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An Assessment of the American Plaice Stock in NAFO Subarea 2 and Div. 3K

by

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Abstract

At present, the database for this stock is not sufficient to allow an analytical assessment to be performed. Catches since 1981 have been well below the 10,000t TAC, although the catch in 1986 of about 3,100t was up considerably over the 1985 level. Research vessel surveys indicate a steady decline in biomass in Div. 2J from 1983-86 despite negligible catches, but indicate a relatively stable biomass in Div. 3K where over 90% of recent catches have been taken. Catches by Canadian offshore trawlers in many years were too low to permit an accurate measure of CPUE to be obtained. Continuation of the 10,000t TAC is recommended for 1988.

Résumé

A l'heure actuelle, la base de données pour ce stock est insuffisante pour permettre d'effectuer une évaluation analytique. Depuis 1981, les prises ont été bien inférieures au TPA de 10 000 t, quoique les prises de 3 100 t en 1986 représentent une hausse considérable par rapport à celles de 1985. Les relevés effectués à bord de navires de recherches indiquent une diminution régulière de la biomasse dans la division 2J de 1983 à 1986, et ce malgré des prises négligeables, mais également une biomasse relativement stable dans la division 3K où plus de 90 % des prises récentes ont été effectuées. Pour un grand nombre d'années les prises par les chalutiers hauturiers canadiens ont été trop faibles pour permettre une mesure précise des PUE à obtenir. On recommande pour 1988 le maintien du TPA de 10 000 t.

Introduction

TAC Regulation

This stock has come under quota regulation since 1974, and the TAC's since then have been between 6,000 and 10,000 t. The latter figure, in place from 1982-87, was determined from an assessment of the stock in 1981 and was based on a sequential population analysis (Pitt and Brodie, 1981).

Catch Trends

The largest nominal catch reported for this stock was 12,686 t in 1970. Throughout most of the 1970's, catches were around 5,000 t, declining to less than 2,000 t in the 1982-85 period. The 1986 catch of 3,096 t was up markedly over the 1985 value of 747 t which is the lowest value in the 20 year series (Table 1). Prior to the declaration of the Canadian 200 mile limit in 1977, catches by foreign vessels comprised a substantial portion of the total landings, but have dwindled to negligible amounts in recent years (Fig. 1). The catches by the inshore sector ranged between 1,000 and 2,000 t in the 1976-81 period, declined to around 500 t in 1982-85 and increased to 1,000 t in 1986 (Table 1). Catches by Canadian offshore trawlers have shown wide fluctuations since 1976, ranging from only 161 t in 1985 to 6,332 t in 1981. Total catches from Subarea 2 have not exceeded 325 t since 1976, with only 21 t recorded from Subarea 2 in 1986 (Table 2). In 1986, the largest monthly catch was 1,091 t in March, virtually all of which was taken by Canadian trawlers (Table 3). In previous years of high offshore catches by Canada, i.e. 1977 and 1980-81, peak catches occurred in the March-April period. In years where the offshore catch was low, i.e. 1984-85, the peak catches, generated by the inshore sector, were in the June-September period.

Catch/Effort

CPUE data are available from Canadian trawlers for the period 1976-85 (Table 4). However, in both 1984 and 1985, the catches in the directed (main species American plaice) fishery declined to less than 25t, and in most other years was less than 750t. Therefore no significance can be given these values as an adequate index of stock abundance.

Stock Assessment

Length and Age Sampling

All samples collected from the Subarea 2 + Div. 3K stock in 1986 (Table 5) were taken from the Canadian catch in Div. 3K, which comprised 91% of the total landings. As was the case in 1985, the 1986 catch was comprised largely of fish aged 10-12 (76% of the catch in numbers), these being in the 35-45 cm range (Table 6).

Research Vessel Survey Data

The mean catch per tow, by stratum, from Canadian stratified random surveys is shown in Table 7a for Div. 2J from 1977-86, and Table 8 for Div. 3K from 1978-86. The stratification scheme used in these surveys is shown in Fig. 2 and 3. A survey was begun in Div. 2G and 2H in 1986, but only 22 sets in Div. 2H were completed. Fig. 4 and 5 show the new stratification scheme used in these 2 NAFO Divisions. The biomass estimate of plaice in Div. 2H from the 22 sets was 5516 t, 5324 of which was in stratum 930. Only 7 of 35 strata were surveyed in Div. 2H, and only 3 of 10 strata less than 300 metres were fished.

The biomass in Div. 2J plus 3K has declined from a level of around 120,000t in 1982-83 to around 70,000 t in 1985-86 (Table 11, Fig. 6). Virtually all of this decline has occurred in Div. 2J (Table 7a), while the biomass in Div. 3K has remained at a level between 26,000 and 41,000 t since 1979 (Table 8), with the 1986 value of 32,923 representing approximately the average biomass in Div. 3K from 1979-86. In Div. 2J, it is highly improbable that the fishery had any effect on the stock biomass, given that the catch from 1983 to 1986 totalled only 316t. Although there is recent evidence from an adjacent population of American plaice (Div. 3L) that significant concentrations of fish can be found in depths greater than 500 metres at certain times of the year, there is no indication of such an occurrence in the fall surveys in Div. 2J in recent years. There is no evidence, either from surveys or the inshore fishery, to suggest large-scale migration into shallow water. Thus with survey coverage in Div. 2J complete from 100 to 1000 metres in 1985 and 1986, it is unlikely that the probable bounds of plaice distribution were not surveyed in these years. In any case, Table 7b shows that the decrease in biomass in Div. 2J occurred primarily in shallow strata, mainly in the 101-200m depth range. This table also shows that an increase in biomass has occurred in the deeper strata from 1983 to 1986, although the percentage of total biomass in 1986 found deeper than 300m was still only 7%, or 2731 t, compared to less than 1% (708t) in 1983.

Tables 9 and 10 contain the mean number per tow, by age, from selected strata in the Canadian surveys in Div. 2J and 3K respectively. The trends in the total numbers, which are similar to those shown in the biomass estimates, can be seen in Fig. 7. The survey catches in 1986 were dominated by plaice of ages 7-9, which is consistent with the pattern observed in recent years. Although estimates of recruitment are difficult to obtain because of the low catchability of young plaice with the high-rise trawl, the catch per tow of plaice aged 3 and 4 in Div. 3K in 1986 comprised 10.6% of the total catch numbers per tow, compared with 5% or less in each year from 1978-85.

Mortality estimates

Estimates of total mortality (Z) were obtained, using the catch-curve method, from both research vessel survey and commercial catch-at-age data. Using the 1986 survey data for Div. 2J and 3K, both separate and combined, gave Z-values in the range of 0.68 to 0.87 (Table 12), while the 1983-86 combined 2J3K estimate from the survey data was 0.92 (Fig. 8). Using the 1986 commercial data, a Z-value of 0.99 was obtained. The slopes of the curves were

calculated for ages 8 to 15 for the survey data, and ages 11 to 18 for the commercial data.

Z-values were also calculated using adjacent age-groups in the 1985 and 1986 research vessel surveys. These values were in the range of 0.75 to 1.05 for most of the groups of ages used. The lack of sufficient CPUE data for 1985 precludes the calculation of Paloheimo-type Z-values from the commercial catch-at-age.

Discussion

The decline in biomass in Div. 2J, as measured by the surveys, from about 90,000 t in 1982 and 1983, to 37,000 t in 1986, is difficult to rationalize. As noted above, the commercial catch in Div. 2J in this period was negligible. Given that American plaice are not generally believed to undergo long-distance migrations (Pitt 1969), it is not probable that significant numbers of fish moved out of the survey area in Div. 2J, either inshore or to a different Division. A partial explanation of the decline in Div. 2J may lie with environmental conditions, notably bottom temperatures. In 1983-85, water temperatures in most Newfoundland and Labrador areas were lower than normal. This was particularly true for most shallow-water strata affected by the Labrador current, most of which are strata inhabited by American plaice. Recent declines in the plaice biomass in NAFO Div. 3L have been shown to be correlated with this decreasing temperature (Brodie, unpublished data), as have declines in biomass and commercial CPUE in the mid 1970's with an earlier drop in water temperatures. The reasons for the apparent decrease in abundance, (i.e. higher mortality, decreased availability to the trawl gear, migration to deeper water, etc.) are not known at present. In any case, the decrease in abundance of plaice in Div. 2J follows the pattern observed in Div. 3L, although significant correlations between research survey catches and temperatures could not be found. It should be noted that the cooling trend appears to have ended, and the average bottom temperature in the survey in Div. 2J in 1986 was significantly higher than the 1985 value (2.42°C vs 1.00°C).

