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Status of witch flounder in NAFO Divisions 4RST

by

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Abstract

The provisional landings of witch flounder totalled 448 t in NAFO divisions 4RST and 95 t in divisions 4RS in 1994. Witch flounder landings throughout the Gulf reached their lowest annual level over the time series of landings statistics since 1960. Annual landings of witch since 1960 have averaged 2811 t in 4RST and 1714 t in 4RS. Declines were registered in most areas of the Gulf, including St. George's Bay (unit area 4Rd) and the western part of 4T (4Tk and 4Tnoq), although slightly higher landings were recorded from eastern 4T (4Tf and 4Tg). Seines contributed most of the landings. The nominal effort by seines (number of days fishing) increased slightly in 4T from its level in 1993, although nominal effort by seiners throughout 4RST declined in 1994. In spite of weak landings of witch by trawlers, nominal effort by trawlers directing for witch flounder increased sharply from the levels recorded over the previous 3-4 years. The directed fishery accounted for 81% of the witch landings in 4RST in 1994, with 16% of witch landings originating from the plaice-directed fishery. Research surveys conducted in the northern and southern Gulf indicated that witch abundance declined during the late 1980s. Northern Gulf surveys indicated that abundance peaked in 1985 or 1986 and that the stock is currently at its lowest level since the northern Gulf surveys began in the late 1970s. In the southern Gulf, witch abundance was low during the early 1980s, rose to a peak in 1988, then declined yearly until 1992. Abundance estimates in 1993 and 1994 were in the upper range of values since the 4T survey began in 1971.

Résumé

Les débarquements provisoires de la plie grise ont atteint 448 t dans les divisions 4RST de l'OPANO et 95 t dans les divisions 4RS en 1994. Ces débarquements représentent le plus bas niveau enregistré depuis le début de la série des statistiques en 1960. Depuis 1960, les débarquements de plie grise ont atteint en moyenne 2 811 t dans les divisions 4RST et 1 714 dans les divisions 4RS. Les débarquements ont décliné dans la plupart des secteurs du golfe, y incluant la Baie St-George (secteur 4Rd) et la partie ouest de 4T (4Tk et 4Tnoq). Cependant, les débarquements ont augmenté faiblement dans la partie est de 4T (4Tf et 4Tg). Les seines ont contribué à la plus grande partie des débarquements. L'effort nominal par les senneurs (le nombre de jours de pêche) a augmenté dans 4T par rapport à son niveau en 1993, tandis que l'effort nominal de la part des senneurs dans 4RST s'est décliné en 1994. L'effort nominal par les chalutiers qui dirigent pour la plie grise a augmenté fortement par rapport à son niveau durant les 3-4 ans précédents, malgré les faibles débarquements de plie grise par les chalutiers en 1994. La pêche dirigée représentait 81% des débarquements de plie grise en 1994, et 16% des débarquements de plie grise provenaient de la pêche dirigée pour la plie canadienne. Les relevés scientifiques dans le nord et le sud du golfe indiquent que l'abondance de la plie grise a décliné durant la fin des années 1980. Les relevés du nord du golfe indiquent que l'abondance de la plie grise a atteint un sommet en 1985 ou 1986, tandis que l'abondance du stock est présentement à son plus bas niveau depuis le début des relevés, vers la fin des années 1970. Dans le sud du golfe, l'abondance de la plie grise était faible au début des années 1980, mais elle a augmenté pour atteindre un sommet en 1988, et ensuite a décliné annuellement jusqu'à 1992. Les estimations en 1993 et 1994 font état des taux d'abondance les plus élevés depuis 1971.

Introduction

Witch flounder has been under international quota regulation since 1974. In the Gulf of St. Lawrence, the fishery has been regulated within NAFO divisions 4RS. This designation of the management unit initially recognized the fishery that developed in 4R in the 1950s and that later extended offshore into the Esquiman Channel (Bowering 1979). The adequacy of management units for witch in the Gulf of St. Lawrence is a longstanding issue. Bowering (1978) first questioned whether witch fished in 4T off the coast of Cape Breton should be considered as part of the stocks managed within 4RS. The issue was most recently taken up by Morin and Hurlbut (1994) who showed that witch stocks straddle the 4RS-4T boundary, especially in winter. In 1994, DFO accepted the recommendation by the Fisheries Resource Conservation Council (FRCC) that the management of witch flounder in 1995 should be 4RST.

This assessment reports on the status of the witch fishery in 4RS and 4RST. We address the need to incorporate catch statistics and information on the fishery throughout 4RST. Similarly, we have analyzed groundfish survey data from the northern and southern parts of the Gulf, to evaluate abundance and biomass throughout 4RST.

Description of the fishery

Landings of witch flounder in 4RS declined to 95 tons in 1994, their lowest level since 1960 (Table 1). All divisions recorded weak landings of witch (Figure 1) and combined 4RST landings totalled 448 tons, the lowest since 1960 (Table 2, Figure 2). Most landings have originated from the 4T fishery since 1984 (Figure 1). The 4S division contributes a small portion of the total landings; in 1994, landings from 4S totalled 4 tons.

Seines were the dominant gear landing witch in 4RS and 4RST in 1994 (Tables 1 and 2). The witch fishery developed in the 1950s and 1960s with seiners concentrated in summer in St. George's Bay (4R). Witch was caught in winter as a bycatch of the cod and redfish fisheries. Seines have usually contributed most of the annual landings in 4RST since 1960. In the late 1970s, otter trawls dominated the landings in 4RS, but since 1981 seines have been the dominant gear. Seines did not register witch landings from 4RS in 1984; however, NAFO statistics for that year recorded exceptionally high landings (664 tons) in 3Pn. The witch fishery in 4R occurred mainly between July and September of 1994 (87 of 90 tons landed). In 4T, witch were landed from May to October, with maximum monthly landings in September and October (87 and 84 tons of annual total of 353 tons). Seines were the main gear landing witch in 4R and 4T in all months. All fleet sectors landed witch at levels far below quotas that were allocated for 1994 (Table 3).

The opening of the groundfish fishery was delayed in 1994 because of the presence of cod in inshore areas of 4T. The migration of cod into the Gulf was reported to occur later than in past years. Severe ice conditions in spring also contributed to delaying the outset of the witch fishery in some sectors. Once the fishery began there were fewer closures in the 4T groundfish fisheries than had occurred in 1993 and only one in 4RS that affected the witch fishery (Table 3).

Landings of witch flounder over the past four years have been concentrated in the 4Rd, 4Tf, 4Tg, 4Tk, 4Tn, 4To and 4Tq unit areas (Figure 3). These unit areas combined account for 87-98% annually of the 4RST landings since 1991 (Figure 4). The strongest declines in 1994 were in 4Rd and

4Tk. Landings in 4Tf and 4Tg increased slightly from their level in 1993. Landings from the western Gulf in unit areas off the Gaspé Peninsula (4Tnoq) declined in 1993 and remained low in 1994.

The witch fishery in 4RST is mainly a directed fishery. Since 1985, fishing vessels have reported that 55-81% of their landed catch of witch was obtained while directing fishing effort on witch flounder (Figure 5). The cod-directed fishery contributed between 11 and 30% of the annual witch landings from 1985-1993. In 1994, the plaice-directed fishery accounted for 16% of witch landings in 4RST. The pattern varies across NAFO divisions in the Gulf (Figure 6). Witch landings in 4S are a bycatch of other fisheries. Since 1985, at most 38% of witch landings in 4S have originated from directed effort on witch. In most years, cod, shrimp and redfish fisheries were the main source of witch landings in 4S. For 4R and 4RS witch landings, the directed fishery has accounted for >60% of witch landings. Landings of witch in 4T derived from predominantly witch-directed and secondarily from cod and plaice-directed fisheries.

We compiled the number of days that seines and otter trawls fished witch flounder in 4RST. Since not all vessels provided effort data in their logbooks, the total number of fishing days was corrected for non-reporting by applying the ratio of reported effort (days) to reported landings with effort. The quality of effort data was evaluated by the proportion of annual landings with effort data. Since 1991, 93-99% of witch landed annually in 4R and 4T by seines have indicated effort data and 89-99% of directed witch landings have indicated effort data. In 1985, less than 2% of witch landed by seines in 4R and 4T had effort data. Landing statistics improved in 4T in 1986 (39%) and by 1987, 62% of witch landings had effort data. In 4R, 26% of landings by seines provided effort by 1989. Effort data from trawler logbooks generally provided more effort data than seines. In 4R, trawls have usually provided >60% of their annual witch landings with effort data (the minimum was in 1985: 29%). In 4T, effort data have been provided on >80% of yearly landings in eight of the past 10 years. Effort data in the witch-directed trawl fishery of 4R were less consistent: effort was provided for <10% of directed witch landings in 1985, 1990 and 1992. In conclusion, we feel that effort data on seines in 4T are best since 1986 and in 4RST since 1989. For trawls, effort data are acceptable for 4T and for total effort in 4RST over all years (1985-1994). However, to interprete the directed effort by trawls on witch in 4R and 4RST, the years 1985, 1990 and 1992 should be discounted.

Annual totals of fishing days are given for directed fisheries and for all vessels landing witch flounder in 4T (Figure 7). Although the 4T landings of witch by seiners declined in 1994, the overall effort by seines landing witch increased from 1017 fishing days in 1993 to 1331 days in 1994. Effort by seiners directing for witch increased slightly from 216 days in 1993 to 262 days in 1994. The total effort by seiners landing witch has declined since 1990 in 4T, while the directed effort since 1990 has been relatively stable ranging between 216 and 313 days. The effort by otter trawls landing witch has sharply declined since 1992; however, the effort by trawlers directing for witch increased to 67 days in 1994. Although this is a small effort by a directed fishery, the same effort (68 days) yielded 67 tons of witch in 1986, whereas 19 tons of witch were landed by trawls directing in 1994.

Similar trends were noted in fishing effort for 4RST, but the number of days declined or stabilized in the directed and overall seine fishery (Figure 8). Only 5 tons of witch were landed in 4RS during 1994 and no directed effort was declared on witch. The increase in directed effort by trawlers in 4RST during 1994 was caused by vessels in 4T.

