AGENDA C-6(c)
DECEMBER 2009

MEMORANDUM

TO:	Council, SSC and AP Members
FROM:	Chris Oliver Executive Director
DATE:	December 2, 2009
SUBJECT:	BSAI Crab Issues

ESTIMATED TIME
8 HOURS
All C-6 Items

ACTION REQUIRED

(c) Review alternatives for BSAI snow and Tanner crab rebuilding plans

BACKGROUND

Rebuilding plans for EBS snow crab and Pribilof Islands blue king crab are to be revised for implementation by the 2011/12 fishing year. A new rebuilding plan to EBS Tanner crab will be developed for implementation by the 2011/12 fishing year. At the October 2009 meeting, the Council reviewed and approved alternatives for the Pribilof Islands blue king crab rebuilding plan but requested further review of alternatives for snow crab and Tanner crab rebuilding plans as they are developed. A draft range of alternatives for snow crab and Tanner crab are attached as Items C-6(c)(1) and Item C-6(c)(2) respectively.

As noted in the description of alternatives, the maximum time frame for rebuilding for the snow crab stock (noted as T_{end} for reasons specified in the document) is less than 10 years due to the fact that this represents a revised rebuilding plan (after failing to achieve rebuilding during the original rebuilding time frame). Alternatives for both rebuilding plans are established in terms of years necessary to rebuild, with appropriate management measures to be determined for achieving rebuilding under the selected time frame. Additional information is provided, per SSC request in October, on the estimated number of years for the end of the rebuilding time frame for snow crab. Additional information on progress towards development of a Tanner crab model for estimating rebuilding probabilities will be provided at the meeting. The SSC further requested a review of the snow crab projection model methodology. This description is attached at Item C-6(c)(3).

As noted for several meetings, compliance with new annual catch limit (ACL) and accountability measure (AM) requirements for ending overfishing of federal fisheries under the revised guidelines for National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for the BSAI Crab FMPs will require substantive changes, primarily in order to incorporate an ABC control rule into the annual specifications process for both FMPs. The Crab Plan Team and SSC recommended an approach for the formulation of uncertainty-based buffer approaches to ABC control rules for BSAI crab stocks. Further information is provided here for SSC review and comment on the approach being applied in estimating uncertainty-based buffers for crab stocks. A description of the proposed methodological approach and preliminary results for crab stocks in comparison with groundfish stocks is provided as Item C-6(c)(4).

To facilitate the concurrent timeframe for meeting both the rebuilding plan amendment statutory requirements as well as those for ACL requirements, two analyses are planned to comprehensively evaluate these proposed amendments. The ACL analysis for all 10 crab stocks will be analyzed in conjunction with the rebuilding plans for snow crab and Tanner crab, while a separate analysis will evaluate the alternative rebuilding measures for the Pribilof Islands blue king crab stock. Draft outlines for these two analyses are attached as Item C-6(c)(5). A preliminary review of both analyses is scheduled for the April Council meeting following review by the Crab Plan Team at a special March 2010 CPT meeting. Initial review of these analyses is scheduled for June 2010.

Snow Crab Rebuilding Alternatives:

The alternatives below represent different target years for rebuilding the snow crab stock to the proxy for B_{MSY} with a pre-specified probability (values for T_{target})[1]. Options (applicable to each alternative) establish probabilities for rebuilding by T_{arget} (either fixed probabilities or increasing probabilities by year until T_{target}). The maximum permissible year for rebuilding[2] (denoted T_{end}) is the number of years to rebuild at a probability at least 50% if the total catch fishing mortality was set to the maximum permissible level of 75% of F_{OFL}[3] unless the SSC recommends an alternative value in December 2009.

Alternative 1: Set T_{target} based on minimum number of years necessary to rebuild under the current best assessment of the snow crab stock if all sources of fishing-related mortality are set to zero[4].

For example, the current estimate of the minimum number of years (see Tables 1, 2) to recover to $B_{35\%}$ for two consecutive is 2 years (i.e. under assumption of catch at 75% of F_{OFL} through 2010/11 and implementing F=0 beginning in 2011/12 fishing year). The minimum number of years is the same with very low levels of catch (equivalent to estimated incidental catch in other fisheries). However the probability of rebuilding is higher under F=0.

Alternative 2 –Alternative [#TBD]: Set T_{target} above the minimum number of years (between 1 above the minimum and T_{end}). Rebuilding in this timeframe would occur with 50% probability based on a strategy in which the fishing mortality[5] is constant during the rebuilding period. Here each separate alternative (numbered consecutively starting from Alternative 2) represents a time increment in one year intervals to T_{end}.

For example, using the current estimate of the minimum number of years under Alternative 1 (2 years) and the maximum number of years (T_{end}= 5 years, see Table 1) there with be 3 additional alternatives (to Alternative 1) considered.
The timeframes associated with these alternatives would be the following:

- Alternative 2: 3 years to rebuild
- Alternative 3: 4 years to rebuild
- Alternative 4: 5 years to rebuild (= T_{end})

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[1] No less than 50%.

[2] The maximum permissible year is denoted T_{end} rather than T_{max} because T_{max} (10 years or T_{min} plus one generation time) appears in the NS1 Guidelines and clearly pertains to a new rebuilding plan. This is a revised rebuilding plan so although there is needs to be a maximum rebuilding time, the rules which define T_{max} do not apply (i.e. a further ten years for rebuilding)..

[3] The year corresponding to this level of fishing mortality will be calculated by projecting the current best assessment of the snow crab stock ahead under the average fishing mortality for the groundfish fishery and the maximum permissible level of fishing mortality for the directed crab fishery.

[4] Recovery by the minimum T_{target} could occur with low levels of catch although this would decrease the probability of rebuilding by T_{end}. See attached table for probability of rebuilding under low levels of catch (equivalent to incidental catch in other fisheries)

[5] For all options, absent specific direction from the Council, snow crab bycatch in the groundfish and scallop fisheries would not be restricted and all reductions in catch would come from the directed snow crab fishery.

Options (applies to all alternatives): Increased probability of rebuilding by the agreed T_{target}.

1. 75% probability of rebuilding by T_{target}.
2. 90% probability of rebuilding by T_{target}.
3. Annually increasing probability of rebuilding by T_{target}. The annual fishing mortality rate would be calculated so that the probability of rebuilding by T_{target} increases annually according to an agreed schedule. Note that if F=0 is necessary to achieve agreed probability in a given year then closures in groundfish fisheries and crab fisheries would be necessary. Under this option, T_{target} would be the year in which the probability of rebuilding is 50%.

   Sub-options below refer to different annual and end-point probabilities of rebuilding.
   - **a.** Range from 50% in first year of rebuilding to 70% by T_{target}.
   - **b.** Range from 50% in first year of rebuilding to 90% by T_{target}.

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

Table 1 Estimated catch and probability of rebuilding (defined as mature male biomass being above $B_{35\%}$ for consecutive two years) for three catch scenarios: Catch scenarios in each year = 75% F_{OFL}, F=0 directed and total F=0. All scenarios assume catch = 75% F_{OFL} in 2010/11 fishing year and the listed strategy thereafter. In **bold** is the year in which the probability of being rebuilt is greater than 50% for the first time for each catch scenario.

Year	Catch: 75% F_{OFL}	Probability: 75% F_{OFL}	Catch: directed[1] F=0	Probability: directed[1] F=0	Catch: Total F=0	Probability: Total F=0
2009/10	56.95	0.000	56.95	0	56.95	0
2010/11	73.53	0.090	73.88	0.088	73.88	0.088
2011/12	77.85	0.156	1.05	0.167	0.00	0.167
2012/13	73.44	0.194	1.27	**0.770**	0.00	**0.782**
2013/14	83.06	0.227	1.52	0.957	0.00	0.961
2014/15	93.45	0.382	1.79	0.999	0.00	0.999
2015/16	97.09	**0.529**	2.01	1	0.00	1
2016/17	99.35	0.593	2.18	1	0.00	1
2017/18	101.81	0.646	2.34	1	0.00	1
2018/19	107.07	0.697	2.50	1	0.00	1

1-estimated incidental catch only included, no directed fishery

Table 2 Probability of being above $B_{35\%}$ for the first time under three catch scenarios. In **bold** is the year in which the probability of being above $B_{35\%}$ is greater than 50% for each catch scenario.

