Appendix C:

Addressing the biomass scaling issue for the Aleutian Islands Golden King Crab model based assessment

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At the September 2015 CPT meeting, the CPT requested the authors to address the golden king crab biomass scaling issue. We addressed this issue in the main document (draft 5) and extended it in this document. The scaling issue is addressed in the following ways:

1. Estimating M (yr^{-1}) in the integrated model fit and using that M (yr^{-1}) for OFL and ABC calculations (assessment model document);
2. Projecting the abundance from unfished equilibrium in 1960 to initialize the 1985/86 abundance (assessment model document);
3. Using dome shaped total selectivity (assessment model document);
4. Predicting CPUE using the area shrinkage factor (assessment model document); and
5. Identifying the data components to be down weighted based on the component negative log likelihoods vs. OFL plot (this document).

In this document, we explored the total and component negative log likelihood values for different levels of fixed OFL separately for EAG and WAG (Figure C.1). For this analysis, we added the following OFL likelihood penalty (P_{OFL}) to the total likelihood:

$$P_{OFL} = \lambda_{OFL}[\ln(OFL) - \ln(K)]^2 \qquad \text{(C.1)}$$

where $\lambda_{OFL} = \frac{0.5}{\ln(1+CV^2)}$ and CV is set to a small value of 0.02 to get the predicted OFL value very close to the input value of K (i.e., input OFL).

Figure C.1 indicates that retained and total catch biomass and retained and total catch length composition data components for WAG produced minima at low OFL levels whereas retained and total catch biomass components for EAG produced minima at low OFL levels. Therefore, we created the scenario 17 by down weighting those components by 75% of the base weight values (i.e., for EAG and WAG: retained catch biomass likelihood weight = 125; total catch biomass likelihood weight (maximum) = 75; and groundfish bycatch biomass likelihood weight = 0.2 (base value); and for WAG: retained catch length composition likelihood weight = 0.25 and effective sample size maximum = 50; total catch length composition likelihood weight = 0.25 and effective sample size maximum = 37.5). The base weights are explained below:

The retained catch base weight (500) was selected based on the best fit to retained catch data. Higher weight is given to the retained weight component because it is the most reliable information among all available data sets. The total catch base weight was scaled to a maximum 300 based on number of observer sampled pots as per CPT suggestion. This was because total catches were estimated from observer total CPUE and fishing effort data. The ground fish bycatch base weight (0.2) was chosen based on another CPT suggestion of lowering its weight. We used the best fit criteria to choose the lower weight for the groundfish bycatch. Groundfish bycatch in the golden king crab fisheries is very minor.

The base input effective sample sizes for retained catch, total catch, and groundfish bycatch size compositions were computed using the set of equations A.21 provided in Appendix A of the main assessment document (draft 5). The effective sample sizes were scaled to maximum values of 200, 150, and 25 for retained catch, total catch, and groundfiah discarded catch size compositions, respectively. The maximum values were chosen based on best fit to size composition data.

The scenario 17 results are shown in various tables and figures below. In most tables and figures, we compared scenario 17 results with that of the base scenario (scenario 1). We recommend scenario 17 to be included with the other three suggested scenarios (1, 10, and 16).

Aside from scenario 17 related figures we included a TAC achievement figure during the post rationalization period in the context of OFL and ABC estimates presented in the model based assessment documents. Figure C.19 indicates that the TAC was not achieved in a number of years in WAG. However, the non-achievement of WAG TAC in 2006/07–2008/09 has been attributed to “a mismatch of processor share holdings and processing capacity” in the WAG fishery during 2006/07–2008/09, but the non-achievement in 2014/15 is difficult to explain.

EAG (Tier 4):

Biomass, total OFL, and ABC for the next fishing season in million pounds.

Scenario	Tier	MMB_{ref}	Current MMB	MMB/ MMB_{ref}	F_{OFL}	Years to define MMB_{ref}	γ	M (yr^{-1})	OFL	ABC (P*=0.49)
17	4a	14.667	20.397	1.39	0.23	1986–2015	1	0.23	3.579	3.562

Biomass in 1,000 t; total OFL and ABC for the next fishing season in t.

Scenario	Tier	MMB_{ref}	Current MMB	MMB/ *MMBref*	F_{OFL}	Years to define MMB_{ref}	γ	M (yr^{-1})	OFL	ABC (P*=0.49)
17	4a	6.653	9.252	1.39	0.23	1986–2015	1	0.23	1,623.595	1,615.630

WAG (Tier 4):

Biomass, total OFL, and ABC for the next fishing season in million pounds.

Scenario	Tier	MMB_{ref}	Current MMB	MMB/ MMB_{ref}	F_{OFL}	Years to define MMB_{ref}	γ	M (yr^{-1})	OFL	ABC (P*=0.49)
17	4a	13.672	13.852	1.01	0.23	1986–2015	1	0.23	2.493	2.481

Biomass in 1,000 t; total OFL and ABC for the next fishing season in t.

Scenario	Tier	MMBref	Current MMB	MMB/ MMBref	F_{OFL}	Years to define MMBref	γ	M (yr^{-1})	OFL	ABC (P*=0.49)
17	4a	6.202	6.283	1.01	0.23	1986–2015	1	0.23	1,130.739	1,125.376

Aleutian Islands (sum of OFL and ABC for EAG and WAG):

OFL and ABC for the next fishing season.

Scenario	OFL (million pounds)	ABC (P*=0.49) (million pounds)	OFL (1,000 t)	ABC (P*=0.49) (1,000 t)
17	6.072	6.043	2.754	2.741

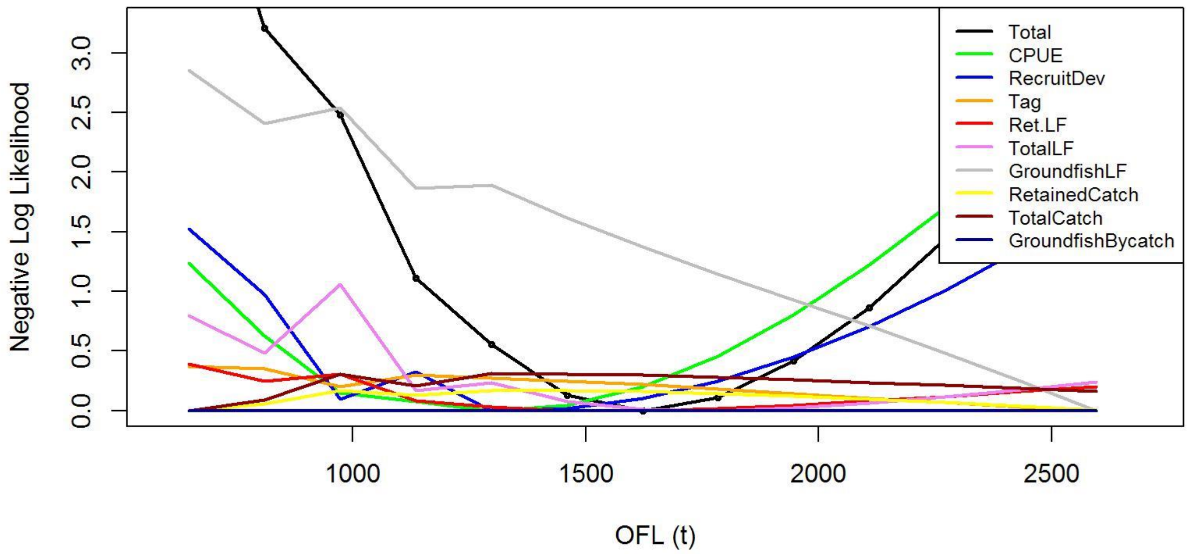
Table C.1. Parameter estimates and standard deviations with the 2015 (February 15) MMB for scenarios 1 and 17 for the golden king crab data from the EAG and WAG, 1985/86–2014/15. Recruitment and fishing mortality deviations and initial size frequency determination parameters were omitted from this list.

