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Status of the Scotian Shelf Silver Hake Populations in 1993 with Projections to 1995

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. Prior to 1977, fishing was unrestricted in terms of area and gear. During this period fishing was shelf wide, and the use of trawl mesh as small as 40 mm was common. In 1977 Canada amended *fishing* regulations to restrict fishing for this species to the seaward side of the Small Mesh Gear Line (Figure 1), west of 60°W longitude, with a minimum mesh size of 60mm. However, on an experimental basis a portion (4-6 vessels) of the fleet was allowed to fish inside the line during 1978 and 1979. From 1980 through 1983 fishing was permitted by condition of license in an eastern extension of the box as far as 57°W longitude; from 1984 to present this eastern extension has been restricted to 59°W longitude.

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	1994
Advice	80	100	100	100	100	167	235		100	105	75	51
TAC	80	100	100	100	100	120	135	135	100	105	86	30
Catch	36	74	75	83	62	74	91[1]	69[1]	68[1]	32[1]	29[1]	NA

1 Preliminary

Removals and Weights at Age

Sampling for length composition of the commercial catch in 1993 was conducted by the Canadian Observer Program (IOP) while otoliths were collected by both Canada and CIS (Russia). More than 2000 samples consisting of 350,440 lengths were collected during the fishery. Of the otoliths collected, 1,563 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 1993 were calculated from Canadian length sampling and a combined Canada/Russia age-length key, following the same procedures used since 1991. 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 1977-1992 were taken from the previous assessment (Showell *et al.*, 1993) to provide estimates for the period 1977-93 inclusive. (Table 4, 5; Figure 2).

Indices of Abundance

Commercial Catch Rates

The APL program STANDARD was used to standardize catch rates for the period 1977 to 1993. In the previous assessment of this resource (Showell *et al.*, 1993), six factors were included in the model: data source, month, year, area, fishing regime and country. As data source and fishing regime were not significant, the model used in this assessment was simplified to include month, year, area and country only, with data from the Canadian Observer Program.

Examination of the regression results (Table 6 and accompanying graphs) show year, month, and country all have a significant effect on the model. A comparison of catch rates calculated with the previous and reduced models is shown in Figure 3.

The standardized catch rate for this stock has dropped in recent years, from a peak of 5 t/hr in 1989 to 1.6 t/hr in 1992 and 1993. 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 (Figure 4).

In numbers at age (Table 7), the July RV surveys in 1991 and 1992 show the 1990 and 1991 year classes to be weak. However, the 1993 survey shows slightly higher estimates for these year classes at age 2 and 3 respectively. Further, the 1993 survey confirms initial indications that the 1992 year class is large, with 166 million fish estimated at age 1.

Silver hake juvenile survey

A standardized IYGPT 0-group survey for this species was conducted in Oct/Nov. 1993 using the Canadian R/V *Alfred Needler*. Results suggest the 1993 year class is of average size for the time series 1981-91, with a stratified mean number per tow of 186.5. These data as well as those of previous years for the core strata (60-78) are presented in Table 8.

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 Showell *et al.* 1993). Commercial catch-at-age, age disaggregated standardized CPUE, Canadian July Survey catch-at-age and the juvenile 0-group 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 1993 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	1977 through 1993
CPUE	5	1977 through 1993

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, excluding the 0-group survey from the tuning process. Resulting fishing mortality and population numbers are shown in Table 11. The results of the two analyses closely correspond, particularly since 1983 (Figure 6). In 1993 the Laurec-Shepherd technique gave a slightly higher fishing mortality over ages 3-5, at 0.414 vs 0.323 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 (Figure 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 1993 fishing mortality produced by ADAPT is also underestimated.

Recruiting Yearclass Sizes

The 1993 yearclass will make a significant contribution to the catch in 1995 at age 2. Based on the 0-group survey, it appears this year class is of average strength. The 1992 yearclass will also be critical at age 3 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 1991 and earlier yearclasses as given by the SPA, the strength of the 1992 year class was inferred from July survey data.

Yearclass estimates from the survey were regressed against estimates from the SPA for the 1982-91 yearclasses at age 1, using the model SPA = a + b(*log*RV). (Figure 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=0.72), including that for the 1985 yearclass. Prediction from this relationship for the strength of the 1992 yearclass was 1.2 billion fish. 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 0.70 (yield per recruit = 0.059 kg) was calculated using a Thompson-Bell model, taking partial recruitment and weights at age as the average of those observed for the five most recent years in the fishery (1989-93). These same mean weights-at-age and PR at age were used for projection as follows:

Age	Avg wt (kg)	PR
1	0.062	0.02
2	0.133	0.30
3	0.182	0.73
4	0.211	1.00
5	0.254	0.96
6	0.308	0.89
7	0.399	0.47
8	0.431	0.34
9	0.717	0.08

Two projections were made. For the first population numbers at age at the beginning of 1993 were taken from the SPA (Table 10a) except that the 1992 yearclass was set at 1.2 billion, from the regression in Figure 7, and the 1993 year class was set at the geometric mean of 1.1 billion based on the 0-group survey.

Due to delays in the allocation process, the silver hake fishery did not start until the last week of April in 1994. Given this late start and a reduced level of participation anticipated in 1994, the catch is predicted to be at most 20,000t. Projection of stock and catch trends through 1995 utilizing these data gave the results in Table 12a.

A second projection was run in an ad-hoc attempt to provide correction for the retrospective pattern. Based on Figure 5, F appears to be underestimated by at least 40% in retrospect, and the population numbers from the SPA were therefore reduced by this amount for the projection. These results are presented in Table 12b.

Based on the actual numbers from the SPA, a catch of 20,000t in 1994 will result in an *estimated fully recruited fishing mortality* of F=0.18. Fishing at $F_{0.1}$ in 1995 is estimated to equate to a catch of 77,000t.

Using 'corrected' populations numbers from SPA reduced by 40%, the fully recruited F for 1994 is 0.30, with an $F_{0.1}$ catch estimated at 59,000t in 1995.

References

Fanning, L.P. 1985. Intercalibration of research survey results obtained by different vessels. CAFSAC Res. Doc. 85-3. 43p.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. CAFSAC Res. Doc. 88-29. (Mimeo)

NAFO 1990. Scientific Council Reports 1990:68

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Table 1. Nominal catches for 4VWX silver hake 1970-1993 (1990-1993 preliminary).

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Bulgaria	0	0	0	0	0	1722	3088	862	606	4639	817	0
Canada	0	0	0	0	11	101	26	10	26	13	104	6
Cuba	0	0	201	0	0	1724	12572	1847	3436	1798	2287	642
France	0	0	0	0	0	0	0	15	0	0	0	0
FRG	0	0	10	0	296	106	97	684	0	0	0	0
GDR	0	0	0	0	0	0	0	0	3	0	0	0
Ireland	0	0	0	0	0	108	106	0	0	9	0	0
Italy	0	0	0	0	0	0	0	38	106	5	0	541
Japan	129	8	63	88	67	54	78	19	161	219	239	120
Poland	0	0	0	0	0	0	0	295	2	0	0	1[1]
Portugal	0	0	0	0	0	0	0	0	0	0	56	2044
Romania	0	0	0	0	0	0	0	10	0	1	0	0
Spain	0	15	0	0	0	6	0	0	2	0	40	0
USA	0	1	1	1	1	7	1	14	0	0	0	3
USSR	168916	128633	113774	298533	95371	112566	81216	33301	44062	45076	40982	41243
Total	169045	128657	114048	298621	95745	116394	97184	37095	48404	51760	44525	44600

Country	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Bulgaria	0	0	0	0	0	0	0	0	88	0	0	0
Canada	38	15	10	2	9	13	9	337	10	58[1]	4[1]	73[1]
Cuba	11969	7418	14496	17683	16041	20219	9016	14541	13888	17786[1]	16528[1]	22018[1]
France	2[1]	0	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	93	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0
Italy	37[1]	2[2]	0	0	0	0	0	0	0	0	0	0
Japan	937	649	530	120	66	144	0	194	322[1]	744[1]	547[1]	0
Poland	31[2]	0	0	0	0	0	0	0	0	0	0	0
Portugal	2[1]	378	1714	1338	0	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	2	0	0	0	1	0	0	0	0	0	0	0
USSR	47261	27377	57423	56337	66571	41329	65349	72917	55981	49311[1]	14716[1]	7139[1]
Total	60251	35839	74266	75480	82688	61705	74374	87989	70289	67899	31795	29230

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

Table 2. Sampling used in this assessment.

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	556765	1712
1992	336562	1721
1993	350440	1563

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 Canadian July Research Vessel Survey of the Scotian Shelf (4VWX).

Year	Male - Alpha	Female - Alpha	Male - Beta	Female - Beta
1977	0.000006260	0.000006930	3.0626	3.0350
1978	0.000004630	0.000003070	3.1366	3.2531
1979	0.000010200	0.000005880	2.9001	3.0675
1980	0.000002330	0.000001800	3.3417	3.3989
1981	0.000006830	0.000005080	3.0206	3.1172
1982	0.000011600	0.000006740	2.8575	3.0232
1983	0.000006480	0.000003320	2.9935	3.2034
1984	0.000018300	0.000006490	2.7052	3.0284
1985	0.000013500	0.000004530	2.7848	3.1235
1986	0.000007970	0.000003820	2.9384	3.1685
1987	0.000009990	0.000004240	2.8798	3.1456
1988	0.000014300	0.000004800	2.7942	3.1241
1989	0.000006750	0.000004440	3.0114	3.1416
1990	0.000034320	0.000021000	2.5234	2.6958
1991	0.000006040	0.000004265	2.9582	3.2036
1992	0.000004025	0.000003447	3.1750	3.2241
1993	0.000004429	0.000003089	3.1082	3.2202

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

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

Age	1986	1987	1988	1989	1990	1991	1992	1993
1	45598	6804	5110	24264	6516	5738	9074	33319
2	70269	214235	62791	85846	209620	117305	76663	77413
3	229126	114417	265307	158745	142862	201243	72896	71982
4	84097	54211	39242	145105	41215	46414	27020	32769
5	28635	13063	21303	20025	11741	12154	3467	5531
6	8760	6045	3106	9369	1648	3954	1102	743
7	1436	347	2133	1569	640	290	186	111
8	497	156	208	1166	107	181	33	43
9	111	117	143	39	40	50	5	4

Table 5: Silver hake commercial mean weights at age.

