Initial[1] updated 2016 assessments for West Coast rock lobster and some initial constant catch projections

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Summary

Initial assessment results for the west coast rock lobster, taking new abundance index data and revised poaching into account, are reported. Key results are:

- The resource overall is some 20% less abundant than was thought to be the case last year. There has been a decline in abundance overall by about 20% over the last five years.
- Super-area 8+ has declined by about 50% in abundance over this same period. Even in the absence of any future catches, it is predicted to decline further under the central poaching scenario, i.e. this level of poaching alone is more than this component of the resource can sustain.
- Projections for the resource as a whole show that it is currently 15% below the 2006 baseline abundance, and even if the fishing is completely closed for the next five years, it will be unable to reach the recovery target of 35% above the 2006 abundance by 2021. If the current overall TAC is continued, there will be no increase in abundance above the present level by 2021.

This document reports updated assessments for the five super-areas which are considered as separate populations of the west coast rock lobster resource. The previous assessment was conducted in 2015 (see Johnston 2015). The "new" data available since the 2015 assessment are the commercial CPUE data (2 more seasons), FIMS catch-at-length and F% data for 2014 (i.e. 1 more year of these data) and for super area 8+ there are also FIMS data for the 2015 season. The poaching scenarios have also been revised. The input data overall are thus:

- Commercial catches – see FISHERIES/2016/JUL/SWG-WCRL/13.
- Estimates of recreational takes – these assume the OMP recommended allocations were taken for the 2015 season.
- Updated poaching scenarios – see FISHERIES/2016/JUL/SWG-WCRL/23.
- Interim relief catch estimates – these assume the OMP recommended allocations were taken for the 2015 season.
- Commercial CPUE – see FISHERIES/2016/JUN/SWG-WCRL/15, 16, and 17.

[1] This document has been prepared with little time available to be ready for the 5 August WCRL SWG meeting. Not every option intended has been able to be evaluated as yet. Further results will be included in an updated document for the following SWG meeting.

- Commercial trap and hoopnet catch-at-length and F% data - see FISHERIES/2011/MAR/SWG-WCRL/12.
- FIMS CPUE, catch-at-length and F% – see FISHERIES/2016/JUL/SWG-WCRL/09.
- Somatic growth rate – see FISHERIES/2016/JUL/SWG-WCRL/18.

Estimation and projection of recruitment

The recruitment trend is modeled as for the 2013-2015 assessments: recruitment is assumed to change linearly between a set of estimated recruitment values over time. Recruitment is estimated for the following years:

R1910, R1920, R1950, R1970, R1975, R1980, R1985, R1990, R1995, R1998, R2001, R2004 and R2007. The R2007 is a new additional recruitment parameter estimated in the model fit given the further data now available.

- R2010+ is set equal to the geometric mean ($\bar{R}$) of the R1975, R1980, R1985, R1990, R1995, R1998, R2001, R2004 and R2007 estimated values.
- The R2007 value is constrained by a penalty added to the –*ln*L based on the geometric mean as follows:

$$pen = \frac{1}{2}\frac{(lnR_{2007} - ln\bar{R})^2}{\sigma_R^2} \quad \text{where}$$

$$\sigma_R^2 = \frac{\sum_{y=1975}^{y=2007}(lnR_y - ln\bar{R})^2}{8}$$

- All recruitments are constrained to be less than R1910.

Note that values assumed for recruitment after 2010 do not affect the assessment results shown, but do impact future projections.

Projections

The previous section describes the assumptions made for future (2010+) recruitment while Appendix A details the assumptions made and weights accorded previously for projections. An assumption regarding the future (2016+) somatic growth also needs to be made. Here we assume future somatic growth to be the average of the somatic growth rates from 1989-2015. This assumption has been afforded the most weight in previous OMP developments. Subsequent work may include other options for this and for starting values for abundance in each super-area.

Sensitivity for future recruitment and somatic growth assumptions

Sensitivity to the assumption made for future recruitment and future somatic growth rate is explored for super-area A8+ (for poaching scenario 5, P2008=500 and future catches equal to 2015 values). The options explored are:

Future recruitment = **High** : future recruitment (2010+) is set equal to the **highest** estimated parameter of the R1975, R1980, R1985, R1990, R1995, R1998, R2001, R2004 and R2007 set.

Future recruitment = **Low** : future recruitment (2010+) is set equal to the **lowest** estimated parameter of the R1975, R1980, R1985, R1990, R1995, R1998, R2001, R2004 and R2007 set.

Future somatic growth = **Mid**: future somatic growth (2016+) is equal to the1968-2015 average.

Future catches

These are set to constant values over time from 2016-2021 in each super-area, where such values include 0 and 2015 TAC amounts. The distribution amongst traps (offshore commercial) and hoops (nearshore commercial, subsistence and recreational) is assumed as for the 2015 season, which is:

A1+2: 0% trap: 100% hoop

A3+4: 54% trap: 46% hoop

A5+6: 66% trap: 34% hoop

A7: 97% trap: 3% hoop

A8+: 66% trap: 34% hoop

Total: 65% trap: 35% hoop

Poaching scenarios

Figure 1a and b plot the different poaching scenarios as outlined in FISHERIES/2016/JUL/SWG/WCRL/23. Note that the different poaching scenarios affect both the assessment (historic poaching levels) as well as future projections. Figure 1a shows the ten scenarios grouped into three categories. The idea is that in order to reduce the number of options, one might reasonably select one scenario from each of the three categories. Figure 1b shows scenarios 1, 5 and 10 as well as the overall weighted average poaching trends. It is suggested that these three poaching scenarios be used initially to explore the sensitivity of the assessments and projections to different poaching levels.

Results

Tables 1-5 report the updated 2016 assessment results for each super-area (for four different poaching scenarios). Results for the 2015 assessment are also provided for comparison. Figure 2-6 show the model fits to abundance data for the 2015 assessments (Figures 2a-6a) whilst Figures 2b-6b show the model fits for the updated 2016 assessments.

Table 6a and 6b report the B75m(2014/K) and B75m(2014/2006) estimates for each super-area and four poaching scenarios for the updated 2016 assessments. The 2015 assessment results and results for the resource as a whole are also provided.

Figure 7 shows the super-area A8+ recruitment trends estimated for the updated 2016 assessment (scenario 5) compared to that estimated for the 2015 assessment.

Table 7 focuses on super-area A8+ and reports the estimated B75m(2021/2006) values for four poaching scenarios and a range of future constant catches ranging from zero to the 2015 TAC values. Table 8 similarly reports for each super-area the B75m(2021/2006) estimates for four poaching scenarios and where the future catches are set equal to the 2015 TAC levels.

Tables 9a and 9b again focus on super-area A8+, and compare the B75m(2021/2006) values for scenario 5 (P2008=500) and future TACs set at the 2015 TAC levels, but where different future recruitment assumptions are explored (Table 9a) as well as an alternate somatic growth assumption for the future (Table 9b).

Figures 8a and b show the B75m estimated trends for each super-area for the 2015 assessment (Figure 8a) and for the updated 2016 assessment (Figure 8b). Figure 8c compares the 2015 and 2016 assessment estimated trajectories for the resource as a whole.

Figure 9 compares the B75m trends estimated for the 2014, 2015 and 2016 assessments for the resource as a whole. The OMP predicted trend as calculated in 2013 is indicated along with the biomass target (35% increase in 2021 over 2006 level). Two biomass projections for the 2016 assessment are shown – these assume either zero future catches or future catches set at the 2015 TAC levels. Figure 10 shows these biomass projections at a super-area level.

Discussion

Key points to note from these results are as follows (note that remarks refer to the central poaching scenario 5 unless otherwise indicated).

- Overall abundance is now estimated to be some 20% less than was thought to be the case last year. This is a consequence of a combination of updated resource monitoring data and revision of poaching estimates. Thus the resource is now estimated to be some 2% rather than 2.5% of pristine male biomass above 75mm carapace length. This correspondingly indicates about 16% below compared to 8% above the 2006 level, as was thought to be the case last year (see Table 6).

- Abundance in super-area A8+ has fallen by about 50% over the last 5 years, and is now at an abundance comparable to rather than well above that in A3+4, A5+6 and A7 (see Figure 8b). This follows from the marked drop in trap and hoop CPUE over the last five years (see Figure 6b). Poaching levels are now such that the abundance of the resource in this super-area will fall even in the absence of any legal catch, i.e. the current poaching level exceed what the resource can sustain in this super-area (see Table 8).
- Under continuation of current TACs, by 2021 three super-areas will be below their 2006 levels. Only A5+6, which started from a very low level in 2006, will have increased by a reasonably large amount (see Table 8).
- Projections for the resource as a whole (Figure 8c) show that abundance has dropped by 20% since 2011. Even if legal catches are set to zero everywhere for the next five years, the recovery target of 35% above the 2006 level by 2021 cannot be reached. If the current overall TAC is continued, no increase in abundance from the current level (some 15% below the 2006 baseline) is projected by 2021. (See Figure 9).

Note that these comments are based on central (best estimate assumptions), and do not address uncertainties about these. These will be covered in more detail in an update of this paper the the next SWG meeting.

Reference

Johnston, 2015. Updated 2015 assessments for West Coast rock lobster. DAFF document, FISHERIES/2015/JUL/SWG_WCRL11.

Table 1: Updated 2016 assessment results for super-area A1+2.

	2015 Historic Poaching= 500 MT	**2015 Historic Poaching= 250 MT**	**2016**
B_{75}^{m}(1910) MT	49 769	49 399	55 176
B_{75}^{m}(2010) MT	276	305	805
B_{75}^{m}(2014) MT	276	305	759
B_{75}^{m}(2015) MT	-	-	736
B_{75}^{m}(2010)/ B_{75}^{m} (1910)	0.006	0.006	0.015
B_{75}^{m}(2014)/ B_{75}^{m} (1910)	0.004	0.004	0.014
B_{75}^{m}(2015)/ B_{75}^{m} (1910)	-	-	0.013
B_{75}^{m}(2010)/ B_{75}^{m}(1996)	1.307	1.206	1.409
B_{75}^{m}(2014)/ B_{75}^{m}(1996)	0.958	0.843	1.328
B_{75}^{m}(2010)/ B_{75}^{m}(2006)	0.855	0.840	0.913
B_{75}^{m}(2014)/ B_{75}^{m}(2006)	0.626	0.588	0.861
B_{75}^{m}(2015)/ B_{75}^{m}(2006)	-	-	0.835
Egg (2010)/Egg (1910)	0.014	0.012	0.023
Egg (2014)/Egg (1910)	0.010	0.010	0.020
Egg (2015)/Egg (1910)	-	-	0.019

Table 2: Updated 2016 assessment results for super-area A3+4.

	2015 Historic Poaching= 500 MT	**2015 Historic Poaching= 250 MT**	**2016 Historic poaching= 500 MT in 2008** **Scenario 1**	**2016 Historic poaching= 500 MT in 2008** **Scenario 5**	**2016 Historic poaching= 500 MT in 2008** **Scenario 10**	**2016 Historic poaching= 350 MT in 2008** **Scenario 5**
B_{75}^{m}(1910) MT	166 501	163 390	167 221	167 255	167 357	167 255
B_{75}^{m}(2010) MT	3 358	3 970	3 692	3 610	3 680	4509
B_{75}^{m}(2014) MT	4 864	5 035	4 389	4 362	4 417	5 068
B_{75}^{m}(2015) MT	-	-	4 208	4 131	4 229	4 786
B_{75}^{m}(2010)/ B_{75}^{m} (1910)	0.020	0.024	0.022	0.022	0.022	0.027
B_{75}^{m}(2014)/ B_{75}^{m} (1910)	0.029	0.031	0.026	0.026	0.026	0.030
B_{75}^{m}(2015)/ B_{75}^{m} (1910)	-	-	0.025	0.025	0.025	0.029
B_{75}^{m}(2010)/ B_{75}^{m}(1996)	1.719	1.701	1.671	1.678	1.599	1.334
B_{75}^{m}(2014)/ B_{75}^{m}(1996)	2.490	2.158	1.986	2.028	1.920	1.500
B_{75}^{m}(2010)/ B_{75}^{m}(2006)	1.197	0.955	0.926	0.927	0.917	0.898
B_{75}^{m}(2014)/ B_{75}^{m}(2006)	1.733	1.211	1.101	1.120	1.100	1.010
B_{75}^{m}(2015)/ B_{75}^{m}(2006)	-	-	1.056	1.061	1.050	0.953
Egg (2010)/Egg (1910)	0.055	0.056	0.055	0.055	0.055	0.059
Egg (2014)/Egg (1910)	0.067	0.066	0.061	0.058	0.060	0.061
Egg (2015)/Egg (1910)	-	-	0.061	0.056	0.059	0.057
Total -lnL			100.39	100.22	100.28	104.42

Table 3: Updated 2016 assessment results for super-area A5+6.

