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Status of the Scotian Shelf Silver Hake Population in 1992 with Projections to 1994

by

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Management and Current Fishery

The silver hake fishery on the Scotian Shelf has traditionally been pursued by large (TC 7) non-Canadian fishing vessels using bottom trawls; Cuba, USSR, and Japan have been customary participants. Under Canadian fishing regulations in place since 1977, catches are restricted to the seaward side of the Small Mesh Gear Line (Fig. 1), and are highest during the period April to July of each year. By regulation the fishery opens April 1 and closes November 15 each year; however, in recent years vessels have been allowed to commence fishing under experimental permits in March.

Since 1990 renewed attempts have been made to boost Canadian participation in fishing this species. However, attempts by Canadian fishing vessels to catch this species have met with mixed success, as long distances to the fishing ground and deeper water preferred by silver hake caused difficulty for smaller vessels. Since 1991 Canadian companies have negotiated charter arrangements with fishing companies of Cuba and the CIS (formerly USSR) to fish Canadian allocations using TC 7 vessels. These arrangements were much more successful, and have continued. As a result allocations to foreign nations have been reduced, although the overall vessel/gear composition of the fishery has remained the same as in previous years.

Nominal catches from this stock have ranged from 300,000 tons in 1973 to 32,000 tons in 1992 (Table 1); the provisional catch in 1993 is 29,000t. The Scientific Council advice on catch levels, the Total Allowable Catches (TAC's) established, and resultant catches, from 1983 have been as follows:

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Advice	80	100	100	100	100	167	235		100	105	75
TAC	80	100	100	100	100	120	135	135	100	105	86
Catch	36	74	75	83	62	74	91[1]	69[1]	68[1]	32[1]	29[1]

1 Preliminary

Removals and Weights at Age

Sampling for length composition of the commercial catch in 1992 was conducted by the Canadian Observer Program (IOP) while otoliths were collected by both Canada and CIS (Russia). More than 2000 samples consisting of 287,000 lengths were collected during the fishery. Of the otoliths collected, 1,658 ages were read by Canadian scientists and 531 by Russian scientists. A summary of length and age sampling is presented in Table 2.

The commercial removals at age for 1992 were calculated from Canadian length sampling and a combined Canada/Russia age-length key, following the same procedure used in the previous two assessments. Regressions of lengths and weights from the Canadian July research vessel surveys were used to calculate yearly α and β values (Table 3) used in the calculation of sample weights and weights-at-age. The removals-at-age and weights-at-age for 1977-1991 were taken from the previous assessment (Waldron *et al.*, 1992) to provide estimates for the period 1977-92 inclusive. (Table 4, 5; Fig. 2).

Indices of Abundance

Commercial Catch Rates

The APL program STANDARD was used to standardize catch rates for the period 1977 to 1993. Catch and effort from NAFO and the IOP were categorized in a manner similar to that used in previous assessments (Waldron *et al.*, 1992). Examination of the regression results (Table 6 and accompanying graphs) show year, month, and fishing regime all have a significant effect on the model.

The standardized catch rate for this stock has dropped in recent years, from a peak of 5.5 t/hr in 1989 to 2.2 t/hr in 1992. In 1993 the standardized catch rate remained essentially the same as 1992, at 2.2 t/hr. The most recent catch rates are similar to those experienced in the late 70's and early 80's.

Canadian Bottom Trawl Surveys

The July stratified random groundfish survey has been conducted on the Scotian Shelf from 1970 using three Canadian research vessels (*A.T. Cameron, Lady Hammond,* and the *Alfred Needler*). A conversion factor of 2.3 is applied to the series prior to 1982 to account for the effect of vessel and gear changes between the *A.T. Cameron* and the other two vessels (Fanning, 1985). No conversion is required between the *Lady Hammond* and *Alfred Needler*.

The survey results indicate a continual decline in total numbers and biomass over the period 1986-1992. Results of the 1993 survey indicate both numbers and biomass have risen moderately (Fig. 3).

In numbers at age (Table 7), the surveys show the 1990 year class to be below average in 1991 and 1992 at ages 1 and 2 respectively. The 1991 year class appears even weaker than the 1990 year class at age 1 in 1992. The 1993 survey is not yet aged, but the length frequency has a clear mode corresponding to age 1 fish (Fig. 4). An estimate of the numbers at age 1 of 164 million was obtained by adding all fish 21 cm

and less, and half those at 22 cm, together. This method was tested on several earlier years and the results were close or identical to those obtained using age length keys. This suggests that the 1992 year class is above average in strength.

Silver hake juvenile survey

No 0-group survey was conducted in 1992. Data from previous years for the core strata (60-78) are presented in Table 8. These suggest that the 1990 year class is average strength, and that of 1991 below average.

Estimation of Parameters

Sequential Population Analysis

As in previous years, a Sequential Population model was used to assess the silver hake stock. This assessment used the ADAPTive framework (Gavaris, 1988) and included a dome shaped partial recruitment pattern achieved by setting F at age 9 to 10% of that on the fully recruited ages 3-5 (after Waldron *et al.* 1992). Canadian commercial catch-at-age, age disaggregated standardized CPUE, Canadian July Survey catch-at-age and the juvenile index were included in the analysis. Ages 3-5 were assumed fully recruited and ages 1-8 were included in the calibration block. The formulation is summarized below; results are in Table 9.

1) Catch at Age extends from 1977 to 1992 and Ages 1 to 9
   The Catch at Age did NOT contain a PLUS Group
2) Partial Recruitment -* indicates ages used to calculate mean fully recruited F.

Ages		PR
1		0.020
2		0.249
3	*	1.000
4	*	1.000
5	*	1.000
6		0.775
7		0.550
8		0.325
9		0.100

3) Natural Mortality was set at 0.4
4) F's over Ages 1 to 8 will be estimated starting from:

Ages	F
1	0.06
2	0.075
3	0.306
4	0.306
5	0.306
6	0.236
7	0.167
8	0.099

5) Mortality at age 9 was 10% of that for fully recruited ages.

6) Research Survey Estimates of Abundance for ages 1 to 8 were given.
   No standard errors were applied. Log transformation used.
   There were 2 age disaggregated series used for tuning.

	Month	Year															
July R/V	7	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92
CPUE	5	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92

7) The Lower Limit for Estimated Numbers at Age was the CATCH
   Upper Limit for Estimated Numbers at age was 10000000
8) The Lower Limit for RV survey slope was 0
   The Upper Limit for RV survey slope was 9000

Several other formulations were tested; RV alone, CPUE alone, RV with juv., CPUE with juv., and RV & CPUE. Comparison of the results suggested that the model including RV, CPUE, and juvenile surveys gave the best diagnostics.

Population numbers, biomass, and F at age are shown in Table 10(a,b,c).

An analysis using the Laurec-Shepherd technique was also conducted. As the 0-group survey was not conducted in 1992, this survey was excluded from the analysis. Resulting fishing mortality and population numbers are shown in Table 11. The results of the two analyses closely correspond, particularly since 1983 (Fig. 6). In 1992 the Laurec-Shepherd technique indicated a slightly higher fishing mortality over ages 3-5, at 0.433 vs 0.324 for ADAPT.

A retrospective analysis on ages 3-5 (the most important fully or almost fully recruited ages) was performed using the results of the ADAPT formulation (Fig. 5). As a progressively shorter time series of data was introduced as input to the model, F was consistently underestimated, by 40-60%. This retrospective pattern has been noted in other Northwest Atlantic groundfish stocks; however the underlying cause remains obscure. Given the historical pattern, it is reasonable to assume that the 1992 fishing mortality produced by ADAPT is also underestimated.

Recruiting Yearclass Sizes

The 1992 yearclass will make a significant contribution to the catch in 1994 at age 2. As an 0-group survey was not conducted, the only available estimate of this cohort is that from the 1993 July research vessel survey. The 1991 yearclass is also important and it's estimation in the SPA is based only on a single occurrence in the catch matrix. While it was decided to accept the estimates of the 1990 and earlier yearclasses as given by the SPA, the strength of the 1991 and 1992 yearclasses was inferred from July survey data.

Yearclass estimates from the survey were regressed against estimates from the SPA for the 1981-90 yearclasses at age 1, using the model SPA = a + b(*ln*RV). (Fig. 7). Data for yearclasses prior to 1981 were excluded because the surveys in 1977-81 were conducted by the *A.T. Cameron*, which had a lower catch efficiency for silver hake than vessels used in subsequent years. The logarithmic curve fitted the data well (R^2=0.84), including that for the 1985 yearclass. Predictions from this relationship for the strength of the 1991 and 1992 yearclasses were 0.4 and 1.2 billion fish, respectively. It is recognized that there is an element of circularity in this calculation, as the survey age 1 estimates contributed to the SPA calibration. However, the RV index was one of several data elements contributing to the SPA estimates.

Catch Projections

An $F_{0.1}$ value of 0.72 was used as in last year's assessment, based on the yield-per-recruit analysis of the Scientific Council in 1990 (NAFO, 1990). The mean weights-at-age for projection were taken as the average of recent years (1988-92) observed in the fishery (Table 5). The partial recruitment pattern was based on the average F at age in the SPA for 1987-91 (Table 10c). Weight and PR at age used were as follows:

Age	Avg wt (kg)	PR
1	0.059	0.012
2	0.138	0.24
3	0.189	0.84
4	0.219	1.000
5	0.260	1.000
6	0.310	0.95
7	0.403	0.54
8	0.466	0.41
9	0.662	0.09

Population numbers at age at the beginning of 1992 were taken from the SPA (Table 10a) except that the 1991 and 1992 yearclasses were set at 0.4 and 1.2 billion respectively, from the regression in Fig. 7. Provisional catch in 1993 based Canadian observer data is 29,000t. Projection of stock and catch trends through 1994 utilizing these data gave the results in Table 12.

The catch of 29,000t in 1993 is estimated to have resulted in a fishing mortality of F=0.42. Fishing at $F_{0.1}$ in 1994 is estimated to equate to a catch of 48,500t.

Acknowledgments

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References

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Table 1. Nominal catches for 4VWX silver hake 1970-1992 (1990-1992 preliminary).

