Continuity Run of the Spreadsheet Virtual Population Analysis

Joseph D. Grist and Laura M. Lee
Virginia Marine Resources Commission
Fisheries Management Division
Newport News, Virginia

Introduction

Term of Reference (TOR) 2 for the SEDAR 18 (Southeast Data, Assessment, and Review) Assessment Workshop (AW) requires the working group to perform a continuity run of the model used in the previous assessment if the group proposes to use a different model in the current assessment. The last stock assessment for red drum was completed in 2000 by Vaughan and Carmichael. Vaughan and Carmichael applied three separate models—a Separable Virtual Population Analysis (SVPA), a Spreadsheet Virtual Population Analysis (SprdVPA), and a virtual population analysis using F-ADAPT. At the SEDAR 18 AW, the working group agreed that a statistical catch-at-age model (SEDAR 18-AW09) would be the most appropriate model to use in the current assessment. According to TOR 2, a continuity run of the previous model is needed. Of the three models utilized by Vaughan and Carmichael (2000), only the SprdVPA could be reproduced for the continuity run.

Model and Data Inputs

Vaughan and Carmichael (2000) described the SprdVPA as a spreadsheet-based catch-age analysis, with a separable forward projection population model that was solved iteratively using the Excel Solver function. The assessment of both the northern and southern regions modeled ages 1 through 5 during 1986 through 1998. The model of the northern region used auxiliary information that included the North Carolina Division of Marine Fisheries (NCDMF) juvenile abundance index (JAI) and the Marine Recreational Fisheries Statistics Survey (MRFSS) target catch-per-unit-effort (CPUE) as tuning indices. The model of the southern region used the MRFSS target CPUE and a South Carolina trammel net survey catch-at-age as tuning indices. Two selectivity periods (1986 through 1991 and 1992 through 1998) were used to account for regulatory changes in both the northern and southern fisheries. Selectivity for ages 2 and 3 were fixed at the same values for both periods ($F_3 = F_2$). This assumption was different than that used by Vaughan and Carmichael, but presented the simplest approach to meeting the requirements for TOR 2.

The catch-at-age (CAA) matrices for the northern management region (Tables 1, 2) and the southern management region (Tables 3, 4) differed between the previous and current SprdVPA models where the time series overlapped. Due to these differences, the continuity model was run using the original CAA (Vaughan and Carmichael 2000) and again using the updated CAA (SEDAR 18 DW). Similarly, natural mortality estimates were updated at the SEDAR 18 DW and were applied in the continuity run using the updated CAA ($M_{\text{North}} = 0.12$; $M_{\text{South}} = 0.17$); whereas the natural mortality estimates used in the model based on the original CAA assumed the values used by Vaughan and Carmichael ($M_{\text{North}} = 0.20$; $M_{\text{South}} = 0.23$). The index values used in the original

SprdVPA could not be located or reproduced, so the values of the auxiliary indices were updated for all years.

Retrospective analyses were performed to evaluate the consistency of successive estimates of fishing mortality and total population size within each model and to provide a comparison of retrospective patterns among the models.

Continuity Model Comparison (1986 through 1998)

Northern Region

Recruitment (age 1), catch, total population size, selectivity-at-age, catch, full *F*, retrospective total population size and retrospective full *F* were estimated and plotted for the northern region (Figures 1–7). Overall, the model estimates were similar for the model based on the CAA used in Vaughan and Carmichael (2000) the model based on the updated CAA. Selectivity-at-age estimates for the second selectivity period (1992 through 1998) differed between the models (Figures 4a, 4b). The model based on the original CAA suggested a dome-shaped selectivity pattern for both selectivity periods (Figure 4a). While the model based on the updated CAA also estimated a dome-shaped selectivity pattern for the first selectivity period (1986 through 1991), this model predicted an asymptotic selectivity pattern for the second selectivity period (1992 through 1998; Figure 4b). The estimates of full *F* predicted by the model based on the original CAA (Figure 5a) were consistently lower than the full *F* values estimated by the model based on the updated CAA (Figure 5b). The retrospective analyses suggested some similarities between the model based on the original CAA and the model based on the updated CAA. The retrospective analysis of the model based on the original CAA suggested a pattern of consistent overestimation of total population size (Figure 6a). The trajectories of total population size predicted by the model based on the updated CAA were similar in trend to those predicted by the model based on the original CAA, but a pattern of consistent bias was not as apparent (Figure 6b). The general trends in the predicted fishing mortality rate trajectories were fairly similar between the models (Figures 7a, 7b). The retrospective analyses did not suggest a consistent bias in the fishing mortality estimates for either model.

Southern Region

Recruitment (age 1), catch, total population size, selectivity-at-age, catch, full *F*, retrospective total population size and retrospective full *F* were estimated and plotted for the southern region (Figures 8–14). The estimates from the model based on the CAA used in Vaughan and Carmichael (2000) differed from the estimates based on the updated CAA. The model based on the original CAA predicted a decline in total population size in 1998 (Figure 10a); however, estimates from the model based on the updated CAA suggest a steady or slightly rising population (Figure 10b). Selectivity-at-age estimates were similar between the models (Figures 11a, 11b). Both models estimated that ages 2 through 4 were fully selected for both selectivity periods (1986 through 1991 and 1992 through 1998). The *F* estimates were similar in overall pattern (Figures 12a, 12b), with declining trends in *F* and catch noted in the last two or three years of the time series. The retrospective analyses of total population size and fishing mortality revealed differences in the predicted trajectories of these parameters between the model based on the original

CAA and the model based on the updated CAA (Figures 13–14). There was no evidence of a consistent estimation bias for total population size (Figures 13a, 13b) or fishing mortality rates (Figures 14a, 14b) for either model.

Conclusions

A true continuity run (i.e., original model run appended with the more recent data) was not possible due to changes in the methodologies used to calculate indices. The suggested alternative was to use the original model with updated data where needed and compare to a model run where all data were updated based on the findings of SEDAR 18 DW. The SEDAR 18 AW did not find the results of the continuity model worthy of consideration given the inability to reproduce all the original input data. Additionally, the working group will not be using the SprdVPA for the current assessment of red drum in favor of the statistical catch-at-age model.

Table 1. Catch-at-age matrix for the red drum northern management region used in Vaughan and Carmichael (2000).

YEAR/AGE	1	2	3	4	5
1986	101,938	24,874	2,452	74	91
1987	116,635	28,332	3,578	2,174	149
1988	141,765	60,424	25,013	146	94
1989	126,086	44,436	7,492	66	53
1990	85,935	15,926	4,621	182	27
1991	80,141	20,584	1,211	824	28
1992	4,064	64,480	4,746	306	51
1993	4,837	76,259	31,366	47	20
1994	7,401	29,995	20,006	3,416	45
1995	11,718	114,051	11,038	1,135	520
1996	18,487	30,534	10,983	985	37
1997	18,516	8,043	4,116	371	77
1998	12,056	209,647	5,076	388	350

Table 2. Catch-at-age matrix for the red drum northern management region developed at the SEDAR 18 DW.

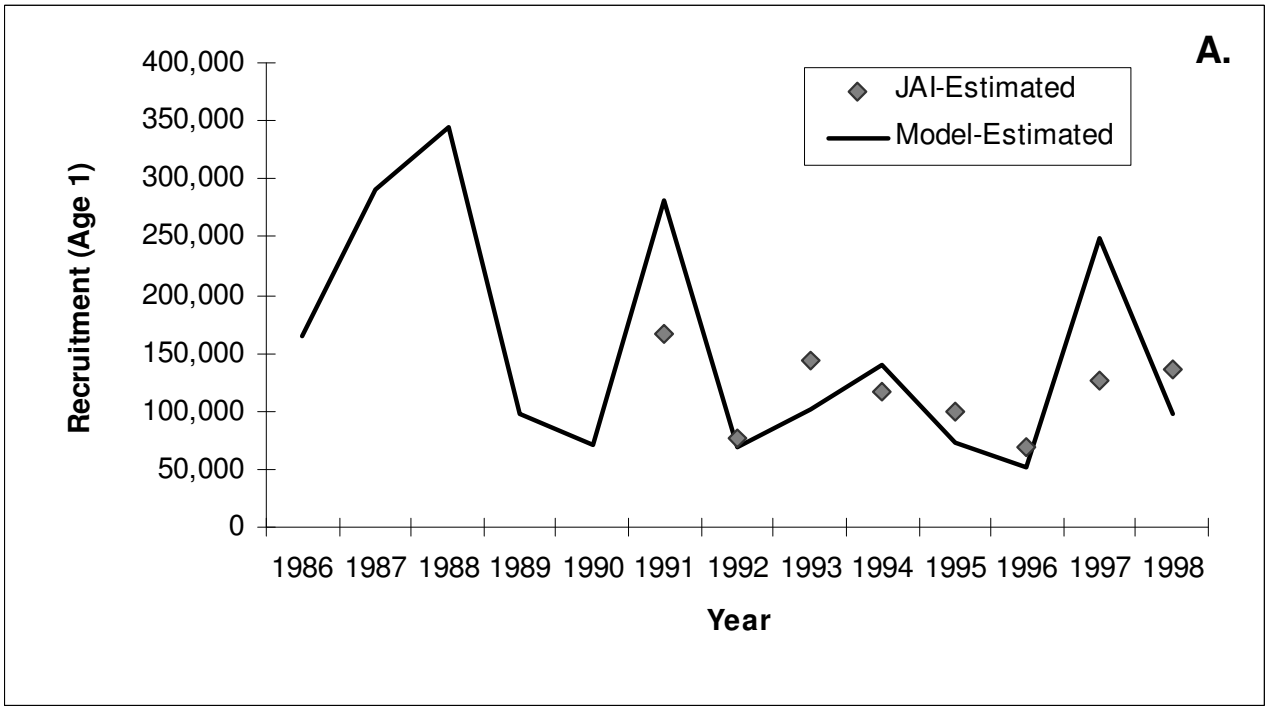
YEAR/AGE	1	2	3	4	5
1986	92,581	43,611	2,417	191	52
1987	135,831	59,062	4,221	2,949	30
1988	165,296	50,021	6,573	532	118
1989	65,172	76,983	7,016	163	8
1990	71,079	24,039	2,626	96	29
1991	86,545	25,284	725	1,134	65
1992	2,843	65,823	4,142	250	66
1993	4,882	71,226	29,953	59	41
1994	2,431	25,939	20,789	2,846	110
1995	12,858	109,157	15,154	1,058	883
1996	15,875	31,163	10,948	1,148	460
1997	7,544	10,619	4,005	593	218
1998	10,972	207,423	5,481	717	545

Table 3. Catch-at-age matrix for the red drum southern management region used in Vaughan and Carmichael (2000).

