AGENDA D-5
JUNE 2008

MEMORANDUM

TO: Council, SSC and AP Members

FROM: Chris Oliver for
Executive Director

DATE: May 21, 2008

ESTIMATED TIME
0 HOURS
(SSC-only)

SUBJECT: BSAI Crab Overfishing Limits (SSC only)

ACTION REQUIRED
(a) Receive Plan Team Report on BSAI Crab OFLs
(b) Review preliminary BSAI Crab SAFE report

BACKGROUND

(a) Receive Plan Team Report on BSAI Crab OFLs

The Crab Plan Team met in Seattle, WA from May 6-9, 2008 to review draft BSAI Crab stock assessments and provide recommendations for the model parameterizations and tier establishments for BSAI Crab stocks. This is the first year of the new process for annual determination of Crab OFLs and the Crab Plan Team is part of the newly established review process. 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 thus OFLs are recommended at this time given that no survey information will be incorporated prior to OFL determination over the summer. Much of the Crab Plan Team's stock assessment and OFL recommendations are contained within the Crab SAFE Introduction (see below) while some additional recommendations and discussions are included in the Crab Plan Team Report, which is attached as Item D-5(a). Additional items discussed by the Crab Plan Team at this meeting included research priorities and modifications to the terms of reference in accordance with their new role in the process for stock assessment review.

(b) Review preliminary BSAI Crab SAFE report

As indicated above, in accordance with the new process for stock assessment review and annual establishment of BSAI Crab OFLs, annual stock assessments are prepared for the 10 BSAI Crab stocks. The main purpose of the May Crab Plan Team meeting is to review draft stock assessments and provide recommendations. An introduction to the stock assessment chapters compiled by the Crab Plan Team includes the team's recommendations for stocks assessment modifications (for the following year's assessment) as well as recommendations for this year for model parameterization, Tier level determination and for those two stocks for which OFLs are established in the summer, the Crab Plan Team's recommended OFLs for those stocks. The introduction also provides the overview of the new process and approved Tier system for OFL determination. The full draft SAFE report including the introduction and all 10 draft SAFE chapters was mailed to you on May 12th. The Introduction section is attached as Item D-5(b)

Crab Plan Team Report

The Crab Plan Team convened their Spring meeting from May 6-9, 2008 at the Alaska Fisheries Science Center in Seattle, WA.

All Crab Plan Team members were present:
Forrest Bowers (ADF&G-Dutch Harbor), Chair
Ginny Eckert (UAF/UAS), Vice-Chair
Diana Stram (NPFMC)
Doug Pengilly (ADF&G-Kodiak)
Gretchen Harrington (NOAA Fisheries –Juneau)
Wayne Donaldson(ADF&G-Kodiak)
Jack Turnock (NOAA Fisheries/AFSC-Seattle)
Shareef Siddeek (ADF&G-Juneau)
Herman Savikko (ADF&G-Juneau)
Lou Rugolo NOAA Fisheries /AFSC-Kodiak)
André Punt (Univ. Of Washington)
Bill Bechtol (UAF)
Bob Foy (NOAA Fisheries /AFSC-Kodiak)
Josh Greenberg (UAF)

Members of the public (and state and agency staff) present for all or part of the meeting included: Dick Tremaine, Linda Kozak,, Jack Tagart, Joel Webb (ADF&G), Doug Woodby (ADF&G), Arni Thomson, Lance Farr, Phil Hanson, Margo Posten, Kevin Kaldestad, Edward Poulsen, Roger Thomas, Doug Wells, Jie Zheng (ADF&G), Hamazan Hamazaki (ADF&G), Steve Hughes, and Pat Livingston (NOAA).

Administration

Agenda
The team approved the attached agenda for the meeting with some timing constraints as discussed previously due to the scheduling and availability of some team members.

Review and Approve Minutes
The Team reviewed and approved the September 2007 minutes: No changes from the draft version as circulated were noted.

Revise Terms of Reference
The team revised their terms of reference to accommodate the new role of reviewing stock assessments for OFL determination. The Team notes that given the first year of the process, there will be many challenges as the role and responsibilities of the CPT review evolve. The revised TORs are attached. The team will revisit these again in September to see how they accord with the new process.

External review guidelines
The team revised the external review guidelines for crab stock assessments. The team discussed the difficult in establishing an appropriate review period, noting competing staff timing and availability with other work assignments at various time of the year. However, given the experience with the

timing of review of the snow crab assessment the team made recommendations for revising timelines for an external review, noting particularly the importance of structuring review timing such that the resulting report is available no later than one month prior to the deadline for stock assessment. Revised external review guidelines are attached.

Economic Discussion:

The team intends to schedule an economic discussion for the September Plan Team meeting and intends to request the participation of AFSC economists for this agenda item. The discussion will include crab rationalization, future plans for data collections and analysis, and utility of these data in economic analyses. This discussion remains a high priority for the team, but has been tabled for several meetings, including being deferred from the current meeting due to other meeting conflicts (i.e. the Port Townsend Socio-Economic meeting). Josh Greenberg will coordinate with AFSC economist Ron Felthoven and others to identify documentation relevant to the September meeting presentation. The team further requests, if possible, a presentation on Crab Rationalization from Council economist Mark Fina, as well as documentation and a summary of the 3-year review documentation for CRP and economic analyses and overview.

Research Priorities:

The team annually reviews and revises their research priorities. After designating a sub-group of the CPT to lead this process, the team has the following revisions to the research priorities: The revised list of research priorities is appended to the CPT report.

Objectives for OFL Review

The team discussed the goals for the week and organization for the draft SAFE report for SSC review in June, as well as the final Fall SAFE report. The team devised a template for the summary sections for each stock, working from one that was provided to the team the previous week as well as a draft summary table for OFL recommendations. The team may revise this structure and information for the summary again in the fall following the first round of this process noting that it will continue to strive to improve upon the summary material and information provided therein.

Bycatch and Discard discussion

The team discussed the need to develop mechanisms to obtain data necessary for all stocks for bycatch and discards. Doug Pengilly noted that a process via the State/Federal Action Plan currently provides bycatch data, but is timed for fall, not spring, release. Team members noted that this information is needed by the end-of July in order to calculate total catch, Doug suggested that requests for information be provided by Mid-May. It would help if a single person were identified for each agency to be the point person to obtain these data consistently.

Catch accounting program data, as well as scallop fishery bycatch data, are available by mid-June. Catch for Pribilof vs. St Matthew blue king crab stocks will need to be extrapolated accordingly. Gretchen noted that NMFS catch accounting annually posts bycatch by species in mid-June for all assessment authors. The team noted that the annual Bycatch Chapter of the fall SAFE report may no longer be needed if this information is adequately contained in the individual stock assessments.

Review of stock assessments

The team commends all stock assessment authors for their careful and timely work and consideration of multiple issues and analyses in this first year of annual crab stock assessment for OFL determination. The team notes the difficulty in its immense new role in reviewing all of the assessments and providing individual stock assessment reviews, comments for stock assessment authors, recommendations for the draft SAFE report, and compiling the draft SAFE report. The team strived to complete this task to the best of its ability, noting that further review and comments will be forthcoming on each assessment as the progress unfolds in the coming years.

The team discussed general issues for the calculation of average retained catch under Tier 5. Doug provided an overview of consideration in determining the appropriate time period. The Team noted concerns with the use of confidential data for calculating the overfishing levels for these stocks. It is necessary to use confidential data to calculate the OFLs for these stocks, however, that data can not be reproduced in the stock assessment reports which are available to the public. The Team noted that authors need to be very clear in requesting data that it is screened for confidentiality and/or clarified the number of vessels.

Aleutian Island golden king crab

Doug summarized the AI golden king crab assessment. This stock is assessed as a single stock with TACs established east and west of 174 W. long. The assessment starts in 1985/86 on due to a size limit modification at that time.

Information was provided in the assessment to help the plan team evaluate annual by stock. The OFL for this stock must be established prior to the summer. The team extensively discussed the years to use in calculation of average catch for determining total catch OFL. The author's sole OFL recommendation was to exclude years prior to 1986 which exhibited high, but unsustained, catch. Discussion noted that the large increase in CPUE likely resulted from improved fishing practices and not from increased recruitment. Concurrently, survey catch declined substantially in the first three surveys since 1997, then increases slightly. Thus, survey and fishery trends are somewhat contradictory. The tag recovery rate also dropped in 2003. There was no major change in bycatch trends over time and no groundfish bycatch included in the assessment.
Linda Kozak noted that fishing effort declined in the earlier time period,but that CPUE increased prior to rationalization as fishing practices were modified. Linda recommended that the OFL be based on the same years as in the EA for Amendment 24.

Doug provided an overview of golden king crabs bycatch the directed fishery, noting that results could be construed as either indication of a clean fishery or a decline in recruitment. However, the marked increase in CPUE more likely relates to better fishing practices.

In discussing the range of year options provided in the assessment for OFL determination, the team noted that if using the entire fishing history such that high years balance out years of constrained catch, then the average catch calculation becomes a moving target that converges toward the GHL/TAC.

The Team weighed the pros and cons of establishing a retained or total catch OFL for this stock based on information available in the assessment, and additional data presented. There was much discussion, and some confusion, regarding what components of the population are included in the total catch OFL. The OFL could be total (all sublegal males, legal males and females), male only (sub and legal but no females), or retained only (legal males). The team recommends a retained catch OFL for this stock this year. For next year's assessment, the team requests the inclusion of fishery bycatch information (including groundfish fisheries) over the time periods under consideration for average catch (Tier 5) and for Tier 4 consideration, should an appropriate model be developed.

In selecting the years to calculate average catch, one option considered was post-1990 through 2006/07, which biases the OFL low by including the period of constrained catch and also due to issues raised by the public with respect to the decreased catch in 06/07. However, the team recommend a period after 1990 and prior to the years of constrained catch is most appropriate given the data available at this time. This results in an OFL of 6.93 million pounds as a retained catch OFL.

The team discussed the75% buffer put forward in the assessment while recognizing that the current TAC level is approximately 85% of the proposed OFL. The team further recognizes that under a rationalized fishery, a retained catch buffer as large as 75% might not be needed. Thus, the OFL of 6.93 million pounds appears to be an appropriate level based on the information presented to the CPT at this meeting.

Pribilof Golden King crab

Doug Pengilly summarized the PI golden king crab assessment. This stock is not surveyed and no biomass estimate is available for this stock. The difficulty with this assessment for average catch information has to do with the presentation of confidential data. The team recommends that this be evaluated in the next year's assessment and presented in as screened a manner as possible. The team also recommends that bycatch data from the groundfish fisheries be tabulated to the extent possible for the assessment next year.

