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An Assessment Update for American Plaice in NAFO Divisions 3LNO

by

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Abstract

Catches from this stock were generally in the range of 40,000 to 50,000 t per year throughout the 1970's and 1980's, before declining to low levels in the early 1990's. There has been no directed fishing on this stock since 1993. The TAC's in 1995-98 have been set at 0. The catch in 1997 was 1407 t, up from the 1996 level of 913 t. Recent catches have been taken mainly in the NAFO Regulatory Area (NRA). The Canadian spring and fall surveys show a large decline in abundance and biomass from the mid to late 1980's until 1998. Currently the stock is composed mainly of fish less than 7 years old, and recruitment has been below average for many years. Most of the indicators evaluated suggest that the stock remains at a low level.

TAC regulation

This stock has been under TAC regulation since 1973 when a TAC of 60,000 t was established. From 1973-87, the TAC varied from 47,000 t to 60,000 t (Table 1) but was lowered to 33,585 t in 1988. Further reductions followed, bringing the TAC to 10,500 t in 1993. In 1994, a TAC of 4,800 t was implemented, but the Fisheries Commission of NAFO stated that no directed fisheries were to take place on this stock. The TAC has been set at 0 since then.

Catch trends

Catches increased from about 20,000 t in the early 1960s to a peak of 94,000 t in 1967, were relatively stable around 45,000-50,000 t in 1973-82, then declined to 39,000 t in 1984-85 (Table 1, Fig. 1). Catches increased to 65,000 t in 1986 and then declined rapidly thereafter, to about 7400 t in 1994. The catch declined following the moratorium in 1995, but has more than doubled from 637 t in 1995, to 913 t in 1996, to 1407 t in 1997. Most of these catches occurred as by catch in the G. halibut and skate fisheries in the NRA. In 1997, the Canadian catch totalled about 114 t (Table 3).

From 1977 to 1982, the catch was taken almost exclusively by Canadian vessels, but the catch by other nations increased rapidly from less than 2,000 t in 1981-82 to over 30,000 t in 1986 as new fisheries were developed in the Regulatory Area. Catches from these fleets have generally declined in recent years, as has the Canadian catch (Tables 1 and 2), although non-contracting party (NCP) catches in 1993 were an exception to this trend. Considerable doubts have arisen about some nominal catches in the 1985 to 1994 period, resulting in various catch estimates being used. These include surveillance estimates, breakdowns of unspecified flounder catches by S. Korea prior to 1991 based on reported flounder catches, and any other estimates deemed by Scientific Council to be reliable. There is also some uncertainty regarding catches prior to 1973, when large amounts of unspecified flounder catches from some nations were broken down by species based on estimates of species composition. As well, estimates of discards are not available, and are believed to be substantial during some periods.

Canadian research vessel surveys

Spring

Stratified-random surveys have been carried out on the Grand Bank on Canadian research vessels in the spring (April to June period) of each year from 1971 to 1998, with the exception of 1983. The stratification scheme used is shown in Figure 2. The data can be split into 3 time periods, based on the trawl used in each period : 1971-82 was Yankee 36, 1983-95 was Engel 145, and 1996-98 was Campelen 1800 (see McCallum and Walsh (1996) for a description of the various trawls). Conversions exist for the first to second series (Gavaris and Brodie 1984), and from the second to the third (Morgan et al. 1998). However, data from the first series have not been converted to be comparable with the third series. Thus comparable data exist for 1971-95, and for 1984 to 1998.

Engel data

In Div. 3L, the trawlable biomass and abundance indices were highest from 1978-82, then declined to a lower but stable level from 1985 to 1988. From 1989 to 1994, the index declined by at least 38% in each year (Fig. 5). Strata 729-736 in the deep water, which had not been surveyed in this series from 1986 to 1990, accounted for less than 5% of the 1991 estimate. This percentage increased to 52% of the estimate in 1995 (Morgan et al. 1997). In Div. 3N, the biomass index also shows a decline in recent years, with 1992, 1994, and 1995 estimates being the lowest points in the series (Fig. 5). There was a slight increase in the percentage of plaice found in deepwater in 1995 (Morgan et al. 1997). In Div. 3O, the biomass index has shown a consistent decline since 1990 (Fig. 5), with the 1994 and 1995 values being the lowest in the series (Morgan et al. 1997). Most of the trawlable biomass was found in the shallower strata up to 1995.

Figure 4 shows the trends in the trawlable abundance indices and the 95% confidence limits around the abundance estimates, in Div. 3L, 3N, and 3O respectively. In all areas, trends in abundance generally track the biomass trends. The abundance of older fish in the stock declined very rapidly, with the 1995 value for age 9+ abundance being 90% lower than the 1990 value, and about 98% lower than the peak values in 1981-82. In 1994 and 1995, the abundance at each age over 3 years was the lowest ever observed (Table 10).

Campelen Data

Beginning in 1996, the spring survey has been conducted using a Campelen 1800 trawl. The biomass estimates by stratum and depth for 1996-97 in Div. 3L, 3N and 3O are given in Tables 4-6. The biomass indices for Div. 3L, 3N and 3O in 1997 were 13 000, 27 000, and 51 000 t respectively. The value for 3L was down from 31 000 t in 1996, while the values for Div. 3NO were similar to those estimated from the 1996 survey. The biomass in the deepest strata in Div. 3L in 1996 and 1997 accounted for approximately 10% of the estimate, which is in contrast to the results from Div. 3L in 1995 in the last Engel survey. The largest concentration of fish appeared to be in the southwestern area of Div. 3O in both 1996 and 1997 (Fig. 6). The preliminary estimate for Div. 3NO in 1998 (approx. 80 000 tons) is very close to the 1997 survey estimate for these Divisions (Fig. 9).

Table 8 shows the trawlable abundance at age, by Division and for Div. 3LNO combined from the 1997 spring survey. The total abundance in 1997 was 41% lower than the 1996 estimate, although about 70% of the population abundance in both years is made up of fish from the 1990 to 1993 year classes (Table 9). In both years, less than 8% of the population numbers were comprised of fish aged 9 years and older.

Conversion of Engel data to Campelen equivalents

Details of the length-based conversion of Engel data into Campelen equivalents for American plaice from the spring surveys of 1985 to 1995 are contained in Warren et al (1997) and Morgan et al. (1998). Converted biomass estimates were obtained, by Division, then summed for Div. 3LNO combined (Fig. 10). The converted time series shows a sharp drop in biomass from 1988 to 1992, followed by a further decline to 1995. The actual Campelen surveys of 1996 and 1997 gave biomass estimates in the range of those in the 1992-95 converted series, which are 10 to 15% of the converted estimates of biomass from the mid-1980's.

Applying age-length keys to the converted numbers at length from the Engel data of 1985-95 gave estimates of population abundance at age (Table 11). However, in comparing data from the converted Engel surveys (1985-95) with the data from the actual Campelen surveys of 1996-97, caution must be exercised. Because of the methodology used in

applying the length based conversions, there is less reliability associated with the converted estimates of abundance at younger ages. Morgan et al. (1998) suggested that conversions for fish below 20 cm. were likely to be underestimated, resulting in converted estimates of abundance which were very unreliable for ages 1-3, of intermediate reliability for ages 4-5, and of good reliability for ages 6+. Restricting comparisons to ages 6+ shows the 1997 abundance estimate to be just over 10% of values calculated in 1985-88 (Table 11). Further, the Engel estimates from 1985-88 were only about half of the peak 6+ estimates of 1977-81 (Table 10), although as noted previously, direct comparisons of pre-1983 data with post-1995 data from the spring surveys are not possible at present. Morgan (1998) discussed the effects of the Engel to Campelen conversion exercise on estimates of SSB, noting that SSB calculations were lower for the Campelen data, but that differences were usually within 10% (1995 was an exception at 37%).

Fall

Stratified-random surveys have been conducted in Div. 3L in the fall from 1981 to 1997, usually in October-November. From 1990 to 1997, fall surveys were also carried out in Div. 3NO. Surveys from 1983 onward were done with the Engel trawl and starting in fall 1995, a Campelen 1800 trawl was used.

Engel Data

Fig. 3 shows the abundance estimates from the various fall surveys in Div. 3L since 1981 relative to other seasonal surveys in this Division. By 1994, biomass and abundance had declined to very low levels. Fig. 11 shows the declining trend in biomass from Div. 3LNO combined in the period 1990-94. Similar to the spring surveys, the number of older fish declined rapidly between 1990 and 1994, with age 9+ abundance decreasing by 85% in this period (Morgan et al. 1997). The fall surveys in Div 3LNO showed a 75% decrease in abundance from 1990 to 1994 while spring Div 3LNO surveys showed an 80% decrease in abundance over the same time period (Figs 10 & 11).

Campelen Data

The biomass estimates by depth zone and strata for fall 1995 to 1997 in Div. 3L are given in Table 4, for Div. 3N in Table 5, and for Div. 3O in Table 6. The biomass estimate for 1995 and 1996 remained stable in 3L, and declined somewhat in 1997. It should be noted that the Div. 3L estimates for 1996 and 1997 include several new strata in the inshore area, which were added prior to the 1996 survey. In 1997, these strata accounted for about 17% of the total biomass estimate in Div. 3L (Table 4). Also of interest in the 1997 survey in Div. 3L was that 16% of the biomass estimate came from strata in the 732-914 depth range (Table 4); the catches which contributed to this biomass can be seen clearly in the last panel of Fig. 7. In Div. 3N, biomass decreased between 1995 and 1996, then increased in 1997 (Table 5, Fig. 6 & 7). The increase seen in 1997 in the fall survey was not seen in Div. 3N in the spring survey (Table 5). In Div. 3O, biomass decreased from 1996 to 1997, to about the level observed in 1995. Estimates of biomass in Div. 3O from 4 of the 5 Campelen surveys since 1995 (3 fall, 2 spring) have been around 50,000 tons, with the exception being the 75,000 ton estimate in fall 1996 (Table 6). About 53% of the 1996 biomass estimate in Div. 3O came from 2 strata (337, 353 see Fig. 2) on the Southwest Slope area (Fig 7). Overall, the biomass estimate for Div. 3LNO combined was relatively stable from 1995 to 1997 (Fig. 9).

Abundance at age for Div. 3LNO combined in 1996 is given in Table7. As with spring 1996, most of the fish were less than 6 years old with ages 6+ constituting 30% of the population and ages 9+ less than 2%. For Divisions 3LNO combined, the abundance estimate declined by about 22% between 1995 and 1996, and a further 17% from 1996 to 1997 (Table 9). Age readings of A. plaice from the 1997 fall surveys were not available for inclusion in this paper.

Conversion of Engel data to Campelen equivalents

Details of the length-based conversion of Engel data into Campelen equivalents for American plaice from the fall surveys of 1990 to 1994 are contained in Warren et al (1997) and Morgan et al. (1998). Converted biomass estimates were obtained, by Division, then summed for Div. 3LNO combined (Fig. 11). The converted time series shows a sharp drop in biomass from 1990 to 1994, followed by a period of stability at this low level from 1994 to 1997.

Conversion of the length based estimates of abundance into age based ones for the fall surveys showed some discrepancies when compared to the original Engel data, which could not be explained at this time. However, the calculation of biomass estimates from the length based abundance estimates was not affected. Given the discrepancies with the age-based data, neither series of age compositions from the Engel surveys of 1990-94 (actual Engel data and

Campelen equivalents) have been presented here. These discrepancies should be resolved for inclusion in the 1999 assessment of this stock.

Comparison of Spring and Fall Surveys

Comparisons of biomass from the Campelen surveys of 1995-98 can be seen in Fig. 9, which shows that the index of biomass for Div. 3LNO decreased between fall of one year and spring of the next year. However, the fall survey in a given year was always higher than the spring survey of that year (ie. there was not a continuous decrease across all surveys, regardless of season). This pattern is also seen in the 1990-95 surveys using Engel gear (Morgan et al. 1997). This spring to fall increase is seen in Div. 3L during the 1990-96 period but was not consistent before that time (Fig. 3). One possible explanation for this is that more American plaice may be distributed in deeper water, outside the survey area, in spring compared to fall. Since the Campelen trawl was introduced, fall surveys in Div. 3L have been extended to 800 fm (1462 m), with coverage being relatively complete in 1996 and 1997 (Table 4). In these 2 surveys, A.plaice were found in depths to around 900 m, with few in depths beyond that. Coverage in depths beyond 731 m in spring surveys of Div. 3LNO has been minimal, as was coverage beyond this depth in Div. 3NO during fall surveys, therefore no data from these depths in these areas have been presented.

Proportion of Biomass North of 45 Degrees N latitude

To further investigate changes in the biomass and distribution of this stock, biomass indices from the spring surveys were divided into portions north and south of 45 degrees N latitude (Fig. 2). This showed that from 1985 to 1990, about 80-85% of the stock was located north of 45 degrees, most of which was in Div. 3L (Fig.8). With the decline in biomass, this proportion decreased, so that the values from 1993 to 1997 were around 35 to 45%. After an increase between 1995 and 1996, the percentage in 1997 decreased to a value similar to that observed in 1993-95. Distribution maps from both surveys in 1997 (Fig. 6 and 7) as well as those from 1994 to 1996 (Morgan et al. 1996 & 1997) indicate that more of the biomass is in the southern area compared to earlier years, as shown in Brodie et al. (1993).

Age of full recruitment to Canadian RV surveys

The abundance at age matrices (Tables 10 & 11) from the Canadian spring surveys were examined to determine age of full recruitment to the gear. This is defined as the last age up to which a cohort appears to be increasing in successive survey estimates, due to increased catchability by the trawl. In the Engel data (Table 10), this value declined from around age 12-13 in the mid 1970's to age 9 for most years between 1978 and 1987, followed by a further decline since then to values of 5-7 in most surveys in the 1990's (Fig. 12). The same trend is seen in the Campelen data (Table 11), with age of full recruitment to the survey trawl declining from age 8-9 in the mid-1980's to around age 6 in the most recent surveys. These declines are consistent with the pattern of increased mortality and sharply declining stock size in the late 1980's and early 1990's. With the limited amount of data actually collected with a Campelen trawl, it is not possible at present to estimate patterns in the age of full recruitment to this trawl.

