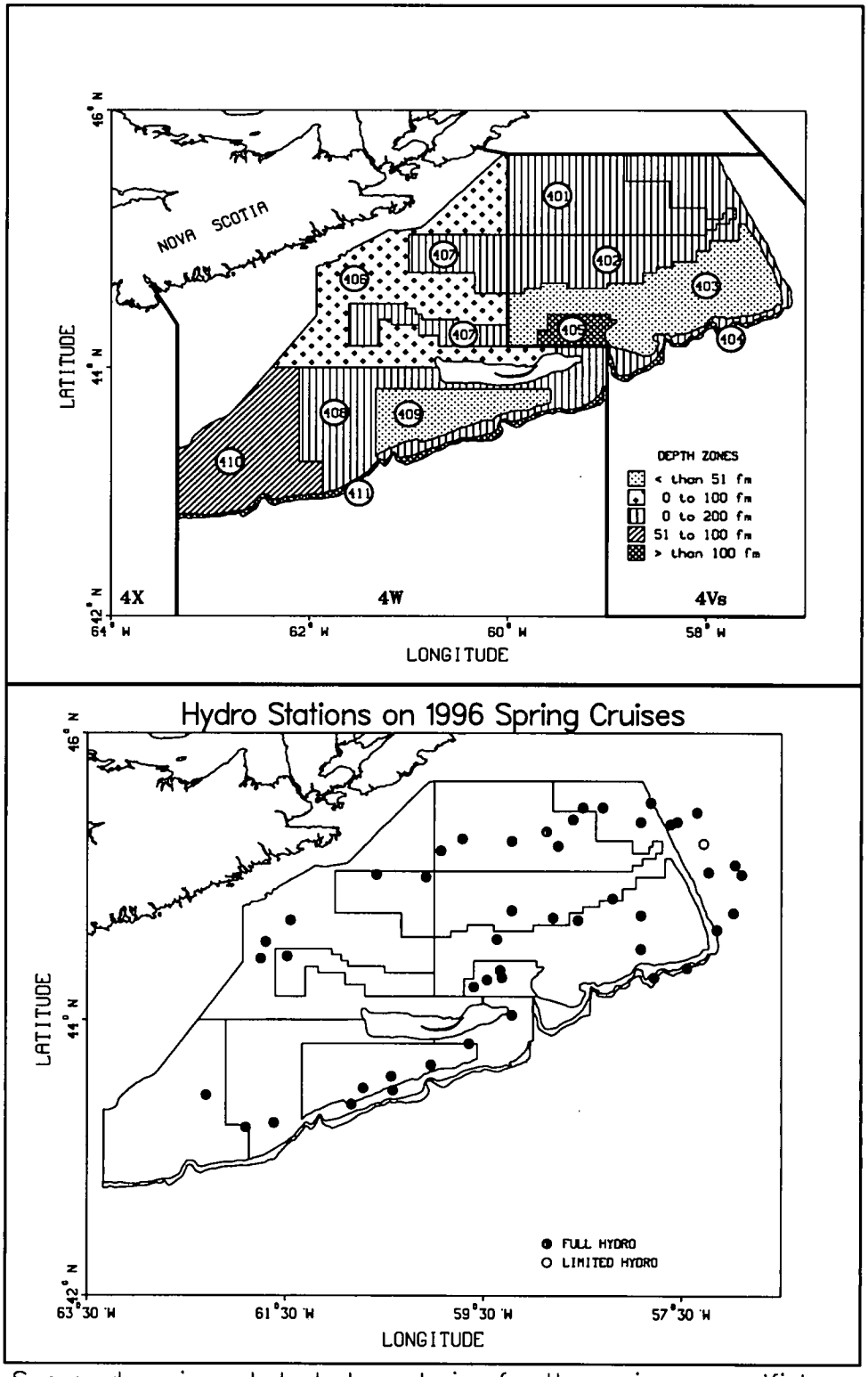

Figure 1: Survey domain and strata boundaries for the spring groundfish research vessel surveys conducted within NAFO area 4VsW from 1987–1996 (top panel) and the location of hydrographic sampling stations taken during the 1996 survey (bottom panel). In the bottom panel solid circles indicate a CTD cast and open circles indicate where only bottom temperatures and salinities were measured. (In the top panel the numbers enclosed within circles are the strata designations.)

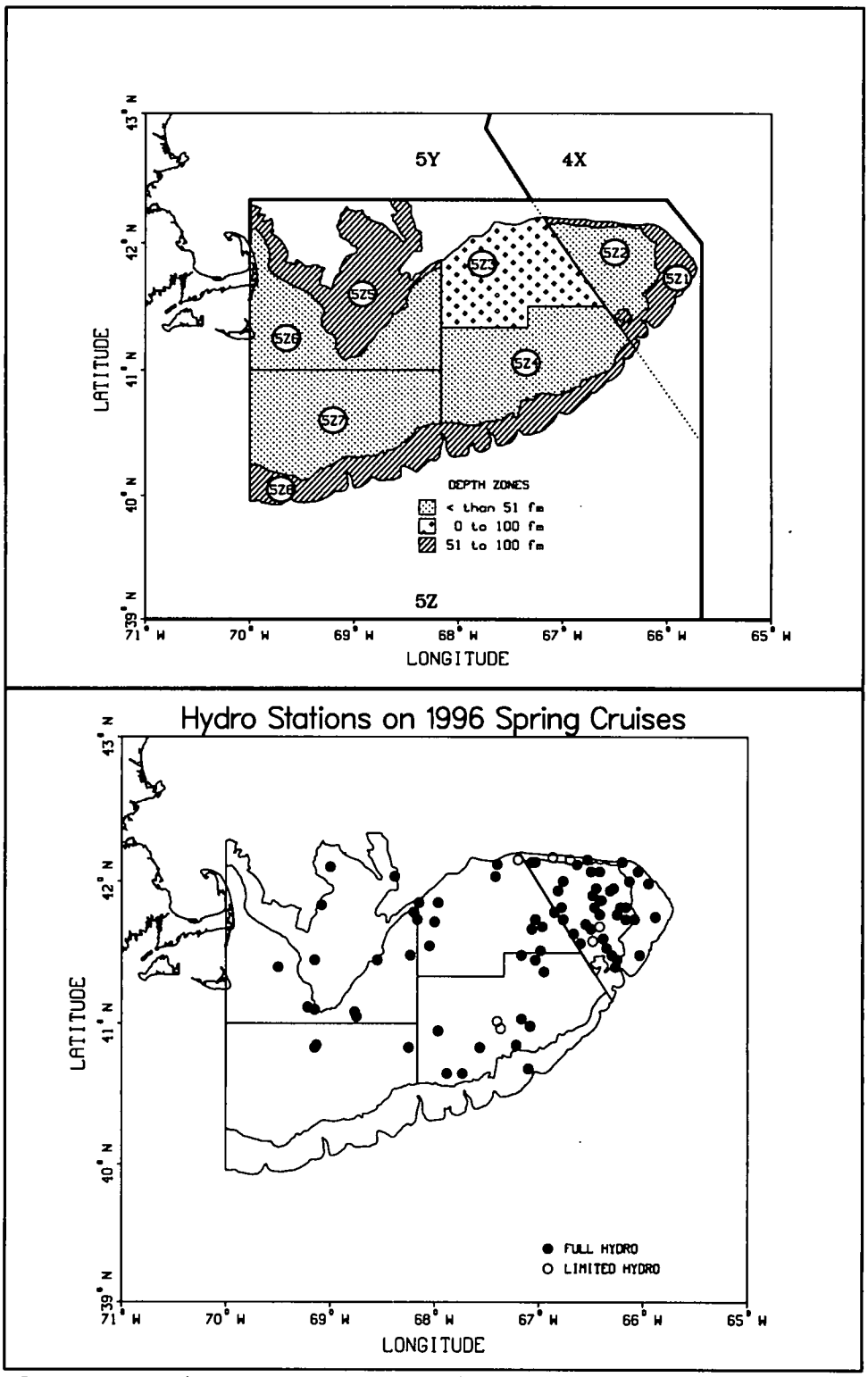

Figure 2: Survey domain and strata boundaries for the spring groundfish research vessel surveys conducted within NAFO area 4VWX from 1987–1996 (top panel) and the location of hydrographic sampling stations taken during the 1996 survey (bottom panel). In the bottom panel solid circles indicate a CTD cast and open circles indicate where only bottom temperatures and salinities were measured. (In the top panel the numbers enclosed within circles are the strata designations.)