	EAG					**WAG**				
	Scenario 1		Scenario 17			Scenario 1		Scenario 17		
Parameter	Estimate	Std Dev	Estimate	Std Dev	Limits	Estimate	Std Dev	Estimate	Std Dev	Limits
log_ω_1 (growth incr. intercept)	2.54	0.02	2.54	0.02	1.0, 4.5	2.53	0.02	2.53	0.02	1.0, 3.85
ω_2 (growth incr. slope)	-9.30	1.77	-9.19	1.78	-12.0,-5.0	-10.54	1.74	-11.49	1.77	-60.0,-2.0
log_a (molt prob. slope)	-2.50	0.07	-2.50	0.07	-4.61,-1.39	-2.46	0.06	-2.33	0.07	-4.61,-1.39
log_b (molt prob. L50)	4.95	0.01	4.95	0.005	3.87,5.05	4.95	0.004	4.95	0.004	3.87,6.0
σ (growth variability std)	3.68	0.10	3.68	0.10	0.1,12.0	3.66	0.10	3.65	0.10	0.1,9.0
log_total sel deltaθ, 1985-04	3.38	0.13	3.38	0.12	0.,4.4	3.27	0.11	3.36	0.24	0.,4.4
log_ total sel deltaθ, 2005-14	3.10	0.19	3.06	0.19	0.,4.4	2.87	0.18	2.65	0.47	0.,4.4
log_ ret. sel deltaθ, 1985-14	1.86	0.08	1.88	0.08	0.,4.4	1.73	0.06	1.71	0.19	0.,4.4
log_tot sel θ_{50}, 1985-04	4.83	0.02	4.83	0.02	4.0,5.0	4.83	0.01	4.78	0.04	3.98,5.1
log_tot sel θ_{50}, 2005-14	4.92	0.02	4.93	0.02	4.0,5.0	4.86	0.01	4.84	0.02	3.98,5.5
log_ret. sel θ_{50}, 1985-14	4.91	0.002	4.91	0.003	4.0,5.0	4.91	0.002	4.91	0.004	4.85,4.98
log_β_r (rec.distribution par.)	-0.73	0.25	-0.72	0.25	-12.0, 12.0	-0.71	0.30	0.50	1.06	-12.0, 12.0
logq2 (catchability 1985-04)	-0.63	0.11	-0.64	0.11	-9.0, 2.25	-0.37	0.10	-0.70	0.16	-9.0, 2.25
logq3 (catchability 2005-14)	-0.96	0.21	-1.01	0.21	-9.0, 2.25	-0.92	0.14	-1.09	0.16	-9.0, 2.25
log_mean_rec (mean rec.)	0.90	0.05	0.90	0.05	0.01, 5.0	0.83	0.05	0.84	0.06	0.01, 5.0
log_mean_Fpot (Pot fishery F)	-1.07	0.10	-1.06	0.09	-15.0, -0.01	-1.06	0.08	-1.23	0.12	-9.0, -0.01
log_mean_Fground (GF byc. F)	-9.51	0.39	-9.50	0.39	-15.0, -1.6	-8.87	0.38	-8.96	0.39	-15.0, -2.0
σ_e^2 (observer CPUE additional var)	0.02	0.01	0.01	0.005	0.0, 0.15	0.02	0.01	0.01	0.005	0.0, 0.15
2015 MMB	10,124	1,714	9,252	4,395		5,546	2,683	6,283	3,236	

Table C.2. Negative log-likelihood values of the fits for scenarios (Sc) 1 (equilibrium initial cond., base scenario) and 17 (weights reduced by 75%) for EAG and WAG for golden king crab. Likelihood components with zero entry in the entire rows are omitted.

	EAG			WAG		
Likelihood Component	**Sc 1**	**Sc 17**	**Sc 17 – Sc 1**	**Sc1**	**Sc17**	**Sc 17 – Sc 1**
Number of free parameters	134	134		134	134	
Data	base	base		base	base	
Retlencomp	-889.22	-889.91	-0.70	-1,004.70	-212.83	791.88
Totallencomp	-866.78	-869.61	-2.83	-984.67	-235.41	749.26
GroundFish discdlencomp	-678.72	-680.22	-1.49	-586.66	-595.18	-8.52
Observer cpue	-12.59	-14.75	-2.16	-9.43	-17.52	-8.08
RetdcatchB	8.10	6.51	-1.59	10.74	4.13	-6.60
TotalcatchB	31.77	20.31	-11.46	49.13	10.18	-38.95
GdiscdcatchB	0.01	0.01	0.00	0.01	0.01	0.00
Rec_dev	7.08	6.52	-0.56	6.66	9.83	3.17
Pot F_dev	0.01	0.01	0.00	0.03	0.03	0.00
Gbyc_F_dev	0.08	0.08	0.00	0.10	0.10	0.00
Tag	2,690.79	2,691.06	0.27	2,688.94	2,691.01	2.07
Total	290.54	270.02	-20.52	170.15	1,654.36	1,484.21

EAG



WAG:

