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Stock Status of 4X Cod in 1987

by

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Abstract

The 1987 nominal catch of 4X cod was 18,700 t. Both of the major gear components (MG < 65'; FG < 65') reached or exceeded their allocation. Interpretation of commercial catch rates was complicated by misreporting and the multispecies nature of the fishery. Nevertheless, catch rates for both otter trawlers and longliners have declined steadily and substantially since the late 1970s. In addition, all research vessel indices of stock abundance and biomass have reached their lowest level since 1973. Calibration of the cohort analysis with the ADAPT framework indicated a terminal fishing mortality of 0.56. This estimate is consistent with the time series of fully-recruited fishing mortalities and the observed mean weight in the catch. SPA biomass and spawning stock biomass continued their decline of recent years and may now have reached their lowest levels in 40 years. While there has been no apparent relationship between stock and recruitment to this point, there is also no evidence of strong recruitment in the upcoming year classes. If the 1988 TAC of 14,000 t is caught, the 1989 catch under the 50% rule would be 12,500 t.

Résumé

La prise nominale 1987 de morue 4X a été de 18 700 t. Les deux grands types d'engins de pêche (MG < 65'; FG < 65') ont atteint ou dépassé leur quota. L'interprétation des taux de prise commerciale a été compliquée par le fait que les rapports ont été mal faits et que cette pêcherie exploite plusieurs espèces de poissons. Néanmoins, les taux de prise par chalutiers et palangriers ont régressé régulièrement et substantiellement depuis la fin des années 1970. En outre, tous les indices obtenus par les vaisseaux de recherche et portant sur l'abondance des stocks et la biomasse ont atteint leur plus faible valeur depuis 1973. L'étalonnage de l'analyse des cohortes dans le cadre du ADAPT montre que la mortalité par la pêche en estuaire est de 0,56. Cette évaluation est conforme au résultat de la série chronologique des mortalités par la pêche chez les sujets entièrement recrutés ainsi que le poids moyen observé dans les prises. La biomasse SPA et la biomasse des reproducteurs ont continué de diminer ces dernières années et ont peut-être atteint maintenant leur plus bas niveau depuis 40 ans. Il n'y a pas de relation apparente entre les stocks et le recrutement jusqu'ici, mais il n'y a pas non plus l'indice d'un fort recrutement dans les classes d'âge à venir. Si le TPA 1988 14 000 t est atteint, la prise de 1989 établie en vertu de la règle du 50 % serait de 12 500 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 35,500 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 32,000 t; however, there has been a marked decline in catches since 1982 (Figure 3). The 1986 nominal catch was 18,700 t.

Both the fixed (< 65') and mobile (< 65') gear categories caught their allocation in 1987. The fishery by small (< 65') otter trawlers (OT) was closed or restricted several times during the year (Table 2). 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. Since misallocation was also apparent in 1987, adjustments have again been made (Table 3). A more serious misreporting problem first became apparent in 1986 and continued into 1987; comments by both fishermen 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. Catches in each of the major gear categories peaked in the summer months (Figure 4). Landings were split between otter trawlers and fixed gear, but the former continued their recent domination of the fishery. Catches by TC-1 vessels accounted for 42% of the total in 1987, somewhat higher than the proportion reported last year. Landings by both otter trawlers and longliners have declined substantially since 1983 (Figure 5).

Stock Abundance Indices

Commercial Catch Rates

Catch rates for 4X cod were calculated for 6 gear/TC categories (4-Longline (LL); 2-otter trawl (OT)) selected on the basis of available effort data (Table 5). Catch rates were calculated on a quarterly basis and then standardized. Standardization was conducted through normalization of each value to the mean post-1976 catch rate within a given gear/quarter; yearly values were then averaged across tonnage classes. The results indicated that the strong downward trend noted in previous assessments was continued into 1987 (Figure 6). This trend was consistent among gear types, although as an indicator of the trend in cod abundance, it was confounded by

misreporting by the OT sector, the multispecies nature of the fishery and the increased abundance of dogfish in 4X (Annand, MS 1985). Reported longline effort has remained roughly constant between 1985-87, while that of otter trawlers declined by over 50% between 1986-87 (Table 5). Less than 20% of the landed catch was reported with the associated effort statistics.

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. As per the recommendation of the Statistics, Sampling and Surveys Subcommittee of CAFSAC, no inter-vessel conversion factors have been applied. All RV data have been presented in terms of Alfred Needler trawlable units (41' wingspread); previous assessments employed a trawlable unit based on a 34' wingspread.

Age-structured survey population estimates, and their standard errors, are presented in Table 6. While age 5+ numbers fluctuated in the early 1970s, the years between 1979-85 suggested relative stability (Table 6a). However, all RV indices of stock abundance (Figure 7) and biomass (Table 8; Figure 8) declined substantially in 1986 and 1987. The 1987 RV biomass index reached its lowest level in 18 years. No prominent trends in weights-at-age (weighted by stratum area) are evident over the past 6 years (Table 7). With respect to incoming recruitment, the 1984 year-class appears to be particularly weak, while the 1983 and 1985 cohorts are about average (Figure 9).

Age Composition of the Catch

In a previous assessment, quarterly age-length keys were computed for each of the major gear types (pooled among tonnage classes) for the period 1948-86. Details of key construction and sample aggregation policy are described elsewhere (Campana and Simon, MS 1986). Forty two samples went into the construction of comparable keys for 1987. Length-weight relationships were derived from seasonal RV data; in years where a survey was not conducted, seasonal means were applied.

Quarterly landings data and sample information for 1987 are presented in Table 9. Numbers at age caught in 1987 by each of the major gear categories are presented in Table 10. 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).

Total catch numbers and percent catch numbers-at-age for the period 1948-87 are presented in Tables 11 and 12. A comparison of the 1987 catch

composition and that predicted last year for 1987 indicates that all ages were reasonably well predicted, although the partial recruitments of ages 2 and 3 were slightly under- and over-estimated, respectively (Figure 10). No trends in mean weight-at-age in the catch (Table 13) were noted. Fish aged 2-5 made up the largest proportion of the catch numbers (77%) in 1987 while ages 4-7 made up most of the catch weight (66%) (Tables 14 and 15). Catch composition curves indicate that age 5 fish were fully recruited to the fishery.

Estimation of Stock Size

Survivor Analysis

Survivor analysis was run on 4X cod using the catch at ages 2-7, a calibration block of 1970-86 (ages 2-7) and full recruitment to the survey gear at age 5. However, the resulting population matrix was unstable, suggesting incomplete convergence, and the results were not considered further.

Cohort Analysis

Cohort analyses were run on ages 1-13 in the catch-at-age matrix in Table 11. Natural mortality was set at 0.2 and the age of full recruitment at 5. Fishing mortality on the oldest age group was a weighted mean (weighted on population numbers) of Fs on age 6^+ fish. Partial recruitment (defined as F ÷ weighted mean of fully recruited Fs) in the final year was set at the mean of the years 1982-86; the partial recruitment of age 5^+ fish in 1987 was set at 1.0. Cohort runs were conducted for terminal Fs of 0.2-0.8 at 0.05 intervals.

Calibration of the SPA

The SPA was calibrated against RV population numbers through use of the ADAPT framework (NLLS) (CAFSAC Subcommittee Rep. 87/9). Six parameters were estimated: ages 6, 7, and 8 in 1988 and the slopes of the regression relating SPA to RV population numbers at ages 5, 6, and 7. The model assumed a fixed partial recruitment at ages 2-4 (fixed at the mean PR of 1982-86) and flat-topped recruitment at age 5+. The terminal Fs for ages 8-12 were a weighted mean of Fs on ages 5-7 in 1987. RV population numbers were inversely weighted by their standard errors (Table 6b).

The above model reached a stable optimum when fitted; the parameters remained constant after removal of the penalty function and were uncorrelated among themselves (Figure 11). 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; 2 of the 3 intercepts were not significantly different from 0, and the remainder was only marginally so. Examination of the age-by-age weighted calibration plots indicated that the model fit the data well (Figure 11). The residuals were randomly distributed across year, predicted values, and SPA population numbers.

The result of the SPA calibration was a terminal F of 0.56. This value is almost identical to that produced through use of last year's calibration procedure (least squares regression of SPA ages 4-6 on RV ages 4-6) (Campana and Simon, MS 1987). In addition, the time series of fully recruited Fs indicates that a 1987 F_t of 0.56 is comparable to those of the past 25 years and equivalent to the mean of the past 7 years (Figure 12). 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 13). 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 0.56 was considered to be a reasonable estimate for 1987.

Assessment Results

Population numbers and fishing mortalities corresponding to $F_T = 0.56$ are presented in Tables 16 and 17. Population biomass in 1987 was not significantly different from that of 1986, with both years representing the lowest values observed in the stock since 1948 (Table 18). This fact probably stems from the overexploitation of the stock at catch levels exceeding surplus production since 1979 (Figure 14).

Recruitment

Recruitment of 4X cod has varied by a factor of 9 between 1948-86; the 1985 year class appears to be the weakest in the time series (Figure 15). It is tempting to ascribe these recent difficulties in recruitment to the record-low levels of population biomass now present in the population (Table 18). To test this hypothesis, preliminary estimates of spawning stock biomass were generated through application of an age-maturity vector to beginning-of-year population biomass values. A mean age-maturity vector, unweighted by length frequency, was calculated from 1979-84 summer RV surveys of female 4X cod with the implicit assumption that temporal trends in the maturity ogive were not present. The vector of percent mature females at age was:

Age	% Mature Females
1	0.00
2	0.37
3	0.84
4+	1.00

The above vector was then multiplied by one half the population biomass matrix (corresponding to a 1:1 sex ratio) to produce a spawning stock biomass matrix, and summed across ages to produce yearly values. The time series of spawning stock biomass was similar to that of fishable biomass, and now appears to have reached its lowest level in 40 years (Figure 16). Despite

this fact, there is no evidence of a stock-recruitment relationship (Figure 17), and thus no evidence that the low number of spawners is inducing a lower level of recruitment.

Yield per recruit was calculated in 2 ways: using 1987 weights at age, and using the mean of 1985-87 weights at age. Partial recruitment was set at the mean of 1982-86 in both cases. Both analyses produced similar results (Table 19), with $F_{0.1}$ = 0.16, F_{max} = 0.27, and $F_{0.1}$ yield per recruit equal to 1.1-1.2 kg. At the present level of fishing mortality, yield per recruit is approximately 10% lower than it could be (Figure 18). Expected annual yield (long-term) at $F_{0.1}$ is 21,000 t (assuming geometric mean recruitment at age 1 = 18,843,000).

Catch Projections

Projections were made with the mean of the 1985-87 weights at age, the mean PR between 1982-86, and the geometric mean of age 2 recruitment between 1970-84. The 1988 TAC, 14,000 t, which is above that recommended by CAFSAC, corresponds to a fishing mortality of 0.43. Assuming the 1988 TAC is caught, the projected $F_{0.1}$ catch in 1989 is 8,200 t (Table 20).. However, since the 1987 F_T exceeds $F_{0.1}$, the 50% rule was applied, resulting in a 1989 F of 0.32. The 1989 catch at this level would be 12,500 t.

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). However, our current view of the stock suggests that recent fishing mortalities have been taking their toll. All indices of abundance show a marked decline in 1987 — catch rates have reached their lowest level since 1976 and RV population numbers are at their lowest level since 1973. Of particular concern is the fact that SPA biomass is at a 40-year low. Given these facts, it is possible that stock biomass is approaching a critical level. While there has been no apparent relationship between stock and recruitment to this point, the current record-low levels of spawning stock biomass are outside the range of previous years' observations, and thus cannot be used for predictive purposes. There is no evidence of strong recruitment in the upcoming year classes; indeed, the 1984 year class now appears to be one of the weakest on record. If abundance indices continue their decline in 1988, serious consideration may have to be given to stock preservation measures.

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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*				29					18700	99.9

Sources: 1948-53 ICNAF Suppl. Ann. Proc. 11 (Appendix) (1962).
1954-66 NAFO Statistical Bulletins
1967-87 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[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

* Adjusted in mid-year.

[1] Preliminary

** Fishery closed or restricted several times during the year.

Table 3. Adjustment of OT (TC 2, 3) nominal catches in 4X to reflect misreported catches in 5Y (as justified in Campana and Simon 1985).

Year	Reported		Adjusted	
	4X	5Y	4X	5Y
1977	4777	106	4883	0
1978	4018	380	4398	0
1979	4096	340	4436	0
1980	6786	161	6947	0
1981	5731	300	6031	0
1982	6409	1180	7589	0
1983	8396	2562	10958	0
1984	7554	2905	10459	0
1985	8320	1363	9683	0
1986	8203	694	8897	0
1987	5905	194	6099	0

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[A] 2	LL / LHP[A] 3	LL / LHP[A] 4	GN 1	GN 2	Misc.	Total
1984	M	-	17	26	2	315	762	395	124	-	536	12	77	2266
	N	-	190	269	34	1064	31	570	199	2	-	9	9	2377
	O	68	528	355	47	68	4282	391	59	-	392	140	67	6397
	P	4	244	399	-	66	178	560	386	-	-	-	-	1837
	Q	95	692	1148	14	-	540	56	41	-	4	-	175	2765
	R	235	1202	1774	-	-	562	8	-	-	2	-	2	3785
	S	119	423	391	-	-	421	14	1	-	179	43	27	1618
	U	-	901	1898	12	-	-	929	167	1	-	18	94	4020
	Total	521	4197	6260	109	1513	6778	2923	977	3	1112	222	451	25066
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

* Catches misreported as being from 5Y have been allocated proportionally among OTB TC 2 and 3 vessels in 4X (see Table 3).

A LHP = handline

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

Table 5. Commercial catch rates for otter trawlers (OT) and longliners (LL) in 4X (all unit areas combined). Effort values in parentheses. a) Effort units are hundreds of lines (LL) and tons/hr (OT); b) Effort is in terms of days fishing.

a)

	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)

b)

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	-	-	1.85 (71)	-	-	-
1974	3.50 (38)	2.19 (108)	2.06 (82)	4.12 (73)	-	-
1975	2.81 (47)	2.24 (150)	1.69 (77)	3.21 (53)	-	-
1976	2.14 (37)	1.87 (53)	1.64 (109)	3.20 (19)	0.88 (77)	1.27 (38)
1977	2.93 (115)	2.84 (117)	2.56 (103)	4.11 (74)	2.74 (165)	2.55 (157)
1978	3.85 (149)	2.48 (119)	2.18 (141)	5.02 (83)	2.07 (108)	5.31 (163)
1979	3.04 (119)	2.70 (141)	2.50 (173)	5.28 (61)	2.72 (94)	3.51 (78)
1980	2.74 (99)	2.16 (223)	2.02 (107)	4.11 (80)	2.86 (288)	3.27 (154)
1981	3.29 (189)	2.47 (147)	1.76 (67)	5.20 (71)	2.10 (208)	3.38 (56)
1982	3.52 (228)	2.41 (192)	2.58 (201)	4.77 (112)	1.83 (243)	2.86 (177)
1983	2.76 (135)	2.11 (143)	1.06 (87)	4.03 (75)	2.31 (455)	2.48 (240)
1984	2.49 (140)	1.85 (78)	1.43 (22)	3.37 (89)	1.15 (264)	2.41 (273)
1985	2.64 (100)	1.62 (71)	0.98 (28)	3.44 (24)	1.46 (290)	3.10 (300)
1986	2.24 (123)	1.31 (43)	1.19 (10)	3.60 (29)	1.20 (301)	2.30 (247)
1987	1.70 (139)	0.78 (41)	2.50 (25)	3.24 (29)	1.02 (181)	1.83 (120)

Table 6a. Population numbers at age ('000) in summer RV surveys of 4X cod.

