Station 27 Oceanographic Monitoring Station—A Long History

E. B. Colbourne and C. Fitzpatrick

Northwest Atlantic Fisheries Centre, Box 5667, St. John's, NL, A1C 5X1

Colbourn@dfo-mpo.gc.ca fitzpatrickc@dfo-mpo.gc.ca

Résumé

L'activité de monitorage le long de plusieurs transects traversant le plateau continental de Terre-Neuve et du Labrador a été initiée vers la fin des années quarante. Le transect qui était situé immédiatement au large du port de St. John's, Terre-Neuve, débutait par le nombre séquentiel 27 et était orienté vers le sud-est des Grands Bancs de Terre-Neuve. La première station du transect (Station 27) était située à environ 7 km au large du port de St. John's et avait une profondeur de 176 mètres. Cette station avait été intentionnellement localisée dans le chenal d'Avalon pour monitorer les propriétés de la branche côtière du courant du Labrador. La proximité de cette station avec le port de St. John's en faisait un site pratique pour pouvoir effectuer le monitorage en utilisant les navires de recherche sur les pêches qui partaient ou qui arrivaient de leur mission d'échantillonnage. La base de données pour cette station contient maintenant plus de 1 800 profils de température et plus de 1 500 profils de salinité, ce qui en fait le site le plus fréquemment échantillonné dans les eaux de Terre-Neuve et du Labrador, et de ce fait, l'une des séries les plus utiles pour les études climatiques en océanographie et en pêcheries dans cette région. Avant les années 1980, les données de la Station 27 étaient principalement utilisées par les chercheurs des pêches pour fournir la description physique annuelle de l'habitat du poisson et occasionnellement, pour relier les variations de l'environnement physique aux changements observés dans les pêcheries locales. Même si la description annuelle du climat océanique est encore le principal but de cet échantillonnage, au début des années 1980, on a aussi commencé à utiliser ces données pour aborder des enjeux reliés aux échelles de variabilité, aux changements climatiques, au mélange vertical et aux remontées d'eaux profondes ainsi qu'à la circulation locale. En 1998, avec l'implantation du Programme de Monitorage de la Zone Atlantique (PMZA), un échantillonnage biologique et chimique a été ajouté à l'échantillonnage physique de la station 27. Depuis ce temps, les conditions océanographiques basées sur cet échantillonnage sont disponibles de façon routinière. Ce monitorage devrait contribuer dans le futur à augmenter notre compréhension des écosystèmes marins en général, et nous permettre d'identifier les tendances à long terme du climat océanique.

Sampling History

Oceanographic observations on the Grand Banks of Newfoundland began as early as 1894 and were presented in the annual report of the Newfoundland Department of Fisheries for the year 1895. However, no systematic, regular oceanographic observations were conducted until 1931, when the Newfoundland Fisheries Research Commission opened the Biological Laboratory at Bay Bulls, Newfoundland. This laboratory was destroyed by fire in 1937 and it was not until the commissioning of the *Investigator II* as a full-time research vessel in 1946 that hydrographic work resumed under the directorship of Dr. Wilfred Templeman. During the late 1940s and early 1950s, hydrographic monitoring along several sections crossing the Newfoundland and Labrador Shelf was initiated. The section beginning immediately off St. John's Harbour with Station 27 (47° 32.8' N, 52° 35.2' W) proceeded to the southeast Grand Bank, ending with Station 32. The second station on this line, Station 28, was the first monitoring station on the Flemish Cap section (47° N), with stations numbering 28-42. The southeast Grand Bank section was not sampled regularly, but Station 27 was often included as part of the Flemish Cap section. The site is located about 7 km off St. John's Harbour in a water depth of 176 metres and was intentionally located in the Avalon Channel to monitor the water properties of the inshore branch of the Labrador Current (Fig. 1). In this area, the cold (<0°C) water that forms the cold intermediate layer (CIL) on the continental shelf is present year-round, and variations in water properties are representative of conditions across a broad area of the Newfoundland Shelf. Logistically, the station's proximity to St. John's Harbour also made it a convenient location for sampling by departing and arriving fisheries research vessels.

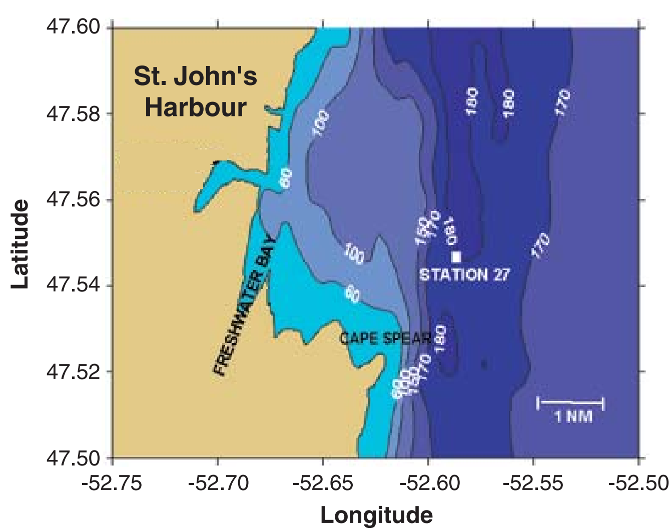

Fig. 1 Map showing the bathymetry (m) and location of Station 27 off St. John's Harbour.

