Assessment of the 1989 4X Cod Fishery

by

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Abstract

The 1989 nominal catch of 4X cod was 19,585 t. The TAC of 12,000 t was greatly exceeded under CHP management, although the catch statistics are believed to be considerably more accurate than those of 1987 and 1988. Due primarily to the strength of the 1985 yearclass, indices of stock abundance from RV surveys are near the long-term mean after a substantial decline between 1985-87. Calibration of the SPA with the ADAPT framework indicated a terminal fishing mortality of 0.36. This estimate is is much lower than that of previous years, but is consistent with the mid-year closure of the fishery for MG < 65'. SPA biomass has recovered from the record-low level of 1985, and is now at a record-high level. The rapid increase in stock abundance is primarily due to the speed with which new yearclasses enter the fishery, and illustrates the difficulty of assessing this stock in the absence of predictions of incoming recruitment. Assuming that the nominal catch in 1990 is 20,000 t, the 1991 catch under the 50% rule would be 20,100 t.

Résumé

Les prises nominales de morues dans la division 4X en 1989 ont été de 19 585 t. Le TPA de 12 000 t a été grandement dépassé dans le cadre de la gestion morue/aiglefin/goberge, bien que les données statistiques sur les prises soient jugées beaucoup plus précises que celles de 1987 et 1988. À cause principalement de l'effectif de la classe d'âge de 1985, les indices de l'abonance du stock à partir des relevés des NR se rapprochent de la moyenne à long terme après un déclin substantiel entre 1985 et 1987. L'étalonnage de l'ASP à l'aide de la méthode ADAPT a indiqué une mortalité terminale par pêche de 0,36. Cette estimation est beaucoup plus faible que celle des années antérieures, mais est conforme avec la fermeture au milieu de l'année de la pêcherie pour les engins mobiles inférieurs à 65 pieds. La biomasse par ASP s'est rétablie du minimum record enregistré en 1985 et se situe maintenant à un maximum record. L'augmentation rapide de l'abondance du stock est attribuable principalement à la vitesse avec laquelle les nouvelles classes d'âge sont arrivées dans la pêcherie et illustrent bien combien il est difficile d'évaluer ce stock en l'absence de prévisions du recrutement à venir. En supposant que la prise nominale en 1990 soit de 20 000 t, les prises de 1991 en vertu de la règle de 50 % seraient de 20 100 t.

Nominal Catches

Historically, the cod fishery in Division 4X (Figure 1) has been prosecuted by the Canadian inshore fleet. Between 1947 and 1961, nominal catches for the Division averaged 15,000 t, with less than 3,000 t estimated as having come from the offshore grounds. The introduction of large Canadian and foreign trawlers in 1962 resulted in a rapid increase in catches, which peaked at 35,543 t in 1968 (Table 1). Imposition of quotas on 4X haddock by ICNAF in 1970 substantially reduced cod catches (to approximately 22,000 t), emphasizing the by-catch nature of many cod catches. Since 1976, the fishery has been nearly 100% Canadian and catches increased to almost 33,000 t; however, there was a marked decline in catches after 1982 to about 20,000 t, where it has remained since 1985 (Figure 2). The 1989 nominal catch was 19,585 t.

Both the fixed (< 65') and mobile (< 65') gear categories exceeded their allocations in 1989 (Table 2), largely because of the CHP (cod-haddock-pollock) management system which pooled each species quota. The fishery by both MG<65' and FG<65' was closed or restricted several times during the year (Table 3). However, the fishery was closed to MG 45-65' on July 19, and was not reopened for the remainder of the year. This relatively early closure had a significant impact on both catch and effort in the 4X cod fishery.

The accuracy of the 4X cod catch statistics is believed to have greatly improved in 1989 over those of previous years. In 1987 and 1988 in particular, substantial quantities of cod were either unreported during the year or incorrectly reported as other species such as white hake. Comments by fishermen, industry representatives, and port samplers all indicate that 1989 catch statistics were relatively accurate, due both to enhanced enforcement and the presence of CHP management. The small mobile gear sector has misreported 4X cod to 5Y in previous years (documented in Campana and Simon, MS 1985), necessitating adjustment of reported catches for stock assessment purposes. The problem has not been significant since 1986; nevertheless, the adjustment procedure was continued for the current assessment.

A breakdown of nominal catches by gear, tonnage class, and unit area over recent years is presented in Table 4. Landings were split relatively evenly between otter trawlers and fixed gear in 1989. Longline/handline catches have remained roughly stable since 1985, following record-high catches in the early 1980's (Fig. 3). Catches by TC-1 vessels accounted for 37% of the total in 1989, with gillnets (GN) accounting for over 1000 t of that catch. Catches in each of the major gear categories peaked in the summer months (Figure 4).

Stock Abundance Indices

Research Vessel Surveys

Random stratified surveys of the Scotian Shelf have been conducted since 1970; Strata 70-95 comprise the offshore and Bay of Fundy region of 4X (Figure 5). Inshore regions are not surveyed due to the prevalence of rough bottom. Surveys between 1970 and 1981 were carried out by the A.T. Cameron, while the Lady Hammond was used in 1982 and the Alfred Needler in subsequent years. All RV data have been presented in terms of Alfred Needler trawlable units (41' wingspread). As per the recommendation of the Statistics, Sampling and Surveys Subcommittee of CAFSAC, RV data prior to 1983 were multiplied by an inter-vessel conversion factor of 0.8.

Age-structured survey population indices were based on 2-6 sets in each stratum (Table 5). The 1989 indices of number and weight per tow were lower than those of 1988 (1988 was anomalously high due to large sets on Browns Bank)(Table 6), but were similar to the long-term mean. Survey 3-7 numbers and biomass have remained relatively stable since 1970, although both declined between 1984-87 (Table 7; see also Fig. 15). Age 5+ population numbers in 1989 were near a post-1970 record low level (Fig. 6), although the total biomass index was near the long-term mean (Fig. 7). Total biomass was apparently maintained at mean levels by the relatively large numbers of age 2-4 individuals in the population (Table 7; Fig. 8). Variation around the age-structured population indices was considerably lower than that of 1988 (Table 8). To determine if the 1989 population indices were unduly influenced by a few large sets, the deviation of the 1989 mean weights per tow for each stratum (from the long-term (1970-89) mean for each stratum) were calculated. Both the absolute (Fig. 9) and proportional (Fig. 10) deviations indicated that the RV population was distributed among many strata, and that the RV population size was very close to the long-term mean.

With respect to incoming recruitment, the 1985 year-class (age 4) appears to be particularly strong, while the 1987 cohort (age 2) may be above average (Figure 8).

The record low biomass of 4X haddock in recent years has led to informal discussions between industry and management concerning possible area closures which might protect the haddock stock and/or the juveniles of both cod and haddock. Given the mixed fishery in 4X, any area closure for haddock would inevitably affect the cod resource to some extent. As a preliminary assessment of the relative influence of an area closure on cod catches, the mean long-term (1970-88) distribution of 4X cod in the summer RV surveys was examined. Small cod (< 43 cm) were most concentrated near the mouth of the Bay of Fundy (on the eastern side), and on the offshore banks (Fig. 11). Large cod (> 50 cm) were more widely distributed, but were also most concentrated in the above areas (Fig. 12). The mean distribution in the spring and fall RV surveys was similar to that of the summer, although the spring distribution tended to be centred further offshore. Given the substantial overlap of the small and large cod in 4X, any area closure that might be implemented to protect the young cod would also be expected to protect a portion of the adult cod stock.

Commercial Catch Rates

Given the historic misreporting problem in the region, the multiple closures and fishery restrictions in recent years, and the low number of C/E observations per gear category (Campana and Hamel, MS1989), the use of commercial CPUE as an index of 4X cod abundance was discontinued in last years assessment. However, commercial CPUE had never been used to calibrate the SPA.

Age Composition of the Catch

In previous assessments, quarterly age-length keys were computed for each of the major gear types (pooled among tonnage classes) for the period 1948-88. Details of key construction and sample aggregation policy are described elsewhere (Campana and Simon, MS 1986). Fifty seven samples went into the construction of comparable keys for 1989. Length-weight relationships were derived from seasonal RV data on an annual basis; in years where spring or fall surveys were not conducted, seasonal means were applied.

Quarterly landings data, sample information, and the calculated numbers at age for each of the major gear categories in 1989 are presented in Table 9. Catch numbers-at-age for the miscellaneous gear category was computed quarterly, through a pro-rated comparison of miscellaneous landings with the sum of OT, LL, and GN landings. Foreign catches were treated similarly, but were pro-rated only on the basis of OT landings (since all foreign catches employed trawl gear). The data for previous years has been presented elsewhere (Campana and Simon, MS 1986, 1987, 1988; Campana and Hamel MS 1989).

Total catch numbers and percent catch numbers-at-age for the period 1948-89 are presented in Tables 10 and 11. A comparison of the 1989 catch composition and that predicted last year for 1989 indicates that all ages were reasonably well predicted, although the partial recruitments of ages 3 and 4 were slightly under-estimated (Figure 13). Fish of ages 3-4 made up 74% of the catch numbers and 63% of the catch weight in 1989 (Tables 11, 12). Catch composition curves indicate that age 5 fish were fully recruited to the fishery. No recent trends in mean weight-at-age in the catch (Table 13; Fig. 14) were noted, although there have been long-term trends (Table 13).

Estimation of Stock Size

Calibration of the SPA

The SPA was calibrated against RV population numbers through use of the ADAPT 2 framework (Gavaris MS 1988). In last year's assessment, the SPA-RV regression slopes and population numbers at ages 4-7 were estimated. Ten parameters were estimated in this year's assessment: population numbers at ages 3-7 in 1989 and the slopes of the regression relating SPA to RV population numbers at ages 3-7. All data were ln transformed. The ADAPT formulation used is summarized in Table 14.

The calibration model reached a stable optimum when fitted; the parameters remained constant after removal of the penalty function and were uncorrelated among themselves (Table 15). All parameters were significantly different from 0. Use of a model without an SPA:RV intercept was justified through fitting of a slope-intercept model; none of the intercepts were significantly different from 0, but 4 of the 5 slopes remained so. Examination of the age-by-age weighted calibration plots indicated that the model fit the data well. The residuals were usually randomly distributed across year, predicted values, and SPA population numbers. A comparison of the predicted and observed population numbers for ages 3-7 is presented in Figure 15.

The estimate of terminal F (5+) = 0.36 was smaller than that of previous years, but was consistent with the mid-year closure of the fishery for MG < 65'. To determine if the accuracy of the 1989 catch statistics (compared to the relative inaccuracy of the 1987-88 statistics) influenced the results, the SPA was recalibrated assuming the 1987-88 nominal catches by MG < 65' were 50% of the true value and that 1984-86 catches were 80% of the true value. The simulation resulted in about a 10% increase in terminal F and a corresponding decrease in the 1989 population. While the degree of misreporting assumed in the simulation was somewhat arbitrary, the results indicated that our perception of current stock status would not be unduly influenced by recent, moderate changes in catch reporting practices.

The results of the calibration indicated that the 1985 yearclass was the largest of the 42-year time series (55,000,000 at age 1). While it is clear from a variety of sources that the yearclass is indeed large, the ADAPT estimate may have been unduly influenced by a single large survey estimate (1988, age 3). It was for this reason that the age 2 population numbers in 1989 were set to the geometric mean (for the period 1948-88), rather than the much larger estimate based on mean PR.

Assessment Results

Population numbers and fishing mortalities corresponding to Ft = .36 are presented in Tables 16 and 17. The 1989 estimate of F = 0.36 is the lowest value in 13 years, and well below the long-term mean of 0.55 (Fig. 17). However, the relatively low value of F for 1989 can be ascribed almost entirely to the early closure of the fishery. The mean weight in the catch is well below that expected of F_{max}, let alone $F_{0.1}$ (Fig. 18). Nevertheless, biomass is increasing rapidly as the very strong 1985 yearclass moves through the fishery (Table 18; Fig. 16). The influence of the very weak 1984 yearclass has now largely dissipated. The 1984 and 1985 yearclasses make up the weakest and the strongest yearclasses, respectively, in 42 years (Fig. 19). Despite some uncertainty concerning the absolute strength of the 1985 yearclass, its influence is likely to be felt until 1992. The strength of the 1987 yearclass remains uncertain, but preliminary results suggest that it is above average. If the strength of the 1987 yearclass in 4X parallels that of Georges Bank cod in the same way it did in 1985, the outlook for upcoming recruitment is positive.

Prognosis

The fishable biomass of 4X cod will remain relatively high through 1991 as the strong 1985 yearclass moves through the fishery. Subsequent stock status will continue to depend heavily upon the strength of the incoming yearclasses.

The strength of the 1985 yearclass has a substantial impact on the subsequent catch projections. Thus, two scenarios were considered: a) the strength of the 1985 yearclass was as estimated in the assessment (55,000,000 at age 1), and b) the yearclass was somewhat less strong, as estimated by an ADAPT formulation using only ages 4-7, thus excluding the high 1988, age 3 RV survey point (30,500,000 at age 1). This latter estimate would still be the second highest recruitment level of the time series. However, Scenario b) was considered only to assess the relative influence of the 1985 and 1987 yearclass estimates of abundance. The assumed 1987 yearclass strength also had a significant influence on the 1991 and 1992 catch projections: in fact, the higher estimate for the 1987 yearclass (as calculated from the average PR at age 2) was sufficient to offset the effects of using a lower estimate for the size of the 1985 yearclass.

The accuracy of the catch projections in Table 19 was also influenced by the assumed 1990 catch. While CAFSAC advised a cod catch of 12,000 t (under the 50% rule), the 1990 fishery is operating under CHP management. Further, the TAC was changed to 22,000 t in June 1990. Assuming that the catch level of the past 5 years will persist into 1990, a 1990 catch of 20,000 t has been assumed in Table 19.

The assumed 1990 catch of 20,000 t corresponds to a fishing mortality of 0.26, which is well below the fishing mortality of previous years. Under the 50% rule, the 1991 catch at F = 0.23 would equal 20,100 t. The corresponding catch under Scenario b) would be 18,900 t.

Expected annual yield (long-term) at $F_{0.1}$ is 21,000 t for this stock (Campana and Hamel MS 1989).

Conclusions

Stock status as indicated by this assessment differs substantially from that of last year. Three factors contributed to the substantial change in perception. First, the strength of the 1985 yearclass was underestimated last year, in part because age 3 (the 1985 yearclass) was not included in the calibration. Second, despite a fishing mortality of 0.36, the 1989 F was 2/3 the size of previous years, largely due to the early closure of the fishery. And finally, the rapid growth and early age of recruitment in the fishery magnifies the influence of recruiting yearclasses, both with respect to catch composition and population biomass. In the absence of predictions of incoming recruitment, this problem is likely to continue, making it difficult to react to shifts in population growth until after they have become pronounced. As an example, during the 3 years it generally takes to feel confident of a trend in the data, a recruiting yearclass of 4X cod will go from a partial recruitment of 10% to fully recruited. Thus, the fishery will often

respond to a population shift well before it can be detected in the assessment. Research to define early predictors of incoming 4X cod recruitment, such as the possible correlation with 5Z cod recruitment, appears to be warranted.

Historic assessments of this stock have always reported overexploitation (Halliday, MS 1971, MS 1974; Sinclair, MS 1980; de Lafontaine, MS 1981; Gagne et al., MS 1983; Campana and Simon, MS 1984). This view of the fishery was substantiated in 1985 when the first analytical assessment of the 4X stock complex was presented (Campana and Simon, MS 1985). Extension of the SPA back to 1948 revealed a long history of overexploitation (Campana and Simon, MS 1986, MS 1987, MS 1988; Campana and Hamel, MS 1989). Our current view of the stock suggests that the 1989 rate of overexploitation would not have changed if the fishery had not been closed. The relative long-term stability of the stock is thus testament to its resilience. Resilience is further demonstrated by the rapid shift in stock status over the past 5 years, from a record-low biomass in 1985 to a record-high biomass in 1989. There has been no apparent relationship between stock and recruitment to this point (Campana and Hamel, MS 1989; Campana et al., 1989). Given the high rate of exploitation, the status of this stock is inexorably linked to the strength of the recruiting yearclasses.

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Table 1. 4X cod nominal catches (t) by country.

Year	Canada M&Q	Canada NLFD.	Spain	USSR	USA	FRG	France	Japan	Other	Total	% Canada	TAC
1948	17761				1999					19760	89.9	
49	14282				1799					16081	88.9	
1950	19088				1581					20669	92.4	
51	16543				1639					18182	91.0	
52	16570				1651					18221	90.9	
53	12903				1461					14364	89.8	
54	14406				2523		19			16948	85.0	
55	13432				1378					14810	90.7	
56	14849				1663					16512	89.9	
57	13619				1083					14702	92.6	
58	11103				1110					12213	90.9	
59	12866				862					13728	93.7	
1960	12123				1605					13728	88.3	
61	12424		2	9	1263					13698	90.7	
62	14656		3	80	1157					15896	92.2	
63	15849		1	684	1301	9				17844	88.8	
64	20767			2922	1413	338			15	25455	81.6	
65	24221		144	1553	871	125				26914	90.0	
66	24244		803	4961	966				5	30979	78.3	
67	27813		2536	667	1445					32461	85.7	
68	30770		2829	1061	859		24			35543	86.6	
69	24056		8217	1	448		3		1	32726	73.5	
1970	18001		3647	10	499			152		22309	80.7	
71	20180		2615	337	239			6		23377	86.3	
72	20490		1547	30	323	2				22392	91.5	
73	20002		1519	562	136			5		22224	90.0	
74	19005		1640	119	385	15	5		2	21171	89.8	
75	19493		900	207	480	3			5	21088	92.4	
76	16138		175		339				3	16655	96.9	
77	22002			4	760		185			22951	95.9	
78	23719	10		6	276	2		3	1	24017	98.8	
79	28647	28			46			1		28722	99.8	
1980	30735	355	2	94	75			10	6	31277	99.4	
81	31043	47			125			5		31220	99.6	
82	32701	9			234			1		32945	99.3	30000
83	28963			11	286			1		29261	99.0	30000
84	25068			5	189					25262	99.2	30000
85	21370				9					21379	100.0	30000
86	19869				43					19912	99.8	20000
87	18671				11					18682	99.9	17500
88	19766*				4					19770	100.0	14000
89	19581*				4					19585	100.0	12500

Sources: 1948-53 ICNAF Suppl. Ann. Proc. 11 (Appendix) (1962).
1954-66 NAFO Statistical Bulletins
1967-89 MFD Statistics: Foreign catches from NAFO Statistical Bulletins
* = Preliminary

Table 2. Canadian quota allocation and reported Maritime landings by gear category for cod in 4X and 5Y. Landings are derived from Atlantic quota reports (FG = fixed gear; MG = mobile gear).

