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Calibration of Division 4VWX Silver Hake VPA Including Calculations of Yield per Recruit

by

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INTRODUCTION

The last time a sequential population model for 4VWX silver hake was accepted by the NAFO Scientific Council was in 1983. The Committee had difficulty in calibrating the VPA using commercial catch rates because it considered that these data were not representative of stock biomass.

"The Committee considered methods of validating the VPA results by using catch-effort data for 1970-1982 (standardized by the multiplicative model). However, the commercial catch rates observed in 1982 were influenced by the abnormally-low water temperatures on the Scotian Shelf. Furthermore, the catch rates for the periods before and after 1977 are not comparable because of the regulations imposed since 1977. Therefore it was agreed to consider the results of Canadian research surveys as a means of validating the VPA. The best relationship between age 3+ numbers from VPA and 3-year running means of age 3+ numbers from survey data was obtained with F = 0.25 in 1982." (Red Book, 1983 p.43).

STACFIS advised the TAC associated with fishing at F0.1 (0.418) in 1984 be 100,000 tons.

The "Others working group" of STACFIS at the June, 1986 Scientific Council meetings reviewed several documents relating to catch and effort data before and since imposition of the Small Mesh Gear Line and its associated regulations in 1977. The working group agreed that a multiplicative model used to analyze commercial catch and effort (Waldron et. al., 1986) provides an acceptable standardized catch rate series which can be used for calibration of a sequential population model.

The working group also reviewed the July and March Canadian research vessel groundfish survey results. They noted the close agreement between the July R/V biomass and the standardized commercial catch rates from the multiplicative model. In particular the fact that both the commercial catch rates and survey biomass are considerably larger after 1981 than at any other previous time in the series. However, the July survey estimates were not used to calibrate the sequential population model (SPA). At this time there is no new evidence that the working group would be any more successful at calibration of the SPA using this series than it has in the past two years.

MATERIALS AND METHODS

An estimate of partial recruitment in 1985 was developed in the following manner.

1. One VPA (Rivard, 1982) was run using a natural mortality of 0.4, the catch at age from Waldron and Fanning, 1986, the last accepted partial recruitment vector (see 1983 assessment meeting PR in table below) as input for 1985 (Red book, 1983 p.43) and the F at age 9 from Waldron et al (1983).

2. Using the AutoF function of Rivard (1982). F's for age 9 were iterated over age 4+. The above partial recruitment and these F's at age 9, were used in another VPA.

3. Partial recruitment at ages 1 and 2 in 1985 were estimated by the following iterations. F's for ages 3 and 4 were weighted by population numbers at ages 3 and 4 then averaged from 1977 to 1984. Average F's at ages 1 and 2 for the years 1977 to 1984 were also calculated.
Partial recruitment at ages 1 and 2 were then calculated by dividing the average F's at each age by the average weighted F's of ages 3 and 4. These were used as input in a second VPA.

4. The procedure in 3 above was run until no change in partial recruitment at age 1 and 2 in 1985 was noted. This took two iterations.

5. The new partial recruitment pattern for 1985 was used in all subsequent VPA's and calibrations.

ASSESSMENT MEETING	1	2	3	4	5	6	7	8	9
1983 PR	0.030	0.250	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1986 PR	0.041	0.304	1.00	1.00	1.00	1.00	1.00	1.00	1.00

For the VPA's at various terminal F fishable population biomass was calculated using the following partial recruitment pattern, population numbers from the VPA and average weights at age from Waldron and Fanning (1985).

AGE	1	2	3	4	5	6	7	8	9
PR 1970-1976	0.350	1.000	1.00	1.00	1.00	1.00	1.00	1.00	1.00
PR 1977-1985	0.041	0.304	1.00	1.00	1.00	1.00	1.00	1.00	1.00

A Thompson and Bell Yield per Recruit model was calculated (Rivard, 1982) using the above partial recruitment (1977-1985) and average weights at age (1977-1985) from Waldron and Fanning (1986).

RESULTS AND DISCUSSION

The Fishing Mortalities at age for three terminal F's (.1, .25 and .4) are presented in table 1. Fishing mortalities at ages 3-5 from 1977- 1983 suggest that F is between .1 and .5 with the averages calculated below.

VPA @ TF	1977-1983 Average @ age 3	1977-1983 Average F @ age 4
0.100	0.31	0.40
0.250	0.34	0.46
0.400	0.38	0.49

The results of regressions between fishable biomass and the standardized catch rates are given in Table 3. The plots of these regression lines are given in Figures 1 to 8. The 1982 catch rate is the largest in the series. It is difficult to rationalize that the stock biomass would have increased so dramatically from 1981 to 1982. Therefore the 1982 cpue is regarded by the authors as anomalous and should not included in the calibration. However, for comparative purposes we provide the results of including and excluding the 1982 data point in the various calibrations.

