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Size of the Scotian Shelf Silver Hake Population in 1988 with Projections to 1990

by

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Introduction

General Biology

Silver hake (Merluccius bilinearis, Mitchill, 1814), sometimes referred to as whiting, is a member of the class Pisces (Osteichtyes), order Anacanthini, and family Gadidae. The presence of one as opposed to two or three anal fins makes the Merlucciidae readily distinguishable from other gadoids such as cod, haddock and pollock. Various species of Merluccius are found throughout the world's oceans generally in temperate waters and around upwellings in some tropical areas. In the eastern Atlantic from Norway to South Africa there is a large stock complex composed of seven varieties either classified as subspecies of Merluccius merluccius (Franca, 1960 and Jones, 1974) or as a separate species.

Several of the hake stocks along the eastern Atlantic support major fisheries. In particular the European hake, Merluccius merluccius, found along the coast of Western Europe is the third largest groundfish fishery in the area producing 80,000 metric tons annually. Another species, Merluccius capensis found off the West African coast provides a large fishery to Namibia and South Africa.

There are five species of Merluccius in the western Atlantic (Bullock, 1980). Two species, M. albidus and M. bilinearis, are present in the northwest Atlantic. Merluccius albidus, commonly referred to as the offshore hake, is similar in appearance but often larger than M. bilinearis. Only the larger members of this species have been observed in research vessel and commercial catches off Nova Scotia (Waldron and Fanning, 1986). Merluccius albidus have a bluish back in contrast to the dark grey back of M. bilinearis. Speciation is confirmed by counting the number of gill rakers on the first gill arch. M. albidus has 9-11 gill rakers while M. bilinearis has 15-22 gill rakers. Bigelow and Schroeder (1955) propose that M. albidus caught in Nova Scotian waters are rare and definitely at their northern extreme.

Silver hake is a deep water species inhabiting an area from Cape Hatteras to the Grand Banks including the Gulf of St. Lawrence (Bigelow and Schroeder, 1953 and Leim and Scott, 1966). The major portion of the population (42%) is found in waters from 100-149m during the summer (Scott, 1982). Silver hake were seldom present (< 1%) in waters deeper than 200m while 11.5% were in waters more shallow than 50m.

Silver hake have a temperature range of 1-13^{0}C with a preferred range between 7^{0}C and 10^{0}C (Scott, 1982). The average winter bottom temperature on the Scotian Shelf is between 1 and 6^{0}C. At this time of year part of the silver hake population are found in the deep basins of the Scotian Shelf (Waldron, 1983) and the Gulf of Maine (Almeida, 1985) where the temperature is 4-8^{0}C. The major portion of the silver hake stock resides in the deeper slope waters off Nova Scotia and the northeast coast of the USA (Almeida, 1985 and Waldron et al., 1982).

Historical Fisheries Management

Fisheries management of silver hake in the northwest Atlantic commenced in 1958 under the International Commission for the Northwest Atlantic Fisheries (ICNAF). Quotas and stock boundaries were first imposed by ICNAF in 1973 for Subarea 5 and Statistical Area 6 and in 1974 for Subarea 4 (Anon., 1972, 1973). Since 1977 the silver hake stocks have been managed separately by Canada and the United States.

Four stocks were defined as a result of several biological studies conducted by Soviet, American and Canadian researchers (Conover et al., 1961, Konstantinov and Noskov,1966 and 1969, Nichy, 1969, Halliday, 1973, Kohler, 1968, Sarnits and Sauskan, 1966 and Sauskan, 1964). Those management units were;

1. the Scotian Shelf (Subarea 4VWX) stock,
2. the Gulf of Maine (Subarea 5Y) stock,
3. the Georges Bank (Subarea 5Ze) stock, and
4. the Southern New England - Middle Atlantic stock (Subarea 5Zw and Statistical Area 6).

An active Scotian Shelf silver hake fishery commenced in 1961 with the arrival of the Soviet fishing fleets. Peak catches occurred in 1963 (123,000 t), 1970 (169,000 t) and the largest in 1973 (300,000 t). Historically the fishery operated from March to early October with minimal catches occurring earlier and later in the year. The most active fishing areas were and still are the slope waters of the Emerald and Sable Island Banks (Figure 1).

Concern over the low levels of certain fish stocks on the Scotian Shelf prompted a 1976 meeting of the ICNAF Standing Committee on Research and Statistics (STACRES) to review the distribution of the silver hake fishery in relation to other groundfish (Anon., 1977). Three areas were identified as being actively fished for silver hake. In one area, along the edge of the Scotian Shelf, Canadian research survey results indicated the least overlap in distribution with other commercial species. The committee noted however that:

> "... the northern limit of this fishery area is critically important, as the haddock could be subjected to by-catch problems, particularly in the winter when they are aggregated in prespawning and spawning concentrations. These aggregations can occur to a depth of 155 m (85 fath.) in winter (November to March or April inclusive), depending on hydrological conditions. However, in summer (May to October inclusive), haddock occur in shallower areas, and fishing for silver hake along the edge of the continental shelf in depths as shallow as 120 m (65 fath.) would avoid the main areas of haddock distribution".
>
> (Anon., 1977)

Based on this advice, ICNAF made the following regulatory proposal for the Scotian Shelf silver hake fishery: fishing with small meshed gear (60mm) will be permitted in an area south and east of a line defined along the edge of the Scotian Shelf and will occur between April 15 and November 15 of each year (Waldron and Sinclair, 1984). This line has become known as the Small Mesh Gear Line (SMGL) (Figure 1). When Canada declared a 200 mile Economic Management Zone in 1977, the ICNAF recommendations were accepted and codified in the Canadian Foreign Fishing Regulations. In addition regulations were introduced to increase the trawl codend mesh size from 40mm to 60mm and limit the by-catch of haddock to less than 1%. Other important commercial species were restricted to a by-catch less than 10% of the total weight aboard the vessel.

Current Fishery

The vessels used in this fishery are large Tonnage Class (TC) 7 vessels (greater than 2000 gross registered tons) usually between 80 and 100 meters in length. The gear most often used is a large bottom trawl with an average wing spread of 29 meters and an average head rope height of 8 meters. Using these nets, vessels have been observed to catch as much as 60 tons of silver hake in one day with one tow having as much as 25 tons of silver hake.

Catches are highest during the period April to July of each year, and come primarily from the NAFO Subarea 4W. The historical catches for this fishery have ranged from 300,000 tons in 1973 to 34,000 tons in 1983. There was a steady decrease in silver hake catch from 1973 to 1981 (Figure 2, Table 1). Nominal catches from 1977 until 1983 have fluctuated between 33 and 60 thousand tons. Below are reported catches ('000 t) and the Total Allowable Catch (TAC '000 t) since 1977.

YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Advice												161	235
TAC	70	80	70	90	80	80	80	100	100	100	100	120	135
CATCH	37	48	52	45	45	60	36	74	75	83[1]	62[1]	74[1]	42[2]

[1] Preliminary
[2] As of May 21, 1989

As indicated in the previous assessment, official NAFO catch statistics for 1985 were modified. Revised catches for 1986 were also available from NAFO during 1987. These updated catches and the catches used in this assessment document are presented in Table 2. Overall catch totals are similar to those used in the last assessment.

Since 1976, the low level of catches against TAC is due in part to the amount of silver hake Canada allocates to other nations. A more informative method of viewing the post-1976 catches is to evaluate catch against the amount of silver hake allocated. Percentages of their total allocations caught by non-Canadian fleets have ranged from 64% to 90%. In the most recent years the majority of the allocations were caught.

Historical catches from this fishery indicate that the major fishing season was between April and August (Table 2) with peak catches from May to July. Unlike previous years, in 1984, 1985, and 1986 the USSR started fishing in May rather than early April. The USSR commenced fishing their 1987 allocations during the last week of May. Delays in fishing are reflected in the decreased catches during the months of April and May for those years (Table 2). Despite the late start for the fleet from 1984 to 1986 they still caught their allocations, as did the Cuban fleet (Figure 3). In 1988 both the USSR and Cuba commenced fishing in April. Monthly catches in 1988 were highest in May and June when 51,500 tons or 69% of the catch was taken. Catches from April to July accounted for 100% of the total yearly landings. At the start of 1988, Canada was allocated 36000 t. of which 30000 t. was for development. Later in the season this was reduced to 16000 t. and the difference allocated to the USSR and Cuba who were unable to take full advantage of it.

Commercial Sampling

Sampling for length and age of the commercial catch in 1988 was conducted by the Canadian International Observer Program (IOP) (Table 4a). The IOP observed 95% or 70,674 t. of the 74,482 t. caught. More than 370,000 lengths and 1,798 otoliths were collected from the fishery. This places coverage levels for 1988 and previous years above the NAFO standard.

Otoliths were randomly selected from those collected and aged using the ICNAF standards (Anon., 1977) by Mr. J. Hunt of the Canadian Department of Fisheries and Oceans, St. Andrews Laboratory, St. Andrews, New Brunswick.

Catch-at-age

The catch-at-age matrix used in this assessment was reconstructed and is presented in Table 5a. Separate male and female length frequency samples for silver hake collected during the small-meshed fishery were adjusted to vessel catch then aggregated to produce a single yearly length frequency for the total fishery. The alpha and beta values used were obtained during the July research vessel surveys (Table 4b). These yearly length frequencies were weighted to the yearly catch (Table 2). For each year and sex the weighted length frequencies were multiplied by age-length keys to produce catch numbers at age. The vectors for each sex were summed to give a final vector of catch numbers at age.

Table 5c shows the difference in catch at age used in this and the most recent assessment. Differences in ages 1 and 2 are related to the inclusion of discard and reduction samples in the construction of the catch at age presented in the previous assessment.

In numbers, the 1988 fishery was composed of one large (1985), and one average (1986) year-class (Table 5a). The catch numbers at age matrix and percent catch numbers at age (Table

6) indicate the 1985 year-class continues to dominate the fishery. The 1985 year-class at age 3 in 1988 is the largest of the age 3 series. The 1984 year-class, in 1988 appears weak compared to other year-classes at age 4. The 1983 and 1986 year-classes in 1988 are at an average level.

Monthly mean catch weights at age are presented in Table 7 and Figure 4. For 1988, mean weight at age for ages 1-4 and 6 increased over 1987.

The catch biomass and percent biomass at age is given in Table 8 and 9. The 1987 fishery was strongly supported by the 1984 and 1985 year-class. The catch from the 1983 year-class, which made up the bulk of the fishery in 1986, dropped sharply.

There is good agreement between the catch biomass and the reported catch per year as shown below. The difference between reported and calculated catch in 1988 could be the result of discrepancies between the catch reported to Canada and available NAFO statistics. As more data becomes available these estimates will be adjusted by recalculating the catch-at-age for 1988.

Catches and TAC's for 4VWX silver hake

Year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Catch	37095	48404	51760	44525	44600	60251	35839	74266	75480	82689	61704	74476
Biomass	36864	48095	51168	44290	44170	60281	36253	74622	75488	84159	61980	75663
Difference	231	309	592	235	430	-30	-414	-356	-8	-1,470	-276	-1,187

Indices of Abundance

Commercial Catch and Effort

The 1986 to 1988 CPUE estimates use monthly catch and effort data from the IOP. With one exception, the 1977 to 1985 CPUE used catch and effort reported to NAFO. The exception was the 1985 reported effort, which varied from that licensed and reported to Canada (FLASH) by the USSR. FLASH reports 56865 t. caught, 2287 days licensed, 1761 days on ground, and 1578 days fished. The 1985 NAFO Statistical Bulletin reports 56337 t. caught, 2493 days on ground, and 2100 days fished. Data collected by the IOP shows that the Soviet fleet fished an average of 12.97 hours per day. The observed difference between the days fished reported to FLASH and NAFO suggests the hours fished could be inflated in the NAFO statistics by as much as 6770 hours. With such a large difference in hours fished the 1985 observed catch and effort from the IOP were used as inputs to the catch rate standardization analysis.

A regression analysis to compare monthly catch rates for the USSR from NAFO and the Canadian IOP was highly significant with a correlation of 0.96, a slope of 1 and intercept of 0 (Waldron and Parnell, 1986). On this basis the IOP catch rates have been used when Soviet and Cuban catch and effort were not available.

Catch Rate Standardization:

Catch and effort from 1977-1988 were categorized similar to that used in the previous assessment. The regression results (Table 10) indicate there is a significant effect due to year, month, regime and country in the model. As in the previous assessments there are significant monthly effects due to better catch rates in April, the only month with a significant coefficient.

There were no significant effects due to data source (NAFO or IOP) or NAFO area.

The standardized catch rates for 1988 dropped from the peak seen in 1986 and 1987 (Table 11, Figure 5). Since 1982, catch rates have been highly variable from year to year but at higher levels. While there is no apparent trend over this time period, the high catch rates would normally indicate a larger population biomass after 1981 than in the period prior to 1982.

Abundance Surveys

Canadian Adult Surveys

The July stratified random groundfish survey is another index of adult abundance. From 1970 to 1986 three vessels were used to conduct this survey. Analysis of comparative fishing experiments between pairs of vessels (Fanning, 1985) indicated that a conversion factor of 2.3 should be applied to the series prior to 1982. This adjustment is assumed to account for the effect of vessel and gear changes in the time series.

A recommendation from the 1988 June meeting of STACFIS was to investigate the use of the July survey in the calibration of the SPA. The 1970-1988 survey data set was re-edited using more stringent editing criteria than used previously. The revised estimates of numbers and standard errors and cv's at age for the July survey are given in Tables 12 and 13a,b. The percent at age by numbers is presented in Table 14.

Numbers in the 1987 year-class at age 1 in 1988 are the fourth lowest in the series and is almost a full order of magnitude below that of the 1985 year class at age 1 (Table 12). In terms of numbers at age the 1985 year-class in 1988 remains quite large (Figure 6). It constitutes 29% of the total numbers in the survey estimates at age 3 in 1988 (Table 14). Survey estimates for age 4 and 5 fish (1983 and 1984 year-classes) appear average.

