Assessment of 4TVW Haddock with Catch Projections to 1990

by

K. Zwanenburg

Biological Sciences Branch
Scotia-Fundy Region
Marine Fish Division
Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth
Nova Scotia, B2Y 4A2

Abstract

The nominal catch of 4TVW haddock totalled 4471 t in 1988 representing 99% of the advised $F_{0.1}$ catch. The fishery on this resource has been restricted to by-catches since January 1987. As in the previous assessment an adaptive framework for least-squares optimization was used to estimate fishing mortality at age. However, the formulation differed in that only full year catch was used in the analysis whereas half year catches were used previously. Since F is not uniformly distributed throughout the year, the use of half-year formulations which make that assumption are inappropriate. The full year formulation employed in this assessment, although resulting in estimates of F which were consistent with known removals resulted in a change in perception of fully recruited F in 1987 from 0.14 in last year's assessment to 0.54 in the present assessment. Given these results, we used the estimate of 1987 beginning of year population numbers derived from the 1988 full year formulation to project catches for 1990 after accounting for known removals in 1988 and the recommended $F_{0.1}$ catch in 1989. These analyses indicate that the 1990 age 3+ biomass is projected to be about 38,000 t. Given the uncertainty in the adaptive framework formulation with respect to the half year SPA and the difficulties in estimating F at older ages, a catch of 6000 t approximates the $F_{0.1}$ catch in 1989 and 1990.

Résumé

Les prises nominales d'aiglefin dans les divisions 4TVW se sont élevées à 4 471 t en 1988, représentant 99 % des prises au niveau $F_{0,1}$ recommandé. La pêche de cette ressource est limitée aux captures accidentelles depuis janvier 1987. Comme dans l'évaluation précédente, on a utilisé un cadre adaptatif aux fins d'optimisation par la méthode des moindres carrés, cela afin d'obtenir une estimation de la mortalité selon l'âge. La formule différait cependant, en ce sans que l'on utilisait exclusivement les prises de l'année entière, alors qu'auparavant on s'était servi des prises d'un semestre. Comme la valeur F n'est pas répartie uniformément sur toute l'année, l'utilisation de prises semestrielles, fondée sur l'hypothèse contraire, est impropore. Le calcul sur l'année entière auquel on a eu recours ici, bien qu'il aboutisse à des valeurs F estimées correspondant aux prélèvements connus, s'est traduit par un changement de perception de la valeur F de plein recrutement, qui de 0,14 qu'elle était dans l'estimation de 1987 est passée à 0,54 dans la présente analyse. A la lumière de ces résultats, nous avons utilisé les chiffres de population du début de l'année 1987, dérivés des données portant sur toute l'année 1988, afin d'établir des projections de prises pour 1990 en tenant compte des prélèvements connus de 1988 et des prises au niveau $F_{0,1}$ recommandé pour 1989. Ces calculs chiffrent à environ 38 000 t la projection de la biomasse des poissons d'âge 3+. Etant donné, d'une part, l'incertitude des paramètres du cadre adaptatif relativement au calcul de l'ASP sur un semestre et, d'autre part, les difficultés que soulève l'estimation de la valeur F aux âges avancés, une prise de 6 000 t correspond approximativement aux prises au niveau $F_{0,1}$ pour 1989 et 1990.

Introduction

Description of the Fishery

Catches have averaged 26,500 t per year from 1950 to 1969, 5,000 t from 1970 to 1979 and ranged between 8,000 and 20,000 t until 1987 (Table 1). The nominal catches in 1987 and 1988 were taken exclusively as by-catch in other groundfish fisheries operating in Divisions 4T, 4V, and 4W, and totalled 4471 t in 1988. The 1988 total represents 99% of the advised $F_{0.1}$ catch of 4501 t. Recent TACs and nominal catches are given below:

	1983	1984	1985	1986	1987	1988	1989
CAFSAC Advice	19	12	25	17	3.8	4.5	6.7
TAC	19	15	15	17	-[2]	-[2]	-[2]
Nominal Catch	9	8	11	17[1]	3.9[1]	4.5[1]	-

1 - Provisional data
2 - No TAC - by-catch only

Until 1984, most of the catch from this stock was taken in Div. 4W by large OTBs (TC4 and TC5) fishing in the spring. In 1984-1986, Subdiv. 4Vs accounted for an increasing proportion of the total catch. In 1986, the combination of apparently poor recruitment over several successive years (1983-1985), low levels of spawning stock biomass and the concentration of the fishery on the only two remaining year-classes of any appreciable size (1981,1982), resulted in the recommendation of TAC's for 1987 and 1988 of 3,800 and 4,500 t respectively. These TAC's were considered to be too low to allow for directed fisheries thus resulting in the restriction of catches from this stock to by-catches in the other groundfish fisheries active in the stock area. Management further imposed a year-round ban on mobile gear fisheries in areas identified as nursery grounds -- mainly Western and Emerald Banks -- (Fanning et al. 1987). The 1989 TAC of 6747 t will again be restricted to by-catches in other groundfish fisheries active in the stock area. The nursery ground closures will also remain in effect.

Input Data

Age Composition and Weight at Age of the Catch

The recent catch history of this stock indicates that most of the catch has been taken by trawlers with longliners accounting for approximately 10% of the annual total since 1980 (Table 2). Between 1970 and 1979 longliners took about 20% of the annual totals indicating a decline in their proportional contribution in recent years. However, in 1987 and 1988 their landings again represent 21 and 28% of the total respectively. Since

1980 seiners have accounted for approximately 5% of total annual landings. In 1988 the foreign small-meshed gear fishery (mainly USSR and Cuba) caught 391 t of haddock as a by-catch (Table 3).

The age composition of the 1988 small mesh gear catch taken primarily by the USSR and Cuba was estimated in a manner consistent with recent practices (Zwanenburg and Fanning 1987). These were combined with estimated removals by the domestic fisheries calculated as first and second half removals by trawlers (OTB1, OTB2, PTB), and a full year key for other gears (mainly LL) (Table 4). As in the previous assessment (Zwanenburg and Fanning 1988) the length-weight parameters used in the calculation of catch at age were derived using all observations from the July RV surveys conducted since 1970 (Table 5). The commercial catch and weights at age since 1948 are given in Tables 6 and 7. An examination of the entire time series of weights at age for 4TVW haddock indicates that these show some temporal trends, but are presently at approximately average levels for those ages comprising the bulk of the fishery (Figure 1).

Comparison of the 1988 observed catch at age to that predicted by the previous assessment indicates that catches at ages 1 through 5 were significantly underestimated while removals at ages 5 and older were overestimated (Table 8 and Figure 2). This may be attributable to significant differences in the age composition of catches taken during the first and second halves of the year. Catches taken during the first half of the year consistently contain a greater proportion of older fish than those taken during the second half. Use of first half catches in the half year formulation of the adaptive framework would have estimated a population age composition skewed toward older ages relative to a full year catch. Projections of this biased age composition may then have resulted in the observed differences.

The half year removals at age employed in the retrospective analysis were estimated in a manner similar to that employed for the full year removals except that all small mesh catches were assumed to have been taken during the first half of the year (Table 9).

The age composition for the 1986 and 1987 commercial catches, presented in the previous assessment of this resource (Zwanenburg and Fanning 1988) were updated. For 1986, this resulted in an overall increase of 4% in the estimated total numbers removed by the fishery (Table 10). The revision of the 1987 catch at age reduced overall removals by 8% mainly as a result of a change in the intercept of the length-weight relationship used in the calculation of the age-length keys. These revised data resulted in no significant changes to the estimated fishing mortality or population numbers when used in the adaptive framework formulated in a manner equivalent to that of the previous assessment (Table 11).

Commercial Catch Rates

The by-catch nature of this fishery since 1987 makes present catch rates incomparable to those of earlier years from directed fisheries. By-catch catch rates are not considered to be representative of the abundance of this stock.

Research Vessel Index

The research survey catch rates from 1970 to 1988 show a decline in overall abundance from 1983 to 1987 with a subsequent increase in 1988 (Table 12, Figure 3). Examination of this overall index by age group and area reveals that the abundance of all age-classes in Sub-divisions 4Vn and 4Vs continued to decline in 1988 (Figures 4 and 5), while those in Division 4W increased (Figure 6). Furthermore, the abundance of age-classes 0-3 in 4W showed larger increases than ages 4-7 and were largely responsible for the increase in overall abundance. These observations may be indicative of an increase in the number of fish recruiting to this stock; however since they are based on a single year of data and the estimates of the size of the largest incoming year-class (1986) has a large CV (91%, Table 13) it is premature to draw firm conclusions.

Estimation of Parameters

Stock Size

A summary of the inputs and assumptions used in the adaptive framework are given below.

PARAMETERS:

- Year-class estimates

  N_i,1988 $\quad$ i = 2 to 5

- Calibration slopes and intercepts for mid-year RV No's

  K_{0i},K_{1i} $\quad$ i = 2 to 5

STRUCTURE:

- assumed error in catch at age to be negligible
- F at ages 6 to 11 in 1988 set equal to age 5
- F at age 11 set equal to weighted (population numbers) mean of ages 5 6 7
- Natural mortality set at 0.2

INPUT:

- $C_{i,t}$ $\quad$ i = 1 to 11 $\quad$ t = 1970 to 1988
- $RV_{i,t}$ $\quad$ i = 2 to 5 $\quad$ t = 1970 to 1988
- RV numbers related to July population

OBJECTIVE FUNCTION:

- minimize

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

SUMMARY:

- number of observation = 76
- number of parameters = 12

The estimated F's at age for 1988 are given below. Although the weighted (population numbers) mean F of about 0.2 indicates that the fishery in 1988 was prosecuting the resource below $F_{0.1}$ = 0.25, current estimates of fully recruited F have significantly underestimated the subsequent retrospective value.

Age	1	2	3	4	5	6....
F_{1988}	.001	.002	.014	.209	.196	.....

In the previous assessment of this resource fully recruited F at ages 5+ for 1987 was estimated to have been 0.14, the present estimate of F at ages 5+ in 1987 is approximately 0.5. In addition to this significant change in the perception of fishing mortality some estimates of year-class strengths have also changed. Most significantly the 1983 year-class, which was considered to have been relatively weak, is now estimated to be well above average.

It has become common practice in the assessment of several Scotian Shelf resources to use half year catches from the current year and current year survey results to estimate previous year population numbers at age. This is a departure from the more traditional formulation which uses previous year's catch and survey results to estimate that year's population numbers. The change in perception of the relative numbers of young and older fish resulting from this formulations prompted an examination of the proportional catches of these fish as a proxy for the distribution of F over the fishing year. This revealed that significantly more younger fish were caught during the second half of the year then during the first presumably as a result of recruitment to the fishery over the course of the year., since the differences were most notable in the mobile gear fisheries. Given this result and the large changes in perception of age specific exploitation and population size, a retrospective analysis using the adaptive framework with three different sets of input data was used to investigate that sensitivity of the resulting estimates to underlying assumptions. Estimates of 1987 population numbers at age derived from the 1987 full year, 1988 half year, and 1988 full year formulations were used to estimate 1988 beginning of year

population estimates. The F matrix from each of these analyses was used to estimate an unique PR vector (population weighted mean of 1984-1986) which was then used to project catches in 1989 and 1990 after accounting for observed catches in 1988. The results of these formulations gave divergent estimates of F. In the 1988 half year formulation the fully recruited F at ages 5+ was estimated to have been 0.14, while the 1988 full year estimate of F at these ages is approximately 0.5. The two full year formulations projected $F_{0.1}$ catches and population biomass estimates in 1990 which were more consistent with each other and with previous estimates than with the half year estimate. Given this result we used the estimated population numbers for 1987 resulting from the 1988 full year formulation of the adaptive framework (Table 11 "New") to project catches at $F_{0.1}$ in 1990.

