# Tilefish

## SEDAR 25 vs. 2016 Update

The 2016 update of the SEDAR 25 stock assessment for  Tilefish (also commonly called golden Tilefish) produced estimates of projected catch levels at a P* of 0.3 at just over 41% of the current catch level. This equates to an almost 60% drop in the projected catch level between that in place in 2016 and the projected value for 2017. This change came about even though the Council implemented what was considered a precautionary ACL based on yield at 75% of $F_{MSY}$ in response to the SEDAR 25 benchmark assessment. The Council's chosen ACL was over 20% lower in the first year, and over 10% lower by 2016, than the ABC recommended by the SSC based on the stock projections and application of the ABC control rule. The Council charged the SSC with investigating the reasons why the outcomes of SEDAR 25 and the 2016 Update are so different and to review the application of the P* analysis to determine the key uncertainties causing the apparent large buffer between the OFL and ABC projections.

### Differences in Stock Status

The 2016 Update estimated a much higher degree of overfishing to have been occurring than SEDAR 25 did during most of the time series (Figure 1). Also, the update estimated the terminal SSB to be below $SSB_{MSY}$ and just above MSST (Figures 2 & 3). This is in contrast to the SEDAR 25 estimates, which show the stock well above $SSB_{MSY}$ in the terminal year (Figure 2). Overall biomass is also estimated to be below $B_{MSY}$ in the Update, but well above it in SEDAR 25 (Figure 4). However, these differences cannot be explained by differences in the landings stream in the overlapping years, since they are nearly identical (Figure 5).

Most of the other input parameters also remained the same from SEDAR 25. The point estimate of natural mortality (M) and the use of the Lorenzen curve were the same as those used in SEDAR 25. Also, steepness was fixed at the same value of 0.84 as it was in SEDAR 25. These two parameters account for a lot of uncertainty in most assessments and are very influential in determining benchmark parameters, such as $F_{MSY}$. The Review Panel from SEDAR 25 even had this to say about steepness and the Stock-Recruitment relationship.

"*$F_{MSY}$ is largely determined by steepness of the stock-recruitment relationship. Steepness could not be freely estimated, largely because of the estimate of strong recruitment produced at low stock size (though the strong recruitment is not consistently supported in the age composition data). Therefore, steepness was assumed to be 0.84 based on a meta-analysis of fishes with similar life histories.*"

Therefore the data added for the update, from 2011-2014, must contain some information that affected the parameters that influence stock productivity, such as recruitment, life history traits, the stock-recruit relationship, and selectivity.