Also difficult to explain for this stock are the very high Z-values obtained from the various sources. With the value of M estimated at 0.20 (Pitt and Brodie, 1981), estimates of F from the calculations in Table 12 would be around 0.7 to 0.8, although the estimates from catch curves would represent mortality over an earlier period. However, previous assessments of this stock have often found large discrepancies in values of Z from different sources, casting some doubt on their usefulness. For example, Brodie and Pitt, 1982, found Z values ranging from less than zero using commercial CPUE at age, to 0.75 using survival rates between research vessel surveys. Catch curves, based on commercial catch-at-age, presented in the 1981 and 1982 assessments, indicated Z-values around 0.55. In any case, it is very difficult to rationalize F's of the magnitude calculated in this assessment, given the catch levels of 1982-85 compared to estimated trawlable biomass from surveys in the same period in Div. 2J and 3K. However, it is likely that the decline in biomass observed in the surveys in Div. 2J and the apparent high mortalities from the commercial data are related, whether the causes actually are mortality rates or changes in distribution, migration, etc.

In summary, it should be pointed out that there are a number of positive indications for this stock, despite the apparent decline in abundance in Div. 2J. These are:

- 1) The biomass of Am. plaice in Div. 3K has remained relatively constant, although over 90% of the removals in recent years have come from this Division.
- 2) There appears to be a significant Am. plaice population in Div. 2H. Two of nine sets in depths less than 300m indicated commercial concentrations of Am. plaice.
- 3) Am. Plaice landings increased markedly from 1985 to 1986, with the directed fishery offshore taking its highest catch since 1981 while experiencing good catch rates.
- 4) If the apparent decline in biomass in Div. 2J has been environmentally induced, then the increase in water temperatures observed in 1986 may halt or reverse the trend.
- 5) The ratio of catch to biomass (from surveys) has been very low in recent years, and the 1986 biomass estimate in Div. 2J+3K was about 70,000 tons.

In conclusion, it should be noted that the average catch in Division 3K from 1979-83, which were years of close to average bottom temperatures, was about 3,600t. Given that the biomass estimates from surveys were greater in Div. 2J than Div. 3K in each of the years from 1978-86, a catch of at least 3,600t should be possible in Div. 2J. Also, a substantial population of A. plaice appears to exist in Divs. 2GH. Therefore, a continuation of the 10,000t TAC is recommended for 1988 for this stock.

References

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Table 1. Nominal catches and TAC's (t), American plaice, NAFO Subarea 2 plus Division 3K, 1967-86.

Year	[Inshore	Canada Offshore ^b	Total]	Poland	USSR	Other	Total	TAC
1967	395	-	395	1,134	1,701	414	3,644	
1968	1,023	-	1,023	1,889	2,911	128	5,951	
1969	1,689	-	1,689	867	4,129	217	6,902	
1970	3,751	-	3,751	378	8,160	397	12,686	
1971	2,486	-	2,486	233	2,597	32	5,348	
1972	1,188	9	1,197	849	6,760	315	9,121	
1973	1,368	16	1,384	225	3,011	520	5,140	
1974	462	106	568	91	4,643	318	5,620	10,000
1975	813	46	859	95	4,449	344	5,747	8,000
1976	1,741	736	2,477	118	3,373	139	6,107	8,000
1977	1,925	4,691	6,616	27	698	184	7,525	8,000
1978	1,723	1,452	3,175	138	123	86	3,522	6,000
1979	1,792	1,058	2,850	31	39	45	2,965	6,000
1980	1,140	3,746	4,886	39	26	89	5,040	6,000
1981	1,069	6,332	7,401	58	56	30	7,545	6,000
1982	576	1,265	1,841	13	8	38	1,900	10,000
1983	445	863	1,308	266	11	48	1,633	10,000
1984	559	502	1,061	81	6	27	1,175	10,000
1985 ^a	551	161	712	14	7	14	747	10,000
1986 ^a	1,007	1,883	2,890	61	39	106	3,096	10,000
1987								10,000

^aProvisional.

^bIncludes some catches by inshore otter trawlers.

Table 2. Nominal catch by Division, American plaice in Subarea 2 plus Division 3K, 1972-86.

	2G	2H	2J	3K	Unknown	Total
1972	1	196	4,818	4,106		9,121
1973	0	26	1,788	3,326		5,140
1974	0	11	938	4,671		5,620
1975	73	0	1,101	4,573		5,747
1976	24	43	645	5,395		6,107
1977	0	0	224	7,301		7,525
1978	1	49	145	3,327		3,522
1979	0	11	221	2,733		2,965
1980	0	36	142	4,862		5,040
1981	0	38	96	7,411		7,545
1982	0	108	204	1,588		1,900
1983	0	124	168	1,341		1,633
1984	0	54	92	1,029		1,175
1985 ^a	0	10	35	702		747
1986 ^a	0	0	21	2,866	209	3,096

^aProvisional.

Table 3. Nominal catch by month, American plaice in Subarea 2 plus Division 3K, 1972-86.

	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Unk.	Total
1972	1089	924	297	2688	321	423	849	1313	334	169	13	701		9121
1973	1570	1133	106	519	232	347	491	403	181	30	20	108		5140
1974	373	371	50	1	1425	1799	116	224	141	508	340	272		5620
1975	555	768	648	331	26	161	867	847	181	124	342	897		5747
1976	1517	579	30	156	382	657	592	549	429	413	274	529		6107
1977	64	641	2778	1488	675	691	665	425	67	20	2	9		7525
1978	469	748	259	119	394	534	479	401	63	22	5	29		3522
1979	62	328	66	146	609	707	603	284	47	13	0	100		2965
1980	3	137	796	2454	643	334	352	143	93	62	1	22		5040
1981	717	524	4380	507	411	246	306	253	51	11	8	131		7545
1982	36	298	178	327	377	204	147	148	143	7	2	33		1900
1983	236	118	30	18	179	223	231	181	72	201	105	39		1633
1984	51	20	78	36	84	217	280	251	103	16	8	31		1175
1985 ^a	11	3	8	23	51	66	129	240	160	40	3	13		747
1986 ^a	55	640	1091	62	136	248	336	238	74	6	3	92	115	3096

^aProvisional.

Table 4. Catch and effort, Can(N) offshore trawlers, American plaice, Subarea 2 plus Division 3K, 1976-86.

Year	Total Catch (t)	Directed CPUE (t/hr)	Directed catch (t)
1976	6,107	0.395	701
1977	7,525	0.402	3,628
1978	3,522	0.375	652
1979	2,965	0.467	315
1980	5,040	0.525	2,151
1981	7,545	0.970	4,998
1982	1,900	0.505	500
1983	1,633	0.480	310
1984	1,175	0.419	21
1985 ^a	747	0.172	14
1986 ^a	3,096	0.808	950

^aProvisional.

Table 5. List of commercial sampling by quarter and division available for 1986, for American plaice in Subarea 2 and Division 3K as collected by the St. John's Commercial Sampling Section.

	Quarter				Total
	1	2	3	4	
Offshore					
Can(N) Catch (t)	1,751	49	6	14	1,820
Samples	11	-	-	-	11
Measured	3,825	-	-	-	3,825
Otoliths	589	-	-	-	589
Inshore					
Catch (t)	-	131	800	76	1,007
Samples	-	-	3	-	3
Measured	-	-	1,295	-	1,295
Otoliths	-	-	308	-	308

Table 6. Catch and weight at age for A. plaice in the commercial fishery in NAFO Subarea 2+ Div. 3K in 1986.

AGE	AVERAGE		CATCH		
	WEIGHT	LENGTH	MEAN	STD, ERR,	C, V,
7	0.254	31.000	1	1.05	1.07
8	0.329	33.361	29	6.19	0.22
9	0.376	34.644	283	24.79	0.09
10	0.463	36.855	1209	52.32	0.04
11	0.626	40.431	1372	58.75	0.04
12	0.847	44.347	876	45.41	0.05
13	1.126	48.357	461	30.99	0.07
14	1.466	52.432	205	18.97	0.09
15	1.830	56.077	63	9.12	0.14
*16	2.203	59.294	27	4.51	0.17
*17	2.687	63.000	2	0.02	0.01
*18	3.426	67.763	3	0.02	0.01

Table 7a. Mean weight of American plaice per tow, by stratum, from research vessel surveys in Division 2J. Numbers in parentheses are the number of successful 30 minute tows in each stratum. The stratified mean weight per tow, the total number of sets in each year, and the biomass estimates are given at the bottom of the table. Strata marked with an asterisk were used in the calculation of abundance and biomass in Tables 9-11. (GA = R/V GADUS ATLANTICA.)

