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An assessment of the 4VW haddock stock for 1981 with projections to 1983

by

R. Mahon, G.N. White 3rd, B. Charlton, and P. Simpson

Marine Fish Division
Fisheries Research Branch
Dept. of Fisheries and Oceans
P.O. Box 1006
Dartmouth, N.S.
B2Y 4A2

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Abstract

Research vessel surveys and commercial catch rates indicate a slight decline in total stock biomass from a maximum in 1980. There has been a trend of decreasing size at age in recent years. Consequently although the 1981 quota was undercaught, $F_{0.1}$ was achieved. It was difficult to discriminate among a wide range of 1981 terminal fishing mortalities using conventional relationships. A terminal F of 0.35 was considered most appropriate for projection of catches. $F_{0.1}$ catches in 1982 and 1983 were 18,500 and 20,000 mt respectively. If the TAC is taken in 1982 (23,000 mt) the projected catch for 1983 is 19,000 mt.

Résumé

D'après les relevés des bateaux de recherche et les prises commerciales, la biomasse totale des stocks aurait légèrement diminué après avoir atteint un maximum en 1980. Ces dernières années, on a observé une tendance à la baisse du rapport taille-âge. Par conséquent, même si le quota de 1981 n'a pas été atteint, le $F_{0,1}$ a été atteint. De même en 1981, il a été difficile de distinguer les divers taux fixés mortalité au moyen des relations habituelles. On a considéré qu'un F fixé de 0,35 était des plus appropriés à la prévision des prises. Les prises $F_{0,1}$ en 1982 et 1983 s'élevaient à 18 500 et 20 000 tm respectivement. Si le TPA est atteint en 1982 (23 000 tm) la prise prévue en 1983 s'élèvera alors à 19 000 tm.

Introduction

In 1981 the TAC of 23,000 mt was undercaught by approximately 3,000 mt. Nonetheless the numbers of fish caught-at-age were similar to numbers-at-age projected in 1981 for the 23,000 mt TAC (Figure 1). The reason for this is that the average weights-at-age of fish in the catch were lower than those used for the projection. Lower weights-at-age may have been due to changes in the seasonal pattern of fishing, and also to a trend of decreased length-at-age over the last several years.

The reason for the quota underfill is unclear. It may have been due to the reported poor quality of the fish, or low catch rates. The latter does not appear to be the case.

Commercial Removals

1. Trends in Reported Landings

Nominal catches for the period 1954 through 1964 were between 20,000 mt and 30,000 mt with the exception of a catch of 38,000 mt in 1959 (Table 1, Figure 2). Following a catch of 55,000 mt in 1965 the fishery declined rapidly to a minimum catch of 1,360 mt in 1976. Prior to 1965 approximately two-thirds of the nominal catch was attributed to Div. 4W. However more recent catches have been largely confined to 4W.

Recent catches and TAC's ('000 mt) have been as follows:

	1975	1976	1977	1978	1979	1980	1981
TAC	(a)	2	2	2	2	15	23
Nominal catch	2	1	3	6	3	15	20*

* Provisional statistics
(a) "Lowest practicable level"

The 1982 quota was set at 23,000 t.

2. Distribution of Catch by Division, Gear and Season

The majority of the catch (90%) continues to be reported from 4W (Table 1). The fishery continues to be dominated by trawlers (Table 2) primarily TC4 and TC5. In 1981 the seasonal distribution of the otter trawl fishery returned to its historical pattern i.e. primarily in the spring (Table 3, Figure 3). Longliner catches were, as usual, concentrated in the late summer (Table 4).

3. Foreign Removals

Recent foreign removals are all by-catch, primarily in the USSR small-mesh fishery for silver hake (Table 1). The derivation of foreign removals in 1981 was according to White et al. (1981) (Table 5).

4. Length-Weight Relationships

The previous assessment of this stock raised questions about the validity of certain of the length-weight relationships available at that time (White et al. MS 1981). During the intervening year a length-weight database was prepared using such groundfish research vessel survey data as were available in machine readable form. This database contains the observed values of length and weight for each fish, together with a case weight for each fish, and also a factor which reflects the stratified sampling design. Relationships were obtained using the BMDP1R linear regression program (Brown 1977) on the central computer at BIO. It was found that the residuals were generally heavy tailed. By eliminating observations on fish shorter than 30 cm (that is, smaller than is generally found in commercial samples), the regressions improved dramatically.

This experience bears out the warning provided by Anscombe (1981, p. 262) that "the method of least squares should never be used blind". Since it is not feasible, given the time constraints on the conduct of an assessment, to perform an acceptable least-squares analysis, a new approach is required. Robust methods (Huber 1981) provide some hope that more automatic procedures can be developed. The use of robust procedures would require larger sample sizes to achieve a given precision. Since the size of a length-weight sample is usually dictated by more stringent requirements for ageing, sample size should not be a problem.

Sample by sample comparisons of the average weights of fish in a sample estimated from the sample weight ÷ sample number and by applying the length-weight relationship to the sample length frequency showed generally good agreement. The parameters of the relationships used in each year are given in Table 6. In three cases (Table 6) samples were excluded from the age-length keys because the average weight of the fish in the sample did not agree with that calculated using the length-weight relationship (Figure 4).

5. Age Composition of Reported Landings

The catch-at-age for the commercial landings was calculated in three parts (Table 7) which were subsequently combined with the Foreign small mesh removals:

OTB January - June
OTB July - December
All other gear January - December
Foreign removals January - December

The 1980 catch-at-age was revised (in four parts as above) using the new length-weight relationships (see above) which were considered more appropriate than those used for the 1981 assessment.

In previous assessments the age composition of the foreign small-mesh removals was assumed to be similar to that of the Research Vessel survey in the same year. Length-frequency distributions of OBSERVER PROGRAM samples from the USSR small-mesh fishery in July 1980 and 1981 differed substantially from the RV survey length-frequency (Figures 5a,b). The summer RV survey age-length key was applied to the OBSERVER PROGRAM length-

frequencies (Figures 5a,b) to obtain the age composition of the foreign removals.

The removals-at-age in numbers and weight are shown in Tables 8 and 9. The weights-at-age estimated from the commercial samples are in Table 10. Nominal catch estimated from weights-at-age times numbers-at-age is compared to reported nominal catch as a check (Figure 6).

Abundance Trends

Due to changing characteristics of the fishery CPUE estimates (Table 11, Figure 7) for recent years are unlikely to be comparable to earlier years (Figure 8). Apart from the usual technological changes; which affect catch rate series, there are two specific problems which diminish the interannual comparability of CPUE estimates for 4VW haddock in the last 12 years (Figure 7). The first is that in the mid 1970s there was little or no directed fishing and catch rates are based on very small total catches (Table 11). The second is the 1980 departure of the otter trawl fishery from its normal seasonal pattern (Figure 3).

The trends in the RV survey mean catch-per-standard-tow of biomass (Table 12) and of numbers-at-ages 3+ and 4+ (Table 13) are shown (Figures 8a,b,c). With estimates of the 95% confidence intervals in the most recent years (Table 14, Figure 9) calculated by a heuristic modification of the bootstrap method (White unpublished).

The RV mean catch-per-tow estimates in 1978 and 1980 were largely determined by single exceptional sets. Replacement of these sets by the next largest set in the same stratum (Winsorization) considerably reduces the overall stratified mean catch-per-standard tow (Table 15).

RV survey mean catch-per-standard-tow at ages 1 and 2 were summed (within cohorts) for use as a recruitment index. The mean catch-per-tow values for all available surveys (Table 16 - spring and fall included) were smoothed along cohorts using repeated medians of three smoothing with Tukey's end value rule (Tukey 1977).

Estimation of Stock Abundance

The following 5 relationships were examined with the purpose of determining an appropriate terminal F for input in cohort analysis. SPA beginning of year values were adjusted to midyear using loglinear interpolation. All calculations were performed using Pope's cohort formula.

a) SPA numbers, ages 3+ vs RV mean catch-per-standard-tow, ages 3+

b) SPA numbers, ages 5+ vs RV mean catch-per-standard-tow, ages 5+

c) SPA fishable biomass vs RV fishable biomass

Assuming full recruitment at age 5, partial recruitment of younger fish in each year was estimated as F-at-age divided by fully recruited F. Partial recruitment was assumed to be 1 for all fully recruited ages.

d) SPA fishable biomass vs weighted catch rate for OTB, TC4, and TC5 (Table 11)

e) SPA numbers, age 1 vs recruitment index

In each case the intercepts and R^2 values from least squares regressions were compared for terminal F values of 0.2, 0.35, and 0.5 (Table 17). With the above relationships we were unable to discriminate clearly among the 3 trial levels of terminal F. The "bootstrap" confidence intervals on mean catch-per-standard-tow at 3+ indicate that terminal F is unlikely to be less than 0.3 (Figure 9) i.e. exceeds $F_{0.1}$. However on the basis of the above relationships, and assuming that the RV estimate of fishable biomass is a minimum estimate, a terminal F value of 0.35 appeared to be most appropriate (Table 18). This value was adopted for further calculations, the results of the final SPA run are shown in Table 19 and Figures 9 to 13.

Projections

1. Growth

There have been pronounced changes in the average weight of individuals in commercial catches of 4VW haddock (Table 10, Figure 14). There is considerable variability in the observations during the mid-1970's when catches were low and, consequently, sampling was inadequate. Changes in seasonal pattern of the catches have obscured the changes in growth in recent years for which sampling is more satisfactory. Seasonal effects are not a problem in the summer research vessel surveys, but prior to 1977 low catches are.

A preliminary analysis of growth changes, similar to that of O'Boyle and White (unpublished), was conducted. Analysis of variance of residuals from a constant parameter growth model (length-at-age) showed a significant time trend (Figure 15) when applied to observations on individual fish collected during summer research surveys in 1977-1981.

This finding suggested further explorations using a model with time varying parameters. In order to obtain an adequate data set the mean lengths-at-age for the spring otter trawl fishery (1970-1981, ages 3-11) and the summer research survey (1977-1981, ages 3-8) were combined. For the years 1977-1981 these two data sets did not differ noticeably (Table 19) suggesting that the effects of growth and mesh selection were well below the level of uncertainty in the data. A regression analysis was conducted as described for 4X haddock (O'Boyle and White, unpublished). As expected, the variability in the data was considerable. However, in comparison to 4X haddock the recent decline in length-at-age appears to have affected all age groups at the same time (1978 or 1979) (Figure 16). In 4X the size of age 3 and 4 fish began to decline in 1978 or 1979 but older fish were not affected until 1980.

Historically, yearly observations have shown considerable variation in weights-at-age thus past practice has been to project on the basis of average weights from commercial samples over the past four years. This

weights-at-age thus past practice has been to project on the basis of average weights from commercial samples over the past four years. This procedure is even less appropriate this year because of the anomalous seasonal pattern in 1980 (Table 3, Figure 3) and the decreased importance of longliner catches (Table 2). Projections were based on the weights observed in the 1981 fishery. If the current trend continues these will be optimistic.

2. Results

The partial recruitment-at-age used for the Thompson and Bell yield per recruit analysis and for the catch projections was the same as in previous years (Waldron 1980, White et al. 1981), as the values calculated this year were not appreciably different.

Age	1	2	3	4	5	6	7	8	9	10	11
PR	0.04	0.05	0.18	0.55	0.67	1	1	1	1	1	1

Two catch projections were run; the first assuming that the TAC is caught in 1982 (Table 20), the second with the $F_{0.1}$ catch taken in 1982 (Table 21). The results of the above analyses are summarized in Table 22.

Conclusions

Research vessel surveys and commercial catch rates indicate a slight decline in total stock biomass from a maximum in 1980. There has been a trend of decreasing size at age in recent years. Consequently although the 1981 quota was undercaught, $F_{0.1}$ was achieved. It was difficult to discriminate among a wide range of 1981 terminal fishing mortalities using conventional relationships. A terminal F of 0.35 was considered most appropriate for projection of catches. $F_{0.1}$ catches in 1982 and 1983 were 18,500 and 20,000 mt respectively. If the TAC is taken in 1982 (23,000 mt) the projected catch for 1983 is 19,000 mt.

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Table 1. Nominal catches (mt) of eastern Scotian Shelf haddock (4TVW) by NAFO Division and country, as reported by NAFO.

	4T					4Vn(3)					4Vs					4W					All Areas & Countries	
Year	Canada	USA	USSR	Spain	Other	Canada	USA	USSR	Spain	Other	Canada	USA	USSR	Spain	Other	Canada	USA	USSR	Spain	Other		
1953	4742					3546										9357					17645	
1954	5918	1044			40	5549	405		1058	24						12323	1956		17		28334	
1955	3101	31				3339	450		1183	13						12777	1217				22111	
1956	2861					4899	147		1350	12						18273	1661		354		29557	
1957	1740	1				5869	120		747	9						19960	1533		132		30111	
1958	2599			151		3166	71		1343	6						17572	427		1593		26928	
1959	2996	1		64		1594	159		69		3456	111		2870		21156	4804		640		37920	
1960	2041					1317	6		97		1187	18		3926	1	20093	127		1024		29837	
1961	1297			273	2	1055	1		47	1	846			1526	7	22277	23	151	1441	16	28963	
1962	1132			10		1097	1		5	2	1235			1076		15566	51	2567	3224		25966	
1963	1019			46		1213	1	6	64		1061	1		2828	195	11002	60	3295	4915	866	26572	
1964	461			1		958			59	52	677	11		2057	2	9810	42	4391	2884	1889	23294	
1965	432			3	3	402			53	84	1201			1806	47	7007	8	42876	1500	96	55518	
1966	149			1		311		516	30		1494			940	9	8259	19	9985	1885	51	23649	
1967	112			9		203		95	26	31	898			839	9	7180	5	459	1046		10912	
1968	144				4	127			70	6	1128		59	1702	23	8392		195	1458	10	13318	
1969	167				3	245				112	726			631	66	8270		235	864	1	11320	
1970	160					395	2		75	1	620		34	830	16	4754	574	636	1332		9429	
1971	151					466			215	1	1133		11	1114		7940	497	464	1477		13469	
1972	60					362	3		136	19	421		3	599	37	2096	70	103	737	102	4748	
1973	21				2	286			76	164	233			431	9	2830	173	76	95	18	4414	(2)
1974	17				14	161			3	1	147		30	174	196	907	6	102	521	78	2357	(0)
1975	35				2	67			15	4	107	1		48	2	1393	20	52	63	59	1868	(0)
1976	12					40				1	52	1	9		1	1198	31	15			1360	(2000)
1977	8					189				8	144				1	2845	1	14		38	3248	(2000)
1978	18					119				3	441		3		38	4949	82	139		109	5901	(2000)
1979	59					194				11	650				3	2339		104		73	3433	(2000)
1980	76					181					1836					12411		247		30	14797	(15000)
(1)1981	176					118					1796					17684		271		22	20067	(23000)
1982																						(23000)

(1) Provisional 4/82
(2) TAC
(3) Catches for 1953-58 are for 4Vn and 4Vs combined.

Table 2. Nominal catches (mt) of eastern Scotian Shelf haddock in 4V and 4W (4TVW) by gear type for Canada (M,Q, & Nfld.) as reported by NAFO.

