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Silver Hake (*Merluccius bilinearis*) in Division 4VWX: A Stock Assessment and Estimate of the Total Allowable Catch (TAC) for 1981

by

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Introduction

The silver hake (Merluccius bilinearis) stock of NAFO division 4VWX has had an extremely variable history during the past twenty years. Catches have ranged from nearly 300,000 tonnes in 1973 to 3,000 tonnes in both 1967 and 1968. The last three years (1977-1979) have seen a stabilization at approximately 50,000 tonnes. The provisional catch for 1979 is 51,735. Although the quota's of the last 3 years have not been filled this has been, to a certain extent, the result of national allocations and not a lack of stock abundance. The USSR has filled its national allocation in both 1978 and 1979 while Canada and Cuba have both fallen far short on filling their allocations.

Catches

Provisional catch statistics were taken from NAFO Circular Letters (monthly), FLASH data system, and the Statistics Branch, Department of Fisheries and Oceans, Canada (Table 1).

Catch-at-age

Length frequency samples were summarized by country on a monthly basis from May until November from data of the International Observer Program (IOP). For March and April (prior to commencement of IOP monitoring) Soviet samples have been provided for NAFO and are available. These samples were weighted by month for sexes combined where possible. The resulting catch-at-length matrix was broken down by an age-length-key provided by the Aging Unit, Marine Fish Division, St. Andrews Biological Station, New Brunswick, Canada. The otoliths for this key were collected by the IOP.

Previous assessments (Clay, 1979 and Clay, 1980) have used catch-at-age tables including only ages 1 to 6+. As age-length-keys are now available for fish over age 6, the catch-at-age table for this assessment has been expanded to include these older age groups. The catch-at-age table (Table 2) uses the historic catch-at-length data however it is now broken down to ages 1 to 10+. (The catch-at-age length data has been adjusted by the weight-at-age data see below).

Weight-at-age

The weight-at-age for ages 1 to 9 and 10+ have been calculated for all years (1958-1979) (Table 3). These weights were multiplied by the catch-at-age to give the catch biomass-at-age (Table 4). Clay (1980) showed how there was some variation between the nominal reported catch

and the catch biomass as calculated above. This difference could be due to either error in the weight-at-age (caused by sampling errors) or errors in reporting of catch data. In order to standardize the tables with reported NAFO data the catch-at-length data were adjusted by the ratio of these two values to reduce the difference between the nominal catch and the catch biomass.

The weight-at-age pattern appears slightly different for 1979 compared to recent years. The point where year-class growth is less than natural mortality has shifted from 3 to 4 years of age to 2 to 3 years of age. As such a change is more likely due to sampling errors than a change in growth, the weight of 2 year olds used for this assessment was taken as the mean of 1976 to 1978 levels.

Age	1	2	3	4	5	6+	7	8	9	10+
1980 Weight (kg)	.050	.130	.200	.250	.315	.500				
1981 Weight (kg)	.061	(.135)	.200	.245	.285	.344	.411	.520	.553	1.189

Natural Mortality

The natural mortality used in previous assessments (M = 0.4) was based on work done by Terre and Mari (1977) on the earlier catch at age table of Doubleday et al. (1976). The same M is used for this assessment as for the last.

Virtual Population Analysis (VPA)

Arbitrary partial recruitments (PR) were applied to the last year of fishing and the oldest age groups. From these, improved estimates of the PR were obtained and the starting fishing mortalities (F) calculated from the effort - F relationship of Clay (1980). This value of F was adjusted until the relationship between F weighted by population numbers and effort (f) reached its highest value. At this stage (F = 0.2) the biomass versus CPUE relationship was very poor. To improve this, the terminal F was raised to 0.35 and the F versus effort relationship remained almost as good as before. The final partial recruitment (normalized to 1 at the highest fishing mortality) was then calculated from 1977 and 1978 data (Figure 1). A longer series of years was not used as the F table generated from these calculations showed PR pattern in 1977 and 1978 had departed from the pattern of previous years (Table 5). An upwards shift of one year has occurred in the fully recruited age groups. Taking this shift into account a normalized partial recruitment was chosen as follows:-

Age	1	2	3	4	5	6+	7	8	9	10+
1980 NPR	0.05	0.52	1.0	0.97	0.75	0.65				
1981 NPR	0.035	0.5	1.0	0.7	0.6	0.6	0.55	0.5	0.45	0.4

Population Biomass and Problems Associated with its Derivation

Since the first Canadian assessment on silver hake (Halliday, 1973) analysts have commented on the difficulty in projecting catches. This was due mainly to the catch of such a short-lived species being dependent on 1 or 2 year-classes. With small mesh gear, this dependence was on age groups 2 and 3 (Figure 2, Table 4). As recruitment estimates have always been a problem, it was extremely difficult to predict more than 1 year ahead with any certainty. Looking back through a VPA table much of this problem is resolved and an indication of stock biomass can be arrived at for past years (Table 6). Three past VPA's show different absolute values, however the trends in biomass appear similar (Halliday, 1973; Halliday et al. 1978; Clay, 1979). The CPUE (Table 6) does not bear a good relationship to biomass estimates (index) derived from VPA's (VPA =-0.19 + 0.44 CPUE; r^2 = 0.23, n = 14) or R/V surveys (R/V = 24.2 + 25.9 CPUE; r^2 = 0.32, n = 10) (Table 6; Figure 3). This is true with both unadjusted and adjusted CPUE data. One factor aiding in the breakdown of this relationship may have been the behaviour of the fishermen. The

Soviet fishing fleet prior to regulation in 1977 tended to maintain a catch of approximately 2.6 tonnes per hour irrespective of species makeup - this effectively destroys any chance of low biomass levels showing up in the effort statistics although it may be indicated in the catch statistics.

The effort bears an interesting relationship to the VPA biomass index (Figure 4). The relationship is not good when taken for each individual year, however when the effort is lagged one year it improves.

