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Stock Status of Witch Flounder in NAFO Subdivision 3Ps

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Abstract

Landings from this stock over the last 20 years have fluctuated generally between 300t and 1000 t annually but have not exceeded 500t since 1993. Survey stock size indices since 1976 have been highly variable although recent estimates appear to be at the low end of the range. Survey results suggest that the recent biomass levels may be about two thirds of that of the late 1980's and early 1990's when the stock appeared relatively stable at a catch level of 1000t annually. The age and size structure observed in this stock since the early 1980s also appear to have remained stable with little change in growth pattern. Geographic distribution has not changed appreciably since 1983 except during the early to mid 1990's when fish disappeared from the 51-100 fath. depth zone coincident with extremely cold sea bottom water temperatures. Relative mortality rates indicate little change during the past 20 years although there may have been some increase in the mid-1990s. Data from surveys and recent observations from the commercial fishing industry suggest that witch flounder in Subdiv. 3Ps are found in deeper water than in past years.

Résumé

Au cours des vingt dernières années, les débarquements provenant de ce stock ont généralement fluctué entre 300 t et 1 000 t par année, mais ils n'ont pas excédé 500 t depuis 1993. Depuis 1976, les indices sur la taille du stock obtenus par relevés ont été très variables; les dernières estimations semblent être parmi les plus faibles. Les résultats des relevés montrent que le niveau récent de la biomasse se situe à environ les deux tiers de celui de la fin des années 1980 et du début des années 1990, période où la taille du stock était relativement stable, avec un niveau de prises de 1 000 t par année. La structure selon l'âge et la taille de ce stock observée depuis le début des années 1980 est aussi demeurée relativement stable, avec peu de changements dans le mode de croissance. La répartition géographique n'a pas beaucoup changé depuis 1983, sauf entre le début et le milieu des années 1990, alors que le poisson a disparu de la zone située entre 51 et 100 brasses de profondeur, ce qui coïncide avec une température au fond de l'eau étant extrêmement froide. Les taux de mortalité relatifs n'ont pas vraiment changé durant les 20 dernières années, même s'il y a eu une légère augmentation au milieu des années 1990. Les données provenant des relevés et des observations faites récemment dans le cadre de la pêche commerciale montrent que la plie grise de la sous-division 3Ps se retrouve à de plus grandes profondeurs que par le passé.

Description of the fishery

With the exception of 1977 when landings were reported to be about 3800 tons, landings of witch flounder in NAFO Subdiv. 3Ps fluctuated mainly between about 300 and 1000 t annually since the early 1970's (Table 1; Fig. 1). From 1986-93, landings were relatively stable averaging around 1000 tons annually, however, since then have not exceeded 500 tons and were as low as 250 tons in 1996 (Table 1; Fig. 1). During the 1980's the catch was primarily a by-catch of other groundfish fisheries, however, in recent years with the severe declines in major groundfish resources (cod and other flatfish species in particular) certain sectors of the fishing industry had come to depend more on this stock.

Landings from this stock have been taken mainly by Canadian trawlers fishing offshore on St. Pierre Bank. However, a significant portion of the landings is taken by small Scottish/Danish seiners and gill-netters fishing primarily in Fortune Bay, Statistical Area 3Psb, off the south coast of Newfoundland (Tables 2 and 3; Fig. 2 and 3). Prior to the boundary settlement between Canada and France, fishermen from St. Pierre and Miquelon also caught small amounts of witch flounder on St. Pierre Bank although this no longer appears to be the case (Table 1).

The fishing pattern for offshore Canadian participants since about 1993 has remained much the same with fishing being conducted mostly at the south-eastern tip of St. Pierre Bank in depths ranging from 200 to 900 m and sometimes deeper. As a result of the closure of the American plaice and cod fisheries in Subdiv. 3Ps from 1994, combined with a 5% by-catch constraint, the fishery for witch flounder has been seriously hampered and have at least partly resulted in the low catch levels since then. Although most of the seine and gillnet landings have been in area 3Psb there have been some increase in the landings in 3Psa in recent years (Table 3; Fig. 3).

The first total allowable catch (TAC) was established for this stock in 1974 at 3000 tons which remained in effect until 1988 when it was reduced to 1000 tons (Fig. 1). It was further reduced to 500 tons in 1996 and 1997 but was increased again to 650 tons for 1998 and 1999.

Research Vessel Surveys

i) *Vessel / Gear Conversions*

During 1995 the Canadian Department of Fisheries and Oceans, Science Branch, Newfoundland Region replaced its *Engel* bottom otter trawl with bobbin footgear used in groundfish surveys with a *Campelen 1800* shrimp trawl using rockhopper footgear. In order to ensure an orderly transition and maintain continuity with the older data time series, comparative-fishing trials were conducted in 1996 to develop conversion factors between the two fishing gears. The trials were conducted between the research vessel *Wilfred Templeman* (the regular survey vessel) using the new survey gear and its sister ship *Alfred Needler* using the old survey gear. It was assumed that there was no difference between vessels and that the only observed differences in catch were a result of the use of the different fishing gears. Six target species were investigated (one being witch flounder) because of their commercial significance and management requirements. A thorough description of the experimental design and mathematical determinations can be found in Warren et al. (1997) and thus will not be described in detail here.

Length frequencies, standardised for towing distance, for witch flounder in NAFO Subdiv. 3Ps were converted from Engel 145 trawl catches to Campelen 1800 trawl catch equivalents for the years beginning in 1983 (the year the Engel 145 trawl was introduced as the standard survey trawl in this area). The data converted were winter-spring surveys in Subdiv. 3Ps during 1983-95. All subsequent surveys were actually carried out using the Campelen 1800 trawl. Conversion factors as presented in Warren et al. (1997) for witch flounder were applied using weighted least squares as follows:

For the converted length y_i

$$y_i = \beta * n_i$$

where

n_i = number at length in the set

$$\beta = e^a X_i^b e^{cx_i}$$

x_i = midpoint of length class

$a = 23.209213$, $b = -7.475675$ and $c = 0.11559$

β was set at 8.41 for $x_i < 24$ and β was set at 0.75 for $x_i > 49$

Weights were applied as the number of fishing sets used to estimate the ratio for a given length class.

After the length frequencies were converted to Campelen trawl catch equivalents they were summed to provide total numbers of witch flounder caught per standard Campelen set (0.8 nautical mile tow distance in 15 minutes with a wing spread of 16.84 m). Using various combinations of length-weight relationships available from surveys during the 1990's, the converted length frequencies were adjusted also to provide the total weights caught per standard Campelen set. The impact of the change in survey gear on length frequency distributions is illustrated in Fig. 4 and age frequency distributions for Engel 145 in Fig. 5 and Campelen 1800 in Fig. 6. As anticipated from the equations above, the numbers at length and age are considerably higher at smaller sizes and younger ages whereas the differences are small when fish become progressively larger and older.

ii) *Survey Abundance and Biomass Indices*

The estimated abundance and biomass (tons) by stratum and year for Campelen 1800 data from 1983-99 and Engel 145 data for 1983-95 are presented for detailed information purposes in Tables 4-7, respectively, with a graphic comparison of the biomass trends shown in Fig. 7. A map illustrating the location of the respective strata is shown in Fig. 8. Abundance and biomass indices have been highly variable over the past 15 years showing little in the way of distinct trends (Tables 4-7; Fig. 7). However, a lowess smoother drawn through the data points suggest that a general decline in biomass occurred in the late 1980's for the Engel data series and in the early 1990's for the Campelen data series (Fig. 9). Both suggest that the recent biomass levels be about two thirds of that of the 1980's when the stock appeared relatively stable.

A cursory examination of survey indices by depth zone indicated that up until about 1988 there was considerable biomass in 93-183 m (51-100 fath) whereas during 1990-97 there was very little (Table 4). More recently, however, witch flounder are again appearing in higher abundance in this depth zone especially during the 1999 survey (Tables 4-7). It is possible that this is a distribution shift to and from the area related to bottom temperature. During the period of absence the bottom temperatures were extremely cold being negative in all years from 1990-95 within this depth zone (Table 8). Prior to this period and since then, bottom temperatures within this depth zone were considerably higher with both the 1998 and 1999 temperature well above the average of the entire period (Table 8).

iii) *Geographic distribution*

Distribution plots of witch flounder in Subdivision 3Ps are presented as Canadian survey catches (kg/set) based on the Campelen equivalent catches for the survey years 1983-99 (Fig. 10). Witch flounder are generally distributed in the deeper water along the southwestern slope of St. Pierre Bank and throughout the Laurention and Hermitage Channels. Few, if any, are caught on the shallow parts of St. Pierre Bank or Green Bank or Burgeo Bank. Although recent surveys have been extended to some degree into Fortune Bay and Placentia Bay none have been encountered. On the other hand, the distribution does extend from Hermitage Channel to Hermitage Bay (Fig. 10). Overall, the distribution of witch flounder does not appear to have changed greatly with one exception. As stated above, during years of cold bottom temperatures few witch flounder are caught in the 93-183m-depth zone whereas in years of warmer temperatures they are more widespread in this area. Geographically, this seems to be representative of the Halibut Channel region. Nevertheless, the difference in distribution pattern appears to have little impact on the overall abundance and biomass index.

iv) *Catch at age and length*

Survey catch-at-age data are presented for 1983-94 (Fig. 5 and 6). Due to the scaling down of the witch flounder research program no ageing data have been available since then. During most years the age composition is usually represented by an age range from 4-12 years old but generally peaking at 7-8 with these two age groups comprising half of the catch (Fig. 6). The age structure has been relatively stable during the period shown, however, historically witch flounder in Subdivision 3Ps comprised fish up to 22 years old with most of the catch over age 10 (Bowering 1989).

Length compositions from the Campelen converted data from 1983-95 show that the survey catches generally represent fish in the length range of about 20-50 cm with a peak in the 25-35 cm range (Fig. 4). Few fish are caught over 50 cm (Fig. 4). A comparison with length composition data from the 1996-99 surveys actually using the Campelen reveal similar results which may suggest little overall variation in size composition at least during the last 17 years (Fig. 11).

The trend in mean size at age from 1983-94 where age data were available suggests little change in growth for at least the last 6-7 years of the period examined (Table 9; Fig. 12). If this apparent stability is assumed to have continued to 1999 then based on the length compositions from 1983-1999 it could be assumed that there has been little appreciable change in the age composition at least since 1983.

v) *Total Mortality Trends*

Estimates of total mortality (Z) were calculated from survey data for ages 4-12 using Engel unconverted data in order to extend the number of data points (Fig. 13). Lowess smoothers also were added to the individual plots to help discern any trends in the mortality calculations. Although the data were highly variable, ages 7-9 showed a generally increasing trend from the late 1970's to the early 1990's with the ages 10-12 data rather flat (Fig. 13). A further examination of relative trends in total mortality was carried out by conducting a multiple regression analysis using fully recruited cohorts (ages 8-13) from 1976-94 (Engel data) and utilising the information in the age*cohort interaction term (Fig. 14). The results indicate no trend in mortality over the cohorts of 1965-79 with an increasing trend to 1984. Although there was a drop in relative mortality for the 1985-86 year-classes they are estimated by only 2 and 1 data points, respectively.

References

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- Warren, W.,W. Brodie, D. Stansbury, S. Walsh, J. Morgan, and D. Orr. 1997. Analysis of the 1996 comparative fishing trials between the *Alfred Needler* with the Engel trawl and the *Wilfred Templeman* with the Campelen 1800 trawl. NAFO SCR Doc. 97/68, Ser. No. N2902: 12p.

Table 1. Landings of witch flounder in Subdivision 3Ps by country during 1974-98.

Year	COUNTRY							TOTAL
	CAN(MQ)	CAN(N)	FRA(SP)	POR	USSR	FRA(M)	CAN(M)	
1974	94	1605	47	40	-	-	-	1786
1975	-	1179	-	-	4	-	-	1183
1976	40	801	-	-	-	-	-	841
1977	-	3841	-	-	-	-	-	3841
1978	23	969	-	-	-	-	-	992
1979	-	561	-	-	-	-	-	561
1980	-	790	-	-	-	-	-	790
1981	-	412	53	-	-	-	4	469
1982	-	334	0	-	-	-	-	334
1983	-	154	125	-	-	-	-	279
1984	-	325	34	-	-	2	-	361
1985	-	376	118	-	-	2	-	496
1986	-	613	606	-	-	-	110	1329
1987	-	1131	71	-	-	53	18	1273
1988	-	475	53	-	-	6	102	636
1989	-	831	67	-	-	-	29	927
1990	-	940	-	-	-	-	31	971
1991	-	1056	-	-	-	-	59	1115
1992	-	1012	50	-	-	-	68	1130
1993	-	956	-	-	-	-	17	973
1994	-	429	-	-	-	-	2	431
1995	-	273	-	-	-	-	1	274
1996	-	250	-	-	-	-	6	256
1997	-	282	7	-	-	-	30	319
1998	-	-	-	-	-	-	-	473
1999	-	-	-	-	-	-	-	472

** 1998-99 from Canadian quota reports only. 1999 to the end of September.

Table 2. Landings of witch flounder in Subdivision 3Ps by gear type during 1974-99 for Canada (N) only.

YEAR	GEAR			TOTAL	TAC
	OTB	SEINES	OTHER		
1974	1409	177	19	1605	3000
1975	684	491	4	1179	3000
1976	590	153	58	801	3000
1977	3387	454	-	3841	3000
1978	627	342	-	969	3000
1979	484	75	2	561	3000
1980	569	219	2	790	3000
1981	168	233	11	412	3000
1982	284	50	-	334	3000
1983	147	1	6	154	3000
1984	322	-	3	325	3000
1985	198	175	3	376	3000
1986	285	297	31	613	3000
1987	879	217	35	1131	3000
1988	260	153	62	475	1000
1989	557	196	78	831	1000
1990	635	244	61	940	1000
1991	789	195	72	1056	1000
1992	761	214	37	1012	1000
1993	712	183	61	956	1000
1994	131	288	10	429	1000
1995	3	270	-	273	1000
1996	78	171	1	250	500
1997	156	126	-	282	500
1998	288	-	-	473	650
1999	304	-	-	472	650

** 1998-99 from Canadian quota reports only.
1999 to the end of September.

Table 3. Landings of witch flounder in Subdivision 3Ps by statistical area from 1985-98.

