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**Stock Assessment for the 1986
Cod Population in 4X**

by

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Abstract

For the fourth consecutive year, the TAC for 4X cod was not caught; the 1986 nominal catch was 19,912 t. Mobile gear <65' effectively reached their allocation, but other gear categories fell far short. Longline effort continued its decline of recent years. 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 substantially since the late 1970s. In addition, all research vessel indices of stock abundance and biomass declined in 1986. Calibration of the cohort analysis ages 4-6 against RV ages 4-6 indicated a terminal fishing mortality of 0.55. This estimate is consistent with the time series of fully-recruited fishing mortalities and the observed mean weight in the catch. SPA biomass has declined in recent years and has now reached a 27-year low. Given the low stock biomass and the absence of strong recruiting year-classes, consideration may have to be given to more serious stock preservation measures if abundance indices continue their decline in 1987. If the 1987 TAC of 17,500 t is caught, the 1988 catch under the 50% rule would be 14,000 t.

Résumé

Pour la quatrième année consécutive, le TPA pour la morue dans 4X n'a pas été atteint; les prises nominales de 1986 ont été de 19 912 t. Les quotas pour les engins mobiles < 65 pied ont été effectivement atteints, mais cela a été loin d'être le cas pour les autres catégories d'engins. L'effort de pêche à la palangre a poursuivi son déclin des dernières années. L'interprétation des taux de prises commerciales a été compliquée par les déclarations inexactes et par la diversité des espèces pêchées. Néanmoins, les taux de prises autant des chalutiers que des palangriers ont fléchi sensiblement depuis la fin des années 1970. De plus, tous les indices d'abondance des stocks et de biomasse des navires de recherche ont chuté en 1986. L'étalonnage des âges 4-6 de l'analyse des cohortes en fonction des âges 4-6 de NR a révélé une mortalité par pêche de la dernière année de 0,55. Cette estimation est en accord avec la série chronologique de mortalité par pêche de plein recrutement et le poids moyen observé dans la capture. L'ASP a révélé que la biomasse a diminué au cours des dernières années et atteint maintenant son plus bas niveau depuis 27 ans. Vu la faible quantité de biomasse et l'absence de classes d'âge de recrutement élevé, il se peut qu'il faille envisager des mesures plus strictes de protection des stocks si les indices d'abondance continuent de chuter en 1987. Si le TPA de 1987 de 17 500 t est capturé, les prises de 1988 d'après la règle de 50 % seraient de 14 000 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 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 19,912 t.

None of the gear categories caught their allocation in 1986 although the fishery by small (< 65') otter trawlers (OT) was closed or restricted 6 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. Since misallocation was also apparent in 1986, adjustments have again been made (Table 3). A more serious misreporting problem first became apparent in 1986: 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. As indicated in Figure 4, catches peaked in the summer months. 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 34% of the total in 1986, similar to the proportion reported last year, but considerably lower than that of previous years. Much of this decline was attributed to reduced catches by longliners, who in turn blamed dogfish and aberrant temperature conditions for their reduced effort (Campana and Simon, MS 1986). It now appears that the low mature stock biomass in 4X is an equally plausible explanation.

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. Catch rates were calculated on a quarterly basis and then standardized. Standardization was conducted through normalization of the mean post-1976 catch rate within a given gear/quarter; yearly values were then averaged across gears. The results indicated that the strong downward trend noted in the last assessment was continued into 1985 (Table 5; Figure 5). 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 declined by over 50% since 1982, while that of otter trawlers has increased over the same period (Table 5).

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 (34' wingspread).

Age-structured survey population estimates are presented in Table 6a. Table 6b presents the same data adjusted to the beginning-of-the-year (through within-cohort geometric means of adjacent years). While age 5+ numbers fluctuated in the early 1970s, the years between 1979-85 suggested relative stability (Table 6). However, all RV indices of stock abundance (Figure 6) and biomass (Figure 7) declined substantially in 1986. 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.

Age Composition of the Catch

In the last assessment, quarterly age-length keys were computed for each of the major gear types (pooled among tonnage classes) for the period 1948-85. Details of key construction and sample aggregation policy are described elsewhere (Campana and Simon, MS 1986). Fifty samples went into the construction of the 1986 keys. 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 1986 are presented in Table 8. Numbers at age (1986) for each of the major gear categories are presented in Table 9. Catch numbers-at-age for the miscellaneous gear category was computed quarterly, through a pro-rated comparison of miscellaneous landings with the sum of OT, LL, and GN landings. Foreign catches were treated similarly, but were pro-rated only on the basis of OT landings (since all foreign catches employed trawl gear). The data for previous years has been presented elsewhere (Campana and Simon, MS 1986).

Total catch numbers and percent catch numbers-at-age are presented in Tables 10 and 11. A comparison of the 1986 catch composition and that predicted last year for 1986 indicates that all ages but age 4 were well

predicted (Figure 8). The partial recruitment of age 4 may have been underestimated in last year's assessment. A declining trend in mean weight-at-age 5 in the catch (Table 12) was noted, but was not evident among the other ages. Fish aged 3-4 made up the largest proportion of the catch numbers (66%) while ages 3-6 made up most of the catch weight (75%) (Table 13). 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 a calibration block of 1972-85 (ages 2-7) and full recruitment to the survey gear at age 5. The results are presented in Table 14. Terminal F on 5+ fish was calculated as 0.38 which is identical to that calculated in last year's assessment. However, the coefficients of variation were considerably higher than those of last year and the estimate of terminal fishing mortality appears to be inconsistent with the 1986 RV survey results. Given the fact that the fully recruited F of 1985 now appears to be much higher than that estimated last year, Survivor may be underestimating terminal F for this stock.

Cohort Analysis

Cohort analyses were run on ages 1-13 in the catch-at-age matrix in Table 10. 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 F_s on age 6+ fish. Partial recruitment (defined as $F \div$ weighted mean of fully recruited F_s) in the final year was set at the mean of the years 1981-85; the partial recruitment of age 5+ fish in 1986 was set at 1.0. Cohort runs were conducted for terminal F_s of 0.2-0.8 at 0.05 intervals.

Calibration of the SPA

Calibration of the cohort runs was difficult in view of the relative stability in the RV survey estimates since 1972; this resulted in a narrow range of values through which the regression was calculated. While age-by-age, age 4-6 and age 5+ tuning was attempted, regressions were insignificant at all levels of F_t . However, 1975 values were outliers in all of the relationships (Figure 9) and thus removed from subsequent calibrations. The result was a significant regression at $F_t = 0.55$ (Figure 10). The tuning criterion was the correlation coefficient (Table 15). Assumptions of linearity and a normal distribution of residuals were not totally met (Figure 10), but few alternatives were available.

Commercial catch rates were also used in calibration. The mid-year SPA fishable biomass was calculated as

$$(\text{POP} \times e^{-(F+M) \times 0.5}) \times \text{mean weight} \times \text{partial recruitment}$$

for each cohort run. Mean partial recruitment-at-age was used for the intervals 1948-56, 1957-65, and 1966-79 (since no temporal trends were apparent in intra-interval PRs). Partial recruitment was set to 1.0 for all fully-recruited ages. When fishable biomass was tuned against the standardized catch rate, none of the relationships were significant (Table 15). However, where F_t exceeded 0.60 the trend in the two series were similar (Figure 11).

Calibration of the cohort run against RV data produced estimates of F_t in the order of 0.55-0.60. This range is somewhat higher than that estimated by Survivor analysis. However, the time series of fully recruited F_s indicates that a 1986 F_t of 0.55 would be comparable to those of the past 25 years and lower than the mean of the past 7 years (Figure 12). Fishable biomass has been declining since 1980, and is now at one of its lowest levels since 1959 (Table 19; Figure 12). Further, the observed mean weight in the catch lies far below that expected of fishing at F_{max} , let alone $F_{0.1}$ (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 0.55 was considered to be a minimum estimate for 1985. The corresponding cohort run is presented in Tables 16-17. Partial recruitment values are indicated in Table 18.

Yield Per Recruit

Yield per recruit was calculated in 3 ways: using 1986 population parameters, using the mean of 1982-86 weights at age, and using the mean of 1948-86 weights-at-age and PR. All produced similar results (Table 20). $F_{0.1}$ was calculated as 0.16-0.17, F_{max} as 0.27-0.29, and $F_{0.1}$ yield per recruit as 1.04-1.10.

Recruitment of 4X cod has varied by a factor of 6 between 1948-85, and by only a factor of 2 since 1965 (Figure 14). Long-term yield of 4X cod was estimated from the geometric mean of age 1 recruitment through this period ($18,752 \times 10^3$). Expected annual yield (long-term) at $F_{0.1}$ is 21,000 t.

Catch Projections

Projections were made with the mean of the 1984-86 weights-at-age, the mean PR between 1981-85 and the 1986 population size from the cohort analysis (Table 21). Since the age 2 cohort estimate in 1986 was the lowest observed, it was adjusted upwards to the size of the smallest year-class in the previous 30 years (1981 year-class at age 2).

The 1987 TAC, which is above that recommended by CAFSAC, corresponds to a fishing mortality of 0.47. If $F_{0.1}$ catches in both 1987 and 1988 were realized, catches are projected to be 8,000 and 10,000 t respectively. Given the TAC catch in 1987 (of 17,500 t), the projected $F_{0.1}$ catch in 1988 is 9,000 t. However, since the 1986 F_t exceeds $F_{0.1}$, the 50% rule was applied,

resulting in a 1988 F of 0.34. The 1988 catch at this level would be 14,000 t. Partially recruited ages would make up 35% of the catch biomass.

The long-term yield at $F_{0.1}$ is 21,000 t for this stock.

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). However, our current view of the stock suggests that recent fishing mortalities have been taking their toll. The current estimate of fully-recruited F in 1985 is 0.71 — substantially above that of the long-term mean, and more than twice that of F_{max} . All indices of abundance show a marked decline in 1986 — catch rates have reached their lowest levels since 1976 and RV numbers are at their lowest level since 1973. Of particular concern is the fact that SPA biomass is at a 27-year low. Given these facts, it is possible that stock biomass is approaching a critical level. This view is exacerbated by the absence of strong recruitment in the upcoming year-classes. Since it appears unlikely that stock biomass will increase in the near future, serious consideration will have to be given to stock preservation measures if abundance indices continue their decline in 1987.

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Table 1. 4X cod nominal catches (t) by country (1948-86).

Year	Canada		Spain	USSR	USA	FRG	France	Japan	Other	Total	% Canada
	M&Q	NLFD.									
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					16948	85.0
55	13432				1378		19			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

Sources: 1948-53 ICNAF Suppl. Ann. Proc. 11 (Appendix) (1962).
1954-66 NAFO Statistical Bulletins
1967-86 MFD Statistics

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 ¹	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

* Adjusted in mid-year.

¹ Preliminary

** Fishery closed or restricted 6 times between July 18th - December 31st.

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

Table 4. Nominal catch (t) of 4X cod in the Maritimes. Underlined catches represent the most dominant TC for a gear/unit area.

Year	Unit ^B Area	OTB*					LL / LHP ^A				GN		Misc.	Total
		1	2	3	4	5	1	2	3	4	1	2		
1983	M	4	22	<u>42</u>	1	<u>321</u>	<u>1339</u>	257	187	-	1131	4	146	3454
	N	-	168	159	92	<u>379</u>	<u>3</u>	609	180	2	-	6	121	1719
	O	81	<u>462</u>	320	65	<u>307</u>	<u>5962</u>	<u>365</u>	140	3	725	141	126	8697
	P	-	<u>1023</u>	647	15	84	<u>7</u>	<u>714</u>	337	3	-	-	2	2832
	Q	234	<u>828</u>	<u>1341</u>	26	-	<u>721</u>	<u>329</u>	23	-	1	7	176	3686
	R	266	1334	<u>2399</u>	15	-	<u>612</u>	32	-	-	38	13	2	4711
	S	52	289	<u>494</u>	11	-	<u>771</u>	39	6	-	156	42	6	1866
	U	1	608	<u>821</u>	75	-	<u>1</u>	<u>448</u>	7	2	-	14	18	1995
Total	638	4734	6223	300	1091	9416	2793	880	10	2051	227	597	28960	
1984	M	-	17	26	2	<u>315</u>	<u>762</u>	395	124	-	536	12	77	2266
	N	-	190	269	34	<u>1064</u>	<u>31</u>	<u>570</u>	199	2	-	9	9	2377
	O	68	<u>528</u>	355	47	<u>68</u>	<u>4282</u>	<u>391</u>	59	-	392	140	67	6397
	P	4	244	<u>399</u>	-	66	<u>178</u>	<u>560</u>	386	-	-	-	-	1837
	Q	95	692	<u>1148</u>	14	-	<u>540</u>	<u>56</u>	41	-	4	-	175	2765
	R	235	1202	<u>1774</u>	-	-	<u>562</u>	8	-	-	2	-	2	3785
	S	119	<u>423</u>	<u>391</u>	-	-	<u>421</u>	14	1	-	179	43	27	1618
	U	-	901	<u>1898</u>	12	-	-	<u>929</u>	167	1	-	18	94	4020
Total	521	4197	6260	109	1513	6778	2923	977	3	1112	222	451	25066	
1985	M	-	42	62	8	<u>530</u>	<u>641</u>	224	76	1	1196	34	206	3020
	N	-	132	221	27	<u>577</u>	<u>7</u>	<u>158</u>	122	-	-	3	2	1249
	O	89	<u>642</u>	272	3	<u>38</u>	<u>3731</u>	<u>288</u>	40	-	392	24	46	5565
	P	-	<u>777</u>	<u>506</u>	1	29	<u>3</u>	<u>272</u>	92	-	-	-	-	1130
	Q	68	<u>709</u>	<u>946</u>	10	-	<u>316</u>	<u>80</u>	9	-	-	-	93	2231
	R	83	867	<u>1324</u>	4	-	<u>305</u>	-	-	-	3	-	22	2608
	S	101	<u>553</u>	<u>435</u>	-	-	<u>317</u>	1	-	-	192	49	-	1648
	U	-	1181	<u>1564</u>	-	12	-	<u>789</u>	245	-	-	55	69	3915
Total	342	4353	5330	54	1185	5320	1813	585	1	1783	166	439	21370	
1986	M	25	41	179	5	<u>347</u>	<u>863</u>	336	45	-	893	44	175	2953
	N	-	148	<u>553</u>	172	<u>533</u>	<u>1</u>	<u>262</u>	116	-	-	1	62	1848
	O	41	<u>379</u>	320	31	151	<u>3143</u>	<u>219</u>	59	-	324	27	40	4734
	P	-	<u>100</u>	143	-	9	-	<u>170</u>	138	-	-	-	-	560
	Q	103	764	<u>751</u>	4	-	<u>153</u>	<u>31</u>	-	-	8	-	47	1861
	R	127	<u>782</u>	649	-	-	<u>317</u>	6	-	-	23	-	1	1905
	S	148	<u>425</u>	314	-	-	<u>455</u>	13	-	-	174	31	2	1562
	U	-	1257	<u>1978</u>	3	-	-	<u>907</u>	215	-	-	39	42	4441
Total	443	3895	4888	216	1042	4932	1944	573	-	1422	142	369	19869	