Year	75% F_{OFL}	Directed F=0	Total F=0
2009/10	0.092	0.092	0.092
2010/11	0.165	0.171	0.171
2011/12	0.221	**0.770**	**0.782**
2012/13	0.253	0.957	0.961
2013/14	0.409	0.999	0.999
2014/15	**0.572**	1	1
2015/16	0.636	1	1
2016/17	0.686	1	1
2017/18	0.736	1	1
2018/19	0.782	1	1

Tanner crab rebuilding alternatives:

The alternatives below represent different target years for rebuilding the Tanner crab stock to the proxy for B_{MSY} with a pre-specified probability (values for T_{target})[1]. Options (applicable to each alternative) establish probabilities for rebuilding by T_{arget} (either fixed probabilities or increasing probabilities by year to T_{max}). The maximum permissible year for rebuilding (denoted T_{max}) is defined as 10 years (or T_{min}[2] plus one generation time if rebuilding cannot occur with 50% probability within 10 years).

Alternative 1: Set T_{target} equal to T_{min}[3].

Alternative 2 –Alternative [#TBD]: Set T_{target} above the minimum number of years (between T_{min}+1 and T_{max}). Rebuilding in this time frame would occur with 50% probability based on a strategy in which the fishing mortality by the directed fishery is constant during the rebuilding period and the bycatch in the snow crab fishery is based on the alternative selected in the snow crab rebuilding plan. Each separate alternative (numbered consecutively starting from Alternative 2) represents a time increment in one year intervals to T_{max}.

Options (applies to all alternatives): Increased probability of rebuilding by the agreed T_{target}.

1. 75% probability of rebuilding by T_{target}.
2. 90% probability of rebuilding by T_{target}.
3. Annually increasing probability of rebuilding by T_{target}. The annual fishing mortality rate would be calculated so that the probability of rebuilding by T_{target} increases annually according to an agreed schedule. Note that closures in groundfish, scallop and crab fisheries may be necessary to achieve some annual probabilities. Under this option, T_{target} would be the year in which the probability of rebuilding is 50% given the agreed probability of rebuilding by T_{max}.
   Sub-options below refer to different annual and end-point probabilities of rebuilding.
   a. Range from 50% in first year of rebuilding to 70% by T_{target}.
   b. Range from 50% in first year of rebuilding to 90% by T_{target}.

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

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[1] No less than 50%.

[2] T_{min} is the lowest year in which rebuilding to the proxy for B_{MSY} could occur with 50% probability.

[3] Recovery by the minimum T_{target} could occur with low levels of catch although this would decrease the probability of rebuilding by T_{max}. Catch levels in non-directed fisheries (e.g. snow crab, groundfish and scallop fisheries) may need to be constrained under this alternative.

Bering Sea Snow Crab Projection Model Description

Benjamin J. Turnock
National Marine Fisheries Service
November 20, 2009

A projection model was developed to evaluate overfishing reference points and rebuilding strategies for Bering Sea snow crab (Amendment 24 and, Turnock and Rugolo 2009). The projection model uses the same parameter values and population dynamic structure as the snow crab stock assessment model (Turnock and Rugolo 2009). The projections are stochastic, incorporating error in initial biomass, implementation error and variability in recruitment about a Beverton-Holt stock-recruitment curve. Recruitment can be generated from other stock-recruitment model forms, or assume that recruitment is independent of mature male biomass.

Variability in recruitment, as well as implementation error, was simulated with temporal autocorrelation. Recruitments are bias-corrected accounting for the lognormal distribution. Recruitment was generated from a Beverton-Holt stock-recruitment model,

$$R_t = \frac{0.8\, h\, R_0\, B_{t-lag}}{0.2\; spr_{F=0}\; R_0(1-h)+(h-0.2)B_{t-lag}}\; e^{\varepsilon_t - \sigma_R^2/2} \qquad (1)$$

$spr_{F=0}$	mature male biomass–per-recruit fishing at F=0. $B_0 = spr_{F=0}\, R_0$,
B_{t-lag}	mature male biomass at time *t-lag*, where *lag*=5,
h	steepness of the stock-recruitment curve defined as the fraction of R_0 expected at 20% of B_0,
R_0	recruitment when fishing at F=0, set at 1.0 billion,
σ_R^2	variance for recruitment deviations, estimated at 0.74 from the assessment model.

The temporal autocorrelation error (ε_t) was estimated as,

$$\varepsilon_t = \rho_R \varepsilon_{t-1} + \sqrt{1+\rho_R^2}\;\eta_t \qquad where\ \eta_t \sim N(0;\sigma_R^2) \qquad (2)$$

ρ_R temporal autocorrelation coefficient for recruitment, set at 0.6.

Recruitment variability, autocorrelation and R_0 were estimated using recruitment estimates from the stock assessment model. R_0 was estimated at 1.0 billion which is approximately the 75% percentile of the cumulative distribution of the recruitment from the assessment model. Steepness (h) was fixed at 0.68 which equates the estimated $F_{35\%}$ to F_{msy} estimated from the Beverton-Holt stock-recruitment curve.

Recruitment to the stock occurs over a range of size classes from 25 mm to about 35 mm. The maturity function and growth define how long before recruits reach maturity and terminal molt. Recruits may take about 3-5 years to start contributing to the male mature biomass. Therefore, recruits generated in the projection model will require several years before contributing to the mature stock. Different assumptions concerning recruitment generated in the projection model will affect the length of time for the stock to rebuild.

Implementation error was modeled as a lognormal autocorrelated error on the mature male biomass used to determine the fishing mortality rate in the harvest control rule,

$$B_t^{'} = B_t e^{\phi_t - \sigma_I^2/2}; \quad \phi_t = \rho_I \phi_{t-1} + \sqrt{1+\rho_I^2} \;\; \varphi_t \qquad where\ \varphi_t \sim N(0;\sigma_I^2) \qquad (3)$$

$B_t^{'}$	mature male biomass in year t with implementation error input to the harvest control rule,
B_t	mature male biomass in year t,
ρ_I	temporal autocorrelation for implementation error, set at 0.6 to approximate autocorrelation in the stock assessment prosess,
σ_I	standard deviation of φ which determines the magnitude of the implementation error, set at 0.15.

Lognormal error with a cv=0.15 was added to the first year biomass in the projections as an approximation to the uncertainty in ending biomass from the assessment model. Implementation error in mature male biomass results in fishing mortality values applied to the population that are either higher or lower than the values without implementation error. The autocorrelation was assumed to be the same value as that estimated for recruitment. Autocorrelation on implementation error was used to more closely approximate the process of estimating a biomass time series from within a stock assessment model. The variability in biomass of the simulated population results from the variability in recruitment and variability in full selection F arising from implementation error on biomass. The population dynamics equations were identical to those presented for the assessment model in the model structure section of the 2009 snow crab assessment.

1,000 runs of the projection model were used to estimate mean and variability of future biomass, F and catch for a given rebuilding strategy. To estimate the probability of rebuilding, the year when MMB in a particular run was above $B_{35\%}$ for the 2^{nd} year in a row (for the first time in the projection) was taken as the rebuilding year. The number of runs that were determined to be rebuilt in each year of the projection divided by 1,000 was used as an estimate of the probability of rebuilding by year. Once a particular run is determined to be rebuilt, even if the stock subsequently goes back down below $B_{35\%}$ or the MSST, it remains in the rebuilt status.

Literature. Cited

NPFMC (North Pacific Fishery Management Council). 2007. Environmental Assesment for Amendment 24. Overfishing definitions for Bering sea and Aluetian Islands King and Tanner crab stocks. North Pacific Fishery Management Council,Anchorage, AK, USA..

Turnock B.J., Rugolo, L.J., 2009. Bering Sea snow crab. In: Bering Sea and Aleutian Islands Crab Stock Assessment and Fishery Evaluation 2009. North Pacific Fishery Management Council, Anchorage, AK, USA.

AGENDA C-6(c)(4)
DECEMBER 2009

Outline of a process for defining scientific uncertainty when computing buffers and evaluating the risk associated with ACL alternatives, with some example applications

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Background
The difference (buffer) between the Overfishing Level (OFL) and the Acceptable Biological Catch (ABC) for crab stocks should reflect the extent of scientific uncertainty. For the P* (Pstar) method (Caddy and McGarvey, 1996; Prager *et al.*, 2003; Shertzer *et al.*, 2008; Hanselman, 2009), the extent of scientific uncertainty relates directly to the size of the buffer (Fig. 1). However, the extent of scientific uncertainty also impacts how the various alternative buffers and choices for P* impact the probability of overfishing and socio-economic impacts.