YEAR	OTTER TRAWLER	LONGLINER	DANISH SEINER	MISCELLANEOUS	TOTAL
1960	20835	1077	23	696	22631
61	22060	448	52	1377	23937
62	16453	665	76	705	17899
63	11943	511	147	526	13127
64	10679	70	62	874	11685
1965	8033	352	66	160	8611
66	10222	233	19	130	10604
67	7855	126	25	573	8579
68	8819	296	16	364	9495
69	8603	289	30	341	9263
1970	5056	479	20	262	5817
71	8709	538	77	179	9503
72	2141	528	76	138	2883
73	2459	628	28	232	3347
74	543	493	17	162	1215
1975	593	873	10	82	1558
76	383	657	10	75	1125
77	2198	729	26	170	3123
78	4009	1069	67	364	5509
79	1745	1232	64	142	3183
1980	13063	933	176	332	14504
81[1]	17859	1253	213	449	19774

[1] Preliminary

Table 3. Nominal catches (mt) of eastern Scotian Shelf haddock in 4V and 4W by month by Canadian (MQ) otter trawlers, as reported to NAFO

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1960	578	3372	4827	1328	1177	597	1427	1678	1543	1199	1665	1442	20833
1961	1387	2761	5029	6605	1389	324	508	489	859	927	1022	488	21788
1962	626	1863	4749	2401	1164	615	954	1079	1015	739	654	449	16308
1963	664	236	388	4444	1357	645	844	1079	1004	434	659	237	11991
1964	406	1531	1473	1557	1155	378	688	1082	804	359	342	638	10413
1965	347	819	1005	1114	986	350	1563	644	109	206	338	363	7844
1966	369	463	3301	1821	2151	264	247	138	136	63	262	101	9316
1967	198	294	4038	800	258	85	263	237	100	526	661	187	7647
1968	254	546	3302	782	730	901	602	114	317	391	650	408	8997
1969	888	1183	3108	1472	852	183	132	106	61	117	81	349	8532
1970	425	480	1436	1459	141	86	398	110	74	78	115	227	5029
1971	408	772	4740	1946	147	225	47	39	16	20	32	200	8592
1972	103	90	1022	280	105	221	19	56	26	18	49	128	2117
1973	93	155	1218	313	150	282	4	2	23	16	32	107	2395
1974	45	78	58	20	24	103	18	43	35	28	30	40	522
1975	25	71	68	124	65	20	85	9	40	34	20	27	588
1976	15	1	18	39	76	102	4	32	17	22	13	42	381
1977	44	90	79	57	217	37	49	114	184	180	297	796	2144
1978	118	151	669	1121	193	25	124	113	58	62	226	66	2926
1979	26	76	157	43	357	136	120	112	45	110	193	268	1643
1980	107	1165	2391	1099	316	486	744	676	411	1108	1444	1466	11413
1981	426	752	3099	3308	2006	607	513	213	105	590	346	290	12256

Table 4. Nominal catches (mt) of eastern Scotian Shelf haddock in 4V and 4W by month by Canadian (MQ) longliners, as reported to NAFO

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1960	50	122	76	66	18	-	133	80	172	25	190	145	1077
1961	3	36	23	35	6	1	8	13	63	64	159	81	492
1962	13	1	74	2	7	6	25	33	67	145	206	86	665
1963	25	3	4	49	9	17	26	30	49	85	68	52	417
1964	3	-	3	5	3	-	-	-	-	23	12	22	71
1965	17	41	27	65	23	10	5	23	28	39	53	21	352
1966	-	24	71	11	-	-	7	12	9	52	30	17	233
1967	3	1	19	10	-	3	7	5	15	29	25	9	126
1968	10	19	17	42	10	10	12	42	42	49	38	6	297
1969	1	1	8	8	4	9	25	56	39	68	53	17	289
1970	19	4	43	22	12	12	25	57	120	110	40	15	479
1971	-	14	12	33	18	26	94	61	106	107	38	29	538
1972	-	-	3	9	17	26	102	88	73	111	81	18	528
1973	1	6	115	149	47	40	39	62	56	78	59	17	669
1974	10	4	16	20	27	44	74	78	59	71	63	27	493
1975	31	37	69	78	93	81	74	138	88	105	57	24	875
1976	20	36	93	113	71	56	106	85	72	70	57	17	796
1977	15	33	55	36	42	86	65	92	72	116	100	34	746
1978	31	63	78	104	121	116	175	166	105	53	49	8	1069
1979	5	18	123	109	129	110	148	215	142	94	109	30	1232
1980	4	2	36	98	103	111	125	189	98	89	32	12	899
1981	4	29	152	37	82	68	142	168	173	196	189	82	1325

Table 5. Derivation of adjusted nominal catch (mt) of eastern Scotian Shelf haddock (4TVW) for 1981 by foreign countries, as determined by International Observer Program.

Country	Directed Species	Nominal catch of 4VW haddock in all fisheries (FLASH)	Observed catch of 4VW haddock in directed fisheries (OBS)	Observed catch of directed species (OBS)	Nominal catch of directed species (FLASH)	Ratio 4 ÷ 5	Estimated by-catch of 4VW haddock in directed fishery
1	2	3	4	5	6	7	(6x7)
Cuba	silver hake	16.81	13.0	424.3	500.6	0.031	15.5
Japan	squid	6.11	3.8	3543.6	5987.2	0.001	6.0
USSR	silver hake	193.41	138.6	18443.3	35994.6	0.0075	270.0
Total							291.5

Table 6. Parameters used to calculate removals-at-age.

PERIOD	A	B	RESEARCH SURVEY
1970-1975	0.00885	3.039	Summer 1975 (Cameron)
1976	0.00553	3.160	Summer 1976 (Cameron)
1977	0.00909	3.041	Summer 1977 (Cameron)
1978	0.00580	3.152	Summer 1978 (Cameron)
1979	0.00640	3.126	Summer 1979 (Cameron)
1980 (OTB, Jan.-June)	0.00610	3.124	Spring 1980 (Hammond) [1,2]
1980 (OTB, July-Dec.)	0.00475	3.204	Fall 1980 (Hammond) [2]
1980 (All other, Jan.-Dec.)	0.00610	3.268	Summer 1980 (Cameron)
1981 (OTB, Jan.-June)	0.10900	2.988	Summer 1981 (Cameron) [1,2]
1981 (OTB, July-Dec.)	0.00824	3.066	Summer 1981 (Cameron)
1981 (All other, Jan.-Dec.)	0.00824	3.066	Summer 1981 (Cameron)

[1] Fish < 30cm excluded

[2] Outlier samples excluded from Age Length Key.

Table 7. Nominal catch, number of commercial samples and number of fish aged in each period and gear category for which catch-at-age was calculated (1980 and 1981).

	1980	1981	
OTB Jan.-June	6997	15,778	(Catch)
	24	29	(# Samples)
	759	642	(# Aged)
OTB July-Dec.	6066	2081	(Catch)
	22	14	(# Samples)
	619	374	(# Aged)
OTHER Jan.-Dec. (L.L., SND, Etc.)	1441	1915	(Catch)
	6	15	(# Samples)
	180	407	(# Aged)

Table 8. a) Removals-at-age ('000) from the 4VW haddock stock
b) Percent age composition of removals in numbers

(a)

Age	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81
1	348	309	295	329	38	386	294	37	141	1	1015	1289
2	132	681	207	1132	224	55	613	149	165	146	74	221
3	675	849	600	545	948	404	144	986	860	472	2424	257
4	1718	2126	718	1359	240	736	191	413	2234	1196	4274	5067
5	1407	2651	911	806	449	272	244	542	434	669	3184	5094
6	1381	1177	675	703	291	183	144	245	725	156	1667	3013
7	1196	918	339	325	109	63	102	94	211	142	244	1184
8	390	1150	186	155	44	30	29	56	62	14	126	140
9	91	270	155	69	8	8	6	14	24	6	39	105
10	38	38	10	102	14	4	7	8	9	4	10	29
11	18	20	18	2	12	1	2	5	2	2	7	10
12	16	24	0	4	0	2	8	4	0	0	2	2
13	6	4	10	3	1	2	30	1	1	0	1	3
14	4	2	0	1	0	0	0	0	1	1	0	2
15	0	1	0	0	0	0	0	0	0	1	1	0
16	0	0	0	0	0	0	0	0	0	0	0	0
TOT	7420	10221	4125	5533	2378	2146	1815	2554	4869	2812	13067	16415

(b)

Age	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81
1	4.7	3.0	7.2	5.9	1.6	18.0	16.2	1.4	2.9	0.0	7.8	7.9
2	1.8	6.7	5.0	20.5	9.4	2.5	33.8	5.8	3.4	5.2	0.6	1.3
3	9.1	8.3	14.5	9.8	39.9	18.8	8.0	38.6	17.7	16.8	18.5	1.6
4	23.2	20.8	17.4	24.6	10.1	34.3	10.5	16.2	45.9	42.5	32.7	30.9
5	19.0	25.9	22.1	14.6	18.9	12.7	13.4	21.2	8.9	23.8	24.4	31.0
6	18.6	11.5	16.4	12.7	12.2	8.5	7.9	9.6	14.9	5.5	12.8	18.4
7	16.1	9.0	8.2	5.9	4.6	3.0	5.6	3.7	4.3	5.0	1.9	7.2
8	5.3	11.3	4.5	2.8	1.8	1.4	1.6	2.2	1.3	0.5	1.0	0.9
9	1.2	2.6	3.8	1.2	0.3	0.4	0.3	0.5	0.5	0.2	0.3	0.6
10	0.5	0.4	0.3	1.9	0.6	0.2	0.4	0.3	0.2	0.1	0.1	0.2
11	0.2	0.2	0.4	0.0	0.5	0.0	0.1	0.2	0.0	0.1	0.1	0.1
12	0.2	0.2	0.0	0.1	0.0	0.1	0.4	0.1	0.0	0.0	0.0	0.0
13	0.1	0.0	0.2	0.0	0.0	0.1	1.7	0.0	0.0	0.0	0.0	0.0
14	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9. a) Nominal catch-at-age (mt) for the 4VW haddock stock
b) Percent age composition of nominal catch weight

(a)

Age	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81
1	51	46	44	49	6	57	26	5	12	0	81	103
2	54	278	85	462	91	22	206	83	51	47	17	90
3	445	584	431	393	618	329	96	898	586	342	1710	177
4	1576	2102	751	1402	281	909	220	501	2426	1381	4385	4869
5	1730	3437	1272	1112	718	428	385	819	667	1070	4341	6401
6	2154	1941	1197	1292	595	365	297	461	1454	318	3126	5000
7	2372	1842	738	707	275	156	248	217	517	349	576	2551
8	938	2692	467	403	126	87	79	151	173	41	345	371
9	259	718	455	204	25	26	19	42	79	18	125	315
10	125	116	34	327	48	14	24	28	35	13	34	98
11	69	66	64	5	43	4	9	21	10	9	27	35
12	67	90	0	14	0	6	29	16	0	0	8	9
13	27	16	39	13	4	8	112	4	4	2	3	15
14	21	11	0	5	0	0	0	0	5	3	0	4
15	0	5	0	0	0	0	0	0	0	3	3	2
16	0	0	0	0	0	0	0	0	0	0	0	0
TOT	9887	13944	5576	6389	2831	2411	1751	3245	6019	3598	14781	20040

(b)

Age	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81
1	0.5	0.3	0.8	0.8	0.2	2.4	1.5	0.2	0.2	0.0	0.5	0.5
2	0.5	2.0	1.5	7.2	3.2	0.9	11.7	2.5	0.8	1.3	0.1	0.5
3	4.5	4.2	7.7	6.2	21.8	13.6	5.5	27.7	9.7	9.5	11.6	0.9
4	15.9	15.1	13.5	21.9	9.9	37.7	12.6	15.4	40.3	38.4	29.7	24.3
5	17.5	24.6	22.8	17.4	25.4	17.7	22.0	25.2	11.1	29.7	29.4	31.9
6	21.8	13.9	21.5	20.2	21.0	15.2	17.0	14.2	24.2	8.8	21.1	24.9
7	24.0	13.2	13.2	11.1	9.7	6.5	14.2	6.7	8.6	9.7	3.9	12.7
8	9.5	19.3	8.4	6.3	4.4	3.6	4.5	4.7	2.9	1.1	2.3	1.9
9	2.6	5.2	8.2	3.2	0.9	1.1	1.1	1.3	1.3	0.5	0.8	1.6
10	1.3	0.8	0.6	5.1	1.7	0.6	1.3	0.9	0.6	0.4	0.2	0.5
11	0.7	0.5	1.1	0.1	1.5	0.2	0.5	0.6	0.2	0.2	0.2	0.2
12	0.7	0.6	0.0	0.2	0.0	0.3	1.7	0.5	0.0	0.0	0.1	0.0
13	0.3	0.1	0.7	0.2	0.2	0.3	6.4	0.1	0.1	0.1	0.0	0.1
14	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 10. Estimated midyear weights-at-age (kg) from commercial samples of 4VW haddock

Age	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81
1	0.15	0.15	0.15	0.15	0.15	0.15	0.09	0.13	0.08	0.11	0.08	0.08
2	0.41	0.41	0.41	0.41	0.41	0.41	0.34	0.56	0.31	0.32	0.23	0.41
3	0.66	0.69	0.72	0.72	0.65	0.81	0.67	0.91	0.68	0.72	0.71	0.69
4	0.92	0.99	1.05	1.03	1.17	1.23	1.16	1.21	1.09	1.15	1.03	0.96
5	1.23	1.30	1.40	1.38	1.60	1.58	1.58	1.51	1.54	1.60	1.36	1.26
6	1.56	1.65	1.77	1.84	2.05	1.99	2.07	1.88	2.00	2.04	1.88	1.66
7	1.98	2.01	2.18	2.17	2.52	2.45	2.44	2.31	2.45	2.46	2.36	2.16
8	2.41	2.34	2.51	2.61	2.88	2.89	2.77	2.68	2.81	2.83	2.73	2.66
9	2.85	2.66	2.93	2.96	3.13	3.25	3.13	3.07	3.26	3.22	3.24	3.02
10	3.32	3.05	3.25	3.19	3.39	3.27	3.36	3.45	3.85	3.49	3.58	3.32
11	3.74	3.32	3.45	2.94	3.59	4.62	3.74	3.86	4.25	3.77	3.69	3.63
12	4.09	3.66	-	3.65	-	3.67	3.80	4.17	-	3.70	4.29	4.53
13	4.78	3.92	3.82	4.76	3.82	4.69	3.70	4.27	3.68	4.26	5.37	4.52
14	5.37	4.47	-	5.15	-	-	-	-	5.42	4.48	-	2.52
15	-	4.30	-	-	-	-	-	-	-	4.64	4.30	5.75

1970-1979 values from the previous assessment.

Table 11. Catch rates (mt/hr fishing) exhibited by Canadian otter trawl fishery (side and stern) during the February-June period from 1970 to the present. Catch (mt) given in parentheses.

Year	TC 3	TC 4	TC 5	Weighted* TC 4 and TC 5
1970	0.349	0.366 (1496)	0.475 (1025)	0.410
1971	0.158	0.332 (3116)	0.497 (3482)	0.419
1972	0.143	0.245 (385)	0.311 (439)	0.280
1973	-	0.212 (579)	0.364 (434)	0.277
1974	-	0.201 (31)	0.240 (28)	0.222
1975	0.124	0.275 (14)	0.298 (28)	0.290
1976	0.080	0.318 (96)	0.191 (30)	0.288
1977	0.188	0.228 (106)	0.413 (153)	0.337
1978	0.413	0.665 (1366)	0.737 (949)	0.695
1979	0.189	0.492 (31)	0.484 (49)	0.487
1980	0.450	0.863 (2303)	1.690 (3020)	1.332
1981	0.580	0.813 (4899)	1.540 (7252)	1.247

* Mean catch rate weighted by catch in parentheses after TC 4 and TC 5.