Carte indiquant la bathymétrie (m) et la position de la Station 27 au large du port de St. John's, Terre-Neuve.

The first data from Station 27 were collected in June of 1947, and during the remainder of that year, the station was sampled 14 times. In subsequent years, sampling increased to include all months; there were 15-30 occupations per year up to the late 1970s. In recent years, the station has been sampled about 2-4 times per month on average. Historically, most of the data at Station 27 were collected at standard oceanographic depths (0, 10, 20, 30, 50, 75, 100, 125, 150, and 175 m) using bottles fitted with reversing

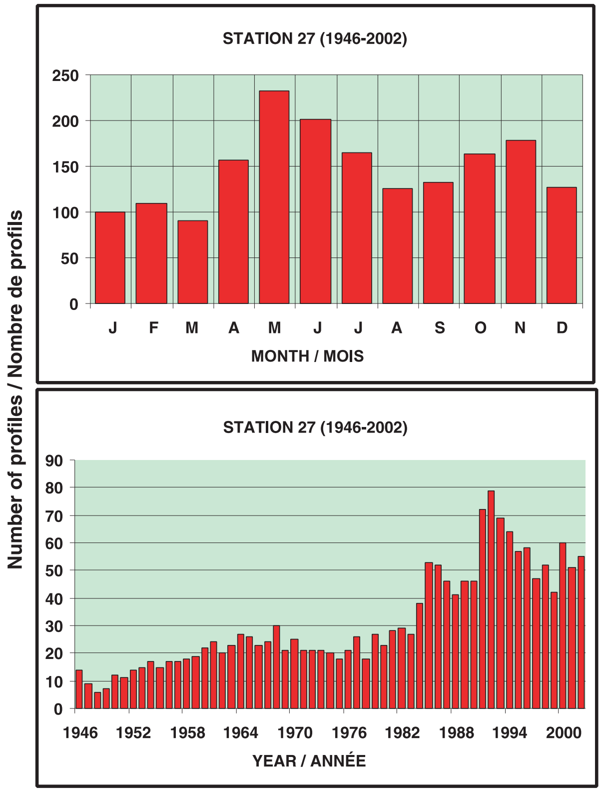

Fig. 2 The total number of temperature profiles collected at Station 27 by month (top panel) and by year (bottom panel).

Nombre total de profils de temperature échantillonnés à la Station 27 par mois (panneau du haut) et par année (panneau du bas).

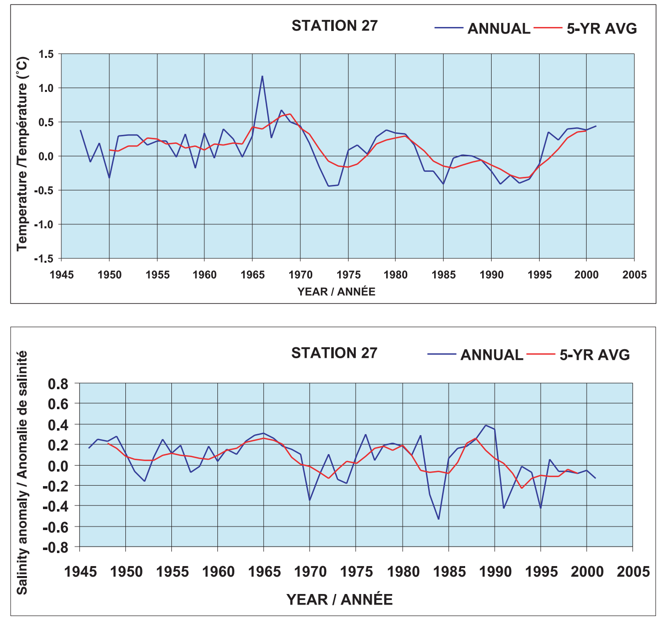

Fig. 3 Station 27 annual bottom temperature anomalies (top panel) and surface salinity anomalies (bottom panel) with their 5-year averages (red lines). The reference period is from 1971-2000.

