Appendix A: Integrated model

Aleutian Islands Golden King Crab (*Lithodes aequispinus*) Stock Assessment Model Development- East of 174° W (EAG) and west of 174° W (WAG) Aleutian Island stocks

Basic population dynamics

The annual [male] abundances by size are modeled using the equation:

$$N_{t+1,j} = \sum_{i=1}^{j}[N_{t,i}e^{-M} - (\hat{C}_{t,i} + \widehat{D}_{t,i} + \widehat{Tr}_{t,i})e^{(y_t-1)M}]X_{i,j} + R_{t+1,j} \quad \text{(A.1)}$$

where $N_{t,i}$ is the number of [male] crab in length class *i* on 1 July (start of fishing year) of year *t*; $\hat{C}_{t,i}$, $\hat{D}_{t,i}$, and $\widehat{Tr}_{t,i}$ are respectively the predicted fishery retained, pot fishery discard dead, and groundfish fishery discard dead catches in length class *i* during year *t*; $\widehat{D}_{t,i}$ is estimated from the intermediate total ($\hat{T}_{t,i\,temp}$) catch and the retained ($\hat{C}_{t,i}$) catch by Equation A.2c. $X_{i,j}$ is the probability of length-class *i* growing into length-class *j* during the year; y_t is elapsed time period from 1 July to the mid –point of fishing period in year *t*; *M* is instantaneous rate of natural mortality; and $R_{t+1,j}$ recruitment to length class *j* in year *t*+1.

The catches are predicted using the equations

$$\hat{T}_{t,j,temp} = \frac{F_t s^T_{t,j}}{Z_{t,j}} N_{t,j}e^{-y_tM}(1 - e^{-Z_{t,j}}) \quad \text{(A.2a)}$$

$$\hat{C}_{t,j} = \frac{F_t s^T_{t,j} s^r_{t,j}}{Z_{t,j}} N_{t,j}e^{-y_tM}(1 - e^{-Z_{t,j}}) \quad \text{(A.2b)}$$

$$\widehat{D}_{t,j} = 0.2(\hat{T}_{t,j,temp} - \hat{C}_{t,j}) \quad \text{(A.2c)}$$

$$\widehat{Tr}_{t,j} = 0.65\frac{F^{Tr}_t s^{Tr}_j}{Z_{t,j}} N_{t,j}e^{-y_tM}(1 - e^{-Z_{t,j}}) \quad \text{(A.2d)}$$

$$\hat{T}_{t,j} = \hat{C}_{t,j} + \widehat{D}_{t,j} \quad \text{(A.2e)}$$

where $Z_{t,j}$ is total fishery-related mortality on animals in length-class *j* during year *t*:

$$Z_{t,j} = F_t s^T_{t,j} s^r_{t,j} + 0.2F_t s^T_{t,j}(1 - s^r_{t,j}) + 0.65\, F^{Tr}_t s^{Tr}_j \quad \text{(A.3)}$$

F_t is the full selection fishing mortality in the pot fishery, F^{Tr}_t is the full selection fishing mortality in the trawl fishery, $s^T_{t,j}$is the total selectivity for animals in length-class *j* by the pot fishery during year *t*, s^{Tr}_j is the selectivity for animals in length-class *j* by the trawl fishery, $s^r_{t,j}$ is the probability of retention for animals in length-class *j* by the pot fishery during year t. Pot bycatch mortality of 0.2 and groundfish bycatch mortality of 0.65 (average of trawl (0.8) and fish pot (0.5) mortality) were assumed.

The initial conditions are computed as the equilibrium initial condition using the following relations:

The equilibrium stock abundance is

$$\underline{N} = \mathbf{X}.\mathbf{S}.\underline{N} + \underline{R} \tag{A.4}$$

The equilibrium abundance in 1960, $\underline{N}_{1960}$, is

$$\underline{N}_{1960} = (\mathbf{I} - \mathbf{XS})^{-1}\underline{R} \tag{A.5}$$

where **X** is the growth matrix, **S** is a matrix with diagonal elements given by e^{-M} , **I** is the identity matrix, and $\underline{R}$ is the product of average recruitment and relative proportion of total recruitment to each size-class.

