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Dynamics of Juvenile American Plaice Populations on the Grand Banks, NAFO Divisions 3LNO

by

Stephen J. Walsh

Department of Fisheries and Oceans, Science Branch
P. O. Box 5667, St. John's, Newfoundland, Canada A1C 5X1

Introduction

The Grand Bank American plaice fishery in NAFO Divisions 3L, 3N, 3O, which has yielded 30,000-60,000 t annually during the last half of the 1980's, occurs mainly on the northern part of the Bank (Div. 3L) in depths of 75 to 185 m, along the eastern edge (Div. 3N) in depths of 70-275 m, and to a lesser extent on the southwestern part of the Bank (Div. 3O) in depths of 70-185 m (Pitt,1975; Brodie et al. 1992) (see Fig. 1 for area names).

Walsh (1982) proposed that both juvenile and adult plaice in catches from spring groundfish surveys, were concentrated in the same areas of the Grand Bank. Walsh (1991a,b; 1992) reported that bottom trawl results from the 1985-91 juvenile flatfish surveys confirm this overlap of juveniles and adults and identified three oceanic nursery areas: the northern slope of the bank, Div. 3L, in an average bottom depth range of 130-140 m; the southern tip of the bank (NAFO Regulatory Area) of Div. 3N and 3O, in an average bottom depth range of 70-72 m; and Whale Deep, a deepwater basin on the western side of Div. 3O, in an average bottom depth range of 105-115 m. These oceanic nursery areas are also the same areas where the commercial fishery, by both Canadian and non-Canadian vessels, take place.

This paper will report the results of the 1992 survey and compare distribution of juvenile plaice with earlier surveys conducted since 1985. I will focus mainly on the time period 1989-92 for which the overall coverage of the population on the Grand Bank is the most extensive.

Materials and Methods

Survey design

Annual juvenile flatfish surveys of the Grand Bank were started in 1985. The main purpose of the surveys was to determine year-class strength of juvenile American plaice and yellowtail flounder as early as possible for the management of the resource. From 1985 to 1988, the survey area incorporated the entire Grand Bank inside the 91-m isobath, NAFO Div. 3L, 3N, and 3O (Fig. 1); in 1989, it was extended to the 183-m isobath and in 1992 it was further extended to the 273 m isobath to investigate distribution of juvenile plaice in deep water. In 1992 the stratified-random trawl survey for juveniles consisted of 46 strata on the Grand Bank, designated by 1° X 1° squares (Fig. 1). This stratification scheme has also been used in the annual spring Canadian groundfish surveys of the Grand Bank since 1971. The number of fishing hauls was proportioned according to the area of each stratum, and stations were randomly derived prior to each cruise. Since data on gear efficiency were not available, only relative abundance estimates were derived using a swept area model.

Survey gear and time

The survey gear used was a two-bridle Yankee 41 (80/104) shrimp trawl with a mesh size of 38 mm throughout and equipped with a 12-mm stretched mesh liner in the codend. The groundgear was rigged with 30-cm rubber rollers in the bosum, 30-cm rubber bunts in the

quarters, and 11-cm rubber discs in the wing ends. The standard towing speed used, measured by Doppler speed log, was 2.5 knots with each haul being 30-minutes duration (on-bottom time), covering an average distance of 1.25 miles as calculated from Loran C navigation. At each fishing station, a surface-to-bottom temperature profile was taken with an XBT (Expendable Bathythermograph) from 1985 to 1988 and a trawl mounted CTD system since 1989, and bottom depth was recorded from sounder records. The surveys were generally conducted from mid- August to mid-September 1985, 1986, 1988, 1989, 1990, 1991 and 1992 and November 1-13 in 1987 aboard the r.v. WILFRED TEMPLEMAN, a 50-m stern trawler. Nine hundred seventy-seven (977) successful fishing hauls were made during the combined period of 1985-91. In the 1992 survey, 250 (combined total=1227) successful sets were completed in Div. 3LNO and seven (7) additional strata were added to the survey coverage in the depth range 183 to 273 m.

All of the catch was sorted by species and weighed. All plaice were measured to the nearest centimeter (total length). Otoliths were removed for ageing. Fish were classified as juveniles based on the age they began to mature and for this species this was approximately age 5. All analyses of the data were done on a 1-cm size category using SAS software (SAS Institute Inc. 1985)

Results abd Discussion

SURVEY TRAWL CATCHES

DIV. 3L

Table 1 show average catch (numbers and weights) abundance and biomass of American plaice catches in Division 3L derived from the 1985-92 juvenile surveys. In the 1992 survey, plaice (juveniles and adults) were concentrated on the north and northeast slope in an average bottom depth of 134.1 m and an average temperature of -0.7°C (Table 4).In 1992 the average bottom depth was higher than in 1989-91 surveys due to catches in the new deepwater strata, while average bottom temperature was comparable to 1989 and 1990 surveys, but warmer than 1991. Highest average catches in numbers, generally around 1000 fish, were found in strata 365, 348, 364, 385, 370 and 390, similar to the 1989 to 1991 surveys. Average weights per tow were generally low. All of the 7 new deepwater strata, in the depth range 183- 273 m, had fairly consistent average catch in numbers, but more variable average weights. The overall average catch in numbers in 1992 showed a 22% decrease from the stable catches during the 1989-91 period. The average catch in weight has been showing a declining trend since 1990.

Table 1 and Figure 2 shows that stock biomass in Div. 3L has shown a 19% decline from 1990 to 1991, with a further 18% decrease in 1992 . The 1992 revised estimate of 166.6 thousand tons is the result of having removed the catches from the 7 new deepwater strata (46.5 thousand tons) from the overall biomass to be comparable to the 1989-91 estimates. This decline in biomass in Div 3L was also evident in the biomass estimates derived from the spring time groundfish surveys (Brodie et al 1992)

DIV. 3N

Table 2 shows average catch in numbers, in 1992, were concentrated in stratum 360, similar to results in the 1989-91 surveys; stratum 376, in the Regulatory Area; and stratum 383, on the eastern edge. Catches were found in an average bottom depth of 68.3 m, similar to the 1989-91 surveys, and an average bottom temperature of 1.0°C (Table 4). Average weight per tow were all less than 60 kg. Noteworthy, is the small average catches in stratum 360, in the Regulatory Area. From 1986-91, stratum 360 had average numbers per tow in excess of 1000 fish, however, the 1992 value is 50% below the long term average catch in numbers. The overall average catch in numbers in 1992 showed an approximate 49% decrease from the stable catches during the 1990- 91 period. The average catch in weight has also been showing a declining trend since 1990.

Table 2 and Figure 2 show that the biomass has declined since 1990. The 1991 estimate decreased by 38% from 1990 and this was followed by a further 24% decline from 1991-1992, to a low of 59.4 thousand tons. This decline was also evident in the biomass estimates derived from the spring time groundfish surveys (Brodie et al 1992). The single new deepwater stratum (358) contributed only 0.7 thousand metric ton to the overall total.

DIV. 30

In Div. 3O, the highest average numbers and weight per tow were found in Whale Deep, a deepwater basin, on the western side of the Bank (stratum 339) consistent with the 1989 to 1991 surveys and stratum 354, in the Regulatory Area. Average catches in numbers showed an increase in several strata from 1991, across most of southwest slope area, being the highest in the time series. In 1992, plaice were found in an average depth of 89.9 m, comparable to previous years, and an average bottom temperature of 0.6°C, which was the coldest in the 4 year series (Table 4). The overall average catch in numbers in 1992 showed a 38% increase from the stable catches during the 1989-91 period, and the average catch in weight also showed a corresponding 21% increase from 1991.

Table 3 and Figure 2 showed that the biomass has decreased from 1989 to 1991, however, the 1992 estimate of 121.4 thousand tons was a 21% increase from 1991. This increase was not seen in the biomass estimates from the spring or fall groundfish surveys, which showed a declining trend since 1990 (Brodie et al 1993).

AGE COMPOSITION

Div. 3L

Table 5 and Figure 3 show the age-by-age composition of the 1989-92 surveys. In 1992, there are two estimates derived, one with the catches of the new 7 deepwater strata and one without. The latter revised estimate makes the 1992 estimate comparable to estimates derived from the 1989-91 surveys and will be referred to here when discussing trends in population abundance at age for the division. The total abundance estimates for the four years were remarkedly similar at around 2000 X 10-6 level, mainly due to high estimates of juveniles ages 1-5. In the 1992 estimates, the 1987 (age 5) and the 1988 (age 4) yearclasses contributed 66% to this overall estimate. Coincidently, ages 5 and 4 contributed the bulk of the abundance of juveniles in 1990 and 1991, but ages 3 and 4 were the main contributor in 1989.

Since 1989, there has been a steady decreasing trend in the number of older fish in the population at age 7+. The 1985 yearclass, at age 7, which has contributed to the high estimates of juveniles in the 1989-91 surveys, beginning with age 3 in the 1989 survey, was the lowest in the 4 year time series, but contributed 54% to the age 7+ estimate. The 1986 yearclass at age 6 ranks close to the 1991 estimate of the 1985 yearclass at the same age.