It is considered that the half year formulation of the adaptive framework employed in previous assessments of this resource may have made assumptions regarding the distribution of fishing mortality over seasons and age-classes which are inconsistent with observed age compositions of seasonal catches. In particular the assumption of an equal partitioning of fishing mortality between the two halves of the year is not evident at all ages. The imposition of this assumption in the half year formulation of the adaptive framework may have resulted in the estimation of population numbers at age which were biased. The overall effects of this bias remains to be established. These inconsistencies in the present analysis do not; however, alter the overall view of this resource in that population biomass remains relatively low and recruitment, with the possible exception of the 1986 year-class has been at best average or below average.

Assessment Results

The mid-year biomass estimate for 1988 (1+) indicates an increase over the 1984-1987 period; however, about 45% of this estimate is comprised of fish aged 1 and 2 which were derived from average recruitment values. The estimate of age 3+ biomass is not influenced by the contribution of these younger ages and also shows an increase for 1988 (Figure 7, Table 14). The trend in population numbers at age 1 shows low values in the early 1970s followed by two pulses of good recruitment in the late 1970s and early 1980s (Figure 8, Table 15). Long-term estimates of F are given on Table 16.

Prognosis

Although RV surveys indicate that the 1986 year-class may be above average, the associated variance (CV=0.91) dictates assumption of a mean value (23 million) for this year-class pending confirmation. The timespan (1977-1986) used in calculating the geometric mean recruitment recognizes that recruitment in recent years has generally been higher than that observed in the early to mid-1970s, but reflects the uncertainty inherent in the estimate of this year-class. The 1987 and 1988 year-classes were also set equal to 23 million. Catch projections were made using the following parameters:

Age	1989 Beginning of Year Population	PR[1]	Weights[2]
1	23300	.002	0.10
2	19026	.006	0.26
3	15494	.038	0.60
4	8049	.443	0.89
5	6128	1.000	1.16
6	7190	1.000	1.61
7	1625	1.000	2.28
8	162	1.000	2.37
9	17	1.000	2.63
10	17	1.000	3.17
11	4	1.000	4.60

1 - Weighted (population numbers) mean 1984-1986
2 - Weighted (population numbers) mean 1986-1988

The years used to obtain average PR correspond to a period where there was a directed fishery. The expected catch of 6747 t in 1989 would approximate F = .32. The 1990 biomass (3+) is projected to be about 38,000 t. Given the uncertainty in the formulations with respect to the half year SPA and the difficulties in estimating F as a result of the disappearance of older ages, a catch of 6000 t approximates the $F_{0.1}$ catch in 1989 and 1990. Application of the 50% rule is not advised for this stock.

Research Recommendations

That the use half year catches at age in tuning be investigated for as many years as feasible.

References

Fanning, P., K. Zwanenburg, and M. Showell. 1987. Haddock nursery closed areas: Delineation and impact. CAFSAC Research Document 87/59.

Zwanenburg, K., and P. Fanning. 1987. Haddock in 4TVW -- Population status and catch projections for 1988. CAFSAC Research Document 87/103.

Zwanenburg, K., and P. Fanning. 1988. Assessment of haddock in 4TVW -- Population status and catch projections for 1989. CAFSAC Research Document 88/76.

Table 1. Nominal catches (t) of eastern Scotian Shelf haddock (4TVW) by NAFO Division and country as reported to NAFO (from NAFO Statistical Bulletin).

	4T					4Vn+					4Vs					4W						
Year	Canada	USA	USSR	Spain	Other	Canada	USA	USSR	Spain	Other	Canada	USA	USSR	Spain	Other	Canada	USA	USSR	Spain	Other	Total	TAC
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	
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	3	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				2	2339		104		73	3433	2000
1980	81					188				42	1841					12448		209		31	14840	15000
1981	177					119				25	1796					17684		187		21	20009	23000
1982	47					183				23	2373					12498		53		49	15226	23000
1983	30					206				17	1542					7302		149		166	9412	15000
1984	120					299				11	3195		2		1	3992		168		233	8021	15000
1985	498					598				59	7291				2	2862		275		79	11664	15000
*1986	579					880					8764				4	6169		312		78	16786	17000
*1987	459					488				13	1587				1	994		207		154	3903	0
*1988	383					506					2041					1150		391			4471	0

+ — Between 1954 and 1958 catches for 4Vn and 4Vs were combined as 4V.
* — Provisional data

Table 2. Canadian (M, Q, & Nfld.) nominal catches (t) of eastern Scotian Shelf haddock (4TVW) by gear. (From IS files for 86-88.)

Year	Otter Trawler	Danish/Scottish Longliner	Danish/Scottish 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	340	5485
79	1745	1232	66	147	3190
1980	13063	933	229	270	14495
81	17859	1253	464	113	19689
82	12346	1567	890	249	15052
83	6969	1254	541	235	8997
84	6188	908	451	112	7659
85	9548	822	830	50	11249
86*	13939	1101	1188	105	16334
87*	2084	734	580	82	3480
88*	2341	1134	424	180	4079

* - Provisional Statistics

Table 3. Estimation of small mesh removals of haddock in 4VW in silver hake directed fisheries by Cuba, Bulgaria, Romania, Japan, Portugal, and the USSR. In 1984 The GDR also carried out directed fisheries for silver hake.

Year	Nominal Catch of Silver Hake (t)	IOP Haddock By-Catch Ratio (%)	Reported Catch of Haddock (t)	Estimated By-Catch Of Haddock (t)
1970	164,013	0.82*	670	1345
1971	122,616	0.82*	475	1005
1972	108,828	0.82*	106	892
1973	269,420	0.82*	76	2209
1974	87,497	0.82*	132	717
1975	98,994	0.82*	109	812
1976	90,483	0.82*	24	742
1977	30,019	0.64	33	192
1978	45,966	1.25	229	575
1979	50,374	0.51	176	257
1980	37,709	0.75	229	283
1981	37,554	0.80	201	300
1982	58,132	0.40	94	233
1983	34,259	1.64	326**	562
1984	72,297	1.33	557**	959
1985	76,003**	0.72	357	547
1986***	82,467	0.60	-	500
1987***	61,675	0.58	308	332
1988***	61,753	-	-	391

* Mean of 1977-1979 weighted by-catch observed.
** FLASH
*** Preliminary data (1988 preliminary to 30-06-88)

Table 4. Catch at age - 1988. Contributions by gear sector and time of year. Note large contribution of 4 and 5 year olds in "others" key.

Age	Trawlers 1st Half		Trawlers 2nd Half		Others		Small Mesh		Total	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
1	0	-	0	-	0	-	56	0.113	56	.11
2	0	-	0	-	1	0.41	67	0.293	68	.30
3	0	0.49	35	0.77	53	0.66	41	0.565	129	.65
4	116	0.88	407	0.97	946	0.90	115	0.807	1584	.91
5	540	1.15	525	1.30	552	1.19	109	1.134	1726	1.21
6	238	1.45	56	1.91	77	1.88	19	1.475	390	1.59
7	22	1.80	2	2.89	14	2.69	1	2.333	39	2.19
8	0	-	0	4.36	4	1.57	0	2.798	4	2.31*
9	3	3.31	0	-	1	3.65			4	2.57
10	1	2.69	0	-	0	-			1	2.69
11	0	-	0	-	0	5.12				4.61*

* - replaced with $\overline{X}$ 1985-87

Table 5. Grouping of catch by gears and time period for estimation of removals-at-age. Trawlers are primarily stern and side bottom trawls but also pair trawls, other is primarily longline, Danish seine, and Scottish seine (for 1948-1969 see Mahon et al. 1985).

Year	Period	Gears	No. of Samples	Number Aged	Number Measured	Catch (t)	Weight-Length Relationship a	b	Cruise
1970	Jan - Dec	Trawlers	11	405	2172	7986	0.0062	3.136	Cameron #170 March 1970
	Jan - Dec	Other	3	107	602	779	0.0112	2.989	Cameron #175/176 July 1970
1971	Jan - Dec	Trawlers	24	966	5930	12174	0.0052	3.168	Cameron #184 March 1971
	Jan - Dec	Other	5	197	966	820	0.0088	3.035	Cameron #188/189 July 1971
1972	Jan - Dec	Trawlers	7	255	1661	3802	0.0036	3.261	Cameron #196 March 1972
	Jan - Dec	Other	1	29	200	817	0.0133	2.943	Cameron #200/201 July 1972
1973	Jan - Dec	Trawlers	8	299	1831	3407	0.0036	3.261	Cameron #196 March 1972
	Jan - Dec	Other	3	100	652	927	0.0096	3.017	Cameron #212/213 July 1973
1974	Jan - Dec	Trawlers	1	37	364	1545	0.0089	3.035	Cameron #225/226 July 1974
	Jan - Dec	Other	2	70	459	680	0.0089	3.035	Cameron #225/226 July 1974
1975	Jan - Dec	Trawlers	4	136	1048	778	0.0045	3.204	Cameron #219 March 1974
	Jan - Dec	Other	1	30	200	982	0.0094	3.023	Cameron #236/237 July 1975
1976	Jan - Dec	Trawlers	3	106	850	424	0.0191	2.837	Cameron #250/251 July 1976
	Jan - Dec	Other	3	89	478	912	0.0191	2.837	Cameron #250/251 July 1976
1977	Jan - June	Trawlers	3	105	616	548	0.0103	2.983	Cameron #259 March 1977
	July - Dec	Trawlers	11	319	2419	1684	0.0108	2.996	Cameron #265/266 July 1977
	Jan - Dec	Other	4	133	885	982	0.0108	2.996	Cameron #265/266 July 1977
1978	Jan - June	Trawlers	18	582	5776	3453	0.0019	3.425	Cameron #274 March 1978
	July - Dec	Trawlers	2	55	507	649	0.0103	3.000	Cameron #279/280 July 1978
	Jan - Dec	Other	5	164	1068	1536	0.0103	3.000	Cameron #279/280 July 1978
1979	Jan - June	Trawlers	3	80	650	847	0.0063	3.117	Hammond #13/14 March 1979
	July - Dec	Trawlers	6	189	1324	878	0.0050	3.187	Hammond #26/27 Oct-Nov 1979
	Jan - Dec	Other	12	347	2675	1528	0.0057	3.155	Cameron #292/293 July 1979
1980	Jan - June	Trawlers	24	759	5527	7077	0.0069	3.091	Hammond #33/34 March 1980
	July - Dec	Trawlers	22	619	5021	6122	0.0049	3.197	Hammond #42/43 October 1980
	Jan - Dec	Other	6	180	1421	1412	0.0117	2.970	Cameron #306/307 July 1980
1981	Jan - June	Trawlers	29	642	7450	15709	0.0070	3.102	Hammond #48/49 March 1981
	July - Dec	Trawlers	14	374	3062	2067	0.0087	3.049	Hammond #64/65 October 1981
	Jan - Dec	Other	15	407	2793	2025	0.0093	3.037	Cameron #321/322 July 1981
1982	Jan - June	Trawlers	48	1339	11563	10702	0.0059	3.143	Hammond #71/72 March 1982
	July - Dec	Trawlers	13	379	2682	1657	0.0068	3.100	Needler #2/3 October 1982
	Jan - Dec	Other	18	472	3337	2676	0.0123	2.954	Hammond #80/81 July 1982
1983	Jan - June	Trawlers	39	694	9253	6068	0.0086	3.026	Hammond #94/95 March 1983
	July - Dec	Trawlers	17	133	3642	936	0.0085	3.045	Needler #17/18 October 1983
	Jan - Dec	Other	15	131	2676	2060	0.0116	2.961	Needler #12/13 July 1983
1984	Jan - June	Trawlers	33	535	7716	3546	0.0079	3.052	Needler #24/25 March 1984
	July - Dec	Trawlers	33	315	7279	2655	0.0049	3.178	Needler #36/37 October 1984
	Jan - Dec	Other	11	256	2329	1471	0.0097	3.005	Needler #31/32 July 1984
1985	Jan - June	Trawlers	33	615	7285	7174	0.0235	2.739	Needler #41 March 1985
	July - Dec	Trawlers	14	85	3019	2358	0.0049	3.178	Needler #36/37 October 1984
	Jan - Dec	Other	6	109	1087	1731	0.0129	2.921	Needler #48/49 July 1985
1986	Jan - June	Trawlers	46	531	10651	7230	0.006073	3.133906	Needler #65/66 July 1986
	Jul - Dec	Trawlers	27	329	5768	6709	0.006073	3.133906	Needler #65/66 July 1986
	Jan - Dec	Other	27	504	3954	2394	0.006073	3.133906	Needler #65/66 July 1986
1987	Jan - June	Trawlers	25	410	4827	1045	0.00770612	3.072610	All summer surveys 70-88
	Jul - Dec	Trawlers	15	272	3036	1040	0.00770612	3.072610	All summer surveys 70-88
	Jan - Dec	Other	8	150	1403	1396	0.00770612	3.072610	All summer surveys 70-88
1988	Jan - June	Trawlers	16	264	3363	1117	0.00770612	3.072610	All summer surveys 70-88
	July - Dec	Trawlers	20	344	4059	1223	0.00770612	3.072610	All summer surveys 70-88
	Jan - Dec	Other	18	283	3459	1739	0.00770612	3.072610	All summer surveys 70-88

Table 6. Commercial catch at age (thousands of fish) for 4TVW haddock.

