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Trends in growth and condition of 4VWX silver hake, 1970-96.

by

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Abstract

Weight-at-length and weight-at-age data from Canadian summer groundfish surveys were examined for 4VWX silver hake to examine long term changes. Condition, expressed as expected weight at length, declined by 15% from 1970 to 1996. Survey timing did not explain this decline. Mean weight-at-age exhibited similar declines for both sexes. While timing of silver hake sampling accounted for some of the decrease, a decline was still evident after the effect of sampling date was removed. Weight-at-age is a function of both condition and mean length-at-age. As a result, the weight-at-age for this stock in recent years the was the lowest observed since 1970.

Introduction

In recent years commercial mean weight-at-age for 4VWX silver hake has dropped significantly (Showell, MS1996). These changes were evaluated (Hunt, MS1995) and it was concluded that the reduction was real rather than an artifact of age determination. As a result, in 1995 and 1996 a relatively short time series of mean weight-at-age was averaged for the calculation of potential future yields (Showell and Bourbonnais, MS1995; Showell, MS1996).

The purpose of the present study was to extend the time series of data evaluated back to 1970 and include data from the most recent years. Further, the analysis by Hunt (MS1995) did not include sex as a factor. Given the significant differences in growth rate between the two sexes in this species, it is possible that temporal trends might be masked by this treatment, and sexes were treated separately here.

Materials and Methods

A standardized bottom trawl survey has been conducted by Canada on the Scotian Shelf during summer since 1970. Stations are allocated using a random design stratified by depth. Observations on individual silver hake include length and weight by sex, as well as otoliths for age determination. Fish are selected for sampling stratified by sex and length, with one fish per 1 cm interval taken from each length frequency. The mean date of each survey, and the mean date when silver hake was sampled was calculated in Julian days (Table 1). Ages were determined using standard protocols for this stock (Hunt, 1980; Hunt MS1994). Growth parameters (a and b) were calculated by sex for each year using a ln-ln linear relationship (Table 2).

Results

The Canadian summer bottom trawl survey is generally conducted through the month of July. However, due to vessel scheduling logistics as well as equipment problems in some years, some inter-annual variation exists in the timing of the survey. Further, silver hake is often not encountered at the beginning and end of the survey due to the vessel fishing shallow inshore strata while near Halifax. Thus, the mean date when silver hake were sampled can differ from the mean date of the survey overall (Table 1). Mean silver hake sampling date was less variable than mean survey date. Differences in the mean sampling date for silver hake, in terms of days relative to the long term mean is presented in Fig. 1. Hunt (MS1995) examined the distribution of survey timing

over a shorter time series (1983-94) and concluded there were no trends. However, when the whole time series is examined a general temporal trend is apparent, with the survey occurring later in the mid-1970's and earlier in the period 1987-95. A maximum difference of 14 days is seen between the earliest and latest mean survey dates, and 12 days between extremes of sampling dates.

Condition, expressed as an expected weight for a given length, over a length range of 20-40 cm, which is representative of the general range found in the commercial fishery, declined for both sexes over the time series (Fig. 2). To illustrate these trends more clearly, the proportion deviation from the 1970-96 mean was calculated for a length of 25 cm, which is close to the mean length in the commercial catch (Fig. 3). The proportions are variable but there are indications of a declining trend in weight at length from the mid-1970s to the mid-1980s. A sharp decline is seen in 1993 and despite a subsequent increase, the expected weight at length is still almost 15% below levels seen in the mid-1970s. As both the mean date of the summer survey and the condition of male and female silver hake show a decline over the time series, it is possible to test if the changes in condition result from the survey timing. A regression analysis was conducted, with the mean sampling date (days) regressed against calculated weight (Table 3) for both males and females. A lack of a significant relationship suggests that mean sampling date is not a factor affecting the observed trends in condition.

A decline is seen in length-at-age for both sexes and all ages (Fig. 4) from high levels in the mid-1970s to 1994 which are the lowest in the time series, in most cases, and this is most clearly seen when the data are illustrated as deviation from the long term mean (Fig. 6). At ages 2-4, the main groups fished, mean length in 1994-95 was about about 15% smaller than in 1974-76.

As was the case for condition, survey timing might be the cause of these declines. To examine this, a regression analysis was conducted, with the mean sampling date (days) regressed against the mean length-at-age from the 1971-95 mean, for males (Table 4) and females (Table 5), at ages 3 and 4, chosen because they are well represented in the data and the commercial fishery. A significant relationship was seen for each combination of age and sex, indicating that a higher mean length-at-age was positively correlated a later average sampling date for the survey. However, the adjusted R^2 for the relationships ranged from 0.19 to 0.27, indicating the model accounts for a relatively low level of the total variation.

To determine if trends with time still exist in the data after survey timing was accounted for, the residuals from the regression analysis were examined over the time series (Fig. 6). While considerable variation exists, the pattern in the residuals shows the highest positive values for the mid-1970s, followed by relatively stable levels over 1978-92. A sharp decline was seen in 1993-94. Mean weight-at-age is a function of both condidtion and mean length-at-age. To examine trends in this parameter, the mean length-at-age was calculated for ages 4 and 5, adjusted for the effect of sampling timing. Mean weight-at-age was then calculated using the growth parameters for each year. The calculated weight-at-age showed a decline from 1970-84, followed by a period of relative stability from 1985-92. A further decline was seen in 1992 (Fig. 7). In 1995, weight-at-age was seen to increase, but still remains substantially below pre-1993 levels.