Depth (m)	Stratum	Year-survey									
		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
101-200	201*	52.7(2)	56.5(3)	69.4(2)	121.2(3)	71.2(5)	151.0(6)	81.0(6)	59.5(3)	41.2(6)	29.5(5)
201-300	202*	45.9(2)	14.5(2)	7.0(2)	17.8(2)	18.8(2)	46.8(2)	51.5(2)	7.0(2)	7.0(2)	14.3(2)
301-400	203	7.4(2)	-	-	16.0(2)	2.3(2)	0.9(3)	0.7(3)	1.5(2)	0.3(3)	17.8(2)
401-500	204	16.3(2)	-	-	-	6.9(2)	2.7(3)	9.0(3)	4.3(2)	50.8(14)	12.9(2)
101-200	205*	75.3(4)	13.7(4)	51.7(2)	27.9(4)	74.9(8)	181.8(12)	67.1(8)	23.6(8)	31.5(8)	11.2(7)
101-200	206*	253.3(11)	129.4(7)	31.0(8)	62.5(7)	131.0(11)	120.7(18)	213.6(14)	150.3(11)	2.9(2)	60.6(11)
101-200	207*	72.6(5)	21.9(4)	30.0(5)	10.3(5)	22.3(9)	68.7(15)	33.7(10)	25.9(7)	21.6(13)	3.4(7)
301-400	208*	16.9(4)	15.3(3)	25.4(2)	15.8(2)	15.0(2)	3.3(3)	3.5(2)	2.2(3)	10.1(3)	34.5(2)
201-300	209*	54.1(7)	20.5(4)	21.9(5)	66.3(4)	52.0(6)	22.4(11)	15.8(7)	22.6(7)	21.4(9)	34.8(7)
201-300	210*	12.8(6)	40.9(4)	18.8(2)	16.3(3)	13.4(3)	17.5(6)	272.8(2)	20.8(4)	9.1(4)	38.7(3)
301-400	211	8.9(2)	24.7(2)	28.6(2)	44.4(3)	1.6(2)	2.5(2)	7.5(2)	2.3(2)	10.0(3)	8.5(2)
501-750	212	2.2(4)	-	-	-	0.3(2)	0.1(5)	0.1(3)	0.1(3)	0.3(4)	6.7(3)
201-300	213*	61.8(8)	48.4(4)	17.9(4)	100.2(5)	43.1(6)	45.5(10)	37.1(10)	12.0(5)	56.1(9)	52.2(9)
201-300	214*	23.6(4)	26.6(4)	11.7(4)	11.5(3)	13.1(5)	4.0(8)	36.4(8)	39.6(4)	79.6(6)	2.7(6)
201-300	215*	27.8(4)	59.0(5)	26.8(4)	4.0(2)	12.0(5)	4.1(9)	11.5(8)	1.5(3)	3.8(6)	3.3(5)
301-400	216	0.6(2)	-	2.0(2)	0.2(2)	0.5(2)	0.5(2)	0.0(3)	1.3(2)	0.3(2)	0.3(2)
401-500	217	0.2(3)	-	-	-	0.0(2)	0.0(2)	0.0(2)	-	0.0(2)	0.0(2)
501-750	218	0.0(2)	-	-	-	0.0(2)	0.0(2)	0.0(2)	-	0.0(2)	0.0(2)
751-1000	219	-	-	-	-	0.0(2)	-	0.0(2)	-	0.0(2)	0.0(2)
1001-1250	220	-	-	-	-	-	-	-	-	-	-
1251-1500	221	-	-	-	-	-	-	-	-	-	-
301-400	222*	3.2(4)	2.7(3)	4.1(2)	8.0(2)	0.4(2)	2.3(3)	0.0(3)	0.2(3)	0.5(2)	0.0(2)
401-500	223	0.0(2)	-	-	-	0.1(2)	0.0(2)	0.0(2)	0.0(2)	0.0(2)	0.0(2)
501-750	224	0.0(2)	-	-	-	0.0(2)	0.0(2)	0.0(2)	0.0(2)	0.0(2)	0.0(2)
1001-1250	225	0.0(2)	-	-	-	-	-	-	-	-	-
1251-1500	226	-	-	-	-	-	-	-	-	-	-
401-500	227	0.6(4)	-	-	-	0.2(2)	1.0(5)	0.3(4)	0.0(3)	0.1(4)	0.4(3)
201-300	228	21.9(8)	-	8.3(4)	6.2(3)	8.8(6)	3.9(10)	4.5(6)	5.0(7)	9.1(7)	28.8(6)
301-400	229*	7.0(4)	0.5(2)	1.6(2)	1.5(2)	0.1(2)	0.9(4)	1.3(4)	0.2(3)	0.1(3)	1.0(3)
501-750	230	0.0(3)	-	-	-	0.0(2)	0.0(2)	0.0(2)	0.0(2)	0.0(2)	0.0(2)
751-1000	231	0.0(2)	-	-	-	-	0.0(2)	0.0(2)	0.0(2)	0.0(2)	0.0(2)
1001-1250	232	0.0(2)	-	-	-	-	-	-	-	-	-
1251-1500	233	-	-	-	-	-	-	-	-	-	-
201-300	234	23.6(2)	9.8(2)	6.4(2)	32.8(2)	5.0(2)	3.5(3)	14.5(3)	14.7(2)	1.7(3)	3.3(2)
401-500	235	14.3(4)	-	-	-	16.8(2)	1.3(3)	2.3(2)	1.2(3)	0.0(2)	8.0(2)
751-1000	236	0.0(2)	-	-	-	0.0(2)	0.0(2)	0.0(2)	0.0(2)	0.0(2)	0.2(2)
Mean (#set)		58.4(117)	44.4(53)	26.7(54)	40.0(56)	36.9(102)	50.6(157)	53.6(129)	31.6(99)	23.6(131)	21.1(109)
Biomass(+)		104,542	57,867	38,383	58,989	65,110	88,996	95,259	53,942	41,929	37,444

Table 7b. Biomass estimates (t) of *A. plaice*, by depth zone, in NAFO Div. 2J from 1983-86 surveys. Numbers in parentheses are the percentages of biomass in each depth zone.

Depth range(m)	Year			
	1983	1984	1985	1986
101-200	69,418 (74.4)	46,055 (80.6)	22,037 (52.3)	18,502 (47.2)
201-300	23,082 (24.8)	10,690 (18.7)	19,184 (45.6)	17,916 (45.8)
301-400	344 (0.4)	236 (0.4)	786 (1.9)	1,915 (4.9)
401-500	360 (0.4)	148 (0.3)	75 (0.2)	559 (1.4)
501-750	4 (0.0)	4 (0.0)	12 (0.0)	265 (0.7)
751-1000	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.0)
Total	93,208	57,133	42,094	39,159

Table 8. Mean weight of American plaice per tow, by stratum, from research vessel surveys in Division 3K. Numbers in parentheses are the number of successful 30 minute tows in each stratum. The stratified mean weight per tow, the total numbers of sets in each year, and the biomass estimates are given at the bottom of the table. Strata marked with an asterisk were used in the calculation of abundance and biomass in Tables 9-11.

