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Timing of Cod Migrations Into and Out of the Gulf of St. Lawrence Based on Commercial Fisheries, 1986-93.

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Abstract

Landings data from mobile gear vessels fishing at the entrance of the Gulf of St. Lawrence (4Tfg and 4Vn) provide useful information on the timing of the annual migrations of cod. During the period 1986-89, the 4Tfg and 4Vn spring fisheries were about half over by May 1, indicating that a substantial portion of the southern Gulf stock was still in 4Vn in early May. In 1991 and 1992, the spring fisheries were delayed by late ice-out and almost all of the spring fisheries in both areas occurred in May. This indicates that there were large landings of southern Gulf cod made in 4Vn during May. The fall fisheries in 4Tfg occurred almost entirely during the month of November. Mobile gear landings increased in 4Vn in mid-November and the timing of these increases indicates the arrival of southern Gulf cod.

Resumé

Les données sur les débarquements réalisés par les bateaux à engins mobiles qui exploitent la pêche à l'entrée du golfe du Saint-Laurent (4Tfg et 4Vn) constituent de l'information chronologique utile au sujet des migrations annuelles de la morue. Entre 1986 et 1989, la pêche printanière dans 4Tfg et 4Vn était à peu près la moitié terminée au 1er mai, ce qui signifie qu'une importante partie du stock du sud du golfe était toujours dans 4Vn au début mai. En 1991 et 1992, la pêche printanière a été retardée par le départ tardif des glaces, et la presque totalité des prises du printemps dans les deux secteurs ont eu lieu en mai. Ces données indiquent qu'il y a eu d'importants débarquements de morues du sud du Golfe dans 4Vn en mai. Les prises de la pêche automnale dans 4Tfg surviennent presque entièrement en novembre. Les débarquements du secteur des engins mobiles augmentent dans 4Vn à la mi-novembre et ces hausses coïncident avec l'arrivée de la morue du sud du golfe.

Introduction

Cod fisheries at the entrance to the Gulf of St. Lawrence are very seasonal and are based on the migration of cod into and out of the area (Sinclair 1993). The current management unit for southern Gulf of St. Lawrence cod includes landings in all of 4T with those in 4Vn during January-April. In a recent study, Lambert (1993) concluded that the migration of cod out of 4T begins in October and is largely completed in December and recommended that landings in 4Vn during December be included in the assessment of southern Gulf of St. Lawrence cod. There was no discussion of the timing of the spring migration.

We have investigated the variation in the timing of the spring and fall fisheries in the eastern part of 4T in relation to sea ice retreat in spring, to tidal and lunar cycles and to management measures . The implications of the timing of these fisheries and the associated migration on the current definitions of the 4TVn°(J-A) and 4Vn (M-D) cod management units are discussed.

Methods

The data used in this study were obtained from the Department of Fisheries and Oceans regional statistics branches. Data were taken for the statistical unit areas 4Tfg and 4Vn for otter trawls and seines.

Data were aggregated based on date landed. This was necessary because although date caught is recorded in some records, it is inconsistent among vessels, regions, and years.

In some records, date landed preceded date caught indicating errors in these fields. We assumed that the date landed was more accurate than the date caught, but this was not confirmed. While using date landed may obscure the actual peak of the fisheries, over 90% of the fishing trips were less than or equal to 3 days duration and thus the error is likely to be small.

We calculated the cumulative frequency distribution of landings (percent) and determined the dates corresponding to the 25th, 50th (median date), and 75th percentiles of the total cod landings in the spring and fall fisheries. Weekly landings were also calculated with weeks defined as

$$\text{week} = \text{int}\left(\frac{\text{dayofyear}}{7}\right)$$

where int = the integer portion of the expression in brackets.

We examined the timing of landings for the entire year in both areas and then more specifically the timing of the spring (April-June inclusive) and fall (October-December inclusive) fisheries in 4Tfg.

We were also interested in both the location of the fisheries and thus a subset of the data was extracted for those vessels which submitted logbook information giving positions to at least 10' rectangles of latitude and longitude. Data on this spatial scale were available from the Quebec and Gulf regions from 1986-92 and from the Scotia Fundy Region from 1990-92. No data on the appropriate spatial scale were available from the Newfoundland Region. Weekly maps of catch were produced using the ACON mapping software (G. Black, pers comm.) and assembled into animations using the Quicktime facility on a Macintosh personal computer. Selected maps are presented here.

Reference dates, days of year, and weeks are given in Table 1.

Ice maps were obtained from DOE Ice Central and were examined to determine the extent of coverage in the 4Tfg fishing area during the spring period (Figure 1). The available maps were classified as to the percentage ice free and the results were plotted against day of year. The date of 50% ice coverage was estimated by eye. No ice was present in the study area during the fall fishing period.

Tide charts for Pictou were consulted to determine daily tidal amplitudes and dates of spring tides. Dates of full moons were obtained from annual calendars.

Details of annual groundfish management plans and fishery closures were obtained from Fisheries and Habitat Management Branch, DFO.

Results

The weekly landings data were smoothed using a spline function and are plotted for 4Vn and 4Tfg in Figure 2. In most years there were two peak periods of landings from 4Tfg, in the spring around the beginning of May and in the fall in mid-November. The fall fisheries in 1986-87 were curtailed by low catch quotas; most of the annual quota was taken in the spring and summer fisheries. In 4Vn there was a peak in early winter (January) and spring (late April-early May). However, the landings often increased in November-December and in 1992 there was a distinct peak in November. The spring peaks in 4Tfg and 4Vn coincided during weeks 17 and 18 of 1986-89. In 1990-91 the

4Vn peak preceeded that in 4Tfg. In 1991 and 1992 both spring fisheries occurred later than normal with the peak landings in both 4Tfg and 4Vn occurring in the month of May. Landings in 1993 were very low because of greatly reduced TAC's at the beginning of the year and fishery closures in September.

The 1990-92 spring fisheries in 4Vn and 4Tfg followed a similar spatial pattern each year (Figures 3-5). The fishery was concentrated in the southern portion of 4Vn in the early part of the spring, then moved northwest along the edge of the Laurentian Channel to the tip of Cape Breton, then into 4T. Within 4T the fishery then moved in a southwesterly direction along the Cape Breton Trough to a latitude off East Point, P.E.I. At the same time, a smaller branch of the fishery continued along the Laurentian Channel edge, north of the Magdalen Islands. While the spatial pattern was similar, the fisheries became progressively later in each year.

The fall fisheries followed similar spatial and temporal patterns in the 3 years (Figure 6-8). The fishery passed through 4Tfg in the opposite direction to the spring fishery. The highest catches were first experienced in the southwestern area and moved northeast along the Cape Breton Trough during weeks 44-46. A second branch appeared north of the Magdalen Islands in week 45 and joined the other branch off the tip of Cape Breton.

The median dates of the spring fishery in 4Tfg ranged from April 29 (1986) to May 22 (1992), a range of 23 days (Figure 9). There was little variation in the median date from 1986-90 (range 7 days), but the median dates became progressively later in 1991-92. The number of days between when 25th and 75th percentile of the annual spring fisheries varied between 16-21 days with no apparent trend (Figure 10).

The median dates of the fall fishery in 4Tfg ranged from November 10 (1987) to November 19 (1990), a range of 9 days (Figure 9) and there was no apparent trend. The number of days between when 25th and 75th percentiles of the 1986-87 fall fisheries was very short, due to quota restrictions. Since then it has varied between 8-21 days with the 1990-92 fisheries being shorter than the 1988-89 fisheries (Figure 10). The landings peaked during weeks 45-46 and by week 48 the fisheries were over. In both the spring and fall, the weeks of peak landings corresponded with the weeks of median landings.