Table 12. Catch-(kg)-per-standard-tow by summer groundfish survey in 4VW

	AREA (Strata)					
YEAR	4Vn 40-42	4Vs 43-46	4Vs 47-52	4V[1] 50-52	4W 53-66	4VW[2] 40-66
1970	2.38	-	15.13	5.11	10.59	8.03
1971	0.00	0.19	1.50	0.52	9.01	5.18
1972	0.00	1.92	2.63	1.67	4.16	3.04
1973	0.15	0.13	0.90	0.36	5.07	2.94
1974	0.00	-	1.54	0.44	9.09	5.19
1975	0.37	0.00	2.57	0.83	12.33	7.14
1976	1.64	-	2.57	1.13	8.07	4.94
1977	3.08	0.17	7.28	2.90	28.86	17.15
1978	0.87	-	0.03	0.21	40.38	22.26
1979	0.11	0.16	0.97	0.38	40.18	22.22
1980	0.50	0.60	2.39	1.09	60.01	33.43
1981	4.21	1.19	1.25	1.92	31.73	18.28

[1] 4V = 0.2367 x 4Vn + 0.4758 (43-46) + 0.2875 (47-52)

[2] 4VW = 0.4512 x 4V + 0.5488 x 4W

Table 13 . a) Mean catch-per-standard-tow in July RV surveys, for 4VW haddock
b) Percent mean catch-per-tow in a)

(a)

Age	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81
0	0.09	0.05	0.01	0.00	0.19	0.06	0.25	0.21	0.00	1.24	1.20	18.52
1	2.27	1.44	1.10	0.48	0.30	3.85	2.74	5.01	8.25	0.07	2.93	13.51
2	0.84	3.02	0.74	1.59	1.79	0.55	3.01	9.49	9.23	7.61	0.23	7.65
3	1.53	1.00	1.08	0.48	2.42	1.60	0.42	7.49	12.34	8.28	12.40	0.80
4	1.70	1.32	0.49	0.45	0.44	1.43	0.82	1.02	6.93	8.61	11.60	5.95
5	0.82	0.52	0.41	0.16	0.45	0.37	0.79	1.62	0.43	2.41	7.21	3.73
6	0.52	0.30	0.31	0.33	0.23	0.68	0.18	0.60	0.41	0.31	1.74	1.64
7	0.58	0.14	0.12	0.07	0.17	0.17	0.19	0.17	0.10	0.25	0.28	0.26
8	0.30	0.21	0.06	0.08	0.07	0.07	0.05	0.10	0.01	0.08	0.10	0.07
9	0.13	0.01	0.03	0.03	0.04	0.04	0.01	0.00	0.00	0.00	0.02	0.08
10	0.03	0.00	0.02	0.04	0.03	0.04	0.01	0.06	0.01	0.03	0.00	0.01
11	0.03	0.00	0.00	0.00	0.03	0.00	0.01	0.01	0.01	0.02	0.00	0.00
12+	0.04	0.00	0.00	0.00	0.00	0.02	0.05	0.02	0.00	0.01	0.00	0.00
UK	0.00	0.00	0.04	0.00	0.01	0.01	0.27	0.08	0.03	0.00	0.04	0.03

(b)

Age	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81
0	0.99	0.62	0.31	0.00	3.12	0.68	2.81	0.81	0.00	4.29	3.18	35.44
1	25.58	17.95	24.95	12.95	4.92	43.29	31.12	19.38	21.85	0.26	7.75	25.86
2	9.52	37.81	16.85	42.93	28.98	6.14	34.18	36.68	24.44	26.32	0.61	14.64
3	17.27	12.45	24.50	12.89	39.21	17.97	4.81	28.95	32.69	28.64	32.86	1.53
4	19.21	16.46	11.09	12.12	7.15	16.08	9.36	3.93	18.36	29.75	30.74	11.39
5	9.19	6.54	9.24	4.44	7.36	4.21	8.95	6.25	1.13	8.34	19.10	7.14
6	5.90	3.69	6.94	8.88	3.65	7.69	2.00	2.31	1.08	1.08	4.61	3.14
7	6.55	1.72	2.77	1.85	2.73	1.95	2.18	0.66	0.28	0.85	0.74	0.50
8	3.34	2.63	1.37	2.22	1.09	0.80	0.56	0.38	0.03	0.28	0.26	0.13
9	1.41	0.14	0.75	0.74	0.62	0.43	0.12	0.00	0.00	0.00	0.04	0.15
10	0.31	0.00	0.37	0.98	0.49	0.47	0.12	0.22	0.03	0.11	0.00	0.02
11	0.34	0.00	0.00	0.00	0.52	0.00	0.12	0.02	0.04	0.06	0.00	0.00
12+	0.40	0.00	0.00	0.00	0.00	0.19	0.56	0.07	0.00	0.02	0.00	0.00
UK	0.00	0.00	0.87	0.00	0.15	0.10	3.11	0.32	0.07	0.00	0.10	0.06

Table 14. Confidence intervals for summer groundfish surveys - 4VW haddock.

	Biomass (kg per-standard-tow)				3+ numbers-per-standard-tow				4+ numbers-per-standard-tow			
Year	Stratified Mean	Bootstrap Estimate	95% Confidence	Interval	Stratified Mean	Bootstrap Estimate	95% Confidence	Interval	Stratified Mean	Bootstrap Estimate	95% Confidence	Interval
1977	17.2	17.1	9.1	26.7	11.2	10.8	5.5	17.4	3.7	3.6	2.0	5.4
1978	22.3	21.7	8.8	42.8	20.3	19.8	7.4	41.1	7.9	7.9	3.3	15.2
1979	22.2	22.0	10.4	38.9	20.0	19.6	8.4	36.3	11.7	11.4	5.6	20.2
1980	33.4	32.8	14.1	57.3	33.4	32.8	13.4	58.5	21.0	20.4	8.3	37.8
1981	18.3	18.3	11.3	25.5	12.7	12.5	7.2	18.5	11.8	11.7	6.7	17.3

Table 15. Changes in RV mean catch-per-standard-tow after Winsorization (adjusted estimate - original estimate)

Age	1978	1980
0	0	0
1	-2.68	-0.06
2	-4.66	5.79
3	-5.72	-2.96
4	-2.69	-4.96
5	-0.22	-3.52
6	-0.16	-0.47
7	-0.04	-0.04
8	0	-0.01
9	0	0
10	0	0
11	0	0
12+	0	0
UK	0	0

Table 16. Mean catch-per-standard-tow in all available surveys (Su = summer, Sp = spring, Fa = Fall)

Age	Su70	Su71	Su72	Su73	Su74	Su75	Su76	Su77	Su78	Sp79	Su79	Fa79	Sp80	Su80	Fa80	Su81
0	0.09	0.05	0.01	0.00	0.19	0.06	0.25	0.21	0.00	0.00	1.24	8.63	0.00	1.20	53.79	18.52
1	2.27	1.44	1.10	0.48	0.30	3.85	2.74	5.01	8.25	0.09	0.07	0.20	4.32	2.93	7.66	13.51
2	0.84	3.02	0.74	1.59	1.79	0.55	3.01	9.49	9.23	2.26	7.61	6.32	0.23	0.23	1.16	7.65
3	1.53	1.00	1.08	0.48	2.42	1.60	0.42	7.49	12.34	3.84	8.28	11.03	7.74	12.40	6.84	0.80
4	1.70	1.32	0.49	0.45	0.44	1.43	0.82	1.02	6.93	5.99	8.61	7.56	2.30	11.60	7.08	5.95
5	0.82	0.52	0.41	0.16	0.45	0.37	0.79	1.62	0.43	3.02	2.41	1.25	1.92	7.21	3.01	3.73
6	0.52	0.30	0.31	0.33	0.23	0.68	0.18	0.60	0.41	0.56	0.31	0.32	0.71	1.74	0.84	1.64
7	0.58	0.14	0.12	0.07	0.17	0.17	0.19	0.17	0.10	0.54	0.25	0.24	0.24	0.28	0.09	0.26
8	0.30	0.21	0.06	0.08	0.07	0.07	0.05	0.10	0.01	0.15	0.08	0.03	0.15	0.10	0.02	0.07
9	0.13	0.01	0.03	0.03	0.04	0.04	0.01	0.00	0.00	0.03	0.00	0.00	0.06	0.02	0.05	0.08
10	0.03	0.00	0.02	0.04	0.03	0.04	0.01	0.06	0.01	0.04	0.03	0.00	0.01	0.00	0.01	0.01
11	0.03	0.00	0.00	0.00	0.03	0.00	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00
12+	0.04	0.00	0.00	0.00	0.00	0.02	0.05	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.05	0.00
UK	0.00	0.00	0.04	0.00	0.01	0.01	0.27	0.08	0.03	0.02	0.00	0.04	0.00	0.04	0.00	0.03

Table 17. R^2* and intercept values for various relationships at various terminal Fs.

	R^2/intercept		
Terminal F	0.20	0.35	0.50
a) SPA 3+ vs RV 3+	0.922 -6470	0.920 -175	0.911 2340
b) SPA 5+ vs RV 5+	0.923 -1105	0.884 391	0.828 988
c) SPA vs RV fishable biomass	0.9403 -4157	0.887 1046	0.8233 3151
d) SPA fishable biomass vs OTB catch rate	0.882 -11861	0.921 -4081	.801 -1140
e) SPA age 1 numbers vs recruitment index	0.779 -4444	0.805 -878	0.821 544

* 1981 point not included.

Table 18. Comparison of SPA and RV estimates of fishable biomass at F_t values of 0.2, 0.35, and 0.5.

	Fishable Biomass					
	F_t = 0.2		F_t = 0.35		F_t = 0.5	
YEAR	RV	SPA	RV	SPA	RV	SPA
1970	16359	23447	16366	23442	16369	23437
1971	8739	19838	8755	19828	8761	19820
1972	5960	9937	5969	9890	5971	9866
1973	5265	7786	5301	7730	5314	7703
1974	8041	5049	8107	4866	8130	4789
1975	14518	7616	14692	7090	14781	6886
1976	6834	5717	6917	5084	6965	4835
1977	15681	11940	16141	10069	16429	9332
1978	14027	17920	14669	14133	15091	12633
1979	24996	38597	25713	27279	26254	22795
1980	58526	90456	60076	60627	61409	48808
1981	32262	118797	32262	71645	32262	52878

Table 19. Cohort analysis of the 4VW haddock stock using F_t = 0.35

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	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	7693	4081	7945	8239	5723	28630	42605	69256	62342	7026	18304	102247
2	5330	5984	3062	6238	6448	4651	23091	34615	56669	50913	5751	14067
3	6981	4245	4284	2319	4083	5077	3758	18350	28204	46247	41552	4642
4	7477	5105	2707	2964	1406	2485	3791	2946	14131	22315	37436	31826
5	4072	4567	2255	1567	1197	934	1368	2931	2039	9549	17188	26783
6	3254	2061	1340	1022	554	574	519	900	1909	1276	7212	11191
7	3386	1414	622	487	201	191	304	295	515	907	904	4396
8	817	1691	328	203	104	66	99	157	156	231	614	519
9	204	316	344	99	26	46	27	55	78	72	176	388
10	79	85	14	141	19	14	30	16	33	42	54	109
11	46	31	35	2	23	3	8	18	6	19	31	35
1+	39340	29579	22937	23282	19785	42670	75599	129539	166082	138596	129221	196205

FISHING MORTALITY 17/ 6/82

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.051	0.087	0.042	0.045	0.007	0.015	0.008	0.001	0.003	0.000	0.063	0.014
2	0.028	0.134	0.078	0.224	0.039	0.013	0.030	0.005	0.003	0.003	0.014	0.017
3	0.113	0.250	0.168	0.301	0.297	0.092	0.043	0.061	0.034	0.011	0.067	0.063
4	0.293	0.617	0.347	0.706	0.209	0.397	0.057	0.168	0.192	0.061	0.135	0.192
5	0.481	1.026	0.591	0.840	0.535	0.388	0.219	0.229	0.268	0.081	0.229	0.234
6	0.633	0.997	0.813	1.426	0.866	0.435	0.366	0.358	0.545	0.145	0.295	0.350
7	0.495	1.262	0.921	1.341	0.917	0.458	0.462	0.436	0.602	0.190	0.354	0.350
8	0.749	1.393	0.992	1.843	0.621	0.699	0.387	0.505	0.574	0.071	0.258	0.350
9	0.677	2.808	0.690	1.461	0.417	0.218	0.294	0.319	0.421	0.090	0.278	0.350
10	0.747	0.678	1.603	1.621	1.737	0.397	0.296	0.789	0.361	0.107	0.217	0.350
11	0.580	1.220	0.840	1.450	0.840	0.440	0.390	0.390	0.550	0.150	0.300	0.350
1+	0.256	0.584	0.255	0.375	0.163	0.063	0.028	0.024	0.036	0.023	0.121	0.103

Table 20. Lengths at age used for non-linear regresion a) for research vessel, b) for commercial samples (OTB Jan-Jun. inclusive), and c) the difference between a and b for corresponding ages and years.