Depth (m)	Stratum	Year-survey									
		1978 GA15	1979 GA29	1980 GA44	1981 GA58 GA59	1982 GA71 GA72	1983 GA86 GA87 GA88	1984 GA101 GA102 GA103	1985 GA116 GA117 GA118	1986 GA131 GA132 GA133	
101-200	618	-	-	-	-	-	-	23.3(5)	25.5(6)	3.2(5)	
101-200	619	-	-	-	-	-	-	10.7(7)	4.3(7)	0.8(5)	
201-300	620*	112.9(7)	29.5(7)	50.2(9)	33.5(10)	37.9(9)	38.4(10)	51.9(13)	21.8(14)	24.7(9)	
201-300	621*	92.8(7)	64.3(8)	21.0(10)	66.0(11)	29.4(14)	39.7(12)	41.7(14)	39.8(15)	10.3(14)	
401-500	622	-	-	-	9.5(2)	16.2(3)	8.3(2)	9.4(4)	1.2(4)	28.0(2)	
301-400	623*	50.4(3)	16.0(3)	88.4(4)	50.2(4)	15.0(5)	23.3(6)	18.7(5)	3.3(6)	23.6(4)	
201-300	624*	18.3(3)	11.3(2)	5.0(2)	25.3(2)	17.0(4)	13.9(4)	17.6(4)	16.1(4)	9.0(2)	
301-400	625*	12.3(3)	7.7(3)	5.3(4)	9.9(4)	7.3(2)	16.8(3)	10.3(5)	11.6(5)	12.7(3)	
301-400	626*	7.2(4)	21.2(3)	40.5(3)	58.4(5)	20.3(5)	31.8(4)	38.5(6)	17.3(5)	85.8(4)	
401-500	627	-	-	-	14.6(6)	6.1(7)	6.2(6)	12.5(8)	11.4(7)	41.7(5)	
301-400	628*	5.6(5)	22.2(2)	6.6(4)	3.9(6)	2.3(6)	16.3(6)	17.0(7)	11.8(6)	7.9(4)	
301-400	629*	6.8(3)	6.6(2)	8.0(3)	7.5(3)	3.3(2)	8.8(3)	5.3(4)	4.5(4)	16.9(3)	
301-400	630*	-	5.4(2)	24.9(2)	8.5(2)	-	4.3(2)	4.9(3)	3.6(4)	3.4(2)	
401-500	631	-	-	-	7.4(5)	4.0(2)	3.8(5)	6.9(5)	7.9(7)	24.8(4)	
201-300	632*	9.2(3)	14.1(2)	6.4(2)	8.5(2)	5.3(3)	10.2(3)	-	5.3(3)	3.5(2)	
301-400	633*	5.9(5)	4.8(6)	2.3(7)	2.6(8)	3.2(7)	2.4(12)	1.7(10)	1.3(12)	14.3(8)	
201-300	634*	5.5(5)	4.3(6)	4.6(5)	6.5(7)	5.3(11)	2.4(5)	4.5(7)	2.2(9)	3.8(5)	
201-300	635*	10.5(5)	7.5(5)	13.8(4)	13.2(5)	16.8(5)	26.5(6)	18.8(8)	4.9(7)	7.5(6)	
201-300	636*	14.2(3)	7.0(5)	4.7(5)	4.4(6)	8.3(10)	11.4(6)	14.4(8)	6.5(8)	4.7(4)	
201-300	637*	7.5(4)	7.0(4)	7.3(4)	9.0(6)	16.9(7)	9.5(5)	15.6(6)	4.1(7)	7.0(4)	
301-400	638*	11.8(5)	10.1(7)	10.0(6)	12.1(8)	5.6(15)	8.0(11)	5.9(10)	12.3(11)	13.9(4)	
301-400	639*	6.4(5)	1.0(2)	5.2(4)	2.1(6)	3.9(10)	1.0(7)	6.0(8)	1.4(8)	5.8(6)	
401-500	640	-	-	-	0.0(2)	0.0(2)	-	0.0(2)	0.3(3)	4.1(2)	
501-750	641	-	-	-	0.0(2)	0.0(4)	0.0(3)	0.0(3)	0.3(4)	-	
751-1000	642	-	-	-	0.0(3)	0.0(6)	-	0.0(6)	0.0(5)	-	
1001-1250	643	-	-	-	-	-	-	-	-	-	
1251-1500	644	-	-	-	-	-	-	-	-	-	
401-500	645	-	-	-	0.0(2)	0.0(3)	0.1(2)	0.0(2)	0.1(3)	-	
501-750	646	-	-	-	0.0(2)	0.0(2)	0.3(2)	0.0(2)	0.0(3)	-	
751-1000	647	-	-	-	0.0(2)	0.0(2)	-	-	0.0(3)	-	
1001-1250	648	-	-	-	-	-	-	-	-	-	
1251-1500	649	-	-	-	-	-	-	-	-	-	
Mean (#sets)		34.3(70)	18.3(69)	19.0(78)	18.8(121)	12.6(146)	15.9(125)	17.4(162)	11.2(180)	15.1(107)	
Biomass(t)		57,314	31,354	32,480	40,222	26,455	32,167	40,026	26,548	32,923	

Table 9. Mean number of American plaice per tow from R.V. surveys in Division 2J. The same strata were used in the calculations for each year.

Age	GA 3 1977	GA 15 1978	GA 29 1979	GA 44 1980	GA 58-59 1981	GA 71,72 1982	GA 86-88 1983	GA 101- 103 1984	GA 116- 118 1985	GA 131, 132, 133 1986
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	0.01	0.01	-	-	0.01	-
3	-	0.03	-	-	0.01	0.17	0.06	-	0.05	0.10
4	0.20	0.57	0.32	0.07	0.81	0.38	0.85	0.34	0.16	0.23
5	8.54	5.24	2.20	0.66	3.41	3.86	1.88	1.34	1.65	1.20
6	17.56	15.90	9.45	5.42	21.19	10.83	10.32	4.62	6.50	4.59
7	34.54	24.24	16.99	27.48	29.15	33.06	32.13	16.20	15.24	11.05
8	48.43	20.35	17.62	21.65	22.98	38.34	41.28	23.38	19.11	12.05
9	27.63	15.47	10.64	13.08	8.92	38.63	23.81	18.76	17.34	11.68
10	12.77	9.80	5.89	8.69	5.99	17.06	17.09	8.04	5.99	5.05
11	8.13	5.50	2.66	4.82	2.15	6.81	8.80	4.17	2.24	1.28
12	5.62	4.42	3.55	4.41	0.87	4.18	2.50	1.36	1.40	1.01
13	3.71	3.71	2.11	1.96	0.07	2.56	1.62	1.14	0.69	0.40
14	2.10	1.70	0.62	1.16	-	1.13	0.42	0.21	0.11	0.08
15	0.87	1.22	0.16	0.34	-	0.22	0.16	0.08	-	0.04
16	-	0.58	0.06	0.15	-	0.11	-	-	-	-
17	-	0.20	-	0.05	-	0.02	0.01	-	-	-
18	-	0.01	-	0.02	-	-	-	-	-	-
19	-	0.01	-	-	-	-	-	-	-	-
UNK	-	-	-	-	0.08	0.03	0.01	0.01	0.01	0.0
Mean	170.10	108.95	72.27	89.96	95.64	157.40	140.94	79.65	70.50	48.76
No.Sets	67	49	44	44	66	107	84	63	85	69

Table 10. Mean number of American plaice per tow from R.V. surveys in Division 3K. The same strata were used in the calculations for each year.

Age	GA 15 1978	GA 29 1979	GA 44 1980	GA 58,59 1981	GA 71,72 1982	GA 86-88 1983	GA 101- 103 1984	GA 116- 118 1985	GA 131- 133 1986
1	-	0.01	-	-	-	-	0.01	-	0.02
2	-	-	0.01	-	0.02	0.01	0.07	0.18	0.09
3	0.24	0.01	0.08	0.16	0.31	0.57	0.17	0.21	1.34
4	4.02	0.40	0.12	0.23	0.55	0.79	1.70	0.66	1.98
5	10.28	2.31	1.19	1.09	1.20	2.97	2.38	1.90	2.36
6	15.12	5.06	4.01	2.33	2.95	5.46	6.78	2.75	4.47
7	13.59	6.89	10.31	8.18	5.75	9.46	7.00	5.10	4.69
8	10.05	7.51	7.25	11.65	7.69	9.72	12.44	5.70	5.91
9	8.65	6.11	5.29	6.71	6.29	4.00	6.96	4.46	5.17
10	7.23	4.45	4.49	7.19	3.27	3.10	3.35	2.23	2.62
11	4.33	2.07	2.62	2.24	2.18	1.13	2.03	1.00	1.09
12	3.72	2.64	2.09	3.03	1.06	1.18	1.39	1.06	0.87
13	3.23	1.32	1.03	1.45	0.86	0.56	0.67	0.52	0.41
14	1.67	0.43	0.66	0.61	0.42	0.30	0.30	0.11	0.17
15	1.30	0.17	0.26	0.37	0.22	0.12	0.20	0.08	0.04
16	0.67	0.15	0.10	0.26	0.07	0.03	0.05	0.03	-
17	0.25	0.01	0.05	-	0.05	-	0.02	-	-
18	0.08	0.03	0.03	0.04	0.01	-	-	-	-
19	0.01	-	-	-	-	-	-	-	-
UNK	0.04	0.02	-	0.01	0.01	0.04	-	-	0.01
Mean	84.48	39.59	39.59	45.55	32.91	39.44	45.51	25.99	31.24
No.Sets	70	69	78	95	115	105	119	128	84

Table 11. Biomass estimates (t) for American plaice from random stratified surveys in Division 2J and 3K, 1978-86. The same strata were used in the calculations shown in the first three rows of the table. The last row gives the total estimated biomass for all strata surveyed.

