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Assessment of the Scotian Shelf silver hake population size in 1983

by

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INTRODUCTION

The Scotian Shelf fishery for silver hake is conducted within an area southwest of Sable Island. The fleets are comprised of otter trawlers, tonnage class 7. Several countries have a historical presence in the fishery with the Soviet Union reporting over 50% of the catch. Nominal catches from this fishery increased to a record high of 300,000 t in 1973. Recent catches are in the vicinity of 50,000 t primarily due to Canadian regulations and allocations of this resource. In 1982, 90% of the foreign allocation was caught. This was as a result of abnormally cold water temperatures on the Scotian Shelf (Waldron et al., 1983).

Assessment of silver hake is hindered by the lack of an independent estimate of recruitment to the fishery and the availability of a reliable independent estimate of stock size. In order to improve this situation cooperative research surveys for juvenile silver hake are being conducted between Canada and the Soviet Union. Canada has also increased its surveys for silver hake and other groundfish from the historical July surveys to the months of March and October of each year. These surveys will be introduced in this assessment to investigate possible levels of recruitment.

CATCH AND EFFORT

Silver hake catches in NAFO Divisions 4VWX have been decreasing since 1973 (Figure 1, Table 1). This trend is due partially to the implementation of the small mesh gear line (SMGL) in 1977. The major silver hake fishery has been conducted primarily by the Soviet Union with Cuba becoming involved only recently (Figure 2).

Silver hake catches against the TAC have varied from 43% in 1983 to a high of 75% in 1982 (Table 2). Discounting the Canadian allocation, which can be regarded as a reserve, the catch against non-Canadian allocations ranges from a low in 1983 of 51% to a high of 90% in 1982. The overall average catch for 1977 to 1983 is 72% of the allocated, and actively fished, 4VWX silver hake TAC.

The most recent assessment presented a catch rate series based on Soviet OTB2 TC 7 vessels from 1970-1982 (Waldron et al., 1983). The 1982 fishery was very successful and the catch rates were almost twice those seen in the series. The series was further complicated by the imposition of a SMGL which may have altered the historical fishing pattern during the peak fishery. Data presented by Clay (1979) and Waldron (1977, 1978, and 1979) show that the months of April to July are the peak fishery and the majority of the catch and

the highest catch rates do occur in the area seaward of the SMGL. Still the possibility of shifts in catchability due to the current regulations does exist. The 1983 silver hake fishery was much shorter than usual with the fishery effectively completed in early July (Table 3). The 1983 catch was 34,000 t which is 43% lower than the catch in 1982. Catch rates were higher than those reported for 1981 and of course lower than 1982 which is regarded as an anomolous year. The reported catch was the lowest since 1977 with only 51% of the foreign allocation being caught.

A multiplicative model was again used to analyse catch rates (Gavaris, 1980; Waldron, 1983). As in the last assessment two category types, month and year for Soviet OTB2 TC 7 vessels, were used in the analysis. Relative catch rates were standardized to June 1970. Standardized catch fluctuated from a low of 1.39 to a high of 2.38 t/hour during the 1970-1976 period (Table 4, Figure 3). After 1976 catch rates decreased until 1982 when 60,000 t was reported caught. The 1982 catch rate may have been caused by a cold water thermocline along the shelf break which kept the major portion of the silver hake stock available to the fishery (Waldron et al., 1982).

The 1982 data was eliminated from a subsequent run of the multiplicative model. The multiple R squared decreased from 0.492 to 0.477 with a similar decrease in the F value of the regression (6.832 to 5.60) (Tables 4 and 5). The standardized CPUE displays a similar trend as that with the 1982 point included (Figure 4). Since 1980 the catch rate has been increasing. The latter series of catch per unit of effort and effort with the 1982 point excluded was used to tune the VPA.

1983 SAMPLING INTENSITY

Sampling for catch, effort, length, and age was conducted by the Canadian Scotia-Fundy observers. From the approximately 34,000 tons of silver hake reported caught, 15,000 tons, or 42 percent was observed for all foreign fleets. Coverage levels from 1977 to 1982 are given in Waldron, 1981a; Waldron and Harris 1982; and Waldron et al., 1983.

Sampling levels for lengths were above the NAFO recommended levels for all months (Table 6). Otolith samples were good for all months. Ageing was done at the St. Andrews laboratory, New Brunswick, Canada.

CATCH-AT-AGE

Monthly lengths by country were weighted to catch using weight-length relationships from laboratory observations (Table 7). Monthly age-length keys were used to calculate monthly removals-at-age for each country. These data were summed to give the 1983 removals-at-age for the 4VWX silver hake fishery. The 1982 final nominal catch of 60,207 t was used to adjust the 1982 removals-at-age given in the previous assessment which was based on an estimated catch of 58,765 t (Waldron et al., 1983).

The removals-at-age for 1970-1978 were from Clay and Beanlands (1980) and for 1979 to 1981 from Waldron et al. (1983). The removals-at-age used in this assessment are presented in Table 8a and b. Catch biomass is given in Table 9.

MEAN WEIGHTS-AT-AGE

Weight/length relationships from the July 1970-80 Canadian research vessel cruises and from laboratory observations (1981-83) were used to calculate the mean weights-at-age used in this assessment (Table 10). Mean weights for ages 8 and 10 in 1983 were slightly higher than those observed in 1982. Conversely, mean weights-at-age

for all other ages in 1983 were lower than those observed in 1982. Overall, most ages have shown a general increasing trend since the low levels of mean weight in 1978.

Mean weights for ages 5 to 8 are much lower during the period 1978-83 when compared to those from 1970-1977 (Figure 5). This is not the case for ages 1-4 (Figure 6). Comparison of average mean weights for the pre and post implementation of the SMGL in 1977 shows a steady decrease in weight for ages 5 and older after 1976 (Figure 7). The results above correspond with earlier observations that fish aged 1-5 before and after 1976 are similar on average. The average weights of fish aged 7 and older are a response to stock sizes in the late 1960s and early 1970s.

There was generally good agreement between reported nominal and estimated catch biomass as shown below.

Years	1970	1971	1972	1973	1974	1975	1976	1977
Catch	169045	128657	114048	299530	95449	116288	97087	36401
Est.	169663	127698	113188	299843	95598	116671	97243	36839
Diff.	-613	959	860	-313	147	-277	-59	256

Years	1978	1979	1980	1981	1982	1983*
Catch	48404	51750	44525	42927	60207	34275
Est.	48004	51761	44727	41299	59890	33263
Diff.	397	-10	-202	-293	317	1012

*preliminary

RESEARCH VESSEL INDICIES

Adult Surveys

Research vessel abundance indicies have played an ever increasing role in the tuning of the VPA. This is due primarily to the supposition that the Canadian regulations have altered the availability of silver hake to the fishery. This translates into a new catch and effort series which may or may not be comparable to the pre 1977 series.

The July research vessel abundance time series for silver hake also has been affected by changes in vessels and gear used during the surveys. The 1970-1981 July random stratified surveys were conducted by the R/V A.T. Cameron. The July 1982 and 1983 surveys were conducted by the R/V Lady Hammond and Alfred Needler respectively. The A.T. Cameron was a side trawler using a Yankee 36 trawl. Both the Lady Hammond and the Alfred Needler are stern trawlers using a higher opening Western II A trawl.

Over the last five years Canadian scientists have been actively conducting comparative trawling experiments involving combinations of all three vessels. Analysis of these data sets have been presented by Koeller and Smith (1983) and Fanning (1984). Koeller and Smith recommend a conversion, for silver hake abundance indicies of 1.749, 2.915, and 2.841 for the July surveys in 1979 through to 1981.

The average for conversion of Lady Hammond to A.T. Cameron silver hake catches is 2.399 (i.e. A.T. Cameron catch = Lady Hammond catch ÷ 2.399).

Fanning (1984) has recently conducted an analysis of the Alfred Needler and Lady Hammond comparative experiments for silver hake abundance. Fanning's analysis indicates that the conversion factor for silver hake catches between the two vessels is not significant from 1.000. Examination of the mean catch per tow for both vessels support Fanning's observations (Figure 8a).

The 1982 and 1983 July research vessel survey numbers were adjusted downward by 2.399 based on the above studies. Examination of 1982 survey data showed that Stratum 81 accounted for 50% of the total estimate. In the past this stratum has usually accounted for 4-5% of the estimate. This stratum was windsorized to the next highest in the series and the numbers-at-age in 1982 were recalculated (Table 11a). Tables 11b and 11c are the percent and biomass-at-age for July surveys.

The research vessel estimates of population numbers range from a high of 229 million in 1973 to a low of 33 million fish in 1977 (Figure 8b). The trend from 1977-1981 has been upward except for the estimate in 1980. The low 1980 estimate appears to be related to the poor 1977 year class and the failure to catch the 1978 year class. The 1978 year class is well represented as age 1 (in 1979) and age 3 in 1981.

The 1981 to 1983 estimates are decreasing slowly from 172 to 149 million. These population numbers are no doubt well within the confidence intervals for these data and therefore the population appears to have stabalized in the 1981-83 period.

PARTIAL RECRUITMENT

The partial recruitment pattern developed for the previous assessment was estimated from catch curves for the 1977-1981 fishery. This partial recruitment pattern was lower for ages 1 and 2 fish than that used in other assessments (below). The partial recruitment pattern for the current (1983) assessment was derived from a VPA using the 1982 pattern and last year's terminal F of 0.25. Average F's for the years 1978-1981 were calculated. The resultant partial recruitment pattern used in this assessment is given below.

Age	1	2	3+
Partial Recruitment 1979 Assessment	0.150	1.000	1.000
Partial Recruitment 1980-1981 Assessment	0.044	0.444	1.000
Partial Recruitment 1982 Assessment	0.030	0.250	1.000
Partial Recruitment 1983 Assessment	0.041	0.330	1.000

The current pattern is similar to those used in assessments in 1980 and 1981.

NATURAL MORTALITY

Natural mortality for silver hake has been set at 0.40 since sequential population analysis were begun in the 1970s. As in the previous assessment the regression of Paloheimo Z's (Table 12) from commercial CPUE (no./hr.) (Table 13) on average fishing effort (with the 1982 data included) gave an insignificant r (0.200) and this method of estimating M was abandoned.

Natural mortality used in this assessment was set at 0.40 as in previous assessments.

CATCH CURVES AND VALUES OF Z

Paloheimo Z's were averaged across ages from commercial catch/hr (Table 14). Average Z values for ages 3-8 and 4-9 over the period 1977-1982 gave a Z = .747. Assuming an M = 0.40 then average F since 1978 is .347.

A catch curve of ln CPUE (No. Hr.) at age for 1977-1983 gave a Z = .931, and a M = 0.4, a fully recruited F = .531 (Figure 9). A curve of ln research vessel numbers for the same period gives a Z = .741 suggesting a fully recruited F = .341 (Figure 10).

VIRTUAL POPULATION ANALYSIS

A virtual population analysis was used to estimate the population size of silver hake in 1983. Input parameters used in this analysis were presented above and are the natural mortality of 0.40, partial recruitment for 1983, and the commercial catch-at-age. Fishing mortalities for the oldest ages were iterated from ages 5 to 10 for each terminal fishing mortality tested.

VALIDATION OF TERMINAL F IN 1983

In the most recent assessment the terminal F was selected based on the relationship of 3+ VPA and smoothed 3+ research vessel numbers. The least squares regression model was used to determine which terminal F gave the best fit of the 1982 point to the predicted line. Selection by use of the highest r was not possible as r increased with decreasing terminal F values.

This assessment investigated the use of the least squares regression of 3+ VPA and unsmoothed 3+ research vessel numbers to determine the most appropriate terminal F. This model could not be used to determine a terminal F because of the scatter of the points determining the regression (Tables 15, Figure 11).

Relationships between VPA estimates and CPUE and effort were also used irrespective of any debate whether the SMGL may have interrupted the effort time series. The criterion for selecting terminal F was again based on the best fit of the last point and a r which is significant although it may not be the largest in the series of F's studied. Table 16 and Figure 12 presents the results of the regression of fishable population biomass on CPUE from Table 5. The partial recruitment pattern used in this analysis was derived by averaging F's at a TF = 0.25 for ages 1 before 1977 and ages 1 and 2 after 1976. This relationship gives a terminal F near 0.25.

