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# Status of the Scotian Shelf Silver Hake (Whiting) Population in 1990

by

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## Introduction

## Management and 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.

Under Canadian fishing regulations in place since 1977, catches are restricted to the seaward side of the Small Mesh Gear Line (Figure 1), and are highest during the period April to July of each year, in NAFO Div. 4W. The fishery opens April 1 and closes November 15 each year. In recent years experiments have been conducted to determine the feasibility of moving the starting date of the fishery to early March. Results of these studies are under consideration.

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 (Table 1). Nominal catches from 1977 until 1983 fluctuated between 33 and 60 thousand tons. Below are reported catches ('000 t) and the Total Allowable Catch (TAC '000 t) since 1977.

| Year | '77 | '78 | '79 | '80 | '81 | '82 | '83 | '84 | '85 | '86 | '87 | '88 | '89 | '90 | '91 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Advice | 70 | 80 | 70 | 90 | 80 | 80 | 80 | 100 | 100 | 100 | 100 | 161 | 235 | | 100 |
| TAC | 70 | 80 | 70 | 90 | 80 | 80 | 80 | 100 | 100 | 100 | 100 | 120 | 135 | 135 | 100 |
| Catch | 37 | 48 | 52 | 45 | 45 | 60 | 36 | 74 | 75 | 83 | 62 | 74[1] | 91[1] | 69[1] | 40[2] |

[1] Preliminary
[2] As of May 30, 1991

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 examine the ratio of silver hake allocation vs catch. Percentages of their total allocations caught by non-Canadian fleets have ranged from 64% to 90%.

Patterns of historical catches from this fishery indicate that the major fishing season

occurs between April and August, with peak catches from May to July. Unlike previous years, in 1984, 1985, 1986 and 1987 the USSR started fishing in May rather than early April. Delays in fishing are reflected in the decreased catches during the months of April and May for those years. Despite the late start for the fleet from 1984 to 1986 they still caught their allocations, as did the Cuban fleet. In 1988, 1989 and 1990 both the USSR and Cuba commenced fishing early in the season. In 1989 and 1990 an experimental fishery began March 15 with 4 vessels operating under special licence. During 1990, the majority of the fishery occurred during April to July. However, the normal pattern is that CPUE peaks in April and May with the fishery declining through to July. By August the fishery is finished.

In 1990 the pattern was different with April and July showing high catch rates while May and June were unexpectedly low (Figure 2). The number of days fished peaked in May and quickly declined as the catch rates dropped (Figure 3). This decrease in effort contributed to the lower catches reported in 1990.

In 1990, the Canadian Observer Program (OP) observed 68Kt of the reported 69Kt or 99%. 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. In 1989, Canada was allocated 45,000 t. In mid June this was reduced, with 6,000 going to Cuba and 20,000 to the USSR. Similarly, in 1990 Canadian developmental allocations were redistributed to other foreign nations.

## Input Data

### Commercial Sampling

As in the past, sampling for length and age of the commercial catch in 1990 was conducted by the OP. More than 2000 samples consisting of 450,000 lengths and 2400 otoliths were collected from the fishery. This coverage level for 1990 and previous years is above the NAFO standard.

From the total number of samples (Table 2), a subset were randomly selected 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 to provide a single fishing season age length key.

### Catch-at-age

The Commercial Catch at age was calculated from Canadian sampling and ageing from the 1977-1988 silver hake fishery on the Scotian Shelf (Table 4). Canadian and Soviet age length keys were combined for 1989 and 1990. Canadian length frequencies were adjusted to catch, using sample weights calculated using yearly $\alpha$'s and $\beta$'s values from Canadian survey data (Table 3).

The commercial catch at age matrix used in this assessment is shown in Table 4. Catches in 1983, 1987 and 1990 were dominated by catches of age 2 fish (ie. the 1981, 1985 and 1988 year classes). These three year classes were estimated to be amongst the largest in the Juvenile survey series (see Table 7). The fisheries in 1984, 1986, and 1988 were dominated by catches of age 3 fish (ie. the 1981, 1983, and 1985 year classes). The 1989 fishery was largely composed of one large (1985) and one strong (1986) year classes. The 1990 fishery was dominated by the 1988 year class (51% by numbers). The 1987 year class at age 3 made an average contribution to the 1990 fishery (34% by numbers).

## Indices of Abundance

### Commercial Catch and Effort: Catch Rate Standardization

The APL program STANDARD, was used to standardize catch rates for 1977-1990. Catch and effort from NAFO and the Canadian Observer Program were categorized in a manner similar to that used in previous assessments (Waldron et al, 1990). The regression results (Table 5 and accompanying graphs) indicate there is a significant effect due to year, month, regime and country in the model. There were no significant effects due to NAFO area and data source at the 1% level.

The standardized catch rate for 1990 decreased over that of 1989, and is comparable to those seen in the earlier 1980's.

## Abundance Surveys

### Canadian Adult Surveys

The July stratified random groundfish survey is another index of adult abundance (Table 6). Since 1977 three vessels have been 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.

The survey results indicate a continual decline in total numbers since 1986 with some stabilization in the most recent years (Figure 4).

### Silver hake juvenile survey

A joint USSR-Canada juvenile silver hake survey was standardized in 1981 and continues to the present. The survey index based on the core strata (60-78) (Koeller et al., 1984) is presented in Table 7. The time series of this survey provides an important index of pre-recruitment abundance for this species. In 1990, 105 stations in total were completed, with 68 in the core (strata 60 - 78) area (Figure 5).

This series indicates that the 1981, 1983, 1985, 1986, 1988 and 1990 year-classes are of a similar magnitude, and are the highest in the series. The 1989 index (131.5) is approximately equal to that of 1987, but still well below the numbers reported for the 1988 year class. The 1990 estimate (187.4) is above the 1989 index being near to that for the 1986 and 1988 year class.

A comparison of age 0 numbers from the juvenile survey to the corresponding year class estimated by the July R/V survey shows reasonable correspondence for ages one and two; however, by age three the relationship is less clear (Figure 6).

## Growth

Growth rates for the 1983-1988 year classes have remained stable over the last 10 years (Figure 7).

## Estimation of Parameters

### Sequential Population Analysis

Sequential Population models have been used to assess the silver hake stock since 1977. However, satisfactory results have not always been possible. Last year a successful analysis was

completed using the ADAPTive frame work (Gavaris, 1988). The formulation outlined below was used as the initial formulation for this assessment. This formulation included a dome shaped partial recruitment pattern was achieved by setting F at age 9 to 10% of that on ages 3-5 (assumed fully recruited). Canadian commercial catch at age, age disaggregated CPUE (from section on the ) and Canadian July Survey catch at age were included in the analysis. Ages 3-5 were assumed fully recruited and ages 1-8 were included in the calibration block. This year, the juvenile survey index was also included in the preliminary analyses. Although this index provided a significant contribution to the model, the model was being over-parameterized which outweighed the advantages of including the index.

Several formulations were explored all providing some degree of success. However, STACFIS felt that debating over which formulation was most appropriate would not be worthwhile at this point:. Rather effort was directed towards estimates of the size of those year classes which would contribute to the 1992 fishery. STACFIS did recommend that "further investigations of different formulations be coarried out prior to the June 1992 meeting".

Of particular note were experiments conducted by P. Gassuikov and D. Waldron on the issue of scaling in logged ADAPT formulations. These showed that the application of any multiplier to survey or CUPE data had no effect on the results from the model. Gassuikov and Waldron are now exploring the use of age by age scaling factors for R/V and CPUE data.

1) Catch at Age extends from 1977 to 1990 and Ages 1 to 9
   The Catch at Age did NOT contain a PLUS Group

2) Partial Recruitment -* indicates ages used to calculate mean fully recruited F.

| Ages | | PR |
|---|---|---|
| 1 | | 0.020 |
| 2 | | 0.249 |
| 3 | * | 1.000 |
| 4 | * | 1.000 |
| 5 | * | 1.000 |
| 6 | | 0.775 |
| 7 | | 0.550 |
| 8 | | 0.325 |
| 9 | | 0.100 |

3) Natural Mortality was set at 0.4

4) F's over Ages 1 to 8 will be estimated starting from:

| Ages | F |
|---|---|
| 1 | 0.010 |
| 2 | 0.126 |
| 3 | 0.515 |
| 4 | 0.515 |
| 5 | 0.515 |
| 6 | 0.397 |
| 7 | 0.280 |
| 8 | 0.165 |

5) Mortality at age 9 was 10% of that for fully recruited ages.

6) Research Survey Estimates of Abundance for ages 1 to 8 were given.
   No standard errors were applied. Log transformation used.

There were 2 age disaggregated series were used for tuning.

| Survey | Month | Year | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July R/V | 7 | '77 | '78 | '79 | '80 | '81 | '82 | '83 | '84 | '85 | '86 | '87 | '88 | '89 | '90 |
| Age Disaggregated CUPE | 5 | '77 | '78 | '79 | '80 | '81 | '82 | '83 | '84 | '85 | '86 | '87 | '88 | '89 | '90 |

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

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

**Yield-per-recruit**

Previous yield-per-recruit analysis used a partial recruitment that was flat topped at age 3+. $F_{0.1}$ was 0.464 with a corresponding yield-per-recruit of 0.063 kg. The current assessment indicates an exploitation pattern that is dome shaped with full recruitment occurring at ages 3 to 5 with F on the oldest age (9) about 10% of this value. The partial recruitment is the average of 1984-88 and weight-at-age data is the average over 1984-89.

The current analysis estimates $F_{0.1}$ to be 0.72 with a corresponding yield-per-recruit of 0.060 kg. $F_{max}$, as in previous yield-per-recruit analyses for this stock, is not well defined.

**Assessment Results**

**Prognosis**

Commercial catch rates since 1982 are well above those of the late 1970's. Indeed for 1989, the CPUE had increased over that estimated for 1988 while that for 1990 is much lower. However, the high degree of variance about each estimate make it difficult to detect any difference since 1982. The July adult survey suggests a decline in the population numbers since 1986 to a level similar to that estimated for 1983. There appears to be a leveling of this trend for 1988 to 1990.

The fall juvenile survey agrees well with the July adult survey age 1 estimates. This suggests that the fall juvenile survey is a good indicator of the relative strength of incoming recruitment. The 1990 year class is the 6th highest in the series and is similar to that of the 1986 and 1988 year classes. This would imply above average recruitment to the 1991 and 1992 fisheries for this year class.

The 1992 fishery will be composed of a above average 1990 year class which should dominate the catch, a moderate 1989 year class at age 3 and an above average 1988 year class at age 4. The 1990 fishery catch was average while the cpue was the lowest seen since the early 1980's. This fishery was dominated by the large 1988 year class which will contribute marginally to the fishery in 1992. The decrease in cpue may be due to a shift in the distribution of silver hake brought on by a change in oceanographic features, or a reaction to an increase in the number of vessels fishing in the area (such activity may cause the schools to remain disturbed hence influence availability), or as suggested in this assessment to a decline in the size of the population in 1990 over that estimated for 1989 (Figure 9).

The 1991 fishery appears strong with catch rates and catch to date above average. Until the 1991 fishery data are analyzed the authors suggest a conservative approach to the management of the silver hake fishery in 1992.

STACFIS made further comments on projections. Below is a quote from the 1991 STACFIS Report which explains the adopted Catch Projection and prognosis.

*Although none of the ADAPT formulations were accepted, STACFIS noted that the size of the 1988 year-class ranged between 1.5-2.0 billion fish at age 1 in all formulations and considered that setting the size of this year-class at 1.75 billion at age 1 for projections would be reasonable. Based on 0-group surveys, the 1990 year-class was set equal to that of 1988, while the 1989 year-class was set equal to that of 1987 (1.16 billion). The juvenile and research vessel survey indices appeared to provide consistent estimates of year-class strengths. Therefore, the 1991 year-class was set equal to the geometric mean (1982-88) of 1.4 billion fish. As older ages (>3) in 1990 will not contribute significantly to yield in 1992, estimates were arbitrarily selected from one of the ADAPT formulations for projections.*

*The weight-at-age has remained fairly stable over the 1977-90 period, so mean weights for projections were calculated from that period. The partial recruitment for this projection was that used in the previous assessment. The Table below summarizes the parameters used in the projection.*

| Age | Jan 1, 1991 population numbers ('000) | Average weight (kg) | Partial Recruitment |
|---|---|---|---|
| 1 | 1,750,000 | 0.057 | 0.035 |
| 2 | 772,273 | 0.137 | 0.235 |
| 3 | 609,396 | 0.182 | 1.000 |
| 4 | 138,221 | 0.224 | 1.000 |
| 5 | 55,474 | 0.259 | 1.000 |
| 6 | 16,130 | 0.308 | 0.761 |
| 7 | 2,313 | 0.411 | 0.381 |
| 8 | 1,537 | 0.525 | 0.141 |
| 9 | 911 | 0.665 | 0.078 |

*Reports from the 1991 fishery suggest that the catch may be 66,000 tons on the assumption that Canada will not catch its allocation. A catch projection, using these data, indicated that the $F_{0.1}$ catch in 1992 would be 105,000 tons as given in the Table below.*

| 1992 Catch (tons) | Population Numbers (1.1.1992) ('000) | Population Biomass (mid-year) (tons) |
|---|---|---|
| 105,000 | 3,373,701 | 317,163 |

**Acknowledgments**

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**Table 1. Nominal catches for 4VWX silver hake 1970-1990 (1989-1990 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 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bulgaria | 4639 | 817 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Canada | 13 | 104 | 6 | 38 | 15 | 10 | 2 | 9 | 11[3] | 9[3] | 337[3] | |
| Cuba | 1798 | 2287 | 642 | 11969 | 7418 | 14496 | 17683 | 16041 | 20219 | 9016 | 14222[2] | 13596[3] |
| France | 0 | 0 | 0 | 2[1] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FRG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GDR | 0 | 0 | 0 | 0 | 0 | 93 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ireland | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Italy | 5 | 0 | 541 | 37[1] | 2[2] | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Japan | 219 | 239 | 120 | 937 | 649 | 530 | 120 | 67 | 145 | 0 | 194[3] | 322[1] |
| Poland | 0 | 0 | 1[1] | 31[2] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Portugal | 0 | 56 | 2044 | 2[1] | 378 | 1714 | 1338 | 0 | 0 | 0 | 0 | 0 |
| Romania | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spain | 0 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| USA | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| USSR | 45076 | 40982 | 41243 | 47261 | 27377 | 57423 | 56337 | 66571 | 41329 | 65349 | 76752[2] | 54658[3] |
| TOTAL | 51760 | 44525 | 44600 | 60251 | 35839 | 74266 | 75480 | 82689 | 61704 | 74374 | 91505 | 68582 |

[1] Observer Program Data (data not reported to NAFO)

[2] FLASH data

[3] NAFO Circular Letters and provisional reporting to NAFO.