	Year										
Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Bulgaria	0	0	0	0	0	1722	3088	862	606	4639	817
Canada	0	0	0	0	11	101	26	10	26	13	104
Cuba	0	0	201	0	0	1724	12572	1847	3436	1798	2287
France	0	0	0	0	0	0	0	15	0	0	0
FRG	0	0	10	0	296	106	97	684	0	0	0
GDR	0	0	0	0	0	0	0	0	3[1]	0	0
Ireland	0	0	0	0	0	108	106	0	0	9	0
Italy	0	0	0	0	0	0	0	38	106	5	0
Japan	129	8	63	88	67	54	78	19	161	219	239
Poland	0	0	0	0	0	0	0	295	2	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	56
Romania	0	0	0	0	0	0	0	10	0	1	0
Spain	0	15	0	0	0	6	0	0	2	0	40
USA	0	1	0	0	0	7	1	14	0	0	0
USSR	168916	128633	113774	298533	95371	112566	81216	33301	44062	45076	40982
TOTAL	169045	128657	114048	298621	95745	116394	97184	37095	48404	51760	44525

Country	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Bulgaria	0	0	0	0	0	0	0	0	0	88	0	0
Canada	6	38	15	10	2	9	13	9	337	10	58[1]	4[1]
Cuba	642	11969	7418	14496	17683	16041	20219	9016	14541	13888	17786[1]	16528[1]
France	0	2[1]	0	0	0	0	0	0	0	0	0	0
FRG	0	0	0	0	0	0	0	0	0	0	0	0
GDR	0	0	0	93	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0
Italy	541	37[1]	2[2]	0	0	0	0	0	0	0	0	0
Japan	120	937	649	530	120	66	144	0	194	322[1]	744[1]	547[1]
Poland	1[1]	31[2]	0	0	0	0	0	0	0	0	0	0
Portugal	2044	2[1]	378	1714	1338	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0
USA	3	2	0	0	0	1	0	0	0	0	0	0
USSR	41243	47261	27377	57423	56337	66571	41329	65349	72917	55981	49311[1]	14716[1]
TOTAL	44600	60251	35839	74266	75480	82688	61705	74374	87989	70289	67899	31795

[1] Observer Program Data (data not reported to NAFO)
[2] FLASH data

Table 2: Sampling used in this assessment; length frequency and age data.

Year	No. Lengths	No. Ages
1977	34379	600
1978	137468	674
1979	101908	1108
1980	247369	1462
1981	195493	987
1982	160878	1152
1983	134226	986
1984	203314	1255
1985	216912	1163
1986	197654	1311
1987	377527	681
1988	309767	1158
1989	300100	1135
1990	447587	1817
1991	472365	1712
1992	286356	2189

Table 3: Male and Female Alpha and Beta's used in the construction of the silver hake catch at age used in this assessment. Lengths (cm) and weights (kg) used were from the Canadain July Research Vessel Survey of the Scotian Shelf (4VWX).

Year	Male Alpha	Female Alpha	Male Beta	Female Beta
1977	.000006260	.000006930	3.0626	3.0350
1978	.000004630	.000003070	3.1366	3.2531
1979	.000010200	.000005880	2.9001	3.0675
1980	.000002330	.000001800	3.3417	3.3989
1981	.000006830	.000005080	3.0206	3.1172
1982	.000011600	.000006740	2.8575	3.0232
1983	.000006480	.000003320	2.9935	3.2034
1984	.000018300	.000006490	2.7052	3.0284
1985	.000013500	.000004530	2.7848	3.1235
1986	.000007970	.000003820	2.9384	3.1685
1987	.000009990	.000004240	2.8798	3.1456
1988	.000014300	.000004800	2.7942	3.1241
1989	.000006750	.000004440	3.0114	3.1416
1990	.000034320	.000021000	2.5234	2.6958
1991	.000006040	.000004265	2.9582	3.2036
1992	.000004025	.000003447	3.1750	3.2241

Table 4: Commercial catch numbers at age for 4VWX silver hake.

*	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1 *	17911	20940	20569	16588	2358	20189	5849	59588	14970	45598
2 *	72529	70302	57893	70696	25214	52976	96852	45828	130814	70269
3 *	59862	80196	72891	70391	109035	75876	56158	206900	98346	229126
4 *	15070	35025	36669	32032	37573	68400	29282	82911	128365	84097
5 *	2218	12709	22380	14465	11928	31752	11388	19344	34110	28635
6 *	725	5227	9970	5184	3234	5945	3395	4268	9327	8760
7 *	97	1906	3168	1431	1201	2042	819	1038	2344	1436
8 *	91	1168	495	451	290	465	253	183	226	497
9 *	4	338	374	98	141	64	88	10	85	111

*	1987	1988	1989	1990	1991	1992
1 *	6804	5110	24264	6516	5738	9074
2 *	214235	62791	85846	209620	117305	76663
3 *	114417	265307	158745	142862	201243	72896
4 *	54211	39242	145105	41215	46414	27020
5 *	13063	21303	20025	11741	12154	3467
6 *	6045	3106	9369	1648	3954	1102
7 *	347	2133	1569	640	290	186
8 *	156	208	1166	107	181	33
9 *	117	143	39	40	50	5

Table 5. Silver hake Commercial Mean Weights at age

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 :	0.065	0.074	0.076	0.040	0.061	0.066	0.067	0.070	0.068	0.053	0.045	0.045
2 :	0.183	0.153	0.178	0.151	0.168	0.169	0.128	0.146	0.136	0.145	0.119	0.139
3 :	0.264	0.229	0.227	0.223	0.215	0.231	0.196	0.181	0.177	0.184	0.168	0.185
4 :	0.340	0.266	0.274	0.287	0.276	0.275	0.239	0.224	0.210	0.250	0.211	0.227
5 :	0.446	0.335	0.304	0.341	0.326	0.317	0.289	0.272	0.244	0.250	0.248	0.260
6 :	0.632	0.405	0.389	0.391	0.401	0.394	0.365	0.353	0.295	0.274	0.286	0.292
7 :	0.886	0.438	0.455	0.531	0.553	0.446	0.395	0.405	0.410	0.392	0.453	0.401
8 :	0.922	0.540	0.838	0.839	0.923	0.513	0.457	0.624	0.582	0.514	0.422	0.497
9 :	2.120	0.892	0.838	0.859	1.137	0.506	0.444	0.650	0.669	0.644	0.518	0.688

	1989	1990	1991	1992
1 :	0.060	0.063	0.047	0.080
2 :	0.135	0.139	0.139	0.140
3 :	0.195	0.184	0.189	0.190
4 :	0.224	0.217	0.215	0.210
5 :	0.278	0.240	0.263	0.260
6 :	0.349	0.315	0.314	0.280
7 :	0.403	0.370	0.471	0.370
8 :	0.511	0.401	0.511	0.410
9 :	0.820	0.545	0.568	0.690

Table 6. CPUE standardization results for the 4VWX silver hake population. Includes years 1977-1993.

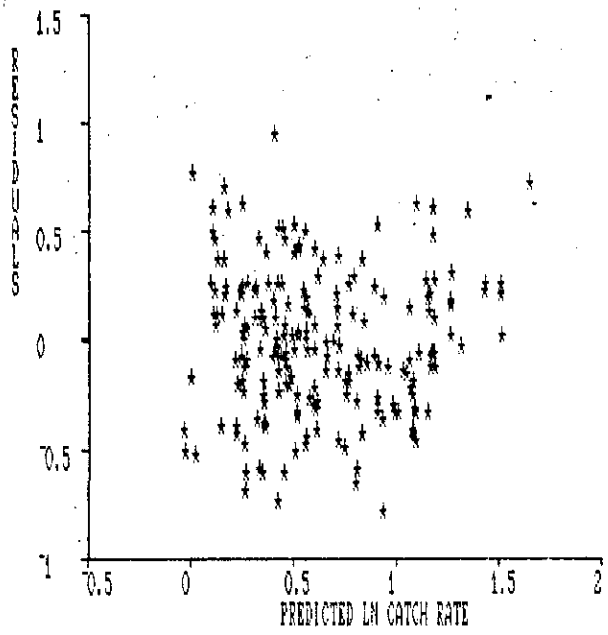
Key
Type 1: Data Source, NAFO or IOP
Type 2: Month
Type 3: Year
Type 4: Area
Type 5: Regime either Old or New
Type 6: Country

