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DFO Atlantic Fisheries
Research Document 95/60

MPO Pêches de l'Atlantique
Document de recherche 95/60

Status of winter flounder in NAFO Division 4T, 1994

by

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Abstract

Provisional landings of winter flounder in NAFO Division 4T totalled 1161 t in 1994. This was the third consecutive year of decline since 1991 when landings were at 2535 t. Since 1960, winter flounder landings have fluctuated widely, with a minimum of 149 t in 1984 and a maximum of 4412 t in 1965. The strongest declines in winter flounder landings in 1994 occurred in Chaleur Bay (unit area 4Tm) and in the eastern Gulf (4Tf). Otter trawls contributed most of the landings (724 t). The nominal effort of otter trawls (number of days fishing) declined sharply between 1991 and 1993, but the directed effort on winter flounder by otter trawls remained stable in 1993 and 1994. Winter flounder is mainly a directed fishery, with 95% of landings in 1994 originating from directed effort. Winter flounder in 4T is not under quota management. Research survey data for 4T indicate that winter flounder are at an intermediate level of abundance relative to abundance indices since 1971. The abundance of winter flounder varies regionally within 4T, suggesting that numerous stock units contribute to the abundance of 4T winter flounder.

Résumé

Les débarquements provisoires de plie rouge dans la division 4T de l'OPANO ont atteint 1 161 t en 1994. Pour la troisième année consécutive, les débarquements ont subi un déclin, alors qu'en 1991 ils atteignaient 2 535 t. Depuis 1960, les débarquements de plie rouge ont fluctué, avec un minimum de 149 t en 1984 et un maximum de 4 412 t en 1965. Les plus forts déclins dans les débarquements de plie rouge en 1994 ont été enregistrés dans la Baie des Chaleurs (le secteur 4Tm) et dans l'est du golfe (4Tf). Des chaluts ont contribué à la plus grande partie des débarquements en 1994 (724 t). L'effort nominal par les chalutiers (le nombre de jours de pêche) a décliné entre 1991 et 1993; cependant, l'effort dirigé vers la plie rouge par les chalutiers a atteint un niveau stable en 1993 et 1994. La plie rouge est pêchée surtout avec un effort dirigé. En 1994, 95 pour cent des débarquements de plie rouge provenait d'un effort dirigé. La plie rouge de 4T n'est pas gérée avec un contingent. Les relevés scientifiques de 4T indiquent que la plie rouge est à un niveau d'abondance intermédiaire par rapport au patron d'abondance observé depuis 1971. L'abondance de la plie rouge varie par secteur de 4T, ce qui indique que plusieurs unités de stock habitent 4T.

Introduction

Winter flounder is a common coastal flatfish in the southern Gulf of St. Lawrence (NAFO Division 4T, Figure 1). The recent closure of the cod and hake fisheries and reductions in the quota allocations for other groundfish have generated concern for the future of secondary groundfish resources, such as winter flounder.

Aside from an analysis of flatfish catch rates by Clay and Nielsen (1983), no assessment was undertaken until 1994 (Morin et al. 1994). That assessment described the fishery, provided information on the catch-at-age from the commercial fishery and research surveys, and indices of abundance based on survey data (Morin et al. 1994). It was noted that over 80% of winter flounder landings since 1990 originated from a directed fishery. Data on the age composition of commercial and survey catches were also provided.

This assessment updates landings statistics and abundance indices for this resource. Further information is provided on uncertainties in landing statistics and research data.

Description of the fishery

The landings of 4T winter flounder have declined annually since 1991 (Table 1, Figure 2), although landings in 1994 (1161 t) were only marginally lower than the total for 1993 (1238 t). This difference, as well as the decline since 1991, are within the range of variability that has been observed in landing statistics since 1960 (Figure 1). Trawls continue to contribute most of the landings of winter flounder in 4T and their combined landings (724 t) remained equal to their level in 1993. Gillnets have reported relatively stable landings of winter flounder since 1986, ranging between 321 and 588 t. The most prominent change in the gear composition of the landings has been the decline in landings by seines.

The winter flounder fishery by mobile gear was disrupted in 1994 by the late opening of the fishing season in some sectors and by closures due to high bycatches of cod in areas of 4T. Mobile gear landings of winter flounder before July totalled less than two tons in 1994 (Table 2), whereas in the same months of 1993, close to 200 t were landed (Morin et al. 1994). Mobile gear landings of winter flounder peaked in September, similar to the pattern recorded in 1993. The winter flounder fishery is typically an open-water fishery with landings reported mainly from May to October (Table 2).

The landings of winter flounder that were caught in Northumberland Strait and east of PEI (unit areas 4Th and 4Tg) increased in 1994 from their level in 1993 (Figure 3). Landed catches from the outer Chaleur Bay and Gaspé coast (4Tn) also increased and in the area west of PEI (4Tl) landings remained the same as in 1993. The strongest declines occurred in the upper Chaleur Bay and east of the Magdalen Islands (4Tm and 4Tf).

Winter flounder has become a mainly directed fishery in 4T. In 1994, 1105 t of the winter flounder landings, 95% of the total landings, were declared as directed for winter flounder. Directed fisheries for American plaice and white hake contributed only about 2% of all the winter flounder landings in 1994.

The effort by otter trawls landing 4T winter flounder appears to have declined since 1991 (Figure 4). These data, recorded in vessel logbooks, indicate the number of days spent fishing. The number of days of fishing by all vessels reporting winter flounder catches declined from over 12000 days in 1991 to approximately 1500 days in 1994. Otter trawls directing for winter flounder registered approximately 2000 days in 1991 and 851 days in 1993. Effort remained the same in 1994, at 865 fishing days. Data from logbooks before 1991 were insufficient to evaluate effort in the fishery. Since not all vessels recorded effort in their logbooks, less than 10% of annual winter flounder landings from 1985 to 1990 were recorded with the number of days spent fishing. Since 1991, effort has been indicated for 47-87% of the annual landings of winter flounder by otter trawls.

Winter flounder in 4T are not under quota regulation. In 1994, some management measures came into effect for the winter flounder fishery. The approved mesh size for winter flounder became 130 mm square for Northumberland Strait and the Magdalen Islands; in Chaleur Bay and Miscou Bank, the approved mesh size became 135 mm square. The opening date of the fishery in eastern Northumberland Strait was set at July 15, a measure to protect cod and spawning white hake. The minimum size for winter flounder became 25 cm. Groundfish closures were imposed when 20%, by number, of the catch of flatfish species or 15% of roundfish were below the minimum size. No closures were reported due to winter flounder catches; however, catches of other groundfish and the regulation on the bycatch of cod (maximum 10% of weight of total catch) may have reduced fishing activity at times.

Information on the 1994 winter flounder fishery in the southeastern Gulf was provided by the regional office in that sector from discussions with fishermen and buyers (P.E. George, DFO Antigonish, N.S.). Fishermen west of Lismore reported July and September as the two best months for winter flounder in 1994, similar to past years. East of Lismore, the fishery was best in September and October. Several vessels were inactive in 1994; however, participation in the fishery was about the same as in 1993 and landings were considered better than in 1993. The market for winter flounder in this sector was excellent in 1994. One buyer reported that all winter flounder less than 11" (<28 cm) were sold as bait and the remainder sold for fillets. The price paid for winter flounder was $0.40/lb in 1994 and the quality landed was excellent. Some fishermen expressed the view that the 130-mm square mesh was the largest mesh size feasible for this fishery; however, this view was not held by all and one fishermen was satisfied with using 145-mm square mesh. Most agreed that the current mesh size prevents the capture of small winter flounder and that discarding was not common. Some fishermen appealed for closer monitoring of non-reported landings caused, in part, by a local market for fresh fillets. In general, fishermen found that the resource was more abundant in 1994 than in 1993.

The Groundfish Index Fisher Program was introduced in 1990 to obtain catch and effort data from groundfish fisheries as a fishery-based index of stock abundance, as well as to obtain observations on biological changes in fish stocks. The participants in the program are active in the groundfish fisheries and they agree to provide logbook data and information on the status of fish stocks through periodic telephone surveys. In 1994, 53 fishermen participated in the program. At the end of the fishing season, the participants responded to a telephone questionnaire concerning the 1994 groundfish fishery. Seven respondents fished for winter flounder in 1994.

Five of the 7 respondents in the program considered that groundfish closures did not significantly affect the time that they spent fishing in 1994. Most of the respondents (5) judged that they spent the same number of days fishing in 1994 as in the previous 10 years, whereas the remainder (2) felt that their effort had declined since that period. Five respondents considered winter flounder abundance in 1994 to be above average; only one respondent felt that winter flounder abundance was average and only one felt that it was below average. All of the 7 respondents considered the size of winter flounder in their catches to be average or above average. In comparing the 1994 fishing season to previous years, winter flounder fishermen were divided in their opinions. Compared to 1993, four respondents felt that it was somewhat better in 1994, one felt that it was much better, and the remainder felt that it was worse. Compared to the previous five years, the 1994 season was judged to be the same by four respondents. One respondent felt that it was much worse, one felt that it was much better, and one fisherman did not respond to the question. Compared to all of their years of experience, two of the 7 respondents judged the 1994 season to be somewhat better, three respondents considered it to be considerably worse, and two fishermen did not respond to the question.

