Status of the 4X Cod Stock in 1988

by

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Abstract

The 1988 nominal catch of 4X cod was 19,421 t. Both of the major gear components (MG < 65'; FG < 65') exceeded their allocations. While a multiplicative analysis of commercial catch rates indicated a steady and substantial decline since the late 1970s, the commercial C/E data were deemed unreliable and the analysis was not pursued. Indices of stock abundance from RV surveys showed a decline since 1975. Calibration of the SPA with the ADAPT framework indicated a terminal fishing mortality of 0.54. This estimate is consistent with the time series of fully-recruited fishing mortalities and the observed mean weight in the catch. SPA biomass and population egg production are slightly above the near record-low levels of recent years. There has been no apparent relationship between stock and recruitment to this point, but current predictions are being made at the extreme lower end of the data range. If the 1989 TAC of 12,500 t is caught, the 1990 catch under the 50% rule would be 11900 t.

Résumé

En 1988, les prises nominales de morue dans la division 4X se sont établies à 19 421 t. Les deux grands secteurs d'engins (EM< 65 pi et EF< 65 pi) ont dépassé leur allocation. Une analyse multiplicative des taux de prises commerciales a révélé une diminution constante et importante depuis la fin des années 1970, mais on a estimé que les données sur l'effort de pêche et les prises commerciales n'étaient pas fiables et on n'a pas poursuivi l'analyse. Les indices d'abondance de stocks obtenus lors des missions des NR dénotent une baisse depuis 1975. L'étalonnage des ASP selon le modèle ADAPT aboutit à un taux de mortalité due à la pêche de 0,54 pour la dernière année. Cette estimation correspond à la série temporelle des taux de mortalité due à la pêche dans le stocks pleinement recruté et au poids moyen observé dans les prises. La biomasse obtenue par l'ASP et la production d'oeufs sont légèrement supérieures aux bas niveaux, presque sans précédents, que l'on a connus ces dernières années. Jusqu'ici, il ne semble pas y avoir de rapport apparent entre le stock et le recrutement, mais les prévisions actuelles sont fondées sur les valeurs les plus basses de la fourchette de données. Si le TPA de 1989, soit 12 500 t est capturé, les prises de 1990 seraient de 11 900 t, conformément à la règle des 50 p. 100.

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 essentially 100% Canadian and catches increased to almost 33,000 t; however, there has been a marked decline in catches since 1982 (Figure 3). The 1988 nominal catch was 19,421 t.

Both the fixed (< 65') and mobile (< 65') gear categories exceeded their allocation in 1988 (Table 2). The fishery by both gear categories was closed or restricted several times during the year (Table 3). 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. However, the problem has not been significant since 1986, and the adjustment procedure was discontinued for the current assessment. A more serious misreporting problem first became apparent in 1986 and continued into 1988; comments by fishermen, industry representatives, and port samplers indicate that substantial quantities of cod were either unreported during the year or incorrectly reported as other species such as white hake. It was impossible to quantify the magnitude of this underreporting, but its extent appeared to greatly exceed that of previous years. Therefore, reported catches may underestimate actual catches by anywhere between 10-40%.

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 1988. Longline/handline gear in 1988 appear to have reversed their recent decline in landings (Fig. 4). Catches by TC-1 vessels accounted for 37% of the total in 1988, somewhat higher than the proportion reported last year. Catches in each of the major gear categories peaked in the summer months (Figure 5).

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 2). 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).

Age-structured survey population estimates in each stratum are presented in Table 5. The 1988 indices of number and weight per tow are uniformly higher than those of 1987, but much of the increase in population estimates (Table 6) is attributable to a single set, largely of 3-yr old fish, on

Browns Bank (Stratum 80)(Table 5). This is reflected in the high standard errors around the population estimates (Table 7). Age 5+ population numbers were similar to the long term mean (Fig. 6), while the total biomass index, which included the large single set noted above, was anomolously high (Fig. 7). No trends in weights-at-age (weighted by length frequency and stratum area) are evident over recent years (Table 8). With respect to incoming recruitment, the 1984 year-class appears to be particularly weak, while the 1985 cohort may be above average (Figure 8).

Commercial Catch Rates

Less than 20% of the landed catch of 4X cod was reported as having been the product of directed effort (Table 9). Exploratory examination of standardized catch rates calculated with the multiplicative model (Table 10) produced results similar to those of previous years. A decline in catch rates since 1978 was indicated (Fig. 9), but the inter-annual contrast was low. Much of the explained variance in the analysis was due to a gear effect. Given the misreporting problem in the region, the multiple closures and fishery restrictions in recent years, the low proportion (7%) of catch entered into the model, and the low number of observations per model category, the model results were not considered to be useful. In addition, the use of commercial CPUE as an index of 4X cod abundance was deemed inappropriate.

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 1948-87. Details of key construction and sample aggregation policy are described elsewhere (Campana and Simon, MS 1986). Sixty samples went into the construction of comparable keys for 1988. 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 and sample information for 1988 are presented in Table 11. Numbers at age caught in 1988 by each of the major gear categories are presented in Table 12. 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).

Total catch numbers and percent catch numbers-at-age for the period 1948-88 are presented in Tables 13 and 14. A comparison of the 1988 catch composition and that predicted last year for 1988 indicates that all ages were reasonably well predicted, although the partial recruitments of ages 3 and 4 were slightly over- and under-estimated, respectively (Figure 10). No recent trends in mean weight-at-age in the catch (Table 15; Fig. 11) were noted, although there have been long-term trends (Fig. 12). Fish aged 3-5 made up the largest proportion of the catch numbers (78%) in 1988 while ages 3-6 made up most of the catch weight (71%) (Table 16). Catch composition

curves indicate that age 5 fish were fully recruited to the fishery.

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 1989). Eight parameters were estimated: population numbers at ages 4, 5, 6 and 7 in 1988 and the slopes of the regression relating SPA to RV population numbers at ages 4, 5, 6, and 7. All data were ln transformed. The ADAPT formulation used is summarized in Table 17.

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 18). 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 3 of the 4 slopes remained so. Examination of the age-by-age weighted calibration plots indicated that the model fit the data well (Figure 13). The residuals were randomly distributed across year, predicted values, and SPA population numbers. However, the estimate for Age 4 numbers in 1988 appeared to be too high, and thus was recalculated using the mean partial recruitment at age 4 for the previous 6 years. A comparison of the predicted and observed population numbers for ages 4-7 is presented in Figure 14.

The result of the SPA calibration was a terminal F of 0.54. This value is almost identical to that produced through use of last year's calibration procedure (ADAPT calibration of SPA ages 4-6 on RV ages 4-6) (Campana and Simon, MS 1988). In addition, the time series of fully recruited Fs indicates that a 1988 F_t of 0.54 is equivalent to the mean of the past 25 years (Figure 15). Further, the observed mean weight in the catch lies far below that expected of fishing at F_{max}, let alone at $F_{0.1}$ (Figure 16). Finally, if misreporting/nonreporting of cod landings increased in 1986, apparent F_t would be lower than that actually present. For these reasons, an F_t of 0.54 was considered to be a reasonable estimate for 1988.

Assessment Results

Population numbers and fishing mortalities corresponding to $F_t = .54$ are presented in Tables 19 and 20. Table 21 presents the corresponding partial recruitment matrix. Population biomass in 1988 was marginally higher than that of 1987, although both years represented the lowest values observed in the stock since 1958 (Table 22, Fig. 17).

Recruitment

Recruitment of 4X cod has varied by a factor of 5 between 1948-87; the 1984 year class appears to be among the weakest in the time series (Figure 18). It is tempting to ascribe the recent difficulties in recruitment to

the near record-low levels of population biomass now present in the population (Table 22). To test this hypothesis, preliminary estimates of population egg production were generated for the period 1948-88. Egg production for each year was estimated through application of the length-fecundity relationship for 4T cod (Buzeta and Waiwood 1982) to the SPA numbers at length for 4X cod. Length-fecundity relationships differ little among stocks (Powles 1958; May 1967), so there is little reason to question the validity of the fecundity relationship that was applied. SPA numbers at length were generated as per Campana (1987) using the mean RV age-length key for the period 1983-87. The time series of egg production (Fig. 19) was similar to that of both population biomass and the time series of spawning stock biomass generated through independent means for last year's assessment (Campana and Simon, MS 1988). Despite the fact that egg production for the 1988 population is near its lowest level in 41 years (Figure 19), there is no evidence of a stock-recruitment relationship (Figure 20), and thus no evidence that the low number of eggs/spawners is inducing a lower level of recruitment. However, the current levels of egg production are at the extreme lower end of the observed range, rendering the stock-recruitment relationship inappropriate for recruitment prediction beyond this point.

Yield per recruit was calculated using the mean of 1980-87 weights at age and partial recruitment. The analysis produced similar results to that of previous years (Table 23), with $F_{0.1}$ = 0.16, F_{max} = 0.27, and yield per recruit at $F_{0.1}$ equal to 1.13 kg. Expected annual yield (long-term) at $F_{0.1}$ is 21,000 t (assuming geometric mean recruitment at age 1 = 18,911,000).

Catch Projections

Projections were made with the mean of the 1980-88 weights at age, the mean PR of ages 1-4 between 1982-87, and the geometric mean of age 1 recruitment between 1948-87. The 1989 TAC, 12,500 t, which is above the $F_{0.1}$ reference level, corresponds to a fishing mortality of 0.34. Assuming the 1989 TAC is caught, the projected $F_{0.1}$ catch in 1990 is 9000 t (Table 24). Projections consistent with the 50% rule result in a 1990 F of 0.27 and a catch of 11900 t (Table 24).

Conclusions

Historic assessments of this stock have always reported overexploitation (Halliday, MS 1971, MS 1974; Sinclair, MS 1980; de Lafontaine, MS 1981; Gagné 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). Our current view of the stock suggests that the rate of overexploitation has not been changed. The relative long-term stability of the stock is thus testament to its resilience. While there is some evidence that the decline in stock abundance since the early 1980's has now stabilized, not all of the indices reflect this stabilization. The declining catch rates in the fishery cannot be considered reliable. However, the RV index of abundance shows a slight but long-term decline since 1970. SPA biomass is near a 41-year low but may now have stabilized. While there has been no apparent relationship between stock and recruitment to this

point, the current record-low levels of population egg production are outside the range of previous years' observations, and thus cannot be used for predictive purposes. There is evidence of above-average recruitment in the 1985 year class; however, the 1984 year class now appears to be one of the weakest on record. Given the high rate of exploitation, the recovery of this stock is inexorably linked to the recruitment of the 1986+ 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
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
83	28963			11	286			1		29261	99.0
84	25068			5	189					25262	99.2
85	21370				9					21379	100.0
86	19869*				43					19912	99.8
87	18671*				11					18682	99.9
88	19417*				4					19421	100.0

Sources: 1948-53 ICNAF Suppl. Ann. Proc. 11 (Appendix) (1962).
          1954-66 NAFO Statistical Bulletins
          1967-88 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).

Year	Gear	4X		5Y	
		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[1]	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

* 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 1988.

Gear Category	Date	Restrictions
Mobile gear < 45'	March 19	2000 kg trip limit
	March 25	3400 kg trip limit
	May 1	4500 kg trip limit
	June 25	1500 kg trip limit
	July 9	0 kg trip limit (10% by-catch only)
Mobile gear 45'-65'	March 19	4500 kg trip limit
	April 22	0 kg trip limit (10% by-catch only)
	May 6	1000 kg trip limit
	May 19	0 kg trip limit (10% by-catch only)
Fixed gear < 45'	August 10	9000 kg trip limit
	August 12	18000 kg trip limit
	October 11	1500 kg trip limit
Fixed gear 45'-65'	August 10	9000 kg trip limit
	August 12	18000 kg trip limit
	October 11	1500 kg trip limit

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	2	3	4	5	LL / LHP[A] 1	2	3	4	GN 1	2	Misc.	Total
1985	M	–	42	62	8	530	641	224	76	1	1196	34	206	3020
	N	–	132	221	27	577	7	158	122	–	–	3	2	1249
	O	89	642	272	3	38	3731	288	40	–	392	24	46	5565
	P	–	227	506	1	29	3	272	92	–	–	–	–	1130
	Q	68	709	946	10	–	316	80	9	–	–	–	93	2231
	R	83	867	1324	4	–	305	–	–	–	3	–	22	2608
	S	101	553	435	–	–	317	1	–	–	192	49	–	1648
	U	–	1181	1564	–	12	–	789	245	–	–	55	69	3915
	Total	342	4353	5330	54	1185	5320	1813	585	1	1783	166	439	21370
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
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
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

[A] LHP = handline

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

Table 5. Mean numbers (TOP) and mean weight (BOTTOM) per tow in RV surveys.

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
70	.0	4.4	.8	4.9	.0	.5	.0	2.9	.0	1.0	.0	.0	.0	1.6	.0	.0	3.6	.0	.3
71	.0	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	.0	.0	1.2	.0	.0	.0	.6
72	4.6	3.1	.0	.0	4.6	3.3	10.9	2.7	1.8	5.2	10.5	18.4	2.9	4.6	5.2	15.6	1.0	1.3	2.6
73	3.6	8.8	3.7	7.3	8.5	7.0	11.5	10.7	10.0	5.3	2.6	5.8	2.2	12.1	2.7	10.1	4.5	2.6	4.5
74	9.1	3.3	5.0	21.0	7.4	10.0	12.4	11.5	2.4	14.3	2.6	18.9	6.7	24.1	.0	13.1	15.9	1.1	5.2
75	28.5	11.4	11.8	11.7	12.7	3.2	11.8	6.7	9.3	9.4	9.1	13.4	7.2	.0	9.4	18.2	6.2	7.3	7.7
76	61.9	81.7	27.3	4.5	12.3	11.8	17.5	4.8	3.4	.0	9.2	6.5	.5	24.3	10.3	1.5	3.9	.8	6.0
77	1.6	4.7	1.2	5.3	5.0	3.0	7.5	5.2	6.6	4.6	3.1	1.8	4.7	5.7	12.4	4.0	7.9	6.5	11.4
78	.0	.0	.0	.0	.3	.2	1.5	1.0	7.6	1.4	.7	6.3	.4	.0	1.1	1.0	.0	.0	.0
80	7.6	16.1	9.2	13.4	5.1	9.5	7.7	30.8	11.4	13.9	18.1	14.7	3.8	20.9	8.2	4.2	11.8	16.0	286.3
81	11.7	1.6	11.3	10.5	17.5	13.1	1.8	2.9	4.6	7.1	4.3	2.0	5.6	8.5	17.0	2.3	3.4	3.7	34.5
82	3.9	.0	.0	.0	1.9	12.3	1.6	3.2	2.2	3.8	3.9	.7	3.7	.5	2.4	.0	.0	.4	3.2
83	.4	.0	8.8	.0	.0	.0	.0	1.7	1.2	.0	.7	1.5	.5	.0	1.0	.5	.0	.0	.0
84	.0	1.0	.7	1.0	1.6	.5	3.5	.3	.0	2.8	.0	1.3	.5	.0	2.4	.0	.0	2.5	1.1
85	8.5	2.1	1.5	7.5	1.1	6.0	1.2	15.4	2.5	4.3	7.1	11.9	8.7	2.3	13.1	7.5	5.9	4.0	8.9
90	13.4	7.6	13.1	5.5	24.1	47.3	5.1	19.0	17.6	13.1	7.8	39.9	20.4	10.8	13.7	120.9	30.7	15.0	58.0
91	2.4	3.8	11.9	6.1	3.7	6.0	16.5	20.1	18.6	75.1	20.4	18.1	9.5	18.3	46.9	32.4	10.6	8.6	20.0
92	3.0	3.4	7.8	1.8	6.5	13.9	5.9	14.4	4.6	16.8	1.6	13.0	32.5	11.0	3.1	22.2	9.7	3.0	37.7
93	.0	.4	2.4	1.7	4.9	12.4	10.5	1.9	7.9	7.9	9.1	8.9	16.9	9.9	24.7	40.6	9.3	5.9	10.3
94	1.4	7.2	3.0	6.1	1.0	20.6	15.7	4.9	3.6	2.1	15.4	4.3	.5	.0	13.9	4.1	1.0	10.9	2.1
95	3.2	9.6	18.6	5.8	22.5	12.3	9.3	29.9	.0	33.3	46.2	24.7	6.1	.9	21.6	35.3	7.2	5.7	7.5

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
70	.0	11.2	1.1	15.8	.0	2.9	.0	8.2	.0	.4	.0	.0	.0	1.6	.0	.0	6.2	.0	.3
71	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
72	13.3	5.7	.0	.0	6.2	8.2	17.9	2.7	3.7	10.0	24.0	9.9	1.9	6.5	5.7	16.0	.0	1.8	1.9
73	4.0	13.2	9.7	15.6	9.3	10.4	31.2	35.8	16.8	21.6	6.6	4.8	2.7	7.5	3.3	20.6	9.3	9.3	10.8
74	24.9	12.8	17.9	24.0	16.0	18.1	34.8	32.5	7.1	36.7	12.4	42.2	20.6	38.5	.0	30.3	44.9	2.2	8.2
75	87.7	33.1	28.1	20.2	28.8	17.5	17.6	10.9	19.2	26.2	13.5	39.8	19.0	.0	19.3	23.5	4.6	4.9	10.3
76	151.4	65.6	64.0	8.9	40.2	27.9	32.8	11.2	13.1	.0	15.2	20.0	.0	38.5	19.0	2.4	6.4	3.4	10.8
77	3.7	12.0	1.5	10.6	8.8	3.9	11.7	22.1	6.1	9.9	19.5	3.5	13.5	10.8	22.7	7.5	19.0	17.9	22.4
78	.0	.0	.0	.0	.3	.5	3.0	2.8	13.4	3.6	4.4	24.6	2.6	.0	1.0	6.8	.0	.0	.0
80	21.7	22.1	19.9	38.0	14.1	14.2	13.8	54.3	22.4	36.0	60.4	19.9	12.3	35.1	15.9	12.3	40.4	14.4	265.4
81	32.1	4.3	33.5	22.7	29.9	31.3	4.2	6.2	9.2	40.0	11.3	5.1	16.3	14.4	17.8	4.4	5.8	8.0	47.1
82	16.0	.0	.0	.0	2.9	49.6	6.5	13.9	5.7	17.5	17.9	1.4	4.6	1.0	6.8	.0	.0	1.1	9.7
83	4.0	.0	19.4	.0	.0	.0	.0	7.7	7.6	.0	6.6	10.8	.5	.0	5.2	1.0	.0	.0	.0
84	.0	4.9	1.6	3.7	16.4	1.4	12.4	.7	.0	9.3	.0	2.6	.9	.0	6.5	.0	.0	8.7	2.2
85	24.8	8.1	6.8	23.0	3.2	23.9	1.2	33.6	8.4	10.9	27.0	35.0	19.0	7.0	18.6	26.9	10.4	12.1	11.4
90	22.2	13.6	34.1	9.2	52.7	74.9	7.7	38.5	53.8	16.1	26.8	52.5	51.9	25.3	19.3	153.0	60.5	21.0	62.6
91	13.3	12.2	48.7	17.5	12.9	16.8	82.3	46.6	53.2	80.0	55.8	51.1	27.6	34.1	74.9	93.4	29.5	45.0	53.9
92	15.0	18.5	31.9	6.1	21.7	52.5	20.8	58.9	16.6	56.5	7.1	57.2	126.5	48.4	13.7	39.9	32.1	20.1	100.1
93	.0	.0	8.1	4.0	9.2	35.1	38.4	5.3	41.7	11.5	31.3	35.3	50.4	36.1	44.2	78.0	17.4	21.0	18.1
94	.7	7.5	16.1	17.2	5.9	40.8	42.3	16.3	10.0	7.7	.5	3.9	1.4	.0	30.5	6.2	1.0	17.8	7.2
95	22.3	10.6	45.7	18.2	41.0	18.6	23.2	62.8	.0	65.4	21.0	59.4	9.4	1.4	33.4	45.9	14.9	14.4	7.3

Table 6. Mid-year RV population numbers ('000).