**Table 2 .Sampling used in this assessment.**

| Year | No. Lengths | No. Ages |
|---|---|---|
| 1977 | 34379 | 600 |
| 1978 | 137468 | 674 |
| 1979 | 101908 | 1108 |
| 1980 | 247369 | 1462 |
| 1981 | 195493 | 987 |
| 1982 | 160878 | 1152 |
| 1983 | 134226 | 986 |
| 1984 | 203314 | 1255 |
| 1985 | 216912 | 1163 |
| 1986 | 197654 | 1311 |
| 1987 | 377527 | 681 |
| 1988 | 309767 | 1158 |
| 1989 | 300100 | 1135 |
| 1990 | 447587 | 1817 |

Table 3: Male and Female Alpha and Beta's used in the construction of the silver hake catch at age used in this assessment. Lengths (cm) and weights (kg) used were from the Canadain July Research Vessel Survey of the Scotian Shelf (4VWX).

| Year | Male Alpha | Female Alpha | Male Beta | Female Beta |
|---|---|---|---|---|
| 1977 | .000006260 | .000006930 | 3.0626 | 3.0350 |
| 1978 | .000004630 | .000003070 | 3.1366 | 3.2531 |
| 1979 | .000010200 | .000005880 | 2.9001 | 3.0675 |
| 1980 | .000002330 | .000001800 | 3.3417 | 3.3989 |
| 1981 | .000006830 | .000005080 | 3.0206 | 3.1172 |
| 1982 | .000011600 | .000006740 | 2.8575 | 3.0232 |
| 1983 | .000006480 | .000003320 | 2.9935 | 3.2034 |
| 1984 | .000018300 | .000006490 | 2.7052 | 3.0284 |
| 1985 | .000013500 | .000004530 | 2.7848 | 3.1235 |
| 1986 | .000007970 | .000003820 | 2.9384 | 3.1685 |
| 1987 | .000009990 | .000004240 | 2.8798 | 3.1456 |
| 1988 | .000014300 | .000004800 | 2.7942 | 3.1241 |
| 1989 | .000006750 | .000004440 | 3.0114 | 3.1416 |
| 1990 | .000034320 | .000021000 | 2.5234 | 2.6958 |

Table 4. Commercial Catch Numbers at age for 4VWX silver hake (Thousands)

| Age | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17911 | 20940 | 20569 | 16588 | 2358 | 20190 | 5849 | 59588 | 14970 | 45598 | 6804 | 5110 | 21549 | 6516 |
| 2 | 72529 | 70302 | 57893 | 70696 | 25214 | 52976 | 96852 | 45828 | 130814 | 70269 | 214235 | 62791 | 115939 | 209620 |
| 3 | 59862 | 80196 | 72891 | 70391 | 109035 | 75876 | 56158 | 206900 | 98346 | 229126 | 114417 | 265307 | 172700 | 142862 |
| 4 | 15070 | 35025 | 36669 | 32032 | 37573 | 68400 | 29282 | 82911 | 128365 | 84097 | 54211 | 39242 | 107956 | 41215 |
| 5 | 2218 | 12709 | 22380 | 14465 | 11928 | 31752 | 11388 | 19344 | 34111 | 28635 | 13063 | 21303 | 17640 | 11741 |
| 6 | 725 | 5227 | 9970 | 5184 | 3234 | 5945 | 3395 | 4268 | 9327 | 8760 | 6045 | 3106 | 6686 | 1648 |
| 7 | 97 | 1906 | 3168 | 1431 | 1201 | 2042 | 819 | 1038 | 2344 | 1436 | 347 | 2133 | 1574 | 640 |
| 8 | 91 | 1168 | 495 | 451 | 290 | 465 | 253 | 183 | 226 | 497 | 156 | 208 | 742 | 107 |
| 9 | 4 | 338 | 374 | 98 | 141 | 64 | 88 | 10 | 85 | 111 | 117 | 143 | 130 | 40 |
| 1+ | 168,507 | 227,811 | 224,409 | 211,336 | 190,974 | 257,710 | 204,084 | 420,070 | 418,588 | 468,529 | 409,395 | 399,343 | 444,916 | 414,389 |

Table 5. CPUE standardization results for the 4VWX silver hake population. Includes years 1977-1989.

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

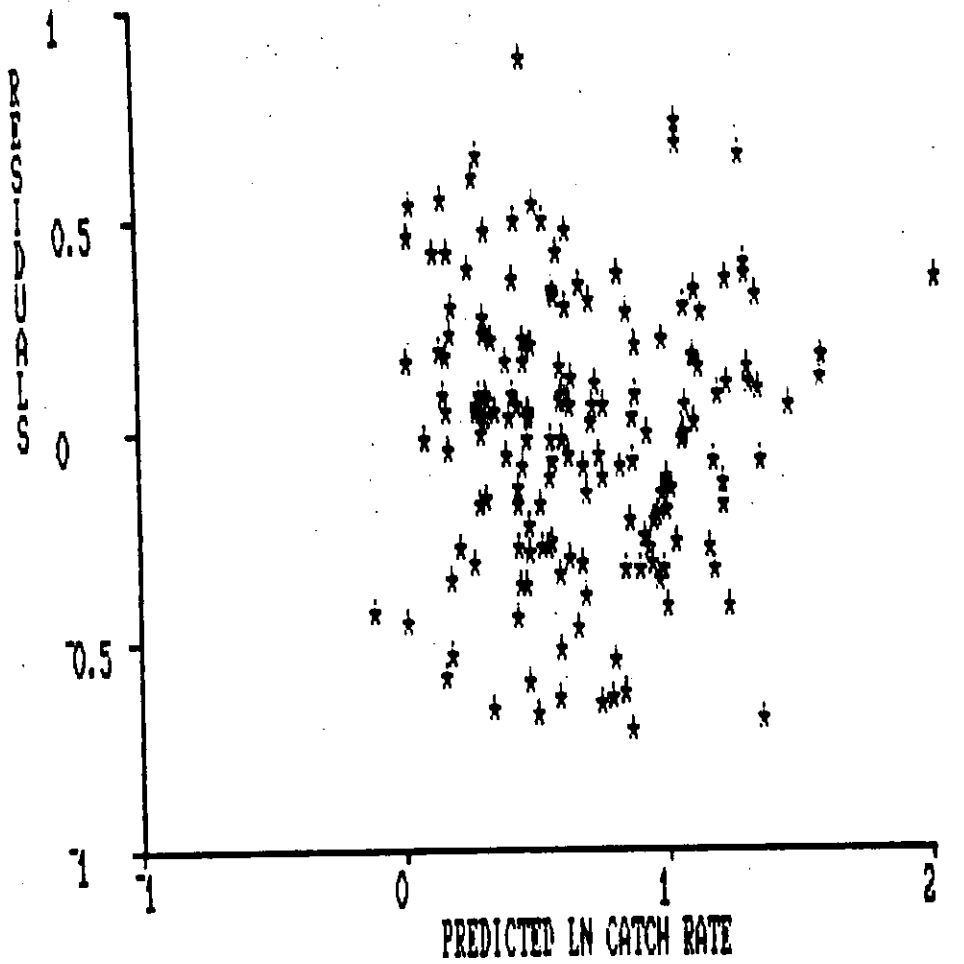
MULTIPLE R..... .766
MULTIPLE R SQUARED..... .587

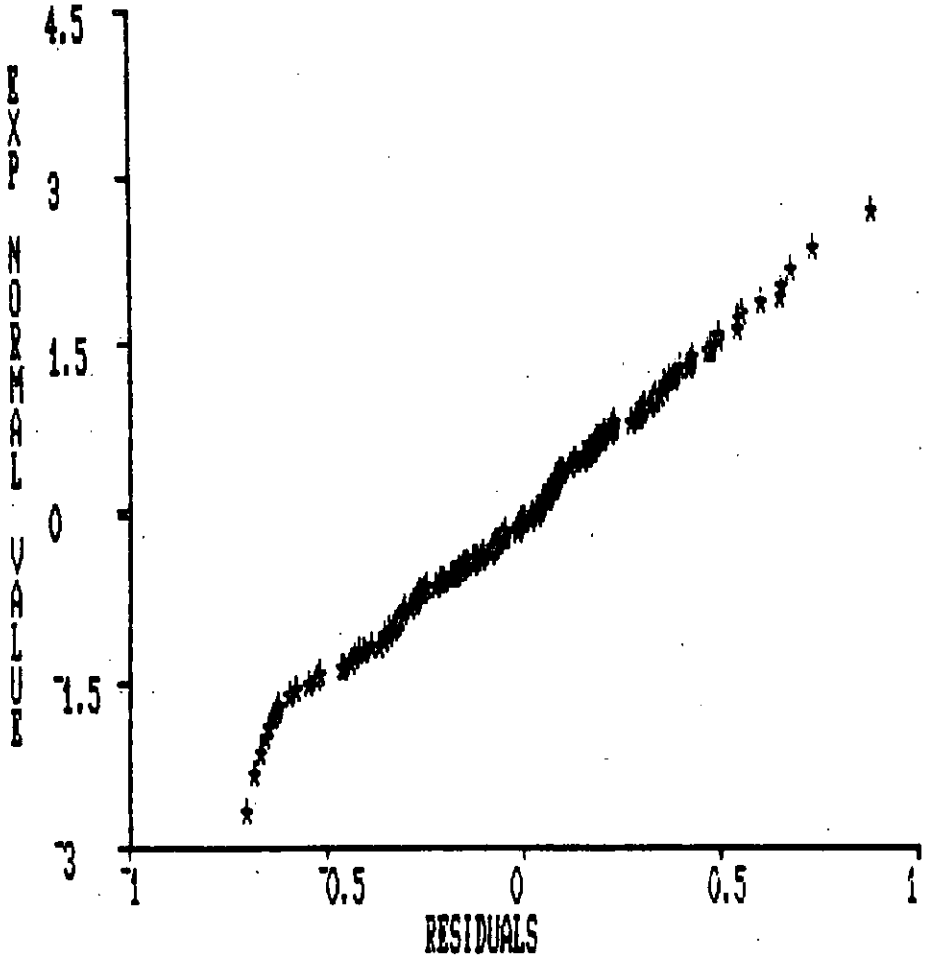
ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DF | SUMS OF SQUARES | MEAN SQUARES | F-VALUE |
|---|---|---|---|---|
| INTERCEPT | 1 | 7.862E0001 | 7.862E0001 | |
| REGRESSION | 24 | 2.471E0001 | 1.030E0000 | 8.456 |
| TYPE 1 | 1 | 1.228E-001 | 1.228E-001 | 1.009 |
| TYPE 2 | 6 | 5.365E0000 | 8.941E-001 | 7.346 |
| TYPE 3 | 13 | 1.420E0001 | 1.092E0000 | 8.972 |
| TYPE 4 | 2 | 7.108E-001 | 3.554E-001 | 2.920 |
| TYPE 5 | 1 | 3.695E-001 | 3.695E-001 | 3.035 |
| TYPE 6 | 1 | 1.306E0000 | 1.306E0000 | 10.726 |
| RESIDUALS | 143 | 1.741E0001 | 1.217E-001 | |
| TOTAL | 168 | 1.207E0002 | | |

REGRESSION COEFFICIENTS

| CATEGORY | CODE | VARIABLE | COEFFICIENT | STD. ERROR | NO. OBS. |
|---|---|---|---|---|---|
| 1 | 1 | INTERCEPT | 1.019 | 0.189 | 168 |
| 2 | 5 | | | | |
| 3 | 77 | | | | |
| 4 | 460 | | | | |
| 5 | 1 | | | | |
| 6 | 1 | | | | |
| 1 | 2 | 1 | -0.140 | 0.139 | 86 |
| 2 | 3 | 2 | -0.670 | 0.220 | 13 |
| | 4 | 3 | 0.238 | 0.093 | 24 |
| | 6 | 4 | -0.122 | 0.078 | 44 |
| | 7 | 5 | -0.139 | 0.084 | 34 |
| | 8 | 6 | -0.280 | 0.100 | 20 |
| | 9 | 7 | -0.476 | 0.175 | 5 |
| 3 | 78 | 8 | -0.314 | 0.116 | 26 |
| | 79 | 9 | -0.153 | 0.121 | 21 |
| | 80 | 10 | -0.464 | 0.150 | 9 |
| | 81 | 11 | -0.333 | 0.151 | 9 |
| | 82 | 12 | 0.593 | 0.169 | 7 |
| | 83 | 13 | -0.112 | 0.163 | 8 |
| | 84 | 14 | 0.377 | 0.163 | 8 |
| | 85 | 15 | -0.238 | 0.163 | 8 |
| | 86 | 16 | 0.697 | 0.192 | 10 |
| | 87 | 17 | 0.683 | 0.194 | 9 |
| | 88 | 18 | 0.453 | 0.198 | 9 |
| | 89 | 19 | 0.737 | 0.185 | 13 |
| | 90 | 20 | 0.070 | 0.183 | 15 |
| 4 | 450 | 21 | 0.156 | 0.128 | 10 |
| | 470 | 22 | -0.126 | 0.071 | 39 |
| 5 | 2 | 23 | -0.257 | 0.147 | 147 |
| 6 | 2 | 24 | -0.250 | 0.076 | 41 |


RESIDUALS
1
0.5
0
-0.5
-1
-1
0
1
2
PREDICTED LN CATCH RATE


EXP NORMAL VALUE
4.5
3
1.5
0
-1.5
-3
-1
-0.5
0
0.5
1
RESIDUALS

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 1 5 460 1 1

| YEAR | TOTAL CATCH | PROP. | CATCH RATE MEAN | S.E. | EFFORT |
|---|---|---|---|---|---|
| 77 | 37095 | 0.702 | 2.893 | 0.543 | 12824 |
| 78 | 48404 | 0.879 | 2.117 | 0.375 | 22862 |
| 79 | 51760 | 0.827 | 2.476 | 0.494 | 20908 |
| 80 | 44525 | 0.920 | 1.814 | 0.361 | 24541 |
| 81 | 44600 | 0.833 | 2.067 | 0.417 | 21579 |
| 82 | 60251 | 0.957 | 5.214 | 1.072 | 11556 |
| 83 | 35839 | 0.921 | 2.578 | 0.521 | 13903 |
| 84 | 74266 | 0.967 | 4.206 | 0.850 | 17658 |
| 85 | 75480 | 0.981 | 3.661 | 0.740 | 20619 |
| 86 | 82689 | 0.427 | 5.651 | 1.670 | 14634 |
| 87 | 61704 | 0.926 | 5.569 | 1.646 | 11079 |
| 88 | 74374 | 0.864 | 4.422 | 1.312 | 16817 |
| 89 | 91505 | 0.934 | 5.890 | 1.707 | 15536 |
| 90 | 68582 | 0.965 | 3.025 | 0.871 | 22673 |