MID-YEAR RV POPULATION, STRATA 70-95 24/ 4/88

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	27	0	0	23	111	0	0	0	23	0	1822
1	942	345	305	114	411	1019	152	252	190	2728	205
2	1502	7043	1433	2109	969	2812	1256	2151	1060	3448	876
3	2330	3920	3180	1123	4503	1603	2813	4242	1721	1758	2819
4	4104	637	2525	2229	1069	2945	2326	2591	2481	1988	1132
5	1818	1456	714	715	1619	2497	2054	796	1343	1784	1046
6	2404	662	494	272	938	979	835	1272	493	999	1423
7	1043	921	211	159	119	777	405	358	368	451	458
8	513	45	530	51	0	149	234	213	91	309	212
9	172	0	388	184	46	99	62	46	72	60	126
10	94	17	154	45	22	0	63	27	0	61	0
11	13	0	22	25	44	112	13	25	0	82	69
12	0	0	22	6	0	27	0	12	0	0	0
0+	14962	15047	9979	7055	9851	13019	10213	11985	7841	13668	10187
1+	14935	15047	9979	7032	9740	13019	10213	11985	7818	13668	8365
2+	13993	14701	9674	6918	9329	12001	10061	11733	7628	10940	8160
3+	12491	7658	8241	4809	8360	9188	8805	9582	6568	7492	7285
4+	10161	3738	5062	3686	3857	7585	5992	5340	4847	5734	4465
5+	6057	3101	2537	1457	2788	4640	3666	2749	2366	3746	3333
6+	4239	1645	1822	742	1169	2143	1612	1953	1023	1962	2288
7+	1835	983	1328	470	231	1164	777	681	530	963	865
8+	792	62	1117	311	112	387	372	323	163	513	407
9+	279	17	586	260	112	239	138	110	72	203	195
10+	107	17	199	76	66	139	76	64	0	144	69
11+	13	0	44	31	44	139	13	37	0	82	69
12+	0	0	22	6	0	27	0	12	0	0	0

	1981	1982	1983	1984	1985	1986	1987
0	61	73	136	0	70	26	6
1	2215	727	140	820	495	750	381
2	2407	1792	1070	5411	8752	999	2342
3	2271	1770	4122	3541	4204	2621	589
4	2563	1856	2358	2366	1487	1277	1137
5	1343	1526	1468	1937	1518	358	602
6	869	873	919	714	788	629	260
7	478	239	373	503	538	459	226
8	389	246	0	62	294	218	312
9	108	213	76	65	159	97	75
10	92	66	37	26	12	19	41
11	26	31	0	0	0	0	66
12	7	27	0	0	7	0	0
0+	12829	9439	10700	15446	18324	7453	6037
1+	12767	9366	10564	15446	18255	7428	6031
2+	10552	8638	10424	14626	17760	6678	5650
3+	8145	6846	9354	9215	9008	5679	3308
4+	5875	5076	5232	5673	4803	3058	2719
5+	3312	3220	2873	3307	3316	1780	1582
6+	1969	1694	1406	1371	1799	1422	980
7+	1100	821	487	657	1011	794	720
8+	622	582	114	153	473	334	494
9+	233	336	114	91	178	116	182
10+	125	123	37	26	19	19	107
11+	33	57	0	0	7	0	66
12+	7	27	0	0	7	0	0

Table 6b. Standard error ('000) of summer RV population estimates.

RV STANDARD ERROR 13/ 6/88

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	22	0	0	5	82	0	0	0	19	0
2	120	78	51	37	61	71	61	30	56	450
3	675	4448	515	314	151	241	210	235	153	319
4	1175	2497	907	180	727	190	723	441	327	119
5	1952	245	363	343	111	360	673	224	215	214
6	754	449	73	154	178	492	355	116	149	179
7	891	155	62	36	187	166	71	135	43	96
8	355	106	49	32	68	188	39	44	52	129
9	181	10	50	16	0	24	32	87	22	156
10	69	0	135	54	8	34	7	17	5	16
11	52	4	37	15	3	0	5	5	0	33
12	11	0	3	10	8	89	11	5	0	27
13	0	0	3	5	0	4	0	10	0	0

	1980	1981	1982	1983	1984	1985	1986	1987
1	331	49	34	81	0	40	6	6
2	30	1003	166	62	156	48	105	57
3	94	211	194	216	932	863	143	240
4	407	361	156	585	784	458	237	59
5	151	239	134	241	415	158	145	121
6	115	155	157	255	382	163	51	114
7	191	77	121	130	128	118	100	51
8	44	76	17	48	108	125	86	46
9	30	28	20	0	10	94	46	54
10	32	30	44	13	20	34	14	21
11	0	16	29	3	6	11	16	6
12	41	6	4	0	0	0	0	16
13	0	6	6	0	0	6	0	0

Table 7. Mean weight at age (kg) as derived from summer RV surveys. Weights were weighted by stratum area.

RV WEIGHTS AT AGE (KG) 24/ 4/88

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	.12	.09	.11	.10	.11	.13	.08	.16	.11	.09
2	.75	.37	.62	.62	.51	.55	.52	.66	.71	.56
3	1.42	.95	1.44	1.22	1.28	1.16	1.38	1.42	1.62	1.65
4	2.37	1.87	2.22	3.00	2.00	2.29	1.96	2.40	2.65	2.75
5	3.04	2.92	3.75	4.17	4.17	3.01	3.49	3.84	3.73	4.04
6	4.41	3.41	4.82	5.11	5.98	4.73	5.48	5.84	5.59	4.95
7	5.31	5.29	3.96	6.80	7.84	7.00	7.89	7.32	7.41	8.10
8	7.21	6.40	7.85	5.35	.00	7.28	8.79	10.66	10.15	10.07
9	8.40	.00	8.25	8.09	12.50	15.35	9.08	7.61	9.62	7.96
10	11.26	13.00	12.71	7.87	6.30	.00	9.74	11.50	.00	14.15
11	15.00	.00	16.00	3.80	7.54	17.00	14.60	7.60	.00	11.44
12	.00	.00	13.40	18.00	.00	7.50	.00	15.00	.00	.00

	1980	1981	1982	1983	1984	1985	1986	1987
1	.11	.18	.14	.11	.10	.11	.15	.11
2	.55	.60	.51	.60	.56	.56	.53	.44
3	1.44	1.29	1.45	1.31	1.33	1.43	1.62	1.20
4	2.15	2.50	2.41	1.85	2.39	2.50	2.73	3.01
5	3.44	3.39	3.74	3.08	2.77	3.91	3.47	3.90
6	5.05	5.21	5.38	4.51	3.53	4.71	3.77	5.24
7	6.74	7.09	8.44	5.70	4.72	6.26	6.52	8.36
8	8.82	7.15	9.89	.00	11.61	8.87	6.79	7.63
9	11.04	11.60	12.34	9.96	9.60	8.90	11.17	12.13
10	.00	10.34	15.00	7.90	12.20	13.00	6.50	11.96
11	17.28	15.00	8.00	.00	.00	.00	.00	11.76
12	.00	19.00	16.00	.00	.00	15.80	.00	.00

Table 8. Population biomass ('000 t) at age as derived from summer RV surveys.

RV BIOMASS (T) AT AGE, STRATA 70-95 24/ 4/88

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	113	31	34	11	45	132	12	40	21	246
2	1127	2606	888	1307	494	1547	653	1420	752	1931
3	3309	3724	4579	1370	5764	1860	3882	6024	2788	2901
4	9726	1192	5606	6687	2138	6743	4559	6218	6575	5467
5	5527	4251	2679	2982	6751	7516	7168	3057	5008	7206
6	10602	2256	2382	1390	5609	4632	4576	7428	2754	4944
7	5538	4872	837	1080	933	5436	3195	2621	2725	3652
8	3699	290	4163	273	0	1082	2057	2271	922	3113
9	1445	0	3198	1489	575	1524	563	350	690	474
10	1058	222	1960	355	139	0	614	311	0	870
11	195	0	355	95	332	1904	190	190	0	942
12	0	0	297	108	0	205	0	180	0	0
1+	42338	19444	26979	17147	22780	32582	27469	30109	22235	31745
2+	42225	19413	26945	17136	22735	32450	27457	30069	22214	31500
3+	41099	16807	26057	15829	22241	30903	26804	28649	21462	29569
4+	37790	13083	21478	14459	16477	29043	22922	22625	18673	26668
5+	28064	11891	15872	7772	14339	22300	18363	16407	12099	21201
6+	22537	7640	13193	4790	7588	14784	11194	13350	7090	13995
7+	11935	5384	10811	3400	1978	10152	6619	5922	4337	9051
8+	6397	512	9974	2320	1045	4716	3423	3301	1612	5399
9+	2698	222	5811	2047	1045	3633	1366	1031	690	2286
10+	1253	222	2612	558	470	2109	803	681	0	1812
11+	195	0	652	203	332	2109	190	370	0	942
12+	0	0	297	108	0	205	0	180	0	0

	1980	1981	1982	1983	1984	1985	1986	1987
1	23	399	102	15	82	54	112	42
2	482	1444	914	642	3030	4901	530	1030
3	4060	2929	2567	5400	4710	6012	4247	707
4	2434	6406	4473	4363	5655	3717	3486	3422
5	3597	4552	5707	4521	5365	5934	1243	2348
6	7186	4527	4698	4144	2520	3711	2370	1362
7	3084	3389	2016	2127	2376	3369	2995	1889
8	1867	2783	2436	0	722	2611	1481	2381
9	1395	1248	2630	760	628	1417	1084	910
10	0	953	983	295	314	162	124	490
11	1195	397	245	0	0	0	0	776
12	0	130	425	0	0	105	0	0
1+	25321	29157	27195	22267	25401	31993	17672	15358
2+	25299	28759	27093	22252	25319	31939	17559	15316
3+	24817	27314	26179	21610	22289	27038	17030	14286
4+	20757	24385	23612	16210	17579	21025	12783	13579
5+	18323	17979	19139	11847	11925	17308	9297	10156
6+	14726	13427	13432	7326	6559	11374	8054	7809
7+	7540	8900	8734	3182	4039	7664	5684	6446
8+	4457	5511	6718	1055	1663	4295	2689	4557
9+	2589	2728	4283	1055	941	1684	1208	2176
10+	1195	1480	1653	295	314	267	124	1267
11+	1195	527	670	0	0	105	0	776
12+	0	130	425	0	0	105	0	0

Table 9. Input data used in the construction of the 1987 catch-at-age matrix. A) Quarterly 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				
1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	Foreign
1980	2663	2498	718	1817	2413	2631	1542	254	373	858	483	222	152	12	53	29

(B)

Gear	Jan-Mar	Apr-June	July-Sept	Oct-Dec
OT	7	6	3	1
LL	5	10	5	3
GN	0	1	1	0

(C)

Jan-Mar	Apr-June	July-Sept	Oct-Dec
.0081/3.0503	.0084/3.041	.0071/3.0822	.0063/3.1152

Table 10. Catch numbers-at-age by gear category in 1987.

Age	Numbers-at-age ('000) by gear				
	OT	LL	GN	Misc.	Foreign
1	0	0	0	0	0
2	876	163	0	14	3
3	415	352	4	13	2
4	1004	938	154	44	4
5	460	393	134	29	2
6	131	189	140	13	0
7	170	194	101	13	1
8	52	138	34	7	0
9	23	78	8	3	0
10	10	44	1	2	0
11	0	30	0	1	0
12	0	7	0	0	0
13	1	6	0	0	0
14	1	3	0	0	0
15	0	3	0	0	0
16	0	2	0	0	0

Table 11. Total catch numbers at age.

TOTAL NUMBERS AT AGE (THOUSANDS) 25/ 4/88

	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	2625	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
1	0	2	0	0	0	0	0	4	39	0	0	0
2	410	1609	285	326	885	886	982	766	804	888	147	1057
3	1693	3063	1803	1294	4773	4063	2549	3896	2381	1594	3129	785
4	2476	1683	2274	3405	1952	4424	4476	2112	3243	1488	2204	2143
5	1401	1606	1991	2632	2476	1684	3332	2376	1845	2458	906	1017
6	467	775	2188	1217	1288	1017	873	1148	923	1159	985	473
7	190	272	636	703	426	535	398	620	444	491	343	479
8	122	257	199	218	242	299	301	251	159	174	164	230
9	74	101	55	99	86	165	140	136	54	66	82	112
10	18	81	49	79	51	65	99	71	50	44	37	56
11	7	36	9	23	12	27	52	52	31	26	15	31
12	2	39	16	13	16	18	27	9	22	8	15	8
13	4	10	6	3	4	20	18	18	6	8	9	7
14	1	25	2	7	1	6	0	5	2	2	0	4
15	2	2	1	0	1	2	4	0	4	1	2	3
16	0	12	1	7	3	6	0	2	15	4	0	2

Table 12. Percent catch numbers at age.

PERCENT NUMBERS AT AGE 25/ 4/88

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

Table 13. Mean weight at age (kg) in catch.

MEAN WEIGHT (KG) IN CATCH 25/ 4/8

	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	12.90	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	13.71	13.71	16.85
15	13.49	10.81	9.99	11.67	15.38	16.15	12.44	12.34	15.38	11.22	11.21	15.38	15.38	15.38
16	16.45	16.45	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	16.45

	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	12.90	8.43	17.38	14.74	16.35	12.90	14.33	17.49	16.78	15.31	12.66
14	16.92	13.66	13.71	13.71	13.71	16.78	15.72	16.78	16.03	15.02	17.93	16.80	11.82	16.62
15	16.92	11.17	15.25	15.25	15.32	15.61	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
1	.46	.48	.46	.46	.46	.46	.46	.36	.38	.37	.38	.46
2	.60	1.04	.84	.83	.71	.75	.81	.85	.95	.82	.80	.91
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
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
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
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
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
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
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	12.01	9.44	9.22	11.24	9.81	11.21	9.07	11.42	11.69	9.86	9.20	11.90
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	12.47	15.41	7.23	12.00	14.11	12.41	14.16	15.10	14.15	14.52	14.38	15.53
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
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
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
16	15.59	16.01	16.92	16.57	17.37	16.69	16.76	15.98	17.01	14.62	16.45	21.03

Table 14. Catch weight at age (t).

CATCH BIOMASS (T) 25/ 4/88

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
2	22	562	543	209	661	119	246	42	66	0	105	0	0	3	1
3	870	1884	2166	2981	1698	1218	618	1368	763	133	926	170	0	228	604
4	2275	3154	5349	3001	5293	1741	3373	1292	4563	430	1747	2275	338	646	2354
5	3320	2626	3798	3674	2958	4799	2461	3732	1901	3301	1544	2976	2202	5141	4288
6	1909	3211	2461	1914	1809	1739	4452	2304	2546	685	3347	2388	2814	3729	3548
7	1185	290	2503	2332	1961	1253	1689	3209	2875	1848	477	1902	1614	1830	2682
8	2042	647	332	1367	945	503	888	1025	2620	1426	999	2207	2088	575	1710
9	2330	1107	308	489	1170	741	748	413	765	2252	1170	736	1767	752	611
10	1760	1225	796	212	155	1220	679	305	219	1667	839	0	1270	473	438
11	896	431	138	727	126	499	682	334	630	0	236	275	798	242	50
12	529	181	664	495	200	105	205	300	542	580	56	79	90	145	0
13	534	350	33	177	329	0	277	156	355	934	88	0	500	0	147
14	1091	73	13	207	99	123	260	35	64	571	0	0	0	0	56
15	350	251	308	76	0	0	164	0	0	0	76	0	0	0	56
16	0	0	23	0	0	0	24	63	0	0	3	0	0	0	0

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	21	7	9	9	352	176	336	248	240	60	525	246
3	272	90	1337	1998	1634	1599	3215	1839	1128	3420	2342	2383	1911	2020
4	2480	976	4237	7465	10165	3992	3744	2801	1748	6211	5336	3233	6329	5310
5	3360	6301	6983	8152	8838	13705	7362	4701	3616	4665	6055	4746	3222	4207
6	3263	8161	7719	5783	4263	8652	8123	4748	4109	3942	2448	5130	4161	2066
7	4295	3264	3455	4463	2521	2497	3276	2636	2794	816	1446	1474	2417	1153
8	1960	4590	1557	1930	2511	1306	1735	532	2733	830	568	1374	788	1041
9	1577	3492	882	305	1085	1953	1296	1107	1501	867	1519	996	545	804
10	310	734	433	508	343	572	1844	415	1613	424	768	969	469	212
11	469	345	334	213	427	445	375	221	433	72	537	1102	344	111
12	318	950	63	267	138	412	113	452	913	32	155	605	190	21
13	170	122	115	43	39	84	127	0	1242	21	126	143	104	55
14	90	0	19	0	9	98	84	0	0	78	140	153	0	24
15	49	0	0	0	0	53	160	0	683	0	252	338	0	30
16	0	176	0	54	89	169	367	0	114	282	0	262	20	0

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	1	0	0	0	0	0	1	15	0	0	0
2	1678	240	271	628	668	800	649	766	732	117	966
3	3873	2835	1647	6745	5063	3392	5181	3568	2242	4042	1148
4	3122	4352	6929	4231	8785	8276	3912	6498	2934	4180	4638
5	3764	4764	8190	7375	4723	9472	6210	5037	6184	2380	3227
6	3316	7752	5047	6114	3665	3603	4832	3528	4091	3895	1840
7	1566	2653	3756	2855	3016	2173	3463	2403	2435	1722	2658
8	1989	1225	1585	1678	2165	2131	2021	1211	1199	1225	1817
9	919	339	856	828	1385	1170	1397	508	531	784	1018
10	760	455	892	505	726	895	811	585	432	344	669
11	392	58	248	143	333	555	599	406	318	179	403
12	607	115	160	224	223	381	129	316	122	221	118
13	159	40	50	47	302	251	284	91	94	138	106
14	415	26	89	7	87	5	86	28	18	5	70
15	37	15	0	11	36	60	0	59	18	43	78
16	186	22	120	44	104	0	39	259	56	0	38

Table 15. Percent catch biomass at age.