A stratified random spring groundfish survey was conducted in March from 1979 to 1985. However, no new data are available beyond what was presented in Waldron and Fanning (1986). The estimated total numbers in the March surveys were:

Year	1979	1980	1981	1982	1983	1984	1985
Numbers	381469	192500	335821	998784	964176	960484	379573

Silver hake juvenile survey

A joint USSR-Canada juvenile silver hake survey was initiated in 1978 and continues to the present (Table 15). From 1978 to 1980 the survey was conducted over a 24 hour period, using a groundfish trawl. In 1981 a gear change was made, substituting an International Young Gadoid Pelagic Trawl (IYGPT) for the bottom trawl. Since 1981 the survey has been conducted on a 12-hour night-time only basis, using the IGYPT. The survey index based on the core strata (60-78) (Koeller et al., 1984) from 1978 to 1985 was recalculated in 1986 (Koeller et al., 1986) and the same method has been used for subsequent years.

Only the estimates from 1981 to 1988 (IGYPT.) gear are used as a series for juvenile silver hake abundance. This series indicates that the 1981, 1983, 1985, and 1986 year-classes are large relative to the 1982 and 1984 year-classes. The 1988 index is approximately equal to that of 1986 but still well below the numbers reported for the 1985 year class. The juvenile index corresponds with age 1 silver hake for the subsequent year. (Figure 7)

Sequential Population Analysis

The last SPA was accepted by the NAFO Scientific Council in 1987 using a catch rate series which had been standardized by means of a multiplicative model regression (Fanning et al., 1987). In this current assessment the Adaptive framework (Gavaris, 1988) is used to calibrate an SPA with the catch rate and R/V series. As in previous years a natural mortality of 0.4 on all ages was assumed.

Model Inputs

The initial partial recruitment used was the same as that of the last assessment. After several Adapt runs a new Input PR for ages 1 and 2 in 1987 was calculated from the ratio of F on ages 1 and 2 to average F on fully recruited ages (3 to 6) for years 1982 to 1987. The resulting input partial recruitment in the final year was below that used in the previous assessment and is the lowest in the series presented.

Partial Recruitment Patterns
for Silver Hake
by Assessment Year

	Age		
Assessment	1	2	3-9
Current	.022	.249	1.000
Previous[1]	0.045	0.301	1.000
1987[2]	0.080	0.580	1.000
1986	0.041	0.304	1.000
1985	0.035	0.350	1.000
1984	0.030	0.250	1.000
1983	0.030	0.250	1.000
1981-82	0.044	0.444	1.000
1979	0.150	1.000	1.000

ADAPTIVE Framework

The results of several ADAPT runs are summarized in Table 16. An ADAPT run with ages 1-8, R/V numbers and standard errors is presented in Table 17. Table 18 shows an ADAPT run with only CPUE (ie. age aggregated calibration). In all cases, the 1982 CPUE value is masked.

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1 Based on fixing recruitment for 1983-1986 year-classes. See last years assessment.

2 The PR, prior to 1987, used in the calculation of exploitable biomass was based on annual PR vectors which were estimated as the ratio of F on ages 1 and 2 to average F on the fully recruited ages (3-9). PR's greater than 1.000, were set 1.0.

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Table 1. Nominal catches for 4VWX silver hake 1970-1988 (1987-1988 preliminary).

	Year								
Country	1970	1971	1972	1973	1974	1975	1976	1977	1978
Bulgaria	0	0	0	0	0	1722	3088	862	606
Canada	0	0	0	0	11	101	26	10	26
Cuba	0	0	201	0	0	1724	12572	1847	3436
France	0	0	0	0	0	0	0	15	0
FRG	0	0	10	0	296	106	97	684	0
GDR	0	0	0	0	0	0	0	0	3[1]
Ireland	0	0	0	0	0	108	106	0	0
Italy	0	0	0	0	0	0	0	38	106
Japan	129	8	63	88	67	54	78	19	161
Poland	0	0	0	0	0	0	0	295	2
Portugal	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	10	0
Spain	0	15	0	0	0	6	0	0	2
USA	0	1	0	0	0	7	1	14	0
USSR	168916	128633	113774	298533	95371	112566	81216	33301	44062
TOTAL	169045	128657	114048	298621	95745	116394	97184	37095	48404

Country	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Bulgaria	4639	817	0	0	0	0	0	0	0	0
Canada	13	104	6	38	15	10	2	9	11[3]	9[3]
Cuba	1798	2287	642	11969	7418	14496	17683	16041	20219	9002[3]
France	0	0	0	2[1]	0	0	0	0	0	0
FRG	0	0	0	0	0	0	0	0	0	0
GDR	0	0	0	0	0	93	0	0	0	0
Ireland	9	0	0	0	0	0	0	0	0	0
Italy	5	0	541	37[1]	2[2]	0	0	0	0	0
Japan	219	239	120	937	649	530	120	67	145	0
Poland	0	0	1[1]	31[2]	0	0	0	0	0	0
Portugal	0	56	2044	2[1]	378	1714	1338	0	0	0
Romania	1	0	0	0	0	0	0	0	0	0
Spain	0	40	0	0	0	0	0	0	0	0
USA	0	0	3	2	0	0	0	1	0	0
USSR	45076	40982	41243	47261	27377	57423	56337	66571	41329	65465[3]
TOTAL	51760	44525	44600	60251	35839	74266	75480	82689	61704	74476

[1] Observer Program Data (data not reported to NAFO)
[2] FLASH data
[3] NAFO Circular Letters and provisional reporting to NAFO.

Table 2. Scotian Shelf silver hake reported monthly catch (t) (monthly catch reported in previous year's assessment in parenthesis).

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979[3]	1980	1981[3]	1982[3]	1983[3]	1984	1985	1986[1]	1987[4,1]	1988[1]
Jan.	12	3	-	-	1088	2850	982	-	-	-	-	-	-	-	-	-	-	1[2]	-
Feb.	43	3555	43	103	261	1416	1174	2	-	6	-	-	-	-	-	-	-	-	-
Mar.	4335	30821	7199	12133	7345	2808	15028	3718	-	2	-	-	-	-	1[2]	-	17 (25)	3[2]	-
Apr.	16682	19415	12129	91367	10182	13673	10344	8142	2118	2190	1558	981	2409	6990	2614	3207	5751 (4902)	4971 (4967)	16063
May	19880	11742	21303	72443	15766	14715	7860	5714	8761	13000	9809	15332	19482	16369	22079 (19529)	15491 (11323)	27723 (21382)	13068[2] (12793)	29320[2]
June	19115	9419	16982	41948	14369	11364	7030	3284	13591	17651	13875	13669	24786	11274	24054[2] (22000)	33319 (30483)	34810 (41594)	22190 (21611)	22211
July	34873	22118	26425	42955	10676	26874	22531	11990	14449	14417	15011	13654	12607	543	22020 (26041)	17639 (25600)	13088 (13572)	20152[2] (19247)	6880
Aug.	43814	21621	14610	13394	10365	23904	8895	2805	8851	2930	4025	909	641	490	3248[2] (3411)	5766 (4891)	933 (893)	1319 (3081)	-
Sept.	19028	8258	11481	8656	14871	18076	6480	1046	236	903	103	41	260	156	245 (516)	54 (22)	361 (483)	- (1)	-
Oct.	6132	1092	3223	5493	4981	139	7625	190	285	403	84	8	7	7	2 (17)	-	(1)	-	-
Nov.	4115	613	452	1078	5256	26	3900	201	55	248	60	3	13	8	2 (4)	1	4	-	2[2]
Dec.	1016	-	-	9050	10585	549	5335	3	55	1	-	2	2	-	1 (2)	3 (10)	2 (2)	-	-
Total	169045	128657	114048	298621	95745	116394	97184	37095	48404	51751	44525	44599	60207	35837	74266 (74226)	75480 (75492)	82689 (82854)	61704[3]	74476

1. Reported to Canada (FLASH System). Note: catch was updated and is not reflected in this column.

2. Canada did not report on a monthly basis, thus IOP data used to locate appropriate months.

3. Some countries did not report catches by months.

4. Soviet catch was not reported by month, thus was prorated to the Flash data.

Table 3. Nominal catch and allocations (t) (in parenthesis) for 4VWX silver hake. 1988 Preliminary.

Country	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Bulgaria	862 (950)	606 (1000)	4639 (6860)	817 (1200)	0 (1000)	0 (1000)	0	0	0	0	0	0
Canada	10 (15190)	26 (16700)	13 (10000)	104 (20000)	6 (20000)	38 (13000)	15 (1000)	10 (1000)	2 (1000)	9 (1000)	11 (19500)	9 (16000)
Cdn. Reserve							(11808)	(13000)	(8100)	(4600)		
Cuba	1847 (8910)	3436 (10300)	1798 (8070)	2287 (11200)	642 (9500)	11969 (13500)	7418 (9500)	14496 (15200)	17683 (15200)	16041 (17700)	20219 (20200)	9002[2] (23500)
EEC	0	0	0	0 (100)	0	0	0	0	0	0	0	0
France[4]	15	0	0 (100)[3]	0 (100)[3]	0 (100)[3]	2[1] (100)[3]	0 (100)[3]	0 (100)	0 (100)	0 (100)	0 (100)	0
FRG	684	0	0	0	0	0	0	0	0	0	0	0
GDR	0	3[1]	0	0	0	0	0 (2000)	93 (100)	0	0	0	0
Italy[4]	38	106	5	0	541	37[1]	2[2]	0	0	0	0	0
Japan	19	161	219	239	120	937 (2000)	649 (5000)	530 (10000)[2]	120 (10000)	67 (10000)	145 (7500)	0 (7500)
Poland	295	2	0	0	1[1]	31	0	0	0	0	0	0
Portugal	0	0	0	56	2044	2[1] (2000)	378 (3000)	1714 (4000)[2]	1338 (4000)	0	0	0
Romania	10	0	1	0	0	0	0	0	0	0	0	0
Spain	0	2	0	40	0	0	0 (4000)	0	0 (5000)	0	0	0
USA	14	0	0 (2)	0	3	2	0	0	0	1	0	0
USSR	33301 (44950)	44062 (52000)	45076 (44940)	40982 (56600)	41243 (48400)	47261 (48400)	27377 (43400)	57423 (56600)	56337 (56600)	66571 (66600)	41329 (52700)	65465[2] (73000)
Others	0	0	9 (30)	0 (900)	0 (1000)	0	0 (192)	0	0	0	0	0
Total Catch and TAC	37095 (70000)	48404 (80000)	51760 (70000)	44525 (90000)	44600 (80000)	60251 (80000)	35839 (80000)	74266 (100000)	75480 (100000)	82689 (100000)	61704 (100000)	74476 (120000)
Percent Sum Catch/Tac	53	61	74	50	54	75	45	74	75	83	62	62
Percent Sum Catch/Foreign TAC	68	76	86	64	72	90	53	86	83	87	77	72

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 4a .Sampling used in this assessment.

Year	No. Samples	No. Lengths	No. Ages
1977	73	13387	587
1978	200	42038	674
1979	200	43108	1108
1980	200	54473	1462
1981	200	49737	987
1982	200	47810	1152
1983	200	46888	986
1984	200	50851	1255
1985	200	52951	1163
1986	200	46856	1311
1987	192	43115	681
1988	200	42685	1158

Table 4b. Values or a and b for June 1989 Silver Hake Assessment Derived from July R/V Surveys

Year	Sex	a	b	n	Catch(t)
1977	M	.00626	3.06263	231	37095
	F	.006934	3.03498	397	
1978	M	.00463	3.1366	209	48404
	F	.00307	3.25310	440	
1979	M	.011852	2.90005	219	51760
	F	.00588	3.06745		
1980	M	.002228	3.34168	215	44525
	F	.001796	3.39888	337	
1981	M	.00683	3.02055	230	44600
	F	.00508	3.11719	412	
1982	M	.011647	2.85751	299	60251
	F	.006737	3.02324	487	
1983	M	.00641	2.99348	384	35834
	F	.003324	3.20335	553	
1984	M	.01829	2.7053	422	74266
	F	.00649	3.0284	689	
1985	M	.013475	2.78480	450	75480
	F	.00453	3.12351	783	
1986	M	.007979	2.9384	511	82689
	F	.00382	3.16852	795	
1987	M	.009987	2.87981	319	61697
	F	.00425	3.14565	831	
1988	M	.01434	2.79421	331	74482
	F	.004803	3.12408	553	

Table 5a : Current commercial catch at age.

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	18372	17505	19260	14612	2431	16948	6334	72261	13319	53559	6831	6098
2	74356	66439	53960	75735	27596	49079	94529	48496	132410	67950	227946	62755
3	61512	81552	68542	71647	110845	75919	56666	207702	98008	225764	104160	263757
4	14899	36433	34693	32879	36939	69673	29443	79166	124261	84348	53140	38118
5	2050	13036	21108	14629	11141	32184	11445	18583	33256	29225	9056	21058
6	571	5321	9245	5153	2748	5812	3556	4397	9220	8465	6891	3126
7	78	1943	2935	1398	986	1955	820	1201	2326	1235	612	2420
8	40	1149	475	431	259	412	236	214	245	577	186	244
9	1	296	308	108	181	51	67	18	70	198	138	182
1+	171879	223674	210526	216592	193126	252033	203096	432038	413115	471321	408960	397758

Table 5b : Commercial catch at age used in NAFO Res. Doc. 88/51.