COMMERCIAL CATCH AT AGE 4TVW HADDOCK

	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
1	0	0	0	50	0	0	0	0	0	0	0	0	0	2	205	1287	2591	53595
2	0	10	0	0	6	3	12	0	213	0	63	8	0	31	436	924	3073	32161
3	177	855	83	765	449	349	211	504	1926	647	2115	2938	455	409	1491	511	4074	24140
4	2194	1126	2389	4967	1915	2324	2881	1021	11209	3634	3817	6803	6408	4901	2039	3471	2368	15192
5	3269	4330	2823	6056	6626	4113	10071	2592	2400	13199	2504	5559	7580	8501	7794	3673	6023	7775
6	1297	3090	5018	2216	4654	4445	2159	5132	2539	2045	8128	3388	3339	4298	6190	6594	2069	4057
7	1412	483	3227	1794	1831	1407	2466	1765	2866	1538	1076	7071	2164	1362	1957	3190	2906	1282
8	1088	357	293	1306	1079	457	1318	1642	963	1233	777	809	1964	1062	839	1243	1562	1234
9	556	303	575	98	405	247	431	620	1334	341	788	528	372	727	317	287	403	402
10	433	228	230	66	96	25	265	313	340	244	276	534	157	193	223	126	81	72
11	253	142	358	79	65	18	68	51	89	92	164	213	161	61	59	113	45	54

	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
1	2127	89	5	31	306	268	306	487	59	279	431	213	714	1	332	870	530	497	10
2	9696	181	13	42	129	667	288	1178	233	61	676	283	433	268	376	318	433	470	360
3	9638	1006	398	438	679	888	671	646	975	470	157	965	811	423	2372	262	1520	1084	1514
4	8887	2622	1806	1408	1743	2189	751	1467	254	805	249	335	2412	1120	4334	5072	764	3207	4158
5	4645	2836	2926	2039	1400	2740	924	811	464	282	323	513	436	675	3238	5081	5629	2040	2225
6	1217	1113	2494	1955	1365	1208	668	723	298	185	189	283	715	159	1702	3010	1957	1677	821
7	1637	441	793	939	1163	944	345	342	114	63	132	117	203	149	249	1178	1220	530	410
8	499	597	379	279	389	1177	191	159	47	30	36	80	61	16	129	139	214	235	90
9	272	212	406	131	88	277	159	60	8	8	8	19	23	5	39	105	48	29	30
10	89	174	116	118	38	39	9	99	17	4	10	15	8	6	9	30	28	18	5
11	12	55	78	39	19	21	18	2	16	1	3	6	2	2	7	10	5	19	2

	85	86	87	88
1	133	12	30	56
2	69	50	76	68
3	411	1289	160	129
4	8006	10064	983	1584
5	4162	5954	1686	1726
6	881	767	377	390
7	232	100	24	39
8	47	13	6	4
9	14	1	1	4
10	2	1	0	1
11	1	1	1	0

Table 7. Commercial mean weights at age (kg) for 4TVW haddock.

Commercial Mean Weights at Age 4TVW Haddock

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
1	.082	.082	.082	.680	.082	.082	.082	.082	.082	.082	.082	.082	.082
2	.305	.680	.305	.305	.680	.580	.680	.305	.500	.305	.530	.800	.305
3	1.130	.838	.821	.997	.885	.954	.869	.786	.750	.762	.704	.680	.667
4	1.189	1.189	1.026	1.073	1.095	1.133	1.084	1.038	.888	.986	.976	.892	.912
5	1.611	1.393	1.385	1.292	1.353	1.517	1.144	1.298	1.252	1.185	1.264	1.168	1.096
6	2.250	1.821	1.861	1.626	1.662	1.822	1.574	1.476	1.527	1.557	1.472	1.477	1.414
7	2.692	2.465	2.165	2.081	2.113	2.253	1.953	1.813	1.722	1.816	1.749	1.788	1.829
8	3.022	2.925	2.634	2.332	2.615	2.761	2.127	2.151	2.127	2.074	2.102	2.173	2.191
9	3.097	2.986	2.562	1.612	2.986	3.175	2.438	2.392	2.227	2.370	2.089	2.405	2.461
10	3.383	3.162	2.838	1.391	2.514	3.868	2.691	2.597	2.283	2.388	2.460	2.740	2.703
11	3.490	3.315	3.593	2.316	2.463	3.540	3.063	2.780	2.815	2.791	2.407	2.946	2.678

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	.060	.049	.099	.102	.103	.090	.122	.108	.099	.108	.119	.098	.115
2	.190	.200	.142	.281	.254	.267	.384	.174	.218	.332	.335	.280	.347
3	.794	.453	.364	.445	.421	.356	.534	.434	.652	.638	.625	.586	.651
4	.899	.825	.939	.710	.715	.698	.784	.800	.883	.913	.921	.955	.976
5	1.147	1.022	1.146	1.096	1.114	1.034	1.149	1.118	1.260	1.288	1.302	1.344	1.374
6	1.526	1.350	1.356	1.350	1.297	1.332	1.485	1.593	1.616	1.565	1.627	1.832	1.866
7	1.867	1.735	1.748	1.644	1.928	1.551	1.767	2.159	2.277	2.072	1.930	2.187	2.218
8	2.225	2.182	2.007	1.925	2.232	2.177	2.167	2.188	2.774	2.595	2.303	2.407	2.593
9	2.406	2.730	2.356	2.345	2.418	2.300	2.548	2.572	3.313	3.137	2.867	2.971	3.248
10	2.762	2.597	2.547	2.724	2.791	2.670	2.816	3.103	3.324	4.044	3.435	3.861	3.174
11	3.298	3.455	2.443	2.393	3.119	3.040	3.065	3.343	3.210	3.553	3.752	3.830	3.630

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	.122	.159	.092	.140	.080	.090	.080	.080	.060	.070	.090	.120	.100
2	.407	.245	.369	.515	.349	.335	.231	.383	.265	.186	.263	.197	.270
3	.643	.852	.526	.927	.666	.708	.716	.686	.631	.526	.577	.462	.630
4	1.123	1.203	1.217	1.234	1.067	1.167	1.031	.954	.957	.822	.738	.698	.820
5	1.656	1.572	1.607	1.514	1.511	1.554	1.361	1.266	1.203	1.160	1.036	.986	1.050
6	1.978	2.137	2.027	1.905	1.967	2.020	1.846	1.677	1.606	1.428	1.462	1.429	1.570
7	2.468	2.447	2.271	2.345	2.582	2.444	2.319	2.190	2.154	1.721	1.794	1.926	2.410
8	2.789	2.800	2.327	2.505	2.687	2.965	2.662	2.708	2.779	1.905	2.154	2.350	2.280
9	2.841	3.036	3.194	2.811	3.276	3.273	3.128	3.082	3.138	2.802	2.664	2.964	2.580
10	3.435	3.131	2.611	3.328	3.497	3.435	3.402	3.409	3.513	2.065	3.240	2.200	3.760
11	3.395	4.120	3.102	3.196	3.846	4.208	3.654	3.664	4.496	1.816	3.182	5.590	4.470

	1987	1988
1	.100	.110
2	.210	.300
3	.510	.650
4	.930	.910
5	1.220	1.210
6	1.670	1.590
7	2.250	2.190
8	2.520	2.310
9	2.740	2.570
10	3.070	2.690
11	4.730	4.610

Table 8. Comparison of predicted and observed 1988 catch at age for 4TVW haddock.

Catch at Age Observed	Catch at Age Projected	Proportional Catch at Age Observed	Proportional Catch at Age Projected	Observed/ Projected
56	6	0.014	0.002	9.241
68	32	0.017	0.009	1.822
129	50	0.032	0.015	2.198
1584	445	0.396	0.131	3.032
1726	1026	0.431	0.301	1.434
390	1493	0.097	0.438	0.223
39	331	0.010	0.097	0.101
4	21	0.001	0.006	0.167
4	6	0.001	0.002	0.612
1	1	0.000	0.000	0.918
0	1	0.000	0.000	0.000

Table 9. Half year commercial catch at age for 4TVW haddock. Small mesh gear catches were allocated to the first half of the year (catch in 000's of fish).

Age	1986	1987*	1988
1	12	30	56
2	41	76	67
3	236	129	52
4	3921	371	361
5	4085	882	921
6	533	283	299
7	96	19	24
8	7	8	0
9	1	2	3
10	1	0	1
11	1	0	0

* - In 1987 no first half "others" samples were available so that all catch in the first half (except small mesh gear) was put into trawler keys.

Table 10. Updated vs old catch at age for 4TVW haddock.

	1986			1987			1988*	
Age	Old	New	Δ	Old	New	Δ	Old*	New
1	12	12	0	34	30	-0.12	56	56
2	50	50	0	86	76	-0.12	67	68
3	1257	1289	+0.02	179	160	-0.11	44	129
4	9770	10064	+0.03	1080	983	-0.09	262	1584
5	5747	5954	+0.04	1823	1686	-0.08	709	1726
6	738	767	+0.04	403	377	-0.06	265	390
7	98	100	+0.02	25	24	-0.04	23	39
8	12	13	+0.08	7	6	-0.14	0	4
9	1	1	0	1	1	0	3	4
10	1	1	0	0	0	0	1	1
11	1	1	0	1	1	0	0	0
Σ	17687	18252	+0.04	3639	3344	-0.08		

* - 1988 old = ½ year catch

Table 11. Comparison of ADAPT results using the old and new (updated) catch at age. The differences in the two catch at age matrices are given on Table 10.

