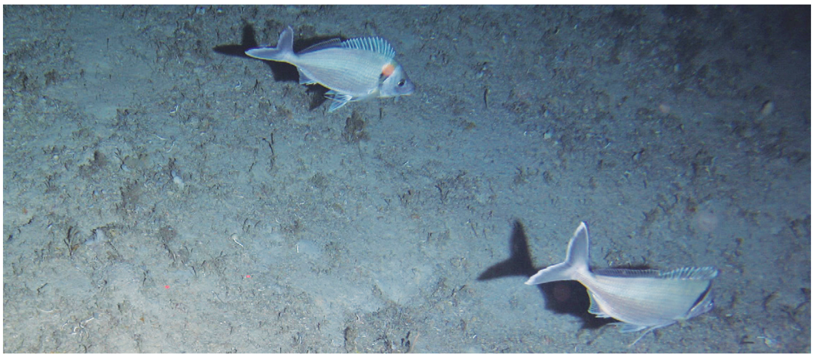
Cite as:
Thomson, R., Day, J. and Tuck, G. (2015) Silver Warehou (*Seriolella punctata*) stock assessment based on data to 2014 – development of a preliminary base case. pp 51 - 73 *in* Tuck, G.N. (ed.) 2016. *Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2015*. Part 1. Australian Fisheries Management Authority and CSIRO Oceans and Atmosphere, Hobart. 245p.

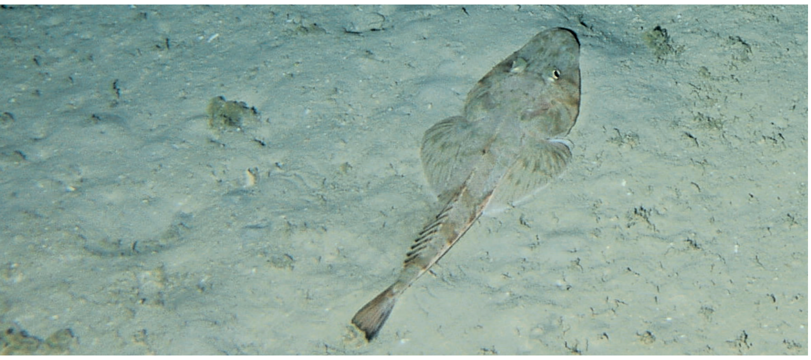
Australian Government
Australian Fisheries Management Authority

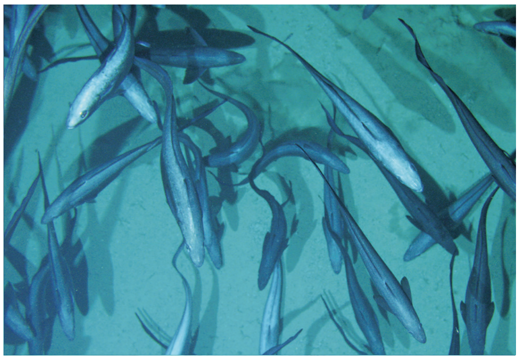
2014/0818 June 2016

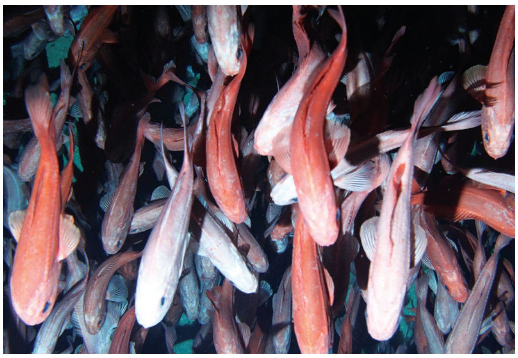
Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2015

PART 1









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Tuck, Geoffrey N. (Geoffrey Neil).
Stock assessment for the southern and eastern scalefish and shark fishery: 2015.

ISBN 978-1-4863-0695-4

Preferred way to cite this report

Tuck, G.N. (ed.) 2016. Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2015. Part 1. Australian Fisheries Management Authority and CSIRO Oceans and Atmosphere, Hobart. 245p.

Acknowledgements

All authors wish to thank the science, management and industry members of the slope-deepwater, shelf, GAB and shark resource assessment groups for their contributions to the work presented in this report. Authors also acknowledge support from Fish Ageing Services (for fish ageing data) and AFMA (for the on-board and port length-frequencies, and in particular John Garvey, for the log book data). Toni Cracknell is greatly thanked for her assistance with the production of this report, and Tim Ryan and Bruce Barker are thanked for the cover photographs of SESSF fish.

Cover photographs

Front cover, jackass morwong, orange roughy, blue grenadier, and flathead.

Report structure

Part 1 of this report describes the Tier 1 assessments of 2015. Part 2 describes the Tier 3 and Tier 4 assessments, catch rate standardisations and other work contributing to the assessment and management of SESSF stocks in 2015.

Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2015

Part 1: Tier 1 assessments

G.N. Tuck
June 2016
Report 2014/0818

Australian Fisheries Management Authority

Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2015 Part 1

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6. Silver Warehou (*Seriolella punctata*) stock assessment based on data up to 2014 – development of a preliminary base case

Robin Thomson, Jemery Day, and Geoff Tuck

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6.1 Summary

This chapter presents a suggested base case for an updated silver warehou assessment. The assessment has been updated by the inclusion of data up to the end of 2014, which entails an additional three years of catch, discard, CPUE, length and age data since the 2012 assessment. Length frequency data collected onboard commercial trawl vessels has been separated from those collected in port, but a joint selectivity pattern is estimated. Data collected east and west of 147º longitude have been separated in east and west fleets, each with its own selectivity pattern. Abundance time series for the east and west from the trawl Fishery Independent Survey (FIS, Knuckey et al 2015) have been added.

The model has been restructured to allow estimation of size-base discarding, and recognises a change in the pattern of discarding from 2002. This, along with the addition of three more years of data, allows the estimation of five additional years of recruitment. These are estimated to have been poor to average in size. The model estimate of depletion for 2015 is 35% and for the start of 2016 is 40% (projected assuming 2014 catches in 2015). The selectivity patterns indicate that much smaller fish are caught in the east compared with the west, which strongly supports the separation of the data in to east and west fleets.

6.2 Background

The first integrated analysis stock assessment for silver warehou (formerly spotted warehou) in Australia was developed by the Blue Warehou Assessment Group (BWAG) between 2000 and 2002 (e.g. Thomson 2002). The assessment was updated by Taylor & Smith (2004). Tuck & Punt (2007) and Tuck (2008) improved the estimation of natural mortality (increasing it from $0.25y^{-1}$ to $0.3y^{-1}$) and growth, improving fits to the length frequency data (Tuck, 2008). The estimated depletion for 2007/2008 continued at the 2011 level. However, the authors warned that the estimated trend in stock size was not matching that of the observed CPUE index in the most recent years and they cautioned that the stock might "breakout" according to the SESSF Tier 1 projections rules. Their prediction was correct (Figure 6.1, Klaer *et al.* 2014) – the 2012 and 2013 CPUE observations fell well below the forecast 95% prediction interval for silver warehou.

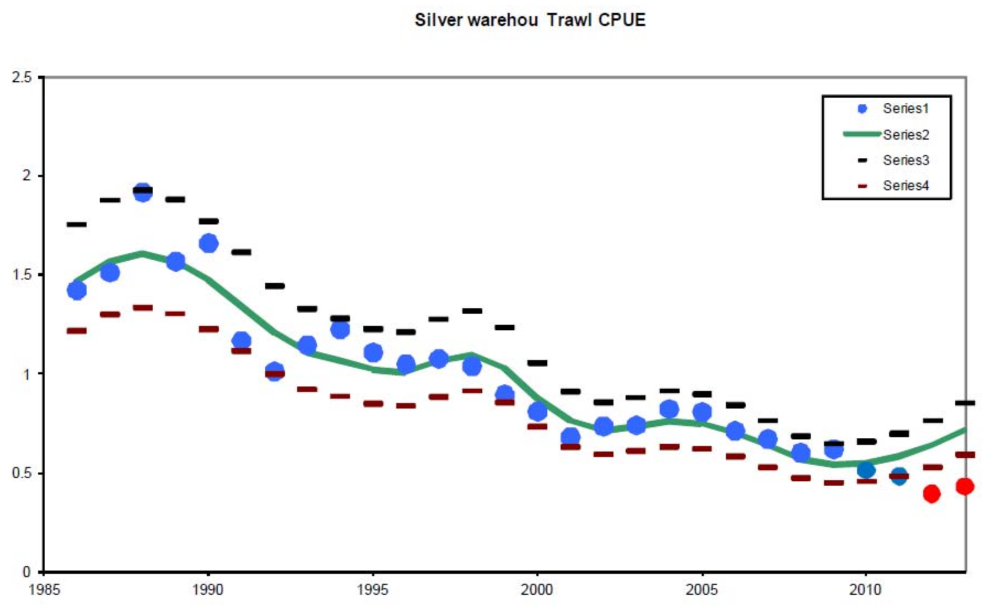

Figure 6.1. "Breakout" for silver warehou (taken from Klaer *et al.* 2014) showing estimated stock abundance (green line with prediction interval) and observed standardised CPUE (blue and red spots.

6.3 Changes to the 2012 Assessment

The assessment model framework used here is based on that of the previous assessment, performed in 2012. The following changes have been made:

1. Catch, discard, length frequency, and age at length data for 2012, 2013 and 2014 have been added.
2. Discarding is being estimated and discard length frequency data have been included in the assessment.
3. Fishery Independent Survey (FIS) abundance series added.
4. Five more years of recruitment are being estimated (note that this is two more than the number of years of data that have been added).
5. Length frequency data have been split into onboard and port collected components (sharing a single selectivity pattern).
6. The single trawl fleet has been split into east and west (of 147^{o}) fleets, each with its own estimated selectivity pattern and discards (retention function).
7. Data collected from non-trawl vessels have been excluded from the dataset (this makes a negligible difference).
8. A new tuning procedure has been used to balance the weighting of each of the data sources that contribute to the overall likelihood function (this is a forerunner of an even newer protocol for tuning expected to be agreed on during a workshop in the USA next month - October 2015).

6.3.1 *Discarding*

Examination of LFs for the retained and discarded components of the catch, derived from the onboard Observer Program revealed a change in the discarding pattern. During 2000-2002 the Blue (and later the Spotted) Warehou Assessment Group concluded that both size and market related discarding occurred for silver warehou (Thomson 2002) resulting in a decision to combine the discarded with the landed tonnage and not estimate a length-related discard (retention) pattern. This assumption was largely correct, but did ignore the size-relating discarding of small fish that was occurring along with market related discarding of fish of all sizes, as evidenced by the greater proportion of small fish in the discarded LFs relative to the retained LFs prior to 2002 (Figure 6.2).