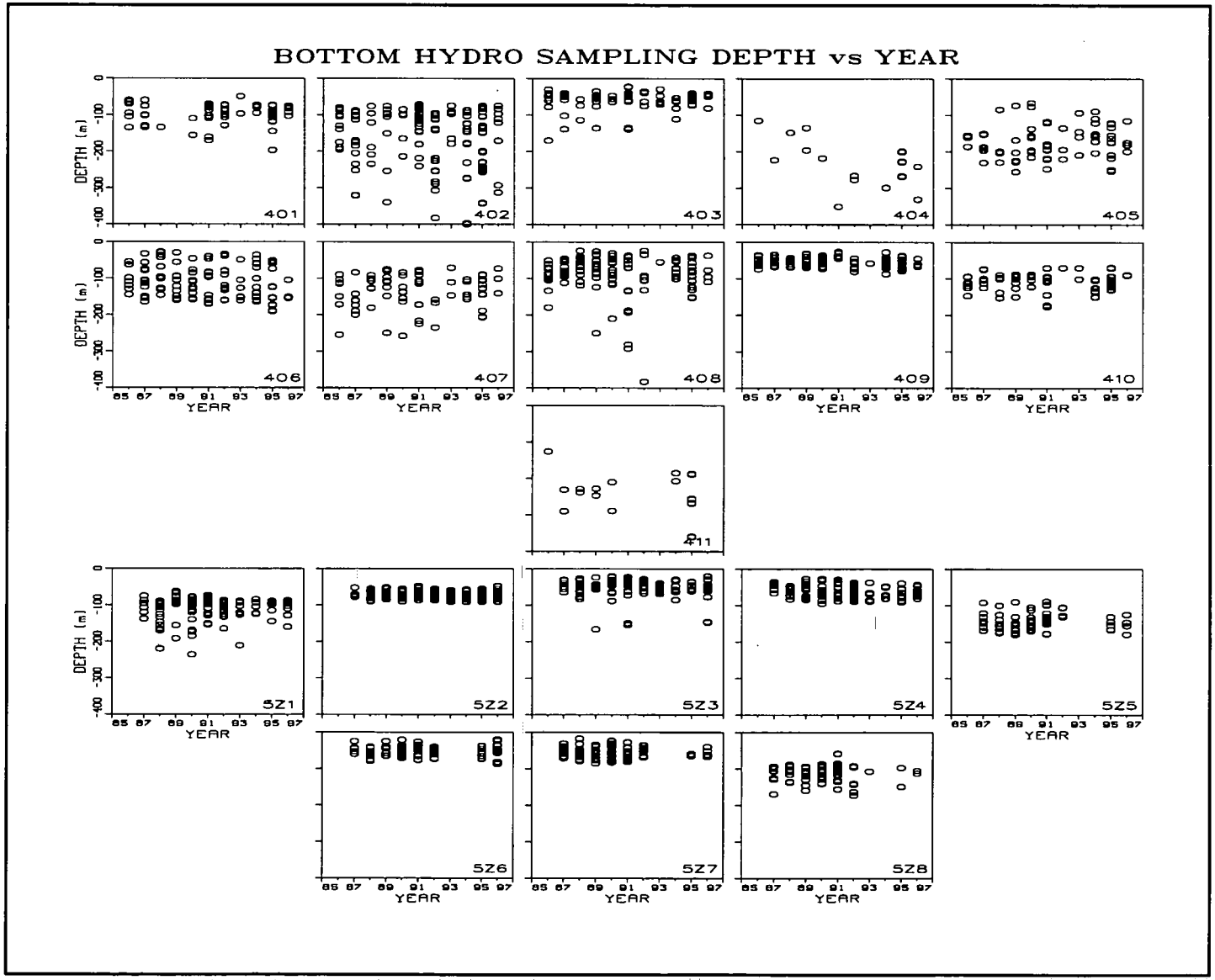

Figure 3: Time series of the near–bottom hydrographic sampling depth for each station within the spring 4VsW and 5Z surveys. The numbers and letters in the lower right hand corner of each panel indicate the survey stratum. Each open circle represents the near–bottom sampling depth of one hydrographic station.

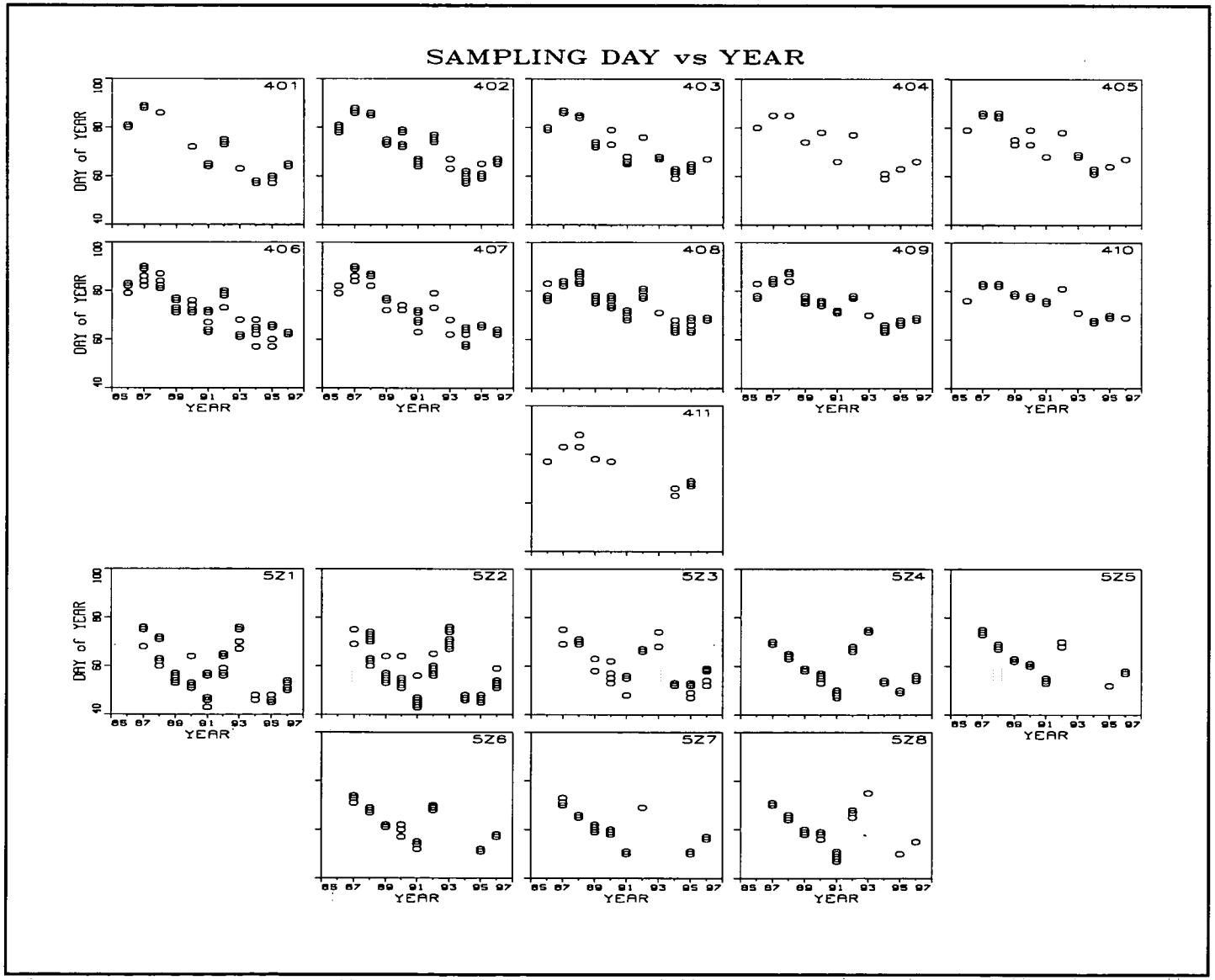

Figure 4: Time series of the consecutive day of sampling within the spring 4VsW and 5Z surveys. The numbers and letters in the upper right hand corner of each panel indicate the survey stratum. Each open circle represents the sampling day of one hydrographic station.

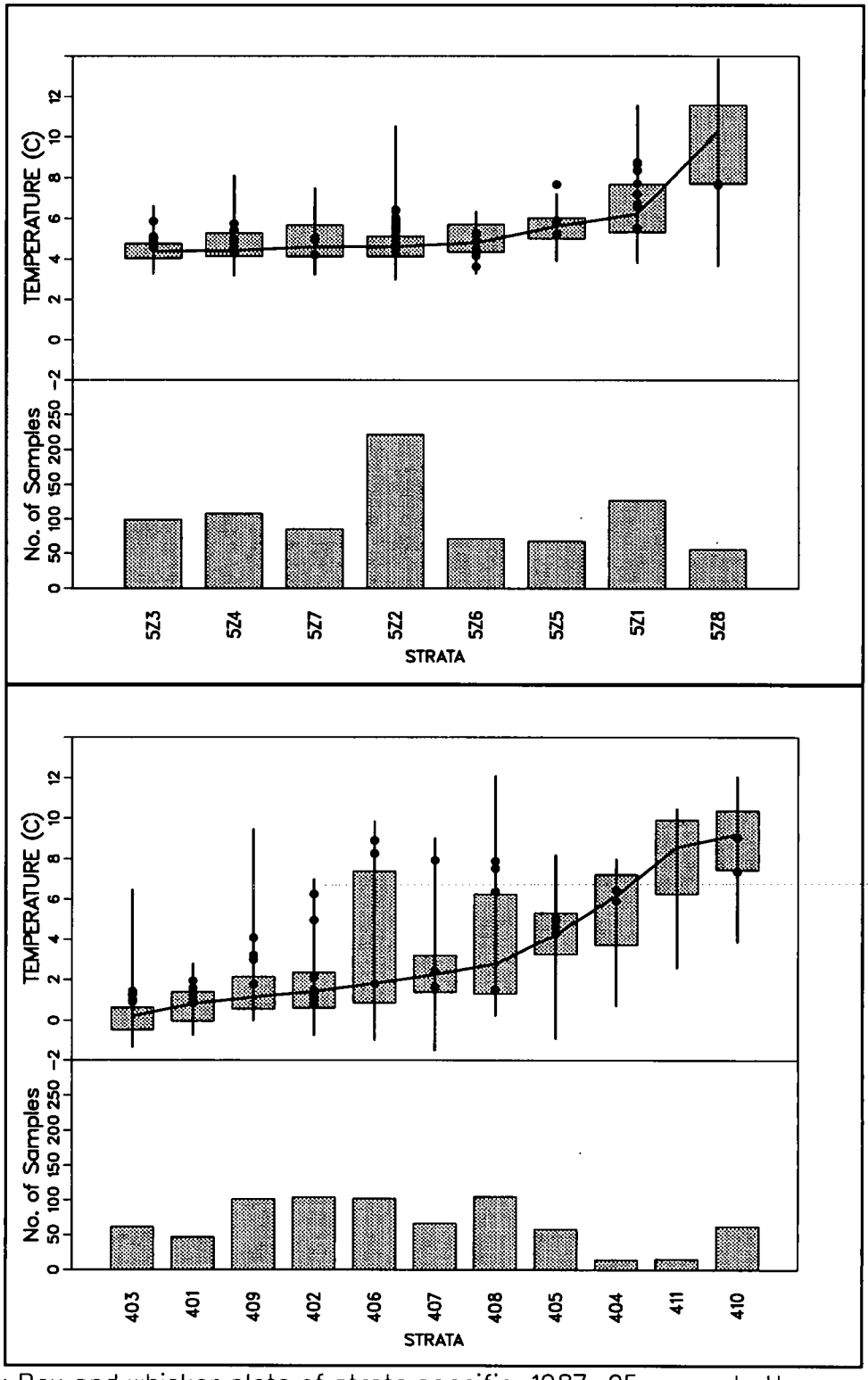

Figure 5: Box and whisker plots of strata specific, 1987–95, near–bottom water temperatures for strata within 5Z (top panel) and 4VsW (lower panel) ordered by temperature medians. The maxima, 75th percentiles, medians, 25th percentiles and minima are shown along with the total number of samples taken within each strata over the entire 1987–95 period. Solid circles are 1996 observed temperature data.