YEAR/AGE	1	2	3	4	5
1986	339,538	126,015	924	158	158
1987	536,142	284,945	18,954	7,599	9,383
1988	93,516	249,649	89,717	10,760	396
1989	51,063	120,233	36,235	4,261	470
1990	118,924	102,136	10,301	3,991	3
1991	91,671	288,607	11,176	2,694	1,347
1992	25,124	174,419	95,487	5,807	306
1993	13,177	128,294	130,498	16,923	877
1994	23,156	91,653	146,348	87,405	20,210
1995	31,029	159,861	202,318	49,976	7,171
1996	30,533	157,009	63,295	54,450	18,585
1997	95,568	47,110	41,786	32,788	20,853
1998	1,745	85,449	66,850	21,035	3,315

Table 4. Catch-at-age matrix for the red drum southern management region developed at the SEDAR 18 DW.

YEAR/AGE	1	2	3	4	5
1986	218,891	166,744	42,916	5,955	823
1987	529,070	169,181	26,725	6,898	781
1988	232,231	180,916	19,940	2,351	100
1989	101,618	87,623	20,741	4,920	374
1990	103,999	98,740	20,890	6,230	710
1991	226,429	105,765	32,695	24,372	3,304
1992	148,778	106,902	28,669	15,939	1,981
1993	124,240	115,337	38,331	16,086	2,122
1994	160,089	141,740	52,047	23,506	1,565
1995	222,895	121,603	46,583	21,144	2,547
1996	114,400	148,737	45,789	24,300	2,758
1997	147,352	49,452	25,815	19,048	2,308
1998	218,891	166,744	42,916	5,955	823



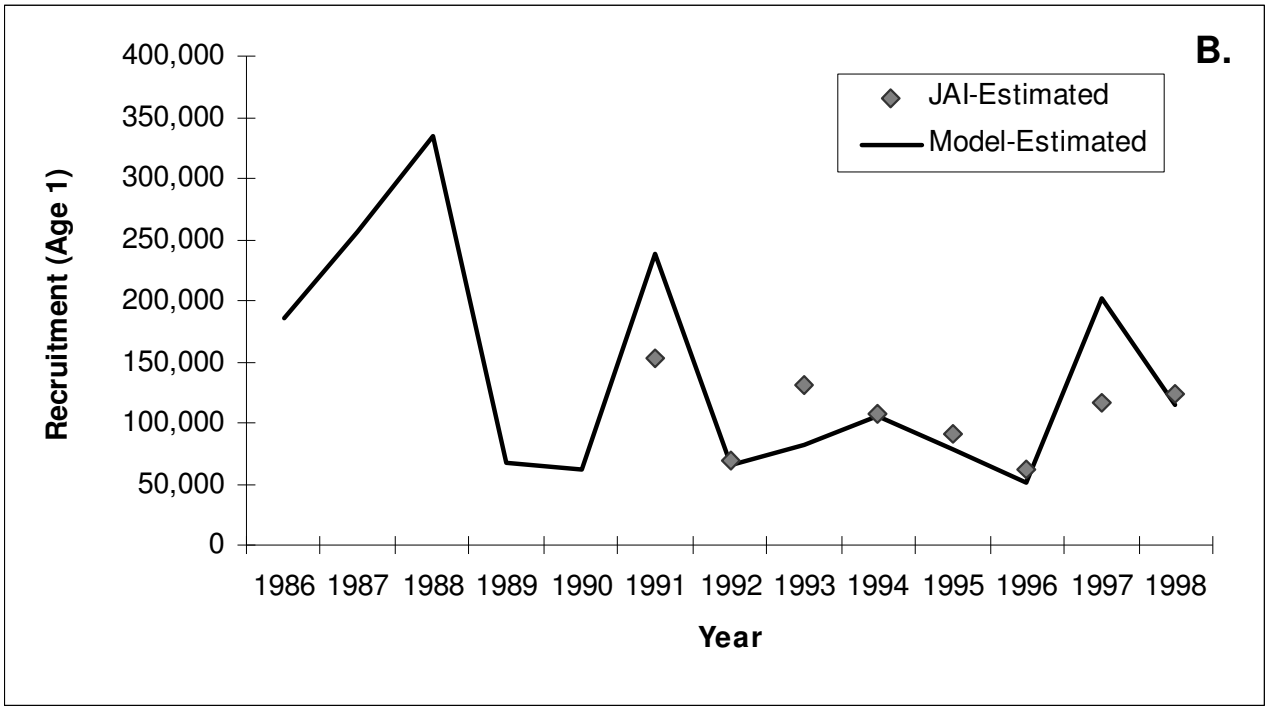
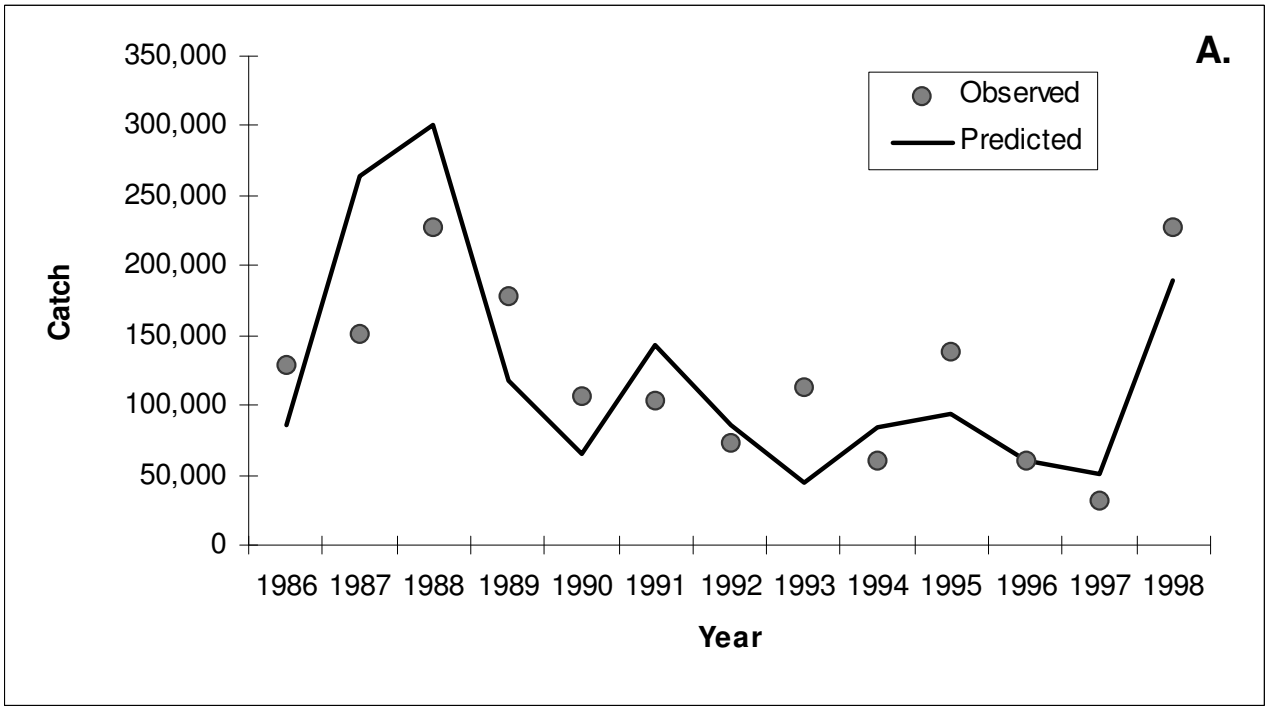


Figure 1. Recruitment (age 1) estimates for the red drum northern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.