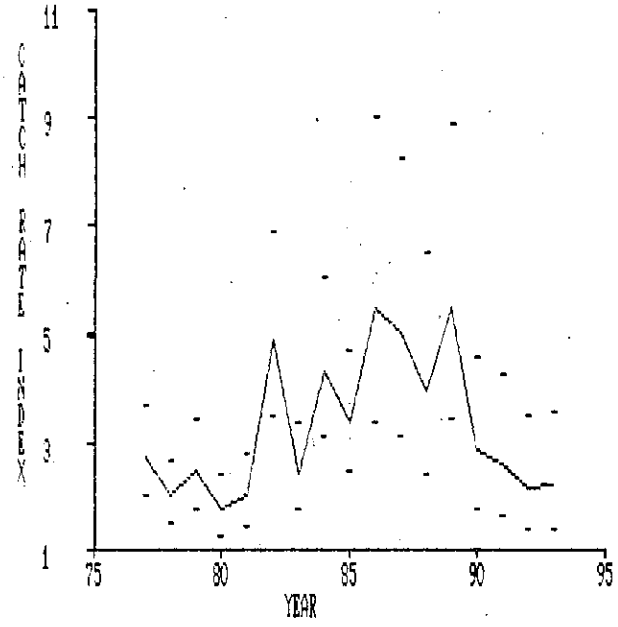
PREDICTED CATCH RATE

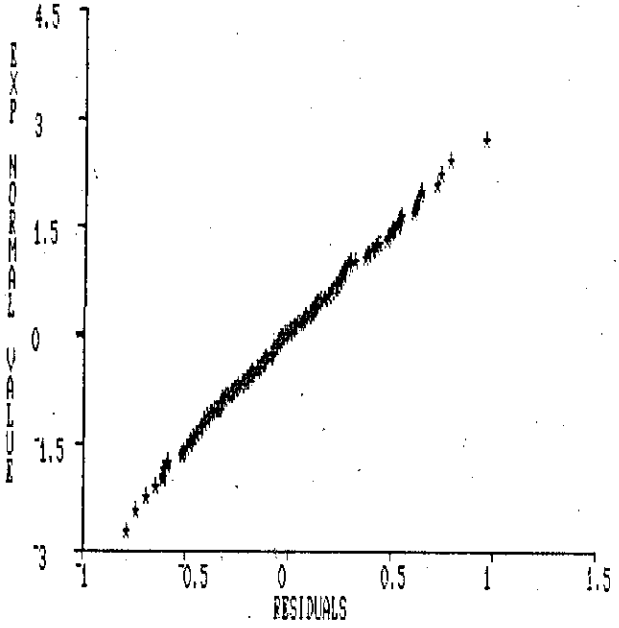
STANDARDS USED VARIABLE NUMBERS: 1 5 460 1 1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
77	37000	0.704	2.692	0.501	13742
78	43000	0.887	1.990	0.348	24121
79	52000	0.822	2.437	0.490	21341
80	45000	0.910	1.728	0.340	26046
81	45000	0.825	2.000	0.401	22494
82	50000	0.961	4.300	1.001	12245
83	36000	0.917	2.396	0.480	15024
84	74000	0.967	4.342	0.988	17043
85	75000	0.937	3.394	0.630	22099
86	83000	0.421	5.510	1.619	15063
87	62000	0.922	5.048	1.485	12282
88	74000	0.868	3.970	1.170	18641
89	91000	0.939	5.502	1.584	16539
90	69000	0.960	2.834	0.909	24348
91	68000	0.955	2.627	0.753	25885
92	33000	0.867	2.171	0.625	14739
93	29000	0.963	2.211	0.634	13119

AVERAGE C.V. FOR THE MEAN: .240







REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	1	INTERCEPT	0.947	0.187	211
2	5				
3	77				
4	460				
5	1				
6	1				
1	2	1	-0.139	0.139	130
2	3	2	0.388	0.147	7
	4	3	0.247	0.082	30
	6	4	-0.107	0.068	55
	7	5	-0.093	0.075	40
	8	6	-0.250	0.088	25
	9	7	-0.249	0.192	4
3	78	8	-0.304	0.117	26
	79	9	-0.097	0.122	20
	80	10	-0.441	0.150	9
	81	11	-0.294	0.151	9
	82	12	0.602	0.167	7
	83	13	-0.114	0.161	8
	84	14	0.482	0.167	7
	85	15	0.234	0.160	8
	86	16	0.744	0.193	9
	87	17	0.656	0.193	9
	88	18	0.416	0.196	9
	89	19	0.740	0.183	13
	90	20	0.076	0.178	16
	91	21	0.001	0.181	15
	92	22	-0.190	0.183	14
	93	23	-0.172	0.179	16
4	450	24	0.206	0.127	10
	470	25	0.005	0.059	56
5	2	26	-0.287	0.150	191
6	2	27	-0.077	0.062	64

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .750
MULTIPLE R SQUARED..... .563

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	8.185E0001	8.185E0001	
REGRESSION	27	2.855E0001	1.057E0000	8.738
TYPE 1	1	1.223E-001	1.223E-001	1.011
TYPE 2	6	4.922E0000	8.204E-001	6.779
TYPE 3	16	2.201E0001	1.376E0000	11.368
TYPE 4	2	3.255E-001	1.627E-001	1.345
TYPE 5	1	4.445E-001	4.445E-001	3.673
TYPE 6	1	1.902E-001	1.902E-001	1.572
RESIDUALS	183	2.215E0001	1.210E-001	
TOTAL	211	1.326E0002		

Table 7. Scotian Shelf silver hake Canadian July research vessel survey catch numbers ('000) at age.

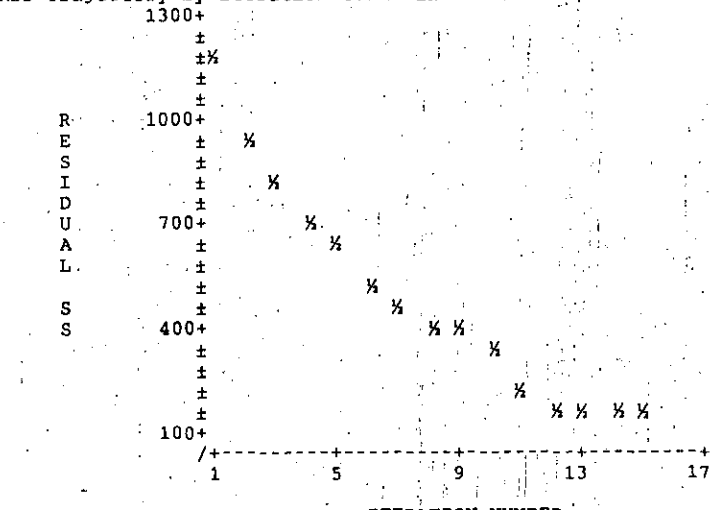
Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	7737	26740	89437	17730	32839	192025	114273	188970	102726	552598	146007	69740	172095	117089	66678	45284
2	27660	23257	152705	55638	84724	293420	108957	70369	172576	84325	266663	89508	63810	125952	84743	56347
3	21421	16266	67003	97253	131420	80348	38209	208723	34402	70625	46095	81458	24151	42329	35293	46180
4	4592	8874	20048	45862	60469	60487	19340	37926	71191	22623	18982	16709	13405	13022	13257	11097
5	1348	6733	11522	10684	16241	32426	10632	11828	21488	13448	6048	14249	4130	4173	6577	4477
6	1278	3046	5055	4525	5127	8257	2882	7942	9445	4235	4168	2502	1868	1169	2456	2237
7	984	1286	2664	2001	2367	3549	876	2860	2667	1622	1199	2338	769	432	402	424
8	336	502	969	589	794	2535	401	1136	1175	673	672	468	282	227	143	139
9	283	865	275	385	564	327	337	522	215	376	471	121	129	82	124	192
1+	65,639	87,569	349,678	234,667	334,545	673,374	295,907	530,276	415,885	750,525	490,305	277,093	280,639	304,475	209,904	168,890

Table 8: Stratified mean catch/tow for the Canada-USSR juvenile silver hake survey, core strata (60-78).

Year Class	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Stratified Mean catch/tow	579.0	8.8	232.2	43.4	284.8	198.0	102.0	204.8	131.5	187.4	78.6
Standard Error of Mean	64.4	1.2	24.4	7.1	62.2	37.9	23.0	35.3	19.0	24.1	10.4
CV	.11	.14	0.11	0.16	0.22	0.19	0.11	0.17	0.10	0.12	0.05
Number of Sets	77	61	64	71	82	74	105	79	74	68	71
July R/V Age 1 #'s (10^{-6})	192	114	189	103	553	146	70	172	117	67	45
Comm. catch Age 1 #'s (10^{-6})	20.2	5.9	59.6	15.0	45.6	6.8	5.1	24.3	6.5	5.7	9.1

Table 9: Output from ADAPT run for 4VWX Silver Hake using the Juvenile Index, RV and CPUE-at-Age. (Log Model for ages 1-8 with a dome =.1).

```
RUN 1: SILVER HAKE, RV+CPUE+JUV INDEX ('83 COR). LOG MODEL FOR AGES 18 WITH THE
4VWX Silver Hake                                   DATED: 1993 8 31 TIME: 9 39
RSS Trajectory by Iteration 4VWX Silver Hake          1993 8 31 9 39 8 330
```




```
 CALIBRATION COEFFICIENTS BY AGE FOR 4VWX Silver Hake      1993 8 31 9 39 8 33
AGE  1 :  I =     0.00001  POP
AGE  2 :  I =     0.00002  POP
AGE  3 :  I =     0.00003  POP
AGE  4 :  I =     0.00003  POP
AGE  5 :  I =     0.00004  POP
AGE  6 :  I =     0.00005  POP
AGE  7 :  I =     0.00004  POP
AGE  8 :  I =     0.00003  POP

  MEAN SQUARE RESIDUALS : 0.651181713
         MEAN RESIDUAL : 7.783658196E»7
   SUM OF ALL RESIDUALS : 0.0002078236738
```

```
RUN 1: SILVER HAKE, RV+CPUE+JUV INDEX ('83 COR). LOG MODEL FOR AGES 18 WITH THE
4VWX Silver Hake                                   DATED: 1993 8 31 TIME: 9 39

                          LOG RESIDUALS FOR RV INDEX                  31/ 8/93
```

±	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1 ±	»1.946	»0.845	0.148	»1.152	»0.828	0.375	0.477	0.512	0.478	1.265
2 ±	»0.813	»0.954	0.748	»0.480	0.212	1.176	»0.369	»0.198	0.306	0.145
3 ±	»0.828	»0.803	0.620	0.708	0.856	0.561	»0.559	0.768	»0.483	0.134
4 ±	»1.448	»1.176	0.209	0.955	0.826	0.972	»0.305	0.142	0.691	0.169
5 ±	»2.307	»0.584	»0.288	0.479	0.587	1.204	»0.026	»0.211	0.680	0.102
6 ±	»1.510	»1.063	0.100	»0.569	0.655	0.782	»0.237	0.291	0.419	0.731
7 ±	»2.009	»0.762	»0.323	0.369	»0.460	1.814	»0.472	0.656	0.131	»0.358
8 ±	»2.229	»1.818	»0.046	»0.828	0.522	0.514	1.341	0.745	0.754	»0.173

±	1987	1988	1989	1990	1991	1992
1 ±	0.728	0.010	0.484	0.288	0.214	»0.208
2 ±	0.435	0.074	»0.207	0.141	»0.153	»0.062
3 ±	0.157	»0.112	»0.506	0.121	»0.260	»0.375
4 ±	»0.243	0.041	»0.423	»0.044	0.206	»0.570
5 ±	»0.056	0.360	0.050	»0.238	0.334	»0.086
6 ±	»0.116	»0.060	»0.062	0.151	0.456	0.031
7 ±	0.877	0.435	0.003	0.167	0.143	»0.211
8 ±	»0.305	1.064	»0.070	»0.007	0.470	0.065

```
SUM OF RV RESIDUALS : 0.0001090791874  MEAN RESIDUAL : 8.521811516E»7
```

