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Status of Silver Hake Stocks in NAFO Divisions 4VWX in 1991 and TAC for 1993

by

P. S. Gasiukov

Atlantic Scientific Research Institute of Marine Fisheries and Oceanography
5 Dmitry Donskoy Street, Kaliningrad, 236000, Russia

1. Introduction

Some results of silver hake stock and TAC assessment in NAFO Div. 4VWX for 1993 are presented.

The work was conducted due to the possibility of joint use of data collected by the Russian and Canadian scientists in 1991. In its turn this possibitity resulted from bilateral meeting of the scientists from two countries in March 1992.

Aggregate silver hake catch in 1991 was shown to be 68,848 tons. STACFIS advised that the TAC for 1992 was set at 105,000 tons.

2. Data Used for Calculations

General information on silver hake biology and fishery in Div. 4VWX is presented in series of reports (Waldron et al.,1990; Waldron et al,1991).

As in previous years the Gavaris adaptive framework (1988) was used to determine the stock size. Taking into account efforts made to collect input data the model formulation assumes the use of information obtained form different sources. They include fishery and biological statistics, data of the annual Canadian July surveys on abundance and results of juvenile silver hake cooperative studies.

2.1. Age Composition of Catches and Average Weight

Data on age composition of catches and average weight of fish (Tables 1 and 2) for 1977-1991 are used for the ADAPT formulation. Data for 1977-1988 correspond to those presented by Waldron et al.(1991). Data for 1988-1990 were adjusted during the 1991 NAFO session and now include both size and age estimates obtained by the Canadion observers and age data collected and analysed by the Russian scientists.

Age composition of catches and average weight estimates for 1991 were obtained using the methods employed for 1989-1990.

Programme developed by J.Wright (1987-1990) was used to make relevant calculations.

2.2. Standardized Catch-per-Unit-Effort values and Fishing Effort

Standardization of catch-per-unit-effort values is made basing Robson-Gavaris multiplicative model (Gavaris,1980). The input data for 1977-1991 were prepared by D.Waldron using the primary NAFO information and data collected by the Canadian observers. By their structure these data correspond to those used in previons years (Waldron et al.,1991).

Results of standardization are presented in Tables 3,4,5 and Figures 1,2,3. Tendency to the standardized catch-per- unit-effort values decrease in 1990 is clearly traced in 1990.

2.3. Canadian Trawl surveys

Data of the 1991 July trawl survey were analysed by Dr.Waldron. Abundance indices for 1991 and 1977-1990 (Waldron et al.,1991) are given in Table 6. Temporal variation of total abundance and biomass indices in 1977-1991 is shown in Figure 4.

These data confirm the tendency to the biomass decrease observed in the previons years but a slight slowing down of the process can be noted.

2.4.Silver Hake juvenile Survey

The survey was carried out by the R/V Maltsevo in November 1991. The relevant abundance indices supplemented by the observation data for 1981-1990 (Waldron et al.,1991) are presented in Table 7.

The 1991 survey results indicate that the 1990 year-class being a strong one was followed by the relatively weak 1991 year-class.

The abundance indices for age-group 1 are given in the same table basing the July survey results. Discrepancies should be noted in the 1990 year-class abundance estimate derived from the juvenile silver hake survey and 1991 july survey. In the first case it was characterized as a strong one while in the second case it was estimated on the 1987 level.

3. Sequential Population Analysis

Objective function formulation within the ADAPT framework includes CPUE-at-age values, abundance indices from the trawl surveys and data collected in the juvenile hake surveys.

Provisional calculations, however, showed that inclusion of the juvenile survey abundance indices resulted in a sharp solution variation as compared to that where only two first types of information were used.

Thus, the formulation suggested requires a certain weighing of contribution to the component objective function connected with the juvenile survey data. It should be noted that these data are to be taken into account with respect to the above-mentioned discrepancies between abundance indices for age-group 1 derived from the July trawl surveys and from the juvenile surveys.

ADAPT Formulation

Unknown parameters:

- abundance indices for age-groups 2-8 in 1991.

The following model relationships are used:

- abundance index for age-group 1 in 1991 is the mean value for 1977-1990
- fishing mortality for the older age-group is mean-weighted value of fishing mortality coefficients for age-groups 3-8.

Input:

- data for age-groups 1-9
- observation period from 1977 to 1991
- natural mortality = 0.4
- Catch-at-age estimates for 1977-1991
- to calculate CPUE-at-age standardized fishing effort values for 1977-1991 are used
- abundance indices from the 1977-1991 trawl surveys
- abundance indices for age-group 0 from the 1982-1991 juvenile surveys.

Objective function:

$$SS = \lambda_{RV} \cdot SS_{RV} + \lambda_{cpue} \cdot SS_{cpue} + \lambda_{juv} \cdot SS_{juv} \qquad (1)$$

$$SS_{RV} = \sum_{a=1}^{a_k} \sum_{y=1}^{y_k} \left(obs\ ln\ I_{ay}^{RV} - calc\ ln\ I_{ay}^{RV} \right)^2 \qquad (2)$$

$$SS_{cpue} = \sum_{a=1}^{a_k} \sum_{y=1}^{y_k} \left(obs\ ln\ I_{ay}^{cpue} - calc\ ln\ I_{ay}^{cpue} \right)^2 \qquad (3)$$

$$SS_{juv} = \sum_{y=1}^{y_k} \left(obs\ ln\ I_{y}^{juv} - calc\ ln\ I_{y}^{juv} \right)^2 \qquad (4)$$

where

obs = observed value

calc = estimated value

λ_{RV}, λ_{cpue}, λ_{juv} = weight multipliers

I_{ay}^{RV} = trawl survey abundance index

I_{ay}^{cpue} = CPUE-at-age

I_{y}^{juv} = juvenile survey abundance index for age-group 0

a_k - older age-group

y_k - terminal year.

