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# Evaluation of Changes in Weight at Age and Growth Rate for 4VWX Silver Hake, 1983-94

by

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## Introduction

In the last review of stock status for 4VWX silver hake it was noted that mean weight at age and length had shown a decreasing trend in recent years (NAFO, 1994). Preliminary investigations of possible causes for decline concluded that the low length-weight parameters derived from the 1993 Canadian summer survey were the source. However, this was assessed to be an artifact and average mean weights for the 1989-93 commercial fishery were used for catch projection.

The present study was undertaken to examine size at age and weight at length for the 1983-94 time period in order to document trends and to consider possible errors in the data.

## Material and Methods

Timing of the Canadian summer survey, progression of length and age modes, maturity composition and distribution of the population were evaluated. Recent changes in Canadian age determination responsibility and training have been fully documented (Hunt and Bourbonnais, 1994; Bourbonais and Hunt, 1995) with no apparent bias between readers. However, age determination was considered to be a potential source of bias and was included in the analysis.

The Canadian summer survey was used as the primary source of data to ensure consistency in the methodology for data collection, measurement and documentation. To provide a comparison with commercial fishery data only information relating the Scotian Shelf (Canadian strata 453 to 478) was used in the analyses of length and weight.

Survey data are collected using a two phase sample design in which one fish per sex per one centimetre length interval are selected from the length frequency for detail observation on length, individual weight and maturity stage. Therefore it is necessary to use age length keys to partition the length frequency data to obtain total population estimates. Standard computer software (STRAP; Smith and Somerton, 1981) was used for these calculations.

The population length frequencies for 1983-94 was examined to compare progression of modal components and the assignment to age group for these components.

The observed mean weight at length for the 20-30 centimetre range was used to assess any trend over the time period and to determine if specific lengths accounted for the trend. Length weight parameters for the entire observed length range as well as the 20-35 subset were derived using a multiplicative model.

Maturity stage was used to calculate the proportion of the population in pre-spawning condition at the time of the survey. This information was used to estimate the potential influence of gonadal weight on the observed total body weight.

The influence of spatial distribution of the population within the 4VWX area was examined. Abundance in the 4W, 4X and Bay of Fundy geographic areas was used as a measure of stock distribution.

## Results

The population length frequency and derived age components for 1983-94 are shown in Figure 1 for lengths from 6 to 35 centimetres. Age components are shown as shaded areas with the age one component in year t progressing to age two in year t+1 and age three in year t+2 for ages one to three. Both the length and age modes appear to follow a logical progression with high abundance in one year reflected in the following year. For example, the very abundant group at 14-22 cm in 1986 (age one) appears as a strong component in 1987 at 22-28 cm (age two). There do not appear to be many indications of incorrect assignment to age as might be reflected in substantial overlap or discontinuity in distributions.

It is apparent from Figure 1 that the modal lengths have shown a substantial decrease in recent years and in particular those at age one in 1993 and 1994 are the smallest observed. There is also an increase in the number of fish less than 12 cm and in 1994 there is evidence of a bimodal distribution, similar to that seen in 1984 but at much smaller lengths. The variation in the size of the first mode is even more evident in Figure 2 which overlays data for the entire time series.

Calculated mean length at age is given in Table 1 and in Figure 3. The decrease in size at age appears to be most evident in the last three years of the series and occurs for all three age groups. Size at age in 1994 is about 2 cm less than the long term average but the decrease appears to have been gradual with no indication of an abrupt change which might be associated with bias in age determination.

Mean length at age in the 1992-94 commercial fishery for the 1989-93 year classes is shown in Figure 4. Results are consistent with those of the research survey and show a substantial decrease in size over the time period. The apparent decrease in the size at age one between May and June, 1994 is probably due to the partial recruitment of the smaller mode seen in the 1994 survey data.

Weight at length derived from 1983-94 survey data are shown in Figure 5. Results indicate a relatively small variation in weight for most of the length range although there is some divergence at lengths >45 cm, probably due to smallsample size. The observed weight at length is shown in Figure 6 and there is evidence of some strong year effects. In particular, weights in 1990 appear to be anomalously high while those in 1989 are below average. To investigate these effects, a similar analysis for cod was completed for 1989 and 1990 but the year effect was not apparent. Data entry and editing were also verified with no evidence of measurement or calibration error. However, 1990 was the first year in which electronic balances were used for fish weights. These balances provide a more precise measure of weight and also permit weighing of fish less than 50 gm.

Annual parameters of the length weight relationship, for the entire length range and the 22-35 cm subset, are given in Table 2. The predicted weight at 25 cm using these parameters is also provided and are shown in Figure 7. As expected, the values for 1989 and 1990 show a very abrupt change from one year to the next. However, the trend for decreasing weight at length since 1990 is evident with a slight increase in 1994 over 1993.

The mean date of the research surveys is also given in Table 2 but there appears to be no trend in timing.

The proportion by maturity stage is shown in Figure 8 and summarized for pre-spawning fish (stages R1, R2, ripe and spawning) in Figure 9. The proportion was variable over the time series with some indication of a declining trend since 1991. This would imply that more fish had completed spawning prior to the survey in the recent part of the time series and that the contribution of the gonad to total weight had therefore decreased.

The impact of maturity stage on weight for three length groups (26, 28, 30 cm) is shown in Figure 10. In general, weight at length increases as maturity progresses and then declines in the post-spawning stages.

The relative contribution of the three geographic areas is shown in Figure 11. The 4W area accounts for highest proportion of the abundance in most years but 1983, 1989 and 1992 show a substantial contribution from the 4X area. The Bay of Fundy typically contributes a small proportion but was above average in 1986 and again in 1993. The influence of area on size at age was not investigated but the apparent shifts could produce changes in rates of maturation, specific growth rates and condition factor.

## Conclusions

Results of this study confirm that a decrease in both size at age and weight at age of silver hake in the Scotian Shelf area have occurred in recent years. Investigation of age determination does not appear to show evidence as the source of this decrease. The change in size at age is consistent with the shift to smaller modal lengths in the length frequency and age data match length modes with good correlation. The decrease in mean length appears to have been gradual rather than abrupt, as might be expected if an ageing bias or error had been introduced. Analysis with length alone tracks the decline seen with age as a factor and further reduces the probability of ageing error.

Changes in the timing of spawning in relation to the summer research survey appear to be a factor which could result in a reduction in total weight.

The apparent anomaly seen in the 1989 and 1990 weight at length may be associated with the change from spring to electronic balances. It would therefore be more appropriate to consider the average weight at length since 1990 as indicative of a declining trend.

## References

Bourbonnais, M.C. and J.J. Hunt. 1995. Update on age training for silver hake. NAFO SCR. Doc. 95/53 Number N2564 4p

Hunt, J.J. and M.C. Bourbonnais. 1994. Summary of age training for silver hake. NAFO SCR Doc. 94/34 Number N2402 7p.