AVERAGE C.V. FOR THE MEAN: .232

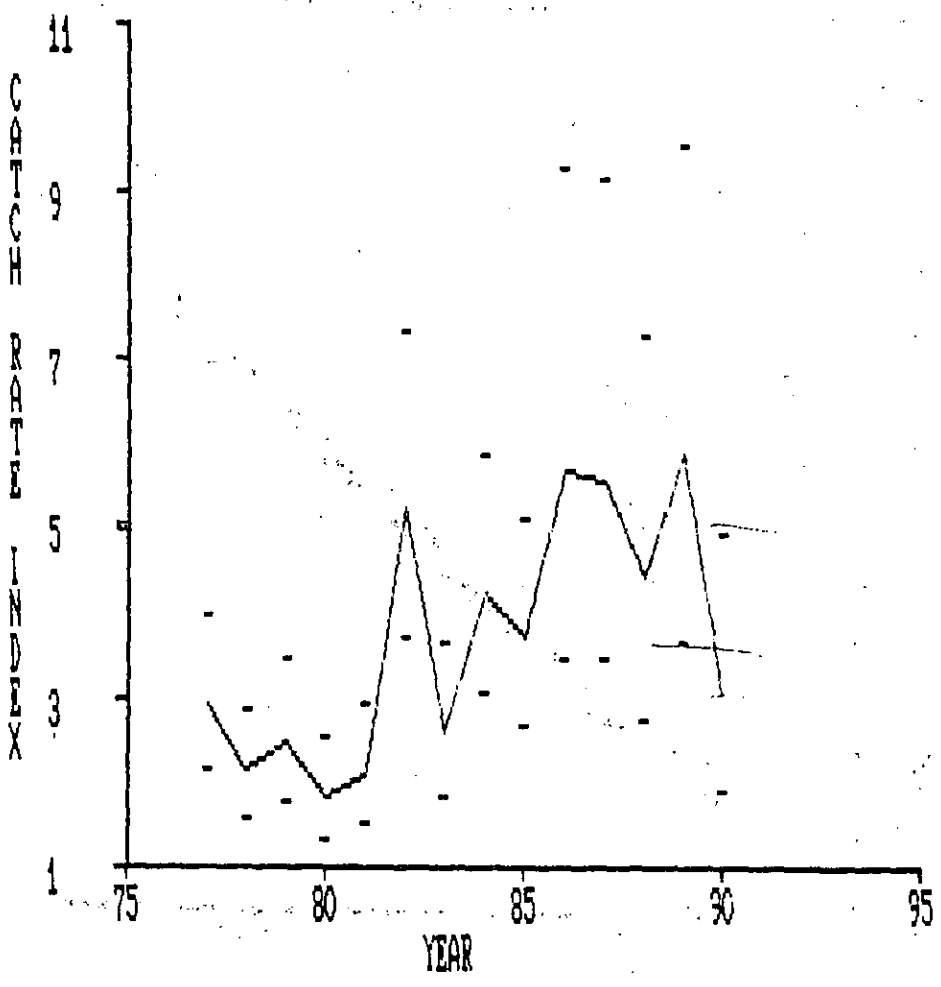


**Table 6. Scotian Shelf silver hake Canadian July research vessel survey catch numbers ('000) at age.**

| Age | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7737 | 26740 | 89437 | 17730 | 32839 | 192025 | 114273 | 188970 | 102726 | 552598 | 146007 | 69740 | 172095 | 117089 |
| 2 | 27660 | 23257 | 152705 | 55638 | 84724 | 293420 | 108957 | 70369 | 172576 | 84325 | 266663 | 89508 | 63810 | 125952 |
| 3 | 21421 | 16266 | 67003 | 97253 | 131420 | 80348 | 38209 | 208723 | 34402 | 70625 | 46095 | 81458 | 24151 | 42329 |
| 4 | 4592 | 8874 | 20048 | 45862 | 60469 | 60487 | 19340 | 37926 | 71191 | 22623 | 18982 | 16709 | 13405 | 13022 |
| 5 | 1348 | 6733 | 11522 | 10684 | 16241 | 32426 | 10632 | 11828 | 21488 | 13448 | 6048 | 14249 | 4130 | 4173 |
| 6 | 1278 | 3046 | 5055 | 4525 | 5127 | 8257 | 2882 | 7942 | 9445 | 4235 | 4168 | 2502 | 1868 | 1169 |
| 7 | 984 | 1286 | 2664 | 2001 | 2367 | 3549 | 876 | 2860 | 2667 | 1622 | 1199 | 2338 | 769 | 432 |
| 8 | 336 | 502 | 969 | 589 | 794 | 2535 | 401 | 1136 | 1175 | 673 | 672 | 468 | 282 | 227 |
| 9 | 283 | 865 | 275 | 385 | 564 | 327 | 337 | 522 | 215 | 376 | 471 | 121 | 129 | 82 |
| 1+ | 65,639 | 87,569 | 349,678 | 234,667 | 334,545 | 673,374 | 295,907 | 530,276 | 415,885 | 750,525 | 490,305 | 277,093 | 280,639 | 304,475 |

**Table 7: 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 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| Stratified Mean catch/tow | 579.0 | 8.8 | 232.2 | 43.4 | 284.8 | 198.0 | 102.0 | 204.8 | 131.5 | 187.4 |
| Standard Error of Mean | 64.4 | 1.2 | 24.4 | 7.1 | 62.2 | 37.9 | 23.0 | 35.3 | 19.0 | 24.1 |
| CV | .11 | .14 | 0.11 | 0.16 | 0.22 | 0.19 | 0.11 | 0.17 | 0.10 | 0.12 |
| Number of Sets | 77 | 61 | 64 | 71 | 82 | 74 | 105 | 79 | 74 | 68 |
| July R/V Age 1 #'s ($10^6$) | 192 | 114 | 190 | 103 | 553 | 146 | 70 | 172 | 117 | |
| Comm. catch Age 1 #'s ($10^6$) | 20.2 | 5.9 | 59.6 | 15.0 | 45.6 | 6.8 | 5.1 | 21.5 | 6.5 | |

## Table 8. Results from Adapt Runs

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.026883
MEAN SQUARE RESIDUALS..... 0.685364

| AGE | PAR. EST. | STD. ERR. | T-STATISTIC |
|---|---|---|---|
| 1.00000E0000 | 9.27722E0005 | 4.64063E0005 | 1.99900E0000 |
| 2.00000E0000 | 1.33532E0006 | 4.91772E0005 | 2.71533E0000 |
| 3.00000E0000 | 8.86078E0005 | 1.07846E0005 | 3.57369E0000 |
| 4.00000E0000 | 1.34695E0005 | 4.76901E0004 | 2.82413E0000 |
| 5.00000E0000 | 3.91845E0004 | 1.42672E0004 | 2.74648E0000 |
| 6.00000E0000 | 5.93734E0003 | 2.30546E0003 | 2.40184E0000 |
| 7.00000E0000 | 3.14309E0003 | 1.33982E0003 | 2.34591E0000 |
| 8.00000E0000 | 1.52458E0003 | 6.55427E0002 | 2.29558E0000 |
| 1.00000E0000 | 1.00722E 005 | 2.29866E 006 | 4.39706E0000 |
| 2.00000E0000 | 1.93223E 005 | 4.34421E 006 | 4.44784E0000 |
| 3.00000E0000 | 2.68124E 005 | 5.98727E 006 | 4.45424E0000 |
| 4.00000E0000 | 3.13723E 005 | 7.05972E 006 | 4.44353E0000 |
| 5.00000E0000 | 3.94801E 005 | 8.96222E 006 | 4.39959E0000 |
| 6.00000E0000 | 4.46813E 005 | 1.01765E 005 | 4.39867E0000 |
| 7.00000E0000 | 3.94984E 005 | 9.00622E 006 | 4.38568E0000 |
| 8.00000E0000 | 2.61815E 005 | 5.91423E 006 | 4.42689E0000 |
| 1.00000E0000 | 9.13817E 007 | 2.08943E 007 | 4.37744E0000 |
| 2.00000E0000 | 8.70657E 006 | 1.95557E 006 | 4.45219E0000 |
| 3.00000E0000 | 2.66375E 005 | 6.00362E 006 | 4.46576E0000 |
| 4.00000E0000 | 3.33534E 005 | 7.47847E 006 | 4.45725E0000 |
| 5.00000E0000 | 3.29870E 005 | 7.45502E 006 | 4.42491E0000 |
| 6.00000E0000 | 2.69403E 005 | 6.10523E 006 | 4.41276E0000 |
| 7.00000E0000 | 1.45782E 005 | 3.31116E 006 | 4.40276E0000 |
| 8.00000E0000 | 8.89147E 006 | 1.99452E 006 | 4.43318E0000 |
| | 8.10966E 005 | 2.33276E 005 | 1.47642E0000 |

Parameter Correlation Matrix 4/ 6/91

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.000 | .072 | .050 | .033 | .009 | .007 | .006 | .007 | -.172 | -.016 | -.010 | -.007 | -.004 | -.005 | -.006 | -.006 | -.172 | -.016 |
| 2 | .072 | 1.000 | .060 | .040 | .012 | .009 | .007 | .009 | -.134 | -.142 | -.012 | -.008 | -.005 | -.006 | -.007 | -.339 | -.134 | -.137 |
| 3 | .050 | .060 | 1.000 | .006 | .011 | .026 | .030 | .042 | -.093 | -.096 | -.137 | -.010 | -.021 | -.036 | -.052 | -.081 | -.253 | -.092 |
| 4 | .033 | .040 | .006 | 1.000 | -.001 | .024 | .034 | .045 | -.062 | -.052 | -.094 | -.150 | -.014 | -.007 | -.057 | -.074 | -.052 | -.061 |
| 5 | .009 | .012 | .011 | -.001 | 1.000 | .047 | .040 | .051 | -.015 | -.020 | -.030 | -.090 | -.198 | -.042 | -.054 | -.063 | -.018 | -.019 |
| 6 | .007 | .009 | .026 | .024 | .047 | 1.000 | .051 | .045 | -.214 | -.015 | -.022 | -.038 | -.109 | -.134 | -.038 | -.026 | -.014 | -.014 |
| 7 | .006 | .007 | .030 | .034 | .040 | .051 | 1.000 | .066 | -.011 | -.012 | -.018 | -.028 | -.050 | -.110 | -.164 | -.029 | -.011 | -.011 |
| 8 | .007 | .009 | .043 | .045 | .051 | .045 | .066 | 1.000 | -.013 | -.014 | -.019 | -.031 | -.058 | -.065 | -.136 | -.166 | -.013 | -.013 |
| 9 | -.172 | -.134 | -.093 | -.062 | -.018 | -.014 | -.011 | -.013 | 1.000 | .038 | .019 | .012 | .008 | .029 | .011 | .016 | .035 | .029 |
| 10 | -.016 | -.142 | -.096 | -.052 | -.020 | -.015 | -.012 | -.014 | .038 | 1.000 | .020 | .013 | .008 | .009 | .011 | .215 | .032 | .031 |
| 11 | -.010 | -.012 | -.137 | -.094 | -.030 | -.022 | -.018 | -.019 | .019 | .020 | 1.000 | .019 | .012 | .014 | .017 | .021 | .019 | .019 |
| 12 | -.007 | -.008 | -.010 | -.150 | -.090 | -.038 | -.028 | -.031 | .012 | .013 | .019 | 1.000 | .025 | .019 | .026 | .021 | .012 | .012 |
| 13 | -.004 | -.005 | -.021 | -.014 | -.198 | -.109 | -.050 | -.058 | .008 | .008 | .012 | .015 | 1.000 | .035 | .026 | .024 | .008 | .035 |
| 14 | -.005 | -.006 | -.036 | -.007 | -.042 | -.134 | -.110 | -.065 | .029 | .009 | .014 | .019 | .035 | 1.000 | .036 | .025 | .029 | .029 |
| 15 | -.006 | -.007 | -.052 | -.057 | -.054 | -.038 | -.164 | -.136 | .011 | .011 | .017 | .020 | .026 | .029 | 1.000 | .034 | .011 | .011 |
| 16 | -.006 | -.009 | -.081 | -.074 | -.063 | -.026 | -.029 | -.166 | .016 | .215 | .021 | .021 | .024 | .025 | .034 | 1.000 | .014 | .014 |
| 17 | -.172 | -.134 | -.093 | -.062 | -.018 | -.014 | -.011 | -.013 | .035 | .032 | .019 | .012 | .008 | .029 | .011 | .014 | 1.000 | .029 |
| 18 | -.016 | -.137 | -.093 | -.061 | -.019 | -.014 | -.011 | -.013 | .029 | .031 | .019 | .012 | .008 | .029 | .011 | .014 | .029 | 1.000 |
| 19 | -.020 | -.011 | -.125 | -.085 | -.027 | -.020 | -.016 | -.018 | .017 | .018 | .026 | .017 | .011 | .013 | .015 | .019 | .017 | .017 |
| 20 | -.006 | -.007 | -.008 | -.144 | -.074 | -.034 | -.026 | -.027 | .011 | .012 | .017 | .020 | .021 | .017 | .018 | .019 | .011 | .011 |
| 21 | -.005 | -.004 | -.015 | -.012 | -.179 | -.091 | -.044 | -.052 | .027 | .027 | .010 | .022 | .047 | .008 | .023 | .021 | .007 | .007 |
| 22 | -.004 | -.005 | -.033 | -.052 | -.037 | -.101 | -.101 | -.078 | .008 | .006 | .013 | .017 | .032 | .051 | .034 | .022 | .008 | .026 |
| 23 | -.005 | -.007 | -.043 | -.054 | -.052 | -.020 | -.183 | -.124 | .012 | .011 | .016 | .019 | .025 | .056 | .055 | .022 | .012 | .012 |
| 24 | -.007 | -.009 | -.074 | -.078 | -.061 | -.028 | -.028 | -.163 | .013 | .014 | .020 | .023 | .023 | .024 | .032 | .023 | .013 | .013 |
| 25 | -.016 | -.164 | -.114 | -.075 | -.020 | -.016 | -.012 | -.016 | .065 | .037 | .025 | -.015 | -.009 | -.011 | -.013 | -.017 | -.065 | -.036 |

| | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|
| 1 | -.020 | -.006 | -.005 | -.004 | -.005 | -.007 | -.016 |
| 2 | -.011 | -.007 | -.004 | -.005 | -.007 | -.009 | -.164 |
| 3 | -.125 | -.008 | -.015 | -.033 | -.043 | -.074 | -.114 |
| 4 | -.085 | -.144 | -.012 | -.052 | -.054 | -.078 | -.075 |
| 5 | -.027 | -.074 | -.179 | -.037 | -.052 | -.061 | -.020 |
| 6 | -.020 | -.034 | -.091 | -.101 | -.020 | -.028 | -.016 |
| 7 | -.016 | -.026 | -.044 | -.101 | -.183 | -.028 | -.012 |
| 8 | -.018 | -.027 | -.052 | -.078 | -.124 | -.162 | -.016 |
| 9 | .017 | .011 | .027 | .008 | .013 | .013 | .065 |
| 10 | .018 | .012 | .027 | .009 | .011 | .014 | .037 |
| 11 | .026 | .017 | .010 | .013 | .016 | .020 | .023 |
| 12 | .017 | .020 | .022 | .017 | .019 | .020 | .015 |
| 13 | .011 | .021 | .047 | .032 | .025 | .023 | .009 |
| 14 | .013 | .017 | .008 | .051 | .056 | .024 | .011 |
| 15 | .015 | .018 | .023 | .034 | .055 | .033 | .013 |
| 16 | .019 | .019 | .021 | .023 | .022 | .033 | .017 |
| 17 | .017 | .011 | .007 | .008 | .010 | .013 | .065 |
| 18 | .017 | .011 | .007 | .008 | .010 | .013 | .036 |
| 19 | 1.000 | .016 | .010 | .011 | .014 | .018 | .021 |
| 20 | .016 | 1.000 | .019 | .015 | .017 | .018 | .013 |
| 21 | .010 | .019 | 1.000 | .027 | .022 | .021 | .006 |
| 22 | .011 | .015 | .027 | 1.000 | .052 | .022 | .010 |
| 23 | .014 | .017 | .022 | .052 | 1.000 | .031 | .012 |
| 24 | .018 | .018 | .021 | .022 | .031 | 1.000 | .016 |
| 25 | .021 | .013 | .006 | .010 | .012 | .016 | 1.000 |

## Table 8. Results from Adapt Runs

LOG RESIDUALS FOR RV INDEX

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -1.091 | -.790 | .203 | -1.102 | -.774 | .423 | .525 | .556 | .519 | 1.260 | .615 | -.131 | .087 | .470 |
| 2 | -.754 | -.896 | .806 | -.423 | .265 | 1.232 | -.319 | -.147 | .352 | .188 | .457 | -.302 | -.369 | -.344 |
| 3 | -.809 | -.734 | .638 | .726 | .873 | .572 | -.548 | .774 | -.476 | .126 | .146 | -.157 | -.816 | -.272 |
| 4 | -1.890 | -1.119 | .267 | -1.011 | .982 | 1.024 | -.257 | .194 | .715 | .194 | -.240 | .041 | -.640 | -.884 |
| 5 | -2.211 | -.468 | -.195 | .575 | .678 | 1.292 | .058 | -.152 | .758 | .117 | -.035 | .029 | -.087 | -.664 |
| 6 | -1.372 | -.625 | .237 | -.484 | .792 | .910 | -.114 | .418 | .523 | .781 | -.131 | -.864 | -.368 | -.235 |
| 7 | -1.696 | -.648 | -.209 | -.468 | -.358 | 1.926 | -.572 | .746 | .221 | -.298 | .835 | .291 | -.157 | -.575 |
| 8 | -2.103 | -1.893 | .881 | -.782 | .644 | .637 | 1.462 | .856 | .856 | -.870 | -.284 | .679 | -.485 | -.245 |