	2015 Historic Poaching= 500 MT	**2015 Historic Poaching= 250 MT**	**2016 Historic poaching= 500 MT in 2008 Scenario 1**	**2016 Historic poaching= 500 MT in 2008 Scenario 5**	**2016 Historic poaching= 500 MT in 2008 Scenario 10**	**2016 Historic poaching= 350 MT in 2008 Scenario 5**
B^m_{75}(1910) MT	255 837	255 214	257 471	259 001	260 057	259 135
B^m_{75}(2010) MT	2 612	2 403	2 686	2 577	2 735	2 759
B^m_{75}(2014) MT	3 587	3 194	3 356	3 376	3 532	3 379
B^m_{75}(2015) MT	-	-	3 530	3 579	3 751	3 526
B^m_{75}(2010)/ B^m_{75} (1910)	0.010	0.009	0.010	0.010	0.010	0.011
B^m_{75}(2014)/ B^m_{75} (1910)	0.014	0.012	0.013	0.013	0.014	0.013
B^m_{75}(2015)/ B^m_{75} (1910)	0.014	0.012	0.014	0.014	0.014	0.014
B^m_{75}(2010)/ B^m_{75}(1996)	1.553	2.224	2.341	2.271	2.392	2.424
B^m_{75}(2014)/ B^m_{75}(1996)	-	-	2.920	2.294	3.091	2.969
B^m_{75}(2010)/ B^m_{75}(2006)	1.485	1.468	1.518	1.611	1.620	1.465
B^m_{75}(2014)/ B^m_{75}(2006)	2.039	1.951	1.893	2.110	2.092	1.794
B^m_{75}(2015)/ B^m_{75}(2006)	-	-	2.000	2.230	2.222	1.872
Egg (2010)/Egg (1910)	0.030	0.028	0.031	0.031	0.032	0.031
Egg (2014)/Egg (1910)	0.034	0.032	0.035	0.035	0.037	0.034
Egg (2015)/Egg (1910)	-	-	0.037	0.037	0.038	0.035
Total -lnL			74.01	74.41	73.34	73.64

Table 4: Updated 2016 assessment results for super-area A7.

	2015 Historic Poaching= 500 MT	**2015 Historic Poaching= 250 MT**	**2016 Historic poaching= 500 MT in 2008 Scenario 1**	**2016 Historic poaching= 500 MT in 2008 Scenario 5**	**2016 Historic poaching= 500 MT in 2008 Scenario 10**	**2016 Historic poaching= 350 MT in 2008 Scenario 5**
B_{75}^{m}(1910) MT	139 888	147 279	181 484	174 083	162 469	176 297
B_{75}^{m}(2010) MT	2 869	2 966	3 402	4 105	3 806	3 135
B_{75}^{m}(2014) MT	2 861	2 712	2 546	3 236	2 981	2 329
B_{75}^{m}(2015) MT	-	-	2 446	3 084	2 848	2 235
B_{75}^{m}(2010)/ B_{75}^{m} (1910)	0.021	0.020	0.019	0.024	0.023	0.018
B_{75}^{m}(2014)/ B_{75}^{m} (1910)	0.021	0.018	0.014	0.019	0.018	0.013
B_{75}^{m}(2015)/ B_{75}^{m} (1910)	-	-	0.014	0.018	0.018	0.013
B_{75}^{m}(2014)/ B_{75}^{m}(1996)	0.477	0.492	0.454	0.626	0.590	0.439
B_{75}^{m}(2010)/ B_{75}^{m}(2006)	0.818	0.912	0.916	1.039	1.011	0.905
B_{75}^{m}(2014)/ B_{75}^{m}(2006)	0.815	0.834	0.686	0.820	0.792	0.672
B_{75}^{m}(2015)/ B_{75}^{m}(2006)	-	-	0.659	0.780	0.762	0.645
Egg (2010)/Egg (1910)	0.089	0.082	0.067	0.077	0.080	0.067
Egg (2014)/Egg (1910)	0.074	0.068	0.051	0.057	0.060	0.050
Egg (2015)/Egg (1910)	-	-	0.048	0.054	0.056	0.047
Total -lnL			92.65	92.70	92.63	92.43

Table 5: Updated 2016 assessment results for super-area A8+.

	2015 Historic Poaching= 500 MT	**2015 Historic Poaching= 250 MT**	**2016 Historic poaching= 500 MT in 2008 Scenario 1**	**2016 Historic poaching= 500 MT in 2008 Scenario 5**	**2016 Historic poaching= 500 MT in 2008 Scenario 10**	**2016 Historic poaching= 350 MT in 2008 Scenario 5**
$B_{75}^{m}(1910)$ MT	199 708	188 628	177 723	175 011	175 290	172 970
$B_{75}^{m}(2010)$ MT	9 007	8 594	8 884	8 233	8 227	7 863
$B_{75}^{m}(2014)$ MT	8 863	7 892	5 194	4 917	4 800	4 744
$B_{75}^{m}(2015)$ MT	-	-	3 984	3 934	4 129	3 953
$B_{75}^{m}(2010)/\ B_{75}^{m}\ (1910)$	0.045	0.046	0.050	0.047	0.047	0.046
$B_{75}^{m}(2014)/\ B_{75}^{m}\ (1910)$	0.044	0.042	0.029	0.028	0.027	0.027
$B_{75}^{m}(2015)/\ B_{75}^{m}\ (1910)$	-	-	0.022	0.022	0.024	0.023
$B_{75}^{m}(2010)/\ B_{75}^{m}(1996)$	0.709	0.701	0.730	0.714	0.711	0.706
$B_{75}^{m}(2014)/\ B_{75}^{m}(1996)$	0.698	0.644	0.427	0.426	0.415	0.426
$B_{75}^{m}(2010)/\ B_{75}^{m}(2006)$	0.918	0.900	0.938	0.911	0.911	0.898
$B_{75}^{m}(2014)/\ B_{75}^{m}(2006)$	0.904	0.802	0.546	0.544	0.532	0.542
$B_{75}^{m}(2015)/\ B_{75}^{m}(2006)$	-	-	0.420	0.435	0.457	0.452
Egg (2010)/Egg (1910)	0.206	0.198	0.216	0.213	0.211	0.203
Egg (2014)/Egg (1910)	0.223	0.202	0.205	0.196	0.193	0.187
Egg (2015)/Egg (1910)	-	-	0.207	0.197	0.193	0.189
Total –lnL			-61.67	-59.70	-58.50	-58.69

Table 6a: Summary statistics in the form of B75m(2014)/K estimates for each super-area and for the resource as a whole for the final updated 2015 assessment and for four scenarios for the 2016 updated assessment.

	2015 Assessment B75m(2014)/K	**2016 Historic poaching=500 MT in 2008 Scenario 1 2016 Assessment B75m(2014)/K**	**2016 Historic poaching=500 MT in 2008 Scenario 5 2016 Assessment B75m(2014)/K**	**2016 Historic poaching=500 MT in 2008 Scenario 10 2016 Assessment B75m(2014)/K**	**2016 Historic poaching=350 MT in 2008 Scenario 5 2016 Assessment B75m(2014)/K**
A1+2	0.004	0.014	0.014	0.014	0.014
A3+4	0.030	0.026	0.026	0.026	0.030
A5+6	0.013	0.013	0.013	0.014	0.013
A7	0.020	0.014	0.019	0.018	0.013
A8	0.044	0.029	0.028	0.027	0.027
Total resource	**0.025**	**0.019**	**0.020**	**0.020**	**0.020**

Table 6b: Summary statistics in the form of B75m(2014/2006) estimates for each super-area and for the resource as a whole for the final updated 2015 assessment and for four scenarios for the 2016 updated assessment.

	2015 Assessment B75m(2014/2006)	**2016 Historic poaching=500 MT in 2008 Scenario 1 2016 Assessment B75m(2014/2006)**	**2016 Historic poaching=500 MT in 2008 Scenario 5 2016 Assessment B75m(2014/2006)**	**2016 Historic poaching=500 MT in 2008 Scenario 10 2016 Assessment B75m(2014/2006)**	**2016 Historic poaching=350 MT in 2008 Scenario 5 2016 Assessment B75m(2014/2006)**
A1+2	0.612	0.862	0.862	0.862	0.014
A3+4	1.502	1.101	1.092	1.100	0.010
A5+6	2.010	1.897	2.110	2.092	1.794
A7	0.822	0.686	0.820	0.792	0.672
A8	0.877	0.548	0.544	0.532	0.542
Total resource	**1.078**	**0.819**	**0.855**	**0.851**	**0.814**

Table 7: Estimated B75m(2021/2006) values for super-area **A8+** for four poaching scenarios and a range of future constant catches ranging from 0 MT to the 2015 TAC.

Future TACs	**2016 Historic poaching=500 MT in 2008 Scenario 1**	**2016 Historic poaching=500 MT in 2008 Scenario 5**	**2016 Historic poaching=500 MT in 2008 Scenario 10**	**2016 Historic poaching=350 MT in 2008 Scenario 5**
0 MT	0.682	0.955	1.376	1.182
40% of 2015 TAC (503 MT)	0.433	0.691	1.114	0.909
60% of 2015 TAC (754 MT)	0.304	0.556	0.980	0.770
80% of 2015 TAC (1006 MT)	0.168	0.415	0.844	0.627
100% of 2015 TAC (1257 MT)	0.074	0.264	0.704	0.479

Table 8: Estimated B75m(2021/2006) values for each super-area for four poaching scenarios and assuming future constant catches remain at the 2015 TAC levels.

Super-area	**2016 Historic poaching=500 MT in 2008 Scenario 1**	**2016 Historic poaching=500 MT in 2008 Scenario 5**	**2016 Historic poaching=500 MT in 2008 Scenario 10**	**2016 Historic poaching=350 MT in 2008 Scenario 5**
A1+2 (2015 TAC=42 MT)	0.631	0.631	0.631	0.631
A3+4 (2015 TAC=308 MT)	1.171	0.907	1.004	0.818
A5+6 (2015 TAC=167 MT)*	2.878	3.23	3.27	2.626
A7 (2015 TAC=83 MT)	1.064	1.082	1.000	1.033
A8+ (2015 TAC=1257 MT)	0.074	0.264	0.704	0.479

*The commercial TAC is assumed to be 100 MT for these calculations

Table 9a: Estimated B75m(2021/2006) values for super-area **A8+** for scenario 5 (P2008=500) and future constant catches set at the 2015 TACs. Results are shown for three different future recruitment assumptions. (See text for more details of these alternative assumptions.)

Future recruitment	**2016 Historic poaching=500 MT in 2008 Scenario 5**
Low	0.164
Geometric mean (baseline assumption)	**0.264**
High	0.370

Table 9b: Estimated B75m(2021/2006) values for super-area **A8+** for scenario 5 (P2008=500) and future constant catches set at the 2015 allocated quotas. Results are shown for two different future somatic growth rate assumptions.

Future somatic growth	**2016 Historic poaching=500 MT in 2008 Scenario 5**
Low (baseline assumption)	**0.264**
Mid	0.841

Figure 1a: Poaching scenarios grouped into three different "categories".