The team feels that the years used for estimation of the OFL of 1993-1999 appear to be representative of the reproductive potential of the stock. This would be a retained catch OFL only at this time. Consideration of a total catch OFL could be evaluated next year if additional bycatch information is available.

Adak Red King Crab

Doug Pengilly presented the Adak red king crab assessment. There is no assessment model for this stock. Four candidate time periods were considered for average catch estimates for OFL determination. The author recommended excluding the period prior to 1985/86. The team discussed differences and rationales for dropping some years from average catch consideration. Doug noted that because the fishery was historically constrained due to stock conservation concerns, basing average catch on only unconstrained years may be neither representative of the reproductive potential of the stock, nor risk averse.

The team discussed the possibility of an OFL set to zero given the history of the fishery and that this may be a remnant population of Petrel Bank.

Andre commented that because insufficient information is available to determine the actual appropriate level, the team is exploring a proxy level that is non-zero but lower than some of the average retained catch estimates. Linda Kozak commented regarding dangers of establishing a zero OFL. Team members felt that a 400,000 lbs OFL is too high given the historical performance of this fishery.

The team evaluated bycatch information for the last ten years (1996/97-2006/07) and requested further development of an OFL based on average of the bycatch from all sources. This tema requests this evaluation be completed for the revised stock assessment for OFL determination in the fall. [The team notes this calculation was included in the revised assessment for distribution at the end of the current meeting].

Andre commented that discussion suggests that the stock is overfished without the ability to actually make that determination due to a lack of biomass information for this stock. However, if an appropriate assessment of this stock were to be conducted, it would very likely be determined to be overfished. Given the availability of information for this stock it is not possible to make a determination of stock status.

Pribilof Island blue king crab

Bob Foy presented an overview of the Pribilof Islands blue king crab stock. The team discussed the bycatch for this stock and the appropriate breakout for catch accounting accordingly. The team recommends that the assessment author work with NMFS catch accounting to isolate bycatch from only that area representative of the distribution of the stock. The team expressed concern about the bycatch estimates in 2007 and looks forward to additional information in the next assessment regarding actual bycatch of this stock in other fisheries to evaluate the total fishing mortality.

The stock is recommended for Tier 4. As a tier 4 stock, if the NMFS summer trawl survey abundance estimates put this stock into in stock status level c, the directed fishery F would be zero and an OFL would need to be set for all other sources of fishing morality that is less than the estimated F_{MSY}. The team recommended the assessment authors provide an estimate of F_{MSY} for the fall meeting to estimate the OFL.

The team requested additional information on the coefficient of variation (confidence intervals) for the estimates in the assessment. General comments were provided regarding reporting of trends within noise of data and the necessity of specifying to what extent reported changes in point estimates are statistically significant.

Additional assessment specific recommendations are provided in the SAFE intro plan team recommendations section.

With respect to all existing rebuilding plans, the CPT requests that the SSC discuss and provide guidance on the rebuilding plans and the necessity of revising them under the new biological reference points, status determination criteria, and estimates of stock recovery.

Pribilof Island red king crab

Bob Foy provided an overview of the Pribilof Island red king crab assessment. The team noted similar possible issues with bycatch estimates from the groundfish fisheries and the need for more explicit information in the following assessment.

The team discussed the appropriate time periods for estimating Bref. The authors suggested two different time periods. Andre suggested that, given the survey noise apparent in this time series, the most appropriate time period would be for the entire recent period (ie not excluding years).

The team discussed the possibility of using exploitation rate from the BBRKC model to estimate the F rate in the model to estimate gamma. This stock seems to be one in which a model estimate of gamma would be appropriate given that there is a BBRKC model which can be used to inform the F rate. The team had a further discussion of the use of gamma and how it can be estimated and applied. Estimation of gamma could be done from a modeling framework (ie extrapolate from the BBRKC estimate) and applied in the stock assessment. This would be a useful exercise even if it is not used eventually in the assessment to calculate the OFL. The team recommends this consideration be given to the extent possible following the discussion of the resulting gamma during the BBRKC discussion and at that time will weigh in on whether or not the team recommends this gamma to go forward for use in the assessment this year.

The team recommends that the calculation for MMB at time of mating be explicitly detailed in the assessment such that it can be repeated. The team also recommends inclusion of a table to explicitly detail the calculations involved in moving from the catch OFL vs portions attributable to directed and non-directed retained and discarded.

The team recommended that model estimation of bycatch indicates explicitly what is included in the bycatch by size and sex.

The team recommended the use of the time period for Bref1 ie 1991-2008 given that previous years were indicative of the stock at a very depressed level. The time period from 1991-present includes survey abundance of both high and low years and seems to better account for the survey variability (ie rather than excluding years where the survey abundance estimate dropped precipitously form one year to the next).

Norton Sound red king crab

Hamachan Hamazaki presented an overview of the Norton Sound red king crab assessment. There is no bycatch or discard information available for this stock. The team discussed model parameterization. Andre commented that additional information should be included regarding the asymptotic standard errors and selectivity parameters (to indicate which are fixed not estimated). The model is pre-specifying the selectivity 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 configuration should be investigated and new model configuration potentially sought as an improvement over the current model. The residual plots as shown are difficult to interpret and should be revised.

Additional recommendations for the assessment are included in the SAFE report introduction section for this stock.

The team discussed alternative OFL setting approaches for this stock given concerns expressed about the model. Three alternative approaches were 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-dropping this stock down 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 felt that use of survey biomass estimates that have not yet been presented was not sufficient and that use of a Tier 5 formulation when biomass estimates are available would not be appropriate.

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 period from 1976. 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 due to issues with the model and assumptions regarding selectivity in the model.

Jack Tagart commented on the shallow water distribution of this species and the possibility that this could sustain higher harvest rates than deeper water species. The degree to which this is true for crab is unknown.

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 the assessment authors explore of a broader range of models and sensitivity analyses for this stock in the future.

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

St Matthew blue king crab

Jie Zheng presented the stock assessment for St. Matthew blue king crab. The team discussed gamma and the justification for the use of gamma values greater than 1. Jie discussed that the gamma value resulting from three evaluations of BBRKC information indicating values ranging from 1.667 to 1.944 depending upon the adjustments employed or lack thereof for survey selectivity and catchability. The team deferred further discussion of gamma to a break in order to further examine the calculations involved in Jie's presentation.

The team discussed model formulation and estimates of $F_{35\%}$. Jack noted that discard catch needs to be estimated in conjunction with observed estimates. Additional justification of discards are necessary for inclusion in the assessment. Andre questioned variance employed on random walk calculation for the molting probability ?? random walk parameterization noting that it must be documented in the assessment but also should include sensitivity analysis to explore model behavior. A table of model parameterization should be included.

The team questioned the size at maturity assumed in the model (>105 mm CL) and the extent this is consistent with studies or other estimates of maturity. The team discussed the natural mortality estimates for 1999 in the model. The team requested that tables include the CVs associated with all abundance estimates to ensure that weighting in the model is equivalent. Andre noted that currently equal weight is being given to all datasets and this assumption should be explored to ensure it is accurate based on the CVs of the data.

Team members questioned ability to estimate q and M together. Jie commented that he could but was not comfortable with estimating them both at the same time rather than keeping one fixed and estimating the other as included in the assessment currently. All model results should include confidence intervals. Jack noted some confounding interaction between M and growth.

Residual plots should be improved for greater clarity. The actual fits to trawl and pot survey data should also be included. Team members noted that given the results and residuals shown in log space is not a good means of indicating the relative fit.

The team discussed relative results from pot and trawl surveys and the potential relative weighting. Currently these are assumed to be equally precise which is problematic. Data as listed in table 3 should be plotted in conjunction with model results for comparative purposes. Plotting this may indicate some auto-correlations in the residuals by size-classes.

Jie noted that the estimated Brefs through 2008 include the model estimates of biomass in the calculation. This is intended to reflect that it will be updated with the new model estimate following incorporation of the summer survey information.

The team discussed the time periods under consideration for the B_{MSY} proxy period. This represents a difference from previous estimates of both B_{MSY} and MMB currently from model-based estimates as included in the EA for Amendment 24. Note that EA did not include catch for the fishery rather it included catch at the time of mating and reducing historical catch has a very large impact on the relative estimate of B_{MSY} and the related stock status in relation to this compared to biological refer points, eg MSST. Diana requested additional comparisons to better understand the differences between the model and assumptions in the EA versus the analysis noting that this will have a profound effect on perception of stock status and recovery under the rebuilding plan (e.g. on this trend the stock would be rebuilt in 2009).

The team recommends Tier 4 consideration for this stock. The team discussed the rationale for beginning the time period under consideration at 1986, after the period of stock collapse. Beginning from the time period of the constant harvest rate would be an improvement and a recommended

consideration of this next year. The team discussed ranges of years to be included in the time frame for determination of B_{MSY} proxy. The team evaluated several different time frames outside of the range included in the assessment including years of variable harvest rates, both high and low stock abundance as well as year combinations that would remove both high harvest rate years and include stock recovery. The team looked at averages resulting from these different year combinations to evaluate trends focusing on results from model 1 where both M and q are fixed.

The team endorses the approach employed in model 1. The team recommends a B_{MSY} proxy for 1989-2008. The team did not see compelling evidence to recommend a gamma greater than or less than the default 1 at this time but recommends that in the next assessment estimates of B35 and F35 for evaluation of possible changes to this gamma value in a subsequent analysis.

Additional recommendations are included in the SAFE report introduction for this stock.

EBS Tanner

Lou Rugolo presented an overview of the Tanner crab stock assessment. The authors recommend Tier 4 for this stock. Three different time periods were presented for the B_{MSY} proxy value estimation. A new table was presented comparing results across the three B reference values considered. The team discussed the new table and the changes inherent in it from the assessment as reported in table 7. Andre suggested including additional information on model structure and model parameterizations in order to be able to calculate the OFLs and catch accordingly. The retained catch component for this stock is very small as compared to total removals.

The team debated the issue involved with conservation issues of application of this tier calculation to this particular stock with respect to conserving spawning biomass versus the yield issue of this application. This raises issues of the problems involved in the use of MMB as a proxy for spawning biomass and the Tier 4 formulation particular for this fishery where much of the overall catch is in other crab and groundfish fisheries.