		4X		5Y	
Year	Gear	Allocation	Reported Landings	Allocation	Reported Landings
1981	All gear	Unlimited	30742	192	599
1982	All gear	30000	31520	200	871
	FG < 65'	20250	20505	-	-
	MG < 65'	6000	7942	200	871
	FG 65-100'	200	168	-	-
	MG 65-100'	400	150	-	-
	> 100'	3150	2494	-	-
1983	All gear	30000	25610	1500	2578
	FG < 65'	20250	14892	700	176
	MG < 65'	8000*	9167	700	2394
	FG 65-100'	200	54	-	-
	MG 65-100'	400	192	-	-
	> 100'	3150	1305	100	8
1984	All gear	30000	24088	1500	1404
	FG < 65'	20250	12206	700	164
	MG < 65'	6000	10201	700	1240
	FG 65-100'	200	5	-	-
	MG 65-100'	400	88	-	-
	> 100'	3150	1588	100	0
1985	All gear	30000	20810	1500	1474
	FG < 65'	17000	9843	500	78
	MG < 65'	8900	9683	900	1392
	FG 65-100'	200	6	-	-
	MG 65-100'	400	38	-	-
	> 100'	3500	1240	100	4
1986	All gear	20000	18190	1500	686
	FG < 65'	9381*	8646	700	103
	MG < 65'**	8619*	8381	700	583
	FG 65-100'	130	0	-	-
	MG 65-100'	270	37	-	-
	> 100'	1600	1126	100	0
1987	All gear	17500	17531	1500	449
	FG < 65'	9690	9654	700	257
	MG < 65'**	5870	6360	700	161
	FG 65-100'	48	48	-	-
	MG 65-100'	160	98	-	-
	> 100'	1732	1371	100	31
1988	All gear	14000	19158	1500	803
	FG < 65'	7915	10888	700	203
	MG < 65'**	4340	7598	700	600
	FG 65-100'	70	0	-	-
	MG 65-100'	190	10	-	-
	> 100'	1485	662	100	0
1989[1]	All gear	12500	19365	965	341
	FG < 65'	7390	10027	750	261
	MG < 65'**	4050	8513	215	80
	FG 65-100'	55	0	-	-
	MG 65-100'	120	30	-	-
	> 100'	885	795	-	-

* Adjusted in mid-year.
[1] Preliminary
** Fishery closed or restricted several times during the year.

Table 3. Restrictions and closures of the 4X cod fishery in 1989.

Gear Category	Date	Restrictions and Options
Mobile <45'	Feb. 22 =	0 Kg/trip limit, 0% bycatch. Revoked Feb. 23.
	Mar. 16 =	0 Kg/trip limit, 0% bycatch. Revoked Mar. 22.
	Jul. 19 =	Specialists: closed for all CHP* fishing. Generalists: 2000 lbs CHP combined/trip.
	Aug. 02 =	0 Kg/trip limit, 0% bycatch. Revoked Aug. 04.
	Aug. 04 =	1) 3300 lbs CHP combined/trip. Max. 2 trips/period - Aug. 4-10; Aug. 11-17. or 2) 10% CHP combined/trip until Aug. 17.
	Aug. 23 =	1) 3300 lbs CHP combined/trip. Max. 2 trips/period - Aug. 21-24; Aug. 25-31. or 2) 10% CHP combined/trip until Aug. 31.
	Sept. 7 =	1) 3300 lbs CHP combined/trip. Max. 2 trips/period - Sept. 8-14. or 2) 10% CHP combined/trip until Sept. 14.
	Sept. 27=	1) 2000 lbs CHP combined/trip. Max. 2 trips/period - Sept. 26-Oct. 2. or 2) 10% CHP combined until Oct. 31.
	Oct. 04 =	10% CHP combined/trip until Oct. 31.
	Nov. 03 =	10% CHP combined/trip until Nov. 15.
	Nov. 16 =	No more permits to be issued.
Mobile 45-65'	Mar. 16 =	0 Kg/trip limit, 0% bycatch. Revoked Mar. 22.
	Jul. 19 =	Closed for all CHP fishing.
Fixed < 65'	Sept. 27=	35000 lbs. CH combined until Oct. 8.
Fixed < 45'	Oct. 11 =	1) 3300 lbs ea. CHP until Dec. 31. or 2) 3300 lbs ea. CH no limit on P until Oct. 20.
	Oct. 27 =	opt. 2) 3300 lbs ea. CH no limit on P until Oct. 31.
	Nov. 03 =	opt. 2) 3300 lbs ea. CH no limit on P until Nov. 30.
	Dec. 01 =	opt. 2) 3300 lbs ea. CH no limit on P until Dec. 31.
Fixed 45-65'	Oct. 11 =	No more permits to be issued.
	Nov. 03 =	0 Kg/trip limit, 10% bycatch until Nov. 30.
	Dec. 01 =	0 Kg/trip limit, 10% bycatch until Dec. 31.

* CHP: Cod Haddock Pollock

Table 4. Nominal catch (t) of 4X cod by Maritime vessels. Underlined catches represent the dominant TC for a gear/unit area.

Year	Unit[B] Area	OTB 1	OTB 2	OTB 3	OTB 4	OTB 5	LL/LHP[A] 1	LL/LHP 2	LL/LHP 3	LL/LHP 4	GN 1	GN 2	Misc.	Total	5Y[C]
1986	M	25	41	179	5	347	863	336	45	-	893	44	175	2953	
	N	-	148	553	172	533	1	262	116	-	-	1	62	1848	
	O	41	379	320	31	151	3143	219	59	-	324	27	40	4734	
	P	-	100	143	-	9	-	170	138	-	-	-	-	560	
	Q	103	764	751	4	-	153	31	-	-	8	-	47	1861	
	R	127	782	649	-	-	317	6	-	-	23	-	1	1905	
	S	148	425	314	-	-	455	13	-	-	174	31	2	1562	
	U	-	1257	1978	3	-	-	907	215	-	-	39	42	4441	
Total		443	3895	4888	216	1042	4932	1944	573	-	1422	142	369	19869	686
1987	M	11	92	49	35	81	809	133	-	-	1277	41	151	2679	
	N	-	152	275	301	586	6	201	47	-	-	3	52	1623	
	O	14	182	116	8	47	3651	293	64	-	329	45	37	4786	
	P	1	237	325	65	201	33	161	68	-	-	8	49	1148	
	Q	112	383	260	30	10	371	59	-	-	-	-	34	1259	
	R	126	252	74	-	-	385	-	-	-	18	8	3	866	
	S	82	328	75	-	-	522	16	-	-	175	19	2	1219	
	U	-	1071	2226	45	3	5	1259	297	22	1	42	112	5083	
Total		346	2697	3400	484	928	5782	2122	476	22	1800	166	440	18663	449
1988	M	4	67	85	-	146	537	77	1	-	446	9	80	1452	
	N	-	161	229	49	104	1	368	64	-	3	40	49	1068	
	O	57	218	123	31	38	4205	143	41	-	199	132	28	5215	
	P	2	456	255	18	99	49	238	98	-	-	54	1	1270	
	Q	96	262	112	49	36	327	103	55	-	2	-	39	1081	
	R	184	52	26	-	-	463	11	-	-	7	-	1	744	
	S	87	293	66	-	-	424	36	-	-	146	45	8	1105	
	U	18	2300	2437	7	-	9	2136	406	-	-	140	29	7482	
Total		448	3809	3333	154	423	6015	3112	665	-	803	420	235	19417	348
1989	M	7	14	15	1	-	554	70	19	-	618	1	69	1368	
	N	-	199	227	33	80	1	266	69	40	1	25	78	1019	
	O	66	576	230	-	91	4081	126	28	-	260	41	8	5507	
	P	-	797	1017	15	494	1	350	129	-	-	-	16	2819	
	Q	25	398	499	3	25	196	93	8	-	-	88	22	1357	
	R	143	225	302	-	-	436	1	-	-	1	-	3	1111	
	S	150	134	74	-	-	334	6	-	-	193	24	1	916	
	U	11	1504	1567	3	-	63	1421	343	-	-	253	9	5174	
Total		402	3847	3931	55	690	5666	2333	596	40	1073	432	206	19271	310

A LHP = handline

B See Figure 1 for location of unit area; U = unspecified.

C Catch reported in area 5Y by OTB tonnage class 2 and 3.

Table 5. NUMBER OF SETS PER STRATUM IN RV SURVEYS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
70	0	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2
71	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
72	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	4	4	5
73	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
74	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2
75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
76	2	2	2	2	2	3	2	4	2	0	2	2	2	2	2	2	2	4	4	4
77	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	5	4	4
78	2	2	3	2	3	3	3	3	2	3	3	3	3	3	3	3	3	2	2	2
80	4	4	4	2	3	3	4	4	3	4	3	3	4	4	4	4	4	4	4	4
81	5	3	4	5	4	3	4	2	5	4	3	4	4	4	4	4	4	6	7	6
82	2	2	2	2	2	2	3	2	2	3	2	2	2	2	2	2	2	3	3	3
83	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2
84	2	2	3	3	3	3	3	3	2	3	3	3	4	3	3	3	3	4	4	4
85	2	2	2	3	3	3	3	3	3	3	2	3	4	3	3	3	3	6	7	6
90	2	2	2	2	2	3	3	3	3	2	3	3	3	3	3	3	3	4	4	4
91	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
92	3	2	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
93	0	2	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
94	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
95	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2

Table 6.

MEAN NUMBERS PER TOW IN RV SURVEYS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
70	.0	3.5	.6	3.9	.0	.4	.0	2.3	.0	.8	.0	.0	.0	1.6	.0	.0	3.6	.0	.3	.0
71	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	1.2	.0	.0	.0	.6	.0
72	3.7	2.4	.0	.0	3.6	2.6	8.8	2.2	1.5	4.2	8.4	14.7	2.3	4.6	5.2	15.6	1.0	1.3	2.6	.2
73	2.9	7.0	2.9	5.8	6.8	5.6	9.2	8.6	8.0	4.2	2.0	4.6	1.7	12.1	2.7	10.1	4.5	2.6	4.5	2.0
74	7.3	2.6	4.0	16.8	5.9	8.0	9.9	9.2	1.9	11.4	2.1	15.1	5.4	24.1	.0	13.1	15.9	1.1	5.2	9.0
75	22.8	9.1	9.4	9.4	10.2	2.6	9.4	5.4	7.4	7.5	7.3	10.7	5.7	.0	9.4	18.2	6.2	7.3	7.7	21.1
76	49.5	65.3	21.8	3.6	9.8	9.4	14.0	3.9	2.7	.0	7.4	5.2	.4	24.3	10.3	1.5	3.9	.8	6.0	23.2
77	1.3	3.8	1.0	4.2	4.0	2.4	6.0	4.1	5.2	3.7	2.4	1.4	3.7	5.7	12.4	4.0	7.9	6.5	11.4	10.2
78	.0	.0	.0	.0	.2	.2	1.2	.8	6.1	1.1	.6	5.0	.3	.0	1.1	1.0	.0	.0	.0	.0
80	6.1	12.9	7.4	10.7	4.1	7.6	6.2	24.7	9.1	11.1	14.5	11.7	3.0	20.9	8.2	4.2	11.8	16.0	286.3	12.8
81	9.4	1.3	9.0	8.4	14.0	10.5	1.5	2.3	3.7	5.7	3.4	1.6	4.5	8.5	17.0	2.3	3.4	3.7	34.5	11.4
82	3.1	.0	.0	.0	1.5	9.8	1.3	2.6	1.8	3.0	3.1	.5	3.0	.5	2.4	.0	.0	.4	3.2	5.5
83	.3	.0	7.0	.0	.0	.0	.0	1.3	.9	.0	.6	1.2	.4	.0	1.0	.5	.0	.0	.0	.0
84	.0	.8	.5	.8	1.3	.4	2.8	.3	.0	2.2	.0	1.0	.4	.0	2.4	.0	.0	2.5	1.1	.2
85	6.8	1.7	1.2	6.0	.9	4.8	.9	12.4	2.0	3.5	5.7	9.6	6.9	2.3	13.1	7.5	5.9	4.0	8.9	7.8
90	10.7	6.1	10.5	4.4	19.3	37.8	4.1	15.2	14.0	10.4	6.2	31.9	16.3	10.8	13.7	120.9	30.7	15.0	58.0	57.6
91	1.9	3.0	9.5	4.9	2.9	4.8	13.2	16.1	14.8	60.0	16.3	14.5	7.6	18.3	46.9	32.4	10.6	8.6	20.0	4.6
92	2.4	2.7	6.3	1.4	5.2	11.1	4.7	11.5	3.7	13.4	1.2	10.4	26.0	11.0	3.1	22.2	9.7	3.0	37.7	4.6
93	.0	.3	1.9	1.4	3.9	9.9	8.4	1.5	6.3	6.3	7.2	7.1	13.6	9.9	24.7	40.6	9.3	5.9	10.3	41.2
94	1.1	5.8	2.4	4.8	.8	16.4	12.6	3.9	2.9	1.6	12.4	3.4	.4	.0	13.9	4.1	1.0	10.9	2.1	2.1
95	2.5	7.7	14.9	4.7	18.0	9.8	7.4	24.0	.0	26.7	36.9	19.8	4.9	.9	21.6	35.3	7.2	5.7	7.5	4.4

MEAN WEIGHT (KG) PER TOW IN RV SURVEYS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
70	.0	8.9	.9	12.7	.0	2.3	.0	6.5	.0	.3	.0	.0	.0	1.6	.0	.0	6.2	.0	.3	.0
71	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
72	10.6	4.6	.0	.0	4.9	6.6	14.4	2.2	2.9	8.0	19.2	7.9	1.6	6.5	5.7	16.0	.0	1.8	1.9	.0
73	3.2	10.6	7.8	12.4	7.5	8.3	25.0	28.7	13.4	17.3	5.3	3.8	2.2	7.5	3.3	20.6	9.3	9.3	10.8	4.4
74	19.9	10.3	14.3	19.2	12.8	14.5	27.8	26.0	5.7	29.4	9.9	33.7	16.5	38.5	.0	30.3	44.9	2.2	8.2	20.6
75	70.1	26.5	22.5	16.1	23.0	14.0	14.1	8.7	15.3	20.9	10.8	31.9	15.2	.0	19.3	23.5	4.6	4.9	10.3	43.8
76	121.1	52.5	51.2	7.1	32.1	22.3	26.2	9.0	10.5	.0	12.1	16.0	.0	38.5	19.0	2.4	6.4	3.4	10.8	19.6
77	3.0	9.6	1.2	8.5	7.0	3.1	9.3	17.7	4.9	7.9	15.6	2.8	10.8	10.8	22.7	7.5	19.0	17.9	22.4	7.8
78	.0	.0	.0	.0	.2	.4	2.4	2.2	10.7	2.8	3.5	19.7	2.0	.0	1.0	6.8	.0	.0	.0	.0
80	17.3	17.7	15.9	30.4	11.3	11.3	11.0	43.4	18.0	28.8	48.3	15.9	9.8	35.1	15.9	12.3	40.4	14.4	265.4	28.5
81	25.7	3.5	26.8	18.1	23.9	25.0	3.3	5.0	7.4	32.0	9.1	4.1	13.1	14.4	17.8	4.4	5.8	8.0	47.1	11.4
82	12.8	.0	.0	.0	2.3	39.7	5.2	11.1	4.6	14.0	14.3	1.1	3.7	1.0	6.8	.0	.0	1.1	9.7	13.4
83	3.2	.0	15.6	.0	.0	.0	.0	6.1	6.1	.0	5.2	8.6	.4	.0	5.2	1.0	.0	.0	.0	.0
84	.0	3.9	1.3	3.0	13.1	1.1	9.9	.6	.0	7.4	.0	2.1	.7	.0	6.5	.0	.0	8.7	2.2	.7
85	19.8	6.5	5.4	18.4	2.5	19.1	.9	26.9	6.7	8.7	21.6	28.0	15.2	7.0	18.6	26.9	10.4	12.1	11.4	16.7
90	17.7	10.8	27.3	7.4	42.2	59.9	6.2	30.8	43.0	12.9	21.4	42.0	41.5	25.3	19.3	153.0	60.5	21.0	62.6	77.5
91	10.6	9.7	38.9	14.0	10.4	13.4	65.8	37.3	42.5	64.0	44.6	40.9	22.1	34.1	74.9	93.4	29.5	45.0	53.9	11.1
92	12.0	14.8	25.5	4.9	17.4	42.0	16.7	47.1	13.3	45.2	5.7	45.7	101.2	48.4	13.7	39.9	32.1	20.1	100.1	16.4
93	.0	.0	6.5	3.2	7.4	28.1	30.7	4.2	33.4	9.2	25.0	28.2	40.3	36.1	44.2	78.0	17.4	21.0	18.1	71.5
94	.6	6.0	12.9	13.7	4.7	32.6	33.8	13.1	8.0	6.2	.4	3.1	1.1	.0	30.5	6.2	1.0	17.8	7.2	2.6
95	17.8	8.5	36.6	14.6	32.8	14.9	18.5	50.2	.0	52.3	16.8	47.5	7.5	1.4	33.4	45.9	14.9	14.4	7.3	16.4

Table 7.

MID-YEAR RV, STRATIFIED MEAN NO/TOW 1/ 1/80

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	.01	.00	.00	.01	.06	.00	.00	.00	.01	.00	.93	.03	.04	.09	.00	.04	.02	.00	.18	.20
1	.48	.18	.15	.06	.21	.52	.08	.13	.10	1.39	.10	1.13	.37	.09	.52	.31	.48	.24	1.66	.50
2	.76	3.58	.73	1.07	.49	1.43	.64	1.09	.54	1.75	.45	1.22	.91	.68	3.44	5.57	.64	1.49	6.06	3.89
3	1.19	1.99	1.62	.57	2.29	.82	1.43	2.16	.88	.89	1.43	1.16	.90	2.62	2.25	2.67	1.67	.37	10.24	2.12
4	2.09	.32	1.28	1.13	.54	1.50	1.18	1.32	1.26	1.01	.58	1.30	.94	1.50	1.50	.95	.81	.72	1.77	1.66
5	.92	.74	.36	.36	.82	1.27	1.04	.40	.68	.91	.53	.68	.78	.93	1.23	.97	.23	.38	1.08	.28
6	1.22	.34	.25	.14	.48	.50	.42	.65	.25	.51	.72	.44	.44	.58	.45	.50	.40	.17	.33	.31
7	.53	.47	.11	.08	.06	.40	.21	.18	.19	.23	.23	.24	.12	.24	.32	.34	.29	.14	.13	.02
8	.26	.02	.27	.03	.00	.08	.12	.11	.05	.16	.11	.20	.13	.00	.04	.19	.14	.20	.19	.02
9	.09	.00	.20	.09	.02	.05	.03	.02	.04	.03	.06	.05	.11	.05	.04	.10	.06	.05	.04	.05
10	.05	.01	.08	.02	.01	.00	.03	.01	.00	.03	.00	.05	.03	.02	.02	.01	.01	.03	.00	.03
11	.01	.00	.01	.01	.02	.06	.01	.01	.00	.04	.04	.01	.02	.00	.00	.00	.00	.04	.00	.01
12	.00	.00	.01	.00	.00	.01	.00	.01	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00
0+	7.61	7.66	5.08	3.59	5.01	6.62	5.20	6.10	3.99	6.95	5.18	6.53	4.80	6.80	9.82	11.65	4.74	3.84	21.68	9.09
1+	7.60	7.66	5.08	3.58	4.96	6.62	5.20	6.10	3.98	6.95	4.26	6.50	4.76	6.72	9.82	11.61	4.72	3.84	21.50	8.89
2+	7.12	7.48	4.92	3.52	4.75	6.11	5.12	5.97	3.88	5.57	4.15	5.37	4.39	6.63	9.30	11.29	4.25	3.59	19.84	8.39
3+	6.35	3.90	4.19	2.45	4.25	4.67	4.48	4.87	3.34	3.81	3.71	4.14	3.48	5.95	5.86	5.73	3.61	2.10	13.78	4.51
4+	5.17	1.90	2.58	1.88	1.96	3.86	3.05	2.72	2.47	2.92	2.27	2.99	2.58	3.33	3.61	3.05	1.94	1.73	3.53	2.39
5+	3.08	1.58	1.29	.74	1.42	2.36	1.87	1.40	1.20	1.91	1.70	1.68	1.64	1.83	2.10	2.11	1.13	1.01	1.76	.73
6+	2.16	.84	.93	.38	.59	1.09	.82	.99	.52	1.00	1.16	1.00	.86	.89	.87	1.14	.90	.62	.68	.45
7+	.93	.50	.68	.24	.12	.59	.40	.35	.27	.49	.44	.56	.42	.31	.42	.64	.50	.46	.36	.14
8+	.40	.03	.57	.16	.06	.20	.19	.16	.08	.26	.21	.32	.30	.07	.10	.30	.21	.31	.23	.10
9+	.14	.01	.30	.13	.06	.12	.07	.06	.04	.10	.10	.12	.17	.07	.06	.11	.07	.12	.04	.08
10+	.05	.01	.10	.04	.03	.07	.04	.03	.00	.07	.04	.06	.06	.02	.02	.01	.01	.07	.00	.04
11+	.01	.00	.02	.02	.02	.07	.01	.02	.00	.04	.04	.02	.03	.00	.00	.00	.00	.04	.00	.01
12+	.00	.00	.01	.00	.00	.01	.00	.01	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00

Table 8.