PERCENT AT AGE 26/ 4/88

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
1	.00	.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	.00
3	.05	.12	.11	.17	.10	.09	.04	.09	.04	.01	.08	.01	.00	.02	.04	.01	.00	.05
4	.12	.20	.28	.17	.30	.12	.20	.09	.25	.03	.15	.17	.03	.05	.14	.13	.03	.16
5	.17	.16	.20	.21	.17	.34	.15	.26	.11	.24	.13	.23	.16	.37	.26	.18	.22	.26
6	.10	.20	.13	.11	.10	.12	.27	.16	.14	.05	.29	.18	.21	.27	.21	.18	.28	.28
7	.06	.02	.13	.13	.11	.09	.10	.22	.16	.13	.04	.15	.12	.13	.16	.23	.11	.13
8	.11	.04	.02	.08	.05	.04	.05	.07	.15	.10	.09	.17	.15	.04	.10	.11	.16	.06
9	.12	.07	.02	.03	.07	.05	.04	.03	.04	.16	.10	.06	.13	.05	.04	.08	.12	.03
10	.09	.08	.04	.01	.01	.09	.04	.02	.01	.12	.07	.00	.09	.03	.03	.02	.03	.02
11	.05	.03	.01	.04	.01	.04	.04	.02	.04	.00	.02	.02	.06	.02	.00	.03	.01	.01
12	.03	.01	.03	.03	.01	.01	.01	.02	.03	.04	.00	.01	.01	.01	.00	.02	.03	.00
13	.03	.02	.00	.01	.02	.00	.02	.01	.02	.07	.01	.00	.04	.00	.01	.01	.00	.00
14	.06	.00	.00	.01	.01	.01	.02	.00	.00	.04	.00	.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	.00
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.00

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.01	.01	.01	.01	.01	.00	.02	.01	.07	.01	.01	.02	.02	.02	.02
3	.06	.05	.04	.10	.09	.05	.16	.11	.10	.09	.12	.17	.11	.06	.21	.16	.10	.17
4	.24	.32	.11	.12	.14	.08	.28	.24	.14	.30	.31	.14	.17	.23	.13	.28	.25	.13
5	.26	.28	.39	.23	.24	.16	.21	.28	.21	.15	.24	.17	.19	.27	.23	.15	.29	.21
6	.19	.13	.24	.25	.24	.18	.18	.11	.22	.20	.12	.15	.31	.17	.19	.12	.11	.16
7	.14	.08	.07	.10	.13	.12	.04	.07	.06	.11	.07	.07	.11	.13	.09	.10	.07	.12
8	.06	.08	.04	.05	.03	.12	.04	.03	.06	.04	.06	.09	.05	.05	.05	.07	.06	.07
9	.01	.03	.05	.04	.06	.07	.04	.07	.04	.03	.05	.04	.01	.03	.03	.04	.04	.05
10	.02	.01	.02	.06	.02	.07	.02	.04	.04	.02	.01	.03	.02	.03	.02	.02	.03	.03
11	.01	.01	.01	.01	.01	.02	.00	.02	.05	.02	.01	.02	.00	.01	.00	.01	.02	.02
12	.01	.00	.01	.00	.02	.04	.00	.01	.03	.01	.00	.03	.00	.01	.01	.01	.01	.00
13	.00	.00	.00	.00	.00	.05	.00	.01	.01	.00	.00	.01	.00	.00	.00	.01	.01	.01
14	.00	.00	.00	.00	.00	.00	.00	.01	.01	.00	.00	.02	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.03	.00	.01	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.01	.00	.00	.01	.00	.01	.00	.00	.01	.00	.00	.00	.00	.00	.00

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

Table 16. Population numbers ('000) derived from cohort analysis with F_T = 0.56.

POPULATION NUMBERS

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
1	17960	24804	12692	16150	8830	18518	9121	14153	16523	18227
2	13482	14704	20307	10391	13222	7229	15161	7467	11583	13528
3	9207	11006	11596	16030	8240	10135	5810	12178	6065	9389
4	9702	6809	7676	7732	10748	5602	7520	4321	8813	4402
5	7388	6480	4280	3823	4614	6151	3931	4325	2939	5049
6	1801	4586	4464	2200	1395	2701	3763	2396	2423	1745
7	1103	863	2917	2956	1349	638	1804	2130	1491	1455
8	1001	659	646	1725	1996	778	321	1153	1216	763
9	1071	490	444	493	1162	1481	570	138	772	571
10	624	548	266	318	329	722	1054	350	60	527
11	181	271	302	135	237	243	393	740	255	14
12	244	55	175	235	14	174	132	240	551	139
13	145	154	31	83	129	0	128	77	167	381
1+	63910	71410	65797	61771	52265	54373	49710	49668	52860	56189
2+	45950	46606	53105	45621	43435	35854	40589	35515	36337	37962
3+	32468	31902	32798	35230	30213	28625	25428	28047	24753	24434
4+	23261	20896	21202	19200	21973	18490	19617	15869	18688	15045

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	16036	24062	29095	18828	22692	33665	42777	20777	16370	16167
2	14923	13129	19700	23821	15415	18578	27563	35023	17011	13403
3	11076	12073	10749	16129	19493	12619	15211	22566	28645	13914
4	7495	8316	9590	8801	12366	15243	9973	12357	17121	21725
5	3275	5000	5012	7602	6835	8754	10696	7486	7786	9762
6	2829	2151	2532	3229	4469	3122	5742	5948	3502	3323
7	1217	1588	772	1345	1829	2589	1577	2393	2884	1281
8	446	920	923	386	811	1033	1281	520	1326	1359
9	365	377	383	452	228	450	573	354	180	762
10	159	164	230	137	298	113	168	121	219	108
11	171	45	134	92	75	195	57	67	63	121
12	11	119	14	64	58	55	122	22	34	27
13	28	0	83	0	44	48	16	25	12	7
1+	58231	67945	79217	80885	85213	96465	115754	107660	95153	81959
2+	42195	43883	50123	62057	62521	62800	72977	86883	78782	65792
3+	27272	30754	30422	38236	47107	44222	45414	51861	61772	52389
4+	16196	18681	19673	22107	27614	31603	30204	29294	33127	38475

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	14268	20691	19662	15354	20701	24288	20526	25488	24620	17400
2	13237	11682	16940	16098	12571	16949	19885	16805	20868	20157
3	10958	10827	9152	13624	12680	9368	13577	16189	13066	16714
4	9943	7443	6551	6279	9976	8168	6481	9132	11647	9165
5	12067	5811	4242	4099	4208	5390	4487	3417	4803	7459
6	4653	4316	2697	2057	2158	1723	2647	2032	1873	2664
7	1571	1499	1712	1322	723	904	799	1108	1049	1111
8	615	871	689	1008	674	443	473	413	577	687
9	761	331	536	494	474	442	295	198	259	362
10	495	401	144	244	255	261	217	137	110	144
11	55	352	121	71	57	148	152	80	81	74
12	57	9	266	83	29	42	75	36	42	60
13	13	19	0	194	4	22	21	26	17	33
1+	68694	64251	62712	60928	64510	68747	69636	75060	79210	76031
2+	54426	43560	43050	45573	43809	44460	49110	49572	54590	58631
3+	41189	31878	26110	29475	31237	27511	29225	32767	33722	38474
4+	30231	21051	16958	15851	18557	17543	15647	16578	20656	21760

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	32590	29469	21312	27334	13458	13929	18006	5145	23637	18816
2	14244	26683	24127	17449	22380	11019	11401	14707	4212	19352
3	15047	11404	21551	18952	13484	17434	8328	8607	11238	3316
4	10913	10688	8166	13025	11841	8734	10749	4665	5604	6370
5	5981	6877	5670	4920	6907	5644	5239	5866	2473	2594
6	4654	3095	3249	2402	2504	2640	2471	2621	2579	1205
7	1480	1831	1433	1495	1046	1260	1122	1188	1096	1220
8	664	636	863	788	740	496	471	518	528	587
9	330	363	324	487	375	334	179	241	266	284
10	205	221	208	187	249	181	150	98	138	143
11	45	123	109	124	94	115	84	78	40	79
12	27	29	80	78	77	30	47	41	40	19
13	13	8	12	51	48	38	17	18	26	19
1+	86194	91428	87103	87593	73203	61853	58265	43792	51878	54005
2+	53604	61959	65791	60258	59745	47925	40259	38647	28242	35190
3+	39360	35276	41664	42809	37365	36906	28858	23940	24030	15838
4+	24313	23872	20113	23857	23881	19472	20529	15333	12792	12522

Table 17. Fishing mortality matrix derived from cohort analysis with F_T = 0.56.

FISHING MORTALITY 9/ 5/88

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.003	.037	.037	.032	.066	.018	.019	.008	.010	.000	.012
3	.102	.160	.205	.200	.186	.098	.096	.123	.120	.025	.087
4	.204	.264	.637	.316	.358	.154	.353	.185	.357	.096	.205
5	.281	.173	.465	.668	.335	.291	.295	.380	.321	.379	.220
6	.536	.248	.212	.289	.582	.204	.369	.275	.310	.160	.377
7	.316	.089	.325	.192	.350	.486	.248	.360	.469	.611	.079
8	.514	.194	.071	.195	.099	.111	.647	.201	.556	.539	.338
9	.470	.412	.135	.202	.276	.140	.289	.626	.182	1.080	.602
10	.633	.397	.477	.095	.106	.408	.153	.115	1.286	.926	1.062
11	.988	.238	.049	2.056	.105	.407	.295	.095	.411	.001	.164
12	.258	.374	.547	.403	5.361	.108	.343	.158	.170	1.394	5.866
13	.484	.244	.238	.235	.274	.225	.310	.260	.365	.497	.319
6+	.492	.247	.243	.253	.298	.232	.315	.265	.376	.548	.345

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.000	.000	.001	.000	.000	.000	.001	.001	.001	.001	.044
3	.030	.000	.018	.046	.035	.008	.076	.077	.136	.187	.302
4	.306	.032	.053	.193	.154	.087	.262	.362	.388	.337	.362
5	.481	.240	.331	.583	.222	.387	.560	.651	.541	.828	.567
6	.824	.432	.369	.346	.483	.675	.524	.806	.549	.933	.725
7	.343	.495	.305	.371	.504	.909	.391	.553	.534	.390	.578
8	.677	.514	.327	.389	.389	1.096	.860	.354	.380	.420	.284
9	.294	.831	.216	.499	.788	1.352	.279	.314	.231	.441	.630
10	.000	.722	.405	.227	.481	.717	.463	.396	.464	.140	.999
11	.934	.541	.248	.101	.266	.738	.479	.628	.546	1.597	.082
12	.160	5.725	.162	.000	1.068	1.384	.405	1.454	.554	.921	5.402
13	.548	.501	.334	.350	.489	.800	.492	.606	.471	.658	.608
6+	.580	.519	.335	.351	.494	.820	.498	.623	.477	.701	.634

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.018	.039	.032	.022	.006	.052	.022	.092	.022	.014	.041	.058
3	.177	.112	.240	.230	.197	.112	.155	.226	.142	.134	.281	.270
4	.269	.200	.416	.399	.440	.443	.263	.227	.262	.434	.307	.457
5	.524	.442	.693	.511	.592	.401	.389	.272	.459	.550	.659	.475
6	.513	.846	.670	.568	.671	.461	.322	.388	.733	.570	.576	.631
7	.329	.474	.290	.448	.460	.452	.223	.315	.644	.553	.398	.503
8	.133	.554	.222	.206	.671	.268	.265	.532	.402	.477	.372	.543
9	.587	.460	.399	.508	.568	.391	.382	.369	.203	.358	.350	.471
10	.504	1.264	.341	.341	.806	.329	.196	.957	.309	.506	.320	.483
11	.171	.692	.089	.483	1.245	.446	.099	.791	.241	.234	.131	.278
12	.115	2.964	.085	.483	.865	.569	.045	1.299	1.031	.701	.248	.293
13	.390	.669	.458	.468	.647	.429	.279	.413	.635	.533	.469	.549
6+	.402	.710	.478	.475	.657	.431	.281	.423	.648	.535	.475	.552

	1982	1983	1984	1985	1986	1987
1	.000	.000	.002	.000	.000	.001
2	.050	.080	.081	.069	.039	.062
3	.234	.284	.380	.229	.368	.301
4	.541	.311	.406	.435	.570	.459
5	.762	.626	.493	.622	.519	.560
6	.487	.655	.532	.671	.548	.560
7	.546	.785	.574	.610	.425	.560
8	.597	.818	.468	.465	.420	.560
9	.530	.599	.408	.357	.419	.560
10	.576	.570	.460	.685	.355	.560
11	.945	.689	.518	.454	.531	.560
12	.490	.378	.743	.258	.547	.560
13	.529	.693	.529	.606	.489	.560
6+	.531	.696	.531	.611	.492	.560

Table 18. Population biomass (t) at beginning of year as derived from cohort analysis.