* 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)

Year	G e a r					
	LL - TC2	LL - TC2	LL - TC2	LL - TC3	OT - TC2	OT - TC3
	Jan-Mar	Apr-June	July-Sept	Jan-Mar	Apr-June	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)

b)

Year	LL - TC2	LL - TC2	LL - TC2	LL - TC3	OT - TC2	OT - TC3
	Jan-Mar	Apr-June	July-Sept	Jan-Mar	Apr-June	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)

Table 6. Numbers-at-age ('000) in RV surveys of 4X cod. Surveys between 1970-81 were made by the A.T. Cameron; 1982 by the Lady Hammond; and 1983-86 by the Alfred Needler. All values converted to Needler trawlable units. No other inter-vessel conversion factors were used. a) summer; b) beginning of year numbers calculated from the geometric mean of within-cohort values between adjacent years.

a)

	STRATA 70-95																29/ 4/87
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
0	0	0	0	28	196	0	0	0	28	0	2197	74	88	164	0	84	31
1	1136	404	304	138	496	1294	171	383	239	3491	247	2671	877	169	971	597	904
2	1810	8481	1886	2652	1173	3162	1370	2845	1289	4521	1056	2903	2161	1290	6525	10554	1205
3	2950	4713	3703	1405	5811	1863	2916	5101	2131	2259	3400	2738	2135	4971	4270	5070	3161
4	5077	758	3283	2501	1346	3634	2398	3150	3101	2390	1365	3090	2238	2844	2859	1793	1540
5	2232	1733	858	794	2256	2445	2221	931	1813	2078	1261	1619	1840	1770	2343	1830	432
6	2996	786	587	316	1211	1382	934	1476	648	1149	1716	1048	1053	1108	866	950	758
7	1266	1106	151	189	189	888	477	430	496	543	552	576	288	450	607	649	554
8	620	55	661	61	0	290	259	255	110	360	255	469	297	0	75	355	263
9	208	0	272	217	56	181	67	55	86	61	152	130	257	92	79	192	117
10	113	21	129	55	27	33	68	32	0	74	0	111	79	45	31	15	23
11	16	0	30	35	42	200	15	46	0	100	83	32	37	0	0	0	0
12	0	0	30	7	0	177	0	14	0	0	0	8	32	0	0	8	0
0+	18324	18056	11892	8397	12803	15549	10899	14719	9941	17026	12284	15470	11382	12903	18626	22097	8988
1+	18324	18056	11892	8370	12607	15549	10899	14719	9914	17026	10088	15396	11294	12739	18626	22013	8957
2+	17188	17652	11588	8232	12111	14255	10728	14336	9675	13536	9841	12725	10417	12570	17655	21416	8053
3+	15378	9171	9703	5580	10938	11093	9358	11491	8386	9015	8784	9822	8256	11280	11130	10862	6848
4+	12528	4458	6000	4175	5127	9230	6442	6389	6255	6756	5385	7084	6121	6309	6860	5792	3687
5+	7451	3701	2717	1674	3781	5597	4043	3239	3154	4365	4020	3994	3883	3465	4001	3999	2147
6+	5220	1967	1859	880	1524	3152	1822	2309	1341	2287	2759	2375	2043	1695	1658	2169	1715
7+	2223	1181	1272	564	314	1769	888	833	693	1138	1042	1327	990	587	792	1219	957
8+	957	75	1121	375	125	861	410	402	197	595	491	750	702	137	195	570	403
9+	338	21	460	314	125	591	150	147	86	235	236	281	405	137	110	215	140
10+	130	21	188	97	69	410	83	93	0	174	83	151	148	45	31	23	23
11+	16	0	60	42	42	377	15	61	0	100	83	40	69	0	0	8	0
12+	0	0	30	7	0	177	0	14	0	0	0	8	32	0	0	8	0

b)

	BEGINNING OF YEAR RV POPULATION STRATA 70-95																29/ 4/87
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	
1	20	17	12	117	503	13	20	15	311	16	2422	255	122	399	24	276	
2	3104	872	897	402	1253	1331	697	702	1039	1920	847	2403	1064	1050	3201	848	
3	2920	5604	1628	3925	1479	3037	2644	2462	1706	3921	1700	2489	3278	2347	5752	5776	
4	1469	3933	3043	1375	4595	2114	3031	3978	2257	1756	3241	2475	2464	3770	2767	2794	
5	2966	806	1614	2376	1814	2841	1494	2389	2539	1736	1487	2384	1790	2581	2287	880	
6	1325	1008	521	980	1766	1511	1811	777	1443	1888	1149	1306	1428	1238	1492	1178	
7	1820	345	333	245	1037	813	634	856	594	796	995	549	688	820	750	725	
8	263	855	96	14	234	480	350	218	423	372	509	414	17	184	464	413	
9	25	122	379	58	13	139	119	149	82	234	182	347	165	9	120	204	
10	65	11	122	76	43	111	46	7	80	8	130	101	108	53	34	66	
11	11	25	67	48	73	23	56	6	10	79	6	64	9	7	6	4	
12	4	5	15	6	86	14	15	7	1	10	26	32	6	1	3	1	
1+	13974	13605	8727	9623	12897	12427	10915	11566	10485	12736	12694	12820	11339	12459	16900	13165	
2+	13974	13587	8715	9505	12394	12414	10896	11550	10173	12720	10272	12565	11217	12060	16876	12890	
3+	10869	12715	7817	9103	11141	11083	10199	10848	9134	10800	9425	10163	10153	11010	13675	12042	
4+	7949	7111	6190	5178	9663	8046	7555	8386	7428	6880	7725	7673	6875	8663	7923	6266	
5+	6479	3178	3146	3802	5068	5932	4524	4408	5171	5124	4483	5198	4411	4893	5156	3472	
6+	3513	2372	1532	1427	3253	3091	3030	2019	2632	3388	2997	2813	2421	2312	2869	2592	
7+	2188	1363	1012	447	1487	1580	1220	1242	1189	1499	1847	1508	993	1074	1377	1414	
8+	368	1018	678	202	450	767	586	386	596	703	853	958	305	254	627	688	
9+	105	163	582	188	216	287	236	168	173	331	344	545	288	70	163	275	
10+	80	42	204	130	202	148	117	20	91	96	162	197	123	61	43	71	
11+	15	30	82	54	160	37	71	12	11	89	32	96	15	8	8	5	
12+	4	5	15	6	86	14	15	7	1	10	26	32	6	1	3	1	

Table 8 . Input data used in the construction of the 1986 catch-at-age matrix. A) Quarterly catch data 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	
2127	2936	3625	1797	1664	1540	2745	1500	343	186	769	267	139	116	89	26	43

(B)

Gear	Jan-Mar	Apr-June	July-Sept	Oct-Dec
OT	10	8	5	0
LL	4	10	10	2
GN	0	1	0	0

(C)

Jan-Mar	Apr-June	July-Sept	Oct-Dec
.0081/3.0503	.0084/3.041	.0080/3.0508	.0063/3.1152

Table 9. Catch numbers-at-age by gear category.

Age	Numbers-at-age ('000) by gear				
	OT	LL	GN	Misc.	Foreign
1	0	0	0	0	0
2	101	44	0	2	0
3	2233	807	26	54	9
4	1261	707	191	40	5
5	413	439	35	17	2
6	381	497	85	20	2
7	111	194	30	8	0
8	48	98	14	3	0
9	22	46	13	2	0
10	3	34	0	0	0
11	7	8	0	0	0
12	5	10	0	0	0
13	0	9	0	0	0
14	0	0	0	0	0
15	0	2	0	0	0
16	0	0	0	0	0

Table 10. Total catch numbers at age.

		TOTAL NUMBERS AT AGE (THOUSANDS)																			30/4/87	
		1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1		0	0	0	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
2		35	489	660	295	765	120	260	54	105	0	160	0	0	11	2	0	0	0	0	17	11
3		806	1475	1947	2626	1265	860	482	1277	622	241	831	326	0	263	792	396	106	1478	1909	1601	1690
4		1617	1431	3274	1898	2927	724	2024	662	2395	365	1257	1986	275	409	2057	1372	751	2576	4703	8321	2575
5		1639	930	1441	1465	1189	1407	909	1236	731	1442	585	1726	966	1940	2734	1576	3104	2483	3372	3590	6147
6		676	968	773	500	557	450	1051	521	584	214	805	1093	804	901	1183	1683	2550	2194	1753	1271	2554
7		270	67	732	468	361	222	358	583	505	602	84	417	273	320	513	927	852	701	1108	460	459
8		364	105	40	277	170	74	139	190	470	288	168	409	336	97	237	301	768	271	357	388	191
9		363	150	51	82	234	175	129	58	116	341	147	87	196	77	81	242	365	78	44	142	246
10		265	162	91	26	30	219	136	34	40	288	94	0	107	41	55	39	76	41	65	36	59
11		103	52	13	107	21	73	91	60	78	0	23	25	51	18	0	41	27	23	24	46	40
12		50	16	67	71	13	16	35	32	78	94	10	16	13	9	0	33	83	7	24	11	31
13		51	30	6	16	28	0	31	16	47	136	7	0	30	0	12	17	8	9	5	12	6
14		74	9	1	16	6	27	23	4	9	64	0	0	0	0	3	7	0	1	0	1	6
15		26	23	31	7	0	0	13	0	0	0	7	0	0	0	3	4	0	0	0	0	3
16		0	0	1	0	0	0	2	4	0	0	0	0	0	0	0	0	10	0	3	5	10

1		456	272	553	358	331	101	766	410	1609	285	326	889	0	0	4	39	0	0	0	0	0
2		2557	1341	1302	2446	1857	2193	1556	1693	3063	1803	1294	4763	864	862	766	604	888	147	0	0	0
3		2047	1398	1031	3071	2432	2088	2955	2476	1683	2274	3405	1951	4426	2549	3696	2381	1594	3129	0	0	0
4		2277	1365	1324	1903	1952	1614	1022	1401	1606	1991	2632	2472	1684	4476	2112	3243	1888	2204	0	0	0
5		2014	980	1062	953	673	1171	679	467	735	2169	1217	1287	1018	3332	2376	1845	2458	906	0	0	0
6		595	435	452	165	293	267	365	190	272	2169	703	427	535	873	1148	923	1159	965	0	0	0
7		195	78	368	122	75	209	88	122	257	199	218	245	299	301	221	159	174	164	0	0	0
8		140	215	165	141	159	116	58	174	101	55	99	87	166	140	136	54	66	182	0	0	0
9		222	52	159	67	66	109	35	18	81	47	77	52	95	199	71	50	44	37	0	0	0
10		25	17	32	4	52	98	26	7	36	9	23	12	27	52	52	31	26	15	0	0	0
11		8	26	72	2	15	39	14	2	39	16	13	16	18	27	9	22	8	15	0	0	0
12		8	0	87	1	7	9	8	4	10	6	3	4	20	18	16	0	8	9	0	0	0
13		5	0	0	4	6	13	0	1	25	2	7	1	6	0	5	2	2	0	0	0	0
14		10	0	0	4	15	20	0	1	0	1	3	1	0	4	0	0	1	0	0	0	0
15		10	0	43	0	15	20	0	2	2	1	7	1	6	0	0	0	0	0	0	0	0
16		20	0	7	18	0	17	1	0	12	1	7	3	6	0	0	0	4	0	0	0	0

Table 12. Mean weight at age (kg) in catch.

		MEAN WEIGHT (KG) IN CATCH													30/ 4/87
		1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1		0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00
2		0.62	1.15	0.82	0.71	0.87	0.99	0.95	0.78	0.63	0.00	0.66	0.00	0.00	0.32
3		1.08	1.28	1.11	1.14	1.34	1.42	1.28	1.07	1.23	0.63	1.11	0.52	0.00	0.86
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	5.89	3.07	5.89	4.56	5.72	5.71
8		5.61	6.17	6.26	4.94	5.57	6.63	6.41	5.39	5.38	4.76	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	9.05	9.49
10		6.65	7.55	8.72	6.09	5.15	5.56	5.01	6.85	5.55	5.79	6.92	0.00	11.85	11.49
11		8.71	8.29	10.57	6.82	5.89	6.81	7.50	5.52	8.10	0.00	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	0.00	8.92	9.76	7.62	6.86	12.57	0.00	16.78	0.00
14		14.72	8.46	16.80	13.05	16.78	4.57	11.42	9.15	8.91	8.99	0.00	0.00	0.00	0.00
15		13.49	10.81	9.99	11.67	0.00	0.00	12.44	0.00	0.00	0.00	11.21	0.00	0.00	0.00
16		0.00	0.00	15.52	0.00	0.00	0.00	15.52	15.52	0.00	0.00	15.52	0.00	0.00	0.00
		1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	
1		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2		0.28	0.00	0.00	0.64	0.50	0.53	0.78	0.77	0.65	0.61	0.69	0.73	0.60	
3		0.76	0.69	0.85	0.89	1.05	1.02	0.95	1.26	1.41	0.87	1.40	1.26	1.09	
4		1.14	1.26	1.50	1.64	1.59	1.61	1.55	1.83	2.21	1.70	2.02	2.19	1.55	
5		1.57	2.13	2.03	2.41	2.42	2.37	2.23	3.23	2.99	2.73	2.45	3.10	2.82	
6		3.00	3.01	3.20	3.52	3.30	3.35	3.39	4.03	4.88	3.67	4.13	3.62	4.38	
7		5.23	4.63	3.83	4.93	4.03	5.26	5.44	5.50	6.17	6.19	4.96	4.90	5.53	
8		7.23	6.50	5.98	5.74	5.40	6.47	6.85	6.90	6.95	7.05	6.83	7.63	6.56	
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	
10		7.99	7.94	9.45	10.63	7.82	9.46	9.75	8.05	8.04	10.18	6.36	11.23	8.90	
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	
12		0.00	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		12.32	10.02	15.52	0.00	8.43	17.38	14.74	16.35	0.00	14.33	17.49	16.78	15.31	
14		16.92	13.66	0.00	0.00	0.00	16.78	15.72	16.78	0.00	0.00	17.93	16.80	11.82	
15		16.92	11.17	0.00	0.00	0.00	0.00	16.92	15.24	0.00	15.72	0.00	16.78	17.01	
16		0.00	0.00	16.78	0.00	16.78	16.92	17.50	17.93	0.00	16.55	15.81	0.00	15.41	
		1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986		
1		0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.36	0.38	0.37	0.38		
2		0.69	0.60	1.04	0.84	0.83	0.71	0.75	0.81	0.65	0.95	0.82	0.80		
3		1.23	1.19	1.26	1.57	1.27	1.41	1.25	1.33	1.33	1.50	1.41	1.29		
4		2.14	2.14	1.66	1.91	2.04	2.17	1.99	1.85	1.85	2.00	1.97	1.90		
5		3.15	3.00	2.34	2.39	3.11	2.97	2.80	2.84	2.61	2.73	2.52	2.63		
6		6.13	4.42	4.28	3.54	4.15	4.75	3.60	4.13	4.21	3.62	3.53	3.93		
7		6.63	6.07	5.76	4.17	5.34	6.70	5.64	5.46	5.58	5.42	4.96	5.02		
8		8.97	8.56	7.75	6.16	7.26	6.91	7.24	7.08	8.05	7.61	6.89	7.47		
9		9.41	10.83	9.08	6.18	8.65	9.56	8.37	8.38	10.26	9.34	8.09	9.51		
10		13.52	12.01	9.44	9.22	11.24	9.80	11.21	9.07	11.42	11.69	9.86	9.20		
11		13.30	16.17	10.75	6.56	10.64	11.85	12.27	10.63	11.59	13.27	12.41	11.90		
12		13.54	12.47	15.41	7.23	12.00	14.02	12.41	14.16	15.10	14.15	14.52	14.38		
13		12.66	14.90	15.83	6.90	16.72	11.59	15.35	13.99	16.13	14.34	12.31	15.07		
14		0.00	16.32	16.65	13.33	13.56	9.32	15.34	16.14	16.14	15.10	12.28	13.19		
15		0.00	17.93	15.54	16.92	0.00	17.52	14.51	16.54	0.00	16.74	16.20	20.33		
16		14.01	0.00	16.01	16.92	16.57	17.37	16.69	0.00	15.98	17.01	14.62	0.00		

Table 13. Catch weight and percent catch weight at age.

