**2008 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), 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 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*,(Bristol Bay, Pribilof Islands, Norton Sound and Adak), 2 blue king crab, *Paralithodes platypus*, (Pribilof District and St Matthew Island) 2 golden (or brown) king crab *Lithodes aequispinus* stocks (Aleutian Island and Pribilof Islands), EBSTanner crab *Chionoecetes bairdi*, and EBS snow crab *C. opilio*. All other BSAI crab stocks are exclusively managed by the State of Alaska.

The report is assembled by the Crab Plan Team with contributions from the Alaska Department of Fish and Game (ADF&G) and the National Marine Fisheries Service (NMFS), and is available to the public and presented to the North Pacific Fishery Management Council (NPFMC) on an annual basis. Under a process approved in 2008 for revised overfishing level (OFL) determinations, the Crab Plan Team reviews draft assessments in May to provide recommendation in a draft SAFE report for review by the Council's Science and Statistical Committee (SSC) in June. Additional information on the new OFL determination process is contained in this report. The Crab Plan Team met from May 6-9, 2008 at the Alaska Fisheries Science Center in Seattle WA to review the status of stocks and draft stock assessments for providing recommendations contained in this report. 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, Josh Greenburg, Herman Savikko, Gretchen Harrington, Doug Pengilly, Bob Foy, Lou Rugolo, Wayne Donaldson, and Diana Stram. Revised assessments will be reviewed by the Team in September 2008 with this report revised accordingly at that time to form the final 2008 Crab SAFE report. The final 2008 Crab SAFE report will be presented to the Council in October for their annual review of the status of BSAI Crab stocks.

## 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.

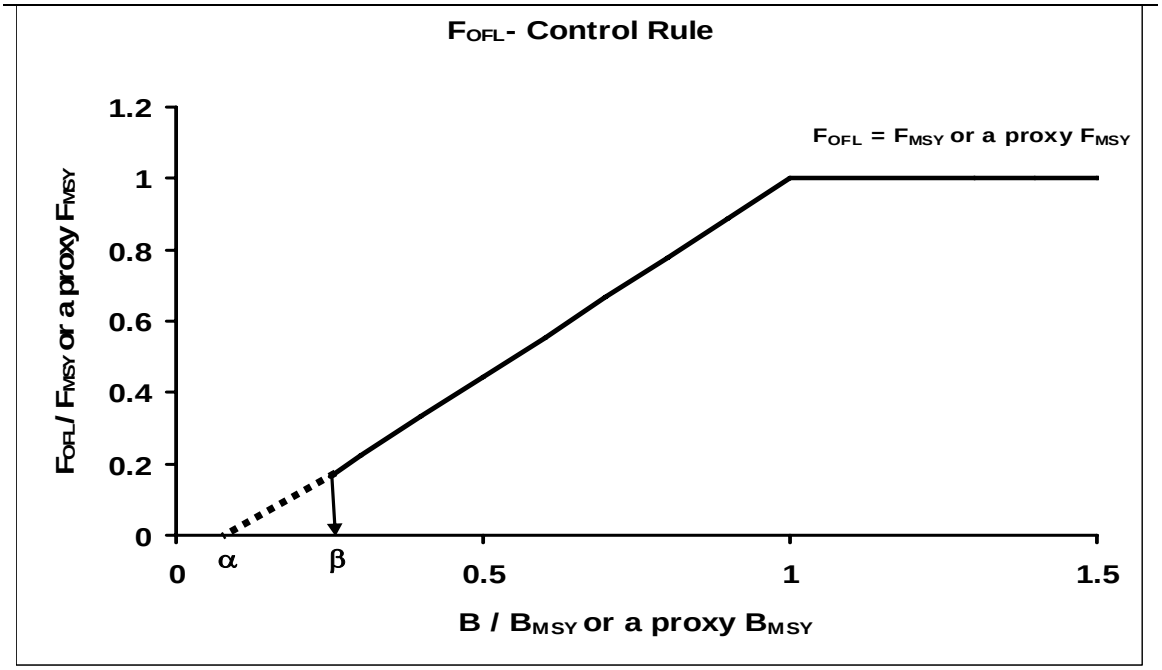

Table 1. Five-Tier System for setting overfishing limits for crab stocks. The tiers are listed in descending order of information availability. Table 6-2 contains a guide for understanding the five-tier system.

| 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. $\beta < \frac{B}{B_{msy}} \leq 1$ | $F_{OFL} = \mu_A \frac{B/B_{msy} - \alpha}{1-\alpha}$ |
| | | c. $\frac{B}{B_{msy}} \leq \beta$ | *Directed fishery F = 0* <br> $F_{OFL} \leq F_{MSY}$† |
| $B$, $B_{MSY}$, $F_{MSY}$ | **2** | a. $\frac{B}{B_{msy}} > 1$ | $F_{OFL} = F_{msy}$ |
| | | b. $\beta < \frac{B}{B_{msy}} \leq 1$ | $F_{OFL} = F_{msy} \frac{B/B_{msy} - \alpha}{1-\alpha}$ |
| | | c. $\frac{B}{B_{msy}} \leq \beta$ | *Directed fishery F = 0* <br> $F_{OFL} \leq F_{MSY}$† |
| $B$, $F_{35\%}^*$, $B_{35\%}^*$ | **3** | a. $\frac{B}{B_{35\%*}} > 1$ | $F_{OFL} = F_{35\%}*$ |
| | | b. $\beta < \frac{B}{B_{35\%}*} \leq 1$ | $F_{OFL} = F^*_{35\%} \frac{\frac{B}{B^*_{35\%}} - \alpha}{1-\alpha}$ |
| | | c. $\frac{B}{B_{35\%}*} \leq \beta$ | *Directed fishery F = 0* <br> $F_{OFL} \leq F_{MSY}$† |
| $B$, $M$, $B_{msy^{prox}}$ | **4** | a. $\frac{B}{B_{msy^{prox}}} > 1$ | $F_{OFL} = \gamma M$ |
| | | b. $\beta < \frac{B}{B_{msy^{prox}}} \leq 1$ | $F_{OFL} = \gamma M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$ |
| | | c. $\frac{B}{B_{msy^{prox}}} \leq \beta$ | *Directed fishery F = 0* <br> $F_{OFL} \leq F_{MSY}$† |
| 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 $F_{OFL} \leq F_{MSY}$ 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 $0 \leq \beta < 1$.
  - $\alpha$ — a parameter with restriction that $0 \leq \alpha \leq \beta$.
- 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 $B \leq \beta\cdot B_{MSY}$, F = 0 for the directed fishery and $F_{OFL} \leq F_{MSY}$ 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 $\beta\cdot B_{MSY} < B \leq B_{MSY}$.
  - 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 $\beta\cdot B_{MSY} < B \leq B_{MSY}$.