SUM OF RV RESIDUALS : 2.426695868E-3 MEAN RESIDUAL : 2.166951434E-5

LOG RESIDUALS FROM EFFORT (JV SURVEY) INDEX

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.022 | .461 | .319 | .257 | -1.050 | .351 | -.450 | 1.153 | .193 | .737 | -.227 | -.908 | .206 | -1.024 |
| 2 | .654 | .077 | -.157 | -.378 | -.397 | .227 | -.056 | -.491 | .249 | .334 | .627 | -.214 | .195 | .858 |
| 3 | -.186 | -.192 | -.195 | -.643 | -.250 | .216 | -.609 | .024 | -.307 | .695 | .735 | .382 | .411 | -.072 |
| 4 | -.518 | -.763 | -.102 | -.465 | -.563 | .731 | -.326 | -.157 | .258 | .804 | .474 | -.183 | .903 | -.658 |
| 5 | -1.261 | -.635 | -.252 | -.047 | -.275 | 1.044 | -.130 | -.184 | .422 | .466 | .619 | .211 | -.922 | -.172 |
| 6 | -1.758 | -.821 | .438 | -.508 | -.092 | .757 | .087 | -.394 | -.115 | -.307 | .491 | -.008 | -.228 | -.055 |
| 7 | -3.536 | -.200 | .037 | -.106 | -.890 | 1.947 | -.121 | .050 | .231 | .893 | .361 | .536 | -.948 | -.122 |
| 8 | -2.256 | -.425 | -.083 | -.615 | -.187 | -.046 | 1.902 | -.299 | -.267 | .478 | -.533 | .872 | -.713 | -.496 |

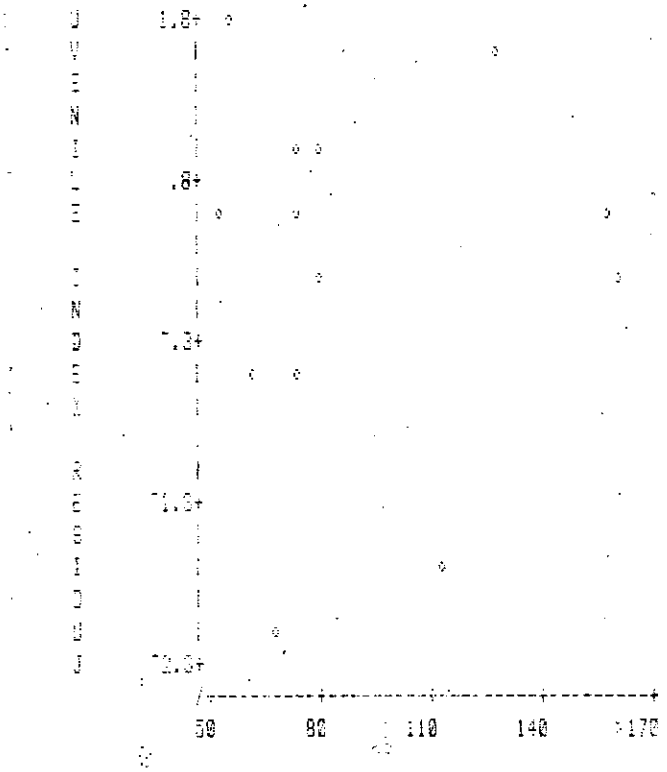
SUM OF RV RESIDUALS : 3.939999532E-3 MEAN RESIDUAL : 1.86961363E-5

RESIDUALS FROM JUVINILE INDEX

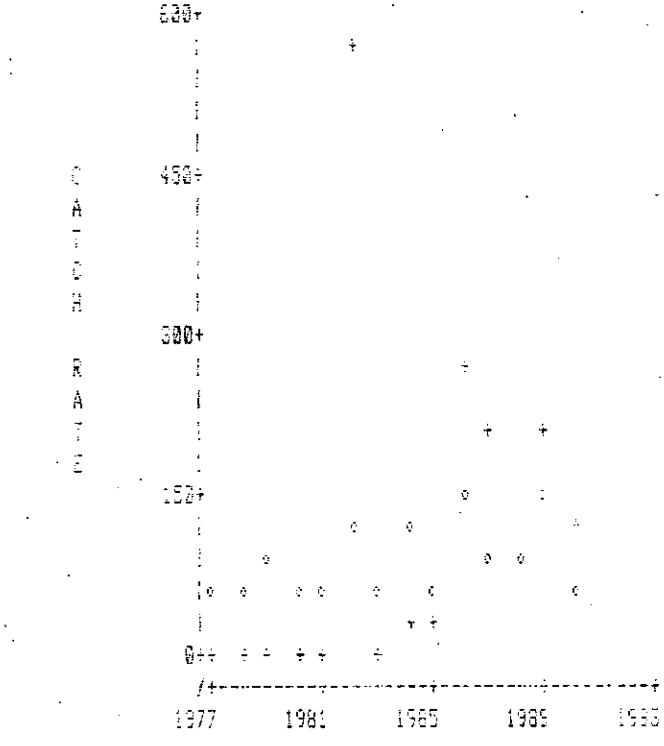
| | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|
| | 1.501 | -2.060 | -1.536 | -.373 | .596 | .896 | .229 | -.238 | .585 |

SUM OF CPUE RESIDUALS : 2.027336645 MEAN RESIDUAL : 3.1490954746

JUVENILE INDEX RESIDUAL VS PREDICTED VALUE

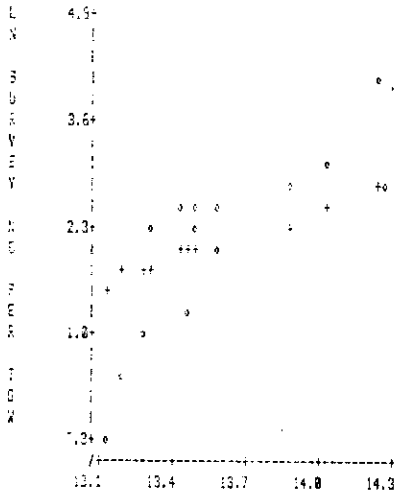



OBSERVED AND PREDICTED JUVENILE INDEX BY YEAR

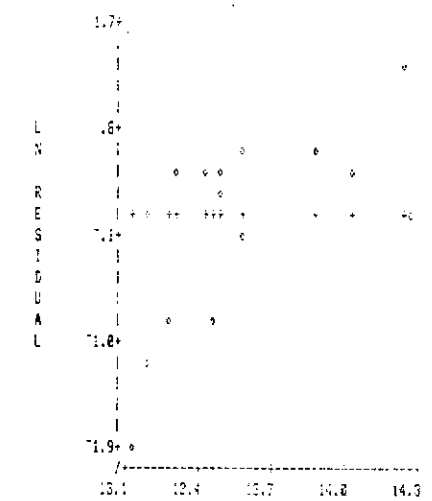


AGE 1 PLOTS

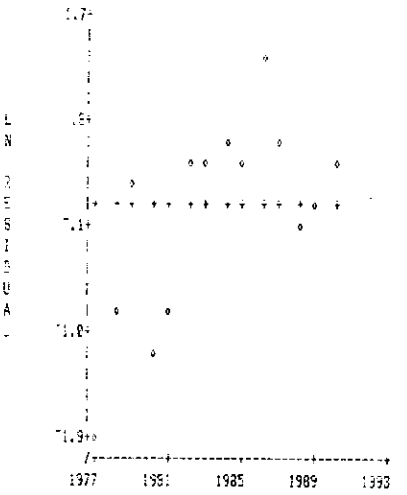
LN SURVEY NO. PER TOW VS LN SPA NUMBERS



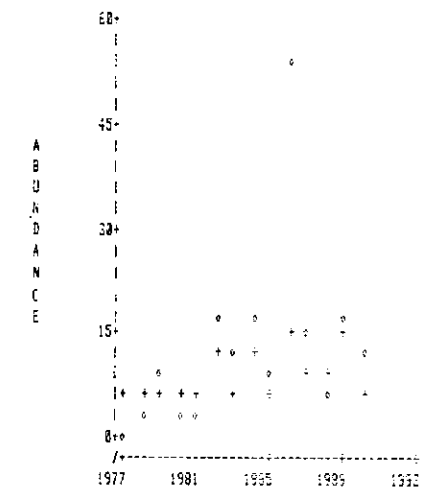

LN RESIDUAL VS OBSERVED LN N



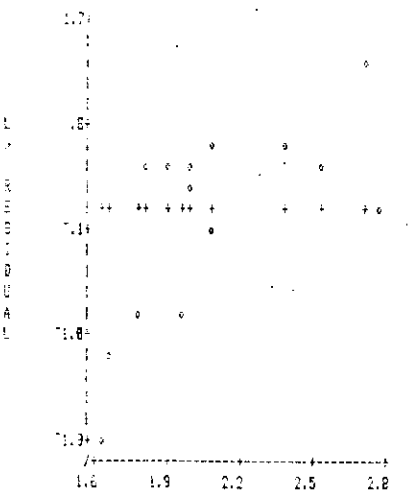

TREND IN LN RESIDUAL OVER TIME




TREND IN POPULATION ABUNDANCE OVER TIME




LN RESIDUAL VS LN PREDICTED VALUE




SUMMARY OF DATA FROM PLOT

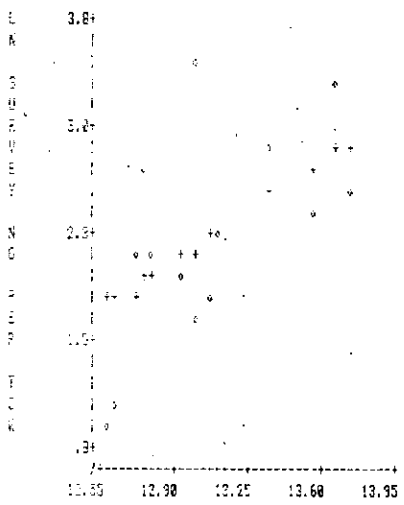
CARRIER VARIABLE: POPULATION NOS

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

| INDEX | CARRIER | o | + | RANK |
|---|---|---|---|---|
| 1977 | 13.14 | -0.2566 | 1.634 | 1977 |
| 1978 | 13.28 | 0.9636 | 1.774 | 1980 |
| 1979 | 13.49 | 2.191 | 1.966 | 1978 |
| 1980 | 13.18 | 0.5727 | 1.674 | 1985 |
| 1981 | 13.47 | 1.169 | 1.964 | 1983 |
| 1982 | 14.04 | 2.955 | 2.532 | 1981 |
| 1983 | 13.42 | 2.436 | 1.911 | 1979 |
| 1984 | 13.09 | 2.933 | 2.383 | 1990 |
| 1985 | 13.32 | 2.329 | 1.811 | 1987 |
| 1986 | 14.23 | 4.812 | 2.722 | 1988 |
| 1987 | 13.57 | 2.581 | 2.066 | 1984 |
| 1988 | 13.56 | 1.942 | 2.073 | 1992 |
| 1989 | 14.25 | 2.845 | 2.758 | 1986 |
| 1990 | 13.5 | 2.45 | 1.99 | 1989 |

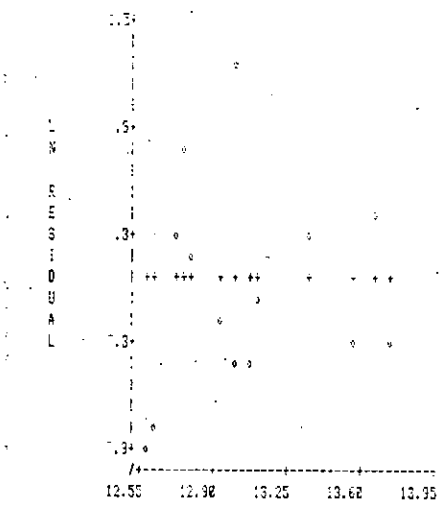
AGE 2 PLOTS

LN SURVEY AD. PER TON VS LN SPA NUMBERS




LN SPA NUMBERS

LN RESIDUAL VS LN PREDICTED VALUE



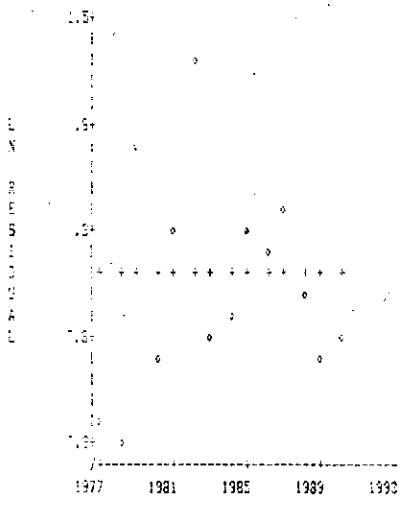

LN PREDICTED VALUE

LN RESIDUAL VS OBSERVED LN X



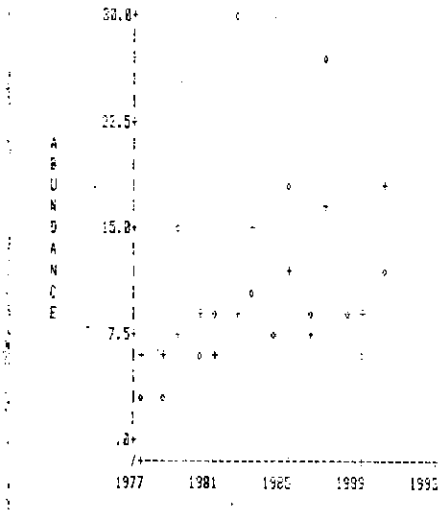

OBSERVED LN X

TREND IN LN RESIDUAL OVER TIME



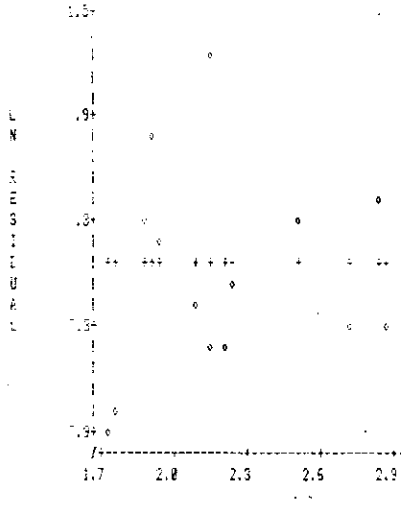

YEAR

TREND IN POPULATION ABUNDANCE OVER TIME




YEAR

LN RESIDUAL VS LN PREDICTED VALUE



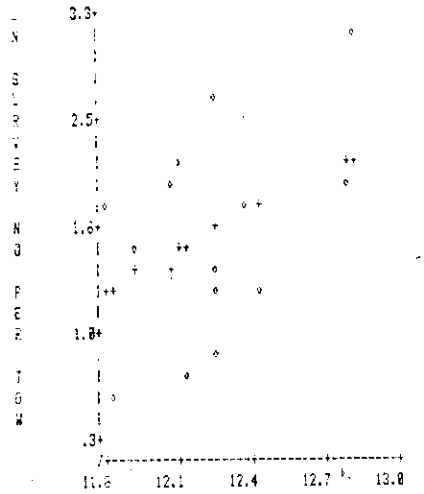

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE: POPULATION NOS

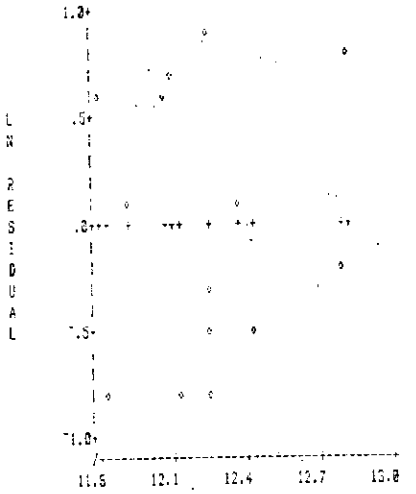
RESPONSE VARIABLE(S): SURVEY - o;OBSERVED, +;PREDICTED

| INDEX | CARRIER | o | + | RANK |
|---|---|---|---|---|
| 1977 | 12.62 | 1.017 | 1.771 | 1978 |
| 1978 | 12.59 | 0.344 | 1.74 | 1977 |
| 1979 | 12.77 | 2.726 | 1.919 | 1981 |
| 1980 | 12.95 | 1.716 | 2.139 | 1979 |
| 1981 | 12.73 | 2.137 | 1.871 | 1986 |
| 1982 | 13 | 3.379 | 2.147 | 1984 |
| 1983 | 13.56 | 2.388 | 2.707 | 1980 |
| 1984 | 12.95 | 1.951 | 2.098 | 1982 |
| 1985 | 13.35 | 2.349 | 2.497 | 1983 |
| 1986 | 13.6 | 2.182 | 2.548 | 1982 |
| 1987 | 13.66 | 3.263 | 2.606 | 1985 |
| 1988 | 13.1 | 2.192 | 2.242 | 1983 |
| 1989 | 13.08 | 1.893 | 2.222 | 1987 |
| 1990 | 13.73 | 2.593 | 2.877 | 1992 |

