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Assessment of Pollock (Pollachius virens) in Divisions 4VWX and Subdivision 5Zc for 1989

by

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Abstract

The Canadian allocation for pollock in 1989 was 43000 t with a catch of 41112 t taken in the domestic fishery. The shortfall amounted to 1888 t. The foreign catch increased in 1989 to 1882 t primarily due to small mesh landings by the USSR fleet fishing silver hake. Under cod/haddock/pollock management in Div. 4X and Subdiv. 5Zc dumping of pollock may have been a problem as more valuable cod and haddock were preferentially kept. The concentration of the eastern part of the pollock fishery in Div. 4V rather than Div. 4W during 1985-1988 has continued in 1989. Research surveys indicate an increase in the age 4-9 abundance from the early 1980s with the 1985 and 1987 total numbers among the highest recorded. No above average year classes have been observed in the fishery since 1983. As in last year's assessment only RV numbers were used to calibrate the cohort analysis using non linear least squares to estimate fishing mortality. The F for 1989 using a domed partial recruitment was 0.24. Catch projections to 1992 under various management strategies indicate that a catch of 40,000 t would be consistent with $F_{0.1}$ management to 1991 and 1992.

Résumé

Les prises de goberge sont restées stables en 1989 atteignant 41 112 t, ce qui représente une déficit de 1 888 t par rapport à l'allocation canadienne fixée à 43 000 t. En revanche, les prises étrangères se sont élevées à 1 882 t, principalement à cause des captures dans les filets à petit maillage de la flottille soviétique qui pêche le merlu argenté. Du point de vue de la gestion morue/aiglefin/goberge dans la division 4X et dans la subdivision 5Zc, il est possible que des pêcheurs aient rejeté en mer de la goberge pour lui préférer la morue et l'aiglefin, espèces qui rapportent davantage. La pêche de la goberge à l'est de la division 4V s'est poursuivie en 1989 comparativement à celle dans la division 4W; phénomène observable depuis 1985. D'après les résultats des relevés de recherche, l'abondance des classes de quatre à neuf ans a augmenté depuis le début des années 1980, pour atteindre de très hauts niveaux en 1985 et en 1987. Cependant, aucune classe d'âge supérieure à la moyenne n'est apparue dans la pêche depuis 1983. Comme dans l'évaluation de l'an dernier, on n'a utilisé que les chiffres provenant des missions de recherche pour calibrer l'analyse des cohortes aux moyen de la méthode des moindres carrés non linéaires, cela dans le but d'estimer la mortalité due à la pêche. En 1989, la valeur F fondée sur une courbe de recrutement partiel en forme de dôme s'établissait à 0,24. D'après les projections de prises pour 1992 établies dans le cadre de diverses stratégies de gestion, des captures de 40 000 t cadreraient avec la gestion de $F_{0.1}$ pour 1991 et 1992.

Introduction

Catch History

Historic landings for pollock for the newly defined management unit, in divs. 4VWX and Subdiv 5Zc, are unavailable prior to 1974. With the exception of the USA, unit area information is not available for the foreign fleet nor is there any detailed information about fleet movement in the Georges Bank area. For the 1989 assessment USA landings which are available by unit area were adjusted to account for those taken in the Canadian zone, i.e. the northeast peak of Georges Bank. USA catches in that area were relatively low with a significant portion (60%) (Pers. Comm. R. Mayo, NMFS, from fishery interviews) taken on the Canadian side. Between 1974-1976 other foreign landings in Subdiv 5Ze were assumed to be taken in the Canadian zone. These adjusted landings 1974-1984 are given in Table 1.

Description of the Fishery

The preliminary estimate of nominal catch for 1989 (42994 t) indicates that catches have remained stable for the past five years (Table 1, Figure 1). Canadian landings have consistently accounted for the largest portion of the landings. Catches by foreign fleets have been primarily 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 2,000 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 proportion being taken in divs. 4VW (Figure 3). There has been a shift in the divs. 4VW fishery from Div. 4W to Div. 4V during 1984-1989. Div. 4V landings have increased from about 5,000 t in 1984 to an average of 13,000 t for the 1985-1989 period (Table 2). The fishery in divs. 4VW is dominated by large offshore vessels greater than 100 ft with mobile gear and in Div. 4X and Subdiv. 5Zc by inshore vessels less than 65 ft both mobile and fixed gear.

Seasonal breakdowns (Table 3) indicate a year round fishery, although with a bias toward May-August. The Canadian catch is broken down by gear, area and season in Table 4. The large trawler tonnage class (TC) 4+ landings dropped a small amount in both areas with the Div. 4X and Subdiv. 5Zc reported catch remaining high as in 1987-1988. This increase over the low landings in the early 1980s may be attributable to the offshore fleet choosing to fish their previously underutilized enterprise allocations (unconfirmed industry report).There was a significant decrease in the Div. 4X and Subdiv. 5Zc landings for otter trawlers, TC 1-3, while in divs. 4VW the landings for the inshore trawler fleet increased significantly. In both areas the fixed gear landings increased slightly.

Small mesh landings by the USSR (Table 3) again show a substantial increase from 1054 t in 1988 to 1792 t in 1989. Possibly higher concentrations of pollock were available due to the earlier start of the USSR silver hake fishery. No notable changes have taken place in this fishery that would account for the high pollock by catch during 1988 and 1989.

The Canadian allocation of 43,000 t was not taken during the 1989 pollock fishery. The shortfall amounted to 1,888 t. The mobile gear sector > 100 ft and 65-100 ft had a combined shortfall of 2369 t. Mobile gear 45-65 ft had a shortfall of 340 t while mobile gear < 45 ft was over their quota by 620 t. Fixed gear <45 ft was 860 t over while fixed gear 45-65 ft took 100% of their quota. For vessels on seasonal quotas most of the catch was taken before the end of June. Quota allocations and associated catch (1983-1989) 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 and fixed gear less than 65 ft were further divided : a) mobile and fixed gear less than 45 ft, and b) mobile and fixed gear 45-65 ft. Seasonal quotas and trip limits were introduced in 1986 for mobile gear under 65 ft in order to extend the fishery to the end of the year and to allow a larger proportion of the catch to be taken during the summer months when the smaller boats are less subject to weather conditions.

For vessels less than 65 ft, fishing with mobile gear in Southwest Nova Scotia, the 1989 management plan has combined the quota for Div. 4X and Subdiv. 5Zc cod and haddock and divs. 4VWX and 5Zc pollock into a single combined quota (CHP). The fishery was limited by the aggregate total. However, individual quotas for cod and haddock were exceeded. By removing landing restrictions from the individual species the 1989 management plan was intended to address the problem of misreporting by area and species. While reported catch was thought to be more accurate in the early months of 1989, discarding of pollock in favour of more valuable cod and haddock was thought to be a serious problem (unconfirmed industry reports). The <45 ft fleet was further split into specialist and generalist categories. These two fleets as well as the 45 to 65 ft fleet were regulated through license conditions and trip limits. For 1989 license condition generally replaced the variation order as a means of regulating the fishery. Under the 1989 management plan, the divs. 4Xand 5Zc mobile gear fleet, 45-65 ft and the under 45 ft specialist, was closed by June 29th. For the 1990 management plan these regulations are still in place although boat quotas may be introduced sometime during 1990 or early in 1991 for the <65 ft mobile gear fleets. If CHP is continued in 1990 it will only be applied to divs. 4X and 5Y. Georges Bank is to be managed separately and was closed to mobile gear between Jan. 1st and June 15th.

Distribution maps of catch per unit effort as recorded by the International Observer Program (IOP) on Canadian vessels in 1980-1989 are shown in Figure 4. These maps show a shift in the concentration of fishing effort for the eastern part of the pollock fishery with the development of a predominantly Subdiv. 4Vs fishing during 1986-1989. From 1987 to 1989, the distribution of fishing effort was more extensive than in the 1983 to 1986 period, consistent with the increased catch by large otter trawlers in divs 4X and 5Zc.

Catch at Age

The catch at age prior to 1989 was taken from Annand et al. (1989). Catch and mean weight at age for 1989 landings were estimated using samples from the commercial fisheries. Sampling for 1989 is shown in Table 6. Seasonal age length keys for TC 4+ otter trawlers by area (4VW,4X5) and annual keys for both small trawlers TC 1-3 and fixed gears for the entire area (4VWX+5) were generated. Length weight parameters were obtained from analysis of the 1989 summer groundfish survey collections. Input data for generating the eight keys used for the Canadian catch at age is given in Table 7. These keys accounted for 42,112 t or 96% of the entire catch, the difference consisting of foreign by-catch. The age composition of the small mesh (foreign after 1976) was based on proportions and weights at age from the Canadian July RV survey. The combined total catch at age reflects the total landings (42,994 t of pollock in divs. 4VWX and Subdiv. 5Zc). The total catch at age is given in Table 8 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 1989 was dominated by the 1982 to 1985 year classes accounting for 82% and 77% of the catch in number and weight respectively (Table 9). The 1979 year class at age 10 was 3% of the catch numbers, the highest value observed at that age since 1974. The 1984 and 1985 year classes were strongest in the overall catch at age (numbers). However, for the large trawler fleet fishing in divs. 4VW and for the fixed gear fleet fishing in divs. 4VWX5Zc, the 1983 and 1984 year classes accounted for the largest portion of the landings. Differences were again noted in the age composition of the large trawler catch between divs. 4VW and Div. 4X and Subdiv. 5Zc (Figure 5).

The observed catch at age for 1989 was compared to that projected in the 1989 assessment (Figure 6). The catch of the 1984 and 1985 year classes at ages 4 and 5 were higher than predicted. Conversely the catch of the 1981 to 1983 year classes (ages 6, 7, and 8) were much lower than projected. Weight at age was similar to that observed in recent year (Table 10).

Abundance Indices

Commercial Catch Rates

A Canadian catch rate series (CPUE) for stern OTB's for April to November (Table 11, Figure 7) was estimated for 1974-1989. A catch rate series for April to November, 1982-1989 was also calculated on a set by set basis from the IOP data (Table 12). As was noted last year, the catch rate trend is not consistent with observations of incoming recruitment (i.e. 1979-1983 year classes) and its effect on fishable biomass in subsequent years. In addition, trip limits adopted by both government and industry were thought to impact on catch rates. Therefore these recent catch rates were not considered representative indices of abundance for this stock and were not used for calibration purposes.

Research Surveys

Three vessels have been involved in the summer stratified random surveys of the Scotian Shelf (Figure 8) since 1970. After analyses 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 13 and ages 4-9 abundance are plotted in Figure 9.

Survey indices (1970-1989) differ slightly from those presented last year (Annand et al., 1989). Abundance estimates are now based on just those sets designated as stratified random and not those used for other purposes i.e. comparative sets, damaged sets etc. Differences in the age 4-9 abundance (1974-1989) were generally less than 5% (Table 14). Information from all sets was used to construct survey age length keys.

Research surveys from 1970-1989 indicate an increase in the age 4-9 abundance from the early 1980s with the 1985 and 1987 numbers among the highest observed. However, for 1988 and 1989 survey numbers have shown a marked decline. The 1984 and 1985 year classes appear to be average, but little information is available for subsequent year classes.

Since the early 1980's mean numbers per tow by stratum (Table 15) indicate an increase in abundance in divs. 4VW notably the Gully (stratum 52) and inshore Div. 4W (stratum 60), with abundance in Div. 4X remaining relatively constant. In order to investigate the changes in abundance of pollock throughout the survey area, the summer groundfish survey data was used to determine which areas had consistently high numbers of pollock. To do this, the grand mean of the stratified mean numbers per tow at age was calculated for the summer survey(1970-1989). These values were then used to determine the percent frequency of occurrence of above average pollock catches (i.e. the stratum mean above the overall stratified population mean) both age aggregated (2-11) and at age for each stratum (Table 16). The results show an increase in the number of stratum with consistently high catches of pollock between the 1970-1980 period and the 1981-1989 period. This increase during 1981-1989 could be due to the extremely large 1979 year-class and above average year classes through to 1983. Most of the important strata were in the 51-100 fathom depth range and associated with edges of banks or sea mounds. Because juvenile pollock, ages 1-3 tend to remain in inshore areas and are unavailable to the surveys, age differential changes in distribution were only evident in the Bay of Fundy area (strata 85-95). Pollock appear to move into the upper part of the Bay of Fundy as they get older.

Selecting strata using this type of criteria may produce a more meaningful index of abundance for pollock than using the entire survey area. It may also be useful in determining areas of overlap between cod, pollock and haddock distributions,and what effect haddock closed areas would have on pollock catches.

Mean weight per standard tow is given in Table 17.

Sequential Population Analysis

Minor modifications were made to the adaptive framework with inclusion of survey points that were left out of last year's formulation i.e. 1987 at age 4 and 1988 ages 4-5. These observations were removed in order to obtain population estimates more consistent with average recruitment than those initially estimated. Because the 1983 year class continued to look above average in the survey these points were again included in the formulation. Because of increasing K values with age in initial runs a domed PR was imposed.

Cohort analysis of ages 2-11 from 1974 to 1989 was calibrated using ADAPT, an implementation of the adaptive framework of Gavaris (1988). 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 age 10-11 were based on the weighted average F of ages 7-9 and the PR given below with a dome of 0.85 and 0.5 applied to ages 10-11 respectively.

Age	2	3	4	5	6	7	8	9	10	11
PR 1989	.013	.166	.416	.668	.848	1	1	1	.85	.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_t were from last year's assessment. The PR was estimated for the 1977-1985 period in order to include dominant year classes that have passed through the fishery in recent years.

Standard errors were available for the RV series but proved unusable even though the CVs (Table 18) were reasonable. Instead log transformations were used in order to try and stabilize variance. The diagnostics from initial runs indicated that intercepts were not necessary between RV and SPA numbers. The ADAPT summary table is given in Table 19. The estimated numbers and slopes were all significant except for the age four numbers (Table 20). Diagnostic plots (Figure 10) of the residuals (Table 21) were reviewed. Imposing a dome of 0.5 (fully recruited ages 7-9 falling to 0.5 at age 11) resulted in the estimation of somewhat more consistent survey K values, while steeper domes (i.e. 0.25) resulted in even more consistent K values but also in higher parameter correlations. A dome of 0.5 was used in the final ADAPT formulation and fishing mortality for fully recruited ages in 1989 varied between 0.23 and 0.29 with an average fully recruited F of 0.24. The fishing mortality matrix, beginning of year numbers and midyear population biomass are given in Tables 22, 23, and 24.

Assessment Results

The 1979 (83 million) and the 1982 (54 million) year classes at age 2 are the largest observed in the 1974-1989 period (Figure 11). The 1980, 1981 and 1983 year classes are all above the long term average of 31 million while the 1984 and 1985 year classes are average. The 1986 and 1987 year classes are relatively weak.

Mid-year biomass for ages 2 and older has increased since 1983 reflecting the strong 1979-1983 year classes and is currently at a relatively high level (Figure 12). Population numbers age 4-9 have increased since 1982 and are presently near their maximum (Figure 13).

Fully recruited fishing mortalities have been fluctuating with a decreasing trend toward F0.1(0.31) for almost the entire series and are currently below the F0.1 target level (Figure 14).

In general recruitment of strong year classes has occurred every 3-4 years since the mid 1970s. Fluctuations in age 4-9 stock size reflect the interaction of recruitment and fishing mortality. Population numbers ages 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 fishing mortality rates associated with elevated effort during this period. Abundance increased substantially in 1983 and peaked in 1986 following the recruitment of the strong 1979 and 1982 year classes. Since 1982 landings have remained relatively constant (35,000-46,000t) while fishing mortality declined from over 0.5 to 0.24. 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 likely due to variability in the catch at age. Abundance has remained high since the mid 1980s due to continued recruitment of strong year classes. Fully recruited fishing mortalities have generally been over $F_{0.1}$ since 1974 but are currently under the $F_{0.1}$ target level.

Yield per Recruit

In order to account for the use of a domed PR in the SPA calibration, yield per recruit analysis for pollock was reviewed and the Thompson and Bell yield per recruit model was used to calculate $F_{0.1}$ values. Because the calculations are sensitive to the oldest age group included, the maximum age group included in the analysis was the commonly observed maximum age in the commercial catch, i.e. age 16. Using the 1985-1988 average PR and the 1985-1989 mean weight at age gave an $F_{0.1}$ value of 0.31 and a yield per recruit value at $F_{0.1}$ of 0.9. The previous $F_{0.1}$ value for pollock using a flat topped PR was 0.25. The $F_{0.1}$ value of 0.31 was used in doing projections for this stock.

Prognosis

Catch projections to 1992 used the 1990 beginning of year population numbers, average weights from 1986-1989 and a domed PR derived from fishing mortalities in the period 1977-1986 assuming full recruitment for ages 7, 8, and 9. The 1989 and 1990 year classes at age 2 were set equal to the geometric mean of the 1974-1987 year classes of 31 million. Input data are given below.

Age	1990 Beginning of Year Population Numbers	Weight[a] (kg)	PR[b]
2	31,000	.80	.01
3	25,335	1.32	.19
4	20,281	1.93	.49
5	14,098	2.54	.80
6	8,884	3.17	1.00
7	12,686	3.65	1.00
8	7,166	4.13	1.00
9	3,201	4.85	.85
10	1,832	5.69	.67
11	1,622	7.09	.50

[a] 1986-1989 average
[b] 1977-1986 average

Catch projections to 1992 were done under three different management strategies ($F_{0.1}$ in 1991 and 1992, constant catch in 1991 and 1992, and moving to $F_{0.1}$ in 1992). Results of these projections are given in Table 25. In view of these results a catch of 40,000 t in 1991 and 1992 would be consistent with an $F_{0.1}$ strategy.

References

Annand, C., D. Beanlands and J. McMillan. 1989. Assessment of Pollock (Pollachius virens) in Divisions 4VWX and Subdivision 5Zc. CAFSAC Research Document 89/56.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. CAFSAC Research Document 88/29.

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, 1978-1989.

Year	Canada	Japan	France St. Pierre & Mainland		Cuba	USSR	USA	Other	Total
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*	45308	84	50		342	314	-	-	46098
1988*	41718	1	-		243	1054	-	-	43016
1989	41112	1	-		99	1782	-	-	42994

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

Table 2. Pollock landings (t, round fresh) for divs. 4VWX and Subdiv. 5Zc, 1974-1989.

