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Assessment of NAFO Division 4T winter flounder in 1996

R. Morin and I. Forest-Gallant

Department of Fisheries and Oceans
Science Branch
Maritimes Region
Gulf Fisheries Centre
P.O. Box 5030
Moncton, New Brunswick
E1C 9B6

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Abstract

Provisional landings of winter flounder in NAFO Division 4T in 1996 increased marginally to 745 t from 662 t reported in 1995. Landings have declined yearly from 2535 t in 1991 and the 1996 landings were considerably lower than the longterm average of 1899 t for the period of 1960-1996. Winter flounder have been used widely in 4T for lobster bait. As a result, misreporting and unreported catches have contributed to large year-to-year fluctuations in winter flounder landings. Otter trawls were the dominant gear in 1996, landing 475 t; however, gillnets have contributed 34-39% of yearly landings since 1993, mainly due to management regulations that have restricted the fishing season for mobile gear. The number of days that otter trawls fished for winter flounder, a measure of nominal fishing effort, declined from approximately 2000 days of directed effort in 1991 to 504 days in 1995 and 671 days in 1996. Research survey data for 4T indicate that the resource is at an intermediate level of abundance relative to abundance indices since 1971. The abundance of winter flounder varies regionally within 4T, suggesting the existence of numerous stock units in this management unit.

Résumé

En 1996, les débarquements provisoires de plie rouge de la division 4T de l'OPANO ont augmenté très légèrement à 745 t comparativement à 662 t en 1995. Chaque année, les débarquements diminuent. Ils étaient de 2 535 t en 1991. Les débarquements de 1996 sont nettement inférieurs à la moyenne à long terme de 1 899 t pour la période de 1960 à 1996. On s'est souvent servi en 4T de la plie rouge comme appât pour le homard. Ainsi, les erreurs de déclaration et les prises non déclarées ont contribué aux importantes fluctuations annuelles des débarquements de plie rouge. L'engin le plus utilisé en 1996 a été le chalut à panneaux. Les débarquements des prises effectuées en utilisant cet engin ont été de 475 t. Cependant, depuis 1993, les filets maillants ont permis de prendre de 34 à 39 p. 100 des captures débarquées chaque année. Cette situation provient principalement du fait que des règlements de gestion ont restreint la saison de pêche aux engins mobiles. Le nombre de jours de pêche de la plie rouge au chalut à panneaux (mesure de l'effort de pêche nominal) est passé d'environ 2 000 jours de l'effort de pêche sélective en 1991 à 504 jours en 1995 et à 671 jours en 1996. Les résultats des relevés de recherche en 4T révèlent que la ressource se situe à un niveau d'abondance moyen par rapport aux indices d'abondance depuis 1971. L'abondance de plie rouge varie d'un endroit à un autre au sein de la division 4T, ce qui laisse croire à l'existence de nombreuses unités de mesure du stock au sein de cette unité de gestion.

Introduction

The distribution of winter flounder is limited to the western North Atlantic, from southern Labrador to the coast of Georgia (Scott and Scott 1988). In the southern Gulf of St. Lawrence (NAFO Division 4T, Figure 1) and through most of its range, it is a common coastal flatfish. The recent closure of the cod and hake fisheries and reductions in the quota allocations for other groundfish have raised concern for the future of secondary groundfish resources, such as winter flounder. A precautionary quota of 1000 t was established for 4T winter flounder in 1996. This was the first time that the resource came under quota management.

Aside from an analysis of flatfish catch rates by Clay and Nielsen (1983), no assessment of winter flounder 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 up to 1993. The assessment of winter flounder in 1995 (Morin et al. 1995) revealed problems in age determination that caused a suspension of age-based analyses of the resource. That assessment focused on trends in effort data for otter trawls, the main gear exploiting 4T winter flounder, as well as trends in the length composition of winter flounder in annual groundfish surveys. Morin and Forest-Gallant (1996) updated catch statistics, nominal effort and abundance indices for winter flounder.

This assessment updates landings statistics and abundance indices for the 4T winter flounder resource up to 1996. Data are presented on the length composition in the commercial fishery and in groundfish surveys of 4T. Analyses of the length of male and female winter flounder at sexual maturity are presented in relation to current minimum size regulations in the commercial fishery.

Description of the fishery

The landings of 4T winter flounder totalled 745 t in 1996, a marginal increase from the level reported in 1995 (662 t). Landings have declined sharply since 1991 (Table 1, Figure 2). Trawls have contributed most of the yearly landings since the time series began in 1960. In 1996, trawlers landed 475 t of winter flounder, an increase from 1995 landings of 387 t. Although landings by gillnets have declined in the past two years, their importance relative to other gears has grown in the 1990s, contributing 34-39% of total yearly landings since 1993. Another notable change in catches by gear has been the decline of seine landings since 1992.

The wide fluctuations in winter flounder landings reflect problems in the reporting of catch statistics from this fishery. A recent assessment of 4T American plaice (Morin et al. 1996) detailed how the category of "unspecified flounder" was designated in landing statistics in the past and how catches from bait fisheries have been estimated. The winter flounder fishery has been an important source of bait for lobster fisheries throughout 4T. Winter flounder were frequently captured for personal use or for private sale. In fish plants, buyers have often indicated mixed flounder catches as "flounder" and these landings were coded in official statistics as American plaice. Estimates of unreported flounder catches have not been made in a consistent manner from year-to-year and between various sectors of 4T (Morin et al. 1996). However, several improvements have been made recently to landing statistics. Since 1995, all vessel logbooks specify winter flounder among the list of species captured. This measure has eliminated most of the references to unspecified flounder. The dockside monitoring program has been considerably extended over the past two years, resulting in more detailed accounting of landed species.

The winter flounder fishery by mobile gears was disrupted in 1996 by frequent closures and a restricted fishing season. Eighty closures occurred in 1996, mainly due to cod bycatch. There were no closures attributed to breaches of regulations on winter flounder. Winter flounder are fished mainly during the open-water period, from May to October (Table 2). Although significant landings were reported by gillnets in May and June, 1996 (Table 2), measures imposed since 1994 to limit cod bycatch have delayed the mobile gears until July (Table 3). Over most of the past 10 years, mobile gears (mainly otter trawls) have reported their peak landings in September.

The increase in 4T landings of winter flounder in 1996, relative to 1995, was concentrated in the southeastern region of the Gulf, east of Northumberland Strait (unit area 4Tg, Figures 1 and 3). Most other unit areas of 4T registered marginal declines in reported catches. Figure 4 shows the distribution of winter flounder catches, grouped in 10-minute blocks. The catch data were taken from logbook records and since not all gear sectors complete logbooks, the total catches in Figure 4 are considerably less than the annual landings. The landed totals for 1993 and 1994 were based on preliminary data files; therefore, the total landings do not correspond to the NAFO statistics in Table 1. Figure 4 shows that catches in Northumberland Strait were concentrated at the eastern extremity, overlapping unit areas 4Th and 4Tg. Landings in Chaleur Bay have declined since the early 1990s (Figure 4). The range of winter flounder catches, particularly in western parts, has diminished considerably since 1992. In 1996, catches that were reported from the Shediac Valley (between eastern Prince Edward Island and Miscou) were due to the groundfish Sentinel Fishery Program. Catches reported from the Magdalen Shallows and along the Laurentian Channel at the 200-m depth contour (dashed line in Figure 4), were outside the normal depth distribution of winter flounder and probably indicate misreported catches of American plaice.

Winter flounder has become a directed fishery in 4T in recent years. The following table shows the percentage of total winter flounder landings in relation to the main directed species, since 1985.

Directed species	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Winter flounder	79.2	78.0	70.6	72.8	78.4	81.3	87.9	82.6	87.2	94.6	91.2	93.6
Cod	3.7	5.1	3.2	4.9	7.7	5.7	2.7	3.5	1.7	0.3	0.2	1.5
Plaice	5.7	4.6	7.1	5.0	2.3	1.7	0.8	0.9	1.0	1.5	3.6	1.8
White hake	8.5	8.3	10.6	6.9	9.6	10.2	8.0	9.7	5.0	1.1	0.4	0.1

In 1996, 697 t, or 94% of the total landings, were attributed to the directed winter flounder fishery. Before closure of the cod and hake fisheries, from 1985 to 1992, the winter flounder-directed fishery accounted for 71-88% of the yearly landings. Other directed fisheries during that period accounted for a larger portion of winter flounder catches: the white hake fishery contributed 7-11%, the cod fishery contributed 3-8%, and the plaice fishery contributed 1-7%.

The effort by otter trawls landing 4T winter flounder appears to have declined since 1991 (Figure 5). These data, recorded in vessel logbooks, indicate the number of days spent fishing. The number of fishing days by all trawling vessels reporting winter flounder catches declined from over 12000 days in 1991 to approximately 1200 days in 1996. Otter trawls directing for winter flounder registered approximately 2000 days in 1991, for 1690 t landed, declined to 504 days (345 t) in 1995, and increased to 671 days in 1996 for 437 t landed. Similar landings were made by the directed otter trawl fishery in 1993 (429 t) with 585 days at sea. Data from logbooks before 1991 were insufficient to evaluate effort in the fishery. From 1985 to 1990, less than 10% of the annual landed had corresponding logbooks indicating the number of fishing days. Since 1991, effort has been indicated for 47-87% of the annual landings of winter flounder by otter trawls.