Nursey Areas

Tables 6 and 7 contain information on abundance estimates at age for the 7 new deepwater strata (1992), in the 183-273 m depth range, and selected strata, in the 93-183 m depth range in the 1989-92 surveys and on the northern slope of the bank. Less than 10% of the abundance at age estimates for all Div 3L juveniles, ages 1 to 5, were distributed in these new deepwater strata (183-273m), but 20 to 30 % of the older fish were found in this area. The majority of catches of juveniles ages 1 to 5 were consistently found in the deepwater strata (93-183 m) on the north and northeast slope of the Bank during 1989-92 surveys.

DIV. 3N

Table 8 and Figure 4 shows the age by age composition of survey catches for 1989-92. The total abundance in 1992 had dropped 49% below the 1991 estimate. In 1990 and 1991 abundance was constant, but down from the 1989 high of 1221.9 x 10-6. This large decrease from the 1991 estimate is reflected in the 56% drop in estimates of juveniles, ages 1 to 5, from 1991 to 1992. The estimate of age 7+ in the population showed a 28% increase due mainly to the 1985 yearclass which has been consistently the dominant yearclass since it was estimated at age 4 in the 1989 survey. The 1986 yearclass which has been the second dominant yearclass since its appearance at age 3 in the 1989 survey is still showing the same ranking at age 6.

Nursery Area

Table 11 shows the age distribution of juveniles from 1989-92 surveys located in the Regulatory Area. The 1992 catches in stratum 358, a new strata in the depth range of 183-273m, and the catches of stratum 376 were added (Fig.1). Small amounts of juveniles were caught in this deepwater strata, however, the

numbers for stratum 376, the lower section of the Southeast Shoal, were higher than in the 1989-91 series (see table 2) and warrant their inclusion. Although it was at first suspected that there has been some northward movement, in effect a plot of the 3 large catches showed two of them being on the edge of stratum 360 and a probable extension of a patch, while the other was located further to the east, on the Shoal.

The low 1987-91 yearclass abundances in the 1992 survey may be underestimates of their true strengths due to an artifact of the stratified random survey in the main section of the nursery area, stratum 360. Table 9 shows that the estimate of juvenile abundance for this stratum was the worst in the catch results since 1986. Furthermore, the 1992 estimate of ages 2 and 3 showed a decrease in abundance from their 1991 estimates at ages 1 and 2. This would normally imply a reduction through mortality, but these numbers should be showing increases, rather than decreases, because they are still recruiting to the sampling trawl, as they have shown in other years. A reexamination of the locations of the 16 survey sets showed that, with the exception of 2 fishing sets, the remaining 14 sets were north of the main concentration of juveniles. A plot of the catches (not presented here) larger than 1000 fish from 1989 to 1991 surveys showed that concentrations were generally located below 43.26N. Table 10 shows that in 1989-91 surveys the randomized location of sets contibuted approximately 50% of the stations to the area below 43.26N and most of these fishing sets had catches greater than 1000 fish (as high as 7600). Juveniles were also found north of this area but the patches appeared not to be as dense, unlike the area below 43.26N. Consequently, it is suspected that the large drop in catches of juveniles was associated with the sampling scheme.

DIV. 3O

Table 12 and Figure 5 shows the age by age composition from the 1989-92 surveys. The total abundance in 1992 was the highest in the 4 year time series due to a 42% increase in the number of juveniles, ages 1 to 5, from 1991. 71-79% of the total abundance, in this area, was comprised of juveniles during 1989-92 surveys. Age 7+ abundance estimates remained stable for the 1990-92 period but below the 1989 estimate. The 1985 yearclass, at age 7, which has appeared to be a dominant yearclass also at younger ages, contributed 41% to the abundance of older fish. The 1986 yearclass at age 6 was still the largest in the time series. The 1988-90 yearclasses appeared strong in the 1992 survey, with their estimates being highest in the time series for juveniles ages 2-4.

Nursery Areas

Table 13 compares the distribution of number at age caught in strata 329 and 339 of the Whale Deep area and strata 353 and 354 on the Tail of the Bank in the Regulatory Area. In the 1989-91 surveys 50%-60% of juveniles were located in these 4 strata, but in 1992 there was a noticeable drop in percentage estimation of juveniles in these two areas. Subsequently, there were increases in catches of juveniles in the surrounding strata most notably 332, 337,338, along the southwest slope and stratum 340, east of Whale Deep. Two large catches of juveniles were made in stratum 352, which were located near the border area with stratum 353 and are probably an extension of the concentration patch in that area of the bank. Generally, juveniles are found regularly in these strata around and south of the Whale Deep area, and west of the "Tail of the Bank" in Div. 3O ,being more widely dispersed, similar to the northern slope of Div 3L (Walsh 1991b).

These increased catches of juveniles was first suspected to have been indicative of some general movement by juveniles from more denser areas like Whale Deep and the Tail of the Bank, as a response some enviromental cue such as temperature, since temperature in this Division was the coldest in the 4 year time series as indicated in Table 4.

Figures 6-8 show a comparison of mean length at age for juveniles from the 1989-92 surveys. In Div. 3O there was little difference in the mean length at age of juveniles in all years, 1992 being slightly lower than 1991 for some age groups. Little difference was seen in Div 3L and Div 3N from 1991 to 1992. Any increase in mean size at age could result in more fish of that age group being caught thus confounding trends in population abundance due to growth (Godo and Walsh 1992).

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Table 1. Mean numbers and weight (kg) of Am. plaice per tow, by stratum from r.v. surveys in Division 3L. Numbers in parentheses are the number of successful 30-minute tows in each stratum. The stratified mean number and weight per tow (kg/30 min.), abundance (millions), and biomass (t x 10^{-3}).

Depth (fm)	Stratum	Category	Year							
			1985	1986	1987	1988	1989	1990	1991	1992
51-100	328	Av.No./set	-	-	-	-	159.85(3)	-	238.15(5)	166.67(3)
		Av.wt./set					15.00		29.52	14.13
51-100	341	Av.No./set	-	-	-	-	1194.50(4)	202.80(5)	735.93(4)	320.78(5)
		Av.wt./set					220.88	41.20	69.32	32.23
51-100	342	Av.No./set	-	-	-	-	223.00(2)	-	-	51.46(2)
		Av.wt./set					51.25			6.36
51-100	343	Av.No./set	-	-	-	-	59.00(2)	-	109.92(2)	154.38(2)
		Av.wt./set					7.50		22.68	18.43
101-150	344	Av.No./set	-	-	-	-	-	-	-	484.25(2)
		Av.wt./set								42.27
101-150	347	Av.No./set	-	-	-	-	-	-	-	366.17(2)
		Av.wt./set								75.97
51-100	348	Av.No./set	-	-	-	-	1562.50(7)	773.90(4)	2165.33(7)	745.51(12)
		Av.wt./set					146.84	104.21	127.65	35.07
51-100	349	Av.No./set	-	-	-	-	1341.40(5)	492.57(7)	803.12(7)	238.07(8)
		Av.wt./set					199.62	93.57	66.64	27.99
31-50	350	Av.No./set	43.60(5)	106.67(6)	-	273.99(5)	71.63(8)	27.50(4)	76.07(8)	109.96(6)
		Av.wt./set	39.80	93.92		69.25	51.44	33.30	47.12	22.93
31-50	363	Av.No./set	161.00(5)	119.40(5)	-	53.79(6)	315.43(7)	549.50(4)	220.08(4)	288.40(5)
		Av.wt./set	56.30	42.61		27.65	88.70	77.86	58.68	58.54
51-100	364	Av.No./set	-	-	-	-	1406.53(11)	2361.60(5)	1370.61(6)	1852.77(17)
		Av.wt./set					113.02	292.07	122.29	130.16
51-100	365	Av.No./set	-	-	-	-	1854.75(4)	912.67(3)	2501.57(4)	1601.89(6)
		Av.wt./set					95.08	89.76	125.65	74.05
101-150	366	Av.No./set	-	-	-	-	-	-	-	386.39(3)
		Av.wt./set								97.58
101-150	369	Av.No./set	-	-	-	-	-	-	-	376.64(3)
		Av.wt./set								68.47

Table 1. (Cont'd.)