The analysis indicates that significant regressions are obtained at TF below .15 (1982 included) and below TF 0.30 (1982

excluded). The authors suggest that the most likely TF is at 0.25 where the intercept is closest to 0 and is insignificant from 0, and both the r and slopes are significant.

The Yield per Recruit analysis (Table 4.) indicates that the F0.1 is 0.474 which is above that recommended in 1983 (F0.1 = 0.418).

REFERENCES

Rivard, D. 1982. APL Programs for stock assessment (revised). Can. Tech. Rep. Fish. Aquat. Sci. 1091: 146p.

Waldron, D.E. and L.P. Fanning. 1986. Assessmenet of the Scotian Shelf silver hake population in 1985. NAFO SCR Doc. 86/62:N1187. 29p.

Waldron, D.E., L.P. Fanning and J. Parnell. 1986. Standardization of 4VWX silver hake catch rates from the Scotian Shelf Small Meshed Fishery. NAFO SCR Doc. 86/85. 13p.

Waldron, D.E., A.F. Sinclair, and J.J. Hunt. 1983. Population abundance of Scotian Shelf silver hake (Merluccius bilinearis) in 1982 with projections to 1984. NAFO SCR. Doc. 83/vi/58, N718: 36p.

SILVER HAKE FISHING MORTALITY (F_t=0.10) 15/06/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	.142	.168	.129	.231	.094	.125	.240	.004	.040	.009	.006	.001	.005	.002	.011	.004
2	.701	.676	.823	1.468	.915	.730	.717	.122	.257	.108	.090	.028	.049	.035	.038	.030
3	.659	.442	.294	.518	.730	.368	.387	.392	.501	.402	.338	.295	.155	.077	.125	.100
4	.461	.657	.260	1.327	.078	1.025	.497	.340	.495	.694	.482	.331	.363	.112	.181	.100
5	.606	.389	.405	1.904	.493	1.027	.289	.243	.503	1.049	.676	.458	.737	.139	.128	.100
6	.654	.122	.276	1.573	.355	.623	.210	.198	.689	1.719	.866	.739	.770	.236	.096	.100
7	.383	1.273	.127	2.390	.029	.064	.151	.066	.727	1.862	1.167	.262	1.603	.257	.095	.100
8	.238	.299	.408	2.251	.120	.185	.034	.309	.535	1.859	.835	.309	1.109	3.374	.070	.100
9	.480	.530	.270	1.620	.160	.950	.390	.290	.510	.910	.560	.430	.720	.230	.340	.100

SILVER HAKE FISHING MORTALITY (F_t=0.25) 15/06/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	.142	.168	.129	.231	.094	.125	.240	.004	.044	.012	.009	.002	.010	.005	.027	.010
2	.701	.676	.823	1.468	.915	.730	.717	.122	.257	.120	.116	.045	.086	.069	.086	.076
3	.659	.442	.294	.518	.730	.368	.387	.392	.501	.402	.385	.406	.266	.143	.270	.250
4	.461	.657	.260	1.327	.078	1.025	.497	.340	.495	.694	.482	.399	.585	.214	.379	.250
5	.606	.389	.405	1.904	.493	1.027	.289	.243	.503	1.049	.676	.458	1.042	.269	.276	.250
6	.654	.122	.276	1.573	.355	.623	.210	.198	.689	1.719	.866	.739	.770	.439	.211	.250
7	.383	1.273	.127	2.390	.029	.064	.151	.066	.727	1.862	1.167	.262	1.603	.257	.209	.250
8	.238	.299	.408	2.251	.120	.185	.034	.309	.535	1.859	.835	.309	1.109	3.374	.070	.250
9	.480	.530	.270	1.620	.160	.950	.390	.290	.510	.910	.560	.430	.720	.230	.340	.250

SILVER HAKE FISHING MORTALITY (F_t=0.40) 15/06/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	.142	.168	.129	.231	.094	.125	.240	.004	.045	.013	.011	.002	.013	.007	.043	.016
2	.701	.676	.823	1.468	.915	.730	.717	.122	.257	.123	.125	.053	.106	.092	.126	.122
3	.659	.442	.294	.518	.730	.368	.387	.392	.501	.402	.399	.449	.324	.181	.380	.400
4	.461	.657	.260	1.327	.078	1.025	.497	.340	.495	.694	.482	.421	.692	.277	.524	.400
5	.606	.389	.405	1.904	.493	1.027	.289	.243	.503	1.049	.676	.458	1.169	.351	.388	.400
6	.654	.122	.276	1.573	.355	.623	.210	.198	.689	1.719	.866	.739	.770	.561	.301	.400
7	.383	1.273	.127	2.390	.029	.064	.151	.066	.727	1.862	1.167	.262	1.603	.257	.297	.400
8	.238	.299	.408	2.251	.120	.185	.034	.309	.535	1.859	.835	.309	1.109	3.374	.070	.400
9	.480	.530	.270	1.620	.160	.950	.390	.290	.510	.910	.560	.430	.720	.230	.340	.400

Table 1. Fishing Mortality Matrices for Silver Hake.