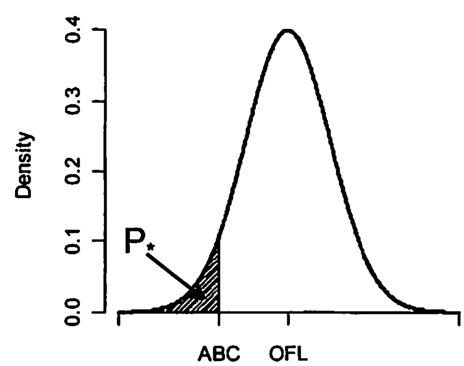


Figure 1. Distribution for the OFL and the value for the ABC such that the probability that the ABC exceeds the OFL is P*.

Scientific uncertainty arises from several sources, but can conveniently be divided into two main sources for the purposes of computing buffers: (a) those sources which are captured within a stock assessment and can be quantified using standard methods of variance estimation (such as asymptotic methods, bootstrapping or Bayesian techniques) and (b) those sources which cannot be captured in this way. The latter sources of uncertainty pertain to, for example:

(a) errors in definitions for proxies for F_{MSY} and B_{MSY},
(b) errors associated with the values for the parameters of population models which are pre-specified rather than being estimated by maximizing the likelihood function or by sampling from Bayesian posterior distributions (such as natural mortality, M, and catchability, q),
(c) the choice of appropriate methodology (e.g. how survey data are summarized for inclusion in assessments), and
(d) the choice of which data sources are included in assessments.

In principle, the impact of the latter sources of error can be quantified using sensitivity tests where, for example, the value of M is varied. However, it is not straightforward to use the results of sensitivity tests to determine measures of uncertainty unless probability statements can be made about the relative likelihood of each sensitivity test. While this can be done in principle, e.g. using a Delphi method, doing so would not be straightforward, would not be replicable, and would greatly lengthen the debates on stock status and hence management advice within the Crab PLAN Team and the SSC. The use of the Delphi method to quantify scientific uncertainty was not supported by the SSC at its June 2009 meeting.

This note outlines an approach, based on the variation in biomass estimates among stock assessments (i.e. "historical retrospective analyses"), which could be used to quantify this second source of scientific uncertainty in the form of a standard deviation, σ_{extra} [1]. This approach is being considered for the same purpose by the Pacific Fishery Management Council (Anon, 2009). Assuming that the extent of uncertainty associated with the OFL that is captured within the stock assessment is quantified by the standard deviation σ_{within} while that due to other sources is σ_{extra}, the buffer for the P* method would be computed based on a standard deviation of $\sqrt{\sigma^2_{\text{within}} + \sigma^2_{\text{extra}}}$.

The approach

The approach relies on the results of retrospective analyses constructed from all previous assessments of a stock. A historical retrospective analysis differs from a standard retrospective analysis (where the data used in the current stock assessment are removed one year at a time and the assessment is repeated) because a historical retrospective analysis captures the impact of sources of uncertainty, such changes in fixed values for parameters and in the values for the weights assigned to data sources, that are not considered during a standard retrospective analysis. Unlike Anon (2009), the analyses in this document are not restricted to "full" assessments only because the notion of "full" assessments does not exist for NPFMC crab stocks and because there is much more consistency in authorship of BSAI crab assessments over time. Two alternative methods for computing σ_{extra} are explored in this document (let $B_{i,y}$ be the biomass in year y based on the i$^{\text{th}}$ assessment, generally the number of mature males for the crab stocks).

The first method is as follows:

(1) Construct the logarithms of the ratios of the estimates of biomass for each year from each assessment for all years for which more than two estimates are available. For a year y for which estimates of biomass are available for the i$^{\text{th}}$ and j$^{\text{th}}$ assessments, this leads to two ratios, $R_{i,j,y} = \ell n(B_{i,y} / B_{j,y})$ and $R_{j,i,y} = \ell n(B_{j,y} / B_{i,y})$.

(2) Restrict the set of ratios to those for the last m years for which at least two estimates of biomass are available (based on the most recent m+1 years; the last year is ignored because there will only be one estimate of biomass for this year).

(3) Compute the standard deviation of the resulting R values (their mean is, by definition, 0).

The second method is as follows:

(1) Compute the geometric mean estimate of biomass for each year y, $\bar{B}_y$.

[1] The focus of this document is on variance rather the bias, the assumption being made that over the long term, assessments are unbiased.

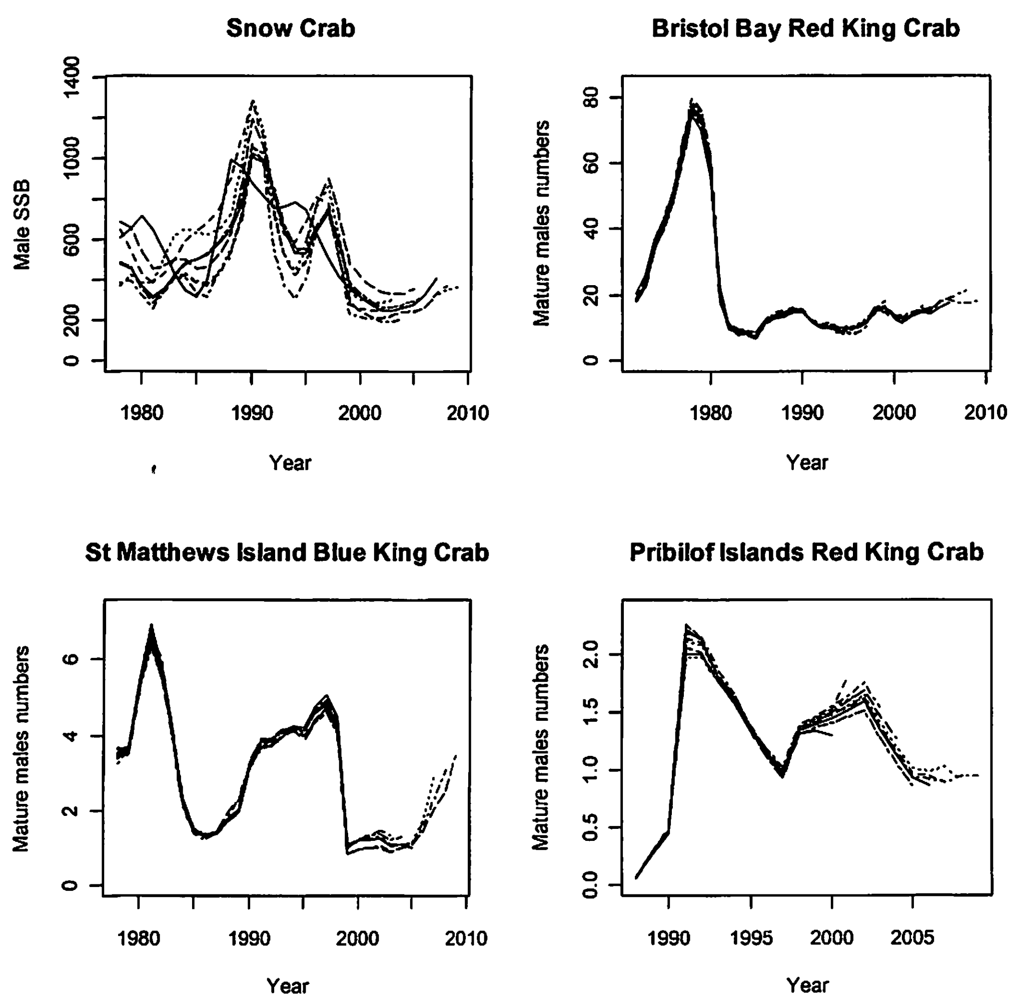
(2) Compute the deviation from each $\bar{B}_y$ for each assessment i and year y, i.e. $R_{y,i} = \ell n(B_{i,y} / \bar{B}_y)$.

(4) Compute the standard deviation of the resulting R values for the most-recent m years for which at least two estimates of biomass are available (their mean is, by definition, 0).

Example applications

Crab stocks

The two methods outlined above have been applied, for illustrative purposes, to assessment results for five BSAI crab stocks (snow crab, Bristol Bay red king crab[2], St Matthews Island blue king crab, Pribilof Islands red king crab, and Pribilof Islands blue king crab). Figure 2 shows the historical retrospective patterns for these five stocks.



