Workshop Report

Crab Overfishing Definitions Inter-agency Workshop

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Alaska Fisheries Science Center

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Summary from Biology Session

Discussions during the Biology Session focused on six main topic areas. Below is a listing of summary points and recommendations for each topic area.

1) Measuring female spawning biomass

  a. *Use of ♀ pre- or post-molt size to calculate spawning stock biomass (SSB)*
  b. *Effects of senescence*

Summary points:

- Ovary size (potential clutch size) is constrained by volume of body cavity.
- Reproductive potential of females degrades in later years of terminal molt, at least in snow crabs.

Recommendations:

- It is appropriate to adjust female snow and Tanner crab spawning biomass to account for the different size-fecundity relationships among primiparous and multiparous crabs to reflect the relationship between fecundity of primiparous crabs and pre-molt body size (multiparous crabs do not molt).
- No such adjustments are necessary for king crab. It was noted that all female king crabs molt previous to mating and spawning, all fecundity-size relationships have been reported based on post-molt king crab size, and back-calculating pre-molt size would introduce estimation errors.
- Available data should be evaluated to determine the appropriate adjustment. For example, differences in fecundity among primiparous and multiparous crabs of the same size were published by Somerton and Meyers (1983) for Tanner crabs.
- Regarding senescence, spawning biomass calculations should not include "graveyard" females in the estimates. Ideally, an adjustment for this should be based on a data analysis of reduced fecundity with shell age. Failing such data, an option could be to discount the spawning biomass associated with females with the oldest shell condition. If possible, the discounting should be informed with data on fecundity of such graveyard crabs.

2) Defining male spawning biomass

  a. *Molt status of mating ♂ king crab*
  b. *Shell condition of mating ♂ snow & Tanner crabs*

Summary points:

<u>Red King Crab (Kodiak observations)</u>

- It is unlikely that many king crabs mate within several months of molting.
- It is not known exactly when males molt, however primiparous females molt before multiparous females.
- In January, mates of primiparous females are oldshell males, i.e., male king crabs, which molt at the same time as females, do not participate in mating.
- In April and May (~4 months post-molt) newshell males are able to mate.
- The transferability of Kodiak results to the Bering Sea is unclear.

<u>Tanner Crab (mostly Kodiak observations)</u>

- Primiparous females molt and mate in December – July (most in Feb.) with small mature males.
- Multiparous females mate in mid April – mid May over a 2 week period after egg hatch
- Males average 30 mm carapace width larger than females.

- Males mating with primiparous females are 43% shell condition 2 and 57% shell condition 3 (oldshell).
- Males mating with multiparous females are 10% shell condition 2 and 90% shell condition 3.
- AJ Paul's laboratory studies show that males cannot mate for at least 99 days after molting.

<u>Snow Crab (observations from Atlantic Canada)</u>

- Snow crab males do not molt and mate within a year.
    - Primiparous females molt and mate over a 3 month period (January to March), whereas multiparous females mate over a 2-3 week period after egg hatch (usually in May).
    - Males molt (April-May) and can potentially mate with primiparous females the following winter (about 7-10 months after molting), and with multiparous females in the spring of the following year (about 12-13 months after molting) while their shell is still new. In the wild, however, intermediate-shelled males usually outcompete newshell males for mates.
    - These features are reinforced by geographic distribution as males molt in shallow waters and multiparous females are located at deeper depths.
- Males mating with multiparous females are usually larger than the females.
- Males mating with primiparous females may be smaller than the females.
- Male mortality is observed around mating aggregations, likely due to reproductive exhaustion and fighting. Laboratory studies suggest that fitness of males is reduced by precocious mating (defined as new shell males mating 7-13 months after molting).
- Male preferential selection of larger females for mating.
- Data indicates that, if females are not well mated at the primiparous mating, the chances of successful multiparous reproduction are diminished in some years.

Recommendations:

- Estimates of male spawning biomass should reflect this knowledge. MSE might be used in order to identify which factors have the largest consequences on medium-term management performance.

3) Mating ratios

c. *Mating ratio (MR) used to determine effective SSB*
d. *Applying the MR to determine effective SSB*

Summary points:

- Potential for sperm limitation exists in snow, Tanner and king crabs so mating ratios are important.
- Quality of males (mating potential) at size/age can change between years.
- There are many difficulties inherent in calculating mating ratios, including: (1) female mate selection that may vary with stock size and sex ratio, (2) competition among males, and (3) difficulty to extend laboratory results to the field because lab studies do not consider geographic distributions of the sexes, pre-copulatory and post-copulatory embracing periods, and other behaviors.
- Mating ratios dependent upon efficiency in survey estimation, which is not equivalent for males and females. Catchability has a large impact on estimates of mating ratios, so use of them is inherently problematic.

Recommendations:

- Consider exploring existing data on male and female abundance, percent barrenness, and clutch size to determine mating ratios that might best explain the existing data including evaluations within the stock assessment models. Figure 5 of the ADF&G report (eggs vs. CW) could be analyzed spatially with respect to survey estimates of male to female sex ratios. Any exploration of survey data with respect to mating ratios needs to take into account: 1) that shell condition is an unreliable estimator of shell age; 2) survey selectivities are different for males and females of mature size, and 3) seasonal migrations between the survey time and the mating season.

4) Spawning stock biomass

- *Define spawning stock biomass*
- *Define effective ♂ spawning biomass (if necessary)*

Summary points:

- Male spawning biomass is temporally more stable than egg biomass. During low recruitment, females may mature at larger sizes. Female sperm load varies with female recruitment and mating ratio.
- Despite uncertain mating ratios, it is necessary to include males in estimates of spawning stock biomass.
- Seasonal movements by males for mating are also uncertain—what fraction of all mature males undertake spawning migrations?
- Methods to study the overall reproductive potential of the stock need to be developed.

Recommendations:

- Males must be included in spawning biomass estimates despite the inherent uncertainty about mating ratios. Some measure of male influence should be incorporated whether by mating ratio, correction for male and female overlap in geographic distribution, or other factors.
- The precise method to incorporate males in SSB should be left to discretion of the stock assessment authors pending approval by an open peer review process. It is advisable to look at available data (e.g., clutch fullness, spatial distribution, etc.) to investigate the best means of incorporating males (see comments above about mating ratios).

5) Stock-Recruitment Relationship

e. Choice of SSR
f. Other issues (tau range, change in productivity, depensation S-R)

Summary points:

- Discussion ensued on the difficulties related to obtaining precise estimates of tau (steepness parameter) for reference point analysis.
    - In particular, the per recruit reference points were complicated by differing approaches for defining spawning biomass.
- The appropriate choice of productive years (i.e., under the new Tier 5) was discussed. The choice should be up to the assessment authors based on their knowledge of stock. However, the workshop stressed the need for consistency in choices between assessment for OFL and assessment for TAC.
    - There was discussion of the ability to annually review these assessments.
    - A Management Strategy Evaluation (MSE) for evaluating productivity periods was suggested as a useful inclusion in the EA.