Andre provided a conceptual diagram of the review of equations and conceptual calculations compared with documentation issues for the team to clarify what information is assumed versus documented in the assessment. The team notes the difficulty in reconciling documentation in the assessment with results for calculation of discarded catches, directed and non-directed. Andre presented overview of assumed equations for calculating each of these components and noted that these equations and the inherent assumptions involved should be included in the stock assessment, including assumption in calculations (rather than data) and intermediate calculations that comprise the final. One assumption that was not clear is the assumption relating the assumed snow crab TAC which drives the estimated Tanner crab bycatch and the handling mortality rates applied therein.

The team commends the assessment author for the well thought out procedure for estimating discards but recognizes that these need to be clearly documented in the assessment. Team members noted that information included in this document may be utilized for purposes beyond overfishing level determination as currently formulated which means that documentation issue must be resolved to allow for explicit consideration of the assumption inherent in the analysis.

The team discussed the distinction between recommendations in the assessments for fishing mortality on individual components of the population as compared with the overall goal of establishing OFLs for the reproductive stock. While stock assessment authors may choose to make recommendations and express concerns on the mortality by stock component, the overriding purpose of the assessment is the establishment of the aggregate (total catch) OFL.

Questions from the public requested clarification on the potential downstream problems with consideration of this as a single stock. They also noted that a total catch OFL for Tanner crab will have immense policy implications. The public noted that there is differential bycatch by fishery for eastern and western fisheries. There is likely to be discussions and comments brought forward to the Council regarding the need for restrictions on bycatch by other fisheries in order to not force an overfishing determination for this stock.

The team discussed the assumptions of handling mortality employed in this and other assessments. Members of the public commented on the research needs for mortality (handling) rate validation by species and fishery.

Diana suggested adding an explicit discussion of handling mortality for September.

The team discussed the range of years utilized to determine B_{REF}. Two methodologies were employed. Option one considers to what extent there is a period of lightly or moderately exploited biomass to be considered as pristine and the authors found that there was no true period that qualified. The other methodology included three different year sets for determining B_{REF}. The team discussed the rationale for the range of years considered and the intent to bracket periods of high and low stock status and range of exploitation to strive to capture a period of B_{MSY}. The stock was likely above it in 1974 and below it in 1985. Ginny commented on the need for consistency in excluding or including early years for some stocks and not others.

The team recommended the years included in the Bref3 calculation of 1975-1980 as best bracketing the period thought to best represent the reproductive productivity of the stock. The team strongly encourages continued development of the model for this stock.

The team discussed gamma noting that for this stock we have both growth and maturity data and are only lacking an actual model for the stock. Andre requested that $F_{35\%}$ should be calculated for Tanner crab based on the biology. Jie noting that Sommerton's estimates of size at maturity are no longer valid and crab are maturing at a younger age than in the past. The maturity curves for all species should be reevaluated to look at what should be used in assessments for all stock given new evidence of changing maturity.

The team notes that this should be further explored but that current timing and review precludes the ability to discuss this at this time. The team recognizes that this discussion raises fundamental issues and concerns with both the use of MMB as representative of the reproduction potential of the stock as well as the ability to estimate and utilize $F_{35\%}$ applied as a benchmark on MMB fore reference purposes.

The team agreed to modify the author's choice of default value of gamma for this assessment. The process recommended by the team for estimating gamma is to use an $F_{35\%}$ under the assumption of uniform selectivity harvesting of MMB (to be estimated for this stock) divided by the recommended natural mortality rate for this stock. This ratio would then be the gamma value applied in the Tier 4 calculation. The team further recommended that additional information regarding the $F_{35\%}$ calculation, the resulting gamma value from the calculation and its resulting impact on comparable example OFL catch values for Bref 3 be provided to the SSC for consideration in June in conjunction with the team's recommendation.

The team also recommends that alternative gamma values from the default and their rationale be evaluated in the next assessment.

Further recommendations by the team are included in the SAFE report introduction for this stock.

Bristol Bay red king crab

Jie Zheng presented and overview of the Bristol Bay red king crab assessment. The team recommended evaluation of alternative weighting on the likelihood functions. Jie presented data on size at maturity for Kodiak as justification for the conservative estimates employed in the assessment. These data indicate the size of males compared with size of females for estimating the portion of the population available for mating. Jack commented that the information necessary is to evaluate the portion of males available for mating, not simply the mating ratio. Understanding that this information was done with divers off Kodiak, similar information is unavailable for Bristol Bay.

The team recommended additional model runs estimating survey selectivity rather than fixing it at the values included in the current assessment. A likelihood profile should be constructed to include for further information on the data included in this parameter. A parameter table should be included to indicate which parameters were fixed and which were estimated.

Questions were raised regarding the use of the underbag experiment results for use in catchability estimates in the assessment. Jie noted that in 2005 there was the highgrading issue resulting in a different selectivity. The team understands the intention to accurately estimate the impact of different selectivity during these periods but it was unclear where this is incorporated in the model equations. This should be made more explicit in model equation formulation. The team recommends better documentation of the residuals as indicated in figures 24-26.

The team discussed handling mortality estimates and the lack of impact within the model on this rate. The recruitment would be impacted but does not represent a large proportion of the catch incorporated into the model. Jack noted that catch history can be reconstructed to 1953 in order to better represent the entire catch history. Another reason why observed handing mortality appears minimal as it is shown for the legal male component. It would be useful to show similar sensitivity on the smaller size classes to better indicate the relative impact of a range of handling mortality rates.

The team discussed the ability to estimate parameters in the model instead of having them all fixed. An issue with the current model formulation is related to fixed parameters. This can result in low

estimated variances but it is not possible to evaluate to what extent these parameters might be mis-specified and thus the low variance uninformative.

Mean recruitment over the period 1995-2008 was used to estimate the biological reference points to obtain $B_{35\%}$. Mean trawl bycatch amounts over the last 10 years is used as an estimate for the contribution due to trawl bycatch.

The team discussed $B_{35\%}$ and the assumptions inherent in its calculation. Team members felt that not including the earlier time period in this estimation inappropriately biases the $B_{35\%}$ estimate to be low by virtue of excluding years of high productivity. The model should start further back than 1985 to evaluate what the difference is in including this time period. Jie explained that the previous time period has not been utilized due to changes in mortality from this period. The team discussed the possibility that this represents either a fishing effect or a productivity shift. Bob noted that if this were a production issue then one would expect that the smaller size classes would be differentially impacted but the data indicates that it is the higher size classes that are missing not the smaller classes. Jie indicated that Pacific cod predation might be the problem and not a fishing related impact. There was great disagreement on what is the likely cause of this decline at that time.

The team strongly recommends that the assessment next year include an evaluation of the model results beginning in 1968 for comparison as a more appropriate time period representative of the population. The team is concerned that a different estimate of Bref using the loner time period would give a different indication of relative stock status in relation to B_{MSY} thus impacting the stock status level and corresponding OFL.

The team evaluated other means of estimating B_{MSY} for purposes of comparing the information necessary for the year choice in the reference values under consideration given express concerns about the use of a single option for B_{MSY} based upon known periods of stock decline from historical levels. The team struggled with the idea of re-running the model for the entire time series and using results of this for the OFL setting process in September. Team members agreed that from a timing and process perspective and given the necessity of an adequate review period of modified parameters and model structure this does not seem to be a feasible solution.

The team evaluated scaling the biomass estimate to account for the amount of biomass over the time period not included. The team looked at using survey biomass estimates from the prior period compared to the period under consideration and multiplied this by the $B_{35\%}$ estimate from Jie's analysis. Jie did not feel that this was an appropriate approach at this time due to the possibility of overestimating the biomass due to not considering the differential harvest rate in the earlier time period. Team members disagreed that this was the case and felt that the calculation is consistent with assumptions and catch calculations for all species in the timing of MMB at survey and discounted for catch.

The team recommended the use of the author's recommended B_{MSY} time period for this year primarily due to the fact that this is the only option that was put forward to the team at this time. The team has very strong concerns regarding the lack of the use of the full time period in considering the appropriate B reference period for this stock. The team however was not in complete agreement that this was the correct approach. Team members felt the use of a time period inclusive of stock

depletion only was inconsistent with approaches used for other stocks. Some members felt that it would be more appropriate to employ the ad hoc adjustment approach discussed for reasons expressed previously or considering dropping this stock to Tier 4 for OFL determination.

Additional stock assessment recommendations are contained in the SAFE Report Introduction section for this stock.

EBS Snow Crab

Jack Turnock provided an overview of the EBS snow crab assessment. Jack provided an overview of the CIE review with some initial responses to their comments. The AFSC has not formally responded to comments from the CIE review at this time.

The team suggested included a table indicating which parameters are fixed, estimates and estimated with tight priors such that for all intents and purposes they are fixed. This would aid in clarity for understanding the specifics of the assessment.

Team members questioned model fits to mature male and female only, noting that this is output only from the model and not a model fit explicitly, and confidence intervals should be included.

Jack noted that it would be useful to standardize soak times for all crab stocks.

The team discussed the residual pattern resulting from the growth and maturity information as presented. Andre commented that growth and maturity perturbations should be further explored to investigate to what extent this residual pattern could be better resolved. Andre suggested building a version of the model that tracks cohorts to see if this is a result of cohort transition. Spatial differences in growth and maturity may also contribute to these observed patterns. Doug noted geographic differences resulting from the survey.

Jack noted issues with the clutch fullness data and Jie indicated problems with the survey data estimation of clutch fullness.

The team discussed and recommended the use of the base model at this time understanding that further exploration of parameters contributing to the observed residual pattern will be provided in the next iteration for further review. The team recommends a retrospective analyses be included in the assessment next year. The team discussed the information to be included in the updated model run including trawl survey biomass estimate, updated catch and discard data.

Additional recommendations for the stock assessments are included in the SAFE Report Introduction section for this species.

Per CPT request, Jack Tagart provided the following overview comments on the industry-initiated snow crab model review. The author should provide explicit documentation of the model in the stock assessment. There are also likelihoods included in the model that are not included in the discussion in the assessment but that influence the fit to the model. The fit to discards is very troublesome due to the model construction in fitting to discards in years where no data is available. The model appears to be fitting to total catch data in these time periods. The residual patterns need

additional exploration. The effective N and multinomial weighting functions were acceptable, all are currently weighted equally and this appears to overweight some data by this convention. The industry also requests documentation of the equations used for the forecasts as well as the model itself.

The team reiterates the necessity of full documentation of the assessments and tables of model parameterization.

Jack Turnock reviewed stock recruit relationships included in the model as a measure of productivity over time. This was presented to help inform the appropriate time period over which to estimate Bmsy. Jack indicated that the author's recommendation for years over which to estimate Bmsy is the entire time period for recruitment, ie 1978-2007. Doug noted that recruitment appeared to be decreasing.

