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Investigations into ADAPT formulations for estimation of Fratio (F between plus group and the last true age) for American plaice in Div. 3LNO

by

K.S. Dwyer, B.P. Healey, and M.J. Morgan, and R. M. Rideout

Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, NF, Canada A1C 5X1

Abstract

In 2010, for American plaice in Div. 3LNO, STACFIS recommended that "*ADAPT model formulations that estimate the F ratio between the plus group and the last true age be investigated and that model fit and resulting retrospective patterns be compared to the current formulation that has an Fratio constraint of 1.*" (NAFO 2011). These investigations involved estimating the Fratio over the entire time period, and estimating the Fratio for fixed blocks throughout the time series. These results were compared with the final ADAPT formulation from the 2011 American plaice assessment.

Introduction

Previous assessments of American plaice in Div. 3LNO used the ADAPTive framework (Gavaris, 1988) to produce estimates of stock size, SSB and fishing mortality. In 2001, the assessment of this stock (Morgan and Brodie, 2001) included a comparison of results from two different model formulations. The first model formulation estimated the ratio of F on the plus group relative to the last true age (i.e. the Fratio), while the other formulation set the Fratio equal to 1. Both runs gave similar estimates of population numbers over the last few years of the period considered but the formulation that estimated the Fratio, which was estimated at 0.5, resulted in slightly higher numbers and lower estimates of F prior to 1990. Details are not provided into the fit of the model. STACFIS concluded, however, that there was no external data to suggest that the selectivity pattern for American plaice was dome-shaped and therefore a flat topped fishing selectivity was assumed (i.e. Fratio = 1). Subsequent assessments of this stock, including the most recent assessment (Rideout *et al*., 2010), have used a model formulation with a fixed Fratio (1.0).

Annual PRs presented in these assessment documents however, provide some evidence that the fishing selectivity pattern for American plaice may not be as flat-topped as is assumed from the current assessment model formulation. STACFIS therefore requested that the method used to estimate F on the plus group be re-examined. This paper evaluated several formulations of ADAPT using results that were produced using ADAPT version 3.1. The mean square residuals (MSR), relative error and bias on the Fratio estimates were examined for all runs in order to determine the preferred model formulation. The resulting retrospective patterns of the various model formulations were also considered.

Methods

Partial recruitment was examined for each year (F at age divided by the maximum F on all ages in each year; Figure 1). Partial recruitment plotted in blocks of 5 years shows a progression from a flat-topped selectivity over 1960-1990 to a more domed-shaped fishing selectivity, especially during the 1990-1999 period, and less so during the most recent periods (Figure 1). However, during the 1990-1999 period, selectivity patterns are very different from year to year.

Catch-at-age and RV surveys at age data used in the ADAPT runs were taken from the 2011 final assessment for American plaice in Div. 3LNO (Rideout et al., 2011).

Within the ADAPT software there are two F-constraint methods used to handle analyses which utilize a plus group. These methods are used to construct the fishing mortality constraints to determine the cohorts for which survivors are not estimated.

Using the Fratio method, the population abundance of the plus-group in the terminal year must be estimated. For all years prior to the terminal year, the plus-group fishing mortality is derived as a ratio of the last true age F (α below), which can either be assigned or estimated. In this method, the catch data in the last true age and in the plus group is used in the estimation of the last true age F. That is:

$$F_{15+,\,y} = \alpha F_{14,\,y} \text{ for y in 1960-2010.}$$

For American plaice in Div. 3LNO, the plus group is age 15 +.

All ADAPT runs were compared with the 2011 assessment which constrained the Fratio at 1.0 (Rideout et al., 2011). The following ADAPT runs were attempted: A run that allowed ADAPT to estimate Fratio over the entire time series was attempted (Run A). Another set of runs in which the period from 1960-1985 had a fixed Fratio because there are no survey tuning indices associated with this time period and N is needed along with C to calculate F in the plus group. A number of Fratio values were looked at for assigning an F constraint for this period of time (1.5, 1.1 and 1.0), based on PR curves (Figure 1). The one that was felt to be the best was 1.1 because when the rate of F was calculated over the linear part of the PR curves (ages 8-14), the same rate was applied to 15+ and this F turned out to be 1.1. Then, some runs were tried whereby ADAPT was allowed to estimate Fratio by individual year, or with 1986-2010 as a block of time or two blocks: 1986-1994 (prior to the moratorium on fishing) and 1995-2010 (after the moratorium was instituted).