The number of vessels reporting directed effort on winter flounder, particularly otter trawls, increased in 1996 (Figure 6). In 1992, 106 vessels (100 trawlers) were directing for winter flounder. By 1995, the number had declined to 51 vessels (47 trawlers), but increased to 68 vessels in 1996, of which 58 were trawlers.

Winter flounder in 4T came under quota regulation in 1996 for the first time. A precautionary quota was set at 1000 t, but the quota was not allocated by sector or gear. The approved mesh size for winter flounder remained 130 mm square for Northumberland Strait and the Magdalen Islands. In Chaleur Bay and Miscou Bank, the approved mesh size was 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 allowable size for winter flounder was 25 cm, although vessels with mobile gear were allowed to return live winter flounder to the water.

Views of the fishing industry

Consultations were held with the fishing industry in December 1996 concerning the status of 4T groundfish stocks. Assemblies were held in selected fishing communities throughout the southern Gulf: Grande Rivière and Cap-aux-Meules (Magdalen Islands), Québec; Caraquet, New Brunswick; Charlottetown, PEI; Port Hawkesbury, Nova Scotia. The meetings were conducted with brief presentations by DFO personnel on recent trends in the fishery and preliminary results of the latest research survey data, followed by general discussions on each stock. The purpose of the meetings was to receive the views of the fishing industry concerning the state of groundfish stocks and their recommendations for assessing stock status.

At the meeting in Grande Rivière, one gillnetter noted that there were fewer winter flounder than in previous years. It was also pointed out that in 1996, vessels fishing turbot in the northern Gulf redirected their effort toward winter flounder along the northern Gaspé Peninsula. Several vessels from Bonaventure also directed for winter flounder. Most fishers agreed that winter flounder overwinter in estuaries in the southern Gulf. However, several felt that large fish move offshore in the autumn and may overwinter in deep channel waters. It appears that the potential for lobster bycatch in winter flounder trawls is still an issue in this sector. At Cap-aux-Meules, a fisher commented that small winter flounder are abundant inshore in October. The distribution of winter flounder and yellowtail was thought to change seasonally, from the spring-early summer period to late summer. One fisher commented that there are many cormorants now and this may have affected the winter flounder population. In Port Hawkesbury, one fisher felt that the local stock was in reasonable shape, and that no changes were required to their management or the TAC. Another fisher indicated that hard bottom provides an unfishable refugium that will protect the local stock from overexploitation (since no rockhopper gear is used in St. George's Bay). Two fishers indicated that larger and older fish migrate offshore and overwinter in deep water. Some fishers were skeptical of the idea that winter flounder overwinter in estuaries. Fishers at the Caraquet meeting were unable to evaluate the condition of the resource because of low fishing effort. They also noted that frequent closures due to cod bycatch are restricting the local winter flounder fishery.

A telephone survey was conducted of fishers who were active in the groundfish fishery in the southern Gulf of St. Lawrence during 1996. In November 1996, 385 vessels from New Brunswick, Nova Scotia, Prince Edward Island and Quebec were identified as active in the 4T groundfish fishery on the basis of purchase slips up to that time. Up to 10 fishers from each statistical district were contacted by telephone in November and December. There were 223 participants interviewed for their views on the 1996 4T groundfish fishery (Hurlbut 1997).

Of the 223 respondents in the survey, 100 directed their fishing effort on winter flounder during 1996 and, of these, 78 identified winter flounder as their primary choice of directed species. Most respondents reported using the same amount of fishing gear in 1996 as in 1995; however, the number of days spent fishing in 1996 was almost evenly distributed among categories of fewer, the same and more days than in 1995. As in the 1995 survey, most fishers felt that the winter flounder resource was at its average level of abundance. The 78 participants who targeted winter flounder as their primary choice were asked to relate the state of the 1996 fishery to the past year, the past five years, and to all of their years of experience. In all cases, the most frequent response was that in 1996 the resource was at the same level of abundance as in the past. However, when comparing abundance levels in 1996 to the previous five years or to the longterm, an increasing proportion of the respondents judged abundance to be lower than higher. The 1996 telephone survey provided similar results to the 1995 survey in that fishers appeared to judge the abundance of the resource less favourably on the basis of their longer term experience than on their recollection of the previous year.

Fishery Data

Commercial catch statistics for 4T winter flounder are based on combined data from the Maritimes, Laurentian and Newfoundland regions of DFO. Information on the commercial fisheries originate from sources such as vessel logbooks, purchase records, observers onboard fishing vessels and port samplers. Logbooks became a condition for all mobile gear permits in 1991.

Commercial catches of winter flounder are regularly sampled at landing ports throughout the active months of the fishery. Commercial port sampling is conducted on sexed length frequencies, with otoliths removed on a sex and length-stratified basis of one sample per sex, per cm body length. Port samplers note the location and weight of each catch, and correct for grading of the catch by size. The number of port samples has ranged from an annual maximum of 80 samples in 1987 to a minimum of 3 samples in 1996 (Figure 7). No winter flounder samples were obtained from otter trawl catches, the main landing gear, in 1996. The recent decline in the number of samples is largely related to the reduced landings of winter flounder and the difficulty for port samplers to obtain samples when the fishing fleet is small and landings are infrequent.

We determined the size composition of winter flounder landings and the total number captured by scaling the port-sampled length frequencies to vessel catches and total landings. All gears and both sexes were grouped for this analysis. No estimate was made for 1996 because of the low number of commercial samples.

The size composition of commercial catches varied widely from year to year with modal size persisting over most years in the size range of 25-30 cm (Figure 8). Parameters for the length-frequency distributions were plotted in Figure 9. There were no significant annual patterns for any of the parameters when regressed on sampling year, although it appears that from 1988 until 1995 the upper limit of the length distribution, the 90th percentile of lengths, appears to have declined over time. The total estimated number of winter flounder caught by the fisheries has fluctuated widely, as may be seen from the area of the size distributions in Figure 8. However, the number of winter flounder captured by the fishery, summed over the range of lengths has declined continuously from approximately 8.2 million in 1991 to 1.7 million winter flounder in 1995.

Research data

Abundance Indices

Abundance indices were calculated using catch rates in the September survey, conducted yearly since 1971. The survey is based on a stratified random design, with strata defined mainly by depth (Figure 10). Some changes have been made since 1971, most notably changes in vessels and trawling gear. The vessel *E.E. Prince* with a Yankee 36 trawl was used until 1984, then replaced with the *Lady Hammond* and a Western IIA trawl. Since 1991, the *Alfred Needler* and the Western IIA have been used. Comparative surveys conducted in 1985 and in 1991 indicated that winter flounder catch rates of the *Prince* and the *Hammond* differed significantly, whereas there was no significant difference between catch rates of the *Hammond* and the *Needler* (Nielsen 1994). Winter flounder catches were standardized to a common distance towed of 1.75 NM, with catches of the *Prince* divided by 0.433 for equivalence to catch rates of the *Hammond* and *Needler*. Strata 401-403 were added to the survey in 1984 to extend the survey coverage inshore. These strata are included in the analyses reported here for the first time.

Research survey analyses, including catch abundance, biomass and size frequencies, were generated by the program RVAN, programmed in SAS IML (SAS Institute 1989) by G. Poirier, based on the RVAN version documented by Clay (1989b). In 1996, some sets that were allocated to stratum 401 since 1984 were reallocated to stratum 429. This measure was undertaken to correct an error of overlap that was introduced when the inshore stratum 401 was added in 1984. RVAN was run on 1971-1996 data including all the strata 415-439 for all years and strata 401-439 since 1984.

Stratified mean catch rates of winter flounder tended to be relatively low in the early to mid-1970s (except for 1974 and 1976) and have fluctuated between 19 and 68 per tow since 1977 (Figure 11). Winter flounder catches in the 1996 survey averaged 32 fish per tow in strata 415-439, 42 fish per tow in strata 401-439. Trawlable biomass appears to have declined since the early 1980s; since 1984. it has been estimated between 10000 tons and 20000 tons. Trawlable stock biomass was estimated at 11623 t in 1996.

Nearly all (99.8%) of the winter flounder caught in the 1971-1993 surveys were caught in 10 strata (Morin *et al.* 1994). Consequently, in previous assessments we restricted our analyses to these ten strata (418-422, 428, 429, 432, 433 and 435). To assess the significance of annual and regional variations in winter flounder abundance, we used multiplicative analyses of catch rates. Winter flounder catches were standardized to a *Hammond-Needler* equivalent, then transformed as ln(catch+0.5) and weighted by the 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). The ten strata were broken down into four subareas of the Gulf: Chaleur Bay (strata 418 and 419); the Miramichi area (strata 420 and 421); the Magdalen Islands (strata 428 and 435); the area southeast of PEI (strata 432 and 433). We have revised the last sector to include 402, 403, 432 and 433 since 1984. The stratified mean catch in each subarea was calculated and separate multiplicative analyses were performed.

Winter flounder inhabit inshore areas and appear to move into estuaries to overwinter (Hanson and Courtenay 1996). 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 multiplicative analysis of catch data in the 10 strata where winter flounder occur revealed a highly significant year*stratum interaction (F=1.56; df=221, 1093; P=0.0001). A pattern of differing abundance trends between sectors of the southern Gulf is consistent with this possibility of a complex stock structure.