We used the mean number of recruits from 1987 to 2012 in equation (A.5) to obtain the equilibrium solution under only natural mortality in year 1960, and then projected the equilibrium abundance under natural mortality with recruitment estimated for each year after 1960 up to 1985 with removal of retained catches during 1981/82 to 1984/85.

Growth Matrix

The growth matrix **X** is modeled as follows:

$$X_{i,j} = \begin{cases} 0 & if\ j < i \\ P_{i,j} + (1 - m_i) & if\ j = i \\ P_{i,j} & if\ j > i \end{cases} \tag{A.6}$$

where:

$$P_{i,j} = m_i \begin{cases} \int_{-\infty}^{j_2 - L_i} N\,(x\,|\mu_i, \sigma^2)\,dx & if\ \ j = i \\ \int_{j_1 - L_i}^{j_2 - L_i} N\,(x\,|\mu_i, \sigma^2)\,dx & if\ \ i < j < n\ , \\ \int_{j_1 - L_i}^{\infty} N\,(x\,|\mu_i, \sigma^2)\,dx & if\ \ \ i = n \end{cases}$$

$$N(x|\mu_i,\sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(\frac{x-\mu_i}{\sqrt{2}\sigma})^2}$$, and

μ_i is the mean growth increment for crabs in size-class *i*:

$$\mu_i = \omega_1 + \omega_2 * \bar{L}_i. \quad \text{(A.7)}$$

ω_1 , ω_2 , and σ are estimable parameters, and j_1 and j_2 are the lower and upper limits of the receiving length-class *j* (in mm CL), and $\bar{L}_i$ is the mid-point of the contributing length interval *i*. The quantity m_i is the molt probability for size-class *i*:

$$m_i = \frac{1}{1 + e^{c(\tau_i - d)}} \quad \text{(A.8)}$$

where *c* and *d* are parameters.

Selectivity and retention

a) Selectivity and retention are both assumed to be logistic functions of length. Selectivity depends on the fishing period for the pot fishery:

$$S_i = \frac{1}{1 + e^{\left[-\ln(19)\frac{\tau_i - \theta_{50}}{\theta_{95} - \theta_{50}}\right]}} \quad \text{(A.9)}$$

where θ_{95} and θ_{50} are the parameters of the selectivity/ retention pattern (Mark Maunder, unpublished generic crab model). In the program, we re-parameterized the denominator (θ_{95} - θ_{50}) to $\log(delta\theta)$ so that the difference is always positive.

Maturity

Maturity is assumed to be a logistic function of length formulated similar to Eq (A.9),

$$Mat_i = \frac{1}{1 + e^{\left[-\ln(19)\frac{\tau_i - mat_{50}}{mat_{95} - mat_{50}}\right]}} \quad \text{(A.10)}$$

where mat_{95} and mat_{50} are the parameters of the maturity curve. In the program, we re-parameterized the denominator (mat_{95} - mat_{50}) to $\log(delta\_mat)$ so that the difference is always positive.

Recruitment

Recruitment to length–class *i* during year *t* is modeled as $R_{t,i} = \bar{R}e^{\epsilon_i}\Omega_i$ where Ω_i is a normalized gamma function

$$gamma(x|\alpha_r, \beta_r) = \frac{x^{\alpha_r - 1} e^{\frac{x}{\beta_r}}}{{\beta_r}^{\alpha_r}\,\Gamma_{(\alpha_r)}} \tag{A.11}$$

with α_r and β_r (restricted to the first six length classes).

Parameter estimation

Table A1 lists the parameters of the model indicating which are estimated and which are pre-specified. The objective function includes contributions related to the fit of the model to the available data and penalties (priors on the various parameters).