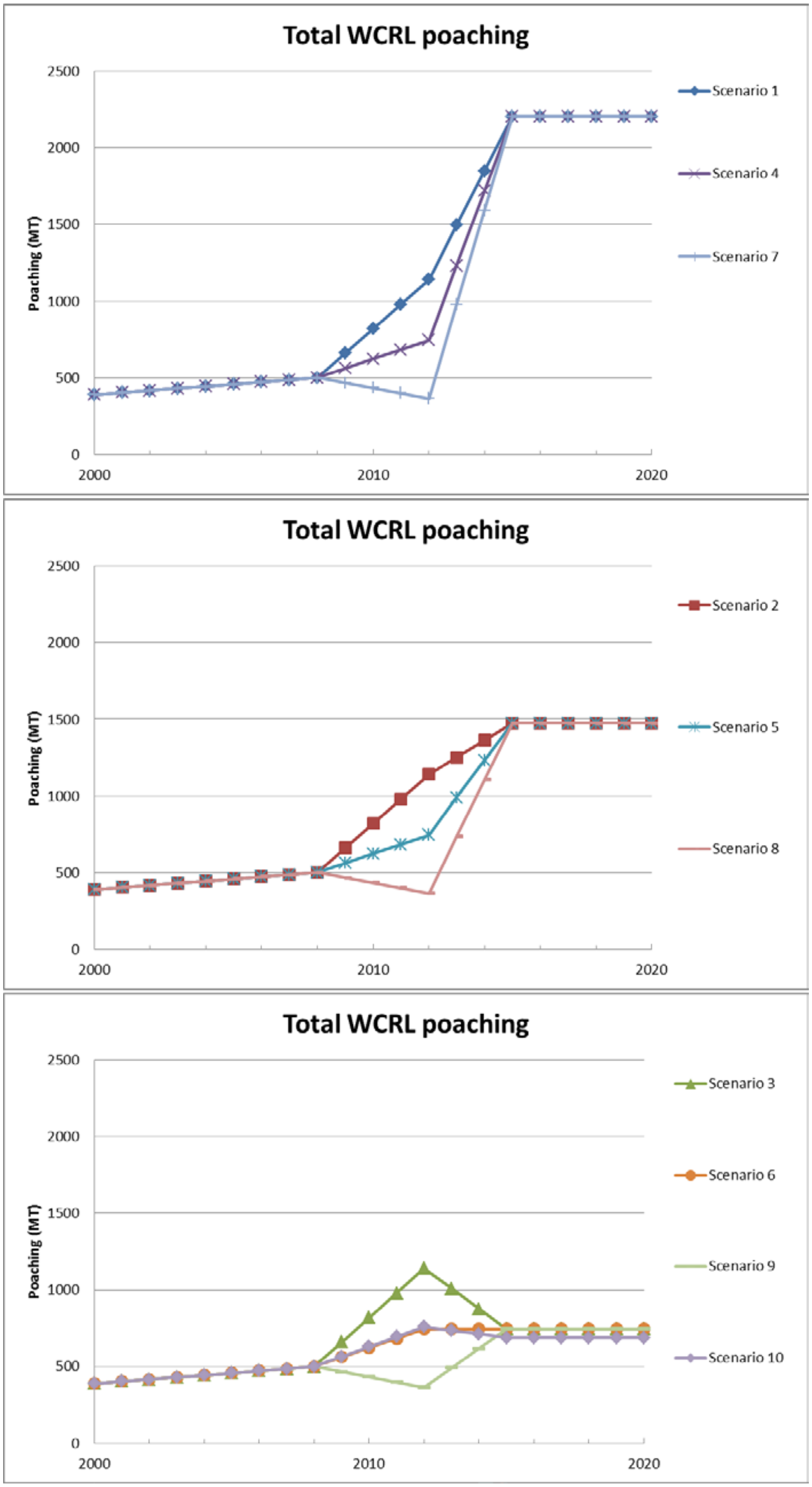


Figure 1b: Poaching scenarios 1, 5 and 10 with the overall weighted average poaching trend also indicated.

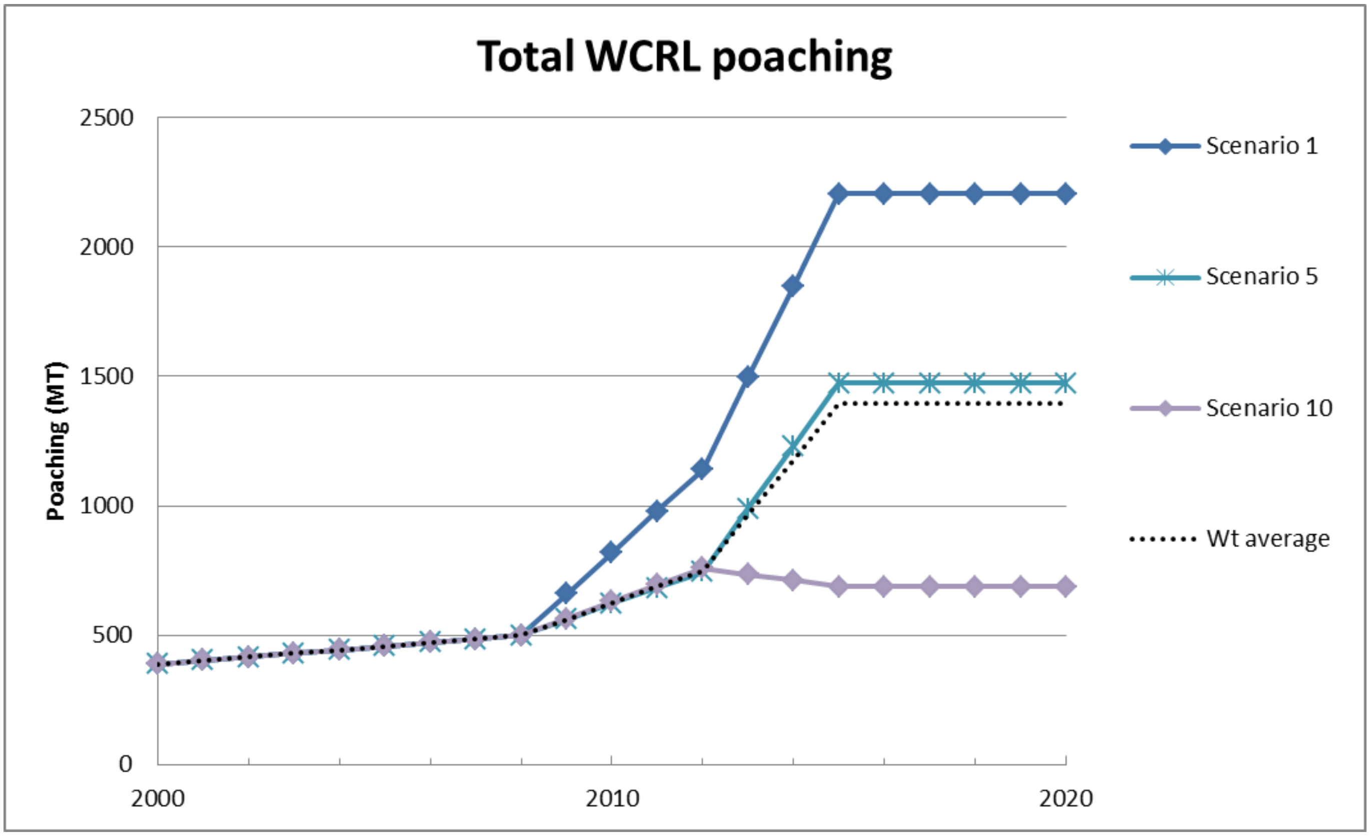


Figure 2a: 2014 and 2015 fits to A1+2 CPUE data.

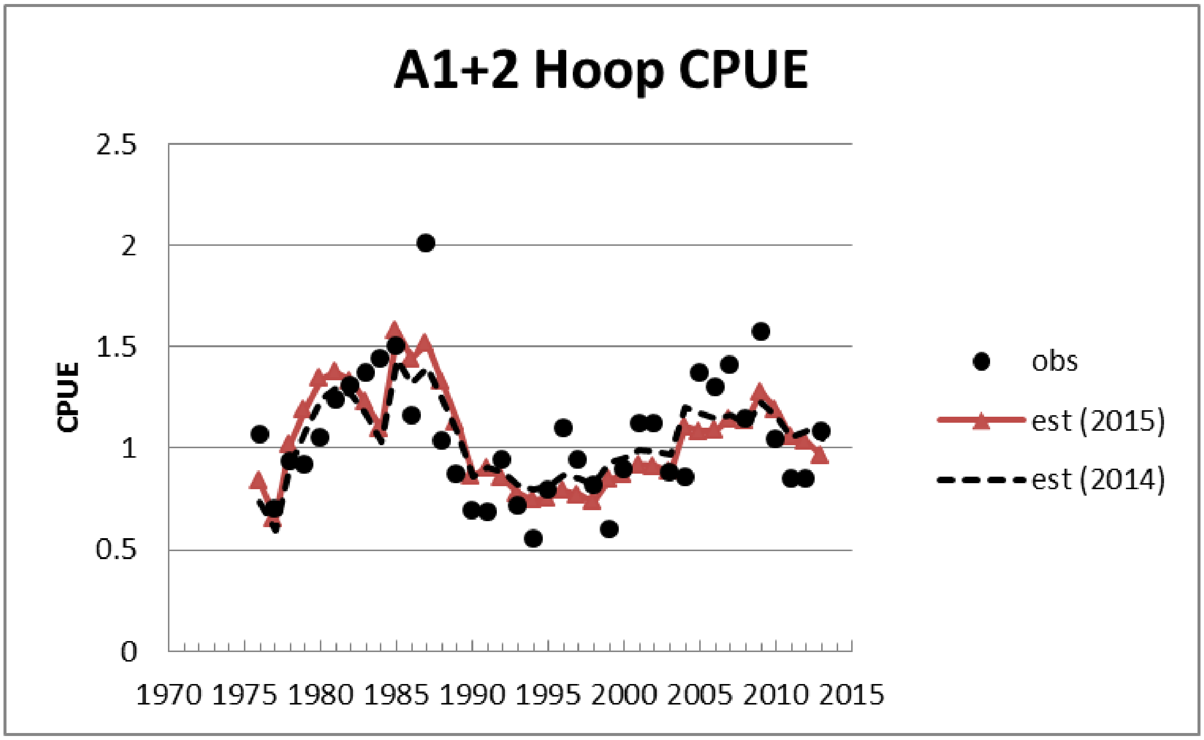


Figure 2b: **2016** fits to A1+2 CPUE data.

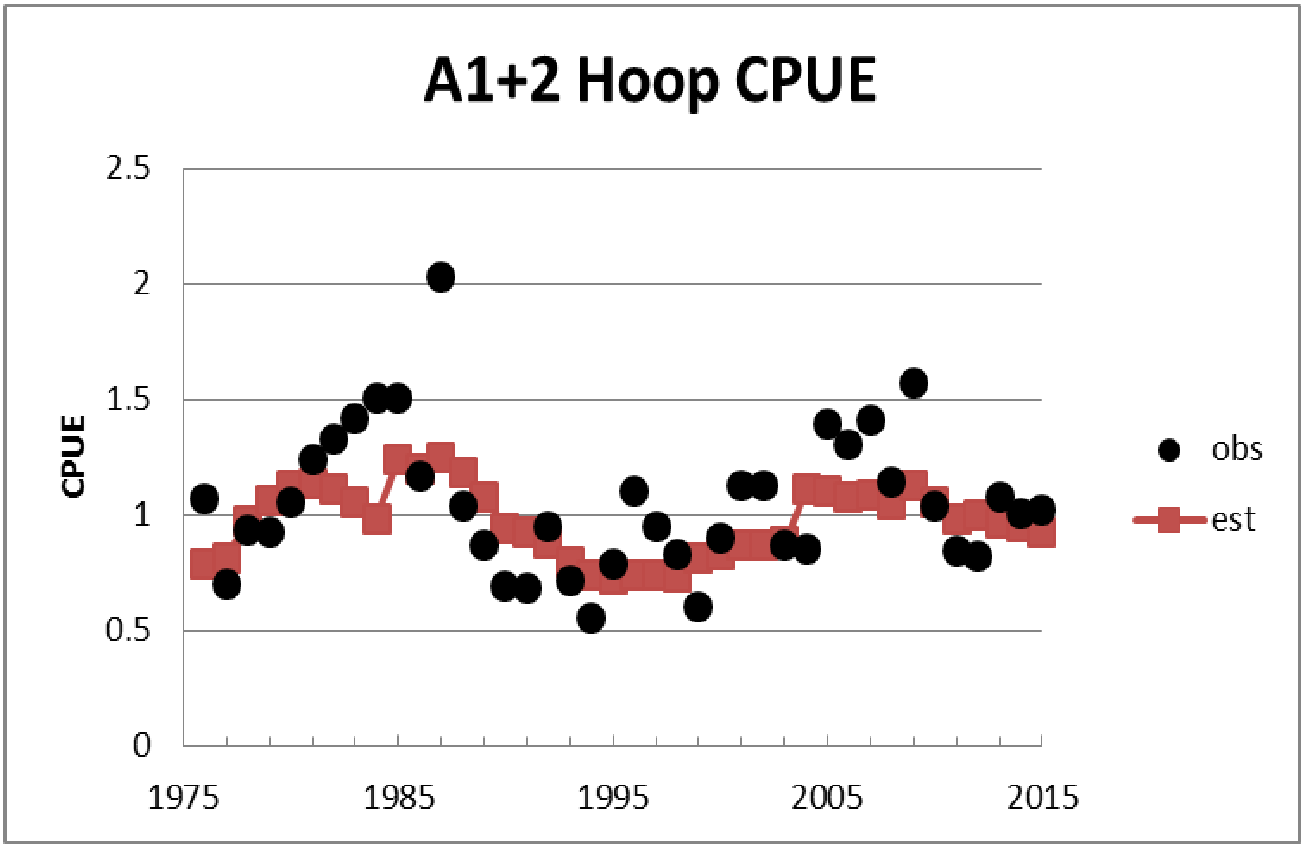


Figure 3a: 2014 and 2015 fits to A3+4 CPUE data.