Fishery data

The last assessment noted some difficulties in obtaining accurate landings statistics for unregulated stocks such as winter flounder. Misreporting of catches has been found through incorrect naming of the species caught, either on the vessel or when landed. In 1994, vessel logbooks were issued with a specific category for winter flounder, replacing logbooks that only identified the general category of "flounders" caught. The past designation of flounders caught was one source of error that was identified as leading to winter flounder catches being coded in official statistics as American plaice.

The winter flounder fishery in 4T is mainly conducted by vessels <45 ft. Since 1990, between 62 and 77% of the annual winter flounder landings have originated from this fleet sector. A significant portion of winter flounder catches is used for bait, mainly in lobster fisheries. Some catches may not be sold to fish buyers, so it is difficult to determine with certainty the total landings from this fishery. As noted above, some catches may be marketed directly to the public, or kept for personal consumption. Unreported catches, usually those destined for bait fisheries or personal consumption, or landings without purchase slips, are estimated periodically by fishery officers through dockside interviews. These estimated landings are entered on forms referrred to as Supplementary "B".

Supplementary "B" landings usually account for a small portion of the total annual landings of winter flounder and American plaice. In 1990, 248 t of winter flounder (12% of annual total) were estimated from Supplementary "B" forms; since then, landings of winter flounder from Supplementary "B" forms have been <3% of annual landings. From 1990 to 1992, Supplementary "B" forms contributed 5-8% of annual plaice landings. In 1993, this reached 445 t, or 24% of the annual total. Although the 1993 landing estimates by Supplementary "B" were exceptional, an analysis of the data reveals some weaknesses in this procedure. Supplementary "B" forms estimated more null catches of winter flounder than plaice. In comparison, 1993 landing statistics for vessels <45 ft indicate that null catches were more prevalent for plaice than winter flounder. Supplementary "B" forms estimate a higher ratio of plaice:winter flounder for most catch levels than are indicated by landing statistics for vessels <45 ft. This suggests that the Supplementary "B" forms tend to identify flounder catches as American plaice. In fact, the forms that fishery officers fill out at wharves do not indicate separate categories for different flounder species.

Research data

Abundance Indices

Abundance indices were calculated using catch rates in the September bottom trawl surveys conducted each year since 1971. These surveys follow a stratified design (Figure 5). Strata 401-403 have been fished only since 1984 and are not included in the analyses reported here. Nearly all (99.8%) of the winter flounder caught in the 1971-1993 surveys were caught in 10 strata (Morin et al. 1994). We restricted our analyses to these 10 strata (418-422, 428, 429, 432, 433 and 435). We used the stratified mean catch of winter flounder (number per standard 1.75-NM tow) as an index of relative abundance. To assess the significance of annual and regional variation in winter flounder catches, we used multiplicative analyses of catch rates. Winter flounder catches were transformed as *ln*(catch+0.5) and weighted by stratum area divided by the number of tows in the stratum. Models with year and stratum effects and their interaction were fitted with the GLM procedure of SAS (SAS Institute 1990). An initial analysis including all 10 'winter flounder' strata indicated that annual trends in relative abundance differed significantly among areas. Thus, we repeated this analysis for each of four subareas of the southern Gulf: the Chaleur Bay area (strata 418 and 419), the Miramichi area (strata 420 and 421), the Magdalen Islands (strata 428 and 435) and the area southeast of PEI (strata 432 and 433).

Mean catch rates of winter flounder in the ten selected strata tended to be relatively low in the early to mid-1970s (except for 1974 and 1976) and relatively high between 1989 and 1992 (Figure 6). Catch rates tended to be at intermediate levels from the late 1970s to the late 1980s and in 1993 and 1994. However, annual variation in catch rate was not statistically significant in the multiplicative analysis of the ten winter flounder strata (F=1.38, df=23,686, P=0.1). This analysis revealed a highly significant year*stratum interaction (F=1.43, df=204,686, P=0.0005). This indicates that annual trends in relative abundance of winter flounder differed among subareas of the southern Gulf.

There was no significant trend in abundance over time in the Chaleur Bay area (Figure 7; P=0.54). In the area southeast of PEI, annual variation in abundance approached significance (P=0.07) after dropping the non-significant (P=0.97) interaction term from the model. Catch rates in this subarea tended to be highest in the mid-1970s and late 1980s, and have declined to relatively low values in recent years (Figure 7). Annual variation in abundance was significant (P=0.04) in the Magdalen Island area after dropping the non-significant (P=0.55) interaction term from the model. Catch rates of winter flounder in this area tended to be high from the mid-1970s to the early 1980s and declined to low levels in recent years. The 1994 catch rate, although higher than the very low 1989-1993 values, remained low relative to the high values of the mid-1970s to early 1980s. All model terms (year, stratum and their interaction) were highly significant (P<0.01) for the Miramichi subarea. Catch rates in this area were relatively low throughout the 1970s, increased through the 1980s to peak values in 1990-1992, and then declined to intermediate levels in 1993 and 1994 (Figure 7). The high catch rates in the Miramichi area in 1989-1992 were due to catches in stratum 421 (Figure 8A). Variation in catch rates differed between the two strata in this subarea in recent years: in stratum 421, catch rates were relatively high in 1989-1992 and low in 1993 and 1994, whereas in stratum 420 catch rates were low in 1989-1990 and relatively high in 1991-1994 (Figure 8B).

Winter flounder inhabit inshore areas and appear to move into estuaries to overwinter (see section on ecological considerations). It is possible that winter flounder in the southern Gulf comprise a number of local stocks with localized movements, as has been observed elsewhere (McCracken

1963, Phelan 1992). The significant differences between regions in abundance trends is consistent with this possibility.

Catch rate time series for winter flounder show considerable annual fluctuation in the southern Gulf (Figures 6 and 7). Winter flounder are distributed in shallow water along the inshore edge of the September survey. Annual variation in the depth distribution of winter flounder and of sampling in the September survey (Morin et al. 1994) could contribute to these fluctuations. This variation in depth distribution suggests that the proportion of winter flounder occurring outside of the survey area has varied from year to year. Unfortunately, we know of no way to correct for this source of error in our estimates of relative winter flounder abundance.

Length frequencies

We examined the length composition of winter flounder catches in the two subareas showing the strongest annual trends in abundance. The stratified mean length frequencies of winter flounder are shown in Figure 9 for strata 420 and 421 and in Figure 10 for strata 428 and 435 from 1971 to 1994. Figure 11 illustrates the trends in key parameters of the length-frequency distributions. The mode, mean, maximum length and minimum lengths varied considerably from one year to the next. The slopes of linear regressions set to each parameter for strata 420 and 421 were negative. The slope of maximum length regressed on year was not significantly different from zero (P=0.35). All other parameters declined over the years, as indicated by significant negative slopes (P=0.0001-0.004). None of the same parameters for length-frequencies in strata 428 and 435 provided significant linear regressions on years (P=0.47-0.96). The maximum size of winter flounder in 428 and 435 fluctuated widely and showed no trend over the years. The modal and mean lengths appear to have increased in the early to late 1980s and to have declined recently. The minimum size may also have increased up to the late 1980s and to have declined since then (Figure 11). Winter flounder were not caught in strata 428 and 435 in 1990.

Age determination

The last assessment of 4T winter flounder reported commercial and survey catch-at-age for the years 1990-1993 (Morin et al. 1994). The DFO Gulf Region undertook the age determination of 4T winter flounder in 1992 following a period of at least 10 years during which age determination was not performed. In 1993, past collections of winter flounder otoliths were read, resulting in catch-at-age data for 1990 and 1991. The age determinations followed procedures that ensure continuity in the interpretation of age readers over time. A reference collection was established that consisted of otoliths read by the last reader of 4T winter flounder (M. Strong, DFO St. Andrew's). Through consultation, the current reader calibrated her readings and interpretations to be consistent with the previous reader. The procedures outlined by Chouinard et al. (1987) for calibration and error testing were then followed. These consist of reading 100 otoliths selected randomly from the reference collection at the outset of age determinations and after every week or 1000 otoliths read. With each reading of the reference collection, the reader was tested for bias with the established ages of the collection.

Our procedures maintain consistency in age reading but do not test against other reading procedures, nor against readers who determine the age of other winter flounder stocks. Winter flounder otoliths in 4T groundfish surveys and commercial sampling were collected at a rate of one/sex/cm/set and preserved in vials containing a glycerine-thymol solution before being read whole.

Preserving otoliths in glycerine solutions serves to clear opaque otoliths (Jearld 1983). The disadvantage of the procedure is that the otoliths soften and erode over several years. The procedure is costly in vials and more inconvenient at sea than dry storage of otoliths. Most studies of winter flounder age determination rely on dry storage of the otoliths with readings performed whole or sectioned (reviewed by Haas and Recksiek 1995).

During the 1993 groundfish survey of 4T, winter flounder otoliths were collected according to the standard procedure of one/sex/cm/set, preserved in glycerine-thymol solution. A second collection of one/sex/cm/set was made of winter flounder otoliths preserved dry. This resulted in 864 otolith pairs preserved in glycerine-thymol for the annual survey age-length key and 536 otolith pairs collected for experiments on age determination.