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**	12710	3762	25609	1127	2096	16864*	28832	46098*
1988**	11759	3061	24143	352	2403	16118*	26898	43016*
1989**	12027	3863	23283	530	1409	17772*	25222	42994*

* - 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)

	4VW				4X+5			
Year	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*	6182	5511	4780	16473	5771	16477	6587	28835
1988*	4587	5635	4597	14819	3754	15720	7425	26899
1989*	4050	7538	4302	15890	6743	12471	6008	25222

* - Data from DFO Statistics Branch

USSR

	4VW					4X+5				
Year	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***	79	400	379	196	1054	-	-	-	-	-
1989***	605	1177	-	-	1782	-	-	-	-	-

*** - Provisional data from NAFO Circular letters

Table 3. (Continued)

Other Foreign Countries

	4VW					4X+5				
Year	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	-	-	286	358	497	472	-	1327
1984	87	83	1	-	171	387	528	776	-	1691
1985	82	70	8	-	160	-	-	-	-	-
1986	204	291	24	-	519	-	-	-	-	-
1987***	-	-	39	437	476	-	-	-	-	-
1988***	3	241	-	-	244	-	-	-	-	-
1989***	99	1	-	-	100	-	-	-	-	-

*** - Provisional data from NAFO Circular Letters & NMFS data tapes.

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+

	4VW				4X+5			
Year	Jan-Apr	May-Aug	Sept-Dec	Total	Jan-Apr	May-Aug	Sept-Dec	Total
1970	1523	212	138	1873	686	1865	1581	4132
71	629	63	208	900	919	3473	2073	6465
72	417	90	545	1052	1461	5800	4138	11399
73	726	276	2173	3175	3259	4227	3239	10725
74	707	1113	628	2448	1057	6350	5964	13371
75	1222	926	1776	3924	1042	5699	5361	12102
76	424	737	1081	2242	877	5418	2746	9041
77	912	1358	4545	6815	4846	1522	2661	9029
78	3558	2107	377	6042	4676	3383	2411	10470
79	1368	5194	1715	8277	3487	3421	1004	7912
1980	2448	3949	3412	9809	4321	3409	2411	10141
81	3980	1382	9017	14379	4280	558	4956	9794
82	2919	3084	4123	10126	1628	3917	3665	9210
83	1879	6144	1032	9055	2890	2652	396	5938
84	2155	3416	3559	9130	729	1633	564	2926
85	3628	4339	5502	13469	581	835	879	2295
86*	4861	6499	3957	15317	1326	939	235	2500
87*	5609	4178	3998	13785	2435	2518	2408	7361
88*	3951	3588	4244	11783	755	3301	2951	7007
89*	3006	4933	3669	11608	1498	2489	2596	6583

* Provisional

Table 4. (Continued)

OTTER TRAWLERS, Tonnage Classes 1-3

Year	4VW				4X+5			
	Jan-Apr	May-Aug	Sept-Dec	Total	Jan-Apr	May-Aug	Sept-Dec	Total
1970	8	0	0	8	336	2042	483	2861
71	4	0	0	4	245	1708	717	2670
72	0	9	1	10	537	2035	902	3474
73	0	0	2	2	1922	6762	618	9302
74	0	39	40	79	562	3398	591	4551
75	0	0	0	0	745	2610	836	4191
76	0	0	0	0	1039	2844	715	4598
77	0	2	0	2	896	2224	808	3928
78	9	23	2	34	955	2187	961	4103
79	0	8	2	10	869	4043	1170	6082
1980	2	137	18	157	1523	4033	823	6379
81	32	302	44	378	957	3178	1547	5682
82	58	220	93	371	713	4775	1734	7222
83	84	155	23	262	1403	6829	855	9087
84	119	598	252	969	1847	8492	3015	13354
85	197	151	89	437	5408	8564	1386	15358
86*	379	804	44	1227	3797	4801	594	9192
87*	504	311	73	888	2747	5859	483	9089
88*	556	708	13	1277	2739	6196	244	9179
89*	934	1296	60	2290	4533	2366	48	6947

* Provisional

Table 4. (Continued)

Gillnet, Longline and miscellaneous gears, all tonnage classes

Year	4VW Jan-Apr	4VW May-Aug	4VW Sept-Dec	4VW Total	4X+5 Jan-Apr	4X+5 May-Aug	4X+5 Sept-Dec	4X+5 Total
1970	0	46	224	270	53	893	663	1609
71	0	118	72	190	5	979	544	1528
72	0	137	170	307	8	927	845	1780
73	6	101	139	246	9	2196	1335	3540
74	6	105	139	250	24	1990	2262	4276
75	1	79	78	158	49	1557	4567	6173
76	1	108	105	214	162	3908	3403	7473
77	19	68	203	290	268	2134	2188	4590
78	308	566	131	1005	204	1914	3029	5147
79	38	275	210	523	202	2559	4402	7163
1980	43	215	203	461	509	5746	2784	9039
81	44	753	1994	2791	555	3434	3257	7246
82	53	778	558	1389	755	5972	2984	9711
83	66	800	589	1455	586	4731	1635	6952
84	14	730	406	1150	244	3775	1917	5936
85	36	541	368	945	600	6274	3922	10796
86*	264	732	403	1399	716	8422	4202	13340
87*	69	1022	709	1800	589	8100	3696	12385
88*	80	1339	340	1759	260	6223	4230	10713
89*	110	1309	573	1992	712	7616	3364	11692

* Provisional

Table 5. Description of the pollock fishery in divs. 4VWX and Subdiv. 5Zc, 1983-1989.

Year	Fleet	Initial Alloc. (t)	Final Alloc. (t)	Rep. Catch (t)	Per. Taken (%)	Dates -Closure (cl) Trip Limit (tl) Bycatch (bc)	Remarks
1983	All vessels - Canadian	40.0K	42.0K	-	-		Directed fishery
	FG	9.6K	10.69K	8.2K	77		70% Can; 30% USA; <1% DWF
	MG>100'	22.4K	21.4K	14.8K	69		(Dec) Companies discouraged
	MG 65'-100'	0.25K	0.28K	0.23K	82	cl 30/07	fishing for pollock because
	MG<65'	7.75K	9.63K	9.5K	99		of low market value; 20,000
	All vessels - USA	5.0K	10.0K	14.0K	140		lb limit except if sold
	All vessels - Foreign	-	-	0.5K	-		fresh.
	Total 4VWX+5	45.0K	52.0K	47.0K	90		
1984	All vessels - Canadian	42.4K	42.4K	-	-		Directed fishery
	FG	10.17K	8.97K	7.0K	78		65% Can; 35% USA; <1% DWF
	MG>100'	23.75K	19.45K	12.0K	62		Trip limits set by
	MG 65'-100'	0.27K	0.77K	0.65K	84		companies (IOP) vary from
	MG<65'	8.21K	13.21K	13.8K	104	Ent. Alloc. Pierce Fishery cl 17/10;4X cl 22/05-01/06; cl 30/06-02/09	20,000-200,000 lb
	All vessels - USA	10.6K	10.6K	17.7K	167		
	All vessels - Foreign	-	-	0.3K	-		
	Total 4VWX+5	53.0K	53.0K	51.0K	96		
1985	All vessels - Canadian	42.4K	42.4K	-	-		Directed fishery
	FG	10.17K	8.37K	11.63K	139	<65' CL 16/11-28/11	No U.S. or foreign alloc.
	MG>100'	23.75K	17.35K	15.8K	91		Trip limits (IOP) imposed
	MG 65'-100'	0.27K	0.47K	0.42K	89		by companies vary from 30-
	MG<65'	8.21K	16.21K	15.14K	93	27/07-20% bc; 13/08-10% bc; 30/08-35% bc; 16/11-10% bc	125,000 lbs
	Total 4VWX+5	42.4K	42.4K	42.9K	101		
	All vessels - USA	-	-	19.3K	-		
	All vessels - Foreign	-	-	0.5K	-		
1986	All vessels - Canadian	40.0K	40.0K	-	-		Directed fishery
	FG	11.0K	11.4K	14.4K	126	Class A - 03/10 - 1500 kg tl 10% bc to 31/12	No US or foreign alloc. Trip limits imposed by companies 15-100,000 lbs
	MG>100'	20.0K	18.8K	18.1K*	96		
	MG 65'-100'	0.25K	0.25K	0.38K	152	cl 13/09	
	MG<65'	8.75K**	9.55K	10.1K	106	28/03 - 4500 kg tl; 8/04-0 kg tl 10% bc; 28/04 - 13600 kg tl; 6/05 - 22500 kg tl; 14/06 - 4500 kg tl; 23/06 - 1500kg tl; 18/07 - 1500 kg tl or 10% bc; 26/08 - 0 kg tl 10% bc; 1/09 - 1000 kg tl or 10% bc; 20/09 - 0 kg tl 10% bc to 31/12	
	Total 4VWX+5	40.0K	40.0K	43.0K	108		
	All vessels - USA	-	-	24.0K	-		
	All vessels - Foreign	-	-	0.8K	-		

* - 1.7K Newfoundland; 16.2 Scotia-Fundy

** - Jan-Apr 1.3K; May-Aug 5.65K; Sept-Dec 1.8K - changed mid year - Jan-Apr 2.97K; May-Aug 5.26K; Sept-Dec 1.31K

Table 5. Continued

Year	Fleet	Initial Alloc. (t)	Final Alloc. (t)	Rep. Catch (t)	Per. Taken (%)	Dates -Closure (cl) Trip Limit (tl) Bycatch (bc)	Remarks
1987	All vessels - Canadian	44.5K	44.5K	-	-		Directed Fishery
	FG<65'	11.825K	11.825K	14.096K	119	20/11 - 1500 kg tl	
	MG>100'	21.5K	21.5K	20.959K	97		
	MG 65'-100'	0.27K	0.468K	0.479K	102	cl 24/03 - 31/03	
	MG<65' (Jan 1-Apr 30)	2.93K	2.962K	2.959K	100	1/01 - 9000 kg tl; 03/02 - 9000 kg tl; 20/02 - 4500 kg tl; 12/03 - 0 kg tl 10% bc	
	MG<65' (May 1-Aug 31)	5.175K	6.252K	6.234K	100	01/05-9000 kg tl;01/06-7000 kg tl;11/06-4500 kg tl;19/06-1500 kg tl; 26/06-0 kg tl 10% bc	
	MG<65' (Sept 1-Dec 31)	1.3K	0.562K	0.512K	91	01/09-900 kg tl; 03/10 - 0 kg tl; 10% bc	
	3PS	1.5K*	0.931K	0.178K	19		
	Total 4VWX+5+3PS	44.5K	44.5K	45.417K	102		
	All Vessels - USA	-	-	20.25K	-		
	All Vessels - Foreign	-	-	0.79K	-		
1988*	All vessels - Canadian	48.4K	-	-	-		Directed Fishery
	FG<45'	11.525K	11.325K	11.5K	102		
	FG 45'-64'	0.3K	0.671K	0.485K	72	16/07 - 1500 kg tl 10% bc (revoked September 20)	
	MG>100'	21.5K	21.885K	19.048K	87		
	MG 65'-100'	0.275K	0.219K	0.077K	35		
	MG 45'-64' (Jan 1-Apr 30)	1.75K	1.75K	2.2K	126	19/03 - 4500 kg tl	
	MG 45'-64' (May 1-Aug 31)	3.1K	2.8K	3.374K	121	06/05 - 9000 kg tl 10% bc; 01/06 - 4500 kg tl 10% bc; 01/07 - 9000 kg tl 10% bc	
	MG 45'-64' (Sept 1-Dec 31)	0.79K	0.79K	0.144K	18	01/08 - 4500 kg tl 10% bc; 06/08 - 0 kg tl 10% bc	
	MG<45' (Jan 1-Apr 30)	1.165K	1.165K	1.118K	96	19/03 - 6800 kg tl	
	MG<45' (May 1-Aug 31)	2.07K	1.87	3.229K	173	01/05-9000 kg tl; 10% bc 23/07 - 6800 kg tl 10% bc 28/07 - 1000 kg tl 10% bc	
	MG<45' (Sept 1-Dec 31)	0.525K	0.525K	0.135K	26	06/08 - 0 kg tl 10% bc	
	Total 3PS	5.4K	5.4K	1.4K	26		
	Total 4VWX+5	43.0K	43.0K	41.31K	96		
	All Vessels - Foreign	-	-	1.3K	-		

* - 3Ps 1.5K; Aug. 15-Sept. 20, MG<65'

Table 5. Continued

Year	Fleet	Initial Alloc. (t)	Final Alloc. (t)	Rep. Catch (t)	Per. Taken (%)	Dates -Closure (cl) Trip Limit (tl) Bycatch (bc)	Remarks
1989	All vessels - Canadian	48.4K	48.4K	-	-		
	FG<45'	12.07K	12.07K	12.933K	107	01/12 - 31/12 4X5 3300 lb tl	
	FG 45'-65'	.315K	.44K	.44K	100	01/11 - 0 kg tl, 10% bc 03/11 - 18000 kg tl, 10% bc	
	MG>100'	20.5K	20.275K	18.092K	89		
	MG 65'-100'	0.275K	.375K	.189K	50		
	MG<45' (Jan 1-Apr 30)	1.22K	1.22K	2.375K	195	01/01 - 6800 kg tl; 26/01 - 9000 kg tl; 22/02-0 kg tl, 10% bc; 23/02-9000 kg tl; 01/03-0 kg tl, 10% bc; 09/03-9000 kg tl; 16/03-0 kg tl, 0% bc; 22/03-1500 kg tl, 10% bc; 28/03-9000 kg tl; 11/04-1500 kg tl; 13/04-9000 kg tl; 29/04-4500 kg tl	
	MG<45' (May 1-Aug 31)	2.165K	2.165K	1.942K	90	05/05-2250 kg tl; 09/05-1500 kg tl; 01/06-15900 kg tl; 16/06-1500 kg tl; 10/07 - revoked; 02/08 - 0 kg tl; 10% bc; 04/08-4VsW 0 kg tl, 10% bc; 04/08-4X5-specialist closed, generalist-3300 lb CHP/max 2 trips	
	MG<45' (Sept 1-Dec 31)	0.55K	0.55K	0.244K	41	01/09-31/12 4VsW 0 kg tl, 10% bc; 01/09-31/12 specialist closed; 01/25/09 generalist - 3300 lb CHP/max 2 trips; 26/09 -02/10 generalist - 2000 lb CHP/max 2 trips; 04/10-15/11 generalist, 10% bc CHP/trip; 16/11-31/12 generalist closed? (no more permits issued)	
	MG 45'-65' (Jan 1-Apr 30)	1.83K	1.83K	3.412K	186	01/01-9000 kg tl; 26/01-11300 kg tl; 01/03-0 kg tl, 10% bc; 09/03-11300 kg tl; 16/03-0 kg tl, 0% bc; 22/03-11300 kg tl	
	MG 45'-65' (May 1-Aug 31)	3.25K	3.25K	2.101K	65	16/05-1500 kg tl; 01/06-15900 kg tl; 16/06-1500 kg tl; 22/06 revoked; 04/08-31/08-4VsW 0 kg tl; 10% bc; 04/08-31/08 4X5 closed	
	MG 45'-65' (Sept 1-Dec 31)	0.825K	0.825K	0.047K	6	01/08 - 31/12 4VWX5 closed	

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	13	8	5	26	2	2	0	4	-	1	1	2	-	-	-	-
4X+ 5Zc	5	4	4	13	25	10	2	37	1	12	7	20	-	-	-	-

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 Class	Tonnage	Gear	No. of Samples	Area	Number Aged	Number Measured	Catch (t)	Weight-Length Relationship a	b	Cruise	
1989	Jan-Dec	TC 1-6	GN, LL, Other	22	4VWX+5	389	4898	13684	0.0126	2.98015	Needler 123/124	July 1989
	Jan-Dec	TC 1-3	OTB	41	4VWX+5	831	9416	9237	0.0126	2.98015	Needler 123/124	July 1989
	Jan-Apr	TC 4+	OTB	13	4VW	387	3212	3006	0.0148	2.92609	Needler 123/124	July 1989
	May-Aug	TC 4+	OTB	8	4VW	199	1896	4933	0.0148	2.92609	Needler 123/124	July 1989
	Sept-Dec	TC 4+	OTB	5	4VW	118	1060	3669	0.0148	2.92609	Needler 123/124	July 1989
	Jan-Apr	TC 4+	OTB	5	4X+5	160	1392	1498	0.0126	2.98015	Needler 123/124	July 1989
	May-Aug	TC 4+	OTB	4	4X+5	146	934	2489	0.0126	2.98015	Needler 123/124	July 1989
	Sept-Dec	TC 4+	OTB	4	4X+5	119	956	2596	0.0126	2.98015	Needler 123/124	July 1989

Table 8. 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
1	0	0	0	0	0	8	0	0	0	1	1	0	0	0	0	0
2	197	175	178	36	23	98	171	105	145	67	23	50	6	11	28	50
3	5603	1058	1361	1476	835	2763	291	1338	3738	1988	722	551	348	486	661	528
4	2662	4023	1974	2873	3119	5786	1864	679	1585	9453	3501	2197	2912	2318	2561	3893
5	2356	2090	3649	1785	3084	3482	5306	2087	563	1252	7178	4146	3572	4990	3307	3935
6	1088	1904	1089	2181	1276	1705	3169	4048	1872	243	641	6229	3622	3541	3451	2434
7	317	835	1089	732	1167	528	1075	2444	2304	526	95	1109	3334	2397	1900	2052
8	164	196	207	417	257	249	277	722	1074	849	223	129	316	1701	1203	918
9	80	55	36	108	143	47	168	215	400	434	215	139	82	176	1013	687
10	83	57	14	19	17	15	32	148	176	166	93	230	122	37	43	406
11	74	35	18	25	19	14	9	31	87	52	19	82	178	46	17	14
12	40	31	49	80	18	0	2	24	24	58	22	58	117	100	97	14

CANADIAN CATCH AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	0	0	0	0	8	0	0	0	1	0	0	0	0	0	0
2	185	167	126	36	23	98	128	42	132	54	22	24	4	8	27	44
3	4784	986	1207	1433	786	2752	244	1333	3516	1857	720	477	317	428	618	495
4	2364	3567	1738	2855	3070	5582	1733	672	1584	9309	3491	2179	2869	2231	2493	3691
5	2125	1852	3170	1760	3022	3341	5035	2043	563	1248	7152	4126	3519	4859	3235	3772
6	954	1660	939	2128	1222	1645	3113	4019	1872	237	639	6178	3575	3489	3345	2335
7	273	795	1001	710	1142	495	1047	2432	2294	523	91	1102	3291	2372	1784	1911
8	144	132	194	395	246	248	269	712	1067	833	215	126	298	1672	1146	847
9	64	45	35	90	134	47	165	207	389	428	207	134	82	175	991	650
10	51	56	12	19	17	15	32	148	172	163	89	221	113	35	43	382
11	33	34	16	25	19	14	9	31	87	50	18	78	165	44	17	12
12	10	30	42	80	18	0	2	24	22	58	21	57	113	95	93	10

FOREIGN CATCH AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	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
3	291	67	121	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
5	152	87	237	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
7	20	23	42	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
9	6	2	2	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
11	3	1	2	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

SMALL MESH GEAR CATCH AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
2	0	0	35	0	0	0	43	63	13	13	1	26	2	3	1	6
3	528	6	33	43	49	11	47	5	222	131	2	74	31	58	43	33
4	136	229	77	18	49	204	131	7	1	144	10	18	44	87	68	202
5	79	151	242	25	62	141	271	44	0	4	26	20	53	131	72	163
6	57	166	86	53	54	60	56	29	0	6	2	51	47	52	106	99
7	24	17	46	22	25	33	28	12	10	3	4	7	43	25	116	141
8	10	60	0	22	11	1	8	10	7	16	8	3	18	29	57	71
9	10	9	0	18	9	0	3	8	11	6	8	5	0	1	22	37
10	29	0	0	0	0	0	0	0	4	3	4	9	9	2	0	24
11	38	0	0	0	0	0	0	0	0	2	1	4	13	2	0	2
12	29	0	0	0	0	0	0	0	2	0	1	1	4	5	4	4

Table 9. Total percent catch at age and total percent biomass at age for 4VWX5 pollock. (1974-1989).

PERCENT TOTAL CATCH AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
2	2	2	2	0	0	1	1	1	1	0	0	0	0	0	0	0
3	44	10	14	15	8	19	2	11	31	13	6	4	2	3	5	4
4	21	39	21	30	31	39	15	6	13	63	28	15	20	15	18	26
5	19	20	38	18	31	24	43	18	5	8	56	28	25	32	23	26
6	9	18	11	23	13	12	26	34	16	2	5	42	25	23	24	16
7	3	8	11	8	12	4	9	21	19	4	1	7	23	15	13	14
8	1	2	2	4	3	2	2	6	9	6	2	1	2	11	8	6
9	1	1	0	1	1	0	1	2	3	3	2	1	1	1	7	5
10	1	1	0	0	0	0	0	1	1	1	1	2	1	0	0	3
11	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0

PERCENT BIOMASS AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	27	4	6	7	4	10	1	6	12	7	3	2	1	1	2	2
4	18	27	14	18	20	29	10	4	11	46	24	10	14	10	12	17
5	24	22	39	18	29	29	39	15	5	11	55	26	21	28	21	23
6	15	24	15	31	18	18	29	33	20	3	7	45	28	23	26	19
7	6	14	19	13	19	7	12	25	26	7	1	9	28	20	16	18
8	3	4	4	9	6	4	4	10	14	13	4	1	3	15	12	9
9	2	1	1	3	4	1	3	4	6	7	4	2	1	2	11	8
10	2	1	0	1	0	0	1	3	3	3	2	3	2	1	1	5
11	2	1	1	1	1	0	0	1	2	1	0	1	3	1	0	0

Table 10. Mean weights at age.

TOTAL WEIGHT AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.00	.00	.00	.00	.19	.00	.00	.00	.63	.36	.00	.10	.00	.00	.00
2	.82	.86	.59	.79	1.14	.77	1.03	.80	.75	.76	1.42	.65	.66	.61	1.14	.78
3	1.38	1.26	1.21	1.10	1.23	1.18	1.68	1.74	1.22	1.25	1.68	1.40	1.34	1.30	1.40	1.22
4	1.94	1.95	1.92	1.52	1.80	1.55	2.08	2.53	2.69	1.67	2.36	1.95	2.02	1.95	1.91	1.84
5	3.00	3.06	2.81	2.48	2.60	2.62	2.77	2.91	3.51	3.13	2.67	2.73	2.52	2.49	2.64	2.49
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	3.20	3.24
7	5.08	5.06	4.67	4.52	4.59	4.34	4.12	4.32	4.45	4.83	5.40	3.42	3.61	3.71	3.50	3.78
8	6.16	6.52	5.64	5.47	6.02	5.55	5.58	5.92	5.19	5.07	5.96	4.39	4.18	4.04	4.23	4.09
9	6.68	7.49	7.02	6.62	6.91	6.61	6.50	6.92	6.19	5.83	5.90	6.10	5.66	4.55	4.41	4.79
10	7.39	7.49	7.80	7.25	7.37	7.14	9.07	7.77	7.63	6.49	6.32	5.86	6.09	6.29	5.26	5.15
11	8.58	8.22	8.76	10.02	8.38	8.79	8.40	7.54	8.00	7.98	7.66	6.18	6.11	6.20	8.03	8.02
12	10.03	9.59	9.11	11.30	10.03	.00	11.65	9.22	8.64	8.72	8.64	7.54	6.63	7.53	8.46	7.38

CANADIAN WEIGHT AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.00	.00	.00	.00	.19	.00	.00	.00	.63	.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
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
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
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
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
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
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
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
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
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
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	7.44

FOREIGN WEIGHT AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.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
3	1.24	1.13	1.04	.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
5	2.89	2.32	2.83	.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
7	5.23	4.33	4.83	.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
9	6.72	5.13	6.70	.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
11	8.43	.00	9.46	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	13.00	.00	8.68	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

SMALL MESH GEAR WEIGHT AT AGE

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.36	.00	.10	.00	.00	.00
2	.00	.00	.42	.00	.00	.00	.77	.66	.62	.43	.48	.37	.32	.32	.26	.42
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
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
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
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
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
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
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
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
11	8.99	.00	.00	.00	.00	.00	.00	.00	.00	7.61	7.25	5.94	6.04	4.84	.00	4.19
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

Table 11. Commercial catch rates (t/hr) for pollock (main species) in divs. 4VWX and Subarea 5.

