AGENDA C-2
JUNE 2010

MEMORANDUM

TO: Council, SSC and AP Members

FROM: Chris Oliver for
Executive Director

ESTIMATED TIME
4 HOURS

DATE: June 2, 2010

SUBJECT: BSAI Crab ACLs and Snow Crab Rebuilding Plan

ACTION REQUIRED
(a) Initial review of BSAI Crab Annual Catch Limit analysis and BSAI snow crab rebuilding plan.
(b) Approve Crab SAFE/OFLs as necessary.
(c) Review PSC discussion paper.

BACKGROUND

(a) Initial review of BSAI Crab Annual Catch Limit analysis and BSAI snow crab rebuilding plan.

At this meeting, the Council will take initial review of an analysis of amendments to address BSAI Crab ACLs and the snow crab rebuilding plan. The executive summary of the ACL and snow crab rebuilding analysis is attached as **Item C-2(a)(1)**. The full analysis was mailed to you on May 18th. Several additional documents are included here that either revise sections of the draft or provide additional information and sections that were not yet included in the initial review draft. This environmental assessment evaluates two actions to amend the BSAI Crab FMP:

Action 1: to amend the FMP to specify the method by which the Council will establish annual catch limits (ACLs) to meet the requirements of the revised Magnuson-Stevens Act. These ACLs are to be established based upon an acceptable biological catch (ABC) control rule which will be set forth in the FMP and will account for the uncertainty in the overfishing limit (OFL) point estimate. Two alternative means of establishing the ABC control rule are considered: 1) a constant buffer approach where the ABC for each stock would be set by application of a constant pre-specified buffer value below the OFL; and 2) a variable buffer approach where the ABC would be established based upon a pre-specified percentile of the distribution for the OFL which accounts for scientific uncertainty regarding the OFL. A range of constant buffers and probabilities are considered under each alternative approach.

Action 2: to prepare and implement an amended plan to rebuild the snow crab stock in compliance with section 304(e)(3) of the Magnuson-Stevens Act. A range of alternative time frames are considered for rebuilding the stock.

The Council reviewed a preliminary draft of this analysis in April. The Council's April motion is attached as **Item C-2(a)(2)**. The Council requested that staff also provide clarification at this meeting on the differential treatment of uncertainty in the ABC control rule under the groundfish tier system compared with the proposed treatment of uncertainty in the ABC control rule under the crab tier system. A description of these differences is attached as **Item C-2(a)(3)** and staff will provide further clarification in presentation at this meeting. The Board of Fisheries (BOF) received a report from Council staff on March 16th regarding the ACL analysis for BSAI crab stocks and rebuilding plans. A letter from the BOF to the Council is attached as **Item C-2(a)(4)**.

A supplemental document is attached as **Item C-2(a)(5)** which provides tables of revised rebuilding trajectories for the snow crab rebuilding plan. These tables replace those included in the initial review draft. Two different model scenarios are included here, Model 1 (base model) and Model 5 (CPT preferred model choice). At the May Crab Plan Team meeting the CPT recommended Model 5 for the 2010/11 stock assessment cycle (see agenda item C-2(b) for stock assessment discussion and CPT report under Item C-2(b)(1)). The SSC will recommend the final snow crab model choice at this meeting. Rebuilding scenarios in the rebuilding analysis will use the recommended model. Tables in the attached document show scenarios using both Model 1 and Model 5.

A modified version of Table 3 from that document is shown below to indicate where these results (using the results from Model 5 for example purposes) relate to the Council suite of rebuilding alternatives for the snow crab stock. Here the probability of rebuilding is projected under the assumption that the definition of 'rebuilt' is the second consecutive year above $B_{MSY}$ (note additional tables in the document indicate the $T_{TARGET}$ dates and probability of rebuilding under a 1-year rebuilt definition option). In bold are the alternatives as selected by the Council with a default 50% probability of rebuilding based upon the projections. Options as described below are applied to each alternative to increase the probability of rebuilding by the selected $T_{TARGET}$ date.

| Alternative (and option) | Probability of rebuilding | $T_{TARGET}$ year-ending date | Probability rebuilding from projections | Buffer |
|---|---|---|---|---|
| **Alternative 1** | **50%** | 2015/16 | 0.572 | 25% |
| **Alternative 2 ($T_{MIN}$)** | **50%** | 2014/15 | 0.943 | 100% |
| **Alternative 3** | **50%** | 2014/15 | 0.500 | 66% |
| Alternative 3-Option 2 | 75% | 2014/15 | 0.757 | 86% |
| Alternative 3-Option 3 | 90% | 2014/15 | 0.911 | 97% |
| **Alternative 4 ($T_{END}$)** | **50%** | 2015/16 | 0.572 | 25% |
| Alternative 4-Option 2 | 75% | 2015/16 | 0.758 | 59% |
| Alternative 4-Option 3 | 90% | 2015/16 | 0.905 | 79% |
| Option 1 | 79% | 2019/20 | 0.792 | 25% |

Alternatives 1-4 are specifically designed to have year-ending dates corresponding to a 50% probability of rebuilding under scenarios of the current rebuilding harvest constraint of 75% $F_{35\%}$ (Alternative 1 and Alternative 4), no directed fishing (Alternative 2), and some directed fishing (Alternative 3). Options 1-3 are intended to allow for increased probability of rebuilding the stock by target year-ending dates. There are two means by which the probability of rebuilding may be increased, either by directed fishery harvest constraints above that which achieves a 50% probability of rebuilding (option 2 at 75% and option 3 at 90%) or by extending the time frame for rebuilding to achieve a higher probability of rebuilding as initially projected (option 1 at 70%). For option 1 the initial projection as shown above achieves a higher probability of rebuilding by extending the projected time frame to 8 years or given an implementation date of 2011/12 2019/20. Here the harvest constraint (25% buffer) is the same under Option 1 as that under Alternative 4 (or Alternative 1) in year one of the rebuilding plan. Under each alternative, it is explicit that the F rates will be adjusted annually to maintain the schedule of rebuilding by achieving either the mature male biomass that is projected by year for the alternative or the specific probability of rebuilding listed for the alternative. Thus the potential harvest constraint to meet a 79% probability of rebuilding by 2019/20 under Option 1 is potentially greater in future years than that under Alternative 4. However, if rebuilding were on track with the specified probability under Alternative 4 until the final year of the rebuilding plan before falling below the trajectory to meet the rebuilt definition, Option 1 would allow for additional time to continue correcting the F rate to meet the initial rebuilding trajectory without the need for a subsequent rebuilding plan.

Economic analysis of rebuilding scenarios for snow crab are attached as **Item C-2(a)(6)**. This document also includes supplemental tables and analysis for inclusion in the ACL analysis under Action 1 for snow crab. Economic analysis of Tanner crab ACLs is attached as **Item C-2(a)(7)**.

(b) Approve Crab SAFE report/OFLs for some stocks.

The Crab Plan Team met in Girdwood, AK from May 10-14, 2010 to review draft BSAI Crab stock assessments and provide recommendations for the model parameterizations and tier establishments for BSAI Crab stocks as well as OFL recommendations for 4 of the 10 stocks. There are 10 crab stocks in the BSAI Crab FMP and all 10 must have annually established OFLs. Six of the ten stocks will have OFLs established following the summer survey information availability. Two of the ten stocks (Norton Sound red king crab and AI golden king crab) have OFL recommendations put forward at this time in order to have approved OFLs prior to the summer fisheries for these stocks. The remaining two stocks (Adak red king crab and Pribilof Islands golden king crab) have OFLs recommended based on Tier 5 formulation (average catch) and OFLs are recommended in the spring. Much of the CPT's stock assessment and OFL recommendations are contained within the Crab SAFE Introduction while some additional recommendations and discussions are included in the CPT Report. The Crab Plan Team Report is attached as **Item C-2(b)(1)** while the Crab SAFE report introduction was mailed to you previously and is attached as **Item C-2(b)(2)**.

Supplemental figures for the snow crab assessment for Model 5 are attached as **Item C-2(b)(3)**. Additional discussion of Model 1 (base model) versus Model 5 (CPT recommendation) is contained in the CPT report under Item C-2(b)(1). The SSC will make the final selection of model choice at this meeting. As noted under C-2(a) the model employed in the 2010/11 assessment cycle will also be used for the revised ACL analysis over the summer.

(c) Review PSC discussion paper

A discussion paper on crab bycatch in the BSAI groundfish and scallop fisheries was mailed to you on May 24th. The Council reviewed a previous iteration of this paper in October 2009 and made several requests for additional information at that time. This discussion paper responds to two specific motions by the Council in April 2010 (Appendix A of the paper) and October 2009 (Appendix B of the paper) as well as to several requests by the Crab Plan Team at their recent meetings. These requests have all been incorporated into the paper at this time. Appendix F (size and sex composition of groundfish bycatch by stock) of the paper was not available at the time of the mailing and is attached as **Item C-2(c)**.

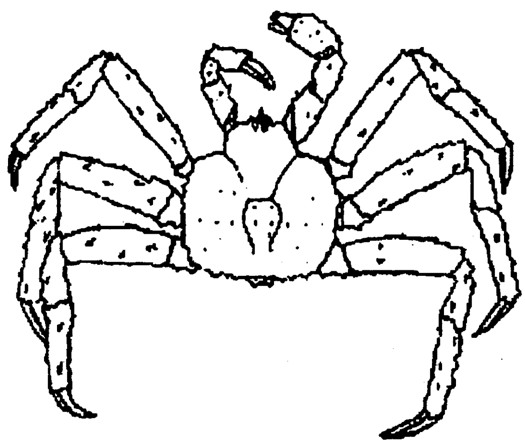
As noted in the paper, following approval of Amendment 24 to the BSAI Crab FMP, all crab stocks now have annually-specified overfishing limits (OFLs). For all stocks for which information is available, these OFLs are intended to cover total removals from the stock, including bycatch in groundfish and scallop fisheries. As discussed under agenda item C-2(a), additional requirements for catch removals for crab stocks will be necessary to comply with Annual Catch Limits (ACLs). The Crab Plan Team discussed relative bycatch management measures in groundfish and scallop fisheries at the May 2020 meeting and their minutes are attached under agenda item C-2(b) above. The Team continues to recommend that the Council consider measures to restrict bycatch in groundfish fisheries. The Team reiterated its request and discussed specific bycatch concerns related to individual in conjunction with ACLs and Accountability Measures (AMs) at the March and May 2010 meetings. This paper intends to provide the Council with the information necessary to determine whether or not to initiate an analysis at this meeting to restrict bycatch of crab stocks in groundfish and scallop fisheries in order to prevent exceeding an annually specified ACL or OFL by crab stock due to catch outside of the directed crab fisheries.

**Initial Review Draft**

# ENVIRONMENTAL ASSESSMENT for proposed amendments 38 and 39

# TO THE FISHERY MANAGEMENT PLAN FOR THE BERING SEA AND ALEUTIAN ISLANDS KING AND TANNER CRABS

**to comply with Annual Catch Limit requirements (amendment 38) and to revise the rebuilding plan for EBS snow crab (amendment 39)**



Abstract: This environmental assessment analyses two actions to amend the BSAI Crab FMP. Action 1: to amend the FMP to specify the method by which the Council will establish annual catch limits (ACLs) to meet the requirements of the revised Magnuson-Stevens Act. These ACLs are to be established based upon an acceptable biological catch (ABC) control rule which will be set forth in the FMP and will account for the uncertainty in the overfishing limit (OFL) point estimate. Two alternative means of establishing the ABC control rule are considered: 1) a constant buffer approach where the ABC for each stock would be set by application of a constant pre-specified buffer value below the OFL; and 2) a variable buffer approach where the ABC would be established based upon a pre-specified percentile of the distribution for the OFL which accounts for scientific uncertainty regarding the OFL. A range of constant buffers and probabilities are considered under each alternative approach. Action 2: to prepare and implement an amended plan to rebuild the snow crab stock in compliance with section 304(e)(3) of the Magnuson-Stevens Act. A range of alternative time frames are considered for rebuilding the stock. The impacts of the alternatives considered under both actions upon crab resources, fishery participants, habitat, marine mammals, and other groundfish resources are discussed in the analysis.

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May 2010

## EXECUTIVE SUMMARY

The king and Tanner crab fisheries in the Exclusive Economic Zone (EEZ) (3 to 200 miles offshore) of the Bering Sea and Aleutian Islands off Alaska are managed under the Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs (FMP). The FMP establishes a State/Federal cooperative management regime that defers crab fisheries management to the State of Alaska (State) with Federal oversight. State regulations are subject to the provisions of the FMP, including its goals and objectives, the Magnuson-Stevens Act, and other applicable Federal laws.

There are two proposed actions contained in this analysis:

*Action 1-Annual Catch Levels for BSAI Crab Stocks:* The first proposed action is to establish annual catch levels (ACLs) to meet the requirements of the revised Magnuson Stevens Act. The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSRA, Public Law 109-479) includes provisions intended to prevent overfishing by requiring that FMPs establish a mechanism for specifying annual catch levels (ACLs) in the plan (including a multiyear plan), implementing regulations, or annual specifications, at a level such that overfishing does not occur in the fishery, including measures to ensure accountability (accountability measures or AMs). All crab fisheries must have ACL and AM mechanisms by the 2011/2012 crab fishing year. The MSRA includes a requirement for the SSC to recommend acceptable biological catch (ABC) levels to the Council, and provides that ACLs may not exceed the fishing levels recommended by the Science and Statistical Committee (SSC).

These ACLs are to be established based upon ABC control rules which account for the uncertainty in the overfishing limit (OFL) point estimate. To meet the ACL requirements, the ABCs for each stock will be established under the FMP such that ACL = ABC and the total allowable catches (TAC) and guideline harvest levels (GHLs) must be established sufficiently below the ABC so as not to exceed the ACL. Determinations of TACs and GHLs are Category 2 management measures and are deferred to the State following the criteria in the FMP. ABCs must be annually recommended by the NPFMC SSC.

*Action 2 - Rebuilding Plan for Snow Crab Stock:* The second proposed action is a revised rebuilding plan for the eastern Bering Sea (EBS) snow crab stock. The EBS snow crab stock will not rebuild by the end of the rebuilding time frame of 2009/2010, thus a revised rebuilding plan must be developed for this stock.

Both of these proposed actions must be implemented prior to the start of the 2011/12 crab fishing year. These actions are considered together in this analysis as the implementation timing is identical and the actions themselves are related in the interplay between rebuilding plan catch constraints and ACL catch constraints for the EBS snow crab stock. For the remaining nine BSAI crab stocks for which rebuilding provisions are not considered in this analysis, only Action 1 (establishment of ACLs) applies. Additionally, Pribilof Islands blue king crab remains overfished. The current rebuilding plan has not achieved adequate progress to rebuild the stock by 2014. The Council is preparing an amended Pribilof Islands blue king crab rebuilding plan. This rebuilding plan will be analysed in a separate document because the primary rebuilding alternatives address bycatch in groundfish fisheries.

These two proposed actions are scheduled for initial review at the June 2010 Council meeting. Final action by the Council is scheduled for October 2010.

## Review of actions under consideration and overview of impacts

### Action 1: Annual Catch Levels for BSAI Crab Stocks

The proposed action is to amend the FMP to specify the method by which the Council will establish annual catch limits (ACLs) to meet the requirements of the revised Magnuson-Stevens Act. These ACLs are to be established based upon an acceptable biological catch (ABC) control rule which will be set forth in the FMP and will account for the uncertainty in the overfishing limit (OFL) point estimate. To meet the ACL requirements, ABCs will be annually established under the ABC control rule and ACLs will be set such that ACL is set equal to the ABC.

Three alternatives are considered under Action 1, with multiple options under Alternative 2 and Alternative 3:

*Alternative 1-Status Quo:* Alternative 1 would continue the current practice of annually established OFLs for the 10 BSAI crab stocks and would not establish annual catch limits below these values. All catch levels (TACs and GHLs) for these stocks are established by the State of Alaska using the management categories outlined in the FMP. Note this alternative is considered for comparative purposes against other alternatives in this analysis but per revised federal guidelines would not meet all applicable legal requirements.

*Alternative 2 and Alternative 3-Establish ACL equal to ABC:* Alternative 2 and Alternative 3 address how the ABC control rule will be specified, the process by which the SSC will recommend the ABC to the Council annually, and the accountability measures that are enacted if the ACLs are annually exceeded. Two approaches are considered for the specification of the ABC control rule, a constant buffer approach and a variable buffer approach.

*Alternative 2- Constant Buffer:* The ACL would be set equal to the total-catch acceptable biological catch (ABC). The ABC for each stock would be set to the product of a constant pre-specified buffer less than 1 and the established OFL. Once the buffer value is selected, the ABC would be annually set below the annual OFL based on the most recent stock assessment using the fixed buffer.

Buffer values under consideration in this alternative include the following[1]:

| | |
|---|---|
| Option 1: | ABC = OFL (no buffer) |
| Option 2: | ABC = 90% of OFL |
| Option 3: | ABC = 80% of OFL |
| Option 4: | ABC = 70% of OFL |
| Option 5: | ABC = 60% of OFL |
| Option 6: | ABC = 50% of OFL |
| Option 7: | ABC = 40% of OFL |
| Option 8: | ABC = 30% of OFL |
| Option 9: | ABC = 20% of OFL |
| Option 10: | ABC = 10% of OFL |

*Alternative 3- Variable Buffer:* The ACL would be set equal to the total-catch acceptable biological catch (ABC). The ABC would be established based upon a pre-specified percentile of the distribution for the

[1] Note that other buffer values may be selected within these ranges.

OFL which accounts for scientific uncertainty regarding the OFL. Here, the probability of the ABC exceeding the OFL (P(ABC>OFL)) is equal to a specified value, P*[2] ('P star').

A range of P* values are considered and result in stock-specific percentage buffer values that vary over time depending on the assessed extent of scientific uncertainty. Once the P* value is selected, the ABC would be annually established below the annual OFL using the buffer which corresponds to the selected P* and taking account of the annual assessed extent of scientific uncertainty. The OFL is based upon the most recent stock assessment.

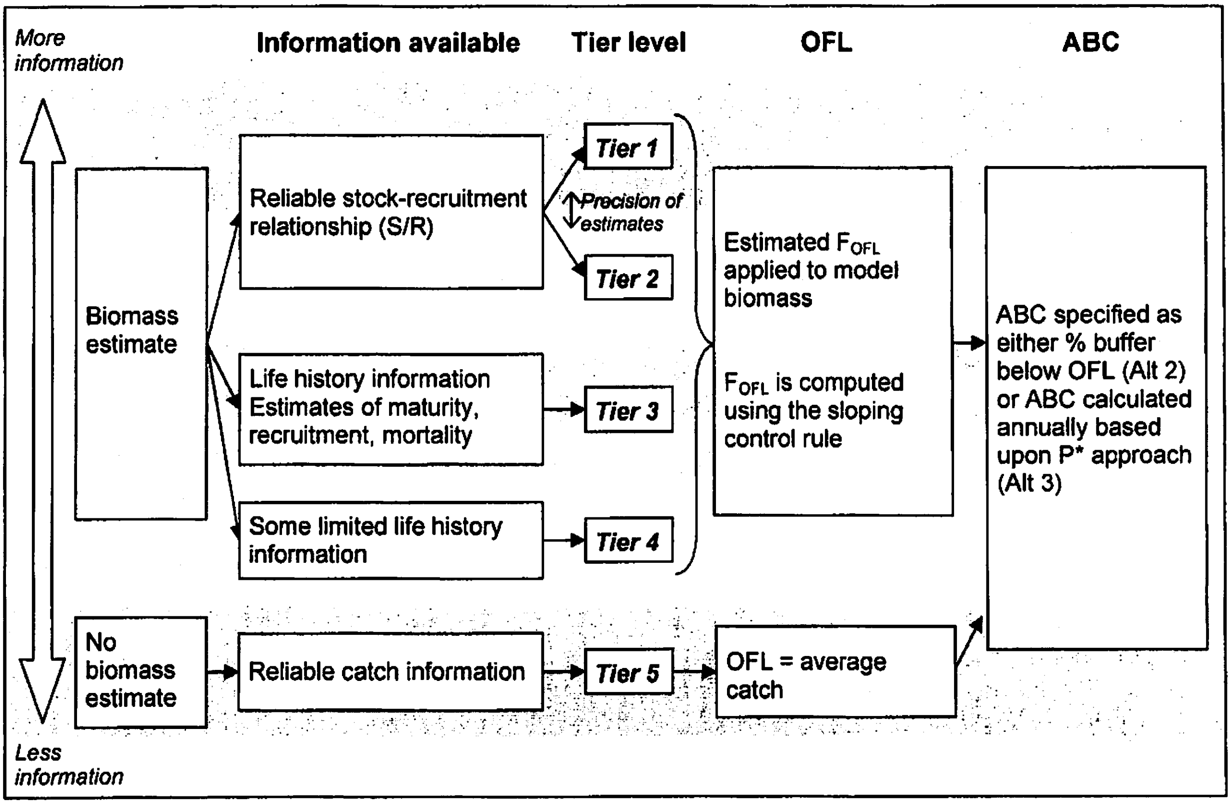
P* values under consideration in this alternative include the following[3]:

Option 1: P* = 0.5
Option 2: P* = 0.4
Option 3: P* = 0.3
Option 4: P* = 0.2
Option 5: P* = 0.1

Selection of either Alternative 2 or 3 will implement a process for annual ABC specification under the FMP. The process by which the ABC is determined differs according to which approach is selected, constant buffer or P*. In either case the Tier system in the FMP is amended to explicitly provide for ABC specification in addition to the current OFL-only control rules. The calculated ABC would be the ABC recommendation for that year noting that the SSC may recommend an alternate ABC value in the annual specification process. A schematic of the current Tier system is provided in Figure ES 1 with indication of how the ABC will be included by Tier. The process for annually specifying the ABC under each approach is described below.

[2] Further information on the background rationale and utility of P* as a reference value for risk is contained in Chapter 3 of this analysis.
[3] Note that other P* values may be selected within these ranges.

**Figure ES1 Schematic of the Current OFL Tier system and proposed ABC process**




*Process for ABC recommendation:* In order to modify this process to allow for the SSC to recommend the ABC on an annual basis, three options are considered:

Option 1: SSC recommends ABC levels annually at October Council meeting (delayed TAC-setting)

Option 2: SSC recommends ABC levels annually prior to October Council meeting (shift timing of October Council meeting)

Option 3: SSC recommends ABC levels annually prior to October Council meeting (convene special SSC meeting prior to TAC-setting)

Option 4: SSC recommends ABC levels annually in June

*Accountability Measures:* Accountability measures (AMs) must also be specified in the case that ACLs are annually exceeded.

### Summary of impacts of Action 1

The treatment of uncertainty is a critical aspect in this analysis. Two aspects to uncertainty are considered: assessment uncertainty and additional uncertainty. Stock-specific OFL distributions are contained in each chapter and indicate the relative uncertainty characterized within the assessment itself due, for example, to the ability of the population dynamics model to mimic the observed length-frequency and survey biomass data. As noted in each stock-specific chapter however, this characterization of uncertainty may not be sufficient to adequately capture the true uncertainty of the stock's OFL. For this reason, a qualitative section is included for each stock that outlines the additional sources of uncertainty not captured in the assessment itself, but which should still be considered when assessing the true uncertainty associated with the estimate of the OFL. The sources listed for each stock are restricted to calculation of OFL in the short-term and do not consider issues such as changes over time in productivity and habitat loss. Whether and how much additional uncertainty is included by stock has a substantial impact on the size of the resulting buffer value.

Based on results of the preliminary analysis, the stocks with the most precise estimates of within-assessment uncertainty are the following: Bristol Bay red king crab, EBS snow crab, St. Matthew blue king crab, AI golden king crab, and Tanner crab. Of these however, the OFL for St Matthew blue king crab in particular should be based on higher (assumed) levels of additional uncertainty, despite the low uncertainty associated with the estimate of the OFL from the assessment itself. It is not possible to estimate the extent of uncertainty associated the OFL for Tier 5 stocks in a manner similar to stocks in Tiers 1-4 due to lack of reliable biomass estimates. Thus a different characterization of uncertainty was employed for Tier 5 stocks.

Additional uncertainty (i.e., in addition to the estimated 'within assessment' uncertainty described above) is included by conducting analyses for range of constants that represent different levels of additional uncertainty, from 0.0 (no additional uncertainty), to 0.2 (low), 0.4 (medium) and 0.6 (high). For all stocks, it is recommended that some additional uncertainty should be allowed for computing ABCs. A value must thus be recommended for each stock. It is recommended that unless a different value is recommended by the CPT and endorsed by the SSC, the additional uncertainty should be set to 0.2 for Bristol Bay red king crab and EBS snow crab, to 0.4 for EBS Tanner crab, AI golden king crab and to 0.6 for St. Matthew blue king crab, Pribilof Islands blue king crab, Pribilof Islands red king crab, Norton Sound red king crab, Pribilof Islands golden king crab and Adak red king crab. Note that the impacts of accounting for these levels of additional uncertainty compared with only employing the buffer resulting from the within-assessment variability can be substantial.

A summary of the analysis of alternatives is provided below to highlight the distinction between the policy choice of a constant buffer (Alternative 2) by stock or Tier and a variable buffer (Alternative 3) by stock or Tier. Under Alternative 3 the Council would choose an appropriate P* value for each stock (or Tier) depending upon an understanding of the relative risk of overfishing. Once the P* decision is made, the buffer value associated with that level of risk is calculated annually and results in a buffer level for that particular stock taking into account the annually calculated within and additional variance of the assessment. As information improves for each assessment, the buffer value calculated will likewise decrease for the same P*, resulting in a gradual increase in the ABC over time. Table ES-1 provides a summary of the buffer values calculated for a range of P*s the current fishing year using the recommended levels of variance. The Council may not select an alternative that would lead to greater or equal to a 50% chance of overfishing thus some P* options for some stocks (and P* = 0.5 for all stocks) are not available to the Council as a policy decision.

**Table ES-1 Buffer values for 8 stocks for a range of P*s under Alternative 3 using the recommended additional variance levels ($\sigma_b$). Shading indicates P* choices that would result in a 50% chance of overfishing.**

| P*: | 0.5 | 0.4 | 0.3 | 0.2 | 0.1 |
|---|---|---|---|---|---|
| **Stock** | **Buffer** | | | | |
| Bristol Bay red king crab | 0% | 6% | 11% | 17% | 24% |
| EBS snow crab | 3% | 8% | 13% | 18% | 16% |
| Tanner crab | 31% | 47% | 69% | 100% | 100% |
| Pribilof Island red king crab | 0% | 69% | 89% | 100% | 100% |
| St. Matthew blue king crab | 0% | 1% | 11% | 23% | 37% |
| Norton Sound red king crab | 0% | 28% | 40% | 48% | 60% |
| Dutch Harbor golden king crab | 0% | 20% | 28% | 35% | 46% |
| Adak golden king crab | 0% | 19% | 29% | 37% | 48% |

Similar information for Alternative 2 is presented in Table ES-2. Here the policy decision is to select an appropriate fixed buffer level by stock (or Tier), taking into account the estimated risk of overfishing indicated in the analysis. Once the policy decision is made on the choice of a fixed buffer level (i.e., ABC = x% OFL, where x is the buffer level selected), that buffer levels would be used annually for that stock regardless of any modification in information contained in the stock assessment annually. The P*s associated with a range of buffer values calculated for the current fishing year using the recommended levels of variance are summarized in Table ES-2. Again, the Council may not select an alternative that would lead to greater or equal to a 50% chance of overfishing thus some buffer options for some stocks (and a 0 buffer equating to a P* = 0.5 for all stocks) are not available to the Council as a policy decision.

**Table ES-2 P* values for 8 stocks for a range of buffer values under Alternative 2 using the recommended additional variance levels ($\sigma_b$). Shading indicates P* choices that would result in a 50% chance of overfishing.**

| Buffers | 0 | 10% | 20% | 30% | 40% |
|---|---|---|---|---|---|
| **Stock** | **P*** | | | | |
| Bristol Bay red king crab | 0.5 | 0.25 | 0.11 | 0.04 | 0 |
| EBS snow crab | 0.5 | 0.36 | 0.18 | 0.07 | 0.01 |
| Tanner crab | 0.64 | 0.60 | 0.56 | 0.50 | 0.44 |
| Pribilof Island red king crab | >0.50 | >0.50 | >0.50 | >0.50 | >0.50 |
| St. Matthew blue king crab | 0.5 | 0.41 | 0.33 | 0.27 | 0.19 |
| Norton Sound red king crab | 0.61 | 0.54 | 0.47 | 0.37 | 0.3 |
| Dutch Harbor golden king crab | 5 | 0.5 | 0.4 | 0.26 | 0.16 |
| Adak golden king crab | 0.5 | 0.49 | 0.39 | 0.29 | 0.16 |

*Directed Harvest Constraint (Short-term)*

Results in each chapter of this analysis (Chapters 4-12) summarize the impact of a range of ACL buffer values on the short-term harvest, i.e. whether the ABC control rule at different buffer values would constrain the State harvest strategy for that stock. Here the State harvest strategy is used to approximate the TAC level in future years.

For Bristol Bay red king crab, the retained component of the catch based on the state harvest strategy would be constrained at buffer levels below 0.9 (i.e., a 10% buffer, or ABC established at 90% of the OFL). For Pribilof red king crab, any buffer (i.e., even at a 0% buffer or ABC established at the OFL) would constrain the State harvest strategy (note that the State harvest strategy has not been employed for this stock since 1993 due to concerns with the potential for bycatch of the Pribilof blue king crab stock in a directed Pribilof Island red king crab fishery and stock fluctuations within the Pribilof Island red king crab stock). All directed catch remains at zero for Pribilof blue king crab stock so there is no short-term impact of any buffer size on the directed catch component of the ABC for this stock. For St. Matthew blue king crab, the retained catch component would be constrained at all buffer levels for the ABC. For Norton Sound red king crab, only buffer levels below 0.5 would constrain the current harvest strategy estimate. For AI golden king crab, only buffers below 0.1 would constrain the retained catch component of an ABC for this stock. For Pribilof Island golden king crab, buffer values below 0.8 would constrain the estimated GHL (based on the 2010 GHL amount). The western Aleutian Islands (WAI) red king crab stock is currently closed at this time thus buffer values considered do not impact the directed catch for this stock at this time.

*Probability of Overfishing*

More constraining buffers (or lower values for P*) decrease the probability that stocks will become overfished in the future. This is shown quantitatively for those stocks for which biomass estimates and projections of stock status are possible. This is highly dependant however upon individual stock status and recruitment assumptions inherent to these models. Additional information by stock should be considered in evaluating long-term implications of these ACL alternatives.

## Action 2: Rebuilding Plan for Snow Crab stock

The purpose of this proposed action is to prepare and implement an amended plan to rebuild the snow crab stock. Several alternatives are considered under Action 2, which are framed in terms of the time frames necessary to rebuild the stock.

*Alternative 1: No Action*
This is the no action alternative. This alternative would be future management under which ever alternative is selected under Action 1.

*Alternative 2: Set target rebuilding time frame ($T_{TARGET}$) based on the minimum number of years necessary to rebuild the stock.*
This alternative would set $T_{TARGET}$ based on minimum number of years necessary to rebuild the stock, under the current assessment of the snow crab stock, if all sources of fishing-related mortality are set to zero.

*Alternative 3 to Alternative 5: Set $T_{TARGET}$ above the minimum number of years (between 1 above the minimum and $T_{END}$).*
Alternative 3: 3 years to rebuild
Alternative 4: 4 years to rebuild
Alternative 5: 5 years to rebuild

Under these alternatives, the annual fishing mortality rate would be calculated so that the probability of rebuilding by $T_{TARGET}$ is fixed at the selected value. Note that closures in groundfish fisheries and crab fisheries would need to occur in a given year if F=0 is necessary to achieve the agreed probability in that year. Under the default scenario (i.e., if none of the options below is selected), $T_{TARGET}$ would be the year in which the probability of rebuilding is 50%.

In addition to these alternatives, options are considered that would increase the probability of rebuilding by the agreed $T_{TARGET}$. Increasing probability of rebuilding for a given $T_{TARGET}$ is achieved through either extending the time frame for rebuilding (option 1) or through directed fishery harvest constraints (options 2 and 3).

Options to increase probability of rebuilding:

- option 1: increase probability of rebuilding to 70% by increasing time frame to $T_{end}$ to 8 years
- option 2: increase probability of rebuilding to 75% by $T_{target}$.
- option 3: increase probability of rebuilding to 90% by $T_{target}$.

Under option 1 the probability of rebuilding would be increased to 70% by extending the time frame for $T_{end}$ while retaining the maximum fishing mortality constraint of 75% of $F_{OFL}$ for 3 additional years from the Alternative 5. Under options 2 and 3, the time frame to rebuild cannot be extended to increase the probability of rebuilding higher than under option 1 thus these options would require a more constraining maximum fishing mortality rate than the 75% of $F_{OFL}$ assumed under the other alternatives and option 1.

The time frames and the relative probability of rebuilding for each alternative and option are summarized below for the Base Model (ES-3)[4]. The probability of rebuilding assumes the current default definition of rebuilt in which calculated biomass must be above the $B_{MSY}$ estimate for the second consecutive year before the stock is considered 'rebuilt'.

**Table ES-3 The relative probability of rebuilding, year-end date in crab fishing year for rebuilding, and resulting buffer value necessary to rebuild in this time frame for each alternative and**

| Alternative | Probability of rebuilding | $T_{TARGET}$ year-ending date | Buffer value % of $F_{OFL}$ |
|---|---|---|---|
| **Alternative 1** (no action) | 0.526 (50% probability) | 2016/17 | 25% |
| **Alternative 2** ($T_{MIN}$) | 0.616 (50% probability) | 2013/14 | 100% |
| **Alternative 3** | 0.52(50% probability) | 2014/15 | 73% |
| Alternative 3-Option 2 | 0.75 (75% probability) | 2014/15 | 85% |
| Alternative 3-Option 3 | 0.90 (90% probability) | 2014/15 | 93% |
| **Alternative 4** | 0.52 (50% probability) | 2015/16 | 40% |
| Alternative 4-Option 2 | 0.755 (75% probability) | 2015/16 | 67% |
| Alternative 4-Option 3 | 0.91 (90% probability) | 2015/16 | 82% |
| **Alternative 5** | 0.526 (50% probability) | 2016/17 | 25% |
| Alternative 5-Option 2 | 0.755 (75% probability) | 2016/17 | 60% |
| Alternative 5-Option 3 | 0.909 (90% probability) | 2016/17 | 80% |
| Alternative 5-Option 1 ($T_{END}$) | 0.704 (70% probability) | 2017/18 | 45% |

For all options, the values for the probability of rebuilding for each year of the rebuilding period and the associated rebuild fishing mortality rate would be calculated annually using the best assessment of the EBS snow crab stock, as recommended by the SSC. The CPT, SSC, and Council will annually review progress towards rebuilding and recommend annual adjustments to the fishing mortality rates on which management decisions are based consistent with the intent of the chosen alternative and progress towards rebuilding. If rebuilding to the proxy for $B_{MSY}$ does not occur by $T_{end}$, then the maximum $F$ will be the *rebuilding* $F$[5], the $F$ of the final year, or 75% of $F_{OFL}$, whichever is lower, until a new rebuilding plan is developed.

[4] See Chapter 4 and snow crab stock assessment (Turnock and Rugolo 2010) for more onformation on the Base Model configuration.

[5] Further consideration should be given prior to initial review as to what the rebuilding $F$ is (possibly average $F$ over rebuilding time frames, or others rebuilding F?)

### Summary of impacts of Action 2

ACLs and rebuilding strategies are considered simultaneously for EBS snow crab stock. For this stock, the probability of rebuilding under different buffer values was estimated.

For EBS snow crab, consideration is also given to different ways to estimate the survey selectivity curve and maximum selectivity, Q. The upper limit of the buffer examined for rebuilding was 0.75 as prescribed by the National Standard Guidelines 1 for stocks that have failed to rebuild at the end of a rebuilding plan. Note this is an interim measure until a revised harvest strategy under the rebuilding plan is adopted or when the stock is rebuilt. For snow crab, the earliest year the stock would achieve a 50% probability of rebuilding under F=0.0 is estimated to be 2013/14, while the latest year the stock would be considered rebuilt is 2017/18 fishing at the maximum permissible $F=0.75F_{OFL}$(Table ES-3).

### Summary of impacts on other marine resources and cumulative effects (Actions 1 and 2)

Changes in interactions with other fish species, marine mammals, and seabirds are linked to changes in target crab fishery efforts. As described above, overall fishing effort in the crab fishery is expected to remain the same or to decrease under Actions 1 and 2. The harvest levels for all crab species, under any Alternative, would remain the same or would be constrained. Further, no changes to the distribution of crab fisheries are anticipated under the proposed Actions. To the extent that crab fishing effort is reduced, and consequently adverse interactions with incidental catch species though bycatch or disturbance are also reduced, there could be some benefit to these species. Any effects on incidental catch species, however, should not be significant under either Action 1 or 2 with any associated Alternative and Option.

The effects of the two proposed Actions on marine mammals, seabirds, and their habitat are considered insignificant and are not expected to alter the current rates of interaction beyond those already evaluated because overall fishing effort in the crab fishery is expected to remain the same or to decrease. Spatial and temporal concentration effects by these fisheries, vessel traffic, gear moving through the water column, or underwater sound production which could affect marine mammal foraging behavior, would not be affected any more than currently by the proposed Actions and Alternatives. The effects of these Federal Actions and Alternatives on seabirds are considered insignificant and are not expected to affect current rates of interaction. No changes in the indirect effects of fisheries on prey (forage fish) abundance and availability, benthic habitat as utilized by seabirds, and processing of waste and offal, all of which could affect seabirds, are expected under these Actions and Alternatives.

The cumulative effects section of this analysis describes additional past, present, or reasonably foreseeable future actions. The reasonably foreseeable future actions are the following:

- Tanner crab rebuilding plan
- Pribilof Island blue king crab rebuilding plan
- Revisions to the Crab Rationalization Program
- Management measures to address crab bycatch in the groundfish fisheries

The Tanner crab and Pribilof Island blue king crab rebuilding plans are currently under development by the Council and NMFS, and include alternatives that could further constrain the allowable catch in those crab fisheries. The analyses for the rebuilding plans will follow the Council's adoption of a preferred alternative on ACLs and so will take into account any reductions in harvest levels attributable to the implementation of ACLs in the discussion of impacts. The Council may also suggest revisions to the Crab Rationalization Program after the Council's five year review concludes in December 2010, which could affect the percentage of the harvest pool distributed as crew shares and could change the distribution and amount of crab landings subject to IPQ and regional landing requirements.

The Council is also considering a discussion paper evaluating crab bycatch in the groundfish fisheries. Currently, there are no hard quotas to cap crab bycatch in the groundfish fisheries, although area closures with associated catch limits are utilized to reduce bycatch. Accountability Measures (AMs) are a required provision of the MSRA in conjunction with provisions for ACL requirements. The intent of AMs are to further protect a crab stock from overfishing by providing for a transparent response mechanism in the event that the established ACLs are exceeded. Without further Council action, crab bycatch in the groundfish fisheries will be accounted for by reducing harvest in the directed crab fisheries. As a future action, however, the Council may consider alternative management measures for bycatch in the groundfish fisheries.

**Council motion (on Crab ACLs) April 2010**

From the April 11, 2010 Council meeting, regarding Agenda item:
D-1(a) Crab ACL Analysis and BSAI snow and Tanner crab rebuilding

*The Council directs staff to incorporate SSC and Plan Team recommendations as well as the following comments in preparing the analysis for initial review.*

The Council supports the SSA and AP recommendations on the draft snow crab rebuilding plan and proposed ABC control rules that would be used to annually establish crab ACLs.

Despite this support, the Council has the following concerns:

- The annual stock assessment and OFL specification process should avoid inclusion of multiple conservative buffers. The Council believes that the appropriate venue for consideration of precautionary measures is in recommendation of ABC by the Crab Plan Team and SSC and in TAC setting conducted by the State of Alaska.
- The Council would like to have a clearer understanding of the National Standard 1 guideline requirements to inform selection of a preliminary preferred alternative. For example, would a range for additional uncertainty of 0.1-0.3 rather than 0.2-0.6 satisfy requirements?
- Moving the timing of the ABC recommendation to June as described in the SSA and AP minutes under a new Option 4 would not allow for use of survey data from the most recent year. As well the Council may set a one year, rather than two year standard, for rebuilt crab stocks. One or both of these options may present an unnecessary risk given the sometimes dramatic inter-annual fluctuations in abundance experienced by some crab stocks.
- Accountability Measures are a means of addressing crab bycatch in fisheries contributing to crab mortality. The Council should begin to develop crab bycatch management measures including PSC limits for each crab species. It is the Council's intent that PSC limits be analyzed to identify the groundfish and scallop fishery sectors contributing to crab bycatch and quantify their relative contribution to total crab bycatch mortality. The Council believes that Accountability Measures should establish a linkage between the crab and groundfish FMPs to equitably spread the burden of crab bycatch mortality amongst all fishery participants.

## Comparison of accounting for uncertainty in the ABC control rule for Crab and Groundfish Tier systems

At preliminary review in April 2010, the Council requested that staff clarify the treatment of uncertainty in establishing the ABC control rule under the proposed Crab ACL analysis versus the existing treatment of uncertainty in establishing ABCs in the BSAI and GOA groundfish tier systems. Below is an excerpt from the groundfish ACL analysis (NMFS/NPFMC 2010) which noted that current treatment of scientific uncertainty in the groundfish Tier system was sufficiently conservative at this time to meet the intent of the National Standard guidelines.

### *Annual Harvest Specification Process and Incorporation of Uncertainty*[1]

*Regulations at 50 CFR part 679 address management of groundfish in the BSAI and GOA. These regulations describe the annual process of specifying OFL, ABC, and TAC levels for target species and other species. Under § 679.20(a), a TAC must be specified for each target species category and for the combined other species category. TACs for the target species may be split or combined by the Council to establish new quota categories through the annual specifications process, as recommended by its scientific advisors; a plan amendment is not required. The Council, however, is not authorized under § 679.20 to split or combine the species in the other species category. Before the Council can specify a TAC for a single species or species group within the other species category, it first must move this species from the other species category to the target species category in the FMPs. Once a species or species group is categorized as a target species in the FMPs, the Council must specify a separate OFL, ABC, and TAC for the species or species group in the annual groundfish specifications process, or combine this new target species with some other target species to form a target species group. Annual specifications for 2010 are listed for the BSAI in Table 10 and for the GOA in Table 11.*

*The control rule used for setting specifications for target groundfish is intended to account for scientific uncertainty in two ways. First, the control rule is structured explicitly in terms of the type of information available, which is related qualitatively to the amount of scientific uncertainty. Second, the size of the buffer between the maximum fishing mortality rate (maxF) and ABC in Tier 1 of the ABC control rule and F and OFL in Tier 1 of the OFL control rule varies directly with the amount of scientific uncertainty. For the information levels associated with the remaining tiers, relating the buffer between maxF/ABC and F/OFL to the amount of scientific uncertainty is more difficult because the amount of scientific uncertainty is harder to quantify, so buffers of fixed size are used instead.*

*The probability that the specified ABC exceeds the "true" OFL (i.e., the OFL that would be specified if all scientific uncertainty were eliminated) was evaluated for a variety of stocks in Tiers 1, 3, 5, and 6. The SSC has determined that the range of resulting probabilities provide sufficient protection against overfishing, at least for the time being. It is anticipated that research regarding estimation of these probabilities will continue. This research may result in a future amendment proposal that prescribes the*

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[1] From Section 1.4.2.1.1 of NMFS/NPFMC 2010. Environmental Assessment for Amendment 96 to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area and Amendment 87 to the Fishery Management Plan for Groundfish of the Gulf of Alaska to Comply with Annual Catch Limit Requirements. North Pacific Fishery Management Council, Anchorage, AK 99501.

*buffer between ABC and OFL explicitly in terms of the amount of scientific uncertainty (presently, Tier 1 prescribes the buffer explicitly in terms of the amount of scientific uncertainty, but the other tiers do not).*

As described above from the analysis for amendments 96 and 87 to the groundfish FMPs, the groundfish Tier system explicitly prescribes the buffer to account for uncertainty in Tier 1 only. For the proposed ACL amendments for the Crab FMP, the approach for specifying the ABC control rule explicitly accounts for the scientific uncertainty in the OFL for Tiers 1-4 and attempts to explicitly account for the uncertainty in the average catch calculation (from which the Tier 5 OFL is derived) for Tier 5 as well. This represents an improvement in terms of meeting the guidelines for the consideration of scientific uncertainty in the ABC control rule for all tiers in the Crab tier system as compared with the groundfish tier system. Future consideration may be given to amending the groundfish Tier system to resemble the direction taken by the Council for the Crab tier system in appropriately accounting for scientific uncertainty in the OFL for all Tier levels.

AGENDA C-2(a)(4)
JUNE 2010

SEAN PARNELL, GOVERNOR

# STATE OF ALASKA

**DEPARTMENT OF FISH AND GAME**
*ALASKA BOARD OF FISHERIES*

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March 23, 2010

Mr. Eric Olson, Chairman
North Pacific Fishery Management Council
605 West 4th, Suite 306
Anchorage, AK 99501-2252

Re: BSAI crab and statewide scallop federal fishery management plan amendments

Dear Chairman Olson:

At our December 2009 joint North Pacific Fishery Management Council (council)/Alaska Board of Fisheries (board) meeting, we received briefings on several Bering Sea/Aleutian Islands (BSAI) crab and statewide scallop fishery management actions scheduled for final action by the council in October 2010. That briefing provided an introduction to more detailed presentations delivered during our March 2010 meeting where we reviewed the preliminary range of alternatives for three crab rebuilding plans and received an overview of alternatives to meet crab and scallop Annual Catch Limit (ACL) requirements. In addition, we were provided a summary of federal fishery management plan (FMP) framework and the state's authority under our joint state-federal management structure for BSAI crab and statewide scallops. This letter provides input from the board meant to assist and inform the council as analyses move forward and preferred alternatives are selected. A detailed briefing document we utilized in shaping the recommendations contained herein is enclosed for your reference.

In establishing ACLs, the board requests that the council give serious consideration to approaches that reasonably meet MSA requirements – without being so precautionary as to encroach upon the state's authority to set TACs. ACL buffers more conservative than required to comply with federal law would diminish the state's ability to exercise policy discretion provided under the BSAI crab FMP. ACL requirements were developed as a means to achieve National Standard 1 under the revised MSA and do not change FMP goals and objectives. The state's conservative approach to harvest strategy implementation and proven ability to account for and respond to the best available stock status information provide added protections from overharvest and should be considered additional protections as the council recommends regulatory buffers to prevent overfishing.

Alternatives for rebuilding overfished crab stocks include a range of rebuilding time periods; options that could be coupled with those alternatives increase the probability of rebuilding in a given time period. The full range of alternatives and options is achieved through harvest rate adjustments, some of which restrict the state's authority and flexibility in setting annual TACs. We are concerned that an overly prescriptive approach to crab rebuilding plans would be inconsistent with the spirit of state-federal joint management established under the BSAI crab

FMP, and could represent a degradation of state's role in meeting rebuilding requirements and management objectives specified in the FMP and as National Standards.

The board is also concerned about crab bycatch in groundfish fisheries and associated impact on stock rebuilding and directed fishery harvest potential. We understand that the council received a crab bycatch discussion paper in October 2009 and subsequently requested that an expanded discussion paper be brought forward in 2010. The board encourages the council to continue review of this issue by initiating analysis of crab bycatch in BSAI groundfish fisheries and to evaluate the impact of bycatch and current bycatch limits on the directed crab fisheries under the council's preferred alternatives for rebuilding plans and ACL management measures.

The intent of the BSAI crab FMP is to preserve the state's management flexibility within the bounds of federal law and the board has consistently met that intent by exercising its FMP deferred authority to adopt harvest strategies satisfying both MSA requirements and FMP management objectives. These harvest strategies, crafted through a transparent regulatory process, demonstrate sound management policy, and provide fishery managers the necessary flexibility to establish TACs within federal rebuilding plan and ACL requirements. In acknowledgment of the state's consistent compliance with federal law and expertise in managing BSAI crab and statewide scallop stocks, we ask that when considering alternatives for rebuilding plans and ACLs, the state's traditional FMP deferred role in establishing TAC levels be recognized and retained. We request the council adopt preferred alternatives that provide the greatest flexibility to the state in setting TACs.