Estimated values for the objective function are obtained setting up regression equations assuming that errors are of multiplicative character:

$$I_{ay}^{RV} = q_{a}^{RV} \cdot N_{ay} \cdot \xi^{RV} \qquad (5)$$

$$I_{ay}^{cpue} = q_{a}^{cpue} \cdot N_{ay} \cdot \xi^{cpue} \qquad (6)$$

$$I_{y}^{juv} = q^{juv} \cdot N_{1,y+1} \cdot \xi^{juv} \qquad (7)$$

where

q_{a}^{RV}, q_{a}^{cpue} и q^{juv} = appropriate proportionality coefficients

ξ^{RV}, ξ^{cpue} и ξ^{juv} = random errors

N_{ay} - VPA abundance estimate for age-group a in year y.

It is assumed that $\lambda_{RV} = \lambda_{cpue}$=I. To select parameter λ_{juv} the following procedure was applied. Basing test calculations it was established that at λ_{juv}=0.I SS_{RV} and SS_{cpue} values practically coincide with those used at λ_{juv}=0. This correspond to the case of calculations when juvenile survey data are not taken into account. Estimates obtained at λ_{juv}=I.0 are completely determined by the juvenile survey data. Thus, multiplier λ_{juv} will be in the range from 0.I to I.0.

The estimates of the component-formula (1) at various values of multiplier λ_{juv} are presented in Table 8 and Figure 5. It can be seen that approximation quality for abundance indices I_{ay}^{RV} и I_{ay}^{cpue} practically does not undergo change up to λ_{juv} = 0.3. At the same time use of juvenile survey data increases number of degrees of freedom for determining unknown parameter. So, as a result λ_{juv}=0.3 may be recommended as an optimum value.

4. Yield-per-Recruit

To determine optimal fishing mortality $F_{0.1}$ values of mean weight and two sets of partial recruitment coefficients were used.

The first set was found to be corresponded to the plateau-shaped pattern of the partial recruitment, the second one to its dome-shaped pattern (Waldron D. et al.,1990; Waldron et al.,1991).

Age (gr)	Mean weight	Pr (I)	Pr (2)
I	0.057	0.022	0.035
2	0.I37	0.249	0.235
3	0.I82	1.000	1.000
4	0.224	1.000	1.000
5	0.259	1.000	1.000
6	0.308	1.000	0.761
7	0.4II	1.000	0.381
8	0.525	1.000	0.141
9	0.665	1.000	0.078

According to the first set of coefficients values of $F_{0.1}$ and yield-per-recruit were found to be 0.55I7 and 0.057I kg, respectively. According to the second set the same values were found to be 0.7209 and 0.0600 kg, respectively.

Calculations were made using Rivard's programmes (1983). The results obtained are presented in Tables 9 and 10.

5. Stock Assessment

Two runs of calculations were made. The first preliminary run allowed to reveal data resulting in residuals exceeding 1,0. These data were excluded from the second run of calculations. Abundance and biomass estimates, fishing mortality coefficients and residuals are given in Tables 12-16. Zero values in the residual tables correspond to the data excluded from the calculations. Totally there were excluded:

- from trawling survey abundance index calculation - 20 values
- from CPUE calculation - 7 values
- from juvenile survey abundance index calculation - 2 values.

Thus, numbers of unknown parameters and observations employed for the model were found to be 7 and 251, respectively. Statistical values for the unknown parameters are included in the table 17.

Results obtained showed that silver hake biomass in 1991 (from age-group 2 and older) accounted for 202,000 tons.

To obtain total biomass value estimate for age-group 1 is to be calculated. As it was mentioned above only the long-term value for this age-group was obtained using ADAPT framework. To adjust this value a regression equation was set up between 0-group abundance indices derived from the juvenile surveys and abundance estimate for age-group 1 for the following year:

$$N_{1,y+1} = 619.5 + 3.1955 \cdot I_y^{juv} \qquad (8)$$

Correlation coefficient was found to be 0.849. Correlation diagram is illustrated in Figure 6. The 1991 abundance index and biomass for age-group 1 estimated by this equation amounted to 1218.3 mln fish and 57,200 tons, respectively.

This, silver hake biomass by the start of 1991 accounted for 259,200 tons.

6. Prognosis of State of Stock and TAC Estimation for 1993

Prognosis of silver hake state of stock is made under the following assumptions:

- abundance estimate for 1991 corresponds to the estimates obtained by the adaptive framework using abundance index for age-group 1 adjusted by the equation (8)
- recruitment for 1992 pre-estimated by the equation (8) will amount to 807,700,000 fish
- the 1992 catch will account for 65,000 tons
- mean weight value corresponds to the long-term means
- recruitment estimate for 1993 will be at the level of the long-term mean value
- partial recruitment coefficients and optimal fishing mortality for 1993 will correspond to the first and second variants of the table, presented in section 4.

Results of calculations for the 1992 and 1993 abundance indices and biomas estimates and TAC for 1993 under the 1-st and 2-nd fishery patterns are presented in Tables 18 and 19. Basing the results obtained a TAC of 51000 -62000 tons may be advised for 1993.