Another group of runs were tried that fixed Fratio for the time period of the stock collapse/early moratorium period (low catches) where the PRs showed very different patterns from year to year. A number of different F constraints were applied (0.5, 0.8 and 1.0) but also fixed at 0.26, which was the average of Fratios on the plus group over that same period when ADAPT was allowed to estimate them by year. Again, then a series of ADAPTs were run in which Fratio was estimated by year, all other years as two blocks of time (1986-1989 and 2000- 2010). In addition, there was a run which broke the most recent period into two time blocks (2000-2004 and 2005-2010) (Run K).

There was some effort put into exploring which years should be included in the fixed Fratio period during the time of the collapse of the stock and the period of small catches afterward (whether it was 1990-1999 or 1992-1998).

Table 1 gives the statistics and Fratio estimates for the selected runs examined in this paper.

CONCLUSION

Estimating Fratio by individual year

The runs with the lowest MSR tended to be the ones that estimated Fratio by individual year. However, these runs also had very high relative error and bias (in many cases >1.0 for relative error) on the Fratio estimates. Therefore, they were not considered further.

Estimating Fratio for blocks of time

The run that had the lowest MSR from the remaining runs (estimating Fratio for blocks of time) was Run M. The MSR on ages by surveys were similar for each of Run M and the 2011 final run (Table 1; Figure 2) up to age 11 for the fall survey; thereafter run M had the lowest MSR at age. In the spring survey, run M had the lower MSR values between ages 8-11 but higher or the same on the rest of the ages. Spain surveys had similar MSE on ages from both runs.

Figure 3 shows the percent of the biomass for that year that is in the plus group. Run M allots more biomass to the plus group than the final run with a fixed Fratio of 1.0, in the 1986 period to the present.

Catchability was higher for the final 2011 assessment run (Fratio constraint at 1.0) than the other run considered here, giving a lower estimate of biomass for the most recent time period (Figure 4).

An examination of a one year retrospective analysis of Run M indicates large revisions to the estimates of SSB from 2011 to 2010 (matrix) (Table 2). There is no improvement in the retrospective pattern from the 2011 final run by estimating Fratio in the ADAPT formulation (Table 2 and Table 3).

The ADAPT formulation used in the assessment of American plaice in Div. 3LNO should not estimate Fratio by individual years for all years in the time series. The ‘best’ run using ADAPT to estimate Fratio for blocks of time had an MSR of 0.270, which was lower than the final assessment

run MSR of 2010 (0.293). This structure also gave better diagnostics than the 2011 final run (lower MSR by age for most ages; reasonable values for the relative error and bias on the Fratio estimates).

However, it seems unlikely that the biomass estimated from run M during the 1980s would be as high or higher than the biomass from the 1960s (Figure 5). Figure 6 is a plot of the surveys over time for American plaice in Div.3LNO. It can be seen that the biomass in 1980-1990 would not be higher than 1975-1980 (and presumably not higher than the 1960s).

The estimates from ADAPT for similar time periods in different runs vary by changing the 1990s time period. Shifting the timing of this 'moratorium' (time of collapse and then very low catches afterwards) period alters the perception of the stock considerably and is sensitive to changes within that time period.

In addition, the retrospective analysis of this run showed an increased pattern compared to the 2011 assessment.

Finally, the current model formulation has a good fit, with small error on the population number estimates and although increasing in recent years, a small retrospective pattern. Run M has a slightly improved overall fit, but places a large portion of the biomass in the plus group (which works backwards to develop a large amount of biomass in the population in the 1980s, which is not in accordance with the perception of the stock based on surveys). Therefore it is recommended that there be no change to the current assessment.

References

Gavaris, S. 1988. An adaptive framework for estimation of population size. Can. Atl. Fish. Sci. Adv. Comm. (CAFSAC) Res. Doc. 88/29, 12p.
Morgan, M. J., and W. B. Brodie. 2001. An exploration of virtual population analyses for Div. 3LNO American plaice. NAFO SCR Doc. 01/4, Ser. No. N4368, 20p.

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Table 1. Mean square residual (MSR) and estimates of Fratio for the ADAPT runs considered in this paper. Numbers in parentheses after Fratio estimates refer to relative bias, and relative error, respectively.