MID-YEAR RV POPULATION, STRATA 70-95

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
0	27	0	0	23	111	0	0	0	23	0	1822	61	73	136	0	70	26	6	280
1	942	345	305	114	411	1019	152	252	190	2728	205	2215	727	140	820	495	750	381	2613
2	1502	7043	1433	2109	969	2812	1256	2151	1060	3448	876	2407	1792	1070	5411	8752	999	2342	9533
3	2330	3920	3180	1123	4503	1603	2813	4242	1721	1758	2819	2271	1770	4122	3541	4204	2621	589	16106
4	4104	637	2525	2229	1069	2945	2326	2591	2481	1988	1132	2563	1856	2358	2366	1487	1277	1137	2790
5	1818	1456	714	715	1619	2497	2054	796	1343	1784	1046	1343	1526	1468	1937	1518	358	602	1693
6	2404	662	494	272	938	979	835	1272	493	999	1423	869	873	919	714	788	629	260	513
7	1043	921	211	159	119	777	405	358	368	451	458	478	239	373	503	538	459	226	206
8	513	45	530	51	0	149	234	213	91	309	212	389	246	0	62	294	218	312	293
9	172	0	388	184	46	99	62	46	72	60	126	108	213	76	65	159	97	75	63
10	94	17	154	45	22	0	63	27	0	61	0	92	66	37	26	12	19	41	0
11	13	0	22	25	44	112	13	25	0	82	69	26	31	0	0	0	0	66	0
12	0	0	22	6	0	27	0	12	0	0	0	7	27	0	0	7	0	0	0
0+	14962	15047	9979	7055	9851	13019	10213	11985	7841	13668	10187	12829	9439	10700	15446	18324	7453	6037	34088
1+	14935	15047	9979	7032	9740	13019	10213	11985	7818	13668	8365	12767	9366	10564	15446	18255	7428	6031	33809
2+	13993	14701	9674	6918	9329	12001	10061	11733	7628	10940	8160	10552	8638	10424	14626	17760	6678	5650	31196
3+	12491	7658	8241	4809	8360	9188	8805	9582	6568	7492	7285	8145	6846	9354	9215	9008	5679	3308	21663
4+	10161	3738	5062	3686	3857	7585	5992	5340	4847	5734	4465	5875	5076	5232	5673	4803	3058	2719	5558
5+	6057	3101	2537	1457	2788	4640	3666	2749	2366	3746	3333	3312	3220	2873	3307	3316	1780	1582	2768
6+	4239	1645	1822	742	1169	2143	1612	1953	1023	1962	2288	1969	1694	1406	1371	1799	1422	980	1075
7+	1835	983	1328	470	231	1164	777	681	530	963	865	1100	821	487	657	1011	794	720	562
8+	792	62	1117	311	112	387	372	323	163	513	407	622	582	114	153	473	334	494	356
9+	279	17	586	260	112	239	138	110	72	203	195	233	336	114	91	178	116	182	63
10+	107	17	199	76	66	139	76	64	0	144	69	125	123	37	26	19	19	107	0
11+	13	0	44	31	44	139	13	37	0	82	69	33	57	0	0	7	0	66	0
12+	0	0	22	6	0	27	0	12	0	0	0	7	27	0	0	7	0	0	0

Table 7. Standard error ('000) of summer RV population estimates.

RV STANDARD ERROR

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
0	27	0	0	23	103	0	0	0	23	0	1570	62	48	103	0	50	25	6	129
1	219	102	104	55	246	281	79	71	82	2113	140	1293	262	81	303	187	494	200	879
2	860	5636	711	416	231	589	356	418	257	1036	297	502	379	298	1627	3677	259	415	5705
3	1488	3163	1179	235	957	299	936	736	440	415	602	490	354	782	1147	1397	636	108	7261
4	2483	312	576	453	248	544	855	444	435	354	234	386	337	326	573	370	276	202	1496
5	959	578	149	196	236	630	463	179	220	313	155	242	247	438	492	283	89	153	479
6	1131	207	97	51	248	238	143	239	67	185	247	119	166	229	164	161	130	76	141
7	450	184	66	49	86	267	124	89	76	171	79	106	30	103	137	162	115	61	83
8	229	17	84	19	0	82	84	110	32	200	47	101	58	0	44	125	59	72	127
9	87	0	171	74	34	46	31	21	21	38	51	40	73	34	29	62	65	33	39
10	65	17	48	20	14	0	19	19	0	42	0	35	37	14	25	13	19	27	0
11	13	0	13	13	25	112	13	20	0	42	53	27	15	0	0	0	0	32	0
12	0	0	13	6	0	16	0	12	0	0	0	7	27	0	0	6	0	0	0

Table 8. Mean·weight at age (kg) as derived from summer RV surveys.
Weights were weighted by stratum area and length frequencies.

RV WEIGHTS AT AGE (KG)

▪	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
0 ▪	.00	.00	.00	.00	.00	.00	.00	.00	.04	.00
1 ▪	.13	.10	.12	.10	.08	.13	.07	.14	.11	.07
2 ▪	.59	.31	.55	.59	.58	.47	.57	.80	.70	.48
3 ▪	1.33	.78	1.64	1.01	1.29	1.08	1.24	1.48	1.70	1.32
4 ▪	2.56	2.25	2.22	2.85	1.72	2.07	1.79	2.03	2.47	2.37
5 ▪	3.32	3.51	3.30	3.78	3.76	2.77	2.80	3.05	3.32	3.44
6 ▪	4.37	3.74	5.02	4.69	5.81	3.78	4.21	5.22	4.68	3.54
7 ▪	4.75	4.71	3.76	6.95	4.58	5.79	4.93	4.90	6.29	4.71
8 ▪	5.91	4.96	5.63	3.36	.00	7.75	6.35	9.70	9.45	7.12
9 ▪	8.11	.00	7.57	6.53	12.59	3.84	6.61	5.40	8.45	9.08
10 ▪	10.39	12.10	10.20	7.72	6.60	·.00	9.41	11.28	.00	14.71
11 ▪	14.83	.00	14.65	4.23	7.87	16.30	15.19	7.71	.00	10.61
12 ▪	.00	.00	14.65	14.87	.00	8.71	.00	17.13	.00	.00

▪	1980	1981	1982	1983	1984	1985	1986	1987	1988
0 ▪	.00	.00	.02	.00	.00	.00	.00	.00	.03
1 ▪	.14	.26	.14	.06	.07	.11	.09	.06	.07
2 ▪	.48	.49	.44	.59	.54	.49	.39	.38	.60
3 ▪	1.39	1.34	1.26	1.27	1.22	.95	1.06	.77	1.17
4 ▪	1.93	2.32	2.09	1.81	2.37	1.65	1.72	2.27	1.73
5 ▪	2.96	3.20	2.93	2.55	2.97	2.49	2.02	2.87	2.69
6 ▪	5.14	4.16	4.84	3.44.	3.30	4.22	4.07	5.20	4.22
7 ▪	5.97	5.70	7.43	6.17	3.94	5.52	5.63	8.61	3.55
8 ▪	6.85	7.60	8.07	.00	11.98	5.91	6.08	8.12	11.68
9 ▪	10.88	10.39	10.63	9.78	6.03	9.31	11.55	11.48	8.73
10 ▪	.00	8.77	11.41	7.41	13.44	14.22	6.84	11.90	.00
11 ▪	14.72	15.84	9.60	.00	.00	.00	.00	11.11	.00
12 ▪	.00	15.84	15.67	.00	.00	15.43	.00	.00	.00

Table 9. Commercial catch rates for otter trawlers (OT) and longliners (LL) in 4X (all unit areas combined). Effort values in parentheses. Effort units are hundreds of lines (LL) and tons/hr (OT).

	Gear					
Year	LL - TC2 Jan-Mar	LL - TC2 Apr-June	LL - TC2 July-Sept	LL - TC3 Jan-Mar	OT - TC2 Apr-June	OT - TC3 July-Sept
1973	1.47 (10)	1.71 (13)	1.05 (125)	1.91 (25)	-	-
1974	1.81 (73)	1.17 (203)	0.99 (171)	1.67 (180)	.10 (174)	-
1975	1.51 (87)	1.31 (256)	0.85 (153)	1.67 (102)	.15 (205)	.20 (173)
1976	1.10 (72)	1.00 (99)	0.76 (235)	1.38 (44)	.10 (716)	.15 (313)
1977	1.31 (258)	1.17 (284)	1.18 (224)	1.80 (169)	.17 (2576)	.35 (1159)
1978	1.59 (362)	1.18 (250)	1.11 (276)	2.19 (190)	.20 (1142)	.58 (1448)
1979	1.38 (262)	1.19 (320)	1.48 (291)	2.25 (143)	.28 (923)	.31 (897)
1980	1.27 (213)	0.93 (519)	1.03 (209)	1.75 (188)	.18 (4636)	.26 (1914)
1981	1.51 (412)	1.17 (310)	0.86 (138)	2.20 (168)	.22 (1947)	.23 (811)
1982	1.20 (670)	1.09 (424)	1.24 (416)	1.62 (329)	.14 (3074)	.25 (1997)
1983	1.26 (295)	1.29 (234)	0.79 (117)	1.70 (177)	.20 (5181)	.21 (2887)
1984	1.18 (294)	0.99 (145)	0.95 (33)	1.45 (207)	.12 (2574)	.24 (2780)
1985	1.30 (203)	0.86 (134)	0.81 (34)	1.42 (58)	.13 (3185)	.26 (3475)
1986	0.99 (278)	0.80 (70)	1.08 (11)	1.40 (75)	.11 (3225)	.22 (2554)
1987	0.85 (272)	0.43 (75)	1.57 (34)	1.34 (68)	.09 (1670)	.17 (1197)
1988	0.82 (296)	0.90 (69)	1.34 (150)	1.06 (88)	.12 (2335)	.15 (94)
Catch With Effort	242.22	61.84	200.74	94.10	270.12	14.14
Reported Catch	996.99	344.87	1016.74	402.56	1624.72	785.32
%	24.3	17.9	19.7	23.4	16.6	1.8

% of 1988 catch by major gear categories for which any effort was reported $= \dfrac{883}{5171} \times 100 = 17.1$

% of 1988 total catch for which any effort was reported $= \dfrac{2181}{19417} \times 100 = 11.8$

% of 1988 total catch with associated effort entered into multiplicative model $= \dfrac{1351}{19417} \times 100 = 7.0$

Table 10. Output from multiplicative model. Types : 1 = gear, 2 = tonnage class, 3 = year, 4 = quarter. Gear codes: 2 = OTB-2, 3 = longlines and handlines

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R............. .943
MULTIPLE R SQUARED..... .888

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	5.649E0003	5.649E0003	
REGRESSION	18	2.736E0003	1.520E0002	437.690
TYPE 1	1	1.307E0003	1.307E0003	3762.929
TYPE 2	2	2.202E0002	1.101E0002	316.954
TYPE 3	12	1.649E0001	1.374E0000	3.956
TYPE 4	3	6.832E0000	2.277E0000	6.557
RESIDUALS	990	3.439E0002	3.473E⁻001	
TOTAL	1009	8.730E0003		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	2	INTERCEPT	⁻1.577	0.118	1009
2	2				
3	76				
4	1				
1	3	1	⁻2.925	0.048	377
2	3	2	0.405	0.044	344
	5	3	1.827	0.073	99
3	77	4	0.315	0.122	81
	78	5	0.374	0.120	88
	79	6	0.275	0.123	77
	80	7	0.109	0.119	97
	81	8	0.162	0.121	88
	82	9	0.132	0.119	99
	83	10	0.064	0.122	83
	84	11	⁻0.026	0.124	77
	85	12	0.067	0.122	88
	86	13	0.032	0.122	91
	87	14	⁻0.065	0.131	56
	88	15	⁻0.039	0.133	51
4	2	16	⁻0.211	0.052	294
	3	17	⁻0.193	0.055	253
	4	18	⁻0.172	0.060	159

PREDICTED CATCH RATE

STANDARDS USED   VARIABLE NUMBERS: 2   2   1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1976	16655	0.049	0.244	0.029	68223
1977	22951	0.169	0.336	0.029	68361
1978	24017	0.180	0.356	0.030	67453
1979	28722	0.110	0.322	0.028	89080
1980	31277	0.173	0.273	0.022	114496
1981	31220	0.138	0.288	0.023	108307
1982	32945	0.168	0.280	0.022	117785
1983	29261	0.155	0.261	0.021	112044
1984	25262	0.128	0.239	0.020	105866
1985	21379	0.186	0.262	0.020	81548
1986	19912	0.164	0.253	0.020	78678
1987	18682	0.099	0.230	0.021	81390
1988	19421	0.070	0.235	0.022	82492

AVERAGE C.V. FOR THE MEAN: .086

Table 11. Input data used in the construction of the 1988 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, and C) Length-weight parameters (A/B).

(A)

Otter Trawl				Longline and Handline				Gillnet				Miscellaneous				Foreign
1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	
2149	2988	2129	901	1723	2174	4118	1777	42	111	896	174	70	137	15	13	4

(B)

Gear	Jan-Mar	Apr-June	July-Sept	Oct-Dec
OT	14	9	5	5
LL	8	5	6	2
GN	0	0	4	2

(C)

Jan-Mar	Apr-June	July-Sept	Oct-Dec
.0081/3.0503	.0084/3.041	.0074/3.0738	.0063/3.1152

Table 12. Catch numbers-at-age by gear category in 1988.

Age	Numbers-at-age ('000) by gear				
	OT	LL	GN	Misc.	Foreign
1	0	0	0	0	0
2	368	57	3	2	0
3	1916	972	22	37	1
4	861	697	61	16	0
5	636	739	114	20	0
6	261	311	88	9	0
7	66	119	19	3	0
8	45	144	11	3	0
9	21	59	13	1	0
10	15	38	5	1	0
11	4	30	0	0	0
12	4	5	0	0	0
13	0	9	0	0	0
14	1	2	0	0	0
15	1	1	0	0	0
16	0	1	0	0	0

Table 13. Total catch numbers at age ('000).

TOTAL NUMBERS AT AGE (THOUSANDS)   25/ 4/89

	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
10	265	162	91	26	30	219	136	34	40	288	94	0	107	41
11	103	52	13	107	21	73	91	60	78	0	23	25	51	18
12	50	16	67	71	13	16	35	32	78	94	10	16	13	9
13	51	30	6	16	28	0	31	16	47	136	7	0	30	0
14	74	9	1	16	6	27	23	4	9	64	0	0	0	0
15	26	23	31	7	0	0	13	0	0	0	7	0	0	0
16	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
10	55	39	78	41	65	36	59	229	52	159	67	68	109	35
11	6	41	27	23	26	46	40	25	17	32	4	52	98	26
12	0	33	83	7	24	11	31	8	26	72	2	15	39	14
13	12	17	8	9	5	2	6	8	0	87	1	7	9	8
14	3	7	0	1	0	1	6	5	0	0	4	8	13	0
15	3	4	0	0	0	0	3	10	0	43	0	15	20	0
16	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
1	0	2	0	0	0	0	0	4	39	0	0	0	0
2	410	1609	285	326	885	886	982	766	804	888	147	1055	431
3	1693	3063	1803	1294	4773	4063	2549	3896	2381	1594	3129	784	2947
4	2476	1683	2274	3405	1952	4424	4476	2112	3243	1488	2204	2140	1635
5	1401	1606	1991	2632	2476	1684	3332	2376	1845	2458	906	1016	1509
6	467	775	2188	1217	1288	1017	873	1148	923	1159	985	472	668
7	190	272	636	703	426	535	398	620	444	491	343	478	207
8	122	257	199	218	242	299	301	251	159	174	164	230	204
9	74	101	55	99	86	165	140	136	54	66	82	111	94
10	18	81	49	79	51	65	99	71	50	44	37	56	58
11	7	36	9	23	12	27	52	52	31	26	15	31	34
12	2	39	16	13	16	18	27	9	22	8	15	8	9
13	4	10	6	3	4	20	18	18	6	8	9	7	10
14	1	25	2	7	1	6	0	5	2	2	0	4	2
15	2	2	1	0	1	2	4	0	4	1	2	3	1
16	0	12	1	7	3	6	0	2	15	4	0	2	1

Table 14. Percent catch numbers at age.

PERCENT NUMBERS AT AGE   25/ 4/89

	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
1	.00	.00	.00	.00	.00	.00	.00
2	.07	.07	.08	.11	.02	.16	.06
3	.19	.34	.24	.19	.39	.12	.38
4	.34	.18	.32	.18	.27	.33	.21
5	.25	.21	.18	.29	.11	.16	.19
6	.07	.10	.09	.14	.12	.07	.09
7	.03	.05	.04	.06	.04	.07	.03
8	.02	.02	.02	.02	.02	.04	.03
9	.01	.01	.01	.01	.01	.02	.01
10	.01	.01	.00	.01	.00	.01	.01
11	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00
13	.00	.00	.00	.00	.00	.00	.00
14	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00

Table 15. Mean weight at age (kg) in catch.

MEAN WEIGHT (KG) IN CATCH   25/ 4/89

	1948	1949	1950	1951	1952	1953	1954	1955	1956.	1957	1958	1959	1960	1961
1	.46	.46	.46	.50	.46	.46	.46	.77	.46	.46	.46	.46	.46	.46
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	13.06	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	13.89	13.89	16.85
15	13.49	10.81	9.99	11.67	15.58	16.15	12.44	12.34	15.58	11.22	11.21	15.58	15.58	15.58
16	16.88	16.88	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	16.88

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	.46	.46	.46	.46	.46	.46	.46	.46	.46	.46	.46	.46	.46	.46
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	13.06	8.43	17.38	14.74	16.35	13.06	14.33	17.49	16.78	15.31	12.66
14	16.92	13.66	13.89	13.89	13.89	16.78	15.72	16.78	16.03	15.02	17.93	16.80	11.82	16.62
15	16.92	11.17	15.33	15.33	15.40	15.69	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
1	.46	.48	.46	.46	.46	.46	.46	.36	.38	.37	.38	.46	.46
2	.60	1.04	.84	.83	.71	.75	.81	.85	.95	.82	.80	.91	.96
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
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
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
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
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
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
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	10.11
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	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
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
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
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
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	20.17
16	15.59	16.01	16.92	16.57	17.37	16.69	16.76	15.98	17.01	14.62	16.88	21.03	26.37

Table 16. Catch weight at age (t).