The collection of dry winter flounder otoliths was used to address three questions:

1. Are winter flounder otoliths, read whole, as readable when preserved dry as when preserved in glycerine-thymol solution?

2. Do otoliths read whole give the same ages as otoliths that are sectioned?

3. Do our interpretations of 4T winter flounder ages agree with those of other readers with equal expertise in the age determination of winter flounder?

The first question was addressed by examining winter flounder otoliths in different media: water, alcohol, mineral oil and glycerine-thymol. It was not possible to examine the same otolith in each medium, particularly because after prolonged immersion glycerine-thymol penetrates the otolith structure. Our procedure consisted of judging the visibility of key features of the otolith: the central hyaline core or "focus" of the otolith, early hyaline bands, and edge features of the otolith. All of these features were equally visible for whole otoliths immersed in mineral oil as they were in otoliths of similar age and size preserved in glycerine-thymol solution.

The sectioning of otoliths, either by breaking and reading the median cross section or thin sectioning the otolith, can expose annuli that are not visible when the otoliths are read whole. Some fish species deposit material on the medial surface of the otolith after several years of growth. This feature was first noted in long-lived species with ages >20 years (e.g. Power 1978, Beamish 1979); however, it has been shown with more short-lived species, including flounders (Campana 1984). An experiment was performed on 48 pairs of otoliths ranging in age from 5-10 years. One otolith was read whole with reflected light, immersed in mineral oil. The other otolith of the pair was broken through the focus and the broken surface was moistened with mineral oil and read under reflected light. Preliminary tests had been conducted with otoliths burned before breaking, but it was felt that this procedure was not necessary.

Age readings of burned and whole otoliths agreed in 32 of the 48 comparisons (67% agreement). We considered this level of agreement to be low in comparison to the level of agreement that we require for routine calibration of otolith readers (80%). However, all of the disagreements were distributed among winter flounder of 6-9 years of age and only 4 disagreements were of more than one year. Most of the disagreements were attributed to interpretations of early growth rings and edge growth on sectioned otoliths and were resolved in subsequent readings. It was not clear that sectioning the otoliths rendered more growth visible than could be seen by reading the otolith whole.

Readings have been subsequently made on whole otoliths with periodic verification of sectioned otoliths.

A comparison of age determinations was made with readers at the Northeast Fisheries Science Center (J. Burnett, NFSC, Woods Hole, MA). A collection of 151 otoliths were read by a DFO reader and sent to NFSC. The NFSC readers were informed of the date of sampling, but all other data (length, weight, sex) were withheld. Age determinations differed strongly between readers across all ages, including age-1 winter flounder (Figure 12). In almost all cases the DFO reader interpreted the otoliths as older than the NMFS readers. The otolith readers at NMFS noted false annuli in some otoliths that they attributed to female maturation. Maturation and sex could not account for the difference in age interpretations between the two groups of readers, since the readings diverged at pre-spawning ages and a similar pattern of disagreement was noted for male winter flounder (Figure 13). Other differences were noted in the interpretation of the last growth annulus; however, this difference appeared in less than half of the cases of disagreement and could only account for a one-year difference. Clearly, the most common source of disagreement was on the formation of annuli and the identification of false annuli.

We sampled winter flounder to determine whether otoliths form growth rings that are not observed in other aging structures from the same fish. Scales, dried vertebrae and otoliths were obtained from 10 winter flounder in July 1994 from Cap Pelé, New Brunswick. We collected young winter flounder (8-20 cm, age <5 years) because growth is rapid in early years and growth rings are usually easily identified. Differences between the DFO and NMFS readers were apparent for winter flounder over this range of size and age. Vertebrae indicated the same number of growth rings as otoliths in all but one case where one more annulus was visible at the edge of the vertebra than the otolith. The interpretation of winter flounder scales was more difficult and tended to indicate fewer annuli than otoliths or vertebrae.

We examined length-frequencies of winter flounder from groundfish surveys to compare modal lengths at 1-3 years-of-age with mean length at age determined by reading otoliths. Age-1 winter flounder are poorly represented in groundfish surveys and length modes appear to overlap for winter flounder aged 2 years and older (Figures 9 and 10). Over 1000 winter flounder were measured in 11 samples from smelt trapnets in the Miramichi estuary of New Brunswick from October 24-November 25, 1994 (T. Hurlbut, DFO Moncton, unpublished data). A mode appeared at 10 cm that would correspond to age-1 winter flounder by our age determinations.

The NMFS otolith readers are presently reviewing their interpretations of the 4T winter flounder samples. In view of the strong disagreement between readers, age determination of 4T winter flounder has been suspended.

Assessment results

The nominal landings of winter flounder in 4T have averaged 1961 t since 1960, varying widely from one year to the next. The landings of 4T winter flounder in 1994 (1161 t) were considerably lower than the longterm average, but similar to landings in 1993. A decline was noted since 1991; however, this decline may be within the variability observed in landing statistics on this resource. Landings by otter trawls, the main gear component in this fishery, have declined since 1991. The fishing effort by otter trawls also appears to have declined, even though the winter flounder fishery has become subject to increasing directed effort.

Current indices of stock abundance, based on research surveys, indicate that 4T winter flounder are at an intermediate level of abundance relative to data since 1971. Winter flounder in 4T probably comprise numerous stocks that vary regionally in abundance.

Ecological considerations

Seasonal Distribution

The spring abundance and distribution data for the southwestern Gulf were obtained from a demersal fish survey conducted on the *CSS Alfred Needler* during April 1991. The southeastern half of the Gulf was surveyed by the *r/v Lady Hammond* during May 1986.

The summer abundance and distribution data were collected from one demersal fish survey that covered the whole southern Gulf, one survey in the southeastern Gulf, and one survey in the southwestern Gulf. The surveys that covered the whole southern Gulf were conducted on the *CSS Alfred Needler* (August 1992). The surveys that covered only the southeastern (late June 1987) and southwestern (July 1990) Gulf were conducted on the *r/v Lady Hammond.*

The autumn abundance and distribution data were collected during annual groundfish abundance surveys of September 1990, 1991, and 1992. These surveys covered the entire southern Gulf of St. Lawrence and were conducted on the Canadian research vessel *CSS Alfred Needler* (1992) and the charter research vessel *r/v Lady Hammond* (1990 and 1991).

The winter abundance and distribution data were obtained from a variety of surveys. Data for the Laurentian channel were obtained from demersal fish surveys done on the *r/v Gadus Atlantica,* which used an Engel high lift trawl (wing width 14.9 m; 19 mm liner in the extension piece and cod end). Two surveys were conducted in open water and in ice of the Laurentian channel during January 1983 and 1984. A third survey was conducted on the *CSS Alfred Needler* along the Laurentian Channel from near the Magdalen Islands to Misaine Bank during January 1994. The eastern Gulf between the Laurentian Channel and eastern end of P.E.I. was surveyed in early December 1986 on the *r/v Lady Hammond* and a second survey was conducted during mid-January 1987 on the *CSS Alfred Needler.* A demersal fish survey was conducted on the *r/v Lady Hammond* in the western part of the southern Gulf (including sets in the Laurentian Channel) at the end of November 1990. Two demersal fish surveys were conducted on the *CSS E.E. Prince,* using a Yankee 36 trawl (wing width 10.7 m; 12 mm mesh liner in the extension piece and cod end) in Chaleur Bay, Miramichi Bay, and the east end of P.E.I. during December 1991 and 1992.

Number per standardized tow and stratified mean number per tow were determined using the research survey analysis program RVAN (Clay 1989) written in SAS/IML.

During spring, no winter flounder were caught in the Laurentian Channel and very few were caught in the area between the Magdalen Islands and Quebec (Figure 14). In general, the largest numbers of winter flounder were caught near shore. There was only one set where >100 fish were caught; it was located at the eastern end of Prince Edward Island.

Winter flounder were only found in nearshore areas during summer. The largest concentrations (> 500 fish tow^{-1}) were observed at either end of P.E.I. and none were collected in the Laurentian Channel or most of the central area of the southern Gulf. Very few winter flounder were caught near the Magdalen Islands or in Chaleur Bay but this may have been due to the fish concentrating in very shallow water.

During autumn, nearly all winter flounder were collected from nearshore areas; none were caught in the deep water of the Laurentian Channel or in the central areas of the southern Gulf. Similar to spring, there appeared to be four groupings of winter flounder: Chaleur Bay; Miramichi Bay and western P.E.I.; Eastern P.E.I.; and near the Magdalen Islands. Part of the strait between P.E.I. and the mainland (Northumberland Strait) could not be trawled due to the presence of lobster traps and no attempt was made to trawl this area during other seasons. Although this was a small fraction of the total survey area, it was an area of high winter flounder abundance; therefore, the trawlable population estimates reported in this study were likely underestimates.

During early winter, substantially fewer winter flounder were captured in sets done at both ends of P.E.I. than during autumn. Small numbers of winter flounder were caught at a greater distance from shore during winter compared with summer and autumn, which suggests that some fish moved to slightly deeper water for the winter and would, therefore, have to withstand the February bottom temperatures of near -1.5°C (Petrie 1990). Nevertheless, the majority of the fish appeared to leave the southern Gulf. No winter flounder were caught in the Laurentian channel; thus, the hypothesis that winter flounder overwinter in the deep warm water of the channel was refuted.