Table 2. SILVER HAKE EXPLOITABLE BIOMASS AT DIFFERENT F 15/06/86

	5	10	15	20	25	30	35	40	45	50
70	274192	274192	274192	274192	274192	274192	274192	274192	274192	274192
71	232476	232476	232476	232476	232476	232476	232476	232476	232476	232476
72	254332	254332	254332	254332	254332	254332	254332	254332	254332	254332
73	232633	232633	232633	232633	232633	232633	232633	232633	232633	232633
74	166027	166027	166027	166027	166027	166027	166027	166027	166027	166027
75	183975	183975	183975	183975	183975	183975	183975	183975	183975	183975
76	178305	178305	178305	178305	178305	178305	178305	178305	178305	178305
77	110058	110058	110058	110058	110058	110058	110058	110058	110058	110058
78	83425	83208	83135	83098	83076	83061	83050	83042	83036	83031
79	92476	88144	86685	85949	85506	85209	84996	84836	84711	84611
80	136622	114292	106783	103004	100727	99203	98112	97293	96655	96145
81	211045	149203	128469	118057	111790	107603	104607	102359	100610	99212
82	374346	226623	177173	152360	137431	127458	120324	114969	110804	107472
83	600779	336002	247692	203515	177003	159329	146709	137250	129901	124030
84	1000042	528069	370617	291821	244505	212940	190383	173463	160304	149781
85	1544233	772596	515369	386745	309563	258102	221339	193762	172310	155145

Table 3. Calibration parameters used in assessing 4VWX silver hake (*=sig. at 5%)

Terminal F	1982 Point Included Slope	Intercept	r	1982 Point Excluded Slope	Intercept	r	Res-83-85	Res85
.05	3.17E+5*	-3.36E+5	.61*	6.38E+5*	-9.49E+5*	.86*	.20	1.91
.10	1.41E+5*	-6.13E+4	.60*	2.98E+5*	-3.61E+5*	.88*	1.80	1.79
.15	8.22E+4*	3.03E+4	.55*	1.84E+5*	-1.65E+5*	.87*	1.37	1.30
.20	5.28E+4*	7.61E+4	.47*	1.28E+5*	-6.73E+4	.80*	1.33	.69
.25	3.51E+4	1.04E+5*	.37	9.37E+4*	-8.47E+3	.70*	.78	.23
.30	2.33E+4	1.22E+5*	.27	7.10E+4*	3.07E+4	.58*	.82	-.08
.40	8.58E+3	1.45E+5*	.10	4.27E+4	7.98E+4	.38	.96	-.41

Table 4: Thompson and Bell Yeild Per Recruit for 4VWX Silver Hake.

SUMMARY:

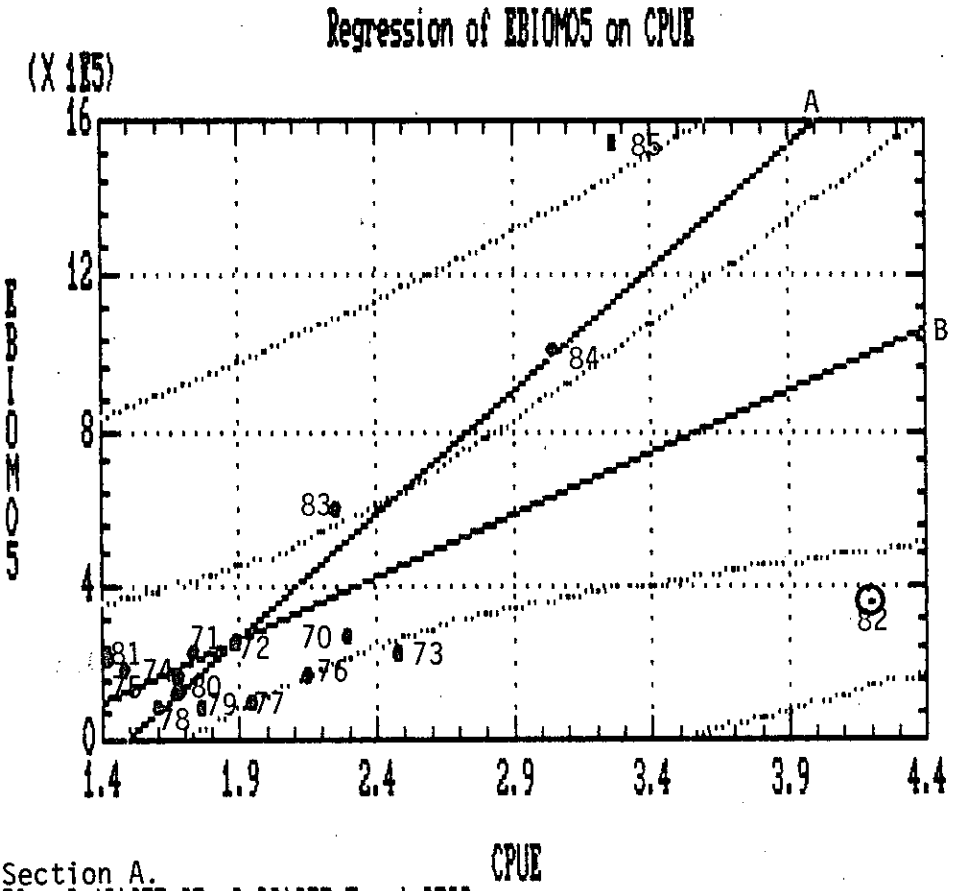
AGE	WEIGHT-AT-AGE	PARTIAL RECRUITMENT
1	.053	.041
2	.140	.304
3	.208	1.000
4	.262	1.000
5	.331	1.000
6	.402	1.000
7	.545	1.000
8	.717	1.000
9	.841	1.000