(a)

Age	1976	1977	1978	1979	1980	1981
3	38.060	42.020	40.060	39.390	39.420	37.800
4	47.960	47.210	46.710	45.680	45.550	44.590
5	52.700	55.310	52.310	50.570	49.640	48.990
6	56.450	55.660	57.600	55.780	54.910	53.800
7	60.980	60.610	62.700	59.390	60.360	59.710
8	62.370	64.990	56.500*	64.400	64.980	61.130

(b)

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
3	38.900	39.790	41.040	39.690	38.780	39.400	35.710	44.450	41.110	42.150	38.390	39.140
4	43.610	44.970	45.140	44.830	45.910	45.090	49.860	48.320	46.670	48.900	45.620	43.950
5	48.630	50.260	50.770	51.080	53.960	49.810	55.610	52.210	52.630	52.950	50.220	48.810
6	52.040	53.840	55.740	55.380	56.560	57.420	57.590	55.960	57.350	58.950	55.720	53.420
7	56.830	56.610	58.420	60.350	62.830	62.380	60.410	61.490	61.330	61.570	60.550	58.430
8	61.090	60.120	60.480	62.420	66.000	65.130	64.480	61.860	65.400	62.770	63.100	62.580
9	65.390	64.500	65.110	66.160	—	68.640	62.500	65.210	66.900	70.340	66.210	64.360
10	71.870	68.440	71.820	67.730	68.500	—	64.500	68.370	67.070	66.020	68.800	67.350
11	64.500*	70.480	69.310	—	70.500	72.500	72.250	69.270	69.780	68.500	69.930	68.280

(c)

Age	1976	1977	1978	1979	1980	1981
3	2.350	-2.430	-1.050	-2.760	1.030	-1.340
4	-1.900	-1.110	0.040	-3.220	-0.070	0.640
5	-2.910	3.100	-0.320	-2.380	-0.580	0.180
6	-1.140	-0.300	0.250	-3.170	-0.810	0.380
7	0.570	-0.880	1.370	-2.180	-0.190	1.280
8	-2.110	3.130	-8.900*	1.630	1.880	-1.450

	Average difference
1978 age 8 included	-0.649
1978 age 8 excluded	-0.413

*excluded from subsequent analysis

Table 21. Catch projection for 4VW haddock at F_t = 0.35, assuming that the TAC (23,000 mt) is taken in 1982

CATCH NUMBERS 11/ 5/82

	1981	1982	1983	1984	1985
1	1289	236	183	183	183
2	221	963	184	185	185
3	257	1933	2119	525	527
4	5067	623	3338	4764	1180
5	5094	4474	391	2775	3962
6	3013	5082	3205	373	2650
7	1184	1892	2276	1944	226
8	140	743	847	1380	1179
9	105	88	333	514	837
10	29	66	39	202	312
11	10	18	29	24	122
1+	16408	16118	12943	12869	11362

CATCH BIOMASS 11/ 5/82

	1981	1982	1983	1984	1985
1	103	19	15	15	15
2	90	392	75	75	75
3	177	1332	1460	362	363
4	4869	599	3207	4578	1134
5	6401	5621	491	3487	4978
6	5000	8434	5318	619	4397
7	2551	4078	4904	4189	488
8	371	1974	2250	3666	3132
9	315	265	1004	1549	2525
10	98	218	131	671	1036
11	35	67	107	86	444
1+	20010	23000	18962	19299	18586

FISHING MORTALITY 11/ 5/82

	1981	1982	1983	1984	1985
1	0.021	0.015	0.012	0.012	0.012
2	0.006	0.019	0.015	0.015	0.015
3	0.063	0.070	0.054	0.054	0.054
4	0.192	0.213	0.165	0.165	0.165
5	0.234	0.260	0.201	0.201	0.201
6	0.350	0.387	0.300	0.300	0.300
7	0.350	0.387	0.300	0.300	0.300
8	0.350	0.387	0.300	0.300	0.300
9	0.350	0.387	0.300	0.300	0.300
10	0.350	0.387	0.300	0.300	0.300
11	0.350	0.387	0.300	0.300	0.300

POPULATION NUMBERS 11/ 5/82

	1981	1982	1983	1984	1985
1	69000	16923	16923	16923	16923
2	38865	55329	13642	13690	13690
3	4642	31620	44430	11003	11041
4	31826	3568	24144	34464	8535
5	26783	21494	2361	16761	23925
6	11191	17344	13574	1581	11224
7	4396	6457	9639	8233	959
8	519	2536	3588	5846	4994
9	388	300	1410	2176	3546
10	109	224	166	855	1320
11	35	63	125	101	519
1+	187756	155859	130002	111633	96675

POPULATION BIOMASS 11/ 5/82

	1981	1982	1983	1984	1985
1	5520.00	1353.81	1353.81	1353.81	1353.81
2	15844.44	22556.15	5561.51	5581.01	5581.01
3	3199.50	21795.11	30624.50	7583.97	7610.56
4	30579.33	3428.55	23198.39	33113.65	8200.40
5	33653.56	27008.41	2966.39	21060.66	30062.23
6	18572.02	28783.17	22526.68	2623.51	18626.32
7	9475.35	13916.49	20774.40	17745.26	2066.65
8	1379.20	6738.07	9532.11	15530.41	13265.91
9	1171.23	903.34	4250.85	6563.34	10693.49
10	362.96	745.01	553.46	2842.57	4388.95
11	128.55	228.35	451.47	366.06	1880.07
1+	119886.14	127456.47	121793.58	114364.28	103729.41

Table 22. Catch projection for 4VW haddock at F_t = 0.35 assuming an $F_{0.1}$ catch in 1982

CATCH NUMBERS 11/ 5/82

	1981	1982	1983	1984	1985
1	1289	183	183	183	183
2	221	747	185	185	185
3	257	1508	2128	527	527
4	5067	493	3391	4785	1184
5	5094	3559	410	2819	3979
6	3013	4095	3398	392	2692
7	1184	1524	2484	2061	238
8	140	599	925	1506	1250
9	105	71	363	561	914
10	29	53	43	220	340
11	10	15	32	26	134
1+	16408	12846	13541	13265	11624

CATCH BIOMASS 11/ 5/82

	1981	1982	1983	1984	1985
1	103	15	15	15	15
2	90	304	75	75	75
3	177	1039	1467	363	363
4	4869	474	3258	4598	1138
5	6401	4472	515	3543	5000
6	5000	6795	5639	650	4467
7	2551	3285	5353	4442	512
8	371	1591	2456	4002	3321
9	315	213	1095	1691	2755
10	98	176	143	732	1131
11	35	54	116	94	484
1+	20010	18419	20132	20205	19261

FISHING MORTALITY 11/ 5/82

	1981	1982	1983	1984	1985
1	0.021	0.012	0.012	0.012	0.012
2	0.006	0.015	0.015	0.015	0.015
3	0.063	0.054	0.054	0.054	0.054
4	0.192	0.165	0.165	0.165	0.165
5	0.234	0.201	0.201	0.201	0.201
6	0.350	0.300	0.300	0.300	0.300
7	0.350	0.300	0.300	0.300	0.300
8	0.350	0.300	0.300	0.300	0.300
9	0.350	0.300	0.300	0.300	0.300
10	0.350	0.300	0.300	0.300	0.300
11	0.350	0.300	0.300	0.300	0.300

POPULATION NUMBERS 11/ 5/82

	1981	1982	1983	1984	1985
1	69000	16923	16923	16923	16923
2	38865	55329	13690	13690	13690
3	4642	31620	44625	11041	11041
4	31826	3568	24528	34615	8565
5	26783	21494	2477	17027	24030
6	11191	17344	14394	1659	11402
7	4396	6457	10520	8730	1006
8	519	2536	3916	6381	5295
9	388	300	1538	2375	3870
10	109	224	182	933	1441
11	35	63	136	110	566
1+	187756	155859	132928	113485	97829

POPULATION BIOMASS 11/ 5/82

	1981	1982	1983	1984	1985
1	5520.00	1353.81	1353.81	1353.81	1353.81
2	15844.44	22556.15	5581.01	5581.01	5581.01
3	3199.50	21795.11	30758.76	7610.56	7610.56
4	30579.33	3428.55	23566.61	33258.82	8229.15
5	33653.56	27008.41	3112.61	21394.95	30194.03
6	18572.02	28783.17	23886.59	2752.84	18921.97
7	9475.35	13916.49	22673.78	18816.52	2168.53
8	1379.20	6738.07	10403.62	16950.34	14066.76
9	1171.23	903.34	4639.50	7163.42	11671.18
10	362.96	745.01	604.07	3102.46	4790.22
11	128.55	228.35	492.75	399.53	2051.97
1+	119883.14	127456.47	127073.11	118384.27	103637.18

Table 23. Input for and results of yield-per-recruit analysis and catch. Projections for 4VW haddock.

Age	Weight (kg)	PR[1]	1981 Numbers[2]	Yield per Recruit (Y/R)
1	0.08	0.04	69000	$F_{0.1}$ = 0.30
2	0.41	0.05	38865	
3	0.69	0.18	4642	F_{max} = 0.54
4	0.96	0.55	31826	
5	1.26	0.67	26783	Y/R at $F_{0.1}$=0.49kg
6	1.66	1.00	11191	
7	2.16	1.00	4396	Y/R at F_{max}=0.53kg
8	2.66	1.00	519	
9	3.02	1.00	388	
10	3.32	1.00	109	
11	3.63	1.00	38	

Projected catches[3] (mt) at $F_{0.1}$

1982	1983	1984	
23,000	19,000	19,000	(Assuming TAC is taken in 1982)
18,000	20,000	20,000	($F_{0.1}$ in 1982)

1 As in previous assessment
2 Age 1 numbers set at highest observed value (Table 19)
3 Recruitment at geometric mean of SPA age 1 numbers, 1970-1980.

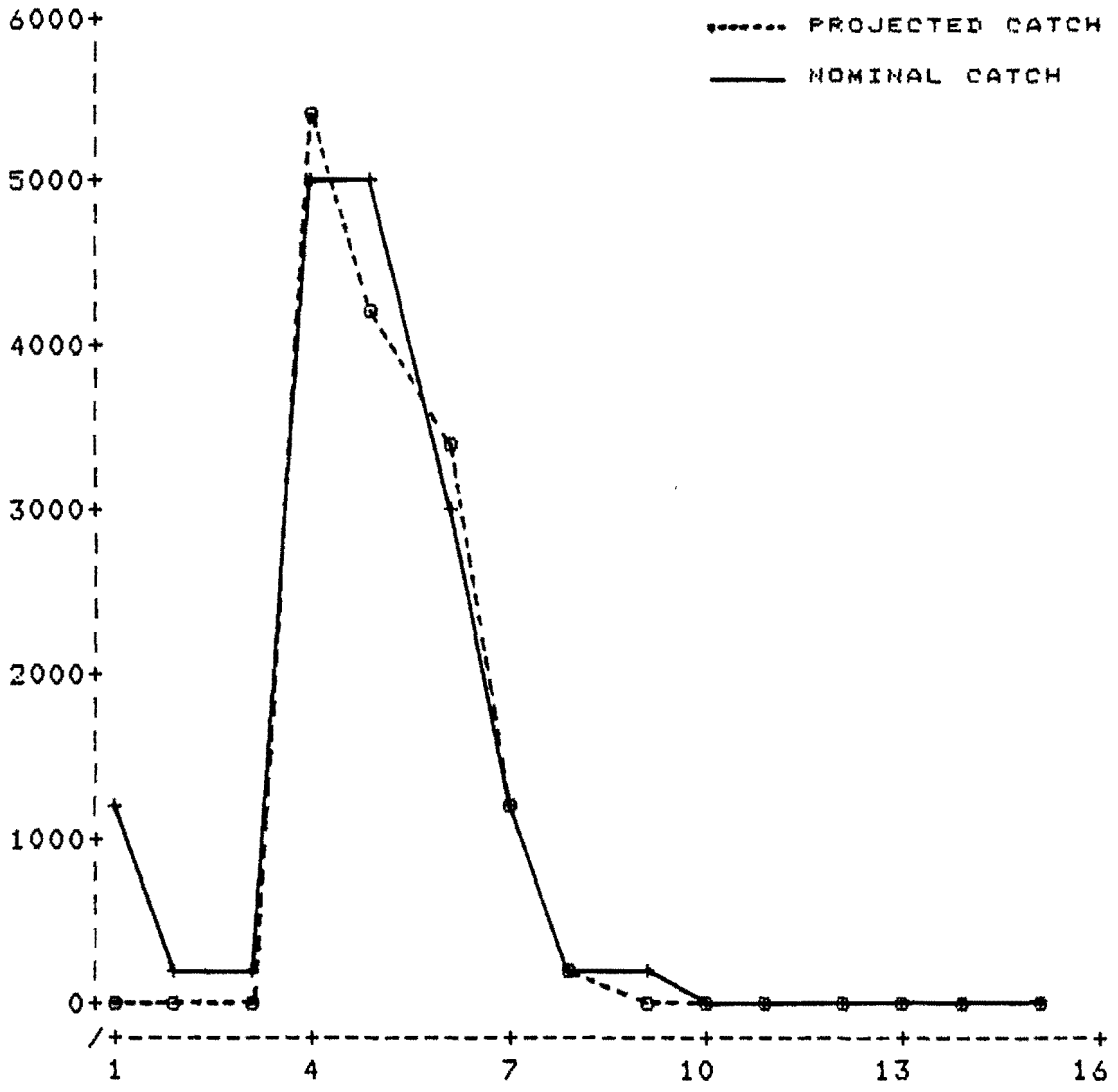


Figure 1. Comparison of nominal catch-at-age in 1981 with the catch-at-age projected for 1981 at TAC 23,000 mt (1981 nominal catch is 20,000 mt)