We believe that these requests will inform the process used to establish crab rebuilding plans and ACLs for crab and statewide scallops, leading to better managed fisheries. In furthering the shared interest of continued dialogue on rebuilding plans and ACLs we suggest that the Joint Protocol Committee of the Board of Fisheries and North Pacific Fishery Management Council meet in September, before final action by the council, and after a preliminary preferred alternative has been selected. We also, as always, invite council and NMFS representatives to participate in the board process and to collaborate with us on topics of mutual interest.

The Board of Fisheries looks forward to the continued coordination on these important fishery topics. Thank you.

Sincerely,

Vince Webster
Chairman, Alaska Board of Fisheries

Enclosure

cc: Jim Balsiger, Regional Administrator, National Marine Fisheries Service
Denby Lloyd, Commissioner, Alaska Department of Fish and Game

RC 26
BOF March 2010

**Briefing to the Alaska Board of Fisheries on BSAI crab FMP amendments**

**Alaska Department of Fish and Game Division of Commercial Fisheries**

**March 16, 2010**

The following briefing identifies issues the Board of Fisheries (board) may wish to consider in response to pending North Pacific Fishery Management Council (council) actions related to Bering Sea and Aleutian Islands (BSAI) crab. This briefing is intended to supplement the presentation you will receive as staff report RC5.

Analyses have been initiated for implementation of Annual Catch Limits (ACL), and development of Pribilof Islands blue king, Bering Sea snow, and Bering Sea Tanner crab stock rebuilding plans. Some alternatives in the analyses have considerable potential to negatively impact management authority deferred to the State of Alaska (state) in the Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs (FMP).

ACLs

National Standard 1 guidelines developed in response to 2007 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSA) require that ACLs be adopted for each crab stock listed in the FMP and that ACLs must be implemented beginning with the 2010/2011 fishing season. ACLs will establish a buffer between the federal overfishing level (OFL; the estimate of the total annual catch that would jeopardize the capacity of a stock to produce maximum sustained yield on a continuing basis) adopted by the council and the maximum Total Allowable Catch (TAC) set by the state. ACL buffers must be crafted to account for biological and management uncertainty for each stock. Examples of biological uncertainty include imprecision in the estimate of abundance and imprecision in the estimates of parameters, such as the natural mortality rate, used in the population model. Examples of management uncertainty include imprecision in estimating the expected number of crab discards, such as sub-legal Tanner crabs in the directed Tanner crab fishery.

An ACL buffer is a precautionary measure implemented to explicitly address overall uncertainty in stock assessment and OFL determinations. This scientific uncertainty must be incorporated when an ACL is specified, and not during the stock assessment process or when adopting an OFL for a specific crab stock. Precautionary measures mitigating for scientific uncertainty (e.g., assuming that the National Marine Fisheries Service bottom trawl survey net captures nearly 100% of the legal crabs in its path) have previously been implicitly integrated into some assessment models, rebuilding plans, and OFLs.

It is notable that state harvest strategies provide for incorporation of additional precautionary considerations during TAC setting beyond those specifically prescribed in regulation. The state has employed this flexibility in prior assessment cycles by implementing time and area fishery closures, lowering harvest rates, and accounting for bycatch mortality to prevent overfishing. In exercising FMP deferred management authority, the state often approaches TAC setting more conservatively than required by federal law, taking into account management concerns not specifically incorporated into stock assessments. This flexibility in TAC setting is among the state's strongest contributions to BSAI crab management under the FMP.

<u>Rebuilding Plans</u>
Bering Sea snow crab and Pribilof Islands blue king crab stocks have failed to make adequate progress towards rebuilding and new rebuilding plans for these stocks must be implemented beginning with the 2011/2012 fishing season. In addition, the board and council have been advised that the Bering Sea Tanner crab stock is approaching an overfished condition, thereby requiring implementation of a rebuilding plan for that stock by the 2011/2012 fishing season.

The council will adopt preferred alternatives for crab rebuilding plans to meet specific goals; rebuilding plans must be crafted within both National Standard guidelines and the framework-nature of the FMP. Previous council actions have been sensitive to the state's FMP Category 2 responsibility and authority to set TACs. This authority was initially deferred in recognition of the state's responsive fishery management practices and use of the best available scientific information in managing BSAI crab stocks. The FMP makes the state and federal government partners in achieving the goals of rebuilding plans. The state's expertise in managing BSAI crab stocks and flexibility in incorporating new information provide assurance that the state is committed to rebuilding BSAI crab stocks.

Options proposed for consideration include annual adjustments to the rebuilding harvest rate for both snow and Tanner crab. Such a prescriptive approach to crab rebuilding plans would be inconsistent with the spirit of the FMP and represents a degradation of the state's deferred management responsibilities. Considerations for annual changes in stock reproductive potential and the highly cyclic nature of BSAI stocks are specific reasons why TAC setting authority is deferred to the state and provide strong justification for options that do not include annual adjustment to the rebuilding goals.

Rebuilding alternatives also consider the time frame for rebuilding. To take maximum advantage of the state's flexibility and knowledge in managing BSAI crab stocks, the time frame specified for stock rebuilding must be responsive to the status and biology of each stock, environmental conditions, and the needs of fishing communities.

<u>Bycatch considerations</u>
Bycatch control measures, along with habitat protection and harvest strategies, represent key components of crab rebuilding plans. In the directed crab fisheries, the state has implemented bycatch control measures including accounting for bycatch in each crab fishery as well as specific area closures; however, under the current management structure, commensurate measures do not exist to control crab bycatch in the groundfish

fisheries. Several crab stocks lack any bycatch limits in groundfish fisheries and crab bycatch limits that are in place have little relationship to the OFL for the crab stock.

Bycatch mitigation in crab fisheries is incorporated into the state TAC setting process, thereby reducing directed crab fishery harvests; however, the impact of crab bycatch during groundfish fisheries and current crab bycatch limits on directed crab fisheries under the alternatives for ACL management measures and each of the three rebuilding plans is not well understood and is of concern. Crab ACLs and rebuilding plans must account for crab bycatch in BSAI groundfish fisheries.

Summary

The state has consistently exercised a high degree of cooperation with the federal government in managing BSAI crab stocks and frequently seeks guidance to ensure that state management actions are in compliance with MSA and the FMP. Given the long history of cooperative BSAI crab management, the board may wish to provide input to the council at this time for their consideration as alternatives are refined in April and June and preferred alternatives are selected in October. Board recommendations or concerns could provide a record demonstrating need and interest to retain the state's management authority and flexibility provided under the BSAI crab FMP.

# Bering Sea Snow Crab Rebuilding Alternatives Supplemental Table and Figures

B.J. Turnock
Alaska Fisheries Science Center
Seattle, WA
May 28, 2010

Rebuilding alternatives for model 1 and model 5(see snow crab assessment May 2010) with rebuilding 2 years in a row and for rebuilding 1 year are shown in Tables 1-4. The catch taken in 2009/10 was determined by the TAC (21,800 t) plus the estimated discard and groundfish bycatch. A 75%F35% control rule was applied in 2010/11 instead of the rebuilding F as in the May draft assessment. Alternatives to determine Tmin have 0.0 directed catch (groundfish bycatch is still extracted) until the stock is rebuilt. All alternatives switch to a 0.8 multiplier when the stock is rebuilt. Tables 5-8 show the estimates of catch and probability of rebuilding by year from 2009/10 to 2020/21 for model 1 and model 5 for the rebuilding alternatives in Tables 1-4. Model 1 MMB is projected to decline from about 73% of B35% in 2009/10 to 70% of B35% in 2011/12 then increase thereafter, when fishing at 75% F35% CR (Tables 5a and 6a). The probability of rebuilding (2 years) was 52.6% in 2016/17 fishing at 75%F35% CR and 55.1% in 2015/16 for rebuilding 1 year.

Model 5 MMB is projected to decline from about 91% of B35% in 2009/10 to 71% of B35% in 2011/12 fishing at 75%F35% CR (Tables 7a and 8a), then increase. The probability of rebuilding (2 years) was 52.6% in 2016/17 fishing at 75%F35% CR and 55.1% in 2015/16 for rebuilding 1 year.

Table 1. Model 1. Ttarget values, probability of rebuilding (2 yrs) and multipliers on the F35% control rule for Alternatives 1-4 and Options 1-3. Fishing at 75%F35% in 2010/11. F= 0.0 on directed fishery only for alternative 2 (Groundfish bycatch extracted). All alternatives switch to 0.8 multiplier when rebuilt.

| Alternative | Probability rebuilding Specified by Alternative | $T_{TARGET}$ year-ending date | Probability Rebuilding (2 yr) from projections | Multiplier |
|---|---|---|---|---|
| **Alternative 1** (no action) | 50% | 2016/17 | 0.526 | 0.75 |
| **Alternative 2** ($T_{MIN}$) | 50% | 2014/15 | 0.886 | 0.00 |
| **Alternative 3** | 50% | 2015/16 | 0.505 | 0.62 |
| Alternative 3-Option 2 | 75% | 2015/16 | 0.756 | 0.31 |
| Alternative 3-Option 3 | 90% | 2015/16 | 0.905 | 0.16 |
| **Alternative 4 (Tend)** | 50% | 2016/17 | 0.526 | 0.75 |
| Alternative 4-Option 2 | 75% | 2016/17 | 0.758 | 0.39 |
| Alternative 4-Option 3 | 90% | 2016/17 | 0.900 | 0.20 |
| Option 1 | | 2019/20 | 0.70 | 0.75 |

Table 2. Model 1. Ttarget values, probability of rebuilding (1 yrs) and multipliers on the F35% control rule for Alternatives 1-4 and Options 1-3. Fishing at 75%F35% in 2010/11. F= 0.0 on directed fishery only for alternative 2 (Groundfish bycatch extracted). All alternatives switch to 0.8 multiplier when rebuilt.

| Alternative | Probability rebuilding Specified by Alternative | $T_{TARGET}$ year-ending date | Probability Rebuilding (1 yr) from projections | Multiplier |
|---|---|---|---|---|
| **Alternative 1** (no action) | 50% | 2015/16 | 0.551 | 0.75 |
| **Alternative 2** ($T_{MIN}$) | 50% | 2013/14 | 0.886 | 0.00 |
| **Alternative 3** | 50% | 2014/15 | 0.500 | 0.64 |
| Alternative 3-Option 2 | 75% | 2014/15 | 0.753 | 0.32 |
| Alternative 3-Option 3 | 90% | 2014/15 | 0.900 | 0.17 |
| **Alternative 4** ($T_{END}$) | 50% | 2015/16 | 0.551 | 0.75 |
| Alternative 4-Option 2 | 75% | 2015/16 | 0.752 | 0.41 |
| Alternative 4-Option 3 | 90% | 2015/16 | 0.903 | 0.21 |
| Option 1 | | 2019/20 | 0.764 | 0.75 |

Table 3. Model 5. Ttarget values, probability of rebuilding (2 yrs) and multipliers on the F35% control rule for Alternatives 1-4 and Options 1-3. Fishing at 75%F35% in 2010/11. F= 0.0 on directed fishery only for alternative 2 (Groundfish bycatch extracted). All alternatives switch to 0.8 multiplier when rebuilt.

| Alternative | Probability rebuilding Specified by Alternative | $T_{TARGET}$ year-ending date | Probability Rebuilding (2 yr) from projections | Multiplier |
|---|---|---|---|---|
| **Alternative 1** (no action) | 50% | 2015/16 | 0.572 | 0.75 |
| **Alternative 2** ($T_{MIN}$) | 50% | 2014/15 | 0.943 | 0 |
| **Alternative 3** | 50% | 2014/15 | 0.500 | 0.34 |
| Alternative 3-Option 2 | 75% | 2014/15 | 0.757 | 0.14 |
| Alternative 3-Option 3 | 90% | 2014/15 | 0.911 | 0.03 |
| **Alternative 4** ($T_{END}$) | 50% | 2015/16 | 0.572 | 0.75 |
| Alternative 4-Option 2 | 75% | 2015/16 | 0.758 | 0.41 |
| Alternative 4-Option 3 | 90% | 2015/16 | 0.905 | 0.21 |
| Option 1 | | 2019/20 | 0.792 | 0.75 |

Table 4. Model 5. Ttarget values, probability of rebuilding (1 yrs) and multipliers on the F35% control rule for Alternatives 1-4 and Options 1-3. Fishing at 75%F35% in 2010/11. F= 0.0 on directed fishery only for alternative 2 (Groundfish bycatch extracted). All alternatives switch to 0.8 multiplier when rebuilt.

| Alternative | Probability rebuilding Specified by Alternative | $T_{TARGET}$ year-ending date | Probability Rebuilding (1 yr) from projections | Multiplier |
|---|---|---|---|---|
| **Alternative 1** (no action) | 50% | 2014/15 | 0.646 | 0.75 |
| **Alternative 2** ($T_{MIN}$) | 50% | 2012/13 | 0.508 | 0.00 |
| **Alternative 3** | 50% | 2013/14 | 0.5 | 0.42 |
| Alternative 3-Option 2 | 75% | 2013/14 | 0.751 | 0.15 |
| Alternative 3-Option 3 | 90% | 2013/14 | 0.91 | 0.03 |
| **Alternative 4** ($T_{END}$) | 50% | 2014/15 | 0.646 | 0.75 |
| Alternative 4-Option 2 | 75% | 2014/15 | 0.756 | 0.47 |
| Alternative 4-Option 3 | 90% | 2014/15 | 0.91 | 0.22 |
| Option 1 | | 2019/20 | 0.864 | 0.75 |

**Table 5. Model 1 rebuilding for Alternatives 1-4 and Options 1, 2 and 3 and rebuilding 2 years in a row. $B_{35\%}$ = 139,200 t. Fishing at 75%F35% in 2010/11. All projections have rebuilding strategy (multiplier) in effect until rebuilt, then strategy switches to a 0.8 multiplier. Total catch ($ABC_{tot}$) and retained catch ($C_{dir}$) and fishing mortality are medians. Percent MMB at mating relative to B35%. Values in parentheses are 90% CI. Probability of rebuilding for 1 year above B35% and probability of rebuilding to 2 years in a row above B35%.**

(a) Alternative 1, alternative 4 and Option 1 (multiplier = 0.75), Model 1, Additional uncertainty = 0.2. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 18(10,30.2) | 16.3(8.9,27.2) | 70.2(58.3,82.3) | 0 | 0 | 0.33 |
| 2012 | 16.5(8.9,29.1) | 14.4(7.7,25.5) | 70.7(57.7,86.2) | 0.004 | 0 | 0.32 |
| 2013 | 24(12.1,40) | 20.8(10.5,34.4) | 81.7(62.7,113.5) | 0.136 | 0.004 | 0.39 |
| 2014 | 33.6(15.8,69.4) | 29.8(14.2,59.9) | 95.9(65.5,166.9) | 0.428 | 0.136 | 0.44 |
| 2015 | 41(14.8,100.1) | 36.1(13.3,89.4) | 104.2(64.3,216.4) | 0.551 | 0.419 | 0.46 |
| 2016 | 42.6(12.8,108.2) | 38(11.5,96.5) | 107.6(60.3,237.7) | 0.617 | 0.526 | 0.47 |
| 2017 | 43.7(11,109.8) | 38.7(9.7,100.1) | 109.7(57.5,243.1) | 0.675 | 0.588 | 0.47 |
| 2018 | 44.4(10.4,115.8) | 39.4(9.3,104.2) | 115.2(54.9,257.8) | 0.729 | 0.646 | 0.47 |
| 2019 | 46.8(10.8,117.4) | 41.6(9.7,102.8) | 115.8(56.5,271.7) | 0.764 | 0.699 | 0.48 |
| 2020 | 44.9(9.5,123.7) | 39.9(8.3,112) | 112.9(56.4,275.9) | 0.79 | 0.736 | 0.47 |

(b) Alternative 2, Model 1, Additional uncertainty = 0.2, directed catch = 0.0 (groundfish bycatch extracted) until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 0.6(0.5,0.7) | 0(0,0) | 82.7(71.3,94.7) | 0.012 | 0 | 0 |
| 2012 | 0.7(0.5,0.9) | 0(0,0) | 92.3(78.9,108.8) | 0.203 | 0.012 | 0 |
| 2013 | 0.8(0.6,1.2) | 0(0,0) | 114.9(95.2,151.7) | 0.886 | 0.203 | 0 |
| 2014 | 1(0.7,86.6) | 0(0,75) | 139.7(105.4,217.9) | 0.988 | 0.886 | 0 |
| 2015 | 61.9(0.8,124.2) | 55.5(0,110.5) | 130(89.5,246.8) | 0.991 | 0.983 | 0.5 |
| 2016 | 54.3(20.1,119.7) | 48.4(18,105.4) | 120.8(73.6,252.4) | 0.993 | 0.986 | 0.51 |
| 2017 | 49.7(14.7,116.5) | 43.4(13.2,103.4) | 115.5(64.2,250) | 0.993 | 0.989 | 0.49 |
| 2018 | 48.3(12.7,120.1) | 41.9(10.9,105.1) | 118.4(58.8,261.9) | 0.994 | 0.99 | 0.48 |
| 2019 | 49.6(11.7,121.6) | 43.1(10,104.1) | 118.2(58.6,279) | 0.997 | 0.993 | 0.49 |
| 2020 | 47.8(10.6,129.3) | 41.8(8.9,113.4) | 118.2(57.6,285.3) | 0.997 | 0.996 | 0.48 |

(c) Alternative 3, Model 1, Additional uncertainty = 0.2, multiplier = 0.62, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 15.9(8.9,27) | 14(7.6,24) | 71.8(60.3,83.6) | 0 | 0 | 0.28 |
| 2012 | 15.4(8.3,27.2) | 12.9(6.8,22.8) | 73.2(60.3,88.8) | 0.006 | 0 | 0.28 |
| 2013 | 22.4(11.2,36.2) | 19(9.4,30.4) | 85.2(66.2,117.1) | 0.17 | 0.006 | 0.34 |
| 2014 | 31.7(14.8,62.8) | 27.5(13,52.2) | 100.8(70.4,175.4) | 0.514 | 0.17 | 0.38 |
| 2015 | 37.9(14.2,105.7) | 33(12.5,94.3) | 110.6(68.7,222.4) | 0.632 | 0.505 | 0.40 |
| 2016 | 42.6(12.5,113.1) | 37.7(10.9,98.5) | 112.9(64.3,242.2) | 0.685 | 0.606 | 0.45 |
| 2017 | 44.2(10.7,113.9) | 38.4(9.2,100.3) | 113.7(60.9,245) | 0.737 | 0.658 | 0.45 |
| 2018 | 45.5(10.3,117.8) | 39.5(8.9,104.3) | 117.6(57.8,258.8) | 0.778 | 0.709 | 0.46 |
| 2019 | 47.3(10.9,121) | 40.7(9.5,103.9) | 117.4(58.8,273.2) | 0.813 | 0.752 | 0.47 |
| 2020 | 45.3(9.5,126.1) | 39.4(8.1,112.9) | 115(59.2,276.9) | 0.838 | 0.789 | 0.47 |

(d) Alternative 3, Option 2, Model 1, Additional uncertainty = 0.2, multiplier = 0.31, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 9.2(5.1,16.1) | 7.9(4.1,14) | 76.5(65.1,88.3) | 0.001 | 0 | 0.15 |
| 2012 | 9.9(5.2,16.9) | 8.2(4.1,14.2) | 80.7(68.4,96.4) | 0.024 | 0.001 | 0.16 |
| 2013 | 15.1(7.4,22.4) | 12.7(6.1,18.7) | 96.3(77.7,131.1) | 0.391 | 0.024 | 0.19 |
| 2014 | 20.3(10.2,39.3) | 17.7(8.6,32.9) | 116.7(85.1,201.3) | 0.765 | 0.391 | 0.2 |
| 2015 | 26.3(10.4,118.3) | 23.1(8.9,104.9) | 126.2(82.5,237.5) | 0.827 | 0.756 | 0.25 |
| 2016 | 52.3(10.3,117.1) | 46.6(9.1,105.1) | 121.1(77,246.7) | 0.852 | 0.814 | 0.47 |
| 2017 | 48.4(9.1,114.8) | 42.5(7.8,102) | 118.3(69.8,253.3) | 0.886 | 0.839 | 0.46 |
| 2018 | 47.3(10,120.4) | 41.2(8.8,105.7) | 120.7(63.9,262) | 0.905 | 0.875 | 0.46 |
| 2019 | 49.7(9.7,123.4) | 43.1(8.3,104.8) | 120.3(62.5,276.3) | 0.915 | 0.895 | 0.47 |
| 2020 | 47.2(9,129.4) | 41.1(7.7,116.1) | 118.7(61.5,281) | 0.936 | 0.909 | 0.47 |

(e) Alternative 3, Option 3, Model 1, Additional uncertainty = 0.2, multiplier = 0.16, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 5.2(3,8.8) | 4.3(2.2,7.5) | 79.2(67.9,91.1) | 0.002 | 0 | 0.08 |
| 2012 | 6(3.1,9.6) | 4.8(2.3,8) | 85.9(73.5,101.8) | 0.066 | 0.002 | 0.08 |
| 2013 | 9.1(4.5,13) | 7.4(3.5,10.6) | 104.1(85.9,140.2) | 0.63 | 0.066 | 0.1 |
| 2014 | 11.9(6.4,64.5) | 10(5.2,55.7) | 128.6(95.8,209.4) | 0.916 | 0.63 | 0.1 |
| 2015 | 51.4(7.1,121.4) | 45.5(5.9,108.3) | 129.9(91,245) | 0.93 | 0.905 | 0.42 |
| 2016 | 55(8.4,119.2) | 49.2(7.1,105.7) | 120.8(79.9,249.1) | 0.945 | 0.918 | 0.5 |
| 2017 | 50(8.8,115.5) | 44(7.6,102.3) | 117.4(69.8,253.1) | 0.957 | 0.934 | 0.48 |
| 2018 | 48.3(9.2,121.7) | 42(7.9,106.5) | 119.8(62.6,263.7) | 0.967 | 0.947 | 0.48 |
| 2019 | 50.1(9.5,121.3) | 43.4(8.3,103.8) | 118.9(60,278.2) | 0.972 | 0.957 | 0.48 |
| 2020 | 47.5(9.4,127.5) | 41.5(7.7,113.1) | 118.6(58.8,281.5) | 0.983 | 0.963 | 0.48 |

(f) Alternative 4, Option 2, Model 1, Additional uncertainty = 0.2, multiplier = 0.39, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 11.1(6.1,19.3) | 9.6(5.1,16.9) | 75.2(63.8,87) | 0 | 0 | 0.19 |
| 2012 | 11.6(6.1,20.2) | 9.7(4.9,17.1) | 78.4(66,94.1) | 0.016 | 0 | 0.19 |
| 2013 | 17.4(8.6,26.4) | 14.7(7.1,22.2) | 92.9(74.5,127) | 0.304 | 0.016 | 0.23 |
| 2014 | 24(11.7,45.8) | 21(10.1,38.3) | 112.1(80.5,193.8) | 0.693 | 0.304 | 0.25 |
| 2015 | 29(11.6,115) | 25.3(10,102.3) | 124.7(78,231.8) | 0.774 | 0.682 | 0.29 |
| 2016 | 50.1(11,115.6) | 44.5(9.4,103.7) | 119.8(73.1,244.4) | 0.815 | 0.758 | 0.44 |
| 2017 | 47.6(9.7,114.6) | 41.6(8.3,101.8) | 118.5(67.3,251.4) | 0.854 | 0.797 | 0.45 |
| 2018 | 47(10.5,119.6) | 40.7(8.9,105.4) | 120.9(62.9,261.1) | 0.879 | 0.837 | 0.45 |
| 2019 | 49.2(10.2,122.1) | 42.9(8.9,104) | 120.1(62.1,276.9) | 0.897 | 0.863 | 0.46 |
| 2020 | 46.4(9.3,130.8) | 40.7(8,114.3) | 118.2(61.2,283.3) | 0.918 | 0.886 | 0.46 |

(g) Alternative 4, Option 3, Model 1, Additional uncertainty = 0.2, multiplier = 0.20, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 6.4(3.6,11) | 5.3(2.8,9.4) | 78.4(67.1,90.2) | 0.002 | 0 | 0.1 |
| 2012 | 7.3(3.8,11.9) | 5.9(2.8,10) | 84.3(71.9,99.9) | 0.047 | 0.002 | 0.11 |
| 2013 | 11.2(5.4,15.9) | 9.1(4.3,13.2) | 101.5(83.3,137.4) | 0.552 | 0.047 | 0.13 |
| 2014 | 14.4(7.5,31.6) | 12.3(6.3,25.9) | 124.9(92.6,210.7) | 0.875 | 0.552 | 0.13 |
| 2015 | 41.1(8.2,121.2) | 37.2(6.9,107) | 129.2(88.4,242.8) | 0.908 | 0.867 | 0.37 |
| 2016 | 54.6(9.1,119.3) | 48.4(7.9,106.6) | 122.1(79.2,248.7) | 0.924 | 0.899 | 0.49 |
| 2017 | 50.2(8.8,115.1) | 44.7(7.6,102.5) | 117.9(69.4,256.1) | 0.942 | 0.915 | 0.48 |
| 2018 | 48.5(10,121.5) | 42(8.4,106.2) | 119.7(62.9,263.8) | 0.953 | 0.933 | 0.48 |
| 2019 | 49.8(9.2,121.2) | 43.3(7.9,104.6) | 119.5(60.7,277.6) | 0.96 | 0.943 | 0.48 |
| 2020 | 47(9,127) | 41.2(7.5,113.6) | 118.8(59.1,282.3) | 0.973 | 0.951 | 0.48 |

**Table 6. Model 1 rebuilding for Alternatives 1-4 and Options 1, 2 and 3, rebuilding 1 year. $B_{35\%}$ = 139,200 t. Fishing at 75%F35% in 2010/11. All projections have rebuilding strategy (multiplier) in effect until rebuilt, then strategy switches to a 0.8 multiplier. Total catch ($ABC_{tot}$) and retained catch ($C_{dir}$) and fishing mortality are medians. Percent MMB at mating relative to B35%. Values in parentheses are 90% CI. Probability of rebuilding for 1 year above B35% and probability of rebuilding to 2 years in a row above B35%.**

(a) Alternative 1, alternative 4 and Option 1 (multiplier = 0.75), Model 1, Additional uncertainty = 0.2. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 18(10,30.2) | 16.3(8.9,27.2) | 70.2(58.3,82.3) | 0 | 0 | 0.33 |
| 2012 | 16.5(8.9,29.1) | 14.4(7.7,25.5) | 70.7(57.7,86.2) | 0.004 | 0 | 0.32 |
| 2013 | 24(12.1,40) | 20.8(10.5,34.4) | 81.7(62.7,113.5) | 0.136 | 0.004 | 0.39 |
| 2014 | 33.6(15.8,69.4) | 29.8(14.2,59.9) | 95.9(65.5,166.9) | 0.428 | 0.136 | 0.44 |
| 2015 | 41(14.8,100.1) | 36.1(13.3,89.4) | 104.2(64.3,216.4) | 0.551 | 0.419 | 0.46 |
| 2016 | 42.6(12.8,108.2) | 38(11.5,96.5) | 107.6(60.3,237.7) | 0.617 | 0.526 | 0.47 |
| 2017 | 43.7(11,109.8) | 38.7(9.7,100.1) | 109.7(57.5,243.1) | 0.675 | 0.588 | 0.47 |
| 2018 | 44.4(10.4,115.8) | 39.4(9.3,104.2) | 115.2(54.9,257.8) | 0.729 | 0.646 | 0.47 |
| 2019 | 46.8(10.8,117.4) | 41.6(9.7,102.8) | 115.8(56.5,271.7) | 0.764 | 0.699 | 0.48 |
| 2020 | 44.9(9.5,123.7) | 39.9(8.3,112) | 112.9(56.4,275.9) | 0.79 | 0.736 | 0.47 |

(b) Alternative 2, Model 1, Additional uncertainty = 0.2, directed catch = 0.0 (groundfish bycatch extracted) until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuildi ng(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 0.6(0.5,0.7) | 0(0,0) | 82.7(71.3,94.7) | 0.012 | 0 | 0 |
| 2012 | 0.7(0.5,0.9) | 0(0,0) | 92.3(78.9,108.8) | 0.203 | 0.012 | 0 |
| 2013 | 0.8(0.6,1.2) | 0(0,0) | 114.9(95.2,151.7) | 0.886 | 0.203 | 0 |
| 2014 | 1(0.7,86.6) | 0(0,75) | 139.7(105.4,217.9) | 0.988 | 0.886 | 0 |
| 2015 | 61.9(0.8,124.2) | 55.5(0,110.5) | 130(89.5,246.8) | 0.991 | 0.983 | 0.5 |
| 2016 | 54.3(20.1,119.7) | 48.4(18,105.4) | 120.8(73.6,252.4) | 0.993 | 0.986 | 0.51 |
| 2017 | 49.7(14.7,116.5) | 43.4(13.2,103.4) | 115.5(64.2,250) | 0.993 | 0.989 | 0.49 |
| 2018 | 48.3(12.7,120.1) | 41.9(10.9,105.1) | 118.4(58.8,261.9) | 0.994 | 0.99 | 0.48 |
| 2019 | 49.6(11.7,121.6) | 43.1(10,104.1) | 118.2(58.6,279) | 0.997 | 0.993 | 0.49 |
| 2020 | 47.8(10.6,129.3) | 41.8(8.9,113.4) | 118.2(57.6,285.3) | 0.997 | 0.996 | 0.48 |

(c) Alternative 3, Model 1, Additional uncertainty = 0.2, multiplier = 0.64, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuildi ng(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 16.3(9.1,27.6) | 14.3(7.8,24.6) | 71.5(60.1,83.3) | 0 | 0 | 0.29 |
| 2012 | 15.6(8.5,27.6) | 13.2(6.9,23.3) | 72.8(59.9,88.3) | 0.006 | 0 | 0.29 |
| 2013 | 22.8(11.4,37) | 19.3(9.6,31) | 84.6(65.6,116.3) | 0.163 | 0.006 | 0.35 |
| 2014 | 32.1(14.9,64.1) | 27.9(13.2,53.2) | 99.9(69.6,173.9) | 0.498 | 0.163 | 0.39 |
| 2015 | 38.6(14.4,104.8) | 33.7(12.6,92.3) | 109.6(68.1,220.4) | 0.616 | 0.491 | 0.41 |
| 2016 | 42.7(12.6,112.3) | 37.6(10.9,98.1) | 112.3(63.5,241.3) | 0.672 | 0.592 | 0.45 |
| 2017 | 44.1(10.8,113.2) | 38.6(9.3,100.2) | 113.4(60.4,244.7) | 0.726 | 0.645 | 0.45 |
| 2018 | 45.6(10.3,118.5) | 39.3(9,104.4) | 117.5(57.2,260) | 0.767 | 0.699 | 0.46 |
| 2019 | 47.2(10.9,120.9) | 40.7(9.5,103.8) | 117.1(58.5,272.9) | 0.804 | 0.742 | 0.47 |
| 2020 | 45.4(9.5,126.3) | 39.5(8.1,112.2) | 114.5(58.9,276.8) | 0.827 | 0.779 | 0.47 |

(d) Alternative 2, Option 2, Model 1, Additional uncertainty = 0.2, multiplier = 0.32, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 9.4(5.2,16.5) | 8.1(4.3,14.3) | 76.4(65,88.2) | 0.001 | 0 | 0.16 |
| 2012 | 10.2(5.3,17.3) | 8.4(4.2,14.6) | 80.4(68.2,96.1) | 0.022 | 0.001 | 0.16 |
| 2013 | 15.4(7.6,22.9) | 13(6.2,19.1) | 96(77.3,130.6) | 0.38 | 0.022 | 0.2 |
| 2014 | 20.8(10.4,40.2) | 18.1(8.8,33.5) | 116.2(84.4,200.3) | 0.753 | 0.38 | 0.21 |
| 2015 | 26.4(10.6,117.8) | 23.2(9.1,104.7) | 125.9(81.9,236.9) | 0.819 | 0.745 | 0.26 |
| 2016 | 52.3(10.3,116.8) | 46.6(9,104.8) | 121(76.7,246.4) | 0.846 | 0.805 | 0.46 |
| 2017 | 48.4(9.1,114.6) | 42.6(7.9,102) | 118.2(69.6,253.1) | 0.88 | 0.832 | 0.46 |
| 2018 | 47.3(10.1,120.3) | 41.3(8.8,105.6) | 120.3(63.8,261.9) | 0.901 | 0.868 | 0.46 |
| 2019 | 49.6(9.9,123.2) | 43.1(8.4,104.7) | 120.8(62.6,276.1) | 0.913 | 0.891 | 0.47 |
| 2020 | 47.6(9.1,129.2) | 41.3(7.7,115.8) | 118.8(61.4,280.6) | 0.934 | 0.908 | 0.47 |

(e) Alternative 3, Option 3, Model 1, Additional uncertainty = 0.2, multiplier = 0.17, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 5.6(3.2,9.5) | 4.6(2.4,8.1) | 78.9(67.7,90.8) | 0.002 | 0 | 0.09 |
| 2012 | 6.4(3.3,10.4) | 5.2(2.5,8.6) | 85.4(73.1,101) | 0.061 | 0.002 | 0.09 |
| 2013 | 9.8(4.8,13.9) | 8(3.7,11.5) | 103.4(85,139.3) | 0.607 | 0.061 | 0.11 |
| 2014 | 12.7(6.7,60.1) | 10.8(5.6,52.2) | 127.5(94.7,208.6) | 0.9 | 0.607 | 0.11 |
| 2015 | 49(7.4,121.3) | 44.3(6.3,108.2) | 129.8(90.5,243.8) | 0.924 | 0.89 | 0.41 |
| 2016 | 54.8(8.5,118.9) | 48.9(7.3,105.4) | 121.8(79.3,248.9) | 0.941 | 0.912 | 0.5 |
| 2017 | 49.9(8.8,115.4) | 44(7.4,102.9) | 117.1(69.7,254.5) | 0.952 | 0.929 | 0.48 |
| 2018 | 48.5(9.5,121.6) | 42.1(8.2,106.4) | 119.5(62.6,263.5) | 0.962 | 0.942 | 0.48 |
| 2019 | 49.9(9.3,121.2) | 43.2(7.9,103.8) | 118.9(60,278) | 0.97 | 0.953 | 0.48 |
| 2020 | 47.3(9.1,127.3) | 41.4(7.7,113) | 118.7(59.2,283.5) | 0.98 | 0.962 | 0.48 |

(f) Alternative 4, Option 2, Model 1, Additional uncertainty = 0.2, multiplier = 0.41, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 11.5(6.4,20) | 10(5.3,17.6) | 74.9(63.5,86.7) | 0 | 0 | 0.2 |
| 2012 | 12(6.3,21) | 10(5.1,17.7) | 77.9(65.4,93.5) | 0.015 | 0 | 0.2 |
| 2013 | 17.9(8.9,27.4) | 15.1(7.3,23) | 92.1(73.6,126) | 0.288 | 0.015 | 0.24 |
| 2014 | 24.8(12,47.4) | 21.8(10.4,39.6) | 110.8(79.4,192.1) | 0.678 | 0.288 | 0.26 |
| 2015 | 29.7(11.8,114.3) | 26.1(10.3,101.4) | 123.1(77.3,230.3) | 0.752 | 0.667 | 0.29 |
| 2016 | 49.5(11.2,116) | 43.8(9.6,103.4) | 119.4(72.6,243.8) | 0.795 | 0.739 | 0.44 |
| 2017 | 47.1(9.6,114.1) | 41.2(8.3,101.7) | 118.7(67.1,250.2) | 0.832 | 0.783 | 0.44 |
| 2018 | 47.1(10.4,119.9) | 40.7(9,105.3) | 120.8(62.7,260.9) | 0.863 | 0.82 | 0.45 |
| 2019 | 48.9(10.2,122) | 42.4(8.8,104.3) | 120.4(61.9,276.1) | 0.888 | 0.852 | 0.46 |
| 2020 | 46.5(9.2,130.2) | 40.6(8,114.2) | 118(61.1,282.1) | 0.907 | 0.877 | 0.46 |

(g) Alternative 4, Option 3, Model 1, Additional uncertainty = 0.2, multiplier = 0.21, until rebuilt then multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.8(22.7,26.8) | 21.8(20,23.6) | 73.2(62.1,84.7) | 0 | 0 | 0.42 |
| 2010 | 20.5(11.6,34.4) | 18.1(10.1,30.5) | 72.8(61.5,84.1) | 0 | 0 | 0.34 |
| 2011 | 6.7(3.7,11.5) | 5.6(2.9,9.9) | 78.3(66.8,90) | 0.002 | 0 | 0.11 |
| 2012 | 7.5(3.9,12.3) | 6.1(2.9,10.4) | 83.9(71.7,99.4) | 0.047 | 0.002 | 0.11 |
| 2013 | 11.6(5.6,16.6) | 9.5(4.5,13.7) | 101(82.8,136.7) | 0.536 | 0.047 | 0.13 |
| 2014 | 15(7.8,32.9) | 12.9(6.5,27) | 124.1(91.9,209.3) | 0.862 | 0.536 | 0.14 |
| 2015 | 37.8(8.4,120.5) | 33.9(7.1,106.8) | 129.1(88.5,242.1) | 0.903 | 0.851 | 0.35 |
| 2016 | 54.4(9.1,119) | 48.2(7.8,106) | 122(79.5,248.4) | 0.918 | 0.889 | 0.49 |
| 2017 | 50.5(8.2,115) | 44.7(7,102.3) | 118.3(70,255.8) | 0.938 | 0.904 | 0.48 |
| 2018 | 48.4(9.7,121.4) | 42(8.3,106.1) | 119.7(64.2,263.6) | 0.949 | 0.924 | 0.48 |
| 2019 | 49.8(9.1,121.2) | 43.3(7.8,104.5) | 119.6(60.9,277.5) | 0.956 | 0.935 | 0.48 |
| 2020 | 47(8.9,127.6) | 41.2(7.6,113.5) | 119.2(60.2,281.9) | 0.969 | 0.944 | 0.47 |

**Table 7. Model 5 rebuilding for Alternatives 1-4 and Options 1, 2 and 3, rebuilding 2 years in a row. $B_{35\%}$ = 139,200 t. Fishing at 75%F35% in 2010/11. All projections have rebuilding strategy (multiplier) in effect until rebuilt, then strategy switches to a 0.8 multiplier. Total catch ($ABC_{tot}$) and retained catch ($C_{dir}$) and fishing mortality are medians. Percent MMB at mating relative to B35%. Values in parentheses are 90% CI. Probability of rebuilding for 1 year above B35% and probability of rebuilding to 2 years in a row above B35%.**

(a) Alternative 1, alternative 4 and Option 1 (multiplier = 0.75), Model 5, Additional uncertainty = 0.2. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.5(24.5,24.6) | 21.7(21.7,21.7) | 91.2(75.9,106.8) | 0.181 | 0 | 0.45 |
| 2010 | 32.6(18.8,51.3) | 28.9(16.6,45.4) | 77.4(64,91.1) | 0.181 | 0.002 | 0.69 |
| 2011 | 23.1(13.6,36.3) | 20.6(12.2,31.8) | 70.7(57.7,85) | 0.182 | 0.002 | 0.63 |
| 2012 | 19.9(11.1,33.8) | 16.8(9.4,26.8) | 72.5(57.5,95.4) | 0.208 | 0.004 | 0.63 |
| 2013 | 29.4(14.5,47.3) | 23.9(12.4,36.5) | 85.9(63.1,141) | 0.379 | 0.037 | 0.78 |
| 2014 | 46.1(20.9,96.9) | 38.3(18.3,77.7) | 106(67.5,207.1) | 0.646 | 0.262 | 0.87 |
| 2015 | 58.6(21.7,154.6) | 49.9(19.2,133) | 120.3(67.5,274.7) | 0.744 | 0.572 | 0.9 |
| 2016 | 63.5(19.5,166.6) | 54.2(17.2,143.8) | 125.1(64.3,291.9) | 0.789 | 0.663 | 0.93 |
| 2017 | 62.2(16.8,165.1) | 52.3(14.7,143.1) | 126.6(61.1,290.6) | 0.818 | 0.716 | 0.91 |
| 2018 | 62.1(14.9,165.1) | 52.4(13.3,139.8) | 130.2(59.1,305) | 0.844 | 0.758 | 0.91 |
| 2019 | 62(14.9,162) | 51.8(12.4,137.1) | 125.7(58.9,310.2) | 0.864 | 0.792 | 0.92 |
| 2020 | 57.2(12.8,163.3) | 48.3(10.7,142.3) | 121.8(58.1,301.8) | 0.883 | 0.817 | 0.91 |

(b) Alternative 2, Model 5, Additional uncertainty = 0.2. Directed catch = 0.0 (groundfish bycatch extracted). When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.5(24.5,24.6) | 21.7(21.7,21.7) | 91.2(75.9,106.8) | 0.181 | 0 | 0.45 |
| 2010 | 32.6(18.8,51.3) | 28.9(16.6,45.4) | 77.4(64,91.1) | 0.181 | 0.002 | 0.69 |
| 2011 | 0.5(0.4,0.7) | 0(0,0) | 87.6(74.1,101.5) | 0.203 | 0.002 | 0.63 |
| 2012 | 0.6(0.5,0.9) | 0(0,0) | 99.5(83,124.8) | 0.508 | 0.082 | 0.63 |
| 2013 | 0.8(0.6,54.3) | 0(0,44.7) | 123.1(97.3,183.9) | 0.943 | 0.485 | 0.78 |
| 2014 | 1.3(0.7,131.8) | 0(0,109.5) | 146.3(102.9,229.6) | 0.996 | 0.943 | 0.87 |
| 2015 | 83.8(0.9,167.7) | 73.6(0,143.4) | 136.5(85.7,280.8) | 0.998 | 0.994 | 0.9 |
| 2016 | 72(27.4,171.4) | 62.3(24.1,148) | 131.8(73.1,296.3) | 0.998 | 0.996 | 0.93 |
| 2017 | 64.3(19.3,167.9) | 54.6(16.9,145.1) | 129.3(64.3,294.5) | 0.998 | 0.996 | 0.91 |
| 2018 | 63.1(16.1,166.2) | 53.4(13.9,140.7) | 131.8(60,307.2) | 0.999 | 0.997 | 0.91 |
| 2019 | 63.2(15.8,162.2) | 52.7(13.1,138.1) | 128.3(60.3,314.5) | 0.999 | 0.998 | 0.92 |
| 2020 | 59.1(13.6,170) | 49.6(11.7,143) | 125.9(59.2,321.2) | 0.999 | 0.998 | 0.91 |

(c) Alternative 3, Model 5, Additional uncertainty = 0.2. Multiplier = 0.34. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.5(24.5,24.6) | 21.7(21.7,21.7) | 91.2(75.9,106.8) | 0.181 | 0 | 0.45 |
| 2010 | 32.6(18.8,51.3) | 28.9(16.6,45.4) | 77.4(64,91.1) | 0.181 | 0.002 | 0.69 |
| 2011 | 13.3(7.6,22) | 11.5(6.4,19) | 77.9(65,92.2) | 0.182 | 0.002 | 0.32 |
| 2012 | 13.6(7.2,22.2) | 11.3(5.8,18.2) | 83(67.4,106.8) | 0.253 | 0.008 | 0.33 |
| 2013 | 20.4(9.9,30.1) | 16.6(8.1,23.8) | 99.9(76.1,158.3) | 0.562 | 0.105 | 0.4 |
| 2014 | 29.3(14.7,110.2) | 24.9(12.6,89.2) | 127.6(84.8,228.4) | 0.826 | 0.499 | 0.43 |
| 2015 | 48.9(16.3,165) | 42.5(14.2,139.6) | 139.5(84.4,284.9) | 0.886 | 0.802 | 0.64 |
| 2016 | 74(16.5,172.4) | 64.3(14.4,149.3) | 134(79.2,297.3) | 0.912 | 0.861 | 0.91 |
| 2017 | 66.5(14.7,167.2) | 56.2(12.7,143.9) | 132.8(70.9,294.9) | 0.927 | 0.889 | 0.9 |
| 2018 | 63.6(14.5,166.2) | 54(12.5,142.2) | 132.8(65.3,306.4) | 0.936 | 0.909 | 0.9 |
| 2019 | 63.7(13.5,162.5) | 53.4(11.6,138.2) | 128.4(62.9,311.6) | 0.947 | 0.918 | 0.91 |
| 2020 | 58.1(12.2,166.6) | 48.9(10.1,144.5) | 125.7(62.8,310.2) | 0.957 | 0.93 | 0.9 |

(d) Alternative 3, Option 2, Model 5, Additional uncertainty = 0.2. Multiplier = 0.14. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.6(22.6,26.8) | 21.8(20,23.7) | 91.1(77,105.6) | 0.181 | 0 | 0.45 |
| 2010 | 32.4(19.1,50.9) | 28.9(16.9,44.9) | 77.4(64.2,90.5) | 0.181 | 0.002 | 0.69 |
| 2011 | 6.5(3.7,10.4) | 5.4(2.9,8.8) | 82.9(70,96.4) | 0.185 | 0.002 | 0.14 |
| 2012 | 7.4(3.9,11.3) | 6(2.9,9.2) | 91.2(75.8,115.6) | 0.306 | 0.022 | 0.15 |
| 2013 | 10.7(5.5,16) | 8.7(4.3,12.8) | 111.9(87.5,172.5) | 0.766 | 0.215 | 0.17 |
| 2014 | 15.4(8.4,124.8) | 12.8(7.1,103.1) | 143(99,237.6) | 0.952 | 0.757 | 0.19 |
| 2015 | 81.7(10.7,167.7) | 70.9(9.3,143) | 141.6(95.4,279.3) | 0.964 | 0.946 | 0.89 |
| 2016 | 74.2(16.1,172.1) | 64.7(14.1,147.6) | 134.4(79.6,299.2) | 0.97 | 0.957 | 0.96 |
| 2017 | 66.2(15,168.5) | 56.4(13,144.7) | 130.5(68.6,294.6) | 0.979 | 0.964 | 0.93 |
| 2018 | 63.6(13.7,166.9) | 53.7(11.9,141.4) | 132.6(62.4,306.3) | 0.983 | 0.973 | 0.93 |
| 2019 | 63.8(13.4,162.3) | 53.3(11.4,138) | 128.5(61.1,313) | 0.988 | 0.978 | 0.93 |
| 2020 | 58.8(12.4,168.4) | 49.4(10.5,142.4) | 125.6(59.5,315.5) | 0.992 | 0.984 | 0.91 |

(e) Alternative 3, Option 3, Model 5, Additional uncertainty = 0.2. Multiplier = 0.03. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuildi ng(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.5(24.5,24.6) | 21.7(21.7,21.7) | 91.2(75.9,106.8) | 0.181 | 0 | 0.45 |
| 2010 | 32.6(18.8,51.3) | 28.9(16.6,45.4) | 77.4(64,91.1) | 0.181 | 0.002 | 0.69 |
| 2011 | 1.9(1.2,2.8) | 1.3(0.7,2) | 86.5(73.1,100.6) | 0.198 | 0.002 | 0.03 |
| 2012 | 2.4(1.4,3.3) | 1.5(0.7,2.3) | 97.3(81.3,122.7) | 0.452 | 0.06 | 0.04 |
| 2013 | 3.2(1.9,36) | 2.1(1.1,31) | 120.7(95,183.2) | 0.911 | 0.418 | 0.04 |
| 2014 | 5(2.8,130.2) | 3.7(1.9,108.5) | 146.5(103.3,230.7) | 0.992 | 0.911 | 0.05 |
| 2015 | 84.8(3.7,167.3) | 74(2.8,143.1) | 139.2(88,280.2) | 0.994 | 0.99 | 0.95 |
| 2016 | 72.1(27.8,171) | 62.7(24.7,147.7) | 133.3(74.1,297) | 0.994 | 0.992 | 0.96 |
| 2017 | 64.6(19.6,167.8) | 54.7(17.1,144.9) | 129.2(64.8,294.4) | 0.995 | 0.992 | 0.94 |
| 2018 | 63.2(16.2,166.7) | 53.4(13.8,140.6) | 132.6(59.8,307.2) | 0.997 | 0.994 | 0.93 |
| 2019 | 63.6(15.7,162.2) | 53(13.1,138) | 128.2(60.3,314.1) | 0.998 | 0.996 | 0.93 |
| 2020 | 59(13.5,169.4) | 49.6(11.3,142.9) | 126(59.1,319.6) | 0.998 | 0.997 | 0.92 |