Depth (fm)	Stratum	Category	Year 1985	1986	1987	1988	1989	1990	1991	1992
51-100	370	Av.No./set	-	-	-	-	1703.83(6)	1119.33(3)	627.85(3)	1305.96(8)
		Av.wt./set					87.53	145.37	60.17	77.81
31-50	371	Av.No./set	252.00(4)	-	-	74.34(5)	67.00(4)	96.67(3)	-	1064.19(3)
		Av.wt./set	102.13			41.45	33.50	40.97		145.37
31-50	372	Av.No./set	98.28(9)	108.50(8)	-	97.80(8)	97.88(8)	73.00(4)	62.95(4)	222.00(6)
		Av.wt./set	72.09	90.38		55.02	38.43	45.23	36.25	45.11
31-50	384	Av.No./set	282.25(4)	-	-	191.45(5)	372.25(4)	246.50(2)	629.18(3)	549.25(4)
		Av.wt./set	105.45			88.33	72.41	105.15	146.21	76.50
51-100	385	Av.No./set	-	-	-	-	1085.80(5)	2084.00(4)	1354.46(6)	1994.67(13)
		Av.wt./set					69.33	87.62	80.72	70.31
101-150	386	Av.No./set	-	-	-	-	-	-	-	409.50(3)
		Av.wt./set								96.73
101-150	389	Av.No./set	-	-	-	-	-	-	-	249.17(3)
		Av.wt./set								35.98
51-100	390	Av.No./set	-	-	-	-	284.00(4)	234.33(3)	1228.00(4)	417.08(4)
		Av.wt./set					50.91	41.27	87.72	55.23
101-150	391	Av.No./set	-	-	-	-	-	-	-	460.96(2)
		Av.wt./set								57.44
Mean No./set (# sets)			142.23(27)	110.89(19)	- (0)	140.50(29)	806.79(84)	809.53(51)	888.77(67)	689.42(122)
Abundance (Nos x 10^{-6})			129.4	74.4		127.8	2231.8	2013.0	2295.5	2412.7(2124.9)*
Mean wt./set			69.24	78.00		55.35	91.72	100.10	78.55	60.89
Biomass (t)			63.0	52.4		50.4	253.7	248.9	202.9	213.1(166.6)*

*Revised estimates with the catches of the 7 new deepwater strata removed for comparison with survey results in 1989-91.

Table 2. Mean numbers and weight (kg) of Am. plaice per tow, by stratum from r.v. surveys in Division 3N. Numbers in parentheses are the number of successful 30-minute tows in each stratum. The stratified mean number and weight per tow (kg/30 min.), abundance (millions), and biomass (t x 10^{-3}).

Depth (fm)	Stratum	Category	Year							
			1985	1986	1987	1988	1989	1990	1991	1992
101-150	358	Av.No./set	-	-	-	-	-	-	-	247.50(2)
		Av.wt./set								30.28
51-100	359	Av.No./set	-	-	-	-	2395.50(2)	898.18(3)	1703.94(4)	284.33(3)
		Av.wt./set					99.55	51.08	78.19	25.24
31-50	360	Av.No./set	189.67(3)	1823.93(14)	1043.14(19)	1271.32(20)	3015.54(19)	1427.81(2)	1509.73(18)	550.69(16)
		Av.wt./set	29.00	86.67	47.28	83.37	165.56	113.05	104.44	55.96
31-50	361	Av.No./set	31.50(6)	29.88(8)	59.08(8)	64.12(6)	53.78(9)	71.36(10)	76.07(8)	33.00(8)
		Av.wt./set	24.17	19.69	41.80	24.90	188.50	38.18	33.63	12.65
31-50	362	Av.No./set	63.78(9)	62.57(7)	201.84(2)	135.76(6)	177.50(8)	162.14(9)	357.12(7)	144.50(6)
		Av.wt./set	37.72	34.71	84.19	45.55	38.44	90.19	61.44	26.89
31-50	373	Av.No./set	399.80(10)	182.93(7)	-	51.59(8)	95.25(8)	198.00(9)	64.27(7)	88.00(5)
		Av.wt./set	313.34	139.68		35.93	54.13	123.16	14.51	37.70
31-50	374	Av.No./set	147.25(4)	408.50(4)	-	166.12(4)	173.33(3)	93.25(4)	42.85(2)	175.67(3)
		Av.wt./set	62.63	218.25		53.98	37.00	36.31	27.09	25.61
≤ 30	375	Av.No./set	57.71(7)	24.38(5)	48.96(7)	23.54(9)	21.63(8)	50.50(11)	24.98(7)	29.64(11)
		Av.wt./set	67.43	31.98	69.54	17.45	17.06	50.58	27.04	27.44
≤ 30	376	Av.No./set	60.00(2)	221.75(4)	347.63(10)	674.98(12)	71.89(9)	110.36(11)	210.04(10)	399.13(8)
		Av.wt./set	45.50	284.31	18.75	52.81	18.89	23.01	36.19	57.12
51-100	382	Av.No./set	-	-	-	-	48.00(2)	584.00(3)	56.77(3)	104.00(2)
		Av.wt./set					5.25	46.51	4.44	10.80
31-50	383	Av.No./set	236.00(4)	-	-	106.42(4)	268.33(3)	396.33(3)	350.66(4)	450.00(2)
		Av.wt./set	75.63			42.59	52.50	65.49	18.43	41.60
Mean No./set (# sets)			155.70(45)	494.50(49)	414.87(46)	388.86(69)	723.63(71)	425.72(84)	453.48(70)	229.90(66)
Abundance (Nos x 10^{-6})			241.5	731.6	461.5	663.2	1204.7	708.7	754.4	388.0
Mean wt./set			89.11	101.70	54.50	47.10	59.89	76.06	47.12	35.23
Biomass (t)			138.2	150.5	60.6	73.1	99.7	126.6	78.4	59.4

Table 3. Mean numbers and weight (kg) of Am. plaice per tow, by stratum from r.v. surveys in Division 3Ø. Numbers in parentheses are the number of successful 30-minute tows in each stratum. The stratified mean number and weight per tow (kg/30 min.), abundance (millions), and biomass (t x 10^{-3}).

Depth (fm)	Stratum	Category	Year							
			1985	1986	1987	1988	1989	1990	1991	1992
51-100	329	Av.No./set	-	-	-	-	803.63(4)	-	640.01(6)	531.30(6)
		Av.wt./set					132.21		41.15	41.26
31-50	330	Av.No./set	-	-	-	24.48(2)	355.06(7)	244.86(7)	182.36(6)	198.20(5)
		Av.wt./set				40.47	80.35	186.71	58.35	61.46
31-50	331	Av.No./set	-	-	-	6.99(2)	305.00(2)	749.00(2)	295.77(3)	291.50(2)
		Av.wt./set				2.50	113.75	123.06	43.58	36.70
51-100	332	Av.No./set	-	-	-	-	592.25(4)	515.00(2)	435.17(4)	963.75(4)
		Av.wt./set					80.53	42.67	24.82	80.49
51-100	337	Av.No./set	-	-	-	-	357.00(2)	501.33(3)	444.66(4)	874.25(4)
		Av.wt./set					45.38	37.58	43.76	71.29
31-50	338	Av.No./set	-	33.00(3)	-	89.60(6)	289.00(6)	99.25(4)	329.58(6)	647.0(4)
		Av.wt./set		15.50		14.49	36.87	17.87	40.41	70.03
51-100	339	Av.No./set	-	-	-	-	2960.50(2)	2666.33(3)	1908.28(4)	1892.00(4)
		Av.wt./set					449.60	253.35	178.36	179.79
31-50	340	Av.No./set	-	-	-	19.79(3)	60.17(6)	38.14(7)	244.21(5)	844.75(4)
		Av.wt./set				6.09	36.87	19.16	39.37	64.53
31-50	351	Av.No./set	66.00(3)	81.33(9)	-	48.11(7)	334.25(8)	390.99(9)	70.83(7)	481.27(7)
		Av.wt./set	35.00	36.28		39.47	54.54	70.23	29.64	49.43
31-50	352	Av.No./set	-	88.62(13)	-	120.09(11)	150.14(14)	106.46(16)	112.40(16)	392.08(13)
		Av.wt./set		37.30		28.22	39.06	35.94	31.21	53.01
31-50	353	Av.No./set	-	794.00(5)	-	700.71(4)	770.33(3)	1306.00(4)	992.44(5)	889.50(4)
		Av.wt./set		51.33		145.90	108.07	113.06	132.53	85.47
51-100	354	Av.No./set	-	-	-	-	472.50(2)	692.00(3)	1334.97(3)	1760.25(4)
		Av.wt./set					80.53	82.46	103.79	115.41
Mean No./set (# sets)			65.95(3)	182.73(30)		126.60(35)	464.37(60)	444.89(60)	406.23(69)	651.57(62)
Abundance (Nos x 10^{-6})			17.7	160.9		168.9	855.4	738.1	747.7	1199.3
Mean wt./set			34.97	34.14		38.51	79.94	76.58	52.19	65.97
Biomass (t)			9.4	30.1		51.4	147.2	127.0	96.1	121.4

Table 4. Average bottom depth (m) and temperature (°C) of catches of American plaice (juveniles and adults) from the 1989-92 surveys. (standard deviation around the mean is in brackets)

Year	Division	Depth (m)	Temperature (°C)
1989	3L	114.8(33.9)	-0.7(0.7)
	3N	64.1(13.9)	1.7(2.0)
	3Ø	83.8(15.8)	1.5(2.3)
1990	3L	112.9(34.4)	-0.6(1.0)
	3N	67.4(22.5)	0.9(1.6)
	3Ø	80.5(17.1)	1.1(1.1)
1991	3L	120.0(37.5)	-1.1(0.4)
	3N	66.9(19.0)	0.7(2.2)
	3Ø	88.7(26.6)	0.9(1.9)
1992	3L	134.1(45.7)	-0.7(0.8)
	3N	68.3(28.7)	1.0(1.6)
	3Ø	89.9(24.1)	0.6(2.0)

Table 5. Division 3L abundance at age (Nos. X 10^{-6}) of plaice in the 1989-92 surveys. Revised estimates are calculated with the removal of catches in the 7 new deepwater strata.

