Assessment of Pollock (*Pollachius virens*) in Divisions 4VWX and Subdivision 5Zc for 1990

by

C. Annand and D. Beanlands

Biological Sciences Branch
Scotia-Fundy Region
Marine Fish Division
Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth
Nova Scotia, B2Y 4A2

Abstract

The Canadian TAC for pollock in 1990 was 43,000 t, increased from the recommended 38,000 t in July due to industry requests. The domestic catch of 36,178 t was 6822 t below the TAC, with both inshore and offshore mobile gear fleets below their allocations. The foreign catch, due primarily to small mesh landings by the USSR, dropped back to 1988 levels while remaining high compared to the 1981-1987 period. The concentration of the eastern part of the pollock fishery in Div. 4V rather than Div. 4W during 1985-1989 has continued in 1990. Research surveys indicate an increase in the age 4-9 abundance from the early 1980s with the 1985, 1987 and 1990 numbers among the highest observed. However the 1990 survey total numbers appear to be extremely high, especially at ages 2 and 3, and are associated with high CV's. For the 1979-1985 period recruitment has been above average. As in last year's assessment, only R.V. numbers at age were used to calibrate the cohort analysis using non-linear least squares to estimate fishing mortality. The F for 1990 using a domed partial recruitment was 0.25. Catch projections to 1993 under the multiyear plan indicate that a constant catch of 43,000 t to 1993 was consistant with an $F_{0.1}$ strategy. However, given an $F_{0.1}$ yield of 1.080 kg and a geometric mean recruitment level of 31 million the long term productivity for this stock is about 33,480 t.

Résumé

Le TPA canadien de goberge était de 43 000 t en 1990, le niveau de 38 000 t recommandé ayant été augmenté à la demande de l'industrie. Les prises des navires canadiens s'établissaient à 36 178 t, soit 6 822 t en dessous du TPA. Les prises des deux flottilles de pêche aux engins mobiles (hautuière et côtière) étaient inférieures à leurs allocations. Les prises étrangères, provenant principalement des filets à petit maillage de la flottille soviétique, sont retombées à leurs niveaux de 1988, mais sont restées elevées comparativement à celles de la période 1981-1987. À l'est, la concentration de la pêche de la goberge dans la division 4V plutôt que dans la division 4W, phénomène que l'on observe depuis 1985, s'est poursuivie en 1990. D'après les résultats des campagnes d'évaluation, l'abondance des poissons de quatre à neuf ans a augmenté depuis le début des années 1980, pour atteindre de très hauts niveaux en 1985, 1987 et 1990. Précisions cependant que les chiffres totaux des campagnes d'évaluation de 1990 paraîssent très élevés, en particulier pour les poissons de deux et trois ans, et sont associés à de forts coefficients de variation. Durant la période 1979-1985, le recrutement a été supérieur à la moyenne. Comme dans l'évaluation de l'an dernier, on n'a utilisé que les chiffres provenant des navires scientifiques pour étalonner l'analyse des cohortes au moyen de la méthode des moindres carrés non linéaires, cela dans le but d'estimer la mortalité due à la pêche. En 1990, la valeur F fondée sur une courbe de recrutement partiel en forme de dôme s'etablissait à 0,25. D'après les projections de prises pour 1993 établies dans le cadre du plan pluriannuel, des captures constantes de 43 000 t jusqu'en 1993 cadreraient avec une stratégie de gestion à $F_{0.1}$. Toutefois, étant donné un rendement $F_{0.1}$ de 1,080 kg et un niveau de recrutement géométrique moyen de 31 millions, la productivité de ce stock s'établit à environ 33,480 t.

Introduction

Description of the Fishery

The preliminary estimate of the nominal catch for 1990 (37,479 t) indicates that landings have dropped significantly for the first time in five years (Table 1, Figure 1). Canadian landings have consistently accounted for the majority of the catch. Catches by foreign fleets have been primarly incidental with the major share taken by the USSR and Cuban trawlers fishing for silver hake and other groundfish, or by the USA fishing on the northeast peak of Georges Bank. Since the extension of jurisdiction in 1977, catches by foreign vessels other than the USA have generally averaged less than 2000 t. With the definition of the new international boundary, the ICJ line (Figure 2) in 1984, no USA catches have been reported.

The pollock fishery is prosecuted mainly in Div. 4X and Subdiv. 5Zc with a smaller portion taken in divs. 4VW (Figure 3). There has been a shift in the divs. 4VW fishery from Div. 4W to Div. 4V during 1984-1990. Div. 4V landings have increased from about 5,000 t in 1984 to an average of 13,000 t for the 1985-1989 period. The 1990 landings of 8,150 t in Div.4V indicate a marked decrease with no corresponding increase in the Div. 4W landings (Table 2). The fishery in divs. 4VW is dominated by large offshore trawlers greater than 100 ft with mobile gear and in Div. 4X and Subdiv. 5Zc by inshore vessels less than 65 ft using both mobile and fixed gear.

Seasonal breakdowns (Table 3) indicate a year round fishery, although with a bias toward May-August especially in Div. 4X and Subdiv. 5Zc. Small mesh landings by the USSR (1040 t) dropped back to 1988 levels, while remaining high compared to the 1981-1987 period. The Canadian catch is broken down by gear,area and season in Table 4. The large trawler, tonnage class (TC) 4+, landings dropped significantly in both areas. Prior to 1985, pollock allocations were generally not taken by this gear sector. However, since that time the offshore has chosen to fish these previously underutilized enterprise allocations. The decrease in landings in 1990 is almost entirely attributable to the offshore fleet not taking their allocation. During the winter fishery there were unconfirmed industry reports of lack of abundance or availability of pollock from this sector. There was a slight drop in the Div. 4X and Subdiv. 5Zc landings for small otter trawlers (TC 1-3) while in divs. 4VW the landings for the inshore trawler fleet decreased more significantly. Marked changes were noted in the seasonal fishing patterns in both areas. These changes, and reduced landings, were probably due to the combined cod, haddock, pollock (CHP) management of the fishery during the early part of the year, as this allowed fishermen to target cod and haddock preferentially, taking advantage of price differentials. Fixed gear landings were generally stable with a slight increase in Div. 4X and Subdiv. 5Zc.

The Canadian allocation of 43,000 t was not taken during the 1990 pollock fishery. The shortfall from the domestic fishery amounted to 6288 t. The mobile gear sector >100 ft and 65-100 ft had a combined shortfall of 5,710 t. Mobile gear 45-65 ft had a shortfall of

1,710 t while mobile gear <45 ft (specialists and generalists) had a combined shortfall of 539 t. Fixed gears <45 ft and 45-65 ft had a combined overrun of 1689 t. Quota allocations and associated catch for 1990 are presented in Table 5. Since 1982, the pollock fishery has been regulated by quotas on four gear sectors: 1) fixed gear, 2) mobile gear greater than 100 ft, 3) mobile gear less than 65 ft, and 4) mobile gear 65-100 ft. In 1988 mobile gear and fixed gear less than 65 ft were further divided: a) mobile gear and fixed gear less than 45 ft, and b) mobile gear and fixed gear 45-65 ft. Seasonal quotas and trip limits were introduced in 1986 for mobile gear <65 ft in order to extend the fishery to the end of the year. Seasonal quotas are applied to the mobile gear <45 ft to allow a larger portion of the catch to be taken during the summer when they are less subject to weather conditions. In 1989 the mobile gear fleet <45 ft was further split into specialist and generalist categories. These two fleets, as well as the 45-65 ft fleet, were regulated through conditions of licence and trip limits, replacing the variation order as a means of controlling the fishery. CHP management was also introduced as a means of addressing the problem of misreporting by area and species.

Individual boat quotas were not introduced in 1990 as expected and the fishery continued to be managed using conditions of licence and trip limits. CHP management continued in Div. 4X for the first half of the year, resulting in very little pollock being taken as cod and haddock were preferentially fished. CHP management was then replaced with a pollock-directed fishery with various by-catch options. For the last three months of the year, vessel quotas were used to divide up the remaining quota for mobile gear <65 ft. Georges Bank was managed separately, with each vessel allowed eight trips of 35,000 lbs. The fishery was open from June 1 to Oct. 31 for mobile gear <65 ft using 130 mm square mesh gear, and to fixed gear all year provided that small hooks were used until June 1. For 1991, individual boat quotas (IQ's), based on catch history, have been introduced for the inshore mobile gear fleet. Georges Bank was not included in IQ's and will continue to be managed separately. As well, a new log and catch monitoring system have been put in place. New regulations dealing with dumping and discarding fish at sea have also been introduced.

Distribution maps of catch per unit effort as recorded by the International Observer Program (IOP) on Canadian vessels TC 4+ in 1990 are shown in Figure 4. Observer coverage of the domestic fleet was higher in 1990 (30-50%) than in previous years (15-20%) (Annand 1989) due mostly to a general slowdown in the fishery. Geographical distribution of fishing effort was similar to recent years with an expanded fishing area, compared to years prior to 1987.

Catch at Age

The catch at age prior to 1990 was taken from Annand et al. (1990). Catch and mean weight at age for 1990 landings were estimated using samples from the commercial fisheries. Sampling for 1990 is shown in Table 6. Seasonal age length keys for otter trawlers TC 4+ (4VW) and annual keys for TC 4+ otter trawlers (4X+5), small trawlers TC 1-3 (4VWX+5) and fixed gears for (4VWX+5) were generated. Length weight parameters were obtained from analysis of the 1990 summer groundfish survey collections. Input data for generating

the six keys used for the Canadian catch at age are given in Table 7. These keys accounted for 36,178 t or 96% of the entire catch, the difference consisting of the foreign by-catch. The age composition of the small mesh catch at age was based on pollock length frequencies from IOP data for the USSR and Cuban fisheries (1981-1990), rather than survey proportions at age as in previous years. Differences were most apparent for ages 2 and 3 (Table 8). Weights at age were from the July RV survey. The total combined catch at age reflects the total landings (37,479 t of pollock in divs.4VWX and Subdiv. 5Zc). The total catch at age is given in Table 9 along with the Canadian catch at age and the small mesh and foreign catch-at-age matrices. As in most years, only four or fewer year-classes contributed significantly to the annual landings.

Catch at age for 1990 was dominated by the 1983-1986 year-classes accounting for 77% and 74% of the catch in number and weight respectively (Table 10). The 1987 year-class at age 3 was 9% of the catch numbers, the highest observed value at that age since 1983. The 1985 year-class was the strongest in the overall catch at age (numbers and weight). Similarities were noted in the age composition of the large trawlers fishing in divs. 4VW and for the fixed gear fleet fishing predominantly in Div. 4X with the 1983-1985 year-classes accounting for the largest portion of the landings. Differences were again noted in the age composition of the large trawler catch between divs. 4VW and and Div. 4X and Subdiv. 5Zc. (Figure 5).

A comparison of the observed and projected 1990 catch at age (Figure 6) indicates close agreement for ages 2, 3 and 4. The catch of the 1984 and 1985 year-classes at ages 5 and 6 were higher than predicted. Conversely the catch of the 1982 and 1983 year-classes (ages 7 and 8) were lower than projected. Weight at age was similar to that observed in recent years (Table 11).

Abundance Indices

Commercial Catch Rates

Commercial catch rates are not used for calibration purposes, however because of peculiarities observed in the 1990 offshore fishery, catch rates were investigated. A Canadian catch rate series (C/E) for stern OTB's TC5 for April to November was estimated using regional data (Figure 7) (1974-1990) and is presented in Table 12. A monthly catch rate series was also estimated for 1989 and 1990(Figure 8). Catch rates were consistently higher in 1990 (January through September), but dropped sharply in the October-December period. These observations were consistent with industry reports that the offshore fleet (National Sea) had some difficulty catching pollock during their winter fishery. A catch rate series for April to November, 1982-1990 was also calculated on a set by set basis from the IOP data (Table 13). This series did not show the same increase in catch rate between 1989 and 1990 and in fact was lower than catch rates calculated on a trip basis for the first time in the time series.

Research Surveys

Three vessels have been involved in the summer stratified random surveys of the Scotian Shelf (Figure 9) since 1970. After analysis of comparative fishing experiments, pollock catches were found to be the same between the different research vessels and hence no conversion factors were applied. The estimated total numbers at age from these surveys for strata 40-95 are in Table 14 and ages 4-9 and 1-3 abundance are plotted in Figure 10.

The research surveys from 1970-1990 indicate an increase in the age 4-9 abundance from the early 1980's with the 1985, 1987 and 1990 numbers among the highest observed while the 1988 and 1989 numbers show a marked decline. However the 1990 survey total numbers appear to be extremely high especially for ages 2 and 3 and are associated with high CV's. All ages exhibit pronounced year effects making it difficult to determine year-class strengths. Pollock surveys tend to suffer from annual variations in availability which are reflected in the abundance of all age classes in a year being larger or smaller than those of an adjacent year. This makes it difficult to follow a cohort through time and the catch may not be representative of the overall abundance. However because juvenile pollock tend to remaine inshore and are generally unavailable to the survey, large numbers of age 3 pollock have in the past indicated large year-classes e.g. 1979 and 1982. As well, although large sets did occur in several strata (Table 15), plots of the survey data by age groups (Figure 11) indicate a fairly widespread distribution of young pollock.

It was noted that a large portion of the pollock fishery takes place in the deep water along the edge of the Shelf. Because the survey only covers the Shelf between the 50 and 200 fm. contour lines this part of the stock area may not be covered.

Mean numbers per standard tow and survey CV's are given in tables 16 and 17 respectively.

Sequential Population Analysis

Cohort analysis of ages 2-11 from 1974-1990 was calibrated using ADAPT with the same formulation as last year (Table 18). Natural mortality was assumed to be constant at 0.2 for all ages and years. The RV numbers at ages 4-9 were used to estimate fishing mortality at ages 4-9. The Fs for ages 2-3 and 10-11 were based on the weighted average of ages 7-9 and the PR given below with a dome of .85 and 0.5 applied to ages 10-11 respectively.

Age	2	3	4	5	6	7	8	9	10	11
PR	.015	.168	.414	.670	.850	1	1	1	.850	.5

Partial recruitment was estimated for the 1977-1985 period from the ratio of Fs at younger ages to fully recruited Fs. The input PR and F were from last years assessment.

The estimated numbers and slopes were all significant except for the age 4 numbers (Table 19). The 1986 year-class at age 4 is poorly estimated in ADAPT with the CV = 0.70, while for the 1987-1990 year-classes very little information is available. The CV's for other estimated ages (5-9) were in the order of 0.35 and those of the slopes were 0.18. Residuals (Table 20) were reviewed and as in previous assessments, yearly patterns were observed. The fishing mortality for fully recruited ages in 1990 varied between 0.23 and 0.30 with an average fully recruited F of 0.25. The fishing mortality matrix, beginning of year numbers and midyear biomass are given in Tables 21, 22 and 23.

Assessment Results

The 1979 (80 million) and the 1985 (63 million) year-classes at age 2 are the largest observed for the 1974-1990 period (Figure 12). The 1980-1984 year-classes are all above the long-term (1974-1986) GM of 31 million.

Midyear biomass for ages 4+ has increased since 1984 reflecting the strong year classes of the early 1980s and is currently at a relatively high level (Figure 13). Population numbers age 4-9 have increased since 1982 and are presently near their maximum (Figure 14). Fully recruited fishing mortalities have been fluctuating with a decreasing trend toward $F_{0.1}$ (0.31) for almost the entire series and are currently below the $F_{0.1}$ target level (Figure 15)

In general, recruitment of strong year classes has occurred at least every 3-4 years since the mid 1970s. Fluctuations in the age 4-9 stock size reflect the interaction of recruitment and fishing mortality. Population numbers age (4-9) peaked in 1979 in response to the recruitment of the 1975 year-class at age 4 while the decline in stock size between 1979 and 1982 reflects increased mortality rates associated with elevated effort during this period. Abundance increased substantially in 1983 and has remained high due to continued good recruitment since 1979. Given the relatively stable catches throughout most of the 1980s, fishing mortality has generally fluctuated inversely with stock size. However the apparent sharp decline in F in 1984 is most likely due to variability in the catch at age. Except for the drop in 1990, landings have remained relatively constant since 1985 (43,000-46,000 t) while fishing mortality has declined from over 0.5 to 0.25.

Yield per Recruit

No new yield per recruit was calculated for this stock and the $F_{0.1}$ value from last year of 0.31 was used.

Prognosis

The ADAPT estimate for the 1986 year-class at age 4 had a high CV, and therefore projections were done with the 1988 year-class at age 2 being set to the 1974-1986 geometric mean of 31 million fish. Because no reliable estimates are available for subsequent year-classes, recruitment for the 1987-1993 year-classes was also set at 31 million. Consequently,

for 1992, over 50% of the catch could come from year-classes that have been set to the geometric mean recruitment value.
The following input data were used in catch projections:

Age	1991 beginning of year Population #'s	Weight[a](kg)	PR[b]
2	31,000	.74	.02
3	25,335	1.31	.17
4	18,766	1.91	.45
5	13,147	2.54	.75
6	20,930	3.09	1.00
7	7,832	3.71	1.00
8	5,336	4.12	1.00
9	2,761	4.67	.87
10	1,374	5.44	.63
11	936	6.76	.48
12+	603	7.43	.48

[a] 1987-1990 average
[b] 1977-1986 average

Catch projections were run to 1994 to allow evaluation to the end of the current multiyear management plan (1993) as well as the impact of $F_{0.1}$ in the year following the end of the plan (1994) for this stock.

Projections were done to 1993 using a constant catch of 43,000 t, the current TAC and in 1994 at an $F_{0.1}$ value of 0.31. Results of these projections are given in Table 24. If the expected catch of 43,000 t to 1993 and an $F_{0.1}$ catch of 36,000 t is taken in 1994 the resultant fishing mortality to 1993 will be about 0.33 just slightly above the $F_{0.1}$ value of 0.31. Assuming average recruitment, beginning of year biomass (2+) is expected to decline from 238,000 t in 1990 to 208,000 t in 1993. In view of these results a catch of 43,000 to 1993 would be consistant with an $F_{0.1}$ strategy. Given an $F_{0.1}$ yield of 1.080 kg and a geometric mean recruitment level of 31 million the long term productivity for this stock is in the order of 33,480 t.

A source of concern for this stock is the drop in catch in both 1989 and 1990 to below the TAC. Although part of the reductions in catch can be attributed to the management plan, the drop in the offshore catch may be due to lack of availability and/or abundance of pollock at older ages, especially in divs. 4VsW as reported by industry. It was also noted that both the pollock RV survey estimates and ADAPT population estimates have high CV's and strong year effects were observed for the survey making it difficult to determine year-class strengths. Thus it may be misleading to place a high level of confidence in the population estimates for 1990.

References

Annand, C., D. Beanlands, and J. McMillan. 1990. Assessment of Pollock (*Pollachius virens*) in Divisions 4VWX and Subdivisions 5Zc. CAFSAC Research Document 90/42.

Table 1a. Pollock landings (t round fresh) by country for divs. 4VWX and Subdiv. 5Zc, 1974-1977.

Year	Canada	Fed. Rep. Germany	German Dem. Rep.	Japan	Spain	USSR	United Kingdom	U.S.A.	Other	Total
1974	24975	149	-	40	1500	2301	47	435	14	29461
1975	26548	236	95	-	708	2004	-	403	124	30118
1976	23565	994	24	-	303	1466	-	443	385	27180
1977	24653	368	-	1	-	182	-	325	53	25582

Table 1b. Pollock landings (t round fresh) by country for divs. 4VWX and Subdiv. 5Zc, 1978-1990.

