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Abundance and Biomass of American Plaice Populations on the Grand Banks
as Derived from the Juvenile Groundfish Surveys, NAFO Divisions 3LNO

by

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Introduction

American plaice, *Hippoglossoides platessoides*, also known as long rough dab in the Northeast Atlantic waters, is an arcto-boreal right eyed flounder (*Pleuronectidae*) inhabiting the continental shelf on both sides of the North Atlantic. Its distribution approximates the range of cod *Gadus morhua*. In the western side of the North Atlantic, where it is the most abundant flatfish, it ranges (42°-74° N) northeast from the Gulf of Maine and Georges Bank area along the Scotian Shelf, into the Gulf of St. Lawrence, St. Pierre Bank, the Grand Bank and Flemish Cap and northward along the Northeast Newfoundland and Labrador shelf to Baffin Island and West Greenland (Bigelow & Schroeder, 1953; Scott & Scott, 1988).

In the Northwest Atlantic there has been a major fishery for this species, as early as the 1940's, occurring mainly on the Grand Bank, southern Gulf of St. Lawrence and Georges Bank and has expanded during the 1970-80's to include the Flemish Cap, St. Pierre Bank and Nova Scotian Shelf as other traditional demersal stocks declined. (Walsh, 1994a). In the last decade stocks on St. Pierre Bank, Grand Bank, Flemish Cap, southern Gulf of St. Lawrence and the Gulf of Maine/Georges Bank have been heavily exploited at levels which have reduced stock size considerably while other stocks in the area are considered moderately exploited. (Bowering & Brodie, 1991; Walsh 1994a)

Walsh (1991) identified three possible oceanic nursery areas for American plaice on the Grand Bank and these areas are also the same areas where the commercial fishery, by both Canadian and non-Canadian vessels, takes place. This paper will report on the results of the 1989-94 surveys and compare distribution of juvenile plaice with earlier surveys conducted since 1985. It will focus mainly on the time period 1989-94 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 1993 the stratified-random trawl survey for juveniles consisted of 48 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 were 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. Expanding symbol plots, using ACON software (Black 1993), were used to show distribution of standard catch per tow of plaice on the Grand Bank.

Survey gear and time

The survey gear is a two-bridle Yankee 41 shrimp trawl with a mesh size of 38 mm throughout and equipped with a 12-mm stretched mesh liner in the codend (Fig. 2). The groundgear was rigged with 30-cm rubber rollers in the bostum, 30-cm rubber bunts in the quarters, and 11-cm rubber discs in the wing ends (Fig. 3). 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. Prior to 1989, a surface-to-bottom temperature profile was taken, at each station, with an XBT (Expendable Bathythermograph) and since 1989, a trawl mounted CTD system has been used. Bottom depth was recorded from sounder records. The surveys were generally conducted from mid- August

to mid-September 1985-86, 1988-93, September-October in 1994, and November 1-13 in 1987 aboard the R. V. WILFRED TEMPLEMAN, a 50-m stern trawler. Sixteen hundred and eighty-two (1682) successful fishing hauls were made during the combined period of 1985-94.

All of the catch was sorted by species and weighed. All American plaice were measured to the nearest centimetre (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. No age data was available for the 1994 survey

Results and Discussion

Distribution

Catches

The surveys from 1989 to 1994 cover the area of the Grand Bank out to a maximum of 274 meters (150 fath.). Figs. 4&5 shows the distribution of catch in numbers and weight per standard tow from 1989-94 for all NAFO Divisions.

1994 survey

In Division 3L, catches were distributed across the bank in a depth range of 62 to 260 m (mean = 141 m, sd=51.7) and a temperature range of -1.6°C (mean = -0.8° ; sd=0.8), similar to distribution since 1992 when surveys covered out to 274 m (Table 1). Concentrations were found mainly on the northern and northeastern slopes of the bank (Figs. 4&5).

In Division 3N, the population was distributed over most of this area of the bank in a depth range of 43 to 241 m (mean=83 m; sd 48.7) and a temperature range of -1.5 to 4.5°C (mean= 0.7° ; sd=1.9) (Table 1). Concentrations were found mainly on the "Tail of the Bank", in the Regulatory Area (Figs. 4&5).

In Division 3O, the population was distributed over the bank in a depth range of 66 to 223 m (mean = 94 m, sd=33.2) and a temperature range of -1.5 to 6.4°C (mean= 0.9° ; sd =2.0) (Table 1). Concentrations were located in the Whale Deep Area (Fig. 1), a deepwater basin on the western side, along the southwest slope and the "Tail of the Bank" in the Regulatory Area of this Division (Figs. 4&5).

In the summary, the northern population (Div. 3L) was concentrated in colder and deeper waters than the southeastern (Div. 3N) and southwestern populations (Div. 3O) which were concentrated in shallower and slightly warmer waters (above 0°C). From Table 1 it can be seen that this species appears to have a wide temperature and depth range. Milinsky (1944) described this species as being both eurybathic and eurythermal. In the North Atlantic it occurs in depths of 20-1300 meters in a temperature range of -1.5°C to 13.0°C (Walsh, 1994a). Morgan (1992) demonstrated that plaice in tanks can survive in water as cold as -1.4 to -1.5°C . Perry et al. 1988 classified plaice on the Scotian Shelf as a temperature seeker and would change depths when it found itself in unfavourable temperatures. Generally, average depth preference of this species in the North Atlantic seems to be in the 100-300 meter range (Milinsky, 1944; Isaksen, 1977; Scott and Scott, 1988; Bowering and Brodie, 1991). American plaice are considered to be relatively sedentary, with limited migrations associated with spawning and feeding (Milinsky, 1944; Pitt, 1969; Simacheva & Glukhov, 1986) and also movements have been documented in response to changes in temperature (Powles, 1965; Morgan & Brodie 1991).

Abundance and Biomass 1994

DIV. 3L

The average catch (numbers and weights) abundance and biomass of American plaice catches in Division 3L derived from the 1985-94 juvenile surveys are presented in Table 2. In the 1994 survey, plaice (juveniles and adults) were concentrated mainly on the north and northeast slope (Figs. 4&5). Highest average catches, were found on the north and northeastern slopes in strata 364, 365, 366, 369, 370, 371, 384, and 385 where average numbers ranged from (900 to 2200 fish). Average weights per tow in several strata showed an increase since 1993.

The abundance estimate of 759 million fish, in 1994, was 18% higher than the 1993 estimate. Fig. 6, shows that the population is somewhat stable, however, it must be kept in mind that estimates, prior to 1992, did not include the deep water strata in 183-274 m depth range, where a large proportion of the resource is located. Correspondingly, there was a 28% increase in biomass from 1993 to 1994 (Fig. 7).

DIV. 3N

The highest average catch in numbers and weights, in 1994, were concentrated in the Regulatory Area, along the "Tail" of the bank and the southeastern edge similar to results in the 1993 surveys (Table 3: Figs. 4&5).

Noteworthy, is the large average catch in stratum 360, in the Regulatory Area, which is 3.5 times higher in both the 1993 and 1994 surveys, when compared to 1992, but comparable to the earlier 1986-91 estimates. The low average catch in 1992, in this stratum, was due to insufficient sampling as a result of expanding the overall survey and survey design (see Walsh, 1993 for details).

The 1994 abundance estimate was 8% higher (486 million fish) than the 1993 estimate and, with the exception of the 1992 point, the estimates show some stability since 1990 (Table 3; Fig 6). Note that this time series is considered to be representative of the population since there have been only a few extra deepwater strata added since 1993. In 1994, the biomass estimate of 137.6 thousand tons was 8% higher than the 1993 estimate.

DIV. 30

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; Fig 1) and strata 353 and 354, in the Regulatory Area, consistent with the 1989 to 1993 surveys (Table 4; Figs. 4&5). Although the abundance estimate of 568 million fish in the 1994 survey showed a 10% decrease, there appears to be some relative stability in the 1989-93 estimates (Fig. 4). With the exception of the 1991 estimate, there appears also to be a stable trend in the biomass estimates since 1989, with the 1994 estimate being 141.3 tons. (Fig. 7)

Age Composition

The age composition of the 1993 survey, which was unavailable in the 1994 assessment of this stock (Walsh 1994b), is presented in Tables 5-8. No age data is available for the 1994 survey.

In Div. 3L, the abundance of juveniles (age 1 to 5) from 1992-1993 showed minor fluctuations in size averaging around 1500 million fish, however there has been a continuous decline in the number of older fish (age 5+ and 7+) (Table 6). The 1985 and 1986 year classes contributed 79% of the age 7+ fish. Similar declines in older fish were seen in the spring and fall regular groundfish surveys (Morgan and Brodie 1995). Recruitment estimates of the 1989 and 1990 year classes appeared to be promising being second and first in abundance at age in the time series.

In Div 3N, the abundance of juveniles in 1993 at 552 million fish was close to the 1990 and 1991 estimates but below the 1989 estimate (Table 6). The 1992 estimate was considerably lower than any other in the time series and, as mentioned above, this was due to insufficient sampling in stratum 360 of the nursery area, as a result of expanding the overall survey and survey design. There was a continuous decline in the number of older fish (age 7+) in the population, similar to the trends in the spring and fall regular groundfish surveys. Moderate recruitment is expected from the 1988-89 year classes, which also appear strong in estimates of stratum 360 in the nursery area (Table 7). Noteworthy is that the 1985 and 1986 year classes contributed 73% of the age 7+ abundance.

In Div. 3O, the abundance of juveniles (773 million fish) has decreased from the high 1992 estimate by 19% and but was closer to the 1989-91 estimates (Table 8). The decline in the number of older fish was not apparent here, with the 1993 estimate being 19% higher than the 1992 estimate. Moderate recruitment is expected from the 1988-89 year classes. Noteworthy is that the 1985 and 1986 year classes contributed 79% of the age 7+ abundance

Length composition

In the absence of age data for the 1994 survey, length compositions of the last 3 surveys, 1992-94 are represented by Division in Fig. 8. Peaks appear to coincide with the 1993 age estimates of pre-recruits with no apparent high estimate of recruitment for age 1 plaice.