(f) Alternative 4, Option 2, Model 5, Additional uncertainty = 0.2. Multiplier = 0.41. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuildi ng(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.5(24.5,24.6) | 21.7(21.7,21.7) | 91.2(75.9,106.8) | 0.181 | 0 | 0.45 |
| 2010 | 32.6(18.8,51.3) | 28.9(16.6,45.4) | 77.4(64,91.1) | 0.181 | 0.002 | 0.69 |
| 2011 | 15.4(8.8,25.1) | 13.3(7.5,21.9) | 76.4(63.5,90.6) | 0.182 | 0.002 | 0.38 |
| 2012 | 15(8.2,25.1) | 12.5(6.6,20.4) | 80.6(65.2,104.2) | 0.236 | 0.005 | 0.39 |
| 2013 | 22.7(11,33.8) | 18.5(9.1,26.5) | 96.8(73.1,154.6) | 0.517 | 0.082 | 0.47 |
| 2014 | 33.3(16.2,103.9) | 28.1(14,83.7) | 122.9(80.9,227.2) | 0.792 | 0.435 | 0.51 |
| 2015 | 46.2(17.4,164.5) | 40.1(15.4,139.8) | 136.7(80.6,283.6) | 0.861 | 0.758 | 0.65 |
| 2016 | 72.2(16.6,170.9) | 62.7(14.7,148.3) | 134.2(75.8,297.4) | 0.886 | 0.832 | 0.89 |
| 2017 | 65.4(15.4,166.7) | 55.9(13.2,145.4) | 132.2(70.1,294.7) | 0.907 | 0.86 | 0.89 |
| 2018 | 63.3(14.6,166) | 53.5(12.6,142) | 132.4(64.4,306.3) | 0.921 | 0.885 | 0.89 |
| 2019 | 63.6(13.9,162.4) | 53.1(12,138) | 128.6(62.6,310.7) | 0.931 | 0.902 | 0.9 |
| 2020 | 57.9(12.2,165.8) | 48.9(10.2,145.5) | 124.5(62.1,308.4) | 0.947 | 0.915 | 0.89 |

(g) Alternative 4, Option 3, Model 5, Additional uncertainty = 0.2. Multiplier = 0.21. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.6(22.6,26.8) | 21.8(20,23.7) | 91.1(77,105.6) | 0.181 | 0 | 0.45 |
| 2010 | 32.4(19.1,50.9) | 28.9(16.9,44.9) | 77.4(64.2,90.5) | 0.181 | 0.002 | 0.69 |
| 2011 | 9.1(5.1,14.8) | 7.7(4.2,12.8) | 81(68.2,94.5) | 0.182 | 0.002 | 0.21 |
| 2012 | 9.9(5.2,15.6) | 8.2(4.1,12.9) | 87.9(72.5,112.6) | 0.274 | 0.016 | 0.22 |
| 2013 | 14.7(7.3,21.5) | 12(5.9,17.5) | 107.1(83.1,166.4) | 0.684 | 0.167 | 0.25 |
| 2014 | 20.9(11,119.3) | 17.7(9.5,97.8) | 137.3(93.1,237.6) | 0.915 | 0.66 | 0.27 |
| 2015 | 76.5(13.2,168.5) | 66(11.4,143.2) | 141.7(93,287.6) | 0.94 | 0.905 | 0.84 |
| 2016 | 74.2(15.3,172.8) | 64.7(13.6,150) | 134.4(80.8,298.6) | 0.953 | 0.932 | 0.94 |
| 2017 | 66.7(15.6,167.7) | 56.7(13.4,144.4) | 130.8(71.3,295.5) | 0.961 | 0.946 | 0.92 |
| 2018 | 63.5(14.6,166.6) | 53.8(12.2,141.1) | 132.7(63.7,306.5) | 0.968 | 0.954 | 0.92 |
| 2019 | 63.5(13.5,162.7) | 53(11.7,138.6) | 128.6(61.3,312.2) | 0.977 | 0.961 | 0.92 |
| 2020 | 58.5(12.5,167.5) | 49.2(10.2,142.3) | 126(59.2,313.3) | 0.985 | 0.972 | 0.91 |

**Table 8. Model 5 rebuilding for Alternatives 1-4 and Options 1, 2 and 3, rebuilding 1 year. $B_{35\%}$ = 139,200 t. Fishing at 75%F35% in 2010/11. All projections have rebuilding strategy (multiplier) in effect until rebuilt, then strategy switches to a 0.8 multiplier. Total catch ($ABC_{tot}$) and retained catch ($C_{dir}$) and fishing mortality are medians. Percent MMB at mating relative to B35%. Values in parentheses are 90% CI. Probability of rebuilding for 1 year above B35% and probability of rebuilding to 2 years in a row above B35%.**

(a) Alternative 1, alternative 4 and Option 1 (multiplier = 0.75), Model 5, Additional uncertainty = 0.2. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.5(24.5,24.6) | 21.7(21.7,21.7) | 91.2(75.9,106.8) | 0.181 | 0 | 0.45 |
| 2010 | 32.6(18.8,51.3) | 28.9(16.6,45.4) | 77.4(64,91.1) | 0.181 | 0.002 | 0.69 |
| 2011 | 23.1(13.6,36.3) | 20.6(12.2,31.8) | 70.7(57.7,85) | 0.182 | 0.002 | 0.63 |
| 2012 | 19.9(11.1,33.8) | 16.8(9.4,26.8) | 72.5(57.5,95.4) | 0.208 | 0.004 | 0.63 |
| 2013 | 29.4(14.5,47.3) | 23.9(12.4,36.5) | 85.9(63.1,141) | 0.379 | 0.037 | 0.78 |
| 2014 | 46.1(20.9,96.9) | 38.3(18.3,77.7) | 106(67.5,207.1) | 0.646 | 0.262 | 0.87 |
| 2015 | 58.6(21.7,154.6) | 49.9(19.2,133) | 120.3(67.5,274.7) | 0.744 | 0.572 | 0.9 |
| 2016 | 63.5(19.5,166.6) | 54.2(17.2,143.8) | 125.1(64.3,291.9) | 0.789 | 0.663 | 0.93 |
| 2017 | 62.2(16.8,165.1) | 52.3(14.7,143.1) | 126.6(61.1,290.6) | 0.818 | 0.716 | 0.91 |
| 2018 | 62.1(14.9,165.1) | 52.4(13.3,139.8) | 130.2(59.1,305) | 0.844 | 0.758 | 0.91 |
| 2019 | 62(14.9,162) | 51.8(12.4,137.1) | 125.7(58.9,310.2) | 0.864 | 0.792 | 0.92 |
| 2020 | 57.2(12.8,163.3) | 48.3(10.7,142.3) | 121.8(58.1,301.8) | 0.883 | 0.817 | 0.91 |

(b) Alternative 2, Model 5, Additional uncertainty = 0.2. Directed catch = 0.0 (groundfish bycatch extracted). When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.5(24.5,24.6) | 21.7(21.7,21.7) | 91.2(75.9,106.8) | 0.181 | 0 | 0.45 |
| 2010 | 32.6(18.8,51.3) | 28.9(16.6,45.4) | 77.4(64,91.1) | 0.181 | 0.002 | 0.69 |
| 2011 | 0.5(0.4,0.7) | 0(0,0) | 87.6(74.1,101.5) | 0.203 | 0.002 | 0.63 |
| 2012 | 0.6(0.5,0.9) | 0(0,0) | 99.5(83,124.8) | 0.508 | 0.082 | 0.63 |
| 2013 | 0.8(0.6,54.3) | 0(0,44.7) | 123.1(97.3,183.9) | 0.943 | 0.485 | 0.78 |
| 2014 | 1.3(0.7,131.8) | 0(0,109.5) | 146.3(102.9,229.6) | 0.996 | 0.943 | 0.87 |
| 2015 | 83.8(0.9,167.7) | 73.6(0,143.4) | 136.5(85.7,280.8) | 0.998 | 0.994 | 0.9 |
| 2016 | 72(27.4,171.4) | 62.3(24.1,148) | 131.8(73.1,296.3) | 0.998 | 0.996 | 0.93 |
| 2017 | 64.3(19.3,167.9) | 54.6(16.9,145.1) | 129.3(64.3,294.5) | 0.998 | 0.996 | 0.91 |
| 2018 | 63.1(16.1,166.2) | 53.4(13.9,140.7) | 131.8(60,307.2) | 0.999 | 0.997 | 0.91 |
| 2019 | 63.2(15.8,162.2) | 52.7(13.1,138.1) | 128.3(60.3,314.5) | 0.999 | 0.998 | 0.92 |
| 2020 | 59.1(13.6,170) | 49.6(11.7,143) | 125.9(59.2,321.2) | 0.999 | 0.998 | 0.91 |

(c) Alternative 3, Model 5, Additional uncertainty = 0.2. Multiplier = 0.42. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.6(22.6,26.8) | 21.8(20,23.7) | 91.1(77,105.6) | 0.181 | 0 | 0.45 |
| 2010 | 32.4(19.1,50.9) | 28.9(16.9,44.9) | 77.4(64.2,90.5) | 0.181 | 0.002 | 0.69 |
| 2011 | 15.6(9,25.4) | 13.5(7.7,22.2) | 76.2(63.5,90) | 0.182 | 0.002 | 0.39 |
| 2012 | 15.2(8.3,25.4) | 12.7(6.7,20.6) | 80.3(64.8,103.9) | 0.217 | 0.004 | 0.39 |
| 2013 | 22.9(11.2,34.3) | 18.7(9.2,26.8) | 96.4(72.7,154.2) | 0.499 | 0.081 | 0.48 |
| 2014 | 33.8(16.4,103.6) | 28.5(14.2,83.5) | 122.2(80.6,226.9) | 0.781 | 0.428 | 0.52 |
| 2015 | 46.4(17.6,163.8) | 40.2(15.5,138.9) | 136.3(80,283.4) | 0.856 | 0.753 | 0.66 |
| 2016 | 72(16.7,170.7) | 62.6(14.8,148.1) | 133.9(75.2,297.2) | 0.879 | 0.831 | 0.89 |
| 2017 | 65.4(15.6,166.7) | 55.9(13.3,145.4) | 131.8(69.9,294.4) | 0.902 | 0.857 | 0.89 |
| 2018 | 63.3(14.6,165.7) | 53.4(12.6,141.9) | 132.4(64.1,305.7) | 0.916 | 0.884 | 0.89 |
| 2019 | 63.5(14,162.4) | 53.1(12.1,138) | 128.4(62.5,310.9) | 0.927 | 0.899 | 0.9 |
| 2020 | 57.8(12.2,165.6) | 48.8(10.3,145.3) | 124.4(62.1,308.2) | 0.942 | 0.914 | 0.89 |

(d) Alternative 3, Option 2, Model 5, Additional uncertainty = 0.2. Multiplier = 0.15. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.6(22.6,26.8) | 21.8(20,23.7) | 91.1(77,105.6) | 0.181 | 0 | 0.45 |
| 2010 | 32.4(19.1,50.9) | 28.9(16.9,44.9) | 77.4(64.2,90.5) | 0.181 | 0.002 | 0.69 |
| 2011 | 6.9(3.9,11) | 5.7(3.1,9.4) | 82.7(69.7,96.1) | 0.184 | 0.002 | 0.15 |
| 2012 | 7.8(4.1,12) | 6.4(3.1,9.8) | 90.7(75.3,115.1) | 0.298 | 0.021 | 0.16 |
| 2013 | 11.3(5.8,16.8) | 9.2(4.6,13.5) | 111.2(86.8,171.5) | 0.751 | 0.205 | 0.18 |
| 2014 | 16.3(8.8,122.5) | 13.6(7.5,102) | 142.3(98.3,241.1) | 0.947 | 0.741 | 0.2 |
| 2015 | 81(11.1,168.7) | 70.3(9.6,143.1) | 141.8(94.8,281.5) | 0.962 | 0.94 | 0.89 |
| 2016 | 74.1(15.5,172.9) | 64.6(12.3,148.2) | 134.9(79.9,300.5) | 0.968 | 0.954 | 0.96 |
| 2017 | 66.1(15.6,168.3) | 56.3(13.2,144.6) | 130.4(70,294.4) | 0.974 | 0.962 | 0.93 |
| 2018 | 63.6(13.6,166.9) | 53.8(11.8,141.3) | 132.8(62.5,306.3) | 0.981 | 0.967 | 0.93 |
| 2019 | 63.6(13.4,162.3) | 53(11.7,138) | 128.2(61.1,312.9) | 0.986 | 0.975 | 0.92 |
| 2020 | 58.7(12.4,168.2) | 49.4(10.4,142.4) | 125.5(59.4,315.2) | 0.991 | 0.983 | 0.91 |

(e) Alternative 3, Option 3, Model 5, Additional uncertainty = 0.2. Multiplier = 0.03. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.5(24.5,24.6) | 21.7(21.7,21.7) | 91.2(75.9,106.8) | 0.181 | 0 | 0.45 |
| 2010 | 32.6(18.8,51.3) | 28.9(16.6,45.4) | 77.4(64,91.1) | 0.181 | 0.002 | 0.69 |
| 2011 | 1.9(1.2,2.8) | 1.3(0.7,2) | 86.5(73.1,100.6) | 0.198 | 0.002 | 0.03 |
| 2012 | 2.4(1.4,3.3) | 1.5(0.7,2.3) | 97.3(81.3,122.7) | 0.452 | 0.06 | 0.04 |
| 2013 | 3.2(1.9,36) | 2.1(1.1,31) | 120.7(95,183.2) | 0.911 | 0.418 | 0.04 |
| 2014 | 5(2.8,130.2) | 3.7(1.9,108.5) | 146.5(103.3,230.7) | 0.992 | 0.911 | 0.05 |
| 2015 | 84.8(3.7,167.3) | 74(2.8,143.1) | 139.2(88,280.2) | 0.994 | 0.99 | 0.95 |
| 2016 | 72.1(27.8,171) | 62.7(24.7,147.7) | 133.3(74.1,297) | 0.994 | 0.992 | 0.96 |
| 2017 | 64.6(19.6,167.8) | 54.7(17.1,144.9) | 129.2(64.8,294.4) | 0.995 | 0.992 | 0.94 |
| 2018 | 63.2(16.2,166.7) | 53.4(13.8,140.6) | 132.6(59.8,307.2) | 0.997 | 0.994 | 0.93 |
| 2019 | 63.6(15.7,162.2) | 53(13.1,138) | 128.2(60.3,314.1) | 0.998 | 0.996 | 0.93 |
| 2020 | 59(13.5,169.4) | 49.6(11.3,142.9) | 126(59.1,319.6) | 0.998 | 0.997 | 0.92 |

(f) Alternative 4, Option 2, Model 5, Additional uncertainty = 0.2. Multiplier = 0.47. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.6(22.6,26.8) | 21.8(20,23.7) | 91.1(77,105.6) | 0.181 | 0 | 0.45 |
| 2010 | 32.4(19.1,50.9) | 28.9(16.9,44.9) | 77.4(64.2,90.5) | 0.181 | 0.002 | 0.69 |
| 2011 | 17(9.8,27.5) | 14.7(8.5,24) | 75.2(62.4,89.1) | 0.182 | 0.002 | 0.43 |
| 2012 | 16.1(8.9,27.1) | 13.4(7.2,21.9) | 78.8(63.4,102.3) | 0.208 | 0.003 | 0.43 |
| 2013 | 24.3(11.9,36.8) | 19.8(9.8,28.6) | 94.2(70.8,151.8) | 0.472 | 0.065 | 0.53 |
| 2014 | 36.3(17.4,96.5) | 30.6(15,76.2) | 119.1(77.9,223.3) | 0.756 | 0.391 | 0.58 |
| 2015 | 48.5(18.5,165.4) | 41.7(16.4,141.1) | 134.7(77.6,282.6) | 0.83 | 0.719 | 0.69 |
| 2016 | 70.5(17.4,169.7) | 61.6(15.1,147.1) | 133.3(73.6,296) | 0.867 | 0.793 | 0.87 |
| 2017 | 65.2(15.8,166.4) | 55.6(13.6,145.2) | 130.8(69.2,293.4) | 0.89 | 0.832 | 0.87 |
| 2018 | 62.6(15.2,167) | 53.3(13,141.8) | 133(63.6,306.4) | 0.904 | 0.864 | 0.88 |
| 2019 | 63.1(14.2,162.3) | 53.1(12.1,138) | 128.8(62.2,310.4) | 0.917 | 0.881 | 0.89 |
| 2020 | 57.6(12.3,166) | 48.7(10.5,144.3) | 124.3(61.5,307) | 0.935 | 0.897 | 0.88 |

(g) Alternative 4, Option 3, Model 5, Additional uncertainty = 0.2. Multiplier = 0.22. When rebuilt multiplier increased to 0.8.

| Year | $ABC_{tot}$ (1000t) | $C_{dir}$ (1000t) | Percent MMB/ $B_{35\%}$ | Prob Rebuilding(1 yrs) | Prob Rebuilding (2 yrs) | Full Selection Fishing Mortality |
|---|---|---|---|---|---|---|
| 2009 | 24.6(22.6,26.8) | 21.8(20,23.7) | 91.1(77,105.6) | 0.181 | 0 | 0.45 |
| 2010 | 32.4(19.1,50.9) | 28.9(16.9,44.9) | 77.4(64.2,90.5) | 0.181 | 0.002 | 0.69 |
| 2011 | 9.4(5.3,15.3) | 8(4.4,13.3) | 80.8(68,94.2) | 0.182 | 0.002 | 0.22 |
| 2012 | 10.2(5.4,16.1) | 8.5(4.3,13.4) | 87.5(72.2,112.2) | 0.269 | 0.015 | 0.23 |
| 2013 | 15.2(7.6,22.1) | 12.4(6.1,18) | 106.5(82.6,166) | 0.664 | 0.158 | 0.27 |
| 2014 | 21.7(11.3,117) | 18.3(9.7,96.5) | 136.3(92.4,238.5) | 0.911 | 0.637 | 0.29 |
| 2015 | 74.2(13.5,168.3) | 64.8(11.7,144.2) | 141.5(92.4,287.4) | 0.937 | 0.899 | 0.81 |
| 2016 | 74.5(14.9,172.7) | 65.2(13.3,149.9) | 135.3(80.5,298.3) | 0.952 | 0.927 | 0.94 |
| 2017 | 66.7(15.5,167.6) | 56.7(13.5,144.3) | 131(71,295.5) | 0.961 | 0.942 | 0.92 |
| 2018 | 63.4(14.5,166.6) | 54(12.2,141) | 132.8(63.6,306.3) | 0.968 | 0.951 | 0.92 |
| 2019 | 63.7(13.5,162.7) | 53(11.7,138.5) | 128.6(61.5,312.1) | 0.976 | 0.958 | 0.92 |
| 2020 | 58.4(12.5,167.4) | 49.1(10.4,142.3) | 125.9(59.1,313.9) | 0.985 | 0.968 | 0.91 |

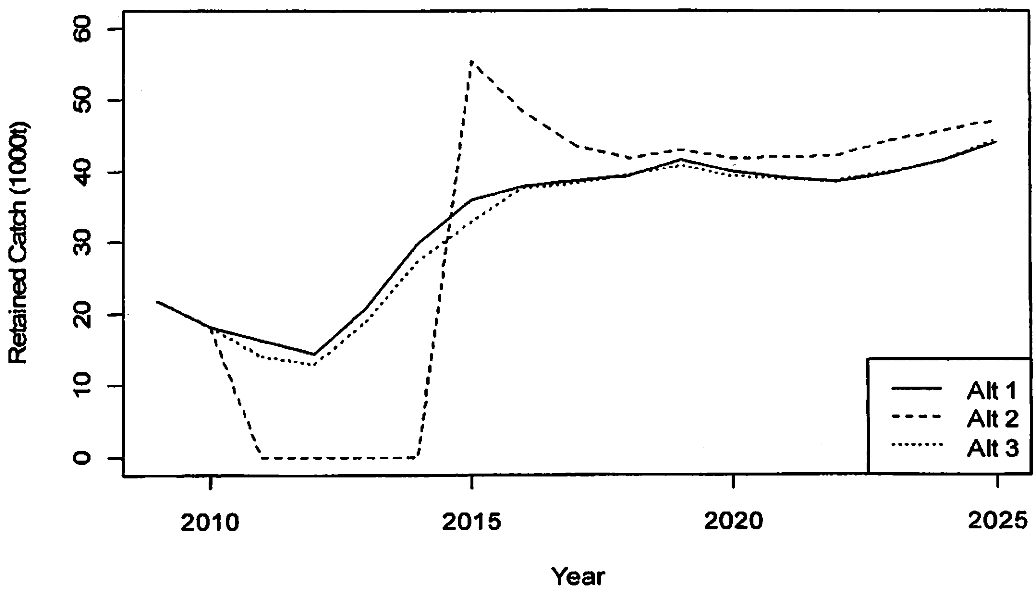


Figure 1. Model 1 projected retained catch for Alternative 1 (75% F35% CR), Alternative 2 (directed catch = 0.0), and Alternative 3 (62% F35% CR, 50% rebuilding (2 yr) 2015/16).

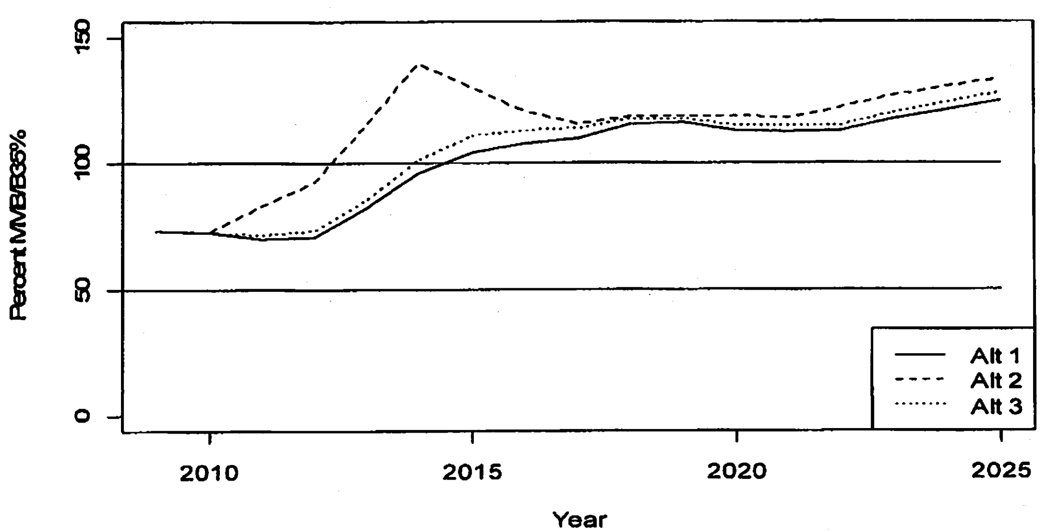


Figure 2. Model 1 projected percent MMB/B35% for Alternative 1 (75% F35% CR), Alternative 2 (directed catch = 0.0), and Alternative 3 (62% F35% CR, 50% rebuilding (2 yr) 2015/16).

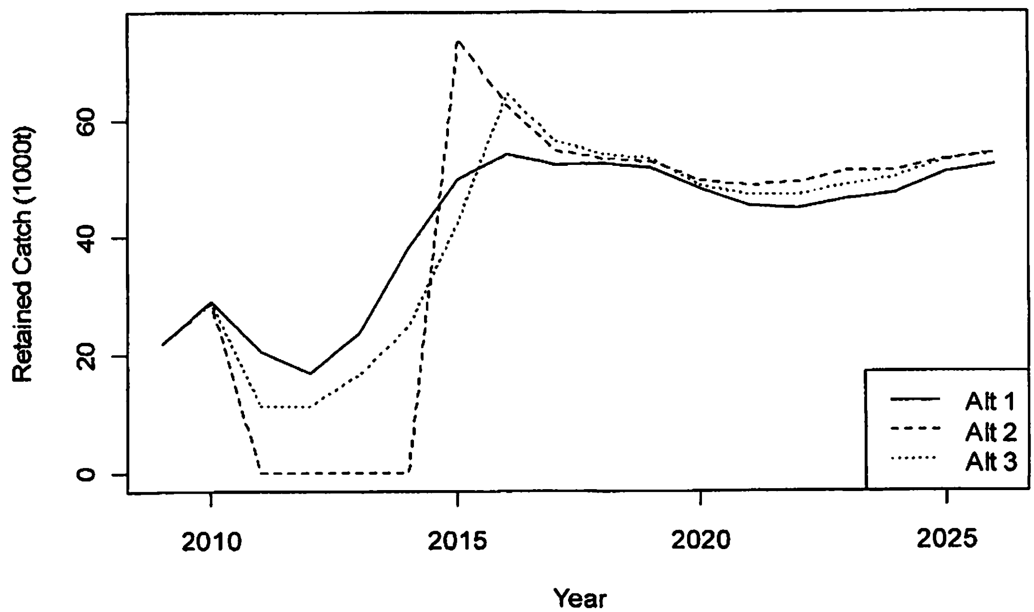


Figure 3 . Model 5 projected retained catch for Alternative 1 (75% F35% CR), Alternative 2 (directed catch = 0.0), and Alternative 3 (34% F35% CR, 50% rebuilding (2 yr) 2015/16).

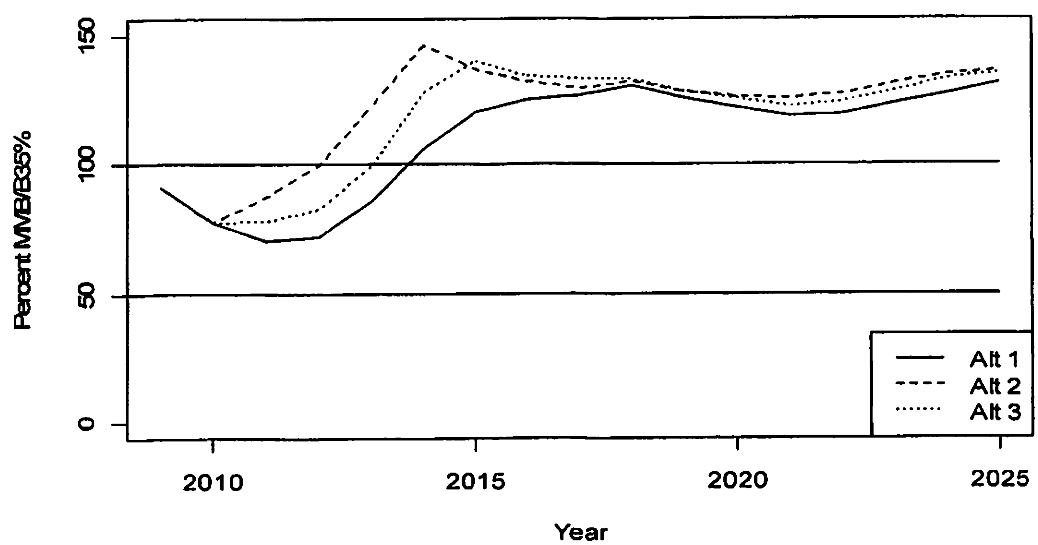


Figure 4 . Model 5 projected percent MMB/B35% for Alternative 1 (75% F35% CR), Alternative 2 (directed catch = 0.0), and Alternative 3 (34% F35% CR, 50% rebuilding (2 yr) 2015/16).

# Bering Sea Snow Crab ACL and Rebuilding Alternatives Supplemental Economic Analysis

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June 2, 2010

This document presents summary results from economic forecast analysis of Bering Sea snow crab ACL and rebuilding alternatives presented in the Environmental Assessment Initial Draft, prepared for the June, 2010 North Pacific Fishery Management Council and other supplementary documents.

Economic implications of both ACL and rebuilding alternatives are presented in terms of the forecasted first wholesale revenue associated with stock projection directed catch forecasts. All results presented below are based on directed catch forecasts produced using the default level of additional uncertainty for Tier 2 crab stocks ($\sigma_b$=0.2) combined with probabilistic price forecasts using an econometric time series model of prices in the Alaska king and snow crab fisheries and in the domestic crab import market, as detailed in Chapter 3 of the Draft EA.

**ACL Alternatives**

The medium term (2009-2014) economic impacts of ACL fixed buffer and P* alternatives are summarized in Tables 1 a-b. As noted in the EA, increasing the size of the buffer (i.e., decreasing multiplier from 1.0 to 0.1) produces a lower probability of overfishing at the cost of substantially lower annual catches, particularly during earlier years. This translates into lower gross earnings in the fishery in the medium term. Tables 1 (a) and (b) present the median and 90% confidence intervals for present value of total annual revenues produced from the annual directed catch projected for the ACL alternatives over the period 2009-2014, and the comparative economic effects of alternatives in foregone revenue relative to a baseline scenario of zero buffer. Results are shown for scenarios that apply the SOA control rule as an upper bound on TAC (Table 1 (a)), and scenarios without the SOA control rule (Table 1 (b)). Results of economic comparisons between ACL alternatives resulting from catch projections constrained by the SOA control rule indicate potential foregone mid-term revenues in the snow crab fishery range from $3 million present value (r=2.6%) at the 0.1 buffer level, to $496 million present value at the 0.9 buffer level, representing a range of 1% to 66% reduction relative to the baseline alternative. The same range of fixed buffer alternatives depicted in Table 1 (b) without the effect of the SOA control rule range from 1% to 69% reduction from baseline revenue. Note that the SOA control rule remains in effect as the protocol for TAC-setting, however, the potential foregone revenues that could result from the ACL alternatives would increase substantially relative to a baseline scenario of zero buffer, with the ABC as the binding constraint on TAC rather than the SOA control rule. Note that this "baseline" does not represent the status quo alternative, but is intended to provide a representation of the effects of ACL alternatives under potential future decision-making scenarios where the SOA control rule is no longer binding. It should be noted that this comparison does not indicate that costs of ACL's would be higher in the event that the SOA rule was not applied, rather that the SOA rule effectively represents a buffer in itself, and results in foregone catch and revenues relative to the least conservative ACL alternatives under consideration.

Economic results of ACL alternatives over the long term (2009-2038) are represented in Table 2 (a) and (b). Results of economic comparisons between ACL alternatives resulting from catch projections constrained by the SOA control rule indicate potential foregone long-term revenues in the snow crab fishery range from $31 million present value (r=2.6%) at the 0.1 buffer level, to $3.5 billion present value at the 0.9 buffer level. The same range of fixed buffer alternatives depicted in Table 1 (b) without the effect of the SOA control rule range from $107 million present value (r=2.6%) at the 0.1 buffer level, to $3.8 billion present value at the 0.9 buffer level.

It is important to note the large range of uncertainty in the revenue figures, particularly over the long range. The figures described above represent median values in a broad distribution of potential outcomes, and should not be interpreted as predicted values for purposes other than to support a comparative evaluation of the ACL alternatives, and the proportional description of potential changes from baseline alternatives are likely more illustrative in this regard. It should also be noted that the relative economic effects of the ACLs are not qualitatively different between the mid- and long-term, nor do alternative discount rates appreciably change the relative ranking of alternatives in terms of economic outcomes. This is largely due to the effect of the constancy of the buffer in the model projections, in both the buffer and P* scenarios. With fixed buffers, which are not responsive to changes in the stock status, there is little change in the timing of harvest over the period of analysis. That is, none of the alternatives under consideration implement different buffers over time according to stock conditions, and thus the timing of relative economic benefits from the fishery across the time horizon are not appreciably different under the alternatives analyzed.

**Rebuilding Alternatives**

Tables 3(a) to 3(l) present economic forecasts of revenue implications for rebuilding alternatives. All figures represent year 2012 as the base year for rebuilding plan implementation, and results are presented as the total present value of revenue forecasts discounted to 2009 value, associated with catch forecasts over five-, ten- and fifteen-year periods (2012-2016, 2012-2021, and 2012-2026, respectively). Results are presented for two alternative stock projection model specifications and using both one- and two-years as the required threshold for stocks to attain a rebuilt status. Model specifications and rebuilding alternatives are described in Turnock, *Bering Sea Snow Crab Rebuilding Alternatives Supplemental Table and Figures* May 28, 2010).

Figure 1 depicts the relative economic implications of rebuilding alternatives across three time periods for Model 1, assuming a 2-year rebuilding threshold. In both the five- and ten-year periods, Alternative 2 (which achieves the most rapid rebuilding) imposes the largest loss in potential revenue relative to the no-action alternative (Alternative 4 (Tend) and Option 1 both implement the same 0.25 buffer level as the baseline alternative). Note that over the 10-year period, relative economic impacts of alternatives that rebuild the stock more rapidly than the baseline are diminished due to larger retained catch in the later part of the period, with the value of foregone revenue in the short-term weighted more heavily with increasing discount rate from 0% to 7%. Over the 15-year period, benefits of more rapid rebuilding result in net gains in revenues over the baseline alternative, indicated in the lower panel of Figure 1 as negative foregone revenue for r=0% and 2.7%. The effect of discounting is particularly critical in the context of rebuilding alternatives due to the difference in relative weight of near-term versus late-term benefits and costs implicit in different discount rates. Since the rebuilding alternatives trade-off rapid rebuilding and later-term gains in larger ABC's versus slower rebuilding and larger near-term ABC's, lower discount rates will place greater weight on the long-term benefits of rapid rebuilding.

Figure 2 depicts the relative effects of model specification and a rebuilding threshold of one- versus two-years to attain rebuild status. The slower rebuilding response indicated by the Model 5 specification results in forecasts of greater foregone revenue values over the longer-term.

**Table 1: Summary of medium-term economic impacts of a subset of the ACL alternatives relative to baseline alternative for Eastern Bering Sea snow crab. Economic impacts are estimated as discounted present value of forecasted gross first wholesale revenues over the five year period 2009-2014, and differences in revenues relative to status-quo baseline, incorporating effects of additional uncertainty, $\sigma_b$. Point estimates are medians and ranges are 90% confidence intervals.**
**(a) Results reflect the effect of the SOA control rule as a constraint.**

| | | Present Value of Total Revenue, 2009-2014 ($ Million) | | | Difference in Gross Revenue Relative to Baseline Alternative, Buffer=0, $\sigma_b$ =0.2 ($ Million) | | | |
|---|---|---|---|---|---|---|---|---|
| $\sigma_b$ | Buffer Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.2 | 0 | 817.3(388.3,1448.7) | 763.4(367.4,1332.1) | 691.9(338.8,1180.3) | 0 | 0 | 0 | 0% |
| 0.2 | 0.1 | 812.9(385,1425.6) | 760.1(364.1,1311.2) | 686.4(334.4,1164.9) | 4 | 3 | 6 | 1% |
| 0.2 | 0.2 | 800.8(368.5,1384.9) | 748(350.9,1273.8) | 677.6(325.6,1127.5) | 17 | 15 | 14 | 2% |
| 0.2 | 0.3 | 777.7(354.2,1318.9) | 727.1(335.5,1218.8) | 657.8(309.1,1085.7) | 40 | 36 | 34 | 5% |
| 0.2 | 0.4 | 735.9(333.3,1240.8) | 688.6(315.7,1156.1) | 623.7(292.6,1036.2) | 81 | 75 | 68 | 10% |
| 0.2 | 0.5 | 677.6(309.1,1140.7) | 633.6(293.7,1060.4) | 575.3(270.6,951.5) | 140 | 130 | 117 | 17% |
| 0.2 | 0.6 | 603.9(280.5,1015.3) | 566.5(266.2,943.8) | 512.6(245.3,849.2) | 213 | 197 | 179 | 26% |
| 0.2 | 0.7 | 513.7(244.2,864.6) | 484(232.1,804.1) | 440(215.6,723.8) | 304 | 279 | 252 | 37% |
| 0.2 | 0.8 | 408.1(196.9,673.2) | 383.9(188.1,629.2) | 353.1(176,572) | 409 | 380 | 339 | 50% |
| 0.2 | 0.9 | 280.5(139.7,440) | 267.3(135.3,415.8) | 249.7(129.8,385) | 537 | 496 | 442 | 66% |
| $\sigma_b$ | P* Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.2 | 0.4 | 815.1(385,1448.7) | 761.2(364.1,1332.1) | 688.6(337.7,1177) | 2 | 2 | 3 | 0% |
| 0.2 | 0.3 | 811.8(385,1416.8) | 759(363,1303.5) | 685.3(334.4,1163.8) | 6 | 4 | 7 | 1% |
| 0.2 | 0.2 | 801.9(374,1393.7) | 748(352,1282.6) | 677.6(326.7,1130.8) | 15 | 15 | 14 | 2% |
| 0.2 | 0.1 | 781(355.3,1327.7) | 730.4(336.6,1224.3) | 660(310.2,1089) | 36 | 33 | 32 | 4% |

**(b): Results are exclusive of SOA control rule effect.**

| | | Present Value of Total Revenue, 2009-2014 ($ Million) | | | Difference in Gross Revenue Relative to Baseline Alternative, Buffer=0, $\sigma_b$ =0.2 ($ Million) | | | |
|---|---|---|---|---|---|---|---|---|
| **$\sigma_b$** | **Buffer Level** | **r=0** | **r=2.7%** | **r=7.0%** | **r=0** | **r=2.7%** | **r=7.0%** | **% Change** |
| **0.2** | 0 | 910.8(421.3,1563.1) | 852.5(399.3,1456.4) | 770(369.6,1287) | 0 | 0 | 0 | 0% |
| **0.2** | 0.1 | 876.7(403.7,1508.1) | 817.3(382.8,1383.8) | 738.1(353.1,1227.6) | 34 | 35 | 31.9 | 4% |
| **0.2** | 0.2 | 834.9(383.9,1423.4) | 779.9(365.2,1312.3) | 705.1(335.5,1173.7) | 76 | 73 | 64.9 | 8% |
| **0.2** | 0.3 | 788.7(363,1333.2) | 738.1(345.4,1243) | 667.7(315.7,1109.9) | 122 | 114 | 102.3 | 13% |
| **0.2** | 0.4 | 738.1(338.8,1248.5) | 690.8(322.3,1158.3) | 625.9(294.8,1036.2) | 173 | 162 | 144.1 | 19% |
| **0.2** | 0.5 | 677.6(312.4,1140.7) | 633.6(295.9,1060.4) | 575.3(271.7,951.5) | 233 | 219 | 194.7 | 26% |
| **0.2** | 0.6 | 603.9(280.5,1015.3) | 566.5(266.2,943.8) | 512.6(245.3,849.2) | 307 | 286 | 257.4 | 34% |
| **0.2** | 0.7 | 513.7(244.2,864.6) | 484(232.1,804.1) | 440(215.6,723.8) | 397 | 369 | 330 | 44% |
| **0.2** | 0.8 | 408.1(196.9,673.2) | 383.9(188.1,629.2) | 353.1(176,572) | 503 | 469 | 416.9 | 55% |
| **0.2** | 0.9 | 280.5(139.7,440) | 267.3(135.3,415.8) | 249.7(129.8,385) | 630 | 585 | 520.3 | 69% |
| **$\sigma_b$** | **P* Level** | **r=0** | **r=2.7%** | **r=7.0%** | **r=0** | **r=2.7%** | **r=7.0%** | **% Change** |
| **0.2** | 0.4 | 897.6(413.6,1541.1) | 840.4(392.7,1430) | 757.9(363,1265) | 13 | 12 | 12 | 1% |
| **0.2** | 0.3 | 872.3(401.5,1499.3) | 812.9(380.6,1372.8) | 734.8(350.9,1221) | 39 | 40 | 35 | 4% |
| **0.2** | 0.2 | 840.4(386.1,1433.3 | 783.2(367.4,1320) | 709.5(337.7,1180.3 | 70 | 69 | 61 | 8% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ) | | ) | | | | |
| **0.2** | 0.1 | 792(365.2,1340.9) | 741.4(346.5,1249.6) | 671(317.9,1114.3) | 119 | 111 | 99 | 13% |

**Table 2: Summary of long-term economic impacts of a subset of the ACL alternatives relative to baseline alternative for Eastern Bering Sea snow crab. Economic impacts are estimated as discounted present value of forecasted gross first wholesale revenues over the five year period 2009-2014, and differences in revenues relative to status-quo baseline, incorporating effects of additional uncertainty, $\sigma_b$. Point estimates are medians and ranges are 90% confidence intervals.**
**(a) Results reflect the effect of the SOA control rule as a constraint.**

| | | Present Value of Total Revenue, 2009-2014 ($ Million) | | | Difference in Gross Revenue Relative to Baseline Alternative, Buffer=0, $\sigma_b$ =0.2 ($ Million) | | | |
|---|---|---|---|---|---|---|---|---|
| $\sigma_b$ | Buffer Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.2 | 0 | 7977.2(1785.3,19241.2) | 5297.6(1314.5,12438.8) | 3085.5(826.1,7007) | 0 | 0 | 0 | 0% |
| 0.2 | 0.1 | 7921.1(1753.4,19137.8) | 5266.8(1301.3,12266.1) | 3062.4(812.9,6919) | 56 | 31 | 23 | 1% |
| 0.2 | 0.2 | 7796.8(1741.3,18965.1) | 5176.6(1278.2,12061.5) | 3015.1(790.9,6736.4) | 180 | 121 | 70 | 2% |
| 0.2 | 0.3 | 7615.3(1690.7,18393.1) | 5060(1230.9,11730.4) | 2911.7(763.4,6583.5) | 362 | 238 | 174 | 5% |
| 0.2 | 0.4 | 7357.9(1585.1,17694.6) | 4856.5(1147.3,11315.7) | 2794(729.3,6259) | 619 | 441 | 292 | 8% |
| 0.2 | 0.5 | 6956.4(1474,16766.2) | 4592.5(1068.1,10568.8) | 2601.5(689.7,5819) | 1021 | 705 | 484 | 13% |
| 0.2 | 0.6 | 6360.2(1332.1,15158) | 4203.1(961.4,9628.3) | 2365(613.8,5281.1) | 1617 | 1095 | 721 | 20% |
| 0.2 | 0.7 | 5520.9(1147.3,13106.5) | 3646.5(817.3,8287.4) | 2037.2(534.6,4522.1) | 2456 | 1651 | 1048 | 31% |
| 0.2 | 0.8 | 4357.1(899.8,10309.2) | 2863.3(634.7,6421.8) | 1600.5(430.1,3511.2) | 3620 | 2434 | 1485 | 45% |
| 0.2 | 0.9 | 2677.4(555.5,6206.2) | 1750.1(396,3868.7) | 991.1(271.7,2134) | 5300 | 3548 | 2094 | 66% |

| $\sigma_b$ | P* Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
|---|---|---|---|---|---|---|---|---|
| **0.2** | 0.4 | 7977.2(1785.3,19241.2) | 5297.6(1314.5,12438.8) | 3085.5(826.1,7007) | 0 | 0 | 0 | 0% |
| **0.2** | 0.3 | 7921.1(1753.4,19137.8) | 5266.8(1301.3,12266.1) | 3062.4(812.9,6919) | 56 | 31 | 23 | 1% |
| **0.2** | 0.2 | 7796.8(1741.3,18965.1) | 5176.6(1278.2,12061.5) | 3015.1(790.9,6736.4) | 180 | 121 | 70 | 2% |
| **0.2** | 0.1 | 7615.3(1690.7,18393.1) | 5060(1230.9,11730.4) | 2911.7(763.4,6583.5) | 362 | 238 | 174 | 5% |

**(b): Results are exclusive of SOA control rule effect.**

| | | Present Value of Total Revenue, 2009-2014 ($ Million) | | | Difference in Gross Revenue Relative to Baseline Alternative, Buffer=0, $\sigma_b$ =0.2 ($ Million) | | | |
|---|---|---|---|---|---|---|---|---|
| $\sigma_b$ | Buffer Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.2 | 0 | 8288.5(1833.7,19769.2) | 5512.1(1383.8,12832.6) | 3234(883.3,7275.4) | 0 | 0 | 0 | 0% |
| 0.2 | 0.1 | 8129(1791.9,19442.5) | 5405.4(1339.8,12507) | 3154.8(853.6,7134.6) | 160 | 107 | 79 | 2% |
| 0.2 | 0.2 | 7942(1751.2,19104.8) | 5274.5(1295.8,12229.8) | 3059.1(816.2,6923.4) | 347 | 238 | 175 | 4% |
| 0.2 | 0.3 | 7722(1683,18569.1) | 5108.4(1222.1,11838.2) | 2943.6(784.3,6637.4) | 567 | 404 | 290 | 7% |
| 0.2 | 0.4 | 7392(1582.9,17835.4) | 4889.5(1147.3,11359.7) | 2790.7(745.8,6298.6) | 897 | 623 | 443 | 11% |
| 0.2 | 0.5 | 6975.1(1474,16766.2) | 4601.3(1069.2,10597.4) | 2600.4(689.7,5846.5) | 1313 | 911 | 634 | 16% |
| 0.2 | 0.6 | 6360.2(1332.1,15158) | 4206.4(961.4,9655.8) | 2365(613.8,5281.1) | 1928 | 1306 | 869 | 23% |
| 0.2 | 0.7 | 5520.9(1147.3,13106.5) | 3650.9(817.3,8287.4) | 2037.2(536.8,4522.1) | 2768 | 1861 | 1197 | 33% |
| 0.2 | 0.8 | 4357.1(899.8,10309.2) | 2864.4(634.7,6421.8) | 1600.5(430.1,3511.2) | 3931 | 2648 | 1634 | 47% |
| 0.2 | 0.9 | 2677.4(555.5,6206.2) | 1750.1(396,3868.7) | 991.1(271.7,2134) | 5611 | 3762 | 2243 | 68% |
| $\sigma_b$ | P* Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.2 | 0.4 | 8236.8(1817.2,19668) | 5474.7(1367.3,12670.9) | 3205.4(872.3,7222.6) | 52 | 37 | 29 | 1% |
| 0.2 | 0.3 | 8107(1785.3,19407.3) | 5386.7(1334.3,12475.1) | 3142.7(849.2,7113.7) | 182 | 125 | 91 | 2% |
| 0.2 | 0.2 | 7966.2(1755.6,19154.3) | 5289.9(1301.3,12265) | 3070.1(820.6,6949.8) | 322 | 222 | 164 | 4% |
| 0.2 | 0.1 | 7741.8(1690.7,18618.6) | 5127.1(1227.6,11874.5) | 2954.6(786.5,6664.9) | 547 | 385 | 279 | 7% |

Table 3. Summary of economic impacts of snow crab rebuilding alternatives over 5-, 10-, and 15-year periods, with results from stock projection Model 1 and Model 5 and assuming 1-year and 2-year thresholds for rebuilding. Economic impacts are estimated as discounted present value of forecasted gross first wholesale revenues over the five year period 2012-2016, and differences in revenues relative to no-action baseline. Point estimates are medians and ranges are 90% confidence intervals. Results are shown for alternative discount rates r=0.0%, 2.7%, and 7.0%.