OLD

4VW HADDOCK 4/25/89 07:55

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.195849
MEAN SQUARE RESIDUALS 0.642823

PAR. EST.	STD. ERR.	T-STATISTIC
4.77364E0004	3.99358E0004	1.19533E0000
9.96108E0003	5.20612E0003	1.91334E0000
9.24524E0003	3.82851E0003	2.41484E0000
1.05375E0004	3.91615E0003	2.69078E0000
-2.32300E-001	5.59491E-001	-4.15198E-001
3.28262E-004	9.93382E-005	3.30449E0000
-1.04069E0000	4.98740E-001	-2.08664E0000
7.78402E-004	1.83478E-004	4.24248E0000
-1.06451E0000	4.57057E-001	-2.32904E0000
1.21062E-003	2.78844E-004	4.34157E0000
-6.23843E-001	3.54931E-001	-1.75765E0000
1.31882E-003	3.52445E-004	3.74193E0000

Parameter Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	.055	.048	.054	.245	-.322	.019	-.024	.014	-.018	.014	-.017
2	.055	1.000	.057	.058	.083	-.163	.144	-.195	.016	-.020	.015	-.018
3	.048	.057	1.000	.079	.082	-.144	.123	-.161	.141	-.177	.020	-.024
4	.054	.058	.079	1.000	.112	-.165	.131	-.165	.162	-.198	.255	-.310
5	.245	.083	.082	.112	1.000	-.812	.033	-.042	.028	-.034	.029	-.035
6	-.322	-.163	-.144	-.165	-.812	1.000	-.056	.073	-.044	.054	-.042	.051
7	.019	.144	.123	.131	.033	-.056	1.000	-.854	.036	-.044	.034	-.041
8	-.024	-.195	-.161	-.165	-.042	.073	-.854	1.000	-.046	.057	-.042	.051
9	.014	.016	.141	.162	.028	-.044	.036	-.046	1.000	-.866	.041	-.050
10	-.018	-.020	-.177	-.198	-.034	.054	-.044	.057	-.866	1.000	-.051	.062
11	.014	.015	.020	.255	.029	-.042	.034	-.042	.041	-.051	1.000	-.895
12	-.017	-.018	-.024	-.310	-.035	.051	-.041	.051	-.050	.062	-.895	1.000

NEW

4VW HADDOCK 4/24/89 18:28

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.197664
MEAN SQUARE RESIDUALS 0.642025

PAR. EST.	STD. ERR.	T-STATISTIC
4.79199E0004	4.00835E0004	1.19550E0000
9.99044E0003	5.22372E0003	1.91251E0000
9.27219E0003	3.83830E0003	2.41570E0000
1.07239E0004	3.96144E0003	2.70706E0000
-2.26604E-001	5.58477E-001	-4.05754E-001
3.26789E-004	9.89111E-005	3.30387E0000
-1.03518E0000	4.98044E-001	-2.07849E0000
7.75785E-004	1.82879E-004	4.24207E0000
-1.06036E0000	4.56358E-001	-2.32352E0000
1.20729E-003	2.78083E-004	4.34148E0000
-6.20549E-001	3.54018E-001	-1.75287E0000
1.31438E-003	3.51181E-004	3.74275E0000

Parameter Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	.055	.048	.054	.245	-.322	.019	-.024	.015	-.018	.014	-.017
2	.055	1.000	.057	.058	.083	-.163	.144	-.195	.016	-.020	.015	-.018
3	.048	.057	1.000	.079	.082	-.144	.123	-.162	.141	-.177	.020	-.025
4	.054	.058	.079	1.000	.112	-.165	.132	-.165	.163	-.200	.255	-.311
5	.245	.083	.082	.112	1.000	-.811	.033	-.042	.028	-.034	.029	-.035
6	-.322	-.163	-.144	-.165	-.811	1.000	-.056	.073	-.044	.054	-.042	.051
7	.019	.144	.123	.132	.033	-.056	1.000	-.853	.036	-.044	.034	-.041
8	-.024	-.195	-.162	-.165	-.042	.073	-.853	1.000	-.046	.057	-.042	.051
9	.015	.016	.141	.163	.028	-.044	.036	-.046	1.000	-.866	.042	-.051
10	-.018	-.020	-.177	-.200	-.034	.054	-.044	.057	-.866	1.000	-.051	.062
11	.014	.015	.020	.255	.029	-.042	.034	-.042	.042	-.051	1.000	-.894
12	-.017	-.018	-.025	-.311	-.035	.051	-.041	.051	-.051	.062	-.894	1.000

Table 11. (Continued).

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

OLD

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	-.291	.879	.232	.222	.410	-.147	-.325	.624	.450	.117	-2.124	.848	1.093	.576	.395	-1.813	-.538	-.652	-.018
3	-.678	-.270	-.361	.309	.762	.020	-.682	.219	.315	-.255	.060	-1.310	.794	1.205	.159	-.182	-.364	-.375	.567
4	-1.065	-.609	-.846	-.935	.432	.535	-.892	.047	.136	-.223	.054	-.595	-.737	.772	1.270	.620	1.079	.161	.741
5	-1.128	-1.347	-1.002	-1.134	.094	.447	.345	.033	-.524	-.607	-.005	-.217	.351	.431	1.012	.907	1.837	.537	-.110

NEW

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	-.290	.880	.230	.223	.411	-.148	-.321	.628	.453	.121	-2.122	.851	1.093	.567	.387	-1.820	-.535	-.651	-.018
3	-.675	-.268	-.359	.307	.763	.022	-.680	.222	.318	-.251	.063	-1.308	.796	1.204	.148	-.192	-.371	-.375	.566
4	-1.062	-.606	-.844	-.934	.431	.537	-.890	.049	.138	-.220	.057	-.592	-.735	.774	1.267	.599	1.090	.149	.740
5	-1.126	-1.344	-.999	-1.133	.095	.447	.346	.036	-.522	-.604	-.001	-.214	.354	.433	1.013	.879	1.851	.538	-.127

Table 11. (Continued).

POPULATION NUMBERS (000S)

OLD

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	8153	4438	8085	7648	4579	19929	27169	31077	35928	10911	18390	24351	35973	32312	27686	17269	14961	58244	77380
2	5479	6398	3391	6343	5821	3696	16064	21854	25251	28770	8932	14756	19149	28972	26006	22659	14018	12239	47656
3	7181	4369	4634	2516	4127	4555	2971	12540	17637	20282	23312	6973	11793	15286	23295	20966	18489	11432	9942
4	7683	5265	2773	3187	1476	2497	3304	2290	9394	13706	16222	16940	5472	8280	11535	17702	16793	14000	9198
5	4136	4713	2330	1590	1282	979	1315	2479	1572	5508	10208	9360	9280	3789	3877	5681	7249	4909	10485
6	3270	2120	1380	1072	568	630	546	785	1565	892	3899	5428	3065	2505	1256	1161	886	735	2369
7	3416	1442	642	525	223	196	348	276	386	634	587	1652	1721	739	533	286	154	57	237
8	825	1745	326	214	121	79	103	165	120	132	385	255	286	305	125	66	24	37	24
9	210	323	363	95	31	56	38	52	62	43	94	198	83	40	37	21	12	9	24
10	84	93	13	154	23	18	39	24	26	31	31	41	67	25	7	4	5	9	6
11	52	34	40	3	36	3	11	23	6	14	20	17	7	30	4	1	1	3	6
	40490	30939	23979	23347	18287	32637	51908	71565	91948	80923	82080	79970	86896	92283	94361	85816	72592	101674	157327

NEW

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	8153	4438	8085	7648	4579	19929	27169	31076	35928	10915	18396	24436	36416	32681	27958	17287	14991	58464	78894
2	5479	6398	3391	6343	5821	3696	16064	21854	25250	28770	8935	14761	19219	29336	26307	22881	14033	12263	47839
3	7181	4369	4634	2516	4127	4555	2971	12540	17637	20281	23312	6976	11797	15344	23593	21212	18671	11444	9971
4	7683	5265	2773	3187	1476	2497	3304	2290	9394	13706	16221	16940	5474	8283	11582	17946	16995	14120	9225
5	4136	4713	2330	1590	1282	979	1315	2479	1572	5508	10208	9359	9280	3791	3880	5720	7449	4808	10671
6	3270	2120	1380	1072	568	630	546	785	1565	892	3899	5428	3065	2505	1257	1164	917	711	2411
7	3416	1442	642	525	223	196	348	276	386	634	587	1652	1721	738	533	287	156	57	241
8	825	1745	326	214	121	79	103	165	120	132	385	255	286	305	125	66	25	37	25
9	210	323	363	95	31	56	38	52	62	43	94	198	83	40	37	21	12	9	25
10	84	93	13	154	23	18	39	24	26	31	31	41	67	25	7	4	4	9	6
11	52	34	40	3	36	3	11	23	6	14	20	17	7	30	4	1	1	3	6
	40490	30939	23979	23347	18287	32637	51908	71563	91946	80926	82088	80063	87416	93077	95282	86588	73254	101924	159314

Table 11. (Continued).

FISHING MORTALITY

OLD

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	.042	.069	.043	.073	.014	.016	.018	.008	.022	.000	.020	.040	.016	.017	.000	.009	.001	.001	.001
2	.026	.122	.098	.230	.045	.018	.048	.014	.019	.010	.048	.024	.025	.018	.015	.003	.004	.008	.002
3	.110	.255	.174	.333	.303	.121	.060	.089	.052	.023	.119	.042	.154	.082	.075	.022	.078	.017	.014
4	.289	.615	.356	.711	.211	.441	.087	.176	.334	.095	.350	.402	.168	.559	.508	.693	1.030	.089	.210
5	.468	1.028	.576	.829	.511	.383	.316	.260	.366	.146	.432	.916	1.110	.904	1.005	1.659	2.088	.529	.200
6	.619	.994	.765	1.369	.864	.393	.483	.509	.703	.219	.659	.949	1.223	1.347	1.281	1.822	2.539	.932	.200
7	.472	1.286	.901	1.271	.835	.442	.545	.629	.873	.300	.634	1.552	1.531	1.575	1.886	2.282	1.219	.657	.200
8	.737	1.369	1.037	1.715	.568	.532	.491	.773	.827	.141	.465	.924	1.757	1.903	1.585	1.534	.812	.226	.200
9	.620	2.978	.661	1.222	.353	.167	.270	.504	.510	.131	.622	.884	1.015	1.579	2.111	1.333	.099	.156	.200
10	.694	.632	1.329	1.245	1.826	.314	.323	1.213	.435	.239	.404	1.565	.617	1.730	1.451	.913	.279	.156	.200
11	.514	1.061	.681	1.077	.641	.393	.394	.344	.571	.169	.500	.991	1.186	1.132	1.150	1.710	2.120	.582	.200

NEW

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	.042	.069	.043	.073	.014	.016	.018	.008	.022	.000	.020	.040	.016	.017	.000	.009	.001	.001	.001
2	.026	.122	.098	.230	.045	.018	.048	.014	.019	.010	.048	.024	.025	.018	.015	.003	.004	.007	.002
3	.110	.255	.174	.333	.303	.121	.060	.089	.052	.023	.119	.042	.154	.081	.074	.022	.079	.016	.014
4	.289	.615	.356	.711	.211	.441	.087	.176	.334	.095	.350	.402	.167	.558	.506	.679	1.063	.080	.209
5	.468	1.028	.576	.829	.511	.383	.316	.260	.366	.146	.432	.916	1.110	.903	1.004	1.631	2.149	.490	.196
6	.619	.994	.765	1.369	.864	.393	.483	.509	.703	.219	.659	.949	1.223	1.347	1.278	1.813	2.583	.882	.196
7	.472	1.286	.901	1.271	.835	.442	.545	.629	.873	.300	.634	1.552	1.531	1.577	1.887	2.243	1.240	.630	.196
8	.737	1.369	1.037	1.715	.568	.532	.491	.773	.827	.141	.465	.924	1.757	1.903	1.596	1.535	.858	.198	.196
9	.620	2.978	.661	1.222	.353	.167	.270	.504	.510	.131	.622	.884	1.015	1.578	2.114	1.373	.099	.137	.196
10	.694	.632	1.329	1.245	1.826	.314	.323	1.213	.435	.239	.404	1.565	.617	1.729	1.446	.918	.297	.137	.196
11	.514	1.061	.681	1.077	.641	.393	.394	.344	.571	.169	.500	.991	1.186	1.132	1.148	1.685	2.179	.542	.196

Table 12. Arithmetic mean catch rates (numbers) per tow from RV surveys for haddock in 4VW. The values for 1970 to 1981 incorporate an adjustment of 1.20 to account for the change in research vessels from 1982 on.

