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Assessment of the Scotian Shelf Silver Hake Population in 1985

by

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INTRODUCTION

The Scotian Shelf silver hake fishery began in 1962. It was once conducted over the total shelf with April to August being the time of the major fishery. From 1977 to the present the fishery continues to be restricted to seaward of the Small Meshed Gear Line (SMGL) (Figure 1). Further, Canada has established regulations which limit the codend mesh size to greater than 60 mm, the amount of by-catch in the fishery and the amount of fishing effort for each country. By-catches of cod, pollock, haddock and redfish, among other species caught in this fishery, are monitored by Canada at the following levels: 1% for haddock, 1% for cod only in NAFO Subarea 4X and 10% elsewhere, and all other species at 10 %. As of 1977, the fishing season has been from April 15 to November 15 each year.

During the 1984 and 1985 fishery, Canada permitted certain vessels from countries given an allocation of silver hake the opportunity to participate in an experiment which evaluated the by-catch in a fishery beginning April 1. Results of this experiment were reviewed at the June 1985 meetings of the NAFO Scientific Council (Anon., 1985 and Wood, 1985). By-catches were found to be minimal during the first half of April while catch rates of silver hake were as high as those observed after April 15. Based upon these results, Canada altered the opening date of the silver hake fishery, in 1986, from April 15 to April 1.

The fleets fishing silver hake on the Scotian Shelf are primarily non-Canadian. The Soviet Union was the first nation to fish for silver hake on the Scotian Shelf. It has been involved in the fishery since 1962 and continues to dominate the catch. The major fishing nations are the Soviet Union and Cuba with countries such as Portugal, Japan and Spain catching various amounts during the history of the fishery.

The vessels used in this fishery are large tonnage class 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.

Silver hake are processed at the rate of 1 to 2 tons per hour depending upon the product type and processing equipment available. The usual product types are whole, gutted head on or gutted head off. Each vessel is equipped with a series of large freezers which are necessary to maintain a market quality for the soft bodied silver hake. These freezers are capable of freezing 3 tons of fish per hour to a temperature of -20 degrees Celsius.

CATCH AND EFFORT

Catch

The historical catches for this fishery have ranged from 300,000 tons in 1973 to 34,000 tons in 1983. Catches are highest during the period April to July of each year. The major catches continue to come from the NAFO Subarea 4W. Specifically, reports from Soviet investigations during the 1961 to 1968 fisheries identified the Scotian Slope, the Gully and the Scotian Channel-Emerald Basin as the prime areas to fish for silver hake (Anon. 1971, Clay, 1979a.). Numerous other studies confirm that these areas continue to have high catches (Waldron & Sinclair 1984).

There was a steady decrease in silver hake catches from 1973 to 1981 (Figure 2, Table 1). Nominal catches from 1977 until 1983 have fluctuated between 33 and 60 thousand tons. In 1984 and again in 1985 the catch increased above 70 thousand tons. Below are reported catches ('000 t) and the Total Allowable Catch (TAC '000 t) since 1975.

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
TAC	120	100	70	80	70	90	80	80	80	100	100	100
CATCH	116	97	37	48	51	45	43	60	36	74	76	26*

* Reported to Canada as of June 2, 1986.

The decreasing trend in catches are in part due to the amount of silver hake Canada allocates to other nations. A more informative method of evaluating the post 1976 catches would be to evaluate catch success against the amount of silver hake allocated. Percent caught of the total allocations for non-Canadian fleets have fluctuated between 64 and 90%. The highest years are 1982 (60,000 t) and 1984 (74,000 t) (Table 2).

In 1984 and 1985 the USSR started fishing in May rather than the usual April 15. This is reflected in the decreased catches during the months of April and May for those years (Table 3). Despite the late start for the Soviet fleet in 1984 and 1985 they, as well as the Cuban fleet, attained their allocation (Figure 3). The 1985 fishery remained strong until August with most of the allocations taken (Table 2). Monthly catches in 1985 were highest in June when 31 thousand tons or 41% of the catch was taken. Catches in April to June accounted for 60% of the total yearly landings.

Monthly Catch and Effort

Historical catches from this fishery indicate that the major fishing season was during the months of April until September (Table 3, Figure 4). Peak catches were in from May to July. This pattern continues to the present.

Reported (1970-1984) and observed (1985) catch rates (t/hr) for the Soviet Fleet from April until September are given in Table 4. Catch rates by Soviet vessels have on average been higher during the April to September period after implementation of the SMGL (Figure 5). In recent years the peak month for silver hake CPUE has shifted from April to May.

Catch Rate Standardization.

A multiplicative model (Gavaris, 1980) was run on 1970 to 1985 monthly catch and effort data for TC 6-7 OTB2 vessels from the Soviet Union (Waldron et al, 1986). The model was used to investigate the affects of the change in fishing regimes after Canada declared its 200 mile zone in 1977.

Catch and effort from 1970 to 1976 were classified as the "old" fishing regime when vessels were generally unrestricted in the area and season of fishing. Catch and effort after 1979 are classified to the "new", more restricted, fishing regime. The catch and effort from the 1977-1979 silver hake fishery is viewed as being intermediate between an "old" regime and the "new" regime. During this time, Canada permitted 4 vessels from the two major silver hake fisheries, Cuban and Soviet, to fish landward of the SMGL. Only certain vessels were licensed for this

experiment. These vessels were directed by the Fleet Commanders to fish either to the landward or seaward of the SMGL depending upon the relative fishing success in either area. As these vessels were required to carry Observers they provide an excellent method of studying the transition between the old and new fishing regimes. Therefore, those vessels which were part of the experiment were classed as the "old" fishing regime.

The results indicated that the only significant effect in the model was years ie. there was interannual variation in the catch rates but no variation that could be explained by month, division, fishing regime or data source, NAFO or Canadian IOP. A separate analysis was carried out comparing monthly catch rates from NAFO and the Canadian IOP and the regression was highly significant with a correlation of 0.96, a slope of 1 and intercept of 0 (Waldron and Parnell 1986). Therefore, IOP catch rates can be conveniently substituted for Soviet catch rates reported to NAFO.

Catch rates for 1982, 1984 and 1985 are the highest in the series (Table 5, Figure 6). The 1983 catch rate is lower than would be expected. There is no explanation for this. The increasing trend in CPUE since 1981 would normally indicate an increase in population biomass.

SAMPLING INTENSITY 1984

Sampling for length and age in 1985 was from the IOP. From the 75,000 tonnes caught, 29,000 tonnes (39%) were observed by the IOP. More than 280,000 lengths and 1500 otoliths were taken from the catch (Table 6.). Coverage levels for 1985 and previous years were above the NAFO standard. Coverage of the August to December catches were lower than expected and required a pooling of samples for the total period.

Otoliths were 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 is presented in Tables 9. The matrix was calculated in the following manner. For 1985, length frequencies of silver hake collected during the small-meshed fishery were aggregated to produce a single monthly length frequency. These monthly length frequencies were weighted to the 1985 monthly catch (Table 3) using the monthly weight-length relationships ($wt=aL^b$) (Table 6). The monthly weight-length relationships were based on individual silver hake lengths and weights measured at sea during the 1985 small-meshed silver hake fishery. For each month the weighted length frequencies were multiplied by age-length keys to produce catch numbers at age. These monthly vectors were summed to give final catch numbers at age for the year (Table 7).

The catch numbers at age for 1972 to 1979 were prepared by Clay and Beanlands (1980). They used age-length keys collected from Canadian July groundfish surveys and silver hake length frequencies reported to ICNAF. The length frequencies were adjusted to catch using weight-length relationships from the Canadian July groundfish surveys. These weighted length frequencies were applied to the Canadian age-length keys to give yearly catch numbers at age. The catch numbers at age for 1970 and 1971 were calculated as above but used an aggregated age-length key from the Canadian July groundfish surveys from 1972 to 1976. Catch numbers at age for 1977 to 1979 used length frequencies collected on board the small-meshed fleets by the IOP and weight-length relationships from the Canadian July groundfish surveys.

Catch numbers at age for 1980 to 1984 (Waldron and Fanning, 1985) used length frequencies and weight-length relationships collected on board the small-meshed fleets by the IOP. As in previous years, these were weighted to catch and used to construct the final catch numbers at age. Research vessel weights at length were not used as weights collected by the IOP were more representative of the weights at length during the fishery.

The 1985 fishery is supported by three year classes, 1981-1983. The catch-at-age matrix (Table 7) and percent catch at age (Table 8) indicates that the 1983 year class, which was observed in the last assessment to be the largest since the 1975 year class remains the dominant year class in

the 1985 fishery. As suggested in last years assessment, the 1985 fishery was supported mostly by the 1983 and 1981 year classes and only moderately by the 1982 year class. The 1982 year class continues to appear weak compared to previous year classes. The 1980 and 1981 year classes in 1985 are average. The 1984 year class at age 1 is the second highest since the start of the more restricted fishery in 1979 and is less than half that of the large 1984 year class. Usually 80 % of the catch is from ages 1 to 4, therefore the above average 1981 year class will give little support to the 1986 fishery. The 1987 fishery will be almost solely supported by the 1983 year class.

MEAN WEIGHT AT AGE

Mean weights at age were calculated by multiplying average lengths (after weighting by catch) by the appropriate weight-length relationship from the Canadian July groundfish surveys (1970-1979) and the IOP (1980-1985) (Table 9). Waldron and Fanning (1985) noted that fish age 4 and 5 were below weights calculated for the 1982 fishery. This trend has continued in the 1985 fishery (Figure 7). Age 1-3 fish continue to show an increase in mean weight at age. If fishing dependent mortality governs this stock, increasing mean weight at age would suggest that the stock is under-exploited.