Examining the abundance trends by sector of 4T, there was no apparent trend over time in Chaleur Bay up to 1994 (strata 418 and 419, Figure 12). Large catches in Chaleur Bay in 1995 caused a strong increase in the stratified mean, along with high variance. The multiplicative model of catches in the Chaleur Bay was not significant (F=1.09; df=26, 171; P=0.36). The ANOVA results for analyses of the remaining sectors are summarized in Table 4. In the Miramichi subarea (strata 420 and 421), catch rates were relatively low throughout most of the 1970s and 1980s, with isolated peaks in 1976 and 1983. Catch rates increased through the 1980s to peak values in 1990-1992, and have declined to intermediate levels since 1993 (Figure 12). The main effects in the model for the Miramichi subarea (year and stratum) were highly significant (P<0.0003), as well as their interaction (P=0.004). These results indicate more localized variation in the abundance trends of winter flounder within this subarea. The high catch rates in the Miramichi area in 1976 and 1989-1992 were due to catches in stratum 421, whereas stratum 420 contributed to the peak catches in 1983 (Figure 13). Since 1992, catch rates in stratum 421 have declined to levels less than in stratum 420. Catch rates of winter flounder in the Magdalen Islands tended to be high from the mid-1970s to the early 1980s, but declined to low levels in recent years (Figure 12). Catch rates have increased annually since 1993, although they remain low relative to the high values of the mid-1970s to early 1980s. Annual variations in Magdalen Island catches were significant (P=0.002, Table 4) after dropping the non-significant interaction term. In the area southeast of PEI, catch rates tended to be highest in the mid-1970s, but have reached intermediate levels in recent years (Figure 12). The catch rate in this area increased sharply in 1995. In catch analyses of this sector, dropping the non-significant interaction term resulted in a significant annual effect (P=0.02). The expanded sector of southeast PEI also varied significantly since 1984 with a peak in abundance in 1995. The year effect was significant (P=0.03, Table 4) when the non-significant interaction term was removed.

Catch rate time series for winter flounder show considerable annual fluctuation in the southern Gulf (Figures 9-11). Winter flounder are distributed in shallow water along the inshore edge of the September survey. Preliminary sampling of winter flounder on an inshore survey of juvenile lobster on the Magdalen Islands in 1996 (Morin 1997) indicated more abundant catches inshore than in stratum 435. Catches in the inshore survey were also composed of a larger proportion of small fish. 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 are unable to correct this source of error in our estimates of relative abundance.

Length-frequency data from the September survey were used to compute the size composition of the winter flounder population in 4T (Figure 14). No persistent recruitment modes were apparent in these data. The parameters of the length frequencies displayed a declining trend throughout the time series

(Figure 15). Modal size appears to have declined from 27-32 cm in the early 1970s to 17-26 cm in the 1990s. Each parameter shown in Figure 15 (mean, mode, 10th and 90th percentile) was significantly related to year (R^2=0.31-0.78). The linear regression models were not significantly improved by the addition of a quadratic term. For each parameter regressed on year, the slope of the relationship was negative and significantly different from zero (P<0.002), indicating that the size composition of the population has significantly shifted towards a smaller range over time. Figure 16 shows that the mean weight of winter flounder in the research surveys, determined by the population biomass divided by the population numbers, has significantly declined over time.

Assessment results

The nominal landings of winter flounder in 4T have averaged 1886 t since 1960, varying widely from one year to the next. Landed catches since 1995 (662 t in 1995; 745 in 1996) were among the lowest on record since 1960. 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. An increase in the abundance of winter flounder was noted in 1995 from the September survey of 4T, but this did not persist in 1996. The research survey data reveal variation in abundance trends amongst different sectors of 4T. Winter flounder in 4T probably comprise numerous stocks that vary regionally in abundance and that may require different management measures. September surveys indicate that abundance is low in the Magdalen Islands area, but intermediate in the Miramichi area and in the sector east of PEI.

Ecological considerations

Size at maturity

Several flatfish species, such as winter flounder, are late-winter or spring spawners. Research surveys conducted in September provide the best discrete sampling of groundfish stocks throughout the southern Gulf; however, for early spawning fishes it is usually difficult to visually assess maturity stages in autumn. For winter flounder, information on the age of first reproduction is necessary to provide advice on appropriate target size for commercial fisheries.

We examined several annual groundfish surveys of 4T and seasonal surveys conducted in April, May and June. The maturity stages were based on visual criteria described by Powles (1958) and Clay (1989a). The stage-1 category represents the immature virgin state with no gonadal develop underway; stage 8 describes a resting or non-ripe state; stages 2-6 represent various stages of active spawning (ripening, spawning, spent stages). The proportions of stage-1 and stages 2-6 were modeled in relation to body length by probit analysis using SAS PROC PROBIT with a logistic fit (SAS Institute 1990). The probit analyses were used to calculate L_{50} and L_{95}, the lengths at which 50% and 95% of the fish attain sexual maturity.

In the last assessment (Morin and Forest-Gallant 1996), we noted that the proportion of stage-8 winter flounder tended to dominate samples of fish >20 cm during September surveys. Spring surveys of 4T are more reliable in determining maturity stages of flatfish. Figure 17 shows maturity ogives for females sampled in surveys conducted in May 1987 and April 1991. The May 1987 survey covered the eastern part of 4T and winter flounder catches were concentrated in the sector east of PEI (stratum 433). The April 1991 survey was conducted in the western part of 4T, with catches throughout Chaleur Bay and the Shediac Valley (strata 418-421). L_{50} for stages 2-6 was reached at 23.6 cm in the May 1987 survey and 26.4 cm in the April 1991 survey. L_{95} was reached at 29.5 and 29.7 cm in the two respective surveys. Male winter flounder reached spawning state at smaller sizes than females (Figure 18). L_{50} was reached at 23.8 cm in the 1987 survey and 20.4 cm in the 1991 survey. L_{95} was reached at 31.2 and 24.8 cm in the two surveys.

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

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	38	1204	141	324	5	235	1973
1993	0	5	769	65	460	2	57	1358
1994	0	44	693	28	408	2	5	1180
1995*	0	0	387	10	261	0	4	662
1996*	0	107	368	11	257	0	2	745
MEAN	477	533	343	241	183	21	101	1899

* Provisional data

Table 2. Preliminary landings of 4T winter flounder in 1996, by gear and month. Gear types: OTB1=side otter trawls, OTB2=stern otter trawls, PTB=pair trawls, TXS=shrimp trawls, SDN=Danish seines, SSC=Scottish seines, GNS=gillnets, LLS=longlines, LHP=jigger.

	Month							
Gear	May	June	July	Aug	Sep	Oct	Nov	Total
OTB1	0	0.118	13.97	25.486	33.829	33.378	0	107
OTB2	0	3.554	59.266	77.947	125.515	101.563	0.059	368
PTB	0	0	0.976	0.216	0	0	0	1
TXS	0	0	0	0	0.913	0	0	1
SDN	0	0	2.444	1.505	0.375	6.673	0	11
SSC	0.023	0	0	0	0	0	0	0
GNS	38.608	76.996	40.347	50.123	50.398	0.905	0	257
LLS	0	0	0.064	0.033	0	0	0	0
LHP	0	0	0	0.022	0	0	0	0
Total	39	81	117	155	211	143	0	745

Table 3. Monthly landings of 4T winter flounder by mobile gear over past 10 years.

Month	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Jan	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0	0	0
Apr	0	2	2	1	0	0	0	0	0	0
May	23	118	177	150	83	74	125	1	1	0
Jun	81	107	217	372	251	136	67	1	4	4
Jul	178	211	240	293	514	306	111	71	60	77
Aug	292	182	350	233	407	351	92	142	68	105
Sep	265	239	409	231	646	469	316	421	158	161
Oct	332	192	186	160	271	271	157	129	109	142
Nov	22	16	2	5	4	10	0	0	0	0
Dec	0	0	0	0	0	0	0	0	0	0

Table 4. Results of general linear model tests of winter flounder catch rates in sectors of the 4T groundfish survey. Tests were repeated (test 2) when models revealed non significant (P>0.05) year•stratum interaction term.

					Test 1		Test 2	
Sector	Strata	Years	n	Effect	F	P	F	P
Miramichi	418, 419	1971-96	178	Stratum	32.69	0.0001		
				Year	2.64	0.0002		
				Year•stratum	2.13	0.0042		
Magdalen	428, 435	1971-96	151	Stratum	22.97	0.0001	23.61	0.0001
				Year	1.31	0.1753	2.24	0.0020
				Year•stratum	1.12	0.3329		
Southeast PEI	432, 433	1971-96	210	Stratum	66.78	0.0001	71.98	0.0001
				Year	0.73	0.8204	1.76	0.0182
				Year•stratum	0.63	0.9078		
SE PEI expanded	432, 433, 402, 403	1984-96	194	Stratum	20.52	0.0001	22.43	0.0001
				Year	0.96	0.4925	1.95	0.0314
				Year•stratum	0.61	0.9324		