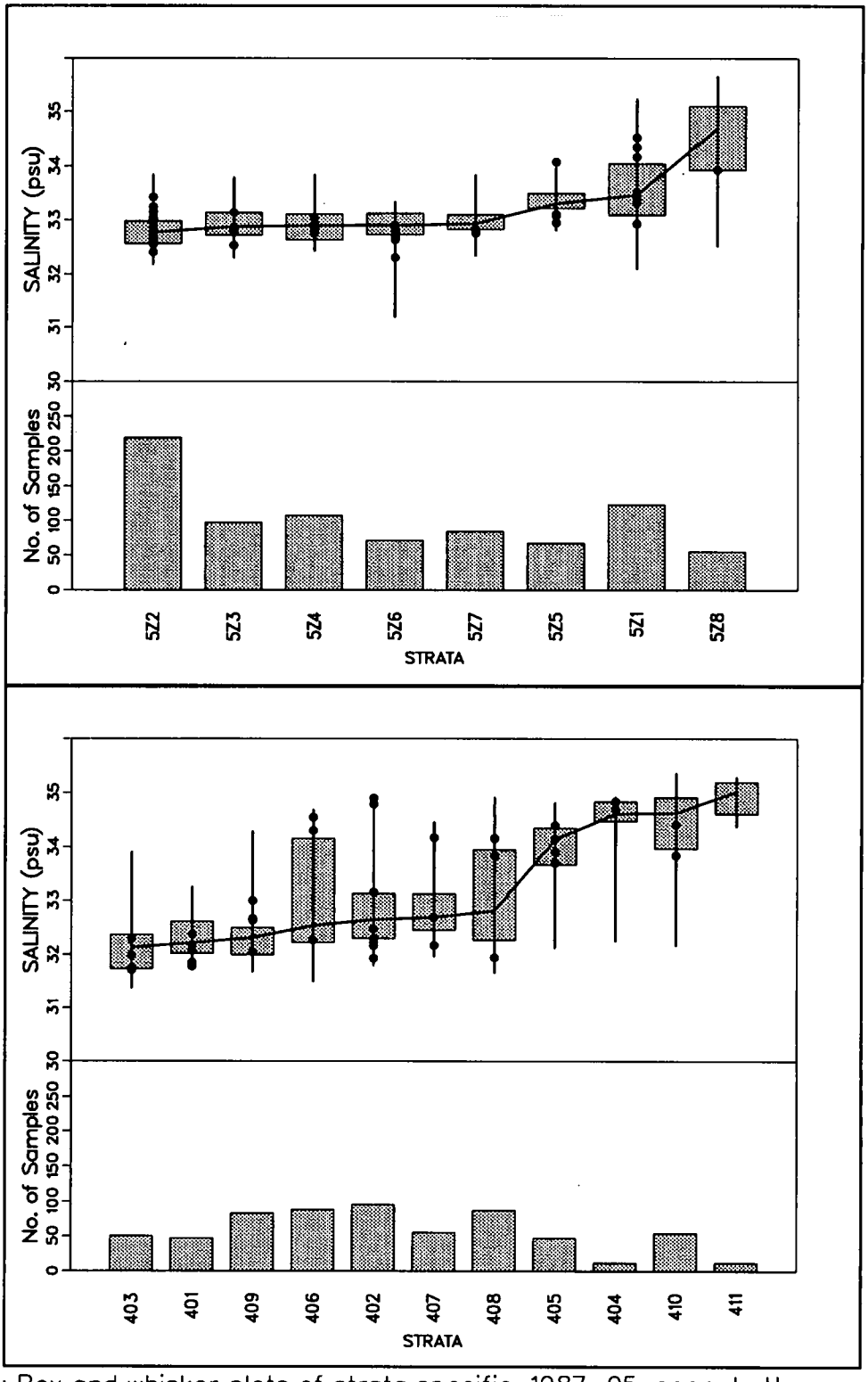

Figure 6: Box and whisker plots of strata specific, 1987–95, near–bottom water salinities for strata within 5Z (top panel) and 4VsW (lower panel) ordered by salinity medians. The maxima, 75th percentiles, medians, 25th percentiles and minima are shown along with the total number of samples taken within each strata over the entire 1987–95 period. Solid circles are 1996 observed salinity data.

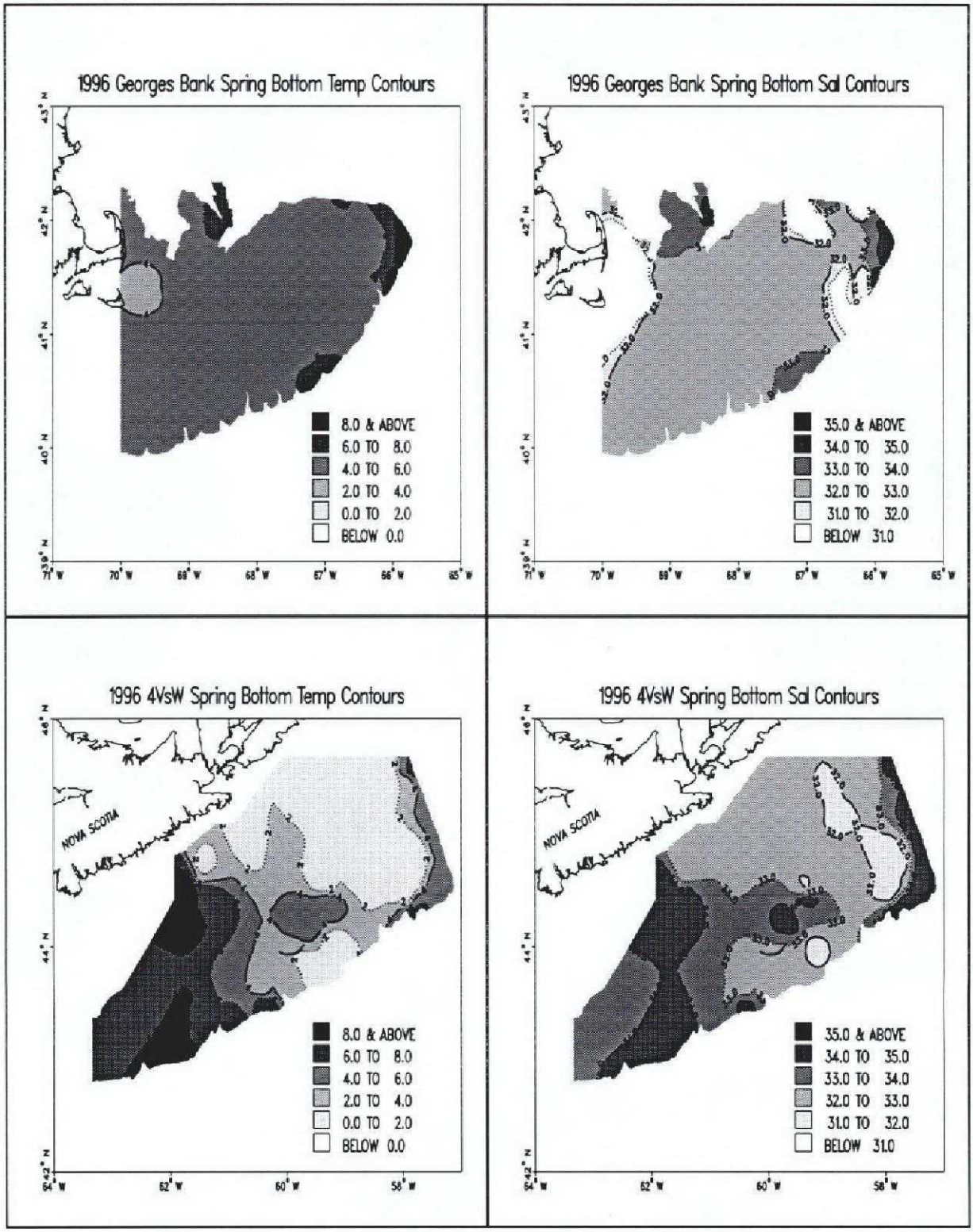

Figure 7: Contour maps of near-bottom temperature and salinities within the 5Z and 4VsW Canadian research vessel bottom-trawl surveys conducted during the spring of 1996.