Summary

Juvenile flatfish surveys of the Grand Bank, NAFO Divisions 3LNO from 1985-1989 showed that the distribution of juveniles (ages 1 to 4 yrs) and adults overlapped extensively (Walsh 1991; 1994b). In 1994, on the northern Grand Bank, juveniles (1000 + fish per standard tow) were found, in each year, to be concentrated on the northern and northeastern slope of this area of the bank. In the southern Grand Bank juveniles were concentrated in the Regulatory Area of Division 3NO. The Whale Deep area of Div. 3O also contain dense concentrations of juveniles. These results confirm earlier descriptions of distribution and abundance.

This discontinuity in the distribution of juveniles and as well in adults may suggest that, at least for the northern Grand Bank and the "Tail of the Bank", there are two distinct stocks which recruit from separate nursery areas (Bowering and Brodie 1991). Further evidence to support this separation is that there is no synchrony in year class strength when you cross correlate estimates of age 4 recruits from the standard Canadian groundfish indices from the spring period, 1971 to 1992 (Walsh, 1994c). Lack of synchrony means that strong year classes in one stock do not always show up in another adjacent stock. Interestingly enough is

that synchrony in year class strength was found between Div 3O and Div. 3L but not 3N. Different oceanographic regimes in these areas may play the key role in the dynamics of populations on the Grand Bank. Further investigation is required because if there is more than one stock on the Grand Bank than new strategies may be necessary to manage this resource.

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References

- Bigelow, H.B. and W.C. Schroeder, 1953. Fishes of the Gulf of Maine. Fishery Bull. Fish Wildl. Serv. U.S. 74: 285-290.
- Black, G.A.P. 1993 ACON data visualization software: User manual, version 7.
- Bowering, W. R. and W. B. Brodie, 1991. Distribution of commercial flatfishes in the Newfoundland-Labrador region of the Canadian Northwest Atlantic and changes in certain biological parameters since exploitation. *Neth. J. of Sea Res.* 27 (3/4):407-422.
- M.J. Morgan and W. B. Brodie 1995 An assessment of the American plaice stock in Div. 3LNO. NAFO SCR Doc 95/xx:39p
- Isaksen, B, 1977. Utbredelse og vekst hos Gapeflyndre, *Hippoglossoides platessoides*. Fabricius), i Barenshavet. Msc. Thesis. Univ of Bergen: 1-92.
- Milinsky, G.I., 1944. On the biology and fisheries of the long rough dab in the Barents Sea. *Trudy PINRO*, 8: 388-415. (Transl. Ser. Fish. Res. Bd. Can., No. 1298).
- Morgan, M. J. 1992. Low temperature tolerance of American plaice in relation to declines in abundance. *Trans. Am. Fish. Soc.* 121:399-402
- Morgan, M. J. and W. B. Brodie 1991. Seasonal distribution of American plaice on the northern Grand Banks *Mar. Ecol. Prog. Ser.* 75: 101-107
- Pitt, T.K. 1969. Migrations of American plaice on the Grand Bank and in St. Mary's Bay, 1954, 1959, and 1961. *J. Fish. Res. Bd. Canada.* 26: 1301-1319.
- Powles, P.M., 1965. Life history and ecology of American plaice (*Hippoglossoides platessoides* F.) in the Magdalen shallows. *J. Fish. Res. Bd. Canada.* 22: 565-598.
- Scott, W.B. and M.G. Scott, 1988. Atlantic Fishes of Canada. *Can. Bull. Fish. Aquat. Sci.* 219: 1-731.
- Simacheva, I.N., & A.A. Glukhov, 1986. Distribution, abundance and size age structure of the Barents Sea long rough dab stock. *ICES CM 1986/G25:* 192-207.
- Walsh, S.J 1991 Commercial fishing practices on offshore juvenile flatfish nursery grounds on the Grand Banks of Newfoundland. *Neth. J. Sea Res.* 27: 423-432.
1993. Dynamics of juvenile American plaice populations on the Grand Banks, NAFO Divisions 3LNO. NAFO SCR Doc. 93/71:22
- 1994a Life history traits and spawning characteristics in populations of long rough dab (American plaice) *Hippoglossoides platessoides* (Fabricius), in the North Atlantic *Neth. J. Sea Res.* 32:241-254.
- 1994b Distribution, abundance and biomass of juvenile and adult American plaice populations on the Grand Banks, NAFO Divisions 3LNO NAFO SCR Doc. 94/56:17p
- 1994c Recruitment variability in populations of long rough dab (American plaice), *Hippoglossoides platessoides* (Fabricius), in the North Atlantic *Neth. J. Sea Res.* 32:421-431.

Table 1. Average bottom depth (m) and temperature (°C) of catches of American plaice (juveniles and adults) from the 1989-94 surveys. (standard deviation around the mean is in brackets).

Year	Division	Depth (m)	Range	Temperature (°C)	Range
1989	3L	114.8(33.9)	67-178	-0.7(0.7)	-1.5 to 1.0
	3N	64.1(13.9)	42-129	1.7(2.0)	-1.5 to 7.5
	3Ø	83.8(15.8)	45-145	1.5(2.3)	-1.5 to 8.0
1990	3L	112.9(34.4)	66-178	-0.6(1.0)	-1.5 to 1.5
	3N	67.4(22.5)	43-163	0.9(1.6)	-1.4 to 4.2
	3Ø	80.5(17.1)	63-148	1.1(1.1)	-1.1 to 3.8
1991	3L	120.0(37.5)	64-179	-1.1(0.4)	-1.6 to 0.4
	3N	66.9(19.0)	43-142	0.7(2.2)	-1.6 to 5.6
	3Ø	88.7(26.6)	64-188	0.9(1.9)	-1.4 to 4.6
1992	3L	134.1(45.7)	64-244	-0.7(0.8)	-1.5 to 1.7
	3N	68.3(28.7)	42-203	1.0(1.6)	-1.5 to 6.3
	3Ø	89.9(24.1)	66-215	0.6(2.0)	-1.5 to 7.6
1993	3L	132.8(48.3)	62-250	-1.1(0.5)	-1.6 to 1.4
	3N	71.1(31.9)	43-223	0.1(1.3)	-1.6 to 3.0
	3Ø	94.0(34.0)	66-218	1.3(2.5)	-1.5 to 8.0
1994	3L	140.9(51.7)	63-260	-0.8(0.8)	-1.6 to 1.6
	3N	82.4(48.7)	43-241	0.7(1.9)	-1.5 to 4.5
	3O	94.3(33.2)	66-223	0.9(2.0)	-1.5 to 6.4

Table 2 Mean numbers and weight (kg) of Am. plaice per tow, by stratum from r.v. juvenile 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 ($t \times 10^3$).

Depth (m)	Stratum	Category	Year											
			1985	1986	1987	1988	1989	1990	1991	1992	1993	1994		
93-183	328	Av. No./set	-	-	-	-	159.85(3)	-	-	238.15(5)	166.67(3)	1033.20(3)	79.18(3)	
		Av. wt./set	-	-	-	-	15.00	-	-	29.52	14.13	35.96	6.11	
93-183	341	Av. No./set	-	-	-	-	1194.50(4)	202.80(5)	735.93(4)	320.78(5)	275.99(5)	290.88(4)	290.88(4)	
		Av. wt./set	-	-	-	-	220.88	41.20	69.32	32.23	17.44	14.85	14.85	
93-183	342	Av. No./set	-	-	-	-	223.00(2)	-	-	-	51.46(2)	35.97(2)	288.17(2)	
		Av. wt./set	-	-	-	-	51.25	-	-	6.36	4.07	22.80	22.80	
93-183	343	Av. No./set	-	-	-	-	59.00(2)	-	-	109.92(2)	154.38(2)	14.99(2)	15.71(2)	
		Av. wt./set	-	-	-	-	7.50	-	22.68	18.43	1.62	1.60	1.60	
184-274	344	Av. No./set	-	-	-	-	-	-	-	-	484.25(2)	137.89(3)	218.98(4)	
		Av. wt./set	-	-	-	-	-	-	-	-	42.27	13.26	19.11	
184-274	347	Av. No./set	-	-	-	-	-	-	-	-	366.17(2)	1192.75(3)	501.40(3)	
		Av. wt./set	-	-	-	-	-	-	-	-	75.97	133.80	38.83	
93-183	348	Av. No./set	-	-	-	-	1562.50(7)	773.90(4)	2165.33(7)	745.51(12)	483.99(11)	812.81(7)	812.81(7)	
		Av. wt./set	-	-	-	-	146.84	104.21	127.65	35.07	28.73	42.84	42.84	
93-183	349	Av. No./set	-	-	-	-	1341.40(5)	492.57(7)	803.12(7)	238.07(8)	370.9(7)	164.45(5)	164.45(5)	
		Av. wt./set	-	-	-	-	199.62	93.57	66.64	27.99	19.18	15.14	15.14	
57-91	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)	513.46(7)	40.35(4)	40.35(4)	
		Av. wt./set	39.80	93.92	-	69.25	51.44	33.30	47.12	22.93	42.84	8.23	8.23	
57-91	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)	133.10(5)	90.19(4)	90.19(4)	
		Av. wt./set	56.30	42.61	-	27.65	88.70	77.86	58.68	58.54	16.59	15.91	15.91	
93-183	364	Av. No./set	-	-	-	-	1406.53(11)	2361.60(5)	1370.61(6)	1852.77(17)	1024.75(16)	994.30(11)	994.30(11)	
		Av. wt./set	-	-	-	-	113.02	292.07	122.29	130.16	55.59	73.78	73.78	
93-183	365	Av. No./set	-	-	-	-	1854.75(4)	912.67(3)	2501.57(4)	1601.89(6)	752.42(6)	1832.19(4)	1832.19(4)	
		Av. wt./set	-	-	-	-	96.08	89.76	125.65	74.05	48.62	119.03	119.03	
184-274	366	Av. No./set	-	-	-	-	-	-	-	366.39(3)	120.41(2)	1435.13(3)	1435.13(3)	
		Av. wt./set	-	-	-	-	-	-	-	97.58	29.40	32.76	32.76	
184-274	369	Av. No./set	-	-	-	-	-	-	-	376.64(3)	771.74(3)	2203.86(3)	2203.86(3)	
		Av. wt./set	-	-	-	-	-	-	-	68.47	96.78	318.76	318.76	
93-183	370	Av. No./set	-	-	-	-	1703.83(6)	1119.33(3)	627.85(3)	1305.96(8)	1245.33(7)	2064.40(5)	2064.40(5)	
		Av. wt./set	-	-	-	-	87.53	145.37	60.17	77.81	58.46	97.84	97.84	