NAFO. 1994. Scientific Council Reports for 1994. p 82.

Smith, S.J. and G.D. Somerton. 1981. STRAP: a user-oriented computer analysis system for groundfish research trawl survey data. Can Tech. Rep. Fish. Aquat. Sci. , 1030:iv+66p

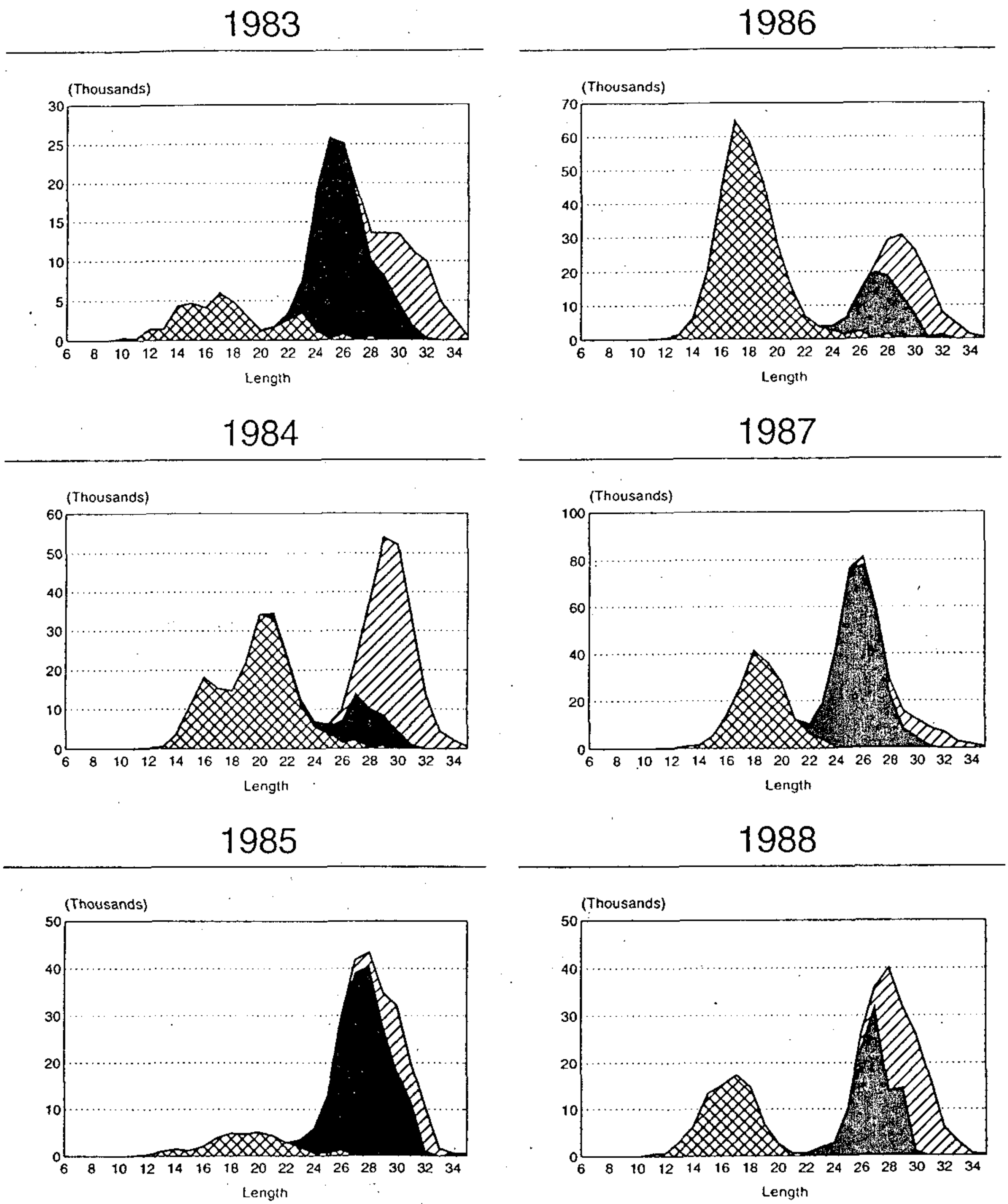
Table 1. Mean length at age for males and females from 1983-94 surveys.

| Year | Age 1 | Age 2 | Age 3 |
|---|---|---|---|
| 83 | 17.41 | 26.12 | 30.95 |
| 84 | 19.63 | 27.26 | 29.67 |
| 84 | 18.97 | 27.70 | 30.30 |
| 85 | 17.97 | 27.61 | 30.12 |
| 86 | 18.49 | 25.78 | 30.32 |
| 88 | 16.50 | 26.86 | 29.49 |
| 89 | 18.11 | 26.61 | 28.84 |
| 90 | 18.32 | 27.05 | 29.25 |
| 91 | 18.35 | 26.44 | 29.38 |
| 92 | 17.70 | 25.75 | 28.51 |
| 93 | 16.73 | 26.25 | 28.75 |
| 94 | 14.96 | 24.46 | 27.43 |

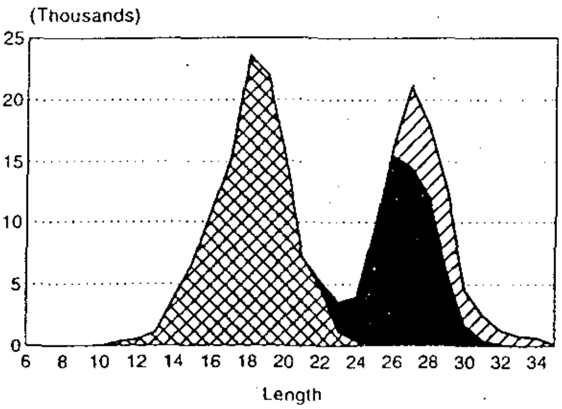
Table 2. Mean calendar day Canadian summer surveys, estimated length/weight parameters for entire length range (total) and for the 20-35 cm subset (20-35) and the predicted values of weight for a 25 cm fish. (weight (gm)) = (EXP a) X (Length (cm))$^b$