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0.065	0.074	0.076	0.040	0.061	0.066	0.067	0.070	0.068
2	0.183	0.153	0.178	0.151	0.168	0.169	0.128	0.146	0.136
3	0.264	0.229	0.227	0.223	0.215	0.231	0.196	0.181	0.177
4	0.340	0.266	0.274	0.287	0.276	0.275	0.239	0.224	0.210
5	0.446	0.335	0.304	0.341	0.326	0.317	0.289	0.272	0.244
6	0.632	0.405	0.389	0.391	0.401	0.394	0.365	0.353	0.295
7	0.886	0.438	0.455	0.531	0.553	0.446	0.395	0.405	0.410
8	0.922	0.540	0.838	0.839	0.923	0.513	0.457	0.624	0.582
9	2.120	0.892	0.838	0.859	1.137	0.506	0.444	0.650	0.669

Age	1986	1987	1988	1989	1990	1991	1992	1993
1	0.053	0.045	0.045	0.060	0.063	0.047	0.080	0.060
2	0.145	0.119	0.139	0.135	0.139	0.139	0.140	0.110
3	0.184	0.168	0.185	0.195	0.184	0.189	0.190	0.150
4	0.250	0.211	0.227	0.224	0.217	0.215	0.210	0.190
5	0.250	0.248	0.260	0.278	0.240	0.263	0.260	0.230
6	0.274	0.286	0.292	0.349	0.315	0.314	0.280	0.280
7	0.392	0.453	0.401	0.403	0.370	0.471	0.370	0.380
8	0.514	0.422	0.497	0.511	0.401	0.511	0.410	0.320
9	0.644	0.518	0.688	0.820	0.545	0.568	0.690	0.960

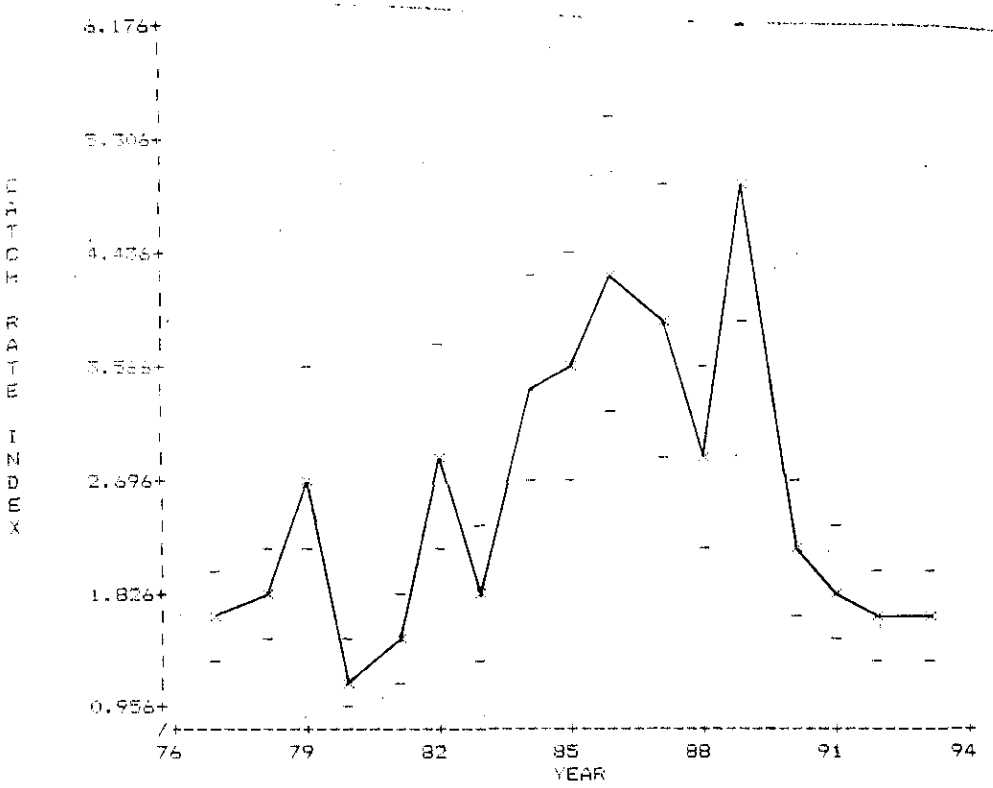
Table 6: CPUE standardization results for the 4VWX silver hake population. Includes years 1977-1993.

Key
Type 1: Country
Type 2: Area
Type 3: Month
Type 4: Year

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
77	0.3739	0.0239	1.584	0.244	37095	23412
78	0.4730	0.0168	1.756	0.227	48404	27566
79	0.9237	0.0233	2.747	0.418	51760	18844
80	0.0870	0.0181	1.193	0.160	44525	37329
81	0.3019	0.0238	1.475	0.227	44600	30247
82	0.9641	0.0261	2.856	0.460	60251	21098
83	0.4890	0.0248	1.777	0.279	35839	20169
84	1.1251	0.0226	3.360	0.504	74266	22100
85	1.1727	0.0228	3.524	0.530	75480	21417
86	1.3495	0.0246	4.202	0.657	82688	19679
87	1.2636	0.0263	3.853	0.622	61705	16016
88	0.9560	0.0229	2.837	0.428	74374	26213
89	1.5056	0.0189	4.926	0.676	87989	17863
90	0.6630	0.0170	2.123	0.276	70289	33109
91	0.5303	0.0176	1.859	0.246	67899	36533
92	0.3765	0.0192	1.592	0.220	31795	19967
93	0.3651	0.0171	1.576	0.206	29230	18547

6. Cont'd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5.306+
4.436+
3.566+
2.696+
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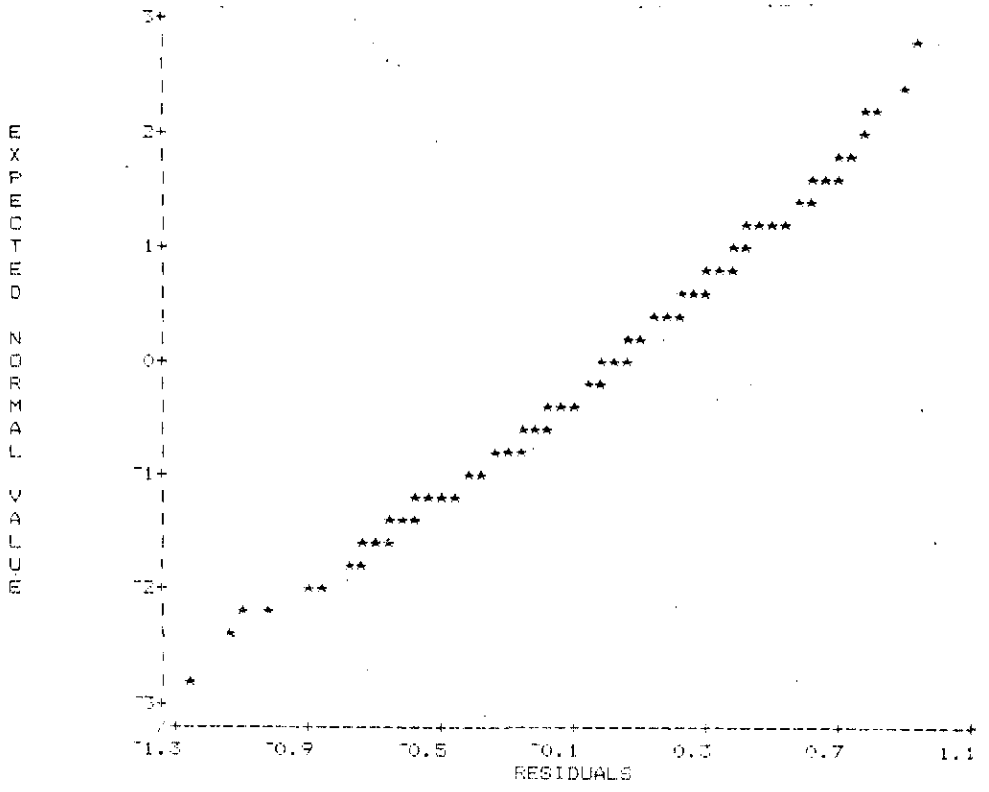
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2+
1+
0+
-1+
-2+
-3+
-1.3
-0.9
-0.5
-0.1
0.3
0.7
1.1
RESIDUALS
EXPECTED NORMAL VALUE

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.759
MULTIPLE R SQUARED..... 0.576

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	7.216E1	7.216E1	
REGRESSION	27	5.099E1	1.888E0	9.647
TYPE 1	1	3.524E0	3.524E0	18.004
TYPE 2	2	1.466E0	7.330E-1	3.744
TYPE 3	8	8.326E0	1.041E0	5.316
TYPE 4	16	3.601E1	2.251E0	11.498
RESIDUALS	192	3.759E1	1.958E-1	
TOTAL	220	1.607E2		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	20	INTERCEPT	0.374	0.155	220
2	460				
3	5				
4	77				
1	4	1	-0.259	0.061	101
2	450	2	0.552	0.207	6
	470	3	0.067	0.073	58
3	3	4	0.535	0.177	8
	4	5	0.277	0.108	28
	6	6	-0.141	0.088	58
	7	7	-0.162	0.093	46
	8	8	-0.301	0.114	24
	9	9	-0.455	0.190	7
	10	10	-0.067	0.347	2
	11	11	0.424	0.469	1
4	78	12	0.099	0.173	21
	79	13	0.550	0.190	14
	80	14	-0.287	0.177	15
	81	15	-0.072	0.195	10
	82	16	0.590	0.200	9
	83	17	0.115	0.196	10
	84	18	0.751	0.191	11
	85	19	0.799	0.192	11
	86	20	0.976	0.194	10
	87	21	0.890	0.201	9
	88	22	0.582	0.192	11
	89	23	1.132	0.181	15
	90	24	0.289	0.176	16
	91	25	0.156	0.178	16
	92	26	0.003	0.181	14
	93	27	-0.009	0.174	17