Year	Statistical Area							
	3Psa	3Psb	3Psc	3Psd	3Pse	3Psf	3Psg	3Psh
1985	15	113	-	36	12	26	94	120
1986	16	227	2	68	5	14	136	163
1987	49	151	1	52	7	44	236	539
1988	4	70	2	37	1	8	58	238
1989	11	167	2	8	-	12	73	476
1990	5	179	2	25	11	3	286	322
1991	4	71	3	10	-	6	115	590
1992	16	62	-	7	-	5	281	464
1993	4	259	-	7	-	-	88	593
1994	7	317	3	1	-	-	1	109
1995	16	213	40	2	-	-	1	2
1996	89	80	-	3	-	-	-	82
*1997	47	76	-	-	-	-	16	148
1998	121	64	6	5	-	-	1	258

*There were 287 tons not reported by gear and area

Table 4. Witch abundance estimates (000s of fish) from research vessel surveys in NAFO Subdivision 3Ps from 1983-99. Estimates are presented in Campelen trawl catch units.

Depth range (fathoms)	Vessel	AN		WT		WT		WT		WT		WT		WT		WT		WT		WT					
		Trips	Sets	Mean Da	sq. mi.	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1993	1994	1995	1996	1997	1997	1998	1999	
<30	314	974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
320	1320	532	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
31-50	293	4	159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	308	112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	312	272	0	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	315	827	284	796	0	265	0	341	179	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	321	1189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	325	944	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	326	166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	783	1	229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
51-100	294	4	135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	297	4	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	307	395	408	109	290	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	311	317	0	414	55	5945	15	240	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	317	193	9779	16487	252	544	9	690	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	319	984	445	338	68	761	587	457	4010	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	322	1567	39	620	0	162	0	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	323	696	1548	48	319	19	383	38	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	324	494	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	781	1	446	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	782	1	183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
101-150	295	4	209	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	298	4	171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	300	4	217	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	306	363	620	58	317	1114	144	43	134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	309	296	556	183	828	305	122	231	163	244	0	922	58	115	305	27	163	801	556	790	457	706	41	0	
	310	170	70	105	304	257	316	70	374	117	35	296	58	94	129	35	296	164	129	66	373	316	0	0	
	313	165	1687	193	340	375	125	863	863	4142	340	1997	329	1975	5062	3007	898	295	6071	11128	4901	2590	0	0	
	316	189	6357	3874	4368	3952	4767	14975	5607	14403	143	14975	288	102	4662	0	6548	719	311	0	0	0	0	0	
	318	129	1128	178	0	3443	178	1870	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	779	1	422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	780	1	403	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
151-200	296	4	71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	299	4	212	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	705	195	957	429	912	1113	590	2106	1194	456	2133	1623	550	724	581	724	86	100	1493	354	661	1073	14	0	
	706	476	5998	3372	2488	4273	5147	3536	2063	5959	8300	6627	2728	5029	4240	7350	3318	891	711	891	1492	2341	502	191	
	707	74	444	198	74	403	512	192	294	6141	2309	678	409	0	2698	75	59	148	23	23	23	23	23	23	
	715	128	751	163	163	209	309	327	890	36	0	163	45	413	295	660	44	72	76	44	44	44	44	44	
	716	539	1112	939	1691	4041	2373	2491	2892	3589	1987	2694	2002	1261	1394	756	5068	1598	2816	968	968	968	968	968	
	708	126	531	370	126	628	370	121	853	3275	3275	467	660	225	1421	225	503	14294	193	193	193	193	193	193	
	711	593	10724	7853	11088	15114	6459	5760	9575	8593	9452	17582	3913	5526	3063	7260	5364	2471	3446	3945	3945	3945	3945	3945	
	712	731	6138	14857	10529	7161	6922	7077	7656	13652	18498	4264	3251	3557	14911	8195	4384	4384	5499	3067	3067	3067	3067	3067	
	713	851	3715	5472	6848	8200	8252	5668	7150	13068	12742	8870	3485	4313	6087	7036	6621	7682	4433	4433	4433	4433	4433	4433	
	714	1074	2252	0	0	9140	5055	10356	8532	8712	12254	8924	4588	4932	2301	7461	7040	7394	6395	3892	3892	3892	3892	3892	
301-400	709	2	147	20	7	0	0	647	647	1631	1631	508	87	30	436	718	1345	1336	1336	1336	1336	1336	1336	1336	1336
401-500	710	1	156	87	42	163	10	74	74	30	436	87	30	436	441	441	441	441	441	441	441	441	441	441	441
501-600	776	1	159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
601-700	777	1	183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
701-800	778	1	166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			56,181	36,877	43,730	69,622	42,819	59,956	51,189	61,057	78,702	89,336	29,668	42,903	29,943	66,736	50,401	56,832	50,780	56,832	50,780	56,832	50,780	34,295	34,295

¹ These strata were added to the stratification scheme in 1994.
² Strata 709 was redrawn in 1994 and includes the area covered by strata 710 in previous surveys. All sets done in 710 prior to 1994 have been recoded to 709.
³ totals are for all strata fished.
⁴ These strata were added to the stratification scheme in 1997.

Table 6. Witch abundance estimates (tons) from research vessel surveys in NAFO Subdivision 3Ps from 1983-95. Estimates are presented in Engel trawl catch units.

Depth range (fathoms)	Vessel	AN		WT		WT		WT		WT		WT		WT		WT	
		9	26	45	55+56	68	81	91	103	118	133	135	150-151	166-167	166-167	166-167	166-167
31-50	Trips	164	109	136	130	146	146	108	158	137	136	130	166	161	161	161	161
51-100	Mean Da	30-Apr	13-Mar	15-Mar	7-Mar	5-Feb	9-Feb	9-Feb	10-Feb	14-Feb	13-Feb	11-Apr	15-Apr	16-Apr	16-Apr	16-Apr	16-Apr
101-150	Strata	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1993	1994	1994	1994	1995
151-200	Strata	sq. mi.	974	1320	1320	1320	1320	1320	1320	1320	1320	1320	1320	1320	1320	1320	1320
<30	974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-50	1320	212	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51-100	293 ⁴	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101-150	159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151-200	112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201-300	272	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
301-400	827	124	298	0	83	0	83	53	0	0	0	0	0	0	0	0	0
401-500	315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
501-600	321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
601-700	944	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
701-800	166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	783 ¹	229	783	1	229	783	1	229	783	1	229	783	1	229	783	1	229
51-100	294 ⁴	135	297	4	152	307	395	52	59	40	10	0	0	0	0	0	0
101-150	183	782	1	183	782	1	183	782	1	183	782	1	183	782	1	183	782
151-200	209	285	4	209	285	4	209	285	4	209	285	4	209	285	4	209	285
201-300	171	298	4	171	298	4	171	298	4	171	298	4	171	298	4	171	298
301-400	217	300	4	217	300	4	217	300	4	217	300	4	217	300	4	217	300
401-500	363	306	306	363	306	306	363	306	306	306	306	306	306	306	306	306	306
501-600	296	309	309	296	309	309	296	309	309	309	309	309	309	309	309	309	309
601-700	170	310	170	310	170	310	170	310	170	310	170	310	170	310	170	310	170
701-800	165	313	165	313	165	313	165	313	165	313	165	313	165	313	165	313	165
Total	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189
51-100	696	740	696	740	696	740	696	740	696	740	696	740	696	740	696	740	696
101-150	494	324	494	324	494	324	494	324	494	324	494	324	494	324	494	324	494
151-200	446	781	446	781	446	781	446	781	446	781	446	781	446	781	446	781	446
201-300	183	782	183	782	183	782	183	782	183	782	183	782	183	782	183	782	183
301-400	209	285	209	285	209	285	209	285	209	285	209	285	209	285	209	285	209
401-500	171	298	171	298	171	298	171	298	171	298	171	298	171	298	171	298	171
501-600	217	300	217	300	217	300	217	300	217	300	217	300	217	300	217	300	217
601-700	363	306	363	306	363	306	363	306	363	306	363	306	363	306	363	306	363
701-800	296	309	296	309	296	309	296	309	296	309	296	309	296	309	296	309	296
Total	170	310	170	310	170	310	170	310	170	310	170	310	170	310	170	310	170
51-100	165	313	165	313	165	313	165	313	165	313	165	313	165	313	165	313	165
101-150	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189
151-200	696	740	696	740	696	740	696	740	696	740	696	740	696	740	696	740	696
201-300	494	324	494	324	494	324	494	324	494	324	494	324	494	324	494	324	494
301-400	446	781	446	781	446	781	446	781	446	781	446	781	446	781	446	781	446
401-500	183	782	183	782	183	782	183	782	183	782	183	782	183	782	183	782	183
501-600	209	285	209	285	209	285	209	285	209	285	209	285	209	285	209	285	209
601-700	171	298	171	298	171	298	171	298	171	298	171	298	171	298	171	298	171
701-800	217	300	217	300	217	300	217	300	217	300	217	300	217	300	217	300	217
Total	363	306	363	306	363	306	363	306	363	306	363	306	363	306	363	306	363
51-100	296	309	296	309	296	309	296	309	296	309	296	309	296	309	296	309	296
101-150	170	310	170	310	170	310	170	310	170	310	170	310	170	310	170	310	170
151-200	165	313	165	313	165	313	165	313	165	313	165	313	165	313	165	313	165
201-300	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189
301-400	696	740	696	740	696	740	696	740	696	740	696	740	696	740	696	740	696
401-500	494	324	494	324	494	324	494	324	494	324	494	324	494	324	494	324	494
501-600	446	781	446	781	446	781	446	781	446	781	446	781	446	781	446	781	446
601-700	183	782	183	782	183	782	183	782	183	782	183	782	183	782	183	782	183
701-800	209	285	209	285	209	285	209	285	209	285	209	285	209	285	209	285	209
Total	171	298	171	298	171	298	171	298	171	298	171	298	171	298	171	298	171
51-100	217	300	217	300	217	300	217	300	217	300	217	300	217	300	217	300	217
101-150	363	306	363	306	363	306	363	306	363	306	363	306	363	306	363	306	363
151-200	296	309	296	309	296	309	296	309	296	309	296	309	296	309	296	309	296
201-300	170	310	170	310	170	310	170	310	170	310	170	310	170	310	170	310	170
301-400	165	313	165	313	165	313	165	313	165	313	165	313	165	313	165	313	165
401-500	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189	1749	189
501-600	696	740	696	740	696	740	696	740	696	740	696	740	696	740	696	740	696
601-700	494	324	494	324	494	324	494	324	494	324	494	324	494	324	494	324	494
701-800	446	781	446	781	446	781	446	781	446	781	446	781	446	781	446	781	446
Total	183	782	183	782	183	782	183	782	183	782	183	782	183	782	183	782	183
51-100	209	285	209	285	209	285	209	285	209	285	209	285	209	285	209	285	209
101-150	171	298	171	298	171	298	171	298	171	298	171	298	171	298	171	298	171
151-200	217	300	217	300	217	300	217	300	217	300	217	300	217	300	217	300	217
201-300	363	306	363	306	363	306	363	306	363	306	363	306	363	306	363	306	363
301-400	296	309	296	309	296	309	296	309	296	309	296	309	296	309	296	309	296
401-500	170	310	170	310	170	310	170	31									

Table 7. Witch biomass estimates (tons) from research vessel surveys in NAFO Subdivision 3Ps from 1983-95. Estimates are presented in Engel trawl catch units.

Depth range (fathoms)	Strata	Vessel		AN		WT		WT		WT		WT		WT		WT		WT		
		Trips	Sets	Mean Da	sq. mi.	974	1320	45	55+56	68	81	91	103	118	133	135	150-151	166-167	WT	WT
<30	314	9	26	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	320	85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-50	293 ⁴	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	308	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	312	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	315	74	137	0	47	0	31	22	0	0	0	0	0	0	0	0	0	0	0	0
	321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	325	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	326	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	783 ¹	229																		
51-100	294 ⁴	135																		
	297 ⁴	152																		
	307	395	11	30	10	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	311	317	0	71	13	547	4	36	2	0	1	0	2	0	2	0	25	0	3	3
	317	193	1425	1735	29	58	2	47	0	0	0	17	0	0	11	0	0	0	0	0
	319	984	74	154	55	175	156	78	981	0	9	0	0	0	0	0	0	0	0	85
	322	1567	21	51	0	11	0	2	0	0	0	0	0	0	0	0	0	0	0	2
	323	696	496	20	228	7	98	15	34	0	0	0	0	0	0	0	0	0	0	0
	324	494	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	781 ¹	446																		
	782 ¹	183																		
101-150	295 ⁴	209																		
	298 ⁴	171																		
	300 ⁴	217																		
	306	363	104	5	55	88	33	13	39	0	7	2	7	2	7	2	13	8	8	8
	309	296	67	43	104	56	3	8	22	16	20	3	8	41	22	22	29	29	29	29
	310	170	21	41	170	89	20	18	61	44	3	0	17	0	17	0	26	5	5	5
	313	165	126	31	48	46	15	77	107	200	13	77	20	165	451	178	451	178	178	178
	316	189	582	433	527	504	473	1234	452	730	10	847	0	656	115	35	656	115	35	35
	318	129	93	9	549	20	217	14	14	0	658	4	33	548	0	462	0	462	0	0
	779 ¹	422																		
	780 ¹	403																		
151-200	296 ⁴	71																		
	299 ⁴	212																		
	705	195	72	55	97	102	102	263	139	56	160	104	33	63	63	58	51	51	51	51
	706	476	404	304	217	451	563	371	165	345	704	471	280	518	284	406	406	406	406	406
	707	74	43	40	73	94	30	30	69	886	262	105	118	0	220	0	220	0	220	0
	715	128	63	22	55	50	42	42	111	16	0	16	5	42	28	43	43	43	43	43
	716	539	202	181	301	671	413	451	430	422	206	278	205	142	116	90	90	90	90	90
201-300	708	126	24	31	66	66	70	33	110	1050	73	102	26	118	24	24	24	24	24	24
	711	593	396	317	353	597	412	290	407	359	366	958	285	340	128	251	251	251	251	251
	712	731	272	512	548	586	256	355	247	207	447	769	294	133	216	430	430	430	430	430
	713	851	177	213	399	686	294	294	314	279	529	558	422	147	188	212	212	212	212	212
	714	1074	118	118	1068	392	683	484	484	484	738	627	238	205	107	300	300	300	300	300
301-400	709 ²	147	1	1	1	1	1	1	47	125	7	36	21	7	236	236	236	236	236	236
401-500	710 ¹	156	5	4	3	8	2	2	2	7	7	7	0	10	10	10	10	10	10	10
501-600	776 ¹	159																		
601-700	777 ¹	183																		
701-800	778 ¹	166																		
Total ³		4,955	3,738	2,835	6,223	3,863	4,594	4,256	3,159	5,937	5,065	2,098	3,207	1,913	3,029	3,029	3,029	3,029	3,029	3,029

¹ These strata were added to the stratification scheme in 1994.
² Strata 709 was redrawn in 1994 and includes the area covered by strata 710 in previous surveys. All sets done in 710 prior to 1994 have been recorded to 709.
³ totals are for all strata fished.
⁴ These strata were added to the stratification scheme in 1997.