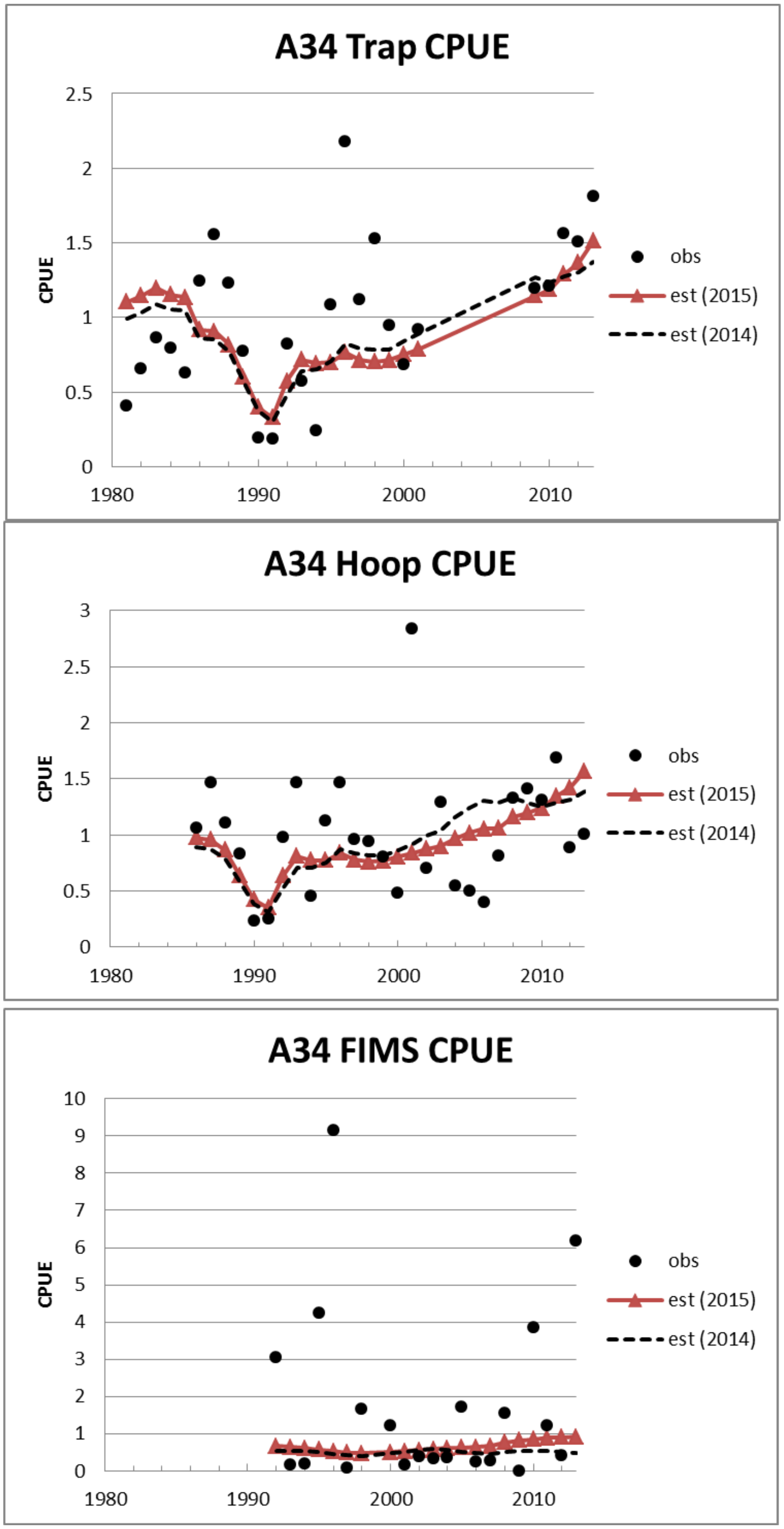
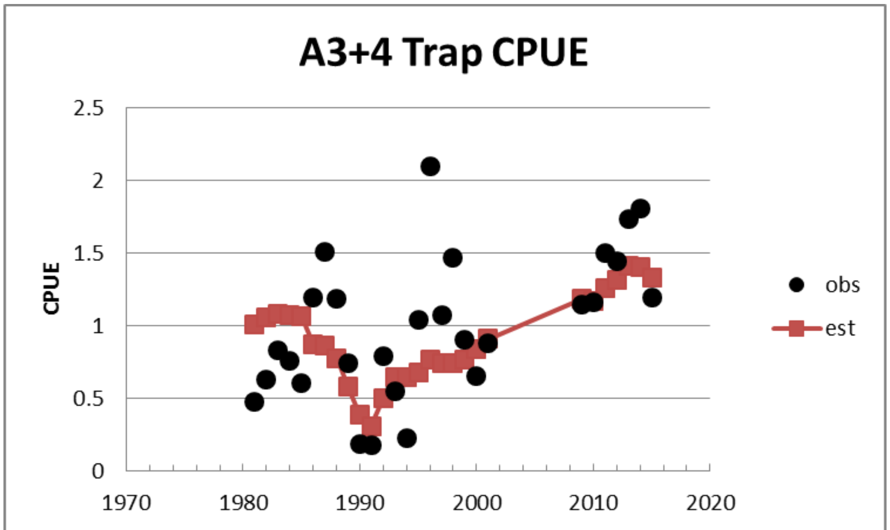
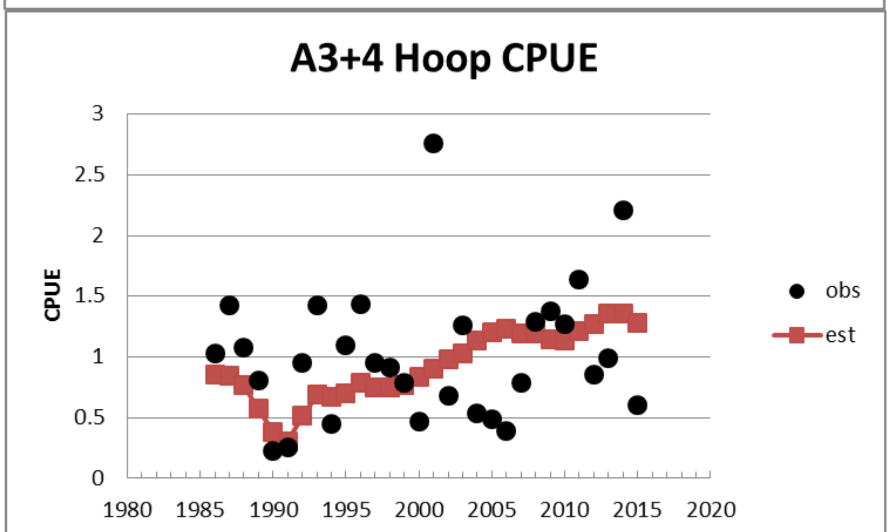


Figure 3b: **2016** fits to A3+4 CPUE data (for scenario 5 poaching scenario).





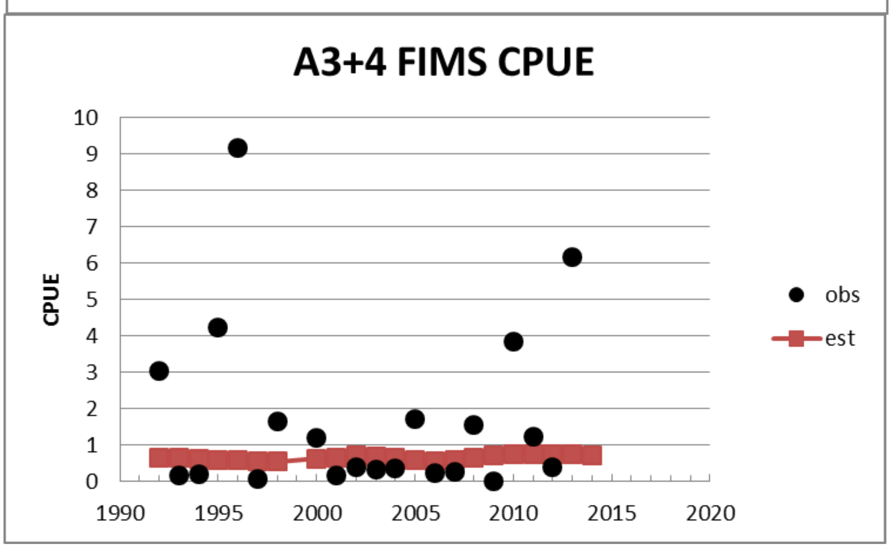
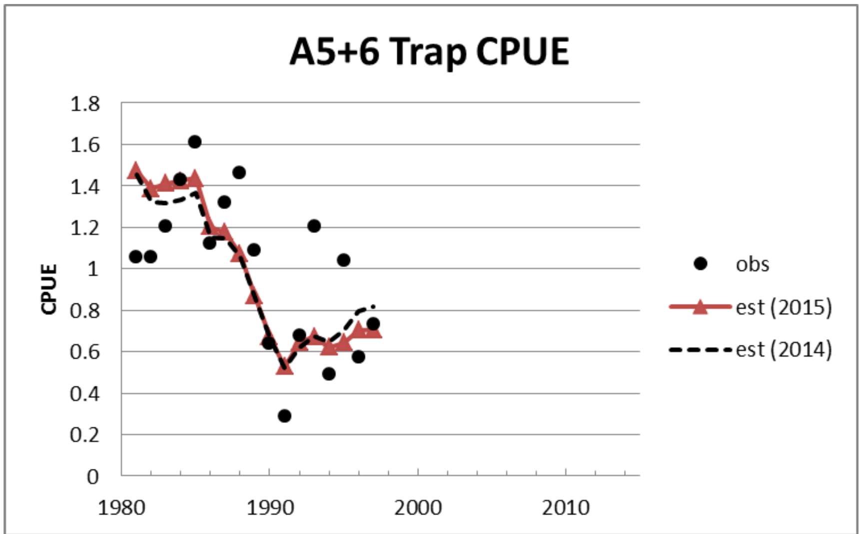
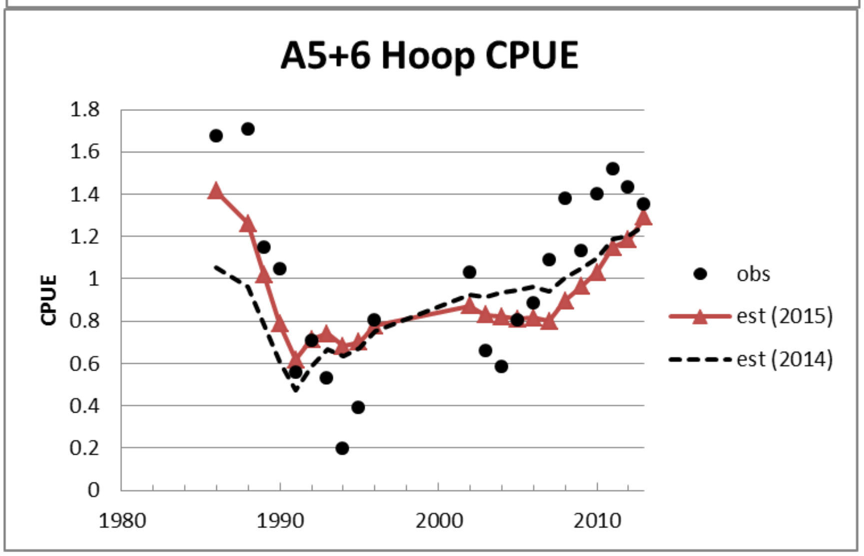


Figure 4a: 2014 and 2015 fits to A5+6 CPUE data.