Run	Fratio parameters	Fratio estimates	Fixed Fratio	Fixed value	MSR
Final run 2011	N/A	N/A	1960-2010	1.0	0.293
Run A	1960-2010	0.861 (0.058,0.004)	N/A	N/A	0.291
Run B*	1986 onward estimated individually	By year, not shown; high relative error and bias on some estimates	1960-1985	1.1 (or 1.0 or 1.5)*	0.230
Run C	1986-2010	0.859 (0.058,0.004)	1960-1985	1.1	0.291
Run D	1986-1994 1995-2010	2.43 (0.644,0.343) 0.894 (0.058,0.002)	1960-1985	1.1	0.288
Run E	1986-1991 1999-2010	Individual years-very high relative error and bias on some estimates	1960-1985 1990-1999	1.1 0.8	0.265
Run E	1986-1991 1999-2010	Individual years-very high relative error and bias on some estimates	1960-1985 1990-1999	1.1 0.5	0.255
Run F	1986-1991 1999-2010	Individual years-very high relative error and bias on some estimates	1960-1985 1990-1999	1.1 1.0	0.271
Run G	1986-1989 2000-2010	0.735 (0.699,0.382) 1.02 (0.09,0.016)	1960-1985 1990-1999	1.1 0.8	0.283
Run H	1986-1991 1999-2010	1.16 (0.444,0.141) 0.947 (0.07,0.009)	1960-1985 1990-1999	1.1 0.8	0.289
Run I	1986-1989 2000-2010	0.517 (0.507,0.165) 0.857 (0.068,0.011)	1960-1985 1990-1999	1.1 0.5	0.289
Run J	1986-1991 1999-2010	0.804 (0.354,0.083) 0.869 (0.063,0.008)	1960-1985 1990-1999	1.1 0.5	0.281
Run K	1986-1991 1999-2004 2005-2010	0.816 (0.355,0.083) 0.906 (0.074,0.007) 0.754 (0.094,0.010)	1960-1985 1990-1999	1.1 0.5	0.281
Run L	1986-1991 1999-2010	0.442 (0.258,0.035) 0.725 (0.050,0.006)	1960-1985 1990-1999	1.1 0.26	0.273
Run M	**1986-1991** **1992-1998** **1999-2010**	**0.257 (0.262,0.034)** **0.159 (0.165,0.013)** **0.646 (0.055,0.004)**	**1960-1985**	**1.1**	**0.270**

*Examined three Fratio constraints here, 1.0, 1.1 and 1.5. There was no improvement in MSR after the first increase, and error and bias increased as the Fratio constraint increased.

Table 2. Retrospective comparison (one year) of SSB at age estimated from ADAPT from Run M. Table entries provide the ratio of the estimated numbers from the current assessment to those estimated with one year removed (model formulation unchanged). Shaded entries highlight changes in excess of +/- 10%.