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	2131	28704	9667	6272	1553	19708	3333	99217	38273	123882	18364
2	43535	90777	48341	60576	19530	51680	86085	40265	175423	68374	224958
3	78239	89717	69058	82013	111209	66973	51617	191048	67117	172291	97196
4	29561	42878	46547	35888	38534	66230	28354	71739	91516	68918	43628
5	6981	19442	29656	15293	14266	34777	13036	19200	22953	29477	13740
6	2004	8587	16964	6179	5548	8925	4431	5392	8958	10504	7639
7	483	3222	5079	1682	679	2790	1150	1006	3399	2152	580
8	564	2009	1765	344	132	1047	475	176	644	870	272
9	522	420	1151	90	61	127	69	3	364	84	339
1+	164020	285756	228228	208337	191512	252257	188550	428046	408647	476552	406716

Table 5c : Differences between the current and last assessment catch at age

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	16241	-11199	9593	8340	878	-2760	3001	-26956	-24954	-70323	-11533
2	30821	-24338	5619	15159	8066	-2601	8444	8231	-43013	-424	2988
3	-16727	-8165	-516	-10366	-364	8946	5049	16654	30891	53473	6964
4	-14662	-6445	-11854	-3009	-1595	3443	1089	7427	32745	15430	9512
5	-4931	-6406	-8548	-664	-3125	-2593	-1591	-617	10303	-252	-4684
6	-1433	-3266	-7719	-1026	-2000	-3113	-875	-995	262	-2039	-748
7	-405	-1279	-2144	-284	307	-835	-330	195	-1073	-917	32
8	-524	-860	-1290	87	127	-635	-239	38	-399	-293	-86
9	-521	-124	-843	18	120	-76	-2	15	-294	114	-201
1+	7859	-62082	-17702	8255	1614	-224	14546	3992	4468	-5231	2244

Table 6: Commercial catch % at age for catch matrix used in this assessment

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	10.7	7.8	9.1	6.7	1.3	6.7	3.1	16.7	3.2	11.4	1.7	1.5
2	43.3	29.7	25.6	35.0	14.3	19.5	46.5	11.2	32.1	14.4	55.7	15.8
3	35.8	36.5	32.6	33.1	57.4	30.1	27.9	48.1	23.7	47.9	25.5	66.3
4	8.7	16.3	16.5	15.2	19.1	27.6	14.5	18.3	30.1	17.9	13.0	9.6
5	1.2	5.8	10.0	6.8	5.8	12.8	5.6	4.3	8.1	6.2	2.2	5.3
6	.3	2.4	4.4	2.4	1.4	2.3	1.8	1.0	2.2	1.8	1.7	.8
7	.0	.9	1.4	.6	.5	.8	.4	.3	.6	.3	.1	.6
8	.0	.5	.2	.2	.1	.2	.1	.0	.1	.1	.0	.1
9	.0	.1	.1	.0	.1	.0	.0	.0	.0	.0	.0	.0
1+	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 7: Commercial catch mean weights (kg) at age

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	.060	.080	.080	.050	.060	.070	.070	.070	.070	.050	.040	.050
2	.180	.150	.190	.140	.170	.170	.130	.150	.140	.150	.120	.140
3	.260	.230	.240	.220	.210	.230	.200	.180	.180	.190	.170	.190
4	.340	.270	.290	.280	.280	.280	.240	.220	.210	.210	.220	.230
5	.430	.330	.330	.330	.320	.320	.290	.280	.250	.250	.270	.260
6	.560	.400	.410	.380	.400	.400	.370	.370	.300	.270	.300	.300
7	1.010	.430	.480	.530	.590	.460	.420	.430	.430	.440	.460	.420
8	.920	.530	.980	.850	.950	.560	.470	.600	.590	.670	.490	.530
9	2.270	.880	.880	.880	1.220	.550	.470	.650	.820	.800	.510	.730

Table 8: Commercial catch biomass at age for catch used in this assessment

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	1102	1400	1541	731	146	1186	443	5058	932	2678	273	385
2	13384	9966	10252	10603	4691	8343	12289	7274	18537	10193	27354	8786
3	15993	18757	16450	15762	23277	17461	11333	37386	17641	42895	17707	50114
4	5866	9837	10061	9206	10343	19508	7066	17417	26095	17713	11691	8767
5	882	4302	6966	4828	3565	10299	3319	5203	8314	7306	2445	5475
6	320	2128	3798	1958	1099	2325	1316	1627	2766	2286	2067	938
7	79	835	1409	741	582	899	344	516	1000	543	282	1016
8	37	609	428	366	246	231	111	128	145	387	91	129
9	2	260	271	95	221	28	31	12	57	158	70	133
1+	36864	48095	51168	44290	44170	60281	36253	74622	75488	84159	61980	75663

Table 9: Commercial catch biomass as % at age for catch used in this assessment

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	3.0	2.9	3.0	1.6	.3	2.0	1.2	6.8	1.2	3.2	.4	.4
2	36.3	20.7	20.0	23.9	10.6	13.8	33.9	9.7	24.6	12.1	44.1	11.6
3	43.4	39.0	32.1	35.6	52.7	29.0	31.3	50.1	23.4	51.0	28.6	66.2
4	13.7	20.5	19.7	20.8	23.4	32.4	19.5	23.3	34.6	21.0	18.9	11.6
5	2.4	8.9	13.6	10.9	8.1	17.1	9.2	7.0	11.0	8.7	3.9	7.2
6	.9	4.4	7.4	4.4	2.5	3.9	3.6	2.2	3.7	2.7	3.3	1.2
7	.2	1.7	2.8	1.7	1.3	1.5	.9	.7	1.3	.6	.5	1.3
8	.1	1.3	.8	.8	.6	.4	.3	.2	.2	.5	.1	.2
9	.0	.5	.5	.2	.5	.0	.1	.0	.1	.2	.1	.2
1+	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 10. CPUE standardization results for the 4VWX silver hake population. Includes years 1977-1988.

Key
Type 1: Data Source, NAFO or IOP
Type 2: Month
Type 3: Year
Type 4: Area
Type 5: Regime either Old or New
Type 6: Country

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .694
MULTIPLE R SQUARED..... .481

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	5.945E0001	5.945E0001	
REGRESSION	21	1.823E0001	8.682E-001	5.523
TYPE 1	1	2.636E-001	2.636E-001	1.677
TYPE 2	5	3.199E0000	6.398E-001	4.070
TYPE 3	11	1.172E0001	1.065E0000	6.776
TYPE 4	2	6.495E-001	3.248E-001	2.066
TYPE 5	1	6.781E-001	6.781E-001	4.314
TYPE 6	1	1.112E0000	1.112E0000	7.072
RESIDUALS	125	1.965E0001	1.572E-001	
TOTAL	147	9.733E0001		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	1	INTERCEPT	0.963	0.197	147
2	5				
3	77				
4	460				
5	1				
6	1				
1	2	1	-0.164	0.126	65
2	4	2	0.202	0.117	19
	6	3	-0.090	0.096	38
	7	4	-0.181	0.100	33
	8	5	-0.295	0.118	20
	9	6	-0.438	0.200	5
3	78	7	-0.220	0.132	26
	79	8	-0.051	0.134	21
	80	9	-0.354	0.169	9
	81	10	-0.228	0.170	9
	82	11	0.716	0.192	7
	83	12	0.016	0.185	8
	84	13	0.503	0.185	8
	85	14	0.535	0.158	13
	86	15	0.836	0.201	10
	87	16	0.833	0.205	9
	88	17	0.483	0.204	10
4	450	18	0.173	0.146	10
	470	19	-0.116	0.087	33
5	2	20	-0.306	0.147	126
6	2	21	-0.272	0.102	29

Table 11. Standardized mean catch rate series for 4VWX silver hake from 1977- 1987

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 1 5 460 1 1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
77	37095	0.703	2.781	0.545	13341
78	48404	0.879	2.239	0.396	21621
79	51751	0.827	2.642	0.523	19587
80	44525	0.920	1.946	0.411	22885
81	44599	0.833	2.205	0.474	20229
82	60207	0.958	5.652	1.266	10652
83	35837	0.921	2.809	0.620	12758
84	74266	0.967	4.571	1.008	16246
85	75480	1.276	4.714	1.069	16012
86	82689	0.427	6.253	1.840	13225
87	61704	0.936	6.231	1.831	9902
88	74482	0.879	4.395	1.289	16945

AVERAGE C.V. FOR THE MEAN: .231

Table 12: July R/V survey stratified numbers at age

I	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	7737	26748	89437	17730	32839	192025	114273	188970	102726	552598	146007	69740
2	27660	23257	152705	55638	84724	293420	108957	70369	172576	84325	266663	89508
3	21421	16266	67003	97253	131420	80348	38209	208723	34402	70625	46095	81458
4	4592	8874	20048	45862	60469	60407	19340	37926	71191	22623	18982	16709
5	1348	6733	11522	10684	16241	32426	10632	11828	21488	13448	6048	14249
6	1278	3046	5055	4525	5127	8257	2882	7942	9445	4235	4168	2502
7	984	1286	2664	2001	2367	3549	876	2860	2667	1622	1199	2338
8	336	502	969	589	794	2535	401	1136	1175	673	672	468
9	283	865	275	385	564	327	337	522	215	376	471	121
1+	65638	87569	349679	234668	334545	673374	295908	530276	415885	750524	490304	277092

Table 13a: July R/V survey standard errors at age

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	1998	5059	6242	5391	8120	48811	15147	44984	20355	147389	42633	10285
2	6015	4847	26711	14144	20180	116921	20234	16609	42265	13798	47908	29730
3	2619	3124	7098	37248	40853	42847	10834	50184	11853	12363	8892	32834
4	576	1912	5727	20856	20149	34198	6523	8625	28886	3953	3722	6758
5	213	1422	3621	4337	4715	18425	3431	2489	7341	2051	1032	4431
6	285	686	2051	1822	1670	3853	623	1684	3460	704	562	615
7	302	396	1097	1376	986	1379	154	613	735	293	220	539
8	110	194	638	382	338	1156	83	302	285	135	159	117
9	140	329	426	302	232	119	100	156	65	86	117	57

Table 13b: July R/V survey coefficients of variation (%) at age

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	25.8	18.9	7.0	30.4	24.7	25.4	13.3	23.0	19.8	26.7	29.2	14.7
2	21.7	20.8	17.5	25.4	23.8	39.8	18.6	23.6	24.5	16.4	18.0	33.2
3	12.2	19.2	10.6	38.3	30.5	53.3	20.4	24.0	34.5	17.5	19.3	40.3
4	12.5	21.5	20.6	43.7	33.3	56.5	33.7	22.7	40.6	17.5	19.6	40.4
5	15.8	21.1	31.4	40.6	29.0	56.8	32.3	21.0	34.2	15.3	17.1	31.0
6	16.1	22.5	40.6	40.3	32.6	46.7	21.6	21.2	36.6	16.6	13.5	24.5
7	30.7	30.0	41.2	68.7	41.6	38.0	17.6	21.4	27.5	18.1	18.4	22.0
8	32.0	38.7	65.0	64.9	42.6	45.6	20.6	26.5	24.3	20.1	23.7	24.6
9	49.4	38.1	154.6	78.4	41.1	36.5	29.5	29.0	30.3	22.0	24.0	42.5

Table 14: July R/V survey % at age

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	11.0	30.5	25.6	7.6	9.0	28.5	38.6	35.6	24.7	73.6	29.0	25.2
2	42.1	26.6	43.7	23.7	25.3	43.6	36.8	13.3	41.5	11.2	54.4	32.3
3	32.6	18.6	19.2	41.4	39.3	11.9	12.9	39.4	8.3	9.4	9.4	29.4
4	7.0	10.1	5.7	19.5	18.1	9.0	6.5	7.2	17.1	3.0	3.9	6.0
5	2.1	7.7	3.3	4.6	4.9	4.8	3.6	2.2	5.2	1.0	1.2	5.1
6	1.9	3.5	1.4	1.9	1.5	1.2	1.0	1.5	2.3	.6	.9	.9
7	1.5	1.5	.8	.9	.7	.5	.3	.5	.6	.2	.2	.0
8	.5	.6	.3	.3	.2	.4	.1	.2	.3	.1	.1	.2
9	.4	1.0	.1	.2	.2	.0	.1	.1	.1	.1	.1	.0
1+	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 15: Stratified mean catch/tow for the joint Canada-USSR juvenile silver hake survey. Strata 60-78 only.

Year Class	1981	1982	1983	1984	1985	1986	1987	1988
Stratified Mean catch/tow	579.0	8.8	232.2	43.4	284.8	198.0	102.0	204.8
Standard Error of Mean	0.11	0.14	0.11	0.16	0.22	0.19	0.11	0.17
Number of Sets	77	61	64	71	82	74	105	116
July R/V Age 1 #'s (10^{-6})	192	114	190	103	553	146	70	--
Comm. catch Age 1 #'s (10^{-6})	16.9	6.3	72.3	13.3	53.6	6.8	6.1	--

Table 16: Summary of ADAPT runs for 4VWX silver hake.

Run	Years	Model	Ages	Numbers	Intercept	Slopes	F_t
JULY RESEARCH VESSEL INDEX							
[1]	77-88	S.E.	1-8	2 n.s.	-	All sig.	.242
	77-88	S.E.	3-6	All sig.	-	All sig.	.325
	77-88	Log	3-6	All sig.	-	All sig.	.879
CPUE							
	77-88	S.E.	4	All sig.	-	All sig.	.362
	77-88	Log	4	All sig.	-	All sig.	.346
CPUE and Research Vessel Indicies							
	77-88	S.E.	3-6	All sig.		All sig.	.341
	77-88	S.E.	1-8	2 n.s.		R/V-All sig. CPUE-Not sig.	.242

1 Presented in Table 17.

Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors.