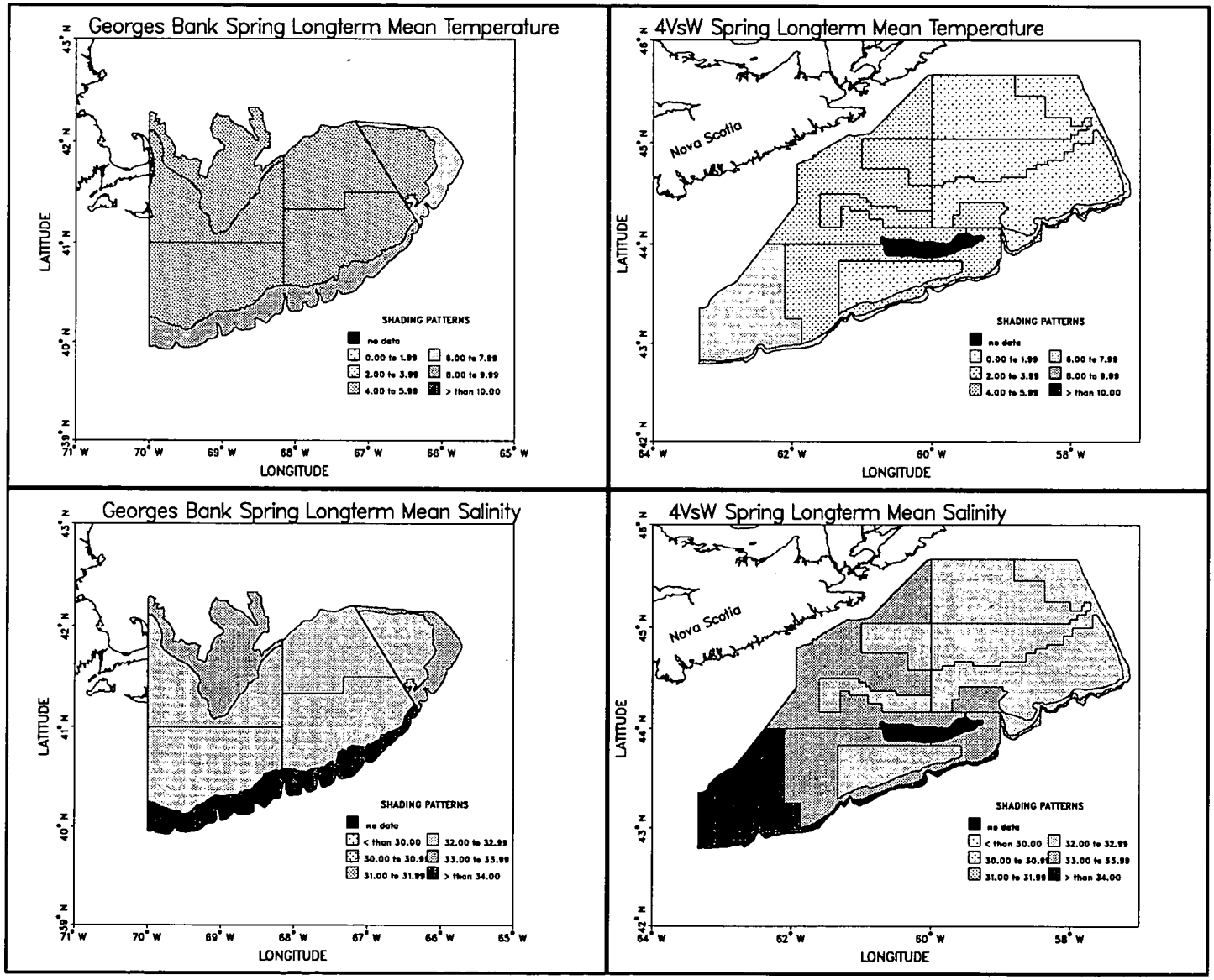

Figure 8: Map of near-bottom strata long term mean temperatures (top panel) and salinities (bottom panel) within NAFO statistical areas 5Z and 4VsW during the Canadian research vessel bottom-trawl survey conducted during the spring of 1987-1990.

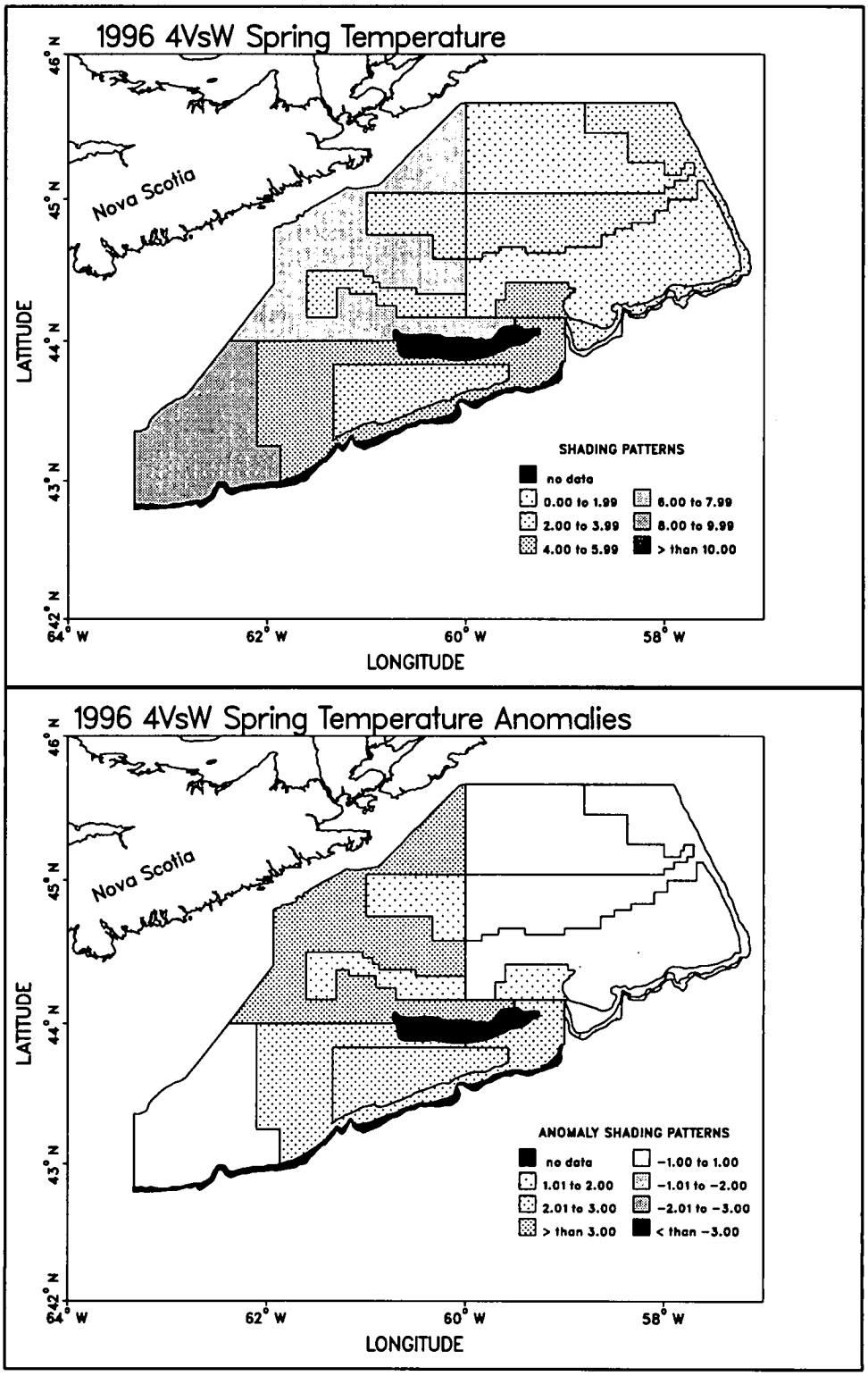

Figure 9: Map of near-bottom strata mean temperatures (top panel) and temperature anomalies (bottom panel) within NAFO statistical area 4VsW during the Canadian research vessel bottom-trawl survey conducted during the spring of 1996.