Table 8. Mean bottom temperature data by depth zone, from sets in the Subdiv. 3Ps surveys.

YEAR	SEASON	DEPTH RANGE (M)					ALL DEPTHS
		<55	56 - 92	93 - 183	184 - 275	>275	
83	S	2.48	0.63	0.41	5.10	4.94	2.74
84	S	1.67	0.94	1.49	6.38	5.68	2.96
85	W	-1.15	-1.14	-0.14	6.09	6.18	2.37
86	W	-0.75	-0.95	0.46	7.35	5.90	2.39
87	W	-0.95	-0.72	0.14	5.84	5.17	1.80
88	W	0.15	0.29	0.73	5.95	4.94	2.51
89	W	-0.51	-0.37	0.03	4.20	5.15	1.91
90	W	-0.90	-0.82	-0.29	3.73	5.14	1.71
91	W	-0.28	-0.47	-0.14	4.06	4.99	1.91
92	W	-0.86	-0.69	0.03	5.24	4.95	2.00
93	W	-0.71	-0.75	-0.07	6.03	5.40	2.32
93	S	-0.40	-0.98	-0.81	6.22	5.68	2.32
94	S	0.53	-0.65	-0.58	3.65	5.24	1.85
95	S	0.29	-0.59	-0.11	3.87	5.32	1.96
96	S	1.11	0.35	0.87	4.22	5.30	2.46
97	S	0.16	-0.43	0.02	4.10	5.13	1.90
98	S	1.73	0.36	0.62	3.67	4.59	2.19
99	S	2.61	0.71	0.98	4.31	4.99	2.69
Mean		0.23	-0.29	0.20	5.00	5.26	2.22

Table 9. Stratified mean length (cm) at age for witch flounder from surveys in Subdivision 3Ps during 1983-94 using data converted to Campelen catch equivalents.

Male Age (yrs)	Year														
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 Feb.	1993 Apr.	1994		
1	-	-	-	-	-	-	-	-	-	8.50	-	-	-	-	
2	14.25	-	12.50	-	-	-	-	-	12.00	12.50	-	-	-	-	
3	16.50	-	14.50	-	-	14.50	-	-	15.20	17.02	14.50	-	14.50	-	
4	20.32	18.71	19.74	18.85	21.77	23.09	19.34	22.89	19.35	18.50	20.50	20.50	-	-	
5	24.68	24.14	23.92	24.75	25.90	26.37	23.67	26.01	22.81	23.99	23.46	23.55	23.71	25.61	
6	28.91	28.81	26.55	28.58	26.46	26.37	25.68	26.01	26.19	27.13	25.25	25.91	25.61	29.42	
7	32.44	32.29	31.03	33.06	31.28	31.29	29.77	30.28	29.25	30.24	29.44	30.01	29.42	33.34	
8	35.82	34.86	35.46	37.48	35.03	35.49	33.72	34.17	33.60	33.65	33.31	33.72	33.34	37.25	
9	38.12	37.58	39.03	40.92	38.44	38.89	37.15	37.92	37.43	37.24	37.09	37.05	37.25	40.75	
10	41.43	39.60	40.62	42.97	40.78	41.75	39.90	40.62	41.13	39.72	40.03	40.43	40.75	44.69	
11	45.46	42.82	45.12	46.95	43.61	43.91	42.73	42.90	53.51	43.85	42.78	41.98	44.69	47.28	
12	50.59	46.65	47.02	47.73	46.54	48.17	46.06	47.26	46.27	46.31	48.24	45.41	47.28	48.50	
13	-	-	-	-	-	-	46.50	49.09	51.15	50.08	-	49.00	-	-	
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Female Age (yrs)	Year														
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 Feb.	1993 Apr.	1994		
1	-	-	-	-	-	-	-	-	-	6.50	-	-	-	-	
2	12.50	-	11.82	-	-	-	-	-	11.91	12.50	10.50	-	8.50	-	
3	18.50	16.50	14.50	-	-	15.88	14.50	-	15.66	16.63	14.50	-	-	-	
4	21.31	-	20.72	20.46	18.50	18.95	18.76	19.14	19.78	20.37	19.14	19.98	20.50	-	
5	24.63	23.61	23.90	23.82	21.87	23.07	22.47	23.43	23.27	22.70	23.38	23.72	23.10	-	
6	28.66	26.93	26.58	28.20	27.33	27.06	25.82	25.73	26.38	27.21	26.24	26.98	26.20	-	
7	32.51	31.88	30.88	32.79	31.64	31.11	29.95	29.40	29.86	30.77	29.87	30.39	30.73	-	
8	35.76	34.72	35.64	38.19	36.15	35.57	34.16	34.41	33.94	34.62	34.22	34.47	33.73	-	
9	39.23	38.04	39.68	41.13	39.38	39.17	37.71	38.12	37.79	37.75	37.98	38.17	37.68	-	
10	43.16	40.77	41.71	44.14	42.99	42.17	41.16	40.97	41.06	41.00	41.58	41.02	41.33	-	
11	47.23	44.37	44.88	47.98	44.31	44.83	43.27	44.05	44.27	43.81	45.11	44.62	44.63	-	
12	50.91	47.97	48.20	51.95	48.34	49.53	46.82	47.02	47.38	47.35	47.19	47.05	47.49	-	
13	57.19	52.04	53.13	53.56	54.71	52.53	49.48	49.55	51.23	51.61	52.67	49.51	50.20	-	
14	58.50	52.65	58.50	56.50	-	57.60	54.17	54.69	53.42	56.50	54.50	55.12	51.46	-	
15	-	-	-	-	-	-	-	-	56.50	-	-	-	54.50	-	

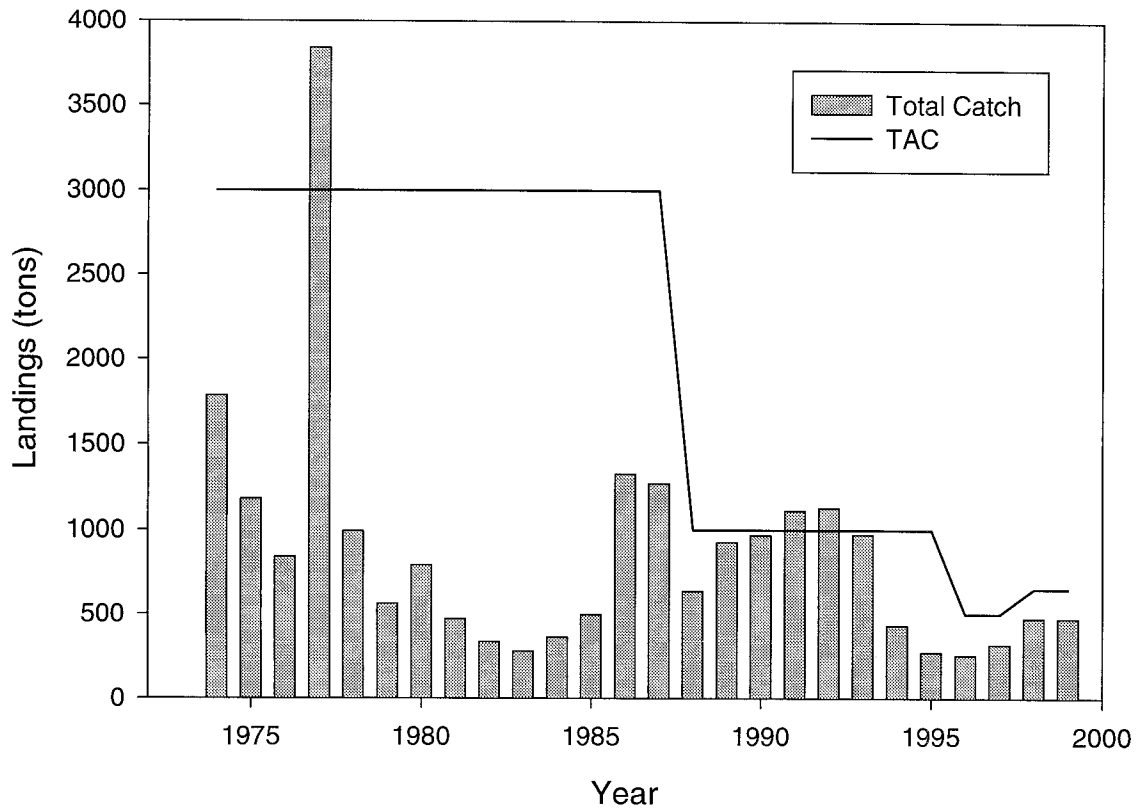


Fig. 1 Total landings and TACs of witch flounder from Subdivision 3Ps during 1974-99. The 1997-99 values are estimated from quota reports with 1999 representing the catch to the end of September.

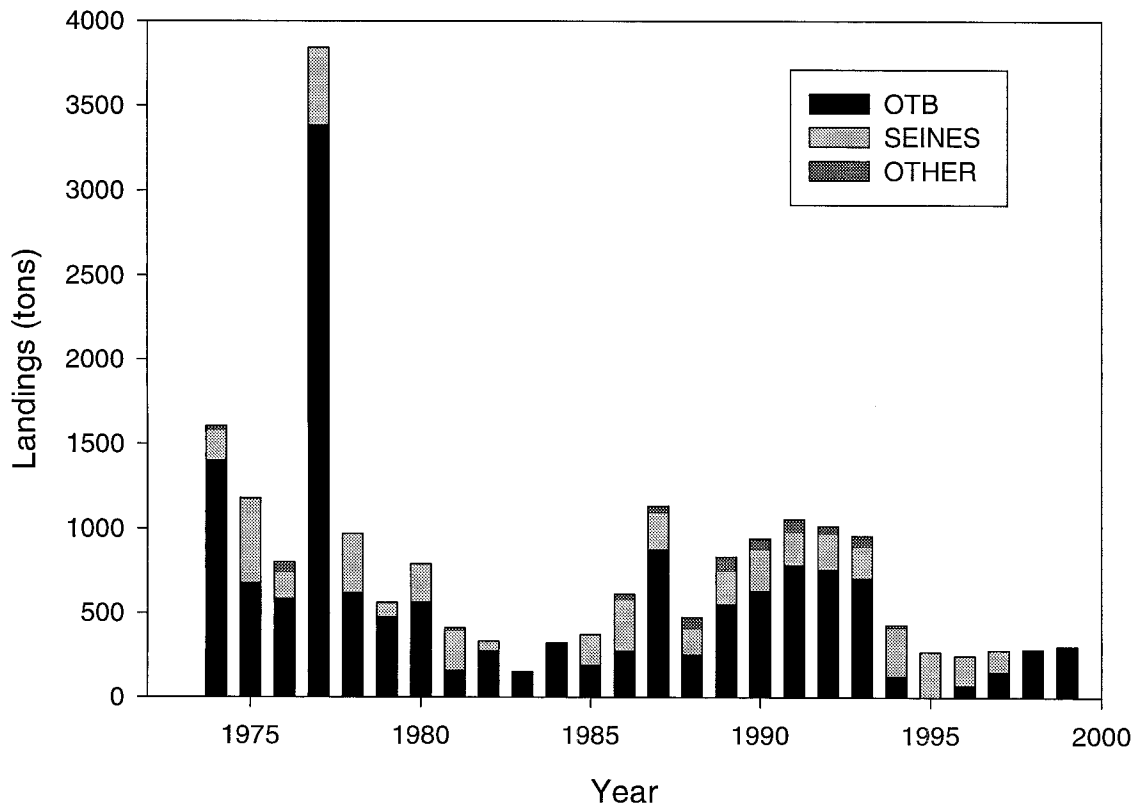


Fig. 2 Landings by gear type of witch flounder by Canada (N) from Subdivision 3Ps during 1974-99. The 1997-99 values are estimated from quota reports with 1999 representing the catch to the end of September.