Abundance

Abundance estimates were obtained from strata 420, 421, 422 and 423 using the RVAN program (Clay 1989) written in SAS IML. The estimated (± S.D.) abundance of winter flounder near the north end of Prince Edward Island (P.E.I.) and offshore of the Miramichi Estuary (approximately NAFO 4Tl) increased from 2.0 ± 0.36 million fish during spring ice-melt to 21.4 ± 9.82 million fish during early summer. During autumn 1990, the estimated population was 79.1 ± 23.26 million fish compared with 56.0 ± 25.32 million fish during autumn 1991. Given the wide standard deviations, the two September estimates likely do not differ significantly. Many of the largest sets in all surveys were at the western end of Northumberland Strait suggesting that a significant portion of the population was not sampled. The estimated abundance during early winter 1990, 2.49 ± 0.73 million fish, was almost identical to that observed during spring 1991. This suggests that at least 77 million fish left the Miramichi Bay area between September and the end of November. Many of these fish may have entered large estuaries, such as the Miramichi (McKenzie 1959; Hanson and Courtenay 1995; J. M. Hanson and S. C. Courtenay, unpublished data).

References

Beamish, R.J. 1979. New information on the longevity of Pacific ocean perch (*Sebastes alutus*). J. Fish. Res. Board Can. 36:1395-1400.

Campana, S.E. 1984. Comparison of age determination methods for the starry flounder. Trans. Am. Fish. Soc. 113:365-369.

Chouinard, G.A., L. Currie and J. Murphy. 1987. Re-examination of 4T-4Vn (Jan-Apr) cod otoliths for the period 1982-1985. (Including a report of the 4T-4Vn (Jan-Apr) cod ageing workshop held June 22-24, 1987 in Moncton, N.B.). CAFSAC Res. Doc. 87/99.

Clay, D. 1989. RVAN: Research vessel analysis programs. Can. Man. Rep. Fish. Aquat. Sci. 2044:133p.

Clay, D. and G. Nielsen. 1983. Flatfish statistics in the Gulf of St. Lawrence, with a review of 4T white hake. CAFSAC Res. Doc. 83/75.

Haas, R.E. and C.W. Recksiek. 1995. Age verification of winter flounder in Narragansett Bay. Trans. Am. Fish. Soc. 124:103-111.

Hanson, J.M. and S.C. Courtenay. 1995. Seasonal abundance and distribution of fishes in the Miramichi Estuary. Can. Spec. Publ. Fish. Aquat. Sci. 123:141-160.

Jearld, A. 1983. Age determination. p. 301-324. *In:* L.A. Nielsen, D.L. Johnson and S.S. Lampton (eds.). Fisheries techniques. American Fisheries Society, Bethesda, Maryland. 468 p.

McCracken, F.D. 1963. Seasonal movements of the winter flounder, *Pseudopleuronectes americanus* (Walbaum), on the Atlantic coast. J. Fish. Res. Board Can. 20:551-586.

McKenzie, R.A. 1959. Marine and freshwater fishes of the Miramichi River and Estuary, New Brunswick. J. Fish. Res. Board Can. 16:807-833.

Morin, R., D. Swain, I. Forest-Gallant and R. Hébert. 1994. Status of winter flounder in NAFO Division 4T. DFO Atl. Fish. Res. Doc. 94/48.

Petrie, B. 1990. Monthly means of temperature, salinity and sigma-t for the Gulf of St. Lawrence. Can. Tech. Hyd. Ocean Sci. 126.

Phelan, B.A. 1992. Winter flounder movements in the Inner New York Bight. Trans. Am. Fish. Soc. 121:777-784.

Power, G. 1978. Fish population structure in Arctic lakes. J. Fish. Res. Board Can. 35:53-59.

SAS Institute. 1990. SAS/STAT user's guide, version 6, edition 4. SAS Institute Inc., Cary, NC. 1686 p.

Table 1. Yearly landings of winter flounder in NAFO Division 4T by major gear types. Gear codes: OTB=otter trawls (unspecified), OTB1=otter trawls side, OTB2=otter trawls stern, SNU=seines, GNS=gillnets, LLS=longlines.

	GEAR							
YEAR	OTB	OTB1	OTB2	SNU	GNS	LLS	OTHER	TOTAL
1960	730	0	0	137	0	17	16	900
1961	1043	0	0	452	1	2	98	1596
1962	1407	0	0	642	115	8	140	2312
1963	2324	0	0	697	66	15	46	3148
1964	2247	0	0	546	0	0	209	3002
1965	4026	0	0	217	12	89	68	4412
1966	0	2639	1	300	53	0	63	3056
1967	0	1853	17	464	58	33	19	2444
1968	0	423	1	107	16	2	1	550
1969	0	1251	12	51	0	12	368	1694
1970	0	1724	85	576	142	21	136	2684
1971	0	1708	61	572	79	23	378	2821
1972	0	1191	2	533	36	44	16	1822
1973	0	1470	336	390	29	42	33	2300
1974	0	1323	6	388	23	4	176	1920
1975	0	1559	18	254	35	3	141	2010
1976	4	1738	400	96	24	3	142	2407
1977	0	709	194	48	24	6	254	1235
1978	0	571	173	104	77	13	183	1121
1979	0	944	336	52	64	10	179	1585
1980	1247	17	0	80	274	147	211	1976
1981	1563	42	0	30	215	16	75	1941
1982	1652	0	0	32	579	1	41	2305
1983	1405	0	8	131	231	7	17	1799
1984	0	6	37	32	13	4	57	149
1985	2	71	862	56	97	38	54	1180
1986	0	66	1101	243	538	6	90	2044
1987	0	20	804	307	526	85	69	1811
1988	0	24	759	280	321	20	10	1414
1989	0	109	1082	392	469	37	0	2089
1990	0	4	1167	274	588	32	12	2077
1991	1	49	1825	181	344	15	120	2535
1992*	0	43	1190	226	324	4	106	1893
1993*	0	16	710	64	387	2	58	1238
1994*	0	83	641	32	399	3	3	1161
MEAN	504	562	338	257	176	22	103	1961

* Provisional data

Table 2. Preliminary landings (t) of 4T winter flounder in 1994 by gear and month. Asterisk indicates values less than 50 kg. Gear types: OTB1= otter trawl (side); OTB2= otter trawl (stern); PTM= pair trawl; SDN= Danish seine; GNS= set gillnets; LL= longlines; LHP= handlines; FIX= traps.

	MONTH												
GEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
OTB1	0.0	0.0	0.0	0.0	0.0	0.0	24.0	13.1	41.1	5.3	0.0	0.0	83.5
OTB2	0.0	0.0	0.0	0.0	0.6	1.2	48.0	140.6	330.9	119.0	0.5	0.0	640.8
PTM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.3
SDN	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.3	21.3	5.8	0.0	0.0	31.8
GNS	0.0	0.0	0.0	0.0	14.3	153.3	81.9	63.1	84.5	2.0	0.0	0.0	399.1
LL	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0*	0.0*	0.0*	0.0	0.0	2.0
LHP	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.2	0.0	0.0	0.0	1.2
FIX	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.2	0.0	0.0	2.6
TOTAL	0.0	0.0	0.0	0.0	17.3	154.5	156.7	221.9	478.0	132.4	0.5	0.0	1161.3