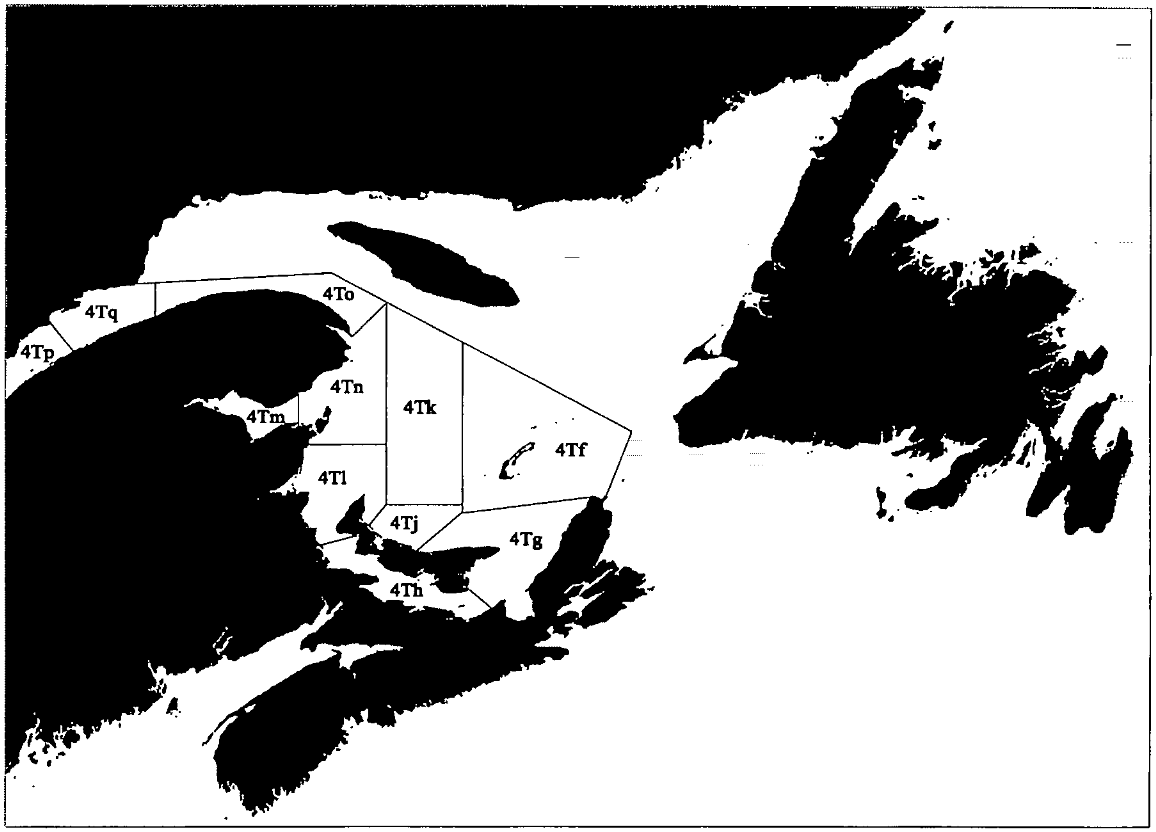

Figure 1. Gulf of St. Lawrence showing unit areas of NAFO Division 4T.

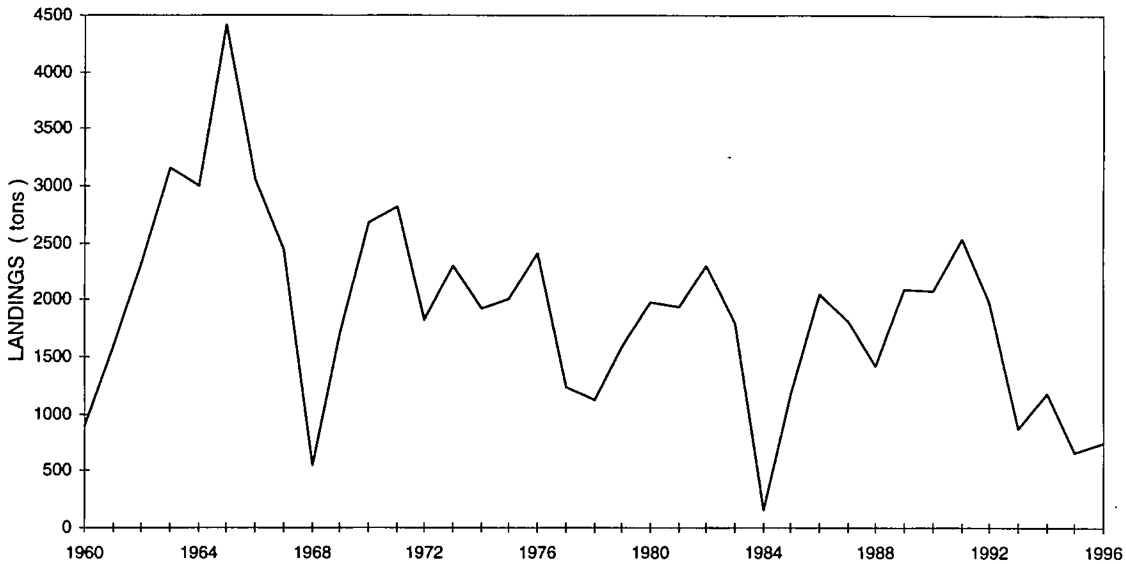

Figure 2. Annual landings of winter flounder in NAFO Division 4T.

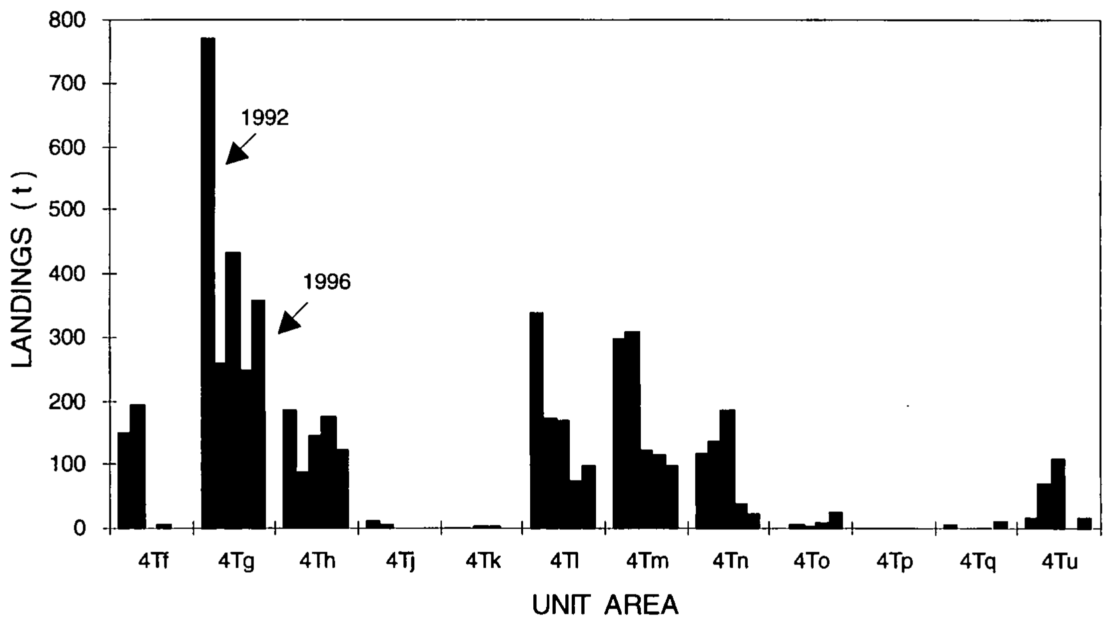

Figure 3. Nominal landings of winter flounder by unit area of 4T since 1992.