The catch biomass at age is given in Table 10. There is reasonable agreement between the catch biomass and the reported catch per year as shown below. The difference between reported and calculated catch in 1985 (2.5%) could be the result of discrepencies between the sum of 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 1985.

YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985
CATCH (T)	37095	48404	51751	44525	42927	60251	35839	74280	75492
BIOMASS(T)	36838	47581	51179	44663	41030	59883	35189	74207	77391
DIFFERENCE	257	823	572	-138	1897	368	650	73	-1899

RESEARCH VESSEL INDICES

Adult Surveys

Two survey series are currently available covering the Scotian Shelf. The major annual survey is the July stratified random groundfish survey. Over the years there have been three vessels used to conduct this survey. Comparative fishing experiments between pairs of vessels were conducted to allow calibration of the survey results from the different vessels. The analysis of the comparative fishing results (Fanning, 1985) resulted in a conversion factor for the series from 1972 to 1981 of 2.3 i.e. all catches in the 1970-81 surveys are multiplied by 2.3 to adjust for the effect of the vessel and gear changes in the time series. By converting the historical catches the current data can be added to the series unchanged.

The abundance at age based on the July survey results is given in Table 11 and plotted in Figure 8. The total abundance index is plotted in Figure 9 for the July surveys and Figure 10 for the March surveys. Total abundance in the March surveys is:

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

Numbers at age are not available for the March 1985 survey as the otoliths have not yet been read.

Table 12 gives the percent at age in the July surveys for each survey year and Table 13 and Figure 11 give the percent at age within each year class. In 1985, the 1983 year class (at age 2) is not as strong as it

appeared in 1984. The 1981 year class remains strong even at age 4 with the largest percentage in any year at age 4. The 1980 year-class is the strongest ever at age 5 after being reasonably strong at age 4 and very strong at age 2. At age.3 however the 1980 year-class was far below average for recent years. The absence of this year-class may have been a major contributor to the apparent drop in abundance in the July 1983 survey. In the March 1983 survey the 1980 year-class was very strong and the overall March abundance index did not drop noticeably in that year. The 1982 year-class is the weakest in numbers at age 3 since the 1977 year-class and the weakest in percent at age 3 since the 1973 year-class. The 1984 year-class is the lowest at age 1 since the 1980 year-class. Happily, the 1980 year-class eventually proved to be a reasonably strong one.

Juvenile Surveys

Since 1978, the USSR and Canada have been conducting joint surveys for Scotian Shelf juvenile silver hake. Initially the gear used was a Soviet designed juvenile bottom trawl. Although it fished well, there was some doubt as to it's ability to sample the total juvenile population. Juvenile silver hake were found to be high in the water column at night and perhaps below the trawl during the day (Koeller, 1979). More probably, these juveniles were above the Soviet bottom survey trawl. In support of this contention, Fanning (1984) suggests that silver hake of age 1 are probably above the research gear used in the Canadian groundfish surveys. Since 1981 the 24 hour cruise design was replaced by a 12 hour night-time cruise using the International Young Gadoid Trawl (IGYPT) used by member countries of the International Council for the Exploration of the Sea (Koeller et al,1984).

The juvenile silver hake survey is of a random stratified design similar to that reported by Halliday (1971) for the Canadian Scotian Shelf July groundfish surveys. Koeller et al. (1984) identified a "core" survey area (strata 60-78, where most of the silver hake juveniles were caught in both the joint USSR-Canada and Canadian Scotian Shelf ichthyoplankton Program surveys.

During the 1984 NAFO meeting of the Scientific Council questions concerning this assumption were raised. The 1984 survey conducted at the usual time, October-November, addressed this issue. It confirmed Koeller's concept of a core survey area as the area where the majority of silver hake juveniles were caught (Neilson, pers. com.).

The survey results presented in Waldron and Fanning (1985) were recalculated by Mr. P. Koeller, DFO, BIO and Dr. John Neilson of the DFO St. Andrew's Laboratory in New Brunswick. See below are those re-calculations plus the new 1985 data. Koeller et. al. (1986) gives an explanation of the methods used to calculate these indices.

Years	1978	1979	1980	1981	1982	1983	1984	1985
Strat. mean catch/tow	235.7	56.3	26.6	579.0	8.8	232.2	43.4	284.8

Only the series from 1981 to 1985, using the IGYPT gear will be used as an index of juvenile silver hake abundance. The series indicates that the 1981, 1983 and 1985 year classes are large relative to the 1982 and 1984 year classes. This observation agrees well with that seen in the Canadian July groundfish surveys and the commercial catch. The low value of the 1982 year class is also seen in the commercial fishery and research vessel data sets. The 1985 year class is the second largest in the series. Based upon the observed between this recruitment index and subsequent performance of individual year classes, the 1986 and in particular the 1987 fishery will have a year class similar in strength to the 1983 year class.

POPULATION MODELING AND PROJECTIONS

The previous assessment (Waldron and Fanning, 1985) outlined the

difficulties in using the current research vessel cruises as a means of calibrating the sequential population model. Further, the NAFO Scientific Council (Anon. 1985) has chosen to regard the placement of the SMGL as a factor which could bias effort and CPUE data for this fishery. Therefore two independent indices of abundance were deemed inappropriate for calibration of a sequential population or for use in general production models.

Showell and Waldron (1986) compared CPUE with bottom temperature and population biomass. They tested the null hypothesis "...that catch rates seaward of the SMGL are independent of bottom temperatures on the shelf.". Because population biomass was calculated from a VPA, only data from the converged part of the VPA (ie. 1977-1982) were analyses. They found there was only one significant relationship between CPUE and bottom temperature and this was influenced by the anomalously high 1982 CPUE. CPUE and population biomass are significantly correlated which is encouraging and suggests that the standardized catch rate series can be use for VPA calibration. Continued work on the relationship between CPUE and other factors such as temperature will be undertaken.

An attempt at calibrating a VPA using fishable (exploitable) biomass with the new standardized catch rates suggested that terminal F (Ft) in 1985 ranged from 0.05 to 0.3 with 0.25 being the most probable level (Waldron, et.al., 1986). It was evident from the plots of a variety of Fts that the 1970-1976 catch rates were different from those of the 1977-1985 (ie. the residuals were serially correlated). From this it would appear that there has been a change in the catchability coefficient (q=CPUE/fishable biomass). Calibration of the VPA should be investigated further by perhaps using only the 1977 and onward standardized CPUE.

CONCLUSIONS

The 1985 fishery was supported by two large year classes (1981 and 1983) as suggested both by the research vessel and juvenile research surveys. These year classes plus the 1984 year class, the size of which is uncertain, will be in the fishery for 1986 but only one, the apparently strong 1983 year class will contribute significantly to the 1986 fishery. There is no confirmation to date of the size of the 1985 year class seen as strong in the 1985 juvenile survey. If the favorable relationship of the abundance indices of the juvenile and research vessel surveys and the fishery continues, the 1987 fishery will be supported by a strong 1985 and 1983 and a 1984 year-class which is slightly below average.

The 4VWX silver hake stock biomass in the 1980's is above the average level seen in the 1970's. The current TAC of 100,000 tons established in 1983 was based upon recruitment indices which suggested that the 1983 year-class would be much higher than those seen since 1978. The fishery in 1987 will be supported by two very good year-classes and possibly a third year-class which is above the average from 1970-1985 but is below that in the 1980's. Therefore, there is no reason to decrease the current TAC from 100,000 tons. However, this catch level may in fact be conservative.

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Table 1. Nominal catches for 4VWX silver hake 1970-1984 (1985 Preliminary).

	YEAR															
COUNTRY	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Bulgaria	0	0	0	0	0	1722	3088	862	606	4639	817	0	0	0	0	0
Canada	0	0	0	0	11	101	26	10	26	13	104	6	38	15	10	0
Cuba	0	0	201	909	0	1724	12572	1847	3436	1798	2287	642	11969	7418	11496	17683
France	0	0	0	0	0	0	0	15	0	0	0	0	2[1]	0	0	0
FRG	0	0	10	0	296	106	97	684	0	0	0	0	0	0	0	0
GDR	0	0	0	0	0	0	0	0	3[1]	0	0	0	0	0	93	0
Ireland	0	0	0	0	0	108	106	0	0	0	0	0	0	0	0	0
Italy	0	0	0	0	0	0	0	38	106	5	0	460[1]	37[1]	2[2]	0	0
Japan	129	8	63	88	67	54	78	19	161	219	239	120	937	649	529	122
Poland	0	0	0	0	0	0	0	295	2	0	0	1[1]	31[2]	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	56	1460[1]	2[1]	378	1714	1350
Romania	0	0	0	0	0	0	0	10	0	1	0	0	0	0	0	0
Spain	0	11	0	0	0	6	0	0	2	0	40	0	0	0	0	0
USA	0	1	0	0	0	7	1	14	0	0	0	3	2	0	0	0
USSR	168916	128633	113774	298533	95371	112566	81216	33301	44062	45076	40982	40235	47261	27377	57423	56337
TOTAL	169045	128653	114048	299530	95745	116394	97184	37095	48404	51751	44525	42927	60251	35839	74266	75492

1 Observer Program Data (data not reported to NAFO)
2 FLASH data

Table 2. Nominal catch and allocations (t) (in parenthesis) for 4VWX silver hake. 1985 Preliminary.