Division	Year								
	1978	1979	1980	1981	1982	1983	1984	1985	1986
2J	56,881	36,487	55,398	63,101	88,164	93,685	52,549	40,524	32,423
3K	57,314	31,354	32,480	37,807	24,787	30,873	34,022	21,459	25,151
Total for selected strata	114,195	67,841	87,878	100,908	112,951	124,558	86,571	61,983	57,574
Total for all strata	115,181	69,737	91,469	105,331	115,451	127,426	93,968 ^a	68,477 ^a	70,367 ^a

^aIncludes strata 618 and 619 added in 1984.

Table 12. Calculation of total mortality estimates for plaice in Subarea 2 + Div. 3K.

Catch Curves					
Age	Ln, 1986 survey nos/tow, 2J	Ln, 1986 survey nos/tow, 3K	Ln, 1986 survey nos/tow, 2J+3K	Ln, 1983-86 Survey nos/ tow 2J+3K	Ln, 1986 Comm. catch numbers, 2+3K
8	1.78	2.49	2.89	4.86	-
9	1.64	2.46	2.82	4.52	-
10	0.96	1.62	2.04	3.86	-
11	0.09	0.25	0.86	3.08	7.22
12	-0.14	0.01	0.63	2.38	6.78
13	-0.89	-0.92	-0.21	1.79	6.13
14	-1.77	-2.53	-1.39	0.53	5.32
15	-3.22	-3.22	-2.53	-0.33	4.14
16	-	-	-	-2.21	3.30
17	-	-	-	-3.51	0.69
18	-	-	-	-	1.10
r ²	.957	.969	.970	.961	.945
intercept	7.723	9.976	9.666	12.978	18.655
Slope	-0.688	-0.866	-0.785	-0.919	-0.988

Survival Estimates

Age	1985 Survey Nos. per tow, 2J&3K	1986 Survey Nos. per tow, 2J&3K
7	20.34	15.74
8	24.81	17.96
9	21.80	16.85
10	8.22	7.67
11	3.24	2.37
12	2.46	1.88
13	1.21	0.81
14	0.22	0.25
15	0.08	0.08
16	0.03	-
Total	82.41	63.61

$$\frac{\sum(8-15) (86)}{\sum(7-14) (85)} = 0.582, Z=0.54$$

$$\frac{\sum(9-15)}{\sum(8-14)} = 0.483, Z=0.75$$

$$\frac{\sum(10-15)}{\sum(9-14)} = .352, Z=1.05$$

$$\frac{\sum(11-15)}{\sum(10-14)} = .351, Z=1.05$$

Nominal Catch Am. Plaice NAFO SA2+Div. 3K

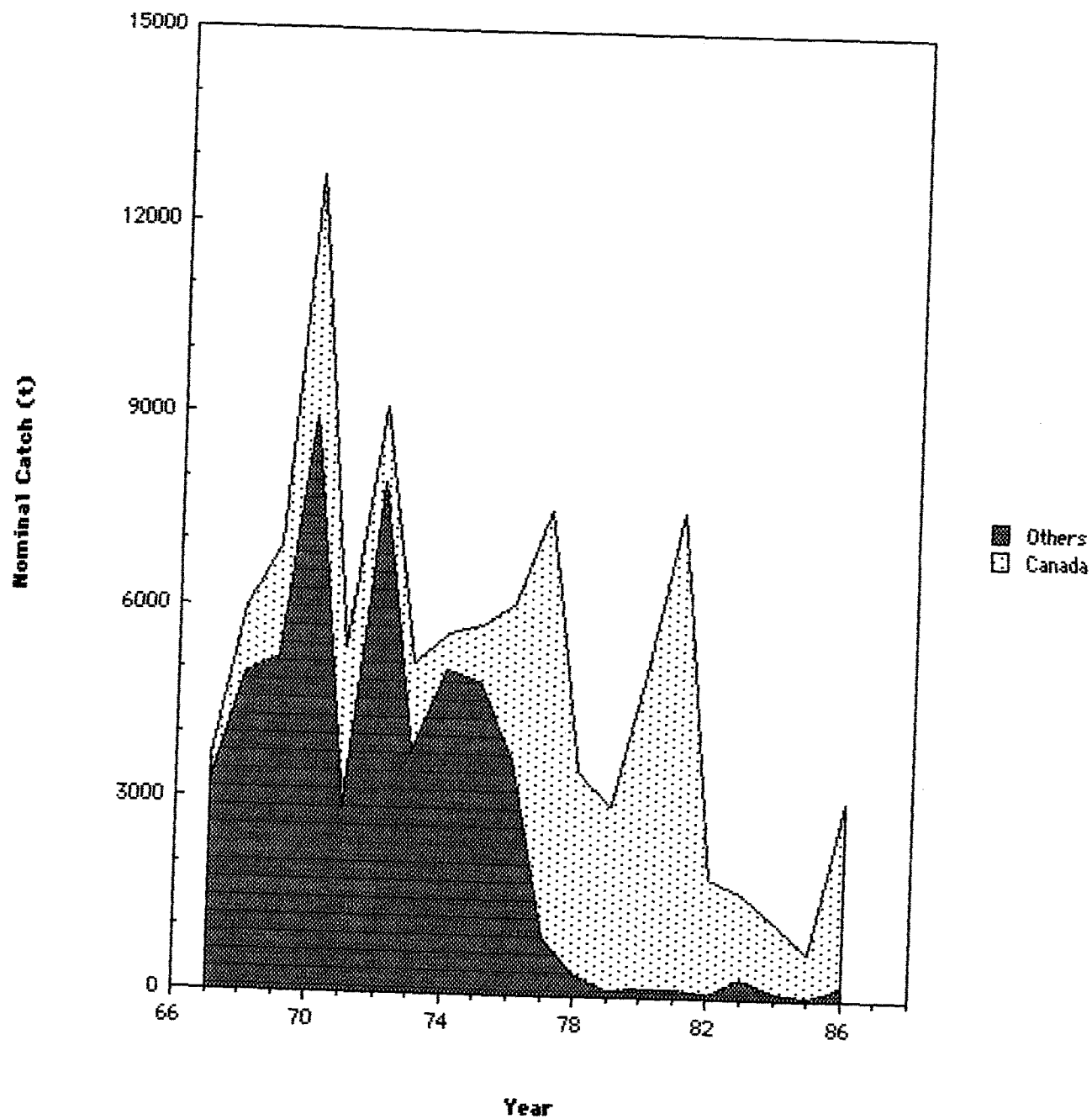


Fig.1. Nominal catch of American plaice in NAFO SA2+3K during 1967-1986.