Recommendations:

- The form of the stock-recruit model (e.g., Ricker versus Beverton-Holt) must be left to the informed discretion of the stock assessment authors based on an examination of the data.
- Regarding the wide range in steepness parameter fits, examining the pdf of these parameter values may provide guidance on reducing or weighting the range considered.
- If steepness remains poorly defined, then omit consideration of stock-recruit relationships for per recruit reference points and default to mortality-based reference points.
- The stock assessment authors should evaluate data and select most appropriate years for high and low productivity stock-recruitment periods, if possible. This could be a break-point type modeling for detecting productivity changes.

6) Female natural mortality

Summary points:

It appears that the maximum age (20 years) being used at present is too high. Maximum age depends upon the instar at which terminal molt (maturity) is attained and how long females survive thereafter. Survey data from the Bering Sea and Atlantic Canada both suggest that females survive 5-6 years after attaining terminal molt. This pattern was repeated three times in survey data for the eastern Bering Sea. Therefore, based on growth data for the Atlantic, the maximum age of females maturing in instar X (mean size of about 56 mm CW) is more likely to be 12-13 years. Females maturing one or two instars larger (i.e., XI at about 66 mm CW or XII at about 77 mm CW) would respectively live to be about 13-14 and 14-15years maximum. Studies of other crustaceans suggest unmated females may have a higher mortality rate due to predation or ovarian necrosis.

- Discussion of rationale for differential *M* rates based on post-terminal molt age (utilized in model).
  - Investigate data for estimation of differential rates.
  - Potential to over-estimate *M* (e.g. in cases of die-off) when basing on 1st percentile of population (unless truly only natural mortality w/no die-off events).
  - Also include fishing mortality rates on females (handling and discard mortality).
- Importance of estimation of mortality and senescence and their relative impact on contribution to reproductive potential.
- Differential survey selectivity by sex complicates estimation of female mortality.

Recommendations:

- Maximum age of female snow crab is unknown, however average maximum age of snow crab females to be utilized should be 12-13 years or slightly greater if appropriate (depending on instar for maturity)
- Consider using total abundance of multiparous females over time to estimate *M*, however, do not necessarily assume constant M over the life span after the terminal molt. More likely, *M* is lower over first few years and higher over last few years. However, given unknown age of post-terminal molt snow crab (since shell condition is not a reliable estimator of shell age) estimating M from survey data will be problematic. A reliable method of estimating shell age is needed to use the survey data to estimate M.

Summary from Modeling/Biological Reference Point/Tier System Session

1) Assessment model review

Assessment authors presented an overview of the stock assessment approaches used for two species of crabs. These presentations were mainly to familiarize the workshop participants with the approaches used and not a review of the methods. However, some comments from the workshop are summarized here.

Snow crab

- The workshop noted that the model could be used to investigate uncertainty in the relationship between shell condition and time intervals based on uncertainties in shell age determinations (e.g., studies presented from Eastern Canada).
- Survey selectivity estimation evaluations could provide insight on model specification issues.
- The initial stock biomass is estimated to be below B_{msy}. However, the level of historical fishing mortality is given little consideration. For consistency, one should be able to have a clear explanation why the initial stock estimates should start at such low biomass levels. This may indicate an issue with the model assumptions about R_0 or value of pre-specified steepness parameter.
- Sensitivity to the recruitment estimates, particularly the large value estimated from mid 1980s is needed (i.e., is this a single large year class or is it strong recruitment spread over multiple years?). This value influences the rebuilding level and understanding the source of uncertainty would be informative. The model specifications may affect the resultant reference point estimations.

Red king crab

- The workshop discussed how the time-varying specification of natural mortality in the assessment model may reflect a number of factors including discard mortality and bycatch rather than simple changes in predation and other sources of natural mortality.
- The new research model presented appears more flexible in addressing reference point uncertainties and shows potential for dealing with natural mortality rate assumptions and a number of other model specification issues (e.g., including molting probability). The group encouraged continued development of this research model.

2) Projection modeling:

Summary

- The importance using comparable parameters between assessment models and projection models was emphasized. In particular, they should strive to be as consistent as possible, particularly regarding parameters that affect productivity estimates (e.g. recruitment).
- Naming conventions between models (assessment and projection) should be consistent such that parameters are specifically defined (e.g., natural mortality defined to not include discards, handling mortality, etc.).
- Exploration on the impact of environmental variability hypotheses should be incorporated to the extent possible.

3) Tier System Review:

The workshop was presented with a tier system from previous meetings. Based on this, a number of further refinements were recommended including:

- The terms F (exploitation or fishing mortality) and B (biomass) should be left unspecified to give stock assessment analysts the flexibility to use the best measure available to them.

- The term F is not explicitly specified (application and interpretation to be specified by the working group). It should include all sources of fishing mortality (directed removals, discards, and bycatch).
- The draft Tiers 3 and 4 should be combined into a single Tier 3 (see Work Group Progress report for more information on draft Tier System).
- In the new Tier 3, proxy values for F_{msy} and B_{msy} would be determined (e.g., from an SPR calculation). The workshop recommended setting SPR values from 50% to 60% for this tier, corresponding to a range of values that appear appropriate based on previous research by the crab working group. This range should be evaluated to determine to what extent its use is defensible.
- In the new Tier 4 (previously Tier 5), a scalar γ is multiplied by natural mortality. The scalar could be less than or greater than 1 and be more or less conservative than the status quo, depending on stock assessment research for a species. For example, when a change from total mature biomass to some other biomass measure (e.g., based on mature males) is used, the scalar can be applied to account for differences between biomass measures.
- The draft Tier 6 would become Tier 5 (see Work Group Progress report for more information on draft Tier System).

A table showing the formulae to be applied for specifying OFL given these recommendations is provided below. Other comments made by the workshop included:

- Specification of other parameters (e.g., values for alpha, gamma, beta) will be determined by workgroup and will be analyzed for the EA.
- The workshop noted that ABCs should not be included in the tier recommendations (though this does not preclude assessments from providing ABC recommendations).
    - Evaluations of GHL relative to OFL (and status quo OFLs) will need to be analyzed for the EA.
- Catch must include all sources (e.g., bycatch from groundfish fisheries not just catch in directed fisheries).
- The analysis should discuss the risk of overfishing from bycatch in rebuilding plans.

The workshop participants discussed the issue of which specific measures of biomass should be used in overfishing definitions. Some alternatives include: total, male, or female spawning biomass; total, male, or female effective spawning biomass; total, male, or female survey biomass; total or viable egg production. The workshop participants recommended that the choice should be left to the discretion of stock assessment scientists and review process. Given that the choice affects biological reference points, it might be wise to establish a group of scientists assist in producing a document offering technical guidance to stock assessment authors.

4) Analytical Guidance and Biological Reference Point Analysis

The workshop participants discussed ideas for EA problem statement and the suite of alternatives and information to be included in the analysis. The following summarizes the key recommendations from the workshop.