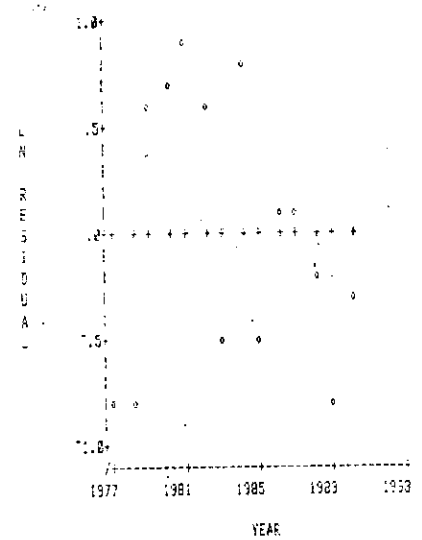
AGE 3 PLOTS
LN SURVEY NO. PER TON VS LN SPA NUMBERS



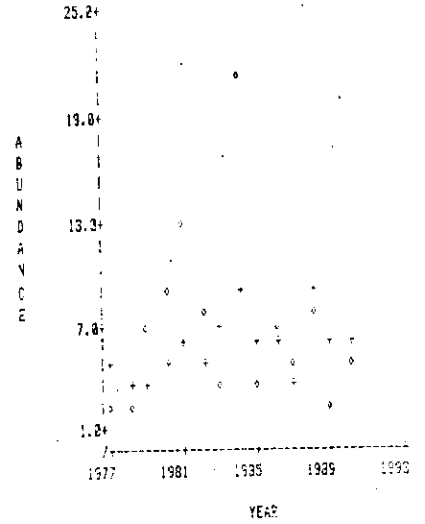

LN RESIDUAL VS OBSERVED LN Y



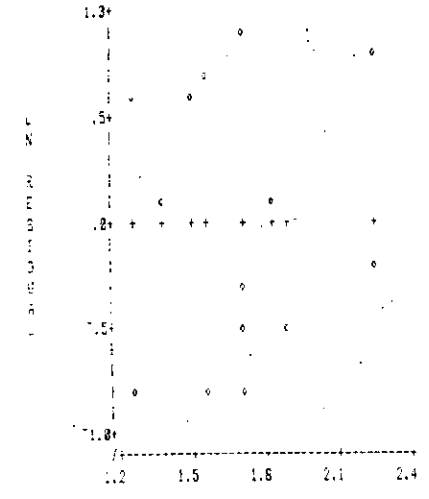

TREND IN LN RESIDUAL OVER TIME




TREND IN POPULATION ABUNDANCE OVER TIME




LN RESIDUAL VS LN PREDICTED VALUE



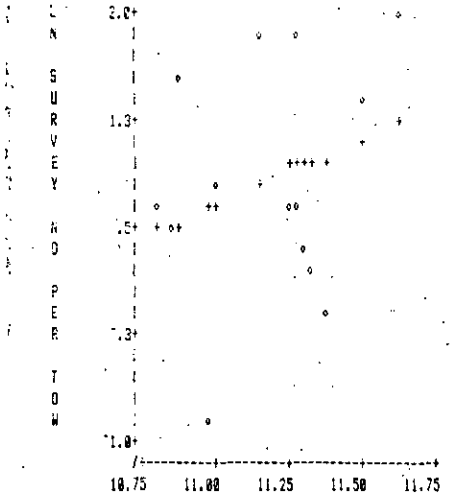

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - 0:OBSERVED, +:PREDICTED

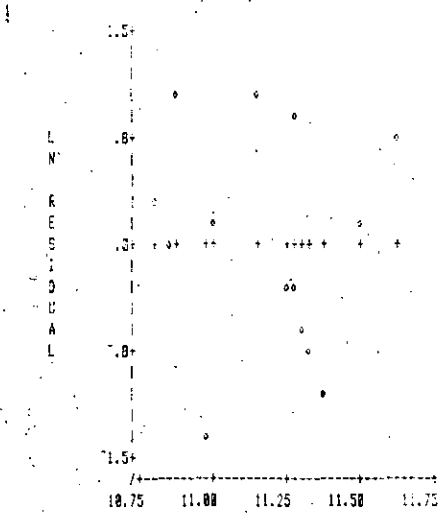
| INDEX | CARRIER | 0 | + | RANK |
|---|---|---|---|---|
| 1977 | 12.11 | 0.7619 | 1.571 | 1978 |
| 1978 | 11.82 | 0.4865 | 1.27 | 1978 |
| 1979 | 11.81 | 1.982 | 1.264 | 1987 |
| 1980 | 12.23 | 2.275 | 1.549 | 1982 |
| 1981 | 12.25 | 2.578 | 1.703 | 1980 |
| 1982 | 12.06 | 2.084 | 1.512 | 1977 |
| 1983 | 12.43 | 1.34 | 1.884 | 1989 |
| 1984 | 12.81 | 3.038 | 2.264 | 1981 |
| 1985 | 12.26 | 1.235 | 1.711 | 1985 |
| 1986 | 12.37 | 1.955 | 1.819 | 1990 |
| 1987 | 11.93 | 1.523 | 1.38 | 1986 |
| 1988 | 12.8 | 2.098 | 2.254 | 1983 |
| 1989 | 12.24 | 0.8617 | 1.698 | 1988 |
| 1990 | 12.26 | 1.442 | 1.715 | 1984 |

AGE 4 PLOTS

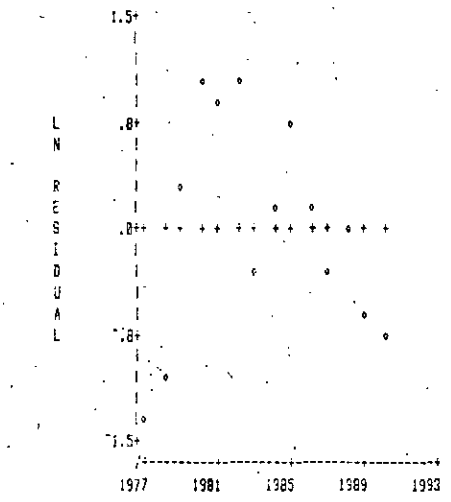
LN SURVEY NO. PER TOW VS LN SPA NUMBERS



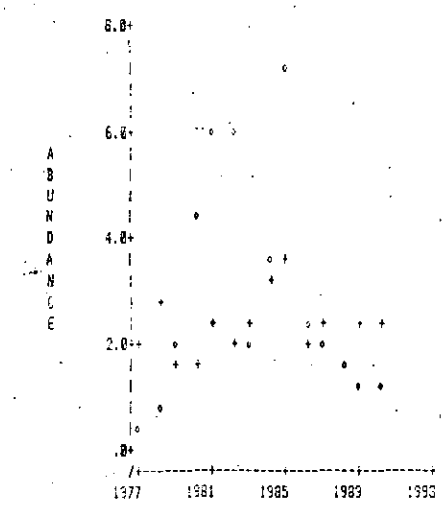

LN RESIDUAL VS OBSERVED LN X



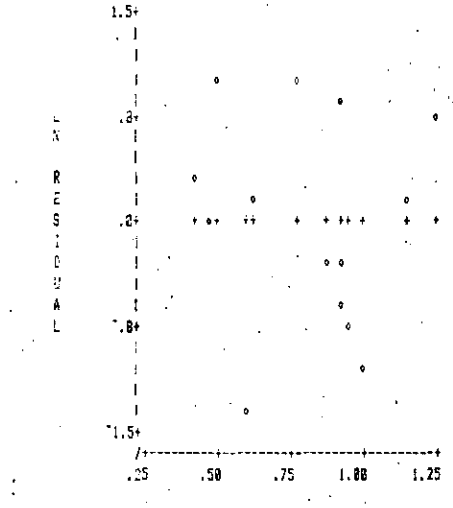

TREND IN LN RESIDUAL OVER TIME




TREND IN POPULATION ABUNDANCE OVER TIME




LN RESIDUAL VS LN PREDICTED VALUE



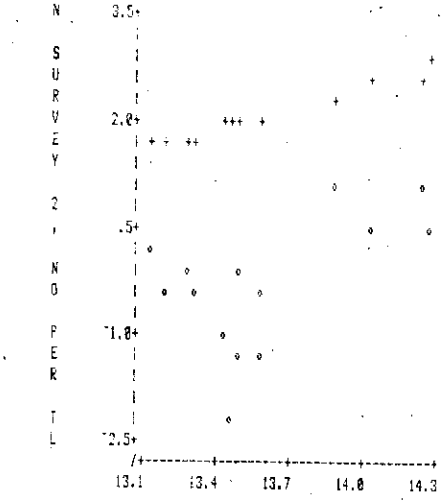

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE: POPULATION NOS

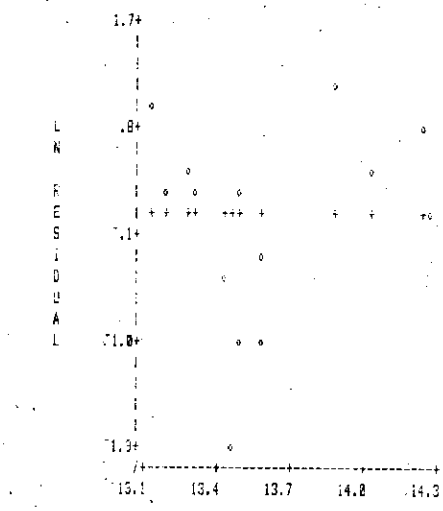
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

| INDEX | CARRIER | o | + | RANK | |
|---|---|---|---|---|---|
| 1977 | 10.96 | 0.7782 | 0.6118 | 1979 | |
| 1978 | 11.37 | 0.1195 | 0.9992 | 1988 | |
| 1979 | 10.8 | 0.6956 | 0.4281 | 1980 | |
| 1980 | 10.88 | 1.522 | 0.512 | 1977 | |
| 1981 | 11.29 | 1.6 | 0.9176 | 1986 | |
| 1982 | 11.15 | 1.8 | 0.7759 | 1982 | |
| 1983 | 11.29 | 0.6536 | 0.9168 | 1987 | |
| 1984 | 11.51 | 1.333 | 1.139 | 1983 | |
| 1985 | 11.62 | 1.963 | 1.246 | 1981 | |
| 1986 | 10.99 | 0.8164 | 0.6221 | 1989 | |
| 1987 | 11.25 | 0.6489 | 0.8806 | 1992 | |
| 1988 | 10.84 | 0.5134 | 0.4721 | 1978 | |
| 1989 | 11.3 | 0.293 | 0.9327 | 1984 | |
| 1990 | 11.32 | 0.2641 | 0.9482 | 1985 | |

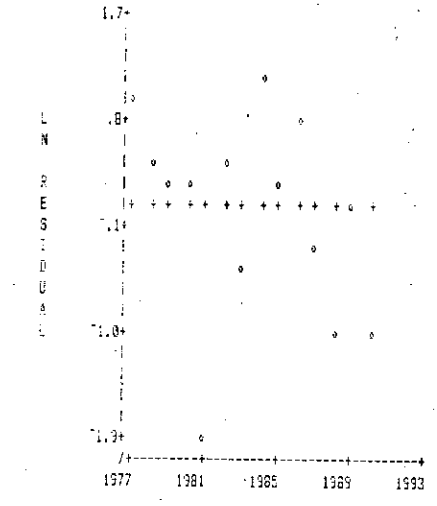
AGE 1PLOT9
LN SURVEY 2, NO. PER TOW VS LN SPA NUMBERS



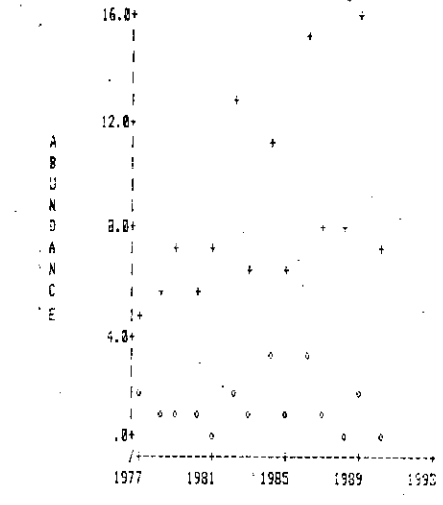

LN RESIDUAL VS OBSERVED LN X



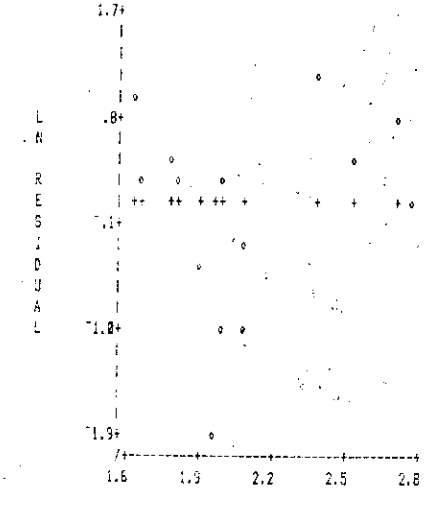

TREND IN LN RESIDUAL OVER TIME




TREND IN POPULATION ABUNDANCE OVER TIME




LN RESIDUAL VS LN PREDICTED VALUE

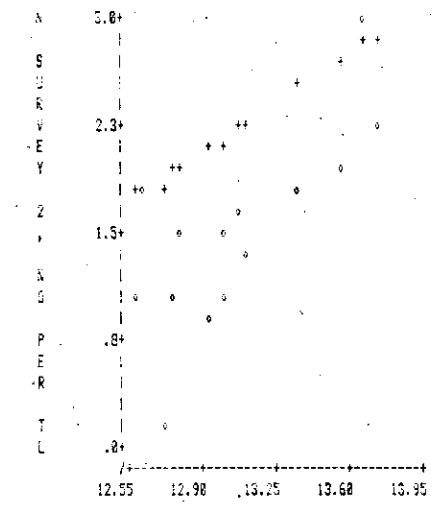



SUMMARY OF DATA FROM PLOT

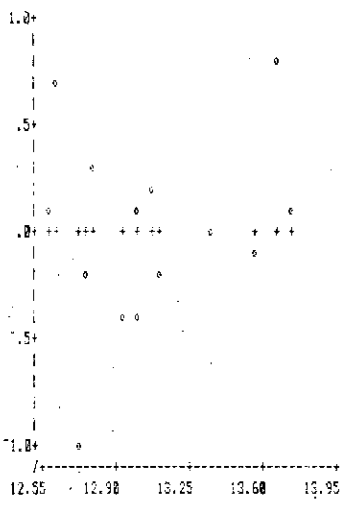
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

| INDEX | CARRIER | o | + | RANK |
|---|---|---|---|---|
| 1977 | 13.14 | 0.3341 | 1.634 | 1977 |
| 1978 | 13.28 | -0.08782 | 1.774 | 1980 |
| 1979 | 13.49 | -0.01634 | 1.988 | 1978 |
| 1980 | 13.18 | -0.3917 | 1.674 | 1985 |
| 1981 | 13.47 | -2.214 | 1.964 | 1983 |
| 1982 | 14.04 | 0.558 | 2.532 | 1981 |
| 1983 | 13.42 | -0.0658 | 1.911 | 1979 |
| 1984 | 13.89 | 1.216 | 2.383 | 1990 |
| 1985 | 13.32 | -0.3202 | 1.811 | 1987 |
| 1986 | 14.23 | 1.137 | 2.722 | 1988 |
| 1987 | 13.57 | -0.4875 | 2.066 | 1984 |
| 1988 | 13.58 | -1.191 | 2.073 | 1982 |
| 1989 | 14.26 | 0.4412 | 2.758 | 1986 |
| 1990 | 13.5 | -1.371 | 1.99 | 1989 |