Age	1989	1990	1991	1992	1992 Revised
1	4.1	2.2	4.1	1.8	1.8
2	84.0	28.6	63.2	157.5	148.7
3	456.9	171.4	177.5	381.2	361.9
4	486.7	476.3	405.4	450.6	423.9
5	199.7	474.9	751.0	640.4	582.9
6	223.5	198.1	450.3	369.7	308.6
7	220.2	194.3	216.5	210.8	159.4
8	238.9	180.8	103.0	103.3	71.1
9	196.2	142.1	50.9	57.9	36.7
10	70.1	77.8	42.6	21.6	15.0
11	30.2	41.9	10.9	7.1	5.6
12	13.8	19.1	6.0	5.3	4.5
13	4.1	5.7	4.7	2.6	2.3
14	1.4	1.4	2.0	1.0	1.0
15	0.5	0.6	1.8	1.0	1.0
16	0	0	0.3	0.8	0.8
17	0	0	0	0.5	0.5
Unknown	0.1	0.2	0	0	0
Total					
1+	2230.6	2015.4	2290.5	2413.1	2125.7
5+	1198.7	1336.7	1640.0	1421.0	1189.4
7+	775.4	663.7	438.7	410.9	297.9
1 to 5	1231.5	1153.3	1401.2	1631.5	1519.2

Table 6. Abundance estimates at age (Nos x 10^{-6}) from plaice catches in the depth zone 183-273 m (first sampled in 1992) during the 1992 survey.

Age	Stratum 344	Stratum 347	Stratum 366	Stratum 369	Stratum 386	Stratum 389	Stratum 391	Abundance
1	0	0	0	0	0	0	0	0
2	4.1	0.2	0.7	1.2	0.6	0.8	1.2	8.8
3	8.2	1.1	1.2	3.0	2.0	2.0	1.8	19.3
4	11.7	2.8	2.2	3.8	2.7	2.2	1.3	26.7
5	21.7	7.2	8.6	6.9	6.6	4.3	2.6	57.9
6	15.7	7.8	13.5	7.2	9.1	4.9	2.9	61.1
7	9.7	7.5	11.9	7.2	8.9	4.0	2.2	51.4
8	4.1	5.9	8.4	5.0	6.5	2.2	1.1	32.2
9	1.3	4.5	6.8	2.8	4.3	1.0	0.5	21.2
10	0.4	1.1	2.6	0.8	1.3	0.3	0.1	6.6
11	0	0.1	0.8	0.2	0.4	0	0	1.5
12	0	0	0.4	0.1	0.3	0	0	0.8
13	0	0	0.1	0	0.2	0	0	0.3
Total	76.9	38.3	57.3	38.5	42.8	21.7	13.8	287.8

Table 7. Abundance estimates at age (10^{-6}) from deepwater strata (93-183 m) on the north and northeast slopes of Division 3L from 1989-92 juvenile surveys. Percentage in brackets refers to composition of catches with the new strata added (183-273 m) from Table __.

	Stratum 348				Stratum 349				Stratum 364				Stratum 365				Stratum 370				Stratum 385				Div. 3L abundance								
Age	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992	1989	%	1990	%	1991	%	1992	%	(%)
1	0.2	0.1	0.6	0.1	0.1	0	0	0	0.3	0.4	0.4	0.4	0.1	0.3	0	0.3	0.5	0	0	0.1	2.0	0	0	0.6	4.1	81	2.2	87	4.1	49	1.8	83	83
2	9.5	0.6	8.0	15.3	3.9	0.2	2.2	1.5	14.2	7.1	14.3	35.6	14.3	0.7	2.7	15.0	14.5	2.2	1.4	13.1	19.3	0	3.0	39.6	84.0	90	28.6	94	63.2	59	157.5	76	82
3	53.8	6.8	31.6	36.4	31.0	1.2	10.0	5.3	109.0	46.2	28.1	84.6	58.8	5.8	66.1	33.5	79.0	11.0	5.3	33.8	84.4	0.4	26.0	103.6	456.9	91	171.4	93	177.5	77	381.2	78	83
4	63.4	25.7	85.7	38.5	40.6	6.4	28.6	7.8	117.1	169.1	71.6	102.3	53.8	21.3	289.0	40.3	79.4	29.0	13.5	40.8	70.9	0.8	71.1	133.3	486.7	87	476.3	92	405.4	83	450.6	81	87
5	42.1	35.2	177.4	45.6	19.5	15.5	57.9	13.6	40.2	197.1	136.0	162.1	21.7	27.9	519.8	55.2	21.7	33.3	28.0	54.6	23.4	0.5	134.2	158.2	199.8	84	474.8	91	751.0	84	640.4	76	86
6	51.5	24.0	120.0	18.9	32.5	12.7	40.2	10.4	36.5	70.8	70.4	95.3	21.2	14.8	44.3	21.8	15.5	16.9	20.5	24.1	23.8	0.2	69.7	48.1	223.5	81	198.1	90	450.3	81	369.7	59	76
7	51.6	28.1	44.5	7.9	44.9	19.5	23.9	7.3	24.5	66.2	40.8	47.1	15.8	13.5	4.0	7.3	9.2	19.8	10.2	9.9	17.3	0.1	20.7	11.7	220.2	76	194.3	90	216.5	71	210.8	43	68
8	45.1	25.8	14.1	3.2	66.9	25.1	9.8	4.4	34.1	61.9	24.5	17.2	11.5	8.2	1.1	2.1	7.4	19.8	4.9	3.2	12.8	0	7.2	2.3	239.0	75	180.8	87	103.0	66	103.3	31	63
9	24.2	18.5	3.8	1.5	49.1	19.5	2.8	2.5	27.6	48.3	12.7	7.4	5.5	5.2	0.5	1.1	7.1	14.7	2.2	1.9	10.3	0	3.6	1.1	196.2	63	142.1	81	50.9	56	57.9	27	63
10	5.8	6.5	2.1	0.3	9.1	7.2	1.6	0.6	9.0	29.0	9.1	1.8	1.5	2.7	0.3	0.2	3.1	6.6	1.6	1.0	4.9	0	2.8	0.4	70.1	48	77.8	71	42.6	45	21.6	20	51
11	1.7	2.2	0.3	0	2.2	2.6	0.3	0	2.7	15.4	1.2	0.4	0.9	0.6		0	1.3	2.5	0.3	0.4	1.7	0	0.6	0.1	30.2	35	41.9	58	11.0	25	7.1	13	34
12	0.7	0.9	0.1	0	1.2	0.7	0.2	0	0.9	6.7	0.6	0.3	0.2	0.5		0	0.4	0.7	0.1	0.2	0.8	0	0.4	0	13.8	30	19.1	53	6.0	22	5.3	9	25
13	0.2	0		0	0.4	0	0	0	0	1.5	0.4	0.1	0	0		0	0.1	0.2		0	0.2	0	0.2	0	4.1	24	5.7	33	4.7	15	2.6	4	15
14	0	0		0	0	0	0	0	0	0.3	0.2	0	0	0		0.1	0	0		0	0	0		0	1.4	13	1.4	22	2.0	15	1.0	10	10
15	0	0		0	0	0	0	0	0	0	0.2	0	0	0		0.1	0	0		0	0	0		0	0.5	4	0.6	9	1.8	11	1.0	10	10
16	0	0		0	0	0		0	0	0		0.1				0				0				0.2					0.3	0	0.8	38	50
17				0			0	0				0				0				0				0.2							0.5	40	40
Total	350.4	174.4	488.2	168.0	301.4	110.7	177.7	53.5	421.2	719.9	410.7	554.8	205.2	101.5	3123.0	177.3	239.3	156.6	88.2	183.3	271.9	2.0	339.5	499.6	2230.5		2015.4		2290.5		2413.1	68	80

Table 8. Division 3N abundance at age (Nos. x 10^{-6}) of plaice in the 1989-92 surveys.

Age	1989	1990	1991	1992
1	52.5	35.2	42.5	4.0
2	254.1	78.5	215.2	55.3
3	405.6	129.5	172.1	93.5
4	332.5	192.0	104.4	74.9
5	94.5	143.8	124.2	60.2
6	35.4	39.0	61.9	43.9
7	13.4	20.0	13.3	24.4
8	9.7	13.9	4.1	12.3
9	5.8	14.0	5.5	5.6
10	6.7	12.0	4.2	4.5
11	5.6	9.9	4.1	2.5
12	2.9	7.3	2.7	1.6
13	2.1	5.0	1.7	1.6
14	0.8	3.9	0.9	1.3
15	0.2	1.5	2.0	1.3
16	0	0.6	1.3	0.4
17	0	0.2	0.4	0.3
18			0.2	0.2
19	0	0	0	0.1
Unknown	0.1	0	0	0
Total				
1+	1221.9	706.3	760.6	387.9
5+	177.1	271.0	226.5	160.2
7+	47.2	88.1	40.4	56.1
1 to 5	1139.1	579.0	658.4	287.9

Table 9. Abundance at age (Nos. x 10^{-6}) for Stratum 360 from surveys in 1986-92.