Anomalies de température du fond (panneau du haut) à la Station 27 et de la salinité de surface (panneau du bas) comparées à leurs moyennes sur 5 ans (ligne rouge). La période de référence s'étend de 1971 à 2000.

thermometers. Since the mid 1960s, a considerable amount of data has also been collected using mechanical and electronic bathythermographs. More recently, conductivity-temperature-depth (CTD) recorders have been the instrument of choice. The monthly distribution of the number of temperature profiles collected at Station 27 shows a bias towards sampling in spring and early summer and to some extent during the fall with minimum sampling in winter (Fig. 2, top panel). The number of temperature profiles collected from 1946 to 1979 accounts for about 40% of the data (Fig. 2, bottom panel). Since the mid 1980s, there has been a large increase in data collection at Station 27, with an average of 45 to 55 profiles per year. In fact, the 1990s account for about 36% of the data collected at Station 27 in its 55-year history. The maximum number (>70) of occupations occurred in 1991 and 1992 during the collapse of the northern cod stock. The complete data set contains over 1800 temperature and over 1500 salinity profiles, making it the most frequently sampled site in Newfoundland and Labrador waters.

Use of Data

In the 1950s, Station 27 data mainly provided annual descriptions of the hydrographic conditions; occasionally these were related to changes in local fisheries. The annual report of the Fisheries Research Board of Canada for the year 1950 contains the first detailed description of oceanographic conditions using Station 27 data (Templeman 1951). Templeman described seasonal variations in temperature with depth and attributed unusually large catches of cod and lobsters in shallow water and the greatest abundance of squid for many years in the Newfoundland area to warmer-than-usual surface waters. By the mid 1950s, enough data had accumulated to allow Templeman and Fleming (1956) to compute the first temperature climatology for inshore Newfoundland waters, which was used to describe the thermal habitat of cod during the longlining experiments of 1950-1953 along the east coast of Newfoundland. Beginning in 1954, summaries of temperature and salinity variations at Station 27 were routinely included in the annual proceedings of the International Commission for the Northwest Atlantic Fisheries (ICNAF) (Templeman 1955). As more data accumulated, ICNAF initiated a series of special symposiums describing environmental conditions in the Northwest Atlantic on decadal time scales (ICNAF 1965).

Beginning in the 1960s, use of the Station 27 data was extended beyond annual descriptions of the physical environment. Bailey (1961), using data collected from 1946-1958, completed a detailed study of the oceanographic variability in the inshore waters of Newfoundland. He used harmonic analysis to construct annual and seasonal cycles of temperature and salinity at several depths and subsequently computed time series of temperature and salinity anomalies. Shortly afterwards, Templeman (1965a) published a report relating anomalies in sea temperature at Station 27 with air temperatures at St. John's. In the same year, he attributed the mass fish mortalities in the Newfoundland area to cold ocean temperatures (Templeman 1965b).

A series of climatologies of temperature, salinity, and density measured at Station 27 were published that were based on progressively longer time series. Huyer and Verney (1975) produced the first analysis using data from 1950 to 1959; Keeley (1981) extended it to include data from 1946 to 1977. More recently, Colbourne and Fitzpatrick (1994) presented an analysis of the Station 27 data for the years 1978 to 1993 and Fitzpatrick and Colbourne (2000) produced an updated temperature, salinity, and density climatology for Station 27 using data from 1946 to 1999. Currently these data sets are used to construct temperature and salinity anomaly time series for the inner Newfoundland Shelf using standard harmonic analysis and reference periods consistent with the World Meteorological Organization (WMO) (Fig. 3).

Petrie et al. (1988), using Station 27 data along with other environmental observations, presented a comprehensive description of the Newfoundland Shelf temperature variability, specifically the CIL, and concluded from correlation analysis that the spatial scales of variability are coherent over large areas of the Newfoundland Shelf. They then went on to describe in detail the phase and amplitude characteristics of the annual cycle in temperature and salinity (Petrie et al. 1991) and examined the spatial and temporal scales of variability in the residual field (Petrie et al. 1992) on the eastern Newfoundland Shelf. In these studies, the data were used to parameterize vertical diffusion coefficients, and kinematic models were employed to interpret the observations. A follow up to these studies by Umoh et al. (1995) used a vertical diffusion model with a horizontal advection adjustment to quantify the annual variations in the temperature cycle and partition the effects of local air–sea heat flux and advection on the Newfoundland Shelf. Mathieu and deYoung (1995) used temperature and salinity data from Station 27 to examine the influence of vertical diffusion and the importance of salinity in constraining a mixed-layer model for the inner Newfoundland Shelf.

Symonds (1986) used the data to model seasonal sea-ice extent on the Newfoundland Shelf, and Myers et al. (1990) concluded that ice-melt over Labrador and the northern Newfoundland Shelf was primarily responsible for the salinity minimum observed during late summer over much of the Newfoundland Shelf. Colbourne et al. (1994) and Drinkwater (1996) examined inter-decadal climate changes in the Northwest Atlantic using data from Station 27. Numerous other studies have used Station 27 data to examine environmental influences on growth, recruitment, and distribution of many marine organisms in Newfoundland waters (e. g., Myers et al. 1993, Parsons and Lear 2001, Colbourne and Anderson 2003). Stein and Lloret (2001) used the data in statistical models to forecast ocean temperatures for up to one year for fisheries assessment applications. These and other studies have contributed greatly to our understanding of the oceanography on the Newfoundland Shelf and the linkages between ocean climate and the marine ecosystem.