Research data

Abundance indices

Annual groundfish surveys of the Gulf of St. Lawrence are conducted by the Quebec and Gulf regions of DFO. The Quebec Region has surveyed the northern Gulf (4R, 4S and part of 4T) yearly in August since 1984 and in January from 1978-1994. The southern Gulf has been surveyed by the Gulf Region every September since 1971.

Survey designs have been detailed by Koeller (1981), Schwab and Hurtubise (1987) and Hurlbut and Clay (1990). Most of these surveys were based on a stratified random survey design with depth as the main criterion of stratification. From 1971-1983, surveys of 4T included 13 fixed stations that were selected from previous exploratory surveys (Halliday and Koeller 1981). From 1984 to 1987, a fixed station survey design was adopted for 4T with some stations selected from previous surveys and the remaining stations selected randomly in 1984. In 1988, experiments were conducted in which stations were sampled both in the day and at night to evaluate diel effects in catch rates. Since 1988, surveys of 4T have adopted a completely random stratified design.

Previous assessments of cod, American plaice and white hake have rejected fixed stations from 4T surveys of 1971-1983, accepted only a subset of stations fished each year for 1984-1987, and excluded all repeat sets from 1988. Nielsen (in prep.) has evaluated several procedures for including fixed stations and repeat sets in 4T survey indices for major groundfish stocks. The procedure that has been retained includes fixed stations and averages repeat sets before including them in the stratum means.

Abundance indices from groundfish surveys are vulnerable to changes in vessels or fishing gear. In winter surveys of the northern Gulf, the *Gadus Atlantica* was used with a Western IIA trawl from 1978-1988 and an Engels-145 trawl from 1989-1994. In summer, the *Lady Hammond* with a Western IIA was used from 1984-1989. In 1990, the *Alfred Needler* with a Western IIA trawl was used and, since 1991, the *Needler* has been used with a U.R.I. trawl. In the southern Gulf surveys, the *E.E. Prince* with a Yankee 36 trawl sampled from 1971-1985, followed by the *Lady Hammond* and a Western IIA (1985-1991) and the *Alfred Needler* with a Western IIA since 1992. Comparative surveys of the southern Gulf were conducted in 1985 and 1992 to assess the difference in catch efficiencies by simultaneously fishing the two vessels with their respective gears. The results of these surveys (Nielsen 1994) suggest that there is no significant difference between the witch flounder catch rates of survey vessels in the southern Gulf. We accept this assumption while recognizing that the statistical power of these tests is probably low, given the variability in catches and the small number of non-zero witch catches ($n<20$ per vessel, Nielsen 1994).

Most sampling procedures have remained constant between surveys and over time. Length frequency data have been sex-based over most years. For this assessment, data on male, female and unsexed witch have been grouped. Abundance indices for surveys of the northern Gulf were estimated with the program STRAP (Smith and Somerton 1981) and by programs written in the SAS language (SAS Institute 1990). Survey data from the southern Gulf were analyzed with the program RVAN, written in SAS/IML by G. Nielsen, based on the version documented by Clay (1989).

Abundance indices indicating mean number of witch per tow are presented in Figure 9 for the three surveys. Coefficients of variation (c.v.) for the winter survey of the northern Gulf ranged between 11 and 43% over most years. Data were not available for 1982 and it was not possible to estimate variance for the 1984 estimate. The c.v. for the summer survey of the northern Gulf ranged from 8 to 25%. The c.v. in 1986 was exceptionally high (63%) and for this estimate error bars were not indicated in Figure 9. Abundance indices from the southern Gulf have produced c.v. ranging from 14 to 52%.

All surveys indicate declining abundance of witch flounder during the late 1980s. The surveys of the northern Gulf indicate that abundance was highest in 1985 or 1986. Witch abundance in 4T declined after 1988. The abundance indices from the northern Gulf indicate that the stock is currently at its lowest levels since those surveys began. The index based on 4T surveys suggest that 1993 and 1994 estimates are at the upper range of stock abundance observed since 1971. Low periods of stock abundance for the whole of 4T were observed in the early 1980s.

The size composition of catches during winter surveys consisted of witch with total lengths <30 cm until 1985 (Figure 10). Length compositions were unimodal and stable over that period. In 1986, the size composition of witch catches shifted to modal sizes >36 cm. There is no evidence to suggest that survey coverage or gear modifications contributed to this change. Summer surveys of the northern Gulf since 1988 indicate that modal size at 36 cm has declined in favor of witch <26 cm (Figure 11).

Biomass estimates

A recommendation from the last assessment of 4RST witch flounder (Morin et al. 1994) was to estimate 4RST witch biomass by combining estimates from northern and southern Gulf surveys. To assess the significance of variability in catch rates of witch due to surveys, we conducted analyses of catch rates in overlapping strata sampled by the two summer surveys of the Gulf. Survey stratification is shown in Figures 12 and 13. Strata 415, 425 and 439 of the southern Gulf survey (DFO Gulf Region) overlap strata 401-408 of the northern Gulf survey (DFO Québec Region).

Models with region (Gulf or Québec), stratum and year effects were fitted to the data using the GLM procedure of SAS. Separate analyses were conducted on log-transformed catch numbers and catch weights, excluding all null catches. The data were analyzed in two time periods: 1984-1989 when both regions conducted their surveys using the same vessel and trawl; 1991-1994 when the Québec Region used the *Alfred Needler* with a U.R.I. trawl, whereas the Gulf Region used the *Lady Hammond* or the *Alfred Needler* with a Western IIA trawl. The year 1990 was excluded from the comparison because it was the unique combination of the *Alfred Needler* and the Western IIA in the data series from the Québec Region. The last analysis of the data pooled all of the years together.

Analyses of data on the number of witch caught indicated non-significant region effects in both time periods (P>0.3, Table 4). The region effect was not significant in the analysis of catch weight data in the 1984-1989 period (P=0.07), but highly significant in the analysis of the 1991-1994 period (P=0.0018, Table 5). Analyses of data, combined over all years, indicate that catch rates in terms of numbers do not vary significantly by region (P=0.28), but vary significantly in terms of weight (P=0.0001, Table 6).

The highly significant region effect that was noted in catch weight data during 1991-1994 may be evidence of a difference in the size-selectivity of the survey gear used by the two regions. This may have occurred when the Québec Region adopted the *Alfred Needler* and the U.R.I. trawl. Figure

11 indicates that the size distribution of catches during the summer survey changed in 1990 in favor of smaller witch flounder. A similar change in length frequencies was not found in data during this period from the winter surveys (Figure 10).

Further research will be required to assess differences in the size composition of catches before the survey results can be combined for an overall estimate of witch abundance in 4RST. Figure 14 shows combined biomass estimates from the summer surveys of the northern and southern Gulf, assuming similar catch efficiencies for the two surveys. Strata 401-834 were included in the northern Gulf surveys since 1985. Stratum 825 and strata >834 were excluded because these were not regularly covered in all surveys. Estimates of the northern Gulf were expanded to cover the total survey area to correct for strata that were not covered. We estimated 4T witch biomass, less strata 415, 425 and 439, because these were covered by the northern Gulf survey. Excluding these strata from the 4T estimate contributed to reducing the biomass in recent years (Figure 14). This preliminary analysis, uncorrected for differences in gear selectivity, indicate that the combined Gulf estimate of witch biomass has dropped from 30367 tons in 1986 to 497 tons in 1993 and 1174 tons in 1994.

Assessment results

Landings of witch flounder in 4RS and 4RST are at their lowest level recorded since 1960. The decline in landings has occurred in all gear sectors and in all of the main unit areas of 4RST. The decline in landings is not consistent with a similar decline in fishing effort. In fact, fishing effort by seines in 4T in 1994, where most of the catches occured, increased from 1993 levels.

Research survey indices of the northern Gulf of St. Lawrence indicate that the stock is at its lowest level since the late 1980s. The 4T survey index indicates that stock abundance was low in the early 1980s, peaked in 1988, and declined later. The 1993 and 1994 abundance indices for 4T are in the upper range of values that have been observed since the survey began in 1971.

Ecological considerations

Morin and Hurlbut (1994) reviewed the survey data of the Gulf of St. Lawrence, combining summer surveys from northern and southern sectors during summer and winter surveys. By mapping the data, it was shown that witch stocks straddle the 4RST boundaries in all seasons, but particularly in winter when they move to deep channel waters in the eastern Gulf. Morin and Hurlbut (1994) also presented evidence that witch move out of the Gulf in winter. In this section we review the results of a survey conducted in January 1995 in eastern 4RT-4Vn that are pertinent to the seasonal distribution of witch flounder.

A groundfish-herring survey was conducted in Cabot Strait from January 10-29, 1995 on the research vessel *CSS Alfred Needler*. A similar but smaller survey was conducted in January 1994 (Chouinard 1994). The main objective of this survey was to determine the distribution and relative abundance of groundfish species and herring in the Cabot Strait area during the winter.

The survey design followed a grid pattern and covered waters deeper than 50 m. The survey extended from 45° 15' to 48° 05' North and from about 58° to 61° East. The survey started at the northern end of the survey area and proceeded in a southerly direction to minimize problems with ice.

At each location, a standard 30-minute tow, using an Atlantic Western IIA trawl (with 19 mm liner in the lengthening piece and codend), was conducted. Depth profiles of conductivity, temperature and oxygen concentrations were also done.

During the survey, 166 sets were attempted, of which 164 were successful. Witch were caught throughout the area surveyed but catches were largest at the boundaries of 4R, 4S, 4T and 4Vn (Figure 15). Another area of concentration was near the boundary of 4Vn and 4Vs. These results suggest a continuous distribution from 4R, 4S and 4T into area 4Vn in winter. Concentrations were found to be predominant in the middle of the Laurentian Channel in the north. Witch were caught exclusively in waters deeper than 200 m. This distribution was relatively similar to that of the previous year (Chouinard 1994).

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Table 1. Yearly landings of witch flounder in NAFO Division 4RS by major gear types. Gear codes: OTB1=side otter trawl, OTB2=stern otter trawl, SNU=seines, GNS=gillnets, LLS=longlines and handlines.