The team agrees with the author's recommendation for the Bmsy time period and the use of the base model for OFL determination.

NPFMC CRAB PLAN TEAM

Draft Agenda –May 6-9, 2008

Room 2076 (Traynor Room)

Tuesday May 6		
Administration	9:00 am	• Introductions • Additions to agenda and approval of agenda • Review and approval of September 2007 minutes • Review and revise Terms of Reference in accordance with new stock assessment review role by CPT • Review and revise external review guidelines for stock assessments
Economic Discussion	10:00 am	• Discussion of Economic Data Review (EDR) issues • Economic SAFE report • Structure and content plan for future • How to merge with existing reports, and studies • Economic analyses by Council and NMFS economists (discussion of research needs and potential for improved impact analyses based on current efforts?)
Review of Crab Research Priorities	11:00 am	• Review and Revise (annual task)
LUNCH	*12:00 pm*	
OFL Stock assessment Review:	1:00 pm	• General discussion of available catch data (historical) and bycatch data
	1:30 pm	• Tier 5 stock reviews: o Aleutian Island golden king crab o Pribilof Island golden king crab o Adak red king crab
	3:30 pm	• Tier 4 stock reviews: o Pribilof Island blue king crab ▪ Stock status ▪ Discussion of rebuilding plan revision o Pribilof Island red king crab
Wednesday May 7		
OFL Stock assessment Review:	9:00 am	• Tier 4 stock reviews: o Norton Sound red king crab o St. Matthew blue king crab ▪ Stock status ▪ Discussion of rebuilding plan revision o EBS Tanner crab
LUNCH	*12:00 pm*	
	1:00 pm	• Tier 4 stock reviews: EBS Tanner crab(cont)
	3:00 pm	• Tier 3 stock reviews: o Bristol Bay red king crab
Thursday May 8		
OFL Stock assessment Review:	9:00am	• Tier 3 stock reviews: o Bristol Bay red king crab (cont) o EBS snow crab
LUNCH	*12:00 pm*	

	1:00 pm	• Tier 3 stock reviews: o EBS snow crab (cont)
	3:00 pm	• **Review OFL recommendations for all 10 species,**
Friday May 9		
OFL Stock assessment Review:	9:00 am	**Report writing, Report finalization**
ADJOURN	*12:00 pm*	

PLAN TEAM FOR THE KING AND TANNER CRAB FISHERIES
OF THE BERING SEA/ALEUTIAN ISLANDS

TERMS OF REFERENCE
(as revised by the Plan Team 5/06/08 changes from 2005 are in **bold/and ~~strikeout~~**)

1. Establishment. The North Pacific Fishery Management Council (Council) shall establish a Plan Team for the king and Tanner crab fisheries of the Bering Sea/Aleutian Islands (BS/AI) area. The Plan Team will provide the Council with advice in the areas of regulatory management, natural and social science, mathematics, and statistics as they relate to the king and Tanner crab fisheries of the BS/AI area.

2. Membership. Plan Team members will be appointed from government agencies, academic institutions, and organizations having expertise relating to the crab fisheries of the BS/AI. Normally, the Plan Team will consist of at least one member from the Council staff, the National Marine Fisheries Service (NMFS), the Alaska Department of Fish & Game, the University of Alaska, and other universities and institutions. Alternate members may be assigned to participate in case a member cannot attend a meeting. With the consent of the sponsoring agency or institution, nominations may be made by the Council, the Scientific and Statistical Committee (SSC), the Advisory Panel (AP), or the Plan Team. All nominations will be subject to approval by the SSC, with the Council retaining final appointment authority. Appointments should reflect the Plan Teams' responsibility to evaluate and make recommendations on management, biological, economic and social conditions of the fisheries.

3. Organization. The Plan Team will be directed by a chairperson, and may divide some of its responsibilities among work groups organized according to subject matter. A work group may also include members from the BS/AI groundfish Plan Team. Each work group will be directed by a work group leader.

(a) Rules of order. In general, rules of order will be informal. Plan Team decisions will be reached by consensus, whenever possible. If a decision is required and consensus cannot be reached, the opinion of the majority will prevail. In representing the Plan Team publicly, the spokesperson will take care to relate Plan Team opinions accurately, noting points of concern where consensus cannot be reached.

(b) Meetings. A minimum of two Plan Team meetings will be held annually in so far as practicable to discuss ~~guideline~~ harvest levels, status and management of the BSAI crab stocks. The timing and scope of meetings, in so far as practicable, will be as follows; a spring meeting will be held with the intention of reviewing ~~the previous year's fishery catch data, the methodology for~~ stock assessment modeling, preliminary stock assessments for OFL recommendations and any additional issues pertinent to the summer research schedule. A following ~~summer/~~fall meeting will be held with the intention to discuss the status of stocks. This meeting would be intended to occur prior to the TAC determinations by the state. ~~The fall meeting shall be held at a time that ensures availability of TAC specifications for the allocation of crab resources under crab rationalization.~~ It is understood that this status of stocks meeting does not preclude additional Inter-agency meetings prior to TAC setting. The Plan Team chairperson may call other meetings as necessary. The Crab Plan Team may meet separately or jointly with the BSAI Groundfish Plan Team to discuss areas of joint concern. A draft agenda will be prepared in advance of each meeting by the Council staff in consultation with the chairperson, and may be revised by the Plan Team during the meeting. Minutes of each meeting will be prepared by the Council staff, distributed to Plan Team members, and revised as necessary at or before the subsequent Plan Team meeting. The Chairperson (or designee) will report the Team's finding to the Council.

(c) Selection of officers. Officers (Plan Team Chair, Vice Chair and workgroup leaders) will be selected at the meeting preceding the annual Plan Team meeting or as vacancies arise. The Plan Team Chairperson and

Vice Chair will be selected at the annual meeting for two-year terms. It is the intent of the Team that after two years the Vice Chair will succeed as Chair and the following election will be for the position of Vice Chair. This process will continue on a two-year cycle. Work group leaders will be selected for one-year terms. There will be no limit on the number of consecutive terms that officers may serve.

4. Functions. The Plan Teams' primary function is to provide the Council with the best available scientific information, including scientifically based recommendations regarding appropriate measures for the conservation and management of the BS/AI king and Tanner crab fisheries. All recommendations must be designed to prevent overfishing while achieving optimum yield (National Standard 1). All recommendations must also be scientifically based (National Standard 2), drawing upon the Plan Teams' expertise in the areas of regulatory management, natural and social science, mathematics, and statistics. Finally, uncertainty must be taken into account wherever possible (National Standard 6).

(a) SAFE report. The Plan Team compiles a SAFE report for the BS/AI king and Tanner crab fisheries on an annual basis. The SAFE report provides the Council with a summary of the most recent biological condition of the crab stocks and the social and economic condition of the fishing and processing industries. The SAFE report summarizes the best available scientific information concerning the past, present, and possible future condition of the crab stocks and fisheries, along with ecosystem concerns.

(b) Plan amendments. The Plan Team may also play a role in the development and evaluation of amendments to the BS/AI king and Tanner crab fishery management plan, as well as evaluate amendments to the groundfish fishery management plan that may affect the conservation and management of BS/AI crab resources.

(i) The Plan Team may evaluate amendment proposals and forward their recommendations to the Council.

(ii) In addition, the Plan Team may develop their own amendment proposals.

(iii) Once an amendment proposal has been accepted for consideration by the Council, an analytical team may be assembled by the responsible agencies. Every analytical team should include at least one member from the Plan Team, drawn from the appropriate working group(s), whenever possible.

(iii) Once an amendment analysis has been completed, it may be reviewed by the Plan Team. The Plan Team's comments, if any, are then forwarded to the SSC, AP, and Council.

(c) Peer Review. The plan team deliberations shall constitute part of the peer review process specified by current OMB policies provided that members directly involved in the production of a scientific product will recuse themselves from the review.

(d) Stock assessment review and recommendations for annual OFL specifications. The plan team shall annually review stock assessments at the spring plan team meeting for recommending OFL levels for two stocks (Norton Sound red king crab and AI golden king crab) and for providing recommendations on appropriate tier levels and model and assessment methodology for the remaining 8 stocks. These recommendations are provided to the NPFMC SSC for their subsequent review and recommendations in June. The team shall review revised stock assessments in the fall including final OFL levels for all stocks. These assessments shall be included in the final Crab SAFE report provided to the Council to inform them of the annual status of BSAI Crab stocks.

Draft Guideline for Crab Assessments

Notification:

The appropriate time period for notification of intent to solicit ~~an~~ **formal** external stock assessment review would be ~~in October~~ **no later than June 15th for consideration in the following assessment cycle** ~~This would give the public the entire time period between May (when stock assessments are first reviewed by the CPT) and October (when TACs are announced) to determine if they had an issue with the stock assessment that they wished to have reviewed externally~~

Timing:

In order to alleviate possible complications with staff workloads, the appropriate time period for an external review (inclusive of any interactions with the stock assessment authors as well as any follow up workshop) would be from October-~~March~~**January 31st if there is an anticipation that consideration of the review will be given by the assessment author in that calendar year cycle. In order to address any recommendations from an external review it is necessary that the final review report be provided to the stock assessment author no later than one month prior to the stock assessment deadline.** This would allow for the normal stock assessment, data analysis and TAC setting process to occur between April and October.

Ideally, the reviewer will work with Assessment Authors in a collegial setting where reviewers would make suggestions to the framework or information used in the assessment. If this procedure is adopted, the Assessment Author would work with the reviewer(s) to find a mutually acceptable time for a pre-assessment workshop.

Responsibilities of External Reviewers and Assessment Authors:

The pre-assessment workshop will allow the reviewer to discuss the stock assessment with the Assessment Author and make requests for model modifications or alternative use of information in the assessment. The External Reviewer should produce a written report of their recommendations. To the extent practicable, the Assessment Author will address the comments and suggestions documented in the External Reviewer's report in their SAFE document. In general it is assumed that the Assessment Author will be able to determine whether any changes in the stock assessment recommended by the External Reviewer are substantial enough to require review by the Plan Teams and SSC. Assessment Authors will have the professional discretion to decide when the External Reviewer's recommendations will be incorporated into the ~~SAFE~~ **stock assessment** ~~document.~~ When the External Reviewer's recommendation involves a matter of professional discretion, such as the choice of statistical or computational methods, Assessment Authors will have the ability to decline to implement the recommendation. In addition, Assessment Authors may defer action on an External Reviewer's recommendation when complying with the recommendation would compromise the SAFE schedule. For example, if an External Reviewer made a request that would require extensive re-analysis of existing data that could not be accomplished prior to the Plan Team meeting, that request could be deferred to a subsequent year.

