Northwest Atlantic      Fisheries Organization

SCIENTIFIC COUNCIL MEETING – APRIL 2017

## eXtended Survivor's Analysis (XSA) update runs for Greenland Halibut in SA 2 + Div. 3KLMNO

by

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## Abstract

eXtended Survivor Analysis (XSA) (Shepherd 1999, Darby and Flatman 1994) was used as the basis of assessment and advice for Greenland Halibut in Subarea 2 + Div. 3KLMNO from 2000 to 2010 and the Management Strategy Evaluation (MSE) for this stock conducted in 2009/2010 used XSA as one of two estimation models to generate operating models. Estimates of stock status of Greenland Halibut in Subarea 2 and Divisions 3KLMNO are produced using this model to compare with the last full assessment of this stock in 2010. This update was illustrative only, and was not meant to be necessarily indicative of current stock status as model settings were not optimized. Recent data has indicated that Greenland Halibut are longer lived and slower growing than once thought based on whole otoliths.  Therefore additional XSA runs which incorporated a lower plus group and lower natural mortality level were considered.

## Introduction

Analytical assessments of the status of Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO using Extended Survivors Analysis (XSA, Shepherd, 1999; Darby and Flatman, 1994) were undertaken from 2000 to 2010. Healey (2011) provides a full chronology of the XSA-based assessments over 2000-2010 with description of input data and model settings used as well as conclusions drawn from each of the annual assessments.  XSA was used as one of two estimation models to generate operating models for the Management Strategy Evaluation (MSE) conducted in 2009/2010.

In 2010, the last time XSA was used as basis of assessment for Greenland Halibut, the results indicated that the estimated biomass (ages 5+) remained well below the long term average, that all recent year classes at that time were relatively weak, F decreased substantially under the initial FC Rebuilding plan (Healey, 2011), and projections indicated that the biomass would continue to decline.  XSA diagnostics revealed "serious problems in the model fit" (Healey, 2011).  In previous years, there was debate within Scientific Council about whether or not to reject the XSA assessment as the basis for management advice.  Therefore the XSA was updated in 2016 for illustrative purposes only.  In addition, however, several studies have indicated that Greenland Halibut are older and longer lived than previously thought using the traditional method of ageing using whole otoliths (Treble et al., 2008; Albert, 2016; Dwyer et al., 2016).  The traditional method does not provide accurate ages for this stock after age 9, therefore some XSA runs used a plus group of 10 years and older (rather than 14+) and since greater longevity is associated with lower mortality (M) rates, there were runs using an M of 0.12 (based on information from Cooper et al., 2005; Gregg et al., 2006; Hewitt and Hoenig, 2007).

**Methods**

Data sources for the update run (Run 1) were the same as those used in the 2010 assessment of Greenland Halibut, merely updated with the recent information:

- Catch-at-age 1975-2015, ages 1-14+
- EU 3M (0-700 m), 1995-2003, ages 1-12
- EU 3M (700-1400 m), 2004-2015, ages 1-13
- Can. Fall 2J3K, 1996-2015, ages 1-13
- Can. Spring 3LNO, 1996-2014, ages 1-8

For run 2, all data was the same, with the exception of the plus group changed from 14+ to 10+.  Survey ages older than age 9 were removed.

- Catch-at-age 1975-2015, ages **1-10+**
- EU 3M (0-700 m), 1995-2003, ages **1-9**
- EU 3M (700-1400 m), 2004-2015, ages **1-9**
- Can. Fall 2J3K, 1996-2015, ages **1-9**
- Can. Spring 3LNO, 1996-2014, ages **1-8**

For run 3, all data was the same as in Run 1, except M was set at 0.12.

For run 4, all data was the same as Run 2, but with M set at 0.12.

**Results**

**Update Run**

Population numbers and fishing mortality at age over the time series are presented in Tables 1 and 2.  Table 3 shows summary values (Tables 1-3) for this run. Results of the XSA estimate exploitable (5+) biomass in 2015 to be about 82, 000t, and fishing mortality (Fbar ages 5-10) at 0.28.  Recruits (at age 1) have been well below the long-term average since 2002 (Figure 1).

These results are presented in Figure 1, along with the catchability by age for each fleet and the associated standard errors, as well as the shrinkage weighting (Figure 2) and the PRs by age and fleet (Figure 3). Standard errors of the log-scale survey catchability parameters, as in 2010, exceeded 0.5 at most of the survey-ages (Figure 2).  This indicates problems with that age for the fleet (Darby and Flatman, 1994). Residual graphics from the XSA analysis are presented in Figures 4-6. The trends and patterns in the residuals described in Healey et al. 2011 persist in the updated XSA run.  There is evidence of year effects, trends along cohorts, high mean squared error for residuals at ages 7-8 in the Canadian spring surveys and ages 1-4 in the EU (0-1400 m) surveys.  All of these indicate poor model fit.

A comparison of the results of the XSA in the updated run with the 2010 final XSA run indicate that biomass estimates from the current assessment is lower and fishing mortality higher in the years 2004-2010 (Figure 7).

Lowering the plus group (Run 2 and Run 4) did not have an effect on the most recent estimates of biomass, but the earliest part of the time series had higher estimates of biomass and were more variable (Tables 4-6) (Figures 8-12).  Lowering the natural mortality rate from 0.2 to 0.12 had the expected effect of lowering estimates of biomass and recruits (and increasing estimates of fishing mortality) (Run 3 and Run 4) (Tables 7-9) (Figures 13-17).

Tables 10-12 and Figures 18-22 showed the results for Run 4, in which the plus group was 10+ and the M was 0.12.  For XSA runs that have a lowered plus group, Fbar is computed over ages 5-9.

Changing these data inputs/parameters did not improve the residual patterns in the XSA analyses examined here.

**Retrospective Analysis, Run 4**

A four-year retrospective analysis was conducted for Run 4 to examine the influence of removing successive years' data on the terminal estimates of biomass, fishing mortality and recruitment (Figure 23). Retrospective

patterns in stock size and fishing mortality estimates have been problematic in earlier assessments of this stock (see Darby et *al.* 2003; Healey and Mahé, 2008).  Retrospective patterns for biomass estimates seem slightly improved in the current analysis, but recruitment estimates show revisions that are substantial. Revisions to recruitment estimates from over a decade ago in the last year of the retrospective analysis are cause for concern.

It is emphasized that the XSA settings applied here were not tuned for optimal performance in the context of producing a best-assessment. Regardless, we note that such choices are subjective and some of the diagnostics can (at times) be improved simply by altering key tuning settings. Methods to estimate population size that incorporate uncertainty into catch that would be preferred over exact-catch approaches such as XSA, particularly given the history of poor catch quality over an extended period of time. It is recommended that further assessment development should focus on these approaches rather than continue to refine XSA settings.

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Table 1. XSA estimated numbers at age (000s), updated run (Run 1).

| N@A (XSA) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 112168 | 126234 | 110110 | 66801 | 53810 | 31890 | 23090 | 14337 | 9312 | 3931 | 1773 | 415 | 720 | 735 |
| 1976 | 116518 | 91835 | 103352 | 90150 | 54692 | 43753 | 23558 | 13702 | 7254 | 4040 | 1691 | 816 | 218 | 113 |
| 1977 | 107372 | 95397 | 75188 | 84617 | 73809 | 44763 | 35270 | 16364 | 6320 | 2529 | 1312 | 635 | 433 | 311 |
| 1978 | 82182 | 87909 | 78105 | 61559 | 69279 | 59946 | 32114 | 19106 | 6751 | 2521 | 1154 | 875 | 402 | 459 |
| 1979 | 98751 | 67285 | 71974 | 63947 | 50400 | 54022 | 41466 | 18176 | 8788 | 2935 | 763 | 290 | 385 | 756 |
| 1980 | 129605 | 80850 | 55089 | 58927 | 52355 | 39105 | 36333 | 22346 | 9329 | 6137 | 1968 | 365 | 103 | 52 |
| 1981 | 131240 | 106112 | 66195 | 45103 | 48245 | 42676 | 30129 | 21468 | 9537 | 2754 | 1561 | 694 | 183 | 291 |
| 1982 | 130203 | 107450 | 86877 | 54196 | 36927 | 38719 | 30853 | 15795 | 7215 | 3911 | 1449 | 1046 | 440 | 510 |
| 1983 | 145031 | 106601 | 87973 | 71129 | 44372 | 29990 | 29620 | 19542 | 7717 | 2702 | 1678 | 647 | 625 | 1027 |
| 1984 | 152188 | 118741 | 87278 | 72026 | 58235 | 35694 | 21335 | 15384 | 9201 | 4242 | 1586 | 1185 | 461 | 791 |
| 1985 | 165959 | 124601 | 97217 | 71457 | 58970 | 46863 | 27121 | 12180 | 5644 | 3835 | 2334 | 931 | 841 | 828 |
| 1986 | 185355 | 135876 | 102015 | 79595 | 58504 | 46486 | 33564 | 16854 | 6805 | 3372 | 2677 | 1767 | 672 | 1119 |
| 1987 | 154691 | 151756 | 111246 | 83522 | 65167 | 47646 | 36033 | 21679 | 9193 | 4242 | 2335 | 1971 | 1320 | 2037 |
| 1988 | 128225 | 126650 | 124247 | 91080 | 68382 | 53230 | 37288 | 19544 | 9665 | 4961 | 2701 | 1564 | 1359 | 1633 |
| 1989 | 112371 | 104982 | 103692 | 101725 | 74570 | 55719 | 40698 | 23167 | 12038 | 6747 | 3641 | 2030 | 1186 | 578 |
| 1990 | 107612 | 92002 | 85952 | 84896 | 83285 | 60889 | 43820 | 26553 | 15101 | 8515 | 4830 | 2585 | 1420 | 1032 |
| 1991 | 94269 | 88106 | 75325 | 70371 | 69421 | 67191 | 43737 | 24447 | 14902 | 8679 | 4536 | 2865 | 1315 | 983 |
| 1992 | 70597 | 77181 | 72135 | 61671 | 57416 | 54247 | 47994 | 23908 | 10247 | 5735 | 3739 | 2026 | 1246 | 1047 |
| 1993 | 83291 | 57800 | 63191 | 59059 | 49529 | 43226 | 34531 | 20619 | 8531 | 4470 | 3101 | 2146 | 991 | 445 |
| 1994 | 141895 | 68193 | 47322 | 51736 | 47439 | 31892 | 20978 | 12242 | 6097 | 2784 | 1998 | 1585 | 884 | 588 |
| 1995 | 171052 | 116173 | 55831 | 38744 | 37476 | 23910 | 11801 | 7094 | 3925 | 2204 | 1282 | 902 | 916 | 728 |
| 1996 | 148556 | 140045 | 95115 | 45711 | 31429 | 29460 | 17457 | 6765 | 3881 | 2143 | 1316 | 737 | 492 | 303 |
| 1997 | 121318 | 121628 | 114659 | 77873 | 37253 | 24231 | 19417 | 8513 | 3807 | 2312 | 1299 | 683 | 393 | 253 |
| 1998 | 105746 | 99327 | 99580 | 93875 | 63454 | 28778 | 16066 | 9071 | 4061 | 2086 | 1345 | 683 | 337 | 185 |
| 1999 | 109640 | 86578 | 81322 | 81530 | 76359 | 48717 | 18669 | 7918 | 4122 | 2027 | 1219 | 760 | 414 | 427 |
| 2000 | 114588 | 89766 | 70884 | 66581 | 66482 | 60573 | 34797 | 7494 | 3050 | 1873 | 1095 | 687 | 345 | 275 |
| 2001 | 112373 | 93817 | 73494 | 58035 | 54267 | 52595 | 38207 | 9329 | 3150 | 1617 | 1056 | 564 | 379 | 180 |
| 2002 | 108004 | 92004 | 76811 | 60172 | 47110 | 42404 | 32056 | 11265 | 2974 | 1665 | 876 | 467 | 278 | 176 |
| 2003 | 86241 | 88426 | 75326 | 62854 | 48831 | 37066 | 28167 | 10337 | 3245 | 1310 | 767 | 391 | 180 | 199 |
| 2004 | 86317 | 70608 | 72397 | 61488 | 50303 | 35916 | 20645 | 7893 | 2686 | 1196 | 605 | 366 | 190 | 162 |
| 2005 | 81876 | 70670 | 57809 | 59259 | 49531 | 37509 | 21953 | 7364 | 2729 | 1016 | 501 | 234 | 133 | 94 |
| 2006 | 81627 | 67034 | 57860 | 47294 | 48034 | 39057 | 25282 | 8642 | 2413 | 958 | 430 | 189 | 89 | 110 |
| 2007 | 89818 | 66831 | 54883 | 47363 | 38526 | 37635 | 26141 | 9711 | 2640 | 990 | 448 | 229 | 112 | 79 |
| 2008 | 93672 | 73537 | 54716 | 44934 | 38698 | 31026 | 27436 | 10624 | 3052 | 1049 | 384 | 219 | 115 | 66 |
| 2009 | 96884 | 76692 | 60207 | 44798 | 36763 | 31278 | 22405 | 12784 | 3669 | 1184 | 503 | 210 | 138 | 150 |
| 2010 | 86241 | 79322 | 62790 | 49293 | 36622 | 29668 | 22784 | 10381 | 3883 | 1241 | 510 | 225 | 111 | 106 |
| 2011 | 52906 | 70608 | 64943 | 51408 | 40226 | 29237 | 19696 | 8518 | 2915 | 1248 | 545 | 224 | 127 | 108 |
| 2012 | 48262 | 43316 | 57809 | 52782 | 41465 | 31681 | 20227 | 9560 | 3397 | 1251 | 610 | 306 | 123 | 99 |
| 2013 | 86625 | 39513 | 35464 | 46230 | 42575 | 32156 | 22842 | 9667 | 2824 | 979 | 430 | 240 | 129 | 146 |
| 2014 | 63880 | 70923 | 32351 | 28921 | 37415 | 33079 | 21938 | 13368 | 3056 | 1169 | 439 | 268 | 165 | 224 |
| 2015 | 43427 | 52300 | 58066 | 26379 | 23440 | 29632 | 23628 | 12728 | 4212 | 1313 | 684 | 282 | 188 | 397 |
| 2016 | 62171 | 35555 | 42820 | 47488 | 21517 | 18803 | 23141 | 15692 | 5403 | 2027 | 873 | 508 | 211 | 454 |

Table 2. XSA estimated fishing mortality at age, updated run (Run 1).

| F @ AGE(XSA) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 0 | 0 | 0 | 0 | 0.0069 | 0.1028 | 0.3219 | 0.4813 | 0.6351 | 0.6435 | 0.5756 | 0.4457 | 0.5595 | 0.5595 |
| 1976 | 0 | 0 | 0 | 0 | 0.0003 | 0.0155 | 0.1644 | 0.5738 | 0.8539 | 0.9244 | 0.7803 | 0.4339 | 0.7197 | 0.7197 |
| 1977 | 0 | 0 | 0 | 0 | 0.008 | 0.1321 | 0.413 | 0.6854 | 0.7192 | 0.5847 | 0.2049 | 0.2567 | 0.351 | 0.351 |
| 1978 | 0 | 0 | 0 | 0 | 0.0487 | 0.1686 | 0.3692 | 0.5766 | 0.633 | 0.9955 | 1.1797 | 0.6224 | 0.9428 | 0.9428 |
| 1979 | 0 | 0 | 0 | 0 | 0.0537 | 0.1967 | 0.4182 | 0.467 | 0.159 | 0.1998 | 0.5377 | 0.8375 | 0.5292 | 0.5292 |
| 1980 | 0 | 0 | 0 | 0 | 0.0044 | 0.0608 | 0.3262 | 0.6514 | 1.0202 | 1.169 | 0.8416 | 0.4908 | 0.8425 | 0.8425 |
| 1981 | 0 | 0 | 0 | 0 | 0.02 | 0.1244 | 0.4458 | 0.8904 | 0.6913 | 0.4419 | 0.2 | 0.2562 | 0.3011 | 0.3011 |
| 1982 | 0 | 0 | 0 | 0 | 0.0081 | 0.0679 | 0.2566 | 0.5162 | 0.7821 | 0.646 | 0.606 | 0.3152 | 0.5266 | 0.5266 |
| 1983 | 0 | 0 | 0 | 0 | 0.0176 | 0.1405 | 0.4552 | 0.5533 | 0.3985 | 0.3327 | 0.1481 | 0.139 | 0.2075 | 0.2075 |
| 1984 | 0 | 0 | 0 | 0 | 0.0173 | 0.0747 | 0.3606 | 0.8027 | 0.6751 | 0.3975 | 0.3334 | 0.1431 | 0.293 | 0.293 |
| 1985 | 0 | 0 | 0 | 0 | 0.0379 | 0.1338 | 0.2757 | 0.3821 | 0.315 | 0.1596 | 0.0783 | 0.1251 | 0.1214 | 0.1214 |
| 1986 | 0 | 0 | 0 | 0 | 0.0053 | 0.0547 | 0.2371 | 0.4062 | 0.2726 | 0.1677 | 0.1062 | 0.0917 | 0.1223 | 0.1223 |
| 1987 | 0 | 0 | 0 | 0 | 0.0023 | 0.0451 | 0.4117 | 0.6079 | 0.4168 | 0.2513 | 0.2006 | 0.1715 | 0.2088 | 0.2088 |
| 1988 | 0 | 0 | 0 | 0 | 0.0048 | 0.0684 | 0.2759 | 0.2846 | 0.1593 | 0.1094 | 0.0858 | 0.0771 | 0.091 | 0.091 |
| 1989 | 0 | 0 | 0 | 0 | 0.0027 | 0.0402 | 0.2271 | 0.228 | 0.1462 | 0.1342 | 0.1427 | 0.1571 | 0.1452 | 0.1452 |
| 1990 | 0 | 0 | 0 | 0.0012 | 0.0147 | 0.1309 | 0.3836 | 0.3777 | 0.3538 | 0.4298 | 0.3222 | 0.4755 | 0.412 | 0.412 |
| 1991 | 0 | 0 | 0 | 0.0035 | 0.0466 | 0.1365 | 0.404 | 0.6695 | 0.7548 | 0.6421 | 0.6059 | 0.633 | 0.6326 | 0.6326 |
| 1992 | 0 | 0 | 0 | 0.0193 | 0.0839 | 0.2517 | 0.6449 | 0.8305 | 0.6297 | 0.4148 | 0.3554 | 0.5151 | 0.4315 | 0.4315 |
| 1993 | 0 | 0 | 0 | 0.0191 | 0.2402 | 0.523 | 0.837 | 1.0183 | 0.9197 | 0.6051 | 0.4715 | 0.6862 | 0.5927 | 0.5927 |
| 1994 | 0 | 0 | 0 | 0.1224 | 0.4851 | 0.7942 | 0.8843 | 0.9375 | 0.8174 | 0.5759 | 0.5952 | 0.3486 | 0.5106 | 0.5106 |
| 1995 | 0 | 0 | 0 | 0.0093 | 0.0407 | 0.1146 | 0.3564 | 0.4032 | 0.4051 | 0.3157 | 0.3531 | 0.4072 | 0.361 | 0.361 |
| 1996 | 0 | 0 | 0 | 0.0046 | 0.0601 | 0.2169 | 0.5181 | 0.3749 | 0.3178 | 0.301 | 0.4559 | 0.4298 | 0.3879 | 0.3879 |
| 1997 | 0 | 0 | 0 | 0.0048 | 0.0581 | 0.2109 | 0.561 | 0.5402 | 0.4015 | 0.342 | 0.4423 | 0.5075 | 0.4871 | 0.4871 |
| 1998 | 0 | 0 | 0 | 0.0065 | 0.0643 | 0.2327 | 0.5076 | 0.5889 | 0.4951 | 0.3377 | 0.3708 | 0.3017 | 0.3595 | 0.3595 |
| 1999 | 0 | 0 | 0 | 0.004 | 0.0316 | 0.1365 | 0.7128 | 0.7538 | 0.5885 | 0.4151 | 0.3726 | 0.5889 | 0.49 | 0.49 |
| 2000 | 0 | 0 | 0 | 0.0045 | 0.0343 | 0.2608 | 1.1164 | 0.6666 | 0.4347 | 0.3732 | 0.464 | 0.3951 | 0.5326 | 0.5326 |
| 2001 | 0 | 0 | 0 | 0.0086 | 0.0467 | 0.2951 | 1.0214 | 0.9431 | 0.4375 | 0.413 | 0.6151 | 0.5073 | 0.6066 | 0.6066 |
| 2002 | 0 | 0 | 0.0005 | 0.0088 | 0.0398 | 0.2091 | 0.9317 | 1.0447 | 0.6203 | 0.5751 | 0.6055 | 0.7544 | 0.695 | 0.695 |
| 2003 | 0 | 0 | 0.003 | 0.0227 | 0.1072 | 0.3852 | 1.0722 | 1.1478 | 0.798 | 0.5717 | 0.541 | 0.5218 | 0.6287 | 0.6287 |
| 2004 | 0 | 0 | 0.0003 | 0.0163 | 0.0935 | 0.2923 | 0.8309 | 0.8621 | 0.7718 | 0.6711 | 0.75 | 0.8123 | 0.7043 | 0.7043 |
| 2005 | 0 | 0 | 0.0008 | 0.01 | 0.0376 | 0.1945 | 0.7323 | 0.9156 | 0.8465 | 0.6594 | 0.7738 | 0.7725 | 0.7601 | 0.7601 |
| 2006 | 0 | 0 | 0.0002 | 0.0051 | 0.044 | 0.2015 | 0.7569 | 0.9858 | 0.6906 | 0.5605 | 0.4297 | 0.3213 | 0.51 | 0.51 |
| 2007 | 0 | 0 | 0 | 0.0021 | 0.0165 | 0.1161 | 0.7004 | 0.9575 | 0.7234 | 0.7481 | 0.5145 | 0.4872 | 0.5171 | 0.5171 |
| 2008 | 0 | 0 | 0 | 0.0007 | 0.0129 | 0.1255 | 0.5637 | 0.8631 | 0.747 | 0.5348 | 0.4023 | 0.2638 | 0.2866 | 0.2866 |
| 2009 | 0 | 0 | 0 | 0.0015 | 0.0144 | 0.1168 | 0.5694 | 0.9916 | 0.8844 | 0.643 | 0.6027 | 0.4345 | 0.2857 | 0.2857 |
| 2010 | 0 | 0 | 0 | 0.0033 | 0.0252 | 0.2096 | 0.7839 | 1.07 | 0.9349 | 0.6221 | 0.6239 | 0.3767 | 0.2462 | 0.2462 |
| 2011 | 0 | 0 | 0.0073 | 0.0149 | 0.0388 | 0.1684 | 0.5229 | 0.7193 | 0.6459 | 0.5156 | 0.3771 | 0.395 | 0.2025 | 0.2025 |
| 2012 | 0 | 0 | 0.0235 | 0.0149 | 0.0543 | 0.1271 | 0.5383 | 1.0194 | 1.0443 | 0.8684 | 0.7334 | 0.6611 | 0.3896 | 0.3896 |
| 2013 | 0 | 0 | 0.004 | 0.0116 | 0.0524 | 0.1824 | 0.3357 | 0.9517 | 0.6818 | 0.6028 | 0.2733 | 0.1758 | 0.1371 | 0.1371 |
| 2014 | 0 | 0 | 0.0041 | 0.0101 | 0.0332 | 0.1365 | 0.3444 | 0.9549 | 0.6448 | 0.3361 | 0.241 | 0.1512 | 0.0766 | 0.0766 |
| 2015 | 0 | 0 | 0.0011 | 0.0037 | 0.0204 | 0.0472 | 0.2093 | 0.6569 | 0.5314 | 0.2079 | 0.0984 | 0.0901 | 0.0542 | 0.0542 |