	GEAR							
YEAR	OTB	OTB1	OTB2	SNU	GN	LLS	OTHER	TOTAL
1960	294	0	0	764	0	3	26	1087
1961	187	0	0	1409	0	17	14	1627
1962	151	0	0	1434	0	22	5	1612
1963	355	0	0	2052	0	25	0	2432
1964	486	0	0	1413	0	86	195	2180
1965	489	0	0	1464	0	36	0	1989
1966	0	426	9	1083	0	3	3	1524
1967	1	419	20	786	3	5	0	1234
1968	0	587	87	861	10	13	0	1558
1969	3	858	271	2427	0	1	0	3560
1970	11	850	443	2298	0	0	0	3602
1971	17	632	146	1604	11	40	0	2450
1972	30	621	217	68	2	7	7	952
1973	66	202	35	559	7	9	9	887
1974	0	366	874	1259	13	0	8	2520
1975	61	404	317	1134	6	4	19	1945
1976	98	1173	3845	101	9	0	115	5341
1977	96	667	1217	606	4	0	6	2596
1978	3	584	2757	787	47	3	114	4295
1979	61	825	1783	1007	94	11	7	3788
1980	42	443	1614	797	50	27	0	2973
1981	87	136	232	731	15	18	0	1219
1982	72	84	120	733	17	2	0	1028
1983	70	45	52	577	10	10	0	764
1984	39	76	44	0	18	11	0	188
1985	26	11	93	539	1	6	21	697
1986	37	7	38	632	3	1	9	727
1987	58	6	76	757	2	0	5	904
1988	52	39	49	946	31	1	15	1133
1989	38	30	120	951	46	0	0	1185
1990	12	23	108	437	16	8	5	609
1991	7	1	84	320	36	1	0	449
1992*	0	2	63	285	11	2	14	377
1993*	0	0	68	276	10	0	96	451
1994*	0	0	5	79	3	0	7	95
MEAN	84	272	423	891	14	11	20	1714

* Provisional data

Table 2. Yearly landings of witch flounder in NAFO divisions 4RST by major gear types. Gear codes: OTB1=side otter trawl, OTB2=stern otter trawl, SNU=seines, GNS=gillnets, LLS=longlines.

	GEAR							
YEAR	OTB	OTB1	OTB2	SNU	GNS	LLS	OTHER	TOTAL
1960	1912	0	0	1309	0	72	45	3338
1961	1428	0	0	1907	7	19	135	3496
1962	1342	0	0	2012	0	28	5	3387
1963	1561	0	0	2612	37	25	15	4250
1964	1377	0	0	1657	0	86	230	3350
1965	1137	0	0	2389	1	67	14	3608
1966	0	1620	39	1845	93	5	110	3712
1967	1	964	33	1647	36	23	10	2714
1968	0	1227	102	1995	46	13	7	3390
1969	3	1286	294	3179	0	1	0	4763
1970	12	1203	504	3078	8	0	0	4805
1971	17	1108	183	2352	11	137	13	3821
1972	30	968	329	636	2	7	29	2001
1973	68	613	56	1330	39	12	106	2224
1974	0	707	946	1569	15	0	10	3247
1975	82	771	371	1449	25	4	20	2722
1976	111	1606	4303	730	9	0	116	6875
1977	99	962	1248	715	4	0	8	3036
1978	3	616	2767	938	69	3	114	4510
1979	62	1065	1970	1309	120	14	21	4561
1980	106	548	1618	1100	98	30	27	3527
1981	108	446	267	1032	24	33	2	1912
1982	93	105	122	934	24	4	0	1282
1983	137	116	52	829	27	10	6	1177
1984	75	110	314	536	51	19	2	1107
1985	27	89	161	1127	28	7	221	1660
1986	49	63	79	1216	6	2	408	1823
1987	58	157	212	1671	7	0	504	2609
1988	56	177	177	1835	34	1	250	2530
1989	45	199	358	1698	47	0	0	2347
1990	12	120	236	873	16	8	7	1272
1991	0	5	180	752	37	2	17	993
1992*	0	4	137	809	11	0	18	979
1993*	0	0	103	691	11	0	96	901
1994*	0	0	31	384	4	0	28	448
MEAN	286	482	491	1433	27	18	74	2811

* Provisional data

Table 3. Resource allocation scheme for witch flounder in 4RS (M.G.= mobile gear; F.G.= fixed gear).

YEAR	GEAR	FINAL ALLOCATION (t)	CATCH (t)	CLOSURES
1994	Vessels >100	430	3	none
	M.G.(65-100)	35	0	none
	M.G. (<65) Danish seines based in 4R, 3PN	450	99	none
	M.G. (<65) other mobile gear	50	2	1
	F.G. (<65)	65	3	none

Table 4. Analyses of variance of GLM on research survey catch data (log number of witch flounder caught, CATN). The model tests the effects of vessel surveys, identified by their respective DFO region (R: Gulf Region, Québec Region), stratum (STRAT: strata 415, 425, 439), and year. Least-square means (LSMEAN) are shown for standardized catches of each region. Separate analyses were made for the periods 1984-1989 and 1991-1994, due to changes in gear and vessels (explained in text).

PERIOD=84-89

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	13.99260408	1.99894344	2.24	0.0360
Error	107	95.28909622	0.89055230		
Corrected Total	114	109.28170030			

R-Square	C.V.	Root MSE	CATN Mean
0.128042	72.81987	0.94369079	1.29592488

Source	DF	Type I SS	Mean Square	F Value	Pr > F
R	1	0.67887310	0.67887310	0.76	0.3846
STRAT	2	1.56277839	0.78138920	0.88	0.4188
YEAR	4	11.75095259	2.93773815	3.30	0.0137

Source	DF	Type III SS	Mean Square	F Value	Pr > F
R	1	0.46983909	0.46983909	0.53	0.4692
STRAT	2	0.67794172	0.33897086	0.38	0.6844
YEAR	4	11.75095259	2.93773815	3.30	0.0137

R	CATN LSMEAN	T / Pr > |T| H0: LSMEAN1=LSMEAN2
Gulf	1.35533612	0.726348
Québec	1.22176866	

PERIOD=91-94

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	13.08379175	2.18063196	2.59	0.0255
Error	68	57.23593549	0.84170493		
Corrected Total	74	70.31972724			

R-Square	C.V.	Root MSE	CATN Mean
0.186061	63.90388	0.91744479	1.43566375

Source	DF	Type I SS	Mean Square	F Value	Pr > F
R	1	0.51282915	0.51282915	0.61	0.4378
STRAT	2	7.14413868	3.57206934	4.24	0.0183
YEAR	3	5.42682392	1.80894131	2.15	0.1021

Source	DF	Type III SS	Mean Square	F Value	Pr > F
R	1	0.62988645	0.62988645	0.75	0.3900
STRAT	2	7.61761350	3.80880675	4.53	0.0143
YEAR	3	5.42682392	1.80894131	2.15	0.1021

R	CATN LSMEAN	T / Pr > |T| H0: LSMEAN1=LSMEAN2
Gulf	1.41734166	0.86507
Québec	1.22739240	

Table 5. Analyses of variance of GLM on research survey catch data (log weight of witch flounder caught, CATW). The model tests the effects of vessel surveys, identified by their respective DFO region (R: Gulf Region, Québec Region), stratum (STRAT: strata 415, 425, 439), and year. Least-square means (LSMEAN) are shown for standardized catches of each region. Separate analyses were made for the periods 1984-1989 and 1991-1994, due to changes in gear and vessels (explained in text).

---------- PERIOD=84-89 ----------

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	18.28181325	2.61168761	2.90	0.0084
Error	99	89.07402045	0.89973758		
Corrected Total	106	107.35583371			

R-Square	C.V.	Root MSE	CATW Mean
0.170292	162.0795	0.94854498	0.58523431

Source	DF	Type I SS	Mean Square	F Value	Pr > F
R	1	3.69172289	3.69172289	4.10	0.0455
STRAT	2	5.08763859	2.54381929	2.83	0.0640
YEAR	4	9.50245178	2.37561294	2.64	0.0382

Source	DF	Type III SS	Mean Square	F Value	Pr > F
R	1	3.10478560	3.10478560	3.45	0.0662
STRAT	2	3.22114215	1.61057107	1.79	0.1723
YEAR	4	9.50245178	2.37561294	2.64	0.0382

R	CATW LSMEAN	T / Pr > |T| H0: LSMEAN1=LSMEAN2
Gulf	0.74990151	1.857624
Québec	0.38622927	

---------- PERIOD=91-94 ----------

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	51.51694877	8.58615813	3.42	0.0052
Error	68	170.47168292	2.50693651		
Corrected Total	74	221.98863169			

R-Square	C.V.	Root MSE	CATW Mean
0.232070	-349.5427	1.58333083	-0.45297203

Source	DF	Type I SS	Mean Square	F Value	Pr > F
R	1	30.38288832	30.38288832	12.12	0.0009
STRAT	2	5.43401404	2.71700702	1.08	0.3441
YEAR	3	15.70004641	5.23334880	2.09	0.1100

Source	DF	Type III SS	Mean Square	F Value	Pr > F
R	1	26.58679452	26.58679452	10.61	0.0018
STRAT	2	4.41987322	2.20993661	0.88	0.4188
YEAR	3	15.70004641	5.23334880	2.09	0.1100

R	CATW LSMEAN	T / Pr > |T| H0: LSMEAN1=LSMEAN2
Gulf	-0.02211722	3.256577
Québec	-1.25618624	

Table 6. Analyses of variance of GLM on research survey catch data (CATN: log number of witch caught; CATW: log weight of witch caught), all years included. The model tests the effects of vessel surveys, identified by their respective DFO region (R: Gulf Region, Québec Region), stratum (STRAT: strata 415, 425, 439), and year. Least-square means (LSMEAN) are shown for standardized catches.