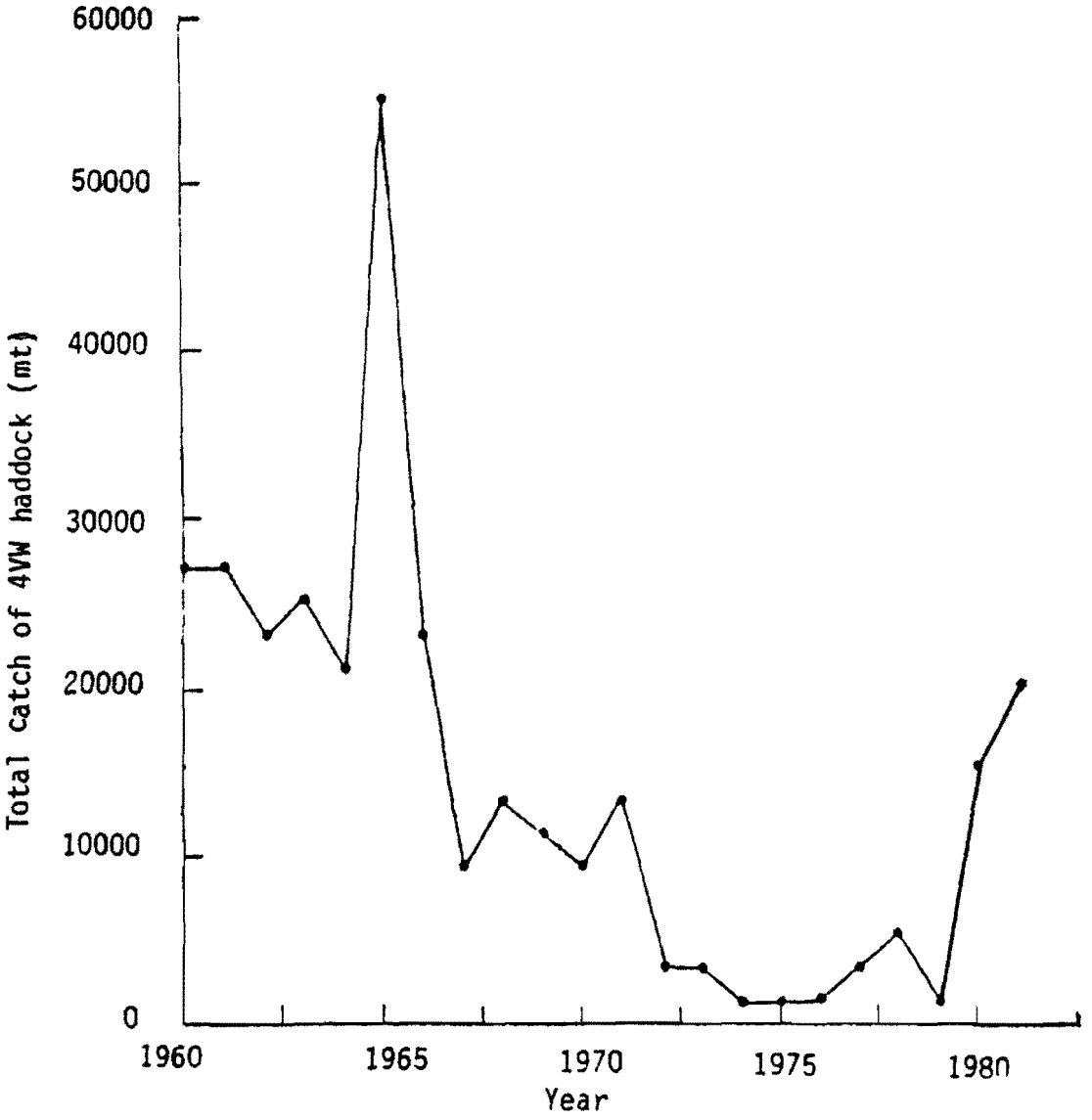


Figure 2. Nominal catch of 4VW haddock (mt), 1981 is preliminary

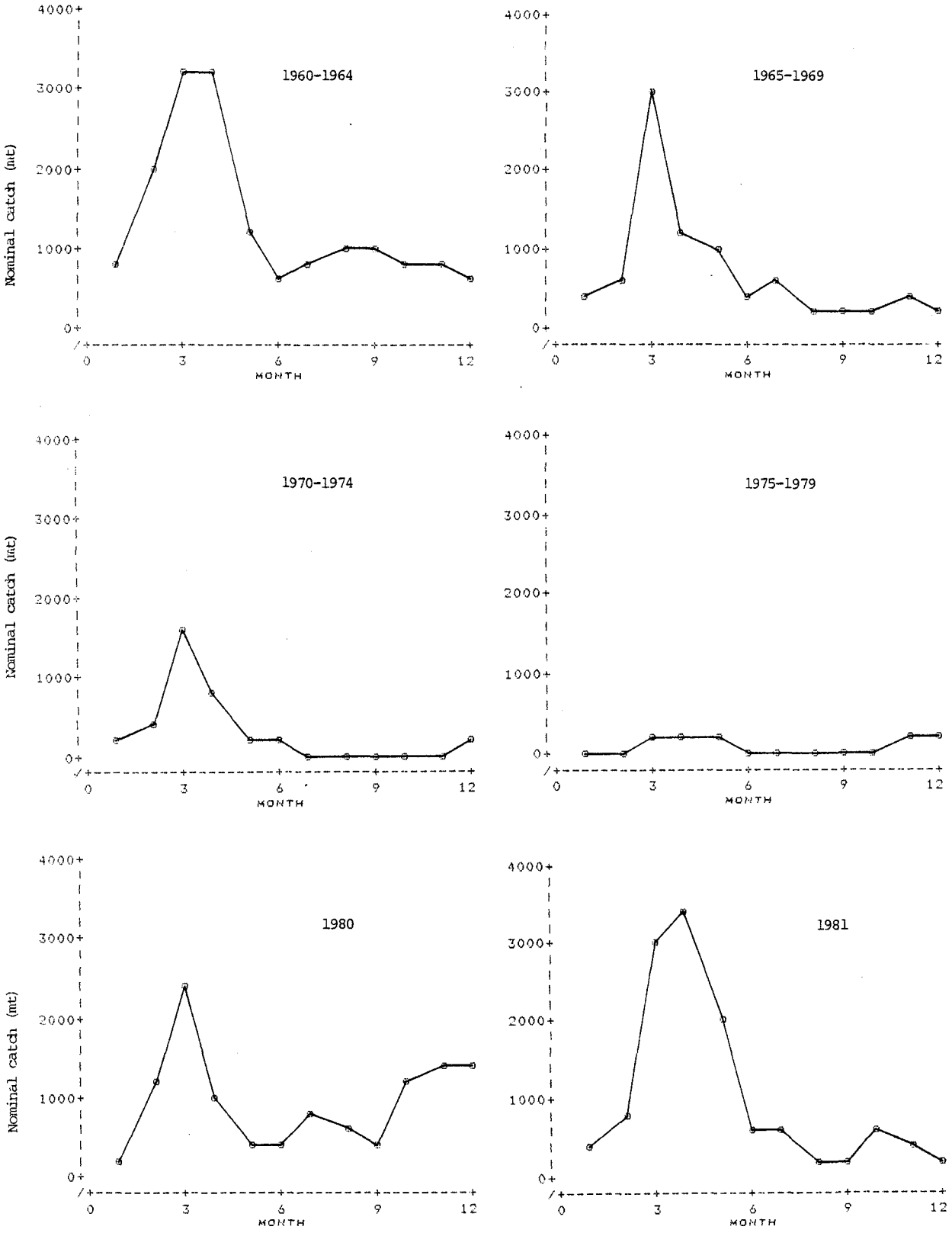


Figure 3 . Seasonal distribution of 4VW haddock landings by otter trawlers since 1960 (means for each five year period 1960-1979)

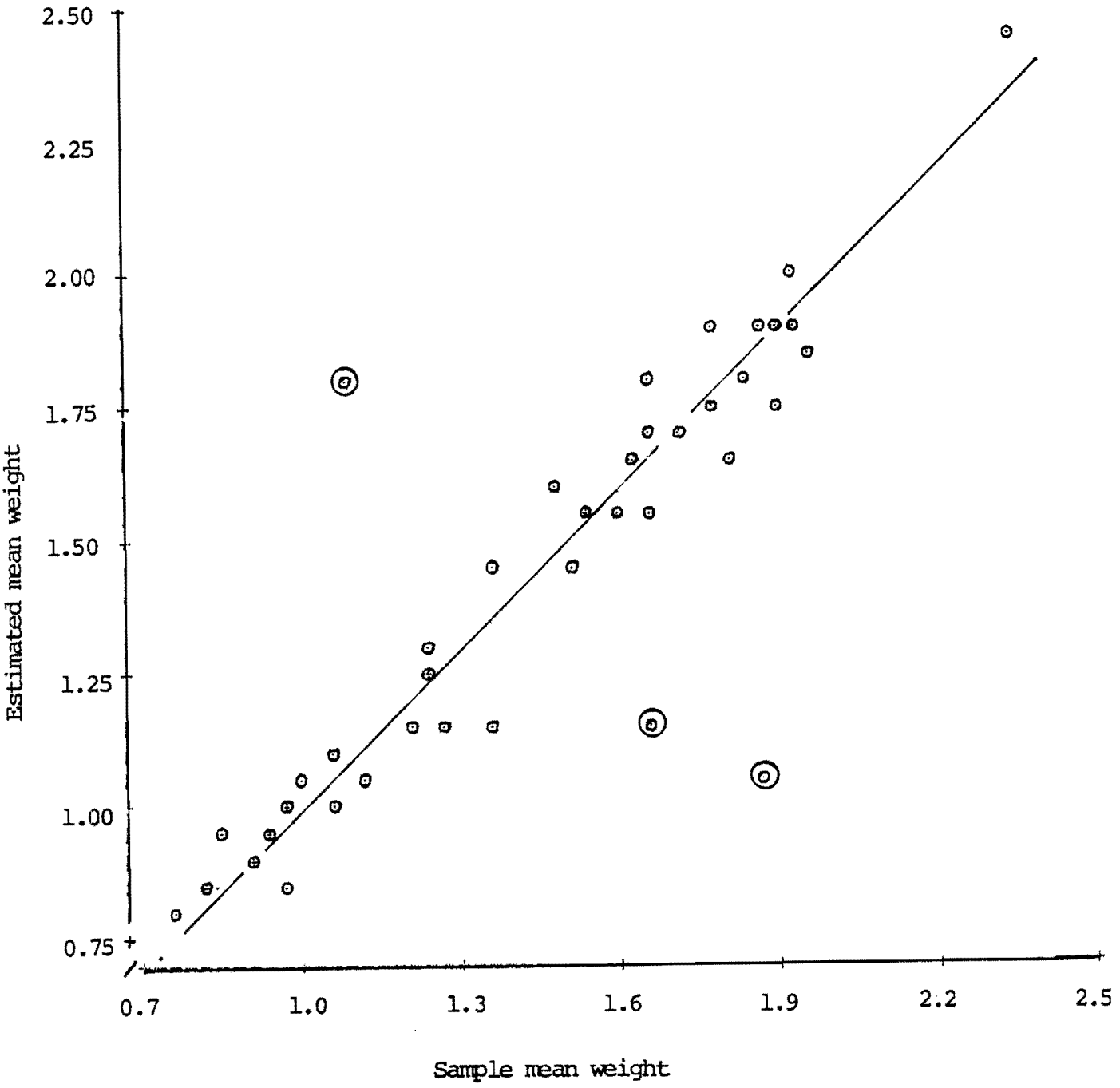


Figure 4. Comparison of mean weight of fish in commercial samples when calculated in two different ways. Encircled outliers were excluded from subsequent analyses.

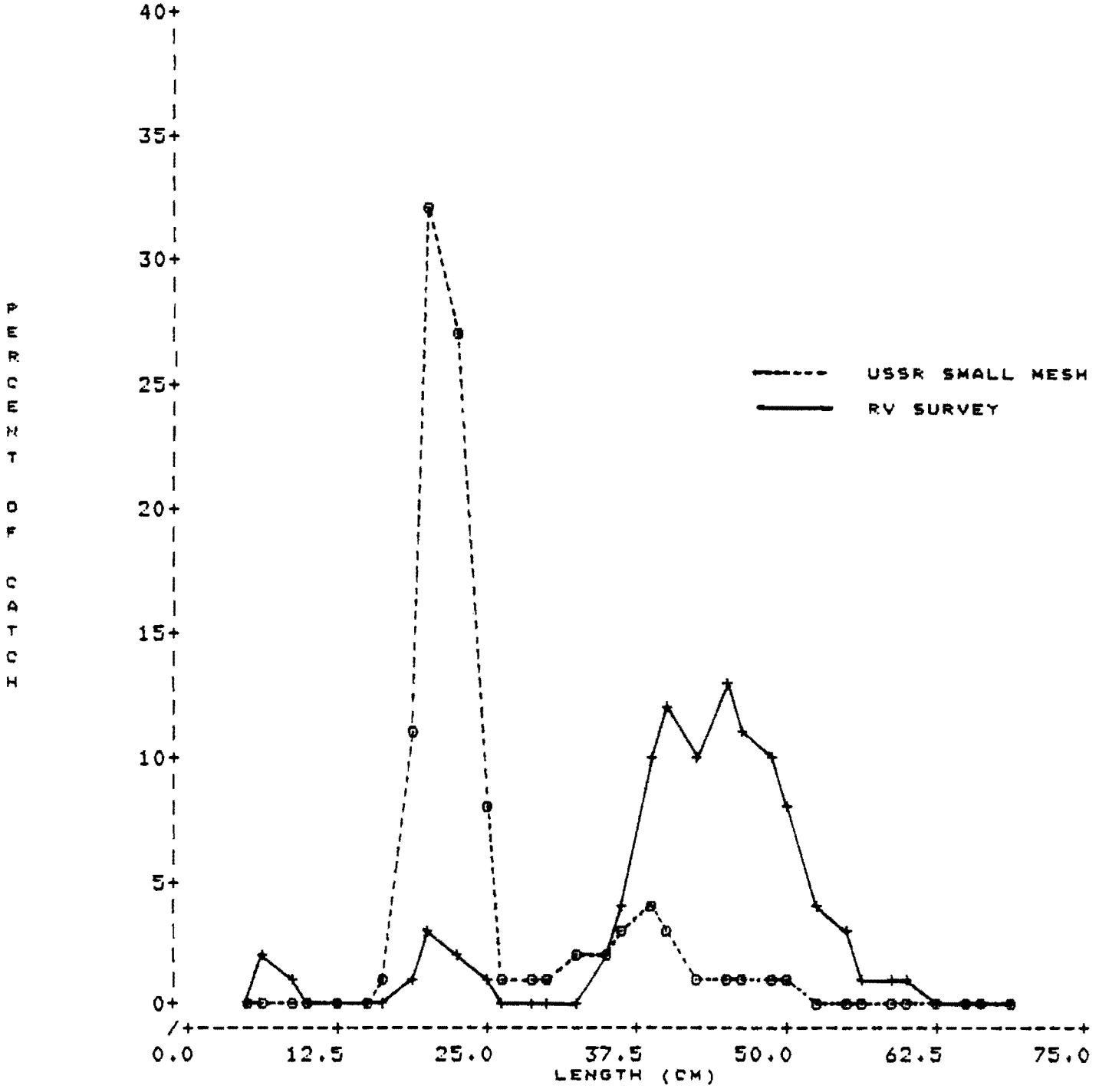


Figure 5a . Comparison of length frequencies of 4VW haddock taken in the USSR small mesh fishery for silver hake (July) and the summer RV groundfish trawl survey, for 1980