Table 3. Stock summary table from XSA update run (Run 1).

| Year | N+ (000s) | Rec(Age 1 | Fbar 5-10 | 5+ Biomass | 10+ Biomass |
|------|-----------|-----------|-----------|------------|-------------|
| 1975 | 555326 | 112168 | 0.36525 | 132735 | 21903 |
| 1976 | 551692 | 116518 | 0.42205 | 134495 | 17671 |
| 1977 | 544320 | 107372 | 0.423733 | 156926 | 14815 |
| 1978 | 502362 | 82182 | 0.465267 | 167723 | 15901 |
| 1979 | 479938 | 98751 | 0.249067 | 162477 | 15612 |
| 1980 | 492564 | 129605 | 0.538667 | 130841 | 12396 |
| 1981 | 506188 | 131240 | 0.435633 | 115171 | 13995 |
| 1982 | 515591 | 130203 | 0.379483 | 121126 | 19816 |
| 1983 | 548654 | 145031 | 0.3163 | 122493 | 24053 |
| 1984 | 578347 | 152188 | 0.387983 | 114899 | 24156 |
| 1985 | 618781 | 165959 | 0.21735 | 147571 | 28813 |
| 1986 | 674661 | 185355 | 0.1906 | 137440 | 33304 |
| 1987 | 692838 | 154691 | 0.289183 | 163647 | 41974 |
| 1988 | 670529 | 128225 | 0.1504 | 167782 | 43872 |
| 1989 | 643144 | 112371 | 0.129733 | 180676 | 43361 |
| 1990 | 618492 | 107612 | 0.28175 | 204146 | 55189 |
| 1991 | 566147 | 94269 | 0.44225 | 221928 | 62209 |
| 1992 | 489189 | 70597 | 0.475917 | 189313 | 47154 |
| 1993 | 430930 | 83291 | 0.69055 | 145226 | 35790 |
| 1994 | 435633 | 141895 | 0.749067 | 99688 | 26306 |
| 1995 | 472038 | 171052 | 0.272617 | 73524 | 22258 |
| 1996 | 523410 | 148556 | 0.298133 | 74016 | 16644 |
| 1997 | 533639 | 121318 | 0.352283 | 71494 | 15716 |
| 1998 | 524594 | 105746 | 0.37105 | 85012 | 14668 |
| 1999 | 519702 | 109640 | 0.439717 | 100670 | 15140 |
| 2000 | 518490 | 114588 | 0.481 | 109483 | 13011 |
| 2001 | 499063 | 112373 | 0.526133 | 110401 | 11758 |
| 2002 | 476262 | 108004 | 0.570117 | 96824 | 10189 |
| 2003 | 443340 | 86241 | 0.68035 | 88909 | 8104 |
| 2004 | 410772 | 86317 | 0.58695 | 75896 | 7270 |
| 2005 | 390678 | 81876 | 0.564317 | 78641 | 5436 |
| 2006 | 379019 | 81627 | 0.539883 | 81002 | 4269 |
| 2007 | 375406 | 89818 | 0.543667 | 78251 | 4621 |
| 2008 | 379528 | 93672 | 0.4745 | 81541 | 4724 |
| 2009 | 387665 | 96884 | 0.5366 | 78661 | 5560 |
| 2010 | 383177 | 86241 | 0.607617 | 73534 | 5699 |
| 2011 | 342709 | 52906 | 0.43515 | 67871 | 6353 |
| 2012 | 310888 | 48262 | 0.608633 | 73476 | 6795 |
| 2013 | 319820 | 86625 | 0.4678 | 81226 | 6184 |
| 2014 | 307196 | 63880 | 0.408317 | 85193 | 7507 |
| 2015 | 276676 | 43427 | 0.27885 | 81789 | 9540 |

Table 4. XSA estimated numbers at age (000s), (Run 2).

| N@A (XSA) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 112168 | 126234 | 110110 | 66801 | 53810 | 31890 | 23090 | 14337 | 9312 | 3931 |
| 1976 | 144679 | 99210 | 141965 | 112198 | 100196 | 40379 | 30170 | 19950 | 27066 | 24651 |
| 1977 | 114526 | 118453 | 81226 | 116231 | 91860 | 82018 | 32508 | 21777 | 11436 | 6050 |
| 1978 | 88771 | 93766 | 96981 | 66503 | 95162 | 74725 | 62616 | 16844 | 11183 | 11657 |
| 1979 | 104859 | 72680 | 76769 | 79402 | 54448 | 75214 | 53566 | 43149 | 6936 | 7934 |
| 1980 | 125413 | 85852 | 59505 | 62853 | 65009 | 42419 | 53683 | 32252 | 29775 | 27701 |
| 1981 | 140084 | 102679 | 70289 | 48719 | 51460 | 53035 | 32842 | 35673 | 17648 | 5697 |
| 1982 | 156001 | 114691 | 84067 | 57548 | 39888 | 41351 | 39335 | 18016 | 18845 | 15291 |
| 1983 | 191881 | 127723 | 93901 | 68828 | 47116 | 32414 | 31775 | 26487 | 9536 | 5192 |
| 1984 | 155949 | 157099 | 104571 | 76880 | 56352 | 37941 | 23320 | 17148 | 14887 | 7583 |
| 1985 | 169003 | 127681 | 128622 | 85615 | 62944 | 45321 | 28961 | 13805 | 7089 | 4816 |
| 1986 | 182985 | 138368 | 104536 | 105306 | 70096 | 49740 | 32302 | 18361 | 8135 | 5740 |
| 1987 | 156676 | 149815 | 113286 | 85587 | 86218 | 57136 | 38696 | 20645 | 10426 | 7635 |
| 1988 | 122624 | 128275 | 122658 | 92751 | 70073 | 70465 | 45058 | 21725 | 8818 | 6863 |
| 1989 | 107600 | 100396 | 105023 | 100424 | 75938 | 57103 | 54809 | 29529 | 13824 | 15686 |
| 1990 | 103211 | 88096 | 82197 | 85985 | 82220 | 62009 | 44953 | 38106 | 20310 | 27436 |
| 1991 | 90575 | 84502 | 72127 | 67297 | 70313 | 66319 | 44654 | 25374 | 24360 | 26317 |
| 1992 | 65958 | 74156 | 69184 | 59052 | 54899 | 54978 | 47280 | 24659 | 11006 | 10659 |
| 1993 | 78237 | 54001 | 60714 | 56643 | 47385 | 41166 | 35129 | 20034 | 9146 | 8612 |
| 1994 | 138842 | 64055 | 44213 | 49708 | 45462 | 30136 | 19291 | 12731 | 5619 | 5148 |
| 1995 | 168556 | 113674 | 52444 | 36198 | 35816 | 22291 | 10364 | 5713 | 4326 | 5842 |
| 1996 | 148641 | 138002 | 93069 | 42937 | 29424 | 28101 | 16131 | 5589 | 2750 | 4002 |
| 1997 | 120492 | 121697 | 112986 | 76198 | 34982 | 22524 | 18304 | 7428 | 2844 | 3698 |
| 1998 | 104790 | 98650 | 99637 | 92505 | 62083 | 26919 | 14669 | 8160 | 3173 | 2667 |
| 1999 | 111144 | 85795 | 80768 | 81576 | 75237 | 47594 | 17147 | 6774 | 3376 | 3144 |
| 2000 | 123042 | 90997 | 70243 | 66127 | 66520 | 59655 | 33877 | 6247 | 2114 | 2855 |
| 2001 | 122583 | 100738 | 74502 | 57510 | 53895 | 52626 | 37456 | 8576 | 2130 | 2845 |
| 2002 | 117078 | 100363 | 82477 | 60997 | 46680 | 42100 | 32081 | 10649 | 2358 | 2705 |
| 2003 | 95896 | 95856 | 82170 | 67493 | 49507 | 36714 | 27918 | 10358 | 2741 | 1851 |
| 2004 | 92691 | 78513 | 78480 | 67092 | 54101 | 36469 | 20357 | 7689 | 2703 | 2373 |
| 2005 | 84347 | 75889 | 64281 | 64239 | 54118 | 40619 | 22406 | 7128 | 2562 | 1629 |
| 2006 | 83711 | 69058 | 62132 | 52593 | 52111 | 42813 | 27828 | 9013 | 2220 | 1260 |
| 2007 | 94254 | 68537 | 56540 | 50861 | 42864 | 40974 | 29217 | 11795 | 2944 | 1856 |
| 2008 | 98574 | 77168 | 56113 | 46291 | 41562 | 34578 | 30170 | 13142 | 4758 | 1932 |
| 2009 | 100475 | 80706 | 63180 | 45942 | 37873 | 33622 | 25313 | 15022 | 5731 | 2464 |
| 2010 | 89854 | 82262 | 66076 | 51727 | 37559 | 30577 | 24704 | 12761 | 5715 | 2229 |
| 2011 | 55292 | 73567 | 67350 | 54099 | 42219 | 30004 | 20441 | 10090 | 4864 | 2751 |
| 2012 | 50097 | 45269 | 60231 | 54753 | 43668 | 33313 | 20854 | 10169 | 4684 | 2655 |
| 2013 | 90054 | 41016 | 37063 | 48213 | 44189 | 33959 | 24178 | 10181 | 3323 | 1460 |
| 2014 | 66688 | 73730 | 33581 | 30230 | 39038 | 34400 | 23415 | 14462 | 3477 | 1170 |
| 2015 | 45276 | 54599 | 60365 | 27386 | 24512 | 30961 | 24709 | 13937 | 5108 | 1067 |
| 2016 | 64785 | 37070 | 44703 | 49370 | 22342 | 19681 | 24230 | 16578 | 6393 | 3337 |

Table 5. XSA estimated fishing mortality at age, updated run (Run 2).

| F @ AGE(XSA) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 0 | 0 | 0 | 0 | 0.0075 | 0.0812 | 0.2317 | 0.1533 | 0.156 | 0.156 |
| 1976 | 0 | 0 | 0 | 0 | 0.0002 | 0.0168 | 0.126 | 0.3565 | 0.1671 | 0.1671 |
| 1977 | 0 | 0 | 0 | 0 | 0.0064 | 0.0699 | 0.4574 | 0.4665 | 0.3333 | 0.3333 |
| 1978 | 0 | 0 | 0 | 0 | 0.0352 | 0.1329 | 0.1724 | 0.6873 | 0.3329 | 0.3329 |
| 1979 | 0 | 0 | 0 | 0 | 0.0496 | 0.1372 | 0.3073 | 0.171 | 0.2061 | 0.2061 |
| 1980 | 0 | 0 | 0 | 0 | 0.0036 | 0.0559 | 0.2087 | 0.403 | 0.2236 | 0.2236 |
| 1981 | 0 | 0 | 0 | 0 | 0.0187 | 0.0989 | 0.4004 | 0.4381 | 0.3143 | 0.3143 |
| 1982 | 0 | 0 | 0 | 0 | 0.0075 | 0.0634 | 0.1955 | 0.4362 | 0.2328 | 0.2328 |
| 1983 | 0 | 0 | 0 | 0 | 0.0166 | 0.1293 | 0.4168 | 0.3762 | 0.3092 | 0.3092 |
| 1984 | 0 | 0 | 0 | 0 | 0.0178 | 0.0701 | 0.3243 | 0.6834 | 0.3616 | 0.3616 |
| 1985 | 0 | 0 | 0 | 0 | 0.0354 | 0.1386 | 0.2557 | 0.3288 | 0.2423 | 0.2423 |
| 1986 | 0 | 0 | 0 | 0 | 0.0044 | 0.0511 | 0.2476 | 0.3659 | 0.2226 | 0.2226 |
| 1987 | 0 | 0 | 0 | 0 | 0.0018 | 0.0375 | 0.3773 | 0.6507 | 0.3574 | 0.3574 |
| 1988 | 0 | 0 | 0 | 0 | 0.0047 | 0.0513 | 0.2226 | 0.2521 | 0.176 | 0.176 |
| 1989 | 0 | 0 | 0 | 0 | 0.0026 | 0.0392 | 0.1635 | 0.1743 | 0.1261 | 0.1261 |
| 1990 | 0 | 0 | 0 | 0.0012 | 0.0149 | 0.1283 | 0.3719 | 0.2474 | 0.2505 | 0.2505 |
| 1991 | 0 | 0 | 0 | 0.0036 | 0.046 | 0.1384 | 0.3938 | 0.6353 | 0.3918 | 0.3918 |
| 1992 | 0 | 0 | 0 | 0.0201 | 0.0879 | 0.2479 | 0.6586 | 0.7919 | 0.5709 | 0.5709 |
| 1993 | 0 | 0 | 0 | 0.0199 | 0.2526 | 0.5579 | 0.815 | 1.0713 | 0.8232 | 0.8232 |
| 1994 | 0 | 0 | 0 | 0.1278 | 0.5127 | 0.8674 | 1.017 | 0.8795 | 0.9314 | 0.9314 |
| 1995 | 0 | 0 | 0 | 0.0099 | 0.0426 | 0.1234 | 0.4176 | 0.5311 | 0.3599 | 0.3599 |
| 1996 | 0 | 0 | 0 | 0.0049 | 0.0645 | 0.2287 | 0.5755 | 0.4756 | 0.4849 | 0.4849 |
| 1997 | 0 | 0 | 0 | 0.0049 | 0.062 | 0.2289 | 0.6079 | 0.6507 | 0.5846 | 0.5846 |
| 1998 | 0 | 0 | 0 | 0.0066 | 0.0658 | 0.251 | 0.5727 | 0.6827 | 0.6929 | 0.6929 |
| 1999 | 0 | 0 | 0 | 0.004 | 0.0321 | 0.14 | 0.8097 | 0.9646 | 0.7834 | 0.7834 |
| 2000 | 0 | 0 | 0 | 0.0045 | 0.0343 | 0.2654 | 1.1737 | 0.8761 | 0.7108 | 0.7108 |
| 2001 | 0 | 0 | 0 | 0.0086 | 0.047 | 0.2949 | 1.0577 | 1.0911 | 0.7425 | 0.7425 |
| 2002 | 0 | 0 | 0.0005 | 0.0087 | 0.0401 | 0.2108 | 0.9305 | 1.1573 | 0.8747 | 0.8747 |
| 2003 | 0 | 0 | 0.0027 | 0.0212 | 0.1056 | 0.3898 | 1.0895 | 1.1434 | 1.0523 | 1.0523 |
| 2004 | 0 | 0 | 0.0002 | 0.0149 | 0.0866 | 0.2871 | 0.8494 | 0.8991 | 0.7645 | 0.7645 |
| 2005 | 0 | 0 | 0.0007 | 0.0092 | 0.0343 | 0.1782 | 0.7107 | 0.9665 | 0.9373 | 0.9373 |
| 2006 | 0 | 0 | 0.0002 | 0.0045 | 0.0404 | 0.1821 | 0.6583 | 0.919 | 0.7812 | 0.7812 |
| 2007 | 0 | 0 | 0 | 0.0019 | 0.0148 | 0.1061 | 0.5989 | 0.7078 | 0.6195 | 0.6195 |
| 2008 | 0 | 0 | 0 | 0.0007 | 0.012 | 0.1119 | 0.4973 | 0.63 | 0.4117 | 0.4117 |
| 2009 | 0 | 0 | 0 | 0.0015 | 0.014 | 0.1082 | 0.4849 | 0.7664 | 0.4714 | 0.4714 |
| 2010 | 0 | 0 | 0 | 0.0031 | 0.0246 | 0.2027 | 0.6954 | 0.7645 | 0.5322 | 0.5322 |
| 2011 | 0 | 0 | 0.0071 | 0.0142 | 0.0369 | 0.1638 | 0.4982 | 0.5674 | 0.3357 | 0.3357 |
| 2012 | 0 | 0 | 0.0226 | 0.0144 | 0.0515 | 0.1205 | 0.517 | 0.9185 | 0.6349 | 0.6349 |
| 2013 | 0 | 0 | 0.0038 | 0.0111 | 0.0504 | 0.1718 | 0.3139 | 0.8745 | 0.5448 | 0.5448 |
| 2014 | 0 | 0 | 0.0039 | 0.0097 | 0.0318 | 0.1309 | 0.3188 | 0.8408 | 0.5408 | 0.5408 |
| 2015 | 0 | 0 | 0.0011 | 0.0036 | 0.0195 | 0.0452 | 0.1991 | 0.5794 | 0.4154 | 0.4154 |

Table 6. Stock summary table from XSA Run 2.