Dependent Variable: CATN

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	25.23449229	2.29404475	2.63	0.0039
Error	178	155.25335608	0.87220987		
Corrected Total	189	180.48784837			

R-Square	C.V.	Root MSE	CATN Mean
0.139813	69.12384	0.93392177	1.35108496

Source	DF	Type I SS	Mean Square	F Value	Pr > F
R	1	1.51716572	1.51716572	1.74	0.1889
STRAT	2	7.03729603	3.51864802	4.03	0.0193
YEAR	8	16.68003053	2.08500382	2.39	0.0180

Source	DF	Type III SS	Mean Square	F Value	Pr > F
R	1	1.01000662	1.01000662	1.16	0.2833
STRAT	2	5.57073223	2.78536611	3.19	0.0434
YEAR	8	16.68003053	2.08500382	2.39	0.0180

R	CATN LSMEAN	T / Pr > |T| H0: LSMEAN1=LSMEAN2
Gulf	1.38147910	1.076097
Québec	1.23065007	

Dependent Variable: CATW

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	108.73477657	9.88497969	6.27	0.0001
Error	170	268.13675509	1.57727503		
Corrected Total	181	376.87153166			

R-Square	C.V.	Root MSE	CATW Mean
0.288519	797.8907	1.25589611	0.15740203

Source	DF	Type I SS	Mean Square	F Value	Pr > F
R	1	13.53393541	13.53393541	8.58	0.0039
STRAT	2	8.28603407	4.14301703	2.63	0.0753
YEAR	8	86.91480710	10.86435089	6.89	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
R	1	23.77686991	23.77686991	15.07	0.0001
STRAT	2	5.62692819	2.81346409	1.78	0.1711
YEAR	8	86.91480710	10.86435089	6.89	0.0001

R	CATW LSMEAN	T / Pr > |T| H0: LSMEAN1=LSMEAN2
Gulf	0.44715058	3.882609
Québec	-0.30726444	

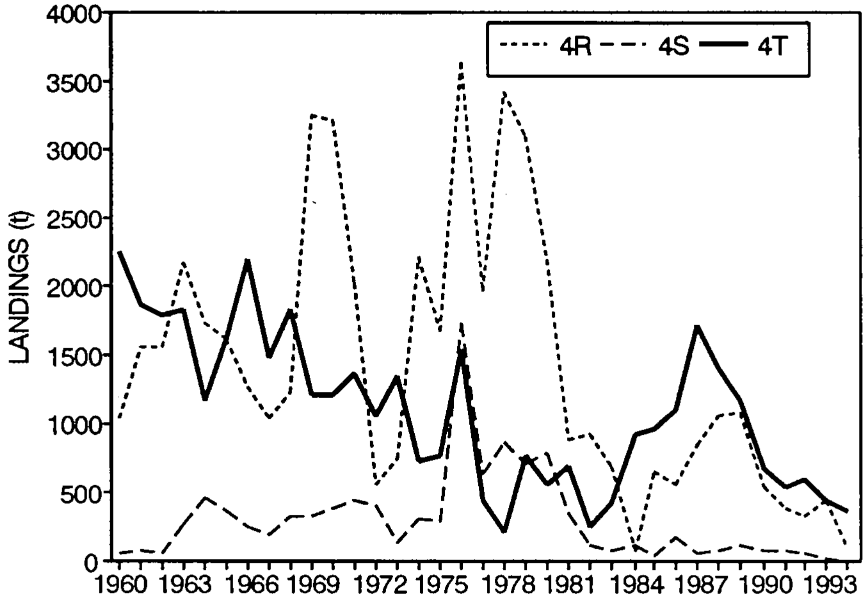


Figure 1. Nominal landings of witch flounder by NAFO division.

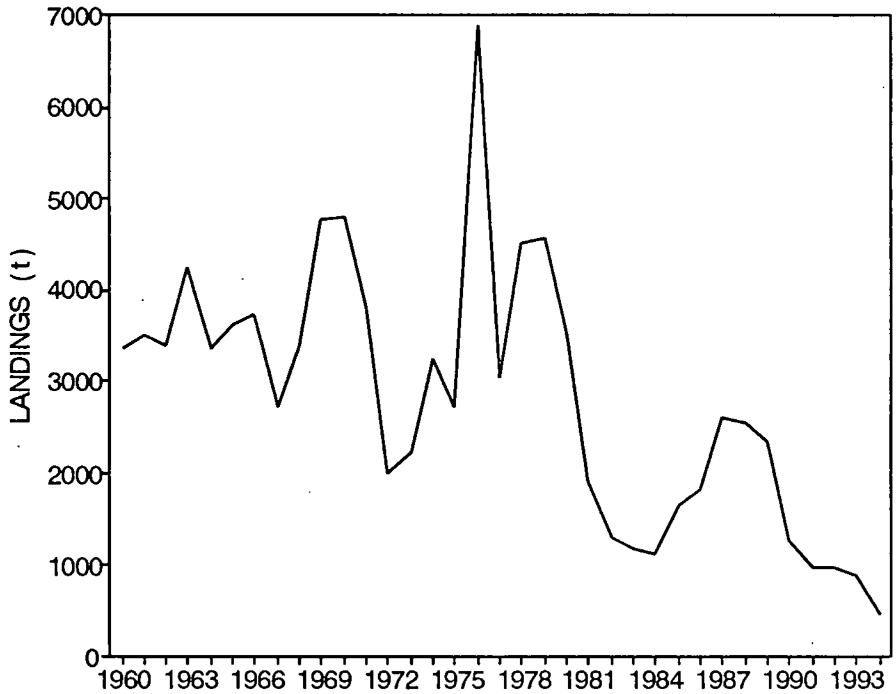


Figure 2. Nominal landings of witch flounder in NAFO Division 4RST.

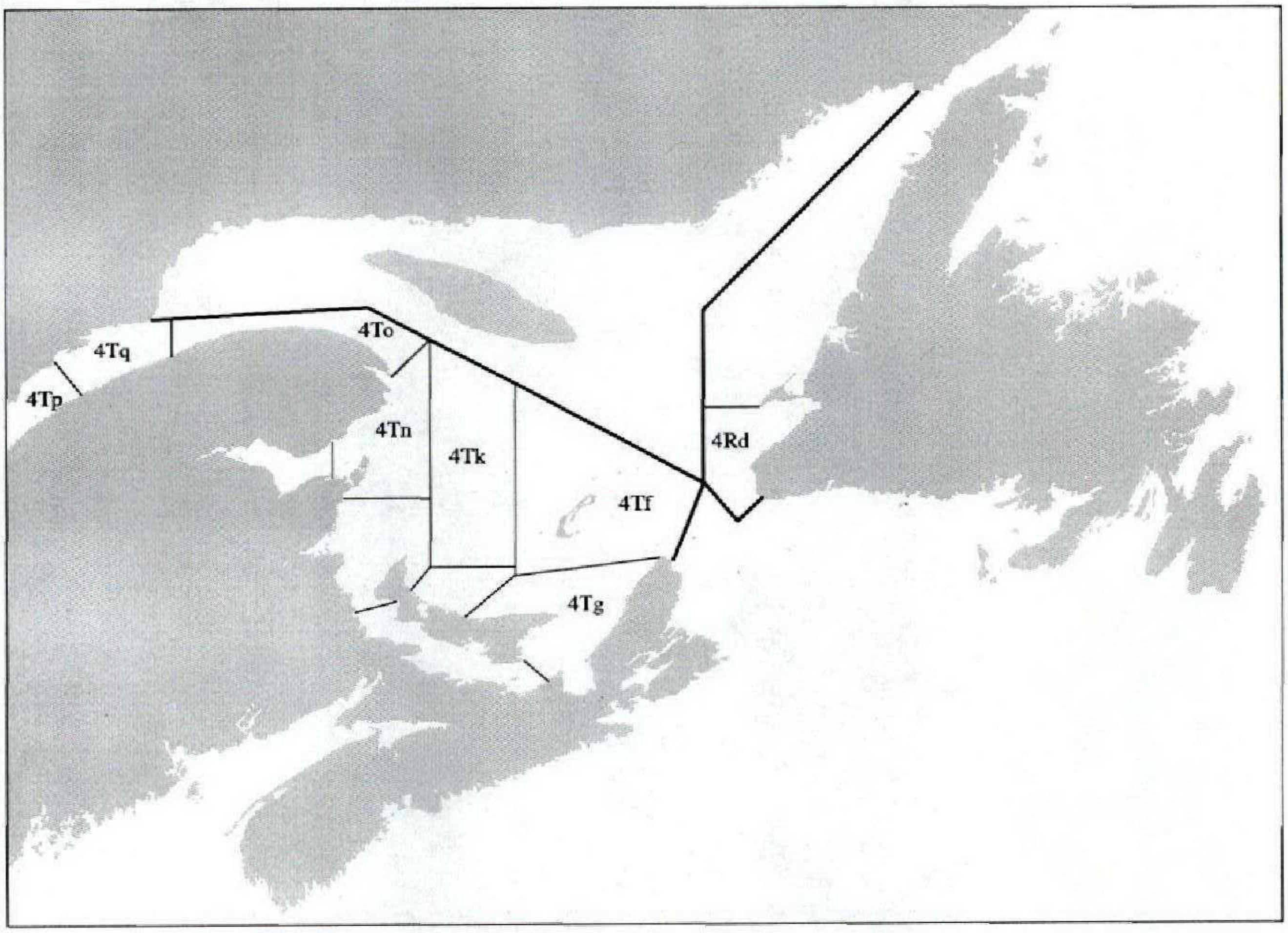


Figure 3. Area map showing Gulf of St. Lawrence and major unit areas where witch flounder are landed in NAFO divisions 4RST.