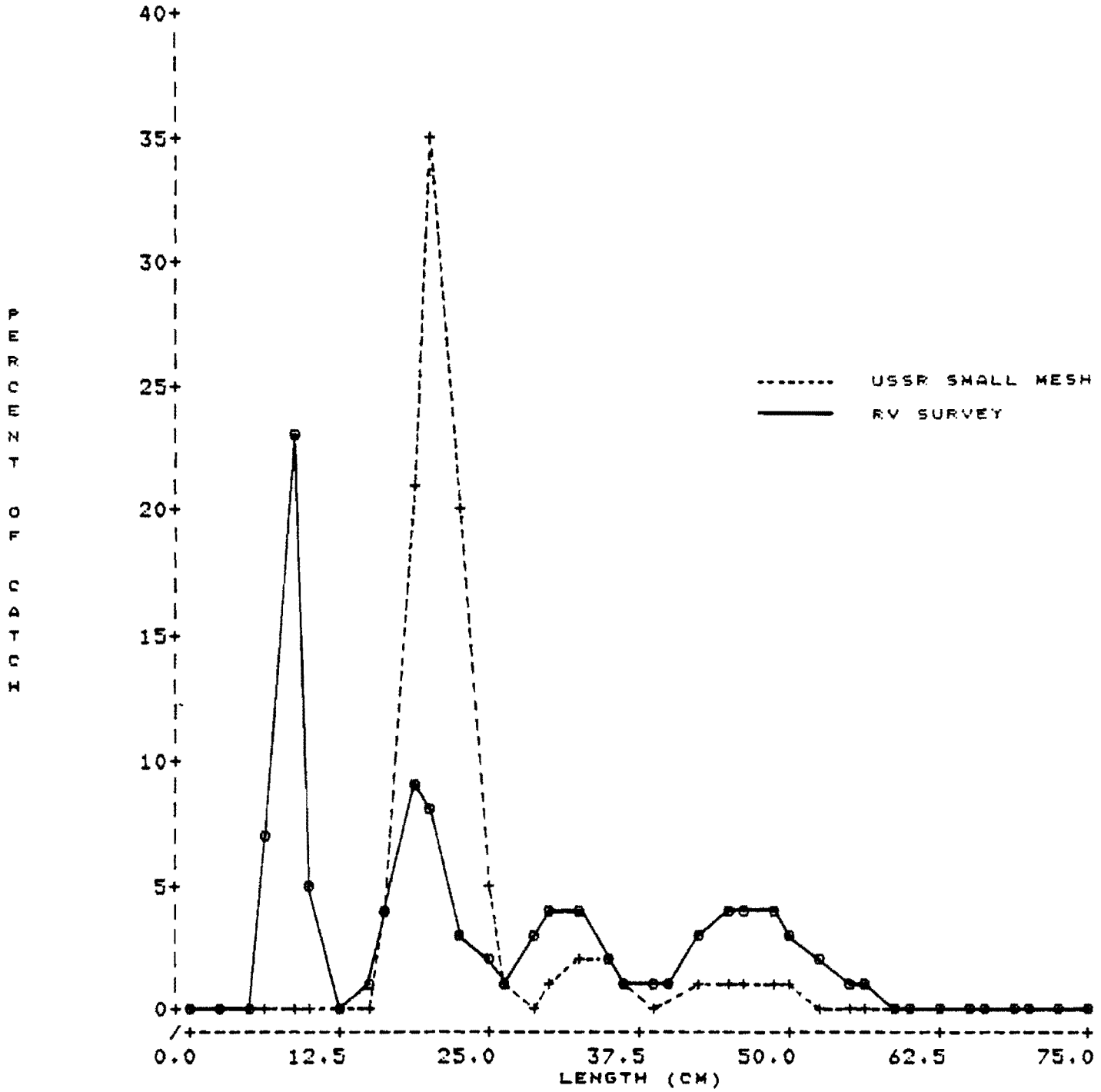


Figure 5b. Similar to Figure 5a,but for 1981

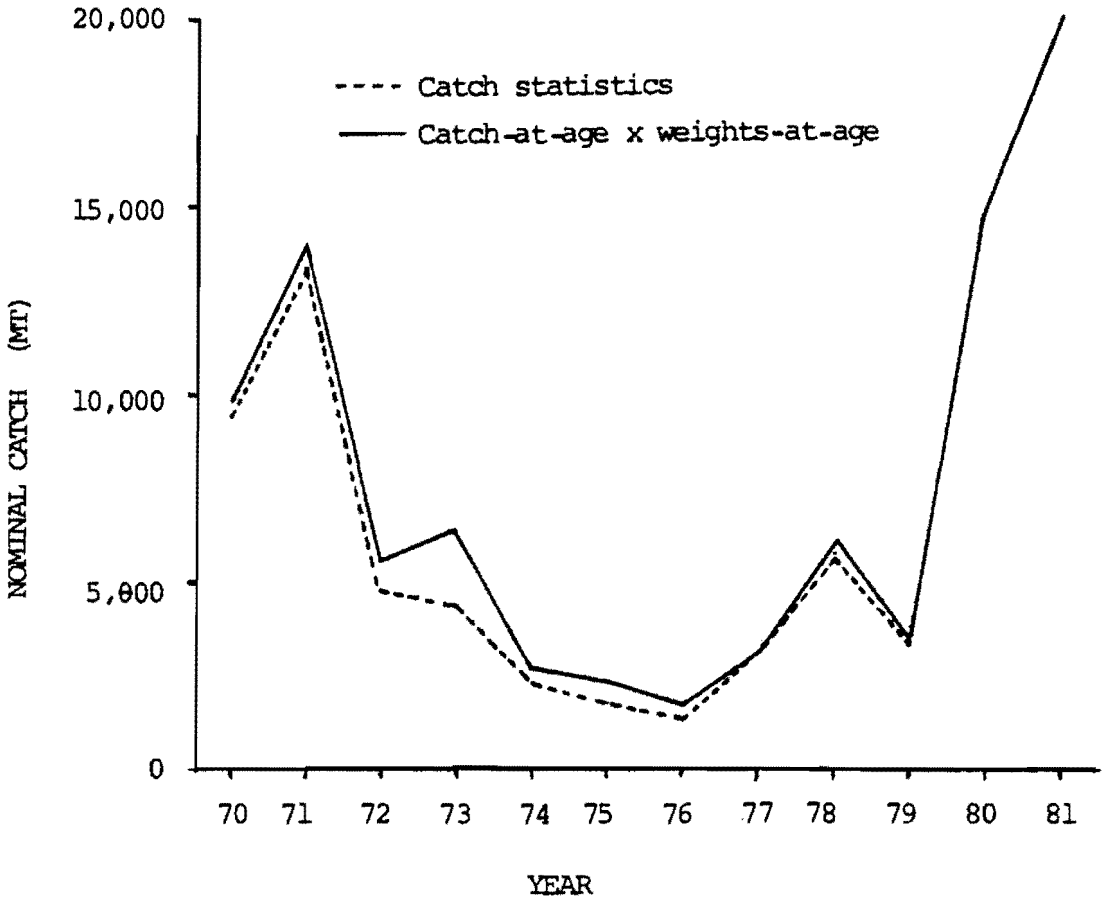


Figure 6. Nominal catch per year from the catch statistics and estimated from catch-at-age times weight-at-age

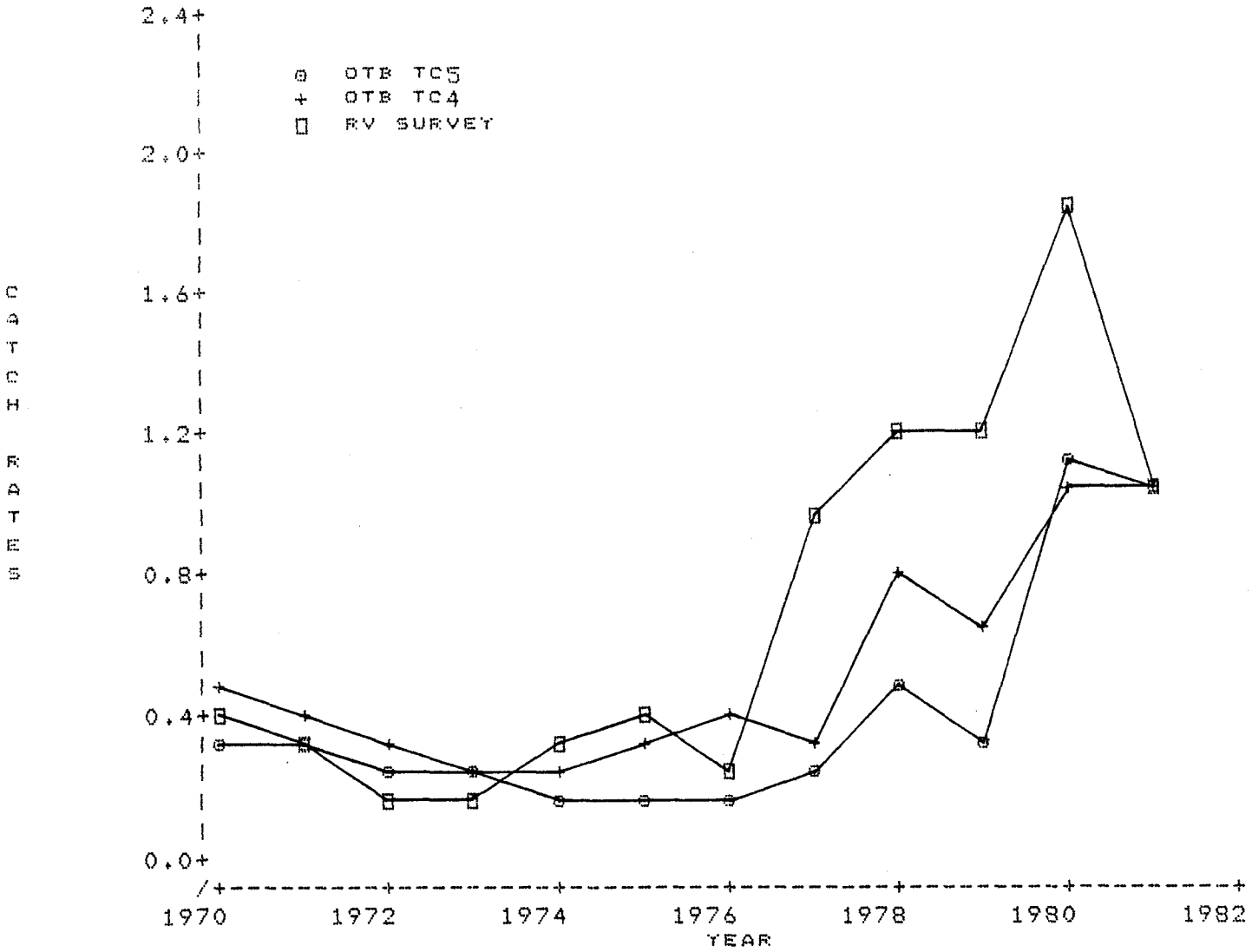


Figure 7. 1970 to 1981 trends in standardized catch rates (weight/time) for Canadian otter trawlers (TC4 and TC5) and the summer RV groundfish trawl survey

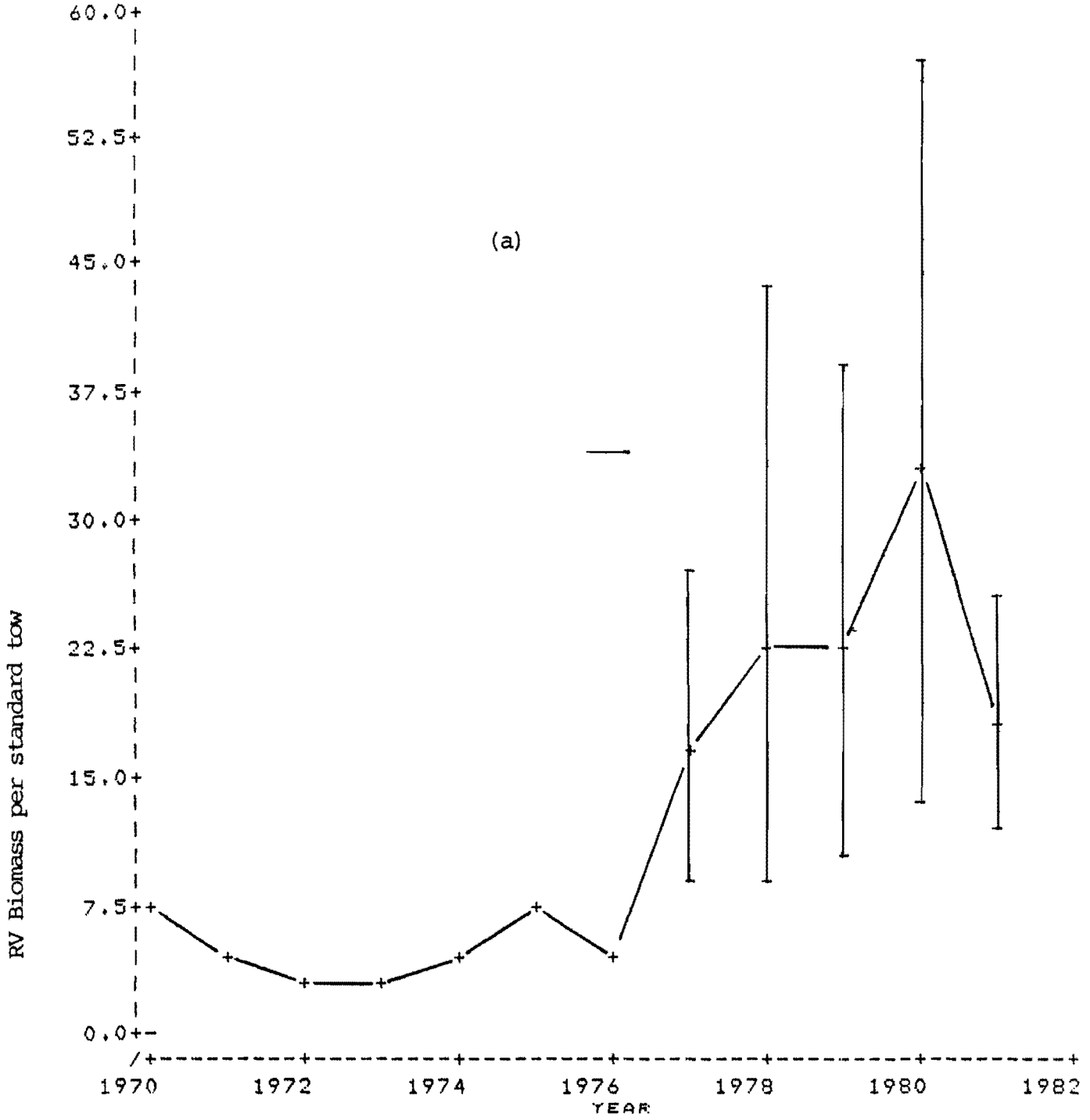


Figure 8a. Trends in Research Vessel mean biomass-per-standard-tow with 95% bootstrap confidence intervals for 1977-1981

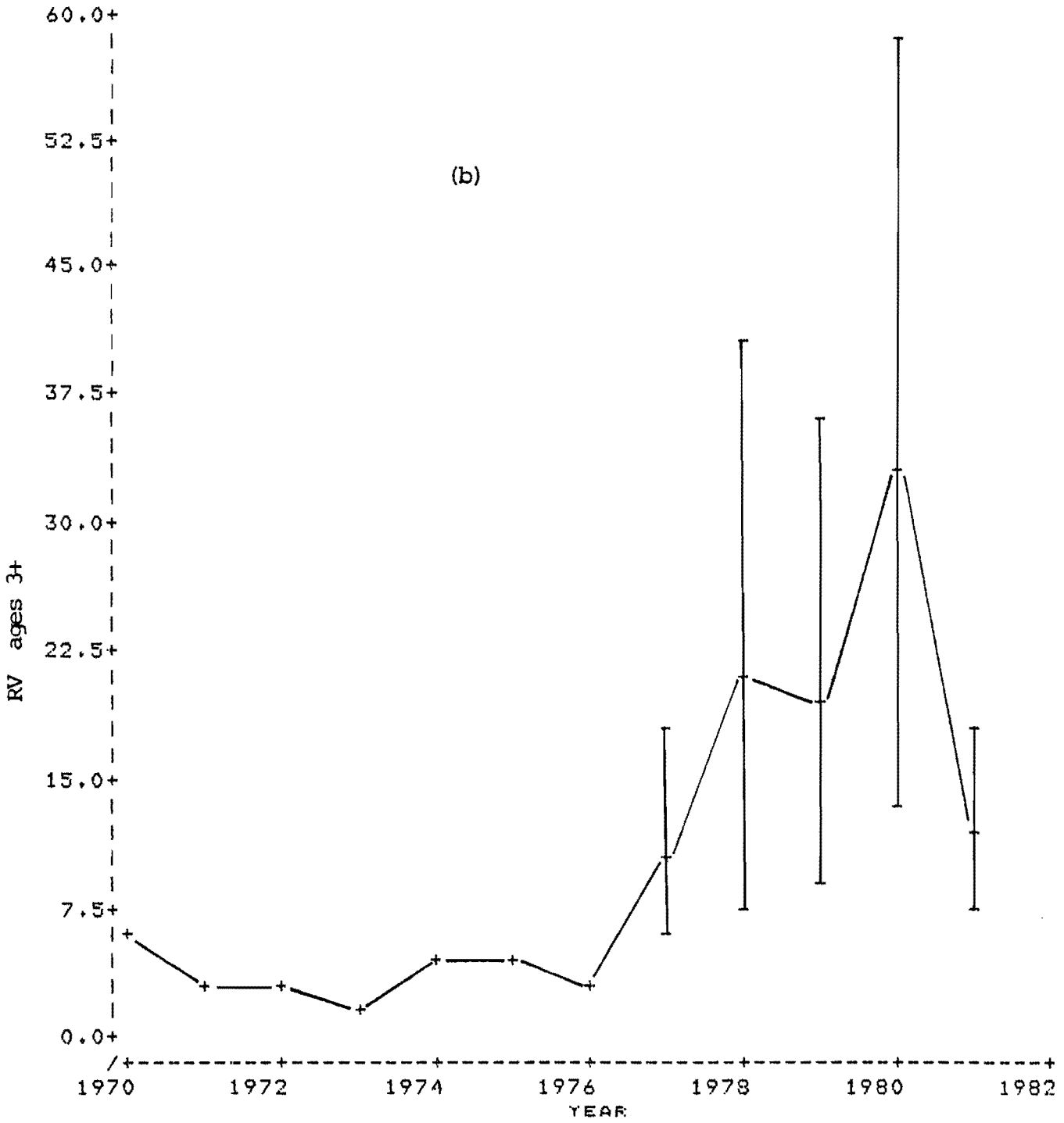


Figure 8b. Trends in Research Vessel mean catch-per-standard-tow at ages 3+ with 95% bootstrap confidence intervals for 1977-1981