COUNTRY	1977	1978	1979	1980	1981	1982	1983	1984	1985
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 (1000)	10 (1000)	0 (1000)
Cdn. Reserve							(11808)	(13000)	(5100)
Cuba	1847 (8910)	3436 (10300)	1798 (8070)	2287 (11200)	642 (9500)	11969 (13500)	7418 (9500)	14496 (15200)	17683 (18200)
EEC	-	-	-	- (100)	-	-	-	-	
France[4]	15	0	0 [3] (100)	0 [3] (100)	0 [3] (100)	2[1] [3] (100)	0 [3] (100)	0 (100)	0 (100)
FRG	684	0	0	0	0	0	0	0	0
GDR	0	[1] 3	0	0	0	0	0 (2000)	93 (100)	0
Italy	38	106	5	0	[1] 460	[1] 37	[2] 2	0	0
Japan	19	161	219	239	120	937 (2000)	649 (5000)	529 (10000)[2]	122[2] (10000)
Poland	295	2	0	0	1[1]	31	0	0	0
Portugal	0	0	0	56	1460[1]	2[1] (2000)	378 (3000)	1714 (4000)[2]	1350[2] (4000)
Romania	10	0	1	0	0	0	0	0	0
Spain	0	2	0	40	0	0	0 (4000)	0	0 (5000)
USA	14	0	0 (2)	0	3	2	0	0	0
USSR	33301 (44950)	44062 (52000)	45076 (44940)	40982 (56600)	40235 (48400)	47261 (48400)	27377 (43400)	57423 (56600)	56337 (56600)
Others			- (30)	- (900)	- (1000)	-	- (192)	-	-
Total Catch and TAC	37095 (70000)	48404 (80000)	51751 (70000)	44525 (90000)	42927 (80000)	60251 (80000)	35839 (80000)	74266 (100000)	75492 (100000)
Sum of Catch Divided by TAC (%)	53	61	74	50	54	75	45	74	76
Sum of Catch Divided by sum of allocations (discounted Can. Alloc. + reserve) (%).	68	76	86	64	72	90	53	86	80

[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

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Table 3: Scotian Shelf silver hake reported monthly catch (t).

	1970	1971	1972	1973	1974	1975	1976
Jan.	12	3			1088	2381	982
Feb.	43	3555	43	103	261	1232	1174
Mar.	4335	30821	7199	12133	7345	2715	15028
Apr.	16682	19415	12129	91367	10182	12501	10344
May.	19880	11742	21303	72443	15766	12439	7860
Jun.	19115	9419	16982	41948	14369	6247	7030
Jul.	34873	22118	26425	42955	10676	24023	22531
Aug.	43814	21621	14610	13394	10365	18261	8895
Sept.	19028	8258	11481	8656	4871	17679	6480
Oct.	6132	1092	3223	5493	4981	11	7625
Nov.	4115	613	452	1078	5256	1	3900
Dec.	1016			9050	10585	50	5335
Total	169045	128657	114048	298621	95745	97540	97184

	1977	1978	1979	1980	1981	1982	1983
Jan.							
Feb.	2		6				
Mar.	3718		2				
Apr.	8142	2118	2190	1558	981	2409	6990
May.	5714	8761	13000	9809	15332	19482	16369
Jun.	3284	13591	17651	13875	13669	24786	11274
Jul.	11990	14449	14417	15011	13654	12607	543
Aug.	2805	8851	2930	4025	909	641	490
Sept.	1046	236	903	103	41	260	156
Oct.	190	285	403	84	8	7	7
Nov.	201	55	248	60	3	13	8
Dec.	3	55	1		2	2	
Total	37095	48404	51751	44525	44599	60207	35837

	1984	1985
Jan.		
Feb.		
Mar.		
Apr.	2706	3163
May	19529	11323
Jun.	22000	30483
Jul.	26041	25600
Aug.	3411	4891
Sept.	516	22
Oct.	17	
Nov.	4	
Dec.	2	10
Total	74226	75492

Table 4: Reported (1970-1984) and observed (1985) catch rates (t/hr) for the Soviet Fleet from April until September.

	1970	1971	1972	1973	1974	1975	1976
April	2.46	1.66	2.25	4.66	1.11	1.17	2.26
May	1.80	1.35	1.66	2.92		1.17	1.61
June	1.83	2.05	2.44	1.64	1.64		
July	2.38	1.39	1.43	2.12		1.78	1.91
August	2.48	1.45	1.58	1.38		1.60	2.17
Sept.	1.53		2.16	2.41	2.31	1.28	2.58

	1977	1978	1979	1980	1981	1982	1983
April	1.96	1.39	1.71	1.30	1.23	5.61	2.97
May	1.89	1.35	1.85	1.15	2.19	4.27	2.18
June	2.09	1.36	1.77	1.30	1.35	3.86	1.44
July	1.99	1.43	1.98	1.38	1.40	2.83	
August	2.01	2.15	1.45	.64	1.40		
Sept.	1.51		1.73				

	1984	1985
April		
May	4.15	2.52
June	2.44	3.10
July	2.46	2.85
August	3.14	4.69
Sept.		

TABLE 5. PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 1 4 450 1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1970	169045	0.905	2.295	0.192	73666
1971	128653	0.531	1.733	0.219	74246
1972	114048	0.879	1.888	0.223	60418
1973	299530	0.891	2.476	0.262	120985
1974	95745	0.240	1.676	0.322	57113
1975	116394	0.743	1.476	0.175	78841
1976	97184	0.424	2.146	0.227	45295
1977	37095	0.703	1.946	0.154	19064
1978	48404	0.879	1.599	0.105	30272
1979	51751	0.828	1.764	0.126	29339
1980	44525	0.457	1.673	0.198	26607
1981	42927	0.488	1.420	0.158	30232
1982	60251	0.496	4.198	0.700	14352
1983	35839	0.497	2.251	0.432	15922
1984	74280	0.522	3.042	0.507	24414
1985	76120	0.278	3.263	0.413	23328

AVERAGE C.V. FOR THE MEAN: .122

Table 6. Catch at age ('000) for silver hake in 1985.

Age	April	May	June	July	August-Dec	TOTAL
1	-	6241	21355	10677	0	38273
2	2794	22838	62221	86600	970	175423
3	4751	15016	22533	22519	2298	67117
4	6119	16430	46816	15529	6622	91516
5	2351	4219	9808	4831	1744	22953
6	343	1399	4183	1863	1170	8958
7	71	573	871	322	1562	3399
8	-	60	52	73	459	644
9	-	1	21	45	297	364
10						
No ages	228	379	411	420	117	1555
No. lengths	44693	95572	87346	46293	571	28711
alpha	0.01219	0.03855	0.01722	0.0253	0.0253	.023712
beta	2.8276	2.50171	2.7476	2.64029	2.64029	2.671498
catch (t)	3136	11323	30779	25896	4923	76084
sample weight (t)	8.5	16.2	16.0	8.4	.2	49.3

TABLE 7: CATCH AT AGE ('000) FOR 4VWX SILVER HAKE 25/ 5/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	187298	219607	379314	246148	101158	145091	153535	2131	28704
2	748021	410149	460610	1482925	390044	365964	381651	43535	90777
3	216246	175005	71536	96784	150741	52837	72418	78239	89717
4	59832	74755	47903	106675	7095	60806	31295	29561	42878
5	20695	22035	17822	96940	9789	38646	5582	6981	19442
6	9636	1877	7452	19671	3245	4803	2669	2004	8587
7	3608	5139	1160	15203	93	311	514	483	3222
8	1988	1333	437	5475	109	363	105	564	2009
9	1114	2062	607	484	60	360	390	522	420
1+	1248438	911962	986841	2070305	662334	669181	648159	164020	285756
2+	1061140	692355	607527	1824157	561176	524090	494624	161889	257052
3+	313119	282206	146917	341232	171132	158126	112973	118354	166275
4+	96873	107201	75381	244448	20391	105289	40555	40115	76558
5+	37041	32446	27478	137773	13296	44483	9260	10554	33680

	1979	1980	1981	1982	1983	1984	1985
1	9667	6272	1553	19708	3333	99217	38273
2	48341	60576	19530	51680	86085	40265	175423
3	69058	82013	111209	66973	51617	191048	67117
4	46547	35888	38534	66230	28354	71739	91516
5	29656	15293	14266	34777	13036	19200	22953
6	16964	6179	5548	8925	4431	5392	8958
7	5079	1682	679	2790	1150	1006	3399
8	1765	344	132	1047	475	176	644
9	1151	90	61	127	69	3	364
1+	228228	208337	191512	252257	188550	428046	408647
2+	218561	202065	189959	232549	185217	328829	370374
3+	170220	141489	170429	180869	99132	288564	194951
4+	101162	59476	59220	113896	47515	97516	127834
5+	54615	23588	20686	47666	19161	25777	36318

TABLE 8 : 4VWX SILVER HAKE PERCENT AT AGE 25/ 5/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	15.00	24.08	38.44	11.89	15.27	21.68	23.69	1.30	10.04	4.24
2	59.92	44.97	46.68	71.63	58.89	54.69	58.88	26.54	31.77	21.18
3	17.32	19.19	7.25	4.67	22.76	7.90	11.17	47.70	31.40	30.26
4	4.79	8.20	4.85	5.15	1.07	9.09	4.83	18.02	15.01	20.39
5	1.66	2.42	1.81	4.68	1.48	5.78	.86	4.26	6.80	12.99
6	.77	.21	.76	.95	.49	.72	.41	1.22	3.01	7.43
7	.29	.56	.12	.73	.01	.05	.08	.29	1.13	2.23
8	.16	.15	.04	.26	.02	.05	.02	.34	.70	.77
9	.09	.23	.06	.02	.01	.05	.06	.32	.15	.50

	1980	1981	1982	1983	1984	1985
1	3.01	.81	7.81	1.77	23.18	9.37
2	29.08	10.20	20.49	45.66	9.41	42.93
3	39.37	58.07	26.55	27.38	44.63	16.42
4	17.23	20.12	26.25	15.04	16.76	22.39
5	7.34	7.45	13.79	6.91	4.49	5.62
6	2.97	2.90	3.54	2.35	1.26	2.19
7	.81	.35	1.11	.61	.24	.83
8	.17	.07	.42	.25	.04	.16
9	.04	.03	.05	.04	.00	.09