- A problem statement needs to be crafted for consideration by the Council and for use in the EA. It should explicitly address necessary changes from current definitions to be included in revised definition. The problem statement should include the following three elements:
    - The current overfishing definitions have specified and locked-in values for natural mortality (0.2 for king, 0.3 for Tanner and snow crabs). There is no way

to change these values without a plan amendment. A framework for these values would facilitate use of the best available scientific information as information improves in the future.
    - The current 3-tier system has flaws. It does not have greater precaution as information becomes less certain. The current system does not take advantage of alternative biological reference points that may be useful. Using natural mortality (*M*) as a proxy value for F_{msy} may be inappropriate.
    - The current overfishing definition uses total mature biomass of males and females while exploitation occurs only on legal males. There is a need to clearly define the status determination criteria and their application to the exploitable section of the population.

The workshop participants proposed evaluating two alternatives in the EA:

Alternative 1: Status Quo (current OFL definitions and overfished/overfishing determination)
Alternative 2: Revised Tier system

Other suggestions for the analysis included:

- Background information detailing the process of crafting tier system as well as alternative definitions (e.g. fixed rates) will be explicitly contained in EA (alternative considered but not carried forward).
- Initial analyses could focus primarily on tiers where majority of crab species will be initially placed.
- It became clear at the workshop that if Alterative 2 is approved, then some changes will be necessary in the specification process by which stock status in relation to overfishing is determined. Under the status quo, the calculation of OFL is made by a single NOAA Fisheries person as an arithmetic operation. Under the new tier system framework, both the stock assessments and OFL calculations will need to be reviewed more formally through a Council process, because a decision will be necessary to determine which tier is appropriate, which model or data should be used, and whether the calculations are correct. One possible model for this would be similar to the groundfish review system. The Crab Plan Team would meet to review the stock assessments and make recommendations about OFL. The Plan Team recommendations would be reviewed by the industry crab committee, SSC, AP, and Council. Other processes could also be envisioned. The EA should contain a discussion of this issue and proposed process for reviewing OFLs and status determination criteria.

Proposed tier system for crab overfishing definitions.

Information available	Tier	Stock status	F_{OFL}
B, B_{msy}, F_{msy}, and pdf of F_{msy}	1a	$\frac{B}{B_{msy}} > 1$	$F_{OFL} = \mu_A$ =arithmetic mean of the pdf
	1b	$\beta < \frac{B}{B_{msy}} \le 1$	$F_{OFL} = \mu_A \frac{B/B_{msy} - \alpha}{1-\alpha}$
	1c	$\frac{B}{B_{msy}} \le \beta$	$F_{OFL} = 0$
B, B_{msy}, F_{msy},	2a	$\frac{B}{B_{msy}} > 1$	$F_{OFL} = F_{msy}$
	2b	$\beta < \frac{B}{B_{msy}} \le 1$	$F_{OFL} = F_{msy} \frac{B/B_{msy} - \alpha}{1-\alpha}$
	2c	$\frac{B}{B_{msy}} \le \beta$	$F_{OFL} = 0$
B, F_{msy}, $B_{msy^{prox}}$	3a	$\frac{B}{B_{msy^{prox}}} > 1$	$F_{OFL} = F_{msy}$
	3b	$\beta < \frac{B}{B_{msy^{prox}}} \le 1$	$F_{OFL} = F_{msy} \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$
	3c	$\frac{B}{B_{msy^{prox}}} \le \beta$	$F_{OFL} = 0$
B, M, $B_{msy^{prox}}$	4a	$\frac{B}{B_{msy^{prox}}} > 1$	$F_{OFL} = \gamma M$
	4b	$\beta < \frac{B}{B_{msy^{prox}}} \le 1$	$F_{OFL} = \gamma M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$
	4c	$\frac{B}{B_{msy^{prox}}} \le \beta$	$F_{OFL} = 0$
Reliable catch history from a time period to be determined (groundfish uses 1978 through 1995).	5		OFL = the average catch from a time period to be determined, unless an alternative value is established by the SSC on the basis of the best available scientific information

Workshop Discussion

Introduction

Gordon Kruse welcomed participants to the workshop and requested that everyone introduce themselves (Attachment 1). He then reviewed changes to the agenda since it was first posted and everyone received an updated version of the agenda (Attachment 2). The first two agenda topics are intended to provide the group with an overview of BSAI crab management, the current overfishing definitions, and the National Standard 1 guideline revisions. These topics provide the necessary background of the regional and national context within which revising these definitions is occurring.

History of crab management/charge for workshop participants

Diana Stram provided an overview of the Federal Fishery Management Plan (FMP) for Bering Sea and Aleutian Island (BSAI) crab stocks and the nature of joint State and Federal management (Attachment 3a). Revisions to the current overfishing definitions require a plan amendment to change (as well as the associated NEPA analyses that accompany all plan amendments). The process for an FMP amendment was outlined as well as the charge for workshop participants.

Revisions to national standard one guidelines

Grant Thompson reviewed the status of the current revisions to the National Standard 1 guidelines (Attachment 3b). He noted that the timeline for the revised guidelines has been considerably delayed and it may likely take an additional year before the revisions are finalized. Gordon Kruse commented that the workgroup should continue to proceed with the analysis. However it will be important that the Council does not seek final action on this amendment until after the final revisions to the guidelines are available.

Andre Punt questioned to what extent generation time has been examined by the workgroup in their progress to date and was informed that this has not been evaluated. As this topic was noted to be tied to mating ratios it was determined best to take this up at that point in the discussion in the agenda.

Jie Zheng questioned what the ramifications are if a stock was shown to be overfished in retrospective analysis but is not presently considered overfished. Grant noted that there would be no need to establish a rebuilding plan under those circumstances. Anne Hollowed questioned the situation where a stock currently under a rebuilding plan is now shown not to be considered overfished. Grant noted that while there are considerations given for either grandfathering existing rebuilding plans or allowing for the option to modify those rebuilding plans, there has not yet been a determination of what to do in the circumstance that a stock under a rebuilding plan is now found not to be overfished.

Overview of proposed revisions

This session focused on allowing the workgroup to provide the workshop participants with an overview of their scope of work, their progress to date and the problems they have encountered which have limited their ability to move forward with their analyses.

Lou Rugolo presented an overview of the workgroup's statement of work (Attachment 3d). This document was provided to workshop participants in advance of the meeting and had been previously presented to the Crab Plan Team (CPT) and the Council's Science and Statistical committee (SSC) (Attachment 4). In the interest of time questions were deferred to the discussion portion of the agenda to follow.

Jack Turnock reviewed the draft Tier System developed by the workgroup (Attachment 3d). This tier system was presented to the CPT in September 2004 within the written progress report compiled by the workgroup (Attachment 5). Terry Quinn requested clarification on why the tier system included an ABC given the aforementioned delegation to the State on authority to establish catch levels. Jack Turnock responded that a buffer between OFL and catch is encouraged. Discussion focused upon the State requirement to stay below the OFL for crab species. However there is no existing mandate for creating a buffer by remaining below an established ABC.