The timing of ice out in 4Tfg varied from year to year, the earliest date when the area was 50% clear of ice was in 1990 (day 94) and the latest in 1992 (day 132) (Figure 11). Ice out in 1987 was the second latest in the study period. There was a significant correlation between the date of 50% landings and 50% ice out, however, it was highly influenced by the 1992 point. While ice out was relatively late in 1987, the date of 50% landings was similar to adjacent years. Cumulative landings and ice coverage are compared in Figure 12 and this shows that the fishery was usually about 20 days behind the ice out. The exception was in 1987 when the two cumulative curves were much closer together. However, it was noted that in 1987 the sea ice was farther from shore in 4Tfg and there was less ice in 4Vn than for the same periods in 1991.

The lunar (date of full moon) and tidal (date of spring tides) cycles follow a regular annual pattern, basically advancing 7 days per year. Given that the peaks of the fall 1986-92 and spring 1986-90 fisheries peaked within 8 days of each other, it would appear that these had little effect on the timing of the migrations.

There has been a proliferation of catch quotas applied to the 4T mobile gear cod fisheries during the spring and fall over the time period of the study (Annex I). There were three catch quotas for the mobile gear fleets in 1986. This increased first to spread the catches

over the year and leave some quota for the fall fishery, then to address the concerns of specialist and generalist fleets. A new fleet sector emerged, the mobile gear less than 45' vessels. Individual transferable quotas were introduced in 1988 for the 65'-100' vessels, in 1989 for the 50'-64' vessels, and finally for the 45'-49' and <45' vessels in 1992. Prior to ITQ's, seasonal quotas were applied to the entire mobile gear fleet in an attempt to preserve quota for the end of the year. However, quota overruns occurred thus indicating that the fisheries continued to operate even if the quotas were exhausted. As a result of spring overruns, however, the fall 1986-87 fisheries were greatly restricted by quotas and only smaller local vessels were able to fish. With the introduction of ITQ's, vessels were able to tailor their harvest plans to suit markets and the proximity of vessels to the fishing grounds. The largest fleet ITQ group included the 50'-64' vessels and their combined quotas were not taken during the 1989-92 period. There were some fishery closures for smaller vessel competitive fleets during the fall of the year, however these were generally after the peak date of the fishery and were for fleets that contributed relatively little to the total landings. Given the number of fleets and quotas as well as the frequency of quota overruns, we conclude that management measures had little impact on the variation in timing of the fisheries in 4Tfg, (with the exception of the fall 1986-87 fisheries).

While a summary of quotas and landings is not presented here for the 4Vn fisheries, it should be noted that no fishing was permitted in 4Vn during December of 1992. This measure was put in place to prevent uncontrolled catches of southern Gulf cod in 4Vn. At the time the 4Vn (M-D) TAC was 10,000t, much higher than warranted by the stock assessment (CAFSAC Adv. Doc. 92/7). The December closure was only announced in early November and the fishers responded by a large increase in fishing effort in 4Vn immediately thereafter.

Discussion

The spring and fall fisheries at the entrance of the Gulf of St. Lawrence provide useful information for determining the timing of the migration of southern Gulf cod through the area. The fisheries in 4Tfg are relatively short, with 1-3 weeks between when 25th and 75th percentiles of the landings , and the dates of peak landings correspond to the dates when 50% of the catch is realized. The timing sequence of the 4Tfg and 4Vn fisheries also indicates movement through the area.

During the period 1986-90, the 4Tfg and 4Vn spring fisheries were only about half over by May 1, indicating that a substantial portion of the southern Gulf stock was still in 4Vn in early May. In 1991 and 1992, the spring fisheries were delayed by late ice-out and there were probably substantial landings of southern Gulf cod made in 4Vn during May of these years. The fall fisheries in 4Tfg occurred almost entirely during the month of November and there was no trend in the timing of these fisheries. The timing of mobile gear landings in 4Vn indicated the regular arrival of fish from 4T in mid-November. These results indicate that the assessment unit for the southern Gulf cod stock should include catches from 4Vn in November and December and that the spring fisheries should be monitored to determine the timing of the return migration from 4Vn into 4T.

References

Lambert, T. C. 1993. The timing of the winter migration of 4T cod into 4Vn. DFO Atlantic Fisheries Research Document 93/25.

Sinclair, A. 1993. Seasonal components in technological interactions in Gulf of St. Lawrence Shrimp and Groundfish Fisheries. NAFO SCR Doc. 93/121.

Table 1: Reference dates, days of year, and weeks.

Date	Day of Year	Week
April 1	91	13
May 1	121	17
June 1	152	21
October 1	274	39
November 1	305	43
December 1	335	47