| Year | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | 196 | 206 | 195 | 198 | 189 | 195 | 196 | 194 | 195 | 184 | 196 | 195 | 195 |
| | | | | | | | | | | | | | |
| $a_{total}$ | -4.971 | -4.714 | -5.275 | -5.091 | -4.914 | -5.189 | -5.377 | -4.222 | -5.487 | -5.754 | -5.305 | -5.472 | -4.97 |
| $b_{total}$ | 3.014 | 2.951 | 3.104 | 3.054 | 3.004 | 3.097 | 3.136 | 2.816 | 3.166 | 3.253 | 3.087 | 3.150 | 3.009 |
| $L_{25\ cm}$ | 113.4 | 119.9 | 112.0 | 114.5 | 116.4 | 119.1 | 111.7 | 126.7 | 110.3 | 111.9 | 102.8 | 106.4 | 111.8 |
| | | | | | | | | | | | | | |
| $a_{20\text{-}35}$ | -5.572 | -5.010 | -5.035 | -5.524 | -5.439 | -4.966 | -5.560 | -3.894 | -5.464 | -5.768 | -5.646 | -5.462 | -5.26 |
| $b_{20\text{-}35}$ | 3.161 | 3.018 | 3.013 | 3.153 | 3.136 | 3.015 | 3.166 | 2.698 | 3.147 | 3.257 | 3.181 | 3.132 | 3.084 |
| $L_{25\ cm}$ | 99.8 | 110.5 | 105.9 | 101.9 | 105.0 | 114.4 | 102.5 | 120.3 | 106.4 | 111.9 | 98.8 | 101.5 | 106.6 |

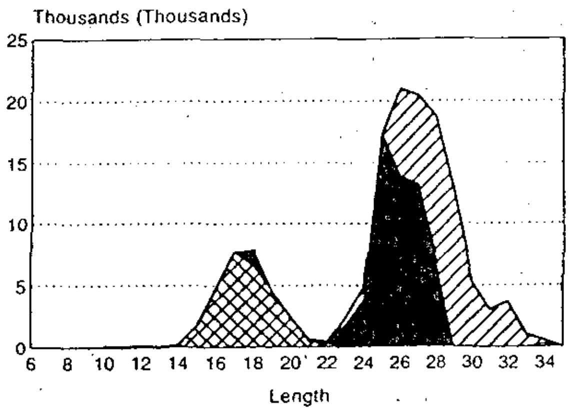
Figure 1. Population length frequency of silver hake derived from 1983-94 research surveys. Corresponding agegroups shown by cross-hatched areas for ages one to three



## 1989




## 1992

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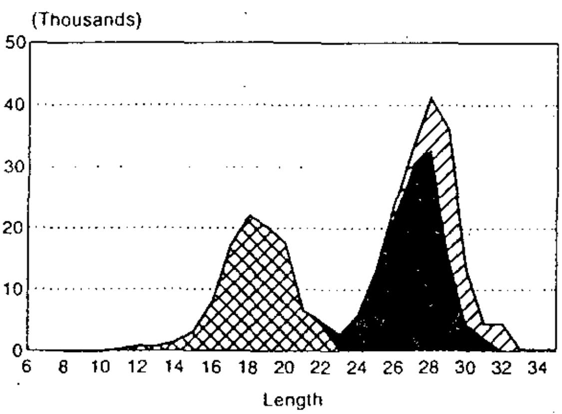
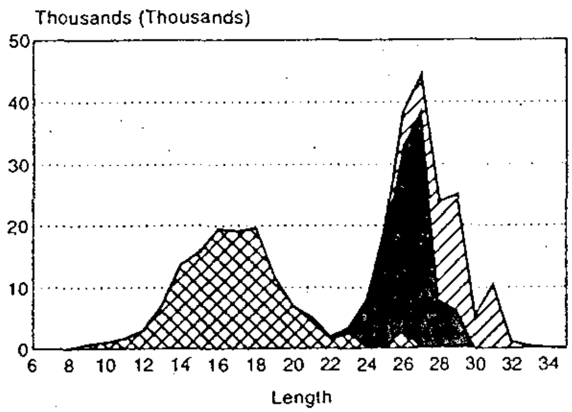
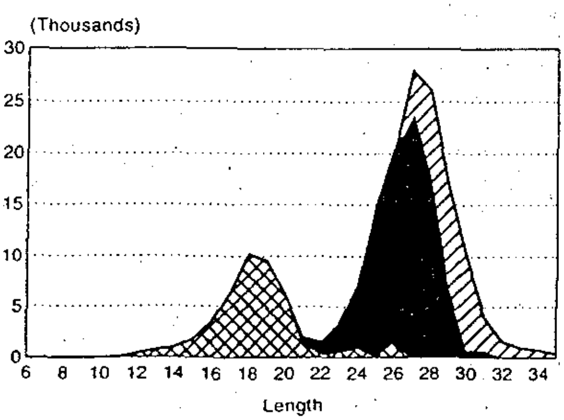