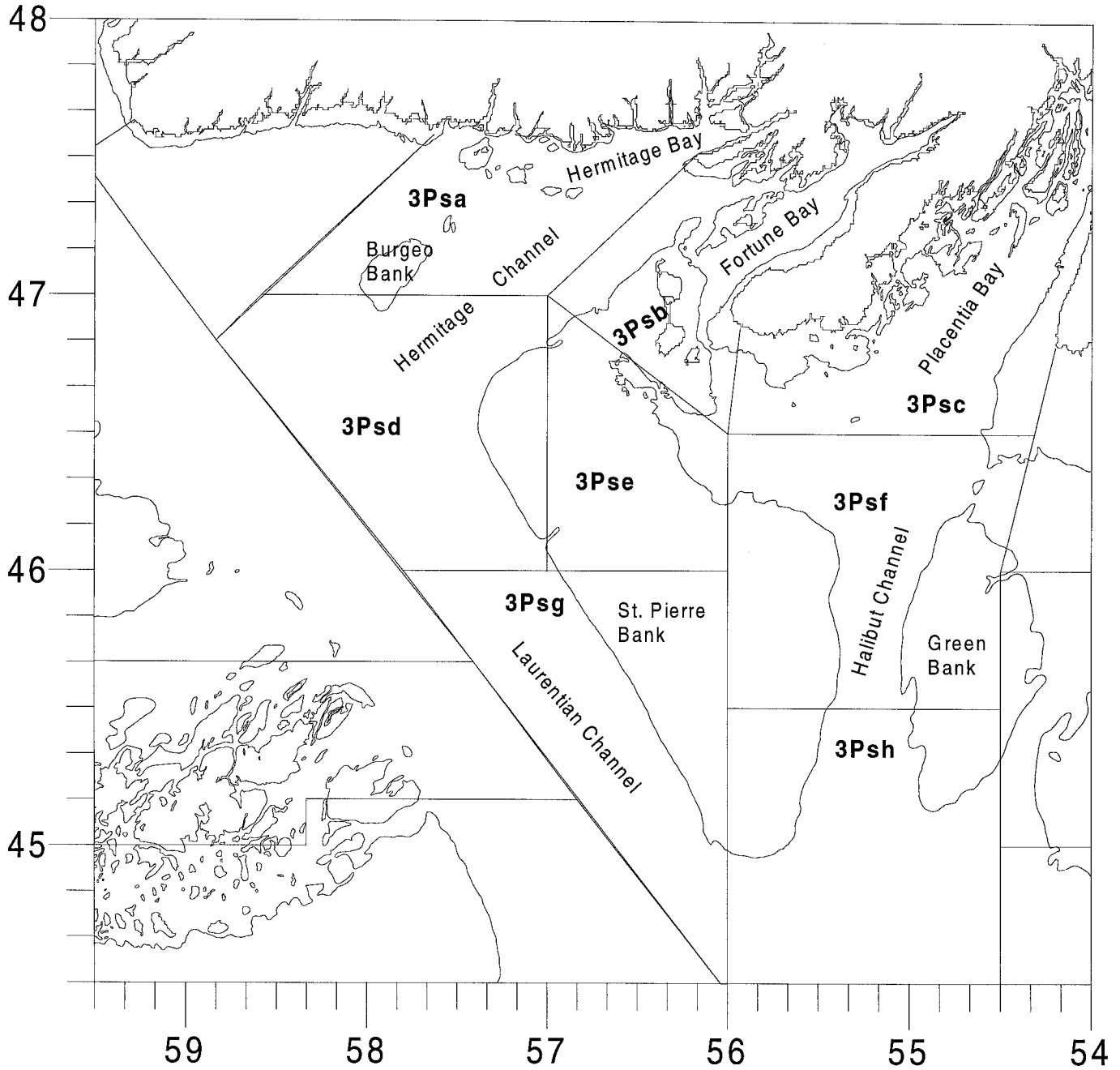


Fig. 3 Commercial catch reporting statistical areas for NAFO Subdivision 3Ps with the major place names mentioned in the text.

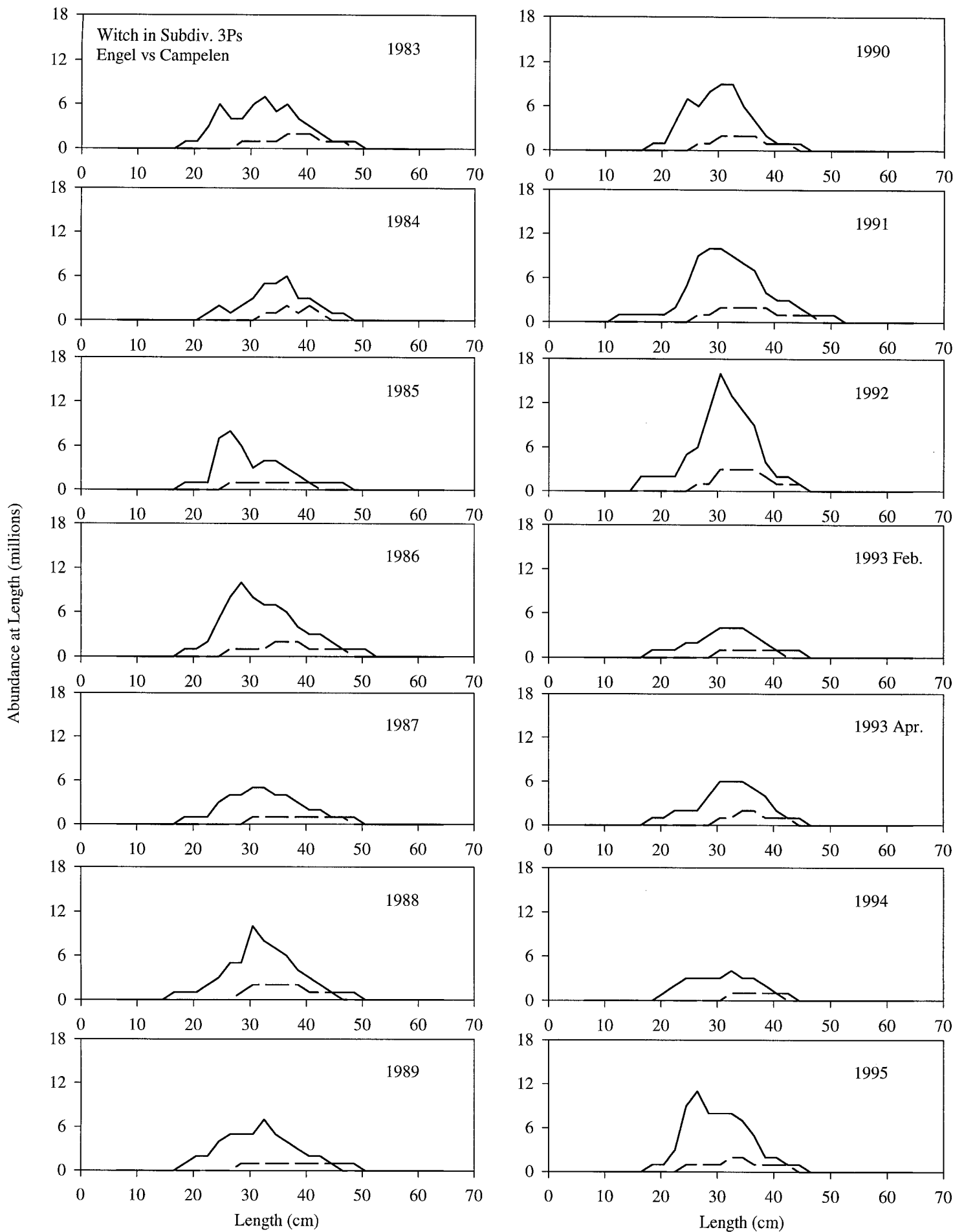


Fig. 4 A comparison of distribution and abundance at length (cm) between the Engel trawl and Campelen catch equivalents for witch flounder from Canadian surveys in Subdiv. 3Ps. Solid lines represent Campelen catches and broken lines represent Engel catches.

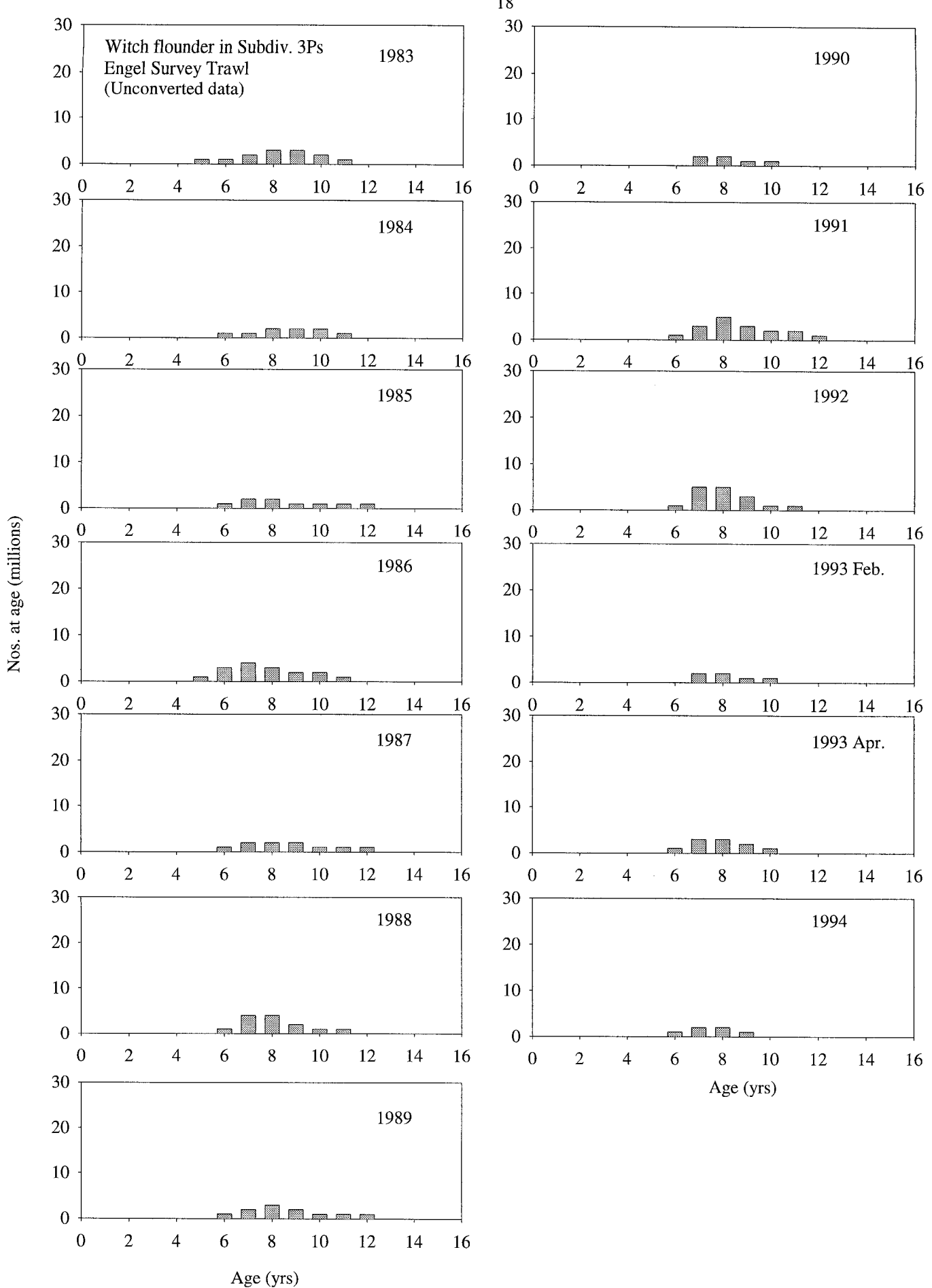


Fig. 5 Number at age (millions) of witch flounder in Subdiv. 3Ps from annual surveys during 1983-94. Surveys were conducted using an Engel otter trawl and are presented accordingly.

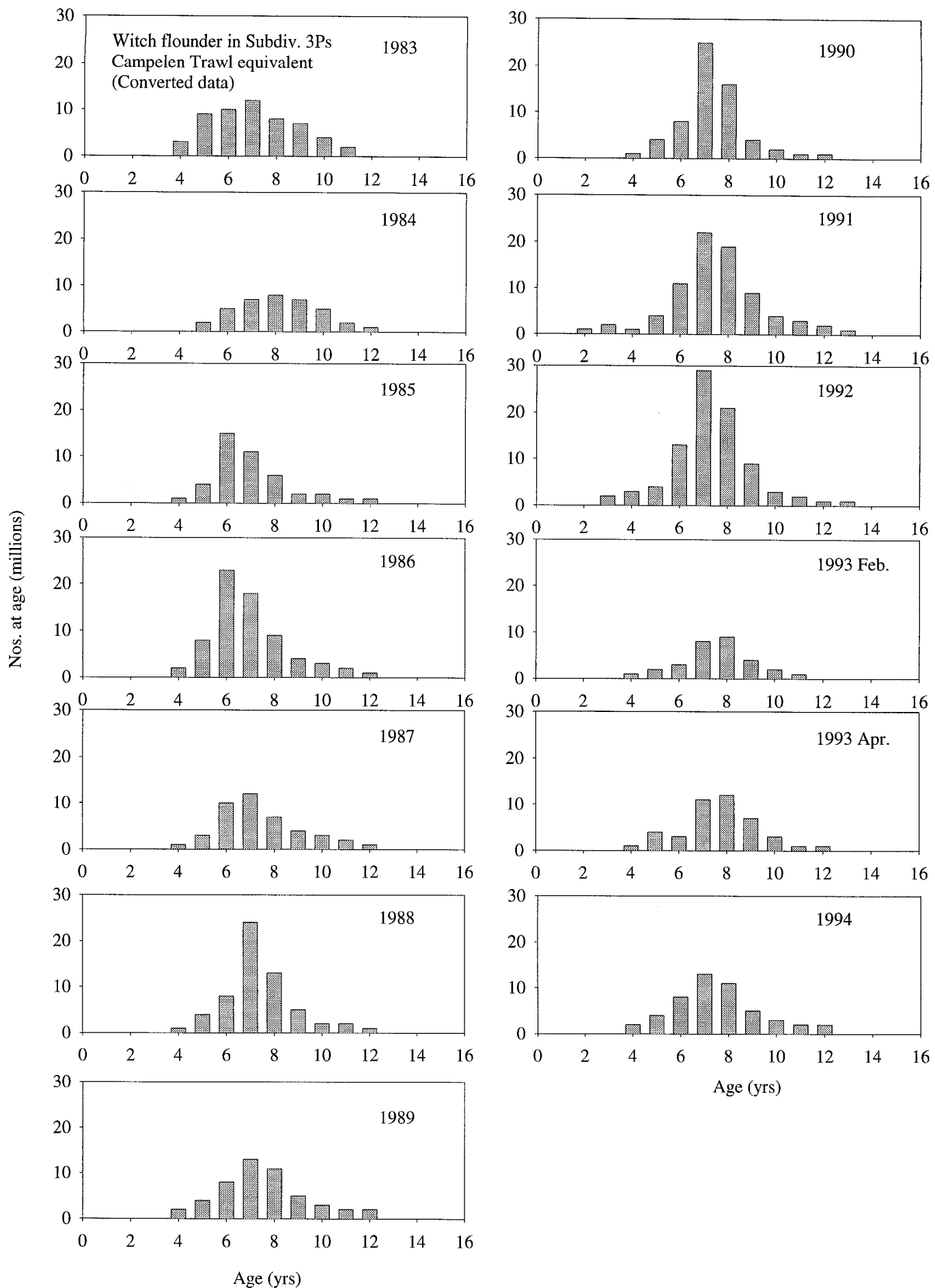


Fig. 6 Number at age (millions) of witch flounder in Subdiv. 3Ps from annual surveys during 1983-94. Surveys were conducted using an Engel otter trawl but data presented here have been converted to Campelen trawl catch equivalents.