A similar analysis for population weighted F on effort using ages 2 to 8 before 1977 and ages 3 to 9 after 1976 fits the above criterion at a terminal F of .50 (Table 17). The predicted line could be influenced by the 1973 data point so it, as well as the 1982, was removed from this analysis. A plot at F=.25 is shown (Fig.13).

Terminal F was set at 0.25 based on the above analysis and the fact that fully recruited F's in 1982 were nearly double those used in the previous assessment (F = 0.25) (Tables 18 and 19). In 1983 half of the 1982 catch was landed so it would seem reasonable to expect the F to decrease proportionally in 1983.

YIELD PER RECRUIT

The mean weights-at-age used in the Thompson and Bell Y/R model were averaged over the 1979-1983 period. This should eliminate any bias towards a lower Y/R due to the 1978 mean weights. The partial recruitment pattern above and a natural mortality (M) of 0.4 were also used in the model.

Fully recruited $F_{0.1}$ was 0.425 which is higher than the $F_{0.1}$ = 0.418 used in the previous assessment (Table 20). At $F_{0.1}$ the yield per recruit is 0.061 kg. The F_{MAX} is 2.666 which is less than the F_{MAX} = 3.119 used in the previous assessment. The yield per recruit is 0.077 kg at F_{MAX}.

Input Parameters for Y/R Calculation

Variable	1	2	3	4	5	6	7
Previous Assessment Weight	.051	.140	.202	.263	.322	.387	.522
Current Assessment Weight	.050	.143	.206	.262	.311	.368	.494
Partial Recruitment - Current Assessment	.041	.330	1.000	1.000	1.000	1.000	1.000

Variable	8	9	10	11	12
Previous Assessment Weight	.638	.844	.923	1.460	2.160
Current Assessment Weight	.581	.799	1.235	1.300	2.160
Partial Recruitment - Current Assessment	1.000	1.000	1.000	1.000	1.000

BIBLIOGRAPHY

Clay, D. and D. Beanlands. 1980. Silver hake (Merluccius bilinearis) in Division 4VWX. A stock assessment and estimate of the total allowable catch (TAC) for 1981. NAFO SCR Doc. 80/87. 14 p.

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. Jr. Fish. Aquat. Sci. 37: 2272-2275.

Koeller, P. and S. Smith. 1983. Preliminary analysis of A.T. Cameron - Lady Hammond comparative fishing experiments 1979-81. Can. Atl. Fish. Sci. Adv. Comm. 85/59. 39 p.

Koeller, P.A., J.D. Neilson, and D.E. Waldron. 1984. The Canada-USSR Juvenile Silver Hake (Merluccius bilinearis) Surveys on the Scotian Shelf: Abundance Indices, Distribution, and Comparison with Independent Estimates of Juvenile Abundance, 1978-83. NAFO SCR Doc. 84/VI/87, Serial No. N877, 9 p.

Mari, A. and R. Coyula. 1979. Actualizacion de la Mortalidad Natural de la Merluza Plateada en la Plataforma de Nueva Escocia. Rev. Cub. Inv. Pesq. 4(3).

Noskov, A.S. 1981. Results of studies conducted by the USSR in the NAFO Divisions 4VWX in 1980. NAFO SCR Doc. 81/IX/105 Ser. No. N409. 7 pp.

Waldron, D.E. 1978. Catch composition during the 1977 Scotian Shelf International fishery with emphasis on the silver hake and squid (Illex) fisheries. ICNAF Res. Doc. 78/9. 23 p.

Waldron, D.E. 1979. Preliminary results of a joint international observer program to evaluate the silver hake small mesh gear line in ICNAF Division 4VWX. ICNAF Res. Doc. 79/17. 38 p.

Waldron, D.E. 1981a. An assessment of the Scotian Shelf silver hake (Merluccius bilinearis) population for 1980. NAFO SCR Doc. 81/VI/74.

Waldron, D.E. 1981b. A summary of the current biology of the Scotian Shelf silver hake Merluccius bilinearis stock(s). Presented at special meeting of marine environmental and ecological subcommittee of CAFSAC. (In press).

Waldron, D.E. and M.C. Harris. 1982. Scotian Shelf silver hake Merluccius bilinearis) population abundance in 1981 with projections to 1983. NAFO SCR Doc. 82/VI/65. 34 p.

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/59. 36 p.

Table 1. Nominal catches for 4VWX silver hake. 1970 - 1983

	YEAR													
COUNTRY	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983[2]
Bulgaria	0	0	0	0	0	1722	3088	862	606	4639	817	0	0	0
Canada	0	0	0	0	11	101	26	10	26	13	104	6	38	15
Cuba	0	0	201	909	0	1724	12572	1847	3436	1798	2287	642	11969	7488
France	0	0	0	0	0	0	0	15	0	0	0	0	2[1]	0
FDR	0	0	0	0	0	0	0	0	3	0	0	0	0	0
FRG	0	0	10	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	108	106	0	0	0	0	0	0	0
Italy	0	0	0	0	0	0	0	38	106	5	0	460[1]	37[1]	2
Japan	129	8	63	88	67	54	78	19	161	219	239	120	937	640
Poland	0	0	0	0	0	0	0	295	2	0	0	1[1]	31	0
Portugal	0	0	0	0	0	0	0	0	0	0	56	1460[1]	2[1]	362
Spain	0	11	0	0	0	6	0	0	2	0	40	0	0	0
USA	0	1	0	0	0	7	1	14	0	0	0	3	2	0
USSR	168916	128633	113774	298533	95371	112566	81216	33301	44062	45076	40982	40235	47261	25768
TOTAL	169045	128653	114048	299530	95449	116288	97087	36401	48404	51750	44525	42927	60251	34275

1 Observer Program Data

2 FLASH Data

Table 2. Nominal catch and allocations (t), in paranthesis, for 4VWX silver hake. 1983 preliminary.

Country	1977	1978	1979	1980	1981	1982	1983
Bulgaria	862 (950)	606 (1000)	4639 (6860)	817 (1200)	0 (1000)	0 (1000)	0
Canada	10 (15190)	26 (16700)	13 (10000)	104 (20000)	6 (20000)	38 (13000)	15[2] (1000)
Cdn. Reserve							(11808)
Cuba	1847 (8910)	3436 (10300)	1798 (8070)	2287 (11200)	642 (9500)	11969 (13500)	7488 (9500)
EEC	-	-	-	- (100)[3]	-	-	-
France[4]	15	0	0 (100)[3]	0 (100)[3]	0 (100)[3]	2[1] (100)[3]	0 (100)[3]
German Dem. Rep.	0	3	0	0	0	0	0 (2000)
Italy[4]	38	106	5	0	460[1]	37[1]	2[2]
Japan	19	161	219	239	120	937 (2000)	640[2] (5000)
Poland	295	2	0	0	1[1]	31	0
Portugal	0	0	0	56	1460[1]	2[1] (2000)	362 (3000)
Spain	0	2	0	40	0	0	0 (4000)
USA	14	0	0 (2)	0	3	2	0
USSR	33301 (44950)	44062 (52000)	45076 (44940)	40982 (56600)	40235 (48400)	47261 (48400)	25768 (43400)
Others			- (30)	- (900)	- (1000)	-	- (192)
Total Catch and TAC	36401 (70000)	48404 (80000)	51750 (70000)	44525 (90000)	(80000)	60251 (80000)	34275 (80000)
% Catch Divided by Allocation	52	61	74	50	54	75	43
% Catch Divided by Allocation (Discounted Can. Alloc.)	66	76	86	64	72	90	57

1. Observed by Canadian Observers but not reported to NAFO
2. Reported to Canada (FLASH System)
3. France, St. Pierre, and Miquelon vessels only.
4. EEC allocations.

Table 3. 1983 provisional nominal catches (t) for 4VWX Silver Hake (data from NAFO and Canadian statistics).

Country	MONTHS									
	March	April	May	June	July	Aug	Sept	Oct	Nov	Total
Canada	0.1	0.1	0.4	0.1	2.0	1.0	0.5	3.0	8.0	15.2
Cuba	0.0	737.4	3874.6	2590.0	286.5	0.0	0.0	0.0	0.0	7488.5
Italy	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	2.3
Japan	0.0	0.0	0.0	0.0	0.0	402.8	233.5	3.9	0.0	640.2
Portugal	0.0	2.1	230.1	129.6	0.0	0.0	0.0	0.0	0.0	361.8
USSR	0.0	2662.1	14706.8	7590.3	808.6	0.0	0.0	0.0	0.0	25767.8
Total	0.1	3401.7	18811.9	10310.0	1097.1	406.1	234.0	6.9	8.0	34275.8

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R,,,,,,,,,,,,,0.706
MULTIPLE R SQUARED,,,,,0.498

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	4.183E1	4.183E1	
REGRESSION	16	8.590E0	5.369E-1	6.832
TYPE 1	3	1.094E1	3.645E0	46.385
TYPE 2	13	6.780E0	5.216E-1	6.637
RESIDUALS	110	8.644E0	7.858E-2	
TOTAL	127	5.906E1		

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1970	169045	0.905	2.164	0.194	78128
1971	128657	0.531	1.604	0.195	80214
1972	114048	0.879	1.769	0.198	64488
1973	299530	0.891	2.277	0.238	131574
1974	95745	0.240	1.491	0.255	64233
1975	116394	0.743	1.391	0.167	83682
1976	97184	0.429	1.910	0.198	50894
1977	37095	0.703	1.876	0.186	19777
1978	48401	0.866	1.503	0.145	32197
1979	51751	0.869	1.722	0.175	30051
1980	44525	0.920	1.163	0.126	38269
1981	41006	0.906	1.390	0.141	29500
1982	58765	0.332	3.694	0.556	15907
1983	27377	0.327	1.624	0.237	16857

AVERAGE C.V. FOR THE MEAN:0.116

Table 4. Standardized CPUE (t/hr) and results of analysis of variance.

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	3.960E1	3.960E1	
REGRESSION	17	7.598E0	4.469E-1	5.630
TYPE 1	5	1.522E1	3.044E0	38.335
TYPE 2	12	5.744E0	4.787E-1	6.030
RESIDUALS	105	8.336E0	7.939E-2	
TOTAL	123	5.554E1		

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1970	169045	0.967	2.542	0.236	66498
1971	128657	0.531	1.646	0.202	78149
1972	114048	0.879	1.812	0.205	62952
1973	299530	0.891	2.333	0.246	128413
1974	95745	0.240	1.536	0.264	62321
1975	116394	0.743	1.437	0.175	81013
1976	97184	0.429	1.980	0.210	49071
1977	37095	0.703	1.928	0.193	19241
1978	48401	0.866	1.533	0.149	31568
1979	51751	0.869	1.769	0.182	29252
1980	44525	0.920	1.189	0.130	37444
1981	41006	0.906	1.420	0.146	28869
1983	27377	0.283	1.552	0.256	17639

Table 5. Standardized CPUE (t/hr) and results of analysis of variance. The 1982 data point excluded.