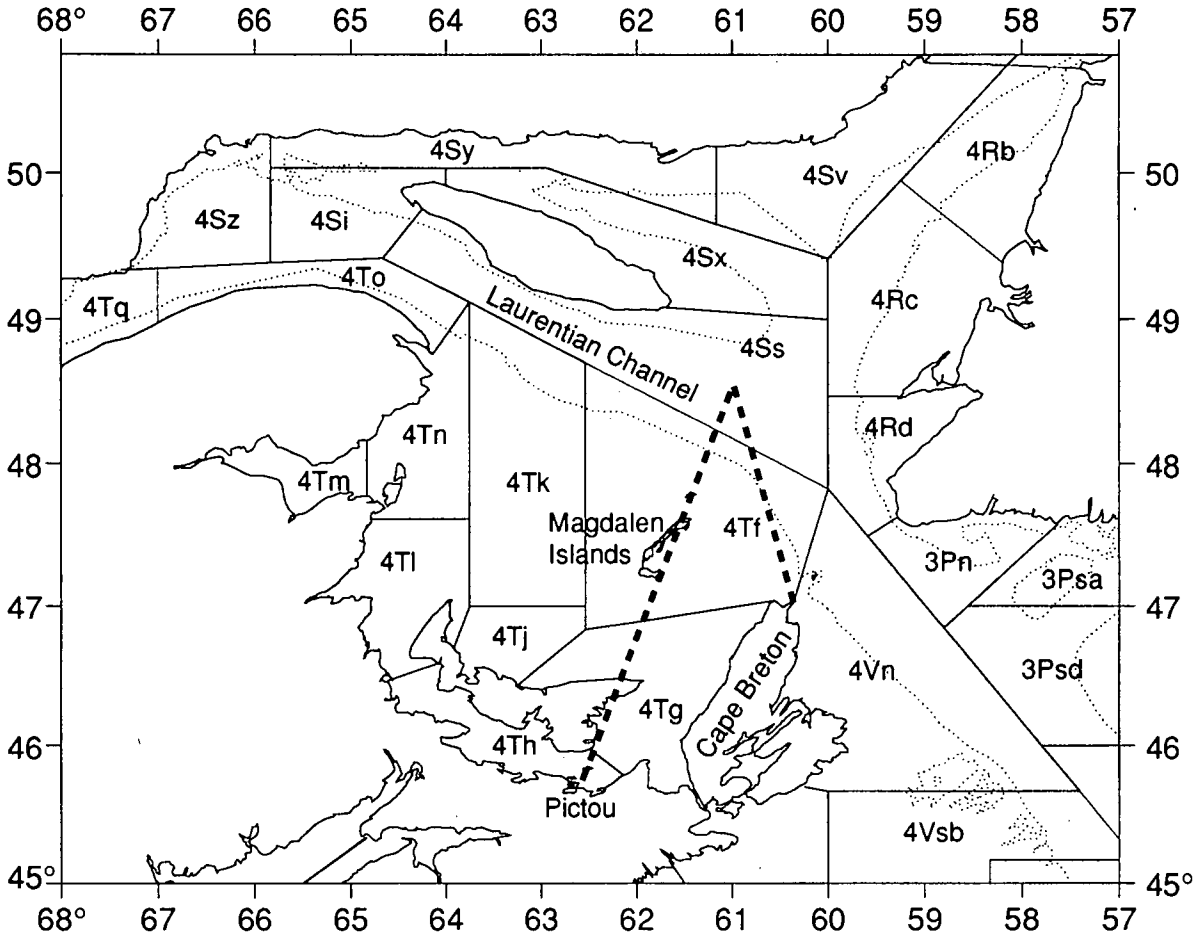

Figure 1: Map of the Gulf of St. Lawrence showing the statistical unit areas and the area used to estimate the percentage of ice coverage during the spring fisheries (enclosed in dashed line).

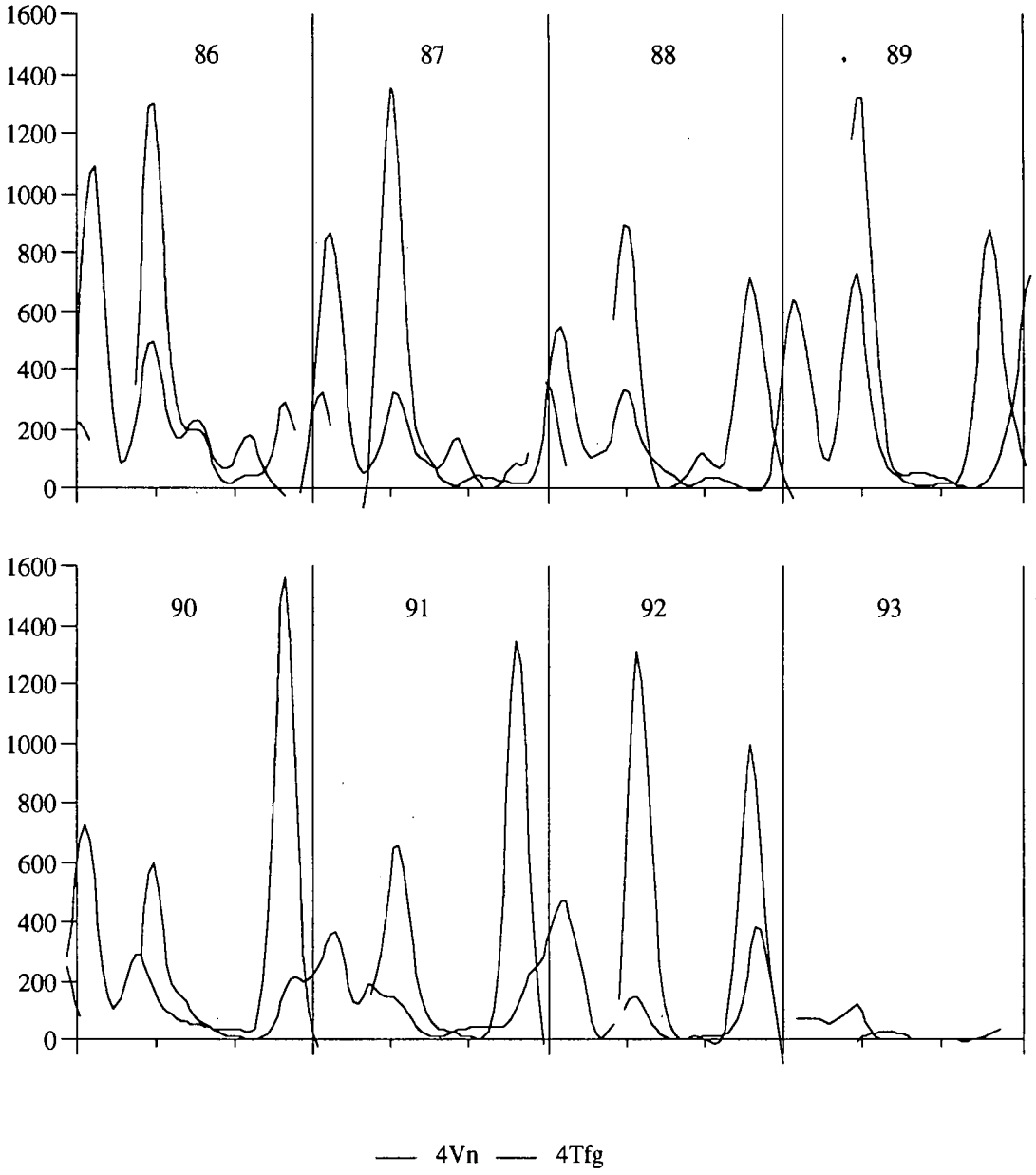

Figure 2: Weekly landings of cod in 4Tfg and 4Vn during 1990-92. The trends were smoothed with a spline function. The vertical lines separate years while the tick marks on the x-axis indicate May 1 and October 1.