# Crab Plan Team Recommendations

This was the first year of implementation of the new process for annual stock assessment and OFL determination for all ten BSAI crab stocks. The Crab Plan Team commends all of the stock assessment authors on the assessments produced (Chapters 1-10) under a limited time frame and with great attention to providing comprehensive details on a stock by stock basis.

The team's recommendations on Tier levels, model parameterizations, time periods for reference biomass estimation or appropriate catch averages, OFLs (Norton Sound and Aleutian Island golden king crab only) and whether an OFL is applied to retained catch only or to all catch are all listed in Table 3. 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 District 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 Islands golden king crab and Adak red king crab). Additional information as indicated in Table 3 will be provided after final assessments are available in September 2008. A listing of handling mortality values utilized in assessments are indicated in Table 4.

The team understands that under this new process, the CPT has the ability to provide recommendations for consideration in the following assessment cycle on an annual basis. The team has general

recommendations for all assessments and specific comments related to individual assessments. All recommendations are for consideration in the following year's assessment 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 2008 CPT Report).

### *General recommendations for all assessments*

- The assessments should provide complete documentation on model formulation, assumptions, data sources and all calculations used in the stock assessment for computing the OFL.
- For stocks where biomass estimates for OFL setting are based on survey estimates, consideration should be given to averaging recent abundance to obtain a more reliable estimate of current stock size.
- Future stock assessments should provide a full analysis on the choice of gamma and a full evaluation of alternatives relative to the default value, $\gamma$=1, and the appropriateness of this default value.
- All three rebuilding plans (EBS snow crab, Saint Matthew blue king crab and Pribilof District blue king crab) need to be revised given new estimates of stock status parameters.
- Research on handling mortality rates needs to be performed to better specify handling mortality rates used in the analysis.
- The assessments must include consistent key management-related stock status information.

# Stock Status Summaries

## 1 Eastern Bering Sea Snow Crab (C. opilio)

*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 harvest strategy that aims to allow recovery to the proxy for $B_{MSY}$ established in 1998 (921.6 million lbs of total mature biomass).

*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 1978-2007 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. Unlike previous assessments, the 2008 assessment pre-specified rather than estimated the parameters determining growth. Two variants of the assessment were presented to the CPT, which selected the base model (in which maturity is not estimated within the assessment, but is rather pre-specified based on auxiliary analysis).

The assessment was modified in 2008 in response to an external industry review and a review by the CIE.

Specifically, the model is no longer fitted to length data by shell condition, but rather to data combined over shell condition, and it now assumes that females and males grow at the same rate at 25mm. The treatment of the size distribution of recruits has been revised to improve the residual patterns for the length-frequency data. The assessment may be refined again in the next year based on further consideration of the comments from the CIE review and the CPT.

*Stock biomass and recruitment trends*

Mature male biomass (at the time of mating) peaked between the late-1980s and mid-1990s, declined to a minimum in 2002 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 1979-2007, with the recruitment (at 25mm) in 1987 the highest on record. Recent recruitment has been near over above average.

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

The CPT recommends that 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 $B_{\mathrm{MSY}}$ ($B_{35\%}$) 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 $B_{\mathrm{MSY}}$. The assessment presented to the CPT will be updated by incorporating 2008 survey and fishery data into the base model to calculate the 2008/09 OFL and MSST.

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

| Year | OFL | Biomass (MMB) | TAC | Retained Catch | Total Catch |
|---|---|---|---|---|---|
| 2005/06 | | 171 | 37.2 | 37.0 | 42.7 |
| 2006/07 | | 209 | 36.6 | 36.4 | 44.1 |
| 2007/08 | | 275.8 | 63.0 | | |
| 2008/09 | TBD | | | | |

Stock status determination relative to overfishing and overfished criteria will be made following review of an updated assessment that incorporates the 2008 survey.

*Additional Plan Team recommendations*

The September assessment should: (a) include retrospective analyses, (b) update the reference list, (c) include a full description of the model, including its forecast component and the weights assigned to the penalties and likelihood components, (d) expand the description of the way in which discards are treated in the model, (d) include past GHLs in the table of catches, (e) include a full list of parameters, indicating which parameters are pre-specified and which are estimated and, for the estimated parameters, which are bounded.