CATCH BIOMASS (T)   25/ 4/89

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1	0	0	0	0	0	0	0	4	0	0	0	0	0	0
2	22	562	543	209	661	119	246	42	66	0	105	0	0	3
3	870	1884	2166	2981	1698	1218	618	1368	763	133	926	170	0	228
4	2275	3154	5349	3001	5293	1741	3373	1292	4563	430	1747	2275	338	646
5	3320	2626	3798	3674	2958	4799	2461	3732	1901	3301	1544	2976	2202	5141
6	1909	3211	2461	1914	1809	1739	4452	2304	2546	685	3347	2388	2814	3729
7	1185	290	2503	2332	1961	1253	1689	3209	2875	1848	477	1902	1614	1830
8	2042	647	332	1367	945	503	888	1025	2620	1426	999	2207	2088	575
9	2330	1107	308	489	1170	741	748	413	765	2252	1170	736	1767	752
10	1760	1225	796	212	155	1220	679	305	219	1667	839	0	1270	473
11	896	431	138	727	126	499	682	334	630	0	236	275	798	242
12	529	181	664	495	200	105	205	300	542	580	56	79	90	145.
13	534	350	33	177	329	0	277	156	355	934	88	0	500	0
14	1091	73	13	207	99	123	260	35	64	571	0	0	0	0
15	350	251	308	76	0	0	164	0	0	0	76	0	0	0
16	0	0	23	0	0	0	24	63	0	0	3	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	1	0	0	21	7	9	9	352	176	336	248	240	60	525
3	604	272	90	1337	1998	1634	1599	3215	1839	1128	3420	2342	2383	1911
4	2354	2480	976	4237	7465	10165	3992	3744	2801	1748	6211	5336	3233	6329
5	4288	3360	6301	6983	8152	8838	13705	7362	4701	3616	4665	6055	4746	3222
6	3548	3263	8161	7719	5783	4263	8652	8123	4748	4109	3942	2448	5130	4161
7	2682	4295	3264	3455	4463	2521	2497	3276	2636	2794	816	1446	1474	2417
8	1710	1960	4590	1557	1930	2511	1306	1735	532	2733	830	568	1374	788
9	611	1577	3492	882	305	1085	1953	1296	1107	1501	867	1519	996	545
10	438	310	734	433	508	343	572	1844	415	1613	424	768	969	469
11	50	469	345	334	213	427	445	375	221	433	72	537	1102	344
12	0	318	950	63	267	138	412	113	452	913	32	155	605	190
13	147	170	122	116	43	39	84	127	0	1242	21	126	143	104
14	56	90	0	19	0	9	98	84	0	0	78	140	153	0
15	56	49	0	0	0	0	53	160	0	683	0	252	338	0
16	0	0	176	0	54	89	169	367	0	114	282	0	262	20

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	0	1	0	0	0	0	0	1	15	0	0	0	0
2	246	1678	240	271	628	668	800	649	766	732	117	965	415
3	2020	3873	2835	1647	6745	5063	3392	5181	3568	2242	4042	1146	3976
4	5310	3122	4352	6929	4231	8785	8276	3912	6498	2934	4180	4632	3066
5	4207	3764	4764	8190	7375	4723	9472	6210	5037	6184	2380	3223	4098
6	2066	3316	7752	5047	6114	3665	3603	4832	3528	4091	3895	1839	2684
7	1153	1566	2653	3756	2855	3016	2173	3463	2403	2435	1722	2655	1085
8	1041	1989	1225	1585	1678	2165	2131	2021	1211	1199	1225	1816	1650
9	804	919	339	856	828	1385	1170	1397	508	531	784	1018	950
10	212	760	455	892	505	726	895	811	585	432	344	669	639
11	111	392	58	248	143	333	555	599	406	318	179	403	420
12	21	607	115	160	224	223	381	129	316	122	221	118	143
13	55	159	40	50	47	302	251	284	91	94	138	106	182
14	24	415	26	89	7	87	5	86	28	18	5	70	44
15	30	37	15	0	11	36	60	0	59	18	43	78	26
16	0	186	22	120	44	104	0	39	259	56	0	38	24

Table 17. ADAPT input summary for 4X cod.

Parameters:

- year class estimates: $N_{i,1988}$ $i = 4-7$

- calibration constants for mid-year RV numbers: K_i $i = 4-7$

Structure:

- error for catch assumed negligible

- fixed PR for ages 1-3, calculated as the mean of 1982-87, assuming flat-top recruitment for age 8 and older

- 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:

- $C_{i,t}$ $i = 1-13$; $t = 1970-88$

- $RV_{i,t}$ (numbers) $i = 4-7$; $t = 1970-88$

Objective Function:

- minimize

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

Summary:

- number of observations = 76

- number of parameters = 8

Table 18. (TOP) Final parameter estimates and significance statistics for ages 4-7 numbers and corresponding slopes from ADAPT. (BOTTOM) Residuals between observed RV (log transformed) and the predicted RV by age and year.

ADAPTIVE FRAMEWORK 2 INDEX TUNING

4X COD   4/27/89 15:37

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET.........   0.023384
MEAN SQUARE RESIDUALS 0.196143

PAR. EST.	STD. ERR.	T-STATISTIC
1.10809E0004	4.61045E0003	2.40342E0000
4.40005E0003	1.18922E0003	3.69995E0000
1.46919E0003	3.74416E0002	3.92395E0000
5.07703E0002	1.37946E0002	3.68045E0000
2.92530E‾001	3.12128E‾002	9.37210E0000
3.74863E‾001	3.98325E‾002	9.41098E0000
4.75707E‾001	5.07136E‾002	9.38027E0000
4.65877E‾001	4.98421E‾002	9.34706E0000

Parameter Correlation Matrix

I	1	2	3	4	5	6	7	8
1 I	1.000	.037	.019	.012	‾.233	‾.012	‾.010	‾.011
2 I	.037	1.000	‾.003	.049	‾.157	‾.235	‾.107	‾.190
3 I	.019	‾.003	1.000	.048	‾.082	‾.129	‾.238	‾.083
4 I	.012	.049	.048	1.000	‾.054	‾.084	‾.135	‾.227
5 I	‾.233	‾.157	‾.082	‾.054	1.000	.050	.042	.046
6 I	‾.012	‾.235	‾.129	‾.084	.050	1.000	.064	.070
7 I	‾.010	‾.107	‾.238	‾.135	.042	.064	1.000	.066
8 I	‾.011	‾.190	‾.083	‾.227	.046	.070	.066	1.000

ADAPTIVE FRAMEWORK 2 INDEX TUNING

4X COD   4/27/89 15:37

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

I	1970	1971	1972	1973	1974	1975	1976	1977	1978
4 I	.996	‾.857	.161	.237	‾.255	.418	‾.167	.180	‾.021
5 I	.494	.267	‾.343	‾.686	.369	.965	.426	‾1.020	‾.182
6 I	.968	.128	‾.296	‾.714	.136	.362	.191	.296	‾1.036
7 I	.540	.714	‾.227	‾.651	‾.802	.727	.049	‾.117	‾.209

I	1979	1980	1981	1982	1983	1984	1985	1986	1987
4 I	‾.148	‾.484	‾.100	‾.261	.185	.026	.432	.049	‾.398
5 I	.006	‾.301	.035	‾.066	.033	.347	.053	‾.544	‾.243
6 I	‾.001	.305	.102	.057	.080	‾.157	.003	‾.271	‾.323
7 I	‾.260	‾.076	‾.026	‾.410	.088	.285	.333	.251	‾.496

I	1988
4 I	.043
5 I	.374
6 I	.153
7 I	.274

Table 19. Population numbers ('000) derived from cohort analysis with F_T = .54.

POPULATION NUMBERS (THOUSANDS)   25/ 5/89

	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	15519
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	3680	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	268	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

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	22589	33510	42661	20579	16306	16124	14200	20423	19405	15180	20612	24197	20383	25393
2	15312	18494	27436	34928	16849	13350	13201	11626	16721	15888	12429	16876	19811	16688
3	19479	12534	15142	22462	28567	13781	10915	10798	9106	13444	12508	9852	13518	16128
4	12466	15232	9904	12301	17036	21662	9834	7407	6528	6242	9829	8027	6386	9083
5	6836	8345	10687	7429	7740	9693	12016	5722	4212	4030	4177	5269	4371	3339
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	462	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

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	24669	17277	32769	29594	21186	27213	13268	14597	20409	11603	23252	11027	18901
2	20786	20197	14143	26829	24229	17346	22280	10863	11948	16675	9499	19037	9028
3	12970	16647	15080	11321	21671	19036	13400	17353	8201	9055	12848	7645	14631
4	11797	9087	10858	10715	8098	13423	11909	8665	10682	4560	5971	7689	5549
5	4763	7418	5917	6832	5692	4864	6987	5701	5183	5811	2387	2894	4358
6	1809	2631	4621	3043	3213	2420	2458	2705	2517	2574	2534	1135	1450
7	972	1059	1453	1803	1390	1465	1061	1223	1176	1226	1059	1184	502
8	511	624	621	614	840	753	716	508	440	562	559	556	536
9	245	308	279	328	306	469	346	314	189	216	302	310	247
10	103	133	161	178	179	172	234	157	134	106	118	173	153
11	72	68	36	87	74	100	82	102	64	64	47	63	91
12	20	53	23	22	50	50	57	20	37	25	29	25	23
13	6	15	7	4	6	27	25	23	9	10	13	10	13

Table 20. Fishing mortality matrix derived from cohort analysis with F_T = .54.

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.003	.038	.037	.033	.067	.019	.019	.008	.010	.000	.012	.000	.000
3	.103	.160	.211	.200	.191	.100	.097	.124	.121	.025	.087	.030	.000
4	.235	.269	.637	.329	.358	.159	.362	.187	.361	.097	.206	.308	.032
5	.304	.206	.477	.668	.354	.291	.307	.393	.325	.385	.222	.483	.241
6	.630	.275	.264	.300	.581	.219	.369	.289	.325	.163	.386	.838	.435
7	.439	.112	.374	.253	.369	.485	.271	.360	.507	.661	.081	.354	.510
8	.514	.303	.091	.235	.136	.118	.645	.225	.556	.613	.384	.694	.540
9	.606	.412	.234	.269	.352	.204	.313	.623	.210	1.079	.769	.353	.878
10	.823	.605	.476	.182	.149	.588	.240	.127	1.272	1.222	1.060	.001	1.009
11	1.424	.366	.085	2.047	.222	.657	.521	.160	.468	.008	.271	.928	.883
12	.633	.878	1.180	.886	4.209	.261	.772	.345	.320	2.158	4.232	.299	4.327
13	.601	.290	.297	.289	.333	.270	.347	.290	.403	.533	.338	.581	.523

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.001	.000	.000	.000	.001	.001	.001	.001	.044	.018	.039	.032	.022	.006
3	.019	.046	.036	.008	.077	.077	.137	.188	.303	.178	.113	.244	.234	.198
4	.053	.201	.154	.088	.263	.364	.389	.342	.364	.270	.202	.423	.408	.448
5	.333	.583	.234	.387	.565	.657	.546	.834	.579	.529	.444	.700	.527	.614
6	.372	.349	.483	.737	.525	.822	.558	.952	.736	.532	.862	.677	.580	.709
7	.308	.375	.511	.909	.455	.554	.556	.400	.603	.337	.503	.299	.456	.476
8	.343	.395	.396	1.122	.859	.444	.381	.448	.294	.142	.576	.242	.214	.693
9	.232	.537	.809	1.418	.297	.314	.317	.444	.706	.619	.500	.425	.577	.604
10	.448	.249	.544	.758	.518	.434	.463	.208	1.014	.621	1.475	.388	.374	1.053
11	.449	.115	.299	.942	.530	.770	.635	1.585	.130	.176	1.069	.119	.591	1.579
12	.349	.004	1.402	1.955	.649	2.056	.833	1.324	3.942	.192	3.680	.169	.744	1.392
13	.345	.357	.497	.855	.515	.639	.497	.692	.638	.414	.703	.481	.491	.691

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.002	.000	.000	.000	.000
2	.052	.022	.092	.023	.014	.041	.058	.050	.081	.077	.061	.017	.063	.054
3	.113	.156	.227	.142	.135	.279	.269	.236	.285	.387	.216	.313	.120	.250
4	.446	.264	.229	.263	.433	.310	.453	.537	.314	.409	.447	.524	.368	.390
5	.413	.393	.273	.465	.555	.655	.482	.749	.617	.500	.630	.544	.491	.477
6	.490	.336	.394	.741	.583	.585	.624	.498	.633	.520	.689	.561	.616	.699
7	.498	.244	.334	.661	.564	.413	.516	.536	.822	.539	.585	.444	.592	.599
8	.281	.305	.606	.437	.499	.384	.577	.625	.789	.510	.419	.391	.611	.537
9	.413	.408	.451	.246	.405	.375	.494	.591	.653	.382	.408	.359	.508	.537
10	.362	.211	1.102	.414	.677	.382	.538	.627	.693	.535	.612	.431	.445	.537
11	.782	.112	.900	.312	.351	.199	.356	1.207	.815	.747	.583	.437	.796	.537
12	1.124	.098	1.750	1.508	1.135	.431	.509	.729	.634	1.097	.466	.870	.413	.537
13	.466	.302	.437	.662	.559	.490	.567	.547	.698	.524	.608	.495	.589	.537

Table 21. Partial recruitment.   29

F÷FULLY RECRUITED F   25/ 5/89

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.13	.12	.11	.20	.07	.06	.03	.02	.00	.04	.00	.00	.00
3	.17	.55	.71	.69	.57	.37	.28	.43	.30	.05	.26	.05	.00	.06
4	.39	.93	2.15	1.14	1.07	.59	1.04	.65	.90	.18	.61	.53	.06	.15
5	.51	.71	1.61	2.31	1.06	1.08	.88	1.35	.81	.72	.66	.83	.46	.97
6	1.05	.95	.89	1.04	1.74	.81	1.06	1.00	.81	.31	1.14	1.44	.83	1.08
7	.73	.39	1.26	.87	1.11	1.80	.78	1.24	1.26	1.24	.24	.61	.98	.89
8	.85	1.05	.31	.81	.41	.44	1.86	.78	1.38	1.15	1.14	1.19	1.03	.99
9	1.01	1.42	.79	.93	1.06	.75	.90	2.15	.52	2.03	2.28	.61	1.68	.67
10	1.37	2.09	1.60	.63	.45	2.18	.69	.44	3.16	2.30	3.14	.00	1.93	1.30
11	2.37	1.26	.29	7.07	.67	2.43	1.50	.55	1.16	.01	.80	1.60	1.69	1.30
12	1.05	3.03	3.97	3.06	12.63	.97	2.22	1.19	.79	4.05	12.54	.52	8.27	1.01
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.07	.04	.06	.07	.04	.01	.11
3	.13	.07	.01	.15	.12	.28	.27	.48	.43	.16	.51	.48	.29	.24
4	.56	.31	.10	.51	.57	.78	.49	.57	.65	.29	.88	.83	.65	.96
5	1.63	.47	.45	1.10	1.03	1.10	1.21	.91	1.28	.63	1.46	1.07	.89	.89
6	.98	.97	.86	1.02	1.29	1.12	1.38	1.15	1.28	1.23	1.41	1.18	1.03	1.05
7	1.05	1.03	1.06	.88	.87	1.12	.58	.95	.81	.72	.62	.93	.69	1.07
8	1.10	.80	1.31	1.67	.69	.77	.65	.46	.34	.82	.50	.44	1.00	.60
9	1.50	1.63	1.66	.58	.49	.64	.64	1.11	1.50	.71	.88	1.18	.87	.89
10	.70	1.09	.89	1.01	.68	.93	.30	1.59	1.50	2.10	.81	.76	1.52	.78
11	.32	.60	1.10	1.03	1.21	1.28	2.29	.20	.42	1.52	.25	1.21	2.29	1.68
12	.01	2.82	2.29	1.26	3.22	1.68	1.91	6.18	.46	5.24	.35	1.52	2.01	2.41
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.07	.21	.03	.02	.08	.10	.09	.12	.15	.10	.03	.11	.10
3	.52	.52	.21	.24	.57	.47	.43	.41	.74	.36	.63	.20	.47
4	.87	.52	.40	.77	.63	.80	.98	.45	.78	.74	1.06	.62	.73
5	1.30	.63	.70	.99	1.34	.85	1.37	.88	.95	1.04	1.10	.83	.89
6	1.11	.90	1.12	1.04	1.19	1.10	.91	.91	.99	1.13	1.13	1.05	1.30
7	.81	.76	1.00	1.01	.84	.91	.98	1.18	1.03	.96	.90	1.00	1.11
8	1.01	1.39	.66	.89	.78	1.02	1.14	1.13	.97	.69	.79	1.04	1.00
9	1.35	1.03	.37	.73	.77	.87	1.08	.94	.73	.67	.73	.86	1.00
10	.70	2.52	.63	1.21	.78	.95	1.15	.99	1.02	1.01	.87	.76	1.00
11	.37	2.06	.47	.63	.41	.63	2.21	1.17	1.42	.96	.88	1.35	1.00
12	.32	4.01	2.28	2.03	.88	.90	1.33	.91	2.09	.77	1.76	.70	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 22. Population biomass (t) at beginning of year as derived from cohort analysis.

POPULATION BIOMASS   25/ 5/89

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1	5141	7286	4304	5946	3329	5809	2932	5033	14014	6429	6220	10399	11253	10411
2	5876	10451	12541	5814	8560	4864	9962	4457	8046	8144	8201	6262	10483	9161
3	6858	9826	12764	15503	7846	11033	6506	12160	5890	5899	10349	7032	7668	11690
4	8475	10344	11092	9922	15399	9783	11332	6781	12471	5254	6996	9362	7628	11255
5	10588	11010	10115	6728	8742	15275	9704	9434	6558	10416	5729	7715	8056	13651
6	3642	11164	11036	6768	3984	7848	14304	7933	8434	4751	8574	5112	6185	9851
7	3106	2440	9013	9215	5892	2734	7110	10289	7051	5030	4887	6737	2712	5965
8	4891	2307	3056	5997	7750	4457	1935	5246	6745	3682	2485	5007	4735	2191
9	5222	3158	1641	2687	4510	5104	3344	934	4047	3467	1917	2298	2582	3256
10	3104	2749	2138	1217	1327	2759	3232	2279	382	2784	1220	1123	1865	1283
11	1131	1392	1579	1044	818	997	1600	2376	1945	77	832	450	1302	698
12	1194	296	967	1143	148	480	453	1013	1949	831	63	482	128	526
13	747	567	80	282	407	3	372	205	592	1292	98	1	377	1

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	13443	13024	16318	8072	7262	6975	5063	7314	7585	6127	7800	8935	8305	9654
2	5512	10194	15366	19077	8105	6612	7932	6955	9165	8433	7037	9791	10416	9402
3	9626	5498	11310	17471	23463	9844	7731	10695	9376	10085	11540	9208	12019	13813
4	12357	14922	9361	14543	20278	28103	12371	9747	10363	9517	13017	14059	8924	13859
5	10759	13036	17076	13138	15432	18898	22748	12813	9875	9545	8516	13199	10471	7378
6	12505	6791	14123	15875	9735	9355	13093	12814	10391	6930	7199	5059	9394	7757
7	8424	9547	5359	8417	10834	5176	6578	6272	8294	6912	3079	4010	3484	5534
8	5155	5939	6620	2439	5682	6908	3502	5880	3993	6404	4061	2624	2622	2788
9	1438	3171	4311	2757	1139	3713	5426	2432	3487	3650	2967	3242	2286	1487
10	2396	798	1323	1093	1918	876	2974	3178	1065	1643	1746	2010	1702	1362
11	618	1678	493	725	503	922	571	2759	1200	564	553	1038	1534	574
12	362	414	1220	170	383	212	520	115	2650	1038	217	409	732	284
13	268	256	119	151	59	44	102	150	2	1758	25	168	153	164

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	10039	5328	11865	10210	7921	9869	4628	4995	4515	2993	5858	2701	6062
2	10942	14032	8999	16660	13883	10247	13684	6801	6999	9334	5162	11222	6030
3	11730	14485	19307	11729	23512	17897	13424	18065	9239	10485	13262	8258	16252
4	19147	13518	16893	19164	13450	22485	18077	13603	17438	7840	9753	12856	9190
5	12076	16632	12466	16676	14015	11993	16600	12530	11656	13048	5435	7097	10564
6	6757	9432	13316	9585	12348	7930	8364	9357	7956	7991	7995	3630	5173
7	5927	5343	6141	7846	7333	7582	4706	5873	5617	5337	4454	5548	2268
8	3848	4278	3697	3381	5111	5250	4524	3370	2870	3430	3404	3499	3595
9	2413	2716	1928	2397	2548	3570	2697	2674	1641	1699	2446	2557	2207
10	1090	1348	1470	1486	1652	1781	2041	1536	1464	1015	1017	1839	1530
11	1064	772	285	861	857	1100	898	1050	792	772	508	684	1091
12	254	832	199	193	614	605	758	255	475	346	391	337	336
13	87	206	77	45	67	392	323	343	129	134	190	143	228

Table 23. Yield per recruit analysis for 4X cod. Weight-at-age and PR were set to the mean of 1980-87.