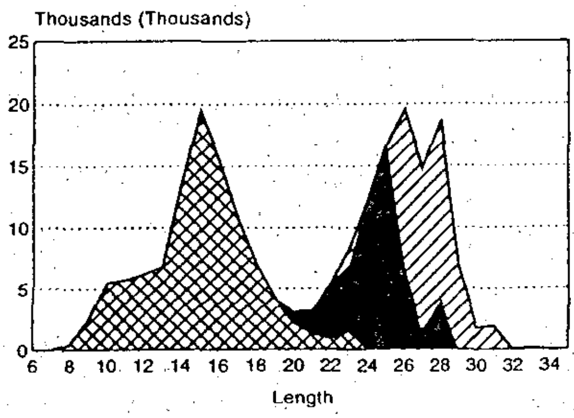

## 1993




## 1991




## 1994



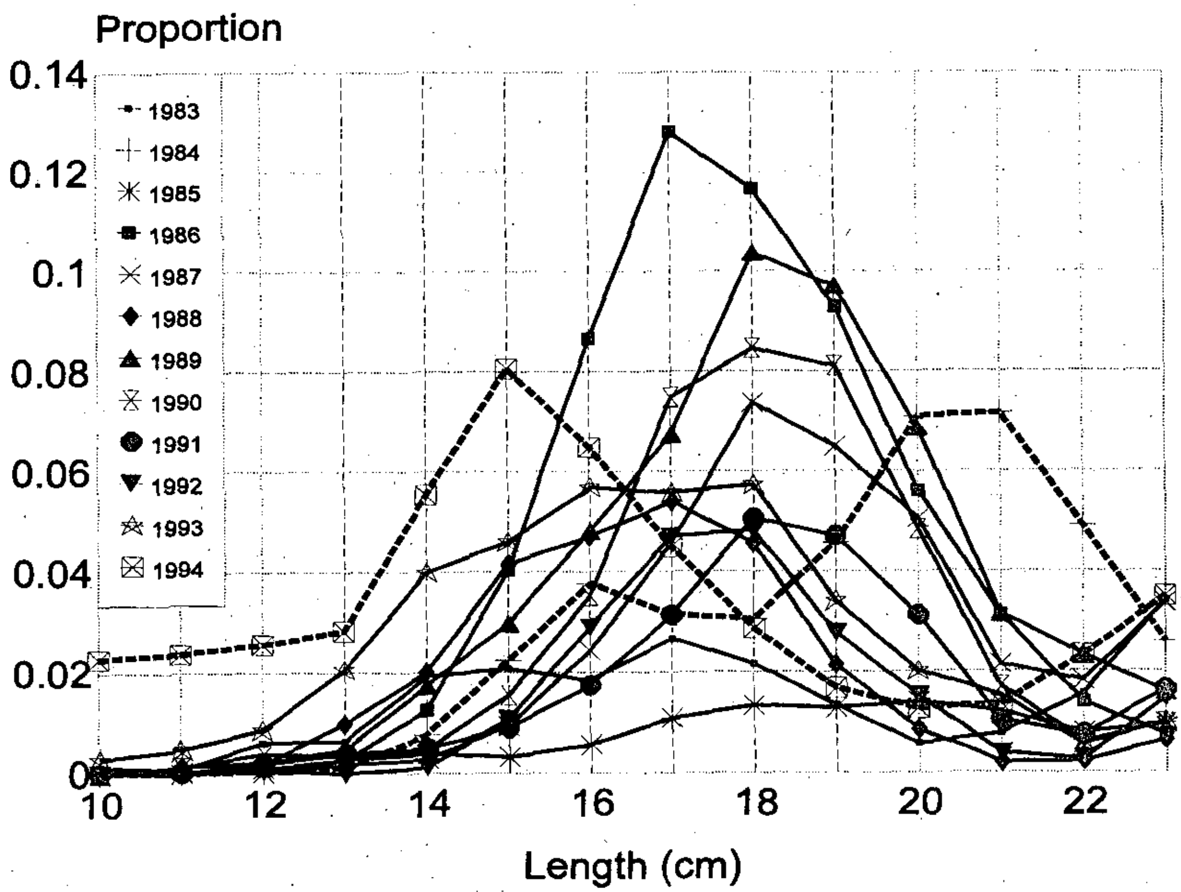



Figure 2. Silver hake population length frequency from surveys for fish 10-23 cm.

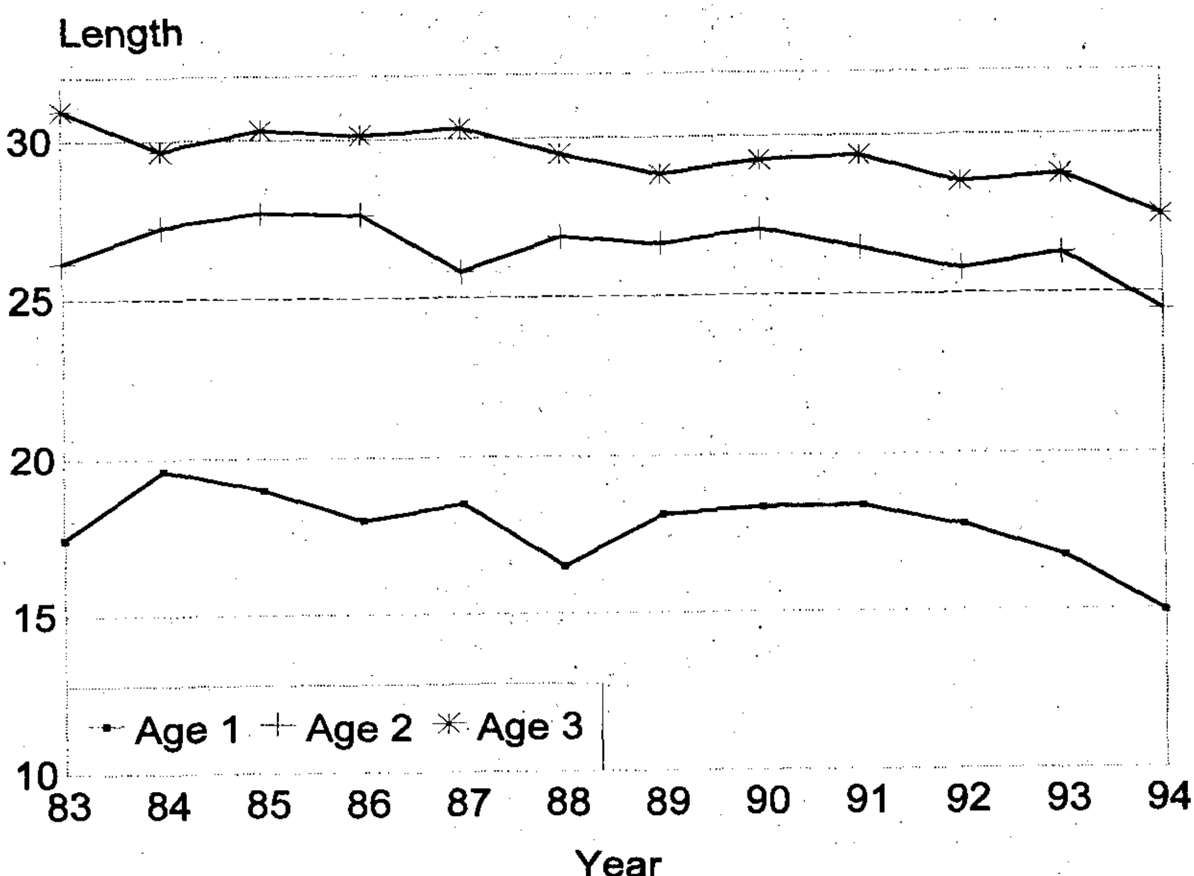



Figure 3. Mean length at age from surveys (sexes combined).