A shift seems to occur from 2002 with small fish dominating the discard LFs and very few larger fish discarded (Figure 6.2). Day et al (2012) noted that "*the length residuals behave differently before and after 2002, with patterns in these residuals indicating some possible issues with the fits to the length data.*"

Time blocked discarding was introduced to the model, with separate retention (discard) functions estimated for the 1980-2001 and 2002-2014 periods. The model that uses separate east and west fleets allows independent discarding patterns in each area. The retention function used has three parameters: slope, intercept, and asymptote. The slope and intercept were estimated for both time periods but the asymptote parameter had to be treated with greater care. For models that do not use time blocking this parameter is confounded with stock size and therefore has to be fixed at 100% (i.e. 100% retention of the very largest fish). Theoretically, it is possible to estimate the asymptote for the earlier time period, when market related discarding might have reduced retention for even the largest fish below 100%. However, a likelihood profile revealed that the data supported a value of 100% for the asymptote for the model that combines east and west data into a single fleet.

The model that uses separate east and west fleets estimated an asymptote of 99% in the east (this was subsequently fixed at 100%) and 95% in the west.

The observed annual discard rates were assigned low CVs (0.1 for 10980-2001 and 0.05 for 2002-2014) to circumvent the model's tendency to estimate discard rates of approximately 40% in the early period and almost 0 in the later period.

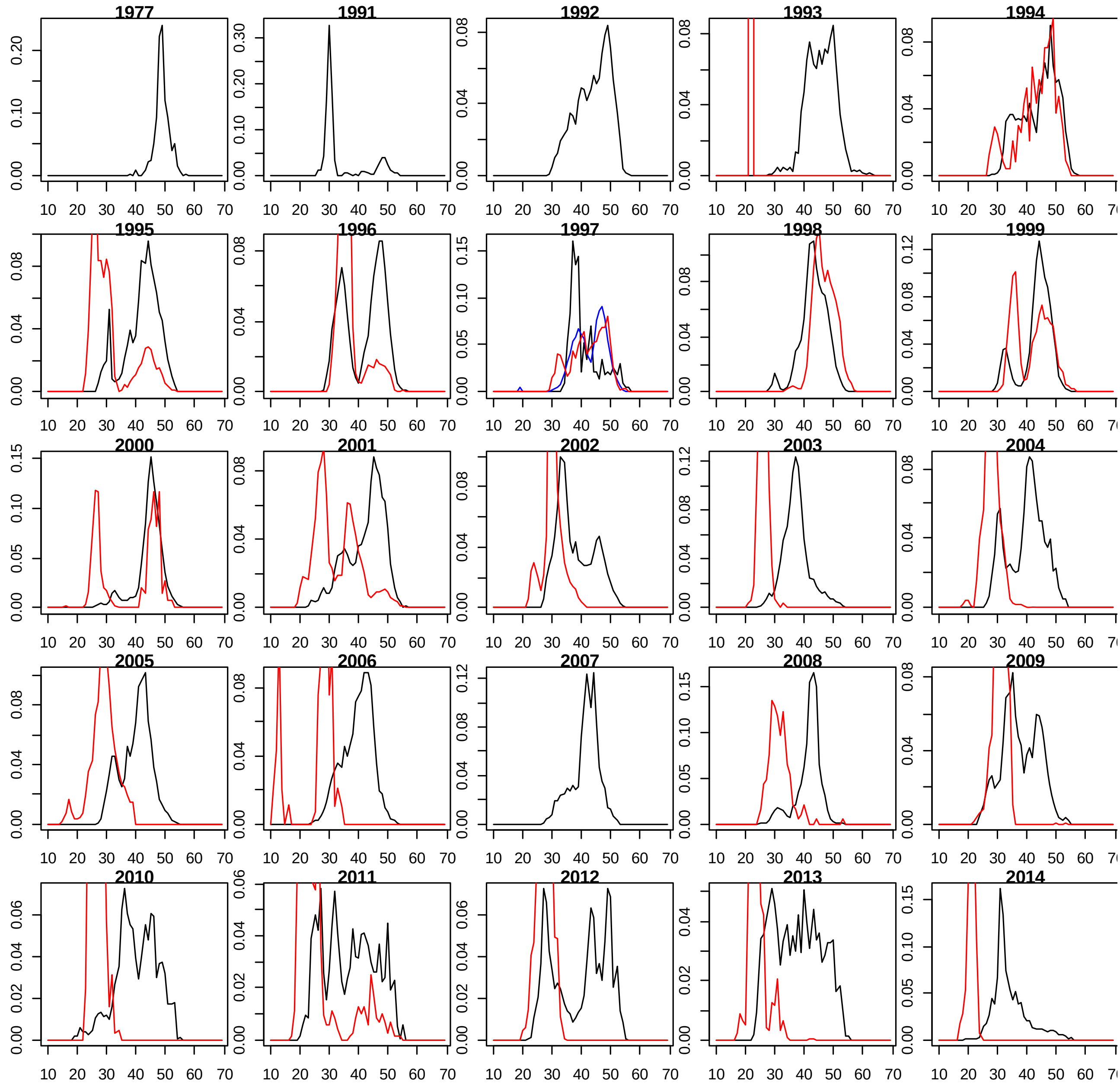

Figure 6.2. Retained (black) and discarded (red) components of the commercial trawl catch of silver warehou. The blue line is a single Kapala LF. Lengths were measured onboard fishing vessels by the AFMA Observer Program and its predecessor the ISMP.

6.3.2 *East and West Fleets*

Noting that silver warehou standardized CPUE was below the 95% prediction interval from the stock assessment model, and this appeared to be a consistent pattern, SlopeRAG suggested that this could be due to separate abundance trends in the east and the west and requested that alternative models that combined, and separated, east and west data be presented to SlopeRAG in September 2015. East and west length and age compositions do appear to differ, and the standardized CPUE trends are also somewhat different (Sporcic *et al.* 2015).

6.3.3 *Tuning Procedure*

Day et al (2012) had difficulties tuning the model, which they were able to solve by down weighting the age data (by multiplying the likelihood component for age by 0.25). This multiplier was removed and the new tuning method converged successfully. The tuning procedure used (Andre Punt pers comm.) was to:

1. Set the CV for the commercial CPUE value 0.1 for all years (set those for the FIS to the estimated CVs shown in Table 6.1)
2. Simultaneously tune the sample size multipliers for the LFs and ages using Francis weights for the LFs and Francis B (the larger of the Francis A and B factors, Francis 2011) - iterate to convergence;
3. Adjust the recruitment variance (σ_R) by replacing it with the RMSE and iterating to convergence (keep altering the recruitment bias adjustment ramps at the same time);
4. Weight the commercial CPUE and FIS abundance indices by replacing these with the relevant variance adjustment factors- iterate to convergence;
5. Reweight the age data using the Francis A adjustment factor, just once (no iterating);
6. Repeat steps 3 and 4.

6.3.4 *Bridging from 2012 to 2015 Assessments*

The previous full quantitative assessment for silver warehou was performed in 2012 (Day *et al.* 2012) using the software Stock Synthesis (SS), version SS-V3.24f (Methot, August 2012). The 2015 assessment uses “SS-V3.24U-fast”. There are only minor changes between these two versions of Stock Synthesis.

The proposed base case model for 2015 was generated from the 2012 assessment by making a series of small (where possible) incremental changes and estimating the parameters of the model after each change. In this way the 2015 assessment was developed in a series of steps. Those steps are listed below (model nicknames are given in italics and the computer files have been placed on a shared CSIRO folder).

1. Run the original assessment using the newest version of *SS [spot12]*.
2. Change the final year for the assessment from 2011 to 2014, revise *catch* data for 2011 and add catch data for 2012, 2013 and 2014 (in keeping with the 2012 assessment, total catches were used, representing landed catches plus estimated discards) [*B1*].
3. Replace *CPUE* series (ending 2011) with updated series ending 2014 (from Sporcic 2015).[*B2*]
4. Replace age-at-*length* data for 1980-2011 (no longer including non-trawl caught fish). [*B3*]
5. Add age-at-*length* data for 2012-2014.[*B4*]
6. Replace *ageing error* matrix with updated matrix (provided by Andre Punt pers comm).[*B5*]
7. Replace length frequencies (LFs, combined onboard and port samples) with *onboard LFs* for 1980-2014 and replace sample size (number of fish) with number of *operations* (shots).[*B6*]
8. Add *port* LFs weighted by number of *operations* (trips).[*B7*]

9. Estimate five more years of *recruitment* and update bias adjustment for recruitment deviations.[*B8*]
10. Separate total catch into landings and discards, add discard LFs and estimate *discarding (no time block)* [*B9*]
11. *Time block* the retention function (discarding) 1980-2001 and 2002-2014 [*B10*]
12. Add *FIS* abundance series for east and west combined and redo bias adjustment (mirror selectivity for east and west FIS fleets to east and west commercial trawl fleets) [*B11 & B12*]
13. Split catch, LF and FIS data between east and west (in the absence of better information, the overall discard rates are assigned to both east and west). [*N1*]
14. Tune the relative weights on the data sources. [*N6*]

The 2015 assessment update assumes that silver warehou constitute a single population (ie a single recruitment pattern) but that fishing fleets in the east and west fish different components of the stock. In keeping with the earlier assessments, only the otter trawl fishery is modelled. The discard proportions used were those calculated by Judy Upston (CSIRO e.g. Upston & Klaer 2014) and were assumed to apply to non-factory trawlers only (factory trawlers are assumed not to discard silver warehou). Natural mortality was fixed at $0.3y^{-1}$. All of these model assumptions were agreed at previous RAG meetings (Day et al 2012).

Relative abundance of silver warehou was calculated from FIS collected data, separately, for the east and west regions. The resulting median values, with their associated CVs, were included in the model (Table 6.1). The inter-annual variability in the estimates, particularly in the east, is much greater than that suggested by the CVs on the individual points in the time series. This is likely to be due to the schooling nature of the fish, resulting in occasional very large shots and consequent high abundance estimates.

Table 6.1. Relative abundance estimates for silver warehou in the east and west, with associated CVs. Calculated using trawl Fishery Independent Survey data (Knuckey et al 2015).

	East		West	
Year	Median	CV	Median	CV
2008	149.0	0.21	110.7	0.18
2010	55.6	0.18	25.9	0.18
2012	218.7	0.28	25.6	0.18
2014	14.7	0.21	32.2	0.15

6.4 Results

Most of the steps in the bridging analysis had very little effect, or made changes that were lost at the very next step. A plot showing all of the steps is very hard to read, consequently Figure 6.3 shows only steps of interest.

Inclusion of all the new data (for 2012, 2013, and 2014) including splitting the LFs into port and onboard components has little effect on the estimated depletion in recent years (B7 vs Spot 12, Figure 6.3), however it substantially alters the size of several recruitments, particularly the very large ones, thus altering the size of the peaks and troughs in the spawning biomass series (B7 vs Spot 12, Figure 6.4). Allowing the model to estimate the retention (discarding) pattern from the discard LFs and estimating five new recruitments results in a declining biomass trend in recent years (B10, Figure 6.3).

Splitting the data into east and west fleets alters the estimated recruitment pattern throughout the time period, increasing or decreasing several estimates thus raising or lowering spawning biomass (N4, Figure 6.3) relative to the original model. However, tuning the model also has a substantial effect, indicating that there are conflicting signals from data sources (N6, Figure 6.3). In particular, the effect of tuning is to increase the size of the estimated recruitments in 2010, 2011 and 2012 (N6, Figure 6.4). The size of many of the recruitments in the series, particularly the older ones, is poorly estimated (Figure 6.4), more so than the recent depletion estimate (Figure 6.3).