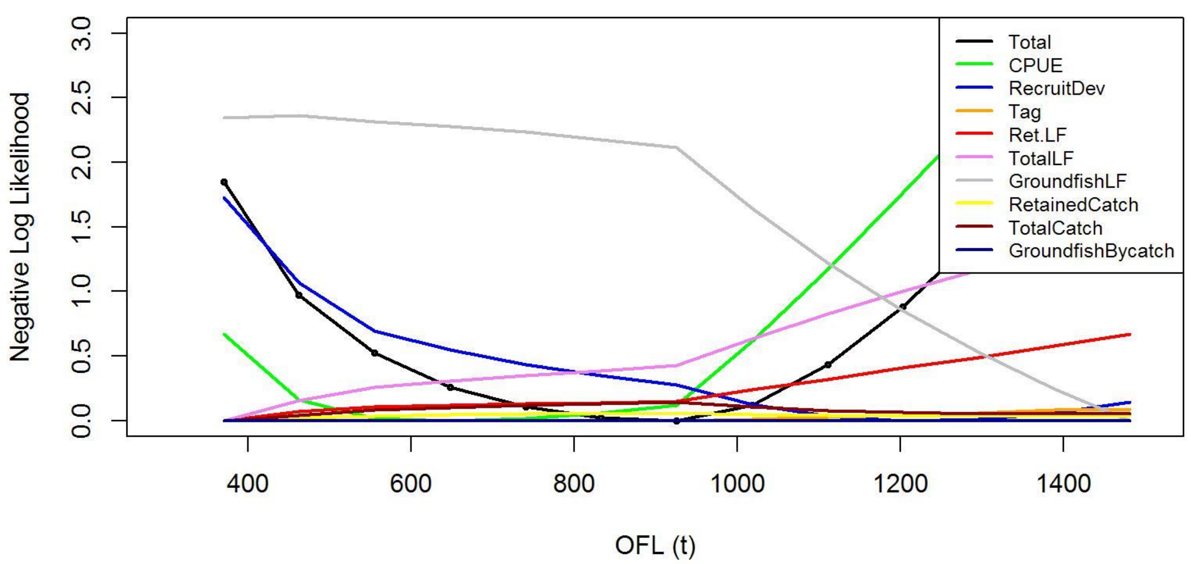


Figure C.1. Total and components negative log-likelihoods vs. OFL for the base scenario (scenario 1) model fit to 1985/86–2014/15 golden king crab data in the EAG (top panel) and WAG (bottom panel). The negative log likelihood values were zero adjusted.

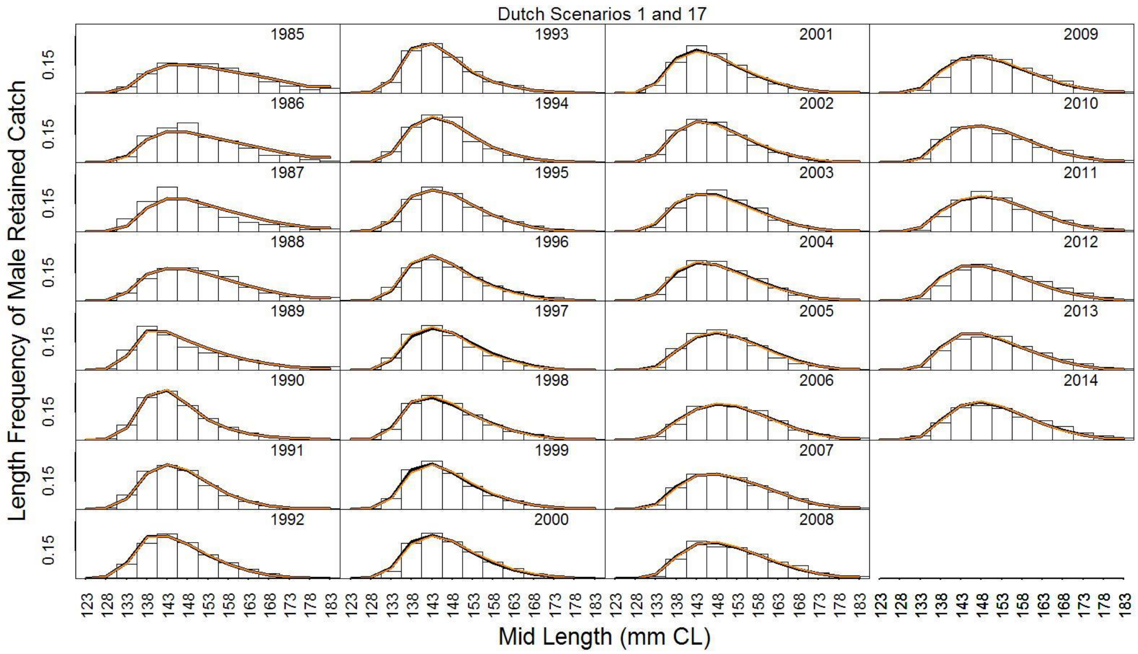


Figure C.2. Predicted (solid lines) vs. observed (bar) retained catch relative length frequency distributions for scenarios 1 (black) and 17 (orange) data of golden king crab in the EAG, 1985/86 to 2014/15.

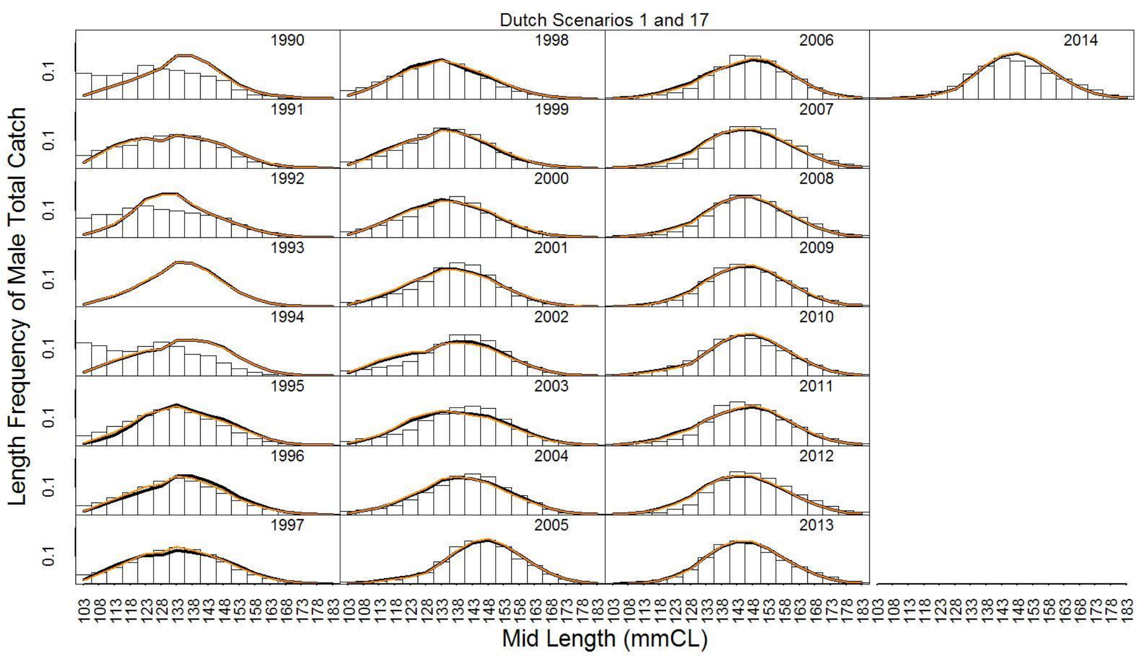


Figure C.3. Predicted (solid lines) vs. observed (bar) total catch relative length frequency distributions for scenarios 1 (black) and 17 (orange) data of golden king crab in the EAG, 1985/86 to 2014/15.