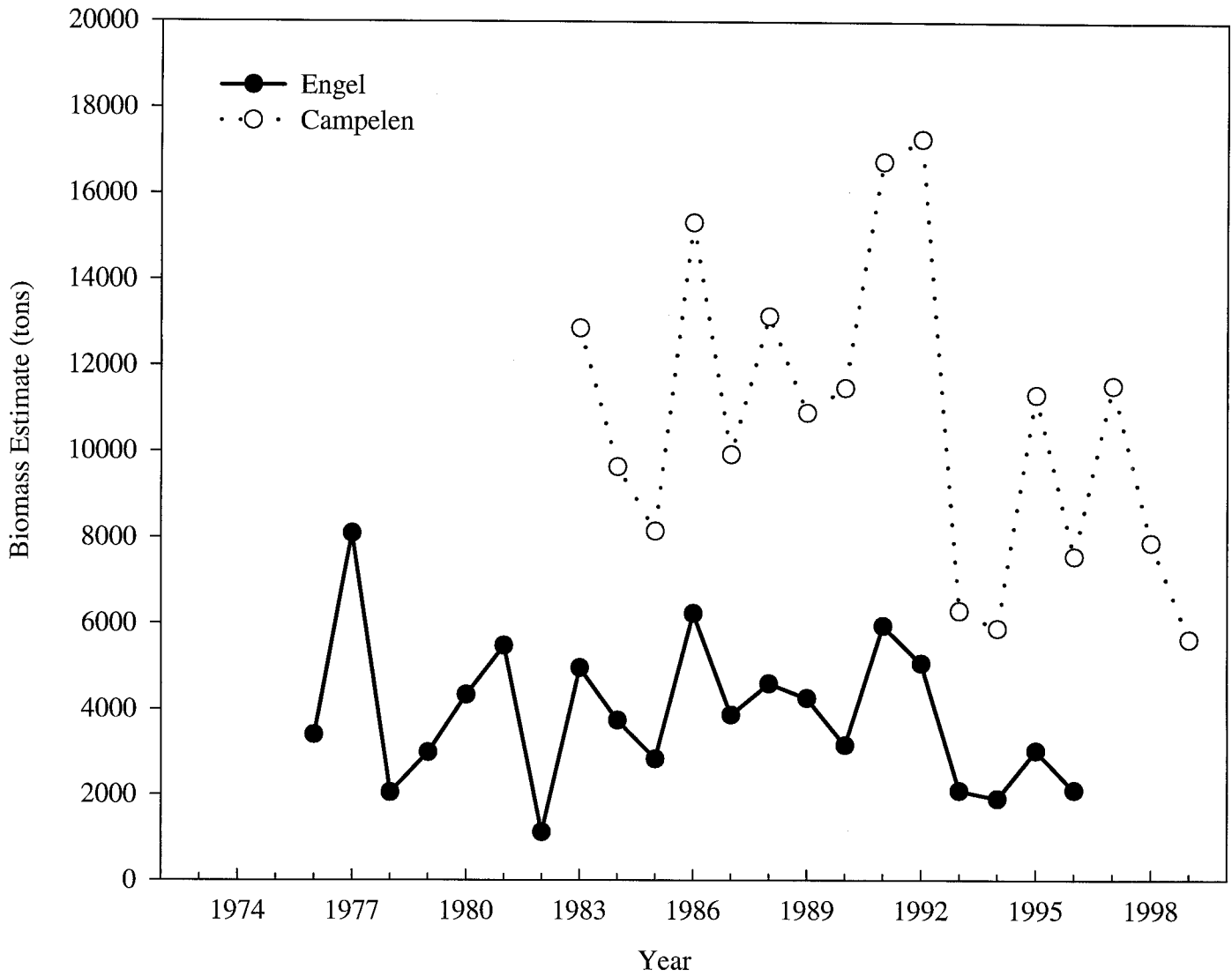


Fig. 7 A comparison between Campelen and Engel biomass estimates of witch flounder in Subdiv. 3Ps from Canadian surveys during 1976-99.

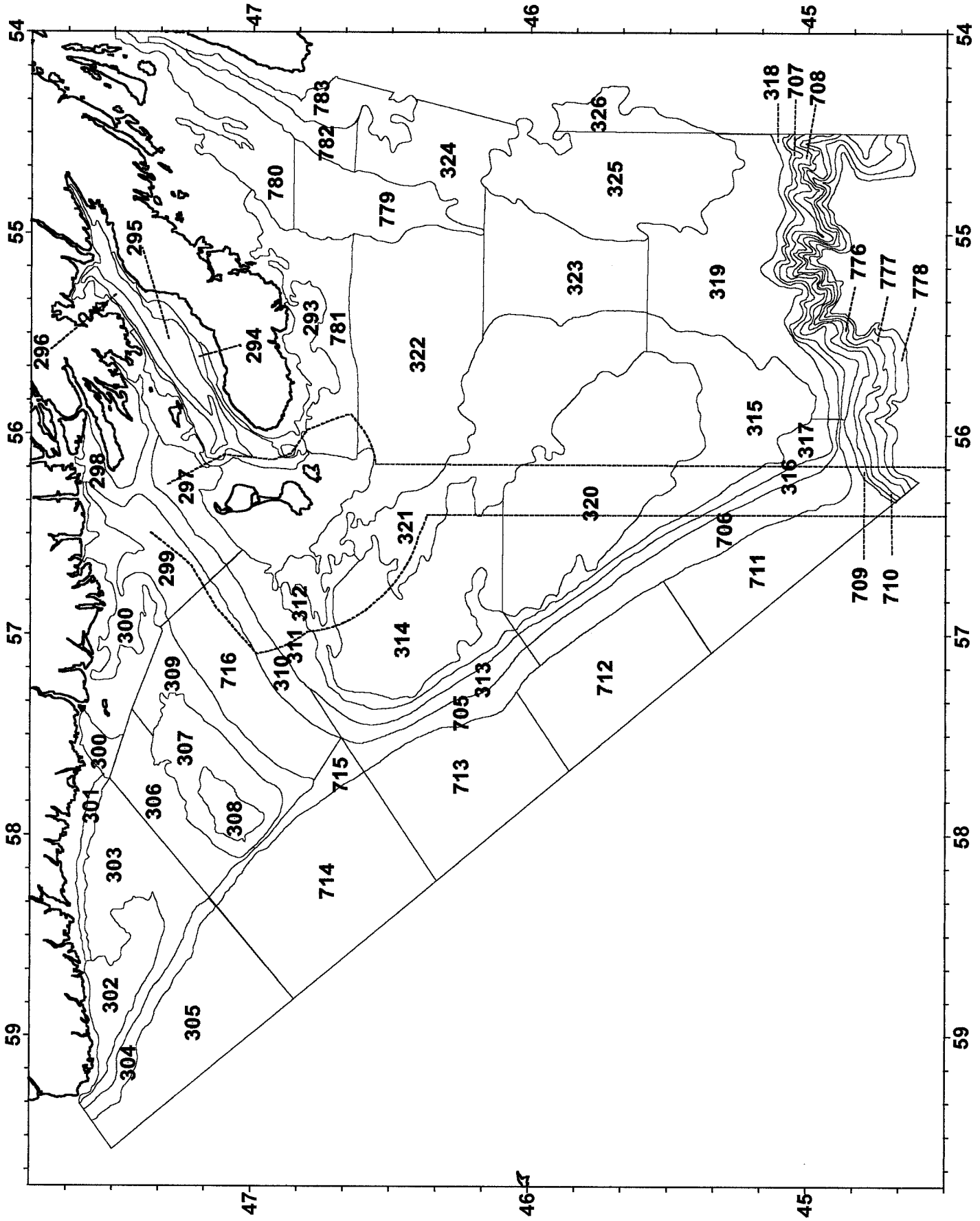


Fig.8 . The survey area in NAFO Div. 3P showing strata boundaries currently in use in the spring research vessel bottom trawl survey. (Revised Feb. 99)

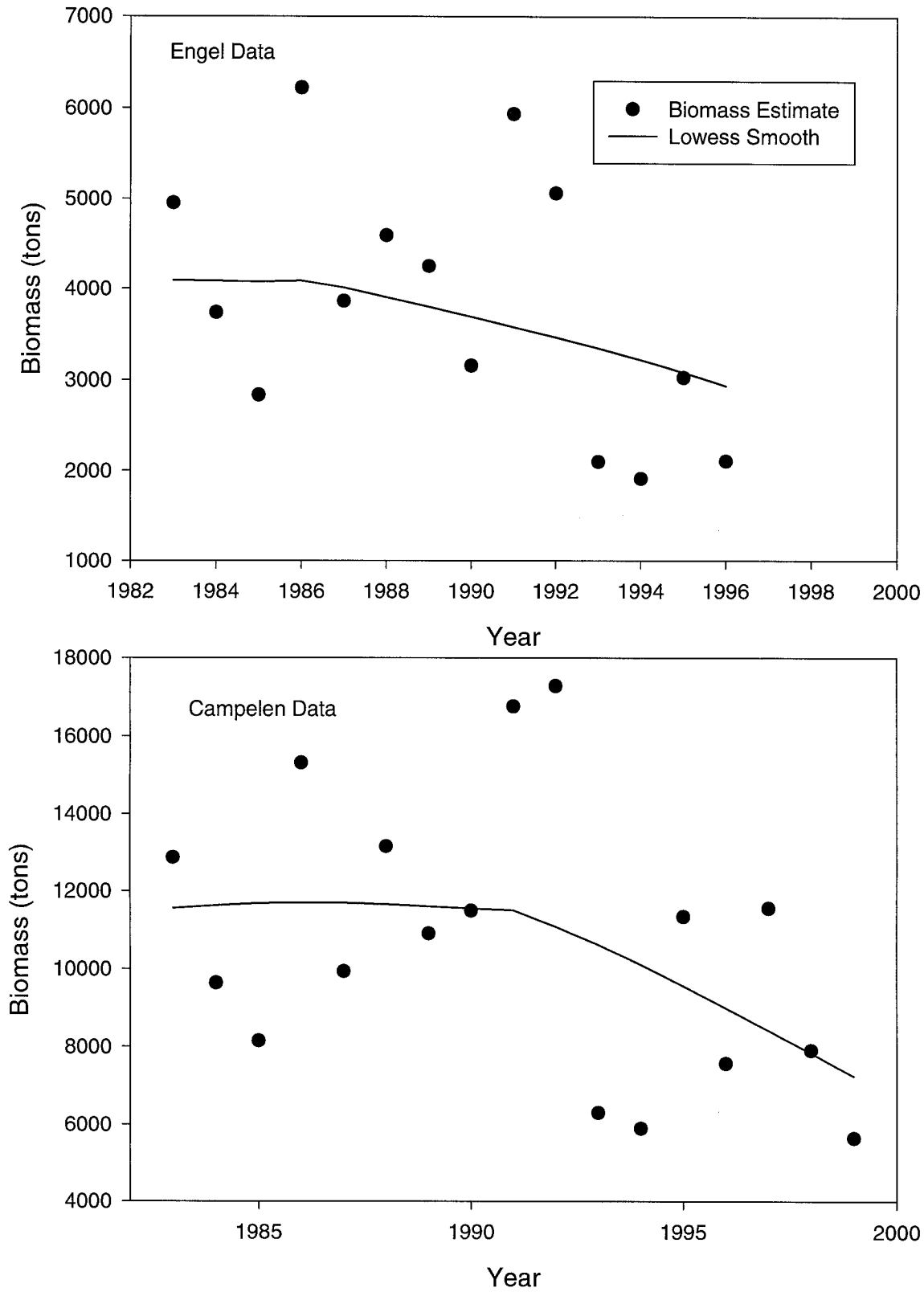


Fig. 9 Biomass estimates of witch flounder in Subdivision 3Ps from Canadian surveys in 1983-99. Upper panel is with unconverted data and lower panel is in Campelen trawl catch equivalents.