LOG RESIDUALS FROM EFFORT (or SURVEY) INDEX 31/ 8/93

	±	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	±	0.986	0.440	0.332	0.234	»1.857	0.333	»0.488	1.232	0.170	0.771
2	±	0.536	»0.025	»0.265	»0.483	»1.082	»0.017	»0.173	»0.436	»0.056	0.263
3	±	»0.231	»0.240	»0.198	»0.695	»0.283	0.171	»0.678	0.078	»0.359	0.696
4	±	»0.711	»0.840	»0.151	»0.546	»0.626	0.655	»0.448	0.174	0.224	0.779
5	±	»1.892	»0.654	»0.233	»0.069	»0.375	1.030	»0.189	»0.095	0.405	0.545
6	±	»1.848	»0.895	0.417	»0.885	»0.154	0.687	0.003	»0.364	0.055	1.328
7	±	»3.601	»0.251	0.080	0.052	»0.925	1.894	0.060	0.108	0.187	0.114
8	±	»2.519	»0.534	»0.159	»0.729	0.014	»0.061	1.705	»0.291	»0.368	0.424

	±	1987	1988	1989	1990	1991	1992
1	±	»0.130	»0.813	0.434	»1.077	»0.776	0.209
2	±	0.711	»0.187	0.292	0.440	»0.076	0.558
3	±	0.683	0.269	0.659	0.238	0.301	»0.412
4	±	0.396	0.058	1.072	»0.021	0.217	»0.231
5	±	0.623	0.248	1.094	0.012	0.082	»0.532
6	±	0.507	»0.001	1.308	0.037	0.355	»0.549
7	±	0.430	0.673	1.126	0.601	»0.145	»0.403
8	±	»0.638	0.913	2.020	»0.334	1.002	»0.445

SUM OF RV RESIDUALS : 0.00009728359422 MEAN RESIDUAL : 7.600280798E»7

RESIDUALS FROM JUVINILE INDEX 31/ 8/93

	±	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	±	»0.445	1.677	»3.080	0.818	»1.353	1.120	»0.141	0.001	0.719	»0.161	0.391

SUM OF CPUE RESIDUALS : 3.15661552 MEAN RESIDUAL : 0.19728847

ESTIMATED PARAMETERS AND STANDARD ERRORS

Analytical Summary

ORTHOGONALITY OFFSET..... 0.005920
MEAN SQUARE RESIDUALS 0.651182

AGE	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	BIAS %/%
1	672228.926340	393170.076475	1.710	0.58	17.56
2	432049.425229	152321.574519	2.836	0.35	6.98
3	375873.149221	114822.644002	3.274	0.31	4.58
4	96905.108880	35123.012947	2.759	0.36	7.17
5	17033.615792	7257.615151	2.347	0.43	9.90
6	6232.655655	2673.007898	2.332	0.43	9.78
7	1644.764384	747.721050	2.200	0.45	10.55
8	580.798179	235.651751	2.465	0.41	7.85
1	0.000011	0.000002	4.823	0.21	1.85
2	0.000021	0.000004	4.891	0.20	1.89
3	0.000027	0.000005	4.904	0.20	1.89
4	0.000033	0.000007	4.871	0.21	1.94
5	0.000043	0.000009	4.856	0.21	1.87
6	0.000051	0.000011	4.845	0.21	1.89
7	0.000044	0.000009	4.845	0.21	1.90
8	0.000030	0.000006	4.879	0.20	1.82
1	0.000001	0.000000	4.824	0.21	1.84
2	0.000009	0.000002	4.896	0.20	1.86
3	0.000027	0.000005	4.912	0.20	1.87
4	0.000034	0.000007	4.886	0.20	1.89
5	0.000032	0.000007	4.871	0.21	1.83
6	0.000028	0.000006	4.862	0.21	1.84
7	0.000015	0.000003	4.854	0.21	1.87
8	0.000007	0.000001	4.884	0.20	1.82
1	0.000121	0.000030	4.052	0.25	2.63

Parameter Correlation Matrix 31/ 8/93

	±	1	2	3	4	5	6	7	8	9	10
1	±	1.000	0.042	0.030	0.011	0.006	0.004	0.002	0.002	»0.185	»0.008
2	±	0.042	1.000	0.051	0.020	0.010	0.007	0.003	0.004	»0.119	»0.132
3	±	0.030	0.051	1.000	»0.014	0.010	0.017	0.019	0.030	»0.085	»0.093
4	±	0.011	0.020	»0.014	1.000	0.010	0.020	0.029	0.039	»0.033	»0.039
5	±	0.006	0.010	0.010	0.010	1.000	0.039	0.024	0.026	»0.017	»0.019
6	±	0.004	0.007	0.017	0.020	0.039	1.000	0.043	0.036	»0.011	»0.012
7	±	0.002	0.003	0.019	0.029	0.024	0.043	1.000	0.055	»0.005	»0.006
8	±	0.002	0.004	0.030	0.039	0.026	0.036	0.055	1.000	»0.007	»0.007
9	±	»0.185	»0.119	»0.085	»0.033	»0.017	»0.011	»0.005	»0.007	1.000	0.024
10	±	»0.008	»0.132	»0.093	»0.039	»0.019	»0.012	»0.006	»0.007	0.024	1.000
11	±	»0.005	»0.008	»0.112	»0.084	»0.034	»0.021	»0.009	»0.012	0.013	0.015
12	±	»0.003	»0.004	»0.001	»0.153	»0.099	»0.046	»0.022	»0.017	0.007	0.008
13	±	»0.002	»0.003	»0.008	»0.017	»0.166	»0.109	»0.047	»0.039	0.005	0.005
14	±	»0.002	»0.003	»0.022	»0.032	»0.020	»0.165	»0.115	»0.083	0.005	0.005
15	±	»0.002	»0.004	»0.043	»0.059	»0.025	»0.022	»0.165	»0.123	0.007	0.008
16	±	»0.003	»0.006	»0.070	»0.081	»0.037	»0.024	»0.019	»0.140	0.010	0.011
17	±	»0.185	»0.119	»0.085	»0.032	»0.017	»0.011	»0.005	»0.007	0.053	0.024
18	±	»0.008	»0.127	»0.090	»0.037	»0.018	»0.012	»0.006	»0.007	0.023	0.025
19	±	»0.004	»0.007	»0.107	»0.072	»0.030	»0.019	»0.008	»0.010	0.012	0.014
20	±	»0.002	»0.004	»0.001	»0.142	»0.083	»0.041	»0.019	»0.015	0.007	0.008
21	±	»0.002	»0.003	»0.007	»0.015	»0.158	»0.094	»0.041	»0.032	0.004	0.005
22	±	»0.002	»0.003	»0.018	»0.029	»0.018	»0.158	»0.099	»0.074	0.004	0.005
23	±	»0.002	»0.004	»0.039	»0.053	»0.023	»0.021	»0.161	»0.117	0.006	0.007
24	±	»0.003	»0.006	»0.065	»0.078	»0.034	»0.022	»0.019	»0.138	0.009	0.010
25	±	»0.009	»0.135	»0.096	»0.037	»0.020	»0.013	»0.006	»0.007	0.025	0.027

	±	11	12	13	14	15	16	17	18	19	20
1	±	»0.005	»0.003	»0.002	»0.002	»0.002	»0.003	»0.185	»0.008	»0.004	»0.002
2	±	»0.008	»0.004	»0.003	»0.003	»0.004	»0.006	»0.119	»0.127	»0.007	»0.004
3	±	»0.112	»0.001	»0.008	»0.022	»0.043	»0.070	»0.085	»0.090	»0.107	»0.001
4	±	»0.084	»0.153	»0.017	»0.032	»0.059	»0.081	»0.032	»0.037	»0.072	»0.142
5	±	»0.034	»0.099	»0.166	»0.020	»0.025	»0.037	»0.017	»0.018	»0.030	»0.083
6	±	»0.021	»0.046	»0.109	»0.165	»0.022	»0.024	»0.011	»0.012	»0.019	»0.041
7	±	»0.009	»0.022	»0.047	»0.115	»0.165	»0.019	»0.005	»0.006	»0.008	»0.019
8	±	»0.012	»0.017	»0.039	»0.083	»0.123	»0.140	»0.007	»0.007	»0.010	»0.015
9	±	0.013	0.007	0.005	0.005	0.007	0.010	0.053	0.023	0.012	0.007
10	±	0.015	0.008	0.005	0.005	0.008	0.011	0.024	0.025	0.014	0.008
11	±	1.000	0.017	0.010	0.009	0.012	0.017	0.013	0.014	0.019	0.016
12	±	0.017	1.000	0.023	0.015	0.015	0.018	0.007	0.008	0.015	0.031
13	±	0.010	0.023	1.000	0.027	0.017	0.014	0.005	0.005	0.008	0.020
14	±	0.009	0.015	0.027	1.000	0.031	0.019	0.005	0.005	0.008	0.013
15	±	0.012	0.015	0.017	0.031	1.000	0.026	0.007	0.007	0.011	0.014
16	±	0.017	0.018	0.014	0.019	0.026	1.000	0.010	0.010	0.015	0.016
17	±	0.013	0.007	0.005	0.005	0.007	0.010	1.000	0.023	0.012	0.007
18	±	0.014	0.008	0.005	0.005	0.007	0.010	0.023	1.000	0.013	0.007
19	±	0.019	0.015	0.008	0.008	0.011	0.015	0.012	0.013	1.000	0.013
20	±	0.016	0.031	0.020	0.013	0.014	0.016	0.007	0.007	0.013	1.000
21	±	0.009	0.022	0.037	0.023	0.015	0.013	0.004	0.005	0.008	0.019
22	±	0.008	0.014	0.025	0.041	0.027	0.017	0.004	0.005	0.007	0.012
23	±	0.011	0.014	0.016	0.030	0.043	0.024	0.006	0.007	0.010	0.013
24	±	0.016	0.017	0.013	0.018	0.025	0.030	0.009	0.010	0.014	0.016
25	±	0.015	0.008	0.006	0.006	0.008	0.011	0.025	0.026	0.014	0.007