COEFFICIENT OF VARIATION FOR RV STRATIFIED MEAN NO/TOW 2/ 5/90

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1.00	.00	.00	1.02	.93	.00	.00	.00	1.01	.00	.86	1.00	.90	.75
1	.33	.37	.47	.67	.69	.32	.63	.38	.60	.80	.68	.69	.51	.72
2	.64	.82	.66	.25	.33	.28	.40	.27	.34	.38	.43	.28	.30	.37
3	.66	.83	.45	.26	.26	.26	.40	.25	.33	.29	.29	.28	.27	.24
4	.66	.55	.32	.25	.32	.26	.40	.24	.24	.25	.29	.21	.24	.18
5	.57	.46	.29	.31	.19	.29	.27	.31	.23	.25	.19	.25	.23	.42
6	.50	.40	.28	.25	.33	.33	.24	.27	.19	.26	.21	.19	.25	.35
7	.46	.28	.42	.43	.82	.46	.38	.35	.29	.48	.24	.30	.18	.38
8	.47	.52	.22	.38	.00	.67	.47	.52	.50	.75	.31	.31	.30	.00
9	.51	.00	.47	.54	.74	.59	.51	.45	.29	.85	.57	.49	.48	.59
.0	.69	1.01	.39	.60	.63	.00	.35	.70	.00	.68	.00	.52	.56	.38
.1	1.04	.00	.58	.50	.69	1.00	.98	.80	.00	.72	.93	1.01	.49	.00
.2	.00	.00	.58	.95	.00	.59	.00	.96	.00	.00	.00	.97	1.01	.00

	1984	1985	1986	1987	1988	1989
0	.00	.72	.99	1.07	.53	.60
1	.52	.44	.67	.64	.42	.33
2	.43	.47	.37	.25	.65	.37
3	.45	.42	.32	.26	.52	.29
4	.32	.34	.30	.25	.55	.27
5	.30	.26	.35	.33	.38	.26
6	.27	.27	.26	.40	.39	.38
7	.31	.36	.32	.35	.55	.42
8	.71	.54	.32	.30	.59	1.00
9	.62	.55	.67	.62	.62	.67
.0	.99	1.03	1.01	.65	.00	.43
.1	.00	.00	.00	.67	.00	1.00
.2	.00	.96	.00	.00	.00	.00

Table 9. Input data used in the construction of the 1989 catch-at-age matrix. A) Quarterly landings used in calculation of numbers-at-age (foreign landings are annual), B) Number of samples available for key construction, C) Length-weight parameters (A/B) and D) Numbers-at-age ('000) by gear type.

(A)

Otter Trawl				Longline and Handline				Gillnet				Miscellaneous				
1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	Foreign
3846	4297	531	561	1915	1800	3493	1427	29	268	899	309	61	112	20	13	4

(B)

Gear	Jan-Mar	Apr-June	July-Sept	Oct-Dec
OT	16	13	2	2
LL	6	3	7	4
GN	0	2	1	1

(C)

Jan-Mar	Apr-June	July-Sept	Oct-Dec
.0081/3.0503	.0084/3.041	.0084/3.0465	.0063/3.1152

(D)

Age	OT	LL	GN	MISC	FOREIGN
1	10	0	0	0	0
2	368	143	1	6	0
3	1371	806	102	25	1
4	1868	1614	240	39	1
5	413	252	35	9	0
6	315	262	30	7	0
7	104	49	3	2	0
8	33	46	2	1	0
9	17	34	2	1	0
10	3	13	2	0	0
11	2	5	0	0	0
12	2	3	0	0	0
13	0	2	0	0	0
14	0	0	0	0	0
15	0	1	0	0	0
16	0	0	0	0	0

Table 10. TOTAL CATCH NUMBERS AT AGE (THOUSANDS) 2/ 5/90

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1	0	0	0	1	0	0	0	5	0	0	0	0	0	0
2	36	489	660	295	763	120	260	54	105	0	160	0	0	11
3	806	1475	1947	2626	1265	860	482	1279	622	211	831	326	0	265
4	1617	1431	3274	1898	2927	724	2024	662	2395	365	1257	1986	275	409
5	1639	930	1441	1465	1189	1407	909	1236	731	1442	585	1726	966	1940
6	676	908	773	500	557	450	1051	521	584	234	805	1093	804	901
7	270	67	732	468	361	222	358	583	505	602	84	417	273	320
8	364	105	40	277	170	74	139	190	470	288	168	409	336	97
9	363	150	51	82	254	175	129	58	116	341	149	87	196	79
.0	265	162	91	26	30	219	136	34	40	288	94	0	107	41
.1	103	52	13	107	21	73	91	60	78	0	23	25	51	18
.2	50	16	67	71	13	16	35	32	78	94	10	16	13	9
.3	51	30	6	16	28	0	31	16	47	136	7	0	30	0
.4	74	9	1	16	6	27	23	4	9	64	0	0	0	0
.5	26	23	31	7	0	0	13	0	0	0	7	0	0	0
.6	0	0	1	0	0	0	2	4	0	0	0	0	0	0

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	0	0	32	15	17	11	456	272	553	358	331	101	766
3	792	396	106	1498	1909	1601	1690	2557	1341	1302	2446	1857	2193	1556
4	2057	1972	751	2576	4703	6321	2575	2047	1398	1031	3071	2432	2088	2955
5	2734	1576	3104	2903	3372	3690	6149	2277	1565	1324	1903	1952	1814	1022
6	1183	1083	2550	2194	1753	1271	2554	2014	980	1062	953	676	1171	679
7	513	927	852	701	1108	480	459	595	435	452	165	295	267	365
8	237	301	768	271	357	388	191	195	78	388	122	75	209	88
9	81	222	385	78	44	142	246	140	215	165	141	159	116	58
.0	55	39	78	41	65	36	59	229	52	159	67	68	109	35
.1	6	41	27	23	26	46	40	25	17	32	4	52	98	26
.2	0	33	83	7	24	11	31	8	26	72	2	15	39	14
.3	12	17	8	9	5	2	6	8	0	87	1	7	9	8
.4	3	7	0	1	0	1	6	5	0	0	4	8	13	0
.5	3	4	0	0	0	0	3	10	0	43	0	15	20	0
.6	0	0	10	0	3	5	10	20	0	7	18	0	17	1

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	2	0	0	0	0	0	4	39	0	0	0	0	10
2	410	1609	285	326	885	886	982	766	804	888	147	1055	439	519
3	1693	3063	1803	1294	4773	4063	2549	3896	2381	1594	3129	784	2996	2305
4	2476	1683	2274	3405	1952	4424	4476	2112	3243	1488	2204	2140	1665	3763
5	1401	1606	1991	2632	2476	1684	3332	2376	1845	2458	906	1016	1534	709
6	467	775	2188	1217	1288	1017	873	1148	923	1159	985	472	686	615
7	190	272	636	703	426	535	398	620	444	491	343	478	211	158
8	122	257	199	218	242	299	301	251	159	174	164	230	207	83
9	74	101	55	99	86	165	140	136	54	66	82	111	96	54
.0	18	81	49	79	51	65	99	71	50	44	37	56	59	17
.1	7	36	9	23	12	27	52	52	31	26	15	31	35	7
.2	2	39	16	13	16	18	27	9	22	8	15	8	9	6
.3	4	10	6	3	4	20	18	18	6	8	9	7	10	2
.4	1	25	2	7	1	6	0	5	2	2	0	4	2	0
.5	2	2	1	0	1	2	4	0	4	1	2	3	1	1

Table 11. PERCENT NUMBERS AT AGE 29/ 3/90

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.01	.08	.07	.04	.10	.03	.05	.01	.02	.00	.04	.00	.00	.00	.00	.00	.00
3	.13	.25	.21	.33	.17	.20	.08	.27	.11	.05	.20	.05	.00	.06	.10	.06	.01
4	.25	.24	.36	.24	.39	.17	.36	.14	.41	.09	.30	.33	.09	.10	.27	.30	.09
5	.26	.16	.16	.19	.16	.32	.16	.26	.13	.35	.14	.28	.32	.47	.36	.24	.36
6	.11	.16	.08	.06	.07	.10	.18	.11	.10	.06	.19	.18	.26	.22	.15	.16	.29
7	.04	.01	.08	.06	.05	.05	.06	.12	.09	.15	.02	.07	.09	.08	.07	.14	.10
8	.06	.02	.00	.04	.02	.02	.02	.04	.08	.07	.04	.07	.11	.02	.03	.05	.09
9	.06	.03	.01	.01	.03	.04	.02	.01	.02	.08	.04	.01	.06	.02	.01	.03	.04
10	.04	.03	.01	.00	.00	.05	.02	.01	.01	.07	.02	.00	.04	.01	.01	.01	.01
11	.02	.01	.00	.01	.00	.02	.02	.01	.01	.00	.01	.00	.02	.00	.00	.01	.00
12	.01	.00	.01	.01	.00	.00	.01	.01	.01	.02	.00	.00	.00	.00	.00	.00	.01
13	.01	.01	.00	.00	.00	.00	.01	.00	.01	.03	.00	.00	.01	.00	.00	.00	.00
14	.01	.00	.00	.00	.00	.01	.00	.00	.00	.02	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.04	.04	.08	.04	.04	.01	.10	.06	.17	.03	.03	.07	.07
3	.14	.14	.11	.12	.24	.21	.19	.26	.23	.27	.21	.25	.32	.19	.13	.39	.31
4	.25	.35	.45	.18	.19	.22	.15	.33	.31	.25	.39	.36	.18	.24	.34	.16	.33
5	.28	.25	.26	.44	.22	.25	.20	.21	.25	.22	.13	.20	.17	.21	.26	.20	.13
6	.21	.13	.09	.18	.19	.15	.16	.10	.09	.14	.09	.07	.08	.23	.12	.11	.08
7	.07	.08	.03	.03	.06	.07	.07	.02	.04	.03	.05	.03	.03	.07	.07	.03	.04
8	.03	.03	.03	.01	.02	.01	.06	.01	.01	.03	.01	.02	.03	.02	.02	.02	.02
9	.01	.00	.01	.02	.01	.03	.02	.02	.02	.01	.01	.01	.01	.01	.01	.01	.01
10	.00	.00	.00	.00	.02	.01	.02	.01	.01	.01	.00	.00	.01	.01	.01	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.01	.01	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
13	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.00	.00	.00	.00	.00	.00	.00
2	.07	.07	.08	.11	.02	.16	.06	.06
3	.19	.34	.24	.19	.39	.12	.38	.28
4	.34	.18	.32	.18	.27	.33	.21	.46
5	.25	.21	.18	.29	.11	.16	.19	.09
6	.07	.10	.09	.14	.12	.07	.09	.07
7	.03	.05	.04	.06	.04	.07	.03	.02
8	.02	.02	.02	.02	.02	.04	.03	.01
9	.01	.01	.01	.01	.01	.02	.01	.01
10	.01	.01	.00	.01	.00	.01	.01	.00
11	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00
13	.00	.00	.00	.00	.00	.00	.00	.00
14	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00	.00

Table 12.

PERCENT CATCH WEIGHT AT AGE 29/ 3/90

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.04	.03	.01	.04	.01	.01	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00
3	.05	.12	.11	.17	.10	.09	.04	.09	.04	.01	.08	.01	.00	.02	.04	.01	.00
4	.12	.20	.28	.17	.30	.12	.20	.09	.25	.03	.15	.17	.03	.05	.14	.13	.03
5	.17	.16	.20	.21	.17	.34	.15	.26	.11	.24	.13	.23	.16	.37	.26	.18	.22
6	.10	.20	.13	.11	.10	.12	.27	.16	.14	.05	.29	.18	.21	.27	.21	.18	.28
7	.06	.02	.13	.13	.11	.09	.10	.22	.16	.13	.04	.15	.12	.13	.16	.23	.11
8	.11	.04	.02	.08	.05	.04	.05	.07	.15	.10	.09	.17	.15	.04	.10	.11	.16
9	.12	.07	.02	.03	.07	.05	.04	.03	.04	.16	.10	.06	.13	.05	.04	.08	.12
10	.09	.08	.04	.01	.01	.09	.04	.02	.01	.12	.07	.00	.09	.03	.03	.02	.03
11	.05	.03	.01	.04	.01	.04	.04	.02	.04	.00	.02	.02	.06	.02	.00	.03	.01
12	.03	.01	.03	.03	.01	.01	.01	.02	.03	.04	.00	.01	.01	.01	.00	.02	.03
13	.03	.02	.00	.01	.02	.00	.02	.01	.02	.07	.01	.00	.04	.00	.01	.01	.00
14	.06	.00	.00	.01	.01	.01	.02	.00	.00	.04	.00	.00	.00	.00	.00	.00	.00
15	.02	.02	.02	.00	.00	.00	.01	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.01	.01	.01	.01	.01	.00	.02	.01	.07	.01	.01	.02	.02
3	.05	.06	.05	.04	.10	.09	.05	.16	.11	.10	.09	.12	.17	.11	.06	.21	.16
4	.16	.24	.32	.11	.12	.14	.08	.28	.24	.14	.30	.31	.14	.17	.23	.13	.28
5	.26	.26	.28	.39	.23	.24	.16	.21	.28	.21	.15	.24	.17	.19	.27	.23	.15
6	.28	.19	.13	.24	.25	.24	.18	.18	.11	.22	.20	.12	.15	.31	.17	.19	.12
7	.13	.14	.08	.07	.10	.13	.12	.04	.07	.06	.11	.07	.07	.11	.13	.09	.10
8	.06	.06	.08	.04	.05	.03	.12	.04	.03	.06	.04	.06	.09	.05	.05	.05	.07
9	.03	.01	.03	.05	.04	.06	.07	.04	.07	.04	.03	.05	.04	.01	.03	.03	.04
10	.02	.02	.01	.02	.06	.02	.07	.02	.04	.04	.02	.01	.03	.02	.03	.02	.02
11	.01	.01	.01	.01	.01	.01	.02	.00	.02	.05	.02	.01	.02	.00	.01	.00	.01
12	.00	.01	.00	.01	.00	.02	.04	.00	.01	.03	.01	.00	.03	.00	.01	.01	.01
13	.00	.00	.00	.00	.00	.00	.05	.00	.01	.01	.00	.00	.01	.00	.00	.00	.01
14	.00	.00	.00	.00	.00	.00	.00	.00	.01	.01	.00	.00	.02	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.03	.00	.01	.01	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.01	.00	.00	.01	.00	.01	.00	.00	.01	.00	.00	.00	.00

	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.00	.00	.00	.00	.00	.00	.00
2	.02	.02	.03	.03	.01	.05	.02	.02
3	.10	.17	.14	.10	.21	.06	.20	.19
4	.25	.13	.26	.14	.22	.25	.16	.44
5	.29	.21	.20	.29	.12	.17	.21	.10
6	.11	.16	.14	.19	.20	.10	.14	.13
7	.07	.12	.10	.11	.09	.14	.06	.04
8	.06	.07	.05	.06	.06	.10	.09	.04
9	.04	.05	.02	.02	.04	.05	.05	.03
10	.03	.03	.02	.02	.02	.04	.03	.01
11	.02	.02	.02	.01	.01	.02	.02	.01
12	.01	.00	.01	.01	.01	.01	.01	.00
13	.01	.01	.00	.00	.01	.01	.01	.00
14	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00	.00

2 OUT ADJMNWT

Table 13.