NATURAL MORTALITY RATE : 0.4
F0.1 COMPUTED AS .4738 AT Y/R OF .0634
FMAX COMPUTED AS 2.5354 AT Y/R OF .0769

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	.1000	.104	.028	.271	2.107
	.2000	.177	.044	.251	1.658
	.3000	.230	.054	.235	1.347
	.4000	.271	.060	.222	1.125
F0.1---	.4738	.295	.063	.215	1.000
	.5000	.303	.064	.212	.961
	.6000	.329	.067	.204	.837
	.7000	.351	.069	.197	.740
	.8000	.370	.071	.191	.662
	.9000	.387	.072	.186	.599
	1.0000	.401	.073	.182	.546
	1.1000	.414	.074	.178	.501
	1.2000	.425	.074	.175	.464
	1.3000	.436	.075	.172	.431
	1.4000	.445	.075	.169	.402
	1.5000	.454	.076	.167	.377
FMAX---	2.5354	.518	.077	.148	.227

Figure 1. Tuning plots for Silver Hake at F_t=0.05. The 1982 point is removed in section A.



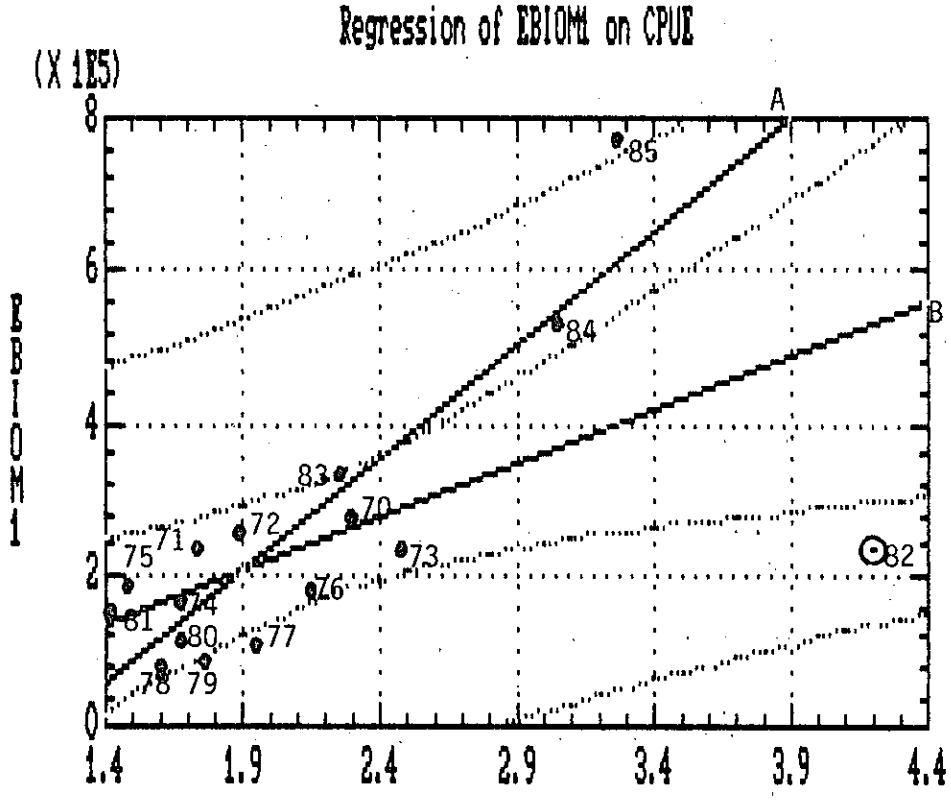
Section A.

B0: -9.4916E5 SE: 2.2313E5 T: -4.2538
B1: 6.375E5 SE: 1.0574E5 T: 6.0291
CORR: 0.85824 MSE: 4.67E10 DF: 13
POINTS DELETED: 1982

Section B.