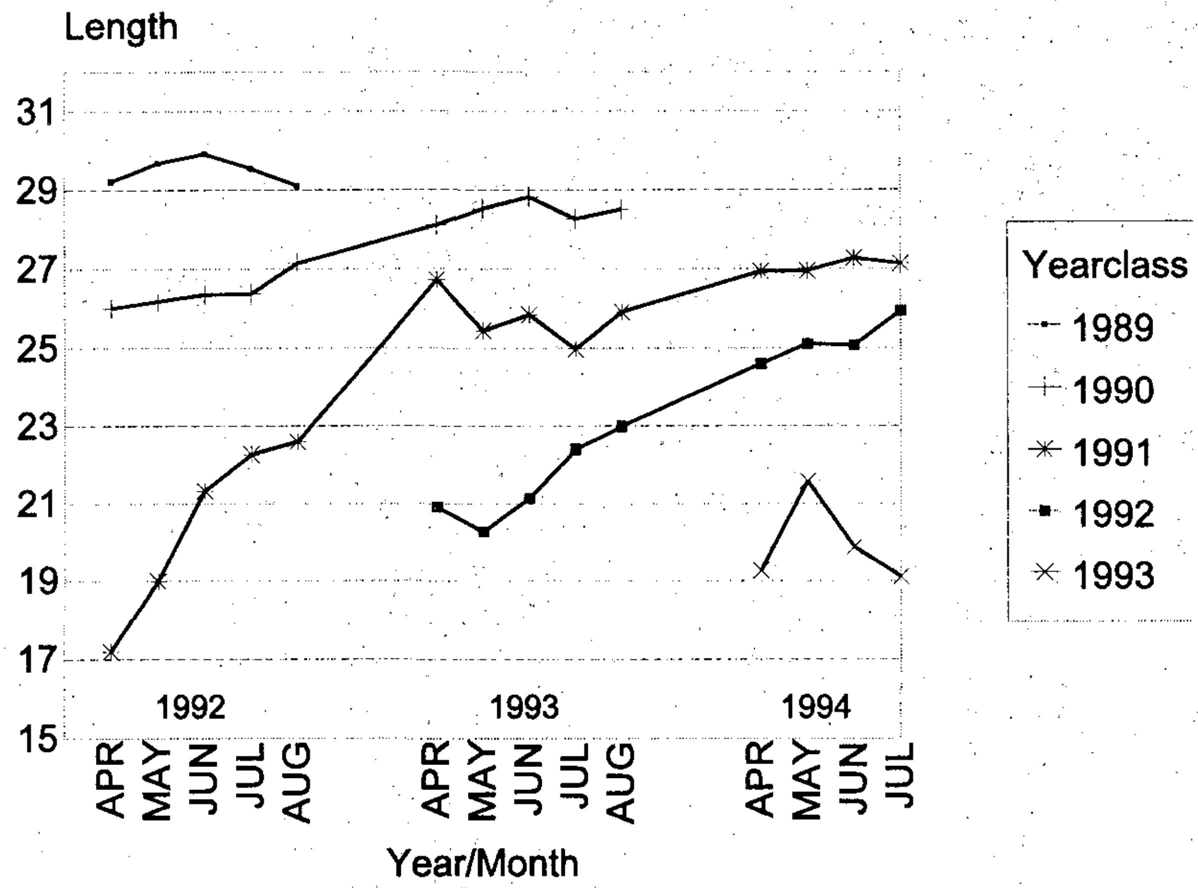



Figure 4. Mean length at age from 1992-94 commercial fishery samples.