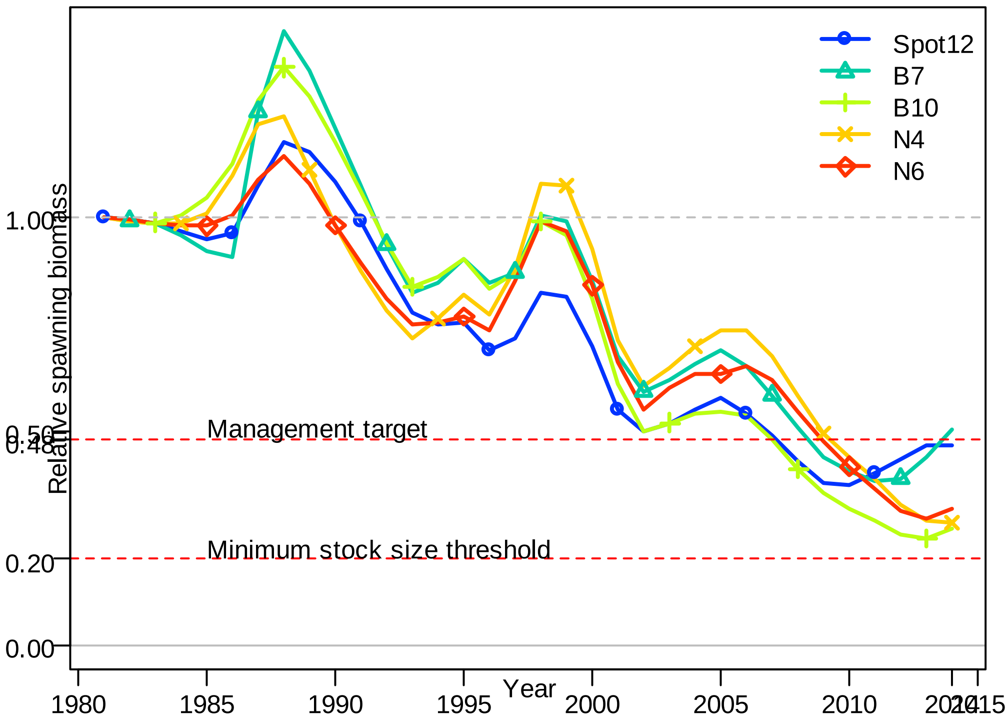

Figure 6.3. Depletion (spawning biomass relative to unfished biomass) for the 2012 base case assessment (Spot12), 2012 base case with updated data including onboard and port LFs (B7), the addition of size related discarding with time blocking (B10); the separation of east and west fleets (N4) and tuning of the final model (N6).

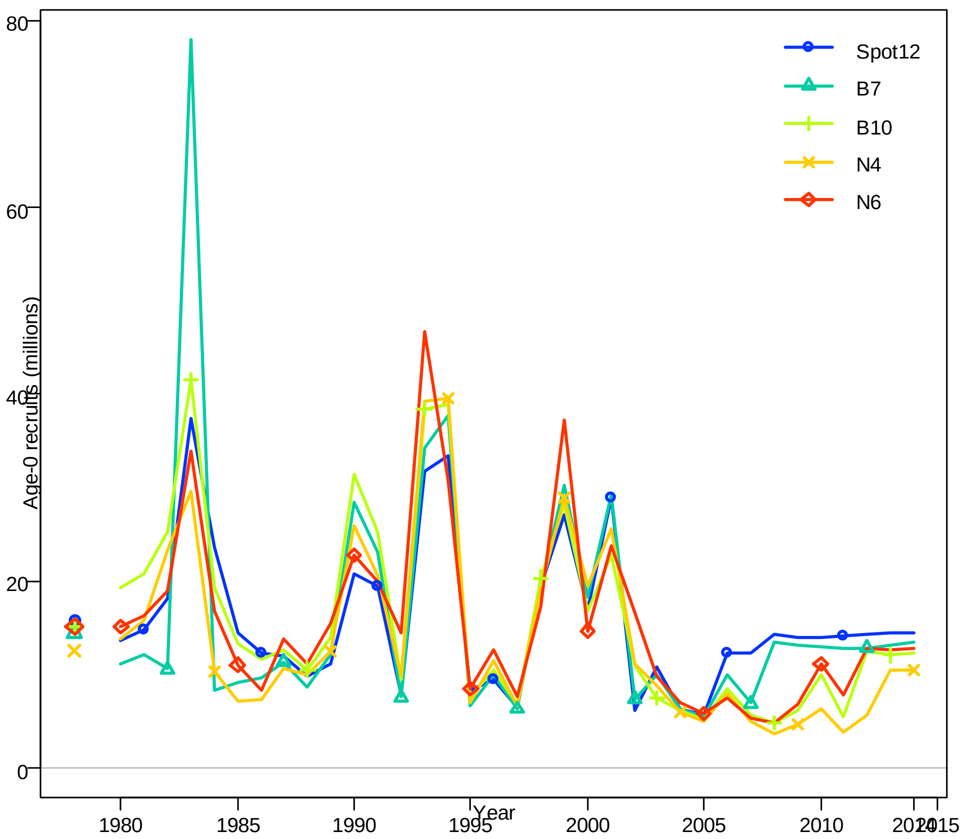

Figure 6.4. Estimated number of recruits for the 2012 base case assessment (Spot12), 2012 base case with updated data including onboard and port LFs (B7), the addition of size related discarding with time blocking (B10); the separation of east and west fleets (N4) and tuning of the final model (N6).

6.4.1 *Sensitivity to Data Weighting*

To better understand the effect of tuning the model, and the conflict between data sources that this implies, each of the LF, age, and commercial CPUE data series was upweighted, one at a time, and the model parameters re-estimated (Figure 6.5. The weight on the FIS abundance index was not altered, as that data series was assigned very low weight by the tuning process and was consequently not influential. Upweighting the LF data leads to a similar relative spawning biomass trajectory to upweighting the CPUE, however a very different trend results from upweighting the age data (Figure 6.5). It is not unusual for LF data to be in conflict with CPUE data, however LF and age date are often in agreement because otoliths are typically drawn from the same samples that are measured. A conflict between the length and age data suggests a possible mis-specification of growth. Thomson (2002) found some evidence for cohort specific (density dependent) growth, and Day et al (2012) recommended and explored the estimation of cohort specific growth. It might be worth investigating that again, particularly now that the estimation of time blocked retention has removed the residual pattern in the post-2002 LF data noted by Day et al (2012).

If the LF data is upweighted, a large recruitment is estimated in 2012 to explain large numbers of small fish seen in the 2013 and 2014 samples (N11, Figure 6.6) but when the age data is upweighted, the 2011 and 2012 recruitments are very small (N9, Figure 6.6). Upweighting the CPUE results in intermediate recruitment levels in those years (N8, Figure 6.6).

The tuning method used here is new, and is still undergoing refinement. Updated methodology is expected to result from a workshop to be held in the USA during October. It is possible, perhaps even probable, that altered tuning methodology would shift the result of this model by changing the relative weights between the conflicting data sources.

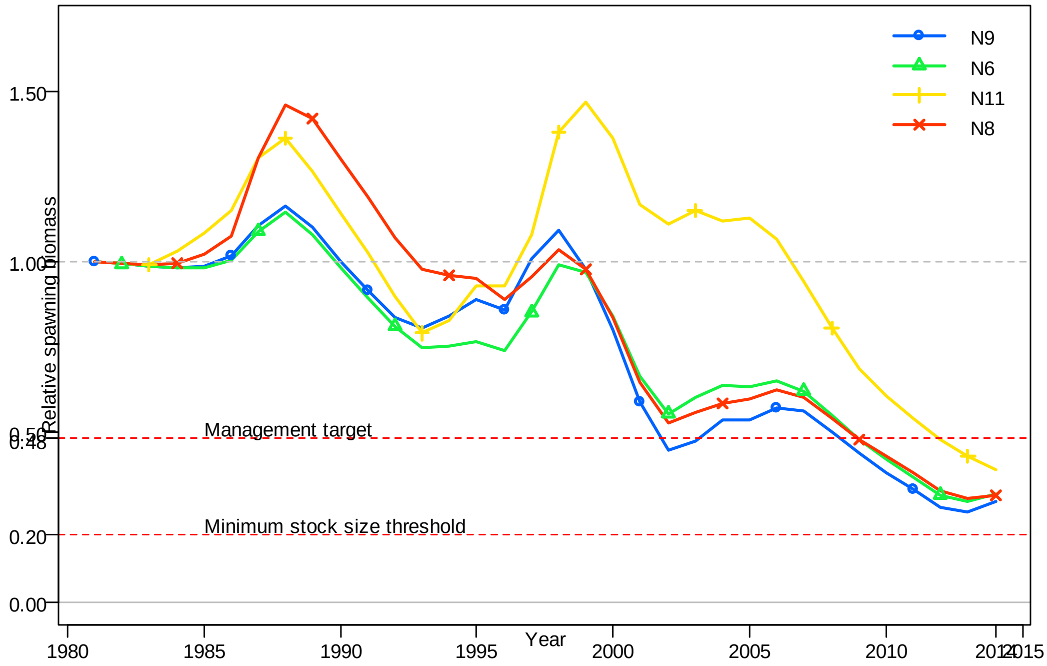

Figure 6.5. Depletion (spawning biomass relative to unfished biomass) for the tuned preliminary base case model (N6), the models that upweight LFs (N9), age data (N11), and commercial CPUE (N8).

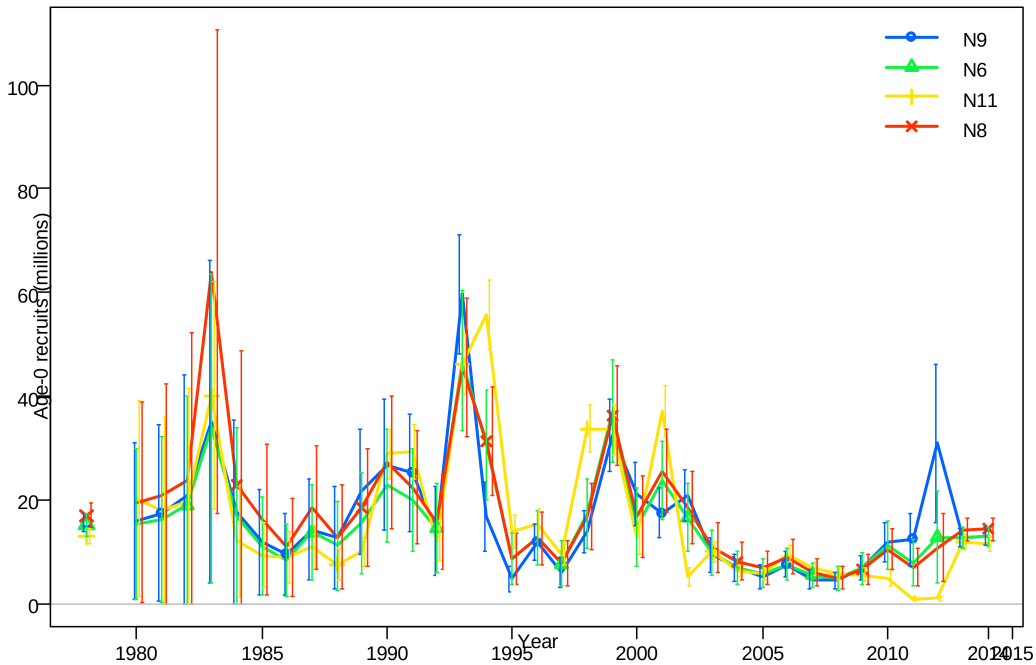

Figure 6.6. Estimated recruitment for the tuned preliminary base case model (N6), the models that upweight LFs (N9), age data (N11), and commercial CPUE (N8).