Conclusions

There have been long term changes in condition and size-at-age for 4VWX silver hake. Condition, expressed as expected weight for a given length, declined by 15% over the period 1970-95, while mean length-at-age decreased by 15% over a similar period. Weight-at-age is a function of both these factors are, and as a result, the weight-at-age in 1993-95 was the lowest observed since 1970. Trends in survey timing do not account for these differences.

References

Hunt, J.J. 1980. Guidelines for age determination of silver hake. J. Northw. Atl. Fish. Sci. 1:65-80.

Hunt, J.J. MS1994. Summary of age training for silver hake. NAFO SCR Doc. 94/34, Serial No. N2402, 7p

Hunt, J.J. MS1995. Evaluation of changes in weight at age and growth rate for 4VWX silver hake, 1983-94. NAFO SCR Doc.95/44, Serial No. N2554, 12p.

Showell, M.A. MS1996. Assessment of the 4VWX silver hake population in 1995. NAFO SCR Doc. 96/78, Serial No. N2753, 24p.

Showell, M.A. & M.C. Bourbonnais. MS1995. Status of the 4VWX silver hake population in 1994. NAFO SCR. Doc. 95/76, Serial No. N2753, 22p.

Acknowledgements

The author wishes to thank Dr. R. Halliday for significant discussion in the preparation and analysis of the survey data set.

Table 1: Timing of the Canadian 4VWX summer groundfish survey; mean date (calender days) and duration for the total survey and sets where silver hake were sampled, 1970-96.

Year	mean survey date	mean sampling date	duration (days)
70	199.00	198.12	21
71	191.81	190.67	16
72	186.87	189.63	11
73	201.96	199.74	20
74	202.57	199.89	22
75	206.89	202.92	16
76	205.14	202.06	19
77	200.30	199.61	21
78	200.79	200.00	21
79	197.40	197.40	21
80	198.16	197.95	20
81	195.58	194.00	19
82	201.05	199.94	18
83	197.00	195.24	19
84	203.55	202.44	21
85	195.72	194.81	21
86	199.43	199.43	23
87	195.44	192.58	21
88	196.50	194.71	21
89	196.70	196.26	22
90	197.32	196.05	27
91	197.29	196.26	24
92	185.96	188.82	15
93	199.43	195.00	21
94	196.96	195.90	24
95	188.48	190.43	19
96	198.65	197.76	26

Table 2: Growth parameters (alpha & beta) for 4VWX silver hake, derived from length-weight regressions of data collected during the Canadian 4VWX summer survey, 1970-96.

year	male alpha	male beta	female alpha	female beta
1970	-6.76518	3.55269	-6.2386	3.38492
1971	-5.34949	3.13816	-5.09611	3.06535
1972	-5.42428	3.13654	-5.56673	3.18647
1973	-5.46277	3.15837	-5.4369	3.14669
1974	-5.33557	3.11691	-5.44738	3.1479
1975	-4.32447	2.83456	-4.98435	3.03746
1976	-4.23852	2.78406	-5.05126	3.03537
1977	-5.07298	3.06263	-4.97121	3.03498
1978	-5.37521	3.1366	-5.78603	3.2531
1979	-4.58821	2.90006	-5.13582	3.06745
1980	-6.10705	3.34168	-6.32186	3.39888
1981	-4.98658	3.02055	-5.28309	3.11719
1982	-4.45318	2.85751	-4.99937	3.02324
1983	-5.03829	2.99348	-5.70676	3.20335
1984	-4.00158	2.70523	-5.03702	3.02842
1985	-4.30686	2.7848	-5.39717	3.12351
1986	-4.83169	2.93837	-5.56734	3.16852
1987	-4.60644	2.87981	-5.46268	3.14565
1988	-4.24493	2.79421	-5.33862	3.12408
1989	-5.11396	3.03073	-5.42768	3.13237
1990	-3.41246	2.53669	-4.06146	2.75163
1991	-4.85714	2.95822	-5.65837	3.20357
1992	-5.53706	3.18243	-5.75825	3.25329
1993	-5.66624	3.17799	-5.78005	3.22019
1994	-5.70313	3.20091	-5.76135	3.22278
1995	-5.70188	3.21505	-6.04611	3.32334
1996	-5.97256	3.29085	-6.00515	3.30326

Table 3: Summary of regression results for condition of 25 cm male and female 4VWX silver hake vs mean sampling date.

Equation Number 1 Dependent Variable.. COND_25M

Block Number 1. Method: Enter SAMP_DAY

Variable(s) Entered on Step Number 1.. SAMP_DAY

Multiple R	.25676	Analysis of Variance			
R Square	.06593		DF	Sum of Squares	Mean Square
Adjusted R Square	.02856	Regression	1	73.02325	73.02325
Standard Error	6.43306	Residual	25	1034.60521	41.38421
		F = 1.76452		Signif F = .1961	

---------- Variables in the Equation ----------

Variable	B	SE B	Beta	T	Sig T
SAMP_DAY	.433877	.326628	.256764	1.328	.1961
(Constant)	23.623144	64.220004		.368	.7161

End Block Number 1 All requested variables entered.