Mortality

Estimates of total mortality (Z) from the Engel spring survey data were calculated for a number of age groups (Fig. 13). In general, these data show increases in Z from the mid 1980's onward, with values above 1.0 for the older ages in most years after 1991. Calculating Z values from ages 10+ in year n+1 and ages 9+ in year n, from the same Engel data, shows the same increasing trend (Fig. 14), with 4 of the 5 values from 1991 to 1995 being above 1.0. Much the same picture emerges from the Campelen equivalent data for ages 7+ to 6+ (Fig. 15). The low point in 1996 is questionable, for reasons outlined above in discussing the conversion of the Engel data to Campelen equivalents, as this is calculated from the 1995 *converted* Engel data and the 1996 *actual* Campelen data,. If the surveys provide an accurate measure of these mortality estimates, Z values of 1.0 mean that the annual mortality of the fish in the age groups in the calculation was more than double the target rate ($F_{0.1}$ of 0.26 for fully recruited ages plus assumed M of 0.2) for management of this stock.

Catch to RV Biomass ratio

As a proxy for the exploitation rate on this stock, the ratio of catch to biomass from spring RV surveys was examined. For the Engel data, the ratio was relatively stable around 15% in the late 1970's and early 1980's (Fig. 16a), when both the biomass and catch were fairly stable. The ratio was somewhat higher from 1985-90, then increased to its highest levels (above 25%) from 1991-94. The catch/biomass ratio again dropped to a very low level (below 5%) in 1995, reflective of

the low catch in that year. Although the stock began its steep decline in the mid to late 1980's, when catch/biomass was generally between 0.15 and 0.20, the higher values of this ratio from 1991-94 suggest that catches in that time period were excessive and probably exacerbated the decline (Morgan et al. 1997). Examination of the catch/biomass ratios from Campelen data from 1985 to 1997 (Fig. 16b) does not change the conclusions, although the ratios overall are lower because of the increased biomass in Campelen equivalents (Fig. 10). The Campelen ratios were highest in the 1991-94 period (although the 1994 value is similar to the values calculated for 1985-87), and the most recent values (1995-97) are very low, reflecting a period of reduced catches (Table 1).

Stock-recruitment data

Estimates of recruitment and spawning stock biomass (SSB) were examined from spring survey data and from virtual population analysis (VPA) of this stock in a previous assessment (Brodie et al. 1993). Fig. 17 shows the trends in recruitment from these 2 sources: age 6 from VPA, and a modelled estimate from spring surveys (from Morgan et al. 1997). Although there are some differences in the trends in these two series, it is clear that estimates of recruitment in the 1980's were lower than in the 1970's, and that recent recruitment to this stock has declined to a very low level.

Examination of recruits (model estimate, from surveys) vs. SSB (female, from surveys) in the 1997 assessment (Morgan et al. 1997) showed that the highest recruitment estimates were from SSB in the middle of the observed range, while 3 of the 4 lowest recruitment estimates were produced from the lowest observed SSB's. There appeared to be temporal trends in the data with high recruitment arising from a range of SSB in the mid to late 1970's and very low recruitment every year since 1987, despite a range of SSB from 11 000 to 150 000 t (Morgan et al. 1997). In any case, survey estimates up to 1995 and VPA estimates up to 1992 indicated that SSB was at a very low level relative to historic levels in each time series (Fig. 18). Estimates of total biomass and abundance from surveys since 1995 suggest that SSB probably has not increased from this low level.

EU-Spain Surveys

In spring 1995 to 1998, bottom trawl surveys were conducted by EU-Spain in the NAFO Regulatory Area of 3NO. The biomass index of A. plaice in commonly surveyed strata showed a large increase between the 1995 and 1996 surveys, and a decrease in 1997 of about the same magnitude as the increase between 1995 and 1996 (Paz et al. 1997). The 1998 survey showed a large increase, to the highest value in the 4-year series. About 41% of the biomass in the 1998 survey was in stratum 360 (Fig. 2) in Div. 3N (Duran et al. 1998).

Assessment

The Canadian spring and fall surveys show a large decline in abundance and biomass from the mid to late 1980's until 1995. Conversion of the Engel data to Campelen equivalents also shows this large decline. Recent surveys indicate the biomass to be stable at this low level, but that the abundance may still be declining. Most of the biomass of the stock is now located in the southern part of the Grand Bank, contrary to the pattern seen in the 1970's and 1980's. The EU-Spanish surveys in the Regulatory Area of Div. 3NO showed a large increase from 1995 to 1996, a large decrease from 1996 to 1997, and another large increase from 1997 to 1998. Currently the stock is composed mainly of fish aged 7 years or less, although there were no good year classes between 1987 and 1993. The fate of year classes since then remains to be determined. The most recent estimates of SSB are far below average. Most of the indicators evaluated suggest that the stock remains low, relative to historic values of these indices.

The actual biomass level for this stock, while likely to be far below historic values, is not known. VPA has not been used in the assessment of this stock since 1993, due mainly to lack of data for estimation of catch and catch at age, as well as with model formulation (Brodie et al. 1994). Depending on the trawl used for research surveys, and the season in which the survey is conducted, very different estimates of biomass can be obtained. Surveys conducted by Canada with Engel, Campelen, and Yankee trawls in the past few years gave very different results when compared among gears types, and with surveys conducted by EU-Spain with a Pedreira trawl. Despite comparative fishing experiments to link some of these data series, comparisons are not without difficulties, as noted above. With no VPA at present, no current estimates of the catchabilities from these surveys are available, and there are no recent CPUE data from commercial fisheries to compare with the survey data or the historic CPUE data. Thus there remains a considerable amount of uncertainty in evaluating the recent estimates of trawlable biomass from surveys as absolute measures of the biomass of this stock. Regardless of the actual stock size at present, there can be little doubt that it has decreased substantially since the late 1980's, and has shown no signs of increase since the moratorium was imposed in 1995.

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Table 1. Nominal catches (t) of American plaice for NAFO Divisions 3LNO, 1960-97 and TACs from 1973 to 1998.

Year	Canada	France	Poland	USSR	South Korea[a]	Other	Total	TAC
1960	21,352	2,106	-	569	-	20	24,047	-
1961	14,903	1,473	286	1,248	-	3	17,913	-
1962	15,217	973	171	1,841	-	4	18,206	-
1963	24,591	93	457	466	-	112	25,719	-
1964	35,474	1,582	539	680	-	292	38,567	-
1965	45,365	2,056	977	4,544	-	319	53,261	-
1966	51,225	1,246	860	11,484	-	196	65,011	-
1967	54,190	1,326	3,234	35,139	-	524	94,413	-
1968	48,674	406	203	23,751	-	133	73,167	-
1969	64,815	43	34	14,493	-	52	79,437	-
1970	54,929	389	40	10,232	-	1,055	66,645	-
1971	49,394	323	370	17,173	-	628	67,888	-
1972	41,605	322	2,515	14,164	-	755	59,361	-
1973	38,586	310	1,116	12,516	-	315	52,843	60,000
1974	35,101	418	615	10,074	-	89	46,297	60,000
1975	34,015	442	537	7,682	-	545	43,221	60,000
1976	47,806	305	5	3,280	-	429	51,825	47,000
1977	42,579	31	-	1,023	-	348	43,981	47,000
1978	48,634	168	-	1,048	-	178	50,028	47,000
1979	47,131	113	-	1,190	-	135	48,569	47,000
1980	48,296	183	-	336	-	271	49,086	47,000
1981	48,177	210	-	847	-	924	50,158	55,000
1982	49,620	133	-	67	715	517	51,052	55,000
1983	35,907	41	-	170	815	1,602	38,535	55,000
1984	33,756	140	1	360	1,582	3,606[b]	39,445	55,000
1985	40,024	-	4	81	2,483	11,620[b]	54,212	49,000
1986	33,409	46	-	188	3,952	26,975[b]	64,570	55,000
1987	33,967	17	-	47	2,741	18,240	55,012	48,000
1988	26,832	-	-	159	2,522	11,322[b]	40,835	33,585[d]
1989	27,901	92	-	6	725	14,645[b]	43,369	30,300
1990	22,600	-	-	17	1,117	8,767[b]	32,501	24,900
1991	23,240[a]	-	-	60	1,910	9,471[b]	34,681	25,800
1992	10,231[a]	-	-	50	518	2,551[b]	13,350	25,800
1993[c]	7,454	-	-	8	13	9,659[b]	17,122	10,500
1994[e]	71	-	-	-	100	7,207[b]	7,378	4,800[f]
1995[e]	59	-	-	-	-	578[b]	637	0
1996[e]	59	-	-	-	-	854[b]	913	0
1997[e]	114	-	-	-	-	1,293[b]	1407	0
1998								0

[a]Includes a portion of catches reported as unspecified flounder.
[b]Includes some catches estimated from surveillance reports.
[c]Catch may have been as high as 19,400.
[d]Effective TAC.
[e]Provisional.
[f]No directed fishing.

Table 2. Breakdown of catches from Table 1 listed as "other" for 1984-97.

			Other				
Year	Spain	Portugal	Panama[b]	USA	Caymen Islands	Misc.[a]	Total
1984	1,622	-	1,800	-	-	184	3,606
1985	5,498	27	3,892	1,310	797	96	11,620
1986	11,882	9,240	3,756	1,506	572	19	26,975
1987	14,476	2,516	-	1,248	-	-	18,240
1988	8,956	872	-	1,379	-	115	11,322
1989	10,909	583	-	1,134	-	2,019	14,645
1990	294	356	-	8	-	8,109	8,767
1991	786	187	-	-	-	8,498	9,471
1992	412	139	-	-	-	2,000	2,551
1993	199	92	-	-	-	9,368	9,659
1994	5,476	630	-	575	-	526	7,207
1995	430	148	-	-	-	-	578
1996	554	263	-	-	-	37	854
1997	951	336	-	-	-	6	1,293

[a]Countries not in Tables 1 or 2, or catches include some estimates.
[b]Not reported to NAFO. Catches estimated from surveillance reports.

Table 3. Catch of American plaice in Div. 3LNO in 1997.

	3L	3N	3O	Total
Canada	11	34	69	114
Japan	6			6
Portugal	55	188	93	336
Spain	236	649	66	951
Total	**308**	**871**	**228**	**1407**

Table 4. Biomass estimates ('000t) of A.plaice, by stratum and depth zone (m), from Canadian surveys in Div. 3L in 1995-97 (Campelen). (+) indicates biomass <50 t, (-) means stratum not surveyed.

		Biomass								Biomass					
Depth	Stratum	Fall 1995	Spring 1996	Fall 1996	Spring 1997	Fall 1997		Depth	Stratum	Fall 1995	Spring 1996	Fall 1996	Spring 1997	Fall 1997
30-56	784	-	-	+	-	+		184-366	789	-	-	0.2	-	0.2
									791	-	-	0.5	-	0.4
	Total	-	-	+	-	+			795	-	-	-	-	0.2
									798	-	-	0.2	-	0.7
57-92	350	0.8	0.6	0.9	0.3	0.5								
	363	3.1	2.3	2	0.8	1.4			Total	-	-	0.9	-	1.5
	371	1.2	0.9	1.1	0.2	0.2								
	372	1.4	1.4	1.6	0.8	1.5		367-549	729	+	0.2	+	0.6	0.2
	384	1.6	0.7	1.6	0.9	0.5			731	0.2	0.5	-	0.1	0.6
	785	-	-	+	-	+			733	0.2	0.7	0.2	0.0	0.5
									735	0.7	1.4	0.7	1.6	0.3
	Total	8.1	5.9	7.2	3.0	4.0								
									Total	1.1	2.8	0.9	2.4	0.8
93-183	328	3.0	0.5	1.6	0.5	0.9								
	341	1.6	1.8	2.8	0.5	0.8		550-731	730	+	+	0	0.0	0.5
	342	0.6	0.1	+	0.1	0.4			732	+	+	+	0.0	1.3
	343	0.7	0.3	0.1	0.0	0.0			734	0	+	0.2	0.0	0.3
	348	3.1	1.4	1.8	0.8	1.3			736	0.2	+	0.5	0.1	0.8
	349	3.4	0.8	1.4	0.3	1.5								
	364	2.8	2	3.6	1.0	2.8			Total	0.2	0.1	0.7	0.1	2.8
	365	1.7	1.1	1.1	0.5	1.0								
	370	2.0	1.3	6.3	0.6	1.3		732-914	737	0.4	-	1.5	-	1.8
	385	3.9	5.6	7.6	0.9	1.9			741	-	-	1.0	-	2.3
	390	1.7	0.6	1.6	0.4	2.2			745	-	-	0.1	-	2.2
	786	-	-	0.3	-	0.1			748	-	-	1.4	-	0.7
	787	-	-	0.4	-	0.5								
	788	-	-	0.3	-	0.3			Total	0.4	-	4.0	-	7.0
	790	-	-	0.2	-	0.2								
	793	-	-	0.1	-	0.1		915-1097	738	0.6	-	0.2	-	0.0
	794	-	-	+	-	0.1			742	-	-	0.1	-	0.0
	797	-	-	0.1	-	0.1			746	-	-	0.1	-	0.0
	799	-	-	0.1	-	0.1			749	-	-	+	-	0.2
	Total	24.5	15.5	29.4	5.5	15.6			Total	0.6	-	0.4	-	0.2
184-274	344	1.0	1	1.1	0.3	0.1		1098-1280	739	-	-	0.0	-	0.0
	347	1.8	0.6	0.7	0.2	0.3			743	-	-	0.0	-	0.0
	366	1.6	0.4	1.2	0.3	0.5			747	-	-	0.0	-	0.0
	369	1.0	0.3	1.6	0.2	0.5			750	-	-	0.1	-	0.0
	386	1.8	0.5	2.6	0.2	1.0								
	389	0.6	0.4	0.6	0.2	0.6			Total	-	-	0.1	-	0.0
	391	0.4	0.3	0.2	0.1	0.2								
	789	-	-	-	-	0.2		1281-1463	740	-	-	0.0	-	0.0
	791	-	-	-	-	0.4			744	-	-	0.5	-	0.0
	795	-	-	+	-	0.2			751	-	-	0.0	-	0.0
	798	-	-	-	-	0.7								
									Total	-	-	0.5	-	0.0
	Total	8.2	3.5	8.0	1.5	4.6								
								Grand Total		50.9	30.7	57.5	13.8	44.0
275-366	345	4.1	0.5	2.4	0.2	0.8								
	346	2.8	0.4	1.1	0.3	2.2								
	368	0.2	0.3	0.3	0.0	0.2								
	387	0.4	0.6	0.7	0.6	0.7								
	388	0.3	0.6	0.1	0.2	0.4								
	392	+	0.5	+	0.1	0.2								
	792	-	-	0.2	-	1.9								
	796	-	-	0.6	-	0.9								
	Total	7.8	2.9	5.4	1.4	7.4								

Table 5. Biomass estimates ('000t) of A.plaice, by stratum and depth zone (m), from Canadian surveys in Div. 3N in 1995-97 (Campelen). (+) indicates biomass <50 t, (-) means stratum not surveyed.