Table 2 (continued)

Depth (m)	Stratum	Category	Year										
			1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	
57-91	371	Av. No./set	252.00(4)	-	-	74.34(5)	67.00(4)	96.67(3)	-	1064.19(3)	369.38(3)	1202.14(3)	
		Av. wt./set	102.13	-	-	41.45	33.50	40.97	-	145.37	17.28	91.70	
57-91	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)	306.16(10)	211.25(5)	
		Av. wt./set	72.09	90.38	-	55.02	38.43	45.23	36.25	45.11	43.01	43.17	
57-91	384	Av. No./set	282.25(4)	-	-	191.45(5)	372.25(4)	246.50(2)	629.18(3)	549.25(4)	1065.93(4)	674.92(4)	
		Av. wt./set	105.45	-	-	88.33	72.41	105.15	146.21	76.50	122.54	66.64	
93-183	385	Av. No./set	-	-	-	-	1085.80(5)	2084.00(4)	1354.46(6)	1994.67(13)	1688.45(12)	1729.54(6)	
		Av. wt./set	-	-	-	-	69.33	87.62	80.72	70.31	83.13	80.42	
185-274	386	Av. No./set	-	-	-	-	-	-	-	409.50(3)	387.70(3)	1670.86(3)	
		Av. wt./set	-	-	-	-	-	-	-	96.73	50.80	208.46	
185-274	389	Av. No./set	-	-	-	-	-	-	-	249.17(3)	144.30(3)	486.06(3)	
		Av. wt./set	-	-	-	-	-	-	-	35.98	19.42	56.69	
93-183	390	Av. No./set	-	-	-	-	284.00(4)	234.33(3)	1228.00(4)	417.08(4)	653.25(4)	409.14(3)	
		Av. wt./set	-	-	-	-	50.91	41.27	87.72	55.23	68.61	78.45	
185-274	391	Av. No./set	-	-	-	-	-	-	-	460.96(2)	327.75(2)	458.25(2)	
		Av. wt./set	-	-	-	-	-	-	-	57.44	27.18	34.61	
Mean No./set (# sets)			142.23(27)	110.89(19)	(0)	140.50(29)	806.79(84)	809.53(51)	888.77(67)	639.42(122)	627.04(123)	756.81(93)	
Abundance (Nos x 10 ⁻⁶)			129.4	74.4	-	127.8	2231.8	2013.0	2295.5	2412.7	2196.0	2648.47	
Mean wt./set			69.24	78.00	-	55.35	91.72	100.10	78.55	60.89	45.81	63.35	
Biomass (t)			63.0	52.4	-	50.4	253.7	248.9	202.9	213.1	160.5	221.69	

Table 3 Mean numbers and weight (kg) of Am. plaice per tow, by stratum from r.v. juvenile 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 ($t \times 10^{-3}$).

Depth (m)	Stratum	Category	Year											
			1985	1986	1987	1988	1989	1990	1991	1992	1993	1994		
185-274	358	Av. No./set Av. wt./set	-	-	-	-	-	-	-	-	-	247.50(2) 30.28	-	-
93-183	359	Av. No./set Av. wt./set	-	-	-	-	2395.50(2) 99.55	898.18(3) 51.08	1703.94(4) 78.19	284.33(3) 25.24	1299.00(3) 160.23	496.75(2) 91.83	-	-
57-91	360	Av. No./set Av. wt./set	189.67(3) 29.00	1823.93(14) 86.67	1043.14(19) 47.28	1271.32(20) 83.37	3015.54(19) 165.56	1427.81(2) 113.05	1509.73(18) 104.44	550.69(16) 55.96	1498.10(14) 195.57	1584.95(13) 213.20	-	-
57-91	361	Av. No./set Av. wt./set	31.50(6) 24.17	29.88(6) 19.69	59.08(8) 41.80	64.12(6) 24.90	53.78(9) 188.50	71.36(10) 38.18	76.07(8) 33.63	33.00(8) 12.65	138.89(8) 43.82	144.01(8) 40.39	-	-
57-91	362	Av. No./set Av. wt./set	63.78(9) 37.72	62.57(7) 34.71	201.84(2) 84.19	135.76(6) 45.55	177.50(8) 38.44	162.14(9) 90.19	367.12(7) 61.44	144.50(6) 26.89	111.47(8) 31.50	234.72(3) 43.30	-	-
57-91	373	Av. No./set Av. wt./set	399.80(10) 313.34	182.93(7) 139.68	-	51.59(8) 35.93	95.25(8) 54.13	198.00(9) 123.16	64.27(7) 14.51	88.00(5) 37.70	112.79(8) 15.97	411.74(4) 61.61	-	-
57-91	374	Av. No./set Av. wt./set	147.25(4) 62.63	408.50(4) 218.25	-	166.12(4) 53.98	173.33(3) 37.00	93.25(4) 36.31	42.85(2) 27.09	175.67(3) 25.61	201.35(4) 14.45	136.00(3) 33.12	-	-
< 56	375	Av. No./set Av. wt./set	57.71(7) 67.43	24.38(5) 31.98	48.96(7) 69.54	23.54(9) 17.45	21.63(8) 17.06	50.50(11) 50.58	24.98(7) 27.04	29.64(11) 27.44	112.59(10) 45.68	198.61(7) 70.34	-	-
< 56	376	Av. No./set Av. wt./set	60.00(2) 45.50	221.75(4) 284.31	347.63(10) 18.75	674.98(12) 52.81	71.89(9) 18.89	110.36(11) 23.01	210.04(10) 36.19	399.13(8) 57.12	208.17(9) 55.93	63.57(7) 32.51	-	-
93-183	377 ^a	Av. No./set Av. wt./set	-	-	-	-	-	-	-	-	968.25(2) 128.15	630.00(2) 118.21	-	-
185-274	378 ^b	Av. No./set Av. wt./set	-	-	-	-	-	-	-	-	-	765.33(3) 248.57	-	-
185-274	381 ^a	Av. No./set Av. wt./set	-	-	-	-	-	-	-	-	-	477.13(2) 33.46	764.00(2) 25.30	-
93-183	382	Av. No./set Av. wt./set	-	-	-	-	48.00(2) 5.25	584.00(3) 46.51	56.77(3) 4.44	104.00(2) 10.80	571.06(2) 92.77	278.96(2) 52.51	-	-
57-91	383	Av. No./set Av. wt./set	236.00(4) 75.63	-	-	106.42(4) 42.59	268.33(3) 52.50	396.33(3) 65.49	350.66(4) 18.43	450.00(2) 41.60	90.93(2) 18.59	42.35(2) 3.76	-	-
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)	448.47(72)	466.17(58)		
Abundance (Nos x 10 ⁻⁶)			241.5	731.6	461.5	663.2	1204.7	708.7	754.4	388.0	760.1	830.53		
Mean wt./set			89.11	101.70	54.50	47.10	59.89	76.06	47.12	35.23	70.17	80.57		
Biomass (t)			138.2	150.5	60.6	73.1	99.7	126.6	78.4	59.4	118.9	137.6		

^a New strata in 1993.

^b New stratum in 1994.

Table 4 Mean numbers and weight (kg) of Am. plaice per tow, by stratum from r.v. juvenile 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 ($t \times 10^3$).

Depth (m)	Stratum	Category	Year											
			1985	1986	1987	1988	1989	1990	1991	1992	1993	1994		
93-183	329	Av.No./set Av.wt./set	-	-	-	-	803.63(4) 132.21	-	640.01(6) 41.15	531.30(6) 41.26	1074.17(5) 60.53	456.81(3) 27.43		
57-91	330	Av.No./set Av.wt./set	-	-	-	24.48(2) 40.47	355.06(7) 80.35	244.86(7) 186.71	182.36(6) 58.35	198.20(5) 61.46	177.06(5) 25.21	381.33(4) 91.46		
57-91	331	Av.No./set Av.wt./set	-	-	-	6.99(2) 2.50	305.00(2) 113.75	749.00(2) 123.06	295.77(3) 43.58	291.50(2) 36.70	95.43(2) 19.56	170.63(2) 17.23		
93-183	332	Av.No./set Av.wt./set	-	-	-	-	592.25(4) 80.53	515.00(2) 42.67	435.17(4) 24.82	963.75(4) 80.49	1145.62(4) 115.17	613.89(3) 75.22		
185-274	333 ^a	Av.No./set Av.wt./set	-	-	-	-	-	-	-	-	50.96(2) 10.64	-		
185-274	336 ^a	Av.No./set Av.wt./set	-	-	-	-	-	-	-	-	57.96(2) 16.91	-		
93-183	337	Av.No./set Av.wt./set	-	-	-	-	357.00(2) 45.38	501.33(3) 37.58	444.66(4) 43.76	874.25(4) 71.29	505.86(4) 63.40	759.00(3) 95.27		
57-91	338	Av.No./set Av.wt./set	-	33.00(3) 15.50	-	89.60(6) 14.49	289.00(6) 36.87	99.25(4) 17.87	329.58(6) 40.41	647.0(4) 70.03	460.90(4) 57.84	582.81(4) 68.71		
93-183	339	Av.No./set Av.wt./set	-	-	-	-	2960.50(2) 449.60	2666.33(3) 253.35	1908.28(4) 178.36	1892.00(4) 179.79	2907.76(4) 210.69	1522.44(3) 117.28		
57-91	340	Av.No./set Av.wt./set	-	-	-	19.79(3) 6.09	60.17(6) 36.87	38.14(7) 19.16	244.21(5) 39.37	844.75(4) 64.53	71.94(3) 14.23	679.61(3) 51.02		
57-91	351	Av.No./set Av.wt./set	66.00(3) 35.00	81.33(9) 36.28	-	48.11(7) 39.47	334.25(8) 54.54	390.99(9) 70.23	70.83(7) 29.64	481.27(7) 49.43	297.77(8) 50.42	296.56(4) 28.07		
57-91	352	Av.No./set Av.wt./set	-	88.62(13) 37.30	-	120.09(11) 28.22	150.14(14) 39.06	106.46(16) 35.94	112.40(16) 31.21	392.08(13) 53.01	418.14(13) 71.10	282.46(9) 52.60		
57-91	353	Av.No./set Av.wt./set	-	794.00(5) 51.33	-	700.71(4) 145.90	770.33(3) 108.07	1306.00(4) 113.06	982.44(5) 132.53	869.50(4) 85.47	985.99(4) 133.12	1261.00(3) 240.52		
93-183	354	Av.No./set Av.wt./set	-	-	-	-	472.50(2) 80.53	692.00(3) 82.46	1334.97(3) 103.79	1760.25(4) 115.41	1511.50(3) 158.24	1262.00(3) 230.92		
185-274	355 ^b	Av.No./set Av.wt./set	-	-	-	-	-	-	-	-	-	145.00(2) 30.68		
Mean No./set (# sets)			65.95(3)	182.73(30)	126.60(35)	484.37(60)	444.89(60)	406.23(69)	651.57(62)	594.99(63)	567.87(46)			
Abundance (Nos $\times 10^6$)			17.7	160.9	168.9	855.4	738.1	747.7	1199.3	1113.2	1051.46			
Mean wt./set			34.97	34.14	38.51	79.94	76.58	52.19	65.97	66.16	76.31			
Biomass (t)			9.4	30.1	51.4	147.2	127.0	96.1	121.4	123.8	141.29			