Year	Canada	Japan	France		Cuba	USSR	U.S.A.	Other	Total
			St. Pierre & Mainland						
1978	26801	110	15	18	141	502	451	-	28038
1979	29967	19	8	15	50	1025	391	7	31482
1980	35986	81	19	80	32	950	443	-	37591
1981	40270	15	17	73	-	358	918	-	41651
1982	38029	3	30	14	84	297	840	-	39297
**1983	32749	6	22		261	226	1324	-	34588
1984	33465	1	46		123	97	1691	1	35424
1985	43300	17	77		66	336	-	-	43796
1986	43249	51	77		387	564	-	4	44332
1987	45330	82	28		343	314	-	-	46097
1988	41831	1	-		225	1054	-	-	43111
*1989	41112	1	-		99	1782	-	-	42994
*1990	36178	-	-		261	1040	-	-	37479

* - Provisional catch statistics
** - From 1983 on, French catches are combined

Table 2. Pollock landings (t, round fresh) for divisions 4VWX and Subdivision 5Zc, 1974-1990.

Year	4V	4W	4X	5Y	5Zc	Total 4VW	Total 4X+5Zc	Total
1974	307	4740	19731	680	4003	5047	24414	29461
1975	799	5697	17977	420	5225	6496	23622	30118
1976	1102	3424	19164	57	3433	4526	22654	27180
1977	1347	6082	14381	237	3535	7429	18153	25582
1978	2931	4910	14997	341	4859	7841	20197	28038
1979	4877	4963	18219	573	2850	9840	21642	31482
1980	3893	7511	20110	530	5547	11404	26187	37591
1981	2316	15678	18689	713	4255	17994	23657	41651
1982	2939	9373	20771	926	5288	12312	26985	39297
1983	5491	5787	17603	1079	4628	11278	23310	34588
1984	5474	6043	18926	2091	2890	11517	23907	35424
1985	12085	3262	26685	853	911	15347	28449	43796
1986	15250	4046	22845	654	1537	19296	25036	44332
1987	12820	4425	26756	-	2096	17245	28852	46097
1988	11871	4240	24596	-	2404	16111	27000	43111
**1989	12027	3863	23283	530	1409	*17772	25222	*42994
**1990	8150	4044	21903	346	1735	*13495	23984	*37479

* - Includes catch where division is unknown.
** - Data from DFO Statistics Branch, provisional data for countries other than Canada.

Table 3. Pollock landings (t round fresh) by season and country for NAFO divs. 4VWX and Subdiv. 5Zc.

Canada (Maritimes & Newfoundland)

Year	4VW				4X + 5Zc			
	Jan-Apr	May-Aug	Sept-Dec	Total	Jan-Apr	May-Aug	Sept-Dec	Total
1974	713	1257	807	2777	1643	11738	8817	22198
1975	1223	1005	1854	4082	1836	9866	10764	22466
1976	425	845	1186	2456	2078	12167	6864	21109
1977	931	1428	4748	7107	6010	5880	5656	17546
1978	3875	2696	510	7081	5835	7484	6401	19720
1979	1406	5477	1927	8810	4558	10023	6576	21157
1980	2493	4301	3633	10427	6353	13188	6018	25559
1981	4056	2437	11055	17548	5792	7170	9760	22722
1982	3030	4082	4774	11886	3096	14664	8383	26143
1983	2029	7099	1644	10772	4879	14212	2886	21977
1984	2288	4744	4217	11249	2820	13900	5496	22216
1985	3861	5031	5959	14851	6589	15673	6187	28449
1986	5522	8157	4534	18213	5859	14091	5086	25036
1987	6177	5521	4780	16478	5766	16496	6590	28852
1988	4744	5807	4397	14948	3761	15710	7412	26883
*1989	4050	7538	4302	15890	6743	12471	6008	25222
*1990	4752	4529	2913	12194	3126	13839	7019	23984

* - Data from DFO Statistics Branch

USSR

Year	4VW					4X + 5Zc				
	Jan-Apr	May-Aug	Sept-Oct	UK Mon.	Total	Jan-Apr	May-Aug	Sept-Dec	UK Mon.	Total
1974	194	903	628	-	1725	11	512	53	-	576
1975	471	981	221	-	1673	58	149	124	-	331
1976	555	488	291	-	1334	10	58	64	-	132
1977	17	82	-	-	99	39	44	-	-	83
1978	9	459	8	-	476	-	26	-	-	26
1979	4	928	-	-	932	6	87	-	-	93
1980	122	715	-	-	837	-	113	-	-	113
1981	45	311	-	-	356	2	-	-	-	2
1982	-	297	-	-	297	-	-	-	-	-
1983	16	204	-	-	220	-	6	-	-	6
1984	-	97	-	-	97	-	-	-	-	-
1985	-	336	-	-	336	-	-	-	-	-
1986	-	564	-	-	564	-	-	-	-	-
1987	-	314	-	-	314	-	-	-	-	-
1988	96	958	-	-	1054	-	-	-	-	-
**1989	605	1177	-	-	1782	-	-	-	-	-
**1990	342	698	-	-	1040	-	-	-	-	-

** - Provisional data from NAFO Circular letters

Table 3. (Continued)

Other Foreign Countries

Year	4VW					4X + 5Zc				
	Jan-Apr	May-Aug	Sept-Oct	UK Mon.	Total	Jan-Apr	May-Aug	Sept-Dec	UK Mon.	Total
1974	176	196	173	-	545	746	605	289	-	1640
1975	421	57	263	-	741	145	253	427	-	825
1976	254	318	162	2	736	288	237	888	-	1413
1977	10	194	19	-	223	168	304	52	-	524
1978	36	153	95	-	284	200	111	140	-	451
1979	22	22	54	-	98	118	136	138	-	392
1980	101	38	1	-	140	272	128	115	-	515
1981	90	-	-	-	90	410	269	254	-	933
1982	23	106	-	-	129	365	221	256	-	842
1983	18	268	-	-	268	358	497	472	-	1327
1984	87	83	1	-	171	387	528	776	-	1691
1985	82	70	8	-	160	-	-	-	-	-
1986	204	291	24	-	519	-	-	-	-	-
1987	110	311	32	-	453	-	-	-	-	-
1988	4	222	-	-	226	-	-	-	-	-
**1989	99	1	-	-	100	-	-	-	-	-
**1990	153	108	-	-	261	-	-	-	-	-

** - Provisional data from NAFO Circular letters

Table 4. Nominal landings of pollock in NAFO divs. 4VW and 4X and Subdiv. 5Zc for Canada (Maritimes, Quebec and Newfoundland).

OTTER TRAWLERS -- Tonnage Classes 4+

Year	4VW				4X + 5Zc			
	Jan-Apr	May-Aug	Sept-Dec	Total	Jan-Apr	May-Aug	Sept-Dec	Total
1970	1523	212	138	1873	686	1865	1581	4132
1971	629	63	208	900	919	3473	2073	6465
1972	417	90	545	1052	1461	5800	4138	11399
1973	726	276	2173	3175	3259	4227	3239	10725
1974	707	1113	628	2448	1057	6350	5964	13371
1975	1222	926	1776	3924	1042	5699	5361	12102
1976	424	737	1081	2242	877	5418	2746	9041
1977	912	1358	4545	6815	4846	1522	2661	9029
1978	3558	2107	377	6042	4676	3383	2411	10470
1979	1368	5194	1715	8277	3487	3421	1004	7912
1980	2448	3949	3412	9809	4321	3409	2411	10141
1981	3980	1382	9017	14379	4280	558	4956	9794
1982	2919	3084	4123	10126	1628	3917	3665	9210
1983	1879	6144	1032	9055	2890	2652	396	5938
1984	2155	3416	3559	9130	729	1633	564	2926
1985	3628	4339	5502	13469	581	835	879	2295
*1986	4861	6499	3957	15317	1326	939	235	2500
*1987	5609	4178	3998	13785	2435	2518	2408	7361
*1988	3951	3588	4244	11783	755	3301	2951	7007
*1989	3006	4933	3669	11608	1498	2489	2596	6583
*1990	4154	2832	1836	8822	1654	1835	1268	4757

* - Provisional

Table 4. (Continued)

OTTER TRAWLERS -- Tonnage Classes 1-3

Year	4VW				4X + 5Zc			
	Jan-Apr	May-Aug	Sept-Dec	Total	Jan-Apr	May-Aug	Sept-Dec	Total
1970	8	0	0	8	336	2042	483	2861
1971	4	0	0	4	245	1708	717	2670
1972	0	9	1	10	537	2035	902	3474
1973	0	0	2	2	1922	6762	618	9302
1974	0	39	40	79	562	3398	591	4551
1975	0	0	0	0	745	2610	836	4191
1976	0	0	0	0	1039	2844	715	4598
1977	0	2	0	2	896	2224	808	3928
1978	9	23	2	34	955	2187	961	4103
1979	0	8	2	10	869	4043	1170	6082
1980	2	137	18	157	1523	4033	823	6379
1981	32	302	44	378	957	3178	1547	5682
1982	58	220	93	371	713	4775	1734	7222
1983	84	155	23	262	1403	6829	855	9087
1984	119	598	252	969	1847	8492	3015	13354
1985	197	151	89	437	5408	8564	1386	15358
*1986	379	804	44	1227	3797	4801	594	9192
*1987	504	311	73	888	2747	5859	483	9089
*1988	556	708	13	1277	2739	6196	244	9179
*1989	934	1296	60	2290	4533	2366	48	6947
*1990	403	594	492	1489	533	3985	1996	6514

* - Provisional

Table 4. (Continued)

GILLNET, LONGLINE and MISCELLANEOUS Gears -- all tonnage classes

Year	4VW				4X + 5Zc			
	Jan-Apr	May-Aug	Sept-Dec	Total	Jan-Apr	May-Aug	Sept-Dec	Total
1970	0	46	224	270	53	893	663	1609
1971	0	118	72	190	5	979	544	1528
1972	0	137	170	307	8	927	845	1780
1973	6	101	139	246	9	2196	1335	3540
1974	6	105	139	250	24	1990	2262	4276
1975	1	79	78	158	49	1557	4567	6173
1976	1	108	105	214	162	3908	3403	7473
1977	19	68	203	290	268	2134	2188	4590
1978	308	566	131	1005	204	1914	3029	5147
1979	38	275	210	523	202	2559	4402	7163
1980	43	215	203	461	509	5746	2784	9039
1981	44	753	1994	2791	555	3434	3257	7246
1982	53	778	558	1389	755	5972	2984	9711
1983	66	800	589	1455	586	4731	1635	6952
1984	14	730	406	1150	244	3775	1917	5936
1985	36	541	368	945	600	6274	3922	10796
*1986	264	732	403	1399	716	8422	4202	13340
*1987	69	1022	709	1800	589	8100	3696	12385
*1988	80	1339	340	1759	260	6223	4230	10713
*1989	110	1309	573	1992	712	7616	3364	11692
*1990	196	1104	584	1884	939	8018	3755	12712

* - Provisional

Table 5. Continued

Year	Fleet	Initial Alloc. (t)	Final Alloc. (t)	Rep. Catch (t) (Quota reports)	Per. Taken (%)	Dates -Closure (cl) Trip Limit (tl) Bycatch (bc)	Remarks
1990	All vessels - Canadian	38.0K	43.0K	36.607K	85		*OPTIONS
	FG<45'	10.67K	12.07K	13.731K	114	Fishery open 15/01-01/12;	
	FG 45'-65'	.28K	.315K	.343K	109	01/12 3300 lb/10% bc <45, 45-65 - 5Z large hook to 01/06	1 10,000 - pol 5,000 - cod
	MG>100'	18.105K	20.059K	14.674K	73	Enterprise Allocations	20% (C&P) - had
	MG 65'-100'	0.245K	.716K	.391K	55	Enterprise Allocations	2 20,000 - pol 10% pol - cod 10% pol - had
	MG 45'-65' (Jan - Apr)	1.74K	1.74K	0.607K	35	CHP 4X 01/01-15/06 20,000 lb tl (19/02-16/04, 08/05-17/05) no conditions issued; 15/06	
	MG 45'-65' (May - Aug)	1.74K	2.425K	2.341K	97	15,000 lb pol 20% had (of C&P) 30% cod (of P) max 4 trips; 17/09 95,000 pol, had 20% (of	
	MG 46'-65' (Sept - Dec)	1.74K	1.74K	1.224K	70	C&P) cod 28,500 (30% P) (per vessel); 5Z 35,000 tl CHP 8 trips max 01/06-31/10; 01/06-17/08 3300/30% 17/08 8000/10%; 4VWX5 (4VW permits) 01/01-01/03 20,000 tl 06/03-13/03 5500/10%; 20/03-01/05 - 3300 lb, 10%, 01/05-20/06 - 5500/10%; 21/06-09/07 - 10,000; 10/07 - 15,000 tl	
	MG<45' (Specialist) (Jan - Apr)	0.89K	0.89K	0.287K	32	4X CHP 01/01-16/03 - 10,000 lbs 1 trip/wk; 13/02-20/02 no condition, 06/03-16/04 closed;	
	MG<45' (Specialist) (May - Aug)	1.50K	1.89K	2.076K	110	16/04-11/06 - 15,000 lb tl, 1 trip/wk; 08/05-17/05 no condition; 12/06-17/08, choice	
	MG<45' (Specialist) (Sept - Dec)	0.60K	0.60K	0.851K	142	of options* (max 4 trips); 17/08-17/09, option 1 (max 4 trips); 17/09 - 42,500 pol, 34,500 cod, had 20% (C&P) (per vessel); 5Z (CHP) 35,000 lb tl with had 8000 lb/30%, 8 trips max 01/06-31/10; 4VWX5 (4VW permits) 01/01 - 10,000 lb tl; 01/03 - 5000 lb tl, 20/03 3300 lb tl, 01/05 5500 lb tl, 01/06 10,000 lb tl, 15/07 15,000 lb tl	
	MG<45' (Generalists)	0.490K	0.555K	0.082K	15	4X CHP 01/01 - 3300/10% 1 trip/wk; 08/01 3300/10% 2 trips/wk; 17/08 10% bc, 07/09 10% or 3300 lbs 2 trips/wk, 04/10 10% bc, 11/10 3300/10% bc 2 trips/wk	

Table 6. Canadian commercial samples available for pollock in divs. 4VW and in Div. 4X and Subdiv. 5Zc by gear and season for 1989.

	OTB 4+				OTB TC, 1-3				GN				LL & Others			
Area	Jan-Apr	May-Aug	Sept-Dec	Total	Jan-Apr	May-Aug	Sept-Dec	Total	Jan-Apr	May-Aug	Sept-Dec	Total	Jan-Apr	May-Aug	Sept-Dec	Total
4VW	20	6	13	39	0	0	0	0	-	0	0	0	-	1	-	1
4X+5Zc	1	5	2	8	6	13	10	29	1	14	6	21	-	1	-	1

Table 7. Grouping of catch by gears and time period for estimation of removals-at-age. OTB trawls are primarily stern bottom trawls, but there are some side trawls; GN are gillnets, LL are longlines, and Others are primarily inshore fisheries.

Year	Period	Tonnage Class	Gear	No. of Samples	Area	Number Aged	Number Measured	Catch (t)	Weight-Length Relationship		Cruise	Date
									a	b		
1990	Jan-Dec	TC 1-6	GN, LL, Other	23	4VWX+5	460	5822	14596	0.0148	2.93576	Needler 123/124	July 1990
	Jan-Dec	TC 1-3	OTB	29	4VWX+5	634	6590	8003	0.0148	2.93576	Needler 123/124	July 1990
	Jan-Apr	TC 4+	OTB	20	4VW	374	4559	4154	0.0169	2.87994	Needler 123/124	July 1990
	May-Aug	TC 4+	OTB	6	4VW	212	1320	2832	0.0169	2.87994	Needler 123/124	July 1990
	Sept-Dec	TC 4+	OTB	13	4VW	326	2735	1836	0.0169	2.87994	Needler 123/124	July 1990
	Jan-Dec	TC 4+	OTB	8	4X+5	175	1827	4757	0.0148	2.93576	Needler 123/124	July 1990

Table 8. Ratio of 1989 catch at age to 1990 catch at age.

Ratio of 1989 Catch at Age to 1990 Catch at Age

	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.000	1.000
2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.120	1.082
3	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.003	.930
4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.009	.997
5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.021	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.007	.999
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.005	1.004
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.013	1.005
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.034	1.028
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.023
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.089

	1983	1984	1985	1986	1987	1988	1989
1	1.000	1.000	.000	.000	1.000	.000	1.000
2	1.196	.265	1.351	.100	1.100	1.037	.704
3	.994	.899	1.118	.548	1.041	.968	.903
4	.994	1.002	1.003	.951	1.026	.960	.891
5	.997	1.003	.997	1.003	1.017	1.005	.996
6	1.021	1.003	1.007	1.008	1.001	1.018	1.024
7	1.004	1.032	1.004	1.008	.997	1.032	1.038
8	1.017	1.028	.985	1.057	.980	1.019	1.036
9	1.014	1.024	1.000	1.000	.994	1.008	1.018
10	1.018	1.011	1.000	1.043	.949	1.000	1.010
11	1.040	1.056	.965	1.041	.958	.895	.933
12	1.000	.957	.983	1.009	1.020	1.000	1.000

Table 9. Catch at age (in thousands)

TOTAL CATCH AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0	0	0	0	0	8	0	10	0	1	1	1	1	0	1	0	8
2	197	175	178	36	23	98	171	871	134	56	87	37	60	10	27	71	51
3	5603	1058	1361	1476	835	2763	291	1334	4018	1999	803	493	635	467	683	585	1226
4	2662	4023	1974	2873	3119	5786	1864	673	1589	9514	3493	2190	3062	2259	2669	4371	2139
5	2356	2090	3649	1785	3084	3482	5306	2044	563	1256	7155	4160	3562	4908	3290	3952	3996
6	1088	1904	1089	2181	1276	1705	3169	4019	1873	238	639	6183	3595	3538	3390	2378	2549
7	317	835	1089	732	1167	528	1075	2432	2295	524	92	1105	3306	2404	1860	1977	1551
8	164	196	207	417	257	249	277	713	1069	835	217	131	299	1736	1181	886	851
9	80	55	36	108	143	47	168	208	389	428	210	139	82	177	1005	675	545
10	83	57	14	19	17	15	32	148	172	163	92	230	117	39	43	402	243
11	74	35	18	25	19	14	9	31	87	50	18	85	171	48	19	15	88
12+	40	31	49	80	18	0	2	24	22	58	23	59	116	98	97	64	50

CANADIAN CATCH AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0	0	0	0	0	8	0	0	0	1	0	0	0	0	0	0	0
2	185	167	126	36	23	98	128	42	132	54	22	24	4	8	27	44	6
3	4784	986	1207	1433	786	2752	244	1333	3516	1857	720	477	317	428	618	495	1018
4	2364	3567	1738	2855	3070	5582	1733	672	1584	9309	3491	2179	2868	2231	2493	3691	1940
5	2125	1852	3170	1760	3022	3341	5035	2043	563	1248	7152	4126	3519	4859	3235	3772	3674
6	954	1660	939	2128	1222	1645	3113	4019	1872	237	639	6178	3575	3489	3345	2335	2484
7	273	795	1001	710	1142	495	1047	2432	2294	523	91	1102	3291	2372	1784	1911	1531
8	144	132	194	395	246	248	269	712	1067	833	215	126	298	1672	1146	847	835
9	64	45	35	90	134	47	165	207	389	428	207	134	82	175	991	650	535
10	51	56	12	19	17	15	32	148	172	163	89	221	113	35	43	382	243
11	33	34	16	25	19	14	9	31	87	50	18	78	165	44	17	12	86
12+	10	30	42	80	18	0	2	24	22	58	21	57	113	95	93	60	43

FOREIGN CATCH AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	12	8	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	291	67	121	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	162	228	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	152	87	237	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	77	78	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	20	23	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	9	4	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	6	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12+	1	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SMALL MESH GEAR CATCH AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0	0	0	0	0	0	0	10	0	0	1	1	1	0	1	0	8
2	0	0	35	0	0	0	43	829	2	2	65	13	56	2	0	27	45
3	528	6	33	43	49	11	47	1	502	142	83	16	318	39	65	90	208
4	136	229	77	18	49	204	131	1	5	205	2	11	194	28	176	680	199
5	79	151	242	25	62	141	271	1	0	8	3	34	43	49	55	180	322
6	57	166	86	53	54	60	56	0	1	1	0	5	20	49	45	43	65
7	24	17	46	22	25	33	28	0	1	1	1	3	15	32	76	66	20
8	10	60	0	22	11	1	8	1	2	2	2	5	1	64	35	39	16
9	10	9	0	18	9	0	3	1	0	0	3	5	0	2	14	25	10
10	29	0	0	0	0	0	0	0	0	0	3	9	4	4	0	20	0
11	38	0	0	0	0	0	0	0	0	0	0	7	6	4	2	3	2
12+	29	0	0	0	0	0	0	0	0	0	2	2	3	3	4	4	7

Table 10. Total percent catch at age and total percent biomass at age for 4VWX5 pollock. (1974 - 1990).