POPULATION BIOMASS AT BEGINNING OF YEAR 9/ 5/86

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
1	5276	7286	4403	6046	3254	5853	2951	5046	14066	6462
2	5876	10725	12541	5947	8703	4900	10038	4487	8068	8175
3	6953	9825	13111	15502	8032	11230	6555	12255	5930	5915
4	9636	10503	11091	10256	15398	10063	11556	6837	12581	5295
5	11329	12919	10318	6726	9151	15274	10030	9701	6624	10548
6	4102	12224	13387	6987	3982	8370	14302	8295	8788	4817
7	4076	3019	10140	11771	6150	2732	7699	10287	7480	5322
8	4889	3424	3867	7088	10520	4739	1932	5816	6743	4054
9	6322	3157	2717	3468	5547	7193	3582	932	4598	3466
10	3714	3811	2136	2227	1832	3661	4854	2501	380	3251
11	1368	2014	2695	1043	1633	1437	2542	3892	2160	76
12	2464	555	1590	2023	146	1076	839	2018	3409	978
13	1600	1702	247	875	1166	1	973	584	1421	2625
1+	67605	81162	88242	79957	75613	76530	77853	72649	82247	60982

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6219	10809	11270	10481	13504	13084	16362	8150	7290	6993
2	8243	6262	10895	9168	5549	10241	15437	19129	8183	6638
3	10388	7069	7668	12151	9632	5535	11362	17552	23526	9939
4	7015	9399	7669	11254	12853	14933	9426	14610	20379	28185
5	5778	7741	8101	13727	10759	13675	17090	13238	15524	19034
6	8733	5166	6219	9920	12602	6790	14999	15895	9865	9463
7	4966	6921	2778	6015	8509	9651	5358	9507	10857	5334
8	2764	5095	4919	2280	5214	6027	6741	2437	6842	6934
9	2275	2678	2673	3473	1520	3225	4405	2911	1137	4895
10	1219	1575	2304	1391	2598	876	1373	1193	2062	874
11	1307	448	1828	1148	700	1859	576	784	580	1029
12	62	842	127	1039	727	476	1398	244	436	281
13	247	0	757	0	640	517	191	305	108	91
1+	59216	64004	67206	82047	84807	86889	104719	105953	106791	99690

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	5087	7410	7685	6197	7833	8968	8364	9692	10019	5366
2	7953	6988	9285	8545	7117	9834	10455	9468	10986	14004
3	7762	10723	9422	10220	11699	9317	12072	13865	11817	14543
4	12507	9793	10401	9574	13212	14306	9058	13934	19228	13835
5	22846	13012	9943	9590	8579	13501	10748	7550	12177	16724
6	13255	12941	10679	7011	7252	5133	9757	8136	6996	9549
7	6710	6473	8466	7238	3164	4069	3575	5969	6399	5608
8	3688	6057	4227	6590	4378	2722	2682	2906	4346	4713
9	5456	2635	3627	3898	3120	3564	2392	1556	2548	3194
10	4273	3205	1244	1767	1941	2169	2004	1478	1165	1461
11	569	4244	1228	741	734	1208	1710	865	1194	838
12	634	113	4273	1067	415	560	950	442	537	945
13	179	275	0	3062	53	349	272	361	235	458
1+	90920	83870	80482	75500	69497	75700	74037	76221	87647	91037

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	11801	10167	7968	9913	4695	4766	3984	1327	5955	4809
2	9063	16569	13824	10308	13745	6899	6678	8233	2289	11408
3	19265	11815	23382	17818	13508	18150	9383	9366	11599	3582
4	16978	19116	13562	22321	17973	13712	17546	8020	9153	10652
5	12602	16786	13961	12130	16409	12407	11783	13171	5629	6361
6	13412	9751	12490	7870	8519	9130	7611	8134	8136	3854
7	6254	7964	7561	7738	4640	6051	5360	5173	4613	5719
8	3952	3502	5246	5497	4680	3290	3069	3161	3217	3694
9	2287	2654	2698	3709	2922	2846	1555	1895	2154	2349
10	1876	1840	1917	1934	2171	1768	1645	937	1193	1525
11	358	1221	1258	1358	1029	1176	1030	935	437	867
12	241	259	978	950	1012	380	603	567	539	264
13	138	88	140	750	630	582	248	242	382	272
1+	98227	101732	104986	102297	91933	81155	70695	61761	55297	55155

Table 19. Yield per recruit analysis for 4X cod. (TOP) 1987 weights-at-age; (BOTTOM) Mean of 1985-87 weights-at age.

AGE	WEIGHT-AT-AGE	PARTIAL RECRUITMENT
1	.463	.001
2	.914	.111
3	1.462	.537
4	2.164	.821
5	3.171	1.000
6	3.893	1.000
7	5.552	1.000
8	7.889	1.000
9	9.129	1.000
10	11.902	1.000
11	12.946	1.000
12	15.526	1.000
13	14.102	1.000
14	16.667	1.000
15	22.202	1.000
16	21.031	1.000

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	.1000	.202	1.006	4.972	1.345
F0.1---	.1582	.272	1.183	4.356	1.000
	.2000	.309	1.236	3.996	.826
FMAX---	.2660	.356	1.259	3.539	.633
	.3000	.375	1.255	3.348	.559
	.4000	.419	1.221	2.912	.408
	.5000	.452	1.179	2.609	.315
	.6000	.477	1.141	2.390	.254
	.7000	.497	1.108	2.227	.212
	.8000	.514	1.080	2.100	.180
	.9000	.528	1.056	2.000	.157
	1.0000	.540	1.036	1.918	.139
	1.1000	.551	1.019	1.850	.124
	1.2000	.560	1.003	1.792	.112
	1.3000	.568	.990	1.742	.102
	1.4000	.576	.978	1.699	.093
	1.5000	.583	.967	1.660	.086

AGE	WEIGHT-AT-AGE	PARTIAL RECRUITMENT
1	.404	.001
2	.846	.111
3	1.387	.537
4	2.011	.821
5	2.771	1.000
6	3.792	1.000
7	5.176	1.000
8	7.416	1.000
9	8.910	1.000
10	10.322	1.000
11	12.420	1.000
12	14.808	1.000
13	13.827	1.000
14	14.046	1.000
15	19.578	1.000
16	17.368	1.000

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	.1000	.202	.932	4.610	1.349
F0.1---	.1592	.273	1.100	4.035	1.000
	.2000	.309	1.149	3.712	.831
FMAX---	.2661	.356	1.170	3.288	.636
	.3000	.375	1.166	3.111	.563
	.4000	.419	1.134	2.704	.410
	.5000	.452	1.095	2.421	.317
	.6000	.477	1.058	2.217	.255
	.7000	.497	1.027	2.065	.212
	.8000	.514	1.001	1.948	.181
	.9000	.528	.980	1.855	.158
	1.0000	.540	.962	1.780	.139
	1.1000	.551	.946	1.718	.124
	1.2000	.560	.933	1.666	.112
	1.3000	.568	.921	1.621	.103
	1.4000	.576	.911	1.582	.094
	1.5000	.583	.901	1.547	.087

Table 20. Catch projections for 4X cod. (TOP) - Assuming F = $F_{0.1}$ = 0.20 in 1989. (BOTTOM) Assuming F = 0.32 (50% rule) in 1989.

POPULATION NUMBERS

	1987	1988	1989
2	19352	17285	17285
3	3316	14890	13490
4	6370	2009	9666
5	2594	3294	1154
6	1205	1213	1751
7	1220	564	645
8	587	571	300
9	284	275	303
10	143	133	146
11	79	67	71
12	19	37	36
13	19	9	20
2+	35190	40347	44867
3+	15838	23062	27582
4+	12522	8172	14092
5+	6152	6163	4426

FISHING MORTALITY

	1987	1988	1989
2	.062	.048	.022
3	.301	.232	.107
4	.459	.354	.164
5	.560	.432	.200
6	.560	.432	.200
7	.560	.432	.200
8	.560	.432	.200
9	.560	.432	.200
10	.560	.432	.200
11	.560	.432	.200
12	.560	.432	.200
13	.560	.432	.200
2+	.244	.190	.096

CATCH BIOMASS

	1987	1988	1989
2	894	620	291
3	1089	3892	1731
4	4309	1099	2673
5	2820	2923	527
6	1793	1473	1095
7	2478	934	550
8	1708	1355	366
9	994	783	446
10	580	439	248
11	387	266	145
12	113	176	87
13	104	40	45
2+	17267	14000	8205
3+	16373	13380	7914
4+	15285	9488	6183
5+	10976	8389	3509

POPULATION NUMBERS

	1987	1988	1989
2	19352	17285	17285
3	3316	14890	13490
4	6370	2009	9666
5	2594	3294	1154
6	1205	1213	1751
7	1220	564	645
8	587	571	300
9	284	275	303
10	143	133	146
11	79	67	71
12	19	37	36
13	19	9	20
2+	35190	40347	44867
3+	15838	23062	27582
4+	12522	8172	14092
5+	6152	6163	4426

FISHING MORTALITY

	1987	1988	1989
2	.062	.048	.035
3	.301	.232	.172
4	.459	.354	.262
5	.560	.432	.320
6	.560	.432	.320
7	.560	.432	.320
8	.560	.432	.320
9	.560	.432	.320
10	.560	.432	.320
11	.560	.432	.320
12	.560	.432	.320
13	.560	.432	.320
2+	.244	.190	.153

CATCH BIOMASS 11.

	1987	1988	1989
2	894	620	462
3	1089	3892	2687
4	4309	1099	4085
5	2820	2923	798
6	1793	1473	1657
7	2478	934	833
8	1708	1355	554
9	994	783	675
10	580	439	376
11	387	266	219
12	113	176	132
13	104	40	68
2+	17267	14000	12547
3+	16373	13380	12085
4+	15285	9488	9398
5+	10976	8389	5312

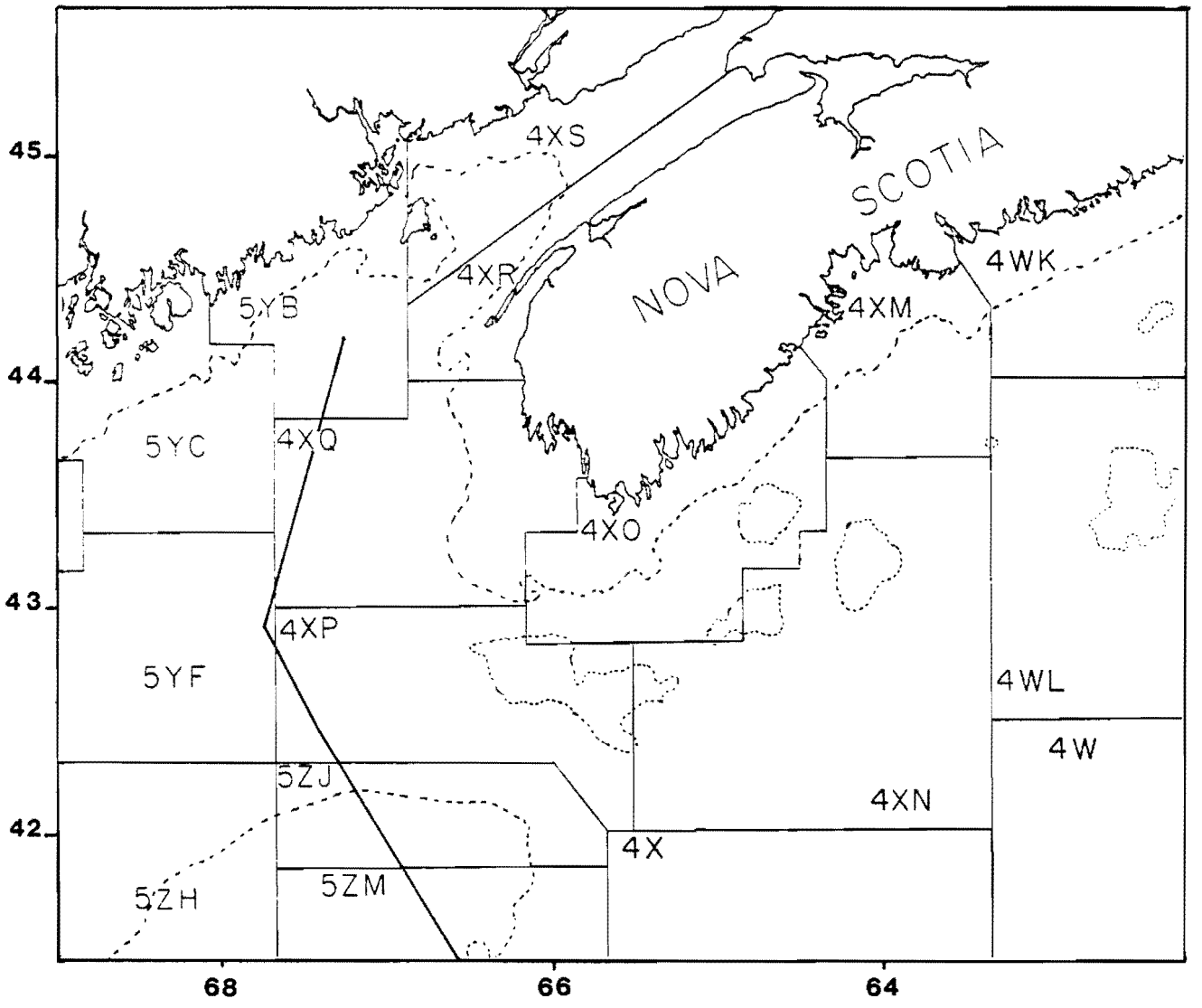


Figure 1. Unit areas in NAFO Division 4X in reference to the ICJ Canada-US boundary.

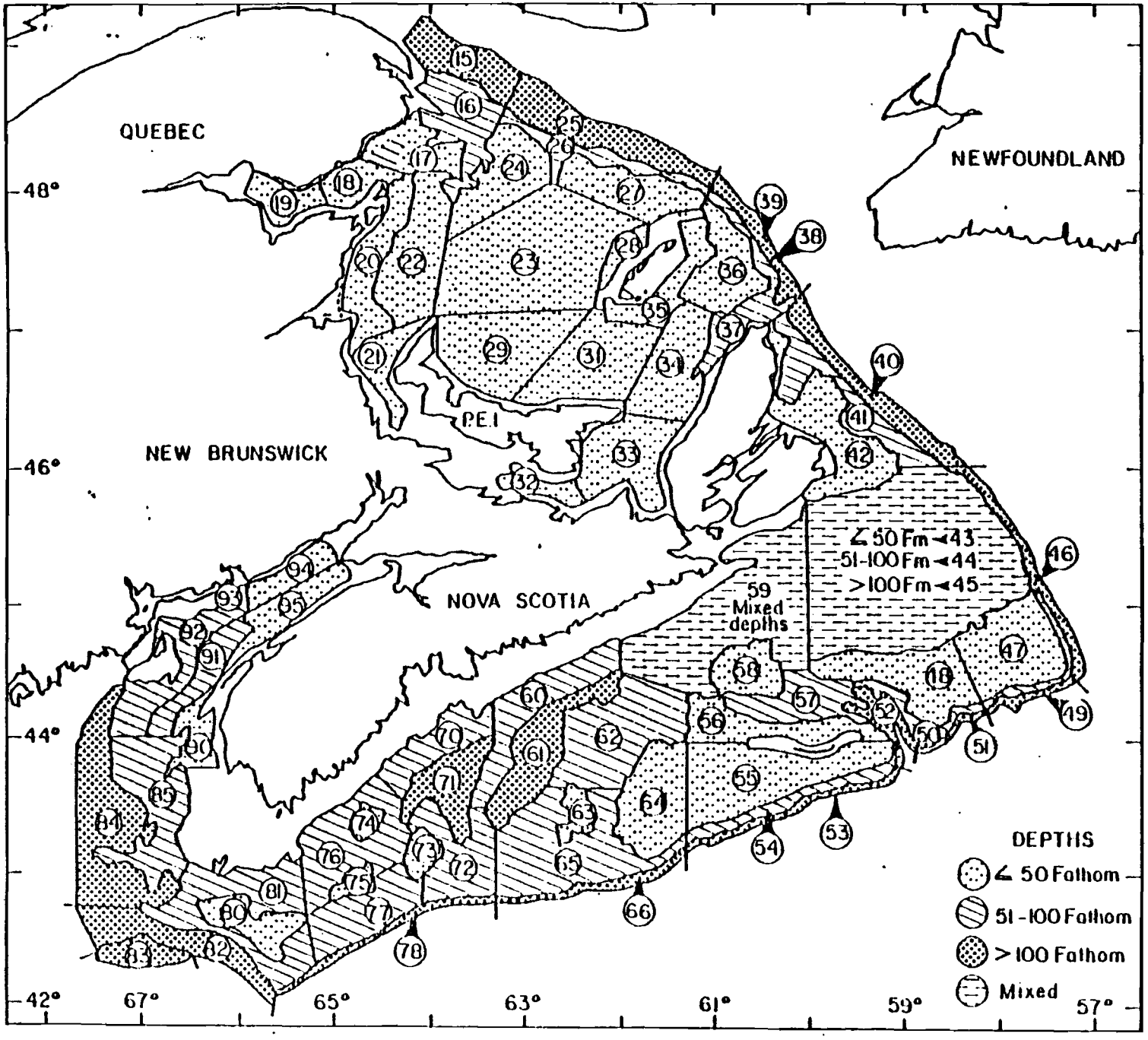


Figure 2. Stratification scheme used for the research groundfish surveys.