TABLE 9 : MEAN WEIGHTS AT AGE KG) OF 4VWX SILVER HAKE 25/ 5/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	.060	.040	.056	.045	.063	.067	.063	.062	.049	.061	.041
2	.126	.128	.119	.128	.129	.155	.148	.147	.110	.154	.141
3	.167	.188	.209	.216	.204	.243	.246	.210	.174	.200	.213
4	.222	.254	.240	.250	.310	.237	.273	.290	.226	.245	.280
5	.303	.315	.274	.295	.396	.477	.407	.397	.283	.285	.322
6	.404	.450	.557	.439	.539	.457	.528	.516	.329	.344	.366
7	.470	.587	.483	.485	.975	1.133	.838	.667	.382	.411	.520
8	.705	.832	1.263	.875	1.156	1.257	1.251	1.077	.498	.520	.601
9	.828	.612	.886	1.174	.001	1.635	.859	1.089	.784	.553	.892

	1981	1982	1983	1984	1985
1	.036	.056	.054	.063	.077
2	.143	.148	.130	.147	.156
3	.193	.223	.203	.190	.206
4	.248	.289	.246	.249	.240
5	.318	.329	.303	.278	.276
6	.369	.399	.362	.366	.326
7	.672	.481	.387	.454	.417
8	.550	.582	.653	.597	.599
9	.794	.949	.809	.753	.630

Table 10 : The catch biomass at age for silver hake.

CATCH BIOMASS 25/ 5/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	11238	8784	21242	11077	6373	9721	9673	132	1406	590
2	94251	52499	54813	189814	50316	56724	56484	6400	9985	7445
3	36113	32901	14951	20905	30751	12839	17815	16430	15611	13812
4	13283	18988	11497	26669	2199	14411	8544	8573	9690	11404
5	6271	6941	4883	28597	3876	18434	2272	2771	5502	8452
6	3893	845	4151	8636	1749	2195	1409	1034	2825	5836
7	1696	3017	560	7373	91	352	431	322	1231	2087
8	1402	1109	552	4791	126	456	131	607	1000	918
9	922	1262	538	568	0	589	335	568	329	637
1+	169068	126345	113186	298430	95481	115722	97094	36838	47581	51179
2+	157830	117561	91944	287354	89109	106001	87421	36706	46174	50589
3+	63579	65062	37132	97539	38793	49277	30937	30306	36189	43145
4+	27466	32161	22181	76634	8042	36437	13122	13876	20578	29333

	1980	1981	1982	1983	1984	1985
1	257	56	1102	180	6251	2947
2	8541	2793	7623	11191	5919	27366
3	17469	21463	14915	10478	36299	13826
4	10049	9556	19167	6975	17863	21964
5	4924	4537	11445	3950	5338	6335
6	2262	2047	3560	1604	1973	2920
7	875	456	1342	445	457	1417
8	207	73	609	310	105	386
9	80	48	120	56	2	229
1+	44663	41030	59883	35189	74207	77391
2+	44406	40974	58781	35009	67956	74444
3+	35865	38181	51158	23818	62037	47078
4+	18396	16718	36244	13340	25738	33252

MEAN WEIGHT OF INDIVIDUALS IN CATCH 25/ 5/86

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
.14	.14	.11	.14	.14	.17	.15	.22	.17	.22	.21	.21	.24	.19	.17

1985
.19

Table 11 : JULY RESEARCH SURVEY NUMBERS AT AGE (THOUSANDS) FOR 4VWX SILVER HAKE 01/06/86

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	55507	114479	60085	37611	44552	56879	26774	86755	14787	32930	191964	117816	427311	102496
2	88955	256653	203557	33014	108935	83741	24163	148112	22094	86213	298055	108591	102616	173893
3	13204	17477	27540	5234	14653	54417	16119	71487	28944	134563	81956	40180	327936	35040
4	7130	14515	3442	2993	11307	16460	8722	19634	8264	57609	64841	18767	54040	72226
5	3071	13474	3558	1592	4176	10589	6679	11579	4256	16670	14633	9574	15061	21840
6	1766	6226	3875	870	1679	4763	2854	5576	3128	5246	10155	3028	10562	9499
7	630	2172	715	301	357	2594	1177	3064	1512	2888	5532	803	4598	2633
8	362	1332	410	397	236	974	458	974	875	860	6723	406	1755	1113
9	34	120	35	38	290	213	922	213	370	499	393	361	908	207
10	436	668	0	0	0	503	450	503	652	252	156	12	1881	545
1+	171095	427117	303218	82051	186186	231132	88318	347897	84882	337730	674408	299537	946668	419493
2+	115588	312638	243133	44440	141634	174253	61544	261142	70095	304799	482445	181721	519357	316998
3+	26633	55985	39576	11426	32699	90513	37381	113030	48002	218586	184390	73131	416741	143104
4+	13429	38508	12036	6192	18046	36095	21262	41543	19057	84023	102434	32951	88805	108064
5+	6299	23993	8594	3199	6739	19635	12540	21909	10793	26415	37593	14184	34765	35838
6+	3228	10518	5036	1606	2564	9047	5861	10330	6538	9745	22960	4610	19705	13998

Table 12 : SILVER HAKE JULY SURVEY PERCENT AT AGE FOR 4VWX 01/06/86

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	32.442	26.803	19.816	45.839	23.929	24.609	30.316	24.937	17.420	9.751	28.464	39.333	45.138	24.433
2	51.991	60.090	67.132	40.236	58.509	36.231	27.359	42.574	26.029	25.527	44.195	36.253	10.840	41.453
3	7.717	4.092	9.083	6.379	7.870	23.544	18.252	20.548	34.100	39.843	12.152	13.414	34.641	8.353
4	4.168	3.398	1.135	3.648	6.073	7.121	9.876	5.644	9.736	17.058	9.615	6.265	5.708	17.217
5	1.795	3.155	1.173	1.941	2.243	4.581	7.562	3.328	5.014	4.936	2.170	3.196	1.591	5.206
6	1.032	1.458	1.278	1.061	.902	2.061	3.231	1.603	3.685	1.553	1.506	1.011	1.116	2.264
7	.368	.508	.236	.367	.192	1.122	1.333	.881	1.782	.855	.820	.268	.486	.628
8	.212	.312	.135	.483	.127	.422	.519	.280	1.031	.255	.997	.136	.185	.265
9	.020	.028	.012	.046	.156	.092	1.044	.061	.436	.148	.058	.120	.096	.049
10	.255	.156	.000	.000	.000	.218	.510	.145	.768	.075	.023	.004	.199	.130
1+	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
2+	67.558	73.197	80.184	54.161	76.071	75.391	69.684	75.063	82.580	90.249	71.536	60.667	54.862	75.567
3+	15.566	13.108	13.052	13.925	17.563	39.160	42.326	32.489	56.551	64.722	27.341	24.415	44.022	34.114
4+	7.849	9.016	3.969	7.547	9.693	15.617	24.074	11.941	22.452	24.879	15.189	11.001	9.381	25.761
5+	3.682	5.617	2.834	3.898	3.620	8.495	14.198	6.298	12.716	7.821	5.574	4.735	3.672	8.543
6+	1.887	2.463	1.661	1.958	1.377	3.914	6.637	2.969	7.702	2.885	3.404	1.539	2.081	3.337

Table 13 : SILVER HAKE PERCENT AT AGE IN JULY SURVEYS FOR EACH YEAR CLASS 01/06/86

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	32.44	26.80	19.82	45.84	23.93	24.61	30.32	24.94	17.42	9.75	28.46
2	.00	.00	.00	.00	.00	.00	.00	.00	51.99	60.09	67.13	40.24	58.51	36.23	27.36	42.57	26.03	25.53	44.19	36.25
3	.00	.00	.00	.00	.00	.00	.00	7.72	4.09	9.08	6.38	7.87	23.54	18.25	20.55	34.10	39.84	12.15	13.41	34.64
4	.00	.00	.00	.00	.00	.00	4.17	3.40	1.14	3.65	6.07	7.12	9.88	5.64	9.74	17.06	9.61	6.27	5.71	17.22
5	.00	.00	.00	.00	.00	1.79	3.15	1.17	1.94	2.24	4.58	7.56	3.33	5.01	4.94	2.17	3.20	1.59	5.21	.00
6	.00	.00	.00	.00	1.03	1.46	1.28	1.06	.90	2.06	3.23	1.60	3.68	1.55	1.51	1.01	1.12	2.26	.00	.00
7	.00	.00	.00	.37	.51	.24	.37	.19	1.12	1.33	.88	1.78	.86	.82	.27	.49	.63	.00	.00	.00
8	.00	.00	.21	.31	.14	.48	.13	.42	.52	.28	1.03	.25	1.00	.14	.19	.27	.00	.00	.00	.00
9	.00	.02	.03	.01	.05	.16	.09	1.04	.06	.44	.15	.06	.12	.10	.05	.00	.00	.00	.00	.00
10	.25	.16	.00	.00	.00	.22	.51	.14	.77	.07	.02	.00	.20	.13	.00	.00	.00	.00	.00	.00

	1982	1983	1984
1	39.33	45.14	24.43
2	10.84	41.45	.00
3	8.35	.00	.00
4	.00	.00	.00
5	.00	.00	.00
6	.00	.00	.00
7	.00	.00	.00
8	.00	.00	.00
9	.00	.00	.00
10	.00	.00	.00