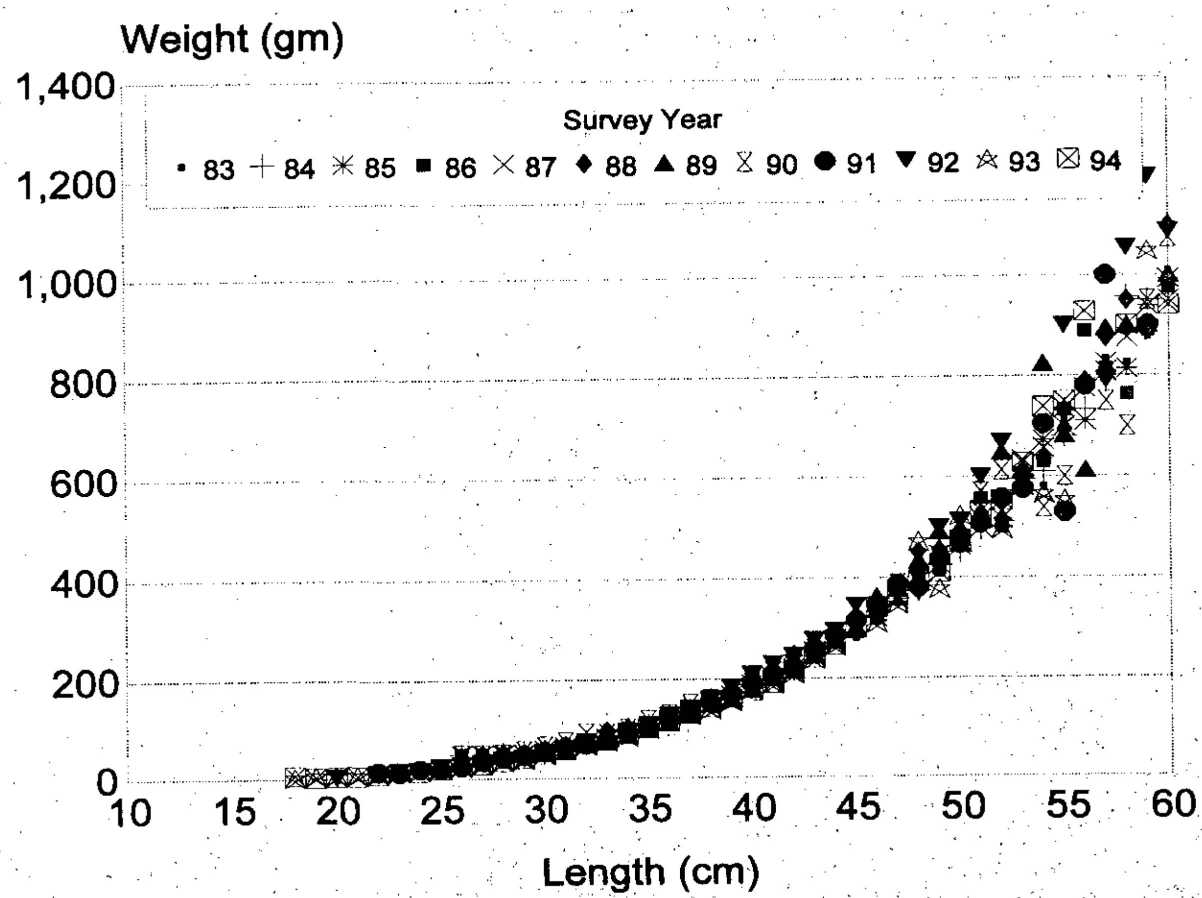



Figure 5. Weight at length for silver hake from surveys

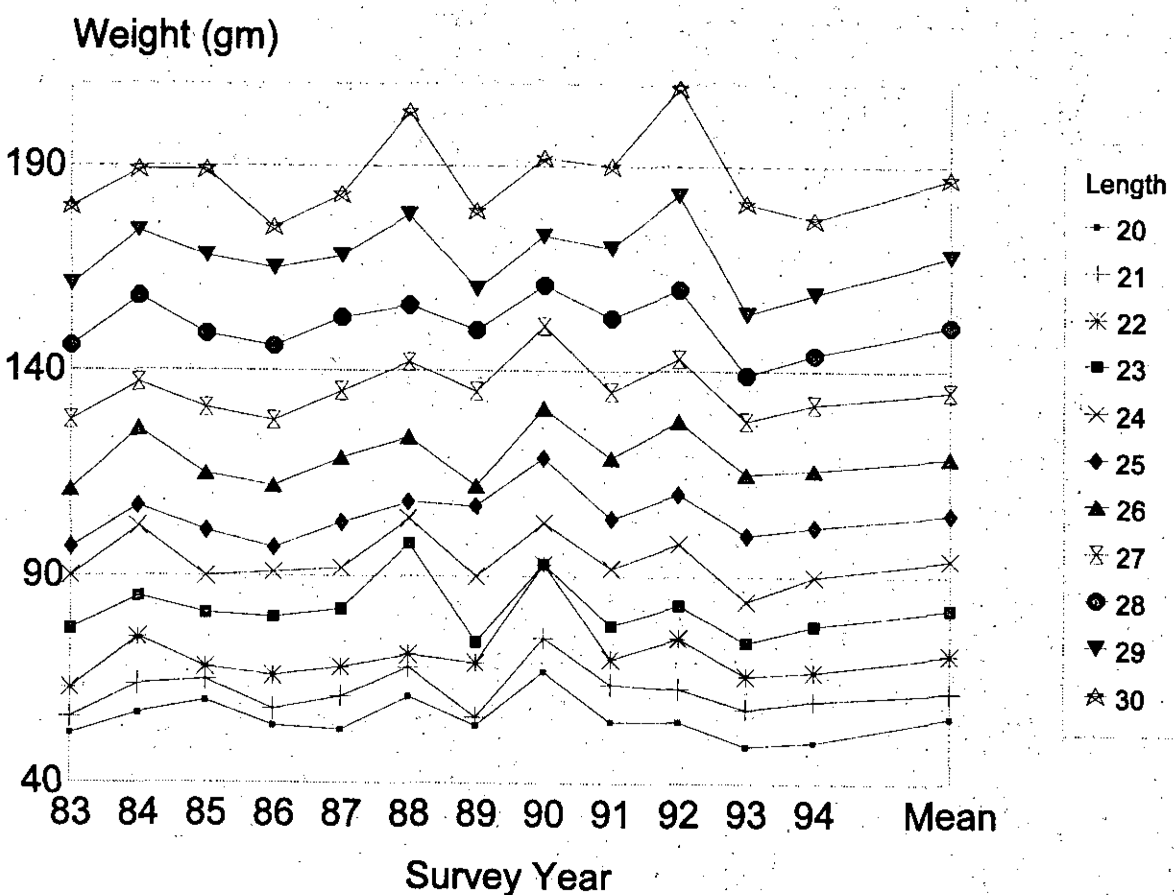



Figure 6. Mean weight at length for silver hake from surveys.