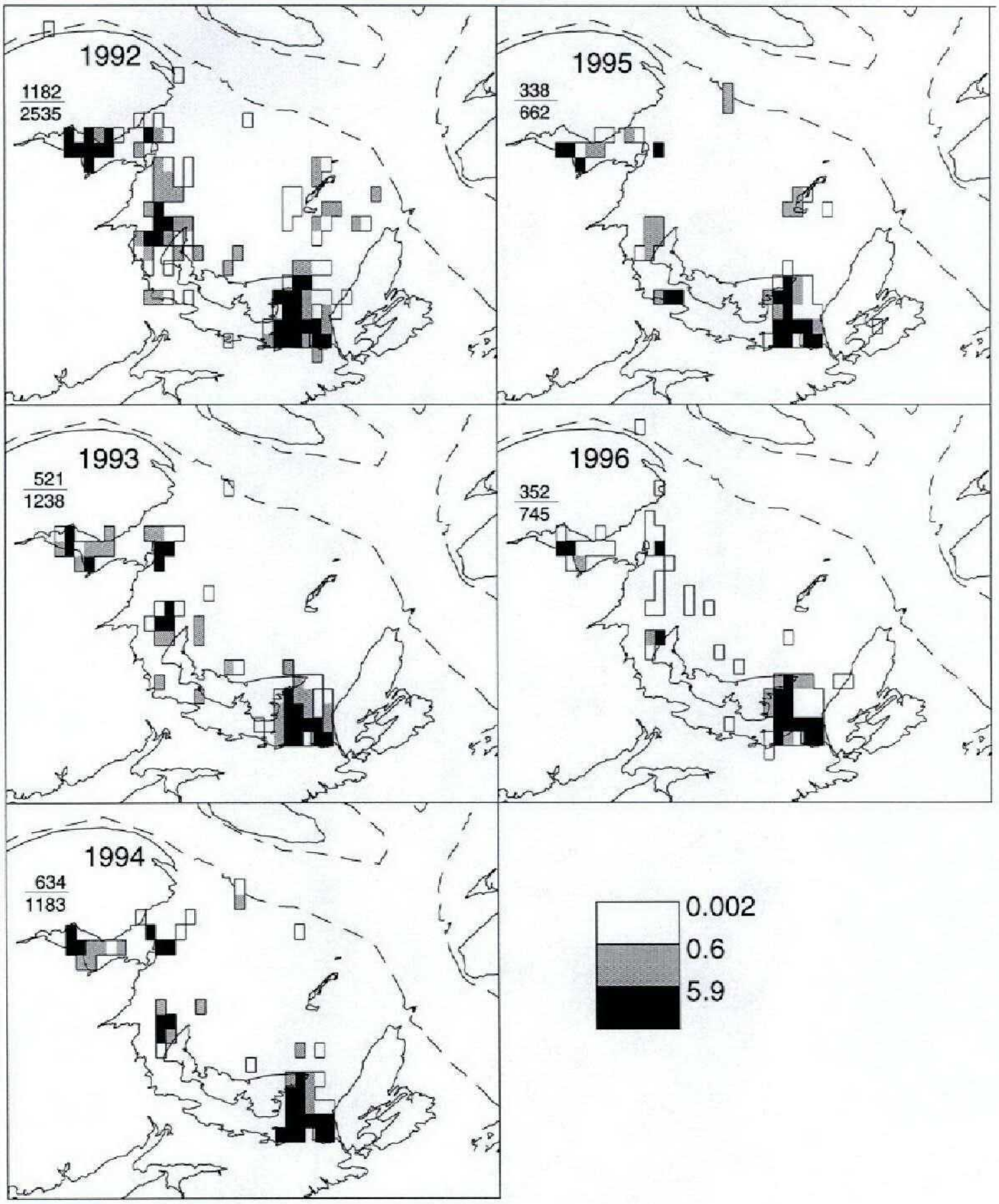

Figure 4. Distribution of 4T commercial catches (tons) of winter flounder in 10-minute blocks. Scale levels correspond to the 5-year minimum catch and average 33rd and 67th percentiles of catch. Fraction indicates the ratio of mapped catches (numerator) to total landings (denominator).

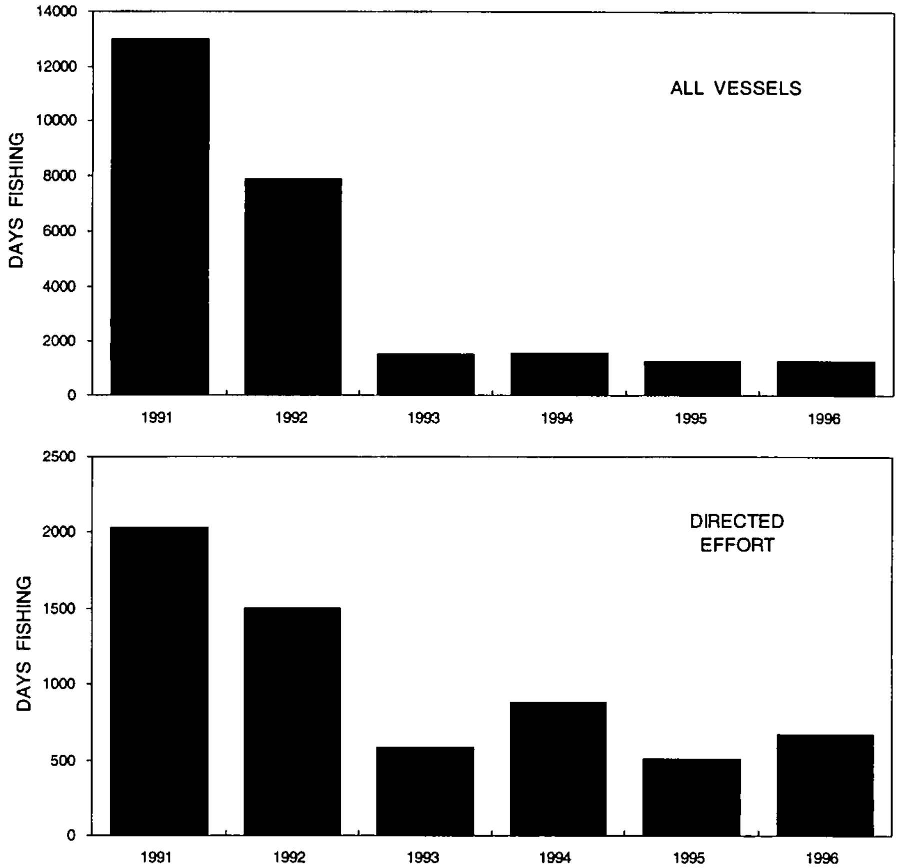

Figure 5. The number of fishing days by all otter trawls landing 4T winter flounder (upper panel) and by otter trawls directing for winter flounder.

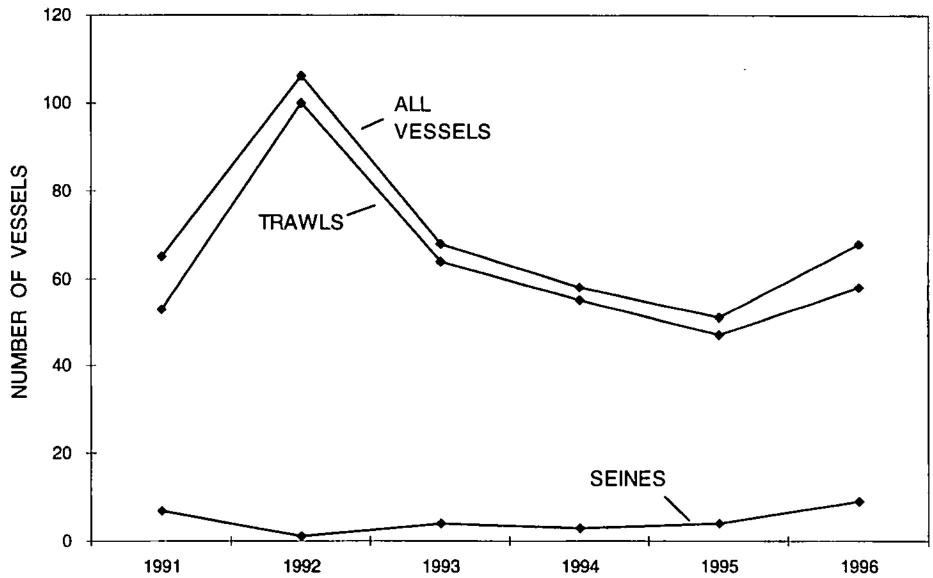

Figure 6. Recent trends in the number of vessels directing for 4T winter flounder.

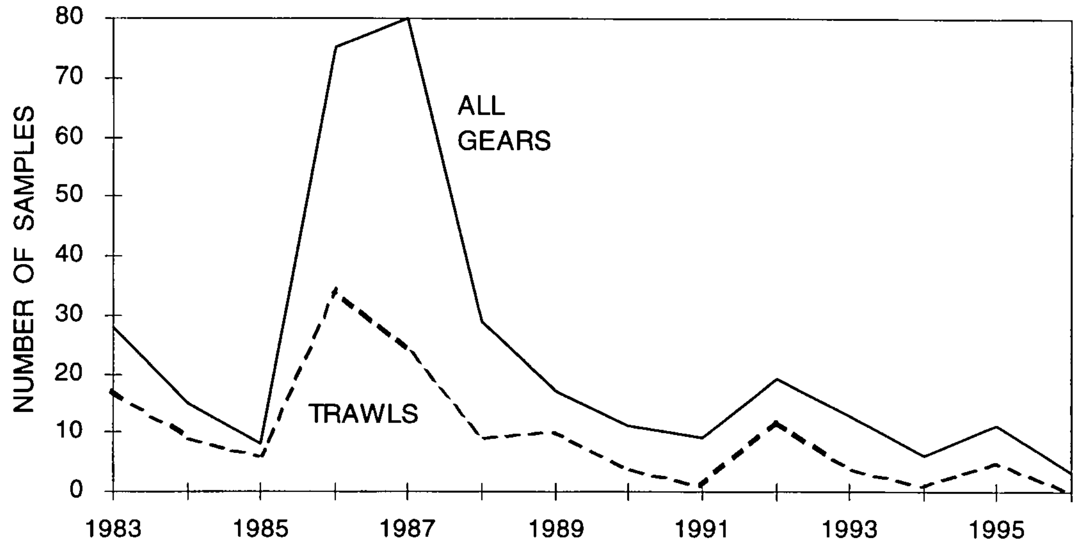

Figure 7. The number of catches of 4T winter flounder sampled at landing ports.