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Table 1. 4VWX Silver Hake commertial Catch Numbers at age ('000)

	77	78	79	80	81	82	83	84	85
1	17911	20940	20569	16588	2358	20190	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	34111
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
1+	168507	227811	224408	211336	190974	257709	204085	420071	418588

	86	87	88	89	90	91
1	45598	6804	5110	21549	6516	9016
2	70269	214235	62791	115939	209620	122134
3	229126	114417	265307	172700	142862	179429
4	84097	54211	39242	107956	41215	57600
5	28635	13063	21303	17640	11741	10788
6	8760	6045	3106	6689	1648	3408
7	1436	347	2133	1574	640	279
8	497	156	208	742	107	165
9	111	117	143	130	48	36
1+	468530	409395	399343	444919	414397	382855

Table 2.4VWX Silver Hake commertial mean weight at age (kg.)

	77	78	79	80	81	82	83	84	85	86	87	88
1	.065	.074	.076	.040	.061	.066	.067	.070	.068	.053	.045	.045
2	.183	.153	.178	.151	.168	.169	.128	.146	.136	.145	.119	.139
3	.264	.229	.227	.223	.215	.231	.196	.181	.177	.184	.168	.185
4	.340	.266	.274	.287	.276	.275	.239	.224	.210	.250	.211	.227
5	.446	.335	.304	.341	.326	.317	.289	.272	.244	.250	.248	.260
6	.632	.405	.389	.391	.401	.394	.365	.353	.295	.274	.286	.292
7	.886	.438	.455	.531	.553	.446	.395	.405	.410	.392	.453	.401
8	.922	.540	.838	.839	.923	.513	.457	.624	.582	.514	.422	.497
9	2.120	.892	.838	.859	1.137	.506	.444	.650	.669	.644	.518	.688

	89	90	91
1	.055	.063	.047
2	.139	.137	.139
3	.198	.193	.189
4	.228	.213	.215
5	.279	.240	.263
6	.332	.301	.314
7	.434	.366	.471
8	.464	.438	.511
9	1.019	.644	.568

Table 3.REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R............. .731
MULTIPLE R SQUARED...... .535

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	7.920E0001	7.920E0001	
REGRESSION	25	2.673E0001	1.069E0000	7.260
TYPE 1	1	8.445E-001	8.445E-001	5.733
TYPE 2	6	6.102E0000	1.017E0000	6.904
TYPE 3	14	1.701E0001	1.215E0000	8.246
TYPE 4	2	3.922E-001	1.961E-001	1.331
TYPE 5	1	1.297E0000	1.297E0000	8.804
TYPE 6	1	6.091E-001	6.091E-001	4.135
RESIDUALS	158	2.327E0001	1.473E-001	
TOTAL	184	1.292E0002		

Table 4.REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	1	INTERCEPT	1.189	0.204	184
2	5				
3	77				
4	460				
5	1				
6	1				
1	2	1	-0.347	0.145	102
2	3	2	0.392	0.193	5
	4	3	0.188	0.098	26
	6	4	-0.158	0.083	48
	7	5	-0.221	0.087	39
	8	6	-0.381	0.109	21
	9	7	-0.505	0.192	5
3	78	8	-0.227	0.128	26
	79	9	-0.032	0.130	21
	80	10	-0.398	0.164	9
	81	11	-0.247	0.165	9
	82	12	0.628	0.185	7
	83	13	-0.082	0.178	8
	84	14	0.414	0.177	8
	85	15	0.275	0.177	8
	86	16	0.929	0.200	10
	87	17	0.925	0.204	9
	88	18	0.569	0.202	10
	89	19	0.985	0.193	13
	90	20	0.473	0.197	12
	91	21	0.178	0.188	17
4	450	22	0.138	0.134	11
	470	23	-0.075	0.075	42
5	2	24	-0.461	0.156	163
6	2	25	-0.157	0.077	48

Table 5. Standardized CPUE values

STANDARDS USED VARIABLE NUMBERS: 1 5 460 1 1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	CATCH RATE S.E.	EFFORT
77	37095	0.703	3.463	0.702	10712
78	48404	0.879	2.768	0.516	17486
79	51760	0.827	3.349	0.703	15454
80	44525	0.920	2.322	0.493	19178
81	44600	0.833	2.697	0.580	16539
82	60251	0.957	6.467	1.424	9317
83	35839	0.921	3.180	0.687	11269
84	74266	0.967	5.223	1.127	14220
85	75480	0.981	4.546	0.981	16604
86	82689	0.427	8.509	2.637	9718
87	61704	0.926	8.479	2.628	7277
88	74374	0.880	5.941	1.832	12519
89	91505	0.934	9.022	2.739	10143
90	68582	0.852	5.404	1.649	12692
91	67848	0.809	4.029	1.215	16840

AVERAGE C.V. FOR THE MEAN: .249

Table 6.Abundance indices for 4VWX Silver Hake (trawl surveys, '000)

	77	78	79	80	81	82	83	84	85
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+	65638	87569	349679	234668	334545	673374	295908	530276	415885
2+	57902	60829	260242	216937	301705	481350	181635	341306	313158
3+	30242	37572	107537	161299	216982	187930	72678	270937	140583

	86	87	88	89	90	91
1	552598	146007	69740	172095	117089	66678
2	84325	266663	89508	63810	125952	84741
3	70625	46095	81458	24151	42329	35275
4	22623	18982	16709	13405	13022	13235
5	13448	6048	14249	4130	4173	6560
6	4225	4168	2502	1860	1169	2451
7	1622	1199	2338	769	432	402
8	673	672	468	282	227	143
9	376	471	121	129	82	124
1+	750524	490304	277092	280640	304476	209609
2+	197926	344297	207352	108545	187387	142931
3+	113602	77634	117844	44735	61434	58190

Table 7. Abundance indices for 0-group from juvenile surveys and age-group 1 from July trawl survey