(straight) Index = $0.24 + 5.59 \times 10^{-4}$ Effort, $r^2 = 0.46$, $n = 16$
(lagged) Index = $0.19 + 6.48 \times 10^{-4}$ Effort, $r^2 = 0.61$, $n = 15$

This indicates that the abundance index (often related to catch and/or catch rate) of one year may have been used to indicate what effort of distant water fleets should be committed in the next year.

Assuming that the trends in VPA biomass index represent the true biomass, we can observe changes in the population of hake since the early 1960's. All past data series indicate a peak in biomass in 1970 with the next three years being consistently high, following this a stabilization occurred from 1974 to date at a lower level.

The population biomass of the current stock assessment does have a better relationship to the CPUE than did the index of previous assessments. The VPA biomass of the current assessment agrees with the trends in the index of earlier years up to the mid 1970's, since that time the current assessment indicates a stabilization at a higher level than past assessments.

Validation of the VPA

The fishing mortality weighted by the population numbers was plotted against effort[1] (f) (Figure 5). The geometric regression (GM) with the years 1963 to 1965 ommitted is:

$$F_{pop} = -0.02 + 5.3 \times 10^{-6} f; \ (r^2 = 0.94, n = 15)$$

The catch per unit effort (CPUE) estimated from that part of the USSR fleet with Canadian observers on board was 2.0 tonnes per hour (Waldron and Sinclair, 1980). This is considerably higher than the 1.3 tonnes per hour CPUE of 1978 (Clay, 1979) although closer to the CPUE reported by the IOP for 1978 (1.8 tonnes/hr). Assuming a direct relationship based on 1978 data a value of 1.5 was chosen for 1979 to correspond to the historic data base. The chosen CPUE for 1979 gives an estimated effort of approximately 35,000 hours. This value puts the 1979 point for the fully recruited F for the PR's used at 0.35.

The population biomass regressed against the CPUE in tonnes (see Figure 6) gives the GM equation (1968 to 1978 omitting 1974 data):-

$$\text{CPUE} = 0.78 + 1.9 \times 10^{-6} \text{ BIOMASS}; \ (r^2 = 0.73, n = 11)$$

Yield Per Recruit

The yield per recruit (YPR) using the Thompson and Bell model is 0.064 kg at a fully recruited $F_{0.1}$ of 0.65. The F_{max} is 3.6 with a YPR of 0.076 kg.

Recruitment

Prediction of future year-class strength has always proved difficult to achieve. With silver hake, prior to 1978, recruitment was

[1] Effort in this case is the effort of Table 6 adjusted by the Chikuni (1976) method to an assumed 70% directed fishery for silver hake.

the single most important factor in catch projections. This was because two year-classes (2 and 3 year olds) have generally made up over 75% of the catch composition and before 1976 age 2 fish made up approximately 70% of the catch. Clay (1979) used a relationship between the natural logarithm of squid numbers in any year to the number of one year olds in the VPA of the following year to predict recruitment. This relationship appeared to hold with the addition of the 1979 data (Clay, 1980). However the new catch data for the current assessment does not appear to support this relationship. In this assessment, although recruitment is useful, it is no longer vital as the catch biomass has shifted to the 3 and 4 year olds. Clay (1980) showed how raising recruitment by 13% only increased the catch by 0.6%.

Catch Projection

Using a recruitment of 1.0×10^9 fish, the geometric mean of the previous 5 years, a catch projection was run with the following parameters:-

Numbers-at-age (79)	- Table 5
Catch-at-age (79)	- Table 2
Weight-at-age	- see text
Partial recruitment	- see text
$F_{0.1}$	- 0.65
M	- 0.4

The results give an $F_{0.1}$ catch for 1981 of 72,000 tonnes assuming the full TAC for 1980 (90,000 tonnes) is taken (Table 7). To indicate the effect of different levels of $F_{0.1}$ a series of catch projections were run with F values between 0.4 and 1.4 (Figure 7). The relationship between F and catch appears to be nearly linear. If we assume the catch in 1980 will be at the $F_{0.1}$ level (80,000 tonnes) the projected $F_{0.1}$ catch in 1981 would be 74,000 tonnes. If, due to national allocation, the 1980 catch is below the $F_{0.1}$ level and is in effect about 60,000 tonnes, the projected $F_{0.1}$ catch for 1981 would be in the range of 80,000 tonnes.

Discussion

The catch projection for 1981 assuming the full quota of 1980 (90,000 tonnes) is taken is 72,000 tonnes. This is lower than the earlier projections of Clay (1980). This change is due to higher F values in the last year. These higher F's were derived by tying the CPUE versus biomass relationship in with the weighted F versus effort relationship. Because of the shift in partial recruitment away from the one year olds (see Table 4) the recruitment now has less effect on the catch projection of the year in question. A series of projections indicate the catch levels resulting from different recruitment regimes (Figure 8).

Acknowledgements

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Table 1. Provisional catch statistics (1979) from ICNAF Circular Letters, FLASH statistics and Statistics Branch, Halifax.

SILVER HAKE CATCH (TONNES)

COUNTRY	National Allocation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
CANADA	10,000			8				87[a]	56[a]	1		1		160
USSR	44,940				2,190	12,932	14,947	11,617	2,541	849				45,076
CUBA	8,070					23	209	483	266	173	258	360		1,798
BULGARIA	6,860						2,387	2,156	96					4,639
JAPAN	-							13	7	5	23	2		50
FRANCE (SPM)	100													-
USA	2													
OTHER	30													12[b]
TOTALS	70,002			8	2,190	12,955	17,543	14,356	2,966	892	281	363		51,735

a - Japanese developmental charters from Canada.

b - Taken from Flash Information System. Total represents the by-catches from Fed. Rep. Germany, Italy, Poland and Spain

Note: Totals do not always add up as the highest level was chosen if more than one etimate was available.

Table 2. Catch-at-age table for 4VWX silver hake (1958-1979). Numbers of fish are in thousands.

Catch at age for silver hake from NAFO divisions 4VWX.