RV Arithmetic Mean Catch Rates at Age 24/ 4/89

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	.105	.062	.000	.000	.228	.074	.295	.197	.000	1.488	1.441	22.353
1	2.736	1.724	1.319	.531	.373	5.073	2.760	6.075	9.899	.088	3.512	15.615
2	1.004	3.630	.886	1.733	2.146	.721	3.130	11.379	11.071	9.133	.276	9.378
3	1.839	1.197	1.295	.537	2.903	1.938	.478	8.969	14.806	9.937	14.882	.991
4	2.044	1.576	.585	.472	.526	1.734	.950	1.217	8.320	10.330	13.921	7.375
5	.993	.627	.488	.169	.541	.461	.931	1.940	.513	2.895	8.650	4.679
6	.621	.355	.367	.349	.270	.833	.206	.722	.488	.372	2.090	2.015
7	.695	.163	.150	.074	.201	.220	.230	.204	.124	.289	.333	.308
8	.348	.255	.071	.096	.080	.088	.052	.108	.015	.098	.119	.088
9	.139	.012	.043	.023	.045	.047	.016	.000	.000	.000	.019	.095
10	.044	.000	.019	.046	.033	.054	.015	.050	.011	.038	.000	.028
11	.038	.000	.000	.000	.039	.000	.016	.009	.014	.018	.000	.000
12	.033	.000	.000	.000	.000	.018	.060	.000	.000	.000	.000	.000
13	.000	.000	.000	.000	.000	.000	.000	.021	.000	.000	.000	.000
14	.009	.000	.000	.000	.000	.000	.000	.000	.000	.007	.000	.000
15	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

	1982	1983	1984	1985	1986	1987	1988
0	.774	.146	.276	.000	.137	.083	1.043
1	18.189	21.800	.302	4.223	.604	1.929	4.695
2	15.752	14.486	10.836	1.040	2.251	1.733	13.432
3	14.215	30.222	16.893	11.084	7.777	4.671	10.201
4	2.048	11.631	29.115	21.685	26.058	15.570	16.163
5	7.212	3.078	5.247	4.731	11.879	6.174	9.257
6	3.053	2.742	2.572	1.263	1.299	.552	1.129
7	.965	.946	1.361	.305	.401	.092	.106
8	.227	.238	.303	.062	.067	.000	.032
9	.020	.070	.108	.000	.000	.053	.000
10	.016	.059	.025	.002	.000	.000	.000
11	.000	.000	.006	.000	.000	.000	.000
12	.000	.045	.000	.000	.000	.000	.000
13	.000	.000	.003	.000	.000	.000	.000
14	.000	.024	.000	.000	.000	.000	.000
15	.021	.000	.000	.000	.000	.000	.000

Table 13. Coefficients of variation for RV mean catch rates per tow.

CVs FOR ARITHMETIC MEAN NUMBERS PER TOW 28/ 4/89

	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
0	.65	.72	.00	.00	.91	.51	.67	.46	.00	.39	.63	.51	.24	.61	.45	.00	.63	.56	.27
1	.47	.36	.34	.28	.51	.56	.42	.33	.28	.82	.22	.24	.33	.32	.44	.57	.36	.38	.34
2	.32	.39	.48	.50	.47	.51	.37	.38	.49	.30	.32	.46	.23	.28	.26	.35	.27	.37	.91
3	.30	.33	.35	.35	.48	.40	.41	.36	.46	.41	.31	.31	.34	.49	.21	.24	.21	.20	.69
4	.31	.30	.24	.33	.46	.42	.49	.32	.40	.34	.40	.24	.23	.33	.21	.14	.20	.21	.38
5	.32	.25	.23	.39	.39	.31	.40	.27	.28	.28	.38	.24	.24	.23	.17	.18	.15	.24	.20
6	.33	.26	.29	.50	.44	.35	.34	.26	.23	.26	.27	.21	.21	.21	.15	.25	.21	.19	.20
7	.33	.26	.29	.46	.40	.35	.31	.33	.43	.33	.27	.24	.19	.23	.20	.28	.23	.28	.30
8	.53	.40	.49	.53	.43	.35	.34	.33	.35	.50	.30	.32	.39	.21	.37	.53	.36	.00	.00
9	.44	.56	.49	.00	.40	.38	.52	.00	.00	.00	.40	.35	.92	.44	.54	.00	.00	.56	.00
10	.83	.00	.71	.80	.42	.34	.45	.78	.00	.71	.00	.66	.38	.74	.69	.00	.00	.00	.00
11	.52	.00	.00	.00	.37	.00	.52	.00	.00	.74	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.42	.00	.00	.00	.00	.86	.00	.00	.00	.00	.00	.00	.00	.83	.00	.00	.00	.00	.00
13	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.91	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
1	5158	2966	5388	21416	1976	9102	3191	3296	4784	5952	5203	2210
2	12242	35015	9034	16409	17517	11440	61792	9717	16402	14570	31479	41558
3	21493	27189	34576	23817	38802	19955	13942	58310	18843	20148	26812	32054
4	25889	17775	25683	34300	20019	39143	16851	13023	48749	17706	19006	23941
5	22930	20496	14306	21159	28066	18303	25235	13278	10798	39713	15111	13384
6	4927	15907	14126	10043	14176	21919	11225	16871	9165	7833	26440	10316
7	6710	2574	8973	7008	6758	10064	13302	7338	10051	5636	4816	13464
8	4947	3850	1342	3425	3853	4649	5090	8037	4501	6266	3221	3034
9	5763	2307	1561	409	1508	2148	2361	2682	3738	2801	3283	1591
10	2826	3748	1106	361	291	973	829	1180	1128	1808	1689	1882
11	2527	1472	2479	440	375	180	492	361	587	640	1054	1002
1+	115412	133300	118573	138785	133340	137875	154311	134092	128745	123070	138114	144436
2+	110255	130334	113185	117370	131365	128774	151120	130796	123961	117118	132911	142227
3+	98013	95319	104151	100961	113848	117334	89328	121080	107559	102549	101432	100668
4+	76520	68130	69575	77144	75045	97378	75385	62770	88717	82401	74620	68614

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	3610	1823	2604	7522	8363	5384	1152	1635	1055	602	782	463	704
2	6729	6831	4932	6103	16881	12345	5034	3656	1902	1738	1629	1833	821
3	28232	14182	13024	7192	14597	14680	8085	5966	3264	5692	3941	2194	2266
4	31179	28784	11091	19906	10488	11884	10272	10551	6250	4660	5550	3315	2032
5	16696	24019	20598	9451	13985	7345	5749	8259	9433	5796	3884	3533	2177
6	7671	11019	14148	13352	5696	7643	2775	3362	5419	7636	3493	2013	1622
7	5901	4562	5587	7818	6551	3773	3742	1783	2120	3060	5155	1449	852
8	5583	2744	2206	2361	3043	3333	1851	2253	967	995	1389	2027	451
9	1560	2310	1231	852	666	1253	1445	1000	1004	499	450	279	724
10	711	750	1033	464	401	162	613	886	548	361	224	216	27
11	750	409	414	439	187	185	51	381	501	258	133	73	103
1+	108621	97433	76867	75461	80858	67987	40771	39732	32464	31297	26629	17396	11777
2+	105011	95610	74263	67938	72495	62604	39619	38097	31409	30695	25848	16933	11074
3+	98283	88779	69331	61835	55614	50258	34585	34441	29507	28957	24218	15100	10252
4+	70050	74597	56308	54643	41017	35578	26499	28475	26244	23265	20277	12906	7987

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	770	503	2850	2246	3929	2574	890	1321	1738	1965	2056	2277	1871	1356
2	1792	2101	813	5249	10123	7909	8677	1826	5070	4558	4910	6228	4073	3424
3	1270	2085	3317	1375	10098	10387	12872	14271	4249	6271	7037	11899	8782	10248
4	2042	1360	2217	3495	2355	7768	13854	12861	12117	4383	4775	6132	8334	7910
5	1364	1519	1166	1651	3008	1813	7236	10298	7138	6196	2663	2337	2587	3011
6	1009	692	1015	802	1071	2027	1472	4829	5413	2626	1791	960	716	485
7	610	343	354	557	440	611	1220	923	1707	1762	594	366	207	198
8	247	235	158	173	264	202	332	748	414	349	242	125	32	35
9	164	69	142	97	104	146	120	200	373	150	53	39	31	0
10	258	34	44	79	43	66	85	79	66	161	22	11	5	13
11	6	83	9	25	57	16	48	52	36	17	30	6	3	2
1+	9532	9023	12086	15750	31491	33521	46808	47409	38320	28438	24174	30382	26641	26684
2+	8763	8520	9236	13504	27562	30947	45917	46088	36582	26473	22118	28105	24770	25328
3+	6971	6419	8422	8255	17440	23038	37240	44262	31512	21915	17208	21876	20697	21903
4+	5701	4334	5105	6880	7342	12651	24368	29991	27263	15645	10171	9977	11914	11655

	1987	1988
1		
2	2323	
3	5245	5825
4	11436	6882
5	4232	10644
6	725	3160
7	87	435
8	76	47
9	20	52
10	0	14
11	9	0
1+		
2+	24153	
3+	21830	27060
4+	16585	21235

Table 14. Mean population biomass (t) at age (1948-1988) estimated by SPA using input parameters derived from ADAPT (Table 11 "New").

Population Numbers

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
1	69398	39915	72501	34774	26582	122467	42932	44346	64374	80081	70010	29730
2	44286	56819	32680	59359	28426	21764	100267	35150	36307	52705	65565	57320
3	21080	36258	46510	26756	48599	23268	17816	82081	28778	29533	43151	53622
4	25221	17099	28912	38004	21214	39383	18734	14395	66746	21819	23594	33415
5	17524	18664	12980	21509	26621	15636	30142	12732	10862	44505	14576	15863
6	3180	11390	11362	8073	12131	15800	9081	15565	8079	6721	24495	9668
7	3578	1430	6529	4763	4604	5721	8914	5481	8100	4317	3652	12701
8	2455	1652	734	2425	2276	2113	3411	5067	2891	4039	2143	2016
9	2365	1025	1030	336	804	886	1317	1600	2663	1495	2191	1051
10	1174	1434	565	323	186	291	502	688	749	973	915	1081
11	941	569	967	255	205	66	216	172	281	305	576	500
1+	191202	186254	214771	196576	171647	247395	233331	217277	229829	246493	250868	216967
2+	121804	146339	142269	161802	145065	124928	190399	172931	165455	166412	180858	187238
3+	77518	89520	109590	102443	116639	103165	90132	137782	129148	113707	115293	129918
4+	56438	53262	63080	75687	68040	79897	72316	55701	100369	84174	72142	76296

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	48572	33516	58753	84525	91858	91520	15293	14837	10776	6726	8153	4438
2	24341	39767	27439	47917	68038	72863	26436	10596	12067	8818	5479	6398
3	46922	19928	32530	22071	38395	52925	30554	12870	8512	9868	7181	4369
4	41244	38005	15946	25285	17608	27749	21489	16295	9627	6609	7683	5265
5	21203	27970	26682	11211	17561	12274	8973	9552	10969	6248	4136	4713
6	7958	10500	15207	14793	5856	8928	3014	3144	5254	6333	3270	2120
7	4850	3494	4708	6850	6145	2922	3639	1367	1566	2045	3416	1442
8	4001	2013	1628	2084	2722	2402	1232	1498	720	565	825	1745
9	919	1498	687	574	581	815	850	557	686	247	210	323
10	383	415	569	276	210	111	304	449	264	195	84	93
11	403	172	166	264	112	98	26	169	210	111	52	34
1+	200794	177279	184316	215848	249085	272606	111809	71333	60652	47764	40490	30939
2+	152221	143763	125563	131323	157227	181086	96516	56497	49876	41039	32337	26501
3+	127881	103996	98124	83406	89189	108223	70080	45901	37809	32221	26858	20103
4+	80958	84067	65594	61336	50794	55298	39526	33031	29297	22353	19676	15734

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	8085	7648	4579	19929	27169	31075	35876	10915	18396	24436	36415	32670	27920
2	3391	6343	5821	3696	16064	21854	25250	28727	8935	14760	19219	29335	26299
3	4634	2516	4127	4555	2971	12540	17637	20281	23277	6976	11797	15344	23592
4	2773	3187	1476	2497	3304	2290	9394	13706	16221	16912	5474	8283	11582
5	2330	1590	1282	979	1315	2479	1572	5508	10208	9359	9257	3791	3880
6	1380	1072	568	630	546	785	1565	892	3899	5428	3065	2486	1257
7	642	525	223	196	348	276	386	634	587	1652	1721	738	518
8	326	214	121	79	103	165	120	132	385	255	286	305	125
9	363	95	31	56	38	52	62	43	94	198	83	40	37
10	13	154	23	18	39	24	26	31	31	41	67	25	7
11	40	3	36	3	11	23	6	14	20	17	7	30	4
1+	23979	23347	18287	32637	51908	71563	91894	80884	82053	80034	87391	93046	95220
2+	15894	15698	13708	12708	24739	40488	56018	69968	63657	55598	50976	60375	67300
3+	12503	9356	7887	9012	8675	18634	30768	41241	54722	40837	31757	31041	41001
4+	7869	6840	3760	4457	5704	6093	13132	20960	31445	33862	19960	15697	17409

	1985	1986	1987	1988
1	17271	14970		
2	22850	14020	12245	
3	21206	18646	11434	9957
4	17945	16990	14100	9216
5	5720	7448	4804	10654
6	1164	917	711	2407
7	287	155	57	241
8	53	25	37	25
9	21	1	9	25
10	4	4	0	6
11	1	1	3	0
1+	86522	73178		
2+	69250	58208	43398	
3+	46400	44188	31152	32531
4+	25194	25542	19719	22574

Table 15. Population numbers at age (1948-1988) estimated by SPA using input parameters derived from ADAPT (Table 11 "New).