Year class	81	82	83	84	85	86	87	88	89	90	91
0-group abundance index	579.0	8.8	232.2	43.4	284.8	198.0	102.0	204.8	131.5	187.4	78.6
Standard error	64.4	1.2	24.4	7.1	62.2	37.9	23.0	35.3	19.0	24.1	3.9
Coefficient of variation	.11	.14	0.11	0.16	0.22	0.19	0.11	0.17	0.10	0.12	0.05
Abundance ind. for age-gr. 1	192	114	189	103	553	146	70	172	117	67	

Table 8. Components of mean square errors for abundance index approximation at varions values of λ_{juv}

λ_{juv}	SS_{rv}	SS_{cpue}	SS_{juv}
0.0	0.220	0.196	0.000
0.1	0.220	0.196	0.159
0.2	0.221	0.196	0.155
0.3	0.226	0.197	0.150
0.4	0.241	0.202	0.139
0.5	0.264	0.212	0.128
0.6	0.284	0.221	0.121
0.7	0.301	0.228	0.117
0.8	0.318	0.234	0.115
0.9	0.397	0.262	0.105
1.0	0.456	0.287	0.098

Table 9. Yield-per-recruit analysis for the 1-st set of partial recruitment coefficients

AGE	WEIGHT-AT-AGE	PARTIAL RECRUITMENT
1	.057	.020
2	.137	.249
3	.182	1.000
4	.224	1.000
5	.259	1.000
6	.308	1.000
7	.411	1.000
8	.525	1.000
9	.665	1.000

NATURAL MORTALITY RATE : 0.4
F0.1 COMPUTED AS .5517 AT Y/R OF .0571
FMAX COMPUTED AS 7.3817 AT Y/R OF .0753

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	.1000	.100	.023	.231	2.229
	.2000	.170	.037	.217	1.780
	.3000	.221	.046	.206	1.467
	.4000	.260	.051	.198	1.240
	.5000	.290	.055	.191	1.071
F0.1—	.5517	.304	.057	.188	1.000
	.6000	.315	.058	.186	.941
	.7000	.336	.061	.181	.839
	.8000	.353	.063	.177	.756
	.9000	.369	.064	.174	.689
	1.0000	.382	.065	.171	.632
	1.1000	.394	.066	.169	.584
	1.2000	.404	.067	.167	.542
	1.3000	.414	.068	.165	.506
	1.4000	.423	.069	.163	.475
	1.5000	.431	.069	.161	.447
FMAX—	7.3817	.596	.075	.126	.098

Table 10. Yield-per-recruit analysis for the 2-nd set of partial recruitment coefficients

AGE	WEIGHT-AT-AGE	PARTIAL RECRUITMENT
1	.057	.035
2	.137	.235
3	.182	1.000
4	.224	1.000
5	.259	1.000
6	.308	.761
7	.411	.381
8	.525	.141
9	.665	.078

NATURAL MORTALITY RATE : 0.4
F0.1 COMPUTED AS .7209 AT Y/R OF .0600
FMAX COMPUTED AS 4.5274 AT Y/R OF .0729

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	.1000	.092	.019	.207	2.292
	.2000	.161	.032	.201	1.940
	.3000	.214	.042	.195	1.666
	.4000	.255	.048	.190	1.450
	.5000	.287	.053	.185	1.277
	.6000	.314	.057	.181	1.137
	.7000	.336	.060	.177	1.021
F0.1—	.7209	.340	.060	.176	1.000
	.8000	.355	.062	.174	.926
	.9000	.371	.063	.171	.846
	1.0000	.385	.065	.168	.777
	1.1000	.398	.066	.166	.719
	1.2000	.409	.067	.163	.668
	1.3000	.419	.068	.161	.624
	1.4000	.428	.068	.159	.585
	1.5000	.436	.069	.158	.551
FMAX—	4.5274	.563	.073	.130	.193

Table 11. Silver hake POPULATION NUMBERS (000S) 6/ 5/92

	77	78	79	80	81	82	83	84
1	623140	721060	883139	622160	887914	1557861	831355	1355514
2	434908	403039	466197	575145	403465	593256	1027736	552485
3	234862	232146	212606	265102	327650	249807	354298	609616
4	77255	108422	89953	82837	120072	130360	105329	191514
5	24713	39447	44001	30275	29302	49725	31382	46630
6	6692	14749	16037	11171	8452	9876	7335	11712
7	4250	3892	5607	2588	3244	3018	1753	2137
8	1559	2770	1048	1165	563	1191	351	504
9	18	971	900	297	411	140	418	28
1+	1407397	1526496	1719490	1590740	1781073	2595234	2359956	2770141

	85	86	87	88	89	90	91
1	744309	1718770	895515	870609	1467604	922922	1007277
2	859841	486669	1114793	594711	579404	966121	613318
3	332821	469268	268693	571868	347238	293463	475988
4	239243	142578	126967	86434	166119	91366	79749
5	60494	55273	26720	40724	25810	22966	27500
6	15419	12623	13606	7216	9857	2858	5782
7	4356	2699	1289	4171	2293	1131	567
8	582	1001	634	580	1050	249	234
9	188	205	264	297	218	96	79
1+	2257254	2889086	2448480	2176610	2599593	2301172	2210494

Table 12. Silver hake Population Biomass (tons) 6/ 5/92

	77	78	79	80	81	82	83	84	85
1	40504	53575	67119	24700	53808	102351	55867	95022	50687
2	79588	61584	83076	86962	67580	100260	131858	80663	117110
3	61886	53069	48219	59065	70478	57655	69301	110280	58976
4	26243	28840	24620	23741	33164	35849	25184	42976	50289
5	11024	13219	13390	10324	9541	15778	9060	12702	14736
6	4229	5972	6237	4365	3390	3887	2676	4131	4550
7	3767	1704	2551	1375	1794	1345	692	866	1786
8	1438	1495	879	978	520	611	160	314	339
9	38	866	754	255	468	71	186	18	126
1+	228718	220324	246845	211764	240741	317808	294984	346971	298600
2+	188214	166749	179726	187065	186933	215457	239117	251949	247912
3+	108626	105165	96650	100103	119353	115196	107258	171286	130802