(a) Five-year (2012-2016) Economic forecasts, using Stock Projection Model 1, 2-year rebuilding threshold

| **Alternative** | **Buffer** | **Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million)** | | | **Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline,** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **r=0.0** | **r=2.7%** | **r=7.0%** | **r=0.0** | | **r=2.7%** | | **r=7.0%** | |
| **Alternative 1 (no action)** | 0.25 | 871(219,2013) | 758(195,1720) | 616(160,1367) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2 ($T_{MIN}$)** | 1 | 591(56,1747) | 503(53,1484) | 393(46,1157) | 280 | 32% | 255 | 34% | 223 | 36% |
| **Alternative 3** | 0.38 | 823(208,1971) | 723(183,1678) | 581(152,1315) | 48 | 6% | 35 | 5% | 35 | 6% |
| Alternative 3-Option 2 | 0.69 | 665(159,1822) | 579(135,1547) | 469(110,1194) | 206 | 24% | 179 | 24% | 147 | 24% |
| Alternative 3-Option 3 | 0.844 | 623(117,1765) | 535(102,1482) | 428(83,1143) | 248 | 28% | 223 | 29% | 188 | 31% |
| **Alternative 4 (Tend)** | 0.25 | 871(219,2013) | 758(195,1720) | 616(160,1367) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.61 | 707(168,1844) | 613(146,1568) | 497(122,1228) | 164 | 19% | 145 | 19% | 119 | 19% |
| Alternative 4-Option 3 | 0.8 | 642(135,1783) | 553(118,1501) | 436(94,1155) | 229 | 26% | 205 | 27% | 180 | 29% |
| Option 1 | 0.25 | 871(219,2013) | 758(195,1720) | 616(160,1367) | 0 | 0% | 0 | 0% | 0 | 0% |

(b) Five-year (2012-2016) Economic forecasts, using Stock Projection Model 1, 1-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 871(219,2013) | 758(195,1720) | 616(160,1367) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 591(56,1747) | 503(53,1484) | 393(46,1157) | 280 | 32% | 255 | 34% | 223 | 36% |
| **Alternative 3** | 0.36 | 835(210,1979) | 731(186,1688) | 588(155,1328) | 36 | 4% | 27 | 4% | 28 | 5% |
| Alternative 3-Option 2 | 0.68 | 670(156,1816) | 582(135,1534) | 472(112,1196) | 201 | 23% | 176 | 23% | 144 | 23% |
| Alternative 3-Option 3 | 0.83 | 629(124,1775) | 541(108,1486) | 432(87,1152) | 242 | 28% | 217 | 29% | 184 | 30% |
| **Alternative 4 (Tend)** | 0.25 | 871(219,2013) | 758(195,1720) | 616(160,1367) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.59 | 717(174,1854) | 621(149,1589) | 507(126,1238) | 154 | 18% | 137 | 18% | 109 | 18% |
| Alternative 4-Option 3 | 0.79 | 647(138,1791) | 552(122,1508) | 437(94,1162) | 224 | 26% | 206 | 27% | 179 | 29% |
| Option 1 | 0.25 | 871(219,2013) | 758(195,1720) | 616(160,1367) | 0 | 0% | 0 | 0% | 0 | 0% |

(c) Five-year (2012-2016) Economic forecasts, using Stock Projection Model 5, 2-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 1168(285,2955) | 1025(251,2503) | 830(207,1975) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 918(117,2738) | 775(109,2336) | 608(82,1823) | 250 | 21% | 250 | 24% | 222 | 27% |
| **Alternative 3** | 0.66 | 975(224,2789) | 852(195,2383) | 681(156,1867) | 193 | 17% | 173 | 17% | 149 | 18% |
| Alternative 3-Option 2 | 0.86 | 919(157,2719) | 791(132,2326) | 628(112,1822) | 249 | 21% | 234 | 23% | 202 | 24% |
| Alternative 3-Option 3 | 0.97 | 918(131,2752) | 783(117,2350) | 614(93,1844) | 250 | 21% | 242 | 24% | 216 | 26% |
| **Alternative 4 (Tend)** | 0.25 | 1168(285,2955) | 1025(251,2503) | 830(207,1975) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.59 | 1013(238,2821) | 878(208,2395) | 708(170,1866) | 155 | 13% | 147 | 14% | 122 | 15% |
| Alternative 4-Option 3 | 0.79 | 948(190,2729) | 812(167,2319) | 647(136,1819) | 220 | 19% | 213 | 21% | 183 | 22% |
| Option 1 | 0.25 | 1168(285,2955) | 1025(251,2503) | 830(207,1975) | 0 | 0% | 0 | 0% | 0 | 0% |

(d) Five-year (2012-2016) Economic forecasts, using Stock Projection Model 5, 1-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 1168(285,2955) | 1025(251,2503) | 830(207,1975) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 918(117,2738) | 775(109,2336) | 608(82,1823) | 250 | 21% | 250 | 24% | 222 | 27% |
| **Alternative 3** | 0.58 | 1017(242,2825) | 884(210,2398) | 713(173,1871) | 151 | 13% | 141 | 14% | 117 | 14% |
| Alternative 3-Option 2 | 0.85 | 928(160,2714) | 794(134,2326) | 627(113,1816) | 240 | 21% | 231 | 23% | 203 | 24% |
| Alternative 3-Option 3 | 0.97 | 918(131,2752) | 783(117,2350) | 614(93,1844) | 250 | 21% | 242 | 24% | 216 | 26% |
| **Alternative 4 (Tend)** | 0.25 | 1168(285,2955) | 1025(251,2503) | 830(207,1975) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.53 | 1044(252,2826) | 898(218,2400) | 734(181,1864) | 124 | 11% | 127 | 12% | 96 | 12% |
| Alternative 4-Option 3 | 0.78 | 953(194,2732) | 818(170,2322) | 650(137,1812) | 215 | 18% | 207 | 20% | 180 | 22% |
| Option 1 | 0.25 | 1168(285,2955) | 1025(251,2503) | 830(207,1975) | 0 | 0% | 0 | 0% | 0 | 0% |

(e) Ten-year (2012-2021) Economic forecasts, using Stock Projection Model 1, 2-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 2414(611,6470) | 1941(514,5147) | 1407(384,3557) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 2290(450,6455) | 1799(370,5093) | 1263(260,3491) | 124 | 5% | 142 | 7% | 144 | 10% |
| **Alternative 3** | 0.38 | 2399(593,6549) | 1925(506,5194) | 1406(366,3592) | 15 | 1% | 16 | 1% | 1 | 0% |
| Alternative 3-Option 2 | 0.69 | 2336(483,6458) | 1849(392,5139) | 1313(300,3523) | 78 | 3% | 92 | 5% | 94 | 7% |
| Alternative 3-Option 3 | 0.844 | 2326(425,6377) | 1831(344,5076) | 1302(253,3538) | 88 | 4% | 110 | 6% | 105 | 7% |
| **Alternative 4 (Tend)** | 0.25 | 2414(611,6470) | 1941(514,5147) | 1407(384,3557) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.61 | 2354(502,6489) | 1865(434,5172) | 1327(333,3558) | 60 | 2% | 76 | 4% | 80 | 6% |
| Alternative 4-Option 3 | 0.8 | 2335(443,6402) | 1841(355,5081) | 1298(267,3548) | 79 | 3% | 100 | 5% | 109 | 8% |
| Option 1 | 0.25 | 2414(611,6470) | 1941(514,5147) | 1407(384,3557) | 0 | 0% | 0 | 0% | 0 | 0% |

(f) Ten-year (2012-2021) Economic forecasts, using Stock Projection Model 1, 1-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 2414(611,6470) | 1941(514,5147) | 1407(384,3557) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 2290(450,6455) | 1799(370,5093) | 1263(260,3491) | 124 | 5% | 142 | 7% | 144 | 10% |
| **Alternative 3** | 0.36 | 2406(598,6555) | 1932(511,5202) | 1409(372,3598) | 8 | 0% | 9 | 0% | -2 | 0% |
| Alternative 3-Option 2 | 0.68 | 2338(488,6461) | 1847(398,5143) | 1317(306,3528) | 76 | 3% | 94 | 5% | 90 | 6% |
| Alternative 3-Option 3 | 0.83 | 2325(429,6385) | 1835(346,5080) | 1303(263,3541) | 89 | 4% | 106 | 5% | 104 | 7% |
| **Alternative 4 (Tend)** | 0.25 | 2414(611,6470) | 1941(514,5147) | 1407(384,3557) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.59 | 2349(512,6497) | 1868(438,5178) | 1322(340,3564) | 65 | 3% | 73 | 4% | 85 | 6% |
| Alternative 4-Option 3 | 0.79 | 2338(443,6407) | 1843(360,5087) | 1297(267,3551) | 76 | 3% | 98 | 5% | 110 | 8% |
| Option 1 | 0.25 | 2414(611,6470) | 1941(514,5147) | 1407(384,3557) | 0 | 0% | 0 | 0% | 0 | 0% |

(g) Ten-year (2012-2021) Economic forecasts, using Stock Projection Model 5, 2-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 3274(785,9027) | 2640(656,7181) | 1931(504,4948) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 3127(655,8835) | 2510(533,7038) | 1770(388,4876) | 147 | 4% | 130 | 5% | 161 | 8% |
| **Alternative 3** | 0.66 | 3205(706,8892) | 2544(564,7105) | 1833(425,4883) | 69 | 2% | 96 | 4% | 98 | 5% |
| Alternative 3-Option 2 | 0.86 | 3165(621,8979) | 2499(523,7085) | 1785(381,4812) | 109 | 3% | 141 | 5% | 146 | 8% |
| Alternative 3-Option 3 | 0.97 | 3133(662,8893) | 2502(532,7054) | 1748(387,4886) | 141 | 4% | 138 | 5% | 183 | 9% |
| **Alternative 4 (Tend)** | 0.25 | 3274(785,9027) | 2640(656,7181) | 1931(504,4948) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.59 | 3208(712,8926) | 2553(588,7141) | 1840(447,4897) | 66 | 2% | 87 | 3% | 91 | 5% |
| Alternative 4-Option 3 | 0.79 | 3167(622,8932) | 2513(499,7120) | 1800(386,4845) | 107 | 3% | 127 | 5% | 131 | 7% |
| Option 1 | 0.25 | 3274(785,9027) | 2640(656,7181) | 1931(504,4948) | 0 | 0% | 0 | 0% | 0 | 0% |

(h) Ten-year (2012-2021) Economic forecasts, using Stock Projection Model 5, 1-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 3274(785,9027) | 2640(656,7181) | 1931(504,4948) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 3127(655,8835) | 2510(533,7038) | 1770(388,4876) | 147 | 4% | 130 | 5% | 161 | 8% |
| **Alternative 3** | 0.58 | 3210(709,8930) | 2558(592,7142) | 1851(447,4898) | 64 | 2% | 82 | 3% | 80 | 4% |
| Alternative 3-Option 2 | 0.85 | 3146(635,8981) | 2496(540,7090) | 1782(385,4817) | 128 | 4% | 144 | 5% | 149 | 8% |
| Alternative 3-Option 3 | 0.97 | 3133(662,8893) | 2502(532,7054) | 1748(387,4886) | 141 | 4% | 138 | 5% | 183 | 9% |
| **Alternative 4 (Tend)** | 0.25 | 3274(785,9027) | 2640(656,7181) | 1931(504,4948) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.53 | 3230(729,8953) | 2581(617,7167) | 1864(465,4906) | 44 | 1% | 59 | 2% | 67 | 3% |
| Alternative 4-Option 3 | 0.78 | 3173(622,8949) | 2517(510,7128) | 1790(392,4850) | 101 | 3% | 123 | 5% | 141 | 7% |
| Option 1 | 0.25 | 3274(785,9027) | 2640(656,7181) | 1931(504,4948) | 0 | 0% | 0 | 0% | 0 | 0% |

(i) Fifteen-year (2012-2026) Economic forecasts, using Stock Projection Model 1, 2-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 3974(838,10434) | 3003(638,7821) | 2005(445,5001) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 4033(735,10713) | 3006(543,8040) | 1914(354,5081) | -59 | -1% | -3 | 0% | 91 | 5% |
| **Alternative 3** | 0.38 | 4014(845,10634) | 3032(632,7926) | 1997(429,5082) | -40 | -1% | -29 | -1% | 8 | 0% |
| Alternative 3-Option 2 | 0.69 | 4050(779,10684) | 3022(587,7949) | 1978(393,5055) | -76 | -2% | -19 | -1% | 27 | 1% |
| Alternative 3-Option 3 | 0.844 | 4055(744,10671) | 3016(562,7966) | 1944(367,5045) | -81 | -2% | -13 | 0% | 61 | 3% |
| **Alternative 4 (Tend)** | 0.25 | 3974(838,10434) | 3003(638,7821) | 2005(445,5001) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.61 | 4025(815,10674) | 3001(602,7923) | 1969(423,5084) | -51 | -1% | 2 | 0% | 36 | 2% |
| Alternative 4-Option 3 | 0.8 | 4054(758,10661) | 3003(569,7970) | 1943(376,5059) | -80 | -2% | 0 | 0% | 62 | 3% |
| Option 1 | 0.25 | 3974(838,10434) | 3003(638,7821) | 2005(445,5001) | 0 | 0% | 0 | 0% | 0 | 0% |

(j) Fifteen-year (2012-2026) Economic forecasts, using Stock Projection Model 1, 1-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 3974(838,10434) | 3003(638,7821) | 2005(445,5001) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 4033(735,10713) | 3006(543,8040) | 1914(354,5081) | -59 | -1% | -3 | 0% | 91 | 5% |
| **Alternative 3** | 0.36 | 4007(847,10612) | 3021(635,7932) | 1981(433,5086) | -33 | -1% | -18 | -1% | 24 | 1% |
| Alternative 3-Option 2 | 0.68 | 4053(780,10677) | 3021(588,7947) | 1981(396,5059) | -79 | -2% | -18 | -1% | 24 | 1% |
| Alternative 3-Option 3 | 0.83 | 4053(749,10656) | 3019(565,7967) | 1944(370,5049) | -79 | -2% | -16 | -1% | 61 | 3% |
| **Alternative 4** **(Tend)** | 0.25 | 3974(838,10434) | 3003(638,7821) | 2005(445,5001) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.59 | 4022(817,10686) | 2983(605,7919) | 1973(422,5062) | -48 | -1% | 20 | 1% | 32 | 2% |
| Alternative 4-Option 3 | 0.79 | 4055(761,10662) | 3005(573,7972) | 1946(378,5034) | -81 | -2% | -2 | 0% | 59 | 3% |
| Option 1 | 0.25 | 3974(838,10434) | 3003(638,7821) | 2005(445,5001) | 0 | 0% | 0 | 0% | 0 | 0% |

(k) Fifteen-year (2012-2026) Economic forecasts, using Stock Projection Model 5, 2-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1** (no action) | 0.25 | 5291(1091,13978) | 4000(837,10416) | 2696(576,6815) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2** ($T_{MIN}$) | 1 | 5313(1017,14153) | 3969(737,10688) | 2538(491,6834) | -22 | 0% | 31 | 1% | 158 | 6% |
| **Alternative 3** | 0.66 | 5304(1041,14064) | 4001(790,10481) | 2619(535,6838) | -13 | 0% | -1 | 0% | 77 | 3% |
| Alternative 3-Option 2 | 0.86 | 5273(1011,14024) | 3959(748,10592) | 2584(495,6846) | 18 | 0% | 41 | 1% | 112 | 4% |
| Alternative 3-Option 3 | 0.97 | 5304(1014,14178) | 3960(732,10687) | 2555(481,6838) | -13 | 0% | 40 | 1% | 141 | 5% |
| **Alternative 4 (Tend)** | 0.25 | 5291(1091,13978) | 4000(837,10416) | 2696(576,6815) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.59 | 5310(1059,14035) | 4000(817,10454) | 2644(547,6830) | -19 | 0% | 0 | 0% | 52 | 2% |
| Alternative 4-Option 3 | 0.79 | 5285(998,14017) | 3971(760,10570) | 2593(508,6808) | 6 | 0% | 29 | 1% | 103 | 4% |
| Option 1 | 0.25 | 5291(1091,13978) | 4000(837,10416) | 2696(576,6815) | 0 | 0% | 0 | 0% | 0 | 0% |

(l) Fifteen-year (2012-2026) Economic forecasts, using Stock Projection Model 5, 1-year rebuilding threshold

| Alternative | Buffer | Total Present Value of 1st Wholesale Revenues 2011-2016 ($Million) | | | Potential Foregone Revenue, Total Present Value and Percent Decrease, Relative to Alternative 1 Baseline, | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | r=0.0 | r=2.7% | r=7.0% | r=0.0 | | r=2.7% | | r=7.0% | |
| **Alternative 1 (no action)** | 0.25 | 5291(1091,13978) | 4000(837,10416) | 2696(576,6815) | 0 | 0% | 0 | 0% | 0 | 0% |
| **Alternative 2 ($T_{MIN}$)** | 1 | 5313(1017,14153) | 3969(737,10688) | 2538(491,6834) | -22 | 0% | 31 | 1% | 158 | 6% |
| **Alternative 3** | 0.58 | 5289(1068,14036) | 3999(819,10448) | 2647(550,6831) | 2 | 0% | 1 | 0% | 49 | 2% |
| Alternative 3-Option 2 | 0.85 | 5271(1014,14019) | 3956(751,10597) | 2579(497,6847) | 20 | 0% | 44 | 1% | 117 | 4% |
| Alternative 3-Option 3 | 0.97 | 5304(1014,14178) | 3960(732,10687) | 2555(481,6838) | -13 | 0% | 40 | 1% | 141 | 5% |
| **Alternative 4 (Tend)** | 0.25 | 5291(1091,13978) | 4000(837,10416) | 2696(576,6815) | 0 | 0% | 0 | 0% | 0 | 0% |
| Alternative 4-Option 2 | 0.53 | 5296(1076,14018) | 3996(819,10443) | 2654(555,6825) | -5 | 0% | 4 | 0% | 42 | 2% |
| Alternative 4-Option 3 | 0.78 | 5287(1007,14024) | 3979(764,10566) | 2587(510,6810) | 4 | 0% | 21 | 1% | 109 | 4% |
| Option 1 | 0.25 | 5291(1091,13978) | 4000(837,10416) | 2696(576,6815) | 0 | 0% | 0 | 0% | 0 | 0% |

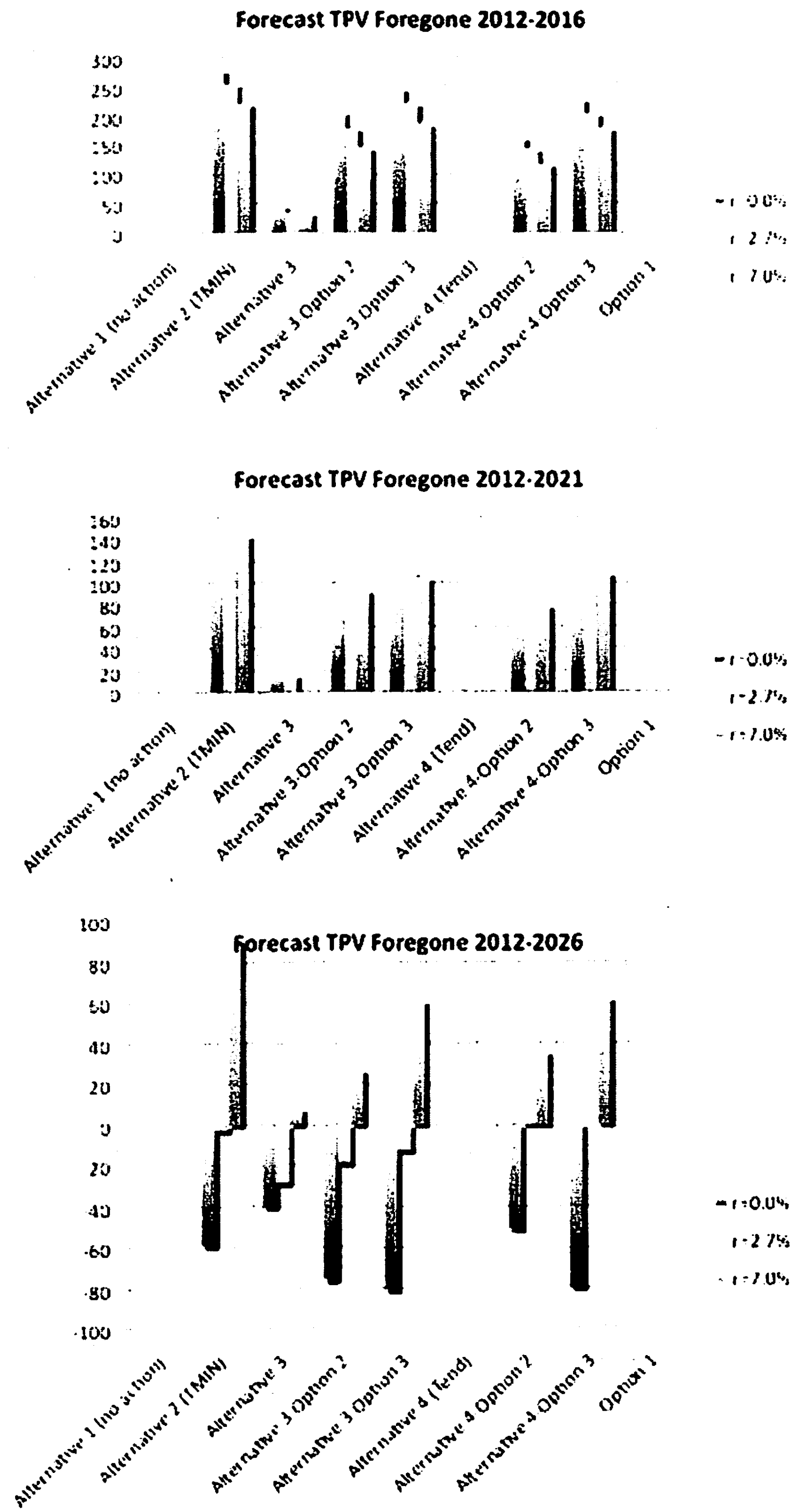


Figure 1: Five-, ten, and fifteen-year forecasts of potential foregone revenue under snow crab rebuilding alternatives. Results are from Model 1, 2-year rebuilding scenario.

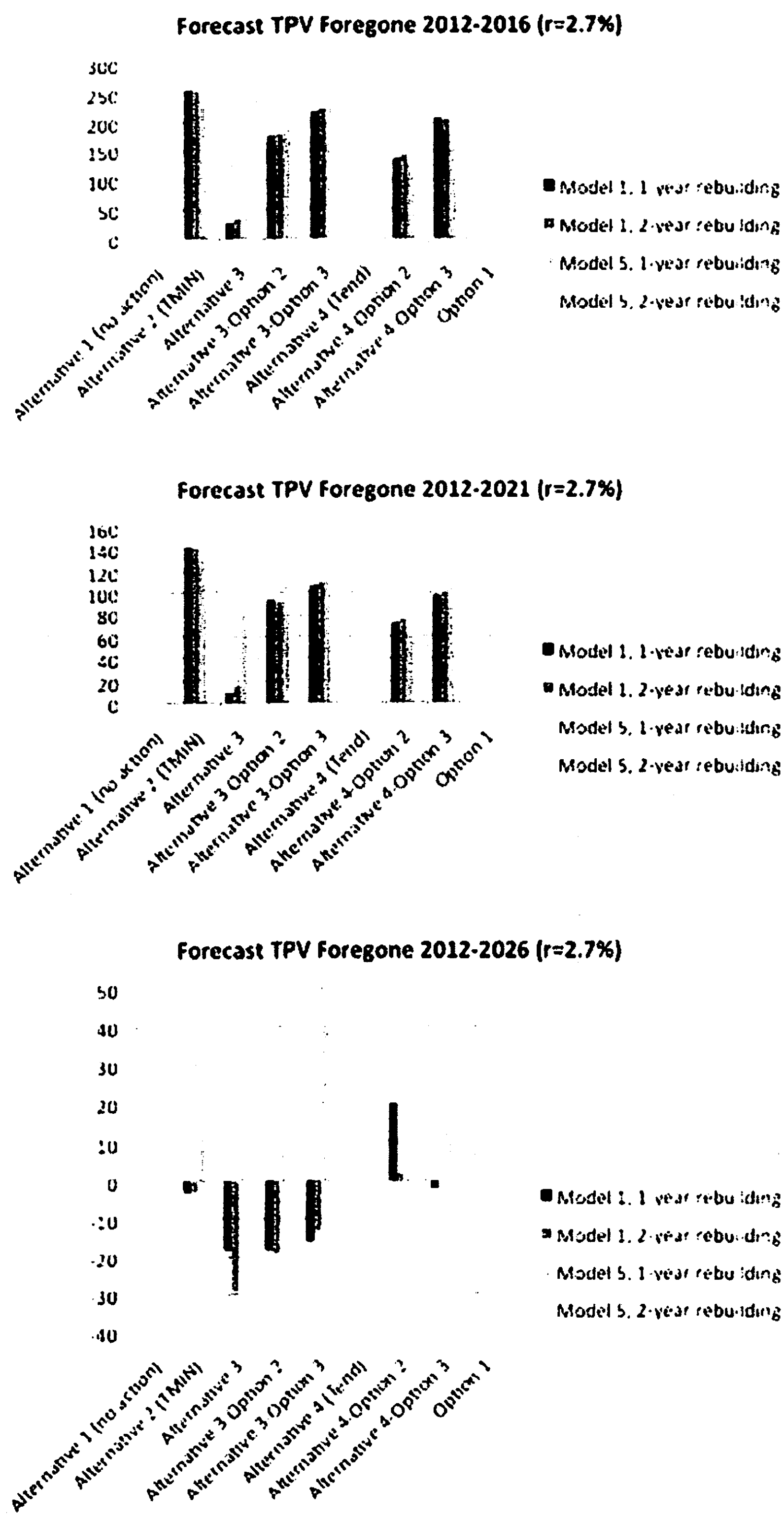


Figure 2: Comparison of rebuilding alternative economic impacts for alternative model specifications and rebuilding thresholds, five- ten, and 15-year results.

# Bering Sea Tanner Crab ACL Alternatives Supplemental Economic Analysis

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This document presents summary results from economic forecast analysis of Bering Sea Tanner crab ACL alternatives presented in the Environmental Assessment Initial Draft, prepared for the June, 2010 North Pacific Fishery Management Council and other supplementary documents.

Economic implications of ACL alternatives are presented in terms of the forecasted first wholesale revenue associated with stock projection model directed catch forecasts. All results presented below are based on directed catch forecasts produced using the default level of additional uncertainty for Tier3 crab stocks ($\sigma_b$=0.4). Catch projections are combined with probabilistic price forecasts produced using an econometric time series model of prices in the Alaska king and snow crab fisheries and in the domestic crab import market, as detailed in Chapter 3 of the Draft EA. Due to limited availability of Tanner crab price data in sufficiently long time series, no price forecasting model is possible for Tanner crab using the methods employed for other stocks that have more consistently supported directed fisheries over the last 20 years. As a proxy method for forecasting revenue in the Tanner crab fishery, an adjustment to the snow crab price model was employed to generate probabilistic price forecasts for Tanner crab. As described in Chapter 3 of the Draft EA, the snow crab price forecast was adjusted by the mean ratio of Tanner crab first wholesale price to snow crab first wholesale price over the period 2006-2009 (=1.15).

**ACL Alternatives**

The medium term (2009-2014) economic impacts of ACL fixed buffer and P* alternatives are summarized in Tables 1 a-b. As noted in the EA, increasing the size of the buffer (i.e., decreasing multiplier from 1.0 to 0.1) produces a lower probability of overfishing at the cost of substantially lower annual catches, particularly during earlier years. This translates into lower gross earnings in the fishery in the medium term. Tables 1 (a) and (b) present the median and 90% confidence intervals for present value of total annual revenues produced from the annual directed catch projected for the ACL alternatives over the period 2009-2014, and the comparative economic effects of alternatives in foregone revenue relative to a baseline scenario of zero buffer. Results are shown for scenarios that apply the SOA control rule as an upper bound on TAC (Table 1 (a)), and scenarios without the SOA control rule (Table 1 (b)). Results of economic comparisons between ACL alternatives resulting from catch projections constrained by the SOA control rule indicate potential foregone mid-term revenues in the snow crab fishery range from $4.4 million present value (r=2.6%) at the 0.1 buffer level, to $94 million present value at the 0.9 buffer level, representing a range of 5% to 95% reduction relative to the baseline alternative. The same range of fixed buffer alternatives depicted in Table 1 (b) without the effect of the SOA control rule range from 7% to 96% reduction from baseline revenue. Note that the SOA control rule remains in effect as the protocol for TAC-setting, however, the potential foregone revenues that could result from the ACL alternatives would increase substantially relative to a baseline scenario of zero buffer, with the ABC as the binding constraint on TAC rather than the SOA control rule. Note that this "baseline" does not represent the status quo alternative, but is intended to provide a representation of the effects of ACL alternatives under potential future decision-making scenarios where the SOA control rule is no longer binding. It should be noted that this comparison does not indicate that costs of ACL's would be higher in the event that the SOA rule was not applied, rather that the SOA rule effectively represents a buffer in itself, and results in foregone catch and revenues relative to the least conservative ACL alternatives under consideration.

Economic results of ACL alternatives over the long term (2009-2038) are represented in Table 2 (a) and (b). Results of economic comparisons between ACL alternatives resulting from catch projections constrained by the SOA control rule indicate potential foregone long-term revenues in the snow crab fishery range from $24 million present value (r=2.6%) at the 0.1 buffer level, to $1.2 billion present value at the 0.9 buffer level. The same range of fixed buffer alternatives depicted in Table 1 (b) without the effect of the SOA control rule range from $38 million present value (r=2.6%) at the 0.1 buffer level, to $1.3 billion present value at the 0.9 buffer level.

It is important to note the large range of uncertainty in the revenue figures, particularly over the long range. The figures described above represent median values in a broad distribution of potential outcomes, and should not be interpreted as predicted values for purposes other than to support a comparative evaluation of the ACL alternatives, and the proportional description of potential changes from baseline alternatives are likely more illustrative in this regard. It should also be noted that the relative economic effects of the ACLs are not qualitatively different between the mid- and long-term, nor do alternative discount rates appreciably change the relative ranking of alternatives in terms of economic outcomes. This is largely due to the effect of the constancy of the buffer in the model projections, in both the buffer and P* scenarios. With fixed buffers, which are not responsive to changes in the stock status, there is little change in the timing of harvest over the period of analysis. That is, none of the alternatives under consideration implement different buffers over time according to stock conditions, and thus the timing of relative economic benefits from the fishery across the time horizon are not appreciably different under the alternatives analyzed.

**(a): Summary of medium-term economic impacts of a subset of the ACL alternatives relative to baseline alternative for Eastern Bering Sea Tanner crab. Economic impacts are estimated as discounted present value of forecasted gross first wholesale revenues over the five year period 2009-2014, and differences in revenues relative to status-quo baseline, incorporating effects of additional uncertainty, $\sigma_b$. Point estimates are medians and ranges are 90% confidence intervals.**
**(a) Results reflect the effect of the SOA control rule as a constraint.**

| | | Present Value of Total Revenue, 2009-2014 ($ Million) | | | Difference in Gross Revenue Relative to Baseline Alternative, ($ Million) Multiplier=1, $\sigma_b$=0.4 | | | |
|---|---|---|---|---|---|---|---|---|
| $\sigma_b$ | Multiplier Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.4 | 1 | 104.5(19.8,229.9) | 97.9(17.6,213.4) | 89.1(15.4,194.7) | 0 | 0 | 0 | 0% |
| 0.4 | 0.9 | 100.1(18.7,220) | 93.5(17.6,205.7) | 84.7(14.3,184.8) | 4.4 | 4.4 | 4.4 | 5% |
| 0.4 | 0.8 | 94.6(17.6,207.9) | 88(16.5,194.7) | 79.2(14.3,176) | 9.9 | 9.9 | 9.9 | 11% |
| 0.4 | 0.7 | 85.8(15.4,193.6) | 80.3(14.3,180.4) | 73.7(13.2,162.8) | 18.7 | 17.6 | 15.4 | 17% |
| 0.4 | 0.6 | 75.9(14.3,176) | 71.5(13.2,165) | 64.9(12.1,149.6) | 28.6 | 26.4 | 24.2 | 27% |
| 0.4 | 0.5 | 64.9(12.1,156.2) | 60.5(11,145.2) | 55(9.9,133.1) | 39.6 | 37.4 | 34.1 | 38% |
| 0.4 | 0.4 | 51.7(9.9,134.2) | 48.4(8.8,124.3) | 44(8.8,112.2) | 52.8 | 49.5 | 45.1 | 51% |
| 0.4 | 0.3 | 37.4(6.6,104.5) | 35.2(6.6,97.9) | 31.9(5.5,86.9) | 67.1 | 62.7 | 57.2 | 64% |
| 0.4 | 0.2 | 18.7(4.4,68.2) | 17.6(4.4,63.8) | 16.5(4.4,57.2) | 85.8 | 80.3 | 72.6 | 81% |
| 0.4 | 0.1 | 4.4(2.2,19.8) | 4.4(2.2,18.7) | 4.4(2.2,16.5) | 100.1 | 93.5 | 84.7 | 95% |
| $\sigma_b$ | P* Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.4 | 0.4 | 103.4(19.8,225.5) | 95.7(17.6,211.2) | 86.9(14.3,191.4) | 1.1 | 2.2 | 2.2 | 2% |
| 0.4 | 0.35 | 100.1(19.8,221.1) | 93.5(17.6,206.8) | 84.7(14.3,185.9) | 4.4 | 4.4 | 4.4 | 5% |
| 0.4 | 0.3 | 96.8(18.7,214.5) | 91.3(17.6,201.3) | 81.4(14.3,181.5) | 7.7 | 6.6 | 7.7 | 9% |
| 0.4 | 0.25 | 93.5(17.6,206.8) | 88(16.5,193.6) | 79.2(14.3,174.9) | 11 | 9.9 | 9.9 | 11% |
| 0.4 | 0.2 | 89.1(16.5,199.1) | 83.6(15.4,187) | 75.9(13.2,168.3) | 15.4 | 14.3 | 13.2 | 15% |
| 0.4 | 0.15 | 83.6(15.4,189.2) | 78.1(14.3,177.1) | 71.5(13.2,160.6) | 20.9 | 19.8 | 17.6 | 20% |
| 0.4 | 0.1 | 77(14.3,177.1) | 71.5(13.2,166.1) | 64.9(12.1,150.7) | 27.5 | 26.4 | 24.2 | 27% |
| 0.4 | 0.05 | 66(12.1,158.4) | 62.7(12.1,148.5) | 57.2(9.9,135.3) | 38.5 | 35.2 | 31.9 | 36% |

**(b): Results are exclusive of SOA control rule effect.**

| | | Present Value of Total Revenue, 2009-2014 ($ Million) | | | Difference in Gross Revenue Relative to Baseline Alternative, ($ Million) Multiplier=1, $\sigma_b$=0.4 | | | |
|---|---|---|---|---|---|---|---|---|
| $\sigma_b$ | Multiplier Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.4 | 1 | 117.7(39.6,232.1) | 110(36.3,217.8) | 99(34.1,198) | 0 | 0 | 0 | 0% |
| 0.4 | 0.9 | 108.9(35.2,221.1) | 102.3(33,207.9) | 92.4(30.8,188.1) | 8.8 | 7.7 | 6.6 | 7% |
| 0.4 | 0.8 | 100.1(30.8,207.9) | 93.5(29.7,195.8) | 84.7(27.5,177.1) | 17.6 | 16.5 | 14.3 | 14% |
| 0.4 | 0.7 | 90.2(26.4,193.6) | 84.7(25.3,181.5) | 75.9(23.1,163.9) | 27.5 | 25.3 | 23.1 | 23% |
| 0.4 | 0.6 | 79.2(22,177.1) | 73.7(20.9,165) | 67.1(18.7,151.8) | 38.5 | 36.3 | 31.9 | 32% |
| 0.4 | 0.5 | 67.1(17.6,156.2) | 61.6(16.5,145.2) | 56.1(15.4,134.2) | 50.6 | 48.4 | 42.9 | 43% |
| 0.4 | 0.4 | 52.8(13.2,134.2) | 49.5(12.1,124.3) | 45.1(12.1,112.2) | 64.9 | 60.5 | 53.9 | 54% |
| 0.4 | 0.3 | 37.4(7.7,104.5) | 35.2(7.7,97.9) | 31.9(7.7,86.9) | 80.3 | 74.8 | 67.1 | 68% |
| 0.4 | 0.2 | 18.7(4.4,68.2) | 17.6(4.4,63.8) | 16.5(4.4,57.2) | 99 | 92.4 | 82.5 | 83% |
| 0.4 | 0.1 | 4.4(2.2,19.8) | 4.4(2.2,18.7) | 4.4(2.2,16.5) | 113.3 | 105.6 | 94.6 | 96% |
| $\sigma_b$ | P* Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.4 | 0.4 | 114.4(38.5,228.8) | 106.7(35.2,214.5) | 96.8(33,194.7) | 3.3 | 3.3 | 2.2 | 2% |
| 0.4 | 0.35 | 110(36.3,222.2) | 103.4(34.1,209) | 93.5(30.8,189.2) | 7.7 | 6.6 | 5.5 | 6% |
| 0.4 | 0.3 | 104.5(34.1,214.5) | 97.9(30.8,201.3) | 89.1(28.6,183.7) | 13.2 | 12.1 | 9.9 | 10% |
| 0.4 | 0.25 | 100.1(30.8,206.8) | 93.5(29.7,194.7) | 83.6(26.4,177.1) | 17.6 | 16.5 | 15.4 | 16% |
| 0.4 | 0.2 | 94.6(28.6,199.1) | 88(26.4,187) | 79.2(24.2,169.4) | 23.1 | 22 | 19.8 | 20% |
| 0.4 | 0.15 | 88(26.4,190.3) | 81.4(24.2,177.1) | 73.7(22,160.6) | 29.7 | 28.6 | 25.3 | 26% |
| 0.4 | 0.1 | 79.2(23.1,177.1) | 74.8(20.9,166.1) | 67.1(19.8,151.8) | 38.5 | 35.2 | 31.9 | 32% |
| 0.4 | 0.05 | 68.2(17.6,158.4) | 63.8(17.6,148.5) | 57.2(16.5,136.4) | 49.5 | 46.2 | 41.8 | 42% |

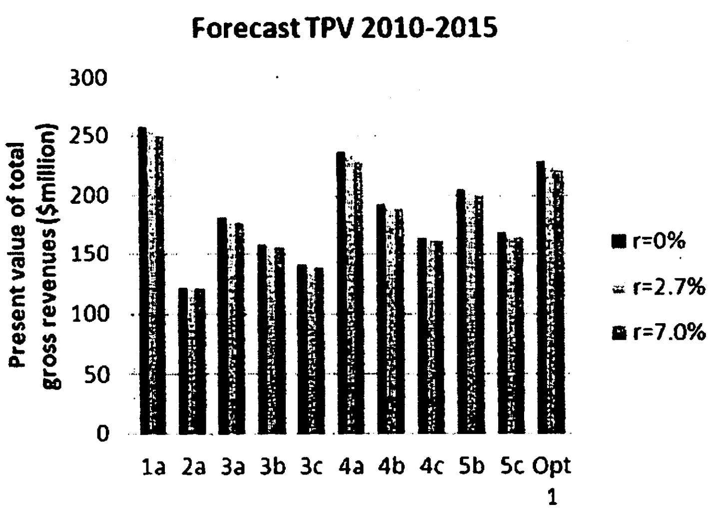
**Summary of long-term economic impacts of a subset of the ACL alternatives relative to baseline alternative for Eastern Bering Sea Tanner crab. Economic impacts are estimated as discounted present value of forecasted gross first wholesale revenues over the five year period 2009-2014, and differences in revenues relative to status-quo baseline, incorporating effects of additional uncertainty, $\sigma_b$. Point estimates are medians and ranges are 90% confidence intervals.**

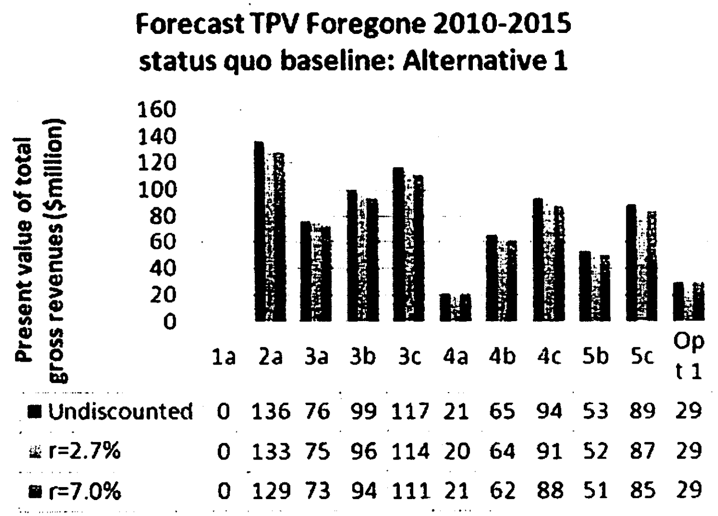
**(a) Results reflect the effect of the SOA control rule as a constraint.**

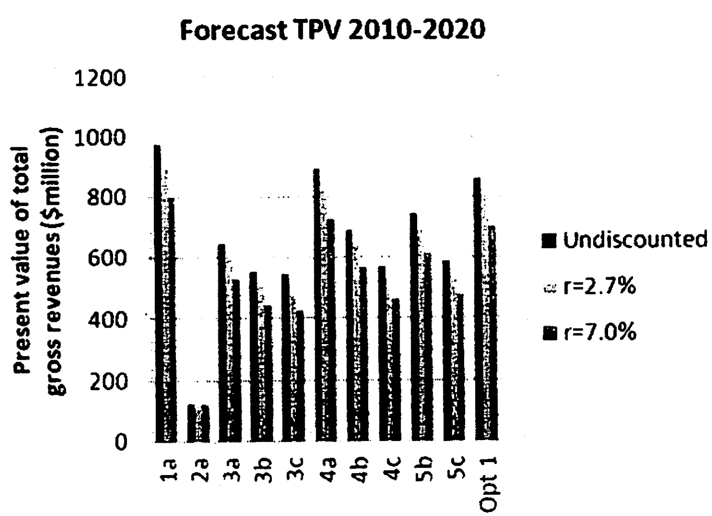
| | | Present Value of Total Revenue, 2009-2014 ($ Million) | | | Difference in Gross Revenue Relative to Baseline Alternative, ($ Million) Multiplier=1, $\sigma_b$=0.4 | | | |
|---|---|---|---|---|---|---|---|---|
| $\sigma_b$ | Multiplier Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.4 | 1 | 2281(366,6002) | 1398(226,3592) | 704(135,1775) | 0 | 0 | 0 | 0% |
| 0.4 | 0.9 | 2257(354,5978) | 1374(222,3574) | 691(132,1738) | 24 | 24 | 13 | 2% |
| 0.4 | 0.8 | 2221(344,5900) | 1346(216,3507) | 675(128,1700) | 60 | 52 | 29 | 4% |
| 0.4 | 0.7 | 2151(327,5800) | 1299(210,3443) | 654(122,1654) | 130 | 99 | 50 | 7% |
| 0.4 | 0.6 | 2071(311,5636) | 1242(202,3301) | 622(115,1577) | 210 | 156 | 82 | 12% |
| 0.4 | 0.5 | 1937(300,5325) | 1170(187,3092) | 572(104,1467) | 344 | 228 | 132 | 19% |
| 0.4 | 0.4 | 1734(275,4822) | 1051(165,2795) | 509(88,1328) | 547 | 347 | 195 | 28% |
| 0.4 | 0.3 | 1444(227,4058) | 872(137,2342) | 414(69,1121) | 837 | 526 | 290 | 41% |
| 0.4 | 0.2 | 1017(152,2897) | 608(90,1641) | 282(46,767) | 1264 | 790 | 422 | 60% |
| 0.4 | 0.1 | 378(51,1101) | 223(30,621) | 101(15,286) | 1903 | 1175 | 603 | 86% |
| $\sigma_b$ | P* Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| 0.4 | 0.4 | 2276(362,6005) | 1391(224,3587) | 701(134,1762) | 5 | 7 | 3 | 0% |
| 0.4 | 0.35 | 2261(355,5986) | 1377(223,3577) | 694(132,1742) | 20 | 21 | 10 | 1% |
| 0.4 | 0.3 | 2240(347,5926) | 1363(219,3546) | 684(130,1716) | 41 | 35 | 20 | 3% |
| 0.4 | 0.25 | 2217(343,5894) | 1344(215,3504) | 674(127,1698) | 64 | 54 | 30 | 4% |
| 0.4 | 0.2 | 2179(333,5840) | 1316(213,3473) | 663(125,1677) | 102 | 82 | 41 | 6% |
| 0.4 | 0.15 | 2134(326,5775) | 1287(208,3411) | 647(121,1642) | 147 | 111 | 57 | 8% |
| 0.4 | 0.1 | 2075(312,5641) | 1245(202,3308) | 623(115,1580) | 206 | 153 | 81 | 12% |
| 0.4 | 0.05 | 1960(301,5383) | 1182(190,3126) | 580(106,1484) | 321 | 216 | 124 | 18% |

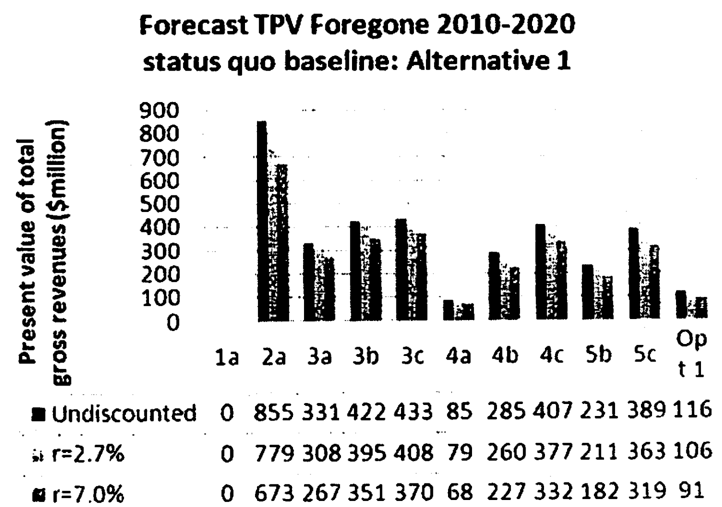
**(b): Results are exclusive of SOA control rule effect.**

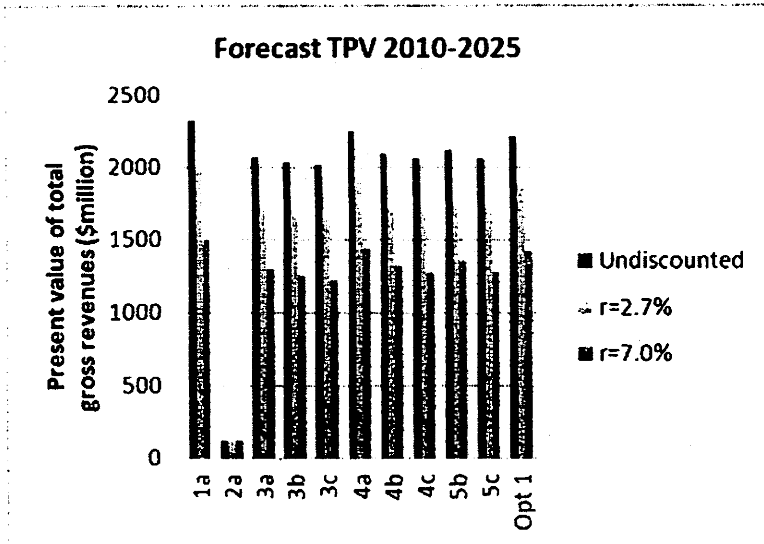
| | | Present Value of Total Revenue, 2009-2014 ($ Million) | | | Difference in Gross Revenue Relative to Baseline Alternative, ($ Million) Multiplier=1, $\sigma_b$=0.4 | | | |
|---|---|---|---|---|---|---|---|---|
| $\sigma_b$ | Multiplier Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| **0.4** | 1 | 2504(428,6798) | 1536(278,4039) | 768(160,1934) | 0 | 0 | 0 | 0% |
| **0.4** | 0.9 | 2446(420,6656) | 1498(269,3955) | 743(153,1863) | 58 | 38 | 25 | 3% |
| **0.4** | 0.8 | 2392(391,6463) | 1454(253,3850) | 715(143,1779) | 112 | 82 | 53 | 7% |
| **0.4** | 0.7 | 2311(360,6206) | 1393(238,3702) | 681(132,1723) | 193 | 143 | 87 | 11% |
| **0.4** | 0.6 | 2183(341,5858) | 1312(224,3498) | 639(117,1648) | 321 | 224 | 129 | 17% |
| **0.4** | 0.5 | 2015(314,5531) | 1203(203,3246) | 586(102,1514) | 489 | 333 | 182 | 24% |
| **0.4** | 0.4 | 1778(277,4832) | 1070(175,2858) | 512(87,1350) | 726 | 466 | 256 | 33% |
| **0.4** | 0.3 | 1455(229,4064) | 875(137,2349) | 415(69,1132) | 1049 | 661 | 353 | 46% |
| **0.4** | 0.2 | 1016(152,2897) | 610(90,1640) | 283(47,767) | 1488 | 926 | 485 | 63% |
| **0.4** | 0.1 | 378(51,1101) | 223(30,621) | 101(15,286) | 2126 | 1313 | 667 | 87% |
| $\sigma_b$ | P* Level | r=0 | r=2.7% | r=7.0% | r=0 | r=2.7% | r=7.0% | % Change |
| **0.4** | 0.4 | 2484(425,6751) | 1523(275,4010) | 759(158,1907) | 20 | 13 | 9 | 1% |
| **0.4** | 0.35 | 2454(421,6676) | 1502(270,3966) | 746(154,1871) | 50 | 34 | 22 | 3% |
| **0.4** | 0.3 | 2427(407,6565) | 1475(263,3905) | 729(148,1824) | 77 | 61 | 39 | 5% |
| **0.4** | 0.25 | 2387(389,6448) | 1451(251,3840) | 713(142,1774) | 117 | 85 | 55 | 7% |
| **0.4** | 0.2 | 2349(370,6313) | 1420(242,3768) | 695(137,1745) | 155 | 116 | 73 | 10% |
| **0.4** | 0.15 | 2283(357,6139) | 1376(235,3666) | 673(129,1709) | 221 | 160 | 95 | 12% |
| **0.4** | 0.1 | 2191(342,5876) | 1316(225,3505) | 642(118,1652) | 313 | 220 | 126 | 16% |
| **0.4** | 0.05 | 2039(318,5599) | 1220(206,3276) | 593(104,1537) | 465 | 316 | 175 | 23% |

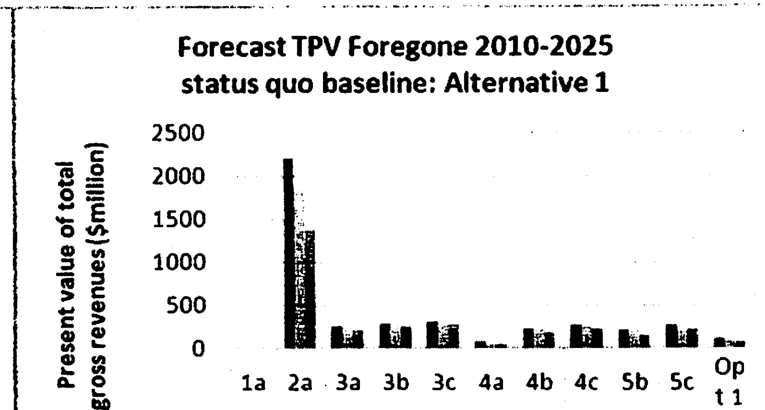

Forecast TPV 2010-2015
Present value of total gross revenues ($million)
300
250
200
150
100
50
0
1a 2a 3a 3b 3c 4a 4b 4c 5b 5c Opt 1
r=0%
r=2.7%
r=7.0%


Forecast TPV Foregone 2010-2015
status quo baseline: Alternative 1
Present value of total gross revenues ($million)
160
140
120
100
80
60
40
20
0
1a 2a 3a 3b 3c 4a 4b 4c 5b 5c Opt 1
Undiscounted 0 136 76 99 117 21 65 94 53 89 29
r=2.7% 0 133 75 96 114 20 64 91 52 87 29
r=7.0% 0 129 73 94 111 21 62 88 51 85 29


Forecast TPV 2010-2020
Present value of total gross revenues ($million)
1200
1000
800
600
400
200
0
1a 2a 3a 3b 3c 4a 4b 4c 5b 5c Opt 1
Undiscounted
r=2.7%
r=7.0%


Forecast TPV Foregone 2010-2020
status quo baseline: Alternative 1
Present value of total gross revenues ($million)
900
800
700
600
500
400
300
200
100
0
1a 2a 3a 3b 3c 4a 4b 4c 5b 5c Opt 1
Undiscounted 0 855 331 422 433 85 285 407 231 389 116
r=2.7% 0 779 308 395 408 79 260 377 211 363 106
r=7.0% 0 673 267 351 370 68 227 332 182 319 91




| | 1a | 2a | 3a | 3b | 3c | 4a | 4b | 4c | 5b | 5c | Opt 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Uniscounted | 0 | 219 | 256 | 286 | 304 | 81 | 228 | 261 | 207 | 262 | 113 |
| r=2.7% | 0 | 183 | 250 | 288 | 314 | 66 | 227 | 272 | 204 | 264 | 105 |
| r=7.0% | 0 | 137 | 202 | 248 | 277 | 55 | 180 | 229 | 145 | 219 | 75 |

# Crab Plan Team Report

The Crab Plan Team (CPT) met May 10-14, 2010 in Girdwood, AK.