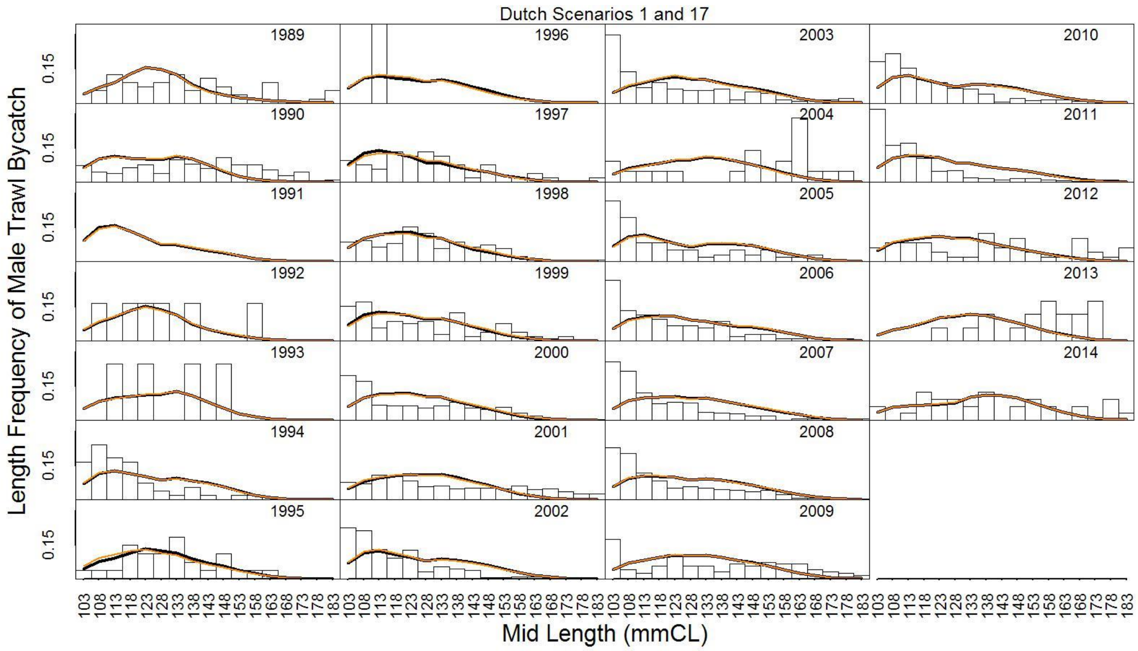


Figure C.4. Predicted (solid lines) vs. observed (bar) groundfish (trawl) discarded catch relative length frequency distributions for scenarios 1 (black) and 17 (orange) data of golden king crab in the EAG, 1985/86 to 2014/15.

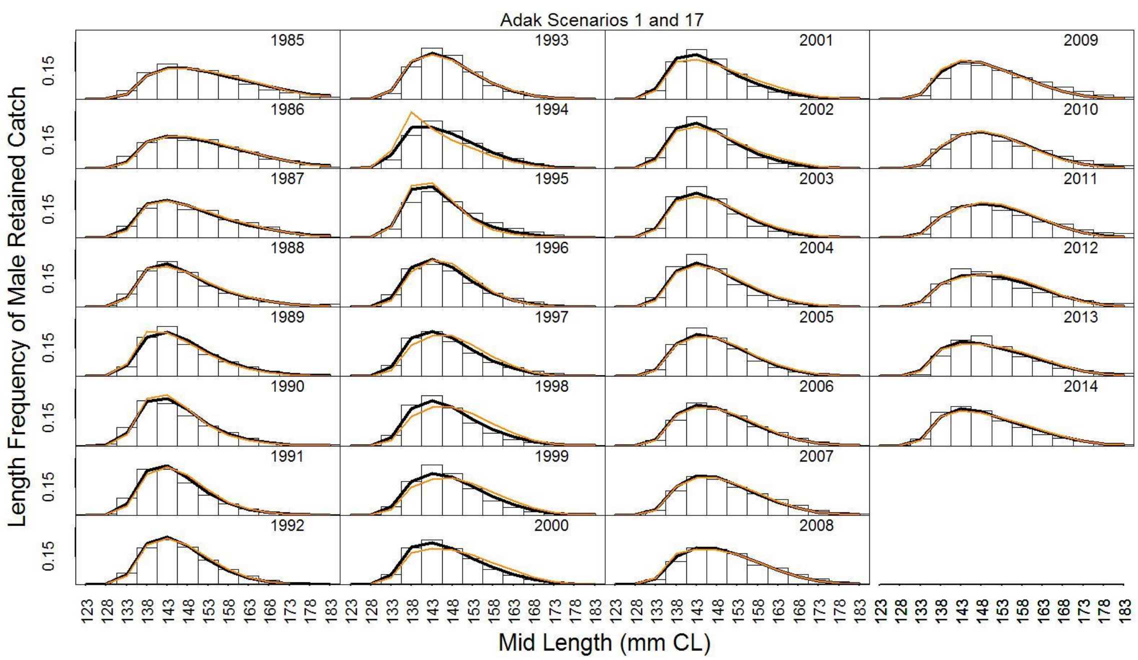


Figure C.5. Predicted (solid lines) vs. observed (bar) retained catch relative length frequency distributions for scenarios 1 (black) and 17 (orange) data of golden king crab in the WAG, 1985/86 to 2014/15.

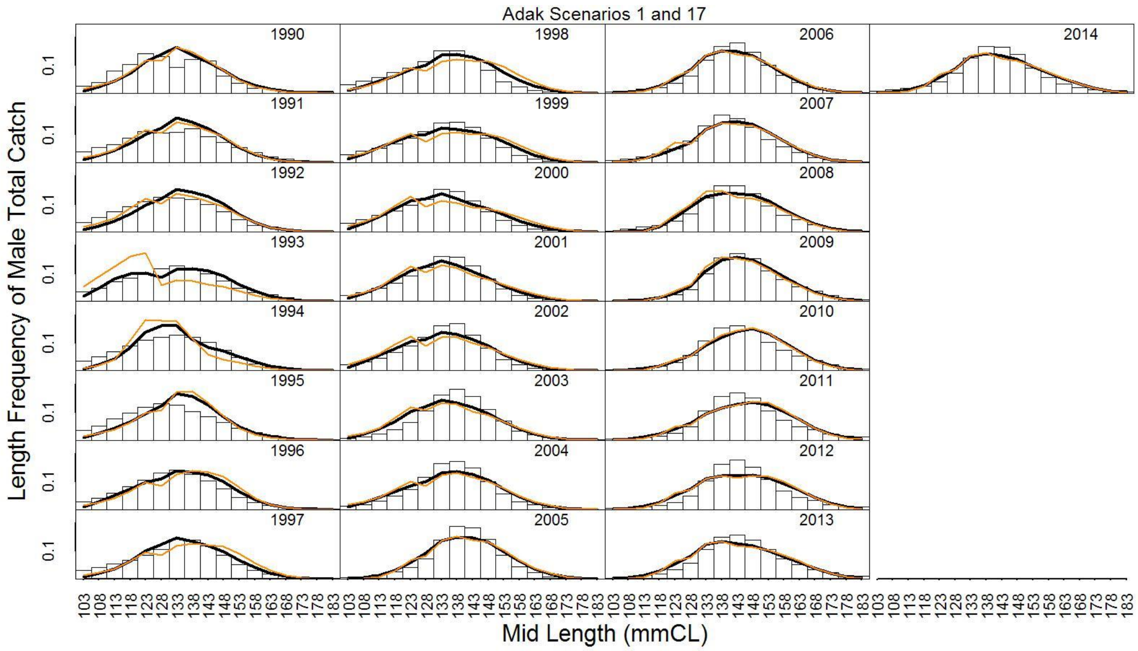


Figure C.6. Predicted (solid lines) vs. observed (bar) total catch relative length frequency distributions for scenarios 1 (black) and 17 (orange) data of golden king crab in the WAG, 1985/86 to 2014/15.