Tables A2 lists parameter values (with the corresponding coefficient of variations in parentheses) used to weight the components of the objective functions for EAG and WAG.

Likelihood components

Catches

The contribution of the catch data (retained, total, and groundfish discarded) to the objective function is given by:

$$LL_r^{catch} = \lambda_r \sum_t \{\ell n(\sum_j \hat{C}_{t,j} w_j + c) - \ell n(\sum_j C_{t,j} w_j + c)\}^2 \tag{A.12a}$$

$$LL_T^{catch} = \lambda_T \sum_t \{\ln(\sum_j \hat{T}_{t,j} w_j + c) - \ln(\sum_j T_{t,j} w_j + c)\}^2 \tag{A.12b}$$

$$LL_{GD}^{catch} = \lambda_{GD} \sum_t \{\ln(\sum_j \widehat{Tr}_{t,j} w_j + c) - \ln(\sum_j Tr_{t,j} w_j + c)\}^2 \tag{A.12c}$$

where λ_r, $\lambda_{T,}$ and λ_{GD} are weights assigned to likelihood components for the retained, pot total, and groundfish discard catches; w_j is the average mass of a crab is length-class *j*; $C_{t,j}$, $T_{t,j}$, and $Tr_{t,j}$ are, respectively, the observed numbers of crab in size class *j* for retained, pot total, and groundfish fishery discarded crab during year *t*, and *c* is a small constant value. We assumed $c = 0.001$.

An additional retained catch likelihood (using Equation A.12a without w) for the retained catch in number of crabs during 1981/82 to 1984/85 was also considered in all scenarios.

Catch-rate indices

The catch-rate indices are assumed to be lognormally distributed about the model prediction. Account is taken of variation in addition to that related to sampling variation:

$$LL_r^{CPUE} = \lambda_{r,CPUE} \left\{ 0.5 \sum_t \ln\left[2\pi\left(\sigma_{r,t}^2 + \sigma_e^2\right)\right] + \sum_t \frac{\left(ln(CPUE_t^r + c) - \ln(\widehat{CPUE}_t^r + c)\right)^2}{2\left(\sigma_{r,t}^2 + \sigma_e^2\right)} \right\} \tag{A.13}$$

where $CPUE_t^r$ is the standardized retain catch-rate index for year *t*, $\sigma_{r,t}$ is standard error of the logarithm of $CPUE_t^r$, and $\widehat{CPUE}_t^r$ is the model-estimate of $CPUE_t^r$:

$$\widehat{CPUE}_t^r = q_k \sum_j S_j^T S_j^r \left(N_{t,j} - 0.5\left[\widehat{C_{t,J}} + \widehat{D_{t,J}} + \widehat{Tr_{t,J}}\right]\right)e^{-y_t M} \tag{A.14}$$

in which q_k is the catchability coefficient during the *k*-th time period (e.g., pre- and post-rationalization time periods), σ_e is the extent of over-dispersion, *c* is a small constant to prevent zero values (we assumed c = 0.001), and $\lambda_{r,CPUE}$ is the weight assigned to the catch-rate data. We used the same likelihood formula (A.14) for fish ticket retained catch rate indices for scenario 3 model.

Following Burnham et al. (1987), we computed the *ln(CPUE)* variance by:

$$\sigma_{r,t}^2 = \ln(1 + CV_{r,t}^2) \tag{A.15}$$

Length-composition data

The length-composition data are included in the likelihood function using the robust normal for proportions likelihood, i.e., generically:

$$LL_r^{LF} = 0.5\sum_t\sum_j \ell n(2\pi\sigma_{t,j}^2) - \sum_t\sum_j \ell n\left[\exp\left(-\frac{(P_{t,j}-\hat{P}_{t,j})^2}{2\sigma_{t,j}^2}\right) + 0.01\right] \tag{A.16}$$

