

# **A Guide to the Preparation of Bering Sea and Aleutian Islands Crab SAFE Report Chapters**

A chapter should be produced for the SAFE report for each crab stock, and should include all sections listed in the "Outline of SAFE Report Chapters" below. This Outline is intended to provide a consistent structure and logical flow for stock assessments; using the numbering system outlined below will help to standardize the SAFE document and make the review process for assessments more straightforward. Some variation from this outline is permissible if warranted by limitations of data, analytical methods, or other extenuating circumstances; major deviations from the suggested report structure should, however, be justified. Many of the items under Section E are not appropriate for stocks in Tier 5 (see Table 1 of this Appendix for a list of sections needed for different types of assessments). It is particularly important that all of the items listed under "Calculation of the OFL" be included to the maximum extent possible, in that many of these are critical to the fishery management process. Careful consideration should be given to all applicable SSC and CPT comments from the previous assessment(s).

Important notes:

- To maintain consistency among SAFEs, the documents should report everything in the document in metric tons. The executive summary and the data used in the harvest strategy should be presented in both metric tons (abbreviated t) and pounds (lbs). Use the appropriate conversion factors and significant digits in the result.
- Dates should be specified as "2008" for the 2008 calendar year and "2008/09" for the 2008/09 fishing year. By default crab assessments are based on fishing years, but the notation 2xxx/yy should nevertheless be adopted.
- Fishing mortality values ( $F$ ) are always full selection fishing mortalities (the  $F$  at fishing selection equal to 1.0).

## **Outline of SAFE Report Chapters**

### **Title page and list of preparers**

### **Executive Summary**

1. Stock: species/area.
2. Catches: trends and current levels.
3. Stock biomass: trends and current levels relative to virgin or historic levels, description of uncertainty.
4. Recruitment: trends and current levels relative to virgin or historic levels.
5. Management performance: a table showing estimates of mature male biomass (at the time of mating), overfishing levels (OFL and MSST), allowable biological catch (ABC), TACs, retained catch and discards in all fisheries; show results from 2005/06 to the current year (Table 2 of this Appendix lists examples of how these tables should be constructed for stocks in each Tier)
6. Basis for the OFL: Table listing estimates of  $M$ , Tier level, current mature male biomass (MMB, at the time of mating),  $B_{MSY}$  (or the proxy thereof) and the basis for the calculation of  $B_{MSY}$ , current mature male biomass relative to  $B_{MSY}$  (or its proxy),  $\gamma$ , and the basis for calculating average catch; show from 2008/09 to the current year (Table 3 of

this Appendix lists examples of how these tables should be constructed for stocks in each Tier).

7. Provide the Probability Density Function of the OFL (if applicable) and what additional uncertainty is included in this estimate.
8. Provide the basis for the ABC recommendation (if the recommendation is below maxABC, report both the recommended and maxABC).
9. A summary of the results of any rebuilding analyses: table showing the year by which rebuilding is expected to occur, the rebuilding time period, the catch for the next fishing year and probability of recovery to the proxy for  $B_{MSY}$  for a range of harvest strategies (including one for which the probability of recovery within the rebuilding period is 0.5).

#### **A. Summary of Major Changes**

1. Changes (if any) to the management of the fishery.
2. Changes to the input data (e.g. specify any new data sources and which data sources have been updated)
3. Changes (if any) to the assessment methodology.
4. Changes to the assessment results, including projected biomass, TAC/GHL, total catch (including discard mortality in all fisheries and retained catch), and OFL.

#### **B. Responses to SSC and CPT Comments**

1. Responses to the most recent two sets of SSC and CPT<sup>2</sup> comments on assessments in general (for each comment that is addressed in the main text, list the comment and give name of the section where it is discussed; if the SSC or CPT did not make any comments on assessments in general, say so).
2. Responses to the most recent two sets of SSC and CPT<sup>1</sup> comments specific to the assessment (for each comment that is addressed in the main text, list the comment and give the name of section where it is discussed; if the SSC or CPT did not make any comments specific to the assessment, say so).

All comments relevant to the assessment and crab assessments in general must be listed. If a comment has not been addressed in the assessment, the comment should be listed and the reasons for not addressing it must be provided.