Input Documentation for 4VWX Silver Hake Run

This Analysis was Performed Using the Following Criteria :

---

1) Catch at Age extends from 1977 to 1988 and Ages 1 to 9
   The Catch at Age did NOT contain a PLUS Group
2) Partial Recruitment values Imposed:

Ages	PR
1	0.022
2	0.249
3	1.000
4	1.000
5	1.000
6	1.000
7	1.000
8	1.000
9	1.000

3) Natural Mortality was set at 0.4

4) F's over Ages 1 to 8 will be derived starting from initial estimates:

Ages	F
1	0.011
2	0.126
3	0.515
4	0.515
5	0.515
6	0.515
7	0.515
8	0.515

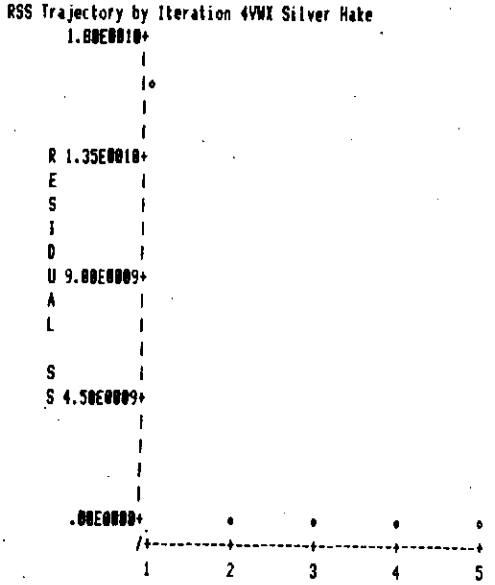
5) No Initial Estimates of F at the oldest ages were used

6) Research Survey Estimates of Abundance for ages 1 to 8 were given
   Standard errors of abundance index applied to residuals

8) The Lower Limit for Estimated Numbers at Age was the CATCH
   Upper limit for Estimated Numbers at age was 10000000

9) The Lower Limit for RV survey slope was 0
   The Upper Limit for RV survey slope was 9000

RSS Trajectory by Iteration 4VWX Silver Hake



CALIBRATION COEFFICIENTS BY AGE FOR 4VWX Silver Hake

AGE 1 : I = .046 x POP
AGE 2 : I = .125 x POP
AGE 3 : I = .153 x POP
AGE 4 : I = .105 x POP
AGE 5 : I = .113 x POP
AGE 6 : I = .348 x POP
AGE 7 : I = .684 x POP
AGE 8 : I = .522 x POP

MEAN SQUARE RESIDUALS : 4559710.535
MEAN RESIDUAL : 968.1538997
SUM OF ALL RESIDUALS : 92942.77437

Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.015968
MEAN SQUARE RESIDUALS 4559710.535317

PAR. EST.	STD. ERR.	T-STATISTIC
1.91773E0006	8.49343E0005	2.25790E0000
1.18065E0006	7.97730E0005	1.48001E0000
1.38813E0006	5.18527E0005	2.67706E0000
2.81055E0005	1.00764E0005	2.78925E0000
1.79735E0005	6.70082E0004	2.68228E0000
1.59594E0004	6.48113E0003	2.46244E0000
7.98481E0003	2.70357E0003	2.95343E0000
1.56603E0003	6.51889E0002	2.40229E0000
4.63405E-002	8.51879E-003	5.43988E0000
1.25078E-001	2.50720E-002	4.98875E0000
1.52641E-001	2.99822E-002	5.09107E0000
1.04775E-001	2.53776E-002	4.12866E0000
1.12500E-001	2.86592E-002	3.92546E0000
3.47606E-001	8.14020E-002	4.27020E0000
6.84331E-001	1.57680E-001	3.83265E0000
5.22468E-001	1.66147E-001	3.14461E0000

Parameter Correlation Matrix

I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.000	.017	.007	.018	.008	.004	.003	.005	-.414	-.009	-.008	-.005	-.002	-.003	-.004	-.006
2	.017	1.000	.049	.065	.018	.007	.010	.013	-.041	-.249	-.038	-.014	-.004	-.007	-.017	-.021
3	.007	.049	1.000	.009	.047	.027	.099	.148	-.018	-.196	-.214	-.029	-.013	-.048	-.218	-.226
4	.018	.065	.009	1.000	.102	.022	.042	.005	-.044	-.255	-.316	-.142	-.019	-.029	-.090	-.157
5	.008	.018	.047	.102	1.000	.032	.038	.065	-.020	-.078	-.225	-.398	-.149	-.036	-.071	-.116
6	.004	.007	.027	.022	.032	1.000	.179	.061	-.009	-.029	-.031	-.038	-.074	-.442	-.089	-.042
7	.003	.010	.099	.042	.038	.179	1.000	.170	-.007	-.041	-.039	-.022	-.034	-.395	-.395	-.091
8	.005	.013	.148	.005	.065	.061	.170	1.000	-.012	-.051	-.068	-.036	-.017	-.121	-.381	-.488
9	-.414	-.041	-.018	-.044	-.020	-.009	-.007	-.012	1.000	.023	.019	.012	.004	.007	.010	.013
10	-.009	-.249	-.196	-.255	-.078	-.029	-.041	-.051	.023	1.000	.120	.054	.014	.028	.057	.082
11	-.008	-.038	-.214	-.316	-.225	-.031	-.039	-.068	.019	.120	1.000	.120	.037	.038	.081	.109
12	-.005	-.014	-.029	-.142	-.398	-.038	-.022	-.036	.012	.054	.120	1.000	.061	.024	.039	.052
13	-.002	-.004	-.013	-.019	-.149	-.074	-.034	-.017	.004	.014	.037	.061	1.000	.041	.024	.022
14	-.003	-.007	-.048	-.029	-.036	-.442	-.395	-.121	.007	.028	.038	.024	.041	1.000	.177	.064
15	-.004	-.017	-.218	-.090	-.071	-.089	-.395	-.381	.010	.057	.081	.039	.024	.177	1.000	.193
16	-.006	-.021	-.226	-.157	-.116	-.042	-.091	-.488	.013	.082	.109	.052	.022	.064	.193	1.000

4VWX Silver Hake

WEIGHTED RESIDUALS FOR RV INDEX

I	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	-6.951	.116	9.031	-.962	.081	2.750	5.434	2.588	2.640	2.883	1.919	.000
2	-1.589	-2.132	4.114	.140	2.266	2.043	.585	.979	1.247	.074	1.119	-.738
3	-.391	-1.113	6.848	1.907	2.523	1.324	.056	3.845	.185	-.879	-1.189	-1.833
4	-1.219	1.700	2.659	2.857	2.610	1.582	1.073	3.106	2.049	4.013	-1.372	-.593
5	-3.348	2.989	2.613	2.114	3.883	1.645	2.444	3.545	2.511	4.753	3.482	-.848
6	-2.074	.192	1.586	1.590	2.157	1.819	1.926	3.861	1.976	3.100	.257	-1.926
7	-2.793	.441	1.092	1.036	1.487	2.195	2.317	2.992	1.285	.384	-.186	-.960
8	-1.598	-.788	1.083	.461	2.023	1.962	4.138	3.304	2.790	.913	.831	-.831

SUM OF RV RESIDUALS : 119.264349 MEAN RESIDUAL : 1.242336969

Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

4VWX Silver Hake

POPULATION NUMBERS (000S)

I	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 I	602458	725385	914922	634894	878692	1586543	875435	2038515	1344610	3522877	1754084	1984759
2 I	431306	388798	471855	597522	413619	587815	1049615	581636	1307295	898414	2317604	1170205
3 I	233018	228235	206224	272115	338524	254663	353385	626184	350177	767898	541230	1366910
4 I	75169	105835	86222	82118	123745	136168	108549	198433	249692	154489	329897	277518
5 I	24618	38189	41114	29392	28127	52785	34232	48657	62836	65637	34498	177629
6 I	6605	14823	14926	10278	7725	9732	8979	13576	17481	14892	28071	15711
7 I	3877	3960	5588	2436	2671	2928	1765	3188	5588	4116	3852	7812
8 I	1266	2535	1064	1337	488	983	362	512	1188	1783	1748	1545
9 I	4	816	758	324	544	115	322	58	168	537	723	1819
1+I	1378320	1588496	1742665	1638417	1794134	2638852	2432565	3502678	3338779	5422642	5882987	4923189

4VWX Silver Hake

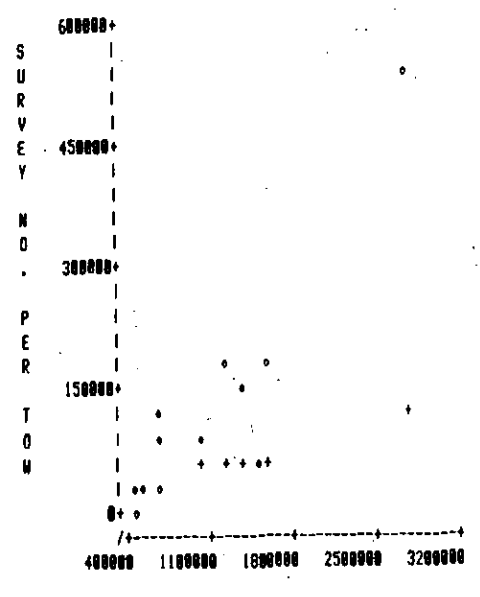
FISHING MORTALITY

I	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 I	.038	.038	.026	.029	.003	.013	.009	.044	.012	.019	.005	.004
2 I	.236	.234	.158	.168	.085	.188	.117	.107	.132	.098	.128	.067
3 I	.389	.573	.521	.388	.511	.453	.218	.519	.418	.445	.268	.264
4 I	.277	.546	.676	.671	.454	.981	.402	.709	.936	1.099	.219	.181
5 I	.107	.539	.986	.936	.661	1.370	.525	.628	1.040	.785	.387	.154
6 I	.112	.577	1.413	.948	.570	1.387	.661	.503	1.042	1.185	.544	.273
7 I	.025	.915	1.029	1.207	.600	1.690	.038	.639	.727	.457	.281	.462
8 I	.039	.887	.788	.588	1.044	.717	1.589	.714	.318	.503	.139	.211
9 I	.335	.566	.658	.507	.506	.742	.288	.566	.682	.578	.261	.242

Age 1

4VWX Silver Hake

SURVEY NO. PER TOW VS SPA NUMBERS



TREND IN STANDARDIZED RESIDUAL OVER TIME

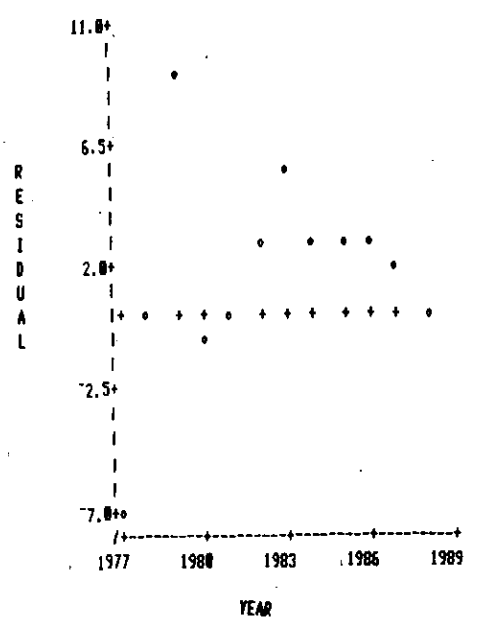
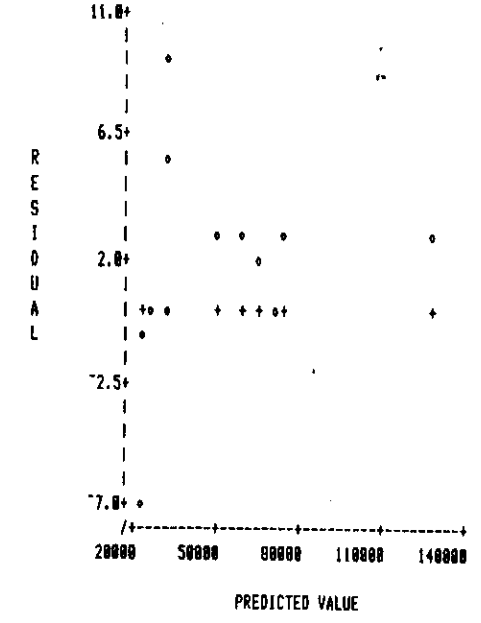


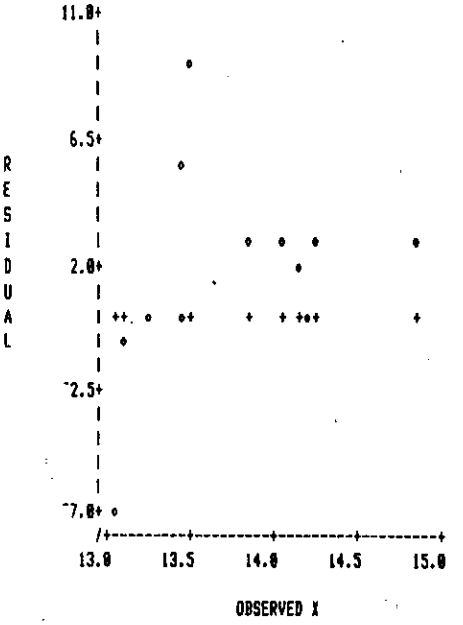
Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