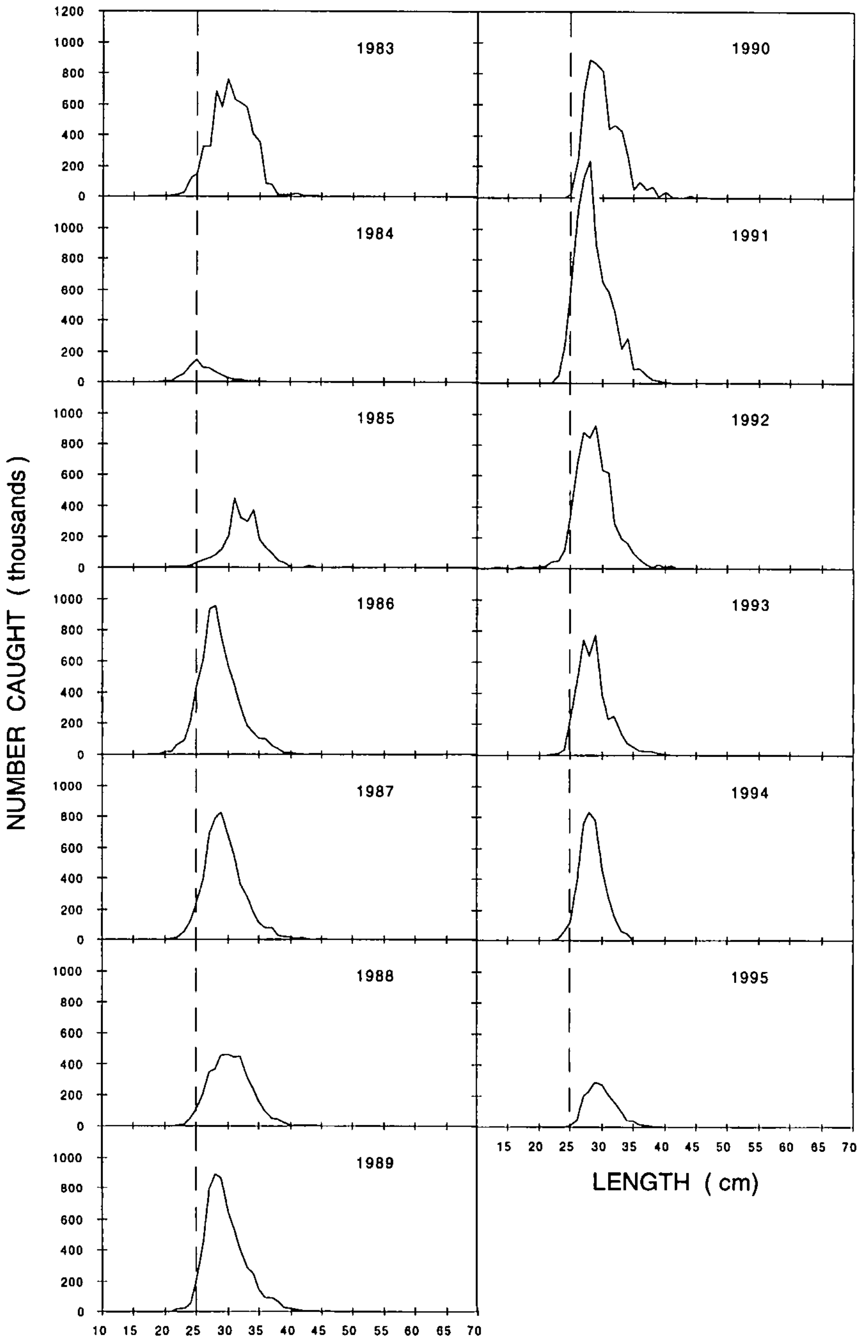

Figure 8. The size composition of commercial catches of 4T winter flounder, based on catches sampled in landing ports. The vertical dashed lines indicate the minimum allowable size based on the small fish protocol established in 1993.

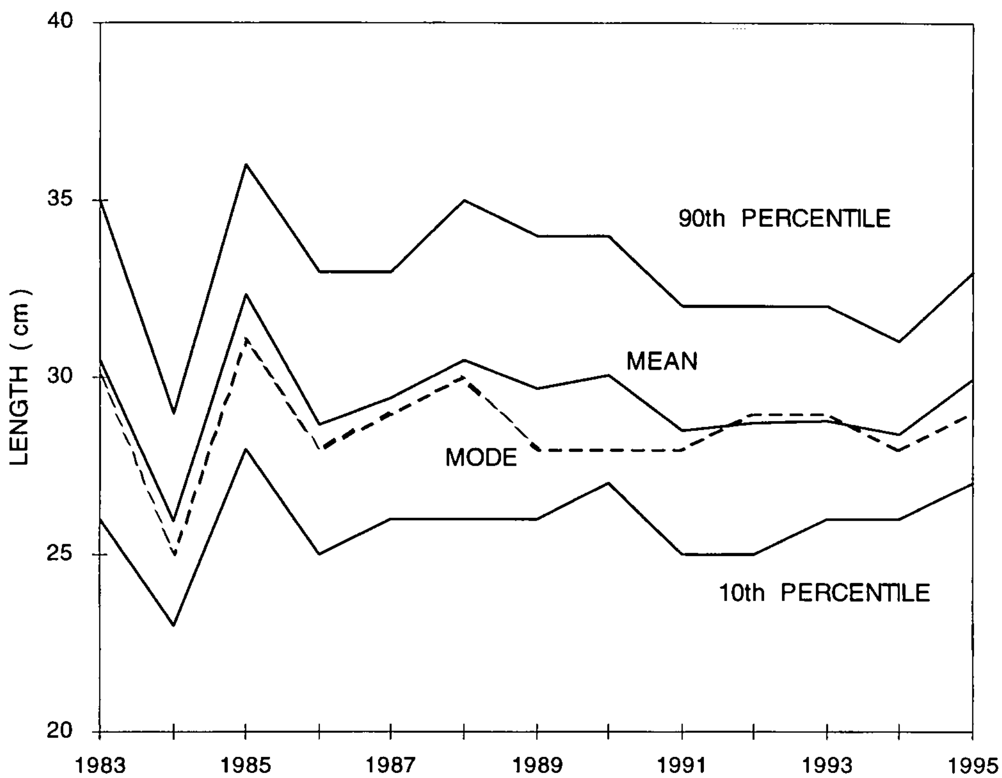

Figure 9. Parameters of length-frequency distributions of winter flounder landings.

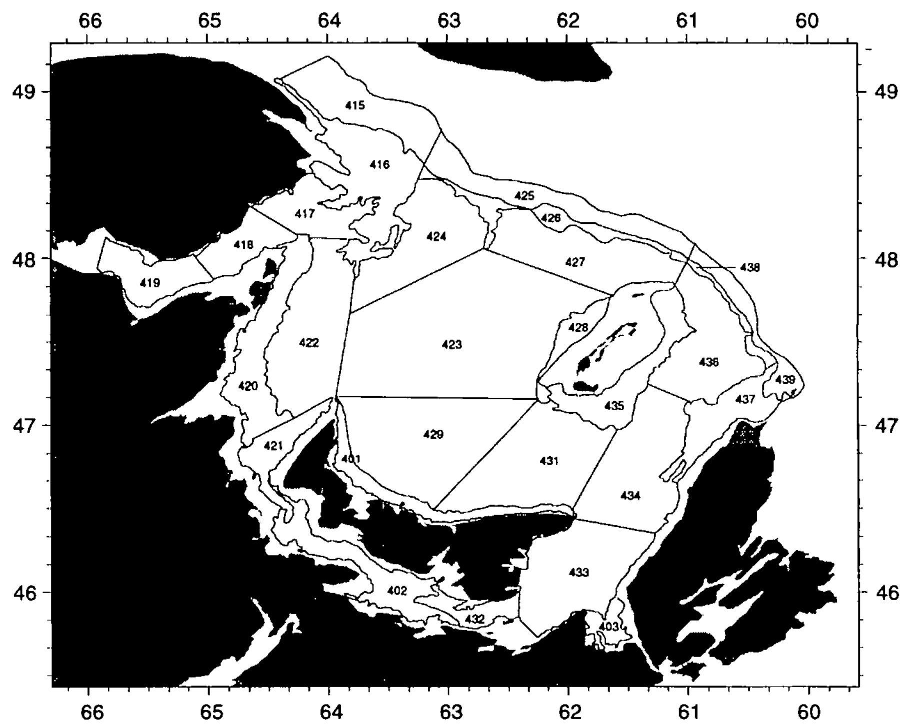

Figure 10. Stratification of the annual groundfish abundance survey in the southern Gulf of St. Lawrence.

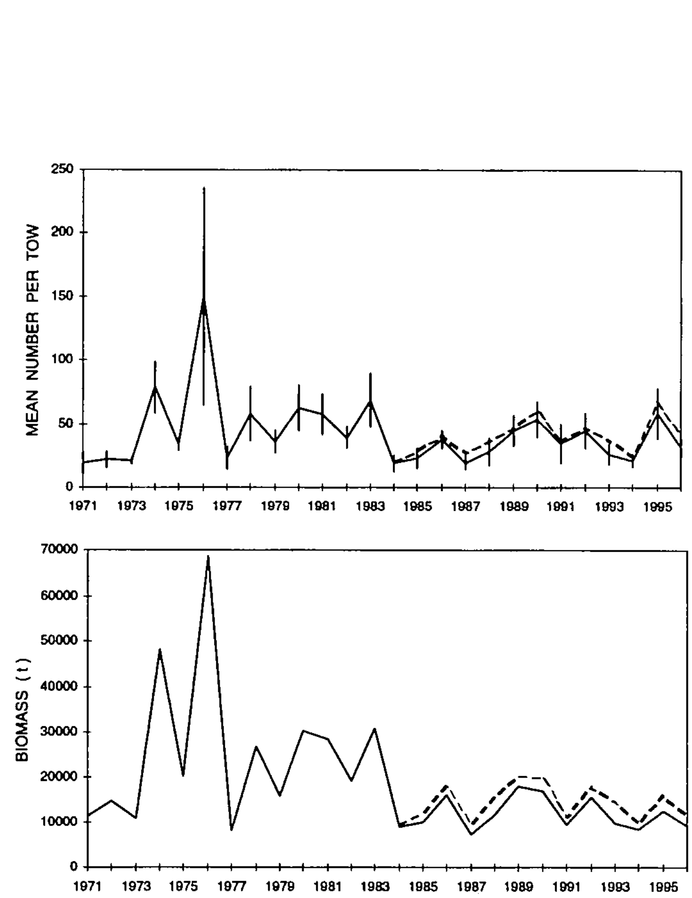

Figure 11. Stratified mean number per tow of winter flounder (upper panel) and trawlable biomass, from research surveys of the southern Gulf. Solid line indicates catch rates of strata 415-439, sampled in all years, with vertical bars indicating ± one standard deviation. Dashed lines indicate values including strata 401-403, sampled since 1984.