| Year | N+ (000s) | Rec(Age 1 | Fbar 5-9 | 5+ Biomas | 10+ Bioma |
|------|-----------|-----------|----------|-----------|-----------|
| 1975 | 551683 | 112168 | 0.12594 | 119519 | 8688 |
| 1976 | 740464 | 144679 | 0.13332 | 241503 | 54479 |
| 1977 | 676085 | 114526 | 0.2667 | 206676 | 13371 |
| 1978 | 618208 | 88771 | 0.27214 | 238018 | 25762 |
| 1979 | 574957 | 104859 | 0.17424 | 221317 | 17534 |
| 1980 | 584462 | 125413 | 0.17896 | 211028 | 34903 |
| 1981 | 558126 | 140084 | 0.25408 | 144506 | 9685 |
| 1982 | 585033 | 156001 | 0.18708 | 158385 | 27371 |
| 1983 | 634853 | 191881 | 0.24962 | 125726 | 11578 |
| 1984 | 651730 | 155949 | 0.29144 | 117935 | 14711 |
| 1985 | 673857 | 169003 | 0.20016 | 136836 | 10788 |
| 1986 | 715569 | 182985 | 0.17832 | 124998 | 12169 |
| 1987 | 726120 | 156676 | 0.28494 | 154174 | 16263 |
| 1988 | 689310 | 122624 | 0.14134 | 156924 | 15208 |
| 1989 | 660332 | 107600 | 0.10114 | 194395 | 35090 |
| 1990 | 634523 | 103211 | 0.2026 | 230999 | 59618 |
| 1991 | 571838 | 90575 | 0.32106 | 243340 | 64766 |
| 1992 | 471831 | 65958 | 0.47144 | 169480 | 26242 |
| 1993 | 411067 | 78237 | 0.704 | 128245 | 19885 |
| 1994 | 415205 | 138842 | 0.8416 | 81937 | 11676 |
| 1995 | 455224 | 168556 | 0.29492 | 61978 | 14290 |
| 1996 | 508566 | 148641 | 0.36584 | 61166 | 9917 |
| 1997 | 521153 | 120492 | 0.42682 | 59110 | 8709 |
| 1998 | 513253 | 104790 | 0.45302 | 71308 | 6270 |
| 1999 | 512555 | 111144 | 0.54596 | 87782 | 7190 |
| 2000 | 521677 | 123042 | 0.61206 | 98640 | 6507 |
| 2001 | 512861 | 122583 | 0.64664 | 101922 | 6734 |
| 2002 | 497488 | 117078 | 0.64268 | 90668 | 6159 |
| 2003 | 470504 | 95896 | 0.75612 | 83867 | 4009 |
| 2004 | 440468 | 92691 | 0.57734 | 74993 | 5092 |
| 2005 | 417218 | 84347 | 0.5654 | 80130 | 3546 |
| 2006 | 402739 | 83711 | 0.5162 | 85209 | 2361 |
| 2007 | 399842 | 94254 | 0.40942 | 86260 | 3615 |
| 2008 | 404288 | 98574 | 0.33258 | 92286 | 3937 |
| 2009 | 410328 | 100475 | 0.36898 | 88530 | 5172 |
| 2010 | 403464 | 89854 | 0.44388 | 80877 | 4681 |
| 2011 | 360677 | 55292 | 0.3204 | 74813 | 6190 |
| 2012 | 325693 | 50097 | 0.44848 | 77942 | 6080 |
| 2013 | 333636 | 90054 | 0.39108 | 83165 | 3606 |
| 2014 | 320191 | 66688 | 0.37262 | 85643 | 2984 |
| 2015 | 287920 | 45276 | 0.25172 | 80196 | 2657 |

Table 7.  XSA estimated numbers at age (000s), Run 3 (M = 0.12).

| N@A (XSA) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 59349 | 76286 | 70792 | 46022 | 38981 | 25029 | 19769 | 12658 | 8235 | 3479 | 1538 | 359 | 630 | 646 |
| 1976 | 60715 | 52638 | 67660 | 62787 | 40817 | 34258 | 19544 | 12118 | 6560 | 3574 | 1496 | 703 | 191 | 100 |
| 1977 | 57351 | 53849 | 46685 | 60009 | 55687 | 36186 | 29810 | 14291 | 5650 | 2268 | 1093 | 546 | 379 | 273 |
| 1978 | 42362 | 50866 | 47760 | 41406 | 53223 | 48887 | 27374 | 16270 | 5757 | 2249 | 1058 | 762 | 362 | 416 |
| 1979 | 50341 | 37572 | 45114 | 42359 | 36724 | 44396 | 35434 | 15831 | 7295 | 2408 | 641 | 257 | 330 | 652 |
| 1980 | 67318 | 44648 | 33323 | 40012 | 37569 | 30324 | 31157 | 19350 | 8262 | 5369 | 1682 | 298 | 88 | 44 |
| 1981 | 68167 | 59706 | 39599 | 29555 | 35488 | 33124 | 24931 | 19017 | 8047 | 2244 | 1157 | 538 | 144 | 230 |
| 1982 | 65929 | 60459 | 52954 | 35122 | 26213 | 30662 | 25125 | 12877 | 6082 | 3081 | 1152 | 785 | 344 | 400 |
| 1983 | 75274 | 58474 | 53622 | 46966 | 31150 | 22995 | 25030 | 16333 | 5993 | 2059 | 1146 | 461 | 455 | 749 |
| 1984 | 81910 | 66762 | 51862 | 47558 | 41655 | 26967 | 17045 | 12970 | 7409 | 3154 | 1174 | 820 | 337 | 579 |
| 1985 | 92010 | 72647 | 59212 | 45997 | 42181 | 36096 | 21729 | 9614 | 4269 | 2722 | 1612 | 658 | 592 | 584 |
| 1986 | 105197 | 81606 | 64432 | 52517 | 40796 | 35543 | 27014 | 13704 | 5231 | 2486 | 1932 | 1280 | 490 | 818 |
| 1987 | 89903 | 93301 | 72378 | 57146 | 46578 | 35919 | 29414 | 17922 | 7359 | 3256 | 1762 | 1484 | 1003 | 1551 |
| 1988 | 76283 | 79736 | 82751 | 64193 | 50684 | 41182 | 30066 | 15725 | 7480 | 3857 | 2084 | 1201 | 1052 | 1266 |
| 1989 | 68635 | 67657 | 70720 | 73393 | 56934 | 44674 | 33525 | 19004 | 9822 | 5422 | 2983 | 1659 | 966 | 472 |
| 1990 | 65314 | 60874 | 60006 | 62723 | 65094 | 50326 | 37750 | 22689 | 12831 | 7316 | 4086 | 2233 | 1220 | 889 |
| 1991 | 55401 | 57928 | 53991 | 53221 | 55541 | 56696 | 38271 | 21585 | 13007 | 7545 | 3953 | 2490 | 1147 | 861 |
| 1992 | 40137 | 49136 | 51378 | 47885 | 46995 | 46565 | 42980 | 21557 | 8977 | 4807 | 3188 | 1750 | 1063 | 897 |
| 1993 | 48007 | 35598 | 43580 | 45568 | 41468 | 37744 | 31013 | 18683 | 7625 | 3882 | 2604 | 1874 | 857 | 386 |
| 1994 | 83240 | 42578 | 31573 | 38652 | 39464 | 27767 | 18476 | 10822 | 5346 | 2391 | 1714 | 1316 | 754 | 504 |
| 1995 | 100938 | 73828 | 37763 | 28003 | 29200 | 19462 | 9733 | 5894 | 3252 | 1840 | 1082 | 756 | 770 | 613 |
| 1996 | 87707 | 89524 | 65479 | 33493 | 24532 | 24625 | 15056 | 5618 | 3221 | 1770 | 1123 | 635 | 414 | 256 |
| 1997 | 71260 | 77789 | 79401 | 58075 | 29527 | 20196 | 16946 | 7338 | 3180 | 1957 | 1095 | 586 | 343 | 222 |
| 1998 | 62618 | 63202 | 68993 | 70422 | 51192 | 24396 | 13986 | 7925 | 3481 | 1748 | 1165 | 576 | 288 | 159 |
| 1999 | 64938 | 55537 | 56055 | 61191 | 61939 | 42037 | 16545 | 6954 | 3589 | 1736 | 1040 | 678 | 359 | 372 |
| 2000 | 67383 | 57595 | 49257 | 49716 | 53992 | 52911 | 31986 | 6565 | 2596 | 1621 | 953 | 600 | 313 | 251 |
| 2001 | 65089 | 59764 | 51082 | 43687 | 43839 | 45976 | 35078 | 8427 | 2715 | 1386 | 940 | 498 | 341 | 163 |
| 2002 | 61478 | 57729 | 53006 | 45306 | 38325 | 36773 | 29322 | 10277 | 2620 | 1457 | 763 | 420 | 251 | 160 |
| 2003 | 48739 | 54526 | 51201 | 46977 | 39731 | 32426 | 25797 | 9449 | 2893 | 1152 | 672 | 338 | 162 | 180 |
| 2004 | 48982 | 43227 | 48360 | 45220 | 40460 | 31009 | 18661 | 7092 | 2368 | 1046 | 536 | 323 | 164 | 140 |
| 2005 | 46306 | 43443 | 38339 | 42875 | 39262 | 32060 | 19746 | 6623 | 2405 | 869 | 429 | 203 | 113 | 80 |
| 2006 | 46026 | 41069 | 38531 | 33966 | 37524 | 33266 | 22785 | 7801 | 2110 | 805 | 353 | 151 | 73 | 91 |
| 2007 | 50050 | 40821 | 36425 | 34164 | 29922 | 31521 | 23430 | 8771 | 2302 | 846 | 364 | 185 | 90 | 63 |
| 2008 | 53256 | 44391 | 36205 | 32306 | 30218 | 26001 | 24442 | 9562 | 2681 | 884 | 306 | 169 | 88 | 51 |
| 2009 | 55533 | 47233 | 39371 | 32111 | 28626 | 26379 | 19942 | 11604 | 3247 | 1009 | 414 | 163 | 107 | 116 |
| 2010 | 49663 | 49253 | 41892 | 34919 | 28422 | 24941 | 20457 | 9399 | 3439 | 1044 | 417 | 173 | 82 | 78 |
| 2011 | 30340 | 44047 | 43684 | 37155 | 30833 | 24432 | 17339 | 7594 | 2524 | 1041 | 436 | 168 | 93 | 79 |
| 2012 | 27827 | 26909 | 39066 | 38339 | 32304 | 26042 | 17807 | 8544 | 3013 | 1057 | 495 | 241 | 87 | 70 |
| 2013 | 49929 | 24680 | 23866 | 33503 | 33339 | 26784 | 19874 | 8619 | 2371 | 796 | 319 | 168 | 88 | 99 |
| 2014 | 36727 | 44283 | 21889 | 21048 | 29262 | 27717 | 19188 | 12076 | 2587 | 913 | 328 | 195 | 116 | 158 |
| 2015 | 25005 | 32574 | 39275 | 19302 | 18420 | 24911 | 20987 | 11571 | 3703 | 1057 | 526 | 211 | 141 | 297 |
| 2016 | 35792 | 22177 | 28891 | 34779 | 17035 | 15933 | 20929 | 14812 | 5040 | 1805 | 727 | 411 | 167 | 362 |

Table 8. XSA estimated fishing mortality at age (Run 3).

| F @ AGE(XSA) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 0 | 0 | 0 | 0 | 0.0091 | 0.1274 | 0.3694 | 0.5374 | 0.7148 | 0.7242 | 0.6627 | 0.5095 | 0.6353 | 0.6353 |
| 1976 | 0 | 0 | 0 | 0 | 0.0004 | 0.0191 | 0.193 | 0.643 | 0.9419 | 1.0648 | 0.8882 | 0.4984 | 0.822 | 0.822 |
| 1977 | 0 | 0 | 0 | 0 | 0.0102 | 0.1591 | 0.4855 | 0.7892 | 0.8011 | 0.6428 | 0.2405 | 0.2916 | 0.3931 | 0.3931 |
| 1978 | 0 | 0 | 0 | 0 | 0.0613 | 0.2018 | 0.4276 | 0.6821 | 0.7517 | 1.1359 | 1.2935 | 0.7161 | 1.0556 | 1.0556 |
| 1979 | 0 | 0 | 0 | 0 | 0.0715 | 0.2341 | 0.485 | 0.5303 | 0.1865 | 0.2384 | 0.6457 | 0.9538 | 0.6157 | 0.6157 |
| 1980 | 0 | 0 | 0 | 0 | 0.0059 | 0.0758 | 0.3737 | 0.7574 | 1.1834 | 1.4147 | 1.0198 | 0.6093 | 1.0213 | 1.0213 |
| 1981 | 0 | 0 | 0 | 0 | 0.0262 | 0.1564 | 0.5407 | 1.02 | 0.8401 | 0.5467 | 0.2678 | 0.3287 | 0.3824 | 0.3824 |
| 1982 | 0 | 0 | 0 | 0 | 0.011 | 0.083 | 0.3107 | 0.6448 | 0.9633 | 0.8686 | 0.7969 | 0.4249 | 0.7006 | 0.7006 |
| 1983 | 0 | 0 | 0 | 0 | 0.0242 | 0.1794 | 0.5374 | 0.6704 | 0.5219 | 0.4415 | 0.2152 | 0.1926 | 0.2839 | 0.2839 |
| 1984 | 0 | 0 | 0 | 0 | 0.0233 | 0.096 | 0.4526 | 0.9913 | 0.8812 | 0.5514 | 0.459 | 0.2048 | 0.4066 | 0.4066 |
| 1985 | 0 | 0 | 0 | 0 | 0.0512 | 0.1698 | 0.341 | 0.4887 | 0.4205 | 0.2228 | 0.1107 | 0.174 | 0.1695 | 0.1695 |
| 1986 | 0 | 0 | 0 | 0 | 0.0073 | 0.0693 | 0.2903 | 0.5017 | 0.3541 | 0.2246 | 0.144 | 0.1235 | 0.1643 | 0.1643 |
| 1987 | 0 | 0 | 0 | 0 | 0.0031 | 0.0579 | 0.5062 | 0.7537 | 0.526 | 0.326 | 0.2632 | 0.2245 | 0.272 | 0.272 |
| 1988 | 0 | 0 | 0 | 0 | 0.0062 | 0.0857 | 0.3387 | 0.3506 | 0.2019 | 0.137 | 0.108 | 0.0974 | 0.1143 | 0.1143 |
| 1989 | 0 | 0 | 0 | 0 | 0.0034 | 0.0484 | 0.2704 | 0.2728 | 0.1746 | 0.1628 | 0.1695 | 0.1874 | 0.1736 | 0.1736 |
| 1990 | 0 | 0 | 0 | 0.0016 | 0.0181 | 0.1538 | 0.439 | 0.4364 | 0.411 | 0.4955 | 0.3752 | 0.546 | 0.4743 | 0.4743 |
| 1991 | 0 | 0 | 0 | 0.0044 | 0.0563 | 0.157 | 0.454 | 0.7573 | 0.8754 | 0.7416 | 0.695 | 0.7309 | 0.7265 | 0.7265 |
| 1992 | 0 | 0 | 0 | 0.0239 | 0.0992 | 0.2864 | 0.7131 | 0.9193 | 0.7183 | 0.493 | 0.4111 | 0.5939 | 0.5016 | 0.5016 |
| 1993 | 0 | 0 | 0 | 0.0238 | 0.2811 | 0.5944 | 0.9328 | 1.1312 | 1.0397 | 0.6975 | 0.5625 | 0.7901 | 0.687 | 0.687 |
| 1994 | 0 | 0 | 0 | 0.1604 | 0.5869 | 0.9283 | 1.0226 | 1.0824 | 0.9466 | 0.673 | 0.698 | 0.4163 | 0.5987 | 0.5987 |
| 1995 | 0 | 0 | 0 | 0.0123 | 0.0504 | 0.1367 | 0.4296 | 0.4841 | 0.4882 | 0.3734 | 0.4134 | 0.4832 | 0.425 | 0.425 |
| 1996 | 0 | 0 | 0 | 0.006 | 0.0745 | 0.2537 | 0.5987 | 0.4491 | 0.3785 | 0.36 | 0.5312 | 0.494 | 0.4572 | 0.4572 |
| 1997 | 0 | 0 | 0 | 0.0061 | 0.0709 | 0.2474 | 0.64 | 0.6259 | 0.4786 | 0.3988 | 0.5229 | 0.5904 | 0.5508 | 0.5508 |
| 1998 | 0 | 0 | 0 | 0.0084 | 0.077 | 0.2683 | 0.5787 | 0.6722 | 0.5758 | 0.3986 | 0.4212 | 0.3522 | 0.4144 | 0.4144 |
| 1999 | 0 | 0 | 0 | 0.0052 | 0.0375 | 0.1533 | 0.8044 | 0.8655 | 0.6751 | 0.4799 | 0.4309 | 0.6527 | 0.56 | 0.56 |
| 2000 | 0 | 0 | 0 | 0.0058 | 0.0407 | 0.291 | 1.2139 | 0.7628 | 0.5076 | 0.4246 | 0.5279 | 0.4454 | 0.5755 | 0.5755 |
| 2001 | 0 | 0 | 0 | 0.0109 | 0.0558 | 0.3298 | 1.1076 | 1.0482 | 0.5025 | 0.4769 | 0.685 | 0.5665 | 0.6658 | 0.6658 |
| 2002 | 0 | 0 | 0.0007 | 0.0113 | 0.0471 | 0.2345 | 1.0124 | 1.1476 | 0.7014 | 0.6544 | 0.6952 | 0.8346 | 0.7622 | 0.7622 |
| 2003 | 0 | 0 | 0.0042 | 0.0293 | 0.1279 | 0.4325 | 1.1712 | 1.2641 | 0.8974 | 0.6452 | 0.6133 | 0.6031 | 0.6907 | 0.6907 |
| 2004 | 0 | 0 | 0.0004 | 0.0213 | 0.1127 | 0.3313 | 0.9159 | 0.9616 | 0.8824 | 0.7702 | 0.8496 | 0.9302 | 0.8299 | 0.8299 |
| 2005 | 0 | 0 | 0.0011 | 0.0133 | 0.0457 | 0.2215 | 0.8087 | 1.0236 | 0.9744 | 0.7822 | 0.9247 | 0.9048 | 0.9212 | 0.9212 |
| 2006 | 0 | 0 | 0.0003 | 0.0068 | 0.0543 | 0.2305 | 0.8346 | 1.1003 | 0.7939 | 0.6748 | 0.5271 | 0.401 | 0.6268 | 0.6268 |
| 2007 | 0 | 0 | 0 | 0.0027 | 0.0204 | 0.1344 | 0.7762 | 1.0654 | 0.8377 | 0.8971 | 0.6464 | 0.6166 | 0.6639 | 0.6639 |
| 2008 | 0 | 0 | 0 | 0.001 | 0.0159 | 0.1453 | 0.625 | 0.9602 | 0.8569 | 0.6392 | 0.5092 | 0.3412 | 0.3746 | 0.3746 |
| 2009 | 0 | 0 | 0 | 0.002 | 0.0178 | 0.1343 | 0.6323 | 1.096 | 1.0145 | 0.7645 | 0.7527 | 0.573 | 0.3696 | 0.3696 |
| 2010 | 0 | 0 | 0 | 0.0044 | 0.0313 | 0.2435 | 0.871 | 1.1946 | 1.0753 | 0.7525 | 0.788 | 0.4997 | 0.3374 | 0.3374 |
| 2011 | 0 | 0 | 0.0105 | 0.0199 | 0.0489 | 0.1963 | 0.5877 | 0.8046 | 0.7506 | 0.624 | 0.4735 | 0.5395 | 0.2742 | 0.2742 |
| 2012 | 0 | 0 | 0.0336 | 0.0197 | 0.0674 | 0.1503 | 0.6056 | 1.162 | 1.211 | 1.0791 | 0.9576 | 0.8923 | 0.5794 | 0.5794 |
| 2013 | 0 | 0 | 0.0057 | 0.0154 | 0.0647 | 0.2135 | 0.3782 | 1.0835 | 0.834 | 0.7656 | 0.371 | 0.2494 | 0.2007 | 0.2007 |
| 2014 | 0 | 0 | 0.0058 | 0.0134 | 0.041 | 0.1581 | 0.3858 | 1.0621 | 0.7752 | 0.4326 | 0.3215 | 0.2048 | 0.1058 | 0.1058 |
| 2015 | 0 | 0 | 0.0016 | 0.0049 | 0.025 | 0.0542 | 0.2285 | 0.7112 | 0.5987 | 0.2537 | 0.1247 | 0.1173 | 0.0702 | 0.0702 |

Table 9. Stock summary table from XSA Run 3.