Shareef Siddeek reviewed the parameter inputs to the Spawner Per Recruit (SPR) models utilized in the analysis (Attachment 3e). Gordon Kruse questioned what the uncertainty was in the estimates of male mortality rate. Siddeek responded that he has not yet looked into this, but that female mortality may be higher. Jim Ianelli questioned the benchmarks against which comparisons are being made, i.e. changing the sensitivity parameters and changing the SPR. This topic was deferred to further discussion in the later sessions.

Jack Turnock provided further review of parameter value for SPR models. (Attachment 3f). He commented that in working together for the last 2 years, the workgroup has agreed upon some aspects of the analysis (e.g., base values for natural mortality of Tanner and snow crab = 0.23 yr^{-1}, for king crab = 0.18yr^{-1}, and discard mortality for snow crabs = 50%, for king crabs = 25%) The group has not yet specified a discard mortality rate for Tanner crab. Jack noted that there is a need for consistency between the stock assessment models utilized as outputs and the inputs used in the SPR models. Similar scenarios should be run in the stock assessment models as are being run in the SPR models. He felt that the red king crab models lacked this consistency.

Lou Rugolo provided an overview of the model simplifications (Attachment 3g). He noted some problems inherent with mating assumptions (i.e. assuming that all mature males and females will mate).

Jie Zheng provided an overview of additional considerations in model simplifications (Attachment 3h). Bernard Sainte-Marie questioned why there is an observed peak in the pulse recruitment for newshell females. He noted that if there was a pulse of females entering the population there should have been a subsequent spike in the abundance. Jie answered that this is due to the catchability in the survey whereby the survey does not catch juvenile crab as well as it catches mature crab. Brad Stevens requested clarification on how mature females are defined. Jie commented that they are from the survey data which indicate whether they are immature or mature. Brad noted that the survey is unable to define them without dissection and instead relies on a size cutoff. This cutoff defines crabs as mature and immature but he felt that this is likely inadequate designation for *Chionoecetes* crab. Lou Rugolo noted that he felt that Jie was combining size categories from the NMFS classification (e.g. shell 4 and 5 but counting them all as shell 4). Jie noted that shell 4 and 5 are combined to represent crab two years or longer post terminal molt in the figure.

Shareef Siddeek provided an overview of the model structures utilized (Attachment 3i). Jack Turnock discussed approaches to estimate biological reference points (Attachment 3j). Siddeek questioned the observed discrepancy between Jack's tau values and the values he had calculated. He questioned if this was an artifact of Jack fitting to data from post 1977. Andre Punt questioned to what extent the tau parameter is actually comparable across stock recruitment relationships that differ in relation to the definition of spawning biomass. He noted that it may not be appropriate to estimate tau from various fits and then use a range of taus from one stock recruitment relationship across all stocks. There is the potential here for an inconsistency in logic. Andre questioned the effective biomass calculation in Jack's presentation noting that it seemed to be double-counting males. Jack noted that female spawning biomass is not affected by the fishery. Further discussion on this noted that it is inconsistent to have a definition of spawning biomass that is not affected by the fishery. This discussion will be taken up further in the afternoon sessions.

Andre commented that the scenarios presented by Jack need to be narrowed down if possible. Scenarios should be run which could allow the analysts to begin to reject some hypotheses. Currently there are too many options available. He asked whether Jack had looked at fecundity against those measures in the assessment given that these are all very different and he should be able to evaluate and then reject some of them. Jack noted that the stock recruitment data for snow crab were not definitive. Jack commented that there are uncertainties in the available data, and better measures are needed of fecundity. Jie noted that there are difficulties with utilizing egg clutch size data (per suggestion to use this data to evaluate the fits with the available data). Andre suggested that the available data should be utilized to resolve these difficulties.

Siddeek presented some additional preliminary results of model runs (Attachment 3k). His results included some changes to the Tier system presented by Jack, reducing the number of Tiers and excluding the alpha parameter included in Jack's overview.

Siddeek provided an overview of the issues which are as yet unresolved by the working group in attempting to move forward with their analysis (Attachment 3l).

Biology Session

Measuring female spawning biomass:

The group discussed the problem noted by the workgroup on how to resolve the use of pre- or post-molt size for the calculation of SSB. Background information was requested on fecundity in relation to internal body size. A paper by Somerton and Myers (1983) that examined the fecundity of primiparous vs. multiparous Tanner crab was referenced in this regard. The apparent shift in fecundity with body size is explained by plotting fecundity of primiparous females against their pre-molt (rather than post-molt) body size.

Brad Stevens commented that king crab studies in Kodiak have been based on post-molt size. He noted that the limit on ovary size is based on pre-molt body size, but the studies themselves have focused on post-molt body size. There is a need for consistency in the choice of body size. Gordon Kruse noted that this is different for king vs. Tanner and snow crab. Brad commented that it is safe to assume that pre-molt and post-molt can be proxies for each other provided there is consistency amongst the choice.

Bernard commented that there is general consensus that this does not matter for king crab, but it does matter for Tanner and snow crab. He commented that it might be possible to use the relationship of pre-molt vs post-molt to scale down primiparous females. He noted that he has some information and data on females for scaling purposes.

Andre commented that either metric is ok provided it is used consistently. Lou noted that he feels that it is important to decide on simple biological first principles. If the workgroup is using female biomass as an index of egg production then they need to establish the appropriate categorization of weight. Doug Pengilly commented that survey data records carapace size and clutch fullness. The largest females might represent a significant part of the reproductive biomass. Siddeek commented that if the growth increment in the model is 40-50% then the model will be prone to larger errors. Andre noted that if the molt probability index included in the model is believable then there should be output from this in the model.

The group discussed the necessity of some form of adjustment but agreed that the data should best inform the measure of the adjustment.

Spawning Stock Biomass

The workshop participants discussed the problems noted by the workgroup in defining what measure should be utilized for spawning stock biomass. Fundamentally the group discussed to what extent this should be established or should analysts be allowed to use their best judgment in making these decisions. There was general agreement that it is necessary to framework OFL definitions.

The use of frameworking is encouraged and it was noted by Anne Hollowed that there is particular need for specificity in direction given that the possibility exists for the State to use a different measurement in determining harvest rates than NMFS will use in determining OFLs. Some clarity should be provided to the analysts rather than frameworking everything.

Bernard commented that it is simplest to use female mature biomass however this is defined. Brad noted that spawning biomass depends upon the efficiency of the assessment. He does not believe that this is equivalent for males and females and instead it is more likely that the efficiency for females is approximately 50% of males in the survey. Therefore he feels that the use of mating ratios is not valid.

The group discussed the protocol for stock assessment and OFL and ABC determination for groundfish and how parameters are specified for each North Pacific groundfish stock. Grant Thompson noted that similar parameters for groundfish are not explicitly specified (e.g., exploitable biomass) in order to allow flexibility to the analysts based upon availability of information.