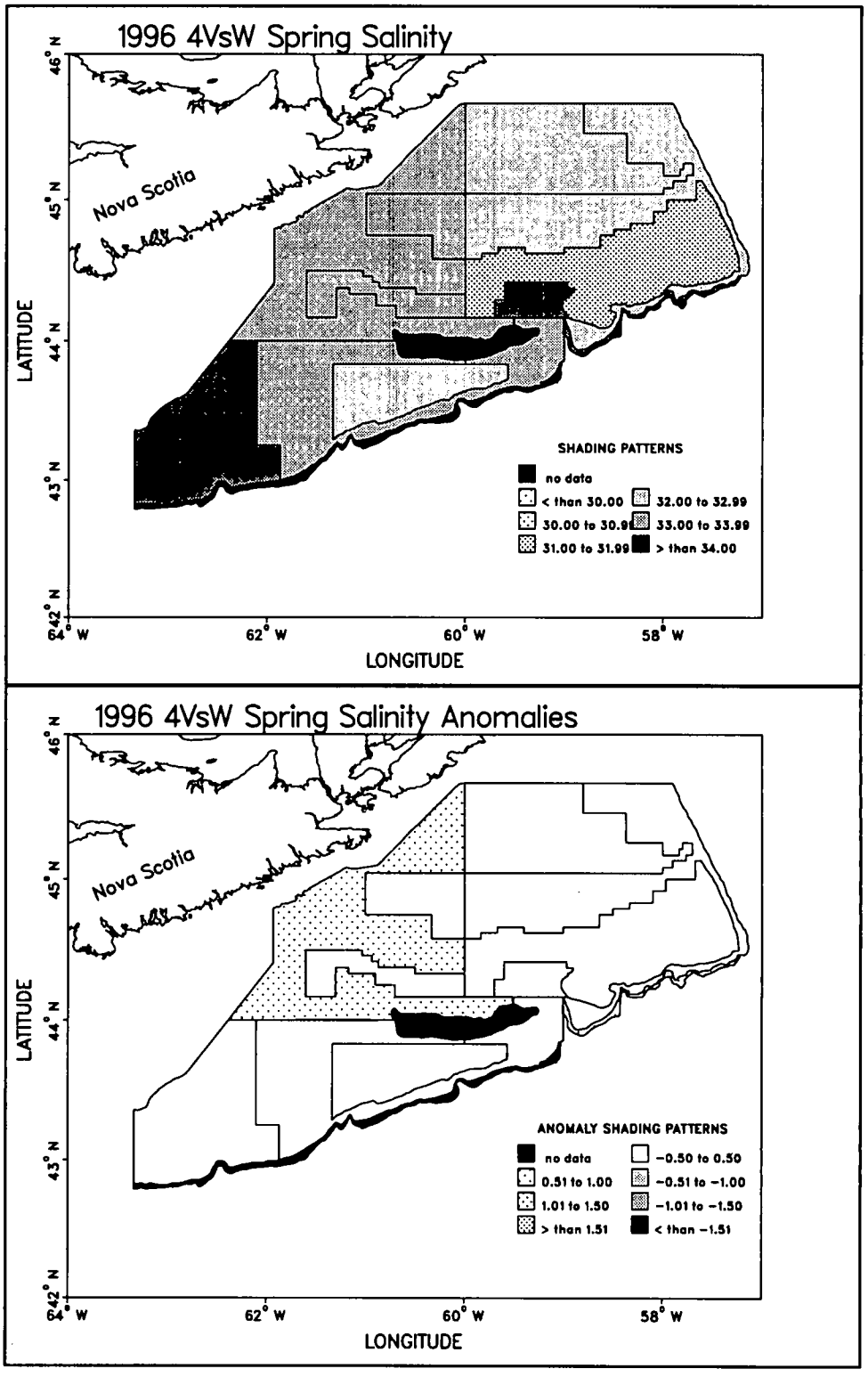

Figure 10: Map of near-bottom strata mean salinities (top panel) and salinity anomalies (bottom panel) within NAFO statistical area 4VsW during the Canadian research vessel bottom-trawl survey conducted during the spring of 1996.

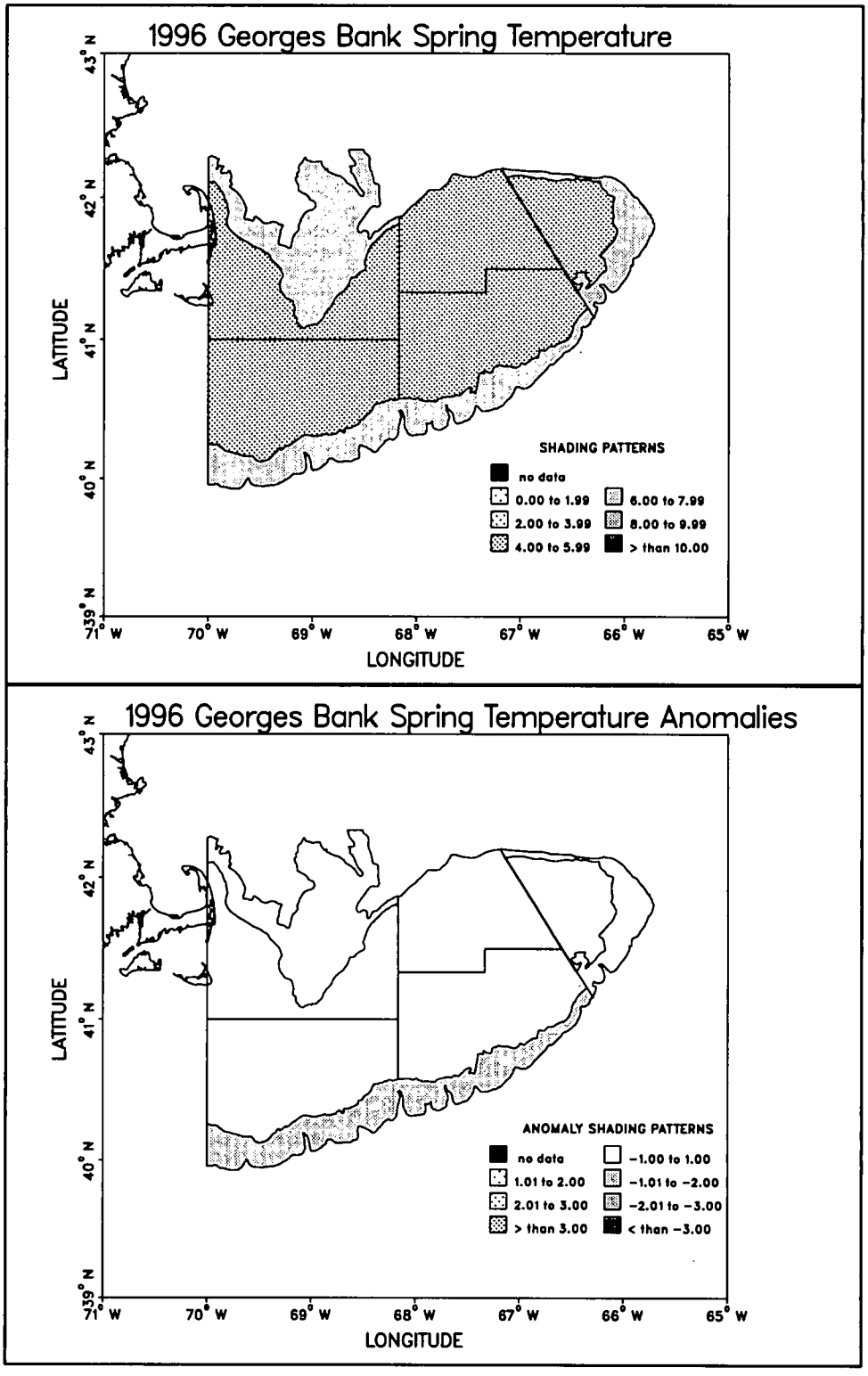

Figure 11: Map of near-bottom strata mean temperatures (top panel) and temperature anomalies (bottom panel) within NAFO statistical area 5Z during the Canadian research vessel bottom-trawl survey conducted during the spring of 1996.

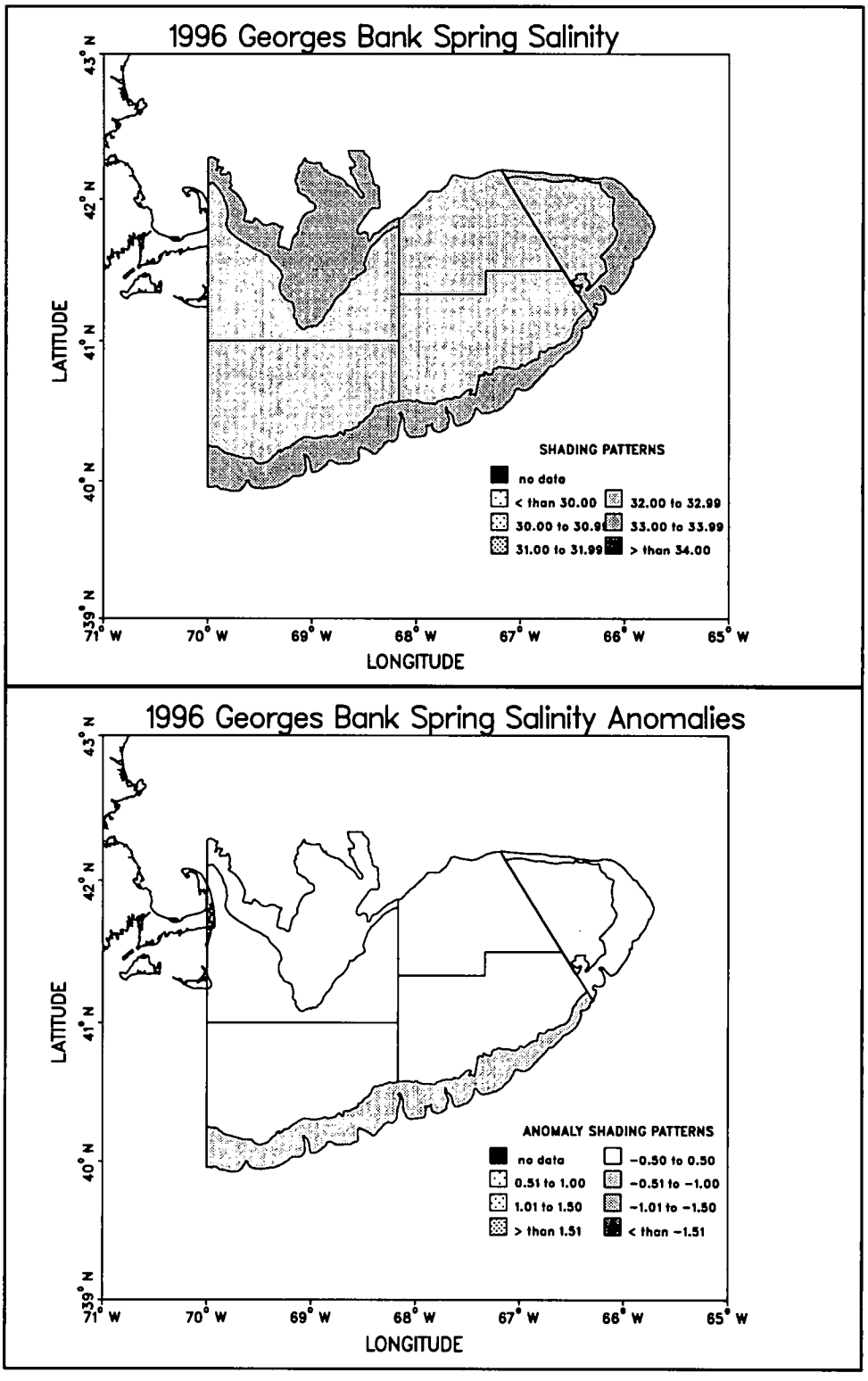

Figure 12: Map of near-bottom strata mean salinities (top panel) and salinity anomalies (bottom panel) within NAFO statistical area 5Z during the Canadian research vessel bottom-trawl survey conducted during the spring of 1996.