WEIGHTED RESIDUAL VS PREDICTED VALUE

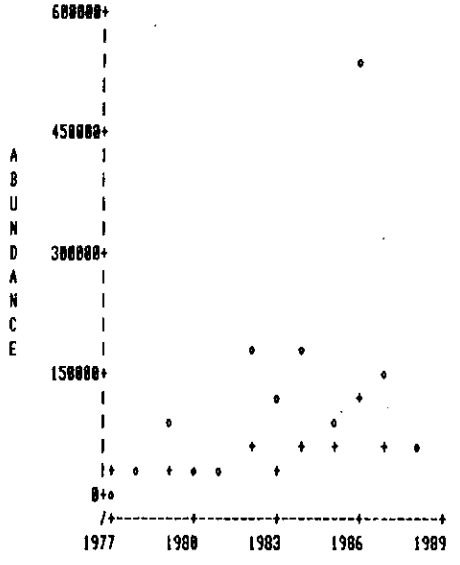
age 1



RESIDUAL VS OBSERVED X



TREND IN POPULATION ABUNDANCE OVER TIME



SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

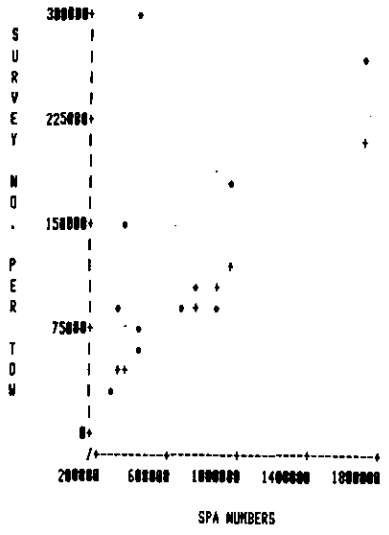
INDEX	CARRIER	o	+	RANK
1977	4.666E5	7737	2.162E4	1977
1978	5.644E5	2.674E	2.616E4	1980
1979	7.136E5	8.944E	3.387E4	1978
1980	4.945E5	1.773E	2.291E4	1983
1981	6.945E5	3.284E	3.218E4	1981
1982	1.247E6	1.92E5	5.778E4	1979
1983	6.897E5	1.143E	3.196E4	1985
1984	1.573E6	1.89E5	7.29E4	1982
1985	1.057E6	1.027E	4.899E4	1987
1986	2.759E6	5.526E	1.279E5	1988
1987	1.385E6	1.46E5	6.419E4	1984
1988	1.505E6	6.974E	6.974E4	1986

Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

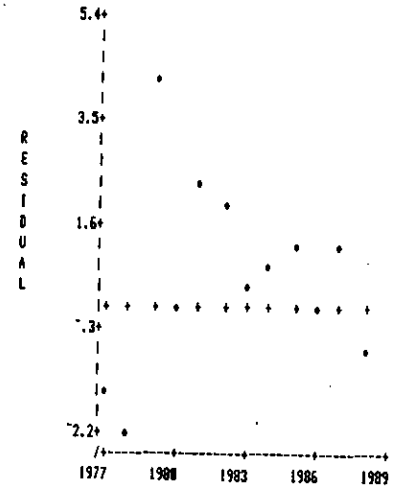
Age 2

4VWX Silver Hake

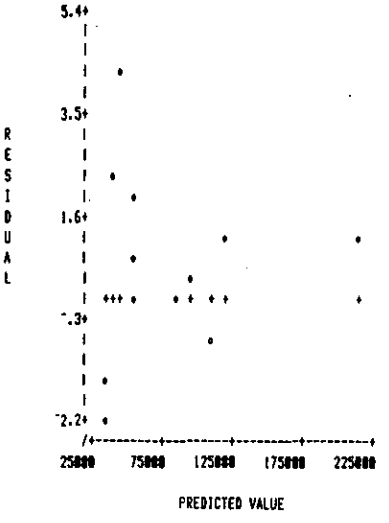
SURVEY NO. PER TOW VS SPA NUMBERS



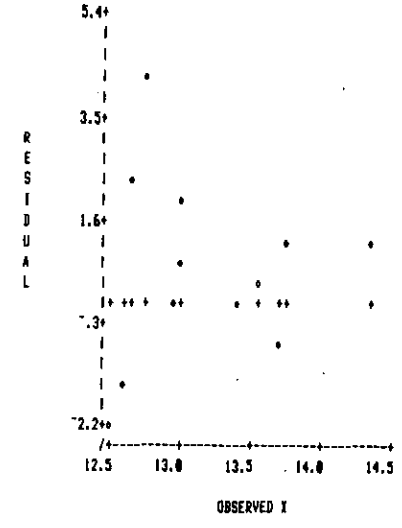
TREND IN STANDARDIZED RESIDUAL OVER TIME



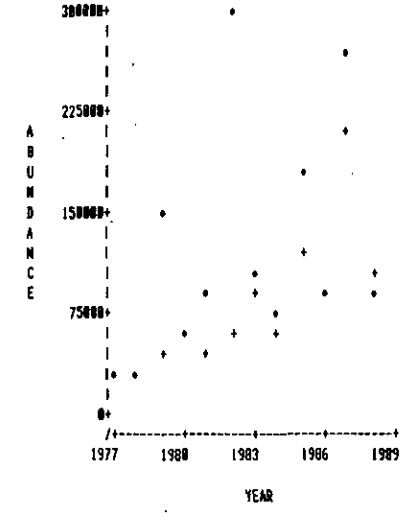
WEIGHTED RESIDUAL VS PREDICTED VALUE



RESIDUAL VS OBSERVED X



TREND IN POPULATION ABUNDANCE OVER TIME



SUMMARY OF DATA FROM PLOT

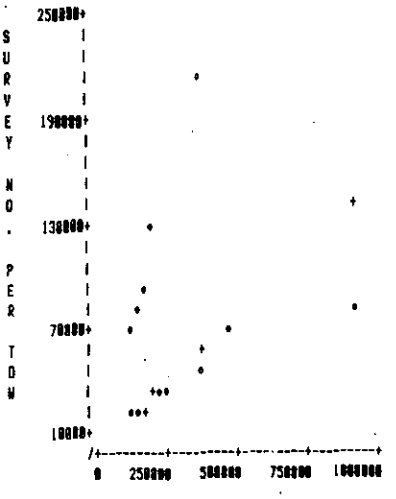
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

INDEX	CARRIER	o	+	RANK
1977	2.975E5	2.766E4	3.722E4	1978
1978	2.686E5	2.326E4	3.359E4	1977
1979	3.423E5	1.527E5	4.281E4	1981
1980	4.29E5	5.564E4	5.365E4	1979
1981	3.117E5	8.472E4	3.899E4	1980
1982	4.365E5	2.934E5	5.46E4	1984
1983	7.766E5	1.09E5	9.713E4	1982
1984	4.326E5	7.837E4	5.411E4	1986
1985	9.585E5	1.726E5	1.199E5	1983
1986	6.66E5	8.432E4	8.33E4	1988
1987	1.703E6	2.667E5	2.13E5	1985
1988	8.911E5	8.951E4	1.115E5	1987

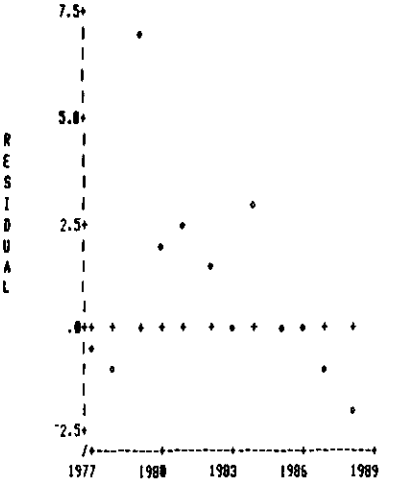
Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

Age 3

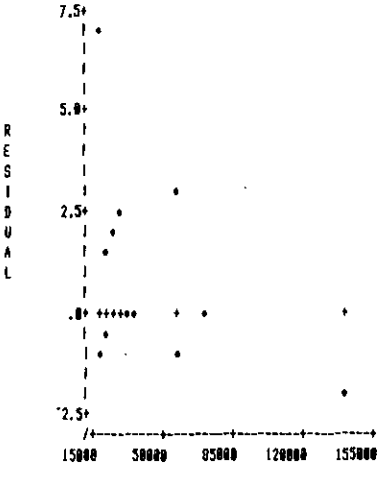
SURVEY NO. PER TOW VS SPA NUMBERS



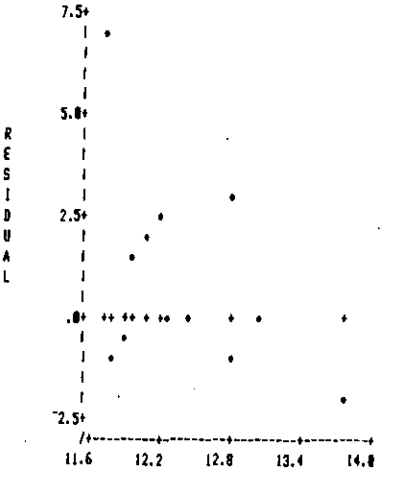
TREND IN STANDARDIZED RESIDUAL OVER TIME



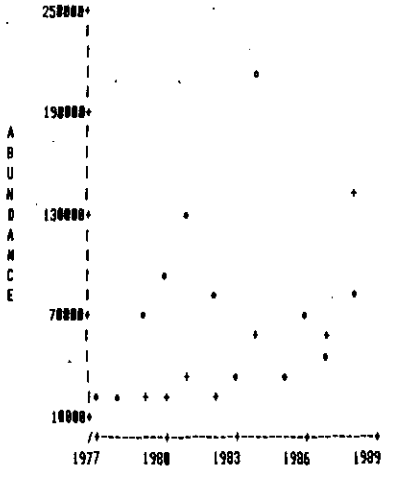
WEIGHTED RESIDUAL VS PREDICTED VALUE



RESIDUAL VS OBSERVED X



TREND IN POPULATION ABUNDANCE OVER TIME



SUMMARY OF DATA FROM PLOT

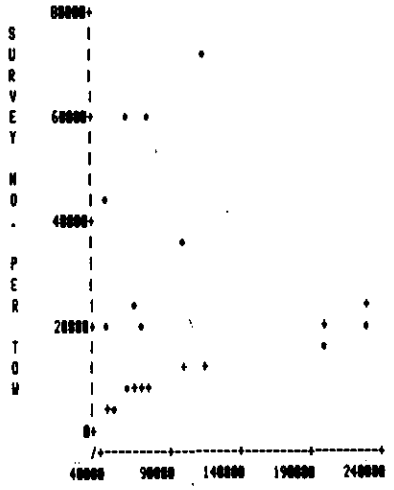
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

INDEX	CARRIER	o	+	RANK
1977	1.47E5	2.142E4	2.244E4	1979
1978	1.294E5	1.627E4	1.974E4	1978
1979	1.205E5	6.7E4	1.84E4	1977
1980	1.718E5	9.725E4	2.623E4	1982
1981	1.99E5	1.314E5	3.038E4	1980
1982	1.549E5	8.035E4	2.364E4	1981
1983	2.464E5	3.821E4	3.761E4	1985
1984	3.663E5	2.087E5	5.591E4	1983
1985	2.173E5	3.44E4	3.316E4	1984
1986	4.691E5	7.862E4	7.16E4	1987
1987	3.666E5	4.609E4	5.595E4	1986
1988	9.279E5	8.146E4	1.416E5	1988

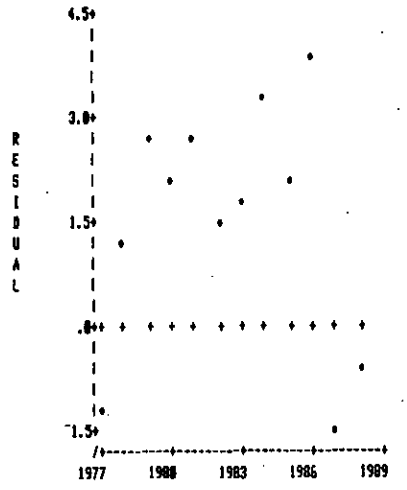
Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

Age 4

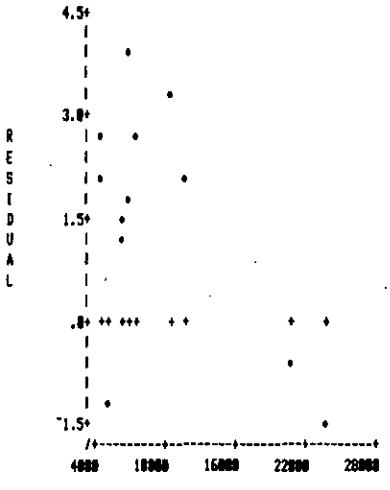
SURVEY NO. PER TON VS SPA NUMBERS



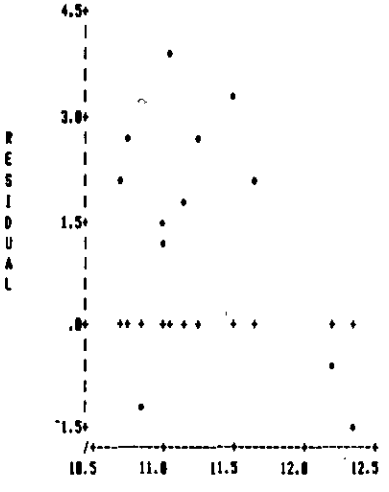
TREND IN STANDARDIZED RESIDUAL OVER TIME



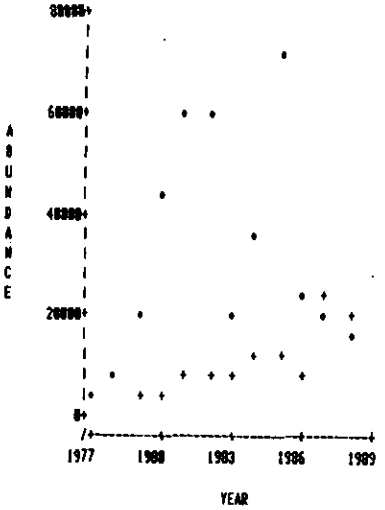
WEIGHTED RESIDUAL VS PREDICTED VALUE



RESIDUAL VS OBSERVED I



TREND IN POPULATION ABUNDANCE OVER TIME



SUMMARY OF DATA FROM PLOT

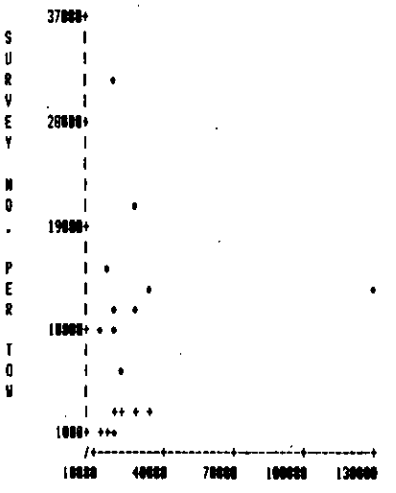
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