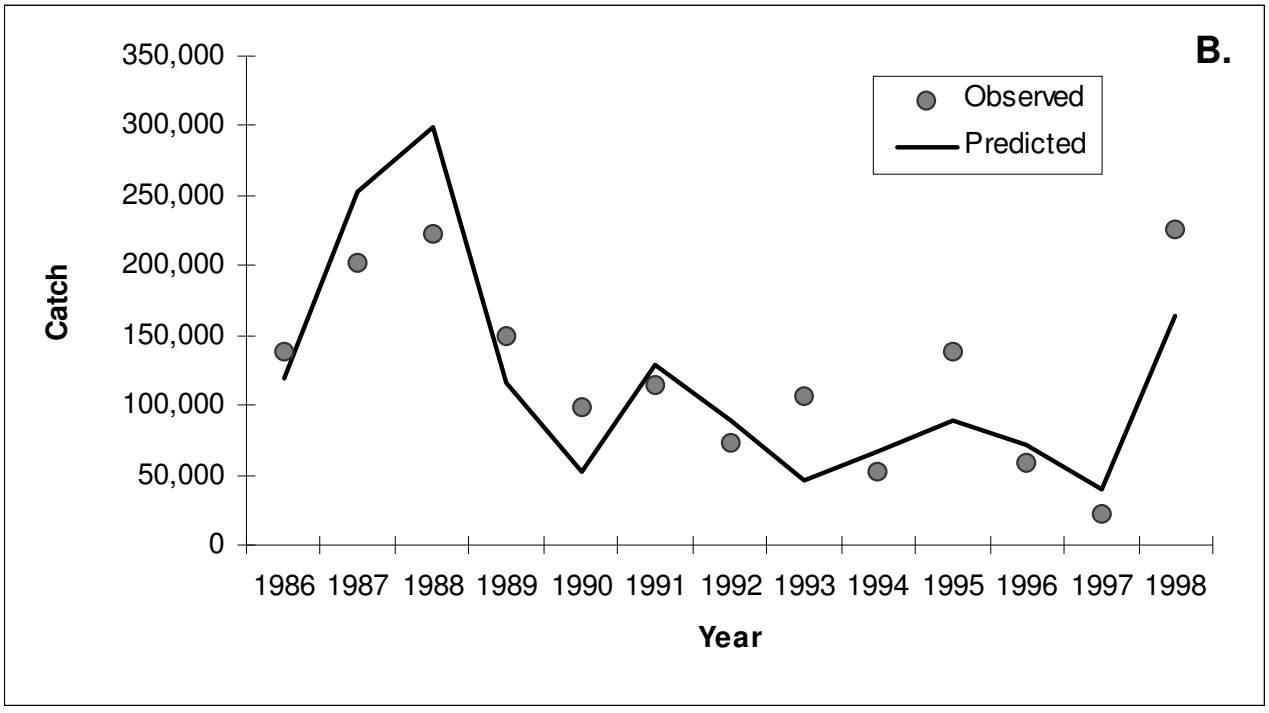


Figure 2. Estimated catch (numbers) for the red drum northern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.

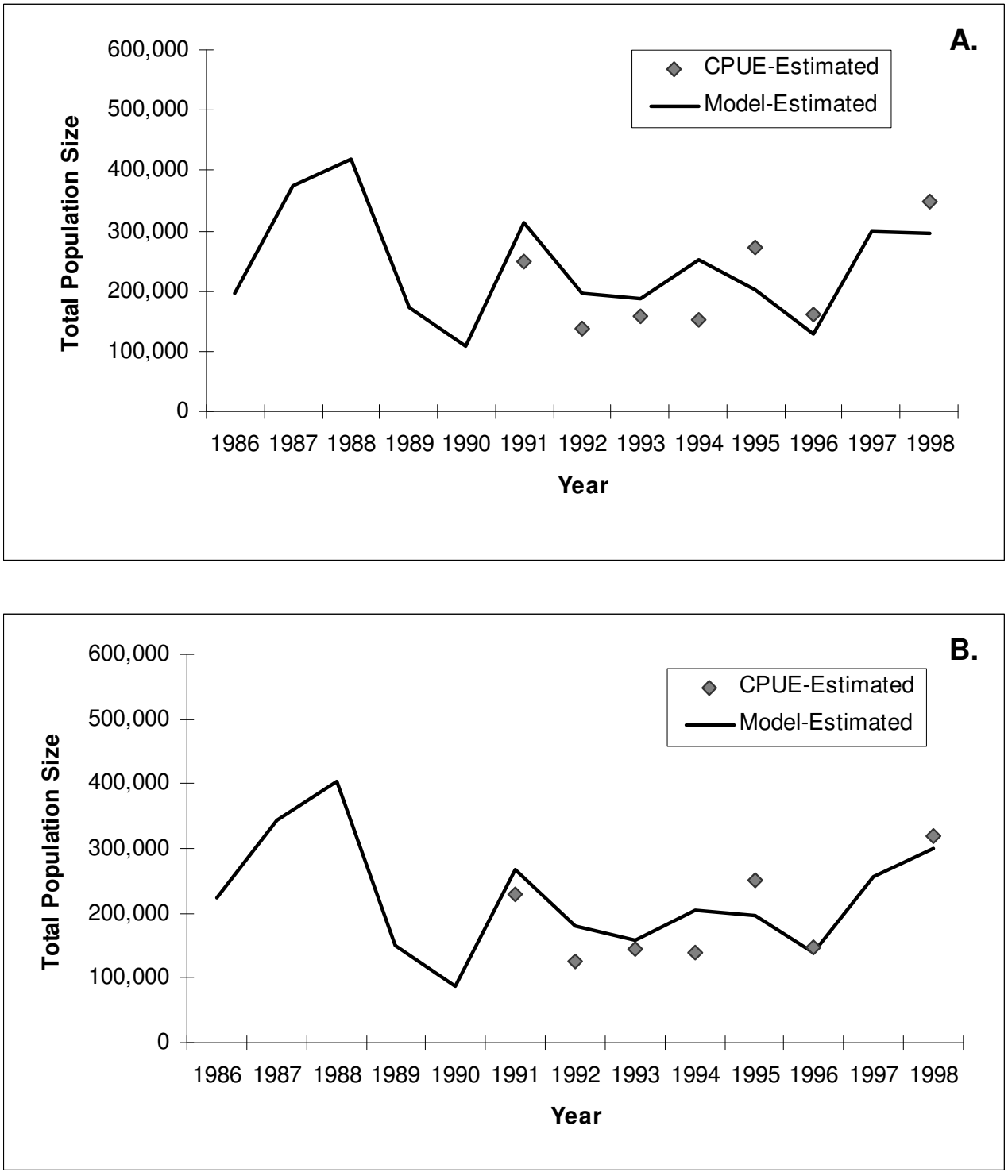


Figure 3. Estimated population size (numbers) for the red drum northern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.

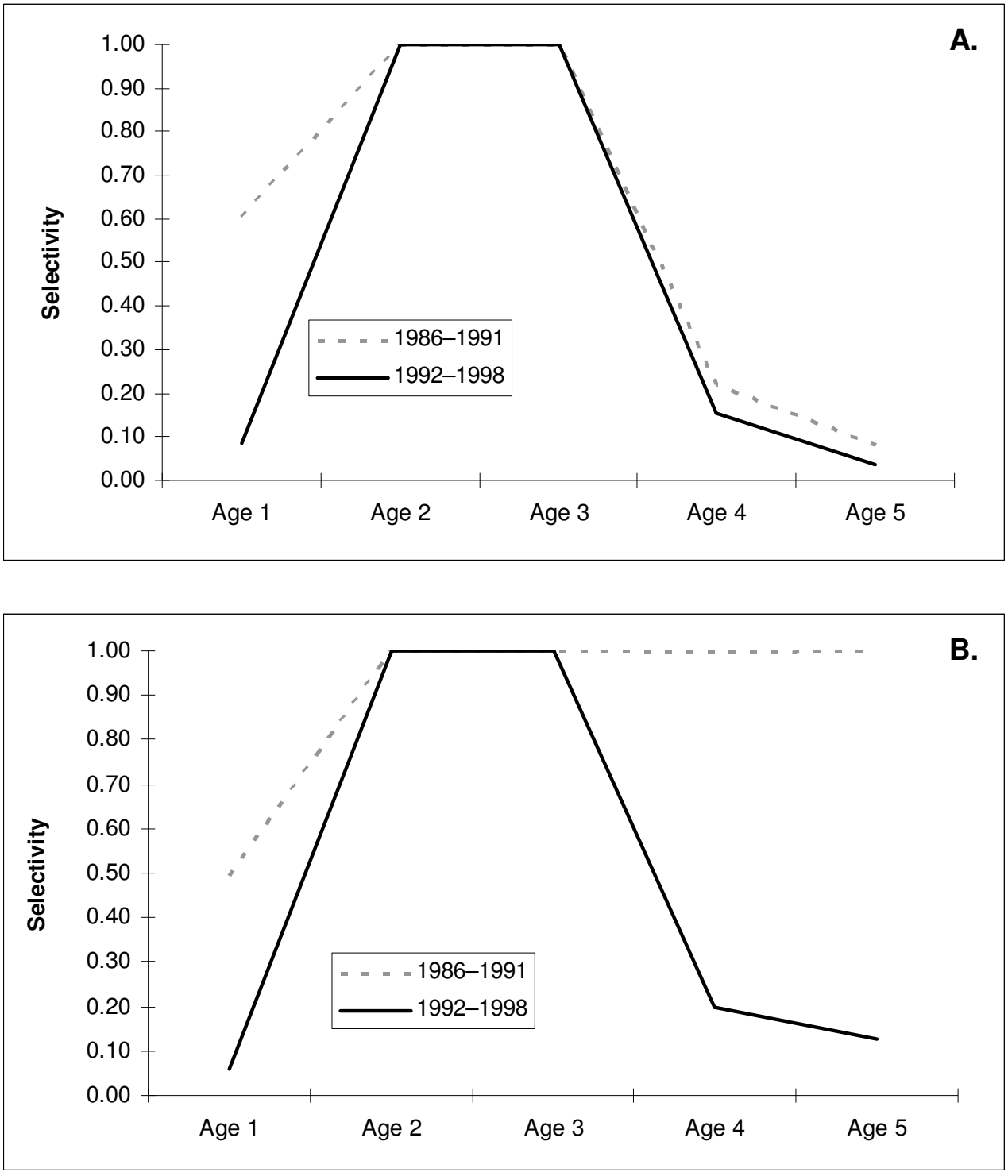


Figure 4. Selectivity-at-age estimates for the red drum northern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.