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Canadian OTB-2 (TC5) CPUE (t/Hr)																
April-November	.66	.70	.57	.78	.89	1.09	.94	1.01	1.32	1.05	1.33	.96	1.26	.94	.906	1.046

Table 12. International Observer Program catch rates (t/hr) for pollock (main species) in divs. 4VWX and Subarea 5.

	1982	1983	1984	1985	1986	1987	1988	1989
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

Table 13. Stratified total numbers at age (x 10^{-3}) in Canadian summer bottom trawl surveys (strata 40 - 95).

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

Table 14. Ratio of old survey numbers to new survey numbers.

RATIO OLD TO NEW SURVEY NUMBERS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
4	.86	1.00	1.00	1.00	1.00	.98	.99	1.00	1.00	1.00	1.00	.98	.99	1.00	.94	1.00
5	.93	1.00	1.00	1.00	1.00	.98	.98	1.00	1.00	1.00	1.00	.97	.99	1.00	.98	1.00
6	.94	1.00	.99	1.00	1.00	.98	.94	1.00	1.00	1.00	1.00	.92	.99	.99	.98	1.00
7	.95	1.00	.99	1.00	.99	.92	.90	1.00	1.00	1.00	1.00	.91	.98	.99	.98	1.00
8	.84	1.00	1.00	1.00	1.00	.99	.83	1.00	1.00	1.00	1.00	.89	.96	.99	.98	1.00
9	.84	1.00	.99	1.00	1.00	1.00	.79	1.00	1.00	1.00	1.00	.90	.96	1.00	.99	1.00

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

	Year																				
Stratum	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.26	.41	45.11	.34	.51	2.33
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	3.49
42	.32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.34	0	.16	.33	0	.06
43	0	0	0	0	0	0	0	0	0	0	0	0	.21	.23	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	.08
45	0	0	.19	0	0	0	0	0	0	0	0	0	0	0	0	21.63	.17	5.85	0	0	1.39
46	0	0	0	0	0	0	0	.34	0	0	0	0	.97	16.47	0	3.09	.69	0	.97	13.35	1.79
47	0	0	0	.37	0	.44	0	0	0	.61	0	0	.51	.26	0	0	0	0	0	.66	.14
48	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	.52
50	0	0	0	0	0	.36	0	0	0	1.56	0	15.10	1.09	0	0	0	.34	.34	0	0	.94
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	43.18
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	9.84
53	0	0	0	0	0	0	0	.34	0	0	0	0	0	0	0	0	.34	0	.58	0	.06
54	0	0	.34	0	0	0	0	0	.39	0	0	0	0	0	0	1.05	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	.12
56	.39	.27	0	.18	0	0	0	.34	0	0	0	0	0	.16	2.97	1.94	.17	.70	4.73	.35	.61
57	0	0	0	0	0	0	0	0		0	0	0	.49	0	0	0	0	0	0	0	.03
58	0	0	0	0	0	0	0	0	0	0	0	0	0	2.27	0	0	.21	0	1.03	0	.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	2.37
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	47.07
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	2.82
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	8.33
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	2.35
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	4.09
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	3.09
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.24	.39	.55	0	2.19	.32
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	26.89
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	8.38
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	23.69
73	0	0	0	0	0	0	0	.55	0	0	.38	0	0	0	0	.49	2.13	.51	0	0	.20
74	0	.49	0	0	0	0	0	0	0	0	.52	0	0	0		0	1.88	.55	0	0	.18
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.51	0	1.03	0	0	1.03	.13
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	8.91
77	0	0	.44	1.84	0	0	0	0	0	.58	0	0	0	1.03	0	0	0	23.50	0	0	1.37
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	.93
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	3.09
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	1.68
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	3.69
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	.60
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	4.37
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	30.57
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	8.05
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	9.91
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	2.57
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	3.37
94	0	0	0	0	.42	.46	2.17	0	0	1.03	.51	0	0	0	.55	.49	0	0	0	0	.28
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	.63

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

Table 16. Number of times the strata mean is above the overall stratified population mean.

STOCK AREA - % OCCURRENCE (1970-1980)

	1	2	3	4	5	6	7	8	9
40	0	0	0	0	0	0	0	0	0
41	9	9	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0
49	0	0	9	0	0	0	0	0	0
50	0	0	9	0	0	0	0	0	0
51	0	0	9	9	9	18	9	0	0
52	0	0	0	0	9	9	0	0	0
53	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0
57	0	9	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0
60	27	18	36	27	36	18	27	36	36
61	0	0	9	9	18	18	9	18	18
62	0	9	0	9	27	18	18	27	27
63	9	0	27	18	0	0	9	18	18
64	0	9	0	0	0	0	0	0	0
65	9	18	18	9	9	0	0	9	9
66	0	0	0	0	0	0	0	0	0
70	45	27	63	36	36	27	36	36	36
71	0	0	0	9	18	18	18	0	0
72	18	18	0	9	9	9	0	9	9
73	0	0	0	0	0	0	0	0	0
74	9	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0
76	27	27	9	18	27	36	18	36	36
77	9	0	0	0	0	0	0	0	0
78	0	0	9	0	0	0	9	18	18
80	9	9	9	0	0	0	0	0	0
81	9	9	18	0	9	0	0	18	18
82	0	0	9	9	9	9	9	0	0
83	0	0	18	0	0	0	0	0	0
84	0	9	27	18	18	18	36	27	27
85	9	54	45	54	45	36	36	54	54
90	18	9	9	27	18	27	9	18	18
91	0	0	27	27	27	36	27	36	36
92	0	0	0	0	9	27	36	45	45
93	0	0	0	0	9	18	36	18	18
94	0	0	0	0	0	9	9	9	9
95	0	0	0	0	0	0	27	18	18

STOCK AREA - % OCCURRENCE (1981-1989)

	1	2	3	4	5	6	7	8	9
40	0	11	11	11	11	11	11	0	0
41	11	22	11	11	33	44	33	22	22
42	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0
45	11	11	11	11	22	22	22	22	22
46	11	11	22	11	22	11	22	11	11
47	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0
49	0	0	11	0	0	0	11	11	11
50	11	11	11	0	0	0	0	0	0
51	11	44	33	33	55	55	44	22	22
52	0	22	22	22	22	22	44	33	33
53	0	0	0	0	0	0	11	0	0
54	0	0	0	0	0	0	0	0	0
55	0	11	0	0	0	0	0	0	0
56	0	11	0	0	0	0	0	0	0
57	0	11	0	0	0	0	0	0	0
58	11	0	0	0	0	0	0	0	0
59	11	11	22	22	33	44	33	22	22
60	11	44	66	55	66	77	66	66	66
61	0	11	11	11	11	55	55	77	77
62	22	33	44	33	44	55	44	66	66
63	0	22	33	11	44	44	22	55	55
64	33	55	22	11	0	0	0	22	22
65	0	0	0	0	22	22	11	33	33
66	0	0	0	0	11	0	11	11	11
70	44	77	55	77	77	77	66	66	66
71	0	22	33	33	33	33	44	55	55
72	11	55	77	55	55	55	33	44	44
73	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	11	11
76	22	55	44	33	44	44	44	88	88
77	0	11	11	11	11	11	11	11	11
78	0	0	0	0	22	11	11	33	33
80	0	11	11	11	22	11	22	11	11
81	11	11	11	11	11	11	0	33	33
82	0	0	11	11	11	44	44	44	44
83	0	0	0	0	0	0	11	22	22
84	11	22	11	33	55	44	33	77	77
85	33	44	77	77	88	77	66	77	77
90	33	0	11	11	33	22	33	55	55
91	0	0	11	33	44	44	55	99	99
92	0	0	0	0	33	44	44	88	88
93	0	0	11	11	22	33	44	44	44
94	11	0	0	0	0	0	0	11	11
95	11	0	0	0	0	0	0	22	22

STOCK AREA- % OCCURENCE 1970-1989

	1	2	3	4	5	6	7	8	9	211
40	0	5	5	5	5	5	5	0	5	5
41	5	10	5	5	15	20	15	10	15	15
42	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0
45	0	5	5	5	10	10	10	10	10	10
46	0	5	10	5	10	5	10	5	10	10
47	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0
49	0	0	5	0	0	0	5	5	5	0
50	5	5	5	0	0	0	0	0	0	5
51	5	20	20	20	30	35	25	10	30	30
52	0	10	10	10	15	15	20	15	15	15
53	0	0	0	0	0	0	5	0	0	0
54	0	0	0	0	0	0	0	0	0	0
55	0	5	0	0	0	0	0	0	0	0
56	0	5	0	0	0	0	0	0	0	0
57	0	5	0	0	0	0	0	0	0	0
58	5	0	0	0	0	0	0	0	0	0
59	5	5	20	10	15	20	15	10	15	15
60	20	20	50	40	50	45	45	50	55	55
61	0	5	10	10	15	35	30	35	10	10
62	10	15	20	20	35	35	30	30	25	25
63	0	10	30	15	20	20	15	25	20	20
64	15	5	10	5	0	0	0	10	10	10
65	0	0	10	0	10	10	5	15	10	10
66	0	0	0	0	5	0	5	5	0	0
70	45	35	60	55	55	50	50	50	65	65
71	0	10	0	20	25	25	30	25	20	20
72	15	25	35	30	30	30	15	20	35	35
73	0	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	5	0	0
76	25	25	25	25	35	40	30	40	35	35
77	5	5	5	5	5	5	5	5	5	5
78	0	0	0	0	10	5	10	15	0	0
80	5	5	10	5	10	5	10	5	10	10
81	10	5	15	5	10	5	0	15	10	10
82	0	0	10	10	10	25	25	20	10	10
83	0	0	10	0	0	0	5	10	0	0
84	5	15	20	25	35	30	35	35	20	20
85	20	50	60	65	65	55	50	65	65	65
90	25	0	10	20	25	25	20	25	20	20
91	0	0	20	30	35	40	40	45	35	35
92	0	0	0	0	20	35	40	40	20	20
93	0	0	5	5	15	25	40	20	5	5
94	5	0	0	0	0	5	5	5	0	0
95	5	0	0	0	0	5	15	10	0	0

Table 17. Stratified mean weights-per-standard-tow in Canadian summer bottom trawl surveys (strata 40 - 95).

	Year																			
Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.001	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000	.001	.000	.013	.012	.001	.010	.000	.005	.001
2	.994	.321	.012	.181	.021	.003	.016	.179	.006	.000	.880	.110	.123	.053	.262	.651	.295	.203	.017	.033
3	.497	.514	.011	.605	.975	.021	.335	.926	.143	.136	1.582	.363	2.588	1.160	.354	4.730	.771	1.804	.585	.144
4	.673	.350	.331	4.822	.350	.571	1.559	2.132	1.356	1.346	6.292	.142	.662	2.668	1.750	6.171	1.819	5.600	2.169	1.221
5	.684	.118	1.147	2.387	.864	.850	3.858	6.030	2.865	2.460	11.945	1.827	.364	.632	6.208	8.832	2.818	12.511	6.353	2.600
6	.845	.075	.720	.358	.594	1.422	1.249	5.189	1.550	2.402	4.282	2.171	1.612	.186	1.401	9.592	5.185	6.733	6.696	3.404
7	.745	.158	.216	.271	.824	.315	2.732	.904	1.617	1.245	3.043	1.782	1.277	.405	1.097	1.671	4.175	6.384	7.199	4.582
8	.474	.066	.426	.292	.525	.596	1.108	1.817	.678	1.133	1.564	1.481	.944	1.243	2.626	.598	.354	5.576	4.709	2.406
9	.205	.048	.362	.382	.465	.283	.302	.783	.356	.072	.678	.842	1.059	.882	4.279	1.322	.067	.304	2.901	1.542
10	.000	.130	.160	.022	.295	.075	.383	.422	.139	.290	.410	.715	.524	.383	2.906	1.903	.654	.760	.273	.577
11	.331	.000	.097	.176	.753	.094	.121	.247	.000	.000	.000	.255	.095	.433	.546	.829	.819	.503	.315	.135
12+	.059	.000	.210	.145	.314	.000	.432	.103	.220	.000	.000	.103	.421	.162	1.326	.861	.589	2.636	1.329	.413
UK	.000	.000	.006	.085	.000	.000	.109	.035	.161	.240	.278	.580	.367	.246	.473	.027	.064	.262	.000	.079
TOTAL	5.508	1.779	3.697	9.724	5.982	4.229	12.204	18.768	9.091	9.327	30.955	10.370	10.035	8.468	23.240	37.188	17.620	43.277	32.552	17.137
4+	4.016	.945	3.669	8.854	4.985	4.205	11.745	17.628	8.781	8.950	28.214	9.316	6.957	6.996	22.139	31.779	16.480	41.007	31.945	16.880
5+	3.343	.595	3.338	4.033	4.635	3.634	10.186	15.496	7.425	7.604	21.922	9.174	6.295	4.328	20.389	25.608	14.661	35.407	29.776	15.659
6+	2.659	.477	2.191	1.646	3.770	2.784	6.327	9.465	4.560	5.144	9.977	7.347	5.931	3.695	14.180	16.776	11.843	22.896	23.423	13.059

Table 18. Survey coefficients of variation (C.V.'s) 1974-1989.

SURVEY CVs

	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

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

Table 19. ADAPT summary for divs. 4VWX + Subdiv. 5Zc pollock.

Parameters of the ADAPT framework

Year-class estimates

N_i 1989 i = 4 to 9

Calibration constants for July RV numbers

K_i i = 4 to 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 1989 was the average from 1977-1985 and a dome was applied to ages 10 and 11.

Age	2	3	4	5	6	7	8	9	10	11
PR	.013	.166	.416	.668	.848	1	1	1	.85	.5

- F for oldest age groups calculated as population numbers weighted F for ages 7-9 x a 0.5 dome parameter.

Input

- $C_{i,t}$ i = 2 to 11 t = 1974-1989
- $RV_{i,t}$ i = 4 to 9 t = 1974-1989

Objective Function

- log transformation
- minimize
- $\Sigma_i\Sigma_t$ (obs.(Ln $RV_{i,t}$) - pred (Ln $RV_{i,t}$))^2

Summary

- number of observations = 96
- number of parameters = 12

Table 20. Final parameter estimates and significant statistics for age 6 - 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..... 0.007888
MEAN SQUARE RESIDUALS 0.475045

PAR. EST.	STD. ERR.	T-STATISTIC
2.16150E0004	1.34283E0004	1.60966E0000
1.52794E0004	7.00262E0003	2.18196E0000
1.82534E0004	7.82106E0003	2.33388E0000
1.10679E0004	4.27121E0003	2.59129E0000
4.94546E0003	2.03833E0003	2.42623E0000
3.01175E0003	1.26404E0003	2.38264E0000
2.13997E0002	3.97850E0001	5.37883E0000
4.52649E0002	8.29356E0001	5.45783E0000
5.05251E0002	9.25150E0001	5.46129E0000
6.97898E0002	1.30055E0002	5.36618E0000
9.63451E0002	1.81110E0002	5.31971E0000
7.91709E0002	1.50402E0002	5.26395E0000

Parameter Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	.046	.041	.039	.031	.027	-.260	-.026	-.021	-.020	-.020	-.021
2	.046	1.000	.060	.059	.047	.041	-.178	-.219	-.032	-.031	-.030	-.031
3	.041	.060	1.000	.081	.065	.057	-.157	-.172	-.192	-.042	-.041	-.043
4	.039	.059	.081	1.000	.052	.091	-.150	-.176	-.217	-.274	-.180	-.242
5	.031	.047	.065	.052	1.000	.097	-.119	-.139	-.175	-.224	-.289	-.182
6	.027	.041	.057	.091	.097	1.000	-.102	-.121	-.155	-.203	-.262	-.335
7	-.260	-.178	-.157	-.150	-.119	-.102	1.000	.098	.082	.077	.076	.079
8	-.026	-.219	-.172	-.176	-.139	-.121	.098	1.000	.095	.091	.089	.093
9	-.021	-.032	-.192	-.217	-.175	-.155	.082	.095	1.000	.113	.112	.117
10	-.020	-.031	-.042	-.274	-.224	-.203	.077	.091	.113	1.000	.144	.150
11	-.020	-.030	-.041	-.180	-.289	-.262	.076	.089	.112	.144	1.000	.158
12	-.021	-.031	-.043	-.242	-.182	-.335	.079	.093	.117	.150	.158	1.000

Table 21. 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	1984	1985	1986
4	-.526	-.797	.408	.371	-.506	-.733	1.957	-.934	-.259	-.194	-.623	1.100	-.453
5	-.840	-.474	.356	1.244	.050	-.546	1.114	-.196	-.326	-.862	-.333	.620	-.552
6	-.734	.036	.206	1.034	-.087	.024	.447	-.771	.069	-.852	-.080	.461	.068
7	.412	-1.002	.987	.153	-.058	-.263	.578	-.535	-1.154	-1.013	.693	.687	-.343
8	.245	.362	.643	1.131	.041	-.501	-.101	-.305	-.908	-.881	.755	.279	-.639
9	.615	.163	.403	.859	.470	-.486	-.459	-.282	-.032	.170	.665	.662	-1.434

	1987	1988	1989
4	.922	.268	.000
5	.973	-.023	-.206
6	.645	.211	-.677
7	.479	.605	-.227
8	.172	.183	-.477
9	-.052	.037	-.299

Table 22. Fishing mortality matrix for divs. 4VWX5 pollock.

FISHING MORTALITY 14/ 5/90

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
2	.012	.007	.005	.001	.001	.020	.013	.001	.003	.002	.000	.001	.000	.000	.002	.003
3	.239	.082	.070	.054	.023	.193	.076	.130	.063	.056	.023	.014	.009	.020	.027	.040
4	.329	.271	.217	.206	.155	.214	.193	.255	.223	.222	.132	.091	.094	.078	.142	.222
5	.369	.467	.422	.311	.356	.259	.312	.345	.348	.276	.263	.228	.210	.232	.152	.335
6	.451	.581	.476	.483	.384	.341	.398	.417	.600	.248	.222	.383	.319	.333	.250	.159
7	.486	.765	.798	.696	.521	.270	.375	.616	.446	.331	.145	.745	.364	.361	.300	.229
8	.515	.638	.428	.847	.564	.197	.221	.468	.611	.291	.228	.298	.486	.320	.310	.230
9	.397	.325	.227	.416	.818	.184	.197	.267	.517	.539	.110	.216	.314	.555	.320	.290
10	.451	.557	.130	.180	.106	.179	.188	.268	.365	.421	.207	.166	.300	.227	.250	.203
11	.238	.349	.340	.352	.274	.119	.155	.271	.246	.172	.075	.282	.186	.175	.154	.120

Table 23. Beginning of year population numbers for divs. 4VWX5 pollock.

POPULATION NUMBERS (000S) 14/ 5/90

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	18347	27493	38095	50603	21239	5477	15049	83345	49624	42611	54028	51451
3	29097	14843	22351	31029	41397	17368	4395	12167	68142	40498	34826	44214
4	10500	18752	11195	17068	24068	33137	11719	3335	8751	52408	31357	27860
5	8440	6188	11713	7379	11375	16883	21896	7909	2116	5730	34355	22505
6	3311	4778	3175	6288	4427	6523	10672	13126	4587	1223	3559	21632
7	910	1727	2189	1614	3175	2470	3798	5870	7083	2061	781	2333
8	450	458	658	807	659	1543	1544	2136	2595	3714	1212	553
9	269	220	198	351	283	307	1038	1013	1096	1153	2273	790
10	253	148	130	129	189	102	209	698	635	535	551	1666
11	381	132	69	94	88	139	70	142	437	361	287	366
2+	71958	74740	89774	115363	106902	83950	70390	129741	145066	150294	163229	173372

	1986	1987	1988	1989
2	32524	32978	18307	17778
3	42080	26623	26990	14963
4	35701	34137	21358	21499
5	20822	26594	25852	15169
6	14674	13815	17259	18173
7	12075	8737	8107	11007
8	907	6869	4984	4918
9	336	457	4085	2992
10	521	201	215	2428
11	1156	316	131	137
2+	160796	150728	127287	109066

Table 24. Mid-year bomass for divs. 4VWX and Subdiv. 5Zc pollock.