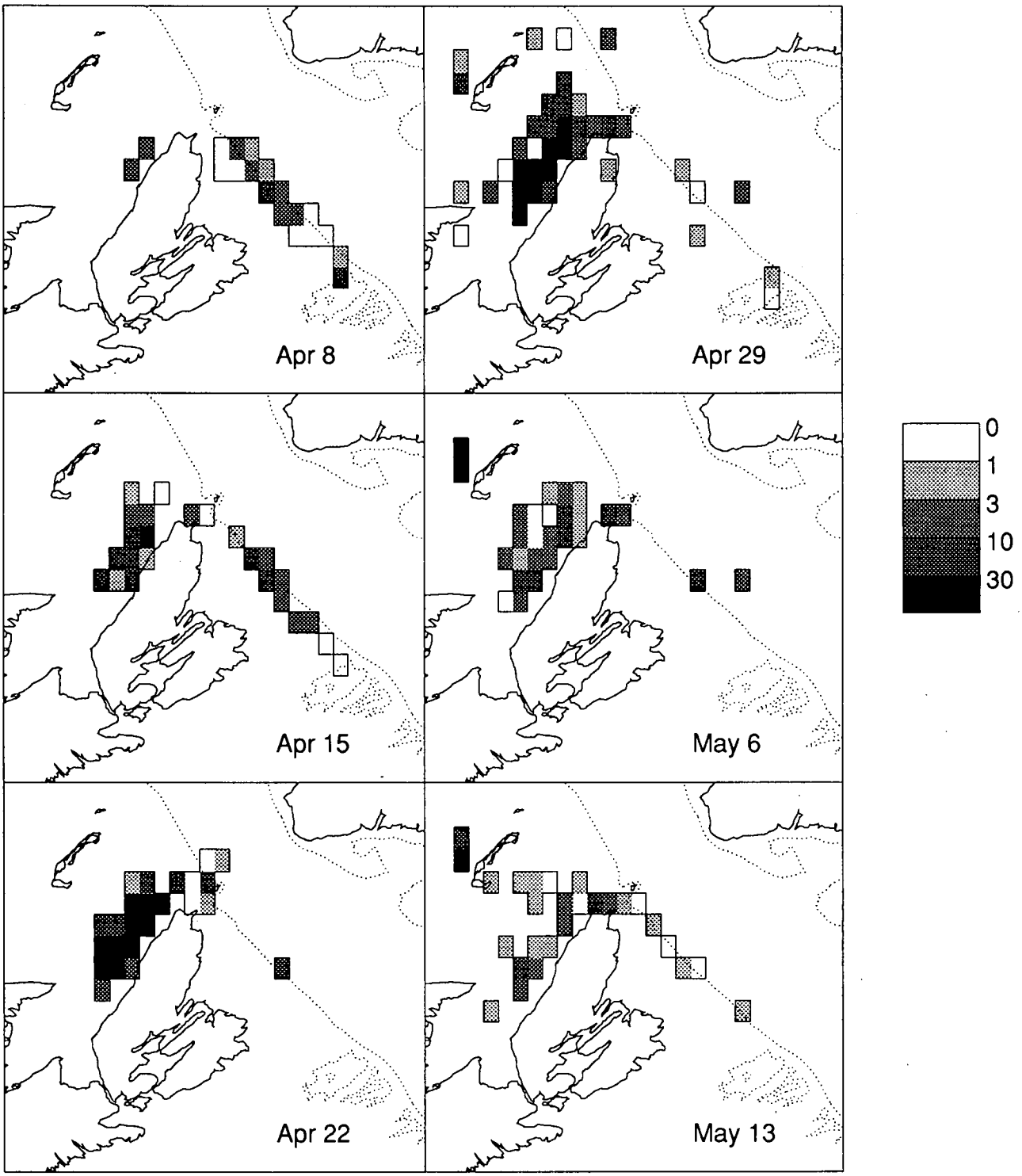

Figure 3: Weekly mobile gear cod catch locations, summarized from logbooks, spring 1990.

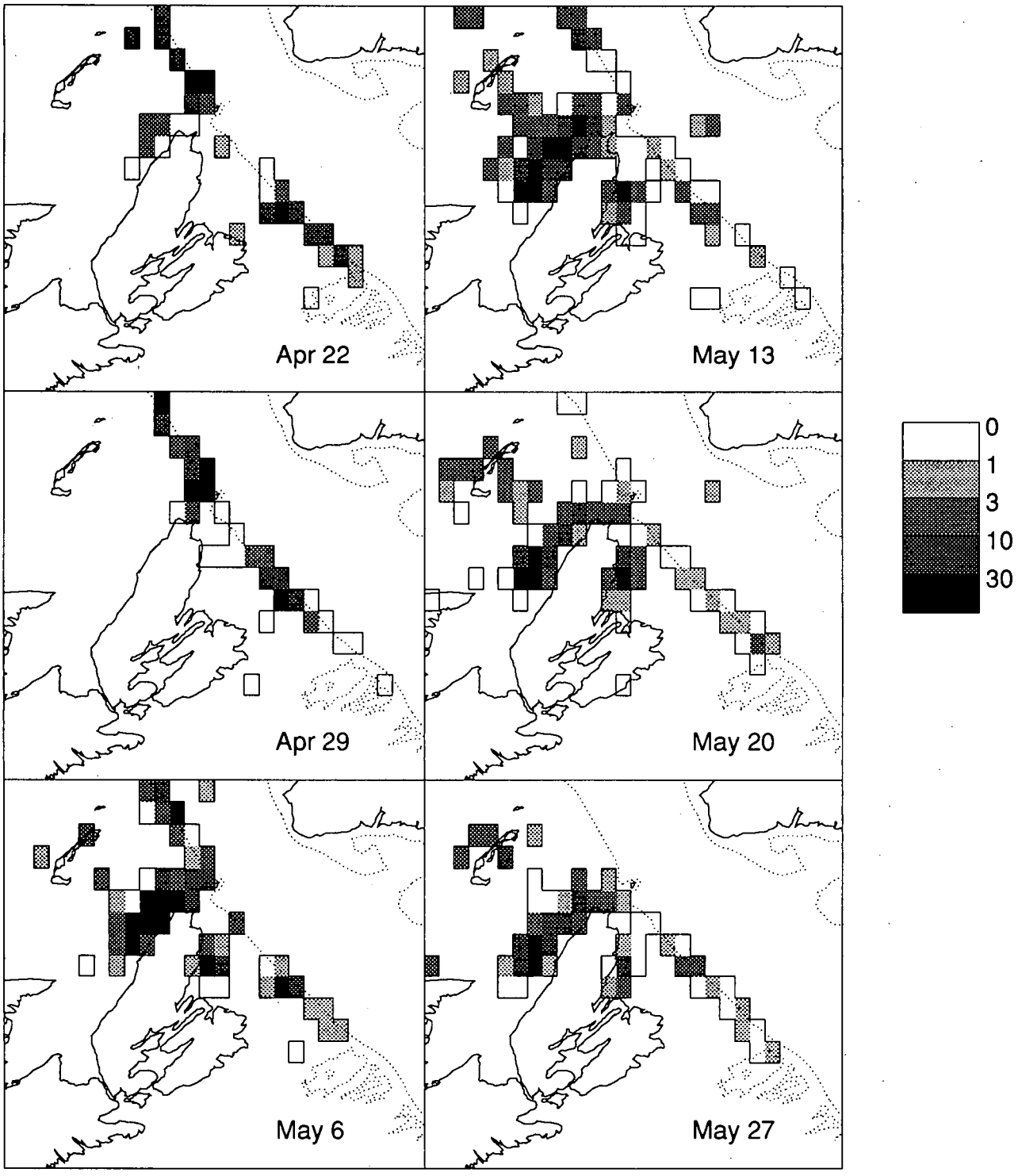

Figure 4: Weekly mobile gear cod catch locations, summarized from logbooks, spring 1991.