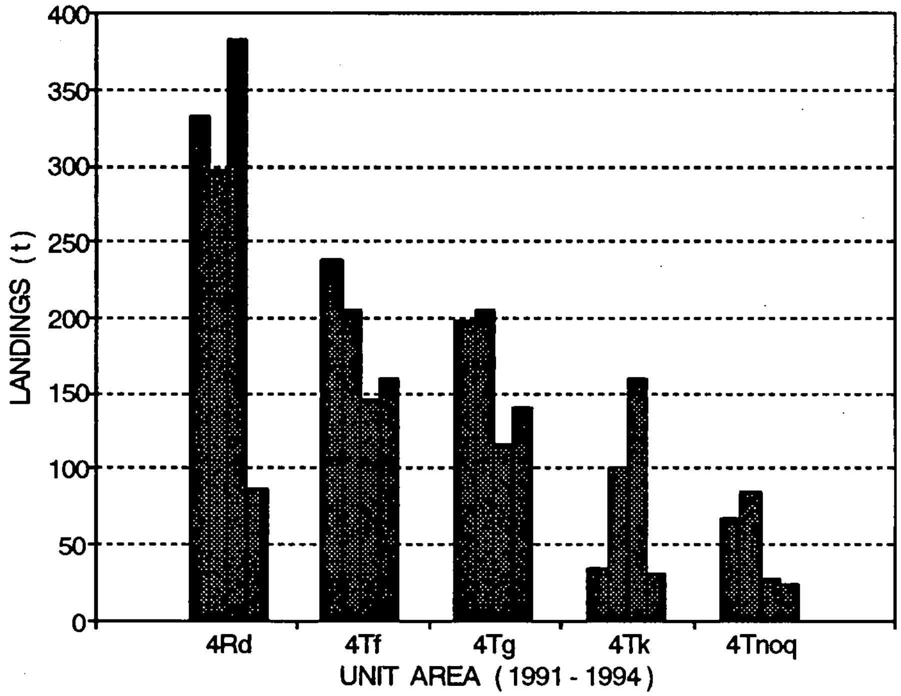


Figure 4. Annual landings of witch flounder by major unit areas.

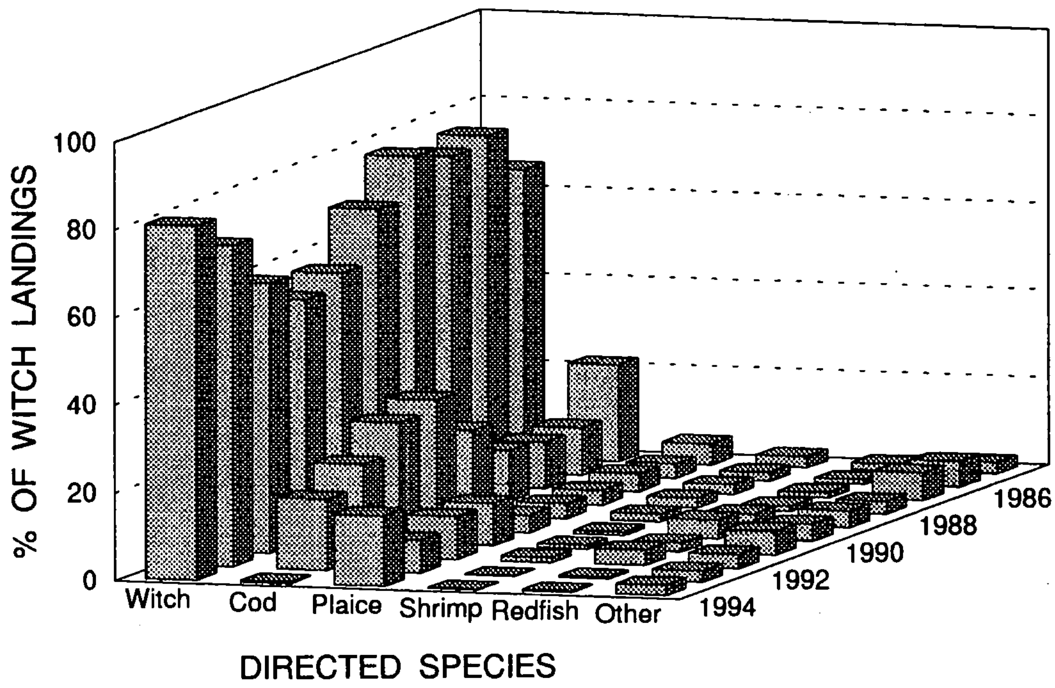


Figure 5. Witch landings by directed species in NAFO divisions 4RST.

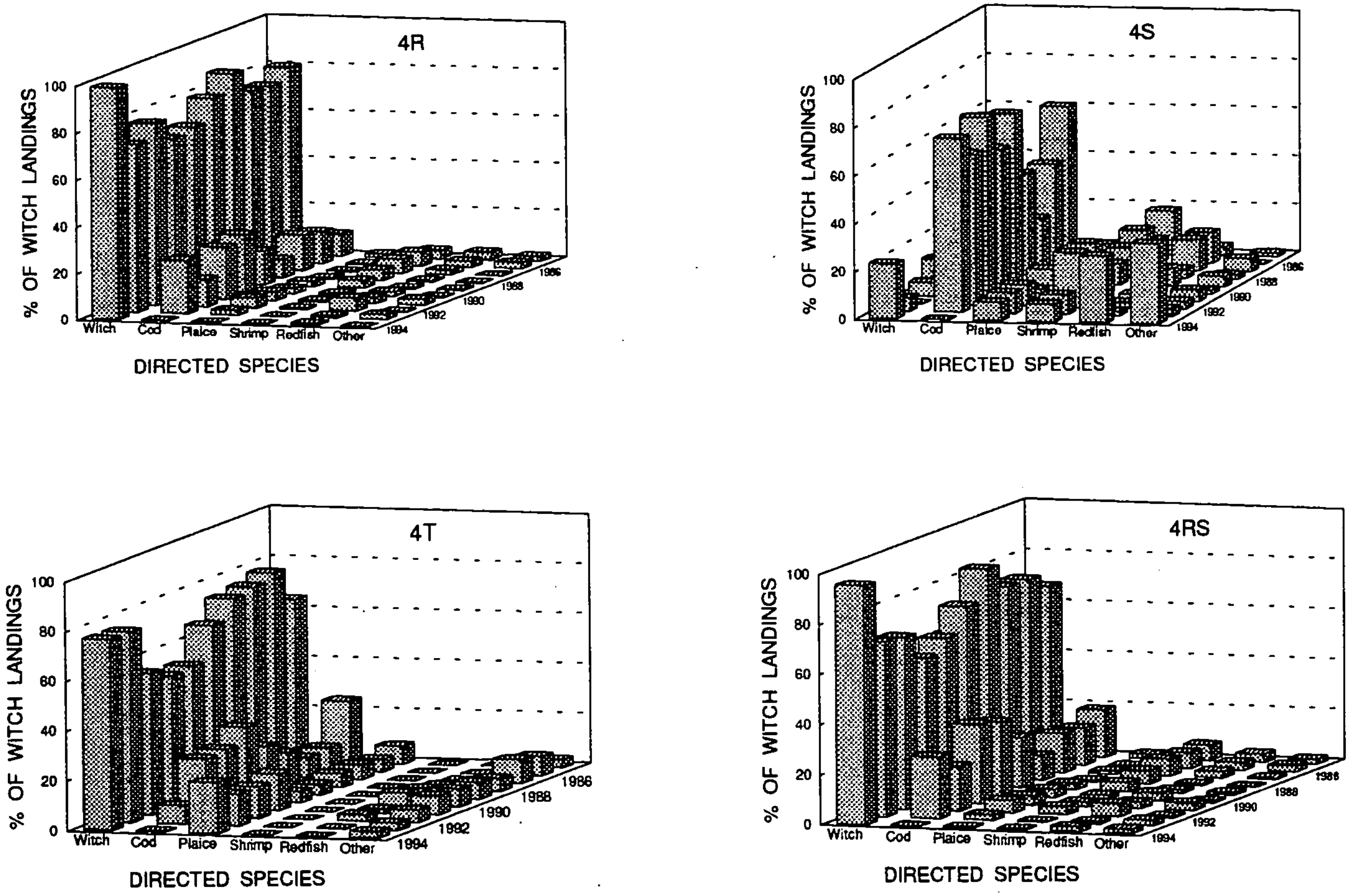
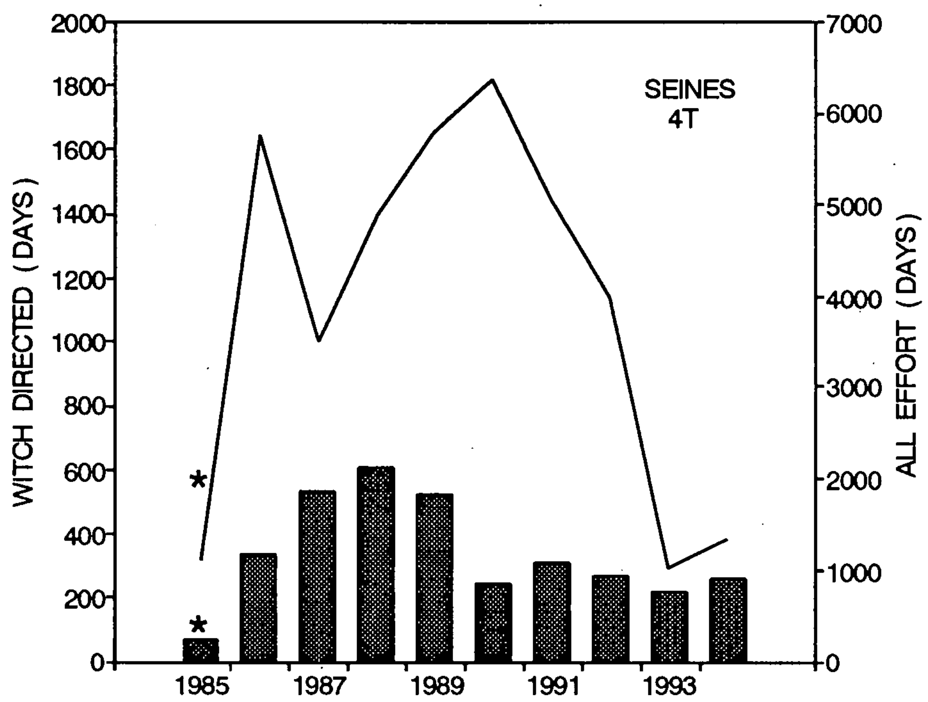


Figure 6. The percentage of annual witch landings in NAFO divisions, by directed species.