#### **C. Introduction**

1. Scientific name.
2. Description of general distribution (including a map, showing the stock boundary and, if possible, the actual distribution).
3. Evidence of stock structure, if any.
4. Description of life history characteristics relevant to stock assessments (e.g., special features of reproductive biology).
5. Brief summary of management history. A complete summary of the management history will be provided in the ADF&G Area Management Report appended to the annual SAFE.

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<sup>1</sup> For an assessment in May, these comments will be from the SSC and CPT meetings in May and September of the previous year. For an assessment in September, these comments will be from the SSC and CPT meetings in May of the current year and September of the previous year.

6. Brief description of the annual ADF&G harvest strategy. All parameters for stocks with an approved harvest strategy should be provided in tables in both t and lbs.
7. Summary of the history of the  $B_{MSY}$ .

***D. Data (Items in this section should be presented primarily in tabular form.)***

1. Summary of new information (the section should essentially repeat the information provided under Section A.2).
2. Data which should be presented as time series, separately by sex and, depending on the assessment also by maturity state and shell condition (table headers should indicate when the data were extracted, and the source for the data; years should be reported as fishing year 2xxx/yy or calendar year, depending on the fishery concerned):
  - a. Total catch, partitioned by strata used in the assessment model, if any.
  - b. Information on bycatch and discards. Non-retained catches and discards should ideally be reported using the categories in Table 4 to this Appendix (the table header should specify the mortality rates applied to discards and bycatch, and whether the values in the table have had these mortality rates applied or not).
  - c. Catch-at-length (with sample sizes) for fisheries, bycatch, discards, and surveys. For surveys include all known surveys that catch crab.
  - d. Survey biomass estimates (with measures of uncertainty).
  - e. Survey catch-at-length (with sample sizes), as appropriate.
  - f. Other time series data (e.g., predator abundance, fishing effort).
3. Data which may be aggregated over time:
  - a. Growth-per-molt; frequency of molting, etc. (by sex and perhaps maturity state)
  - b. Weight-at length or weight-at-age (by sex).
4. Information on any data sources that were available, but were excluded from the assessment.

Notes:

- i. Information on length-composition may be more appropriately presented in the form of plots, especially for assessments for which there is a substantial amount of such data.
- ii. The reported sample sizes should reflect the actual number of samples; information on the sample sizes assumed when fitting any population models should also be reported.

***E. Analytic Approach***

**1. History of modeling approaches for this stock**

In addition to summarizing how assessment methods have changed over time, include a summary of CIE review comments from past reviews and how those comments have been taken into account. Provide a table describing model changes over time since the model was first accepted for use in assessment.

**2. Model Description**

- a. Description of overall modeling approach (e.g., age/size structured versus biomass dynamic, maximum likelihood versus Bayesian). If the model has not been published in its current form, its equations should be listed in full in an Appendix. If there is a technical Appendix, Items b-f below should be included in the appendix, and only a short description of the model and its estimation scheme needs to be included in this section. Specify when the fishery is assumed to occur and, if necessary, provide a

- table which lists the assumed time of the fishery for each year of the assessment period.
- b. Reference for software used (e.g., Synthesis, AD Model Builder).
  - c. List and description of all likelihood components.
  - d. Description of how the state of the population at the start of the first year of the assessment period is determined and the size-range that the model covers.
  - e. Parameter estimation framework:
    - i. List all of the parameters which are estimated outside of the assessment (e.g., the natural mortality rate, parameters governing the maturity schedule) along with how the values for these parameters were estimated (methods do not necessarily have to be statistical; e.g.,  $M$  could be estimated by referencing a previously published value).
    - ii. List all of the parameters that are estimated conditionally on those described above (e.g., full-selection fishing mortality rates, parameters governing the survey and fishery selectivity schedules, recruitments), indicate any bounds and/or priors placed on these parameters.
    - iii. List any constraints that imposed on the estimated parameters (including penalties on recruitment and selectivity).
    - iv. The default for average recruitment should include the entire time series. Justifications for including fewer years should be provided along with model runs of both the full and truncated time series.
  - f. Definition of model outputs
    - i. Biomass measures (e.g., biomass of animals 50 mm and larger). Indicate the assumed time of mating and that of the fishery.
    - ii. Recruitment (e.g., number of males and females in the 50-55mm size-class).
    - iii. Fishing mortality (e.g., full-selection  $F$  multiplied by selectivity for lengths 80 and above). Whether fishing mortality is an exploitation rate or an instantaneous rate should be reported in table headers and the text. The ideal is to report “fishing mortality” as the fully-selected instantaneous fishing mortality rate at the time of the fishery to enhance comparability amongst stock assessments.
  - g. Critical assumptions and consequences of assumption failures (for example, highlight assumptions regarding  $M$ ,  $q$  and selectivity, to which assessments are often very sensitive).
  - h. Changes to any of the above since the previous assessment.
  - i. Outline of methods used to validate the code used to implement the model and whether the code is available.