	86	87	88	89	90	91
1	91610	39940	39352	80718	58144	47745
2	70713	132660	82784	80537	132359	85435
3	86486	45140	105624	68753	56638	89914
4	35659	26739	19586	37875	19461	17114
5	13824	6635	10605	7201	5512	7227
6	3456	3891	2108	3272	860	1813
7	1058	584	1671	995	414	267
8	515	268	288	487	109	120
9	132	137	204	222	62	45
1+	303453	255994	262221	280062	273559	249680
2+	211843	216054	222870	199344	215415	201935
3+	141130	83394	140086	118806	83056	116500

Table 13. Silver hake fishing mortality 6/ 5/92

	77	78	79	80	81	82	83	84	85	86	87
1	.036	.036	.029	.033	.003	.016	.009	.055	.025	.033	.009
2	.228	.240	.164	.163	.079	.115	.122	.107	.206	.194	.268
3	.373	.548	.543	.392	.522	.464	.215	.535	.448	.907	.734
4	.272	.502	.689	.639	.482	1.024	.415	.752	1.065	1.274	.737
5	.116	.500	.971	.876	.688	1.514	.586	.707	1.167	1.002	.909
6	.142	.567	1.424	.837	.630	1.329	.833	.589	1.343	1.882	.782
7	.028	.912	1.171	1.125	.602	1.752	.846	.900	1.071	1.049	.399
8	.074	.724	.860	.641	.992	.647	2.133	.586	.642	.933	.358
9	.323	.536	.678	.500	.525	.774	.293	.594	.766	1.010	.746

	88	89	90	91
1	.007	.018	.009	.011
2	.138	.280	.308	.274
3	.836	.935	.903	.595
4	.809	1.579	.801	1.768
5	1.019	1.800	.979	.628
6	.746	1.765	1.218	1.168
7	.980	1.822	1.176	.868
8	.578	1.990	.746	1.664
9	.843	1.190	.887	.767

Table 14.LOG RESIDUALS FOR RV INDEX 6/ 5/92

	77	78	79	80	81	82	83	84	85	86	87	88
1	.00	-.94	.06	.00	-.96	.25	.36	.40	.37	.00	.53	-.18
2	-.75	-.84	.85	-.37	.36	.00	-.30	-.13	.39	.23	.60	.06
3	-.68	-.84	.66	.72	.89	.63	-.61	.73	-.51	.13	.16	.03
4	.00	.00	-.06	.83	.64	.00	-.41	-.14	.45	-.05	-.43	-.13
5	.00	-.69	.01	.26	.60	.00	.05	-.17	.43	-.04	-.17	.33
6	.00	-.96	-.03	-.13	.16	.89	-.16	.25	.58	.30	-.44	-.33
7	.00	-.63	-.11	.35	-.01	.00	-.25	.77	.08	.05	.11	-.06
8	.00	.00	-.04	-.77	.45	.67	.00	.69	.61	-.32	-.20	-.35
9	.00	-.42	.00	-.07	.00	.68	-.67	.00	-.04	.57	.39	.00

	89	90	91
1	.20	.28	-.37
2	-.17	.01	.05
3	-.63	.08	-.76
4	-.55	-.44	.28
5	.01	-.35	-.28
6	-.34	.11	.11
7	-.08	-.33	.11
8	-.62	-.12	.01
9	-.45	-.26	.28

SUM OF RV RESIDUALS : -4.263256415E-14 MEAN RESIDUAL : -3.685711404E-16

Table 15. LOG RESIDUALS FOR JUV. RV INDEX 6/ 5/92

77	78	79	80	81	82	83	84	85	86	87	88	89
.00	.00	.00	.00	.00	.00	.11	-.97	.07	.36	-.27	-.10	-.08

90	91
.19	.00

SUM OF JUV. RV RESIDUALS : -0.6945260196 MEAN RESIDUAL : -0.07716955774

Table 16. LOG RESIDUALS FROM CPUE INDEX 6/ 5/92

	77	78	79	80	81	82	83	84	85	86	87	88
1	.85	.37	.27	.20	.00	.20	-.60	.00	.06	.87	-.09	-.90
2	.33	-.12	-.33	-.55	.00	-.15	-.29	-.65	-.19	.29	.86	-.29
3	-.12	-.31	-.19	-.66	-.29	.20	-.64	-.11	-.41	.63	.78	.32
4	-.59	-.59	-.23	-.49	-.56	.54	-.29	-.08	-.02	.61	.58	.09
5	.00	-.69	-.11	-.38	-.40	.63	-.13	-.22	-.07	.37	.61	.12
6	.00	-.66	.03	-.47	-.53	.51	.06	-.42	-.06	.61	.45	-.13
7	.00	-.33	-.06	-.29	-.55	.63	.07	-.12	-.17	.35	-.04	.05
8	.00	-.37	-.13	-.54	-.11	.19	.61	-.31	-.39	.39	-.03	-.20
9	-.37	-.44	-.14	-.59	-.41	.46	-.50	-.15	-.12	.59	.68	.21

	89	90	91
1	.24	-.72	-.74
2	.57	.43	.08
3	.60	.36	-.15
4	.66	.08	.29
5	.61	.10	-.43
6	.54	.16	-.08
7	.56	.15	-.25
8	.70	-.02	.21
9	.64	.24	-.11