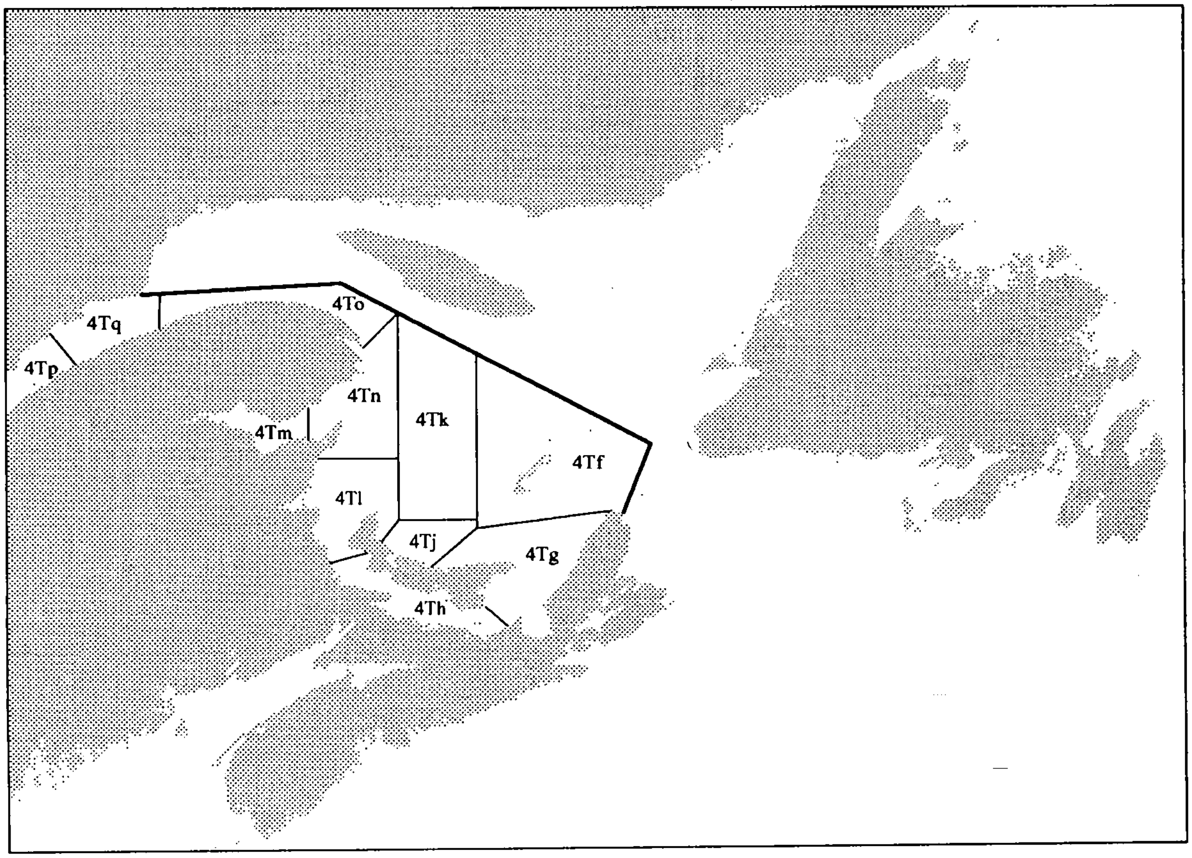

Figure 1. Gulf of St. Lawrence showing unit areas of NAFO Divisions 4T.

Figure 2. Nominal landings of winter flounder in 4T.

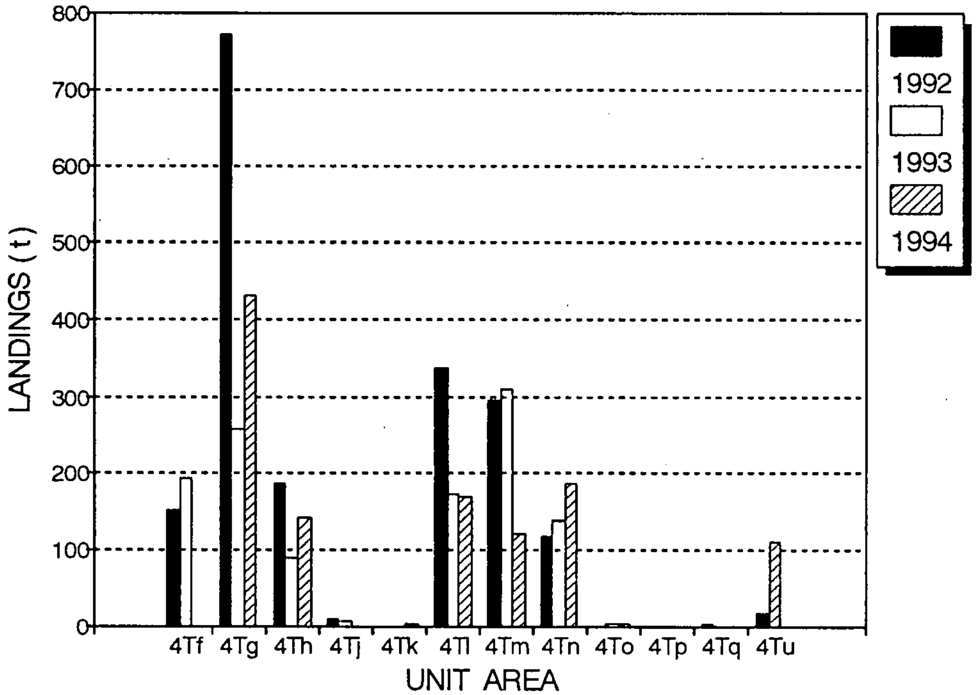

Figure 3. Nominal landings of winter flounder by unit area of 4T.

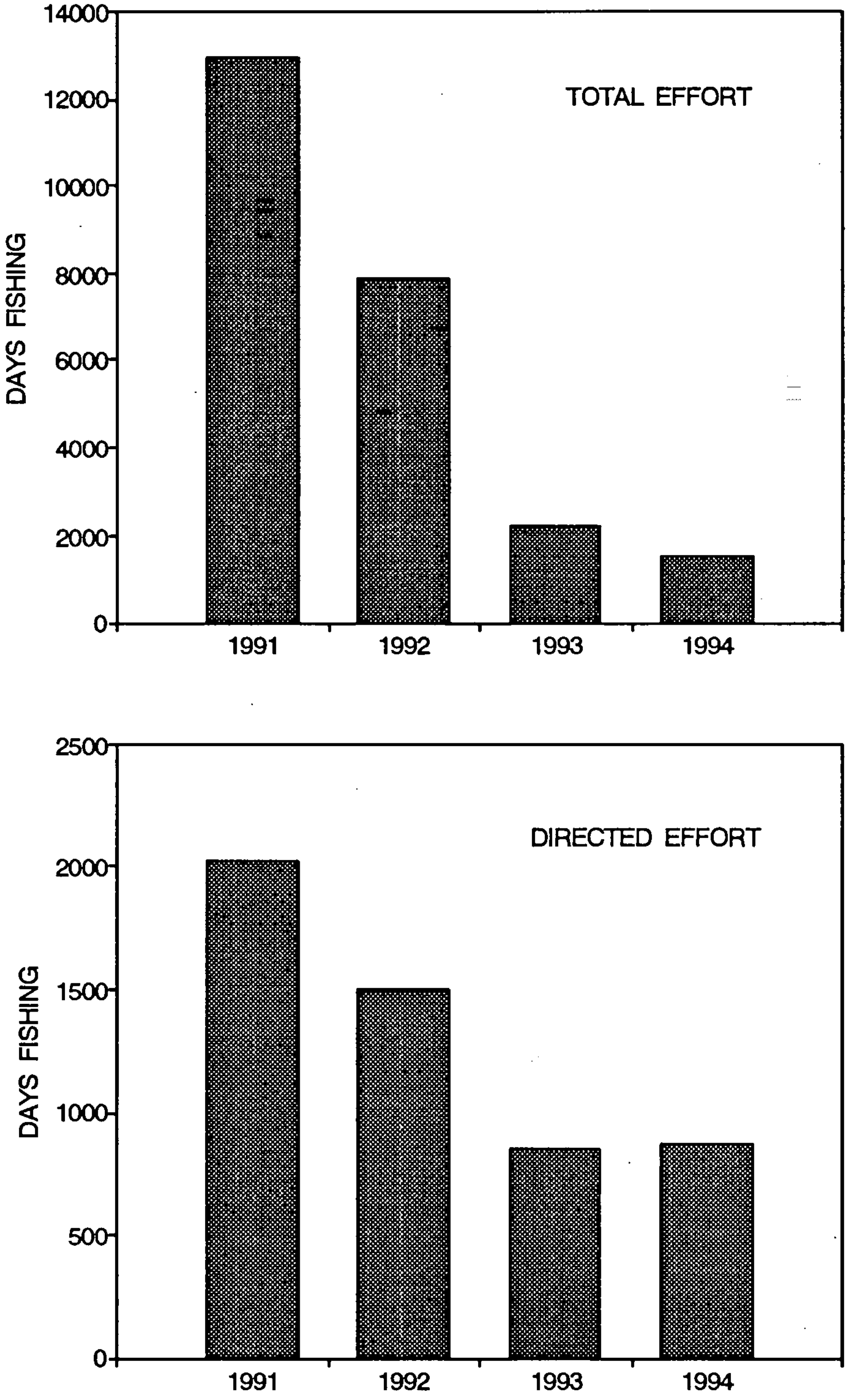

Figure 4. The number of fishing days by all otter trawls landing 4T winter flounder (upper panel) and by otter trawls directing for winter flounder.