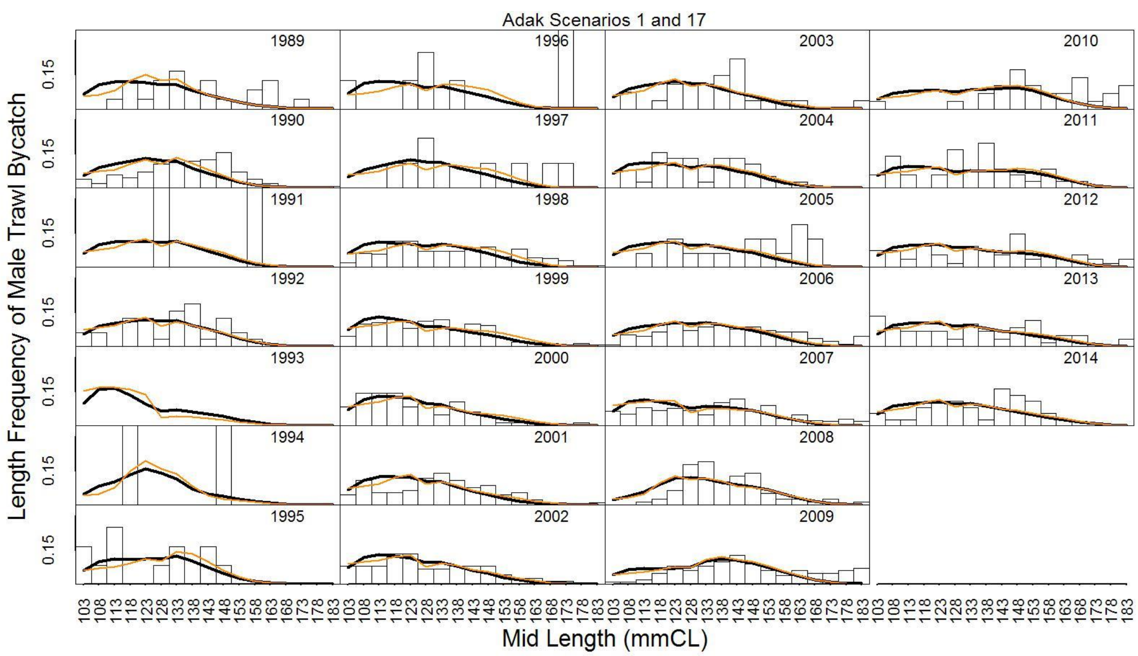


Figure C.7. Predicted (solid lines) vs. observed (bar) groundfish (trawl) discarded catch relative length frequency distributions for scenarios 1 (black) and 17 (orange) data of golden king crab in the WAG, 1985/86 to 2014/15.

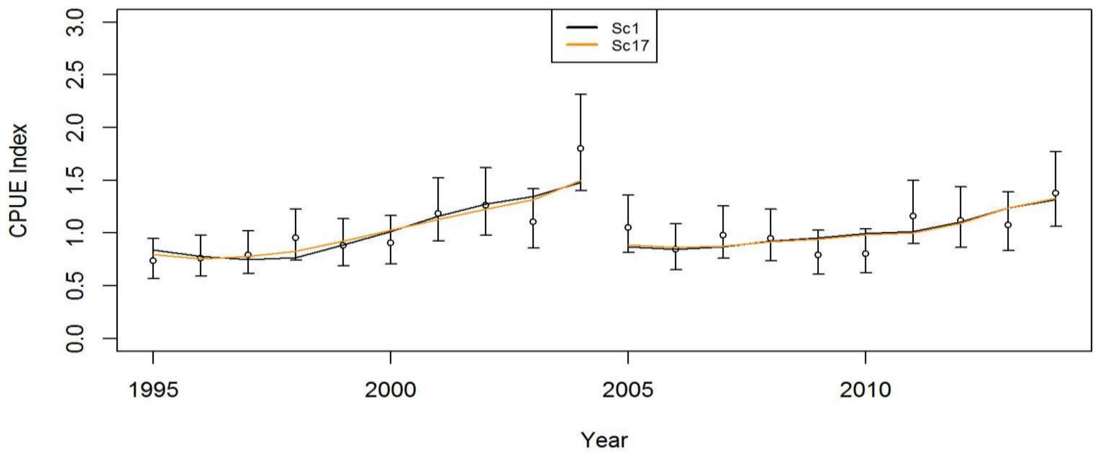


Figure C.8. Comparison of input CPUE indices (open circles with +/- 2 SE) with predicted CPUE indices (colored solid lines) for scenarios (Sc) 1 (black) and 17 (orange) fits for EAG golden king crab data, 1985/86–2014/15. Model estimated additional standard error was added to each input standard error.

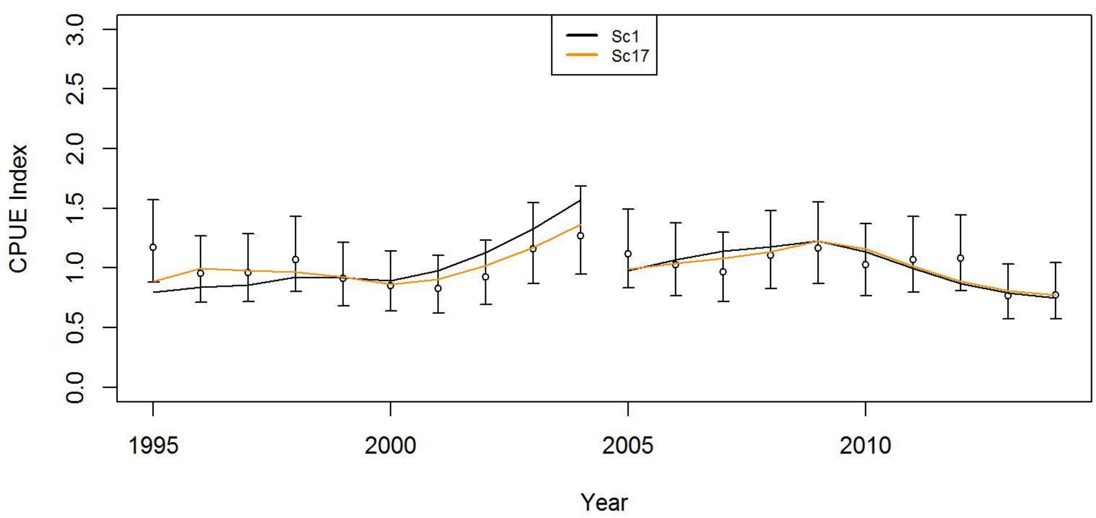


Figure C.9. Comparison of input CPUE indices (open circles with +/- 2 SE) with predicted CPUE indices (colored solid lines) for scenarios (Sc) 1 (black) and 17 (orange) fits for WAG golden king crab data, 1985/86–2014/15. Model estimated additional standard error was added to each input standard error.