^a New strata in 1993.

^b New stratum in 1994.

Table 5 Division 3L abundance at age (Nos. X 10⁶) of plaice in the 1989-93 surveys.

Age	1989	1990	1991	1992 ^a	1993 ^a
1	4.1	2.2	4.1	1.8	1.2
2	84.0	28.6	63.2	157.5	84.9
3	456.9	171.1	177.5	381.2	456.3
4	486.7	476.3	405.4	450.6	509.0
5	199.7	474.9	751.0	640.4	512.1
6	223.5	198.1	450.3	369.7	411.6
7	220.2	194.3	216.5	210.8	107.8
8	238.9	180.8	103.0	103.3	44.9
9	196.2	142.1	50.9	57.9	27.4
10	70.1	77.8	42.6	21.6	6.9
11	30.2	41.9	10.9	7.1	3.3
12	13.8	19.1	6.0	5.3	1.6
13	4.1	5.7	4.7	2.6	0.9
14	1.4	1.4	2.0	1.0	0
15	0.5	0.6	1.8	1.0	0
16	0	0	0.3	0.8	0
17	0	0	0	0.5	0
Unknown	0.1	0.2	0	0	0
Total					
1+	2230.6	2015.4	2290.5	2413.1	2168.1
5+	1198.7	1336.7	1640.0	1421.0	1116.5
7+	775.4	663.7	438.7	410.9	192.7
1 to 5	1231.5	1153.3	1401.2	1631.5	1563.4

^a Estimates include catches in 7 new deepwater strata.

Table 6 Division 3N abundance at age (Nos. x 10⁶) of plaice in the 1989-93 surveys.

Age	1989	1990	1991	1992	1993
1	52.5	35.2	42.5	4.0	0.2
2	254.1	78.5	215.2	55.3	7.5
3	405.6	129.5	172.1	93.5	78.3
4	332.5	192.0	104.4	74.9	215.1
5	94.5	143.8	124.2	60.2	251.7
6	35.4	39.0	61.9	43.9	100.1
7	13.4	20.0	13.3	24.4	50.0
8	9.7	13.9	4.1	12.3	17.8
9	5.8	14.0	5.5	5.6	12.9
10	6.7	12.0	4.2	4.5	4.7
11	5.6	9.9	4.1	2.5	3.0
12	2.9	7.3	2.7	1.6	2.4
13	2.1	5.0	1.7	1.6	1.0
14	0.8	3.9	0.9	1.3	0.5
15	0.2	1.5	2.0	1.3	0.8
16	0	0.6	1.3	0.4	0.4
17	0	0.2	0.4	0.3	0
18			0.2	0.2	0
19	0	0	0	0.1	0
Unknown	0.1	0	0	0	0
Total					
1+	1221.9	706.3	760.6	387.9	746.5
5+	177.1	271.0	226.5	160.2	445.3
7+	47.2	88.1	40.4	56.1	93.5
1 to 5	1139.1	579.0	658.4	287.9	552.8

Table 7 Abundance at age (Nos. x 10⁶) for Stratum 360 from surveys in 1986-93.

Age	1986	1987	1988	1989	1990	1991	1992	1993
1	165.4	95.2	10.1	48.9	29.1	20.9	1.7	0
2	144.9	144.1	100.5	212.8	58.5	140.5	25.6	1.4
3	127.1	58.1	172.1	327.7	93.2	120.0	42.6	34.7
4	53.4	21.8	73.9	275.9	137.1	72.3	41.6	150.8
5	19.9	4.7	26.6	77.3	97.4	84.1	30.9	186.9
6	25.2	3.5	8.3	24.6	23.6	39.6	18.2	58.9
7	11.6	1.5	4.8	5.2	7.9	6.3	8.2	19.2
8	4.7	0.7	3.5	2.3	3.5	1.1	3.6	6.0
9	1.8	0.4	1.3	0.9	1.4	0.9	1.3	3.7
10	1.1	0.2	0.6	0.8	0.7	0.4	0.6	1.2
11	0.7	0.2	0.6	0.6	0.4	0.4	0.4	0.6
12	0.6	0.2	0.4	0.5	0.2	0.2	0.2	0.6
13	0.5	0.2	0.4	0.4	0.2	0.2	0.2	0.2
14	0.3	0.2	0.2	0.2	0.2	0	0	0.1
15	0.2	0	0	0	0	0.2	0.1	0.1
16	0	0	0	0	0	0.2	0	0
17	0	0	0	0	0	0	0	0
Total								
1+	557.7	331.7	403.5	978.3	453.6	487.4	175.2	464.6
5+	66.6	11.8	46.7	112.8	135.5	133.6	63.7	277.5
7+	21.5	3.6	11.8	10.9	14.5	9.9	14.6	31.7
1 to 5	510.7	323.9	383.4	942.6	415.3	437.8	142.4	373.8

Table 8 Division 300 abundance at age (Nos. x 10⁶) of plaice in the 1989-1993 surveys.

Age	1989	1990	1991	1992	1993
1	83.7	41.2	2.8	8.0	0
2	110.5	138.3	163.0	228.6	13.2
3	200.7	80.5	140.3	320.7	184.1
4	141.3	159.9	91.3	254.1	325.2
5	72.7	107.8	151.2	137.8	250.6
6	57.2	44.5	83.2	124.8	160.6
7	57.7	32.5	32.5	58.5	96.0
8	36.5	24.0	36.2	25.8	45.7
9	34.2	17.1	11.4	15.5	17.9
10	22.3	15.7	11.6	8.7	8.2
11	18.8	12.8	6.6	4.9	5.2
12	10.0	9.4	3.7	3.8	2.7
13	3.9	5.5	3.1	2.3	2.0
14	3.3	2.6	1.6	2.1	1.5
15	1.8	1.1	2.2	0.7	1.0
16	0.7	0.5	1.7	1.0	0.3
17	0.2	0	1.4	0.9	0
18	0	0	0.2	0.5	0
19	0	0	0.3	0	0
Total					
1+	855.6	693.5	744.3	1198.5	1114.5
5+	319.4	273.5	346.9	387.3	591.7
7+	189.4	121.2	112.5	124.7	180.5
1 to 5	608.9	527.8	548.6	949.2	773.1