[2] Based on the "management" rather than the "research" model because there are more assessments based on the former. The "management" model assumes that q=1 while the "research" model estimates q.

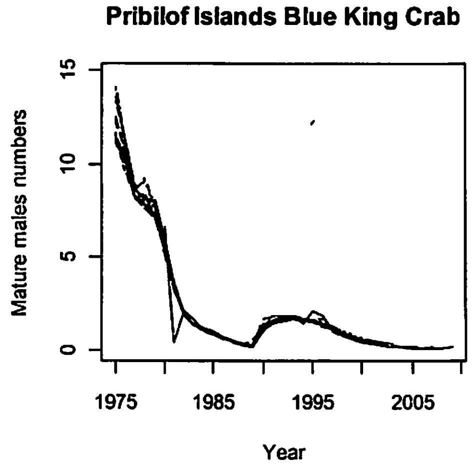


Figure 2. Retrospective analyses for five BSAI crab stocks.

Table 1 lists the values for σ_{extra} for each method and stock, as well as the estimates of σ_{within} for these stocks.

Groundfish stocks
The two methods outlined above have been applied, for illustrative purposes, to assessment results for five North Pacific groundfish stocks (EBS Pollock, sablefish, GOA Pacific ocean perch, BSAI yellowfin sole, and BSAI Atka mackerel). Figure 3 shows the historical retrospective patterns for these three stocks.

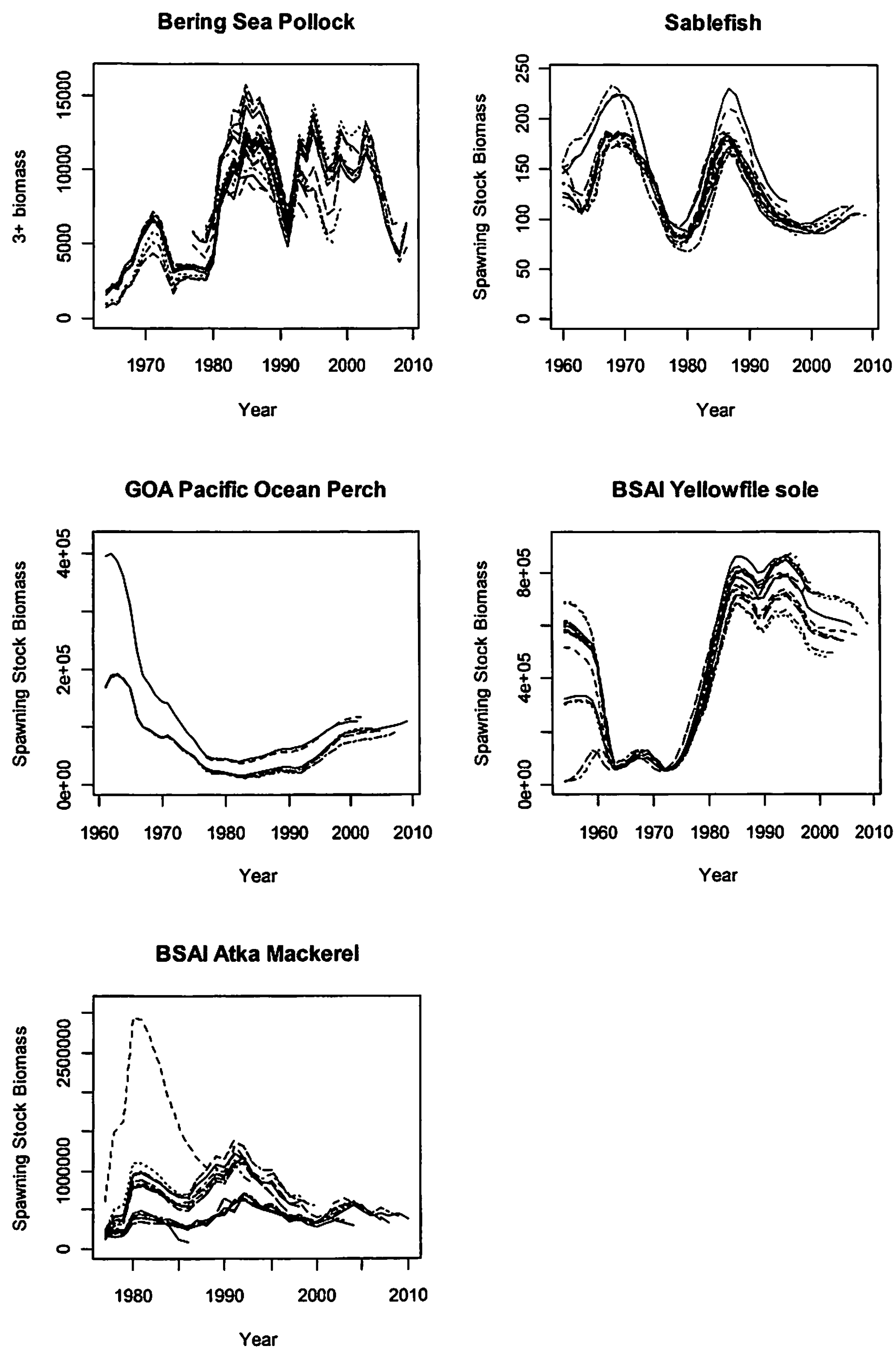


Figure 3. Retrospective analyses for five North Pacific groundfish stocks.

Table 2 lists the values for σ_{extra} for each method and stock, as well as the available estimates of σ_{within} for these stocks.

Discussion

The estimates of σ_{extra} in Tables 1 and 2 are substantially lower than the estimates for σ_{extra} for groundfish stocks off the U.S. west coast (σ_{extra} ~0.5; Anon (2009)). This can be attributed to several factors, but perhaps primarily to: (a) there has been little variation in the assessment authors and software used for BSAI crab and GOA and BSAI groundfish stock assessments (generally 1-2 authors over the period considered in this document), and (b) catchability is generally assumed to be 1 for BSAI crab assessments, which can substantially reduce inter-assessment variation. In contrast, assessment authors have varied considerably, there are fewer survey estimates of abundance, and assumptions regarding catchability have changed over time for west coast groundfish assessments.

Method 1 leads to higher estimates of σ_{extra} than method 2. This is to be expected because method 2 assumes that the average assessment result is correct while method 1 assumes that each assessment is correct in turn. One consequence of this is that some of σ_{extra} for method 1 captures the uncertainty associated with the "correct" assessment. Tables 1 and 2 provide estimates based on the two methods outlined above. Similar estimates are obtained by treating the results of the most recent assessment as being correct.

The estimates of σ_{extra} are generally, but by no means always, larger than σ_{within}. For example, σ_{within} is markedly lower than σ_{extra} for Bering Sea snow crab (0.02 compared to 0.16-0.25). The very low values for σ_{within} for this stock can be attributed to pre-specifying many parameters and the high weight placed on the survey estimates of abundance. In contrast, the value for σ_{within} is almost identical to that for σ_{extra} for Bristol Bay red king crab. However, both of these measures of variation would have been larger had the results been based on the "research" rather than on the "management" versions of the model. Finally, the value for σ_{within} for Pribilof Islands blue king crab is much higher than σ_{extra}.

The estimates of σ_{within} in Tables 1 and 2 relate to biomass estimates only. Actual applications will include the uncertainty of other parameters on which the OFL are based (such as the estimate of $F_{35\%}$).

Table 1 provides stock-specific estimates of σ_{extra} and there is variation among stocks in these estimates. It will likely be necessary to synthesize these estimates (along with the estimates for groundfish species, if this is deemed appropriate) to obtain the estimates of σ_{extra} needed when computing buffers and evaluating ACL alternatives. In the case of the BSAI crab stocks, some of the stocks considered most data poor (e.g. Pribilof Islands red king crab) have the lowest values for σ_{extra} and it may be appropriate to ignore such estimates when synthesizing the estimates of σ_{extra}. The values of σ_{extra} in Tables 1 and 2 should, of course, be considered to minimum estimates because they do not capture all sources of uncertainty because, for example, none of the assessments of St Matthews Island blue king crab estimated the value for *M*.