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	46	2529	270	2	18946	48573	19070	6547	8371	89	2270	27836	187298	219607	379314	245401	101158	144956	153535	2131	28807	9681
2	160	8527	914	7	52677	388718	232433	115396	31209	5398	14130	189232	748021	410149	460610	1478425	390044	365624	381651	43528	91101	48413
3	39	2252	239	1	7412	157119	121703	82387	14964	3607	4831	72147	216246	175005	71536	96490	150741	52788	72418	78226	90036	69161
4	16	986	102	1	2158	72382	50964	37225	7009	1779	1616	21971	59832	74755	47903	106351	7095	60750	31295	29556	43031	46616
5	6	392	39	1	714	32474	20575	14303	2672	855	627	6200	20695	22035	17822	96646	9789	38610	5582	6980	19511	29700
6	1	162	15	1	246	15902	9402	6083	1063	442	312	2038	9636	1877	7452	19611	3245	4799	2669	2004	8618	16989
7	1	44	4	1	67	5087	2971	1781	289	136	99	571	3608	5139	1160	15157	93	311	514	483	3234	5087
8	1	12	1	1	18	2214	1146	588	78	54	32	143	1988	1333	437	5458	109	363	105	564	2016	1768
9	1	4	1	1	4	1121	570	209	20	20	9	29	1114	2062	607	483	60	360	390	522	421	1153
10	1	2	1	1	2	808	350	78	9	10	2	16	580	1900	2000	816	77	1000	82	1	645	490

Table 3. Weight-at-age table for 4VWX silver hake (1958-1979). Weights are expressed in kg.

Weight at age for silver hake from NAFO divisions 4VWX.

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0.076	0.077	0.077	0.039	0.077	0.081	0.077	0.067	0.072	0.078	0.073	0.062	0.060	0.040	0.056	0.045	0.063	0.067	0.063	0.062	0.049	0.061
2	0.112	0.113	0.113	0.096	0.104	0.129	0.140	0.151	0.128	0.150	0.128	0.133	0.126	0.128	0.119	0.128	0.129	0.155	0.148	0.147	0.110	0.154
3	0.178	0.184	0.183	0.001	0.160	0.189	0.189	0.195	0.195	0.196	0.175	0.175	0.167	0.188	0.209	0.216	0.204	0.243	0.246	0.210	0.174	0.200
4	0.232	0.241	0.239	0.001	0.216	0.251	0.241	0.240	0.240	0.259	0.233	0.214	0.222	0.254	0.240	0.250	0.310	0.237	0.273	0.290	0.226	0.245
5	0.225	0.282	0.276	0.001	0.256	0.313	0.302	0.288	0.278	0.322	0.309	0.250	0.303	0.315	0.274	0.295	0.396	0.477	0.407	0.397	0.283	0.285
6	0.001	0.316	0.279	0.001	0.304	0.373	0.362	0.336	0.311	0.376	0.376	0.290	0.404	0.450	0.557	0.439	0.539	0.457	0.528	0.516	0.329	0.344
7	0.001	0.316	0.226	0.001	0.310	0.407	0.391	0.359	0.324	0.389	0.382	0.293	0.470	0.587	0.483	0.485	0.975	1.133	0.836	0.667	0.382	0.411
8	0.001	0.301	0.001	0.001	0.331	0.550	0.508	0.418	0.340	0.446	0.417	0.351	0.705	0.832	1.263	0.875	1.156	1.257	1.251	1.077	0.498	0.520
9	0.001	0.284	0.001	0.001	0.284	0.719	0.721	0.518	0.371	0.445	0.406	0.451	0.928	0.612	0.886	1.174	0.001	1.635	0.859	1.089	0.784	0.553
10	0.001	0.149	0.001	0.001	0.149	0.735	1.031	0.410	0.265	0.417	0.149	0.298	0.875	0.712	0.001	1.726	1.508	0.946	1.818	0.001	0.659	1.189

Table 4. Catch biomass-at-age table for 4VWX silver hake (1958-1979). Biomass is expressed in tonnes.

Biomass at age for silver hake from NAFO divisions 4VWX.

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	3	195	21	0	1459	3934	1468	439	603	7	166	1726	11238	8784	21242	11043.	6373	9712	9673	132	1412	591
2	18	964	103	1	5478	501645	32541	17425	3995	810	1809	25168	94251	52499	54813	189238	50316	56672	56484	6399	100210	7456
3	7	414	44	0	1186	29695	23002	16065	2918	707	845	12626	36113	32901	14951	20842	30751	12827	17815	16427	15867	13832
4	4	238	24	0	466	18168	12282	8934	1682	461	377	4702	13283	10988	11497	26588	2199	14398	8544	8571	9725	11421
5	1	111	11	0	183	10164	6214	4119	743	275	194	1550	6271	6941	4883	28511	3876	18417	2272	2771	5522	8464
6	0	51	4	0	75	5931	3404	2044	331	166	117	591	3893	845	4151	8609	1749	2193	1409	1034	2835	5844
7	0	14	1	0	21	2070	1162	639	94	53	38	167	1696	3017	560	7351	91	352	431	322	1235	2091
8	0	4	0	0	6	1218	582	246	27	24	13	50	1402	1109	552	4776	126	456	131	607	1004	919
9	0	1	0	0	1	806	411	108	7	9	4	13	922	1262	538	567	0	589	335	568	330	638
10	0	0	0	0	0	594	361	32	2	4	0	5	595	1353	2	1408	116	946	149	0	425	583

Table 5. The population numbers (in thousands) and the fishing mortality of 4VWX silver hake (1958-1979). For input parameters see text.