The climatology and year-to-year descriptions dominated the use of the Station 27 data until the mid 1980s. Moreover, annual descriptions of ocean climate that began in 1954 for ICNAF and presently for the Northwest Atlantic Fisheries Organization (NAFO) are still a primary focus and are perhaps one of the longest time series of documentation available anywhere pertaining to ocean climate conditions in the North Atlantic (Colbourne and Fitzpatrick 2002). Beginning in the mid 1980s, there has been increasing use of the data to address issues related to scales of variability, long-term climate changes, vertical mixing, local upwelling, and circulation. During the mid 1990s, oceanographers from Canada began active participation in the ICES Oceanography Committee and its working groups and, using the Station 27 time series, have contributed to the annual ocean climate status summary for the North Atlantic (ICES 2003). National and zonal groups, such as the Fisheries Oceanography Committee (FOC) of Fisheries and Oceans and the regional resource assessment proceedings (RAP), remain primary users of the Station 27 data (Colbourne 2003).

Station 27 and the AZMP Era

In 1992 under the northern cod science program, limited biological sampling was initiated at Station 27 but essentially ended with the termination of the program in 1995. Since 1998, as part of the Atlantic Zone Monitoring Program, biological and chemical sampling has resumed and oceanographic conditions based on these observations are now routinely published (Pepin et al. 2003). With over five years of continuous biological and chemical observations at Station 27, investigators are now beginning to construct short-term mean conditions, much like was done with hydrographic observations throughout the 1950s. Continued monitoring at this site will greatly increase our understanding of physical processes and long-term trends in ocean climate. It is in our understanding of ecosystem processes, however, through ongoing biological and chemical monitoring, that the most significant contribution to ocean science will likely be made in the near future.

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Exceptional Environmental Conditions in 1999 in Eastern Canadian Waters and the Possible Consequences for Some Fish and Invertebrate Stocks

Patrick Ouellet[1], François Grégoire[1], Michel Harvey[1], Erica Head[2], Bernard Morin[1], Ginette Robert[2], Louise Savard[1], Stephen Smith[2], Michel Starr[1], and Doug Swain[3]

[1]Maurice Lamontagne Institute, Fisheries and Oceans Canada, 850 route de la mer, Mont-Joli, QC, G5H 3Z4
[2]Bedford Institute of Oceanography, Fisheries and Oceans Canada, Box 1006, Dartmouth, NS, B2Y 4A2
[3]Gulf Fisheries Centre, Fisheries and Oceans Canada, 343 University Ave, Moncton, NB, E1C 9B6

Résumé

Plusieurs indicateurs des conditions atmosphériques indiquent que des températures de l'air anormalement élevées en 1999 ont entraîné une réduction de la glace de mer en hiver et au printemps sur les plateaux continentaux de Terre-Neuve, du Labrador et de la Nouvelle Écosse et une augmentation des températures de l'eau de surface sur l'ensemble de la zone Atlantique. Également, d'autres indices indiquent que le cycle de production biologique (la floraison du phytoplancton) a été initié plus tôt en 1999 dans la plupart des régions de la zone. Ces conditions océanographiques exceptionnelles auraient eu des conséquences positives sur la production (ex. recrutement, croissance) de nombreux stocks de poissons et d'invertébrés dans l'Est du Canada.

Introduction

Climate impacts on marine populations and individuals may operate through different processes, directly (e.g., influence of water temperature on metabolism, distribution) or indirectly by affecting primary and secondary production and trophic interactions in ecosystems. To understand how marine resources respond to forcing, it is important to assemble time series of biological, ecological, and climatological data and, by appropriate analyses, infer the mechanisms linking climate variability and population abundances.

Each year, the biological, chemical, and physical environmental information from different regions of the Atlantic zone (Gulf of St. Lawrence, Scotian Shelf, Newfoundland–Labrador Shelf), mostly coming from the Atlantic Zone Monitoring Program (AZMP), are reviewed by the Fishery Oceanography Committee (FOC) to produce state of the oceanic environment reports for each region. It was quickly realized that the environmental conditions in 1999 were unusual in Eastern Canada. Since then there is mounting evidence that the production of many stocks, both fish and invertebrate species, responded significantly to the particular conditions of the year 1999.

In this article, we describe and discuss briefly the atmospheric and oceanic (physical and biological) conditions for 1999 in relation to past conditions. We also document the response (recruitment) of certain fish and invertebrate stocks and attempt to establish possible links to observed environmental changes.