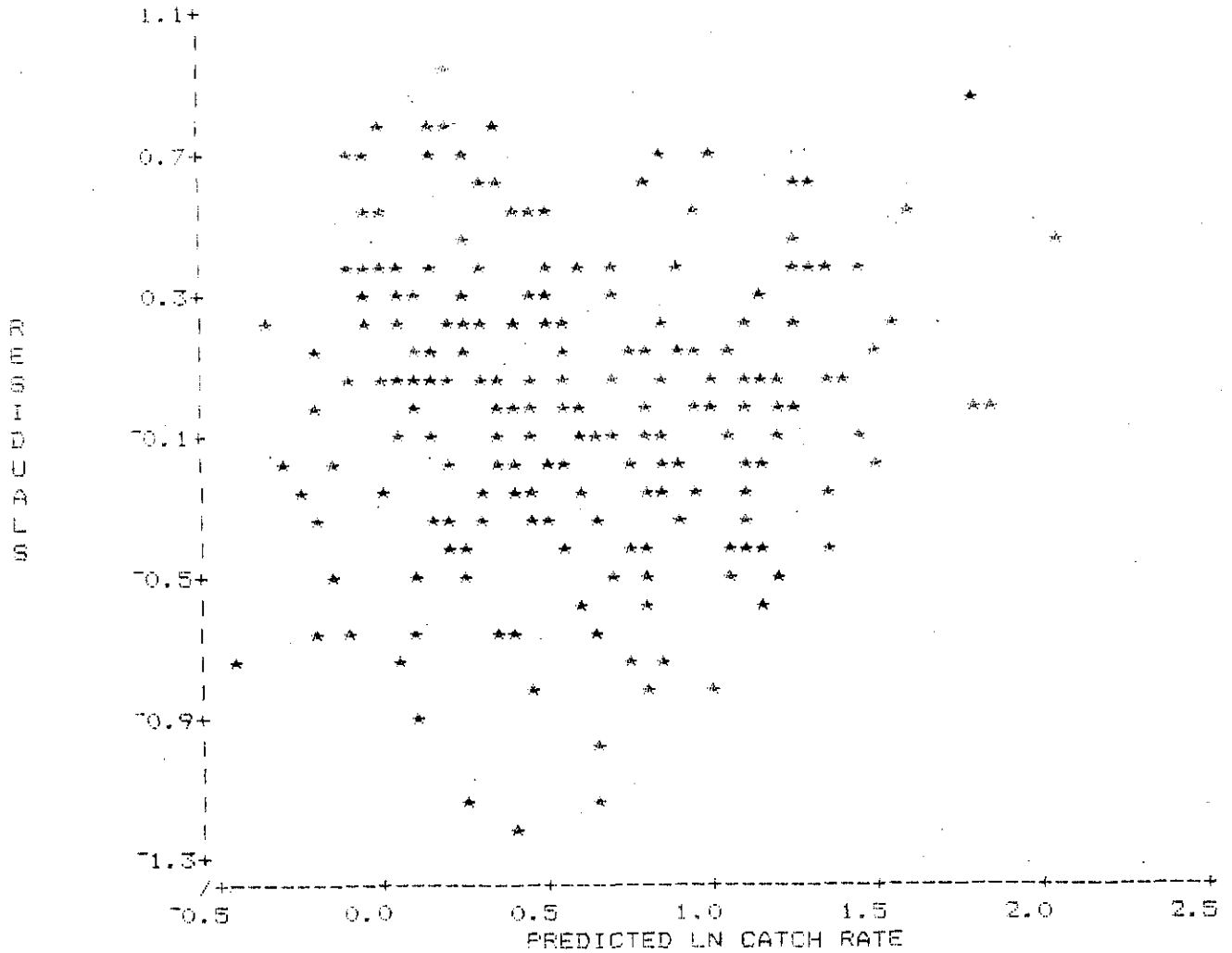

1.1+
0.7+
0.3+
-0.1+
-0.5+
-0.9+
-1.3+
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
PREDICTED LN CATCH RATE

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
1	7737	26740	89437	17730	32839	192025	114273	188970	102726
2	27660	23257	152705	55638	84724	293420	108957	70369	172576
3	21421	16266	67003	97253	131420	80348	38209	208723	34402
4	4592	8874	20048	45862	60469	60487	19340	37926	71191
5	1348	6733	11522	10684	16241	32426	10632	11828	21488
6	1278	3046	5055	4525	5127	8257	2882	7942	9445
7	984	1286	2664	2001	2367	3549	876	2860	2667
8	336	502	969	589	794	2535	401	1136	1175
9	283	865	275	385	564	327	337	522	215
1+	65639	87569	349678	234667	334545	673374	295907	530276	415885

Age	1986	1987	1988	1989	1990	1991	1992	1993
1	552598	146007	69740	172095	117089	66678	45284	166402
2	84325	266663	89508	63810	125952	84743	56347	91306
3	70625	46095	81458	24151	42329	35293	46180	74838
4	22623	18982	16709	13405	13022	13257	11097	25736
5	13448	6048	14249	4130	4173	6577	4477	3296
6	4235	4168	2502	1868	1169	2456	2237	805
7	1622	1199	2338	769	432	402	424	524
8	673	672	468	282	227	143	139	98
9	376	471	121	129	82	124	192	38
1+	750525	490305	277093	280639	304475	209904	168890	363061

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	1992	1993
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	-	186.5
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	-	17.2
CV	.11	.14	0.11	0.16	0.22	0.19	0.23	0.17	0.14	0.13	0.13	-	0.09
Number of Sets	77	61	64	71	82	74	105	79	74	68	71	-	96
July R/V Age 1 #'s (10^{-6})	192	114	189	103	553	146	70	172	117	67	45	166	-
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	33.3	-

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 A2:  SILVER HAKE RV+CPUE(new)+JUV INDEX (1993 DATA)
4VWX Silver Hake                              DATED: 1994 6 7 TIME: 9 45
RSS Trajectory by Iteration 4VWX Silver Hake          1994 6 7 9 45 25 780
          1550+
              ■
              ■°
              ■
              ■
     R   1200+
     E        ■   °
     S        ■
     I        ■
     D        ■      °
     U    850+
     A        ■          °
     L        ■            °
              ■
     S        ■               ° °
     S    500+                     °
              ■                      °
              ■                        °
              ■                          °
              ■
          150+                              ° °  ° °  °
             /+---------+---------+---------+---------+
              1         5         9        13        17

                              ITERATION NUMBER
 CALIBRATION COEFFICIENTS BY AGE FOR 4VWX Silver Hake        1994 6 7 9 45 25 780
AGE  1 :  I =     0.00001 * POP
AGE  2 :  I =     0.00002 * POP
AGE  3 :  I =     0.00003 * POP
AGE  4 :  I =     0.00004 * POP
AGE  5 :  I =     0.00005 * POP
AGE  6 :  I =     0.00005 * POP
AGE  7 :  I =     0.00005 * POP
AGE  8 :  I =     0.00003 * POP