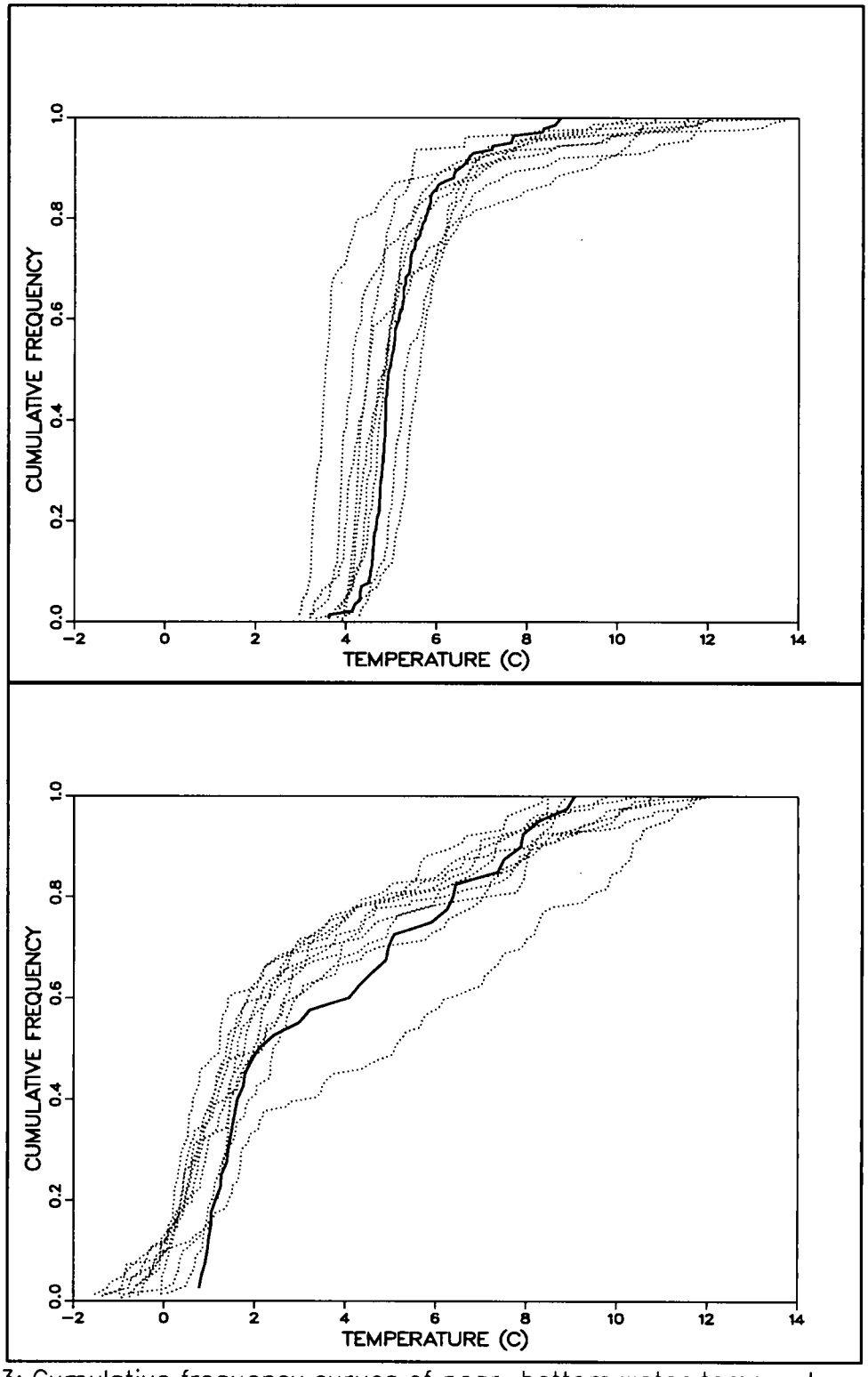

Figure 13: Cumulative frequency curves of near–bottom water temperatures for the 1987–96 Canadian research vessel bottom–trawl spring 5Z (top panel) and 4VsW (lower panel) surveys. Each line represents the cumulative frequency for a single year. The dotted lines are for the years 1987–95 and the heavy solid line is for 1996.

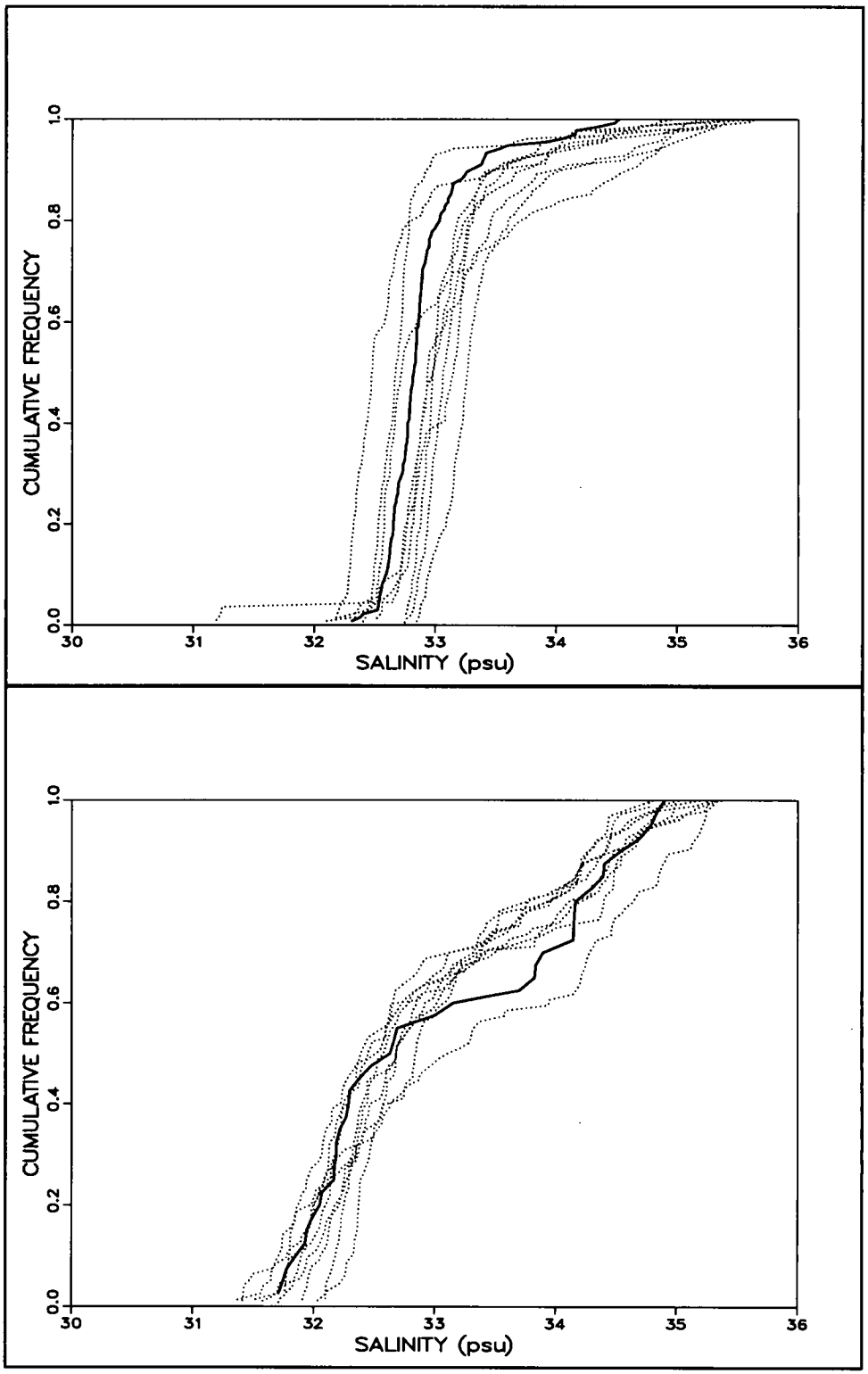

Figure 14: Cumulative frequency curves of near–bottom water salinities for the 1987–96 Canadian research vessel bottom–trawl spring 5Z (top panel) and 4VsW (lower panel) surveys. Each line represents the cumulative frequency for a single year. The dotted lines are for the years 1987–95 and the heavy solid line is for 1996.