The group further discussed the inherent problems with the use of mating ratios. Bernard commented that for snow crab and Tanner crab, potential egg production fluctuates more than male sperm biomass. Any measures of spawning biomass that incorporate males will level out the effective biomass over time more than is necessary due to differences in variability. The issue is that males are sperm conservers and large males tend to suboptimally fertilize females.

Different growth rates to maturity are observed, and these signals were noted to be observed in unfished as well as fished populations. Mating ratios are difficult to calculate; dominant males (e.g. large) can also exclude subordinate (e.g. small) males. Also, if a female snow crab is not fully mated, she will attempt to mate with other males. Siddeek commented that calculating a mating ratio is unnecessary if total mature biomass is used. Bernard noted that total mature biomass may be misleading because they are a sexually size-biased species and can still demonstrate sperm limitation.

Given the aforementioned discussion on year to year variability, and the variability in number of males per female depending on prevailing conditions, the discussion concluded that calculating mating ratios may not be recommended. However it was also clear that despite the inherent uncertainty problems there needs to be some means of including males in spawning biomass estimates. Female biomass varies due to recruitment variability and female biomass is inherent linked to male biomass. Female biomass is not being monitored to the extent that male biomass is.

Jim requested clarification about to what extent sufficient data are available to estimate effective mating ratios given the stock recruitment curves. Andre commented that there is a need to predict fertilization at different levels of exploitation. Jie noted that this approach could be used for red king crab where data are available but there is no recruitment information available for Tanner and snow crabs. Bernard showed slides of fecundity data noting that if these data were compared against theoretical expectations, you could characterize each female as more or less stressed, and then calculate where she might have mated and the sex ratio (Attachment 3m).

The group discussed stock migration with respect to the distances over which a crab population can still be considered a single stock. Bernard commented that tag recovery data indicated movement inshore and offshore and generally of the range of 100-150km, with the largest tag recovery distance of ~200km. Anne noted that the analysis needs to discuss a rational pattern of movement.

The group summarized their conclusions from the discussion. Using females alone for spawning stock biomass was rejected as a possibility. One option is to use a female spawning biomass that somehow accounts for the need for males (i.e., some sort of mating ratio included). The relative distribution of males and females geographically is also important. The problems lie in how to incorporate these. Given that data are available for assessment of males and females and clutch fullness data, the advice to the analysts is to look at the data to see what it might reveal for informed decisions about these parameters. Spatial distribution could also be examined. Some sort of correction factor for males appears necessary (i.e., mating ratio, effect of distribution).

Jack further commented that currently there is no accounting for discard mortality. This would impact the viability of remaining males. Lou also commented that assuming the remaining males and their size distribution is sufficient to mate appropriately with females (regardless of size distribution), questions still remain about what is the value of large males to the stock? What is the size dependency relationship between males and females for mating? Bernard questioned the reason for the terminal molt, could it be a density dependent incentive to become larger such that if the population were fished too hard at the tail end it could drive size at maturity down. This would achieve an ecologically viable but commercially extinct population.

Andre commented that there needs to be an analysis of this density component including all available data to see if these data allow us to say anything about these different hypotheses. It seems that these choices should be left to the discretion of the individual assessment author to justify most reasonable and justifiable estimate of reproductive potential.

The analysis should embrace key biological parameters, explore sensitivities to biological parameters but also strive to establish key OFL levels that capture simplicity. Anne noted that for groundfish a means to incorporate uncertainty is to establish a buffer between ABC and OFL, but for crab we cannot do that. Here any buffer would need to be established in the OFL calculation. Gordon suggested the analysts look at GHLs as a proxy for ABC, and evaluate the performance of target control rules under OFLs. The analysis should evaluate different definitions of OFL and see what harvest strategies remain below that.

Further comments on mating ratios reiterated that studies of mating ratios have only been done in tanks where all crabs are counted. If a mating ratio is based on survey data then the implicit assumption is that the survey is estimating males and females with the same efficiencies and this is not true. Brad Stevens noted that the only non-lab study in Chiniak showed a mating ratio of 10:1 from submersible transects. By comparison, the trawl survey showed a sex ratio range of 1:1 to 2:1. Gordon further noted that mating ratio studies also don't include travel time necessary in searching for a mate. Siddeek referenced an AJ Paul paper on mating ratios for Tanner crab, which suggested it to be 1:3 in the laboratory.

The group commented that research is encouraged to explain the inherent variability in parameters for mating ratios.

Stock-Recruitment Relationship:

The group discussed the relationship of the measure of spawning biomass to the parameter tau. Tau values from the survey are not useful. If this parameter proves too difficult to estimate than a simplified solution should be sought. Terry commented that it seems that establishing a per recruit reference point is too difficult at this point and hampered by lack of sufficient information. He suggested that a feasible substitute for this in the tier system would be to use natural mortality. Lou noted that the working group has advanced a similar idea, i.e., adopt Fmsy = M which is an improvement upon the current fixed values. However the application of this would need to be corrected as it has been applied incorrectly in the past in determining overfishing (see discussion pages 7-8 in Attachment 4).

Doug Pengilly commented that this would allow for determination of overfishing but that some measure of spawning stock biomass would be necessary to determine Bmsy and establish an overfished level. Grant noted that while MSST is currently necessary, its inclusion has been argued effectively both ways and under the new guideline revisions it is likely that if it is not possible to establish an MSST for a given stock, it will not be mandated. Lou noted that one problem with the current MSST are the years which were utilized in the calculation. He feels that these years are neither applicable nor sustainable. Andre asked if there is a logical argument for a different set of years that would allow for a proxy for MSY.

The group discussed the need for flexibility in the specific language included in the tier system, and that is should be left to the discretion of the stock assessment author to define a range of years that is most appropriate for future projections and definitions. Depensation could be explored by the working group in the analysis but should not be hard-wired into the components of the OFL definitions. The analysis should also include an evaluation of conservative OFL levels but these too should not be hard-wired anywhere in the definitions.

Anne discussed the current review process for groundfish whereby assessments and OFLs (and ABCs) are reviewed by the plan teams and then the SSC. A similar process should be employed by the Crab Plan Team whereby an annual review of the assessment (and the OFL calculation) is reviewed by the team with subsequent review and decision-making on appropriate tiers by the SSC. If the annual assessment is used to calculate the GHL/TAC then this should likewise be used for OFL calculations.

Jie Zheng noted the compressed schedule for GHL/TAC calculations by the State. Doug Pengilly clarified that the SSC can review the TACs annually to see if overfishing is occurring, but more extensive review than that would be a matter of interest only. Under the FMP, choosing the stock recruitment curve used to establish the TAC is at the State's discretion provided it does not result in overfishing. Terry noted that a comparison of GHLs to OFLs (historically) should be included in EA.

Female natural mortality

The group discussed the issues of conflict in modeling different mortality rates on males versus females for all crab stocks.

Jie and Siddeek considered that 18-20 years was a sufficient value for maximum age based on the natural mortality values agreed upon by the working group. Bernard noted that 12-13 years may represent a better maximum age for snow crab. He noted that data on the recruitment pulse indicated that a year-class does not last as long as the 18-20 year estimates. These crabs could be alive but do not appear to be contributing to reproduction.