30/ 4/87

CATCH BIOMASS (T)

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	
1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
2	22	562	543	209	661	119	246	42	66	0	105	0	0	0	1	0	0	0	0	0	0
3	870	1884	1698	2981	1698	1218	618	1368	763	133	926	170	0	228	604	272	90	1337	1998	1634	9
4	2275	3154	5349	3001	5293	1741	3373	1292	4563	430	1747	2275	338	646	2354	2480	976	4237	7465	10165	1634
5	3320	2626	3798	3674	2958	4799	2451	3732	1901	3301	1544	2976	2202	5141	4288	3360	6301	6983	8152	8838	1634
6	1909	3211	2461	1914	1809	1739	4452	2304	2346	685	3347	2388	2814	3729	3548	3263	8161	7719	5783	4263	4263
7	1185	290	2503	2332	1961	1253	1887	3209	2875	1848	477	1902	1614	1830	2682	4295	3284	3455	4463	2821	2821
8	2042	647	332	1367	945	503	888	1025	2620	1426	999	2207	2688	575	1710	1960	4590	1557	1930	2511	2511
9	2330	1107	308	489	1170	741	748	413	785	2252	1170	736	1787	752	611	1577	3492	882	305	1085	1085
10	1760	1225	798	212	155	1220	679	305	219	1667	839	0	1270	473	438	310	734	433	506	343	343
11	876	431	136	727	126	499	682	334	630	0	236	275	798	242	50	469	345	334	213	427	427
12	529	181	664	495	200	105	205	300	542	580	56	79	90	145	0	318	950	63	267	138	138
13	534	350	33	177	329	0	277	156	355	934	88	0	500	0	0	170	122	115	43	39	39
14	1071	73	13	207	99	123	260	35	64	571	0	0	0	0	147	70	0	19	0	0	0
15	350	251	308	76	0	0	164	0	0	0	76	0	0	0	56	49	0	0	0	0	0
16	0	0	23	0	0	0	24	63	0	0	3	0	0	0	0	0	176	0	54	0	0
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	
1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	15	0	0	0	0
2	9	352	176	336	248	240	60	525	246	1678	240	271	632	666	800	649	766	732	117	117	117
3	1599	3215	1898	1128	3420	2342	2383	1911	2020	3873	2834	1847	6725	5858	3393	5181	3568	2242	4042	4042	4042
4	3992	3744	3084	1748	6211	5836	3233	6529	5310	3122	4352	6731	4230	8786	8276	3912	6498	2934	4180	4180	4180
5	13705	7362	4677	3616	4665	6055	4746	3222	4207	3744	4764	8192	7352	4722	9472	6210	5037	6184	2380	2380	2380
6	8652	8123	4778	4109	3942	2448	5130	4161	2066	3316	7753	5946	6108	3666	3603	4832	3528	4091	3895	3895	3895
7	2497	3276	2680	2794	816	1446	1474	2417	1153	1566	2653	3755	2885	3016	2173	3463	2403	2435	1722	1722	1722
8	1306	1735	540	2733	830	368	1374	788	1041	1789	1225	1584	1694	2167	2131	2021	1211	1199	1235	1235	1235
9	1953	1296	1107	1501	667	1519	996	545	804	919	339	856	836	1387	1170	1397	508	531	784	784	784
10	572	1644	415	1613	424	768	969	469	212	760	455	891	509	726	885	811	585	432	344	344	344
11	445	375	221	433	72	537	1102	344	111	392	58	248	146	334	555	599	406	318	179	179	179
12	412	113	452	913	32	135	605	190	21	607	115	160	227	223	381	129	316	122	221	221	221
13	84	127	0	1242	21	126	143	104	55	159	40	50	48	303	251	284	91	94	138	138	138
14	98	84	0	0	78	140	153	0	24	415	26	89	7	68	5	86	28	18	5	5	5
15	53	160	0	683	0	252	338	0	30	37	15	0	11	36	60	0	59	18	43	43	43
16	169	367	0	114	282	0	262	20	0	186	22	120	44	104	0	39	259	56	0	0	0

Table 13. (Continued)

		PERCENT CATCH WEIGHT AT AGE																				30/ 4/87
		1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2		0.00	0.04	0.03	0.01	0.04	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3		0.05	0.12	0.11	0.17	0.10	0.09	0.04	0.09	0.04	0.01	0.08	0.01	0.00	0.02	0.04	0.01	0.00	0.05	0.06	0.05	0.04
4		0.12	0.20	0.28	0.17	0.30	0.12	0.20	0.09	0.25	0.03	0.15	0.17	0.03	0.05	0.14	0.13	0.03	0.16	0.24	0.32	0.11
5		0.17	0.16	0.20	0.21	0.17	0.34	0.15	0.24	0.11	0.24	0.13	0.23	0.16	0.37	0.26	0.18	0.22	0.26	0.26	0.28	0.39
6		0.10	0.20	0.13	0.11	0.10	0.12	0.27	0.16	0.14	0.05	0.29	0.18	0.21	0.27	0.21	0.18	0.26	0.28	0.19	0.13	0.24
7		0.06	0.02	0.13	0.13	0.11	0.09	0.10	0.22	0.16	0.13	0.04	0.15	0.12	0.13	0.16	0.23	0.11	0.13	0.14	0.08	0.07
8		0.11	0.04	0.02	0.08	0.05	0.04	0.05	0.07	0.15	0.10	0.09	0.17	0.15	0.04	0.10	0.11	0.16	0.06	0.06	0.08	0.04
9		0.12	0.07	0.02	0.03	0.07	0.05	0.04	0.03	0.04	0.16	0.10	0.06	0.13	0.05	0.04	0.08	0.12	0.03	0.01	0.03	0.05
10		0.09	0.08	0.04	0.01	0.01	0.09	0.04	0.02	0.01	0.12	0.07	0.00	0.09	0.03	0.03	0.02	0.03	0.02	0.02	0.01	0.02
11		0.05	0.03	0.01	0.04	0.01	0.04	0.04	0.02	0.04	0.00	0.02	0.02	0.06	0.02	0.00	0.03	0.01	0.01	0.01	0.01	0.01
12		0.03	0.01	0.03	0.03	0.01	0.01	0.01	0.02	0.03	0.04	0.00	0.01	0.01	0.01	0.00	0.02	0.03	0.00	0.01	0.00	0.01
13		0.03	0.02	0.00	0.01	0.02	0.00	0.02	0.01	0.02	0.07	0.01	0.00	0.04	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
14		0.06	0.00	0.00	0.01	0.01	0.01	0.02	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15		0.02	0.02	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986			
1		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
2		0.01	0.01	0.01	0.01	0.01	0.00	0.02	0.01	0.07	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.01			
3		0.10	0.09	0.05	0.16	0.11	0.10	0.09	0.12	0.17	0.11	0.06	0.21	0.16	0.10	0.17	0.14	0.10	0.21			
4		0.12	0.15	0.08	0.26	0.24	0.14	0.30	0.31	0.14	0.17	0.23	0.13	0.26	0.25	0.13	0.26	0.14	0.22			
5		0.23	0.23	0.16	0.21	0.28	0.21	0.15	0.24	0.17	0.19	0.27	0.23	0.15	0.29	0.21	0.20	0.29	0.12			
6		0.25	0.24	0.18	0.18	0.11	0.22	0.20	0.12	0.15	0.31	0.17	0.19	0.12	0.11	0.16	0.14	0.19	0.20			
7		0.10	0.13	0.12	0.04	0.07	0.06	0.11	0.07	0.07	0.11	0.13	0.09	0.10	0.07	0.12	0.10	0.11	0.09			
8		0.05	0.03	0.12	0.04	0.03	0.06	0.04	0.06	0.09	0.05	0.05	0.05	0.07	0.06	0.07	0.05	0.06	0.06			
9		0.04	0.06	0.07	0.04	0.07	0.04	0.03	0.05	0.04	0.01	0.03	0.03	0.04	0.04	0.05	0.02	0.02	0.04			
10		0.06	0.02	0.07	0.02	0.04	0.04	0.02	0.01	0.03	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.02			
11		0.01	0.01	0.02	0.00	0.02	0.05	0.02	0.01	0.02	0.00	0.01	0.00	0.01	0.02	0.02	0.02	0.01	0.01			
12		0.00	0.02	0.04	0.00	0.01	0.03	0.01	0.00	0.03	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01			
13		0.00	0.00	0.05	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01			
14		0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
15		0.00	0.00	0.03	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
16		0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00			

Table 14. Results of the Survivor analysis. The calibration block was 1972-85, ages 2-7. K was set at 5.

INTEGRATED CATCH

87/05/01

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	9226	13267	15379	12499	16490	16005	11358	22441	19854	13626	16807	7191	5667	4295	77
3	8636	6516	9675	11808	9098	11667	11533	5569	15983	13741	7562	11486	4425	3535	1449
4	6417	4860	3542	5587	7819	5719	7315	7082	5523	6829	7536	5726	6134	1870	1157
5	2226	3004	2069	1515	2535	4572	3174	3756	3140	2660	3820	3112	2901	2477	476
6	863	662	1062	589	578	1185	2011	1163	1331	1023	1218	1116	1081	1030	518
7	87	155	140	192	100	143	334	370	225	251	207	325	233	258	180

INTEGRATED SURVIVORS

87/05/01

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	3363	4843	1153	4807	4587	2119	2651	4415	3267	4424	4701	2166	8067	17946	10706
3	4132	2770	3765	744	3737	3755	1735	2171	3614	2671	3622	3649	1773	5605	14673
4	1926	3363	2268	3246	773	3224	3075	1420	1777	2757	2203	2965	3151	1452	5407
5	570	1577	2767	1657	2658	633	2637	2517	1163	1455	2423	1804	2426	2580	1167
6	598	466	1271	2267	1520	2176	518	2161	2061	952	1191	1984	1477	1966	2112
7	390	490	362	1057	1656	1245	1782	424	1787	1687	779	975	1624	1207	1627

POPULATION NUMBERS

87/05/01

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	12610	16132	16532	17308	21077	16123	14009	26875	23141	16049	21511	9357	13734	22240	10783
3	12767	9286	13660	12751	13035	15622	13267	10731	19597	16632	13184	15335	6199	10140	16338
4	8344	6243	5810	6833	6592	7143	10370	8482	7300	11867	9740	6672	9325	3342	8568
5	2776	4560	4838	3372	5293	5204	5813	6275	4303	4335	6242	4916	5329	5077	1668
6	1461	1148	2353	2637	2097	3561	2528	5324	3392	1974	2407	3159	2553	3617	2430
7	476	645	522	1249	1956	1368	2116	794	1994	1969	989	1302	1857	1467	1808

ESTIMATED SURVIVORS

87/05/01

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	2547	3477	0	5261	0	3149	59	5993	0	4113	1030	2163	31967	66601	9669
3	3340	0	6811	0	1697	4613	0	701	0	0	63	5531	9103	14476	11529
4	2366	1833	527	3395	169	2408	1633	551	0	612	57	1985	2178	3141	3715
5	287	0	3055	3751	2645	0	1537	1670	504	1346	1198	1493	2716	2420	600
6	730	232	2036	2787	1750	2566	23	1619	3017	1667	1535	1736	1216	1454	1692
7	353	397	413	2356	1274	1077	1111	1214	1567	1366	631	787	1517	1616	1415

ESTIMATED VARIANCE OF SURVIVORS

87/05/01

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	16240841	32110665	6268793	45666737	6572622	36968656	7585186	93343105	5093922	38481837	31817172				
3	24149221	3477663	57477149	6114760	14960124	43644247	7977660	6727225	20362667	13206433	8027614				
4	15979697	9278379	2688283	19579633	6530439	14713040	14264542	6471962	2762782	14160577	7427735				
5	1383428	1162315	7556649	11218937	9262483	1625404	6167964	8107671	2984673	4521324	6355312				
6	921187	267224	3921145	5113877	2332453	5830376	1125329	3531235	7676971	2938284	2967097				
7	91401	143203	143203	3150197	914581	739041	962676	1179190	1215194	1326454	351114				

	1983	1984	1985	1986
2	16914114	645577908	2519646417	468223355
3	64938797	71480940	150337810	83305759
4	11794666	18083474	10610416	11158016
5	5880954	10304946	9378237	745007
6	3265144	2006631	2415028	2273671
7	608384	1470656	1681443	1225215

WEIGHTED SURVIVORS

87/05/01

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	61	78	0	81	0	21	3	50	0	68	50	85	507	2136	9687
3	90	0	82	0	60	63	0	33	0	0	5	132	64	784	11160
4	101	128	76	124	8	115	74	16	0	45	5	106	167	176	3404
5	18	0	207	129	205	0	175	172	43	113	146	152	157	400	711
6	98	76	351	353	287	315	7	361	316	145	220	415	363	386	1144
7	353	345	252	593	703	572	810	359	791	843	481	513	812	576	740

Table 15. Diagnostics for the calibration of the SPA. a) SPA numbers (ages 4-6) vs RV numbers (ages 4-6) with 1975 outlier removed. b) SPA fishable biomass vs standardized commercial catch rate from 1977-1986.

F_T	RV			CPUE		
	Slope	Y Intercept	R^2	Slope	Y Intercept	R^2
0.20	0.19	14011	0.002	-86959	112724	0.396
0.25	0.69	10704	0.058	-40927	82160	0.176
0.30	1.03	8493	0.192	-10184	61748	0.014
0.35	1.27	6910	0.345	11812	47144	0.018
0.40	1.46	5720	0.454	28335	36175	0.085
0.45	1.59	4793	0.511	41204	27632	0.151
0.50	1.71	4049	0.534	51513	20790	0.202
0.55	1.80	3439	0.541*	59957	15187	0.240
0.60	1.88	2930	0.539	67001	10514	0.268
0.65	1.95	2497	0.533	72966	6557	0.290
0.70	2.00	2126	0.526	78083	3164	0.308
0.75	2.05	1803	0.520	82519	223	0.321
0.80	2.10	1519	0.513	86403	-2351	0.332

Table 16. Population matrix ($\times 10^{-3}$) derived from cohort analysis with $F_T = 0.55$.