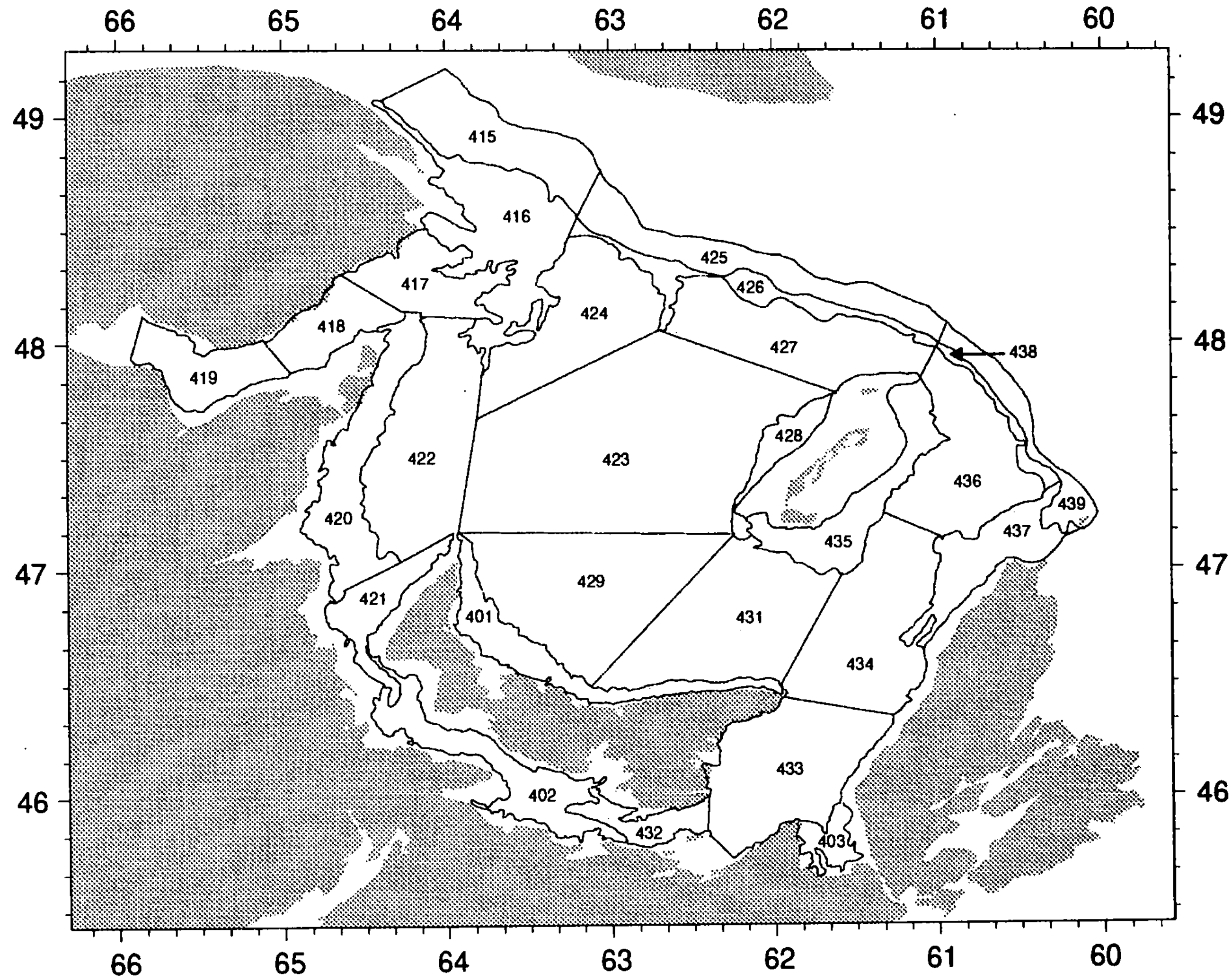

Figure 5. Stratification for the September groundfish survey of the southern Gulf of St. Lawrence.

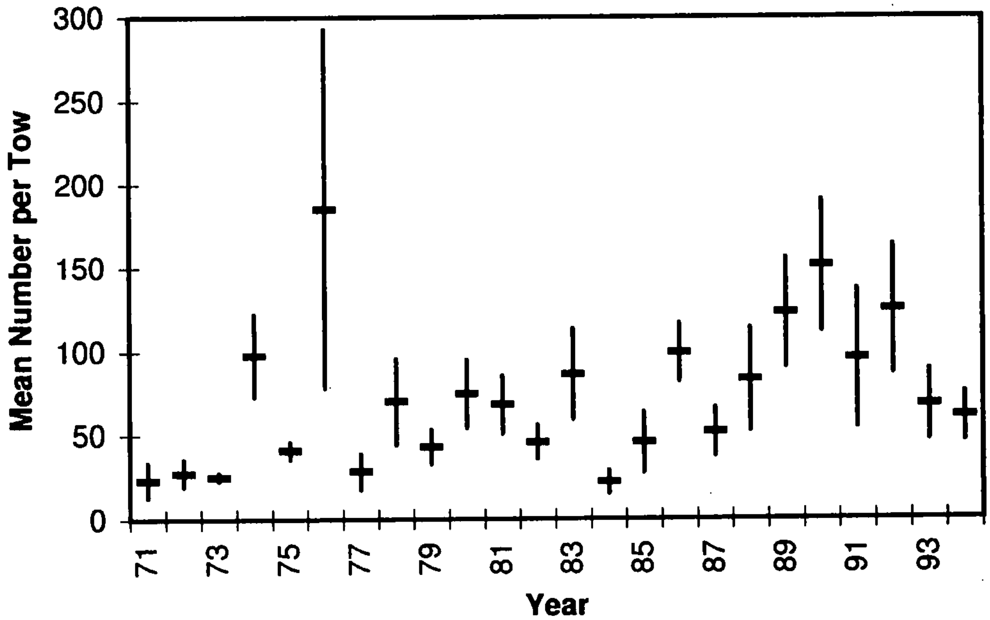

Figure 6. Mean catch per standard tow of winter flounder in selected strata of the September bottom trawl survey of the southern Gulf of St. Lawrence. Horizontal lines show the stratified mean and vertical lines are +/- one standard deviation.

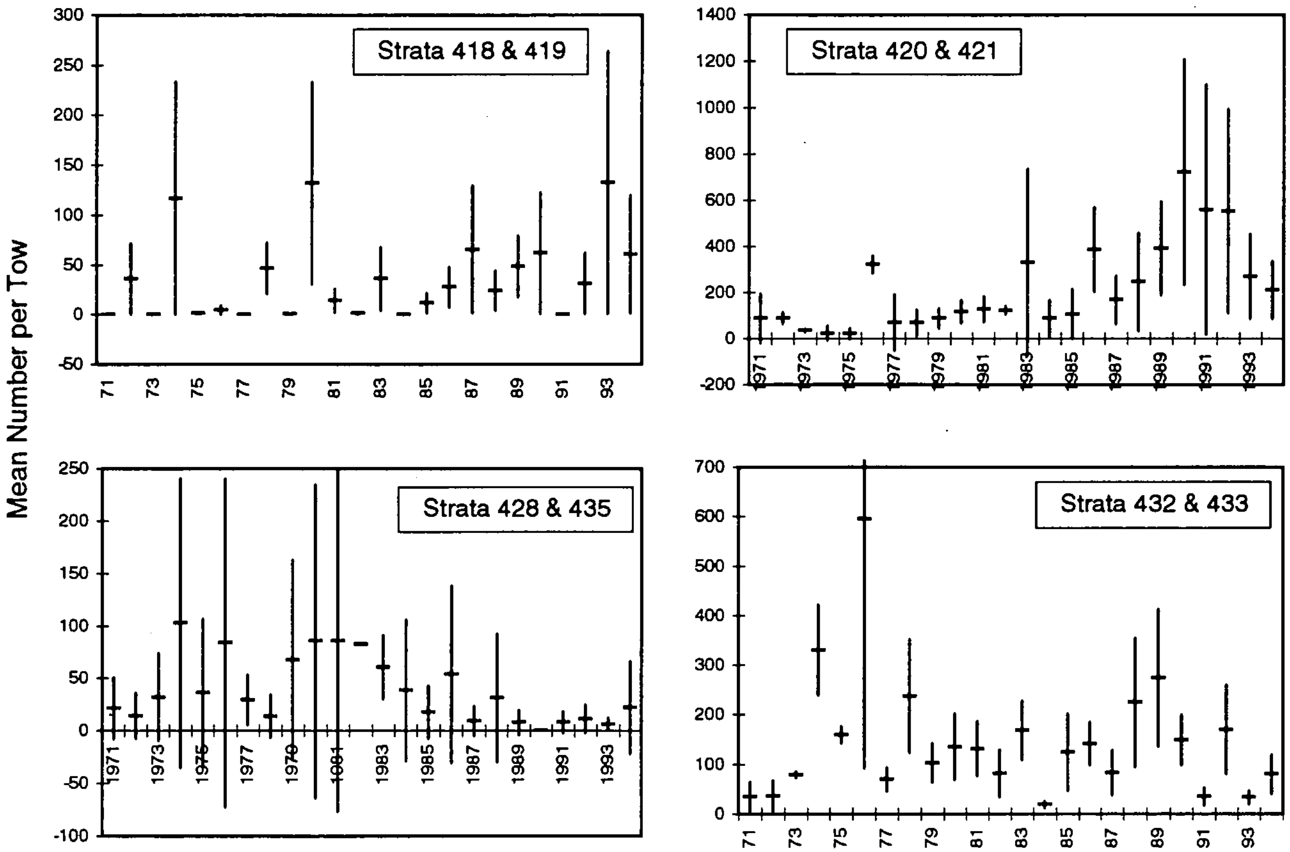

Figure 7. Catch rates of winter flounder in subareas of the southern Gulf of St. Lawrence. Data are from September bottom trawl surveys. Horizontal lines show the stratified mean catch per standard tow. Vertical bars are +/- one standard deviation.