INDEX	CARRIER	o	+	RANK
1977	5.864E4	4592	5386	1980
1978	6.097E4	8074	6388	1979
1979	4.602E4	2.005E 4822		1977
1980	4.395E4	4.586E 4605		1982
1981	7.521E4	6.047E 7881		1978
1982	6.885E4	6.049E 6376		1986
1983	6.797E4	1.934E 7122		1983
1984	9.973E4	3.793E	1.045E	1981
1985	1.145E5	7.119E	1.2E4	1984
1986	6.443E4	2.262E 6751		1985
1987	2.299E5	1.098E	2.489E	1988
1988	1.977E5	1.671E	2.072E	1987

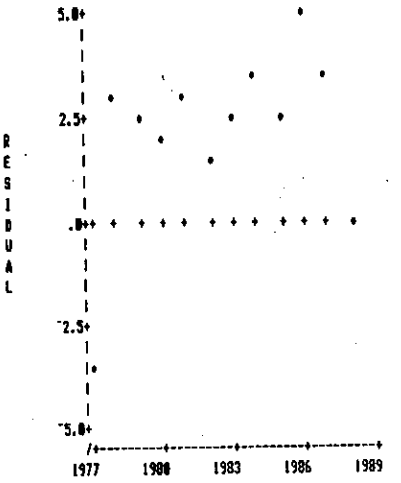
Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

Age 5

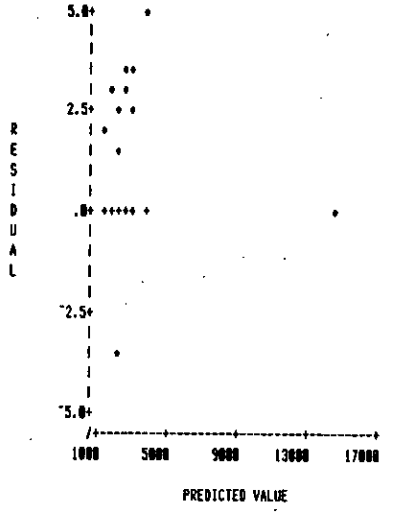
SURVEY NO. PER TON VS SPA NUMBERS



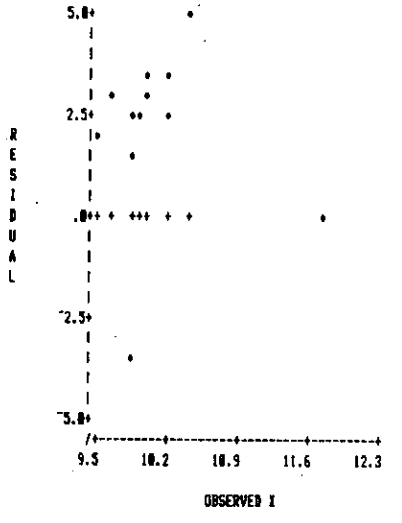
TREND IN STANDARDIZED RESIDUAL OVER TIME



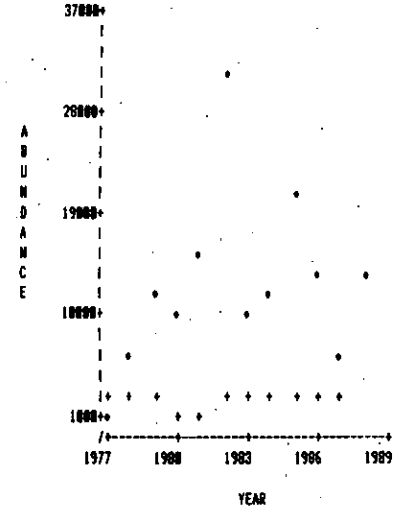
WEIGHTED RESIDUAL VS PREDICTED VALUE



RESIDUAL VS OBSERVED X



TREND IN POPULATION ABUNDANCE OVER TIME



SUMMARY OF DATA FROM PLOT

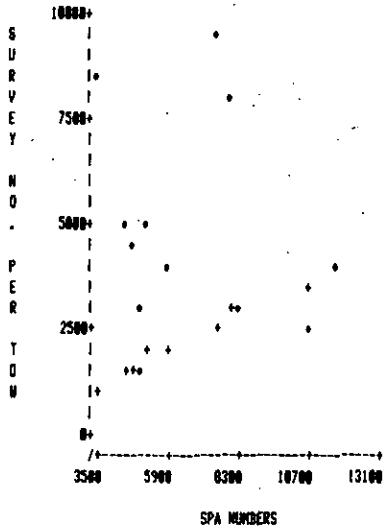
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

INDEX	CARRIER	o	+	RANK	
1977	1.831E4	1348	2060	1980	
1978	2.208E4	6733	2484	1981	
1979	1.831E4	1.152E	2060	1977	
1980	1.348E4	1.068E	1517	1979	
1981	1.514E4	1.624E	1704	1982	
1982	1.877E4	3.243E	2112	1983	
1983	1.996E4	1.063E	2245	1987	
1984	2.671E4	1.183E	3005	1978	
1985	2.713E4	2.149E	3052	1984	
1986	3.288E4	1.345E	3699	1985	
1987	2.18E4	6048	2453	1986	
1988	1.285E5	1.425E	1.446E	1988	

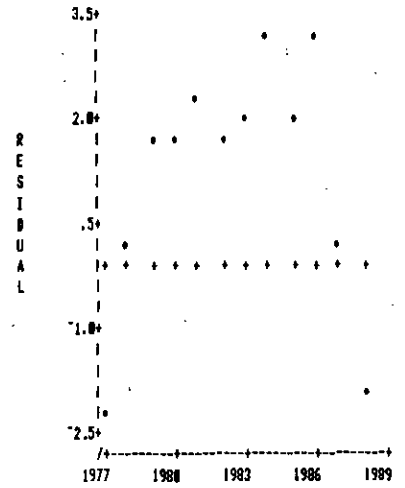
Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

Age 6

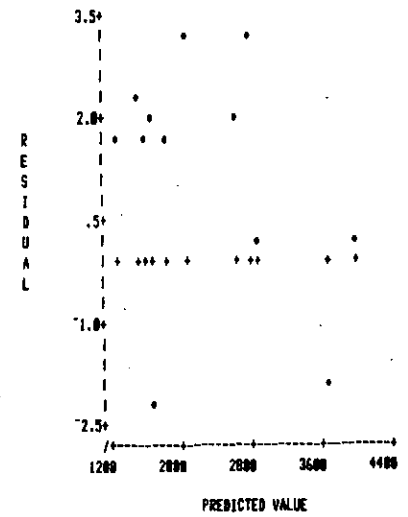
SURVEY NO. PER TON VS SPA NUMBERS



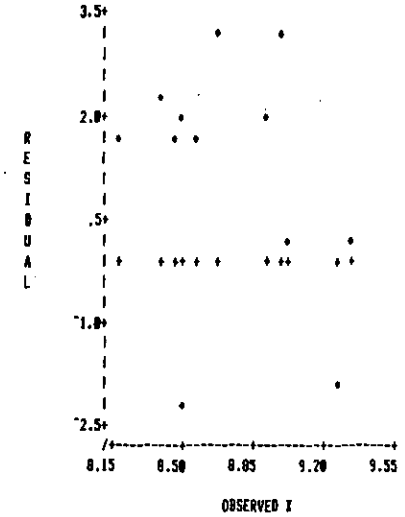
TREND IN STANDARDIZED RESIDUAL OVER TIME



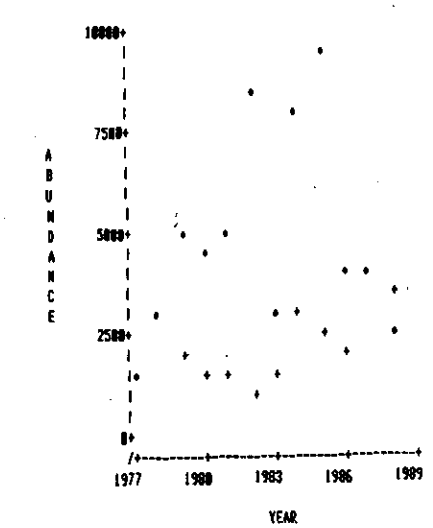
WEIGHTED RESIDUAL VS PREDICTED VALUE



RESIDUAL VS OBSERVED X



TREND IN POPULATION ABUNDANCE OVER TIME



SUMMARY OF DATA FROM PLOT

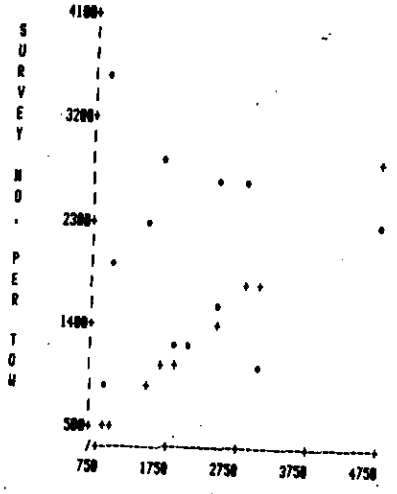
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

INDEX	CARRIER	o	+	RANK
1977	4981	1278	1784	1982
1978	8383	3846	2914	1981
1979	5184	5055	1882	1980
1980	4683	4525	1628	1983
1981	4397	5127	1525	1977
1982	3595	8257	1258	1979
1983	4836	2882	1681	1986
1984	8815	7942	2786	1985
1985	7584	9445	2689	1984
1986	5988	4235	2054	1978
1987	1.157E	4168	4023	1988
1988	1.061E	2502	3687	1987

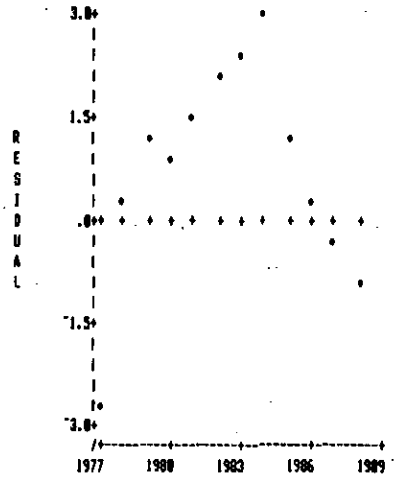
Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

Age 7

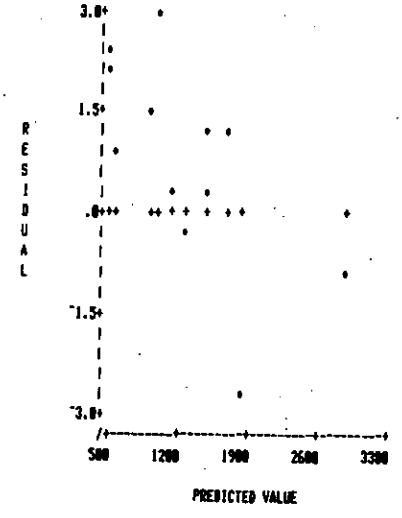
SURVEY NO. PER TOW VS SPA NUMBERS



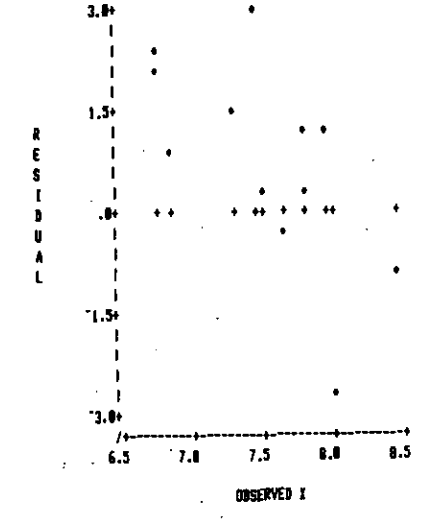
TREND IN STANDARDIZED RESIDUAL OVER TIME



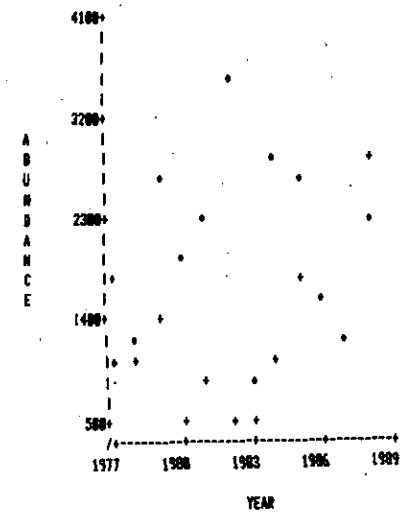
WEIGHTED RESIDUAL VS PREDICTED VALUE



RESIDUAL VS OBSERVED I



TREND IN POPULATION ABUNDANCE OVER TIME



SUMMARY OF DATA FROM PLOT

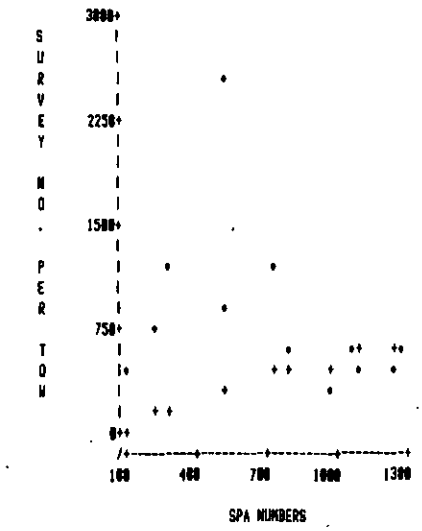
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o;OBSERVED, +;PREDICTED

INDEX	CARRIER	+	+	RANK
1977	3026	904.3	1829	1983
1978	1839	1206	1112	1982
1979	2425	2664	1466	1980
1980	953.9	2001	576.5	1981
1981	1491	2367	900.9	1984
1982	865.2	3549	522.9	1978
1983	857.5	876.1	518.2	1987
1984	1695	2860	1025	1979
1985	2851	2667	1723	1986
1986	2497	1622	1509	1985
1987	2052	1199	1240	1977
1988	4724	2338	2855	1988

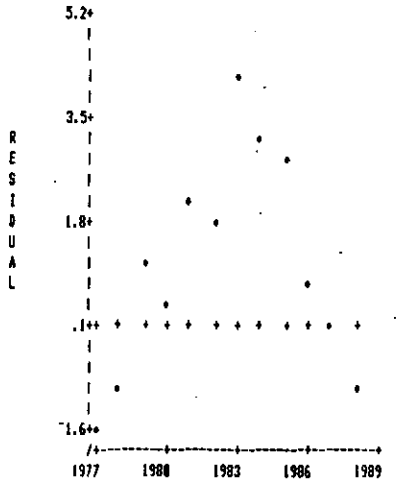
Table 17: Results of An ADAPT run with ages 1-8, R/V numbers and standard errors (Cont.)