B0: -3.36E5 SE: 2.5286E5 T: -1.3288
B1: 3.1714E5 SE: 1.1008E5 T: 2.8809
CORR: 0.61008 MSE: 1.0337E11 DF: 14
POINTS DELETED: none

Figure 2. Tuning plots for Silver Hake at F_t=0.10. The 1982 point is removed in section A.



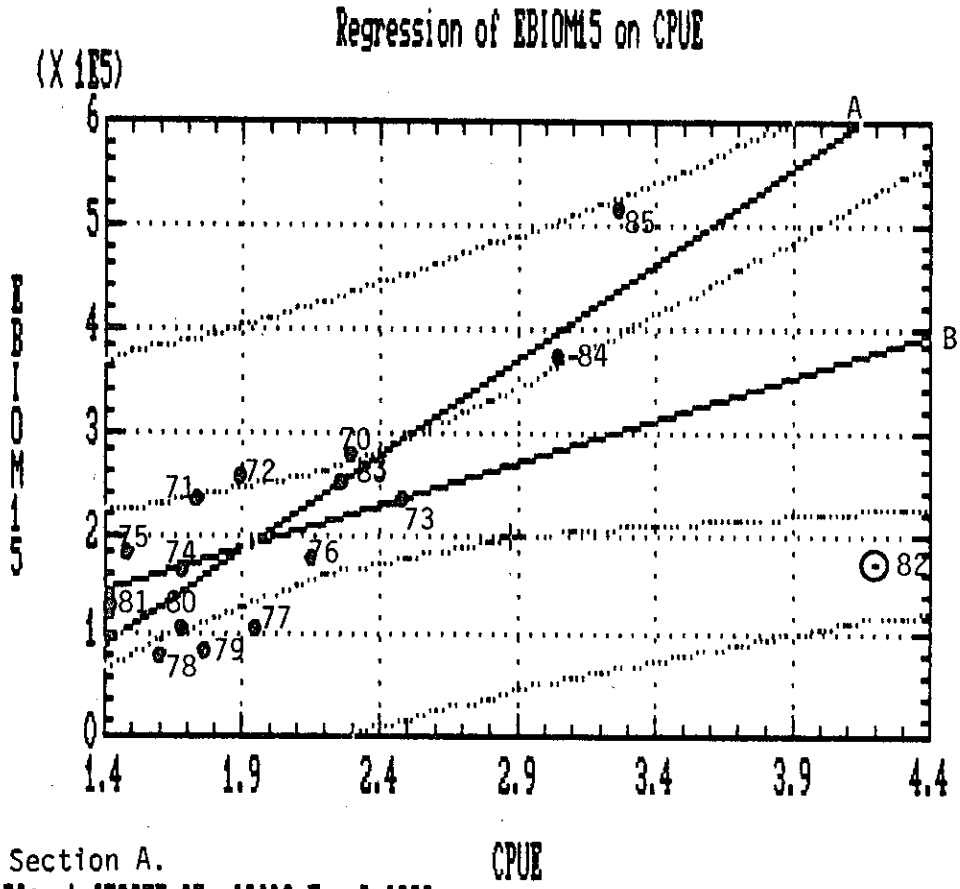
Section A.

B0: -3.6125E5 SE: 93925 T: -3.8461
B1: 2.9765E5 SE: 44509 T: 6.6873
CORR: 0.88021 MSE: 8.2748E9 DF: 13
POINTS DELETED: 1982

Section B.

B0: -61338 SE: 1.1676E5 T: -0.52535
B1: 1.4095E5 SE: 50830 T: 2.773
CORR: 0.59542 MSE: 2.2039E10 DF: 14
POINTS DELETED: none

Figure 3. Tuning plots for Silver Hake at F_t=0.15. The 1982 point is removed in section A.