where $P_{t,j}$ is the observed proportion of crabs in length-class *j* in the catch during year *t*, $\hat{P}_{t,j}$ is the model-estimate corresponding to $P_{t,j}$, i.e.:

$$\hat{L}_{t,j}^r = \frac{\hat{C}_{t,j}}{\sum_j^n \hat{C}_{t,j}}$$

$$\hat{L}_{t,j}^T = \frac{\hat{T}_{t,j}}{\sum_j^n \hat{T}_{t,j}}$$

$$\hat{L}_{t,j}^{GF} = \frac{\widehat{Tr}_{t,j}}{\sum_j^n \widehat{Tr}_{t,j}} \tag{A.17}$$

$\sigma_{t,j}^2$ is the variance of $P_{t,j}$:

$$\sigma_{t,j}^2 = \left[(1-P_{t,j})P_{t,j} + \frac{0.1}{n}\right]/S_t \tag{A.18}$$

and S_t is the effective sample size for year *t* and *n* is the number of size classes.

Note: The likelihood calculation for retained length composition starts from length-class 6 (mid length 128 mm CL) because the length-classes 1 to 5 mostly contain zero data.

Tagging data

Let $V_{j,t,y}$ be the number of males that were released in year *t* that were in length-class *j* when they were released and were recaptured after *y* years, and $\underline{\tilde{V}}_{j,t,y}$ be the vector of recaptures by length-class from the males that were released in year *t* that were in length-class *j* when they were released and were recaptured after *y* years. The multinomial likelihood of the tagging data is then:

$$lnL = \lambda_{y,tag} \sum_j \sum_t \sum_y \sum_i \rho_{j,t,y,i} ln\hat{\rho}_{j,t,y,i} \tag{A.19}$$

where $\lambda_{y,tag}$ is the weight assigned to the tagging data for recapture year *y*, $\hat{\rho}_{j,t,y,i}$ is the proportion in length-class *i* of the recaptures of males which were released during year *t* that were in length-class *j* when they were released and were recaptured after *y* years:

$$\underline{\hat{\rho}}_{j,t,y} \propto \underline{s}^T [\mathbf{X}]^y \underline{\Omega}^{(j)} \tag{A.20}$$

where $\underline{\Omega}^{(j)}$ is a vector with $V_{j,t,y}$ at element *j* and 0 otherwise, $\mathbf{X}$ is the growth matrix, and s^T is the total selectivity vector (Punt et al. 1997).

This likelihood function is predicted on the assumption that all recaptures are in the pot fishery and the reporting rate is independent of the size of crab. The expected number of recaptures in length-class *l* is given by:

$$r_l = \sum_t \sum_j \frac{s_l [\mathbf{X}^t]_{j,l}}{\sum_{l'} s_{l'} [\mathbf{X}^t]_{j,l'}} \sum_k V_{j,k,t} \tag{A.21}$$

The last term, $\sum_k V_{j,k,t}$, is the number of recaptured male crab that were released in length-class *j* after t time-steps. The term $\sum_j \frac{s_l [\mathbf{X}^t]_{j,l}}{\sum_{l'} s_{l'} [\mathbf{X}^t]_{j,l'}} \sum_k V_{j,k,t}$ is the predicted number of animals recaptured in length-class *l* that were at liberty for t time-steps.

Maturity proportion likelihood

$$LL_{maturity} = \lambda_{maturity} \sum_j \left(\hat{P}_j - P_j\right)^2 \tag{A.22}$$

where $\lambda_{msturity}$ is the weight assigned to the maturity likelihood component; P_j and $\hat{P}_j$ are the observed and expected maturity proportions respectively of male crab in size class *j*. We assumed $\lambda_{maturity}$ = 1.0.