Acknowledgments
Dana Hanselman, Sandra Lowe, Jim Ianelli, Doug Pengilly, Diana Stram, Jack Turnock, Tom Wilderbuer and Jie Zheng are thanked for compiling the results of the historical assessments for the crab and groundfish stocks used in the preliminary analyses of this document.

References

Anon. 2009. An approach to quantifying scientific uncertainty in west coast stock assessments. http://www.pcouncil.org/bb/2009/1109/G5b_SUP_SSCCPSSUB_1109.pdf

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Hanselman, D. 2009. A general method to adjust catch limits / targets with survey uncertainty. Draft document submitted to the 21-22 May 2009 ACL workshop. 17pp.

Prager, M.H., Porch, C.E. Shertzer, K.W. and J.F. Caddy. 2003. Targets and limits for management of fisheries: a simple probability-based approach. *N. Am. J. Fish. Manage.* 23:349-361.

Shertzer, C.E., Prager, M.H. and E.H. Williams. 2008. A probability-based approach to setting annual catch levels. *Fish. Bull.* 106:225-232.

Table 1. Estimates of σ_{extra} for the two methods and the estimates of σ_{within} for the five BSAI crab stocks.

Stock	σ_{extra}		σ_{within}
	Method 1	Method 2	
Bering Sea Snow Crab	0.248	0.164	0.02
Bristol Bay Red King Crab	0.068	0.046	0.060
St Matthews Island Blue King Crab	0.091	0.067	0.13
Pribilof Islands Red King Crab	0.052	0.037	0.30
Pribilof Islands Blue King Crab	0.230	0.157	0.37

Table 2. Estimates of σ_{extra} for the two methods and the available estimates of σ_{within} for the four North Pacific groundfish stocks.

Stock	σ_{extra}		σ_{within}
	Method 1	Method 2	
Eastern Bering Sea Pollock	0.214	0.146	0.29
Sablefish	0.109	0.072	0.03
GOA Pacific ocean perch	0.412	0.264	0.30
BSAI Yellowfin sole	0.162	0.113	0.065
Atka mackerel	0.401	0.254	0.27

ACL analysis and rebuilding plans for Snow and Tanner crab stocks

Chapter	Description
ES	**Exec summary**
1	**Introduction-** Purpose and Need, Scope of analysis, Applicable Laws and other requirements
2	**Description of Alternatives** Alternative 1 (Status quo) Alternative 2 Constant buffer approach (range of P*s) Tier 1-3 approach Tier 4 approach Tier 5 approach Alternative 3 Range of constant P* (variable buffer) Tier 1-3 approach Tier 4 approach Tier 5 approach option(applies to both Alt 2 and 3): Snow crab rebuilding measures option(applies to both Alt 2 and 3): Tanner crab rebuilding measures Comparison of alternatives Alternatives considered and not carried fwd
3	**EBS Snow crab** Methodology Assessment information impacts of alternatives ACL control rule Rebuilding control rule Impacts of other rebuilding measures
4	**EBS Tanner crab** Methodology Assessment information impacts of alternatives ACL control rule Rebuilding control rule Impacts of other rebuilding measures
5	**BB red king crab** Methodology Assessment information impacts of alternatives
6	**PI red king crab** Methodology Assessment information impacts of alternatives
7	**PI blue king crab** Methodology Assessment information impacts of alternatives
8	**St. Matthew blue king crab** Methodology Assessment information impacts of alternatives
9	**Norton Sound red king crab** Methodology Assessment information impacts of alternatives

Chapter	Description
10	**AI golden king crab** Methodology Assessment information impacts of alternatives
11	**Pribilof Island golden king crab** Methodology Assessment information impacts of alternatives
12	**Adak red king crab** Methodology Assessment information impacts of alternatives
13	**Effects on other marine resources** Groundfish stocks and fisheries Prohibited species
14	**Economic and Social effects**
15	**Cumulative impacts**
16	**References** **appendix-method for uncertainty analysis**
17	**List of preparers and persons consulted**

Pribilof Islands Blue King Crab Rebuilding Plan

Chapter	Description
ES	**Exec summary**
1	**Introduction-** Purpose and Need, Scope of analysis, Applicable Laws and other requirements
2	**Description of Alternatives** Alternative 1: status quo Alternative 2: PIHCZ modified (in addition to trawl ban) option 1: apply to Pacific cod pot fishery option 2: apply to all groundfish fishing Alternative 3: ADF&G closures modified (in addition to crab closures): option 1: apply to Pacific cod pot fishery option 2: apply to all groundfish fishing Alternative 4: distribution of entire PIBKC stock. Closure applied to: option 1: apply to Pacific cod pot fishery option 2: apply to all groundfish fishing Alternative 5: PSC cap Alternative considered and not carried fwd gear modification
3	**Methodology for Impact analysis** Rebuilding of PIBKC stock impacts on groundfish fisheries
4	**Pribilof Islands blue king crab** Assessment overview Impacts of alternatives on rebuilding stock Alternative 1: status quo Alternative 2: PIHCZ modified (in addition to trawl ban) option 1: apply to Pacific cod pot fishery option 2: apply to all groundfish fishing Alternative 3: ADF&G closures modified (in addition to crab closures): option 1: apply to Pacific cod pot fishery option 2: apply to all groundfish fishing Alternative 4: distribution of entire PIBKC stock. Closure applied to: option 1: apply to Pacific cod pot fishery option 2: apply to all groundfish fishing Alternative 5: PSC cap
5	**Other marine resources** Groundfish stocks and fisheries Impacts of alternatives on Pacific cod stock and fishery Impacts of alternatives on other groundfish fisheries Impacts on marine mammals
6	**Economic and Social effects**
7	**Cumulative impacts**
8	**References**
9	**List of preparers and persons consulted**

PUBLIC TESTIMONY SIGN-UP SHEET

Agenda Item: C6 (c) Snow/Tanner Rebuilding Plans

	NAME *(PLEASE PRINT)*	TESTIFYING ON BEHALF OF:
1	Edward Poulsen handout	ICEPAC
2	Frank Kelty	City of Unalaska
3	HEATHER McCARTY / SIMEON SWETZOF JR.	City of ST. PAUL/CBSFA
4	Leonard Herzog	Homer Crab Cooperative
5	Arni Thomson handout	A.C.C.
6	Steve Branson	~~Crab~~ Crewmen's Association
7	Linda Kozak	Crab Group
8	Stephen Taufen	Groundswell Fisheries Movement
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NOTE to persons providing oral or written testimony to the Council: Section 307(1)(I) of the Magnuson-Stevens Fishery Conservation and Management Act prohibits any person " to knowingly and willfully submit to a Council, the Secretary, or the Governor of a State false information (including, but not limited to, false information regarding the capacity and extent to which a United State fish processor, on an annual basis, will process a portion of the optimum yield of a fishery that will be harvested by fishing vessels of the United States) regarding any matter that the Council, Secretary, or Governor is considering in the course of carrying out this Act.

C 6(c)

December 7, 2009

Eric A. Olson, Chairman
NPFMC
Anchorage, Alaska

Presentation of Edward Poulsen, Executive Director of ICEPAC, to the NPFMC, Scientific and Statistical Committee

RE: Agenda Item C-6(c) Snow and Tanner Crab Rebuilding Plans

Below is language from the Bering Sea and Aleutian Islands King and Tanner Crab FMP, Amendment 24 which refers to excerpts from the National Standard #1 guidelines. In particular, I wanted to focus on the bolded language below relative to the snow crab rebuilding plan. (Review Draft EA, August 31, 2007, page 3)

"(4) Relationship of status determination criteria to environmental change. Some short-term environmental changes can alter the current size of a stock or stock complex without affecting the long-term productive capacity of the stock or stock complex. Other environmental changes affect both the current size of the stock or stock complex and the long-term productive capacity of the stock or stock complex.
(i) If environmental changes cause a stock or stock complex to fall below the minimum stock size threshold without affecting the long-term productive capacity of the stock or stock complex, fishing mortality must be constrained sufficiently to allow rebuilding within an acceptable time frame (also see paragraph (e)(4)(ii) of this section). Status determination criteria need not be respecified.
(ii) If environmental changes affect the long-term productive capacity of the stock or stock complex, one or more components of the status determination criteria must be respecified. Once status determination criteria have been respecified, fishing mortality may or may not have to be reduced, depending on the status of the stock or stock complex with respect to the new criteria."

This language clearly states that respecification of stock status determination criteria is in order if environmental changes have affected the long-term productive capacity of a stock.