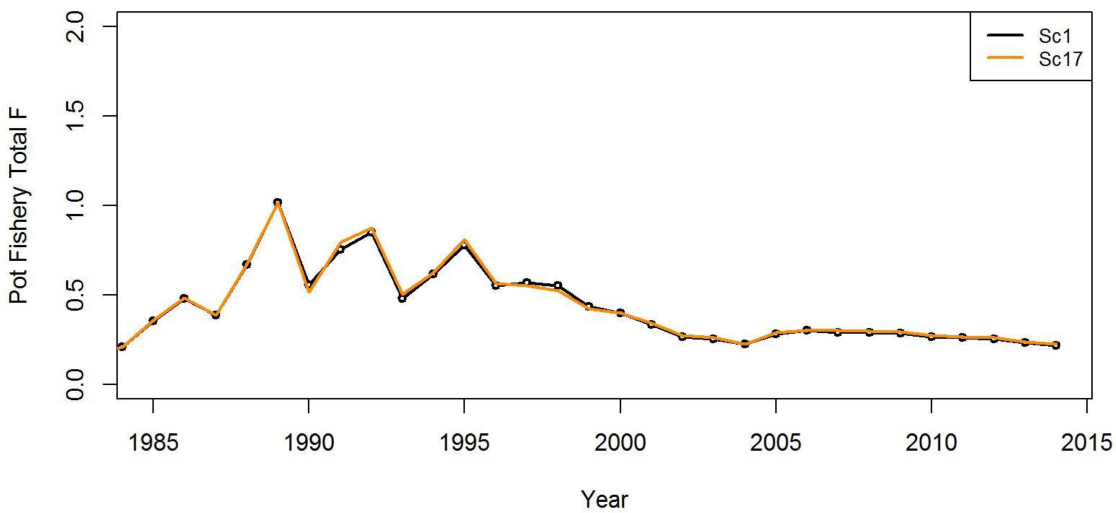


Figure C.10. Trends in pot fishery full selection total fishing mortality of golden king crab for scenarios (Sc) 1 (black solid line) and 17 (orange solid line) fits in the EAG, 1985–2014.

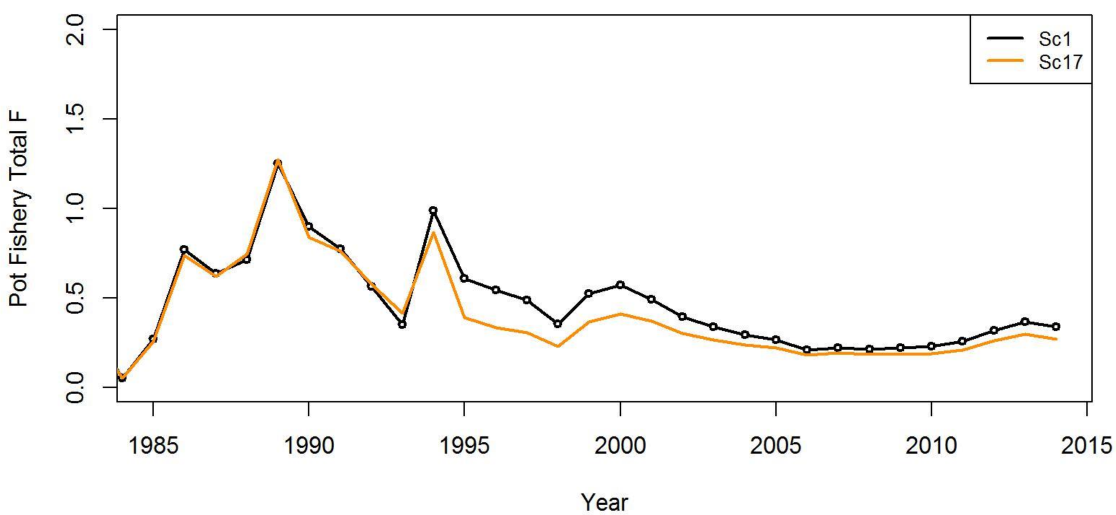


Figure C.11. Trends in pot fishery full selection total fishing mortality of golden king crab for scenarios (Sc) 1 (black solid line) and 17 (orange solid line) fits in the WAG, 1985–2014.

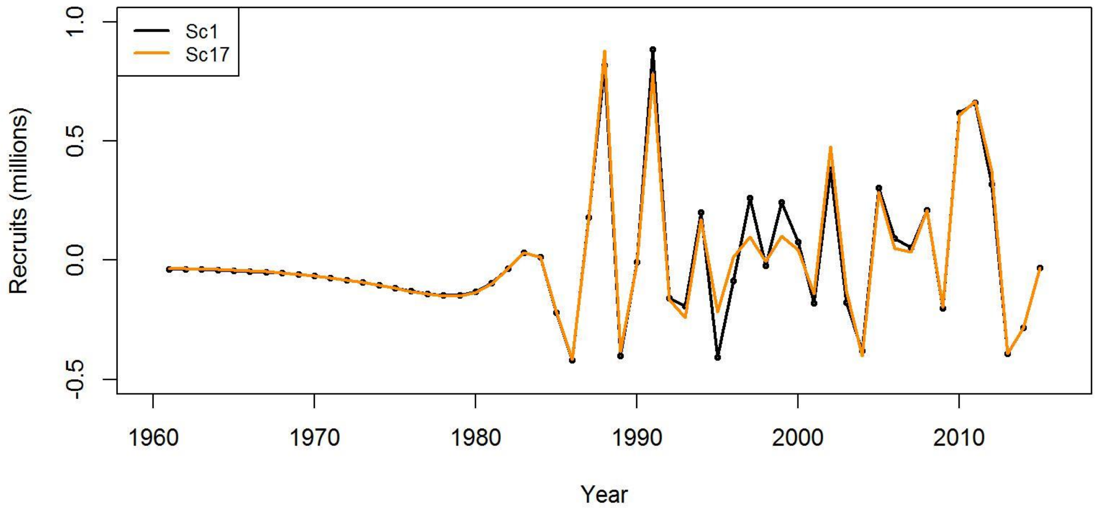


Figure C.12. . Estimated number of male recruits (millions of crab ≥ 101 mm CL) to the golden king crab assessment model for scenarios (Sc) 1 (black solid line) and 17 (orange solid line) fits in the EAG, 1961–2015. The number of recruits are centralized using (R-mean R)/mean R.