Table 6 : Summary of 1983 Observer Program Silver Hake Sampling

Country	Sample	January	April	May	June	July	August	Sept	Oct	Nov	Dec	Totals
Canada	Meas.	32	-	-	-	-	52	249	364	708	-	1405
	Otoliths taken	24	-	-	-	-	0	40	78	91	-	233
	Otoliths aged	24	-	-	-	-	0	40	68	0	-	132
Cuba	Meas.	-	6383	17050	19143	211	-	-	-	-	-	42787
	Otoliths taken	-	29	110	117	0	-	-	-	-	-	256
	Otoliths aged	-	29	62	97	0	-	-	-	-	-	188
Italy	Meas.	-	-	-	-	-	323	-	-	-	-	323
	Otoliths taken	-	-	-	-	-	66	-	-	-	-	66
	Otoliths aged	-	-	-	-	-	0	-	-	-	-	0
Japan	Meas.	-	-	-	-	-	18137	4245	-	-	-	22382
	Otoliths taken	-	-	-	-	-	536	137	-	-	-	673
	Otoliths aged	-	-	-	-	-	355	137	-	-	-	492
Portugal	Meas.	-	274	4456	473	-	-	-	-	-	161	5364
	Otoliths taken	-	51	88	0	-	-	-	-	-	46	185
	Otoliths aged	-	51	88	0	-	-	-	-	-	0	139
USSR	Meas.	-	9353	34383	29689	446	-	-	-	-	-	73871
	Otoliths taken	-	109	310	311	33	-	-	-	-	-	763
	Otoliths aged	-	99	225	240	33	-	-	-	-	-	597
Total	Meas.	32	16010	55889	49305	657	18512	4494	364	708	161	146132
	Otolith taken	24	189	509	428	33	602	177	78	91	46	2176
	Otolith aged	24	179	375	337	33	355	177	68	0	0	1548

Table 7. A's and B's from 4VWX Silver Hake in 1983
Weights and lengths from lab observations

Month	A	B
April	0.00098	3.54310
May	0.00303	3.25135
June	0.01069	2.87568
July	0.00363	3.20580
August	0.02382	2.61674
September	0.02483	2.59911
October	0.00448	3.11221
November	0.00398	3.13925

TABLE 8A: COMMERCIAL CATCH AT AGE (000) FOR 4VWX SILVER HAKE

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	187298	219607	379314	246148	101158	145091	153535	2131	28704	9667	6272	1553	19708	3150
2	748021	410149	460610	1482925	390044	365964	381651	43535	90777	48341	60576	19530	51680	81366
3	216246	175005	71536	96784	150741	52837	72418	78239	89717	69058	82013	111209	66973	48787
4	59832	74755	47903	106675	7095	60806	31295	29561	42878	46547	35888	38534	66230	26800
5	20695	22035	17822	96940	9789	38646	5582	6981	19442	29656	15293	14266	34777	12321
6	9636	1877	7452	19671	3245	4803	2669	2004	8587	16964	6179	5548	8925	4188
7	3608	5139	1160	15203	93	311	514	483	3222	5079	1682	679	2790	1087
8	1988	1333	437	5475	109	363	105	564	2009	1765	344	132	1047	449
9	1114	2062	607	484	60	360	390	522	420	1151	90	61	127	65
10	680	1900	2000	818	77	1001	82	1	643	489	44	243	7	2
1+	1249118	913862	988841	2071123	662411	670183	648241	164022	286398	228718	208380	191757	252264	178215
2+	1061820	694255	609527	1824975	561253	525092	494706	161890	257694	219051	202108	190203	232555	175065
3+	313799	284106	148917	342050	171209	159129	113055	118355	166917	170710	141532	170673	180876	93699
4+	97553	109101	77381	245266	20468	106292	40637	40116	77200	101652	59519	59464	113903	44912
5+	37721	34346	29478	138592	13373	45485	9342	10556	34322	55105	23631	20929	47673	18112

TABLE 8B: PERCENT AT AGE FOR COMMERCIAL REMOVALS OF 4VWX SILVER HAKE

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	14.99	24.03	38.36	11.88	15.27	21.65	23.68	1.30	10.02	4.23	3.01	0.81	7.81	1.77
2	59.88	44.88	46.58	71.60	58.88	54.61	58.87	26.54	31.70	21.14	29.07	10.19	20.49	45.66
3	17.31	19.15	7.23	4.67	22.76	7.88	11.17	47.70	31.33	30.19	39.36	57.99	26.55	27.38
4	4.79	8.18	4.84	5.15	1.07	9.07	4.83	18.02	14.97	20.35	17.22	20.10	26.25	15.04
5	1.66	2.41	1.80	4.68	1.48	5.77	0.86	4.26	6.79	12.97	7.34	7.44	13.79	6.91
6	0.77	0.21	0.75	0.95	0.49	0.72	0.41	1.22	3.00	7.42	2.97	2.89	3.54	2.35
7	0.29	0.56	0.12	0.73	0.01	0.05	0.08	0.29	1.13	2.22	0.81	0.35	1.11	0.61
8	0.16	0.15	0.04	0.26	0.02	0.05	0.02	0.34	0.70	0.77	0.16	0.07	0.41	0.25
9	0.09	0.23	0.06	0.02	0.01	0.05	0.06	0.32	0.15	0.50	0.04	0.03	0.05	0.04
10	0.05	0.21	0.20	0.04	0.01	0.15	0.01	0.00	0.22	0.21	0.02	0.13	0.00	0.00
1+	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2+	85.01	75.97	61.64	88.12	84.73	78.35	76.32	98.70	89.98	95.77	96.99	99.19	92.19	98.23
3+	25.12	31.09	15.06	16.52	25.85	23.74	17.44	72.16	58.28	74.64	67.92	89.00	71.70	52.58
4+	7.81	11.94	7.83	11.84	3.09	15.86	6.27	24.46	26.96	44.44	28.56	31.01	45.15	25.20
5+	3.02	3.76	2.98	6.69	2.02	6.79	1.44	6.44	11.98	24.09	11.34	10.91	18.90	10.16

TABLE 9: CATCH BIOMASS (T) FOR 4VWX SILVER HAKE

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	11238	8784	21242	11077	6373	9721	9673	132	1407	590	257	56	1102	170
2	94251	52499	54813	189814	50316	56724	56484	6400	9985	7445	8541	2793	7623	10578
3	36113	32901	14951	20905	30751	12839	17815	16430	15611	13812	17469	21463	14915	9904
4	13283	18988	11497	26669	2199	14411	8544	8573	9690	11404	10049	9556	19167	6593
5	6271	6941	4883	28597	3876	18434	2272	2772	5502	8452	4924	4537	11445	3733
6	3893	845	4151	8635	1749	2195	1409	1034	2825	5836	2261	2047	3560	1516
7	1696	3017	560	7374	91	353	431	322	1231	2088	875	456	1342	421
8	1402	1109	552	4790	126	457	131	608	1000	918	206	73	609	293
9	922	1262	538	569	0	589	335	569	329	637	80	48	120	53
10	595	1353	2	1413	116	947	149	0	424	582	64	269	8	3
1+	169663	127698	113188	299843	95598	116671	97243	36839	48004	51761	44727	41299	59890	33263
2+	158425	118914	91946	288766	89225	106950	87570	36706	46598	51172	44469	41243	58789	33093
3+	64174	66415	37134	98952	38909	50225	31086	30307	36612	43727	35928	38450	51166	22515
4+	28061	33514	22183	78047	8158	37386	13271	13877	21001	29915	18459	16987	36251	12611
5+	14778	14526	10686	51378	5958	22975	4727	5304	11311	18512	8411	7430	17084	6018

TABLE 10: SILVER HAKE MEAN WEIGHTS (KG)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.060	0.040	0.056	0.045	0.063	0.067	0.063	0.062	0.049	0.061	0.041	0.036	0.056	0.054
2	0.126	0.128	0.119	0.128	0.129	0.155	0.148	0.147	0.110	0.154	0.141	0.143	0.147	0.130
3	0.167	0.188	0.209	0.216	0.204	0.243	0.246	0.210	0.174	0.200	0.213	0.193	0.223	0.203
4	0.222	0.254	0.240	0.250	0.310	0.237	0.273	0.290	0.226	0.245	0.280	0.248	0.289	0.246
5	0.303	0.315	0.274	0.295	0.396	0.477	0.407	0.397	0.283	0.285	0.322	0.318	0.329	0.303
6	0.404	0.450	0.557	0.439	0.539	0.457	0.528	0.516	0.329	0.344	0.366	0.369	0.399	0.362
7	0.470	0.587	0.483	0.485	0.975	1.133	0.838	0.667	0.382	0.411	0.520	0.672	0.481	0.387
8	0.705	0.832	1.263	0.875	1.156	1.257	1.251	1.077	0.498	0.520	0.601	0.550	0.582	0.653
9	0.828	0.612	0.886	1.174	0.001	1.635	0.859	1.089	0.784	0.553	0.892	0.794	0.949	0.809
10	0.875	0.712	0.001	1.726	1.508	0.946	1.818	0.001	0.659	1.189	1.452	1.107	1.127	1.300

TABLE 11 A: JULY RESEARCH VESSEL NUMBES (000) FOR 4VWX SILVER HAKE

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	28271	70044	30601	12226	22689	3770	13636	44392	7454	16750	84743	57165
2	45304	130718	98562	15291	55486	14507	12308	75438	11256	43909	55767	54586
3	6725	8902	14033	9488	7248	10569	8212	36406	14747	68530	9439	20198
4	3628	7393	1751	2402	5761	2159	4422	10001	4228	29338	7811	9433
5	1564	6864	1732	973	2061	743	3429	5897	2171	8449	4337	4813
6	899	3172	1972	675	917	697	1455	2837	1594	2670	2529	1524
7	139	1105	363	296	183	442	600	1560	769	1471	1127	404
8	327	682	208	77	119	173	232	496	445	436	629	204
9	58	61	0	189	149	146	468	107	189	254	175	181
10	223	342	18	0	0	181	230	256	331	127	69	6
1+	87138	229283	149240	41617	94613	33387	44992	177390	43184	171934	166625	148514
2+	58867	159239	118639	29391	71924	29617	31356	132998	35730	155184	81882	91348
3+	13563	28521	20077	14100	16438	15110	19048	57560	24474	111275	26116	36762
4+	6838	19619	6044	4612	9190	4541	10836	21154	9727	42745	16677	16564
5+	3210	12226	4293	2210	3429	2382	6414	11153	5499	13407	8866	7131

TABLE 11B: JULY RESEARCH VESSEL PERCENT AT AGE FOR 4VWX SILVER HAKE

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	32.44	30.55	20.50	29.38	23.98	11.29	30.31	25.03	17.26	9.74	50.86	38.49
2	51.99	57.01	66.04	36.74	58.65	43.45	27.36	42.53	26.07	25.54	33.47	36.76
3	7.72	3.88	9.40	22.80	7.66	31.66	18.25	20.52	34.15	39.86	5.66	13.60
4	4.16	3.22	1.17	5.77	6.09	6.47	9.83	5.64	9.79	17.06	4.69	6.35
5	1.79	2.99	1.16	2.34	2.18	2.23	7.62	3.32	5.03	4.91	2.60	3.24
6	1.03	1.38	1.32	1.62	0.97	2.09	3.23	1.60	3.69	1.55	1.52	1.03
7	0.16	0.48	0.24	0.71	0.19	1.32	1.33	0.88	1.78	0.86	0.68	0.27
8	0.38	0.30	0.14	0.19	0.13	0.52	0.52	0.28	1.03	0.25	0.38	0.14
9	0.07	0.03	0.00	0.45	0.16	0.44	1.04	0.06	0.44	0.15	0.11	0.12
10	0.26	0.15	0.01	0.00	0.00	0.54	0.51	0.14	0.77	0.07	0.04	0.00
1+	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2+	67.56	69.45	79.50	70.62	76.02	88.71	69.69	74.97	82.74	90.26	49.14	61.51
3+	15.56	12.44	13.45	33.88	17.37	45.26	42.34	32.45	56.67	64.72	15.67	24.75
4+	7.85	8.56	4.05	11.08	9.71	13.60	24.08	11.93	22.52	24.86	10.01	11.15
5+	3.68	5.33	2.88	5.31	3.62	7.13	14.26	6.29	12.73	7.80	5.32	4.80

TABLE 11C: JULY RESEARCH VESSEL BIOMASS (T) FOR 4VWX SILVER HAKE

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	1583	3152	1928	819	1429	234	668	2708	306	603	4737	3087
2	5391	16732	12714	2370	8212	2133	1354	11617	1587	6279	8226	7096
3	1406	1923	2863	2306	1783	2219	1429	7281	3141	13226	2102	4100
4	871	1848	543	569	1573	626	999	2450	1184	7276	2261	2321
5	429	2025	686	464	839	295	970	1681	699	2687	1427	1458
6	501	1393	1063	308	484	360	479	976	583	985	1009	552
7	67	536	354	335	153	295	229	641	400	989	542	156
8	413	597	240	97	149	186	116	258	267	240	366	133
9	51	72	0	309	128	159	367	59	169	202	166	146
10	0	590	27	0	0	0	152	304	481	141	78	8
1+	10712	28867	20418	7578	14750	6507	6763	27976	8817	32627	20913	19058
2+	9128	25715	18490	6759	13321	6273	6094	25268	8511	32024	16176	15971
3+	3737	8983	5776	4389	5109	4141	4741	13651	6924	25745	7951	8874
4+	2332	7060	2913	2083	3326	1921	3312	6369	3783	12519	5849	4774
5+	1461	5212	2370	1514	1753	1295	2312	3919	2599	5243	3588	2454