Equation Number 1 Dependent Variable.. COND_25F

Block Number 1. Method: Enter SAMP_DAY

Variable(s) Entered on Step Number 1.. SAMP_DAY

Multiple R	.14495	Analysis of Variance			
R Square	.02101		DF	Sum of Squares	Mean Square
Adjusted R Square	-.01815	Regression	1	23.81769	23.81769
Standard Error	6.66274	Residual	25	1109.80158	44.39206
		F = .53653		Signif F = .4707	

---------- Variables in the Equation ----------

Variable	B	SE B	Beta	T	Sig T
SAMP_DAY	.247791	.338290	.144949	.732	.4707
(Constant)	60.248447	66.512866		.906	.3737

Equation Number 1 Dependent Variable.. M_3_LEN

Block Number 1. Method: Enter DAY

Variable(s) Entered on Step Number 1.. DAY

Multiple R	.54763	Analysis of Variance			
R Square	.29990		DF	Sum of Squares	Mean Squar
Adjusted R Square	.26946	Regression	1	9.91035	9.9103
Standard Error	1.00293	Residual	23	23.13505	1.0058

F = 9.85250 Signif F = .0046

---------- Variables in the Equation ----------

Variable	B	SE B	Beta	T	Sig T
DAY	.160683	.051191	.547632	3.139	.0046
(Constant)	-2.003361	10.059556		-.199	.8439

End Block Number 1 All requested variables entered.

Equation Number 1 Dependent Variable.. F_3_LEN

Block Number 1. Method: Enter DAY

Variable(s) Entered on Step Number 1.. DAY

Multiple R	.50228	Analysis of Variance			
R Square	.25229		DF	Sum of Squares	Mean Squar
Adjusted R Square	.21978	Regression	1	15.44464	15.4446
Standard Error	1.41073	Residual	23	45.77394	1.9901

F = 7.76046 Signif F = .0105

---------- Variables in the Equation ----------

Variable	B	SE B	Beta	T	Sig T
DAY	.200593	.072006	.502282	2.786	.0105
(Constant)	-7.641133	14.149882		-.540	.5944

End Block Number 1 All requested variables entered.

Table 4: Summary of regression results for mean length-at-age (cm) vs mean sampling date (days) for age 3 4VWX silver hake (males & females).

Equation Number 1 Dependent Variable.. M_4_LEN

Block Number 1. Method: Enter DAY

Variable(s) Entered on Step Number 1.. DAY

Multiple R	.47096	Analysis of Variance			
R Square	.22180		DF	Sum of Squares	Mean Squar
Adjusted R Square	.18797	Regression	1	7.25676	7.2567
Standard Error	1.05213	Residual	23	25.46043	1.1069
		F = 6.55548	Signif F = .0175		

---------- Variables in the Equation ----------

Variable	B	SE B	Beta	T	Sig T
DAY	.137498	.053703	.470959	2.560	.0175
(Constant)	4.474975	10.553013		.424	.6755

End Block Number 1 All requested variables entered.

Equation Number 1 Dependent Variable.. F_4_LEN

Block Number 1. Method: Enter DAY

Variable(s) Entered on Step Number 1.. DAY

Multiple R	.54573	Analysis of Variance			
R Square	.29782		DF	Sum of Squares	Mean Squar
Adjusted R Square	.26729	Regression	1	22.37545	22.3754
Standard Error	1.51450	Résidual	23	52.75515	2.2937
		F = 9.75517	Signif F = .0048		

---------- Variables in the Equation ----------

Variable	B	SE B	Beta	T	Sig T
DAY	.241441	.077303	.545730	3.123	.0048
(Constant)	-12.699898	15.190640		-.836	.4117

End Block Number 1 All requested variables entered.

Table 5: Summary of regression results for mean length-at-age (cm) vs mean sampling date (days) for age 4 4VWX silver hake (males & females).