| Year | N+ (000s) | Rec(Age 1 | Fbar 5-10 | 5+ Biomas | 10+ Bioma |
|------|-----------|-----------|-----------|-----------|-----------|
| 1975 | 363773 | 59349 | 0.413717 | 108934 | 19219 |
| 1976 | 363161 | 60715 | 0.477033 | 109906 | 15562 |
| 1977 | 364077 | 57351 | 0.481317 | 128726 | 12910 |
| 1978 | 338752 | 42362 | 0.5434 | 138418 | 14251 |
| 1979 | 319354 | 50341 | 0.290967 | 133471 | 13161 |
| 1980 | 319444 | 67318 | 0.63515 | 106898 | 10710 |
| 1981 | 321947 | 68167 | 0.521683 | 93047 | 10947 |
| 1982 | 321185 | 65929 | 0.480233 | 95663 | 15476 |
| 1983 | 340707 | 75274 | 0.3958 | 95467 | 17458 |
| 1984 | 360202 | 81910 | 0.4993 | 88233 | 17644 |
| 1985 | 389923 | 92010 | 0.282333 | 110837 | 20259 |
| 1986 | 433046 | 105197 | 0.241217 | 104550 | 24267 |
| 1987 | 458976 | 89903 | 0.36215 | 127092 | 31901 |
| 1988 | 457560 | 76283 | 0.186683 | 130699 | 33953 |
| 1989 | 455866 | 68635 | 0.1554 | 145621 | 35235 |
| 1990 | 453351 | 65314 | 0.325633 | 171713 | 47295 |
| 1991 | 421637 | 55401 | 0.506933 | 190877 | 54176 |
| 1992 | 367315 | 40137 | 0.538217 | 164185 | 40122 |
| 1993 | 318889 | 48007 | 0.77945 | 127558 | 30835 |
| 1994 | 304597 | 83240 | 0.8733 | 86091 | 22384 |
| 1995 | 313134 | 100938 | 0.327067 | 60294 | 18691 |
| 1996 | 353453 | 87707 | 0.352417 | 61664 | 14036 |
| 1997 | 367915 | 71260 | 0.410267 | 60282 | 13423 |
| 1998 | 370151 | 62618 | 0.428433 | 71786 | 12477 |
| 1999 | 372970 | 64938 | 0.502617 | 86061 | 13106 |
| 2000 | 375739 | 67383 | 0.5401 | 95443 | 11433 |
| 2001 | 358985 | 65089 | 0.5868 | 96875 | 10357 |
| 2002 | 337887 | 61478 | 0.6329 | 85169 | 9013 |
| 2003 | 314243 | 48739 | 0.756383 | 78197 | 7143 |
| 2004 | 287588 | 48982 | 0.66235 | 65588 | 6368 |
| 2005 | 272753 | 46306 | 0.642683 | 67375 | 4655 |
| 2006 | 264551 | 46026 | 0.614733 | 69096 | 3530 |
| 2007 | 258954 | 50050 | 0.621867 | 66719 | 3823 |
| 2008 | 260560 | 53256 | 0.540417 | 69580 | 3822 |
| 2009 | 265855 | 55533 | 0.6099 | 67386 | 4563 |
| 2010 | 264179 | 49663 | 0.6947 | 62998 | 4603 |
| 2011 | 239765 | 30340 | 0.502017 | 57114 | 5056 |
| 2012 | 221801 | 27827 | 0.712567 | 62060 | 5468 |
| 2013 | 224435 | 49929 | 0.556583 | 67716 | 4633 |
| 2014 | 216487 | 36727 | 0.4758 | 71749 | 5604 |
| 2015 | 197980 | 25005 | 0.311883 | 69930 | 7371 |

Table 10.  XSA estimated numbers at age (000s), Run 4 (10+, M = 0.12).

| N@A (XSA) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 64142 | 97533 | 83813 | 74629 | 36059 | 29744 | 24540 | 29734 | 23620 | 18391 |
| 1976 | 73151 | 56889 | 86504 | 74335 | 66190 | 31667 | 23725 | 16350 | 21704 | 19803 |
| 1977 | 60956 | 64879 | 50456 | 76722 | 65929 | 58689 | 27512 | 18000 | 9403 | 4988 |
| 1978 | 45810 | 54063 | 57543 | 44751 | 68047 | 57971 | 47333 | 14232 | 9046 | 9453 |
| 1979 | 53226 | 40629 | 47949 | 51036 | 39690 | 57544 | 43491 | 33533 | 5487 | 6289 |
| 1980 | 65912 | 47207 | 36035 | 42527 | 45265 | 32955 | 42818 | 26496 | 23962 | 22338 |
| 1981 | 71704 | 58459 | 41869 | 31960 | 37718 | 39949 | 27264 | 29359 | 14384 | 4655 |
| 1982 | 77571 | 63596 | 51848 | 37134 | 28346 | 32640 | 31178 | 14946 | 15255 | 12404 |
| 1983 | 97201 | 68799 | 56404 | 45985 | 32935 | 24887 | 26784 | 21701 | 7829 | 4273 |
| 1984 | 84242 | 86209 | 61020 | 50026 | 40785 | 28551 | 18723 | 14526 | 12171 | 6217 |
| 1985 | 93757 | 74716 | 76461 | 54120 | 44369 | 35324 | 23134 | 11102 | 5649 | 3846 |
| 1986 | 104456 | 83155 | 66267 | 67815 | 48000 | 37484 | 26330 | 14949 | 6551 | 4631 |
| 1987 | 91228 | 92644 | 73752 | 58773 | 60146 | 42308 | 31136 | 17315 | 8464 | 6215 |
| 1988 | 74257 | 80912 | 82168 | 65412 | 52127 | 53216 | 35733 | 17252 | 6942 | 5412 |
| 1989 | 67042 | 65860 | 71762 | 72876 | 58015 | 45954 | 44198 | 24030 | 11176 | 12703 |
| 1990 | 63860 | 59461 | 58413 | 63647 | 64635 | 51284 | 38885 | 32156 | 17288 | 23410 |
| 1991 | 54113 | 56639 | 52737 | 51808 | 56361 | 56289 | 39121 | 22592 | 21403 | 23195 |
| 1992 | 38262 | 47994 | 50234 | 46774 | 45742 | 47292 | 42619 | 22311 | 9870 | 9599 |
| 1993 | 45854 | 33936 | 42567 | 44554 | 40483 | 36633 | 31658 | 18363 | 8294 | 7855 |
| 1994 | 82030 | 40669 | 30098 | 37753 | 38565 | 26892 | 17490 | 11394 | 5062 | 4667 |
| 1995 | 99993 | 72754 | 36070 | 26695 | 28403 | 18665 | 8957 | 5019 | 3759 | 5092 |
| 1996 | 87966 | 88685 | 64527 | 31991 | 23372 | 23918 | 14348 | 4930 | 2446 | 3573 |
| 1997 | 71211 | 78019 | 78657 | 57230 | 28195 | 19167 | 16319 | 6711 | 2570 | 3357 |
| 1998 | 62449 | 63159 | 69196 | 69762 | 50443 | 23214 | 13073 | 7369 | 2924 | 2471 |
| 1999 | 65948 | 55388 | 56017 | 61372 | 61354 | 41372 | 15497 | 6145 | 3096 | 2900 |
| 2000 | 71424 | 58491 | 49124 | 49683 | 54152 | 52392 | 31396 | 5635 | 1878 | 2549 |
| 2001 | 69810 | 63347 | 51877 | 43570 | 43809 | 46118 | 34617 | 7904 | 1891 | 2539 |
| 2002 | 65637 | 61916 | 56184 | 46010 | 38221 | 36747 | 29448 | 9869 | 2157 | 2489 |
| 2003 | 53284 | 58215 | 54915 | 49796 | 40356 | 32334 | 25774 | 9561 | 2531 | 1722 |
| 2004 | 52279 | 47259 | 51632 | 48514 | 42960 | 31563 | 18579 | 7072 | 2467 | 2178 |
| 2005 | 47975 | 46367 | 41915 | 45777 | 42183 | 34277 | 20238 | 6550 | 2386 | 1528 |
| 2006 | 47549 | 42550 | 41124 | 37137 | 40098 | 35857 | 24751 | 8237 | 2046 | 1168 |
| 2007 | 52830 | 42172 | 37739 | 36464 | 32735 | 33804 | 25728 | 10516 | 2689 | 1704 |
| 2008 | 56228 | 46856 | 37403 | 33471 | 32258 | 28496 | 26466 | 11600 | 4228 | 1722 |
| 2009 | 57643 | 49869 | 41557 | 33173 | 29659 | 28188 | 22155 | 13400 | 5054 | 2181 |
| 2010 | 51640 | 51125 | 44230 | 36858 | 29365 | 25857 | 22062 | 11361 | 5032 | 1970 |
| 2011 | 31657 | 45801 | 45344 | 39229 | 32553 | 25267 | 18152 | 9017 | 4265 | 2419 |
| 2012 | 28846 | 28077 | 40622 | 39811 | 34143 | 27567 | 18548 | 9265 | 4275 | 2435 |
| 2013 | 51817 | 25584 | 24902 | 34883 | 34645 | 28415 | 21227 | 9276 | 3010 | 1328 |
| 2014 | 38266 | 45957 | 22691 | 21967 | 30486 | 28876 | 20635 | 13276 | 3170 | 1072 |
| 2015 | 26018 | 33939 | 40760 | 20013 | 19235 | 25997 | 22015 | 12854 | 4767 | 1000 |
| 2016 | 37227 | 23076 | 30101 | 36096 | 17666 | 16656 | 21892 | 15724 | 6178 | 3325 |

Table 11. XSA estimated fishing mortality at age, updated run (Run 4).

| F @ AGE(XSA) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 0 | 0 | 0 | 0 | 0.0099 | 0.1061 | 0.2861 | 0.1948 | 0.1961 | 0.1961 |
| 1976 | 0 | 0 | 0 | 0 | 0.0003 | 0.0207 | 0.1562 | 0.4332 | 0.2038 | 0.2038 |
| 1977 | 0 | 0 | 0 | 0 | 0.0086 | 0.0951 | 0.5391 | 0.568 | 0.4023 | 0.4023 |
| 1978 | 0 | 0 | 0 | 0 | 0.0477 | 0.1674 | 0.2247 | 0.833 | 0.4099 | 0.4099 |
| 1979 | 0 | 0 | 0 | 0 | 0.066 | 0.1756 | 0.3756 | 0.216 | 0.2564 | 0.2564 |
| 1980 | 0 | 0 | 0 | 0 | 0.0049 | 0.0696 | 0.2574 | 0.4908 | 0.2734 | 0.2734 |
| 1981 | 0 | 0 | 0 | 0 | 0.0246 | 0.1279 | 0.4811 | 0.5347 | 0.3826 | 0.3826 |
| 1982 | 0 | 0 | 0 | 0 | 0.0101 | 0.0777 | 0.2423 | 0.5267 | 0.2831 | 0.2831 |
| 1983 | 0 | 0 | 0 | 0 | 0.0229 | 0.1646 | 0.4919 | 0.4583 | 0.3729 | 0.3729 |
| 1984 | 0 | 0 | 0 | 0 | 0.0238 | 0.0904 | 0.4026 | 0.8245 | 0.4409 | 0.4409 |
| 1985 | 0 | 0 | 0 | 0 | 0.0486 | 0.1739 | 0.3166 | 0.4076 | 0.3003 | 0.3003 |
| 1986 | 0 | 0 | 0 | 0 | 0.0062 | 0.0656 | 0.2991 | 0.4488 | 0.272 | 0.272 |
| 1987 | 0 | 0 | 0 | 0 | 0.0024 | 0.0489 | 0.4704 | 0.794 | 0.4395 | 0.4395 |
| 1988 | 0 | 0 | 0 | 0 | 0.006 | 0.0657 | 0.2768 | 0.3141 | 0.2194 | 0.2194 |
| 1989 | 0 | 0 | 0 | 0 | 0.0033 | 0.047 | 0.1981 | 0.2093 | 0.1518 | 0.1518 |
| 1990 | 0 | 0 | 0 | 0.0016 | 0.0183 | 0.1507 | 0.423 | 0.2871 | 0.2878 | 0.2878 |
| 1991 | 0 | 0 | 0 | 0.0045 | 0.0554 | 0.1582 | 0.4416 | 0.7081 | 0.4377 | 0.4377 |
| 1992 | 0 | 0 | 0 | 0.0245 | 0.1021 | 0.2813 | 0.722 | 0.8696 | 0.6275 | 0.6275 |
| 1993 | 0 | 0 | 0 | 0.0244 | 0.289 | 0.6193 | 0.9019 | 1.1685 | 0.9022 | 0.9022 |
| 1994 | 0 | 0 | 0 | 0.1646 | 0.6057 | 0.9794 | 1.1284 | 0.9889 | 1.0391 | 1.0391 |
| 1995 | 0 | 0 | 0 | 0.0129 | 0.0519 | 0.143 | 0.4772 | 0.599 | 0.4067 | 0.4067 |
| 1996 | 0 | 0 | 0 | 0.0063 | 0.0784 | 0.2623 | 0.6399 | 0.5315 | 0.5363 | 0.5363 |
| 1997 | 0 | 0 | 0 | 0.0062 | 0.0744 | 0.2626 | 0.675 | 0.7107 | 0.6361 | 0.6361 |
| 1998 | 0 | 0 | 0 | 0.0084 | 0.0782 | 0.2841 | 0.635 | 0.7473 | 0.7362 | 0.7362 |
| 1999 | 0 | 0 | 0 | 0.0052 | 0.0379 | 0.1559 | 0.8916 | 1.0655 | 0.8418 | 0.8418 |
| 2000 | 0 | 0 | 0 | 0.0058 | 0.0406 | 0.2944 | 1.2593 | 0.9719 | 0.7989 | 0.7989 |
| 2001 | 0 | 0 | 0 | 0.011 | 0.0558 | 0.3286 | 1.1349 | 1.1789 | 0.8373 | 0.8373 |
| 2002 | 0 | 0 | 0.0007 | 0.0111 | 0.0473 | 0.2347 | 1.0049 | 1.2408 | 0.948 | 0.948 |
| 2003 | 0 | 0 | 0.0039 | 0.0277 | 0.1258 | 0.4341 | 1.1733 | 1.2348 | 1.1305 | 1.1305 |
| 2004 | 0 | 0 | 0.0003 | 0.0198 | 0.1058 | 0.3244 | 0.9226 | 0.9664 | 0.827 | 0.827 |
| 2005 | 0 | 0 | 0.001 | 0.0125 | 0.0425 | 0.2056 | 0.7789 | 1.0436 | 0.9873 | 0.9873 |
| 2006 | 0 | 0 | 0.0003 | 0.0062 | 0.0508 | 0.212 | 0.736 | 0.9995 | 0.8329 | 0.8329 |
| 2007 | 0 | 0 | 0 | 0.0026 | 0.0187 | 0.1247 | 0.6765 | 0.7912 | 0.6649 | 0.6649 |
| 2008 | 0 | 0 | 0 | 0.0009 | 0.0149 | 0.1317 | 0.5607 | 0.7108 | 0.454 | 0.454 |
| 2009 | 0 | 0 | 0 | 0.002 | 0.0172 | 0.1251 | 0.5479 | 0.8594 | 0.5267 | 0.5267 |
| 2010 | 0 | 0 | 0 | 0.0042 | 0.0303 | 0.2338 | 0.7747 | 0.8598 | 0.5984 | 0.5984 |
| 2011 | 0 | 0 | 0.0101 | 0.0189 | 0.0462 | 0.1892 | 0.5526 | 0.6264 | 0.3747 | 0.3747 |
| 2012 | 0 | 0 | 0.0323 | 0.019 | 0.0636 | 0.1413 | 0.5729 | 1.0043 | 0.6828 | 0.6828 |
| 2013 | 0 | 0 | 0.0054 | 0.0147 | 0.0621 | 0.2 | 0.3493 | 0.9537 | 0.5898 | 0.5898 |
| 2014 | 0 | 0 | 0.0056 | 0.0128 | 0.0393 | 0.1513 | 0.3533 | 0.9042 | 0.5801 | 0.5801 |
| 2015 | 0 | 0 | 0.0015 | 0.0047 | 0.024 | 0.0518 | 0.2166 | 0.6127 | 0.4307 | 0.4307 |

Table 12. Stock summary table from XSA Run 4.

| Year | N+ (000s) | Rec(Age 1 | Fbar 5-9 | 5+ Biomass | 10+ Biomass |
|------|-----------|-----------|----------|------------|-------------|
| 1975 | 482205 | 64142 | 0.1586 | 193185 | 52481 |
| 1976 | 470318 | 73151 | 0.16284 | 190474 | 49692 |
| 1977 | 437534 | 60956 | 0.32262 | 160786 | 13481 |
| 1978 | 408249 | 45810 | 0.33654 | 189425 | 27494 |
| 1979 | 378874 | 53226 | 0.21792 | 179634 | 21622 |
| 1980 | 385515 | 65912 | 0.21922 | 168815 | 31246 |
| 1981 | 357321 | 71704 | 0.31018 | 118112 | 11170 |
| 1982 | 364918 | 77571 | 0.22798 | 135260 | 32027 |
| 1983 | 386798 | 97201 | 0.30212 | 105229 | 14420 |
| 1984 | 402470 | 84242 | 0.35644 | 98338 | 17104 |
| 1985 | 422478 | 93757 | 0.2494 | 109010 | 12268 |
| 1986 | 459638 | 104456 | 0.21834 | 102190 | 15351 |
| 1987 | 481981 | 91228 | 0.35104 | 127792 | 21407 |
| 1988 | 473431 | 74257 | 0.1764 | 128457 | 18896 |
| 1989 | 473616 | 67042 | 0.1219 | 166727 | 39322 |
| 1990 | 473039 | 63860 | 0.23338 | 213887 | 70472 |
| 1991 | 434258 | 54113 | 0.3602 | 232400 | 78477 |
| 1992 | 360697 | 38262 | 0.5205 | 159405 | 33196 |
| 1993 | 310197 | 45854 | 0.77618 | 122420 | 25377 |
| 1994 | 294620 | 82030 | 0.9483 | 77725 | 15350 |
| 1995 | 305407 | 99993 | 0.33556 | 59181 | 19077 |
| 1996 | 345756 | 87966 | 0.40968 | 56148 | 12181 |
| 1997 | 361436 | 71211 | 0.47176 | 54724 | 11079 |
| 1998 | 364060 | 62449 | 0.49616 | 63826 | 7823 |
| 1999 | 369089 | 65948 | 0.59854 | 78951 | 9265 |
| 2000 | 376724 | 71424 | 0.67302 | 88913 | 7966 |
| 2001 | 365482 | 69810 | 0.7071 | 92181 | 8065 |
| 2002 | 348678 | 65637 | 0.69514 | 82364 | 7456 |
| 2003 | 328488 | 53284 | 0.8197 | 75697 | 4934 |
| 2004 | 304503 | 52279 | 0.62924 | 66860 | 6332 |
| 2005 | 289196 | 47975 | 0.61158 | 69668 | 4247 |
| 2006 | 280517 | 47549 | 0.56624 | 72913 | 2754 |
| 2007 | 276381 | 52830 | 0.4552 | 73901 | 4105 |
| 2008 | 278728 | 56228 | 0.37442 | 79050 | 4207 |
| 2009 | 282879 | 57643 | 0.41526 | 76512 | 5304 |
| 2010 | 279500 | 51640 | 0.4994 | 70433 | 4835 |
| 2011 | 253704 | 31657 | 0.35782 | 65042 | 6422 |
| 2012 | 233589 | 28846 | 0.49298 | 68452 | 6648 |
| 2013 | 235087 | 51817 | 0.43098 | 71589 | 3782 |
| 2014 | 226396 | 38266 | 0.40564 | 74448 | 3171 |
| 2015 | 206598 | 26018 | 0.26716 | 70861 | 2932 |
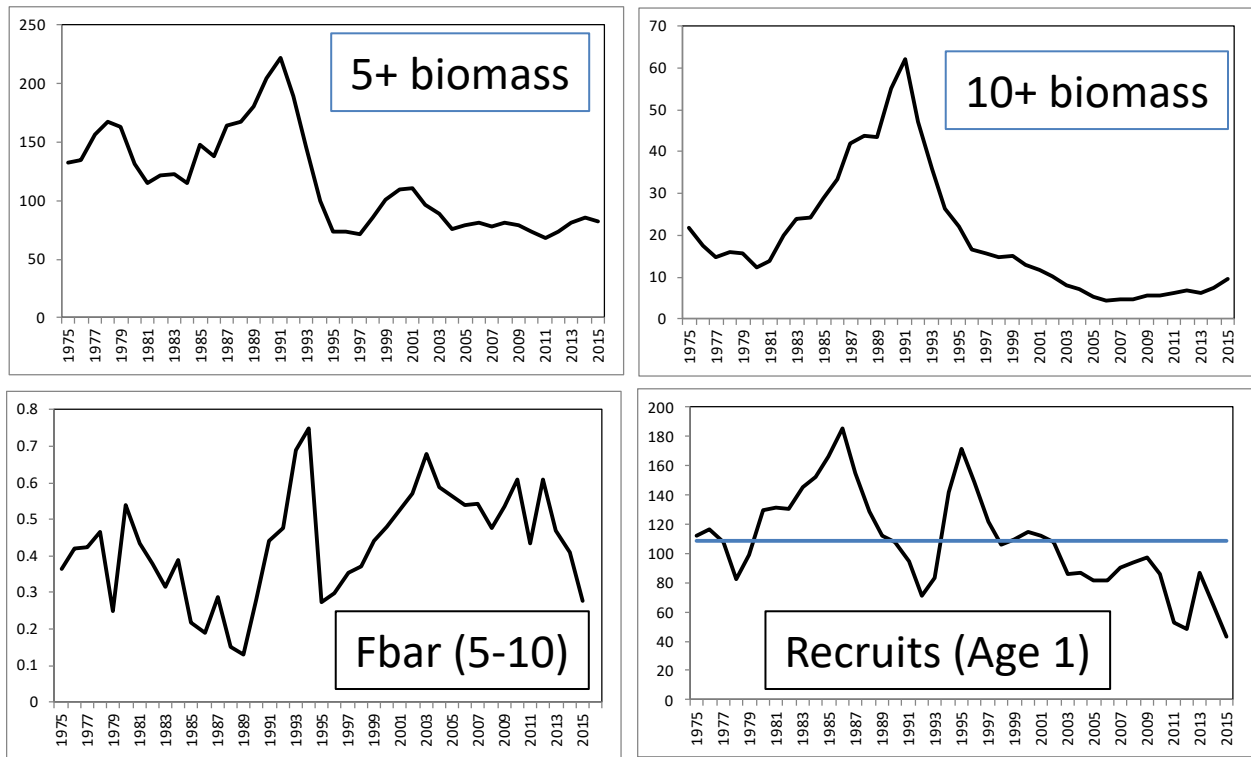
Fig.1.    Results of exploitable (5+) biomass, 10+ biomass, Fbar (ages 5-10) and recruits (age 1) from XSA run 1.