		Biomass				
Depth	Stratum	Fall 1995	Spring 1996	Fall 1996	Spring 1997	Fall 1997
≤ 56	375	1.9	2.9	1.1	2.2	3.9
	376	4.7	0.8	2.4	1.8	7.7
	Total	6.6	3.7	3.5	4.0	11.6
57-92	360	22.3	8.8	7.4	8.6	28.4
	361	3.5	3.8	4.1	1.9	3.3
	362	5.0	2.8	1.1	5.5	5.1
	373	1.8	1.6	0.2	0.5	2.3
	374	2.4	1.1	0.4	0.4	1.8
	383	-	0.5	0.3	0.1	0.5
	Total	35.0	18.6	13.5	17.0	41.4
93-183	359	2.2	1.1	0.3	1.1	3.8
	377	0.5	0.2	0.4	0.1	2.3
	382	0.3	0.1	0.3	0.1	0.8
	Total	3.0	1.4	1.0	1.3	6.9
184-274	358	0.8	0.1	0.2	0.1	0.4
	378	0.1	0.1	0.2	0.2	0.1
	381	0.1	0.3	0.4	0.1	0.2
	Total	1.0	0.5	0.8	0.4	0.7
275-366	357	0.1	0.1	0.1	0.1	0.0
	379	+	+	0.2	0.1	0.1
	380	0.1	0.2	0.2	0.8	0.1
	Total	0.2	0.3	0.5	1.0	0.2
367-549	723	+	0.2	+	0.4	0.0
	725	0.1	0.1	0.1	0.5	0.0
	727	+	0.5	0.1	2.2	0.1
	Total	0.1	0.8	0.2	3.1	0.2
550-731	724	0.1	0.2	0.3	0.5	0.0
	726	+	+	0.3	0.1	0.1
	728	+	0.5	0.8	-	0.1
	Total	0.1	0.7	1.4	0.5	0.2
Grand Total		46.0	26.0	20.9	27.0	61.0

Table 6. Biomass estimates ('000t) of A.plaice, by stratum and depth zone (m), from Canadian surveys in Div. 3O in 1995-97 (Campelen). (+) indicates biomass <50 t, (-) means stratum not surveyed.

		Biomass				
Depth	Stratum	Fall 1995	Spring 1996	Fall 1996	Spring 1997	Fall 1997
57-92	330	7.7	3.8	0.8	0.8	5.5
	331	1.2	1.4	0.3	0.3	0.9
	338	6.6	6.0	3.3	5.7	6.4
	340	7.2	2.2	0.4	1.7	3.2
	351	1.7	2.9	0.9	4.4	5.2
	352	4.6	9.1	9.1	13.8	6.9
	353	5.6	7.8	14.4	8.3	14.8
	Total	34.6	33.2	29.2	34.9	42.9
93-183	329	3.2	1.6	1.5	1.4	2.7
	332	3.5	3.9	3.9	2.5	1.6
	337	2.4	4.6	25.3	1.9	2.5
	339	6.5	1.4	0.9	0.8	5.1
	354	4.5	1.6	8.0	1.1	2.4
	Total	20.1	13.1	39.6	7.8	14.4
184-274	333	+	+	-	0.3	+
	336	+	0.2	0.1	0.3	0.1
	355	0.2	0.5	5.4	0.3	0.1
	Total	0.2	0.7	5.5	0.9	0.2
275-366	334	0.0	0.2	-	0.8	+
	335	+	0.2	+	0.2	+
	356	0.0	0.1	0.1	+	+
	Total	+	0.5	0.1	1.0	0.1
367-549	717	0.0	0.2	-	1.7	+
	719	+	0.1	0.2	0.5	0.0
	721	+	0.2	0.6	0.1	0.0
	Total	+	0.5	0.8	2.2	+
550-731	718	0.0	+	-	0.1	0.0
	720	0.0	+	+	0.1	-
	722	0.0	1.0	+	4.2	0.0
	Total	0.0	1.0	+	4.4	0.0
Grand Total		54.9	49.0	75.2	51.2	57.6

Table 7. Abundance (000) at age from fall survey in Div. 3LNO in 1996.

Age	3L	3N	3O	3LNO
0	-	-	-	-
1	1,124	114	2,278	3,516
2	16,615	1,698	80,150	98,463
3	57,938	4,081	74,468	136,487
4	170,156	3,314	54,271	227,741
5	149,436	9,341	49,516	208,293
6	84,668	13,601	75,810	174,079
7	31,851	12,651	37,699	82,201
8	6,043	4,548	10,774	21,365
9	2,461	1,822	4,537	8,820
10	827	793	1,457	3,077
11	139	356	1,286	1,781
12	62	268	257	587
13	48	-	50	98
14	-	-	116	116
15	-	63	284	347
16	-	-	-	-
17	-	-	-	-
	521,368	52,650	392,953	966,971

Table 8. Abundance (000) at age from spring survey in Div. 3LNO in 1997.

Age	3L	3N	3O	3LNO
0	-	-	-	-
1	-	-	80	80
2	630	152	5,788	6,570
3	5,438	1,514	33,350	40,302
4	14,039	4,278	36,803	55,120
5	31,696	5,459	28,123	65,278
6	26,574	16,840	40,988	84,402
7	14,580	24,415	40,316	79,311
8	6,832	15,659	26,227	48,718
9	2,422	5,920	10,602	18,944
10	688	1,702	3,657	6,047
11	392	862	1,424	2,678
12	87	515	1,217	1,819
13	21	202	339	562
14	-	35	139	174
15	-	35	127	162
16	-	-	127	127
17	-	-	-	-
	103,399	77,588	229,307	410,294

Table 9. Abundance (millions) at age from Campelen surveys in Div. 3LNO.

Age	Fall 95	Fall 96	Fall 97	Spring 96	Spring 97
0		0.0			
1	33.1	3.5		0.4	0.1
2	203.6	98.5		50.4	6.6
3	127.4	136.5		122.8	40.3
4	125.6	227.7		117.2	55.1
5	238.4	208.3		125.2	65.3
6	263.1	174.1		127.7	84.4
7	127.9	82.2		92.0	79.3
8	63.6	21.4		36.9	48.7
9	42.8	8.8		16.5	18.9
10	13.0	3.1		4.6	6.0
11	2.3	1.8		1.9	2.7
12	1.3	0.6		2.1	1.8
13	0.5	0.1		0.9	0.6
14	0.2	0.1		0.2	0.2
15	0.1	0.3		0.3	0.2
16	0.0	0.0		0.0	0.1
17	0.0	0.0		0.0	0.0
18	0.0	0.0		0.0	0.0
1+	1242.9	967.0	797.9	699.1	410.3
6+	514.8	292.5		283.1	242.9
9+	60.2	14.8		26.5	30.5

Table 10 . Abundance index (millions) of A.plaice from spring surveys in Div. 3LNO (Engel data).

Age\Year	73	75	76	77	78	79	80	81	82	84	85	86	87	88	89	90	91	92	93	94	95
1	0.10	0	0.20	0.00	0.10	0.40	0.20	0.68	0.40	0.00	0.10	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1.36	1.6	0.87	0.79	1.19	1.70	2.19	3.85	1.40	0.21	0.10	0.30	1.50	0.50	0.40	0.30	0.12	0.30	0.12	0.00	0.00
3	10.49	9.43	12.91	5.87	17.36	6.71	6.98	20.97	6.31	1.12	2.70	1.60	5.42	4.22	4.79	2.32	1.71	1.80	0.49	0.14	0.14
4	14.57	18.78	23.59	29.84	34.04	25.53	14.75	19.77	20.13	3.40	11.19	6.80	13.03	11.65	26.05	19.57	4.84	3.40	7.81	1.20	0.83
5	57.67	25.96	39.41	77.06	112.00	71.17	50.65	39.46	22.33	9.99	22.09	17.49	28.52	27.46	26.42	48.32	27.12	7.00	10.82	7.60	4.80
6	71.88	46.57	50.47	136.61	144.25	111.41	99.01	82.72	44.13	35.86	45.49	55.49	74.18	69.38	68.52	35.60	39.74	19.30	19.36	13.10	9.20
7	95.05	87.05	94.28	196.39	197.83	171.78	173.45	156.98	80.93	94.34	103.90	120.10	147.07	121.72	98.67	60.14	30.47	23.90	28.05	17.40	11.60
8	59.72	114.25	174.51	249.01	224.93	240.32	271.24	311.17	162.65	135.54	125.70	113.20	152.15	121.62	105.80	63.22	30.89	18.10	27.38	15.80	13.20
9	47.21	119.22	172.69	188.81	163.71	186.35	218.82	295.18	228.15	141.76	94.11	93.00	92.16	106.50	84.50	59.33	29.37	14.80	14.35	9.50	9.30
10	59.59	104.9	172.08	179.14	130.87	156.82	141.46	173.23	184.42	93.33	71.91	52.80	55.23	46.46	37.62	40.65	18.47	9.20	8.67	2.99	3.55
11	51.70	60.6	107.74	85.87	47.53	76.15	64.60	83.93	105.71	42.85	44.60	25.10	22.81	26.63	19.96	17.80	12.21	5.10	4.12	2.11	1.22
12	43.35	42.65	68.21	57.50	32.74	35.93	40.97	37.65	49.71	26.93	24.20	18.80	18.41	17.72	14.03	11.68	7.36	2.90	2.27	0.75	0.33
13	24.86	23.31	36.23	24.56	15.78	13.51	20.74	16.75	25.20	12.42	12.40	11.80	10.81	10.22	8.42	7.65	4.03	1.70	0.97	0.63	0.05
14	15.75	13.15	13.45	10.87	9.43	7.71	8.48	6.76	13.01	7.60	7.70	4.90	6.00	6.51	5.11	4.74	3.02	0.90	0.72	0.53	0.02
15	7.55	7.48	11.62	7.48	4.56	5.11	5.78	6.00	5.10	5.40	5.30	3.90	4.40	4.21	4.60	3.33	2.12	1.30	0.37	0.27	0.00
16	4.75	4.41	6.01	4.19	2.18	2.80	4.59	3.83	4.10	3.57	2.60	2.10	2.30	2.60	2.20	2.32	1.31	0.90	0.45	0.14	0.00
17	2.56	1.15	4.17	1.70	0.99	1.10	1.99	2.25	2.50	1.79	0.60	1.10	1.00	0.90	1.30	1.41	0.71	0.10	0.31	0.00	0.00
18	2.36	0.38	0.97	1.10	0.40	0.30	0.80	0.69	0.70	0.69	0.20	0.30	0.60	0.50	0.50	0.51	0.32	0.30	0.08	0.00	0.00
19	0.48	0.09	0.59	0.20	0.10	0.20	0.30	0.10	0.10	0.19	0.10	0.20	0.20	0.20	0.10	0.10	0.20	0.10	0.06	0.00	0.00
1+	571.0	681.0	990.0	1257.0	1140.0	1115.0	1127.0	1262.0	957.0	617.0	575.0	529.0	636.0	579.0	509.0	379.0	214.0	111.1	126.4	72.2	54.2
6+	486.8	625.2	913.0	1143.4	975.3	1009.5	1052.2	1177.2	906.4	602.3	538.8	502.8	587.3	535.2	451.3	308.5	180.2	98.6	107.2	63.2	48.5
9+	260.2	377.3	593.8	561.4	408.3	486.0	508.5	626.4	618.7	336.5	263.7	214.0	213.9	222.5	178.3	149.5	79.1	37.3	32.4	16.9	14.5
12+	101.7	92.6	141.3	107.6	66.2	66.7	83.7	74.0	100.4	58.6	53.1	43.1	43.7	42.9	36.3	31.7	19.1	8.2	5.2	2.3	0.4
pct9+	0.46	0.55	0.60	0.45	0.36	0.44	0.45	0.50	0.65	0.55	0.46	0.40	0.34	0.38	0.35	0.39	0.37	0.34	0.26	0.23	0.27
pct12+	0.18	0.14	0.14	0.09	0.06	0.06	0.07	0.06	0.10	0.09	0.09	0.08	0.07	0.07	0.07	0.08	0.09	0.07	0.04	0.03	0.01

Table 11 . Abundance (000) at age, A.plaice in Div. 3LNO. Spring survey data, converted into Campelen equivalents 1985-95.