### 3. Model Selection and Evaluation

- a. Description of alternative model configurations<sup>2</sup>, if any (e.g., alternative  $M$  values or likelihood weights; use a hierarchical approach where possible (e.g. asymptotic vs domed selectivities, constant vs time-varying selectivities)). The model configuration

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<sup>2</sup> For Tier 5 assessments “model configuration” refers to the time period over which the mean catch is computed while for Tier 3 and 4 assessments it includes the time period used to define  $B_{MSY}/B_{REF}$ .

- on which the previous assessment was based must be included in the set of model considered in order to retain comparability with previous assessments<sup>3</sup>.
- b. Show a progression of results from the previous assessment to the preferred base model by adding each new data source and each model modification in turn to enable the impacts of these changes to be assessed.
  - c. Evidence of search for balance between realistic (but possibly over-parameterized) and simpler (but not realistic) models.
  - d. Convergence status and convergence criteria for the base-case model (or proposed base-case model) such as randomization run results or other evidence of a search for the global best estimates.
  - e. Table (or plot) of the sample sizes assumed for the compositional data. There are several ways for specify input sample size, including:
    - i. the number of animals actually measured;
    - ii. a fixed constant (e.g. 500);
    - iii. the application of bootstrapping approaches (e.g. Folmer and Pennington, 2000); and
    - iv. as for i and iii, with a maximum imposed on the input sample sizeThe first, third, and last of these approaches allows the input sample sizes (and hence the weight assigned to the compositional data) to reflect uneven sampling over time. The basis for specifying the input sample sizes should be justified and analyses conducted (see Section 4.4 below) to justify the final effective sample sizes.
  - f. Do parameter estimates for all models make sense, are they credible?
  - g. Description of criteria used to evaluate the model or to choose among alternative models, including the role (if any) of uncertainty.
  - h. Residual analysis (e.g. residual plots, time series plots of observed and predicted values or other approach). Note that residual analysis is expected for the base-case model below.
  - i. Evaluation of the model, if only one model is presented; or evaluation of alternative models and selection of final model, if more than one model is presented.

#### **4. Results (best model(s))<sup>4</sup>**

Although the author may focus on the authors recommended model run, results should be provided for all model runs that the assessment author considers sufficiently plausible that they could form the basis for management advice. Assessment authors should come to the May Crab Plan Team meeting with detailed results for all analyses conducted.

1. List of effective sample sizes, the weighting factors applied when fitting the indices, and the weighting factors applied to any penalties.
2. Tables of estimates (all quantities should be accompanied by confidence intervals or other statistical measures of uncertainty, unless infeasible; include estimates from previous SAFEs for retrospective comparisons):

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<sup>3</sup> This information should be included in the May and September versions of the assessment report. However, for ease of reading, information on model configurations considered but not adopted should be included in an appendix to the assessment report.

<sup>4</sup> There may be several “best” models in the May assessment draft, but there should be one “best” model in the September assessment draft.