PERCENT CATCH AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	2	2	0	0	1	1	7	1	0	1	0	0	0	0	0	0
3	44	10	14	15	8	19	2	11	33	13	6	3	4	3	5	4	9
4	21	38	20	30	31	39	15	5	13	63	27	15	20	14	19	29	16
5	19	20	38	18	31	24	43	16	5	8	56	28	24	31	23	26	30
6	9	18	11	22	13	12	26	32	15	2	5	42	24	23	24	16	19
7	3	8	11	8	12	4	9	19	19	3	1	7	22	15	13	13	12
8	1	2	2	4	3	2	2	6	9	6	2	1	2	11	8	6	6
9	1	1	0	1	1	0	1	2	3	3	2	1	1	1	7	4	4
10	1	1	0	0	0	0	0	1	1	1	1	2	1	0	0	3	2
11	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1
12	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0

PERCENT BIOMASS AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
3	26	4	6	5	4	10	1	6	12	7	4	2	2	1	2	2	4
4	18	26	14	17	20	29	10	4	11	46	23	10	14	10	12	18	11
5	24	21	38	17	29	29	39	14	5	11	54	26	20	27	20	23	27
6	15	24	15	30	18	18	29	32	20	3	7	45	27	23	25	18	20
7	5	14	19	13	19	7	12	25	26	7	1	9	27	19	15	18	16
8	3	4	4	9	6	4	4	10	14	12	4	1	3	15	12	8	9
9	2	1	1	3	4	1	3	3	6	7	4	2	1	2	10	8	7
10	2	1	0	1	0	0	1	3	3	3	2	3	2	1	1	5	3
11	2	1	1	1	1	0	0	1	2	1	0	1	2	1	0	0	1
12	1	1	2	4	1	0	0	1	0	1	1	1	2	2	2	0	1

Table 11. Mean weights at age.

TOTAL WEIGHT AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	.00	.00	.00	.00	.00	.19	.00	.00	.00	.63	.36	.00	.10	.00	.00	.00	.25
2	.82	.86	.59	.79	1.14	.77	1.03	.68	.76	.83	.73	.74	.35	.64	1.17	.67	.49
3	1.38	1.26	1.21	1.10	1.23	1.18	1.68	1.74	1.19	1.25	1.64	1.49	1.13	1.32	1.37	1.21	1.35
4	1.94	1.95	1.92	1.52	1.80	1.55	2.08	2.54	2.69	1.66	2.36	1.96	2.00	1.96	1.88	1.77	2.03
5	3.00	3.06	2.81	2.48	2.60	2.62	2.77	2.91	3.51	3.12	2.67	2.73	2.52	2.50	2.64	2.49	2.55
6	4.09	3.81	3.71	3.50	3.90	3.40	3.46	3.34	4.18	4.12	3.84	3.12	3.29	2.94	3.21	3.25	2.95
7	5.08	5.06	4.67	4.52	4.59	4.34	4.12	4.32	4.45	4.83	5.41	3.42	3.61	3.71	3.51	3.80	3.83
8	6.16	6.52	5.64	5.47	6.02	5.55	5.58	5.93	5.19	5.08	5.97	4.39	4.20	4.03	4.23	4.10	4.11
9	6.68	7.49	7.02	6.62	6.91	6.61	6.50	6.90	6.12	5.84	5.90	6.10	5.66	4.55	4.41	4.81	4.92
10	7.39	7.49	7.80	7.25	7.37	7.14	9.07	7.77	7.64	6.48	6.32	5.86	6.09	6.26	5.26	5.15	5.10
11	8.58	8.22	8.76	10.02	8.38	8.79	8.40	7.54	8.00	8.00	7.69	6.17	6.11	6.15	7.18	7.77	5.94
12+	10.03	9.59	9.11	11.30	10.03	.00	11.65	9.22	8.65	8.72	8.53	7.52	6.68	7.57	8.46	9.48	8.20

CANADIAN WEIGHT AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	.00	.00	.00	.00	.00	.19	.00	.00	.00	.63	.00	.00	.00	.00	.00	.00	.00
2	.83	.86	.63	.79	1.14	.77	1.12	1.01	.76	.84	1.46	.94	.83	.72	1.17	.83	.76
3	1.43	1.27	1.23	1.11	1.26	1.18	1.77	1.74	1.24	1.25	1.68	1.52	1.39	1.37	1.46	1.23	1.45
4	1.98	1.99	1.94	1.52	1.81	1.54	2.10	2.54	2.70	1.67	2.36	1.96	2.02	1.97	1.92	1.88	2.05
5	3.02	3.10	2.80	2.48	2.59	2.63	2.80	2.91	3.51	3.13	2.67	2.74	2.52	2.51	2.64	2.51	2.55
6	4.05	3.87	3.73	3.49	3.88	3.38	3.47	3.34	4.18	4.11	3.84	3.12	3.29	2.95	3.22	3.26	2.95
7	5.03	5.07	4.65	4.50	4.59	4.33	4.14	4.32	4.45	4.83	5.41	3.43	3.61	3.72	3.51	3.83	3.83
8	6.06	6.51	5.62	5.45	6.00	5.54	5.56	5.93	5.19	5.08	5.97	4.39	4.20	4.04	4.23	4.12	4.12
9	6.62	7.47	7.04	6.55	6.84	6.61	6.51	6.90	6.12	5.84	5.90	6.13	5.66	4.55	4.41	4.84	4.93
10	7.22	7.69	7.71	7.25	7.37	7.14	9.07	7.77	7.64	6.48	6.34	5.89	6.09	6.32	5.26	5.19	5.10
11	8.12	8.47	8.67	10.02	8.38	8.79	8.40	7.54	8.00	8.00	7.69	6.19	6.11	6.27	8.03	8.66	5.94
12+	9.37	9.89	9.19	11.30	10.03	.00	11.65	9.22	8.65	8.72	8.76	7.56	6.86	7.62	8.52	9.63	7.76

FOREIGN WEIGHT AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.59	.84	.63	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	1.24	1.13	1.04	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	1.81	1.68	1.88	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	2.89	2.32	2.83	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	3.97	3.25	3.52	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	5.23	4.33	4.83	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	6.70	5.13	5.90	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	6.72	5.13	6.70	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	7.00	.00	8.26	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	8.43	.00	9.46	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12+	13.00	.00	8.69	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

SMALL MESH WEIGHT AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.36	.00	.10	.00	.00	.00	.25
2	.00	.00	.42	.00	.00	.00	.77	.66	.62	.43	.48	.37	.32	.32	.26	.42	.45
3	1.02	1.11	.92	.74	.83	1.23	1.25	1.52	.84	1.15	1.29	.62	.87	.79	.50	1.08	.86
4	1.47	1.74	1.45	1.65	1.66	1.81	1.86	1.74	2.15	1.28	2.50	1.39	1.68	1.40	1.22	1.19	1.85
5	2.71	3.04	2.94	2.80	2.88	2.49	2.19	2.96	.00	2.52	2.82	2.35	2.48	1.92	2.39	2.04	2.59
6	4.90	3.47	3.68	3.90	4.32	3.93	2.72	3.63	3.54	4.38	3.77	2.92	3.24	2.65	2.70	2.82	2.80
7	5.50	5.62	5.13	4.99	4.45	4.48	3.14	4.28	4.97	4.62	4.97	3.04	3.20	2.94	3.36	3.08	3.68
8	7.01	6.64	.00	5.90	6.45	5.98	6.32	5.41	6.30	4.35	5.60	4.29	3.85	3.61	4.33	3.69	3.77
9	7.01	8.00	.00	6.92	8.01	.00	6.37	7.36	8.82	5.03	5.87	5.40	.00	4.78	4.30	3.99	4.32
10	7.73	.00	.00	.00	.00	.00	.00	8.87	7.43	7.08	5.96	5.35	6.14	5.74	.00	4.45	5.74
11	8.93	.00	.00	.00	.00	.00	.00	.00	.00	7.61	7.25	5.94	6.04	4.84	.00	4.19	6.12
12+	10.20	.00	.00	.00	.00	.00	.00	.00	8.50	8.39	6.19	6.46	.00	5.96	7.04	7.24	8.33

Table 12. Commercial catch rates (t/hr) for pollock (main species) in divisions 4VWX and Subarea 5.

		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Canadian OTB-2 (TC5) CPUE (t/hr)																		
(Regional)	April-November	.66	.70	.57	.78	.89	1.09	.94	1.01	1.32	1.05	1.33	.96	1.26	.94	.904	.987	1.499

Table 13. International Observer Program catch rates (t/hr) for pollock (main species) in divisions 4VWX and Subarea 5.

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Canadian OTB-2 (TC5) CPUE (t/hr)									
April-November	1.95	1.42	2.05	2.37	1.75	1.06	1.15	1.073	1.097

Table 14. Stratified total numbers at age (x 10^{-3}) in Canadian summer bottom trawl surveys (strata 40-95).

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	30	0	0	0	30	0	0	0	0	0	49	29	0	426	148	30	216	0	86	55	645
2	7613	3109	82	1649	179	37	122	1108	29	0	4842	673	832	504	1989	6694	2570	2504	122	231	41392
3	1866	2573	55	2021	3989	77	928	3266	610	462	5328	744	11816	3884	966	20433	2770	10375	2541	588	31771
4	1132	713	618	9117	975	1375	2826	4177	2525	2676	14106	215	1129	7218	2965	15116	4090	15614	4896	3597	13403
5	825	165	1361	3467	1183	1182	5264	8604	3915	3389	22393	2142	502	830	8509	14751	4273	24762	9311	4090	22173
6	750	76	595	347	549	1587	1328	5999	1459	2462	5947	2140	1558	203	1297	12336	5865	9752	8285	3784	8323
7	505	135	157	213	643	252	2289	779	1372	1007	3378	1491	1070	383	892	1865	4304	7099	7738	4768	2221
8	276	46	288	197	365	389	836	1308	424	715	1052	1028	628	1113	1934	527	309	5802	4284	2290	1457
9	106	31	209	248	278	151	183	458	198	44	412	461	553	703	2920	951	47	221	2477	1319	911
10	0	95	100	10	158	35	188	219	91	155	245	321	306	239	1811	1475	438	502	169	484	280
11	153	0	52	83	368	40	62	129	0	0	0	121	50	250	301	497	575	379	184	119	130
12+	28	0	111	48	131	0	203	49	98	0	0	54	208	86	662	477	377	1490	696	218	516
UK	0	0	17	59	0	0	45	15	71	99	122	195	143	116	186	15	31	129	0	55	0
TOTAL	13312	6943	3646	17459	8848	5125	14275	26110	10793	11047	57875	9612	18796	15954	24578	75167	25866	78630	40789	21597	123222
4+	3774	1261	3491	13730	4651	5010	13179	21721	10083	10450	47534	7972	6006	11024	21290	47996	20279	65622	38039	20668	49414
5+	2642	548	2873	4613	3676	3636	10353	17544	7558	7773	33428	7756	4877	3806	18324	32879	16189	50008	33143	17072	36011
6+	1817	383	1512	1147	2493	2454	5089	8940	3642	4384	11035	5615	4375	2976	9815	18129	11915	25246	23832	12982	13838

Table 15. Mean number/tow for 4VWX + 5 Pollock in Canadian summer bottom trawl surveys (strata 40-95)[1].

Stratum	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	All
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.26	.41	45.11	.34	.51	3.09	2.37
41	0	3.94	0	0	0	0	0	0	.31	0	0	1.46	.65	1.30	.29	1.03	.21	37.43	9.14	14.10	3.89	3.51
42	.32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.34	0	.16	.33	0	.39	.07
43	0	0	0	0	0	0	0	0	0	0	0	0	.21	.23	0	0	0	0	0	0	0	.02
44	0	0	0	0	0	0	0	.17	0	0	0	0	0	0	0	.26	.83	.34	0	0	0	.08
45	0	0	.19	0	0	0	0	0	0	0	0	0	0	0	0	21.63	.17	5.85	0	0	0	1.33
46	0	0	0	0	0	0	0	.34	0	0	0	0	.97	16.47	0	3.09	.69	0	.97	13.35	2.07	1.81
47	0	0	0	.37	0	.44	0	0	0	.61	0	0	.51	.26	0	0	0	0	0	.66	0	.14
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0		4.08	0	0	0	0	5.35	0	.52	0	0	0	0	.47
50	0	0	0	0	0	.36	0	0	0	1.56	0	15.10	1.09	0	0	0	.34	.34	0	0	32.73	2.45
51	0	0	0	0	0	0	.55	.49	3.13	25.93	0	2.92	571.50	0	0	96.76	1.09	133.02	22.13	6.09	21.23	42.14
52	0	1.14	.46	0	0	0	0	.55	.49	3.60	0	0	5.05	3.60	113.75	6.69	60.03	.34	.55	.52	.65	9.40
53	0	0	0	0	0	0	0	.34	0	0	0	0	0	0	0	0	.34	0	.58	0	0	.06
54	0	0	.34	0	0	0	0	0	.39	0	0	0	0	0	0	1.05	0	0	0	0	0	.09
55	0	0	0	0	0	0	0	0	0	0	0	.29	1.42	.26	0	0	.13	.12	0	.15	.68	.15
56	.39	.27	0	.18	0	0	0	.34	0	0	0	0	0	.16	2.97	1.94	.17	.70	4.73	.35	1.40	.65
57	0	0	0	0	0	0	0	0		0	0	0	.49	0	0	0	0	0	0	0	0	.02
58	0	0	0	0	0	0	0	0	0	0	0	0	0	2.27	0	0	.21	0	1.03	0	.20	.18
59	.76	.44	0	.58	0	0	.20	.63	.24	0	0	0	0	.58	17.06	2.34	10.47	3.94	9.43	.78	0	2.26
60	75.99	0	.83	4.12	0	5.07	0	.97	14.72	2.89	353.50	.97	6.55	29.17	36.66	12.40	8.92	337.21	10.49	40.88	111.02	50.11
61	0	0	0	.51	0	20.26	0	2.78	0	0	0	0	2.76	1.46	1.61	5.06	3.78	11.67	3.28	3.28	3.09	2.84
62	0	.65	0	0	5.10	2.73	.51	0	3.82	1.22	55.19	6.87	.78	0	1.29	60.12	14.78	3.98	6.85	2.80	13.68	8.59
63	0	0	0	0	0	3.31	6.13	1.17	0	5.83	.51	5.41	.31	4.86	0	1.46	2.57	6.69	.55	8.23	5.14	2.48
64	0	0	.19	0	0	0	.32	1.79	3.52	.97	0	0	0	41.22	.62	2.96	.28	4.57	1.58	23.77	1.37	3.96
65	.19	14.00	0	0	25.03	1.17	2.33	1.95	.41	.21	0	.85	.15	.51	1.29	2.72	.19	5.65	1.88	3.31	.82	2.98
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.24	.39	.55	0	2.19	0	.30
70	2.19	3.46	.38	27.47	2.40	.49	96.62	18.47	74.79	9.30	1.09	16.40	0	42.41	6.56	60.82	19.56	72.06	74.27	9.07	364.41	42.96
71	0	0	0	.55	0	0	0	6.35	3.04	0	4.86	1.37	0	.97	1.63	27.79	4.63	108.57	6.85	1.03	4.03	8.18
72	2.06	22.75	.82	1.09	2.57	0	2.13	1.74	.46	.34	16.42	5.83	.49	5.47	1.75	377.22	6.18	3.60	8.51	14.41	.98	22.61
73	0	0	0	0	0	0	0	.55	0	0	.38	0	0	0	0	.49	2.13	.51	0	0	0	.19
74	0	.49	0	0	0	0	0	0	0	0	.52	0	0	0		0	1.88	.55	0	0	0	.16
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.51	0	1.03	0	0	1.03	0	.12
76	1.09	.49	0	9.24	8.07	7.70	2.19	20.79	1.75	0	1.17	0	0	6.03	50.95	0	26.74	1.68	35.97	4.31	439.15	29.40
77	0	0	.44	1.84	0	0	0	0	0	.58	0	0	0	1.03	0	0	0	23.50	0	0	.22	1.32
78	1.46	2.43	.88	.97	0	1.09	0	0	1.75	1.72	0	0	0	0	0	3.89	.36	0	4.12	0	20.78	1.88
80	.65	.52	.19	.46	0	0	.23	34.81	.55	0	.97	0	.51	1.46	0	1.84	3.25	14.67	.22	1.42	1.35	3.01
81	0	2.92	0	6.00	1.30	0	.29	0	2.11	0	2.42	1.46	1.80	2.73	.26	.46	8.14	.68	2.36	.73	104.49	6.58
82	.49	.92	.46	0	0	0	.32	.73	1.02	13.64	1.35	4.04	1.41	1.00	.88	.49	1.03	4.25	3.62	38.11	2.98	3.65
83	0	0	2.43	0	0	0	1.95	.49	0	.58	.78	0	.52	.51	1.54	.49	0	1.64	1.03	0	12.43	1.16
84	0	.55	1.25	1.78	1.34	1.58	21.52	2.38	.49	9.82	.25	16.54	.26	0	3.43	3.56	2.40	4.72	14.68	.74	5.60	4.42
85	23.72	0	7.00	83.38	2.17	0	1.99	127.10	1.59	19.79	32.42	3.57	58.78	1.70	23.70	13.35	46.03	14.24	127.16	23.64	6.56	29.42
90	9.85	0	0	0	3.98	1.19	8.17	.78	8.61	3.28	1.35	15.75	2.60	8.20	0	90.55	2.94	.23	1.98	1.56	17.39	8.50
91	0	.38	25.14	5.64	1.13	.65	2.52	1.53	0	46.01	1.92	.53	.60	1.88	3.09	6.06	26.08	64.80	3.65	6.57	3.70	9.61
92	.32	0	4.37	1.63	3.19	2.02	2.10	3.68	2.27	0	0	.29	11.08	1.03	.36	.65	8.43	3.47	5.93	.51	2.06	2.54
93		0	0	1.54	0	.46	.58	1.16	0	.69	1.32	0	4.25	1.94	0	46.94	.65	4.12	0	.34	.92	3.09
94	0	0	0	0	.42	.46	2.17	0	0	1.03	.51	0	0	0	.55	.49	0	0	0	0	0	.27
95	0	0	2.02	0	1.54	.70	0	0	0	1.06	1.21	2.92	0	.67	0	.92	0	0	0	1.64	0	.60

1. Survey vessels: 1970 - 1981 A.T. Cameron
1982 Lady Hammond
1983 - 1988 Alfred Needler

Table 16. Stratified average numbers per tow in Canadian summer bottom trawl surveys (strata 40-95).