Year													
Age (yrs)	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.3	0.0	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.1
2	2.3	4.4	27.9	8.5	6.2	9.7	1.7	4.5	2.4	0.0	0.0	50.4	6.6
3	50.2	31.3	100.7	80.4	86.8	45.5	30.6	33.5	9.5	2.5	2.0	122.8	40.3
4	159.0	109.8	221.6	191.3	445.1	348.3	84.1	59.8	120.5	21.1	11.1	117.2	55.1
5	263.8	256.0	460.2	368.6	336.1	618.7	398.2	110.3	138.1	99.2	41.9	125.2	65.3
6	454.6	561.4	747.5	616.6	551.8	377.9	364.2	190.1	180.1	106.0	57.5	127.7	84.4
7	595.7	577.2	656.2	543.9	470.2	371.0	180.2	150.9	160.1	85.4	59.9	92.0	79.3
8	389.8	307.1	398.3	315.0	273.7	200.3	112.9	63.4	89.4	43.3	49.9	36.9	48.7
9	208.0	193.7	184.6	217.8	187.6	130.5	67.5	34.1	32.2	20.0	27.5	16.5	18.9
10	140.2	98.1	101.1	85.3	74.7	77.5	35.2	17.5	16.5	5.4	8.3	4.6	6.0
11	84.3	46.0	41.8	48.6	39.8	32.4	22.3	9.4	7.6	4.0	2.7	1.9	2.7
12	45.2	34.4	33.8	32.6	27.1	21.5	13.4	5.4	4.3	1.4	0.5	2.1	1.8
13	22.7	21.7	19.9	18.7	16.8	14.4	7.2	3.3	1.8	1.2	0.1	0.9	0.6
14	14.0	8.9	11.1	12.0	9.7	8.8	5.5	1.8	1.3	1.0	0.0	0.2	0.2
15	9.5	7.3	8.9	8.7	8.6	7.0	5.5	3.0	1.5	0.5	0.0	0.3	0.2
16	4.2	3.8	4.2	4.8	4.0	4.2	2.2	1.6	0.8	0.3	0.0	0.0	0.1
17	0.9	2.1	1.9	1.6	2.5	2.6	1.3	0.3	0.6	0.0	0.0	0.0	0.0
18	0.1	0.6	0.9	0.8	0.9	0.9	0.7	0.5	0.1	0.0	0.0	0.0	0.0
19	0.0	0.1	0.2	0.1	0.2	0.3	0.3	0.1	0.1	0.0	0.0	0.0	0.0
20	0.3	0.0	0.0	0.0	0.0	0.1	0.3	0.2	0.1	0.0	0.0	0.0	0.0
unknown	0.4	0.5	0.0	0.0	0.3	2.5	1.1	0.7	0.4	0.0	0.0	0.0	0.0
Ages 1+	2445.4	2264.3	3021.4	2555.3	2542.1	2274.3	1334.4	690.6	767.5	391.3	261.5	699.1	410.3
Ages 6+	1969.8	1862.7	2210.6	1906.6	1667.8	1251.8	819.7	482.4	497.0	268.4	206.5	283.1	242.9
Ages 9+	529.8	417.1	408.6	431.1	372.2	302.6	162.4	78.0	67.4	33.8	39.2	26.5	30.5
Ages 12+	97.3	79.4	81.0	79.3	70.0	62.2	37.4	16.9	11.0	4.4	0.7	3.5	2.9

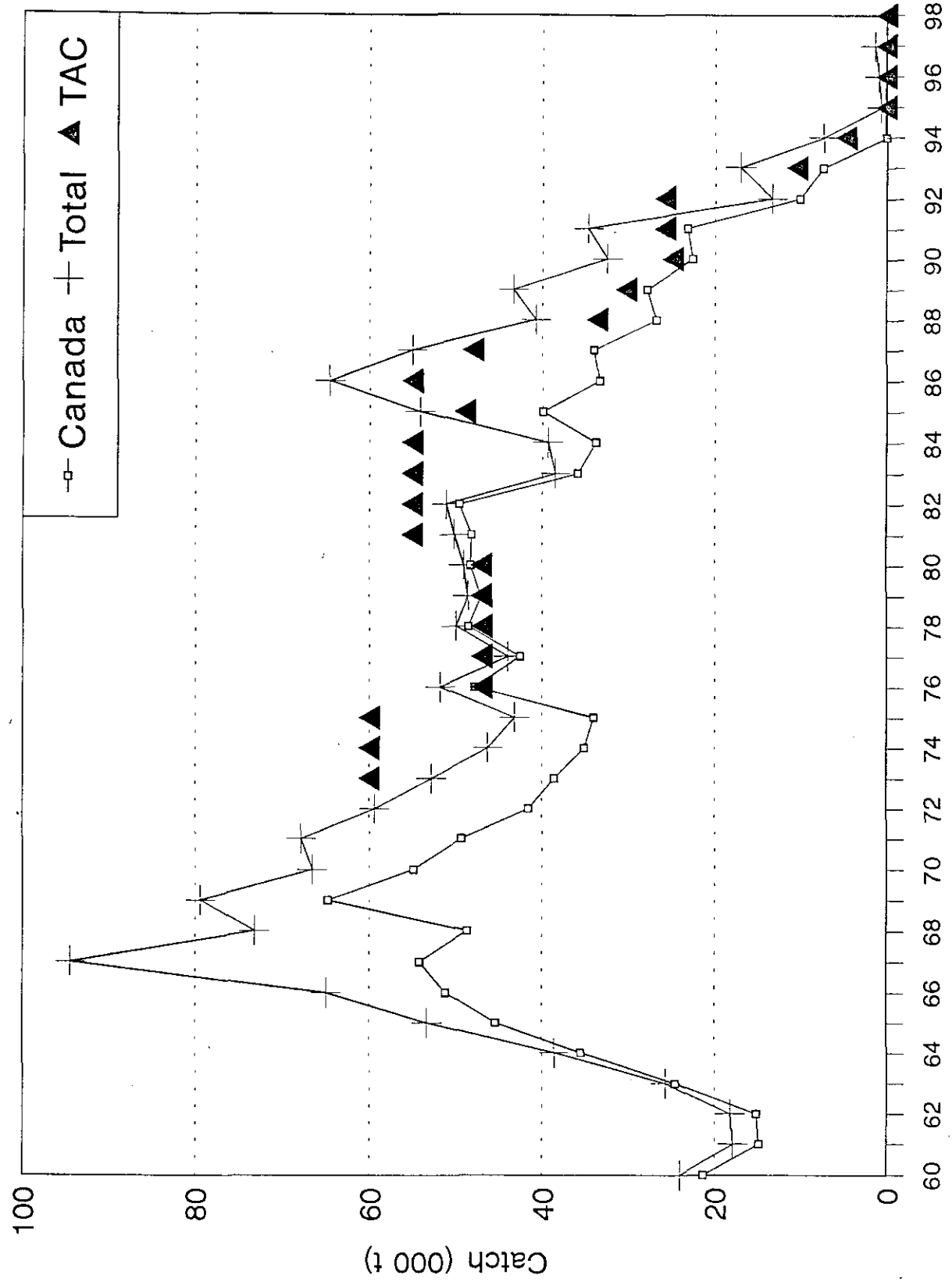

Fig. 1. Catches and TAC's of American plaice in Div. 3LNO.

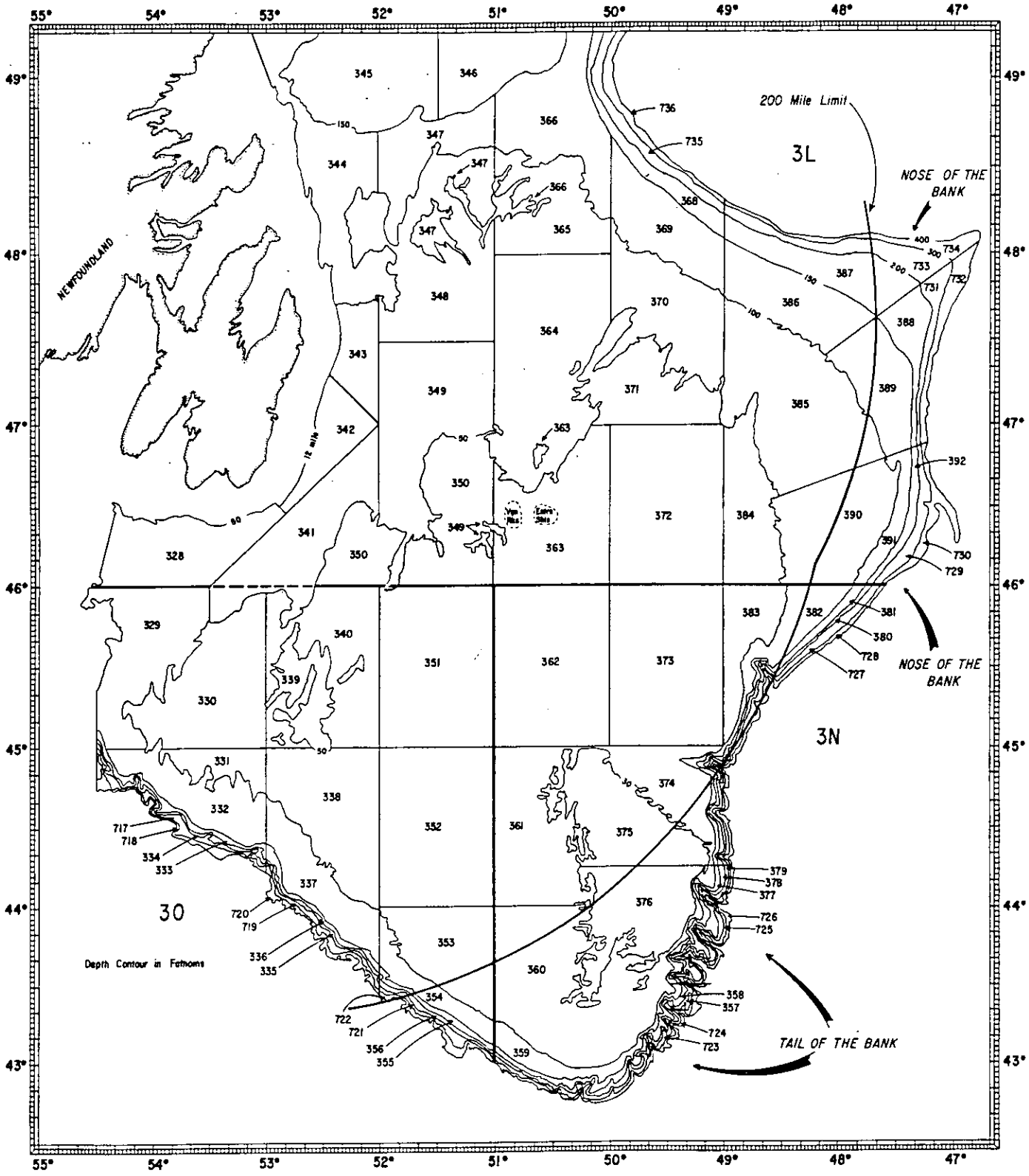

Fig. 2. Map of the Grand Bank, NAFO Div. 3LNO, showing stratification scheme used in groundfish surveys. Not shown are new strata added in inshore areas of Div. 3L, and strata deeper than 731 m.

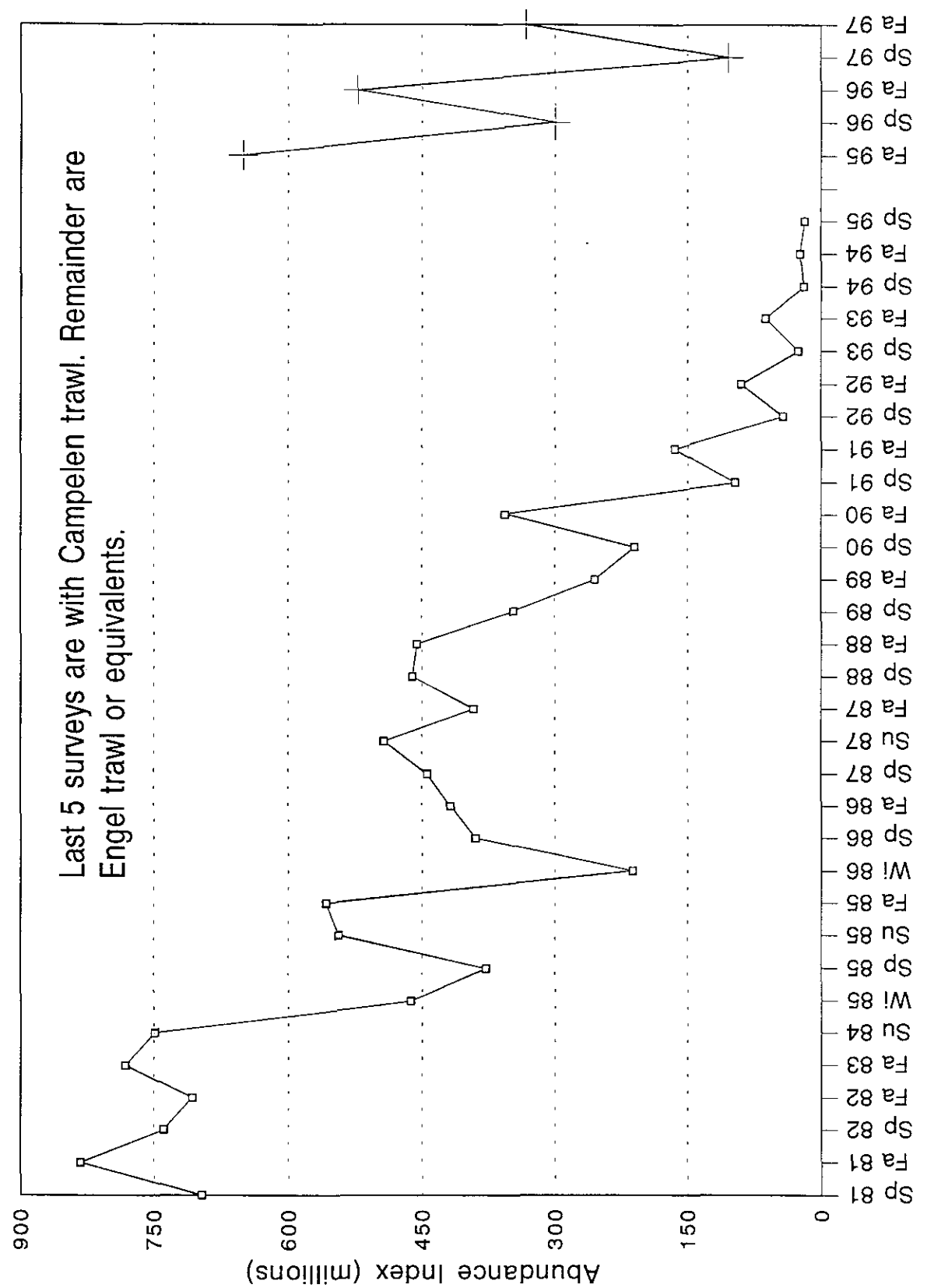

Fig. 3. Abundance of A. plaice from surveys conducted at various times during 1981-97 in Div. 3L.