SUM OF CPUE RESIDUALS : 9.250933353E-14 MEAN RESIDUAL : 6.828034232E-16

Table 17. ESTIMATED PARAMETERS AND STANDARD ERRORS

PAR. EST.	STD. ERR.	T-STATISTIC
6.23036E0005	7.29077E0004	8.54555E0000
4.88630E0005	6.39422E0004	7.64175E0000
8.48242E0004	1.00550E0004	8.43600E0000
2.82604E0004	7.00956E0003	4.03169E0000
6.04329E0003	1.21312E0003	4.98159E0000
5.86911E0002	1.42960E0002	4.10541E0000
2.48059E0002	3.55155E0001	6.98454E0000

Parameter Correlation Matrix 6/ 5/92

	1	2	3	4	5	6	7
1	1.000	.129	.049	.055	.010	.005	.004
2	.129	1.000	-.012	.048	.007	.009	.015
3	.049	-.012	1.000	.035	.010	.007	.014
4	.055	.048	.035	1.000	.025	.012	.011
5	.010	.007	.010	.025	1.000	.030	.009
6	.005	.009	.007	.012	.030	1.000	.020
7	.004	.015	.014	.011	.009	.020	1.000

Table 18. State of stock prognosis and TAC estimation for the 1-st set of the partial recruitment coefficients

POPULATION NUMBERS 6/ 5/92

	91	92	93	94
1	1218000	870700	1007000	1007000
2	613318	809119	574370	667605
3	475988	312684	444274	335593
4	79749	175961	94063	171527
5	27500	9120	52934	36316
6	5782	9839	2744	20437
7	567	1206	2960	1059
8	237	159	363	1143
9	79	31	48	140
1+	2421220	2188820	2178755	2240821
2+	1203220	1318120	1171755	1233821
3+	589902	509001	597385	566216
4+	113913	196317	153111	230622

POPULATION BIOMASS (AVERAGE) 6/ 5/92

	91	92	93	94
1	56980.72	40600.58	47065.47	47065.47
2	61136.23	83375.14	60874.55	70756.13
3	54872.16	33123.71	52159.22	39399.74
4	7296.05	22941.72	13591.83	24785.04
5	4450.37	1374.85	8843.82	6067.52
6	899.23	1763.87	545.09	4060.44
7	131.96	288.55	784.73	280.83
8	53.12	48.69	122.88	387.01
9	30.96	12.02	20.56	60.10
1+	185850.80	183529.12	184008.15	192862.27
2+	128870.08	142928.54	136942.69	145796.80
3+	67733.85	59553.40	76068.13	75040.67
4+	12861.69	26429.69	23908.91	35640.93

CATCH BIOMASS 6/ 5/92

	91	92	93	94
1	514	651	519	519
2	16732	16634	8363	9720
3	32656	26540	28776	21737
4	12902	18381	7499	13674
5	2794	1102	4879	3347
6	1050	1413	301	2240
7	115	231	433	155
8	87	39	68	214
9	24	10	11	33
1+	66874	65000	50849	51639
2+	66360	64349	50329	51120
3+	49627	47716	41967	41400
4+	16971	21176	13191	19663

FISHING MORTALITY 6/ 5/92

	91	92	93	94
1	.009	.016	.011	.011
2	.274	.200	.137	.137
3	.595	.801	.552	.552
4	1.768	.801	.552	.552
5	.628	.801	.552	.552
6	1.167	.801	.552	.552
7	.869	.801	.552	.552
8	1.631	.801	.552	.552
9	.773	.801	.552	.552
1+	.259	.266	.193	.185

SUMMARY OF PROJECTIONS 6/ 5/92

YEAR	91	92	93	94
POPULATION NUMBERS	2421219.86	2188820.46	2178754.76	2240820.78
POPULATION BIOMASS	185850.80	183529.12	184008.15	192862.27
CATCH	66873.74	65000.00	50848.65	51639.26
F OR QUOTA	66873.74	65000.00	.55	.55

AGE GROUPS CONSIDERED:1+

Table 19. State of stock prognosis and TAC estimation for the 2-nd set of the partial recruitment coefficient

POPULATION NUMBERS 6/ 5/92

	91	92	93	94
1	1218000	870700	1007000	1007000
2	613318	809119	567244	658194
3	475988	312684	447886	320980
4	79749	175961	92823	146005
5	27500	9120	52236	30259
6	5782	9839	2707	17028
7	567	1206	3549	1049
8	237	159	593	1807
9	79	31	95	359
1+	2421220	2188820	2174134	2182681
2+	1203220	1318120	1167134	1175681
3+	589902	509001	599889	517487
4+	113913	196317	152003	196507

POPULATION BIOMASS (AVERAGE) 6/ 5/92

	91	92	93	94
1	56980.72	40365.64	46755.60	46755.60
2	61136.23	83679.99	59251.04	68751.09
3	54872.16	32947.58	49016.38	35127.82
4	7296.05	22819.74	12502.79	19666.05
5	4450.37	1367.54	8135.22	4712.57
6	899.23	1899.81	538.61	3387.61
7	131.96	354.90	1060.70	313.41
8	53.12	65.38	244.73	746.13
9	30.96	16.52	50.84	191.68
1+	185850.80	183517.10	177555.91	179651.97
2+	128870.08	143151.47	130800.31	132896.36
3+	67733.85	59471.47	71549.28	64145.28
4+	12861.70	26523.89	22532.90	29017.46