TABLE 12: PALOHEIMO Z S FOR 4VWX SILVER HAKE

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	-0.756	-0.963	-0.648	-1.182	-1.017	-1.468	0.319	-3.263	-0.590	-1.593	-1.398	-4.120	-1.356
2	1.480	1.525	2.276	1.564	2.268	1.120	0.643	-0.234	0.204	-0.287	-0.870	-1.848	0.120
3	1.090	1.074	0.316	1.891	1.177	0.023	-0.046	1.090	0.587	0.896	0.493	-0.097	0.978
4	1.026	1.212	0.011	1.667	-1.426	1.888	0.558	0.908	0.299	1.355	0.660	-0.513	1.744
5	2.428	0.862	0.617	2.675	0.981	2.172	0.082	0.282	0.067	1.810	0.752	-0.146	2.179
6	0.656	0.259	0.003	4.633	2.613	1.734	0.767	0.014	0.456	2.553	1.946	0.072	2.167
7	1.023	2.243	-0.836	4.216	-1.094	0.586	-1.035	-0.936	0.533	2.936	2.282	-1.048	1.889
8	-0.009	0.565	0.613	3.792	-0.927	-0.571	-2.546	0.785	0.487	3.219	1.466	-0.572	2.841
9	-0.506	-0.191	0.417	1.117	-2.545	0.980	5.024	0.281	-0.223	3.509	-1.257	1.561	4.209
10	6.432	6.586	2.769	20.373	0.031	6.464	3.767	-1.072	1.820	14.398	4.072	-6.710	14.770

TABLE 13: CPUE (NO/HR) FOR THE 4VWX SILVER HAKE COMMERCIAL FISHERY

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	2.398	2.735	5.897	1.871	1.582	1.734	3.027	0.108	0.890	0.321	0.164	0.053	1.237	0.186
2	9.577	5.108	7.161	11.270	6.101	4.374	7.524	2.201	2.815	1.606	1.581	0.663	3.244	4.800
3	2.768	2.180	1.112	0.736	2.358	0.631	1.428	3.956	2.782	2.295	2.140	3.773	4.203	2.878
4	0.766	0.931	0.745	0.811	0.111	0.727	0.617	1.495	1.329	1.547	0.936	1.307	4.157	1.581
5	0.265	0.274	0.277	0.737	0.153	0.462	0.110	0.353	0.603	0.985	0.399	0.484	2.183	0.727
6	0.123	0.023	0.116	0.149	0.051	0.057	0.053	0.101	0.266	0.564	0.161	0.188	0.560	0.247
7	0.046	0.064	0.018	0.116	0.001	0.004	0.010	0.024	0.100	0.169	0.044	0.023	0.175	0.064
8	0.025	0.017	0.007	0.042	0.002	0.004	0.002	0.029	0.062	0.059	0.009	0.004	0.066	0.026
9	0.014	0.026	0.009	0.004	0.001	0.004	0.008	0.026	0.013	0.038	0.002	0.002	0.008	0.004
10	0.009	0.024	0.031	0.006	0.001	0.012	0.002	0.000	0.020	0.016	0.001	0.008	0.000	0.000
1+	15.992	11.382	15.374	15.740	10.361	8.009	12.779	8.293	8.880	7.600	5.437	6.505	15.833	10.514
2+	13.594	8.647	9.477	13.869	8.778	6.275	9.752	8.185	7.990	7.279	5.273	6.452	14.596	10.328
3+	4.017	3.538	2.315	2.599	2.678	1.902	2.229	5.984	5.175	5.672	3.693	5.790	11.352	5.528
4+	1.249	1.359	1.203	1.864	0.320	1.270	0.801	2.028	2.394	3.378	1.553	2.017	7.149	2.650
5+	0.483	0.428	0.458	1.053	0.209	0.544	0.184	0.534	1.064	1.831	0.617	0.710	2.992	1.068

TABLE 14 : PALOHEIMO Z FOR AGES 3/8 & 4/9

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
PALOHEIMO Z	1.096	1.091	0.203	2.094	0.754	0.858	0.090	0.920	0.425	1.287	0.608	-0.213	1.454

Table 15. Summary of 3+ VPA against 3+ research vessel numbers. The years 1971, 1979, and 1981 excluded from the regression analysis.

TERMINALF	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.50	0.70	0.90
YEARS	1983	1983	1983	1983	1983	1983	1983	1983	1983	1983
OBSERVED	1190677	812109	623015	509709	434296	380536	340308	284209	220709	186047
PREDICTED	1139297	836442	685308	594676	534310	491236	458993	413990	362958	335049
DIFFERNCE	51380	-24333	-62294	-84967	-100014	-110700	-118684	-129781	-142249	-149002
TERM F	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.500	0.700	0.900
EFFORT	17639	17639	17639	17639	17639	17639	17639	17639	17639	17639
STD CPUE	1.552	1.552	1.552	1.552	1.552	1.552	1.552	1.552	1.552	1.552
R^2	0.761	0.813	0.718	0.384	0.099	0.007	0.005	0.054	0.130	0.170
R	0.873	0.902	0.847	0.620	0.315	0.081	0.069	0.232	0.360	0.412
INTERCEPT	-77116.68	173234.83	298950.06	374068.80	424590.03	460735.89	487700.15	525216.64	567767.14	590925.62

Table 16. Summary of fishable population biomass against standard CPUE. 1982 point excluded from regression analysis.

TERMINALF	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.50	0.70	0.90
YEARS	1983	1983	1983	1983	1983	1983	1983	1983	1983	1983
OBSERVED	402409	267826	200506	160092	133130	113856	99386	79097	55821	42803
PREDICTED	219639	194800	182490	175041	170159	166681	164059	160368	156147	153789
DIFFERNCE	182769	73026	18016	-14950	-37029	-52826	-64673	-81270	-100326	-110986
TERM F	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.500	0.700	0.900
EFFORT	17639	17639	17639	17639	17639	17639	17639	17639	17639	17639
STD CPUE	1.552	1.552	1.552	1.552	1.552	1.552	1.552	1.552	1.552	1.552
R^2	0.100	0.269	0.346	0.375	0.387	0.392	0.394	0.394	0.392	0.390
R	0.316	0.519	0.588	0.612	0.622	0.626	0.627	0.628	0.626	0.625
INTERCEPT	106108.76	29226.90	-8396.01	-30832.90	-46015.08	-56883.28	-65056.01	-76523.68	-89660.17	-96966.02

Table 17. Summary of weighted F against effort. The 1973 and 1982 points excluded from the regression analysis.

TERMINALF	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.50	0.70	0.90
YEARS	1983	1983	1983	1983	1983	1983	1983	1983	1983	1983
OBSERVED	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.500	0.700	0.900
PREDICTED	0.282	0.324	0.355	0.380	0.402	0.422	0.440	0.473	0.532	0.587
DIFFERNCE	-0.182	-0.174	-0.155	-0.130	-0.102	-0.072	-0.040	0.027	0.168	0.313
TERM F	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.500	0.700	0.900
EFFORT	17639	17639	17639	17639	17639	17639	17639	17639	17639	17639
STD CPUE	1.552	1.552	1.552	1.552	1.552	1.552	1.552	1.552	1.552	1.552
R^2	0.649	0.632	0.619	0.609	0.596	0.580	0.555	0.474	0.208	0.036
R	0.805	0.795	0.787	0.780	0.772	0.761	0.745	0.688	0.456	0.189
INTERCEPT	0.16	0.21	0.25	0.28	0.31	0.34	0.36	0.41	0.49	0.57

TABLE 18. SILVER HAKE POPULATION NUMBERS (000) AT TF=.25 AND M=.4

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	1711006	1689321	3807998	1435711	1366446	1492339	901581	719373	866332	1010972	705900	685618	1878611	374654
2	1772299	995308	954788	2245392	763723	833941	882831	480424	480477	557406	669816	468080	458320	1243248
3	518837	593324	340865	275549	353240	204058	268428	288594	286767	248873	334469	399914	297907	265394
4	193181	175803	257414	170865	107384	116985	94336	121790	130639	120376	111403	158264	178825	145788
5	74083	81568	58427	133916	31299	66227	30458	38202	57868	53264	43592	45952	75104	67024
6	27490	33053	36986	24885	15168	13141	14102	15914	19977	23243	12396	17003	19375	22782
7	12433	10728	20633	18787	1737	7554	4975	7301	9047	6568	2539	3427	6958	5913
8	33697	5441	3124	12890	1094	1089	4811	2918	4502	3490	529	396	1749	2442
9	13006	20975	2575	1741	4289	645	439	3139	1501	1424	946	88	160	354
10	3269	7815	12390	1238	778	2826	149	7	1683	670	83	561	12	11
1+	4359301	3613336	5495199	4320975	2645157	2738804	2202110	1677663	1858793	2026286	1881673	1779300	2917020	2127611
2+	2648296	1924015	1687202	2885263	1278711	1246465	1300529	958290	992461	1015314	1175773	1093683	1038409	1752957
3+	875996	928707	732414	639871	514989	412524	417698	477866	511984	457908	505957	625603	580089	509709
4+	357159	335383	391549	364322	161749	208467	149270	189272	225217	209035	171488	225689	282183	244315
5+	163978	159580	134135	193457	54365	91482	54934	67482	94578	88659	60085	67425	103358	98527

TABLE 19. FISHING MORTALITY AT AGE

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.14	0.17	0.13	0.23	0.09	0.12	0.23	0.00	0.04	0.01	0.01	0.00	0.01	0.01
2	0.69	0.67	0.84	1.45	0.92	0.73	0.72	0.12	0.26	0.11	0.12	0.05	0.15	0.08
3	0.68	0.44	0.29	0.54	0.71	0.37	0.39	0.39	0.47	0.40	0.35	0.40	0.31	0.25
4	0.46	0.70	0.25	1.30	0.08	0.95	0.50	0.34	0.50	0.62	0.49	0.35	0.58	0.25
5	0.41	0.39	0.45	1.78	0.47	1.15	0.25	0.25	0.51	1.06	0.54	0.46	0.79	0.25
6	0.54	0.07	0.28	2.26	0.30	0.57	0.26	0.16	0.71	1.81	0.89	0.49	0.79	0.25
7	0.43	0.83	0.07	2.44	0.07	0.05	0.13	0.08	0.55	2.12	1.46	0.27	0.65	0.25
8	0.07	0.35	0.18	0.70	0.13	0.51	0.03	0.26	0.75	0.91	1.40	0.51	1.20	0.25
9	0.11	0.13	0.33	0.41	0.02	1.06	3.71	0.22	0.41	2.44	0.12	1.63	2.29	0.25
10	0.29	0.34	0.22	1.45	0.13	0.55	1.03	0.18	0.61	1.82	0.96	0.72	1.21	0.25

TABLE 20. YIELD PER RECRUIT ANALYSIS FOR SILVER HAKE USING 12 AGES

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	0.200	0.18053	0.045	0.252	1.000
	0.400	0.27453	0.060	0.219	0.660
F0.1---	0.425	0.28315	0.061	0.216	0.633
	0.600	0.33330	0.067	0.200	0.490
	0.800	0.37439	0.071	0.188	0.388
	1.000	0.40531	0.073	0.180	0.321
	1.200	0.42979	0.074	0.173	0.273
	1.400	0.44993	0.075	0.168	0.237
	1.600	0.46696	0.076	0.163	0.209
	1.800	0.48169	0.077	0.159	0.187
	2.000	0.49465	0.077	0.156	0.169
	2.200	0.50623	0.077	0.152	0.154
	2.400	0.51668	0.077	0.150	0.142
	2.600	0.52621	0.077	0.147	0.131
FMAX---	2.666	0.52919	0.077	0.146	0.128
	2.800	0.53496	0.077	0.144	0.121
	3.000	0.54306	0.077	0.142	0.113
	3.200	0.55060	0.077	0.140	0.106
	3.400	0.55765	0.077	0.138	0.100
	3.600	0.56426	0.077	0.136	0.094
	3.800	0.57050	0.077	0.135	0.089
	4.000	0.57640	0.077	0.133	0.084