	5	6	7	8	9	10	11	12	13	14	15
1960	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1961	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1962	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1963	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1964	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1965	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1966	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1967	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1968	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1969	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1970	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1971	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1972	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1973	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1974	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1975	1.04	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1976	1.06	1.04	1.02	1.01	1.01	1.01	1.00	1.00	1.00	1.00	1.00
1977	1.03	1.06	1.04	1.02	1.01	1.01	1.01	1.01	1.00	1.00	1.00
1978	1.03	1.03	1.07	1.05	1.02	1.01	1.01	1.01	1.01	1.01	1.01
1979	1.04	1.03	1.03	1.07	1.05	1.03	1.02	1.01	1.01	1.01	1.01
1980	1.04	1.04	1.04	1.04	1.08	1.06	1.03	1.02	1.02	1.02	1.02
1981	1.05	1.04	1.04	1.04	1.04	1.09	1.07	1.04	1.03	1.02	1.02
1982	1.03	1.05	1.04	1.04	1.04	1.04	1.10	1.08	1.07	1.06	1.05
1983	1.02	1.03	1.05	1.04	1.04	1.04	1.06	1.14	1.13	1.12	1.11
1984	1.01	1.02	1.03	1.06	1.05	1.04	1.05	1.07	1.17	1.17	1.17
1985	1.04	1.01	1.02	1.03	1.06	1.05	1.05	1.07	1.11	1.21	1.21
1986	1.01	1.04	1.01	1.02	1.03	1.07	1.07	1.08	1.11	1.15	1.24
1987	1.02	1.01	1.04	1.02	1.02	1.04	1.08	1.10	1.13	1.18	1.26
1988	1.02	1.02	1.01	1.04	1.02	1.03	1.06	1.12	1.15	1.18	1.26
1989	1.04	1.02	1.02	1.01	1.04	1.02	1.04	1.08	1.15	1.19	1.26
1990	1.05	1.04	1.02	1.02	1.01	1.06	1.03	1.07	1.12	1.18	1.26
1991	1.03	1.05	1.04	1.02	1.02	1.01	1.08	1.06	1.11	1.18	1.26
1992	1.07	1.04	1.06	1.05	1.03	1.04	1.02	1.13	1.10	1.15	1.26
1993	1.08	1.07	1.04	1.06	1.06	1.05	1.06	1.04	1.17	1.15	1.28
1994	1.08	1.08	1.08	1.06	1.12	1.14	1.12	1.16	1.12	1.23	1.32
1995	1.11	1.09	1.10	1.11	1.11	1.19	1.18	1.21	1.22	1.23	1.31
1996	1.09	1.11	1.09	1.10	1.11	1.12	1.19	1.18	1.21	1.22	1.30
1997	1.10	1.09	1.11	1.09	1.11	1.12	1.12	1.19	1.18	1.21	1.30
1998	1.09	1.10	1.09	1.12	1.10	1.11	1.13	1.13	1.20	1.19	1.28
1999	1.09	1.09	1.10	1.09	1.12	1.11	1.13	1.15	1.16	1.22	1.27
2000	1.08	1.09	1.09	1.10	1.09	1.13	1.13	1.16	1.18	1.21	1.26
2001	1.00	1.08	1.09	1.09	1.11	1.11	1.15	1.16	1.20	1.23	1.28
2002	1.03	1.00	1.08	1.10	1.10	1.13	1.13	1.19	1.21	1.25	1.30
2003	0.92	1.03	1.00	1.09	1.11	1.12	1.15	1.16	1.22	1.24	1.29
2004	0.92	0.91	1.03	0.99	1.11	1.15	1.15	1.18	1.21	1.25	1.30
2005	0.95	0.92	0.91	1.04	0.99	1.14	1.18	1.19	1.22	1.24	1.29
2006	0.94	0.95	0.92	0.90	1.04	0.99	1.18	1.22	1.22	1.24	1.30
2007	0.88	0.94	0.95	0.92	0.90	1.05	0.99	1.21	1.24	1.25	1.30
2008	0.89	0.88	0.94	0.95	0.92	0.90	1.05	0.99	1.26	1.28	1.34
2009	1.29	0.89	0.88	0.94	0.94	0.91	0.89	1.05	0.99	1.29	1.35
2010		1.30	0.88	0.87	0.94	0.94	0.91	0.89	1.06	0.99	1.37

Table 3. Retrospective comparison (one year) of SSB at age estimated from ADAPT from the 2011 assessment. Table entries provide the ratio of the estimated numbers from the current assessment to those estimated with one year removed (model formulation unchanged). Shaded entries highlight changes in excess of +/- 10%.

1960	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1961	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1962	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1963	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1964	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1965	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1966	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1967	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1968	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1969	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1970	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1971	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1972	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1973	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1974	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1975	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1976	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1977	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1978	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1979	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1980	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1981	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1982	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1983	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1984	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1985	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1986	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1987	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1988	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1989	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1990	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1991	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1992	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1993	1.01	1.01	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00
1994	1.01	1.01	1.01	1.00	1.01	1.01	1.01	1.01	1.01	1.01
1995	1.02	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.02
1996	1.02	1.02	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02
1997	1.03	1.02	1.02	1.01	1.01	1.01	1.01	1.02	1.02	1.02
1998	1.03	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.02	1.02
1999	1.04	1.03	1.03	1.02	1.03	1.02	1.02	1.02	1.02	1.02
2000	1.04	1.04	1.03	1.03	1.03	1.03	1.02	1.02	1.02	1.03
2001	0.94	1.04	1.04	1.03	1.04	1.03	1.04	1.03	1.04	1.04
2002	0.94	0.94	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
2003	0.83	0.94	0.94	1.04	1.05	1.05	1.05	1.05	1.06	1.06
2004	0.84	0.82	0.94	0.93	1.06	1.07	1.07	1.07	1.08	1.08
2005	0.87	0.84	0.81	0.93	0.91	1.08	1.10	1.09	1.10	1.10
2006	0.88	0.87	0.84	0.80	0.92	0.88	1.11	1.13	1.12	1.12
2007	0.82	0.88	0.87	0.83	0.79	0.91	0.86	1.14	1.16	1.14
2008	0.83	0.82	0.88	0.87	0.82	0.78	0.90	0.83	1.20	1.21
2009	1.22	0.83	0.82	0.87	0.86	0.81	0.77	0.89	0.78	1.25
2010	0.53	1.22	0.83	0.81	0.86	0.85	0.80	0.75	0.88	0.75
2011										