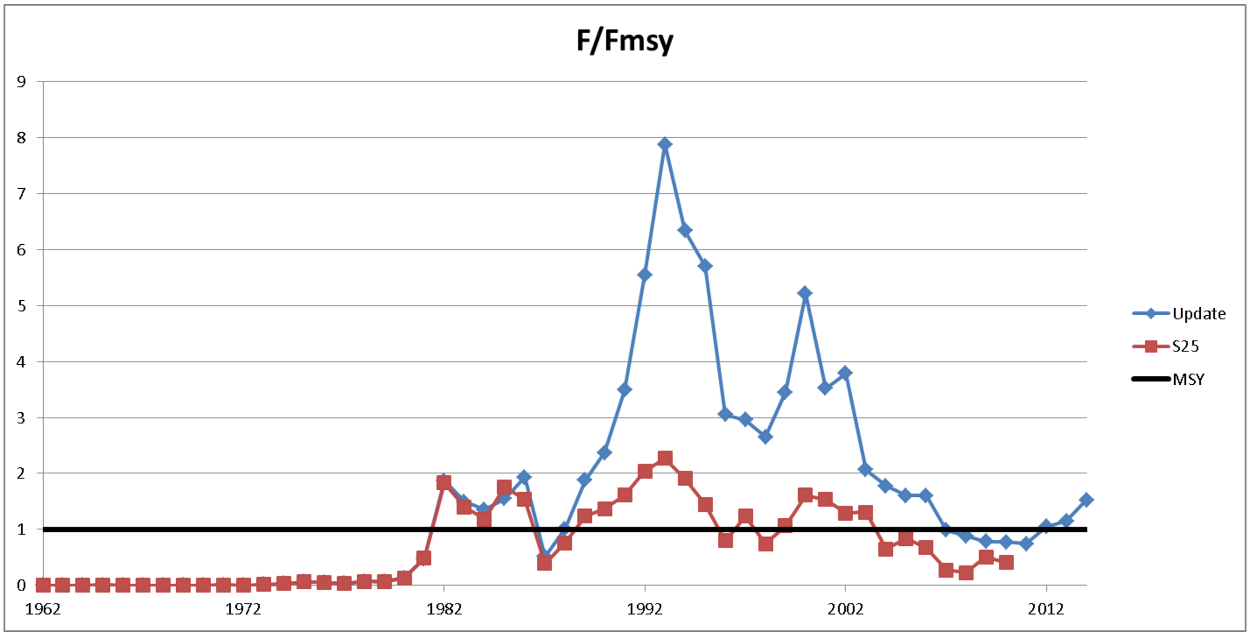

**Figure 1. F/$F_{MSY}$ from SEDAR 25 and the 2016 Update.**

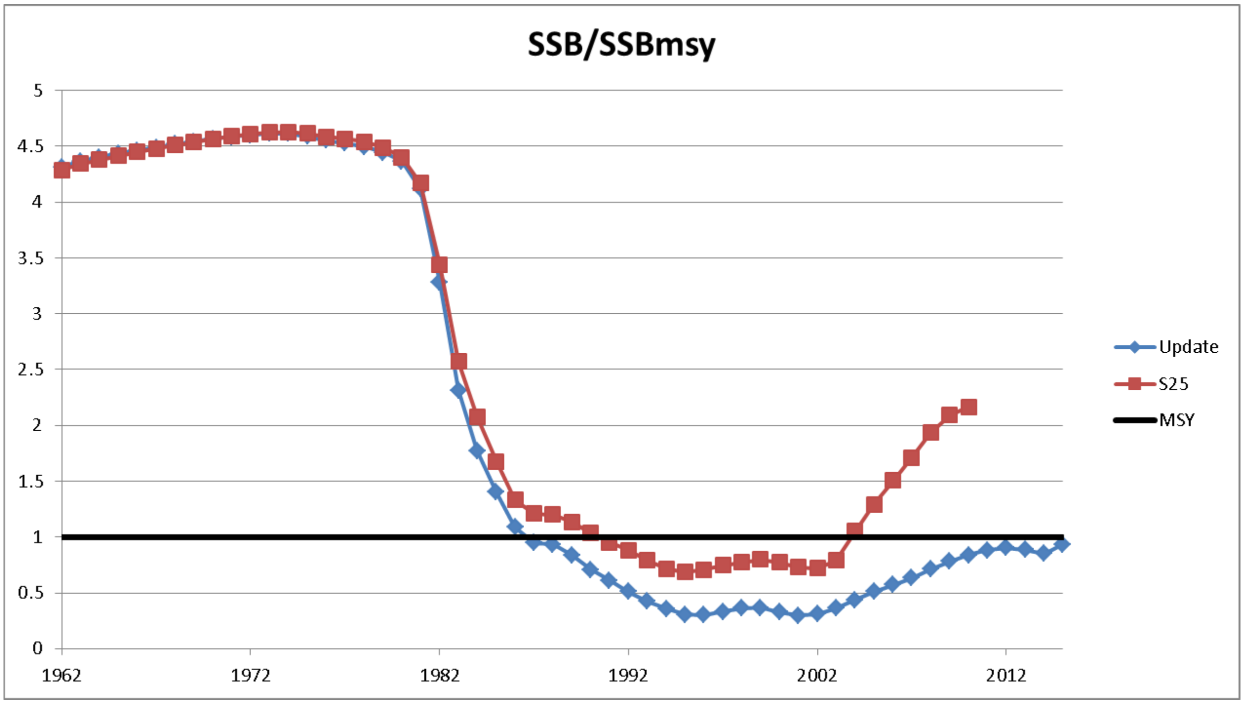

**Figure 2. SSB/$SSB_{MSY}$ from SEDAR 25 and the 2016 Update.**

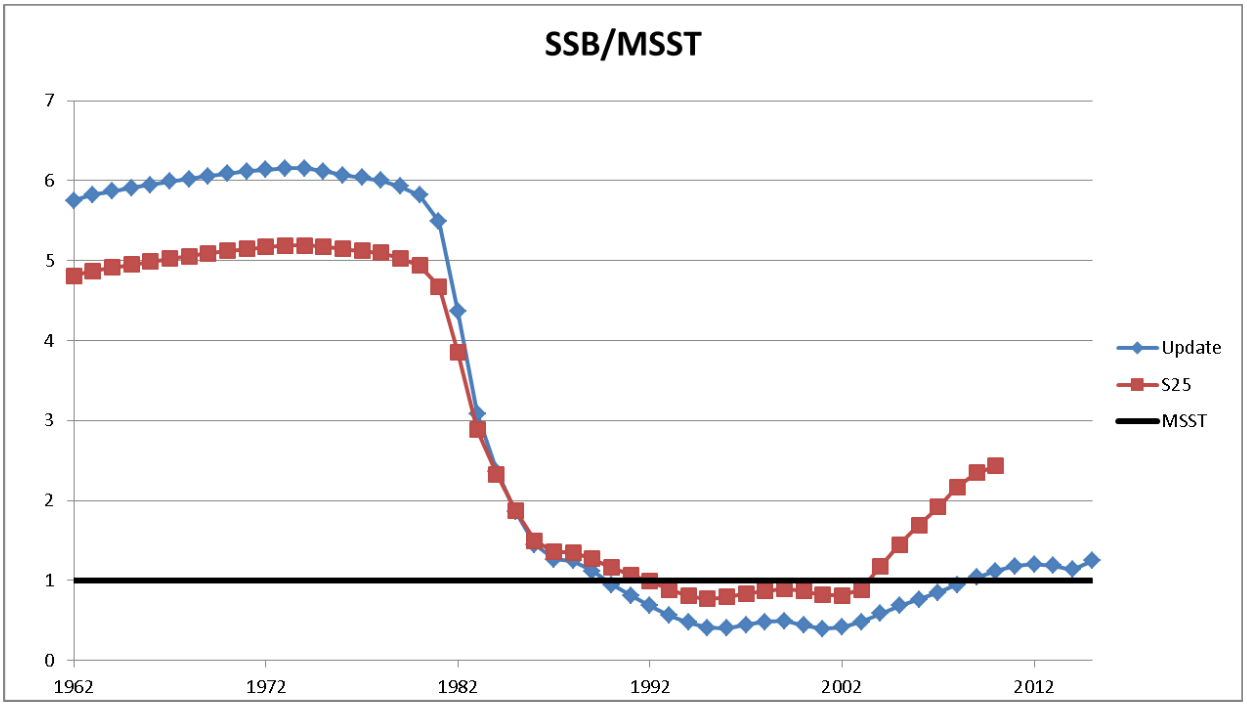

Figure 3. SSB/MSST from SEDAR 25 and the 2016 Update.

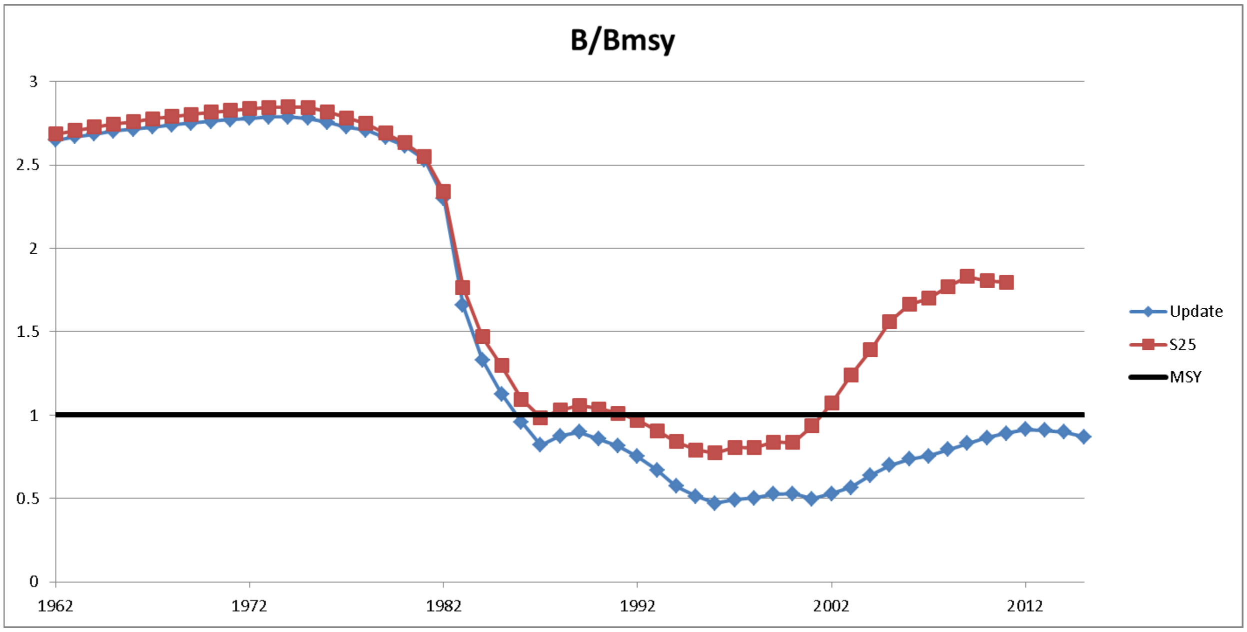

Figure 4. B/$B_{MSY}$ from SEDAR 25 and the 2016 Update.