On May 16, 2000, Commerce Secretary William M. Daley determined that the **Alaska snow crab fishery suffered a commercial fisheries failure due to natural and environmental factors (NOAA/NMFS AKR, News Release, May 16, 2000; and NMFS, Penny Dalton to James Baker, Determination of a Commercial Fishery Failure in the Snow Crab Fishery of the EBS off the Coast of Alaska, May 11, 2000).** The determination by Secretary Daley enabled Congress to appropriate funds to help snow crab fishermen at the request of the State of Alaska under section 312 (a) of the Magnuson-Stevens Fishery Conservation and Management Act. The basis for this determination was distinctly related to the discussions of the NPFMC SSC, as reflected in their minutes of the NPFMC, April 12, 2000, SSC meeting:

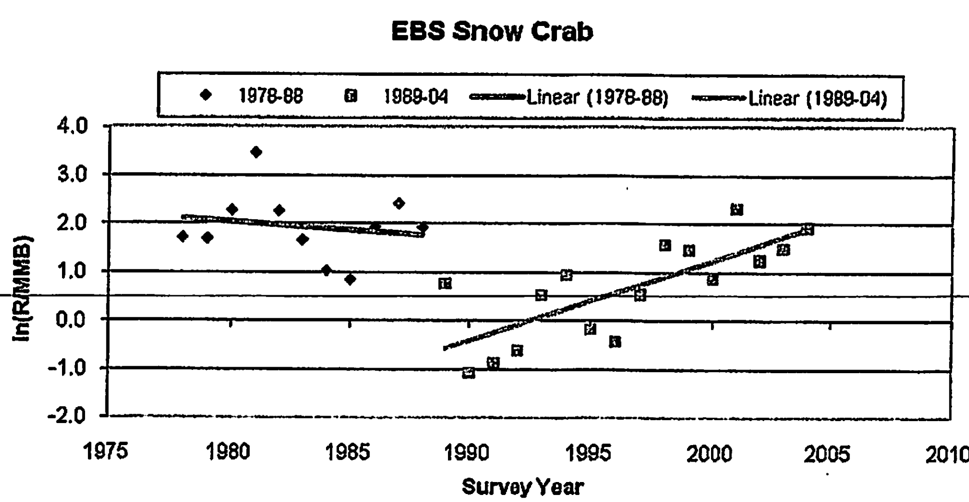
"Sampling variability of surveys is large, and crab availability to surveys appear highly variable. Large declines in abundance appear triggered by surges in mortality that remain unexplained. Recruitment appears to be linked to environmental factors rather than biomass, so trends in recruitment are difficult to predict. Rebuilding simulations simply assume that the future will be similar to what we have observed in the past: highly variable. Rebuilding times can vary over an order of magnitude depending on the particular set of assumptions adopted. It should be emphasized therefore, that these rebuilding scenarios are highly uncertain and are not robust to mis-specification of recruitment variability. The exact functional form and parameters of the recruitment relationship are unknown."

"An exhaustive statistical study of C. bairdi (Tanner) showed that most of the change in recruitment could be explained by physical oceanographic factors (Rosenkrantz, Tyler, and Kruse, 1999). In particular, year-class strength is related to wind-driven currents, and bottom temperatures of the Bering Sea "cold pool". An effect of stock size on yearclass strength could not be found. That is, even if the spawning stock size was reduced by the fishery, the effort was not severe enough to leave behind statistical evidence of a relationship between reduced stock size and year-class strength. C. opilio (snow) are closely related to C. bairdi and are also likely to be strongly influenced by oceanographic processes...."

The SSC goes on to make additional comments about recruitment of snow crab and St. Matthews blue king crab: "**In reality, fishing has probably had little influence on recent declines of these populations.** Rather, a massive natural mortality event between 1998 and 1999 was the most likely explanation given to the SSC for the decline in St. Matthews blue king crab. A period of low recruitment is thought to be the reason for the decline in C. opilio. These events are quite possibly triggered by corresponding events in the physical environment, such as the regime shift and warm Bering Sea conditions in 1997 and 1998. Furthermore, it was suggested that the reproductive capacity of these populations is related to the abundance or biomass of mature females, which are not affected to any great extent by the crab and groundfish fisheries. Only if the fertilization of females was compromised by the low abundance of mature males would the fishery be involved as a contributing factor. Unfortunately, the current state of knowledge precludes precise determination of a reproductive capacity of these crab populations."

There has been more recent research from other scientists that examine shifts in the environment which appear to have negatively affected opilio. From a simple harvesters perspective though, higher water temperatures in the late '90's up until recently has resulted in a Northern migration of the stock. Water temperatures now seem to be cooling and the crab seem to be migrating South again.

Below is a chart, using data from the most recent opilio stock assessment document, showing changes in productivity of the snow crab resource over time.



There was obviously a dramatic drop in productivity in the early 1990's which likely resulted in the recruitment issues experienced in the late 1990's. This information, combined with the SSC's earlier comments as well as more recent research papers begs the question- should the baseline years (currently 1979-Current) be revised or possibly re-weighted for snow crab to reflect current environmental conditions?

ICEPAC's concern is simply that if fishing is not causing the reduced recruitment, we may never have a rebuilt fishery again (or may bounce back and forth from rebuilt to overfished as we are experiencing with bairdi), even though the stock is in no danger of imminent collapse. By including years with an outdated, but more favorable environmental regime as part of the baseline, the snow crab assessment may not be taking environmental changes into account as required by National Standard #1. Another approach would be to change the weighting of the years, as there are a few extremely large recruitment pulses resulting from favorable environmental conditions, which skew the baseline upward.

The ICEPAC goal is not to be selective to certain years that will be opportunistically favorable to show opilio to be rebuilt. Instead, our goal would be to have the SSC and Crab Plan Team review the years and/or methodology used to form the baseline for opilio. Then make a determination if environmental changes occurred that could lead to establishing a different set of years, or weighting certains years should be considered. ICEPAC would then recommend the Crab Plan Team have an open dialogue with industry about this. ICEPAC is not interested in harvesting more opilio if it will cause the long-term yield to decline. However, we are concerned that the current baseline years may be arbitrary and result in instability for the crab industry as it attempts to deal with potentially drastic swings in quotas in an attempt to hit an arbitrary rebuilt level. Regardless of whether the crab industry is not identified as the major reason the stock fails to attain the rebuilt level, we will nonetheless be blamed for the failure to rebuild.

Sincerely,

Edward Poulsen, Executive Director
Inter-Cooperative Exchange Policy Advocacy Committee (ICEPAC)

National Marine Fisheries Service
Alaska Region

NEWS RELEASE

Alaska Region, P.O. Box 21668, Juneau, Alaska 99802-1668

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NMFS 00-08-AKR
FOR IMMEDIATE RELEASE
Date:May 16, 2000

COMMERCE SECRETARY ACTS TO HELP FISHERMEN HURT BY COLLAPSE OF ALASKA SNOW CRAB FISHERY

Commerce Secretary William M. Daley today determined that the Alaska snow crab fishery has suffered a commercial fisheries failure due to natural and environmental factors. The determination by Secretary Daley opens the way for Congress to appropriate funds to help snow crab fishermen.

"The snow crab fishery failure has caused significant economic hardship for crab fishermen and fishing communities that rely on revenue from this fishery," Secretary Daley said. "It is very difficult to anticipate shifts in the environmental regime and the impacts on living marine resources. Therefore, it's important for Congress and the administration to work together to help the fishing industry when these situations arise."

If funds are approved by the Congress, the Secretary would provide financial assistance to the State of Alaska "to assist the affected communities and to improve fisheries research, management, and coordination to help restore the fisheries and prevent similar failures in the future."

The Secretary made the fishery resource disaster determination at the request of the state under section 312 (a) of the Magnuson-Stevens Fishery Conservation and Management Act so assistance could be provided to the adversely impacted communities and fishermen. The Secretary can determine a commercial fishery failure under section 312 (a) if a fishery resource disaster results from natural causes, man-made causes beyond the control of fishery managers, or undetermined causes.

(More)

Recent survey information showed the size of the snow crab resource was approximately 40 percent lower than the minimum established size for this resource by the North Pacific Fishery Management Council. Harvest levels had to be reduced by 85 percent in 2000 from harvest levels the year before. The council, in cooperation with the State of Alaska, is preparing a rebuilding plan for this resource.