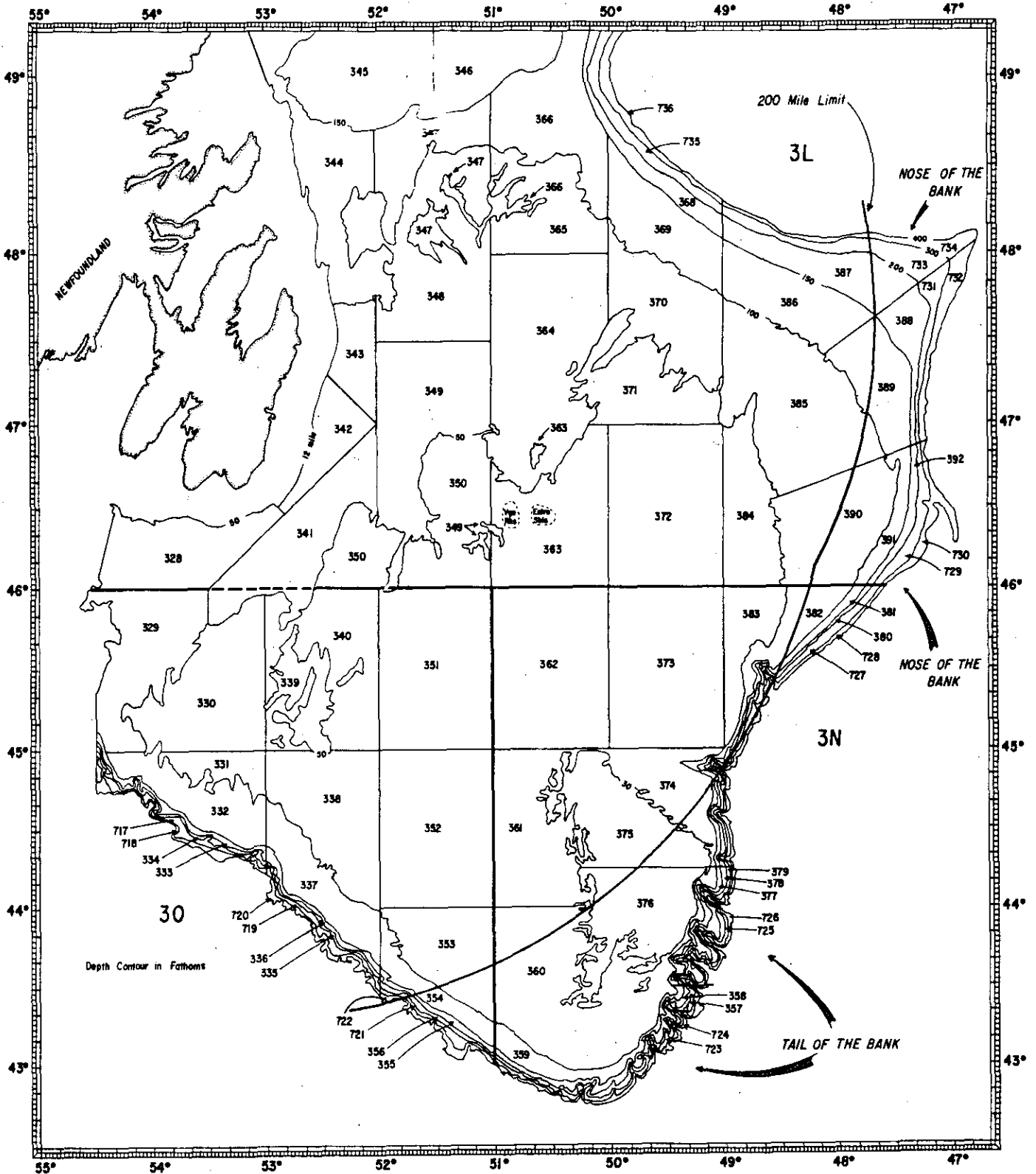


Fig. 1. Grand Banks, NAFO Div. 3LNO, showing the Canadian 200 mile limit in relation to the Nose and Tail of the Bank as well as the stratification scheme used in Canadian groundfish surveys.

Fig. 2. Schematic net plans of the juvenile groundfish survey trawl, Yankee 41

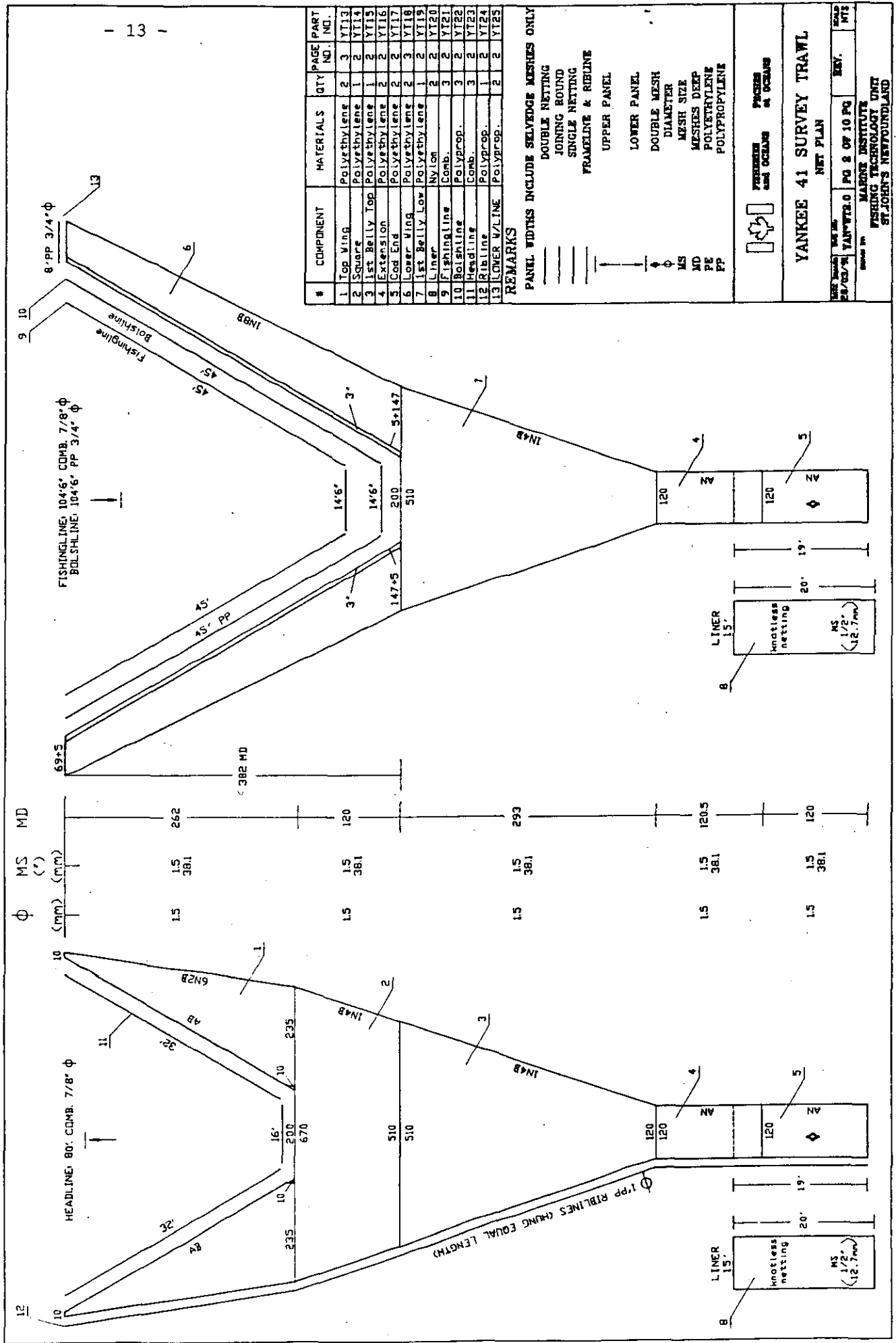
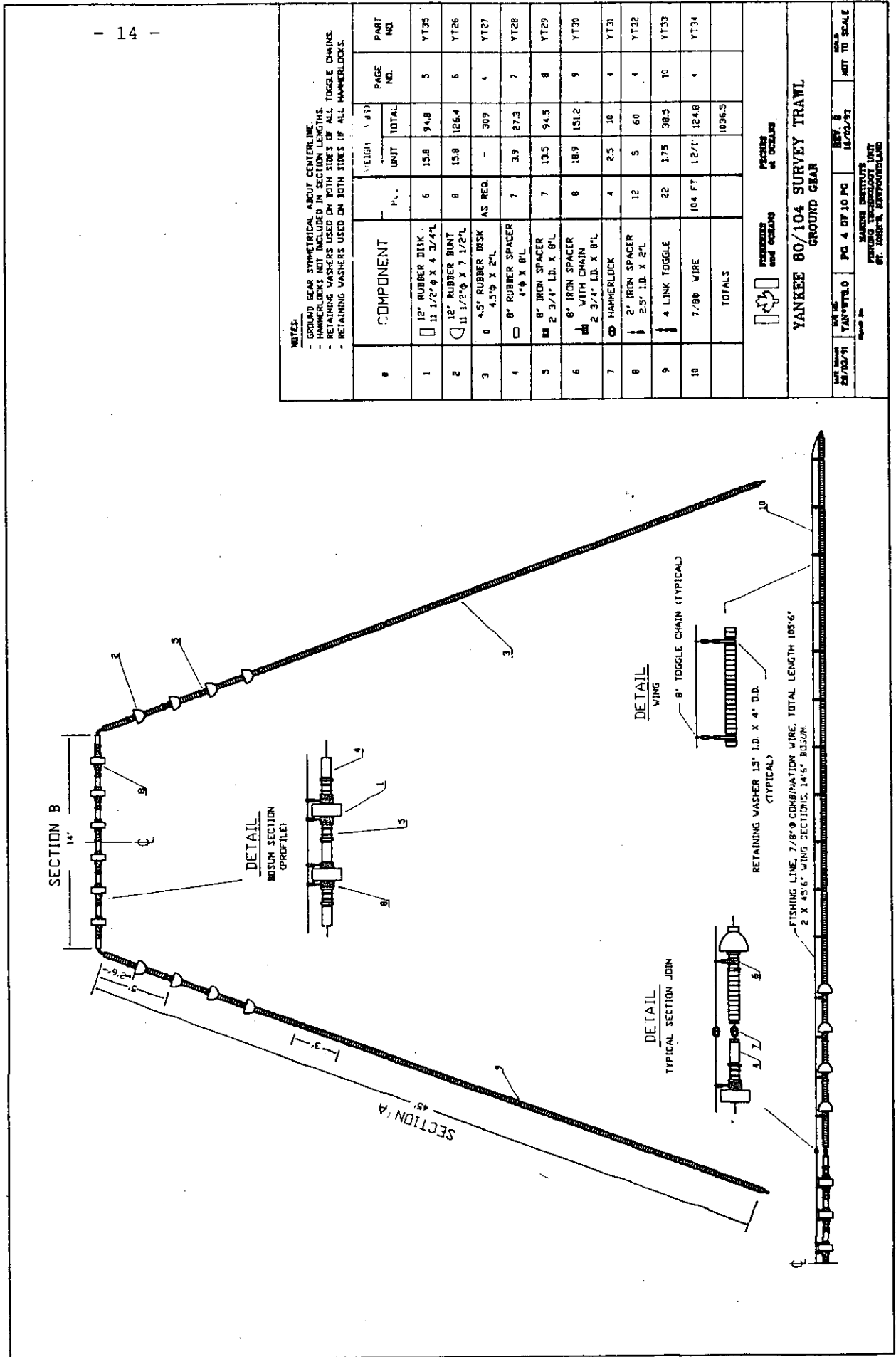


Fig. 3. Schematic rigging plans of the footgear for the juvenile groundfish survey trawl, Yankee 41



NOTES:

- GROUND GEAR SYMMETRICAL ABOUT CENTERLINE
- HAMMERLOCKS NOT INCLUDED IN SECTION LENGTHS
- RETAINING WASHERS USED ON BOTH SIDES OF ALL TOGGLE CHAINS
- RETAINING WASHERS USED ON BOTH SIDES OF ALL HAMMERLOCKS

#	COMPONENT	P.L.	WEIGHT (LBS)		PAGE NO.	PART NO.
			UNIT	TOTAL		
1	12" RUBBER DISK 11 1/2" Ø X 4 3/4" L	6	15.8	94.8	3	YT35
2	12" RUBBER BUNT 11 1/2" Ø X 7 1/2" L	8	15.8	126.4	6	YT26
3	4.5" RUBBER DISK 4.5" Ø X 2" L	AS REQ.	-	309	4	YT27
4	8" RUBBER SPACER 4" Ø X 8" L	7	3.9	27.3	7	YT28
5	8" IRON SPACER 2 3/4" I.D. X 8" L	7	13.5	94.5	8	YT29
6	8" IRON SPACER WITH CHAIN 2 3/4" I.D. X 8" L	8	18.9	151.2	9	YT30
7	8" HAMMERLOCK	4	2.5	10	4	YT31
8	2" IRON SPACER 2.5" I.D. X 2" L	12	5	60	4	YT32
9	4 LINK TOGGLE	22	1.75	38.5	10	YT33
10	7/8" WIRE	104 FT	12.71	1248	4	YT34
TOTALS				1036.5		

PROCESSED AND OCEANIC **FISHING AND OCEANIC**

YANKEE 80/104 SURVEY TRAWL GROUND GEAR

DATE DRAWN: 08/03/78 DRAWN BY: YAN/WTJ:0 PG 4 OF 10 PG REV. 8 11/03/73 NOT TO SCALE

SCALE: 1" = 10' DRAWN BY: YAN/WTJ:0 UNIT: FOOTING TO DIMENSIONS ST. JOSEPH, MARYLAND

Numbers

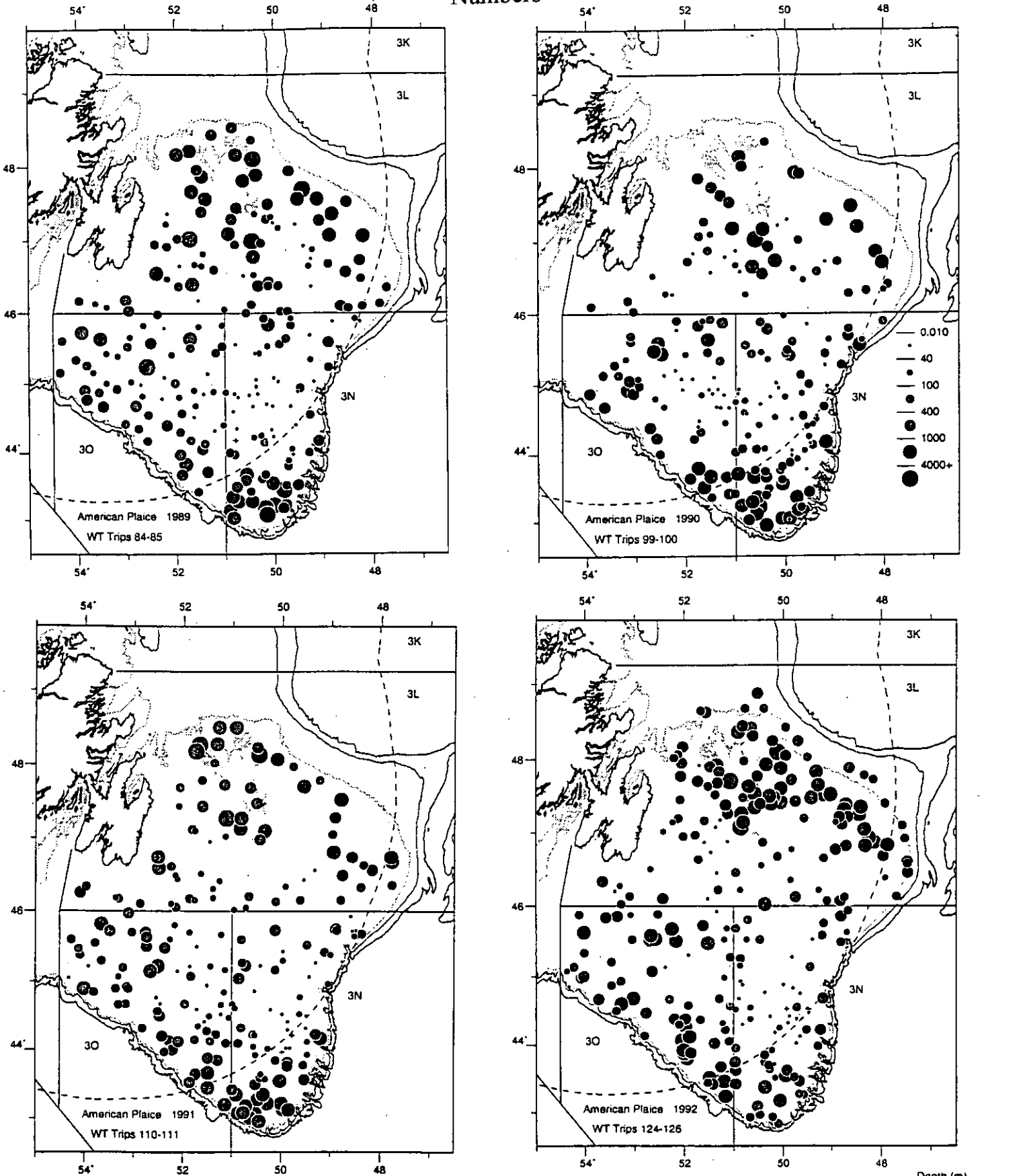


Fig. 4. Distribution of American plaice catches from the 1989-94 Canadian juvenile groundfish surveys of NAFO Divisions 3LNO. Symbols represent catch in numbers per standard tow. All survey tows standardized to 1.3 nautical miles

Depth (m)
..... 200
..... 400
..... 1000
- - - 200 mile limit

Numbers

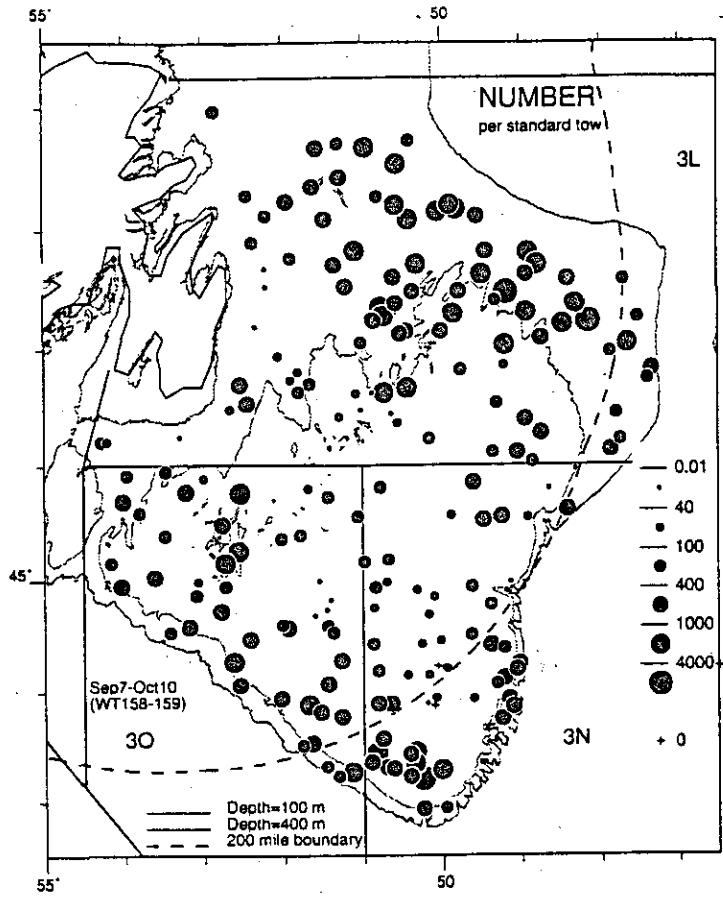
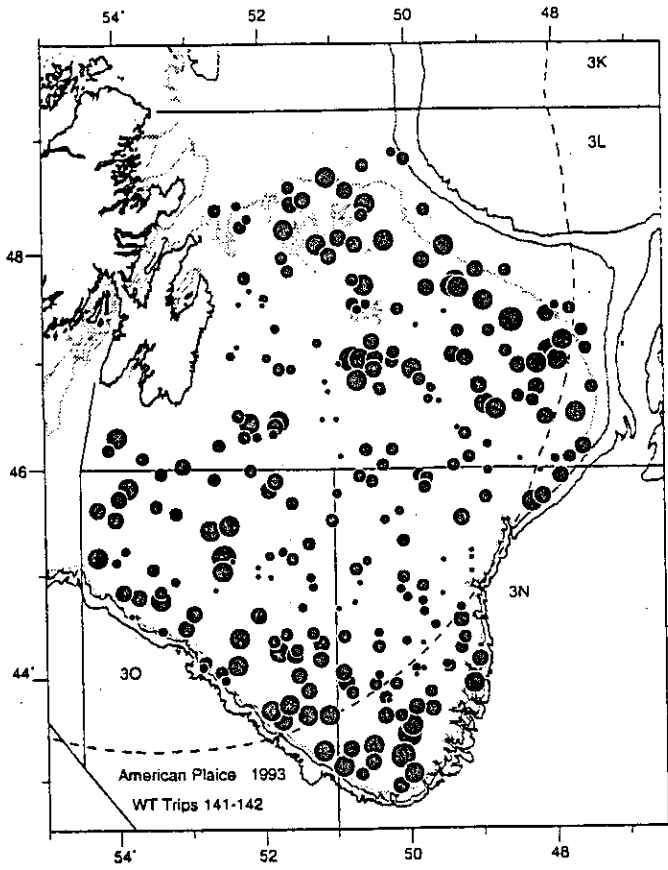