Age	1986	1987	1988	1989	1990	1991	1992
1	165.4	95.2	10.1	48.9	29.1	20.9	1.7
2	144.9	144.1	100.5	212.8	58.5	140.5	25.6
3	127.1	58.1	172.3	327.7	93.2	120.0	42.6
4	53.4	21.8	73.9	275.9	137.1	72.3	41.6
5	19.9	4.7	26.6	77.3	97.4	84.1	30.9
6	25.2	3.5	8.3	24.6	23.6	39.6	18.2
7	11.6	1.5	4.8	5.2	7.9	6.3	8.2
8	4.7	0.7	3.5	2.3	3.5	1.1	3.6
9	1.8	0.4	1.3	0.9	1.4	0.9	1.3
10	1.1	0.2	0.6	0.8	0.7	0.4	0.6
11	0.7	0.2	0.6	0.6	0.4	0.4	0.4
12	0.6	0.2	0.4	0.5	0.2	0.2	0.2
13	0.5	0.2	0.4	0.4	0.2	0.2	0.2
14	0.3	0.2	0.2	0.2	0.2	0	0
15	0.2	0	0	0	0	0.2	0.1
16	0	0	0	0	0	0.2	0
17	0	0	0	0	0	0	0
Total							
1+	557.7	331.7	403.5	978.3	453.6	487.4	175.2
5+	66.6	11.8	46.7	112.8	135.5	133.6	63.7
7+	21.5	3.6	11.8	10.9	14.5	9.9	14.6
1 to 5	510.7	323.9	383.4	942.6	415.3	437.8	142.4

Table 10. Location of fishing sets made in stratum 360 of Division 3N showing the distribution of catches below 43.26N. Catches refer to catch numbers per set.

Year	No. sets	No. sets Below 43.26N	Catches 1000-2000	Catches > 2000
1992	16	2	0	1
1991	18	9	3	6
1990	21	12	5	4
1989	19	9	1	4

Table 11. Abundance estimates at age (Nos x 10^{-6}) from plaice catches on the "Tail of the Bank" (Strata 358, 359, 376, 360) during 1989, 1990, 1991, and 1992 juvenile surveys (stratum 358 first sampled in 1992). Revised percentage estimates are with Strata 358 and 376 catches removed which makes the 1992 estimates comparable to 1989-91.

	Stratum 360				Stratum 359				Stratum 358	Stratum 376	Div. 3N total abundance								%
Age	1989	1990	1991	1992	1989	1990	1991	1992	1992	1992	1989	%	1990	%	1991	%	1992	%	Revised
1	49.0	29.0	20.9	1.7	0.6	3.5	5.1	0	0	1.3	52.5	95	35.2	93	42.5	61	4.0	76	43
2	212.8	58.5	141.4	25.6	19.3	3.8	26.2	2.0	1.1	10.8	254.0	91	78.5	79	215.2	78	55.3	70	52
3	327.8	93.2	120.0	42.6	47.2	9.1	18.4	4.6	1.9	16.8	405.6	93	129.5	79	172.1	80	93.5	69	53
4	275.9	137.1	72.3	41.6	29.5	13.7	9.8	1.9	1.1	12.1	332.5	92	192.0	79	104.4	79	74.9	75	60
5	77.3	97.4	84.1	30.9	5.9	8.4	12.4	1.8	0.6	8.5	94.5	88	143.8	74	124.2	78	60.2	68	55
6	24.6	23.6	39.6	18.2	1.9	1.2	3.2	1.4	0.5	5.9	35.4	75	39.0	64	61.9	69	43.9	55	46
7	5.2	7.9	6.3	8.2	0.5	0.3	0.4	0.5	0.3	3.3	13.4	42	26.0	32	13.3	50	24.4	61	37
8	2.3	3.5	1.1	3.6	0.1	0.1	0	0.2	0.1	1.8	9.7	25	14.0	27	4.1	29	12.3	59	32
9	0.9	1.4	0.9	1.3	0	0	0	0	0	0.7	5.8	17	14.0	10	5.5	18	5.6	55	23
10	0.8	0.7	0.4	0.6	0	0	0	0	0	0.5	6.7	12	12.0	6	4.2	12	4.5	31	13
11	0.6	0.4	0.4	0.4	0	0	0	0	0	0.3	5.6	11	9.8	4	4.1	10	2.5	36	16
12	0.5	0.2	0.2	0.2	0	0	0	0	0	0.3	3.0	17	7.3	3	2.7	7	1.6	31	13
13	0.4	0.2	0.2	0.2	0	0	0	0	0	0.3	2.1	17	5.0	3	1.7	12	1.6	25	13
14	0.2	0.2	0	0	0	0	0	0	0	0.1	0.8	22	3.9	5	0.9	0	1.3	23	0
15			0.2	0.1			0	0	0	0.2	0.2	23	1.5	5	2.0	10	1.3	17	8
16			0.2	0			0	0	0	0			0.5	2	1.3	15	0.4	0	0
17			0	0				0	0	0					0.4	0	0.3	0	0
18			0	0				0	0	0					0.2	0	0.2	0	0
19				0				0	0	0							0.2	0	0
Total	978.3	453.6	487.4	175.2	105.1	40.2	75.7	12.7	5.9	63.5	1221.9		706.3		760.6		387.9		

Table 12. Division 3Ø abundance at age (Nos. x 10^{-6}) of plaice in the 1989, 1990, 1991, and 1992 surveys.

Age	1989	1990	1991	1992
1	83.7	41.2	2.8	8.0
2	110.5	138.3	163.0	228.6
3	200.7	80.5	140.3	320.7
4	141.3	159.9	91.3	254.1
5	72.7	107.8	151.2	137.8
6	57.2	44.5	83.2	124.8
7	57.7	32.5	32.5	58.5
8	36.5	24.0	36.2	25.8
9	34.2	17.1	11.4	15.5
10	22.3	15.7	11.6	8.7
11	18.8	12.8	6.6	4.9
12	10.0	9.4	3.7	3.8
13	3.9	5.5	3.1	2.3
14	3.3	2.6	1.6	2.1
15	1.8	1.1	2.2	0.7
16	0.7	0.5	1.7	1.0
17	0.2	0	1.4	0.9
18	0	0	0.2	0.5
19	0	0	0.3	0
Total				
1+	855.6	693.5	744.3	1198.5
5+	319.4	273.5	346.9	387.3
7+	189.4	121.2	112.5	124.7
1 to 5	608.9	527.8	548.6	949.2

Table 13. Abundance estimates at age (Nos x 10^{-6}) from plaice catches on the "Tail of the Bank" (Strata 353, 354) and Whale Deep area (Strata 339, 329) during 1989, 1990, 1991, and 1992 juvenile surveys. (NS = no survey)

	Stratum 329				Stratum 339				Stratum 353				Stratum 354				Div. 3Ø total abundance							
Age	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992	1989	%	1990	%	1991	%	1992	%
1	10.6		0.4	1.2	39.2	6.8	0.3	1.7	4.0	11.4	0	0.2	0.5	0.9	0	0	83.7	63	41.3	46	2.8	32	8.0	39
2	21.0		31.3	23.3	25.0	42.3	18.7	25.1	5.1	26.6	33.9	18.6	1.1	3.4	16.4	14.4	110.5	47	138.3	52	163.0	62	228.6	36
3	31.4		26.3	30.5	34.0	23.4	28.6	32.6	25.9	16.1	20.2	28.1	6.1	3.0	9.9	27.0	200.7	49	80.5	53	140.3	61	320.7	37
4	20.6		14.9	19.4	15.8	40.7	14.3	22.2	28.5	37.9	17.9	27.7	7.0	9.8	9.6	22.5	141.3	51	160.0	55	91.3	62	254.1	36
5	10.6		22.7	10.7	12.2	21.9	24.4	11.7	14.8	29.4	29.8	17.3	3.1	9.5	16.5	11.4	72.7	56	107.8	56	151.2	62	137.8	37
6	11.9		11.6	6.5	12.5	10.4	16.1	10.1	9.7	10.4	13.2	17.4	1.8	3.3	7.2	9.0	57.3	63	44.5	54	83.2	58	124.7	35
7	13.5		3.5	2.5	14.2	7.7	5.5	5.6	8.3	6.7	5.7	7.5	1.9	2.1	3.1	3.1	57.8	66	32.5	51	32.5	55	58.5	32
8	9.3		3.6	1.0	10.8	5.1	5.7	3.3	3.4	3.4	6.1	2.3	0.7	0.9	3.3	0.8	36.5	67	24.0	39	36.2	52	25.8	29
9	9.2		1.1	0.6	10.4	2.7	1.8	2.4	2.3	1.8	1.3	1.0	0.6	0.4	0.6	0.2	34.2	66	17.1	29	11.4	42	15.5	27
10	5.3		0.8	0.4	6.3	1.7	1.8	1.4	0.8	1.1	1.0	0.5	0.3	0.2	0.3	0.1	22.3	57	15.7	19	11.6	34	8.7	28
11	2.8		0.3	0.2	3.6	0.8	0.9	0.8	0.4	0.7	0.5	0.2	0.2			0	18.8	37	12.8	12	6.6	26	4.9	25
12	0.7			0.2	1.1	0.5	0.3	0.5	0.4	0.2	0.2	0.1	0.1			0	10.0	23	9.4	8	3.7	16	3.8	21
13				0.1	0.3		0.1	0.2	0.3	0.4	0.2	0	0			0	3.9	21	5.5	7	3.1	13	2.3	13
14				0.3	0.5		0.0	0	0.4	0.2	0.3	0	0			0	3.3	33	2.6	8	1.6	25	2.1	14
15				0.1			0.1	0	0.5	0	0.8	0	0.1			0	1.8	39	1.1	9	2.2	41	0.7	14
16				0.1				0	0.1	0	0.7	0	0			0	0.7	29	0.5	0	1.7	47	1.0	10
17				0				0			0.7	0	0			0					1.4	57	0.9	0
18				0				0			0	0	0			0					0.2	0	0.5	0
Total	146.9	N.S	116.7	97.2	184.2	163.9	118.8	117.7	105.2	146.4	132.9	121.2	23.8	33.7	67.3	88.7	855.7		693.5		744.3		1198.5	