The total value of the snow crab fishery averaged $141 million between 1989-1999. Based on the 1999 average ex-vessel price of $0.88/pound, the 2000 guideline harvest level of 28.5 million pounds may have a total value of $25 million. Officials also believe that the Alaska snow crab fishery may not open in 2001 due to rebuilding efforts by the fishery management council.

According to state officials, the affected communities receive a large portion (between 10 percent and 85 percent) of their income from snow crab through fish tax, revenue and employment from crab processors, and secondary income from things like harbor usage, sale of goods and services, transportation, and fuel tax. This money is used for basic services like electricity, operating budgets, education, and health care.

During 1997 and 1998, similar determinations were made and economic assistance was granted to the State of Alaska due to commercial salmon fishery failures in western Alaska. Congress appropriated $57 million to help salmon fishermen and communities.

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State of Alaska

Office of the Governor

Tony Knowles
Governor
P.O. Box 110001
Juneau, Alaska 99811-0001

NEWS RELEASE

Bob King
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Claire Richardson
Deputy Press Secretary
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FOR IMMEDIATE RELEASE: May 17, 2000 00-128

KNOWLES' REQUEST TO HELP SNOW CRAB FISHERS APPROVED

Commerce Secretary Signs Declaration for Affected Bering Sea Communities

Responding to Gov. Tony Knowles' request for assistance for Bering Sea communities affected by the sudden downturn in snow crab stocks, Commerce Secretary William Daley yesterday issued a declaration of a commercial fisheries failure due to natural and environmental factors. The fishery disaster declaration, under section 312 of the Magnuson-Stevens Act, opens the way for Congress to appropriate funds to help snow crab fishermen.

"The snow crab fishery failure has caused significant economic hardship for the Pribilof Islands and other crab fishermen and fishing communities that rely on this resource," Knowles said. "Reduced revenues have already resulted in reduced services and increased costs; impacts that are devastating to small, isolated communities such as these. It's important for the state and federal governments to lend a helping hand to the fishing industry when these situations arise."

Sen. Ted Stevens has included $10 million in assistance in a pending appropriations bill. If approved by Congress, the funds would be available to assist the affected communities and to improve fisheries research, management, and coordination to help restore the fisheries and prevent similar failures in the future.

Knowles requested the declaration on March 10, after surveys showed a dramatic drop in the snow crab populations and harvest levels were sharply reduced. When the fishery took place in April, crabbers caught 26 million pounds of snow crab worth $50 million. Last year, the 250 vessels in the fleet hauled in 196 million pounds, earning about $190 million.

The cause of the decline is unclear, due to a lack of adequate research and stock assessment information, but current estimates predict the fishery will probably be closed entirely next year and remain at low levels through 2004.

Primarily affected are the Pribilof Island communities of St. Paul and St. George that receive a large portion, between 10 percent and 85 percent, of their income from snow crab through fish tax revenue and employment from crab processors. This money and secondary income from things like harbor usage, sale of goods and services, transportation, and fuel tax is used to support basic services like electricity, operating budgets, education, and health care.

-30-

North Pacific Fishery Management Council

Richard B. Lauber, Chairman
Clarence G. Pautzke, Executive Director

605 West 4th Avenue, Suite 306
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Visit our website: http://www.fakr.noaa.gov/npfmc

April 25, 2000

The Honorable William Daley
U.S. Secretary of Commerce
14th & Constitution Avenues NW
Washington, DC 20230

Dear Secretary Daley:

I am writing to seek your help for our crab industry off Alaska. The industry is in jeopardy because of recent downturns in Bering Sea crab stocks. The opilio fishery, for example, which previously harvested around 200 million pounds, was allowed only 28 million pounds this year, and likely will be closed in coming years. We have license limitation for the crab fisheries, but significant excess harvesting capacity still exists. The bottom line is that the critically low levels of crab abundance can no longer support the current fleet.

At our April meeting, the Council discussed with industry how to further address this excess capacity problem. We envision a two-step process. First, we ask you to seek congressional assistance to support a vessel buyback program using a combination of appropriations, federal loans, and modifications of the Capital Construction Fund as appropriate. Though the attached tables show the number of crab vessels qualified in 2000 to be about 470, many of those hold interim, non-transferable licenses that may not qualify after final appeals are settled. So about 300 vessels may be granted permanent licenses. If a significant number of permanent licenses could be removed in step one, further rationalization could proceed more smoothly.

The second step would be to further limit the crab industry. Several different approaches are being contemplated. One might be a catch history-based or other type of comprehensive rationalization program that could include harvesters, processors and coastal communities. Another might be vessel cooperatives as used in the pollock fisheries. In either case, the moratorium on new individual fishing quota programs will need to be lifted by Congress. And crab cooperatives may need additional authorities from Congress.

Whatever path we take, we hope you will support our efforts to further rationalize these critical crab fisheries. We are committed to working toward the reduction of fishing capacity, which fully comports with NOAA Fisheries Strategic Plan to alleviate overcapitalization in 15% of federally managed fisheries by 2004. We hope you will join us in this effort which will set the stage for long term sustainability of the crab resources and the industry that depends on them.

Sincerely,

Richard B. Lauber
Chairman

cc: Congressional Delegations (AK, WA, OR)
State Governors and Fisheries Agencies

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, MD 20910

THE DIRECTOR

MAY 11 2000

MEMORANDUM FOR: D. James Baker
Under Secretary for Oceans and Atmosphere

FROM: Penelope D. Dalton *Penelope D Dalton*

SUBJECT: Determination of a Commercial Fishery Failure Due to a Fishery Resource Disaster in the Snow Crab Fishery in the Eastern Bering Sea off Alaska--INFORMATION MEMORANDUM

The Governor of the State of Alaska formally requested on March 10, 2000, that the Secretary of Commerce (Secretary) determine a commercial fishery failure resource disaster in the snow crab fishery under section 312(a) of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act. Representatives from Pribilof Islands communities and other groups also have petitioned the Secretary to make a section 312 determination for the snow crab fishery and other Bering Sea crab species (red and blue king crab, Tanner crab, and hair crab).

Such a determination would authorize the Secretary to provide funds appropriated for the purpose to the State of Alaska to assess the economic and social effects of the commercial fishery failure, to support any activity that would restore the fishery or prevent a similar failure, and assist the fishing communities affected by the failure.

The National Marine Fisheries Service (NMFS) conducted a summer trawl survey of the Bering Sea, which indicated the biomass of snow crabs declined significantly from the levels in the 1998 survey. On September 24, 1999, NMFS declared the Bering Sea snow crab resource was overfished. The North Pacific Fishery Management Council is preparing a rebuilding plan for this resource. The 2000 fishery was conducted with a harvest level of 28.5 million pounds, an 85 percent decrease from the 1999 harvest level of 196 million pounds. The evidence available to NMFS suggests that natural conditions are the causes of this dramatic reduction in this crab population.

I find that the apparent collapse of the Bering Sea snow crab resource in 2000 and, in all likelihood 2001 and beyond, has resulted in a commercial fishery failure due to a fishery resource disaster as provided under the Magnuson-Stevens Act.

Attachment

DETERMINATION OF A COMMERCIAL FISHERY FAILURE AFFECTING THE 2000 BERING SEA SNOW CRAB (CHIONOECETES OPILIO) FISHERY

A precipitous decline in the Bering Sea snow crab abundance has occurred in the eastern Bering Sea. The Governor of the State of Alaska, as well as the Pribilof Island communities of St. George and St. Paul, have petitioned the Secretary of Commerce (Secretary) to make the determination, pursuant to section 312(a) of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), that a commercial fishery failure has occurred in the Bering Sea snow crab fishery due to a fishery resource disaster. In addition, representatives from Pribilof communities also expressed concern that other Bering Sea crab stocks, such as red and blue king crab, Tanner crab, and hair crab are suffering a resource disaster.

Section 312(a) of the Magnuson-Stevens Act, 16 U.S.C. 1861a, authorizes the Secretary to exercise discretion in determining whether there is a commercial fishery failure due to a fishery resource disaster as a result of:

a. natural causes;
b. man-made causes beyond the control of fishery managers to mitigate through conservation and management measures; or
c. undetermined causes.