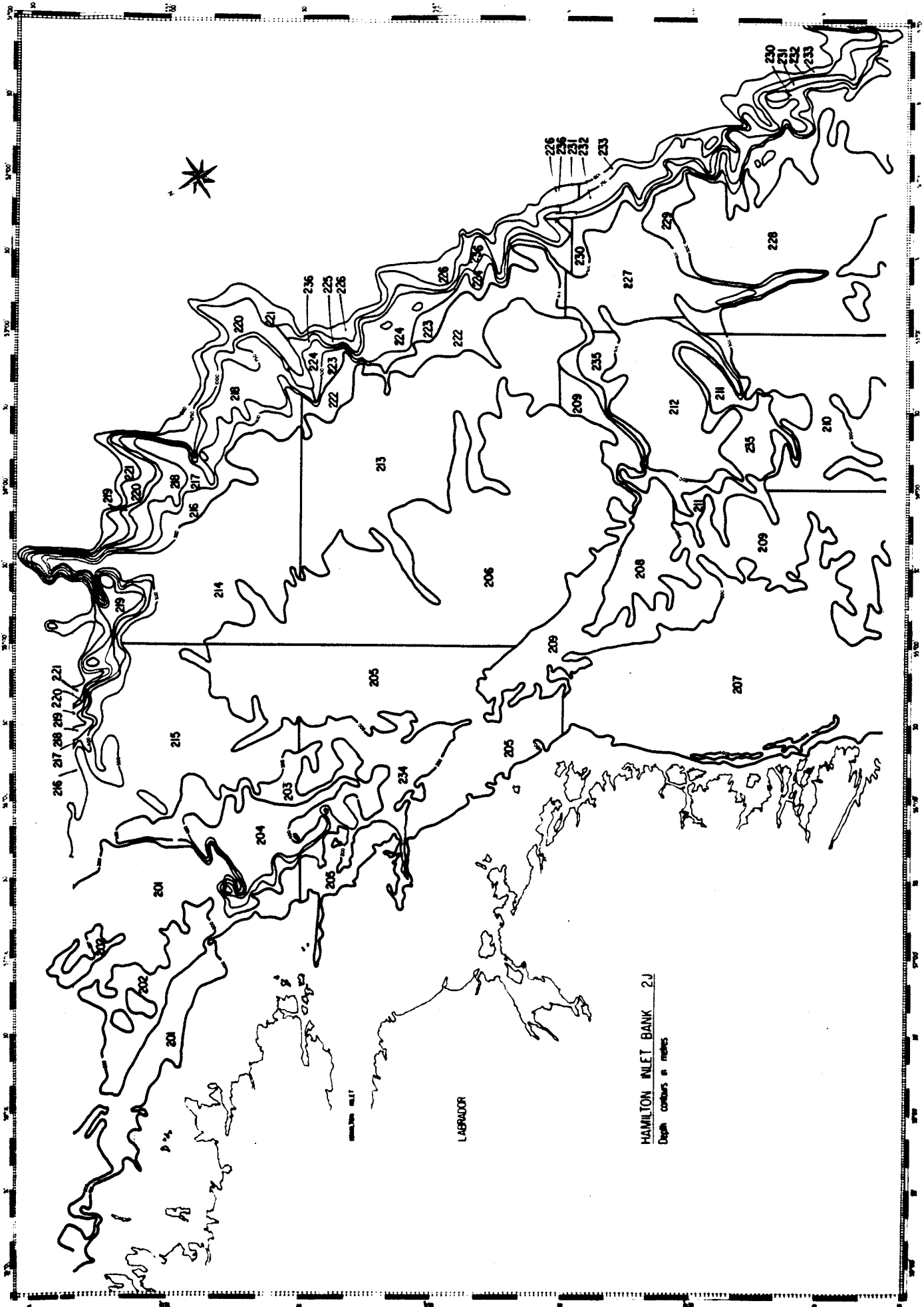


Fig. 2. Stratification scheme used for Canadian surveys in Division 2J.

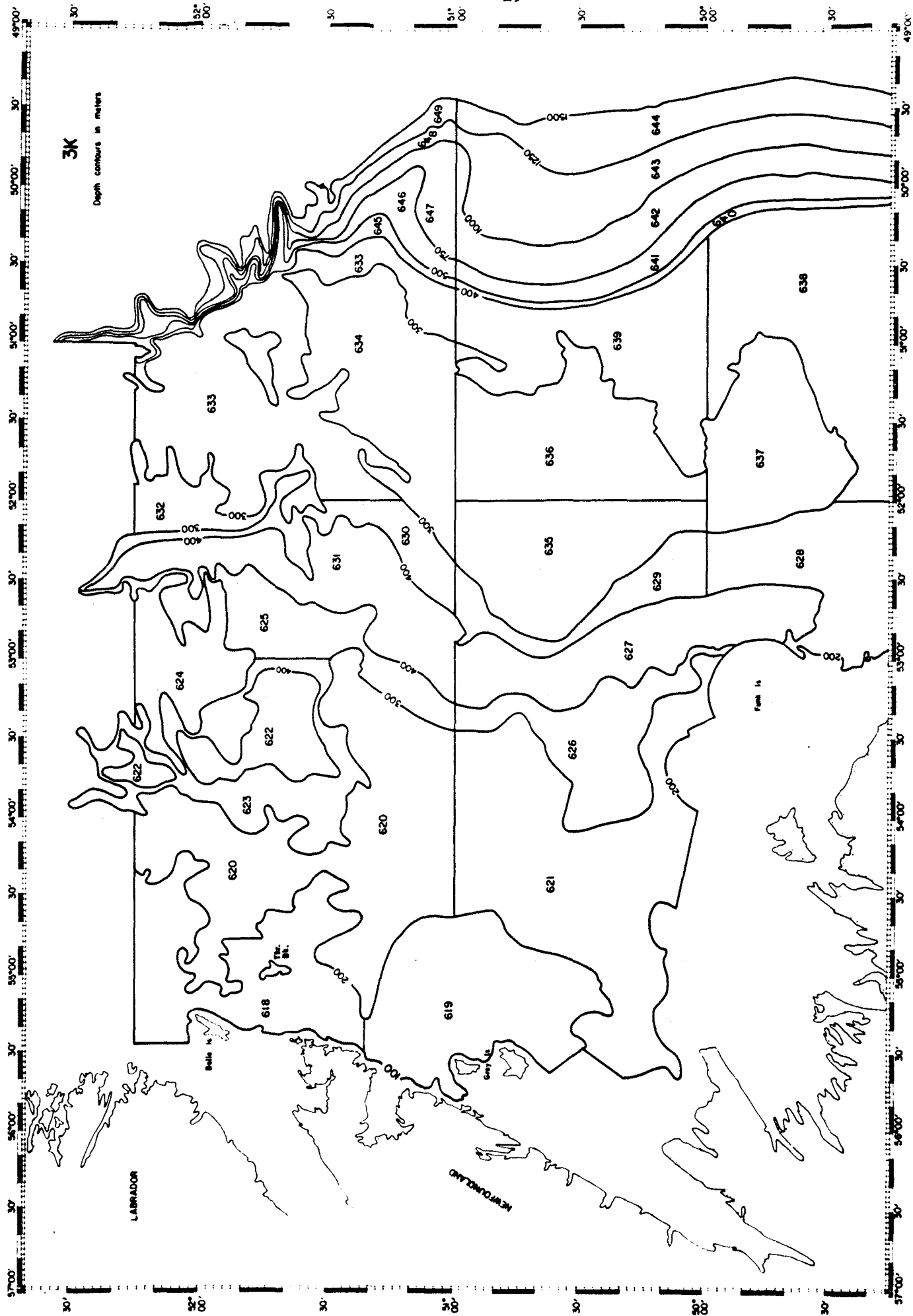


Fig. 3. Stratification scheme used for Canadian surveys in Division 3K.

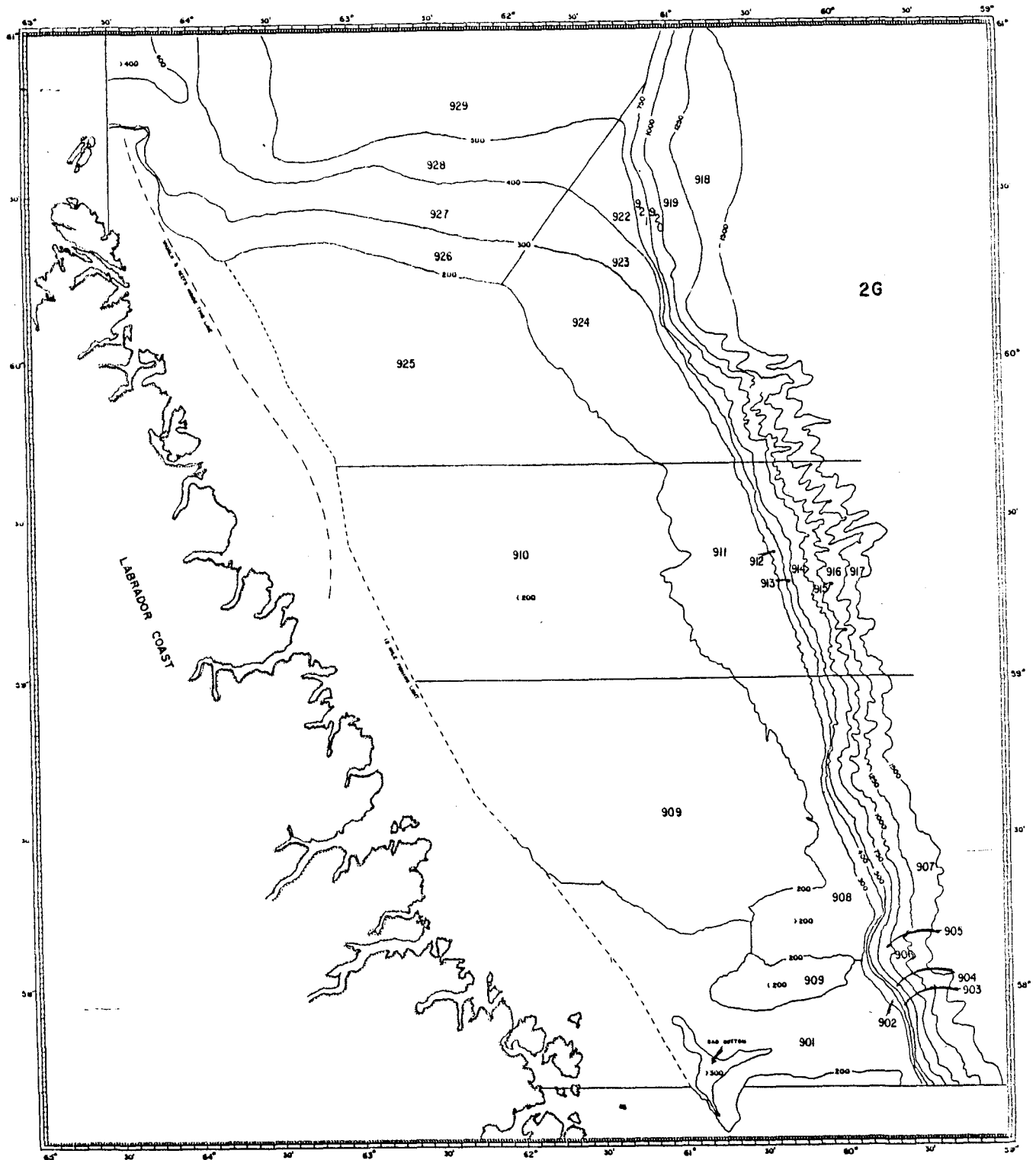


Fig. 4. Stratification scheme used for Canadian surveys in Div. 2G.