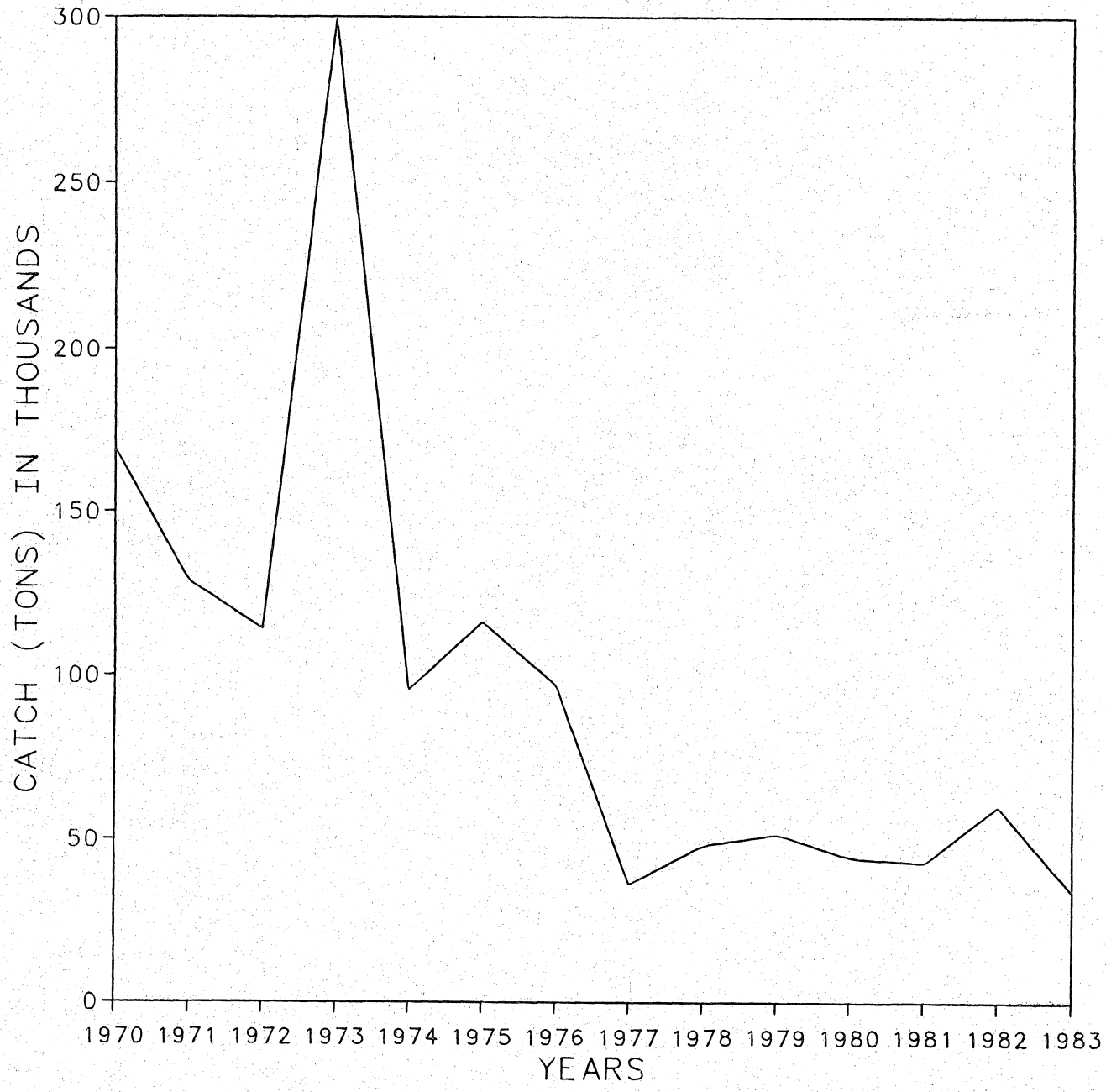


Fig. 1. Nominal catches (t) of 4VWX silver hake.

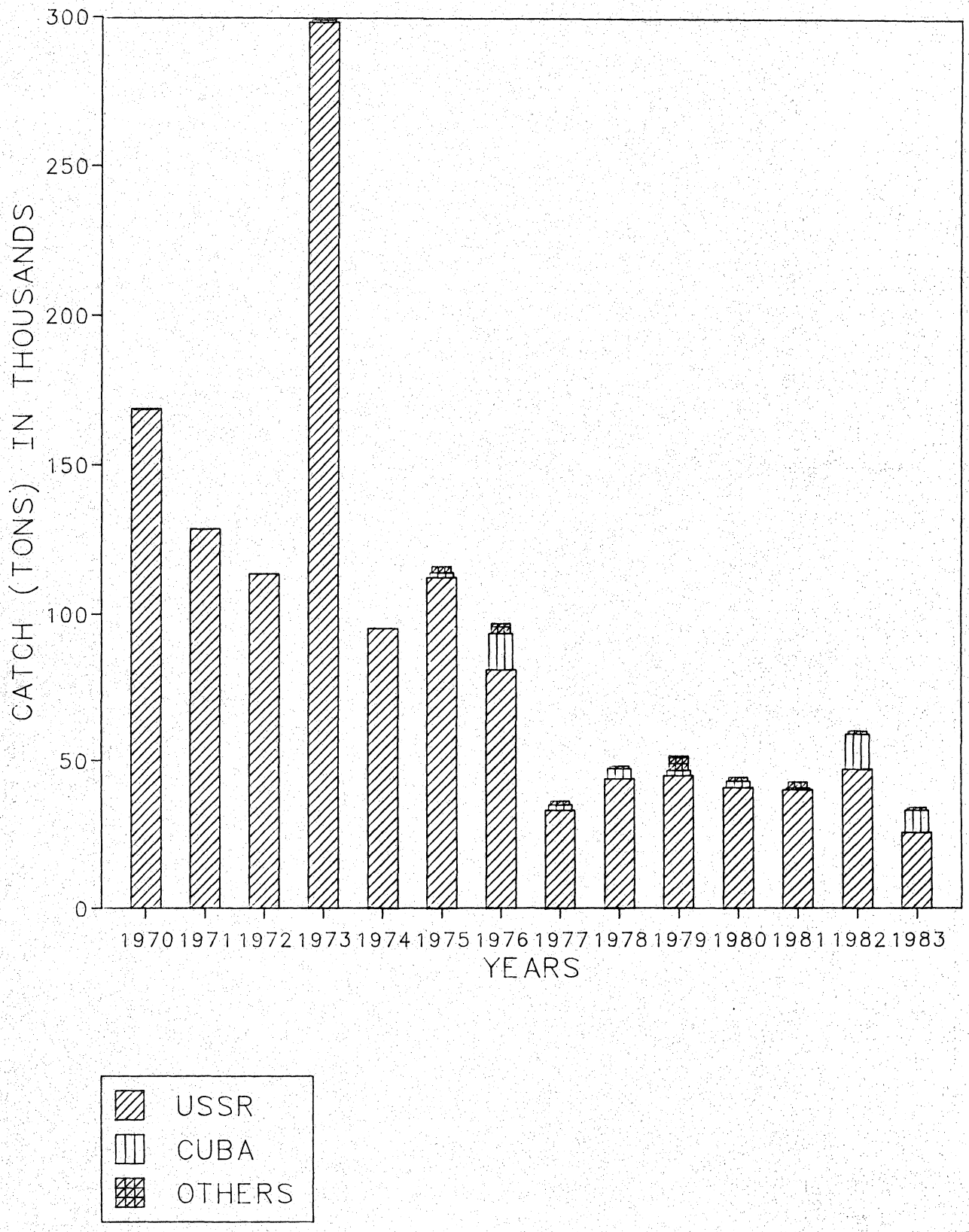


Fig. 2. Nominal catches (t) of 4VWX silver hake by country.

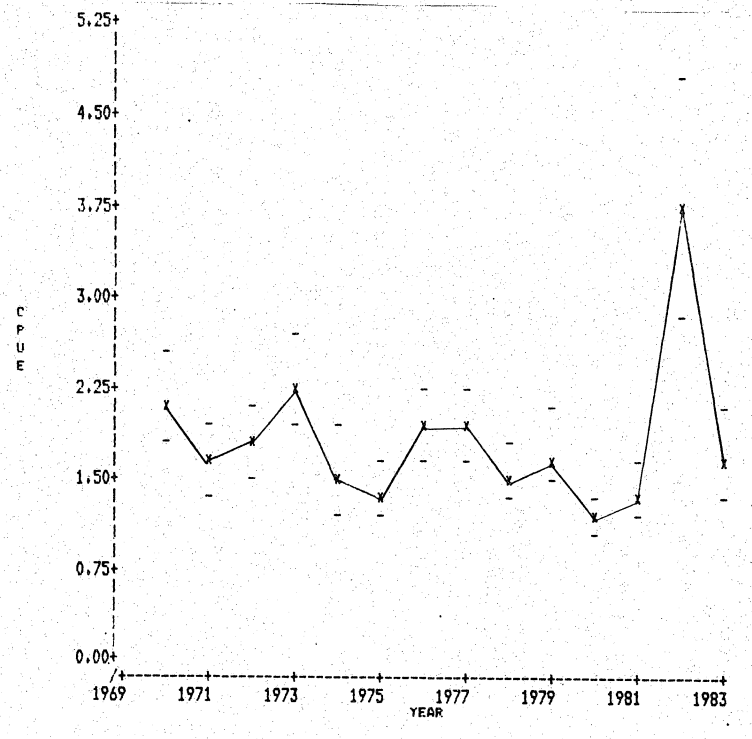


Fig. 3. Standardized catch per unit of effort (t/hr) for 4VWX silver hake.

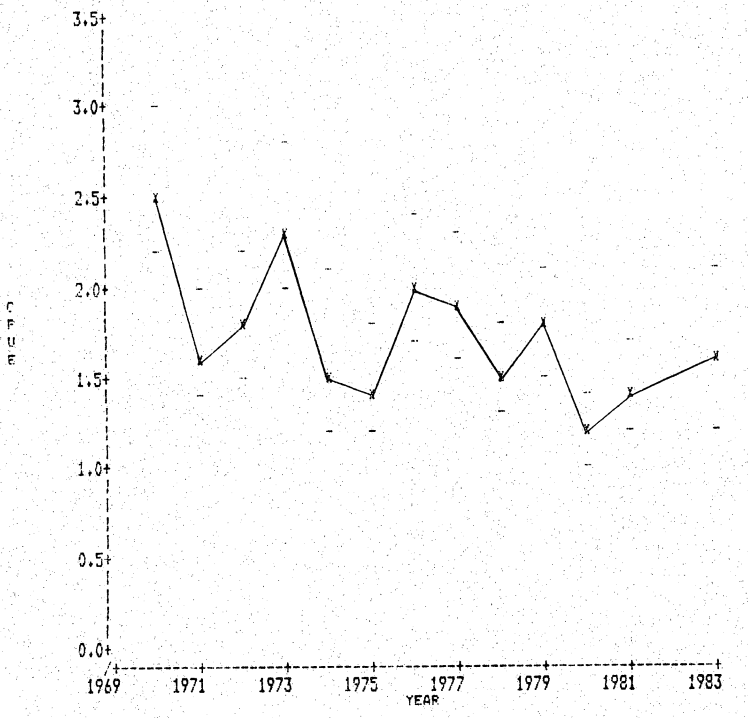


Fig. 4. Standardized catch per unit of effort (t/hr) for 4VWX silver hake. The 1982 data point removed.