Anticipated results of an external review:

The CPT will receive both comments from the external reviewer (to the extent these are made available) as well as a report from the assessment author at the subsequent May CPT meeting indicating how comments by the external reviewer were addressed in the assessment.

General comment from CPT:

- **Priorities should be expanded beyond groundfish focus to include research needs for crab assessment and impact on crab dependent communities**

North Pacific Fishery Management Council

Research Priorities and Needs

Note the CPT worked from the list as identified below

The North Pacific Fishery Management Council has developed a list of research needs and priorities, in three parts. This document contains the following sections:

- Research Priorities for 2007–2008
- Research Priorities for 2007–2012
- Comprehensive Research Needs for North Pacific Fishery Management

Research Priorities for 2007–2008

I. Fisheries

A. Stock Assessments

1. Continuation of annual and biennial surveys in the GOA, AI and EBS are a critical aspect of fishery management in Alaska. It is important to prioritize these surveys in light of recent proposed federal budgets in which funding may not be sufficient to conduct these surveys. These surveys provide baseline distribution, **abundance, and life history** data that form the foundation for stock assessments and the development of ecosystem approaches to management. These surveys are considered the highest priority research activity contributing to assessment of Alaskan groundfish **and crab** fisheries. Moreover, the expansion of routine surveys into the northern Bering Sea and baseline surveys of the Arctic Ocean will become increasingly important under ongoing warming ocean temperatures and range expansions of harvested fishery resources. In particular, increase the annual survey to include the North Bering Sea Research Area (NBSRA) "wedge"[1]. The Council recognizes that funding is tight for stock assessment and surveys. If additional funds are not available, NMFS should consider a scientific research plan that provides a baseline in this relatively untrawled NBSRA as well as "cost recovery" in the "wedge".

   Comment from CPT: The CPT requests additional information on the NBSRA and suggests that the references to this area are dropped from this section. Wording in the five year research priorities section (below) on this topic is preferable.

[1] The "wedge" refers to the area between St Matthew and Nunivak Islands, north to 60° N. The longitudinal expanse between the two islands has been reported as the first area likely to be utilized by the flatfish trawl fleet, if the sea ice edge moves and fish stocks migrate northward.

2. Continuation and expansion of cooperative research efforts to supplement existing surveys to provide seasonal or species specific information for use in improved assessment and management.
3. Improved stock assessment of ~~"other species," non-target~~ **data-poor stocks, including** crab and rockfish. Highest priority research tasks include: (1) alternative indices of abundance (and biomass) and fishing mortality are necessary for species for which standard surveys are inadequate; and (2) life history information (specifically, natural mortality, size at maturity, and other basic indicators of stock production) for ~~"other species" and non-target crab~~ **data-poor stocks** to allow application of Tier 5 or Tier 4 assessment criteria. Little information is available especially for sculpins, skates, octopuses, squids, grenadiers and some sharks. In particular for rockfish, conduct appropriate survey and analysis to aid the Council in developing mechanisms to assess species that are locally lumped in their distribution and are thus not adequately represented (either over or under estimated) in the annual or biannual groundfish surveys.

B. Fishery Management

1. Evaluate the effectiveness (e.g., potential for overharvest or unnecessarily limiting other fisheries) of setting ABC and OFL levels using Tier 5 and 6 approaches for rockfishes and other poorly assessed species (e.g., squid, octopus, skates, ~~non-target~~ crab).

II. Fisheries Interactions

A. Bycatch and Observer Issues

1. Improved estimation of total bycatch including tier 2 marine mammals and seabirds. At present, it is clear that observer coverage in some fisheries is insufficient for estimation of total bycatch. Further, observer coverage must be analyzed to compare, to the extent possible, the total catch, bycatch, and fishing behavior between observed and unobserved fishing vessels. Examples include the CV trawl fisheries, sablefish longline fishery, skate fishery, Pacific cod pot and longline fishery, halibut longline fishery, and sport fisheries. Improved accuracy of identifications and enumerations of bycatch species is necessary. The current program results in imprecise bycatch estimates for species, such as skates, sharks, yelloweye rockfish, and sablefish in halibut longline fisheries and discards in sport fisheries. Improved methods may include direct and alternative monitoring options (e.g., electronic logbooks, video monitoring) on smaller groundfish and halibut vessels.
2. Gear technology. Further research is needed on gear modifications and fishing practices for reducing bycatch, particularly for PSC species (e.g., salmon).

B. Expanded Ecosystem Studies

1. Climate change and fish communities. Changes in ocean temperature and acidity may affect managed species and lower trophic levels. For instance, if recent changes in ice cover and temperatures in the Bering Sea persist, they may have profound effects on marine communities. Apparent declines in zooplankton wet weight over the shelf measured by the Oshoro Maru could imply the loss of

critical copepod and euphausiid prey of important species, such as pollock. Existing data sets (bottom trawl surveys, BASIS surveys) can be used to quantify changes in relative species composition of commercial and non-commercial species, identify and map assemblages, and monitor changes in the distribution of individual species and assemblages. Additional monitoring may be necessary in the Aleutian Islands and other areas of the Gulf of Alaska.

2. Ecosystem structure studies. Studies are needed on the implications of food web interactions and global warming, ocean acidification, and selective fishing. For instance, studies are needed to fully evaluate selective removal of some components of the ecosystem (e.g., Pacific cod, pollock, **crab**)

C. Protected Species Interactions

1. Population dynamics, life history and assessment of protected species including Steller sea lions, northern fur seals, spectacled eider, short-tailed albatross
2. Local fishery interaction studies. Whereas global fishery control rules may generally prevent overfishing on a broad regional basis, non-random patterns of fishing may cause high rates of removals in local areas important to apex predators such as Steller sea lions and northern fur seals, spectacled eider, short-tailed albatross. More studies are needed to fully evaluate potential local effects of fishing on other components of the ecosystem (e.g., marine mammals, seabirds, and the impact on benthic habitat by bottom contact gear).

III. Habitat

A. Habitat Mapping

1. Improved habitat maps are required to identify essential fish habitat and distributions of various substrates and habitat types, including habitat-forming living substrates.
2. Evaluate Bering Sea canyons and skate nursery areas. In particular, an assessment of the extent, distribution, and abundance of important skate nursery areas in support of future HAPC.

B. **Function of Habitat**

1. **Evaluate relationships between and functional importance of habitat-forming living substrates to commercially important species, including juveniles.**

IV. Other Areas of Research Necessary for Management Purposes

A. Social and Economic Research

Kodiak is at the center of controversy associated with the recently adopted crab rationalization program. **In this community and in other affected communities,** what were the direct and indirect impacts and how were the impacts distributed throughout the community? How do these costs and benefits compare to other affected communities? As Kodiak is also likely to be at the center of controversy over the likely consequences of Gulf rationalization, it would be particularly advantageous if research could be designed to use Kodiak or other Gulf communities as case studies in analyses of the potential effects of Gulf rationalization options.

Research Priorities for 2007-2012

I. Fisheries

A. Stock Assessments

1. Continuation of annual and biennial surveys in the GOA, AI and EBS are a critical aspect of fishery management in Alaska. It is important to prioritize these surveys in light of recent proposed federal budgets in which funding may not be sufficient to conduct these surveys. These surveys provide baseline distribution and abundance data that form the foundation for stock assessments and the development of ecosystem approaches to management. These surveys are considered the highest priority research activity contributing to assessment of Alaskan groundfish **and crab** fisheries. Moreover, the expansion of routine surveys into the northern Bering Sea and baseline surveys of the Arctic Ocean will become increasingly important under ongoing warming ocean temperatures and range expansions of harvested fishery resources.
2. Continuation and expansion of cooperative research efforts to supplement existing surveys to provide seasonal or species specific information for use in improved assessment and management.
3. Improved stock assessment of ~~"other species" and non-target crab~~ **data-poor stocks**. Highest priority research tasks include: (1) alternative indices of abundance (and biomass) and fishing mortality ~~are necessary fo~~**for species for which** standard surveys are inadequate; and (2) life history information (specifically, natural mortality, size at maturity, **growth,** and other basic indicators of stock production) for ~~"other species" and non-target crab~~ **data-poor stocks** to allow application of Tier 5 or Tier 4 assessment criteria. Little information is available especially for sculpins, skates, octopuses, squids, grenadiers, **some crab,** and some shark **species.**

B. Fishery Performance and Monitoring

1. Improvements in at-sea observations are needed in several areas: (1) species-specific identification of priority species on scientific surveys; (2) review and revision of observer deployment and coverage to adequately characterize total catch, as well as a review of sampling procedures (e.g., basket versus whole haul) employed by observers that form the basis for total catch estimation; (3) improved means of data collection especially on small vessels; and (4) improved biological data collection of bycatch species (e.g., octopus, squid, skates, sharks, and ~~non-target~~ crab).
2. Improved estimation methods for total catch and fishing mortality of all target and non-target species at the stock and fishery level as well as at the level needed for various management programs. This may include revised observer deployment, use of flow scales, etc.

C. Fishery Management

1. Evaluate the effectiveness (e.g., potential for overharvest or unnecessarily limiting other fisheries) of setting ABC and OFL levels using Tier 5 and 6 approaches for

rockfishes and other poorly assessed species (e.g., squid, octopus, skates, ~~non-target~~ crab).

2. Advancing ecosystem approach to fisheries management. This includes development of suitable indicators and indicator species (including novel approaches such as using corticosterone levels in predators as an indicator of prey availability, developing ecosystem reference points, including OY cap considerations, and improvements of current ecosystem models).
3. Development of forecasting tools that incorporate ecosystem indicators into single or multi-species stock assessments to conduct management strategy evaluations under differing assumptions regarding climate and market demands. Standardization of "future scenarios" will help to promote comparability of model outputs. Process-oriented research focused on local impacts of fishing on prey availability for top trophic level consumers will also be informative.
4. Development of spatially explicit stock assessments that allow for management to be linked appropriately to stock boundaries and habitat use.