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	.007	.000	.000	.000	.007	.000	.000	.000	.000	.000	.012	.007	.000	.100	.035	.007	.051	.000	.020	.013	.152
2	1.815	.733	.019	.389	.042	.009	.029	.261	.007	.000	1.142	.159	.196	.119	.471	1.579	.606	.591	.029	.055	9.763
3	.445	.607	.013	.477	.941	.018	.219	.770	.147	.109	1.257	.175	2.787	.916	.229	4.819	.653	2.447	.599	.139	7.494
4	.270	.168	.146	2.150	.230	.324	.667	.985	.607	.631	3.327	.051	.266	1.702	.702	3.565	.965	3.683	1.155	.848	3.161
5	.197	.039	.321	.818	.279	.279	1.242	2.029	.941	.799	5.282	.505	.118	.196	2.013	3.479	1.008	5.840	2.196	.965	5.230
6	.179	.018	.140	.082	.130	.374	.313	1.415	.351	.581	1.403	.505	.368	.048	.307	2.910	1.383	2.300	1.954	.893	1.963
7	.120	.032	.037	.050	.152	.059	.540	.184	.330	.238	.797	.352	.252	.090	.211	.440	1.015	1.674	1.825	1.125	.524
8	.066	.011	.068	.047	.086	.092	.197	.308	.102	.169	.248	.242	.148	.262	.458	.124	.073	1.369	1.010	.540	.344
9	.025	.007	.049	.059	.066	.036	.043	.108	.048	.010	.097	.109	.130	.166	.691	.224	.011	.052	.584	.311	.215
10	.000	.022	.024	.002	.037	.008	.044	.052	.022	.036	.058	.076	.072	.056	.428	.348	.103	.118	.040	.114	.066
11	.036	.000	.012	.020	.087	.009	.015	.030	.000	.000	.000	.028	.012	.059	.071	.117	.136	.089	.043	.028	.031
12+	.007	.000	.026	.011	.031	.000	.048	.012	.023	.000	.000	.013	.049	.020	.157	.112	.089	.352	.164	.051	.122
UK	.000	.000	.004	.014	.000	.000	.011	.004	.017	.023	.029	.046	.034	.027	.044	.003	.007	.030	.000	.013	.000
TOTAL	3.174	1.638	.860	4.118	2.087	1.209	3.367	6.158	2.595	2.606	13.650	2.267	4.433	3.763	5.816	17.729	6.101	18.546	9.621	5.094	29.065
4+	.900	.297	.823	3.238	1.097	1.182	3.108	5.123	2.424	2.465	11.211	1.880	1.417	2.600	5.038	11.320	4.783	15.478	8.972	4.875	11.656
5+	.630	.129	.678	1.088	.867	.858	2.442	4.138	1.817	1.833	7.884	1.829	1.150	.898	4.336	7.755	3.818	11.795	7.817	4.027	8.495
6+	.433	.090	.357	.270	.588	.579	1.200	2.109	.876	1.034	2.603	1.324	1.032	.702	2.323	4.276	2.810	5.955	5.621	3.062	3.265

Table 17 . Survey coefficients of variation (CVs), 1974-1989.

SURVEY CVs									
Age	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**
2	.684	.669	.562	.731	.468	1.000	.500	.736	.737
3	.906	.446	.481	.517	.508	.504	.466	.485	.674
4	.907	.508	.452	.720	.704	.411	.437	.548	.709
5	.437	.452	.551	.852	.653	.346	.407	.581	.656
6	.470	.390	.640	.747	.416	.331	.395	.357	.582
7	.318	.351	.699	.618	.337	.414	.424	.304	.372
8	.366	.699	.706	.631	.354	.438	.375	.306	.287
9	.284	.378	.653	.403	.288	.563	.384	.312	.268
10	.845	.495	.668	.407	.542	.468	.415	.405	.296
11	.488	.564	.779	.507	1.000	1.000	1.000	.396	.486

Age	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	
2	.361	.775	.715	.602	.853	.333	.421	.705	
3	.530	.271	.736	.541	.656	.292	.533	.541	
4	.468	.386	.776	.354	.680	.266	.496	.400	
5	.557	.359	.548	.232	.616	.394	.366	.315	
6	.282	.314	.279	.191	.416	.480	.335	.295	
7	.509	.521	.290	.182	.318	.528	.316	.234	
8	.400	.395	.281	.223	.291	.590	.287	.211	
9	.256	.344	.346	.359	.420	.605	.291	.241	
10	.311	.312	.301	.283	.347	.590	.245	.379	
11	.280	.205	.290	.272	.317	.526	.358	.533	

Table 18. ADAPT summary for divs. 4VWX + Subdiv. 5Zc pollock.

Parameters of the ADAPT framework

-Year-class estimates

$N_{i,1990}$ i = 4-9

-Calibration constants for July RV numbers

K_i i = 4-9

Framework: assumptions and structure imposed

-Natural mortality equal to 0.2

-Error in catch at age assumed negligible

-No intercepts

-Partial recruitment for ages 2-3 in 1990 was the average from 1977 to 1985 and a dome was applied to ages 10 and 11.

Age	2	3	4	5	6	7	8	9	10	11
PR	.015	.168	.414	.670	.850	1	1	1	.85	.5

-F for oldest age group was assumed to be 50% of the weighted F for ages 7-9.

Input

-$C_{i,t}$ i = 2 to 11 t = 1974-1990

-$RV_{i,t}$ i = 4 to 9 t = 1974-1990

Objective Function

- minimize
- $\sum_i \sum_t (\text{obs.}(\text{Ln } RV_{i,t}) - \text{pred.}(\text{Ln } RV_{i,t}))^2$

Summary

-Number of observations = 102
-Number of parameters = 12

Table 19. Final parameter estimates and significant statistics for age 4-9 numbers and 4-9 slopes from ADAPT. Correlation matrix pertains to the correlations between the estimated parameters.

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.006713
MEAN SQUARE RESIDUALS 0.489437

PAR. EST.	STD. ERR.	T-STATISTIC
7.21975E0004	5.11424E0004	1.41170E0000
3.00902E0004	1.49385E0004	2.01427E0000
1.24407E0004	5.42655E0003	2.29256E0000
8.26721E0003	3.21220E0003	2.57369E0000
4.33255E0003	1.84629E0003	2.34663E0000
2.29215E0003	9.64851E0002	2.37565E0000
2.13180E0002	3.86892E0001	5.51006E0000
4.94057E0002	8.80908E0001	5.60849E0000
5.67540E0002	1.01318E0002	5.60160E0000
7.28826E0002	1.31461E0002	5.54404E0000
9.96069E0002	1.81046E0002	5.50175E0000
8.42776E0002	1.53881E0002	5.47679E0000

Parameter Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	.045	.034	.034	.024	.020	-.251	.021	-.017	-.015	-.014	-.015
2	.045	1.000	.051	.051	.037	.031	-.179	-.200	-.025	-.023	-.021	-.022
3	.034	.051	1.000	.070	.052	.044	-.134	-.157	-.192	-.031	-.030	-.031
4	.034	.051	.070	1.000	.026	.063	-.135	-.157	-.198	-.241	-.137	-.192
5	.024	.037	.052	.026	1.000	.084	-.094	-.114	-.149	-.201	-.273	-.169
6	.020	.031	.044	.063	.084	1.000	-.081	-.096	-.125	-.168	-.222	-.294
7	-.251	-.179	-.134	-.135	-.094	-.081	1.000	.082	.066	.059	.056	.058
8	-.021	-.200	-.157	-.157	-.114	-.096	.082	1.000	.077	.070	.066	.069
9	-.017	-.025	-.192	-.193	-.149	-.125	.066	.077	1.000	.089	.085	.088
10	-.015	-.023	-.031	-.241	-.201	-.168	.059	.070	.089	1.000	.112	.115
11	-.014	-.021	-.030	-.137	-.273	-.222	.056	.066	.085	.112	1.000	.122
12	-.015	-.022	-.031	-.192	-.169	-.294	.058	.069	.088	.115	.122	1.000

LOG RESIDUALS FOR RV INDEX

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
4	-.522	-.787	.431	.389	-.498	-.696	1.985	-.910	-.233	-.116
5	-.927	-.559	.277	1.182	-.018	-.628	1.069	-.255	-.386	-.920
6	-.845	-.078	.092	.932	-.166	-.065	.338	-.825	-.002	-.935
7	.374	-1.034	.948	.115	-.079	-.256	.575	-.568	-1.103	-.990
8	.216	.338	.629	1.109	.018	-.502	-.070	-.280	-.927	-.783
9	.556	.106	.353	.826	.433	-1.535	-.483	-.267	-.013	.125

	1984	1985	1986	1987	1988	1989	1990
4	-.567	1.211	-.230	1.218	.033	-.709	.000
5	-.324	.597	-.512	1.155	.226	-.591	.613
6	-.159	.481	.038	.702	.446	-.390	.437
7	.685	.709	-.186	.560	.801	.190	-.740
8	.804	.291	-.578	.435	.322	-.199	-.821
9	.757	.701	-1.432	.039	.413	-.129	-.450

SUM OF RV RESIDUALS : 6.718882248E-5 MEAN RESIDUAL : 6.587139459E-7

Table 20. Residuals between observed RV (log transformed) and the predicted RV by age and year.

LOG RESIDUALS FOR RV INDEX

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
4	-.522	-.787	.431	.389	-.498	-.696	1.985	-.910	-.233	-.116
5	-.927	-.559	.277	1.182	-.018	-.628	1.069	-.255	-.386	-.920
6	-.845	-.078	.092	.932	-.166	-.065	.338	-.825	-.002	-.935
7	.374	-1.034	.948	.115	-.079	-.256	.575	-.568	-1.103	-.990
8	.216	.338	.629	1.109	.018	-.502	-.070	-.280	-.927	-.783
9	.556	.106	.353	.826	.433	-1.535	-.483	-.267	-.013	.125

	1984	1985	1986	1987	1988	1989	1990
4	-.567	1.211	-.230	1.218	.033	-.709	.000
5	-.324	.597	-.512	1.155	.226	-.591	.613
6	-.159	.481	.038	.702	.446	-.390	.437
7	.685	.709	-.186	.560	.801	.190	-.740
8	.804	.291	-.578	.435	.322	-.199	-.821
9	.757	.701	-1.432	.039	.413	-.129	-.450

SUM OF RV RESIDUALS : 6.718882248E-5 MEAN RESIDUAL : 6.587139459E-7

Table 21. Fishing mortality matrix for divs. 4VWX5 pollock.

FISHING MORTALITY

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
2	.012	.007	.005	.001	.001	.020	.013	.012	.003	.002	.002	.001	.002	.000	.000	.002	.004
3	.240	.083	.070	.054	.023	.197	.077	.132	.071	.059	.028	.015	.022	.016	.015	.007	.042
4	.329	.272	.221	.209	.155	.221	.198	.258	.229	.241	.138	.101	.123	.102	.117	.124	.033
5	.369	.468	.426	.319	.363	.260	.325	.347	.358	.285	.287	.243	.237	.297	.211	.254	.159
6	.453	.582	.478	.490	.397	.350	.400	.439	.625	.251	.230	.433	.344	.393	.345	.232	.257
7	.488	.773	.801	.699	.533	.283	.390	.619	.485	.352	.145	.788	.437	.408	.370	.347	.232
8	.516	.643	.436	.855	.569	.203	.236	.488	.617	.325	.241	.316	.504	.433	.360	.302	.245
9	.398	.326	.230	.428	.838	.186	.205	.278	.544	.541	.126	.239	.334	.643	.484	.360	.305
10	.453	.560	.131	.183	.110	.186	.190	.281	.392	.462	.209	.197	.325	.262	.312	.362	.210
11	.239	.352	.342	.355	.280	.124	.161	.276	.262	.186	.082	.301	.220	.212	.195	.169	.124

Table 22. Beginning of year population numbers for divs. 4VWX5 pollock.

BEGINNING OF YEAR POPULATION NUMBERS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	18068	27175	37963	49206	20856	5383	14799	79738	47392	38703
3	28981	14615	22091	30920	40254	17054	4318	11962	64496	38680
4	10490	18658	11008	16855	23979	32201	11462	3272	8587	49169
5	8431	6180	11635	7226	11201	16810	21129	7698	2070	5592
6	3297	4770	3169	6225	4302	6380	10613	12498	4454	1185
7	907	1715	2183	1609	3122	2367	3681	5821	6596	1951
8	449	456	648	802	655	1500	1460	2041	2566	3323
9	268	219	196	343	279	304	1003	944	1026	1134
10	252	147	129	128	183	99	206	669	585	487
11	380	131	69	93	87	134	67	140	414	324

	1984	1985	1986	1987	1988	1989	1990
2	44273	39445	40579	62732	31000	31000	31000
3	31637	36169	32262	33169	51351	24852	24272
4	29859	25175	29167	25839	26734	41425	18412
5	31648	21286	18630	21109	19111	19473	29961
6	3442	19437	13663	12030	12842	12670	12367
7	755	2240	10319	7934	6648	7446	8222
8	1123	534	834	5457	4320	3760	4308
9	1965	723	319	412	2897	2468	2277
10	540	1419	466	187	178	1462	1410
11	251	359	954	276	118	106	834

Table 23. Midyear biomass for divs. 4VWX5 pollock

MIDYEAR BIOMASS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	13272	21023	20207	35119	21515	3722	13767	48642	32699	29087
3	32415	16014	23379	29930	44530	16603	6344	17699	67186	42461
4	15814	29056	17225	20979	36423	40825	19682	6672	18809	66151
5	19276	13791	24342	13986	22250	35349	45571	17241	5576	13839
6	9905	12614	8541	15755	12625	16695	27570	30859	12675	3926
7	3327	5549	6446	4795	10160	8145	11450	17159	21242	7237
8	1973	2008	2707	2710	2751	6850	6601	8743	9095	13136
9	1348	1275	1119	1686	1201	1666	5366	5179	4424	4675
10	1369	774	859	768	1161	586	1550	4127	3374	2308
11	2642	829	466	716	579	1009	474	838	2650	2149

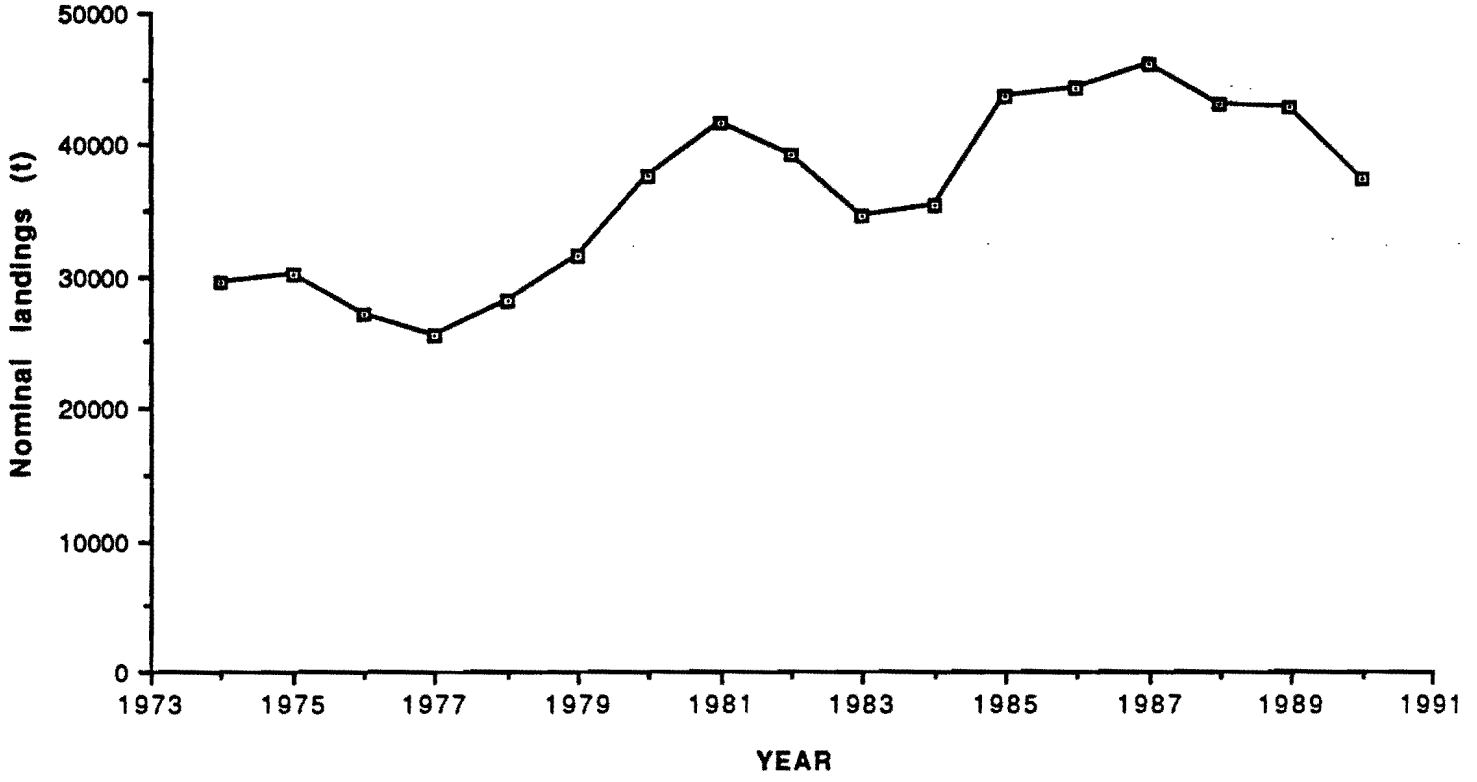
	1984	1985	1986	1987	1988	1989	1990
2	29198	26530	13009	36385	32869	18922	13644
3	46473	48608	32612	39437	63390	27089	29108
4	59850	42514	49915	43783	43026	62724	33360
5	66837	47001	38070	41630	41363	38952	64280
6	10750	44982	34651	26717	31770	33451	29249
7	3453	4874	27545	22040	17766	21820	25552
8	5422	1833	2514	16279	14000	12125	14304
9	9890	3569	1400	1268	9255	9089	8793
10	2805	6867	2208	938	731	5765	5900
11	1683	1742	4758	1389	699	691	4233

Table 24. Catch projections for 4VWX5Zc pollock

Year	1990	1991	1992	1993	1994
M.Y.P[1] catch ('000 t)	37	43	43	43	F=0.31
F	.25	.28	.30	.33	.31
2+ biomass ('000 t)	238	227	219	208	198

[1] Multi-year management plan.

Fig. 1 . Nominal landings for all countries of divs. 4VWX and Subdiv. 5Zc pollock.