Crab Plan Team members present:

| | |
|---|---|
| ***Forrest Bowers, Chair*** | ***(ADF&G)*** |
| ***Ginny Eckert, Vice-Chair*** | ***(Univ. of Alaska – Fairbanks)*** |
| ***Bill Bechtol*** | ***(Univ. of Alaska – Fairbanks)*** |
| ***Karla Bush*** | ***(ADF&G – Juneau)*** |
| ***Wayne Donaldson*** | ***(ADF&G – Kodiak)*** |
| ***Brian Garber-Yonts*** | ***(NOAA Fisheries – AFSC Seattle)*** |
| ***Josh Greenberg*** | ***(Univ. of Alaska – Fairbanks)*** |
| ***Gretchen Harrington*** | ***(NOAA Fisheries – Juneau)*** |
| ***Doug Pengilly*** | ***(ADF&G – Kodiak)*** |
| ***André Punt*** | ***(Univ. of Washington)*** |
| ***Jack Turnock*** | ***(NOAA Fisheries/AFSC – Seattle)*** |
| ***Lou Rugolo*** | ***(NOAA Fisheries /AFSC – Kodiak)*** |
| ***Shareef Siddeek*** | ***(ADF&G – Juneau)*** |
| ***Diana Stram*** | ***(NPFMC)*** |

Bob Foy (NOAA Fisheries /AFSC – Kodiak) was absent.

Members of the public and State of Alaska (State), Federal Agency, and Council staff present for all or part of the meeting included: Jack Tagart, Lenny Herzog, Arni Thomson, John Olson, Matt Eagleton, Diana Evans, Sarah Melton, Ed Poulson, Doug Woodby, Jie Zheng, Richard Tuluk, Maura Sullivan, Skip Gish, Earl Krygier, Sarah Hinkley, Anne Vanderhoeven, Stew Grant, Charlie Lean, Bob Clark, Heather McCarty, Toshihide Hamazaki, Linda Kozak, Dick Powell, and Dick Tremaine.

The attached agenda was approved for the meeting.

## EFH/HAPC update

Diana Evans and Matt Eagleton updated the team on the Council action on EFH and HAPC at the April Council meeting. The Council initiated a discussion paper to look at the Team's March 2010 recommendations with respect to crab EFH and potential HAPC priorities. The paper, as outlined, will address four topics: a) re-evaluating the methodology used for assessing adverse impacts of fishing on crab EFH, in order to capture all appropriate habitat parameters for crab (including pelagic habitat); b) identifying the habitat needs of crab stocks by life history stage, and re-evaluating the conclusions in the EFH EIS and FMP about the effects of fishing on those life history stages (including additional information about the thresholds used to identify "minimal and temporary" effects in the EIS); c) information about habitat usage of red king crab and the potential for adverse interactions in southwest Bristol Bay, where there has recently been an increase both in the red king crab population and in trawling activities; and d) information about changes in crab spatial distribution (especially for red king crab) in recent years, to determine whether the Council's existing area closure protection measures are still appropriate (this latter topic was added at the request of the Council). It was noted that the discussion paper should allow the Team to identify important research priorities for crab habitat. The discussion paper is tentatively scheduled to be presented to the Council in December 2010.

The Team identified that it is important to continue to provide input to the Council on this issue, and will attempt to schedule a review of the draft paper for the September 2010 Plan Team meeting. The Team agreed with the outline of the discussion paper, as presented. The Team noted the importance that this discussion paper reiterate the Team's concern over habitat of red king crab in southwest Bristol Bay. There may also be bycatch interactions, but those are being addressed separately through the Team's bycatch discussions, and this paper should specifically focus on the interaction of the fisheries with crab habitat.

## Pribilof Island blue king crab rebuilding plan

Diana Stram updated the Team on the status of the PIBKC rebuilding plan. The Team would like to review the initial review draft at its September 2010 meeting. This review would focus on identification of a preferred alternative for rebuilding the stock and for the analytical approach to be used for analysis. In addition to the current alternatives, the Team requests that analysts consider a stair-step cap closure in the suite of area-closure alternatives (i.e., where the trigger cap is stair-stepped to close progressively larger areas at different cap levels).

## Paper presentations

### "Patterns of larval snow crab transport in the Bering Sea, and its relation to temperature, cod predation, ice, and recruitment"

Sarah Hinckley provided a summary of work done by her and her colleagues (David Armstrong, Carolina Parada, Julian Burgos, Billy Ernst, Jose Maria (Lobo) Orensanz, Jeff Napp, Albert Hermann, Gordon Kruse, Bernard Megrey) on patterns of snow crab recruitment as a function of larval transport, temperature, ice cover, and cod predation. They created an individual based model (IBM) that uses input from 1978-2003 on female reproductive index, a ROMS oceanographic model, bottom temperatures during NMFS surveys, ice cover, chlorophyll-a from the ice-edge bloom, a cod predation index and outputs larval settlement and recruitment patterns. The results suggest that warm and cold years have different larval trajectories and different optimal settlement areas. In cold years, optimal settlement areas occur over a broader segment of the BS, whereas in warm areas, these areas are restricted in size and are farther to the northwest. Retention of crab larvae is seen in all years in areas off the Pribilofs and St. Matthew Islands. Larval transport is always to the north, outside of these retention areas; larvae are transported farther north in warm years. The parameters that were included in the best fit multiple regression model of the model output with recruitment from the snow crab stock assessment (lagged several years) included proportion settling in the EBS, spawning location, settlement location, mean bottom temperature at settlement, mean cod CPUE years 3 after settlement (an index of cod predation), and mean chlorophyll-a (a proxy for prey near ice-edge blooms).

This modeling project is largely completed, and the authors are willing to provide the model and model output to others that may be interested in using it for further research or management purposes. CPT offered comments that the Hinckley et al. model could use more recent data for model validation purposes. Improvements on how to link the Hinckley et al. model with the stock assessment were suggested (merge covariates from IBM directly into the assessment or account for the variance-covariance structure of the recruitment estimates from the assessment when fitting the GAMs model). Sarah acknowledged that the model needs to be validated with field observations on larval and newly settled crab distributions, although some of this work has been done, and shows quite good results (not shown). After validation, the model could have potential uses for rebuilding analyses, projecting pre-recruits, identifying important spawning areas, analyzing impacts of fishing, and others. The CPT acknowledged the large contribution of this body of work to our understanding of the dynamics of snow crab in the Bering Sea and thanked Sarah for her presentation.

### "Analysis of minimum size limit for Eastern Bering Sea Tanner Crab fisheries"

Bill Bechtol provided a summary of an analysis of the potential impacts of a change in size limit for Tanner crabs conducted by himself, Gordon Kruse, Joshua Greenberg, and Hans Geier. They examined the effect of changing size limits for male Tanner crabs to sizes ranging from 115-150 mm CW (5 mm bins) for catch and discard mortality using historical TACs, yield-per-recruit, and SSB–per-recruit. Results suggest that changing the size limit is projected to have no effect on how mature female biomass is used when setting harvest levels, but would increase the abundance of legal males (because the definition of legal crabs would change), decrease the average weight of legal males, and result in fewer pot pulls in the directed fishery with resultant decreases in discard mortality. An economic analysis suggests that the fishery is not economically profitable currently, and that inconsistency in product availability has damaged market demand and the premium price previously garnered for Tanner crab. Stew Grant reported that the previously published genetic analysis suggesting genetic differentiation between the Eastern and Western region are not supported with a reanalysis of the data using modern analytical techniques. However, the power to detect population structure using this allozyme data set was low. Additional genetic markers are available and may be used in the future to evaluate genetic stock structure for EBS Tanner crab.

The proportion of the population that is reproducing, percent mature, is well above 80% at the current size limit. The percent mature at different sizes has varied over time and geographic areas. For example, greater than 75% of males are mature at 115 mm CW in the Western region, but the size at which 50% are mature is approximately >138 mm CW (the current size limit) in the Eastern region during the current low productivity period. Decreasing the size limit would cause a reduction in SSB-per-recruit, especially for the Eastern region. This analysis only examined bycatch mortality from the directed fishery, and assumes discard mortality in other fisheries would not change with this size limit change. Bycatch differs in the two regions. Further analysis is required to include this non-directed bycatch mortality.

**Ecosystem Considerations**

The CPT appreciates the efforts of the analysts in drafting this chapter as an important annual contribution to the SAFE report. The CPT agreed that the ecosystem considerations sections in each of the SAFE chapters be moved from the chapters and incorporated into the new ecosystem considerations chapter. Each stock assessment author should remove the ecosystem section of their chapter and provide it to Liz Chilton for incorporation into the ecosystem consideration chapter. Once completed, this chapter should be organized to facilitate finding ecosystem considerations for each stock (in the ecosystem status indicators section of the chapter). A summary of ecosystem concerns should eventually be included in the SAFE Introduction. The ecosystem chapter would be prepared by NMFS biologists and reviewed by CPT. Some suggestions for inclusion in the final chapter for September 2010 include identification of possible management-related reference points for the ecosystem indicators. Fishery impacts on the ecosystem though directed and bycatch mortality are addressed in the SAFE chapters and so do not need to be included here.

## Stock Assessment Review:

The team made final OFL recommendations for four stocks at this meeting: AIGKC, PIGKC, NSRKC and Adak RKC. The team noted that authors must compile final total catch information from the previous season for the September 2010 meeting to complete the status determination (overfishing determination) aspect of the final SAFE report at that time even though the assessments for these stocks will not be updated for the final SAFE report in September 2010. This information will be included in the SAFE introduction in September.

Tier determination and model recommendations are made for the assessments for the remaining six stocks, to be completed for the final assessment in September 2010. These recommendations are contained in the SAFE Introduction. Additional discussion and recommendations by stock are listed below.

### General

Some assessments provided results in metric tons. The CPT recommendation to use metric tons refers only to the ACL analysis and traditional assessment currencies (lbs) should continue to be used in stock assessments.

The team requested that all assessments explain how the groundfish bycatch data are used in the assessment and that all assessment chapters should be consistent in distinguishing and separately presenting groundfish bycatch from fixed gear fisheries and trawl gear fisheries.

### Snow Crab

The CPT was briefed by Jack Turnock who presented the results of seven variants of the EBS snow crab model. Six of these models included the survey data collected by the Bering Sea Fishery Research Foundation (BSFRF) and the NMFS in 2009 in the likelihood function. A number of other changes were made to the assessment based on the recommendations of the CPT and SSC at their May and September 2009 and April 2010 meetings. The fit of the model to the BSFRF length-frequency data was considerably better in the current set of models than those presented to the CPT in April 2010. This is due primarily to dropping the length-frequency data for animals smaller than 40 mm CW (as recommended by the CPT in April). The assessment team did not consider all of the recommendations of the April 2010 meetings.

The CPT noted that the selectivity pattern for the NMFS survey suggests that fairly small animals are fully selected to the gear. It noted that this contradicted the "Somerton selectivity curve", at least for males. Members discussed reasons why the model might suggest that selectivity for smaller animals was fairly high, including that natural mortality for smaller animals was, in fact, (much) larger than that for larger animals.

The CPT evaluated the six models when deciding on their recommended model (this model will be used to evaluate stock status relative to the overfished threshold and to determine the OFL for 2010/11). Two main views emerged within the CPT. One view considered that Model 1 (equivalent to the model recommended in 2009) should be recommended for use as the basis for the 2010 assessment. This model provides an adequate fit to the data and does not attempt to estimate growth and natural mortality, parameters which may be confounded with selectivity. The members of the CPT who supported Model 1 also noted that the Canadian tagging data suggested that $M$ was lower than $0.29 yr^{-1}$ and that the estimate of Q for females from Model 5 was 0.58, i.e. substantially below that for males. The second view considered that Model 5 should be recommended for use as the basis for the 2010 assessment. This model provides the best fit to the data and is selected as best among the six models using AIC. The estimate of natural mortality and growth from model 5 are also not implausibly different from the values used in earlier models. Those supporting Model 5 also noted that the extent of confounding between $M$ and selectivity in integrated models such as that for EBS snow crab is not as marked as would be the case for models such as Virtual Population Analysis.

After much discussion, the majority of the CPT supported model 5 as the recommended model.

### Bristol Bay red king crab:

See the introduction to the SAFE report for comments on this assessment. There were no additional comments outside of these.

### Tanner Crab:

Lou Rugolo summarized the Tanner crab assessment. The current analysis estimates a likely upper limit on MMB at time of mating (final results depend on fishery performance). It is estimated from the 2009 survey that the stock was below the MSST at that time, and the catches during the 2009/10 fishery will further result in MMB at mating in 2010 being below MSST. A formal determination of the stock being overfished will occur with the Fall 2010 assessment.

The CPT had the following recommendations for the authors:

- Include CV's with point estimates in the tables.
- Determine whether "groundfish" discards are based on all groundfish fisheries or only trawl fisheries.
- Revise the text for OFL calculation (Eq. 3 and 4) to represent what was actually done.
- Remove Appendix A as it came from a prior assessment.
- Provide the September meeting with a summary of progress with the new model. The CPT may recommend an additional CPT meeting may be necessary depending on progress and the necessity of this model for the rebuilding plan.
- Rebuilding plan considerations
    - Review recommendations from April 2010 ACL workshop for components relevant to the Tanner crab assessment.
    - Consider alternatives that are similar to those in the snow crab rebuilding plan.
- Consider an assessment model with different size limits for areas east and west of 166; do not consider a spatial movement model due to the associated complexity and development time.

### *St. Matthew blue king crab:*

No additional comments- see Crab SAFE introduction for CPT recommendations on this stock

### *Pribilof Island red king crab:*

- The CSA model was not presented to the CPT. This model will be presented in September 2010 with the intent of model approval in May 2011 for use in setting the 2011/12 OFL.
- The assessment methodology remains unchanged from last year.
- The 'Total Crab @ survey' column in Table 4 is incorrect and needs to be recalculated.
- Confidence intervals are still missing from Tables 3 and 4. They must be provided in the September assessment.
- Equation 3 is the same as equation 1 and needs to be corrected for females.
- Reorganize the chapter so that it is in standard format of text, tables, and figures.

### *Pribilof Islands blue king crab:*

- The CSA model was not presented to the CPT. This model will be presented in September 2010 with the intent of model approval in May 2011 for use in setting the 2011/12 OFL.
- The 'Total Crab @ survey' column in Table 4 is incorrect and needs to be recalculated.
- Equation 3 is the same as equation 1 and needs to be corrected for females.
- Reorganize the chapter so that it is in standard format of text, tables, and figures.
- A more complete analysis of spatial and temporal distributions of bycatch needs to be presented in conjunction with the initial draft of the rebuilding plan.
- All tables on page 1 should be updated for final assessment in September 2010.

### *Norton Sound red king crab:*

Jie Zheng presented the Norton Sound red king crab assessment. Jie identified the SSC and CPT recommendations regarding the 2009/10 assessment and the subsequent changes made in this year's assessment. Major changes include specification of $M$=0.18$yr^{-1}$ and $\gamma$=1.0. The CPT recommended that the next iteration explain the derivation of weights on fishing effort data.

Jie presented seven model alternatives, including the 2009/10 selected model and six model configurations with different assumptions. The conclusion that selectivity is uniform across all sizes should be re-evaluated for model 5, which specified a maximum effective sample size of 100 for the commercial catch and winter surveys. Further biological justification should be provided for the value of M to 0.288$yr^{-1}$ for last length group in model 6. It was noted that the assumption that M is higher for the largest crab is not made in the assessments of other RKC stocks and alternative explanations include the potential that last length group moves to inaccessible area, resulting in lower selectivity. The lack of large individuals in the catch and survey is dealt with in two different ways in the assessment: dome-shaped selectivity (models 1-5) and higher M (models 6 and 7). The analysis should isolate effect of selectivity.

### *Aleutian Islands golden king crab:*

**Tier 4 discussion**

The model is based on data from the 1990/91 seasons for the eastern stock and from the 1989/90 season for the western stock.

Model recommendations:

- Check whether the residual variance is compatible with the pre-specified CVs (check the residual patterns to the model fit). Increase the CV inputs (or estimate the extent of overdispersion) if needed
- Include CIs on annual CPUE graphs of model fits
- Include bubble plots
- Run the model with M fixed at 0.18$yr^{-1}$.
- Selectivity for the eastern stock: why are the large crab not available? The shape of the dome is not realistic. Explore standard models in which selectivity is asymptotic for at least one of the periods. Look for empirical evidence such as the size distribution of crab at depth to examine the plausibility of dome-shaped selectivity. Is the need for dome-shaped selectivity a consequence of the model assuming a growth transition matrix that implies higher growth than is actually the case?
- There are tagging data to estimate growth for golden king crab. The CPT recommends including growth data from tagging in the assessment to estimate growth within the model. Andre Punt has a paper in ICES journal on how to do this and will distribute to assessment author.
- Do not apply the selectivity curve when calculating MMB.
- Using $\lambda$ as a correction factor makes it hard to see what the productivity of the stock actually is, it's biologically confusing.
- Model framework looks correct, but secondary fixes need to be worked on. CPT would like to see the model again before Tier 4 adoption.
- Calculate $F_{35}$ for evaluation whether the stock could be moved to Tier 3.
- It appears from Table 3, that some parameters are hitting bounds; this needs to be checked and if parameters hit bounds reported.
- Molting probability is quite different between east and west. However, there are no data on growth in west. The CPT recommends using the tagging data from the east to estimate molting probabilities and use the same molting probability east and west.
- There was some discussion on various gamma values (1, 0.5 and 0.25). Clear justification for gamma alternatives should be included in future assessments.

While the model is much improved, the CPT would like to see the alternative model scenarios recommended above (concerning molting probabilities, fishery selectivity, M, growth) before adoption of the model.

**Tier 5 discussion**

CPT recognizes that using a Tier 5 approach which is based on data obtained from the fishery is sensitive to changes in fishing practices.

A retained catch OFL using the years 1985/86 through 1995/96 would be 9.18 million lbs. This year range was chosen by the SSC for the past two seasons. It represents the years after the legal size changed from 6.5 inches to 6.0 inches and is before the fishery was managed under a GHL or TAC.

The CPT recommended that a total-catch OFL be established for the 2010/11 Aleutian Islands golden king crab season. The CPT requested that the total-catch OFL be computed according to the following alternative:

1. $OFL_{TOT(1)} = (1+RATE_{05/06\text{-}08/09})\cdot OFL_{RET(85/86\text{-}95/96)} + MGF_{96/97\text{-}08/09}$
2. $OFL_{TOT(2)} = (1+RATE_{96/97\text{-}04/05})\cdot OFL_{RET(85/86\text{-}95/96)} + MGF_{96/97\text{-}08/09}$
3. $OFL_{TOT(3)}$ = Average of total catch for all components in Table 4 in assessment.

where:

$(RATE_{05/06\text{-}08/09})$ = mean of annual Rate = (bycatch mortality in crab fisheries)/(retained catch) over the period 2005/06–2008/09,

$(RATE_{96/97\text{-}04/05})$ = mean of annual Rate = (bycatch mortality in crab fisheries)/(retained catch) over the period 1996/97–2004/04,

$OFL_{RET(85/86\text{-}95/96)}$ = mean of annual retained catch over the period 1985/86–1995/96 (this is the retained-catch OFL that was established for the 2008/09 and 2009/10 Aleutian Islands golden king crab seasons, 9.18-million pounds), and

$MGF_{96/97\text{-}08/09}$ = mean of annual bycatch mortality in groundfish fisheries over the period 1996/97–2008/09.

The following information is relevant should the SSC chose to employ a methodology such as that proposed under alternatives 1 or 2 to establish a total catch OFL for the 2010/11 season

- Although data on bycatch during the crab fisheries exists for the golden king crab fishery seasons in the now defunct Adak and Dutch Harbor Areas during 1988/89–1995/96 and for groundfish fisheries in reporting areas 541, 542, and 543 during 1992/93–1995/96, only bycatch mortality estimates from crab and groundfish fishery observer data collected during 1996/97–2008/09 were available to the CPT at this meeting (see Table 4 of the May 2010 SAFE Aleutian Islands golden king crab chapter).
- Both $OFL_{TOT(1)}$ and $OFL_{TOT(2)}$ assume that bycatch mortality during the groundfish fisheries is independent of the retained catch during the golden king crab fishery and varies more-or-less randomly about a mean value estimated by $MGF_{96/97\text{-}08/09}$. On the other hand, $OFL_{TOT(1)}$ and $OFL_{TOT(2)}$ both assume that bycatch during the crab fisheries (which mainly occurs during the directed golden king crab fishery; see Table 2 of the Aleutian Islands golden king crab chapter) depends on the retained catch.

The data. The data are in Table 4 the Aleutian Islands golden king crab chapter. From that table, $MGF_{96/97\text{-}08/09}$ is given as 0.03-million pounds.

Annual values of Rate = (bycatch mortality in crab fisheries)/(retained catch) computed from the table are given in Table A1.

From Table A1, $(RATE_{05/06\text{-}08/09}) = 0.10$ and $(RATE_{96/97\text{-}04/05}) = 0.25$.

Annual bycatch mortality in the crab fisheries and Rate are plotted against retained catch in Figure A1. The value for 1998/99 (retained catch = 4.94-million pounds, bycatch mortality in crab fisheries = 1.48-

million pounds) is something of an outlier. The correlation between bycatch mortality in crab fisheries and retained catch is:

- r = 0.45 for all years (n=13),
- r = 0.83 for all years with 1998/99 excluded (n=12),
- r = 0.38 for 1996/97–2004/05 (n=9),
- r = 0.80 for 1996/97–2004/05 with 1998/99 excluded (n=8), and
- r = 0.35 for 2005/06–2008/09 (n=4).

The correlation between Rate = (bycatch mortality in crab fisheries)/(retained catch) and retained catch is similar:

- r = 0.31 for all years (n=13),
- r = 0.80 for all years with 1998/99 excluded (n=12),
- r = 0.11 for 1996/97–2004/05 (n=9),
- r = 0.75 for 1996/97–2004/05 with 1998/99 excluded (n=8), and
- r = -0.02 for 2005/06–2008/09 (n=4).

Rate = (bycatch mortality in crab fisheries)/(retained catch) tended to decrease with year during 1996/97–2008/09, from 0.26–0.31 during 1996/97–2000/01 to 0.09–0.11 during 2005/06–2008/09 (Table A1, Figure A2). The correlation between Rate = (bycatch mortality in crab fisheries)/(retained catch) and fishery year during 1996/97–2008/09 is r = -0.96.

Total-catch OFL computations.

1. $OFL_{TOT(1)} = (1+RATE_{05/06\text{-}08/09})\cdot OFL_{RET(85/86\text{-}95/96)} + MGF_{96/97\text{-}08/0'9}$

   $= (1+0.10)\cdot(9.18\text{-million pounds}) + 0.03\text{-million pounds}$

   $= 10.13$-million pounds.

2. $OFL_{TOT(2)} = (1+RATE_{96/97\text{-}04/05})\cdot OFL_{RET(85/86\text{-}95/96)} + MGF_{96/97\text{-}08/09}$, where

   $= (1+0.25)\cdot(9.18\text{-million pounds}) + 0.03\text{-million pounds}$

   $= 11.51$-million pounds.

3. $OFL_{TOT(3)} =$ 6.8-million pounds (from Table 4 of AI GKC assessment chapter)

See table, below.

$OFL_{RET(85/86\text{-}95/96)}$ (the retained-catch OFL for the 2008/09 and 2009/10 Aleutian Islands golden king crab fishery seasons compared with two alternatives for the total-catch OFL for the 2010/11 Aleutian Islands golden king crab fishery season.

| $OFL_{TOT(1)}$ | $OFL_{TOT(2)}$ | $OFL_{TOT(3)}$ |
|---|---|---|
| 10.1-million pounds | 11.5-million pounds | 6.8-million pounds |

Table A1. Annual values of Rate = (bycatch mortality in crab fisheries)/(retained catch) computed from the annual values retained catch and crab fishery bycatch morality given in Table 4 of the May 2010 SAFE Aleutian Islands golden king crab chapter.

| Season | Retained Catch | Crab | Rate |
|---|---|---|---|
| 1996/97 | 5,815,772 | 1,815,110 | 0.312 |
| 1997/98 | 5,945,683 | 1,738,534 | 0.292 |
| 1998/99 | 4,941,893 | 1,477,655 | 0.299 |
| 1999/00 | 5,838,788 | 1,510,314 | 0.259 |
| 2000/01 | 6,018,761 | 1,780,307 | 0.296 |
| 2001/02 | 5,918,706 | 1,377,692 | 0.233 |
| 2002/03 | 5,462,455 | 1,134,264 | 0.208 |
| 2003/04 | 5,665,828 | 994,697 | 0.176 |
| 2004/05 | 5,575,051 | 864,203 | 0.155 |
| 2005/06 | 5,520,318 | 504,747 | 0.091 |
| 2006/07 | 5,262,342 | 514,608 | 0.098 |
| 2007/08 | 5,508,100 | 606,926 | 0.110 |
| 2008/09 | 5,680,084 | 552,735 | 0.097 |
| Mean, 96/97–04/05 | 5,686,993 | 1,410,308 | 0.25 |
| CV of Mean | 2% | 8% | 8% |
| Mean, 05/06–08/09 | 5,492,711 | 544,754 | 0.10 |
| CV of Mean | 2% | 4% | 4% |
| Mean, 96/97–08/09 | 5,627,214 | 1,143,984 | 0.20 |
| CV of Mean | 1% | 12% | 12% |

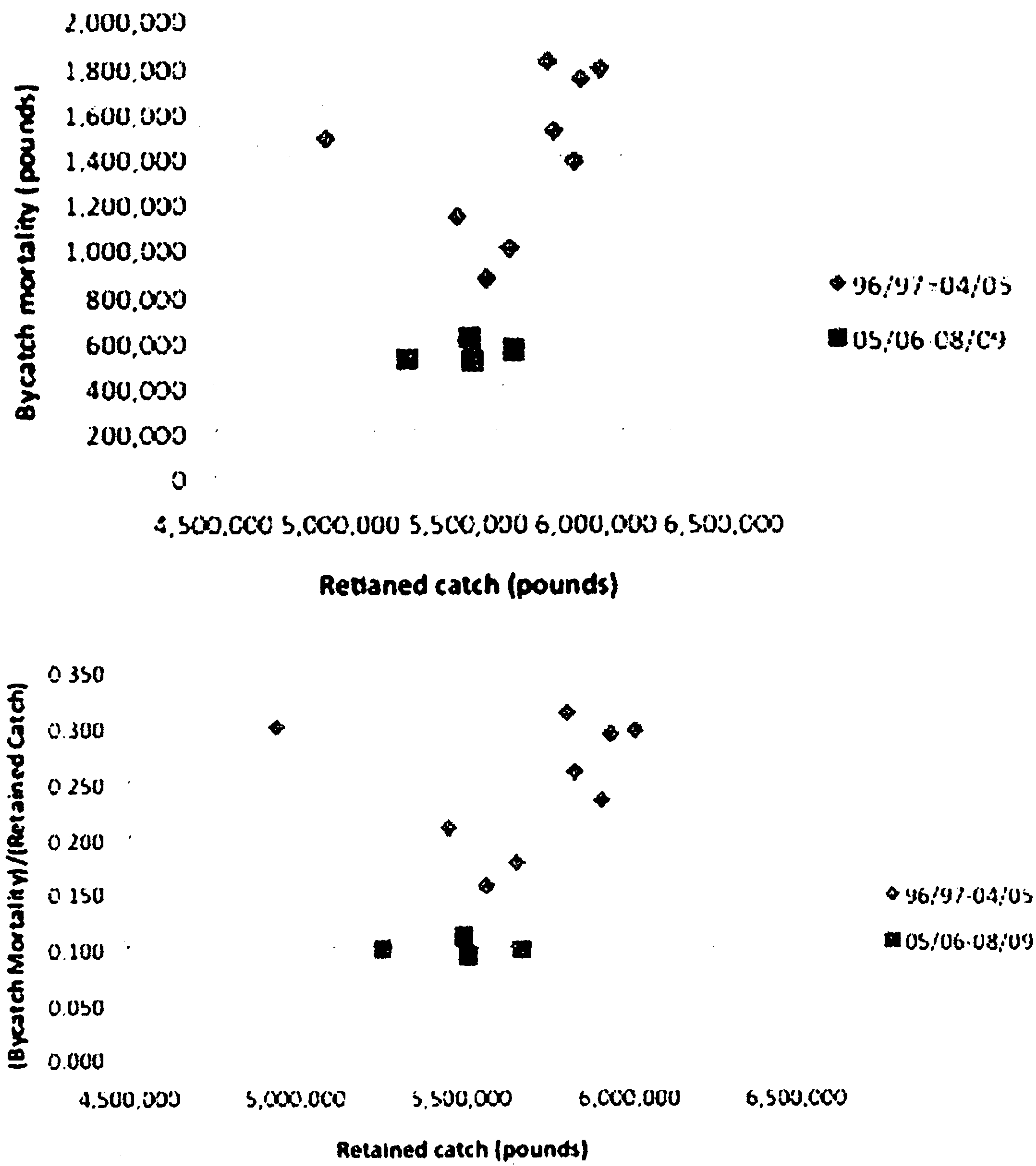



Figure A1. Annual bycatch mortality in the crab fisheries (top panel) and Rate (bottom panel) plotted against retained catch in the 1996/97–2008/09 Aleutian Islands golden king crab fishery seasons.

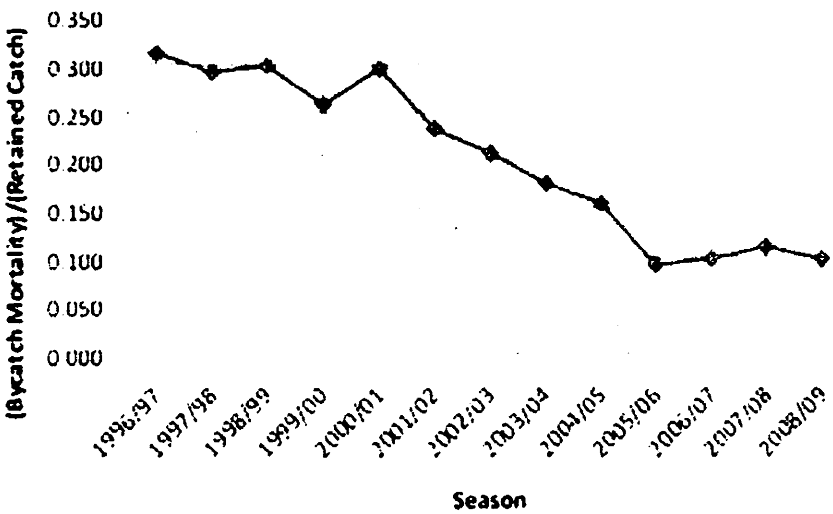



Figure A1. Annual Rate = (bycatch mortality in crab fisheries)/(retained catch) plotted against fishery season during the 1996/97–2008/09 Aleutian Islands golden king crab fishery seasons.

### *Pribilof Islands golden king crab:*
No additional comments- see Crab SAFE introduction for CPT recommendations on this stock.

### *Adak red king crab:*
No additional comments- see Crab SAFE introduction for CPT recommendations on this stock.

## Crab Bycatch in Groundfish Fisheries
Diana Stram presented a draft discussion on crab bycatch in groundfish fisheries. This discussion paper was initiated based on a request from the CPT in March 2010 that was supported by the SSC, AP, and Council in April 2010. The CPT has expressed a desire to initiate a discussion on crab bycatch in the groundfish fisheries several instances in the past, but the requirement that ACLs/AMs be implemented for each FMP crab stock has placed renewed emphasis on this topic.

Diana provided a review of crab bycatch in groundfish fisheries by crab species and gear type for the 2003/04-2008/09 time period. This included a description of existing PSC levels and closure areas in groundfish fisheries. She described the current procedure used by catch accounting staff to convert observer-collected crab bycatch data into the format needed by various end users.

The team recommended that an analysis of crab bycatch in groundfish fisheries be initiated based on the Council's April 2010 request and made the following additional recommendations for inclusion in the analysis:

- An effort should be made to convert all crab bycatch regulatory thresholds to weight rather than numbers and that crab bycatch should be reported as weight. Doing so would standardize crab bycatch in groundfish fisheries to the same currency used in crab stock assessments and would reduce uncertainty resulting from multiple conversions from weight to numbers and back to weight.

- The discussion paper should include sample sizes on the figures depicting sex ratio and size frequency of crab bycatch in various groundfish fisheries. Graphical depictions of size data should include some reference to average size of crabs taken in the directed crab fisheries as a point of comparison.
- The analysis should discuss the implications of the disconnect between timing of the groundfish assessment cycle/fishing year (calendar year) compared to the crab fishing year and consider alternatives for modifying the crab bycatch accounting process to best conform to the crab fishing year.

The Team agreed that current crab PSC limits in groundfish fisheries are not reflective of annual crab abundance and that crab PSC limits in groundfish fisheries should be responsive to annual changes in crab stock status. One approach identified by the Team to achieve this is to set crab PSC limits based on a percentage of the annual ACL for each crab stock.

The CPT agreed that the boundaries of existing crab closure areas should be examined in the context of current crab stock distribution. Existing closure areas do not encompass the entire distribution of each crab stock and crab bycatch can occur outside of the closure areas without accruing towards PSC limits. the team recommends that all crab bycatch in groundfish fisheries should accrue towards a PSC limit give the moves to towards total-catch OFLs for all crab stocks. In addition, the Team agreed that current PSC thresholds should be re-examined; PSC thresholds should be set based on biological impact to a given crab stock and should be considered for each groundfish sector. PSC thresholds could trigger complete fishery closures, or time and area closures. Additional consideration should be given to PSC caps that are stair-stepped based upon crab stock status.

The Team recognized that individual crab stocks may be particularly impacted by bycatch during biologically-sensitive time periods and in specific locations. In this context, the team requested that the analysis include a discussion of the size- and sex-composition of red king crab bycatch in Bristol Bay by location, time period, and groundfish fishery. In addition to the request for Bristol Bay red king crab, the team expressed a desire to prioritize analysis of bycatch in groundfish fisheries of crab stocks under a rebuilding plan (e.g. Pribilof blue king crab, EBS Tanner crab).

The Team again reiterates their recommendation that the Council move forward with an analysis of PSC limits in groundfish fisheries specified at the Crab stock level in light of implementation of ACLs and the AMs. The CPT would like to review any analysis that is initiated by the Council on crab stock PSC limits.

## Crab Annual Catch limits and Rebuilding

***General:***

The CPT appreciates the immense amount of work and effort from the analysts in revising this analysis. The initial review draft is greatly improved from the preliminary draft and includes much more summary information and clarifications pertinent to understanding the complex decision-points that will be put forward to the Council for final action in October. The CPT will review and comment on the revised summary information in September (in the public review draft) with the intention to provide a recommendation on a preferred approach for establishing ACLs by stock at that time as well as a preferred alternative rebuilding strategy for snow crab. The Team requested clarification on the degree of specificity necessary in the AMs as presented in the initial review draft. The Team reiterates their concerns that any overage of an ACL which could trigger an AM would only impact the directed fishery regardless of why the ACL was exceeded (i.e. bycatch in groundfish fisheries). The Team recommended that additional uncertainty levels for $\sigma_b$ at low, medium and high levels should be considered in the analyses and when computing ABCs. However, the Team recommended that these default levels be established as 0.2, 0.3 and 0.4 respectively. Furthermore the team recommended that the St. Matthew stock qualified as a medium (not high) level $\sigma_b$ because this assessment is based on adequate data is has a stable assessment (unlike PIBKC and PIRKC and the Tier 5 stocks).

## Chapter 4: Snow Crab

Jack Turnock introduced the results of the rebuilding analysis and the ACL calculations for EBS snow crab. The CPT noted that the analyses had been revised extensively in response to the suggestions made during the Spring 2010 meetings of the CPT and SSC.

The CPT had the following recommendations which apply to both the ACL and rebuilding analyses:

- The years in all tables should indicate that what is presented are fishing and not calendar years.
- All references to stock-recruitment relationships should be removed as this is discussed in Chapter 3.
- The analyses should be changed to focus on model 5 if the SSC agrees with the CPT recommendation that this model is to be preferred.
- The text should clearly explain the reasons for the including a range of models in the chapter and state which model (1 or 5 depending on the SSC decision) is used in the bulk of the scenarios (and why) and which models are presented only for sensitivity purposes. The results for the non-preferred models should be discussed in separate "sensitivity test" sections within the ACL and rebuilding parts of the chapter.

In relation the rebuilding analyses, the CPT recommended:

- The catch for 2010/11 should be based on 75% of the $F_{OFL}$ for all alternatives because the rebuilding plan will only impact management starting in 2011/12. This may change the values for $T_{MIN}$ and even the number of alternatives.
- $T_{MIN}$ should be computed with the groundfish catch included. This should not impact any of the results noticeably.
- The last column of the summary table should have a "% of $F_{OFL}$" header. If this table contains a "NA", a footnote should be added explaining what this means. The revenue forecasts need to be added to this table.
- A table should be added which lists the results if rebuilding is defined as recovery to $B_{MSY}$ once (instead of for two years in a row).
- Option 1 should be defined in terms of 8 years after the start of the rebuilding plan, i.e. 2019/20. Option 1 is meant to represent an approach that provides additional time for rebuilding within the current harvest constraint of 75%$F_{OFL}$ in order to provide additional time to annually correct for the rebuilding trajectory.
- The write-up needs to be extended to describe the methods and results in more detail. Specific areas where additional information is needed include: (a) mention that a strategy of 80% of $F_{OFL}$ is implemented following recovery, (b) mention that alternative models are presented as sensitivity tests to indicate what might happen if the stock assessment is changed, (c) include the economic results and discuss these, and (d) indicate which alternatives / options lead to a reduction in MMB in the short term.
- The plots can be improved by: (a) using different line-styles for the various alternatives / options so that they can be distinguished in black-and-white copies and perhaps show the results in multi-panel plots instead of single plot, and (b) adding $B_{MSY}$ on the plots of MMB.
- The results for the economic analyses should be presented for 5-, 10- and 15- year periods and reformatted to better emphasize the relative ranks of the alternatives.
- The economic analysis should scale the results to be relative to the status quo baseline
- economic forecasts should also start at the year of implementation of the rebuilding plan.

In relation to the ACL analyses, the CPT recommended:

- The reference to "set to point estimate" in table 4-1 should be deleted.

- The table of long-term results for P* values should be based on the multipliers computed from the log-normal distribution rather than chosen so that the probability of overfishing in 2038 equals the pre-specified values for P*.
- Figure 4-10 should be redrawn to reflect changes in buffer values rather than multipliers.

### Chapter 5: Tanner Crab

- Figure 5-5 should be redrawn to reflect changes in buffer values rather than multipliers.
- Economic results need to be added

### Chapter 6: Bristol Bay Red King Crab (BBRKC)

No additional comments outside of general changes.

### Chapter 7: Pribilof Island Red King Crab (PIRKC)

Need to clarify that results employ a model under development which results in different $\sigma_w$ values than those listed for comparison from the survey.

### Chapter 8: Pribilof Island Blue King Crab

Need to clarify that results employ a model under development which results in different $\sigma_w$ values than those listed for comparison from the survey.

### Chapter 9: St Matthew Blue King Crab

The team recommended that a medium level of uncertainty ($\sigma_b$ =0.4) be assumed when computing ABCs for the St. Matthew blue king crab stock.

### Chapter 10: Norton Sound Red King Crab

No additional comments outside of general changes.

### Chapter 11: Aleutian Island Golden King Crab (AIGKC)

No additional comments outside of general changes.

### Chapter 12: Pribilof Islands Golden King Crab (PIGKC)

No additional comments outside of general changes.

### Chapter 13: Adak Red King Crab

No additional comments outside of general changes.

### Economic SAFE

Brian Garber-Yonts outlined a draft of the BSAI crab Economic SAFE. The document is nearly complete with most tables and figures available. Interpretive text will be added by June 2010 and the complete document will be available for inclusion in the final crab SAFE in October 2010. The author would like to circulate the current draft of the document for public review and comments prior to finalizing the document for September. This will likely be done by web-posting either via the AFSC or the Council website (or both)

The author has begun to include stock-specific economic extracts, including summaries of employment, earnings, and participation by fishery to the assessment authors and will continue to do so on an annual basis. There is some difficulty in accessing ex-vessel price data for some stocks, particularly EBS Tanner crab. Price data for EBS Tanner are confounded because EBS Tanner crab are delivered at ports where other Tanner crab stocks are landed.

The team recommended that the figures depicting vessel days should be reexamined to insure that fishing days are correctly characterized during the rationalized period. The team suggested that the Tanner crab figures could be improved by removing vessels that only made small bycatch landings of Tanner crab and focusing on those vessels that were involved in directed Tanner crab harvesting.

The Team requested that captain and crew share payment depictions be expressed as a percentage of total ex-vessel value to better illustrate potential changes from rationalization. In addition, the CPT inquired about QS lease rates in the rationalized fisheries. Data on lease rates were not presented due to issues of data quality.

The team requests that, if possible, a presentation on the CRP 5-year review be provided at the September 2010 CPT meeting.

## New Business

The team discussed scheduling and timing for the September CPT meeting. The following items were discussed for consideration at the next meeting, with priority for timing on items in bold. The Team decided the meeting should be 4 days (instead of 3) and will occur September 13-16, 2010 at the Alaska Fisheries Science Center.

**September 2010 CPT meeting topics:**
**Final SAFE reports (6):**

  - **Snow**
  - **BBRKC-including CIE review results and plans**
  - **Tanner**
  - **PIRKC**
  - **PIBKC**
  - **St Matts BKC**
  - **survey overview and results**
- **ACL/Snow crab rebuilding analysis: discussion to review revised summary information and select preferred alternative**
- **Review initial review draft of PIBKC rebuilding plan EFH discussion paper**
- **Model review day**
  - **Tanner crab model review**
  - PIRKC/PIBKC model review
  - **AIGKC model review**
- **James Murphy snow crab spatial dynamics presentation**
- Presentation on crab crew remuneration
- Overview of final Economic SAFE
- 5 year economic review of CRP
- Crab Ecosystem considerations chapter
- **general update on Council actions from June**

The May CPT meeting will be May 9-13, 2011 in Juneau (possibly at TSMARI).

The meeting adjourned at 4:00pm.

North Pacific Fishery Management Council Crab Plan Team Meeting
May 10-14, 2010
Hotel Alyeska, Girdwood, AK

AGENDA

| | | |
|---|---|---|
| **Monday, May 10** | | **Room (TBD, all week)** |
| 9:00 | **Administration** | • Introductions, agenda, minutes, meeting goals, and 2001 timing |
| 9:45 | **EFH / HAPCs** | • Update from the April 2010 Council Meeting |
| 10:15 | **PIBKC Rebuilding Plan**<br>Break 10:30 – 10:45 | • Update on status and timing on Pribilof Islands blue king crab |
| 10:45 | **Paper Presentations** | • Snow crab larval drift – *Hinckley*<br>• Snow crab spatial dynamics (T) – *Murphy* |
| Noon | | Lunch |
| 1:00 | **Paper Presentations (cont as necc)** | • Snow crab spatial dynamics (T) – *Murphy* |
| 2:15 | **Ecosystem Appendix**<br>Break 3:00 – 3:15 | • Chapter outline for CPT approval – *Foy* |
| 3:15 | **Stock Assessment Review / OFL** | • EBS Tanner crab: assessment and discuss rebuilding alternatives |
| **Tuesday, May 11** | | |
| 9:00 | **Stock Asses. / OFL cont.**<br>Break 10:30 – 10:45 | • Norton Sound red king crab, St. Matthew blue king crab<br>• Bristol Bay red king crab |
| Noon | | Lunch |
| 1:00 | Break 3:00 – 3:15 | • Bering Sea snow crab<br>• Pribilof red and golden king crab<br>• Aleutian Islands red and golden king crab, Pribilof Islands golden |
| **Wednesday, May 12** | | |
| 9:00 | **Crab Bycatch** | • Discussion paper on crab bycatch in the groundfish fisheries |
| 10:00 | **ACLs / AMs**<br>Break 10:30 – 10:45 | • Discussion on initial review draft of annual catch limits and accountability measures (Changes to Chapters 1 and 2) |
| Noon | | Lunch |
| 1:00 | | • Bristol Bay red king crab |
| 1:30 | Break 3:00 – 3:15 | • Norton Sound red king crab, St. Matthew blue king crab |
| 3:15 | | • Pribilof red and blue king crab |
| **Thursday, May 13** | | |
| 9:00 | **ACLs / AMs cont.** | • EBS Tanner crab |
| 9:30 | Break 10:30 – 10:45 | • Bering Sea snow crab |
| Noon | | Lunch |
| 1:00 | | • Bering Sea snow crab rebuilding plan |
| 2:00 | Break 3:00 – 3:15 | • Aleutian Islands red and golden king crab<br>• Pribilof Islands golden king crab |
| 3:15 | **ACLs**<br>End of day 4:00 | • Finalize ACL discussion<br>*Note must adjourn from room at 4pm!* |
| **Friday, May 14** | | |
| 9:00 | **ACLs (cont if needed)** | • Finalize ACL discussion (if necessary) |

| | | |
|---|---|---|
| 9:30 | **Economic SAFE** | • Discussion |
| | Break 10:30 – 10:45 | |
| 10:45 | **SAFE / Minutes** | • Complete the draft SAFE report and CPT minutes |
| Noon | | Lunch |
| 1:00 | **SAFE / Minutes cont.** | • Cont' draft SAFE report and CPT minutes |
| 4:00 | **New Business** | |
| 4:30 | | Adjourn |

AGENDA C-2(b)(2)
JUNE 2010

# Stock Assessment and Fishery Evaluation Report for the **KING AND TANNER CRAB FISHERIES** of the Bering Sea and Aleutian Islands Regions

## 2010 Draft Crab SAFE

Compiled by

The Plan Team for the King and Tanner Crab Fisheries
of the Bering Sea and Aleutian Islands

With Contributions by

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**May 2010**

North Pacific Fishery Management Council
605 W. 4th Avenue, #306
Anchorage, AK 99501

# Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries Fisheries of the Bering Sea and Aleutian Islands Regions

Table of Contents

**2010 Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries in the Bering Sea and Aleutian Islands**

# Introduction

The annual stock assessment and fishery evaluation (SAFE) report is a requirement of the North Pacific Fishery Management Council's *Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs (FMP)*, and a federal requirement [50 CFR Section 602.12(e)]. The SAFE report summarizes the current biological and economic status of fisheries, total allowable catch (TAC) or Guideline Harvest Level (GHL), and analytical information used for management decisions. Additional information on Bering Sea/Aleutian Islands (BSAI) king and Tanner crab is available on the NMFS web page at http://www.fakr.noaa.gov and the Alaska Department of Fish and Game (ADF&G) Westward Region Shellfish web page at: http://www.cf.adfg.state.ak.us/region4/shellfsh/shelhom4.php.