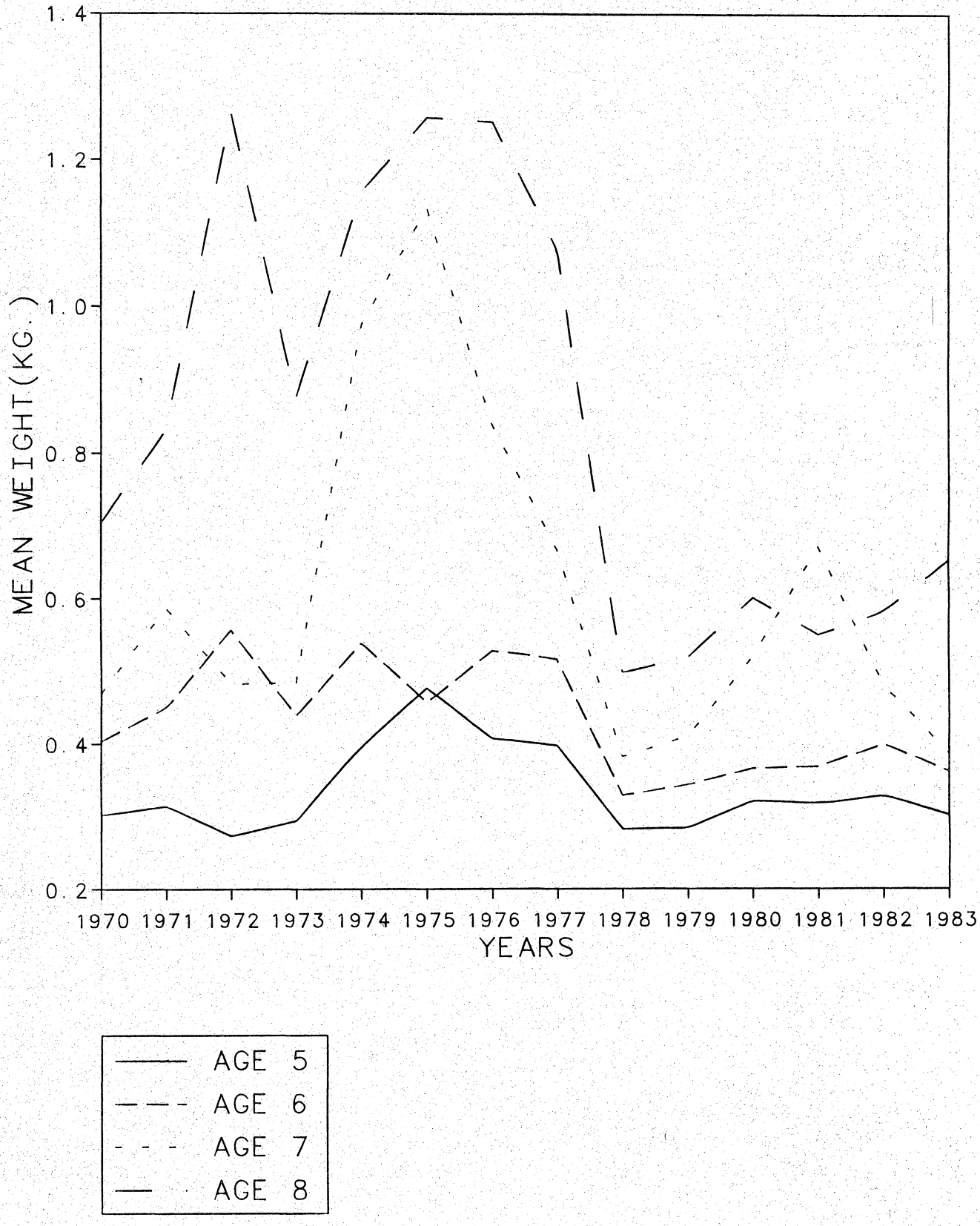


Fig. 5. Mean weights at age for ages 5, 6, 7, and 8.

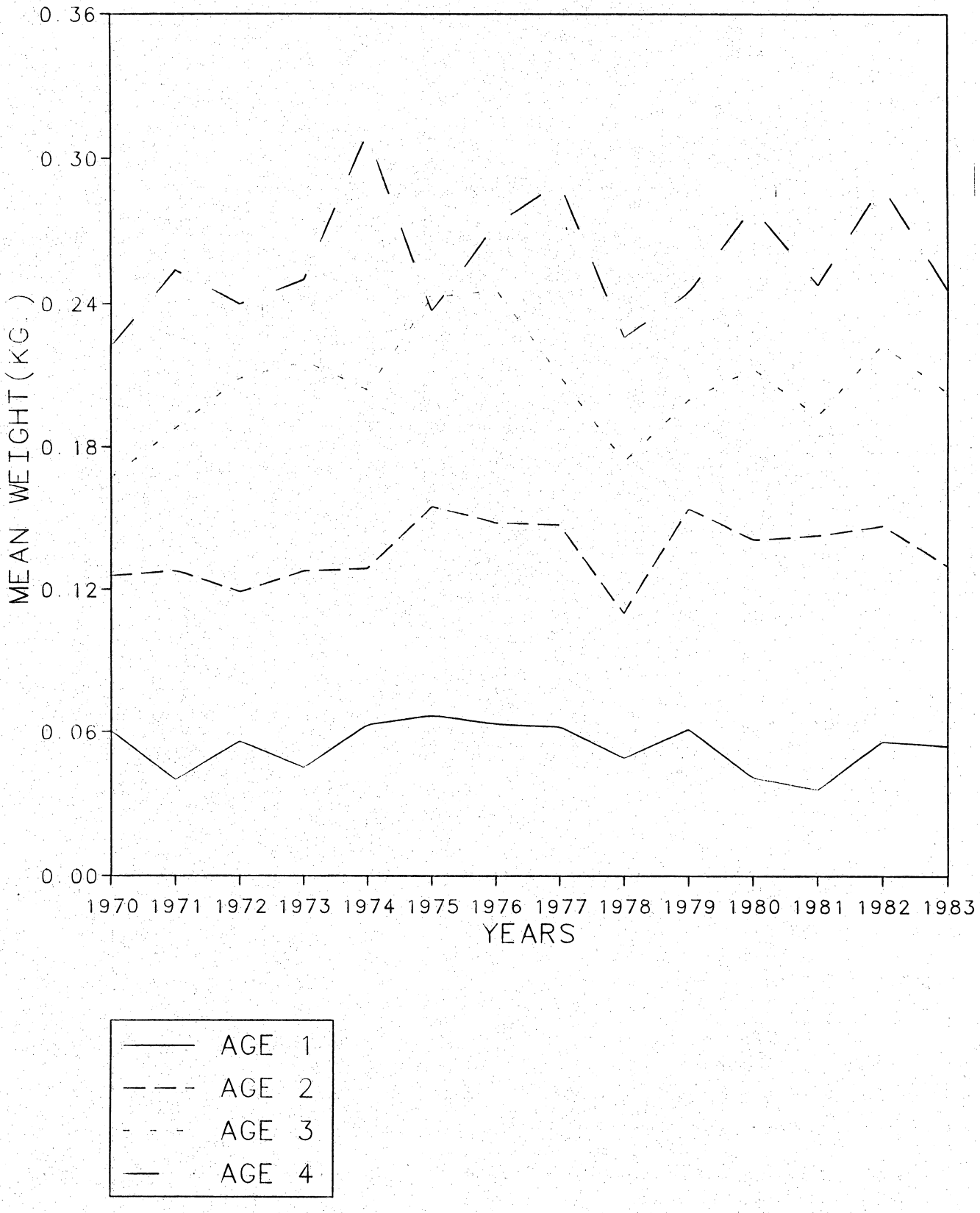


Fig. 6. Mean weights (kg) for ages 1, 2, 3, 4.

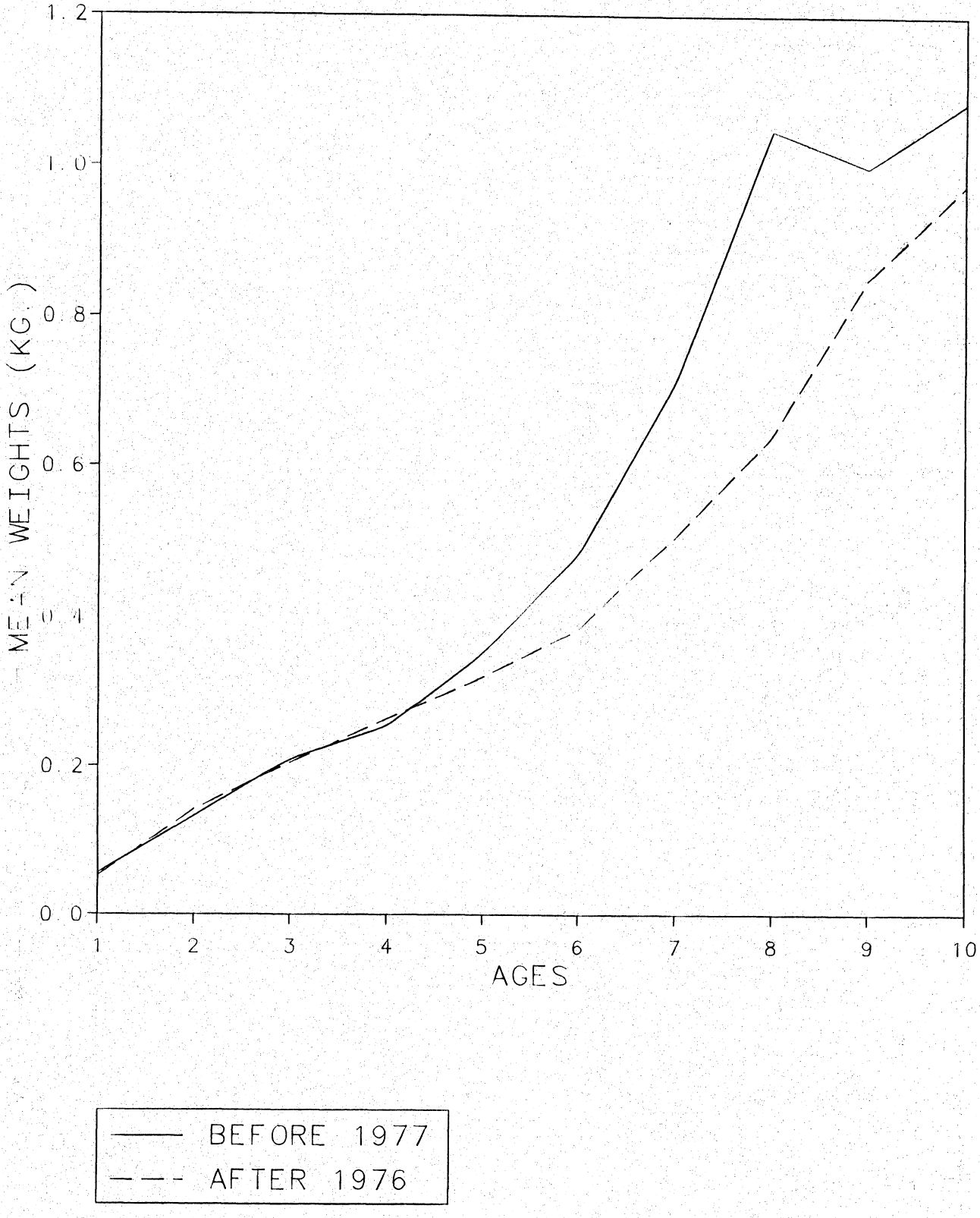


Fig. 7. Mean weights (kg) before 1977 and after 1976.