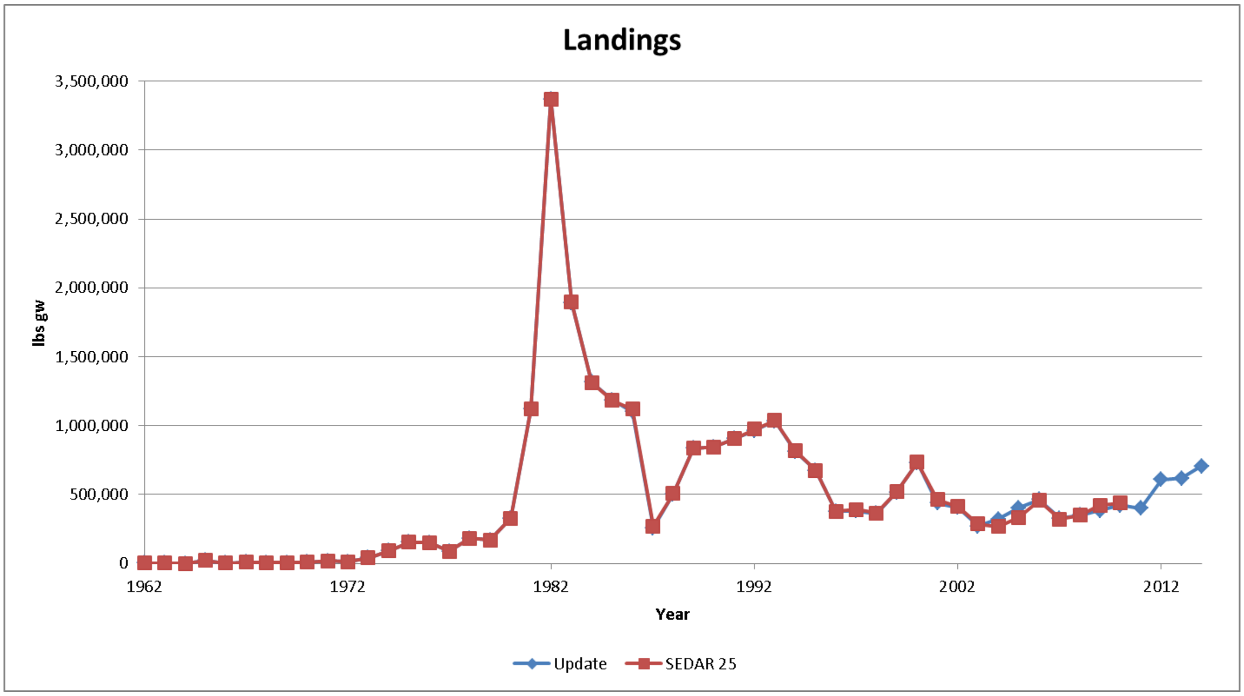

**Figure 5. Input landings of Tilefish for SEDAR 25 and the 2016 Update.**

### Abundance at Age and Recruitment

The abundance at age estimated for Tilefish from SEDAR 25 and the 2016 Update depict large differences in the latter half of the time series (Figures 6 & 7). Up until 2001, the trend in abundance is very similar, although the estimated abundance from SEDAR 25 is higher for every year. The largest differences in these time series come after 2001. In 2001 SEDAR 25 estimated an extremely high recruitment spike (shown in Figure 6 as the blue portion of the 2001 bar). That year class was subsequently reduced by both natural mortality and fishing pressure (when they recruited to the fishery) until the terminal year of 2011. The 2001 year class can be tracked by color as it transitions from blue to red to green to purple to teal, etc. (Figure 6). Since that spike doesn't show up in the update, the abundance time series remains fairly constant, with a slight increase from 2001 to 2015 (Figure 7).

Both the Assessment Workshop (AW) and the Review Workshop (RW) from SEDAR 25 commented on the validity of the large recruitment spike estimated in 2001. The excerpt below is taken from the SEDAR 25 Stock Assessment Report for Tilefish.

"*The assessment predicted relatively high abundance in recent years.*

*What is not clear is whether these observed patterns in the data are the result of (1) a single large year class, (2) several moderate to large year classes, or (3) an immigration of fish into the fished area.*

*The age composition data do not support a single strong year class and do not really indicate any year classes passing through the years. But ageing error for this species is high and could be masking year class signals. In the end, the data cannot give us a clear indication if (1), (2), or (3) listed above is the* *correct explanation of the increased abundance and shift in age structure. The base run model has chosen (1), but managers should note the risks involved if (2) or (3) are correct and management actions are based on (1).*"

This excerpt was written by the AW and corroborated by the RW in the report. The RW also asked whether the sampling of recruitment residuals in the projections would lead to uncharacteristically high estimated recruitments being carried forward in projections. This was in fact the case, which is why deterministic projections were used to determine catch level recommendations for SEDAR 25 rather than the probabilistic projections.

The recruitment peak estimated in 2001 during SEDAR 25, coupled with the age data, lead to an estimate of $R_0$ (recruitment when SSB is at unfished levels) of 409,000 age-1 fish (Figures 8 & 9). In the 2016 Update, the additional years of data and the use of a robust multinomial likelihood function lead to an estimate of the 2001 recruitment that was similar to the surrounding years (Figure 9). A sensitivity run done during the 2015 Update showed that the use of a new robust multinomial function for estimating the age comps had an effect on model estimates (Figures 10 & 11, Table 1). If the multinomial function that was used during SEDAR 25 had been used in the Update, F would have been found to be below $F_{MSY}$, SSB would have been found to be above $SSB_{MSY}$, and MSY would have been estimated to be 27,000 lbs gw higher (Table 1). Increases in the estimates of $SSB_{MSY}$ and MSY suggests that use of the SEDAR 25 multinomial would have resulted in higher estimates of productivity than the robust multinomial used in the Update estimated.

It should be noted that even using the multinomial from SEDAR 25, the trajectory of F in the last few years is increasing and is very close to $F_{MSY}$ in the terminal year (Figure 10). Also, both SEDAR 25 and the sensitivity run using the SEDAR 25 multinomial are optimistic compared to the results of the 2016 Update. It may be that the SEDAR 25 multinomial exacerbates model tendencies, or has the potential to be biased by outlier data.

With the 2001 recruitment peak gone, the new estimate of $R_0$ was 362,000 age-1 fish (Figure 9). So, the estimate of $R_0$ from the Update is about 88% of the estimate from SEDAR 25. Consequently, the estimate of MSY from the Update (560,000 lbs gw) is also roughly 88% of the estimate from SEDAR 25 (638,000 lbs gw). Thus it appears that a major factor in the decline of productivity is the change in expected recruitment between SEDAR 25 and the Update.

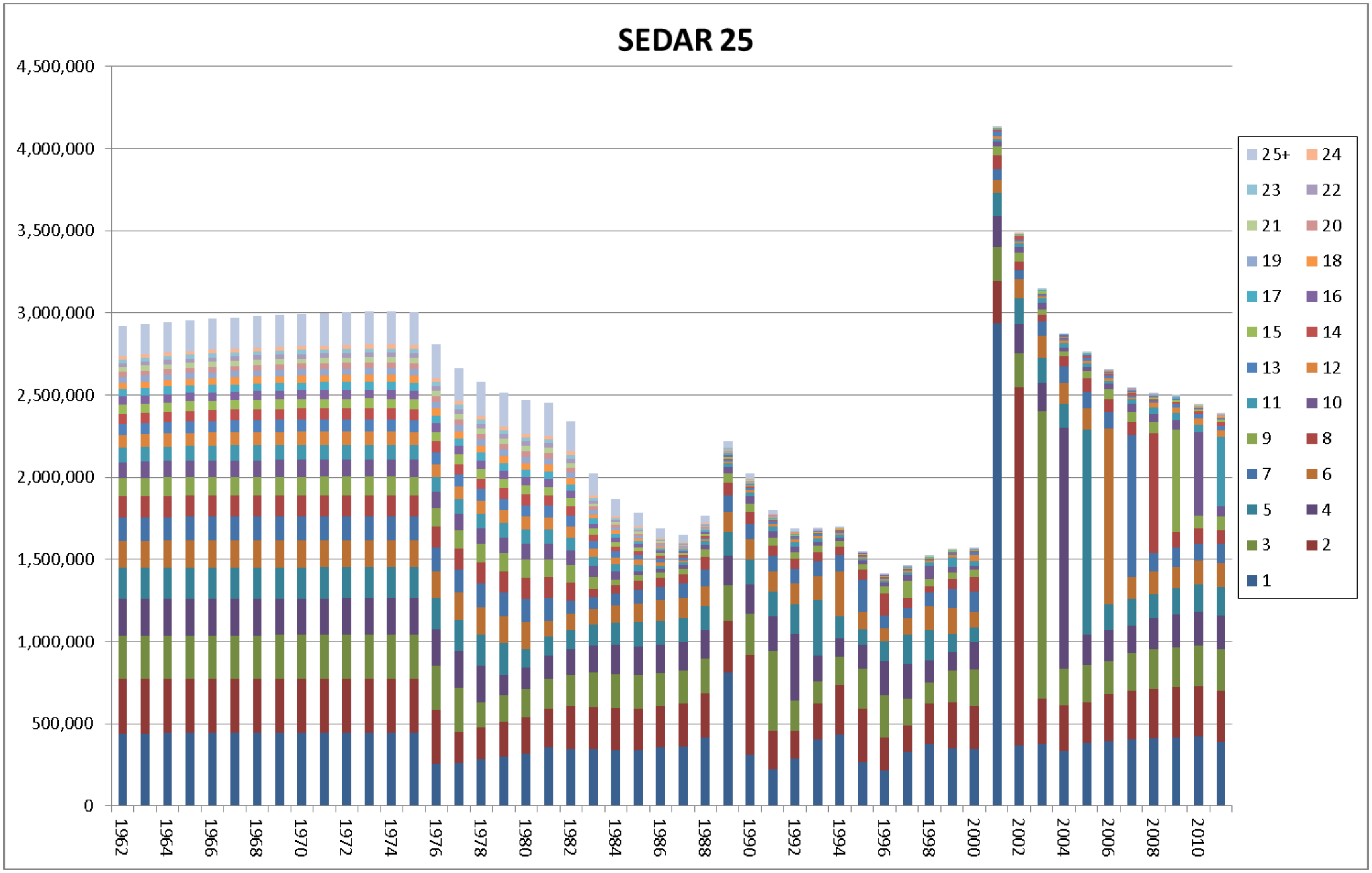

Figure 6. Estimated abundance at age from SEDAR 25.