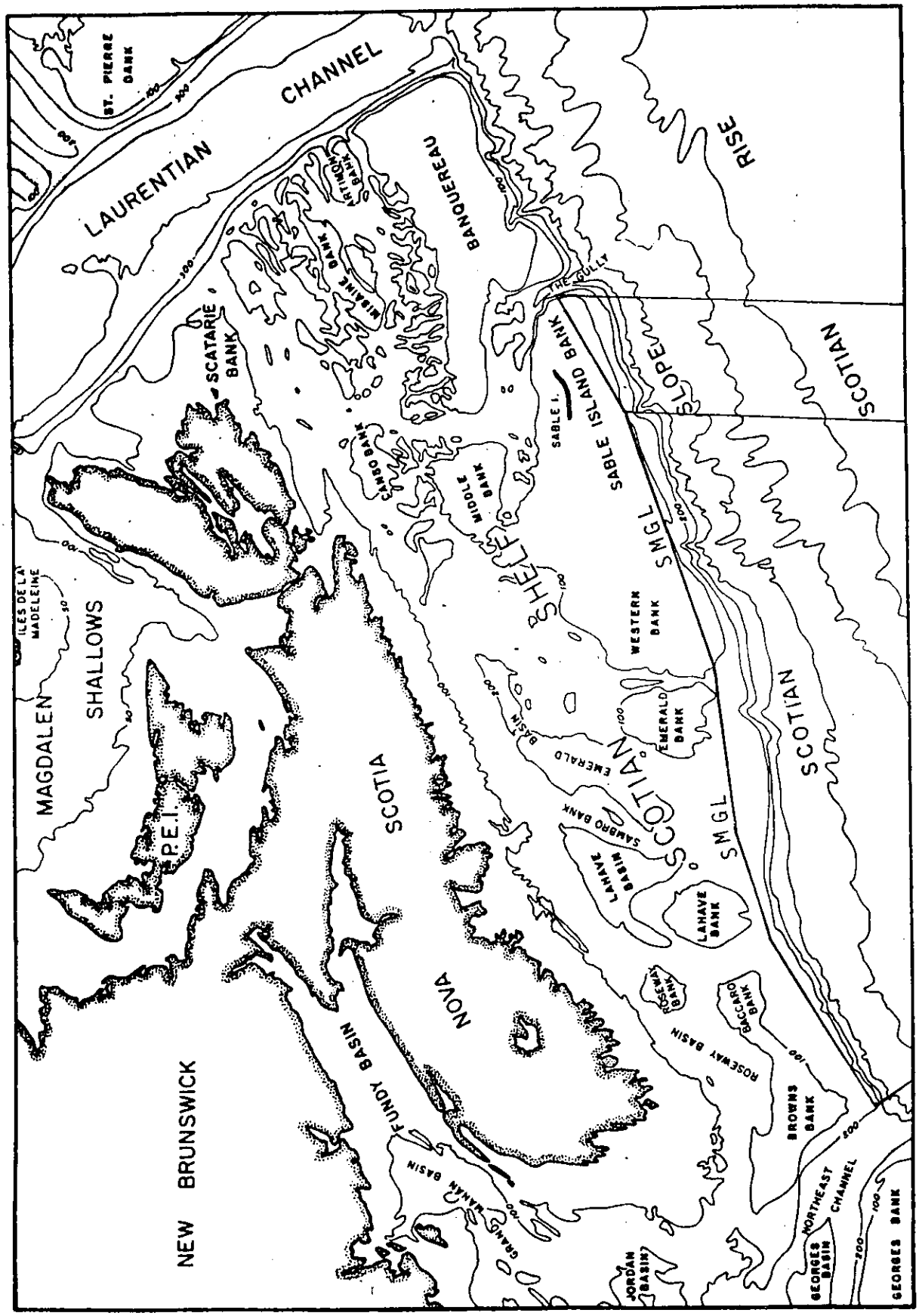


Figure 1. Bathymetric map of the Scotian Shelf and the Bay of Fundy showing the Small Mesh Gear Line (SMGL)

Figure 2 : 4VWX silver hake catch (t).

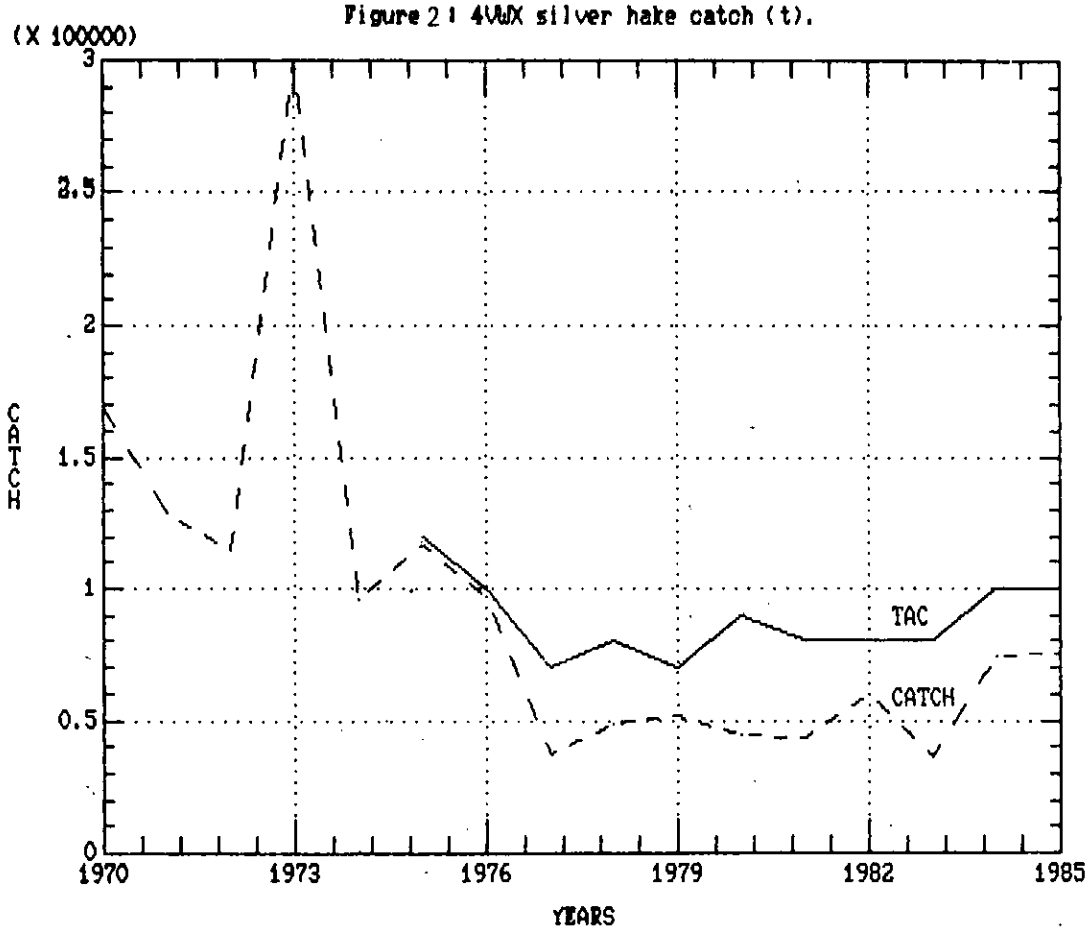


Figure 3 : Catch and Allocations for Cuba and the USSR and TAC for silver hake.

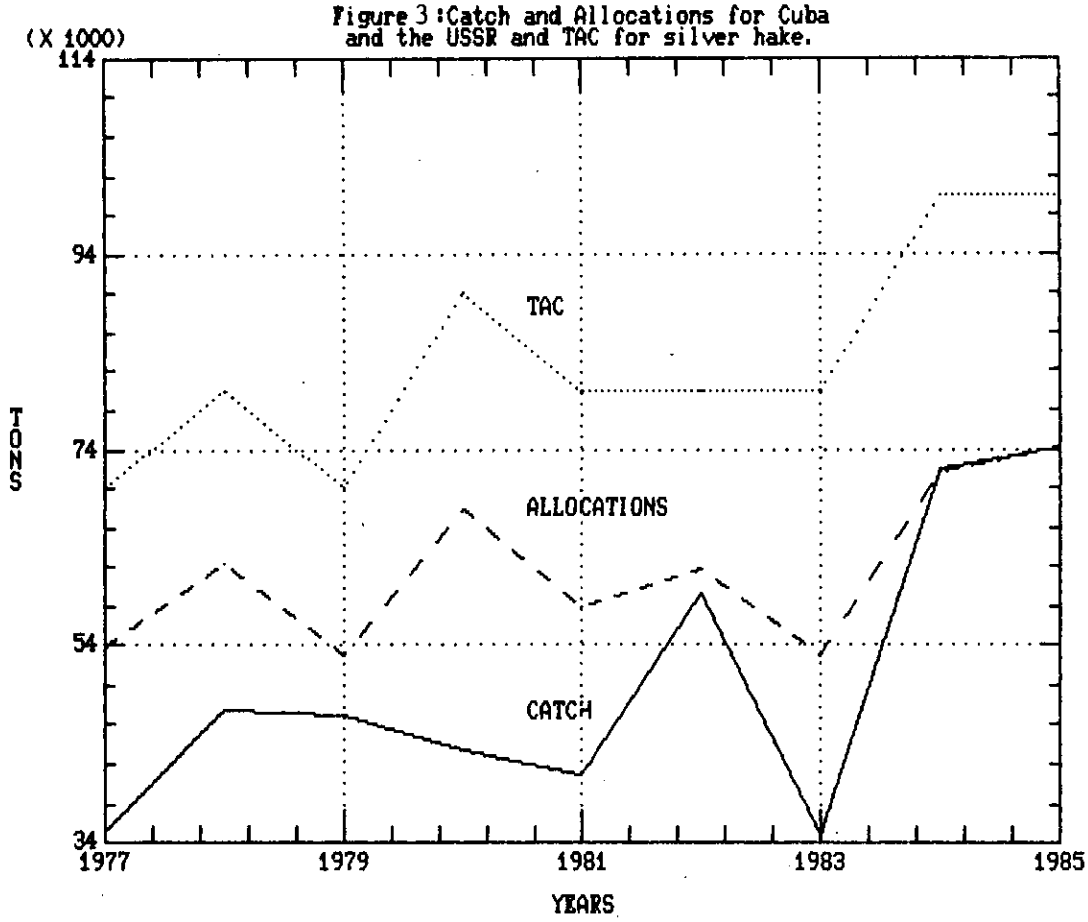


Figure 4 : Component Line Chart of 4VWX silver hake catches (t).