Penalties

Penalties are imposed on the deviations of annual pot fishing mortality about mean pot fishing mortality, annual trawl fishing mortality about mean trawl fishing mortality, recruitment about mean recruitment, and the posfunction (fpen):

$$P_1 = \lambda_F \sum_t (\ell n F_t - \ell n \bar{F})^2 \quad \text{(A.23)}$$

$$P_2 = \lambda_{F^{Tr}} \sum_t (\ell n F_t^{Tr} - \ell n \bar{F}^{Tr})^2 \quad \text{(A.24)}$$

$$P_3 = \lambda_R \sum_t (\ell n \varepsilon_t)^2 \quad \text{(A.25)}$$

$$P_5 = \lambda_{posfn} * fpen \quad \text{(A.26)}$$

Standardized Residual of Length Composition

$$Std.Res_{t,j} = \frac{P_{t,j} - \widehat{P_{t,J}}}{\sqrt{2\sigma^2_{t,j}}} \quad \text{(A.27)}$$

Output Quantities

Harvest rate

Total pot fishery harvest rate:

$$\mathrm{E_t} = \frac{\sum_{j=1}^{n}(\hat{C}_{j,t} + \hat{D}_{j,t})}{\sum_{j=1}^{n} N_{j,t}} \quad \text{(A.28)}$$

Exploited legal male biomass at the start of year t:

$$LMB_t = \sum_{j=legal\ size}^{n} s_j^T s_j^r N_{j,t}\ w_j \quad \text{(A.29)}$$

where w_j is the weight of an animal in length-class j.

Mature male biomass on 15 February spawning time (NPFMC 2007) in the following year:

$$\mathrm{MMB_t} = \sum_{j=\text{mature size}}^{n}\{N_{j,t}e^{-y'M} - (\hat{C}_{j,t} + \hat{D}_{j,t} + \widehat{Tr}_{j,t})e^{(y_t - y')M}\}w_j \quad \text{(A.30)}$$

where y' is the elapsed time from 1 July to 15 February in the following year.

For estimating the next year limit harvest levels from current year stock abundances, a F_{OFL} value is needed. Current crab management plan specifies five different Tier formulas for different stocks depending on the strength of information available for a stock, for computing F_{OFL} (NPFMC 2007). For the golden king crab, the following Tier 3 formula is applied to compute F_{OFL}:

If,

$MMB_{current} > B_{35\%}, F_{OFL} = F_{35\%}$

If,
$\mathrm{MMB_{current}} \leq \mathrm{B_{35\%}}$ and $\mathrm{MMB_{current}} > 0.25\mathrm{B_{35\%}}$,

$$\mathrm{F_{OFL}} = \mathrm{F_{35\%}} \frac{\left(\frac{\mathrm{MMB_{current}}}{\mathrm{B_{35\%}}} = \alpha\right)}{(1-\alpha)} \quad \text{(A.31)}$$

If,
$\mathrm{MMB_{current}} \leq 0.25\mathrm{B_{35\%}}$,

$\mathrm{F_{OFL}} = 0.$

where α is a parameter, $\mathrm{MMB_{current}}$ is the mature male biomass in the current year and $\mathrm{B_{35\%}}$ is the proxy $\mathrm{MMB_{MSY}}$ for Tier 3 stocks. We assumed $\alpha = 0.1$.

Because projected $\mathrm{MMB_t}$ (i.e., $\mathrm{MMB_{current}}$) depends on the intervening retained and discard catch (i.e., MMB_t is estimated after the fishery), an iterative procedure is applied using Equations A.30 and A.31 with retained and discard catch predicted from Equations A.2b-d. The next year limit harvest catch is estimated using Equations A.2b-d with the estimated $\mathrm{F_{OFL}}$ value.