II. Fisheries Interactions

A. Bycatch

1. Improved estimation of total bycatch including tier 2 marine mammals and seabirds. At present, it is clear that observer coverage in some fisheries is insufficient for estimation of total bycatch. Examples include the sablefish longline fishery, skate fishery, Pacific cod pot and longline fishery, halibut longline fishery, and sport fisheries. Improved accuracy of identifications and enumerations of bycatch species is necessary. The current program results in imprecise bycatch estimates for species, such as skates, sharks, yelloweye rockfish, and sablefish in halibut longline fisheries and discards in sport fisheries. Improved methods may include direct and alternative monitoring options (e.g., electronic logbooks, video monitoring) on smaller groundfish and halibut vessels.
2. Research on discard and handling mortality rates. Better estimates of discard mortality rates by gear and fishery is needed to estimate more accurately total bycatch mortality for all discarded species, with an emphasis on such species as crabs, skates, sharks, rays, and octopus.
3. Gear technology. Further research is needed on gear modifications and fishing practices for reducing bycatch, particularly for PSC species.

B. Expanded Ecosystem Studies

1. Climate change and fish communities. Changes in ocean temperature and acidity may affect managed species and lower trophic levels. For instance, if recent changes in ice cover and temperatures in the Bering Sea persist, they may have profound effects on marine communities. Apparent declines in zooplankton wet weight over the shelf measured by the Oshoro Maru could imply the loss of critical copepod and euphausiid prey of important species, such as pollock. Existing data sets (bottom trawl surveys, BASIS surveys) can be used to quantify changes in relative species composition of commercial and non-commercial species, identify and map assemblages, and monitor changes in the distribution of

individual species and assemblages. Additional monitoring may be necessary in the Aleutian Islands and other areas of the Gulf of Alaska.

2. Ecosystem structure studies. Studies are needed on the implications of food web interactions and global warming, ocean acidification, and selective fishing. For instance, studies are needed to fully evaluate selective removal of some components of the ecosystem (e.g., Pacific cod, pollock) relative to others (e.g., arrowtooth flounder).

C. Protected Species Interactions

1. Population dynamics, life history and assessment of protected species including Steller sea lions, northern fur seals, spectacled eider, short-tailed albatross
2. Local fishery interaction studies. Whereas global fishery control rules may generally prevent overfishing on a broad regional basis, non-random patterns of fishing may cause high rates of removals in local areas important to apex predators such as Steller sea lions and northern fur seals, spectacled eider, short-tailed albatross. More studies are needed to fully evaluate potential local effects of fishing on other components of the ecosystem (e.g., marine mammals and seabirds).
3. Economic, social, and cultural valuation research (e.g., consumptive use, passive use, non-consumptive use).

III. Habitat

A. Habitat Mapping

Improved habitat maps are required to identify essential fish habitat and distributions of various substrates and habitat types, including habitat-forming living substrates.

B. **Function of Habitat**

1. **Evaluate relationships between and functional importance of habitat-forming living substrates to commercially important species, including juveniles.**

IV. Other Areas of Research Necessary for Management Purposes

A. Social and Economic Rresearch

1. Development of an ongoing database of product inventories (and trade volume and prices) for principal shellfish, groundfish, and salmon harvested by US fisheries in the North Pacific and Eastern Bering Sea. This database needs to include information about product form (e.g., canned, frozen, whole fish, fillets, value-added product, etc.), but does not need to be firm specific.
2. Analyses of current determinants of exvessel, wholesale, international, and retail demands for principal seafood products from the GOA and BSAI;
3. Kodiak is at the center of controversy associated with the recently adopted crab rationalization program. **In this community and in other affected communities,** what were the direct and indirect impacts and how were the impacts distributed throughout the community? As Kodiak is also likely to be at the center of

controversy over the likely consequences of Gulf rationalization, it would be particularly advantageous if research could be designed to use Kodiak or other Gulf communities as case studies in analyses of the effects.

4. Develop a framework for collection of economic information on commercial, recreational, charter fishing, and fish processing to meet the requirements of this MSFCMA sections 303(a)(5, 9, 13), 303(b)(6), and 303A.

Comprehensive List of Research Needs

I. Fisheries

A. Stock Assessment

The SSC notes that continuation of annual or biennial surveys in the GOA, AI and EBS are a critical aspect of natural resource management. These surveys provide baseline distribution and abundance data that form the foundation for stock assessments and the development of ecosystem approaches to management. These surveys should be considered a high priority research activity. Also the SSC notes that continued research on the life history of groundfish, crab and scallop should be considered an essential activity to improve stock assessments and management of managed resources. Critical life history research topics include: estimates of natural mortality (including temporal shifts in predation for target species), size-at-maturity or age-at-maturity (including environmental factors influencing maturity schedules), maternal effects (especially for Pacific cod and long-lived species such as rockfish), environmental impacts on growth, and environmental factors influencing reproductive success.

CPT comment: the importance of mating ratios and maternal affects in crab should also be considered here.

The following lists identify high priority research for groundfish, crab and scallops.

Groundfish

1. Rockfish – a general need for improved fishery independent estimates of abundance, catch, stock structure, and biological variables.
   a. Direct observations (e.g., submersible and dive surveys) to compare fish densities, particularly for rockfish, between trawlable and nontrawlable habitats.
   b. Improved surveys for minor rockfish species to verify range relative to standard surveys.
   c. Supplemental trawl survey biomass estimates to address patchy distribution.
   d. Age samples from the fishery, esp. POP, northern rockfish, and dusky rockfish. There is a need to increase the number of age determinations annually conducted for rockfish and to train researchers to make age determinations on species that are difficult to age.
2. Improved stock assessment of "other species." The SSC ranks items a, e, and f very high because they form the basis for a tier 5 calculation.
   a. Improved identification of priority species within each group in the fisheries by both processors and observers to avoid misidentifications, as well as categories containing large numbers of unidentified species.
   b. Species-specific identification of priority species on scientific surveys, including NMFS trawl and longline surveys, IPHC surveys, and ADF&G surveys.

c. Increase knowledge of the acoustic sign types and target strength to length relationships to allow assessment of other targets during hydroacoustic surveys.

d. Improved biological data collection via enhanced survey sampling, fishery port sampling and at-sea observations, including collection of lengths and age structures for priority species.

e. Alternative indices of abundance (and biomass) and fishing mortality are necessary for species for which standard surveys are inadequate. With an increase in the number needed stock assessments, it will be critical to develop alternative estimates of abundance and/or direct estimates of fishing mortality. Two possibilities that require dedicated research for development are: (1) directly estimate fishing mortalities through large-scale tagging programs; and (2) habitat-based estimates of abundance based on local density estimates in combination with large-scale habitat maps.

f. Life history information (specifically, natural mortality, size at maturity, and other basic indicators of stock production) must be improved for many members of the others species complex to allow application of Tier 5 or Tier 4 assessment criteria. Little information is available especially for sculpins, skates, octopuses, squids, grenadiers and some sharks.

g. Improved catch histories for groups in this complex for improved stock assessment and application of Tier 6 criteria. Greater use of historical foreign observer data is needed, as part of this activity.

3. Research is needed to incorporate seasonal movements, and stock boundaries of managed species into stock assessments. To identify stock boundaries, expanded studies are needed in the areas of genetics, reproductive biology, larval distribution and advection. Expanded tagging efforts are needed to support the development of spatially explicit assessments. High priority species for spatially explicit models include: walleye pollock, Pacific cod, sablefish, yellowfin sole, rock sole, Pacific Ocean perch, and Atka mackerel.
4. Incorporating uncertainty into the stock assessment advice. This requirement was proposed in the PSEIS, but progress towards amending the groundfish guidelines to address this issue has not been started. Management strategy evaluations are also encouraged because these evaluations serve as useful tools to assess the efficacy of harvest control measures under different assumptions regarding stock production.
5. Efforts to incorporate ecosystem considerations into stock assessments should be accelerated through research to improve knowledge of the functional relationship between environmental factors (e.g. physics, competition, and predation) and recruitment, growth, natural mortality and availability to surveys.
6. Expand surveys beyond typical boundaries to include the shelf break and the northern Bering Sea to evaluate the fraction of the stocks that are not assessed by the shelf survey. This will become increasingly important as species distributions shift northward as the Bering Sea continues to warm.
7. Expand the collection of underway oceanographic data and marine mammal sighting during standard assessment surveys.

Crabs

1. ~~1.~~ Natural mortality (M) estimates. Estimates of M (obtained independently from models) are needed for all stocks ~~(except Bristol Bay red king crab), with highest priority assigned to Tanner and snow crabs.~~
2. Improved stock assessment of ~~non-target~~ **data-poor** crab **stocks**. Highest priority research tasks include: (1) alternative indices of abundance (and biomass) and fishing mortality are necessary for species for which standard surveys are inadequate, (2) life history information (specifically, natural mortality, size at maturity, **growth,** and other basic indicators of stock production) for ~~non-target~~ crab to allow application of Tier ~~5 or Tier 6~~ **system** assessment criteria and (3)) implications of a male only fishery on stock structure and subsequent stock assessment.
3. Conduct field studies to improve knowledge of growth increments and molting probabilities and the relationship between shell condition and age of Bering Sea Tanner, **AI golden king crab** and snow crabs.
4. Improve understanding of seasonal movements, stock structure, natural mortality and harvest rates of crabs through mark recapture studies with emphasis on snow and Tanner crab stocks. In addition, improved understanding of seasonal movements of species without surveys or with a short time series of existing survey data are needed to assess the probability of incidental capture in other fisheries.
5. Improve understanding of processes influencing the fertilization rate of egg clutches, including consideration of spatial dynamics of crab reproduction and contribution to reproduction by males as a function of size, time post molt, and their distribution during stock assessment surveys and during the fisheries. Primary emphasis is on snow and Tanner crabs, with secondary emphasis on red king crab.
6. Develop a spatial stock assessment model for eastern Bering Sea Tanner crab.
7. Conduct studies to improve crab aging using radiometric aging or lipofuscin and, for Bering Sea Tanner and snow crabs, improve knowledge of the relationship between shell condition and age.
8. Improve understanding of processes controlling recruitment dynamics for all FMP crab species. Incorporate these processes into scenarios regarding temporal trends in recruitment. Perform a management strategy evaluation using variable recruitment scenarios. This is a very broad topic encompassing the need to identify and assess biological and environmental effects on egg production, egg hatching, and larval survival, as well as mechanisms controlling the abundance of juvenile crabs from settlement to recruitment into the fishery. Factors include larval transport, predation, competition, and habitat availability. Effects of ocean acidification on crab larval **and juvenile** growth and survival is also of interest. Primary emphasis is on stocks currently declared overfished: ~~eastern Bering Sea Tanner crab,~~ St. Matthew Island blue king crab, eastern Bering Sea snow crab, and Pribilof Islands blue king crab.