Age 8

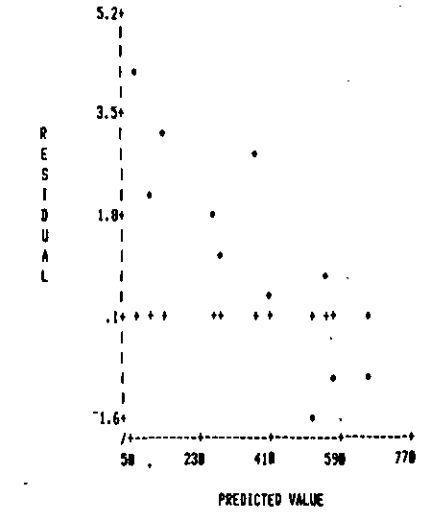
SURVEY NO. PER TOW VS SPA NUMBERS



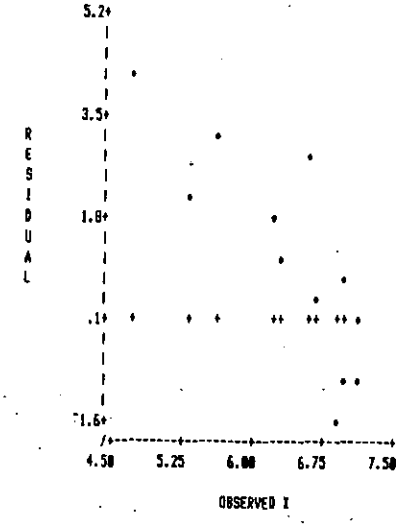
TREND IN STANDARDIZED RESIDUAL OVER TIME



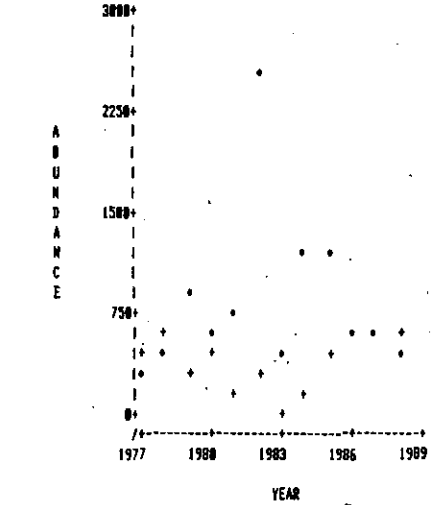
WEIGHTED RESIDUAL VS PREDICTED VALUE



RESIDUAL VS OBSERVED I



TREND IN POPULATION ABUNDANCE OVER TIME



SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

INDEX	CARRIER	o	+	RANK
1977	979.4	335.7	511.7	1983
1978	1254	582.2	655.1	1981
1979	531.8	968.9	277.8	1984
1980	798.9	589.3	413.2	1982
1981	218.3	793.8	189.9	1979
1982	512.2	2535	267.6	1985
1983	113.5	481.1	59.31	1980
1984	267.2	1136	139.6	1977
1985	723.7	1175	378.1	1986
1986	1053	673.3	550	1988
1987	1276	671.6	666.6	1978
1988	1082	467.5	565.1	1987

Table 18 shows an ADAPT run with only CPUE (ie. age aggregated calibration). The 1982 CPUE value is masked.

Input Documentation for 4VWX Silver Hake Run at

This Analysis was Performed Using the Following Criteria :

---

1) Catch at Age extends from 1977 to 1988 and Ages 1 to 9
   The Catch at Age did NOT contain a PLUS Group
2) Partial Recruitment values Imposed:

Ages	PR
1	0.022
2	0.249
3	1.000
4	1.000
5	1.000
6	1.000
7	1.000
8	1.000
9	1.000

3) Natural Mortality was set at 0.4

4) F's over Ages 4 to 4 will be derived starting from initial estimates:

Ages	F
4	0.515

5) No Initial Estimates of F at the oldest ages were used

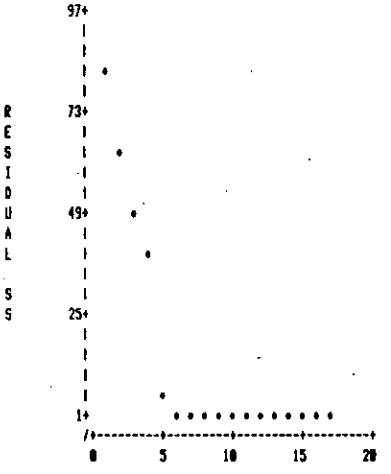
7) Commercial CPUE with standard errors was calibrated on fishable biomass

8) The Lower Limit for Estimated Numbers at Age was the CATCH
   Upper limit for Estimated Numbers at age was 10000000
10) The Lower Limit for CPUE slope was 0

   The Upper Limit for CPUE slope was 9000

4VWX Silver Hake

RSS Trajectory by Iteration 4VWX Silver Hake



CALIBRATION COEFFICIENTS BY AGE FOR 4VWX Silver Hake 6/06/89 10:00

MEAN SQUARE RESIDUALS : 0.1340212449
MEAN RESIDUAL : 6.650617885E-8
SUM OF ALL RESIDUALS : 7.980740485E-7

4VWX Silver Hake

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.002677
MEAN SQUARE RESIDUALS 0.134021

PAR. EST.	STD. ERR.	T-STATISTIC
1.59214E0005	5.26700E0004	3.02286E0000
2.15925E-005	2.66048E-006	8.09170E0000

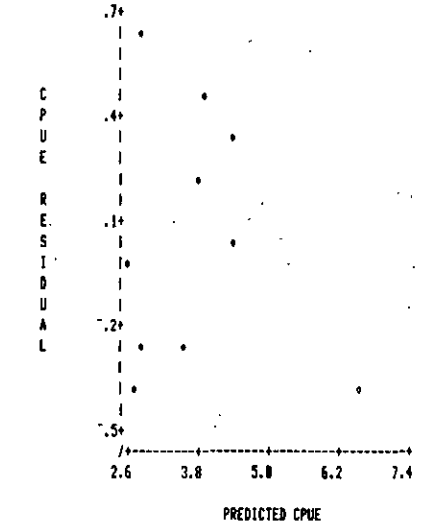
Parameter Correlation Matrix 6/ 6/89

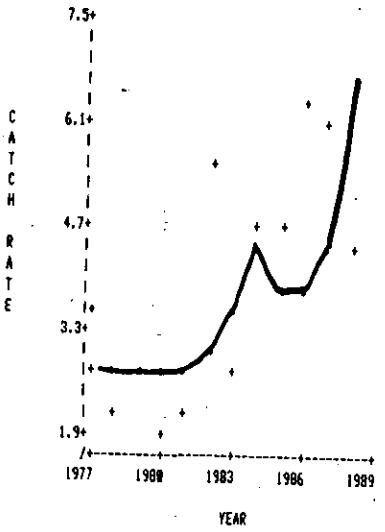
	1	2
1	1.000	-.518
2	-.518	1.000

Table 18 shows an ADAPT run with only CPUE (ie. age aggregated calibration). The 1982 CPUE value is masked (Cont.)

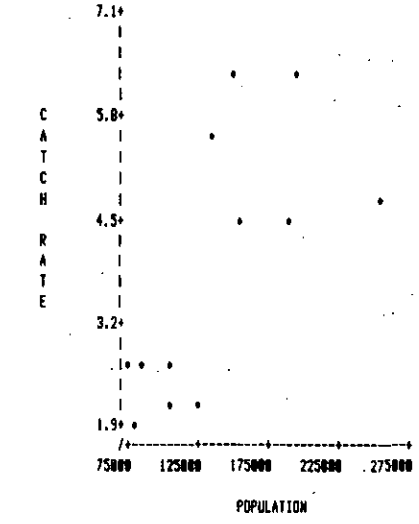
OBSERVED AND PREDICTED AGGREGATE CATCH RATE BY YEAR

4VWX Silver Hake
AGGREGATE CATCH RATE RESIDUAL VS PREDICTED VALUE





AGGREGATE CATCH RATE AGAINST POPULATION



RESIDUALS FROM CPUE INDEX

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
	-.238	-.230	.084	-.354	-.255	.668	-.239	.040	.210	.455	.338	-.408

SUM OF CPUE RESIDUALS : 7.980740405E-7 MEAN RESIDUAL : 6.650617005E-8

4VWX Silver Hake

POPULATION NUMBERS (000S)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	682437	722733	988825	628207	869748	1609856	854097	1586549	942347	2888626	1388815	975781
2	431310	338784	470130	593435	409136	581019	1065243	567332	1084334	620769	1892453	919995
3	232958	228230	286214	270959	335785	251659	349286	636660	340589	564817	360481	1081923
4	75158	105795	86223	82112	122970	134331	106535	187739	256714	148062	193768	156359
5	24598	38101	41088	29393	28122	52186	33081	47386	61030	70344	38190	86379
6	6602	14818	14921	10260	7726	9729	8631	12751	16496	13682	23226	12823
7	3876	3958	5571	2433	2659	2929	1763	2874	4947	3509	2241	9927
8	1265	2535	1862	1331	486	975	363	511	943	1412	1341	1081
9	4	815	758	323	540	114	316	50	167	432	474	747
1+	1378209	1585849	1734793	1618453	1777171	2642797	2419235	3841773	2627567	4311652	3884990	3244854

4VWX Silver Hake

FISHING MORTALITY

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	.038	.038	.026	.029	.003	.013	.009	.057	.017	.023	.006	.008
2	.236	.234	.151	.169	.086	.109	.115	.110	.176	.144	.159	.086
3	.389	.573	.521	.390	.516	.460	.221	.508	.433	.670	.435	.346
4	.277	.546	.676	.672	.457	1.004	.412	.724	.895	1.190	.488	.346
5	.107	.540	.987	.936	.661	1.399	.551	.654	1.095	.788	.456	.346
6	.112	.578	1.414	.958	.578	1.308	.700	.547	1.148	1.489	.458	.346
7	.025	.915	1.031	1.211	.603	1.689	.839	.714	.854	.562	.406	.346
8	.039	.607	.790	.583	1.052	.726	1.585	.717	.382	.691	.186	.346
9+	.235	.566	.650	.589	.511	.757	.294	.563	.607	.787	.429	.346

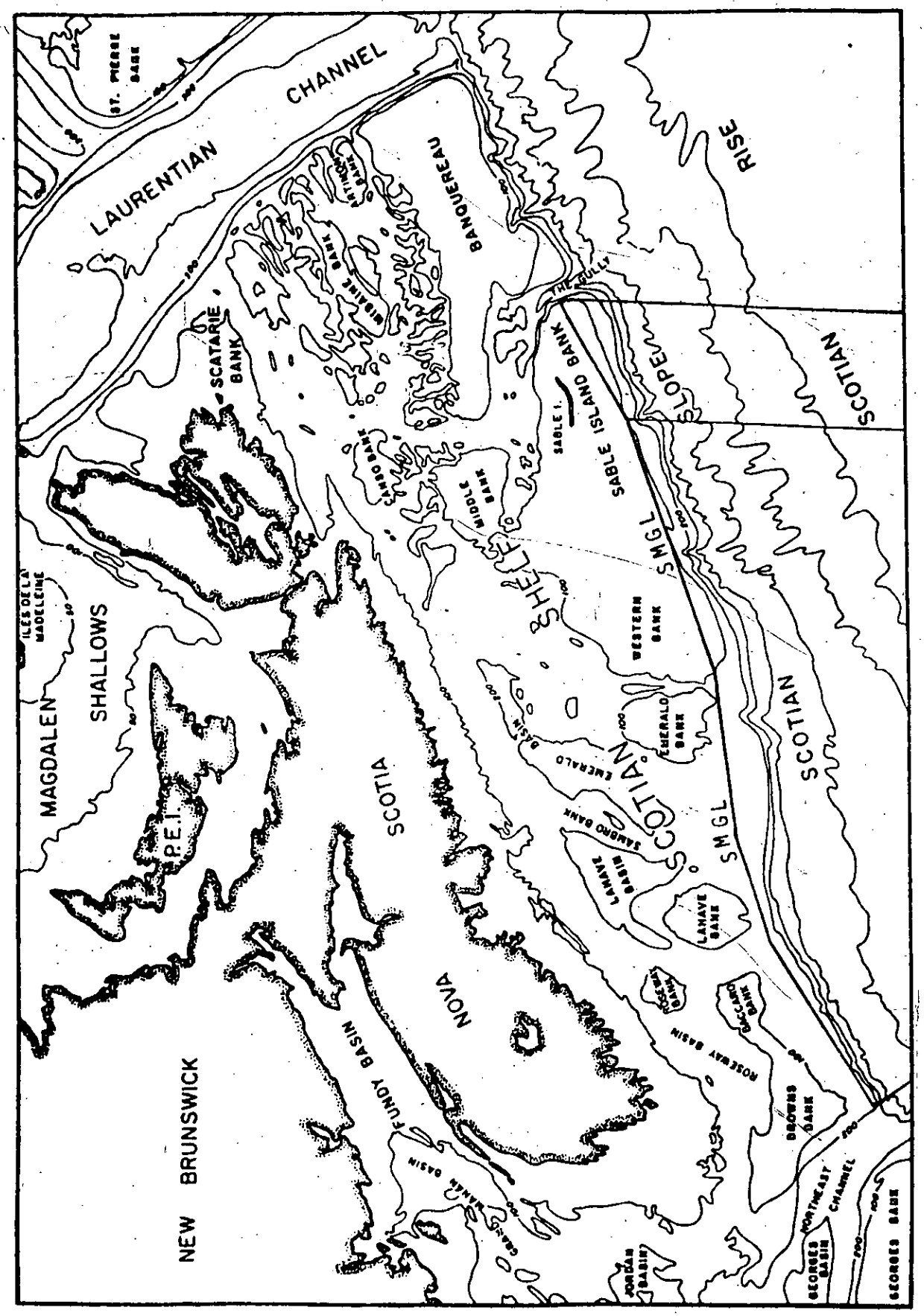


Figure 1 Bathymetric map of the Scotian Shelf and the Bay of Fundy showing the Small Mesh Gear Line (SMGL)