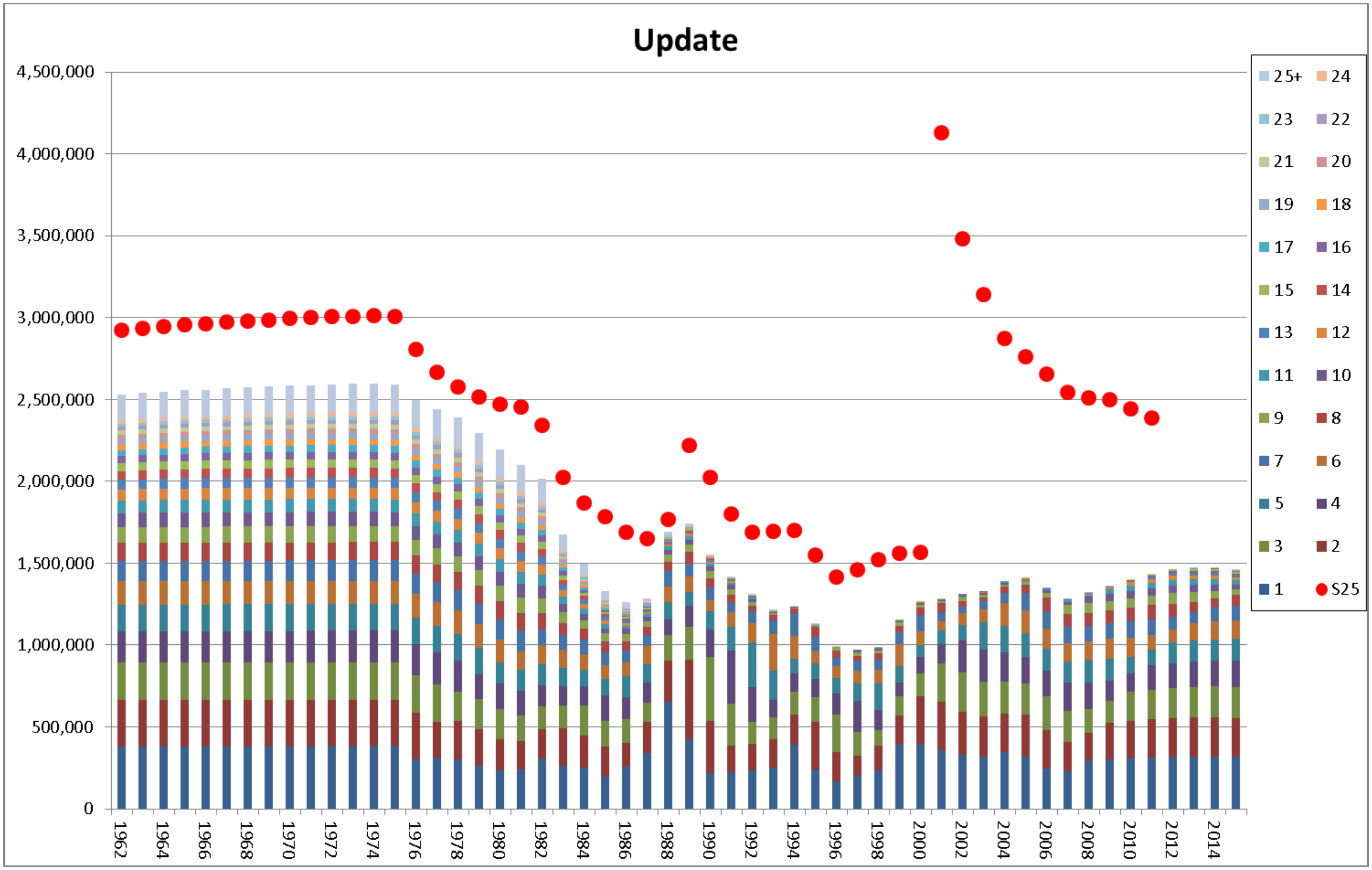

Figure 7. Estimated abundance at age from the 2016 Update, with SEDAR 25 total abundance (S25) for reference.

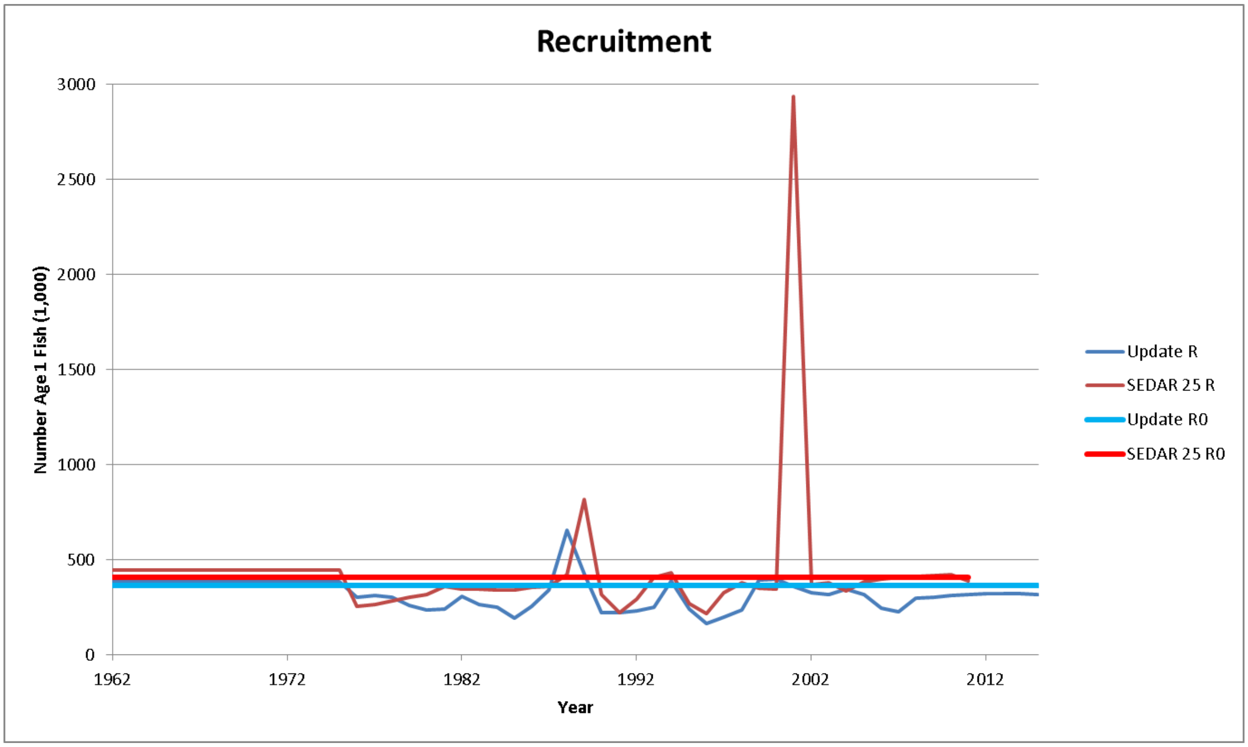

Figure 8. Estimated time series of recruitment from SEDAR 25 and the 2016 Update.

