Appendix D: Francis re-weighting method

We considered number of fishing days as the initial input effective sample sizes (i.e., Stage-1) for retained and total size compositions and number of trips for groundfish discard catch size composition without enforcing any upper limit. Please note that we did not use the groundfish discard size compositions in any of the scenarios optimization although the predicted effective sample sizes were produced as a byproduct. We estimated the Stage-2 effective sample sizes iteratively from Stage-1 input effective sample sizes. We refer to the Stage-1 effective samples sizes for the size-composition of the retained catch, total catch, and the groundfish crab bycatch for year *t* as $\tau^{r}_{1,t}, \tau^{T}_{1,t}$, and $\tau^{Tr}_{1,t}$ respectively. The reiterated effective sample sizes' subscripts replace 1 by 2.

The Francis' (2011) mean length based method [i.e., Francis TA1.8 method, Punt (*in press*)] uses the following formulas:

Observed mean length for year *t*,

$$\overline{l_t} = \sum_{i=1}^{n} l_{t,i} \times P_{t,i} \tag{D.1}$$

Predicted mean length for year *t*,

$$\hat{\bar{l}}_t = \sum_{i=1}^{n} l_{t,i} \times \hat{P}_{t,i} \tag{D.2}$$

Variance of the predicted mean length in year *t*,

$$var\left(\hat{\bar{l}}_t\right) = \frac{\sum_{i=1}^{n} \hat{P}_{t,i}\left(l_{t,i} - \hat{\bar{l}}_t\right)^2}{S_t} \tag{D.3}$$

Francis' reweighting parameter *W*,

$$W = \frac{1}{var\left\{\frac{\bar{l}_t - \hat{\bar{l}}_t}{\sqrt{var\left(\hat{\bar{l}}_t\right)}}\right\}} \tag{D.4}$$

where $\hat{P}_{t,i}$ and $P_{t,i}$ are the estimated and observed proportions of the catch during year *t* in length-class *i*, $l_{t,i}$ is the mid length of the length-class *i* during year *t*, S_t is the effective sample size in year t, $\hat{\hat{l}}_t$ and $\overline{l_t}$ are predicted and observed mean lengths of the catch during year t, and W is the reweighting multiplier of Stage-1 sample sizes.

Francis (*in press* 2016) suggested that a good stopping criterion for the iteration process is when there are no appreciable changes in the key outputs. Hence, we considered a stopping criterion of no appreciable change (<0.01%) in W and terminal year MMB.

S_t is related to the initial input (Stage-1) effective sample size according to:

$$S_{t,i} = W_i \tau_{1,t} \qquad \text{(D.5)}$$

where $S_{t,i}$ is the effective sample size for year t in iteration i and W_i is the Francis weight calculated using Equation D.4 during iteration i.

We did the reweighting for combined data (for M estimation), individual scenarios, MMB profiles, mean MMB profile, and MMB rate of depletion profile. For brevity, we provide the iteration process for Francis Stage-2 weight calculation for individual scenarios for EAG and WAG respectively in Table D:

Table D. Iteration process for stage-2 effective sample size reweighting multiplier, *W*, by Francis method for retained, total, and groundfish discard catch size compositions of golden king crab for various scenarios for EAG and WAG. The effective sample sizes are numbers of days for retained and total catch, but number of trips for groundfish discarded catch size compositions. Note: Groundfish bycatch size compositions were not fitted to the models, but different predicted weights resulted as byproducts from different iterations. Sc. =scenario. Note: For certain scenarios we have done up to six iterations, but we provide only the last three iteration results.