MEAN WEIGHT AT AGE (KG) 29/ 3/90

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1	.47	.47	.47	.50	.47	.47	.47	.77	.47	.47	.47	.47	.47	.47
2	.62	1.15	.82	.71	.87	.99	.95	.78	.63	.79	.66	.49	.66	.32
3	1.08	1.28	1.11	1.14	1.34	1.42	1.28	1.07	1.23	.63	1.11	.52	1.04	.86
4	1.41	2.20	1.63	1.58	1.81	2.40	1.67	1.95	1.91	1.18	1.39	1.15	1.23	1.58
5	2.03	2.82	2.64	2.51	2.49	3.41	2.71	3.02	2.60	2.29	2.64	1.72	2.28	2.65
6	2.82	3.54	3.18	3.82	3.25	3.86	4.24	4.43	4.36	2.93	4.16	2.19	3.50	4.14
7	4.38	4.34	3.42	4.98	5.44	5.64	4.72	5.51	5.69	3.07	5.69	4.56	5.92	5.71
8	5.61	6.17	8.26	4.94	5.57	6.83	6.41	5.39	5.58	4.96	5.96	5.39	6.22	5.91
9	6.41	7.39	6.07	6.00	4.61	4.23	5.78	7.13	6.57	6.60	7.85	8.45	9.03	9.49
10	6.65	7.55	8.72	8.09	5.15	5.58	5.01	8.85	5.55	5.79	8.92	11.81	11.85	11.49
11	8.71	8.29	10.57	6.82	5.89	6.81	7.50	5.52	8.10	5.54	10.10	11.13	15.77	13.27
12	10.54	11.58	9.95	7.00	15.64	6.47	5.91	9.46	6.93	6.15	5.53	4.98	6.88	16.78
13	10.50	11.50	5.43	11.17	11.74	13.53	8.92	9.76	7.62	6.86	12.57	13.17	16.78	11.90
14	14.72	8.46	16.80	13.05	16.78	4.57	11.42	9.15	6.91	8.99	11.89	14.05	14.05	16.85
15	13.49	10.81	9.99	11.67	15.74	16.15	12.44	12.34	15.74	11.22	11.21	15.74	15.74	15.74
16	17.26	17.26	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	17.26

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	.47	.47	.47	.47	.47	.47	.47	.47	.47	.47	.47	.47	.47	.47
2	.28	.66	.68	.64	.50	.53	.78	.77	.65	.61	.69	.73	.60	.69
3	.76	.69	.85	.89	1.05	1.02	.95	1.26	1.37	.87	1.40	1.26	1.09	1.23
4	1.14	1.26	1.30	1.64	1.59	1.61	1.55	1.83	2.00	1.70	2.02	2.19	1.55	2.14
5	1.57	2.13	2.03	2.41	2.42	2.39	2.23	3.23	3.00	2.73	2.45	3.10	2.62	3.15
6	3.00	3.01	3.20	3.52	3.30	3.35	3.39	4.03	4.85	3.87	4.13	3.62	4.38	6.13
7	5.23	4.63	3.83	4.93	4.03	5.26	5.44	5.50	6.07	6.19	4.96	4.90	5.53	6.63
8	7.23	6.50	5.98	5.74	5.40	6.47	6.85	8.90	6.84	7.05	6.83	7.63	6.56	8.97
9	7.55	7.10	9.08	11.31	6.95	7.64	7.95	9.26	5.14	9.11	6.14	9.54	8.62	9.41
10	7.99	7.94	9.45	10.63	7.82	9.48	9.75	8.05	8.04	10.18	6.36	11.28	8.90	13.52
11	7.66	11.41	12.75	14.47	8.09	9.27	11.12	14.88	12.84	13.44	16.55	10.42	11.27	13.30
12	11.65	9.71	11.47	9.28	11.35	13.08	13.22	13.70	17.38	12.77	15.01	10.55	15.41	13.54
13	12.32	10.02	15.52	13.17	8.43	17.38	14.74	16.35	13.17	14.33	17.49	16.78	15.31	12.66
14	16.92	13.66	14.05	14.05	14.05	16.78	15.72	16.78	16.03	15.02	17.93	16.80	11.82	16.62
15	16.32	11.17	15.41	15.41	15.48	15.77	16.92	15.24	16.67	15.72	16.87	16.78	17.01	15.32
16	16.78	16.78	16.78	16.83	16.78	16.92	17.50	17.93	16.95	16.55	15.81	15.45	15.41	14.01

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.47	.48	.47	.47	.47	.47	.47	.36	.38	.37	.38	.47	.47	.50
2	.60	1.04	.84	.83	.71	.75	.81	.85	.95	.82	.80	.91	.96	.92
3	1.19	1.26	1.57	1.27	1.41	1.25	1.33	1.33	1.50	1.41	1.29	1.46	1.35	1.57
4	2.14	1.86	1.91	2.04	2.17	1.99	1.85	1.85	2.00	1.97	1.90	2.16	1.88	2.28
5	3.00	2.34	2.39	3.11	2.98	2.80	2.84	2.61	2.73	2.52	2.63	3.17	2.72	2.76
6	4.42	4.28	3.54	4.15	4.75	3.60	4.13	4.21	3.82	3.53	3.96	3.89	4.02	4.02
7	6.07	5.76	4.17	5.34	6.71	5.64	5.46	5.58	5.42	4.96	5.02	5.55	5.24	4.98
8	8.56	7.75	6.16	7.26	6.93	7.25	7.08	8.05	7.61	6.89	7.47	7.89	8.09	8.45
9	10.83	9.08	6.18	8.65	9.57	8.38	8.38	10.26	9.34	8.09	9.51	9.13	10.12	9.97
10	12.01	9.44	9.22	11.24	9.81	11.21	9.07	11.42	11.69	9.86	9.20	11.90	11.02	11.89
11	16.17	10.75	6.56	10.65	11.86	12.29	10.63	11.59	13.27	12.41	11.90	12.95	12.18	15.24
12	12.47	15.41	7.23	12.00	14.11	12.41	14.16	15.10	14.15	14.52	14.38	15.53	16.30	16.38
13	14.90	15.83	6.90	16.72	11.57	15.35	13.99	16.13	14.34	12.31	15.07	14.10	18.59	17.19
14	16.32	16.65	13.32	13.56	9.32	15.35	16.14	16.14	15.10	12.28	13.19	16.67	19.14	19.00
15	17.93	15.54	16.92	15.35	17.52	14.51	16.54	16.57	16.74	16.20	20.33	22.20	20.18	19.52

Table 14. ADAPT input summary for 4X cod.

Parameters:

- year class estimates: $N_{i,1989}$ i = 3-7
- calibration constants for mid-year RV numbers: K_i i = 3-7

Structure:

- error for catch assumed negligible
- population numbers in 1989 at ages 1 and 2 set to the geometric mean; ages 5+ assumed to be fully recruited
- F for oldest age group calculated as a weighted F for ages 5-9
- model did not include an intercept term
- M = 0.2

Input:

- $C_{i,t}$ i = 1-13; t = 1970-89
- $RV_{i,t}$ (numbers) i = 3-7; t = 1970-89

Objective Function:

- minimize

$$\sum_{t=1970}^{1989} \sum_{i=3}^{7} (\ln RV_{i,t} - \ln K_i N_{i,t})^2$$

Summary:

- number of observations = 100
- number of parameters = 10

Table 15. Results of ADAPT formulation described in Table 14 (Ages 3-7).

ADAPTIVE FRAMEWORK 2 INDEX TUNING

4X COD 5/10/90 06:23

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.008047
MEAN SQUARE RESIDUALS 0.265747

PAR. EST.	STD. ERR.	T-STATISTIC
1.87939E0004	9.14452E0003	2.05521E0000
2.66884E0004	9.66322E0003	2.76185E0000
2.81470E0003	8.79665E0002	3.19974E0000
2.25505E0003	7.08604E0002	3.18239E0000
3.48609E0002	1.03758E0002	3.35984E0000
1.38339E-004	1.67720E-005	8.24822E0000
1.69702E-004	2.02467E-005	8.38168E0000
2.14670E-004	2.56462E-005	8.37046E0000
2.79317E-004	3.34490E-005	8.35079E0000
2.66018E-004	3.19675E-005	8.32151E0000

Parameter Correlation Matrix

	1	2	3	4	5	6	7	8	9	10
1	1.000	.036	.024	.015	.005	-.228	-.011	-.007	-.005	-.005
2	.036	1.000	.039	.025	.009	-.157	-.176	-.012	-.009	-.009
3	.024	.039	1.000	-.031	.022	-.104	-.138	-.193	-.057	-.110
4	.015	.025	-.031	1.000	.036	-.067	-.091	-.138	-.221	-.099
5	.005	.009	.022	.036	1.000	-.023	-.033	-.054	-.115	-.225
6	-.228	-.157	-.104	-.067	-.023	1.000	.047	.031	.023	.022
7	-.011	-.176	-.138	-.091	-.033	.047	1.000	.041	.032	.031
8	-.007	-.012	-.193	-.138	-.054	.031	.041	1.000	.048	.046
9	-.005	-.009	-.057	-.221	-.115	.023	.032	.048	1.000	.052
10	-.005	-.009	-.110	-.099	-.225	.022	.031	.046	.052	1.000

ADAPTIVE FRAMEWORK 2 INDEX TUNING

4X COD 5/10/90 06:23

Standardized Residuals for RV index (s.e.=1 for log model)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
3	.155	.237	.181	-.631	.430	-.827	-.026	.180	-.674
4	.904	-.955	.082	.156	-.332	.341	-.259	.085	-.113
5	.436	.202	-.386	-.745	.318	.898	.357	-1.099	-.245
6	.884	.072	-.367	-.793	.066	.276	.094	.203	-1.100
7	.469	.654	-.301	-.712	-.862	.666	-.029	-.187	-.252

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	-.362	-.451	-.536	-.448	.384	.995	1.065	.225	-.799	.901	.000
4	-.225	-.569	-.166	-.309	.345	.187	.528	.301	-.273	1.056	-.783
5	-.048	-.346	-.020	-.084	.246	.550	.260	-.460	.090	.523	-.448
6	-.079	.229	.031	-.018	.270	.053	.233	-.068	-.320	.709	-.375
7	-.311	-.140	-.079	-.458	.301	.528	.635	.543	-.213	.209	-.463

Table 16.

POPULATION NUMBERS 9/ 1/80

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1	17502	24805	12408	15885	8766	18378	9060	14116	16462	18134	16037	23151	29074	18702
2	13484	14329	20309	10158	13005	7177	15047	7417	11553	13478	14847	13130	18954	23804
3	9081	11007	11289	16030	8050	9957	5767	12084	6024	9364	11035	12011	10750	15518
4	8532	6706	7677	7481	10749	5446	7375	4286	8736	4369	7475	8283	9539	8801
5	6905	5523	4196	3324	4408	6151	3804	4206	2910	4986	3247	4983	4984	7561
6	1599	4170	3660	2132	1395	2533	3763	2292	2325	1721	2778	2129	2518	3207
7	841	697	2593	2314	1292	639	1666	2130	1405	1375	1197	1546	754	1334
8	1002	444	510	1460	1471	732	322	1040	1217	693	581	904	889	371
9	884	491	269	382	945	1051	532	138	680	571	307	324	370	424
10	521	395	266	174	239	544	702	319	61	451	159	117	186	126
11	150	187	177	135	119	168	247	452	230	14	109	45	95	56
12	118	30	106	133	14	78	71	120	315	118	11	68	15	32
13	68	51	10	27	45	0	49	27	70	187	11	0	41	0
1+	60687	68835	63490	59634	50497	52854	48405	48627	51987	55461	57795	66691	78170	79935
2+	43185	44030	51082	43749	41732	34476	39345	34511	35525	37328	41758	43540	49096	61234
3+	29701	29701	30774	33591	28726	27299	24299	27094	23973	23850	26911	30410	30141	37430
4+	20620	18694	19484	17560	20676	17342	18531	15010	17948	14486	15876	18399	19392	21911

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	22589	33510	42661	20579	16306	16124	14200	20423	19405	15179	20611	24195	20379	25387
2	15312	18494	27436	34928	16849	13350	13201	11626	16721	15887	12427	16875	19809	16685
3	19479	12534	15142	22462	28567	13781	10915	10798	9106	13444	12507	9850	13517	16127
4	12466	15232	9904	12301	17036	21662	9834	7407	6528	6242	9829	8027	6385	9082
5	6836	8345	10687	7429	7740	9693	12016	5722	4212	4080	4177	5269	4371	3338
6	4435	3123	5406	5941	3456	3285	4596	4274	2625	2033	2142	1698	2548	1937
7	1810	2561	1577	2119	2878	1243	1540	1452	1677	1262	703	891	779	1027
8	802	1018	1258	520	1101	1354	584	845	651	980	625	427	462	396
9	215	443	561	335	180	578	757	305	516	452	451	402	282	189
10	275	103	161	111	204	108	345	397	123	227	229	242	185	126
11	66	176	49	62	54	108	56	229	118	54	43	128	136	53
12	29	48	107	16	30	21	47	9	165	81	15	31	58	23
13	19	24	10	12	7	3	7	10	0	111	2	11	12	12
1+	84333	95610	114958	106815	94407	81310	68098	63499	61846	60042	63762	68044	68922	74381
2+	61744	62100	72297	86237	78101	65186	53898	43076	42441	44864	43151	43849	48543	48995
3+	46432	43606	44861	51308	61253	51836	40696	31450	25720	28977	30724	26974	28734	32310
4+	26953	31072	29720	28846	32685	33055	29781	20652	16614	15533	18217	17124	15218	16183

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	24656	17189	32573	29259	20861	26937	13591	13860	20566	11064	54775	28516	19234	19705
2	20785	20186	14071	26668	23956	17080	22055	11127	11344	16803	9058	44846	23347	15748
3	12967	16646	15071	11263	21539	18812	13182	17168	8417	8561	12954	7283	35762	19717
4	11796	9085	10857	10707	8050	13316	11726	8486	10531	4737	5567	7775	5254	26569
5	4762	7417	5915	6832	5686	4825	6899	5550	5037	5688	2533	2563	4429	2795
6	1809	2631	4620	3041	3212	2415	2426	2633	2394	2455	2433	1254	1179	2238
7	972	1058	1453	1803	1389	1464	1057	1197	1117	1125	961	1101	599	344
8	511	624	620	614	840	752	715	505	419	513	477	476	468	300
9	245	308	278	328	305	463	345	313	187	199	263	242	181	196
10	103	133	161	178	179	172	234	156	133	104	103	140	97	82
11	72	68	36	87	74	100	82	102	64	64	45	51	64	26
12	20	53	23	22	50	50	57	20	37	25	29	23	13	21
13	6	15	7	4	6	27	24	23	9	10	12	10	12	3
1+	78702	75412	85685	90806	86147	86418	72393	61141	60255	51347	89209	94280	90641	86723
2+	54046	58223	53112	61547	65285	59480	58803	47281	39688	40283	34434	65765	71407	67018
3+	33261	38037	39041	34879	41330	42400	36748	36154	28344	23479	25376	20919	48060	51270
4+	20294	21391	23970	23616	19791	23588	23566	18986	19927	14919	12422	13635	12298	32553

Table 17. FISHING MORTALITY 9/ 1:30

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.008	.038	.037	.033	.067	.019	.019	.008	.010	.000	.012	.000	.000	.001	.000
3	.108	.160	.211	.200	.191	.100	.097	.124	.121	.025	.067	.030	.000	.019	.046
4	.335	.269	.637	.329	.358	.159	.362	.187	.361	.057	.206	.308	.032	.050	.201
5	.304	.206	.477	.668	.354	.291	.307	.393	.325	.385	.222	.488	.241	.333	.583
6	.630	.275	.264	.300	.581	.219	.369	.289	.325	.163	.386	.838	.435	.372	.349
7	.439	.112	.374	.253	.369	.485	.271	.360	.507	.661	.081	.354	.510	.309	.375
8	.514	.303	.091	.235	.136	.118	.645	.225	.556	.613	.384	.694	.540	.342	.395
9	.606	.412	.234	.269	.352	.204	.313	.623	.210	1.079	.769	.353	.878	.282	.557
10	.823	.605	.476	.182	.149	.586	.240	.127	1.272	1.222	1.060	.001	1.009	.448	.245
11	1.424	.366	.085	2.047	.222	.657	.521	.160	.468	.008	.271	.928	.883	.449	.115
12	.633	.878	1.160	.886	4.209	.261	.772	.345	.320	2.158	4.232	.299	4.327	.349	.004
13	.601	.290	.297	.289	.333	.270	.347	.230	.403	.533	.338	.581	.523	.345	.357
6+	.614	.296	.305	.312	.355	.281	.352	.293	.413	.611	.364	.611	.543	.346	.358

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.000	.000	.001	.001	.001	.001	.044	.019	.039	.032	.022	.006	.052	.022	.092
3	.036	.038	.077	.077	.137	.188	.303	.178	.113	.244	.234	.198	.113	.156	.227
4	.154	.068	.263	.364	.389	.342	.364	.270	.202	.423	.408	.448	.446	.264	.229
5	.234	.337	.585	.657	.546	.834	.579	.529	.444	.700	.527	.614	.413	.393	.274
6	.488	.737	.525	.822	.558	.952	.736	.592	.662	.677	.580	.709	.490	.336	.394
7	.511	.909	.455	.554	.556	.400	.603	.337	.503	.299	.456	.476	.498	.244	.334
8	.296	1.122	.859	.444	.381	.448	.294	.142	.576	.242	.214	.693	.281	.305	.606
9	.309	1.418	.297	.314	.317	.444	.706	.613	.500	.425	.577	.604	.413	.408	.451
10	.544	.758	.518	.434	.463	.208	1.014	.621	1.475	.388	.374	1.053	.362	.911	1.102
11	.293	.942	.580	.770	.635	1.585	.130	.178	1.069	.119	.591	1.579	.782	.118	.900
12	1.402	1.055	.649	2.056	.833	1.324	3.842	.192	3.680	.189	.744	1.392	1.124	.088	1.750
13	.497	.955	.515	.639	.497	.692	.638	.414	.709	.481	.491	.691	.469	.302	.487
6+	.503	.977	.519	.655	.502	.753	.659	.426	.758	.499	.493	.710	.470	.308	.453

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.000	.000	.000	.000	.000	.000	.002	.000	.000	.000	.000	.000
2	.023	.014	.042	.059	.050	.079	.062	.060	.018	.026	.021	.037
3	.142	.136	.281	.273	.240	.289	.375	.230	.310	.127	.097	.146
4	.263	.433	.312	.458	.548	.322	.416	.426	.576	.363	.431	.169
5	.465	.555	.656	.487	.763	.641	.519	.649	.503	.577	.483	.326
6	.741	.584	.585	.626	.507	.657	.555	.738	.593	.539	1.031	.359
7	.661	.564	.413	.517	.539	.850	.578	.659	.502	.654	.493	.694
8	.437	.499	.384	.578	.626	.796	.544	.470	.478	.764	.672	.363
9	.246	.406	.375	.495	.592	.654	.389	.454	.426	.711	.873	.363
10	.415	.678	.383	.539	.628	.697	.537	.630	.509	.584	1.121	.363
11	.312	.351	.199	.357	1.214	.819	.756	.586	.458	1.129	.914	.363
12	1.508	1.135	.431	.510	.733	.642	1.111	.476	.879	.446	1.403	.363
13	.662	.559	.490	.568	.553	.719	.558	.664	.546	.628	.606	.363
6+	.672	.561	.495	.570	.557	.723	.560	.669	.548	.633	.834	.396

Table 18. Mean population biomass (kg).