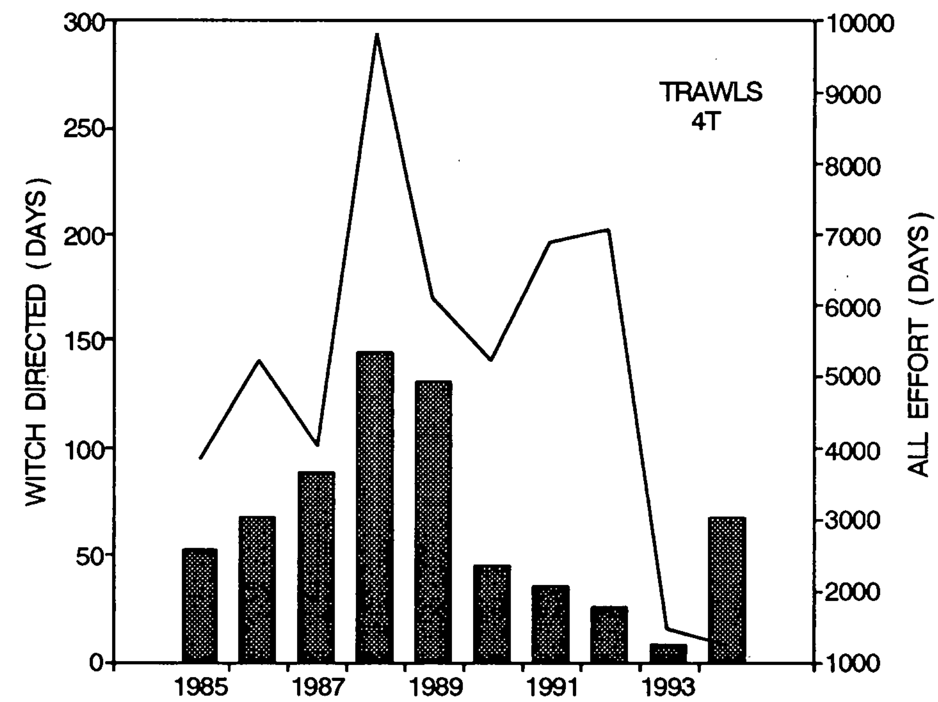


Figure 7. Fishing effort as number of days fishing, for seines and trawls in 4T. Columns indicate the effort attributed to directed witch landings; lines indicate total effort by all vessels landing witch. * indicates effort data for <10% of witch landings.

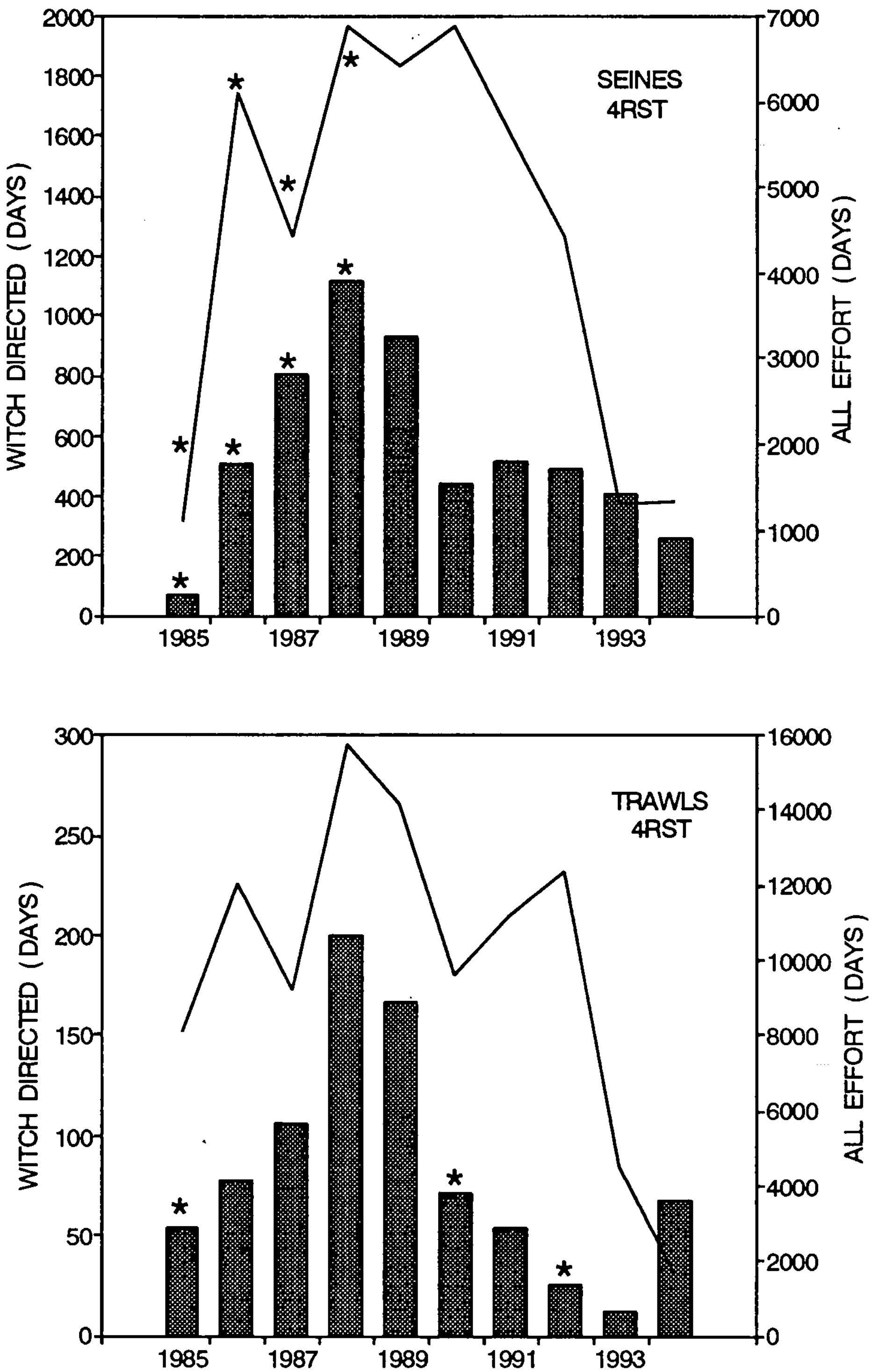


Figure 8. Fishing effort as number of days fishing, for seines and trawls in 4RST. Columns indicate the effort attributed to directed witch landings; lines indicate total effort by all vessels landing witch. * indicates effort data for <10% of 4R or 4T landings.

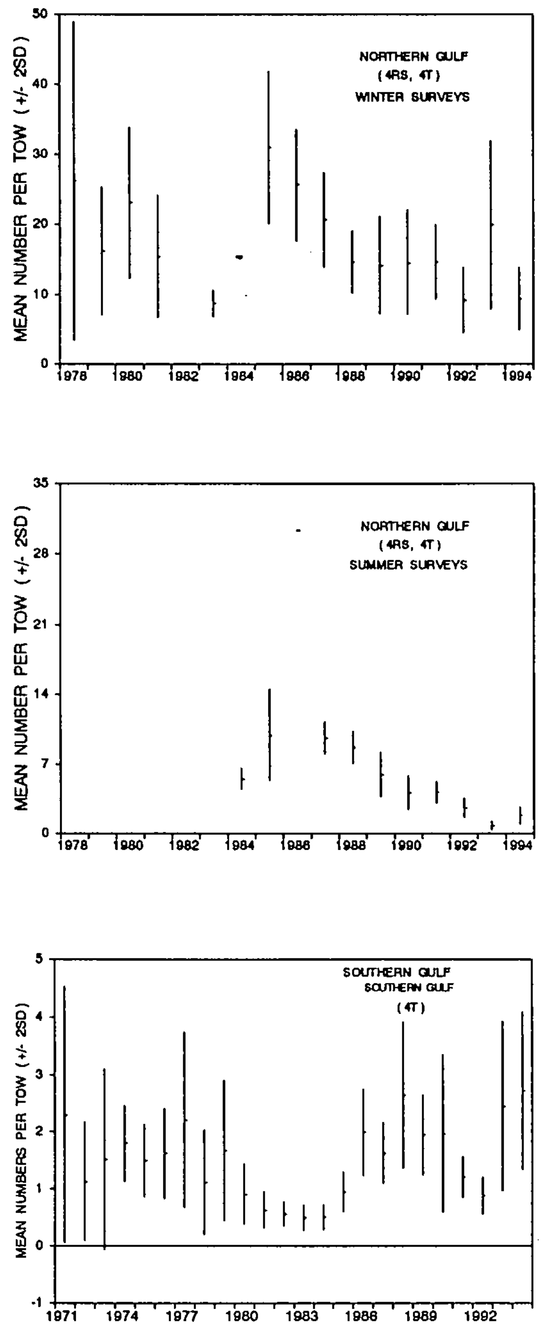


Figure 9. Abundance indices based on surveys of the northern Gulf of St. Lawrence (4RS and part of 4T) in August and January, and surveys of the southern Gulf (4T).