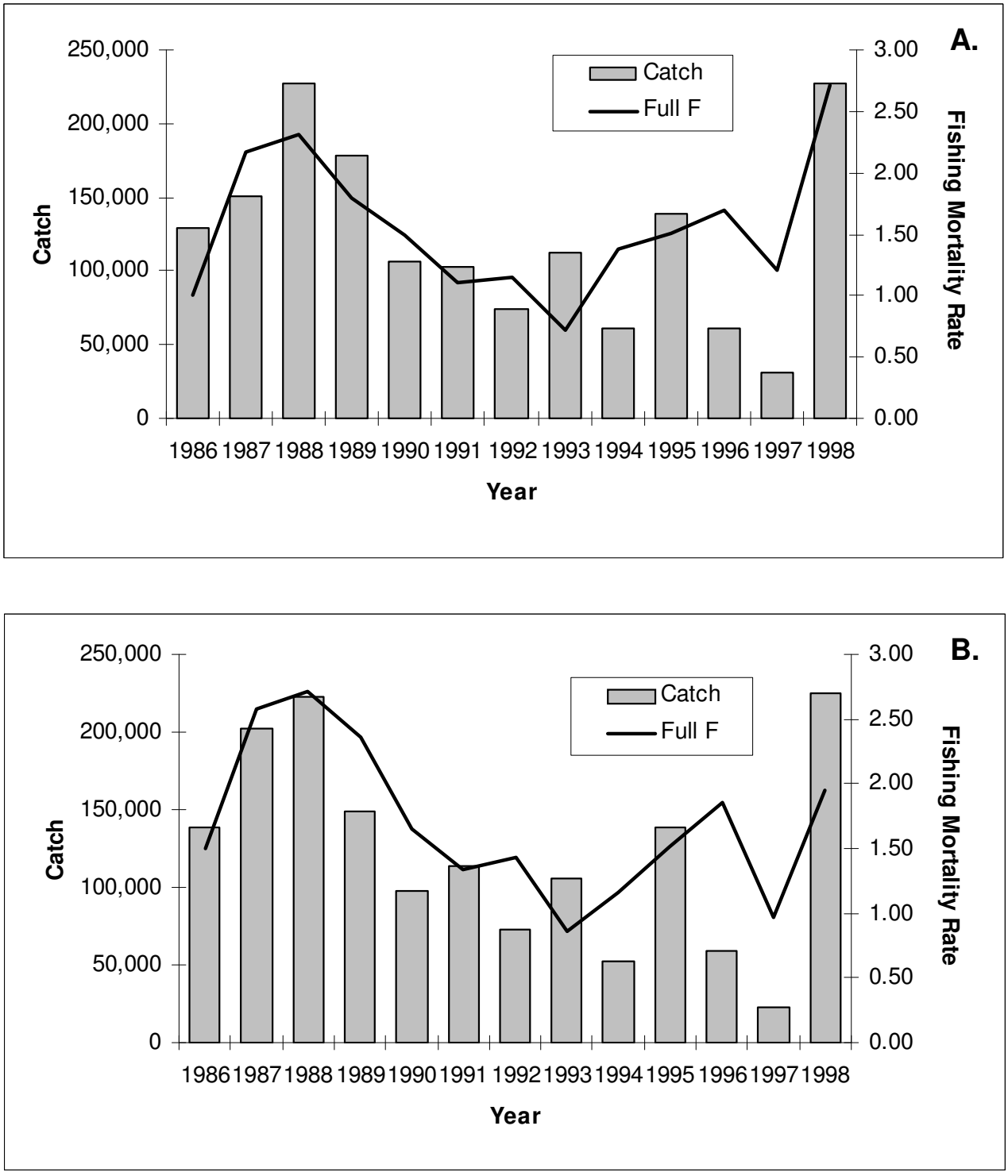
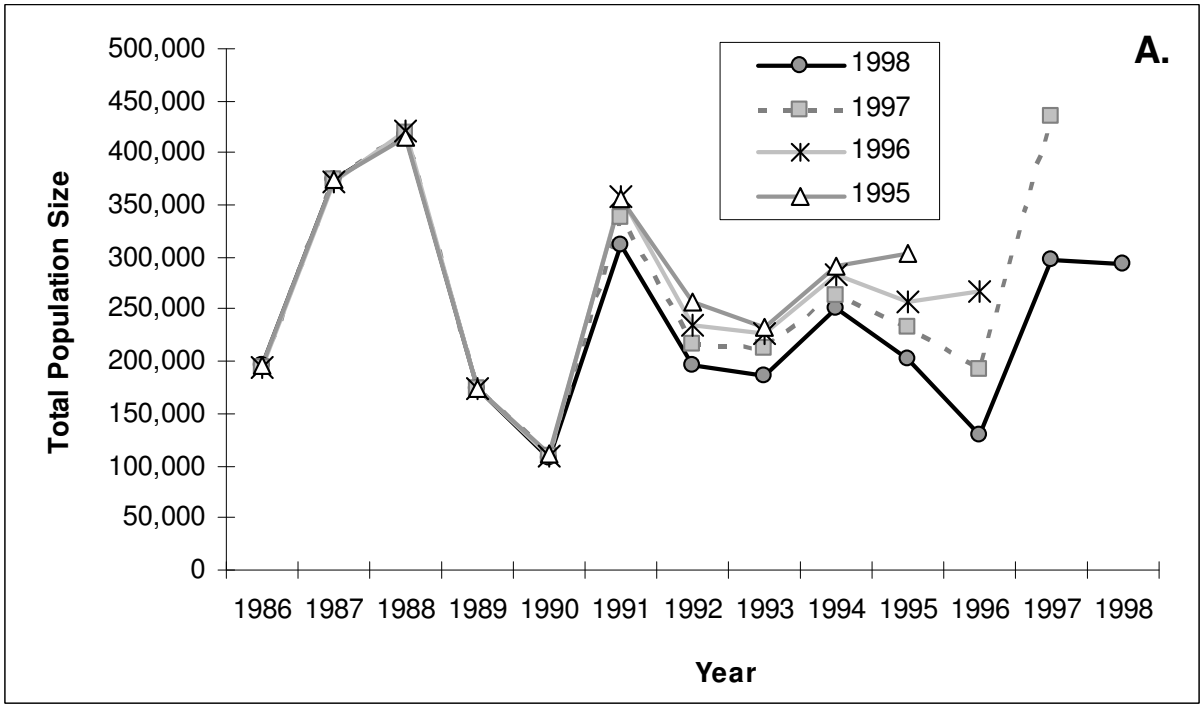


Figure 5. Annual catch and full *F* estimates for the red drum northern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.



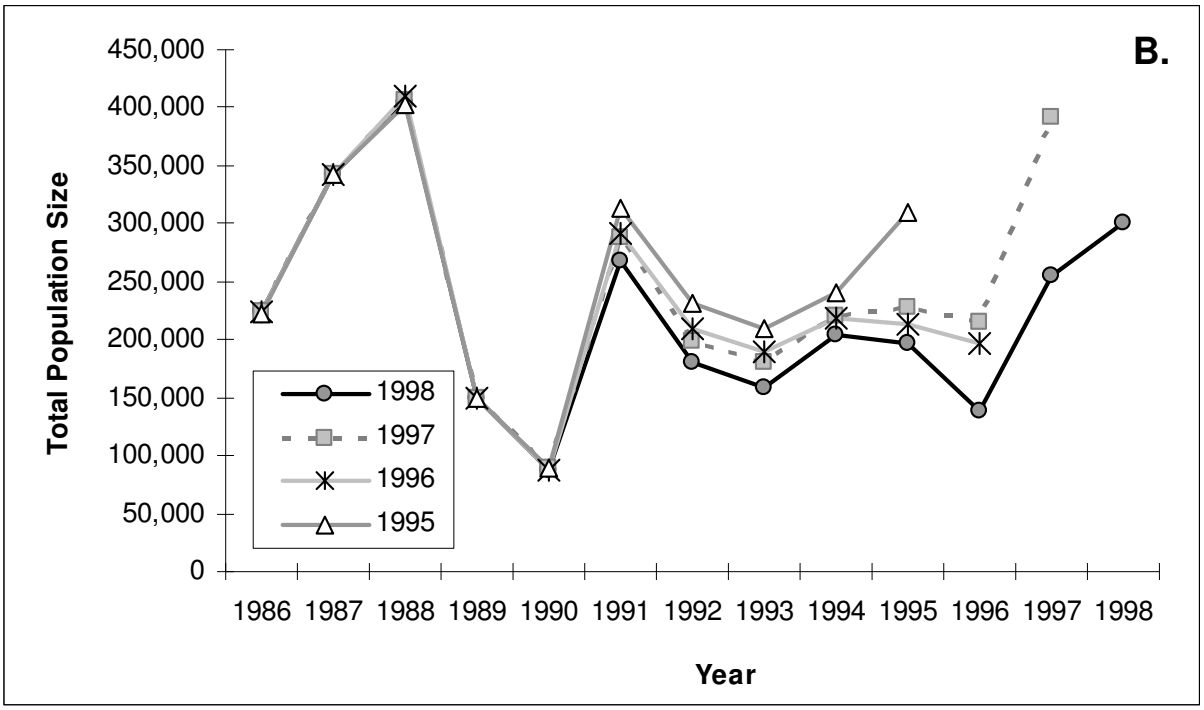


Figure 6. Retrospective analysis of population size (numbers) estimates for the red drum northern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.