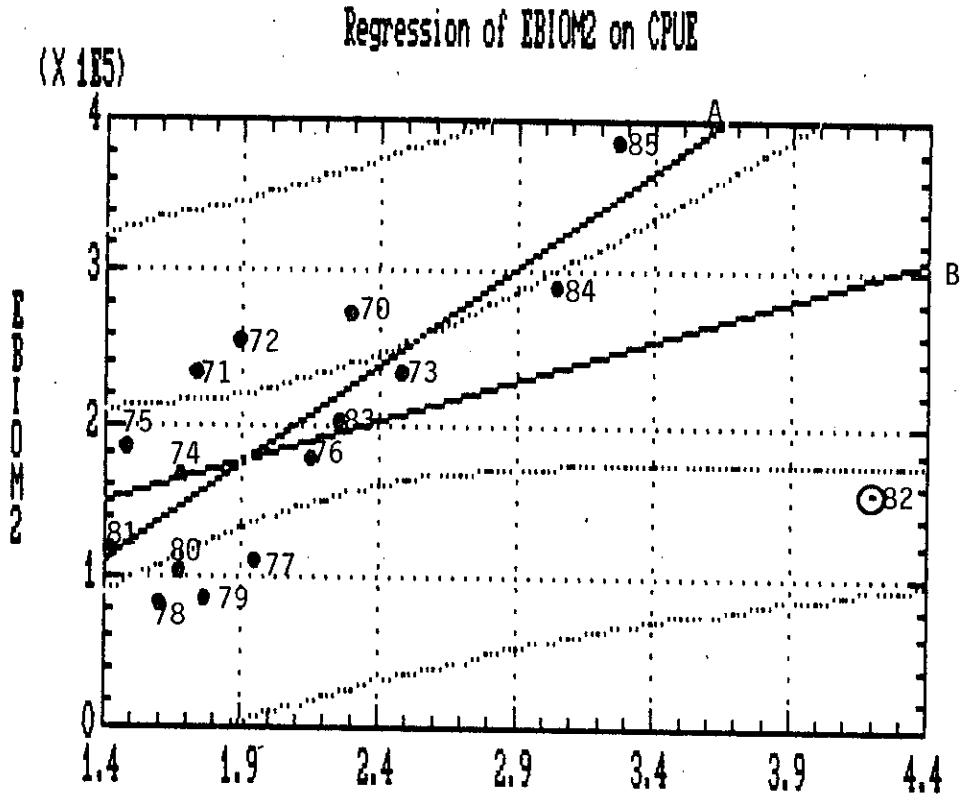
Section A.

BO: -1.6528E5 SE: 62608 T: -2.6399
B1: 1.8435E5 SE: 29669 T: 6.2136
CORR: 0.86493 MSE: 3.6767E9 DF: 13
POINTS DELETED: 1982

Section B.

BO: 30287 SE: 76730 T: 0.39472
B1: 82171 SE: 33404 T: 2.4599
CORR: 0.54935 MSE: 9.518E9 DF: 14
POINTS DELETED: none

Figure 4. Tuning plots for Silver Hake at F_t=0.20. The 1982 point is removed in section A.



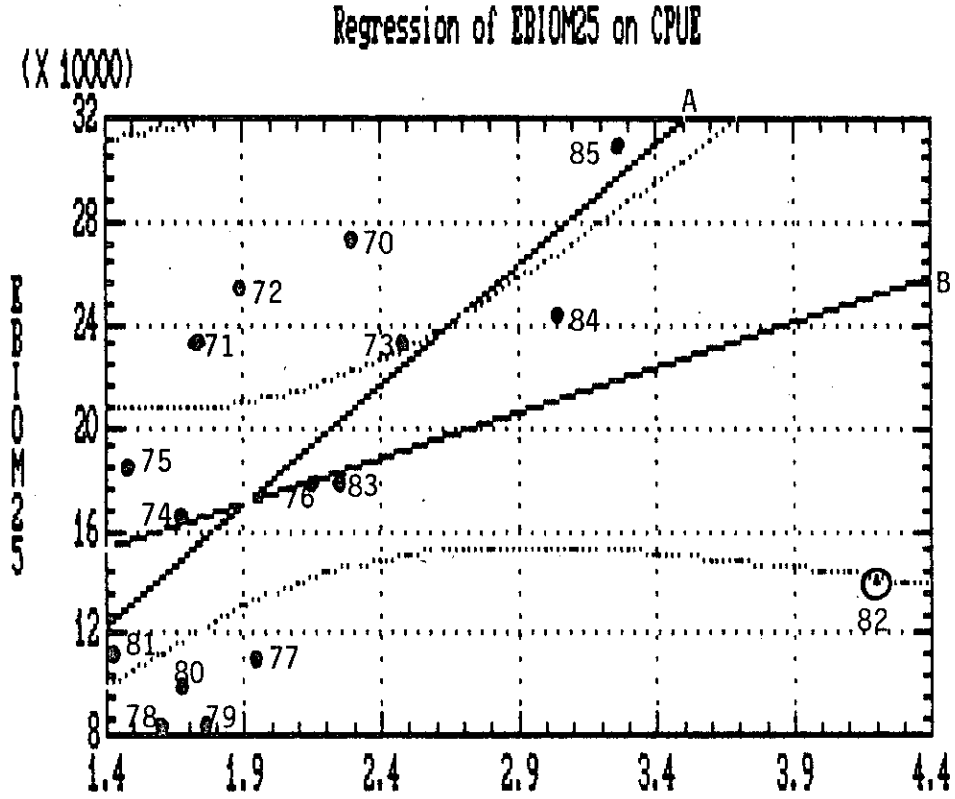
Section A.

BO: -67281 SE: 55784 T: -1.2061
B1: 1.2769E5 SE: 26435 T: 4.8303
CORR: 0.80137 MSE: 2.9189E9 DF: 13
POINTS DELETED: 1982

Section B.

BO: 76135 SE: 60885 T: 1.2505
B1: 52758 SE: 26506 T: 1.9904
CORR: 0.46964 MSE: 5.993E9 DF: 14
POINTS DELETED: none

Figure 5. Tuning plots for Silver Hake at F_t=0.25. The 1982 point is removed in section A.