Bernard showed some data on pulses of primiparous and multiparous females, where the pulse then disappears, noting that mortality could possibly be calculated from this (Attachment 3m). Somerton's thesis tracked a pulse of primiparous *Chionoecetes* females in the Bering Sea and results were roughly similar in the timing of the pulse. Female natural mortality also occurs from mating-induced injuries. The possibility that females that go unmated and have a higher natural mortality rate are due to 1) males offer protection to females from predators during molt (large males are more efficient than smaller males at doing this) if the female molts alone it may be injured and killed by predators; 2) it is unknown what happens to the unmated female, some females extrude clutch of unfertilized eggs but some resorb them and may cause higher mortality rate, there are observation of partial necrosis of ovaries which compromises their future reproductive capacity and may also cause higher mortality rate.

The group further discussed episodic recruitment. Lou questioned the expectation of sampling the oldest 1% of population. Andre commented that by depending upon the upper 1st percentile, there is a possibility of overestimating M if there is a die-off. Using this percentile would work if natural mortality was constant over age. Discussion then focused upon the possibility of specifying different M values based upon age. The actual fishing mortality rate on the population however is unknown. Bernard noted similarity in years of high female egg production between the ADF&G data and eastern Canadian stocks. Jack cautioned reliance on the use of 1980s catch data, noting that in those years the catch of males exceeded the estimate from the survey indicating that the survey was underestimating the actual population in those years. Therefore the decline in abundance might not be as valid as the data suggest.

Doug Pengilly noted the necessity of using a different M following terminal molt in the model. Gordon mentioned that senescence must also be accounted for. Jack commented that M is fixed in the snow crab model due to lack of information. He noted that he could try to estimate it within the model to see the model results, but Andre cautioned against the use of the same data to interpret results and within the model. There needs to be consistency in approach.

Lou commented that Bernard's graphs illustrate the problem in using shell condition for age. The assumption is that there are annual steps between shell conditions, but the graphs indicate that this is not necessarily true. Using survey data as an index of abundance can be difficult given the differential survey selectivity by sex. Andre noted that catchability always varies, and questioned if these data are used in the assessment, and if not is it because catchability varies, noting that you cannot argue the data both ways.

In summary for the discussion, females enter a terminal molt then die in approximately 6 years. However, trying to estimate a fixed point on life expectancy is difficult given the stated uncertainty in actual timing. Data could be utilized to generate an estimate of rates. The effect of fishing could be treated through estimating bycatch and handling mortality as well as previously summarized comments on female mortality.

Male spawning biomass

This discussion focused upon the role of shell condition and age of males in participation in breeding, and specifically when molting males mate with females. Males molt late in winter and the question for discussion is can they and do they participate in late spring/early summer mating?

Brad Stevens summarized some studies in the Kodiak region on red king crab, noting that there is no strong understanding of when king crab males molt. Some studies recently in Women's Bay observed that females molt to maturity roughly along the same timing as males. There are observations of females being grasped by oldshell males that had molted previous years (therefore in Kodiak studies they are not observing molting males participating in mating).

Jie questioned to what extent the data from the Bering Sea survey in June indicated molted red king crab males participating in mating. He noted that crabs are coded by shell condition and those coded as shell 2 crabs could have molted anytime in the past year and may participate in mating in January/February before they molt in April/May. He indicated a graph from the NMFS issues paper (provided as background material but not part of this report), noting that the shell hardness does not change until 30 days prior to molting.

Brad commented that it is unlikely that king crabs mate within several months of molting. However, it is still possible that crabs 4 months post-molt do participate in mating. Crabs which are molting at the same time as females are not participating in mating.

Doug Pengilly commented that tag recovery data (from both the fishery and survey) from primiparous females in Kodiak shows they are mating with oldshell or very oldshell males. The mating period starts in January and continues into April/May. By that time, 40% have been scored as newshell males. This is not entirely inconsistent with tag return studies, and from this it does not appear impossible that some mating is occurring with males that molted during that season (i.e. by that time they would be ~4 months post-molt). Even if you discount 40% due to possible misclassification, this still leaves 20% newshells involved in mating based on the Kodiak data. To what extent this is applicable to Bristol Bay is unknown.

The discussion summarized the following: that males molt before multiparous females, primiparous females mate first (followed by multiparous), and early mating is dominated by oldshell males. Later on, there are suggestions that newshell crabs begin to participate, however as year moves on it becomes more difficult to accurately classify shell ages

Lou noted that the time for shells to harden after the molt indicates that May is not the prime molting period. Otherwise observations would show much higher incidences of soft-shell crabs in Bristol Bay in June (except in cold years where molt characterization differs).

Fundamentally, the issue is to what extent can red king crab males mate and molt in the same year. Brad commented that there is no data to determine this.

Brad Stevens summarized available information from Kodiak on Tanner crab. Here, there is a similar situation, with a primiparous molt from December-July but the majority of molting occurs in February. Mating occurs with small mature males. Multiparous females mate later (variable from mid April to mid May) within roughly a two week period. Males are not participating in mating in that year. On average they are approximately 30 mm larger than their partners. Shell condition indicates 90% oldshell, 10% shell-2 (for mating with multiparous females) and for mating with primiparous females 57% shell-3 or greater, and 43% shell-2. Some of those shell-2 crabs can mate with primiparous but are excluded from mating with multiparous. If they are molting in that two week period then they are excluded from mating that year.

Bernard summarized snow crab timing for mating. Female crabs molt and mate from the end of December to the end of March, while males molt April-May and sometimes into June. Males mate with primiparous females the following winter but not in the current year. For multiparous they mate the following spring. Males tend to be in shallow waters when molting, and are not physically present at deeper depths. Males can be of equal size or smaller for primiparous mating. In multiparous mating, males are considerably larger than females and typically of intermediate shell condition (SC3). Bernard showed some figures on precocious mating, noting that mating in early May could increase natural mortality (Attachment 3m).

Brad commented that they have also observed increased natural mortality around mating. They have never observed competition amongst males, but do observe mortality presumably due to reproductive exhaustion

Bernard showed a study indicating preferential selection of larger females for mating. For snow crab, if crabs are poorly mated at primiparous mating, then the resulting operational sex ratio is biased to males. There is little chance that at multiparous mating they will then mate successfully.

The operational sex ratio is sharply skewed to females, and the sperm reserve aspect to their biology is not as effective if they have not been well mated at the primiparous mating.

Modeling and Biological Reference Point Session

Snow Crab Stock Assessment model

Jack Turnock presented an overview of his snow crab stock assessment model (Attachment 3n). He noted that uncertainty in moving from one shell condition to the next is not explicitly considered, instead it is a deterministic move. Discussion noted that this uncertainty should be investigated particularly in light of the previous conversation on the uncertainty inherent in shell aging.