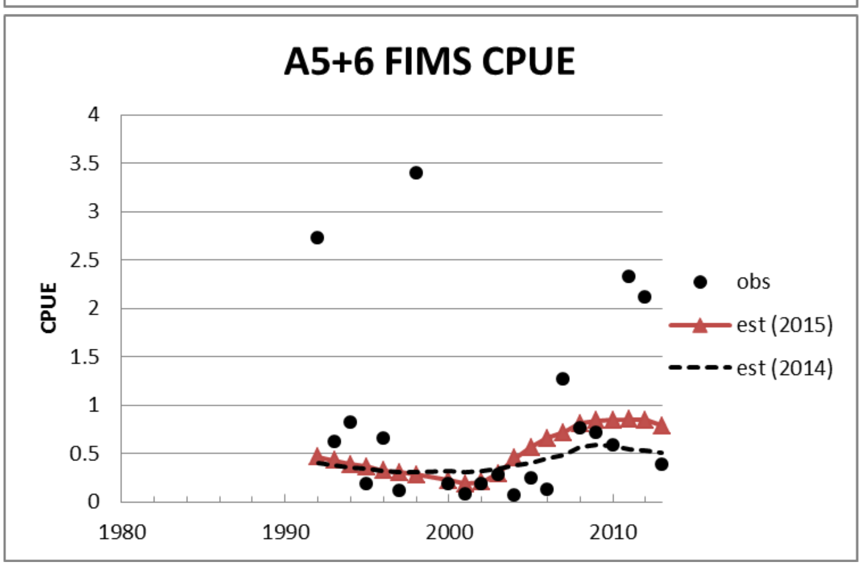
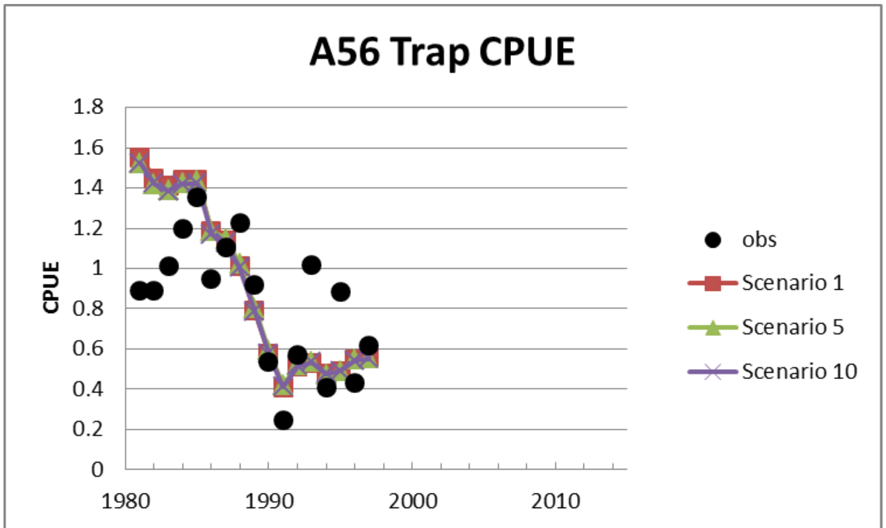
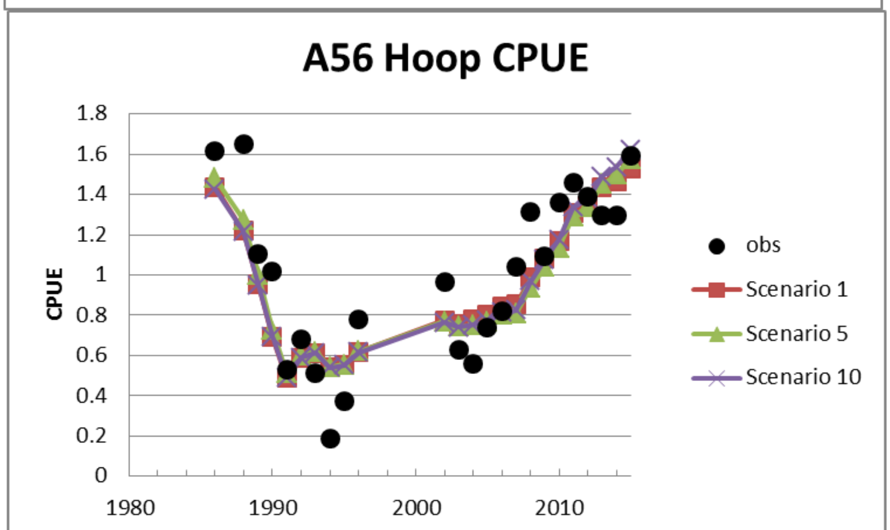


Figure 4b: **2016** fits to A5+6 CPUE data (for three poaching scenarios).





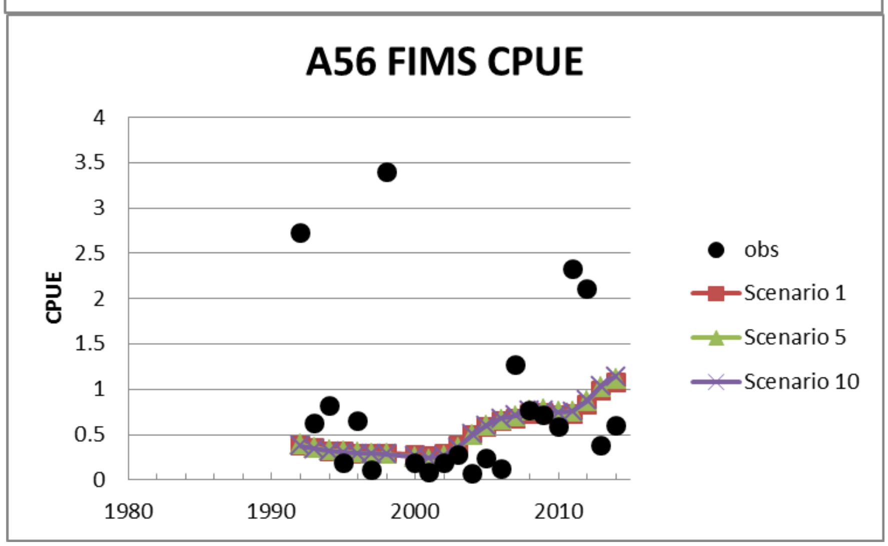
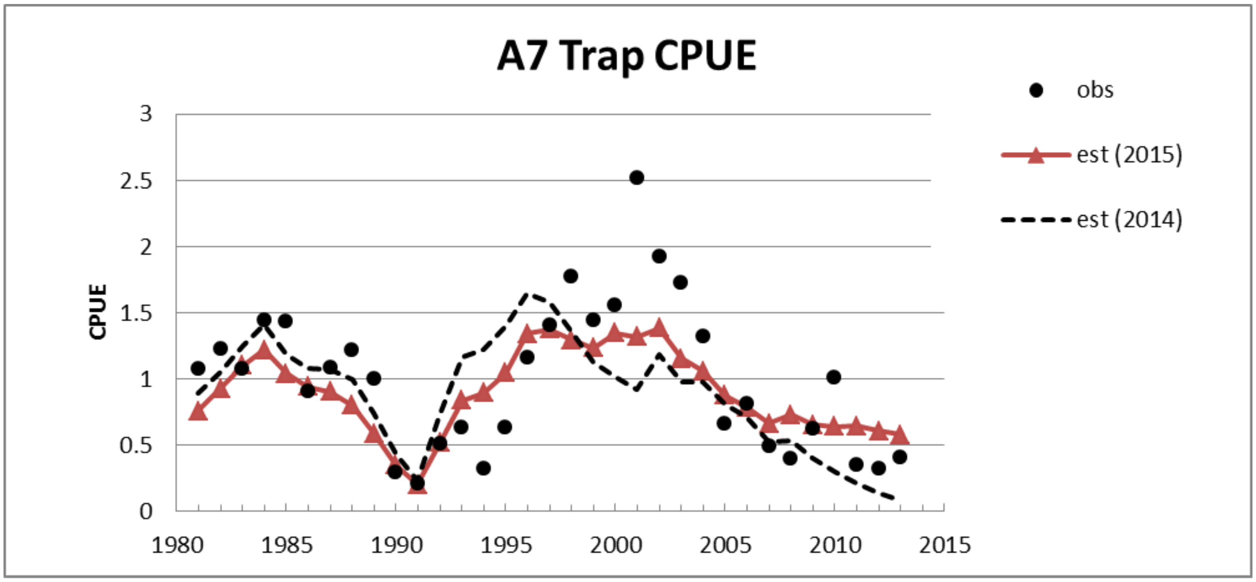


Figure 5a: 2014 and 2015 fits to A7 CPUE data.



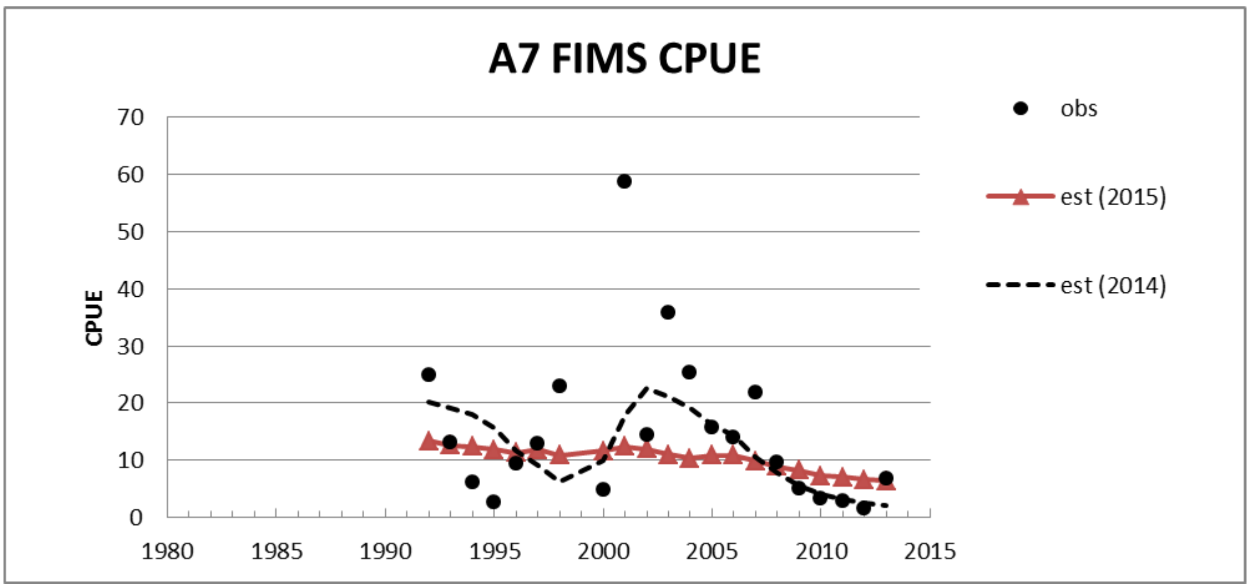
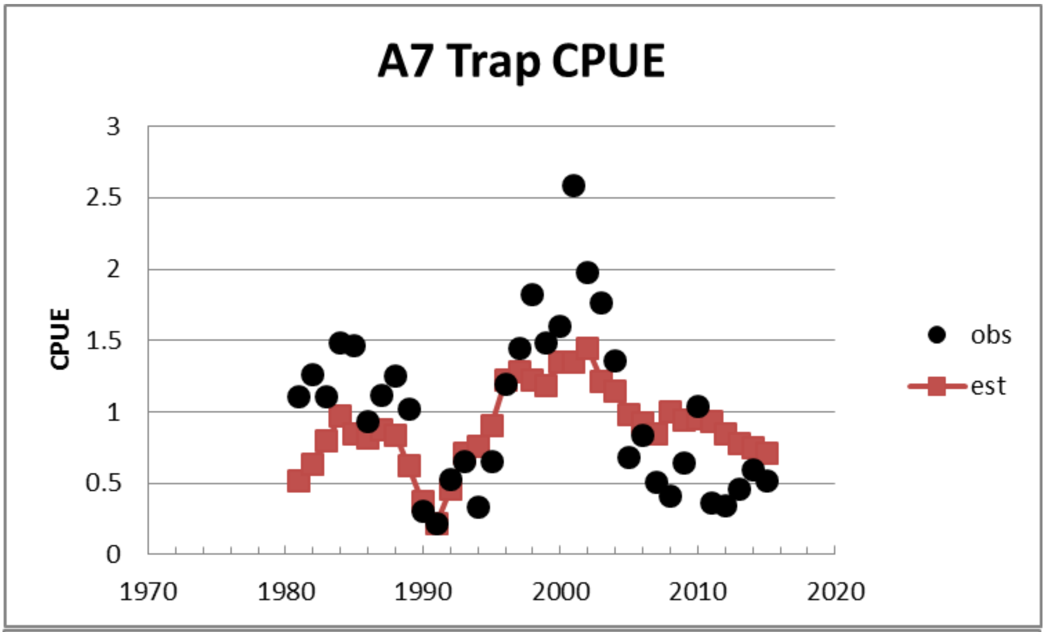


Figure 5b: **2016** fits to A7 CPUE data (for scenario 5 poaching scenario).