		POPULATION NUMBERS														87/05/0
8		1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
1		17952	24847	12697	16157	8828	18516	9119	14152	16519	18223	16076	23970	29094	18826	22692
2		13511	14697	20342	10394	13227	7227	15159	7465	11582	13524	14918	13161	19624	23820	15412
3		9198	11029	11590	16058	8243	10139	5808	12176	6063	9388	11072	12070	10774	16066	19492
4		9528	6801	7695	7727	10771	5604	7524	4319	8812	4401	7495	8313	9587	8820	12913
5		7368	6338	4274	3338	4609	6170	3933	4328	2938	5048	3273	4999	5009	7600	6851
6		1795	4549	4348	2196	1408	2698	3778	2398	2425	1744	2828	2150	2531	3227	4467
7		1096	858	2903	2850	1345	649	1801	2143	1492	1457	1216	1587	771	1345	1827
8		1016	653	642	1714	1918	775	330	1151	1227	764	648	920	923	385	811
9		1053	502	439	489	1153	1417	567	145	770	580	366	379	382	452	227
10		614	534	275	314	327	714	1002	347	66	525	166	164	231	136	298
11		180	263	290	143	233	240	387	697	253	18	170	51	134	92	74
12		241	54	168	226	21	172	130	234	516	137	14	118	19	64	59
13		142	152	30	78	121	5	126	75	163	352	27	2	82	4	44
1+		63692	71276	65694	61693	52203	54326	49664	49631	52827	56160	58268	67883	79162	80836	85169
2+		45741	46429	52997	45536	43376	35810	40545	35479	36308	37937	42192	43914	50067	62010	62477
3+		32230	31733	32655	35142	30148	28583	25387	28014	24725	24413	27274	30753	30444	38190	47065
4+		23032	20703	21065	19084	21905	18444	19578	15838	18662	15025	16202	18683	19669	22124	27573
		1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
1		33666	42776	20770	16369	16168	14271	20691	19652	15342	20695	24281	20510	25484	24603	
2		18577	27562	35021	17004	13401	13236	11683	16939	16089	12560	16943	19878	16791	20864	
3		12617	15209	22565	28644	13909	10957	10827	9153	13623	12672	9959	13573	16184	13054	
4		15242	9971	12356	17120	21724	9938	7442	6551	6280	9976	8162	6474	9128	11842	
5		8711	10695	7484	7785	9762	12067	5807	4241	4089	4209	5389	4482	3411	4799	
6		3136	5707	5948	3501	3322	4653	4316	2695	2056	2158	1723	2646	2028	1868	
7		2587	1588	2365	2884	1280	1570	1499	1711	1320	722	904	800	1107	1046	
8		1032	1279	529	1302	1359	614	870	688	1008	672	442	473	413	577	
9		450	572	353	187	743	761	330	536	493	474	440	295	198	259	
10		113	167	120	219	114	480	401	144	244	255	260	216	137	110	
11		194	57	67	62	120	60	340	121	71	56	148	151	78	80	
12		55	122	22	34	27	57	13	255	83	29	42	75	36	41	
13		48	15	25	12	6	12	18	3	185	3	22	21	26	16	
1+		96428	115721	107625	95122	81934	68676	64235	62688	60892	64481	68716	69593	75020	79159	
2+		62762	72945	86855	78753	65766	54405	43545	43036	45550	43785	44435	49083	49536	54557	
3+		44185	45383	51834	61749	52365	41169	31861	26097	29461	31225	27492	29205	32745	33693	
4+		31568	30174	29268	33105	38456	30212	21035	16944	15839	18553	17533	15632	16561	20638	
		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986					
1		17147	32315	29045	20616	27243	13165	17084	24634	3750	18753					
2		20142	14036	26456	23779	16878	22303	10778	13984	20133	3070					
3		16710	15035	11234	21366	18664	13019	17372	8131	10722	15680					
4		9156	10910	10678	8027	13183	11608	8352	10698	4503	7336					
5		7455	5974	6875	5662	4806	6789	5453	4927	5824	2341					
6		2661	4651	3089	3247	2399	2411	2543	2315	2365	2545					
7		1107	1478	1028	1428	1494	1043	1184	1043	1060	887					
8		684	660	635	861	783	739	494	408	453	424					
9		362	328	361	322	483	370	333	177	190	213					
10		145	205	219	206	185	245	177	149	96	97					
11		74	46	123	107	121	93	112	80	77	39					
12		60	27	29	80	77	75	29	45	38	40					
13		32	13	8	12	51	47	37	16	16	24					
1+		75735	85678	90580	85712	86365	71906	63946	66607	49227	51447					
2+		58588	53363	61535	65096	59123	58741	46863	41973	45478	32694					
3+		38446	39326	35079	41317	42245	36438	36085	27990	25345	29624					
4+		21736	24271	23845	19951	23581	23419	18713	19858	14623	13944					

Table 17. Fishing mortality matrix derived from cohort analysis with $F_t = 0.55$.

FISHING MORTALITY AND WEIGHTED F FOR FULLY-RECRUITED AGES																
87/05/0																
3																
	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.003	0.037	0.036	0.032	0.066	0.018	0.019	0.008	0.010	0.000	0.012	0.000	0.000	0.001	0.000	0.000
3	0.102	0.160	0.205	0.199	0.186	0.098	0.096	0.123	0.120	0.025	0.087	0.030	0.000	0.018	0.046	0.035
4	0.208	0.265	0.635	0.317	0.357	0.154	0.353	0.186	0.357	0.096	0.205	0.307	0.032	0.053	0.194	0.154
5	0.282	0.177	0.466	0.664	0.336	0.290	0.295	0.379	0.322	0.379	0.220	0.481	0.240	0.331	0.582	0.223
6	0.538	0.249	0.219	0.290	0.574	0.204	0.367	0.274	0.310	0.160	0.378	0.825	0.432	0.369	0.346	0.481
7	0.318	0.090	0.327	0.199	0.352	0.476	0.248	0.358	0.469	0.610	0.079	0.343	0.495	0.305	0.371	0.504
8	0.505	0.196	0.072	0.197	0.103	0.111	0.623	0.201	0.550	0.538	0.337	0.677	0.515	0.328	0.309	0.390
9	0.480	0.400	0.137	0.204	0.279	0.147	0.291	0.584	0.183	1.052	0.600	0.293	0.834	0.216	0.501	0.788
10	0.647	0.410	0.453	0.097	0.107	0.413	0.182	0.116	1.079	0.931	0.986	0.007	0.718	0.407	0.227	0.484
11	1.002	0.246	0.051	1.742	0.107	0.411	0.301	0.101	0.414	0.062	0.166	0.774	0.543	0.246	0.102	0.266
12	0.262	0.385	0.573	0.425	1.163	0.110	0.349	0.162	0.183	1.427	1.542	0.162	1.403	0.162	0.019	1.081
13	0.496	0.249	0.247	0.254	0.294	0.235	0.316	0.265	0.376	0.550	0.336	0.580	0.508	0.336	0.352	0.493
6+	0.496	0.249	0.247	0.254	0.294	0.235	0.316	0.265	0.376	0.550	0.336	0.580	0.508	0.336	0.352	0.493
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.001	0.001	0.001	0.001	0.044	0.018	0.039	0.032	0.022	0.006	0.052	0.022	0.099	0.023	0.014
3	0.008	0.076	0.077	0.136	0.187	0.302	0.177	0.112	0.240	0.231	0.197	0.112	0.155	0.226	0.142	0.136
4	0.087	0.262	0.362	0.388	0.337	0.362	0.269	0.200	0.416	0.400	0.441	0.443	0.263	0.227	0.262	0.435
5	0.387	0.560	0.652	0.541	0.828	0.568	0.524	0.442	0.693	0.511	0.593	0.402	0.390	0.272	0.459	0.550
6	0.681	0.524	0.806	0.550	0.933	0.725	0.514	0.847	0.670	0.568	0.671	0.462	0.323	0.388	0.734	0.571
7	0.899	0.397	0.553	0.535	0.390	0.578	0.329	0.475	0.290	0.448	0.460	0.452	0.224	0.317	0.645	0.553
8	1.088	0.837	0.361	0.380	0.420	0.285	0.133	0.554	0.223	0.206	0.672	0.268	0.265	0.535	0.405	0.478
9	1.359	0.280	0.300	0.237	0.442	0.632	0.587	0.460	0.399	0.511	0.569	0.391	0.381	0.370	0.205	0.361
10	0.718	0.468	0.398	0.433	0.145	1.000	0.506	1.268	0.342	0.342	0.813	0.330	0.196	0.954	0.310	0.512
11	0.746	0.480	0.640	0.551	1.321	0.086	0.172	0.698	0.089	0.484	1.249	0.454	0.099	0.793	0.240	0.234
12	1.392	0.412	1.463	0.574	0.937	1.184	0.120	2.996	0.086	0.488	0.869	0.573	0.046	1.310	1.036	0.695
13	0.823	0.499	0.625	0.479	0.702	0.630	0.403	0.713	0.479	0.475	0.657	0.432	0.282	0.424	0.650	0.537
6+	0.823	0.499	0.625	0.479	0.702	0.630	0.403	0.713	0.479	0.475	0.657	0.432	0.282	0.424	0.650	0.537
	1980	1981	1982	1983	1984	1985	1986									
1	0.000	0.000	0.000	0.000	0.002	0.000	0.000									
2	0.042	0.060	0.050	0.082	0.066	0.050	0.054									
3	0.283	0.275	0.244	0.285	0.391	0.180	0.247									
4	0.313	0.464	0.555	0.328	0.408	0.454	0.399									
5	0.659	0.490	0.782	0.657	0.534	0.628	0.550									
6	0.576	0.633	0.511	0.691	0.581	0.781	0.550									
7	0.402	0.504	0.548	0.865	0.635	0.717	0.550									
8	0.378	0.549	0.593	0.825	0.563	0.553	0.550									
9	0.357	0.477	0.540	0.601	0.414	0.479	0.550									
10	0.327	0.491	0.588	0.587	0.463	0.703	0.550									
11	0.135	0.284	0.975	0.717	0.546	0.459	0.550									
12	0.255	0.299	0.507	0.402	0.807	0.279	0.550									
13	0.478	0.556	0.546	0.736	0.583	0.715	0.550									
6+	0.478	0.556	0.546	0.736	0.583	0.715	0.550									

Table 19. Mid-year estimate of SPA population biomass ($\times 10^{-3}$).

MID-YEAR SPA POPULATION BIOMASS															3/ 5/87
	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
1	7518	10406	5317	7309	3697	7755	3819	9858	6918	7632	6732	10038	12185	7884	9503
2	7614	14999	14891	6550	10034	6430	12867	5248	6569	9653	8847	5852	11733	6895	3905
3	8537	11770	10525	14928	9125	12377	6422	11075	6332	5285	10696	5594	10094	12370	13153
4	10935	11886	8282	9440	14740	11286	9508	6956	12710	4479	8512	7393	10499	12278	12137
5	11730	14826	9075	5437	8767	16466	8316	9780	5886	8652	6999	6133	9167	15443	7271
6	3503	12854	11227	6571	3107	8511	12053	8370	8152	4266	8815	2814	6458	10049	10198
7	3706	3219	7621	11669	5548	2608	6790	8927	6076	2983	6011	5523	3226	5968	7182
8	4002	3302	4628	6943	9189	4526	1402	5078	4705	2622	2951	3197	4014	1746	4366
9	4805	2748	2252	2399	4186	5043	2567	698	4182	2046	1923	2501	2059	3479	1208
10	2672	2971	1731	2189	1444	2931	4188	2625	194	1728	817	1750	1732	1154	1922
11	858	1746	2704	369	1178	1206	2259	3310	1509	90	1427	346	1454	981	488
12	2016	467	1137	1156	162	950	586	1849	2954	374	33	489	59	890	618
13	1055	1396	131	690	1108	57	867	583	933	1659	259	22	965	35	414
	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	14099	17915	8698	6855	6771	5977	8665	8230	6425	3667	10169	8589	10673	10304	7447
2	11034	16902	20413	7689	6422	9337	7996	9846	8692	7746	11029	10712	10153	11179	18147
3	7708	11652	17544	26108	11998	8548	10591	10725	10107	14221	10128	12079	17003	13040	17074
4	16058	11231	16129	20520	26037	11780	10274	11432	8718	14831	13267	7276	14175	20153	13722
5	15036	16191	12313	12293	16141	16084	12793	8826	8123	6601	11715	7885	7959	10722	13801
6	6726	11755	14570	6984	7661	8946	10960	9196	4712	5775	4252	7499	8926	6362	8489
7	8429	3510	8653	7971	4660	6358	5591	8099	5824	2801	3202	3176	5297	5134	4923
8	4995	4018	1806	5314	6573	3083	6075	4053	4869	3713	2753	2007	2932	3911	3673
9	1949	2382	3140	1014	4558	4387	2018	1858	3230	2158	2943	1728	1385	2097	2473
10	636	1000	916	1267	785	3933	1769	812	1191	1236	2239	1159	1417	1079	767
11	1756	452	689	328	765	314	4380	1287	608	805	1097	827	752	1120	482
12	280	630	151	167	237	424	90	3781	215	376	315	675	327	450	432
13	337	142	225	67	80	115	196	31	1683	42	260	211	237	192	370
	1978	1979	1980	1981	1982	1983	1984	1985	1986						
1	13534	12164	8634	11409	5514	5564	8463	1255	342						
2	10592	19807	14969	11174	16041	7929	11671	14651	2158						
3	19917	12083	23698	18338	13877	18130	9069	12475	16197						
4	16577	15828	13464	18780	14711	11881	15816	6404	10309						
5	10277	14706	10962	9543	11810	9284	9322	9686	4227						
6	10332	8713	10452	5699	6975	6856	5989	5110	6918						
7	4040	6699	7086	5928	3915	3884	3724	3323	3059						
8	3006	3282	4450	3898	3511	2381	2123	2139	2176						
9	1656	2357	2331	2881	2142	2288	1217	1097	1393						
10	1463	1723	1549	1465	1501	1361	1252	602	610						
11	240	1054	1077	1170	547	818	734	687	318						
12	106	226	890	743	744	319	381	435	393						
13	59	92	99	532	450	373	152	127	244						

Table 20. Yield-per-recruit analysis for 4X cod. a) 1986 parameters; b) mean of 1982-86 weights and PR; and c) mean of 1948-86 weights and PR..