Other discussions included the growth matrix utilized, noting that the same growth transition matrix is used for both males and females. Jack noted that while mean growth is estimated, the variability in the growth matrix is fixed.

There was discussion of survey selectivity by size, and the potential that the inflection point might be mis-specifed. Jim noted that Q=1 is a very strong assumption. It should instead be estimated to see what it actually is. There appear to be diagnostic problems within the model, as when issues cannot otherwise be accounted for in the model specification, the tendency is for the model to put them into Q. This may therefore be an indication of a larger modeling problem when this is not possible. Andre commented that another problem is the suggestion that the population is not robust to variability.

There was a larger discussion of the characterization of historical fishing. Jim noted that there needs to be a defensible explanation of why the F rate is starting at such a high level. This indicates that there was historical fishing but this is not being backed up with any information. There needs to be additional information or at least a clear hypothesis put forward regarding this starting point.

Technical issues were raised with respect to model specification and this raises concerns regarding reference point estimation.

Red King Crab:

Jie Zheng presented an overview of his red king crab assessment model and an additional research model he has been working on (Attachment 3o).

Jack commented on the inherent assumption in the calculation of M in this model. He noted that the lack of consideration of discard mortality is critical to the establishment of correct OFLs.

Other comments included consideration of the 2001 survey estimate of male abundance which does not fit model trajectories. Jie attributed this to sampling error. Discussion noted this could represent a change in catchability, or possible sampling effects of cold year (i.e., climate-related) effects.

Jie explained his Bristol Bay red king crab research model. This model was developed to address some research issues in 2003/2004 and can be used to address specific criticisms which have been raised by the workgroup previously with the red king crab stock assessment model. The research model is more flexible in treatment of parameters than the assessment model. Here M can be fixed and other parameters added to address things such as handling or discard mortality. There is no documentation at this point on this model but it is anticipated in the future.

Projection models

This discussion focused upon concerns which have been raised regarding the possibility of the workgroup taking assessment results using SRR and M values and evaluating these in the projection model. Concerns were raised regarding a potential disconnect between assessments and projections.

Jack indicated the need for inclusion of appropriate stock assessment information and its equivalent in the projection model. Grant noted that requiring the assessment and projection models to be equivalent is a high standard that would be difficult to obtain (nor is done for groundfish). Some differences are possible and it would be wise not to set impossibly high standards that cannot be met.

Jie commented that the most important input in the projection model is what recruitment is being utilized. Siddeek noted that the projection model parameters may not be the same as for stock assessment parameters. Grant indicated that even if the numbers are directly from the assessment their meaning in the projection model could be different. Jack felt that there was a distinction between the use of the projection model for groundfish versus the use for crab. The crab projection model is to be used for F proxy values and for evaluating different control rules. Grant commented that likewise for groundfish the SPR values reported are from the projection model not from the assessment.

There was a general discussion of the current status determination process. Survey data for each stock are compared with the calculated OFL for that stock. A letter from NMFS (previously from Bob Otto) was submitted indicating the overfished versus overfishing status determination. While this determination has been recently included in the Crab SAFE report, in the last two years no formal letter has been submitted with this determination.

Bernard commented that with a highly variable stock, a definition of overfishing based on biomass value is straying from real overfishing i.e., the impact on females. The definition must be tied to changes in reproductive potential. You could have a stock at high biomass levels in which overfishing is occurring based on reproductive capacity versus a stock at low levels that is achieving its reproductive capacity.

One recommendation regarding the parameterization between stock assessment models and the projection models is that correct naming conventions be utilized in. Equivalent parameterization should be utilized in both the projection model and for assessments.

Climate change should also be considered, with temperature and ice cover considered to the extent possible. Climate effects on populations, particularly king crab need to be included. Recruitment is tied to climate variability. Further exploration of environmental variability to explain the variability in the assessments should be incorporated.

Biological reference points/discussion of tier system

Discussion during this session focused on revising the draft tier system initially put forward by the workgroup in their progress report (Attachment 5). The discussion covered revisions to this draft tier system to craft a workable tier system for the analysis, specific suggestions of what to include in the analysis itself, as well as suggestions for inclusion in a problem statement to be crafted to frame the analysis.

The group discussed the problem statement which will frame the alternatives to be included in the environmental assessment of this amendment analysis. An important aspect of this problem statement is the necessity of a frameworked process (to the extent possible), to avoid having fixed values in the FMP, as with the current system. Fixed values limit flexibility as any change to these values requires an FMP amendment. The problem statement should highlight the need for increased flexibility in crafting new overfishing definitions. The second part of the problem statement should relate to creating a tier system for OFL definitions which relates to the quality of information available on a stock by stock basis. Finally, it was discussed that the problem statement should also clearly relate to the need to appropriate application of status determination criteria utilized in the determination of overfished and overfishing. The process by which this will be determined should be clearly outlined as well as the portion of the stock to which it applies. It has been discussed previously that the process by which overfishing has been determined has not been appropriately applied and one goal of this analysis is to ensure that the process for future application is not ambiguous.

There will be two alternatives analyzed in the environmental assessment for the amendment. These are: Alternative 1, the status quo definitions and method of determination and, Alternative 2, the proposed tier system and method of status determination. Depending upon the specific analytical needs under each tier, there may be options included for analysis under alternative 2. Other alternatives have been discussed during the course of the workgroup's progress on crafting these definitions, such as analyzing different fixed values and other draft tier systems. These alternatives will all be noted as well as the process by which the final tier system was devised in the section of the analysis focusing upon alternatives considered but not carried forward for analysis. This section of the document will note the process by which alternative 2 was crafted. This includes on-going work by the work group, review and recommendations by the plan team and SSC, as well as the workshop itself in providing guidance on refining this alternative

Jie Zheng presented a modified tier system from the one included in the progress report presented earlier in the workshop (Attachment 3p). The group used this draft tier system as a template from which to make modifications to formulate a revised tier system. The final version of the workshop's revised tier system is included in the summary section at the beginning of this document. Many modifications were made both to include aspects of the work group's original tier system as well as aspects from the North Pacific groundfish tier system. The following discussion characterizes the changes that were made in refining the tier system to the final version included in this document.

All reference to an ABC determination by tiers has been excluded in the final tier system version. This is due to the nature of State and Federal management whereby the determination of OFL is made by the Federal government while the determination of harvest levels (formerly GHLs) or TACs are made by the State. There is no mandate to specify an ABC for crab stocks, nor any specification in the State/Federal management system by which an ABC would be utilized. In order to not further complicate the nature of shared management, the group chose to exclude ABC from tier status determination.