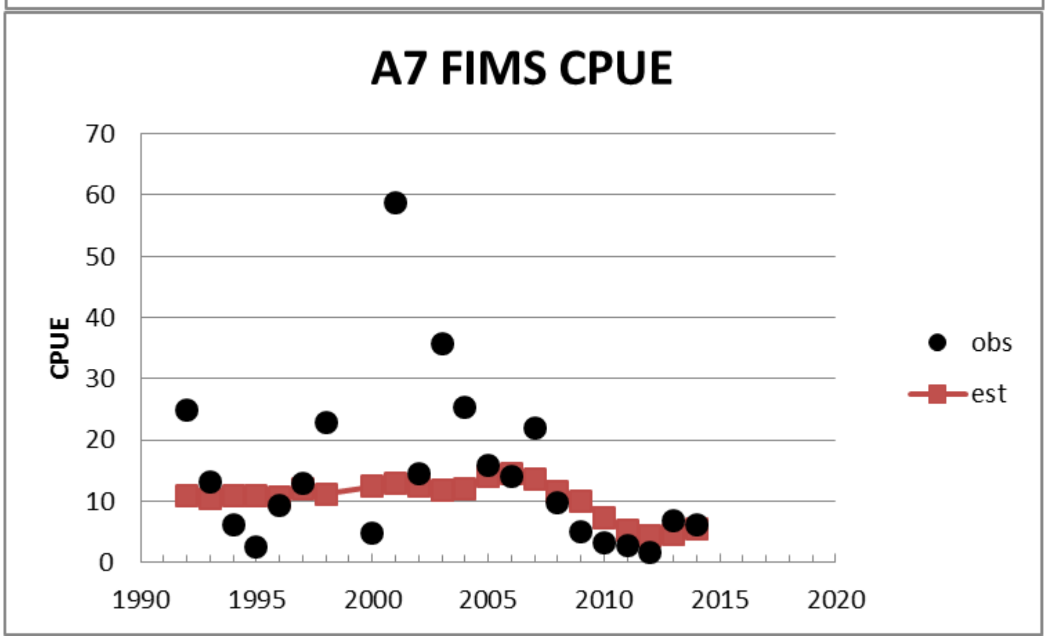
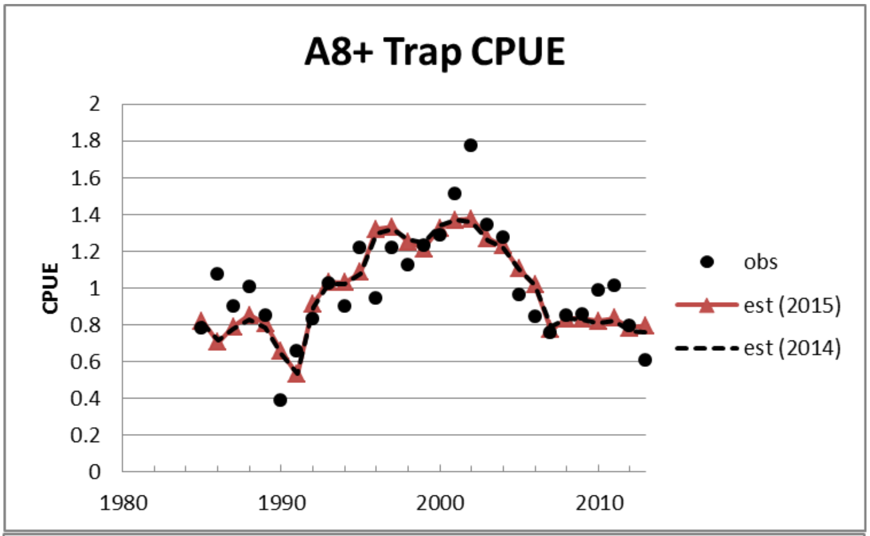
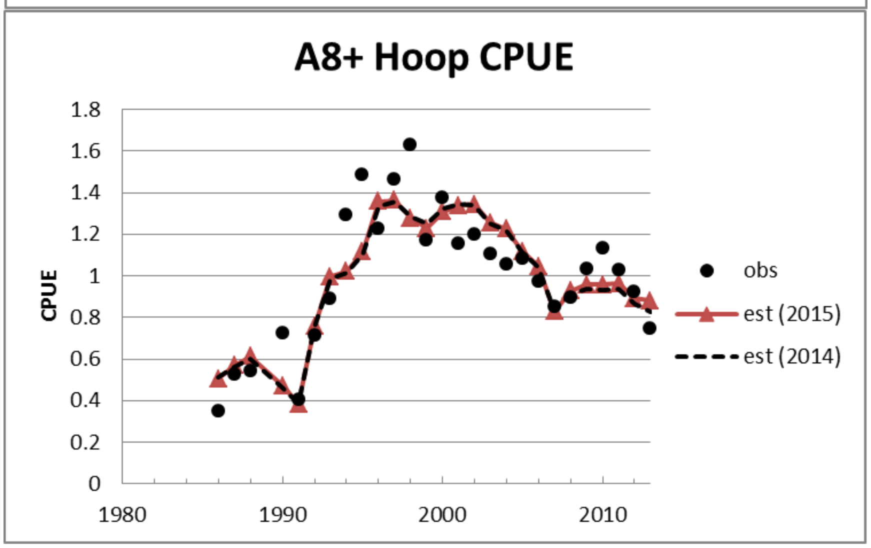


Figure 6a: 2014 and 2015 fits to A8+ CPUE data.





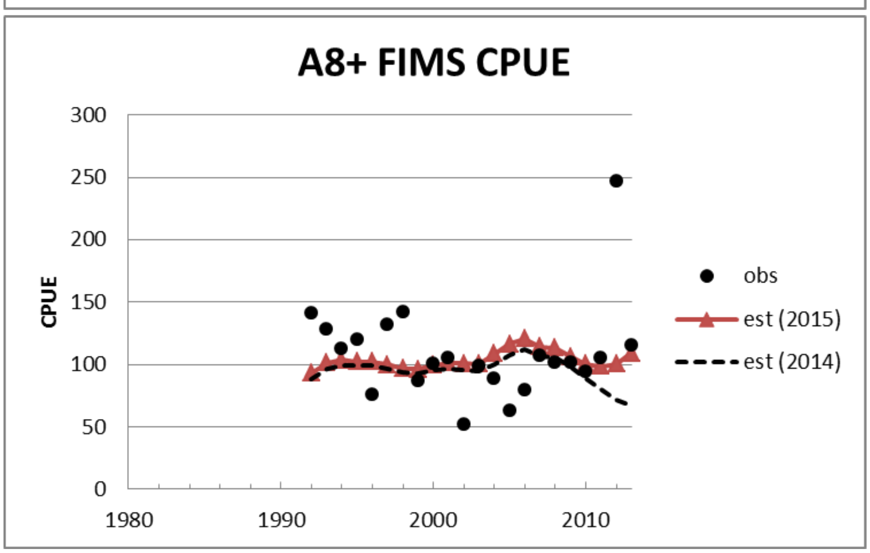


Figure 6b: **2016** fits to A8+ CPUE data (for three poaching scenarios).

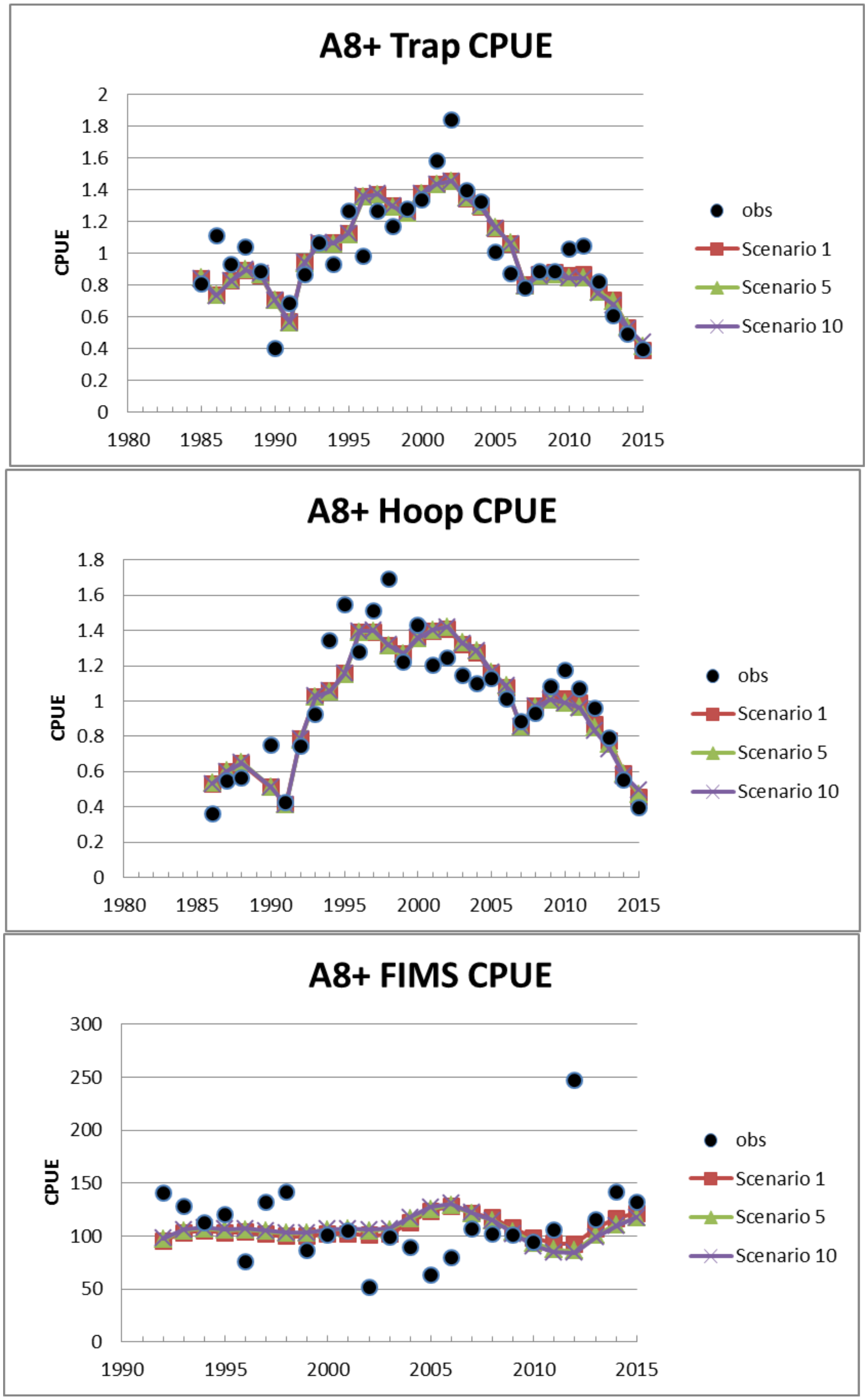


Figure 7: A8+ recruitment trends for estimated for scenario 5 for the 2016 assessment compared to that estimated for the 2015 assessment.