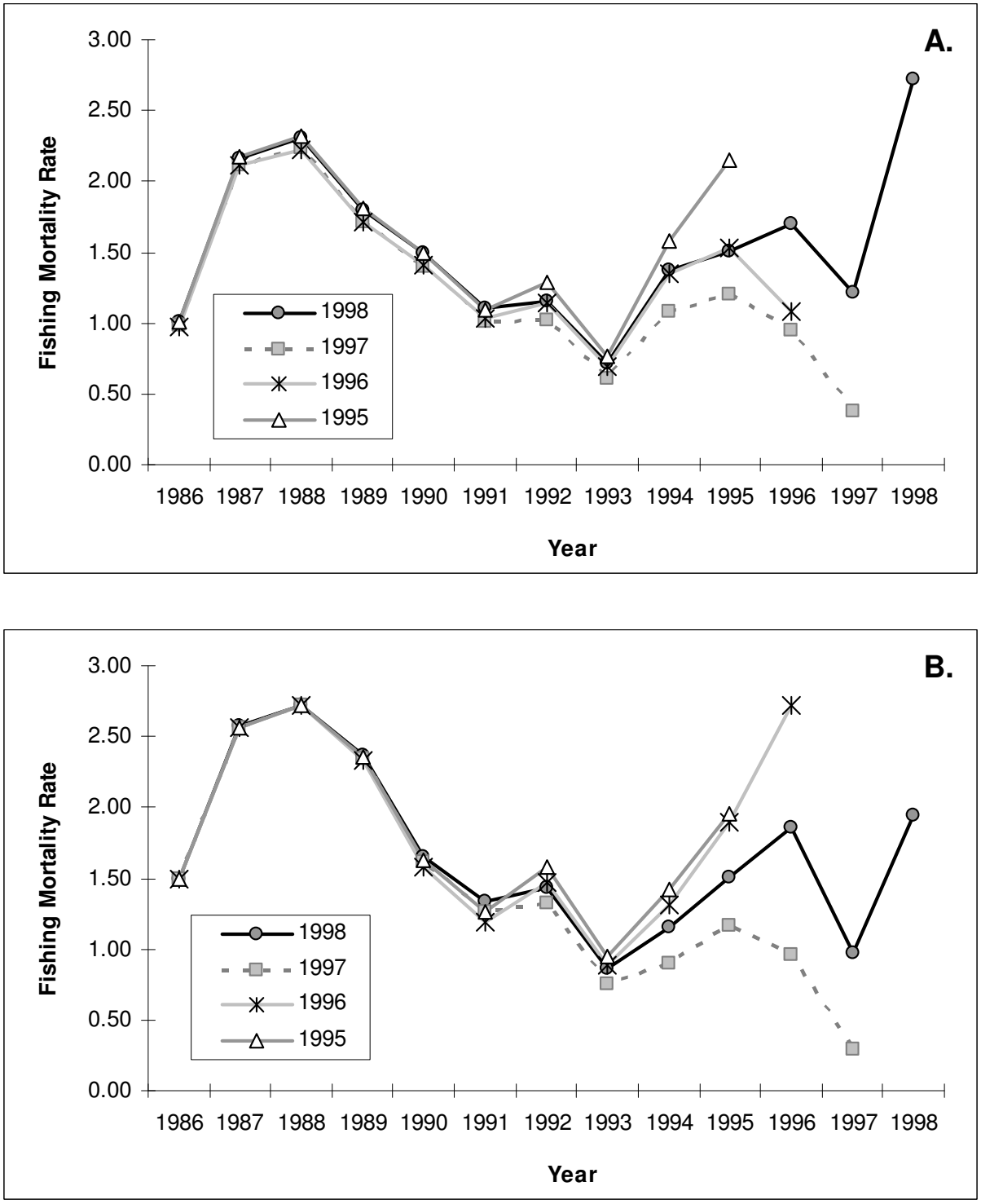
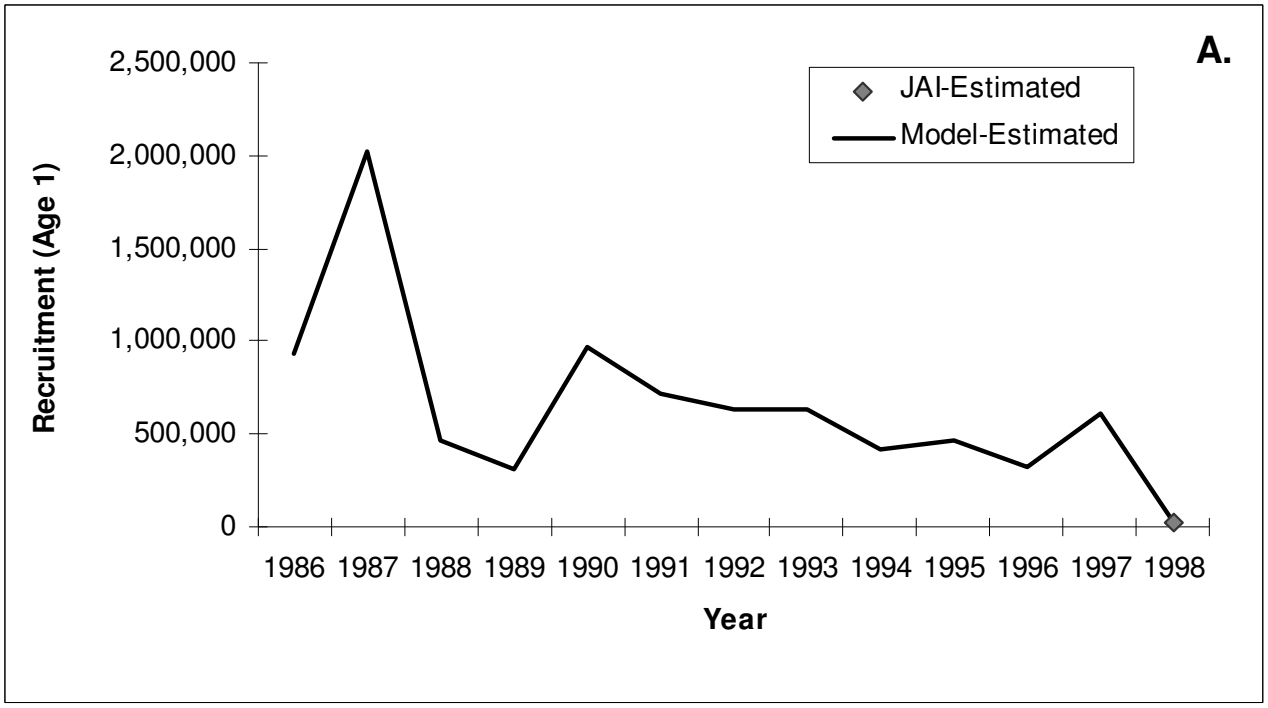


Figure 7. Retrospective analysis of *F* estimates for the red drum northern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.