This FMP applies to 10 crab stocks in the BSAI: 4 red king crab, *Paralithodes camtschaticus*, stocks (Bristol Bay, Pribilof Islands, Norton Sound and Adak), 2 blue king crab, *Paralithodes platypus*, stocks (Pribilof District and St Matthew Island), 2 golden (or brown) king crab, *Lithodes aequispinus*, stocks (Aleutian Island and Pribilof Islands), EBS Tanner crab *Chionoecetes bairdi*, and EBS snow crab *Chionoecetes opilio*. All other BSAI crab stocks are exclusively managed by the State of Alaska.

The Crab Plan Team (CPT) annually assembles the SAFE report with contributions from ADF&G and the National Marine Fisheries Service (NMFS). This SAFE report is presented to the North Pacific Fishery Management Council (NPFMC) and is available to the public on the NPFMC web page at: http://fakr.noaa.gov/npfmc/membership/plan_teams/CRAB_team.htm. Under a process approved in 2008 for revised overfishing level (OFL) determinations, the Crab Plan Team reviews draft assessments in May to provide recommendations in a draft SAFE report for review by the Council's Science and Statistical Committee (SSC) in June. In September, the CPT reviews final assessments and provides final OFL recommendations and stock status determinations. Additional information on the new OFL determination process is contained in this report.

The Crab Plan Team met from May 10-14, 2010 in Girdwood, Alaska to review the draft stock assessments as well as Annual Catch Limits analysis and related issues, in order to provide the recommendations contained in this draft SAFE report. The Team will review revised assessments in September 2010 for 7 stocks and will revise this report accordingly at that time to form the final 2010 Crab SAFE report. The final 2010 Crab SAFE report will be presented to the Council in October for their annual review of the status of BSAI Crab stocks. Members of the team who participated in this review include the following: Forrest Bowers (Chair), Ginny Eckert (Vice-Chair), André Punt, Jack Turnock, Shareef Siddeek, Bill Bechtol, Karla Bush, Brian Garber-Yonts, Gretchen Harrington, Doug Pengilly, Bob Foy, Lou Rugolo, Wayne Donaldson, Josh Greenberg, and Diana Stram. The final SAFE report in September 2010 will build upon recommendations contained in this report.

## Stock Status Definitions

The FMP (incorporating all changes made following adoption of Amendment 24) contains the following stock status definitions:

Maximum sustainable yield (MSY) is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions. MSY is estimated from the best information available.

$F_{MSY}$ control rule means a harvest strategy which, if implemented, would be expected to result in a long-term average catch approximating MSY.

$B_{MSY}$ stock size is the biomass that results from fishing at constant $F_{MSY}$ and is the minimum standard for a rebuilding target when a rebuilding plan is required.

Maximum fishing mortality threshold (MFMT) is defined by the $F_{OFL}$ control rule, and is expressed as the fishing mortality rate.

Minimum stock size threshold (MSST) is one half the $B_{MSY}$ stock size.

Overfished is determined by comparing annual biomass estimates to the established MSST. For stocks where MSST (or proxies) are defined, if the biomass drops below the MSST (or proxy thereof) then the stock is considered to be overfished.

Overfishing is defined as any amount of catch in excess of the overfishing level (OFL). The OFL is calculated by applying the $F_{OFL}$ control rule annually estimated using the tier system in Chapter 6.0 to abundance estimates.

## Status Determination Criteria

The FMP defines the following status determination criteria and the process by which these are defined following adoption of amendment 24.

Status determination criteria for crab stocks are annually calculated using a five-tier system that accommodates varying levels of uncertainty of information. The five-tier system incorporates new scientific information and provides a mechanism to continually improve the status determination criteria as new information becomes available. Under the five-tier system, overfishing and overfished criterion are annually formulated and assessed to determine the status of the crab stocks and whether (1) overfishing is occurring or the rate or level of fishing mortality for a stock or stock complex is approaching overfishing, and (2) a stock or stock complex is overfished or a stock or stock complex is approaching an overfished condition.

Overfishing is determined by comparing the overfishing level (OFL), as calculated in the five-tier system for the crab fishing year, with the catch estimates for that crab fishing year. For the previous crab fishing year, NMFS will determine whether overfishing occurred by comparing the previous year's OFL with the catch from the previous crab fishing year. This catch includes all fishery removals, including retained catch and discard losses, for those stocks where non-target fishery removal data are available. Discard losses are determined by multiplying the appropriate handling mortality rate by observer estimates of bycatch discards. For stocks where only retained catch information is available, the OFL will be set for and compared to the retained catch.

NMFS will determine whether a stock is in an overfished condition by comparing annual biomass estimates to the established MSST, defined as ½ $B_{MSY}$. For stocks where MSST (or proxies) are defined, if the biomass drops below the MSST (or proxy thereof) then the stock is considered to be overfished. MSSTs or proxies are set for stocks in Tiers 1-4. For Tier 5 stocks, it is not possible to set an MSST because there are no reliable estimates of biomass.

If overfishing occurred or the stock is overfished, section 304(e)(3)(A) of the Magnuson-Stevens Act, as amended, requires the Council to immediately end overfishing and rebuild affected stocks.

Annually, the Council, Scientific and Statistical Committee, and Crab Plan Team will review (1) the stock assessment documents, (2) the OFLs and total allowable catches or guideline harvest levels for the upcoming crab fishing year, (3) NMFS's determination of whether overfishing occurred in the previous crab fishing year, and (4) NMFS's determination of whether any stocks are overfished.

Five-Tier System

The OFL for each stock is annually estimated for the upcoming crab fishing year using the five-tier system, detailed in Table 6-1 and 6-2. First, a stock is assigned to one of the five tiers based on the availability of information for that stock and model parameter choices are made. Tier assignments and model parameter choices are recommended through the Crab Plan Team process to the Council's Scientific and Statistical Committee. The Council's Scientific and Statistical Committee will recommend tier assignments, stock assessment and model structure, and parameter choices, including whether information is "reliable," for the assessment authors to use for calculating the OFLs based on the five-tier system.

For Tiers 1 through 4, once a stock is assigned to a tier, the stock status level is determined based on recent survey data and assessment models, as available. The stock status level determines the equation used in calculating the $F_{OFL}$. Three levels of stock status are specified and denoted by "a," "b," and "c" (see Table 6-1). The $F_{MSY}$ control rule reduces the $F_{OFL}$ as biomass declines by stock status level. At stock status level "a," current stock biomass exceeds the $B_{MSY}$. For stocks in status level "b," current biomass is less than $B_{MSY}$ but greater than a level specified as the "critical biomass threshold" ($\beta$).

Lastly, in stock status level "c," current biomass is below $\beta$ * ($B_{MSY}$ or a proxy for $B_{MSY}$). At stock status level "c," directed fishing is prohibited and an $F_{OFL}$ at or below $F_{MSY}$ would be determined for all other sources of fishing mortality in the development of the rebuilding plan. The Council will develop a rebuilding plan once a stock level falls below the MSST.

For Tiers 1 through 3, the coefficient $\alpha$ is set at a default value of 0.1, and $\beta$ set at a default value of 0.25, with the understanding that the Scientific and Statistical Committee may recommend different values for a specific stock or stock complex as merited by the best available scientific information.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, $\gamma$, are used in the calculation of the $F_{OFL}$.

In Tier 5, the OFL is specified in terms of an average catch value over an historical time period, unless the Scientific and Statistical Committee recommends an alternative value based on the best available scientific information.

OFLs will be calculated by applying the $F_{OFL}$ and using the most recent abundance estimates. The Crab Plan Team will review stock assessment documents, the most recent abundance estimates, and the proposed OFLs. The Alaska Fisheries Science Center will set the OFLs consistent with this FMP and forward OFLs for each stock to the State of Alaska prior to its setting the total allowable catch or guideline harvest level for that stock's upcoming crab fishing season.

Tiers 1 through 3

For Tiers 1 through 3, reliable estimates of B, $B_{MSY}$, and $F_{MSY}$, or their respective proxy values, are available. Tiers 1 and 2 are for stocks with a reliable estimate of the spawner/recruit relationship, thereby enabling the estimation of the limit reference points $B_{MSY}$ and $F_{MSY}$.

- Tier 1 is for stocks with assessment models in which the probability density function (pdf) of $F_{MSY}$ is estimated.
- Tier 2 is for stocks with assessment models in which a reliable point estimate, but not the pdf, of $F_{MSY}$ is made.
- Tier 3 is for stocks where reliable estimates of the spawner/recruit relationship are not available, but proxies for $F_{MSY}$ and $B_{MSY}$ can be estimated.

For Tier 3 stocks, maturity and other essential life-history information are available to estimate proxy limit reference points. For Tier 3, a designation of the form "$F_X$" refers to the fishing mortality rate associated with an equilibrium level of fertilized egg production (or its proxy) per recruit equal to X% of the equilibrium level in the absence of any fishing.

The OFL calculation accounts for all losses to the stock not attributable to natural mortality. The OFL is the total catch limit comprised of three catch components: (1) non-directed fishery discard losses; (2) directed fishery discard losses; and (3) directed fishery retained catch. To determine the discard losses, the handling mortality rate is multiplied by bycatch discards in each fishery. Overfishing would occur if, in any year, the sum of all three catch components exceeds the OFL.

Tier 4

Tier 4 is for stocks where essential life-history, recruitment information, and understanding are lacking. Therefore, it is not possible to estimate the spawner-recruit relationship. However, there is sufficient information for simulation modeling that captures the essential population dynamics of the stock as well as the performance of the fisheries. The simulation modeling approach employed in the derivation of the annual OFLs captures the historical performance of the fisheries as seen in observer data from the early 1990s to present and thus borrows information from other stocks as necessary to estimate biological parameters such as $\gamma$.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, $\gamma$, are used in the calculation of the $F_{OFL}$. Explicit to Tier 4 are reliable estimates of current survey biomass and the instantaneous M. The proxy $B_{MSY}$ is the average biomass over a specified time period, with the understanding that the Council's Scientific and Statistical Committee may recommend a different value for a specific stock or stock complex as merited by the best available scientific information. A scalar, $\gamma$, is multiplied by M to estimate the $F_{OFL}$ for stocks at status levels a and b, and $\gamma$ is allowed to be less than or greater than unity. Use of the scalar $\gamma$ is intended to allow adjustments in the overfishing definitions to account for differences in biomass measures. A default value of $\gamma$ is set at 1.0, with the understanding that the Council's Scientific and Statistical Committee may recommend a different value for a specific stock or stock complex as merited by the best available scientific information.

If the information necessary to determine total catch OFLs is not available for a Tier 4 stock, then the OFL is determined for retained catch. In the future, as information improves, data would be available for some stocks to allow the formulation and use of selectivity curves for the discard fisheries (directed and non-directed losses) as well as the directed fishery (retained catch) in the models. The resulting OFL from this approach, therefore, would be the total catch OFL.

Tier 5

Tier 5 stocks have no reliable estimates of biomass or M and only historical data of retained catch is available. For Tier 5 stocks, the historical performance of the fishery is used to set OFLs in terms of retained catch. The OFL represents the average retained catch from a time period determined to be representative of the production potential of the stock. The time period selected for computing the average catch, hence the OFL, would be based on the best scientific information available and provide the appropriate risk aversion for stock conservation and utilization goals. In Tier 5, the OFL is specified in terms of an average catch value over a time period determined to be representative of the production potential of the stock, unless the Scientific and Statistical Committee recommends an alternative value based on the best available scientific information.

For most Tier 5 stocks, only retained catch information is available so the OFL will be estimated for the retained catch portion only, with the corresponding overfishing comparison on the retained catch only. In the future, as information improves, the OFL calculation could include discard losses, at which point the OFL would be applied to the retained catch plus the discard losses from directed and non-directed fisheries.

Figure 1. Overfishing control rule for Tiers 1 through 4. Directed fishing mortality is 0 below β.

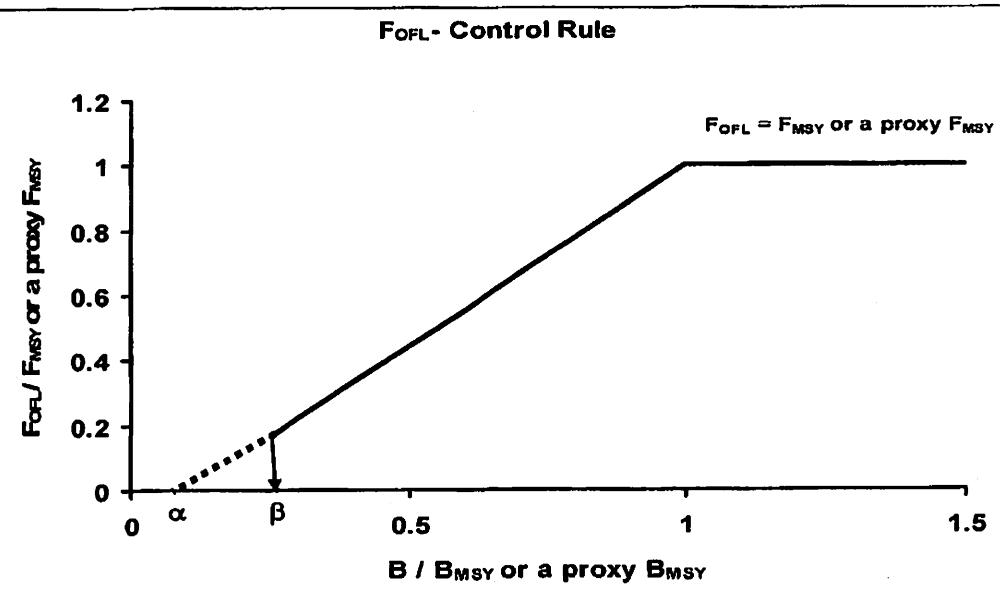


Table 1 Five-Tier System for setting overfishing limits for crab stocks. The tiers are listed in descending order of information availability. Table 6-2 contains a guide for understanding the five-tier system.

| Information available | Tier | Stock status level | $F_{OFL}$ |
|---|---|---|---|
| $B$, $B_{MSY}$, $F_{MSY}$, and pdf of $F_{MSY}$ | 1 | a. $\frac{B}{B_{msy}} > 1$ | $F_{OFL} = \mu_A$ =arithmetic mean of the pdf |
| | | b. $\beta < \frac{B}{B_{msy}} \le 1$ | $F_{OFL} = \mu_A \frac{B/B_{msy} - \alpha}{1-\alpha}$ |
| | | c. $\frac{B}{B_{msy}} \le \beta$ | Directed fishery $F = 0$<br>$F_{OFL} \le F_{MSY}$† |
| $B$, $B_{MSY}$, $F_{MSY}$ | 2 | a. $\frac{B}{B_{msy}} > 1$ | $F_{OFL} = F_{msy}$ |
| | | b. $\beta < \frac{B}{B_{msy}} \le 1$ | $F_{OFL} = F_{msy} \frac{B/B_{msy} - \alpha}{1-\alpha}$ |
| | | c. $\frac{B}{B_{msy}} \le \beta$ | Directed fishery $F = 0$<br>$F_{OFL} \le F_{MSY}$† |
| $B$, $F_{35\%}$*, $B_{35\%}$* | 3 | a. $\frac{B}{B_{35\%}*} > 1$ | $F_{OFL} = F_{35\%}$* |
| | | b. $\beta < \frac{B}{B_{35\%}*} \le 1$ | $F_{OFL} = F^*_{35\%} \frac{\frac{B}{B^*_{35\%}} - \alpha}{1-\alpha}$ |
| | | c. $\frac{B}{B_{35\%}*} \le \beta$ | Directed fishery $F = 0$<br>$F_{OFL} \le F_{MSY}$† |
| $B$, $M$, $B_{msy^{prox}}$ | 4 | a. $\frac{B}{B_{msy^{prox}}} > 1$ | $F_{OFL} = \gamma M$ |
| | | b. $\beta < \frac{B}{B_{msy^{prox}}} \le 1$ | $F_{OFL} = \gamma M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$ |
| | | c. $\frac{B}{B_{msy^{prox}}} \le \beta$ | Directed fishery $F = 0$<br>$F_{OFL} \le F_{MSY}$† |
| Stocks with no reliable estimates of biomass or M. | 5 | | OFL = average catch from a time period to be determined, unless the SSC recommends an alternative value based on the best available scientific information. |

*35% is the default value unless the SSC recommends a different value based on the best available scientific information.

† An $F_{OFL} \le F_{MSY}$ will be determined in the development of the rebuilding plan for that stock.

Table 2 A guide for understanding the five-tier system.

- $F_{OFL}$ — the instantaneous fishing mortality (F) from the directed fishery that is used in the calculation of the overfishing limit (OFL). $F_{OFL}$ is determined as a function of:
  - $F_{MSY}$ — the instantaneous F that will produce MSY at the MSY-producing biomass
    - A proxy of $F_{MSY}$ may be used; e.g., $F_{x\%}$, the instantaneous F that results in x% of the equilibrium spawning per recruit relative to the unfished value
  - B — a measure of the productive capacity of the stock, such as spawning biomass or fertilized egg production.
    - A proxy of B may be used; e.g., mature male biomass
  - $B_{MSY}$ — the value of B at the MSY-producing level
    - A proxy of $B_{MSY}$ may be used; e.g., mature male biomass at the MSY-producing level
  - $\beta$ — a parameter with restriction that $0 \le \beta < 1$.
  - $\alpha$ — a parameter with restriction that $0 \le \alpha \le \beta$.
- The maximum value of $F_{OFL}$ is $F_{MSY}$. $F_{OFL} = F_{MSY}$ when $B > B_{MSY}$.
- $F_{OFL}$ decreases linearly from $F_{MSY}$ to $F_{MSY} \cdot (\beta - \alpha)/(1 - \alpha)$ as B decreases from $B_{MSY}$ to $\beta \cdot B_{MSY}$
- When $B \le \beta \cdot B_{MSY}$, F = 0 for the directed fishery and $F_{OFL} \le F_{MSY}$ for the non-directed fisheries, which will be determined in the development of the rebuilding plan.
- The parameter, $\beta$, determines the threshold level of B at or below which directed fishing is prohibited.
- The parameter, $\alpha$, determines the value of $F_{OFL}$ when B decreases to $\beta \cdot B_{MSY}$ and the rate at which $F_{OFL}$ decreases with decreasing values of B when $\beta \cdot B_{MSY} < B \le B_{MSY}$.
  - Larger values of $\alpha$ result in a smaller value of $F_{OFL}$ when B decreases to $\beta \cdot B_{MSY}$.
  - Larger values of $\alpha$ result in $F_{OFL}$ decreasing at a higher rate with decreasing values of B when $\beta \cdot B_{MSY} < B \le B_{MSY}$.

# Crab Plan Team Recommendations

Table 3 lists the team's recommendations for 2010/2011 on Tier assignments, model parameterizations, time periods for reference biomass estimation or appropriate catch averages, OFLs (for four stocks), and whether an OFL is applied to retained catch only or to all catch. The team recommends two stocks be placed in Tier 3 (EBS snow crab and Bristol Bay red king crab), five stocks in Tier 4 (EBS Tanner crab, St. Matthew blue king crab, Pribilof Island blue king crab, Pribilof Island red king crab and Norton Sound red king crab) and three stocks in Tier 5 (AI golden king crab, Pribilof Island golden king crab and Adak red king crab).

Stock status in relation to status determination criteria are evaluated in the September 2010 report. The team has general recommendations for all assessments and specific comments related to individual assessments. All recommendations are for consideration for the 2010 assessment cycle unless indicated otherwise. The general comments are listed below while the comments related to individual assessments are contained within the summary of plan team deliberations and recommendations contained in the stock specific summary section. Additional details regarding recommendations are contained in the Crab Plan Team Report (May 2010 CPT Reports).

## *General recommendations for all assessments*

The CPT is aiming to provide total catch OFLs. The male component of OFLs is based on the OFL control rule and relate directly to the sustainability of harvest relative to management benchmarks, i.e. $B_{MSY}$. The measure of what produces MSY on a continuing basis is mature male biomass ($B_{MSY}$ defined in terms of MMB). There is an inherent mis-match when considering female catch. When female catch is additive to mature male catch it represents what is expected from current fishing practices rather than a catch that would jeopardize the ability of the stock to achieve MSY on a continuing basis. This can lead to potentially undesirable outcomes. For example if a total catch OFL such as Tanner crab in 2010 is computed as the sum of males and female estimated losses at 2.0 metric tons with the breakout estimated at 1.76 tons of males and 0.24 of females, overfishing would not be designated to occur if more than the estimated fraction of males or females were caught such that the sum did not exceed 2.0 tons. This could allow for more males being extracted than have been estimated as sustainable based on the assessment without being considered overfishing and does not seem responsive to the intent of the overfishing definition.

The team discussed that each assessment should explain how the groundfish bycatch data is used in the assessment and that all assessment chapters should be consistent in how the groundfish bycatch data is used and which handling mortality rate is applied.

Each assessment should highlight the last three years in the harvest control rule plots

All ecosystem considerations sections should be removed from the assessments and transferred to the authors of the new ecosystem considerations chapter as they are all going to be folded into this chapter.

# Stock Status Summaries

## 1 Eastern Bering Sea Snow Crab

*Fishery information relative to OFL setting.*

The snow crab fishery has been opened, and harvest reported, every year since the 1960s. Prior to 2000, the GHL was 58% of abundance of male crab over 101 mm CW, estimated from the survey. The target harvest rate was reduced to 20% following the declaration of the stock as overfished in 1999, and the GHL/TAC since 2000 has been based on a rebuilding plan that aimed to allow recovery to a proxy for $B_{MSY}$. The stock remained below the proxy for $B_{MSY}$ ($B_{35\%}$) during the 2008/09 fishing year. Consequently, the current rebuilding plan failed to recover the snow crab stock within the required 10-year time period. A new rebuilding plan for EBS snow crab is currently under development.

*Data and assessment methodology*

The assessment is based on a size-structured population dynamics model in which crabs are categorized into mature, immature, new shell and old shell crabs by sex. The model is fitted to data on historical catches (landed and discard), survey estimates of biomass, and fishery, discard and survey size-composition data. It covers the 1978-2009 seasons and estimates abundance from 25-29mm to 130-135mm using 5mm size bins. The results of the annual Bering Sea bottom trawl survey are analyzed in three periods: before 1982, 1982-88, and 1989 onwards, with different selectivity and catchability parameters for each period. The model is based on the assumption of a terminal molt at maturity. The 2010 assessment differs from the 2009 assessment by including the revised EBS bottom trawl survey time-series, eliminating the over-weighting of the NMFS survey data, estimating the probability of maturing as a function of size, and estimating separate survey selectivity curves for males and females. The 2010 assessment included the BSFRF survey data (estimates of abundance and size-composition) in order to inform survey selectivity and catchability.

Seven models were presented in the assessment report. The CPT could not reach consensus on which model should form the basis for the September 2010 assessment of EBS snow crab (see CPT minutes for arguments for and against the two models considered viable alternatives). However, the bulk of the CPT recommends that the 2010 assessment be based on "Model 5" in which the parameters which determine growth and natural mortality are estimated within the model, but are subject to penalties based on auxiliary information. The remaining members recommended that the 2010 assessment be based on "Model 1" in which the parameters which determine growth and natural mortality are set to the values used in the 2009 assessment.

*Stock biomass and recruitment trends*

Mature male biomass (MMB at the time of mating) peaked between the late-1980s and mid-1990s, declined to a minimum in 2006 and has increased thereafter. The increase in mature male biomass has been greater than in mature female biomass. Recruitment has varied considerably over the period 1979-2009, with the recruitment (at 25mm) in 1991 the highest on record. Recent recruitment has been near or below average. The most recent assessment indicates that MMB never declined below the new definition of MSST.

*Tier determination/Plan Team discussion and resulting OFL determination*

The CPT recommends that EBS snow crab is a Tier 3 stock so the OFL will be based on the $F_{35\%}$ control rule. The team recommends that the proxy for $B_{MSY}$ ($B_{35\%}$) be the mature male biomass at mating, computed as the average recruitment from 1979 to the last year of the assessment multiplied by the mature male biomass-per-recruit corresponding to $F_{35\%}$ , less the mature male catch under an $F_{35\%}$ harvest strategy. The MSST is defined as half of the proxy for $B_{MSY}$. The assessment presented to the CPT will be updated by incorporating 2010 survey and fishery data into the base model to calculate the 2010/11 OFL and MSST.

*Historical status and catch specifications (millions lbs.) of snow crab*

| Year | MSST | Biomass (MMB) | TAC | Retained Catch | Total Catch | OFL |
|---|---|---|---|---|---|---|
| 2006/07 | | N/A | 36.2 | 36.4 | 44.9 | |
| 2007/08 | 158.9 | 218 | 63.0 | 63.0 | 77.1 | |
| 2008/09 | 163.4 | 241 | 58.6 | 58.5 | 69.5 | 77.3 |
| 2009/10 | TBD | TBD | 48.0 | TBD | TBD | 73.0 |
| 2010/11 | TBD | TBD | TBD | TBD | TBD | TBD |

Stock status determination relative to overfishing and overfished criteria will be made following review of an updated assessment that incorporates the 2010 survey data.

*Additional Plan Team recommendations*

The September 2010 assessment should (a) include the predictions from the May 2010 version of the model (models 1 and 5) to evaluate how well the model forecasts biomass, (b) document the basis for the standard deviations assumed for the penalties on the growth parameters, and (c) update the references.

The next assessment in May 2011 should: (a) include the model number in the table and figure captions if multiple models are presented, (b) further justify the values chosen for the weighting factors (the lambdas) and explore sensitivity to alternative weights, as outlined in the report of the 13-14 May 2009 stock assessment workshop, (c) explore whether it is possible to improve the residual patterns for the length-frequency data by modifying how maturity, growth and natural mortality are modeled and the implications of the change in distribution of the population over time, (d) consider reducing the number of size classes for females, (e) consider fitting to the discard length-frequency data for males rather than to the total length-frequency data for males (to avoid fitting to the retained length-frequency data twice), (f) explore the implications of not placing penalties on the growth and mortality parameters to determine what values for these parameters are preferred by the data, and (g) identify what changes need to be made to the model so that the model is able to fit all of the data adequately if survey selectivity is set to the "Somerton selectivity curve".

The CPT continues to support development of a spatially-structured stock assessment model so that the implications of differences in where the catch is taken and where the survey finds snow crab can be evaluated.

*Ecosystem Considerations summary*
No additional ecosystem considerations were included in the assessment at this time.

## 2 Bristol Bay red king crab

*Fishery information relative to OFL setting.*

The commercial harvest of Bristol Bay red king crab (BBRKC) dates to the 1930s, initially prosecuted mostly by foreign fleets but shifting to a largely domestic fishery in the early 1970s. Retained catch peaked in 1980 at 129.9 million lbs, but harvests dropped sharply in the early 1980s, and population abundance has remained at relatively low levels over the last two decades compared to that seen in the 1970s. The fishery is managed for a total allowable catch (TAC) coupled with restrictions for size (≥ 165.1mm (6.5-in) carapace width), sex (male only), and season (no fishing during mating/molting periods). Prior to 1990, the harvest rate was based on estimated population size and prerecruit and postrecruit abundances, and varied from 20% to 60% of legal males. In 1990, the harvest strategy became 20% of the mature male (≥120-mm CL) abundance, with a maximum of 60% on legal males, and a threshold abundance of 8.4 million mature females. The current stepped harvest strategy allows a maximum harvest rate of 15% of mature males but also incorporates a maximum harvest rate of 50% of legal males, a threshold of 14.5 million lbs of effective spawning biomass (ESB), and a minimum GHL of 4.0 million lbs to prosecute a fishery. The TAC increased from 15.5 million lbs for the 2006/07 season to 20.4 million lbs for the 2007/08 and 2008/09 seasons, then declined to 16.0 million lbs for 2009/2010. Catch of legal males per pot lift was relatively high in the 1970s, low in the 1980s to mid-1990's. Following implementation of the crab rationalization program in 2005, CPUE increased to 31.0 crab/pot in 2006, but fell to 21.0 crab/pot in 2009. Annual non-retained catch of female and sublegal male RKC during the fishery averaged less than 3.9 million lbs since data collection began in 1990. Estimated fishing mortality ranged from 0.28 to 0.38$yr^{-1}$ following implementation of crab rationalization. Total catch (retained and bycatch mortality) increased from 17.2 million lbs in 2006/07 to 23.2 million lbs in 2007/08 and 23.1 million lbs in 2008/09.

*Data and assessment methodology*

The stock assessment model is based on a length-structured population dynamics model incorporating data from the eastern Bering Sea trawl survey, commercial catch, and at-sea observer data program. Stock abundance is estimated for male and female crabs ≥ 65-mm carapace length during 1968-2009, an extension from the previous assessment that considered the years 1985-2008. Catch data (retained catch numbers, retained catch weight, and pot lifts by statistical area and landing date from the fishery which targets males ≥ 165.1mm (6.5 in) carapace width) were obtained from ADF&G fish tickets and reports, red king crab and Tanner crab fisheries bycatch data from the ADF&G observer database, and groundfish trawl bycatch data from the NMFS trawl observer database. Catch and bycatch data were updated to May 2010. Several other changes to the assessment, included re-analysis of the trawl survey data based on revised estimates of the area-swept from 1975 to 2009, and allowances for changes over time in the size at maturity for females, and mortality. The author evaluated nine model scenarios, including a model similar to the base model from the 2009 assessment. Additional model scenarios included variations in: (1) additional mortality for males and females in either 1980-84, 1976-79 and 1985-93, or additional bycatch mortality in 1980-84; (2) inclusion of the Bering Sea Fisheries Research Foundation (BSFRF) survey data for 2007 and 2008; and (3) estimation of male molting probabilities. A natural mortality of 0.18$yr^{-1}$ was assumed, with additional "unexplained" mortality for males and females in specific scenarios.

*Stock biomass and recruitment trends*

Model estimates of total survey biomass increased from 177.2 million lbs in 1968 to 721.1 million lbs in 1978, fell to 66.3 million lbs in 1985, generally increased to 202.6 million lbs in 2008, and declined to 196.5 million lbs in 2009. Mature male biomass at mating increased from 63.3 million lbs in 2004 to 95.2 million lbs in 2009. Estimated recruitment was high during the 1970s and early 1980s and has been generally low since 1985. During 1985-2009, estimated recruitment was higher than the historical average in 1995, 2002, and 2005. Estimated recruitment was extremely low during the last 3 years.

*Tier determination/Plan Team discussion and resulting OFL determination*

This assessment showed improvement in exploring the use of the data that are available, and model sensitivity to inclusion of various data. In the absence of additional diagnostics, the CPT supports the use of scenario 3 [constant natural mortality (0.18), estimation of additional natural mortality for males during 1980-1984 for females during 1976-1993, BSFRF data], and recommends that the variance for the BSFRF data be selected to ensure that the estimates and model predictions are consistent.

The Plan Team recommends Bristol Bay red king crab as a Tier 3 stock. The team recommends that the proxy for $B_{MSY}$ ($B_{35\%}$) be the mature male biomass at mating, computed as the average recruitment from 1995 to the last year of the assessment multiplied by the mature male biomass-per-recruit corresponding to $F_{35\%}$ less the mature male catch under an $F_{35\%}$ harvest strategy. Estimated $B_{35\%}$ is 68.5 million lbs. Total catch includes retained male catch and all other bycatch sources.

*Status and catch specifications (millions lbs.) of Bristol Bay red king crab*

| Year | MSST | Biomass (MMB) | TAC | Retained Catch | Total Catch | OFL |
|---|---|---|---|---|---|---|
| 2006/07 | | NA | 15.53 | 15.75 | 17.22 | |
| 2007/08 | 44.8 | 85.9 | 20.38 | 20.51 | 23.23 | |
| 2008/09 | 37.6 | 87.8 | 20.37 | 20.32 | 23.10 | 24.20 |
| 2009/10 | 34.3 | 95.2[A] | 16.0 | 16.0 | TBD | 22.56 |
| 2010/11 | TBD | TBD | TBD | TBD | TBD | TBD |

A- Model forecast based on the 2009 assessment under the assumption that the 2009/10 catch equals to the OFL. This value will be updated during the September 2010 assessment when the 2010 survey data and the 2009/10 catch data become available.

Stock status determination relative to overfishing and overfished criteria will be made following review of an updated assessment that incorporates the 2010 survey data.

*Additional Plan Team recommendations*

The CPT noted some inconsistencies in data trends (e.g., BSFRF fit in Fig. 12c of mature male abundance), although the apparent magnitude of these differences may also represent different scaling in the presentation of the results. It was also cautioned that improved model fit attributed to additional mortality factors could be readily attributed to mortality sources other than the bycatch discard that are assumed in some model scenarios. The team noted that detailed results for many of the scenarios (e.g., molting probabilities for scenarios 6 and 7) were not presented in the document. Additional diagnostics, such as bubble plots, would facilitate evaluation of the different scenarios. The lack of detailed results limits the ability of the CPT to evaluate the scenarios.

CPT looks forward to a revision in May 2011 that addresses previous CPT and SSC comments that were not addressed in this assessment (likelihood profiles, Bayesian approach, effective sample sizes, CIE comments).

The CPT will review alternative definitions for $B_{MSY}$ time frames. The assessment author should provide alternatives and comment on the appropriateness of each.

*Ecosystem Considerations summary*

Ecosystem considerations for this stock were not discussed by the CPT.

## 3 Eastern Bering Sea Tanner crab

*Fishery information relative to OFL setting.*

Two fisheries, one east and one west of 166° W. longitude, harvest eastern Bering Sea (EBS) Tanner crab. Under the Crab Rationalization Program, ADF&G sets separate TACs and NMFS issues separate individual fishing quota (IFQ) for these two fisheries. However, one OFL is set for EBS Tanner crab. Both fisheries were closed from 1997 to 2005 due to low abundance. NMFS declared this stock overfished in 1999 and the Council developed a rebuilding plan. In 2005, abundance increased to a level to support a fishery in the area west of 166° W. longitude. ADF&G opened both fisheries for the 2006/07 to 2008/09 crab fishing years, but only the area east of 166° W. longitude opened in 2009/10. In 2007, NMFS determined the stock was rebuilt because spawning biomass was above $B_{MSY}$ for two consecutive years. However, annual harvests have declined steadily since 2007 as subsequent TACs have been reduced in response to declining stock biomass.

Tanner crab are caught as bycatch in the directed Tanner crab fishery (principally as non-retained females and sublegal males), in other crab fisheries (notably, eastern Bering Sea snow crab and Bristol Bay red king crab), in the groundfish fisheries, and in the scallop fishery.

*Data and assessment methodology*

This stock is surveyed annually by the NMFS EBS trawl survey. The current stock assessment model includes the entire EBS stock area. Area-swept estimates of mature male biomass (MMB), legal male biomass (LMB), and female biomass are derived from the EBS trawl survey data, revised for survey net width. Fish ticket data are used to compute retained catch, and observer data from the crab and groundfish fisheries are used to estimate the non-retained catch; assumed handling mortality rates for fishery components are used to estimate the discard mortality.

A length-based Tanner crab stock assessment model (TCSAM) is being developed; model updates were presented to the CPT in March 2010 and the SSC in April 2010, but not in May 2010. The new model will likely play a significant role in the development of a rebuilding plan; rebuilding plan timing was discussed. The CPT would potentially be reviewing a preliminary rebuilding plan next May. Because a new assessment model should be one of the alternatives in that plan, and a new model will likely need some adjustments, it will be important to have some assessment model review in September 2010.

*Stock biomass and recruitment trends*

MMB and LMB showed peaks in the mid-1970s and early 1990s. MMB at the survey revealed an all-time high of 623.9 million pounds in 1975, and a second peak of 255.7 million pounds in 1991. From late-1990s through 2007, MMB increased at a moderate rate from 25.1 million lbs in 1997. After 1997, MMB at the time of survey increased to 185.2 million pounds in 2007 and subsequently decreased to 77.1 million pounds in 2009. Survey estimated biomass of legal males declined 51% from 2008 to 2009.

*Tier determination/Plan Team discussion and resulting OFL determination*

The team recommends the OFL for this stock be based on the Tier 4 control rule because an assessment model to move the entire EBS stock into a Tier-3 is still being developed. The team recommends that $B_{MSY}$ is based on the average MMB for the years 1969-1980, discounted by fishery removals (retained and non-retained mortalities) and natural mortality between the time of survey and the time of mating. This time period is thought to represent the reproductive potential of the stock because it encompasses periods of both high and low stock status. The team recommends that gamma be set to 1.0.

*Historical status and catch specifications (millions lbs) for eastern Bering Sea Tanner crab*

| Year | MSST | Biomass (MMB) | TAC (east + west) | Retained Catch | Total Catch | OFL |
|---|---|---|---|---|---|---|
| 2006/07 | | 130.46 | 2.97 | 2.12 | 6.95 | |
| 2007/08 | | 151.58 | 5.62 | 2.11 | 8.00 | |
| 2008/09 | 94.88 | 118.20 | 4.30 | 1.94 | 4.96 | 15.52 |
| 2009/10 | 94.88 | 62.28[A] | 1.85[B] | TBD | TBD | 5.57 |
| 2010/11 | 92.37[C] | TBD | TBD | TBD | TBD | TBD |

A- Projected 2009/10 MMB at time of mating after extraction of the estimated total catch OFL.
B- Only the area east of 166 deg. W opened in 2009/10; TAC was 1.85 million lbs.
C- Now based on the revised historical bottom trawl survey data.

Total catch for 2009/10 (TBD) was less than/more than the 2009/10 OFL (5.57 million lbs), so overfishing did/did not occur during 2009/10. It is estimated that the Tanner crab stock will be in an overfished condition after final accounting for losses from the 2009/2010 fisheries and M from the survey to mating. The May 2010 assessment estimates a likely upper limit on MMB at time of mating; it is apparent that the stock was below the MSST during the 2009 survey, the 2009/10 fishery, and at 2010 mating, although a formal determination of the stock being overfished will occur with the Fall 2010 assessment.

*Ecosystem Considerations summary*

Ecosystem considerations for this stock have been moved to the ecosystem chapter and were not discussed by the CPT.

## 4 Pribilof Islands red king crab

*Fishery information relative to OFL setting*

There is no harvest strategy for this fishery in State regulation. The fishery began as bycatch in 1973 during the blue king crab fishery. A red king crab fishery opened with a specified GHL for the first time in September 1993. The 1993/94 fishery yielded1,179 t under a 1,542 t GHL, with the highest catches occurred east of St. Paul Island, but harvests also south, southwest, west, and northeast of St.Paul Island. The 1994 fishery was also prosecuted with a specified red king crab GHL. Since 1995, a combined GHL for red and blue king crabs was set and ranged from 567 to 1,134 t. The fishery has remained closed since 1999 because of uncertainty with estimated red king crab survey abundance and concerns for incidental catch and mortality of blue king crab, an overfished and very depressed stock. Prior to the closure, the CDQ harvest (3.5%) in 1998/99 was 16 t. The non-retained catches (without application of bycatch mortality rate) from pot and groundfish bycatch estimates of red king crab ranged from 50 to 86 t during 1991/92 – 2008/09.

*Data and assessment methodology*

Although a catch survey analysis has been used for assessing the stock in the past, which incorporated data from the eastern Bering Sea trawl survey, commercial catch, pot survey, and at-sea observer data; for this assessment, trends in MMB at mating are based on NMFS annual trawl survey estimates for 1980-2010 and incorporated commercial catch and observer data. The revised NMFS trawl survey historical abundance estimates were used in this assessment. The 2009/2010 assessments of non-retained catch from all groundfish fisheries are included in this SAFE report. Groundfish catches of crab are reported for all crab combined by federal reporting areas. Catches from observed fisheries were applied to non-observed fisheries to estimate a total catch. For 2010 reference points' estimation, an $F_{OFL}$ is determined using a mean mature male biomass (MMB) at the time of mating (projected to mating time), the default $\gamma$ value of 1, and an $M$ value of 0.18$yr^{-1}$. The stock assessment analyzes two time period options for estimating mean MMB as a proxy $B_{MSY}$, 1991-2009, the recommended period, and 1980-2009, for comparison purposes. This $F_{OFL}$ is applied to the projected legal male biomass at the time of the fishery to determine the catch OFL. Total crab removal (retained, and directed and non-directed bycatch losses) with legal male biomass and MMB are used to estimate the exploitation rates on legal male and mature male biomasses, respectively, at the time of the fishery.

*Stock biomass and recruitment trends*

The stock exhibited widely varying mature male and female abundances during 1980-2009. The estimate of MMB from the 09 survey was 2,023 t; the estimate from the 2010 survey was not available.. Recruitment indices are not well understood for Pribilof red king crab. Pre-recruitment have remained relatively consistent in the past 10 years, although may not be well assessed with the survey. Stock biomass in recent years has decreased since the 2007 survey with a substantial decrease in all size classes in 2009 and this will be updated for 2010. Red king crabs have been historically harvested with blue king crabs and are currently the dominant of the two species in this area.

*Tier determination/Plan Team discussion and resulting OFL determination*

This stock is recommended to be in Tier 4. The CPT recommends that $\gamma$ be set to 1.0.

*Historical status and catch specifications (million pounds) of Pribilof Islands red king crab*

| Year | MSST | Biomass (MMB) | TAC | Retained Catch | Total Catch | OFL |
|---|---|---|---|---|---|---|
| 2006/07 | | 13.87 | Closed | 0 | 0.024 | |
| 2007/08 | 4.33 | 14.70$^{A}$ | Closed | 0 | 0.008 | |
| 2008/09 | 4.39 | 11.06$^{B}$ | Closed | 0 | 0.021 | 3.32 |
| 2009/10 | TBD | TBD$^{C}$ | Closed | 0 | TBD | 0.50 |
| 2010/11 | TBD | TBD$^{D}$ | TBD | TBD | TBD | TBD |

A – Based on survey data available to the Crab Plan Team in September 2007 and updated with 2007/2008 catches
B – Based on survey data available to the Crab Plan Team in September 2008 and updated with 2008/2009 catches
C – Based on survey data available to the Crab Plan Team in September 2009 and updated with 2009/2010 catches
D – Based on survey data available to the Crab Plan Team in September 2010

Stock status determination relative to overfishing and overfished criteria will be made following review of an updated assessment that incorporates the 2010 survey data.

*Additional plan team recommendations*

The plan team looks forward to the presentation of the CSA model in September.

*Ecosystem Considerations summary*

This section was removed from the assessment and will be incorporated into the crab ecosystem considerations chapter for September 2010 distribution.

## 5 Pribilof District blue king crab

*Fishery information relative to OFL setting.*

The Pribilof blue king crab fishery began in 1973, with peak landing of 11.0 million lbs in the 1980/81 season. A steep decline in landings occurred after the 1980/81 season. Directed fishery harvest from 1983 until 1987 was annually less than 1.0 million lbs with low CPUE. The fishery was closed in 1988 until 1995. The fishery reopened from 1995 to 1998. Fishery harvests during this period ranged from 1.3 to 0.5 million lbs. The fishery closed again in 1999 due to declining stock abundance and has remained closed through the 2009/10 season. The stock was declared overfished in 2002.

*Data and assessment methodology*

The NMFS conducts an annual trawl survey that is used to produce area-swept abundance estimates. In 2009 NMFS updated the trawl survey time series resulting in a minor adjustment in current and historical survey biomass and a minor adjustment in the $B_{MSY}$ calculation. This assessment uses the new survey data series with measured net widths. The CPT discussed the history of the fishery and the rapid decline in landings. It is clear that the stock has collapsed, although the annual area-swept abundance estimates are imprecise.

*Stock biomass and recruitment trends*

Based on 2009 NMFS bottom-trawl survey, the estimated total mature-male biomass increased to 1.28 million lbs from 0.29 million lbs in 2008. However, the 2009/10 MMB at mating is projected to be 1.13 million lbs which is about 12% of $B_{MSY}$. The Pribilof blue king crab stock biomass continues to be low. From recent surveys there is no indication of recruitment.

*Tier determination/Plan Team discussion and resulting OFL determination*

This stock is recommended for placement into Tier 4. The time period for $B_{MSY}$ is 1980/81-1984/85 plus 1990/1991-1997/1998, excluding the period 1985/1986-1989/1990. This range was chosen because it eliminates periods of extremely low abundance that may not be representative of the production potential of the stock. $B_{MSY}$ is estimated as 8.99 million pounds.

The CPT recommended $\gamma = 1$, given the absence of information presented to establish an alternate value at this time. Natural mortality was $M=0.18yr^{-1}$.

*Historical status and catch specifications (million lbs.) of Pribilof blue king crab in recent years.*

| Year | MSST | Biomass (MMB) | TAC | Retained Catch | Total Catch | OFL |
|---|---|---|---|---|---|---|
| 2006/07 | | 0.33 | closed | 0 | 0.0004 | |
| 2007/08 | | 0.66 | closed | 0 | 0.005 | |
| 2008/09 | 4.64 | 0.25 | closed | 0 | 0.001 | 0.004 |
| 2009/10 | 4.64 | TBD | closed | 0 | TBD | 0.004 |
| 2010/11 | TBD | TBD | TBD | TBD | TBD | TBD |

Stock status determination relative to overfishing and overfished criteria will be made following review of an updated assessment that incorporates the 2010 survey data.

*Additional Plan Team recommendations*

A revised rebuilding plan is under development. Initial review of this analysis will occur at the October 2010 Council meeting. The team's comments on the preliminary review draft are contained in the Crab Plan Team report from March 2010.

*Ecosystem Considerations summary*

This section was removed from the assessment and will be incorporated into the crab ecosystem considerations chapter for September 2010 distribution.

# 6 St. Matthew blue king crab

*Fishery information relative to OFL setting*

The St. Matthew Island fishery developed when 10 U.S. vessels harvested 1.202 million pounds in 1977/78. Harvests peaked in 1983/84 when 9.454-million pounds were landed. From 1986/87 to 1990/91 the fishery was fairly stable, with a mean annual harvest of 1.252-million pounds. The mean catch increased to 3.297-million pounds during 1991-1998. This fishery was declared overfished and closed in 1999 when the stock size estimate was below the minimum stock size threshold (MSST) of 11.0 million pounds as defined by the Fishery Management Plan for the Bering Sea/Aleutian Islands King and Tanner crabs (NPFMC 1998). In November of 2000, Amendment 15 to the FMP for the Bering Sea/Aleutian Islands King and Tanner crabs was approved to implement a rebuilding plan for St. Matthew Island blue king crab stock. The rebuilding plan included a harvest strategy established in regulation by the Alaska Board of Fisheries and area closures to control bycatch as well as gear modifications and an area closure for habitat protection. Since 1999, the abundance estimates calculated from the National Marine Fisheries Service (NMFS) annual eastern Bering Sea shelf survey data have not met the rebuilding plan's harvest strategy threshold or minimum TAC, although 2006 and 2007 abundance estimates, 11.2-and 15.6-million pounds respectively, were above MSST and the stock is considered rebuilding (Bowers et al. 2008). The fishery was closed during 1999/00-2008/09 and re-opened in 2009/10 with a TAC of 1.167-million pounds and 0.461-million pounds of retained catch were harvested. Commercial crab fisheries near St. Matthew Island were scheduled in the fall and early winter to reduce the potential for bycatch from handling mortalities due to molting and mating crabs. Some bycatch has been observed of non-retained St. Matthew blue king crab in the St. Matthew blue king crab fishery, the eastern Bering Sea snow crab fishery, and groundfish fisheries. Based on limited observer data, bycatch of sublegal male and female crabs from the directed blue king crab fishery off St. Matthew Island was relatively high when the fishery was prosecuted in the 1990s, and total bycatch (in terms of number of crabs captured) was often twice as high or higher than total catch of legal crabs.