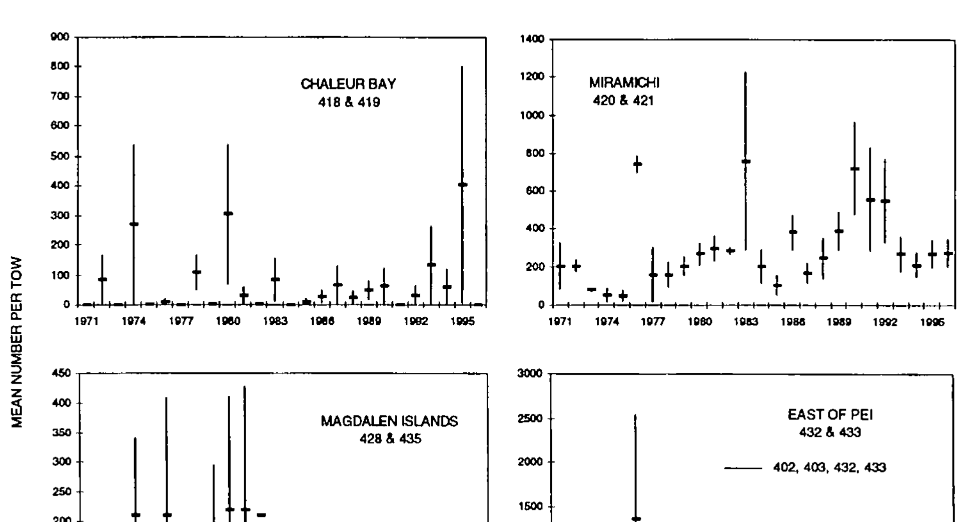

Figure 12. Stratified mean number per tow of winter flounder in sectors of the southern Gulf, indicated by name and stratum numbers. Vertical lines are ± one standard deviation. For the sector east of PEI, the solid line joining open symbols indicates mean catch in strata sampled since 1984. Note differences in scaling for each area.

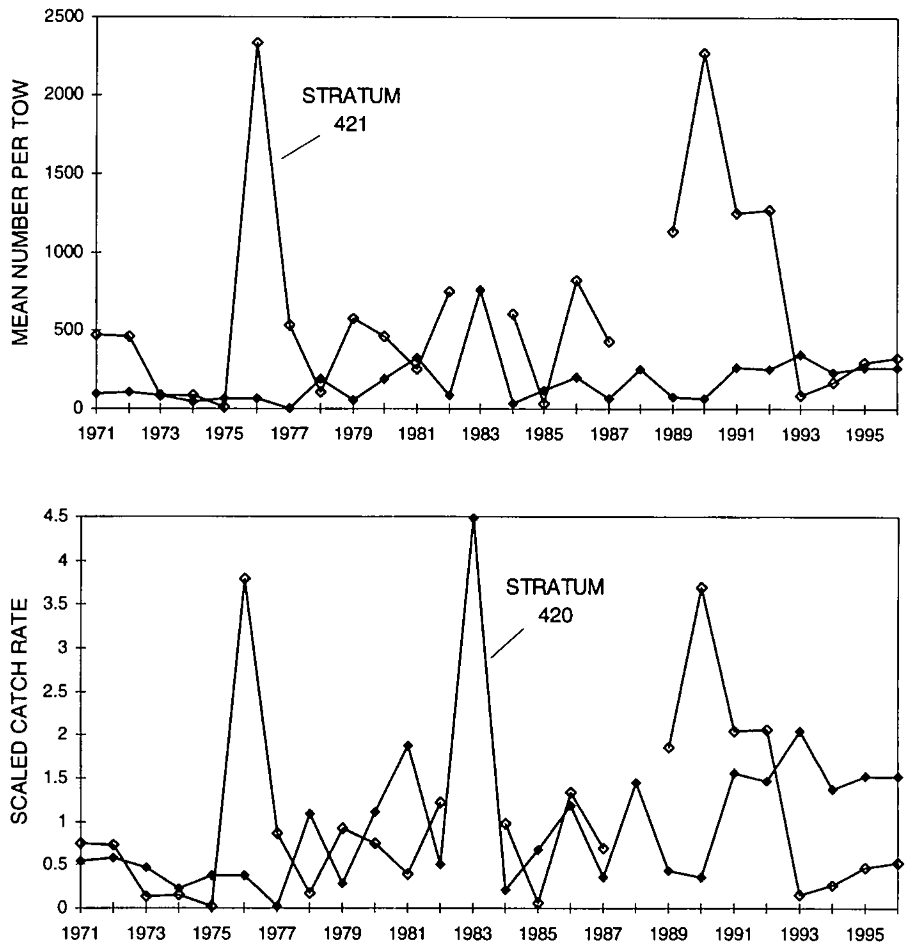

Figure 13. Catch rates of winter flounder in strata 420 (closed diamonds) and 421 (open diamonds) from September groundfish survey. Scaled catch rate is the mean number per tow divided by stratum average over the time series. Stratum 421 was not sampled in 1983 and 1988.

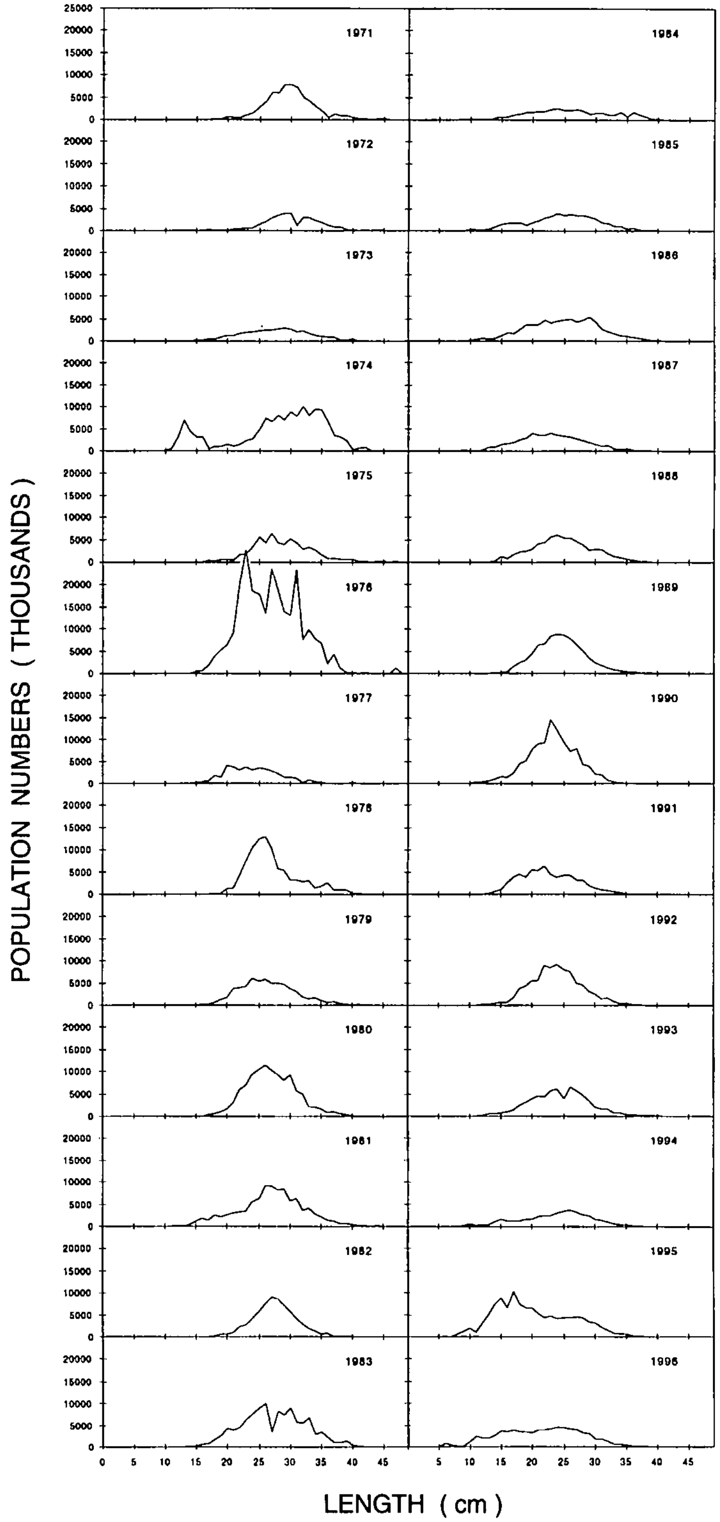

Figure 14. Estimated population numbers-at-length of 4T winter flounder based on research surveys.