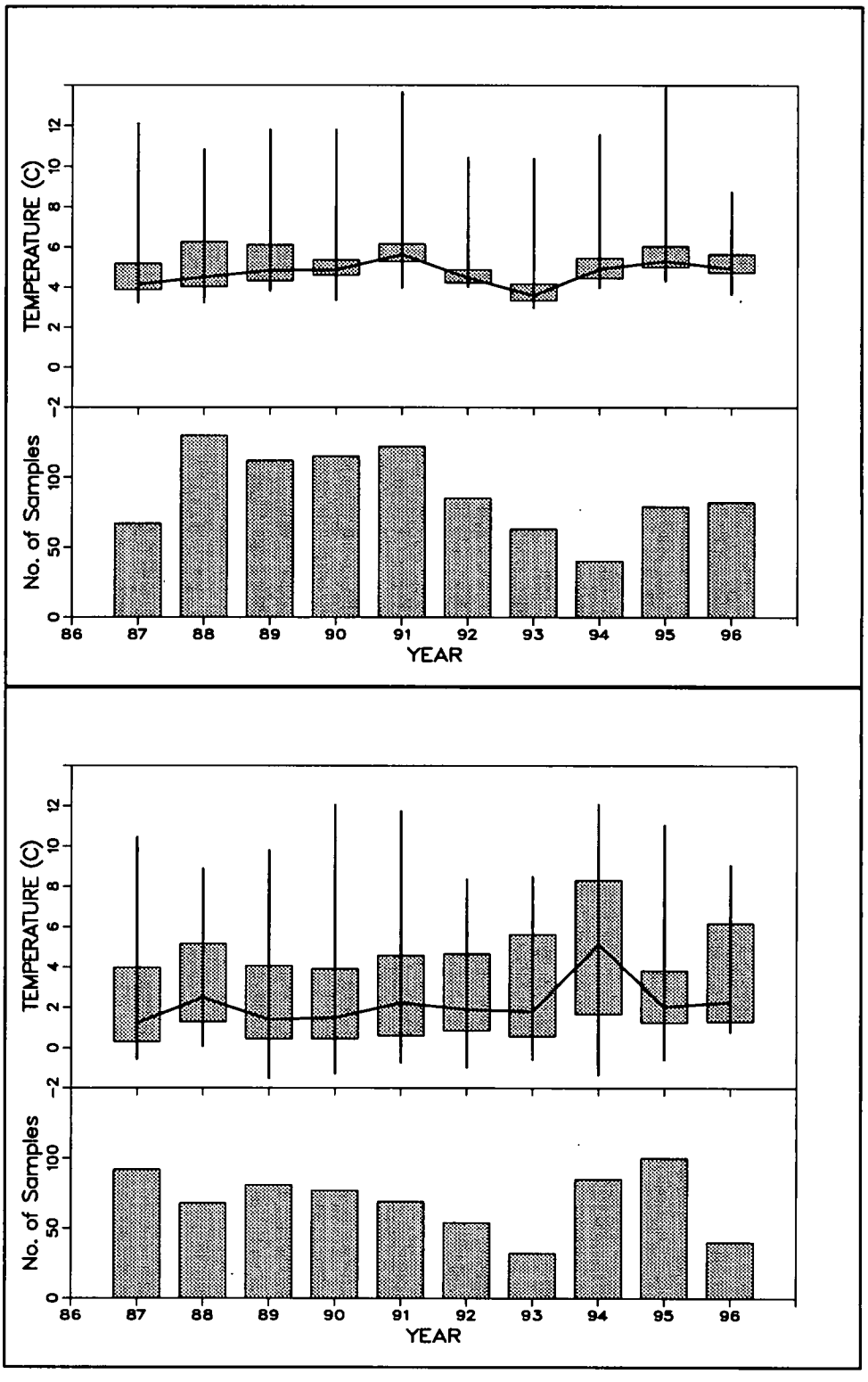

Figure 15: Box and whisker time series plots of near–bottom water temperatures for each year within 5Z (top panel) and 4VsW (lower panel). The maxima, 75th percentiles, medians, 25th percentiles and minima are shown along with the total number of samples taken within each year over the entire 1987–96 period.

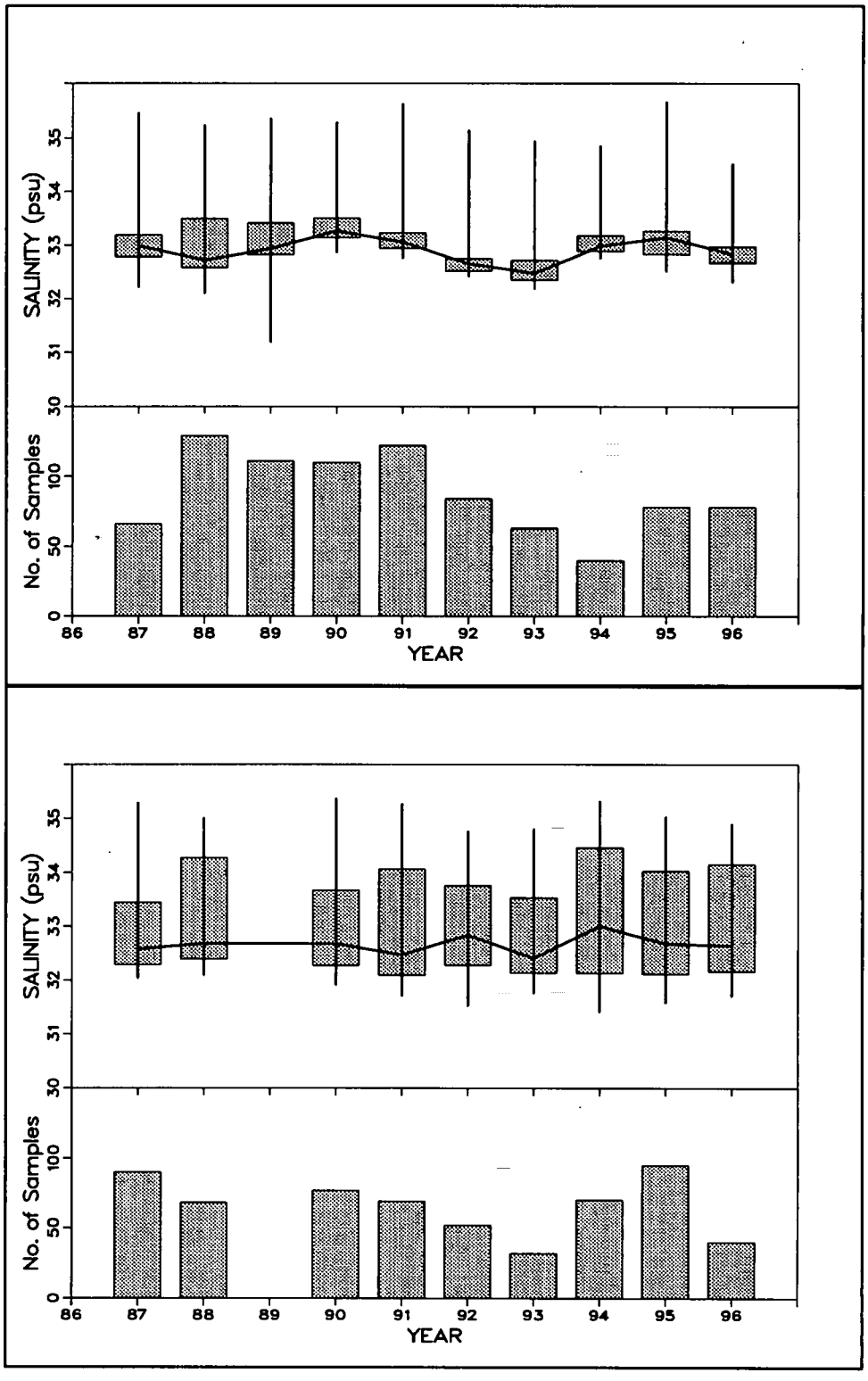

Figure 16: Box and whisker time series plots of near–bottom water salinities for each year within 5Z (top panel) and 4VsW (lower panel). The maxima, 75th percentiles, medians, 25th percentiles and minima are shown along with the total number of samples taken within each year over the entire 1987–96 period.