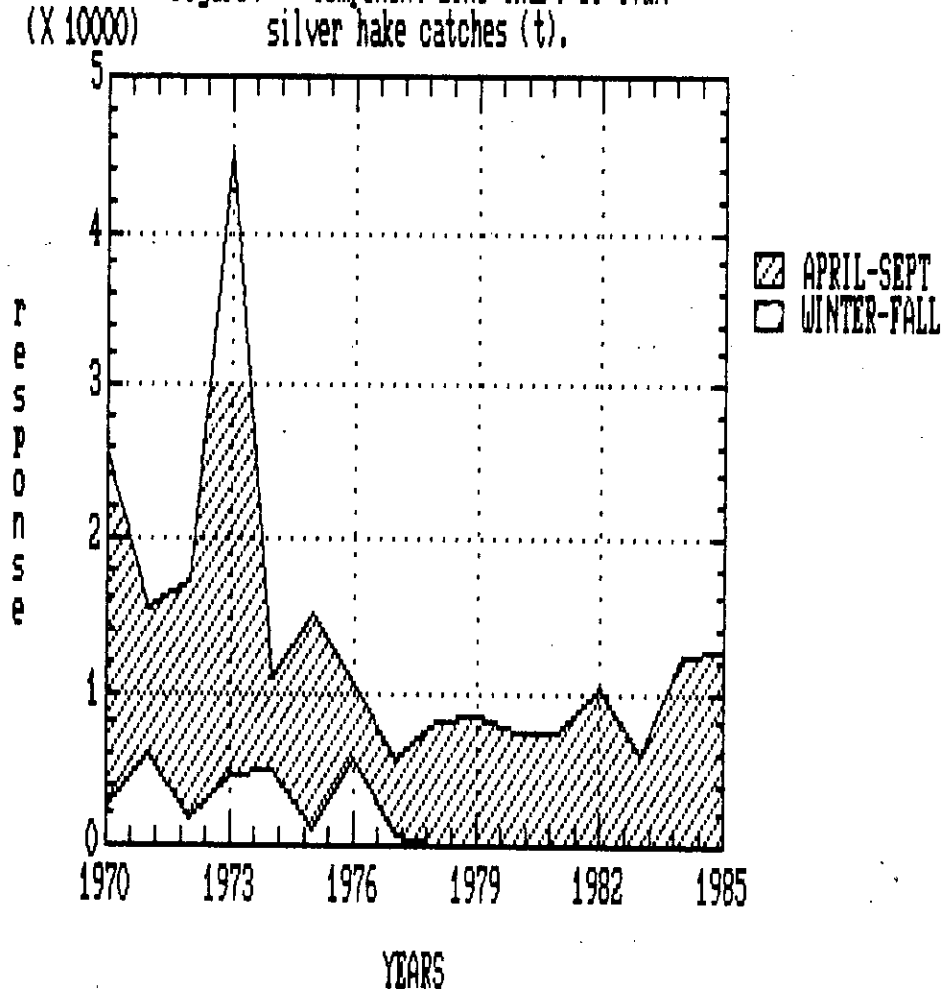
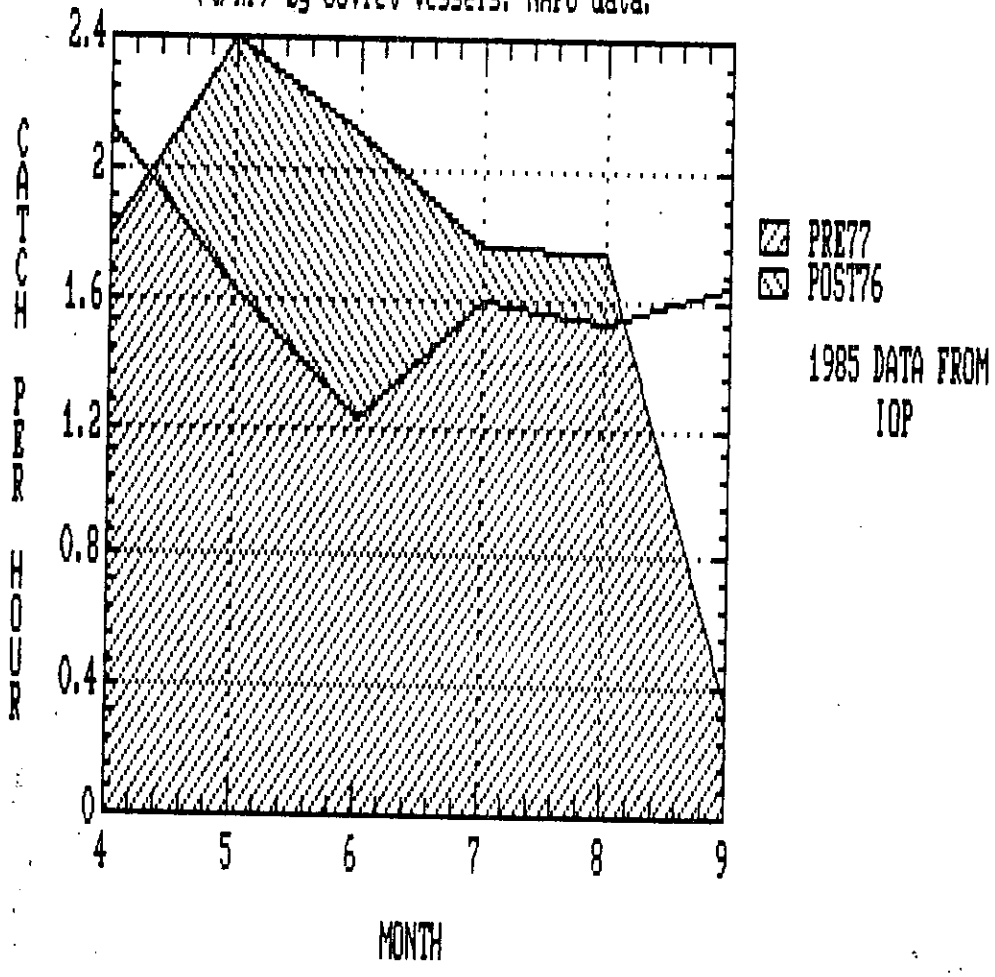


Figure 5: Average 4VWX silver hake CPUE (t/hr) by Soviet vessels. NAFO data.



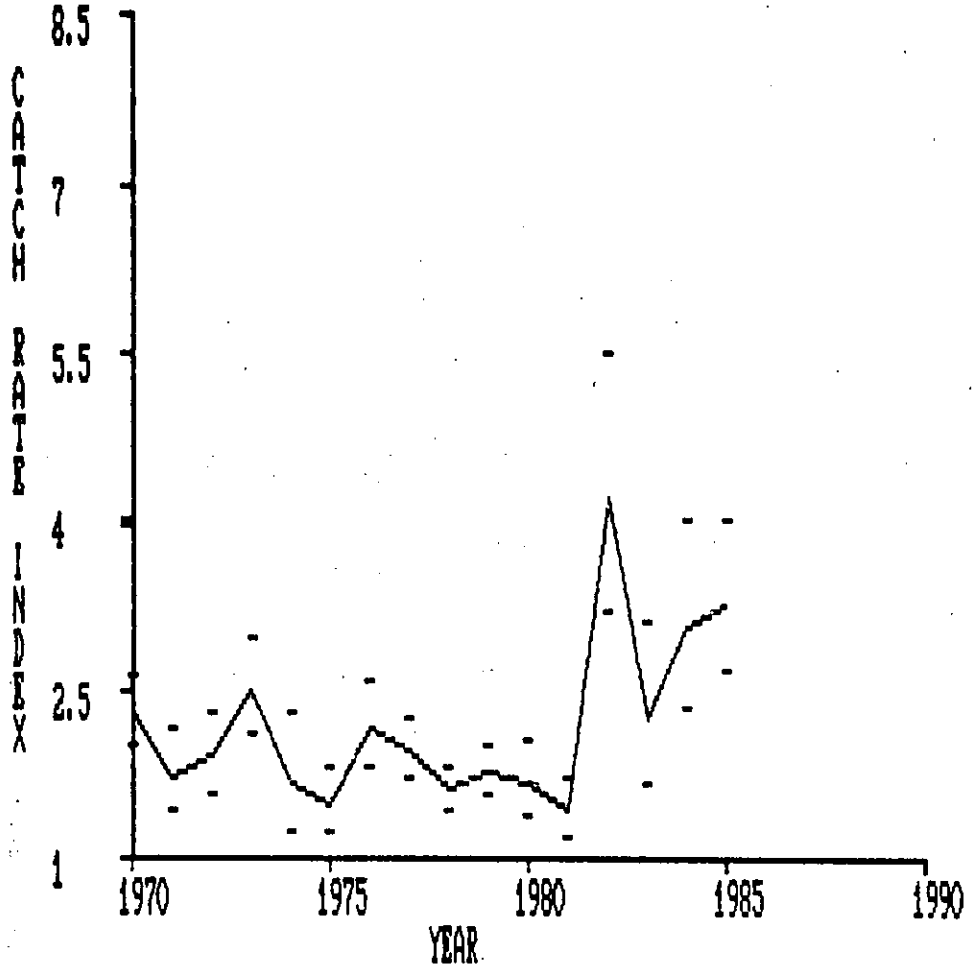


Figure 6. Catch rate index (t/hr) for 4VWX silver hake.