 MEAN SQUARE RESIDUALS : 0.6442962179
        MEAN RESIDUAL : 4.591290533E-8
  SUM OF ALL RESIDUALS : 0.00001299335221
```

RUN A2: SILVER HAKE RV+CPUE(new)+JUV INDEX (1993 DATA)
4VWX Silver Hake DATED: 1994 6 7 TIME: 9 45

LOG RESIDUALS FOR RV INDEX

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	²1.915	²0.814	0.180	²1.121	²0.797	0.407	0.512	0.544	0.515	1.299	0.781	0.085	0.603	0.433	²0.141	²0.358	²0.210
2	²0.818	²0.959	0.744	²0.484	0.208	1.171	²0.373	²0.198	0.302	0.147	0.433	0.094	²0.161	0.250	²0.024	²0.503	0.172
3	²0.875	²0.851	0.573	0.661	0.810	0.514	²0.606	0.722	²0.524	0.089	0.122	²0.153	²0.505	0.179	²0.014	²0.242	0.099
4	²1.501	²1.229	0.155	0.903	0.773	0.921	²0.357	0.089	0.640	0.132	²0.292	0.013	²0.447	0.027	0.538	²0.024	²0.340
5	²2.357	²0.634	²0.339	0.428	0.537	1.154	²0.074	²0.260	0.632	0.058	²0.068	0.318	0.123	²0.207	0.651	0.598	²0.560
6	²1.567	²1.120	0.043	²0.625	0.598	0.726	²0.292	0.238	0.365	0.685	²0.158	²0.044	²0.071	0.436	0.656	0.610	²0.481
7	²2.090	²0.843	²0.403	0.289	²0.541	1.734	²0.550	0.579	0.057	²0.433	0.818	0.381	0.082	0.206	0.671	0.117	²0.076
8	²2.289	²1.879	²0.106	²0.888	0.462	0.455	1.281	0.688	0.698	²0.224	²0.358	1.034	²0.065	0.163	0.638	0.773	²0.384

SUM OF RV RESIDUALS : 0.000004736773204 MEAN RESIDUAL : 3.482921474E²8

LOG RESIDUALS FROM EFFORT INDEX

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.718	0.572	0.722	0.140	²1.888	0.055	²0.514	1.238	0.473	0.772	²0.108	²0.844	0.710	²1.005	²1.241	²0.010	0.211
2	0.248	0.087	0.105	²0.597	²1.132	²0.316	²0.222	²0.447	0.221	0.247	0.694	²0.259	0.509	0.485	²0.048	0.077	0.348
3	²0.516	²0.126	0.175	²0.807	²0.330	²0.125	²0.724	0.067	²0.075	0.678	0.677	0.181	0.872	0.270	0.451	²0.298	²0.370
4	²1.012	²0.741	0.205	²0.674	²0.691	0.344	²0.510	0.146	0.490	0.756	0.366	²0.029	1.250	0.011	0.420	0.242	²0.574
5	²2.226	²0.589	0.090	²0.230	²0.471	0.686	²0.282	²0.154	0.638	0.483	0.591	0.114	1.313	²0.026	0.247	0.048	²0.232
6	²2.173	²0.820	0.750	²1.037	²0.243	0.353	²0.082	²0.412	0.297	1.278	0.462	²0.067	1.476	0.235	0.432	²0.044	²0.405
7	²3.897	²0.147	0.442	²0.070	²0.984	1.587	0.006	0.089	0.462	0.090	0.422	0.593	1.426	0.638	0.311	²0.073	²0.895
8	²2.857	²0.472	0.161	²0.893	²0.086	²0.409	1.606	²0.353	²0.137	0.361	²0.701	0.796	2.195	²0.221	1.060	0.201	²0.251

SUM OF RV RESIDUALS : 0.000008195902503 MEAN RESIDUAL : 6.026398898E²8

RESIDUALS FROM JUVENILE INDEX

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	1.107	²2.451	0.324	²0.756	0.224	0.685	0.066	0.368	0.150	0.493	²0.209

SUM OF CPUE RESIDUALS : 6.067650382E²8 MEAN RESIDUAL : 3.569206125E²9

RUN A2: SILVER HAKE RV+CPUE(new)+JUV INDEX (1993 DATA)
4VWX Silver Hake DATED: 1994 6 7 TIME: 9 45

ESTIMATED PARAMETERS AND STANDARD ERRORS

Analytical Summary

ORTHOGONALITY OFFSET..... 0.001611
MEAN SQUARE RESIDUALS 0.644296

AGE	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	BIAS °/°
1	2551233.432389	1481754.571453	1.722	0.58	17.21
2	534541.141250	190133.905607	2.811	0.36	6.86
3	363361.350569	104787.875654	3.468	0.29	3.98
4	157027.848055	49348.171020	3.182	0.31	4.50
5	20528.341966	7875.621794	2.607	0.38	8.39
6	3631.457130	1458.268918	2.490	0.40	8.67
7	1578.731440	662.985229	2.381	0.42	8.46
8	610.722025	242.080825	2.523	0.40	7.69
1	0.000010	0.000002	5.001	0.20	1.81
2	0.000021	0.000004	5.068	0.20	1.84
3	0.000028	0.000006	5.087	0.20	1.83
4	0.000035	0.000007	5.071	0.20	1.78
5	0.000046	0.000009	5.035	0.20	1.81
6	0.000054	0.000011	5.028	0.20	1.84
7	0.000048	0.000010	5.037	0.20	1.79
8	0.000032	0.000006	5.059	0.20	1.73
1	0.000001	0.000000	5.001	0.20	1.80
2	0.000007	0.000001	5.073	0.20	1.81
3	0.000021	0.000004	5.092	0.20	1.82
4	0.000027	0.000005	5.082	0.20	1.76
5	0.000026	0.000005	5.050	0.20	1.76
6	0.000022	0.000004	5.043	0.20	1.79
7	0.000011	0.000002	5.044	0.20	1.77
8	0.000006	0.000001	5.064	0.20	1.72
1	0.000121	0.000030	4.067	0.25	2.74

Parameter Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1.000	0.040	0.028	0.019	0.004	0.003	0.002	0.002	-0.180	-0.008	-0.005	-0.003	-0.001	-0.002	-0.003	-0.004	-0.179	-0.008
2	0.040	1.000	0.048	0.034	0.008	0.005	0.004	0.004	-0.117	-0.126	-0.008	-0.005	-0.003	-0.003	-0.005	-0.007	-0.117	-0.122
3	0.028	0.048	1.000	-0.040	0.006	0.015	0.022	0.029	-0.081	-0.085	-0.101	0.001	-0.011	-0.028	-0.050	-0.063	-0.081	-0.083
4	0.019	0.034	-0.040	1.000	0.008	0.019	0.025	0.035	-0.056	-0.063	-0.081	-0.117	-0.010	-0.028	-0.053	-0.083	-0.056	-0.061
5	0.004	0.008	0.006	0.008	1.000	0.037	0.029	0.026	-0.013	-0.016	-0.041	-0.096	-0.158	-0.022	-0.033	-0.045	-0.013	-0.015
6	0.003	0.005	0.015	0.019	0.037	1.000	0.046	0.030	-0.008	-0.009	-0.015	-0.052	-0.109	-0.154	-0.019	-0.020	-0.008	-0.008
7	0.002	0.004	0.022	0.025	0.029	0.046	1.000	0.050	-0.007	-0.008	-0.012	-0.024	-0.066	-0.119	-0.144	-0.018	-0.007	-0.007