CATCH BIOMASS 6/ 5/92

	91	92	93	94
1	514	1151	1180	1180
2	16732	16017	10038	11647
3	32656	26836	35336	25324
4	12902	18587	9013	14177
5	2794	1114	5865	3397
6	1050	1178	295	1858
7	115	110	291	86
8	87	8	25	76
9	24	1	3	11
1+	66874	65000	62046	57756
2+	66360	63849	60866	56577
3+	49627	47832	50828	44929
4+	16971	20997	15492	19606

FISHING MORTALITY 6/ 5/92

	91	92	93	94
1	.009	.029	.025	.025
2	.274	.191	.169	.169
3	.595	.814	.721	.721
4	1.768	.814	.721	.721
5	.628	.814	.721	.721
6	1.167	.620	.549	.549
7	.869	.310	.275	.275
8	1.631	.115	.102	.102
9	.773	.064	.056	.056
1+	.259	.270	.254	.231

SUMMARY OF PROJECTIONS 6/ 5/92

YEAR	91	92	93	94
POPULATION NUMBERS	2421219.86	2188820.46	2174133.78	2182680.67
POPULATION BIOMASS	185850.80	183517.10	177555.91	179651.97
CATCH	66873.74	65000.00	62045.93	57756.30
F OR QUOTA	66873.74	65000.00	.72	.72