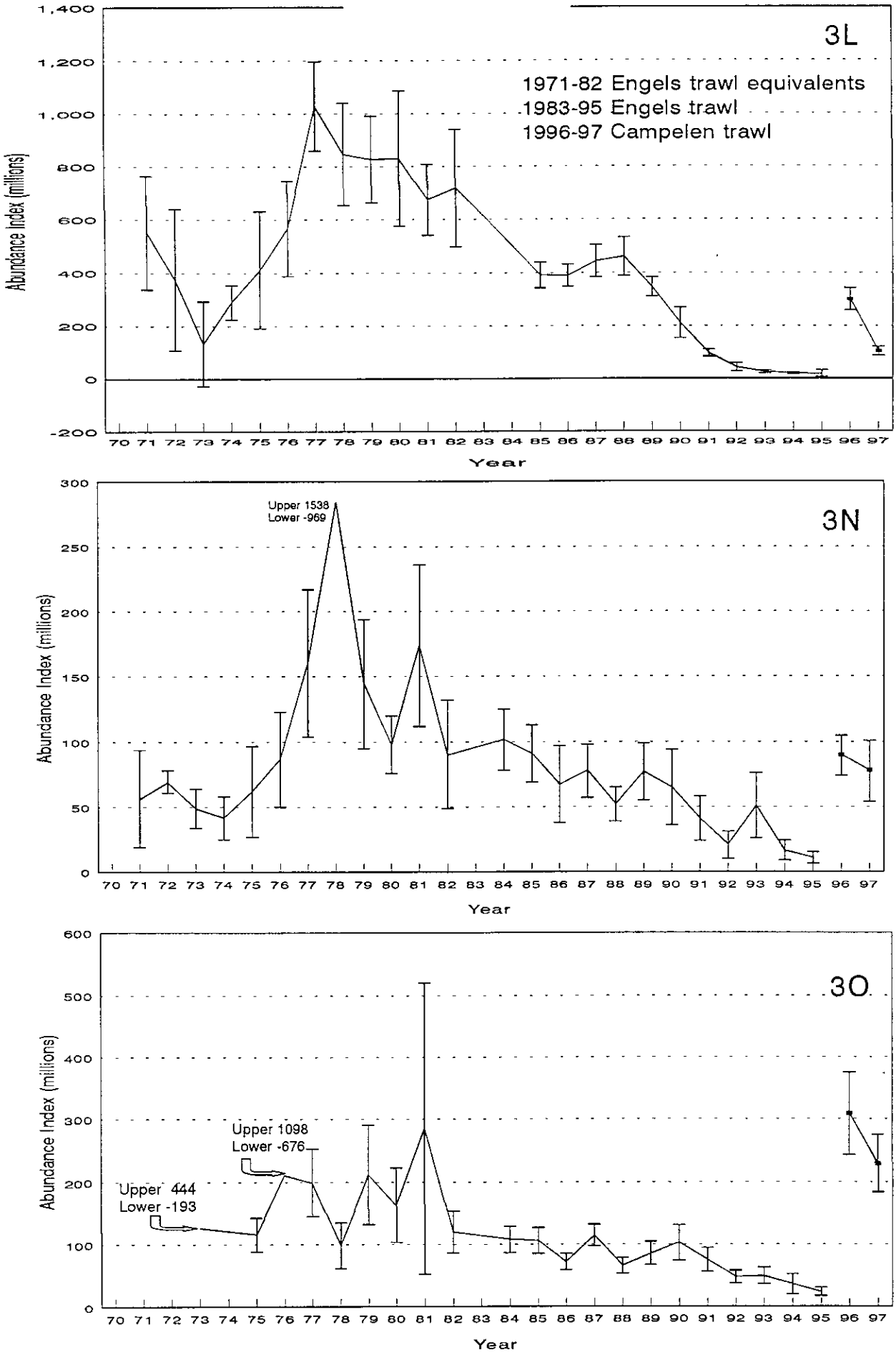

Fig. 4. Abundance estimates of A.plaice (with approx. 95% C.I.) from Canadian spring surveys in Div. 3L, 3N, and 3O.

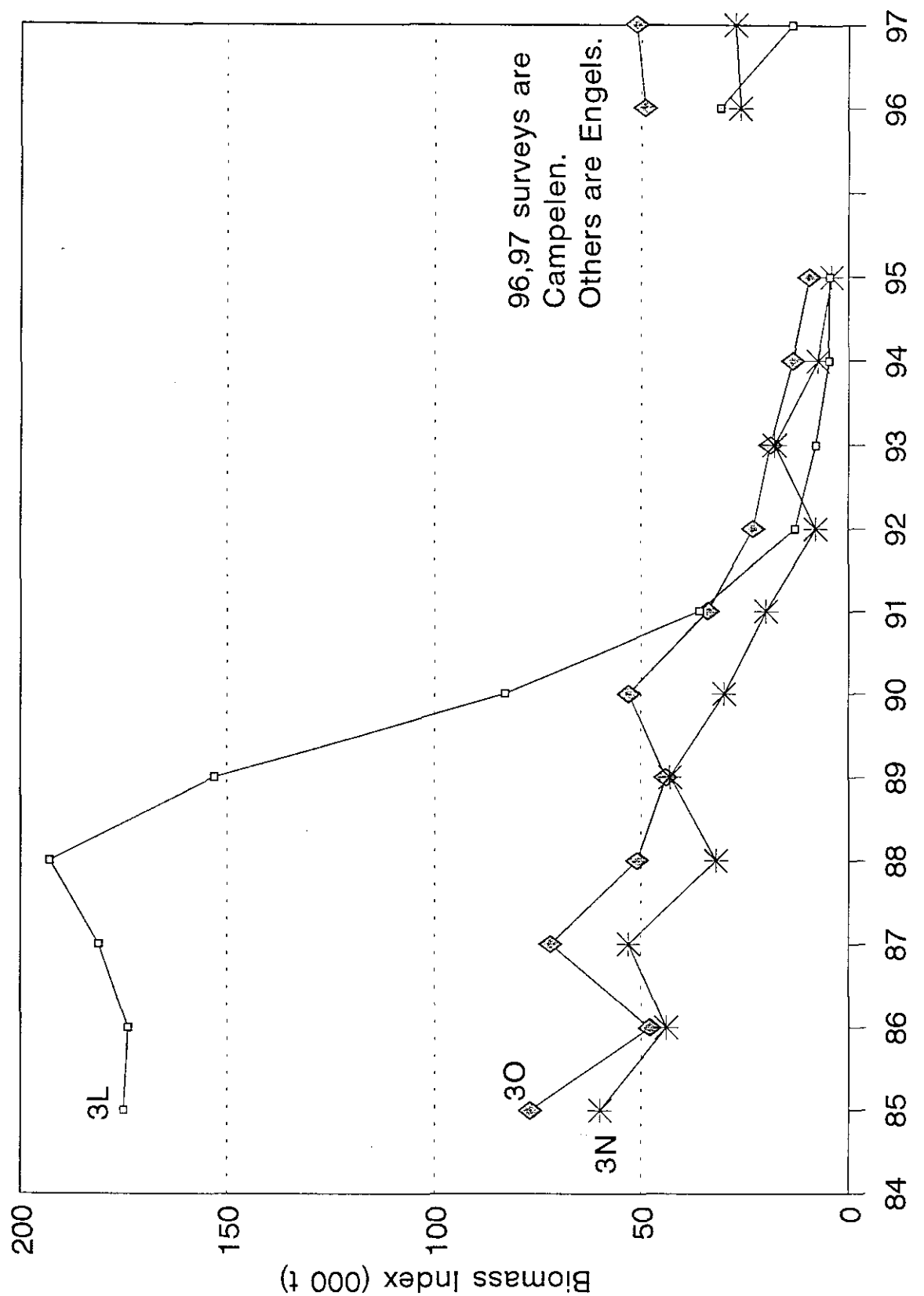

Fig. 5. Biomass indices of A.plaice from spring surveys in Divisions 3L, 3N, 3O.

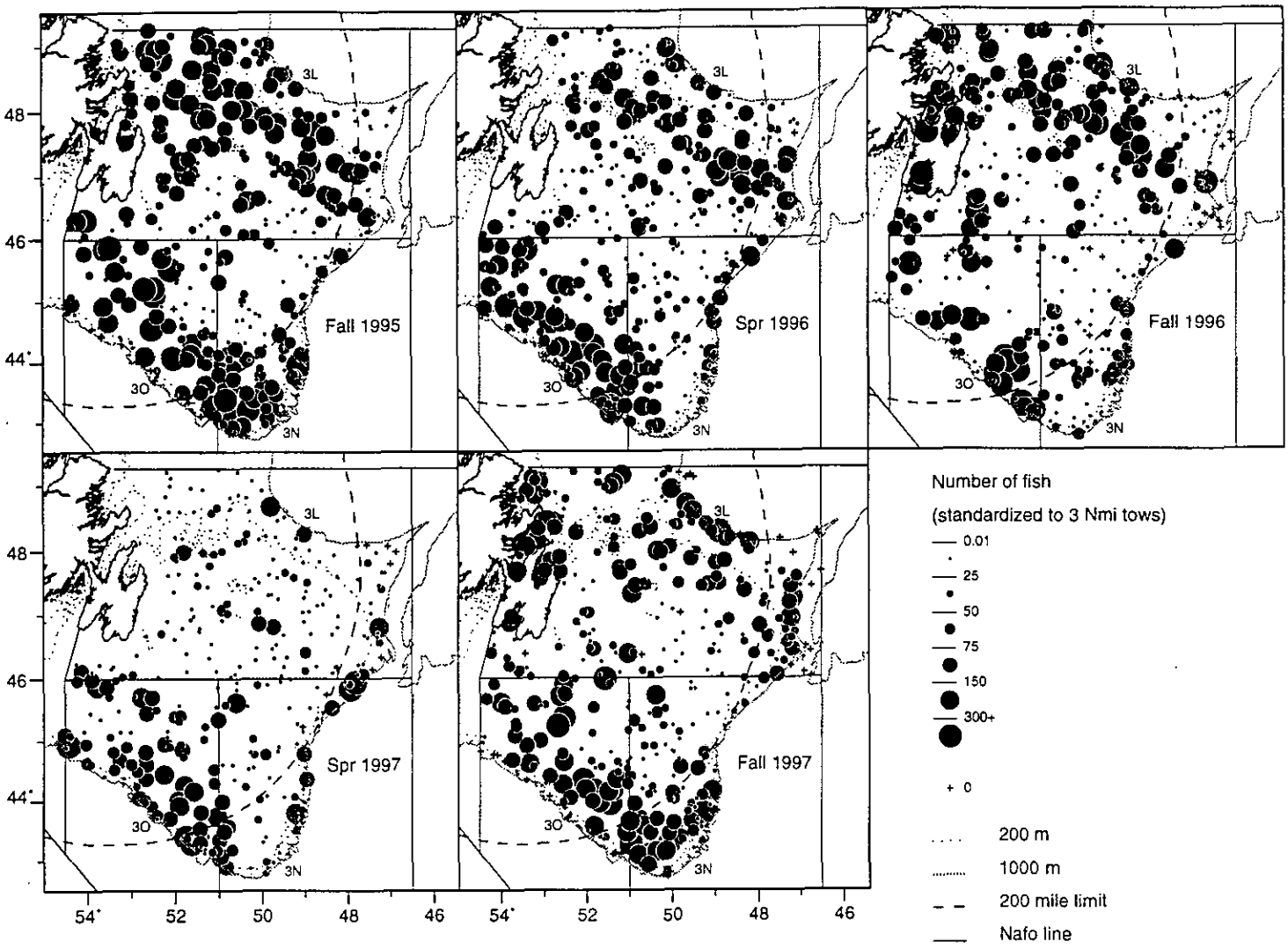

Fig. 6. Distribution of American Plaice (number per set) from stratified random surveys in Div.3LNO for Fall 1995, Spring/Fall 1996, and Spring/Fall 1997.

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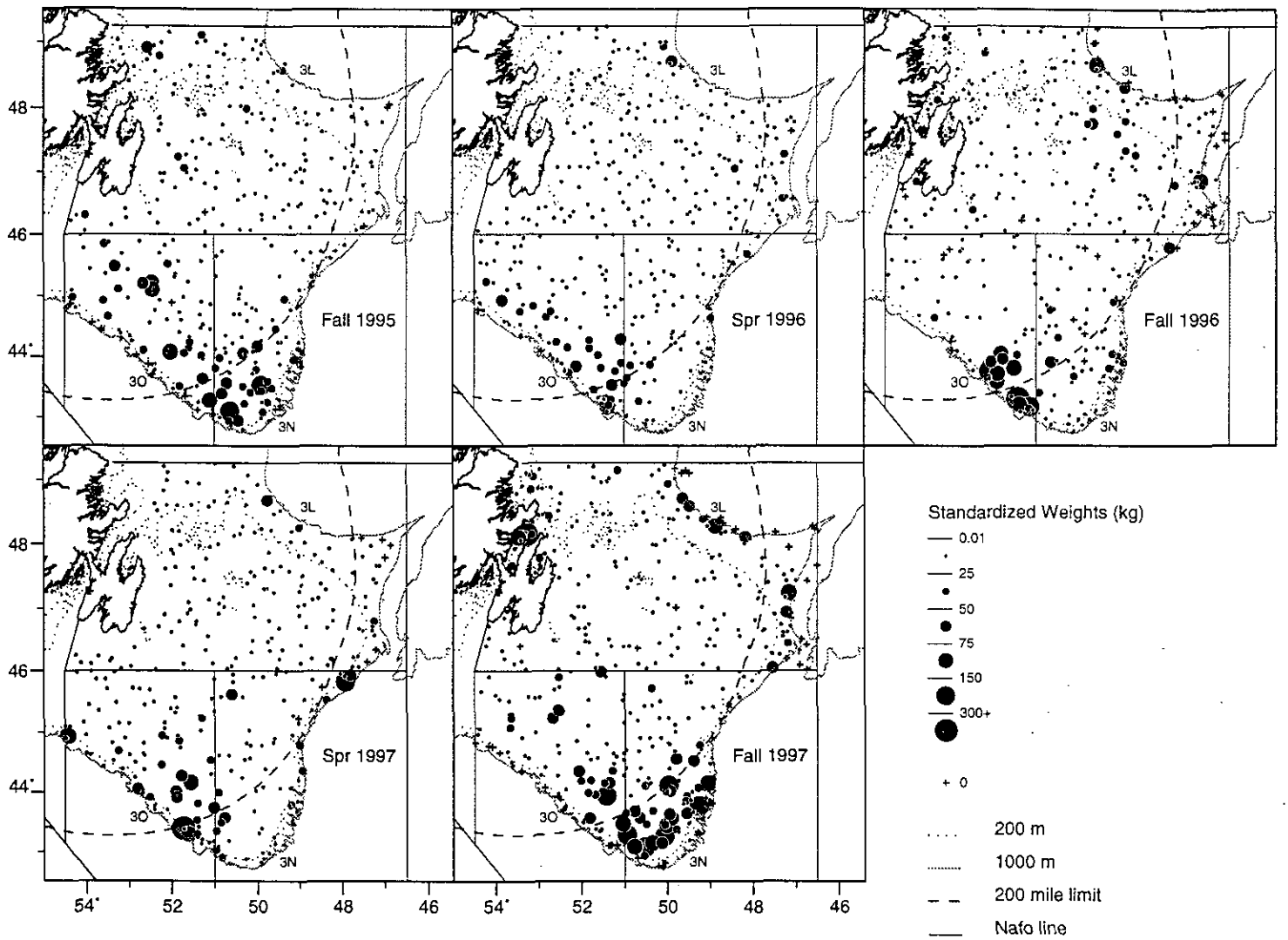

Fig. 7. Distributions of standard weights per tow (kg) of American plaice from stratified random surveys in Div.3LNO for Fall 1995, Spring/Fall 1996, and Spring/Fall 1997.