SUMMARY:

AGE	WEIGHT-AT-AGE	PARTIAL RECRUITMENT
1	.423	.001
2	.842	.097
3	1.370	.474
4	1.974	.744
5	2.778	1.000
6	3.989	1.000
7	5.509	1.000
8	7.473	1.000
9	9.198	1.000
10	10.576	1.000
11	12.120	1.000
12	14.518	1.000
13	14.606	1.000
14	14.814	1.000
15	17.866	1.000
16	18.079	1.000

NATURAL MORTALITY RATE : 0.2

FO.1 COMPUTED AS .1625 AT Y/R OF 1.1288

FMAX COMPUTED AS .2706 AT Y/R OF 1.2001

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	.1000	.197	.947	4.821	1.364
FO.1---	.1625	.268	1.129	4.206	1.000
	.2000	.301	1.175	3.903	.846
FMAX---	.2706	.349	1.200	3.438	.638
	.3000	.365	1.197	3.278	.575
	.4000	.409	1.165	2.850	.419
	.5000	.441	1.123	2.547	.323
	.6000	.466	1.084	2.327	.260
	.7000	.486	1.050	2.161	.216
	.8000	.502	1.021	2.032	.184
	.9000	.517	.997	1.930	.159
	1.0000	.529	.977	1.848	.141
	1.1000	.539	.959	1.779	.126
	1.2000	.549	.944	1.721	.113
	1.3000	.557	.931	1.672	.103
	1.4000	.564	.919	1.629	.095
	1.5000	.571	.909	1.591	.087

Table 24. Catch projections for 4X cod

(Top) F = $F_{0.1}$ = 0.20 in 1990.
(Bottom) F (50% rule) = 0.27 in 1990.

POPULATION NUMBERS

	1988	1989	1990
1	18901	18901	18901
2	9028	15475	15470
3	14631	7003	12247
4	5549	9328	4900
5	4358	3076	5979
6	1450	2216	1797
7	502	590	1295
8	536	226	345
9	247	257	132
10	153	118	150
11	91	73	69
12	23	43	43
13	13	11	25
1+	55483	57316	61353
2+	36582	38415	42452
3+	27554	22940	26982
4+	12923	15938	14735

FISHING MORTALITY

	1988	1989	1990
1	.000	.000	.000
2	.054	.034	.020
3	.250	.157	.093
4	.390	.245	.145
5	.477	.337	.200
6	.699	.337	.200
7	.599	.337	.200
8	.537	.337	.200
9	.537	.337	.200
10	.537	.337	.200
11	.537	.337	.200
12	.537	.337	.200
13	1.536	.337	.200
1+	.185	.107	.067

CATCH BIOMASS 25/5

	1988	1989	1990
1	0	2	1
2	362	393	235
3	4038	1267	1354
4	3221	3631	1185
5	4196	2232	2740
6	2667	2307	1182
7	1140	849	1176
8	1524	440	425
9	864	616	200
10	614	326	261
11	418	231	138
12	128	164	102
13	143	42	61
1+	19314	12500	9060
2+	19314	12498	9058
3+	18952	12105	8824
4+	14914	10838	7470

POPULATION NUMBERS

	1988	1989	1990
1	18901	18901	18901
2	9028	15475	15470
3	14631	7003	12247
4	5549	9328	4900
5	4358	3076	5979
6	1450	2216	1797
7	502	590	1295
8	536	226	345
9	247	257	132
10	153	118	150
11	91	73	69
12	23	43	43
13	13	11	25
1+	55483	57316	61353
2+	36582	38415	42452
3+	27554	22940	26982
4+	12923	15938	14735

FISHING MORTALITY

	1988	1989	1990
1	.000	.000	.000
2	.054	.034	.027
3	.250	.157	.126
4	.390	.245	.196
5	.477	.337	.270
6	.699	.337	.270
7	.599	.337	.270
8	.537	.337	.270
9	.537	.337	.270
10	.537	.337	.270
11	.537	.337	.270
12	.537	.337	.270
13	1.536	.337	.270
1+	.185	.107	.091

CATCH BIOMASS 1/6

	1988	1989	1990
1	0	2	2
2	362	393	316
3	4038	1267	1800
4	3221	3631	1562
5	4196	2232	3581
6	2667	2307	1545
7	1140	849	1537
8	1524	440	555
9	864	616	261
10	614	326	342
11	418	231	180
12	128	164	133
13	143	42	80
1+	19314	12500	11893
2+	19314	12498	11891
3+	18952	12105	11575
4+	14914	10838	9776
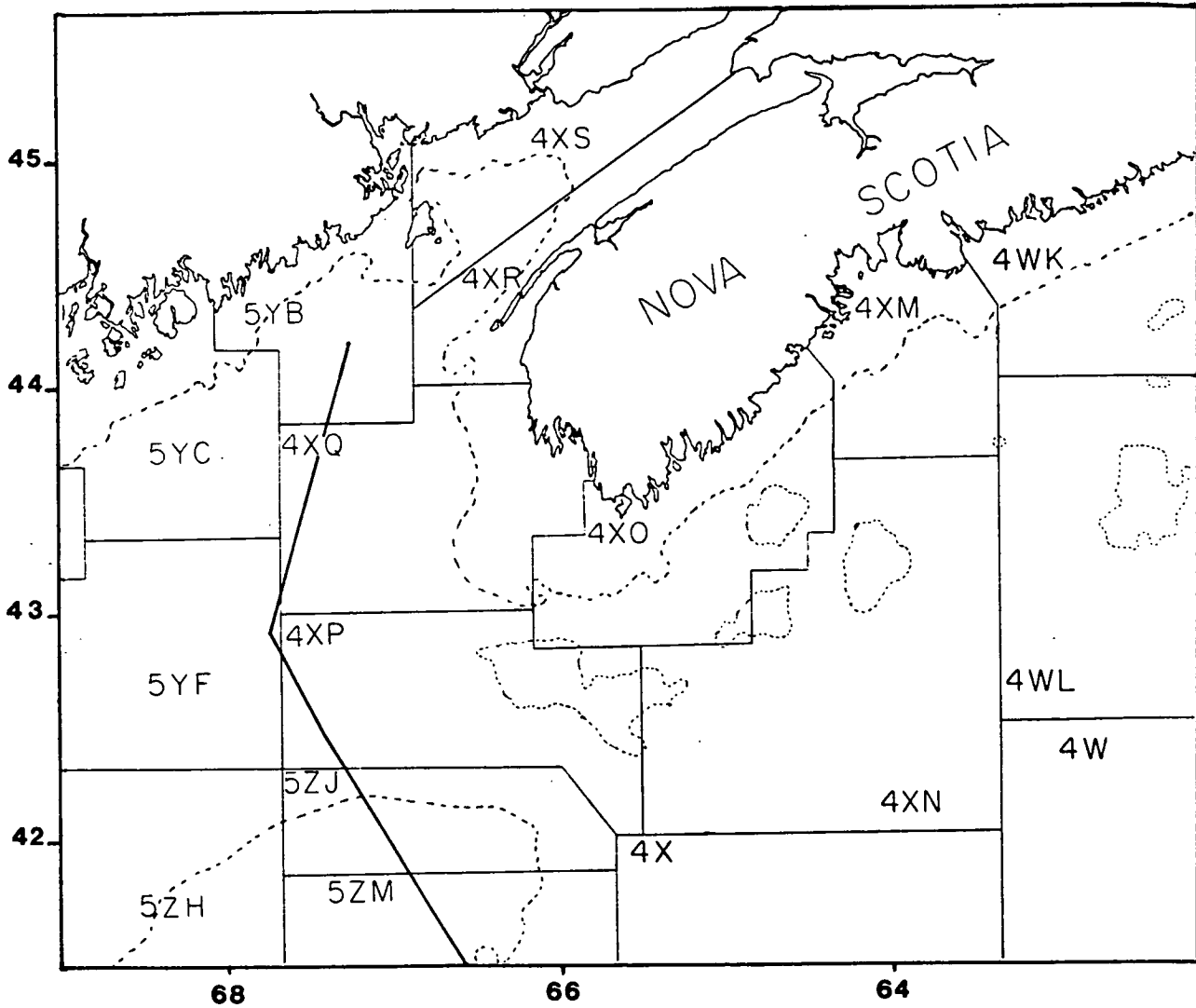
Figure 1. Unit areas in NAFO Division 4X in reference to the ICJ Canada-US boundary.
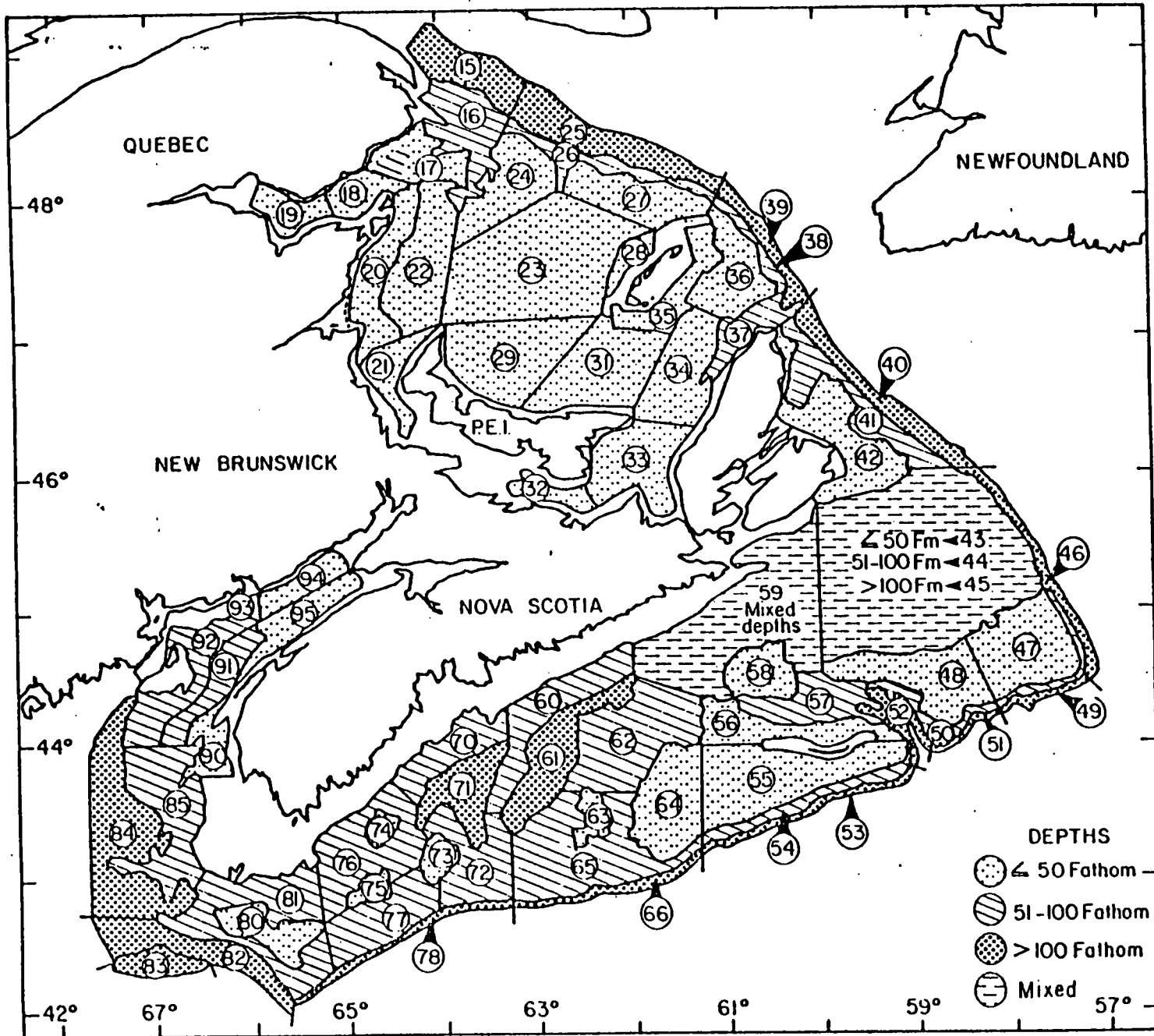
Figure 2. Stratification scheme used for the research groundfish surveys.
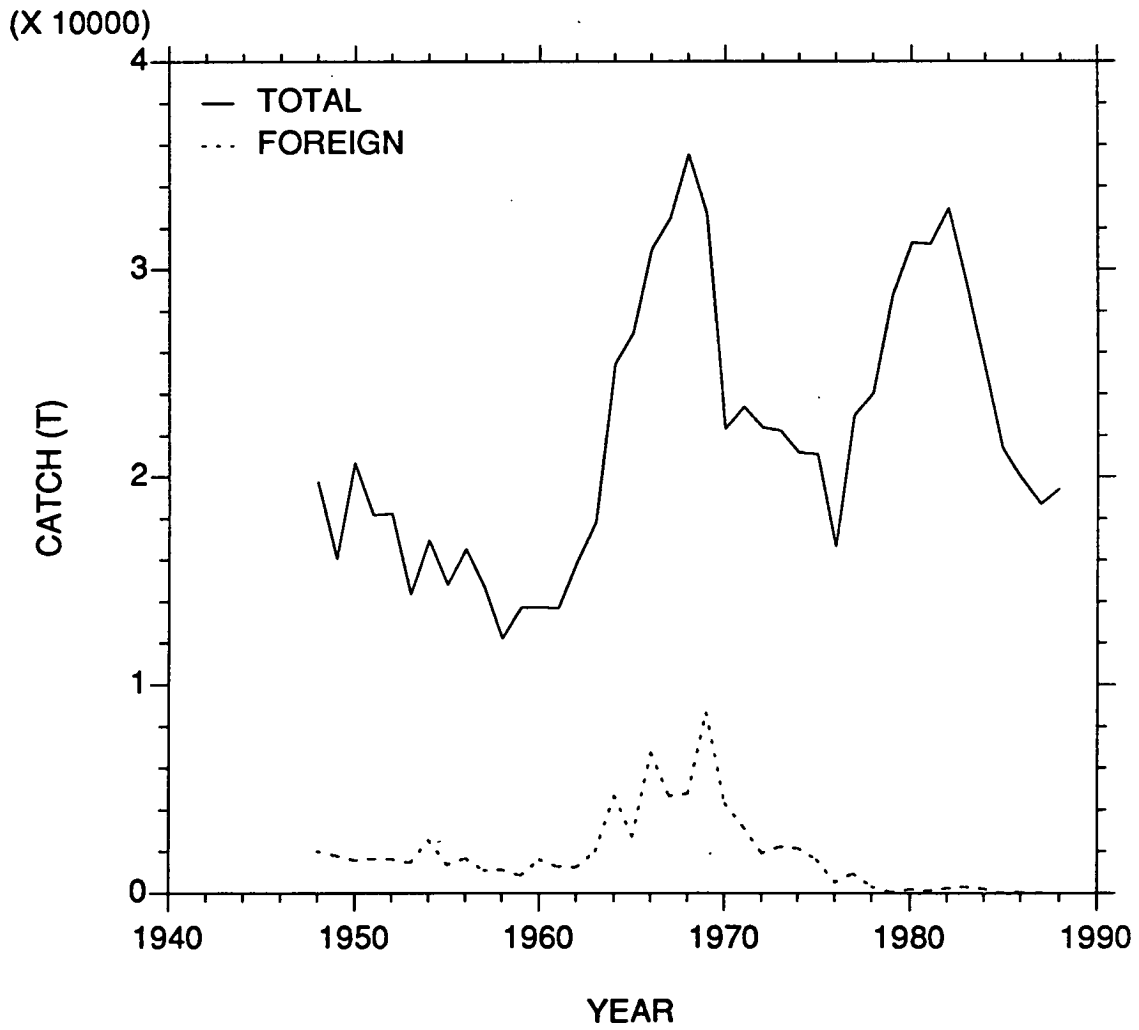
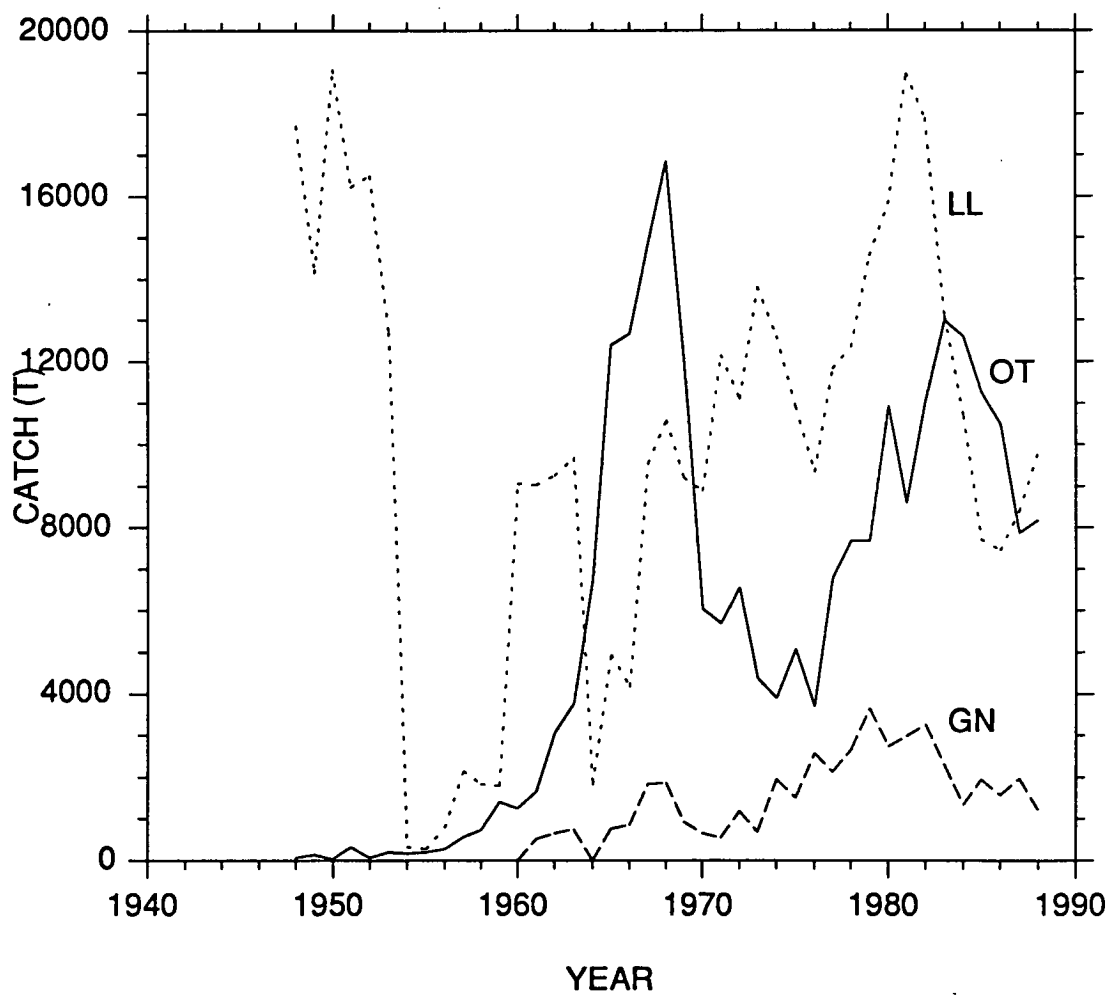Figure 3. Nominal catch (t) of 4X cod between 1948-88.