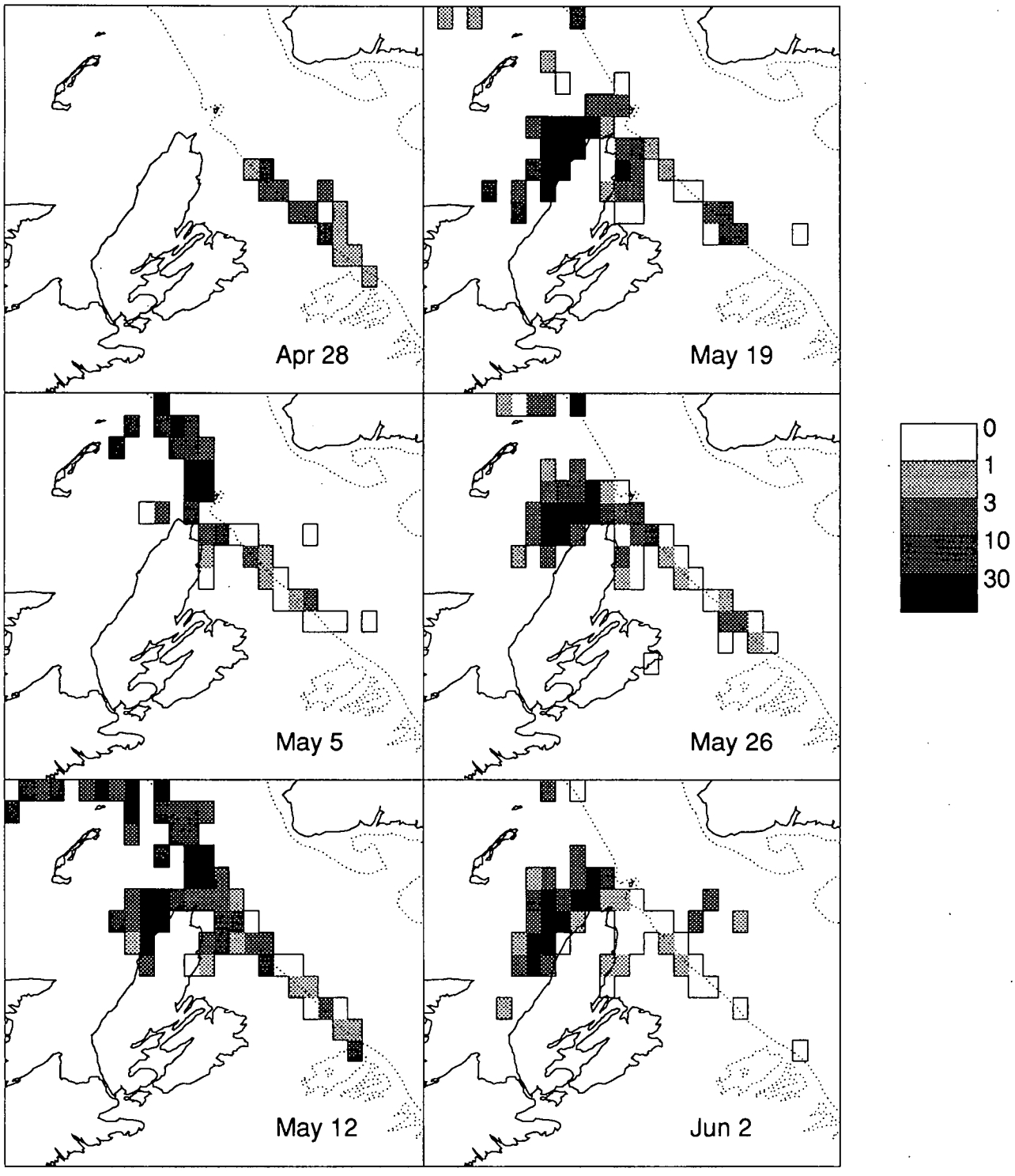

Figure 5: Weekly mobile gear cod catch locations, summarized from logbooks, spring 1992.

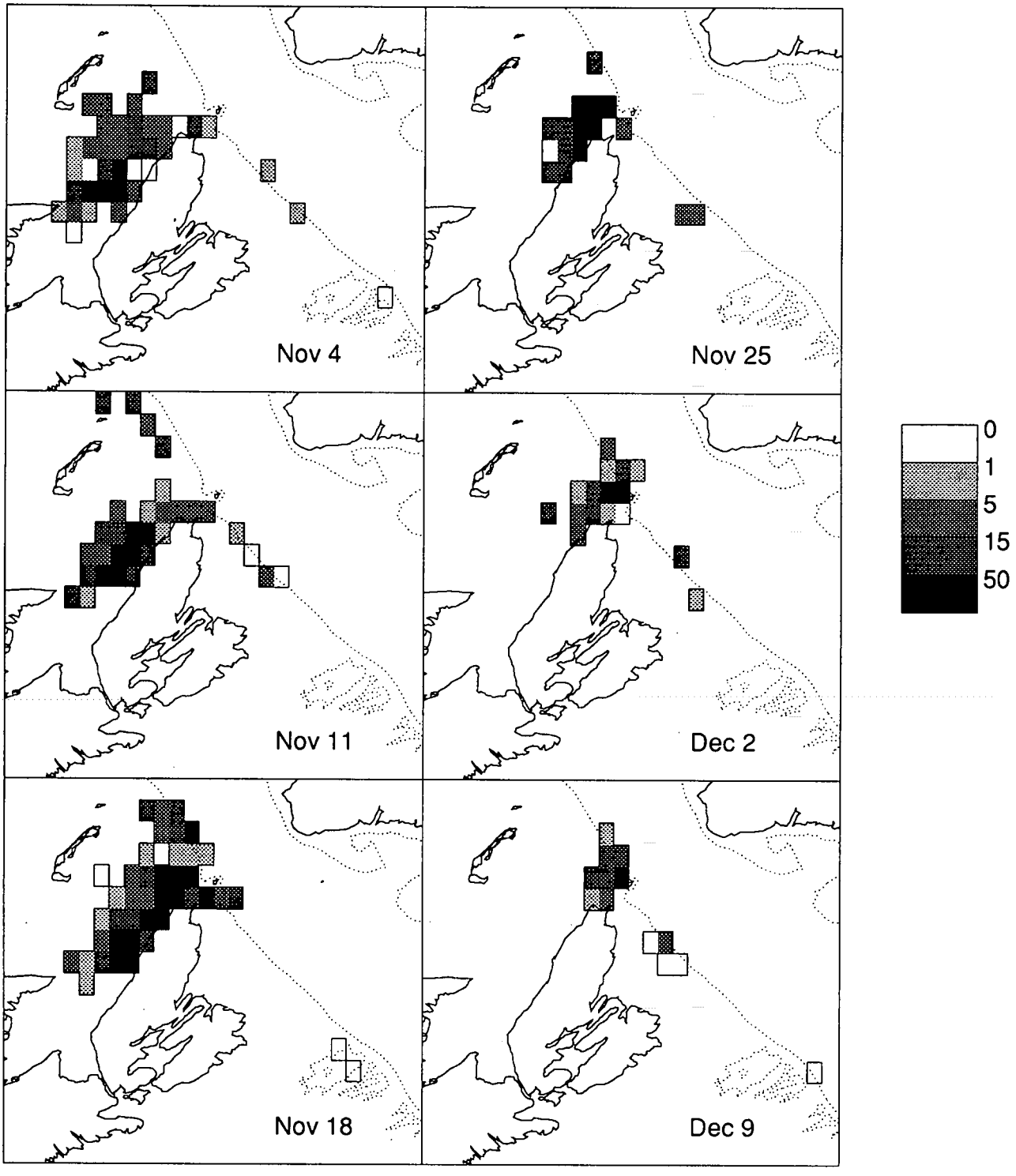

Figure 6: Weekly mobile gear cod catch locations, summarized from logbooks, fall 1990.