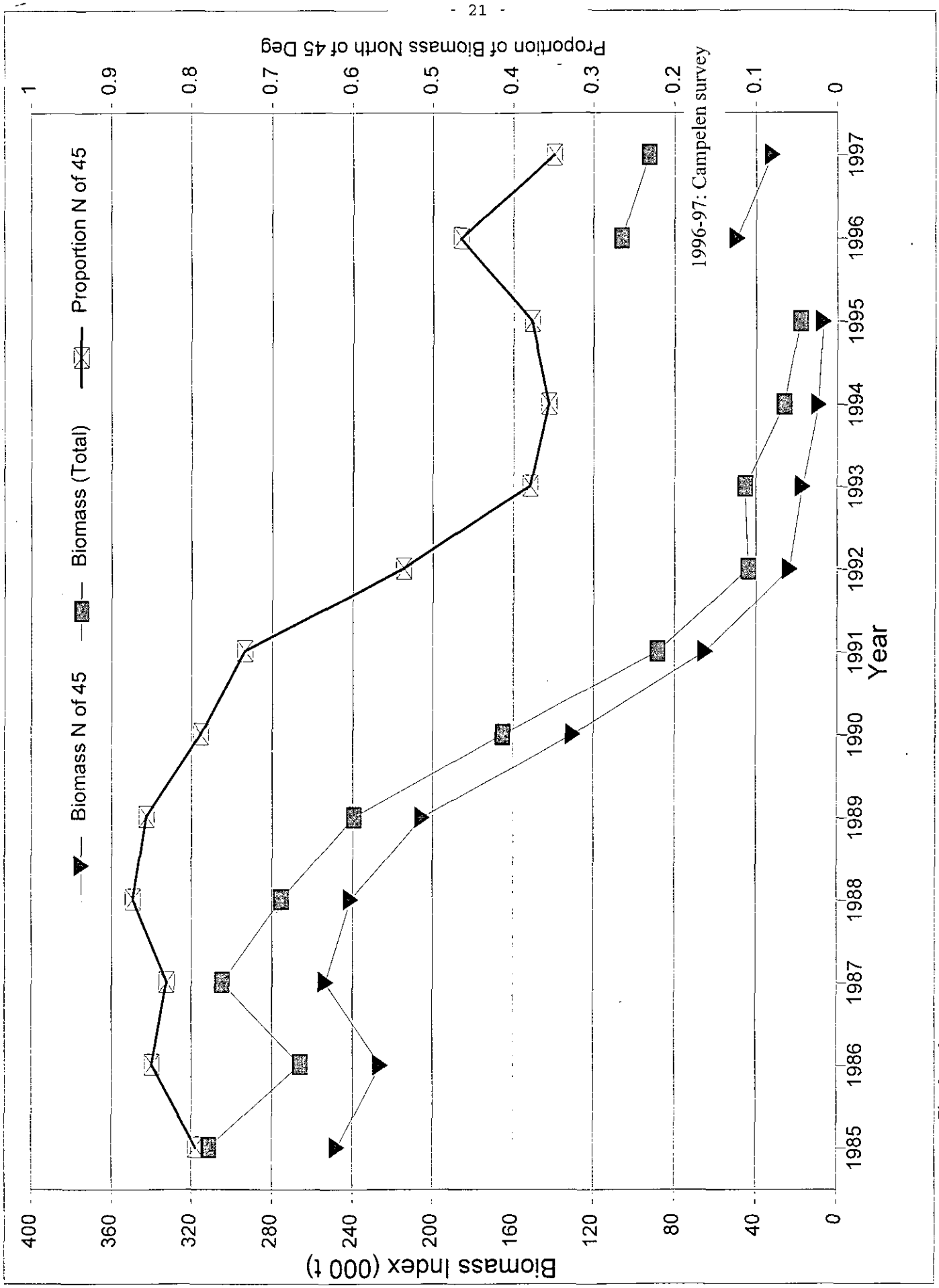

Fig. 8. Comparison of biomass estimates of A.plaice north of 45 degrees with total biomass estimates from spring surveys in Div. 3LNO.

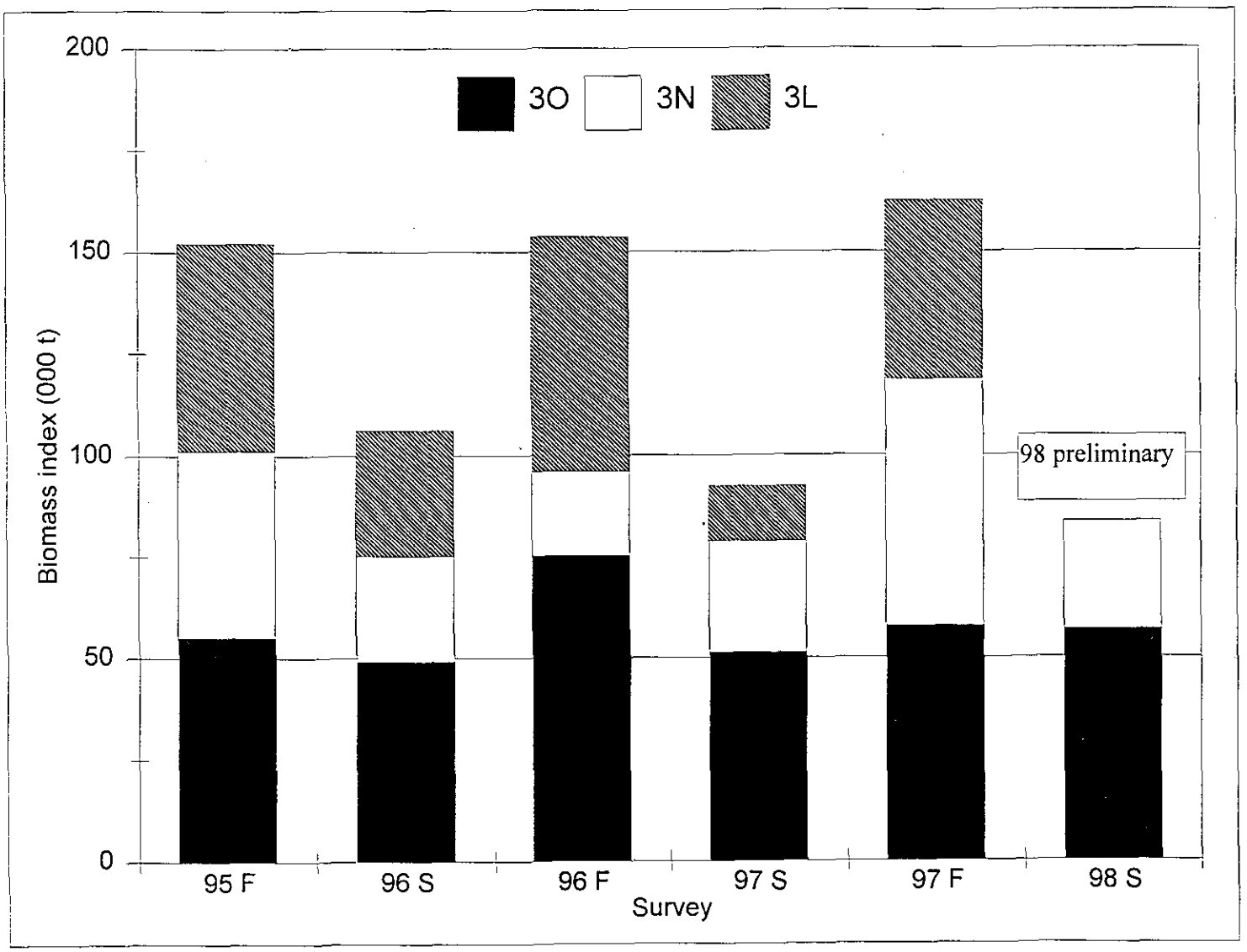

Fig. 9. Comparison of spring and fall biomass estimates from Div. 3LNO from Campelen surveys only.

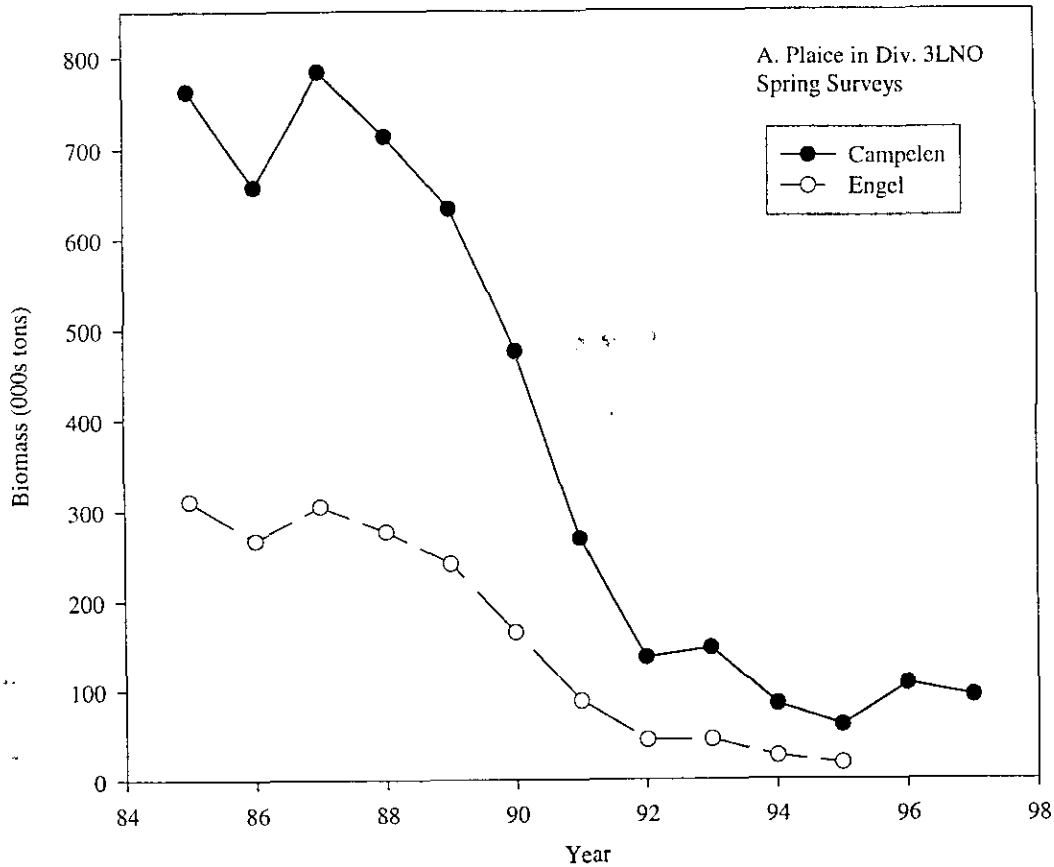

Fig.10 Biomass (000s tons) of A. plaice from Canadian spring surveys in Div. 3LNO combined. Campelen estimates are calculated using converted abundance at length (cm) and a length-weight relationship.

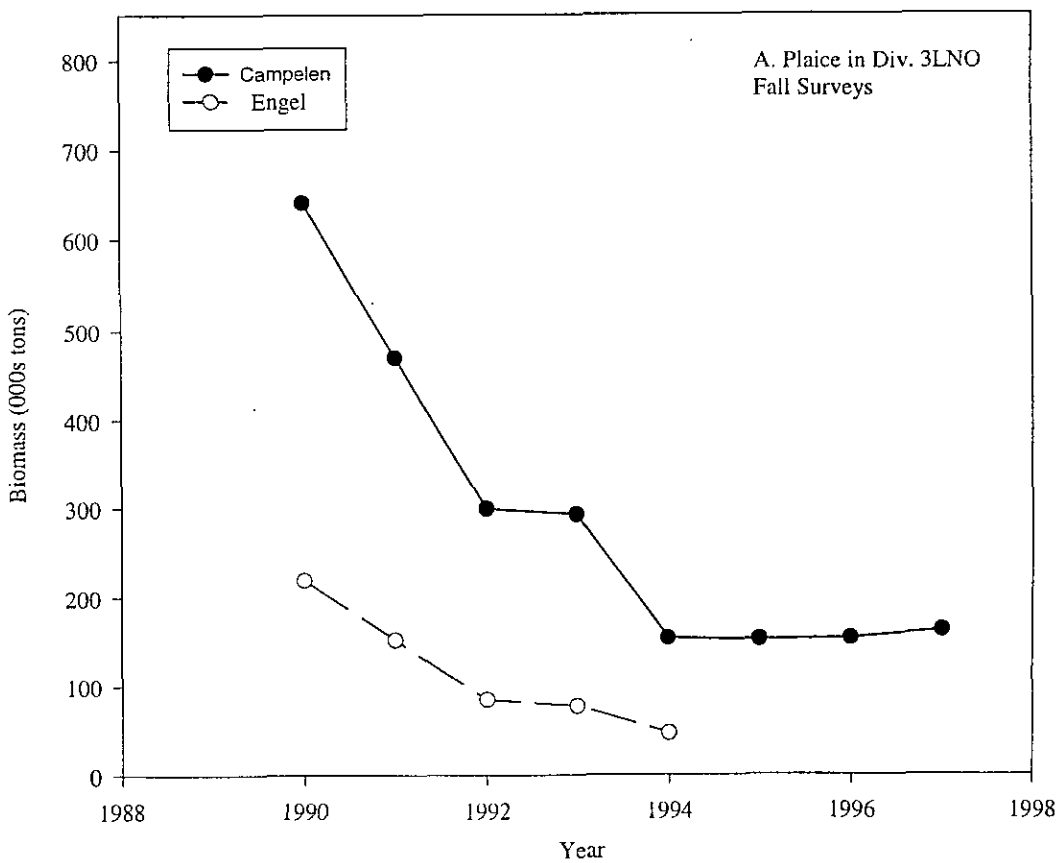

Fig. 11 Biomass (000s tons) of A. plaice from Canadian fall surveys in Div. 3LNO combined. Campelen estimates are calculated using converted abundance at length (cm) and a length-weight relationship.