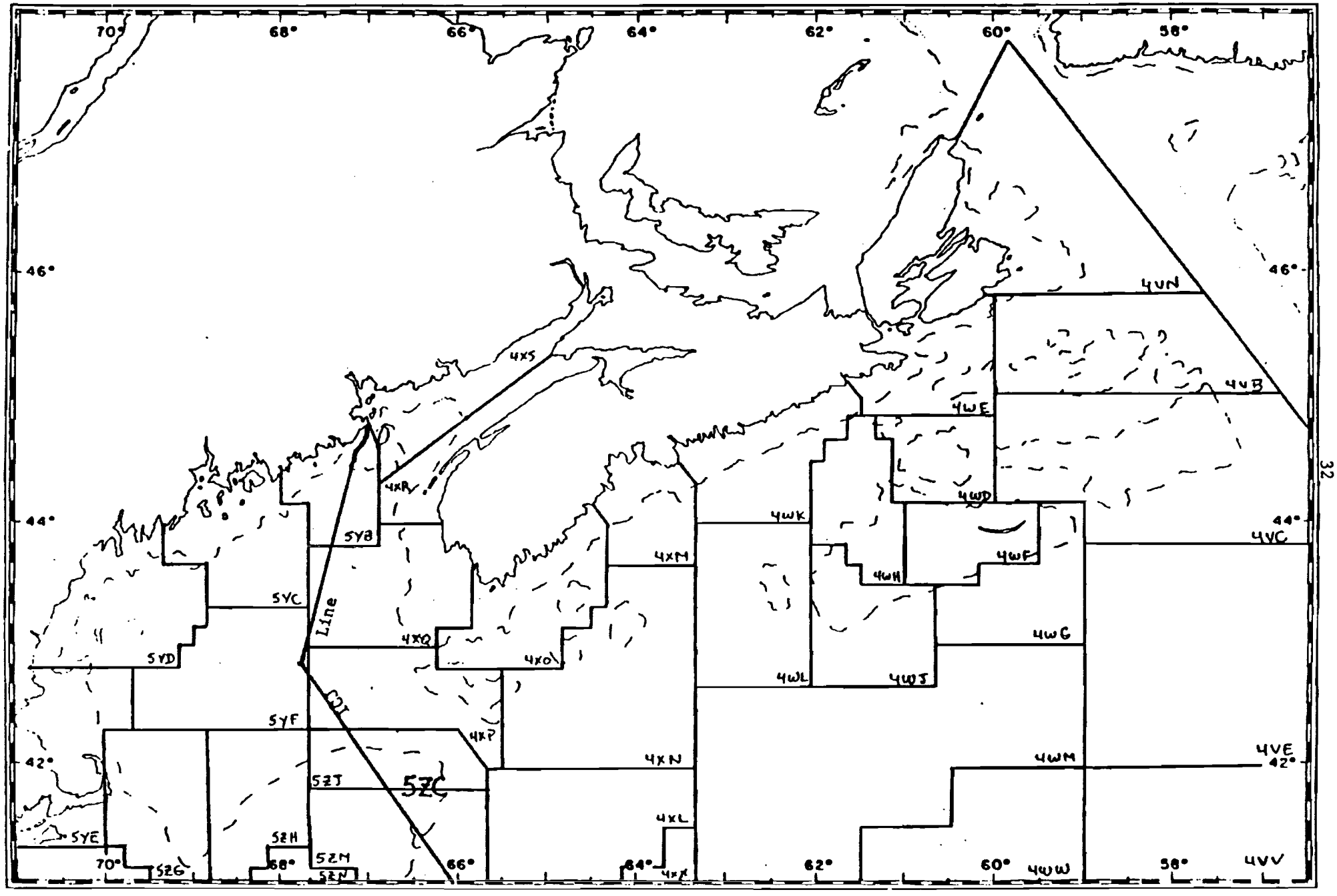
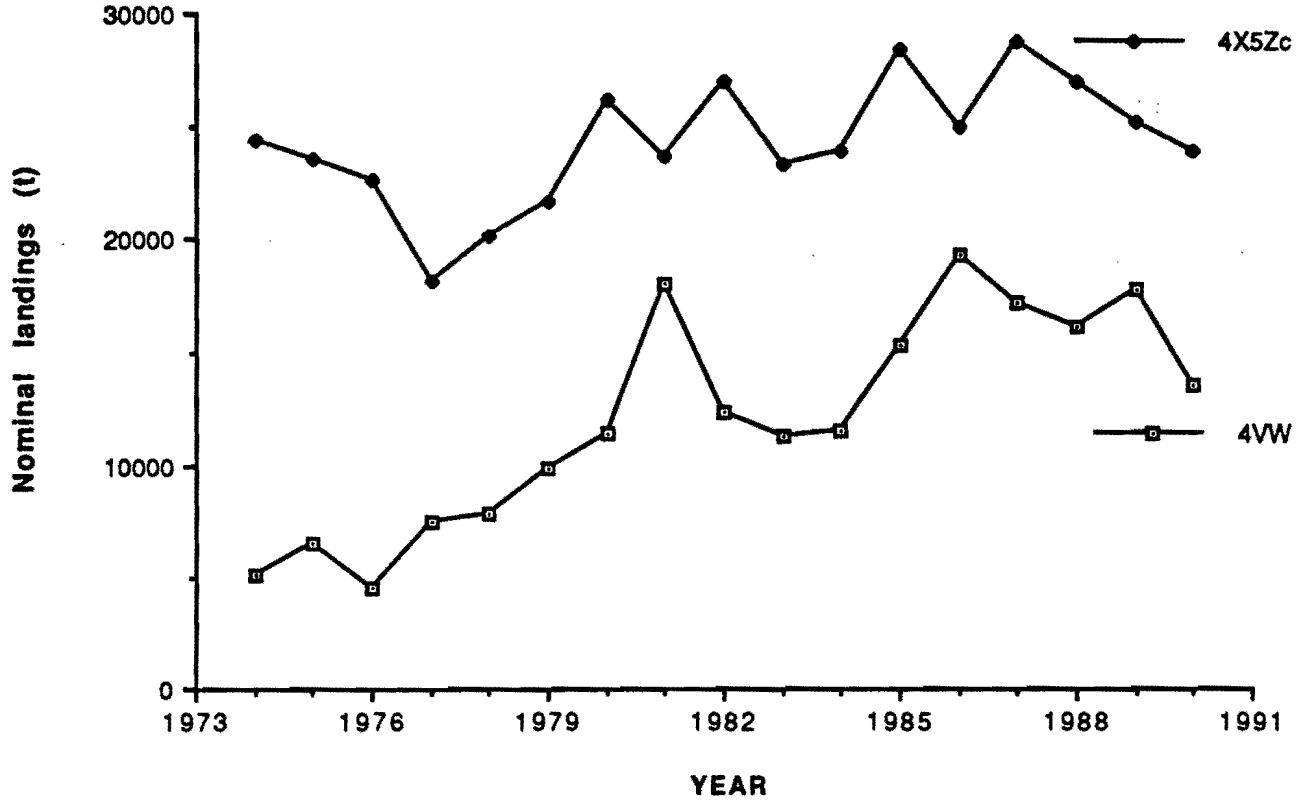
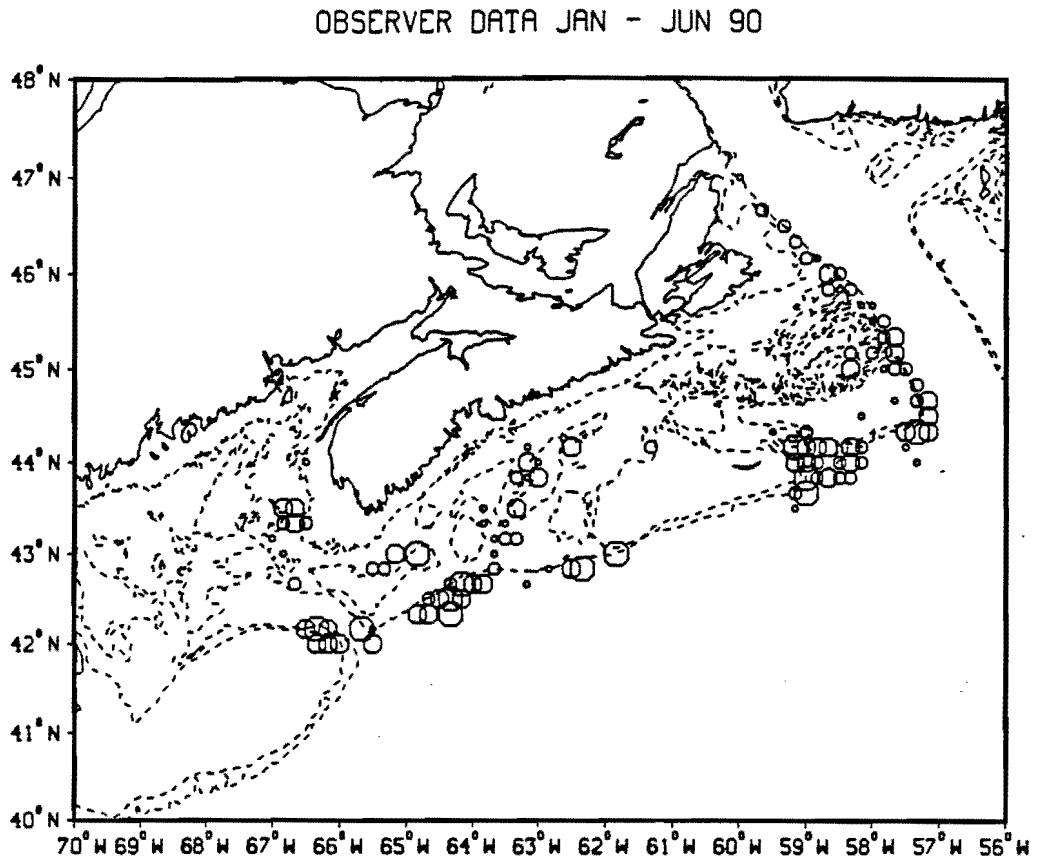


Fig. 2. Diagram of ICJ line which now defines the boundary for the new management unit for 4VWX5 pollock.

Fig. 3 . Nominal landings for all countries of divs. 4VWX and Subdiv. 5Zc pollock.





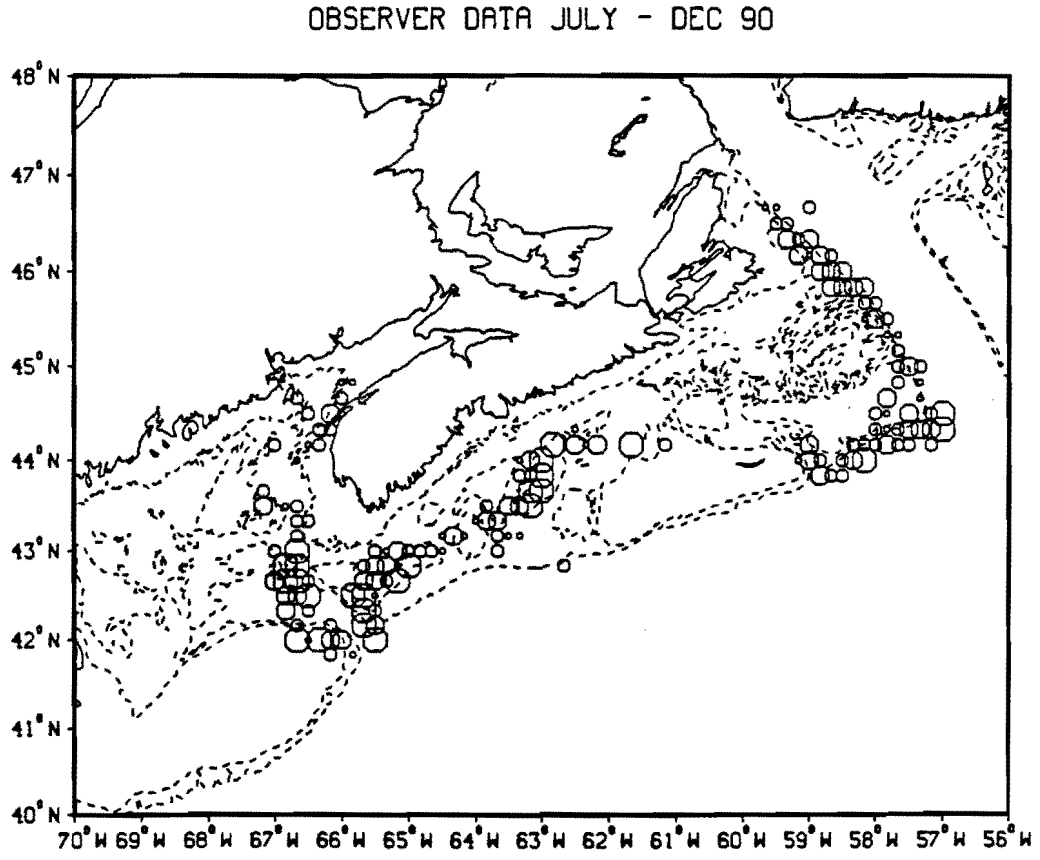


Figure 4. International Observer catch rates (tonnes/hr.) for 4VWX5 pollock (Jan.-June; July-Dec.).

Fig. 5 . Comparison of percent catch at age for Canadian large trawlers in 4VW and 4X5Zc.

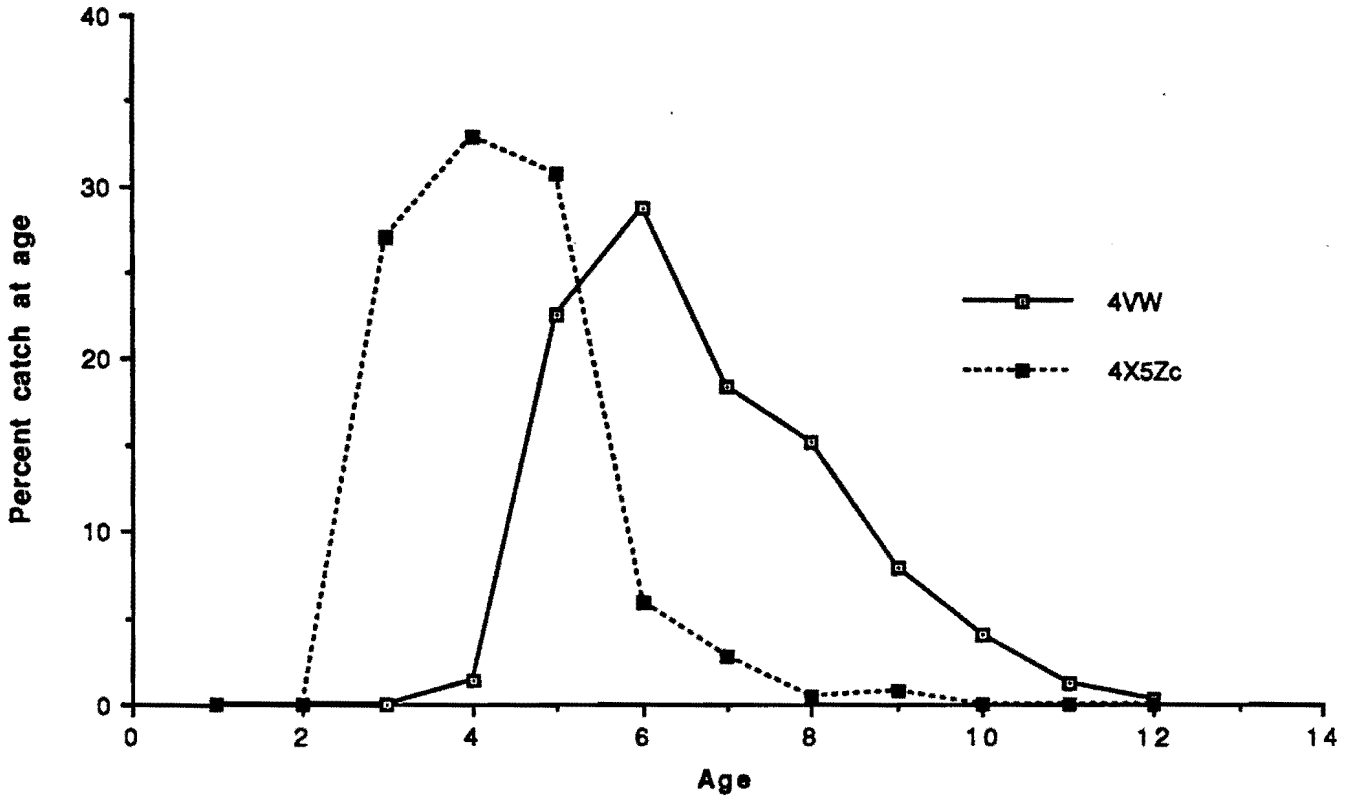


Fig. 6 . Percent projected catch at age vs percent catch at age for 1990.

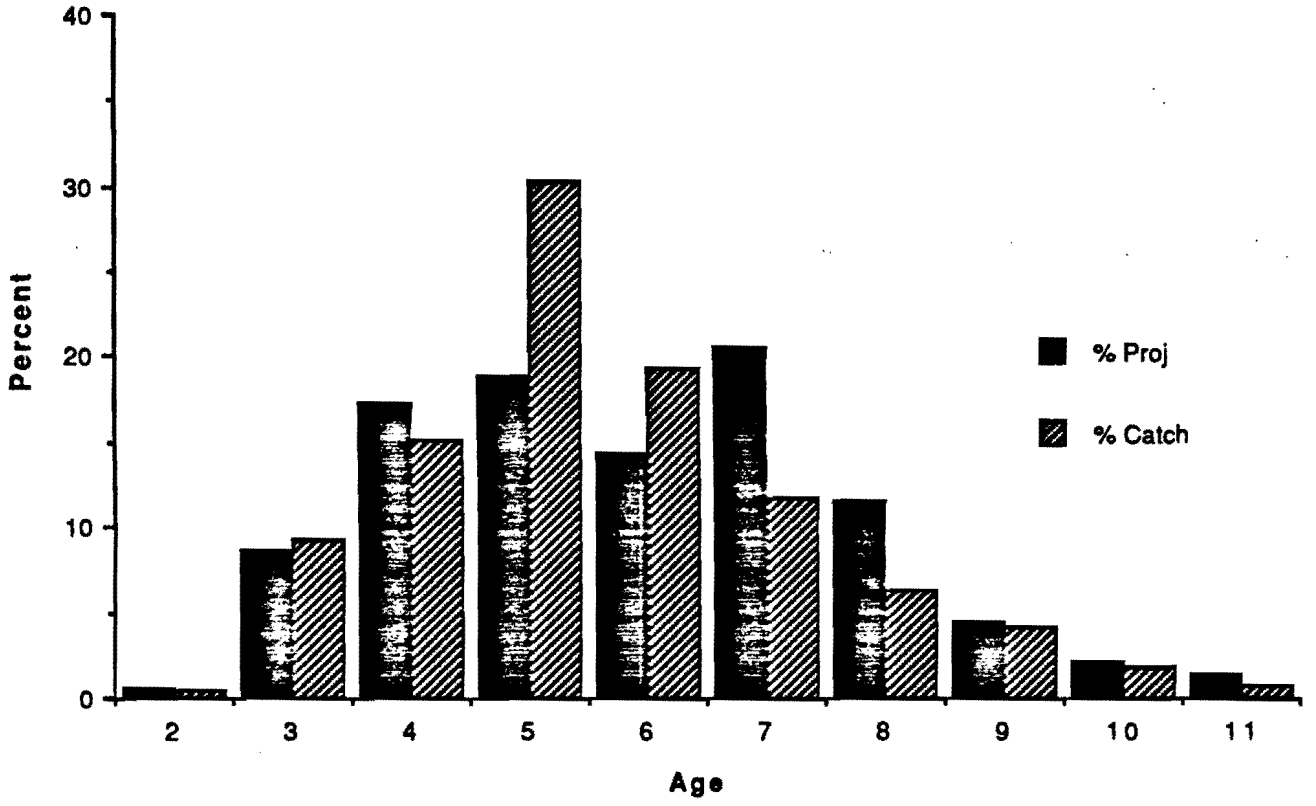


Fig. 7 . Catch rate indices for divs. 4VWX and Subdiv. 5Zc pollock (commercial vs IOP).