9. As an extension to research items 4 and 7, develop a spawning index which is demonstrably proportional to total fertilized egg production and be responsive to fishing mortality that could be used in stock-recruitment models for biological reference points determination for major red king snow, and Tanner crab stocks.
10. Examine the temporal dynamic of size at maturity for eastern Bering Sea Tanner crab and its implications on spawning biomass and fisheries management through analysis of the trawl survey data. **Relate size at maturity to chelae-height estimates of maturity.**
11. Conduct calibration studies to assess survey selectivity and catchability of snow crab, Tanner crab, and blue king crab with current trawl survey gear and new survey net.
12. Research on handling mortality rates. Better estimates of pot handling mortality rates by crab species are needed to estimate more accurately total bycatch mortality for all discarded species.
13. Describe Tanner crab habitat characteristics using side-scanning and/or multi-beam sonar to allow increased precision of survey catch rate estimates.
14. **Evaluate effective mating size of males, how many males contribute to each clutch, and effective population size. Genetic techniques may prove useful in this regard.**
15. **Investigate alternative indices of recruitment, including larval and settlement indices.**
16. **Development and standardization of crab maturity schedules.**

<u>Scallops</u>

1. Development of an age-structured model for assessment of abundance to be applied to each stock (e.g., Yakutat, Prince William Sound, Cook Inlet, and so forth).
2. Identify larval sources, as well as advective pathways, to evaluate the potential effects of fishing on recruitment for major beds.
3. Estimate survival rates for discarded scallops and of scallops contacted by the dredge that are not captured. [SSC modified with ADF&G Shellfish Priorities]
4. Investigate causes of high natural mortality recently observed in the Cook Inlet fishery, and scallop meat quality issues (i.e. off-color meats, 'weak meats', 'weak shell syndrome') observed in the Yakutat area.
5. Expansion of the recently developed remote video survey method for four objectives:
   a. to estimate densities and abundance of scallops in major fishing areas as well as in nearby unfished areas for monitoring environmental effects independent of fishing,
   b. to estimate catchability coefficients for commercial and research dredges,
   c. to evaluate habitat and distribution of non-scallop species that are present in scallop beds, and

d. to conduct field studies to compare the dredge survey used in Central Region to the video sled survey.

6. Develop/standardize scallop shell aging methodology and complete aging of backlogged observer-collected scallop shells.

B. Fishery Performance and Monitoring

1. Improved onboard observations. Improvements in at-sea observations are needed in several areas:

   a. Observer deployment and coverage. There is a long-standing need to review the allocation of observers among fisheries to adequately characterize the total catch, as well as a review of sampling procedures (e.g., basket versus whole haul) employed by observers that form the basis for total catch estimation.

   b. Conduct research on mechanisms to supplement observer program information. Improved means of data collection are needed, especially on small vessels. Research is needed on utility of other data collection methods, such as at-sea video monitoring, port sampling, and other direct methods.

   c. Improved biological data collection. There are needs to improve biological data collection (e.g., age, size, sex) of some bycatch species (e.g., sharks, skates, octopus, squid, sculpins, grenadiers) to better quantify potential effects of bycatch on these stocks. Better estimates of stock of origin are needed for salmon bycatch.

2. Improved estimation methods for total catch (including bycatch) and fishing mortality of all target and non-target species. This may include revised observer deployment, use of flow scales, etc. Two levels of improvements are needed:

   a. Improved estimation at the stock and fishery level. Assessment and management depend critically on catch estimates. More rigorous statistical methods for catch estimation need to be implemented (e.g., Miller 2005). Specifically, identifying sources of variability in actual and estimated bycatch rates is needed. Approaches to integrate estimates of variance on the observed portion of the fisheries into the total catch estimates are needed.

   b. Improved detailed estimation of catch for specific management programs. Some management programs (e.g., IFQ, cooperatives, other rationalization programs) require extensive record keeping to increasingly finer degrees of resolution (e.g., vessel, subareas). Research is needed to evaluate the effectiveness of reporting systems to newly developed management groups or practices.

C. Fishery Management

1. Evaluate the effectiveness (e.g., potential for overharvest or unnecessarily limiting other fisheries) of setting ABC and OFL levels using Tier 5 and 6 approaches for rockfishes and other poorly assessed species (e.g., squid, octopus, skates~~, non-target~~ crab), as appropriate.

2. Continue to develop a systematic approach to lumping and splitting that takes into account both biological and management considerations.

3. Advancing ecosystem approach to fisheries management. This includes development of suitable indicators and indicator species (including novel approaches such as using corticosterone levels in predators as an indicator of prey availability, developing ecosystem reference points, including OY cap considerations, and improvements of current ecosystem models.
4. Development of forecasting tools that incorporate ecosystem indicators into single or multi-species stock assessments to conduct management strategy evaluations under differing assumptions regarding climate and market demands. Standardization of "future scenarios" will help to promote comparability of model outputs. Process-oriented research focused on local impacts of fishing on prey availability for top trophic level consumers will also be informative.
5. Development of spatially explicit stock assessments that allow for management to be linked appropriately to stock boundaries and habitat use.

II. Fisheries Interactions

A. Bycatch

1. Improved estimation of total bycatch including tier 2 marine mammals and seabirds. At present, it is clear that observer coverage in some fisheries is insufficient for estimation of total bycatch. Examples include the sablefish longline fishery, skate fishery, Pacific cod pot and longline fishery, and halibut longline fishery. Improved accuracy of identifications and enumerations of bycatch species is necessary. The current program results in imprecise bycatch estimates for species, such as skates, sharks, yelloweye rockfish, and sablefish in halibut fisheries. Improved methods may include direct and alternative monitoring options (e.g., electronic logbooks, video monitoring) on smaller groundfish and halibut vessesls.
2. Research on discard and handling mortality rates. Better estimates of discard mortality rates by gear and fishery is needed to estimate more accurately total bycatch mortality for all discarded species, with an emphasis on such species as crabs, skates, sharks, rays, and octopus.
3. Efficacy of bycatch mitigation measures. Research is needed on the efficacy of bycatch mitigation measures (e.g., PSCs, time/area closures) and their effects on populations of the bycatch and target species, effects of changes in abundance of bycatch species on bycatch rates, and methods for assessing the economic and social costs of bycatch.
4. Gear technology. Further research is needed on gear modifications and fishing practices for reducing bycatch, such as research that has been conducted to protect salmon, halibut, rockfish and seabirds.

B. Expanded Ecosystem Studies

1. Forage fish. Understanding the dynamics of important pelagic and benthic forage species, such as capelin, herring, myctophids, euphausiids, shrimp, squid, and juvenile pollock remains a high priority for understanding energy flow to commercially important species and to protected species, including seabirds and mammals. Innovative approaches to assessing such stocks are needed and may

include novel acoustic techniques (e.g. low-frequency sound), air-borne surveys, and indices based on the diet of predators, including seabirds or marine mammals.

2. Ecological effects of bycatch and discards. Selective removal of certain species of certain size ranges can affect the relative abundance of fish communities, perhaps with consequences on their ecological interactions. Moreover, fishery discards can favor scavenging species over others, perhaps with consequences on groups, such as seabirds and benthic communities.
3. Climate change and fish communities. Changes in ocean temperature and acidity may affect managed species and lower trophic levels. For instance, if recent changes in ice cover and temperatures in the Bering Sea persist, they may have profound effects on marine communities. Apparent declines in zooplankton wet weight over the shelf measured by the Oshoro Maru could imply the loss of critical copepod and euphausiid prey of important species, such as pollock. Existing data sets (bottom trawl surveys, BASIS surveys) can be used to quantify changes in relative species composition of commercial and non-commercial species, identify and map assemblages, and monitor changes in the distribution of individual species and assemblages. Additional monitoring may be necessary in the Aleutian Islands and other areas of the Gulf of Alaska.
4. Ecosystem structure studies. Studies are needed the implications on food web interactions of global warming, ocean acidification, and selective fishing. For instance, studies are needed to fully evaluate selective removal of some components of the ecosystem (e.g., Pacific cod, pollock) relative to others (e.g., arrowtooth flounder).
5. Ocean acidification and effects on marine ecosystems. As atmospheric greenhouse gas emissions increase, more CO_2 is absorbed by the sea surface, thus increasing levels of carbonic acid, resulting in lower pH. If trends continue, the ability of organisms, such as pteropods and ~~king~~ crab larvae, to form exoskeletons will be compromised, perhaps resulting in **reduced recruitment success, fitness, or even** extirpation of these species. Monitoring of pH levels and additional studies of these effects are necessary.
6. Environmental effects on recruitment and growth. Studies on effects of climate on recruitment and growth (GPT C1) could include the development of standard environmental scenarios for future variability based on observed patterns. There is also a clear need for information that covers a wider range of seasons than presently available.
7. Nutrients and lower trophic levels. There is limited information regarding nutrient dynamics and phytoplankton/zooplankton dynamics on the Bering Sea and Gulf of Alaska shelves and through the Aleutian Island passes (e.g., supply of nutrients to the shelf, interannual variability and changes in nutrient supply, potential for HABs, etc.). Recent advances in technology such as towed undulating vehicles with various sensors and plankton recorders allow high-frequency sampling of both nutrients and plankton. Such sampling could support detailed process studies as well as the development of relatively low-cost monitoring programs in conjunction with existing surveys or through new surveys.

8. Predator-prey interactions. Diet information from seasons in addition to summer is needed to assess seasonal changes in predator-prey interactions. The diet information should be collected on the appropriate spatial scales for key predators and prey to determine how food webs may be changing.
9. Local fishery interaction studies. Whereas global fishery control rules may generally prevent overfishing on a broad regional basis, non-random patterns of fishing may cause high rates of removals in local areas important to apex predators. More studies are needed to fully evaluate potential local effects of fishing on other components of the ecosystem (e.g., marine mammals and seabirds).
10. Relationships between oceanographic conditions, prey, and effects on scallop population health and distribution with an emphasis on Yakutat. Sporadic poor quality of scallop meats from the Yakutat area is an issue. A broader issue is the relationship between ocean currents and scallop metapopulation structure.

C. Protected Species Interactions

1. Population dynamics, life history and assessment of protected species including Steller sea lions, northern fur seals, spectacled eider, short-tailed albatross.
2. Local fishery interaction studies. Whereas global fishery control rules may generally prevent overfishing on a broad regional basis, non-random patterns of fishing may cause high rates of removals in local areas important to apex predators such as Steller sea lions and northern fur seals, spectacled eider, short-tailed albatross. More studies are needed to fully evaluate potential local effects of fishing on other components of the ecosystem (e.g., marine mammals and seabirds).
3. Economic, social, and cultural valuation research (i.e., non-market consumptive use, passive use, non-consumptive use).