*Data and assessment methodology*

Assessment data are from three sources: 1) fishery effort and catch data; 2) trawl survey data; and pot survey data. Fishery effort and catch data are the vessel numbers, potlifts, catch number and weight, and CPUE for the directed pot fishery; total annual retained catches (including deadloss) were used in the catch-survey analysis. Trawl survey data are from the 1978–2009 NMFS annual summer trawl survey for stations within the St. Matthew Section. Survey design within that area changed between 1982 and 1983 in the number and density of tows; since 1983 the tows in that area are divided into a low-density strata and a high-density strata. Trawl gear used in the NMFS survey changed between 1980 and 1981. Trawl survey data provided estimates of density (number/nm$^2$) at each station for males in four size and shell-condition categories that were used in the assessment: 105–119 mm carapace length (CL); 90–104 mm CL; new-shell 120–133 mm CL; and old-shell ≥120 mm CL and newshell ≥134 mm CL) males. Pot survey data are from the July–August 1995, 1998, 2001, 2004 and 2007 ADF&G triennial pot surveys for Saint Matthew Island blue king crab, which sample from areas of important habitat for blue king crab, particularly females, that the NMFS trawl survey cannot sample from. Data used are from only the 96 stations fished in common in each of the five surveys. The CPUE (catch per pot lift) indices from those 96 stations for the male sex and shell-condition categories listed above were used in the assessment.

A four-stage catch-survey analysis (CSA) is used to assess abundance. Annual abundance of male crabs in the four size and shell-condition categories listed above (representing prerecruit-2s, prerecruit-1s, recruits, and postrecruits, respectively) is modeled by the CSA. The CSA model links the crab abundances in four stages in year $t+1$ to the abundances and catch in the previous year through natural mortality, fishing mortality, molting probability, and a growth matrix. Five scenarios of the CSA model were developed for the assessment, differing in whether parameters for natural mortality or trawl survey selectivity are fixed (estimated independently) or conditionally and whether natural mortality is constant or variable with time.

*Stock biomass and recruitment trends*

Based on data through 2009/10 and modeled by the "Scenario 1" assessment model, the stock is estimated to have been above BMSY during 2008/09 and 2009/10. Numbers of legal males, post-recruit-sized legal males, and mature male biomass and abundance (numbers of crabs) are estimated to have increased since 1999/00 and, especially, since 2005/06 through 2009/10. Numbers of recruit-sized legal males and pre-recruit-1-sized sublegal males are estimated to have increased during 2005/06–2009/10. Numbers of pre-recruit-2-sized sublegal males and recruits to the modeled male size class are estimated to have increased during 2004/05–2008/09, but their numbers, especially those of the recruits to the modeled male size class, are estimated to have decreased in 2009/10.

*Tier determination/Plan Team discussion and resulting OFL determination*

The CPT recommends that the stock be in Tier 4 with gamma =1 used for calculating $F_{OFL}$. The author recommended using the Scenario 1 model (i.e., same as used for 2009/10, with M fixed at 0.18 for 1978–1998, 2000–2009 and estimated for 1999 and Q fixed at 1.0). The CPT agrees and recommends using the Scenario 1 model, updated with the 2010 survey data and 2009/10 bycatch data for computing the OFL for 2010/11.

*Status and catch specifications (millions lbs.)*

| Year | MSST | Biomass (MMB) | TAC | Retained Catch | Total Catch | OFL |
|---|---|---|---|---|---|---|
| 2006/07 | | 7.1[A] | closed | closed | 0.66 | |
| 2007/08 | | 9.7[B] | closed | closed | 0.35 | |
| 2008/09 | 4.0 | 10.74[C] | closed | closed | 0.20 | 1.63 (retained) |
| 2009/10 | 4.0 | TBD | 1.167 | 0.461 | TBD | 1.72 total male catch |
| 2010/11 | TBD | TBD | TBD | TBD | TBD | TBD total male catch |

A – Calculated from the assessment reviewed by the Crab Plan Team in September 2007
B – Calculated from the assessment reviewed by the Crab Plan Team in September 2008
C – Calculated from the assessment reviewed by the Crab Plan Team in September 2009

Stock status determination relative to overfishing and overfished criteria will be made following review of an updated assessment that incorporates the 2010 survey data.

*Additional Plan Team recommendations*

For the September assessment, the author should: (1) on page 19, that says "the mean bycatch", clarify that the calculation of OFL uses the mean fishing mortality of bycatch; (2) clarify the subcomponents of bycatch mortality (i.e., to fixed gear versus trawl gear for groundfish fishery bycatch); (3) add a table that shows the annual trawl and fixed-gear bycatch, and (4) up-date the text to include most recent year and current status of the stock.

For the September assessment, the author should: (1) justify weights used in log likelihood computation (e.g., lambda = 100 for retained catch); (2) report CVs in table on pot survey data; and (3)report whether any model parameter estimates are hitting parameter bounds (e.g., trawl fishery mortality), possibly by widening the bounds.

The team also requests that ADF&G review the pot survey data, particularly for overestimation of recruit class (possible misclassification of recruit class).

*Ecosystem Considerations summary*

The stock assessment contains a comprehensive ecosystem considerations section. This section should be folded into the new ecosystem considerations chapter.

# 7 Norton Sound Red King Crab

*Fishery information relative to OFL setting*

This stock supports three main fisheries: summer commercial, winter commercial, and winter subsistence fisheries. The summer commercial fishery, which accounts for the majority of the catch, reached a peak in the late 1970s at a little over 2.9 million pounds retained catch. Retained catches since 1982 have been below 0.5 million pounds, averaging 275,000 pounds, including several low years in the 1990s. Retained catches in the past two years have been about 400,000 pounds.

*Data and assessment methodology*

Four types of surveys have been conducted periodically during the last three decades: summer trawl, summer pot, winter pot, and preseason summer pot, but none of these surveys were conducted every year. To improve abundance estimates, Zheng et al. (1998) developed a length-based stock synthesis model of male crab abundance that combines multiple sources of survey, catch, and mark-recovery data from 1976 to 1996. A maximum likelihood approach was used to estimate abundance, recruitment, and catchabilities of the commercial pot gear. We updated the model with data from 1976 to 2010 and estimated population abundance in 2010. Estimated abundance and biomass in 2010 are dependent on the choice of natural mortality (*M*).

*Stock biomass and recruitment trends*

Mature male biomass is estimated to be on an upward trend following a recent low in 1997 and an historic low in 1982 following a crash from the peak in 1977. Estimated recruitment was weak during the late 1970s and high during the early 1980s with a slight downward trend from 1983 to 1993. Estimated recruitment has been highly variable but on an increasing trend in recent years. Uncertainty in biomass is driven in part by infrequent trawl surveys (every 3 to 5 years).

*Tier determination/Plan Team discussion and resulting OFL determination*

The team recommended Tier 4 stock status for Norton Sound red king crab. The team reviewed 7 different models. The Team recommended model 6 for OFL determination in 2010. This model included an estimation of bycatch mortality in the directed fishery, changed the weight on the fishing effort data, increased M to 0.288 for the largest length bin, and assumed flat selectivity for the summer fishery. The estimated abundance and biomass in 2010 are:

Legal males: 1.6940 million crabs with a standard deviation of 0.1892 million crabs.
Mature male biomass: 5.4410 million lbs with a standard deviation of 0.6284 million lbs.
Average of mature male biomasses during 1983-2010 was used as the *BMSY* proxy and the CPT chose gamma = 1.0 to derive the *FMSY* proxy.
Estimated *BMSY* proxy, *FMSY* proxy and retained catch limit in 2010 are:
*BMSY* proxy = 3.1173 million lbs,
*FMSY* proxy = 0.18,
Retained catch limit: 0.2791 million crabs or 0.7335 million lbs.

*Status and catch specifications (millions lbs.)*

| Year | MSST | Biomass (MMB) | GHL | Retained Catch | Total Catch | OFL |
|---|---|---|---|---|---|---|
| 2006 | | 3.62 | 0.45 | 0.45 | 0.48 | |
| 2007 | | 4.40 | 0.32 | 0.31 | | |
| 2008 | 1.78 | 5.24[A] | 0.41 | 0.39 | | 0.68[A] |
| 2009 | 1.54 | 5.83[B] | 0.37 | 0.40 | TBD | 0.71[B] |
| 2010 | 1.56 | 5.44[C] | TBD | TBD | TBD | 0.73[C] |

A – Calculated from the assessment reviewed by the Crab Plan Team in May 2008
B – Calculated from the assessment reviewed by the Crab Plan Team in May 2009
C – Calculated from the assessment reviewed by the Crab Plan Team in May 2010

Stock status determination relative to overfishing in 2009 will be made in September with total catches tabulated for the 2009 season. Stock biomass is above MSST thus the stock is not overfished.

*Additional Plan Team recommendations*

While the CPT recommended Model 6 (given that no operational differences between Model 2/Model 6), in future iterations, the team recommends improved rationale for model specifications. Other requested changes and modification for the next assessment include:
Figure 3: include CVs for final version, and noted that apparent CV is .16, which is better than for other stocks;
Figure 7: (Applies to all chapters) Use different symbols for last two years to make visible;
Figure 11: Recommend showing CPUE trend and add XY plot of observed and predicted CPUE.
Figure 5, (residuals of length compositions in the winter pot survey and summer fishery): authors should consider time-varying selectivity and investigate reasons for break points in time series.
The authors should also provide a clearer explanation for OFL result and apportionment of OFL between directed catch, bycatch, and discard, noting that although observer data in directed fishery not available, fixed gear bycatch data is available. It would be useful to plot time series trajectories from each model. Authors should explore higher weight on fit to fishery effort and perform and present sensitivity analysis of alternative weighting of survey sources

*Ecosystem Considerations summary*
No additional ecosystem considerations were included in the assessment at this time.

## 8 Aleutian Islands golden king crab

*Fishery information relative to OFL setting*

The directed fishery has been prosecuted annually since the 1981/82 season. Retained catch peaked during the 1985/86–1989/90 seasons (average catch of 11.9 million lbs), but average harvests dropped sharply from the 1989/90 to 1990/91 season to an average harvest of 6.9 million lbs. for the period 1990/91–1995/96. Management based on a formally established GHL began with the 1996/97 season. The 5.9 million lb. GHL, based on the previous five-year average catch, was subsequently reduced to 5.7-million lbs beginning with the 1998/99 season. The GHL (or TAC, since the 2005/06 season) remained at 5.7 million lbs through the 2007/08 season. In March 2008 the Alaska Board of Fisheries set the TAC for this stock in regulation at 5.985 million pounds. Average retained catch for the period 1996/97–2008/09 was 5.6 million lbs, including 5.68 million lbs in the 2008/09 season. This fishery is rationalized under the Crab Rationalization Program.

*Data and assessment methodology*

An assessment model is currently being developed for this stock. Available data are from ADF&G fish tickets (retained catch numbers, retained catch weight, and pot lifts by ADF&G statistical area and landing date), size-frequency data from samples of landed crabs, at-sea observer data from pot lifts sampled during the fishery (date, location, soak time, catch composition, size, sex, and reproductive condition of crabs, etc), data from a triennial pot survey in the Yunaska-Amukta Island area of the Aleutian Islands (approximately 171° W longitude), recovery data from tagged crabs released during the triennial pot surveys and bycatch data from the groundfish fisheries. These data are available through the 2008/09 season and the 2006 triennial pot survey. Most of the available data were obtained from the fishery which targets legal-size (≥6-inch CW) males and trends in the data can be affected by changes in both fishery practices and the stock. The triennial survey is too limited in geographic scope and too infrequent to provide a reliable index of abundance for the Aleutian Islands area. A triennial survey was scheduled for 2009, but was cancelled.

*Stock biomass and recruitment trends*

Estimates of stock biomass are not available for this stock. Estimates of recruitment trends and current levels relative to virgin or historic levels are not available. However, there is good evidence that the sharp increase in CPUE of retained legal males during recent fishery seasons was not due to a sharp increase in recruitment of legal-size males, but rather to changes in fishing practices (i.e. longer soak times).

*Tier determination/Plan Team discussion and resulting OFL determination*

AIGKC is recommended for Tier 5 stock in 2010/11. $B_{MSY}$ and MSST are not estimated for this stock. Observer data on bycatch from the directed fishery and groundfish fisheries can provide estimates of total bycatch mortality for years after the 1996/97 season. For other time periods under consideration there are no directed fishery observer data prior to the 1988/89 season and observer data are lacking or confidential for four seasons in at least one management area in the Aleutian Islands during 1988/89–1994/95.

During the May 2010 CPT meeting, the CPT recommended that a total-catch OFL be established for the 2010/11 Aleutian Islands golden king crab season. The CPT requested that the total-catch OFL be computed according to three different alternatives for consideration:

1. $OFL_{TOT(1)} = (1+RATE_{05/06\text{-}08/09})\cdot OFL_{RET(85/86\text{-}95/96)} + MGF_{96/97\text{-}08/09}$
2. $OFL_{TOT(2)} = (1+RATE_{96/97\text{-}04/05})\cdot OFL_{RET(85/86\text{-}95/96)} + MGF_{96/97\text{-}08/09}$
3. $OFL_{TOT(3)}$ = Average of total catch for all components in Table 4 in assessment.

where:

$(RATE_{05/06\text{-}08/09})$ = mean of annual Rate = (bycatch mortality in crab fisheries)/(retained catch) over the period 2005/06–2008/09,

$(RATE_{96/97\text{-}04/05})$ = mean of annual Rate = (bycatch mortality in crab fisheries)/(retained catch) over the period 1996/97–2004/04,

$OFL_{RET(85/86\text{-}95/96)}$ = mean of annual retained catch over the period 1985/86–1995/96, and

$MGF_{96/97-08/09}$ = mean of annual bycatch mortality in groundfish fisheries over the period 1996/97–2008/09.

Note that $OFL_{RET(85/86-95/96)}$ is the retained-catch OFL that was established for the 2008/09 and 2009/10 Aleutian Islands golden king crab seasons, 9.18-million pounds.

Should the SSC chose to employ a methodology such as proposed under alternatives 1, 2 or 3 to establish a total catch OFL for the 2010/11 season more detailed information and resulting total catch OFLs under each scenario have been provided in the Crab Plan Team Report. The options above result in the following total catch OFLs in millions of pounds:

| $OFL_{TOT(1)}$ | $OFL_{TOT(2)}$ | $OFL_{TOT(3)}$ |
|---|---|---|
| 10.1-million pounds | 11.5-million pounds | 6.8-million pounds |

*Historical status and catch specifications (millions lbs.) of Aleutian Islands golden king crab*

| Year | MSST | Biomass (MMB) | TAC | Retained Catch | Total Catch | OFL (retained) |
|---|---|---|---|---|---|---|
| 2005/06 | NA | NA | 5.70 | 5.52 | 6.0 | |
| 2006/07 | NA | NA | 5.70 | 5.22 | 5.8 | |
| 2007/08 | NA | NA | 5.70 | 5.51 | 6.2 | |
| 2008/09 | NA | NA | 5.99 | 5.68 | 6.3 | 9.18 [retained] |
| 2009/10 | NA | NA | 5.99 | TBD | TBD | 9.18 [retained] |
| 2010/11 | NA | NA | TBD | TBD | TBD | TBD [total catch] |

No overfished determination is possible for this stock given the lack of biomass information. Stock status determination relative to overfishing for 2009/10 will be made in September when total catches for the 2009/10 season are tabulated..

*Additional Plan Team recommendations*

In May 2010, the plan team reviewed a new stock assessment model for Aleutian Islands golden king crab (Chapter 8b, Draft May Crab SAFE report). Use of an assessment model could allow for this stock to be moved to Tier 4 and would provide focus for establishing research and data collection priorities. The team believes that the model has been improved greatly from the 2009 iteration. The team recommends incorporation of plan team comments into the model for the September 2010 plan team meeting but did not recommend adopting the model for OFL determination in this year. Specific comments on model suggestions are contained in the May Crab Plan Team report.

*Ecosystem Considerations summary*

An ecosystem discussion is included in the assessment and is focused on fishery effects on the ecosystem.

## 9 Pribilof Islands golden king crab

*Fishery information relative to OFL setting*

The Pribilof District fishery for male golden king crab ≥ 5.5 in carapace width (≥ 124 mm carapace length) developed in the 1981/82 season. The directed fishery mainly occurs in Pribilof Canyon of the continental slope. Peak directed harvest is 856-thousand pounds during the 1983/84 season. Historical fishery participation has been sporadic and retained catches variable. The current fishing season is a calendar year. Since 2000, the fishery was managed for a guideline harvest level (GHL) of 0.15 million pounds. Non-retained bycatch occurs in the directed fishery as well as Bering Sea snow crab, Bering Sea grooved Tanner crab, and Bering Sea groundfish fisheries. Estimated total fishing mortality in crab fisheries averages 68-thousand pounds (2002-2009). Crab mortality in groundfish fisheries (July 1–June 30, 1991/92–2008/09) averages 3-thousand pounds. There has been no participation in the directed fishery from 2006 through 2009. Pribilof District golden king crab was not included in the Crab Rationalization Program.

*Data and assessment methodology*

Total golden king crab biomass has been estimated during NMFS upper-continental-slope trawl surveys in 2002, 2004, and 2008. There is no assessment model for this stock. Fish ticket and observer data are available (including retained catch numbers, retained catch weight, and pot lifts by statistical area and landing date), size-frequency data from samples of landed crabs, and at-sea observer data from pot lifts sampled during the fishery (including date, location, soak time, catch composition, size, sex, and reproductive condition of crabs, etc), and from the groundfish fisheries. Much of the directed fishery data is confidential due to low number of participants.

*Stock biomass and recruitment trends*

Estimates of stock biomass (all sizes, both sexes) were provided for Pribilof Canyon. The 2008 Pribilof Canyon area-swept estimate of golden king crab biomass is 919 mt, an increase from 692 mt in 2002. There is no recent directed fishery participation (2006-2009).

*Tier determination/Plan Team discussion and resulting OFL determination*

The Team recommends this stock be assigned to Tier 5. Biomass information was provided for Pribilof Canyon, but not specific to mature males.

The assessment author presented a retained-catch OFL based on data from 1993-98, and two alternative retained-catch OFLs based on 1993-1999 and 1993-2002 time periods. The assessment author also presented a total-catch OFL.

The Team recommends a total-catch OFL. The total-catch OFL is derived based on the following relationship to the retained-catch OFL (1993-98 seasons) adopted for 2010 fishing season:

$OFL_{tot} = 1.05 * OFL_{ret} + 0.006$ million

This relationship accounts for groundfish and non-directed crab bycatch mortality at a background level that is independent of the Pribilof District golden king crab stock size and directed catch, however, the bycatch mortality in the directed fishery is assumed to be proportional to retained catch. Bycatch data from crab fisheries was often confidential and only available from 2001 – 2009. The groundfish bycatch data was available from 1991/92 – 2008/09 in federal reporting areas 513, 517 & 521. The 1.05 multiplier accounts for crab bycatch mortality in the directed crab fishery and 6-thousand pounds is the average "background level" groundfish and non-directed crab bycatch mortality. The Team recommends a total catch OFL of 0.18 million pounds for the 2011 Pribilof District golden king crab fishing year.

*Historical status and catch specifications (millions lbs.) of Pribilof Islands golden king crab*

| Year | MSST | Biomass (MMB) | TAC | Retained Catch | Total Catch | OFL (retained) |
|---|---|---|---|---|---|---|
| 2007 | NA | NA | 0.15 | 0 | | |
| 2008 | NA | NA | 0.15 | 0 | 0.00 | |
| 2009 | NA | NA | 0.15 | 0 | 0.001 | 0.17 (retained) |
| 2010 | NA | NA | 0.15 | 0 | TBD | 0.17 (retained) |
| 2011 | NA | NA | TBD | TBD | TBD | 0.18 |

No overfished determination is possible for this stock given the lack of biomass information. Overfishing will be assessed in September for the 2010 fishery.

*Additional Plan Team recommendations*

None

*Ecosystem Considerations summary*

The fishery is concentrated in the Pribilof Canyon at depths of 100 – 300 fathoms. Fishery effects on the ecosystem are not determined at this time.

## 10 Adak red king crab, Aleutian Islands

*Fishery information relative to OFL setting*

The domestic fishery has been prosecuted since 1960/61 and was opened every season through the 1995/96 season. Since 1995/96, the fishery was opened only occasionally, 1998/99, 2000/01-2003/04. Peak harvest occurred during the 1964/65 season with a retained catch of 21 million pounds. During the early years of the fishery through the late 1970s, most or all of the retained catch was harvested in the area between 172° W longitude and 179° 15' W longitude .As the annual retained catch decreased into the mid-1970s and the early-1980s, the area west of 179° 15' W longitude began to account for a larger portion of the retained catch

Retained catch during the 10-year period, 1985/86 through 1994/95, averaged 0.943 million pounds, but the retained catch during the 1995/96 season was low, only 0.039 million pounds. There was an exploratory fishery with a low guideline harvest level (GHL) in 1998/99; three Commissioner's permit fisheries in limited areas during 2000/01 and 2002/03 to allow for ADF&G-Industry surveys, and two commercial fisheries with a GHL of 0.5 million pounds during the 2002/03 and 2003/04 seasons. Most of the catch since the 1990/91 season was harvested in the Petrel Bank area (between 179° W longitude and 179° E longitude) and the last two commercial fishery seasons (2002/03 and 2003/04) were opened only in the Petrel Bank area. Retained catches in those two seasons were 0.506 million pounds (2002/03) and 0.479 million pounds (2003/04). The fishery has been closed through the 2009/10 season since the end of the 2003/04 season.

Non-retained catch of red king crabs occurs in both the directed red king crab fishery (when prosecuted), in the Aleutian Islands golden king crab fishery, and in groundfish fisheries. Estimated bycatch mortality during the 1995/96-2008/09 seasons averaged 0.003 million pound in crab fisheries and 0.023 million pounds in groundfish fisheries. Estimated annual total fishing mortality (in terms of total crab removal) during 1995/96-2008/09 averaged 0.116 million pounds. The average retained catch during that period was 0.09 thousand pounds. This fishery is rationalized under the Crab Rationalization Program only for the area west of 179° W longitude.

*Data and assessment methodology*

The 1960/61-2007/08 time series of retained catch (number and pounds of crabs), effort (vessels, landings and pot lifts), average weight and average carapace length of landed crabs, and catch-per-unit effort (number of crabs per pot lift) are available. Bycatch from crab fisheries during 1995/96-2008/09 and from groundfish fisheries during 1992/93-2008/09 are available. There is no assessment model in use for this stock. The standardized surveys of the Petrel Bank area conducted by ADF&G in 2006 and 2009 and the ADF&G-Industry Petrel Bank surveys conducted in 2001 have been too limited in geographic scope and too infrequent for reliable estimation of abundance for the entire western Aleutian Islands area.

*Stock biomass and recruitment trends*

Estimates of stock biomass are not available for this stock. Estimates of recruitment trends and current levels relative to virgin or historic levels are not available. The fishery has been closed since the end of 2003/04 season due to apparent poor recruitment. A pot survey conducted by ADF&G in the Petrol Bank area in 2006 provided no evidence of strong recruitment. The 2009 survey encountered smaller ageing population with the catch of legal male crabs occurred in a more limited area and at lower densities than were found in the 2006 survey and provided no expectations for recruitment. A test fishery conducted by a commercial vessel during October-December 2009 in the area west of Petrel Bank yielded only one legal male red king crab.

*Tier determination/Plan Team discussion and resulting OFL determination*

The CPT recommends this as a Tier 5 stock for the 2009/10 season. Author provided three model alternatives (Alt.) with different time periods (Base: 1984/85-2007/08; Alt.1: 1977/78-2007/08; Alt.2: 1960/61-2007/08) to compute the average retained catch as OFL. The team recommended a total catch OFL for the 2010/11 season because complete information on total catch is available for the period 1995/96-2007/08. The total catch OFL for this period is 0.12-million pounds. The CPT also recommends freezing the final fishing season at 2007/08.

*Status and catch specifications (millions of lbs) of Adak RKC.*

| Year | MSST | Biomass (MMB) | TAC | Retained Catch | Total Catch | OFL (retained) |
|---|---|---|---|---|---|---|
| 2006/07 | NA | NA | Closed | 0 | 0.004 | NA |
| 2007/08 | NA | NA | Closed | 0 | 0.011 | NA |
| 2008/09 | NA | NA | Closed | 0 | 0.014 | 0.46[A] (retained) |
| 2009/10 | NA | NA | Closed | 0 | TBD | 0.50[A] (retained) |
| 2010/11 | NA | NA | Closed | TBD | TBD | 0.12[B] |

A-based on 1984/85-07/08 mean retained catch
B-CPT recommended total catch OFL of 0.12 million pounds based on the average for 1995/96-07/08 (Table 5)

No overfished determination is possible for this stock given the lack of biomass information. Overfishing will be assessed in September for the 2009/2010 fishery.

*Additional Plan Team recommendations*

None

*Ecosystem Considerations summary*

This stock is unsurveyed, remote, and data-poor. Since the fishery is sporadic and restricted to a limited area (Petrel Bank), fishery specific effects on target size crab, discards, age at maturity, EFH non-living substrate appears minimal.

Table 3. Crab Plan Team recommendations May 2010
(Note diagonal fill indicated parameters not applicable for that tier level while shaded sections are to be filled out for the final SAFE in September 2010)

| Chapter | Stock | Tier | Status (a,b,c) | $F_{OFL}$ | $B_{MSY}$ or $B_{MSYproxy}$ | Years[1] (biomass or catch) | 2010[2] [3] MMB | 2010 MMB / $MMB_{MSY}$ | γ | Mortality (M) | 2010/11 OFL mill lbs [retained] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | EBS snow crab | 3 | | | | 1979-current [recruitment] | | | | Male- estimated Female – 0.23 | |
| 2 | BB red king crab | 3 | | | | 1995-current [recruitment] | | | | 0.18 default, estimated otherwise[4] | |
| 3 | EBS Tanner crab | 4 | | | 183.6 | 1969-1980 [survey] | | | 1.0 | 0.23 | |
| 4 | Pribilof Islands red king crab | 4 | | | | 1991-current [survey] | | | 1.0 | 0.18 | |
| 5 | Pribilof Islands blue king crab | 4 | | | 9.28 | 1980-1984; 1990-1997 [survey] | | | 1.0 | 0.18 | |
| 6 | St. Matthew Island blue king crab | 4 | | | | 1989-current [model estimate] | | | 1.0 | 0.18 (1978-98, 2000-08); 1.8 (1999) | [total male catch] |
| 7 | Norton Sound red king crab | 4 | a | 0.18 | 3.12 | 1983-current [model estimate] | 5.44 | 1.7 | 1.0 | 0.18 | 0.73 |
| 8 | AI golden king crab | 5 | | | | TBD [total catch] | | | | | TBD (see intro) |
| 9 | Pribilof Island golden king crab | 5 | | | | | | | | | 0.18 |
| 10 | Adak red king crab | 5 | | | | | | | | | 0.12 |

1 For Tiers 3 and 4 where $B_{MSY}$ or $B_{MSYproxy}$ is estimable, the years refer to the time period over which the estimate is made. For Tier 5 stocks it is the years upon which the catch average for OFL is obtained.
2 MMB as projected for 2/15/2011 at time of mating.
3 Model mature biomass on 7/1/2010
4 Additional mortality males: two periods-1980-1985; 1968-1979 and 1986-2008. Females three periods: 1980-1984; 1976-1979; 1985 to 1993 and 1968-1975; 1994-2008. See assessment for mortality rates associated with these time periods.

AGENDA C-2(b)(3)
JUNE 2010

Supplemental Figures for Model 5 (see May 2010 snow crab draft assessment) assessment results and fits to data

B.J. Turnock
National Marine Fisheries Service
May 28, 2010

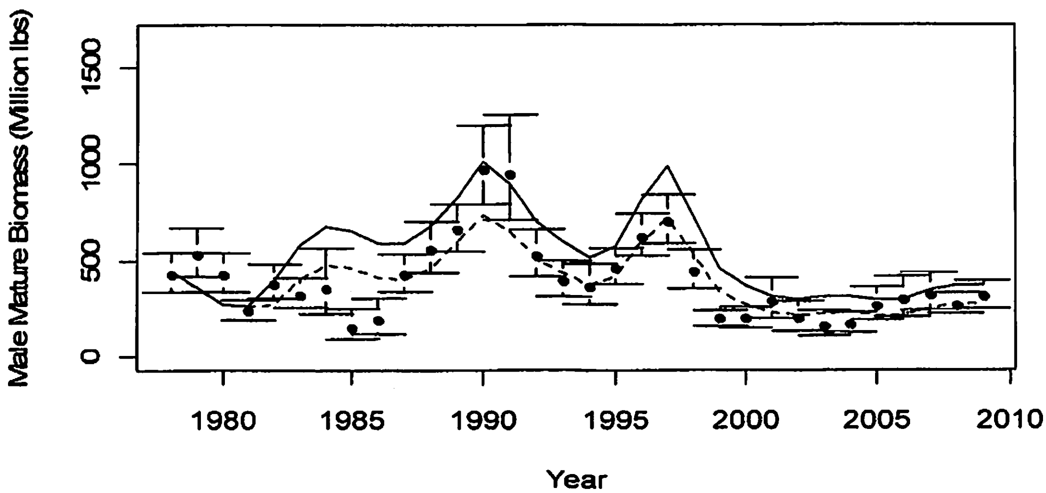



Figure 1. Model 5. Population male mature biomass (millions of pounds, solid line), model estimate of survey female mature biomass (dotted line) and observed survey female mature biomass with approximate lognormal 95% confidence intervals.

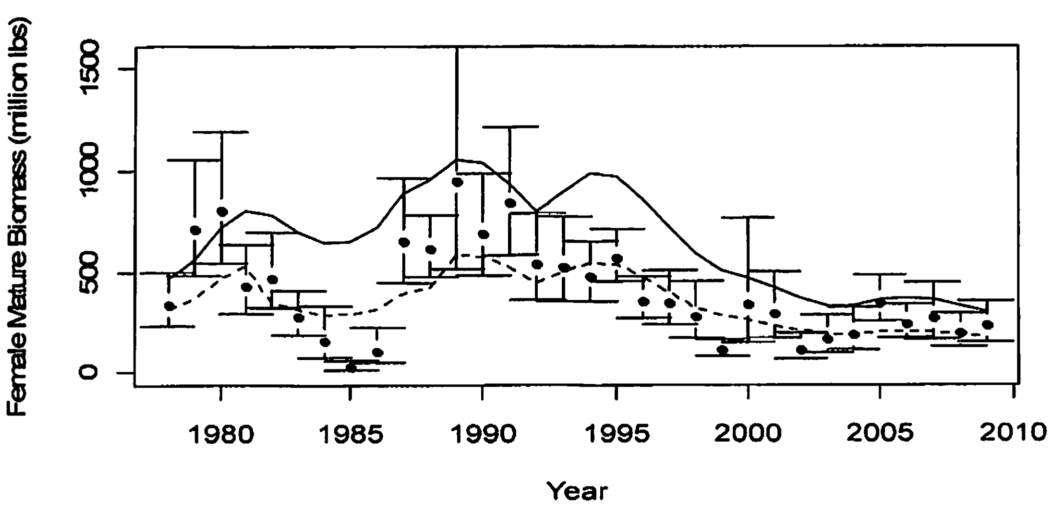



Figure 2. Model 5. Population female mature biomass (millions of pounds, solid line), model estimate of survey female mature biomass (dotted line) and observed survey female mature biomass with approximate lognormal 95% confidence intervals.

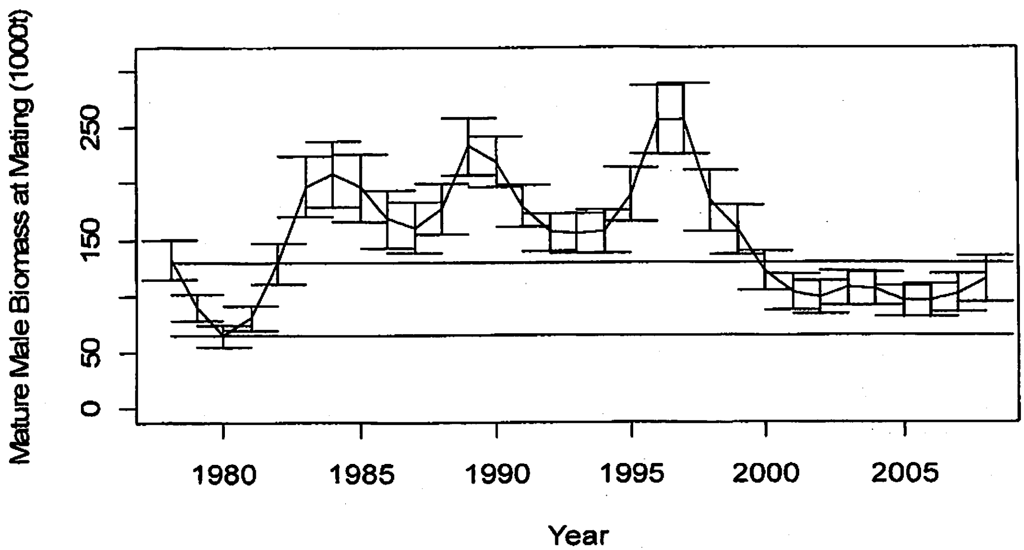



Figure 3. Model 5. Mature Male Biomass at mating with 95% confidence intervals. Top horizontal line is B35%, lower line is ½ B35%.

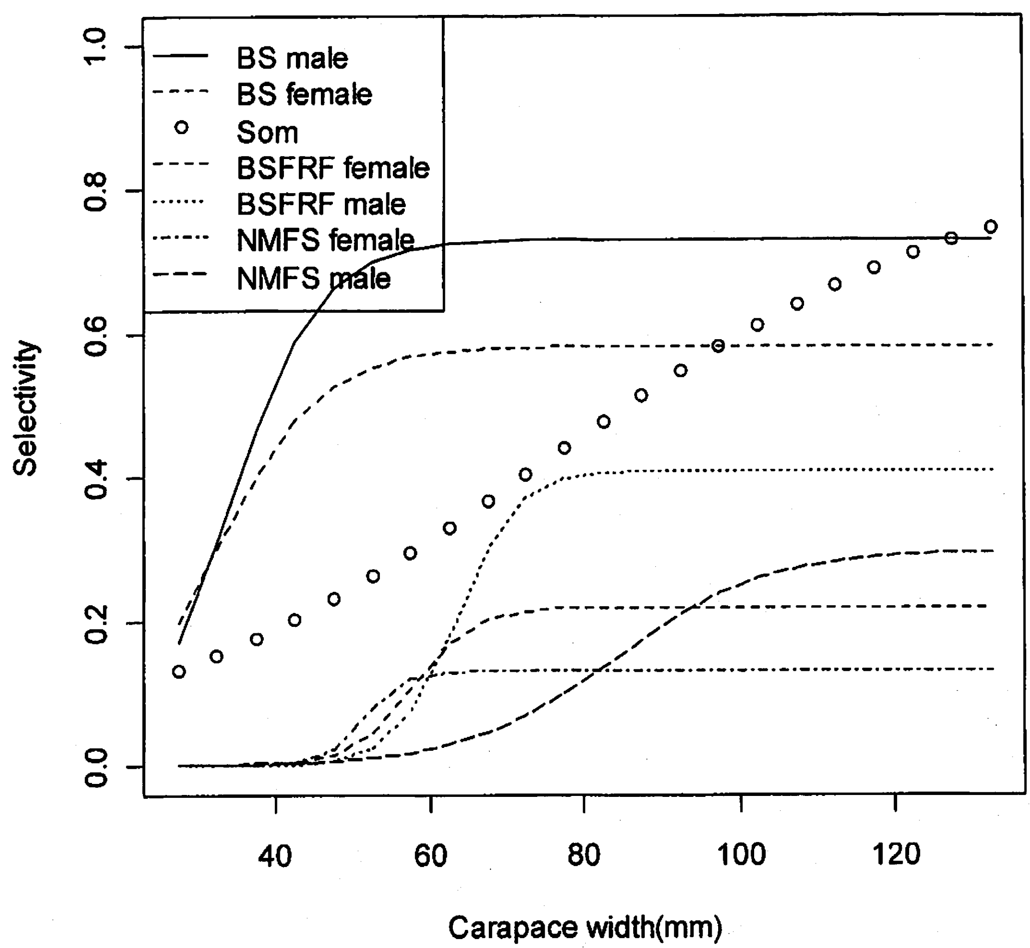



Figure 4. Model 5. Survey selectivity curves entire Bering sea survey for female (upper dashed line, BS female) and male snow crab (solid line, BS male) estimated by the model for 1989 to present. Survey selectivities estimated by Somerton from 2009 study area data (2010) are the circles. Lower lines are survey selectivities in the study area for BSFRF male and female crab and NMFS male and female crab.

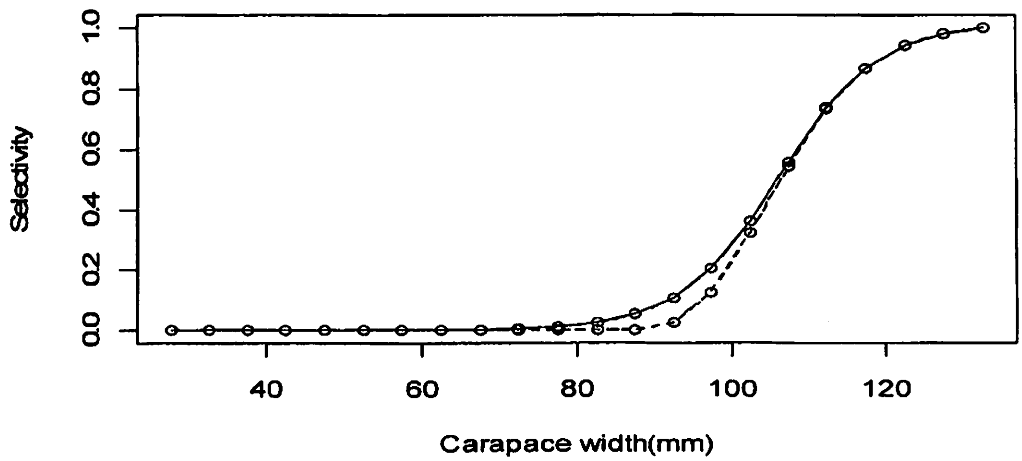



Figure 5. Model 5. Selectivity curve for total catch (discard plus retained, solid line) and retained catch (dotted line) for combined shell condition male snow crab.

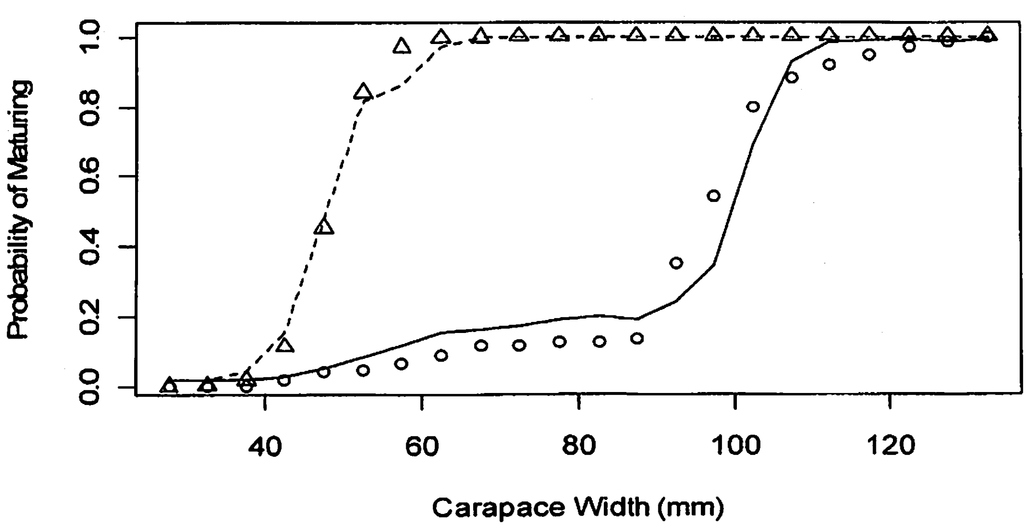



Figure 6. Model 5. Probability of maturing by size estimated in the model for male(solid line) and female (dashed line) snow crab (not the average fraction mature). Triangles are values for females used in the 2009 assessment. Circles are values for males used in the 2009 assessment.

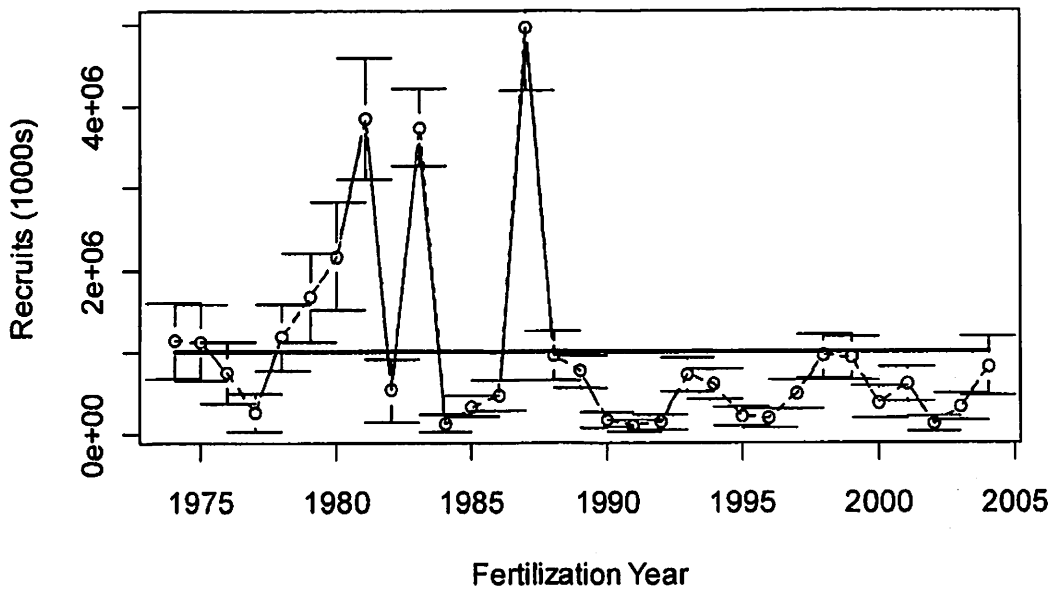



Figure 7. Model 5. Recruitment to the model (about 25 mm to 50 mm CW). Total recruitment is 2 times recruitment in the plot. Male and female recruitment fixed to be equal. Solid horizontal line is average recruitment. Error bars are 95% C.I.

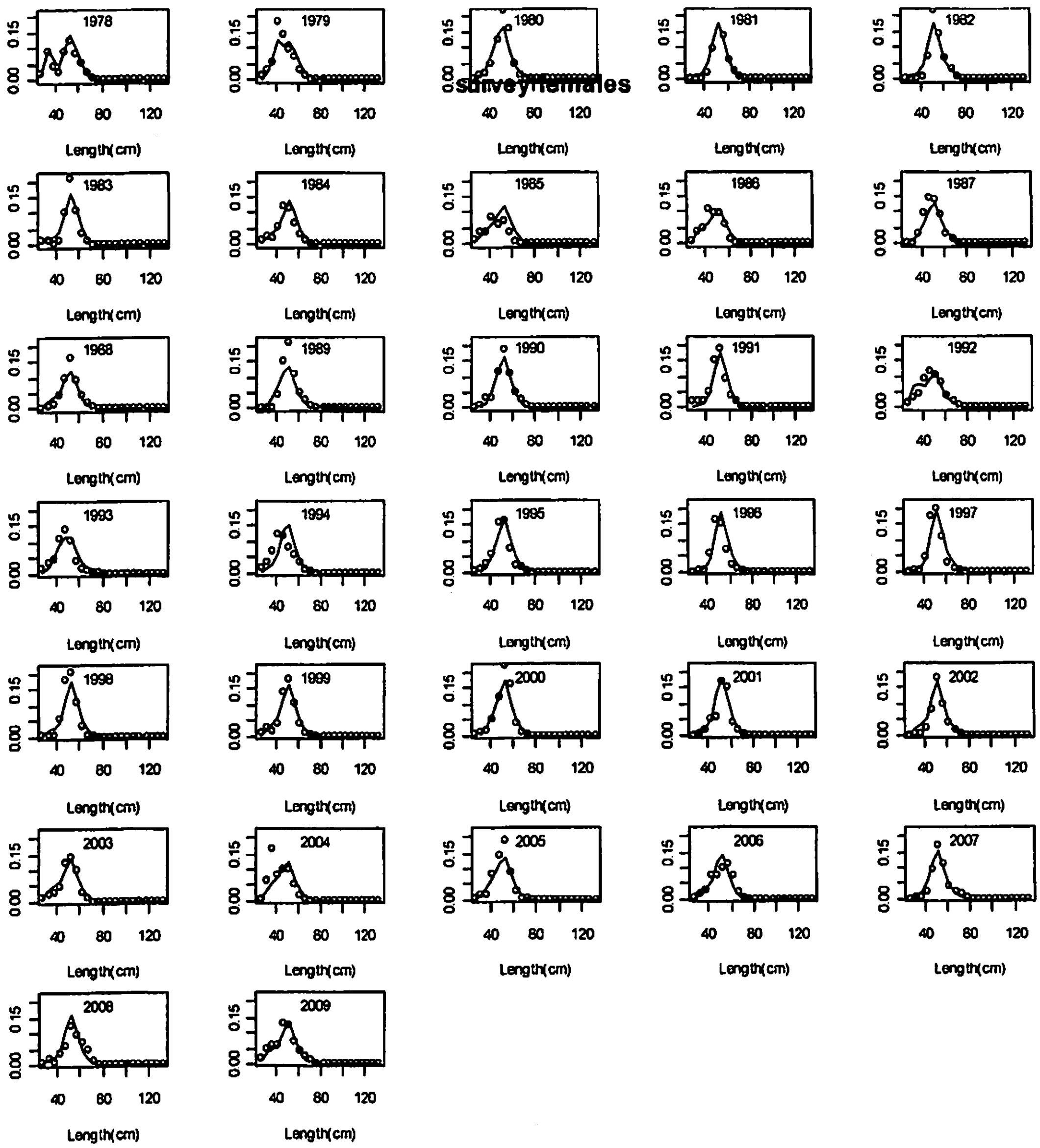



Figure 8. Model 5. Model fit to the survey female size frequency data. Circles are observed survey data. Solid line is the model fit.