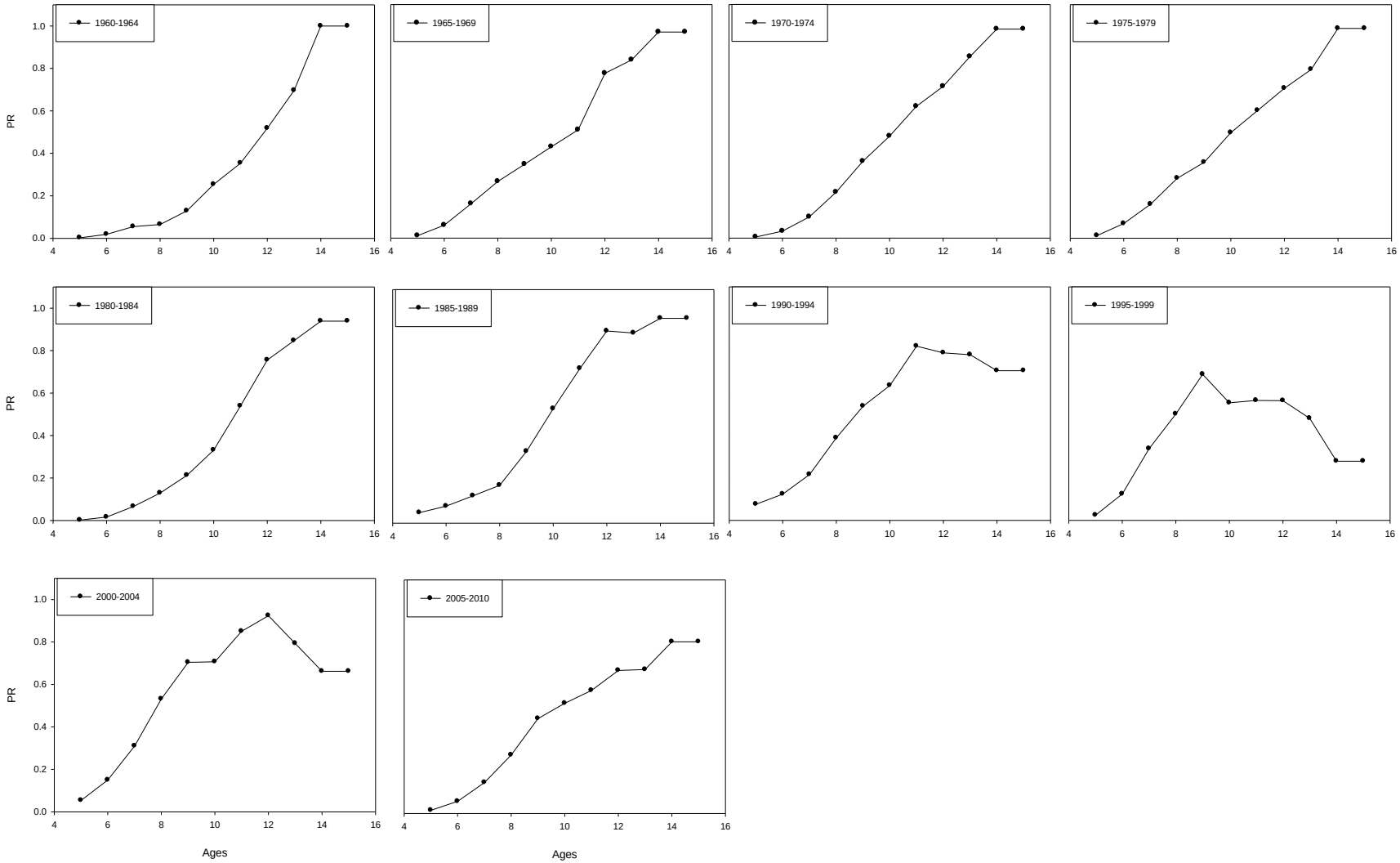

Figure 1. Average partial recruitment vectors (PRs) in time blocks over from 1960-2010.