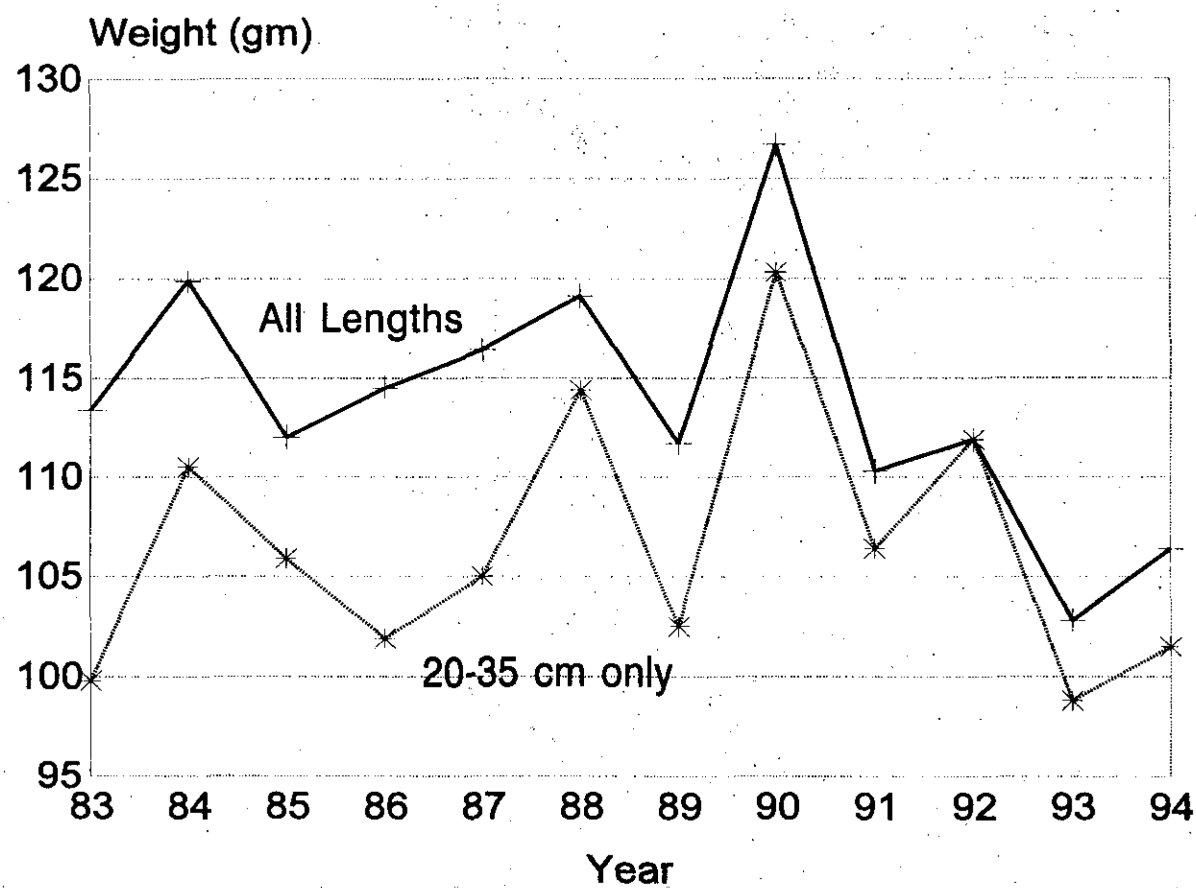



Figure 7. Calculated mean weight at 25 cm using survey length weight parameters

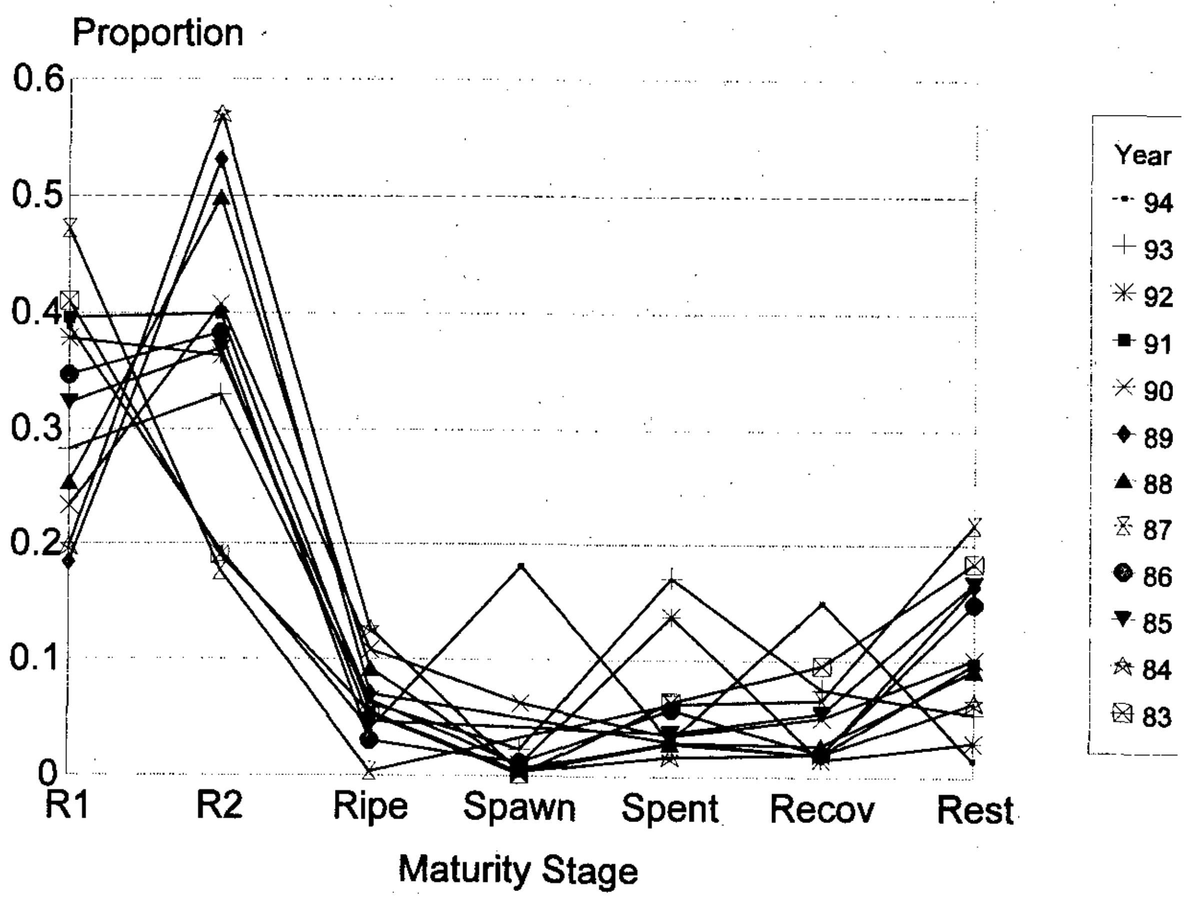



Figure 8. Proportion at maturity stage for silver hake during survey

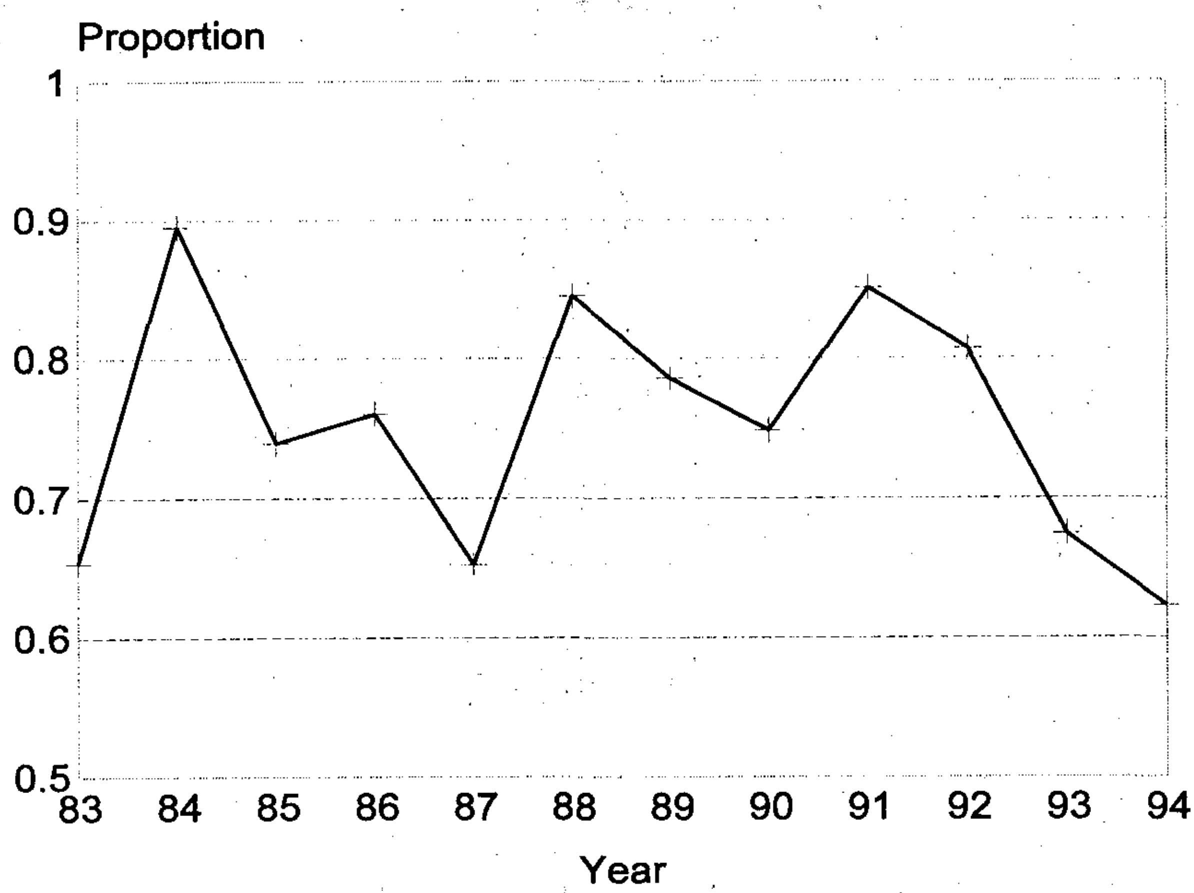



Figure 9. Proportion of mature silver hake in pre-spawning condition during survey.