Fig 4.continued

Weight

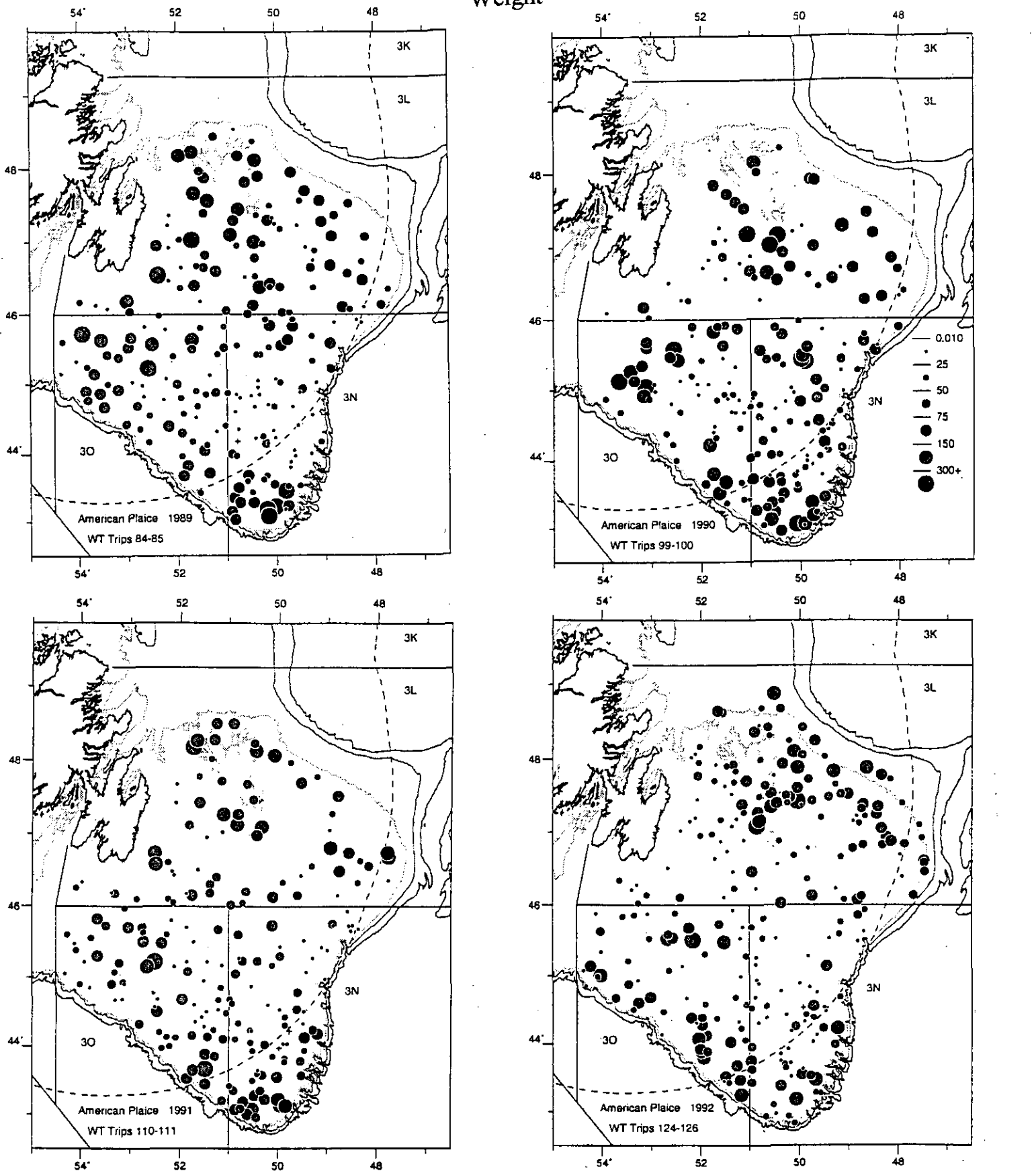


Fig. 5. Distribution of American plaice catches from the 1989-94 Canadian juvenile groundfish surveys of NAFO Divisions 3LNO. Symbols represent catch in weight per standard tow. All survey tows standardized to 1.3 nautical miles