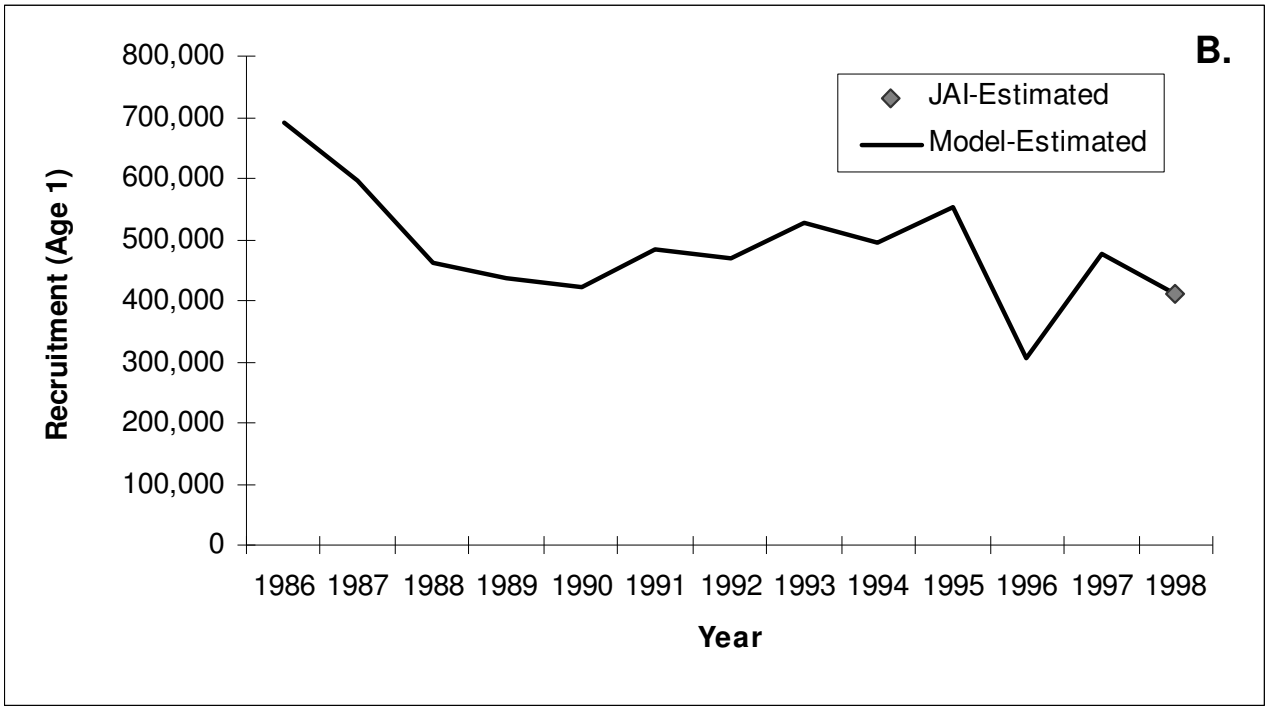
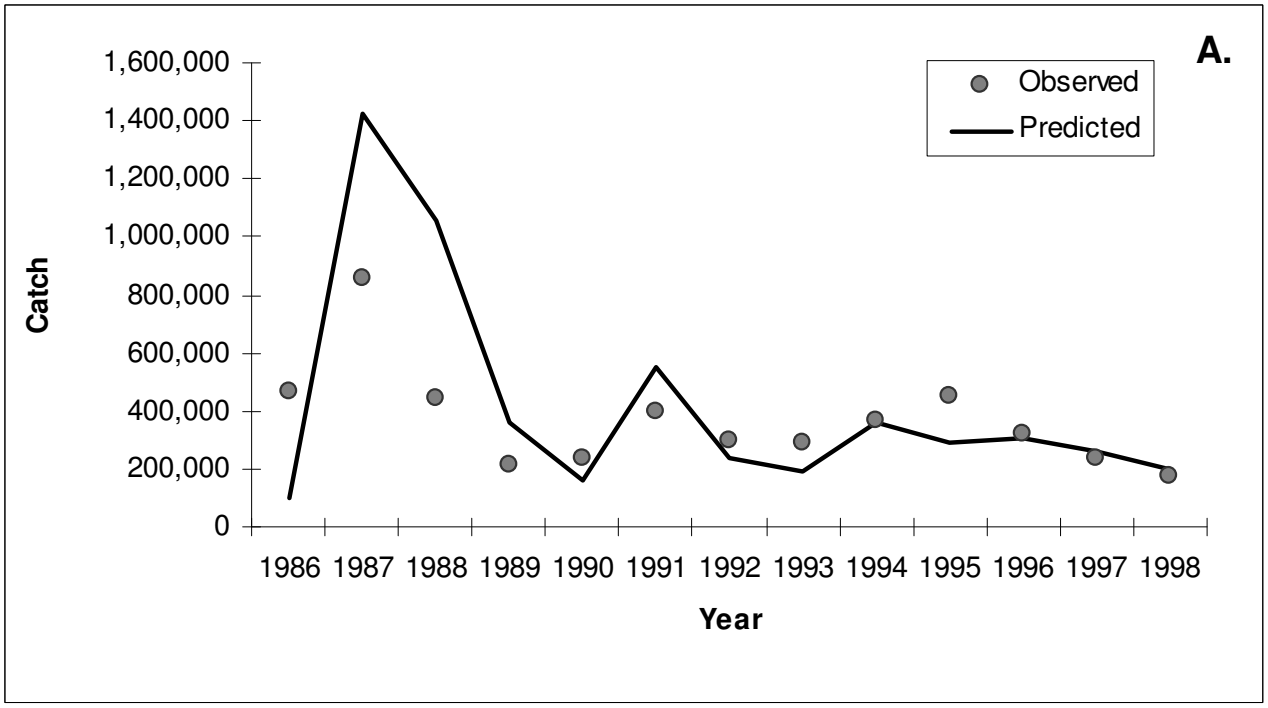


Figure 8. Recruitment (age 1) estimates for the red drum southern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.



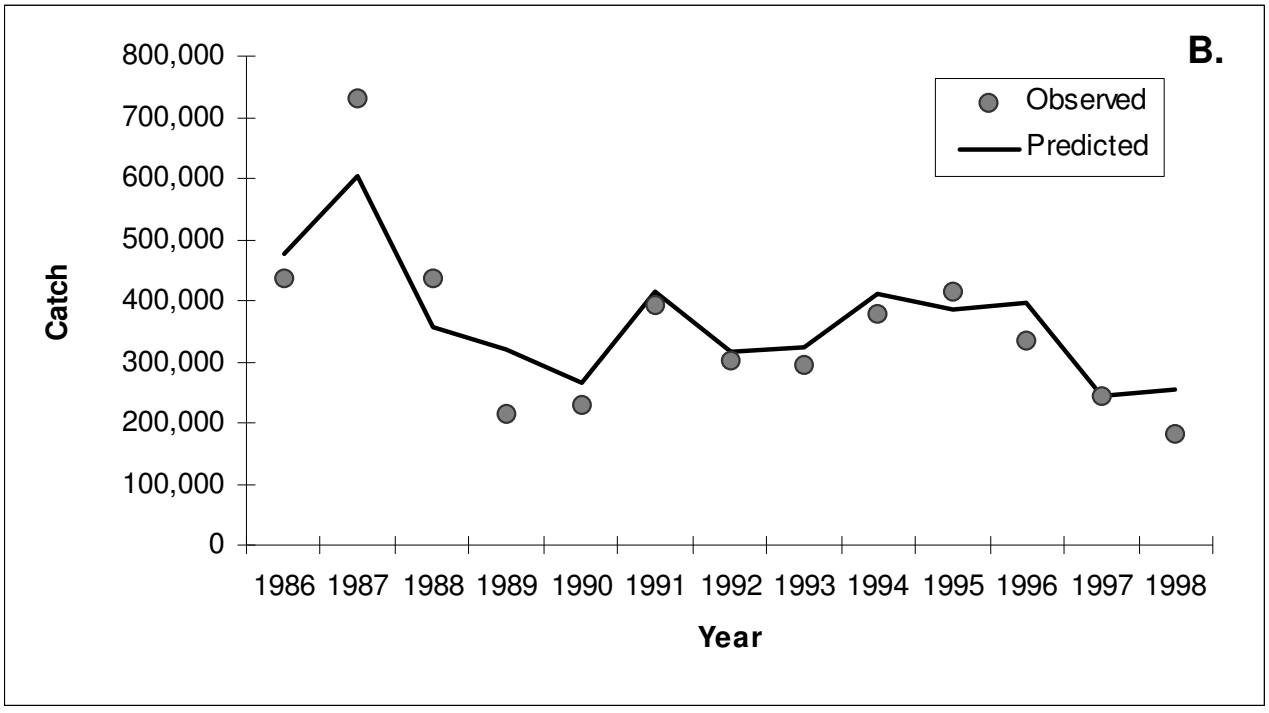


Figure 9. Estimated catch (numbers) for the red drum southern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.

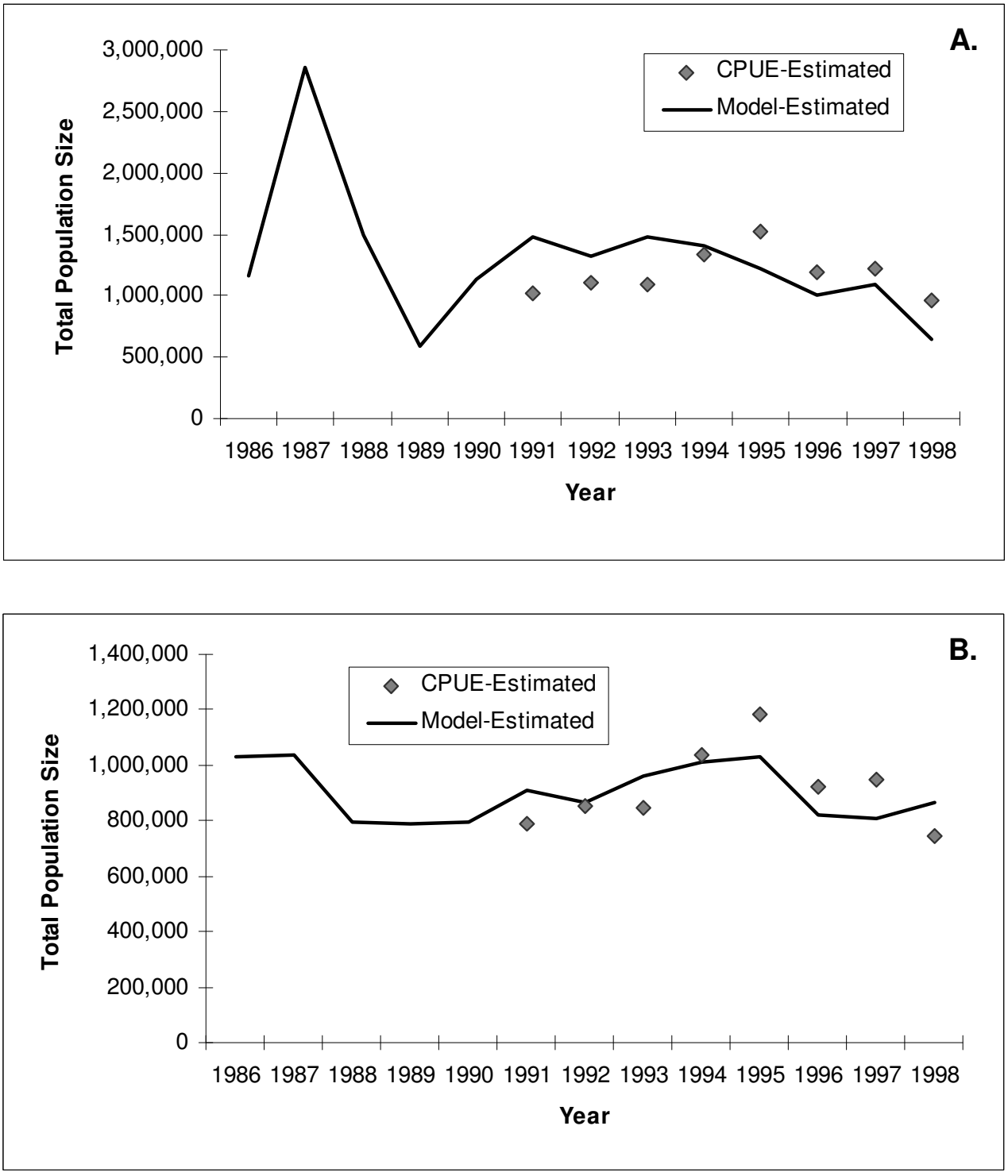


Figure 10. Estimated population size (numbers) for the red drum southern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.