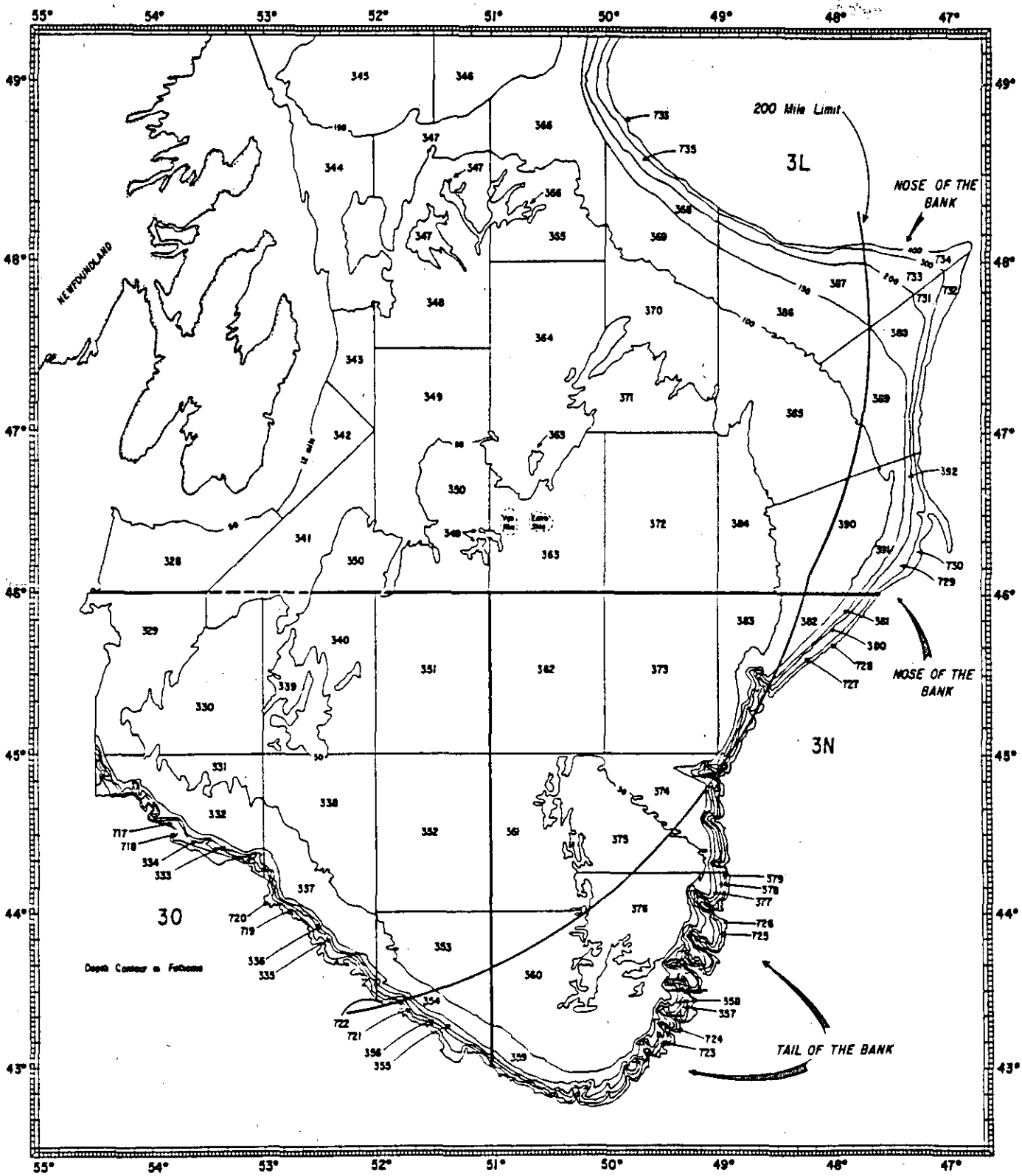

Fig.I. Depth stratification chart of the Grand Bank, NAFO Div. 3LNO

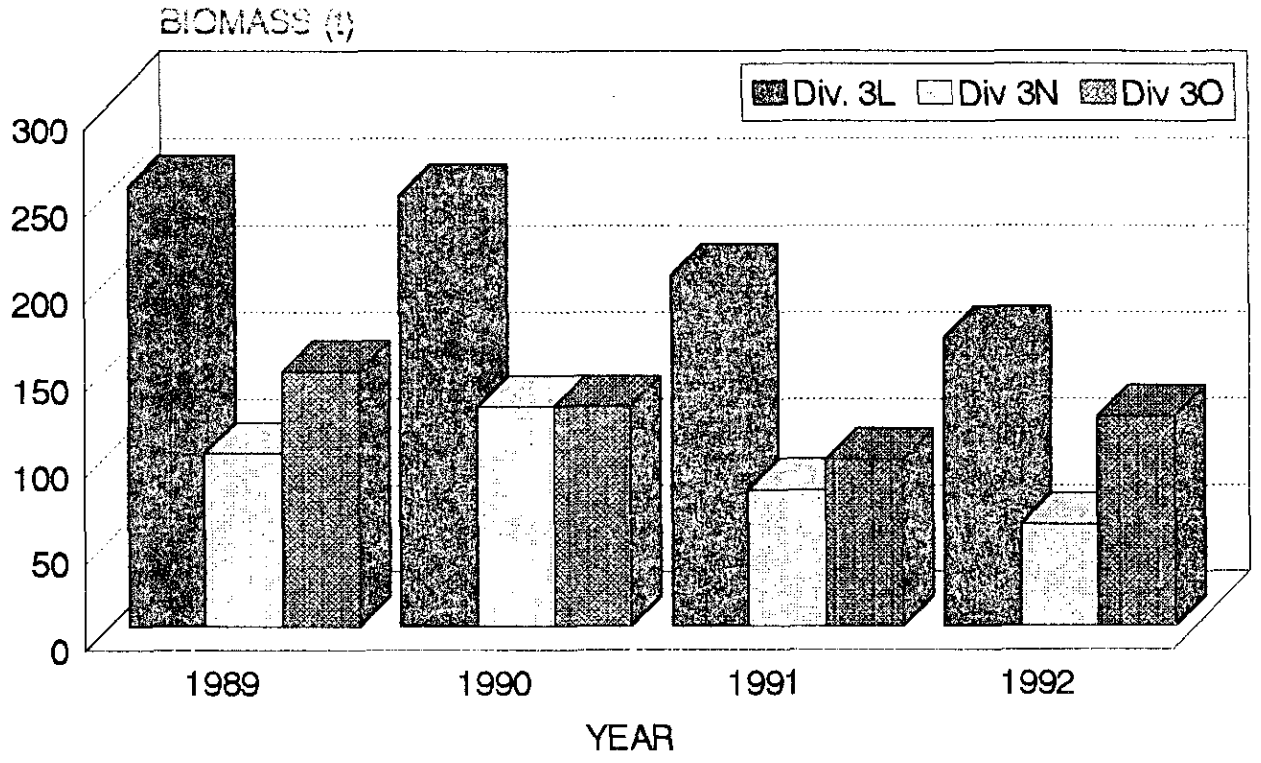

Fig. 2 Biomass of plaice derived from 1989-92 juvenile surveys

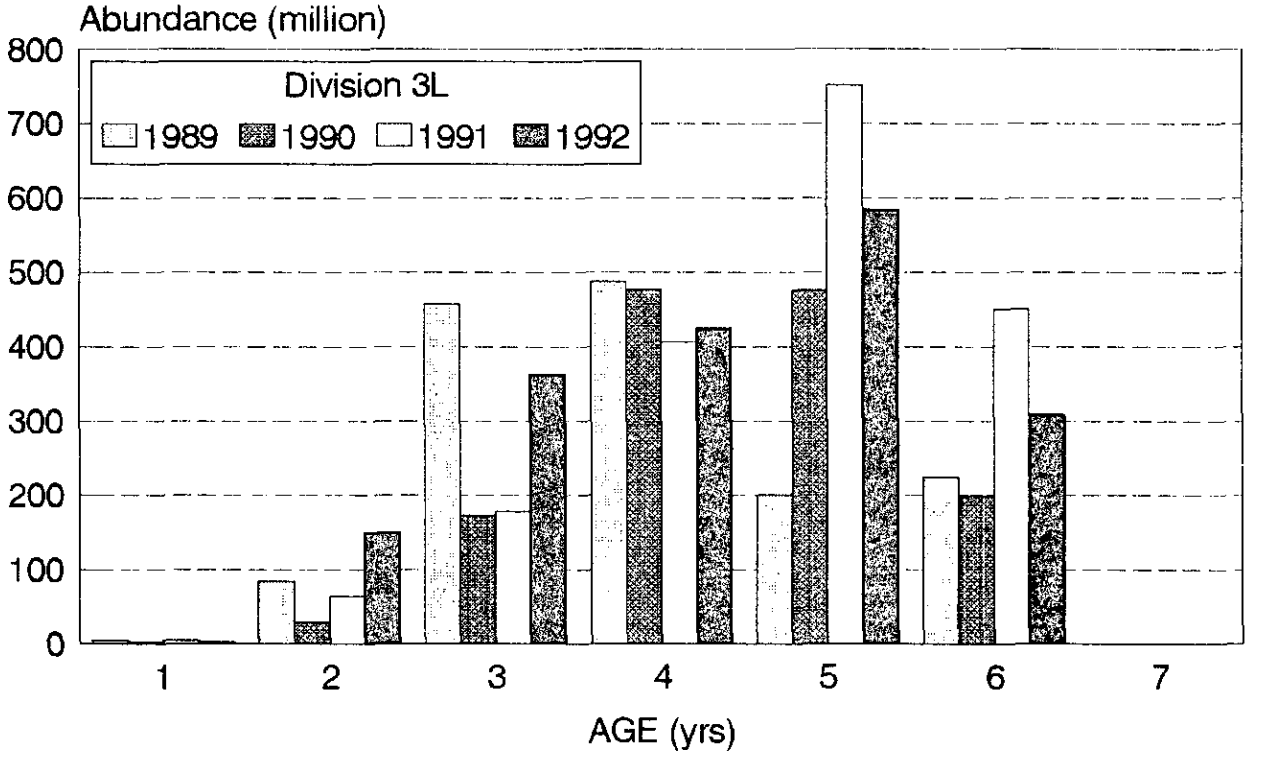

Fig 3. 1989-92 abundance at age estimates of juvenile plaice in Div. 3L