6.5 Recommendations for the 2015 Base Case

1. Large differences between the selectivity pattern in the east and west (see Appendix), as well as visually better fits (not shown) to all data, support the use of separate east and west fleets.
2. Examination of the LF data support the estimation of size based discarding (retention) after 2002, and a separate pattern prior to 2002. This allows the estimation of two extra recruitments.
3. Model fits to the LF and age data are acceptable, but not impressive and the conflict between the length and age data suggest that the model is not capturing a relatively important dynamic. This could be differing growth rates between cohorts, possibly due to density dependence. It is recommended that cohort specific growth be implemented in this model in order to test the support for this.
4. The trawl gear used by the FIS in the west during 2008 was unable to sink to the desired depth and was subsequently changed (Knuckey et al 2012). It is recommended that the 2008 FIS data in the west be excluded.
5. If newer tuning methodology becomes available prior to the October SlopeRAG meeting, this should be applied to the 2015 silver warehou assessment model.
6. The relative weighting given to the age, length and CPUE data, strongly influences the size of recent recruitments; this has more influence on short term forecasts of spawning biomass than on estimated depletion in 2014. The model estimate of depletion for 2015 is 35% and for the start of 2016 is 40% (projected assuming 2014 catches in 2015). Careful consideration should be given to which forecasts are used to set future RBCs. Moreover, recent recruitments have been poor to, at best, average, suggesting that forecasts that assume average recruitment into the future might be optimistic.
7. The observed discard rates for the east and west combined was assumed to apply to the east and west fleets, separately. It would be preferable to estimate separate discard rates for each fleet (however this is unlikely to strongly influence the results).

6.6 References

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6.7 Appendix A

Input data, model fits, estimated functions, and diagnostics for the preliminary 2015 base case assessment model (N6) that assumes separate trawl fleets in the east and west, allows for time blocked discarding (1980-2001, 2002-2014) and uses data to 2014.

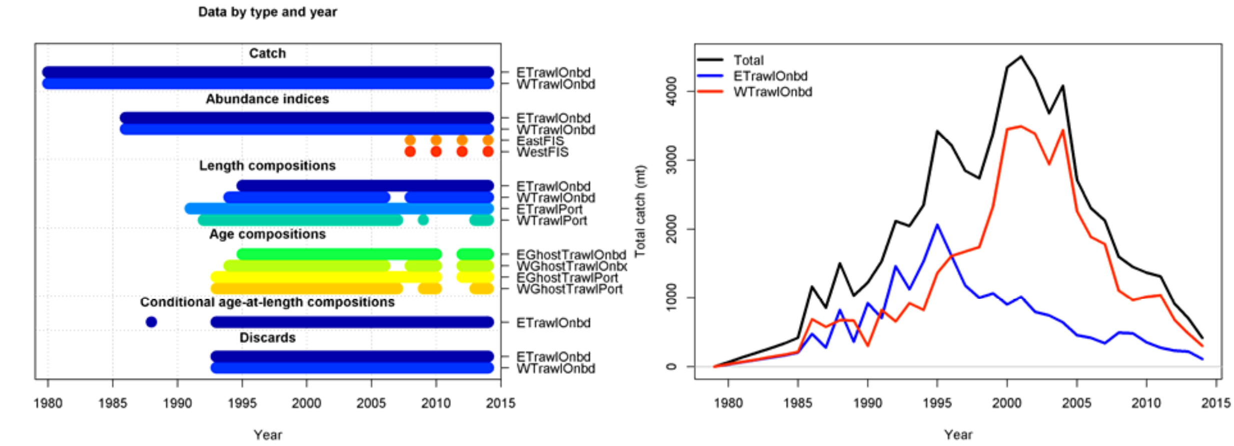


Figure 6A.1. (Left) Data time series used in the preliminary base case assessment; (right) landed catches for east and west fleets and total landings.

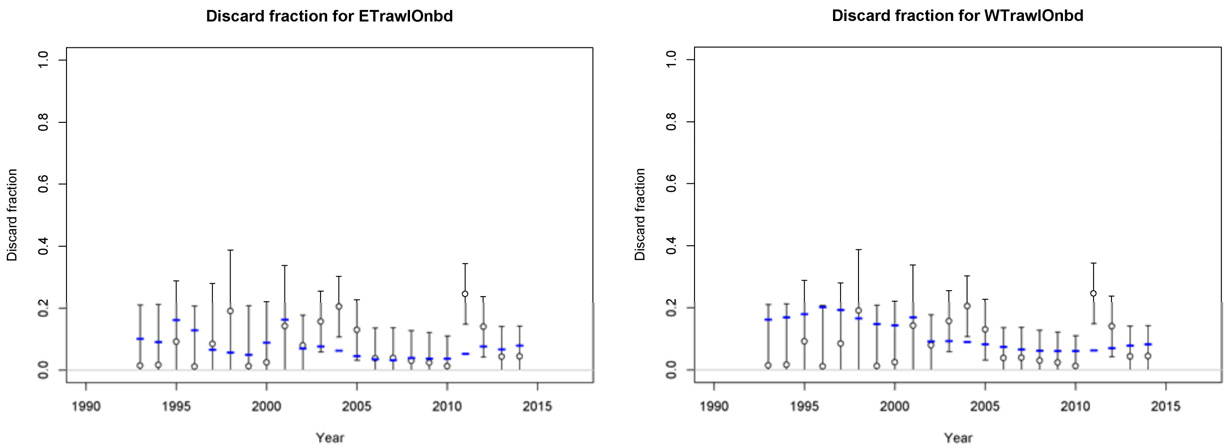


Figure 6A.2. (Left) Observed (black circles with confidence intervals) and model estimated (blue) discard rates for (left) east and (right) west fleets.

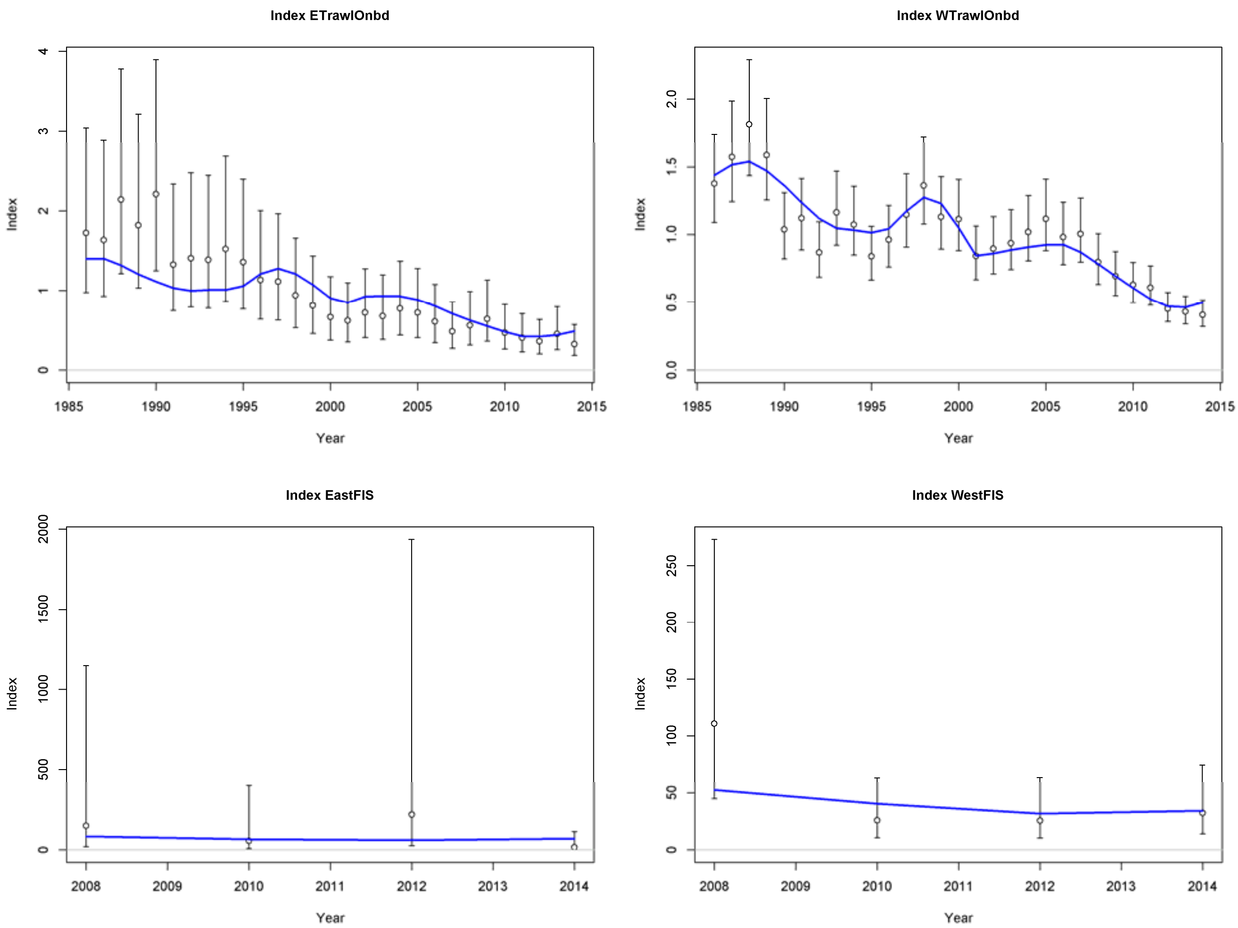


Figure 6A.3. Standardized observed CPUE for the (top left) east and (top right) west commercial trawl fleets; and FIS abundance index for the (bottom left) east and (bottom right) west. Black lines are observed and blue are estimated abundance.