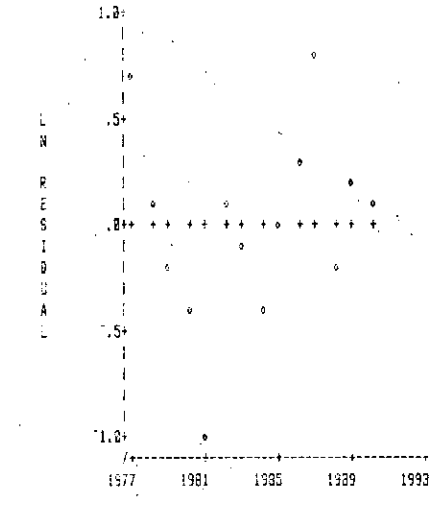
AGE 2PLOTS
LN SURVEY 2, NO. PER TOW VS LN SPA NUMBERS



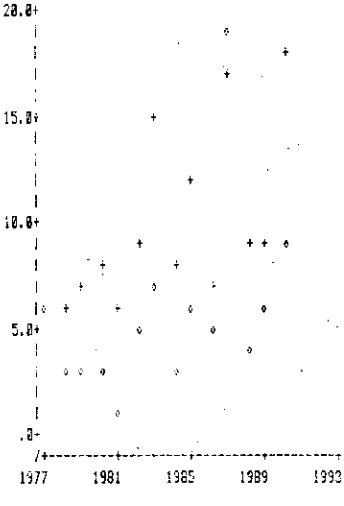

LN RESIDUAL VS OBSERVED LN X



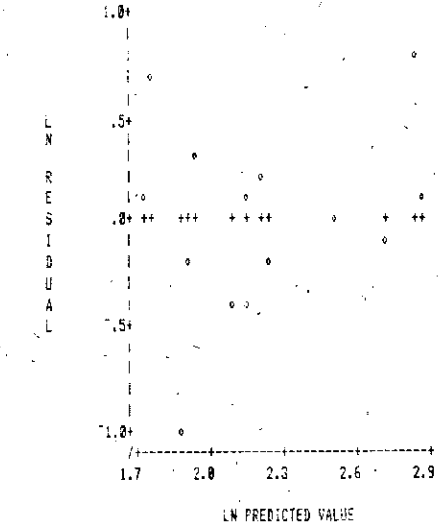

TREND IN LN RESIDUAL OVER TIME




TREND IN POPULATION ABUNDANCE OVER TIME




LN RESIDUAL VS LN PREDICTED VALUE

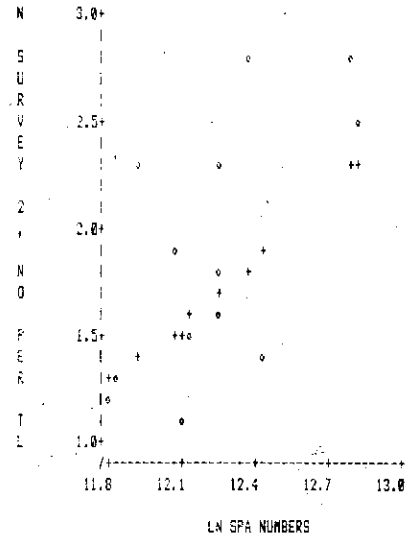



SUMMARY OF DATA FROM PLOT

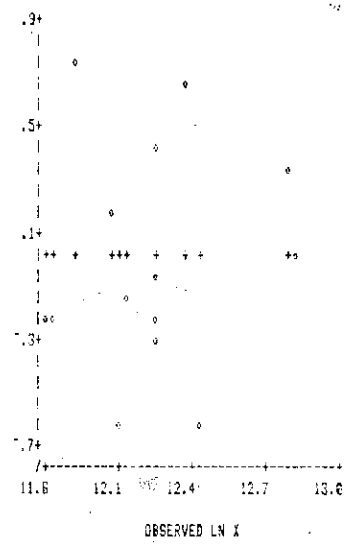
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o;OBSERVED, +;PREDICTED

| INDEX | CARRIER | o | + | RANK |
|---|---|---|---|---|
| 1977 | 12.63 | 1.733 | 1.771 | 1978 |
| 1978 | 12.59 | 1.123 | 1.74 | 1977 |
| 1979 | 12.77 | 1.018 | 1.919 | 1981 |
| 1980 | 12.39 | 1.058 | 2.139 | 1979 |
| 1981 | 12.73 | 0.1557 | 1.871 | 1986 |
| 1982 | 13 | 1.523 | 2.147 | 1984 |
| 1983 | 13.56 | 1.941 | 2.787 | 1980 |
| 1984 | 12.95 | 0.9537 | 2.098 | 1982 |
| 1985 | 13.35 | 1.848 | 2.497 | 1983 |
| 1986 | 12.8 | 1.569 | 1.945 | 1988 |
| 1987 | 13.68 | 2.962 | 2.826 | 1985 |
| 1988 | 13.1 | 1.317 | 2.242 | 1983 |
| 1989 | 13.08 | 1.715 | 2.222 | 1987 |
| 1990 | 13.73 | 2.24 | 2.877 | 1990 |

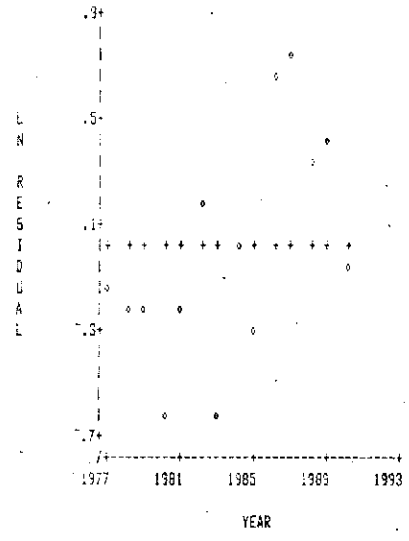
AGE 3PLOTS
LN SURVEY C, NO. PER TOW VS LN SPA NUMBERS



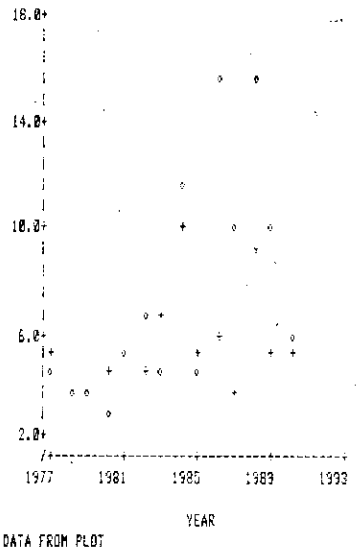

LN RESIDUAL VS OBSERVED LN X



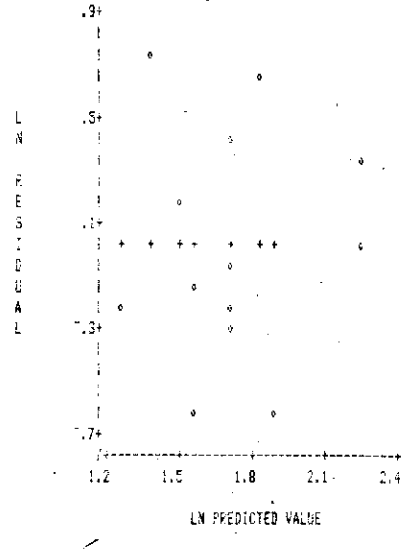

TREND IN LN RESIDUAL OVER TIME




TREND IN POPULATION ABUNDANCE OVER TIME




LN RESIDUAL VS LN PREDICTED VALUE

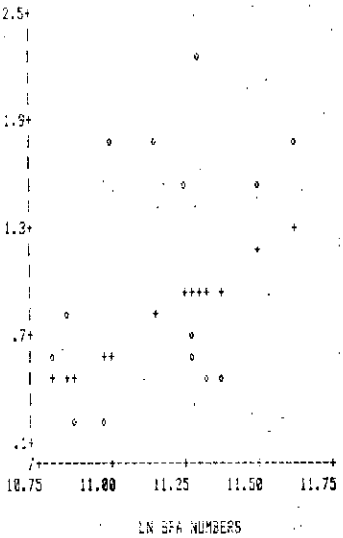



SUMMARY OF DATA FROM PLOT

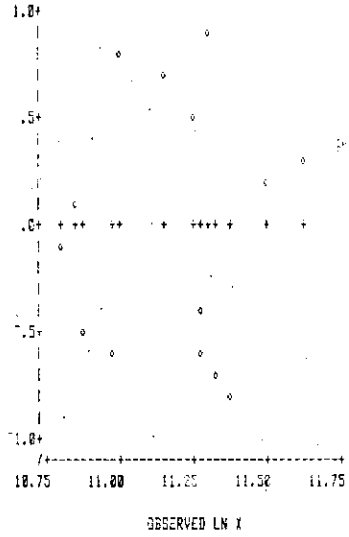
CARRIER VARIABLE: POPULATION NOS
RESPONSE VARIABLE(S): SURVEY - o:OBSERVED, +:PREDICTED

| INDEX | CARRIER | o | + | RANK |
|---|---|---|---|---|
| 1977 | 12.12 | 1.541 | 1.571 | 1979 |
| 1978 | 11.82 | 1.255 | 1.27 | 1978 |
| 1979 | 11.81 | 1.249 | 1.264 | 1987 |
| 1980 | 12.09 | 1.054 | 1.549 | 1982 |
| 1981 | 12.25 | 1.62 | 1.703 | 1980 |
| 1982 | 12.06 | 1.082 | 1.512 | 1977 |
| 1983 | 12.43 | 1.396 | 1.884 | 1989 |
| 1984 | 12.81 | 2.461 | 2.264 | 1981 |
| 1985 | 12.26 | 1.562 | 1.711 | 1985 |
| 1986 | 12.37 | 2.751 | 1.829 | 1990 |
| 1987 | 11.93 | 2.355 | 1.38 | 1986 |
| 1988 | 12.8 | 2.758 | 2.254 | 1983 |
| 1989 | 12.24 | 2.328 | 1.698 | 1988 |
| 1990 | 12.26 | 1.627 | 1.715 | 1984 |

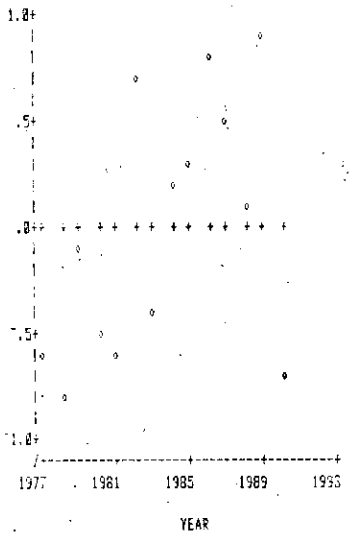
AGE 4PLOTS
LN SURVEY 2, NO. PER TOW VS LN SEA NUMBERS



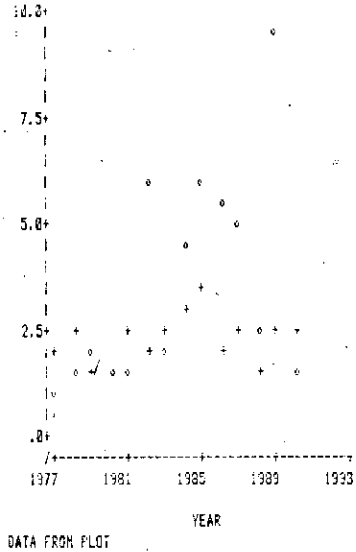

LN RESIDUAL VS OBSERVED LN X



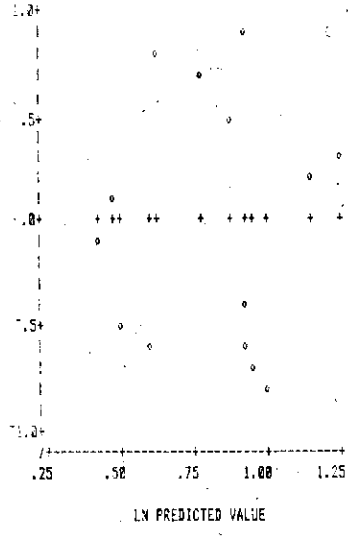

TREND IN LN RESIDUAL OVER TIME




TREND IN POPULATION ABUNDANCE OVER TIME




LN RESIDUAL VS LN PREDICTED VALUE




SUMMARY OF DATA FROM PLOT

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

| INDEX | CARRIER | o | + | RANK |
|---|---|---|---|---|
| 1977 | 10.38 | 0.1614 | 0.6118 | 1979 |
| 1978 | 11.37 | 0.4266 | 0.9992 | 1968 |
| 1979 | 10.8 | 0.5618 | 0.4281 | 1980 |
| 1980 | 10.88 | 0.2664 | 0.512 | 1977 |
| 1981 | 11.29 | 0.5546 | 0.9176 | 1986 |
| 1982 | 11.15 | 1.778 | 0.7759 | 1982 |
| 1983 | 11.29 | 0.7449 | 0.9168 | 1987 |
| 1984 | 11.51 | 1.547 | 1.139 | 1983 |
| 1985 | 11.62 | 1.829 | 1.246 | 1981 |
| 1986 | 10.99 | 1.749 | 0.6221 | 1989 |
| 1987 | 11.25 | 1.588 | 0.8806 | 1990 |
| 1988 | 10.84 | 0.8474 | 0.4721 | 1978 |
| 1989 | 11.3 | 2.228 | 0.9327 | 1984 |
| 1990 | 11.32 | 0.4934 | 0.9482 | 1985 |

# Table 9. Population Numbers and Biomass from Adapt Runs

POPULATION NUMBERS ('0000S)

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 635373 | 752774 | 930426 | 680886 | 894901 | 1591734 | 831675 | 1401156 | 777366 | 1940528 | 994226 | 1000626 | 1994186 | 921311 |
| 2 | 438239 | 424645 | 488126 | 606842 | 442838 | 597939 | 1050441 | 566106 | 990436 | 508823 | 1263442 | 650879 | 666597 | 1316968 |
| 3 | 276336 | 234376 | 227090 | 278802 | 348897 | 276194 | 357437 | 624836 | 341951 | 489778 | 260546 | 671510 | 391592 | 278146 |
| 4 | 58487 | 135213 | 91449 | 82545 | 129525 | 144603 | 123017 | 193619 | 249445 | 148695 | 140714 | 96252 | 232312 | 132020 |
| 5 | 40990 | 44966 | 62634 | 31279 | 35589 | 56338 | 40939 | 58486 | 61985 | 62111 | 30622 | 49936 | 32484 | 29035 |
| 6 | 14762 | 25660 | 19726 | 23651 | 9124 | 14238 | 11763 | 15112 | 23367 | 13569 | 16190 | 9965 | 16054 | 5420 |
| 7 | 21032 | 9301 | 12921 | 5057 | 11616 | 3468 | 4677 | 5105 | 8646 | 8027 | 1923 | 7244 | 4137 | 3062 |
| 8 | 13291 | 14019 | 4674 | 5067 | 2225 | 5803 | 653 | 2464 | 2572 | 3673 | 4285 | 1203 | 3118 | 1499 |
| 9 | 191 | 8862 | 8441 | 2723 | 3698 | 1254 | 4180 | 232 | 1502 | 1539 | 2191 | 3691 | 582 | 1105 |
| 1+ | 1545725 | 1651825 | 1845497 | 1726877 | 1879026 | 2692593 | 2444771 | 2870114 | 2357190 | 3176952 | 2739261 | 2500818 | 3341555 | 2795617 |
| 2+ | 910362 | 998050 | 915071 | 1046991 | 984125 | 1100858 | 1593085 | 1468958 | 1579824 | 1236424 | 1745034 | 1499824 | 1347367 | 1874307 |
| 3+ | 472123 | 473405 | 426946 | 440149 | 541295 | 502991 | 542635 | 902855 | 689386 | 727596 | 481592 | 838745 | 680770 | 557339 |
| 4+ | 195793 | 239027 | 199856 | 161347 | 192398 | 226635 | 185218 | 278016 | 347437 | 237820 | 156045 | 167235 | 289178 | 181192 |

POPULATION BIOMASS (tons)