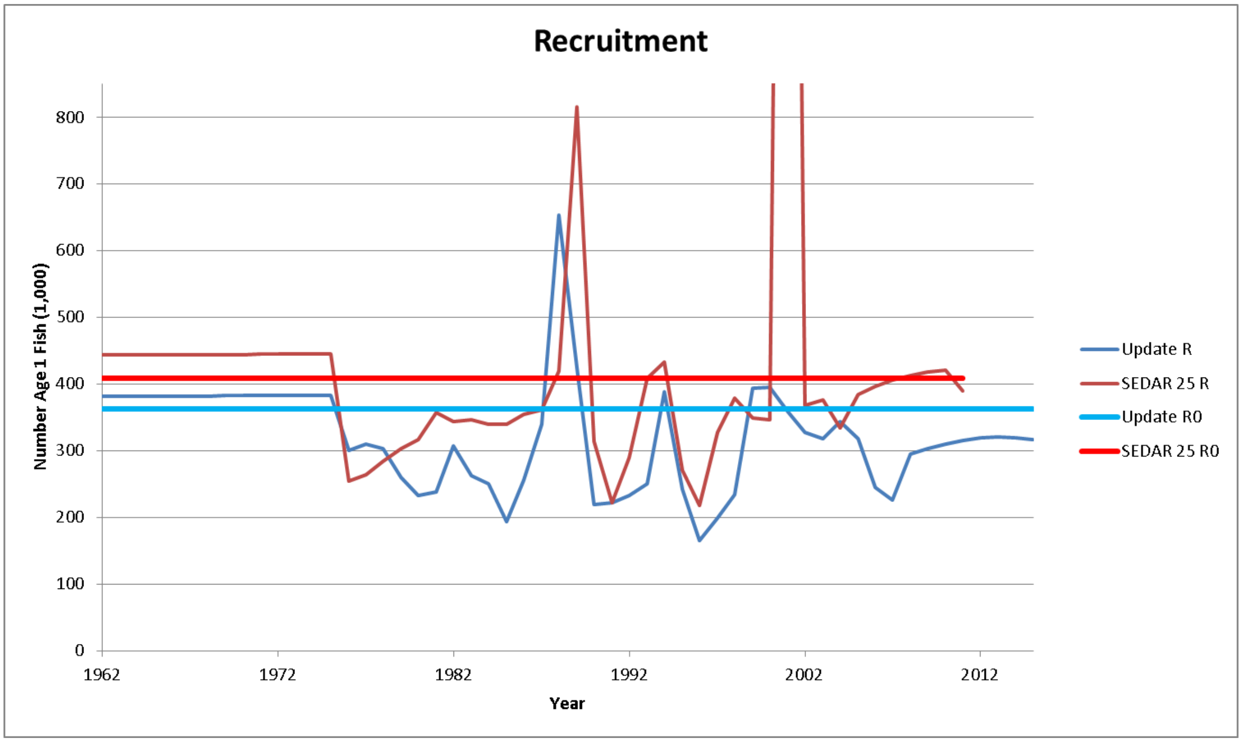

Figure 9. Estimated time series of recruitment from SEDAR 25 and the 2016 Update, ignoring the recruitment spike from SEDAR 25 in 2001 in order to better distinguish the two time series.

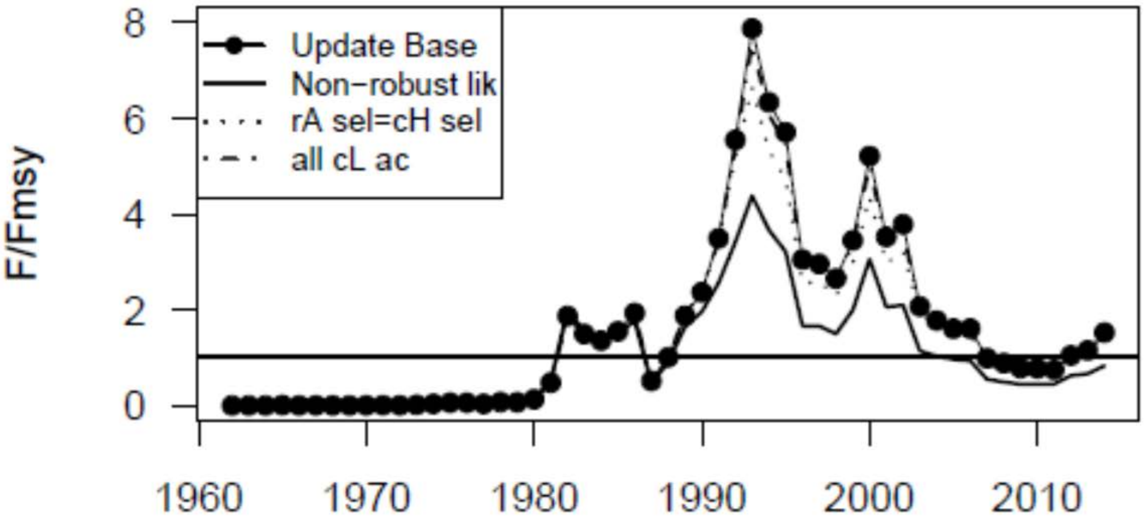

Figure 10. Results of sensitivity runs from the 2015 Update showing effects on F/F$_{MSY}$. Line with dots is the base, solid line uses the non-robust multinomial from SEDAR 25.

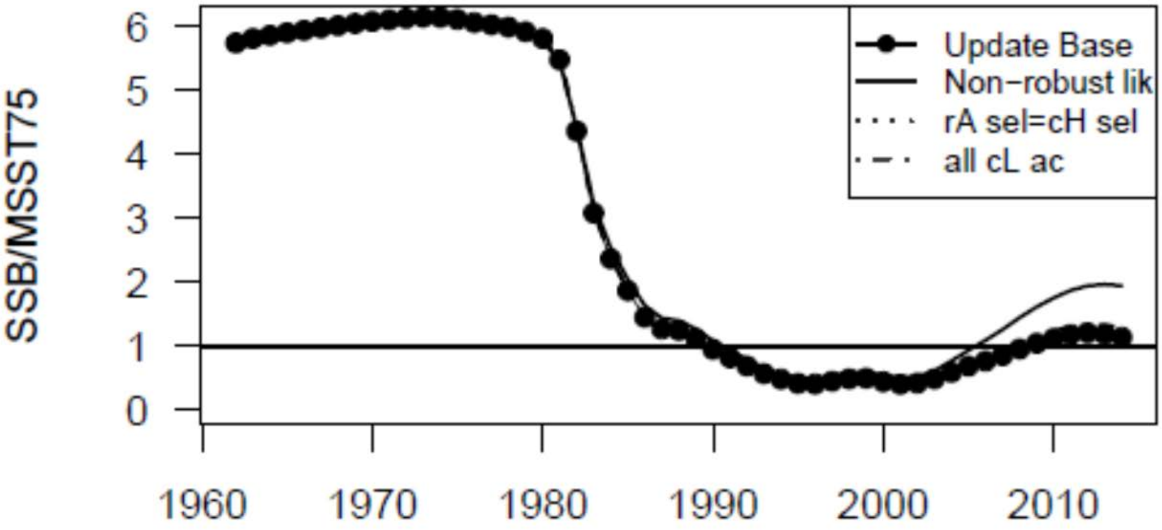

Figure 11. Results of sensitivity runs from the 2015 Update showing effects on SSB/MSST. Line with dots is the base, solid line uses the non-robust multinomial from SEDAR 25.

**Table 1. Results of sensitivity run from the 2015 Update using the SEDAR 25 multinomial showing the differences in parameter estimates between the sensitivity run and the base run.**

| Run | $F_{MSY}$ | $SSB_{MSY}$ (mt) | MSY (1000 lbs gw) | $F_{2012-2014}/F_{MSY}$ | $SSB/SSB_{MSY}$ | SSB/MSST |
|---|---|---|---|---|---|---|
| Base | 0.24 | 21.93 | 560 | 1.22 | 0.85 | 1.13 |
| S25 Multinomial | 0.19 | 23.79 | 587 | 0.70 | 1.46 | 1.94 |

## Changes in Selectivity

Estimates of MSY and other benchmarks, as well as the projections of catch levels, are affected by the estimates of selectivity for each of the fleets. For Tilefish, commercial fleets (especially the longline fleet) dominate the landings and therefore exert the most influence on the model outputs. Selectivity for both the commercial longline and the commercial handline fleets shifted in the 2016 Update toward greater selectivity for older fish (Figures 12 & 13). Because abundance of fish in the older age classes gets exponentially smaller each year, due to removals by fishing and natural mortality, less fish are available to the fishery for harvest at any given fishing mortality rate. It also means that it would take a lot more effort (higher F) to catch the same number of fish as were estimated to be caught during SEDAR 25 if all those fish were older than previously thought. Since the landings being input into the Update are nearly identical to those that were input into SEDAR 25 (Figure 5), the model is being told that the same number of fish is being harvested, but they are all older than what SEDAR 25 thought they were. Since the BAM uses apical F (the highest F value across all ages in a given year) to determine F in a given year and because the fish being harvested are now all older, the F rates were increased in the Update from those estimated in SEDAR 25. This fact can help explain the large difference in relative F values between SEDAR 25 and the Update seen in Figure 1. Some of the reduction in numbers of fish harvested can be offset by the increased weight of fish at older ages, so selectivity changes will affect yield in pounds differently than yield in numbers.