- a. All parameters (include recruitments, selectivity parameters, any estimated growth parameters, catchability, etc.).
  - b. Abundance and biomass time series, including spawning biomass and MMB.
  - c. Recruitment time series (including average recruitment).
  - d. Time series of catch divided by biomass.
3. Graphs of estimates (all quantities should be accompanied by confidence intervals or other statistical measures of uncertainty, unless infeasible):
  - a. Fishery and survey selectivities, molting probabilities, and other schedules depending on parameter estimates.
  - b. Estimated male, female, mature male, total and effective mature biomass time series (indicate the proxy for  $B_{MSY}$  on the relevant plots).
  - c. Estimated full selection  $F$  over time.
  - d. Estimated fishing mortality versus estimated spawning stock biomass, including applicable OFL and maximum  $F_{target}$  definitions for the stock (see, for example, Fig. 54 of Turnock and Rugolo, 2008). Graphs of this type are useful to evaluate management performance.
  - e. Fit of a stock-recruitment relationship, if feasible.
4. Evaluation of the fit to the data. Note that model fits should be represented by a solid line while population estimates should be represented by a dotted line. Estimates confidence intervals should be provided on the fit:
  - a. Graphs of the fits to observed and model-predicted catches (retained catch and discards), including model-predicted of catches and discards for all years to allow discards to be inferred for years for which data are not available.
  - b. Graphs of model fits to survey numbers (include confidence intervals for the data and model predictions).
  - c. Graphs of model fits to catch proportions by length (e.g. using bubble and/or line plots).
  - d. Graphs of model fits to survey proportions by length (e.g. using bubble and/or line plots).
  - e. Marginal distributions for the fits to the compositional data.
  - f. Plots of implied versus input effective sample sizes and time-series of implied effective sample sizes.
  - g. Tables of the RMSEs for the indices (and a comparison with the assumed values for the coefficients of variation assumed for the indices).
  - h. Quantile-quantile (q-q) plots and histograms of residuals (to the indices and compositional data) to justify the choices of sampling distributions for the data.
5. Retrospective and historic analyses (retrospective analyses involve taking the “best” model and truncating the time-series of data on which the assessment is based; a historic analysis involves plotting the results from previous assessments).
  - a. Retrospective analysis (retrospective bias in base model or models).
  - b. Historic analysis (plot of actual estimates from current and previous assessments).
6. Uncertainty and sensitivity analyses (this section should highlight unresolved problems and major uncertainties, along with any special issues that complicate scientific assessment, including questions about the best model, etc.):
  - a. The best approach for describing uncertainty depends on the situation. Possible approaches (not mutually exclusive) are:

- i. Sensitivity analyses (tables or figures) that show ending biomass levels, OFLs, and/or likelihood component values obtained while systematically varying (e.g. halving and doubling) the emphasis factors for each type of data (and penalty) in the model.
  - ii. Likelihood profiles for parameters or biomass levels.
  - iii. CVs for biomass or OFL estimated by bootstrap, the delta method or Bayesian methods.
  - iv. Subjective appraisal of the magnitude and sources of uncertainty.
  - v. Retrospective and historic analyses (see above).
  - vi. Comparison of alternate models and or assumptions (i.e. model structure uncertainty, as evaluated in Section E.3 of this Appendix).
- b. It is important that some qualitative or quantitative information about relative probability be stated if a range of model runs (e.g., based on CV's or alternative assumptions about model structure or recruitment) is used to depict uncertainty. It is important to state that all scenarios (or all scenarios between the bounds depicted by the runs) are equally likely if no statements about relative probability can be made.
- c. Simulation results.