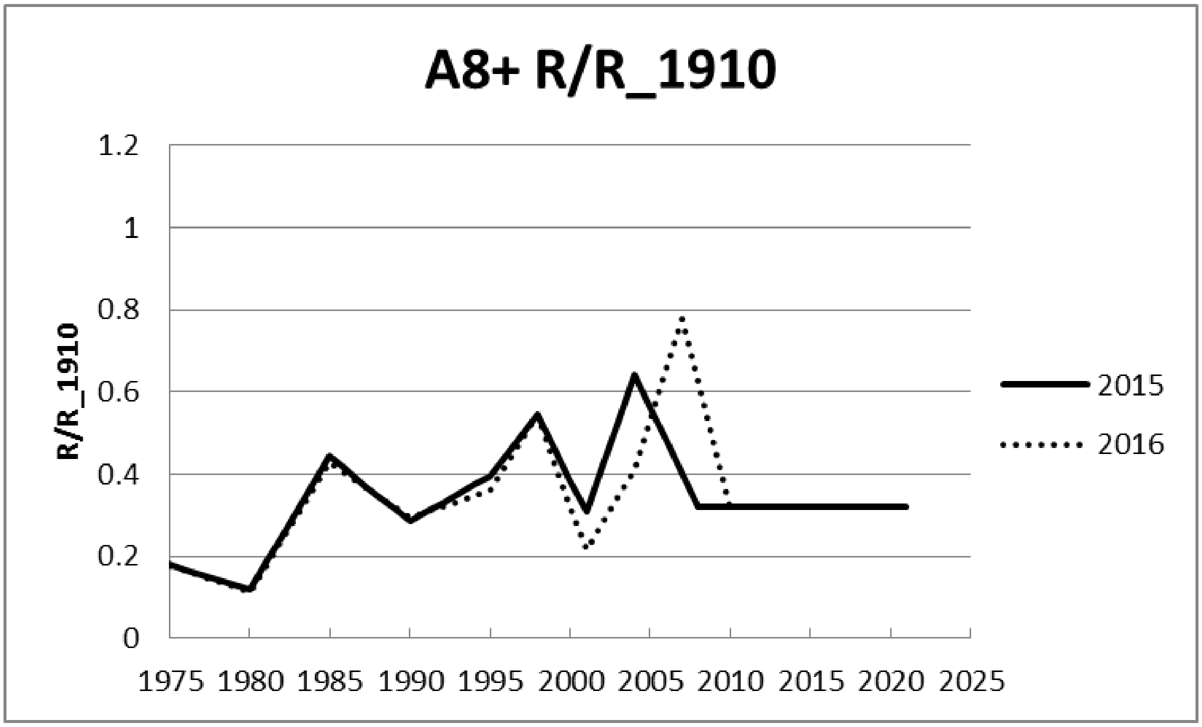
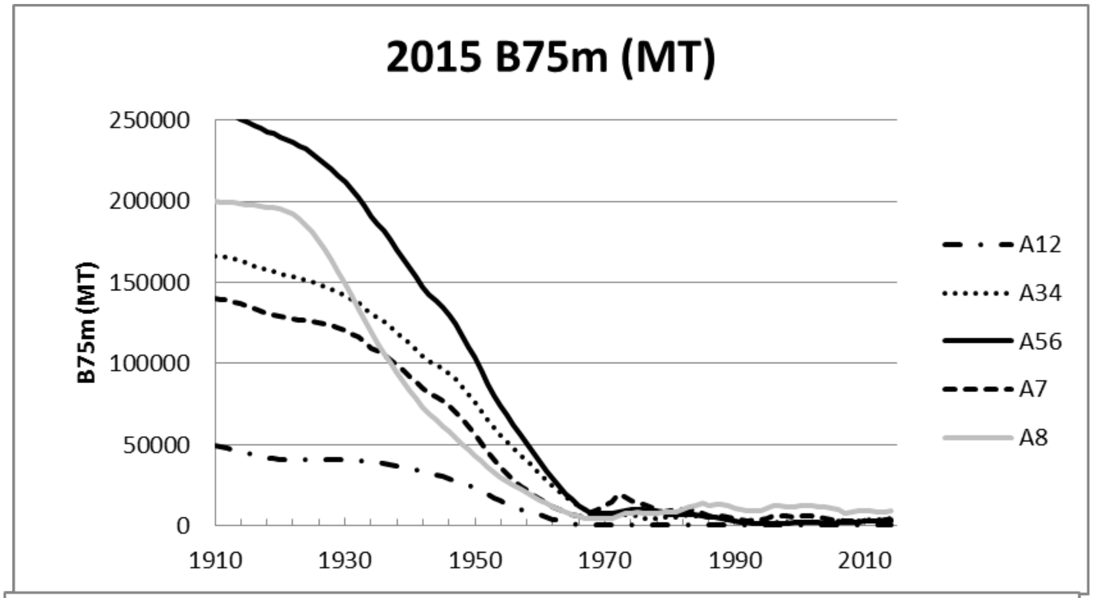


Figure 8a: Comparison of each super-area B75m contribution to overall resource biomass for the 2015 assessments for RC1 poaching scenario.



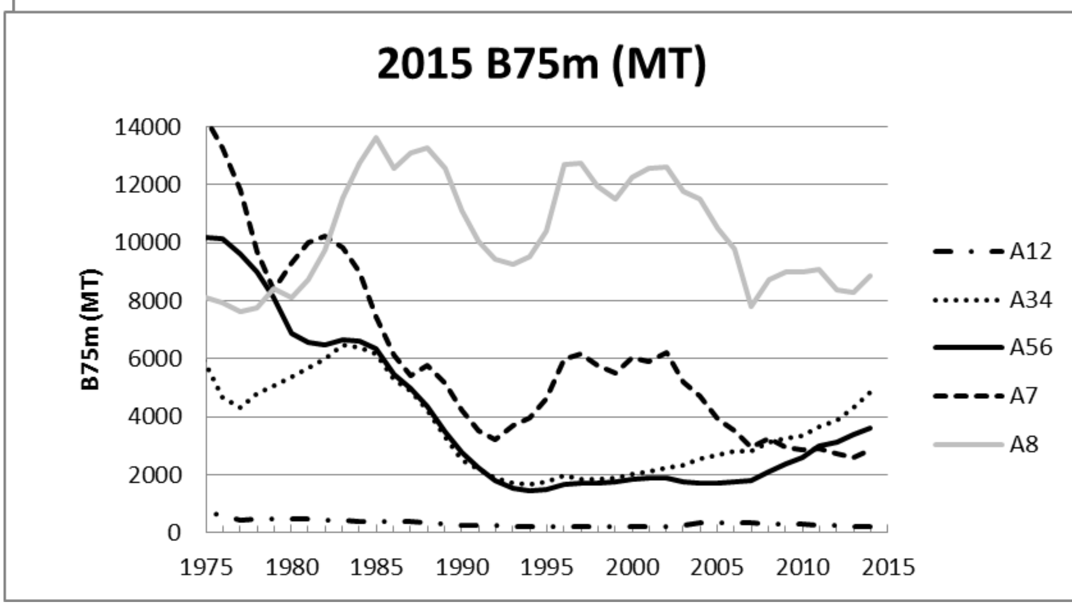
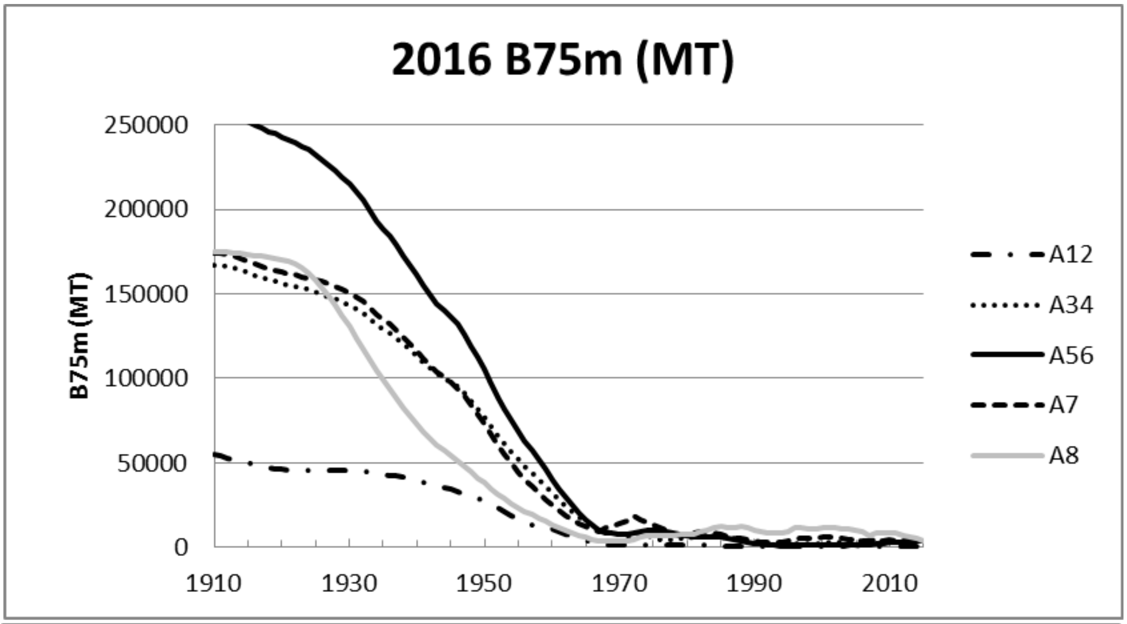


Figure 8b: Comparison of each super-area B75m contribution to overall resource biomass for the 2016 Scenario 5 (P2008=500) assessments.



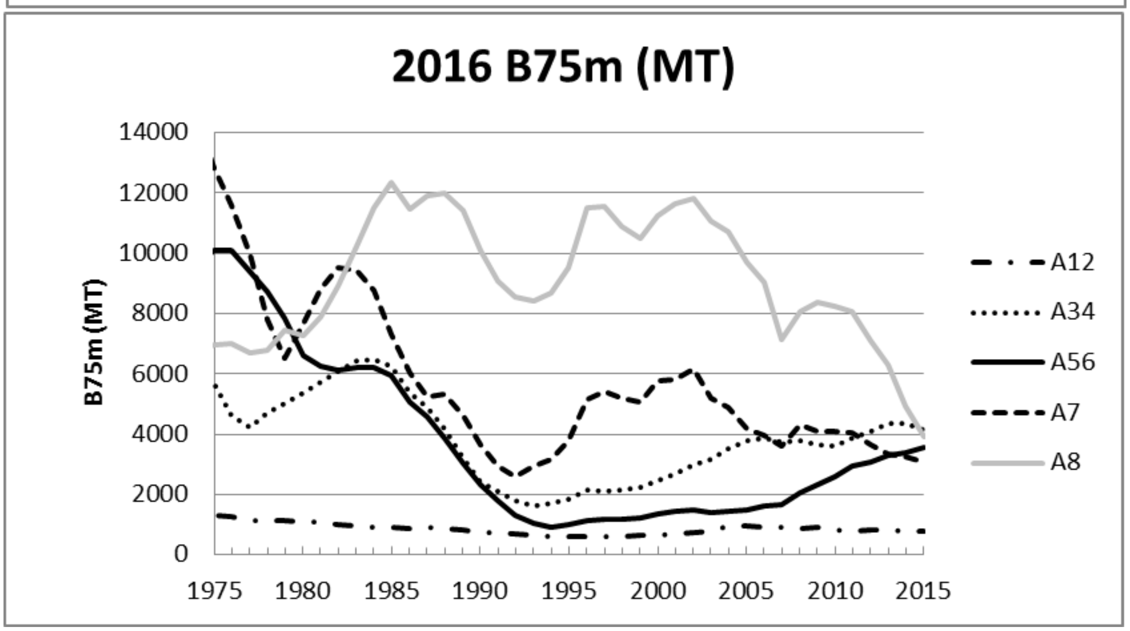


Figure 8c: Comparison of the total B75m trends estimated for the 2015 assessment and the 2016 assessment (Scenario 5 P2008=500).