The next assessment should consider: (a) imposing a penalty to prevent the probability of maturity declining with increasing size if maturity is estimated within the model, (b) set the effective sample sizes for the length-frequency data based on the effective sample sizes estimated from the fit of the model, (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) reducing the number of size classes for females, and (e) including measures of uncertainty for estimated quantities such as recruitment, and mature male biomass

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

# 2 Bristol Bay red king crab (BBRKC)

*Fishery information relative to OFL setting.*

The commercial harvest of 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 have has remained at relatively low levels over the last two decades compared to that seen in the 1970s. The fishery is managed for a TAC coupled with restrictions for size ( ≥ 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 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 of 15% of mature males but also incorporates a cap 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. A TAC of 18.3 million lbs was established for the 2005 season, reduced to 15.0 million lbs for the 2006 season, and increased to 20.4 million lb for the 2007 season. Average retained catch for the period 2004 to 2007 was 18.0 million lbs. Catch abundance of legal males per pot lift was relatively high in the 1970s, low in the 1980s to mid-1990's, and has gradually increased since 2000 to an average of 29.7 crab/pot lift over the last three years; CPUE increased markedly with the implementation of crab rationalization in 2005. 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. Estimates of fishing mortality have ranged from 0.28 to 0.38 following implementation of crab rationalization. Total catch was 22.7 million lbs in 2005, declined to 17.2 million lbs in 2006 and increased to 23.5 million lbs in 2007.

*Data and assessment methodology*

The stock assessment model involves a length-based model incorporating data from the eastern Bering Sea trawl survey, commercial catch, and at-sea observer data. Stock abundance is estimated for male and female crabs ≥ 65-mm CL during 1985 to 2008. Catch data (retained catch numbers, retained catch weight, and pot lifts by statistical area and landing date from the fishery which targets males ≥6.5" carapace width) were obtained from ADF&G fish tickets and reports, fishery bycatch data from the ADF&G observer database, and groundfish trawl bycatch data from the NMFS trawl observer database.

*Stock biomass and recruitment trends*

Estimates of stock biomass have generally increased since 1985, to 39.0 million lbs in 2007, but remain well below historic levels of the 1970s. Recent above-average year classes have largely recruited into the fished population with no evidence of new strong recruitment. Mature male biomass increased from 79.9 million lbs in 2005 to 85.9 million lbs in 2007.

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

The team made several recommendations for improvements to the assessment. For example, it was noted that the assessment model only includes data since 1985, whereas previous assessments included information dating to the 1960s. The team requested that the next assessment incorporate data back to the 1960s. Estimates of stock biomass have slowly increased since at least the mid-1990s, and the authors pointed out that M likely differed substantially before and after the mid 1980s and that crab spatial

distribution has changed substantially since the pre-1980s.

Under the current assessment, the author's recommended $B_{MSY}$ proxy is based on mean recruitment during 1995-2008, which the team felt underrepresented the available stock information. The team noted that the estimate of $B_{35\%}$ may increase substantially under a set of years encompassing a greater portion of the time series and greater range of estimated recruitment levels. The team considered several alternatives including: (1) adopt the author's recommendation; (2) re-scale $B_{35\%}$ in the author's current recommendation by the relative scale of survey MMB in the current recommended time frame against survey MMB in the desired time frame; or (3) drop stock to Tier 4. However, the team felt substantial uncertainty in making OFL decisions in the absences of more thorough model analysis. The team endorsed the author's recommendation for calculating $B_{35\%}$ because it is not feasible to conduct and review alternative analyses prior to the September CPT meeting. The team recommends that these additional analyses be incorporated into the assessment for the Spring 2009 review.

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.

Status and catch specifications (million lbs.) of BBRKC in recent years.

| Year | OFL | TAC | MMB | Retained Catch | Total catch |
|---|---|---|---|---|---|
| 2005/06 | | 18.3 | 79.92 | 18.3 | 22.72 |
| 2006/07 | | 15.5 | 82.03 | 15.4 | 17.22 |
| 2007/08 | | 20.4 | 85.94 | 20.4 | 23.52 |
| 2008/09 | TBD | TBD | | | |

Stock status determination relative to overfishing and overfished criteria will be made following review of an updated assessment that incorporates the 2008 survey

*Additional Plan Team recommendations*

The Plan Team identified the need for a table showing which parameters are model-estimated and which are fixed, as well as CVs or some other uncertainty measure. It was also suggested that future assessments include some analysis of model sensitivity to different weightings (lambda's). The magnitude of lambdas has a direct affect on projected biomass and catch likelihood profiles because increasing lambdas artificially decreases the width of the profiles. In terms of evaluating uncertainty in some of the forcing parameters, the team recommends that the authors provide a plot of a likelihood profile for some of the parameters such as trawl survey catchability and M. It was also recommended that the author consider parameter estimation in a Bayesian context. Figures of standardized residuals should be provided, along with providing clarification on whether the residual patterns reflect a cohort effect or a growth effect. The team also requested clarification of the effect of aging errors on molt probability. The team recommends that a column be added in the catch table for total catch (all sources of catch).

*Ecosystem Considerations summary*

A variety of ecological factors likely affect BBRKC recruitment and growth, although the mechanisms are unclear. For example, previous research suggested BBRKC recruitment trends may partly relate to decadal shifts in physical oceanography. Recruitment may also relate to spatial and temporal patterns in groundfish distributions. Finally, spatial distributions of RKC females have likely shifted in response to changes in near bottom temperatures.

# 3 Eastern Bering Sea Tanner Crab (*C. bairdi*)

*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 IFQ for these two fisheries. However, NMFS will set one OFL for the eastern Bering Sea Tanner crab because evidence indicates that the EBS Tanner crab is one stock. 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 and 2007/08 crab fishing years. In 2007, NMFS determined the stock was rebuilt.

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

*Data and assessment methodology*

This stock is surveyed annually by the NMFS EBS trawl survey. Although a stock assessment model has been developed for the eastern portion of the stock, however this model is not employed to assess the stock as it does not cover the entire EBS. Area swept estimates of biomass from the EBS trawl survey are used to estimate biomass of stock components; mature male biomass (MMB), legal male biomass (LMB), and females. Fish ticket data are used for computing retained catch and observer data from the crab and groundfish data are used to estimate the non-retained catch; assumed handling mortality rates for fishery components are used to estimate the discard mortality.