Figure 4. Canadian nominal catch (t) segregated by major gear type between
1948-88. Landings were classified by different gear types prior
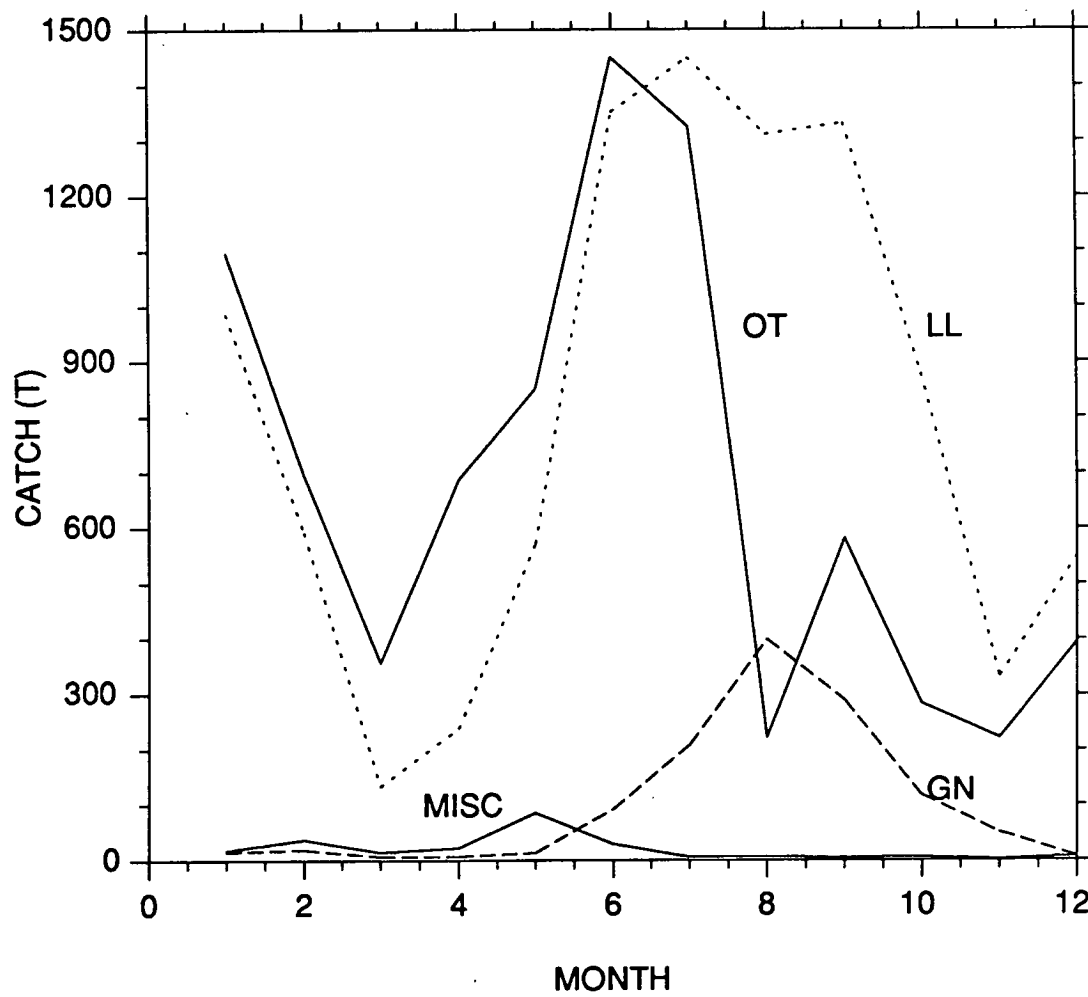to 1960, including a large miscellaneous category between
1955-1959.

Figure 5. Monthly pattern in Canadian landings (t) of 4X cod in 1988. Landings have been segregated by major gear type.

(X 1000)
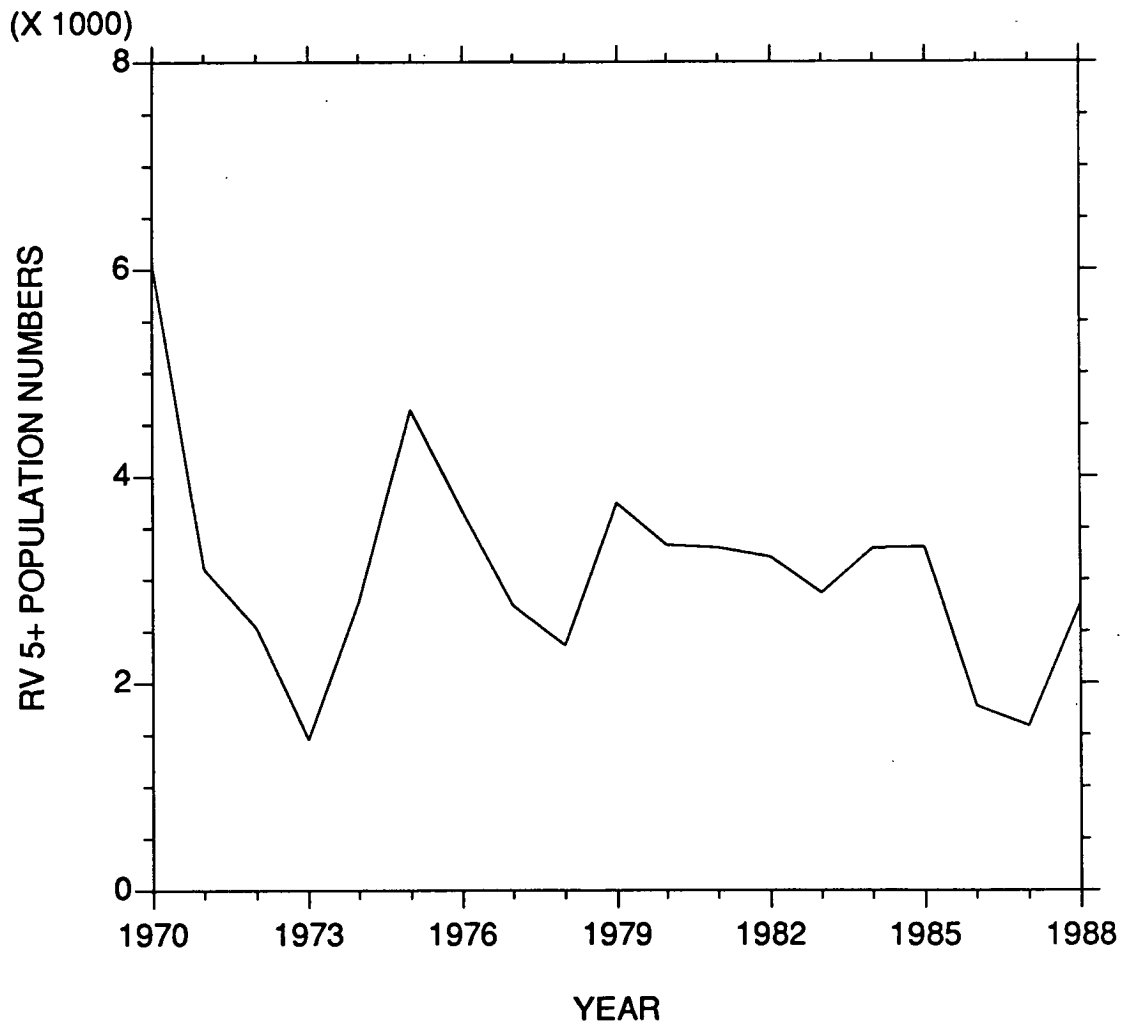
Figure 6. Trends in abundance of fully-recruited 4X cod (age 5+) as determined from RV surveys.
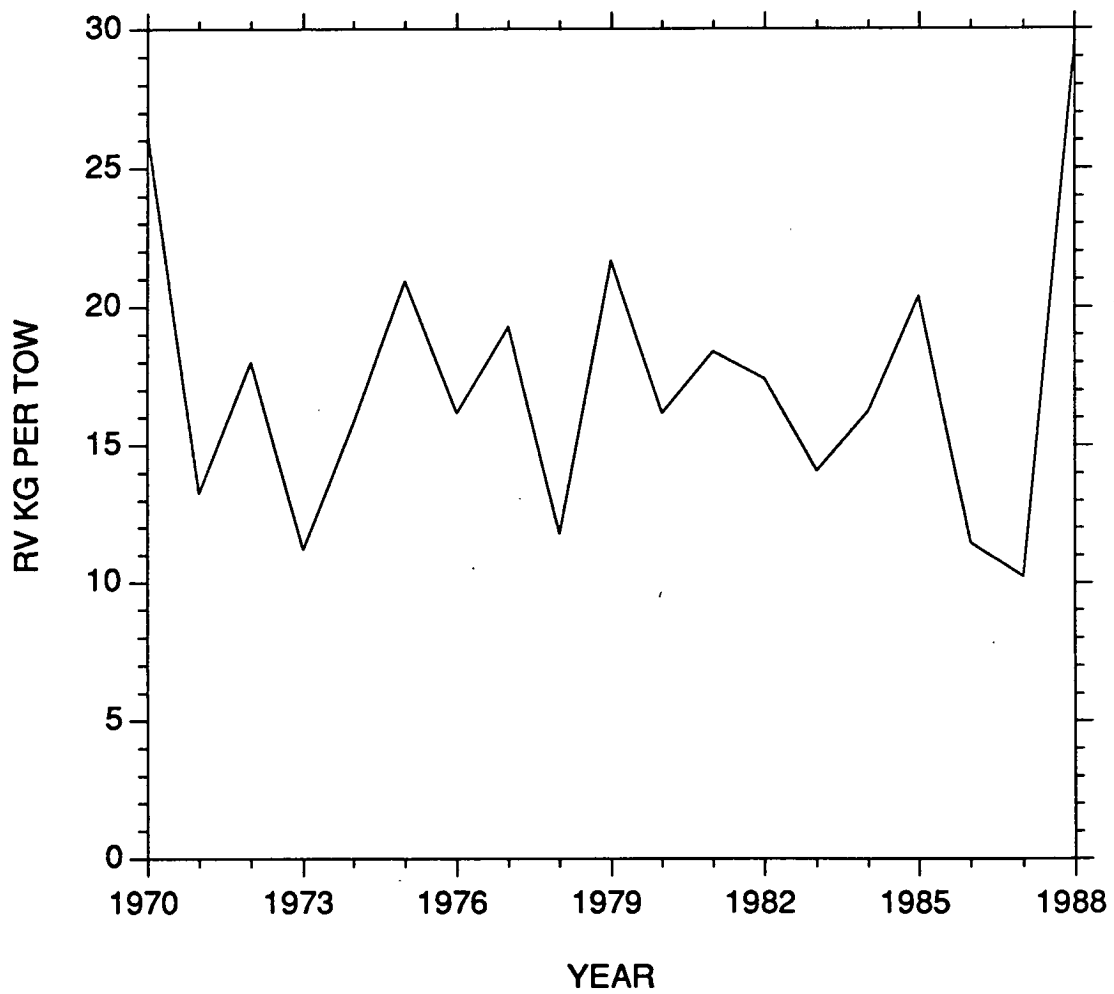
Figure 7. Trends in biomass as determined from summer RV surveys.

(X 1000)