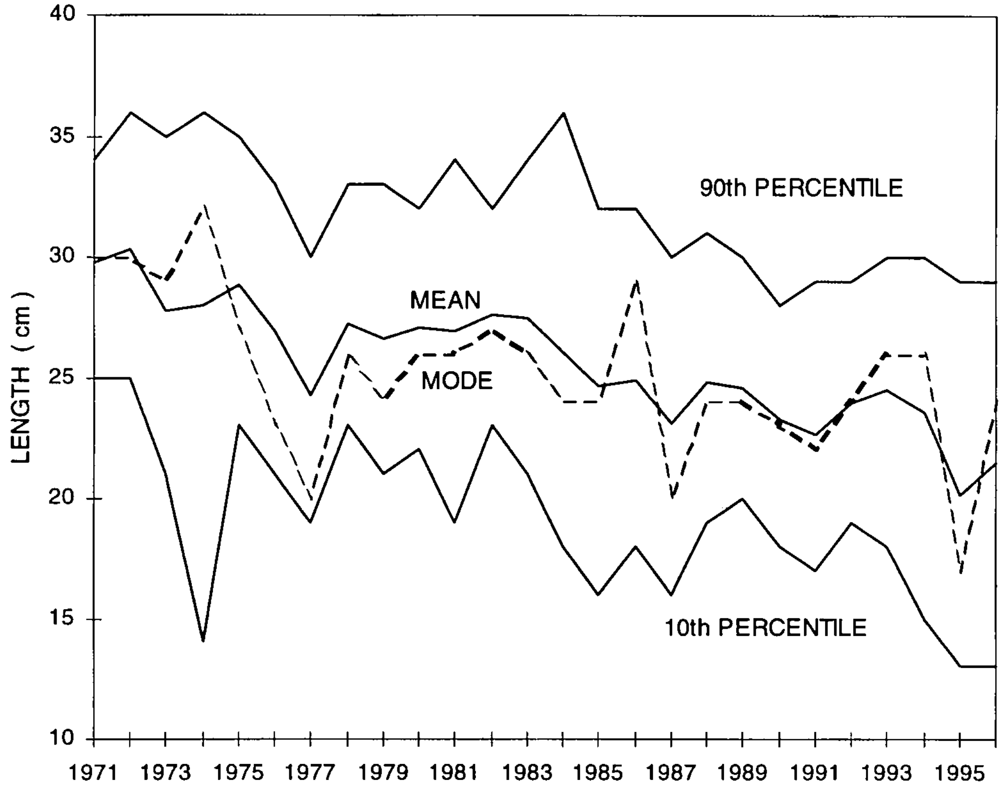

Figure 15. Parameters of length-frequency distributions of winter flounder, based on annual groundfish surveys of 4T.

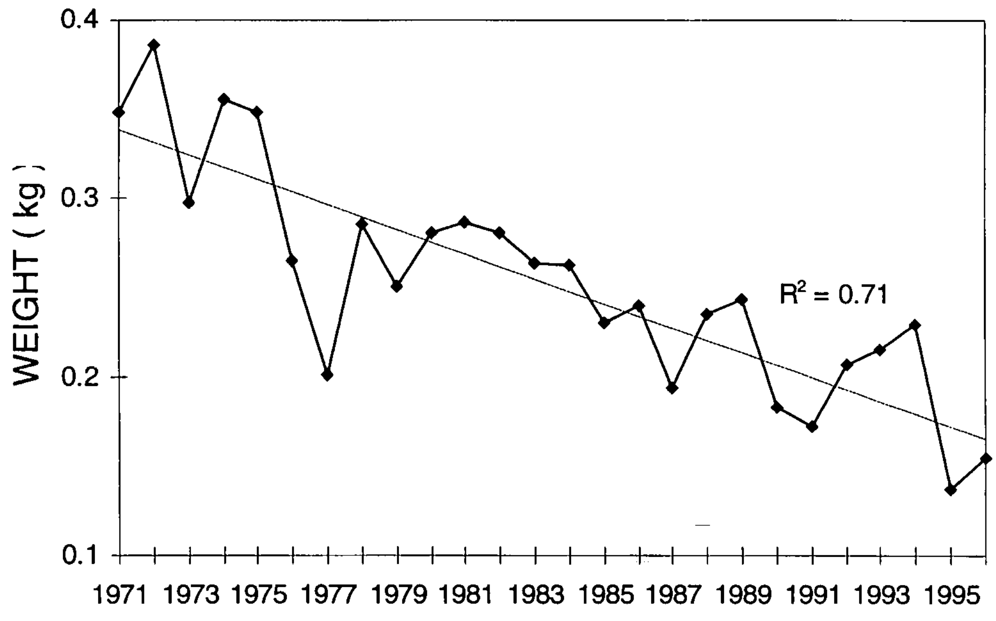

Figure 16. Annual mean weight of winter flounder in groundfish surveys of 4T showing regression line. The regression model was highly significant (P <0.0001) and the slope of the regression line (-0.007) was significantly different from zero (t: -7.74; df: 23; P <0.0001).

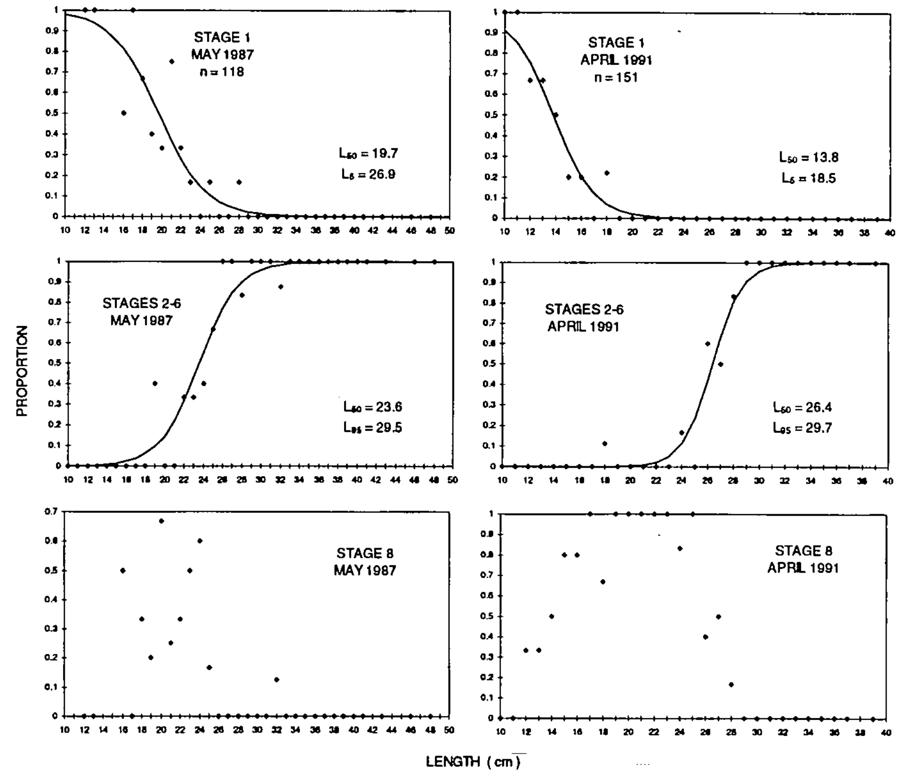

Figure 17. Maturity ogives of female winter flounder based on seasonal surveys of 4T. Stage 1 represents immature fish; stages 2-6 represent spawning and post-spawning reproductive stages; stage 8 represents non-spawning fish. Ogives are based on probit analyses.

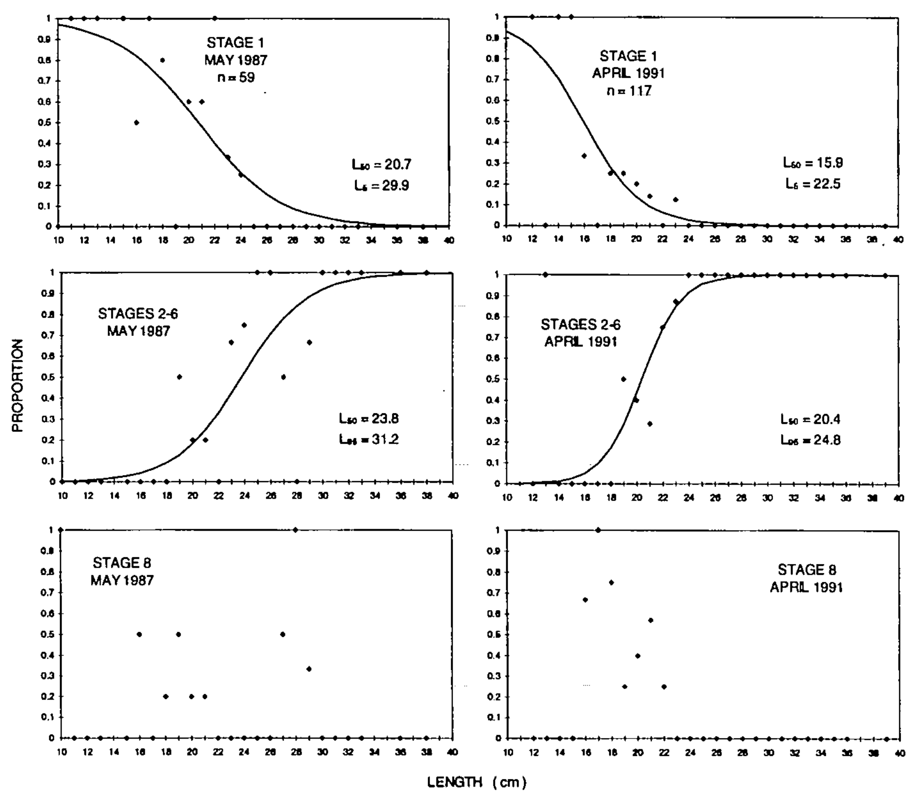

Figure 18. Maturity ogives of male winter flounder based on seasonal surveys of 4T.