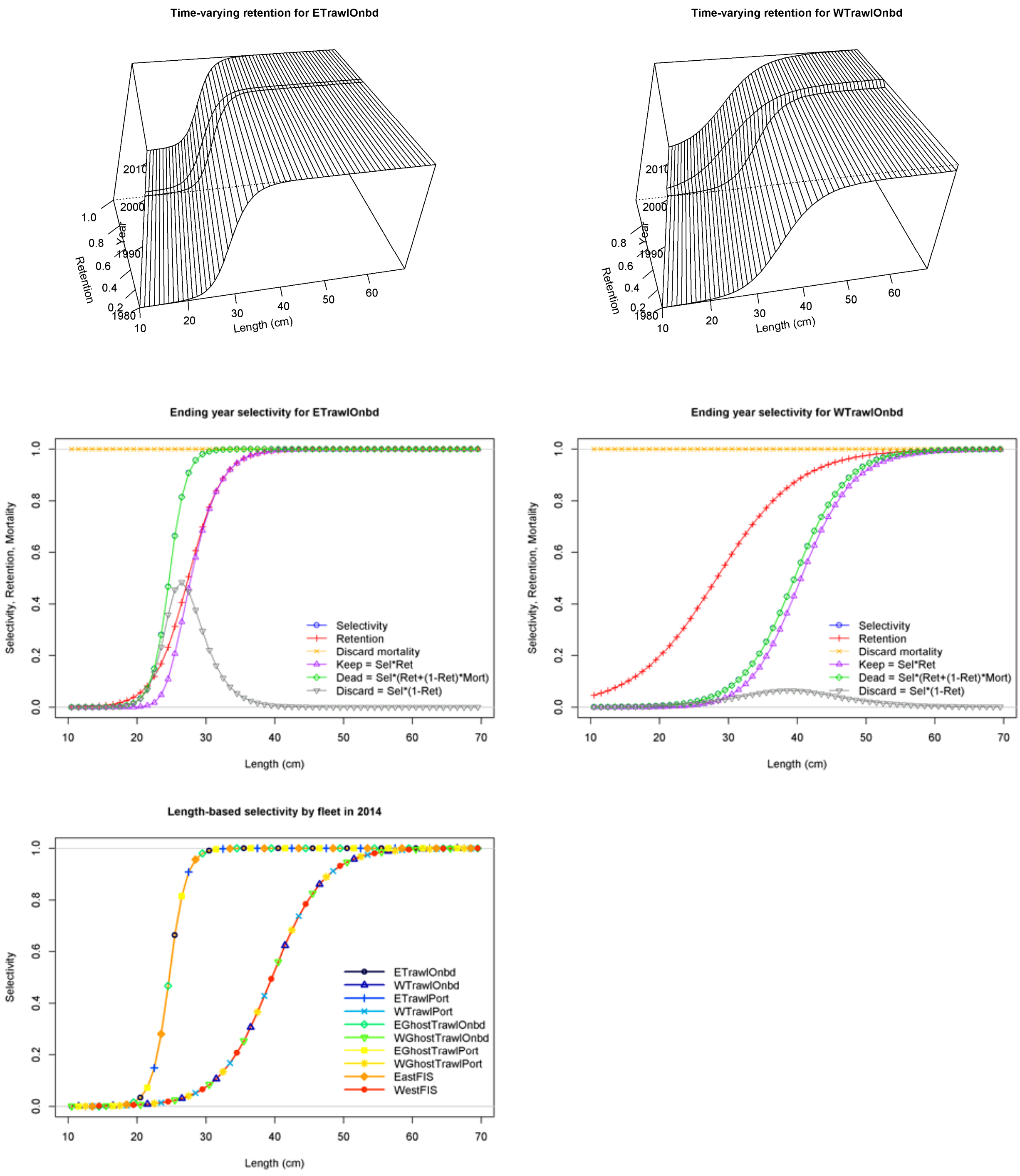


Figure 6A.4. Estimated retention function (discard pattern) for two time blocks (1980-2001, and 2002-2014) for (top left) the east and (top right) the west commercial trawl fleets. Selectivity and discard patterns for (middle left) east and (middle right) west fleets, and east and west selectivity patterns plotted together (bottom).

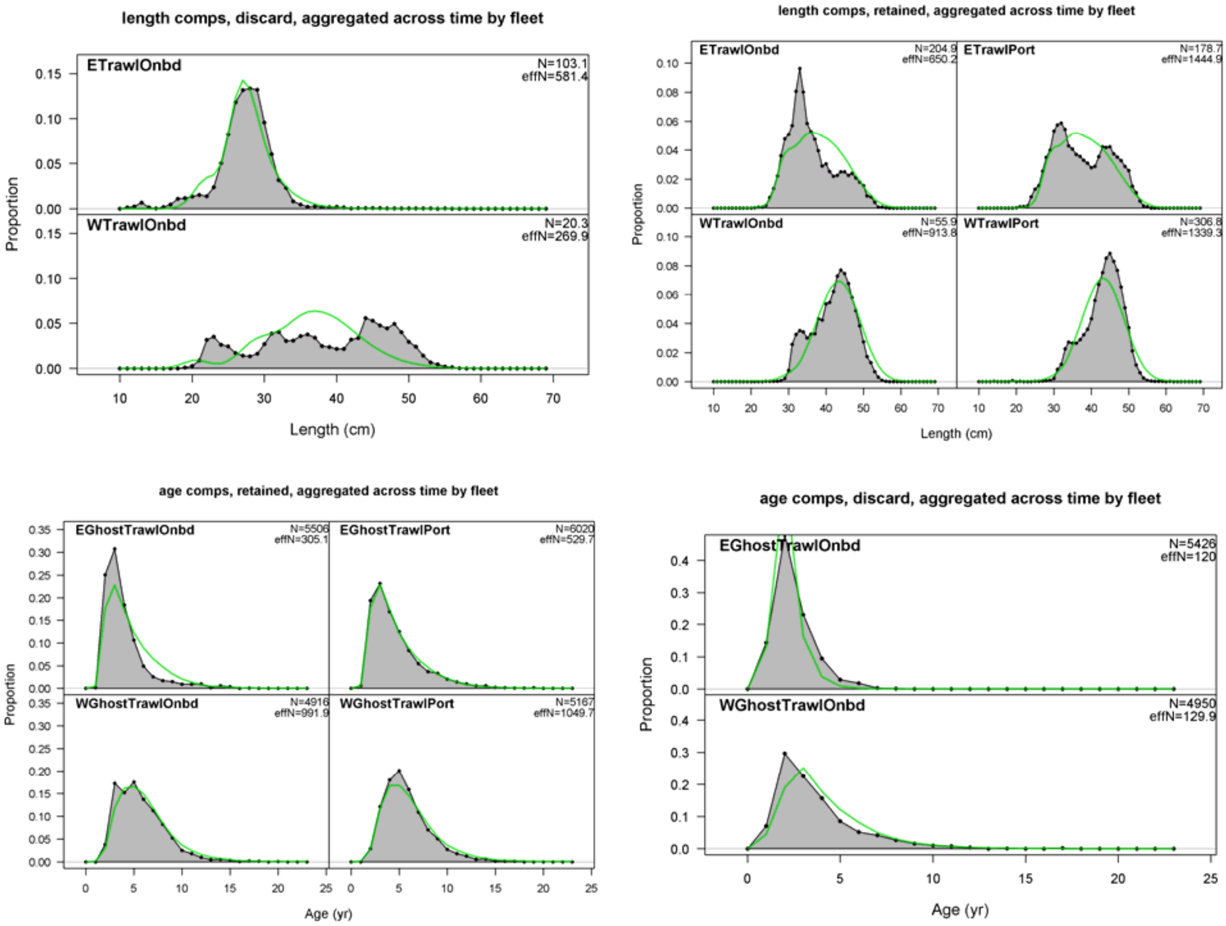


Figure 6A.5. Aggregated length and age compositions for the onboard and port data sources in both the east and west. Observed data are grey and the assessment is a green line. Note that the model is conditioned on the age-at-length data, not on the age compositions themselves.

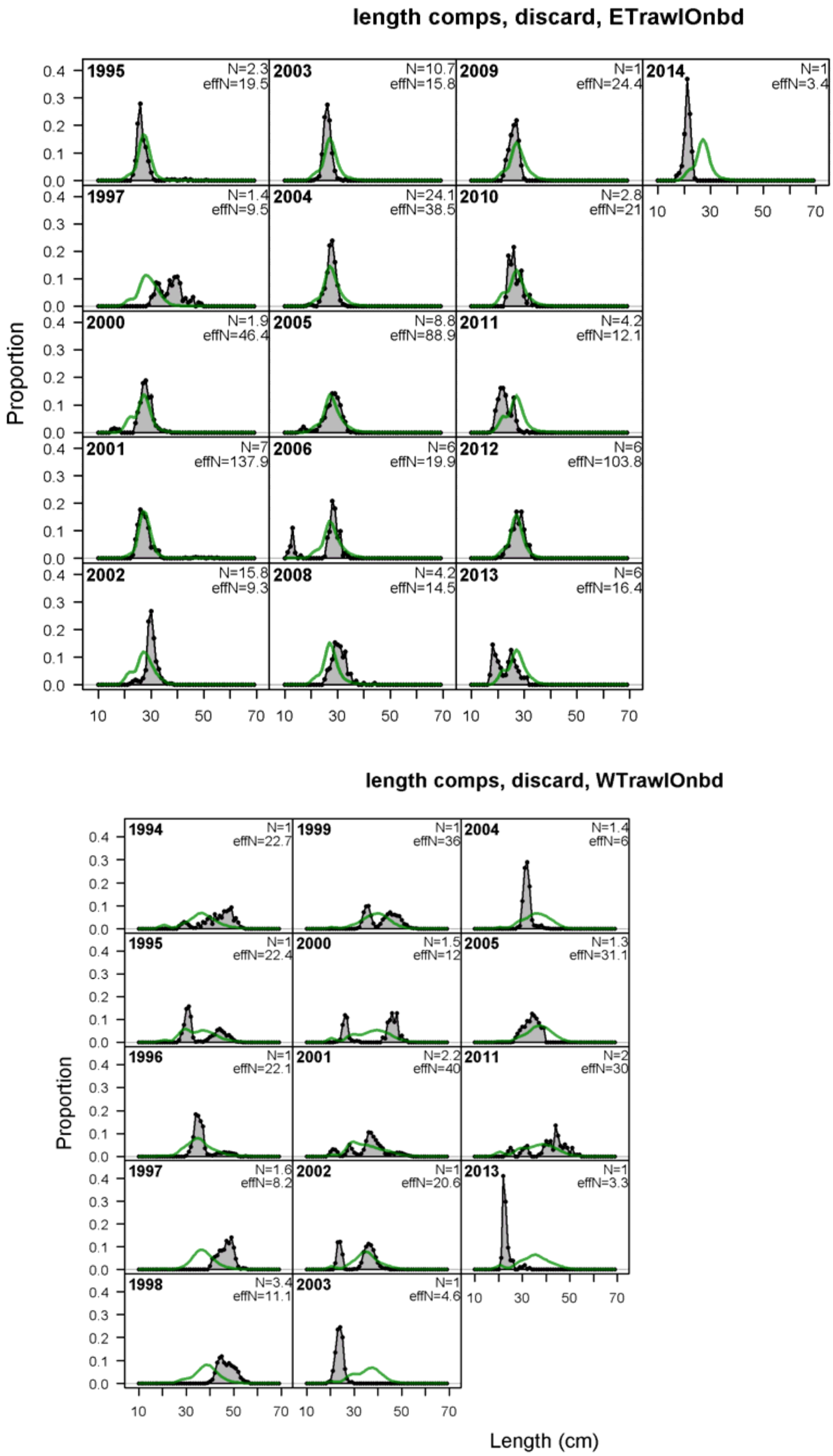
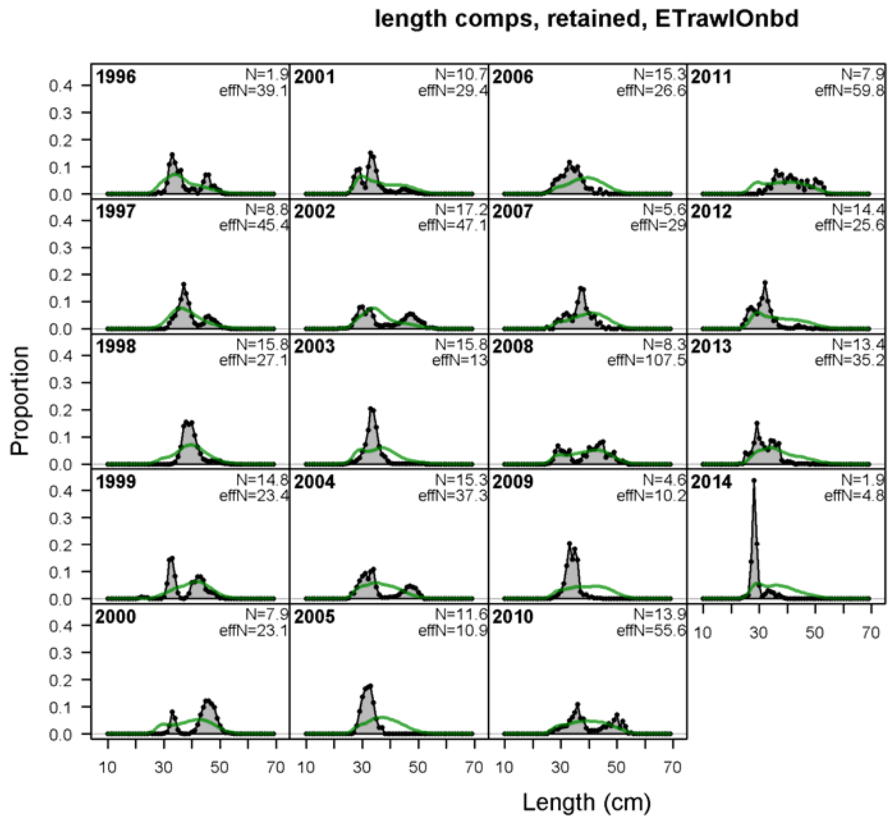