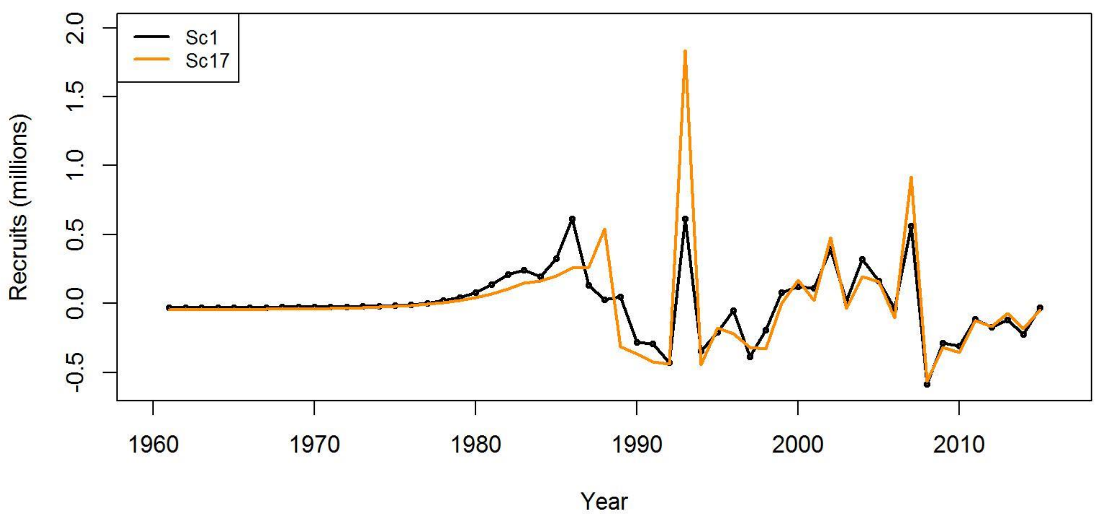


Figure C.13. Estimated number of male recruits (millions of crab ≥ 101 mm CL) to the golden king crab assessment model for scenarios (Sc) 1 (black solid line) and 17 (orange solid line) fits in the WAG, 1961–2015. The number of recruits are centralized using (R-mean R)/mean R.

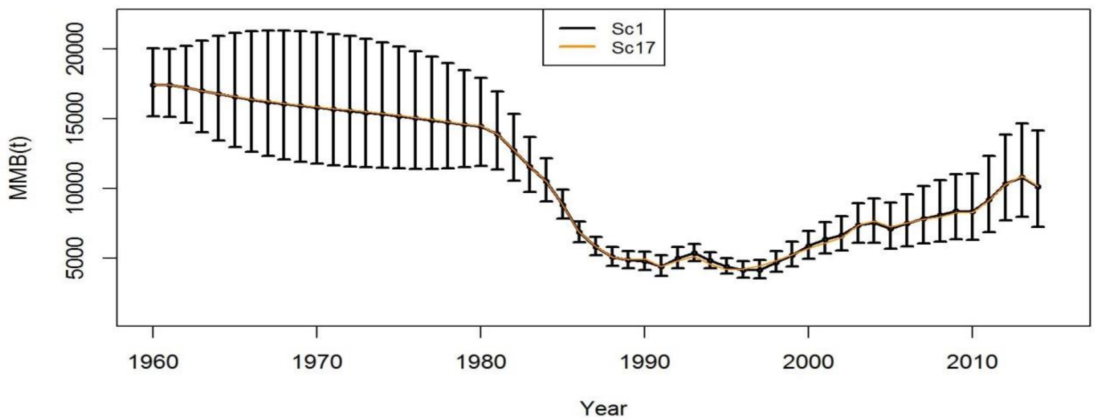


Figure C.14. Trends in golden king crab mature male biomass for scenarios (Sc) 1 (black solid line) and 17 (orange solid line) fits in the EAG, 1960/61–2014/15. Mature male crabs are ≥ 121 mm CL. Scenario 1 estimates have two standard errors confidence limits.

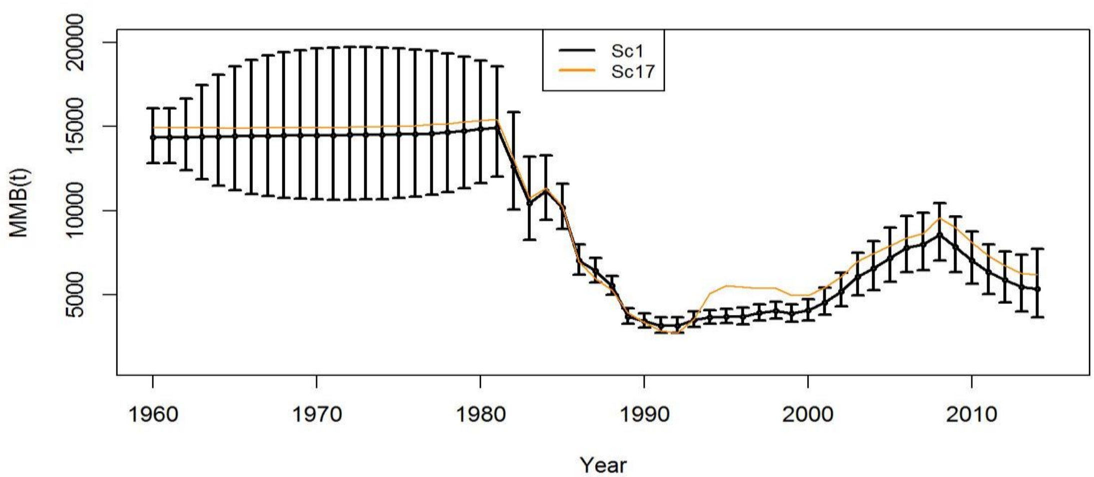


Figure C.15. Trends in golden king crab mature male biomass for scenarios (Sc) 1 (black solid line) and 17 (orange solid line) fits in the WAG, 1960/61–2014/15. Mature male crabs are ≥ 121 mm CL. Scenario 1 estimates have two standard errors confidence limits.

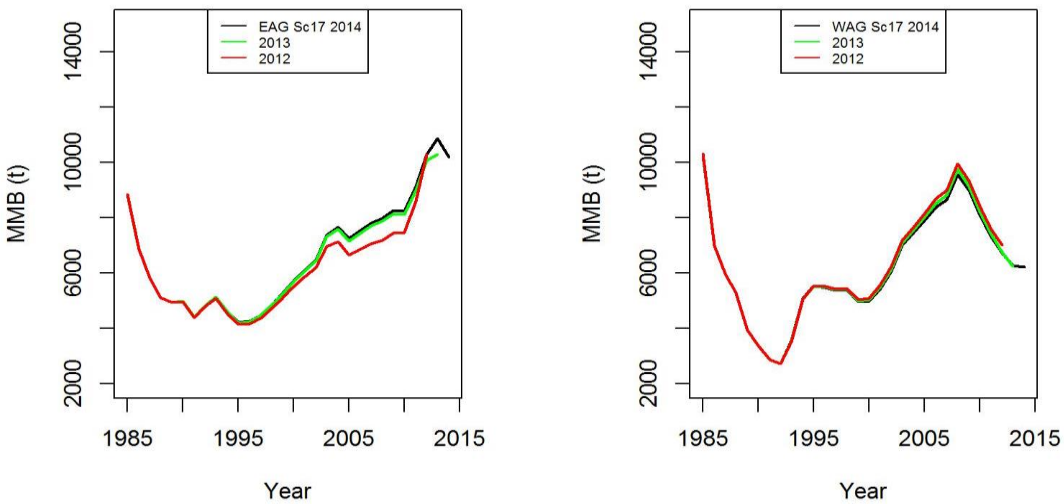


Figure C.16. . Retrospective fits of MMB by the model for removal of terminal year's data for scenario (Sc) 17 fits for golden king crab in the EAG (top left) and in the WAG (top right), 1985/86–2014/15.