VPA POPULATION NUMBERS 2/ 6/80

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	207979	309748	497981	884720	1388140	1005653	432102	307261	435594	857105	1496175	2678718	1737348	1898440	3977755	1758675	2003278	2174880	1362326	791331	577548	964344
2	68822	139375	205574	333587	593044	915098	634684	274165	200643	285185	574462	1001070	1772969	1012954	1094846	2359125	980507	1260738	1340302	788930	528712	363762
3	30195	46002	86509	137057	223604	354848	304436	239931	92030	109287	186778	373593	518445	593766	352525	367671	428116	346622	551890	592276	493515	280881
4	15391	20208	29009	57794	91871	143867	113145	107159	94977	49607	70328	121276	192261	175544	257709	178661	168955	166553	189703	311381	333758	258182
5	8419	10304	12746	19362	38740	59830	39264	35414	42084	57982	31808	45829	63570	80956	58256	134113	36504	107494	63153	101896	184784	188923
6	835	5638	6589	8512	12978	25388	14547	10098	12352	26042	38172	20812	25707	26052	36577	24772	15486	16609	41225	37810	62642	108068
7	399	559	3648	4404	5705	8499	4613	2435	2011	7419	17097	25334	12300	9546	15941	18514	1710	7767	7285	25469	23718	35023
8	120	267	339	2442	2951	3770	1716	780	263	1114	4862	11380	16518	5352	2353	9745	974	1071	4954	4466	16680	13284
9	16	80	169	227	1636	1964	792	261	72	114	703	3233	7512	9464	2516	1224	2244	565	428	3235	2538	9550
10	7	10	50	113	151	1093	437	92	17	33	60	464	2144	4135	4683	1198	436	1455	98	3	1747	1361
	332182	532191	842613	1448218	2358821	2520009	1545736	977595	880043	1393887	2420446	4281710	4348775	3816208	5803161	4853698	3638210	4083753	3561363	2656796	2225642	2223378

VPA FISHING MORTALITY 2/ 6/80

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0.000	0.010	0.001	0.000	0.017	0.060	0.055	0.026	0.024	0.000	0.002	0.013	0.139	0.150	0.122	0.184	0.063	0.084	0.146	0.003	0.062	0.012
2	0.003	0.077	0.005	0.000	0.114	0.701	0.573	0.692	0.208	0.023	0.030	0.258	0.694	0.656	0.691	1.307	0.640	0.426	0.417	0.069	0.233	0.175
3	0.002	0.061	0.003	0.000	0.041	0.743	0.644	0.527	0.218	0.041	0.032	0.264	0.683	0.435	0.280	0.378	0.544	0.203	0.172	0.174	0.248	0.350
4	0.001	0.061	0.004	0.000	0.029	0.899	0.762	0.535	0.093	0.044	0.028	0.246	0.465	0.703	0.253	1.188	0.052	0.570	0.222	0.122	0.169	0.245
5	0.001	0.047	0.004	0.000	0.023	1.014	0.958	0.653	0.080	0.018	0.024	0.178	0.492	0.394	0.455	1.759	0.387	0.558	0.113	0.087	0.136	0.210
6	0.001	0.035	0.003	0.000	0.023	1.305	1.388	1.214	0.110	0.021	0.010	0.126	0.591	0.091	0.281	2.273	0.290	0.424	0.082	0.066	0.181	0.210
7	0.003	0.100	0.001	0.000	0.014	1.200	1.378	1.825	0.190	0.022	0.007	0.028	0.432	1.001	0.092	2.545	0.068	0.050	0.089	0.023	0.180	0.192
8	0.010	0.056	0.004	0.000	0.007	1.160	1.483	1.975	0.438	0.060	0.008	0.015	0.157	0.355	0.253	1.069	0.145	0.518	0.026	0.165	0.158	0.175
9	0.080	0.063	0.007	0.005	0.003	1.104	1.752	2.351	0.401	0.237	0.016	0.011	0.197	0.303	0.342	0.633	0.033	1.350	4.532	0.216	0.223	0.157
10	0.068	0.103	0.008	0.004	0.005	1.132	1.618	2.216	0.468	0.178	0.014	0.014	0.186	0.340	0.298	0.853	0.086	0.878	2.028	0.192	0.234	0.140

Table 6. Indicators of 4VWX silver hake biomass in tonnes $x10^{-3}$, effort expressed in hours and CPUE in tonne/hr.

Year	VPA Halliday (1973)	VPA Halliday et al. (1978)	VPA Clay, 1979	R/V Survey Min. Trawable Biomass	Effort [1.] Adj. by gear	Effort [2.] Adj. to directed effort 70%	CPUE [3.] (adjusted)	Biomass Index [4.]	Current VPA
1963	162	-	-	-	55216	57593	-	0.79	-
1964	102	-	-	-	38675	33514	-	0.50	-
1965	58	-	-	-	44696	23934	2.09	0.28	149
1966	26	10	-	-	44175	9926	1.04	0.08	114
1967	30	18	-	-	3818	1602	1.55	0.11	176
1968	66	54	-	-	19295	2590	1.36	0.27	264
1969	139	164	-	-	36033	26608	1.75	0.65	421
1970	(205)	267	503	23.5	82710	98571	1.72	1.00	512
1971	(147)	238	431	7.9	100624	80710	1.59	0.82	417
1972	-	266	473	15.3	68313	60663	1.88	0.96	538
1973	-	318	441	38.2	128061	146382	2.04	(0.95)	577
1974	-	137	272	36.1	101283	43520	2.20	0.52	419
1975	-	165	298	7.5	94997	66449	1.75	0.60	536
1976	-	178	265	18.6	54430	55852	1.74	(0.60)	532
1977	-	(212)	222	8.2	20382	24372	1.44	(0.50)	465
1978	-	(295)	(228)	11.0	35154	36764	1.31	(0.45)	(341)
1979	-	-	(218)	36.3	(35000) [5.]	-	(1.5) [5.]	(0.43)	(353)
1980	-	-	-	-	-	-	-	-	-

Note:- Numbers in brackets are estimates and for a variety of reasons less confidence can be placed on these.