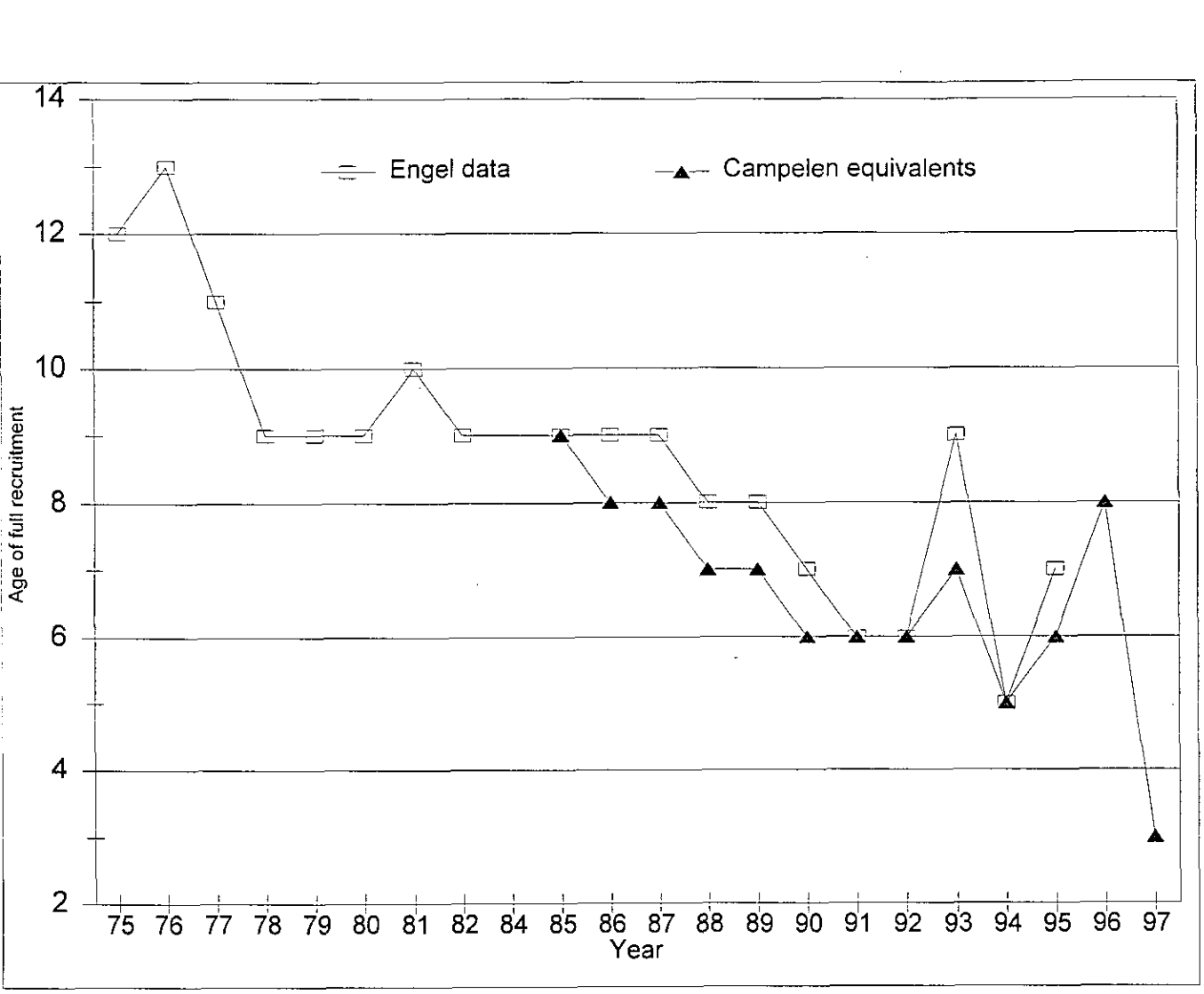

Fig. 12. Age at which American plaice appear fully recruited to survey trawl, from spring surveys in Div. 3LNO. Data are shown for Engel trawl, and for Campelen equivalents.

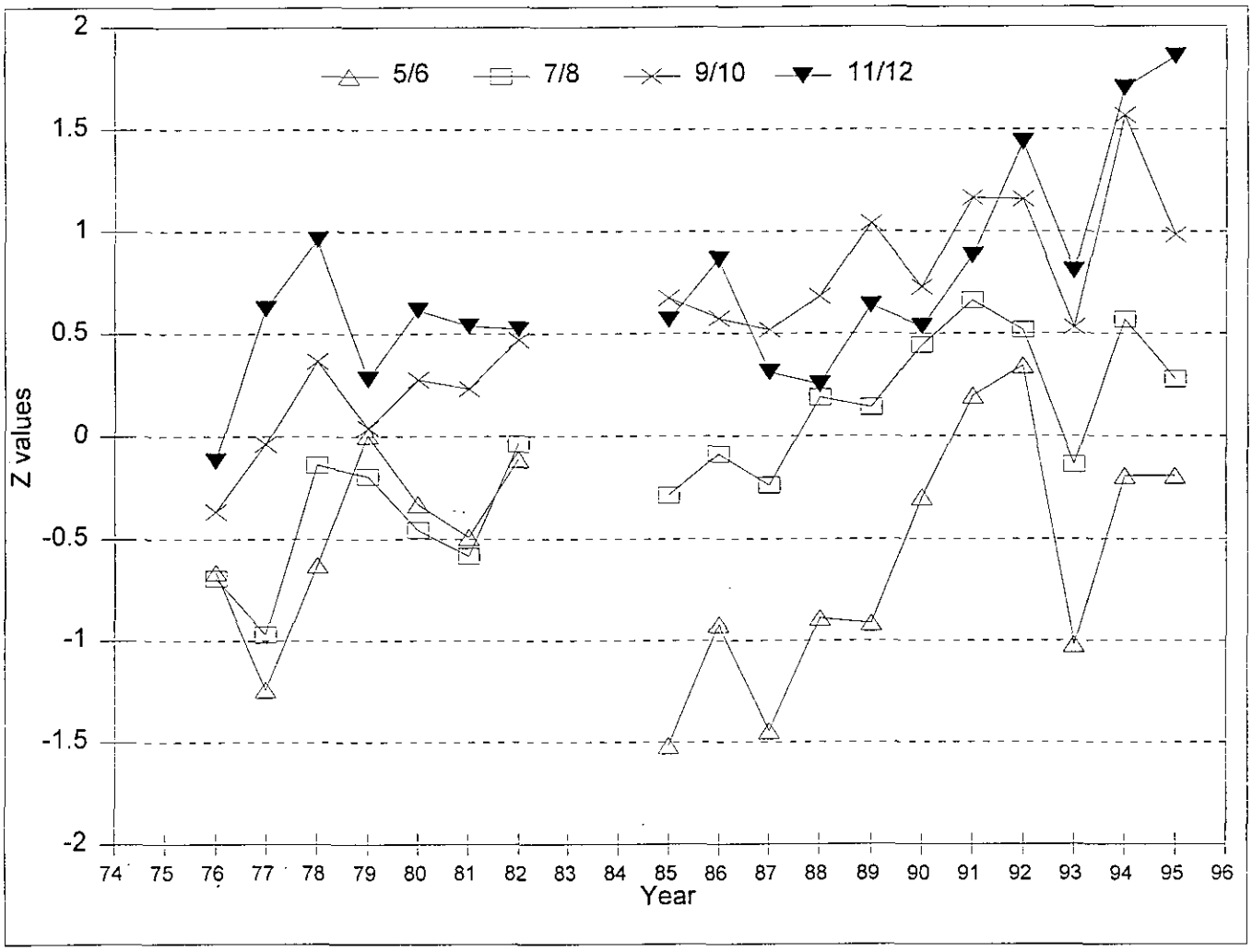

Fig. 13. Estimates of total mortality at selected age groups. Data are Engel values, Div. 3LNO spring surveys.

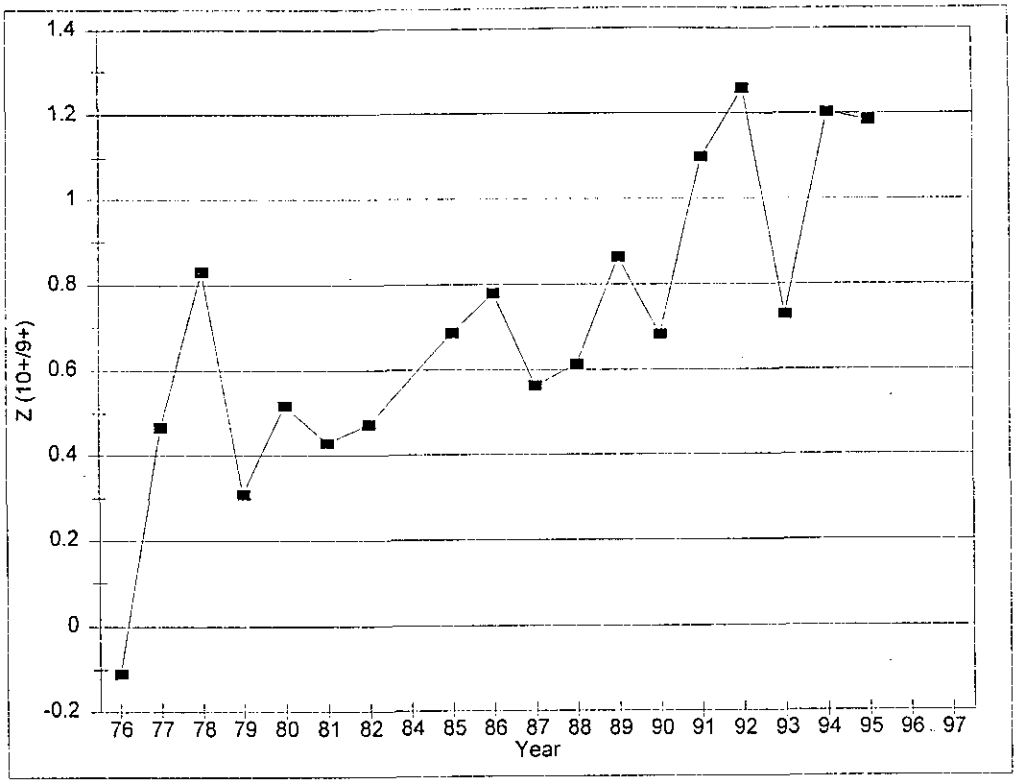

Fig. 14. Estimates of total mortality at ages 9+ to 10+ in successive years. Data are Engel values, Div. 3LNO spring surveys.

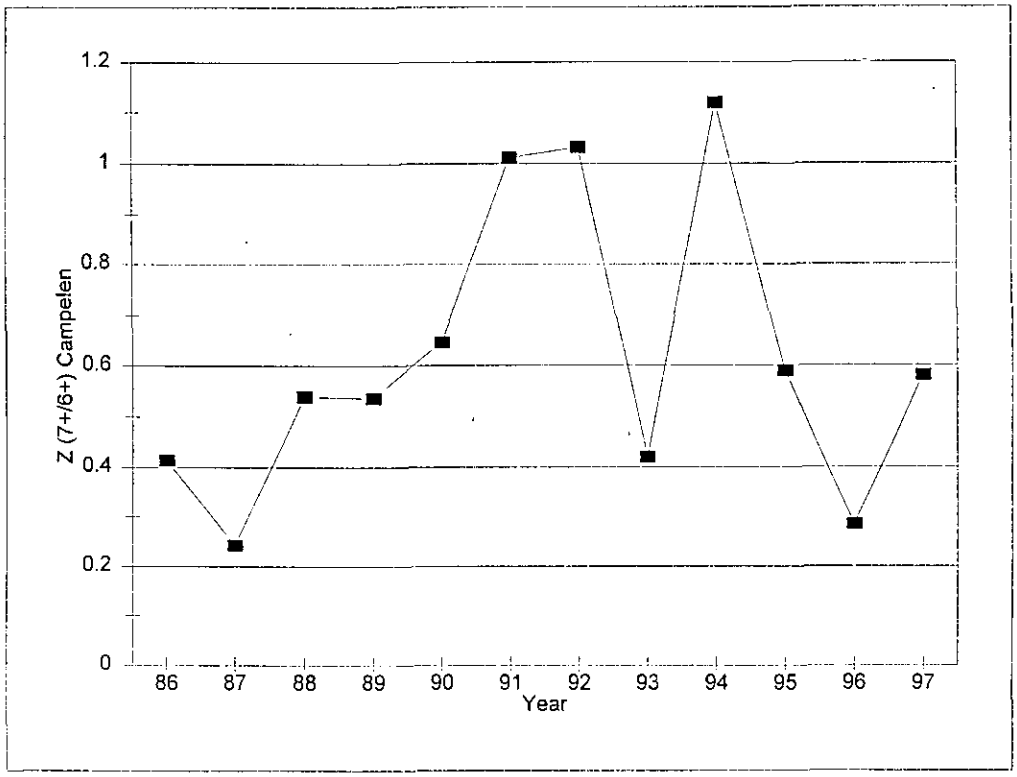

Fig. 15. Estimates of total mortality at ages 6+ to 7+ in successive years. Data are Campelen values, Div. 3LNO spring surveys.