**Catchabilities**



**SE(Log q)**



**Shrinkage Scaled Weights**
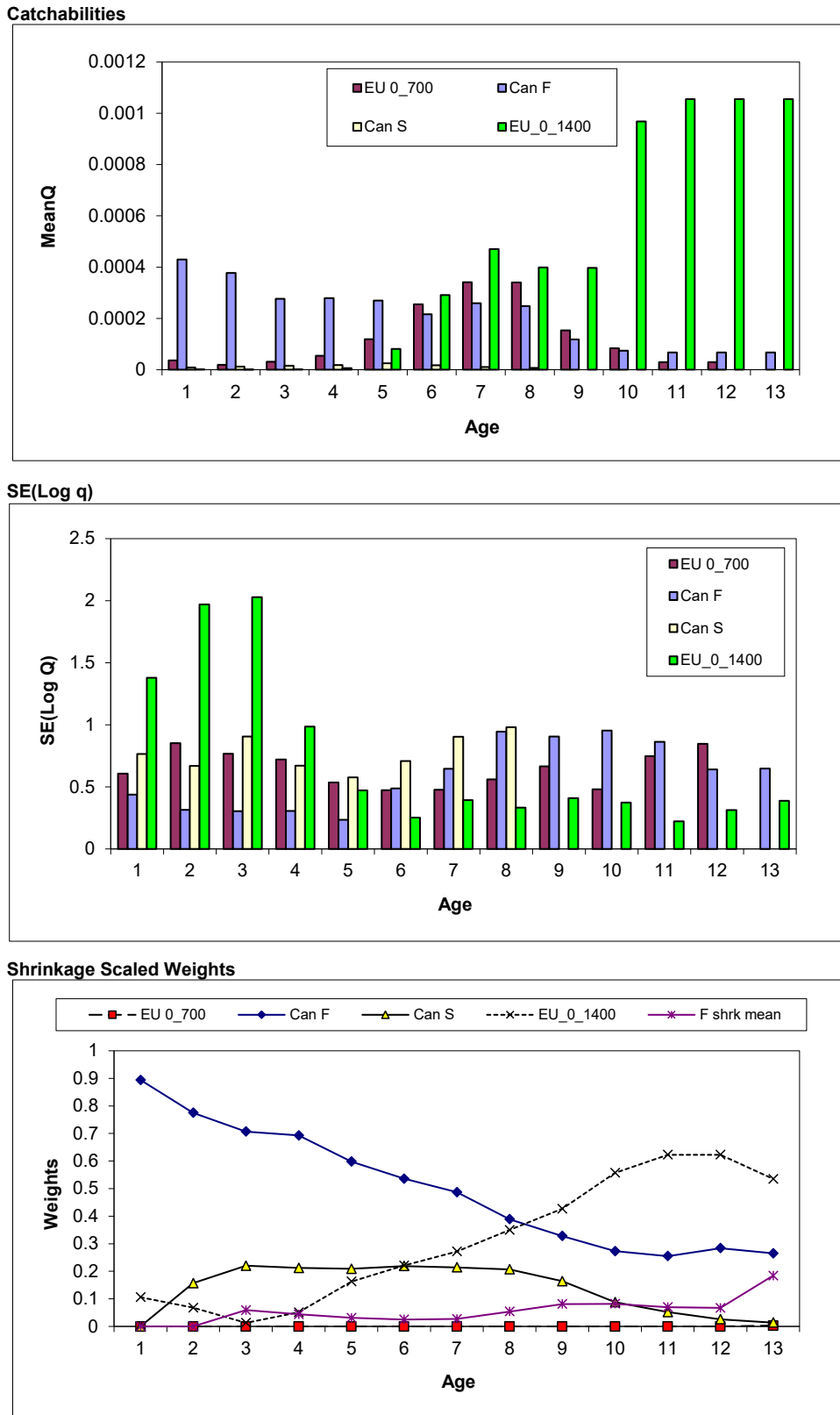


Fig. 2.   XSA update run estimated catchabilities, associated standard errors, and the scaled weights used to estimate survivors in the terminal year.
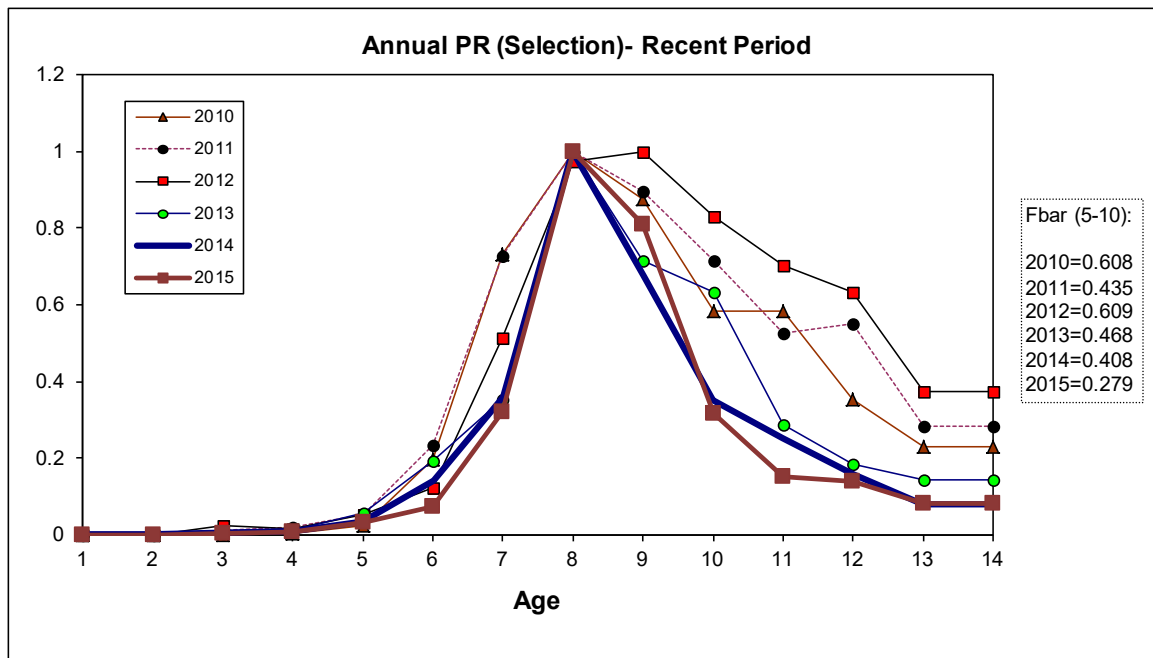
Fig.3.    XSA update run estimated selection pattern in the most recent years.
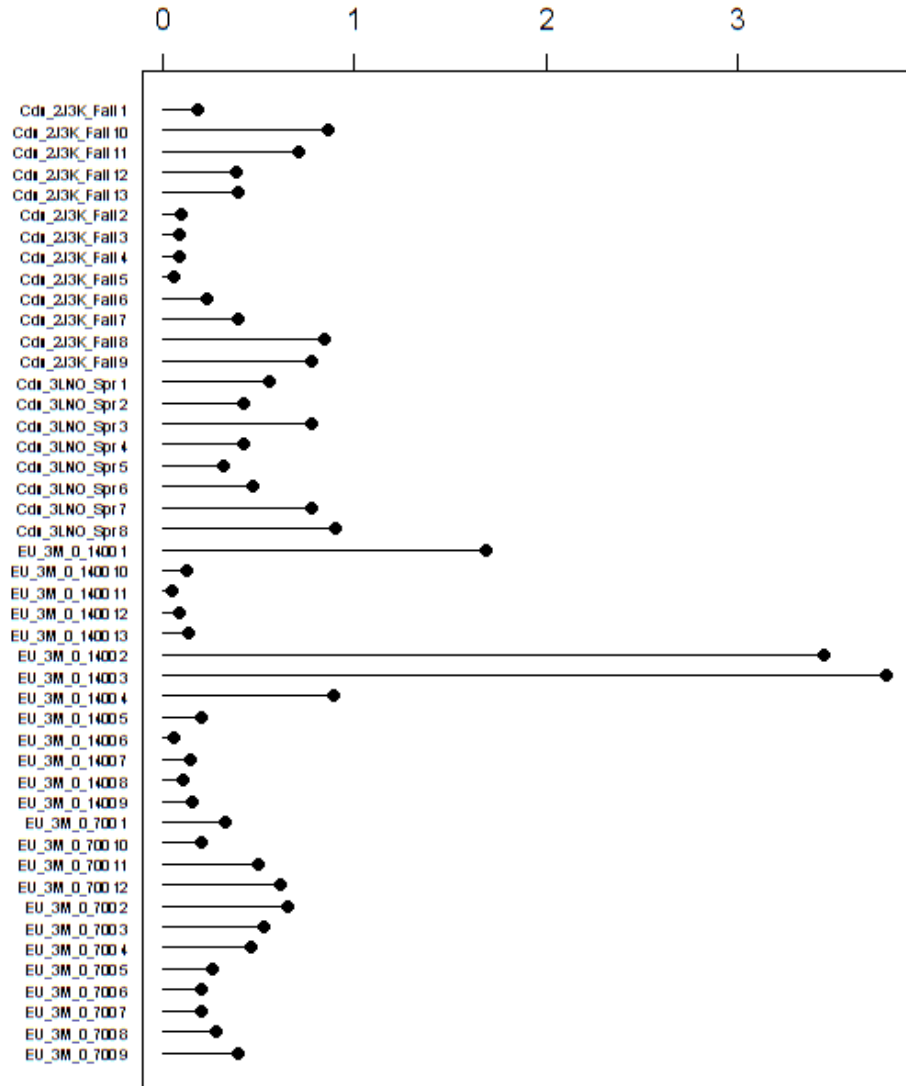
Fig. 4. . Mean square residuals from XSA update run (Run 1) for each survey-age.
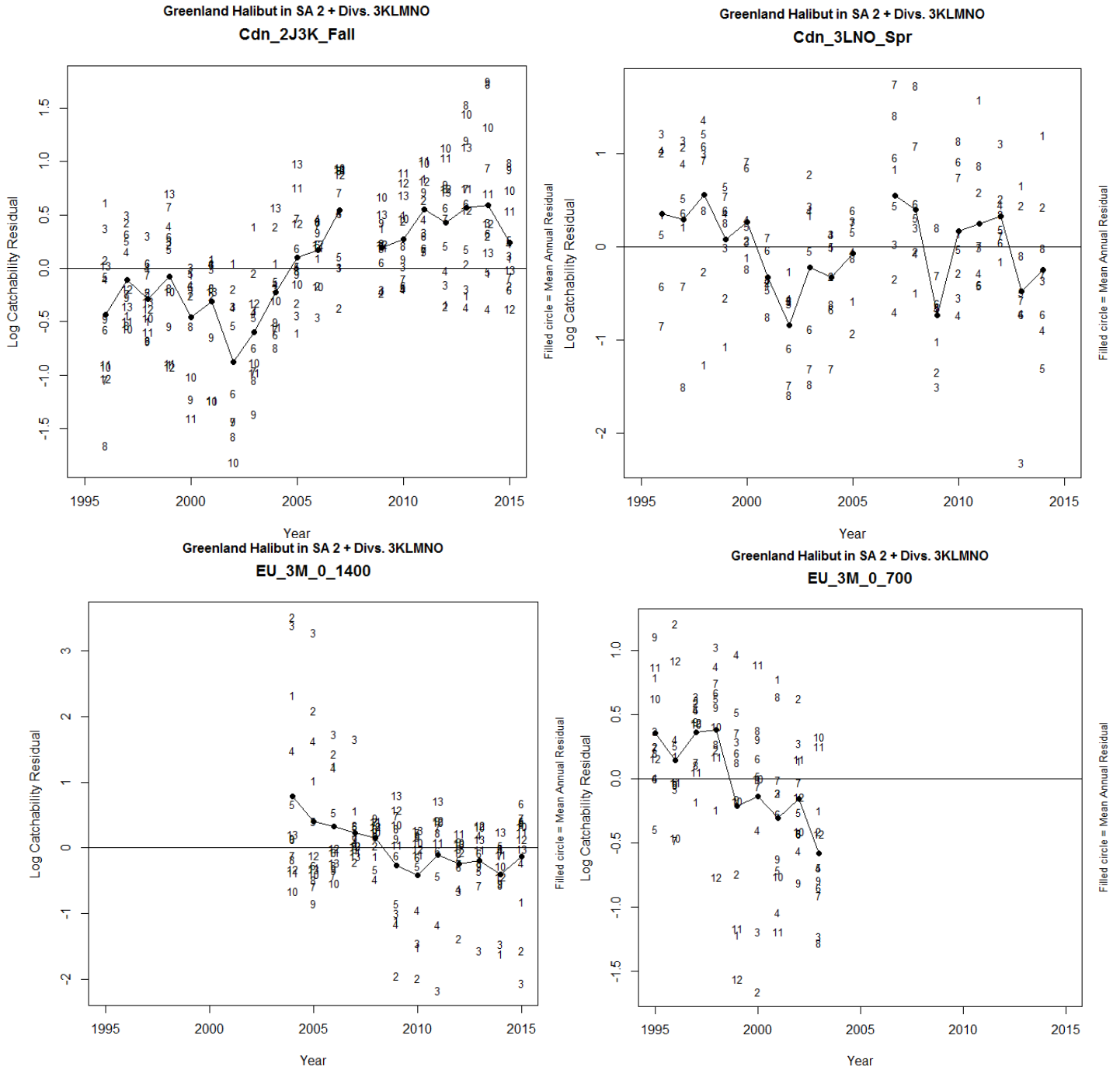
Fig. 5.    XSA update run residuals by survey, age and year. Symbol=age, solid circle=mean annual residual.
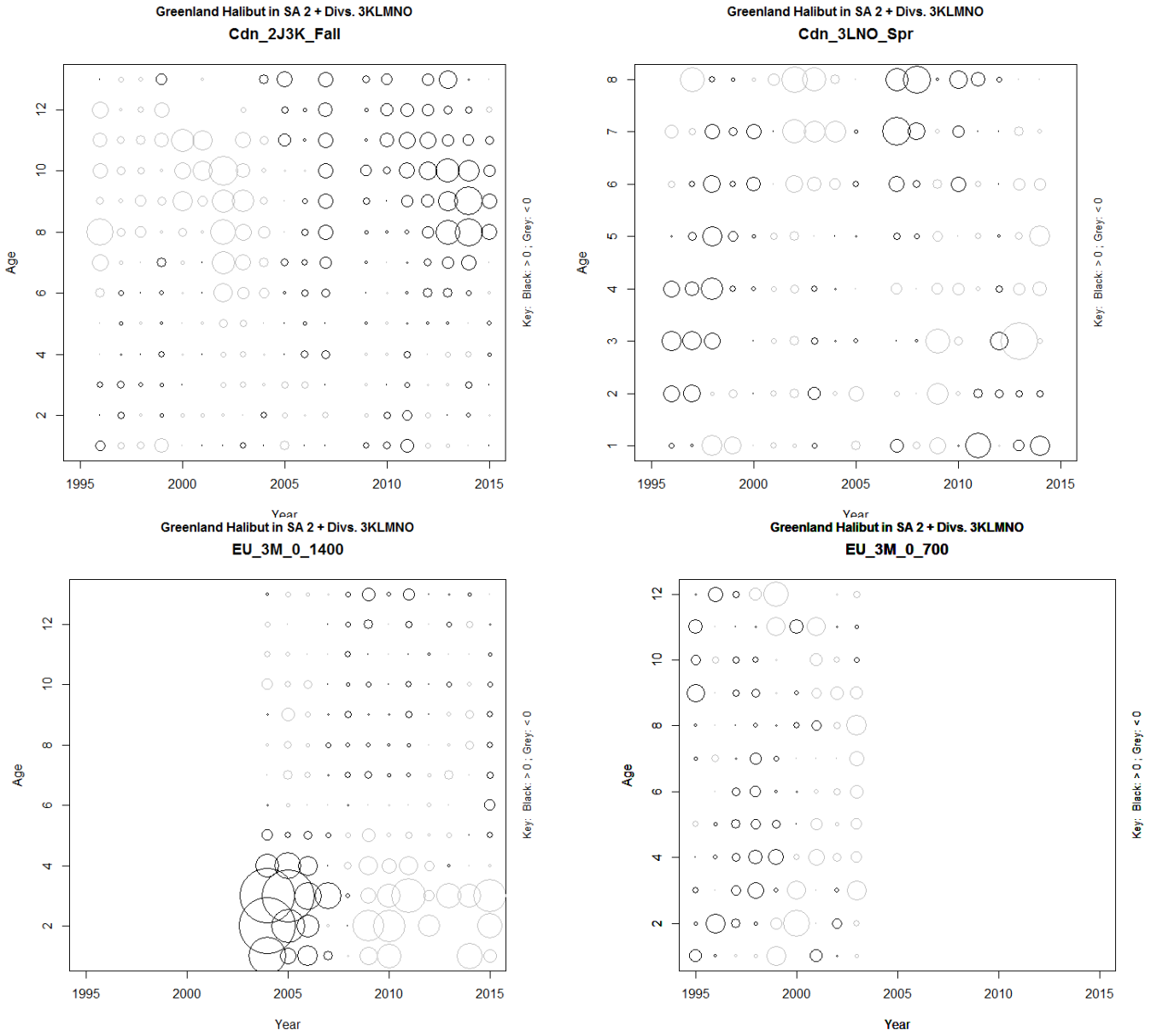
Fig. 6. XSA Residuals update run; cont. Black=positive residual; grey=negative residual. Symbols are scaled to the overall maximum residual to permit comparisons across survey series.
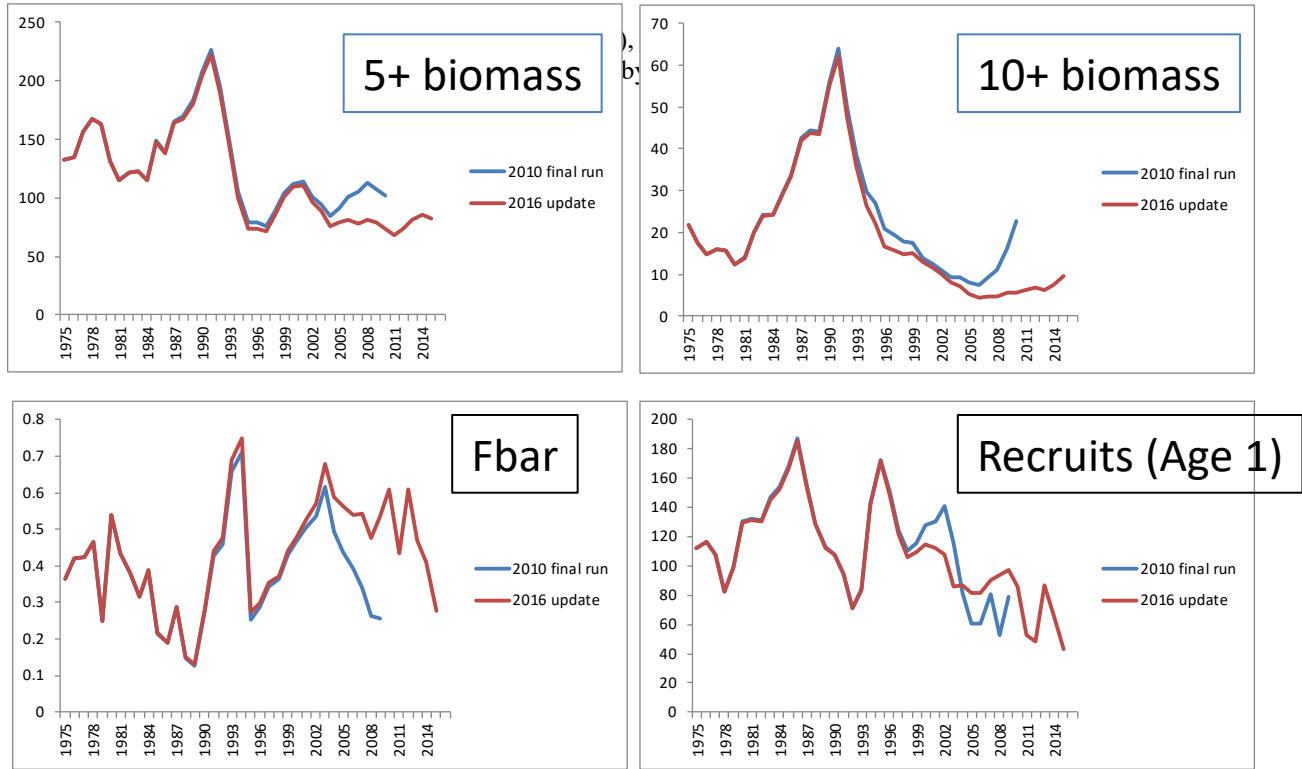