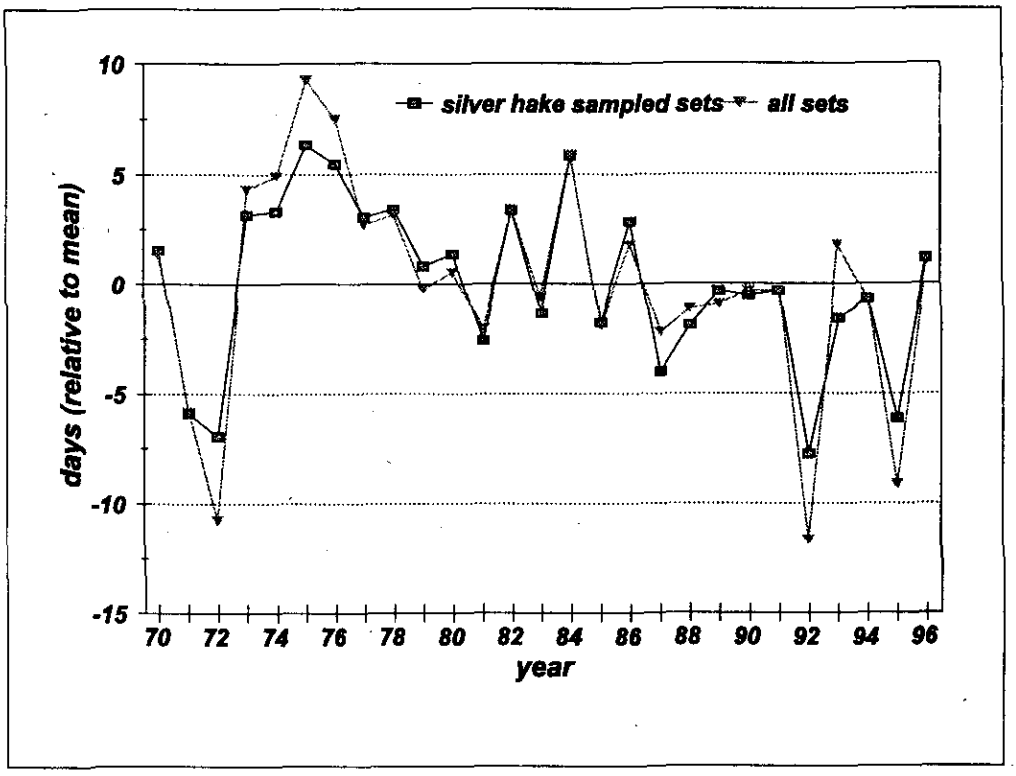


Fig. 1: Interannual variation in the timing of the Canadian summer 4VWX groundfish survey, in terms of total sets and silver hake sampled sets.

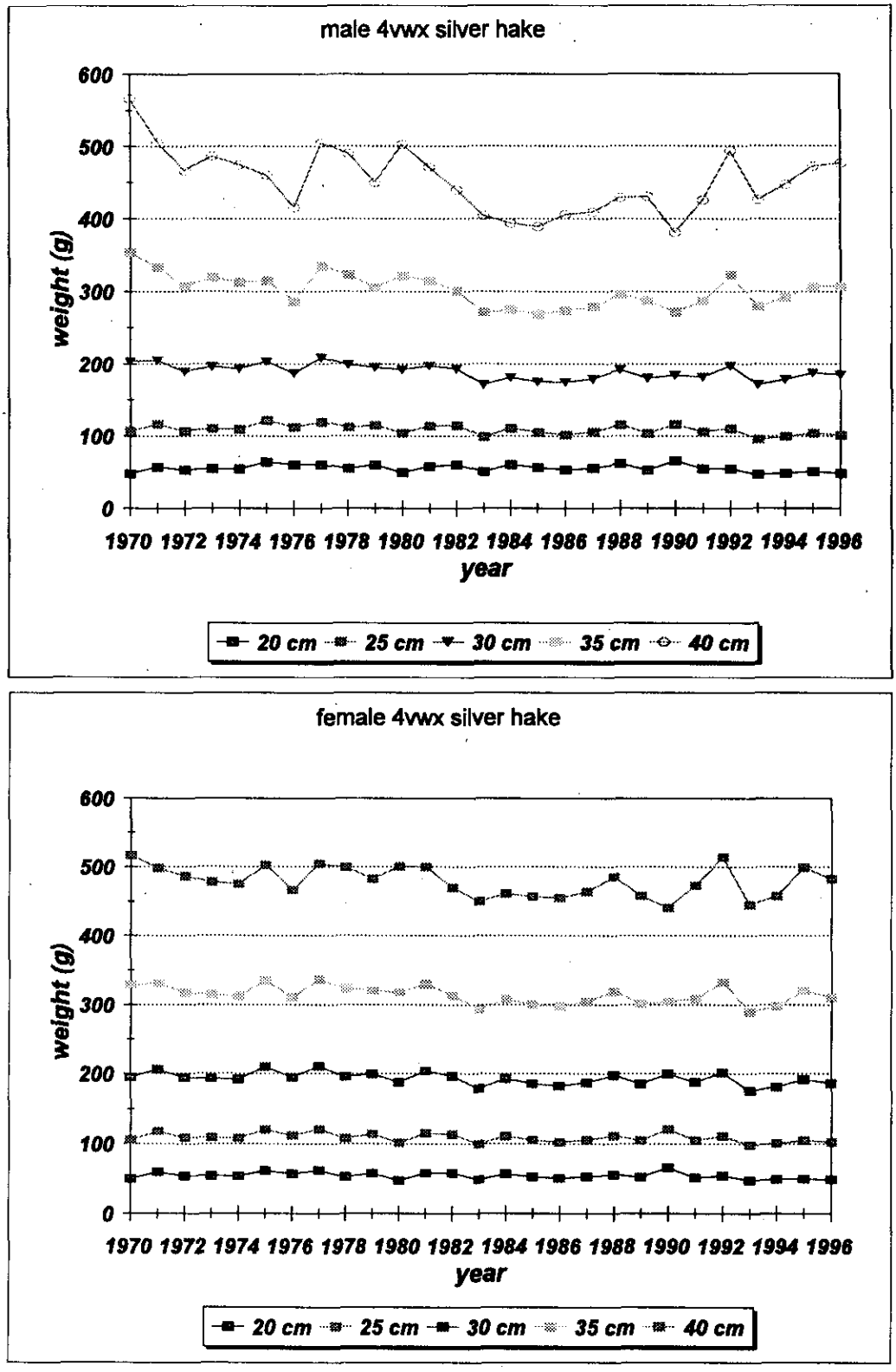


Fig. 2: Condition of 4VWX silver hake, calculated from survey length-weight relationships, 1970-96.