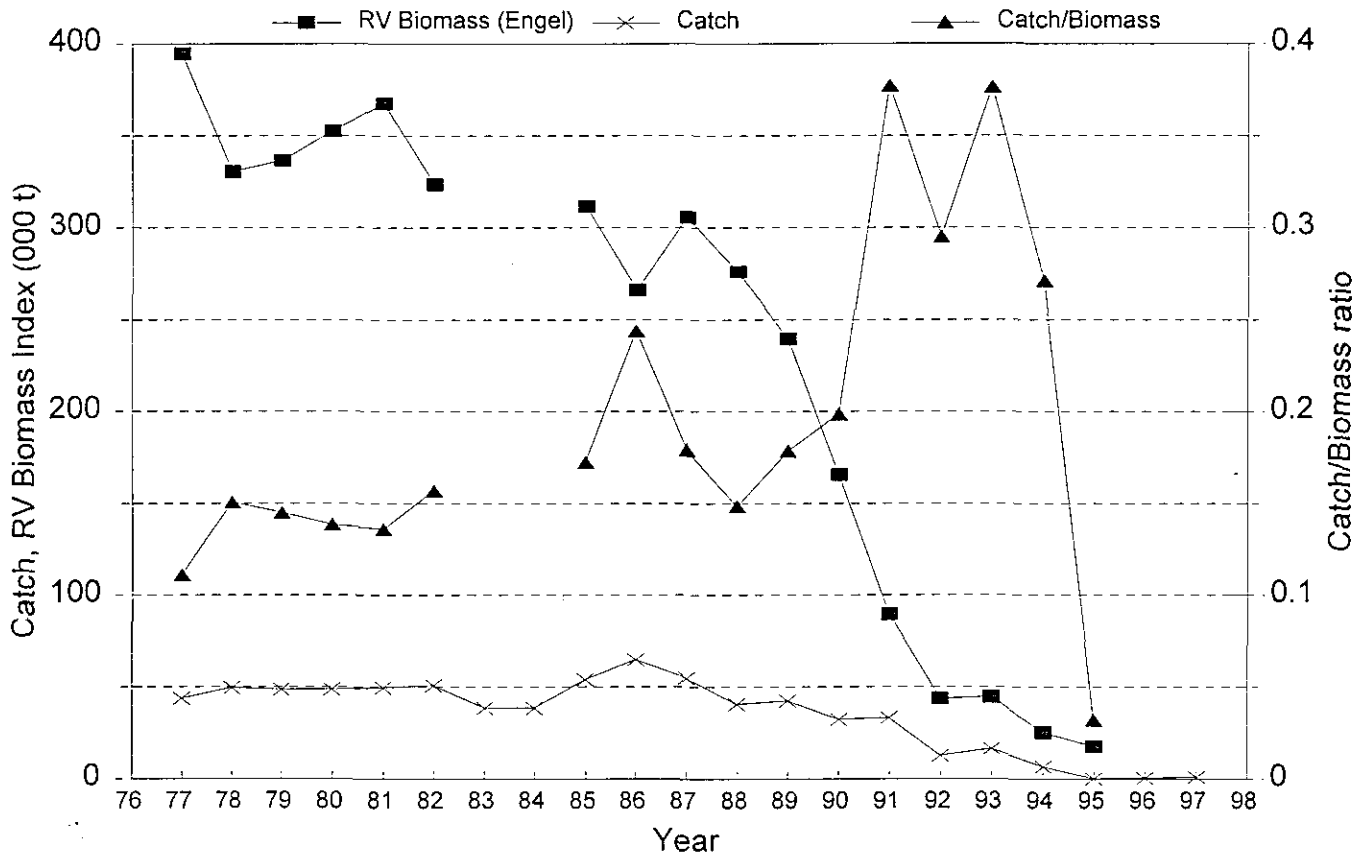

Fig. 16a . Comparison of catch and RV biomass index (Engel), 3LNO A.plaice

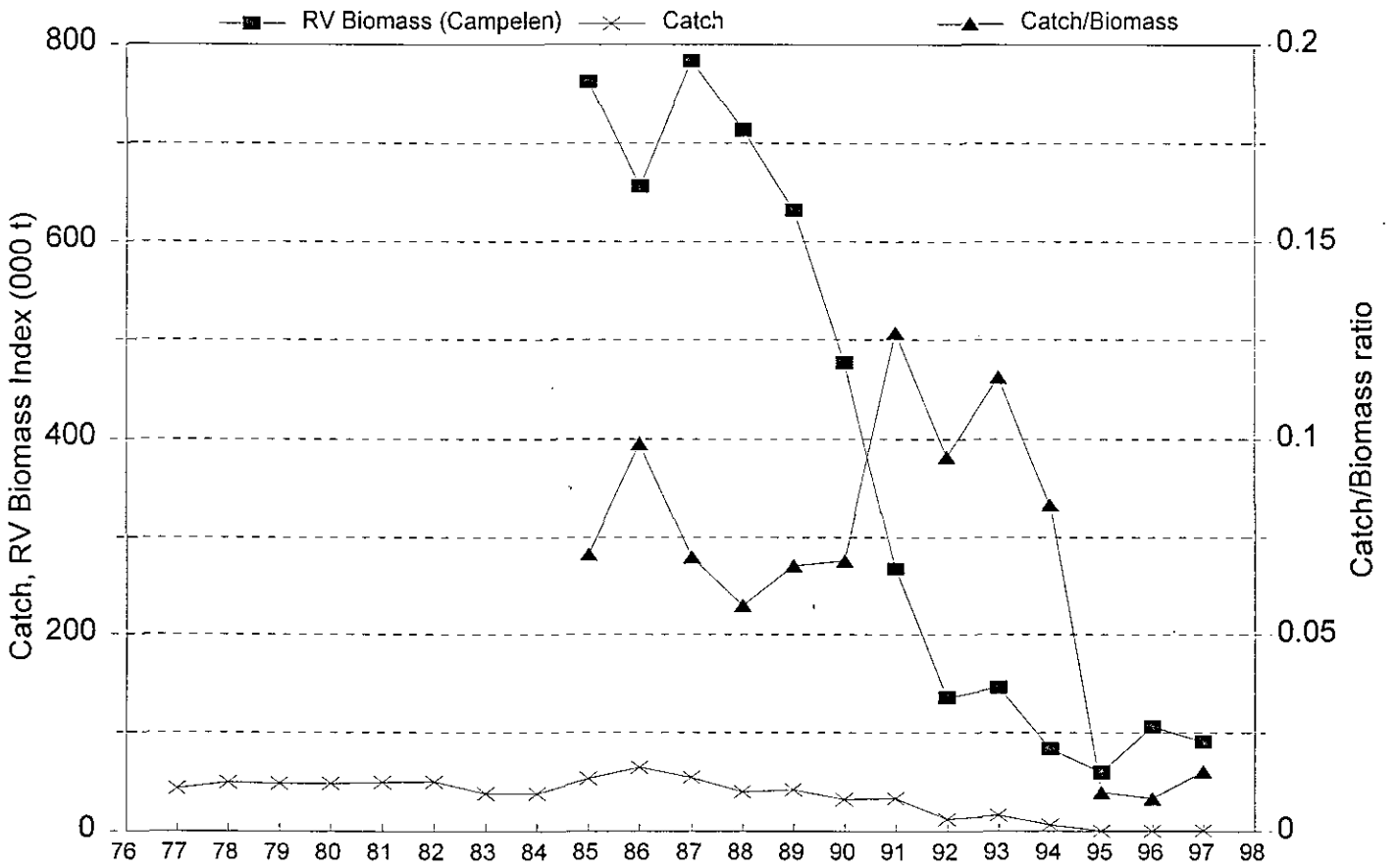

Fig. 16b . Comparison of catch and RV biomass index (Campelen equivalents)

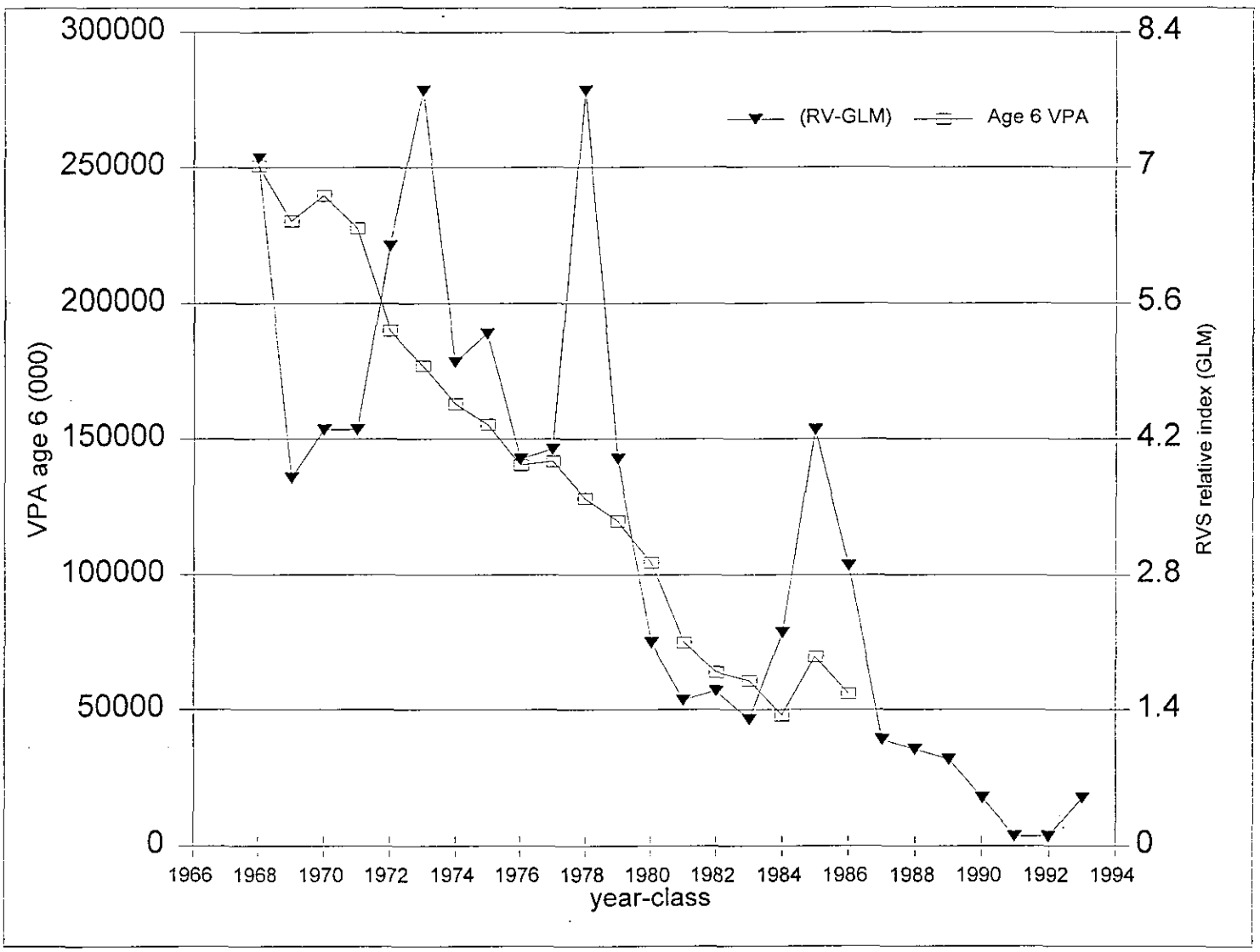

Fig. 17. Comparison of recruitment estimates from VPA at age 6 (from 1993 assessment), with survey estimates (GLM from 1997 assessment). Estimates are by year-class.

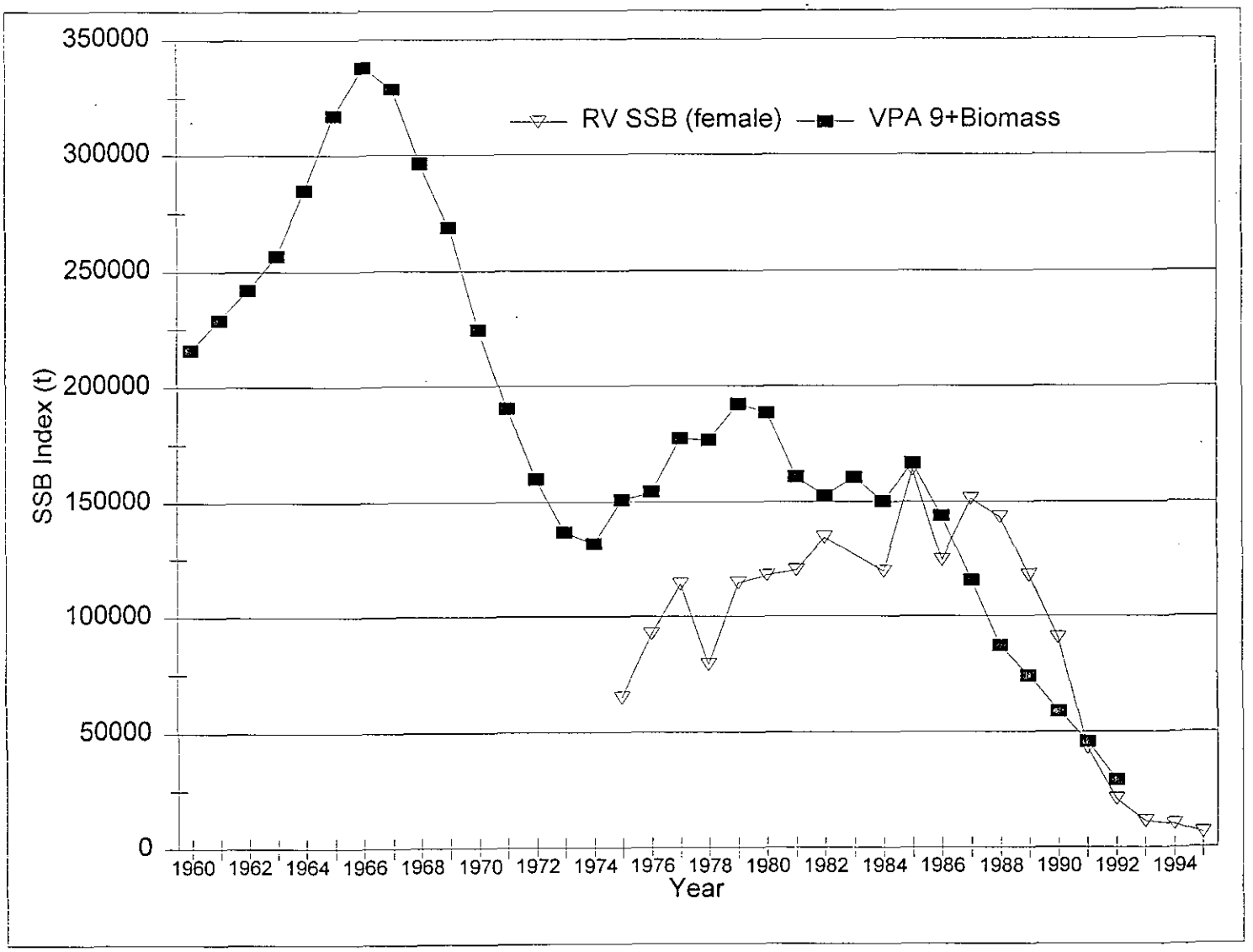

Fig. 18. Comparison of SSB estimates from VPA (1993 assessment) and RV surveys (from 1997 assessment). Data from VPA are 9+ (male + female), data from surveys are female SSB calculated with annual maturity ogives.