To investigate what caused the difference in selectivity estimates, we have to look at the age compositions of the commercial catch. Here, we focus on the longline age comps since they make up the bulk of the landings and the bulk of the age samples. When comparing the combined age comps for the longline fleet from the Update and SEDAR 25 we indeed see a shift towards older fish in the age comps from the Update (Figure 14). In order to explore this further, the age comps were broken down by time period within the Update (Figure 15). What you can see is that the time period that overlaps with SEDAR 25 (green bars) shows a very similar age comp pattern to that of SEDAR 25 (red bars). It's the new years of data that show the selection of older fish (Figure 15, blue bars). But how can only 4 years of additional data have such a large impact on the estimates of selectivity? That's because of the number of age samples in the new years of data compared to those from previous years. For the longline fleet, the 4 new years make up over 17% of all the age samples. For longline and handline combined, the 4 new years comprise almost 25% of all the age samples.

The increase in age samples affects the estimates of selectivity because a single selectivity curve is estimated for each fleet using pooled age data and applied to all years. Therefore, the assumption being made here is that due to the increased age sampling in recent years there is a greater degree of confidence in the overall estimated selectivity pattern for each fleet. There was no indication that selectivity changed at some point, requiring the use of selectivity time blocks.

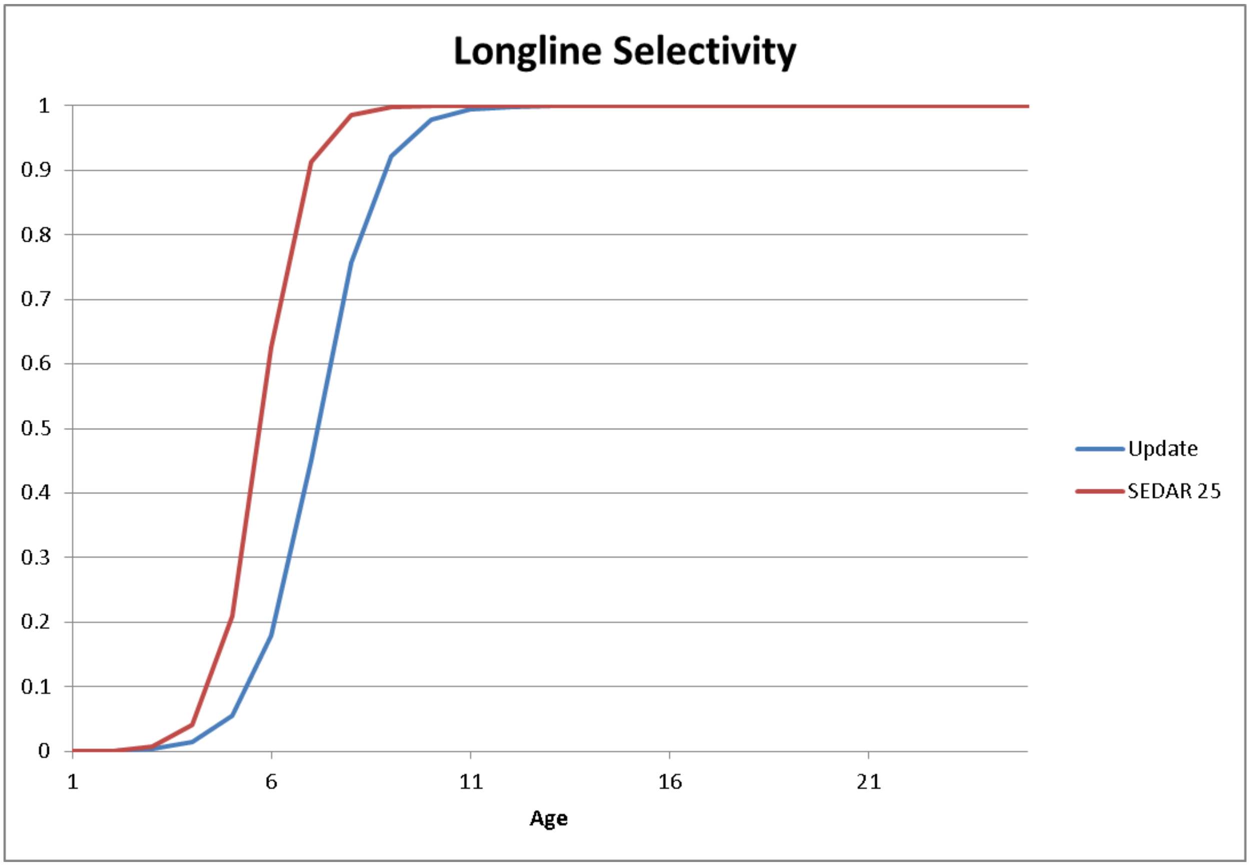

**Figure 12. Estimated selectivity of the commercial longline fleet from SEDAR 25 and the 2016 Update.**

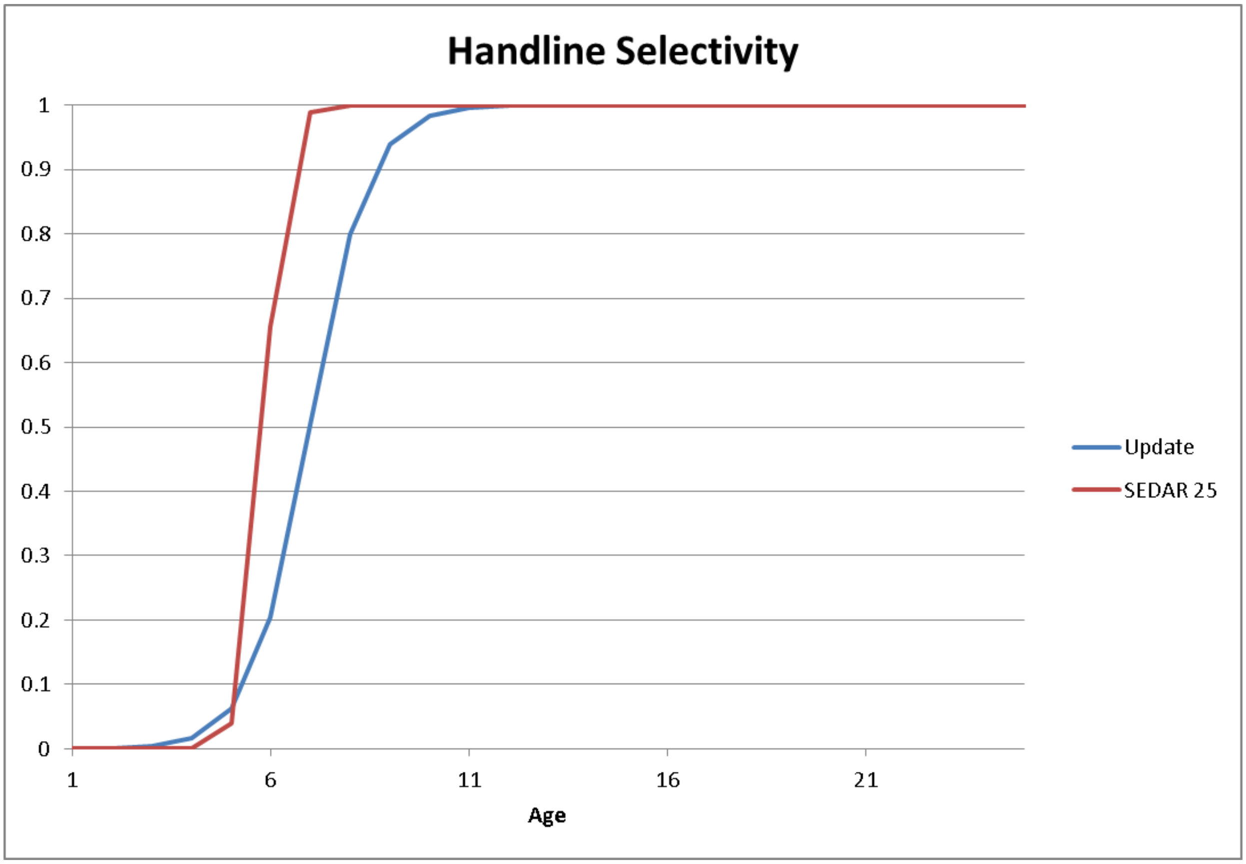