A.	AGE	WEIGHT	PR	M	B.	AGE	WEIGHT	PR	M
	1	0.380	0.001	0.20		1	0.377	0.001	0.20
	2	0.798	0.098	0.20		2	0.859	0.098	0.20
	3	1.292	0.450	0.20		3	1.399	0.450	0.20
	4	1.898	0.726	0.20		4	1.958	0.726	0.20
	5	2.627	1.000	0.20		5	2.625	1.000	0.20
	6	3.956	1.000	0.20		6	3.769	1.000	0.20
	7	5.018	1.000	0.20		7	5.132	1.000	0.20
	8	7.475	1.000	0.20		8	7.324	1.000	0.20
	9	9.509	1.000	0.20		9	8.982	1.000	0.20
	10	9.199	1.000	0.20		10	10.250	1.000	0.20
	11	11.903	1.000	0.20		11	12.527	1.000	0.20
	12	14.377	1.000	0.20		12	14.350	1.000	0.20
	13	15.071	1.000	0.20		13	13.906	1.000	0.20
	14	13.190	1.000	0.20		14	13.524	1.000	0.20
	15	20.326	1.000	0.20		15	17.758	1.000	0.20
	16	16.235	1.000	0.20		16	15.810	1.000	0.20

F0.1	FMAX	YIELD(F0.1)	YIELD(FMAX)
0.16	0.27	1.09	1.16

F0.1	FMAX	YIELD(F0.1)	YIELD(FMAX)
0.16	0.27	1.10	1.17

C.	AGE	WEIGHT	PR	M
	1	0.463	0.000	0.20
	2	0.725	0.060	0.20
	3	1.145	0.347	0.20
	4	1.756	0.704	0.20
	5	2.595	1.000	0.20
	6	3.811	1.000	0.20
	7	5.190	1.000	0.20
	8	6.698	1.000	0.20
	9	7.915	1.000	0.20
	10	9.091	1.000	0.20
	11	10.757	1.000	0.20
	12	11.481	1.000	0.20
	13	12.855	1.000	0.20
	14	13.823	1.000	0.20
	15	15.074	1.000	0.20
	16	16.145	1.000	0.20

F0.1	FMAX	YIELD(F0.1)	YIELD(FMAX)
0.17	0.29	1.04	1.10

Table 21. Input to catch projection.

Age	Population No. ('000)	Weights-at-age (kg)**	Partial Recruitment***
1	18752*	0.38	0.00
2	10778	0.86	0.10
3	15680	1.40	0.45
4	7336	1.96	0.73
5	2341	2.62	1.00
6	2545	3.77	1.00
7	887	5.13	1.00
8	424	7.32	1.00
9	213	8.98	1.00
10	97	10.25	1.00
11	39	12.53	1.00
12	40	14.35	1.00
13	24	13.91	1.00

* GM of age 1 recruitment between 1948-85.

** Mean of 1984-86 values

Figure 22. Catch projection for 4X cod to 1988 assuming a TAC catch of 17,500 t in 1987 and a catch at $F = 0.34$ (50% rule) in 1988. Input parameters are presented in Table 20.

POPULATION NUMBERS				87/06/1			
	1986	1987	1988		1986	1987	1988
1	18752	18752	18752	1	0	6	4
2	10778	15353	15348	2	147	635	458
3	15680	8692	11977	3	3129	1518	1546
4	7336	10023	5750	4	2204	2661	1145
5	2341	4028	5816	5	906	1389	1528
6	2545	1106	2053	6	985	381	539
7	887	1202	564	7	343	414	148
8	424	419	613	8	164	144	131
9	213	200	214	9	82	69	56
10	97	101	102	10	37	35	27
11	39	46	51	11	15	16	13
12	40	18	23	12	15	6	6
13	24	19	9	13	9	6	2
1+	59154	59958	61291	1+	8037	7281	5635
2+	40402	41206	42539	2+	8036	7275	5631
3+	29624	25853	27192	3+	7890	6640	5173
4+	13944	17162	15195	4+	4761	5122	3626

POPULATION BIOMASS (AVERAGE)				CATCH BIOMASS			
	1986	1987	1988		1986	1987	1988
1	6401.69	6400.70	6400.99	1	0	2	2
2	8326.48	11682.17	11752.54	2	126	545	393
3	17686.89	9961.24	14142.27	3	4377	2124	2164
4	10800.74	15131.74	9076.12	4	4315	5209	2241
5	4322.52	7691.61	11796.31	5	2377	3645	4011
6	6747.32	3032.00	5979.05	6	3711	1437	2033
7	3202.58	4487.90	2234.93	7	1761	2127	760
8	2182.54	2232.78	3467.47	8	1200	1058	1179
9	1347.27	1307.51	1482.35	9	741	620	504
10	696.06	751.01	807.71	10	383	356	275
11	342.12	415.57	496.89	11	188	197	169
12	401.67	191.44	257.71	12	221	91	88
13	230.86	190.15	100.43	13	127	90	34
1+	62688.73	63475.81	67994.78	1+	19528	17500	13852
2+	56287.04	57075.12	61593.78	2+	19528	17498	13850
3+	47960.55	45392.95	49841.24	3+	19402	16953	13457
4+	30273.66	35431.71	35698.97	4+	15025	14829	11293

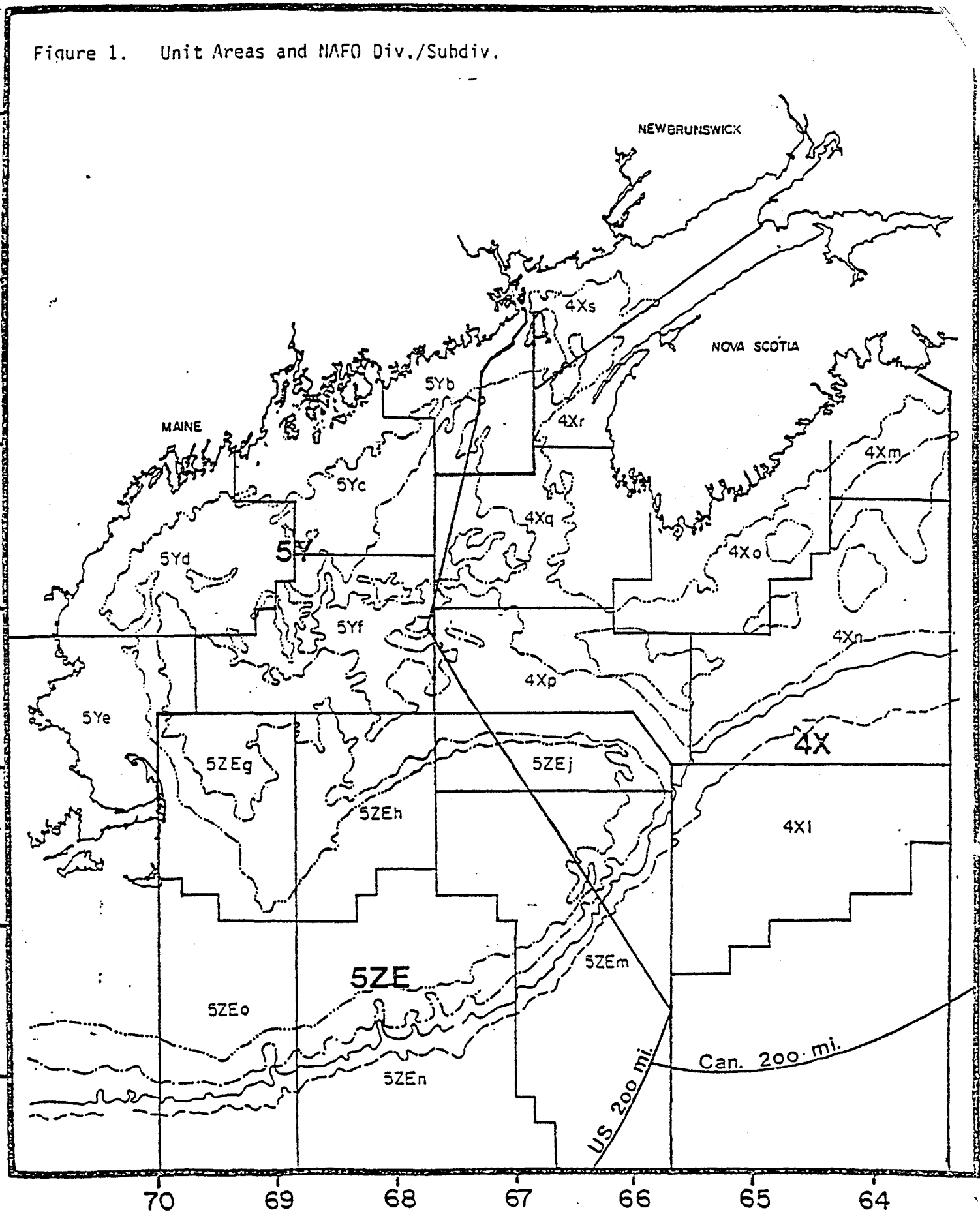
MEAN WEIGHT OF INDIVIDUALS IN CATCH

	1986	1987	1988
	2.4	2.4	2.5

FISHING MORTALITY

	1986	1987	1988
1	0.000	0.000	0.000
2	0.015	0.047	0.033
3	0.247	0.213	0.153
4	0.399	0.344	0.247
5	0.550	0.474	0.340
6	0.550	0.474	0.340
7	0.550	0.474	0.340
8	0.550	0.474	0.340
9	0.550	0.474	0.340
10	0.550	0.474	0.340
11	0.550	0.474	0.340
12	0.550	0.474	0.340
13	0.550	0.474	0.340
1+	0.179	0.157	0.114

Figure 1. Unit Areas and NAFO Div./Subdiv.



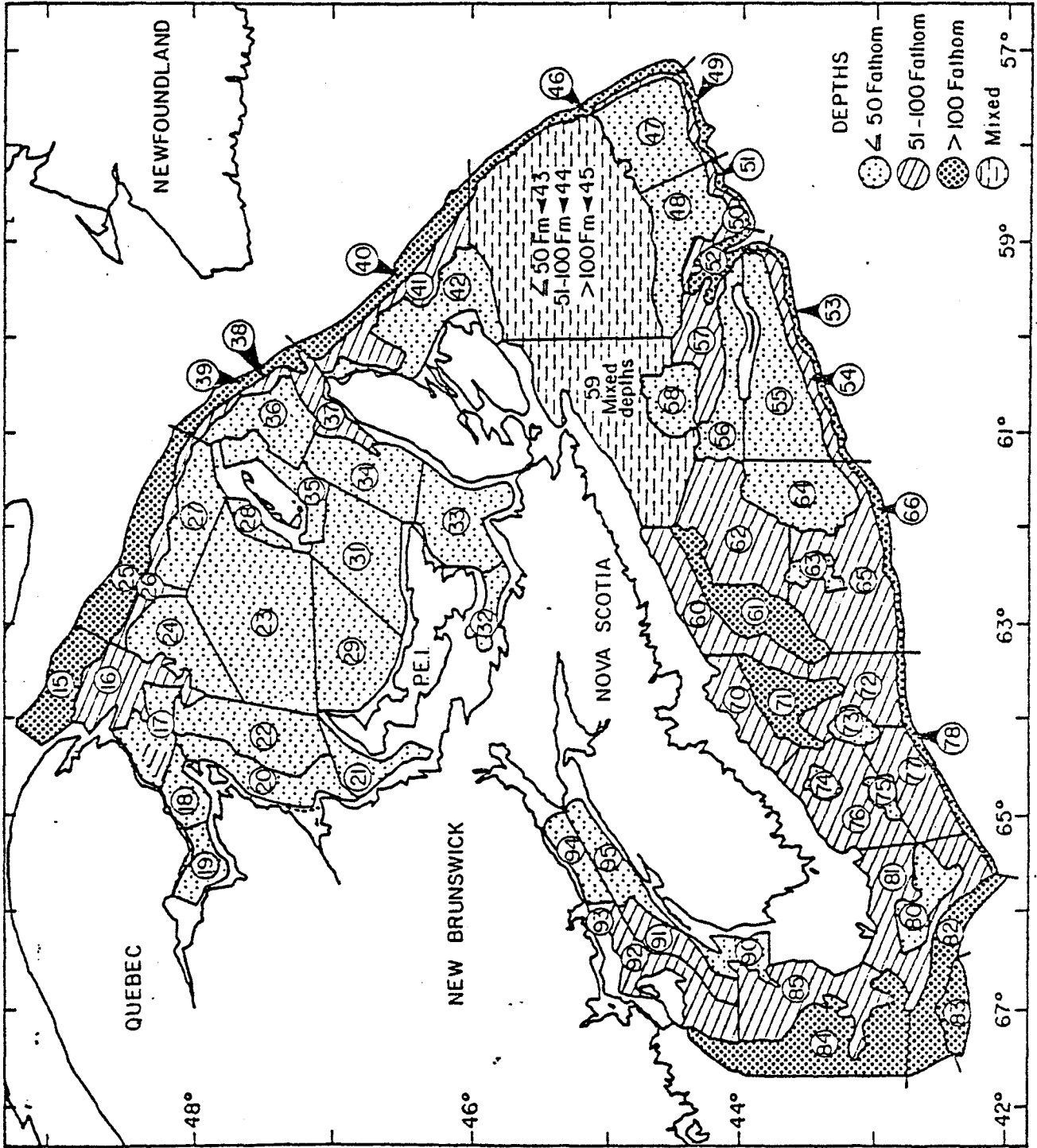


Figure 2. Stratification scheme used for the research groundfish surveys.

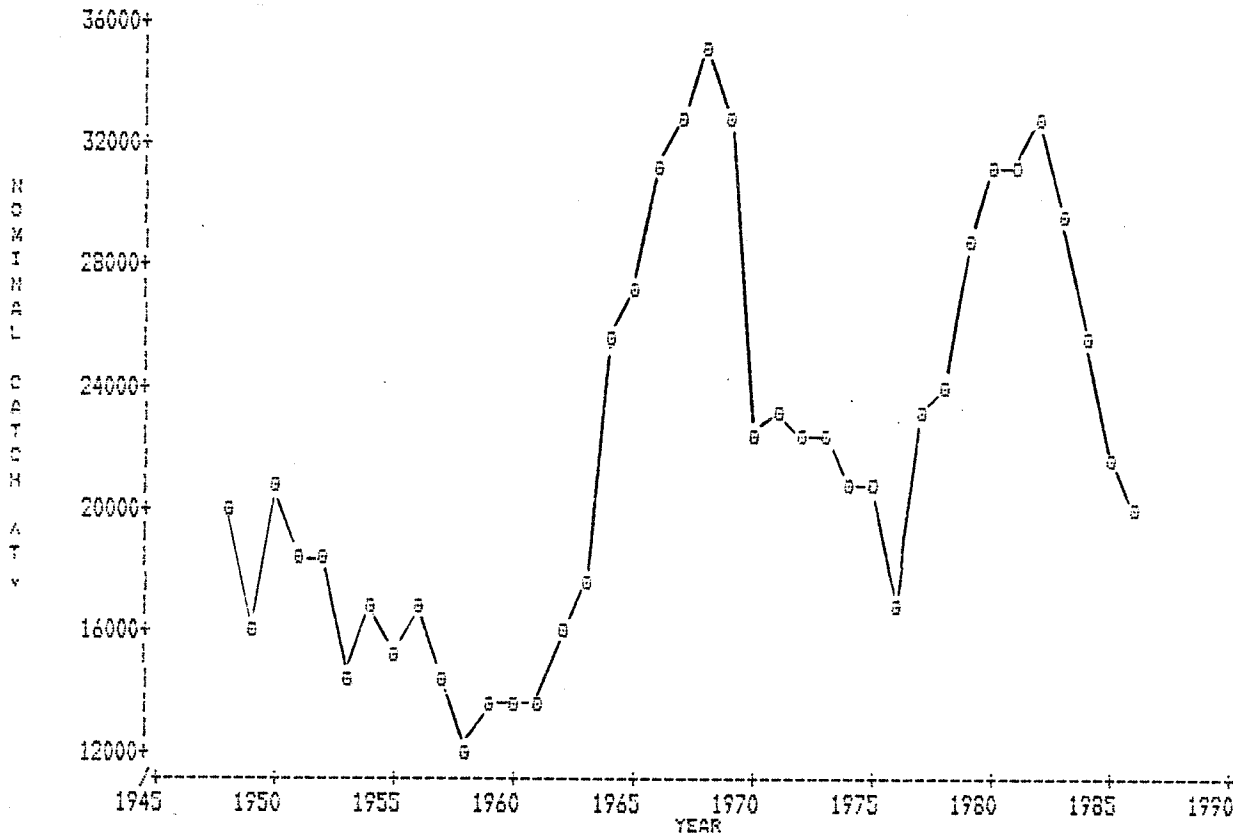


Figure 3. Nominal catch (t) of 4X cod between 1948-86.