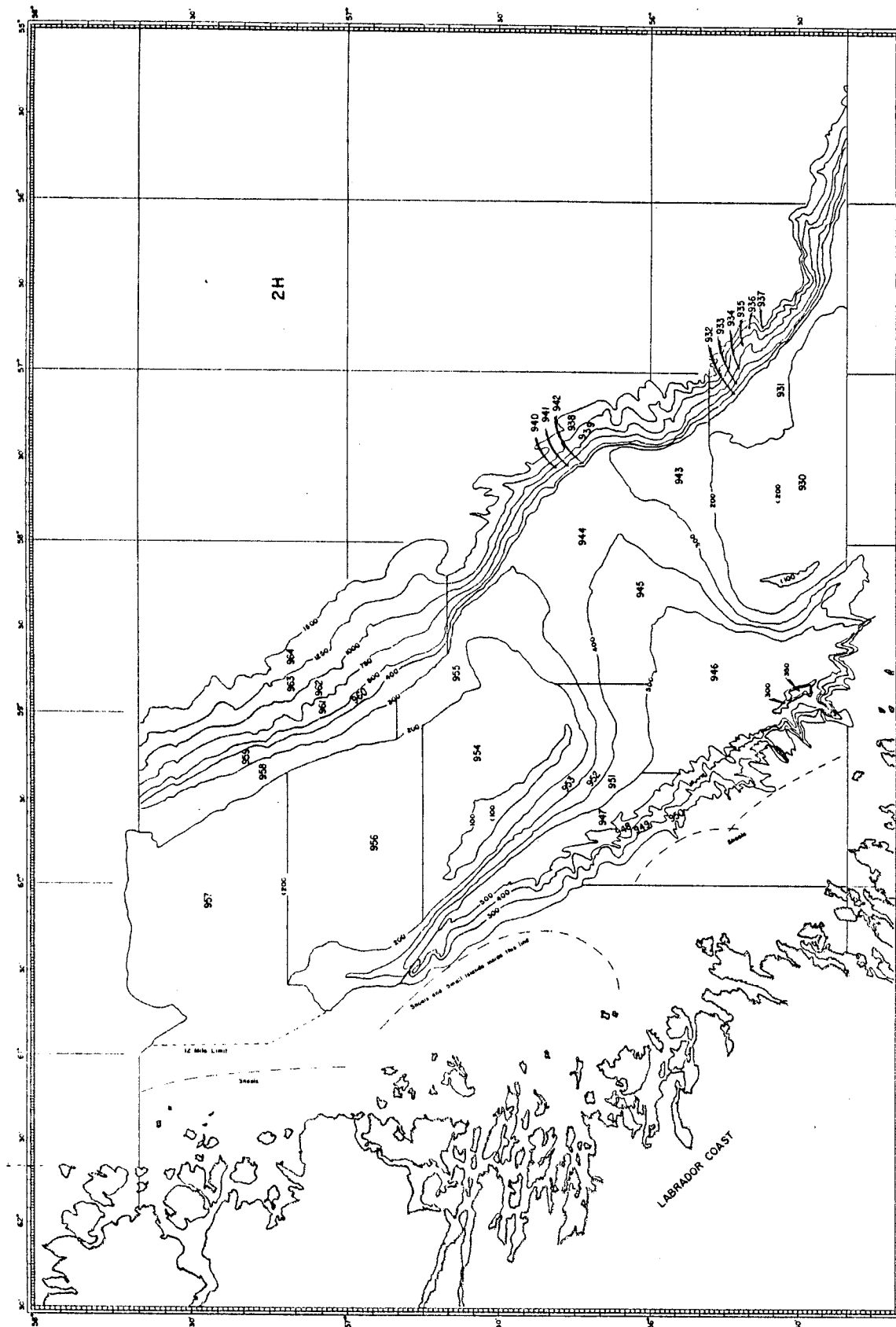


Fig. 5. Stratification scheme used for Canadian surveys in Div. 2H.

American plaice in NAFO SA2+Div. 3K

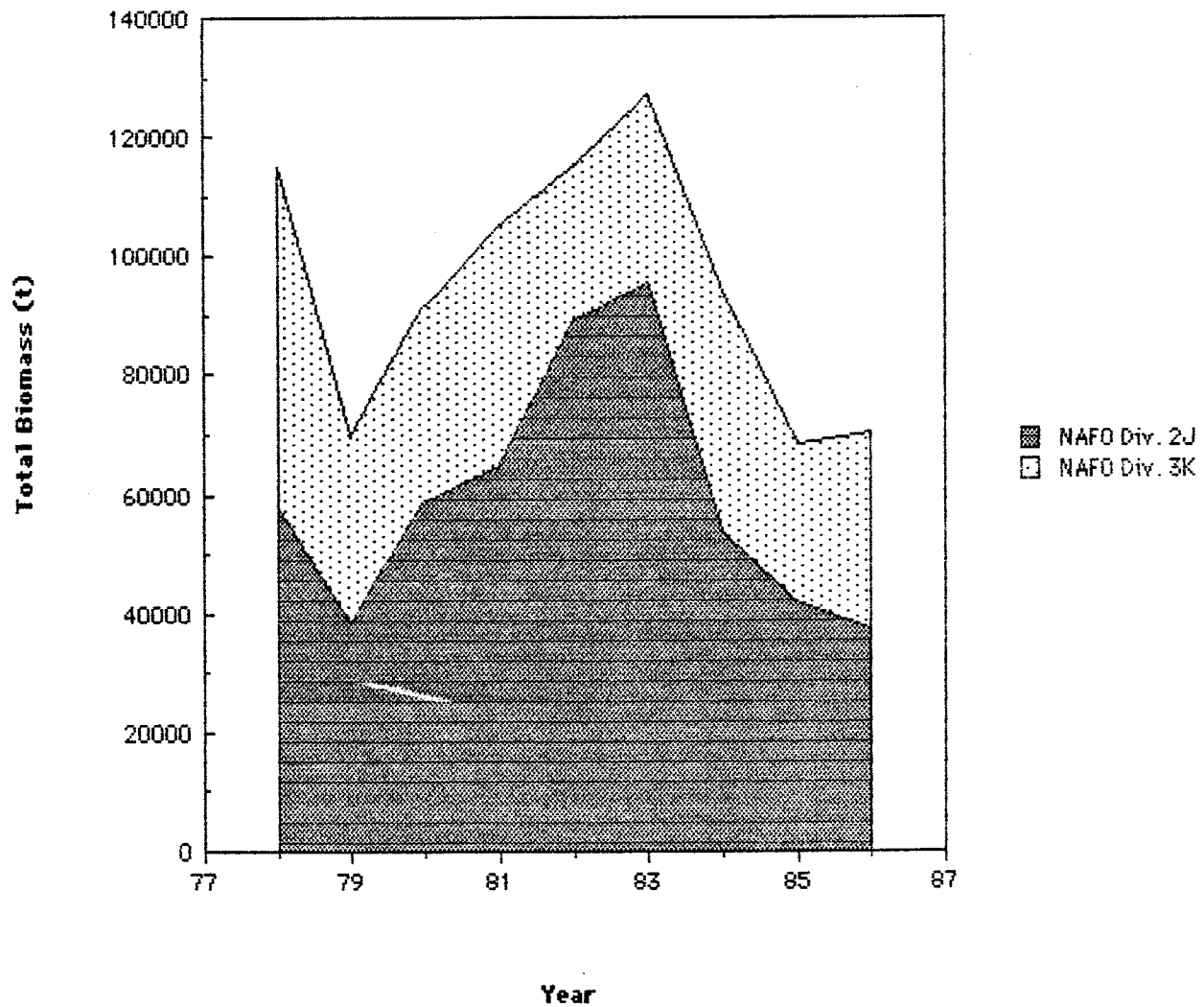


Fig.6. Total biomass of American plaice estimated from research vessel surveys in NAFO Div. 2J,3K in 1978-86.