	±	21	22	23	24	25
1	±	»0.002	»0.002	»0.002	»0.003	»0.009
2	±	»0.003	»0.003	»0.004	»0.006	»0.135
3	±	»0.007	»0.018	»0.039	»0.065	»0.096
4	±	»0.015	»0.029	»0.053	»0.078	»0.037
5	±	»0.158	»0.018	»0.023	»0.034	»0.020
6	±	»0.094	»0.158	»0.021	»0.022	»0.013
7	±	»0.041	»0.099	»0.161	»0.019	»0.006
8	±	»0.032	»0.074	»0.117	»0.138	»0.007
9	±	0.004	0.004	0.006	0.009	0.025
10	±	0.005	0.005	0.007	0.010	0.027
11	±	0.009	0.008	0.011	0.016	0.015
12	±	0.022	0.014	0.014	0.017	0.008
13	±	0.037	0.025	0.016	0.013	0.006
14	±	0.023	0.041	0.030	0.018	0.006
15	±	0.015	0.027	0.043	0.025	0.008
16	±	0.013	0.017	0.024	0.030	0.011
17	±	0.004	0.004	0.006	0.009	0.025
18	±	0.005	0.005	0.007	0.010	0.026
19	±	0.008	0.007	0.010	0.014	0.014
20	±	0.019	0.012	0.013	0.016	0.007
21	±	1.000	0.021	0.014	0.012	0.005
22	±	0.021	1.000	0.026	0.016	0.005
23	±	0.014	0.026	1.000	0.024	0.007
24	±	0.012	0.016	0.024	1.000	0.010
25	±	0.005	0.005	0.007	0.010	1.000

Table 10a: Silver hake population numbers ('000)

±	1977	1978	1979	1980	1981	1982	1983	1984
1 ±	654651	752720	928521	677090	892242	1578056	844452	1384445
2 ±	438196	424161	487419	605566	440286	596157	1041273	561264
3 ±	276044	234350	226765	279328	348042	274488	356243	618690
4 ±	85420	136027	91430	92328	129608	144029	121873	192818
5 ±	40929	44921	62506	31266	35664	56117	40544	57720
6 ±	14739	25619	19706	23575	9115	14140	11620	17854
7 ±	20964	9286	12894	5047	11558	3463	4612	5009
8 ±	13283	13973	4664	6049	2212	6765	649	2420
9 ±	190	8830	8410	2721	3685	1245	4154	228
1+±	1544417	1649887	1842315	1722969	1872412	2674460	2425419	2840449
2+±	889766	897168	913794	1045879	980169	1096404	1580967	1456004
3+±	451569	473006	426375	440313	539884	500247	539694	894739
4+±	175525	238657	199610	160986	191842	225759	183452	276049

±	1985	1986	1987	1988	1989	1990	1991	1992
1 ±	765859	1880299	840279	822238	1273862	1045267	642113	667399
2 ±	879234	501115	1223070	557685	546980	834030	695328	425723
3 ±	338706	482267	278376	644448	322419	296367	387444	370051
4 ±	245325	146523	135681	92925	214771	86155	81695	94948
5 ±	61368	59350	29364	46565	30161	25163	24007	16761
6 ±	22853	13209	16339	8988	13772	3822	7255	6142
7 ±	8473	7683	1682	6003	3482	1561	1213	1626
8 ±	2508	3761	3974	843	2278	1049	522	576
9 ±	1473	1496	2114	2536	395	572	616	202
1+±	2325800	3095702	2530879	2182232	2408119	2293986	1840193	1583428
2+±	1559940	1215402	1690600	1359994	1134257	1248719	1198081	916029
3+±	680706	714288	467530	802308	587277	414689	502752	490305
4+±	342000	232020	189154	157861	264858	118323	115308	120254

Table 10b: Silver hake population biomass (tons)

±	1977	1978	1979	1980	1981	1982	1983	1984	1985
1 ±	42552	55927	70568	26880	54070	103678	56747	97050	52155
2 ±	80190	64812	86858	91562	73748	100751	133595	81945	119752
3 ±	72738	53572	51430	62234	74864	63352	69681	111921	60019
4 ±	29017	36183	25024	26461	35798	39608	29140	43268	51567
5 ±	18258	15053	19020	10662	11612	17806	11705	15723	14949
6 ±	9314	10373	7664	9211	3656	5566	4239	6297	6744
7 ±	18582	4066	5867	2682	6391	1544	1819	2029	3473
8 ±	12250	7543	3909	5078	2041	3469	297	1509	1458
9 ±	403	7875	7046	2338	4190	630	1844	148	986
1+±	283304	255405	277387	237108	266369	336403	309068	359890	311103
2+±	240752	199478	206819	210227	212299	232724	252320	262840	258948
3+±	160562	134666	119961	118666	138551	131974	118725	180896	139197
4+±	87824	81094	68531	56431	63687	68622	49044	68975	79178

±	1986	1987	1988	1989	1990	1991	1992
1 ±	100220	37476	37165	76686	66165	40453	53392
2 ±	72812	145545	77630	74061	116097	96651	59601
3 ±	88882	46767	119029	62711	54472	71290	70310
4 ±	36645	28574	21057	48109	18739	17810	19939
5 ±	14843	7291	12126	8388	6034	5762	4358
6 ±	3617	4673	2626	4809	1203	2285	1720
7 ±	3011	762	2404	1403	577	449	602
8 ±	1934	1677	419	1163	420	209	236
9 ±	963	1095	1745	324	312	336	139
1+±	322927	273861	274201	277653	264019	235244	210296
2+±	222707	236385	237036	200967	197854	194791	156905
3+±	149895	90839	159406	126906	81757	98140	97303
4+±	61014	44072	40377	64195	27285	26850	26994

Table 10c: Silver hake fishing mortality

	±	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	±	0.034	0.035	0.027	0.030	0.003	0.016	0.008	0.054	0.024	0.030	0.010	0.008
2	±	0.226	0.226	0.157	0.154	0.073	0.115	0.121	0.105	0.201	0.188	0.241	0.148
3	±	0.308	0.541	0.499	0.368	0.482	0.412	0.214	0.525	0.438	0.868	0.697	0.699
4	±	0.243	0.378	0.673	0.551	0.437	0.868	0.347	0.745	1.019	1.207	0.669	0.725
5	±	0.068	0.424	0.575	0.833	0.525	1.175	0.420	0.527	1.136	0.890	0.784	0.818
6	±	0.062	0.287	0.962	0.313	0.568	0.720	0.441	0.345	0.690	1.661	0.601	0.548
7	±	0.006	0.289	0.357	0.425	0.136	1.274	0.245	0.292	0.412	0.259	0.290	0.569
8	±	0.008	0.108	0.139	0.096	0.175	0.088	0.647	0.097	0.117	0.176	0.049	0.359
9	±	0.027	0.047	0.055	0.045	0.047	0.064	0.026	0.057	0.073	0.094	0.069	0.071

	±	1989	1990	1991	1992
1	±	0.024	0.008	0.011	0.017
2	±	0.213	0.367	0.231	0.244
3	±	0.920	0.889	1.006	0.270
4	±	1.744	0.878	1.184	0.416
5	±	1.666	0.844	0.963	0.286
6	±	1.777	0.748	1.096	0.243
7	±	0.799	0.695	0.345	0.148
8	±	0.981	0.133	0.550	0.071
9	±	0.127	0.088	0.103	0.030

Table 11: Output from Laurec-Shepherd run for 4VWX silver hake; July RV and CPUE used for tuning.

RUN 2

```
VPA Version 3.0 (MSDOS)

At  6/09/1993  15:02

4VWX silver hake - L-S run with CPUE & RV surveys

CPUE data from file tun.dat

Disaggregated Qs
Log transformation
The final F is the (reciprocal variance-weighted) mean of the raised fleet F's.
No trend in Q (mean used)

Terminal Fs estimated using  Laurec-Shepherd


Tuning converged after   10 iterations


Total of the absolute F residuals for all ages in the
last year, between iterations  9 and  10 =    .000

Regression weights
      , 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000

Oldest age F =  .100*average of 3 younger ages.


Fishing mortalities
   Age,  1977,  1978,  1979,  1980,  1981,  1982,  1983,  1984,  1985,  1986,  1987,  1988,  1989,  1990,  1991,  1992

     1,  .031,  .034,  .025,  .028,  .003,  .016,  .008,  .055,  .024,  .031,  .010,  .008,  .025,  .010,  .008,  .016
     2,  .222,  .200,  .153,  .139,  .066,  .116,  .121,  .105,  .203,  .189,  .246,  .149,  .219,  .397,  .306,  .181
     3,  .292,  .520,  .416,  .352,  .416,  .364,  .217,  .518,  .430,  .857,  .690,  .707,  .896,  .905, 1.145,  .401
     4,  .224,  .350,  .623,  .414,  .409,  .652,  .292,  .741,  .967, 1.112,  .658,  .709, 1.687,  .826, 1.225,  .575
     5,  .044,  .377,  .506,  .708,  .336,  .982,  .263,  .405, 1.099,  .788,  .654,  .784, 1.460,  .790,  .832,  .322
     6,  .034,  .171,  .755,  .261,  .425,  .352,  .317,  .184,  .444, 1.426,  .480,  .401, 1.447,  .541,  .923,  .198
     7,  .004,  .147,  .184,  .281,  .109,  .684,  .091,  .188,  .182,  .139,  .216,  .393,  .463,  .418,  .211,  .116
     8,  .002,  .066,  .063,  .044,  .104,  .069,  .204,  .033,  .070,  .065,  .025,  .242,  .497,  .063,  .249,  .041
     9,  .001,  .013,  .033,  .020,  .021,  .037,  .020,  .013,  .023,  .054,  .024,  .035,  .080,  .034,  .046,  .012
```