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1	7408	10500	5252	7199	3710	7779	3835	9849	6968	7675	6788	9800	12307	7916
2	7612	14652	14901	6414	9889	6398	12796	5223	6565	9663	8820	5873	11388	6902
3	8455	11808	10293	14999	8946	12189	6398	11034	6315	5282	10696	5578	10098	11968
4	9736	11802	8496	9189	14894	11000	9402	6940	12743	4461	8545	7441	10469	12283
5	10988	12821	8035	5572	8416	16574	8080	9580	5888	8644	6988	6226	9190	15530
6	3067	11741	9374	6414	3148	7989	12157	8021	7883	4229	8745	2894	6523	10109
7	2723	2599	6739	9269	5357	2606	6267	8981	5733	2830	5936	5418	3195	5975
8	4014	2150	3659	5947	6961	4279	1393	4569	4764	2353	2621	3224	3905	1689
9	3892	2713	1320	1828	3350	3659	2407	671	3666	2128	1544	2103	2045	3265
10	2170	2050	1688	1163	1038	2099	2845	2405	176	1394	807	1248	1282	1065
11	645	1187	1625	367	570	770	1322	2093	1358	70	877	301	919	544
12	846	209	574	568	50	403	270	877	1703	278	14	266	22	417
13	490	468	43	237	408	2	337	208	399	911	108	1	492	1
1+	62045	84699	72000	69071	66737	75747	67510	70453	64162	49918	62490	50374	71836	77665
2+	54637	74199	66748	61872	63027	67968	63675	60604	57194	42242	55702	40574	59529	69749
3+	47025	59547	51847	55458	53138	61570	50879	55380	50629	32580	46881	34702	48141	62847
4+	38570	47739	41554	40459	44192	49380	44481	44346	44314	27298	36186	29123	38043	50878

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	9562	14184	18058	8711	6902	6825	6011	8645	8214	6425	8724	10241	8626	10746
2	3886	11038	16904	20393	7632	6409	9328	7976	9751	8602	7680	11007	10693	10114
3	13177	7675	11621	17516	26119	11937	8565	10670	10397	10007	14126	10082	12123	17009
4	11749	16131	11190	16191	20669	26821	11774	10353	10438	8718	14794	13195	7274	14330
5	7434	14436	16408	12488	12566	16359	16693	12852	8988	8215	6750	11618	7823	7869
6	10237	6821	11231	14867	7139	7726	9245	11195	9020	4844	5898	4271	7333	8577
7	7201	8491	3650	7666	8139	4584	6300	5495	7869	5608	2744	3200	3127	4899
8	4371	4987	4172	1841	4385	6638	2942	5933	3771	4801	3449	2665	2007	2819
9	1150	1980	2525	2987	980	3447	4435	1860	1809	3028	2061	2665	1670	1332
10	1772	577	982	844	1182	748	2758	1852	677	1122	1103	2072	937	1306
11	433	1579	372	637	281	680	288	2904	1264	413	603	918	717	447
12	307	233	502	98	135	168	319	30	2370	261	192	211	445	172
13	176	171	93	116	38	39	71	113	1	1051	21	128	122	109
1+	71454	88303	97707	104355	95166	91881	73729	79879	74568	63096	68144	72273	62897	79729
2+	61893	74118	79649	95644	89264	85056	72718	71234	66354	56671	59420	62032	54271	68983
3+	53007	63080	62745	75251	81632	78647	63390	63259	56603	48070	51740	51025	43578	58869
4+	44830	55406	51124	57735	55513	66711	54825	52589	46206	38062	37614	40943	31455	41859

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	10437	7478	13738	12385	8330	11402	5753	4522	7076	3710	18865	12070	8142	8861
2	11160	18254	10641	20005	15095	11346	15399	8223	9424	12200	6495	36704	20193	12854
3	13014	17129	20066	12173	24161	18680	14190	18061	9595	9785	13107	9086	41742	24896
4	20242	13706	16633	16146	13659	19377	15267	12246	15753	6944	7344	12867	7307	50541
5	10781	13848	10336	14927	11380	9784	12589	9809	9811	9643	4779	5651	8716	6002
6	6193	8491	10608	8745	10562	5924	7182	7441	6425	5619	6644	3451	2722	6887
7	4762	4721	4063	6732	6965	5900	4078	4137	4207	3744	3464	4109	2266	1132
8	3432	3318	2826	3207	4405	3786	3447	2576	2247	2575	2588	2410	2529	1936
9	1987	2056	1388	2129	2222	2827	1998	2162	1317	1181	1856	1450	1126	1493
10	1009	703	1106	1333	1331	1360	1442	1179	1103	694	681	1158	595	564
11	1000	443	186	711	725	942	467	742	545	549	394	364	471	303
12	213	357	78	144	524	442	527	204	291	259	256	267	109	263
13	72	172	35	48	48	285	240	238	86	82	132	95	144	36
1+	84202	90675	91752	98686	99906	92057	83079	71540	67880	56986	66605	89682	96061	115766
2+	73865	83198	77965	86300	91076	80654	77327	67018	60804	53276	47740	77612	87919	106905
3+	62706	64944	67324	66295	75981	69308	61427	58795	51380	41075	41245	40908	67726	94051
4+	49691	47815	47258	54123	51821	50628	47237	40735	41785	31290	28138	31822	25984	69156

Table 19. Catch projections for 4X cod under 50% rule, assuming a 20,000 t cod catch in 1990 under CHP management.

Input	Age	PR[a]	Weight (Kg)[b]
	1	0.000	0.42
	2	0.10	0.89
	3	0.38	1.42
	4	0.70	2.01
	5	1.00	2.73
	6	1.00	3.92
	7	1.00	5.25
	8	1.00	7.78
	9	1.00	9.49
	10	1.00	11.00
	11	1.00	12.79
	12	1.00	15.20
	13	1.00	15.39

[a] - Mean 1983-88
[b] - Mean 1983-89

POPULATION NUMBERS 1/

	1989	1990	1991
1	19904	19904	19904
2	15937	16287	16293
3	18717	12580	13104
4	26569	13247	9332
5	2795	18364	9032
6	2238	1651	11593
7	344	1280	1042
8	300	141	808
9	196	171	89
10	62	112	108
11	26	35	70
12	21	15	22
13	3	12	9
1+	87112	83797	81406
2+	67208	63893	61502
3+	51271	47607	45209
4+	32554	35027	32106

CATCH BIOMASS 2/

	1989	1990	1991
1	4	1	1
2	461	227	201
3	3264	1519	1407
4	7546	4040	2543
5	1938	10462	4615
6	2411	1349	8495
7	829	1401	1023
8	648	228	1175
9	516	338	158
10	190	256	222
11	92	94	168
12	89	47	63
13	27	38	27
1+	18015	20000	20099
2+	18010	19999	20097
3+	17550	19772	19897
4+	14286	18253	18489

FISHING MORTALITY

	1989	1990	1991
1	.001	.000	.000
2	.037	.017	.015
3	.146	.099	.087
4	.169	.183	.162
5	.326	.260	.230
6	.359	.260	.230
7	.694	.260	.230
8	.363	.260	.230
9	.363	.260	.230
10	.364	.260	.230
11	.363	.260	.230
12	.364	.260	.230
13	1.002	.260	.230
1+	.115	.115	.100

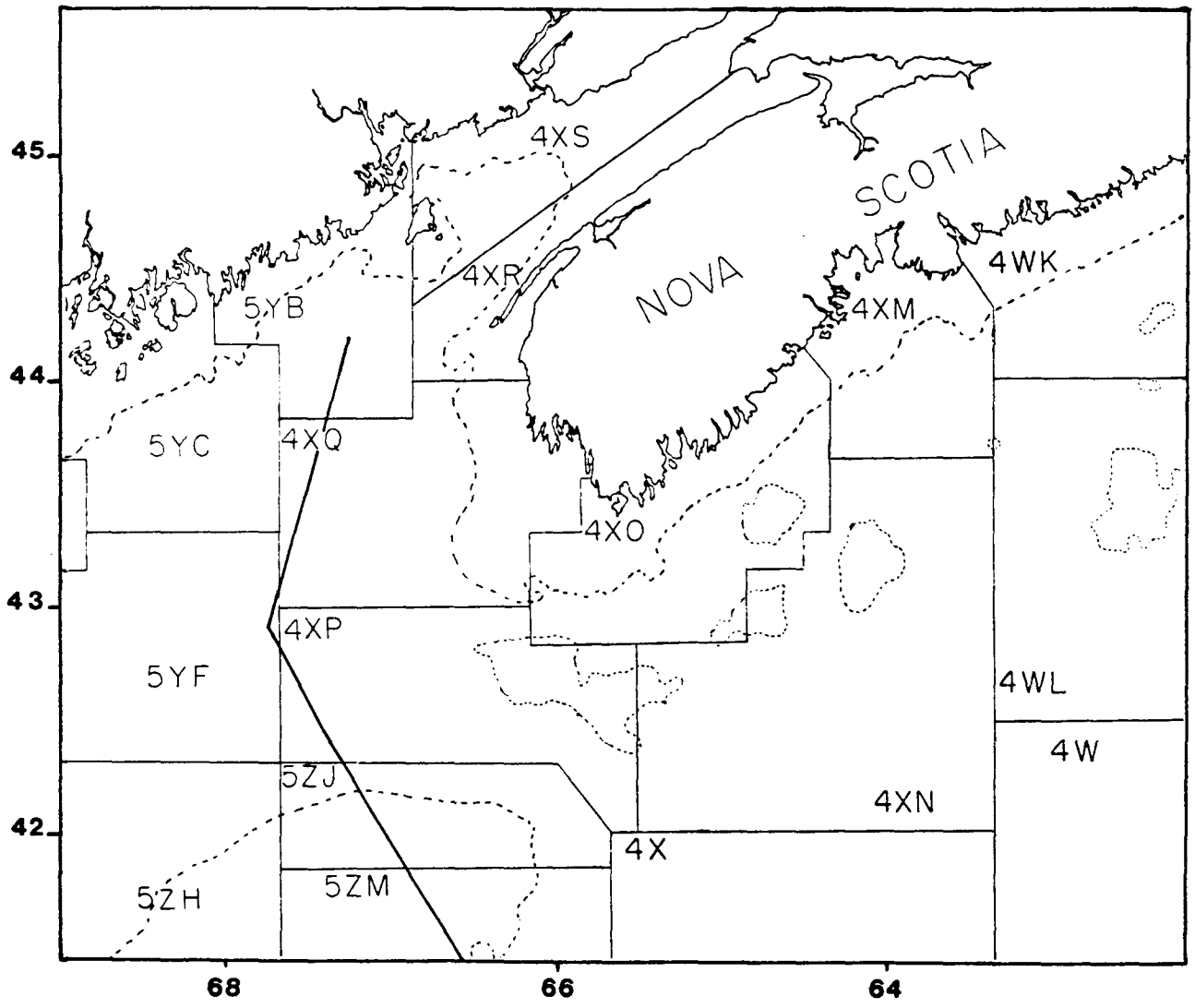


Figure 1. Unit areas in NAFO Division 4X in reference to the ICJ Canada-US boundary.

Figure 2.

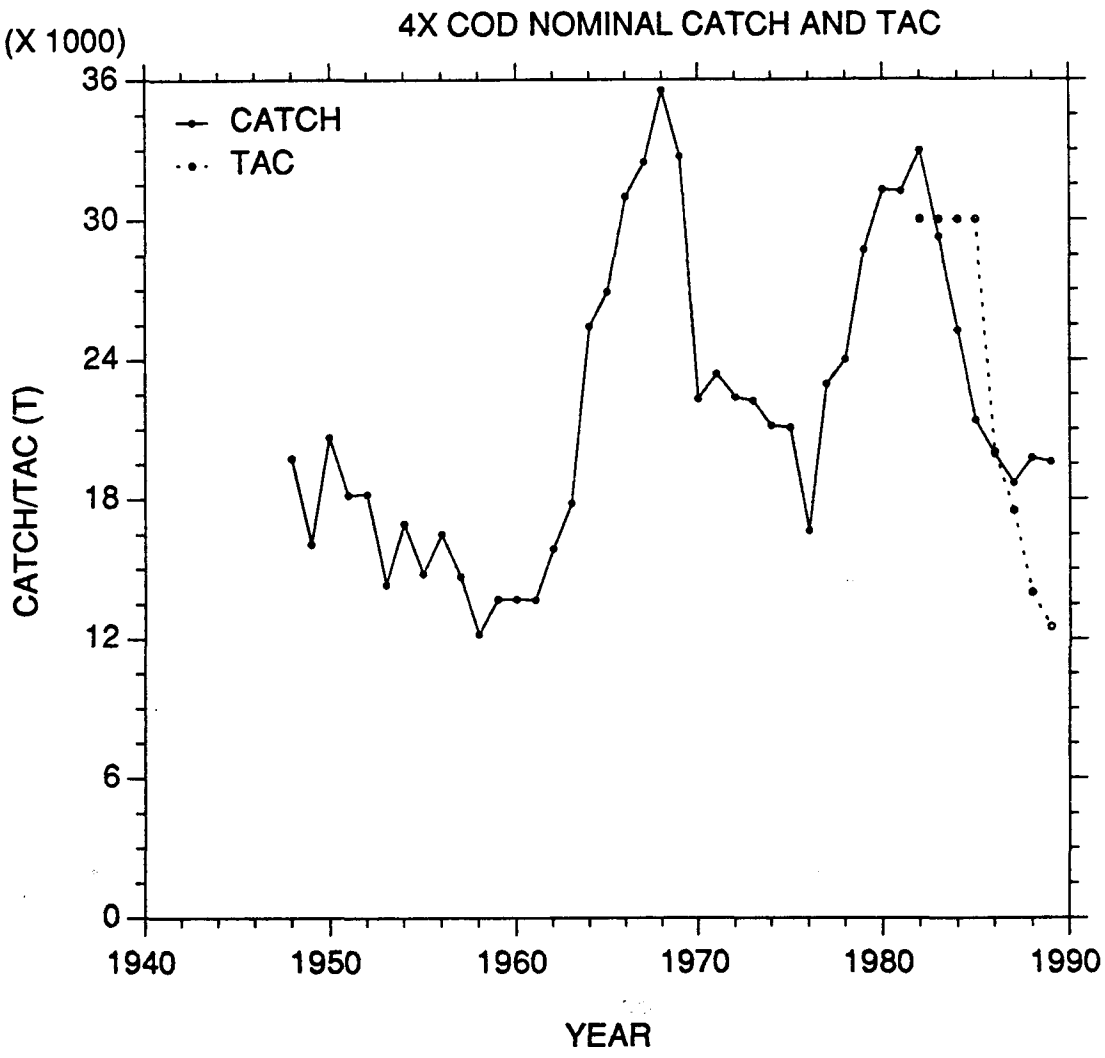

4X COD NOMINAL CATCH AND TAC
(X 1000)
CATCH
TAC
CATCH/TAC (T)
36
30
24
18
12
6
0
1940
1950
1960
1970
1980
1990
YEAR

Figure 3. Nominal catch by major gear category.

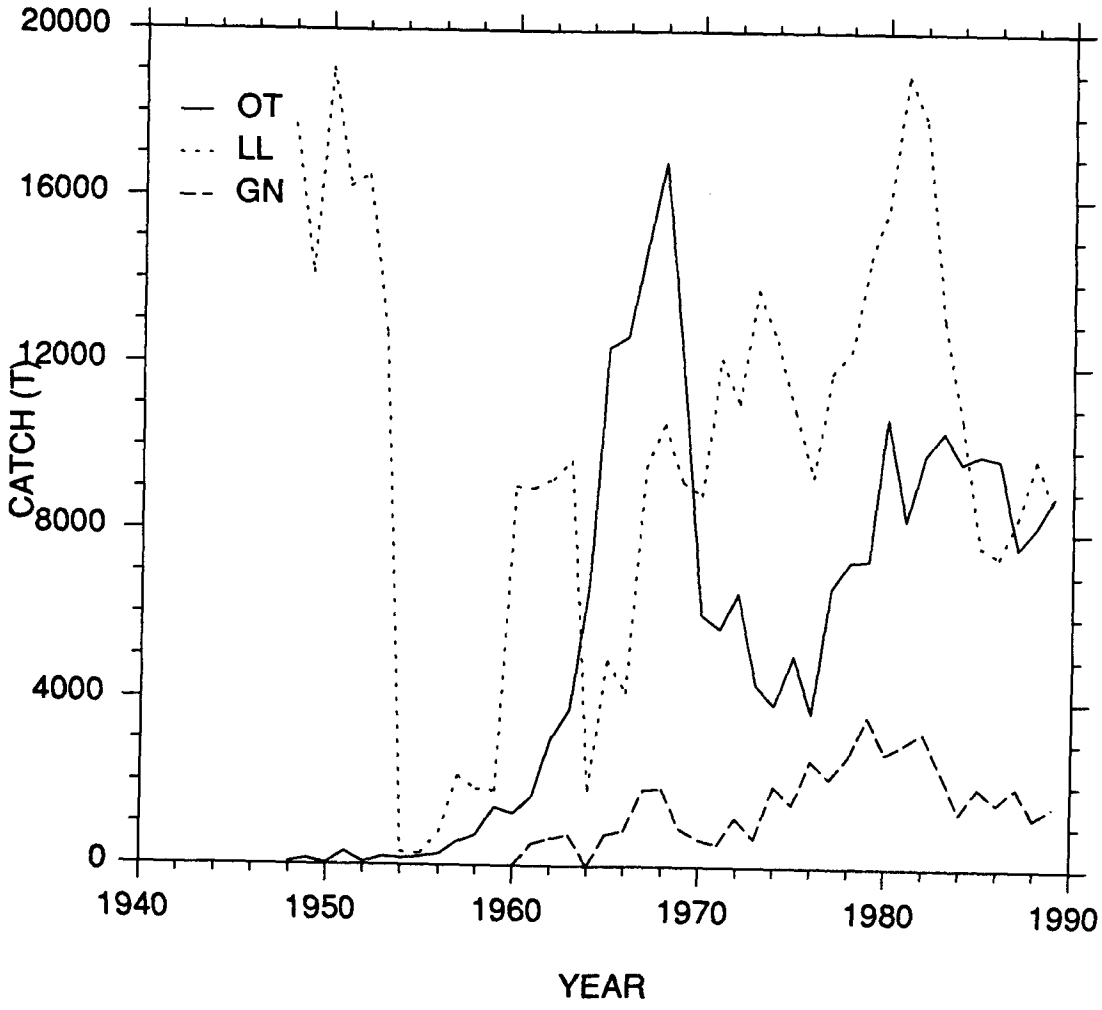
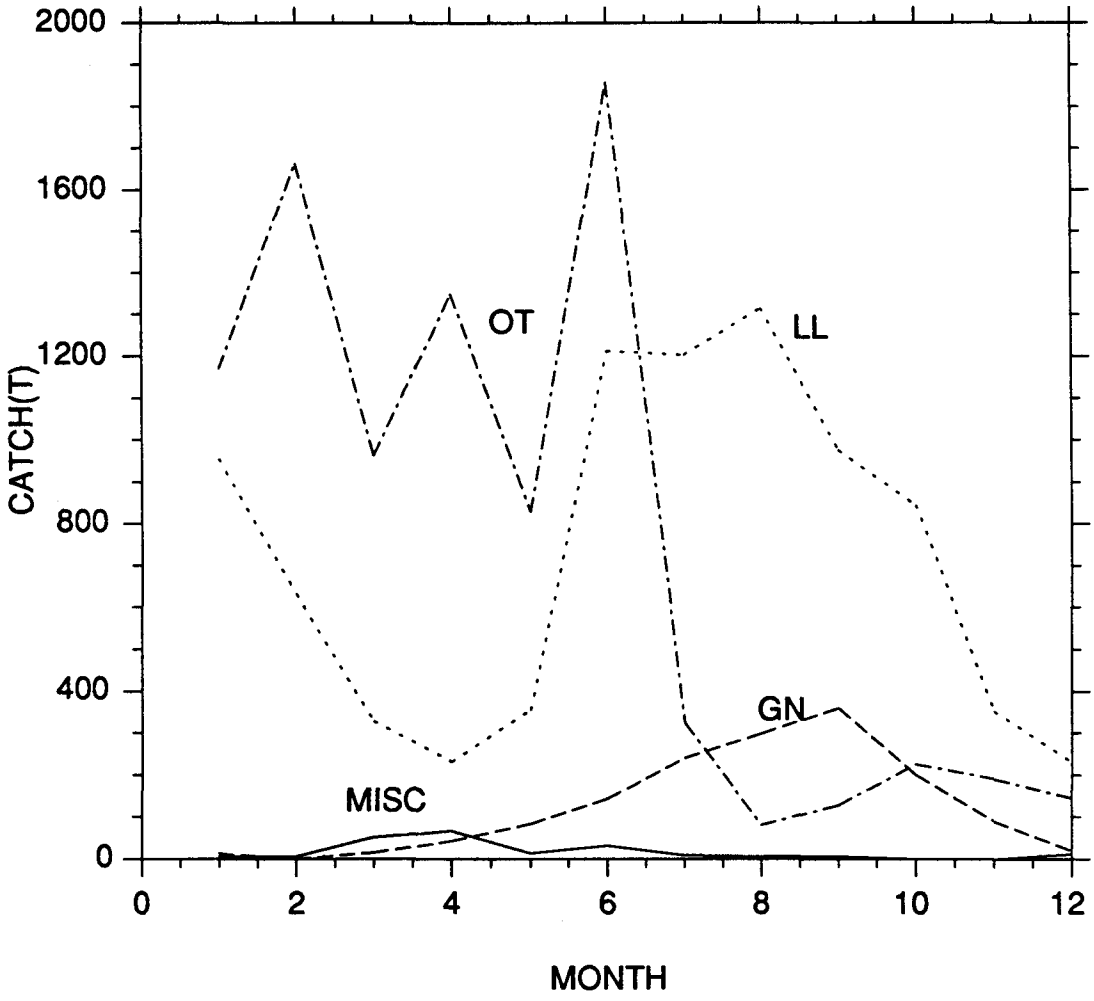


Figure 4. Monthly catches by major gear category in 1989.