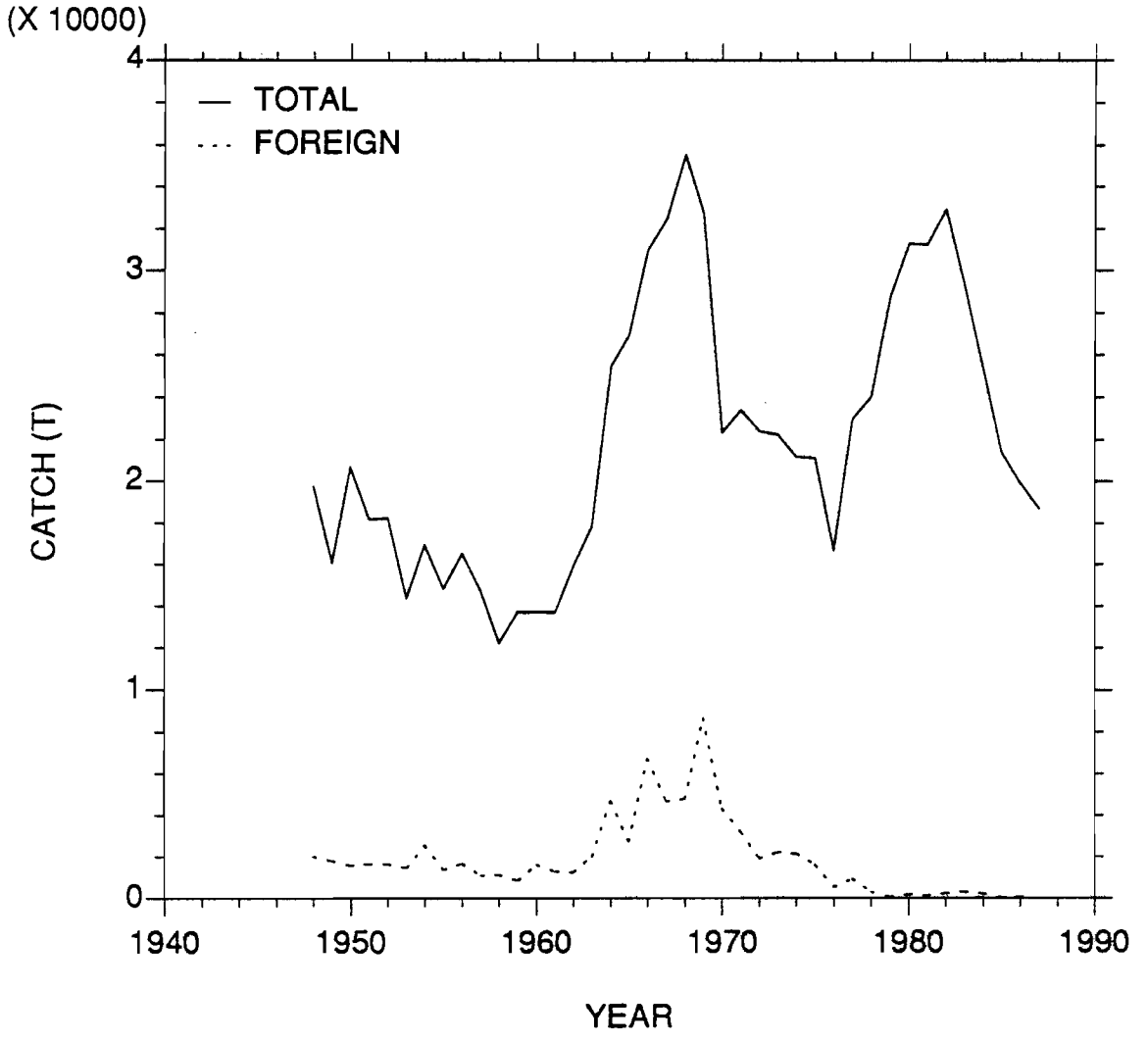


Figure 3. Nominal catch (t) of 4X cod between 1948-87.

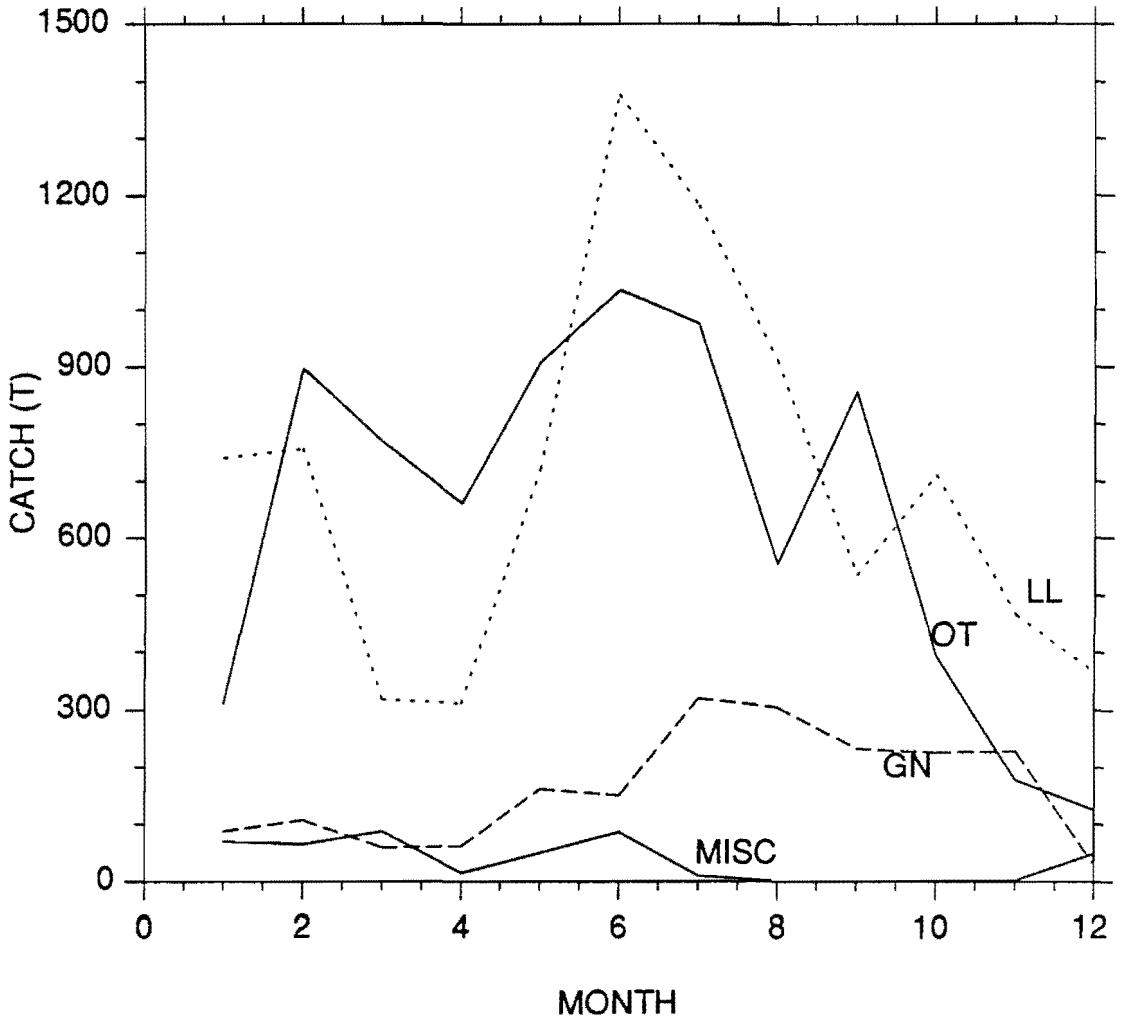


Figure 4. Monthly pattern in Canadian landings (t) of 4X cod in 1987. Landings have been segregated by major gear type.

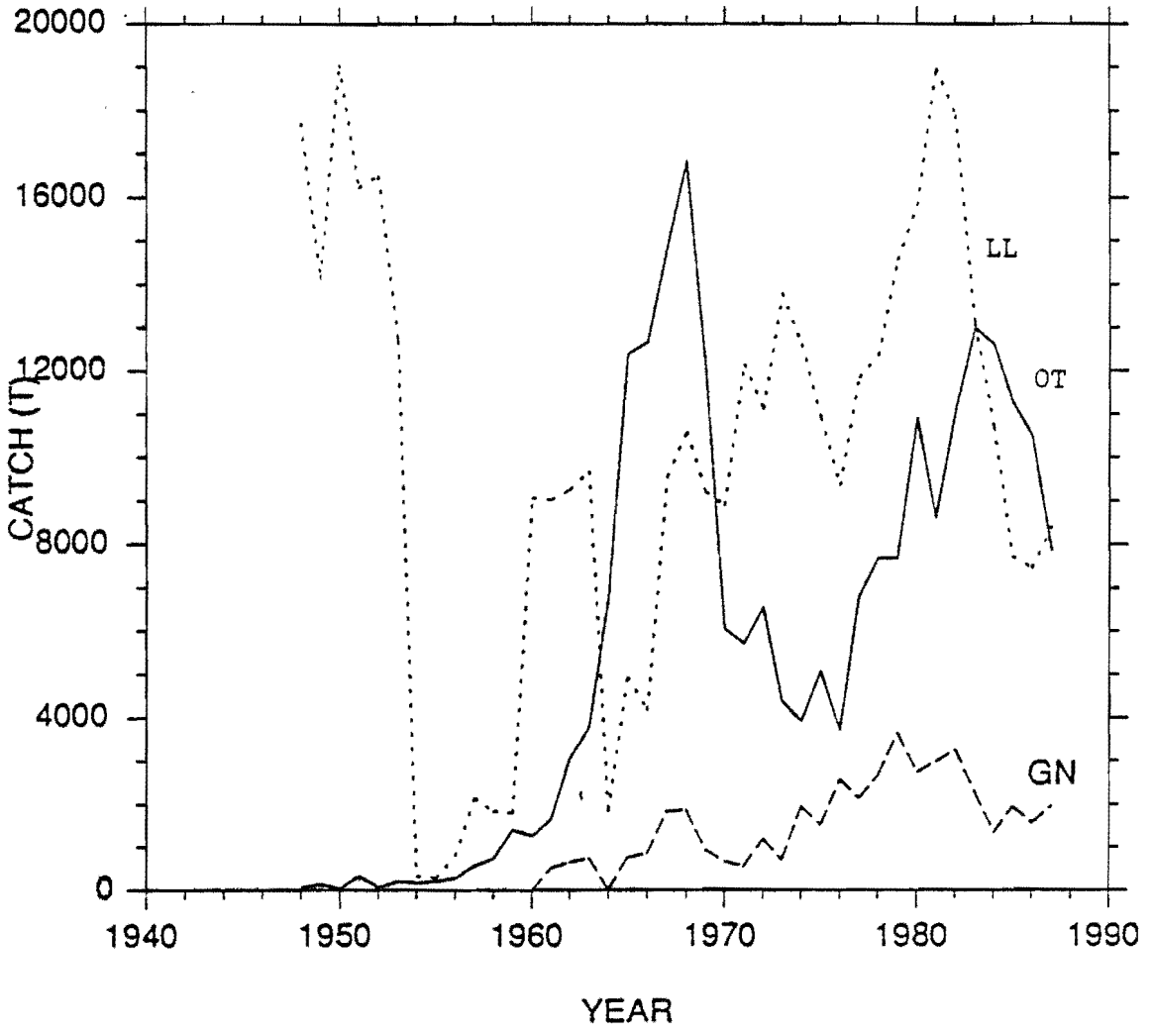


Figure 5. Canadian nominal catch (t) segregated by major gear type between 1948-87. Landings were classified by different gear types prior to 1955.

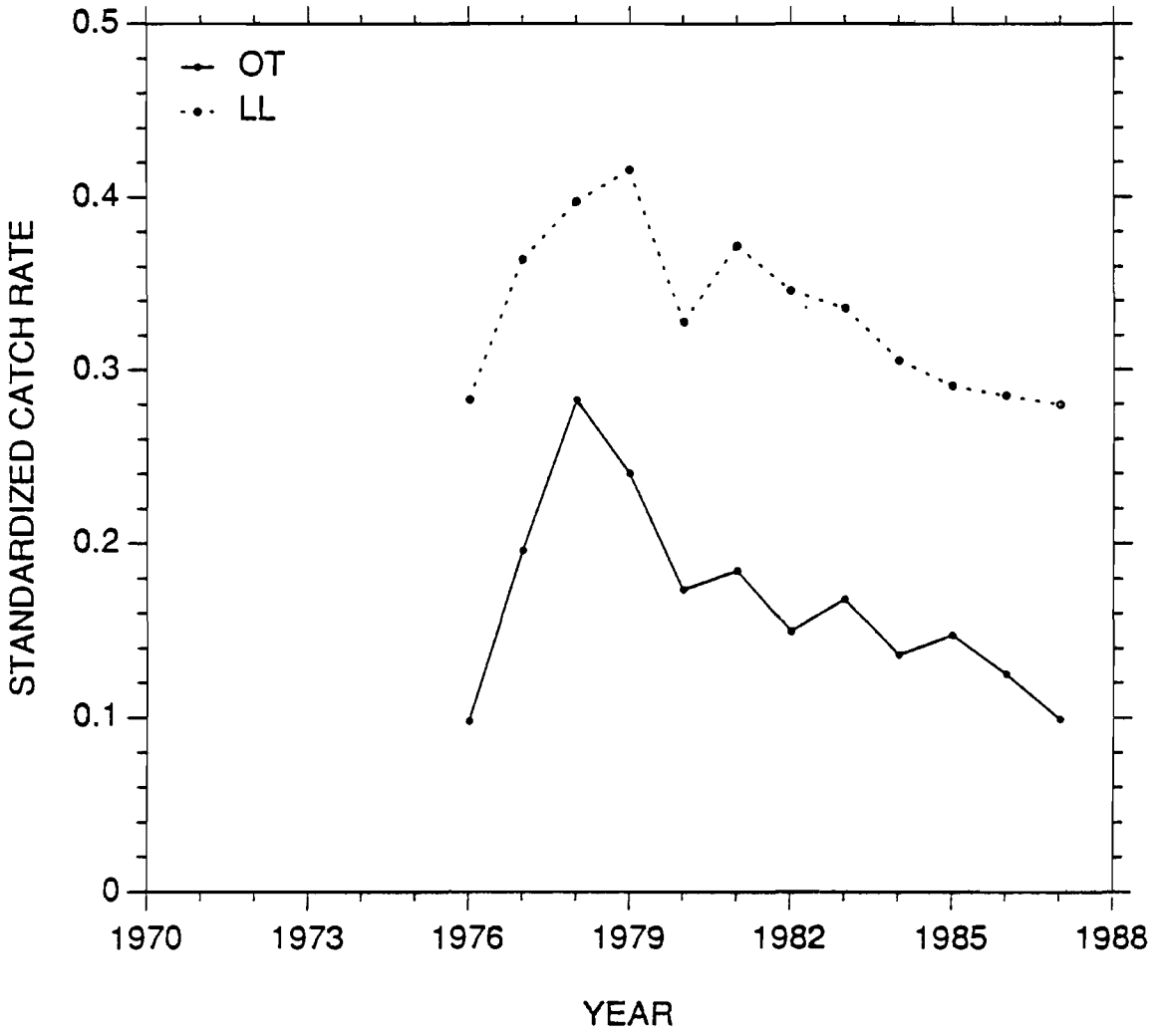


Figure 6. Standardized commercial catch rates by otter trawlers (OT-TC 2 and 3) and longliners (LL-TC 2 and 3).