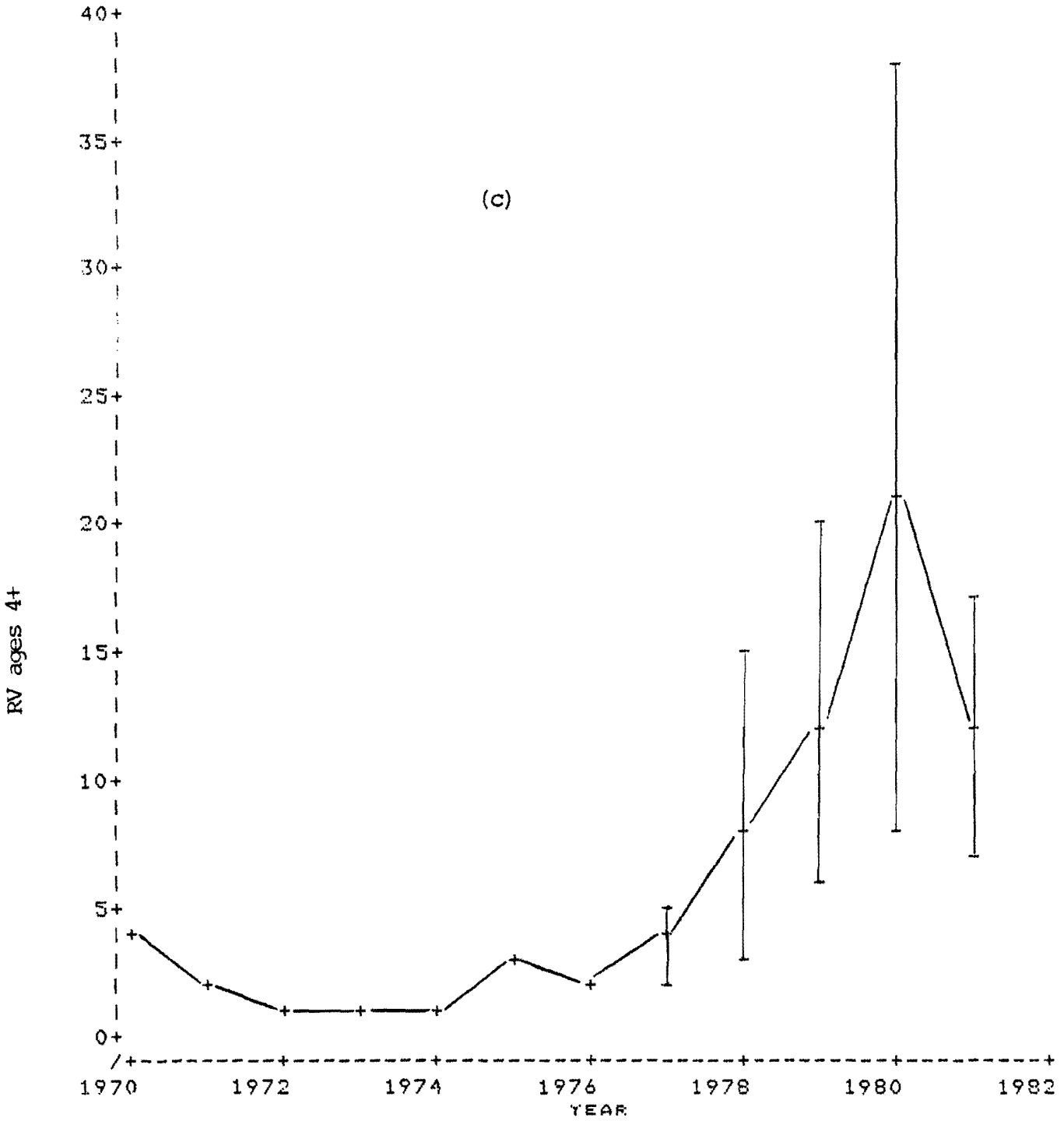
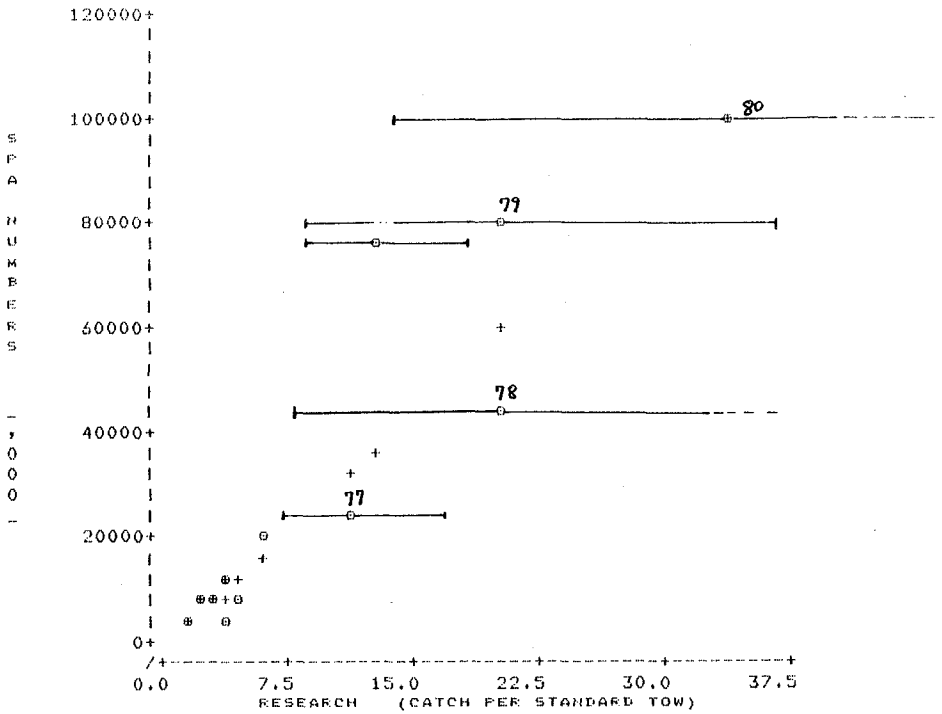


Figure 8c. Trends in Research Vessel mean catch-per-standard-tow at ages 4+ with 95% bootstrap confidence inetrvals for 1977-1981



INTERCEPT AND SLOPE

-1574.9637 3065.6341

R SQUARED

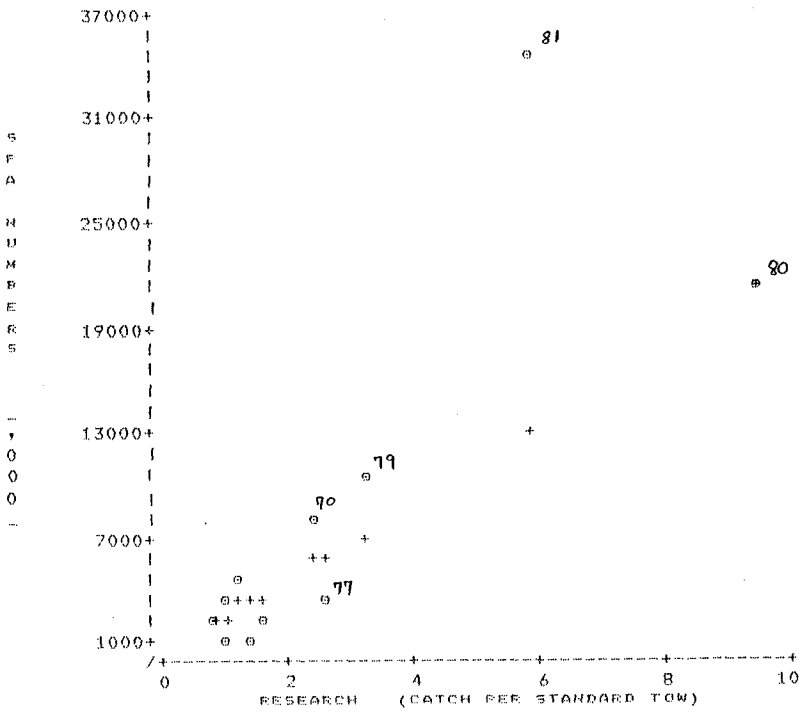
0.9213

YEAR	1970.00	1971.00	1972.00	1973.00	1974.00	1975.00	1976.00	1977.00	1978.00	1979.00	1980.00	1981.00
SPA	19974.02	11980.47	8754.10	5516.65	5800.27	7811.70	8877.06	23540.99	44035.52	80158.90	101258.73	75241.80
RESEARCH	5.67	3.49	2.55	1.64	3.88	4.44	2.81	11.16	20.28	20.00	33.39	12.57
ESTIMATE	15804.48	9120.71	6251.48	3438.99	10318.23	12021.20	7029.27	32625.45	60588.20	59735.24	100775.18	36960.06

FULLY RECRUITED F

0.587 1.287 0.847 1.458 0.846 0.440 0.382 0.377 0.515 0.139 0.265 0.300

Figure 9. The relationship between SPA numbers and RV numbers at ages 3+ for $F_t = 0.35$



INTERCEPT AND SLOPE

391.1491 2229.4689

R SQUARED

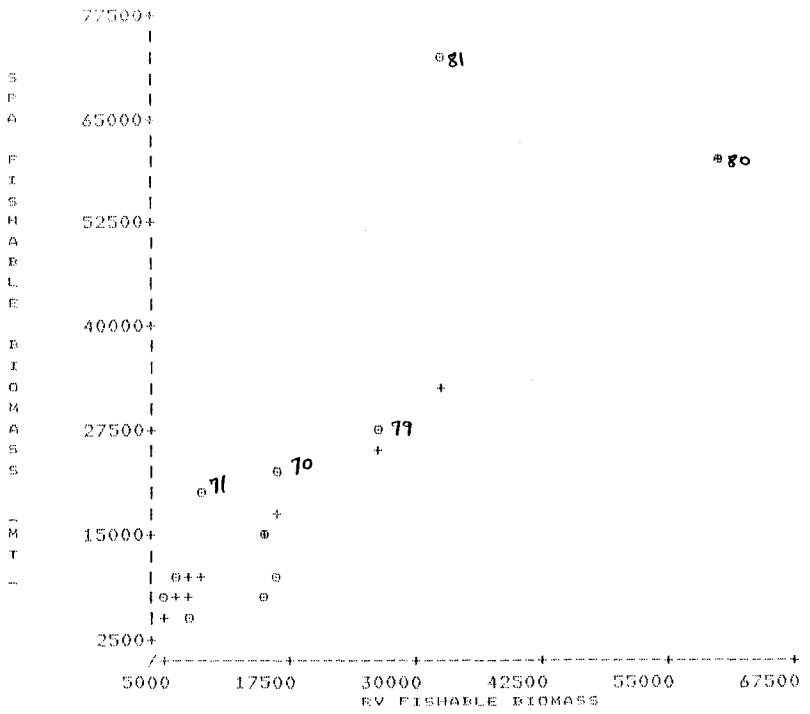
0.8841

YEAR	1970.00	1971.00	1972.00	1973.00	1974.00	1975.00	1976.00	1977.00	1978.00	1979.00	1980.00	1981.00
SPA	8154.94	5186.93	3109.07	1784.92	1378.65	1343.05	1842.75	3436.75	3465.04	10433.51	20879.25	34191.85
RESEARCH	2.43	1.18	0.98	0.71	1.02	1.41	1.56	2.65	1.00	3.11	9.38	5.82
ESTIMATE	5816.43	3014.93	2584.23	1970.86	2673.16	3530.17	3870.05	6297.49	2629.39	7323.03	21305.10	13366.66

FULLY RECRUITED F

0.587 1.287 0.849 1.464 0.854 0.448 0.394 0.394 0.551 0.152 0.298 0.350

Figure 10. The relationship between SPA numbers and RV numbers at ages 5+ for F_t = 0.35



INTERCEPT AND SLOPE ARE
1045.7033 0.9772

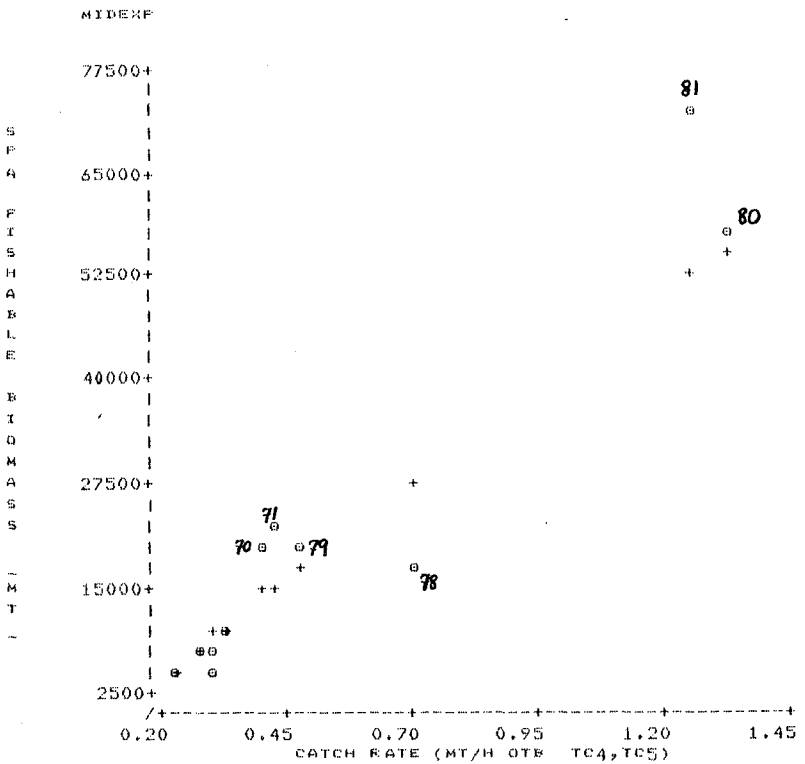
R SQUARED
0.8865

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
SPA	23442	19828	9890	7730	4866	7090	5084	10069	14133	27279	60627	71645
RV BIOMASS	16366	8755	5969	5301	8107	14692	6917	16141	14669	25713	60076	32262
ESTIMATE	17038	9401	6878	6226	8967	15402	7805	16818	15380	26172	59750	32571

AGE OF FULL RECRUITMENT
6

FULLY RECRUITED F
0.587 1.287 0.849 1.464 0.854 0.448 0.394 0.394 0.551 0.152 0.298 0.350

Figure 11. The relationship between SPA fishable biomass and RV fishable biomass at F_t = 0.35