Fishing Mortality

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
1	.000	.000	.000	.002	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.004
2	.000	.000	.000	.000	.000	.000	.000	.000	.007	.000	.001	.000	.000	.001	.018
3	.009	.026	.002	.032	.010	.017	.013	.007	.077	.025	.056	.062	.011	.023	.052
4	.101	.076	.096	.156	.105	.067	.186	.082	.205	.203	.197	.255	.188	.154	.152
5	.231	.296	.275	.373	.322	.343	.461	.255	.280	.397	.211	.490	.503	.409	.390
6	.599	.356	.670	.361	.552	.372	.305	.453	.427	.410	.457	.490	.623	.602	.598
7	.573	.467	.790	.539	.579	.317	.365	.440	.496	.500	.394	.955	.679	.564	.615
8	.673	.273	.582	.904	.743	.273	.557	.443	.459	.411	.512	.586	.782	.875	.843
9	.301	.395	.961	.389	.815	.368	.449	.559	.807	.291	.506	.811	.594	.768	.712
10	.524	.193	.598	.254	.839	.100	.872	.697	.698	.325	.405	.788	.602	.719	.567
11	.350	.319	.519	.416	.428	.346	.425	.392	.425	.402	.374	.628	.576	.492	.489
5+	.362	.320	.544	.425	.438	.346	.428	.397	.435	.403	.381	.649	.580	.500	.497

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	.017	.032	1.042	.167	.007	.001	.005	.042	.069	.043	.073	.014	.016	.018
2	.022	.051	.669	.520	.019	.001	.005	.026	.122	.098	.230	.045	.018	.048
3	.026	.125	.701	.429	.090	.053	.050	.110	.255	.174	.333	.303	.121	.060
4	.165	.161	.929	.611	.196	.232	.269	.289	.615	.356	.711	.211	.441	.087
5	.449	.477	1.204	.849	.398	.349	.447	.468	1.028	.576	.829	.511	.383	.316
6	.679	.495	.697	.591	.497	.744	.417	.619	.994	.765	1.369	.864	.393	.483
7	.723	.739	.664	.688	.441	.819	.708	.472	1.286	.901	1.271	.835	.442	.545
8	1.077	1.006	.839	.594	.580	.871	.790	.737	1.369	1.037	1.715	.568	.532	.491
9	.805	1.457	.786	.437	.547	1.059	.882	.620	2.978	.661	1.222	.353	.167	.270
10	.699	.559	1.264	.389	.559	.664	1.113	.694	.632	1.329	1.245	1.826	.314	.323
11	.629	.573	.908	.720	.444	.518	.488	.514	1.061	.681	1.077	.641	.393	.394
5+	.641	.590	.938	.728	.446	.542	.497	.533	1.170	.707	1.131	.646	.391	.395

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	.008	.022	.000	.020	.040	.016	.017	.000	.009	.001	.001	.001
2	.014	.019	.010	.048	.024	.025	.018	.015	.003	.004	.007	.002
3	.089	.052	.023	.119	.042	.154	.081	.074	.022	.079	.016	.014
4	.176	.334	.095	.350	.403	.167	.558	.506	.679	1.063	.080	.209
5	.260	.366	.146	.432	.916	1.115	.903	1.004	1.631	2.149	.491	.196
6	.509	.703	.219	.659	.949	1.223	1.369	1.278	1.813	2.584	.883	.196
7	.629	.873	.300	.634	1.552	1.531	1.577	2.074	2.243	1.241	.631	.196
8	.773	.827	.141	.465	.924	1.757	1.903	1.596	3.676	.859	.199	.196
9	.504	.510	.131	.622	.884	1.015	1.578	2.114	1.373	34.584	.137	.196
10	1.213	.435	.239	.404	1.565	.617	1.729	1.446	.918	.297	.137	.196
11	.344	.571	.169	.500	.991	1.186	1.132	1.148	1.685	2.180	.542	.196
5+	.370	.578	.168	.500	.990	1.197	1.175	1.179	1.698	2.179	.539	.196

Table 16. Fishing mortality at age (1948-1988) estimated by SPA using input parameters derived from ADAPT (Table 11 "New").

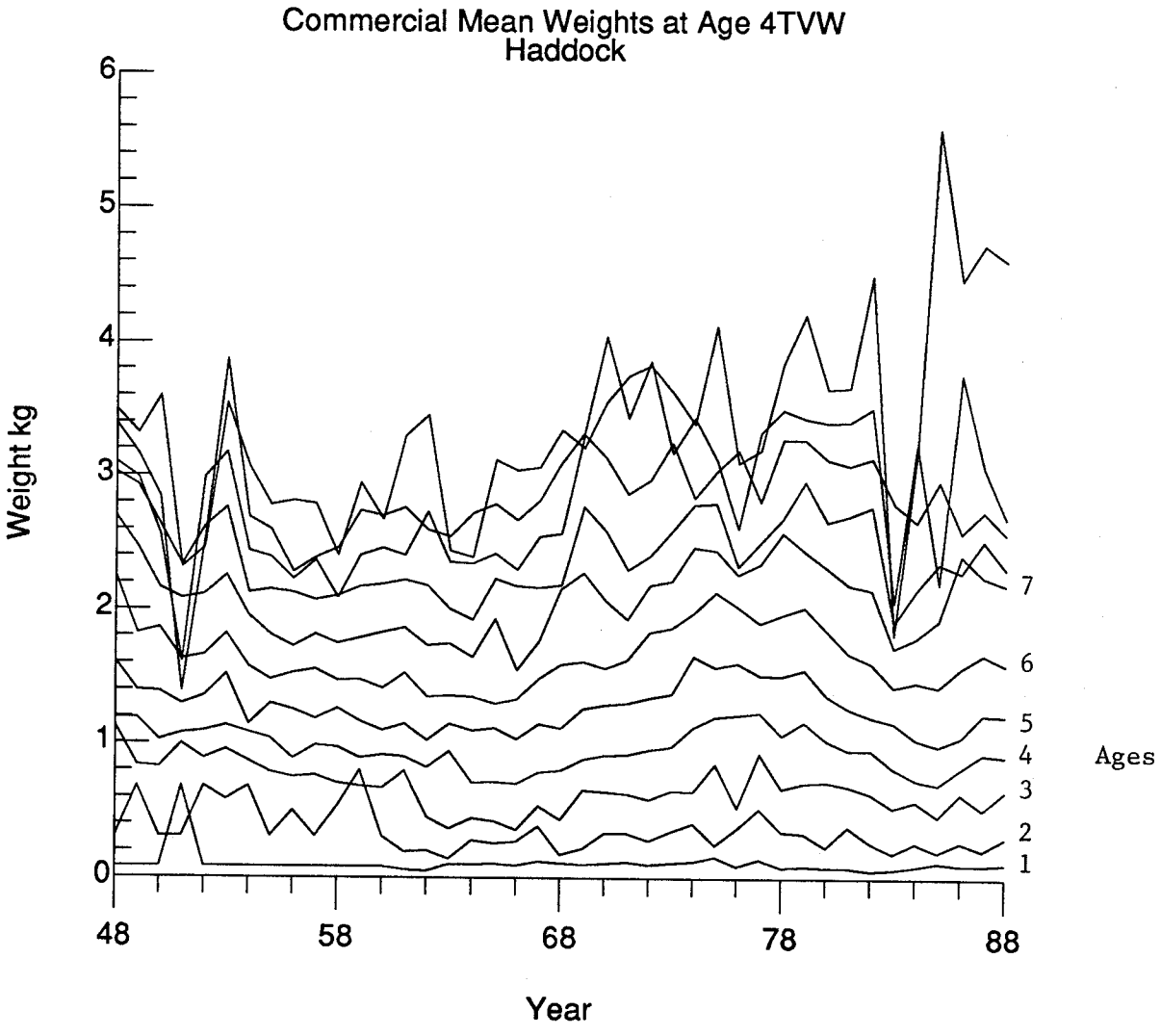

Figure 1. Mean weights at age (kg) of haddock from the commercial fishery in 4TVW.

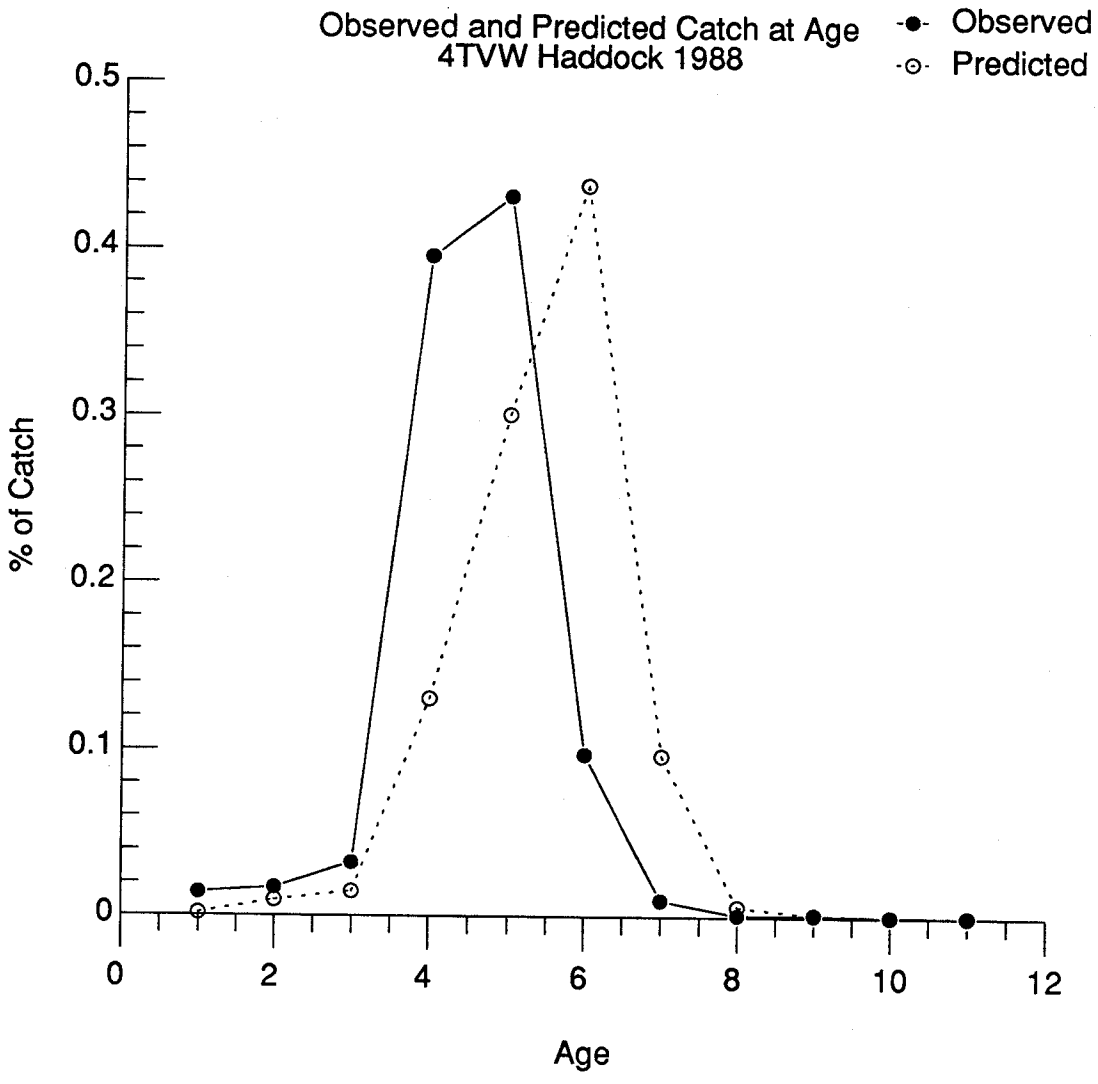

Figure 2. Comparison of the observed and predicted commercial catch at age distributions for 4TVW haddock in 1988.