*Stock biomass and recruitment trends*

Mature male biomass (MMB) and legal male biomass (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 has risen at a moderate rate from a low of 25.1 million pounds in 1997 to its current level of 185.2 million pounds in 2007.

Prior to Amendment 24, biomass relative to overfishing was measured as total mature biomass (TMB; i.e., biomass of mature males and females). The 2007 estimate of total mature biomass (TMB) for this stock is 251.1-million pounds, which is comparable to the 2006 estimate of 253.3-million pounds. The 2006 and 2007 TMB estimates are the two highest since 1994 and represent a sharp increase from the estimates for 2005 and 2004 (162.0 and 87.5-million pounds, respectively). Both the 2006 and 2007 TMB estimates are above BMSY (189.6-million pounds) and the stock is considered rebuilt. Compared to recent years, recruitment of males to the legal size class is expected to continue at similar or higher levels, whereas recruitment to the large female size class may decrease.

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

- The team recommends this stock as a Tier 4 stock because no stock assessment model has been developed for the entire EBS stock.
- The team recommends that $B_{REF}$ is based on the average mature male biomass (MMB) for the years 1975-1980, 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 equivalently.

- The team recommends that gamma be estimated using the $F_{35\%}$ approach. The assessment provided only an analysis using only the default value, $\gamma$=1.0. The CPT recommended that an analysis of the $F_{35\%}$ approach be presented for evaluation at the June SSC meeting as an alternative to the default gamma value.

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

| Year | Biomass (MMB) | OFL | TAC (east + west) | Retained Catch | Total Catch |
|---|---|---|---|---|---|
| 2005/06 | 86.24 | | 1.6 | 0.95 | 4.19 |
| 2006/07 | 125.98 | | 2.97 | 2.12 | 11.66 |
| 2007/08 | TBD | | 5.62 | 1.91 | TBD |
| 2008/09 | 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 2008 survey

*Additional Plan Team recommendations*

- Based on the assessment, much of the data and information needed to develop a stock assessment model for the entire EBS stock may exist. It is recommended that development of such a model should proceed; the stock assessment model developed for the eastern portion of the EBS Tanner crab stock should be reviewed for adaptation for a model to apply to the full EBS.
- Future spring stock assessments should provide a full analysis on the choice of gamma and a full evaluation of alternatives relative to the default value, $\gamma$=1, and the appropriateness of the default value.
- The assessment should provide complete documentation on data sources and the calculations and assumptions used in the stock assessment for computing OFL. The total catch OFL should be clearly specified and provided in a table focused on deriving that OFL. Information on sub-dividing the OFL among catch components should be removed from the assessment because it is confusing and not the focus of our task.
- Research on handling mortality rates needs to be performed to better specify handling mortality rates used in the analysis.
- The team will revise the terms of reference for assessments to include key management related stock status information consistently.

*Ecosystem Considerations summary*
Although studies are limited, the EBS Tanner crab fisheries do not appear to negatively impact any ecosystem components. Climate change may negatively impact Tanner crab abundance through increasing predator abundance, decreasing benthic production, and the potential for decalcification in a more acidic ocean.

# 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 specified GHL for the first time in September 1993. The 1993 fishery yielded 2.6 million lbs under a 3.4 million lb GHL, with 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 1.3 to 2.5 million lbs. The fishery has remained closed since 1999 because of uncertainty with estimated red king crab survey abundance and concerns for incidental catch of blue king crab that are in a depressed state. .The total pot and groundfish bycatch estimates of red king crab ranged from <0.1 to 0.2 million lbs during 1992-2007.

*Data and assessment methodology*

Although a catch survey analysis has been used for assessing the stock in the past, incorporating 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 the period 1980-2007. For 2007 reference points' estimation, an $F_{OFL}$ was determined using a mean mature male biomass (MMB) at the time of mating, 2007 MMB, a default $\lambda$ value of 1, and an M value of 0.18. This $F_{OFL}$ was used on the legal male biomass at the time of the fishery to determine the catch OFL. Total legal crab removal (retained and bycatch losses) with legal biomass and MMB were used to estimate the exploitation rate at the time of the fishery.

*Stock biomass and recruitment trends*

The stock exhibited widely varying mature male and female abundances during 1980-2007. The 2006 and 2007 estimates of MMB were at high levels, 15.65 and 16.58 million pounds, respectively. The recruitment trend appeared to be highly variable. However, survey estimates are highly influenced by the results of a limited number of tows with non-zero catches. 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*
The team recommended Tier 4 for OFL determination and the use of the MMB from the survey abundance estimates at the time of mating for the period 1991-2007 for estimating $B_{ref}$.
Considering the high variability of MMB along with the poor precision of the surveys, the plan team recommends that $B_{ref}$ be based on the entire period 1991-2007.

Stock status determination relative to overfishing and overfished criteria will be made following review of an updated assessment that incorporates the 2008 survey.

Status and catch specifications (million lbs.) of Pribilof Islands red king crab

| Year | OFL | Biomass* (MMB) | TAC | Retained Catch | Total catch |
|---|---|---|---|---|---|
| 2005/06 | | 2.98 | | | |
| 2006/07 | | 15.65 | | | |
| 2007/08 | | 16.58 | | | |
| 2008/09 | TBD | | | | |

*Note here biomass is at the time of the survey

*Additional Plan Team recommendations*

There are concerns about the unreliability of biomass estimates and blue king crab bycatch mortality would occur in a directed red king crab fishery. As a result of this and considering the poor blue king crab stock condition, the crab plan team recommends the fishery not open in 2008/09.