RV POPULATION NUMBERS

— AGE 2
··· AGE 3
-- AGE 4

YEAR
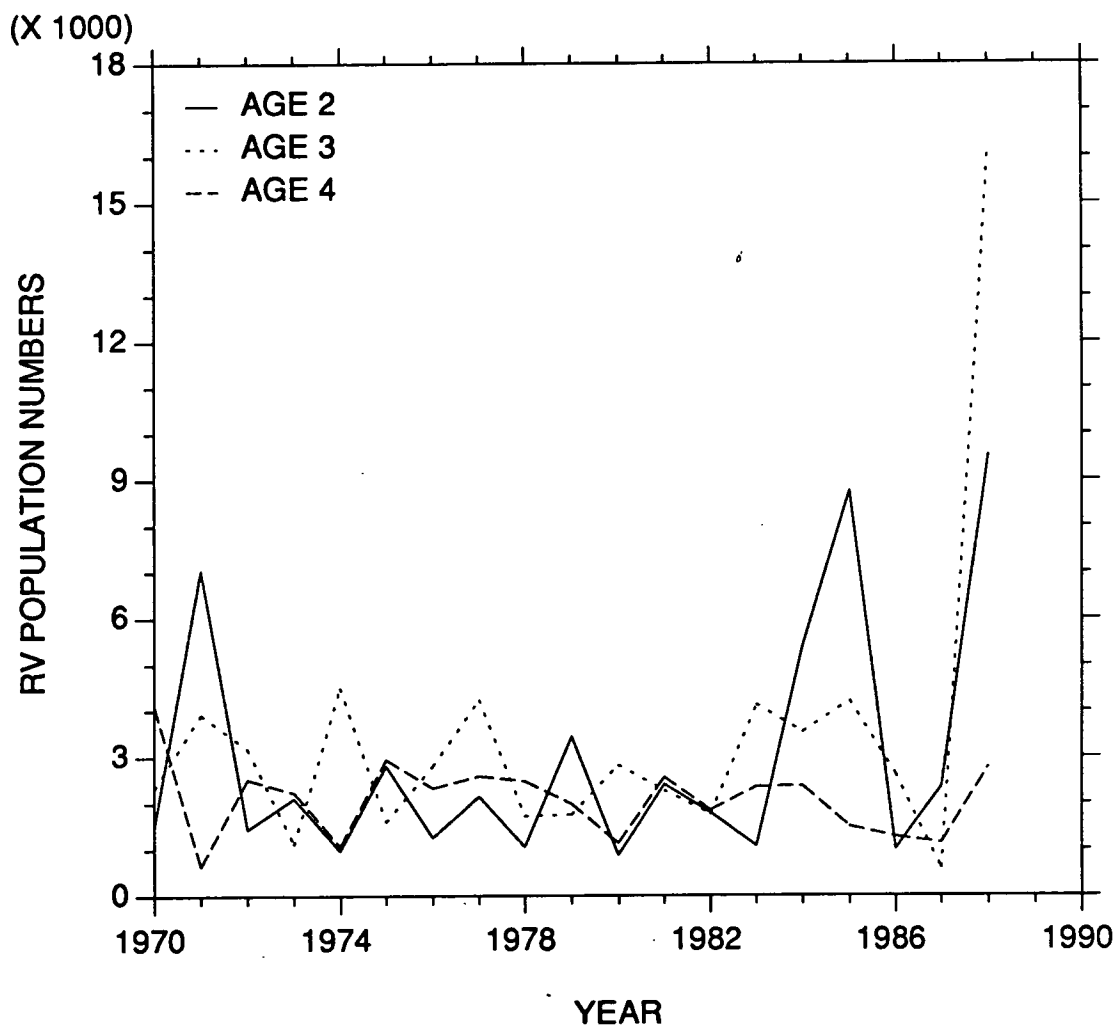
Figure 8. Trends in abundance of partially recruited 4X cod as
determined from RV surveys.
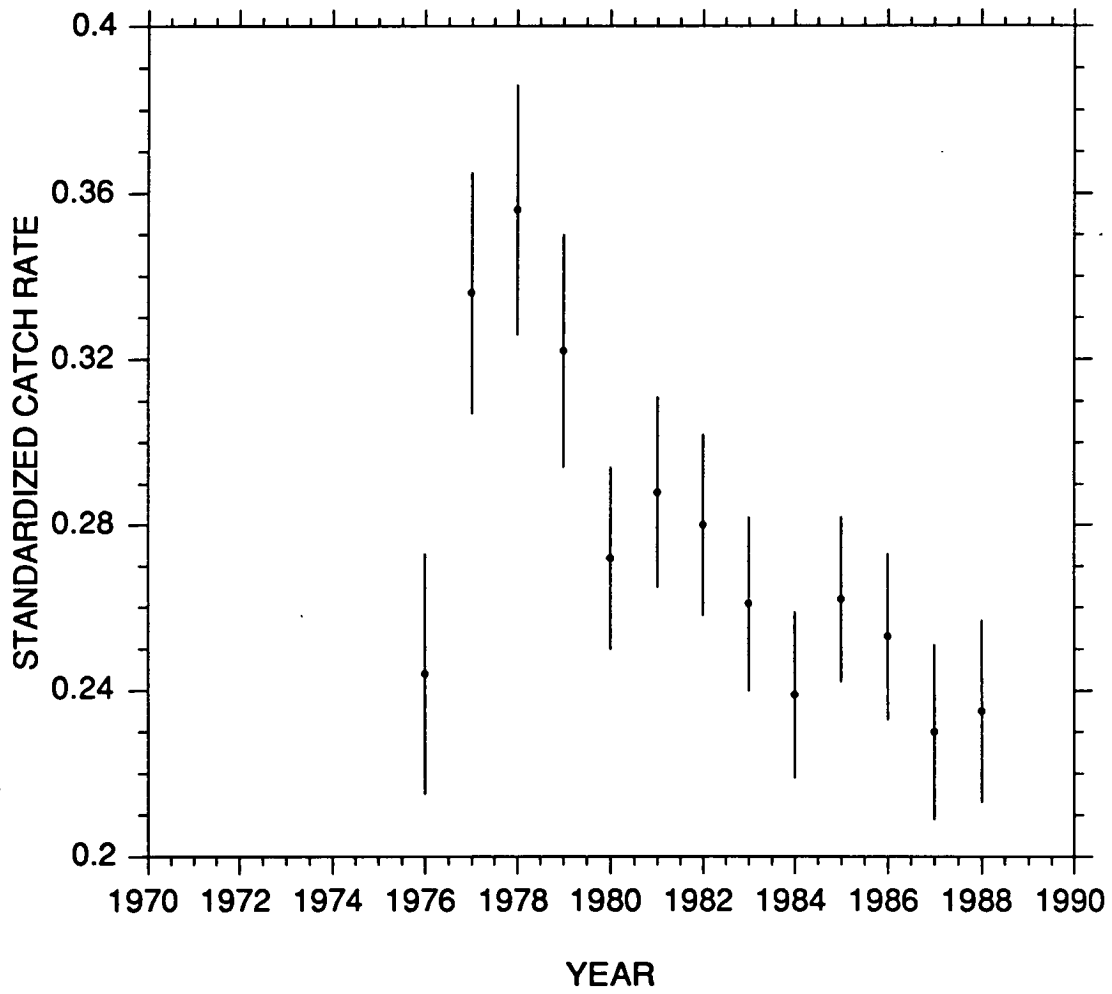
Figure 9. Standardized commercial catch rates from multiplicative model.
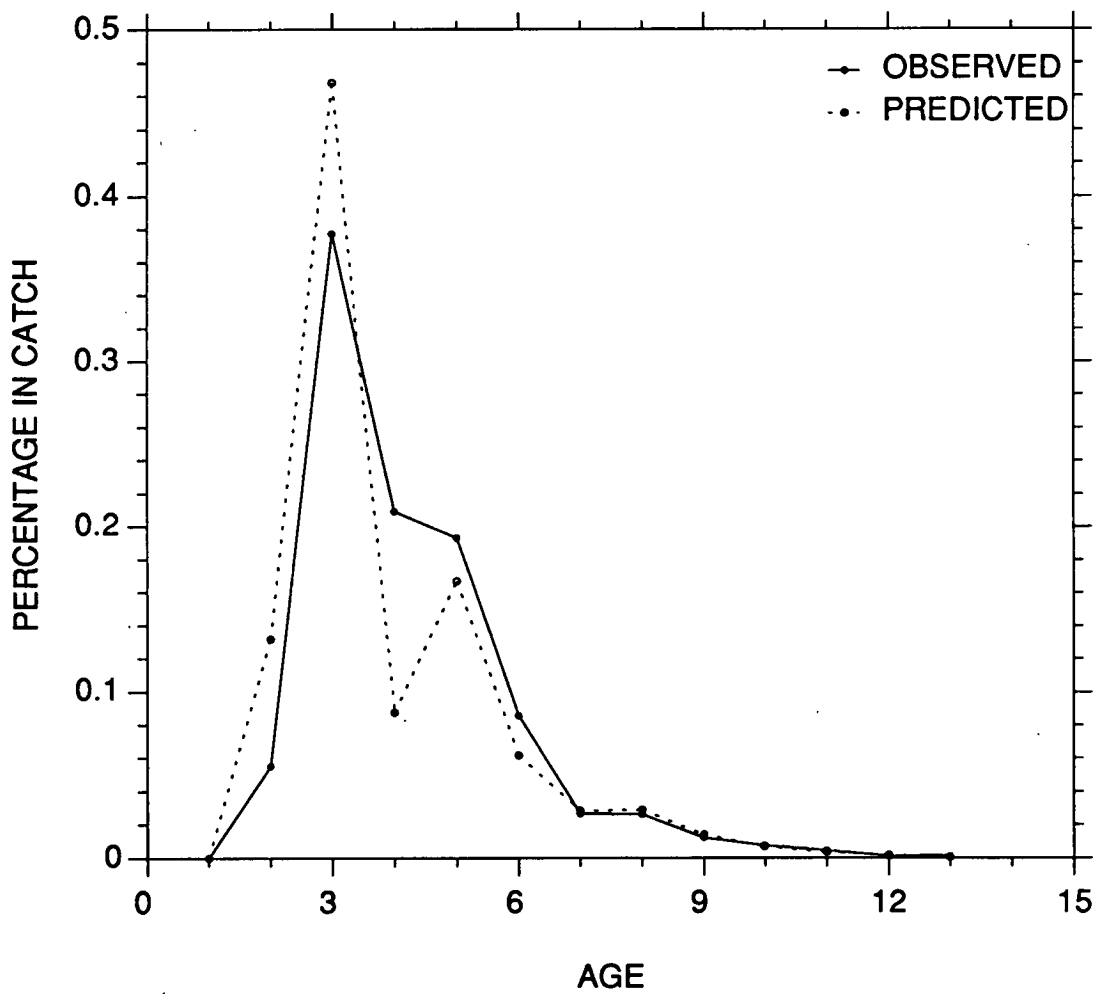
Figure 10. Observed age composition in the 1988 catch compared to that projected in the 1987 assessment.
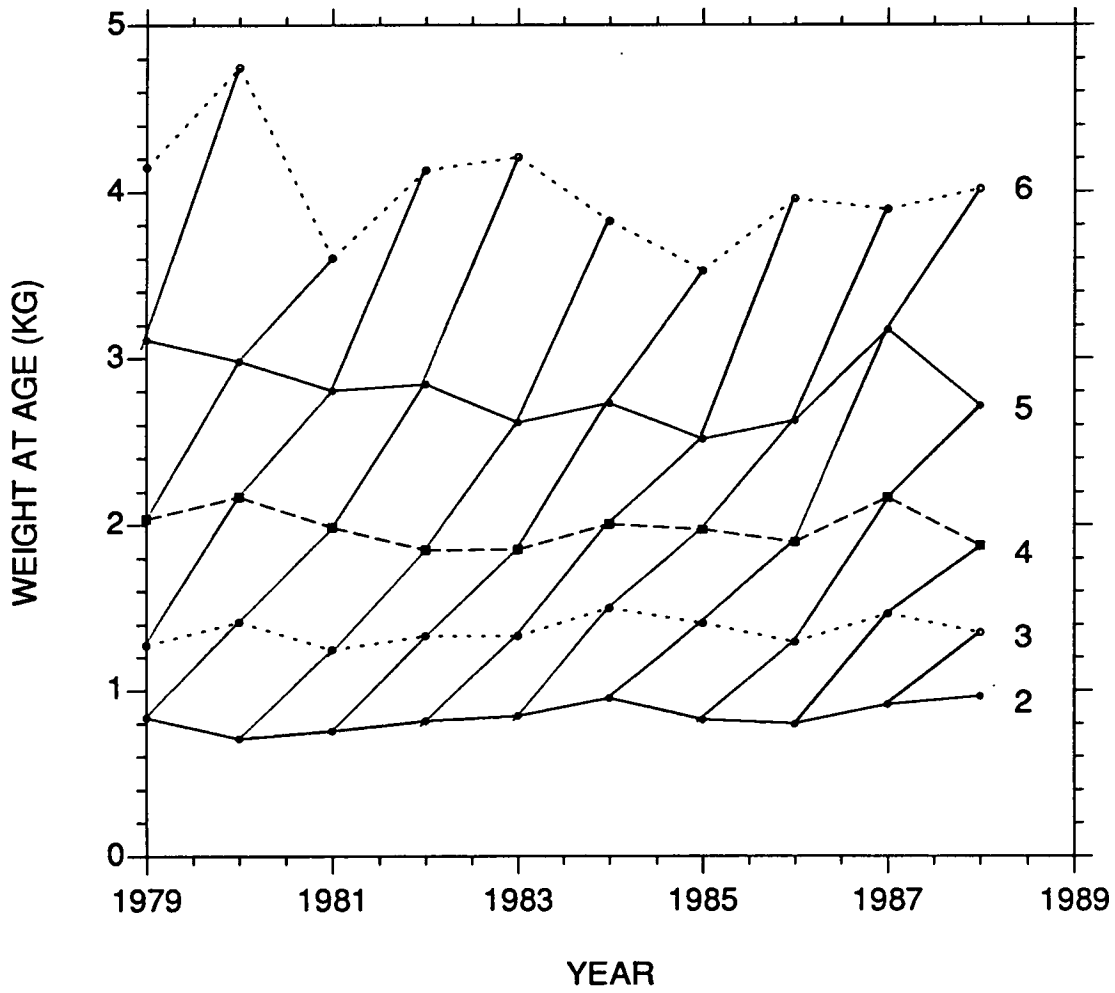
Figure 11. Trends in commercial weight at age for ages 2-6 by cohort since 1979.
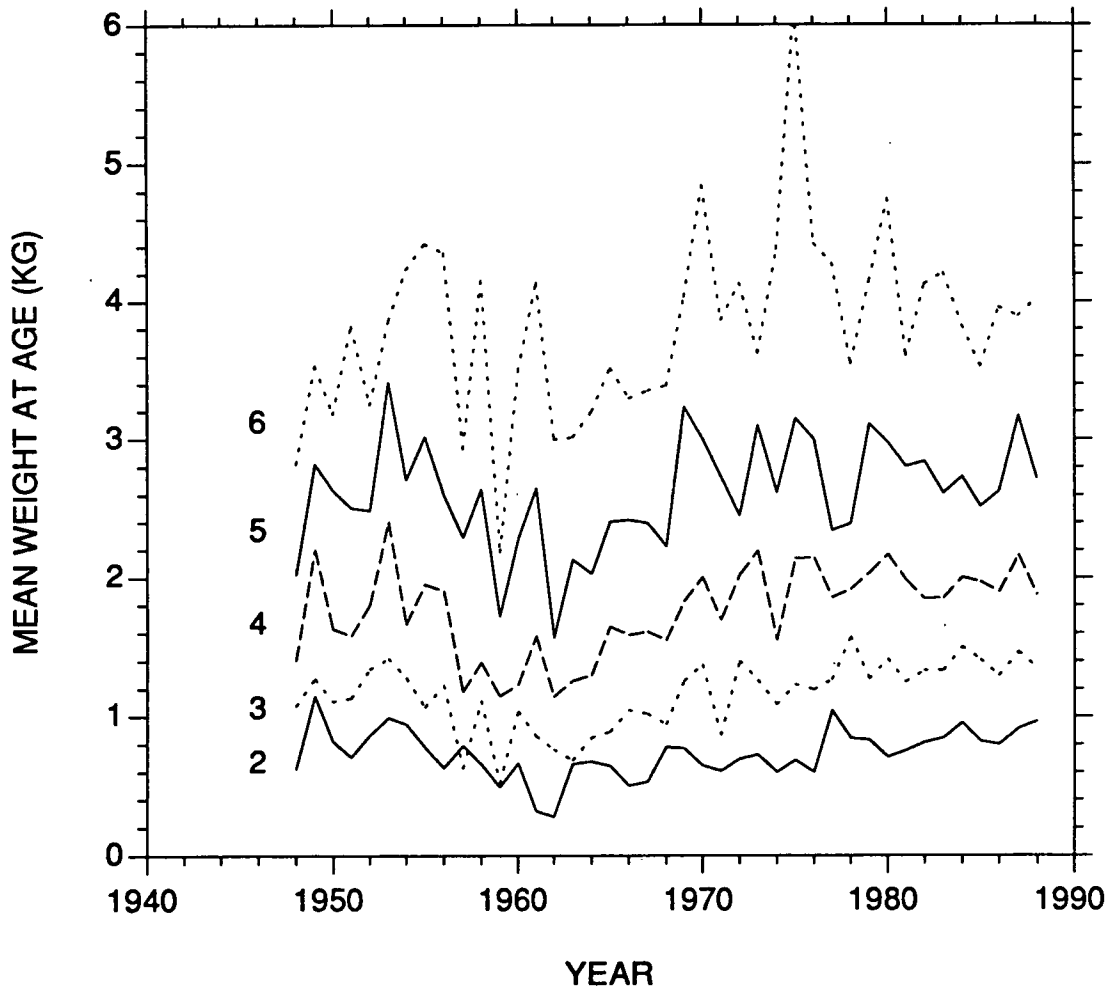
Figure 12. Trends in commercial weight at age for ages 2-6 since 1948.

Figure 13. Age-by-age calibration and residual plots from the ADAPT run.

SUMMARY OF DATA FROM PLOT   age = 4

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

INDEX	CARRIER	o	+	RANK
1970	8.553	8.32	7.324	1985
1971	8.543	6.457	7.314	1986
1972	8.902	7.834	7.673	1974
1973	8.702	7.709	7.473	1971
1974	8.459	6.974	7.23	1970
1975	8.799	7.988	7.57	1987
1976	9.148	7.752	7.919	1973
1977	8.909	7.86	7.68	1980
1978	9.067	7.816	7.838	1975
1979	8.972	7.595	7.743	1983
1980	8.744	7.032	7.515	1972
1981	9.178	7.849	7.949	1977
1982	9.017	7.526	7.787	1979
1983	8.81	7.766	7.581	1984
1984	8.972	7.769	7.743	1982
1985	8.102	7.304	6.872	1978
1986	8.333	7.152	7.103	1988
1987	8.664	7.036	7.434	1976
1988	9.119	7.934	7.89	1981

SUMMARY OF DATA FROM PLOT   age = 5

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

INDEX	CARRIER	o	+	RANK
1970	7.993	7.505	7.011	1986
1971	7.997	7.283	7.016	1987
1972	7.895	6.571	6.914	1975
1973	8.239	6.572	7.258	1972
1974	8.002	7.39	7.02	1970
1975	7.839	7.823	6.858	1971
1976	8.183	7.628	7.202	1974
1977	8.681	6.68	7.7	1988
1978	8.366	7.202	7.385	1981
1979	8.461	7.486	7.48	1976
1980	8.235	6.952	7.254	1984
1981	8.148	7.202	7.167	1980
1982	8.377	7.33	7.396	1973
1983	8.24	7.292	7.258	1983
1984	8.203	7.569	7.222	1985
1985	8.253	7.325	7.271	1978
1986	7.406	5.881	6.425	1982
1987	7.625	6.4	6.644	1979
1988	8.042	7.434	7.06	1977

SUMMARY OF DATA FROM PLOT   age = 6

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

INDEX	CARRIER	o	+	RANK
1970	7.559	7.785	6.816	1987
1971	7.11	6.495	6.367	1988
1972	7.242	6.203	6.499	1973
1973	7.062	5.606	6.319	1971
1974	7.45	6.844	6.707	1972
1975	7.268	6.887	6.525	1975
1976	7.279	6.727	6.536	1976
1977	7.595	7.148	6.852	1981
1978	7.978	6.2	7.235	1985
1979	7.651	6.907	6.908	1974
1980	7.699	7.26	6.956	1986
1981	7.408	6.767	6.666	1982
1982	7.458	6.772	6.715	1984
1983	7.486	6.823	6.743	1983
1984	7.471	6.571	6.728	1970
1985	7.409	6.669	6.666	1977
1986	7.457	6.443	6.714	1979
1987	6.626	5.561	5.883	1980
1988	6.83	6.24	6.087	1978

SUMMARY OF DATA FROM PLOT   age = 7

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

| INDEX	CARRIER	o	+	RANK
1970	7.174	6.95	6.42	1988
1971	6.876	6.825	6.122	1972
1972	6.344	5.354	5.59	1974
1973	6.482	5.068	5.729	1973
1974	6.345	4.779	5.591	1983
1975	6.692	6.655	5.938	1986
1976	6.718	6.004	5.965	1982
1977	6.762	5.881	6.008	1987
1978	6.88	5.907	6.126	1975
1979	7.135	6.111	6.381	1984
1980	6.966	6.126	6.212	1976
1981	6.96	6.17	6.206	1985
1982	6.65	5.476	5.896	1977
1983	6.598	5.922	5.844	1971
1984	6.7	6.221	5.946	1978
1985	6.719	6.288	5.965	1981
1986	6.643	6.13	5.889	1980
1987	6.681	5.421	5.927	1979
1988	5.819	5.329	5.065	1970

Figure 13. (Continued).

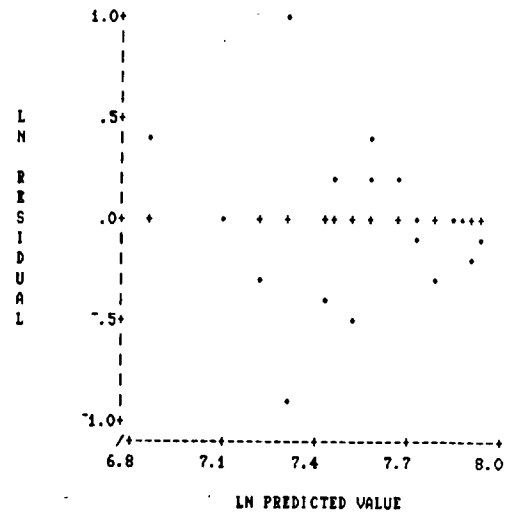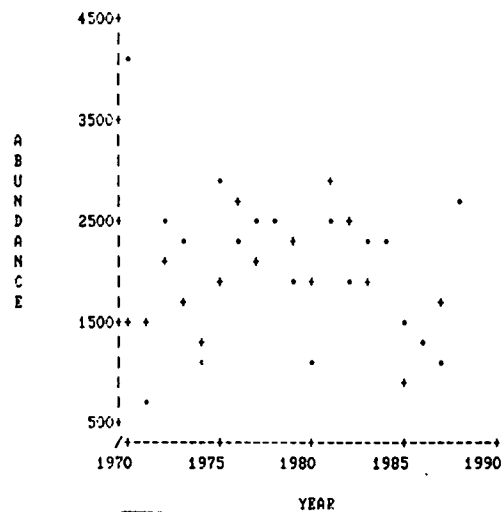TREND IN LN RESIDUAL OVER TIME
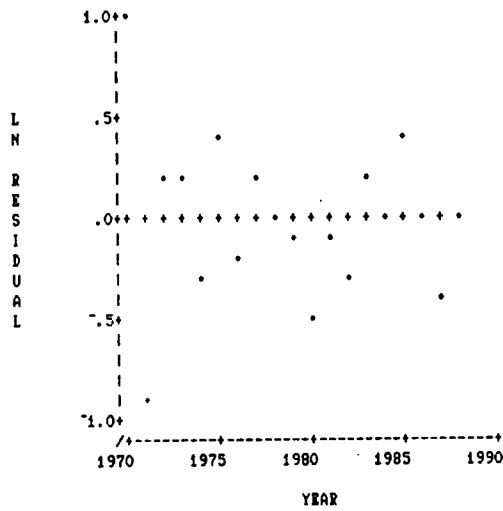
4X COD

AGE 4 PLOTS
LN SURVEY NO. PER TOW VS LN SPA NUMBERS
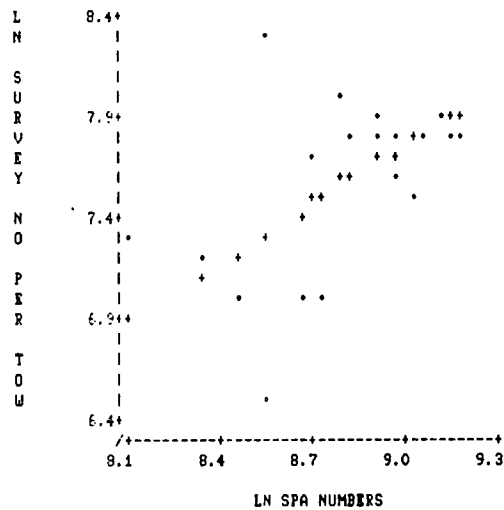
LN RESIDUAL VS LN PREDICTED VALUE

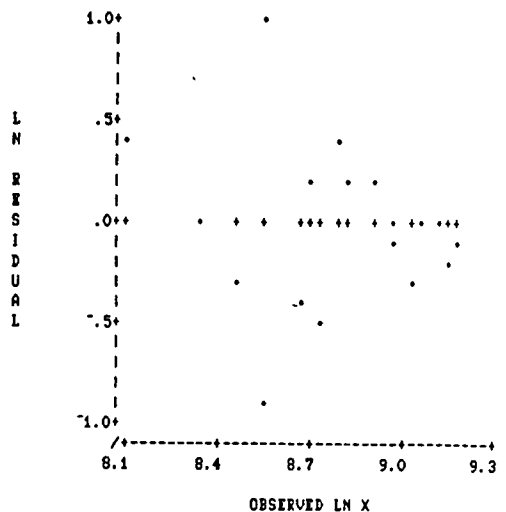TREND IN POPULATION ABUNDANCE OVER TIME

LN RESIDUAL VS OBSERVED LN X

Figure 13. (Continued).