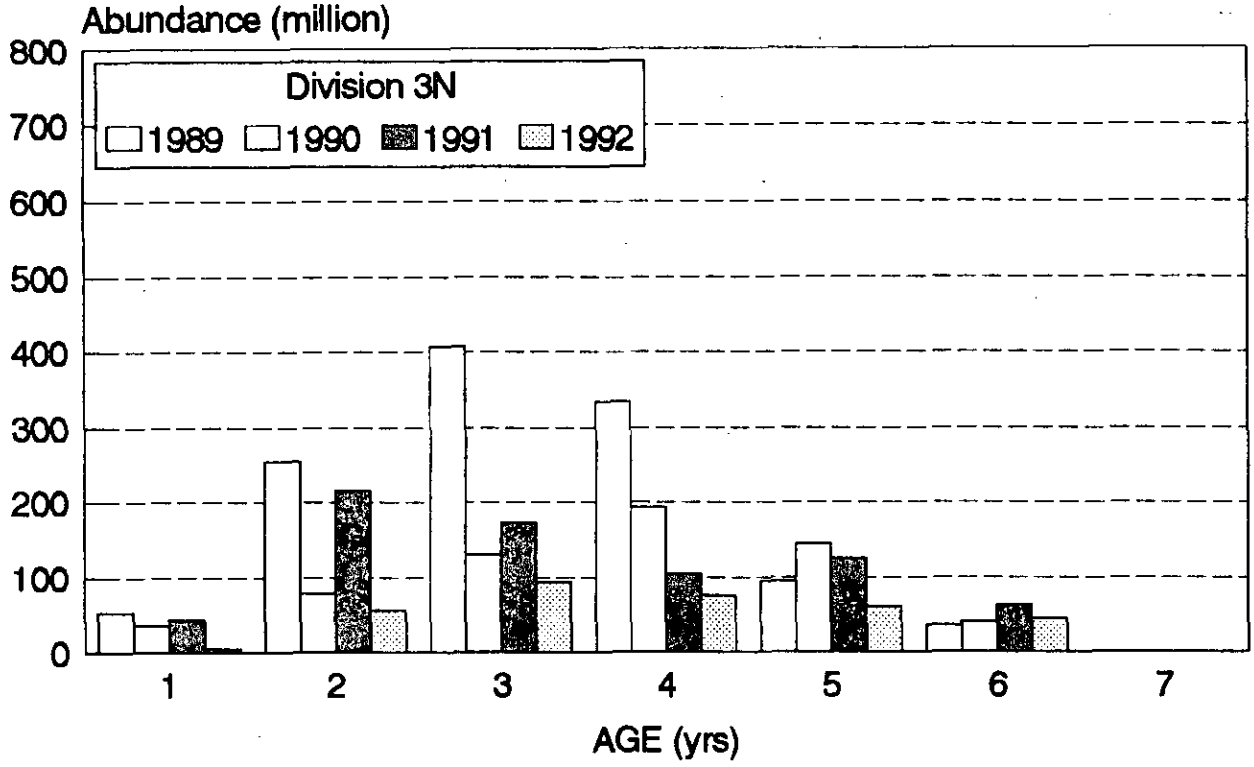

Fig 4. 1989-92 abundance at age estimates of juvenile plaice in Div. 3N

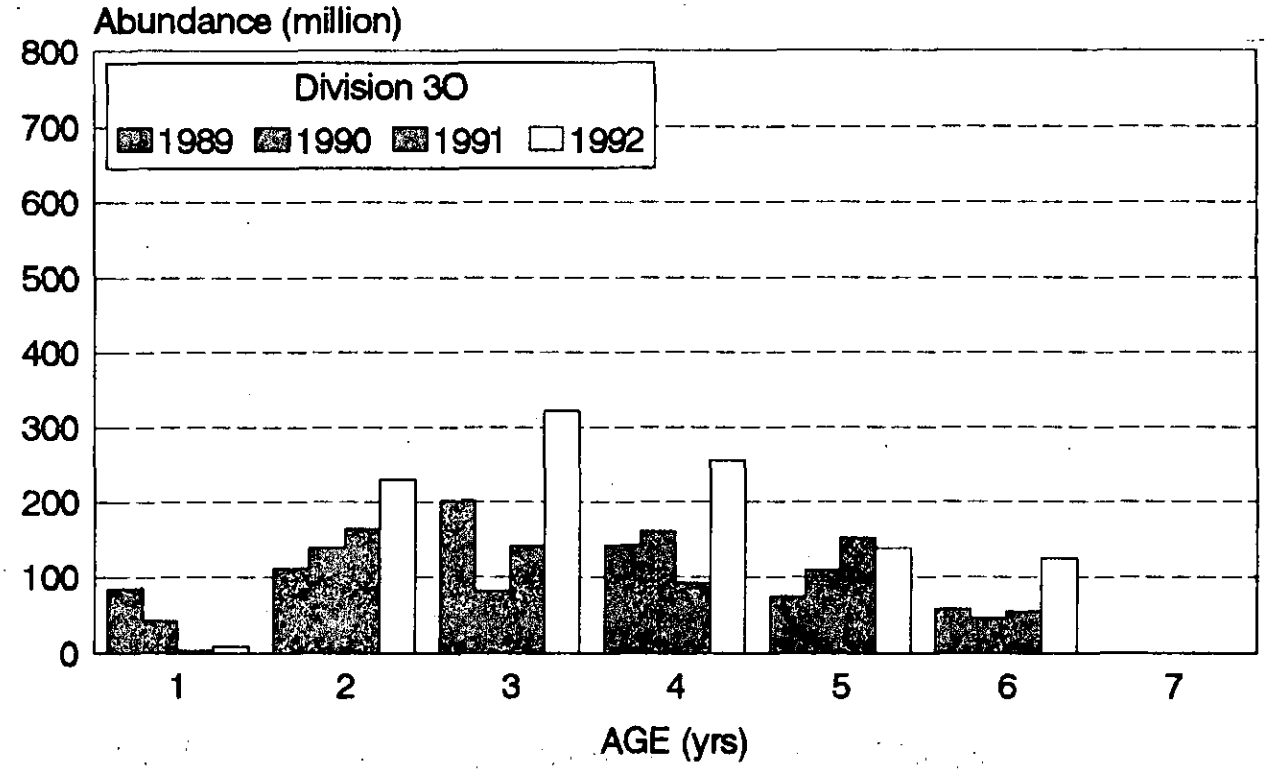

Fig 5. 1989-92 abundance at age estimates of juvenile plaice in Div. 3O

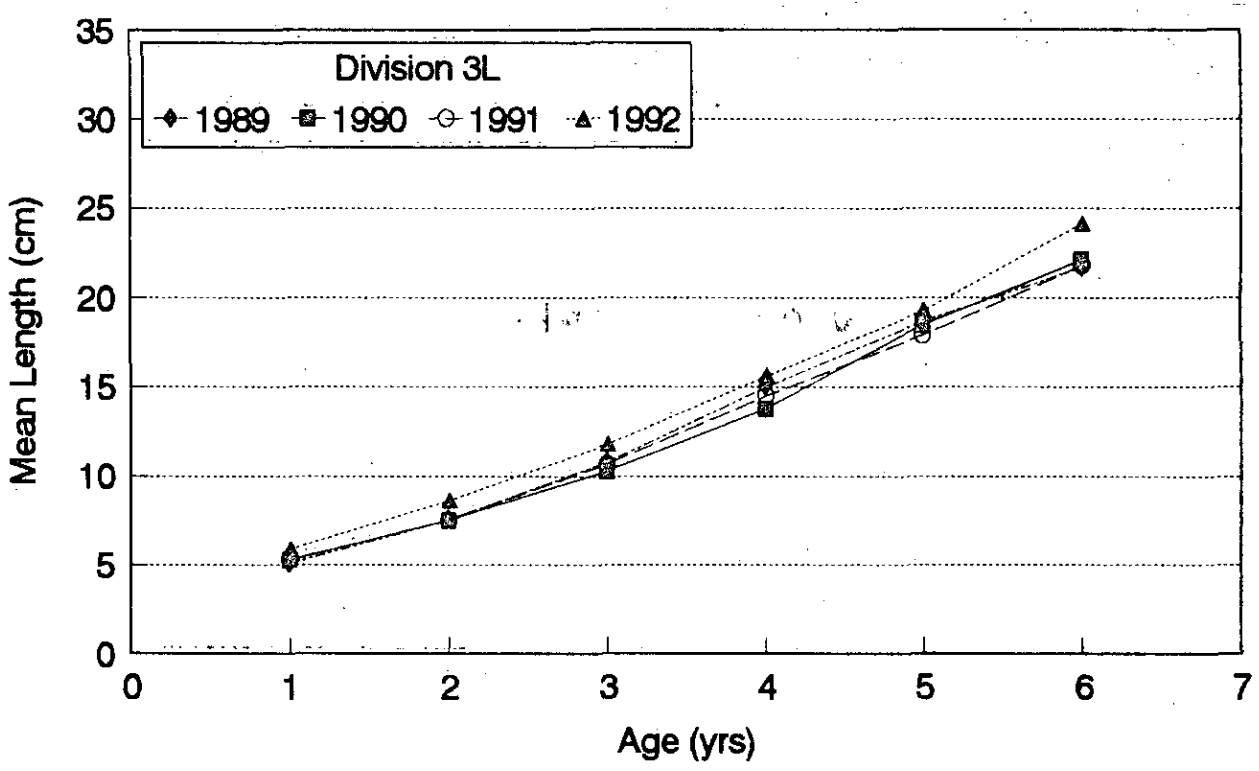