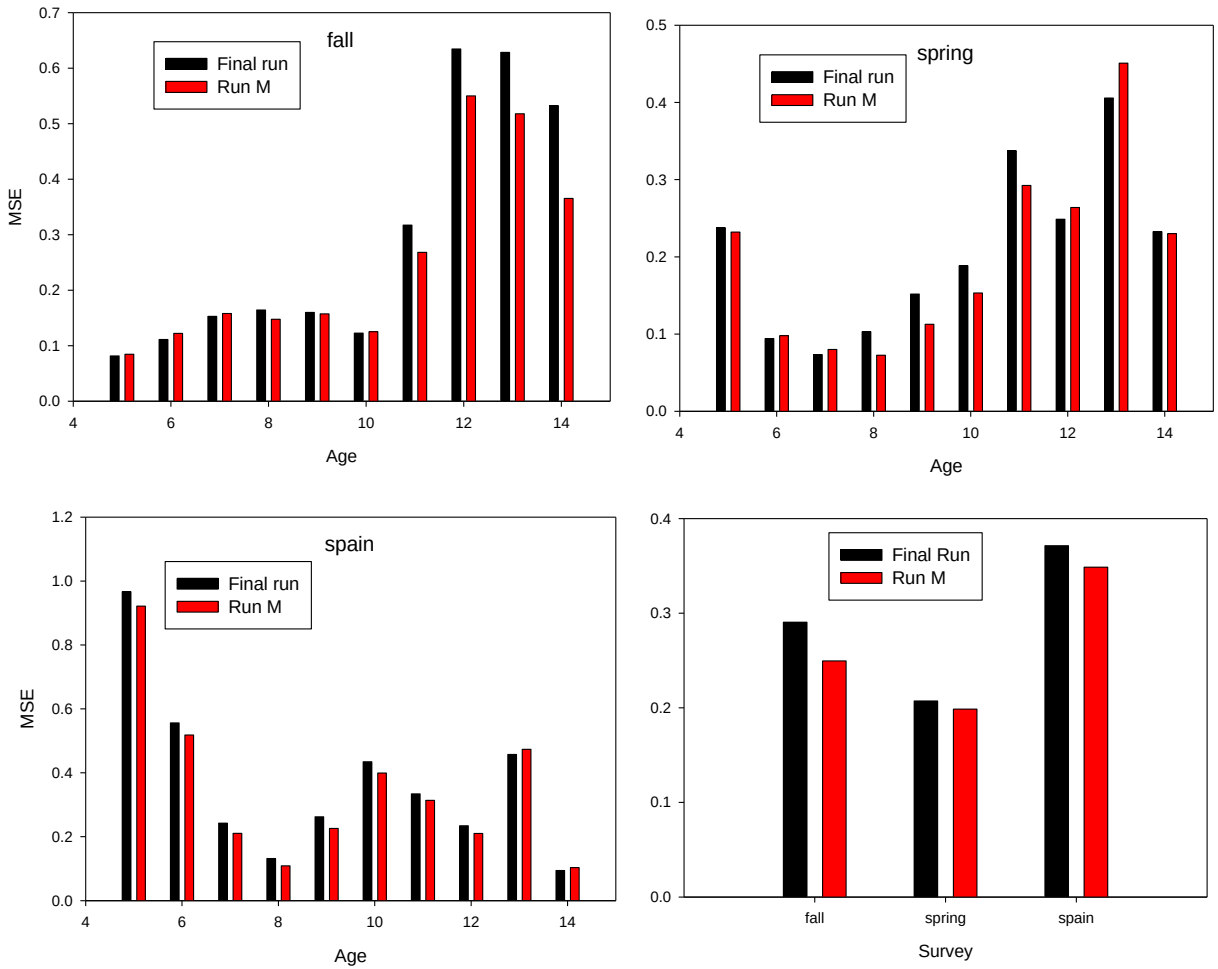

Figure 2. Mean square residuals (MSR) on ages by survey for the final assessment run in 2011 and run M. The fourth plot gives an overall MSR by survey.