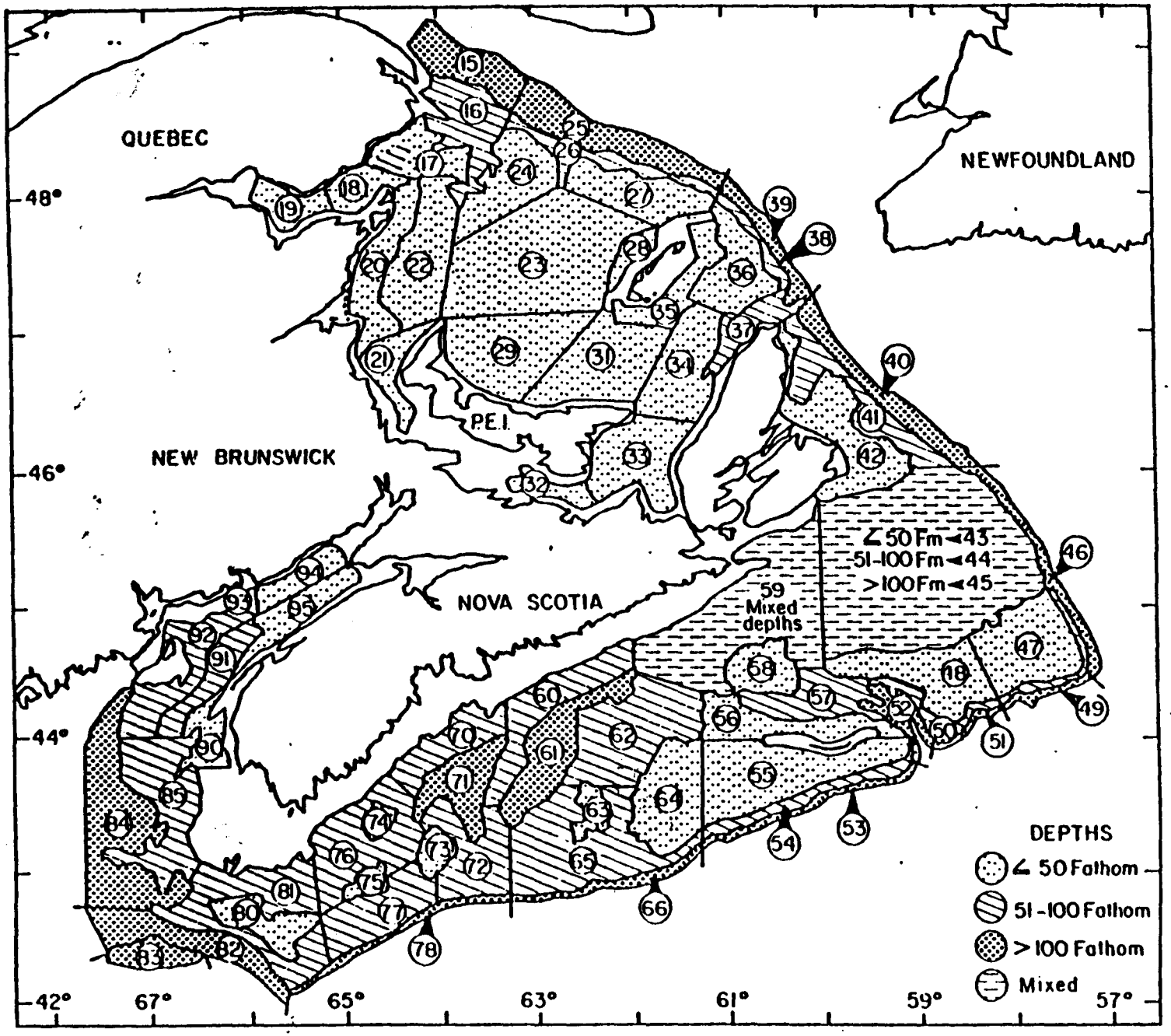


Figure 5. Stratification scheme used for the research groundfish surveys.

Figure 6. RV 5+ numbers per tow.

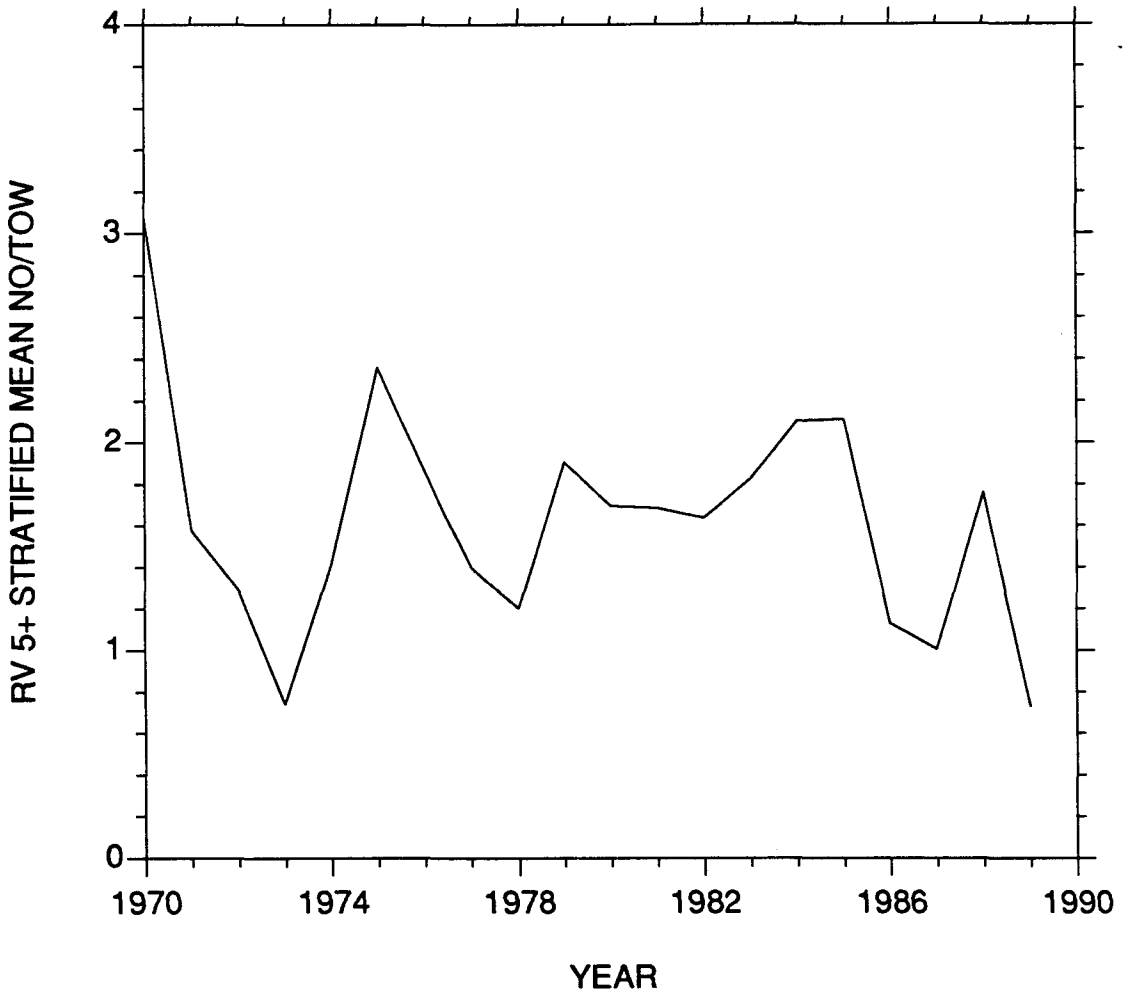


Figure 7. RV weight per tow.

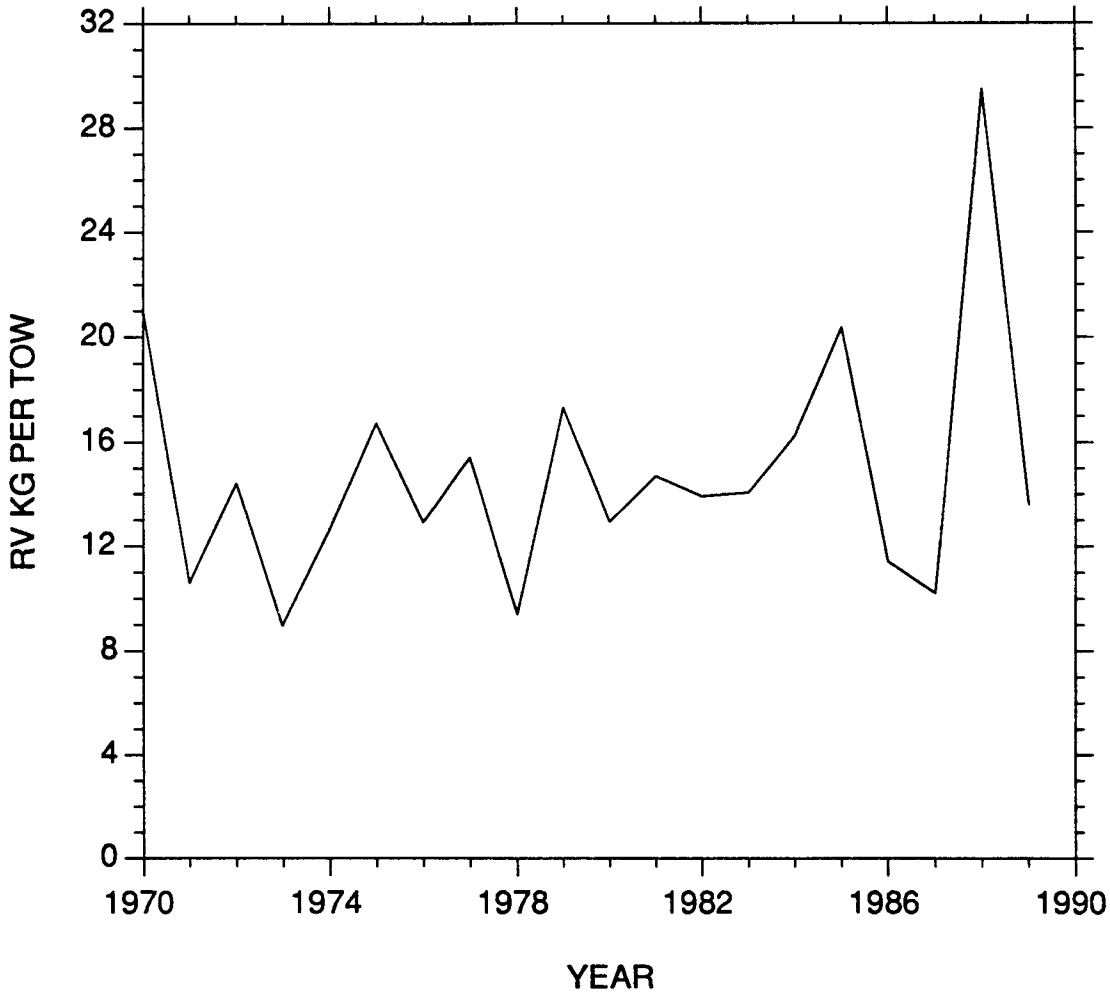


Figure 8. RV numbers per tow at ages 2, 3, and 4.

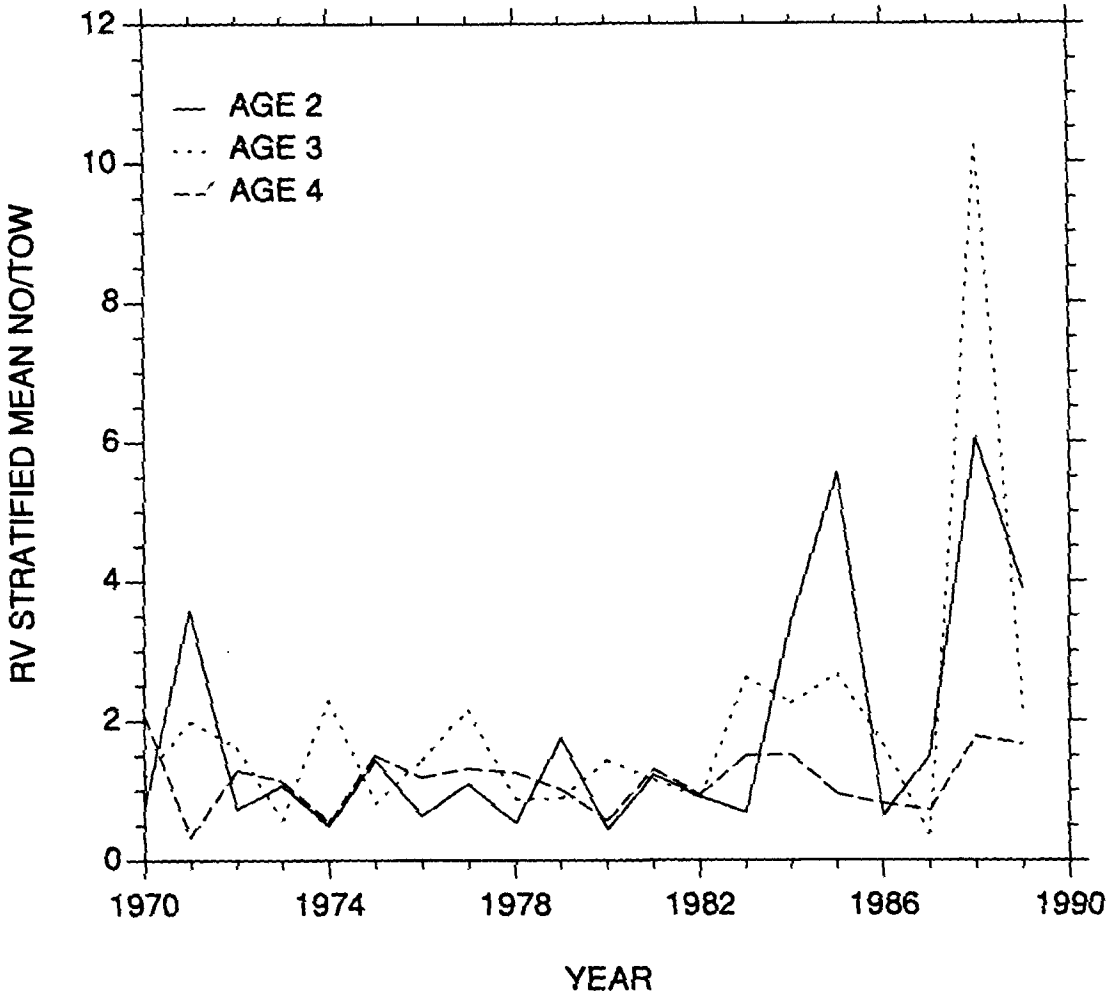


Figure 9. Absolute deviation of 1989 RV weight per tow from 1970-89 mean for each stratum in 4X.