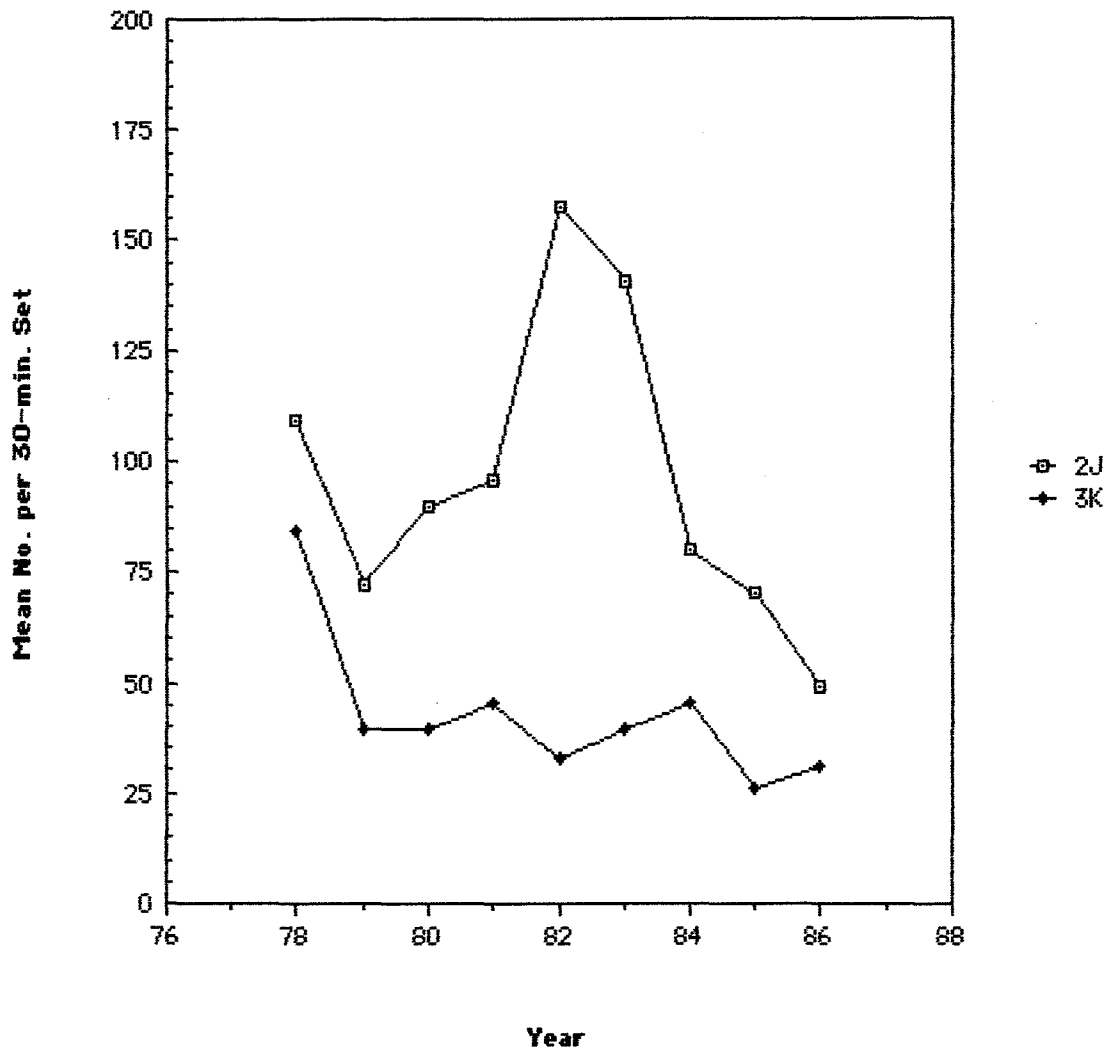
American plaice in NAFO SA2+Div. 3K

Fig.7. Mean no. per set of American plaice from research vessel surveys in NAFO Div. 2J and 3K in 1978-86.

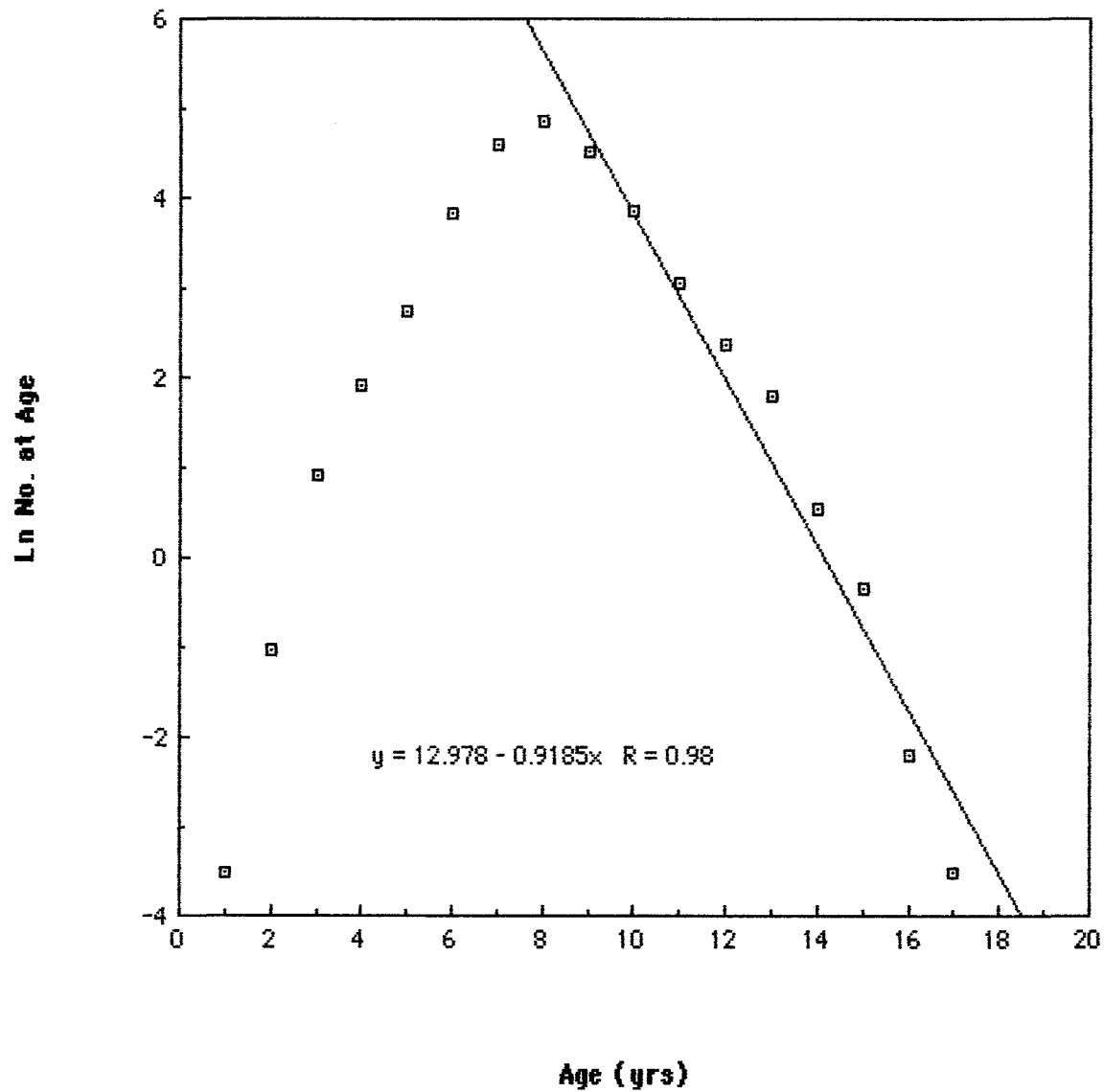
Catch curve of Am. Plaice SA2+3K

Fig. 8. Catch curve of American plaice from research vessel surveys in NAFO Subarea 2 and Div. 3K, 1983-86.