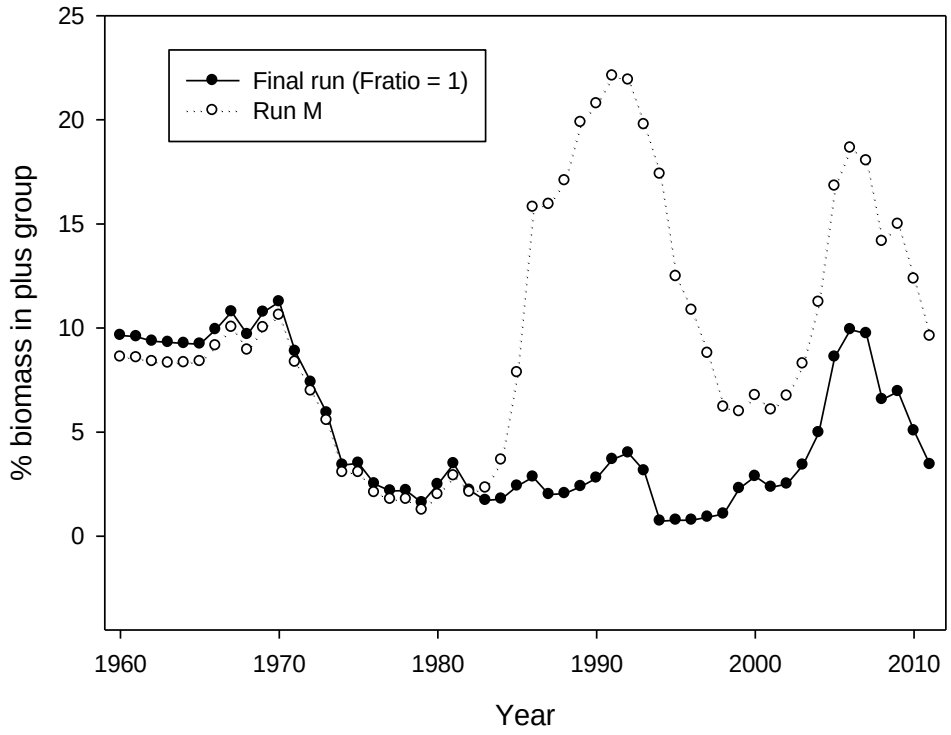

Figure 3. The percentage of the biomass by year that is in the plus group in the final assessment run of 2011 (fixed at 1.0 throughout) and estimating Fratio in three time blocks from 1986 onwards (see text for details).