AGE GROUPS CONSIDERED:1+

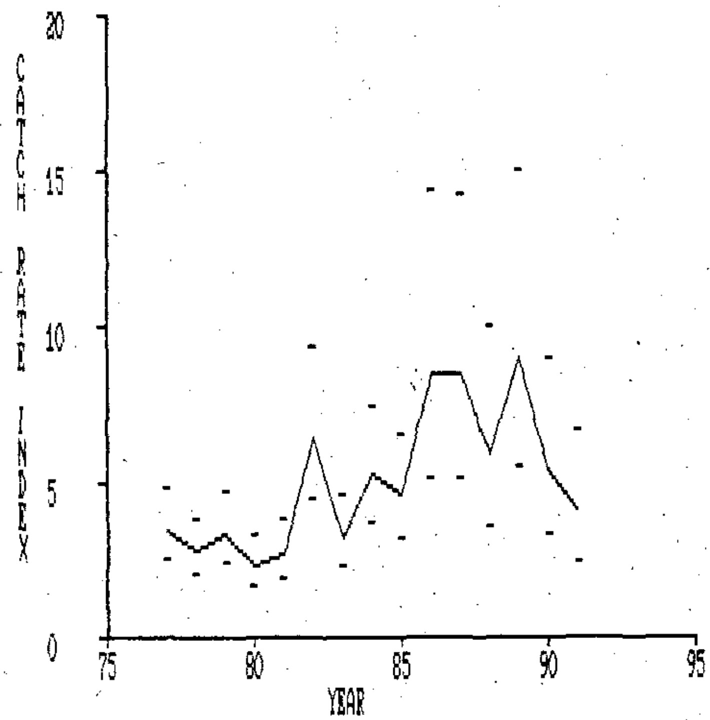


Fig.1. Temporal variation of silver hake CPUE values

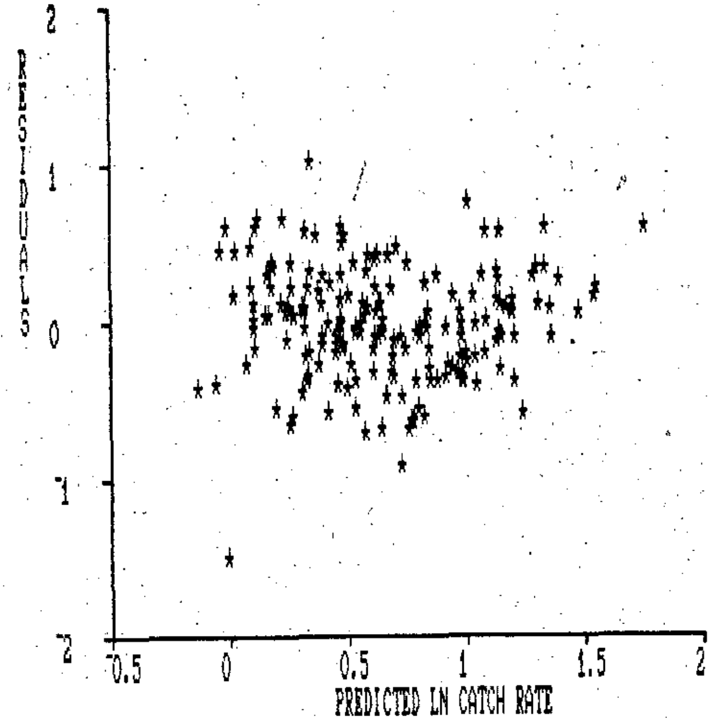


Fig.2. Residuals of multiplicative model

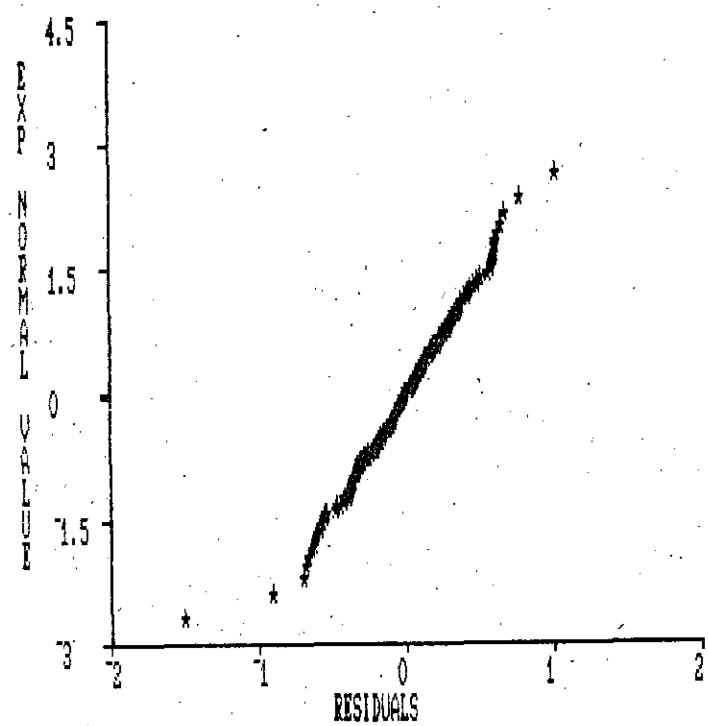
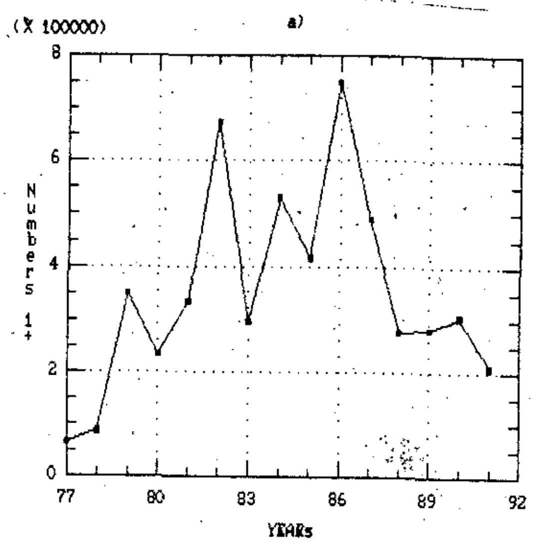


Fig.3. Expected normal residuals of multiplicative model



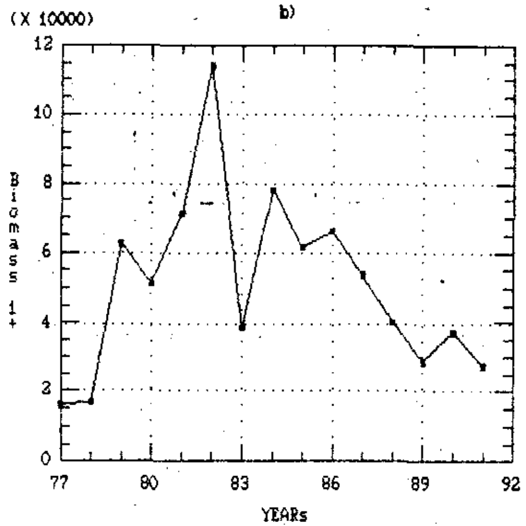


Fig.4. Temporal variation of total abundance and biomass from trawl survey data

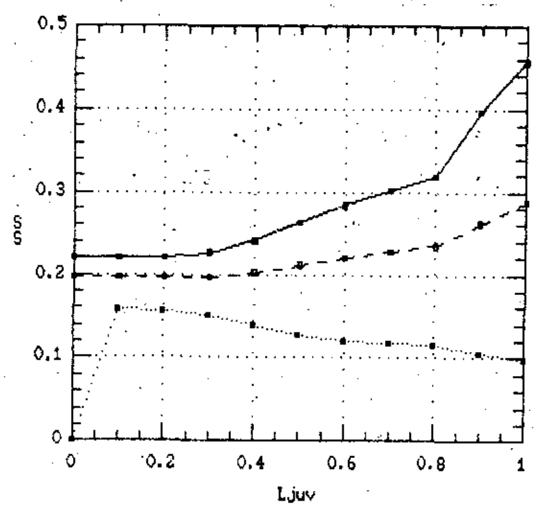


Fig.5. Components of approximation standard errors at varions λ_{juv} values

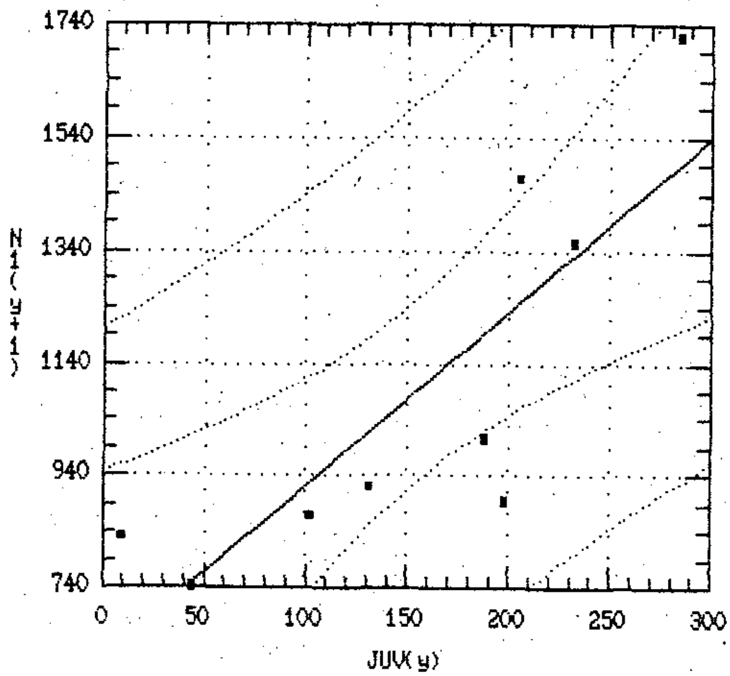


Fig.6. Relationship between 0-group abundance index derived from juvenile surveys and July survey abundance index for age-group 1