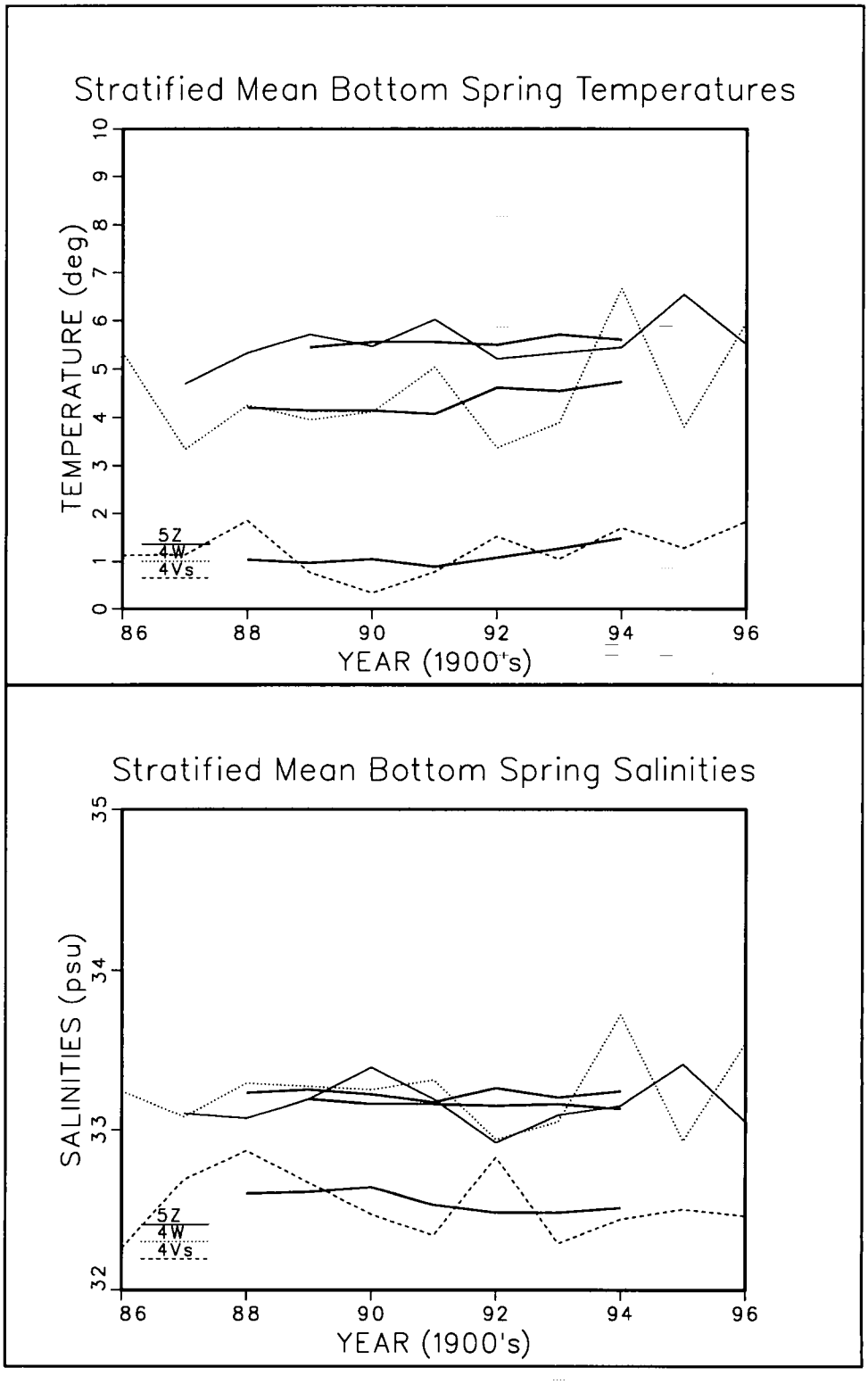

Figure 17: Time series of stratified mean near-bottom temperatures(upper panel) and salinities (lower panel)for Canadian spring research vessel groundfish surveys conducted within 4VsW and 5Z. The smooth curves running through each series is a five year running mean.

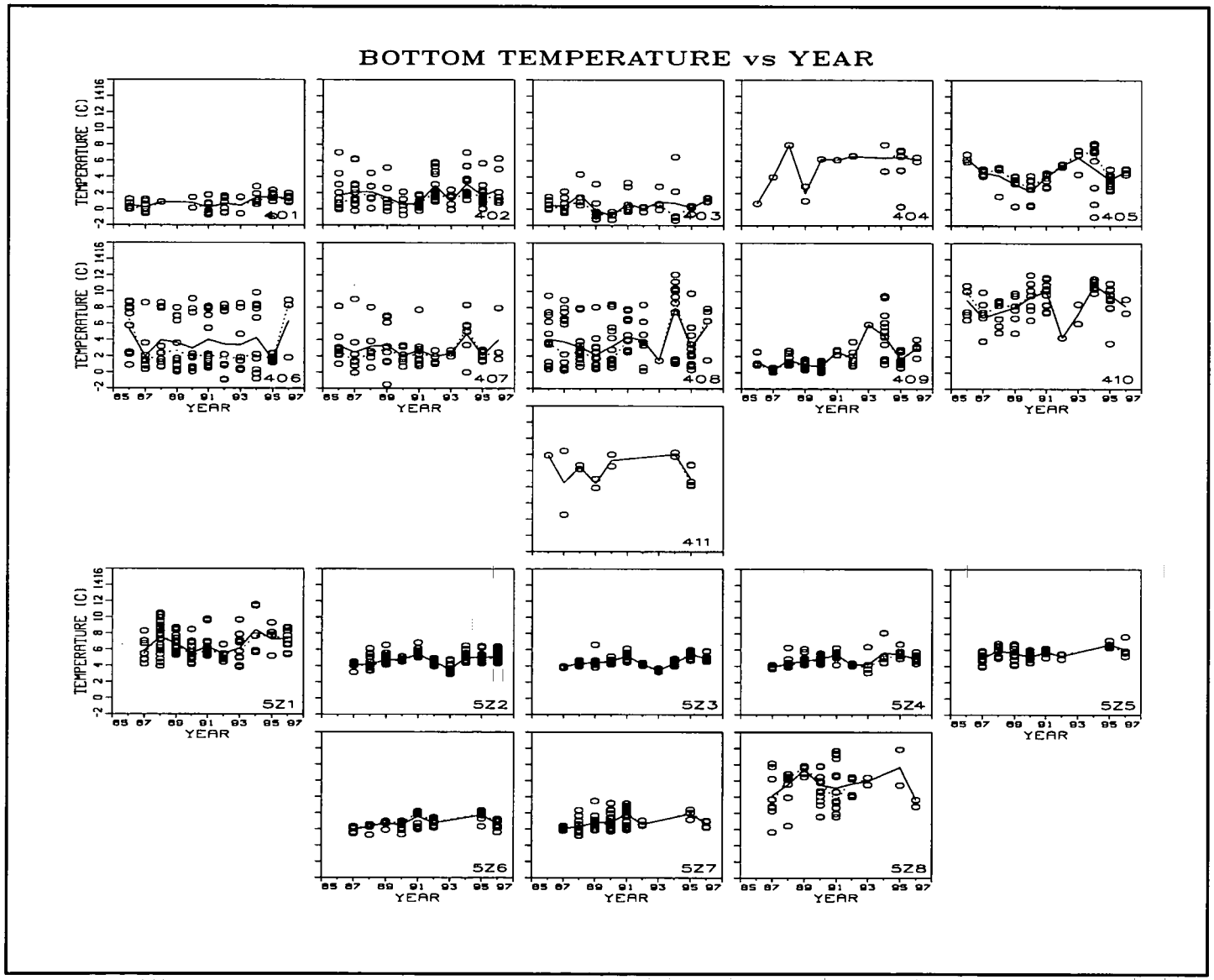

Figure 18: Time series of near-bottom temperatures within the spring 4VsW and 5Z surveys. The numbers and letters in the lower right hand corner of each panel indicate the survey stratum. Each open circle represents the temperature at one hydrographic station.

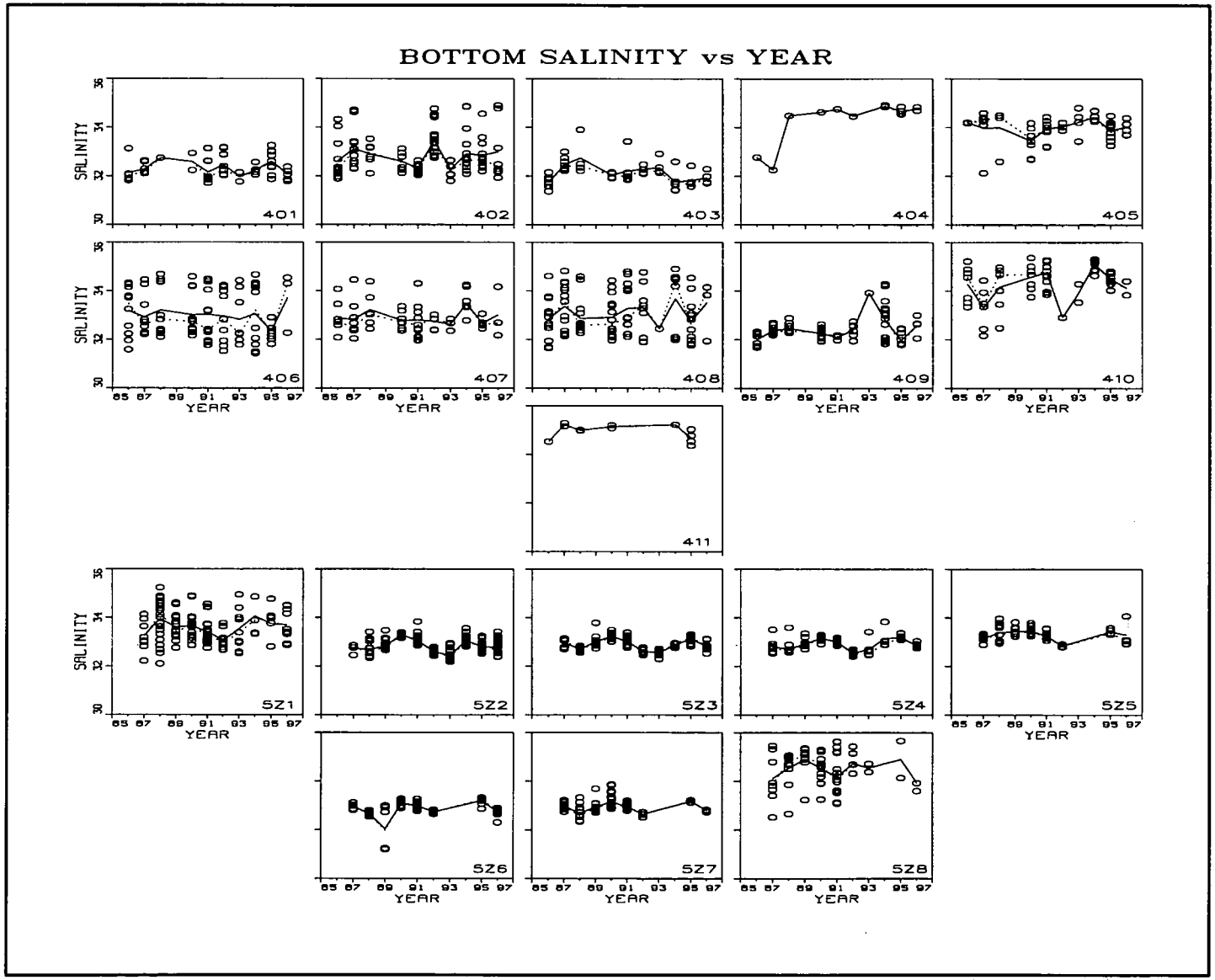

Figure 19: Time series of near-bottom salinities within the spring 4VsW and 5Z surveys. The numbers and letters in the lower right hand corner of each panel indicate the survey stratum. Each open circle represents the salinity at one hydrographic station.