MIDYEAR BIOMASS

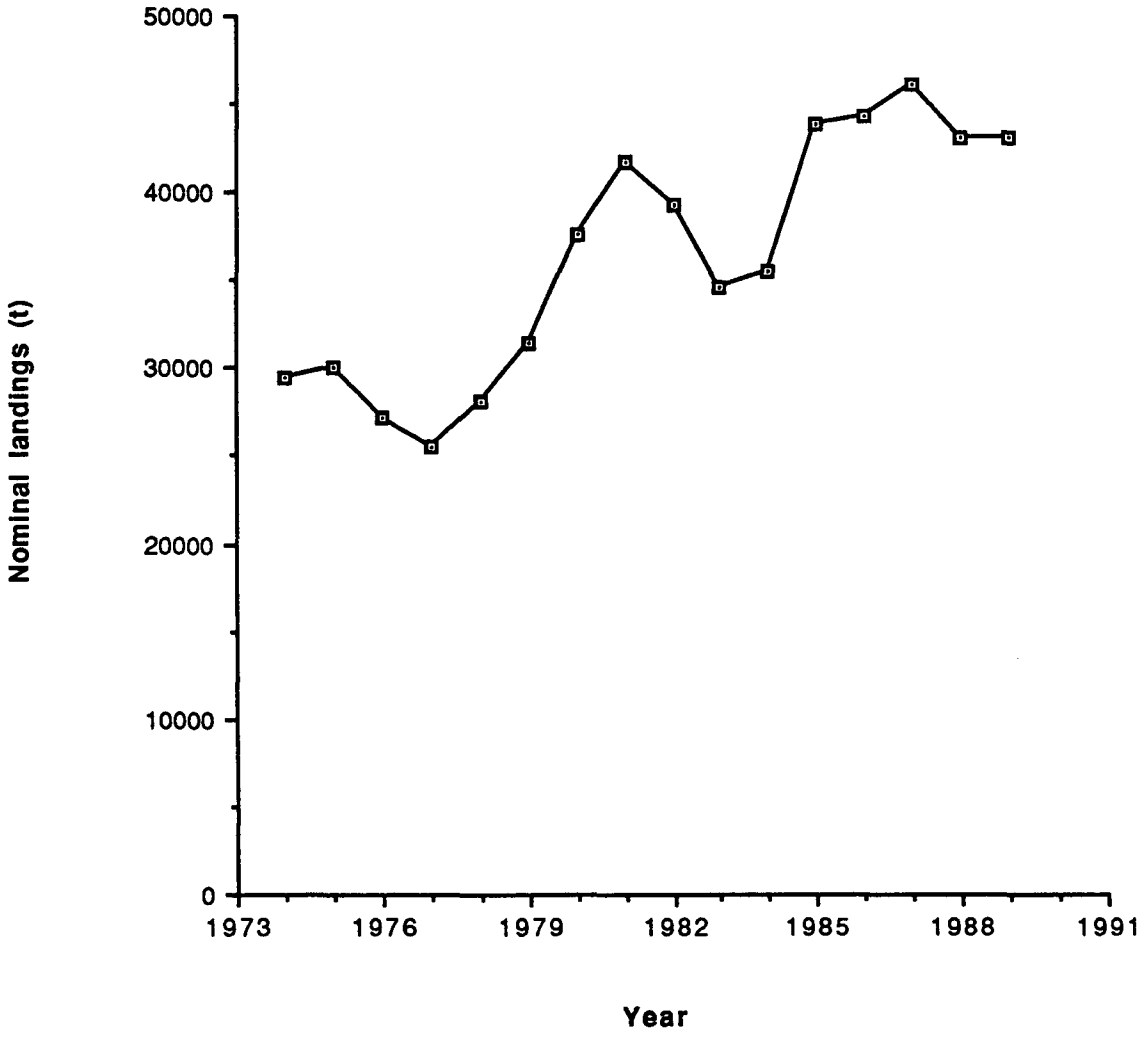
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	13478	21270	20277	36117	21911	3788	14001	60485	33752	29491
3	32561	16274	23664	30038	45810	16940	6461	18011	72853	44540
4	15831	29225	17552	21273	36569	42148	20169	6791	19226	71216
5	19302	13813	24544	14333	22665	35522	47513	17739	5725	14247
6	9958	12641	8563	15961	13073	17140	27758	32755	13200	4062
7	3342	5604	6474	4818	10382	8551	11891	17324	23232	7716
8	1979	2025	2756	2737	2775	7065	7028	9226	9229	14878
9	1351	1282	1133	1733	1228	1687	5572	5598	4841	4750
10	1376	778	865	780	1203	608	1574	4330	3705	2585
11	2650	836	470	722	591	1050	495	854	2821	2408

	1984	1985	1986	1987	1988	1989
2	69398	30093	19454	18256	18859	12562
3	52525	55797	50857	31087	33816	16241
4	63062	47226	62453	58074	34469	32347
5	73406	50081	43087	53828	57485	29259
6	11152	51179	37639	31526	44479	49497
7	3566	5168	33278	24802	22349	33815
8	5873	1914	2743	21616	16528	16340
9	11520	3941	1489	1458	14042	11339
10	2859	8185	2498	1030	910	10283
11	1926	1797	5858	1635	887	940

Table 25. Catch projections for 4VWX5Zc pollock under three different management strategies.

	F				Biomass 2+ ('000 t)				Catch ('000 t)			
Options	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992
$F_{0.1}$ in 1991-92	.24	.25	.31	.31	237	230	215	203	43	38	42.6	38.5
Constant Catch in 1991 and 1992	.24	.25	.31	.35	237	230	215	201	43	38	42.6	42.6
Moving to $F_{0.1}$ in 1992	.24	.25	.29	.31	237	230	216	205	43	38	40.0	39.0

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



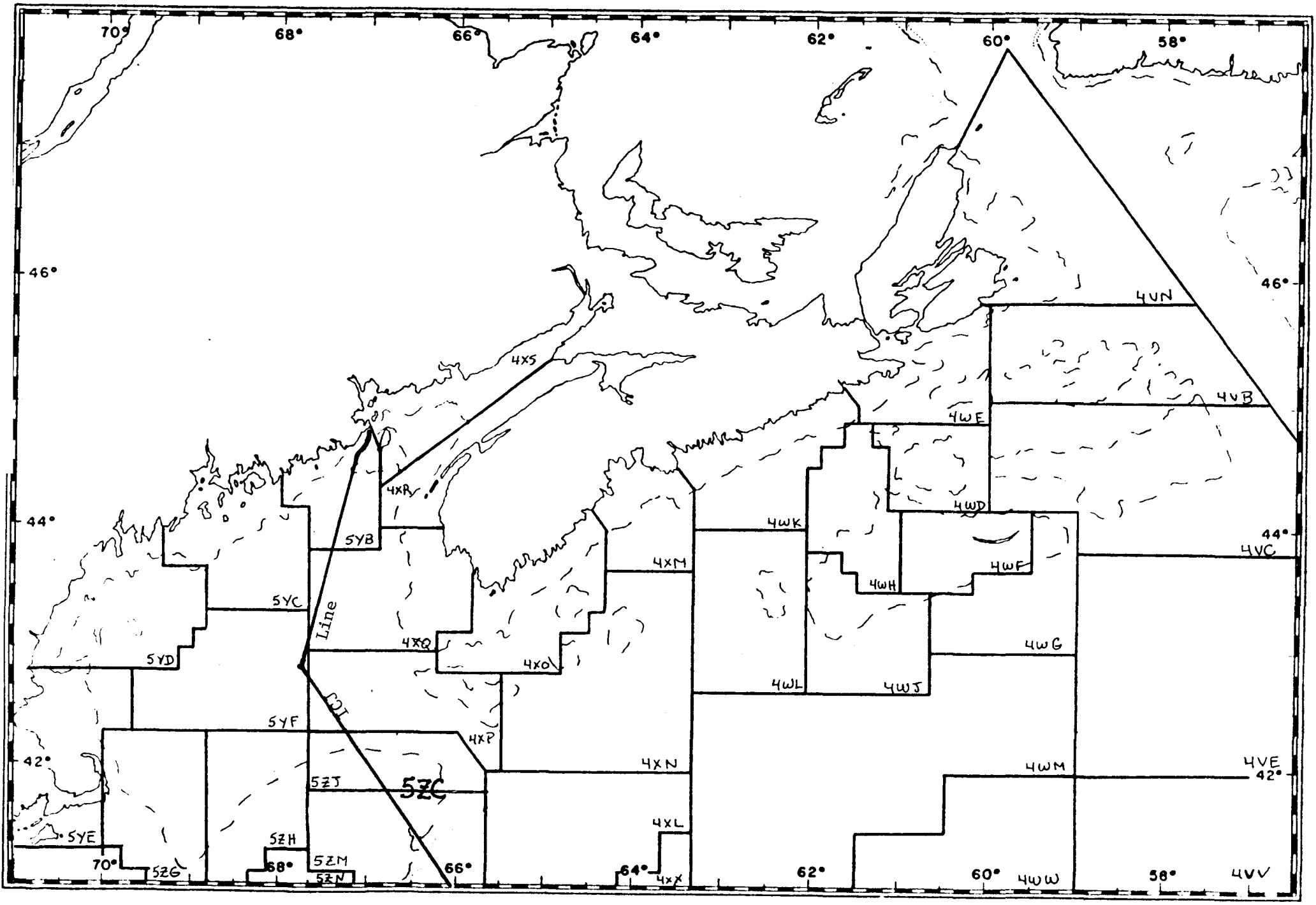
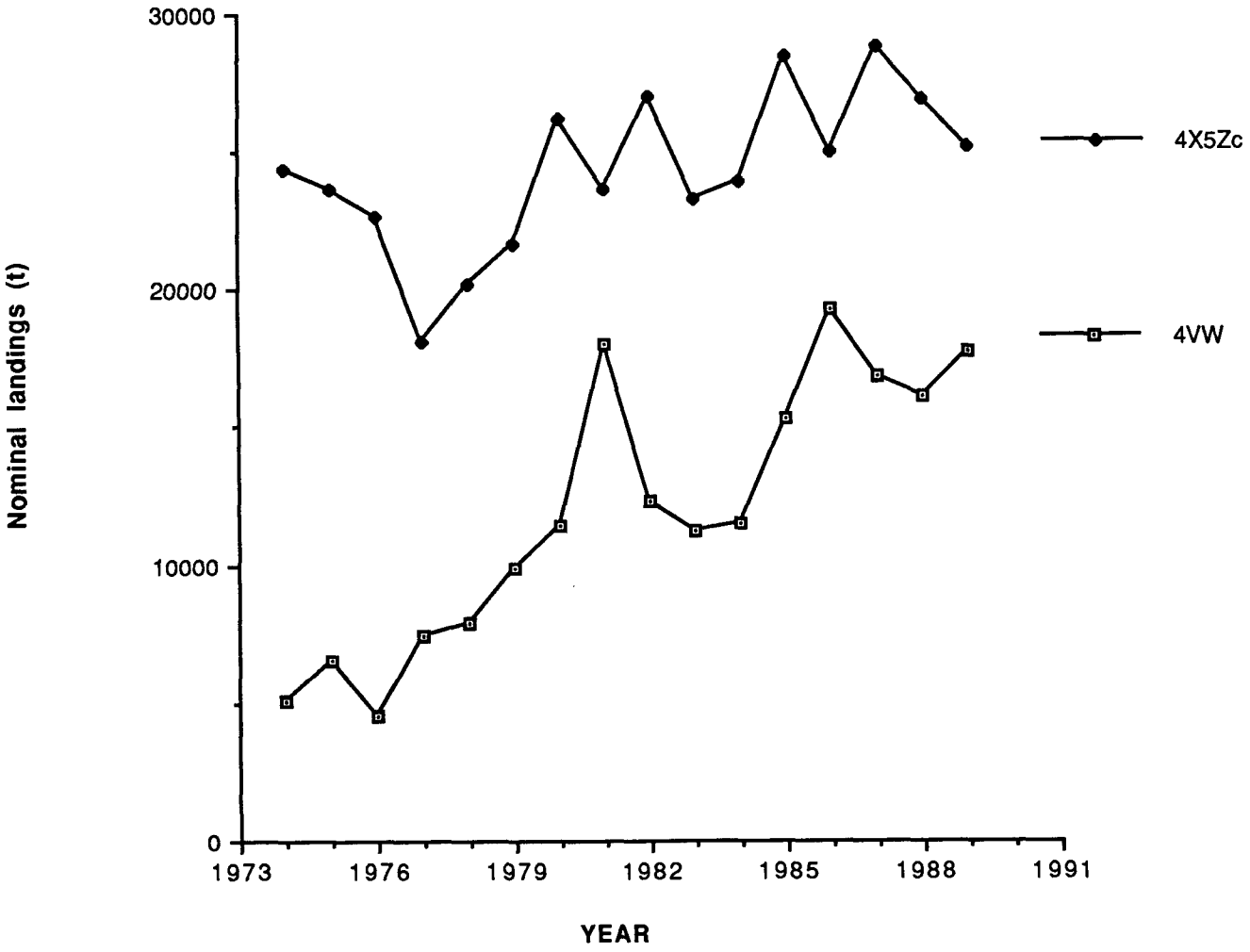


Fig. 2. Diagram of ICJ line which now defines the boundary for the new management unit for 4VWX5 pollock.

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



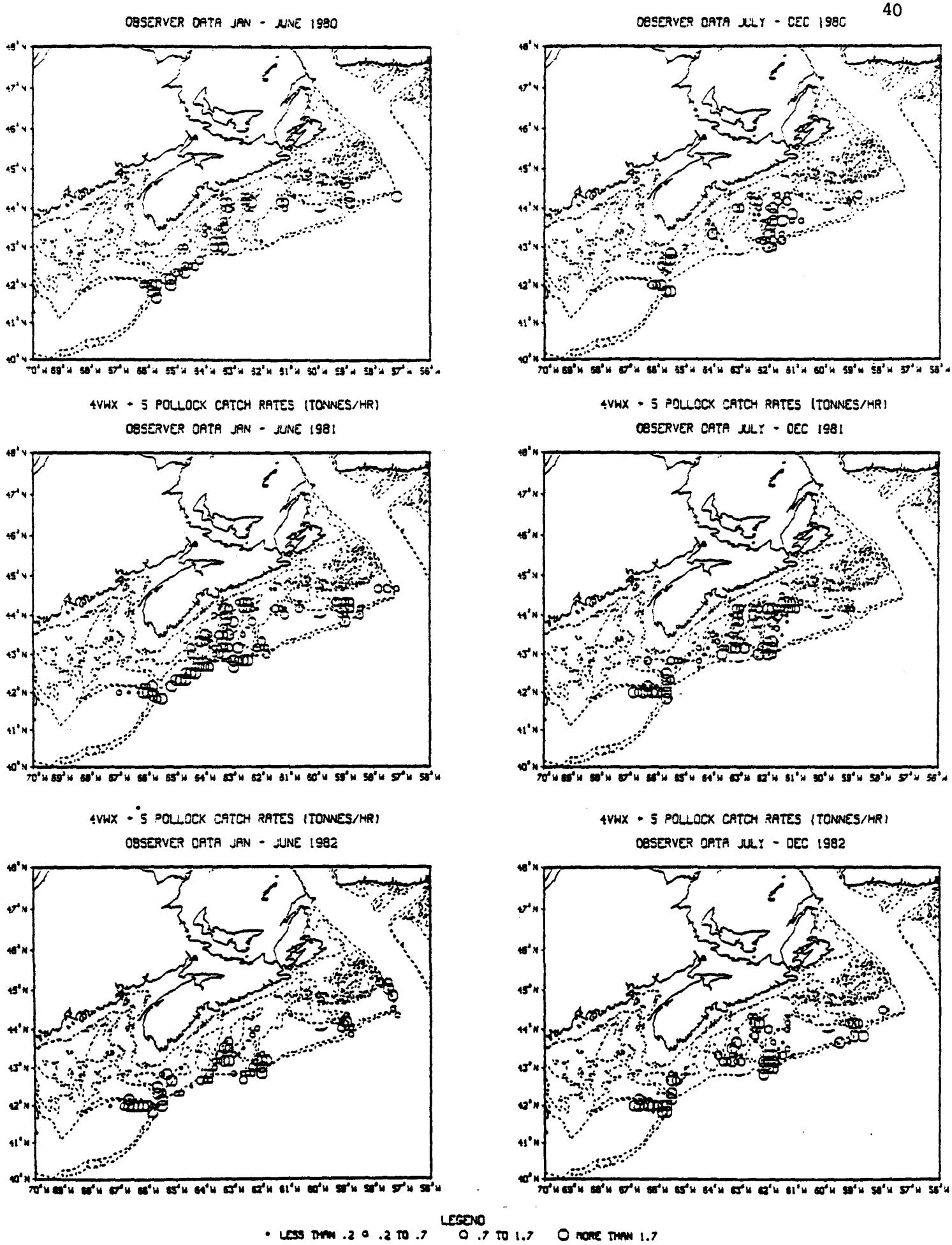
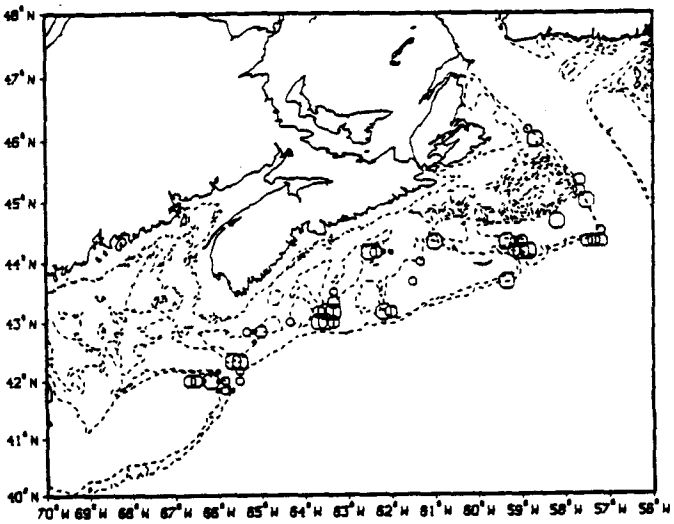
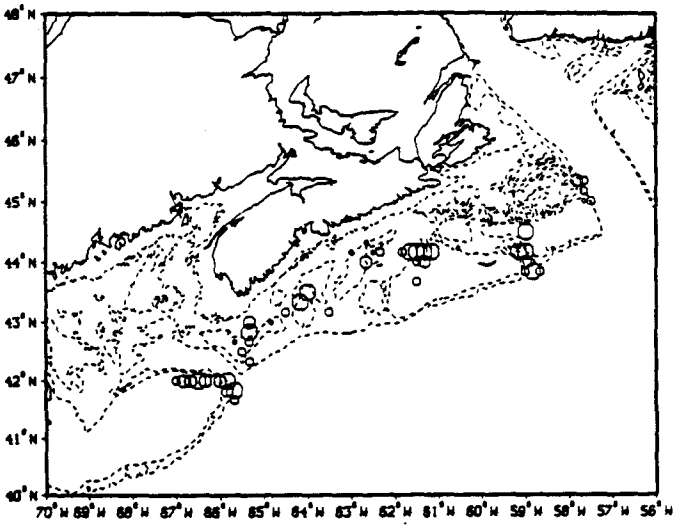


Figure 4. International Observer plots of catch rates for pollock (Jan.-June; July-Dec.; 1980-1989).