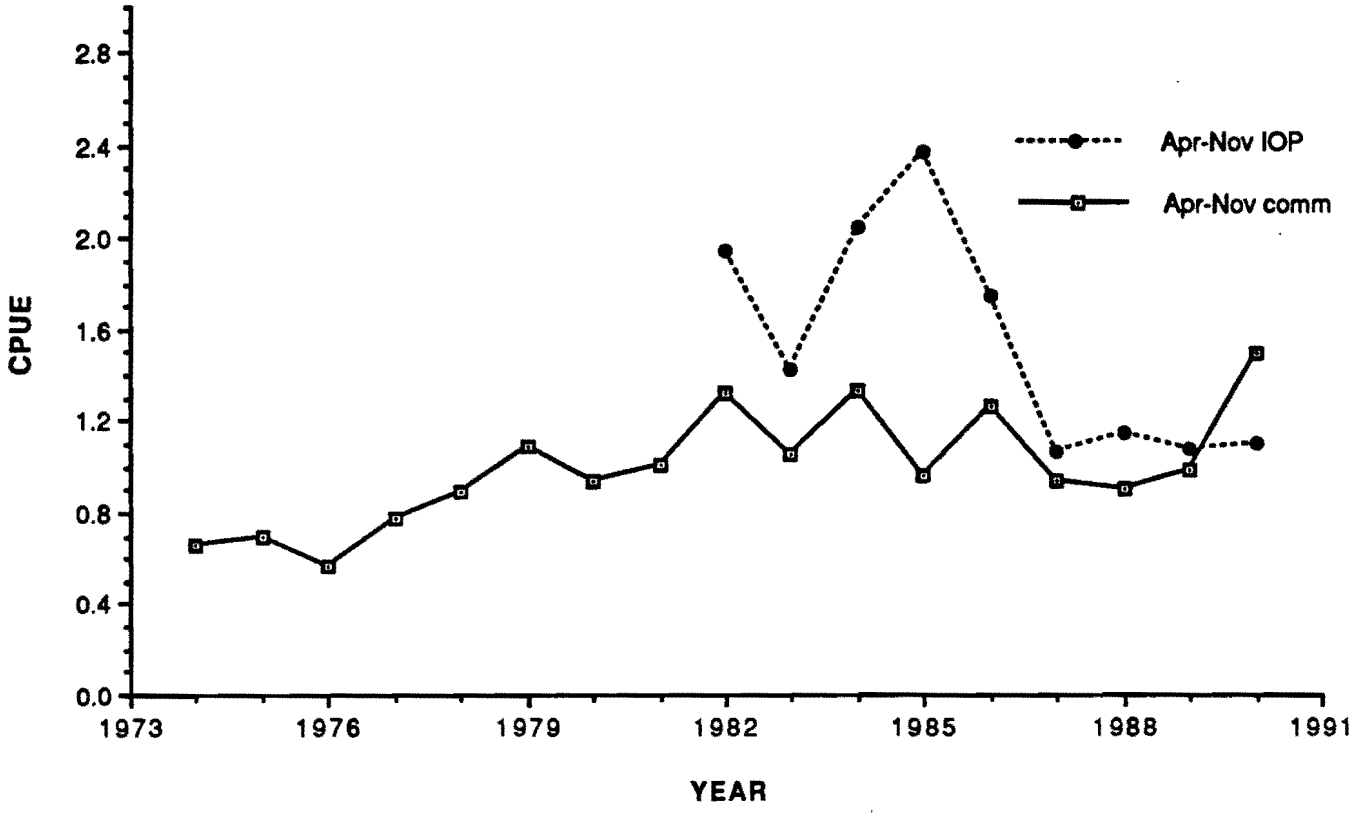
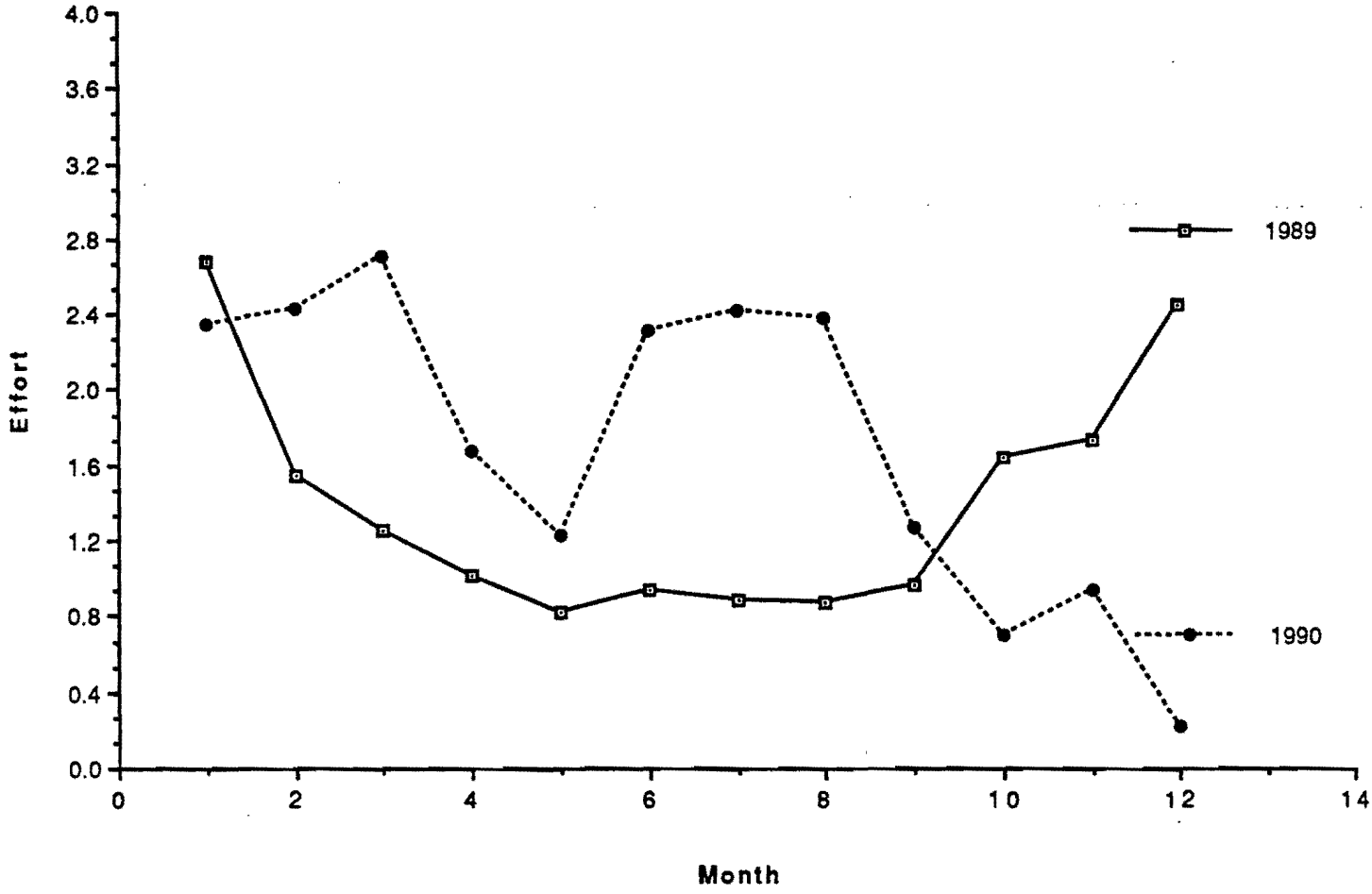


Fig. 8. Comparison of monthly catch rates for large trawlers for 1989 and 1990 based on regional data.



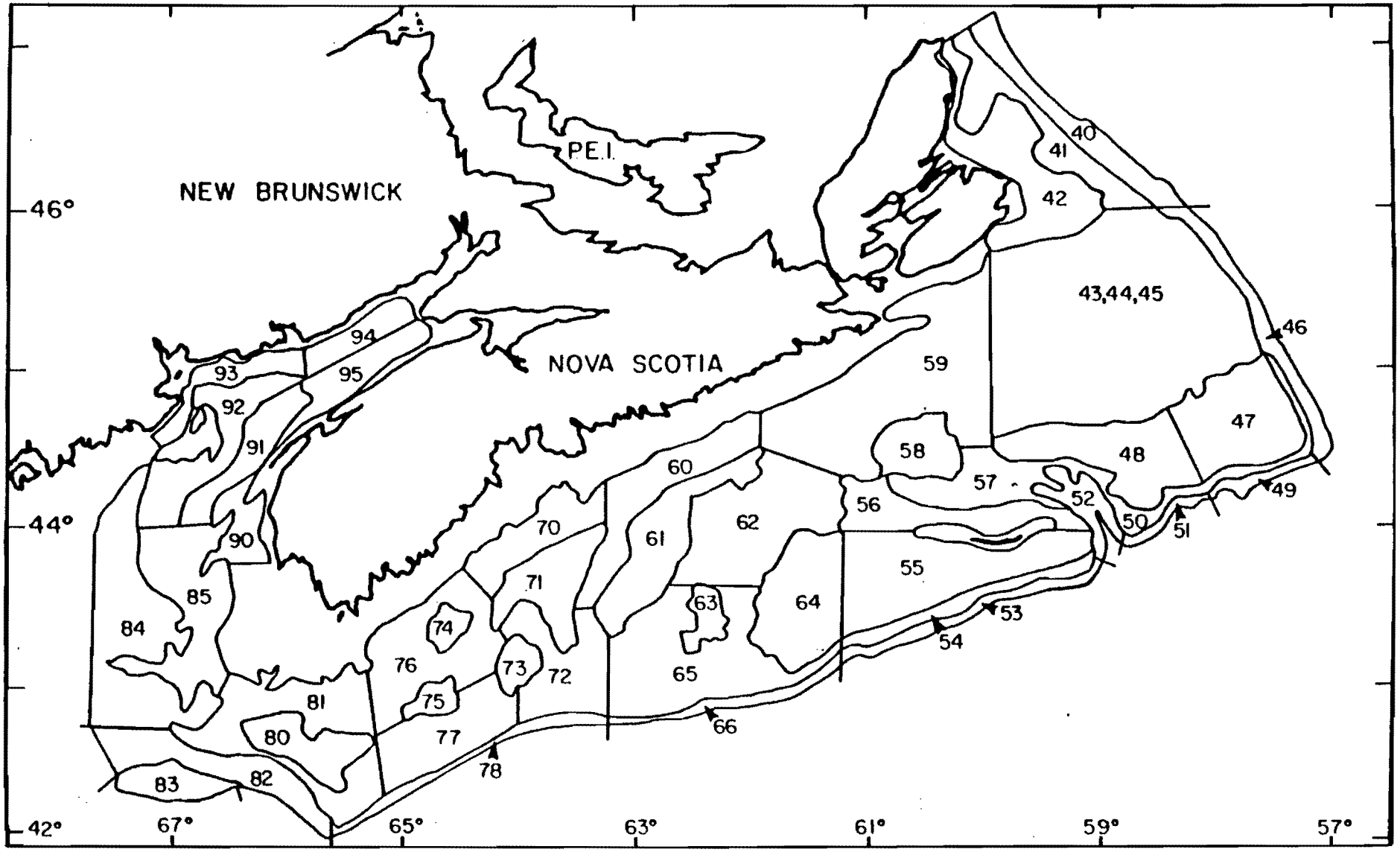
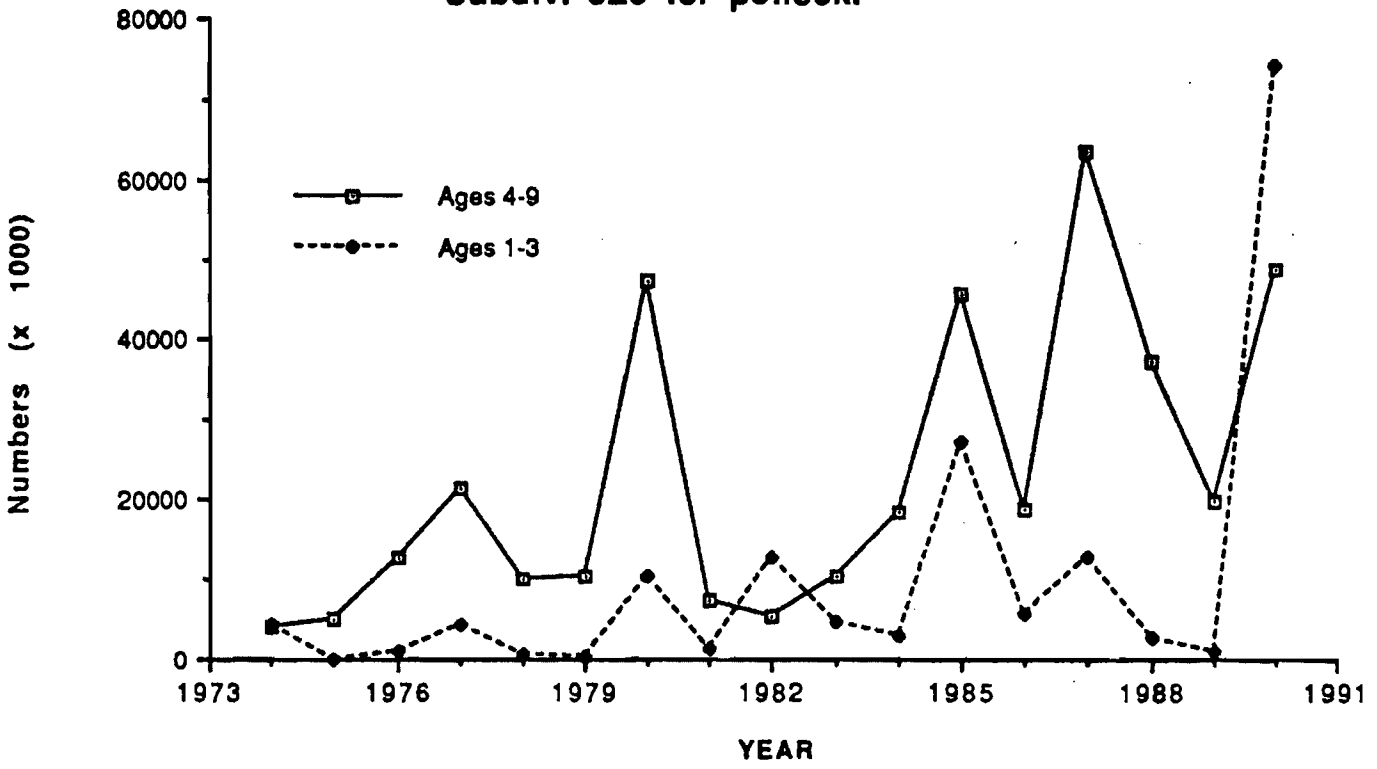


Figure 9. Stratification used for canadian RV bottom trawl surveys (divs. 4VWX + Subdiv.5Zc).

Fig. 10. July RV stratified numbers (ages 4-9 and 1-3) for divs. 4VWX and Subdiv. 5Zc for pollock.



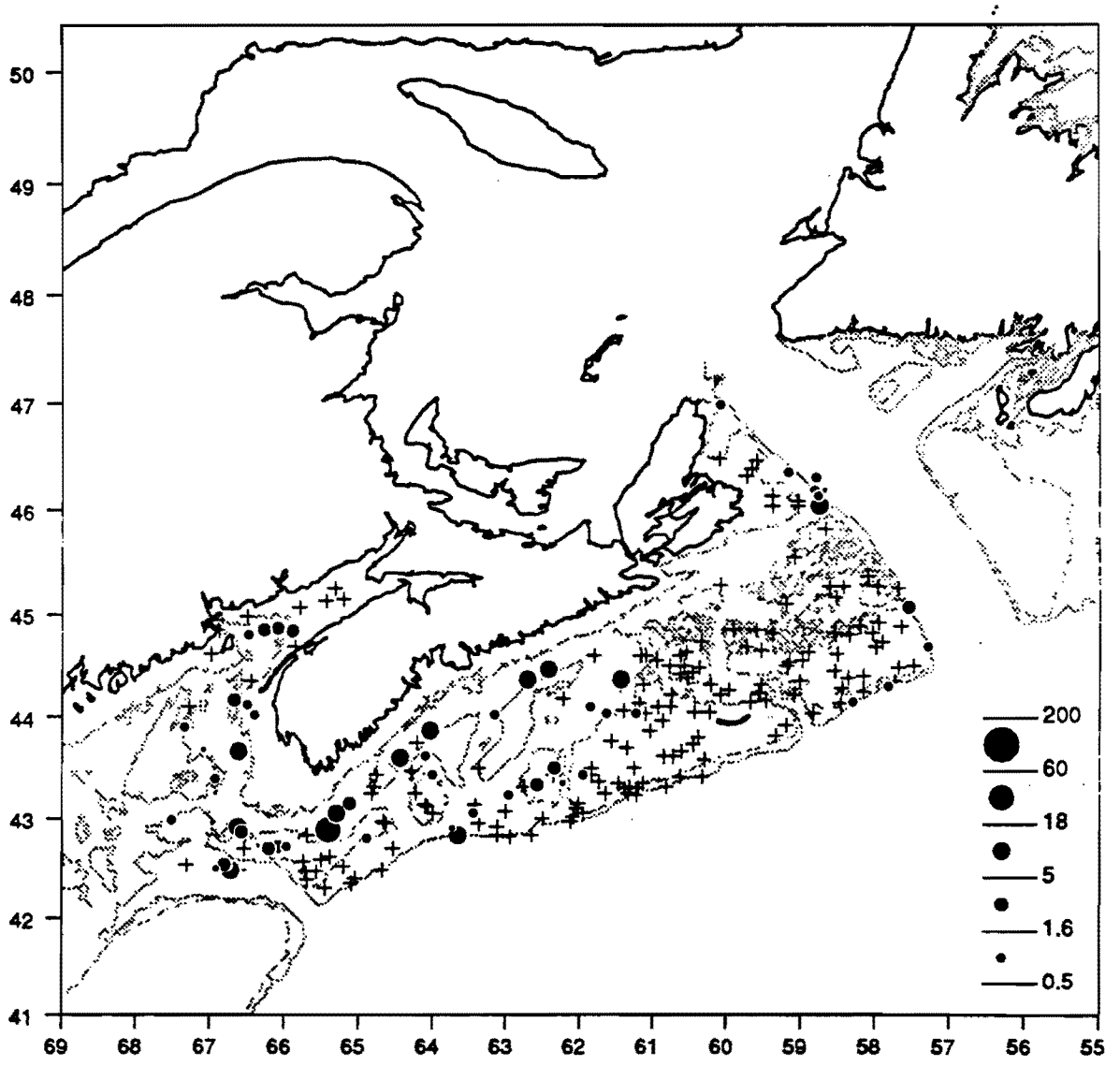


Figure 11. Research vessel survey catches of Pollock (Ages 7+) in July 1990.