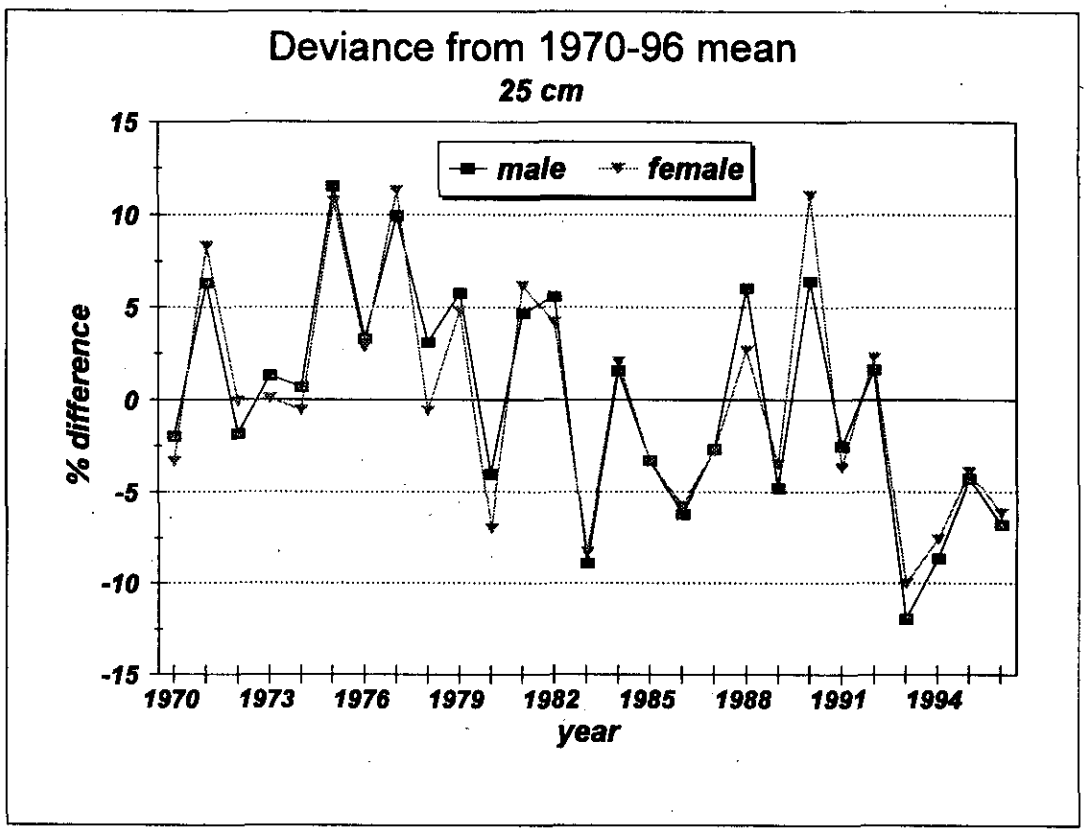
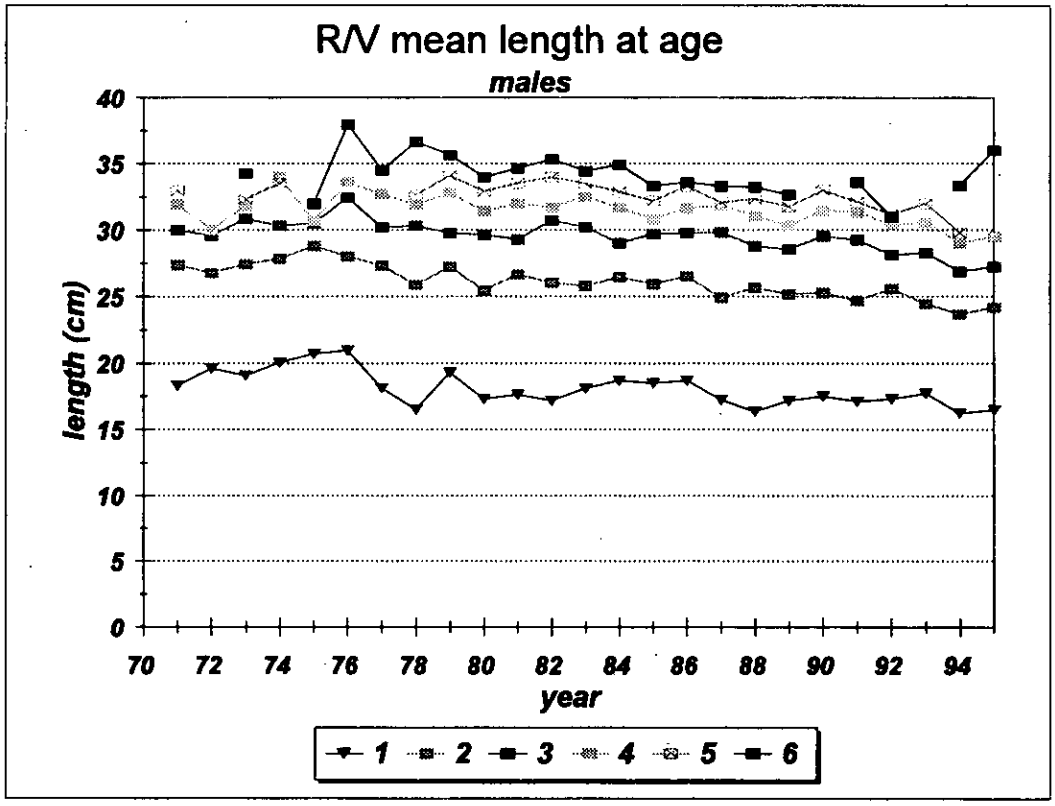