**Figure 13. Estimated selectivity of the commercial handline fleet from SEDAR 25 and the 2016 Update.**

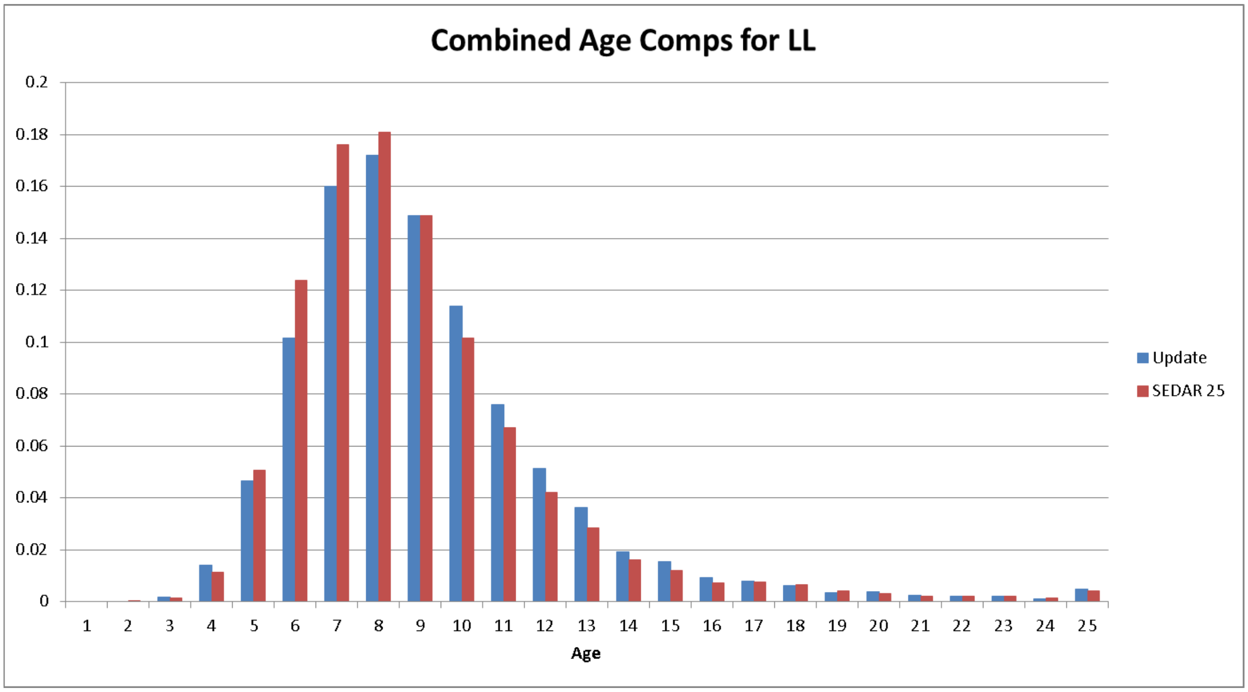

**Figure 14. Combined commercial longline age comps from SEDAR 25 and the 2016 Update.**

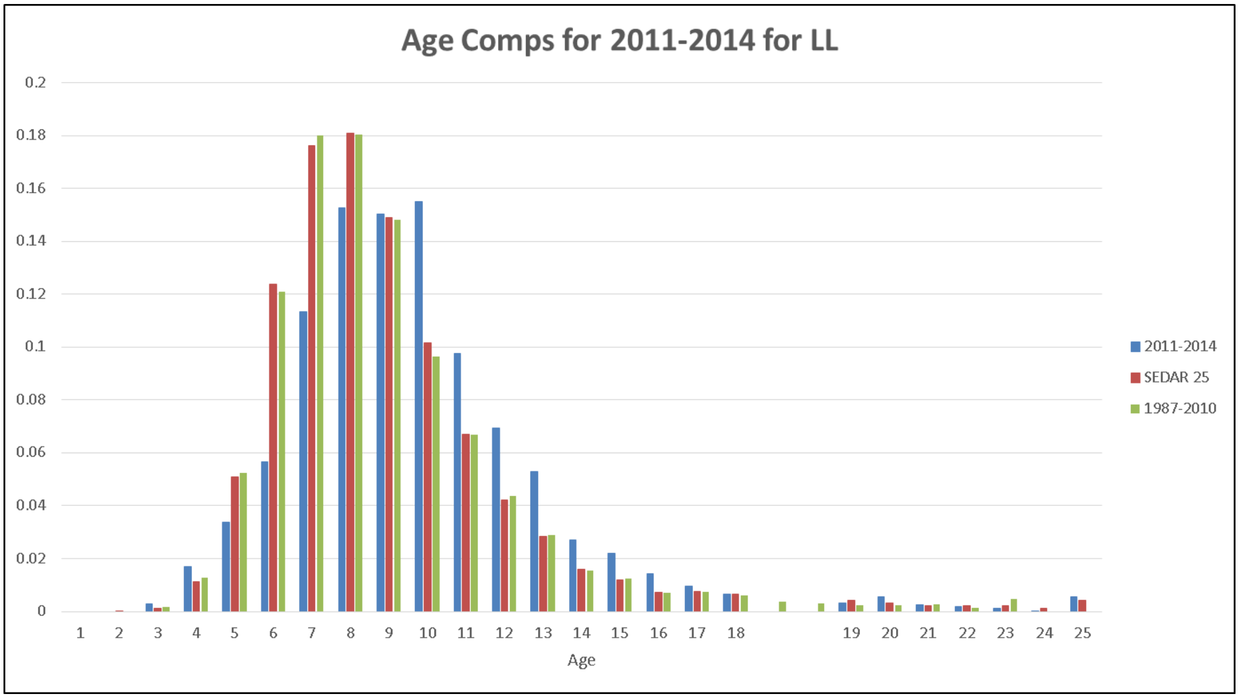

**Figure 15. Combined commercial longline age comps from SEDAR 25, the early part of the 2016 Update (1987-2010), and the new years of the 2016 Update (2011-2014).**

## Buffer between OFL and ABC

There was also concern that the buffer between OFL and ABC, estimated using the P* approach and MCB analysis, was unusually high for Tilefish in the 2016 Update. Comparing the percent buffer between the OFL and ABC from the 2016 Update of Tilefish to that of other recent assessment does show that the buffer is higher for Tilefish than any of the other species, even those with similar and lower P* values (Table 2). However, the 2016 Update isn't unique for Tilefish in the size of the ABC buffer. When compared to SEDAR 25 we see that the ABC buffer is around the same magnitude in each assessment, indicating the larger ABC buffer is not caused by something done differently in the Update than in SEDAR 25 (Tables 3, 4, & 5).

When compared to species with similar P* values and higher buffers between the OFL and ABC (here Black Sea Bass, Snowy Grouper, Vermilion Snapper, and Gag were used) a much higher amount of uncertainty can be seen in the estimated benchmarks for Tilefish than for most of the other species (Table 6). Snowy Grouper does have a larger amount of uncertainty in some of the estimated benchmarks, but lower amounts of uncertainty in others. Tilefish has high uncertainty in the F benchmarks while Snowy Grouper has high uncertainty in the biomass benchmarks. This may partially explain why the buffer for Snowy Groper is smaller than that for Tilefish (Table 6).