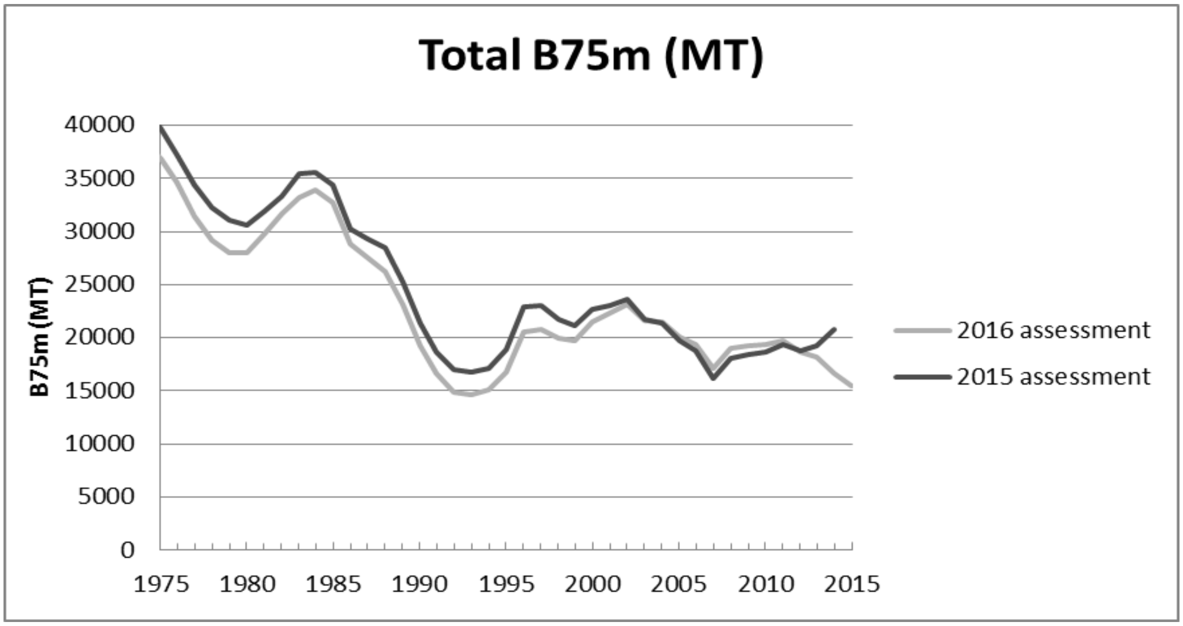


Figure 9: Comparison between the 2014, 2015 and 2016 total estimated biomass trends (B75m) and the biomass recovery target. The OMP predicted trend is as calculated earlier in 2013 following retuning of the OMP to take account of the 2012 decision not to reduce the TAC as per the recommendation from the OMP at that time.

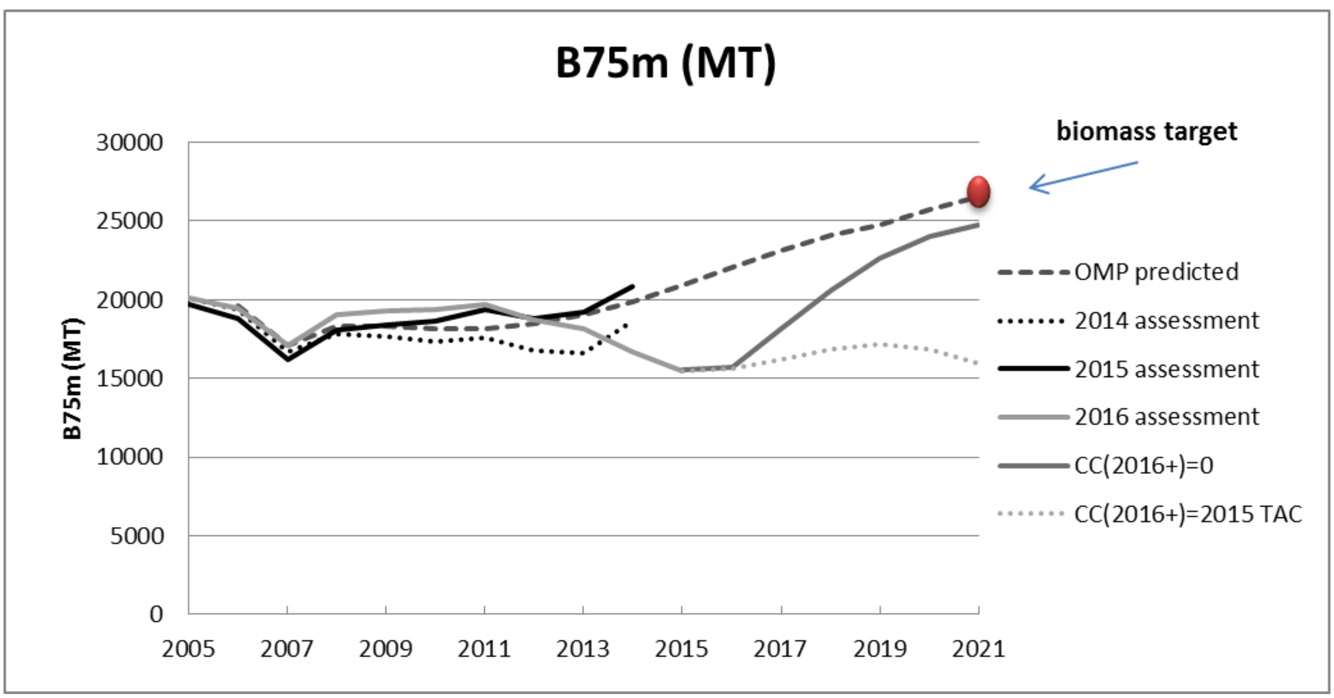
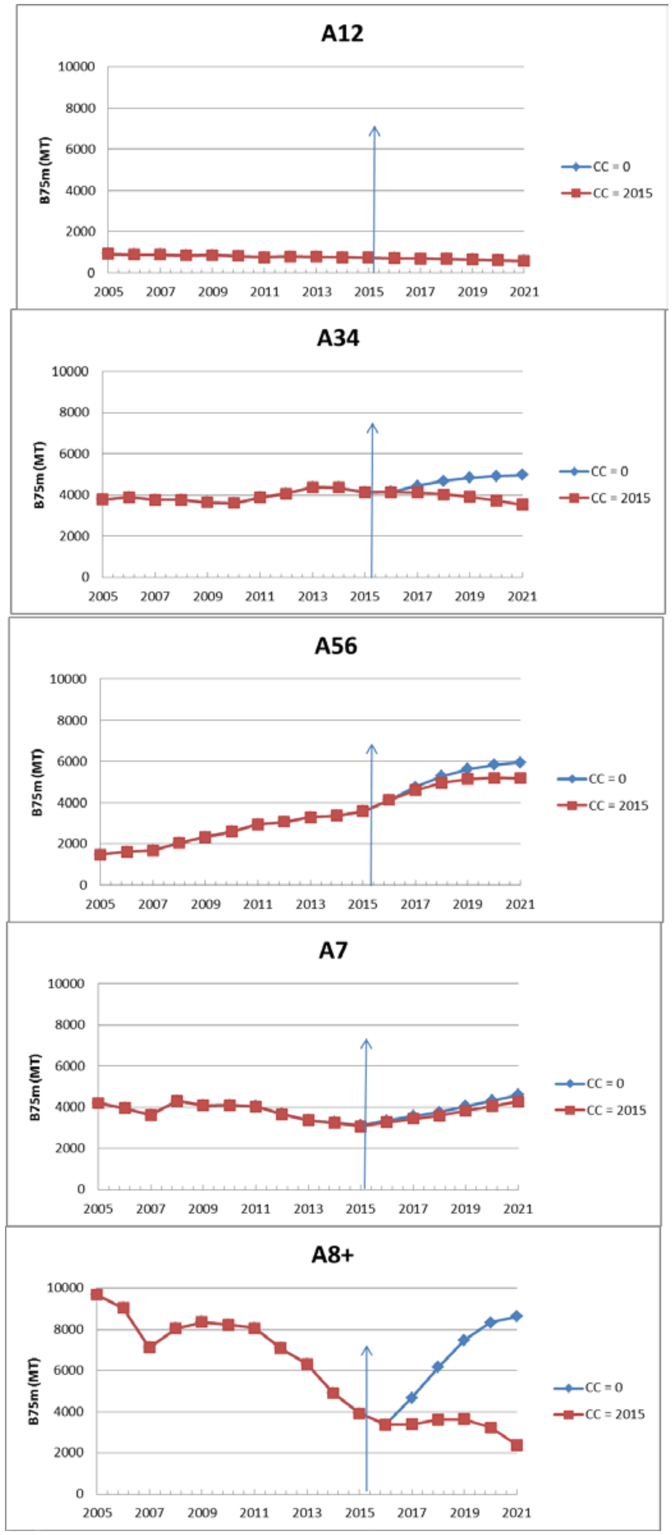


Figure 10: Biomass trajectories for the 2016 assessment (scenario 5, P2008=500) for each super-area under either a future constant catch (CC) of zero, or future CC of 2015 allocations.



Appendix A (Taken from FISHERIES/2015/MAY/SWG/WCRL/13)

Previous projection prescriptions

The baseline future scenarios, which result as combinations of uncertainties regarding future recruitment, future somatic growth, historic poaching, future poaching and current abundance are defined in Johnston and Butterworth (2014). The following are the various possible options for each scenario, with the associated weights (WT) given:

Median Future recruitment **WT**

- FRM: Geometric Mean of $R_{75}, R_{80}, R_{85}, R_{90}, R_{95}, R_{98}, R_{01}, R_{04}$ 0.60
- FRH: Maximum of $R_{75}, R_{80}, R_{85}, R_{90}, R_{95}, R_{98}, R_{01}, R_{04}$ 0.30
- FRL: Minimum of $R_{75}, R_{80}, R_{85}, R_{90}, R_{95}, R_{98}, R_{01}, R_{04}$ 0.10

Note however that the FRL excludes certain extreme estimates which are A12 R_{01} and R_{04}, and A7 R_{80}. [These exclusions were updated slightly from the 2014 assessments.]

Future recruitment

For FHM future R_y: where y = 2008, 2010, 2015 and 2020; linearity between each of these years (and between 2008 and 2010).

Stochastic: R_y randomly selected from $\bar{R}\, e^{\varepsilon_y}$, where,

$$\ln \bar{R} = \frac{1}{8}\left(\ln R_{75} \ldots \ln R_{04}\right)$$

$$\sigma = \text{SD of } \left(\ln R_{75}, \ldots \ln R_{04}\right)$$

$$\varepsilon_y \sim N(0, \sigma^2)$$

or for FRH and FRL, the $\bar{R}$ was replaced by either the maximum or minimum R between $R_{75}, R_{80}, R_{85}, R_{90}, R_{95}, R_{98}, R_{01}, R_{04}$ (with the exceptions noted above).

Future Somatic growth (2014+)

WT

- FSGL: = the 1989-2013 average 0.80
- FSGM: ↑ linearly to 1968-2013 by 2020 0.20

[The above applied to the growth rates for Areas 3+4, 5+6, 7 and 8+. The somatic growth rate for Area 1-2 is assumed to remain constant in the future at the 1989-2013 average level for all scenarios.]

Current Abundance levels

- For the RC model R_{2004} is an estimable parameter, although it is found to be estimated with very low precision. ALTL and ALTH models correspond exactly to the RC model, except for R_{2004} which is fixed at the (approximate) upper and lower 25%iles of this distribution as follows:

$$\ln R_{2004}^{ALTH} = \ln \hat{R}_{2004}^{RC} + \sigma\alpha \qquad (29)$$

and

$$\ln R_{2004}^{ALTL} = \ln \hat{R}_{2004}^{RC} - \sigma\alpha \qquad (30)$$

where σ is from equation (4) below, and the α value (0.741) corresponds to the 25%iles of a *t*-distribution with the appropriate number of degrees of freedom.

$$\ln \overline{R} = \frac{1}{8}\sum_{y=1975}^{2004} \ln R_y \qquad (31)$$

$$\sigma^2 = \frac{1}{7}\sum_{y=1975}^{2004} \left(\ln \overline{R} - \ln R_y\right)^2 \qquad (32)$$

	WT
• RC: Best Estimate of R_{2004}	0.50
• ALTL: Estimated lower 12.5%ile for R_{2004}	0.25
• ALTH: Estimated upper 12.5%ile for R_{2004}	0.25

Historic Poaching

	WT
• HP1: Total historic poaching levels from 1990 to 2008 are 500 MT	0.65
• HP2: Total historic poaching levels from 1990 to 2008 are 250 MT	0.35

Future poaching scenarios – relate to the % change in the poaching level for each super-area between 2008 and 2012. Poaching for 2013+ is assumed to remain at the 2012 level.

The six scenarios to cover different options (with different weights) defined are:

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario6**	**Weighted Average**
Weighting	40	10	20	20	5	5	100
4-yr % change for A3-6	-50	-50	-50	0	0	0	-35%
4-yr % change for A8+	+75	+25	+125	+75	+25	+125	+80
% change in total amount poached	+50	+10	+90	+60	+20	+100	+57

Note: The Super-Area breakdowns of future poaching levels are assumed to be unchanged and are:

Super-area 1+2 = 1%

Super-area 3+4 = 2.5 %

Super-area 5+6 = 2.5%

Super-area 7 = 14%

Super-area 8+ = 80%