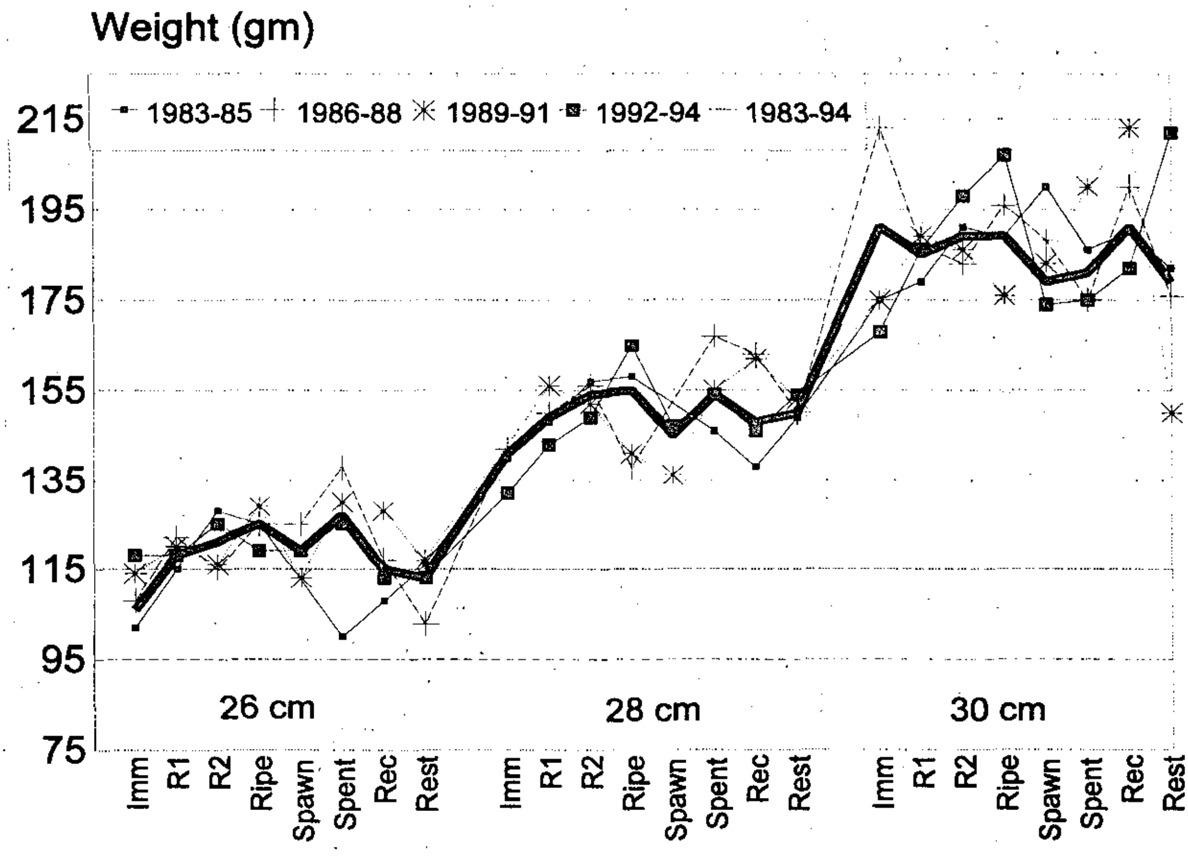



Figure 10. Mean weight at length by maturity stage for four time periods.

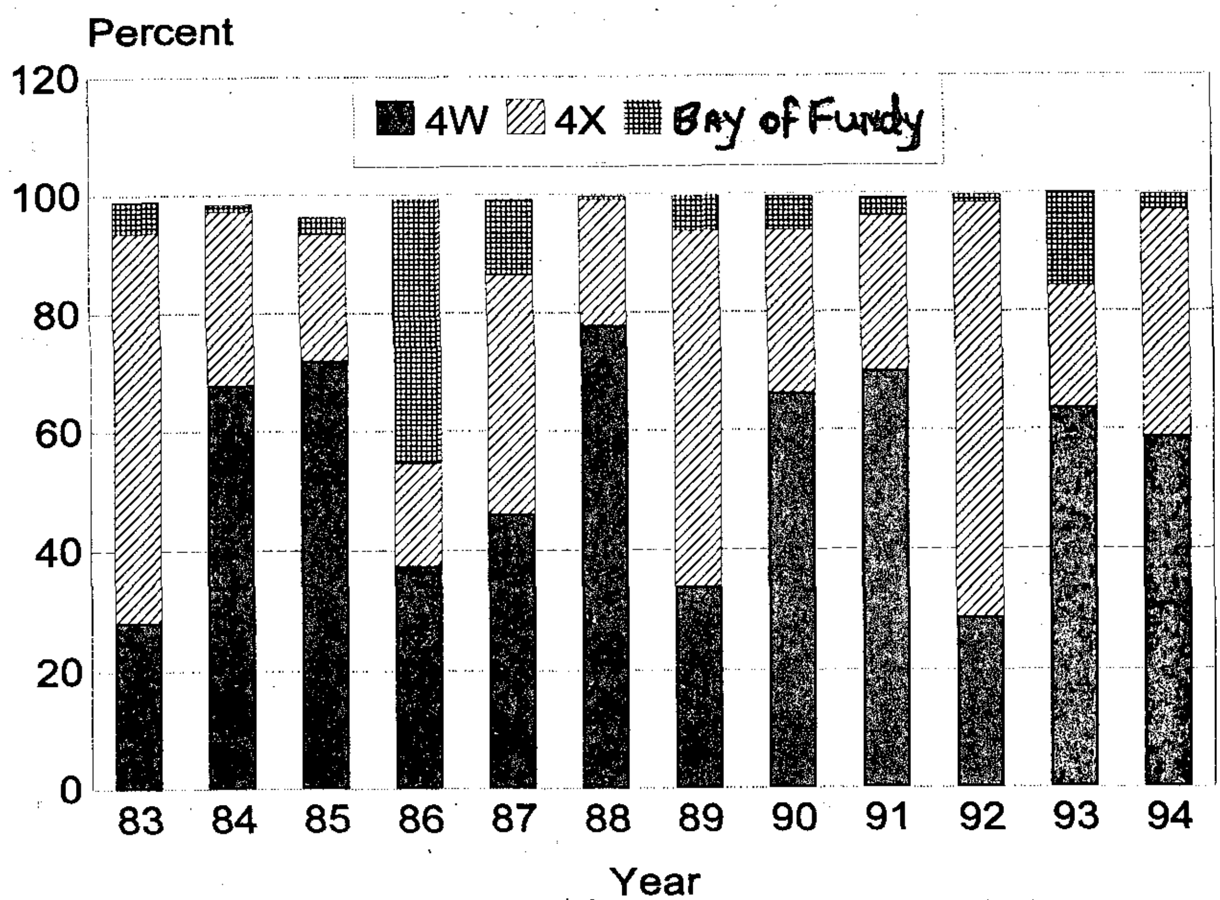



Figure 11. Proportion of total abundance by area for 4VWX silver hake.