Area	Sc.	Iteration No.	Retained Catch Size Comp Effective Sample Multiplier (W)	Total Catch Size Comp Effective Sample Multiplier (W)	Groundfish Discard Catch Size Comp Effective Sample Multiplier (W)	Terminal MMB (t)	M yr^{-1}
EAGpart	0a	1	0.8792	0.5080	0.4481	10,555	0.2224
		2	0.8874	0.5019	0.4486	10,556	0.2225
		3	0.8904	0.5003	0.4487	10,558	0.2225
WAGpart	0a	1	0.5041	0.4888	0.7658	4,307	0.2224
		2	0.5039	0.4889	0.7657	4,309	0.2225
		3	0.5038	0.4889	0.7657	4,309	0.2225
EAGpart	0b	1	0.8909	0.5000	0.4487	10,603	0.2241
		2	0.8918	0.4995	0.4487	10,601	0.2241
		3	0.8921	0.4994	0.4487	10,601	0.2241
WAGpart	0b	1	0.5037	0.4888	0.7651	4,334	0.2241
		2	0.5037	0.4888	0.7651	4,333	0.2241
		3	0.5037	0.4888	0.7651	4,333	0.2241
EAG	1b	1	0.8921	0.4994	0.4487	10,512	0.2208
		2	0.8915	0.4999	0.4489	10,512	0.2208
WAG	1b	1	0.5037	0.4888	0.7651	4,434	0.2308
		2	0.5034	0.4881	0.7629	4,435	0.2308
		3	0.5034	0.4880	0.7629	4,435	0.2308
EAG	1	1	0.8917	0.4996	0.4487	10,597	
		2	0.8920	0.4995	0.4488	10,597	
		3	0.8920	0.4994	0.4488	10,597	
WAG	1	1	0.5037	0.4888	0.7651	4,332	
		2	0.5037	0.4888	0.7652	4,332	
		3	0.5038	0.4888	0.7652	4,332	
EAG	2	1	0.8854	0.4955	0.4480	10,749	
		2	0.8848	0.4951	0.4479	10,749	
		3	0.8848	0.4950	0.4479	10,749	
WAG	2	1	0.5012	0.4647	0.7534	4,227	
		2	0.5017	0.4643	0.7535	4,228	
		3	0.5020	0.4642	0.7536	4,228	

EAG	3	1	0.8914	0.5285	0.4514	11,605
		2	0.8897	0.5294	0.4513	11,605
		3	0.8892	0.5296	0.4513	11,605
WAG	3	1	0.5103	0.4841	0.7639	4,333
		2	0.5110	0.4836	0.7641	4,334
		3	0.5113	0.4834	0.7642	4,334
EAG	4	1	0.9512	0.4832	0.4466	10,036
		2	0.9522	0.4828	0.4467	10,036
		3	0.9525	0.4826	0.4467	10,036
WAG	4	1	0.5227	0.4235	0.7562	3,864
		2	0.5231	0.4232	0.7563	3,865
		3	0.5232	0.4232	0.7564	3,865
EAG	5	1	0.8758	0.5070	0.4497	9,676
		2	0.8747	0.5075	0.4497	9,676
		3	0.8744	0.5076	0.4496	9,676
WAG	5	1	0.5026	0.4923	0.7760	3,826
		2	0.5018	0.4931	0.7755	3,825
		3	0.5014	0.4934	0.7754	3,824
EAG	6	1	0.8923	0.4937	0.4460	11,711
		2	0.8940	0.4929	0.4461	11,711
		3	0.8945	0.4927	0.4461	11,711
WAG	6	1	0.4983	0.4859	0.7498	4,998
		2	0.4982	0.4848	0.7496	4,999
		3	0.4983	0.4846	0.7497	4,999
EAG	7	1	0.8920	0.4994	0.4488	10,597
WAG	7	1	0.5038	0.4888	0.7652	4,332
EAG	8	1	0.8920	0.4994	0.4488	10,597
WAG	8	1	0.5038	0.4888	0.7652	4,332
EAG	9	1	0.8920	0.4994	0.4488	12,051
WAG	9	1	0.5038	0.4888	0.7652	5,005
EAG	10	1	0.8920	0.4994	0.4488	10,519
		2	0.8915	0.4999	0.4489	10,518
		3	0.8912	0.5000	0.4489	10,518
WAG	10	1	0.5038	0.4888	0.7652	4,438
		2	0.5034	0.4881	0.7628	4,438

		3	0.5034	0.4880	0.7628	4,438
EAG	11	1	0.8912	0.5000	0.4489	11,959
WAG	11	1	0.5034	0.4880	0.7628	5,128