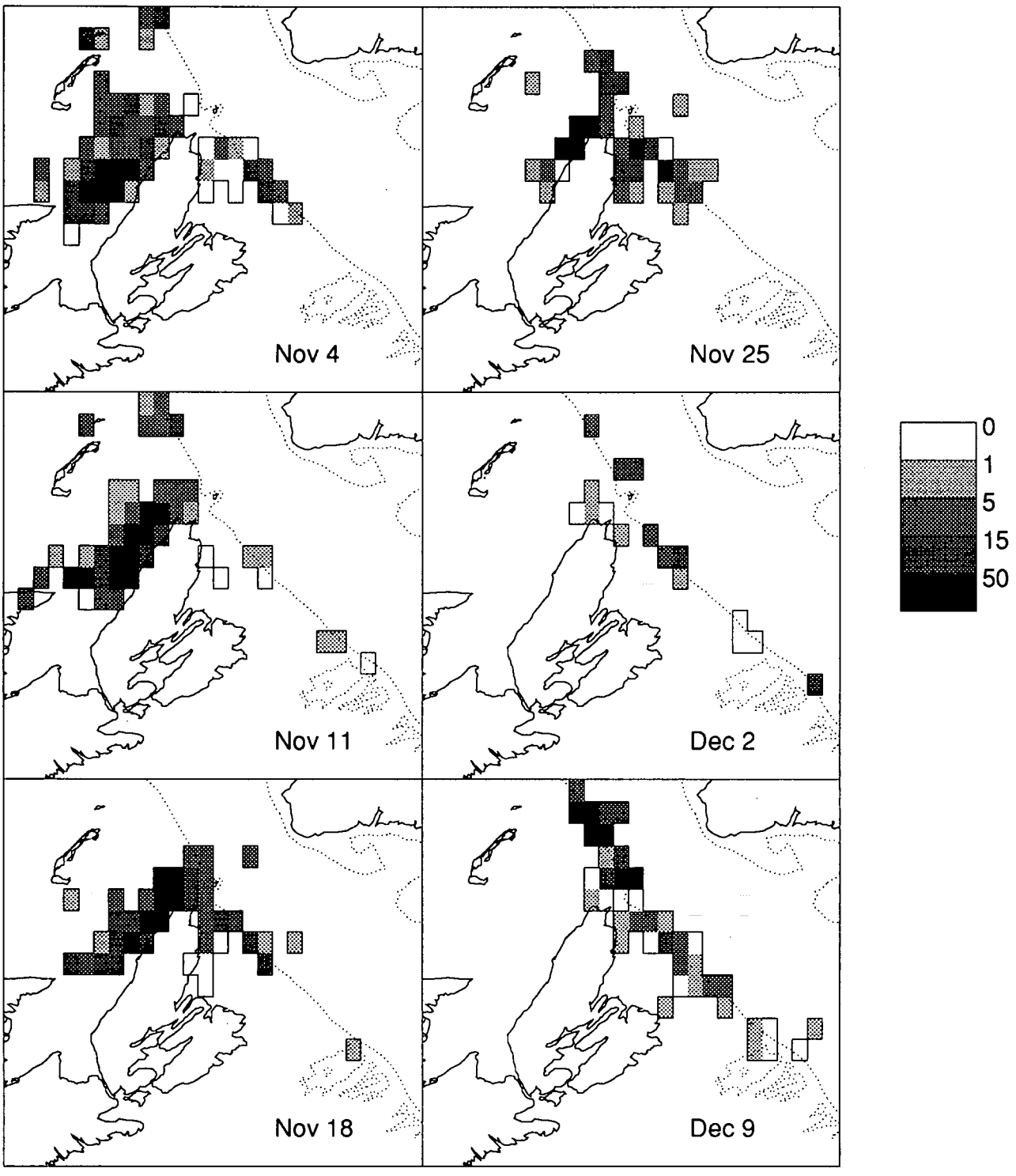

Figure 7: Weekly mobile gear cod catch locations, summarized from logbooks, fall 1991.

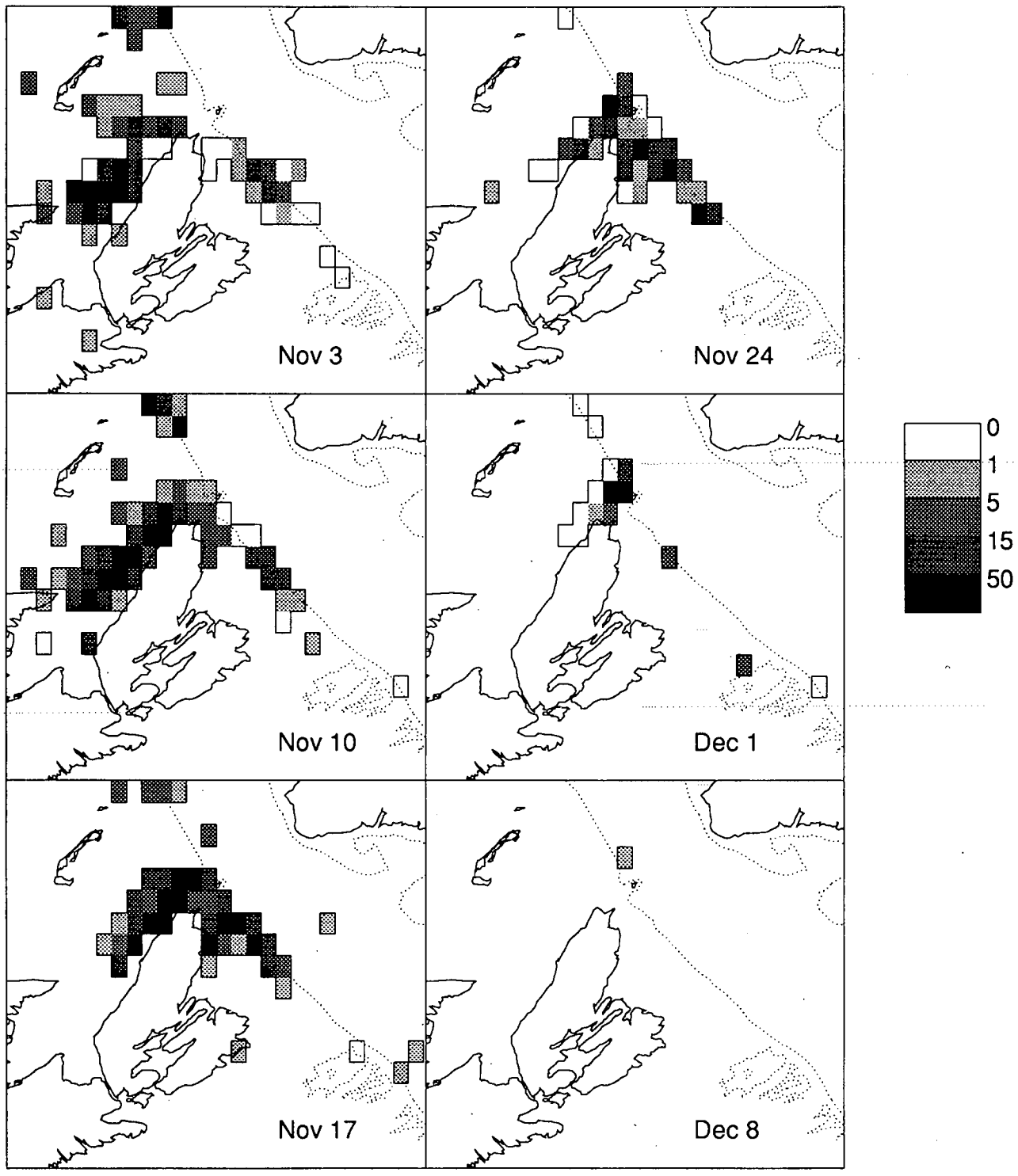

Figure 8: Weekly mobile gear cod catch locations, summarized from logbooks, fall 1992.