Fig. 7.  Comparison of XSA results for the 2010 assessment and the update run (Run 1) for 5+ biomass, 10+ biomass, Fbar (ages 5-10) and recruits estimated at Age 1.
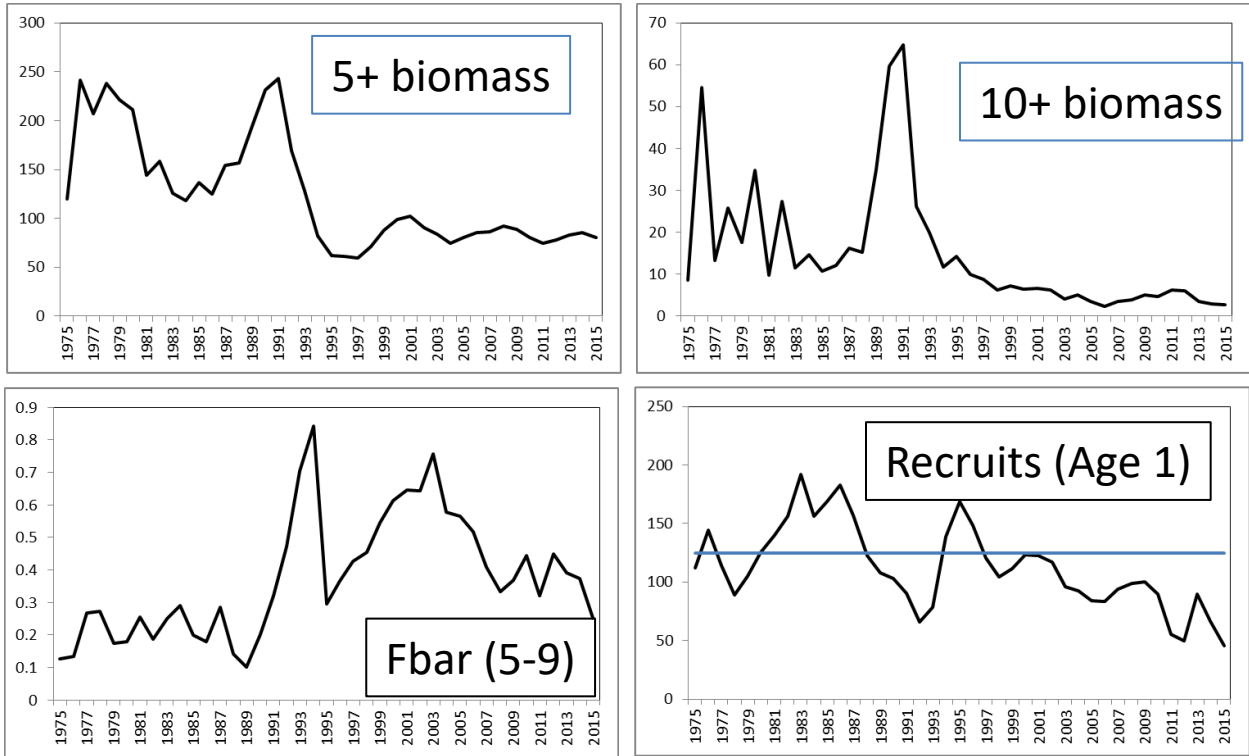
Fig. 8.    Results of XSA for exploitable (5+) biomass, 10+ biomass, Fbar (ages 5-10) and recruits (age 1) from XSA run 2 (plus group 10+).
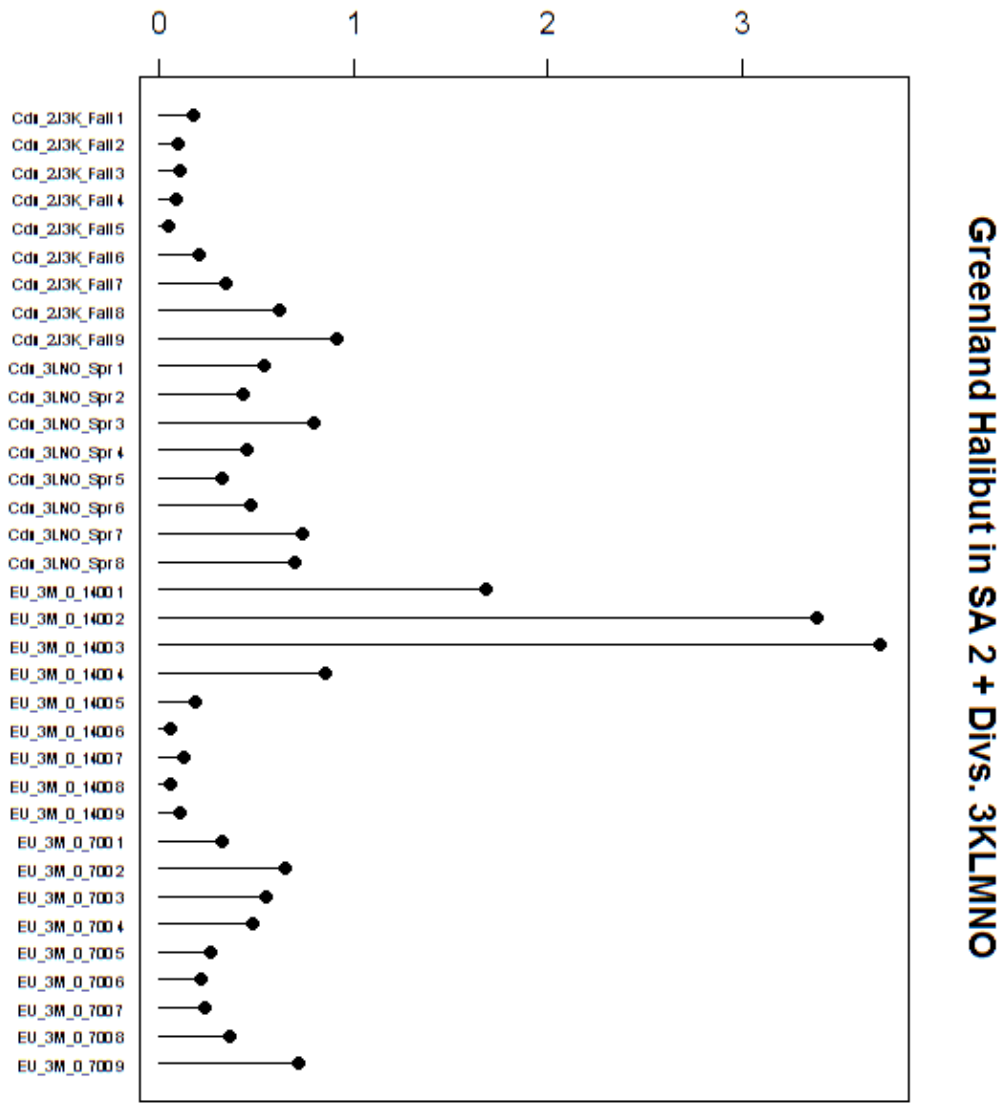
Fig.9.    Mean square residuals from XSA run 2 (10+) for each survey-age.
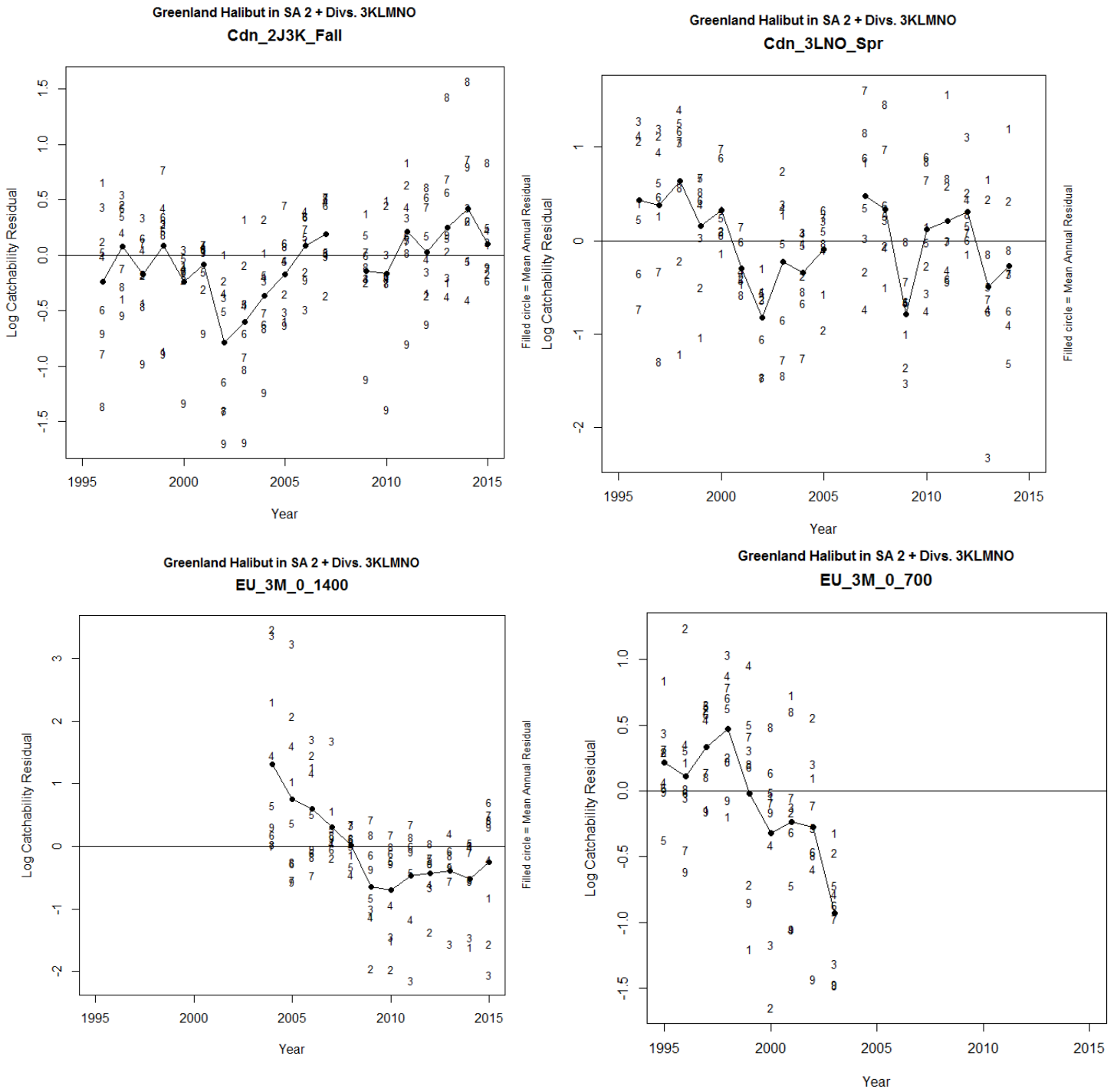
Fig. 10.  XSA Run 2 residuals by survey, age and year. Symbol=age, solid circle=mean annual residual.
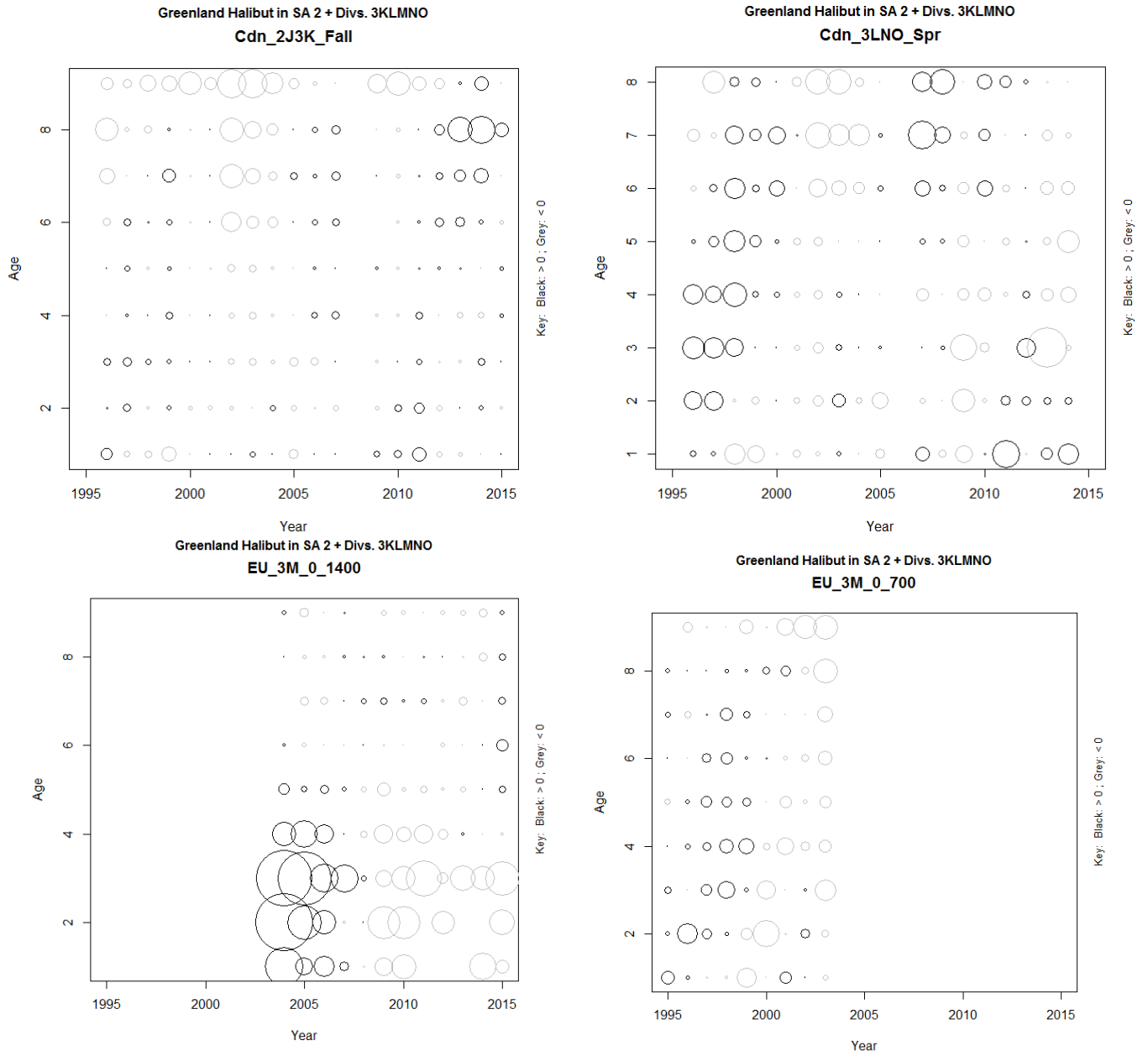
Fig. 11.   XSA Residuals Run 2; cont. Black=positive residual; grey=negative residual. Symbols are scaled to the overall maximum residual to permit comparisons across survey series.
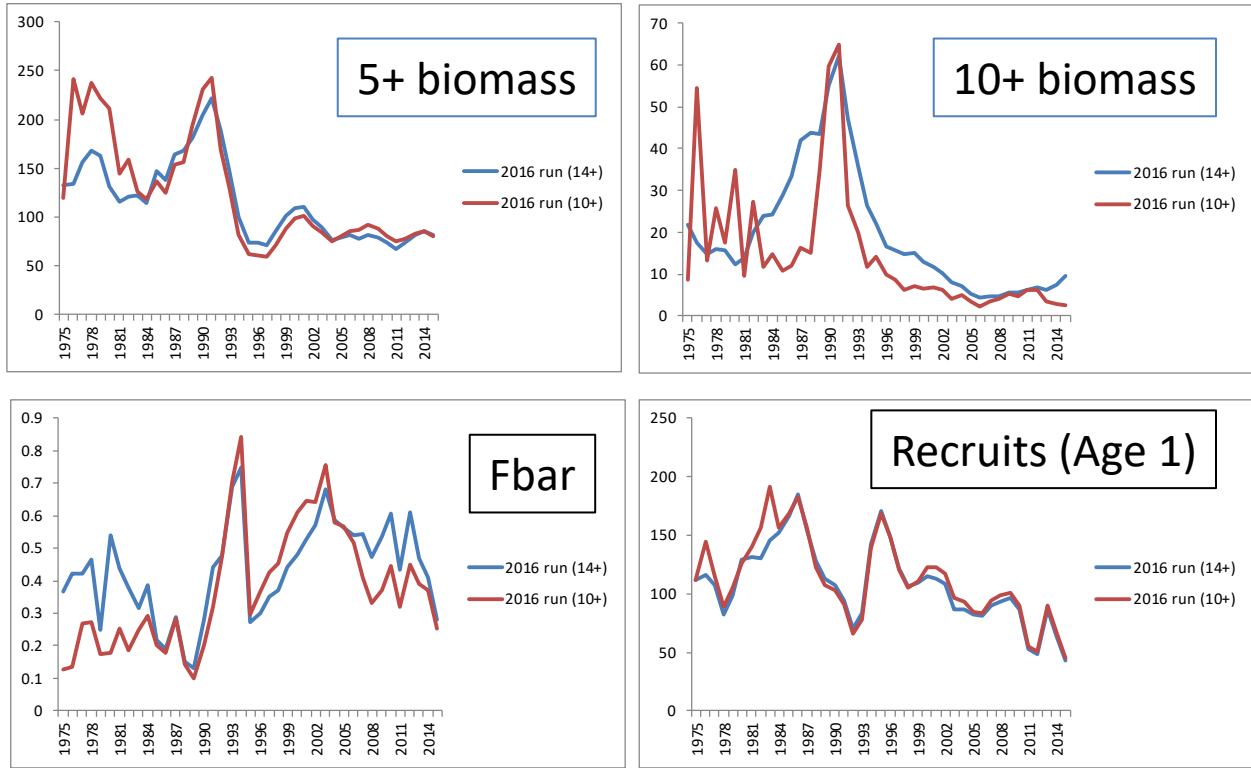
Fig. 12,  Comparison of Run 2 and the update run (run 1).
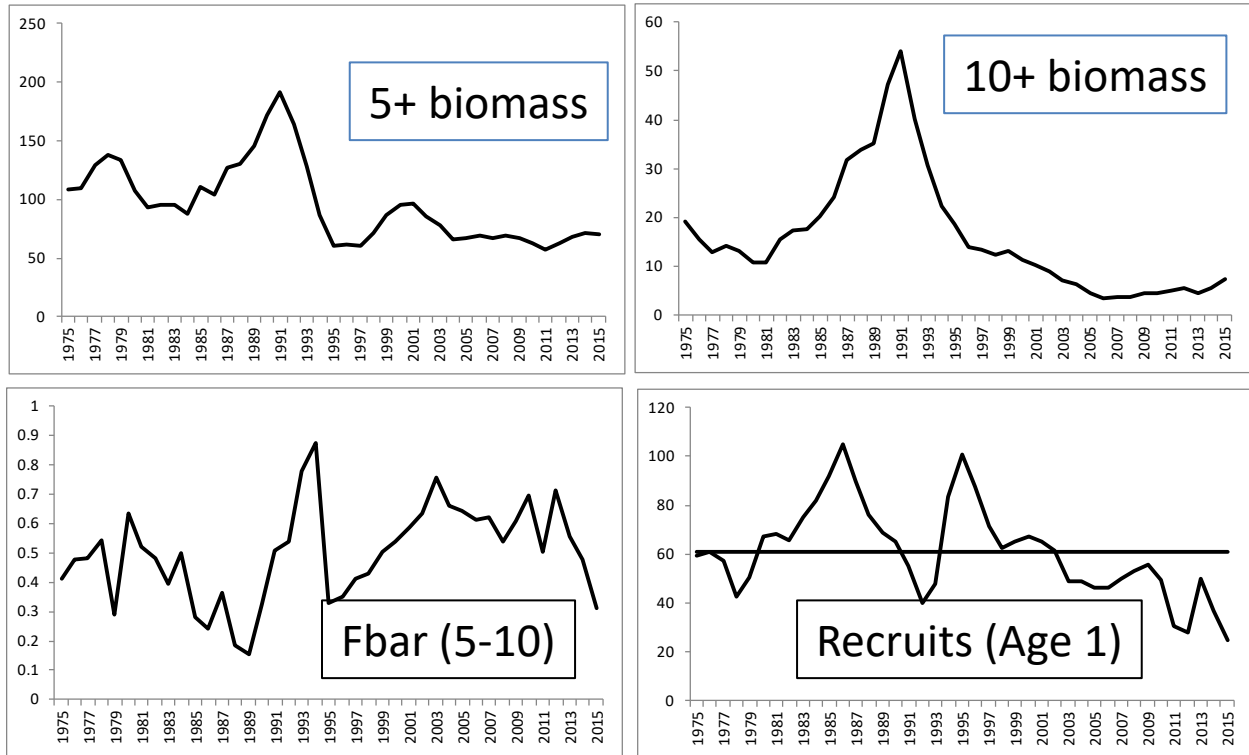
Fig. 13. Results for exploitable (5+) biomass, 10+ biomass, Fbar (5-10), and recruits (at age 1) Run 3 from XSA.