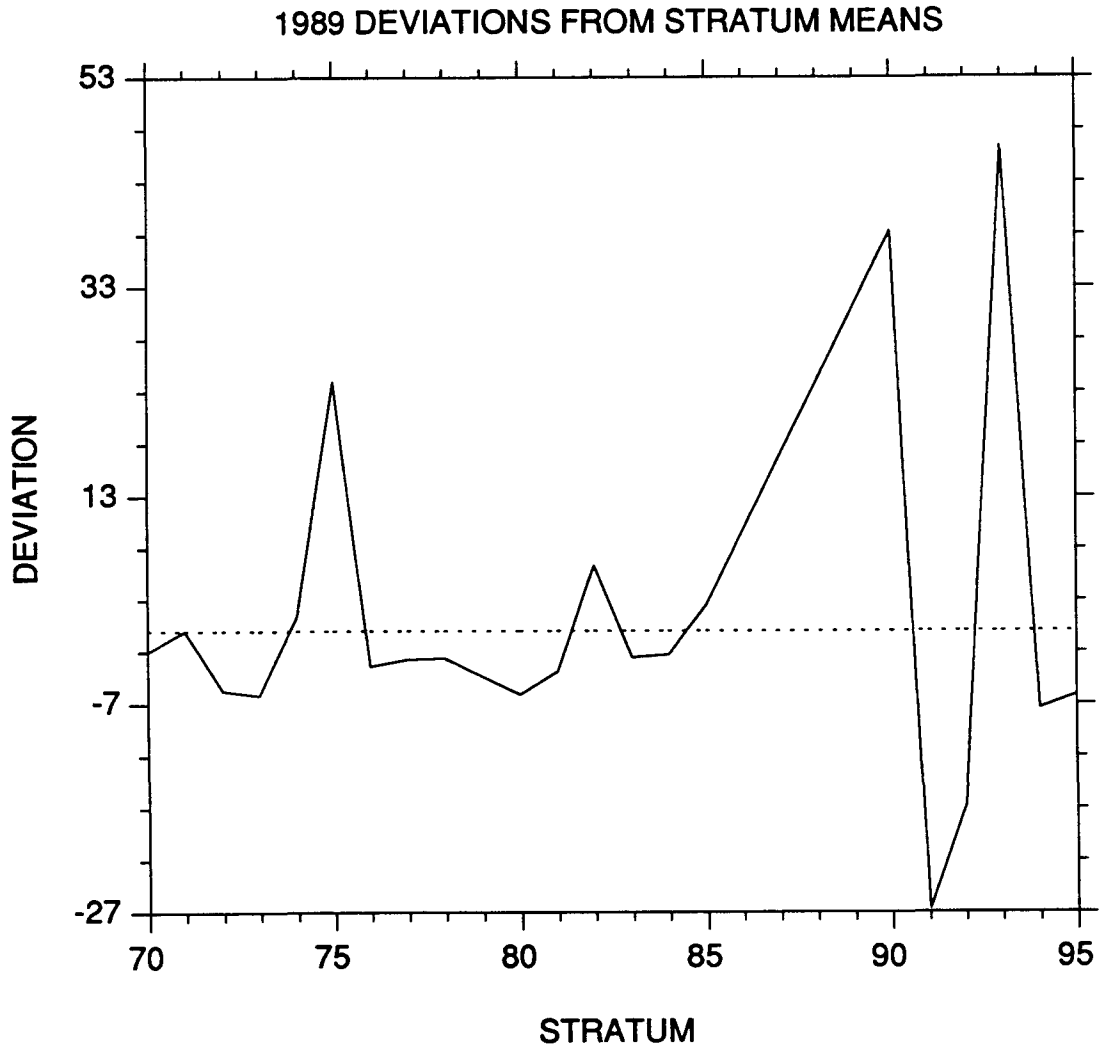
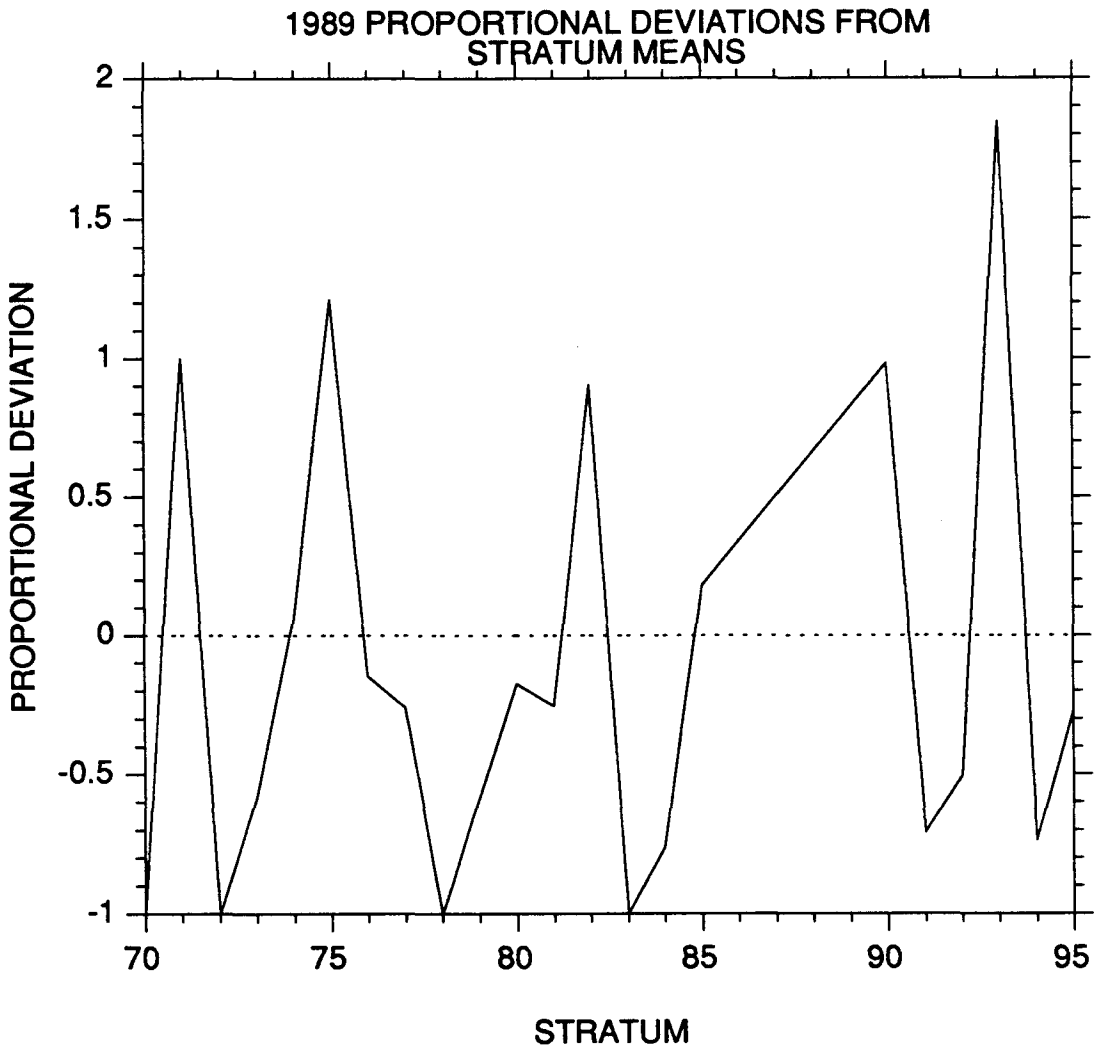


Figure 10. Proportional deviation of 1989 RV weight per tow from 1970-89 mean for each stratum, calculated as Deviation/Mean for each stratum.



MEAN NUMBER OF COD LESS THAN 43 CM

Figure 11. SUMMER SURVEYS 1970-1988

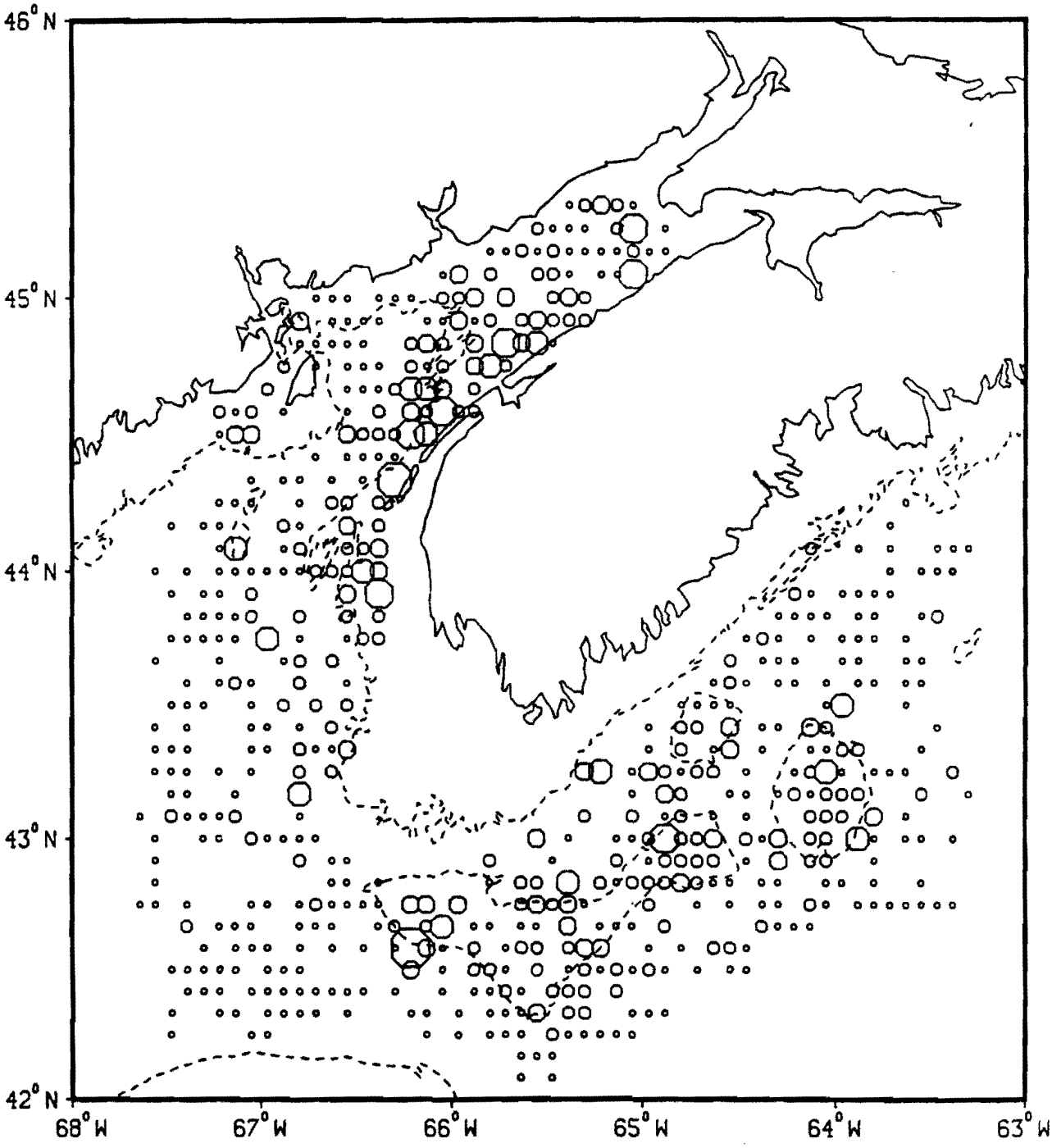


Figure 12.

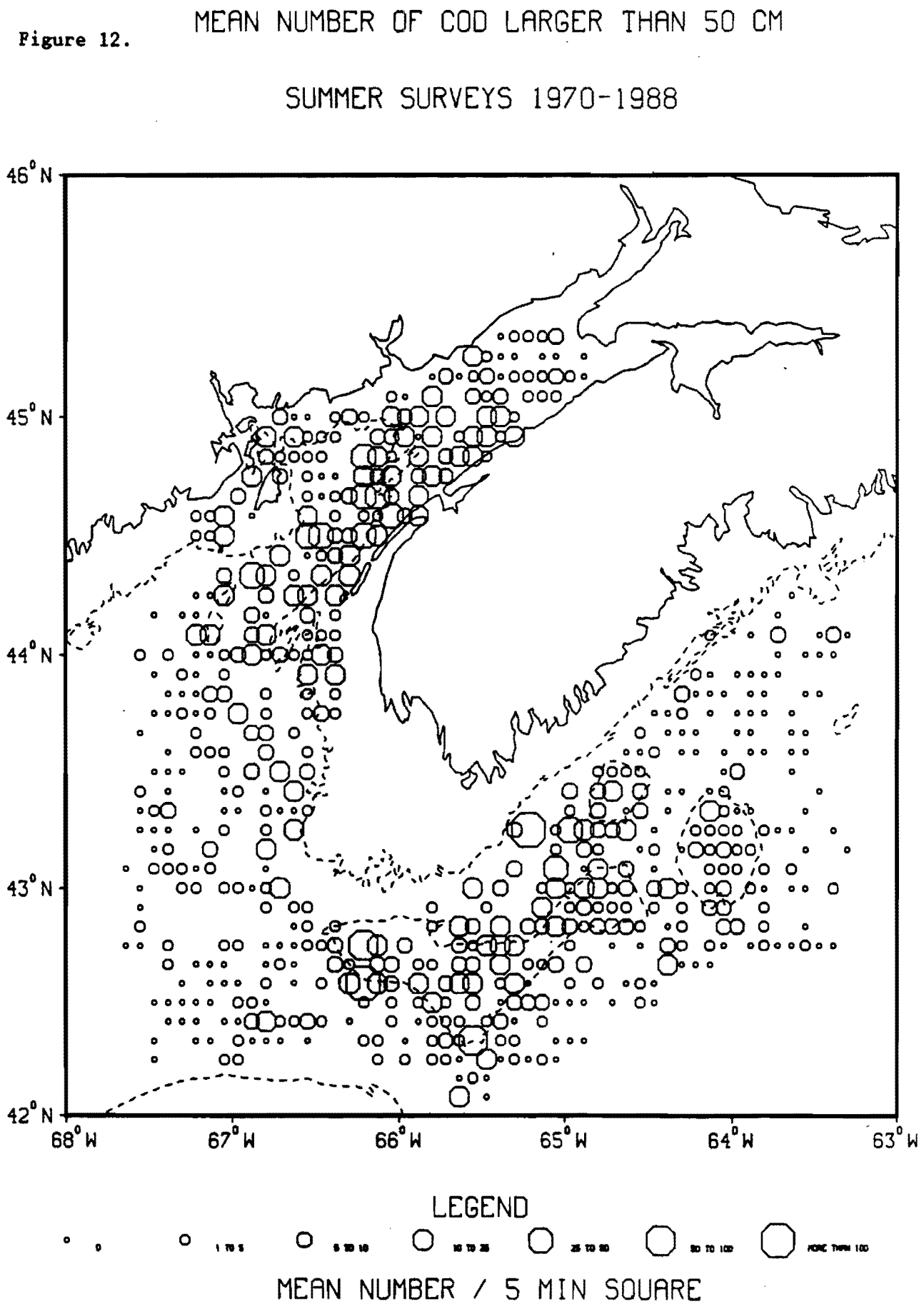

MEAN NUMBER OF COD LARGER THAN 50 CM
SUMMER SURVEYS 1970-1988
46° N
45° N
44° N
43° N
42° N
68° W
67° W
66° W
65° W
64° W
63° W
LEGEND
MEAN NUMBER / 5 MIN SQUARE

Figure 13. Observed age composition in 1989 catch as compared to that predicted last year.

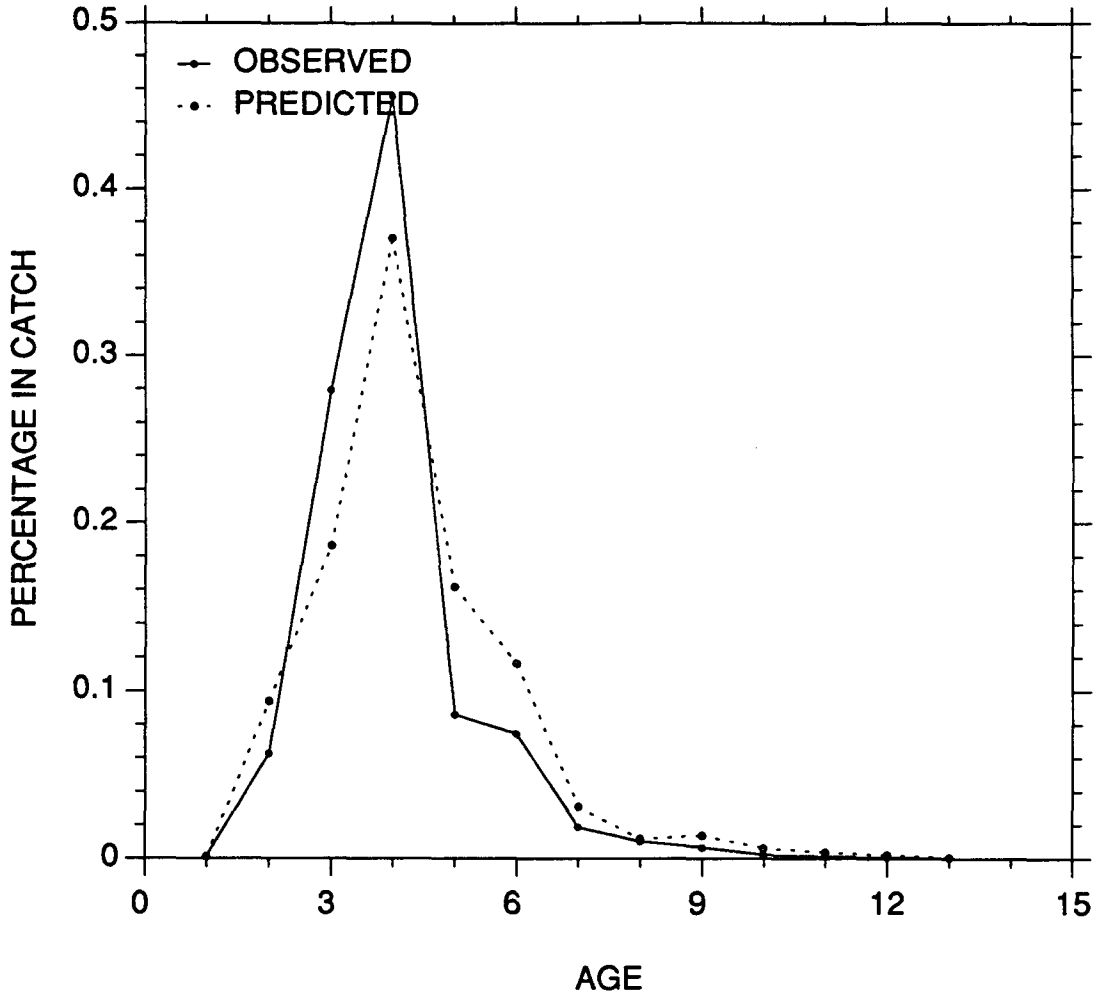


Figure 14. Weight at age in catch.

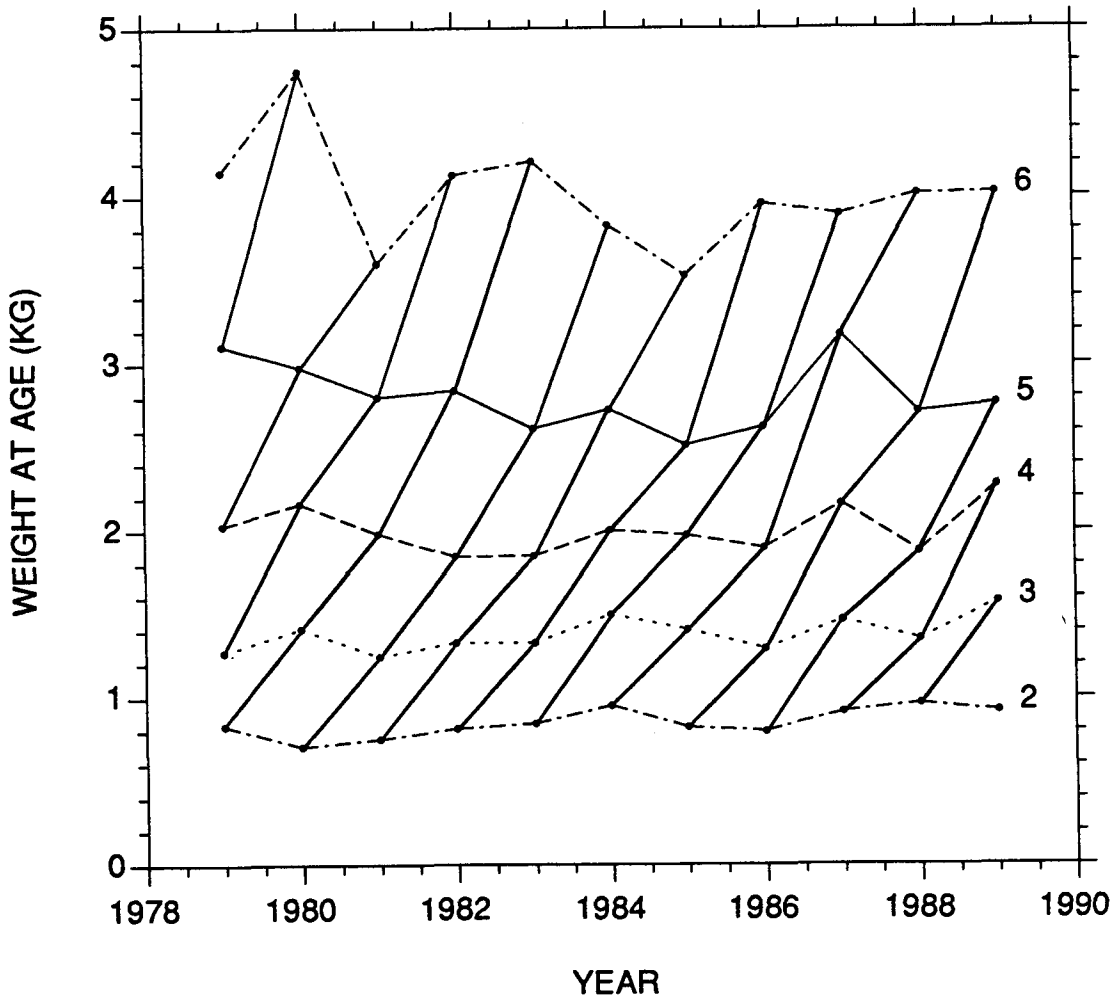


Figure 15. Scaled population numbers (from ADAPT) vs. observed RV abundance, ages 3-7.