#### **F. Calculation of the OFL**

1. Specification of the Tier level and stock status level for computing the OFL, along with the basis for the selection. For Tier 4 and 5 stocks, the rationale for the time period used to define  $B_{REF}$  (Tier 4) and the average retained catch used to compute the OFL (Tier 5) needs to be specified. Note that the default time period to define  $B_{REF}$  is the entire time series. Justification and comparative results should be provided for both alternatives.
2. List of parameter and stock size estimates (or best available proxies thereof) required by limit and target control rules specified in the fishery management plan.
3. Specification of the total catch OFL:
  - a. Provide the equations (from Amendment 24) on which the OFL is to be based, including the equations used to project discard and bycatch by sex (the mathematical specifications for this need to be documented in a peer-reviewed publication or in a technical appendix).
  - b. Basis for projecting MMB to the time of mating (the mathematical specifications for this need to be documented in a peer-reviewed publication or in a technical appendix).
  - c. Specification of  $F_{OFL}$ , OFL, and other applicable measures (if any) relevant to determining whether the stock is overfished or if overfishing is occurring (such as  $B_{REF}$ ,  $B_{35\%}$ ). Include estimates from the present assessment and the assessments since 2006/07. Table 2 of this Appendix lists examples of tables for Tiers 3, 4 and 5.
4. Specification of the retained catch portion of the total catch OFL:
  - a. Provide the equations on which the recommendation for the retained portion of the total catch OFL is to be based.
5. Recommendation for  $F_{OFL}$ , OFL total catch, and the retained catch portion of the OFL for the coming year. List the OFLs by sector (retained catch, discard in the directed fishery, bycatch in other crab fisheries, the groundfish fishery, etc.), where appropriate.

### **G. Calculation of the ABC**

1. Specification of the probability distribution of the OFL used in the ABC control rule including clear explanation and justification for use of the median or mean.
2. List of variables related to scientific uncertainty considered in the OFL probability distribution.
3. List of additional uncertainties considered for alternative  $\sigma_b$  applications to the ABC and include calculation methods for an alternative ABC incorporating  $\sigma_b$ .
4. Author recommended ABC and if less than maxABC provide rationale for establishing less than maximum permissible.

### **H. Rebuilding Analyses**

Rebuilding analyses should be provided for stocks which are currently under a rebuilding plan.

1. Definition of recovery (including the definition of the proxy for  $B_{MSY}$ , the number of years that the biomass needs to exceed the proxy for  $B_{MSY}$  for the stock to be recovered).
2. Year in which the rebuilding plan started and the year by which the stock should be recovered to the proxy for  $B_{MSY}$ .
3. Specification of the approach used to project the model forward (e.g. assumptions about parameter uncertainty; future recruitment and selectivity; and how discards and bycatch are computed given fishing mortality on mature males).
4. Projections under different levels of fishing mortality on mature males to evaluate the probability of recovery to the proxy for  $B_{MSY}$  over time. Results should be produced for (a) no targeted fishing, (b) probabilities of recovery of 0.5, 0.6, 0.7 and 0.8, and (c) a harvest strategy corresponding to 75% of the  $F_{OFL}$ .
5. Tables of total catch, retained catch, and probability of recovery against time for the rebuilding strategies listed under 4).
6. A graph of the annual status of the stock relative to the  $B_{MSY}$  and MSST from the start of the rebuilding period to the present.

### **I. Data Gaps and Research Priorities**

Information which could feasibly be collected and analyses which should be undertaken to improve the assessment should be included in this section. Ideally, data collection and analysis needs should be listed in priority order.

### **K. Literature Cited**

Include citations that are relevant to understanding the stock and its status, but are not cited in the report in a special "extra references" section.

Table 1. Requirements for assessments by Tier.

Report Section	Tiers 1-3; Tier 4 (with assessment)	Tier 4 (no assessment)	Tier 5
Executive Summary	Yes	Yes	Yes
A. Summary of Major Changes	Yes	Yes	Yes
B. Responses to SSC and CPT comments	Yes	Yes	Yes
C. Introduction	Yes	Yes	Yes
D. Data	Yes	Yes <sup>1</sup>	Yes <sup>2</sup>
E. Analytical Approach	Yes	Yes <sup>3</sup>	Yes <sup>3</sup>
F. Calculation of the OFL	Yes	Yes	Yes
G. Calculation of the ABC	Yes	Yes	Yes
H. Rebuilding Analyses	Yes <sup>4</sup>	Yes <sup>4</sup>	Yes <sup>4</sup>
I. Data Gaps and Research Priorities	Yes	Yes	Yes
J. Ecosystem Considerations	Yes	Yes	Yes
K. Literature Cited	Yes	Yes	Yes

1 – Items 2c, 2e need not be reported in full

2 – Items 2c -2e need not be reported in full

3 – Limited to plots of survey data and catches

4 – Only for stocks under rebuilding

Table 2. Examples of summary tables of management performance by Tier level (the table is structured for an assessment conducted in September 2009)

(a) Stocks in Tiers 1-3 and those in Tier 4 for which there is an agreed assessment model

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2005/06		100 <sup>A</sup>	60	40	58		
2006/07		120 <sup>B</sup>	60	51	55		
2007/08	230 <sup>C</sup>	130 <sup>C</sup>	60	55	56		
2008/09	221 <sup>D</sup>	219 <sup>D</sup>	60	47	55	91	
2009/10		280 <sup>D</sup>				78	

The stock was above MSST in 2008/09 and is hence not overfished. Overfishing did not occur during the 2008/09 fishing year.