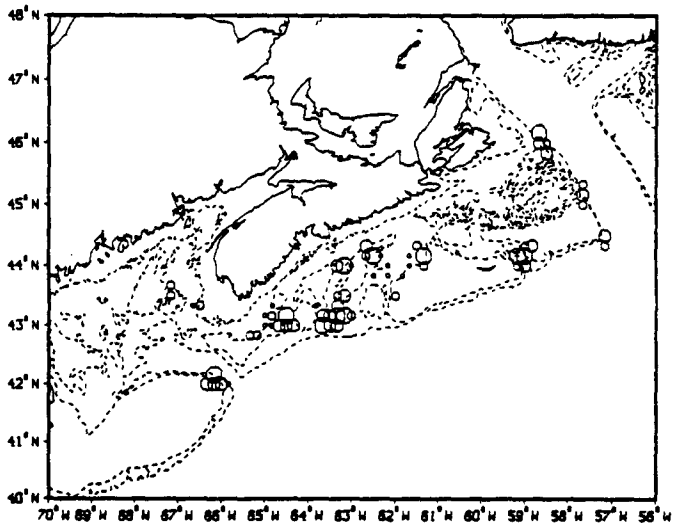
4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JAN - JUNE 1983



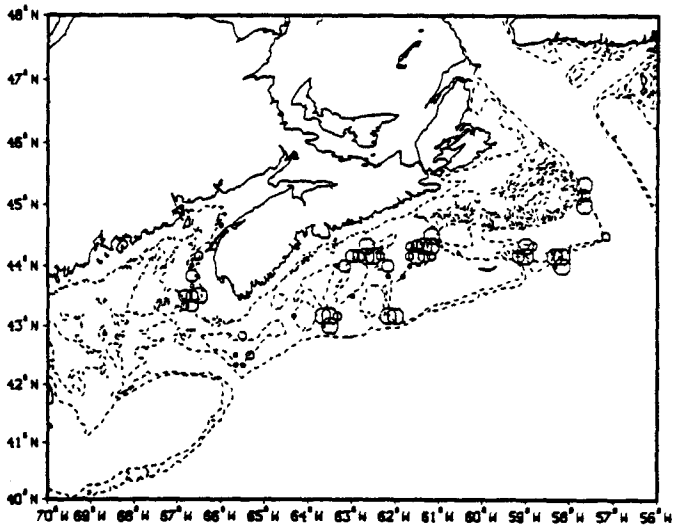
4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JULY - DEC 1983



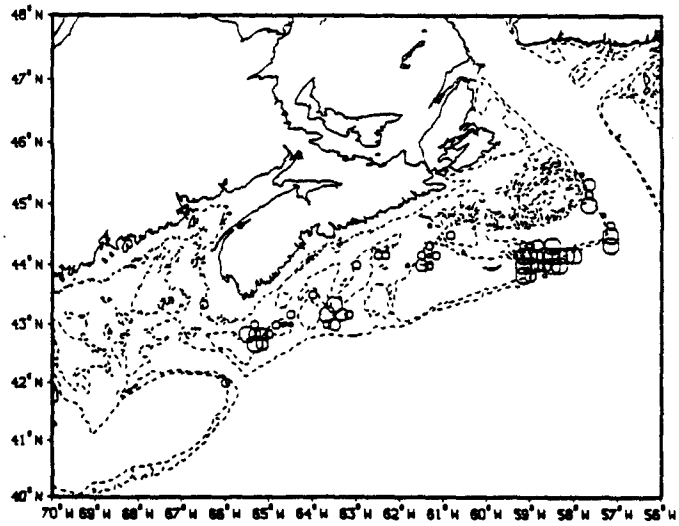
4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JAN - JUNE 1984



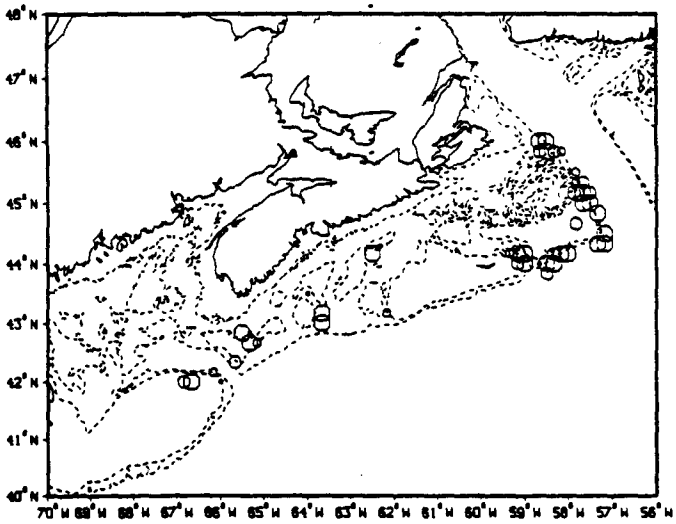
4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JULY - DEC 1984



4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JAN - JUNE 1985



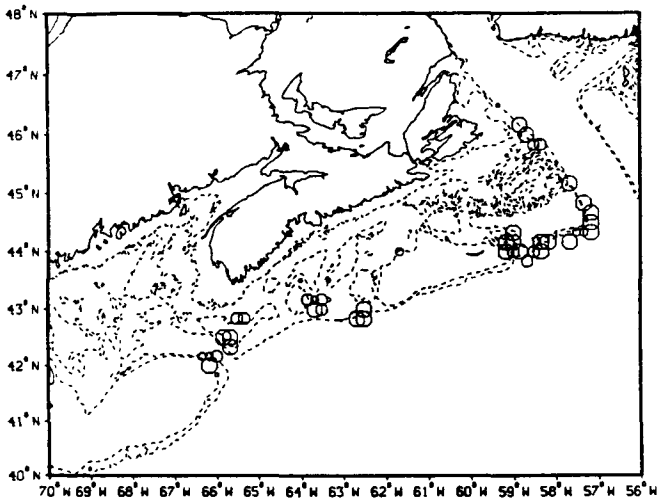
4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JULY - DEC 1985



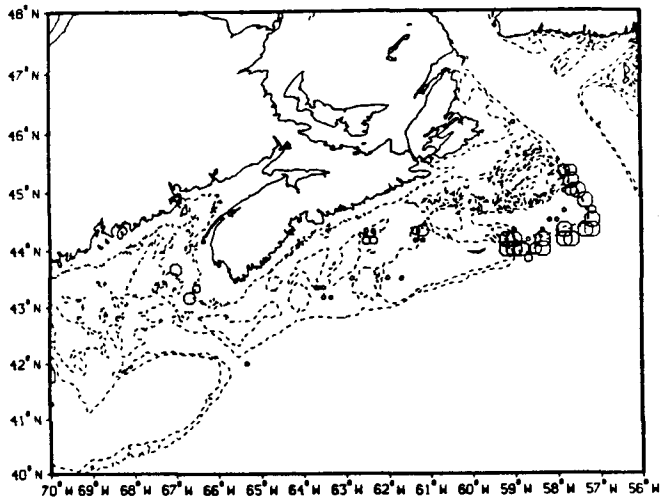
LEGEND
• LESS THAN .2 ○ .2 TO .7 ○ .7 TO 1.7 ○ MORE THAN 1.7

Figure 4. (Continued).

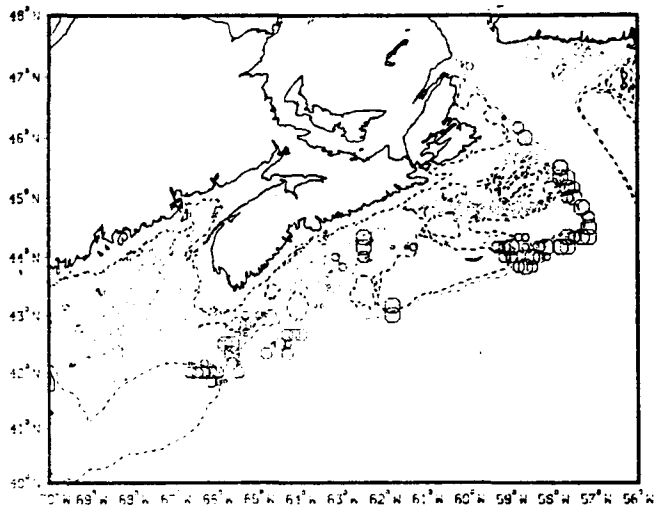
4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JAN - JUNE 1986



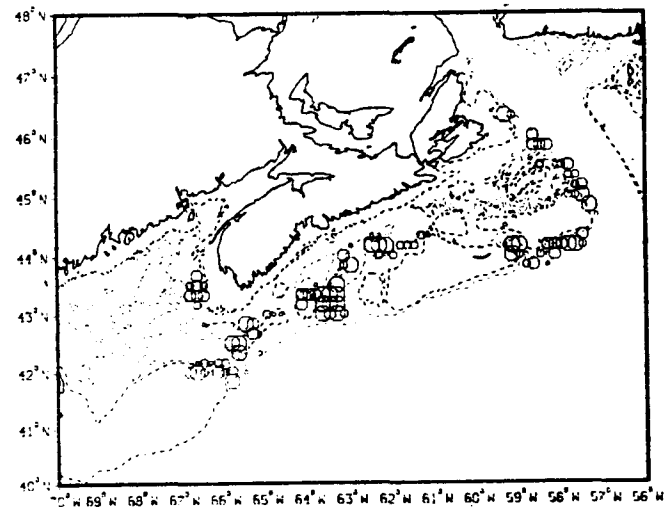
4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JULY - DEC 1986



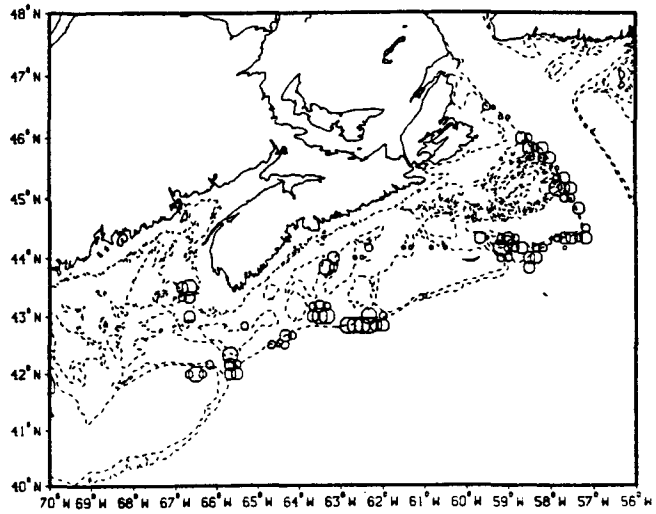
4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JAN - JUNE 1987



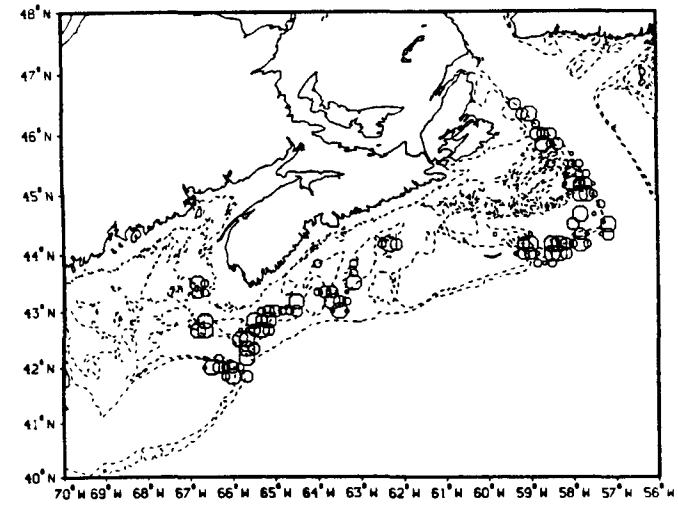
4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JULY - DEC 1987



4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JAN - JUNE 1988

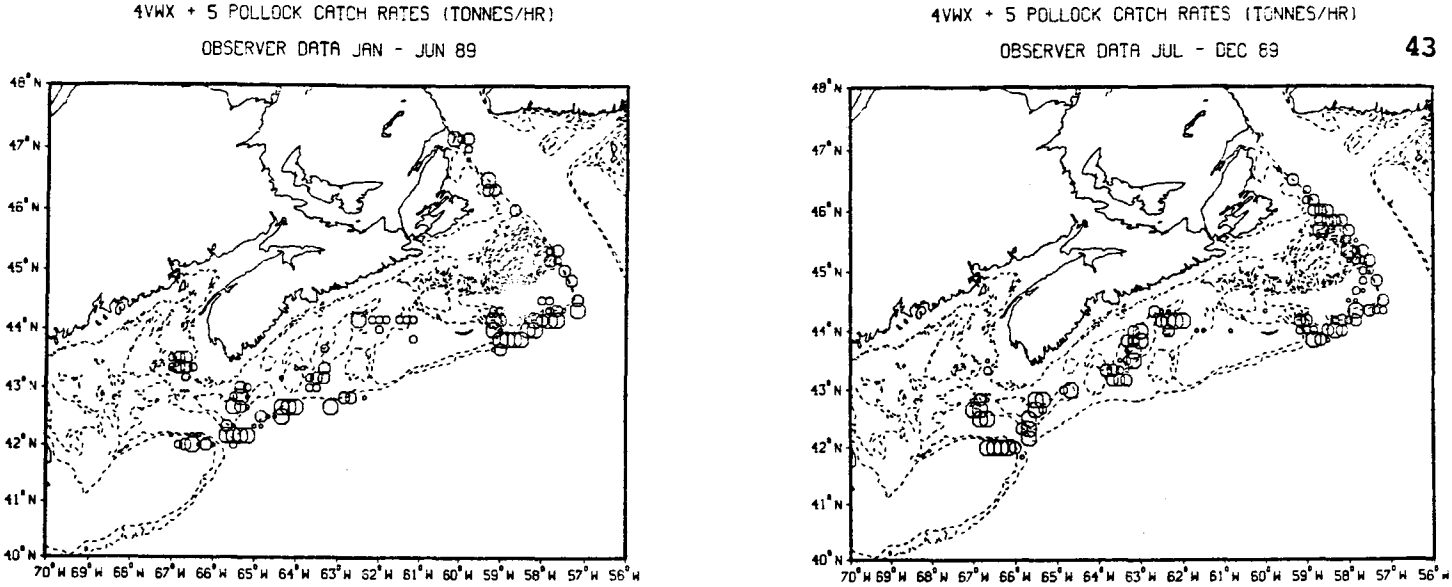


4VWX + 5 POLLOCK CATCH RATES (TONNES/HR)
OBSERVER DATA JULY - DEC 1988



LEGEND
• LESS THAN .2 ○ .2 TO .7 ○ .7 TO 1.7 ○ MORE THAN 1.7

Figure 4. (Continued)



LEGEND

• LESS THAN .2 ○ .2 TO .7 ○ .7 TO 1.7 ○ MORE THAN 1.7

Figure 4. (Continued).

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

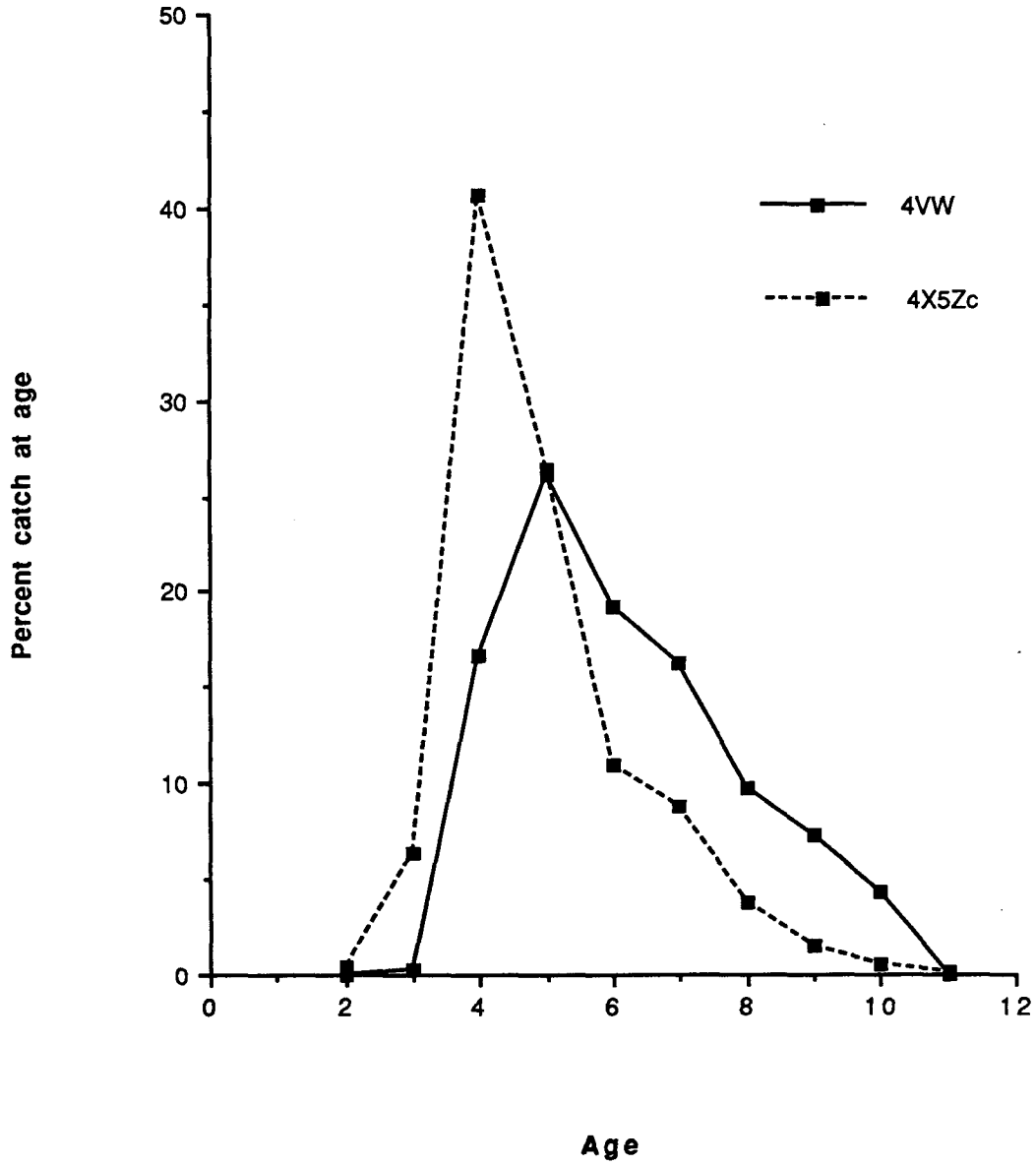


Fig. 6. Percent projected catch at age vs percent catch at age for 1989.