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 42599 | 56035 | 70712 | 27031 | 54231 | 104577 | 57233 | 98221 | 52899 | 105480 | 44342 | 45031 | 120350 | 58319 |
| 2 | 80198 | 64886 | 86984 | 91755 | 74174 | 101852 | 134772 | 82851 | 121277 | 73933 | 150350 | 91594 | 98257 | 183822 |
| 3 | 72813 | 53573 | 51504 | 62340 | 75048 | 53746 | 69915 | 113033 | 60594 | 90266 | 47636 | 124028 | 76165 | 69135 |
| 4 | 29048 | 36234 | 25030 | 26523 | 35885 | 39766 | 29413 | 43448 | 52433 | 37189 | 29634 | 21842 | 52172 | 28710 |
| 5 | 16236 | 15862 | 19868 | 10565 | 11660 | 17973 | 11816 | 15932 | 15080 | 13534 | 7653 | 13004 | 9024 | 9135 |
| 6 | 9328 | 10290 | 7675 | 9245 | 3660 | 5604 | 4291 | 6388 | 6895 | 3715 | 5202 | 2912 | 5599 | 1706 |
| 7 | 18643 | 4073 | 5879 | 2592 | 6423 | 1546 | 1845 | 2068 | 3544 | 2148 | 871 | 3501 | 1557 | 1139 |
| 8 | 12294 | 7567 | 3918 | 5093 | 2053 | 3489 | 299 | 1537 | 1498 | 1994 | 1774 | 499 | 1588 | 597 |
| 9 | 405 | 7324 | 7072 | 2344 | 4204 | 634 | 1856 | 158 | 1005 | 991 | 1135 | 1851 | 412 | 602 |
| 1+ | 283805 | 255787 | 277834 | 237689 | 267337 | 338287 | 311438 | 363427 | 315264 | 330197 | 288598 | 324263 | 356944 | 352656 |
| 2+ | 241006 | 199751 | 207121 | 210658 | 213106 | 233710 | 254206 | 265206 | 262365 | 226767 | 244256 | 239032 | 286894 | 294347 |
| 3+ | 160808 | 134865 | 120137 | 118903 | 138932 | 132858 | 119434 | 182555 | 141048 | 152835 | 93905 | 167038 | 146637 | 111525 |
| 4+ | 87995 | 81236 | 68633 | 56564 | 63884 | 68913 | 49520 | 69522 | 88454 | 62569 | 46270 | 43010 | 70472 | 41889 |

## Table 10. Fishing Mortalities from Adapt Runs

FISHING MORTALITY

| I | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .034 | .035 | .027 | .030 | .003 | .016 | .003 | .053 | .024 | .029 | .008 | .006 | .015 | .006 |
| 2 | .226 | .226 | .156 | .153 | .072 | .115 | .119 | .104 | .198 | .185 | .232 | .123 | .172 | .217 |
| 3 | .307 | .541 | .498 | .367 | .481 | .409 | .213 | .518 | .433 | .847 | .679 | .659 | .687 | .590 |
| 4 | .242 | .377 | .673 | .549 | .436 | .862 | .344 | .740 | .990 | 1.174 | .636 | .688 | 1.411 | .411 |
| 5 | .068 | .423 | .573 | .832 | .522 | 1.166 | .415 | .517 | 1.118 | .828 | .729 | .736 | 1.391 | .657 |
| 6 | .062 | .286 | .960 | .311 | .567 | .713 | .495 | .339 | .669 | 1.554 | .521 | .479 | 1.249 | .446 |
| 7 | .006 | .288 | .356 | .423 | .135 | 1.270 | .241 | .286 | .402 | .246 | .249 | .446 | .622 | .389 |
| 8 | .008 | .107 | .139 | .095 | .173 | .087 | .642 | .095 | .113 | .170 | .046 | .292 | .634 | .104 |
| 9 | .027 | .047 | .055 | .044 | .047 | .064 | .026 | .057 | .071 | .091 | .067 | .067 | .098 | .055 |

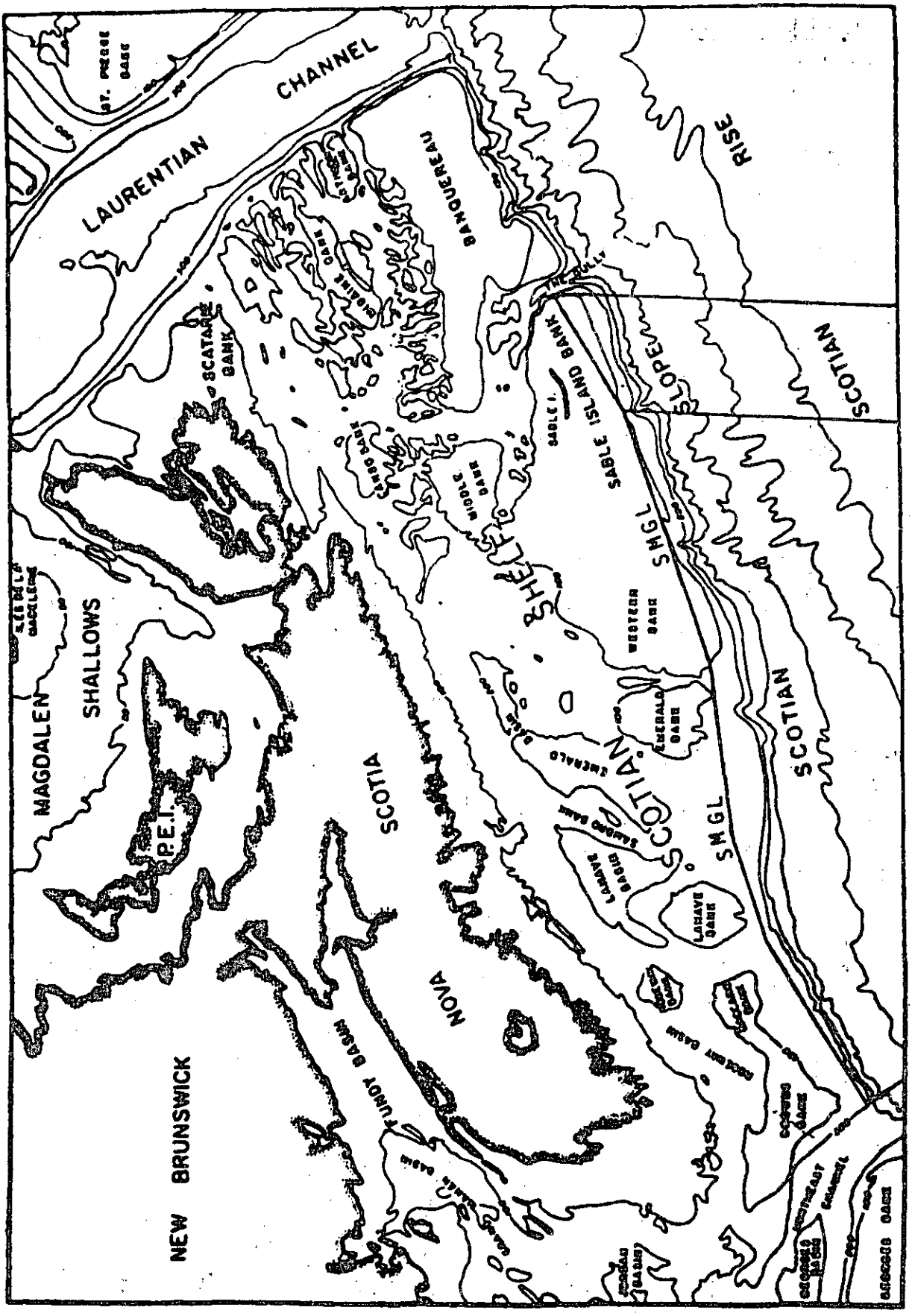



Figure 1 Bathymetric map of the Scotian Shelf and the Bay of Fundy showing the Small Mesh Gear Line (SMGL)

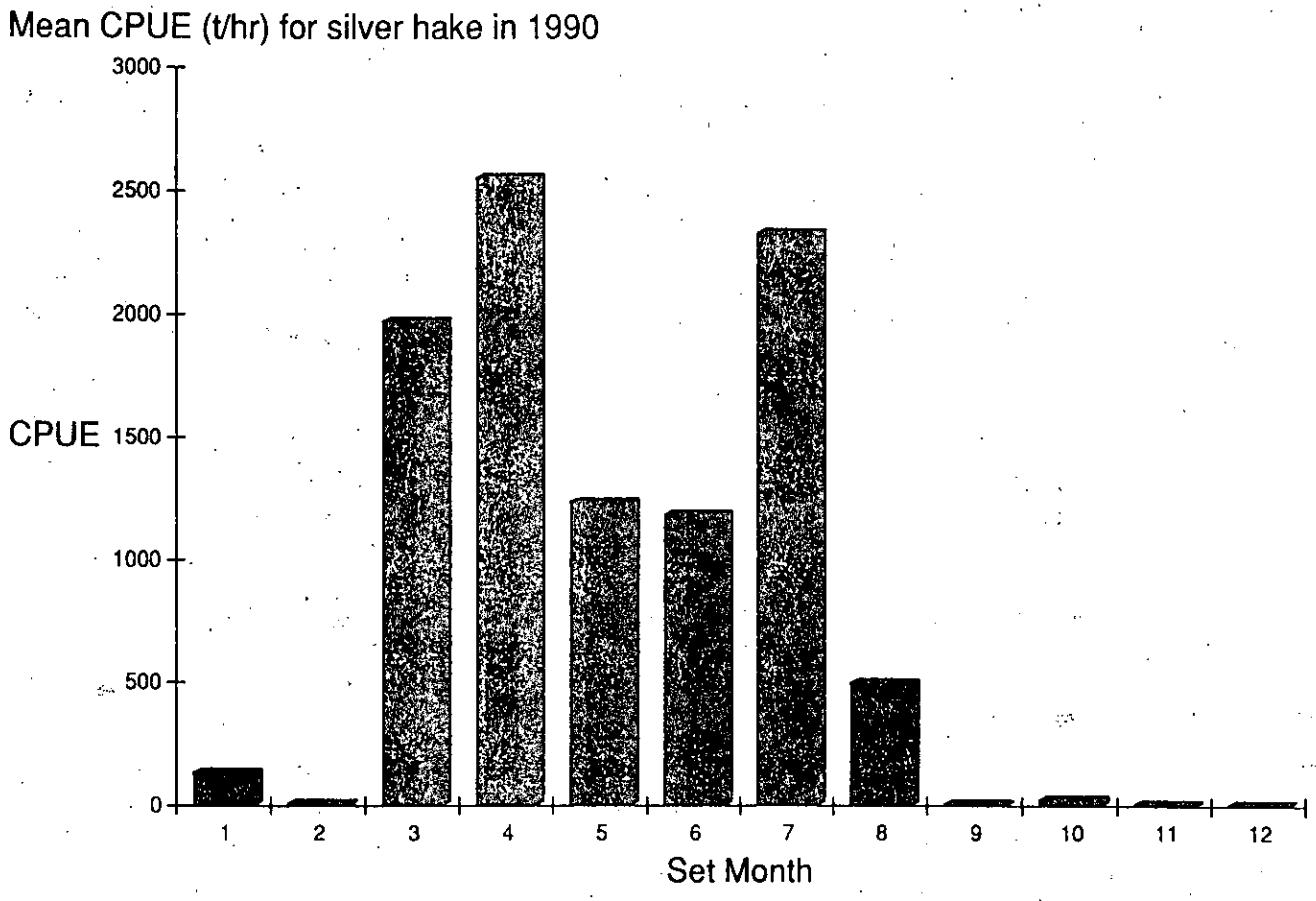



Figure 2. Mean CPUE for silver hake in 1990

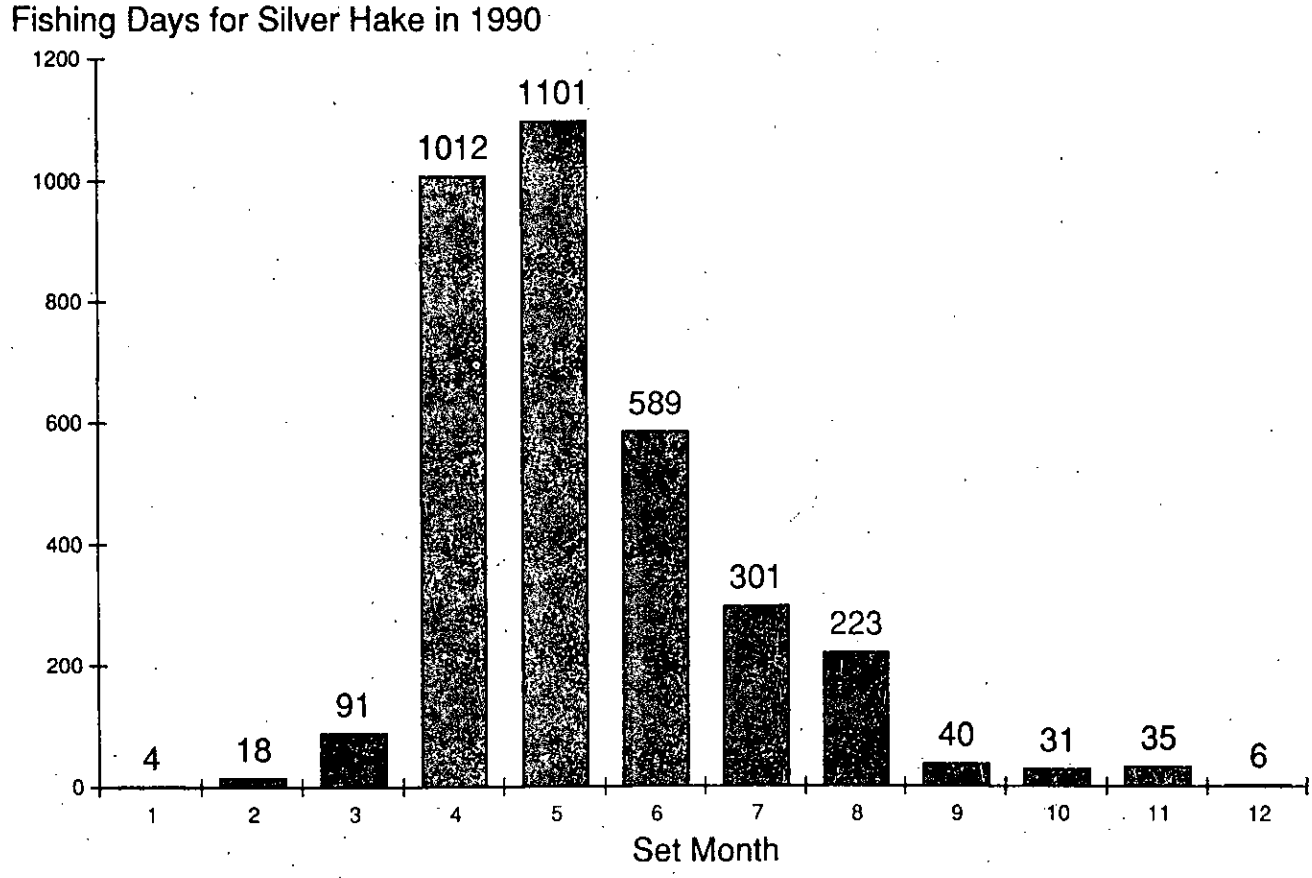
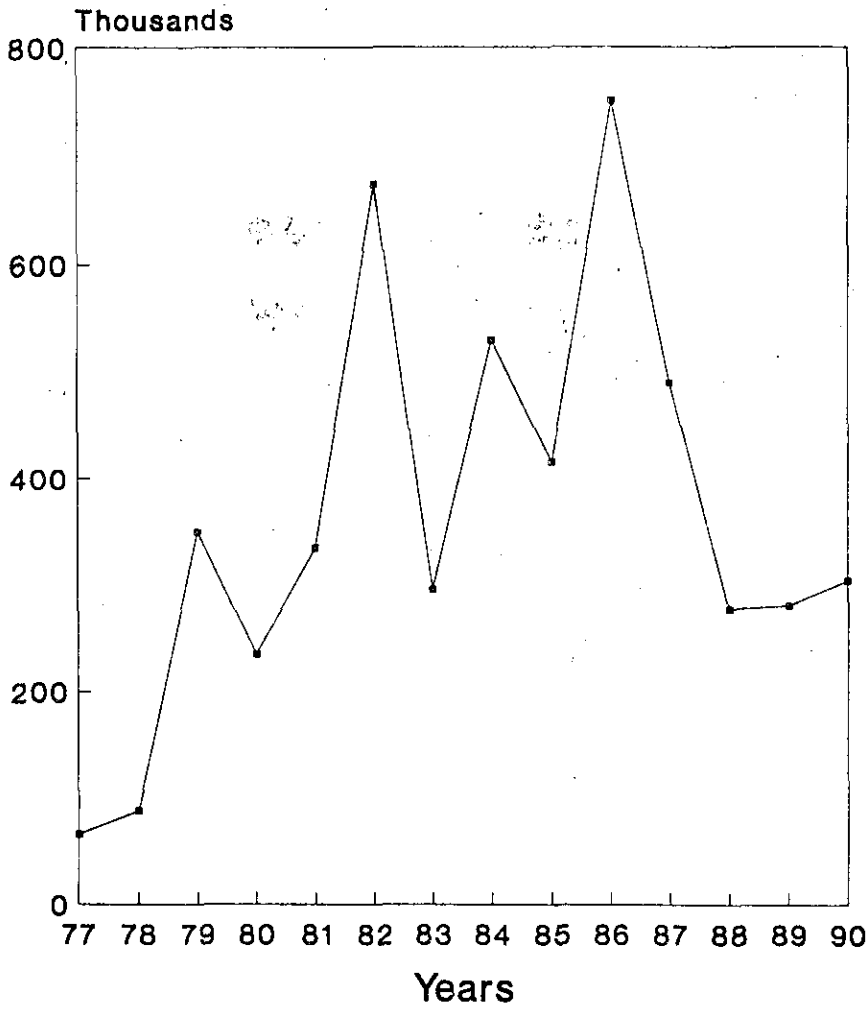