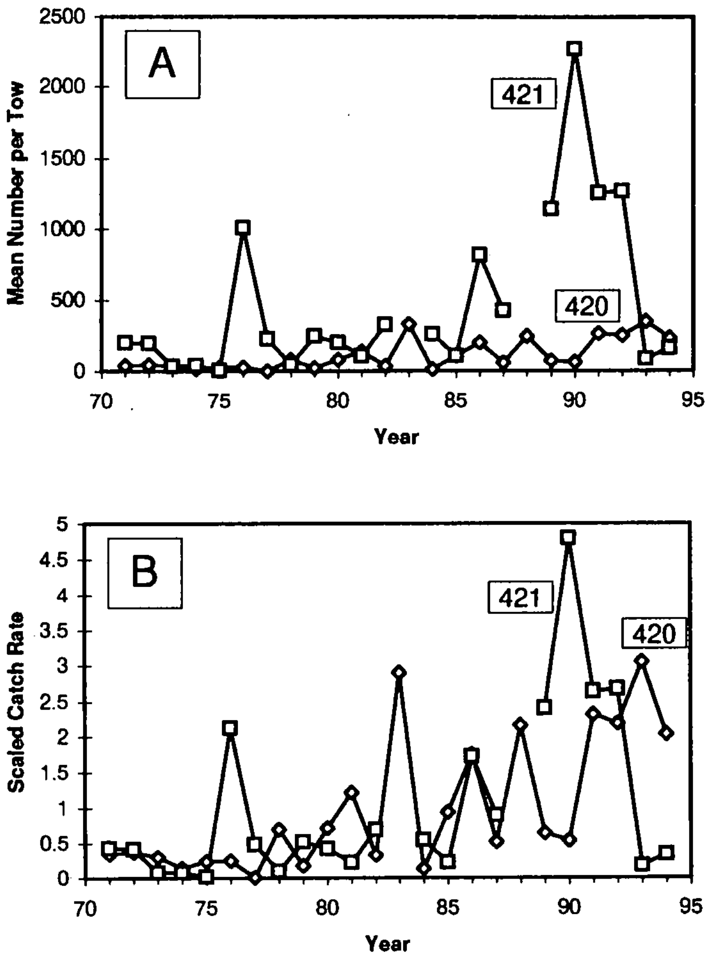

Figure 8. Catch rates of winter flounder in strata 420 and 421, September 1971-1994. A: mean number per tow. B: mean number per tow divided by the stratum average over the time series. Stratum 421 was not sampled in 1983 and 1988.

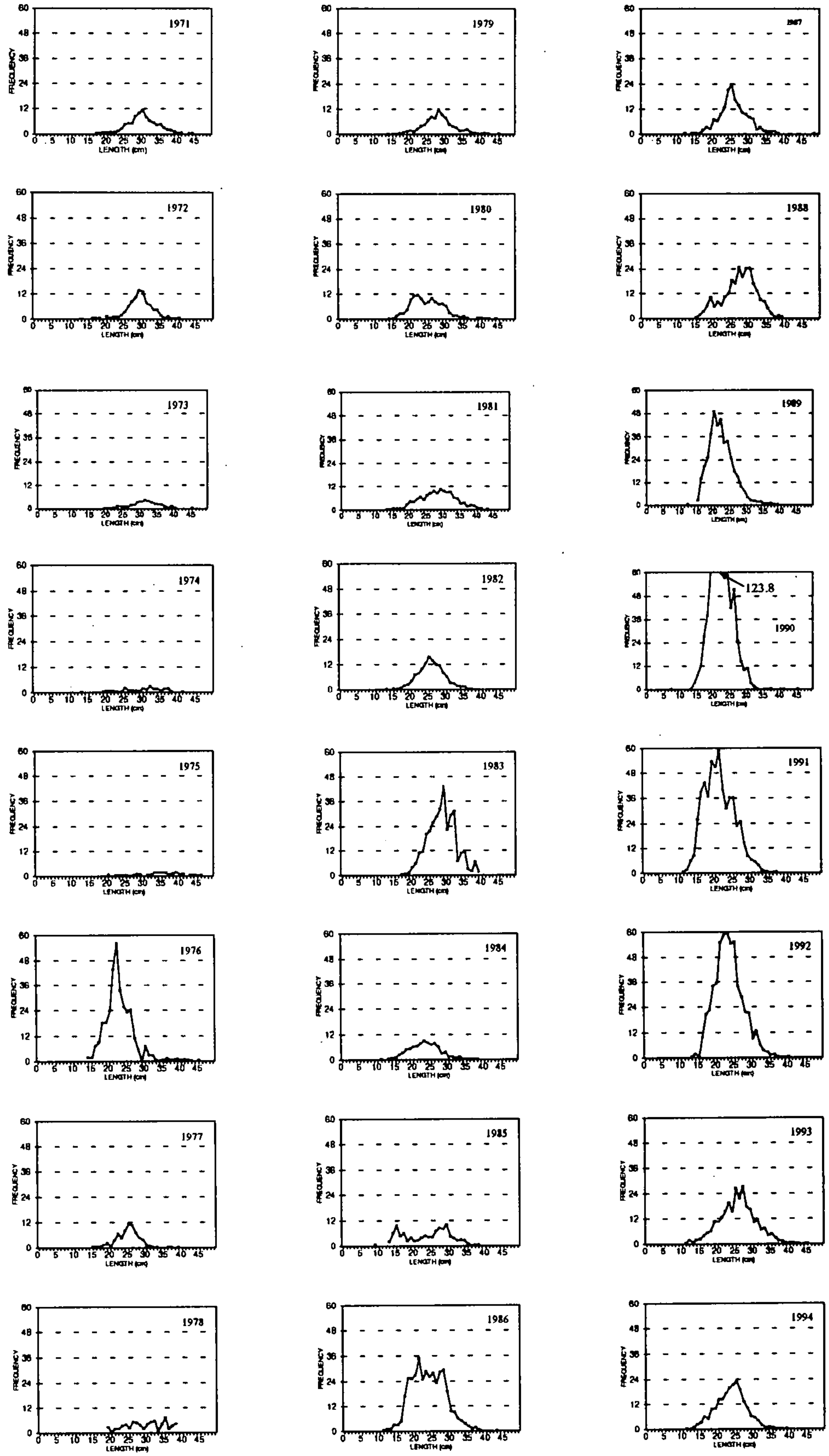

Figure 9. Mean length frequency of winter flounder in the SW Gulf of St. Lawrence (strata 420 and 421).

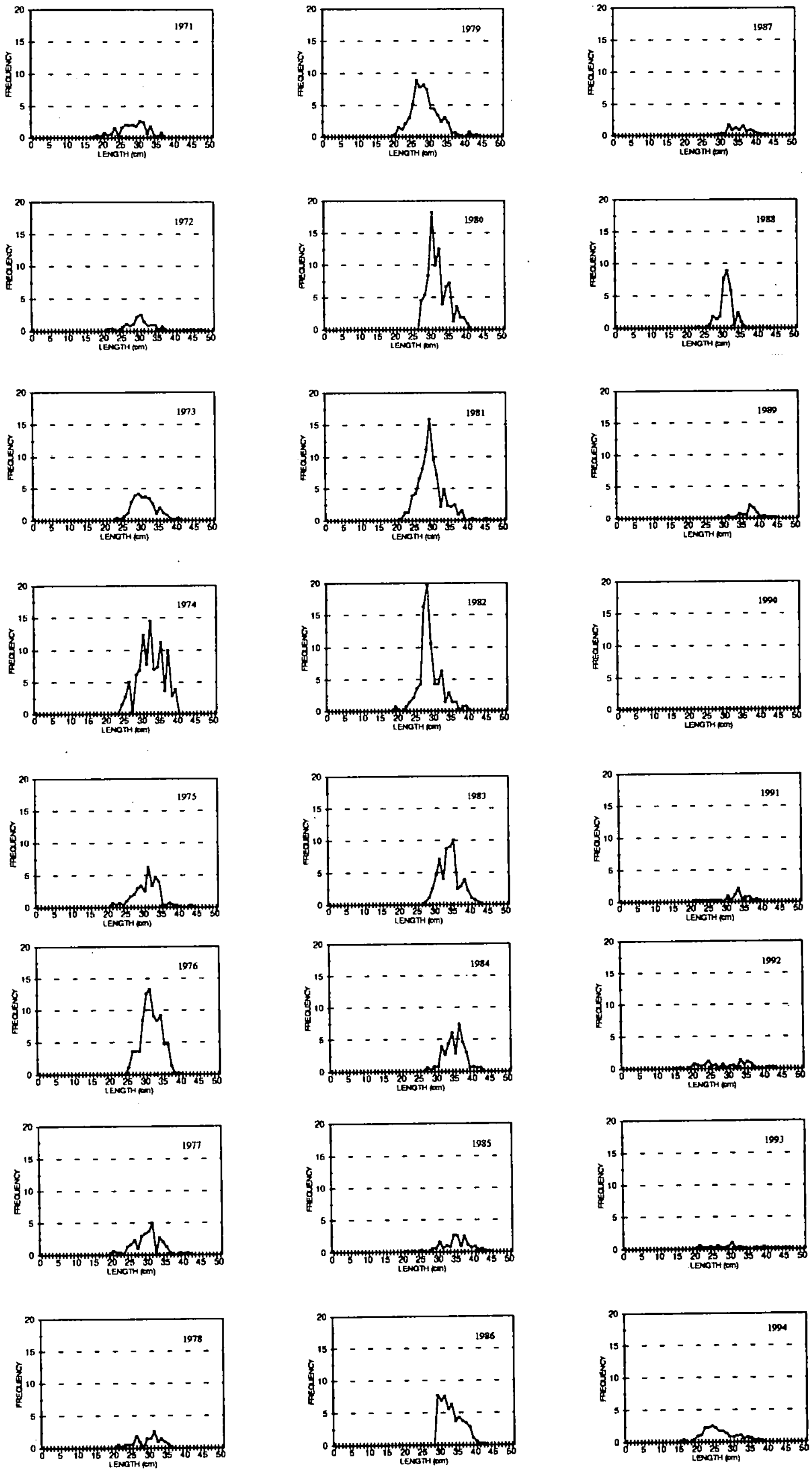

Figure 10. Mean length frequency of winter flounder in the Magdalen Island region (strata 428 , 435), from research surveys