Log catchability residuals

Fleet : Std. CPUE @age

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	.89	.43	.25	.16	-1.83	.35	-.48	1.26	.19	.81	-.11	-.77	.52	-.82	-1.04	.20
2	.53	-.13	-.28	-.57	-1.17	.01	-.16	-.43	-.03	.28	.75	-.17	.34	.54	.22	.26
3	-.29	-.27	-.37	-.74	-.42	.05	-.67	.07	-.37	.70	.69	.29	.65	.27	.45	-.04
4	-.75	-.86	-.16	-.77	-.64	.44	-.57	.24	.24	.77	.44	.10	1.09	-.01	.32	.13
5	-2.19	-.60	-.18	-.05	-.65	1.03	-.49	-.18	.56	.61	.63	.39	1.13	.13	.12	-.26
6	-2.12	-1.07	.53	-.73	-.09	.33	.02	-.65	-.03	1.52	.63	.04	1.44	.07	.54	-.43
7	-3.56	-.41	-.06	.17	-.63	1.81	-.40	.19	-.10	.01	.65	.84	1.12	.61	-.11	-.15
8	-3.10	-.29	-.21	-.78	.23	.43	1.30	-.66	-.16	.17	-.61	1.27	2.10	-.36	.96	-.10

Fleet : Cdn July R/V

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	-2.04	-.86	.07	-1.23	-.80	.39	.49	.53	.50	1.30	.75	.05	.57	.55	-.05	-.22
2	-.82	-1.07	.74	-.56	.15	1.21	-.35	-.18	.33	.17	.46	.10	-.17	.22	.14	-.37
3	-.84	-.83	.46	.70	.73	.47	-.50	.77	-.47	.09	.14	-.11	-.57	.10	-.19	.05
4	-1.40	-1.14	.21	.76	.87	.74	-.36	.21	.66	.08	-.18	.09	-.57	-.06	.24	-.16
5	-2.49	-.48	-.21	.49	.35	1.14	-.27	-.26	.77	.14	-.06	.49	-.07	-.13	.34	.26
6	-1.67	-1.17	.17	-.35	.74	.42	-.18	.06	.33	.76	.03	.00	-.11	.17	.58	.22
7	-1.90	-.90	-.45	.48	-.12	1.59	-.91	.76	-.16	-.44	1.12	.57	-.07	.15	.19	.08
8	-2.77	-1.55	-.08	-.85	.75	1.03	.87	.40	.99	-.42	-.24	1.40	-.11	-.02	.38	.25

SUMMARY STATISTICS FOR AGE 1

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-4.69	.830	.0091	.0135	-.444E-01	.436E-01	-4.695	.201
2	-2.28	.879	.1020	.0204	.102E+00	.393E-01	-2.283	.213

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.016	.603	.208	.603	.119

SUMMARY STATISTICS FOR AGE 2

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-2.36	.496	.0946	.1394	.444E-01	.243E-01	-2.358	.120
2	-1.65	.589	.1923	.2617	.269E-01	.313E-01	-1.648	.143

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.181	.380	.310	.380	.668

SUMMARY STATISTICS FOR AGE 3

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.26	.488	.2827	.4166	.655E-01	.200E-01	-1.263	.118
2	-1.42	.553	.2418	.3817	-.940E-03	.301E-01	-1.420	.134

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.401	.366	.435E-01	.366	.014

SUMMARY STATISTICS FOR AGE 4

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.07	.598	.3435	.5063	.825E-01	.240E-01	-1.068	.145
2	-1.29	.665	.2760	.6720	.195E-01	.358E-01	-1.287	.161

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.575	.445	.141	.445	.100

SUMMARY STATISTICS FOR AGE 5

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.26	.822	.2848	.4198	.905E-01	.377E-01	-1.256	.199
2	-1.13	.812	.3215	.2490	.660E-01	.406E-01	-1.135	.197

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.322	.578	.261	.578	.204

SUMMARY STATISTICS FOR AGE 6

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.57	.932	.2072	.3052	.100E+00	.431E-01	-1.574	.226
2	-1.13	.663	.3221	.1587	.725E-01	.304E-01	-1.133	.161

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.198	.540	.309	.540	.327

SUMMARY STATISTICS FOR AGE 7

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-2.39	1.179	.0912	.1346	.113E+00	.567E-01	-2.395	.286
2	-1.42	.869	.2428	.1065	.714E-01	.433E-01	-1.416	.211

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.116	.699	.112	.699	.026

SUMMARY STATISTICS FOR AGE 8

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-3.30	1.198	.0368	.0551	.120E+00	.568E-01	-3.304	.291
2	-2.00	1.088	.1349	.0320	.107E+00	.519E-01	-2.003	.264

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.041	.806	.270	.806	.113

Run title : 4VWX silver hake - L-S run with CPUE & RV surveys

At 6/09/1993 15:03

Traditional vpa Terminal Fs estimated using Laurec-Shepherd

0 Table 8 Fishing mortality (F) at age

YEAR,	1977,	1978,	1979,	1980,	1981,	1982,
AGE						
1,	.0307,	.0339,	.0251,	.0280,	.0033,	.0158,
2,	.2217,	.2003,	.1525,	.1391,	.0663,	.1165,
3,	.2917,	.5199,	.4165,	.3522,	.4158,	.3638,
4,	.2240,	.3497,	.6229,	.4135,	.4089,	.6516,
5,	.0439,	.3773,	.5058,	.7077,	.3358,	.9815,
6,	.0343,	.1707,	.7548,	.2605,	.4253,	.3518,
7,	.0036,	.1466,	.1842,	.2811,	.1091,	.6835,
8,	.0023,	.0665,	.0633,	.0441,	.1039,	.0690,
9,	.0013,	.0128,	.0334,	.0195,	.0213,	.0368,
0 FBAR 3- 7,	.1195,	.3129,	.4968,	.4030,	.3390,	.6065,

0 Table 8 Fishing mortality (F) at age

YEAR,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	FBAR 90-92
AGE											
1,	.0085,	.0548,	.0245,	.0308,	.0101,	.0079,	.0254,	.0099,	.0083,	.0164,	.0115,
2,	.1210,	.1047,	.2030,	.1894,	.2458,	.1490,	.2193,	.3971,	.3056,	.1811,	.2946,
3,	.2166,	.5183,	.4303,	.8573,	.6898,	.7075,	.8955,	.9047,	1.1454,	.4010,	.8170,
4,	.2920,	.7414,	.9666,	1.1123,	.6577,	.7090,	1.6875,	.8262,	1.2245,	.5747,	.8751,
5,	.2628,	.4048,	1.0994,	.7878,	.6538,	.7836,	1.4599,	.7904,	.8325,	.3223,	.6484,
6,	.3173,	.1845,	.4439,	1.4258,	.4801,	.4005,	1.4466,	.5405,	.9227,	.1977,	.5536,
7,	.0915,	.1876,	.1815,	.1389,	.2158,	.3934,	.4628,	.4183,	.2110,	.1156,	.2483,
8,	.2035,	.0325,	.0697,	.0653,	.0245,	.2423,	.4973,	.0626,	.2489,	.0409,	.1175,
9,	.0204,	.0135,	.0232,	.0543,	.0240,	.0345,	.0802,	.0340,	.0461,	.0118,	.0306,
0 FBAR 3- 7,	.2360,	.4073,	.6243,	.8644,	.5394,	.5988,	1.1904,	.6960,	.8672,	.3223,	

1

Run title : 4VWX silver hake - L-S run with CPUE & RV surveys

At 6/09/1993 15:03

Traditional vpa Terminal Fs estimated using Laurec-Shepherd

0 Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR,	1977,	1978,	1979,	1980,	1981,	1982,
AGE						
1,	718054,	762452,	1006021,	729465,	871568,	1557068,
2,	439309,	466774,	494076,	657641,	475497,	582312,
3,	284303,	235922,	256090,	284342,	383598,	298274,
4,	90436,	142356,	94027,	113190,	134014,	169664,
5,	62627,	48456,	67266,	33809,	50175,	59684,
6,	26048,	40179,	22273,	27189,	11168,	24039,
7,	32927,	16872,	22705,	7019,	14045,	4893,
8,	48216,	21993,	9767,	12659,	3552,	8442,
9,	3626,	32246,	13795,	6145,	8119,	2146,
0 TOTAL,	1705547,	1767249,	1986018,	1871459,	1951736,	2706521,

0 Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	GMST 77-89	AMST 77-89
AGE													
1,	838509,	1352442,	750700,	1820207,	825110,	789631,	1171956,	806150,	839812,	676594,	0,	966847,	1014860,
2,	1027324,	557314,	858195,	491044,	1183074,	547556,	525151,	765869,	535081,	558277,	446159,	606866,	638867,
3,	347416,	610182,	336436,	469587,	272365,	620214,	316222,	282706,	345115,	264231,	312248,	345504,	362689,
4,	138967,	187533,	243593,	146663,	133558,	91596,	204910,	86569,	76683,	73591,	118613,	139059,	145424,
5,	59276,	69566,	59892,	62109,	32324,	46378,	30215,	25409,	25400,	15107,	27766,	50629,	52444,
6,	14992,	30552,	31108,	13371,	18936,	11269,	14200,	4704,	7727,	7406,	7337,	20281,	21948,
7,	11335,	7317,	17030,	13377,	2154,	7854,	5061,	2240,	1837,	2059,	4074,	9988,	12507,
8,	1656,	6934,	4066,	9521,	7804,	1164,	3552,	2136,	988,	997,	1229,	6714,	10717,
9,	5281,	905,	4499,	2542,	5978,	5105,	612,	1448,	1345,	517,	641,	4309,	7000,
0 TOTAL,	2444756,	2822747,	2305519,	3028422,	2481304,	2120766,	2271880,	1977232,	1833987,	1598779,	918067,		

1

Run title : 4VWX silver hake - L-S run with CPUE & RV surveys

At 6/09/1993 15:03

Table 16 Summary (without SOP correction)