*Ecosystem Considerations summary*

There have been no direct studies of the prey of Pribilof Islands red king crab. Studies in other areas indicate that red king crab diet varies with life stage and that red king crabs are opportunistic omnivorous

feeders, eating a wide variety of microscopic and macroscopic plants and animals. Pacific cod is the major predator of red king crab in the eastern Bering Sea. Recruitment trends for red king crab in the eastern Bering Sea may be partly related to decadal shifts in climate and physical oceanography. Strong year classes were observed when temperatures were low and weak year classes were occurred when temperatures were high, but temperature alone cannot explain year class strength trend. The lack of king crab recruitment in the Pribilof Islands area may be the result of a large-scale environmental event affecting abundance and distribution. The seasonal ice cover has an effect on primary productivity and hence crab recruitment, but the changes in the ice cover on benthic communities of the Pribilof Islands are not well known. The trawl fishery ban around the Pribilof Islands protects the critical habitat of the red king crab in this area. The extent that pot gear impacts benthic habitat is not well known and most likely depends on the substrate.

# 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 2007/08 season.

Estimated total mature biomass, based on the ADF&G catch-survey model decreased from 7.0 million lbs in 2001 to 4.5 million lbs in 2002, a level below MSST and resulting in the stock being designated as overfished in 2002.

*Data and assessment methodology*

The NMFS conducts an annual trawl survey that produces area-swept abundance estimates, and ADF&G is developing a catch-survey analysis model. However, because the model was not reviewed, the CPT chose to base the current OFL recommendation on area-swept abundance estimates.

The CPT discussed the history of the fishery and the rapid decline in landings. It is clear that the stock has collapsed, although there is imprecision in the annual area-swept abundance estimates. The CPT discussed averaging recent biomass estimated to account for annual fluctuations to reduce noise in the data. For stocks where biomass estimates for OFL setting are based on survey estimates consideration should be given to averaging recent abundance estimate to obtain a more reliable estimate of current stock size.

*Stock biomass and recruitment trends*

Based on catch-survey analysis from the 2007 NMFS trawl survey, the estimated total mature biomass of 1.3 million pounds is the second lowest on record, exceeding only that of 0.6 million pounds in 2004. Estimated 2007 abundance of 0.1 million mature-sized males is the second lowest on record, whereas estimates of 0.1 million legal males and 0.3 million mature-sized males females are the lowest on record. A continued decline in mature male and female abundances is anticipated for at least two years. The Pribilof blue king crab stock continues to show no indications of near-term recovery.

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

The CPT recommends this stock be placed into Tier 4. The team recommended the use of the time period for $B_{ref}$ is 1980-84 plus 1990-97, excluding the 1985-1989 period. This was chosen as it eliminates

periods of extremely low abundance. $B_{MSY}$ is estimated as $B_{ref2,}$ or 8.96 million pounds MSST is one half of the $B_{ref}$.

The CPT recommended gamma = 1, given the absence of information presented to establish an alternate value at this time. Natural mortality was M=0.18

Status and catch specifications of Pribilof blue king crab in recent years.

| Year | OFL | Biomass MMB* | TAC | Retained Catch | Total Catch |
|---|---|---|---|---|---|
| 2005/06 | | 0.76 | 0 | 0 | 0.002 |
| 2006/07 | | 0.39 | 0 | 0 | 0.004 |
| 2007/08 | | 0.76 | 0 | 0 | 0.060 |
| 2008/09 | TBD | | | | |

*Note this biomass is at the time of the survey

The rebuilding plan needs to be revised given new estimates of stock status parameters. In the absence of revision of the rebuilding plan the assessment author needs to establish an $F_{MSY}$ proxy in order to establish an OFL for this stock in the fall.

# 6 St. Matthew blue king crab

*Fishery information relative to OFL setting*

The fishery was prosecuted as a directed fishery from 1977 to 1998. The stock was declared overfished and closed in 1999, and has been under a rebuilding plan since 2000.

*Data and assessment methodology*

A four-stage catch survey analysis incorporates annual trawl survey data from 1978 to 2007, triennial pot survey data from 1995 to 2007, and commercial catch data from 1978 to 2007, and uses a maximum likelihood approach to estimate male crab biomass and abundance. The model links crab abundance in four crab stages based on a growth matrix, estimated mortalities, and molting probabilities. The four stages include prerecruit-2s (90-104 mm CL), prerecruit-1s (105-119 mm CL), recruits (newshell 120-133 mm CL), and postrecruits (oldshell ≥ 120 mm CL and newshell ≥ 134 mm CL). The model was developed for three scenarios in which either one or both parameters of natural mortality (M) or survey catchability (Q) were fixed (M = 0.18 and Q = 1). The scenario with both Q and fixed M was selected by the CPT because of the uncertainty in parameter estimation.

*Stock biomass and recruitment trends*

Mature male biomass has fluctuated greatly in three waves. The first pulse increased from 7.6 to over 17.6 million lbs from 1978 to 1981, followed by a steady decrease to 2.9 million lbs. in 1985. The second pulse had a steady increase from the low in 1985 to 13.3 million lbs. in 1997 followed by a rapid decrease to 2.8 million lbs. in 1999. The third pulse had a steady increase from the low in 1999 to it present high of over 12.22 million lbs. in 2007.

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

St. Matthew BKC is recommended as a Tier 4 stock in 2008. The $B_{MSY}$ proxy varies as a function of years used to calculate average mature male biomass. The time period selected by CPT for estimating $B_{ref}$ was 1989 to 2008 because before 1986, the fishery was harvested at extremely high rates and this time period incorporates stock rebuilding several years after the stock crash. Gamma was recommended

to be 1. OFL that will be set for this year using the Tier 4 control rule a retained catch OFL because bycatch data was not included in the assessment.