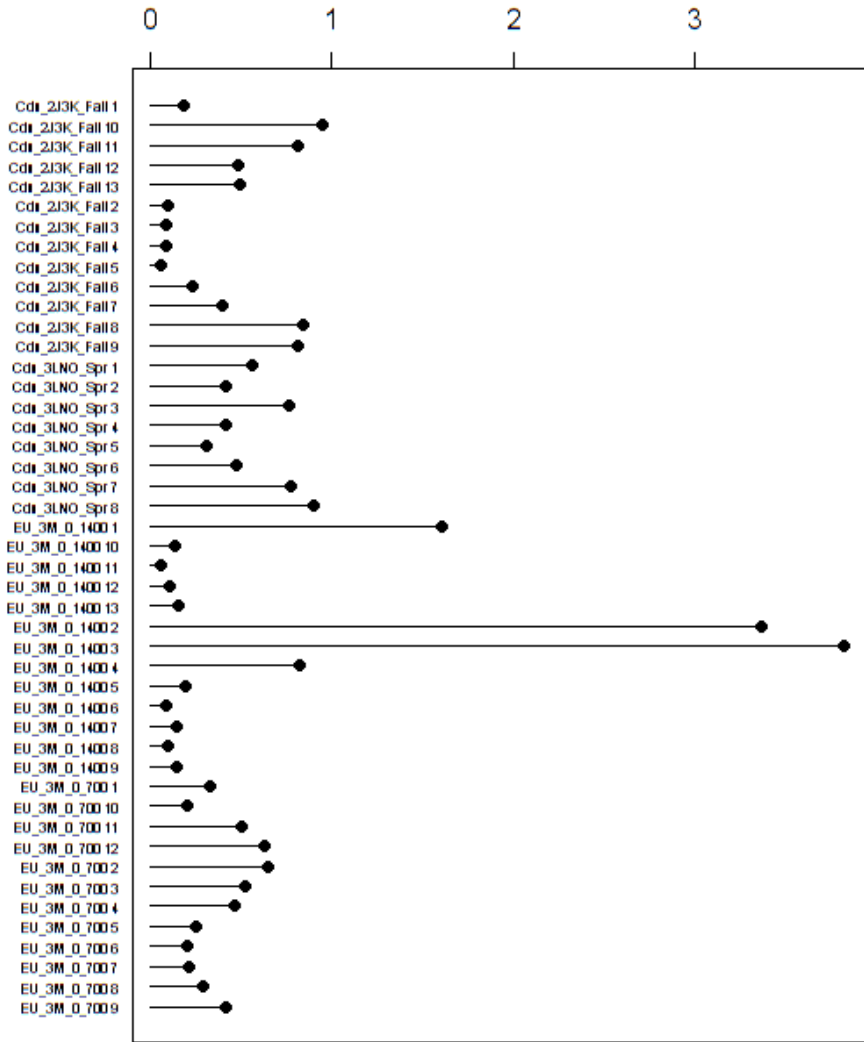
Fig.14.   Mean Squared Residuals from XSA Run 3 (M = 0.12) for each survey age.
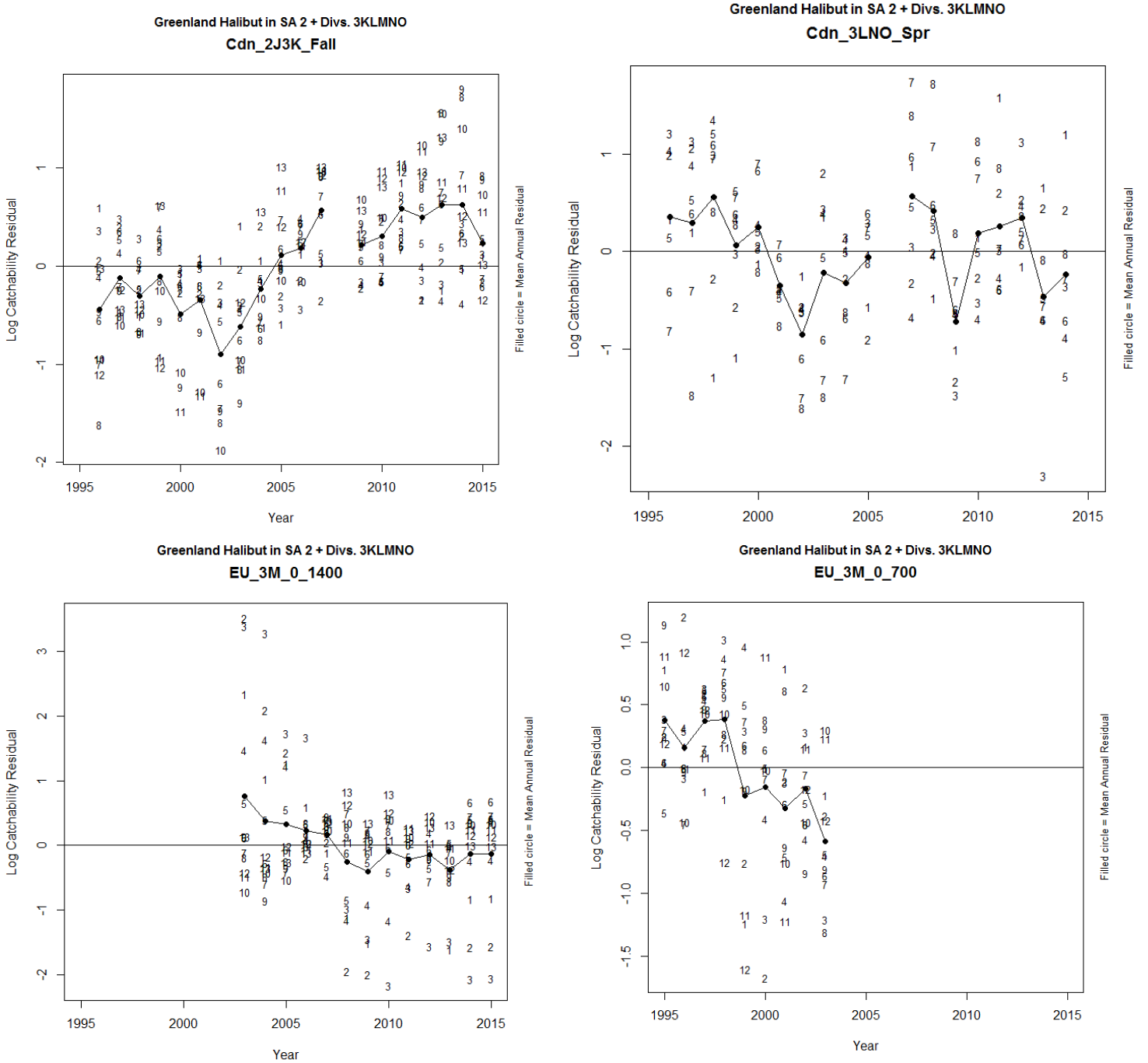
Fig.15.   XSA run 3 residuals by survey, age and year. Symbol = age, solid circle = mean annual residual.
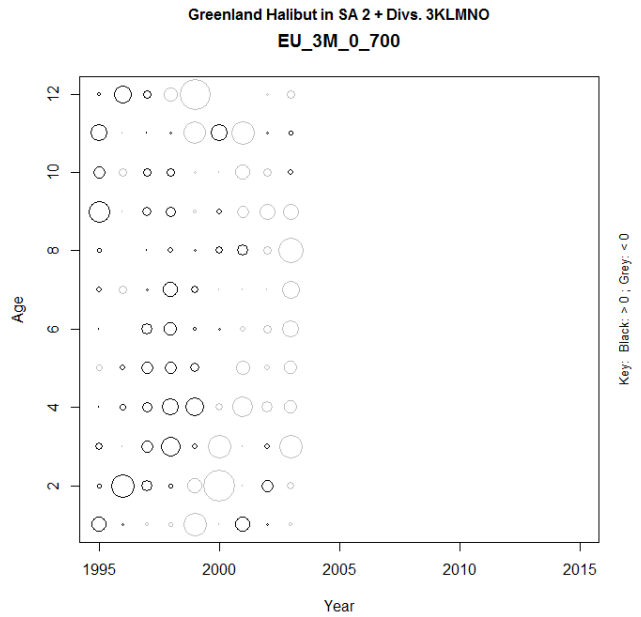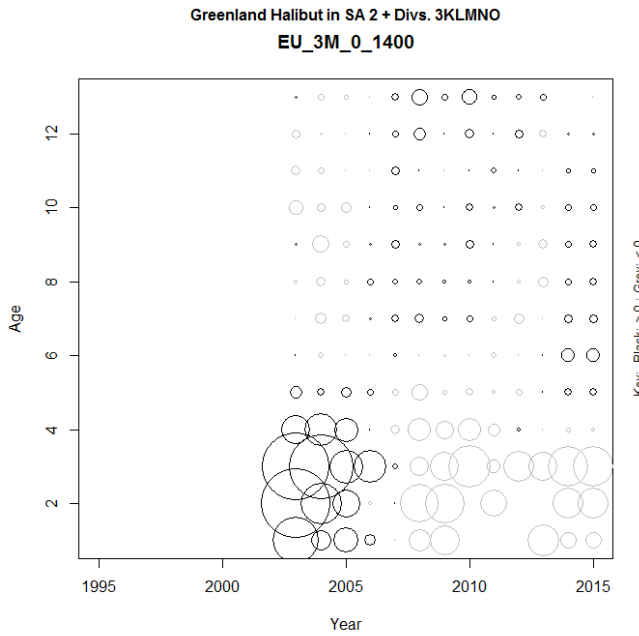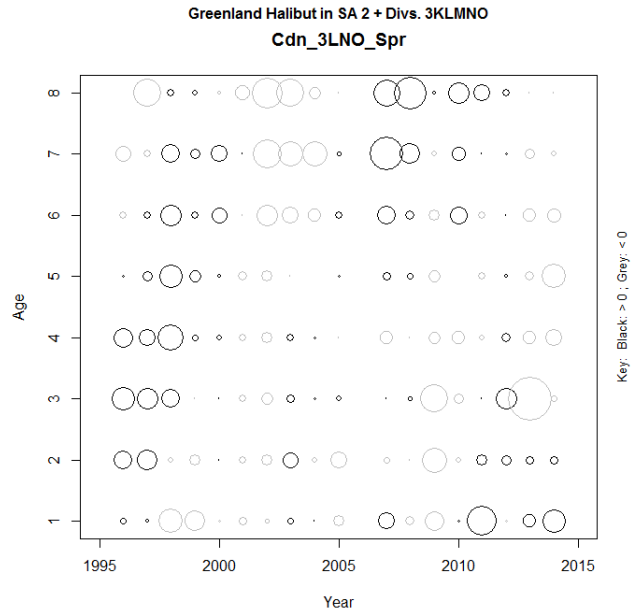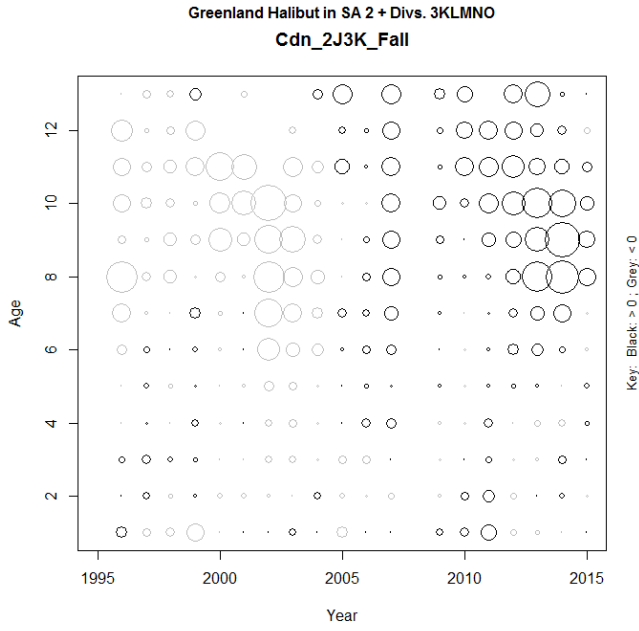
Fig.16.  XSA run 3 residuals, con't. Black = positive residual; grey = negative residual. Symbols are scaled to the overall maximum residual to permit comparisons across survey series.
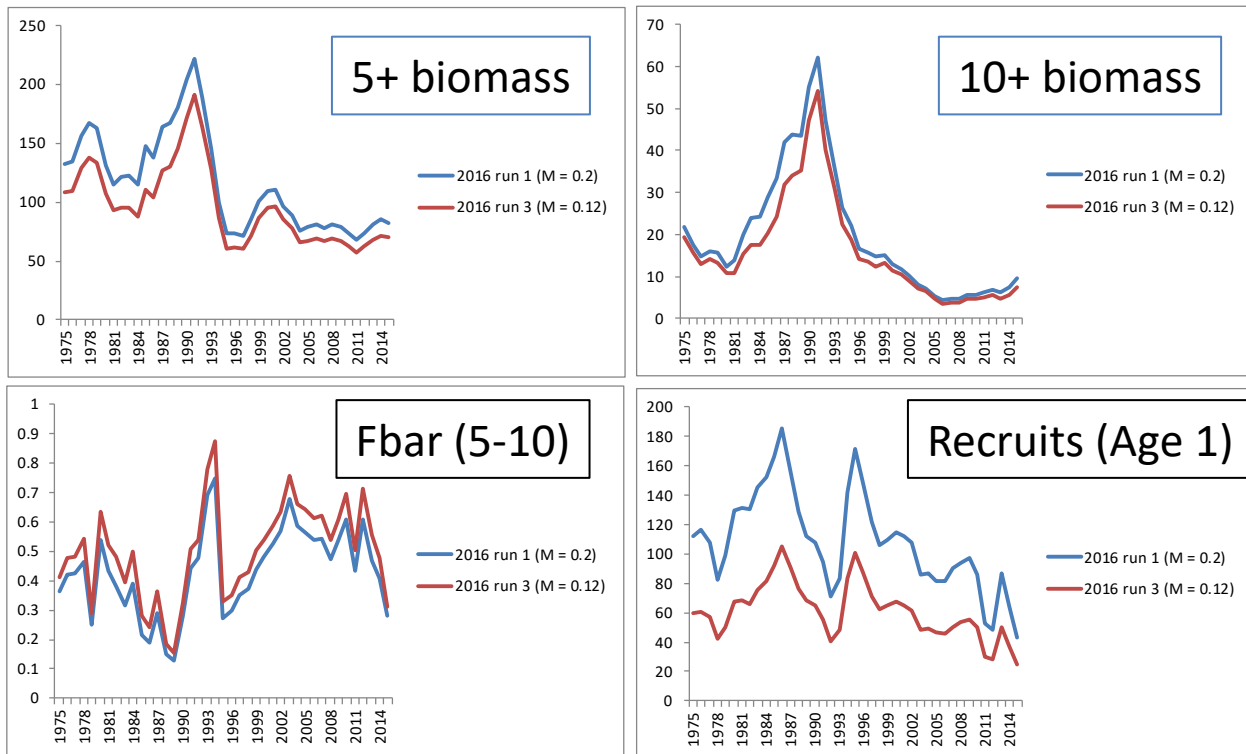
Fig. 17.  Comparison of XSA results for the update run (Run 1) and Run 3.
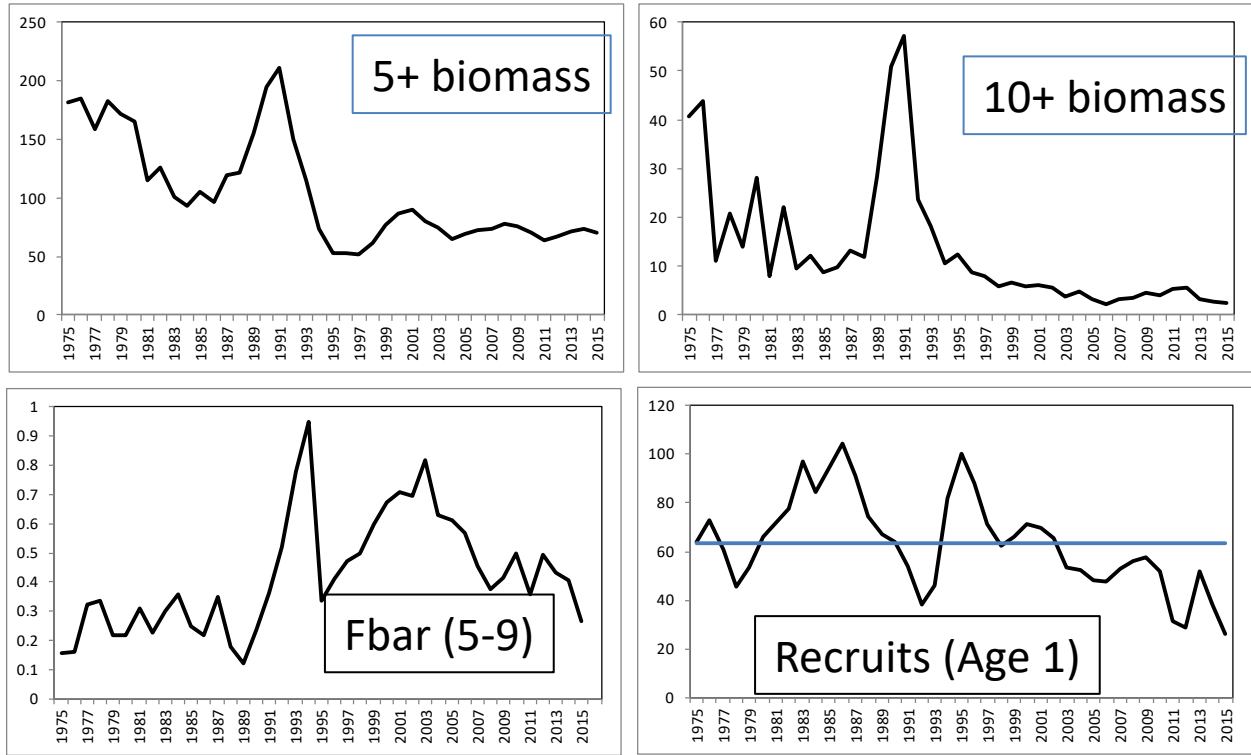
Fig. 18. Results for exploitable biomass (5+), 10+ biomass, Fbar (5-9) and recruits (age 1) for Run 4 from XSA.
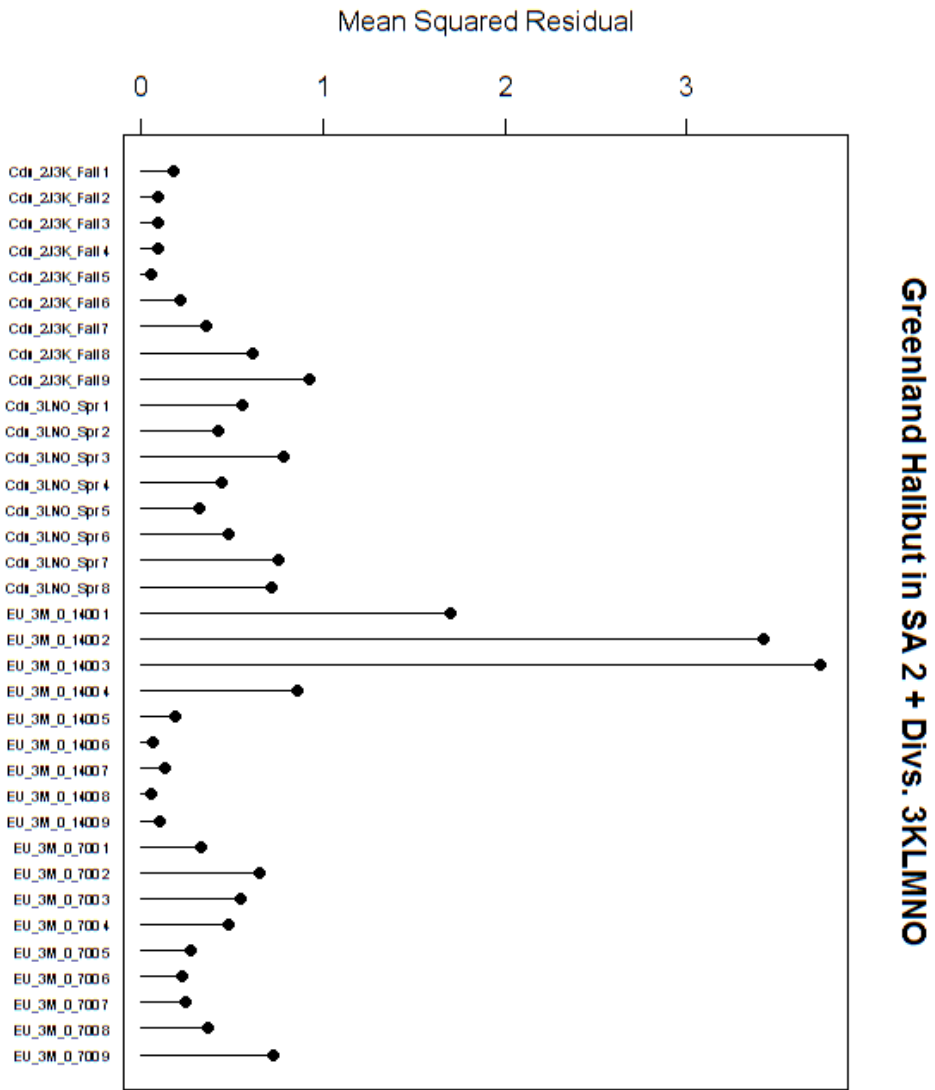
Fig. 19.  Mean squared residuals for Run 4 for each survey age.