Traditional vpa Terminal Fs estimated using Laurec-Shepherd

0,	RECRUITS,	TOTALBIO,	TOTSPBIO,	LANDINGS,	FBAR 3- 7,
0					
1977,	718054,	358580,	358580,	37000,	.1195,
1978,	762452,	300265,	300265,	48000,	.3129,
1979,	1006021,	307487,	307487,	52000,	.4968,
1980,	729465,	266162,	266162,	45000,	.4030,
1981,	871568,	293623,	293623,	45000,	.3390,
1982,	1557068,	352726,	352726,	60000,	.6065,
1983,	838509,	319166,	319166,	36000,	.2360,
1984,	1352442,	366075,	366075,	74000,	.4073,
1985,	750700,	314615,	314615,	75000,	.6243,
1986,	1820207,	321708,	321708,	83000,	.8644,
1987,	825110,	272652,	272652,	62000,	.5394,
1988,	789631,	269764,	269764,	74000,	.5988,
1989,	1171956,	266488,	266488,	91000,	1.1904,
1990,	806150,	238101,	238101,	69000,	.6960,
1991,	839812,	206801,	206801,	68000,	.8672,
1992,	676594,	205473,	205473,	32000,	.3223,
0 Units,	(Thousands),	(Tonnes),	(Tonnes),	(Tonnes),	

1

Table 12: 4VWX silver hake catch projections

POPULATION NUMBERS 1/ 9/93

	1992	1993	1994
1	400000	1200000	1100000
2	425723	260755	801034
3	370051	223523	158131
4	94948	139295	107303
5	16761	41970	83595
6	6142	8442	18535
7	1626	3228	3807
8	576	939	1727
9	202	359	531
1+	1316029	1928512	2274663
2+	916029	728512	1174663
3+	490306	467757	373629
4+	120255	244234	215498

MID-YEAR POPULATION BIOMASS (AVERAGE) 1/ 9/93

	1992	1993	1994
1	19200	58240	53311
2	43310	28315	64153
3	50964	29932	19083
4	14212	28322	14136
5	3154	7455	13074
6	1404	1804	3508
7	504	967	1061
8	214	334	580
9	109	193	281
1+	133071	155562	189187
2+	113871	97322	135876
3+	70561	69007	51723
4+	19597	39075	32640

BEGINNING OF THE YEAR POPULATION BIOMASS (TONS) 1/ 9/93

	1992	1993	1994
1	23600	70800	64900
2	58750	35984	110543
3	69940	42246	29887
4	20794	41456	23499
5	4358	10912	21735
6	1904	2617	5746
7	655	1301	1534
8	268	438	805
9	134	238	351
1+	180402	205992	259000
2+	156802	135192	194100
3+	98053	99207	83557
4+	28113	56961	53670

CATCH BIOMASS 1/ 9/93

	1992	1993	1994
1	535	243	384
2	10579	2836	14542
3	13777	9993	10992
4	5917	11819	10178
5	901	3111	9413
6	342	715	2399
7	75	218	413
8	15	57	171
9	3	7	18
1+	32146	29000	48510
2+	31611	28757	48126
3+	21031	25921	33584
4+	7254	15928	22592

MEAN WEIGHT OF INDIVIDUALS IN CATCH 1/ 9/93

	1992	1993	1994
	.2	.2	.2

FISHING MORTALITY 1/ 9/93

	1992	1993	1994
1	.028	.004	.007
2	.244	.100	.173
3	.270	.334	.576
4	.416	.417	.720
5	.286	.417	.720
6	.243	.396	.684
7	.149	.225	.389
8	.072	.171	.295
9	.030	.038	.065
1+	.199	.107	.171

PRODUCTION 1/ 9/93

SOURCE	1992	1993	1994
RECRUITMENT BIOMASS	15431	46293	42436
GROWTH	58172	80063	105441
TOTAL PRODUCTION	73603	126356	147877
LOSS THROUGH FISHING	32146	29000	48510
SURPLUS PRODUCTION	20374	64131	72202
NET PRODUCTION	11772	35131	23693

PRODUCTION/BIOMASS RATIO 1/ 9/93

	1992	1993	1994
	.55	.81	.78

SUMMARY OF PROJECTIONS 1/ 9/93

YEAR	1992	1993	1994
POPULATION NUMBERS	1316029.00	1928512.29	2274663.16
POPULATION BIOMASS	133071.17	155561.71	189186.96
CATCH	32146.27	29000.00	48509.71
F OR QUOTA	32146.27	29000.00	.72

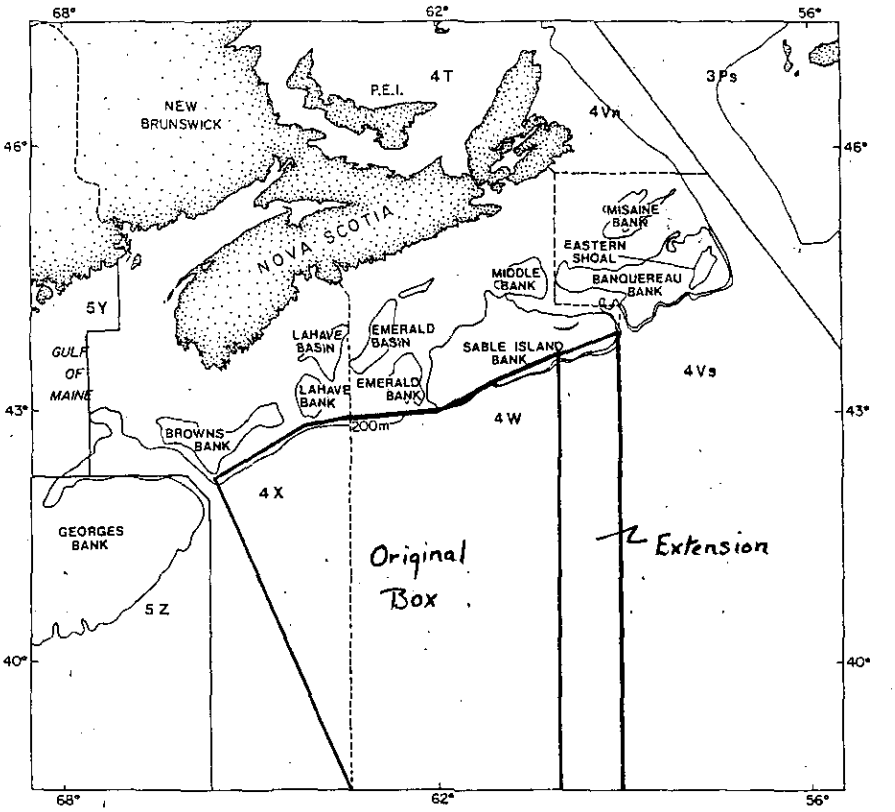


Figure 1: Bathymetric Map of the Scotian Shelf and the Bay of Fundy showing the Small Mesh Gear Line (SMGL)

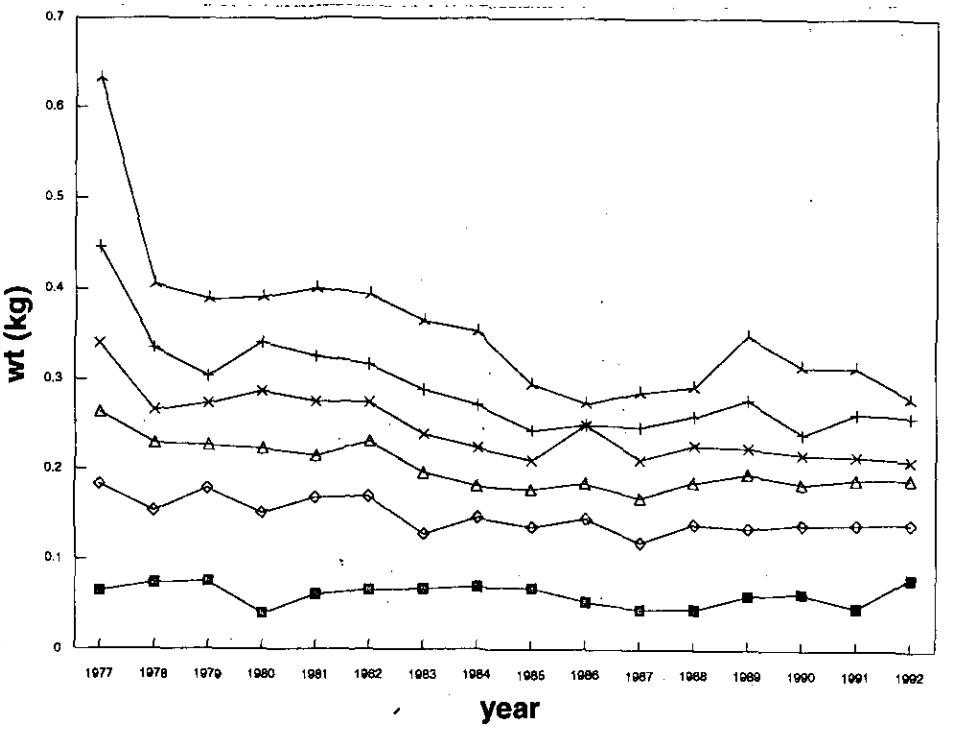


Figure 2: Mean wt at age for 4VWX silver hake, 1977-1992.