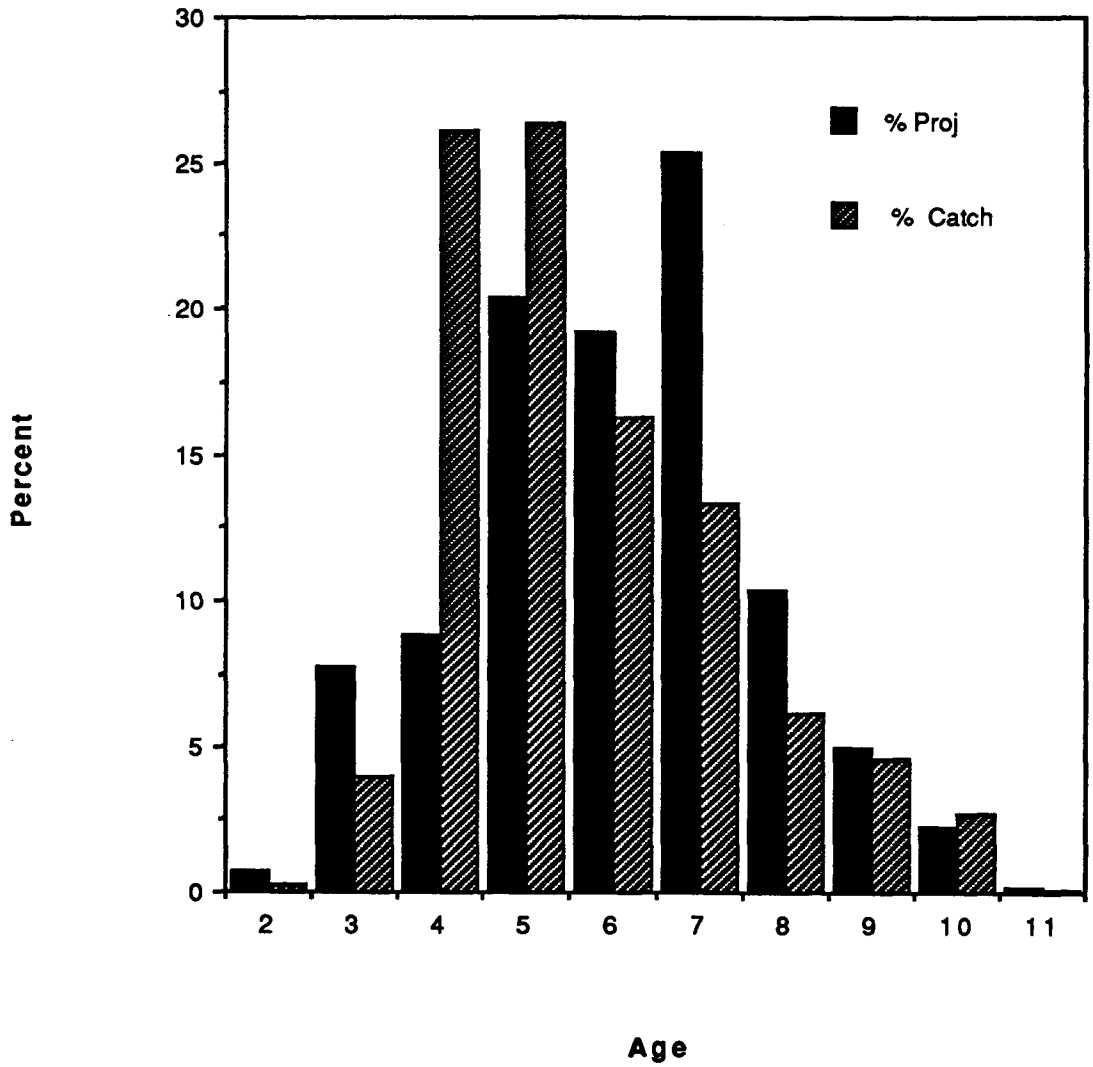
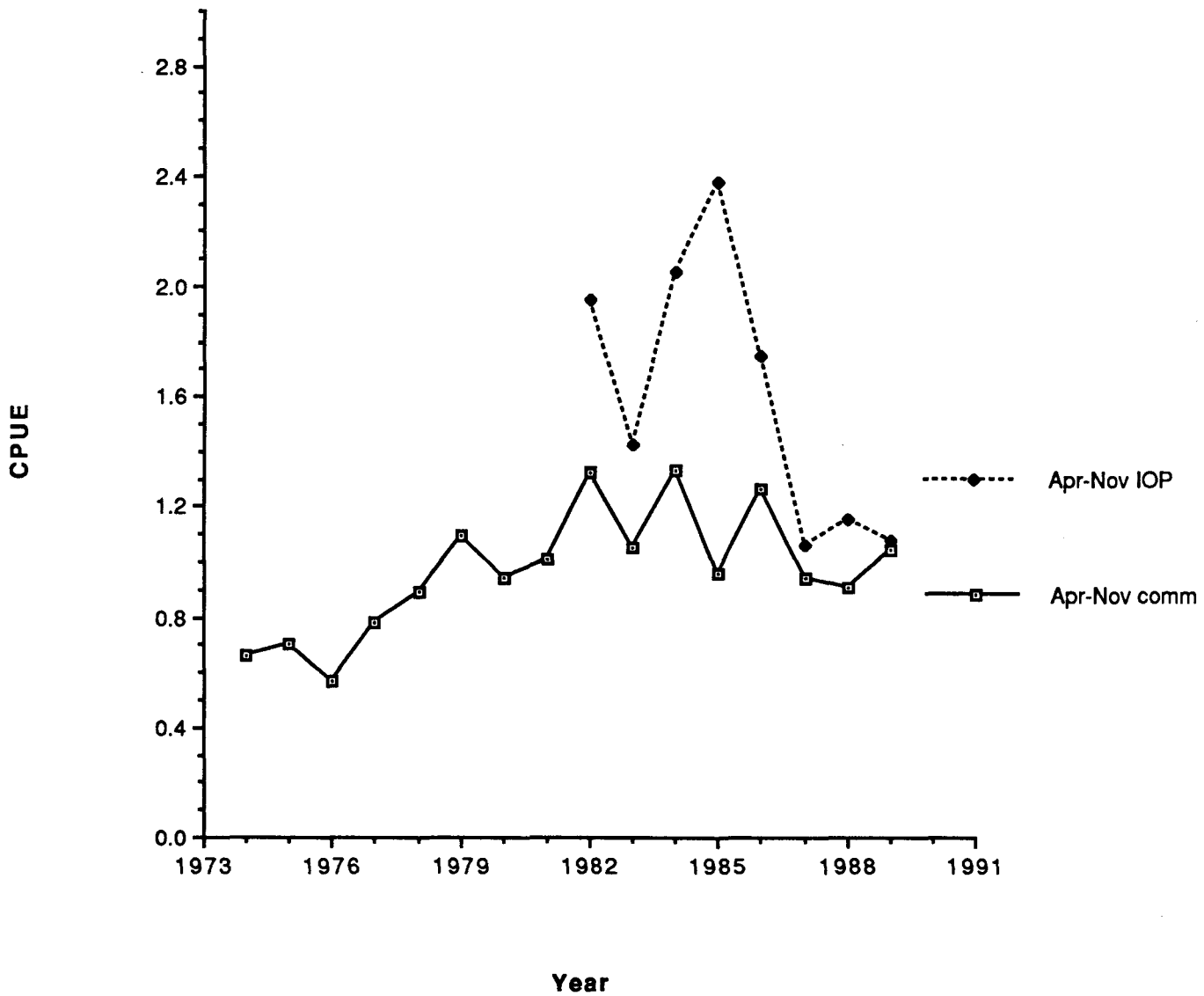


Fig. 7. Catch rate indices for Divs. 4VWX and Subdiv. 5Zc pollock (commercial statistics and IOP).



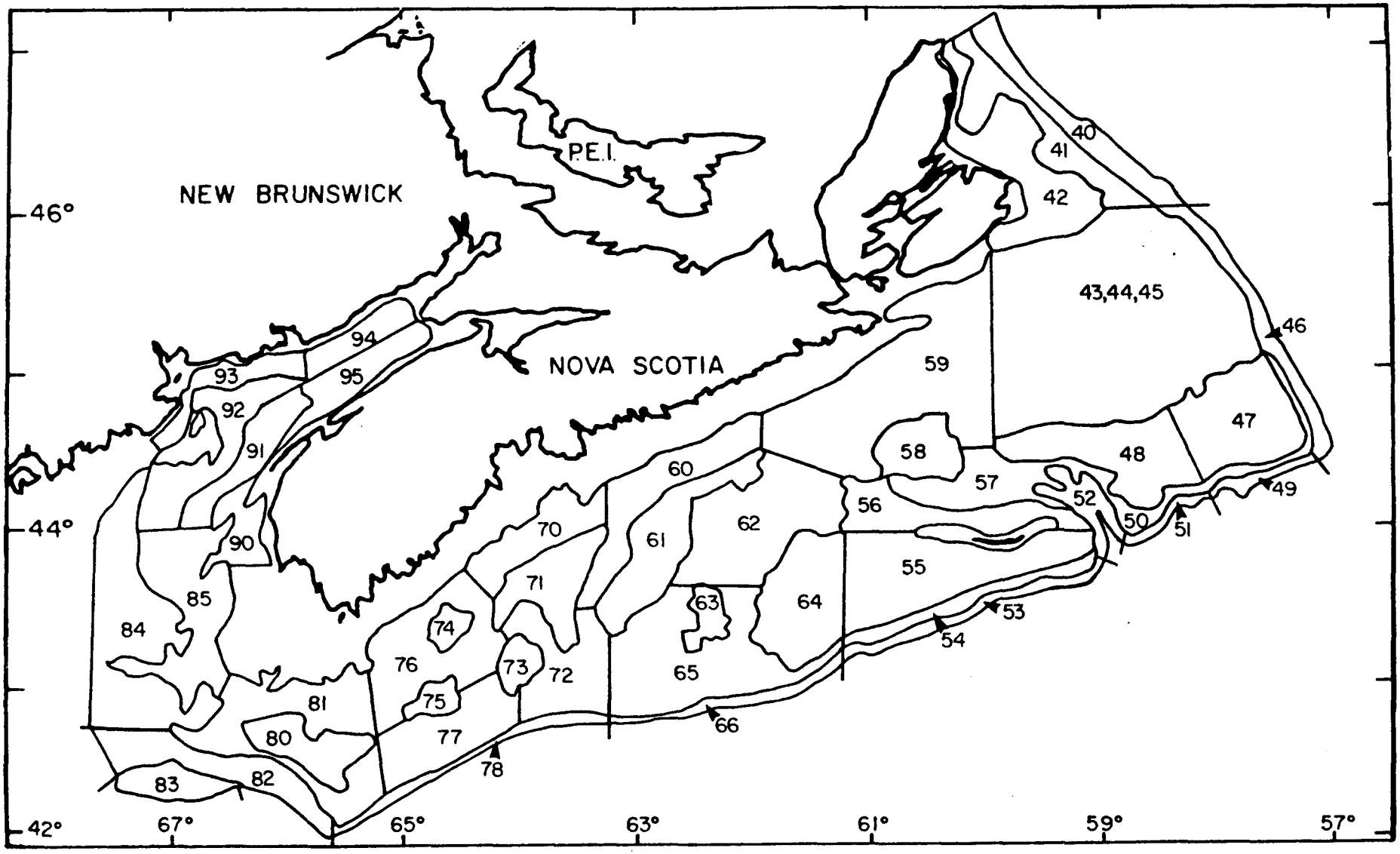


Figure 8. Stratification used for Canadian RV bottom trawl surveys (Divisions 4VWX + Subarea 5).

Fig. 9. July RV stratified numbers (ages 4-9) for Divs. 4VWX and Subdiv. 5Zc for pollock.

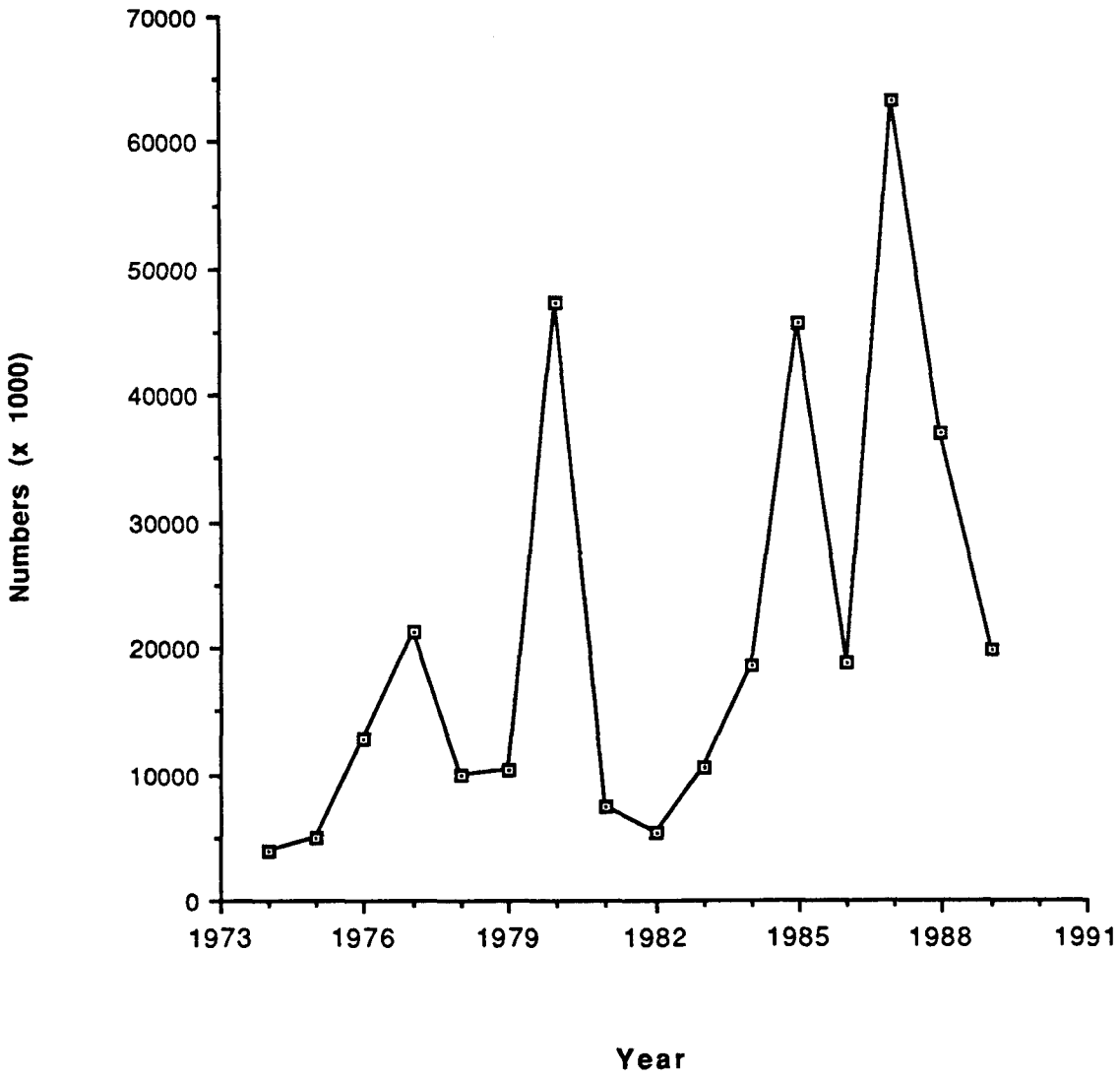
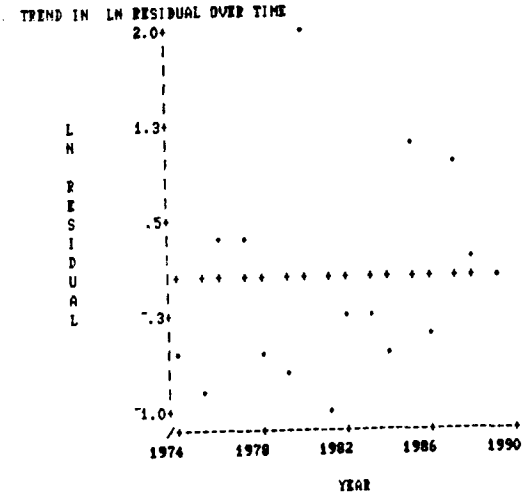


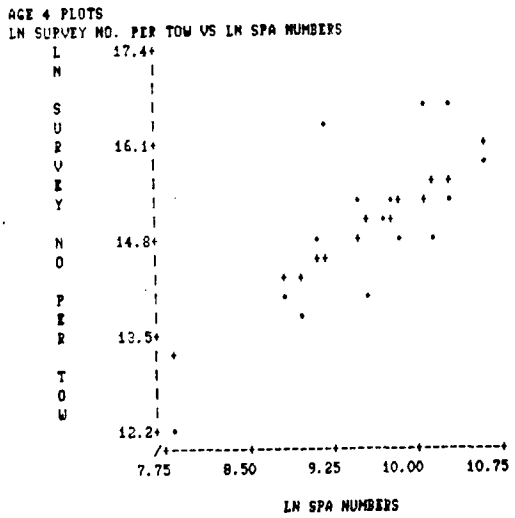
Fig. 10. Age-by-age tuning plots resulting from ADAPT tuning of SPA with RV ages 4 to 9 and age aggregated CPUE.

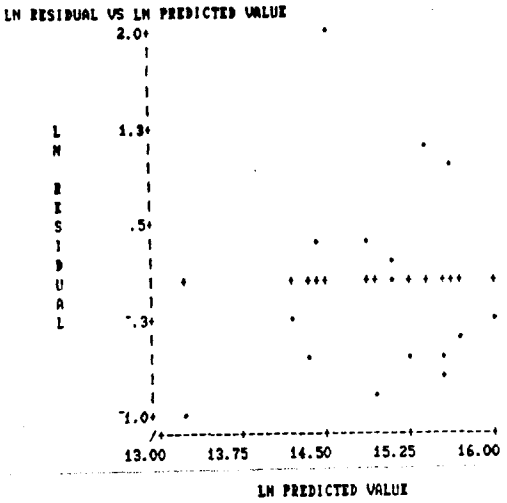
SUMMARY OF DATA FROM PLOT

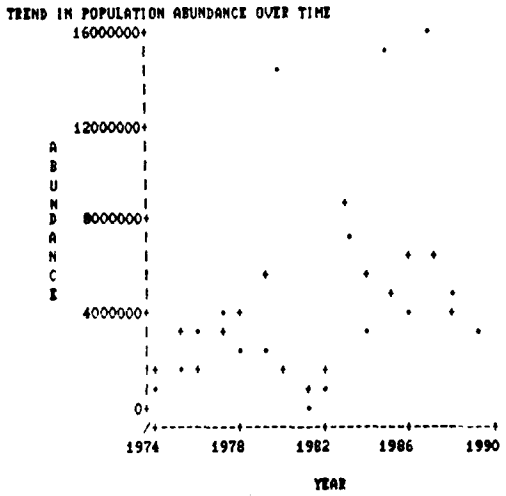
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

INDEX	CARRIER	•	+	RANK
1974	8.951	13.79	14.32	1981
1975	9.565	14.13	14.93	1982
1976	9.08	14.85	14.45	1974
1977	9.508	15.25	14.87	1976
1978	9.882	14.74	15.25	1980
1979	10.17	14.8	15.53	1977
1980	9.14	16.46	14.51	1975
1981	7.847	12.28	13.21	1989
1982	8.83	13.94	14.2	1988
1983	10.62	15.79	15.99	1978
1984	10.16	14.9	15.53	1985
1985	10.07	16.53	15.43	1984
1986	10.31	15.22	15.68	1979
1987	10.28	16.56	15.64	1987
1988	9.77	15.4	15.14	1986
1989	9.73	15.1	15.1	1983









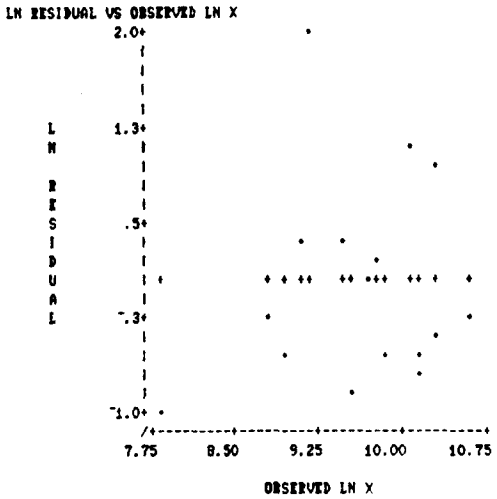


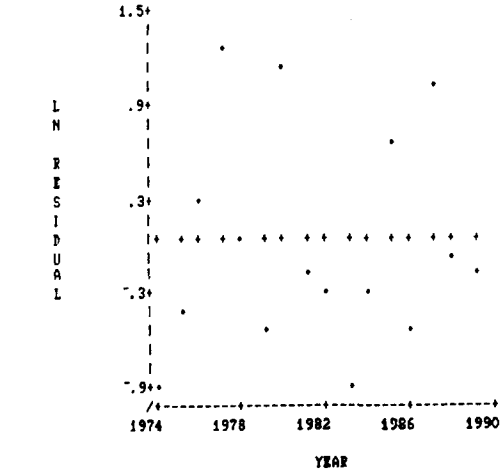
Fig. 10. (Continued)

SUMMARY OF DATA FROM PLOT

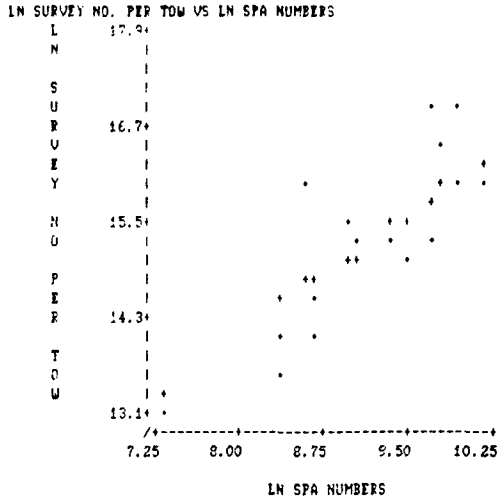
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - O:OBSERVED, +:PREDICTED

INDEX	CARRIER	O	+	RANK
1974	8.709	13.98	14.82	1982
1975	8.341	13.98	14.46	1975
1976	9.006	15.48	15.12	1993
1977	8.608	15.97	14.72	1977
1978	9.015	15.18	15.13	1981
1979	9.466	15.04	15.58	1974
1980	9.696	16.92	15.81	1976
1981	8.658	14.58	14.77	1978
1982	7.337	13.13	13.45	1989
1983	8.376	13.63	14.49	1979
1984	10.17	15.96	16.29	1980
1985	9.772	16.51	15.89	1986
1986	9.704	15.27	15.82	1985
1987	9.936	17.02	16.05	1987
1988	9.955	16.05	16.07	1988
1989	9.315	15.22	15.43	1984