Fig. 6. Mean length at age of juvenile plaice from 1989-92, Div 3L

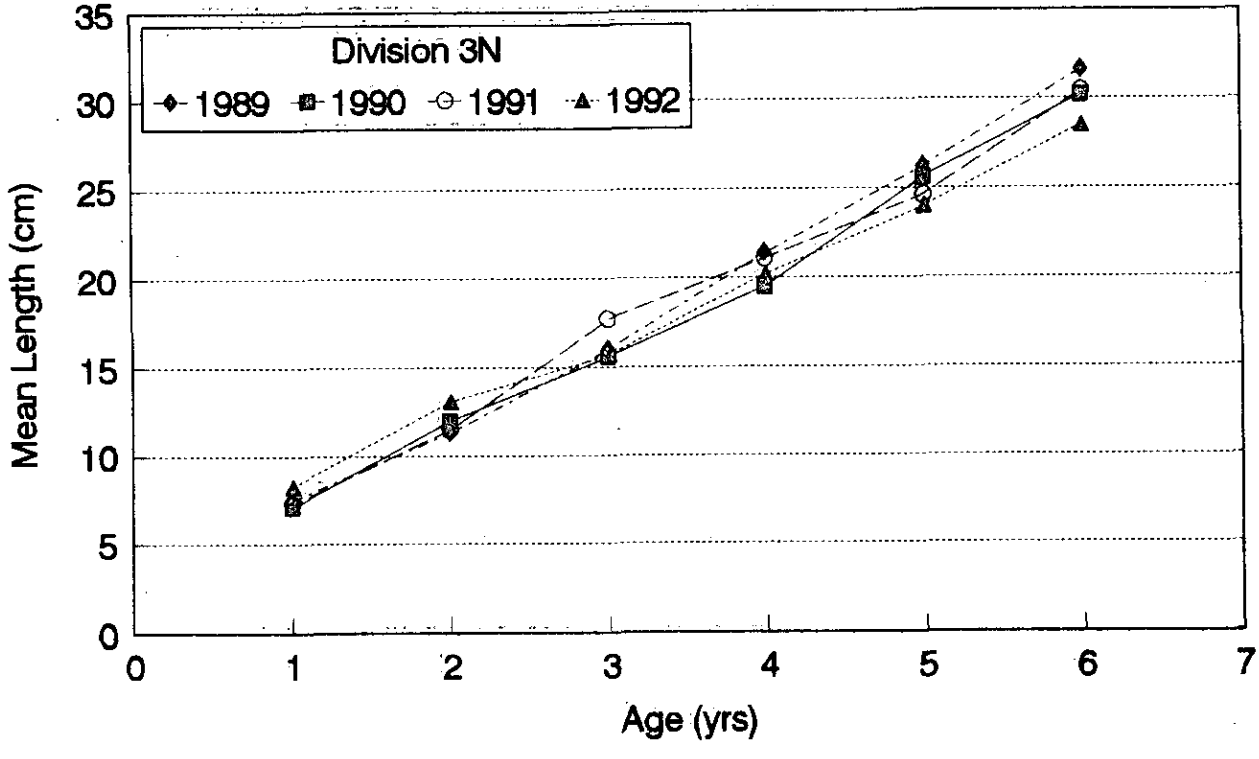

Fig. 7. Mean length at age of juvenile plaice from 1989-92, Div 3N

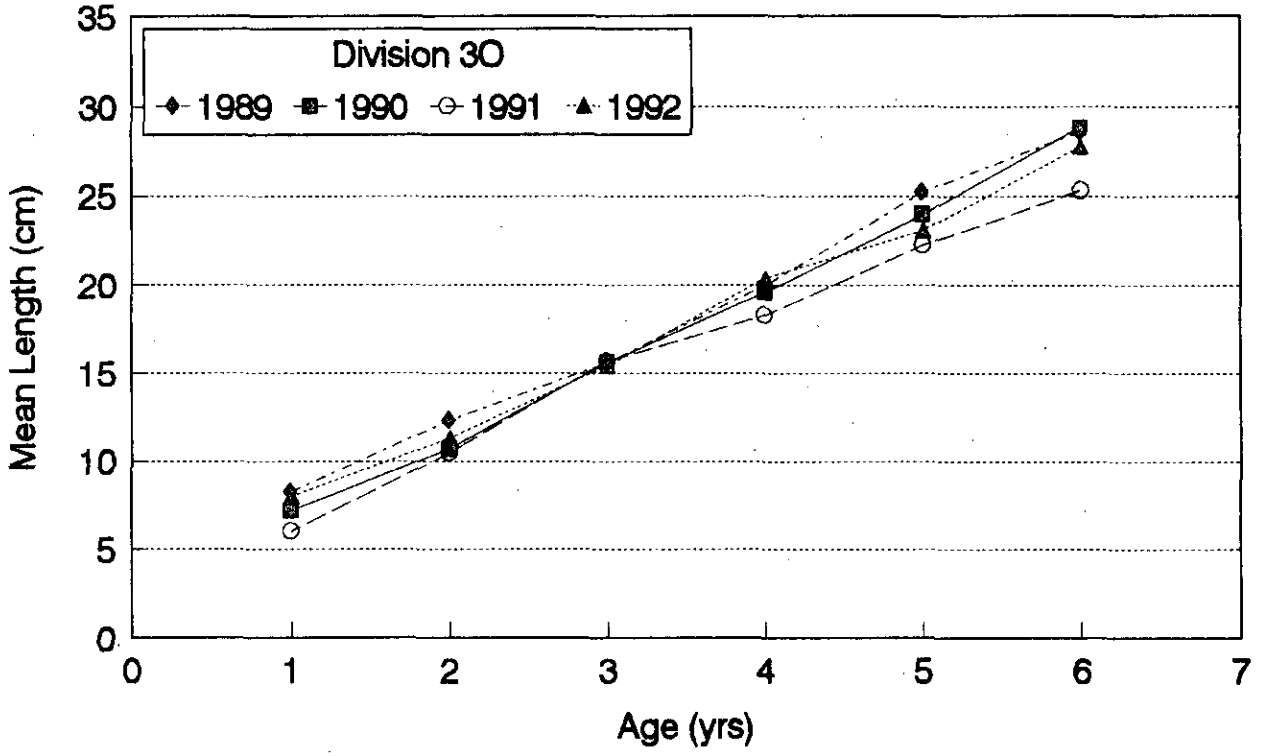

Fig. 8. Mean length at age of juvenile plaice from 1989-92, Div 3O