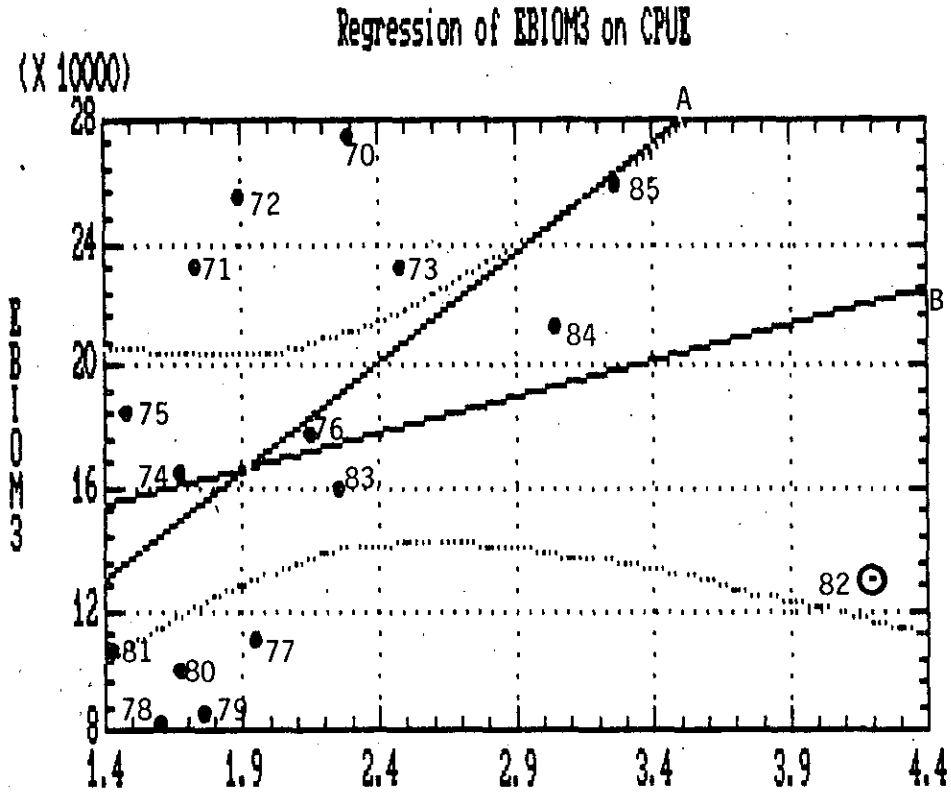
Section A.

B0: -8472.8 SE: 56156 T: -0.15088
B1: 93685 SE: 26611 T: 3.5205
CORR: 0.69862 MSE: 2.9579E9 DF: 13
POINTS DELETED: 1982

Section B.

B0: 1.0366E5 SE: 54224 T: 1.9117
B1: 35097 SE: 23607 T: 1.4868
CORR: 0.36927 MSE: 4.7535E9 DF: 14
POINTS DELETED: none

Figure 6. Tuning plots for Silver Hake at F_t=0.30. The 1982 point is removed in section A.



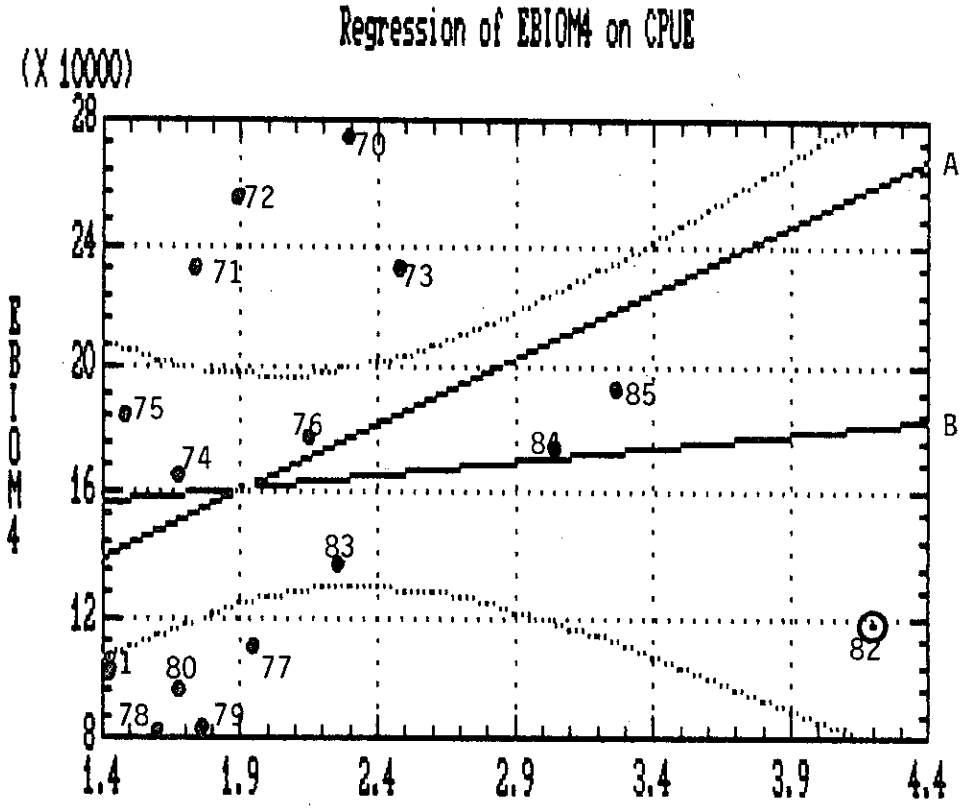
Section A.