1. Effort is adjusted to USSR OTB 2.7 class trawlers.

2. Effort is adjusted to a directed fishery of 70% silver hake (see note 3).

3. CPUE is adjusted according to the effort necessary to generate a 70% catch of hake in a directed fishery. The method used was that proposed by Chikuni (1976).

4. The biomass index was calculated by dividing each series of VPA biomass estimates by the 1970 level (highest) and averaging the three normalized data series.

5. Provisional estimate (see text).

Table 7. The population, catch and fishing mortalites from a catch projection until 1985. (See text for input parameters.)

POPULATION NUMBERS 2/ 6/80

	1979	1980	1981	1982	1983	1984	1985
1	964344	1000000	1000000	1000000	1000000	1000000	1000000
2	363762	638549	653092	655242	655242	655242	655242
3	280881	204691	295075	316308	317350	317350	317350
4	258182	132679	65207	103258	110688	111053	111053
5	188923	135458	52835	27731	43914	47074	47229
6	108068	102652	58108	23979	12586	19930	21364
7	35023	58719	44035	26372	10883	5712	9045
8	13284	19366	26143	20645	12364	5102	2678
9	9550	7475	8949	12662	9999	5988	2471
10	1361	5469	3585	4477	6335	5003	2996
	2223378	2305056	2207028	2190675	2179361	2172454	2169429

POPULATION BIOMASS 2/ 6/80

	1979	1980	1981	1982	1983	1984	1985
1	58824.98	61000.00	61000.00	61000.00	61000.00	61000.00	61000.00
2	56019.35	98336.51	100576.11	100907.33	100907.33	100907.33	100907.33
3	56176.20	40938.13	59014.98	63261.67	63470.00	63470.00	63470.00
4	63254.59	32506.31	15975.64	25298.17	27118.62	27207.92	27207.92
5	53843.05	38605.64	15057.99	7903.42	12515.44	13416.04	13460.23
6	37175.39	35312.12	19989.12	8248.75	4329.49	6855.94	7349.29
7	14394.45	24133.46	18098.25	10838.88	4472.79	2347.62	3717.56
8	6907.68	10070.16	13594.55	10735.44	6429.36	2653.15	1392.55
9	5281.15	4133.64	4948.76	7002.02	5529.40	3311.51	1366.53
10	1618.23	6502.30	4262.68	5323.59	7532.36	5948.21	3562.33
	353495.08	351538.28	312518.09	300519.27	293304.79	287117.73	283433.75

CATCH NUMBERS 2/ 6/80

	1979	1980	1981	1982	1983	1984	1985
1	9681	21202	18553	18553	18553	18553	18553
2	48413	165501	150972	151469	151469	151469	151469
3	69161	90711	118744	127289	127708	127708	127708
4	46616	45158	19943	31581	33853	33965	33965
5	29700	40794	14245	7477	11840	12692	12734
6	16989	30914	15667	6465	3393	5374	5760
7	5087	16472	11039	6611	2728	1432	2267
8	1768	5019	6043	4772	2858	1179	619
9	1153	1772	1889	2672	2110	1264	522
10	490	1172	682	852	1206	952	570
	229058	418714	357777	357741	355719	354587	354167

CATCH BIOMASS 2/ 6/80

	1979	1980	1981	1982	1983	1984	1985
1	591	1293	1132	1132	1132	1132	1132
2	7456	25487	23250	23326	23326	23326	23326
3	13832	18142	23749	25458	25542	25542	25542
4	11421	11064	4886	7737	8294	8321	8321
5	8464	11626	4060	2131	3374	3617	3629
6	5844	10634	5389	2224	1167	1849	1982
7	2091	6770	4537	2717	1121	589	932
8	919	2610	3143	2482	1486	613	322
9	638	980	1044	1478	1167	699	288
10	583	1393	811	1013	1434	1132	678
	51838	90000	72001	69698	68043	66819	66152

FISHING MORTALITY 2/ 6/80

	1979	1980	1981	1982	1983	1984	1985
1	0.012	0.026	0.023	0.023	0.023	0.023	0.023
2	0.175	0.372	0.325	0.325	0.325	0.325	0.325
3	0.350	0.744	0.650	0.650	0.650	0.650	0.650
4	0.245	0.521	0.455	0.455	0.455	0.455	0.455
5	0.210	0.446	0.390	0.390	0.390	0.390	0.390
6	0.210	0.446	0.390	0.390	0.390	0.390	0.390
7	0.193	0.409	0.357	0.357	0.357	0.357	0.357
8	0.175	0.372	0.325	0.325	0.325	0.325	0.325
9	0.157	0.335	0.292	0.292	0.292	0.292	0.292
10	0.560	0.298	0.260	0.260	0.260	0.260	0.260