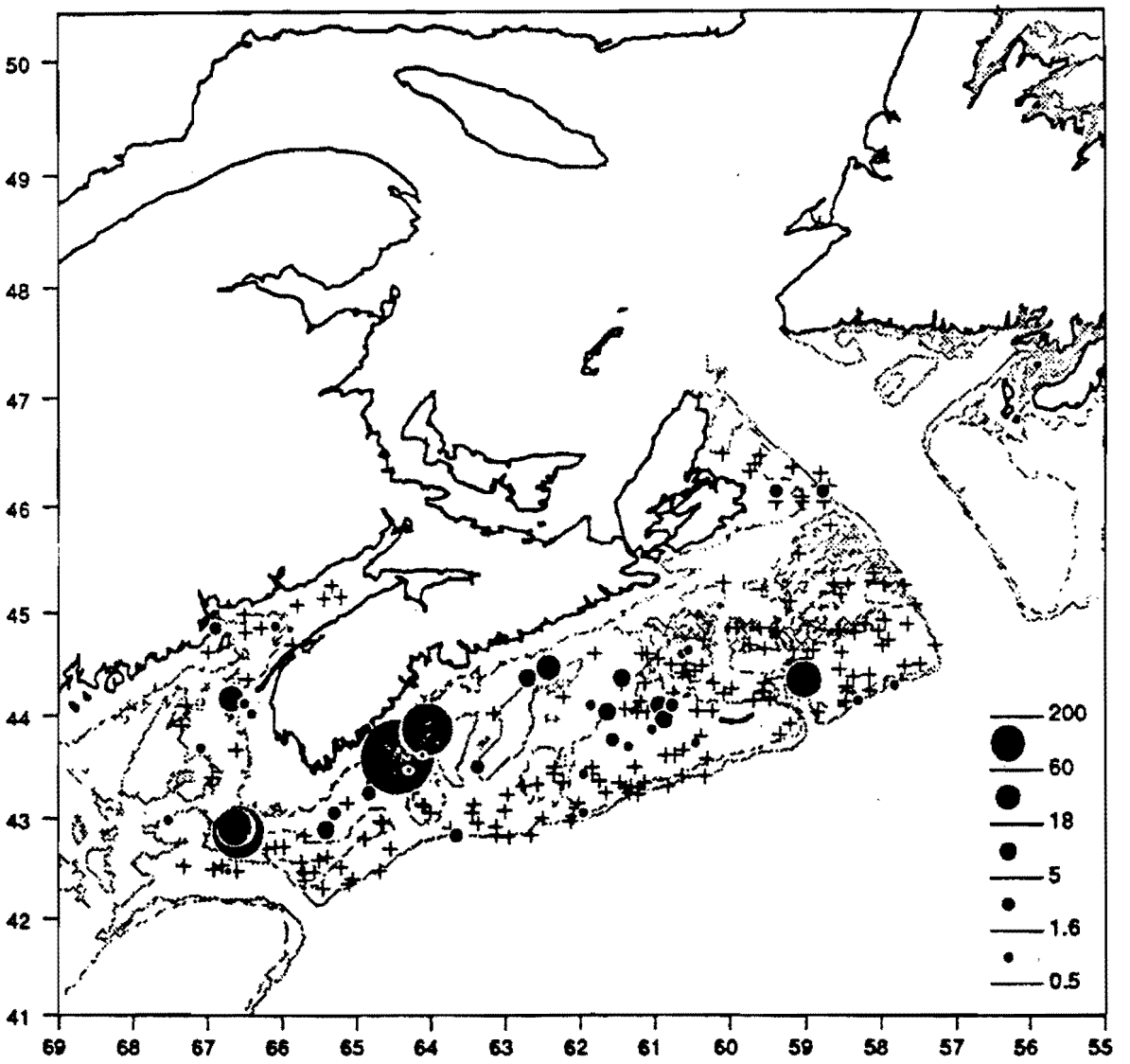


Figure 11. Research vessel survey catches of Pollock (Ages 0-3) in July 1990.

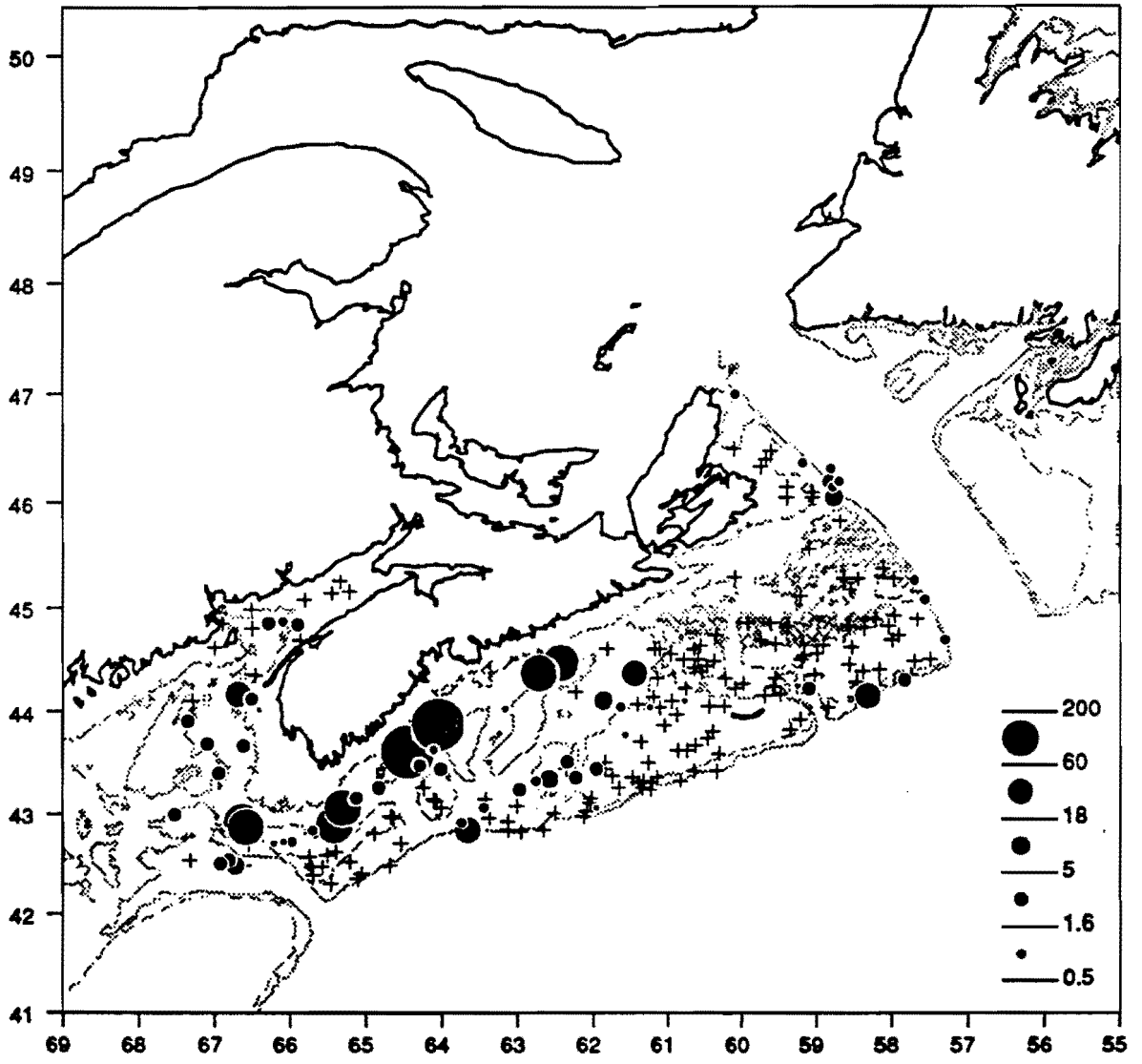


Figure 11. Research vessel survey catches of Pollock (Ages 4-6) in July 1990.

Fig. 12. Age 2 recruits to 4VWX and 5Zc pollock.

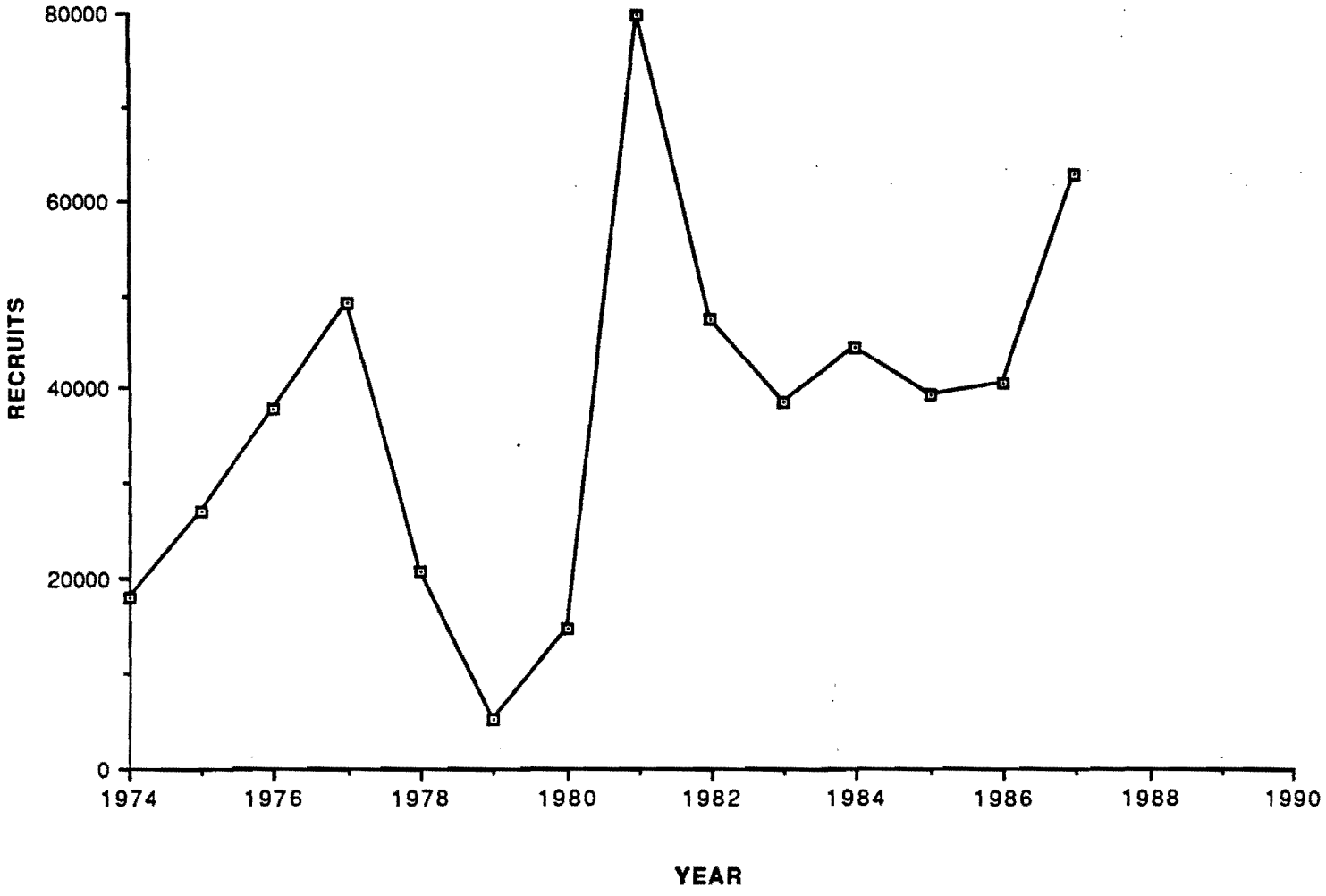


Fig. 13. 4+ mid-year biomass for 4VWX and 5ZC pollock.

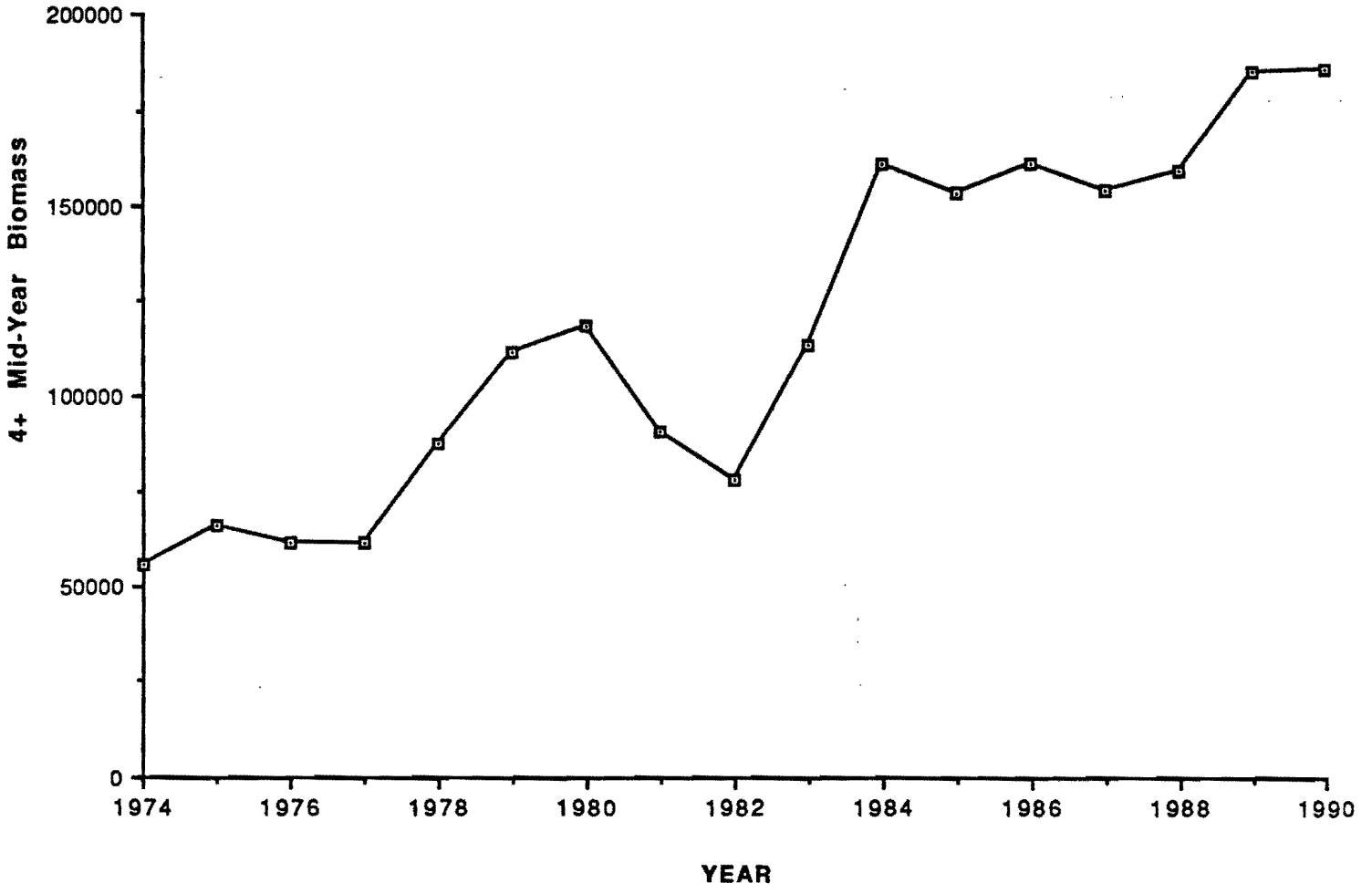


Fig. 14 . Population numbers (ages 4-9) for 4VWX and 5Zc pollock.

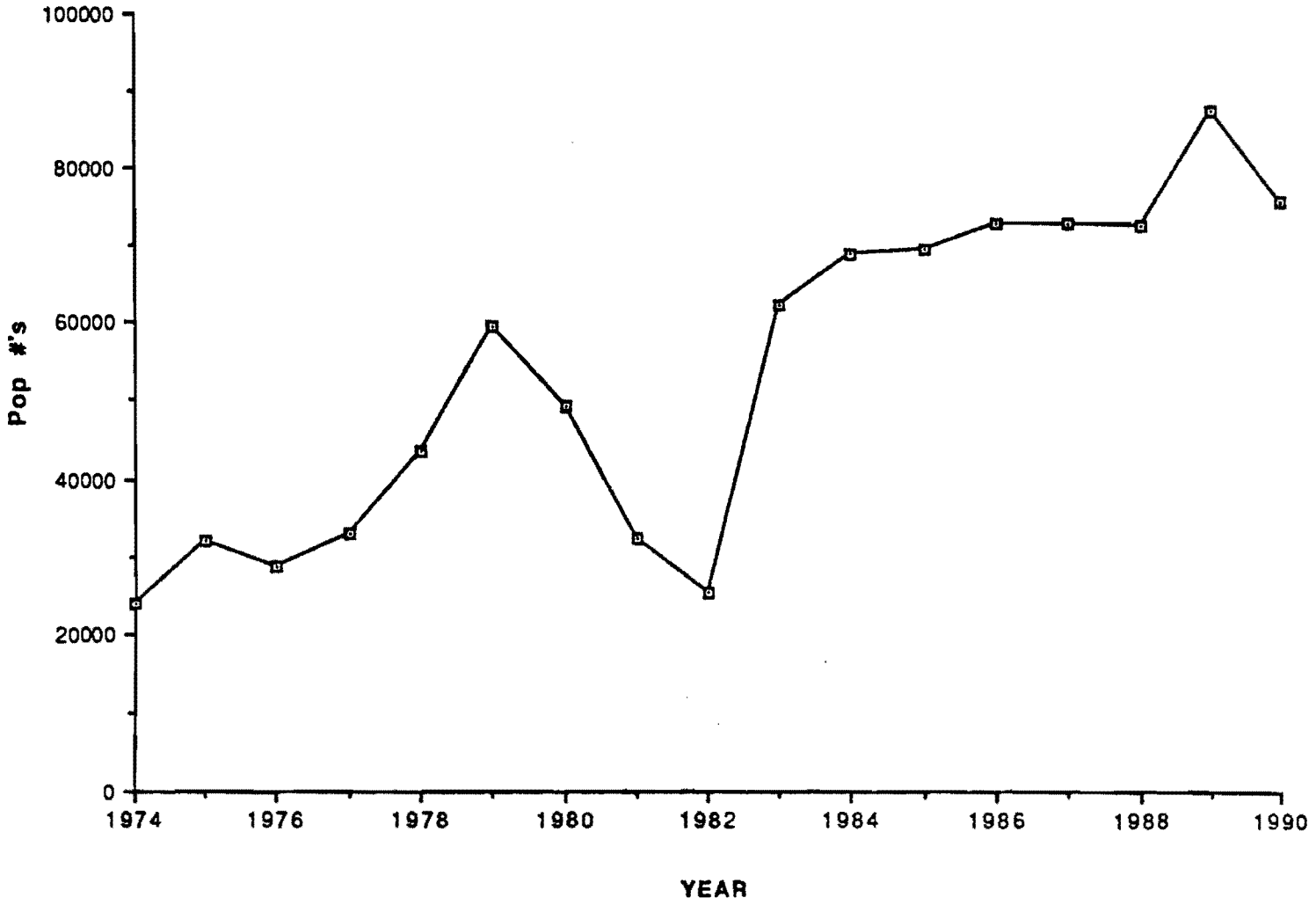


Fig. 15 . Fully recruited F's for 4VWX and 5Zc pollock.