*Status and catch specifications (millions lbs.) of St. Matthew blue king crab*

| Year | OFL | Biomass (MMB) | TAC | Retained Catch | Total Catch |
|---|---|---|---|---|---|
| 2005 | | 5.47 | closed | 0 | |
| 2006 | | 7.38 | closed | 0 | |
| 2007 | | 12.22 | closed | 0 | |
| 2008 | TBD | | | | |

This stock is not overfished and is not approaching overfishing[TBD].

*Additional Plan Team recommendations)*

Bycatch data needs to be compiled with an analysis to generate a total catch OFL for next year's assessments. Bycatch estimates from the model should be tabulated to provide information for estimating total catch OFL. Figures of standardized residuals should be provided, along with clarification on whether the residual patterns reflect a cohort effect or a growth effect. The assessments needs to include figures showing data and fits to these data for both pot and trawl surveys including confidence intervals on data and model results. The assessment should also examine the sensitivity of the weighting choices employed in the model to examine relative influence on results [e.g. conducting the assessment using each of the two indices of abundance in turn (pot and trawl survey)]. The plan team recommends examining the sensitivity of constant M over the whole time period.

*Ecosystem Considerations summary*

Information on habitat, prey availability and predator trends are needed with greater spatial and temporal resolution in order to better understand how they may vary with St. Matthew BKC abundance.

# 7 Norton Sound Red King Crab

*Fishery information relative to OFL-setting*

Norton Sound red king crab harvest occurs in three fisheries: summer commercial, winter commercial, and winter subsistence fishery. The summer commercial fishery is the major fishery. Commercial fishing started in 1977 and, since 1994, commercial vessels were restricted harvesting Norton Sound red king crab only. In 1998, Community Development Quota groups were allocated a portion of the summer fishery quota. The winter commercial fishery is relatively small averaging 2,400 crabs annually during 1997-2007. The subsistence fishery, which averaged 5,300 crabs during 1978-2007, occurs mainly during the winter via hand lines and pots deployed through the near shore ice.

The management strategy for Norton Sound red king crab involves a stepped harvest rate (HR). The guideline harvest level for the summer fishery is established at three levels based on estimated legal biomass (ELB): (1) HR = 0% for ELB < 1.5 million lbs; (2) HR ≤ 5% for ELB from 1.5 to 2.5 million lbs; and (3) HR ≤ 10% for ELB > 2.5 million pounds.

*Data and assessment methodology*

Fishery-dependent data are available for the three fisheries. Fishery-independent data are available through four surveys: summer trawl, summer pot, winter pot, and a preseason pot survey. Surveys are conducted periodically with no survey being conducted on an annual basis. No bycatch or discard data is available for the fisheries. A length based stock model was developed to estimate annual stock abundance for the period 1976-2007. Summer commercial fishery data are available from 1977.

*Stock biomass and recruitment trends*
Estimated legal stock abundance was high during the 1970s, low in the early 1980s and mid 1990s, and has gradually trended upward since 1996. Estimated recruitment was low in the late 1970s and early and late 1990s, and higher in the early 1980s, mid 1990s, and early 2000s, with a generally upward trend in the most recent seasons.

*Tier determination, Plan Team discussion and OFL determination*
The Crab Plan Team discussed the current status of the stock abundance model and had several concerns. The team notes that most model parameters are fixed and recommends that the justification for this be provided as well as a sensitivity analysis conducted to evaluate alternative values. Selectively is currently pre-specified to increase with size. Model results appear to indicate that something is mis-specified in the way that the model reaches each selectivity. The assessment should include greater sensitivity tests, particularly a range of weights on various parameters considered. Model specification should be investigated and alternative configuration sought as an improvement over the current model.

The team discussed alternative OFL setting approaches for this stock given concerns expressed about the model. Three alternative approaches are put forward: (1) use of the model estimate (understanding the issues inherent in the model estimate and suggestions for the following year); (2) use of the survey biomass estimate to calculate a Tier 4 OFL; and (3) placing this stock in to Tier 5 and basing an OFL on average catch. While the team expressed concerns as noted previously with the model and assessment as currently formulated, the team concluded that use of survey biomass estimates not presented was not sufficient, and that use of a Tier 5 formulation when biomass estimates are available is inappropriate.

The team chose to go forward with a Tier 4 recommendation for this stock and the use of the model biomass estimates to determine an appropriate OFL. The team discussed the author's recommendation of the use of the years 1983-2008 in order to exclude the 1976-1982 period. The start date of 1983 was chosen over 1980 due to representing the first appearance of post-regime shift recruitment. Gamma was recommended at 1.0 due to issues with the model and assumptions regarding selectivity in the model.

The team agreed with the assessment author's recommendation for the years under consideration for the BMSY proxy, and resulting OFL noting that for this stock the OFL is included in the recommendation from the plan team.

*Status and catch specifications (million lbs.)*

| Year | OFL | Biomass (MMB) | TAC | Retained Catch | Total Catch |
|---|---|---|---|---|---|
| 2005 | | 3.890 | 0.37 | 0.40 | |
| 2006 | | 3.623 | 0.45 | 0.45 | |
| 2007 | | 4.401 | | | |
| 2008 | 0.6781 | 5.240 | | | |

The OFL for 2008/09 is that recommended by the Plan Team.
For 2008, the $B_{MSY}$ proxy is 3.567 million lbs, $F_{MSY}$ proxy = 0.18, $B$ = 5.240 million lbs, and $LMB$ = 4.1162 million lbs. The 2008 $OFL$ for retained catch is 0.2460 million crabs or 0.6781 million lbs.