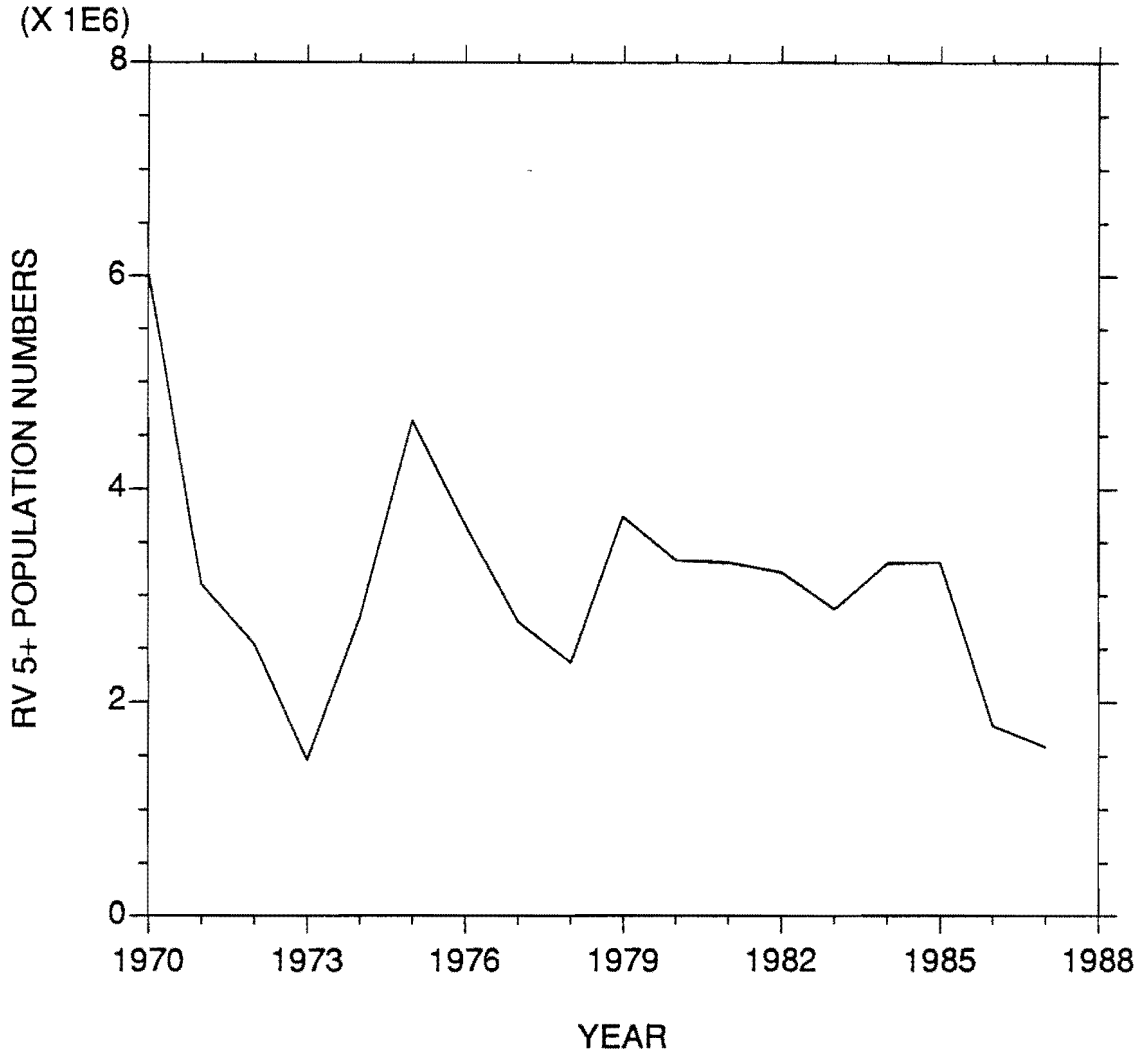


Figure 7. Trends in abundance of fully-recruited 4X cod (age 5+) as determined from summer RV surveys.

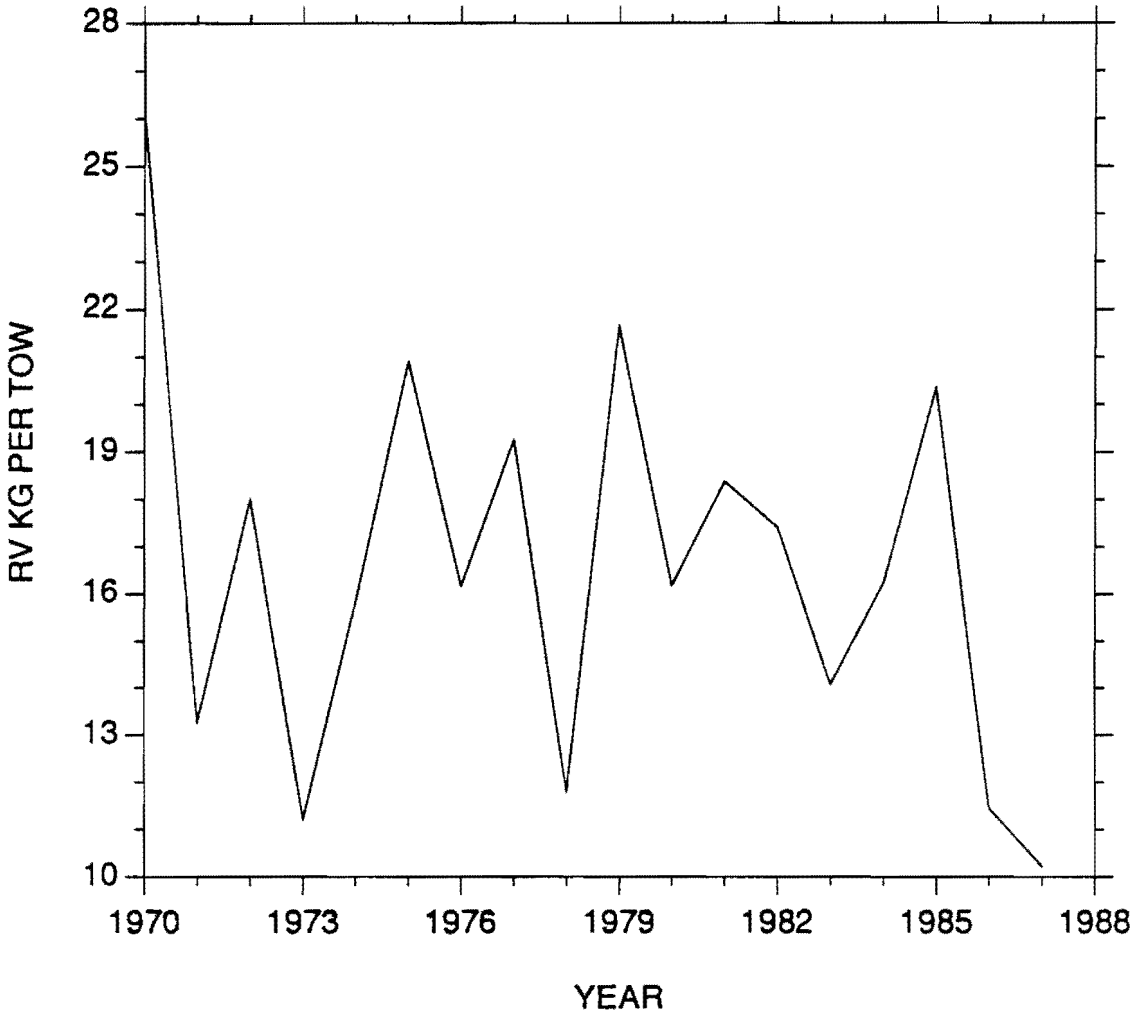


Figure 8. Trends in population biomass as determined from summer RV surveys.

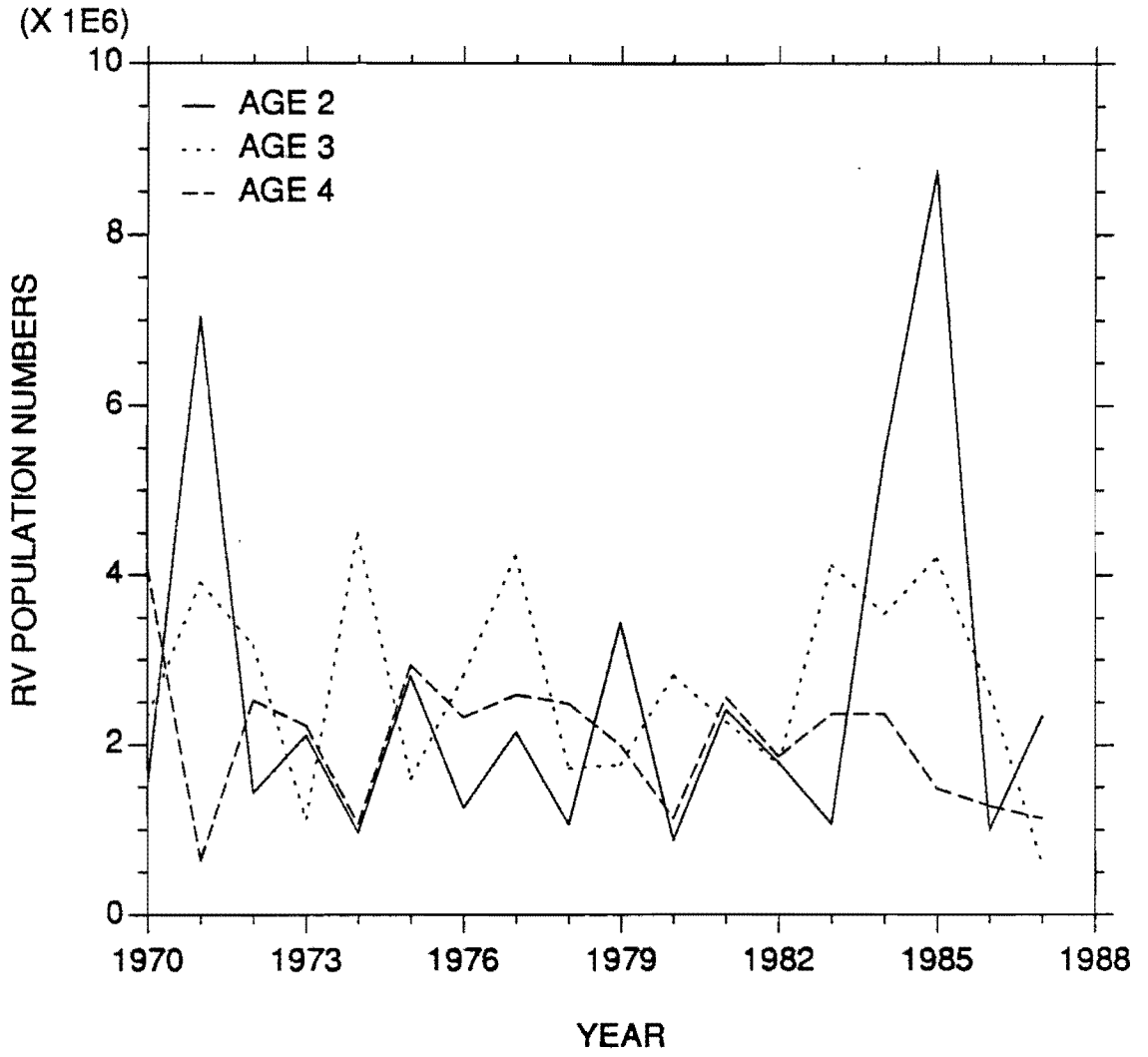


Figure 9. Trends in abundance of partially-recruited 4X cod as determined from summer RV surveys.

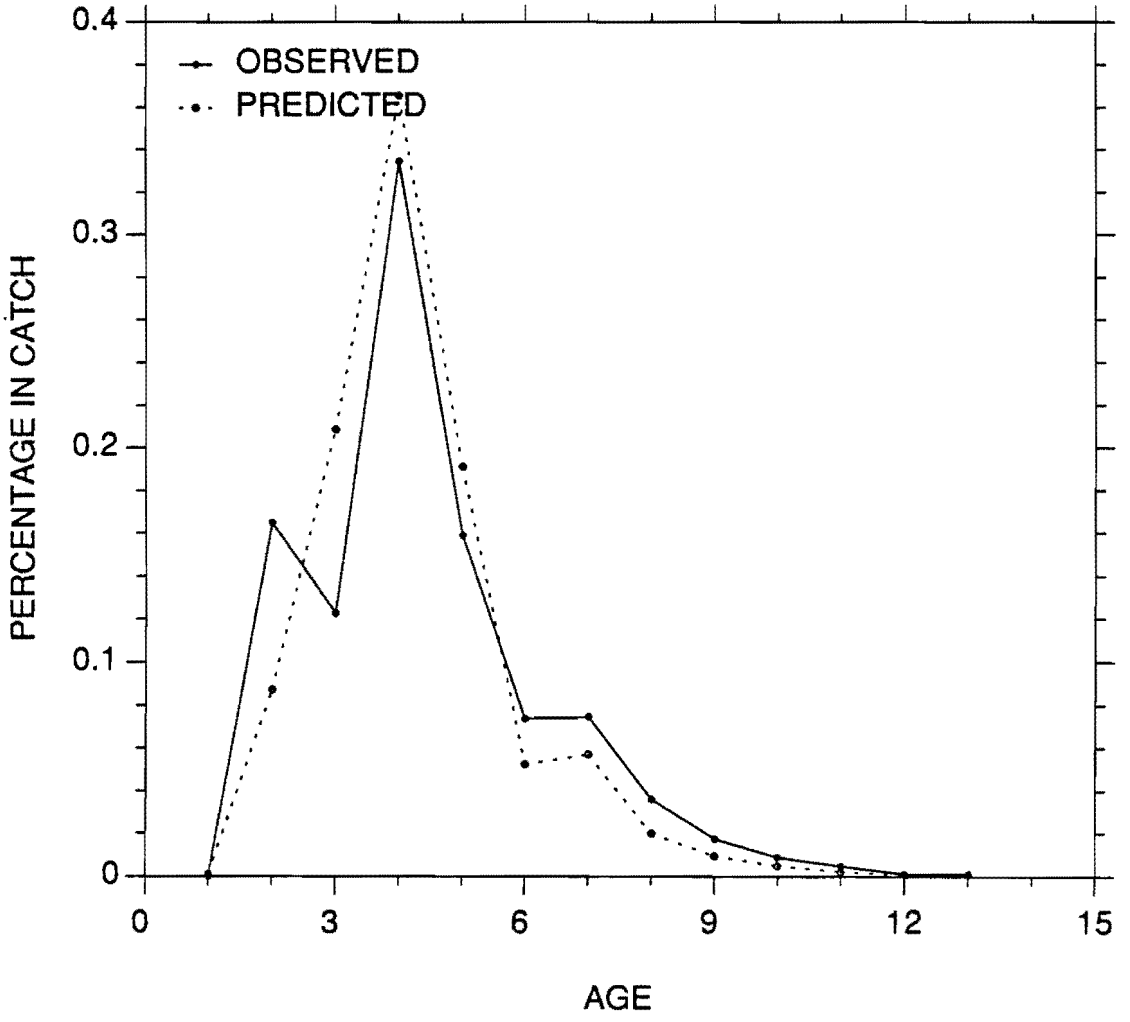
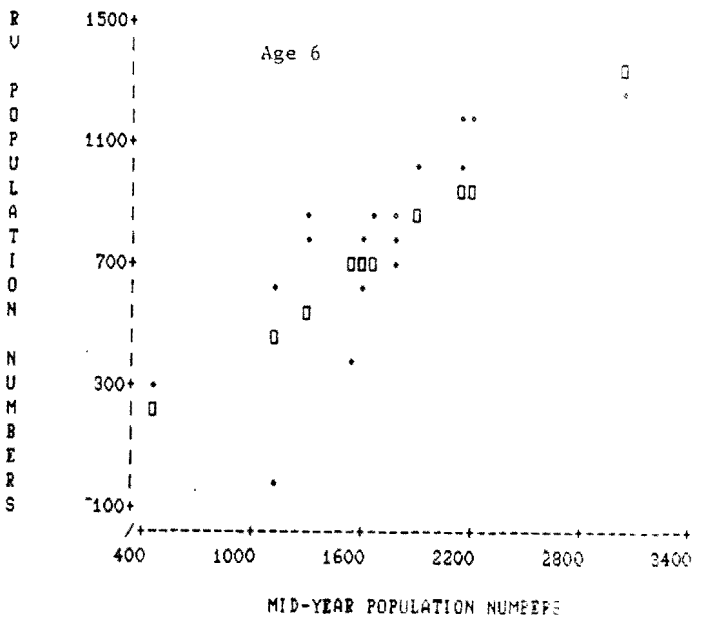