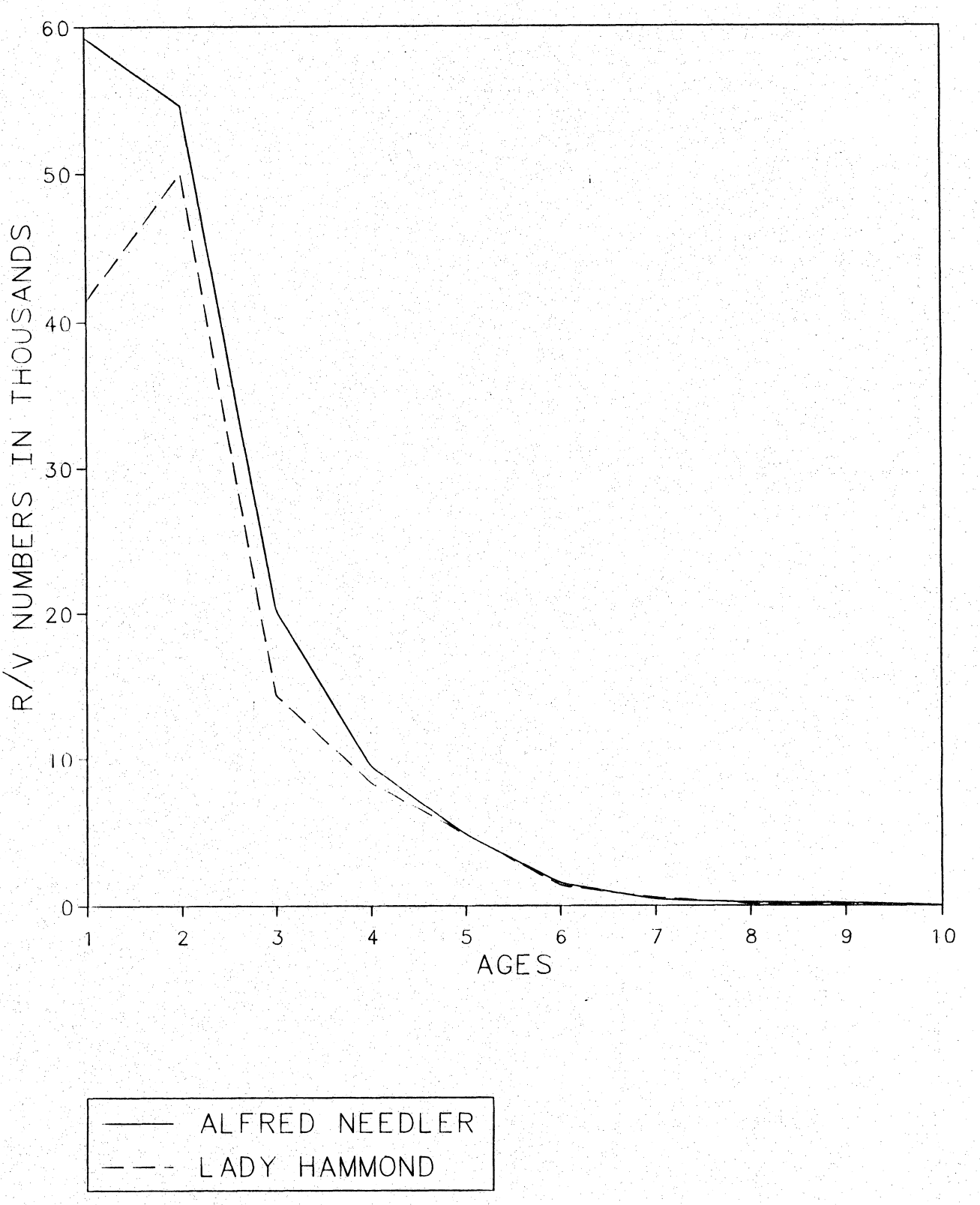


Fig. 8a. Comparison of the July 1983 Needler and Hammond cruise estimates for 4VWX silver hake (includes only those strata which were sampled by both vessels).

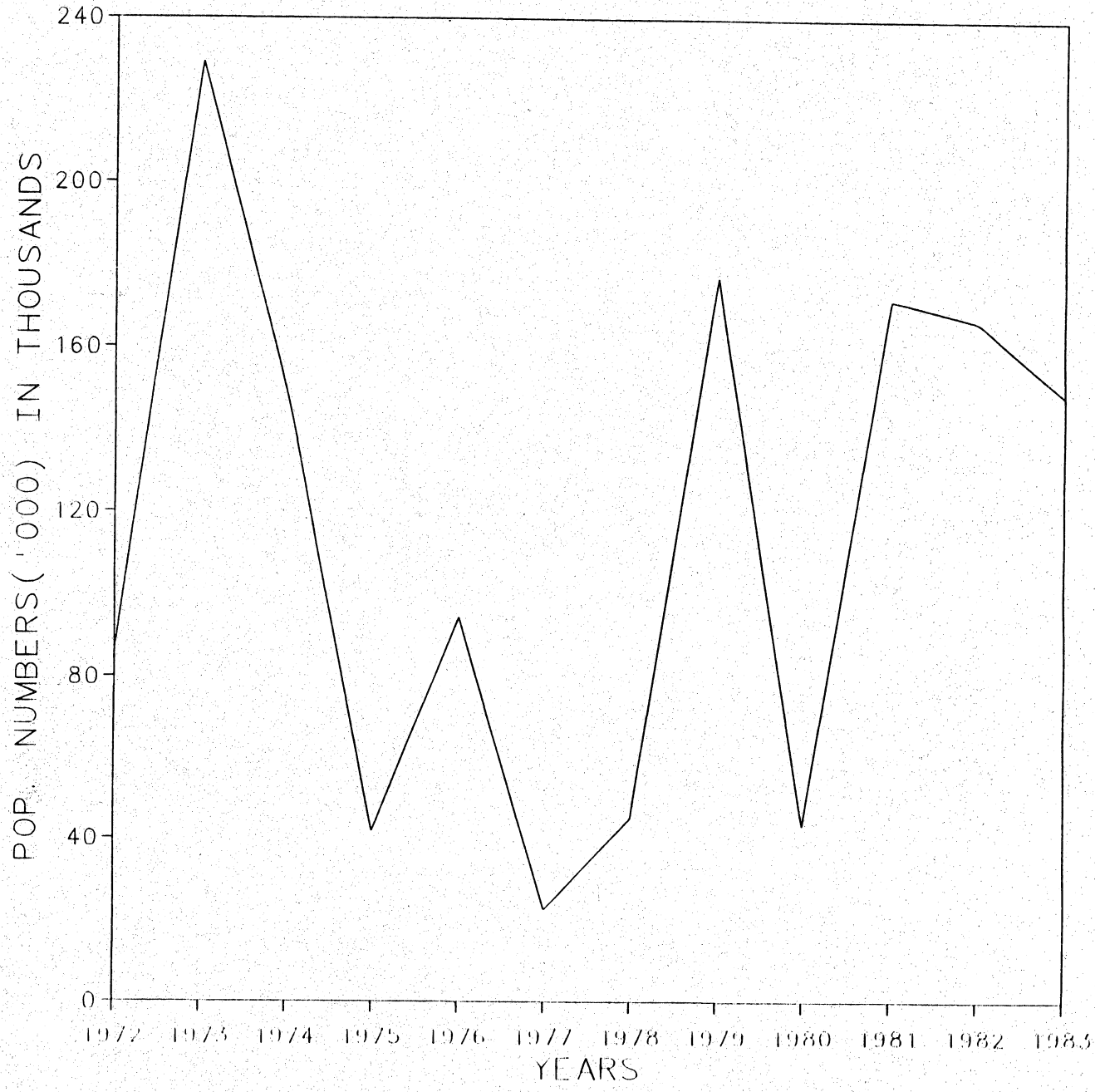


Fig. 8b. Research vessel population numbers.

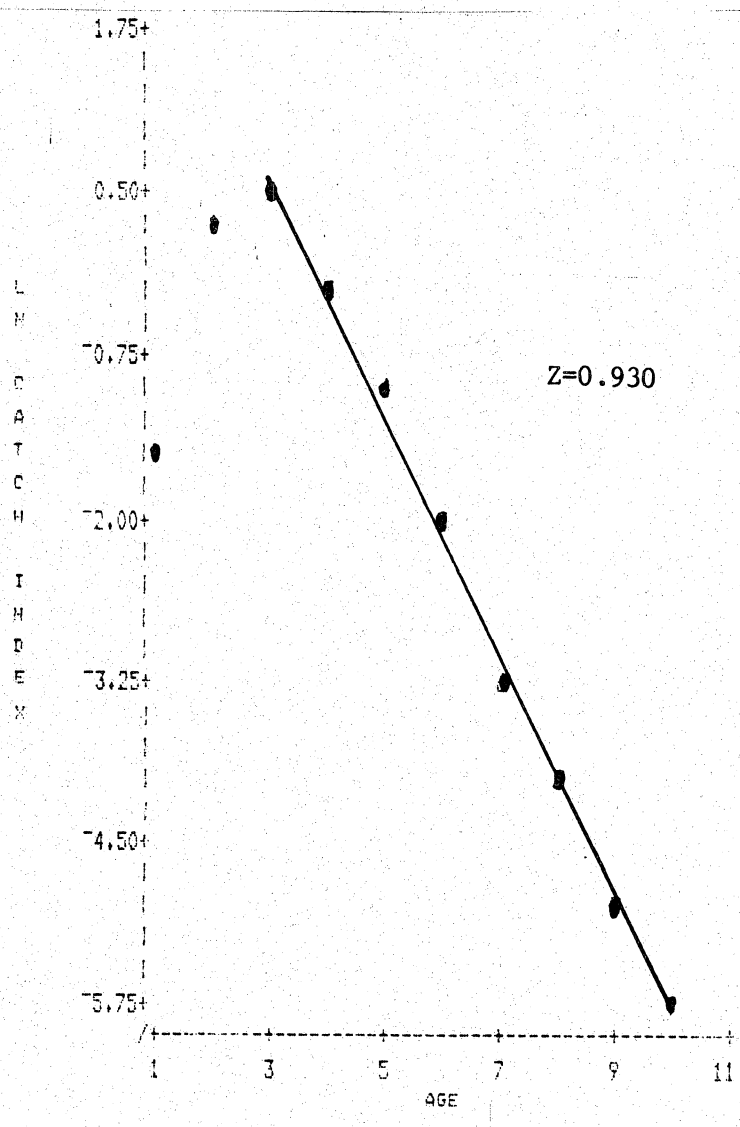


Fig.9 . Catch curve (ln c/hr in numbers) for 4VWX silver hake. Data averaged over the 1977-83 period.

REGRESSION COEFFICIENT	-0.9304503778
INTERCEPT	3.505005137
T-VALUE	-31.33283197
STANDARD ERROR	0.02969569998
DEGREES OF FREEDOM	7
OBSERVATIONS	9
Rx2	0.9939255661
R	0.9969581566