Additional Penalty Functions for Profiles

M estimation:

We used the following penalty function (P6) to estimate *M* for scenario 0a :

$$\mathrm{P_6} = \frac{0.5}{\ln(1+\mathrm{CV}^2)}\left[(\ln(\mathrm{M}) - \ln(0.18))^2\right] \quad \text{(A.32)}$$

where a CV of 50% is assigned to the penalty and $0.18\mathrm{yr}^{-1}$ is the *M* value used for king crab stock assessments.
For *M* profile investigation, we disregarded the *M* penalty and estimated total and component negative log likelihood values at fixed input *M* values varied by ± 0.30 proportion of the base scenario estimate.

Mean MMB profile:
If the current_phase = 1,

$$\mathrm{P_7} = \mathrm{a1}\left(\mathrm{meanMMB} - \mathrm{meanMMB^{input}}\right)^2$$

If the current_phase > 1 and the current_phase <= selectivity_phase, (A.33)

$$\mathrm{P_7} = \mathrm{a2}\left(\mathrm{meanMMB} - \mathrm{meanMMB^{input}}\right)^2$$

If the current_phase > selectivity_phase,

$$P_7 = a3\left(\mathrm{meanMMB} - \mathrm{meanMMB}^{\mathrm{input}}\right)^2$$

where a1, a2, and a3 are weights 0.05 (for EAG) or 0.01 (for WAG), 0.25 (for EAG) or 0.02 (for WAG), and 1.5 (for EAG) or 0.025 (for WAG), respectively. The superscript ‘input” refers to a fixed input value. The fixed input values were varied by ± 0.25 proportion of the scenario 1 estimate.

MMB depletion rate profile:

If the current_phase = 1,

$$P_8 = b1\left(MMB_{depletion} - MMB_{depletion}^{input}\right)^2$$

If the current_phase > 1 and the current_phase <= selectivity_phase, (A.34)

$$P_8 = b2\left(MMB_{depletion} - MMB_{depletion}^{input}\right)^2$$

If the current_phase > selectivity_phase,

$$P_8 = b3\left(MMB_{depletion} - MMB_{depletion}^{input}\right)^2$$

Where b1, b2, and b3 are weights 0.05, 0.25, and 15,000, respectively. The superscript 'input" refers to a fixed input value. $MMB_{depletion} = \frac{MMB_{2015}}{MMB_{1960}}$. The fixed input values were varied by ± 0.25 proportion of the scenario 1 estimate.

Table A1. Pre-specified and estimated parameters of the population dynamics model

Parameter	Number of parameters
Initial conditions:	
Length specific equilibrium abundance, $N_{1960,l}$	17 (estimated)
Fishing mortalities:	
Pot fishery, F_t	1985–2015 (estimated)
Mean pot fishery fishing mortality, $\bar{F}$	1 (estimated)
Groundfish fishery, F_t^{Tr}	1989–2015 (the mean F for 1989 to 1994 was used to estimate trawl discards back to 1985 (estimated)
Mean groundfish fishery fishing mortality, $\bar{F}^{Tr}$	1 (estimated)
Selectivity and retention:	
Pot fishery total selectivity, θ_{50}^{T}	2 or 3 (1985–2004; 2005+) (estimated)
Pot fishery total selectivity difference, $delta\theta^{T}$	2 or 3 (1985–2004; 2005+) (estimated)
Pot fishery retention, θ_{50}^{r}	1 (1985+) (estimated)
Pot fishery retention selectivity difference, $delta\theta^{r}$	1 (1985+) (estimated)
Groundfish fishery selectivity	fixed at 1 for all size-classes
Maturity:	
maturity, mat_{50}	1 (estimated)
maturity difference, $delta\_mat$	1 (estimated)
Growth:	
Expected growth increment, ω_1, ω_2	2 (estimated)
Variability in growth increment, σ	1 (estimated)
Molt probability (size transition matrix with tag data), a	1 (estimated)
Molt probability (size transition matrix with tag data), b	1 (estimated)
Natural mortality, M	1 (pre-specified, 0.224yr^{-1})
Recruitment:	
Number of recruiting length-classes	5 (pre-specified)
Mean recruit length	1 (pre-specified, 110 mmCL)
Distribution to length-class, β_r	1 (estimated)
Median recruitment, $\bar{R}$	1 (estimated)
Recruitment deviations, ε_t	56 (1961–2016) (estimated)
Fishery catchability, q	2 (1985–2004; 2005+) or 3 (1985–1994; 1995–2004; 2005+) (estimated)
Additional CPUE indices standard deviation, σ_e	1 (estimated)
Likelihood weights (coefficient of variation)	Pre-specified, varies by scenario