Fig. 3: Condition of 25 cm 4VWX silver hake, calculated from R/V length-weight data, with condition expressed as % deviation from the 1970-96 mean.



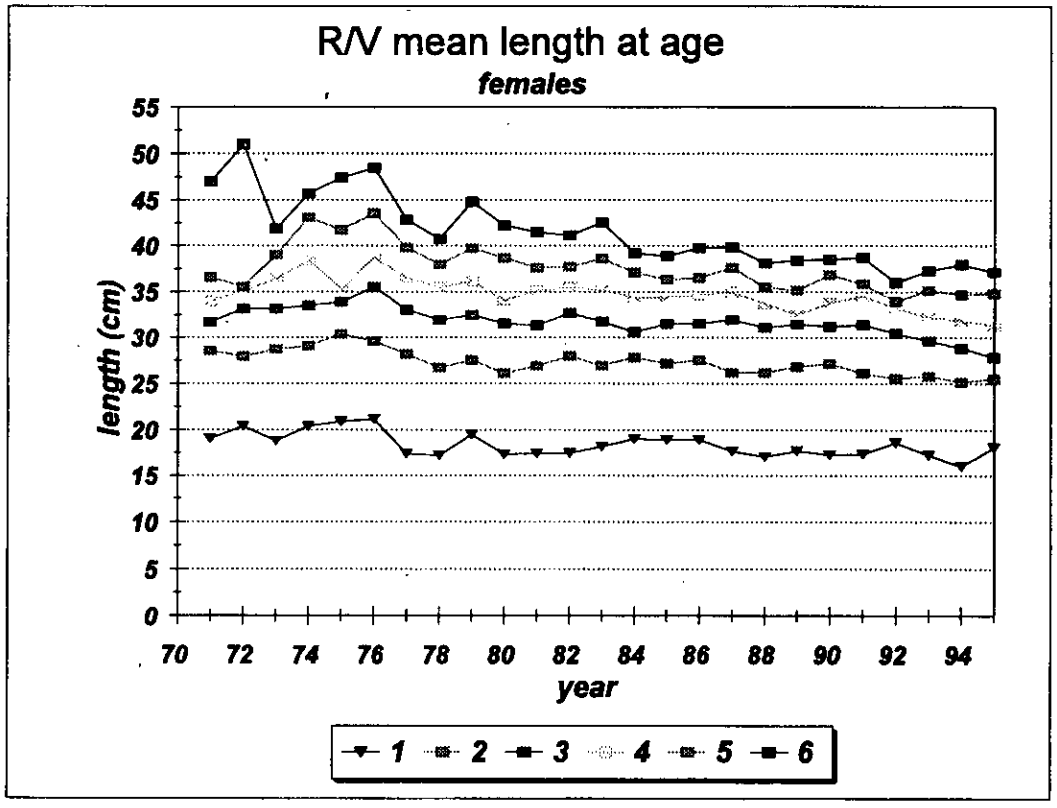


Fig. 4: Mean length-at-age for 4VWX silver hake, 1970-95, from Canadian summer survey data.