According to the SEFSC memo of September 12, 2016 addressing the Council's request for more information regarding the Tilefish Update, natural mortality (M) and steepness (h) can have the largest effect on the outcome of the MCB analysis and P* projections. Uncertainty in steepness was treated the same in all the assessments, but uncertainty in M varied (Table 7). A truncated Normal distribution was used to characterize uncertainty in M for Tilefish, Vermilion Snapper, and Black Sea Bass. The truncated Normal distribution allowed for the use of a wider range of M values to be explored in the MCB analysis (Table 7). Snowy Grouper and Gag used a Uniform distribution to characterize uncertainty in M with a very narrow range of values (Table 7). This may also help explain the differences in buffer size between the different assessments.

Two other crucial pieces of data that have significant effects on model outputs and uncertainty are the number of age samples and the existence of a fishery independent CPUE index. The age samples are especially important since all the assessments being considered are age based assessments. Table 7 shows that as the number of age samples increases, and an independent index of abundance is added, the percent buffer between the OFL and ABC goes down with the exception of Gag. It is unclear why Gag doesn't follow the pattern of the other species, but it may have something to do with the fairly high age samples and the characterization of uncertainty in M. It is possible that given certain criteria there is a threshold number of age samples above which uncertainty drops significantly for an age based assessment. However, the true reason for the discrepancy is unknown.

**Table 2. Year of completion, P* values, and the percent buffer between the OFL and ABC for recently assessed species.**

| Stock | Year | P* | % Buffer |
|---|---|---|---|
| Tilefish | 2016 | 30% | 38.2% |
| Wreckfish | 2015 | 27.5% | 21.7% |
| Black Sea Bass | 2015 | 40% | 21.0% |
| Snowy Grouper | 2013 | 30% | 20.5% |
| FLK/EFL Hogfish | 2017 | 22.5% | 20.1% |
| Vermilion Snapper | 2016 | 40% | 18.8% |
| Gag | 2015 | 30% | 14.8% |
| Spanish Mackerel | 2014 | 40% | 13.8% |
| King Mackerel | 2016 | 32.5% | 11.7% |
| Red Porgy | 2016 | 35% | 11.5% |
| Black Grouper | 2015 | 27.5% | 11.0% |
| Red Grouper | 2014 | 30% | 9.8% |
| Cobia | 2016 | 40% | 7.4% |

**Table 3. SEDAR 25 deterministic projections of OFL (P*=50%), ABC (P*=35%) in lbs ww, and the % Buffer between OFL and ABC.**

| Year | OFL | ABC | % Buffer |
|---|---|---|---|
| 2012 | 1,386 | 789 | 43.1% |
| 2013 | 1,242 | 761 | 38.7% |
| 2014 | 1,124 | 737 | 34.4% |
| 2015 | 1,031 | 715 | 30.6% |
| 2016 | 957 | 696 | 27.3% |
| 2017 | 900 | 681 | 24.3% |
| 2018 | 854 | 667 | 21.9% |
| 2019 | 818 | 656 | 19.8% |
| 2020 | 789 | 646 | 18.1% |

**Table 4. 2016 Update probabilistic projections of OFL (P*=50%), ABC (P*=30%) in lbs ww, and the % Buffer between OFL and ABC.**

| Year | OFL | ABC | % Buffer |
|---|---|---|---|
| 2017 | 422 | 261 | 38.2% |
| 2018 | 450 | 299 | 33.6% |
| 2019 | 477 | 338 | 29.1% |
| 2020 | 494 | 366 | 25.9% |

**Table 5. Percent buffer between the OFL and ABC for Tilefish from SEDAR 25 and the 2016 Update. Proj Year refers to the first three projection years in the projection time series. For SEDAR 25 they are 2012-2014, for the Update they are 2017-2019.**

| Proj Year | SEDAR 25 | Update |
|---|---|---|
| 1 | 43.1% | 38.2% |
| 2 | 38.7% | 33.6% |
| 3 | 34.4% | 29.1% |

**Table 6. Percent Standard Error associated with the estimation of select benchmark values from the Tilefish, Black Sea Bass, Snowy Grouper, Vermilion Snapper, and Gag assessments.**

| Quantity | Tilefish | BSB | Snowy | Vermilion | Gag |
|---|---|---|---|---|---|
| $F_{MSY}$ | 177.3% | 62.5% | 58.3% | 82.5% | 22.2% |
| $F_{30\%}$ | 115.8% | NA | 18.2% | 46.7% | 16.5% |
| $B_{MSY}$ | 25.6% | 12.8% | 74.8% | 17.5% | 7.4% |
| $SSB_{MSY}$ | 40.5% | 12.8% | 117.6% | 21.9% | 9.2% |
| MSST | 232.1% | 15.8% | 117.6% | 23.2% | 8.0% |
| MSY | 16.2% | 5.9% | 30.4% | 14.3% | 14.6% |
| $R_{MSY}$ | 63.5% | 3.3% | 41.3% | 16.9% | 22.8% |
| $F_{current}$ /$F_{MSY}$ | 86.0% | 36.4% | 50.0% | 85.1% | 41.6% |
| $SSB_{Terminal}$ /MSST | 82.7% | 30.7% | 120.0% | 32.5% | 10.9% |
| $SSB_{Terminal}$ /$SSB_{MSY}$ | 91.0% | 22.3% | 118.4% | 30.6% | 10.6% |

**Table 7. Characterization of uncertainty in M, presence of a fishery independent CPUE index, and the number of age samples from assessments of select species. P* is the P* value assigned by the SSC, % Buffer is the percent buffer between the OFL and ABC, M Dist is the distribution used to characterize uncertainty in M in the MCB analysis, Min Value is the minimum value of M used in the distribution, Max Value is the maximum value of M used in the distribution, Range is the range of M values used, Ind CPUE indicates whether a fishery independent CPUE index was used in the assessment, and Age Samples is the total number of age samples across all years and fleets used in the assessment.**

| Species | P* | % Buffer | M Dist | Min Value | Max Value | Range | Ind CPUE | Age Samples |
|---|---|---|---|---|---|---|---|---|
| Tilefish | 30.0% | 38.2% | Trunc N | 0.03 | 0.21 | 0.18 | No | 1,250 |
| Black Sea Bass | 40.0% | 21.0% | Trunc N | 0.27 | 0.53 | 0.26 | Yes | 6,446 |
| Snowy Grouper | 30.0% | 20.5% | Uniform | 0.08 | 0.16 | 0.08 | Yes | 8,111 |
| Vermilion Snapper | 40.0% | 18.8% | Trunc N | 0.16 | 0.28 | 0.12 | Yes | 31,372 |
| Gag | 30.0% | 14.8% | Uniform | 0.1 | 0.18 | 0.08 | No | 14,378 |

## Summary

There appear to be several factors contributing to the change in estimated productivity from SEDAR 25 to the 2016 Update. The first is the removal of the large recruitment spike estimated in 2001 during SEDAR 25. Without that one extreme value, the estimate of $R_0$ and productivity changed. The estimates of recruitment changed in the Update also. Review of the sensitivity runs suggest the changes are partially due to the use of the robust multinomial distribution for estimating age compositions and partially due to the new years of age composition data, which did not support a large recruitment event in 2001.

The new years of data also resulted in a re-estimation of the selectivity functions for each of the fleets. Both the commercial longline and commercial handline fleets were estimated to select for older fish than what was used in SEDAR 25. These new selectivity patterns were used for the entire assessment time period and resulted in significantly higher estimates of fishing mortality for most of the time series. Higher F rates on older fish resulted in a lower estimate of SSB. Rather than the stock being well above $SSB_{MSY}$ as it was in SEDAR 25, the Update estimated the stock to be just below $SSB_{MSY}$. This difference has a large influence on the results of catch projections.

The concern over the size of the buffer between the OFL and ABC estimated from the 2016 Update was also explored. A comparison with other species was conducted looking at how uncertainty in M was characterized, whether a fishery independent index of abundance was used, and how many age samples were used in the assessments. A pattern emerged of decreasing percent buffer in the ABC with increasing age samples and the use of a fishery independent CPUE index. Gag was an outlier to the pattern, but still had a much larger number of age samples than Tilefish. Therefore, Tilefish had the highest amount of uncertainty in parameter estimates and the lowest number of age samples of all the species looked at, which could help explain why it also had the largest ABC buffer.