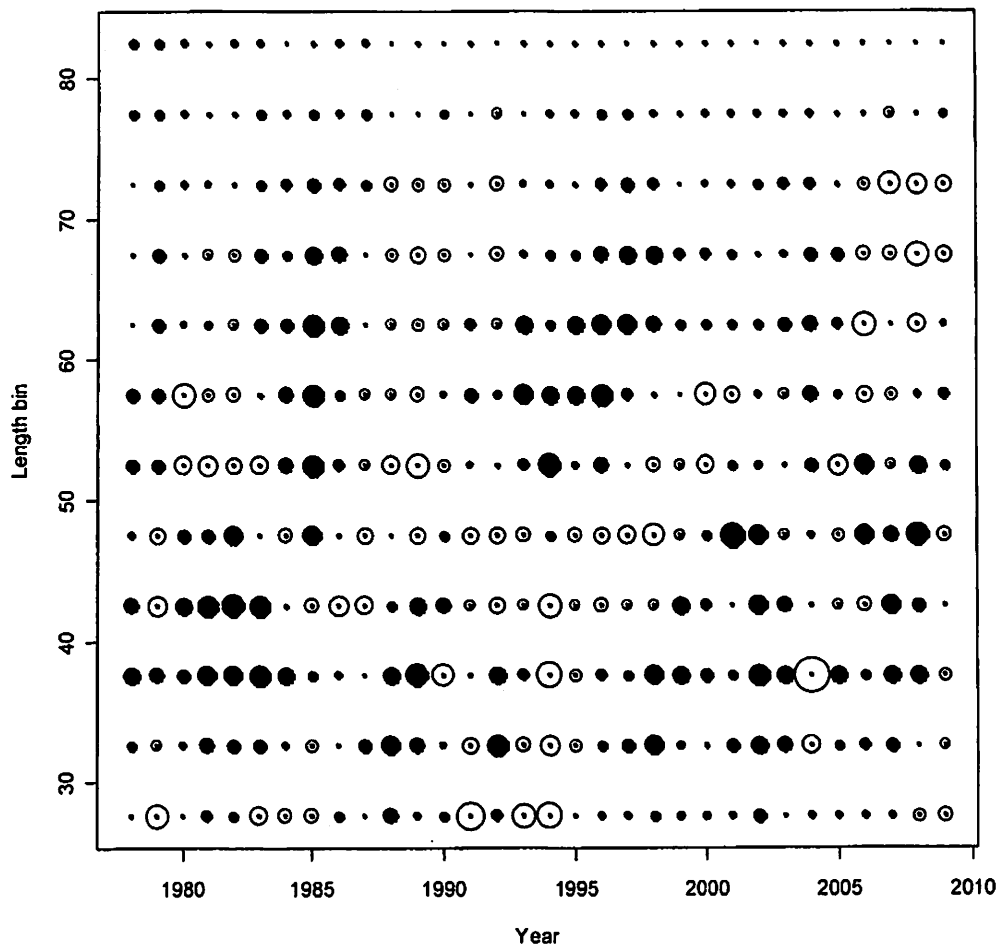



Figure 9. Model 5. Residuals of fit to survey female size frequency. Filled circles are negative residuals.

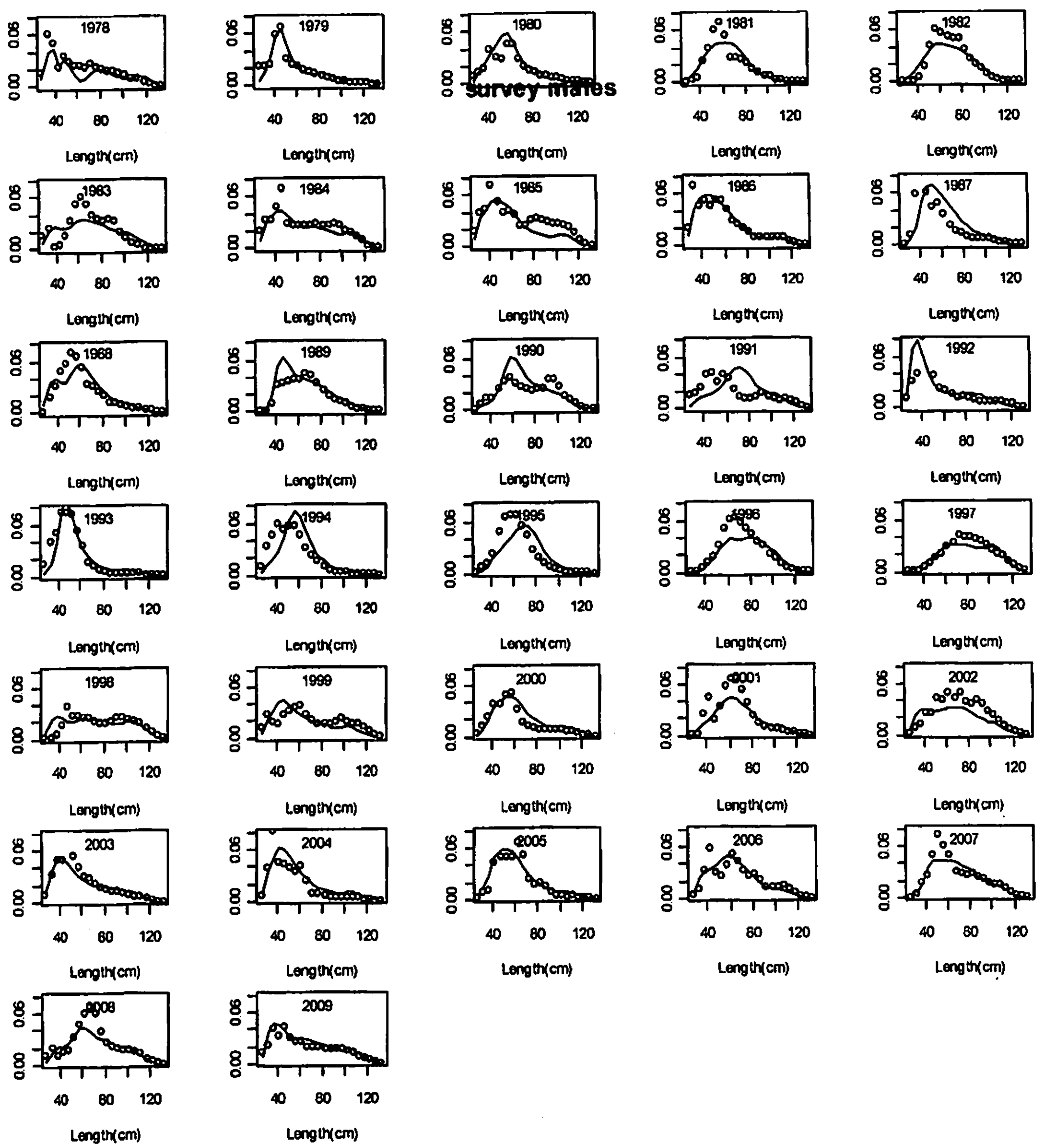



Figure 10. Model 5. Model fit to the survey male size frequency data. Circles are observed survey data. Solid line is the model fit.

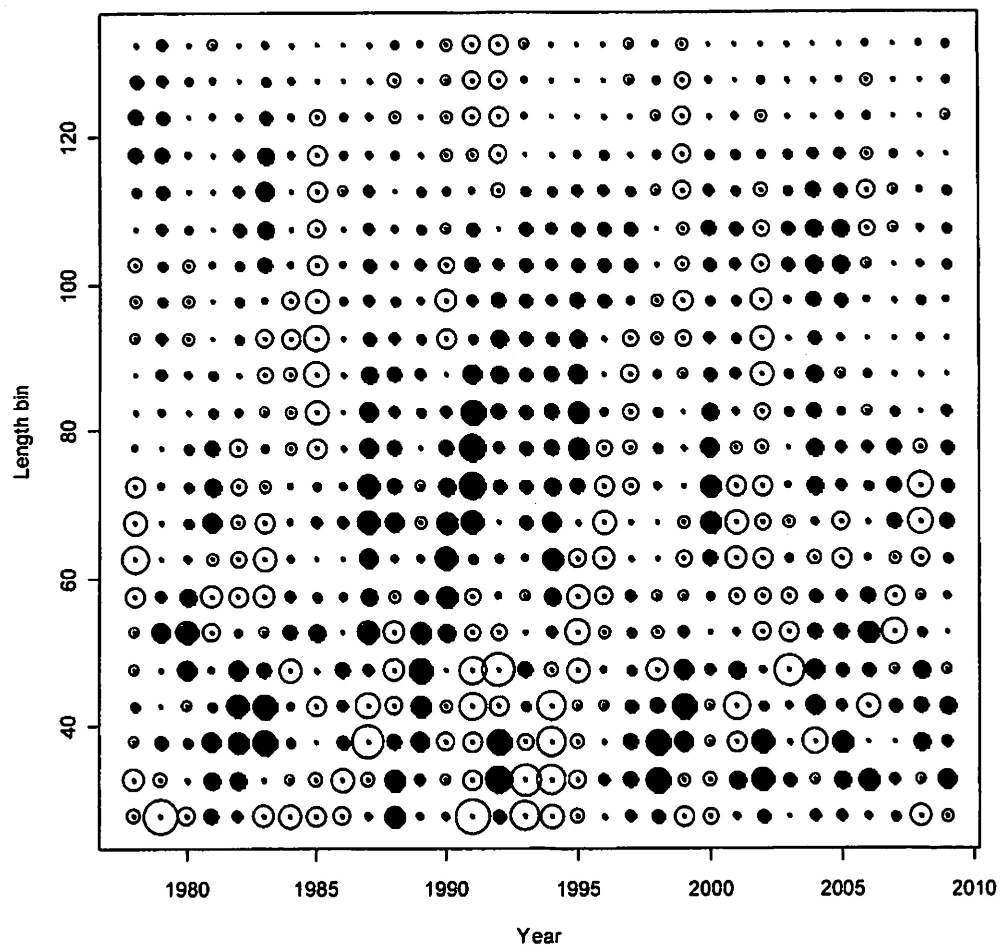



Figure 11. Model 5. Residuals for fit to survey male size frequency. . Filled circles are negative residuals (predicted higher than observed).

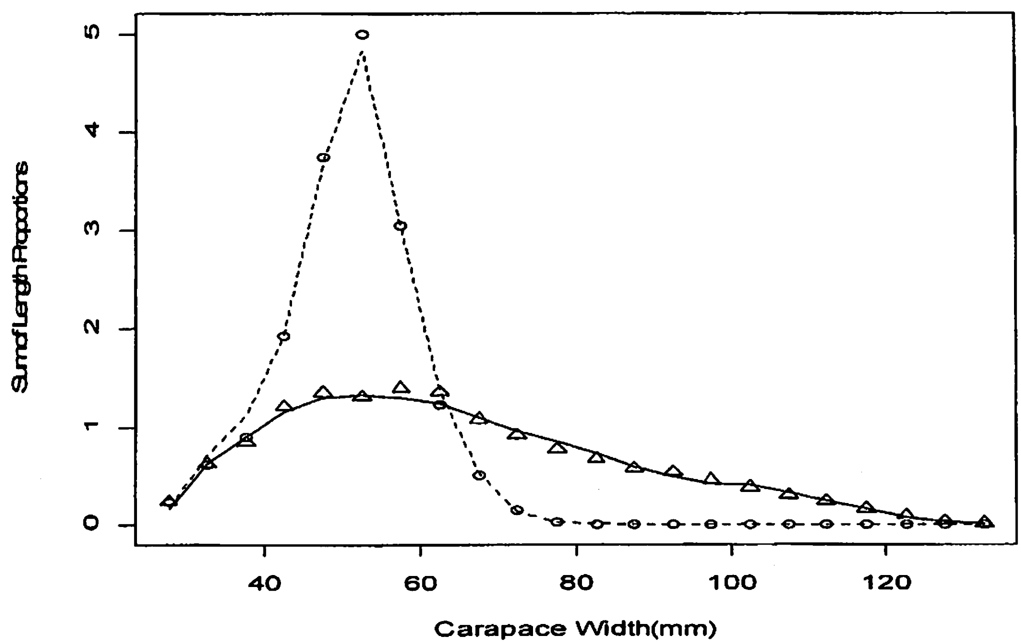



Figure 12. Model 5. Summary over years of fit to survey length frequency data by sex.

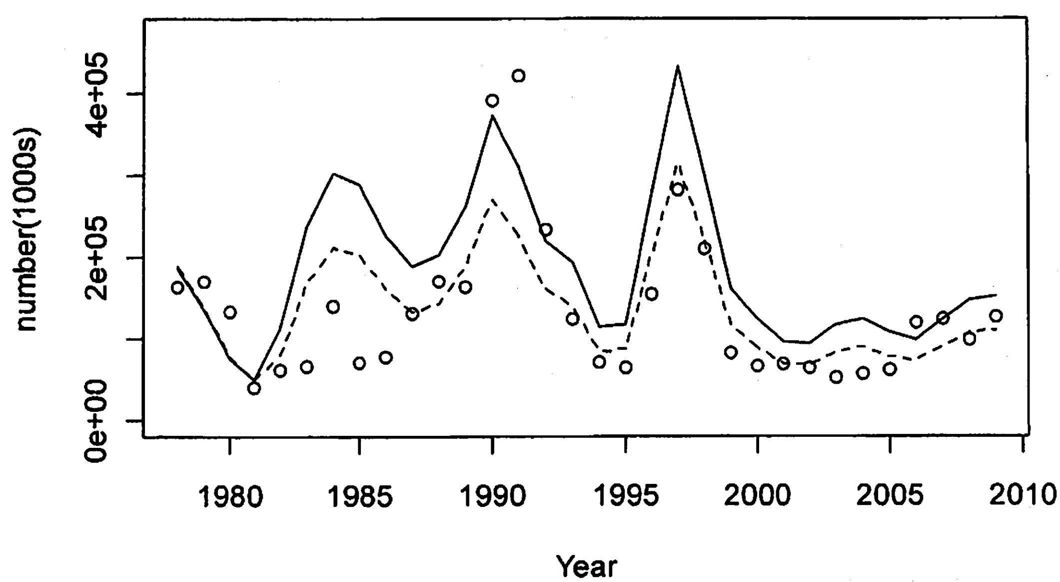


Figure 13. Model 5. Observed survey numbers of males >101mm (circles), model estimates of the population number of males >101mm(solid line) and model estimates of survey numbers of males >101 mm (dotted line).

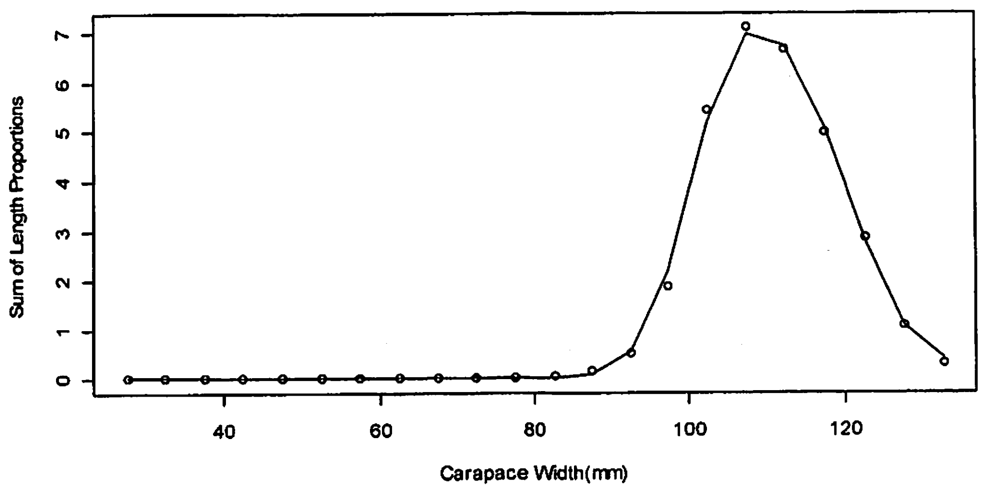



Figure 14. Model 5. Summary fit to retained male length.

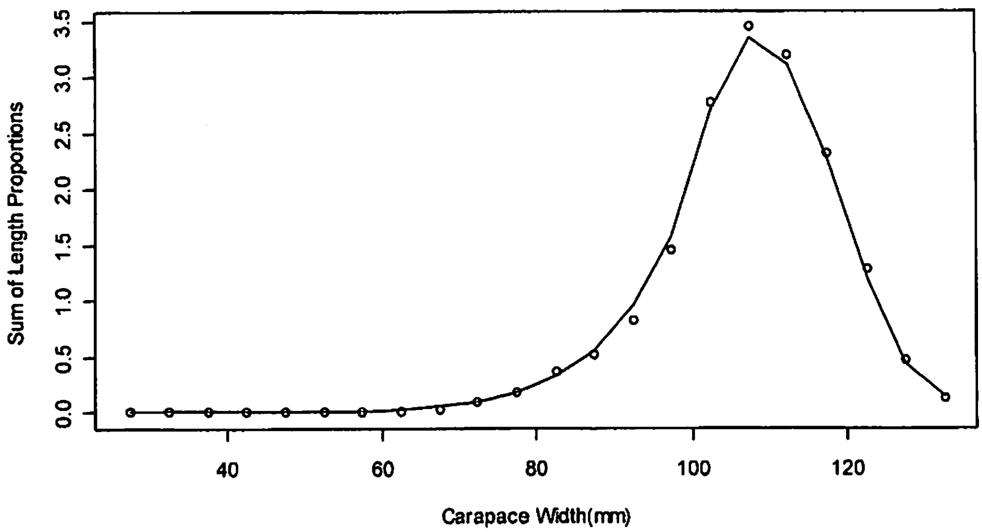
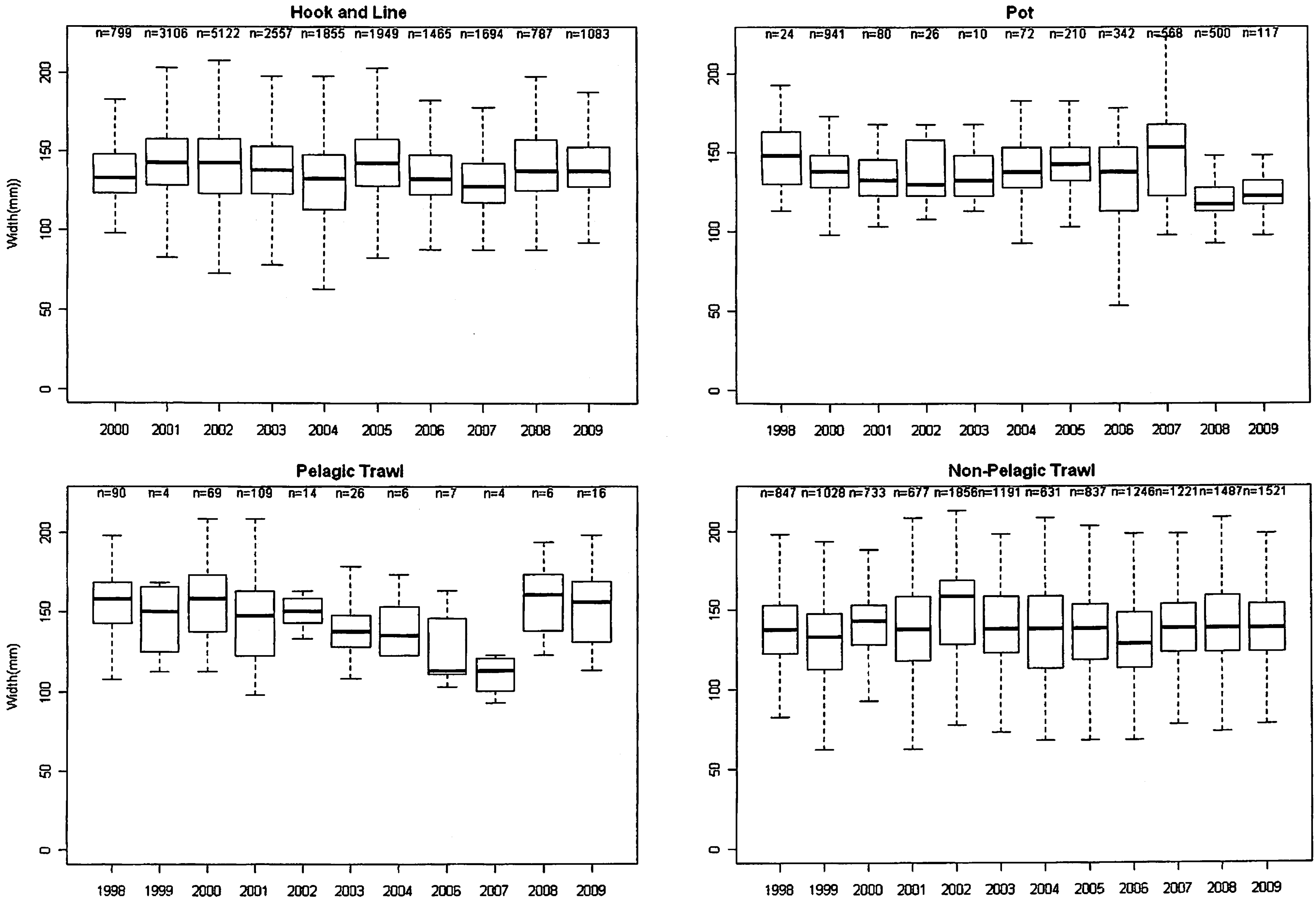



Figure 15. Model 5. Summary fit to total length frequency male catch

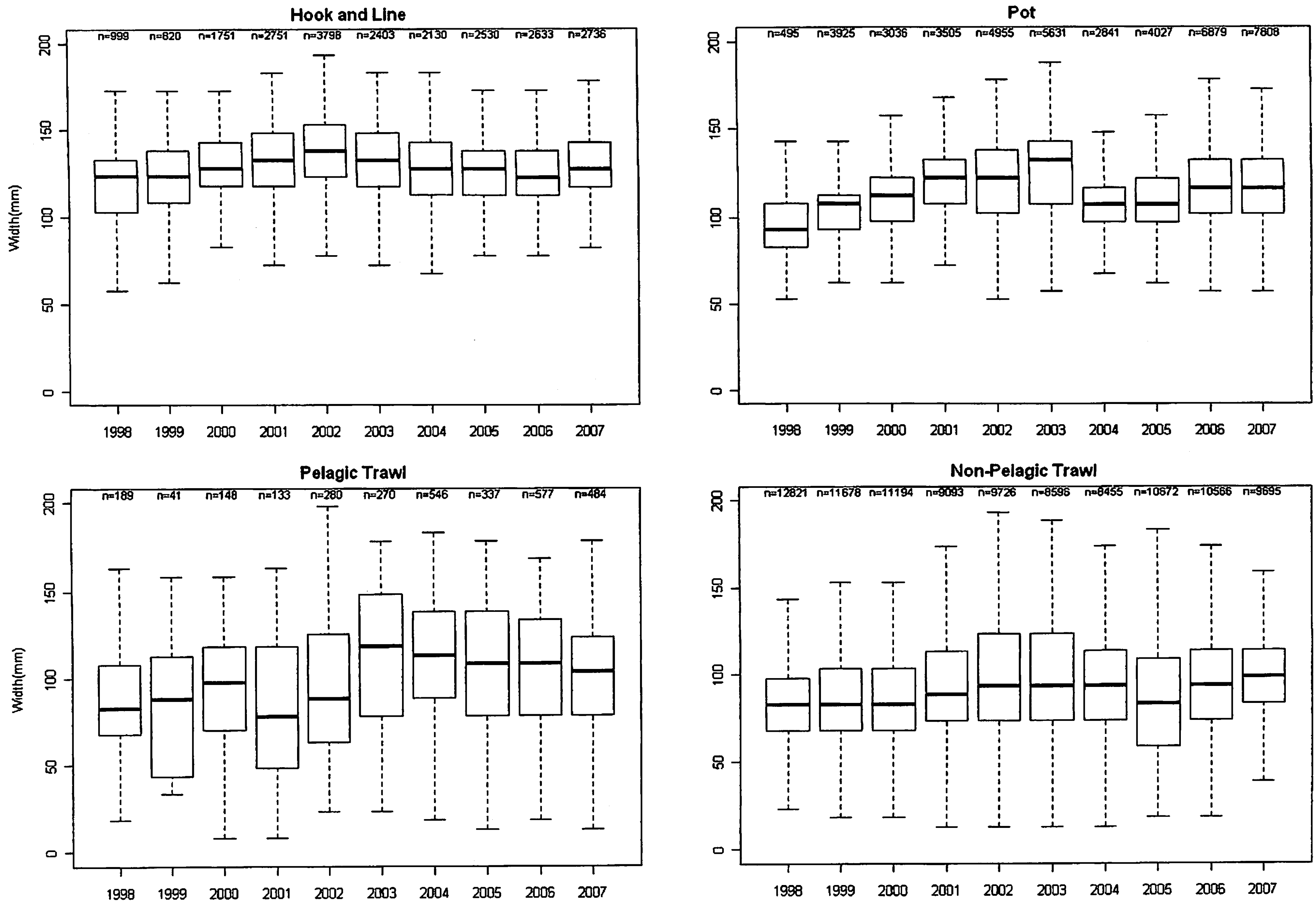
AGENDA C-2 (c)
June 2010

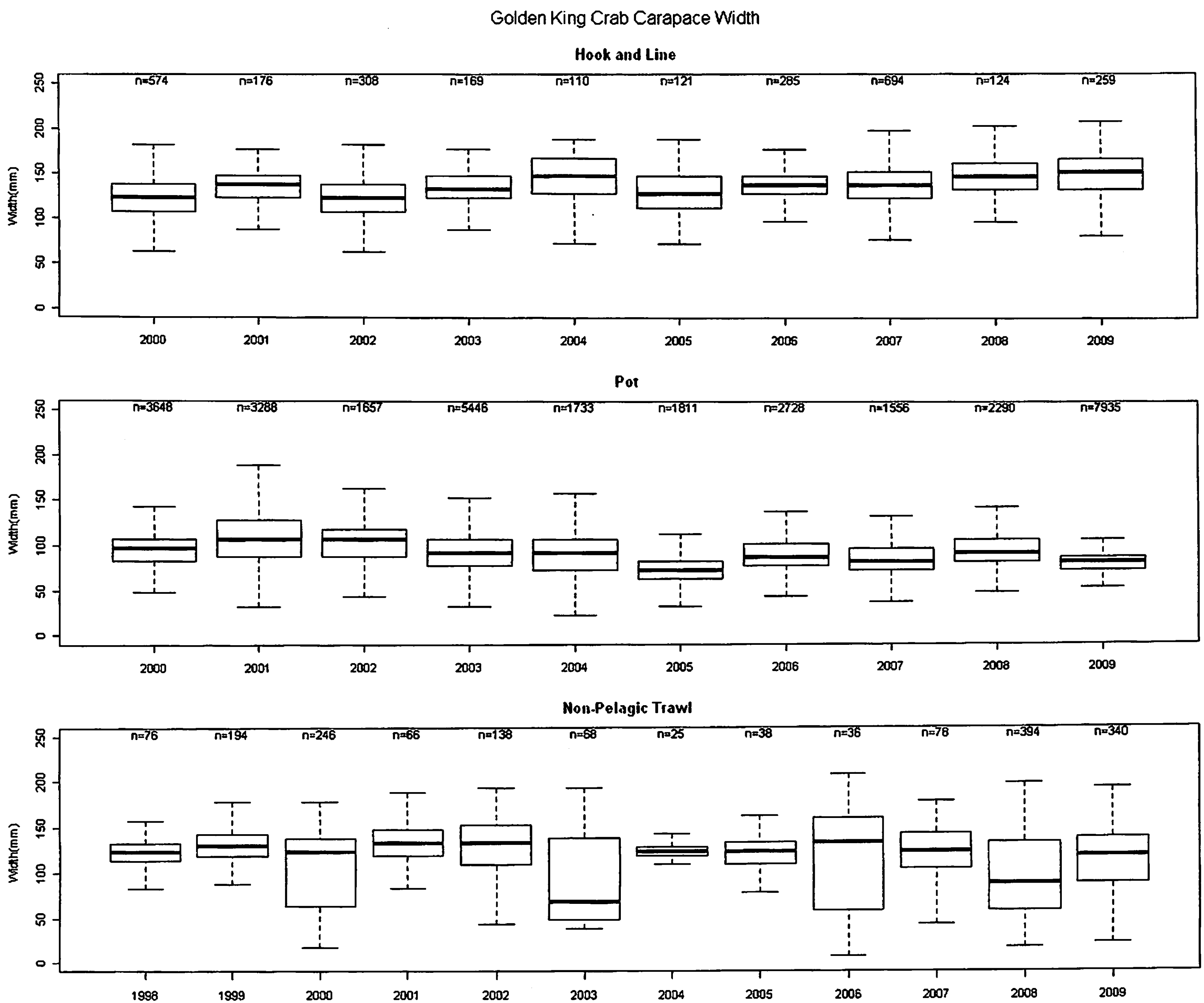
# Appendix F to the Crab Bycatch in the BSAI Fisheries Discussion Paper

Red King Crab Carapace Width

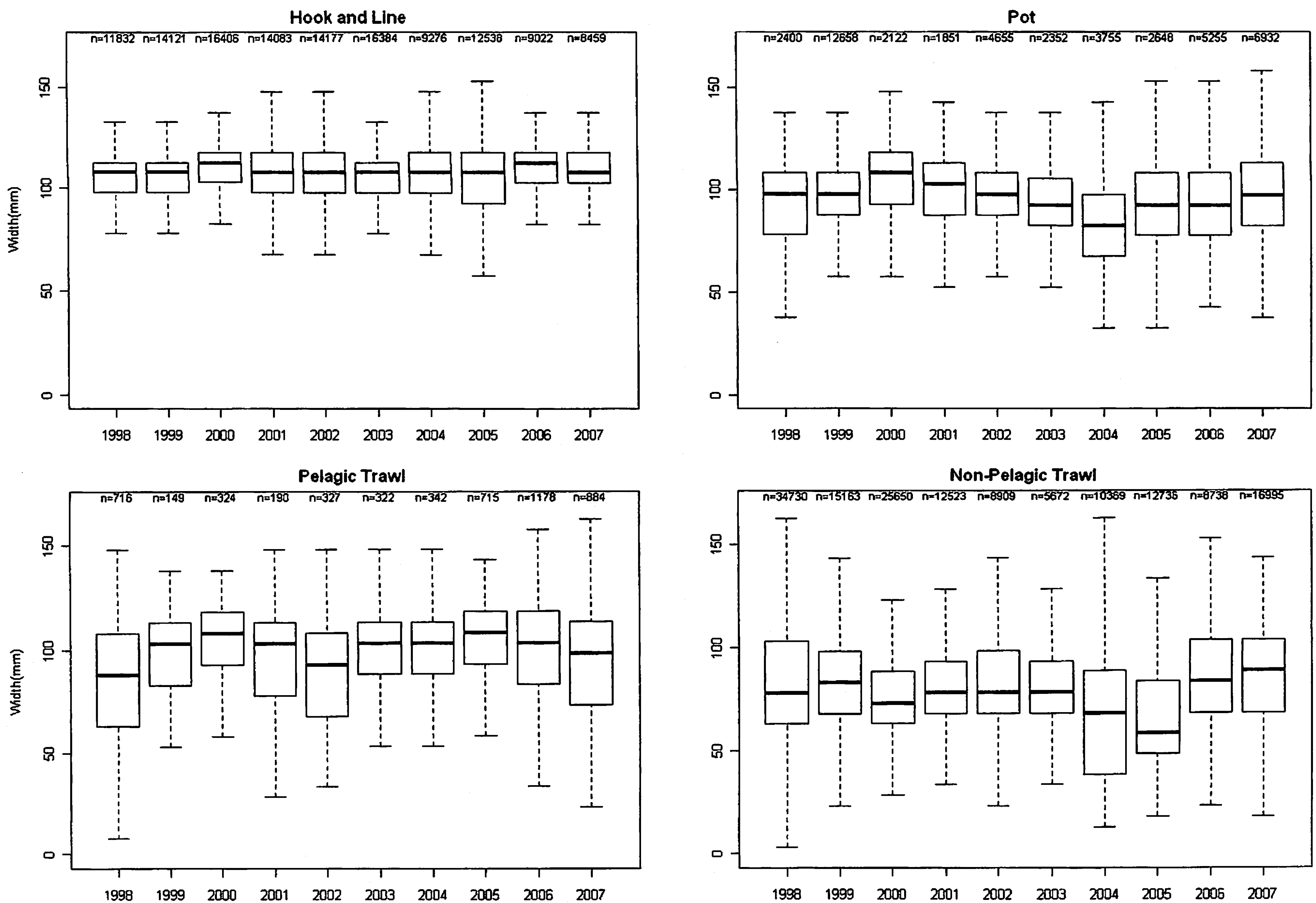


Snow Crab Carapace Width




Golden King Crab Carapace Width
Hook and Line
n=574
n=176
n=308
n=169
n=110
n=121
n=285
n=694
n=124
n=259
Width(mm)
0
50
100
150
200
250
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Pot
n=3648
n=3288
n=1657
n=5446
n=1733
n=1811
n=2728
n=1556
n=2290
n=7935
Non-Pelagic Trawl
n=76
n=194
n=246
n=66
n=138
n=68
n=25
n=38
n=36
n=78
n=394
n=340
1998
1999

Tanner Crab Carapace Width



AGENDA C-2(a)
Supplemental
JUNE 2010

NORTH PACIFIC CRAB ASSOCIATION

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Executive Director

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June 1, 2010

Mr. Eric A. Olson, Chairman
Mr. Chris Oliver, Executive Director
North Pacific Fishery Management Council
605 West 4th Avenue, Suite 306
Anchorage, Alaska 99501

Re: Agenda Item C2(a), Initial Review, Crab ACLs and Opilio Rebuilding Plan

Gentlemen,

On behalf of the North Pacific Crab Association, I am submitting comments regarding the initial review of the BSAI crab ACLs and the Opilio rebuilding plan. We are submitting several specific comments regarding both issues, and ask that you consider our comments during your deliberations.

<u>BSAI Crab ACLs</u>

- In regards to P* values, we ask that you add 0.45 to the range of options. Currently the range includes 0.5, 0.4, 0.3, 0.2 and 0.1. ACLs should result in an ABC that is larger than the OFL, and some analysis by the Bering Sea Fisheries Research Foundation indicates that 0.45 may be an appropriate value to achieve this goal.

- Concerning "uncertainty levels", we would again like to reinforce the concerns of the BSFRF and ask that the Council modify the range of options. Currently, the uncertainty options are 0.2, 0.4 and 0.6. This is a very large range and it seems unreasonable. We ask that the Council consider a range covered by 0.2, 0.3 and 0.4 instead.

- We are also concerned about the inconsistent approach to establishing the probability of exceeding OFLs amongst the crab stocks themselves. One approach is proposed for Opilio and Bairdi, and a distinctly different approach for the other fisheries. It is beyond our expertise to advise the Council which approach is best, but we wanted to raise this as an important issue.

Opilio Rebuilding Plan

- We support the majority of the Crab Plan Team, ICEPAC and the BSFRF in their collective opinion that "Model 5" is the most appropriate alternative. Based on our belief that the Best Available Science should be used, and the extensive deliberations of the CPT, Model 5 seems the best approach to the rebuilding plan. Model 5 incorporates some BSFRF survey data, updated natural mortality and growth rate data and it should therefore yield a better result than the alternatives.

- Finally, we support the option that defines the Opilio stock as "rebuilt" once the stock is above BSMY for one year. We believe that recent advancements in crab surveys and the stock assessment model, as well as the additional precautions required by ACLs, make this a sufficient rebuilding benchmark.

Thank you in advance for your consideration,

Steven K Minor

Date: June 1st, 2010

To: Eric A. Olson, Chairman
Chris Oliver, Executive Director
North Pacific Fishery Management Council
605 West 4th Avenue, Suite 306
Anchorage, Alaska 99501-2252

From: The "Alaska Bering Sea Crabbers", a joint effort of the Alaska Crab Coalition, the Crab Group of Independent Harvesters and ICEPAC

Re: Agenda Item, C 2(a), Initial Review of Analysis to Establish ACLs and Rebuild Snow Crab

The Alaska Bering Sea Crabbers appreciate the opportunity to comment for initial review regarding opilio rebuilding and ACLs. We have some specific comments for both of these items, and we hope these comments could be incorporated in the analysis for final review scheduled for October. We also have a specific comment regarding the methodology for determining Bmsy for bairdi.

**Opilio Rebuilding**

We were encouraged by the discussion at the Crab Plan Team meeting in May where alternative models for opilio were discussed. A majority of the Crab Plan Team felt that "model 5" was most suited for the opilio stock. This model incorporates the Bering Sea Fisheries Research Foundation (BSFRF) survey biomass and size data. It results in a more realistic trawl survey Q based on the results of last summer's BSFRF survey. Model 5 also estimates that natural mortality is a bit higher and growth is a bit slower. It should also be noted that model 5 has the best overall fit to the data. Although the selectivity curve may not match the BSFRF curve in that it is much more asymptotic, model 5 is a solid step in the right direction and we recommend that the SSC and Council also endorse model 5.

In addition, we recommend that the option for defining 'rebuilt' as one-year above BMSY be chosen as the preferred option. This option is viable now that stock abundance is estimated via a model that integrates all sources of available information and ACL requirements will further assure that excessive harvest allowances are unlikely.

**ACLs**

The crab industry is attempting to understand the details of the ACL options in the analysis. This is a very complicated issue with a tight timeframe. At this time, we have four main concerns regarding the ACL analysis.

The first concern is that the analysis is currently limited in regards to options for P*. The P* values in the analysis are 0.5 (which is not legal), 0.4, 0.3, 0.2, and 0.1. It would seem appropriate to have an additional option for a P* of 0.45. The goal of ACLs is to tilt the odds so that given the recognized uncertainty in estimating stock abundance, it is less likely rather than more likely that the assigned ABC will be bigger than the true OFL. We believe that a P* of .45 may be appropriate in that regard and should be added in as an option for the analysis.

The second concern we have is the range of additional uncertainty levels currently in the analysis. The current additional uncertainty options are 0.2, 0.4, and 0.6. For the upper end of this range, the 0.6 value implies that the estimated ABC is one-third to triple the value stated. This is a huge amount of uncertainty and does not sound reasonable. Initially, the thought was to have options for a high, medium, and low level of additional uncertainty. The approach of a high, medium and low level of additional uncertainty seems to be a reasonable approach, however the values assigned to the medium and high level should not be so large. We recommend that the analysis limit additional uncertainty at .4 and that the high, medium and low values be 0.4, 0.3, and 0.2 respectively.

We are also concerned that for bairdi and opilio, the calculations for long-term probabilities of exceeding OFL under different P* options are done differently than for the other stocks. For opilio and bairdi, the analysts determined the multiplier necessary to realize the target P* value in the 30th year of the projection through an iterative process. For the other stocks, the multiplier was set according to the chosen P* value at the outset of the projection. The long-term probability of overfishing is then the average percentage of outcomes from all possible 800 simulations times the 30 years of projections where harvest exceeded OFL. The probability of being overfished is the number of times out of the 800, 30 year simulations that the harvest exceeded OFL in at least one year during the 30 year period. This latter approach more correctly simulates the management actions being promoted by adoption of an ACL harvest policy. The opilio and bairdi long-term overfishing probabilities should be corrected accordingly.

Finally, we are extremely concerned with the 47% buffer between OFL and ABC in the ACL analysis shown for the bairdi stock. From the industry's perspective, this is unreasonable. We expect that the stock assessment authors are conducting their assessments appropriately and at this time we have no option but to trust this is the case with bairdi as the model is not available. Industry has a difficult time understanding how the bairdi model could result in an additional buffer of 47%. This appears to represent that the bairdi model has an extremely high level of uncertainty in its estimates. We also know that the SSC has requested changes to the bairdi model and we are unsure of how that may affect the ACL buffer. Industry is extremely concerned regarding both the bairdi model and the impacts of ACLs on bairdi, yet we have very little constructive comments to make on this as we have almost no ability to understand what is driving this. Again, this is not acceptable.

**Bairdi Bmsy Methodology**

Bmsy for bairdi is currently calculated using average survey biomass from 1969 to 1980. This differs from how Bmsy is calculated for the other Bering Sea crab stocks in that the time series continues to move forward and doesn't simply stop at a certain year as bairdi does in 1980. We have concerns about this for two reasons. First, the time period from 1969 to 1980 has the highest amount of measurement error due to how old the data was and low confidence in the survey methodology from that time period. Second, it is widely recognized that a major regime shift occurred in the Bering Sea in the late 70's and early 80's. The time period currently being used does not reflect this and creates a bar that is much too high for the stock as it is now in a less productive environmental regime and will not consistently be able to attain a rebuilt status even with no fishing due to lower productivity. For these reasons, we recommend that the methodology for calculating Bmsy for bairdi be changed to use the average survey biomass from 1969 to the current.

# PUBLIC TESTIMONY SIGN-UP SHEET

**Agenda Item:** C-2a CRAB ACL / snow crab rebuilding

| | NAME *(PLEASE PRINT)* | TESTIFYING ON BEHALF OF: |
|---|---|---|
| 1 | Edward Poulsen | CEPAC |
| 2 | Mateo Paz-Soldan | City of St. Paul |
| 3 | Frank Kelty | City of Unalaska |
| 4 | Arni Thomson | ACC |
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NOTE to persons providing oral or written testimony to the Council: Section 307(1)(I) of the Magnuson-Stevens Fishery Conservation and Management Act prohibits any person " to knowingly and willfully submit to a Council, the Secretary, or the Governor of a State false information (including, but not limited to, false information regarding the capacity and extent to which a United State fish processor, on an annual basis, will process a portion of the optimum yield of a fishery that will be harvested by fishing vessels of the United States) regarding any matter that the Council, Secretary, or Governor is considering in the course of carrying out this Act.

# PUBLIC TESTIMONY SIGN-UP SHEET

**Agenda Item:** C-2 b c PSC crab bycatch discussion

| | NAME *(PLEASE PRINT)* | TESTIFYING ON BEHALF OF: |
|---|---|---|
| 1 | ~~Edward Poulsen~~ | ~~ICEPAC~~ |
| 2 | JOHN GAUVIN | Best Use Coop. |
| 3 | Edward Poulsen | ICEPAC |
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Component 2: Timing of closure areas

a) Fixed
   i. Year-round
   ii. Seasonal
   Option: based on vulnerable life history or gear susceptibility
b) Triggered
   i. Full
   ii. Stair-stepped (area closed expands as bycatch triggers are reached)

Component 3: Groundfish sectors/target fisheries included

a) All trawl sectors
b) All fixed gear sectors
c) Halibut IFQ

Component 4: Overfished stocks

a) Overfished/overfishing determination would trigger more restrictive PSC limits
b) Overfished/overfishing determination would trigger more restrictive time and area closures

Component 5: Accountability measures

a) Crab bycatch would accrue inseason towards groundfish sector PSC limit and an overage would trigger accountability measures during the subsequent season for that groundfish sector

Component 6: Catch accounting issues

a) Account for PSC limit accrual against time/area closure thresholds on a crab fishing year (June-May)

**C-2(c) Crab bycatch in BSAI groundfish fisheries**

The Council moves the following problem statement and alternatives for analysis:

**Problem Statement**

Total catch overfishing levels (OFLs) are specified annually for the ten crab stocks included in the Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs (FMP); these OFLs account for all sources of fishing mortality including directed crab fishery discards and bycatch mortality caused by groundfish, scallop, and Pacific halibut fisheries. Requirements to comply with Annual Catch Limits (ACLs), addressing uncertainty in OFL estimates, include Accountability Measures (AMs) that trigger a management action if an ACL is exceeded.

Crab bycatch in the directed crab and scallop fisheries is controlled by the State of Alaska, however current management structure does not link the crab and groundfish FMPs; if a crab ACL is exceeded due to bycatch mortality in a groundfish fishery the resulting AM would reduce directed crab fishery harvest the following year. Crab bycatch management measures were first adopted for BSAI groundfish trawl fisheries in 1986. These measures, established in the BSAI groundfish FMP, consist of triggered or fixed time and area closures and prohibited species catch (PSC) limits; PSC limits apply only to Bristol Bay red king, Bering Sea Tanner, and Bering Sea snow crab. There are no PSC limits for the remaining seven FMP crab stocks and the existing closure areas do not circumscribe the full distributional range of stocks they are intended to protect, thereby allowing bycatch mortality to occur without accrual towards PSC limits. Furthermore no bycatch management measures are imposed on the fixed gear groundfish or Pacific halibut sectors. In order to control crab bycatch in BSAI groundfish fisheries, the BSAI groundfish FMP must be amended.

**Alternative 1 - No action**

Maintain existing crab PSC limits and closure areas.

**Alternative 2 - Fixed PSC limits**

Crab PSC limits would be fixed in the BSAI groundfish FMP.

**Alternative 3 - Variable PSC limits**

Crab PSC limits would be set annually based on crab abundance.

Note: Different alternatives may be chosen for each FMP crab stock.

Components with options that could be applied to alternatives 2 and 3:

Component 1: Closure areas

a) Existing closure areas
b) Expand triggered closure areas to include full distribution of each crab stock
   Option: Triggered closure areas encompassing distribution of vulnerable size/sex components of crab stock

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June 10, 2010

Eric A. Olson, Chairman
NPFMC
605 West 4th Avenue, Suite 306
Anchorage, AK 99501-2252

RE: Comments on Agenda item: C-2, BSAI Crab ACLs and Snow Crab Rebuilding Plan; the need for technical clarifications:

ACLs: Reference, NPFMC action memo, Agenda C-2, June 2, 2010

- The State of Alaska Board of Fisheries and ADFG maintain that they are compliant and satisfying the essential M-S Act requirements for establishing conservation buffers, Annual Catch Limits (ACLs), when setting TACs for BSAI crab fisheries, as this is taken into consideration in their Harvest Strategies ~~for contained under this agenda item~~ that addresses the issue of ACLs in BSAI crab and statewide scallop federal fishery management plan amendments. ACC believes the Alaska Board of Fisheries have de facto codified the conservation buffers into State regulations, as noted in harvest strategies for Bering Sea and Aleutian Islands king and tanner crab fisheries.

  The Pacific Northwest Crab Industry Advisory Committee (PNCIAC) and the Alaska Bering Sea Crabbers, an alliance of the major BSAI crab harvesting organizations, ACC, the Crab Group and ICEPAC have filed comments with the NPFMC at the April NPFMC meeting recognizing AKBOF and ADFG compliance with the essence of annual catch limit requirements. The North Pacific Crab Association and the AK Bering Sea Crabbers have also filed additional supporting comments on this agenda item at this June Council meeting.

  Recent examples of ADFG real-time implementation of additional conservation buffers in TAC management: reduction of the Bristol Bay king crab TAC in the fall of 2006 to account for fleet hygrading, and return to normal exploitation rate the following year after fleet demonstrated ability to eliminate hygrading; inseason area closures in the 2008-2009 snow crab fishery to protect depressed Pribilof blue king crab stocks; pre-season closure of the Western subdistrict Tanner crab fishery in the fall of 2009, to protect declining stocks; pre-season implementation of 25% TAC buffer for the 2009-10 snow crab fishery to meet

NMFS recommendations for interim TAC prior to implementation of revised rebuilding plan.

Section 302(h)(6) of the MSA provides, among other things, that the Councils shall in accordance with the provisions of the Act, "develop annual catch limits for each of its managed fisheries that may not exceed the fishing level recommendations of its scientific and statistical committee or the peer review process established under subsection (g)."

Section 303(a) (15) includes the requirement that fishery management plans "establish a mechanism for specifying annual catch limits in the plan (including a multiyear plan), implementing regulations, or annual specifications, at a level such that overfishing does not occur in the fishery, including measures to ensure accountability."

The ACC also notes for the administrative record that the State of Alaska appears to be in compliance with the MSA Section 302 (h)(6) and Section 303(a)(15) relative to TAC annual catch limits, conservation buffers.

Additional uncertainty:

- Given that additional uncertainty is typically larger than within model variance the analysis should include a full range of values for additional uncertainty. The values 0.1, 0.2, and 0.3 were included in the April 2010 Council motion, but are not analyzed in the initial review draft. The public review draft should analyze not only the CPT recommended range of 0.2, 0.3, and 0.4, but also 0.1, 0.2, and 0.3.

Snow Crab rebuilding: Reference, 2010 Draft Crab SAFE, June 2010, page 9

- The Crab Plan Team is preparing a revised rebuilding plan for Snow Crab. However, page 9 of the 2010 Draft SAFE notes: "The most recent assessment indicates that Mature Male Biomass (MMB) never declined below the new definition of Mature Stock Size Threshold (MSST). If this is the case, then the snow crab stock is not overfished.

  Can the Council confirm that the current stock assessment is the best scientific information available and furthermore, can the Council request a stock status determination for snow crab to clarify this issue?

- The CPT recommends that Model 5 be used for the 2010/11 stock assessment. The rebuilding analysis is based on Model 1; if the SSC agrees that Model 5 is the correct approach then the analysis must be updated to include Model 5. The CPT recommends Model 5 because it provides the best fit to the data and is selected as best among the six models. The estimates of natural mortality and growth from Model 5 are not unreasonable based on previous model results.

Tanner crab Bmsy Methodology:

- Bmsy for Tanner crab is currently calculated using average survey biomass from 1969 to 1980. This differs from how Bmsy is calculated for the other Bering Sea crab stocks in that the time series continues to move forward and doesn't simply stop at a certain year as bairdi does in 1980. ACC, NPCA and the AK Bering Sea Crabbers recommend that the methodology for calculating Bmsy for Tanner crab be changed to use the average survey biomass from 1969 to present as this will allow incorporation of recent data that is more accurate, and it also allows for incorporation of data from the widely recognized major regime shift that occurred in the Bering Sea in the late 70's and early 80's.

Arni Thomson
Executive Director
Alaska Crab Coalition