Depth (m)
..... 200
----- 400
———— 1000
- - - - 200 mile limit

Weight

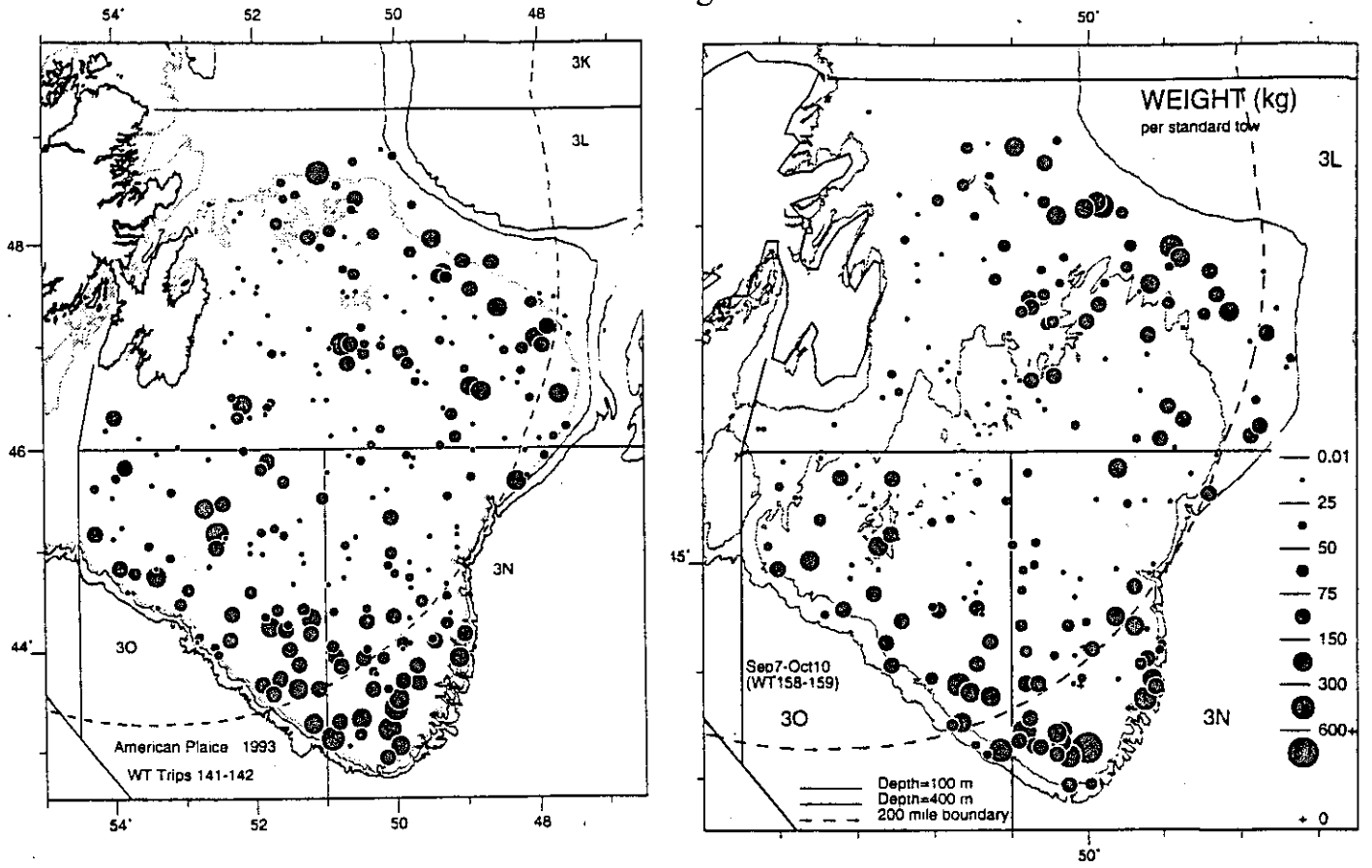


Fig 5 continued

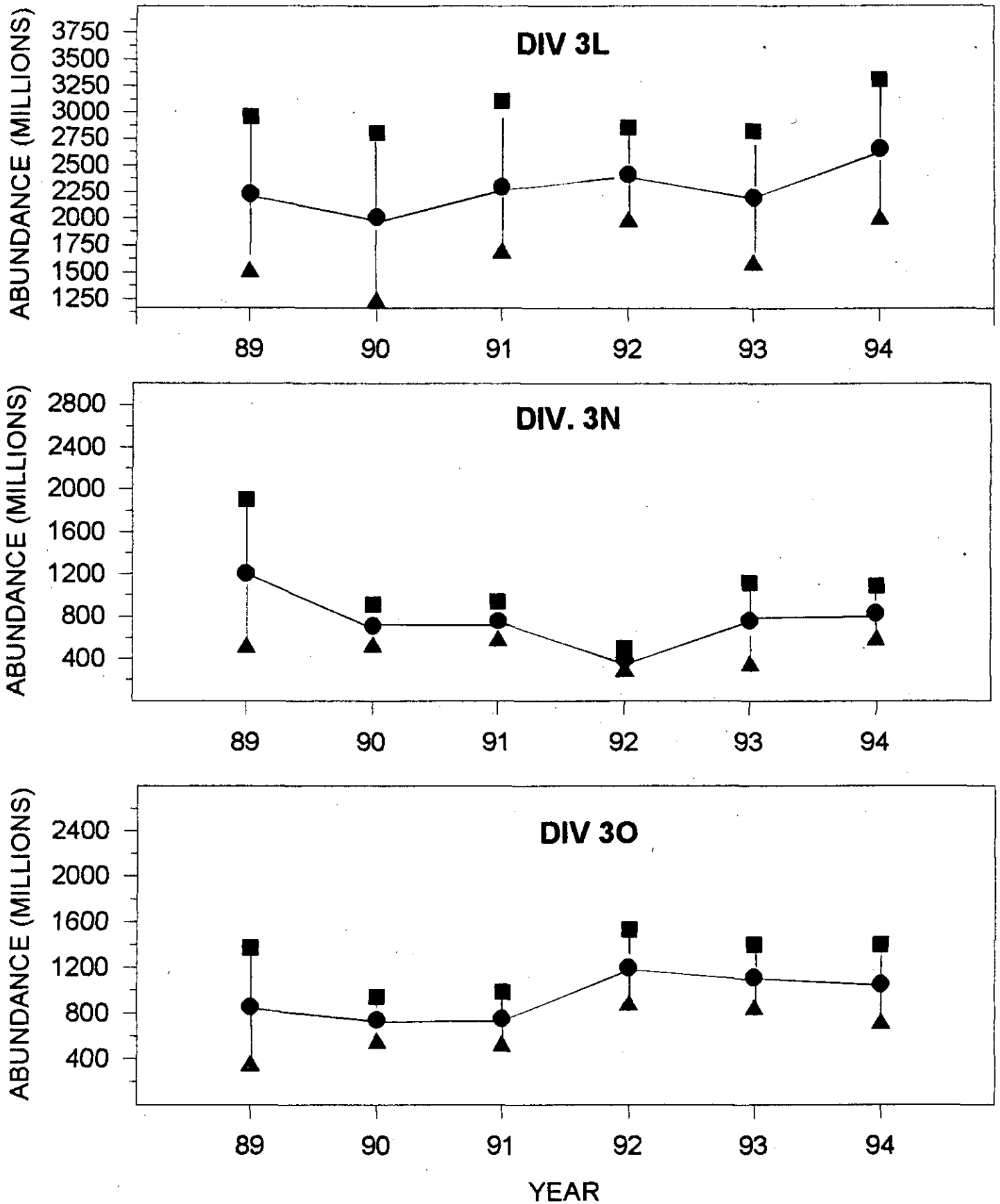


Fig. 6. Abundance estimates of plaice (with 95% C.I.) from the Canadian fall juvenile groundfish surveys of Div. 3LNO

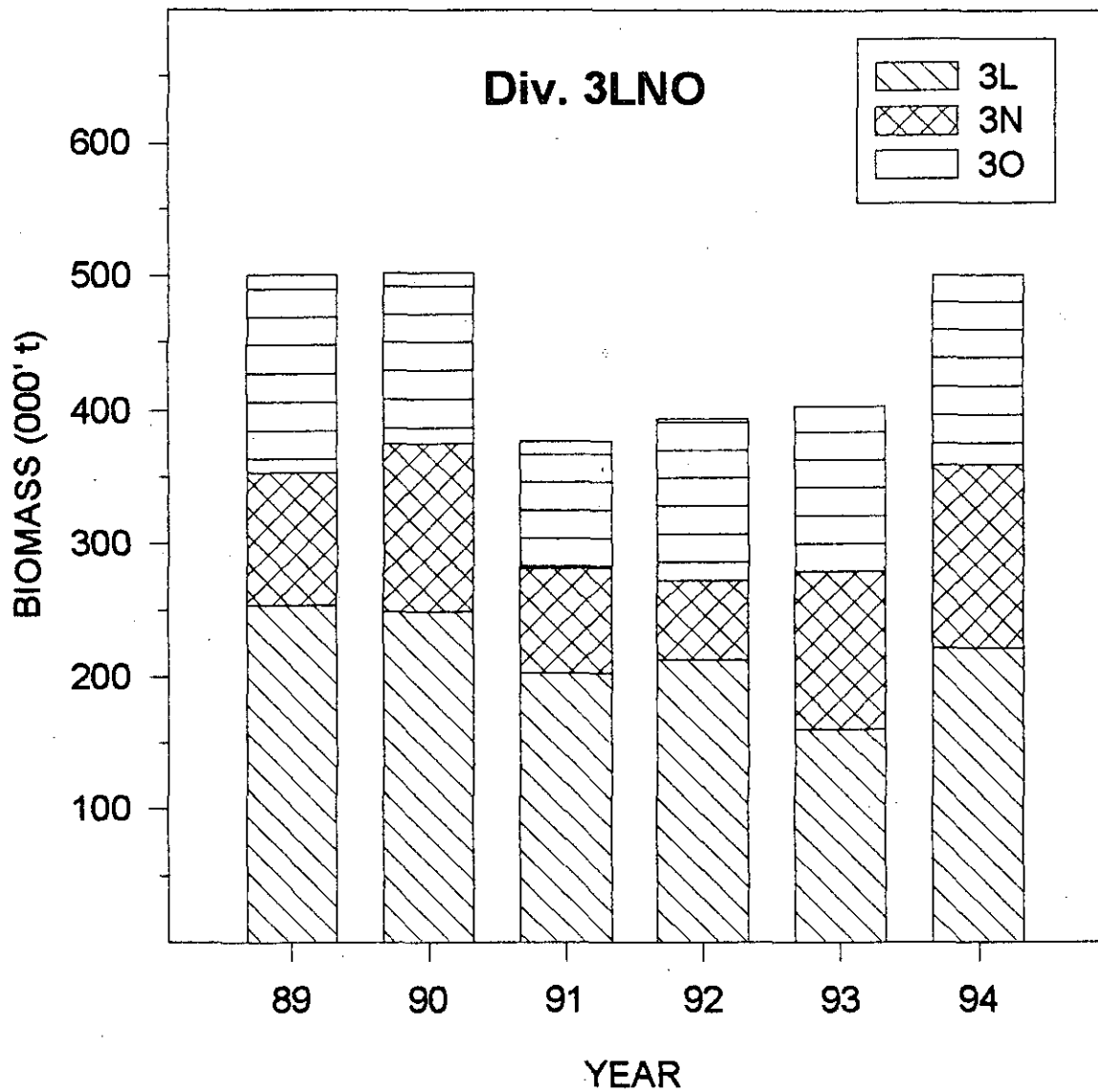


Figure 7. Biomass index for NAFO Div 3L, 3N and 3O from the Canadian juvenile groundfish surveys of Div. 3LNO 1989 to 1994.

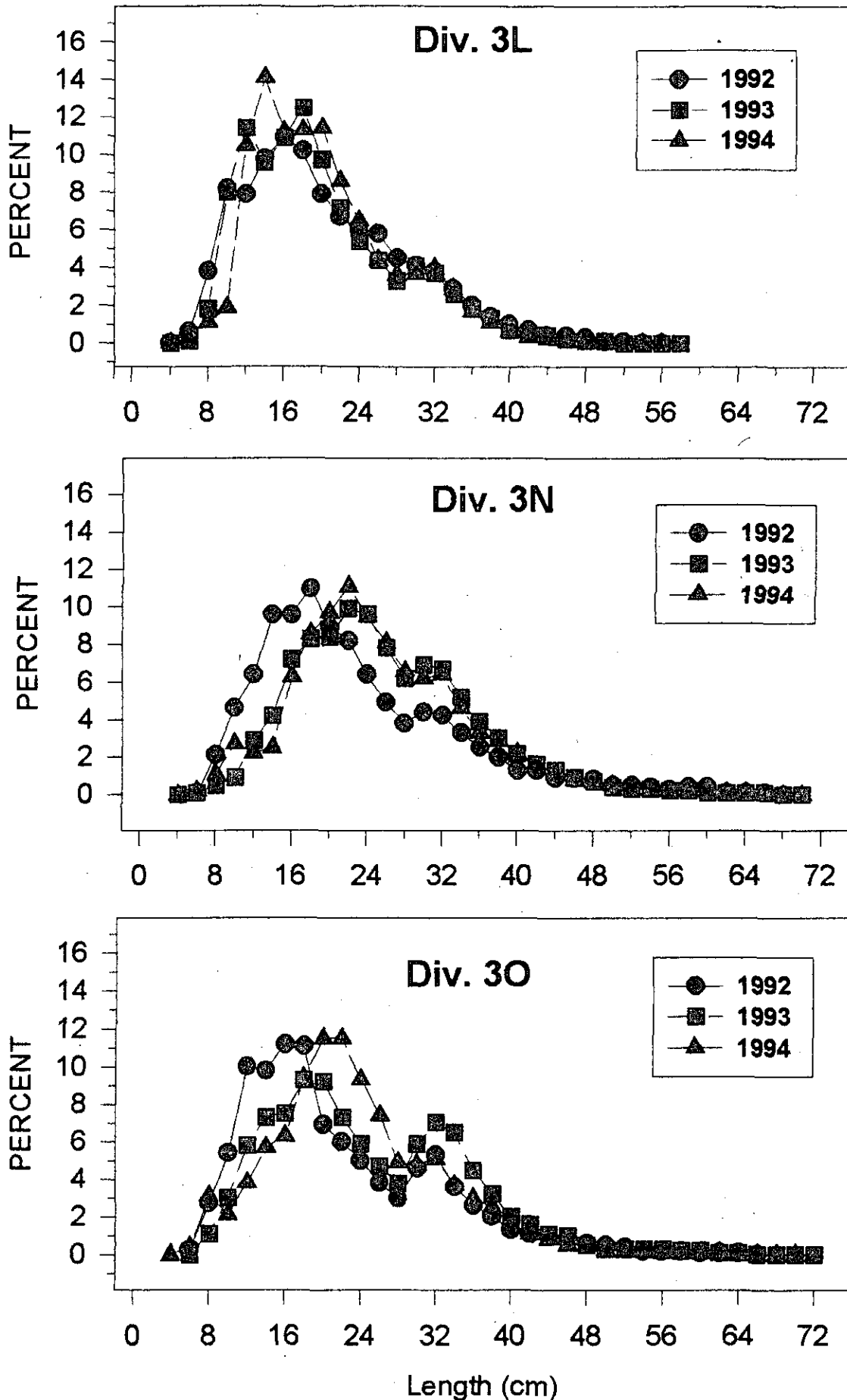


Fig. 8. Length frequency distribution of plaice in the 1992-94 surveys of Div. 3LNO