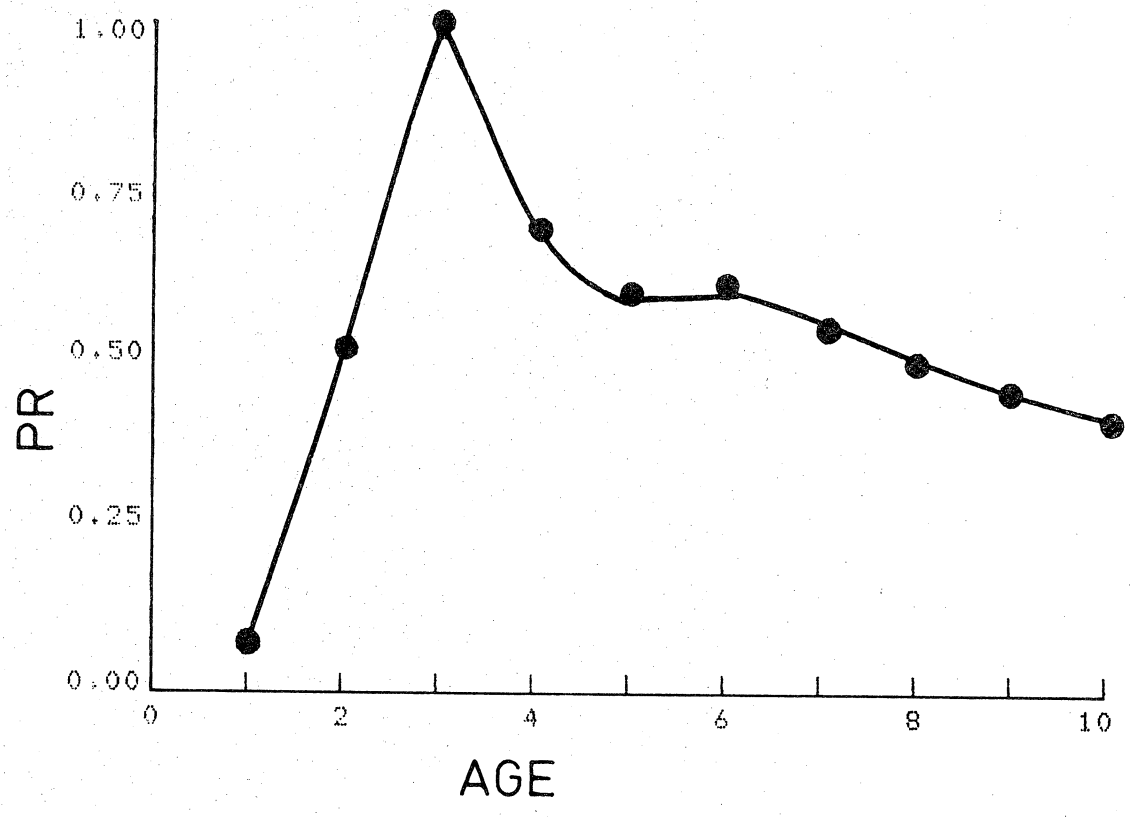

Figure 1. Partial recruitment of silver hake from 1977 and 1978 data (normalized to 1 for fully recruited age groups).

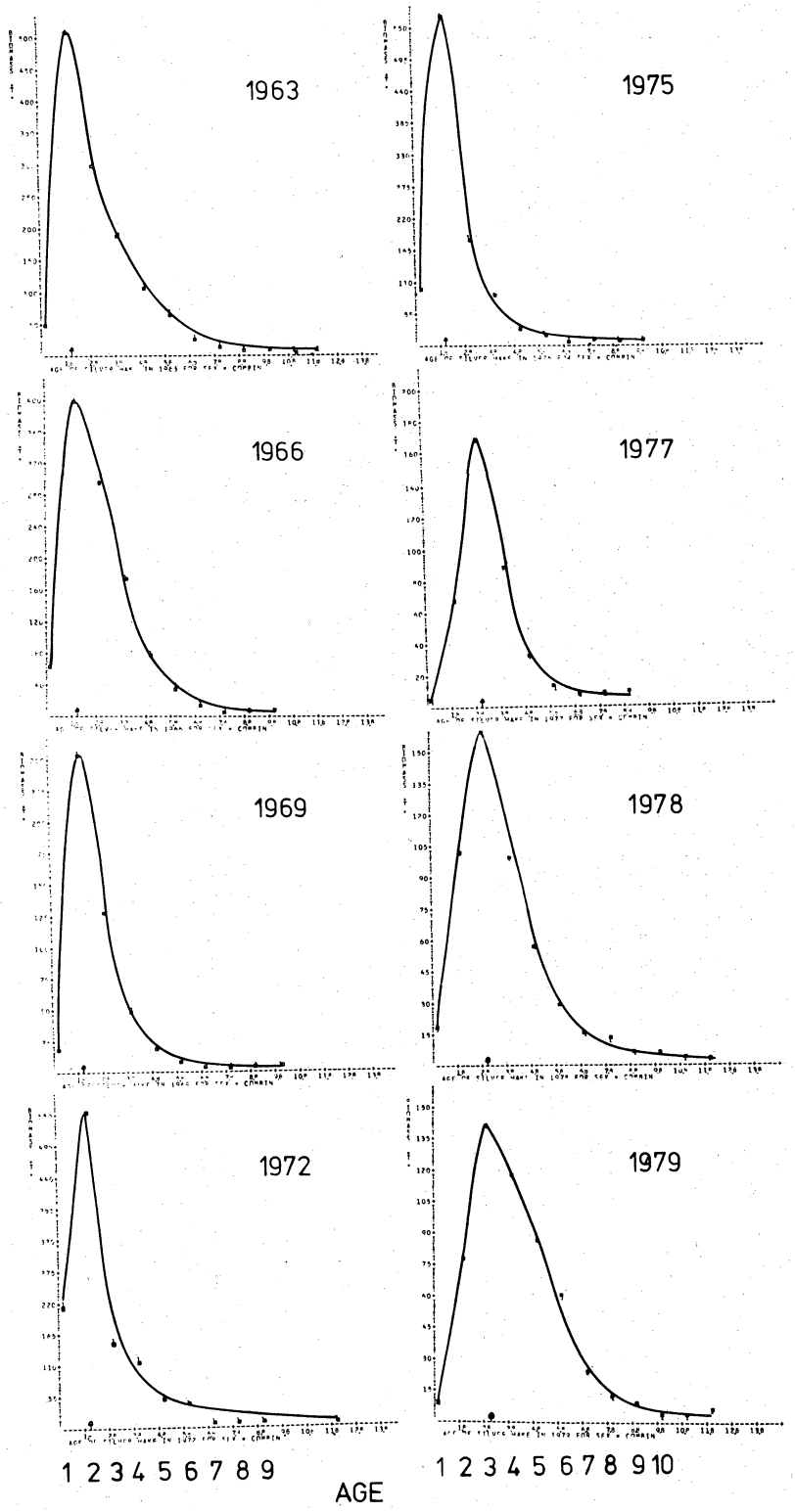

Figure 2. The catch biomass-at-age for silver hake from divisions 4VWX. (NOTE: each Y axis is at a different scale , the result giving all graphs approximately equal vertcal displacement.)