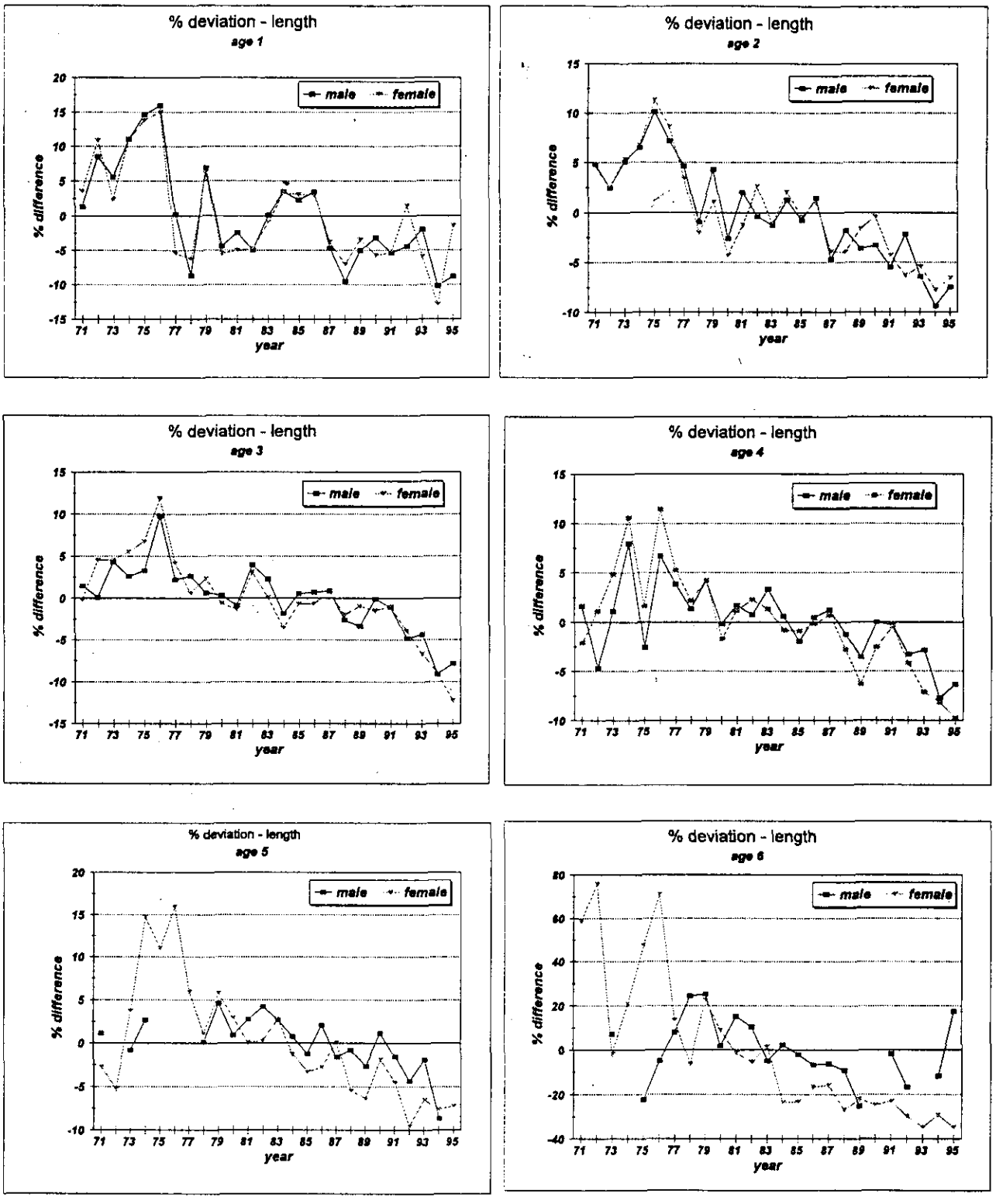


Fig. 5 Mean length-at-age for 4VWX silver hake, from summer survey data. Length-at-age is expressed as a proportion (%) of the 1971-95 mean, for ages 1 through 6 (males and females).