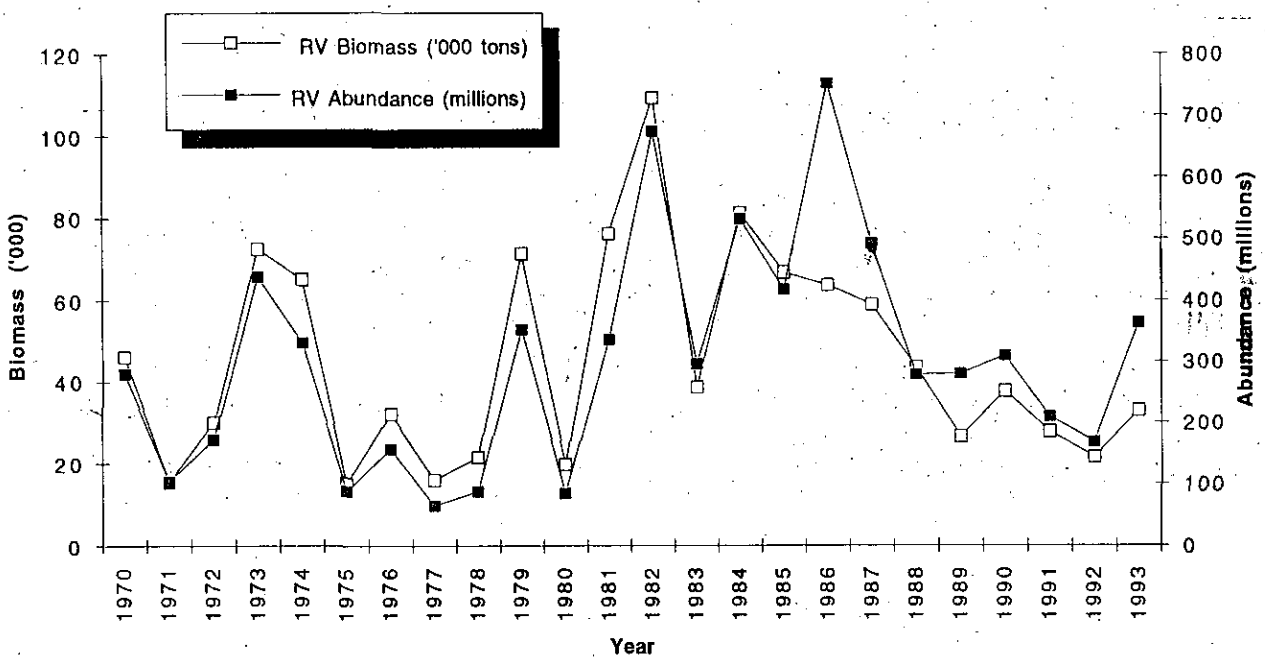


Figure 3: 4VWX silver hake July RV survey estimates of 1+ numbers and biomass

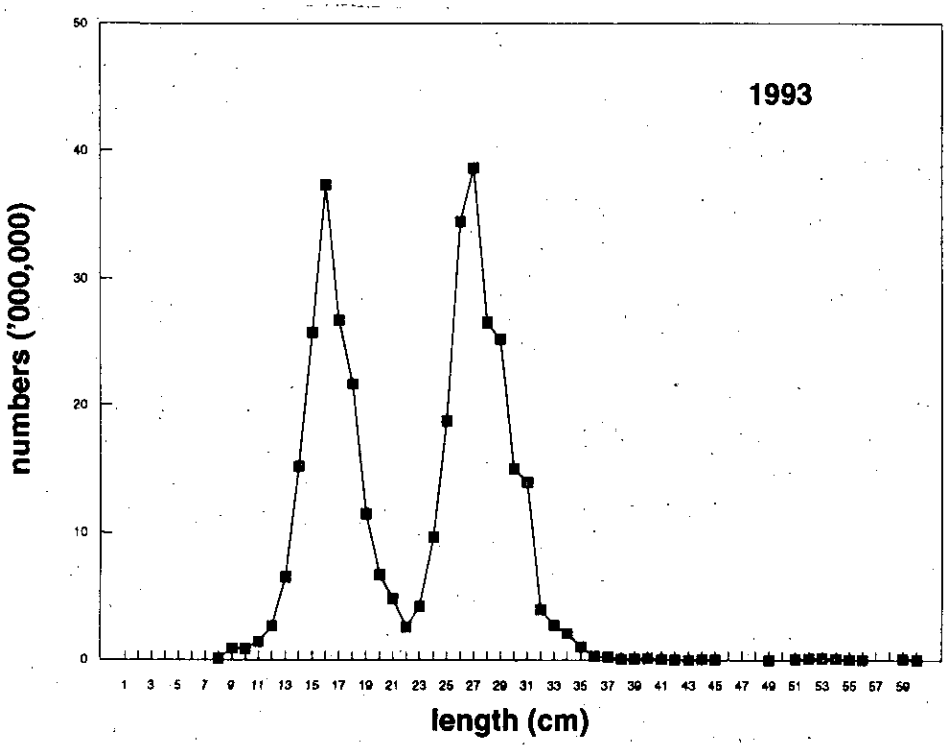


Figure 4: Numbers at length estimates from 1993 July RV survey; 4VWX silver hake.

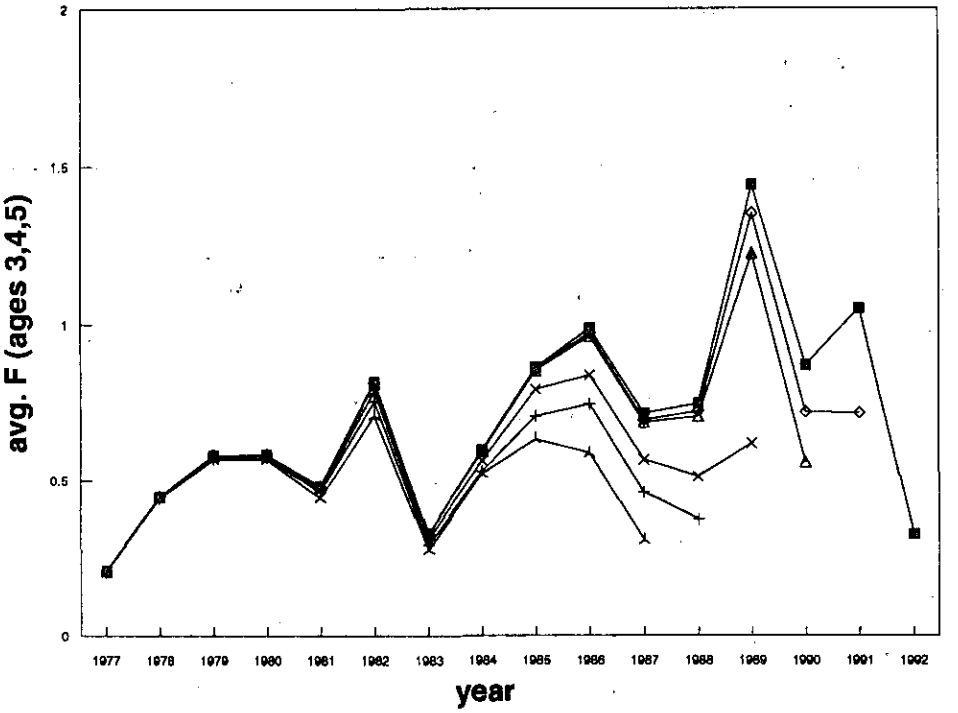


Figure 5: Retrospective analysis of mean fishing mortality from ADAPT for 4VWX silver hake. F's are an unweighted average over ages 3-5.

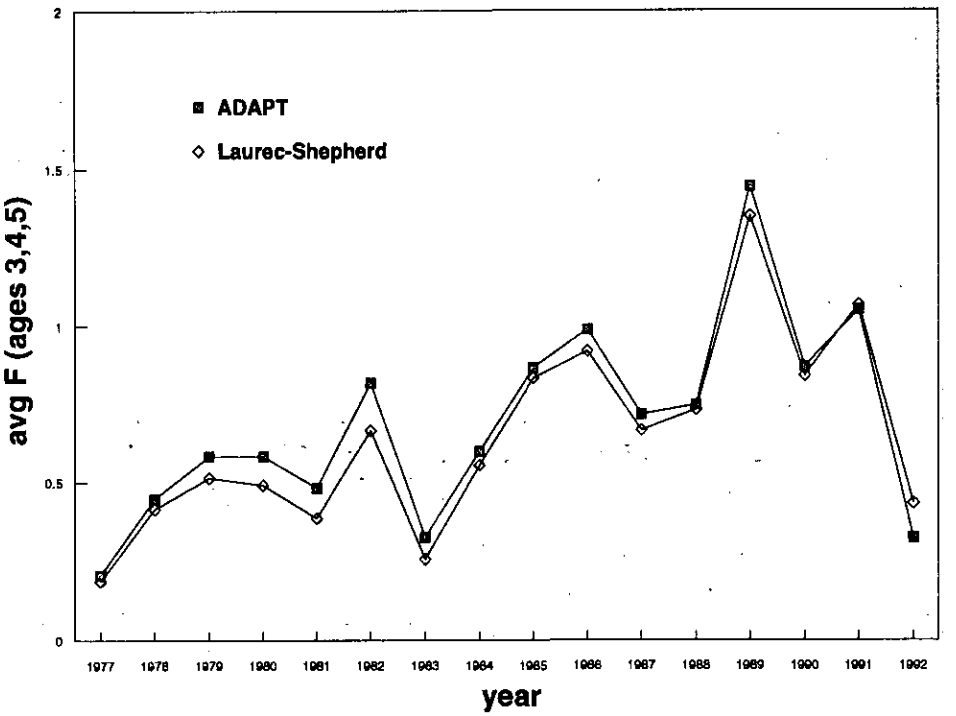


Figure 6: Comparison of fishing mortalities estimated from Laurec-Shepherd and ADAPT, for 4VWX silver hake. F's are an unweighted average over ages 3-5.

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Data   Information

         10 unweighted cases accepted.

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Page   5                          SPSS/PC+                              9/3/93

                                PLOT OF SPA WITH LRV

          ************************************************************R***
          *                                                             *
       1925*                                                            *
          *                                                          1  *
          *                                                             *
          *                                                             *
          *                                                             *
       1750*                                                            *
          *                                                             *
          *                                                             *
          *                                                             *
          *                                                             *
       1575*                              1                             *
          *                                                             *
          *                                                             *
          *                                                             *
          *                                                             *
       1400*                              1                             *
          *                                                             *
 S        *                                                             *
 P        *                                                             *
 A        *                             1                               *
       1225*                                                            *
          *                                                             *
          *                                                             *
          *                                                             *
          *                                                             *
       1050*                    1                                       *
          *                                                             *
          *                                                             *
          *                                                             *
          *                                                             *
        875*                                                            *
          *                    1       1                                *
          *   1                                                         *
          *               1                                             *
          *                                                             *
        700*                                                            *
          *                                                             *
          *  1                                                          *
          R                                                             *
          *                                                             *
          ************************************************************
             4.375     4.725     5.075     5.425     5.775     6.125
           4.2       4.55      4.9       5.25      5.6       5.95      6.3

                                      LRV

10 cases plotted. Regression statistics of SPA on LRV:
Correlation  .91491 R Squared  .83705  S.E. of Est  173.74253 Sig.  .0002
Intercept(S.E.) -1923.9576(476.06497)  Slope(S.E.)  612.02014( 95.47041)
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Figure 7: Regression of ln RV age 1 survey numbers against age 1 numbers from SPA; 1981-90.