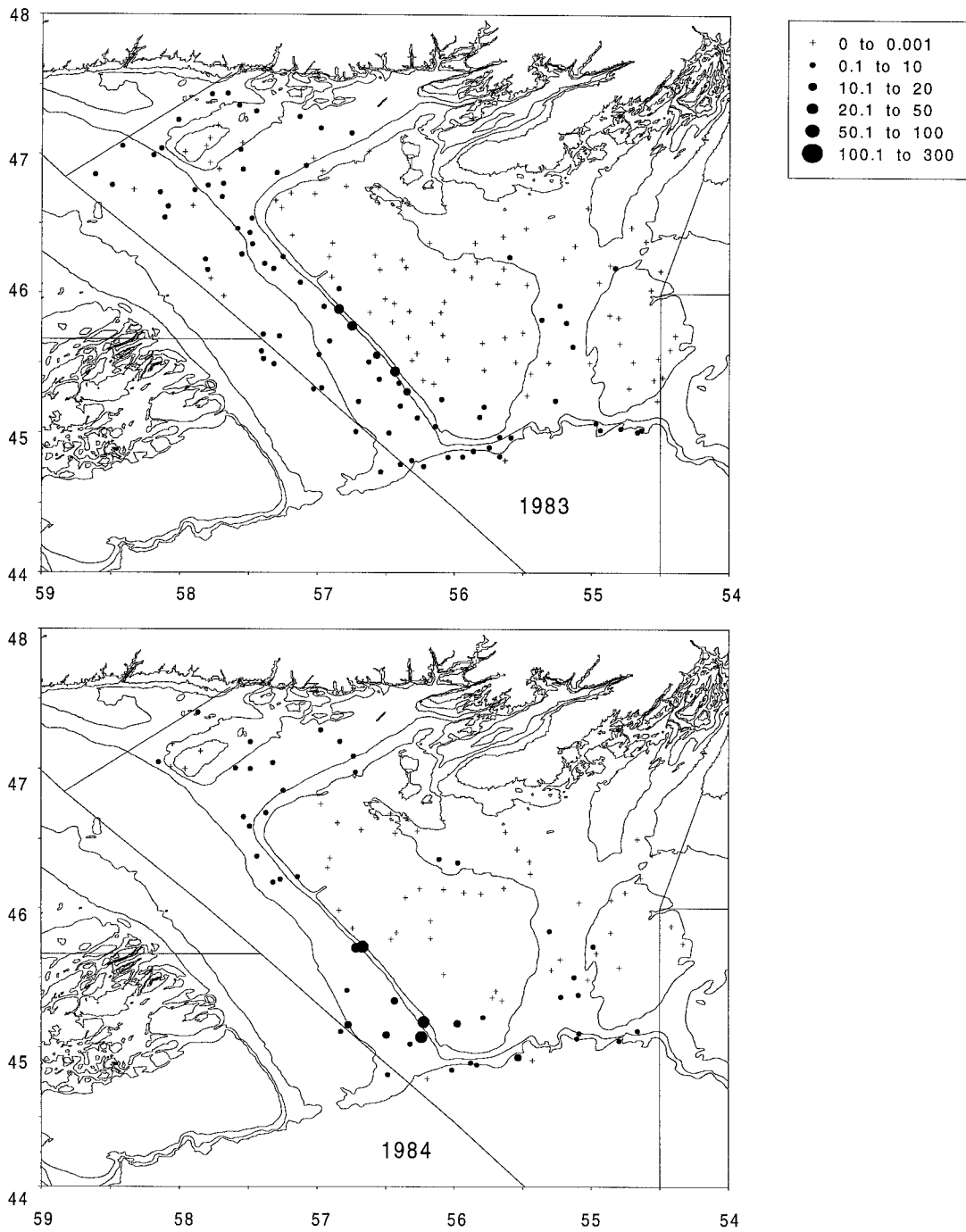


Fig. 10 Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

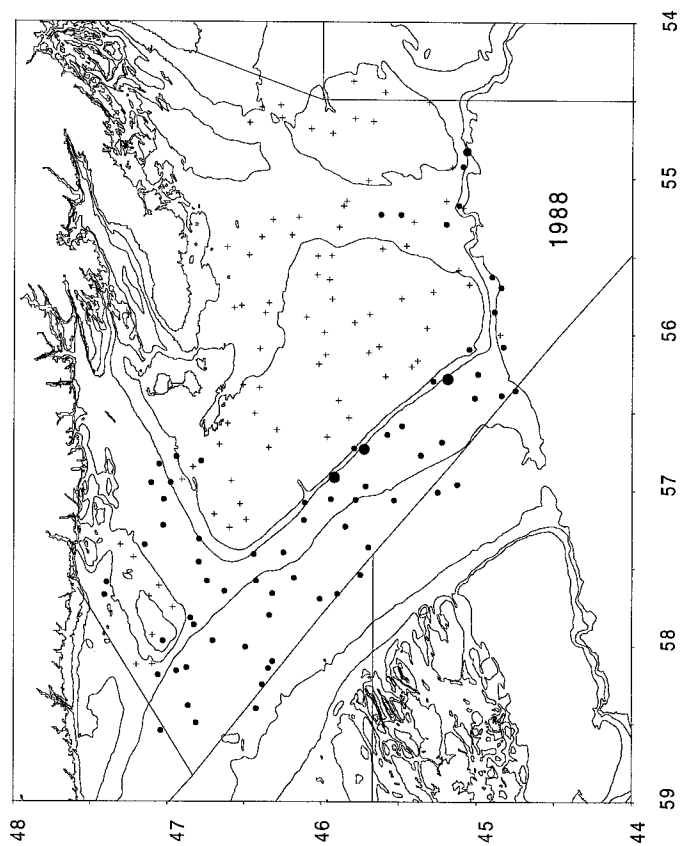
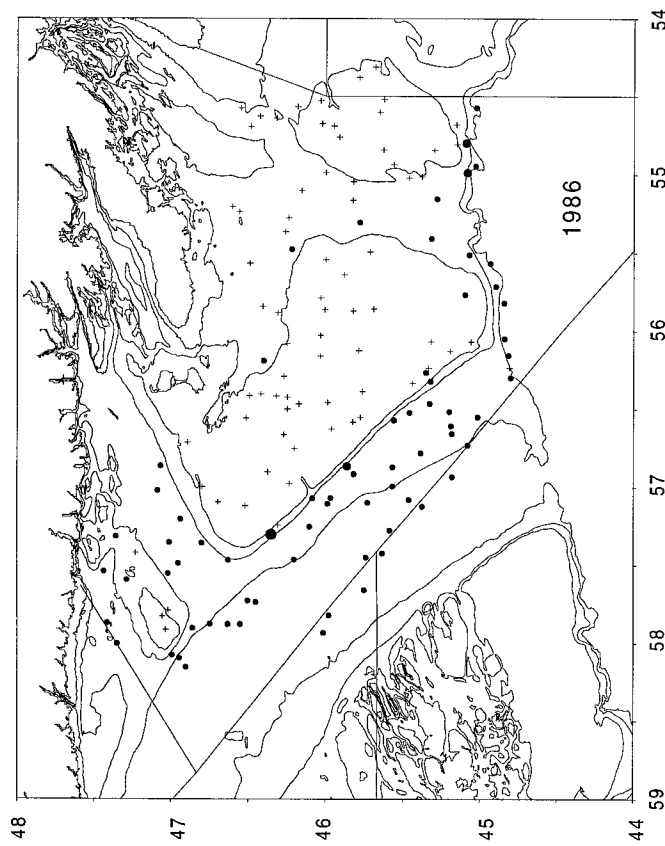
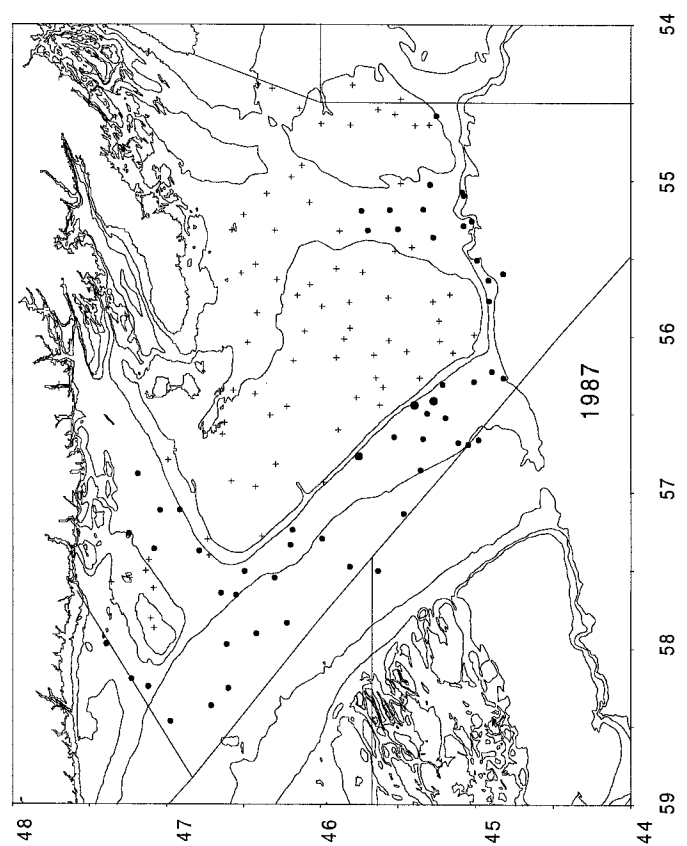
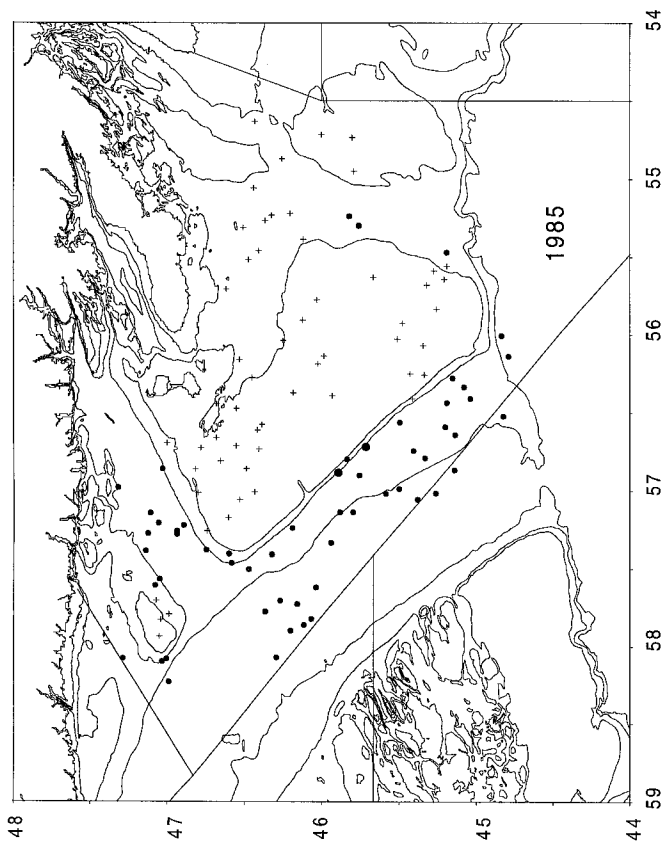