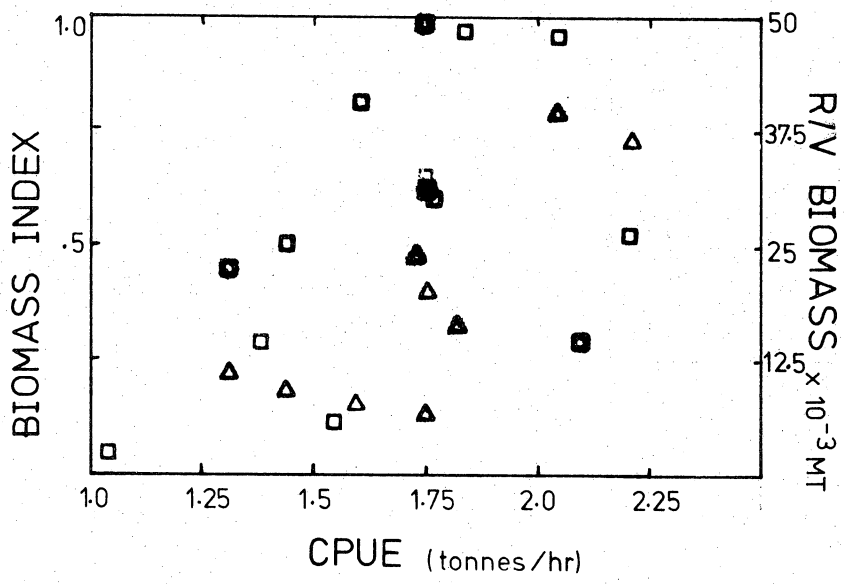

Figure 3. The VPA biomass index (see Table 6) □ and the Canadian R/V biomass △ plotted against the CPUE of USSR stern trawlers of tonnage class 7 adjusted to a directed fishery (Chikuni, 1976). See text.

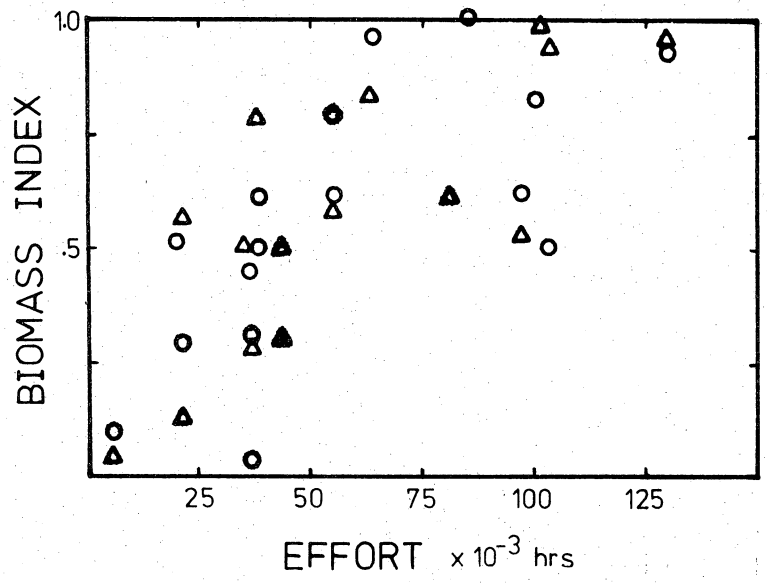

Figure 4. The VPA biomass index (see Table 6) plotted against effort in the same year ○ and in the next year △. See text.

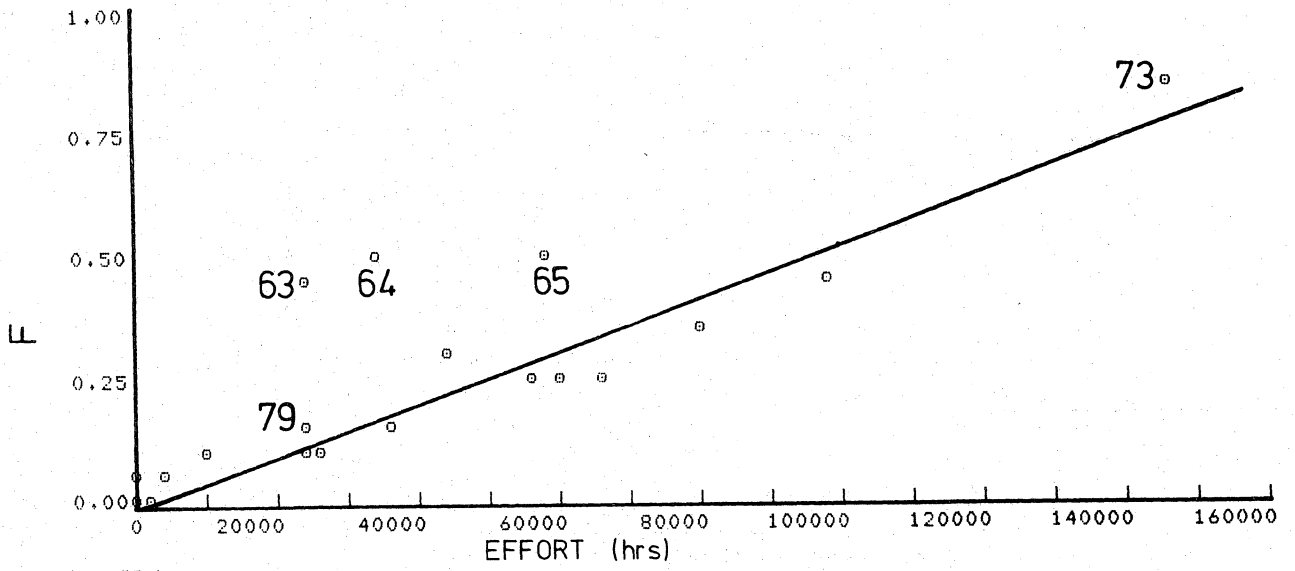

Figure 5. The fishing mortality weighted by population numbers and effort. The three years 1963 to 1965 have been omitted from the regression.