Figure 6A.6. Annual observed (grey) and estimated (green) LFs for the discarded component of the catch of the (top) east and (bottom) west fleets.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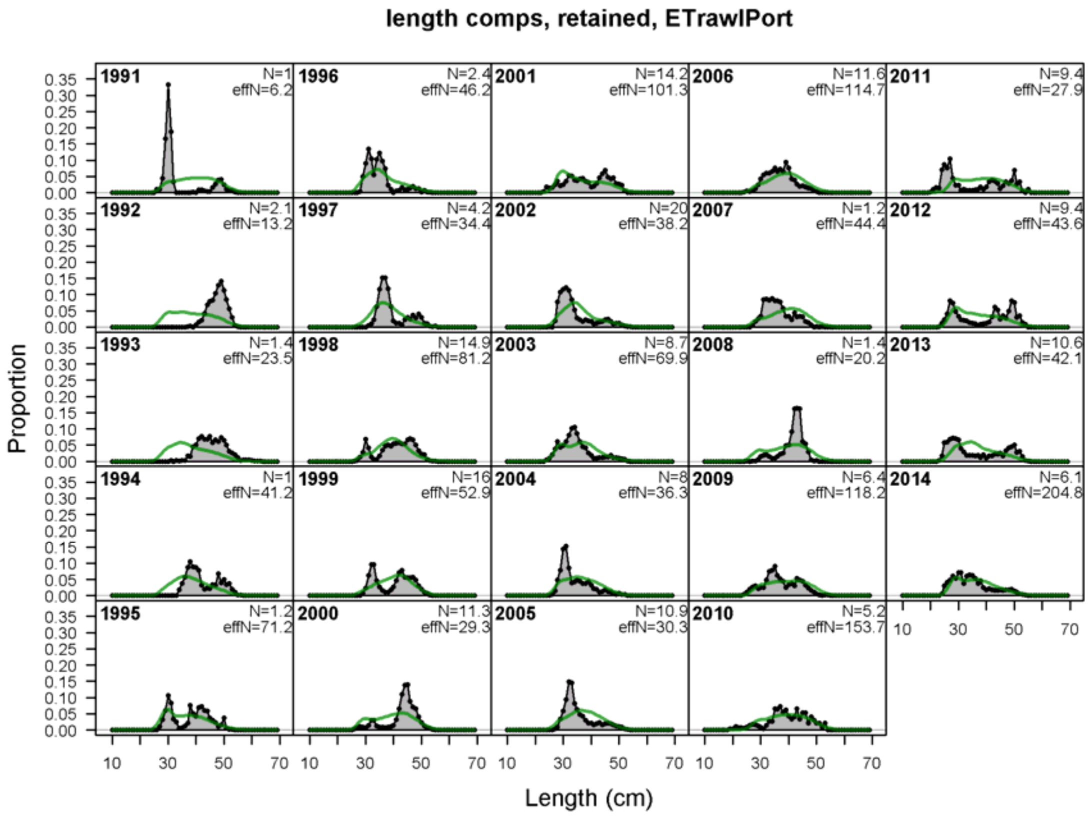
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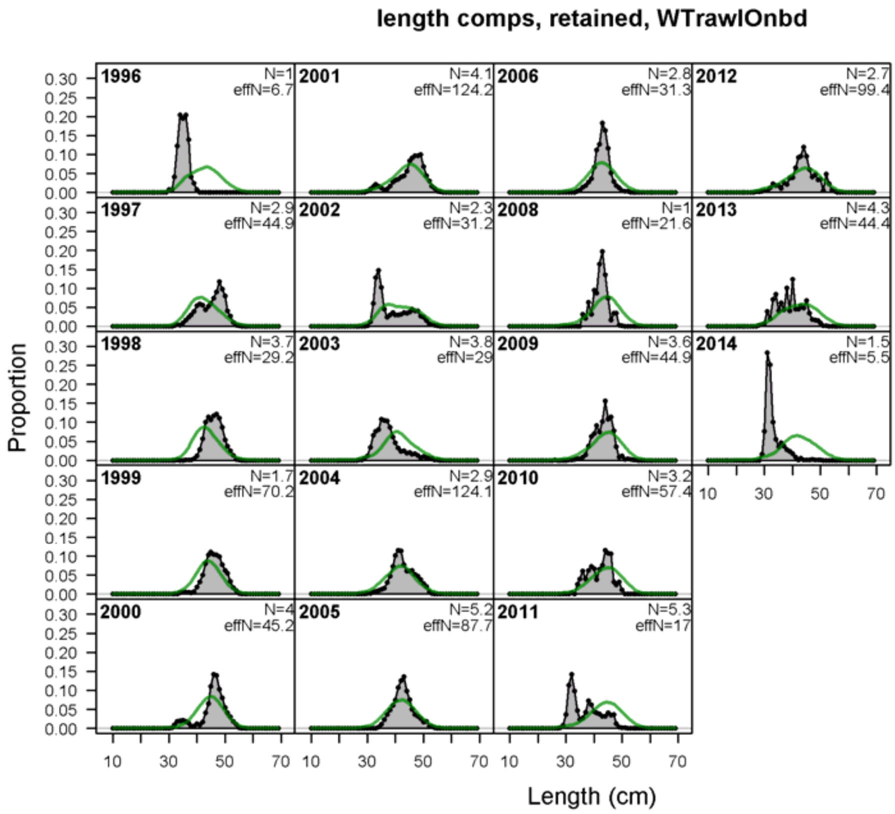


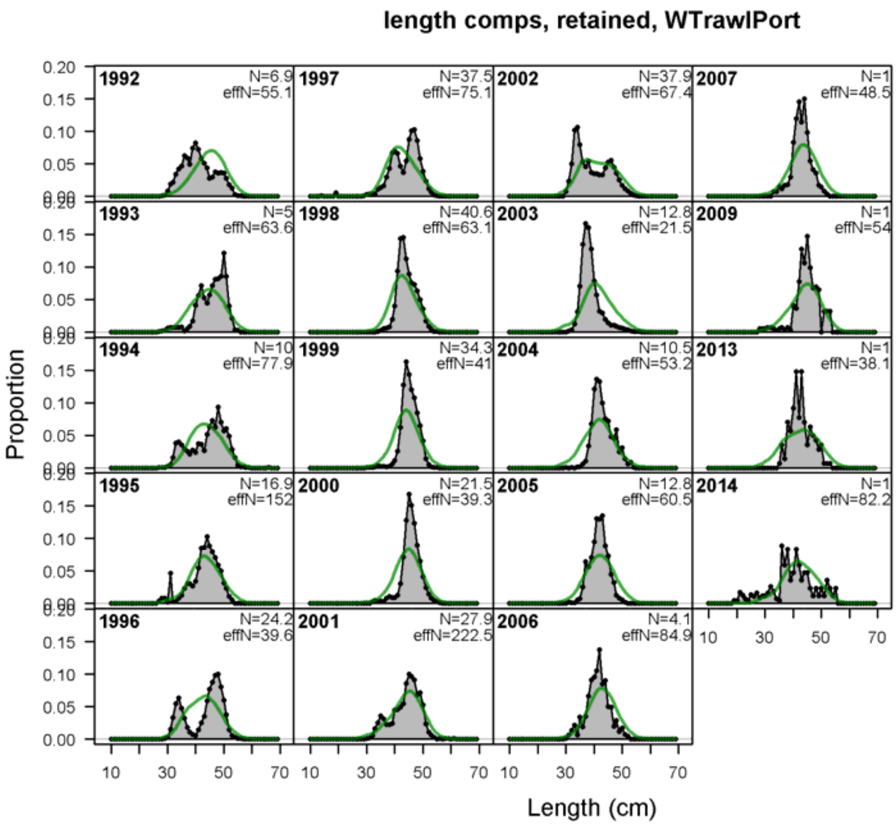


Figure 6A.7. Annual observed (grey) and estimated (green) LFs for the retained component of the catch of the (top) east and (bottom) west fleets for both the onboard and port measurements.