Fig. 10 (con'd) Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

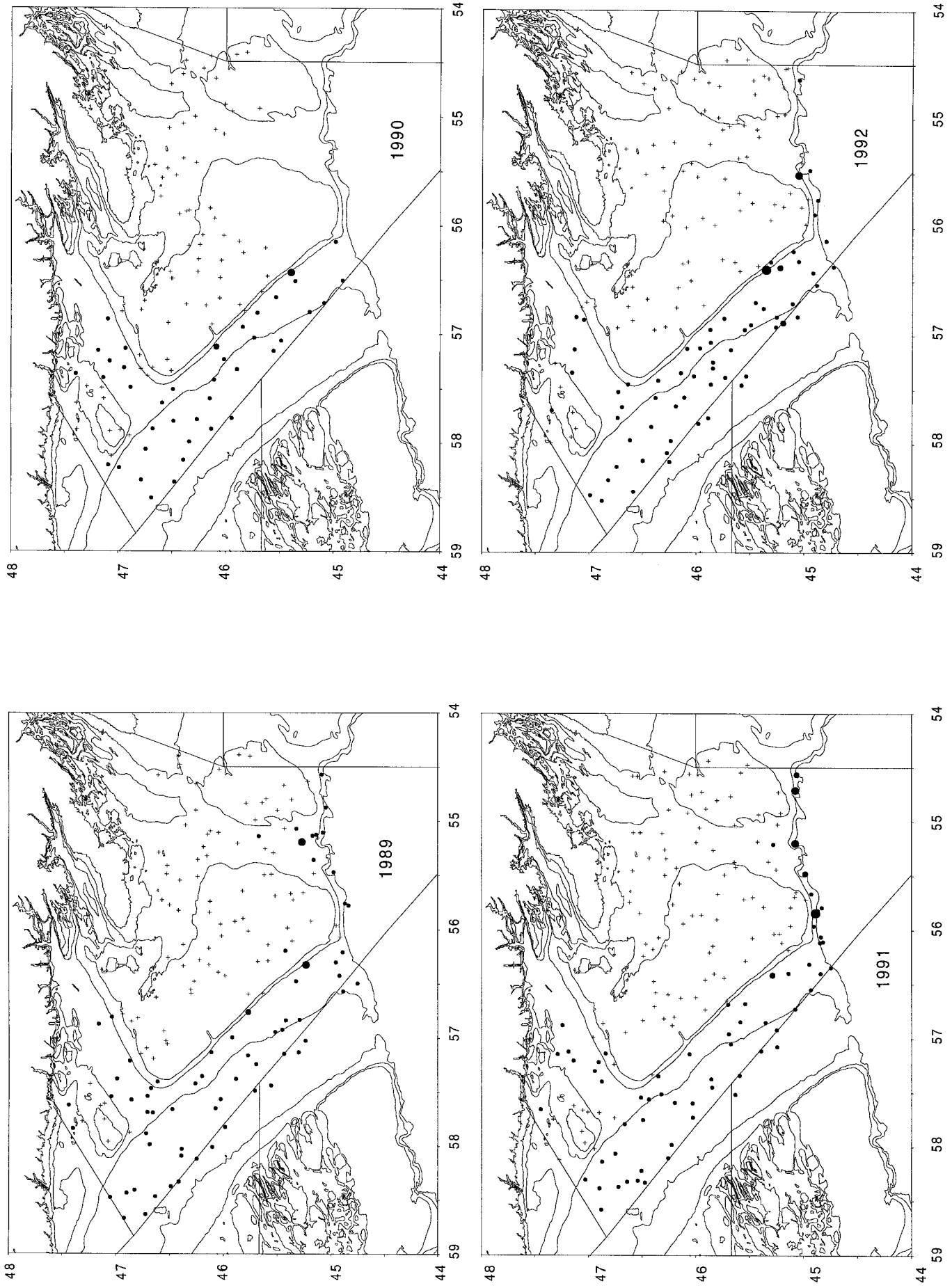


Fig. 10 (con'd) Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

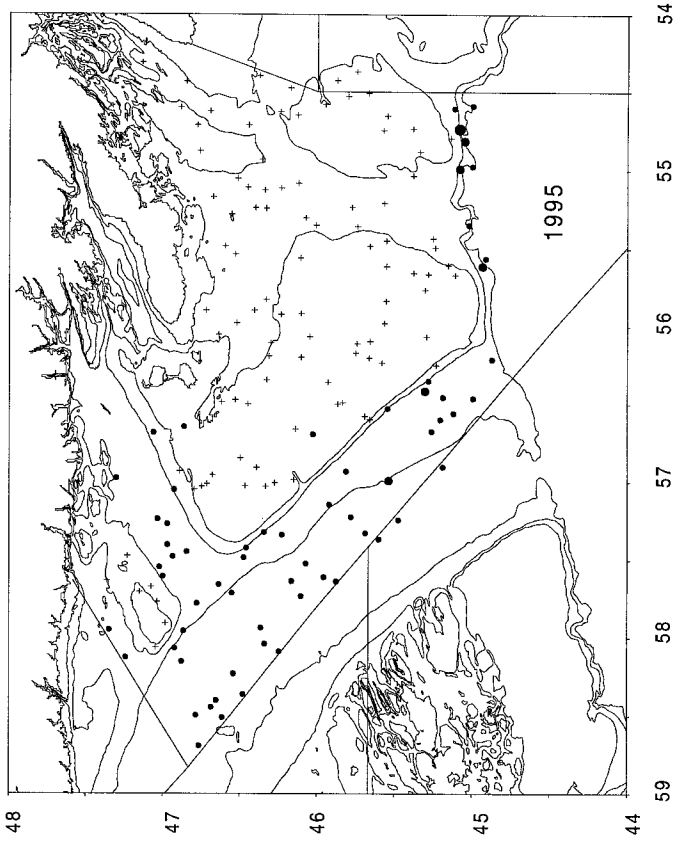
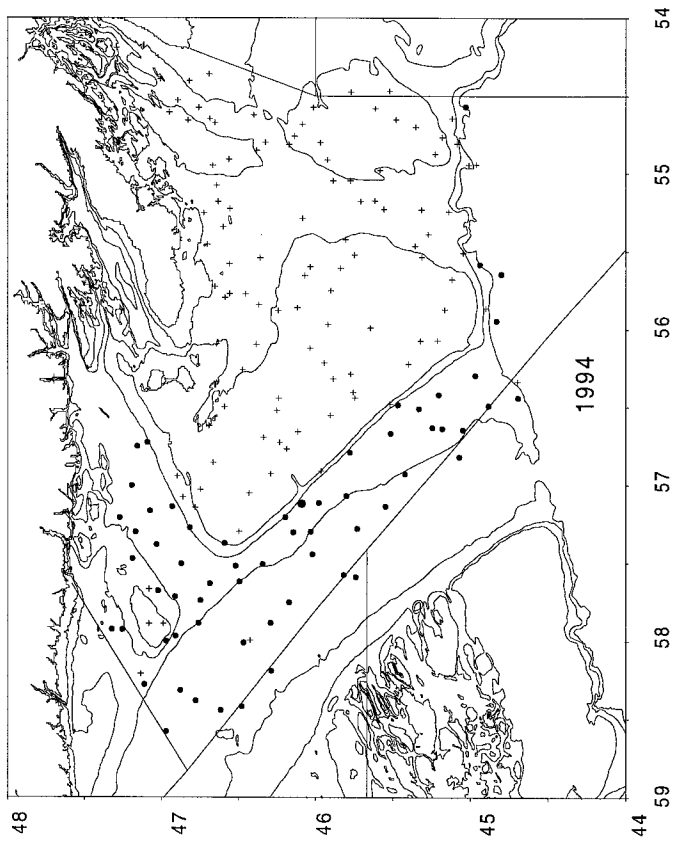
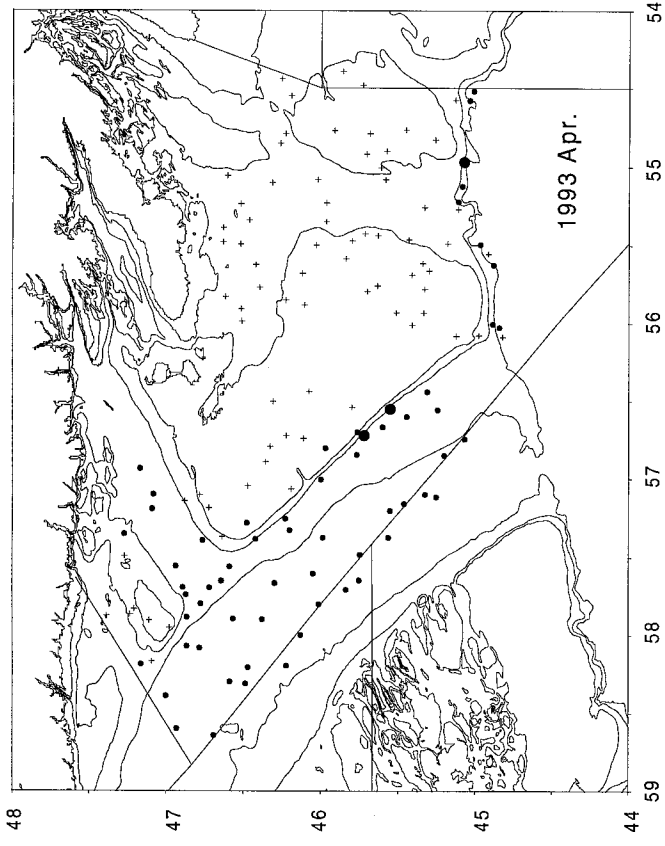
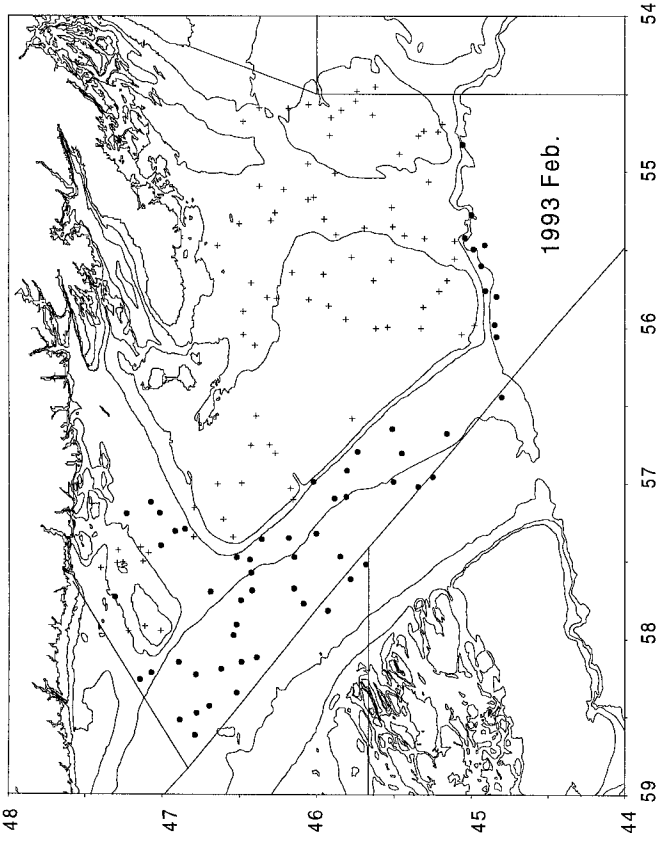


Fig. 10 (con'd) Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

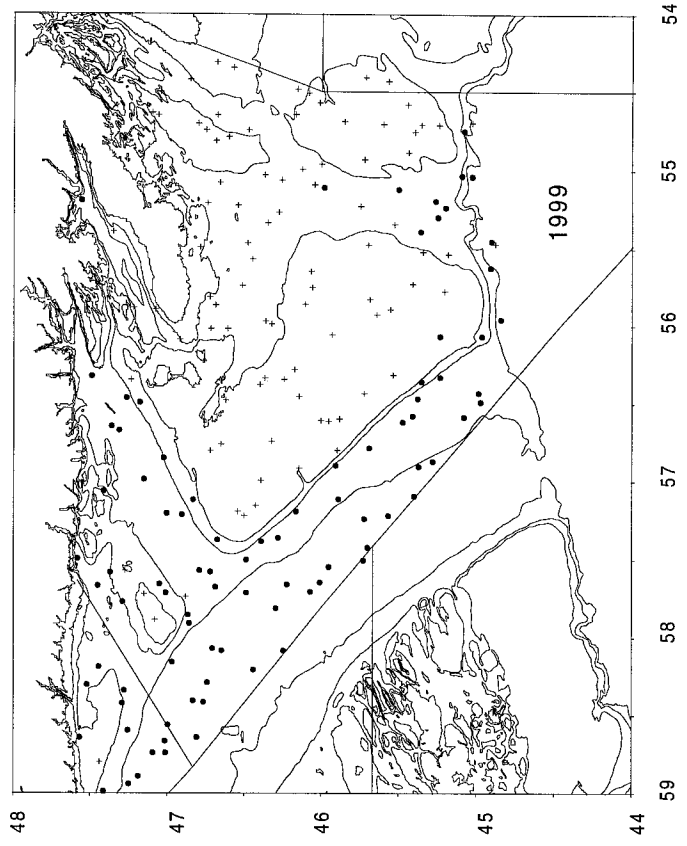
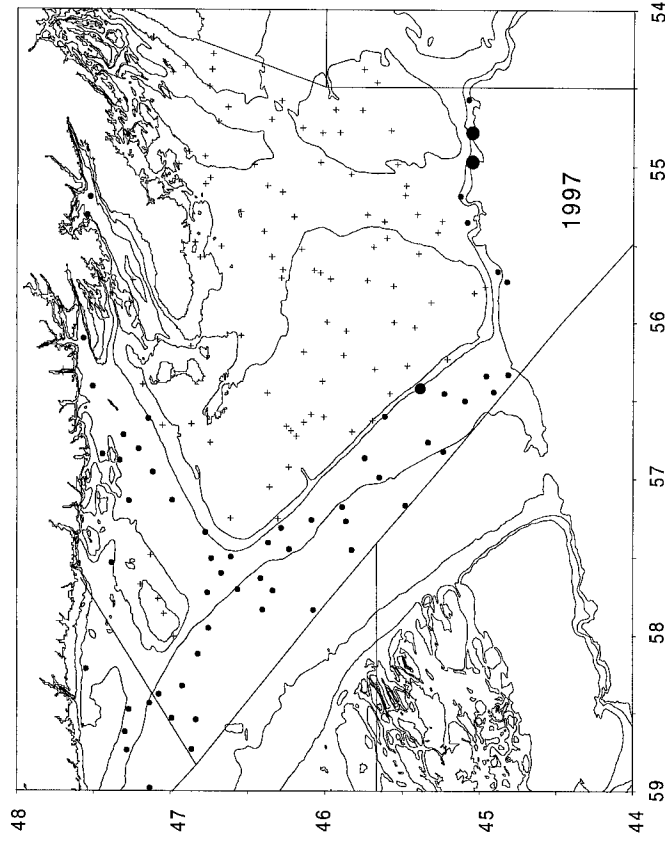
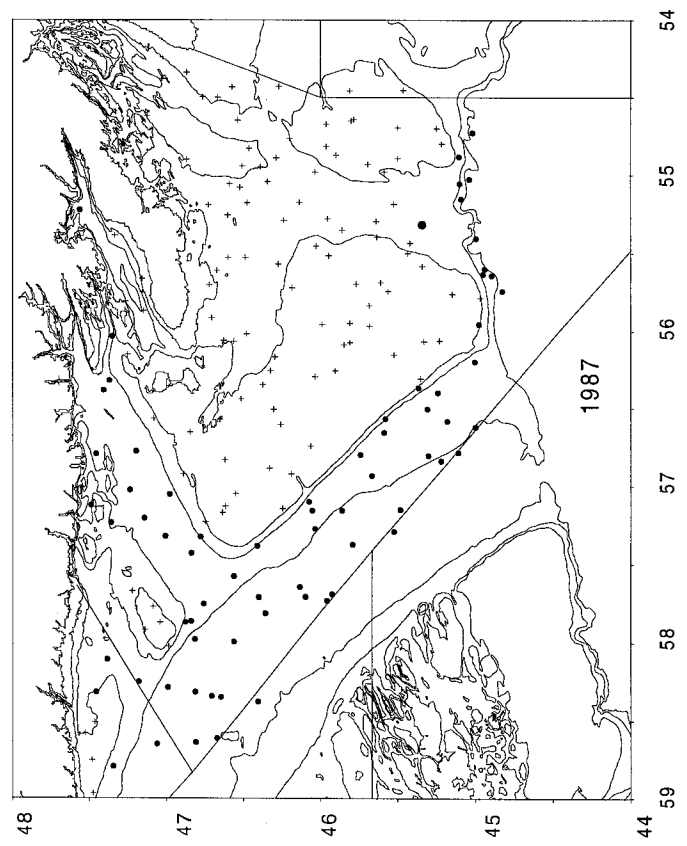
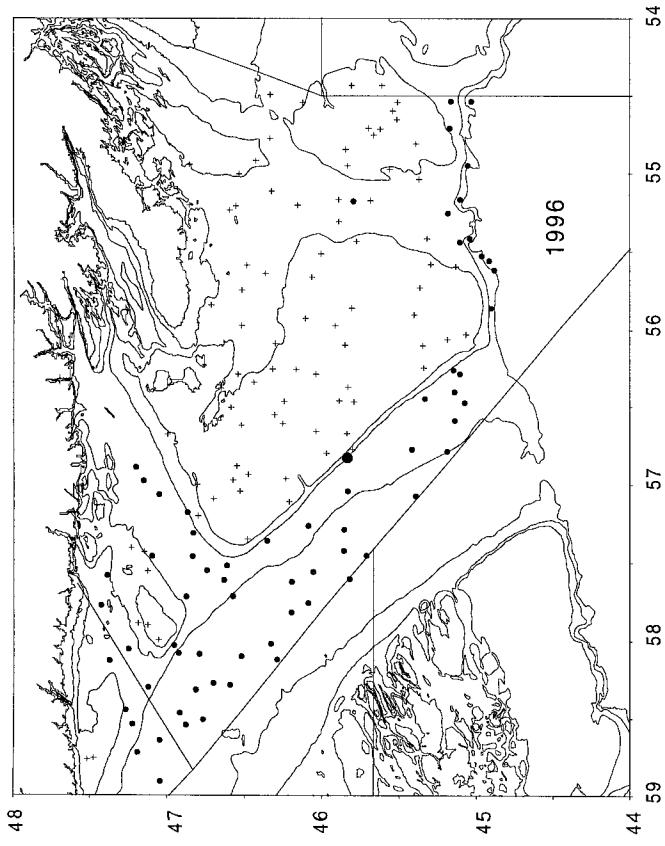