8	0.002	0.004	0.029	0.035	0.026	0.030	0.050	1.000	-0.006	-0.007	-0.009	-0.016	-0.029	-0.078	-0.121	-0.135	-0.006	-0.006
9	-0.180	-0.117	-0.081	-0.056	-0.013	-0.008	-0.007	-0.006	1.000	0.024	0.014	0.008	0.004	0.005	0.008	0.011	0.052	0.024
10	-0.008	-0.126	-0.085	-0.063	-0.016	-0.009	-0.008	-0.007	0.024	1.000	0.015	0.009	0.005	0.006	0.009	0.012	0.024	0.026
11	-0.005	-0.008	-0.101	-0.081	-0.041	-0.015	-0.012	-0.009	0.014	0.015	1.000	0.014	0.010	0.009	0.012	0.016	0.014	0.015
12	-0.003	-0.005	0.001	-0.117	-0.096	-0.052	-0.024	-0.016	0.008	0.009	0.014	1.000	0.022	0.015	0.013	0.016	0.008	0.009
13	-0.001	-0.003	-0.011	-0.010	-0.158	-0.109	-0.066	-0.029	0.004	0.005	0.010	0.022	1.000	0.027	0.018	0.013	0.004	0.005
14	-0.002	-0.003	-0.028	-0.028	-0.022	-0.154	-0.119	-0.078	0.005	0.006	0.009	0.015	0.027	1.000	0.029	0.017	0.005	0.006
15	-0.003	-0.005	-0.050	-0.053	-0.033	-0.019	-0.144	-0.121	0.008	0.009	0.012	0.013	0.018	0.029	1.000	0.025	0.008	0.009
16	-0.004	-0.007	-0.063	-0.083	-0.045	-0.020	-0.018	-0.135	0.011	0.012	0.016	0.016	0.013	0.017	0.025	1.000	0.011	0.012
17	-0.179	-0.117	-0.081	-0.056	-0.013	-0.008	-0.007	-0.006	0.052	0.024	0.014	0.008	0.004	0.005	0.008	0.011	1.000	0.024
18	-0.008	-0.122	-0.083	-0.061	-0.015	-0.008	-0.007	-0.006	0.024	0.026	0.015	0.009	0.005	0.006	0.009	0.012	0.024	1.000
19	-0.004	-0.008	-0.097	-0.077	-0.035	-0.013	-0.011	-0.009	0.013	0.014	0.018	0.013	0.009	0.008	0.011	0.015	0.013	0.014
20	-0.003	-0.005	0.002	-0.112	-0.085	-0.043	-0.021	-0.013	0.008	0.009	0.013	0.023	0.019	0.013	0.012	0.015	0.008	0.008
21	-0.001	-0.002	-0.009	-0.009	-0.148	-0.099	-0.056	-0.026	0.004	0.004	0.009	0.020	0.036	0.024	0.016	0.012	0.004	0.004
22	-0.002	-0.003	-0.025	-0.023	-0.019	-0.147	-0.110	-0.065	0.005	0.005	0.008	0.013	0.025	0.039	0.026	0.015	0.005	0.005
23	-0.003	-0.005	-0.046	-0.048	-0.030	-0.018	-0.141	-0.117	0.008	0.008	0.011	0.012	0.017	0.028	0.037	0.024	0.008	0.008
24	-0.004	-0.006	-0.062	-0.077	-0.043	-0.019	-0.017	-0.132	0.010	0.011	0.015	0.015	0.013	0.017	0.025	0.029	0.010	0.011
25	-0.009	-0.137	-0.095	-0.066	-0.015	-0.009	-0.008	-0.007	0.027	0.029	0.016	0.010	0.005	0.006	0.010	0.013	0.027	0.028

	19	20	21	22	23	24	25
1	-0.004	-0.003	-0.001	-0.002	-0.003	-0.004	-0.009
2	-0.008	-0.005	-0.002	-0.003	-0.005	-0.006	-0.137
3	-0.097	0.002	-0.009	-0.025	-0.046	-0.062	-0.095
4	-0.077	-0.112	-0.009	-0.023	-0.048	-0.077	-0.066
5	-0.035	-0.085	-0.148	-0.019	-0.030	-0.043	-0.015
6	-0.013	-0.043	-0.099	-0.147	-0.018	-0.019	-0.009
7	-0.011	-0.021	-0.056	-0.110	-0.141	-0.017	-0.008
8	-0.009	-0.013	-0.026	-0.065	-0.117	-0.132	-0.007
9	0.013	0.008	0.004	0.005	0.008	0.010	0.027
10	0.014	0.009	0.004	0.005	0.008	0.011	0.029
11	0.018	0.013	0.009	0.008	0.011	0.015	0.016
12	0.013	0.023	0.020	0.013	0.012	0.015	0.010
13	0.009	0.019	0.036	0.025	0.017	0.013	0.005
14	0.008	0.013	0.024	0.039	0.028	0.017	0.006
15	0.011	0.012	0.016	0.026	0.037	0.025	0.010
16	0.015	0.015	0.012	0.015	0.024	0.029	0.013
17	0.013	0.008	0.004	0.005	0.008	0.010	0.027
18	0.014	0.008	0.004	0.005	0.008	0.011	0.028
19	1.000	0.012	0.008	0.007	0.010	0.014	0.015
20	0.012	1.000	0.018	0.011	0.011	0.014	0.009
21	0.008	0.018	1.000	0.023	0.015	0.012	0.004
22	0.007	0.011	0.023	1.000	0.025	0.015	0.006
23	0.010	0.011	0.015	0.025	1.000	0.023	0.009
24	0.014	0.014	0.012	0.015	0.023	1.000	0.012
25	0.015	0.009	0.004	0.006	0.009	0.012	1.000

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

RUN A2: SILVER HAKE RV+CPUE(new)+JUV INDEX (1993 DATA)
4VWX Silver Hake DATED: 1994 6 7 TIME: 9 45

POPULATION NUMBERS ('000S)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	654511	752545	927985	676619	891910	1576848	841174	1383224	761001	1874824	822079	786598	1167877	932726
2	438192	424067	487302	605206	439970	595934	1040463	559067	878416	497858	1219400	545485	523089	762986
3	276001	234347	226702	279249	347800	274277	356093	618148	337233	481718	276193	641987	314241	280353
4	85408	135998	91428	92285	129555	143868	121732	192718	244961	145535	135313	91461	213122	80673
5	40914	44913	62486	31264	35635	56081	40436	57625	61301	59106	28703	46319	29180	24058
6	14736	25610	19701	23562	9115	14121	11596	17781	22790	13164	16175	8544	13607	3165
7	20959	9284	12887	5043	11550	3462	4599	4993	8425	7640	1652	5894	3184	1450
8	13282	13970	4663	6045	2209	6759	649	2412	2497	3728	3946	823	2204	850
9	190	8829	8408	2720	3682	1243	4150	228	1467	1489	2092	2517	381	523
1+	1544193	1649563	1841562	1721995	1871427	2672594	2420892	2836195	2318090	3085062	2505552	2129629	2266886	2086783
2+	889683	897018	913577	1045375	979517	1095746	1579717	1452972	1557089	1210238	1683473	1343031	1099009	1154057
3+	451491	472951	426275	440169	539547	499812	539254	893904	678674	712380	464073	797546	575919	391071