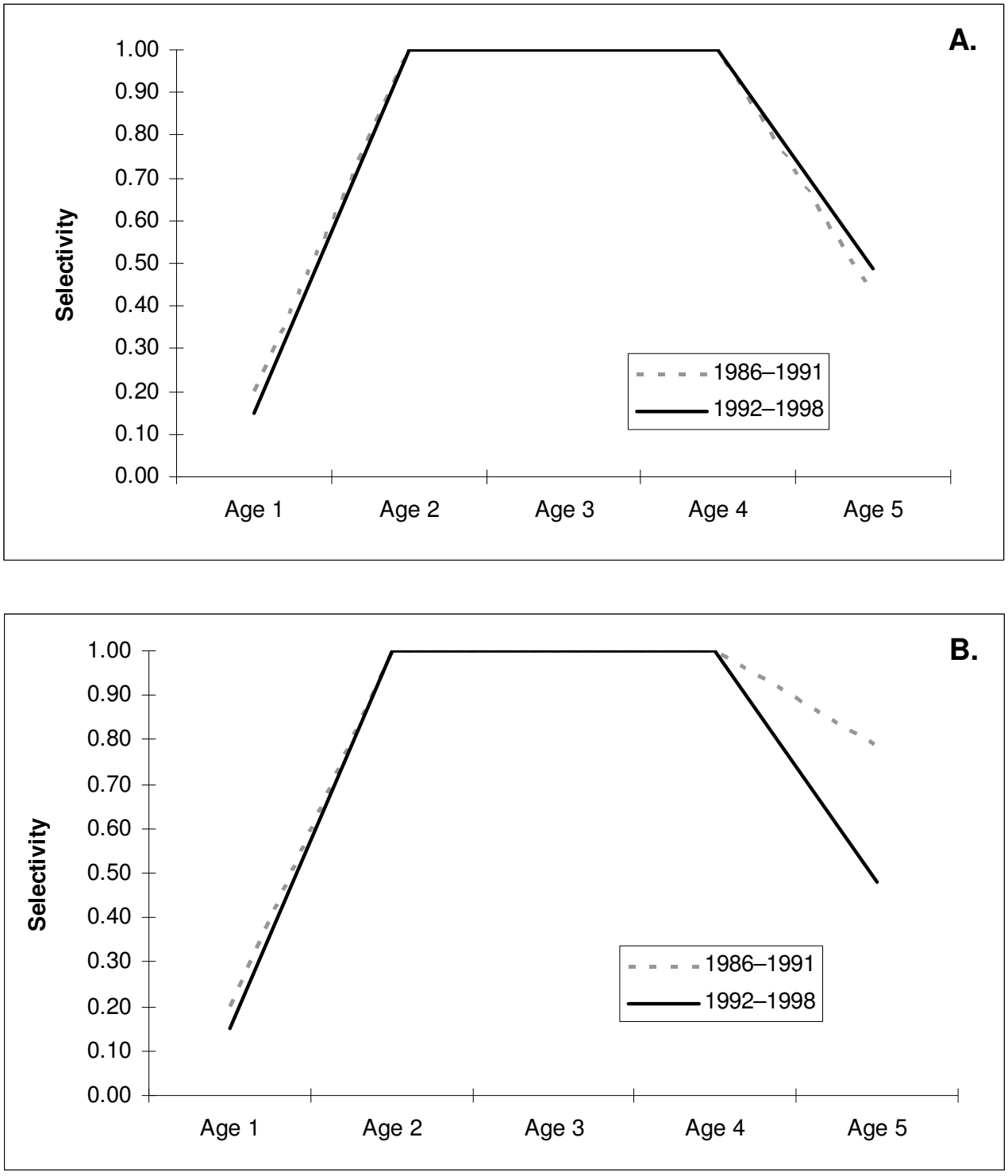
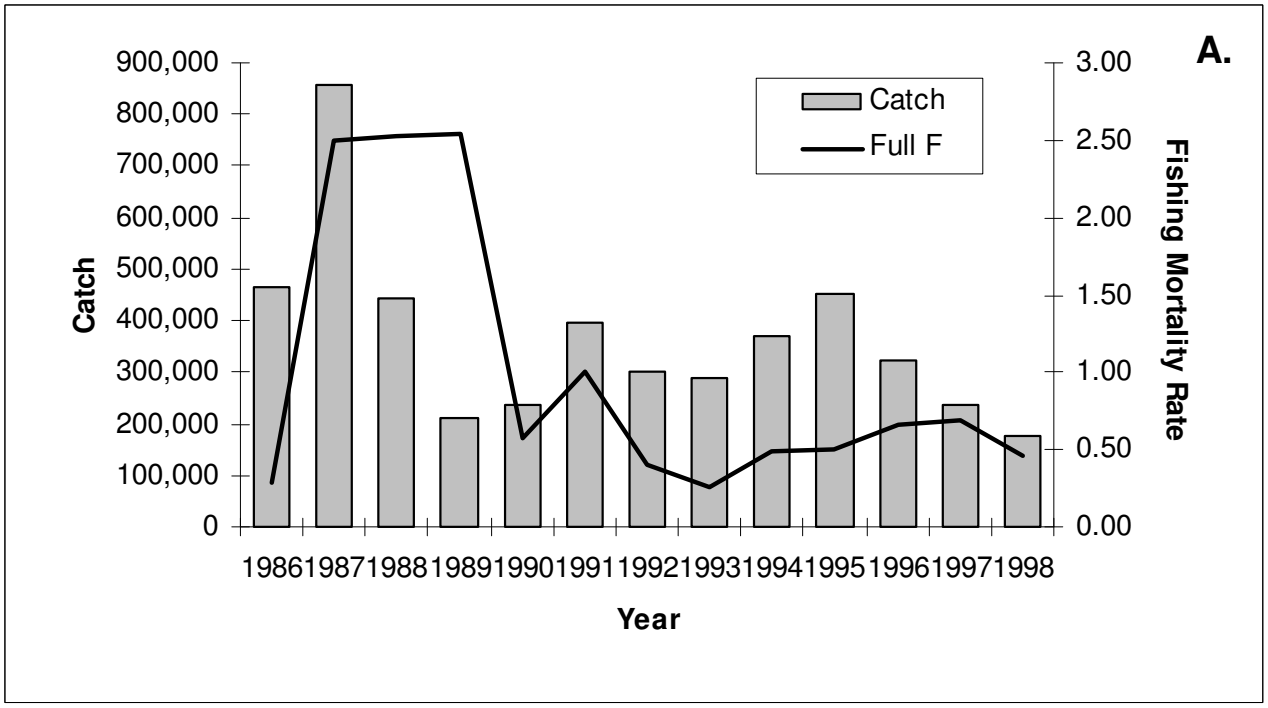


Figure 11. Selectivity-at-age estimates for the red drum southern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.