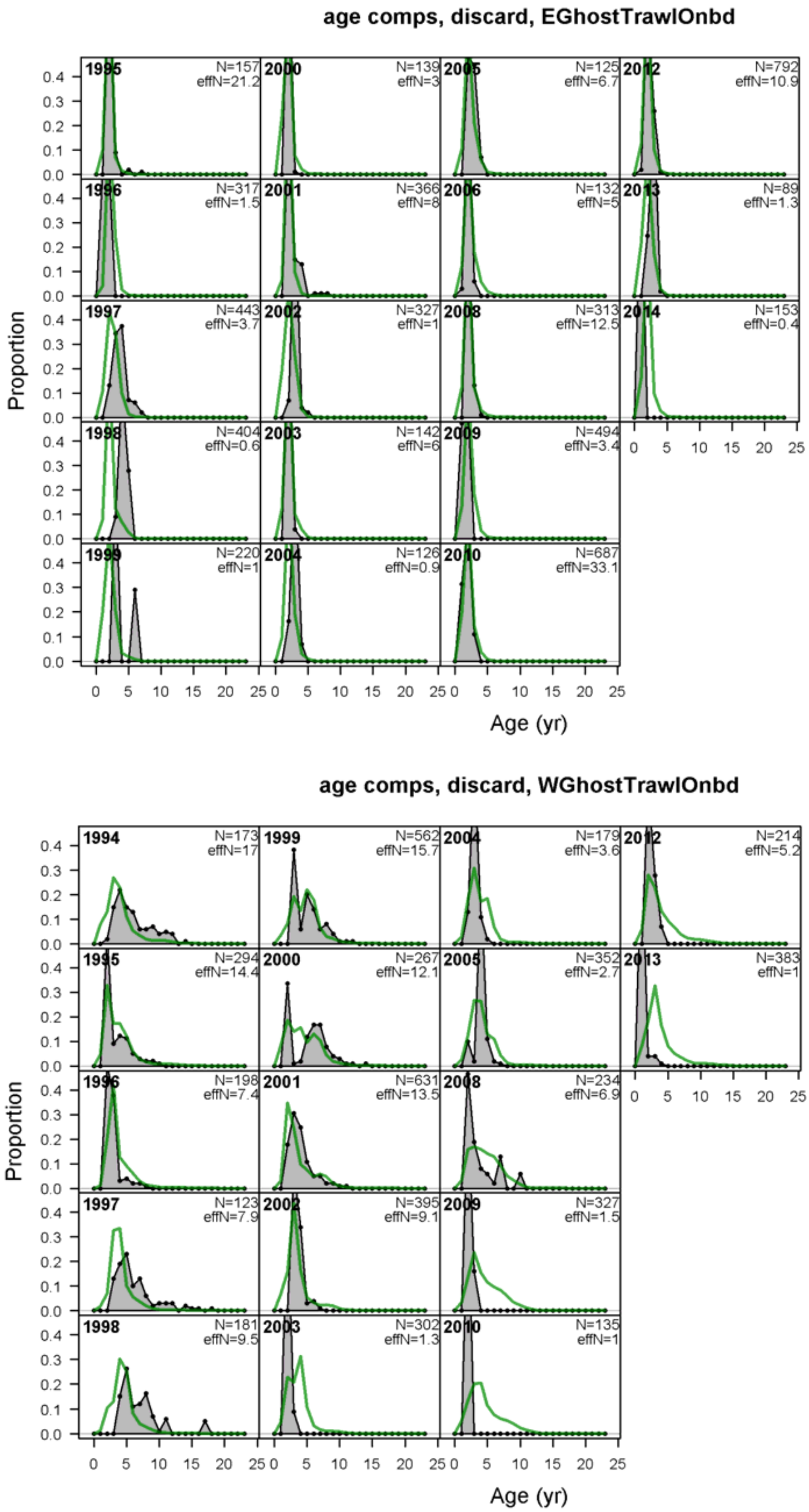
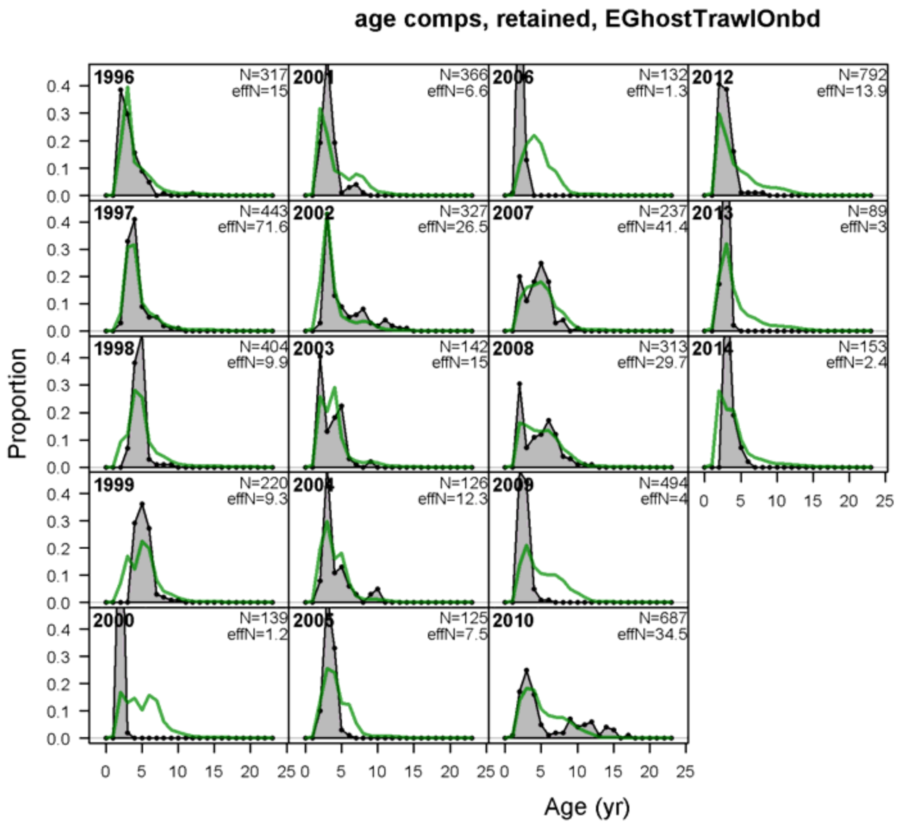
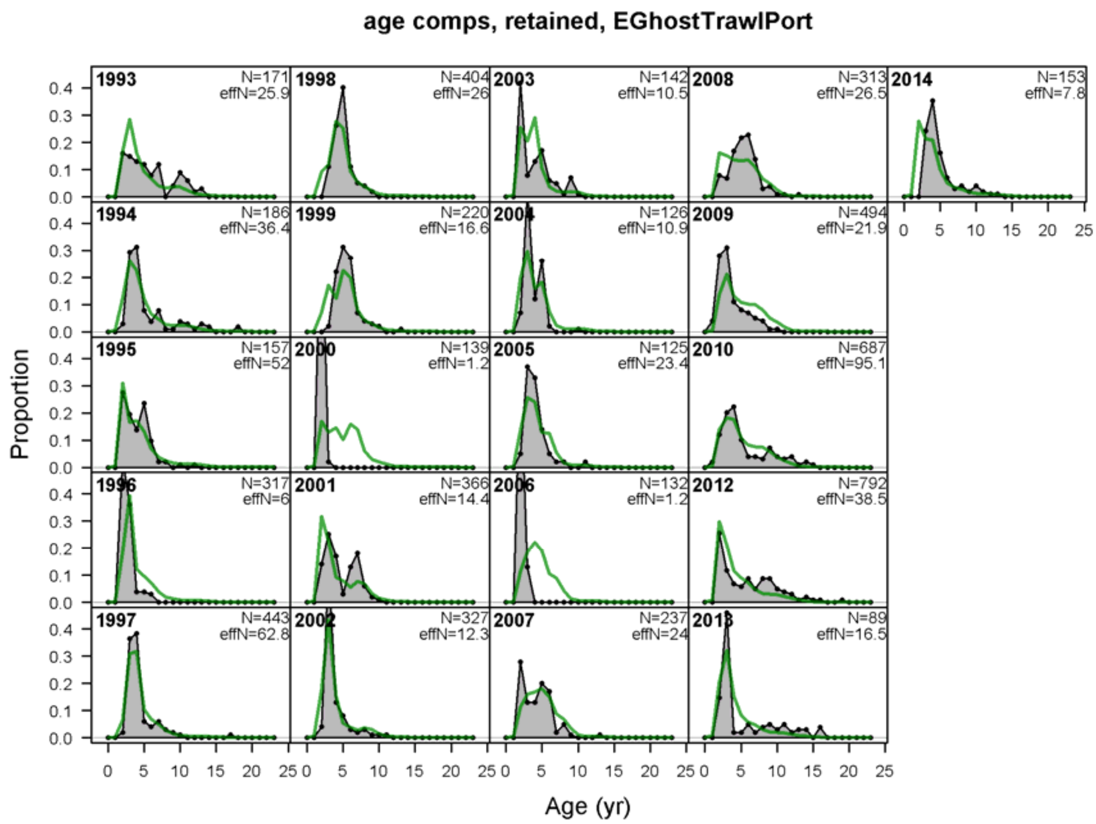
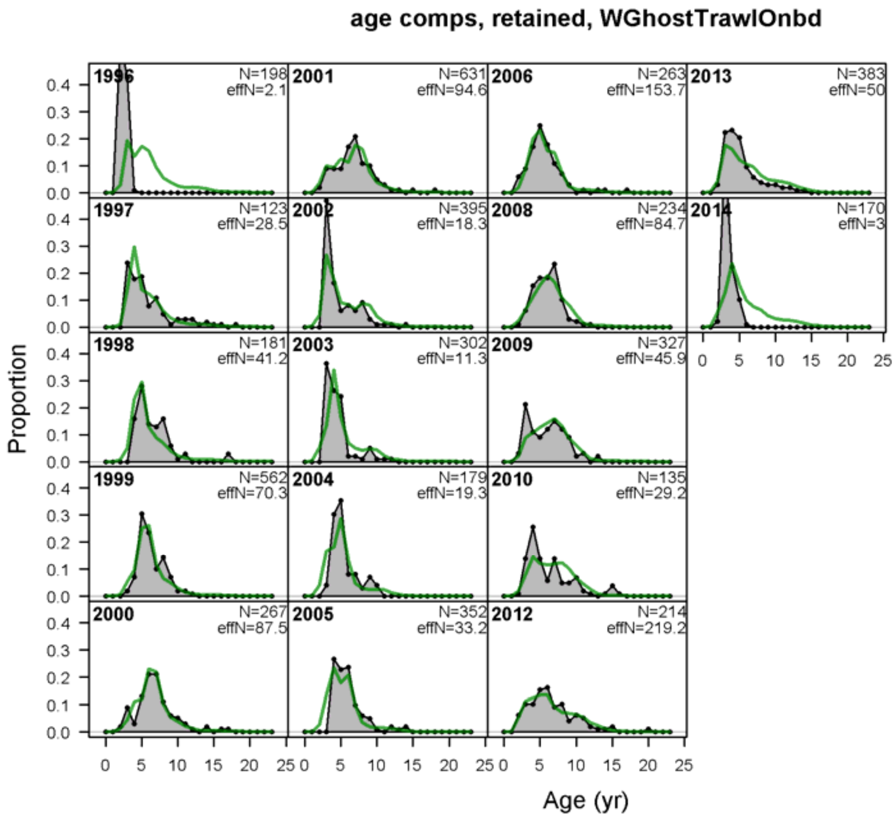


Figure 6A.8. Annual observed (grey) and estimated (green) age composition for the discarded component of the catch of the (top) east and (bottom) west fleets. Note that these are not used in conditioning the model.