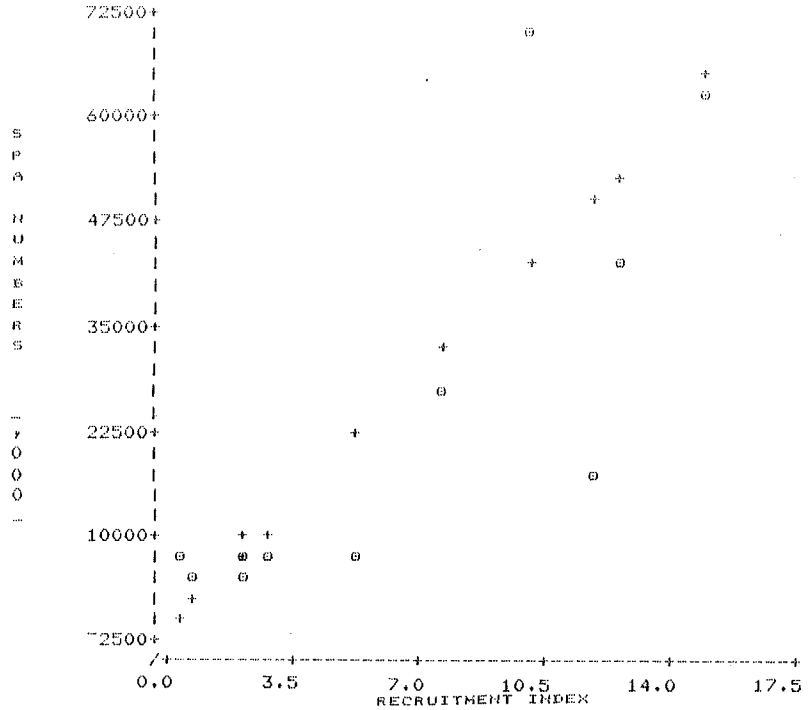


A AND B ARE
-4080.7929
44878.0230
R SQUARED
0.9209

YEAR	1970.00	1971.00	1972.00	1973.00	1974.00	1975.00	1976.00	1977.00	1978.00	1979.00	1980.00	1981.00
SPA	19848.46	21327.61	8734.00	8718.10	5659.26	7220.60	4891.97	8797.59	18670.39	20035.73	57185.50	71645.39
CATCH RATE	0.41	0.42	0.28	0.28	0.22	0.29	0.29	0.34	0.69	0.49	1.33	1.25
ESTIMATE	14333.46	14726.53	8492.35	8355.87	5770.31	8948.79	8833.39	11055.92	27087.68	17779.29	55705.61	51877.19

AGE OF FULL RECRUITMENT
6
FULLY RECRUITED F
0.587 1.287 0.849 1.464 0.854 0.448 0.394 0.394 0.551 0.152 0.298 0.350

Figure 12. The relationship between SPA fishable biomass and the weighted catch rate for OTB TC4 & TC5 at $F_t = 0.35$



INTERCEPT AND SLOPE

-877.8125 4280.6105

R SQUARED

0.8053

YEAR	1970.00	1971.00	1972.00	1973.00	1974.00	1975.00	1976.00	1977.00	1978.00	1979.00	1980.00
SPA	7693.03	4080.96	7945.23	8238.61	5722.54	28629.74	42604.67	69255.60	62341.55	7026.25	18303.56
INDEX	5.29	2.18	2.69	2.26	0.72	7.70	12.50	10.20	15.22	0.18	11.98
ESTIMATE	21766.62	8445.36	10641.31	8817.77	2204.23	32082.89	52629.82	42784.41	64273.08	-107.30	50403.90

FULLY RECRUITED F

0.587 1.287 0.849 1.464 0.854 0.448 0.394 0.394 0.551 0.152 0.298 0.350

Figure 13. The relationship between SPA age 1 numbers and the recruitment index at $F_t = 0.35$

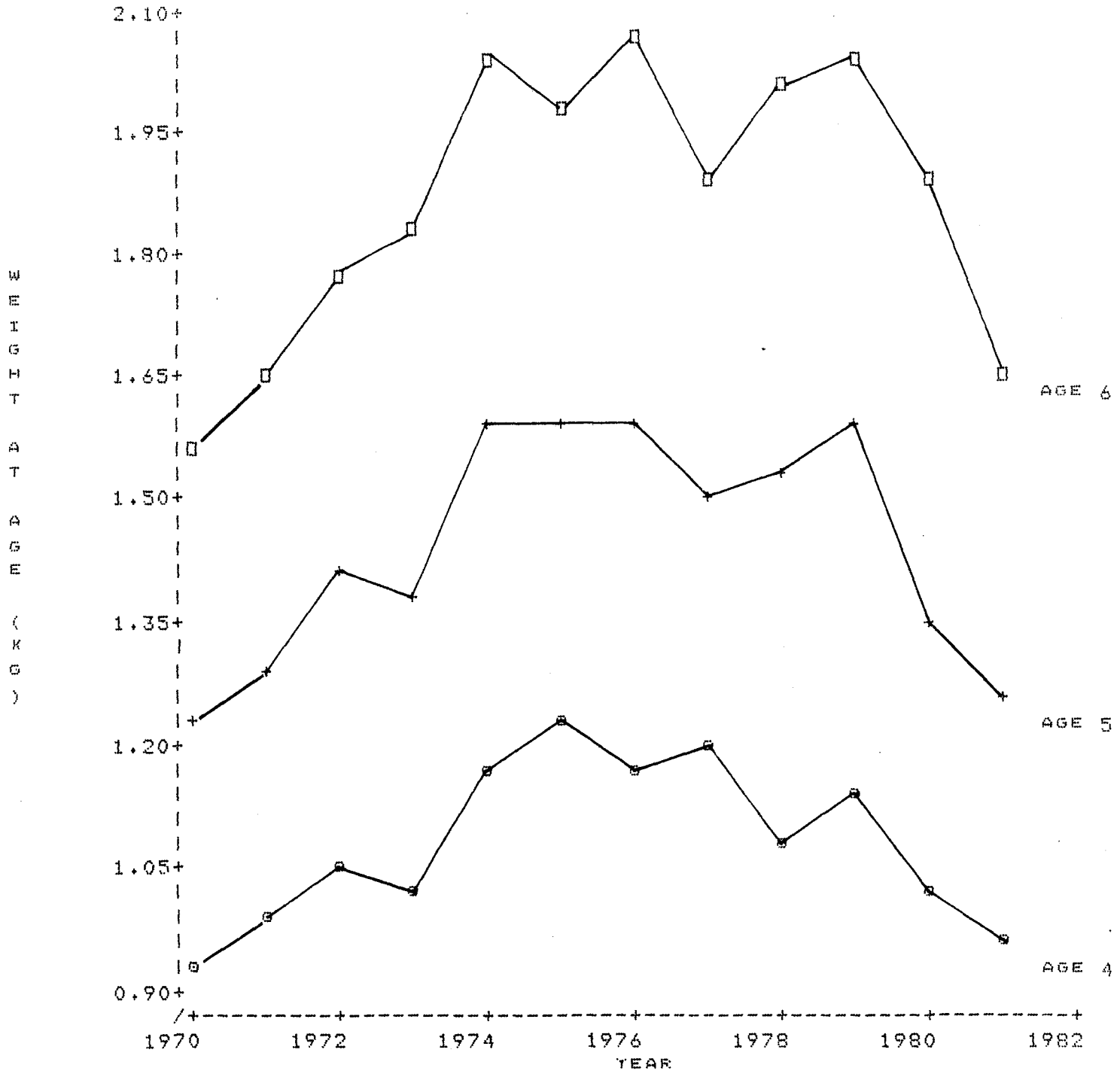
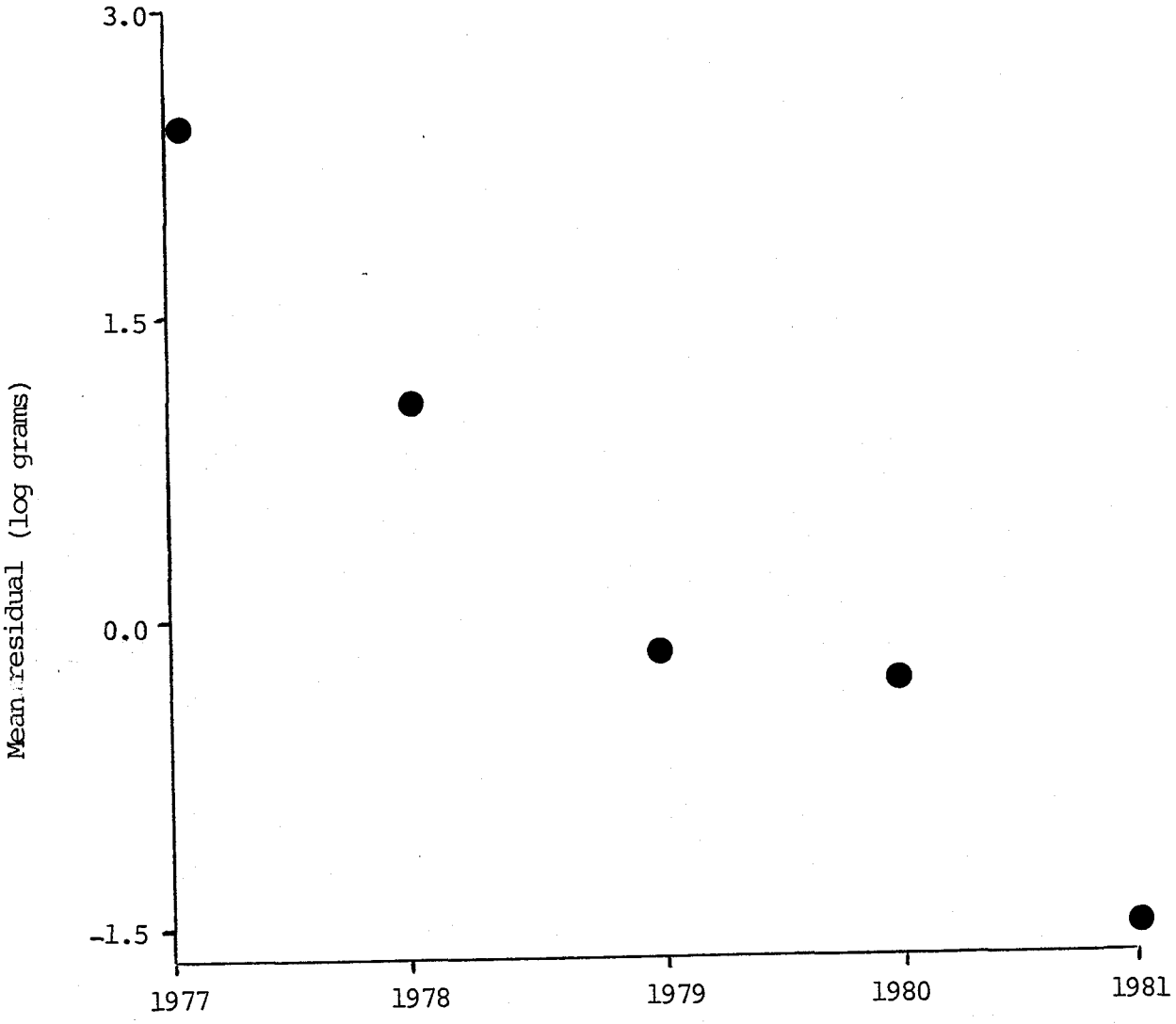


Figure 14 . Trends in weights-at-ages 4, 5 and 6 from commercial samples of 4VW haddock



Year	Mean of Residual	S.E. of mean
1977	2.384	0.211
1978	1.003	0.186
1979	-0.152	0.157
1980	-0.320	0.132
1981	-1.498	0.158

Figure 15. Time trend in residuals for length-age relationship for 4VW haddock from summer RV surveys

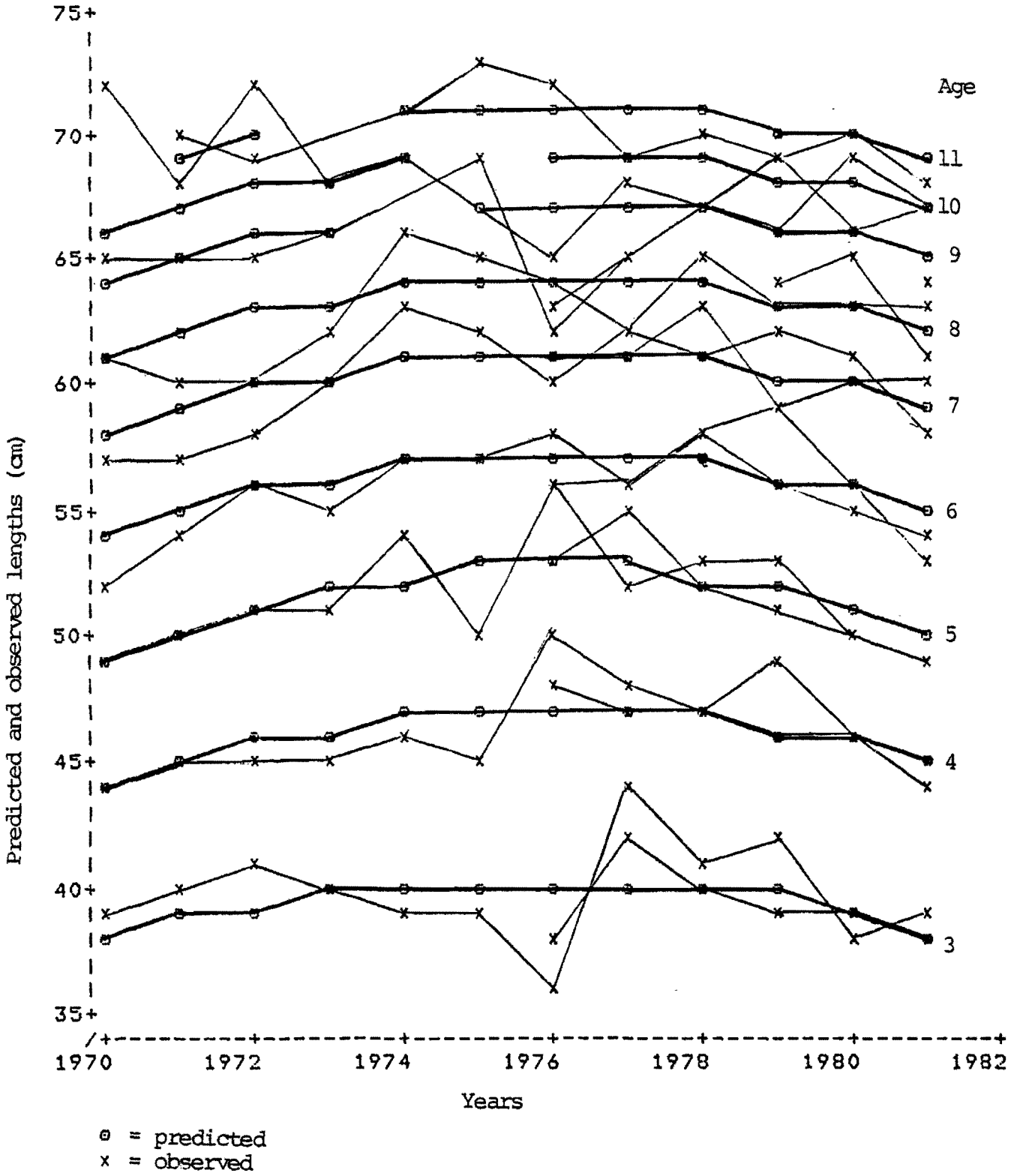


Figure 16. Observed and predicted lengths-at-age for 4VW haddock from 1970-1981.