Fig. 10 (cont'd) Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

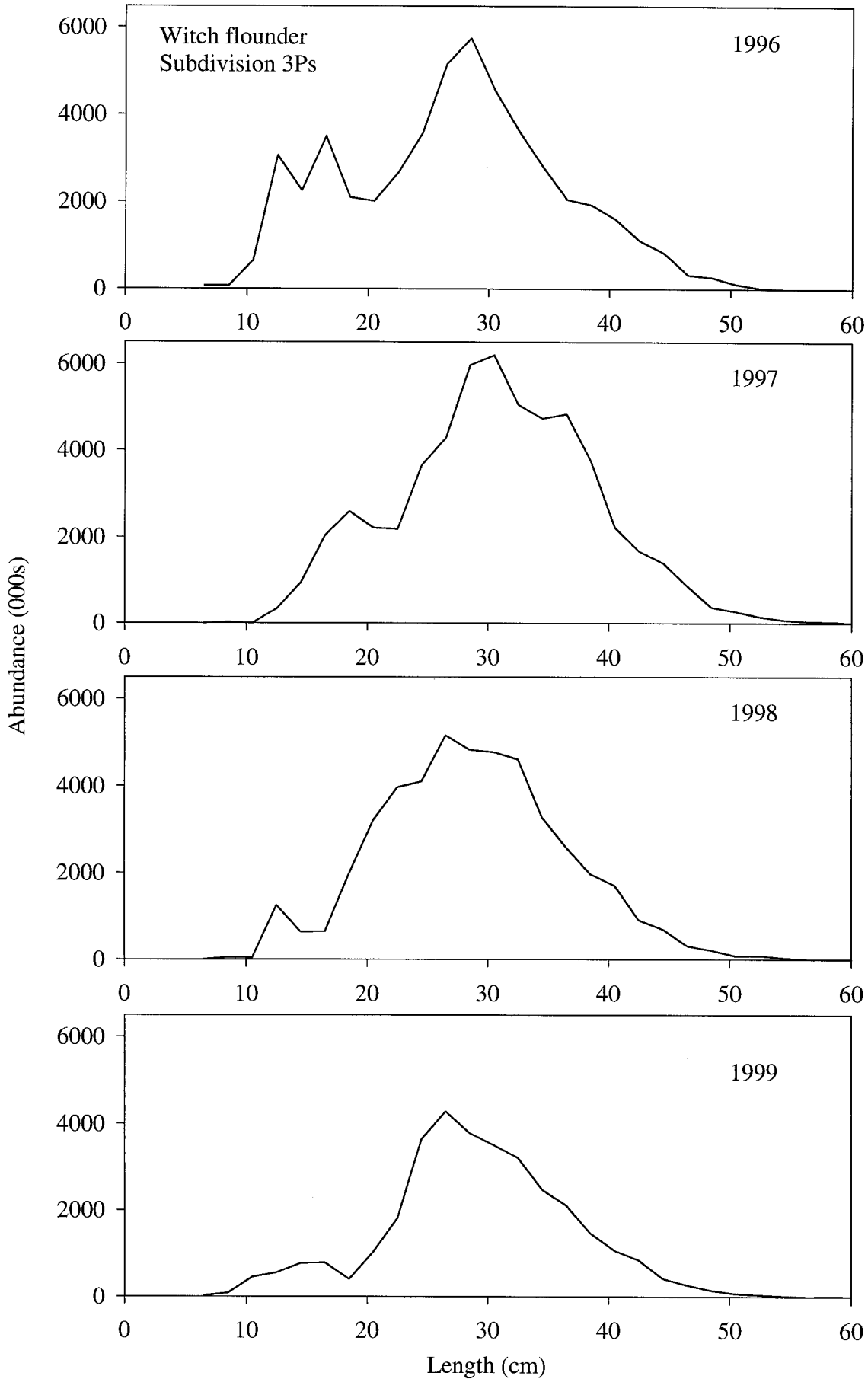


Fig. 11 Length frequency distributions of witch flounder from Subdivision 3Ps surveys in 1996-99 using the Campelen1800 shrimp survey trawl.

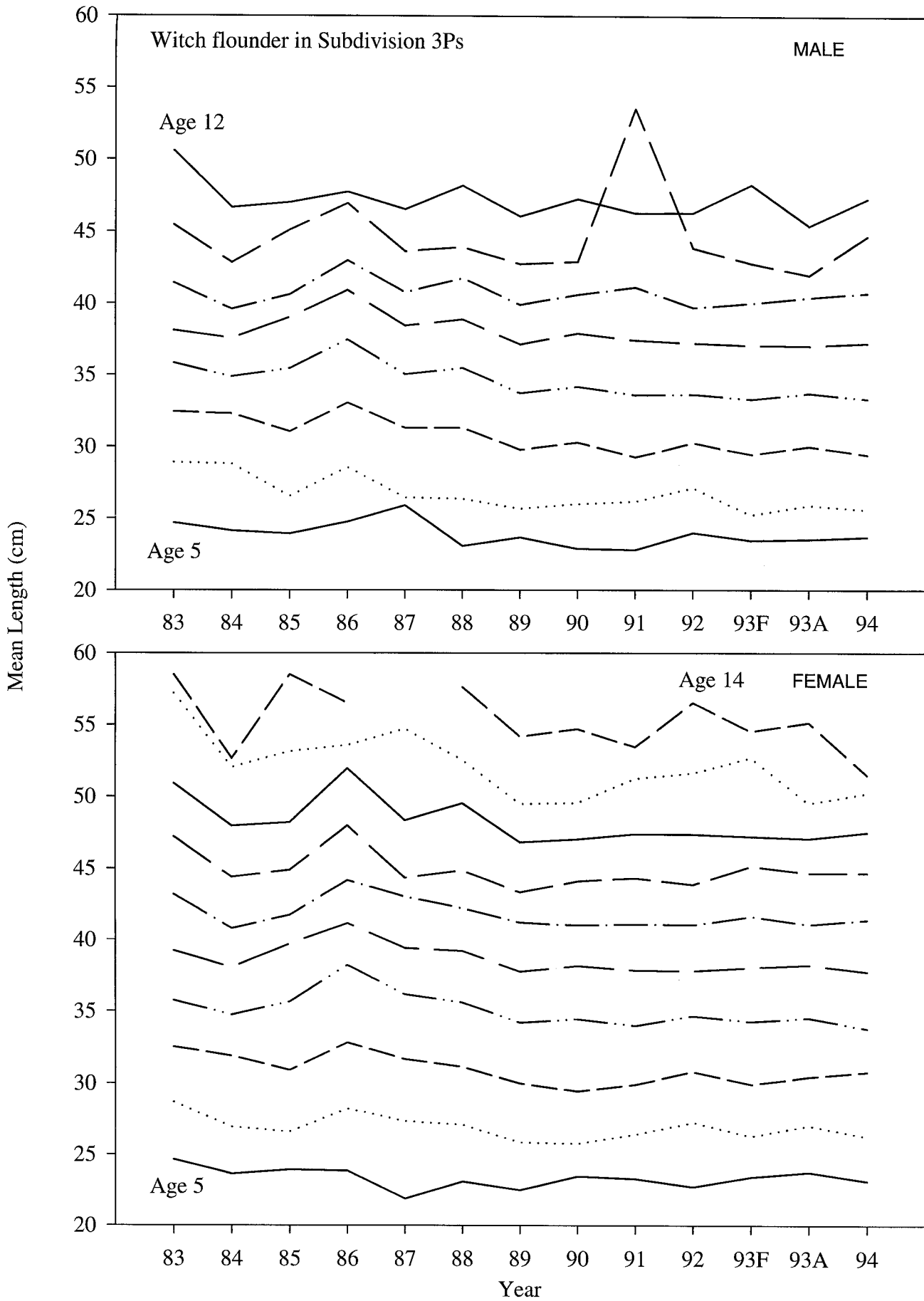


Fig. 12 Mean length (cm) at age for male and female witch flounder from surveys in Subdivision 3Ps during 1983-94. Data converted to Camelen trawl catch equivalents.

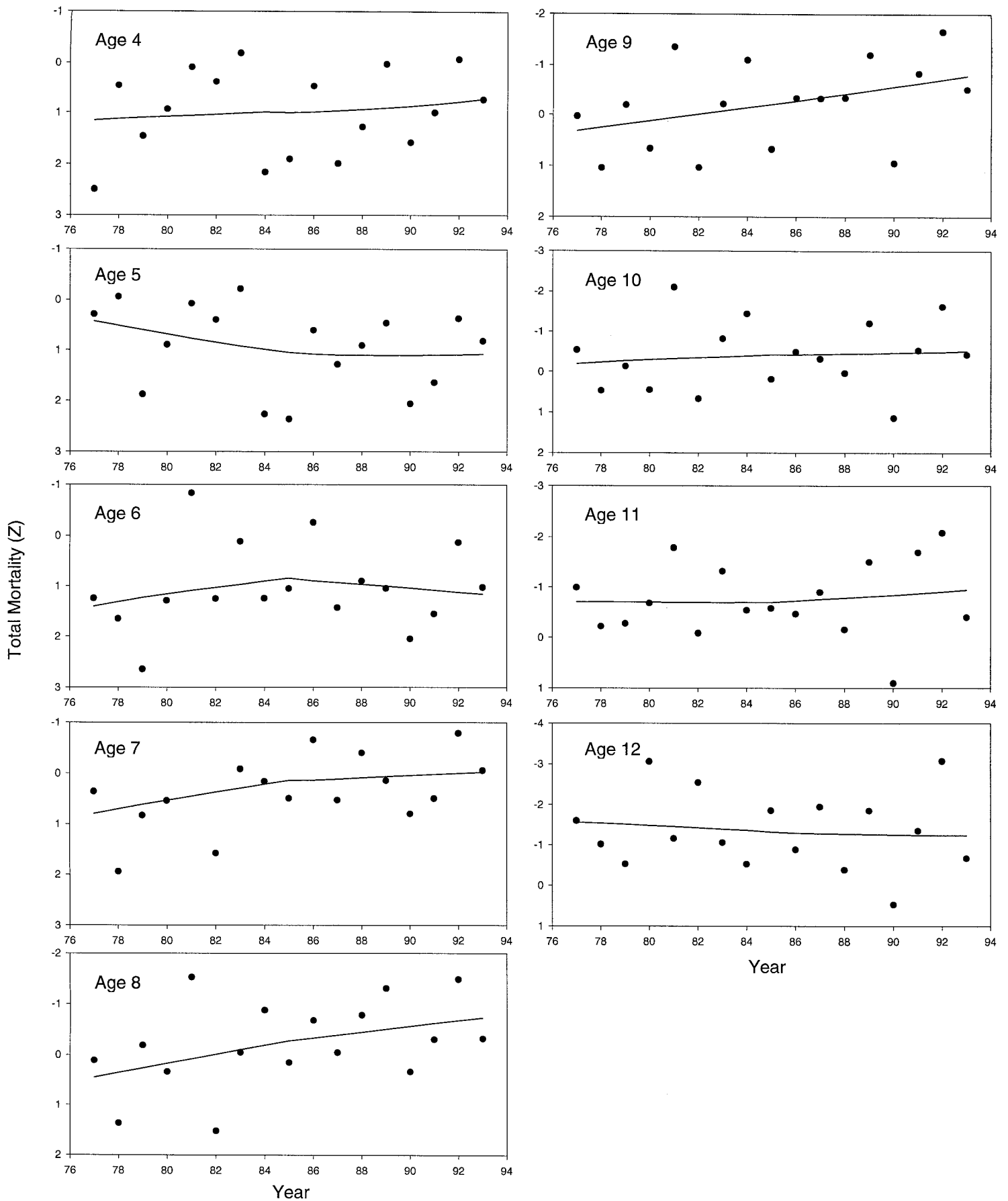


Fig. 13 Estimates of total mortality (Z) for ages 4-12 witch flounder from Canadian surveys in Subdivision 3Ps during 1976-94. Data are in Engel trawl catch equivalents.

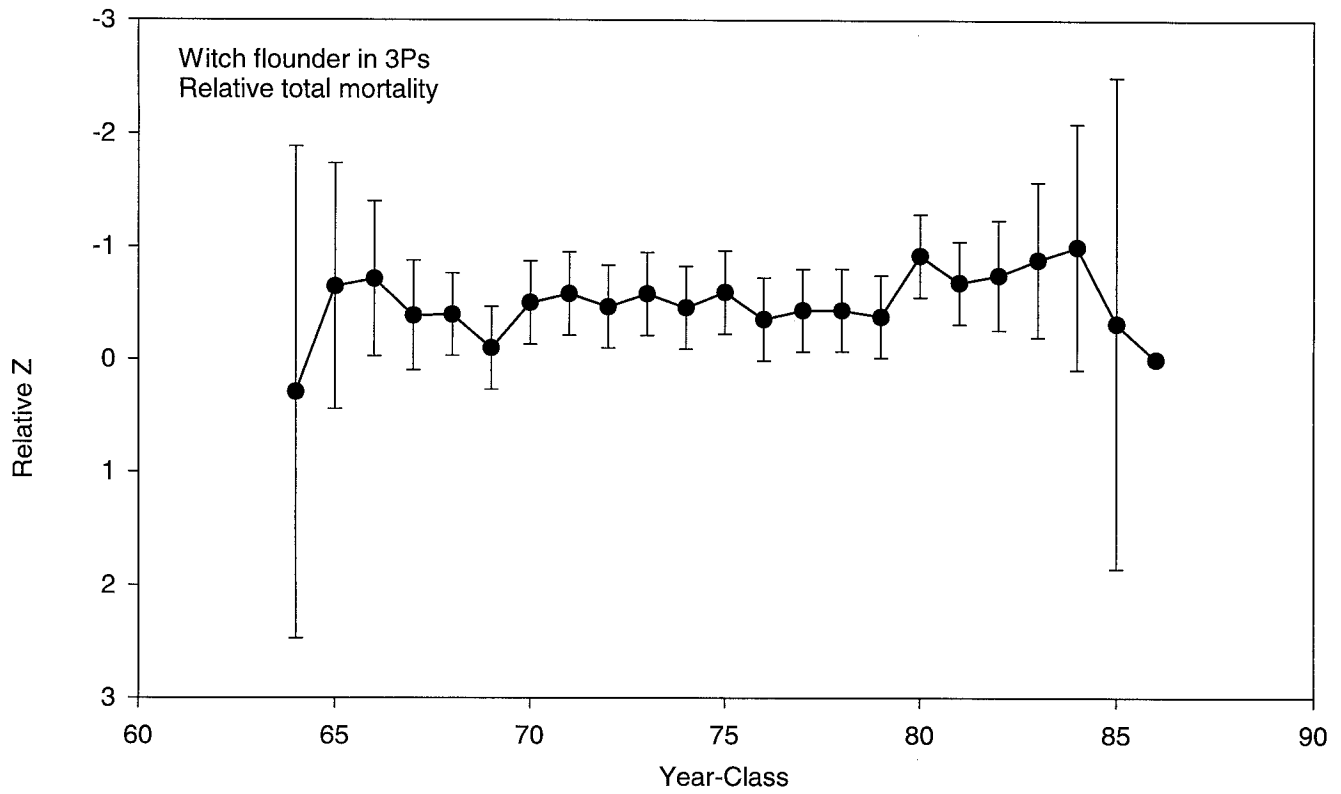


Fig. 14 Trend in relative total mortality of witch flounder fully recruited to the fishery (ages 8-13) in Subdivision 3Ps from the 1964-86 cohorts. Data from Engel surveys unconverted.