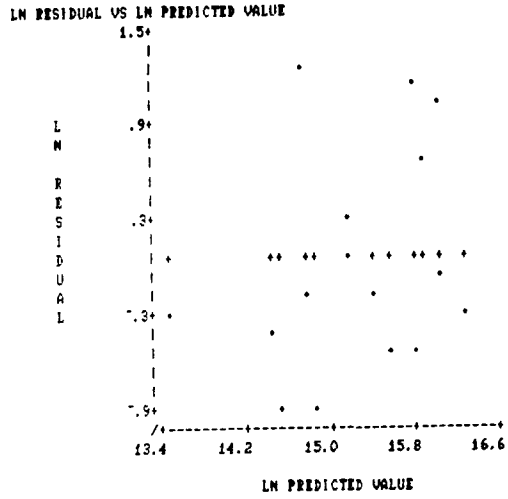
TREND IN LN RESIDUAL OVER TIME



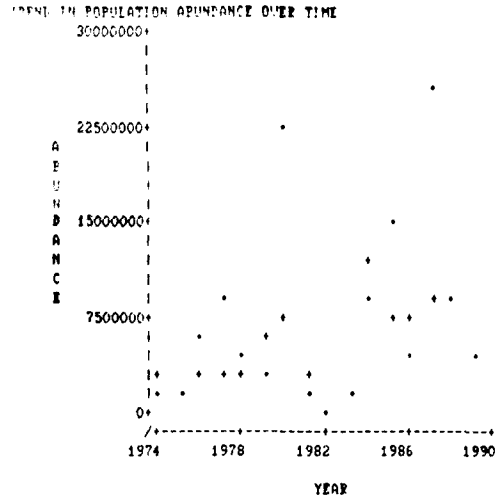
AGE 5 PLOTS
LN SURVEY NO. PER TOW VS LN SPA NUMBERS



LN RESIDUAL VS LN PREDICTED VALUE



TREND IN POPULATION ABUNDANCE OVER TIME



LN RESIDUAL VS OBSERVED LN X

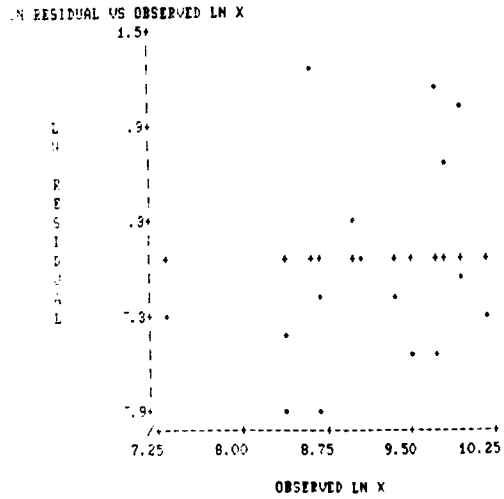


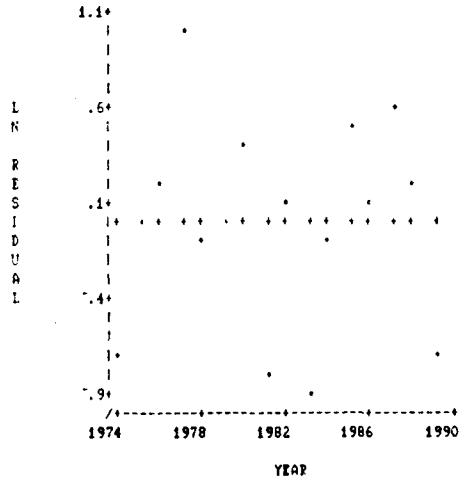
Fig. 10. (Continued)

SUMMARY OF DATA FROM PLOT

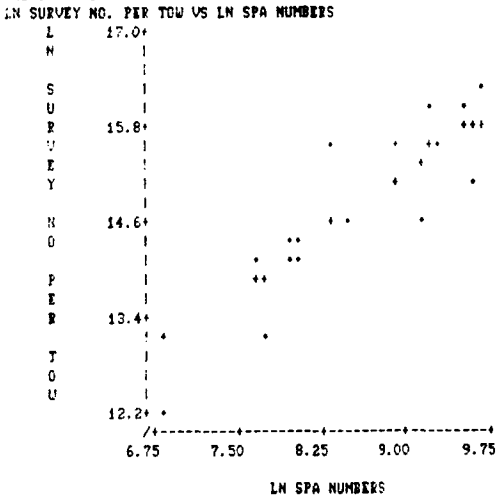
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

INDEX	CARRIER	•	+	RANK
1974	7.725	13.22	13.95	1983
1975	8.016	14.28	14.24	1976
1976	7.669	14.1	13.89	1974
1977	8.348	15.61	14.57	1984
1978	8.055	14.19	14.28	1982
1979	8.468	14.72	14.69	1975
1980	8.927	15.6	15.15	1978
1981	9.123	14.58	15.35	1977
1982	7.964	14.26	14.19	1979
1983	6.848	12.22	13.07	1980
1984	7.931	14.08	14.16	1981
1985	9.642	16.33	15.87	1987
1986	9.291	15.58	15.52	1986
1987	9.223	16.09	15.45	1988
1988	9.494	15.93	15.72	1989
1989	*9.598	15.15	15.82	1985

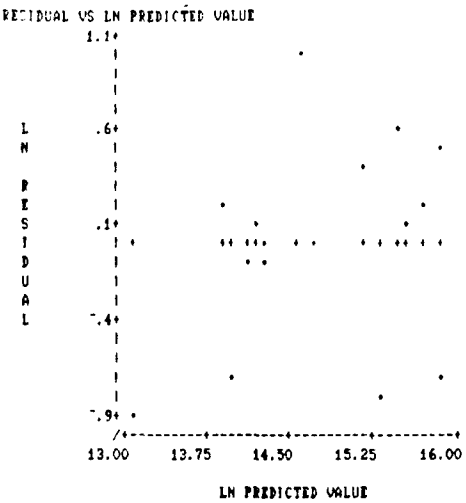
TREND IN LN RESIDUAL OVER TIME



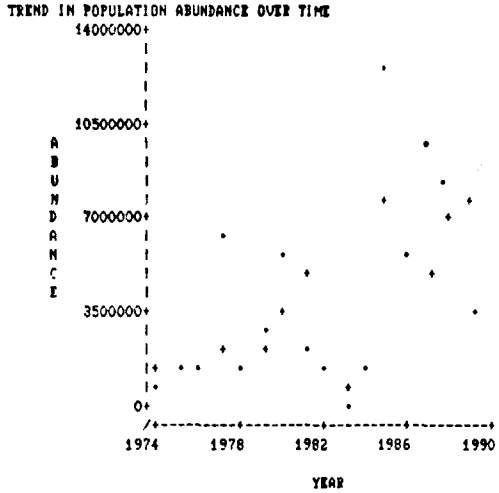
AGE 6 PLOTS
LN SURVEY NO. PER TOW VS LN SPA NUMBERS



LN RESIDUAL VS LN PREDICTED VALUE



TREND IN POPULATION ABUNDANCE OVER TIME



LN RESIDUAL VS OBSERVED LN X

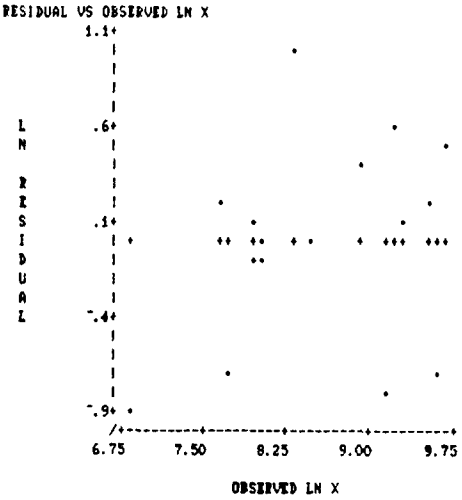


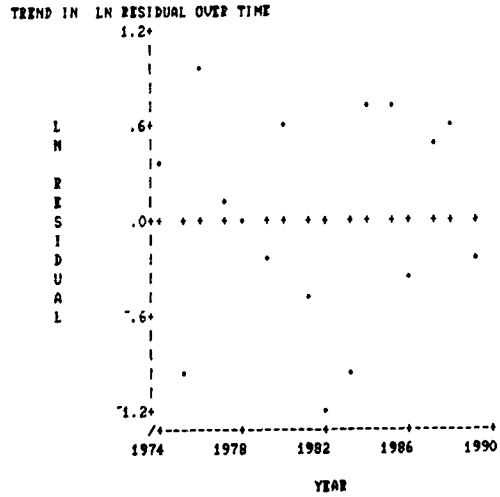
Fig. 10. (Continued)

SUMMARY OF DATA FROM PLOT

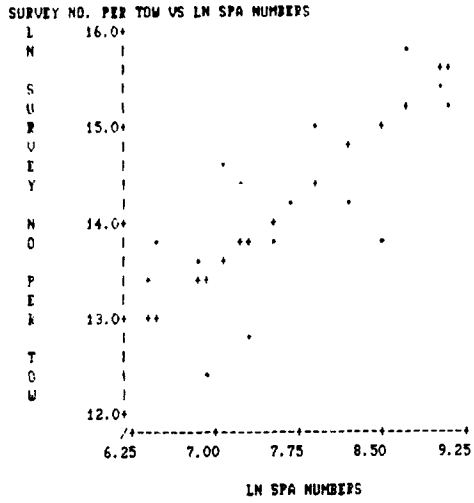
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - O:OBSERVED, +:PREDICTED

INDEX	CARRIER	•	+	RANK
1974	6.413	13.37	12.96	1974
1975	6.891	12.44	13.44	1984
1976	7.109	14.64	13.66	1977
1977	6.864	13.57	13.41	1975
1978	7.642	14.13	14.19	1976
1979	7.538	13.82	14.09	1985
1980	7.907	15.03	14.45	1983
1981	8.201	14.21	14.75	1979
1982	8.489	13.88	15.04	1978
1983	7.321	12.86	13.87	1980
1984	6.46	13.7	13.01	1981
1985	7.204	14.44	13.75	1982
1986	9.07	15.28	15.62	1988
1987	8.748	15.78	15.3	1987
1988	8.709	15.86	15.26	1989
1989	9.056	15.38	15.6	1986

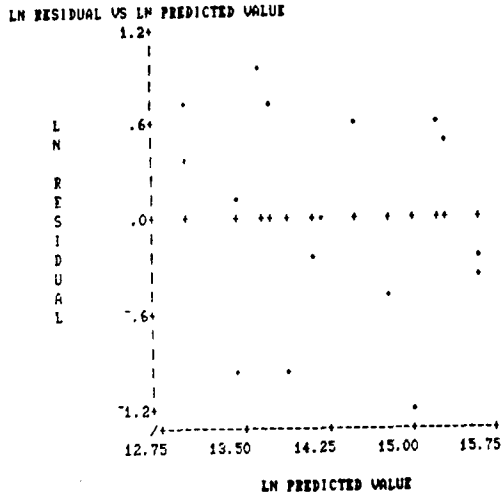
TREND IN LN RESIDUAL OVER TIME



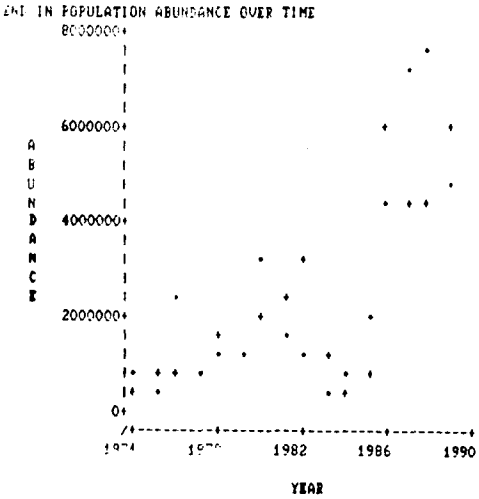
AGE 7 PLOTS
LN SURVEY NO. PER TOW VS LN SPA NUMBERS



LN RESIDUAL VS LN PREDICTED VALUE



TREND IN POPULATION ABUNDANCE OVER TIME



LN RESIDUAL VS OBSERVED LN X

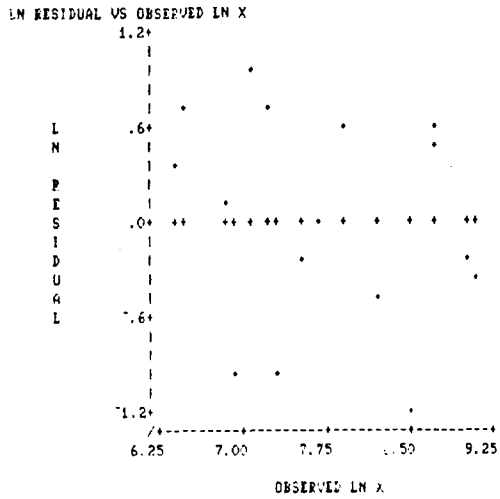


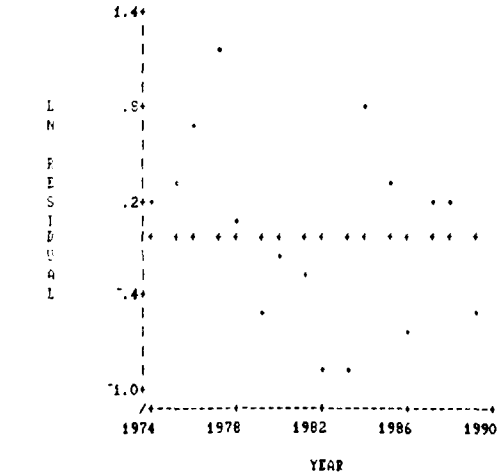
Fig. 10. (Continued)

SUMMARY OF DATA FROM PLOT

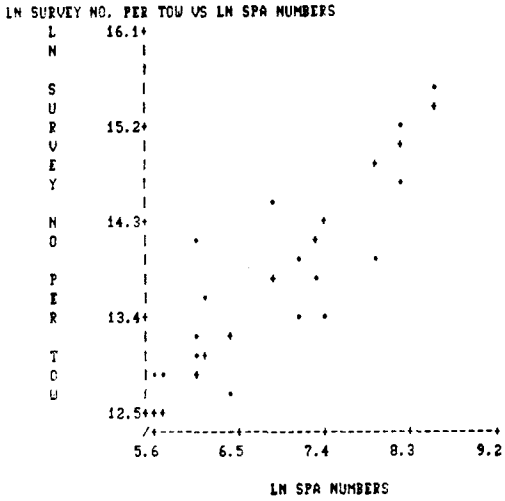
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

INDEX	CARRIER	•	+	RANK
1974	5.692	12.81	12.56	1975
1975	5.639	12.87	12.51	1974
1976	6.122	13.64	12.99	1985
1977	6.083	14.08	12.95	1978
1978	6.046	12.96	12.92	1977
1979	7.11	13.48	13.98	1976
1980	7.096	13.87	13.97	1986
1981	7.277	13.84	14.15	1984
1982	7.388	13.35	14.26	1980
1983	7.933	13.92	14.8	1979
1984	6.85	14.48	13.72	1981
1985	6.025	13.17	12.9	1982
1986	6.41	12.64	13.28	1983
1987	8.532	15.57	15.4	1988
1988	8.216	15.27	15.09	1989
1989	8.25	14.64	15.12	1987

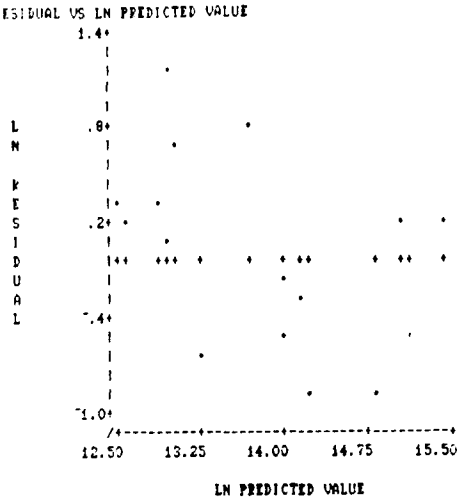
TREND IN LN RESIDUAL OVER TIME



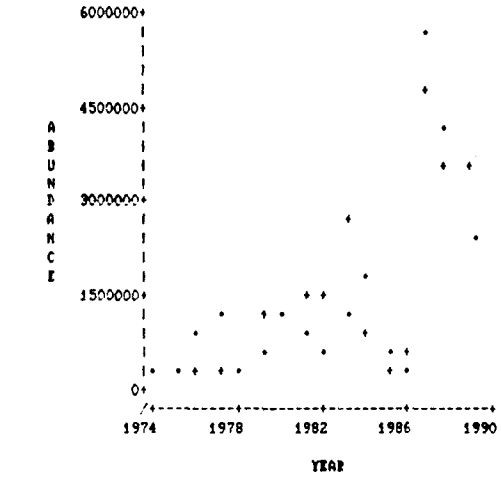
AGE 8 PLOTS
LN SURVEY NO. PER TOW VS LN SPA NUMBERS



LN RESIDUAL VS LN PREDICTED VALUE



TREND IN POPULATION ABUNDANCE OVER TIME



LN RESIDUAL VS OBSERVED LN X

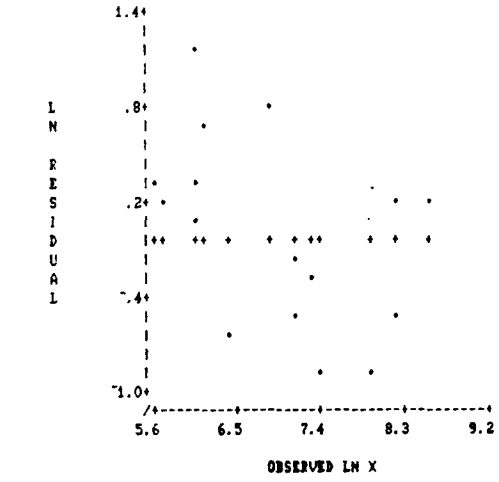


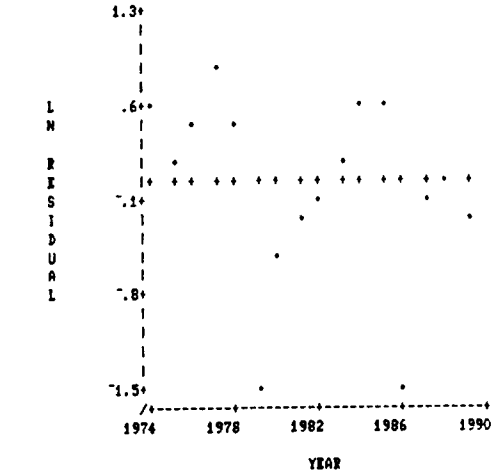
Fig. 10. (Continued)

SUMMARY OF DATA FROM PLOT

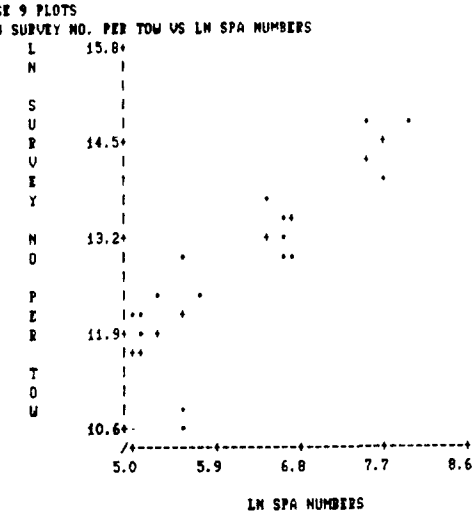
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - O:OBSERVED, +:PREDICTED

INDEX	CARRIER	O	+	RANK
1974	5.246	12.54	11.92	1976
1975	5.088	11.93	11.76	1978
1976	5.04	12.12	11.71	1975
1977	5.501	13.03	12.18	1974
1978	5.052	12.2	11.73	1977
1979	5.503	10.69	12.18	1979
1980	6.713	12.93	13.39	1986
1981	6.649	13.04	13.32	1987
1982	6.581	13.22	13.26	1985
1983	6.619	13.46	13.29	1982
1984	7.548	14.89	14.22	1983
1985	6.429	13.77	13.1	1981
1986	5.518	10.76	12.19	1980
1987	5.684	12.31	12.36	1984
1988	8.012	14.72	14.69	1989
1989	7.718	14.09	14.39	1988

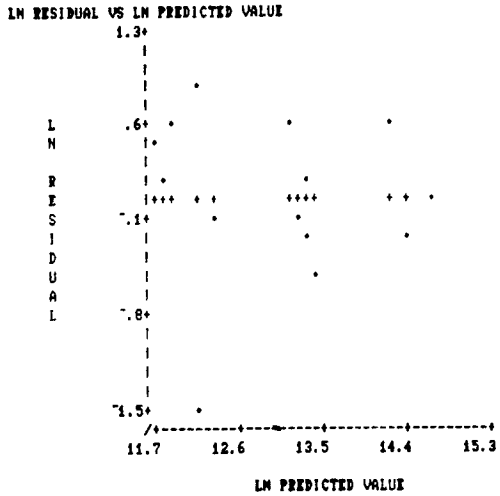
TREND IN LN RESIDUAL OVER TIME



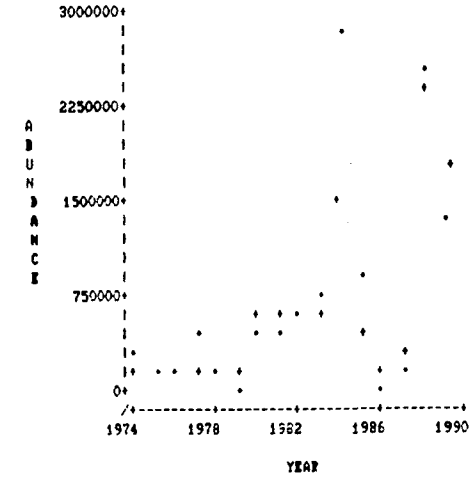
AGE 9 PLOTS
LN SURVEY NO. PER TOW VS LN SPA NUMBERS



LN RESIDUAL VS LN PREDICTED VALUE



TREND IN POPULATION ABUNDANCE OVER TIME



LN RESIDUAL VS OBSERVED LN X

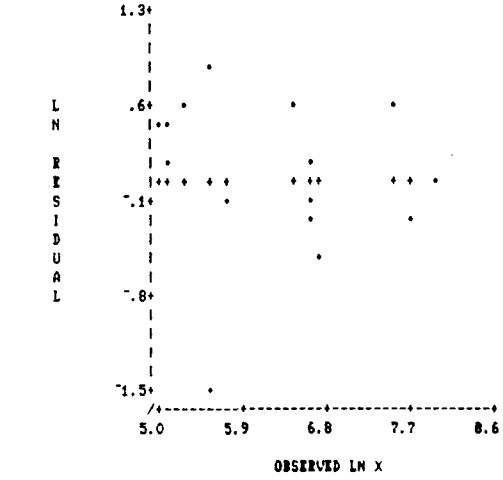


Figure 11. Age 2 recruits to 4VWX5Zc pollock.