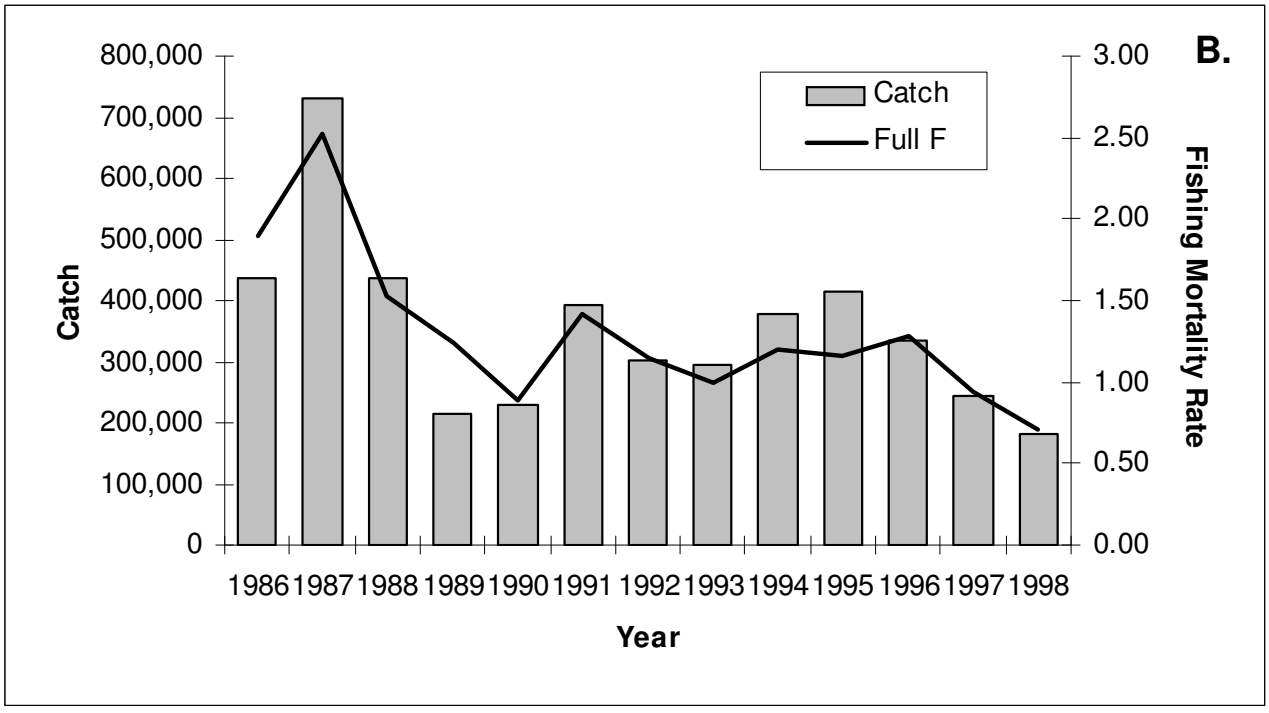


Figure 12. Annual catch and full *F* estimates for the red drum southern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.

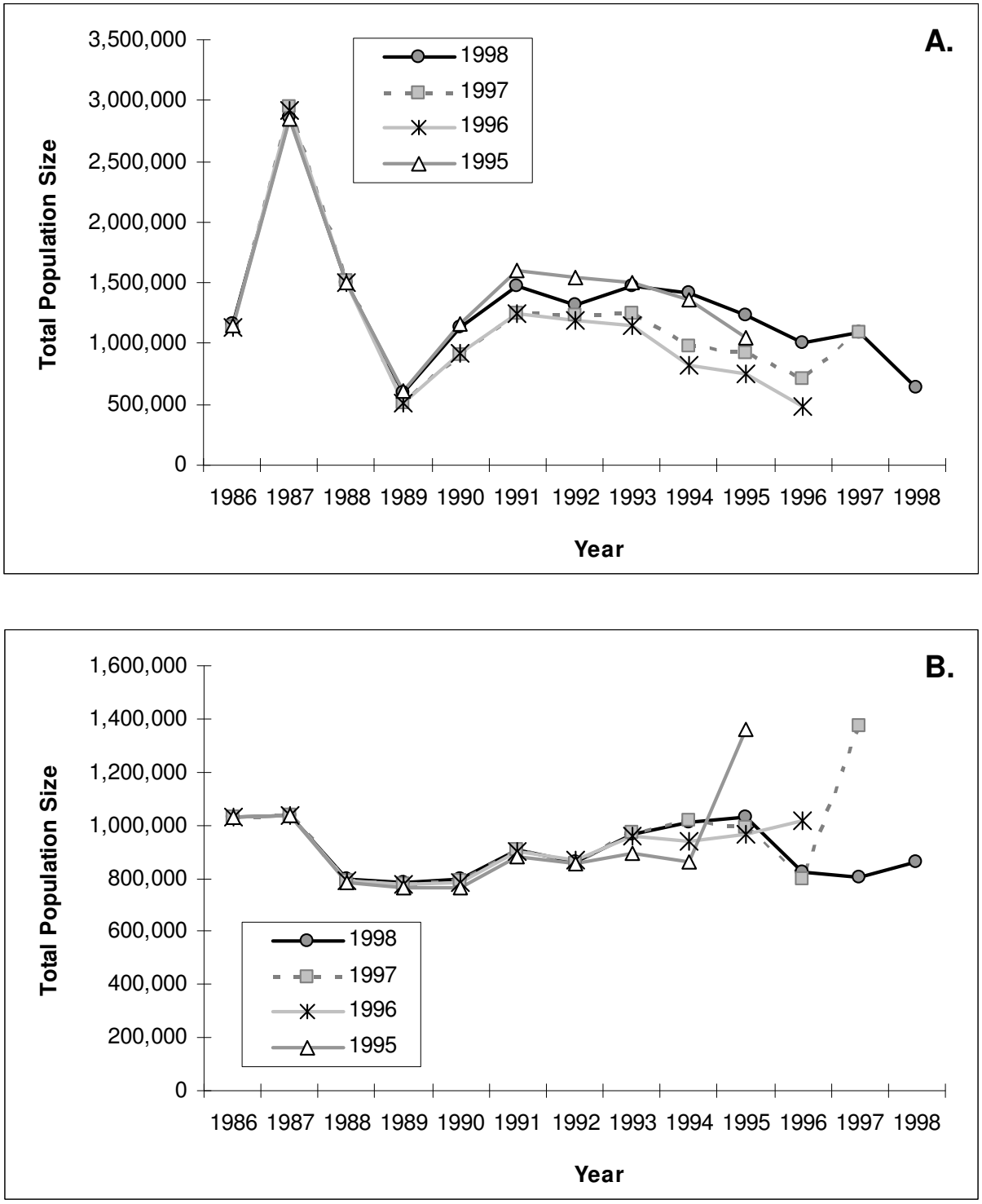


Figure 13. Retrospective analysis of population size (numbers) estimates for the red drum southern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.

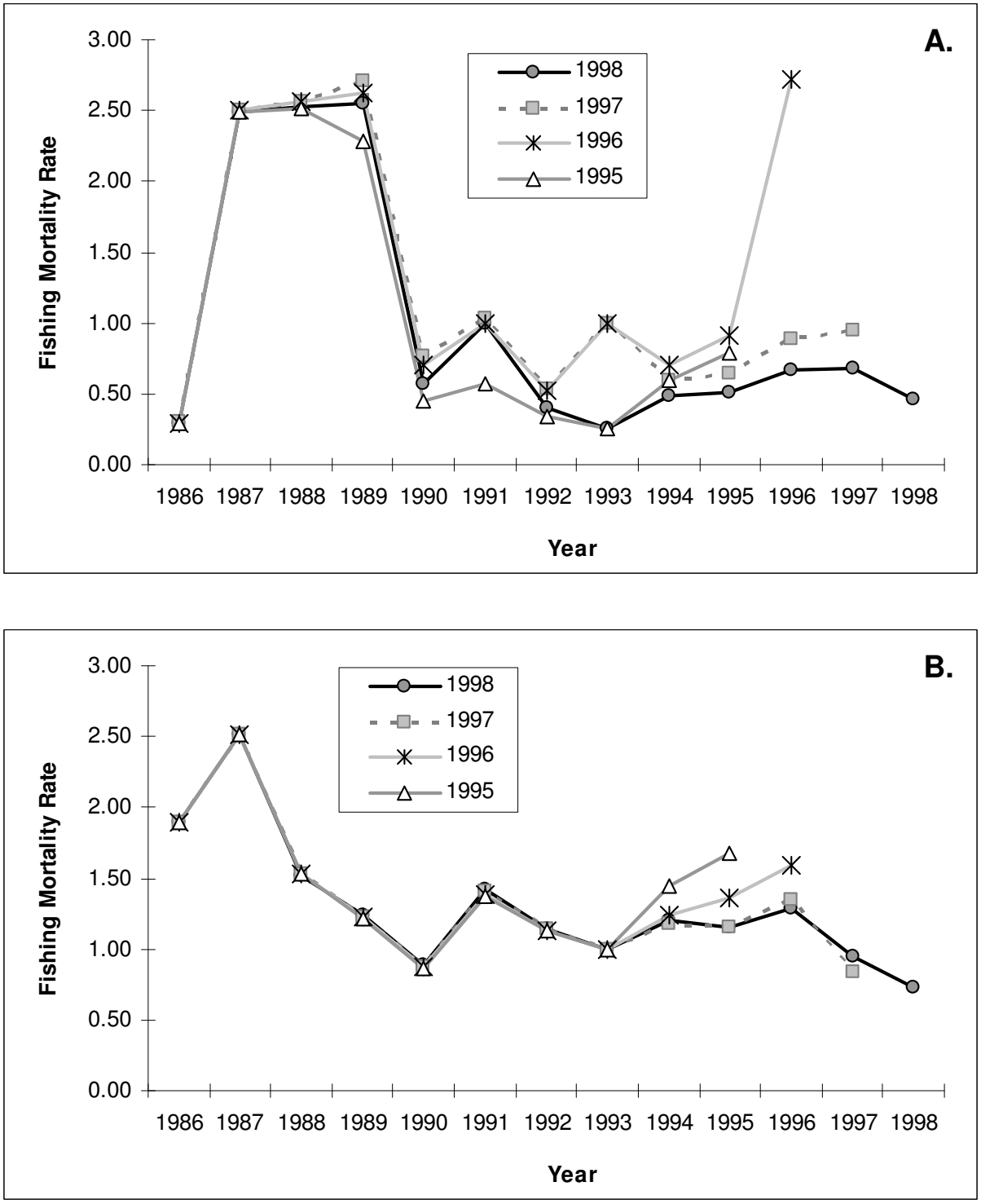


Figure 14. Retrospective analysis of *F* estimates for the red drum southern management region based on the catch-at-age matrix (A.) used in Vaughan and Carmichael (2000) and (B.) developed at the SEDAR 18 DW.