Appendix 1.

```
     ∇INPUT[□]∇
[0]  INPUT;ANS;i⍙IN;Xin;SIN
[1]   c←□EX 'X'
[2]   ⍎(0=□NC 'STOCK⍙NAME')/'''STOCK NAME?''◇STOCK⍙NAME←□'
[3]   cname←('CATCH MATRIX FOR ',STOCK⍙NAME)DEFAULT cname
[4]   c←⍎cname
[5]   ANS←'FIRST YEAR AND YOUNGEST AGE IN CATCH MATRIX ? ' DEFAULT(1↑YR),1↑AG
[6]   YR←((1↑ANS)-1)+⍳¯1↑⍴c
[7]   AG←((¯1↑ANS)-1)+⍳1↑⍴c
[8]   'ENTER PARTIAL RECRUITMENT VECTOR FOR ALL AGES'
[9]   PR←DEFAULT PR
[10]  DOME←¯1↑PR
[11]  'ASSUMED AGES OF FULL RECRUITMENT (START WITH FIRST FULLY RECRUITED AGE) ? '
[12]  AGE←AG⍳DEFAULT AG[AGE]
[13]  NUM←0
[14]  'NATURAL MORTALITY IS 0.2 -- CHANGE m IF YOU DONT LIKE THIS'
[15]  ''
[16]  'ENTER STARTING ESTIMATES OF TERMINAL F FOR LAST YEAR '
[17]  ' WILL BE MULTIPLIED BY INPUT PR'
[18]  FLY←PR×DEFAULT 1↑defaults
[19]  'AGES IN CALIBRATION INDEX ? '
[20]  ROWS←,AG⍳AGES←DEFAULT AGES
[21]  FRST←1↑ROWS ◇ LAST←¯1↑ROWS
[22] ⍝ 'STARTING ESTIMATES OF YEAR-SPECIFIC FS FOR OLDEST'
[23] ⍝ ' NON-PLUS GROUP AGE (ENTER 0 IF NOT DESIRED)'
[24] ⍝ FAG←□
[25]  FAG←0
[26]  FVECT←FLY[¯1+FRST+⍳1+LAST-FRST],1↓⊖FAG
[27]  CVECT←,c[(¯1+FRST+⍳1+LAST-FRST);¯1↑⍴c]
[28]  →(FAG=0)/S1
[29]  CVECT←CVECT,1↓⊖,c[LAST;]
[30] S1:NVECT←(CVECT×(FVECT+m))÷(FVECT×(1-*-FVECT+m))
[31]  lbnd←CVECT××m÷2
[32]  ubnd←(⍴NVECT)⍴10000000
[33]
[34]  'NUMBER OF RV SURVEYS?'
[35]  'ENTER 0 IF NO RV INDEX'
[36]  INDEX⍙TYPE[i]←DEFAULT INDEX⍙TYPE[i]
[37]  SIN←i ◇ 0 0 ⍴□EX 'X'
[38] RVLP:→(SIN)INDEX⍙TYPE[i])/cpue ⍝ No more surveys -- go to CPUE
[39]  'RV INDEX OF ABUNDANCE'
[40]  '   SAME YEARS AS CATCH AT AGE MATRIX '
[41]  '   AGES FOR CALIBRATION BLOCK WILL BE SELECTED'
[42]  rvname[SIN;]←30↑DEFAULT rvname[SIN;]
[43]  i⍙IN←⍎rvname[SIN;]
[44]  'FIRST AGE IN SURVEY'
[45]  FINS←(1↑AG)-FINS←DEFAULT 0
[46]  ⍎'i⍙rv',(' 23 '[SIN]),'←i⍙IN[FINS+ROWS;]'
[47]  'ESTIMATES OF STANDARD ERROR OF INDEX  (ENTER 1 IF LOG MODEL)? '
[48]  rvsename[SIN;]←30↑DEFAULT rvsename[SIN;]
[49]  i⍙IN←⍎rvsename[SIN;]
[50]  ⍎'ise⍙rv',(' 23 '[SIN]),'←1'
[51]  ⍎(0≠⍴⍴i⍙IN)/'ise⍙rv',(' 23 '[SIN]),'←i⍙IN[FINS+ROWS;]'
[52]  'INDEX FOR WHAT MONTH ( NO. FROM 1 TO 12 ) ? '
[53]  MNTH[SIN]←(DEFAULT 12×MNTH[SIN])÷12
[54]  'STARTING AGE - SPECIFIC COEFFICIENTS FOR RV INDEX'
[55]  ' '
[56]  ' MATRIX OF AGE BY AGE COEFFICIENTS (1 OR 2 COLUMNS)'
[57]  (1≠+/+/ise⍙rv)/' MODEL IS      I = [BO] + B1 x POP '
```

```
[58]  (i=+/+/iseΔrv)/' LOG MODEL IS    LN(I) = LN( [BO] + B1 x POP ) '
[59]  ' '
[60]  Kin←DEFAULT i↓defaults ⍝ GLOBAL TO STORE INPUT F AND K'S
[61]  Kin←((⍴AGES),⍴Kin)⍴Kin
[62]  lbnd←lbnd,(⍴,Kin)⍴(¯1↑⍴Kin)↑ ¯9000 0 ⍝ MIN SLOPE =0, MIN INTER.=¯9000
[63]  ubnd←ubnd,(⍴,Kin)⍴9000 ⍝ MAX SLOPE AND INTER. = 9000
[64]  ⍎(0=⎕NC 'K')/'K←Kin ◊ SIN←SIN+1 ◊ →RVLP'
[65]  K←K,Kin ◊ SIN←SIN+1 ◊ →RVLP
[66]
[67] cpue:'AGE-AGGREGATED CPUE INDEX OF ABUNDANCE'
[68]  '              SAME YEARS AS CATCH AT AGE MATRIX'
[69]  'ENTER 0 IF NO CPUE INDEX, 1 OTHERWISE'
[70]  INDEXΔTYPE[2]←DEFAULT INDEXΔTYPE[2]
[71]  →(0=INDEXΔTYPE[2])/exit ⍝ No cpue index so go to exit
[72]  iΔcpue←⍎cpuename[1;]↑30↑DEFAULT cpuename[1;]
[73] l1:'ESTIMATES OF STANDARD ERROR OF CPUE?  (1 FOR LOG MODEL OPTION) '
[74]  iseΔcpue←⍎cpuename[2;]↑30↑DEFAULT cpuename[2;]
[75]  →((⍴iΔcpue)≠⍴iseΔcpue)/l1 ⍝ must be same length as iΔcpue
[76]  'ENTER MEAN WEIGHTS AT AGE - SAME YEARS AND AGES AS CATCH'
[77]  MWT←⍎cpuename[3;]↑30↑DEFAULT cpuename[3;]
[78]  'STARTING COEFFICIENTS FOR CPUE INDEX (AGE AGGREGATED)'
[79]  ''
[80]  →(0=⎕NC 'K')/norv
[81]  'ENTER ',(⍕¯1↑⍴K),' VALUE(S) FOR COEFFICIENT(S)'
[82]  K←K,DEFAULT⍬(¯1↑⍴K)↑1E¯5
[83]  →exit1
[84] norv:
[85]  'ENTER 1 (SLOPE) OR 2 (INTERCEPT AND SLOPE) COEFFICIENTS'
[86]  K←(1,⍴,K)⍴K←,⍬
[87] exit1:lbnd←lbnd,((l1-¯1↑⍴K)↑¯9000),0
[88]  ubnd←ubnd,((l1-¯1↑⍴K)↑9000),9000
[89] exit:initial←NVECT,,K
[90]  alpha←1E¯3×NVECT
[91]  limit←100
[92]  'Penalty constraints ON initially (Y/N)? Default is OFF'
[93]  USEΔCONSTRAINTS←0
[94]  ⍎(('Y'=ANS)∨'y'=ANS←⎕INKEY)/'USEΔCONSTRAINTS←1'
[95]  'Penalty functions turned ',(2 3 ⍴'OFFON ')[1+USEΔCONSTRAINTS;]
[96]  ' '
[97]  'Ready to run minipop'
```

```
[0]  minipop;BOOL;J;DIAG;Q;LAMBDA;HESS;N;P;PAR;RSS;de;CAUSE;I;V;NPHI;PHI;pnlty;dpnlty;SHESS;NORM;i;⍙ts
[1]  ⍝ NON-LINEAR LEAST SQUARES USING MARQUARDT ALGORITHM
[2]   ⍝(2≠⎕NC 'verbose')/'verbose←1'
[3]   ⍙ts←¯7↓TIMEFMT ⎕TS
[4]   'Do you wish to document your input ?'
[5]   ⍝(('Y'=ANS)∨'y'=ANS←⎕INKEY)/'miniDOC'
[6]   page ⍙ts
[7]   rssvec←⍳0
[8]   P←⍴par←PAR←,initial
[9]   RSS←e←.xe←OBJ⍙FN PAR ⍝ RESIDUAL SUM OF SQUARES
[10]  N←⍴,e
[11]  pnlty←alpha PNLTY⍙FN PAR ⍝ PENALTY FOR CONSTRAINTS
[12]  NPHI←PHI←RSS+pnlty
[13]  LAMBDA←0.01
[14]  BOOL←(P×P)⍴1,P⍴0 ⍝ USED TO CREATE DIAG MATRIX
[15]  con←10
[16]  J←1
[17]  PRNT
[18]  rssvec←rssvec,RSS
[19] L3:→(limit<J←J+1)/L6 ⍝MAIN LOOP
[20]  PAR←par
[21]  PHI←NPHI
[22]  de←DIFF⍙OBJ
[23]  Q←2×e+.×de ⍝ GRADIENT
[24]  HESS←2×(⍉de)+.×de ⍝ HESSIAN
[25]  dpnlty←DIFF⍙PNLTY ⍝ DIFFERENCE FOR PENALTY
[26]  Q←Q+dpnlty[1;]
[27]  DIAG← 1 1 ⍉HESS←HESS+(2⍴P)⍴BOOL\dpnlty[2;]
[28]  LAMBDA←9.9999999999999E¯7⌈LAMBDA×0.01
[29]  I←1
[30]  SHESS←HESS+(2⍴P)⍴BOOL\DIAG×LAMBDA←LAMBDA×10 ⍝ MARQUARDT METHOD
[31]  NORM←(+⌿SHESS*2)*0.5 ⍝ COLUMN NORMS
[32]  SHESS←SHESS÷(⍴SHESS)⍴NORM ⍝ SCALE HESSIAN
[33]  par←PAR+V←(Q⌹SHESS)÷NORM ⍝ STEP DIRECTION; STEP SIZE=1
[34]  →(~FRGN⍙FN par)/L4
[35]  RSS←e←.xe←OBJ⍙FN par
[36]  pnlty←alpha PNLTY⍙FN par
[37]  →(PHI≥NPHI←RSS+pnlty)/L6
[38] L4:LAMBDA←LAMBDA×100
[39] L5:par←PAR+V←V×0.1*I ⍝INNER LOOP  REDUCE STEP SIZE
[40]  →(10<I←I+1)/L6
[41]  →(~FRGN⍙FN par)/L5
[42]  RSS←e←.xe←OBJ⍙FN par
[43]  pnlty←alpha PNLTY⍙FN par
[44]  →(PHI≥NPHI←RSS+pnlty)/L6
[45]  →L5
[46] L6:PRNT
[47]  rssvec←rssvec,RSS
[48]  msr←RSS÷N-P
[49]  →(1=∧/CAUSE←(10≥I),(limit≥J),(1E¯3<con←(((N-P)×⌈Q+.×V)÷P×RSS)*0.5),(1E¯4<|(NPHI-PHI)÷PHI),(9.9999
[50]  QPUT(~CAUSE)/[1]exit
[51]  ⍝(USE⍙CONSTRAINTS)/'USE⍙CONSTRAINTS←0 ⋄ ''TURNING CONSTRAINTS OFF''⋄→L3'
[52]  page ⍙ts
[53]  OUTPUT
```

```
[0]  ITERCOHORT;CATCH;J;MORT;FI;FC;ITER;I;Y;A;FCNEW;DIFF1
[1]   CATCH←c
[2]   J←¯1↑⍴CATCH
[3]   MORT←(⍴CATCH)⍴m
[4]   F←(⍴CATCH)⍴0
[5]   FI←FLY
[6]   →(NUM=0)/S3
[7]   FI←FI,¯1↑FI
[8]  S3:→(FAG=0)/S2
[9]   FC←FAG
[10]  →S1
[11] S2:FC←(¯1↑⍴CATCH)⍴(¯1↑FI)
[12] S1:ITER←0
[13] OK9:I←⍴FI
[14]  F[(⍳I);J]←I⍴FI
[15]  F[I;]←J⍴FC
[16]  ITER←ITER+1
[17]  →(ITER≥20)/0
[18]  POP←(⍴CATCH)⍴0
[19]  POP[(⍳I);J]←((,CATCH[(⍳I);J])×FI←(,MORT[(⍳I);J]))÷FI×1-*-FI←(,MORT[(⍳I);J])
[20]  POP[I;]←((,CATCH[I;])×FC←(,MORT[I;]))÷FC×1-*-FC←(,MORT[I;])
[21]  →(NUM=0)/SK1
[22]  I←I-1
[23]  POP[I;]←((,CATCH[I;])×FC←(,MORT[I;]))÷FC×1-*-FC←(,MORT[I;])
[24]  F[I;]←J⍴FC
[25] SK1:Y←J-1
[26] AA:X←MORT[⍳I-1;Y]
[27]  POP[⍳I-1;Y]←(CATCH[⍳I-1;Y]××X÷2)+(POP[1↓⍳I;Y+1]××X)
[28]  →(1≤Y←Y-1)/AA
[29]  F[⍳I-1;⍳J-1]←(⊛(¯1 ¯1 ↓POP[⍳((1↑⍴POP)-NUM);])÷ 1 1 ↓POP[⍳((1↑⍴POP)-NUM);])- ¯1 ¯1 ↓MORT[⍳((1↑⍴POP
[30]  →(FAG≠0)/0
[31]  FCNEW←DOME×(+/[1]POP[AGE;]×F[AGE;])÷+/[1]POP[AGE;]
[32]  DIFF1←|(FCNEW-FC)÷FCNEW
[33]  FC←(¯1↓FCNEW),¯1↑FC
[34]  →((⌈/¯1↓DIFF1)>0.01)/OK9


      ∇OBJ∆FN[⎕]∇
[0]  R←OBJ∆FN A
[1]   s←(⍴NVECT)⍴A ⍝ survivors at designated age
[2]   FVECT←(⊛s÷(s-CVECT××m÷2)××-m)-m
[3]   →(∧/PR=1)/NOPR ⍝ skips PR if no PR was imposed
[4]   FRF←(+/(FVECT×s)[AGE-¯1↓FRST])÷+/s[AGE-¯1+FRST] ⍝ Fully recruited F
[5]   ⍞(FRST=LAST)/'FRF←FVECT'
[6]   FLY←PR×FRF
[7]  NOPR:FLY[¯1+FRST+⍳1+LAST-FRST]←FVECT
[8]   →(FAG=0)/S1
[9]   FAG←(⊛(⍴FAG)↑⊛FVECT)
[10] S1:k←((INDEX∆TYPE[2]+INDEX∆TYPE[1]×⍴ROWS),(¯1↑⍴K))⍴(-(INDEX∆TYPE[2]+INDEX∆TYPE[1]×⍴ROWS)×¯1↑⍴K)↑A
[11] ⍝ k is the current calibration coefficients
[12]  ITERCOHORT
[13]  INTERFACE POP
[14]  R←,RESI k ⍝ calculate index residuals
```

```
[0]  R←DIFF∆PNLTY;I;R1;DELTA;TPAR;fpnlty;bpnlty
[1]  ⍝ CALCULATES FIRST AND SECOND DIFFERENCES OF PENALTY FUNCTION
[2]   I←1
[3]   R← 2 0 ⍴0
[4]   DELTA←(0.01×PAR)⌈0.01×PAR=0
[5]  L1:TPAR←((I-1)↑PAR),(PAR[I]+DELTA[I]),I↓PAR
[6]   R1←(pnlty-fpnlty+alpha PNLTY∆FN TPAR)÷DELTA[I]
[7]   TPAR←((I-1)↑PAR),(PAR[I]-DELTA[I]),I↓PAR
[8]   bpnlty←alpha PNLTY∆FN TPAR
[9]   R←R,,R1,(fpnlty+bpnlty-2×pnlty)÷DELTA[I]
[10]  →L1×⍳2≥I←I+1
```

```
     ∇FRGN∆FN[0]∇
[0]  R←FRGN∆FN A
[1]   R←∧/(A)≥lbnd),A≤ubnd
[2]  ⍝ THIS FUNCTION SHOULD RETURN A 1 IF THE PARAMETERS
[3]  ⍝ ARE IN THE FEASIBLE REGION AND 0 OTHERWISE
[4]  ⍝ R←1 DEFAULT RETURNS 1
```

```
     ∇INTERFACE[0]∇
[0]  INTERFACE POPN;pr;FRF
[1]  ⍝ Produces 1 or 2 global variables POPIND and FBIOM
[2]   →(0=INDEX∆TYPE[1])/CPUE
[3]   POPIND←POPN×⍤-(F+m)×1↑1↓MNTH ⍝ Adjusts SPA population to the survey month
[4]   POPIND←POPIND[ROWS;] ⍝ selects calibration block
[5]   →(1=INDEX∆TYPE[1])/CPUE
[6]   POPIND2←POPN×⍤-(F+m)×1↑1↓MNTH ⍝ Adjusts SPA population to the survey month
[7]   POPIND2←POPIND2[ROWS;] ⍝ selects calibration block
[8]   →(2=INDEX∆TYPE[1])/CPUE
[9]   POPIND3←POPN×⍤-(F+m)×¯1↑MNTH ⍝ Adjusts SPA population to the survey month
[10]  POPIND3←POPIND3[ROWS;] ⍝ selects calibration block
[11] CPUE:→(0=INDEX∆TYPE[2])/EXIT
[12]  FRF←(+⌿(POPN×F×OTBpartCAT)[AGE;])÷+⌿POPN[AGE;] ⍝ Calculates fully recruited Ffor OTB partial F ⍝
[13]  pr←1LF÷(⍴F)⍴FRF ⍝ calculates PR matrix
[14]  pr[AGE;]←1 ⍝ Sets defined fully recruited ages to 1
[15]  FBIOM←+⌿POPN×pr×MWT
[16] EXIT:
```

```
     ∇PNLTY∆FN[0]∇
[0]  R←alpha PNLTY∆FN A
[1]   R←USE∆CONSTRAINTS×+/alpha÷(⍴NVECT)↑A
[2]  ⍝ State variable 'USE∆CONSTRAINTS' controls penalty function
[3]  ⍝ 1 → constraints on; 0 → constraints off
```

```
[0]  R←RES1 K
[1]   R←⍳0
[2]   →(0=INDEX⌷TYPE[1])/cpue ⍝ NO RV SURVEY
[3]   R←R,,POPIND RES1⌷RV K[⍳⍴ROWS;]
[4]   ⍎(1<INDEX⌷TYPE[1])/' R←R,,POPIND2 RES1⌷RV2 K[(⍴ROWS)+⍳⍴ROWS;]'
[5]   ⍎(2<INDEX⌷TYPE[1])/' R←R,,POPIND3 RES1⌷RV3 K[(2×⍴ROWS)+⍳⍴ROWS;]'
[6]   →(0=INDEX⌷TYPE[2])/res ⍝ NO CATCH RATE SERIES
[7]  cpue:K←(⊖K)[1;] ⍝ get bottom row of K
[8]   R←R,,FBIOM RES1⌷CPUE K
[9]  res:
```