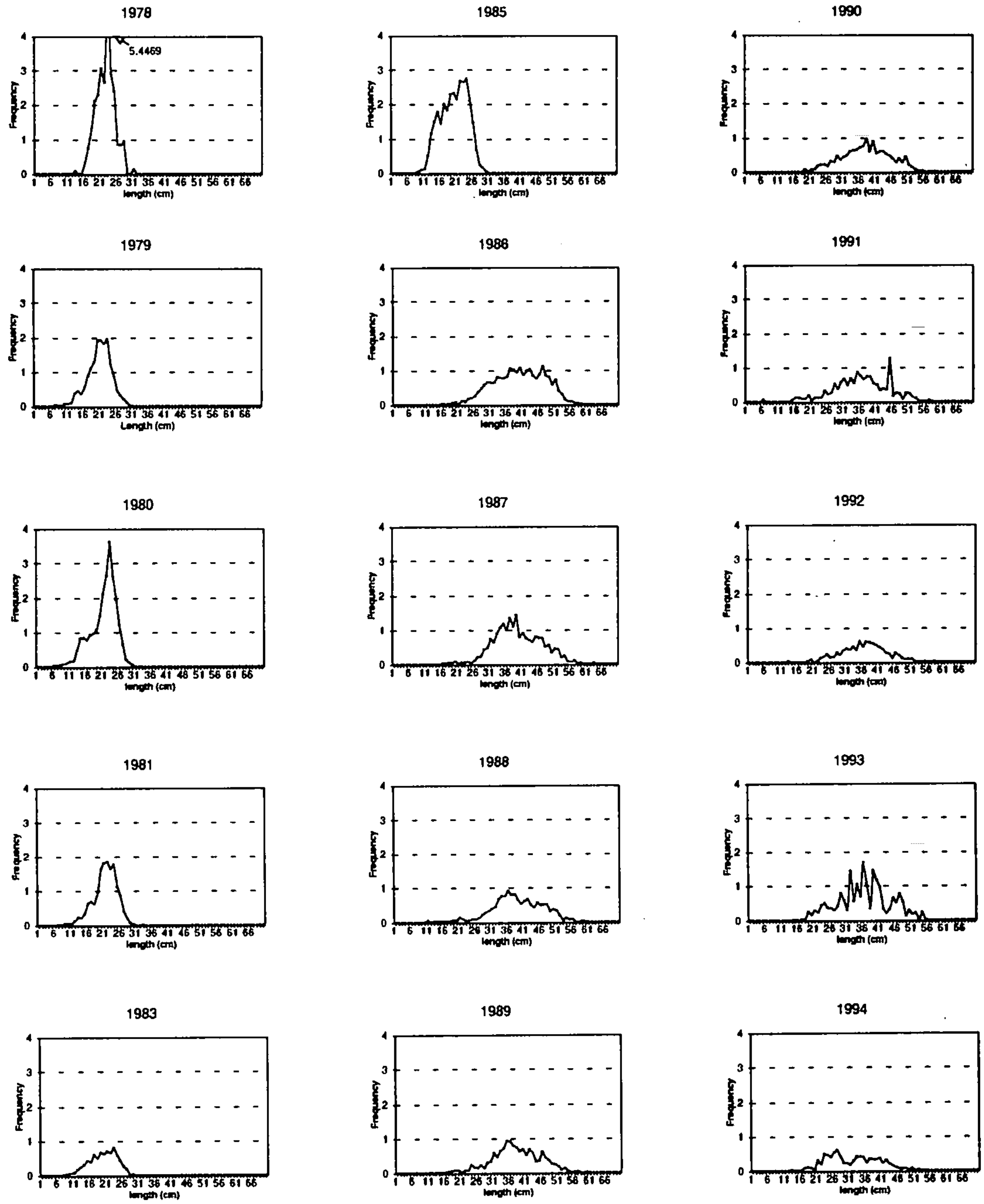


Figure 10. Mean length frequencies of witch flounder in winter surveys of 4RST (DFO Quebec Region). Length frequency data from 1982 and 1984 were unavailable.

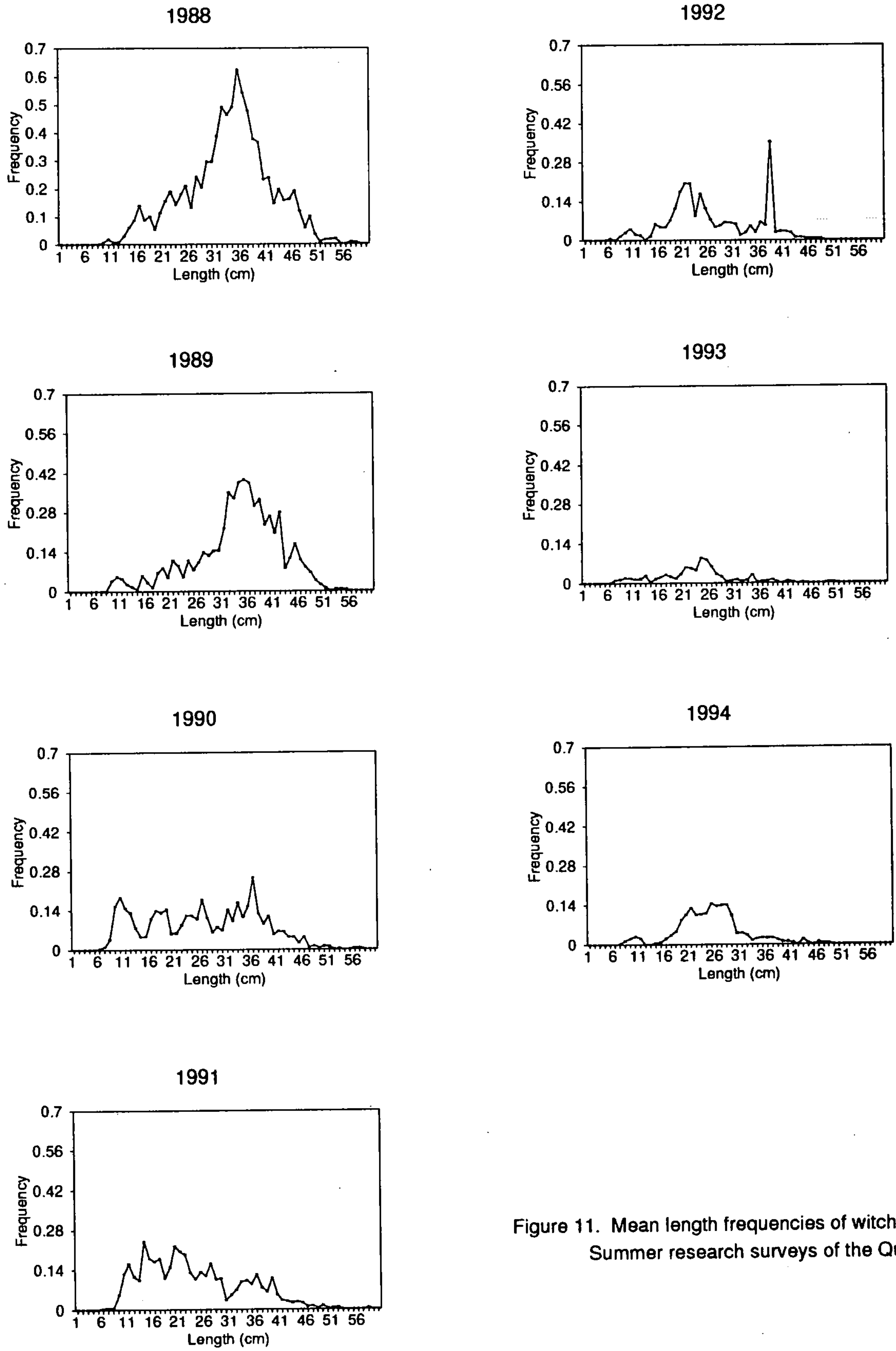


Figure 11. Mean length frequencies of witch flounder in 4RS. Summer research surveys of the Quebec Region.

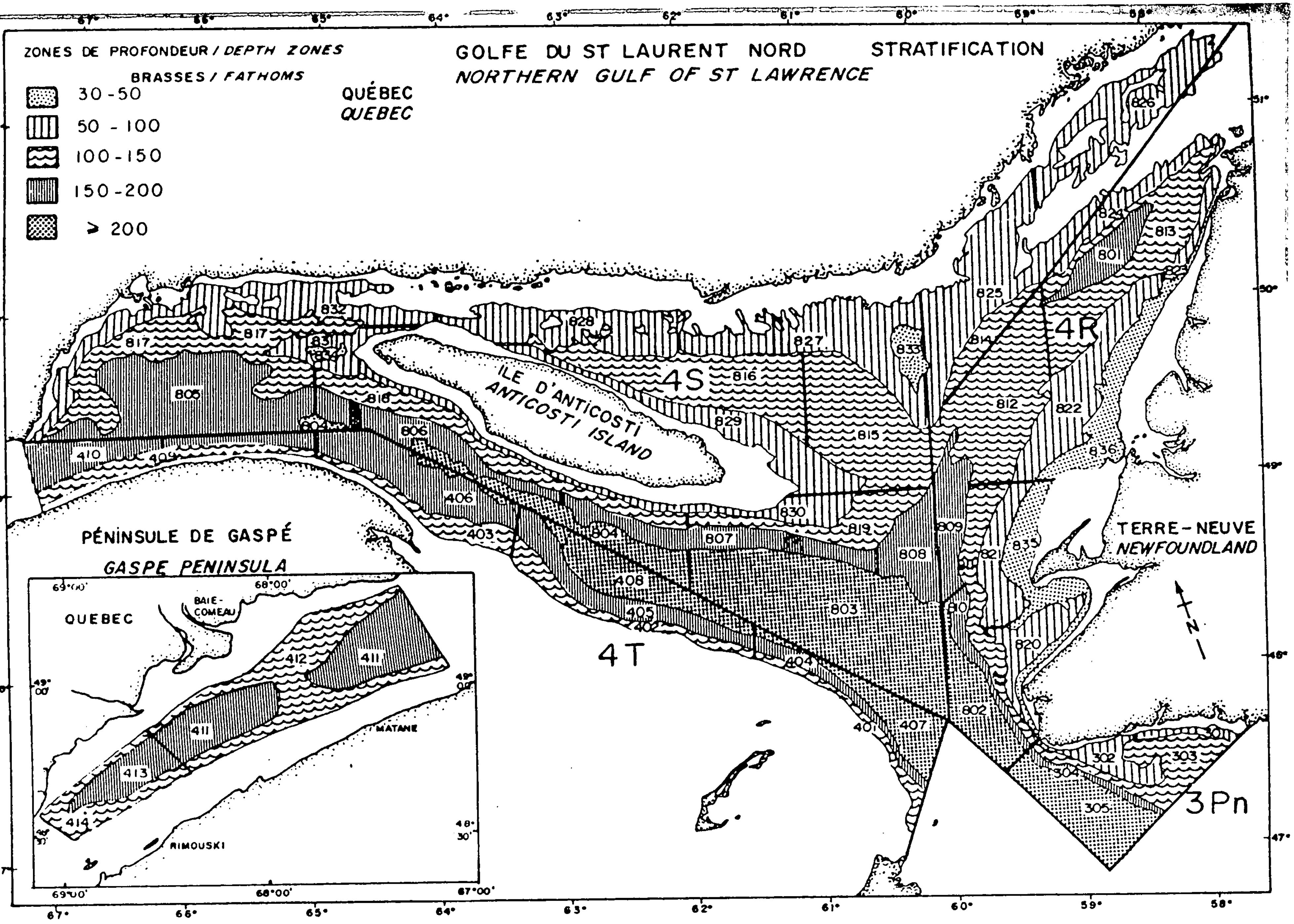


Figure 12. Stratification of the northern Gulf surveys of the Québec Region, DFO.