Figure 7. 4VWX SILVER HAKE MEAN WTS AT AGE (KG) FOR AGES 1 TO 5

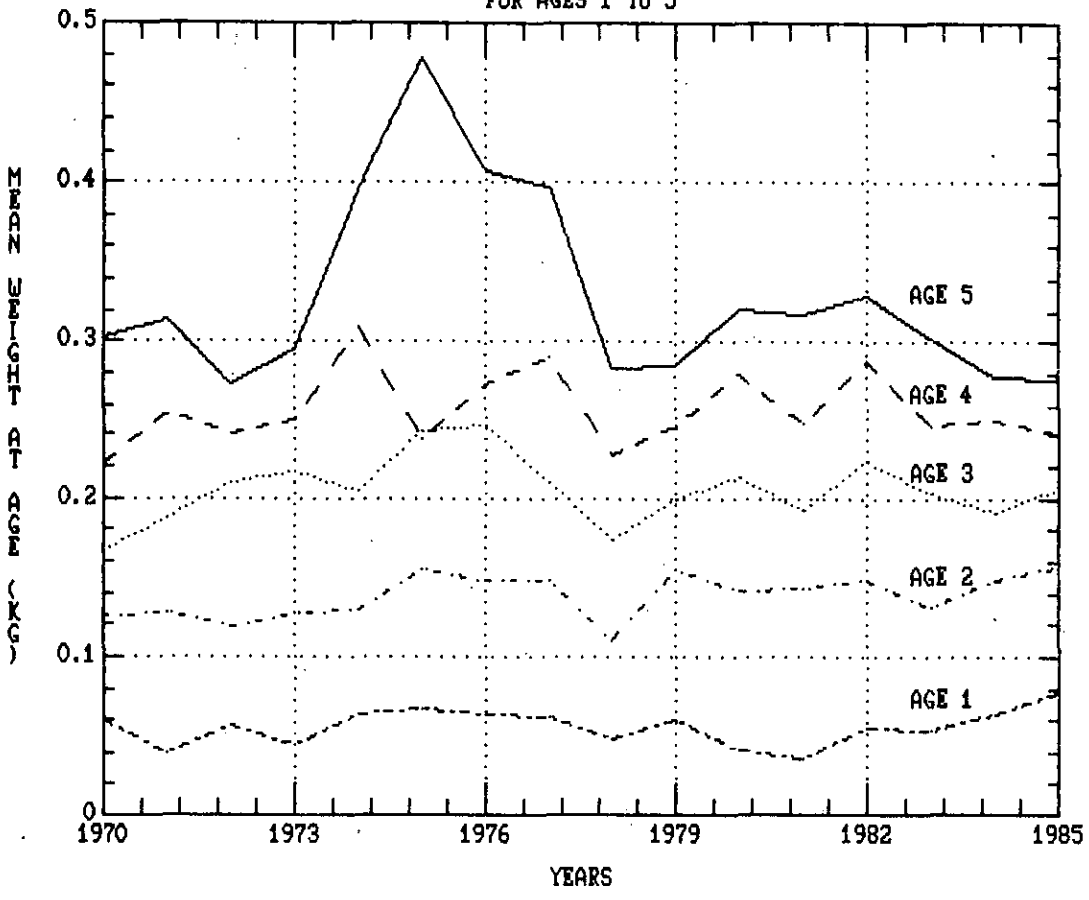


Figure 8 a. Silver Hake Number at Ages 1, 2 and 3 in July Surveys

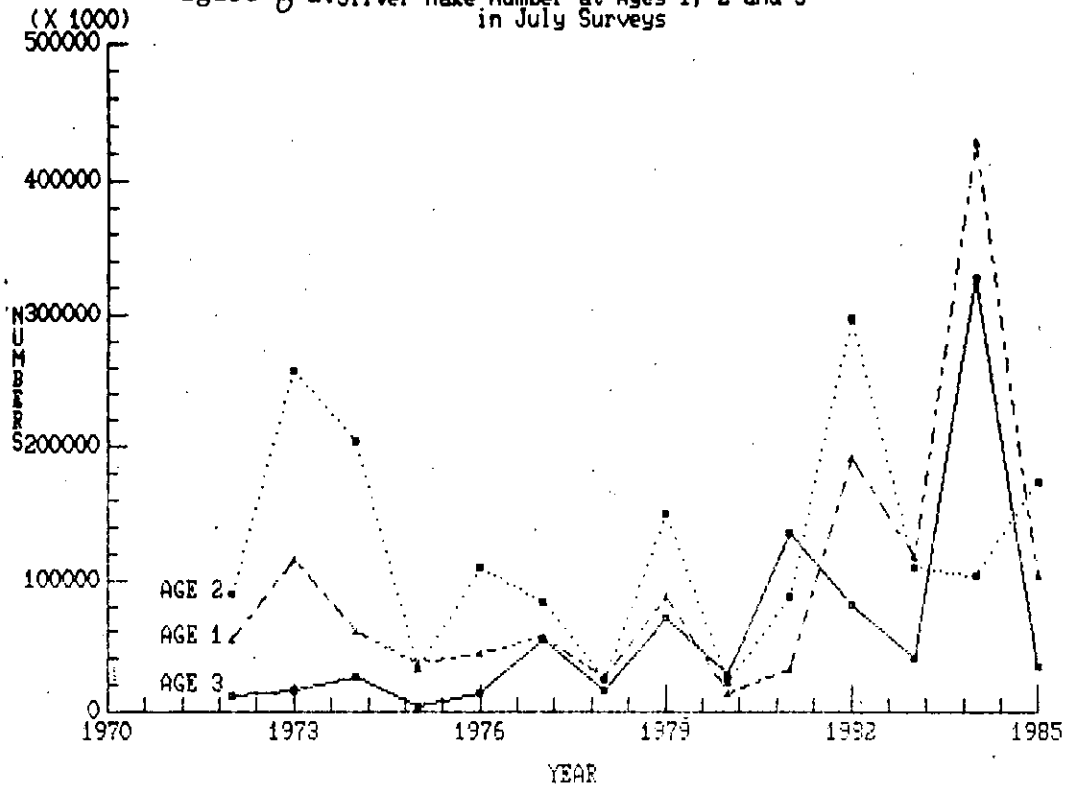


Figure 8 b. Silver Hake Number at Ages 4, 5 and 6 in July Surveys

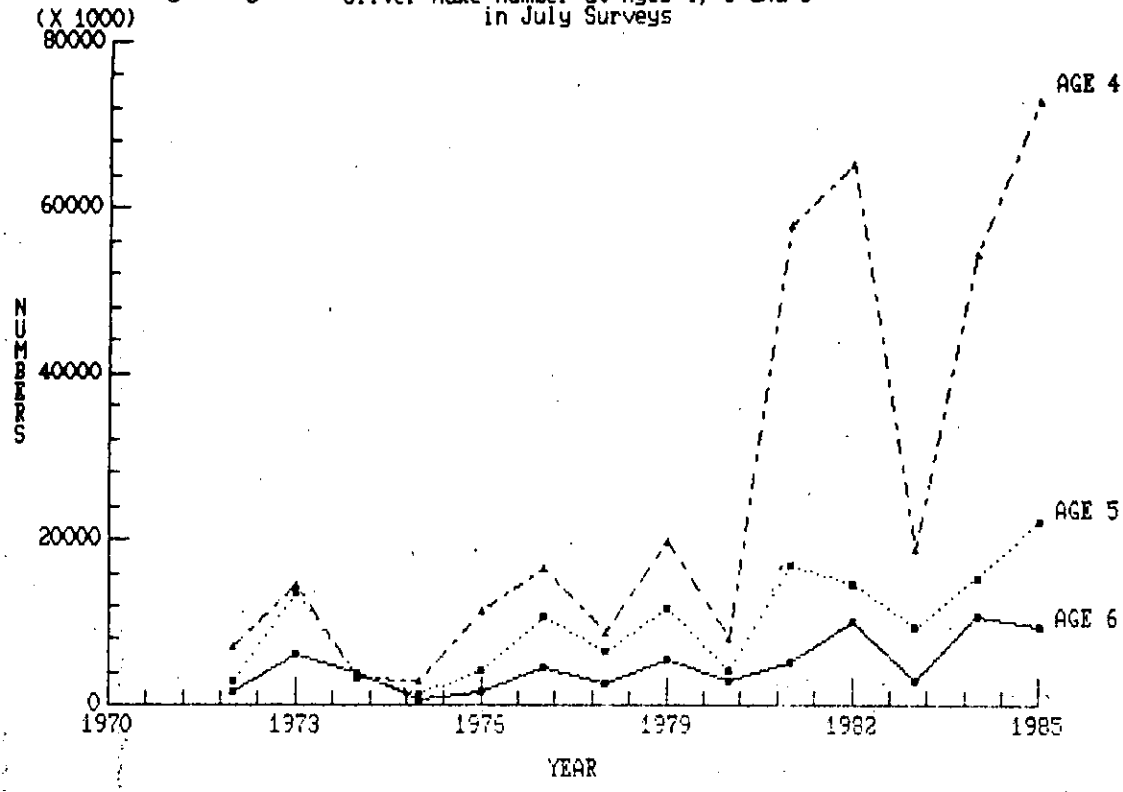