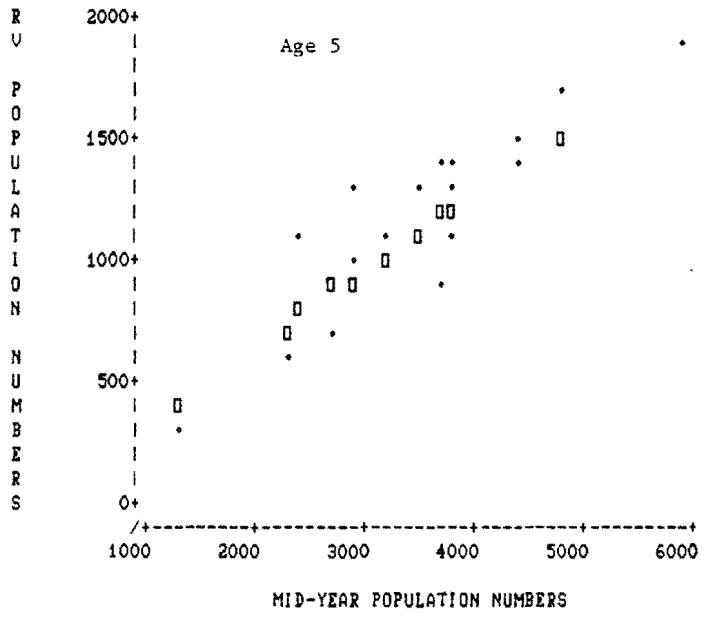
Figure 10. Observed age composition in the 1987 catch compared to that projected in the 1986 assessment.

```
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN 0.00001
     6 3*corr
 1.000  .036  .011 -.222 -.033 -.044
  .036 1.000  .023 -.257 -.150 -.073
  .011  .023 1.000 -.091 -.114 -.313
 -.222 -.257 -.091 1.000  .054  .053
 -.033 -.150 -.114  .054 1.000  .046
 -.044 -.073 -.313  .053  .046 1.000
     PAR*SE
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET.....        0.002346
MEAN SQUARE RESIDUALS .....      5.277803

    PAR. EST.          STD. ERR.          T-STATISTIC
    ---------          ---------          -----------
    1.62549E0003       6.88399E0002        2.36126E0000
    2.53759E0002       1.74625E0002        1.45316E0000
    3.95711E0002       1.99047E0002        1.98803E0000
    3.22069E-001       2.67045E-002        1.20605E0001
    4.33576E-001       3.46479E-002        1.25138E0001
    3.86525E-001       3.26302E-002        1.18456E0001
```





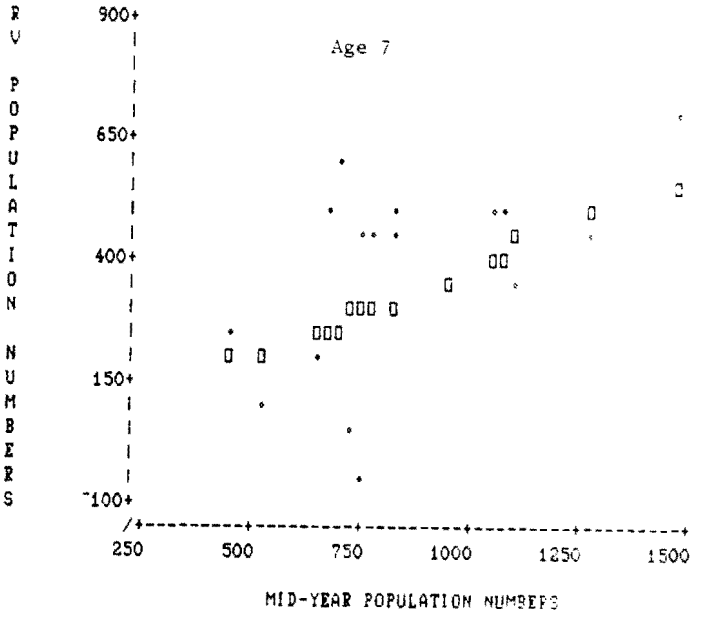


Figure 11. Parameter estimates, correlation table, and weighted calibration plots resulting from NLLS calibration of SPA. The parameters (in order) are: N_6, N_7, and N_8 in 1988, and the 3 slopes relating ages 5, 6, and 7 SPA abundance to RV abundance.

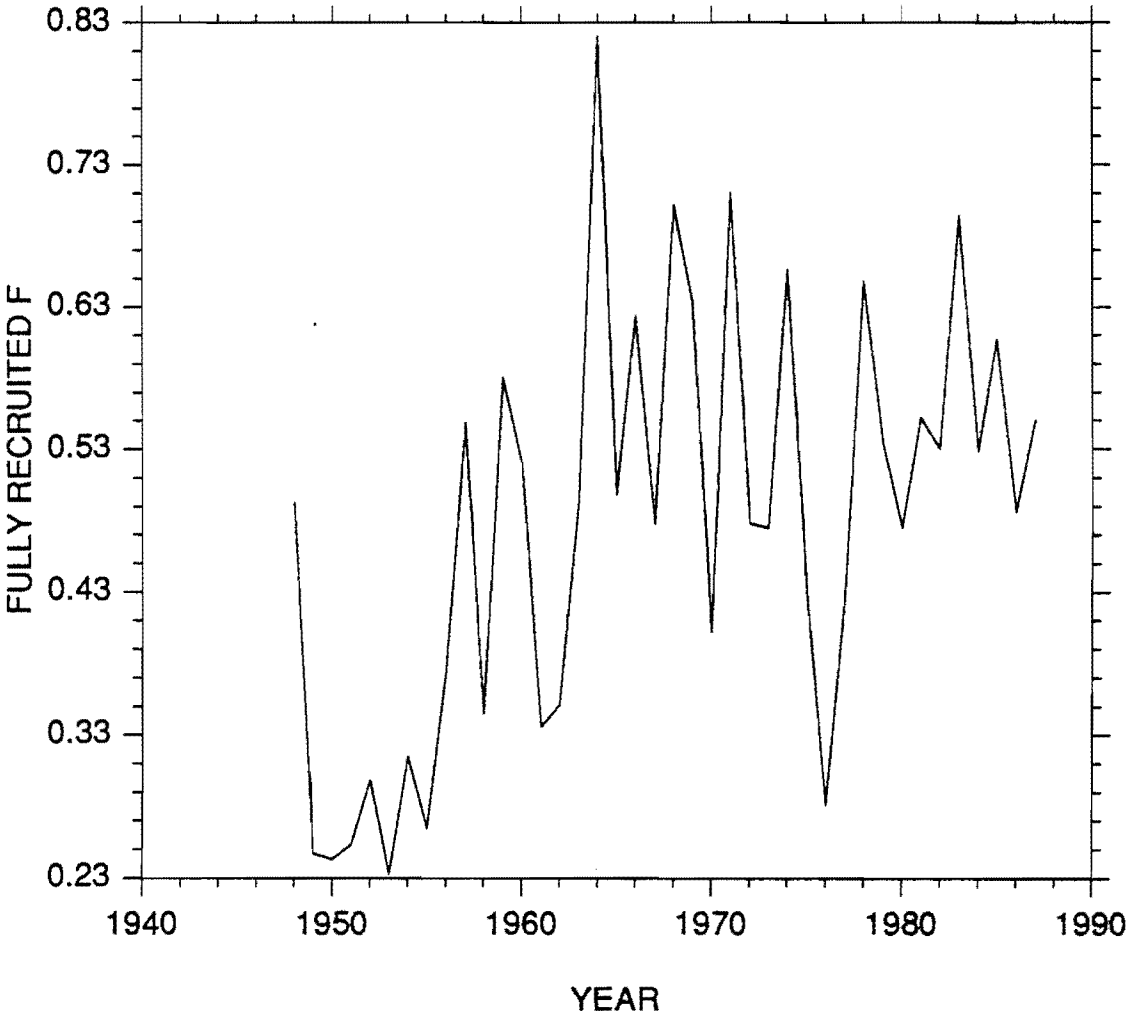


Figure 12. Time series of fully-recruited fishing mortality (age 6+).

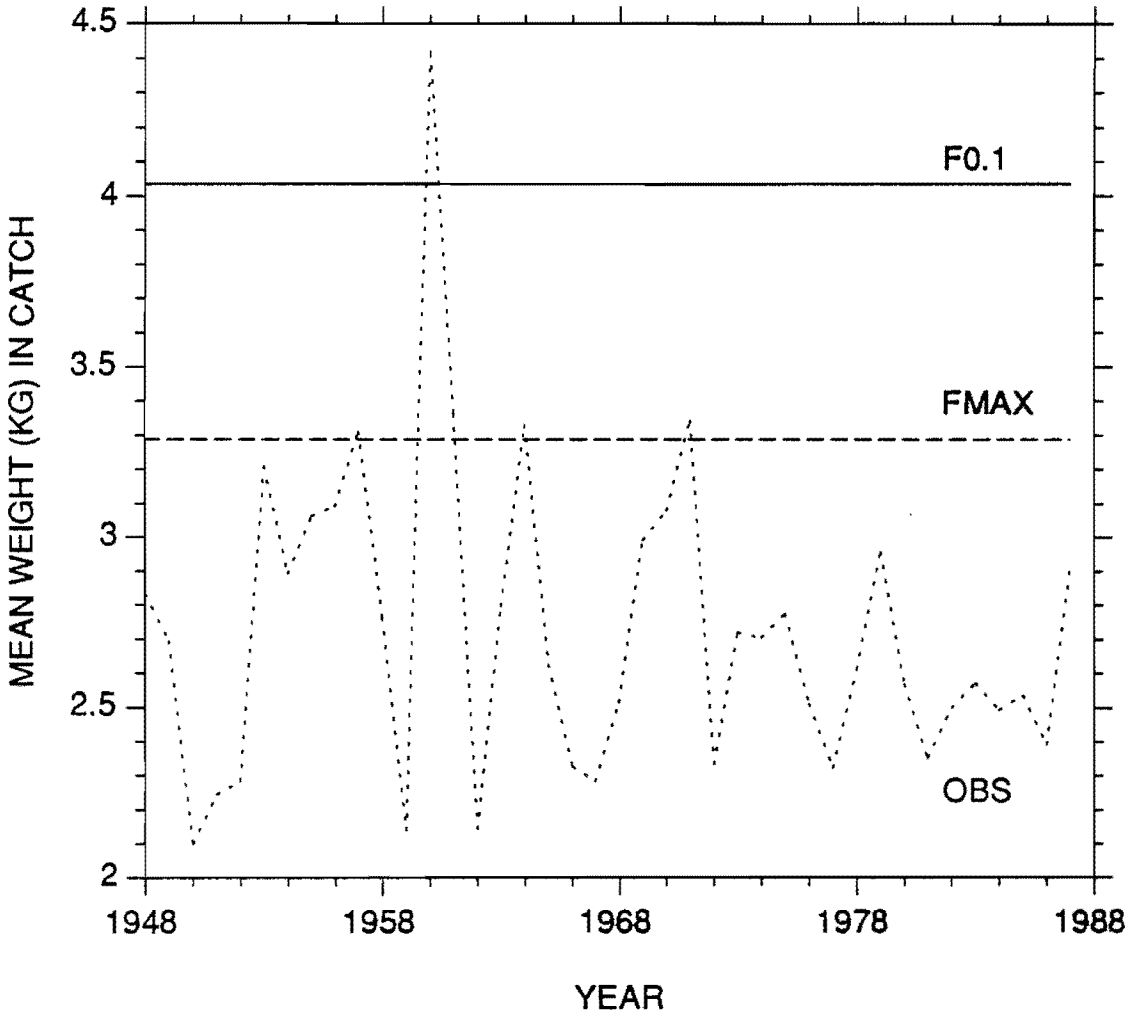


Figure 13. Observed mean weight in catch (kg) compared with that expected of fishing at $F_{0.1}$ or F_{max}.

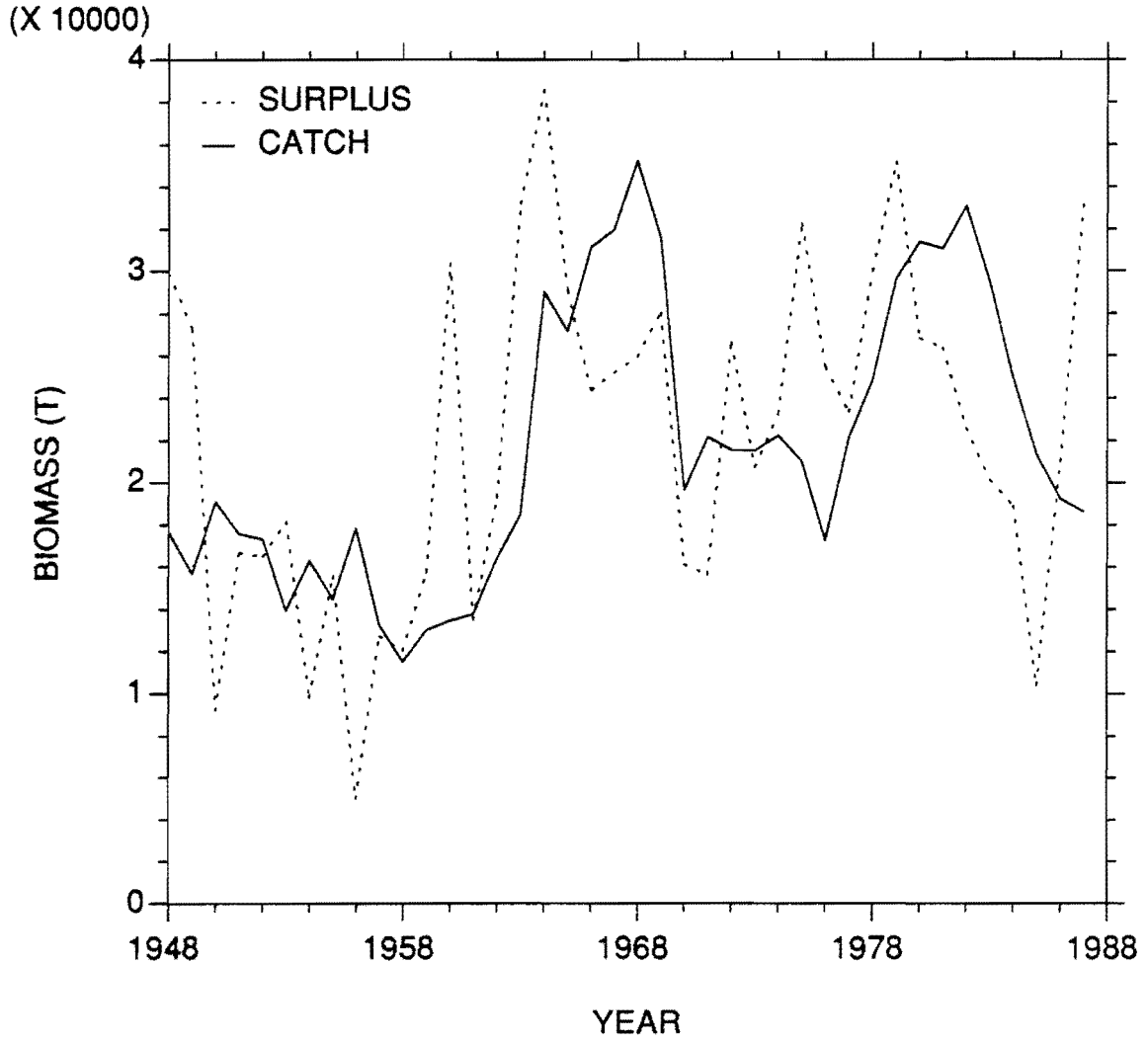


Figure 14. Time series of surplus production and loss through fishing (catch) for 4X cod. The distance between the two lines represents net population production.