One problem that was noted in discussing ABCs, is that in the absence of an ABC there is no specific buffer level between the OFL and the possible harvest strategy. This could pose a conservation concern if OFLs are not properly specified (and hence exceeded by the State in TACs), but can also pose a potential problem with respect to the bycatch of crabs in other Federally-managed groundfish fisheries. In the past the OFL levels for crab fisheries were established at a high enough level that it was highly unlikely that they would be exceeded and therefore shut down groundfish fisheries. The potential exists under new OFLs that this level could be potentially exceeded. Unless specific buffer levels are maintained between OFL and TAC the potential exists for closing down groundfish fisheries which catch crab as bycatch if the combination of the directed fishery and groundfish bycatch of crabs exceeds the crab species OFL. This problem will be noted in the subsequent analysis of this amendment. A State and Federal discussion regarding TACs and OFLs may need to occur to ensure that the bycatch needs of

Federal groundfish fisheries are adequately considered in the establishment of TAC levels by the State.

In all tiers referencing a harvest rate, harvest rate (HR) was changed to reference an F rate. How this F rate is to be defined is left to the discretion of the working group. Tier 1 from the workgroup's draft tier system was included in the final tier system version. This tier was modified to exclude the ABC specification as described above. The ability to analyze tier 1 was noted to be difficult given that no crab stocks will currently fall into this tier. Suggestions were made to possibly use the groundfish tier 1 example for discussion purposes in the analysis of how this tier might in the future be utilized. In all tiers, references to effective spawning biomass were changes to B (Biomass) with the definition of this biomass left to the discretion of the stock assessment analysts as information is available.

The group discussed the definition of parameters such as alpha, beta and gamma as referenced in the tier levels. After discussion of the pros and cons of retaining these parameters as well as specifying these with absolute numbers at this point, it was decided to retain the parameters themselves in tier definitions, but left to the discretion of the workgroup to define the actual numbers in their analysis.

The F rates to be analyzed in Tier 3 were a subject of considerable discussion. It was noted that the F rate for this tier must be specified as objective and measurable, thus cannot be frameworked to be simply Fx% as suggested. Given the previous discussions on the complexities in defining spawning biomass, SPR proxies and stock-recruitment relationships it would be difficult to establish an F rate for this tier or define Fmsy. A range of values was chosen for purposes of analysis whereby F50% - F60% will be utilized.

Tier 4 was modified to combine both tiers 4 and 5 from previous versions of the tier system. Tier 5 was included from the work group's draft tier 6. Specific language determining the definition of OFL in tier 5 was modified from the Tier 6 language for the groundfish tier system which establishes OFL as average catch from a time period to be determined or an alternative value for OFL as established by the SSC based on the best scientific information available.

Wrap-up and future directions

Diana Stram provided an overview of the timeline for compiling the workshop report, and presentation to the SSC and Council at the April Council meeting. Eventually the analysis of the proposed overfishing definitions will be included in a larger environmental assessment of the proposed amendment (which analyzes both alternatives as detailed previously) to be presented for initial and subsequently final review by the Council. Anne Hollowed informed the workshop participants of the scheduled CIE review in late April of the proposed overfishing definitions analysis and the intent to present an analysis to the CPT in May and the SSC in June. Further determination of the schedule for preparing the entire analysis for initial review by the SSC and Council is yet to be determined.

The workshop concluded at 5pm on Wednesday, March 1st.

Crab Overfishing Definitions Inter-Agency Workshop

List of Participants

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Attachment 2

Alaska Crab Overfishing Definitions Workshop

February 28 – March 1, 2006

Alaska Fisheries Science Center, Seattle, WA

Feb 22nd 2005 Draft Agenda

Purpose: To solicit expert advice on proposed overfishing definitions for Bering Sea and Aleutian Islands crab stocks. We are requesting a review of issues critical to formulating new overfishing definitions, biological reference points, input parameters, modeling approaches and methods to deal with uncertainty.

DAY 1 (Traynor Room)

8:00 Coffee and informal discussions 8:30 Introduction - Charge for the workshop participants –Kruse or Stram 8:45 History of crab management - current overfishing definitions and need for revision - Stram 9:00 Revisions to NSG 1, rationale for SPR proxies, and techniques for incorporating uncertainty - Thompson 9:30 Overview of proposed revisions - Working group

- Working group Statement of Work
- Tier System review
- Parameters – input to SPR models
- Model simplifications

10:45 Break 11:00 – 12:15 Overview continued – working group

- Model structures
- Approaches to estimate proxy values for biological reference points
- Preliminary results
- Unresolved issues (moderator will direct audience to written comments)

12:15 – 1:15 Break for lunch 1:00-5:00 Biology session – Chair (Bernard St. Marie)

- Measure of effective spawning stock biomass
- Formulation of effective male spawning stock biomass
- Mating ratio to use in calculation of effective spawning biomass
- Applied mating ratio – method of applying the mating ratio for calculation of effective spawning biomass
- Use of pre-molt vs. post-molt female size in spawning stock biomass calculation
- Males participating in reproduction
  - Non-molting males – king crabs
  - Old shell males (1 yr oldshell or 2 yr oldshell) – snow and tanner crabs
- Female natural mortality estimates
- Stock-Recruitment Relationship [SRR]:

(Rapporteur and session lead will prepare summary of findings for afternoon session on Day 2)

DAY 2 (Traynor Room) 8:00 Coffee and informal discussions 8:30 Session on modeling and biological reference points – Chairs (Quinn and Ianelli)

- Description of stock assessment models and the linkage to projection models
    - Snow crab stock assessment model
    - Red king crab stock assessment model
    - Projection models

10:00 Break (*Note: morning session to reconvene in NMML room until lunch)*

- Review of alternative Biological Reference Points
    - Retain Fmsy=M, application of Fmsy to management of stocks
    - Surplus production models
    - SPR proxies for Tier 3 type management
    - Management Strategy Evaluations based on different families of spawner recruit relationships or different productive regimes to evaluate suitability of control rule under different assumptions regarding stock productivity
    - Indicator approaches based on stock condition or other biological factors.
    - Other suggestions

Break for lunch *(Reconvene back in Traynor room following lunch)* 1:00 Proposed Tier system for crab: review and provide comments
2:00 Report from biology session chair + Discussion *(Rapporteur and chair of modeling session break to compile report)*
3:00 Break 3:30 Report from modeling session chairs + Discussion
4:30 Overview of workshop, feedback from workgroup and future directions (Kruse)

Attachment 3: Powerpoints presented during the workshop (contact the Council office for copies)

Attachment 3a **Overview and purpose of workshop**

Attachment 3b **National Standard Guidelines Overview**

Attachment 3c **Statement of work**

Attachment 3d **Feb WS Tier Proposal**

Attachment 3e **SPR Input parameters 1**

Attachment 3f **SPR Parameters 2**

Attachment 3g **Model Inconsistencies**

Attachment 3h **Model Simplifications**

Attachment 3i **Model Structutures**

Attachment 3j **Biological ref. points approaches 1**

Attachment 3k **Biological ref points 2**

Attachment 3l **Unresolved model issues**

Attachment 3m **Biological considerations**

Attachment 3n **SnowCrab Assessment Overview**

Attachment 3o **Bering Sea Red King Crab Assessment Overview**

Attachment 3p **Tier review ppt**

Attachment 4 **Statement of work report** (contact the Council office for copies)

Attachment 5 **Progress report of workgroup** (contact the Council office for copies)