4+	175490	238604	199573	160920	191746	225535	183161	275757	341440	230662	187880	155558	261678	110718

	1991	1992	1993
1	942673	798136	2532950
2	619890	627194	527578
3	339822	319484	357655
4	70960	63026	154474
5	20333	9566	20125
6	6514	3678	3573
7	772	1129	1564
8	448	280	605
9	482	152	161
1+	2001894	1822646	3598684
2+	1059222	1024509	1065734
3+	439331	397315	538156
4+	99509	77831	180502

Table 10b: Silver hake population biomass (tons).

POPULATION BIOMASS (tons)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	42543	55914	70527	26862	54050	103599	56527	96964	51824	99928	36665	35554	70306	59042	44306	63851
2	80189	64797	86837	91507	73695	100713	133491	81624	119640	72339	145109	75932	70826	106208	86165	87807
3	72726	53572	51416	62217	74812	63303	69652	111823	59758	88781	46400	118575	61120	51529	64226	60702
4	29013	36176	25024	26449	35783	39564	29106	43246	51491	36398	28497	20725	47739	17546	15256	13235
5	18252	15050	19015	10661	11603	17795	11674	15697	14933	14782	7127	12061	8115	5769	5347	2487
6	9312	10369	7662	9206	3656	5558	4230	6271	6725	3604	4626	2497	4751	996	2045	1030
7	18578	4066	5864	2680	6386	1543	1814	2023	3453	2994	748	2360	1283	536	364	418
8	12249	7541	3908	5074	2038	3466	297	1504	1452	1917	1665	409	1126	341	229	115
9	403	7875	7044	2337	4187	629	1842	148	982	959	1084	1732	312	285	274	105
1+	283265	255360	277296	236993	266210	336170	308633	359299	310258	321703	271920	269845	265579	242251	218213	229750
2+	240721	199445	206770	210131	212160	232571	252107	262335	258434	221775	235256	234291	195273	183209	173907	165899
3+	160532	134648	119932	118624	138465	131858	118615	180712	138794	149436	90147	158359	124447	77002	87742	78092
4+	87806	81076	68516	56407	63653	68555	48963	68889	79036	60655	43747	39784	63327	25473	23516	17390

	1993
1	151977
2	58034
3	53648
4	29350
5	4629
6	1000
7	594
8	194
9	155
1+	299580
2+	147603
3+	89570
4+	35922

Table 10c: Silver hake fishing mortality.

RUN A2: SILVER HAKE RV+CPUE(new)+JUV INDEX (1993 DATA)
4VWX Silver Hake DATED: 1994 6 7 TIME: 9 45

FISHING MORTALITY

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.034	0.035	0.027	0.030	0.003	0.016	0.009	0.054	0.024	0.030	0.010	0.008	0.026	0.009	0.007	0.014	0.016
2	0.226	0.226	0.157	0.154	0.073	0.115	0.121	0.105	0.201	0.189	0.242	0.152	0.224	0.409	0.263	0.162	0.195
3	0.308	0.541	0.499	0.368	0.483	0.412	0.214	0.526	0.440	0.870	0.705	0.703	0.960	0.974	1.285	0.327	0.277
4	0.243	0.378	0.673	0.552	0.437	0.869	0.348	0.745	1.022	1.223	0.672	0.742	1.781	0.978	1.604	0.742	0.294
5	0.069	0.424	0.575	0.833	0.526	1.176	0.422	0.528	1.138	0.896	0.812	0.825	1.821	0.907	1.310	0.585	0.399
6	0.062	0.287	0.963	0.313	0.568	0.722	0.443	0.347	0.693	1.676	0.610	0.587	1.839	1.011	1.353	0.456	0.287
7	0.006	0.289	0.357	0.425	0.136	1.275	0.245	0.293	0.415	0.261	0.296	0.583	0.921	0.774	0.614	0.224	0.090
8	0.008	0.108	0.139	0.096	0.175	0.088	0.647	0.097	0.117	0.178	0.050	0.370	1.039	0.167	0.680	0.153	0.089
9	0.027	0.047	0.055	0.045	0.047	0.064	0.026	0.057	0.073	0.095	0.070	0.071	0.132	0.097	0.134	0.040	0.029

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

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

CPUE data from file f:\assess94\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 9 iterations

Total of the absolute F residuals for all ages in the
last year, between iterations 8 and 9 = .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, 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,	1993
1,	.031,	.034,	.026,	.029,	.003,	.016,	.009,	.055,	.025,	.031,	.010,	.008,	.027,	.010,	.008,	.010,	.015
2,	.222,	.204,	.153,	.141,	.068,	.117,	.122,	.106,	.204,	.192,	.247,	.155,	.230,	.423,	.316,	.175,	.141
3,	.295,	.522,	.426,	.355,	.425,	.376,	.217,	.524,	.438,	.866,	.705,	.713,	.956,	.988,	1.323,	.420,	.310
4,	.226,	.356,	.627,	.428,	.413,	.677,	.306,	.746,	.989,	1.154,	.672,	.741,	1.735,	.968,	1.620,	.822,	.431
5,	.045,	.382,	.520,	.717,	.353,	1.004,	.279,	.433,	1.117,	.832,	.714,	.818,	1.673,	.864,	1.244,	.626,	.500
6,	.035,	.175,	.772,	.271,	.435,	.377,	.331,	.199,	.492,	1.509,	.533,	.466,	1.663,	.788,	1.152,	.420,	.330
7,	.004,	.152,	.189,	.292,	.114,	.711,	.100,	.198,	.199,	.160,	.244,	.464,	.590,	.598,	.384,	.170,	.083
8,	.002,	.068,	.066,	.045,	.109,	.073,	.216,	.036,	.074,	.073,	.029,	.284,	.651,	.087,	.426,	.084,	.066
9,	.001,	.013,	.034,	.020,	.022,	.039,	.022,	.014,	.026,	.058,	.027,	.040,	.097,	.049,	.065,	.022,	.016

Log catchability residuals

Fleet : Std. CPUE @age

Age ,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993
1 ,	.91,	.43,	.27,	.19,	-1.83,	.35,	-.47,	1.26,	.20,	.81,	-.08,	-.73,	.57,	-.79,	-1.08,	-.26,	.23
2 ,	.51,	-.14,	-.30,	-.58,	-1.16,	-.01,	-.18,	-.44,	-.05,	.28,	.73,	-.15,	.36,	.59,	.23,	.20,	.11