age comps, retained, EGhostTrawlOnbd
Proportion
Age (yr)
1996 N=317 effN=15
1997 N=443 effN=71.6
1998 N=404 effN=9.9
1999 N=220 effN=9.3
2000 N=139 effN=1.2
2001 N=366 effN=6.6
2002 N=327 effN=26.5
2003 N=142 effN=15
2004 N=126 effN=12.3
2005 N=125 effN=7.5
2006 N=132 effN=1.3
2007 N=237 effN=41.4
2008 N=313 effN=29.7
2009 N=494 effN=4
2010 N=687 effN=34.5
2012 N=792 effN=13.9
2013 N=89 effN=3
2014 N=153 effN=2.4


age comps, retained, EGhostTrawlPort
Proportion
Age (yr)
1993 N=171 effN=25.9
1994 N=186 effN=36.4
1995 N=157 effN=52
1996 N=317 effN=6
1997 N=443 effN=62.8
1998 N=404 effN=26
1999 N=220 effN=16.6
2000 N=139 effN=1.2
2001 N=366 effN=14.4
2002 N=327 effN=12.3
2003 N=142 effN=10.5
2004 N=126 effN=10.9
2005 N=125 effN=23.4
2006 N=132 effN=1.2
2007 N=237 effN=24
2008 N=313 effN=26.5
2009 N=494 effN=21.9
2010 N=687 effN=95.1
2012 N=792 effN=38.5
2013 N=89 effN=16.5
2014 N=153 effN=7.8



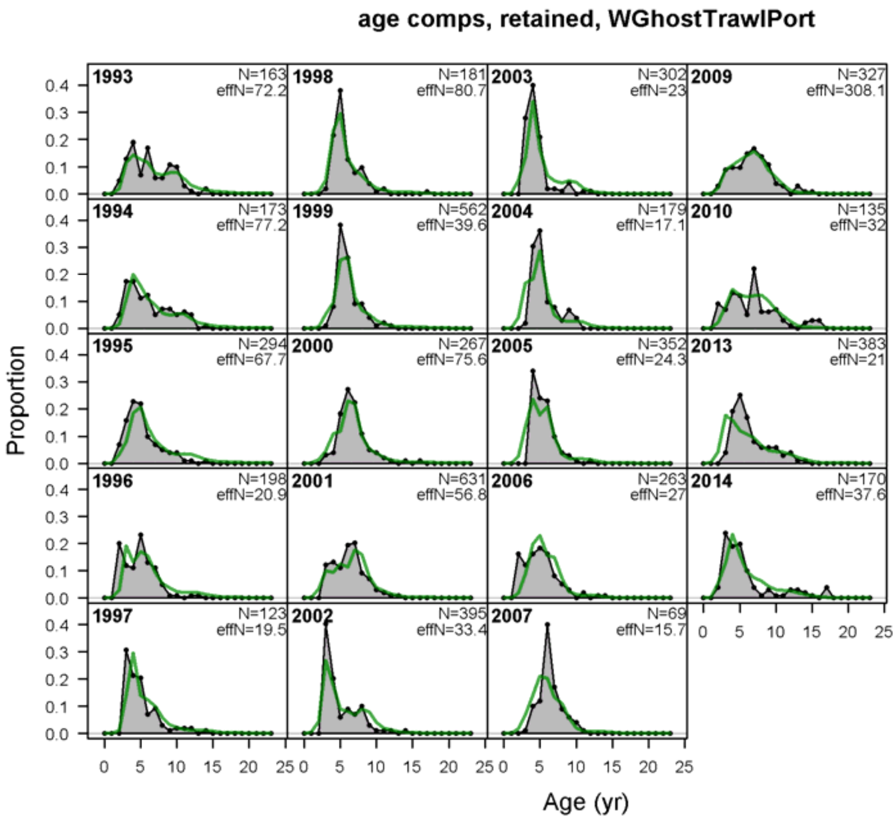


Figure 6A.9. Annual observed (grey) and estimated (green) age compositions for the retained component of the catch of the (top) east and (bottom) west fleets for both the onboard and port measurements. Note that these are not used to condition the model.

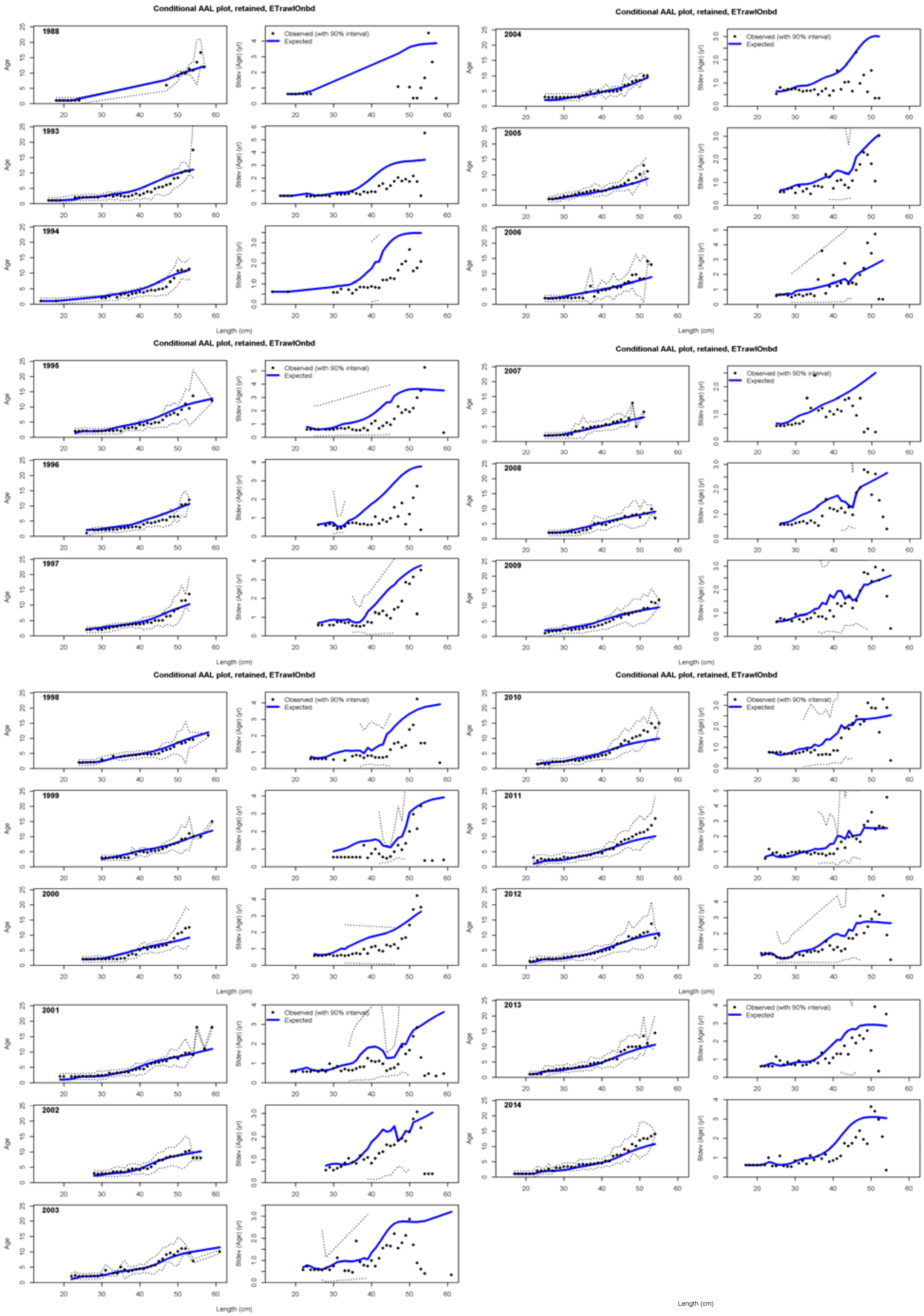


Figure 6A.10. Observed (black with grey shading) and expected (blue lines) age at length.

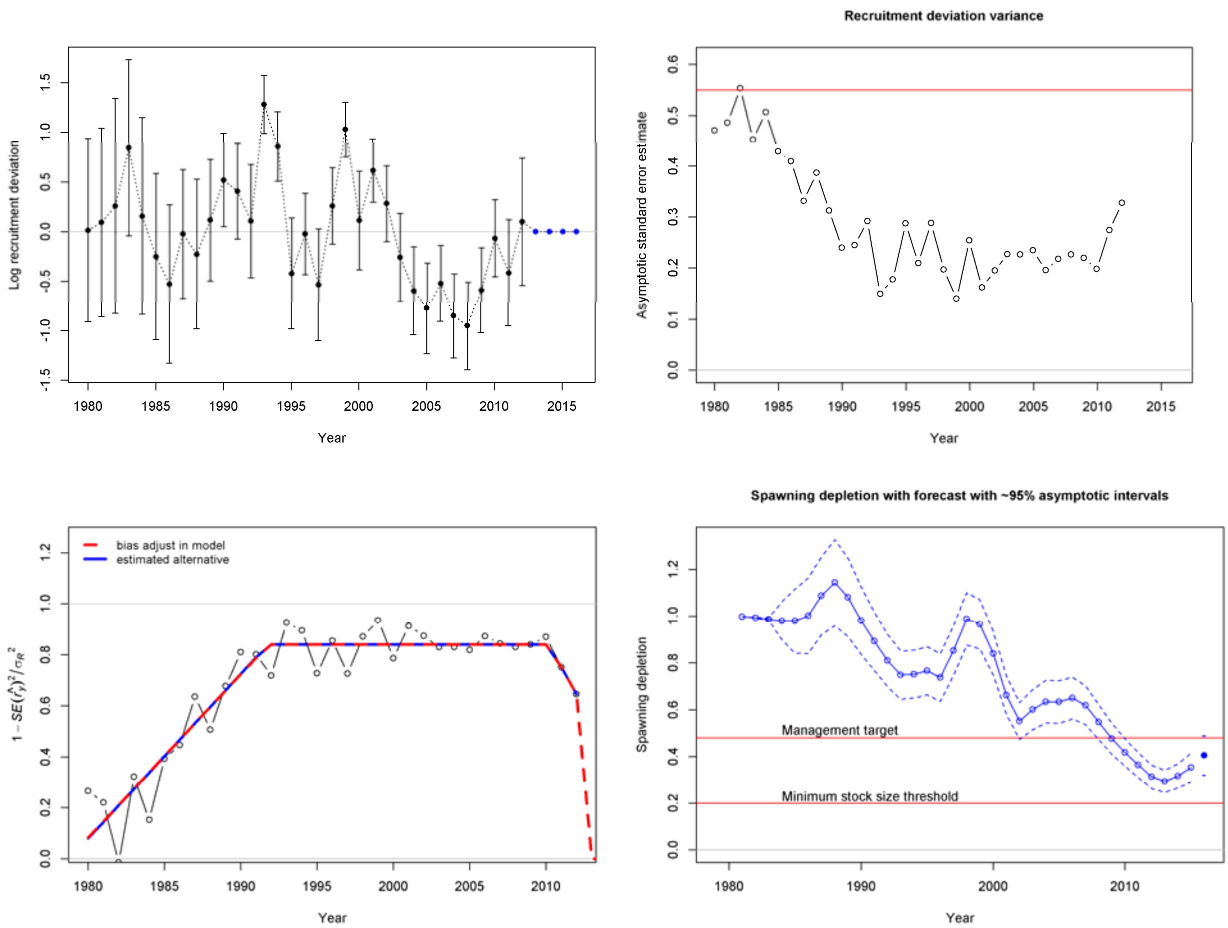


Figure 6A.11. (Top left) Estimated recruitment deviations (plotted on a log scale) with confidence intervals; (top right) standard error on estimated recruitment; (bottom left) bias adjustment factors for recruitment) and (bottom right) estimated depletion (relative spawning biomass) with one year forecast (assuming 2014 catches in 2015).