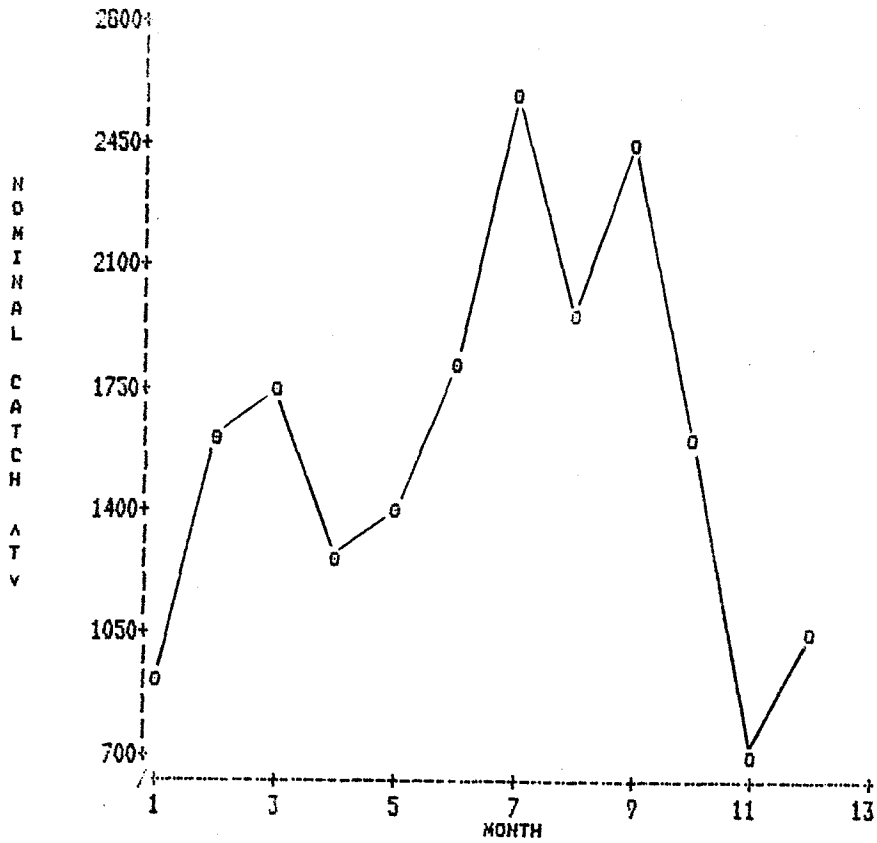


Figure 4. Total landings (t) of 4X cod in 1986 by month.

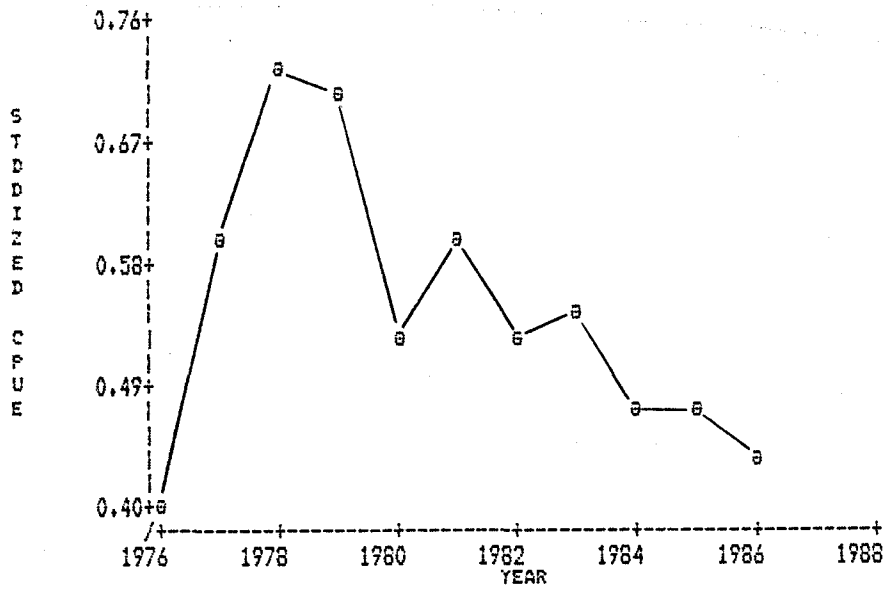
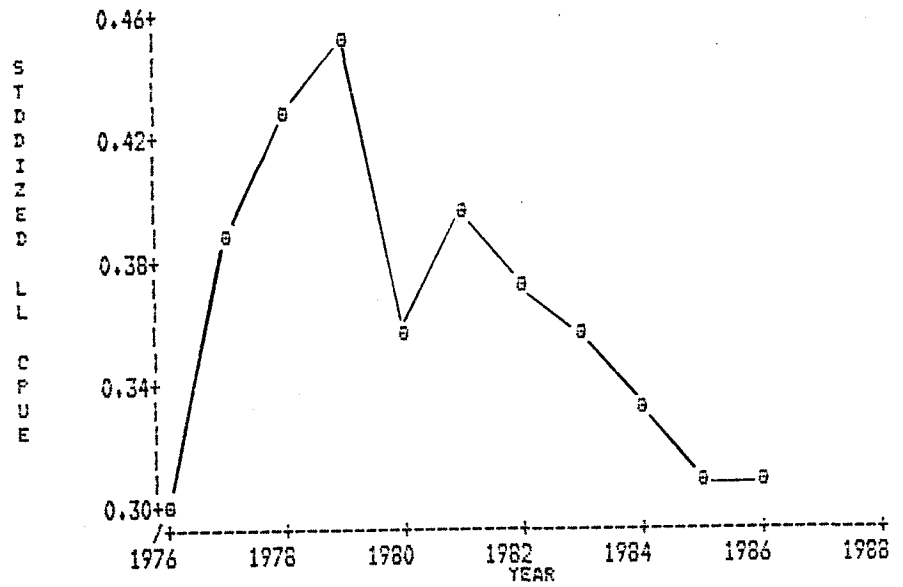
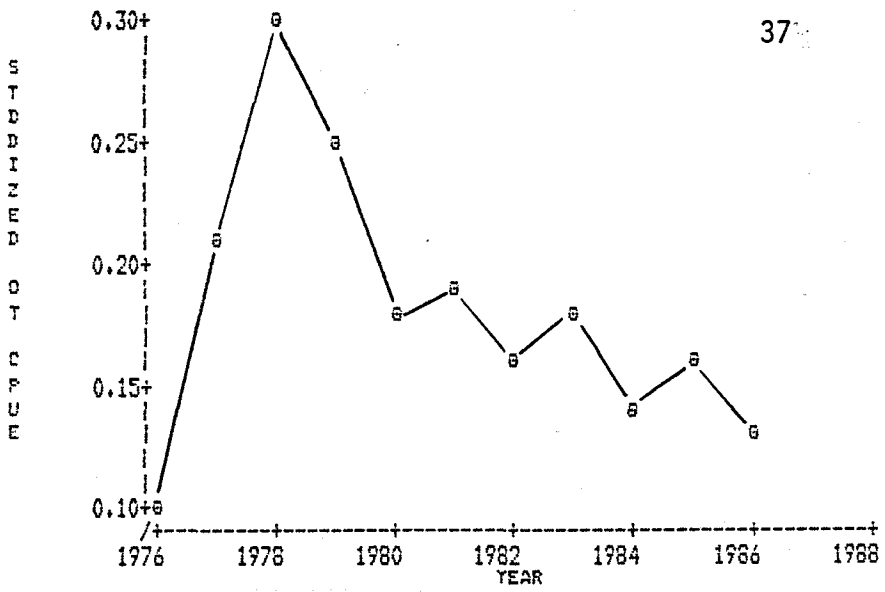
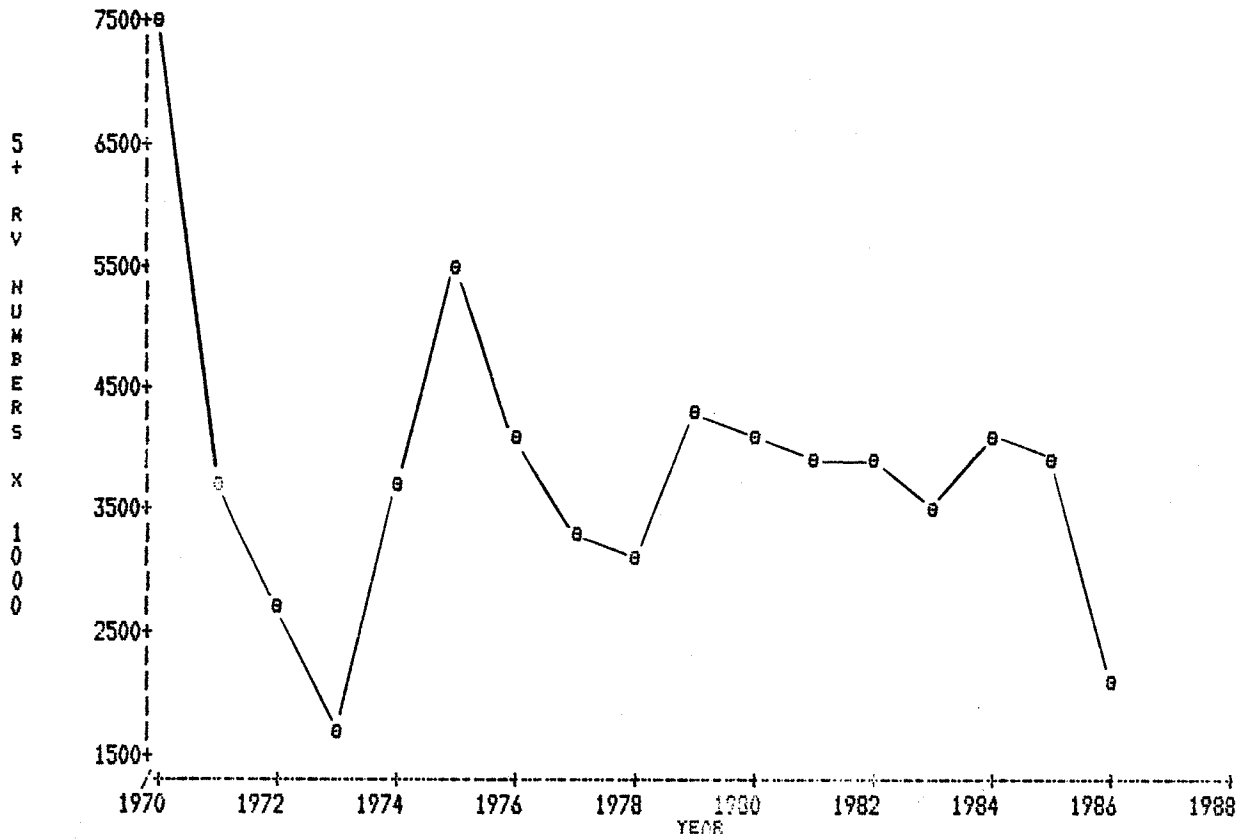


Figure 5. Standardized commercial catch rates for cod in 4X.

a)

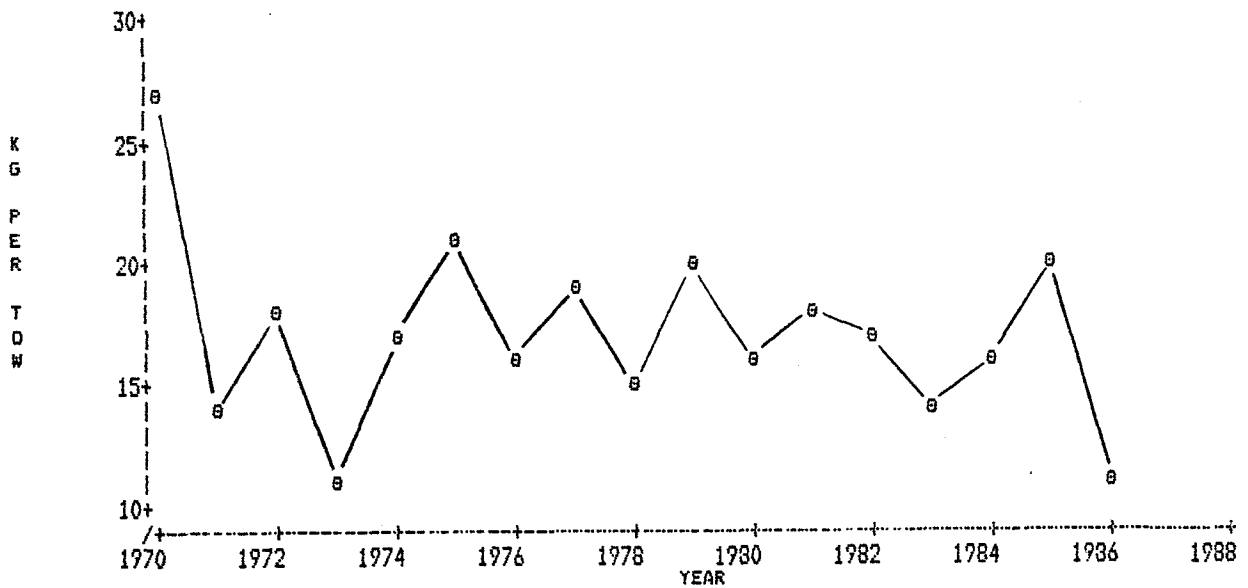


b)



Figure 6. Trends in abundance as determined in RV surveys. a) summer; b) beginning of year, as calculated in text.

Figure 7. Trends in 4X cod biomass as determined from RV surveys.
 (Top) 5+ biomass; (Bottom) weight (kg) per tow.