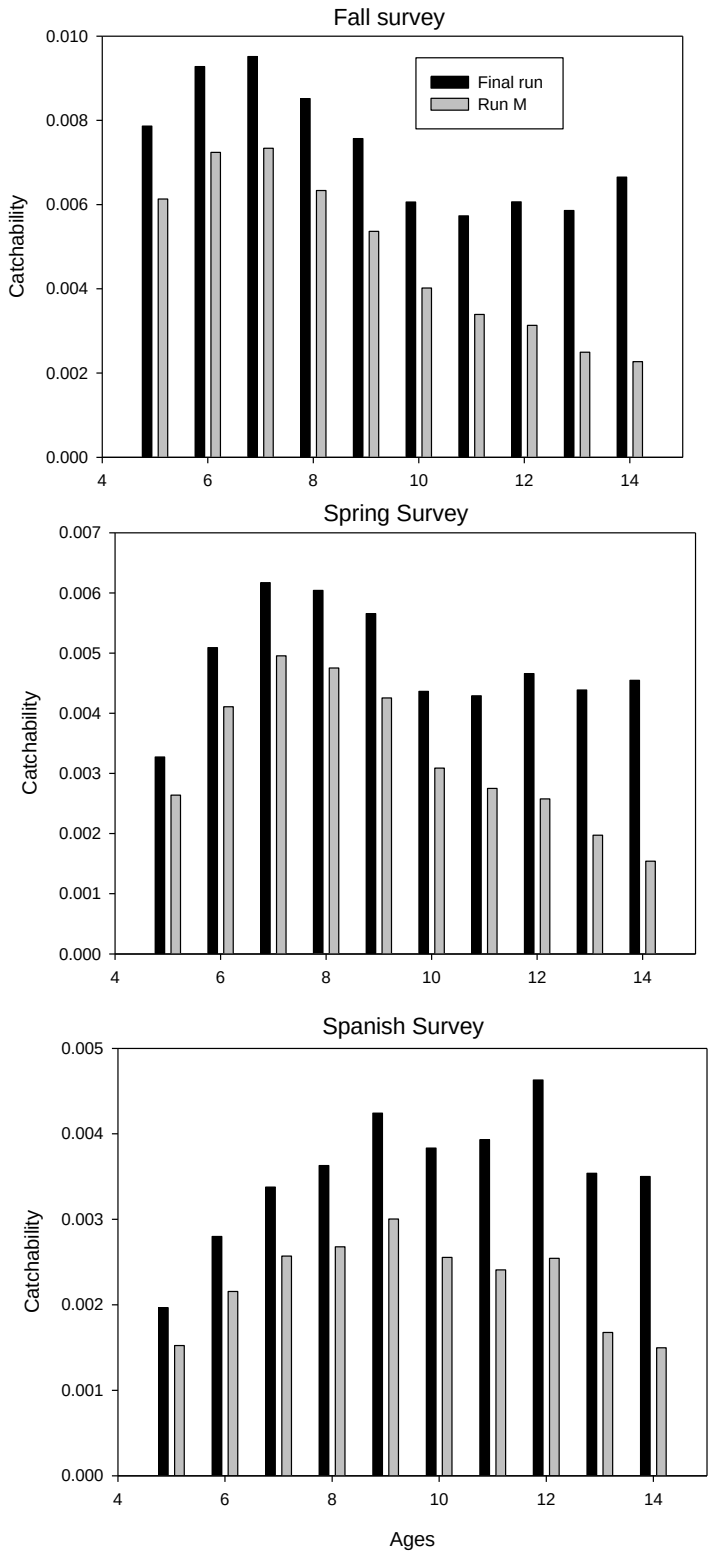

Figure 4. Comparison of catchability parameters from ADAPT analyses using the 2011 final assessment run and run M.

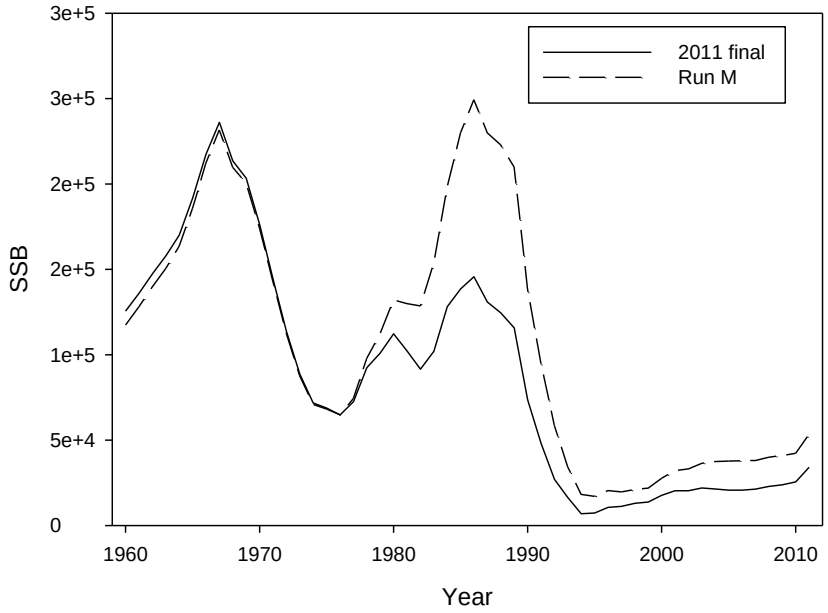

Figure 5. Spawning stock biomass for American plaice in Div. 3LNO for ADAPT run M, allowing ADAPT to estimate Fratio in three periods: 1986-1991, 1992-1998, 1999-2010, and assigning an F constraint of 1.1 for the 1960-1985 period. This run is compared with the final 2011 assessment run (Fratio fixed at 1.0 throughout the time series).

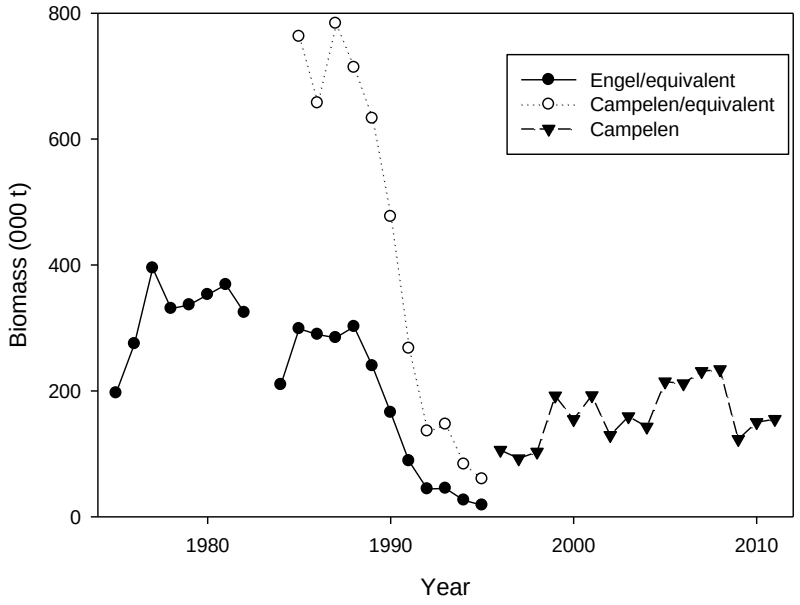

Figure 6. Biomass of American plaice in Div. 3LNO for surveys over time.