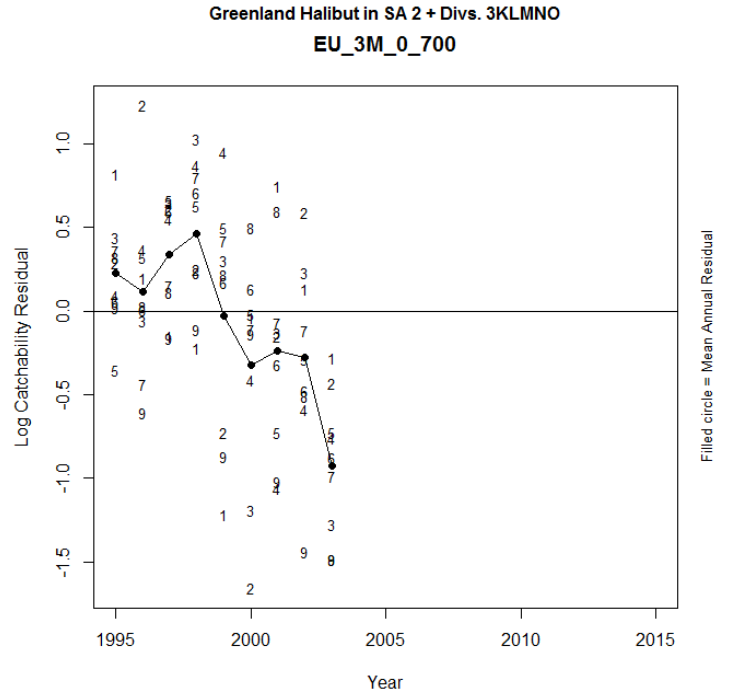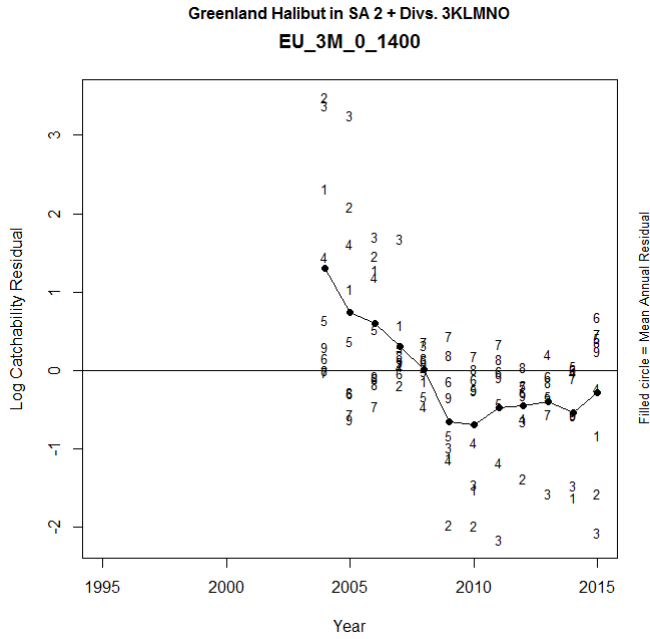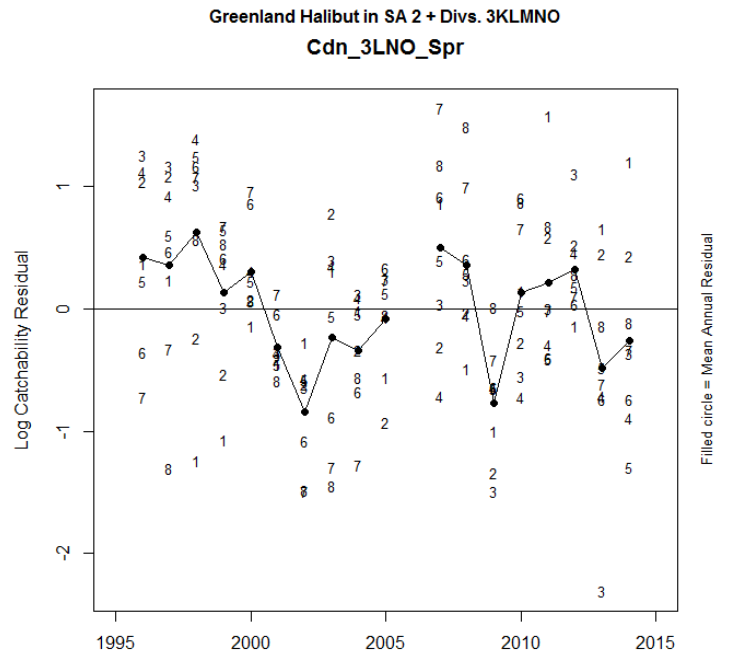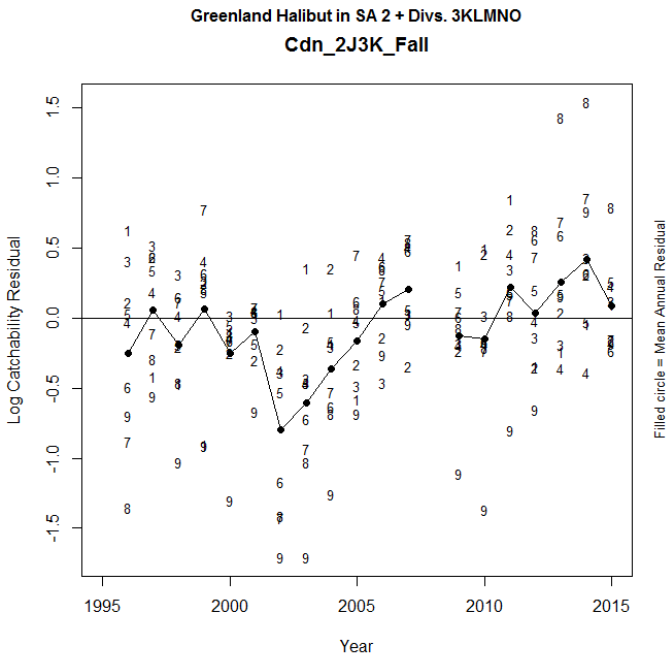
Fig. 20.  XSA run 4 residuals by survey, age and year. Symbol = age, solid circle = mean annual residual.
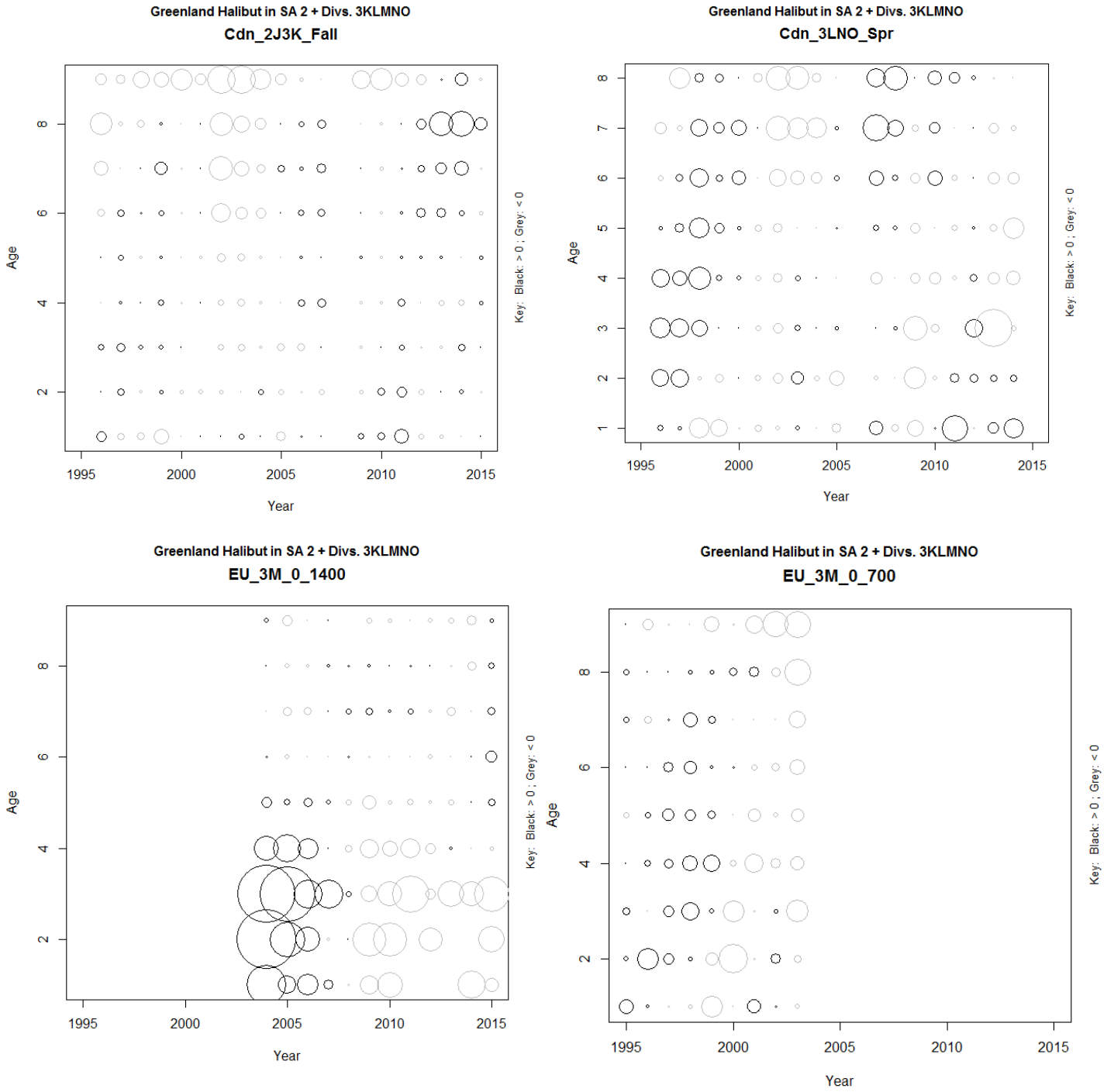
Fig.21. XSA run 4 residuals, con't. Black = positive residual, grey = negative residual. Symbols are scaled to the overall maximum residuals to permit comparisons across survey series.
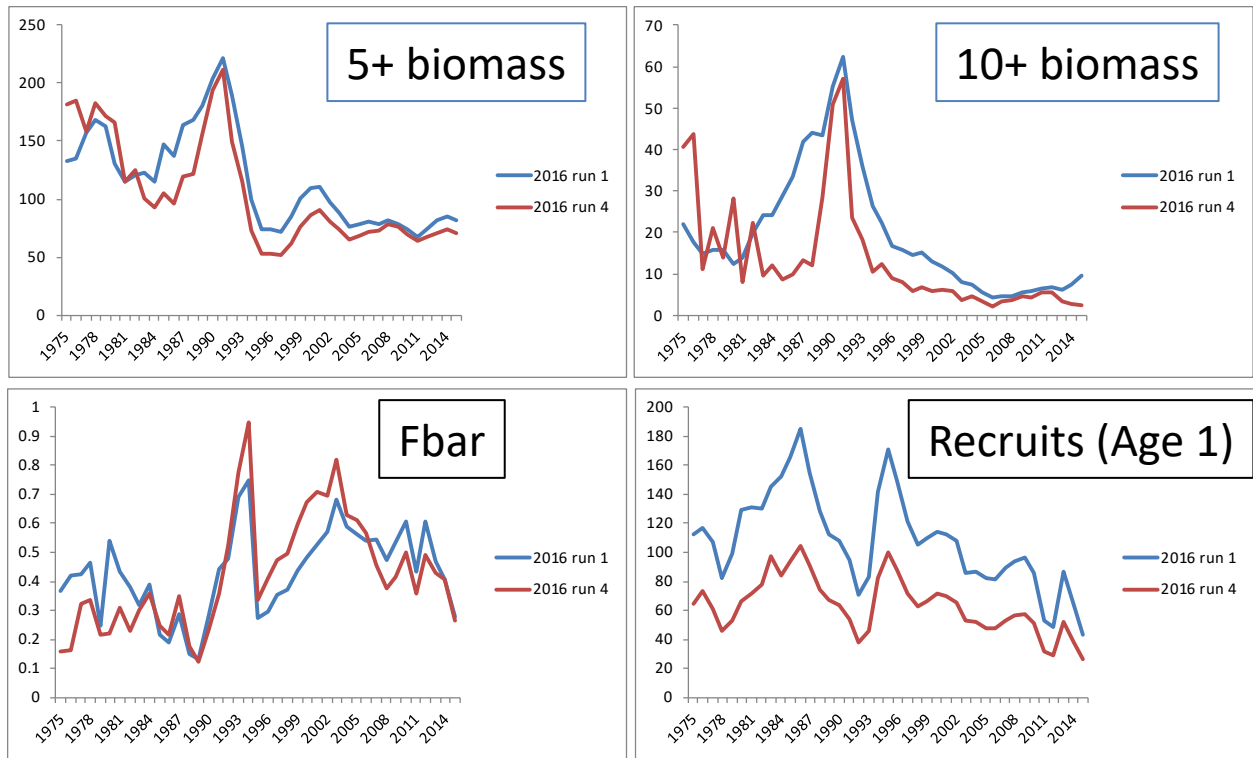
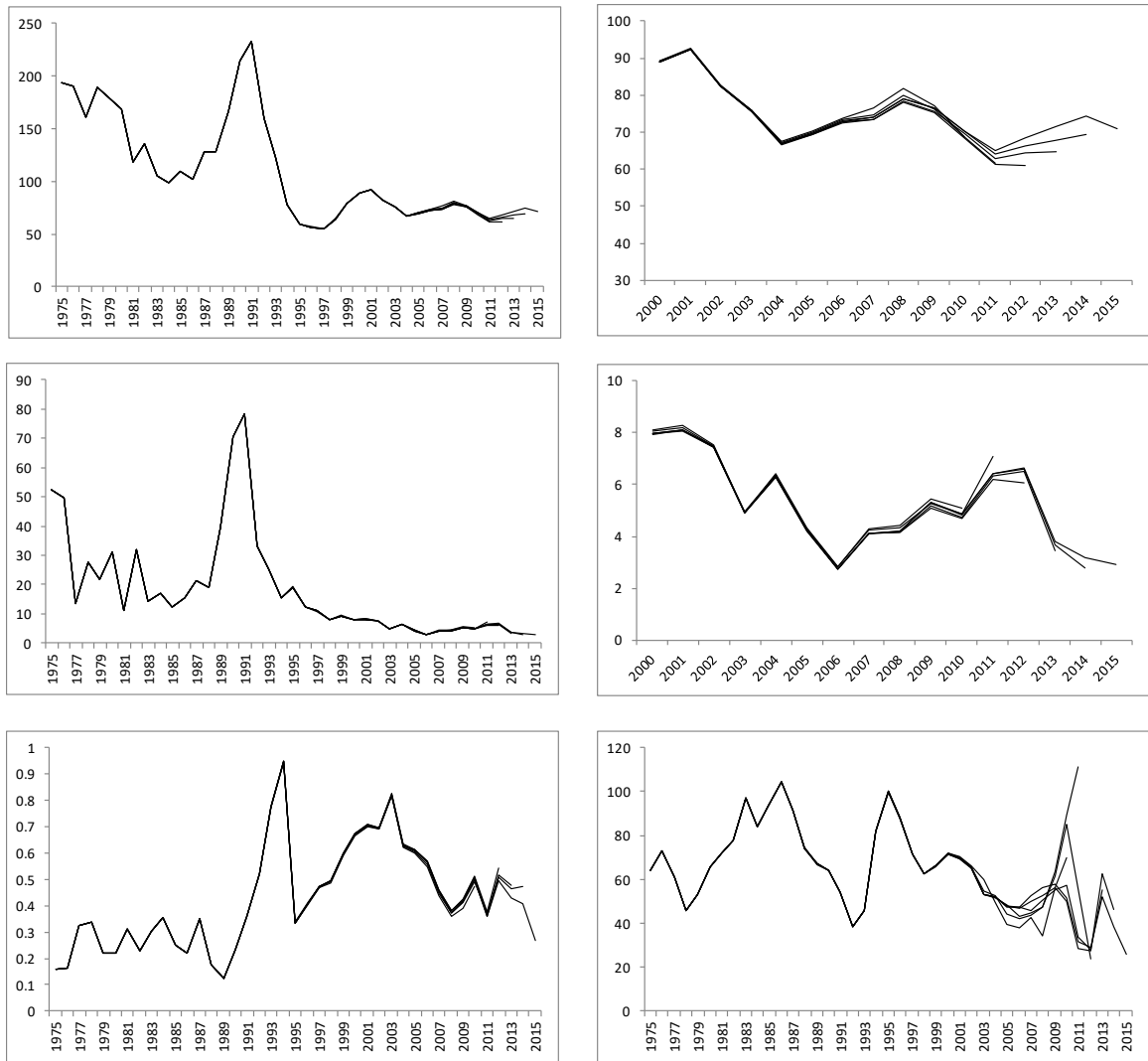Fig. 22.  Comparison of XSA results for update run (Run 1) and Run 4.

Fig. 23. Retrospective analysis for XSA run 4. The top panel (left and right) is the 5+ biomass for the full time series (left) and from 2000 – present (right). The middle panel gives 10 + biomass over the full time series (left) and from 2000-present (right). The bottom panels give fishing mortality (Fbar ages 5-9) (left) and recruits at age 1(right).