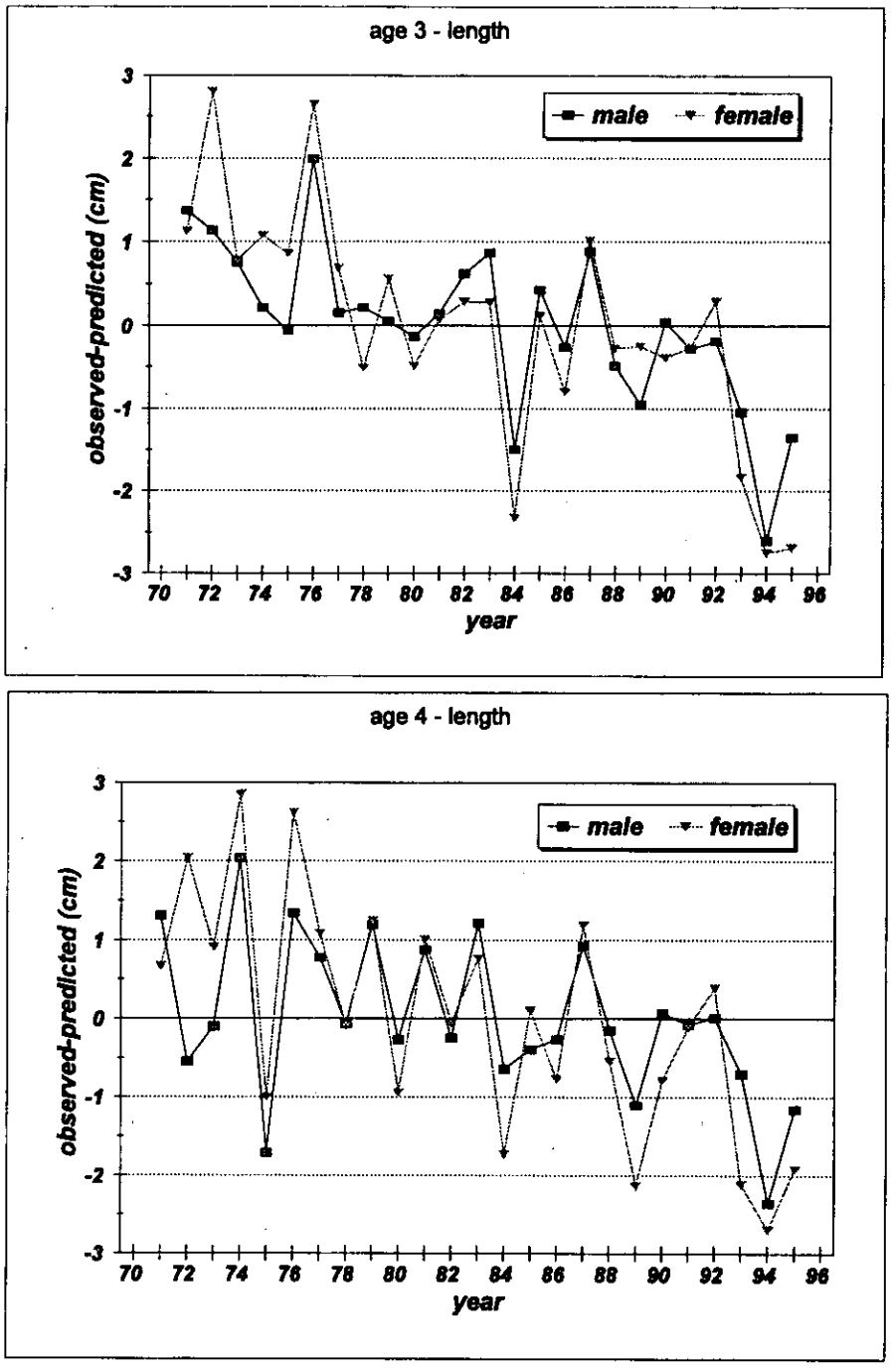


Fig. 6: Plot of residuals (observed-predicted) from regression analysis of timing of sampling vs mean length-at-age from Canadian July survey data, for 4VWX silver hake

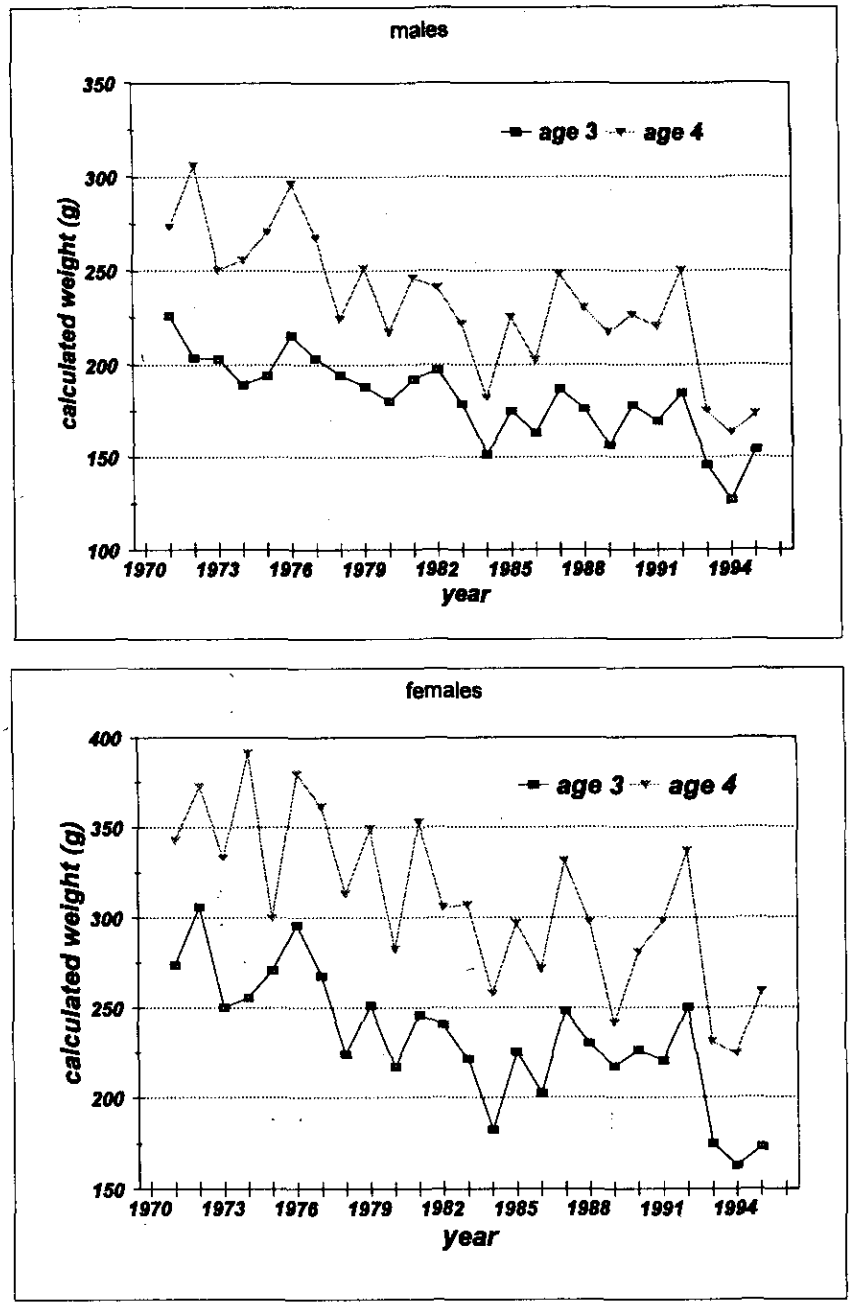


Fig. 7: Calculated weight-at-age for 4VWX silver hake, from Canadian summer survey data, incorporating condition and mean length at age, corrected for timing of sampling.