3 ,	-.29,	-.29,	-.37,	-.75,	-.42,	.06,	-.69,	.06,	-.38,	.69,	.69,	.28,	.70,	.34,	.57,	-.01,	-.20
4 ,	-.80,	-.91,	-.22,	-.80,	-.69,	.41,	-.59,	.18,	.20,	.74,	.40,	.08,	1.05,	.08,	.54,	.42,	-.11
5 ,	-2.29,	-.71,	-.28,	-.16,	-.72,	.94,	-.55,	-.24,	.45,	.54,	.59,	.31,	1.15,	.10,	.40,	.28,	.17
6 ,	-2.23,	-1.20,	.41,	-.83,	-.21,	.25,	-.08,	-.72,	-.07,	1.43,	.60,	.05,	1.44,	.30,	.62,	.18,	.06
7 ,	-3.66,	-.49,	-.15,	.09,	-.70,	1.73,	-.44,	.12,	-.13,	.03,	.66,	.88,	1.25,	.87,	.37,	.12,	-.55
8 ,	-3.24,	-.44,	-.35,	-.92,	.10,	.31,	1.19,	-.74,	-.27,	.10,	-.63,	1.25,	2.20,	-.20,	1.33,	.25,	.06

Fleet : Cdn July R/V

Age ,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993
1 ,	-1.99,	-.82,	.11,	-1.17,	-.77,	.43,	.53,	.57,	.54,	1.33,	.82,	.13,	.65,	.61,	-.05,	-.65,	-.27
2 ,	-.83,	-1.06,	.74,	-.55,	.17,	1.21,	-.35,	-.17,	.33,	.17,	.46,	.13,	-.12,	.27,	.16,	-.41,	-.15
3 ,	-.87,	-.87,	.43,	.66,	.70,	.45,	-.54,	.73,	-.50,	.05,	.11,	-.15,	-.56,	.14,	-.09,	.05,	.24
4 ,	-1.47,	-1.20,	.14,	.72,	.80,	.70,	-.39,	.13,	.61,	.04,	-.24,	.06,	-.62,	.02,	.44,	.12,	.13
5 ,	-2.57,	-.56,	-.28,	.40,	.30,	1.06,	-.31,	-.29,	.68,	.10,	-.07,	.43,	-.03,	-.14,	.64,	.82,	-.18
6 ,	-1.78,	-1.29,	.06,	-.45,	.62,	.35,	-.27,	.00,	.30,	.68,	-.01,	.02,	-.11,	.41,	.66,	.83,	-.03
7 ,	-2.05,	-1.04,	-.60,	.35,	-.25,	1.45,	-.99,	.64,	-.24,	-.47,	1.07,	.57,	.00,	.34,	.61,	.30,	.30
8 ,	-2.91,	-1.70,	-.21,	-.99,	.63,	.91,	.77,	.33,	.88,	-.48,	-.26,	1.39,	-.01,	.15,	.75,	.80,	-.05

SUMMARY STATISTICS FOR AGE 1

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-4.69	.808	.0091	.0120	-.406E-01	.388E-01	-4.695	.191
2	-2.31	.871	.0989	.0198	.711E-01	.392E-01	-2.314	.205

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.015	.593	.250	.593	.178

SUMMARY STATISTICS FOR AGE 2

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-2.33	.481	.0968	.1270	.400E-01	.216E-01	-2.335	.113
2	-1.64	.573	.1938	.1643	.201E-01	.280E-01	-1.641	.135

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.141	.368	.127	.368	.118

SUMMARY STATISTICS FOR AGE 3

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.24	.493	.2884	.3783	.546E-01	.200E-01	-1.243	.116
2	-1.37	.538	.2535	.2437	.843E-02	.266E-01	-1.372	.127

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.310	.363	.219	.363	.364

SUMMARY STATISTICS FOR AGE 4

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.01	.605	.3660	.4801	.792E-01	.220E-01	-1.005	.143
2	-1.21	.654	.2983	.3799	.316E-01	.314E-01	-1.210	.154

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.431	.444	.117	.444	.069

SUMMARY STATISTICS FOR AGE 5

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.13	.819	.3215	.4214	.995E-01	.316E-01	-1.135	.193
2	-1.04	.828	.3551	.5959	.719E-01	.367E-01	-1.035	.195

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.500	.582	.173	.582	.089

SUMMARY STATISTICS FOR AGE 6

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.43	.923	.2391	.3116	.109E+00	.363E-01	-1.431	.218
2	-1.00	.704	.3696	.3411	.835E-01	.276E-01	-.995	.166

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.330	.560	.436E-01	.560	.006

SUMMARY STATISTICS FOR AGE 7

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-2.28	1.189	.1028	.1426	.107E+00	.523E-01	-2.275	.280
2	-1.24	.882	.2884	.0611	.900E-01	.371E-01	-1.243	.208

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.083	.708	.405	.708	.328

SUMMARY STATISTICS FOR AGE 8

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-3.13	1.220	.0437	.0626	.131E+00	.504E-01	-3.131	.288
2	-1.84	1.106	.1592	.0699	.117E+00	.459E-01	-1.838	.261

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.066	.820	.545E-01	.820	.004

Table 12a: 4VWX silver hake projections.

POPULATION NUMBERS

	1993	1994	1995
1	1200000	1100000	1100000
2	527578	777817	734443
3	357655	291091	491049
4	154474	181735	166904
5	20185	77154	99970
6	3573	9051	42779
7	1584	1796	5068
8	605	958	1067
9	161	371	601
1+	2265735	2439474	2643931
2+	1065735	1339474	1543931
3+	538157	562157	809489
4+	180502	271066	318439

MID-YEAR POPULATION BIOMASS (AVERAGE)

	1993	1994	1995
1	60351	56107	55845
2	52892	82894	73124
3	47292	40856	58653
4	23500	28866	21614
5	3520	14805	15578
6	796	2119	8249
7	493	566	1441
8	206	330	350
9	94	217	346
1+	189145	226760	235201
2+	128793	170653	179356
3+	75901	87759	106232
4+	28610	46903	47579

BEGINNING OF THE YEAR POPULATION BIOMASS (TONS)

	1993	1994	1995
1	74400	68200	68200
2	70168	103383	97681
3	65093	52979	89371
4	22594	38346	35639
5	5112	19597	25392
6	1100	2729	13178
7	684	717	2030
8	281	413	473
9	115	266	431
1+	249493	286688	332393
2+	179093	218488	264193
3+	108900	115105	166512
4+	39806	62127	77141

CATCH BIOMASS

	1993	1994	1995
1	3066	282	738
2	10295	4916	19956
3	13101	5636	29978
4	6914	5706	15150