TREND IN LN RESIDUAL OVER TIME

4X COD

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

LN RESIDUAL VS LN PREDICTED VALUE

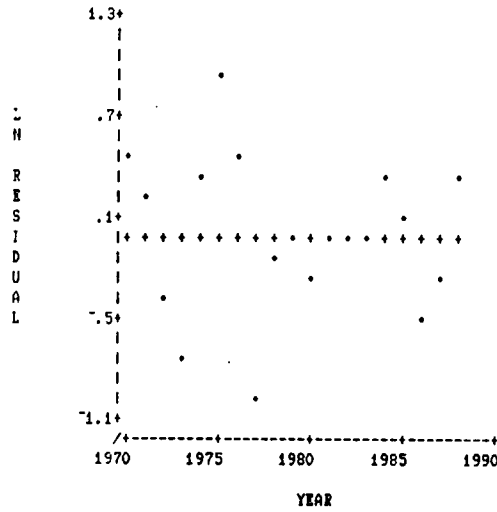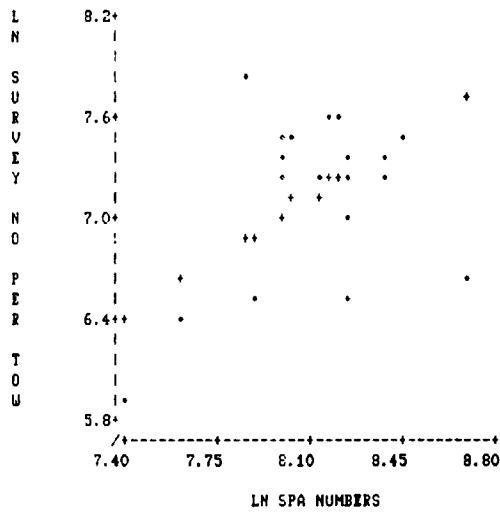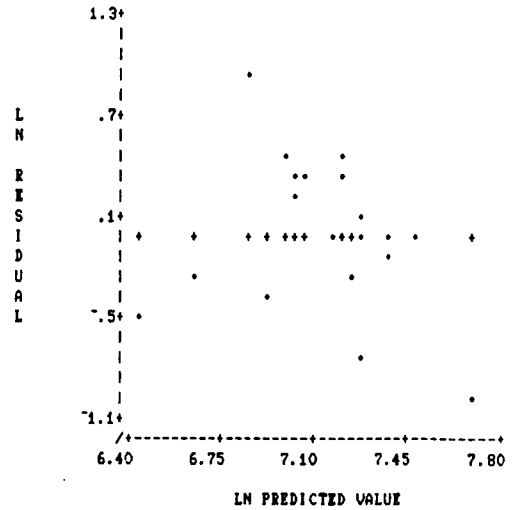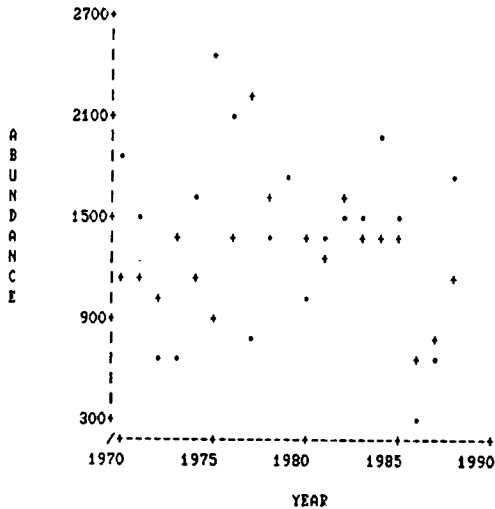TREND IN POPULATION ABUNDANCE OVER TIME
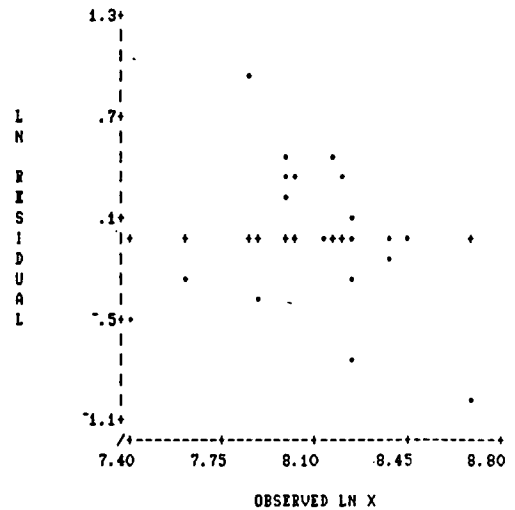
LN RESIDUAL VS OBSERVED LN X
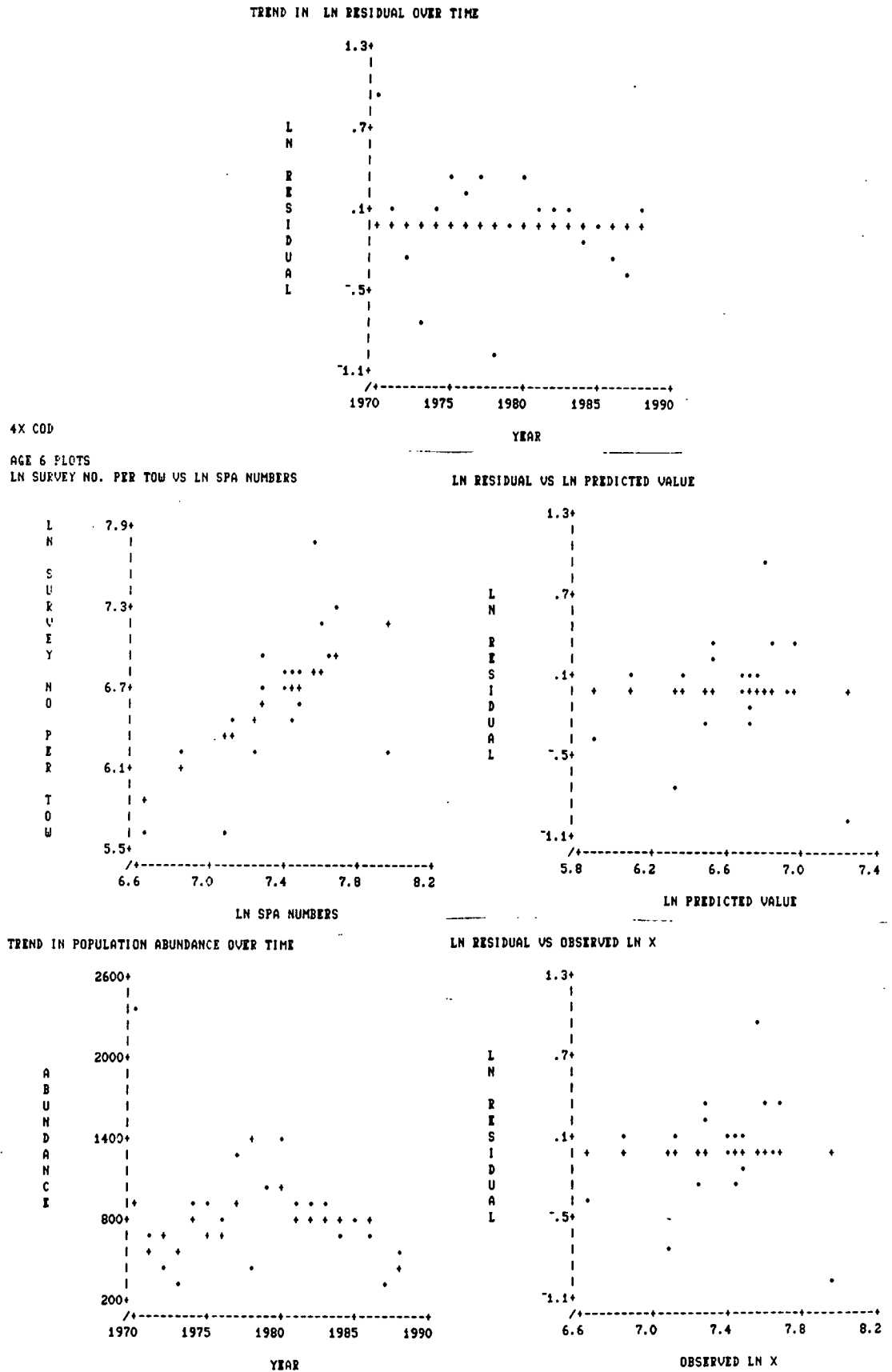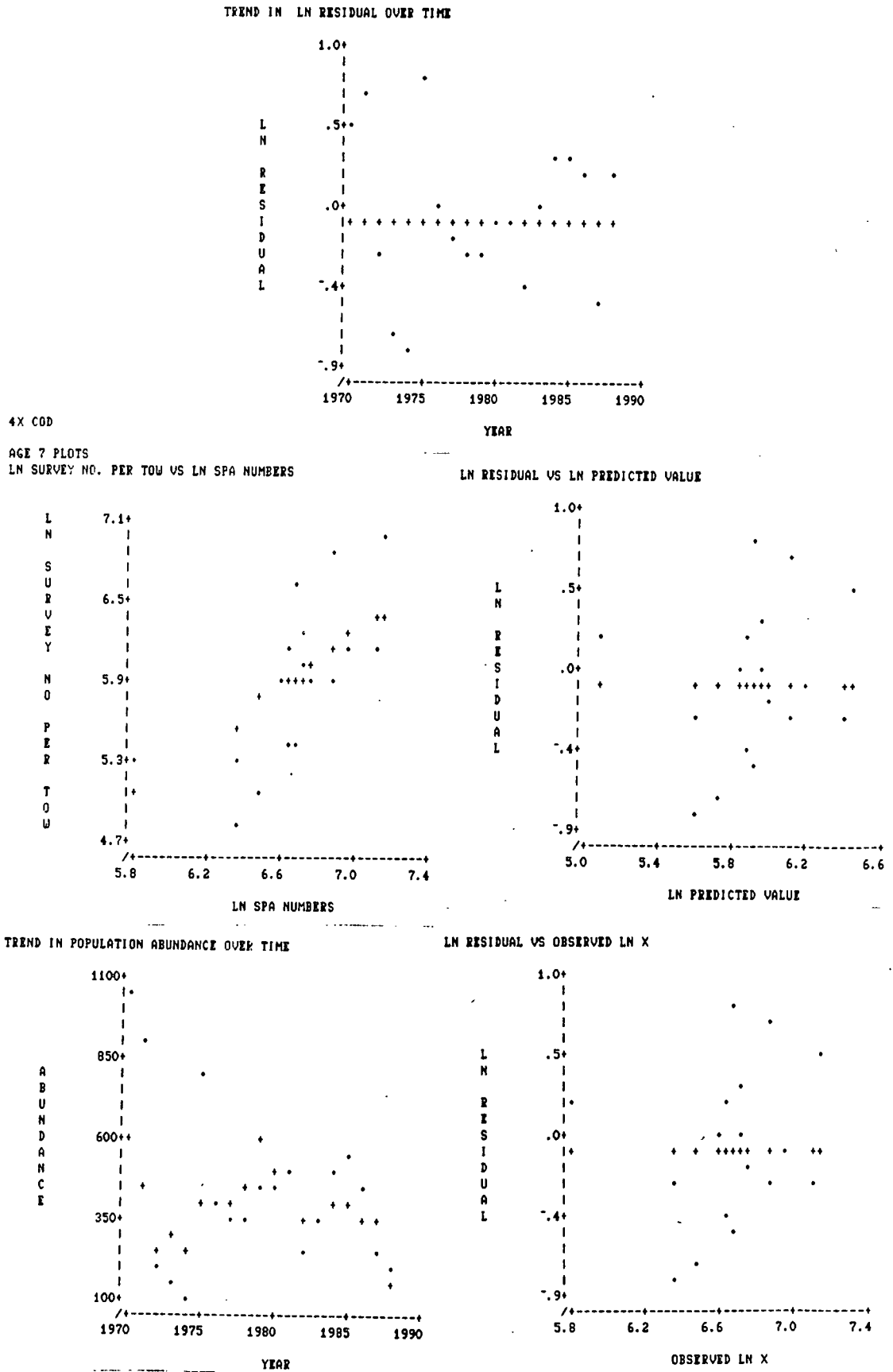
Figure 13. (Continued).

TREND IN LN RESIDUAL OVER TIME

```
        1.3+
           |
           |.
           |
  L     .7+
  N        |
           |
  R        |
  E        |                .    .      .
  S     .1+ .    .                  . . .        .
  I        |+ + + + + + + + + + + . + + + + + . + + +
  D        |
  U        |             .                  .
  A        |                                    .
  L    .5+
           |
           |           .
           |                      .
           |
      1.1+
         /+----------+----------+----------+----------+
          1970      1975      1980      1985      1990
```

4X COD

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

YEAR

LN RESIDUAL VS LN PREDICTED VALUE

```
  L    7.9+                                         1.3+
  N       |                          .                 |
          |                                            |
  S       |                                            |
  U       |                                            |                        .
  R    7.3+                                  L     .7+
  V       |                        .         N        |
  E       |                   .        .               |
  Y       |              .                   R         |           .      .  .
          |            ... ++            E  .1+        .     .    ++
  N    6.7+          . +++             S  .1+  +    +    ++   ++   +++++  ++        +
  O       |          + .               I        |
          |        . .                 D        |
  P       |    . ++                    U        |                .      .
  E       |    .     .          .      A   .5+ .
  R    6.1+  . +                        L       |
          |                                     |         .
  T       |+                                    |
  O       |                           1.1+
  W    .|.      .                         /+----------+----------+----------+----------+
  5.5+                                     5.8   6.2   6.6   7.0   7.4
     /+----------+----------+----------+
      6.6  7.0   7.4   7.8  8.2                    LN PREDICTED VALUE
```

LN SPA NUMBERS

TREND IN POPULATION ABUNDANCE OVER TIME

LN RESIDUAL VS OBSERVED LN X

```
  2600+                                        1.3+
     |                                            |
     |.                                           |
     |                                            |
     |                                  L     .7+
  2000+                                 N        |
  A    |                                         |
  B    |                                R        |          .      . .
  U    |                                E        |        .
  N    |                                S     .1+    .      .   ...
  D  1400+          .    .             I        |+   +    ++  ++  +++ ++++    +
  A    |          .                    D        |                .
  N    |                               U        |          .    .
  C    |        . .                    A        |
  E    |+      .  . .   . . .          L    .5+
  800+      .   +  .   + + + . .               |
     |    . .    + +        .   .               |     .
     |  . .            .                        |
     |  .                       .       1.1+              .
  200+                        .             /+----------+----------+----------+----------+
    /+----------+----------+----------+       6.6   7.0   7.4   7.8   8.2
     1970  1975   1980   1985   1990
```

YEAR

OBSERVED LN X

Figure 13. (Continued).