III. Habitat

A. Habitat Mapping

1. Improved habitat maps are required to identify essential fish habitat and distributions of various substrates and habitat types, including habitat-forming living substrates.
2. Improved identification and quantification of removal of species are needed in the broad "coral" category by the Fishery Observer Program.
3. Improved mapping of critical habitats are needed for listed marine mammals and seabirds, such as short-tailed albatross, spectacled eider, and Steller sea lions.

B. Habitat Models

Further development of habitat-based models of distribution, abundance, and sensitivities are necessary. Such models have great potential to lead to improved estimates of stock size and their spatial structure, as well as areas of sensitivity to fishing impacts.

C. Effects of Fishing on Bottom Habitats

Additional field studies are needed on the effects of fishing on seafloor habitats. Studies need to be conducted in a variety of bottom habitat types using a variety of gear types. Studies should focus on short- and long-term effects on benthic communities and bio-geological processes. Such studies are particularly needed in the northern Bering Sea.

D. Management Strategy Evaluations

Evaluate the effectiveness of existing closures to meet stated management objectives.

IV. Other Areas of Research Necessary for Management Purposes

A. Social and Economic Research

The need for the development and continued maintenance of basic social and economic information databases on the fisheries and fisheries dependent communities of GOA and BSAI is made ever more pressing as the Council continues to adopt actions that are intended to improve the long term net benefits derived from fisheries. This information is required for establishing a baseline to be used in identifying stakeholders to be included in the distribution of dedicated access privileges (e.g., harvesting quotas and processing quotas), a baseline to be used for projecting the likely consequences of alternative management measures, and as a baseline for retrospective analysis of management actions that have been taken.

Particularly pressing research needs include:

1. Development of an ongoing database of product inventories (and trade volume and prices) for principal shellfish, groundfish, and salmon harvested by US fisheries in the North Pacific and Eastern Bering Sea.

2. Analyses of current determinants of exvessel, wholesale, international, and retail demands for principal seafood products from the GOA and BSAI;
3. Pre- and post-implementation studies of the benefits and costs, and distribution of benefits and costs associated with changes in management regimes (e.g., changes in product markets, characteristics of quota share markets, changes in distribution of ownership, changes in crew compensation, as a consequence of the introduction of dedicated access privileges in the halibut/sablefish, pollock, and crab fisheries). "Benefits and costs" include both economic and social dimensions.
4. Prospective analyses of the robustness and resilience of alternative management strategies under varying environmental and ecological conditions; and,
5. Prospective and retrospective analyses of changes in the spatial and temporal distribution of fishing effort in response to management actions (e.g., time/area closures, marine reserves, bycatch restrictions, co-ops, IFQs).
6. Kodiak is at the center of controversy associated with the recently adopted crab rationalization program. What were the direct and indirect impacts and how were the impacts distributed throughout the community? As Kodiak is also likely to be at the center of controversy over the likely consequences of Gulf rationalization, it would be particularly advantageous if research could be designed to use Kodiak or other Gulf communities as case studies in analyses of the effects.
7. Develop a framework for collection of economic information on commercial, recreational, charter fishing, and fish processing to meet the requirements of this MSFCMA sections 303(a)(5, 9, 13), 303(b)(6), and 303A.

Additional important research needs include:

1. Development of longitudinal data sets of:
   a. Transaction level observations of exvessel, wholesale, and retail prices;
   b. Daily or weekly, firm-scale data on production by species and product form;
   c. Trip-scale data on variable costs (e.g., fuel, labor, supplies, etc.) for catcher vessels, catcher-processors, and sportfishing charters (this data should be matched with existing data on catch, catch composition, and production);
   d. Daily or weekly plant-scale data on variable processing costs (e.g., fuel and power, labor, supplies, packaging, etc.) for shore-based and floating processors;
   e. Annual vessel- or plant-level data on fixed costs (e.g., capital replacement, maintenance, repair, upgrades, insurance, etc.);
   f. Trip-scale information about the location and duration of fishing (e.g., VMS records, or observer information on steaming time, fishing time, etc.);
   g. Weekly or monthly data on patterns (location and magnitude) of expenditures associated with harvesting, processing, and sportfishing charters;
   h. Pay-period scale, vessel- and plant-level data on employment and income of fishery participants, especially crew and processing plant workers;
   i. Socioeconomic and demographic data for fishery dependent communities (income levels and distributions, population levels and distributions); and,

j. Community- and regional-scale annual data on the distribution and magnitude of tax receipts and transfer payments associated with commercial and sport fishing.

2. Analyses or the development of models to evaluate:
   a. The evolution of community social and economic structure in response to alternative management actions:
      i) Baseline assessments of selected communities and industry sectors relative to social considerations identified by the Council and the Advisory Panel;
      ii) Field studies to elucidate the full array of linkages between fisheries and social and economic life in fishery dependent communities;
      iii) Regional economic models of activities and impacts associated with commercial, sport and subsistence fisheries;
      iv) Prospective and retrospective studies of the social and economic impacts of alternative management actions;
      v) Development of better methods for determining the social costs and benefits of management actions (e.g. through the use of non-market valuation techniques);
   b. The benefits, costs, and the distribution of benefits and costs associated with consumptive and non-consumptive uses of resources supported by the North Pacific and Eastern Bering Sea ecosystems:
      i) Cost functions for harvesting, processing, and sportfishing charters;
      ii) Producers and consumers surpluses associated with commercial fisheries under current and alternative management regimes;
      iii) The magnitude and distribution of benefits and costs associated with sport and subsistence harvests under current and alternative management regimes;
      iv) Existence and option values associated with corals, seabirds, and marine mammals;
      v) The value of ecosystem services;
   c. Evaluation of alternative management strategies:
      i) The cumulative efficiency and equity consequences of management actions that apply time/area closures;
      ii) Management strategies and optimal yield for multi-use fisheries, e.g., commercial, sport, and subsistence fisheries for halibut and salmon;
      iii) The relationship between sampling strategies and the confidence of bycatch estimates associated with individual and pooled bycatch quotas and the economic and social costs of bycatch;
      iv) Changes in catch efficiency and operating costs associated with gear modification and avoidance behaviors intended to reduce bycatch;
   d. Evolving seafood markets:
      i) Mechanisms for providing and costs of traceability systems for certifying product and production process attributes of seafoods;
      ii) Consumer demand for seafood ands its associated byproducts harvested from stocks that have been certified as sustainably managed.

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" (β).

Lastly, in stock status level "c," current biomass is below β * (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 α is set at a default value of 0.1, and β 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, γ, 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 γ.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, γ, 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, γ, is multiplied by M to estimate the F_{OFL} for stocks at status levels a and b, and γ is allowed to be less than or greater than unity. Use of the scalar γ is intended to allow adjustments in the overfishing definitions to account for differences in biomass measures. A default value of γ 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

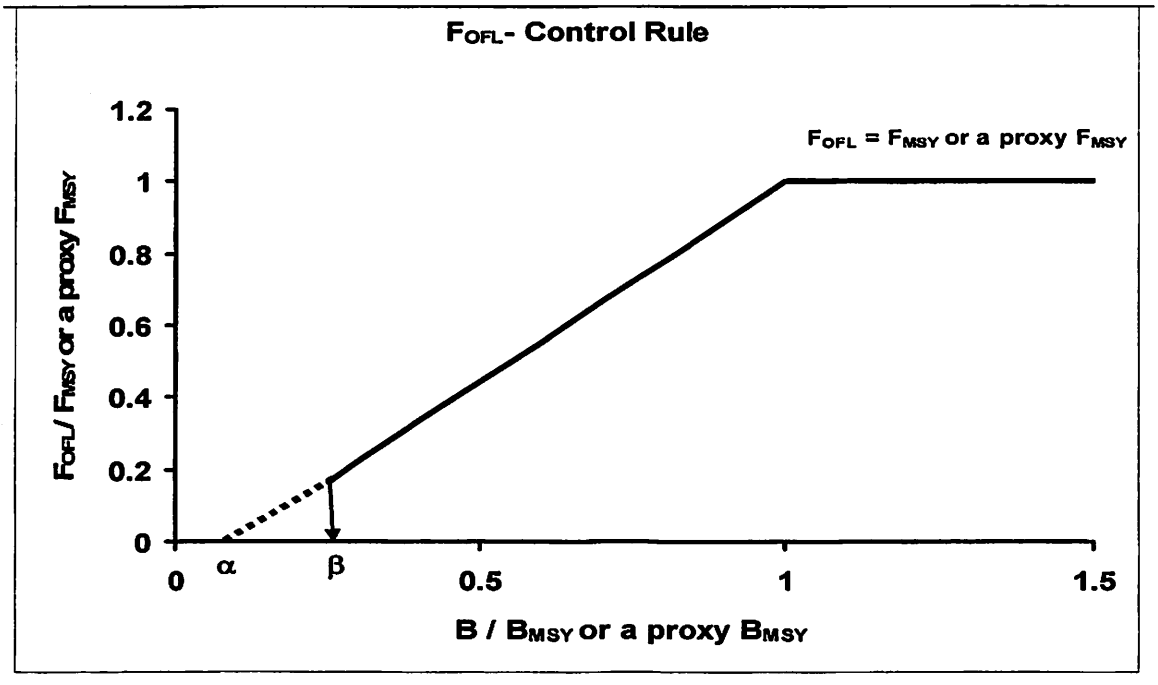

Table 1. Five-Tier System for setting overfishing limits for crab stocks. The tiers are listed in descending order of information availability. Table 6-2 contains a guide for understanding the five-tier system.

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* $F_{OFL} \leq F_{MSY}$†
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* $F_{OFL} \leq F_{MSY}$†
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* $F_{OFL} \leq F_{MSY}$†
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* $F_{OFL} \leq F_{MSY}$†
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
  - β — a parameter with restriction that $0 \leq \beta < 1$.
  - α — 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, β, determines the threshold level of B at or below which directed fishing is prohibited.
- The parameter, α, 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 α result in a smaller value of F_{OFL} when B decreases to $\beta \cdot B_{MSY}$.
  - Larger values of α 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_{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 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 ($\geq$ 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 ($\geq$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 $\geq$ 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 $\geq$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, γ=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, γ=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 λ 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 $\leq$ 5% for ELB from 1.5 to 2.5 million lbs; and (3) HR $\leq$ 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 γ.	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 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	$0.18(M_1\text{-}M_5)$ $0.216(M_6)$	0.678 [retained]
8	Al 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