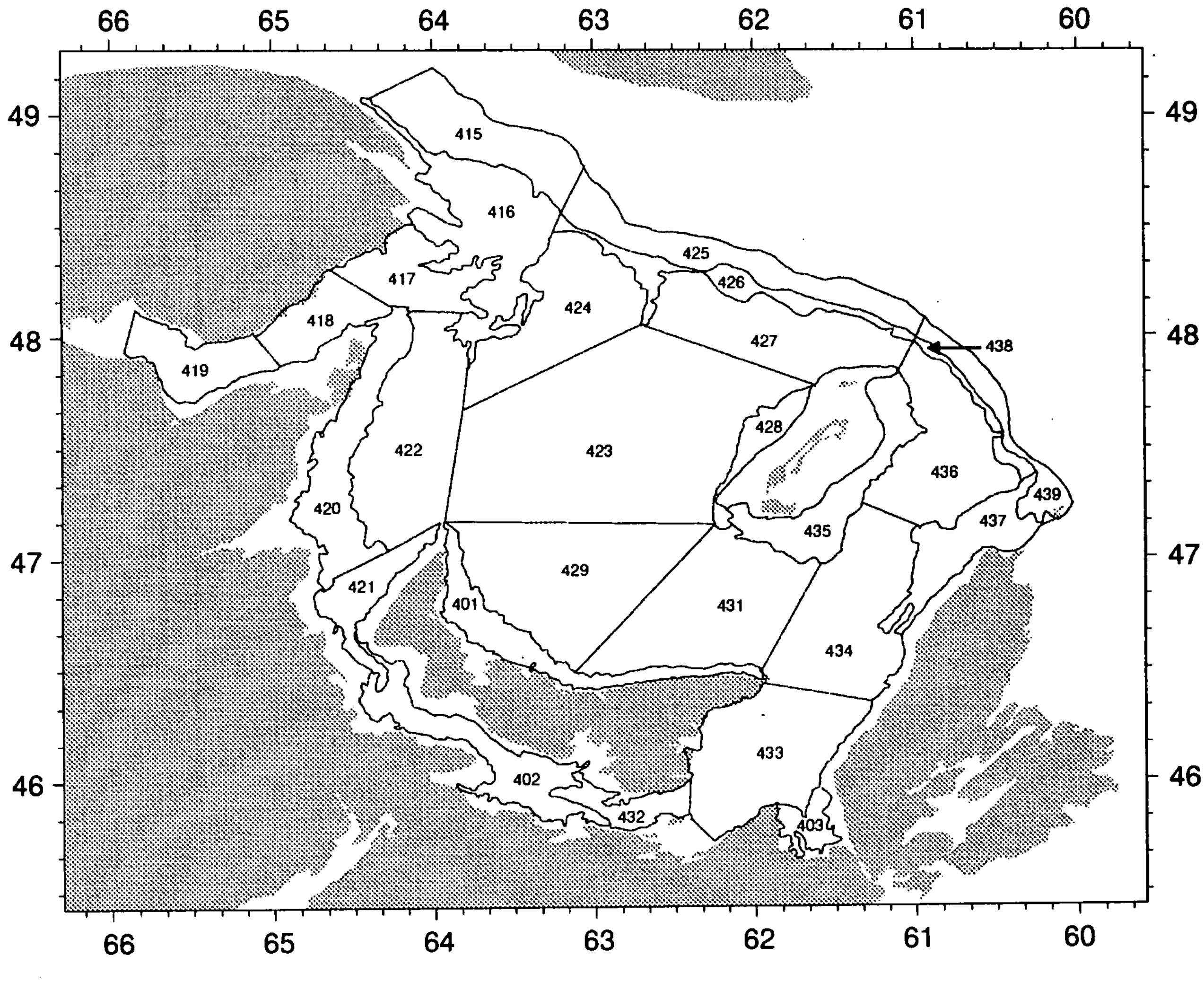


Figure 13. Stratification for the September groundfish abundance survey of the southern Gulf of St. Lawrence.

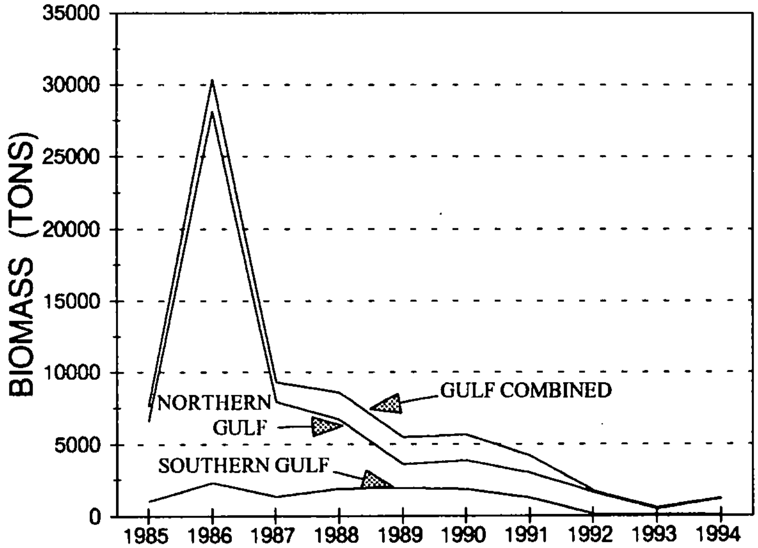


Figure 14. Witch biomass in 4RST estimated from combined survey data of the DFO Quebec Region (northern Gulf August survey) and the DFO Gulf Region (southern Gulf September survey).

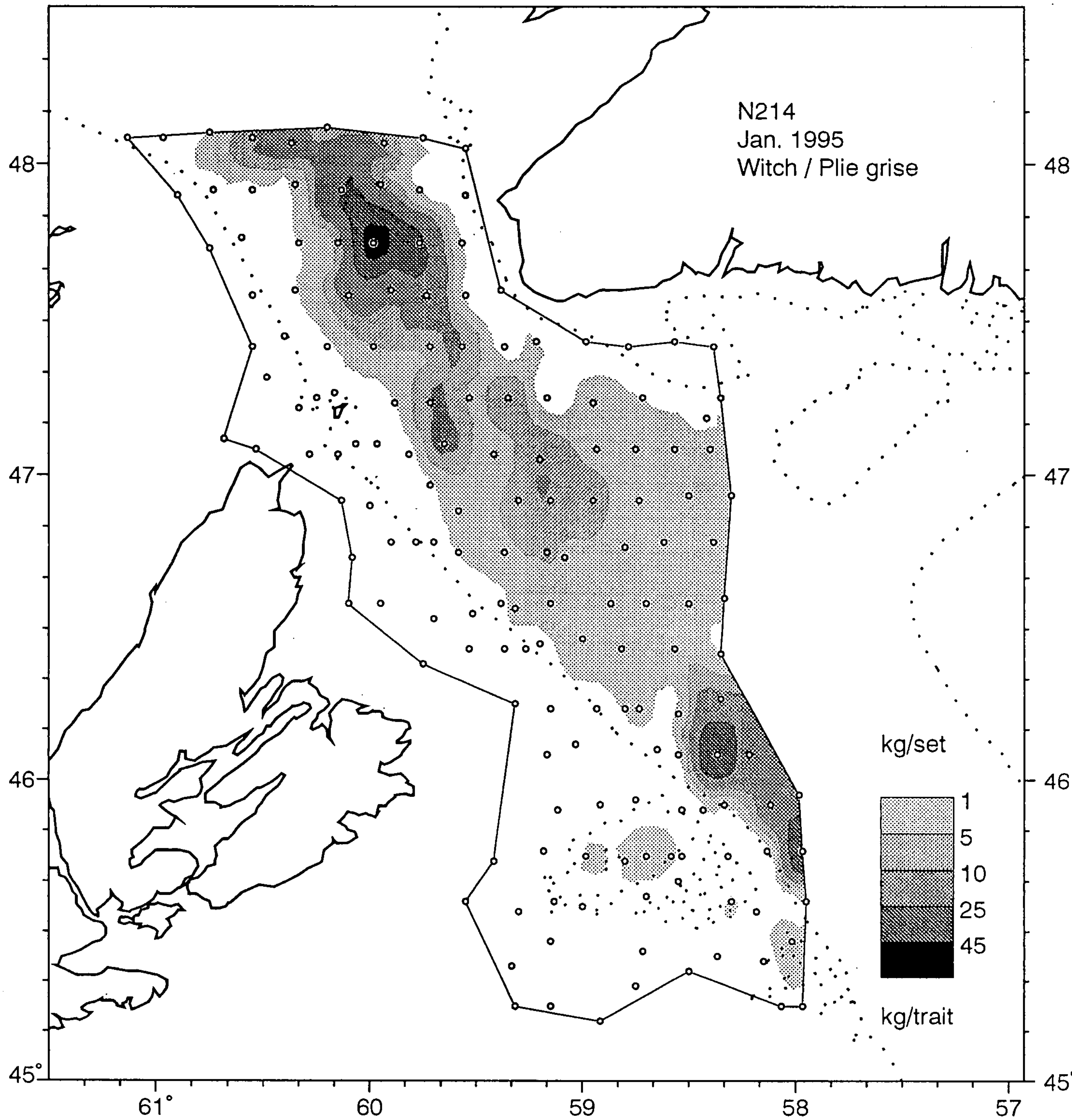


Figure 15.: Catches of witch flounder (kg/standard tow) during the January 1995 groundfish and herring survey in Cabot Strait. Open circles indicate set locations; dotted line is 200m countour.