*Additional Plan Team recommendations*
Additional team recommendations to the assessment authors follow: The team requests that additional information be included in future assessment reports on asymptotic standard errors and selectivity

parameters (to indicate which are fixed not estimated). The residual plots as shown are difficult to interpret and should be revised. The team discussed the rationale for using the M value of 0.18 and its basis on laboratory studies. Some team members did not agree with this estimate usage for this stock noting that model information could be used to inform the best estimate. The team recommends exploration of a broader range of models and sensitivity analyses for this stock in the future.

# 8 Aleutian Islands golden king crab

*Fishery information relative to OFL setting*

The fishery has been prosecuted as a directed fishery since the 1981/82 season and has been open every season since then. 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 and average harvests for the period 1990/91–1995/96 was 6.9 million lbs. Management for a formally established GHL was first introduced with a 5.9-million lb GHL in the 1996/97 season, subsequently reduced to 5.7-million lbs beginning with the 1998/99 season. The GHL (or TAC, since the 2005/06 season) has remained at 5.7 million lbs through the current season. Average retained catch for the period 1996/97–2006/07 was 5.6 million lbs, including 5.3 million lbs in the 2006/07 season. This fishery is rationalized under the Crab Rationalization Program.

*Data and assessment methodology*

There is no assessment model in use for this stock. Available data are from fish tickets (retained catch numbers, retained catch weight, and pot lifts by 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 2006/07 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.

*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.

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

AIGKC is recommended as a Tier 5 stock in 2008/2009. $B_{MSY}$ and MSST are not estimated for this stock. OFL was set for this year using a retained catch OFL The time period for calculating average catch was selected as 1990/1991 to 1995/1996 because before 1990, there were indications that harvest was not sustainable and post 1996, harvests were constrained by a constant GHL/TAC, and therefore this time period best represents the production potential of the stock.

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

| Year | OFL | Biomass (MMB) | TAC | Retained Catch | Total Catch |
|---|---|---|---|---|---|
| 2005/06 | | NA | 5.70 | 5.52 | |
| 2006/07 | | NA | 5.70 | 5.22 | |
| 2007/08 | | NA | 5.70 | | |
| 2008/09 | 6.931 (retained) | | | | |

This stock is not experiencing overfishing [TBD].

*Additional Plan Team recommendations*

The plan team recommends continued development of the stock assessment model. Use of an assessment model would allow for this stock to be moved to Tier 4 and would provide focus for establishing research and data collection priorities. The team would like to review the model at the September plan team meeting.

Sufficient bycatch data exists to generate a total catch OFL and needs to be synthesized with an analysis for future assessments.

*Ecosystem Considerations summary*
No ecosystem considerations were considered at this time.

# 9 Pribilof Islands golden king crab

*Fishery information relative to OFL setting*

The domestic fishery around the Pribilof Islands for male golden king crab ≥5.5 in. CW (≥124 in. CL) developed in 1982. Since then, fishery participation has been sporadic and retained catches variable. The fishery has been managed for a GHL of 0.15 million lbs since 2000. Non-retained bycatch occurs in the directed fishery as well as the Bering Sea snow crab fishery and Bering Sea grooved Tanner crab fishery. No vessels participated in the fishery in 2006 or 2007. This fishery was not included in the Crab Rationalization Program.

*Data and assessment methodology*

There is no survey and no assessment model in use for this stock. Available data are from fish tickets (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 numbers of participating vessels or processors.

*Stock biomass and recruitment trends*

Estimates of stock biomass are not available. Between 2002 and 2005, the average size of legal male golden king crab taken in the commercial fishery decreased while CPUE increased, which may suggest some recruitment to the legal male portion of the stock during that period.

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

The team recommends that this stock be assigned to Tier 5 due to the lack of available biomass

information. Catch history from 1993-1999 is proposed for OFL determination resulting in an OFL of 0.174 million lbs. This OFL is proposed for retained catch only. All sources of mortality should be included in the assessment next year.

*Status and catch specifications (million lbs.) of Pribilof Islands golden king crab*
Status and catch specifications (million lbs.) of PIGKC in recent years. Confidential data not available due to a total of less than three vessels or processors participating in the fishery

| Year | OFL | GHL | Retained Catch | Catch (non retained all fisheries) |
|---|---|---|---|---|
| 2005/06 | | 0.150 | confidential | 0.019 |
| 2006/07 | | 0.150 | 0 | (not available) |
| 2007/08 | | 0.150 | 0 | (not available) |
| 2008/09 | TBD | | | |

No overfished determination is possible for this stock due to the lack of biomass information. This stock is not experiencing overfishing[TBD].

## 10 Adak red king crab, Aleutian Islands

*Fishery information relative to OFL setting*
The domestic fishery has been prosecuted since 1961 and was opened every season through the 1995/96 season. Non-retained catch of red king crabs occurs in both the directed red king crab fishery and in the Aleutian Islands golden king crab fishery. Estimated non-retained catch during the 1996/97-2006/07 seasons has been low (less than 50,000 lbs) and was less than 10 percent of the retained catch in 2002/03 and 2003/04 seasons.

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 943,000 lbs, but the retained catch during the 1995/96 season was only 39,000 lbs. Since the 1995/96 seasons, the fishery was opened only occasionally. There was an exploratory fishery with a low GHL in 1998/99; three Commissioner’s permit fisheries in limited areas during 2001 and 2002 to allow for ADF&G-Industry surveys, and two commercial fisheries with a GHL of 500,000 lbs 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 seasons (2002/03 and 2003/04) were opened only in the Petrel Bank area. Retained catch in the last two commercial fishery seasons was 506,000 lbs (2002/03) and 479,000 lbs (2003/04). The fishery has been closed since the end of the 2003/04 season. Non-retained catch of red king crabs occurs in both the directed red king crab fishery, in the Aleutian Islands golden king crab fishery, and groundfish fisheries. Estimated non-retained catch during the 1996/97-2006/07 seasons averaged 26,000 lbs per year. This fishery is rationalized under the Crab Rationalization Program only for the area west of 179° W longitude.