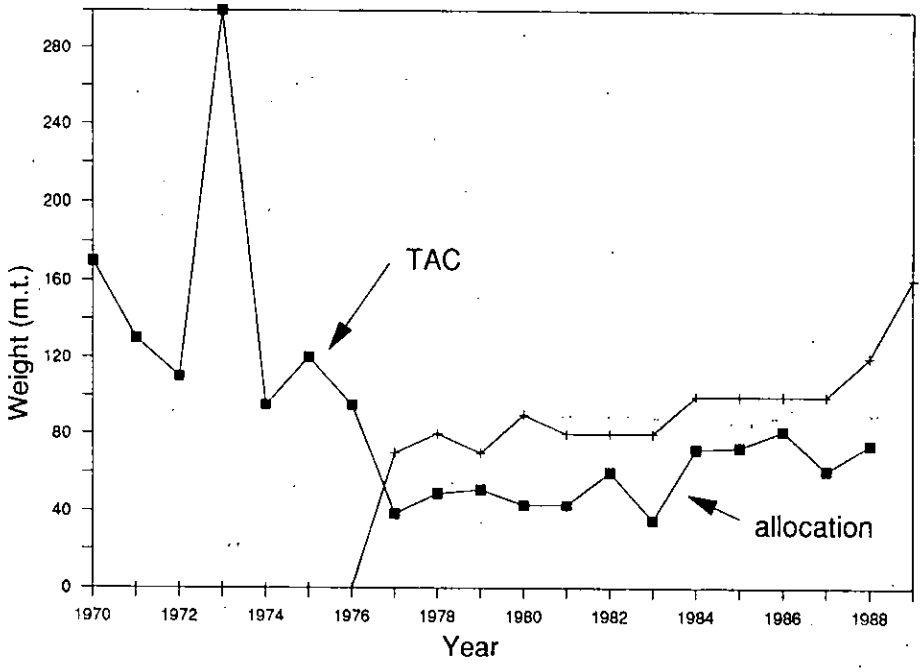


Fig. 2: Catch and TAC for 4VWX silver hake

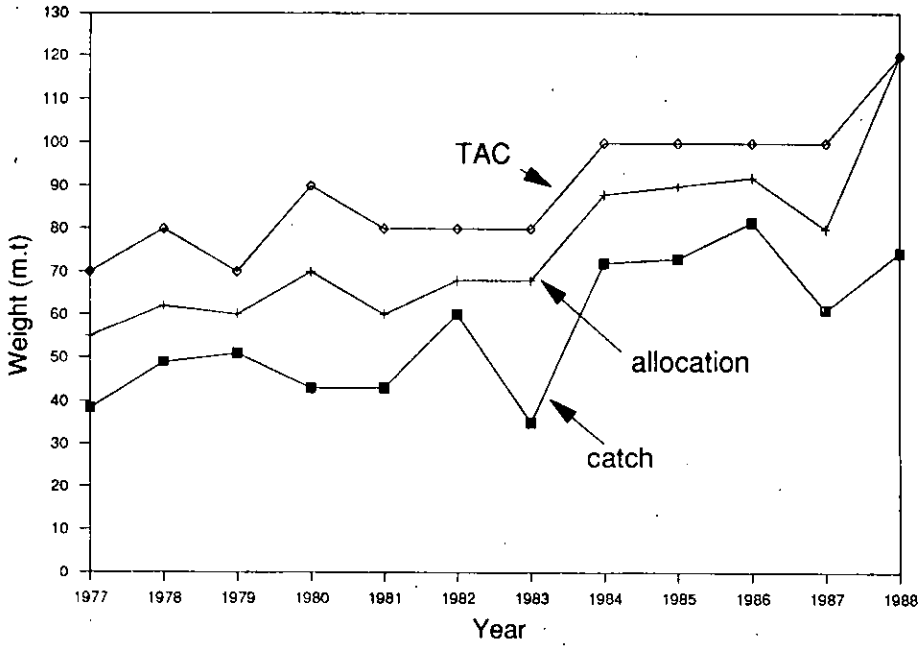


Fig. 3: TAC, allocations and catch for 4VWX silver hake

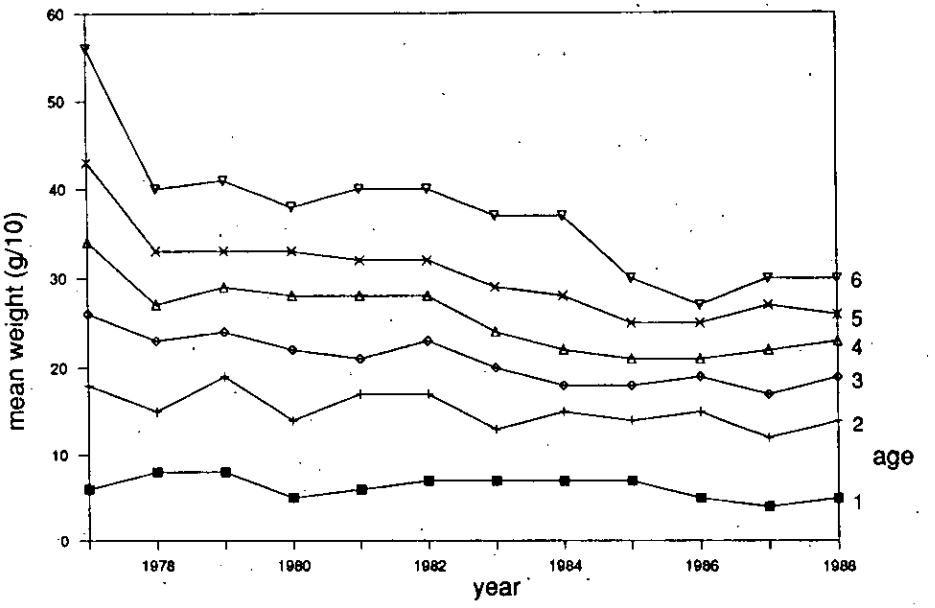
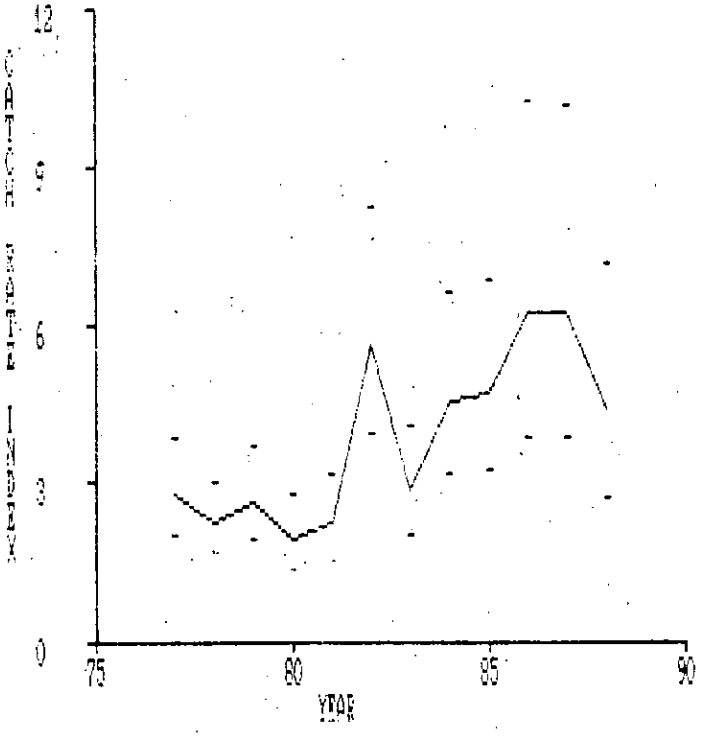


Fig. 4: Mean weight at age in the catch for 4VWX silver hake

Figure 5. Standardized mean catch rate series for 4VWX silver hake from 1977- 1987



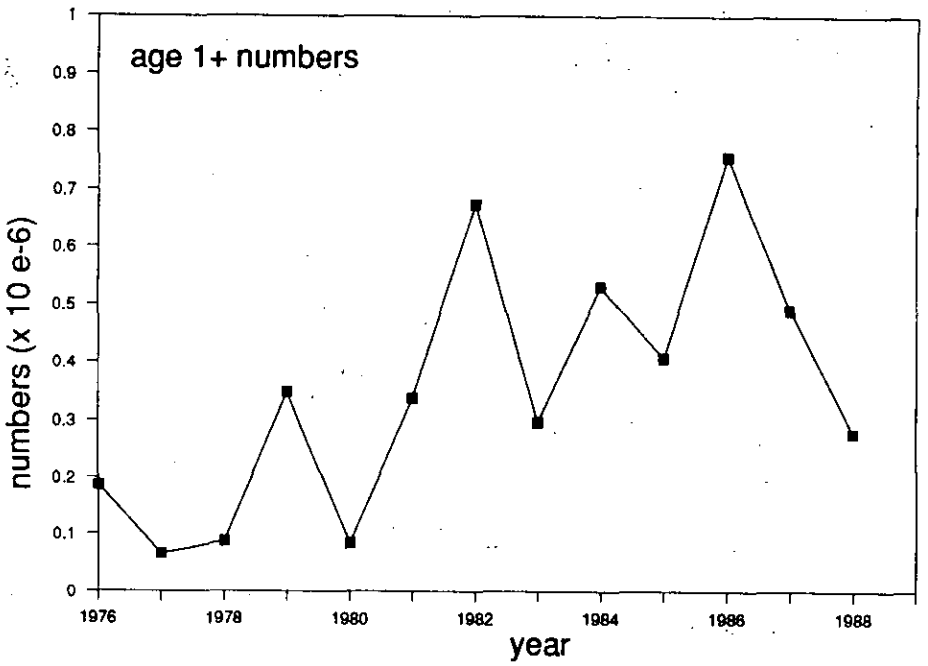


Figure 6: July R/V survey estimates of 4VWX silver hake numbers.

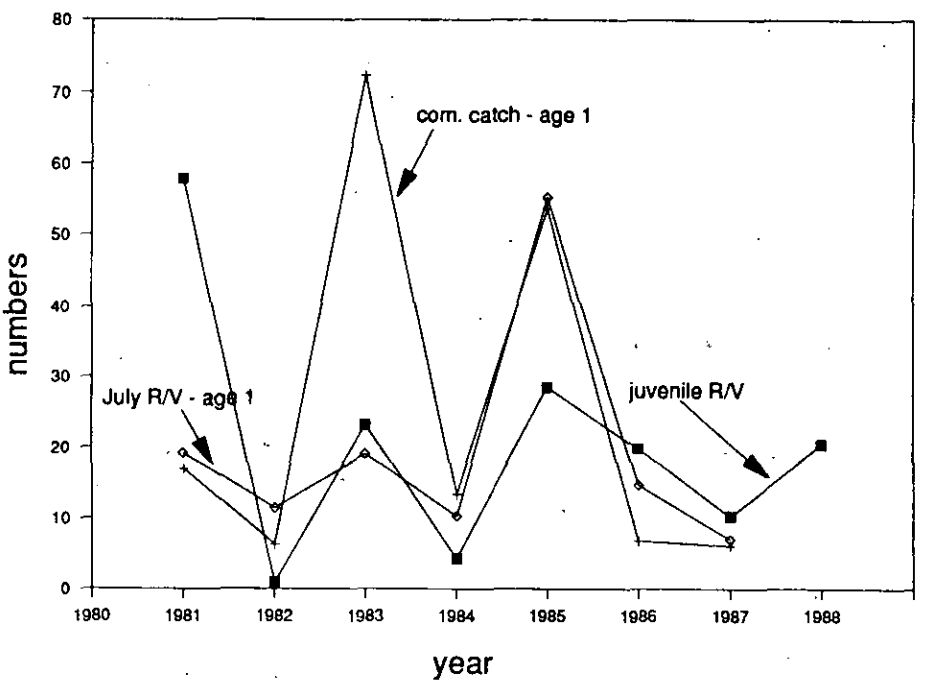


Fig. 7 : Silver hake juvenile stratified mean catch/tow (x 0.1) plotted with R/V (x 10^{-6}) and commercial catch age 1 numbers for the following year.