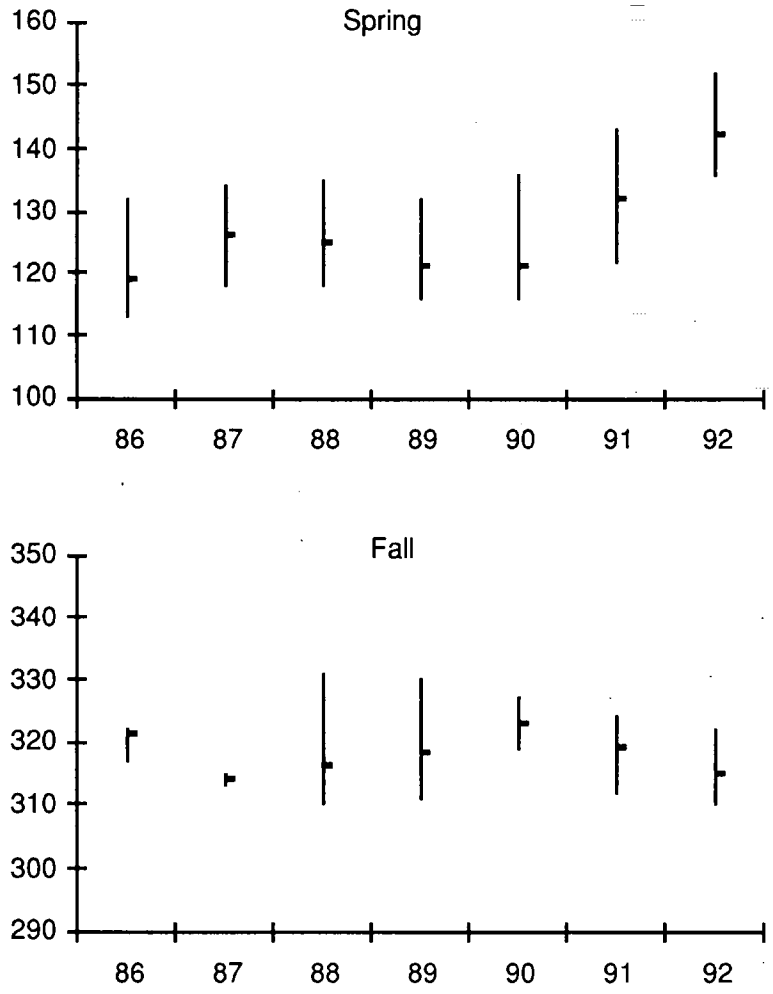

Figure 9: Timing of spring and fall cod fisheries in unit areas 4Tfg, 1986-92. Dates correspond to when 25%, 50%, and 75% of the catch was made.

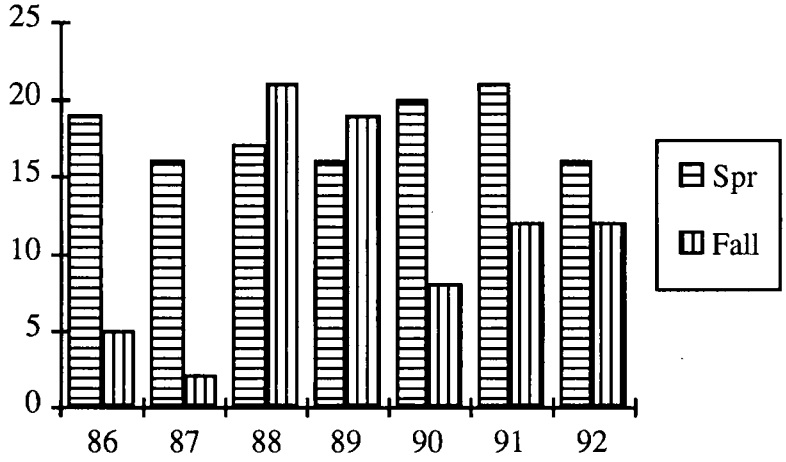

Figure 10: Number of days between when 25% and 75% of the total spring and fall cod catch was made in unit areas 4Tfg, 1986-92.

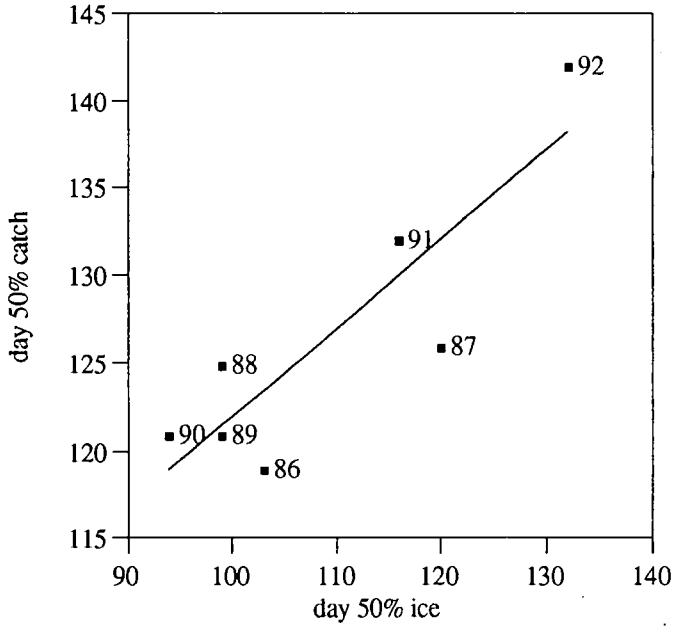

Figure 11: Regression of day of 50% catch as a function of the day of 50% ice out in 4Tfg, 1986-92 ($R^2 = .76$, $p = 0.01$).