*Data and assessment methodology*
There is no assessment model in use for this stock. The department conducts periodic pot surveys in the area. Prior to the 2006 survey, the last one conducted was in 2001, performed with industry participation under provisions of a commissioner’s permit. In 2006 the department also conducted “niche” fishing in addition to their regular survey design. Pots were fished at locations between the survey stations, in strings similar to commercial fishing, utilizing the expertise of the vessel captain to provide location and pot spacing. Niche fishing was conducted to the northwest portion of the Petrel Bank, the area that

produced the highest catch of red king crabs during the 2006 survey. Comparisons with the November 2001 industry survey were made for both the 2006 survey and niche fishing. Due to differences in fishing practices, direct comparisons cannot be made between the CPUE of legal males obtained during this survey with that obtained during the 2001 industry survey. Recognizing the limitations in making direct comparisons of the CPUE of legal males between the 2006 survey and the November 2001 survey, the following observations on CPUE of legal males during the 2006 survey and niche fishing relative to results of the November industry survey provide strong evidence that the abundance of legal red king crabs in the Petrel Bank area was substantially lower in November 2006 than in November 2001. The department attempted to do another systematic pot survey in 2007, but did not receive any bids for the charter. Future pot surveys will be dependent upon the department's ability to secure bids for charter work.

The red king crab survey is too limited in geographic scope and too infrequent to provide a reliable index of abundance for the Aleutian Islands area.

*Stock biomass and recruitment trends*
Estimates of stock biomass are not available for this stock. No stock assessment model has been developed for this stock. Estimates of recruitment trends and current levels relative to virgin or historic levels are not available. However, preliminary evidence indicates that red king crab stocks in the Adak area remain at low levels of abundance.

*Tier determination/Plan Team discussion and resulting OFL determination*
The team recommends this as a Tier 5 stock in 2008. $B_{MSY}$ and MSST are not estimated. The team recommends the use of average bycatch from crab and groundfish fisheries for the time period 1996-2007 to set the OFL. The directed fishery F=0. The team did not feel that the use of average retained catch from the directed fishery was appropriate for OFL setting. Retained catch over the 1996-2007 is highly variable leading to a high average catch for this time period. The team felt that this level was excessively high and exceeds the team's understanding of current abundance levels and is not an accurate representation of the reproductive potential of the stock or an accurate representation of sustained yield for this stock under current environmental conditions.

*Status and catch specifications (millions of lbs) of AIRKC.*
The OFL for the 2008/09 season is that recommended by the Plan Team.

| Year | OFL | Biomass (MMB) | TAC | Retained Catch | Total Catch |
|---|---|---|---|---|---|
| 2005/06 | | | Closed | | |
| 2006/07 | | | Closed | | |
| 2007/08 | | | Closed | | |
| 2008/09 | TBD | | | | |

No overfished determination is possible for this stock given the lack of biomass information. This stock is not experiencing overfishing[TBD]

Table 3. Crab Plan Team recommendations May 2008: Note shaded areas to be filled in Fall 2008

| Chap # | Stock | Tier (1-5) level | Stock Status level (a,b,c) | $F_{OFL}$ | $B_{MSY}$ or $B_{MSYproxy}$ | Years1 (biomass or catch) | 2008 MMB | 2008 MMB / $MMB_{MSY}$ | Gamma $\gamma$. | Mortality (M) | 2008/09 OFL mill lbs [note if retained only] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BB red king crab | 3 | | | | 1995-current [recruitment ] | | | | 0.18 | |
| 2 | EBS snow crab | 3 | | | | 1979-current [recruitment] | | | | 0.23<br>0.29 (mature females only) | |
| 3 | EBS Tanner crab | 4 | | | | 1975-1980 [survey] | | | $F_{35}$/M | 0.23 | |
| 4 | Pribilof Islands red king crab | 4 | | | | 1991-current [survey] | | | 1.0 | 0.18 | |
| 5 | Pribilof Islands blue king crab | 4 | | | | 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 | [retained] |
| 7 | Norton Sound red king crab | 4 | a | 0.18 | 3.567 | 1983-2008 [model estimate] | 5.240 | 1.47 | 1.0 | 0.18($M_1$-$M_5$)<br>0.216($M_6$) | 0.678 [retained] |
| 8 | AI golden king crab | 5 | | | | 1990/91-1995/96 [retained catch] | | | | | 6.93 [retained] |
| 9 | Pribilof Island golden king crab | 5 | | | | 1993-1999 [retained catch] | | | | | 0.174 [retained] |
| 10 | Adak red king crab | 5 | | | | 1996/97-2006/07 [bycatch only] | | | | | 0.0263 |

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.

Table 4. Additional model parameters recommended by the Crab Plan Team May 2008.
*Note these recommendations are based on information presented by assessment authors. The CPT did not differ from authors's recommendations but requests that the final assessment be consistent with these values*

| Stock | Handling mortality crab fisheries | Handling mortality groundfish fishery |
|---|---|---|
| BB red king crab | 0.2 | 0.8 |
| Pribilof red king crab | 0.2 | 0.8 |
| Pribilof blue king crab | 0.2 | 0.8 |
| EBS snow crab | 0.5 | 0.8 |
| EBS Tanner crab | 0.5 | 0.8 |
| St. Matthew Island blue king crab | 0.2 | 0.8 |