Table A2. Specifications for the weights with corresponding coefficient of variations* in parentheses for each scenario for EAG and WAG. select. phase = selectivity phase.

Weight	**Value**						
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**	**Scenario 7**
Catch:							
Retained catch for 1981–1984 and/or 1985–2015, λ_r	500 (0.032)	500	500	500	500	500	500
Total catch for 1990–2015, λ_T	Number of sampled pots scaled to a max 250	Number of sampled pots scaled to a max 250	Number of sampled pots scaled to a max 250	Number of sampled pots scaled to a max 250	Number of sampled pots scaled to a max 250	Number of sampled pots scaled to a max 250	Number of sampled pots scaled to a max 250
Groundfish bycatch for 1989–2015, λ_{GD}	0.2 (3.344)	0.2	0.2	0.2	0.2	0.2	0.2
Catch-rate:							
Observer legal size crab catch-rate for 1995–2015, $\lambda_{r,CPUE}$	1(0.805)	1	(1991–2015)1	1	1	1	1
Fish ticket retained crab catch-rate for 1985–1998 , $\lambda_{r,CPUE}$	1(0.805)		1	1	1	1	1
Penalty weights:							
Pot fishing mortality dev, λ_F	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase

Table A2 Scenarios 1 to 7 continued.

Groundfish fishing mortality dev, $\lambda_{F^{Tr}}$	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase
Recruitment, λ_R	2 (0.533)	2	2	2	2	2	2
Posfunction (to keep abundance estimates always positive), λ_{posfn}	1000 (0.022)	1000	1000	1000	1000	1000	1000
Maturity	1(0.805)	1	1	1	1	1	1
Tagging likelihood	EAG individual tag returns	EAG tag data	EAG tag data	EAG tag data	EAG tag data	EAG tag data	EAG tag data

$* \ Coefficient\ of\ Variation,\ CV = \sqrt{\exp[\frac{1}{2W}] - 1},$ w =weight

Table A2 continued.

Weight	Value			
	Scenario 8	Scenario 9	Scenario 10	Scenario 11
Catch:				
Retained catch. λ_r	500 (0.032)	500	500	500
Total catch, λ_T	Number of sampled pots scaled to a max 250	Number of sampled pots scaled to a max 250	Number of sampled pots scaled to a max 250	Number of sampled pots scaled to a max 250
Groundfish bycatch, λ_{GD}	0.2 (3.344)	0.2	0.2	0.2
Catch-rate:				
Observer legal size crab catch-rate, $\lambda_{r,CPUE}$	1(0.805)	1	1	1
Fish ticket retained crab catch-rate, $\lambda_{r,CPUE}$	1(0.805)	1	1	1
Penalty weights:				
Pot fishing mortality dev, λ_F	Initially 1000, relaxed to 0.001 at phases ≥ select.phase	Initially 1000, relaxed to 0.001 at phases ≥ select.phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase
Trawl fishing mortality dev, $\lambda_{F^{Tr}}$	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase	Initially 1000, relaxed to 0.001 at phases ≥ select. phase
Recruitment, λ_R	2(0.533)	2	2	2
Posfunction (to keep abundance estimates always positive), λ_{posfn}	1000 (0.022)	1000	1000	1000

Table A2 Scenarios 8 to 11 continued.

Maturity	1(0.805)	fixed	1	fixed
Tagging likelihood	EAG tag data	EAG tag data	EAG tag data	EAG tag data