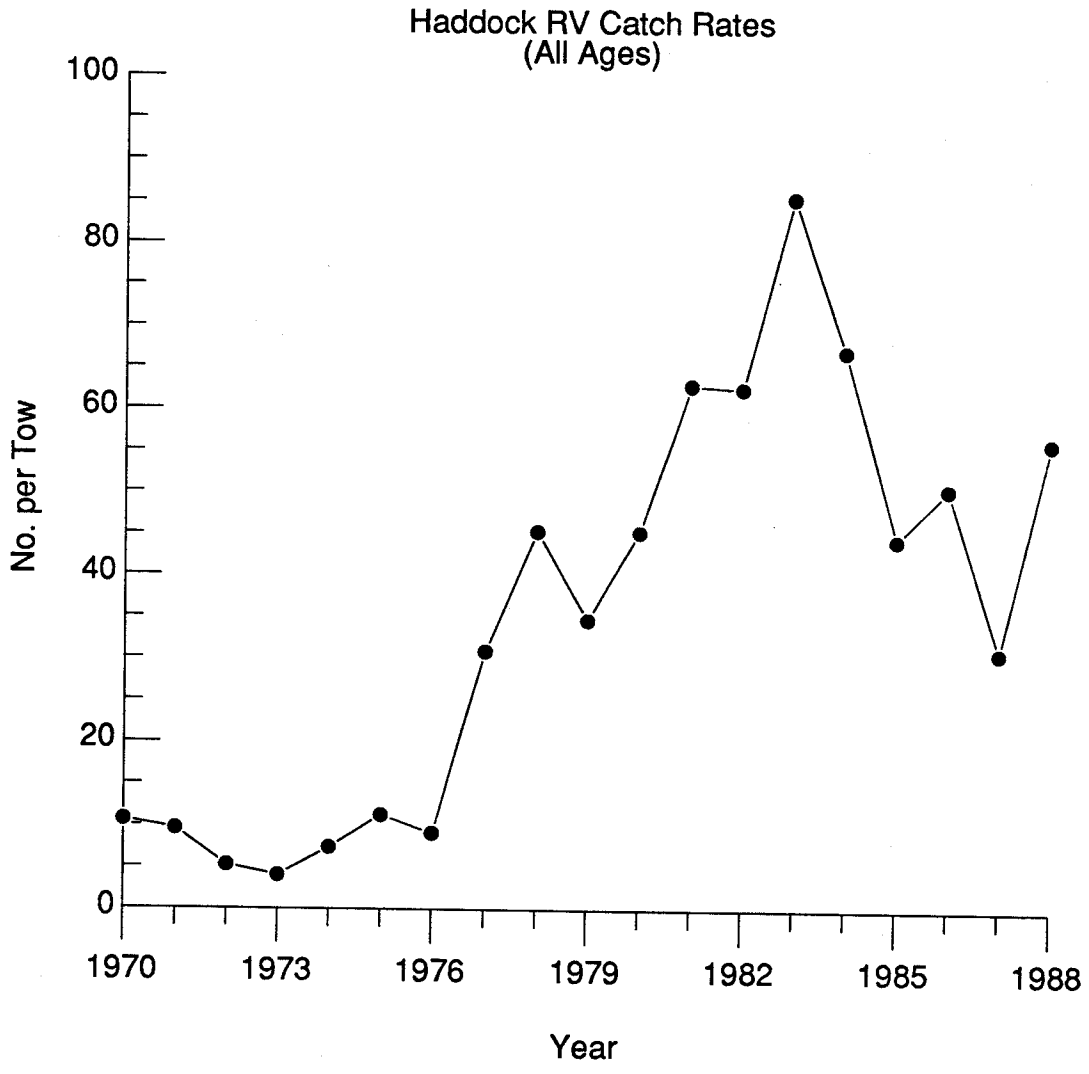

Fig. 3. Research vessel arithmetic mean catch rates at age for haddock in divisions 4VW.

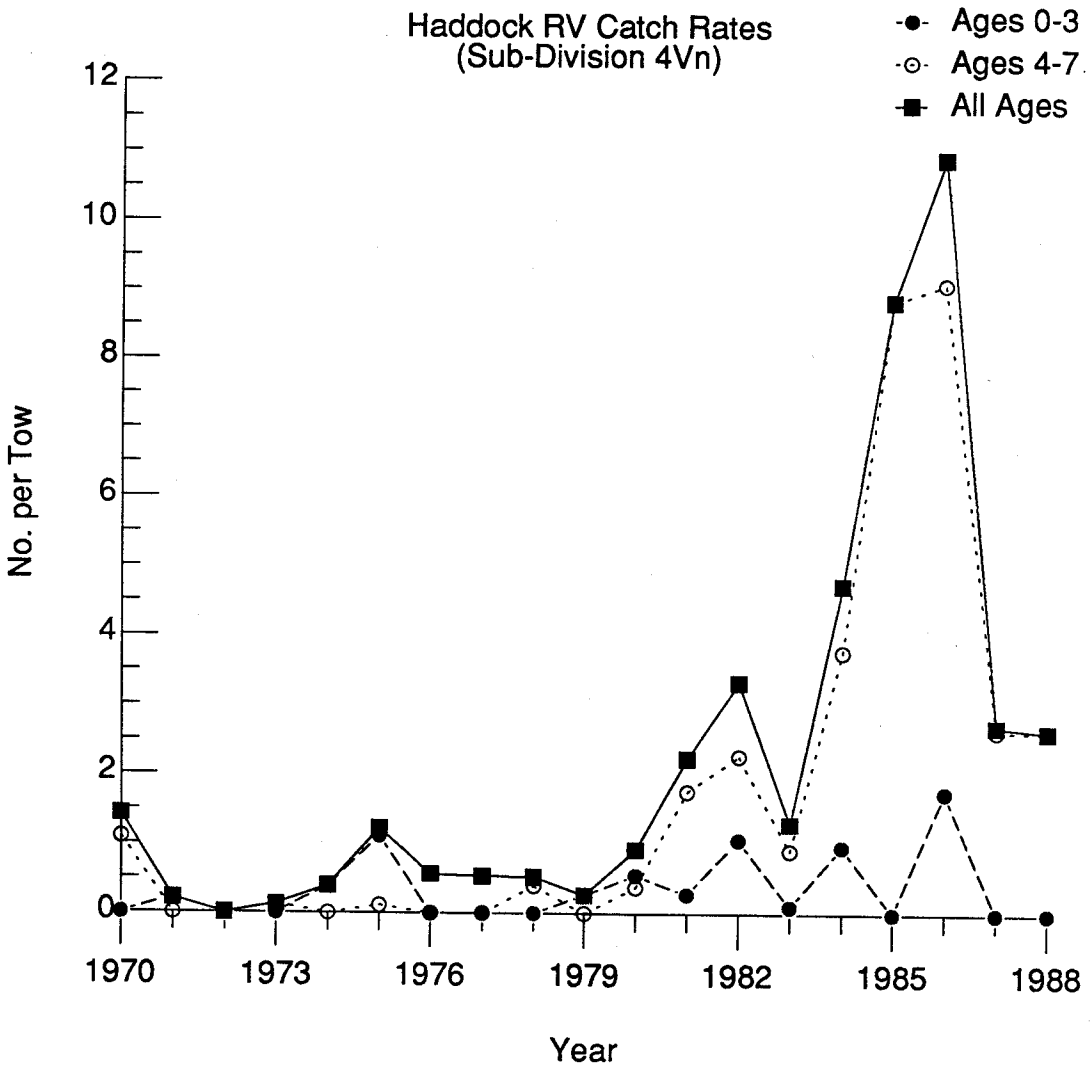

Fig. 4. Research vessel arithmetic mean catch rates at age for haddock in Subdivision 4Vn

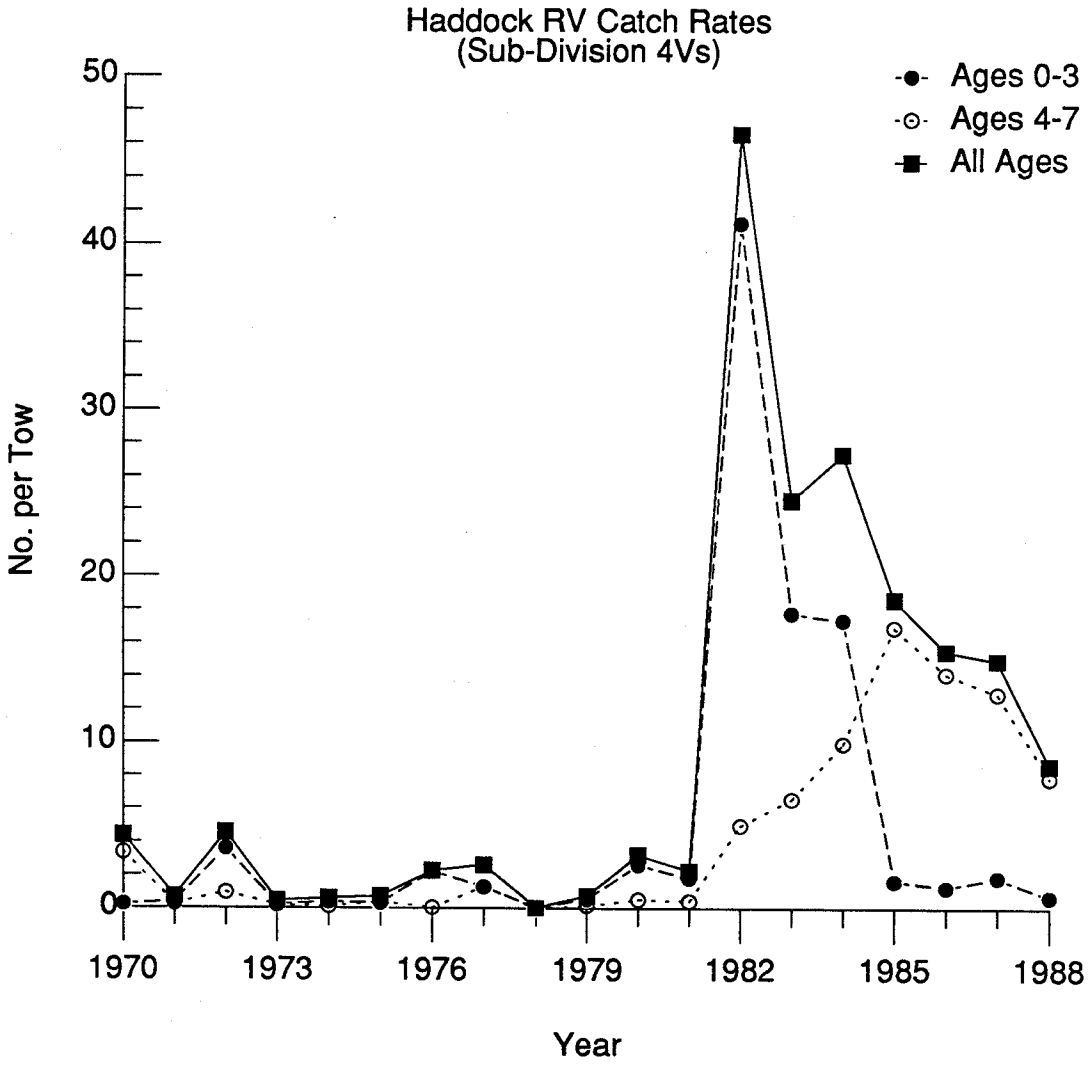

Fig. 5. Research vessel arithmetic mean catch rates at age for haddock in Subdivision 4Vs.