AVERAGE FOR YEARS 1977 1978 1979 1980 1981 1982 1983

AGE	1	2	3	4	5	6	7	8	9	10
AVERAGE	-1.555	0.189	0.453	-0.125	-0.893	-1.903	-3.151	-4.005	-5.005	-5.714

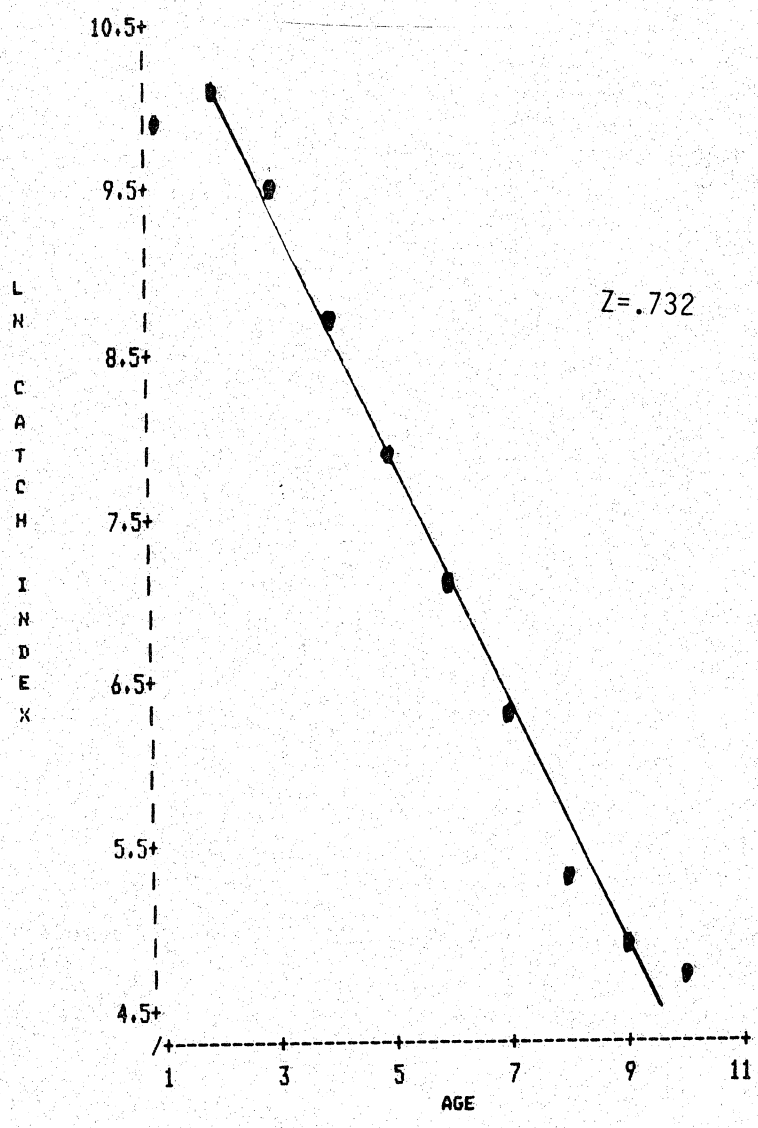
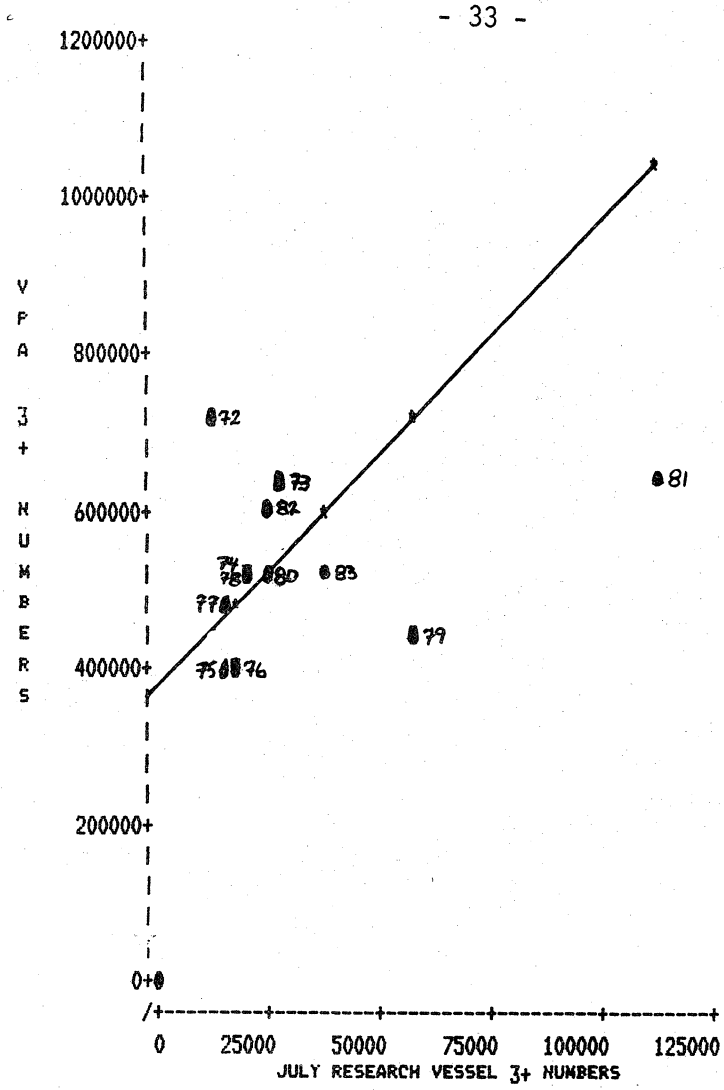


FIG 10: CATCH CURVE USING RESEARCH VESSEL NUMBERS AVERAGED FROM 1977 - 1983

AGE	1	2	3	4	5	6	7	8	9	10
AVERAGE	9.852	10.013	9.547	8.633	7.819	7.012	6.276	5.387	4.846	4.612

REGRESSION COEFFICIENT	-0.732380043
INTERCEPT	11.52694067
T-VALUE	-20.09323525
STANDARD ERROR	0.03644908517
DEGREES OF FREEDOM	7
OBSERVATIONS	8
R^2	0.9853564998
R	0.9926512478



F = .25

FIG.11: CALCULATED VPA 3+ NUMBERS (000) AGAINST RESEARCH 3+ NUMBERS (000) FOR THE 4VWX SILVER HAKE STOCK, (R = 0.620).

CALCULATED 3+ NUMBERS FROM VPA AND 3 YEAR SMOOTHED RESEARCH VESSEL 3+ NUMBERS FOR THE 4VWX SILVER HAKE STOCK,

YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
PRED	455460	545222	494550	458682	472713	464743	488375	719484	520936	1041826	530790	594676
VPA	732414	639871	514989	412524	417698	477866	511984	457908	505957	625603	580089	509709
DIFF	276954	94649	20439	-46158	-55014	13123	23609	-261576	-14979	-416223	49300	-84967
RES	13563	28521	20077	14100	16438	15110	19048	57560	24474	111275	26116	36762

REGRESSION OF VPA 3+ AGAINSTRESEARCH VESSEL 3+ FOR 4VWX SILVER HAKE:
excludes 1972,79,81

REGRESSION COEFFICIENT	6.000960903
INTERCEPT	374068.8029
T-VALUE	2.090892294
STANDARD ERROR	2.870047835
DEGREES OF FREEDOM	8
OBSERVATIONS	9
R*2	0.3844438723
R	0.6200353799

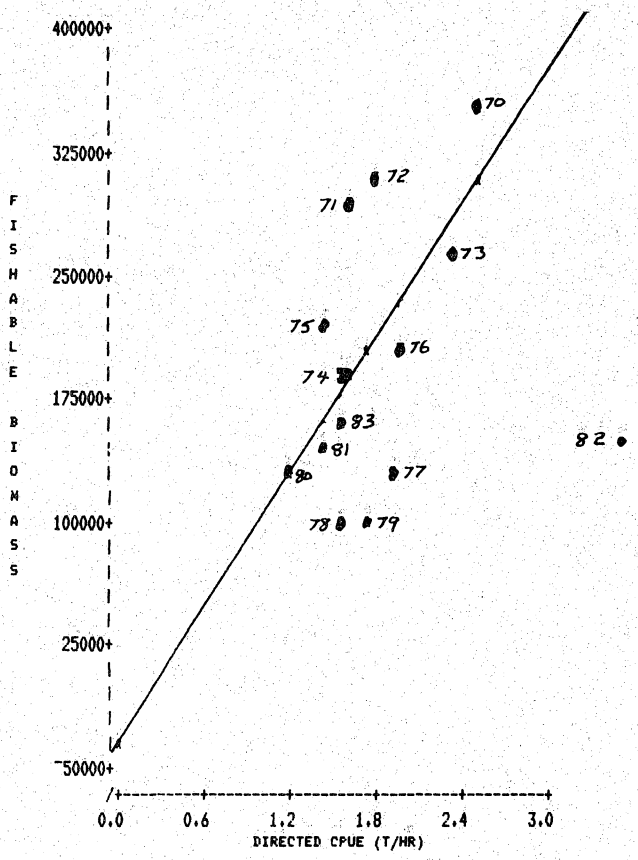


FIGURE 12. FISHABLE POPULATION BIOMASS AND DIRECTED CPUE FOR THE 4VWX SILVER HAKE , (R = 0.612) ;

FISHABLE POPULATION BIOMASS AND OBSERVED AND PREDICTED CPUE
FOR THE 4VWX SILVER HAKE STOCK,
(THE FOLLOWING YEARS WERE USED IN THE REGRESSION EQUATION
YEARS = 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1983)

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
BIOMASS	354001	294134	306441	260190	194317	215280	210860	134796	102770	106483	130203	137732	145275	160092
PRED BIOMS	306366	187511	209531	278642	172919	159786	231816	224918	172521	203827	126889	157531	-30833	175041
DIFFERENCE	47635	106623	96911	-18452	21398	55494	-20956	-90122	-69751	-97344	3314	-19800	176108	-14950
STD, CPUE	2.542	1.646	1.812	2.333	1.536	1.437	1.980	1.928	1.533	1.769	1.189	1.420	3.688	1.552

REGRESSION OF FISHABLE BIOMASS AGAINST CPUE FOR THE 4VWX SILVER HAKE STOCK,
(THE DATA USED IN THE REGRESSION INCLUDES THE YEARS AS FOLLOWS
YEARS = 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1983
FOR TERMINAL F = 0.25)

REGRESSION COEFFICIENT	132650.9217
INTERCEPT	-30832.9028
T-VALUE	2.569237111
STANDARD ERROR	51630.47082
DEGREES OF FREEDOM	12
OBSERVATIONS	13
R^2	0.3750347755

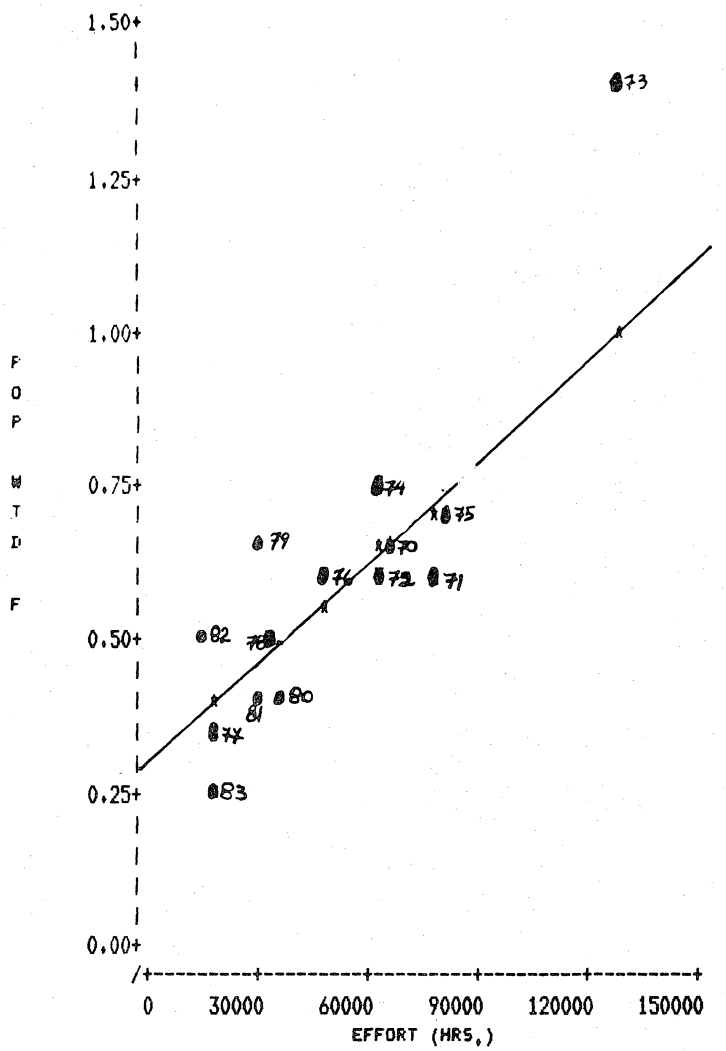


FIGURE 13. WEIGHTED F AND EFFORT (HRS.) FOR THE 4VWX SILVER HAKE STOCK.

(ONLY THE FOLLOWING YEARS ARE INCLUDED IN THE REGRESSION
1970 1971 1972 1974 1975 1976 1977 1978 1979 1980 1981 1983)

PREDICTED AND CALCULATED WEIGHTED F (POPULATION #'S) AND EFFORT (HRS.) FOR THE 4VWX SILVER HAKE STOCK.

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
WTD F	0.664	0.578	0.603	1.382	0.770	0.710	0.616	0.356	0.492	0.635	0.414	0.396	0.479	0.250
PRED F	0.647	0.710	0.627	0.985	0.624	0.726	0.552	0.389	0.456	0.443	0.488	0.441	0.371	0.380
DIFF.	0.017	-0.132	-0.024	0.398	0.146	-0.016	0.065	-0.033	0.036	0.191	-0.074	-0.046	0.108	-0.130
TERM F	0.288	0.345	0.216	1.453	0.127	0.548	1.033	0.184	0.606	1.818	0.964	0.720	1.206	0.250
STD EFF	66498	78149	62952128413	62321	81013	49071	19241	31568	29252	37444	28869	15933	17639	

REGRESSION OF WEIGHTED F (POPULATION NUMBER'S) AGAINST EFFORT (HRS.) FOR THE 4VWX SILVER HAKE STOCK.

REGRESSION COEFFICIENT	5.456692474E-6
INTERCEPT	0.2838649883
T-VALUE	3.943009903
STANDARD ERROR	1.383890127E-6
DEGREES OF FREEDOM	11
OBSERVATIONS	12
R#2	0.6085696182
R	0.780108722