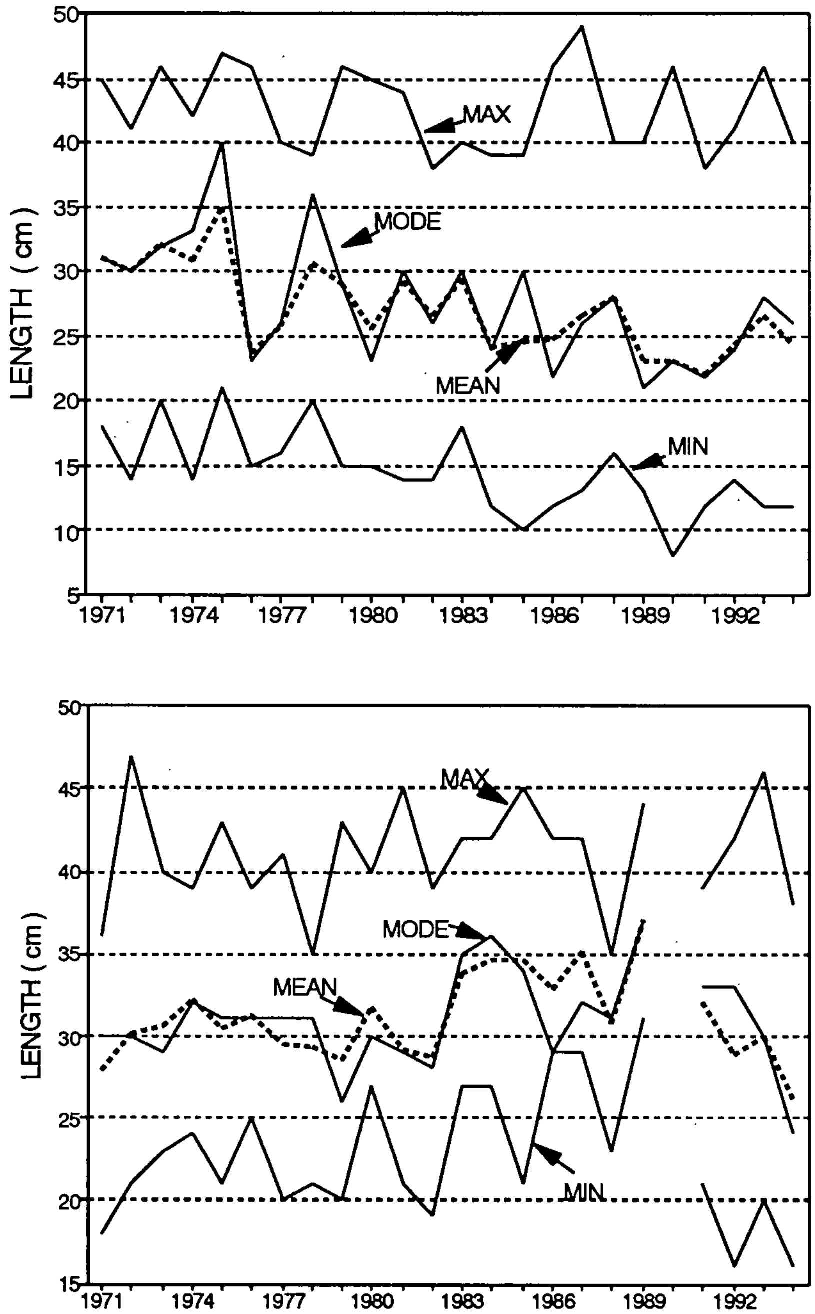

Figure 11. Parameters of length frequencies of winter flounder in research surveys of strata 420 and 421 (upper panel) and strata 428 and 435 (lower panel).

NMFS

DFO

	1	2	3	4	5	6	7	8	9	10
1	2									
2	4	15								
3		11	9							
4			5	1						
5		1	3	11	1					
6			2	10	6	2				
7			1	4	8	7	1			
8				4	5	4	6	1	1	
9					1	1	3	2		
10						5	3	3	1	1
11					1		2	1	1	
12								1		

Figure 12. Comparison of age readings of winter flounder by technical staff of the Northeast Fisheries Center (NMFS) and the Department of Fisheries and Oceans, Gulf Region (DFO). The first row and column indicate the ages read by each group and the remaining squares indicate the number of fish of that age. Shaded boxes on the diagonal indicate the number of cases of agreement between the two groups of readers.

NMFS

DFO	1	2	3	4	5	6	7	8	9
1	1								
2	3	5							
3		5	5						
4			3	1					
5			1	1					
6			2	5	3	1			
7			1	2	4	2	1		
8				2	4		3		
9					1		3		
10						2	1		1
11					1		1	1	
12								1	

Figure 13. Comparison of male winter flounder (see previous Figure caption).

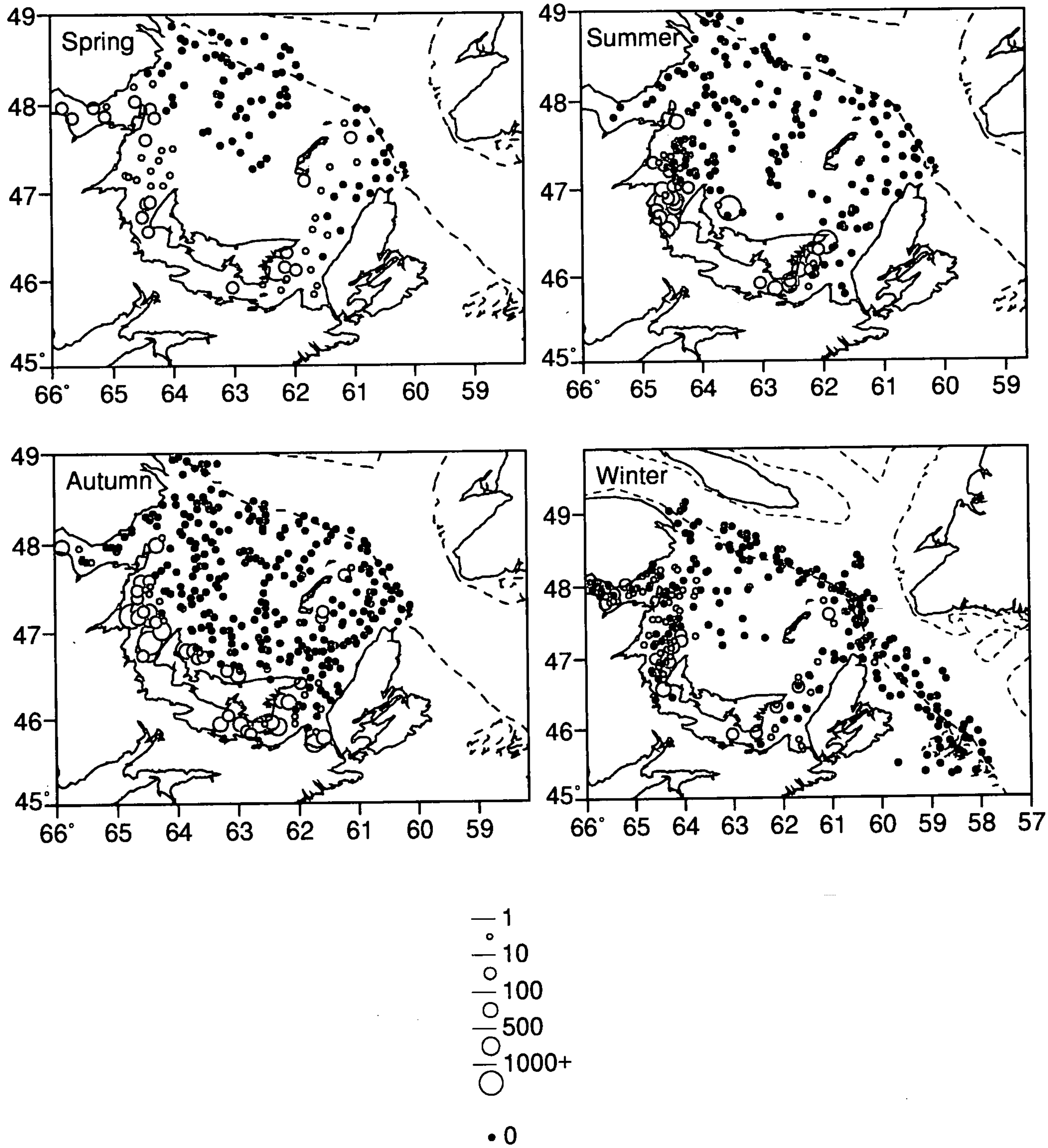

Figure 14. The seasonal distribution of winter flounder. Circles indicate the location and abundance (number per tow) of winter flounder in research surveys.