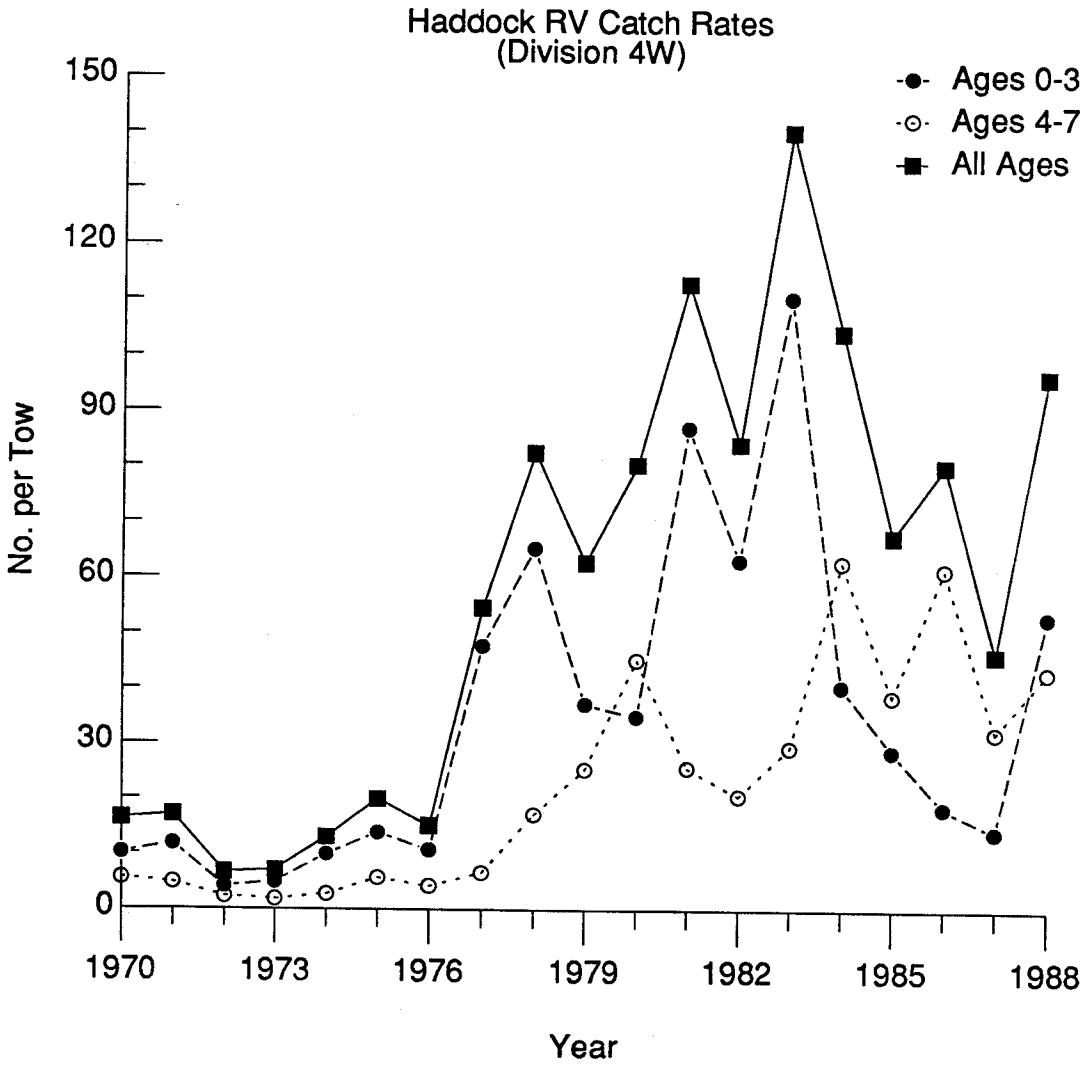

Fig. 6. Research vessel arithmetic mean catch rates at age for haddock in Division 4W.

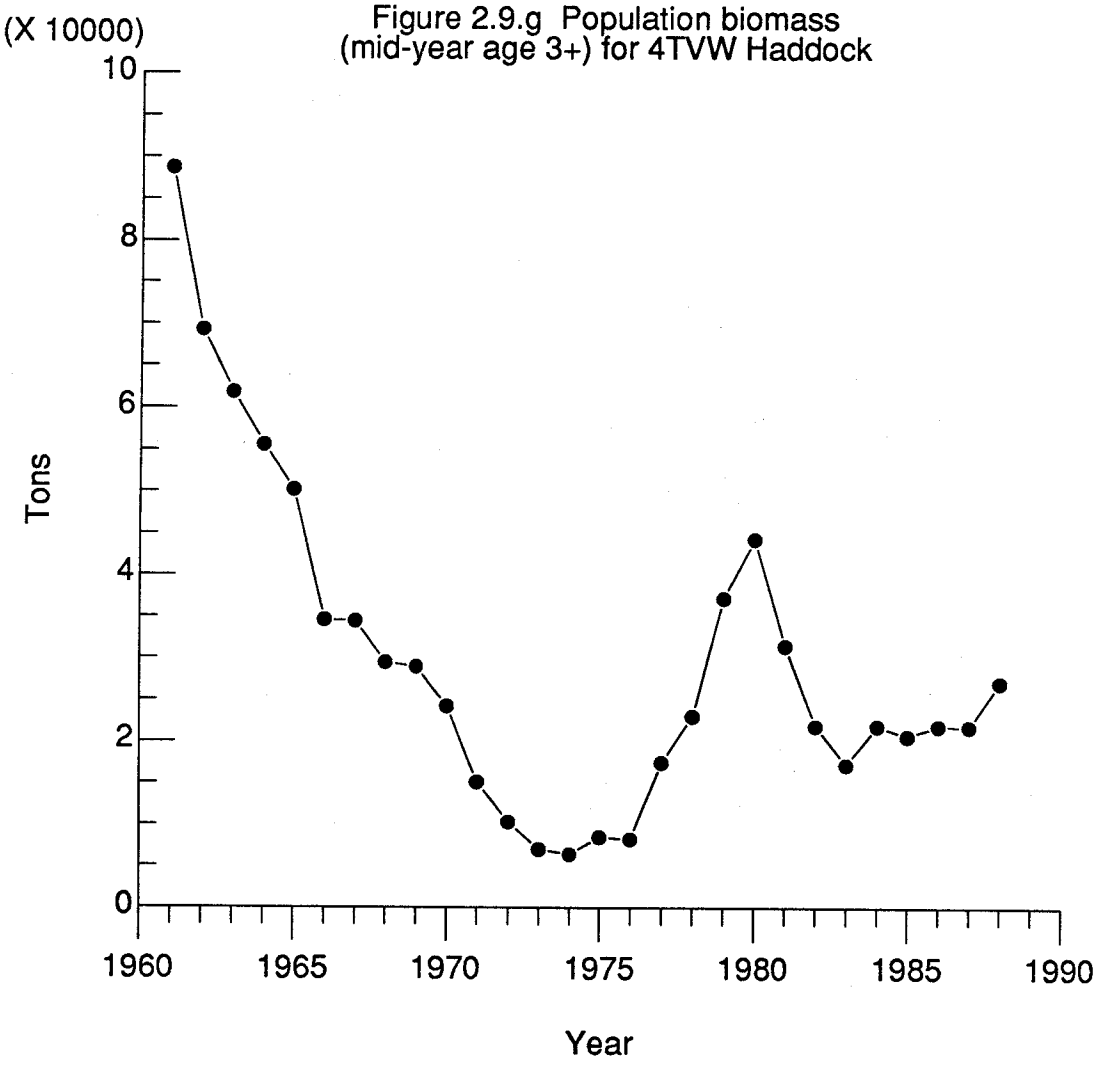

Figure 7. Trend in mid-year population biomass for 4TVW haddock (ages 3+).

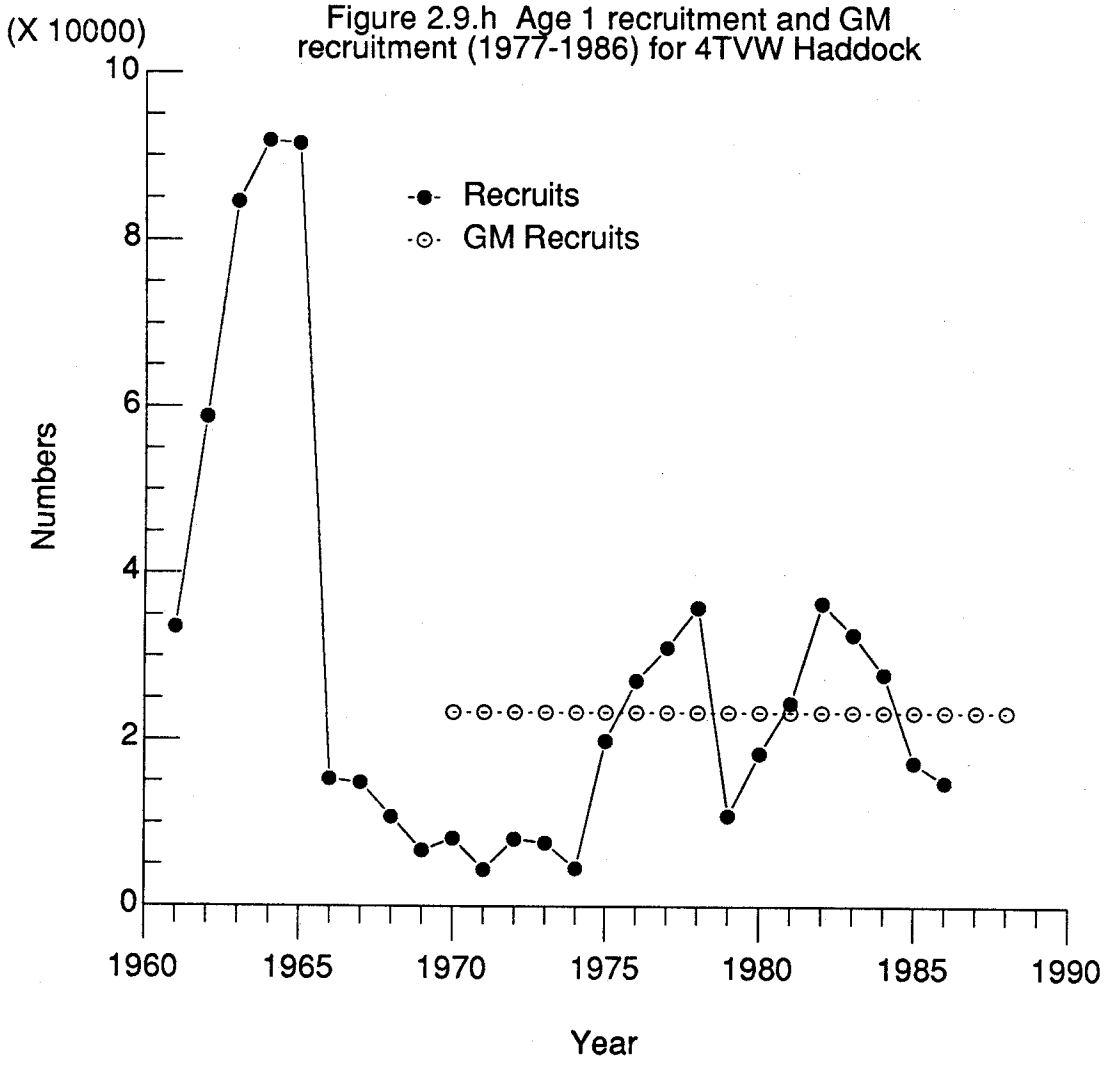

Figure 8. Recruitment at age 1 for 4TVW haddock.