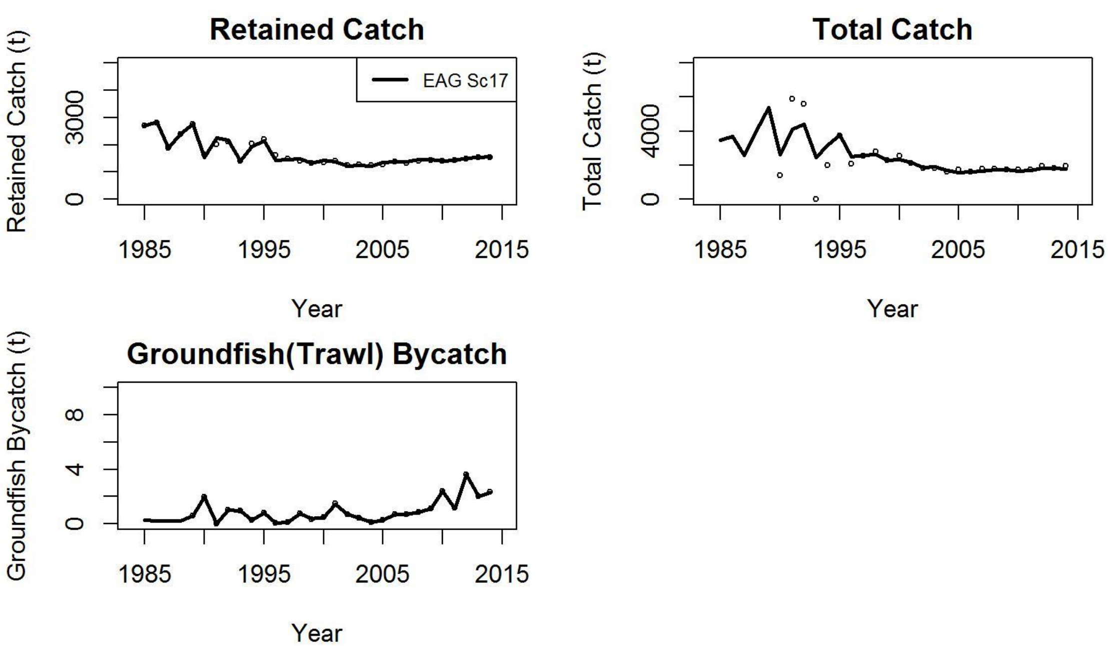


Figure C.17. Observed (open circle) vs. predicted (solid line) retained catch (top left), total catch (top right), and trawl (or groundfish) bycatch (bottom left) of golden king crab for scenario (Sc) 17 fits in the EAG, 1985/86–2014/15.

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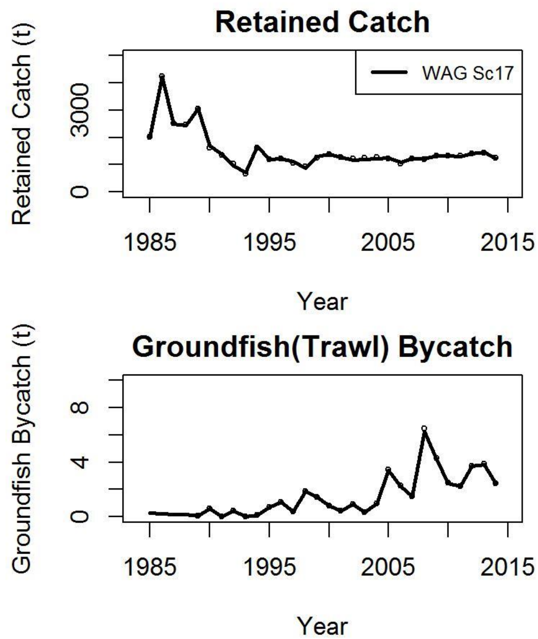

Figure C.18. Observed (open circle) vs. predicted (solid line) retained catch (top left), total catch (top right), and trawl (or groundfish) bycatch (bottom left) of golden king crab for scenario (Sc) 17 fits in the WAG, 1985/86–2014/15.

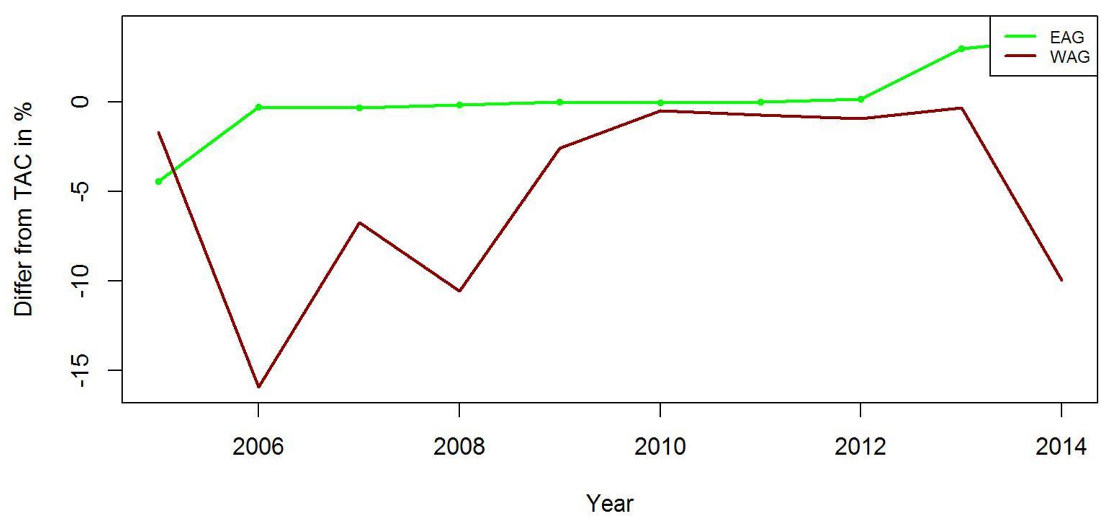

Figure C.19. Comparison of the difference between TAC and actual harvest (in percent) of golden king crab for EAG (green solid line) and WAG (dark red solid line), 2005/06–2014/15.