Determination of a fishery resource disaster

The National Marine Fisheries Service (NMFS) 1999 summer trawl survey of the Bering Sea indicated the biomass of both male and female snow crabs declined significantly from levels observed during the 1998 survey. The 1999 estimate of male crabs 4 inches (industry-standard minimum size) and larger dropped 63% from the prior year and all other components of the stock also declined significantly. Currently, the stock is 60% of the minimum stock size threshold, which represents one half the long-term average mature biomass as defined in the Federal Fishery Management Plan for the Bering Sea and Aleutian Inlands King and Tanner Crab (FMP).

Collapse of the Bering Sea snow crab stocks, as evidenced by severe lack of recruitment into the population, precipitated a guideline harvest level reduction of over 85% in the snow crab fishery in the year 2000. The 2000 guideline harvest level for snow crab was established at 28.5 million pounds compared to the 1999 harvest level of 196 million pounds. Owing to the low biomass of mature crabs, NMFS classified the snow crab stock as "overfished" in 1999 and a rebuilding plan is being prepared by the North Pacific Fishery Management Council. The prospects for a 2001 fishery are uncertain.

Bristol Bay red king crab (Paralithodes camtschaticus) is not suffering a fishery resource disaster. The abundance index of legal male red king crabs was 11.0 million crabs, representing a 49% increase from last year and is near the 20-year average. During 1996-1999, the Bristol Bay red king crab fishery yielded 8.4, 8.9, 14.3, 11.2 million pounds worth $33.5, $28.9, $37.3, and $70 million in ex-vessel values, respectively. Thus, this stock is supporting a productive fishery.

King crab fisheries off St. Matthew and Pribilof Islands were closed in 1999 owing to low stock size and associated high degree of uncertainty. In 1999, the abundance of Pribilof Islands blue king crabs (P. platypus) continued an ongoing decline and fell below the threshold established for this fishery. On the other hand, estimates of red king crabs in the Pribilof Islands area increased significantly from 1998; however, most red king crabs were captured in a single tow, making the reliability of that estimate extremely low. Historically, red king crab have not been abundant in the Pribilof Islands and landings taken incidentally during the blue king crab fishery. Survey estimates for St. Matthew Island blue king crabs indicated dramatic declines of both male and female crabs in all size categories in 1999. Owing to the low biomass of mature crabs, the St. Matthew blue king crab stock was classified as "overfished" in 1999 and a rebuilding plan is being prepared. The decline in abundance for these red and blue king crab stocks constitutes a fishery resource disaster.

The Tanner crab (Chionoecetes bairdi) fishery has been closed since 1997 due to depressed stock conditions. The estimated spawning biomass of this stock is low and the stock is considered "overfished" under the Magnuson-Stevens Act. A rebuilding plan is under public review. Over the past few decades, this stock appears to have experienced a 13-14 year recruitment cycle. The NMFS survey revealed high abundance of juvenile Tanner crabs in 1999, suggesting that an apparent strong recruitment event may soon promote stock rebuilding. Once the stock exceeds the fishery threshold for two consecutive years, fishing will be resumed, perhaps as soon as January 2002.

Hair crab[1] (Erimacrus isenbeckii) abundance index for large males declined from 1981-1992, increased from 1992 to 1995, and is now declining again. The abundance index of 2.3 million large males is 22% lower than last year. Hair crabs constitute a small fishery in the Bering Sea. In 1998, 0.3 million pounds were taken. As with many crab stocks, recruitment is periodic. Lack of recent recruitment has led to chronic stock declines in recent years, and harvests have been cut accordingly. During 1995-1999, commercial catches were 1.9, 0.8, 0.8, 0.3, 0.2 million pounds worth $5.2, $1.6, $1.6, $1.0, and $0.9 million, respectively. This decline is a serious concern when added to other problems with Bering Sea crab stocks.

Therefore, I find that a fishery resource disaster occurred in the Bering Sea in 2000 that significantly reduced the abundance of snow crab; St. Matthew blue king crab; and Pribilof Islands blue king crab; resulting in a considerable reduction in the harvests. Low abundances of Tanner and hair crab have contributed to the overall reduction in available resources for the fishery.

Determination of the cause of the fishery resource disaster

Insufficient evidence exists to determine the cause of the snow crab, St. Matthew blue king crab, and Pribilof Islands blue king crab declines. However, the evidence highly suggests the causes are natural. The crab fisheries only harvest the large male crabs, however, the 1999 NMFS trawl survey showed dramatic declines in all segments of population of these crabs. Recruitment for crab species appears to be linked to environmental factors rather than biomass, so trends in recruitment are difficult to predict.

A period of low recruitment is thought to be the reason for the decline in snow crab. These events are quite possibly triggered by corresponding events in the physical environment, such as the regime shift and warm Bering Sea conditions in 1997 and 1998. Furthermore, it was suggested that the reproductive capacity of these populations is related to the abundance or biomass of mature females, which are not affected to any great extent by the crab and groundfish fisheries. Temperature is likely to be important to snow crab population dynamics. Warmer temperatures hasten growth, but they likely have a negative effect on reproduction as faster growing males have fewer mating

[1]Hair crab is not a Federally managed species under the Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs. The State of Alaska has management authority for hair crab.

opportunities prior to attaining harvestable size. On the other hand, crab larvae feed primarily on copepod nauplii, which we think are favored by warmer water in the Bering Sea. Crab megalopa settle out of the water column at very specific temperatures and depths. Therefore, survival may be favored by cooler, warmer or intermediate temperatures depending on what life stage one considers. In 1997 and 1998, water temperatures were at record high levels, triggering unusual plankton blooms and contributing to salmon run failures. Beyond temperature, we suspect advection of larvae by ocean currents to the nursery areas and cannibalism within the limited nursery areas from older crab cohorts are contributors to recruitment success or failures.

Recruitment to the St. Matthew and Pribilof Islands blue king crab stocks has been declining for several years, but the sharp decline in all sizes of crabs suggest large survey measurement errors, a large increase in natural mortality, or some combination of both. The causes of the decline in recruitment into these blue king crab stocks is unknown, however, its presumed to be environmental.

NMFS conducts annual assessments with a multi-species trawl survey, and the State of Alaska Department of Fish and Game administers onboard observer and dockside sampling programs. Little additional biological information is available to predict the population abundance. The full geographic distribution of these species is uncertain. Most basic biological productivity parameters have never been studied.

Gear selectivity, crab handling mortality, and other potential effects are virtually unknown. These uncertainties are urgently needed to be addressed so that crab stock productivity can be better understood. Better understanding will allow harvest strategies to be adjusted accordingly to promote stock rehabilitation and to diminish risks of future fishery collapses.

Therefore, I find that the cause of the fishery resource disasters are undetermined, but probably due to natural conditions.

Determination of a commercial fishery failure

The impacts of the snow crab decline and the early sea ice advance on communities are dramatic. St. Paul processes over 40 percent of the snow crab harvest, generating $8 million in municipal taxes in 1999. This year, crab tax revenues are projected to be 66 to 90 percent below recent averages. St. George projects a revenue shortfall of $900 thousand and the inability to make bond payments for harbor completion.

Reduced revenues for both communities have already resulted in reduced plane service, reduced municipal and health care services, increased food costs, and the inability to continue capital projects. Fisheries closures for St. Matthew and Pribilof Islands blue king crab as well as Tanner crab may compound the fisheries failure experienced by these communities with the decline of the snow crab stock.

Therefore, I find that the apparent collapse of the Bering Sea snow crab in 2000 has resulted in a commercial fishery failure due to a fishery resource disaster as provided under section 312(a) of the Magnuson-Stevens Act. This determination is supported by the Governor of Alaska's declaration of a commercial fishery failure for the snow crab fishery.

Penelope D. Dalton

Penelope D. Dalton
Assistant Administrator
for Fisheries

5/11/00
Date

Alaska Crab Coalition
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December 14, 2009

Eric A. Olsen, Chairman
NPFMC
Anchorage, Alaska 99501

Re: Comments on Agenda C-6c Crab Rebuilding Plan for Snow Crabs

Recommendations for analytical priorities for the snow crab rebuilding analysis, (reference NPFMC SSC Minutes, December 7-9, 2009).

- The appropriate base years and methodology over which to estimate average recruitment for snow crab stock projections should be reviewed.
- To the extent possible, results from the net efficiency study should be incorporated into the rebuilding plan.
- Add an alternative for an 8 year rebuilding horizon to the rebuilding time frames to address the effect of environmental conditions being unfavorable to recruitment.

Arni Thomson
Executive Director
Alaska Crab Coalition