Figure 3. Number of fishing days by month in the 1990 fishery

Fig 4: Silver Hake July R/V Survey
Catch Numbers



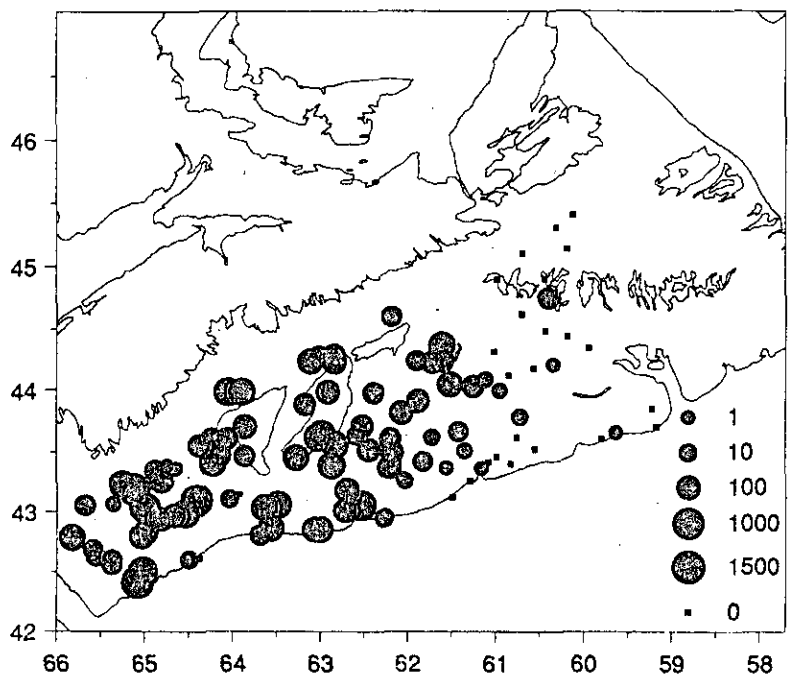
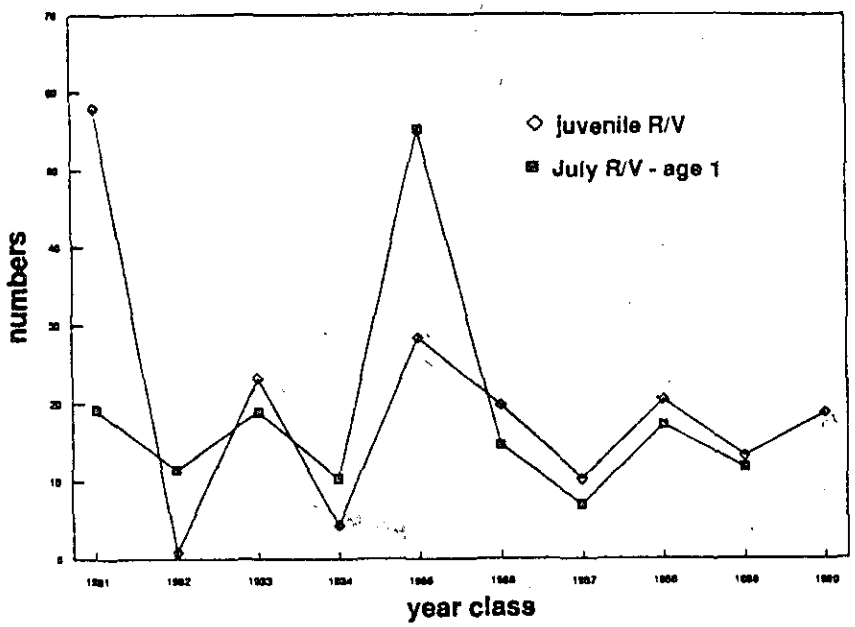
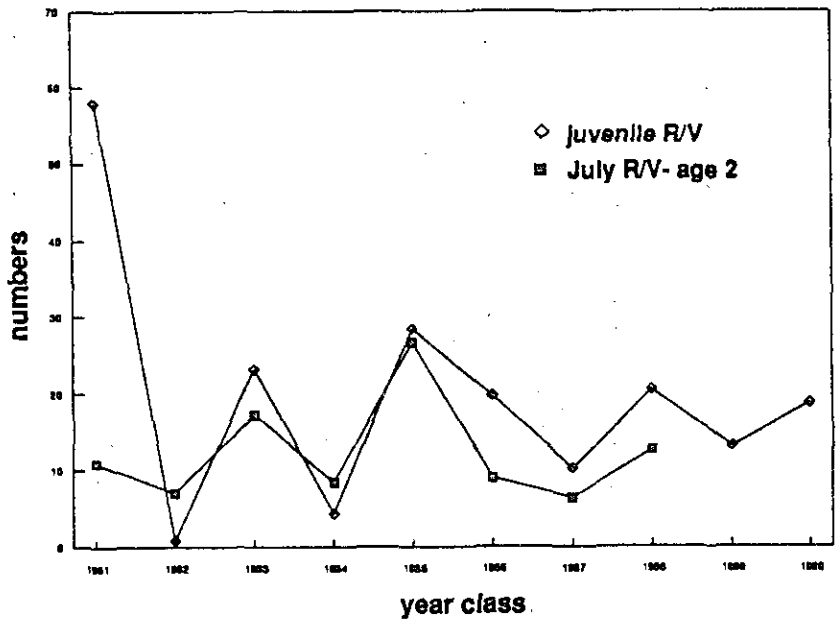




Figure 5: Distribution of silver hake catches during the fall 1990 juvenile silver hake survey



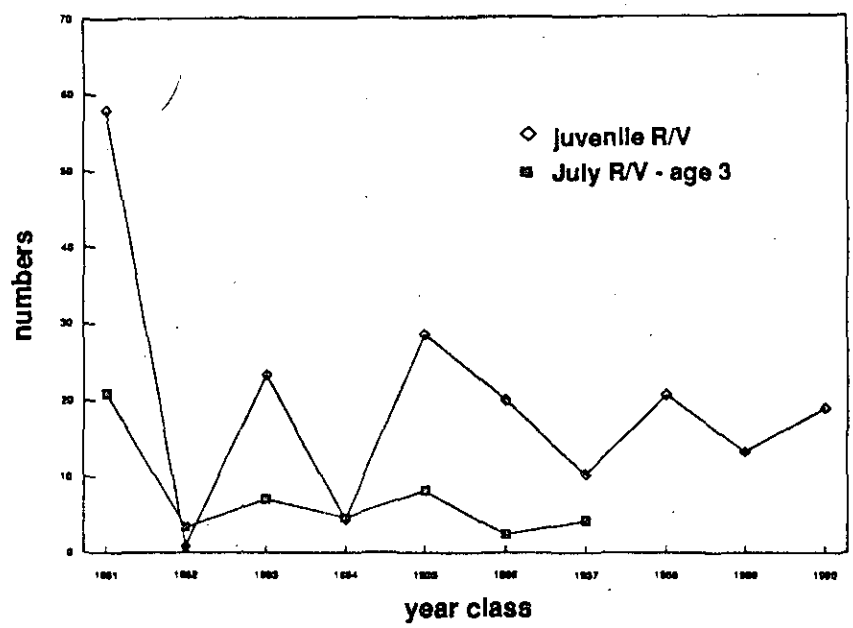




Figure 6 : Comparison of juvenile and adult silver hake surveys

Figure 7.: Silver hake mean weights at age by yearclass.

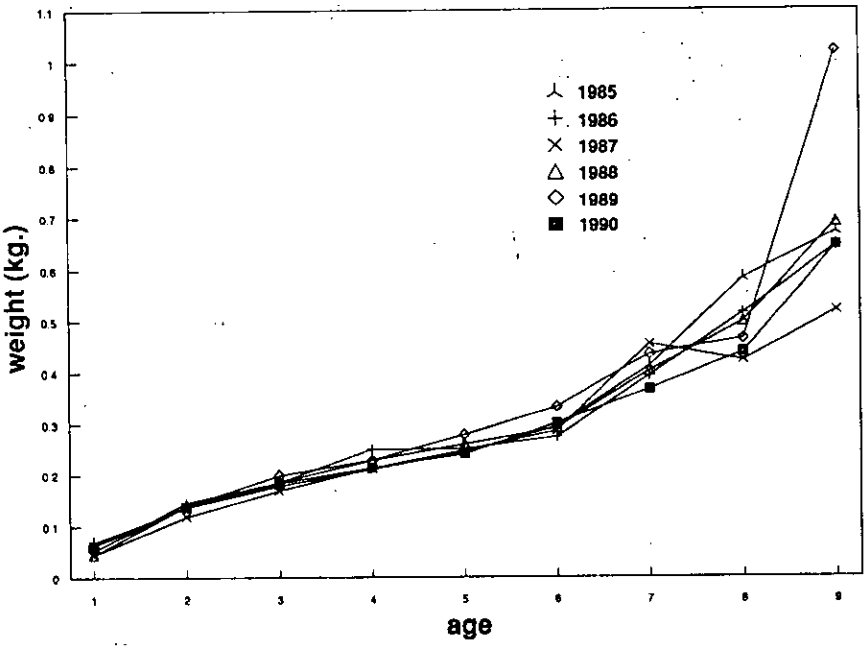
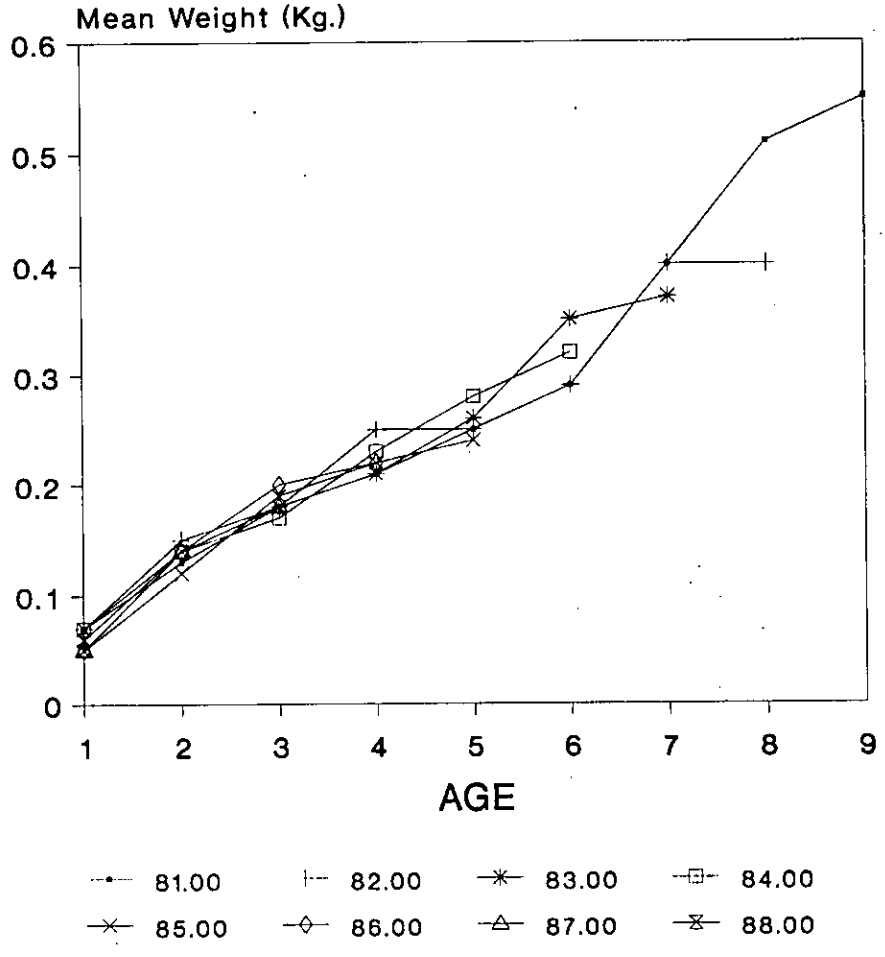



Fig. 8. Silver Hake mean weights at age by yearclass




Year Class Label Above

Fig. Silver Hake Fishing Mortalities by Year and Age

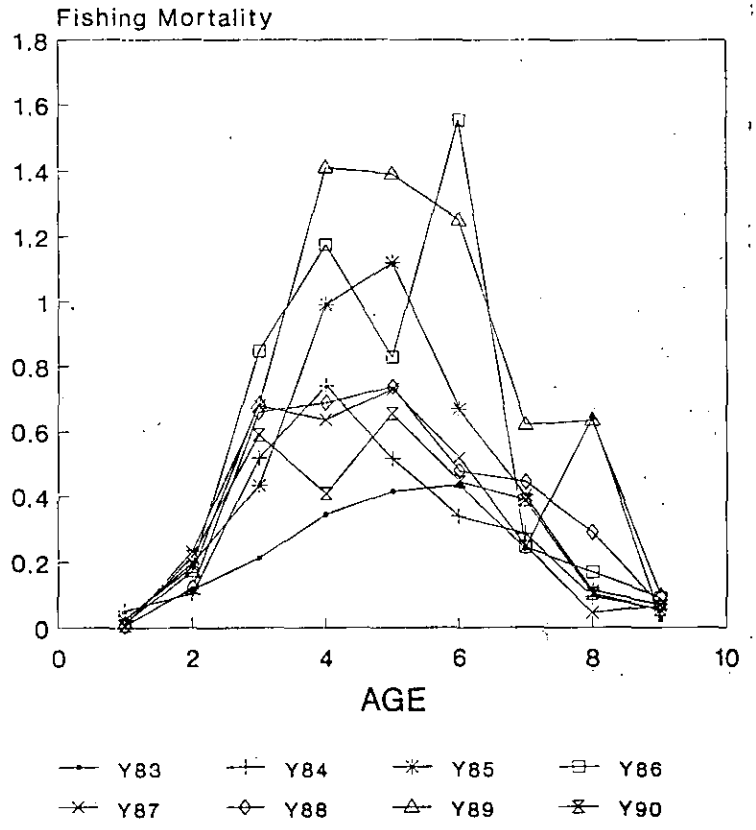



Fig. 10. Population Numbers for silver hake