B0: 30740 SE: 58316 T: 0.52713
B1: 71011 SE: 27635 T: 2.5696
CORR: 0.58038 MSE: 3.1898E9 DF: 13
POINTS DELETED: 1982

Section B.

B0: 1.2202E5 SE: 51525 T: 2.3683
B1: 23317 SE: 22431 T: 1.0395
CORR: 0.26768 MSE: 4.2919E9 DF: 14
POINTS DELETED: none

Figure 7. Tuning plots for Silver Hake at F_t=0.40. The 1982 point is removed in section A.



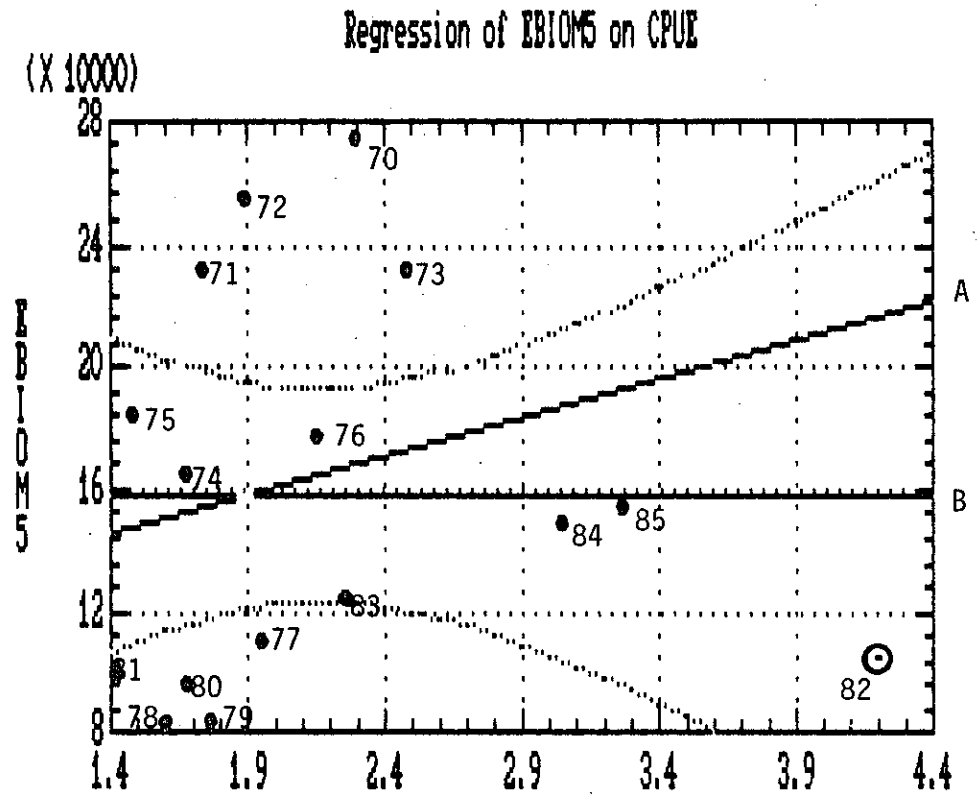
Section A.

B0: 79766 SE: 62903 T: 1.2681
B1: 42662 SE: 29809 T: 1.4312
CORR: 0.36894 MSE: 3.7115E9 DF: 13
POINTS DELETED: 1982

Section B.

B0: 1.4499E5 SE: 50515 T: 2.8702
B1: 8584.6 SE: 21992 T: 0.39036
CORR: 0.10376 MSE: 4.1253E9 DF: 14
POINTS DELETED: none

Figure 8. Tuning plots for Silver Hake at F_t=0.50. The 1982 point is removed in section A.



Section A.

BO: 1.0918E5 SE: 66499 T: 1.6419
B1: 25652 SE: 31512 T: 0.81403
CORR: 0.22023 MSE: 4.1479E9 DF: 13
POINTS DELETED: 1982

Section B.

BO: 1.5877E5 SE: 51237 T: 3.0988
B1: -256.71 SE: 22306 T: -0.011509
CORR: -3.0758E-3 MSE: 4.2441E9 DF: 14
POINTS DELETED: none