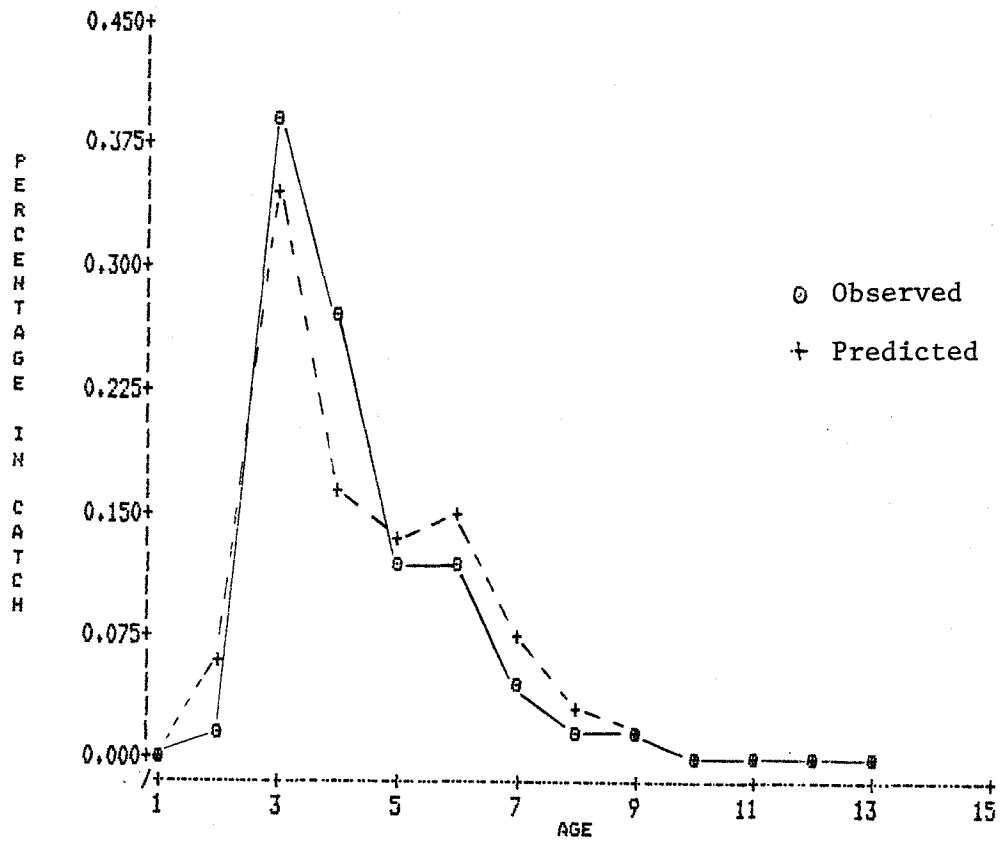
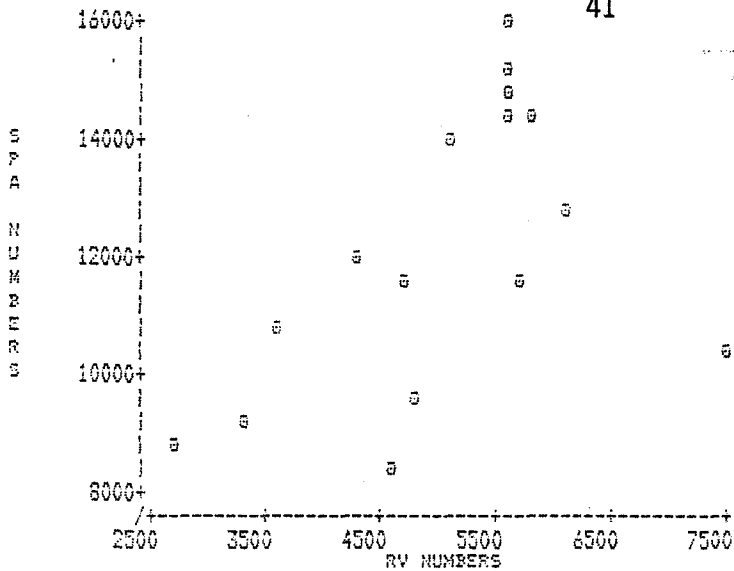


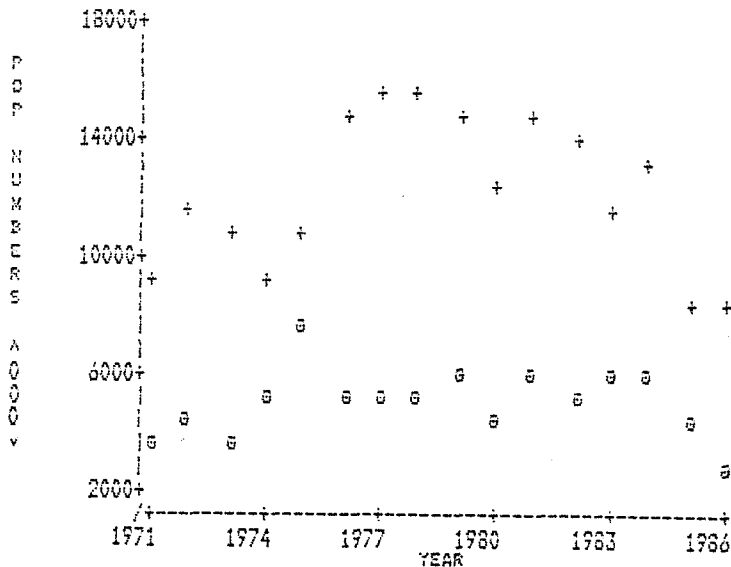
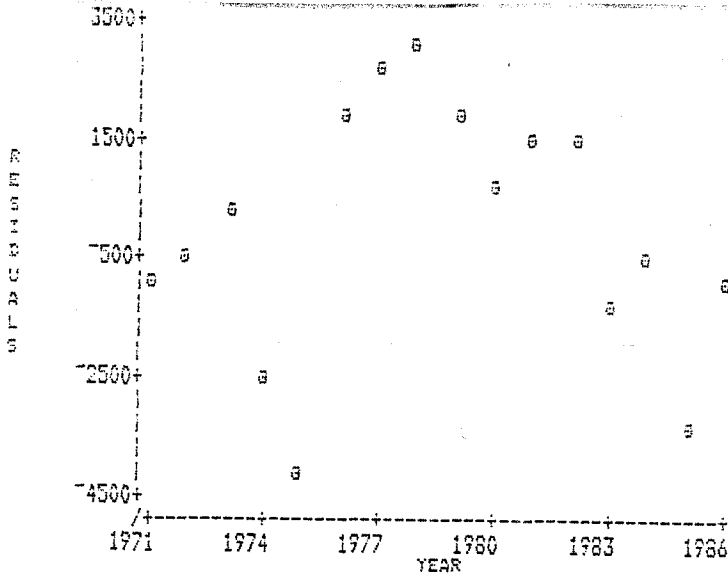
Figure 8. Observed age composition in the 1986 catch compared to that projected in 1985.

FT=0.55

41



YEAR:	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
RV:	3277	4728	3611	4813	7461	5553	5556	5563	5617	4342	5757	5131	5722	6068	4573	2736
SPA:	9333	11422	10998	9425	10600	14408	15267	13672	14601	12099	14446	13601	11577	12874	8545	8794

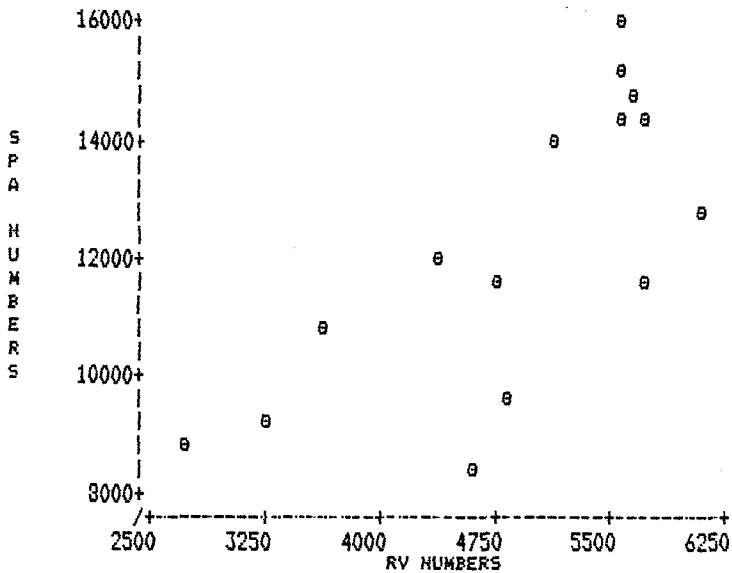


RV=s
SPA=t

Figure 9. Regression of cohort population estimates (ages 4-6) on RV population estimates (ages 4-6) at $F = 0.55$. Note the 1975 outlier.

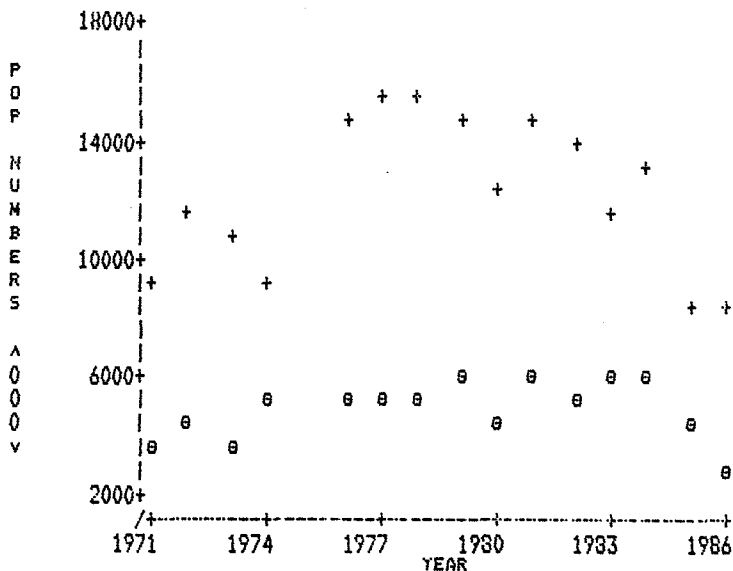
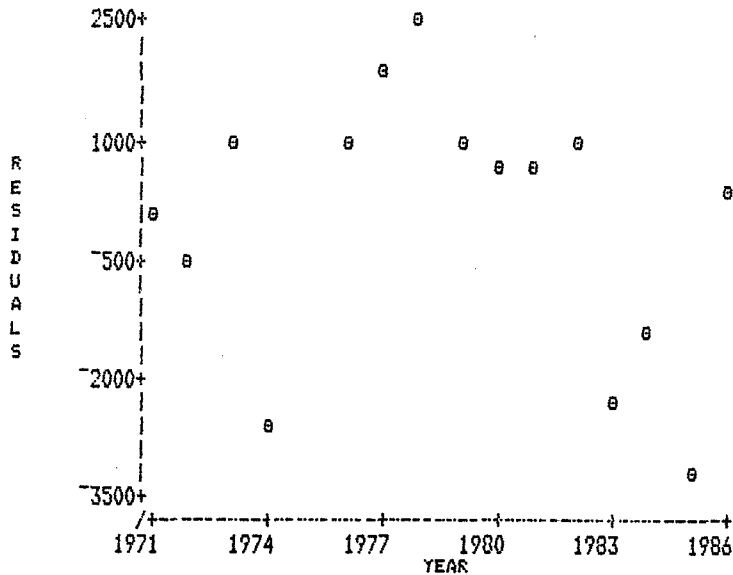
FT=0.55

42



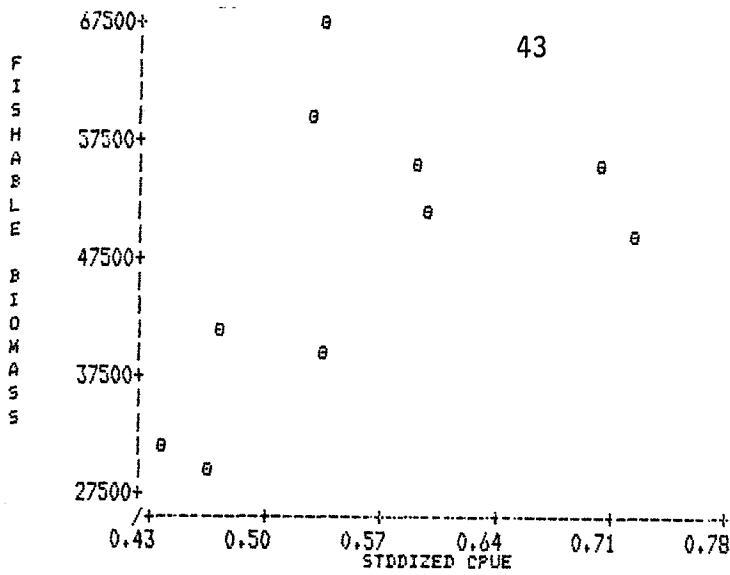
SLOPE IS;
 1.805601058
 Y INTERCEPT IS;
 3439.806722
 R2 IS;
 0.5409568553
 SUM OF RESIDUALS OF LAST 3 YEARS;
 5098.936602

YEAR:	1971	1972	1973	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
RV:	3277	4728	3611	4813	5553	5556	5563	5617	4342	5757	5131	5722	6068	4573	2730
SPA:	9333	11422	10998	9425	14408	15267	15872	14601	12099	14446	13801	11597	12874	8545	8794

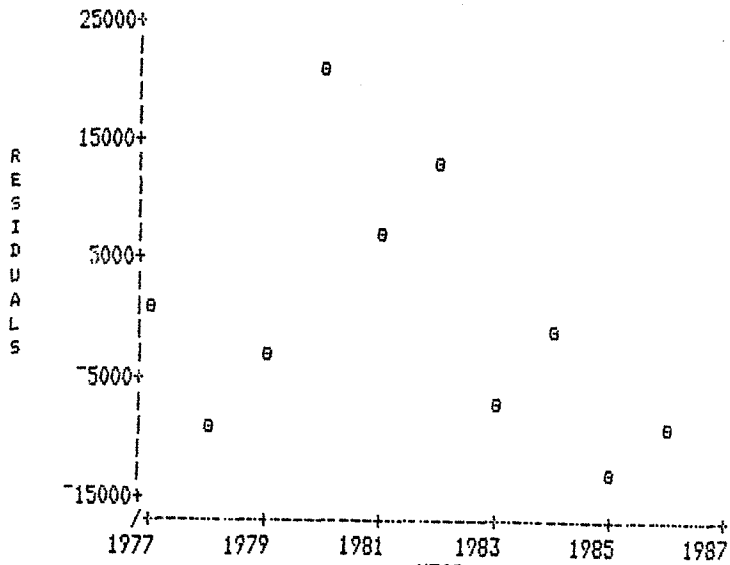


RV=0
 SPA=+

Figure 10. Regression of cohort population estimates (ages 4-6) at $F_T = 0.55$ on RV population estimates (ages 4-6) with 1975 outlier removed.