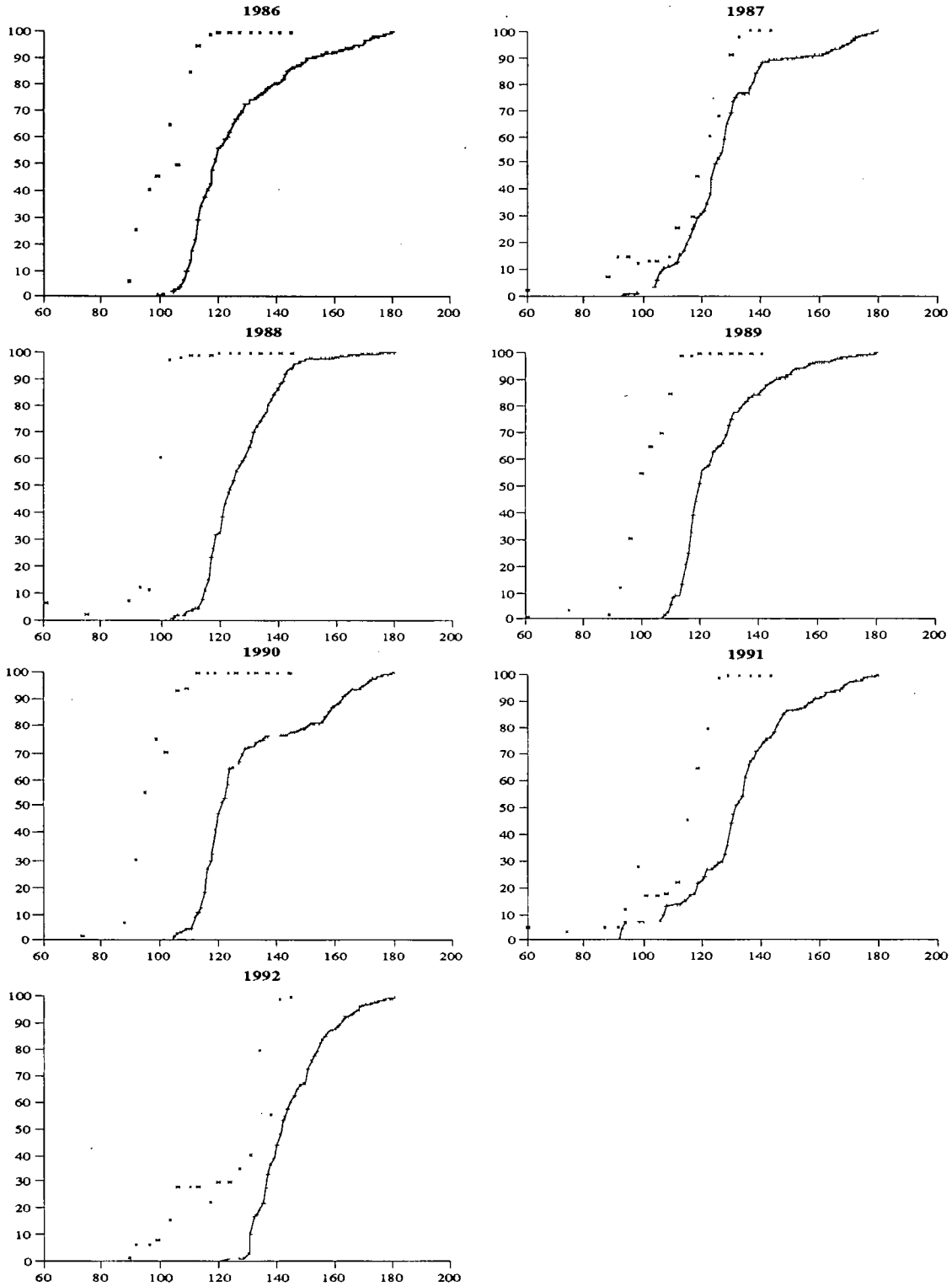

Figure 12: Comparison of cumulative landings (solid line) and percent ice cover (x) in 4Tfg during the 1986-92 spring fisheries. The x axis is day of year.

Annex I: Quotas (t), catches (t), fishery closures, and trip limits (kg) relevant to spring and fall mobile gear fisheries in 4Tfg.

Year	Gear/Period	Quota	Catch	Closure	Trip Limits
1986	MG<100' Jan 1-Sept 7	28158	30198	Jul 20	
	MG<100' Sep 8-Nov 9	3000	4402	Oct 13	
	MG<100' Nov 10-Dec 31	2650	3501	Nov 20	
1987	MG<100' Apr 15-Jun 11	13750	17236	May 22	
	MG<100' Jun 12-Jun 27	3000	3325	Jun 23	
	MG<100' Jun 28-Jul 4	600	938	Jun 30	
	MG<100' Aug 6-Nov 9	5150	5433	Aug 21	
	MG<100' Nov 10-Dec 31	1480	1733	Nov 11	
1988	MG 65-100' g'fish only	1426	1160		
	MG 65-100' crab vessels	326	163		
	MG 65-100' g'fish/shrimp	2164	2109	Nov 14	
	EA W. Nfld.	983	852		
	MG 45-65' Jan 1-Apr 21	775	1017	Apr 18	
	MG 45-65' Apr 22-Jul 31	11040	12047	May 27	20454
	MG 45-65' Aug 1- Sep 1 (by-catch)	825	546		
	MG 45-65' Sep 2-Nov 9 *	8209	8177		20454
	MG 45-65' Nov 10-Dec 31	4030	2612		
	MG<45' Jan 1-Apr 21	200	203	Apr 18	
	MG<45' Apr 22-May 31	3258	3421	Jun 1	9091
	MG<45' Aug 1-Sep 1 (by-catch)	627	634		
	MG<45' Sep 2-Nov 9 *	1768	1741		9091
	MG<45' Nov 10-Dec 31	900	711		
1989	MG 65-100' g'fish only	1072	930		
	MG 65-100' crab vessels	310	497		
	MG 65-100' g'fish/shrimp	555	714		
	EA W. Nfld.	1000	967		
	MG 45-64' 4Vn overlap	1280	381		
	MG 45-64' crab vessels	1600	1657		
	MG 45-64' shrimp vessels	720	847		
	MG 50-65' based in 4T	18500	17408		
	MG 45-49' based in 4T Apr 21-Jun 26	914	1003		
	MG 45-49' based in 4T Jun 27-Oct 27	401	433	Sept 30	
	MG 45-49' based in 4T Oct 29-Dec 31	240	316		
	MG<45' Jan 1-Apr 21	210	0		
	MG<45' Apr 22-Jul 31	5845	6030		
	MG<45' Sep 2-Oct 27	485	768		
	MG<45' Oct 28-Nov 9	800	1045		
	MG<45' Nov 10-Dec 31	535	2330	Nov 29	
1990	MG 65-100' g'fish only	968	912		
	MG 65-100' crab vessels	300	328		
	MG 65-100' g'fish/shrimp	1143	1183	Nov 27	
	EA W. Nfld.	985	1087	Nov 19	
	MG 45-50' 4Vn overlap	1236	1423		
	MG 45-50' crab vessels	1521	1393		
	MG 45-50' shrimp vessels	723	911		

	MG 50-65' based in 4T	18205	17320	
	MG 45-50' based in 4T Apr 23-May 13	482	494	
	MG 45-50' based in 4T May 14-Dec 31	1079	1080	Nov 24
	MG<45' Apr 10-Apr 22	246	246	Apr 18
	MG<45' Apr 23-Jun 30	2148	2154	
	MG<45' Jul 1-Nov 14	2207	2116	
	MG<45' Nov 15-Dec 31	350	1379	Dec 8
	MG<45' Gulf North Apr 29-May 14	152	152	
	MG<45' Gulf North May 15-Jul 28	1403	1447	
	MG<45' Gulf North Jul 29-Dec 31	655	708	Dec 8
	MG<45' Gulf North by-catch	150	74	Dec 8
	MG<45' Gulf North Scotia Fundy	311	482	
1991	MG 65-100' g'fish only	897	829	
	MG 65-100' crab vessels	277	189	
	MG 65-100' g'fish/shrimp	1057	811	
	EA W. Nfld.	894	879	May 1
	MG 45-64' 4Vn overlap	1144	594	
	MG 45-64' crab vessels	1432	1248	
	MG 45-64' shrimp vessels	647	580	
	MG 50-65' based in 4T (ITQ)	16527	15228	
	MG 45-49'	1144	424	Jun 4
	MG 45-49' based in 4T		304	Aug 3
	MG 45-49' Aug 4-Sep 22		83	Sep 22
	MG 45-49' Sep 23-Dec 31		449	
	MG 45-49' lobster vessels	19	0	
	MG<45' Gulf South	2838		
	MG<45' Gulf South Apr 23-Aug 12		2741	Aug 12
	MG<45' Gulf South Aug 13-Sep 30		54	Sep 30
	MG<45' Gulf South Oct 1-Oct 24		249	Oct 24
	MG<45' Gulf South Nov 1-Nov 7		496	Nov 7
	MG<45' Gulf South Nov 11-Dec 31		159	
	MG<45' Gulf North	1374		
	MG<45' Gulf North Apr 29-Aug 19		1231	
	MG<45' Gulf North Aug 19-Sep 22		172	Sep 22
	MG<45' Gulf North Sep 23-Oct 31		252	Oct 31
	MG<45' overlap	221	257	Nov 23
1992	Vessels > 100'	49	0	
	MG 65-100' g'fish only	801	518	
	MG 65-100' crab vessels	247	95	
	MG 65-100' g'fish/shrimp	887	589	
	EA W. Nfld.	798	952	
	MG 45-64' 4Vn overlap	1021	225	
	MG 45-64' crab vessels	1206	1162	
	MG 45-64' shrimp vessels	546	700	
	MG 50-65' based in 4T (ITQ)	13918	13602	
	MG 45-49' based in 4T	1021	1366	
	MG 45-49' lobster vessels	17	0	
	MG<45' overlap	197	275	Nov 18
	MG<45' Gulf South ITQ	1613	1500	
	MG<45' Gulf South competitive	1599	2072	Nov 15
	MG<45' Gulf North ITQ	976	960	Nov 18
	MG<45' Gulf North competitive	656	503	