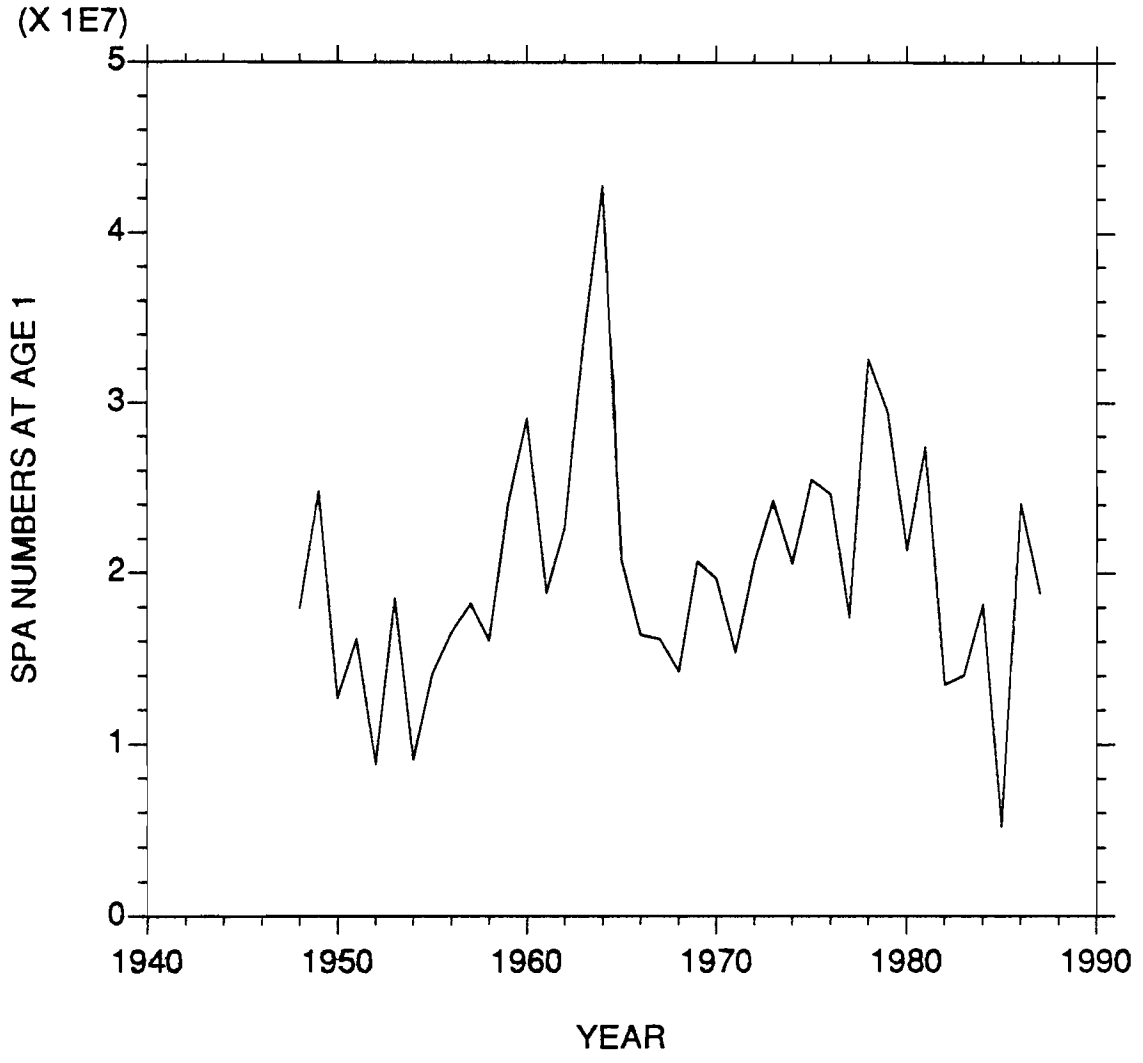


Figure 15. Time series of recruitment determined from cohort analysis.

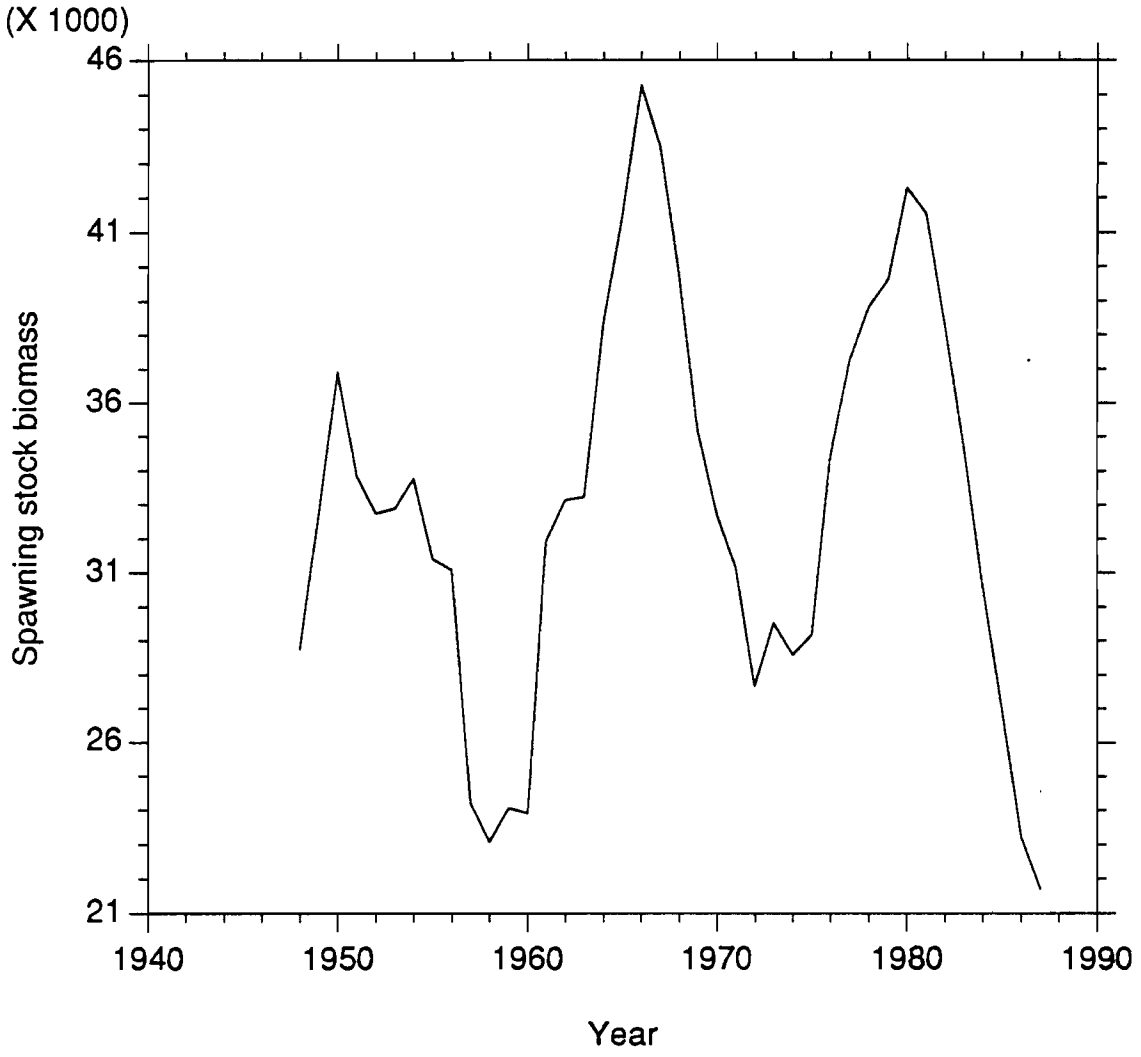


Figure 16. Time series of spawning stock biomass (t).

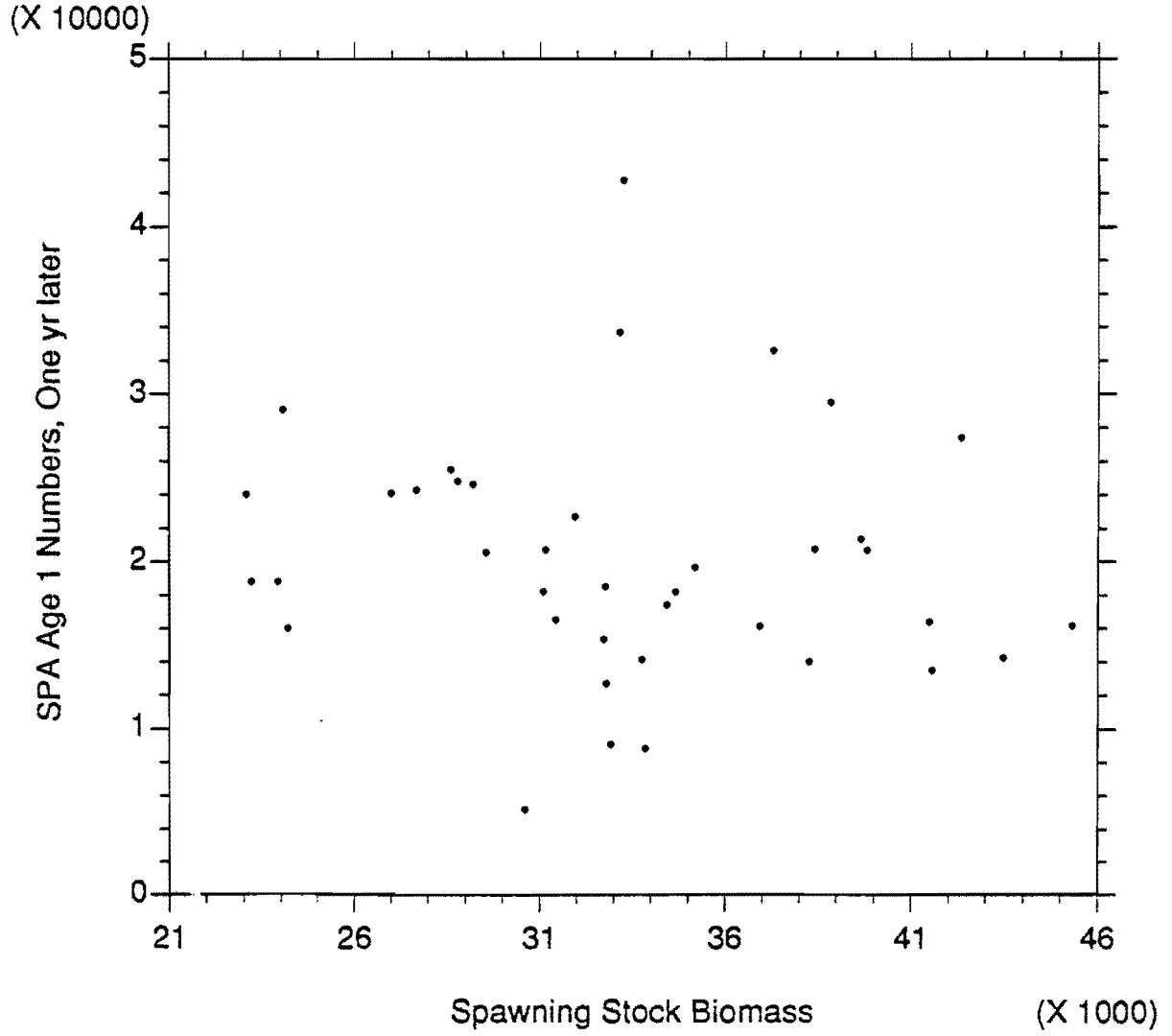


Figure 17. Stock-recruitment relationship for 4X cod.

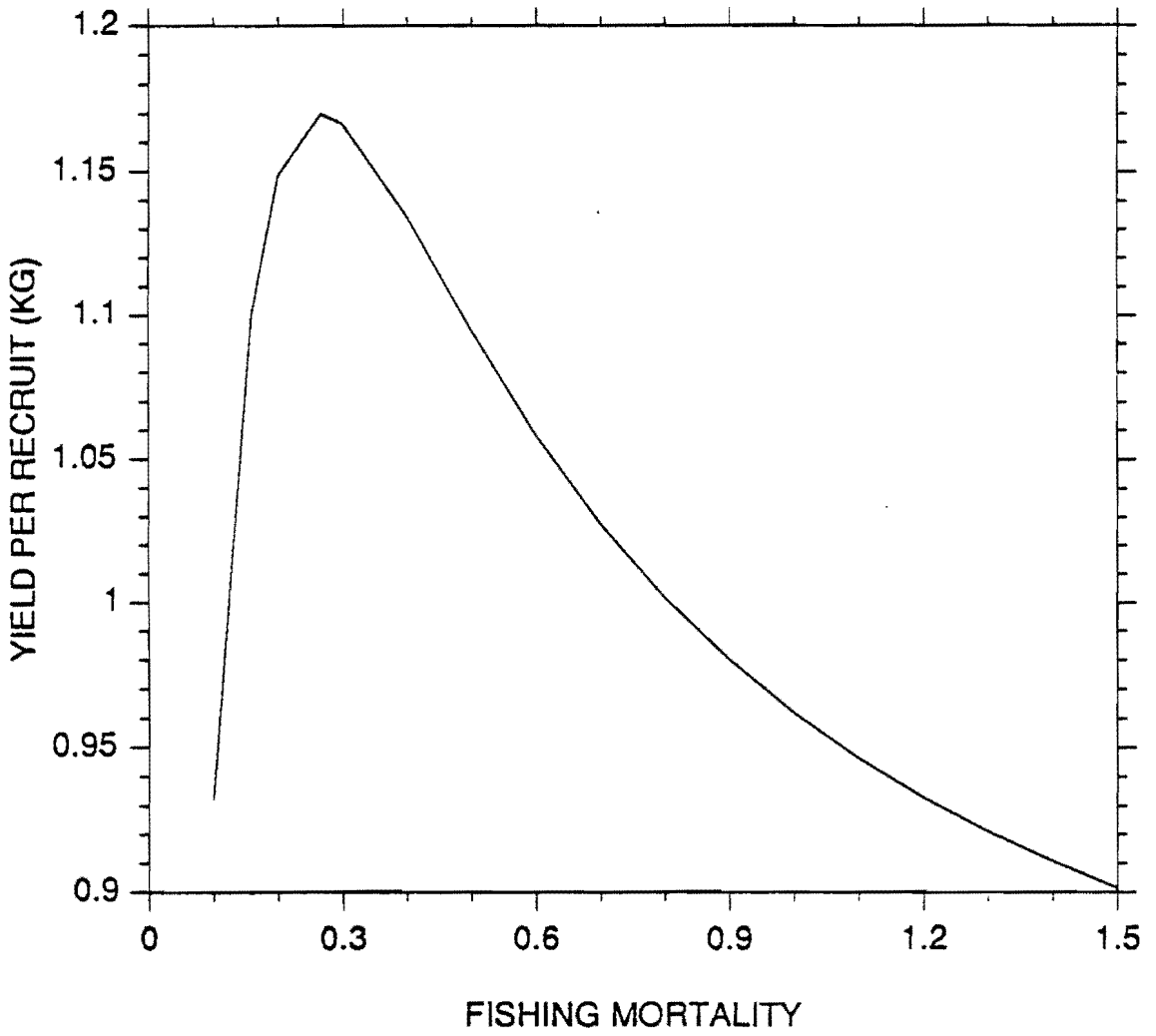


Figure 18. Yield per recruit analysis (Thompson & Bell) for 4X cod. Weight at age was the mean from 1985-87, while partial recruitment was the mean from 1982-86.