SLOPE IS;
 67001.62231
 Y INTERCEPT IS;
 10514.65975
 R2 IS;
 0.2685759005
 SUM OF RESIDUALS OF LAST 3 YEARS;
 22172.24315



YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
FISHABLE BIOMASS	51853	50038	55041	66963	56399	58821	39150	41470	28815	31392
STDDIZED CPUE	0.60	0.72	0.70	0.53	0.59	0.53	0.54	0.47	0.47	0.44

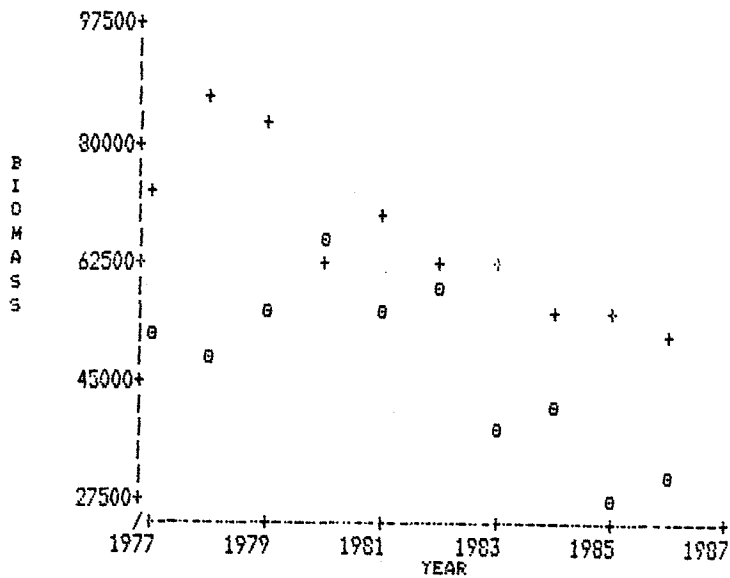


Figure 11. Regression of SPA fishable biomass at $F_T=0.60$ on the standardized commercial catch rate. Comparable relationships were obtained where F_T exceeded 0.60.

FISHABLE BIOMASS= o
 STDDIZED CPUEx120000= +

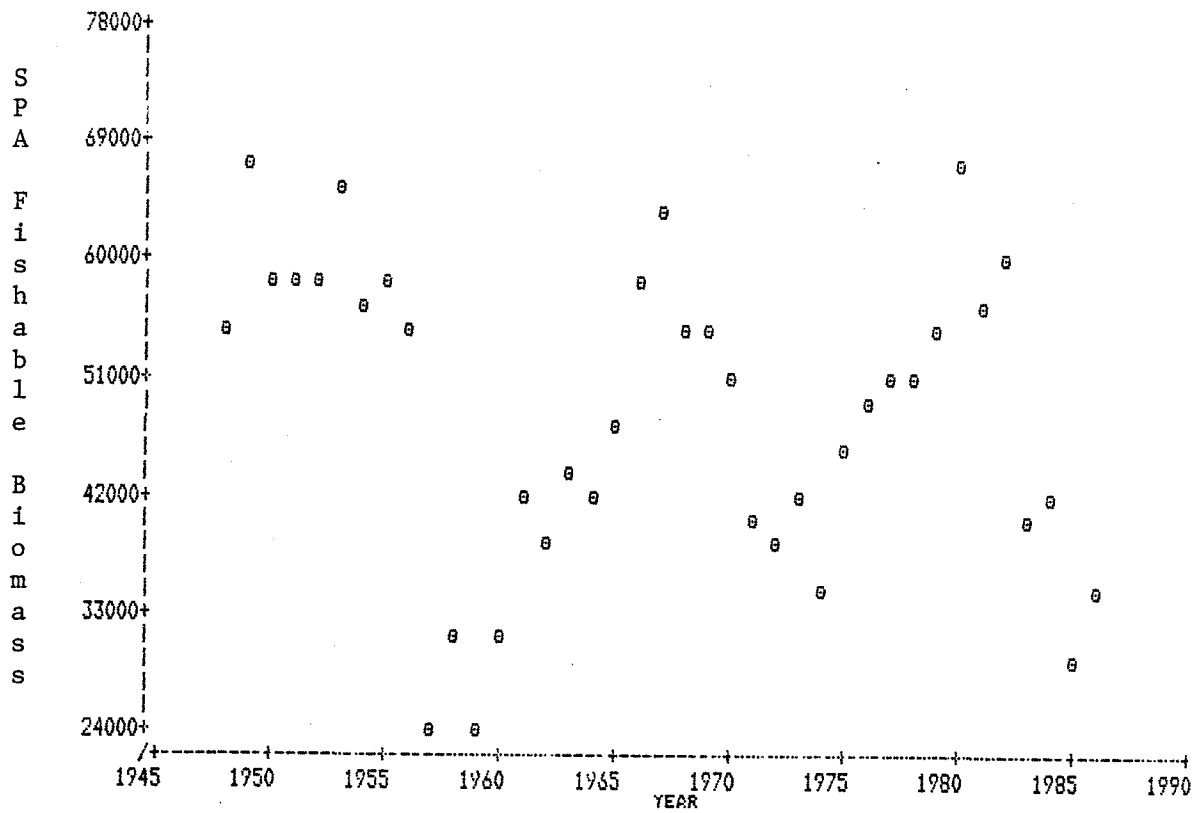
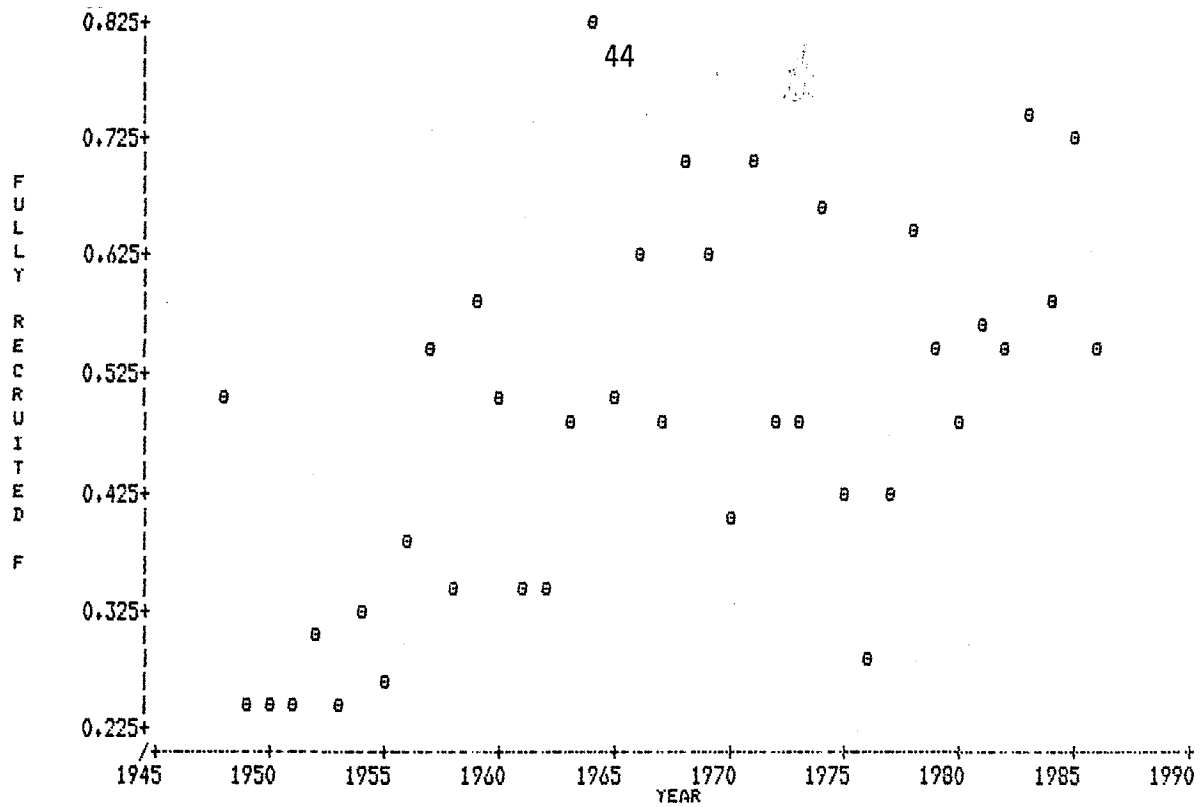


Figure 12. Historic estimates of: (Top) fully recruited F (age 6+) and (Bottom) fishable biomass. F_T was set at 0.55.

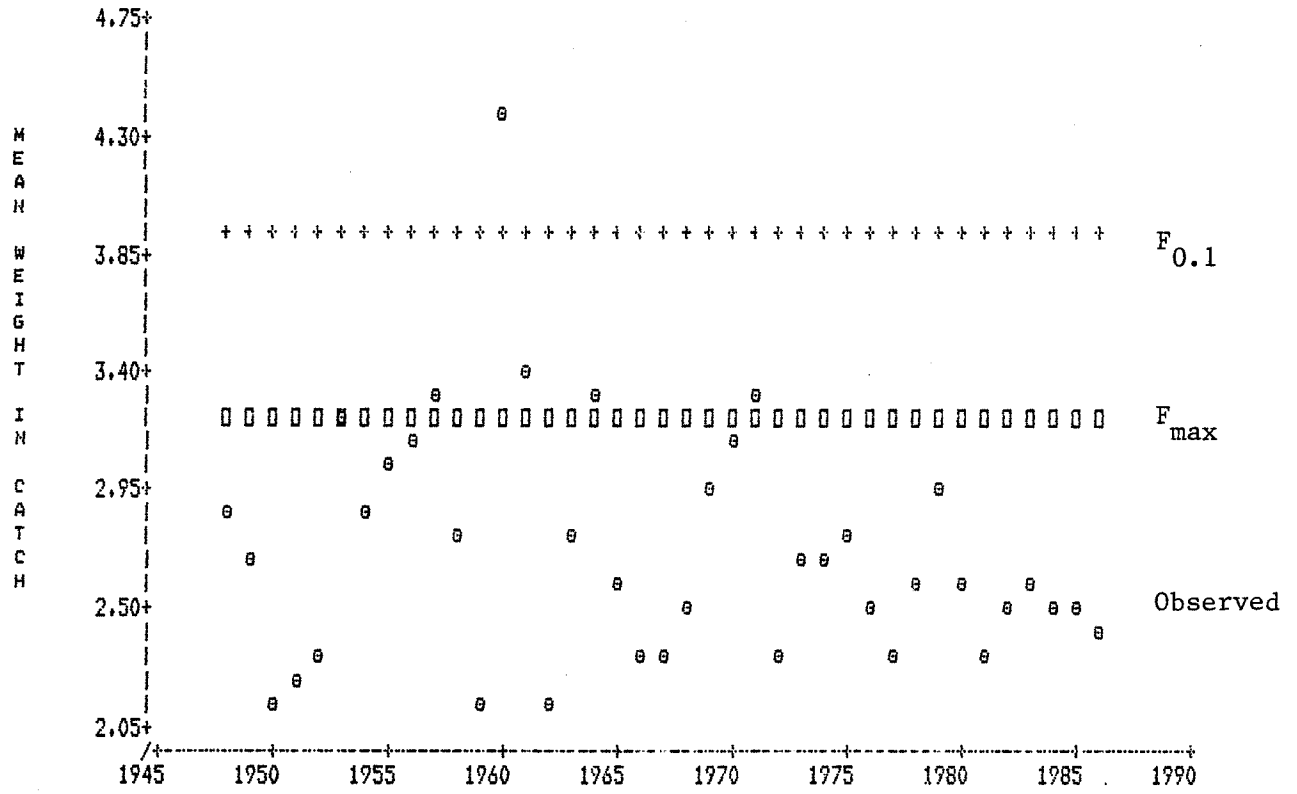


Figure 13. Observed and expected mean weight (kg) in catch.

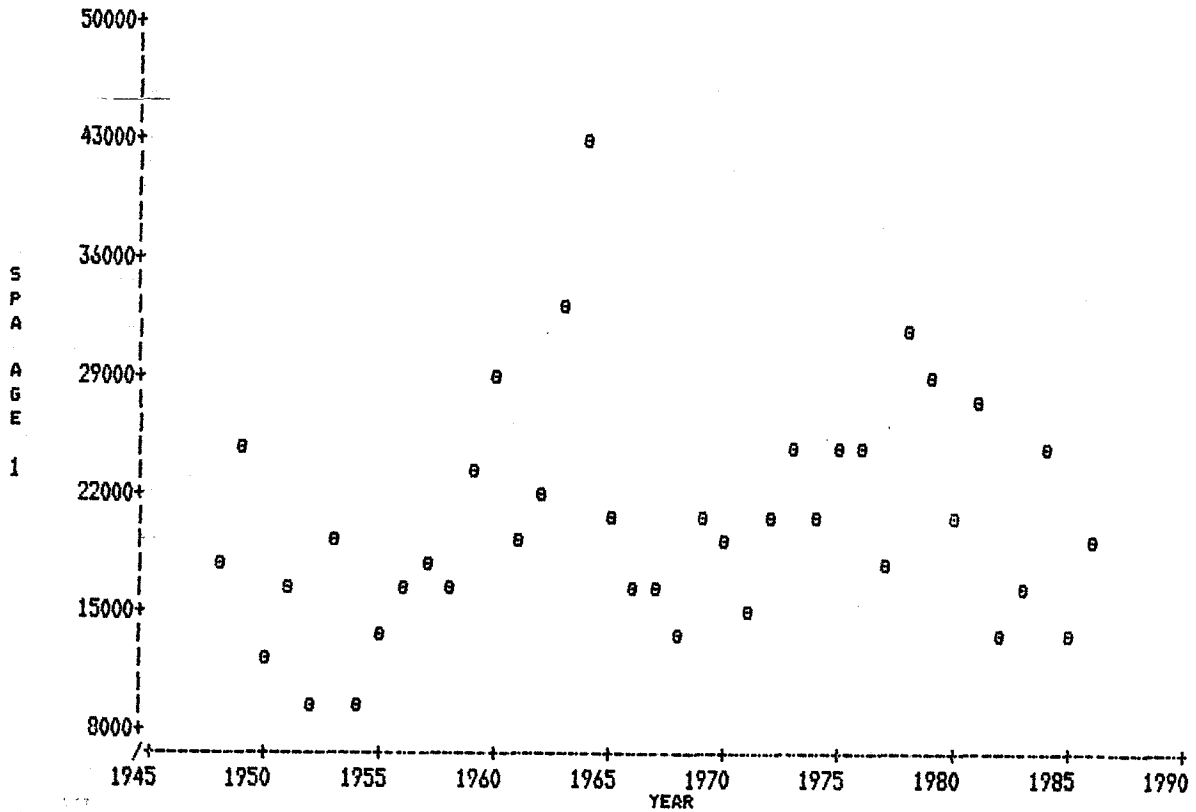


Figure 14. Recruitment time series (age 1 x 10^{-3}) for 4X cod as estimated from cohort analysis with $F_T = 0.55$. Value for 1985 has been adjusted as described in text. Value for 1986 is geometric mean of previous years.