Figure 8 c. Silver Hake Number at Ages 7, 8 and 9 in July Surveys

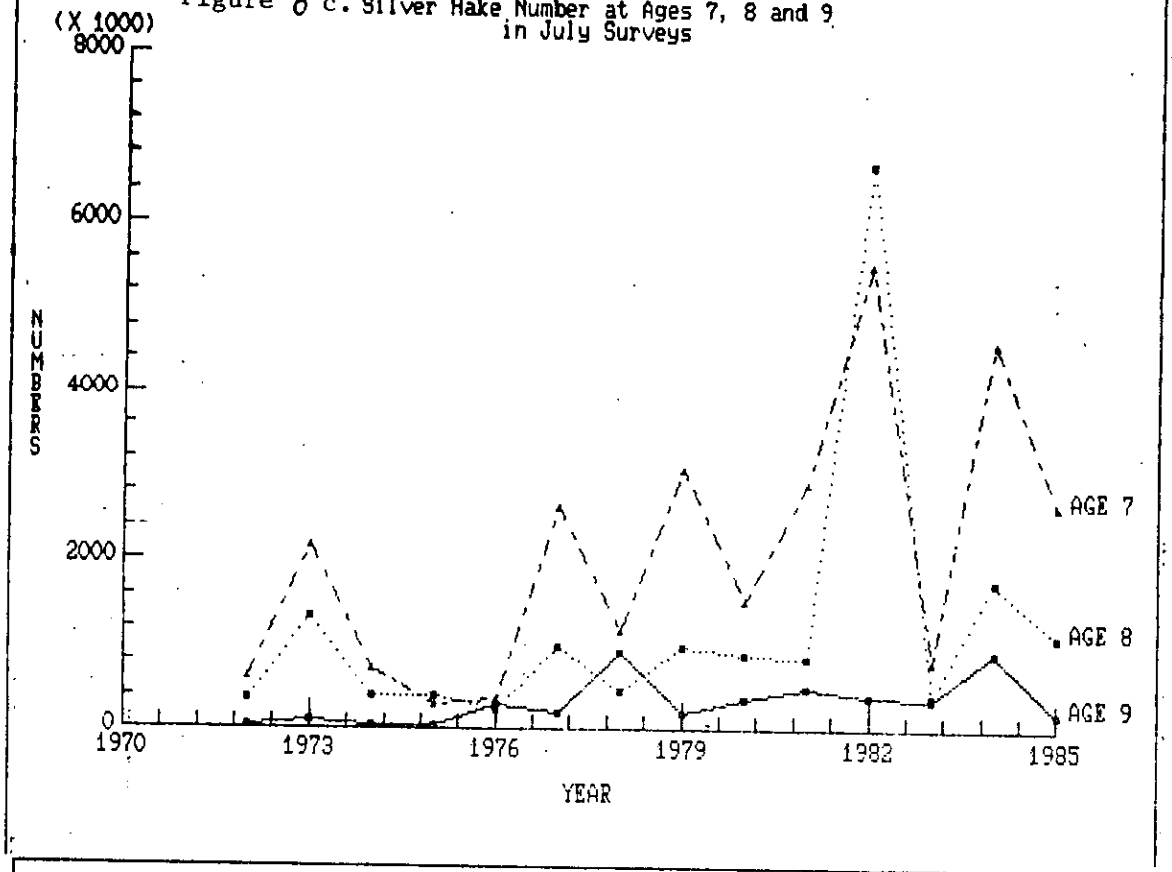


Figure 9 . Silver Hake July Survey Total Abundance in Thousands

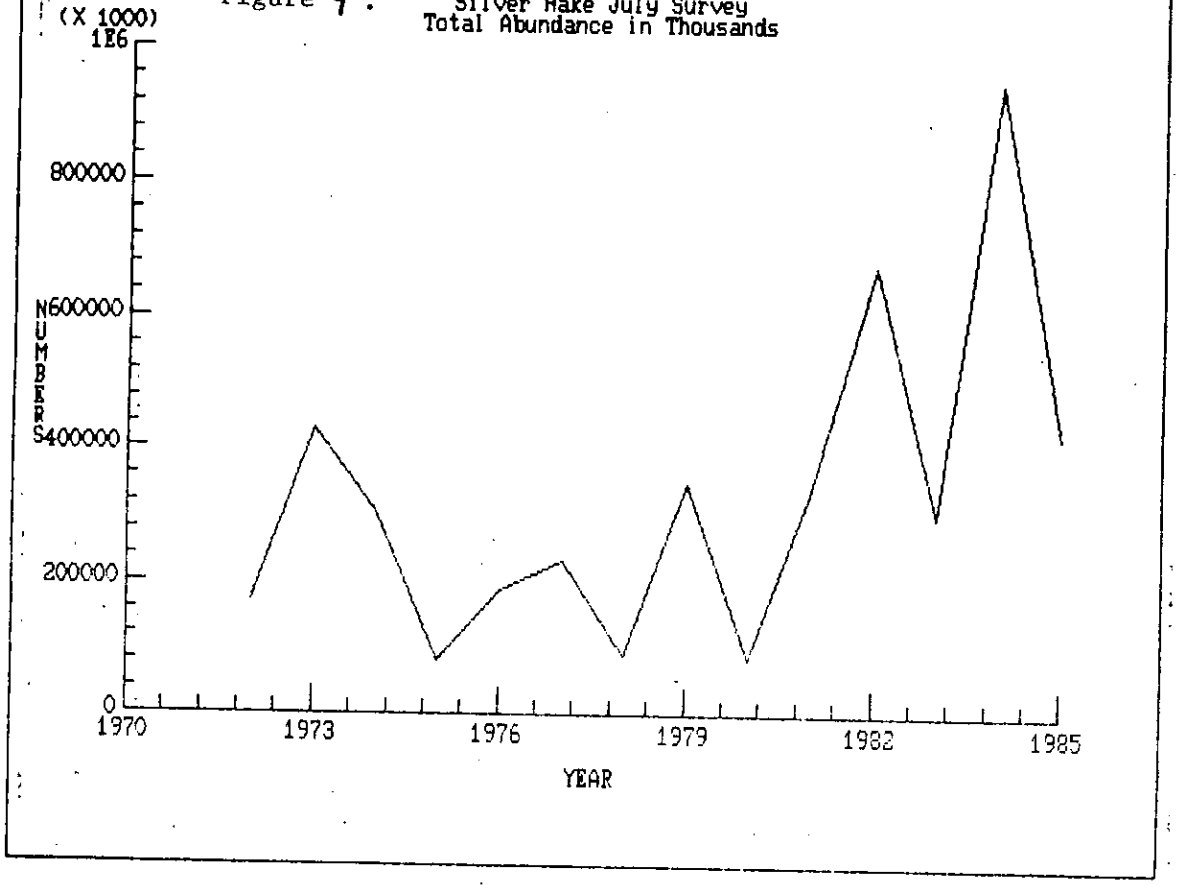


Figure 10. Silver Hake March Survey
Total Abundance in Thousands

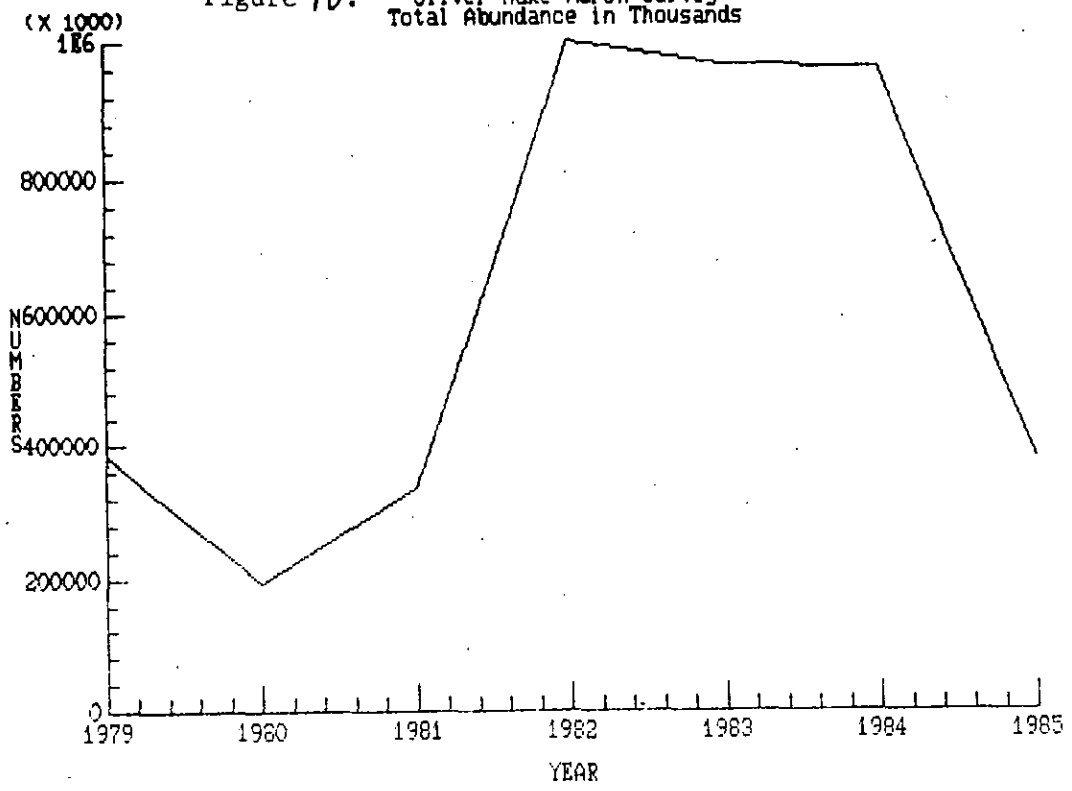


Figure 11. Silver Hake Year Class Strength at Age
in July Surveys