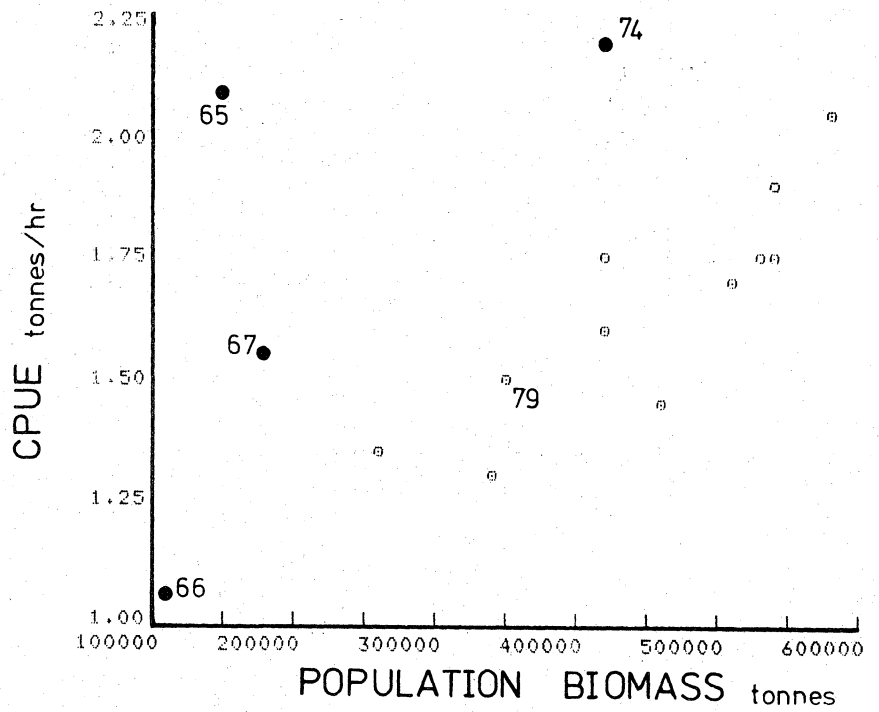

Figure 6. Population biomass of 4VWX silver hake and the CPUE (adjusted to a directed fishery).

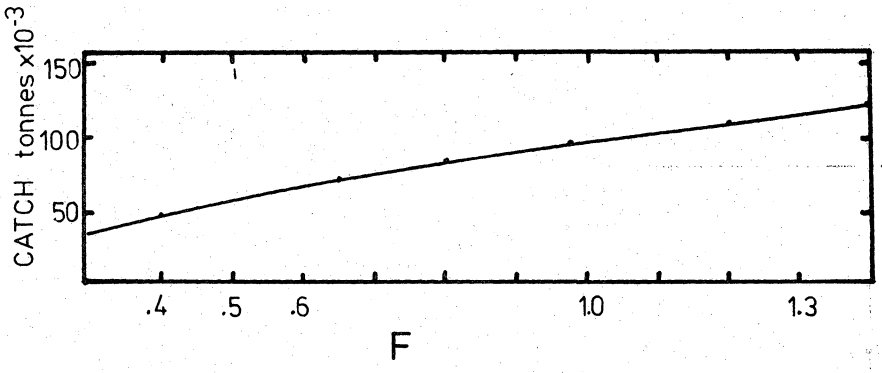

Figure 7. Catch projections for various levels of F all other parameters remaining equal.

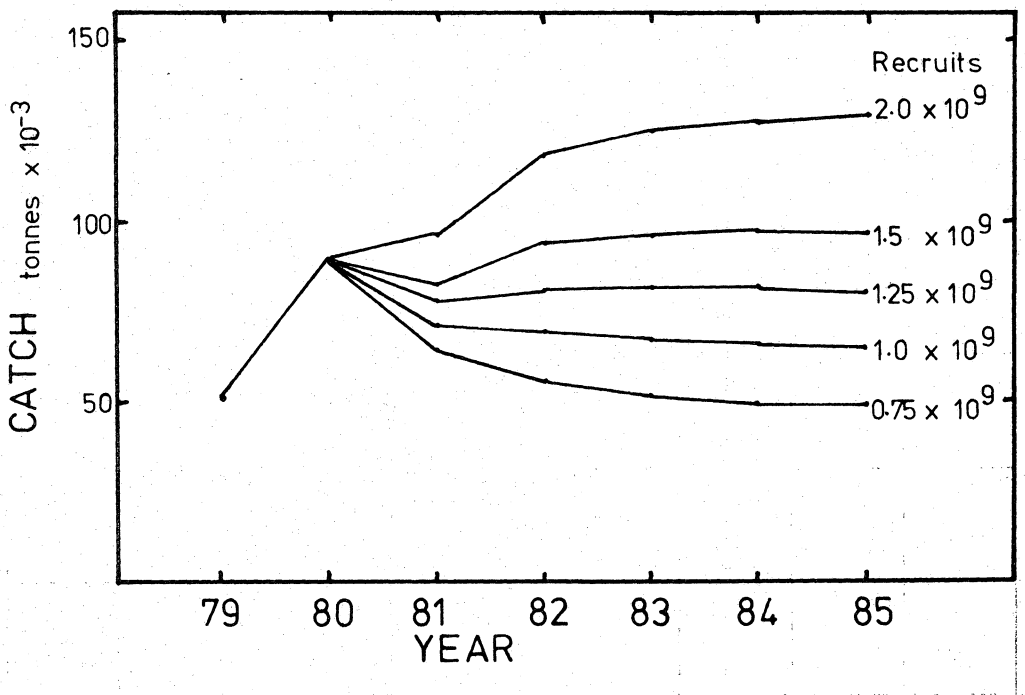

Figure 8. Catch projections for silver hake for various levels of recruitment with fishing levels at the $F_{0.1}$ level for 1980. (Other parameters as described in text).