5	1405	2810	10469
6	289	373	5119
7	44	53	474
8	19	22	33
9	3	3	19
1+	34076	20000	77434
2+	32010	19773	76643
3+	21714	14862	61186
4+	8614	8967	31315

MEAN WEIGHT OF INDIVIDUALS IN CATCH

	1993	1994	1995
	.3	.2	.3

FISHING MORTALITY

	1993	1994	1995
1	.034	.004	.014
2	.135	.059	.310
3	.277	.144	.511
4	.294	.198	.700
5	.399	.190	.673
6	.288	.176	.623
7	.090	.093	.389
8	.090	.067	.238
9	.031	.016	.056
1+	.131	.059	.240

PRODUCTION

SOURCE	1993	1994	1995
RECRUITMENT BIOMASS	50798	46564	46564
GROWTH	91777	105123	107548
TOTAL PRODUCTION	142574	151688	154113
LOSS THROUGH FISHING	34076	20000	77434
SURPLUS PRODUCTION	56316	60984	60032
NET PRODUCTION	32340	40964	17398

PRODUCTION/BIOMASS RATIO 7/ 6/94

	1993	1994	1995
	.75	.67	.66

SUMMARY OF PROJECTIONS

YEAR	1993	1994	1995
POPULATION NUMBERS	2283795.00	2439473.62	3643931.41
POPULATION BIOMASS	168144.62	206759.37	235201.04
CATCH	34076.10	20000.01	77434.40
F OR QUOTA	34076.10	20000.00	.70

Table 12b: 4VWX silver hake projections.

POPULATION NUMBERS

	1993	1994	1995
1	1200000	1100000	1100000
2	316547	777317	732479
3	214593	149946	471721
4	92684	86280	78906
5	12075	35953	41516
6	2144	3709	17530
7	938	843	1851
8	363	539	464
9	97	209	323
1+	1839441	2154796	2444810
2+	639441	1054796	1344810
3+	322894	277480	612331
4+	108301	127533	140610

MID-YEAR POPULATION BIOMASS (AVERAGE)

	1993	1994	1995
1	60351	56037	55845
2	29655	81376	72929
3	25630	20139	56344
4	12640	12912	10097
5	1800	6515	6469
6	429	823	3380
7	287	258	524
8	120	182	154
9	56	122	186
1+	130970	178363	205930
2+	70618	122326	150085
3+	40964	40950	77156
4+	15333	20811	20812

BEGINNING OF THE YEAR POPULATION BIOMASS (TONS)

	1993	1994	1995
1	74400	68200	68200
2	42101	103383	97420
3	39056	27290	85853
4	19556	18205	16649
5	3067	3132	10545
6	660	1142	5399
7	374	538	739
8	156	232	308
9	69	150	232
1+	179441	228071	285245
2+	105041	159871	217045
3+	62940	56488	119625
4+	23884	29198	33772

CATCH BIOMASS

	1993	1994	1995
1	2066	372	782
2	10296	3094	15315
3	15101	4374	28792
4	6914	4281	7068
5	1405	3073	4347
6	289	243	2106
7	44	40	173
8	19	20	37
9	3	3	10
1+	34076	20000	58630
2+	32010	19628	57848
3+	21714	11535	42533
4+	8614	6661	13741

MEAN WEIGHT OF INDIVIDUALS IN CATCH

	1993	1994	1995
	.2	.2	.2

FISHING MORTALITY

	1993	1994	1995
1	.034	.007	.014
2	.347	.099	.210
3	.511	.242	.511
4	.547	.332	.700
5	.780	.318	.672
6	.533	.295	.623
7	.154	.156	.329
8	.154	.113	.238
9	.051	.027	.056
1+	.175	.075	.207

PRODUCTION

SOURCE	1993	1994	1995
RECRUITMENT BIOMASS	50738	46564	46564
GROWTH	72319	95000	101611
TOTAL PRODUCTION	123117	141565	148176
LOSS THROUGH FISHING	34076	20000	58630
SURPLUS PRODUCTION	70729	70213	65804
NET PRODUCTION	36653	50213	7174

PRODUCTION/BIOMASS RATIO

	1993	1994	1995
	.34	.28	.28

SUMMARY OF PROJECTIONS

YEAR	1993	1994	1995
POPULATION NUMBERS	1839441.00	2154736.11	2444610.43
POPULATION BIOMASS	130969.39	173863.16	205939.84
CATCH	34076.10	20000.00	58630.19
F OR QUOTA	34076.10	20000.00	.70

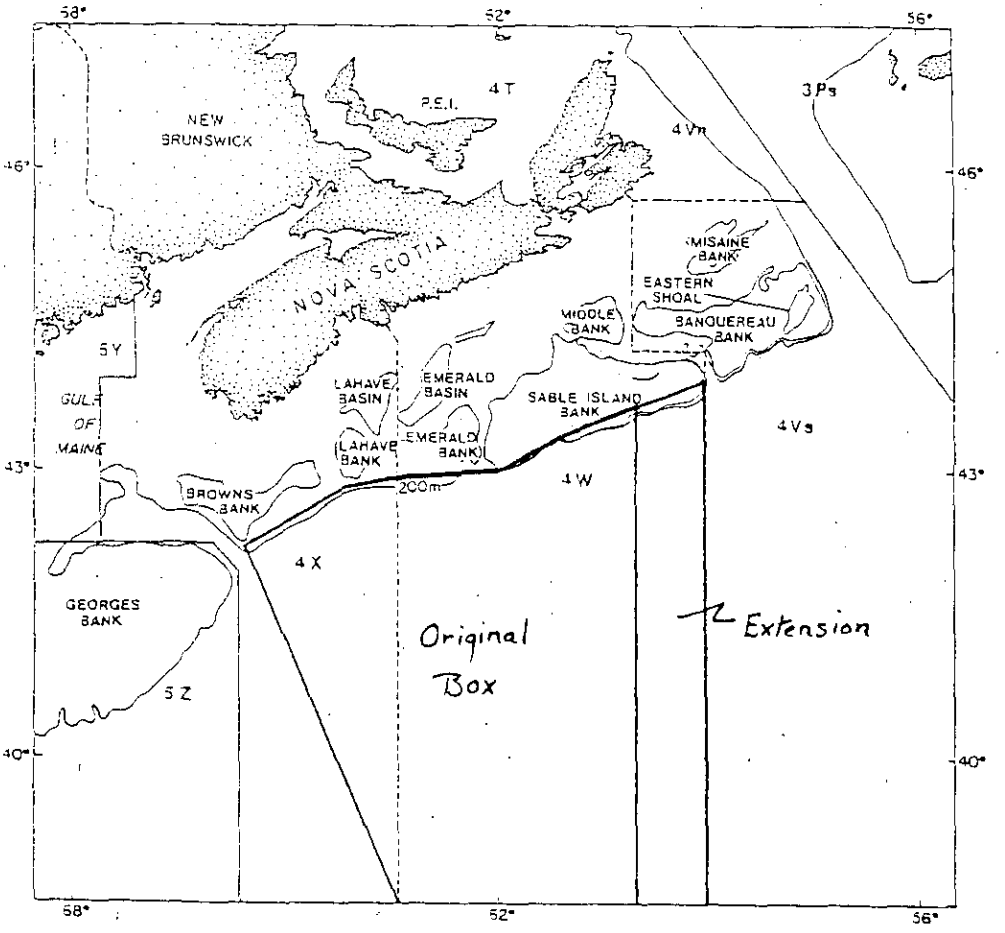


Figure 1: Bathymetric Map of the Scotian Shelf and the Bay of Fundy showing the Small Mesh Gear Line (SMGL)

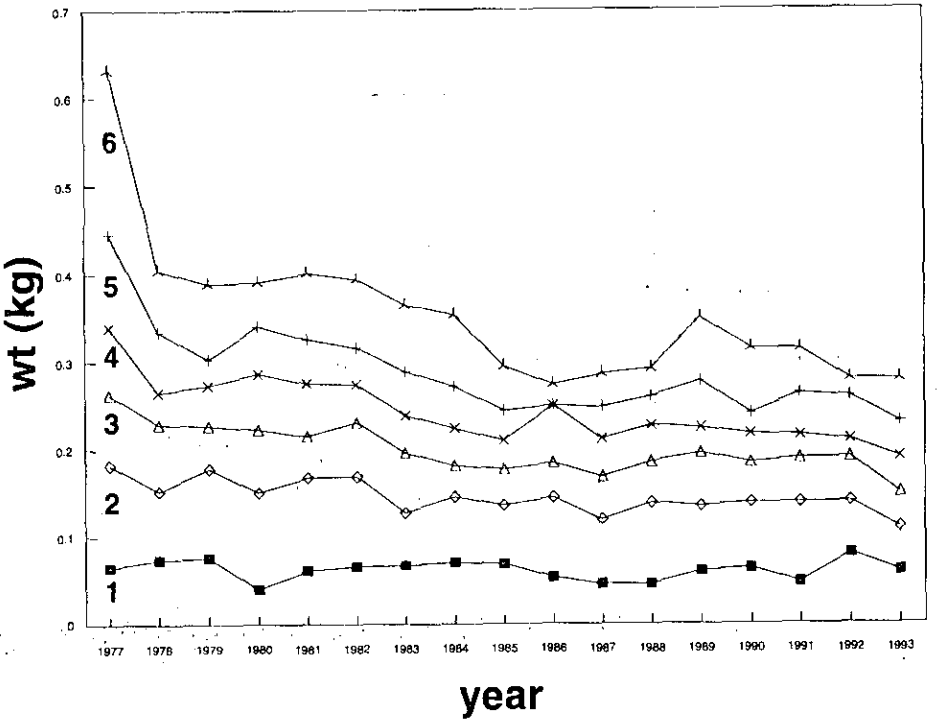


Figure 2: Mean weight at age for 4VWX silver hake, 1977-1993.

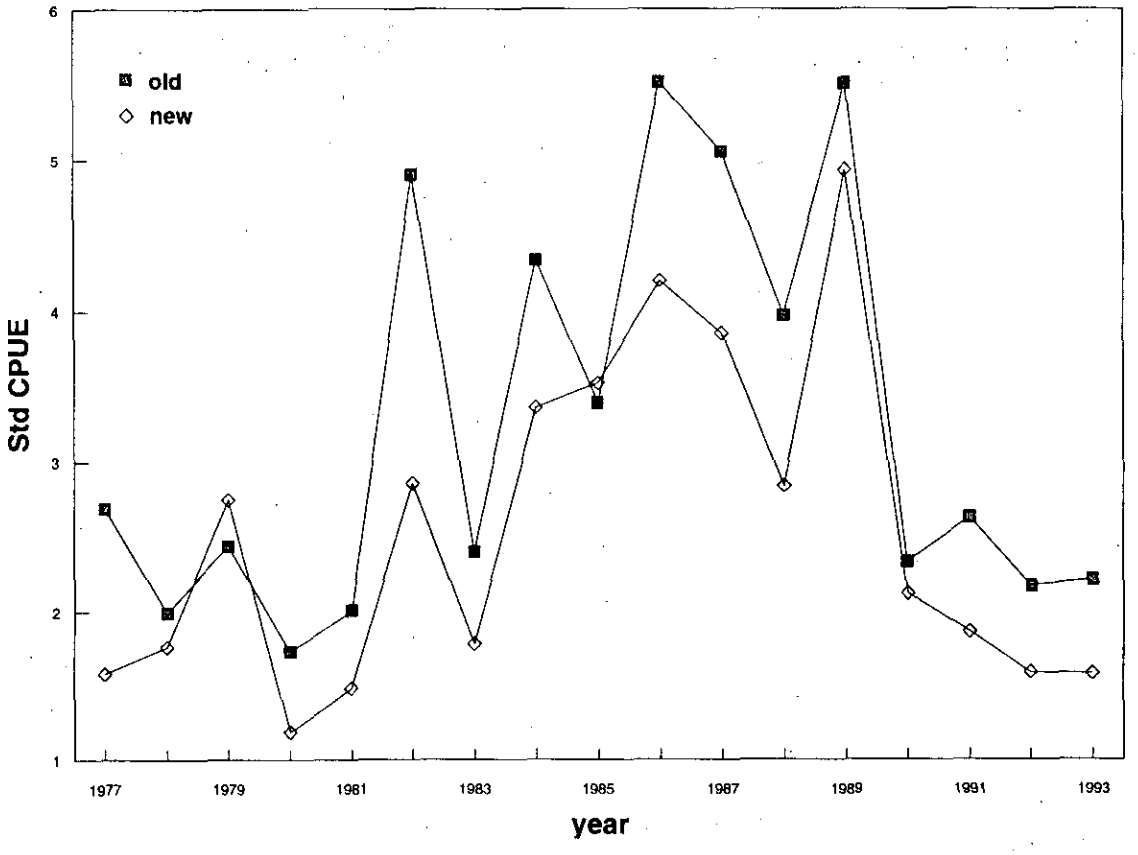


Figure 3: Comparison of standardized catch rates from the previous assessment (Showell et al., 1993) and the simplified model.

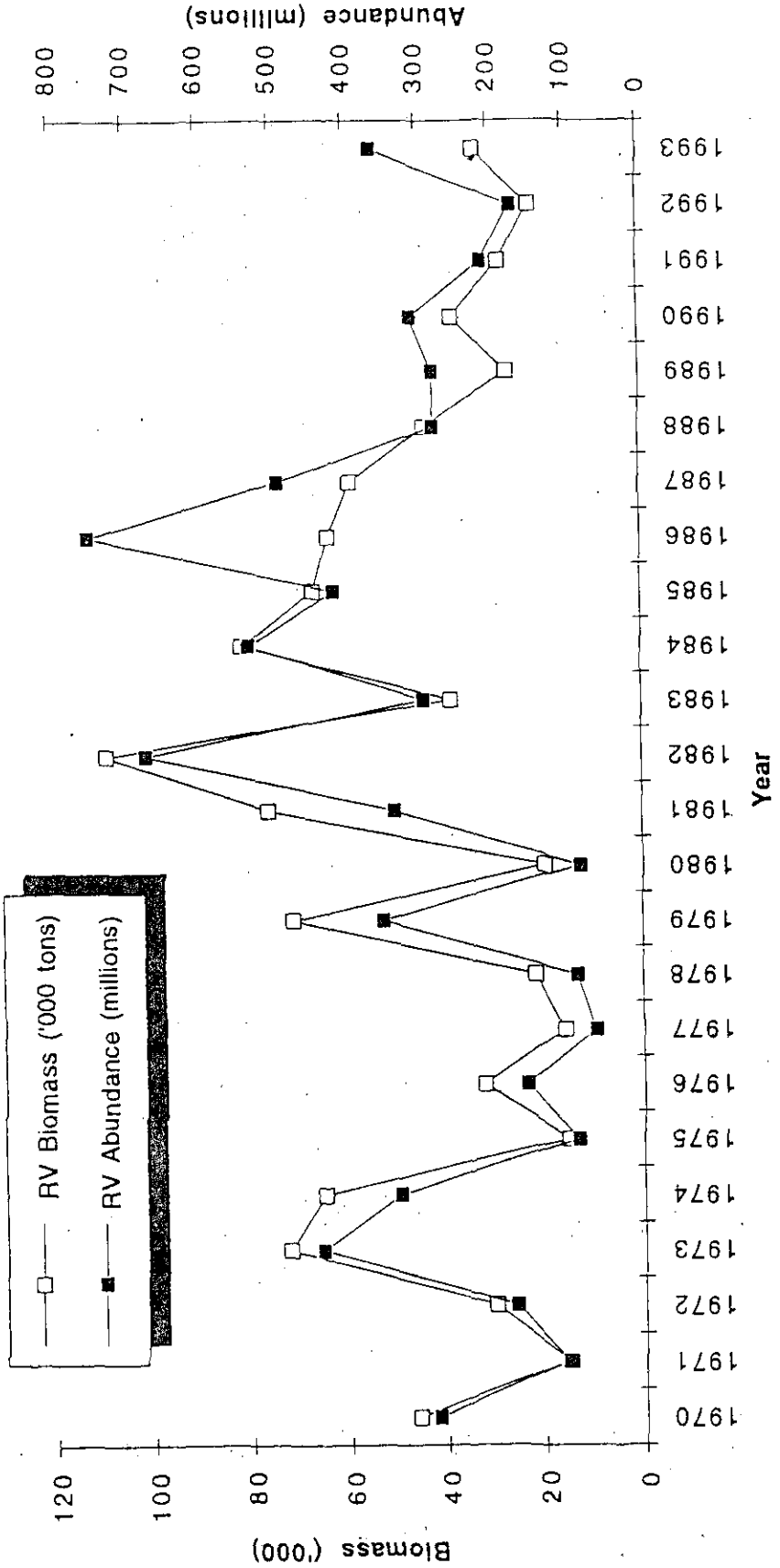


Figure 4: 4VWX silver hake July RV survey estimates of 1+ numbers and biomass

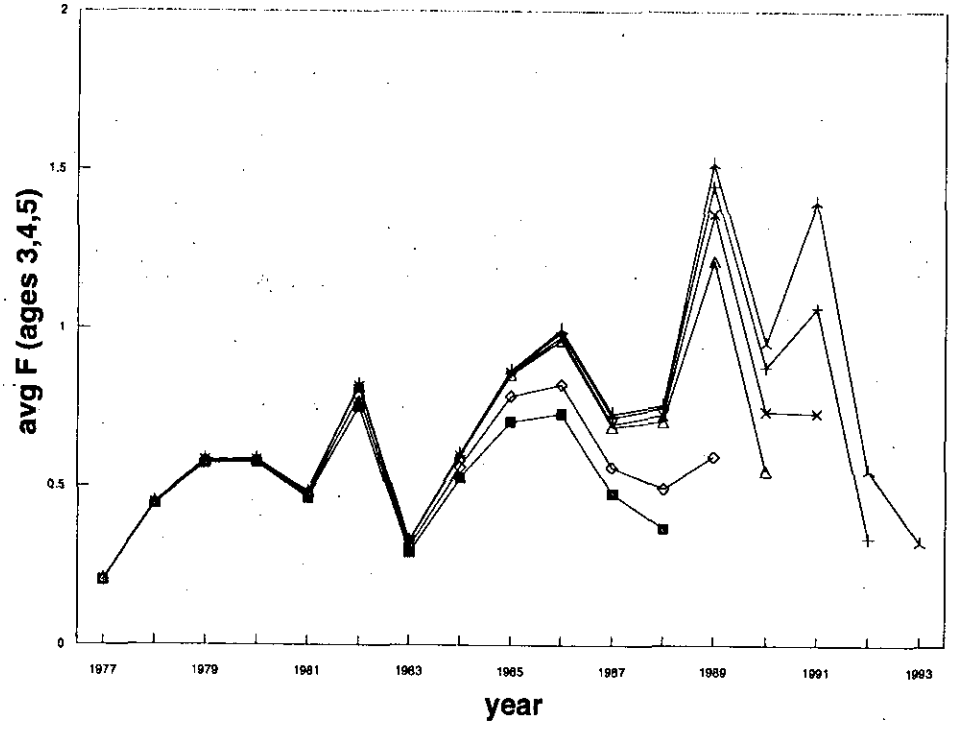


Figure 5: Retrospective analysis of mean fishing mortality from ADAPT for 4VWX silver hake. F's are an unweighted average over ages 3-5.

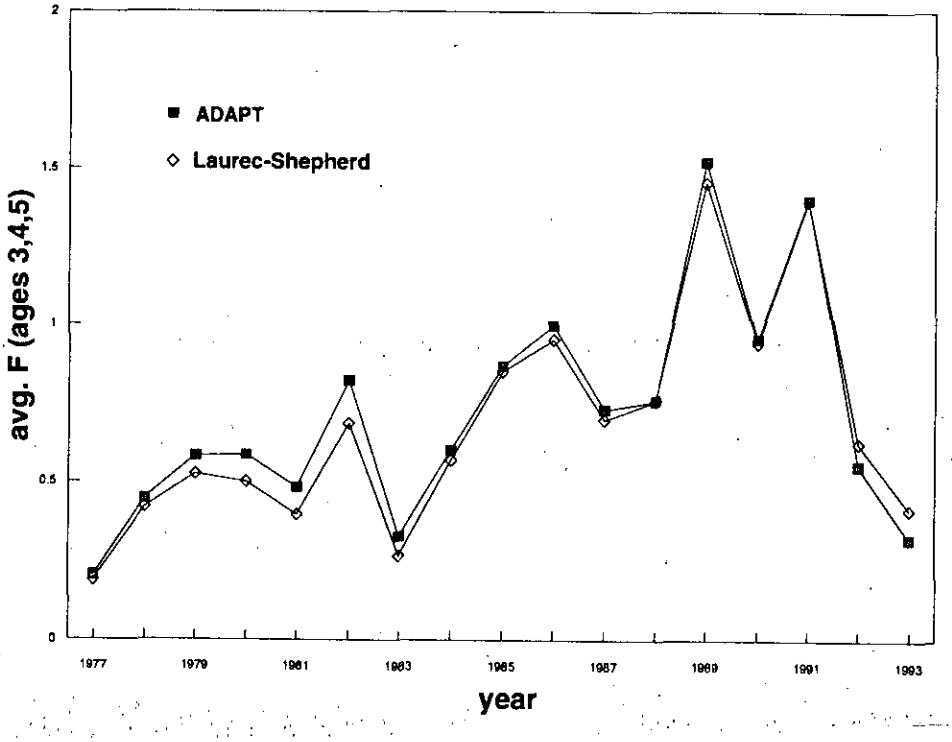
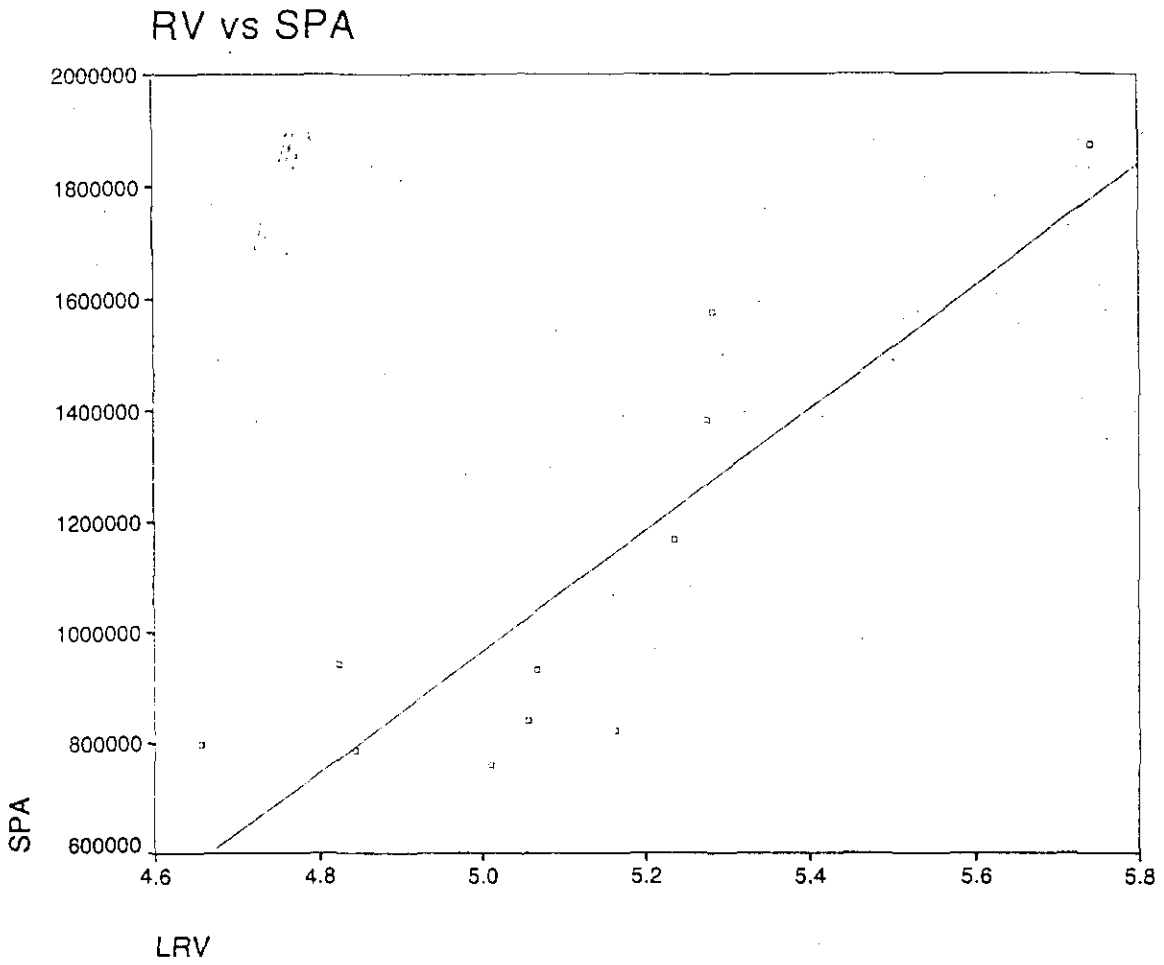


Figure 6: Comparison of fishing mortalities estimated from Laurec-Shepherd and ADAPT, for 4VWX silver hake. F's are an unweighted average over ages 3-5.



* * * * M U L T I P L E R E G R E S S I O N * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. SPA

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000

Variable(s) Entered on Step Number 1.. LRV

Multiple R	.85144	Analysis of Variance			
R Square	.72495		DF	Sum of Squares	Mean Squar
Adjusted R Square	.69439	Regression	1	1021933874081.62600	1021933874081.6
Standard Error	207560.86107	Residual	9	387733599417.28280	43081511046.364
		F = 23.72094		Signif F = .0009	

---------- Variables in the Equation ----------

Variable	B	SE B	Beta	T	Sig T
LRV	1096894.1094	225215.7561	.851438	4.870	.0009
(Constant)	-4519876.147	1151609.361		-3.925	.0035

End Block Number 1 POUT = .100 Limits reached.

Figure 7: Regression of ln RV age 1 survey number against age 1 numbers from SPA; 1982-91.