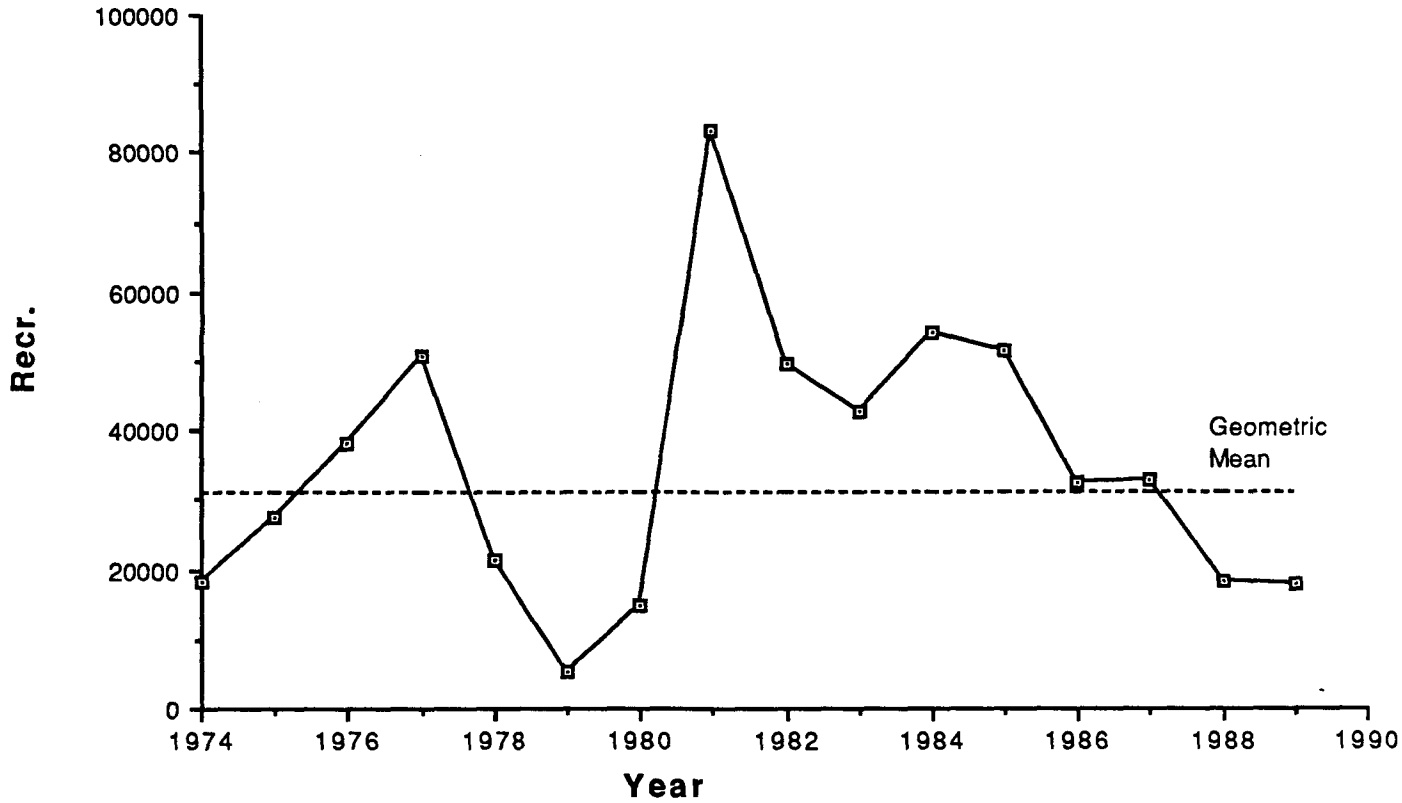


Figure 12. 2+ mid-year biomass for 4VWX5Zc pollock.

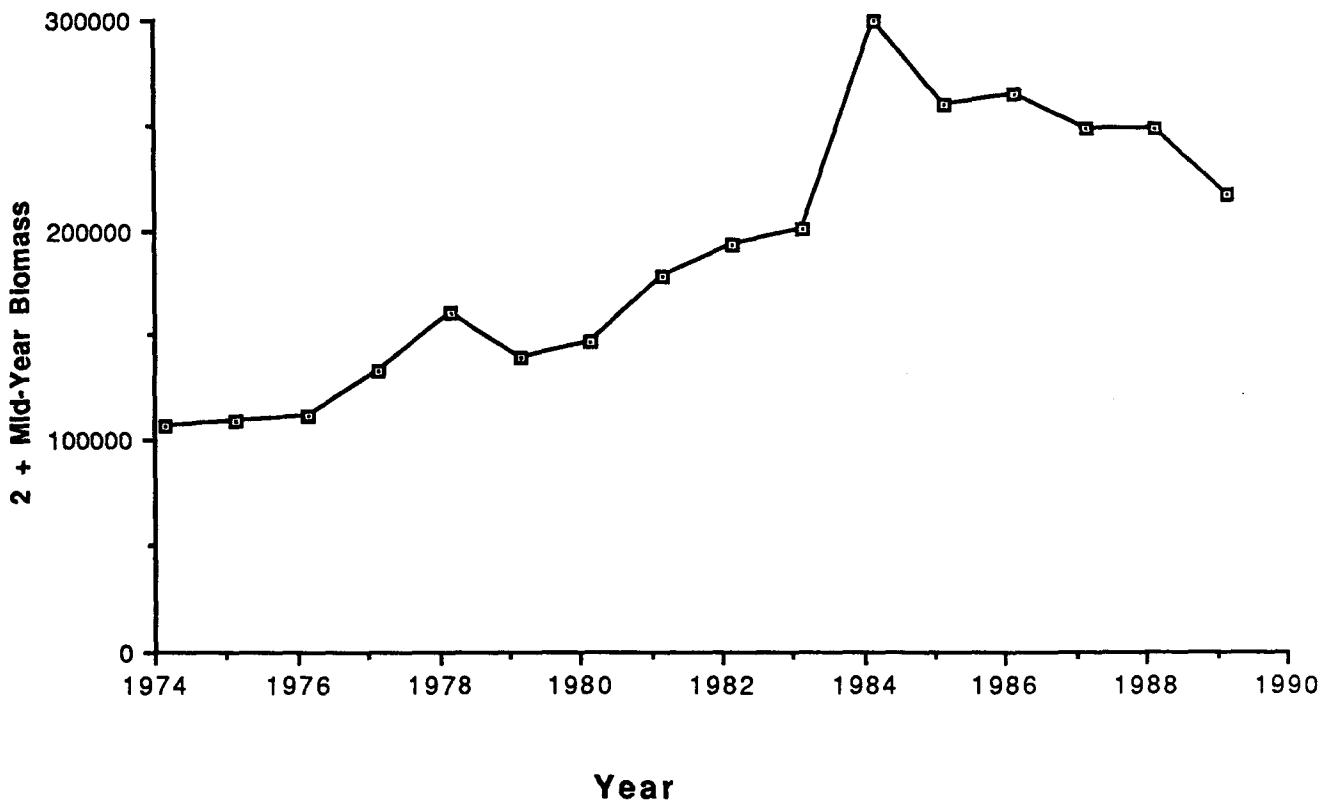


Figure 13. Population numbers (ages 4-9) for 4VWX5Zc pollock.

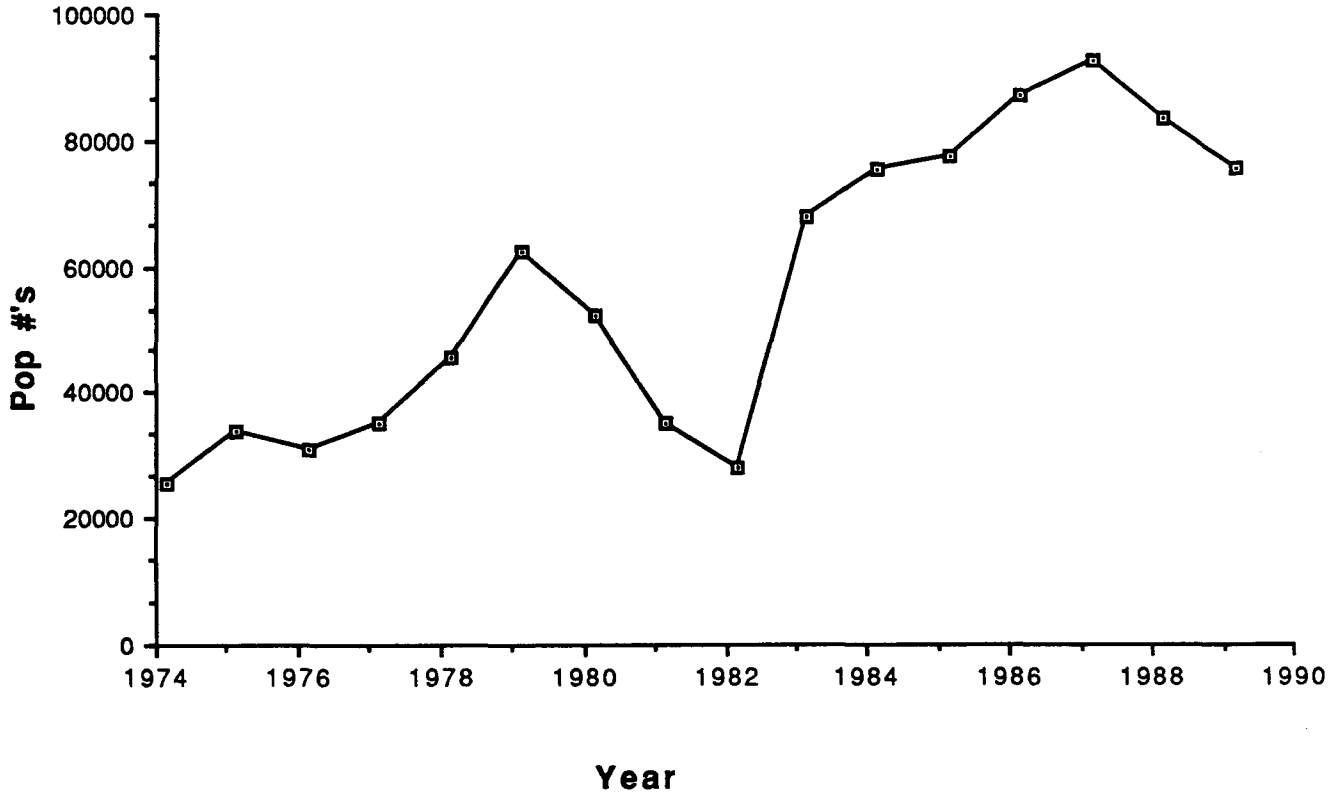
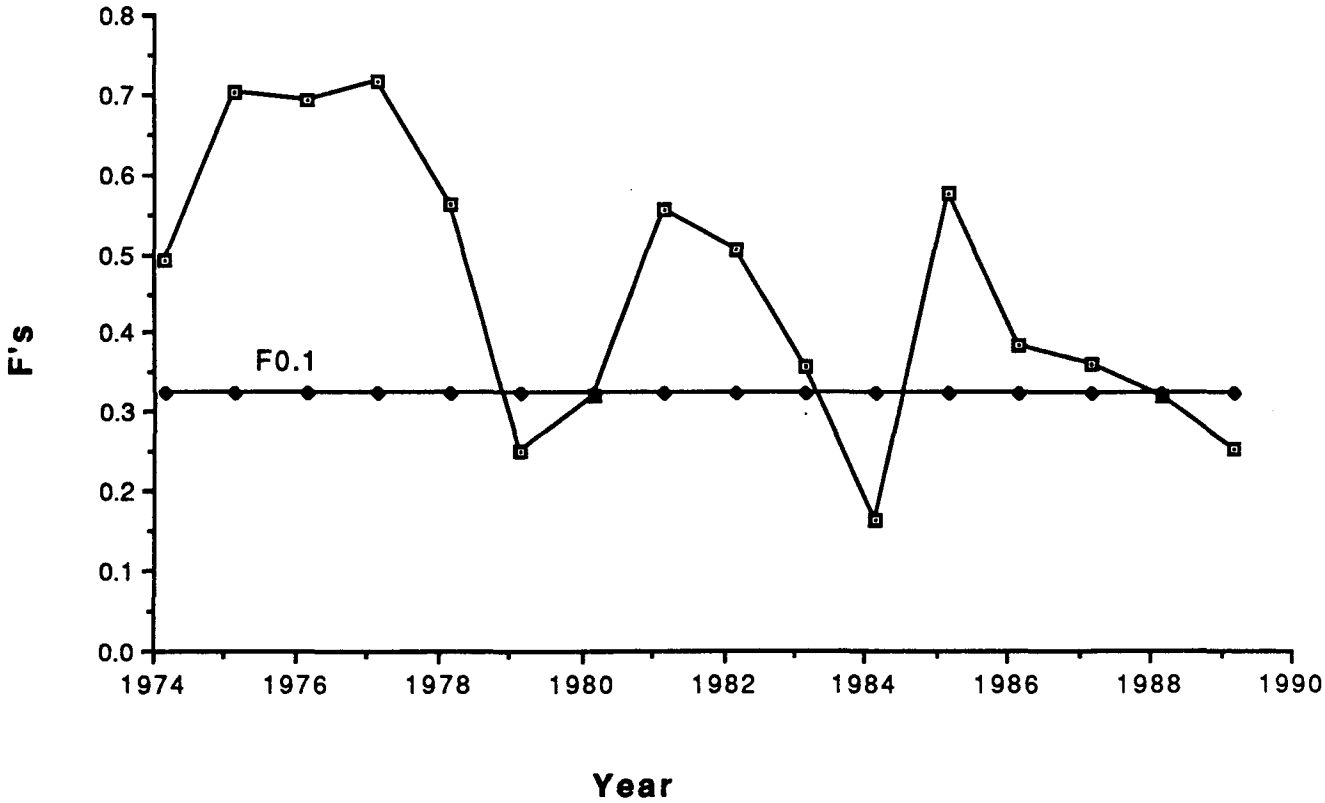


Figure 14. Fully recruited F for 4VWX5Zc pollock.



```
     ∇INPUT[⎕]∇
[0]  INPUT;ANS;i∆IN;Kin;SIN
[1]   c←⎕EX 'K'
[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[1]←DEFAULT INDEX∆TYPE[1]
[37]  SIN←1 ⋄ 0 0 ⍴⎕EX 'K'
[38] RVLP:→(SIN>INDEX∆TYPE[1])/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 = [B0] + B1 × POP '
```

```
[58]  (1=+/+/ise∆rv)/' LOG MODEL IS    LN(I) = LN( [B0] + B1 x POP ) '
[59]  ' '
[60]  Kin←DEFAULT 1↓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]  INDEX∆TYPE[2]←DEFAULT INDEX∆TYPE[2]
[71]  →(0=INDEX∆TYPE[2])/exit ⍝ No cpue index so go to exit
[72]  i∆cpue←⍎cpuename[1;]←30↑DEFAULT cpuename[1;]
[73] l1:'ESTIMATES OF STANDARD ERROR OF CPUE?  (1 FOR LOG MODEL OPTION) '
[74]  ise∆cpue←⍎cpuename[2;]←30↑DEFAULT cpuename[2;]
[75]  →((⍴i∆cpue)≠⍴ise∆cpue)/l1 ⍝ must be same length as i∆cpue
[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,((|1-¯1↑⍴K)↑¯9000),0
[88]  ubnd←ubnd,((|1-¯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]  USE∆CONSTRAINTS←0
[94]  ⍎(('Y'=ANS)∨'y'=ANS←⎕INKEY)/'USE∆CONSTRAINTS←1'
[95]  'Penalty functions turned ',(2 3 ⍴'OFFON ')[1+USE∆CONSTRAINTS;]
[96]  ' '
[97]  'Ready to run minipop'
```

```
      ∇minipop[⎕]∇
[0]   minipop;BOOL;J;DIAG;Q;LAMBDA;HESS;N;P;PAR;RSS;de;CAUSE;I;V;NPHI;PHI;pnlty;dpnlty;SHESS;NORM;I;Δts;A
[1]   ⍝ NON-LINEAR LEAST SQUARES USING MARQUARDT ALGORITHM
[2]    ⍎(2≠⎕NC 'verbose')/'verbose←1'
[3]    Δts←¯7↓TIMEFMT ⎕TS
[4]    'Do you wish to document your input ?'
[5]    ⍎(('Y'=ANS)∨'y'=ANS←⎕INKEY)/'miniDOC'
[6]    page Δts
[7]    rssvec←⍳0
[8]    P←⍴par←PAR←,initial
[9]    RSS←e+.×e←OBJΔFN PAR ⍝ RESIDUAL SUM OF SQUARES
[10]   N←⍴,e
[11]   pnlty←alpha PNLTYΔFN 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←DIFFΔOBJ
[23]   Q←2×e+.×de ⍝ GRADIENT
[24]   HESS←2×(⍉de)+.×de ⍝ HESSIAN
[25]   dpnlty←DIFFΔPNLTY ⍝ 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]   →(~FRGNΔFN par)/L4
[35]   RSS←e+.×e←OBJΔFN par
[36]   pnlty←alpha PNLTYΔFN 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]   →(~FRGNΔFN par)/L5
[42]   RSS←e+.×e←OBJΔFN par
[43]   pnlty←alpha PNLTYΔFN 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),(9.9999999
[50]   QPUT(~CAUSE)/[1]exit
[51]   ⍎(USEΔCONSTRAINTS)/'USEΔCONSTRAINTS←0 ⋄ ''TURNING CONSTRAINTS OFF''⋄→L3'
[52]   page Δts
[53]   OUTPUT
```

```
      ∇ITERCOHORT[⎕]∇
[0]   ITERCOHORT;CATCH;J;MORT;FI;FC;ITER;I;Y;X;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)-N
[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
```

```
      ∇DIFF∆PNLTY[⎕]∇
[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×P≥I←I+1
      ∇FRGN∆FN[⎕]∇
[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
```

```
      ∇DIFF∆PNLTY[⎕]∇
[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×P≥I←I+1
```

```
      ∇FRGN∆FN[⎕]∇
[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]   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↑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 matri
[13]   pr←1⌊F÷(⍴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]   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
```

```
      ∇RESI[⎕]∇
[0]   R←RESI K
[1]    R←⍳0
[2]    →(0=INDEX∆TYPE[1])/cpue ⍝ NO RV SURVEY
[3]    R←R,,POPIND RESI∆RV K[⍳⍴ROWS;]
[4]    ⍎(1<INDEX∆TYPE[1])/' R←R,,POPIND2 RESI∆RV2 K[(⍴ROWS)+⍳⍴ROWS;]'
[5]    ⍎(2<INDEX∆TYPE[1])/' R←R,,POPIND3 RESI∆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 RESI∆CPUE K
[9]   res:
```