TREND IN LN RESIDUAL OVER TIME

4X COD

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

LN RESIDUAL VS LN PREDICTED VALUE

TREND IN POPULATION ABUNDANCE OVER TIME

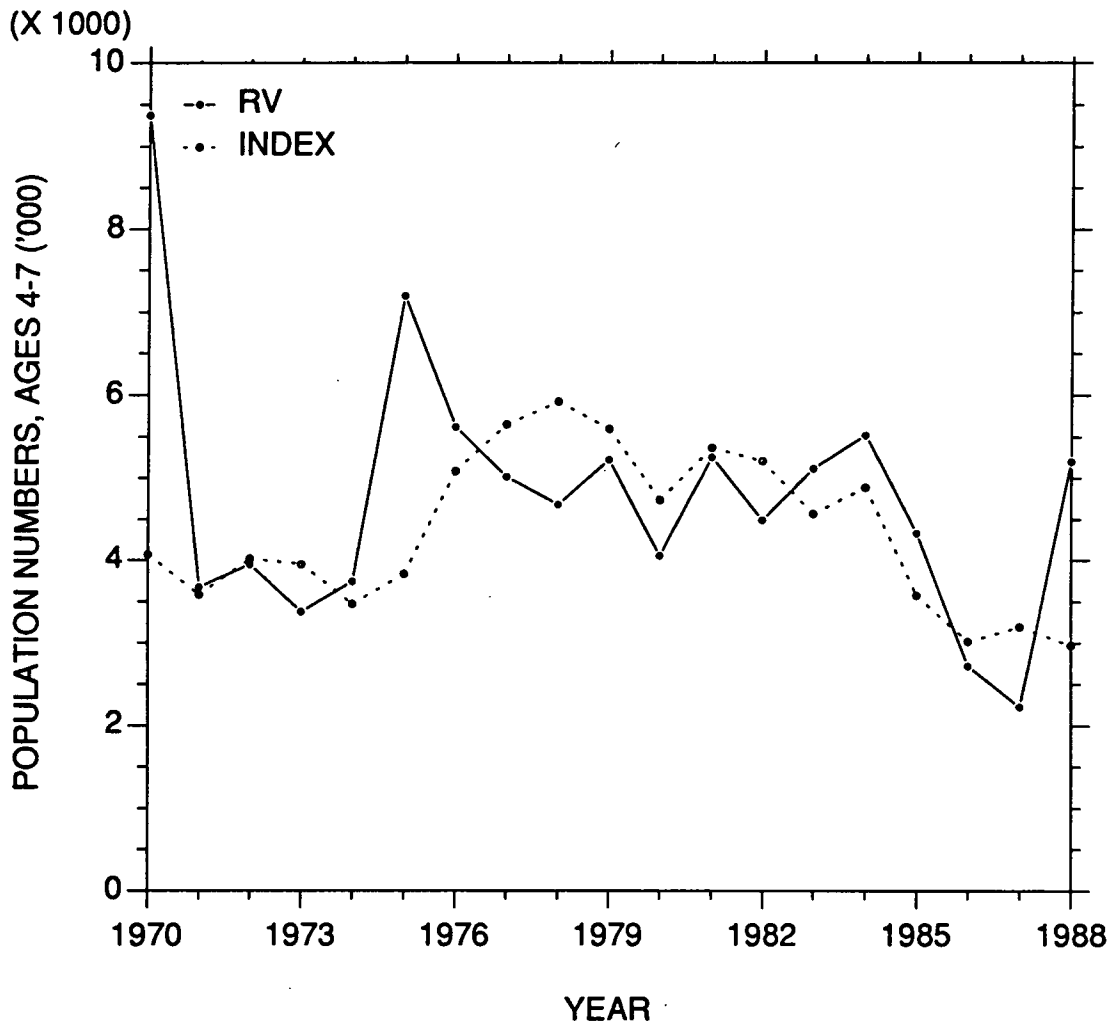LN RESIDUAL VS OBSERVED LN X

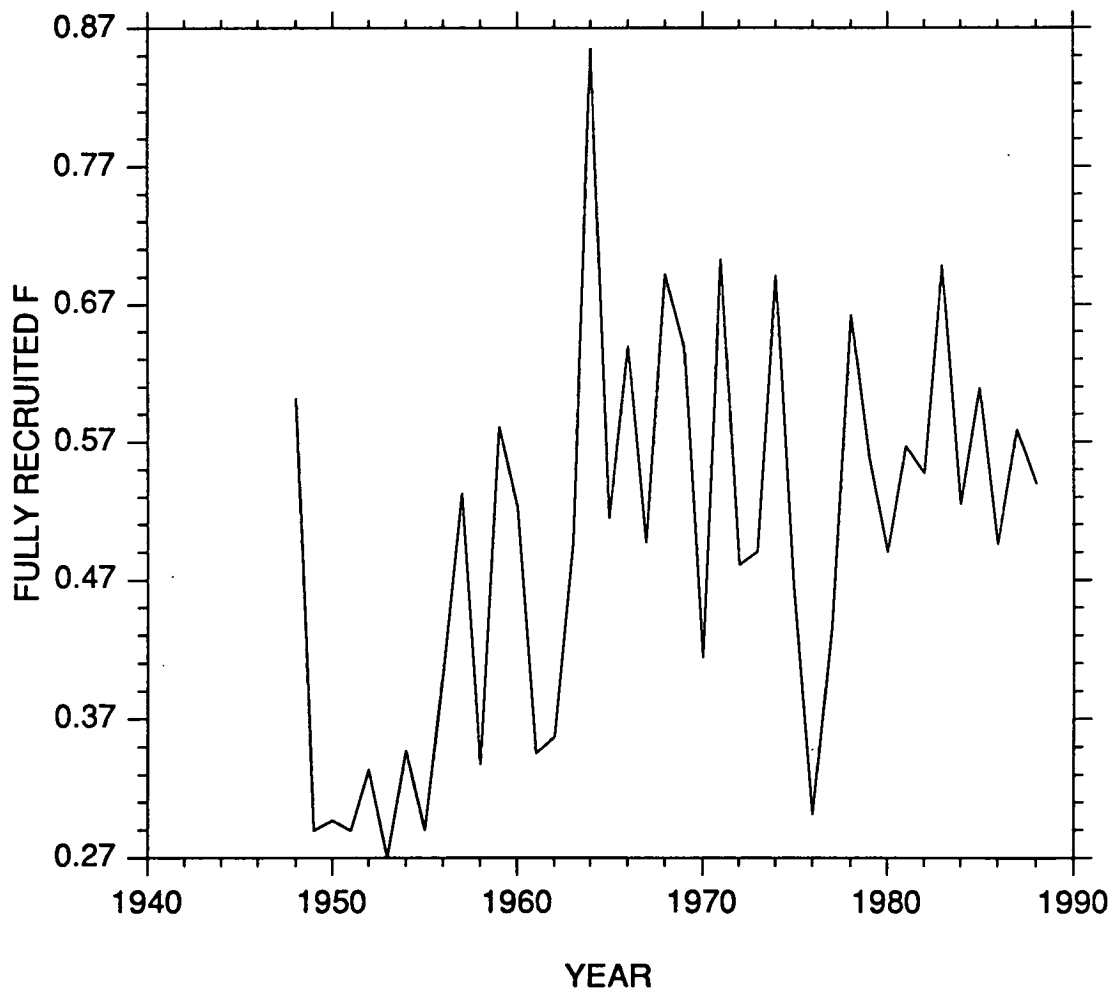Figure 14.   Predicted (from ADAPT calibration) and observed RV population
numbers between ages 4-7.

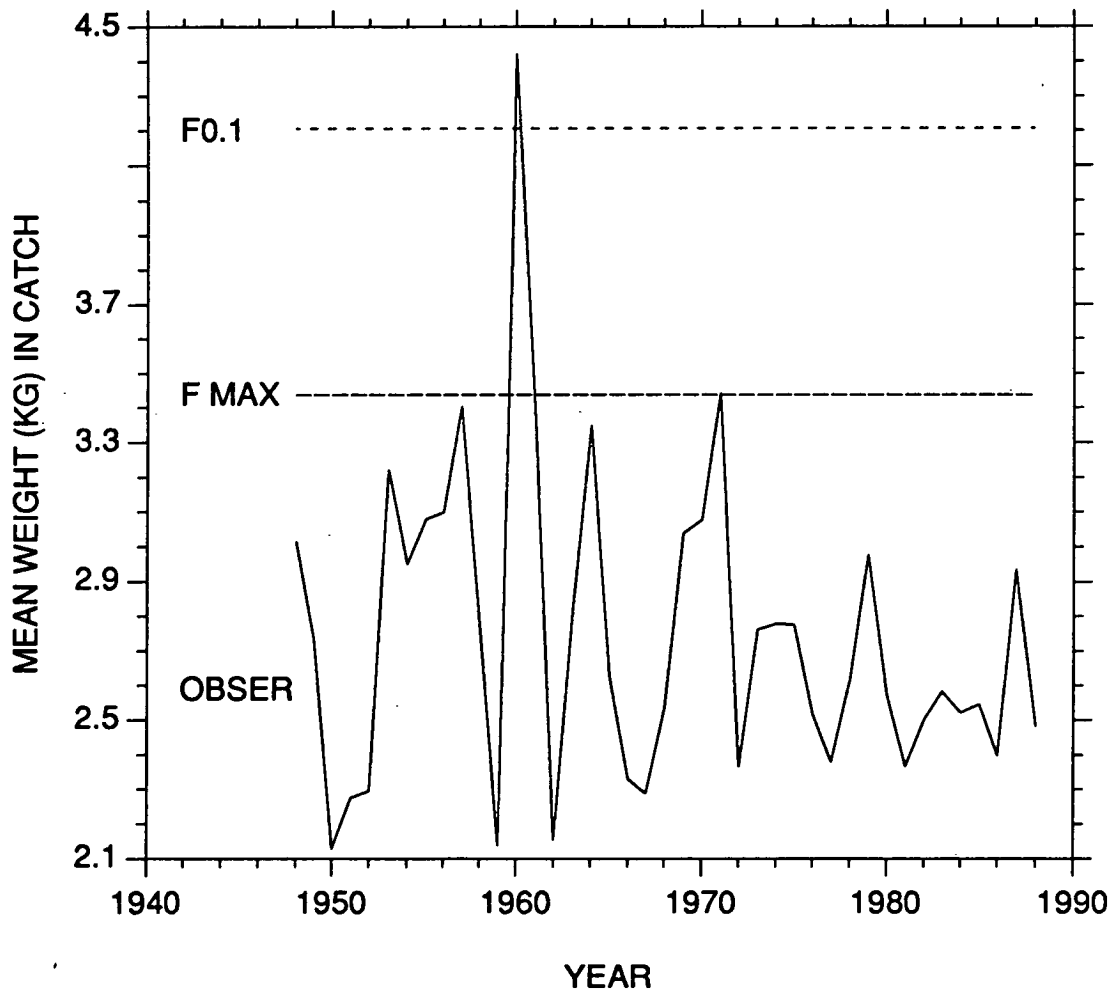Figure 1 5. Time series of fully-recruited fishing mortality (age 6+).

Figure 16. Observed mean weight in catch (kg) compared with that expected of fishing at $F_{0.1}$ of F_{max}.

(X 1E3)
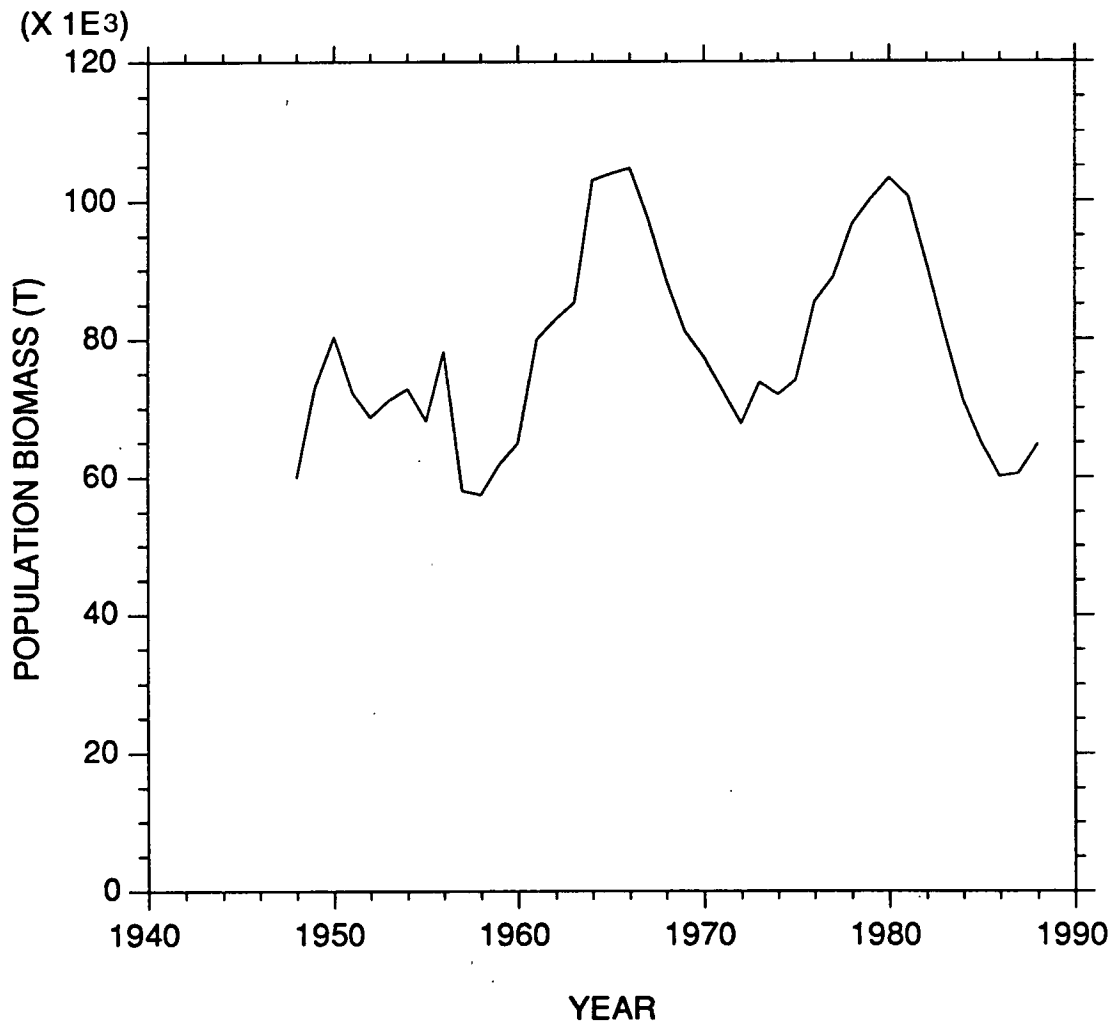
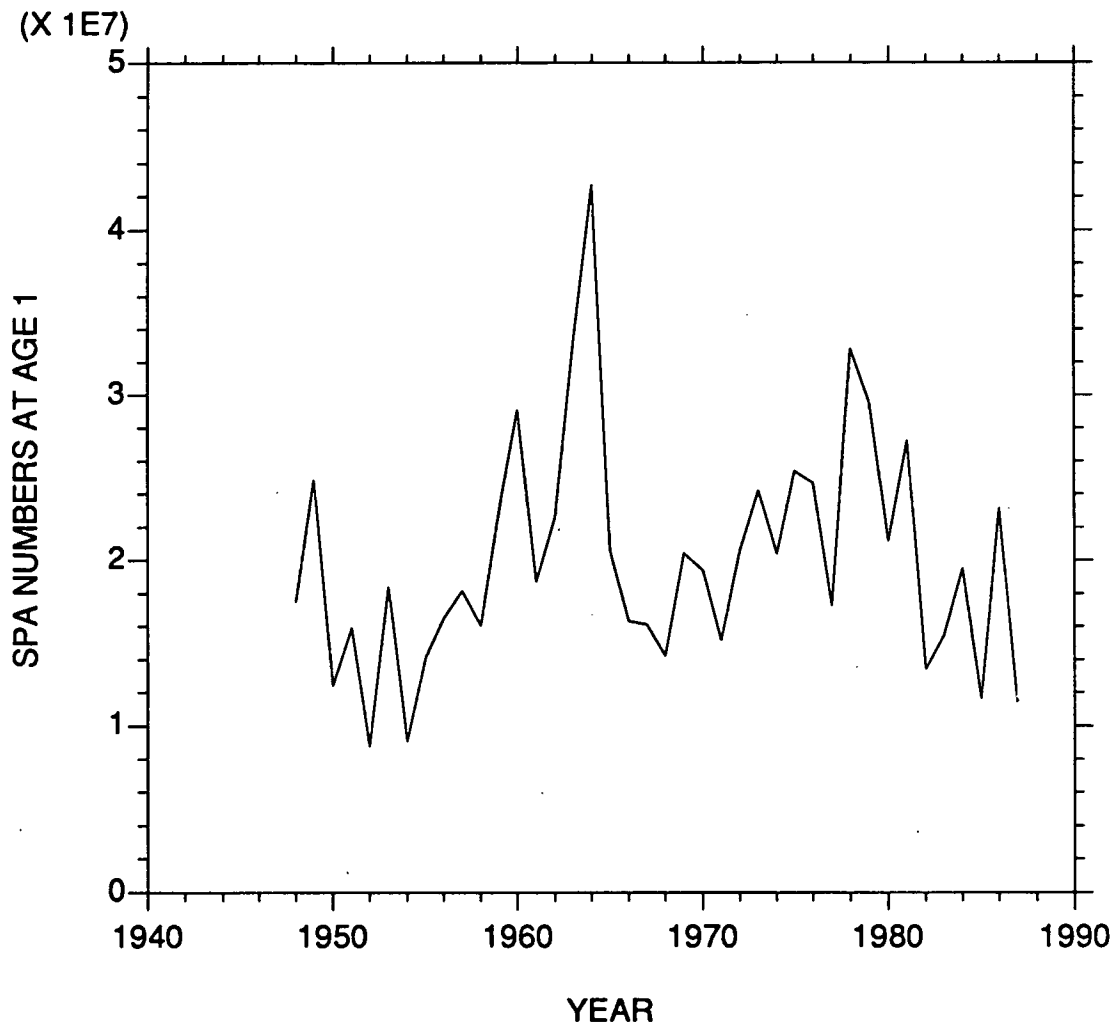Figure 17. Time series of population biomass (t) for 4X cod.

Figure 18. Time series of recruitment determined from cohort analysis.
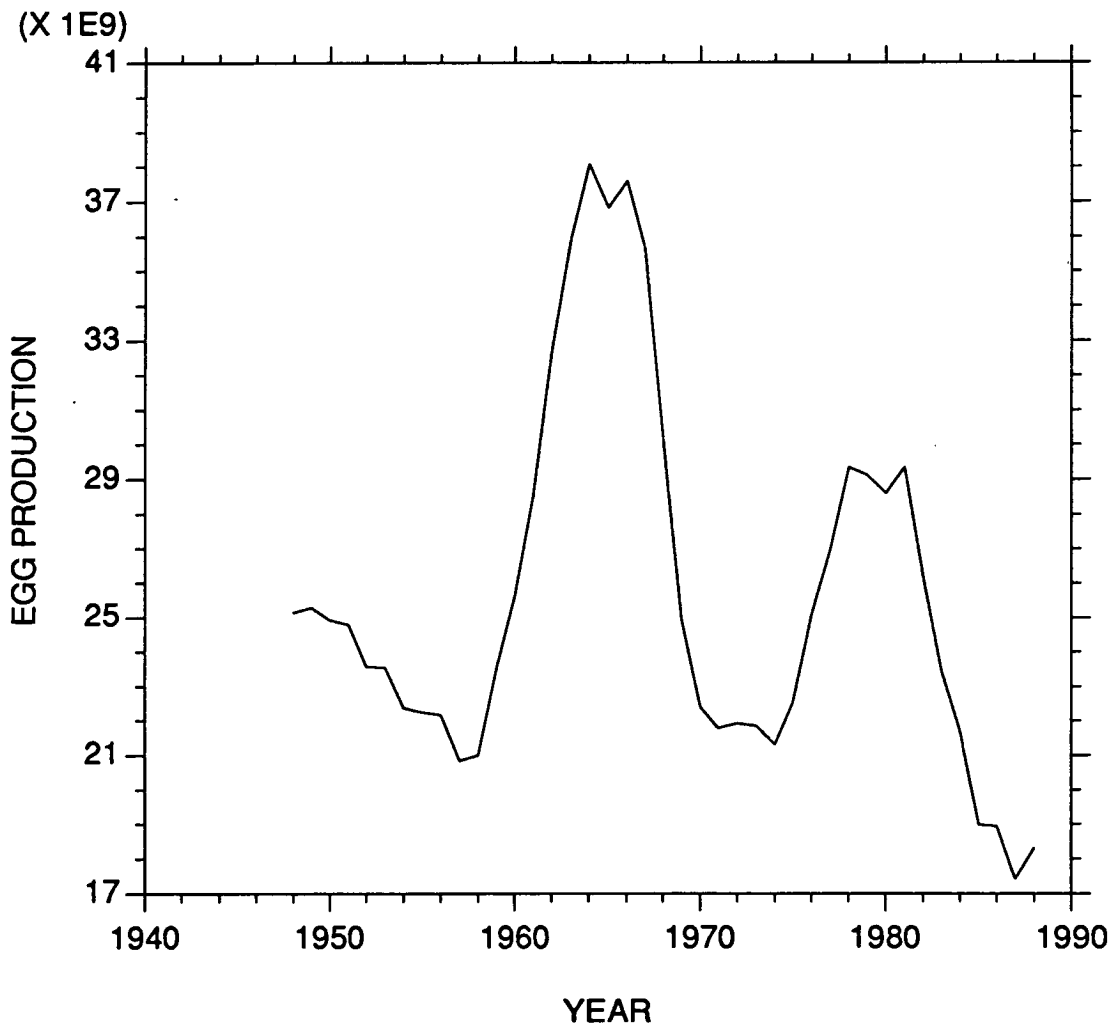
Fig. 19. Time series of egg production.

Fig. 20. Stock recruitment relationship.