Notes:

A – Calculated from the assessment reviewed by the Crab Plan Team in September 2006

B – Calculated from the assessment reviewed by the Crab Plan Team in September 2007

C – Calculated from the assessment reviewed by the Crab Plan Team in September 2008

D – Calculated from the assessment reviewed by the Crab Plan Team in September 2009

(b) Stocks in Tier 4 for which there is not an agreed assessment model

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2005/06		100 <sup>A</sup>	60	40	58		
2006/07		120 <sup>B</sup>	60	51	55		
2007/08	230 <sup>C</sup>	130 <sup>C</sup>	60	55	56		
2008/09	221 <sup>D</sup>	219 <sup>D</sup>	60	47	55	91	
2009/10		280 <sup>D</sup>				78	

The stock was above MSST in 2008/09 and is hence not overfished. Overfishing did not occur during the 2008/09 fishing year.

Notes:

A – Based on survey data available to the Crab Plan Team in September 2006 and updated with 2006/2007 catches

B – Based on survey data available to the Crab Plan Team in September 2007 and updated with 2007/2008 catches

C – Based on survey data available to the Crab Plan Team in September 2008 and updated with 2008/2009 catches

D – Based on survey data available to the Crab Plan Team in September 2009

(c) Stocks in Tier 5

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2005/06		N/A	60	40	58		
2006/07		N/A	60	51	55		
2007/08	N/A	N/A	60	55	56		
2008/09	N/A	N/A	60	47	55	91	
2009/10		N/A				78	

No overfished determination is possible for this stock given the lack of biomass information. Overfishing did not occur during the 2008/09 fishing year.

Table 3. Examples of tables that summarize how the OFL was calculated (the table is structured for an assessment conducted in September 2009). The rows for 2008/09 were agreed by the Crab Plan Team in September 2008 and those for 2009/10 were agreed by the Crab Plan Team in September 2010.

(a) Stocks in Tiers 1-3 and those in Tier 4 for which there is an agreed assessment model

Year	Tier	$B_{MSY}$	Current MMB	$B/B_{MSY}$ (MMB)	$F_{OFL}$	Years to define $B_{MSY}$	Natural Mortality	P*
2008/09	3b	231	219.5	0.95	0.15yr <sup>-1</sup>	1978/79-2008/09	0.25yr <sup>-1</sup>	
2009/10	3a	234	245.7	1.05	0.19yr <sup>-1</sup>	1978/79-2009/10	0.25yr <sup>-1</sup>	

(b) Stocks in Tier 4 for which there is not an agreed assessment model

Year	Tier	$B_{MSY}$	Current MMB	$B/B_{MSY}$ (MMB)	$\gamma$	Years to define $B_{MSY}$	Natural Mortality	P*
2008/09	4b	231	219.5	0.95	1.0	1978/79-2008/09	0.25yr <sup>-1</sup>	
2009/10	4a	234	245.7	1.05	0.6	1978/79-2009/10	0.25yr <sup>-1</sup>	

(c) Stocks in Tier 5

Year	Tier	Years to define Average catch (OFL)	Natural Mortality	P*
2008/09	5	1978/79-2008/09	0.25yr <sup>-1</sup>	
2009/10	5	1978/79-2009/10	0.25yr <sup>-1</sup>	

Table 4. Categories for which information on catches and discards should ideally be provided.

Directed pot fishery (males)
Directed pot fishery (females)
Bycatch in other crab fisheries (by sex)
Bycatch in groundfish pot (by sex)
Bycatch in groundfish trawl (by sex)
Bycatch in the scallop fishery