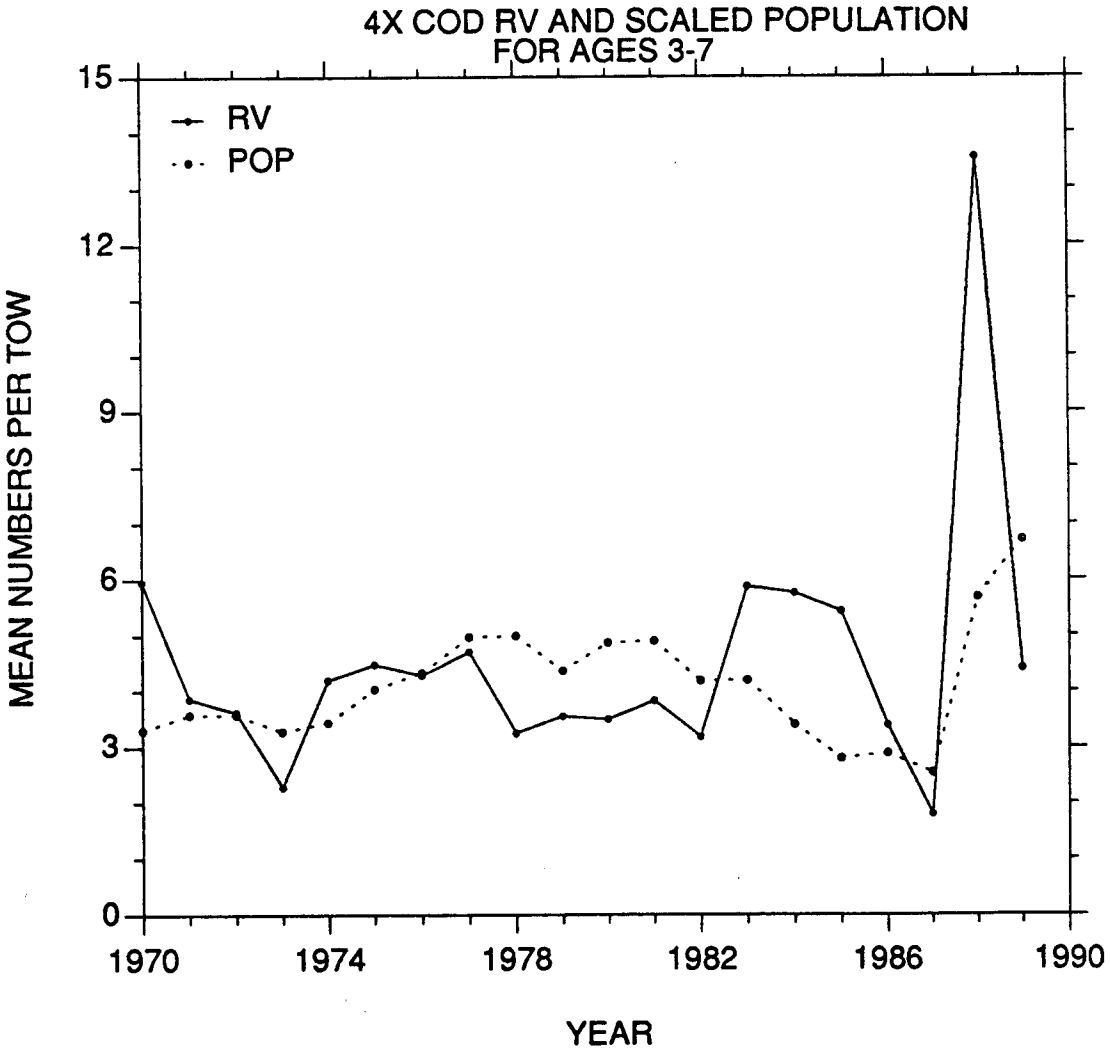


Figure 16.

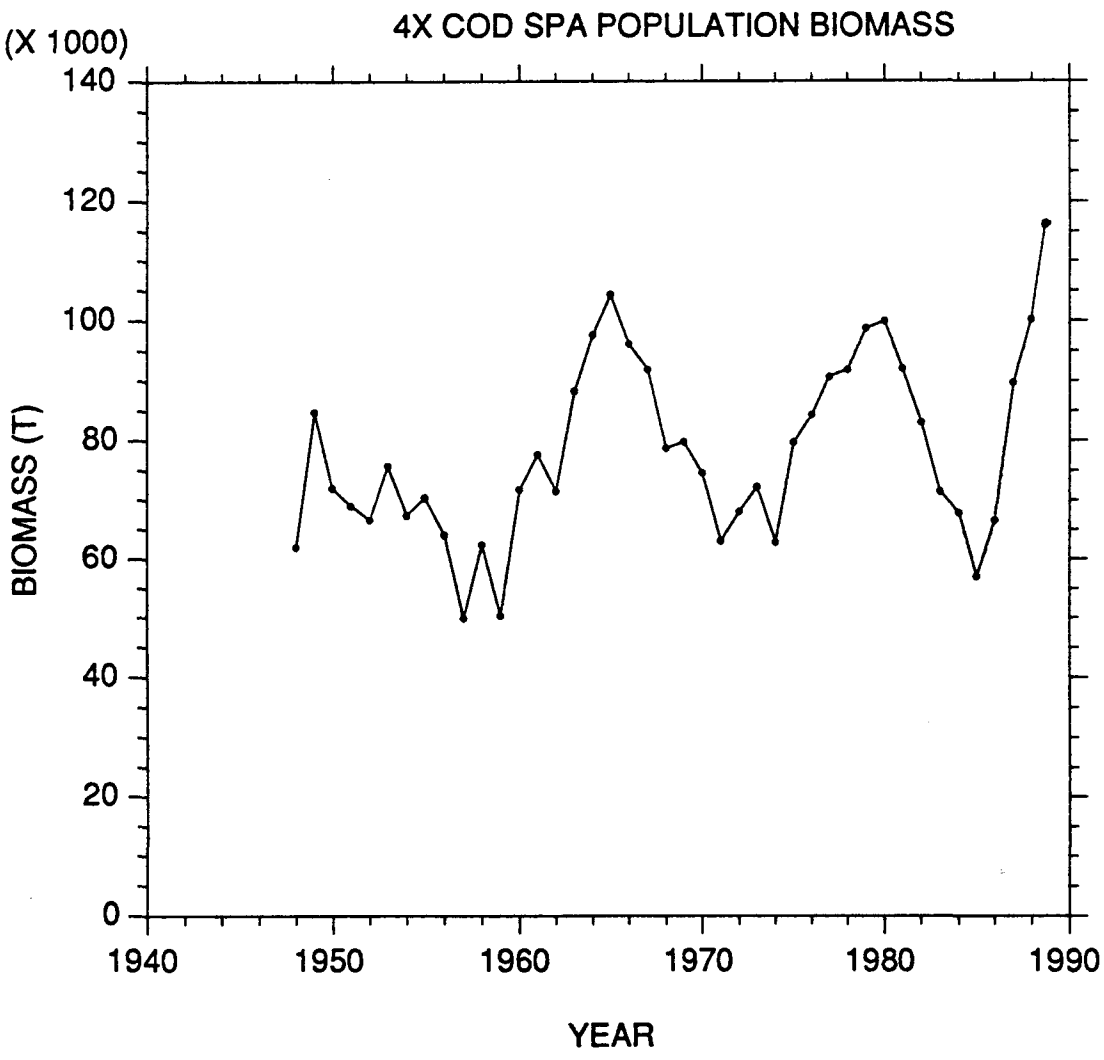

4X COD SPA POPULATION BIOMASS
(X 1000)
140
120
100
80
60
40
20
0
BIOMASS (T)
1940
1950
1960
1970
1980
1990
YEAR

Figure 17. Fully recruited fishing mortality.

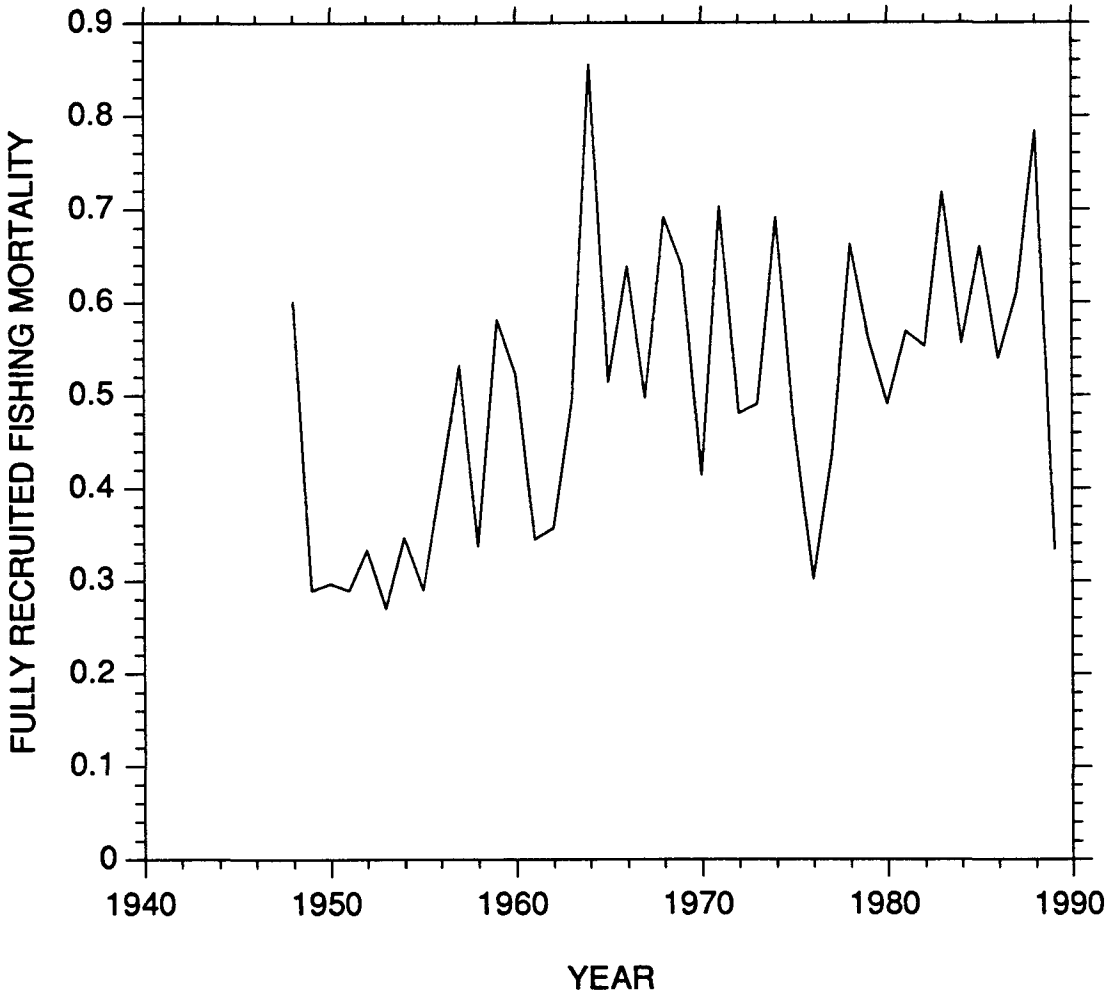


Figure 18. Mean weight (kg) in catch.

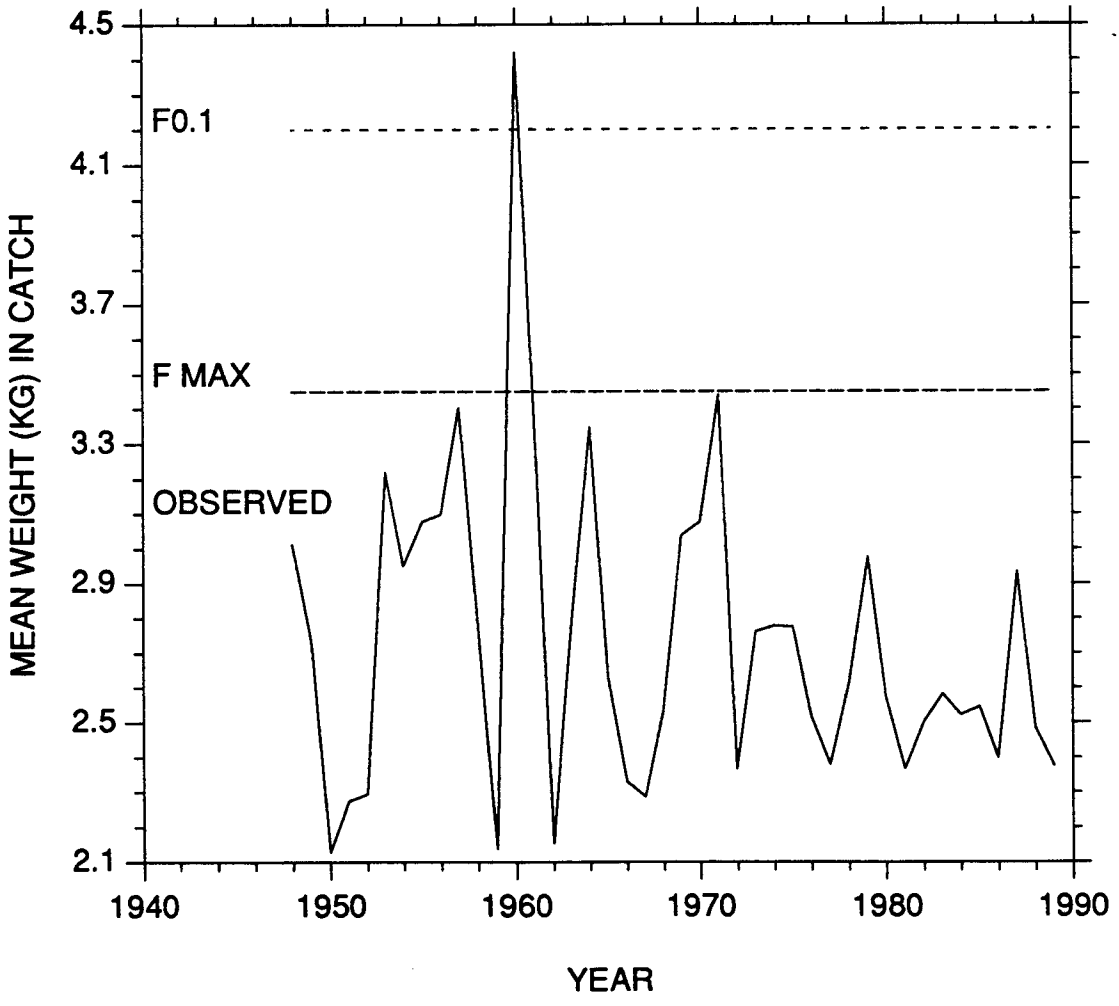
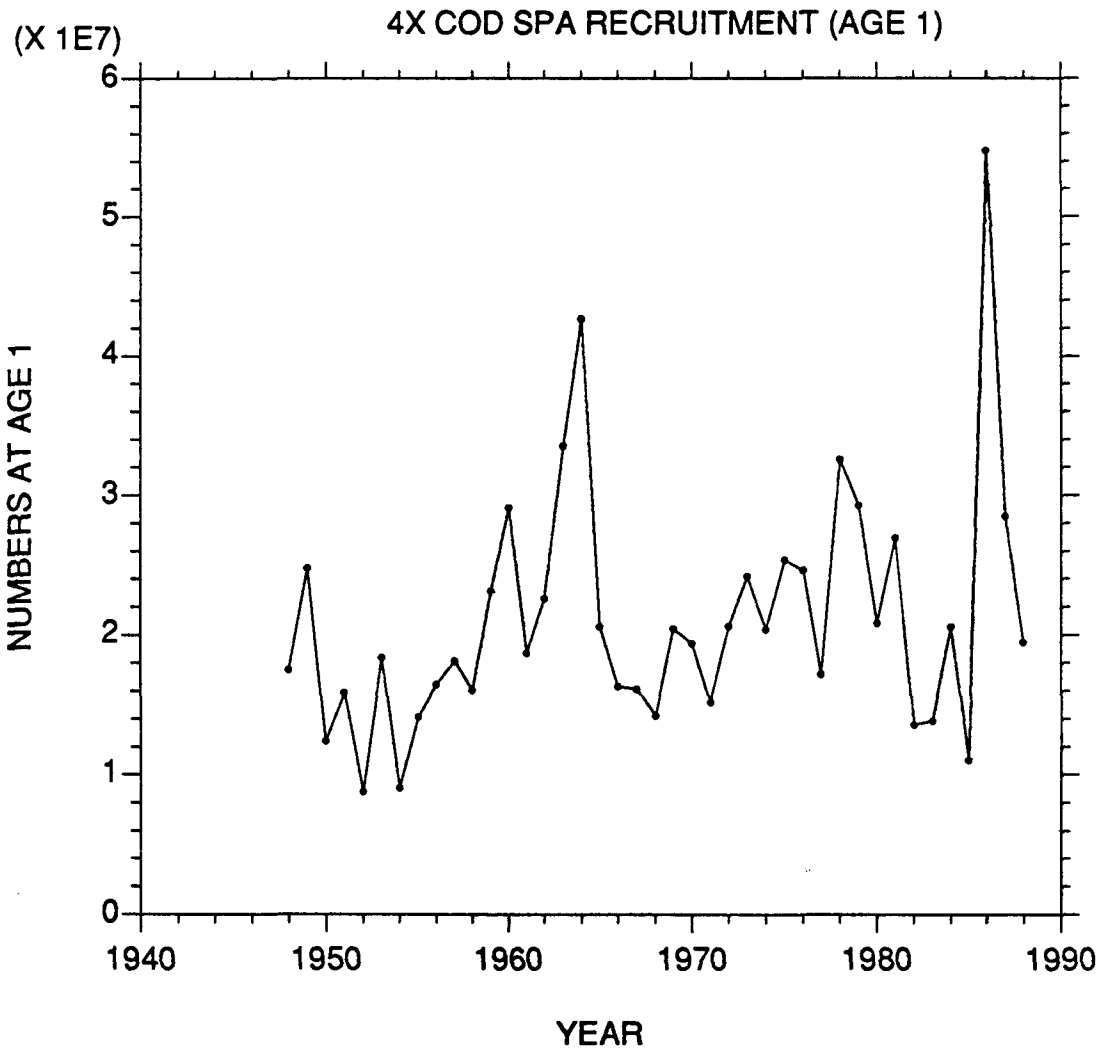


Figure 19.


4X COD SPA RECRUITMENT (AGE 1)
(X 1E7)
NUMBERS AT AGE 1
0
1
2
3
4
5
6
1940
1950
1960
1970
1980
1990
YEAR